Safety Procedures for Using Handtools and Power Tools

LESSON 1

SAFETY PROCEDURES FOR USING HANDTOOLS AND POWER TOOLS

TASK 1: Describe the safety procedures for using handtools and power tools.

CONDITIONS: Within a self-study environment and given the subcourse text, without assistance.

STANDARDS: Within one hour

REFERENCES: No supplementary references are needed for this task.

1. Introduction

No matter how small the job, safety precautions must be taken at all times. A tool may be efficient, essential, time-saving, or even convenient; but it is also dangerous. For this reason, the mechanic must use handtools correctly. The mechanic must also be alert to any conditions that might endanger him or fellow workers. He should take the necessary time to acquaint himself with safety guidelines and remember that he, himself, is the most important part of safety procedures.

2. Safety Rules

a. *General.* It is extremely important for all concerned to recognize the possibilities of injury when using handtools and power tools. There will undoubtedly be a safety program to follow for the shop or area in which you are working. The following general safety precautions and rules are included as a guide to prevent or minimize personal injury when using these tools:

(1) Make certain that before using them all tool handles are securely attached.

(2) Exercise extreme caution when handling edged tools.

(3) Do not use a tool for a purpose other than that for which it was intended.

(4) Do not handle tools carelessly--piling tools in drawers, dropping tools on hard surfaces, etc., can damage them. Damaged tools can cause mishaps.

(5) Keep your mind on your work so that you do not strike yourself or someone else with a hammer or sledge.

(6) Do not carry edged or pointed tools in your pocket.

(7) Always wear goggles when chipping metal and when grinding edges on tools.

(8) Hold driving tools correctly so that they will not slip off the work surface.

(9) Use the right tool for the job. The wrong tool may damage materials, injure workers, or both.

(10) Do not use punches with unsuitable points or mushroomed heads.

(11) Do not use a tool that is oily or greasy. It may slip out of your hand, causing injury.

(12) When using jacks to lift a vehicle, be sure to use blocking or other supports in case of jack failure.

(13) Make sure that work to be cut, sheared, chiseled, filed, etc., is steadied and secure to prevent the tool from slipping.

(14) When using a knife, always cut away from your body, except in the case of a spoke shave or drawknife. (See paragraphs 4b(5) and (6)).

(15) Use torches and soldering irons with extreme care to prevent burns and explosions. The soldering iron must always be placed so that the hot point cannot come in contact with flammable material or with the body.

(16) Familiarize yourself with the composition and hardness of the material to be worked.

(17) Support your local safety program and take an active part in safety meetings.

(18) Advise your supervisor immediately of any unsafe conditions before starting work.

(19) Learn the safe way to do your job before you start.

(20) Think safety, and act safely at all times.

(21) Obey safety rules and regulations--they are for your protection.

(22) Conduct yourself properly at all times--horseplay is prohibited and dangerous.

(23) Operate only the equipment you are authorized to use.

(24) Report any injury to your supervisor immediately.

In addition to the general safety precautions and rules, there are other good tool habits which will help you perform your work more efficiently, as well as safely. These tool habits are described in the following subparagraphs.

b. *Tool Habits.* "A place for everything and everything in its place" is just common sense. You cannot do an efficient, fast repair job if you have to stop and look around for each tool needed. The following rules will make your job easier:

(1) Keep each tool in its proper storage place. A tool is useless if it cannot be found. If you return each tool to its proper place, you will know where it is when you need it.

(2) Keep your tools in good condition. Keep them free of rust, nicks, burrs, and breaks.

(3) Keep your tool set complete. If you are issued a tool box, each tool should be placed in it when not in use. If possible, the box should be locked and stored in a designated area. Keep an inventory list in the box and check it after each job. This will help you to keep track of your tools.

(4) Use each tool only on the job for which it was designed. If you use the wrong tool to make an adjustment, the result will probably be unsatisfactory. For example, if you use a socket wrench that is too big, you will round off the corners of the wrench or nut. If this damaged wrench or nut is not replaced immediately, the safety of your equipment may be endangered in an emergency.

(5) Keep your tools within easy reach and where they cannot fall on the floor or on machinery. Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage may result if the tool falls into the machinery after the equipment is turned on or is running.

(6) Never use damaged tools. A battered screwdriver may slip and spoil the screw slot or cause painful injury to the user. A gage strained out of shape will result in inaccurate measurements.

Remember, a worker's efficiency is often a direct result of the condition of the tools being used. Workers are often judged by the manner in which they handle and care for their tools. You should care for handtools the same way you care for personal property. Always keep handtools clean and free from dirt, grease, and foreign matter. After use, return tools promptly to their proper places in the tool box. Improve your own efficiency by organizing your tools so that those used most frequently can be reached easily without sorting through the entire contents of the box. Avoid accumulating unnecessary items.

3. Safety Rules for Power Tools

Safety is an important factor in the use of power tools and cannot be overemphasized. By observing the following safety guidelines, you can ensure maximum benefits from the tools you use and reduce the chances of serious injury.

a. Never operate any power equipment unless you are completely familiar with its controls and features.

b. Inspect portable power tools before using them; see that they are clean and in good condition.

c. Make sure there is plenty of light in the work area. Never work with power tools in dark areas where you cannot see clearly.

d. Before connecting a power tool to a power source, be sure the tool switch is in the OFF position.

e. When operating a power tool, give it your FULL and UNDIVIDED ATTENTION.

f. DO NOT DISTRACT OR IN ANY WAY DISTURB another person while they are operating a power tool.

g. Never try to clear a jammed power tool until it is disconnected from the power source.

h. After using a power tool, turn off the power, disconnect the power source, wait for all movement of the tool to stop, and remove all waste and scraps from the work area. Store the tool in its proper place.

i. Never plug the power cord of a portable electric tool into a power source before making sure that the source has the correct voltage and type of current specified on the nameplate of the tool.

j. Do not allow power cords to come in contact with sharp objects, nor should they kink or come in contact with oil, grease, hot surfaces, or chemicals.

k. Never use a damaged cord. Replace it immediately.

l. Check electrical cables and cords frequently for overheating. Use only approved extension cords, if needed:

m. See that all cables and cords are positioned carefully so they do not become tripping hazards.

n. Treat electricity with respect. If water is present in the area of electrical tool operation, be extremely cautious and, if necessary, disconnect the power tool.

4. Safety Equipment

Safety equipment is for you. It will protect you from injury and may possibly save your life. Some of the more common types of safety equipment provided for your personal protection follow:

a. *Safety Shoes.* Safety shoes protect and prevent injury or the loss of toes. Some safety shoes are designed to limit damage to your toes from falling objects. A steel plate is placed in the toe area of such shoes, so that your toes are not crushed if an object falls on them. Other safety shoes are designed for use where danger from sparking could cause an explosion. Such danger is minimized by the elimination of all metallic nails and eyelets and by the use of soles which do not cause static electricity.

b. *Eye Protection.* Proper eye protection is of the highest importance for all personnel. Eye protection is necessary because of hazards caused by infrared and ultraviolet radiation, or by flying objects such as sparks, globules of molten metal, chipped concrete, wood, etc. These hazards are always present during welding, cutting, soldering, chipping, grinding, and a variety of other operations. It is absolutely necessary to use eye protection devices such as helmets, handshields, and goggles during eye hazard operations. Appropriate use of goggles will limit eye hazards. Some goggles have plastic windows which resist shattering upon impact. Others are designed to limit harmful infrared and ultraviolet radiation from arcs or flames through the use of appropriate filter lenses. Remember, eye damage can be extremely painful. Protect your eyes.

c. *Helmets.* Protective helmets (hard hats) come in a variety of shapes. They may be made of tough polyethylene or polycarbonate, one of the toughest hat materials yet developed. When falling objects strike the hats, the shock absorbing suspension capabilities minimize injuries.

Regular hard hats must be insulated so that personnel may be protected from accidental head contact with electrical circuits and equipment at comparatively low voltages (less than 2200 volts).

Electrical workers requiring head protection, necessary to their duties or to the working environment, must wear insulating safety helmets or all-purpose protective helmets which must be capable of withstanding 20,000 Volt minimum proof-tests.

d. *Gloves.* Use gloves whenever you are required to handle rough, scaly, or splintery objects. Special flameproof gloves are designed for gas and electric welding in order to limit danger and damage from sparks and other hot, flying objects. Personnel working with electricity are usually required to wear insulated rubber gloves.

Be sure to follow all regulations prescribed for the use of gloves. Gloves must not be worn around rotating machinery unless sharp or rough material is being handled, in which case, extreme care should be used to prevent the gloves from being caught in the machinery.

e. *Seat Seats and Safety Straps.* The safety belt and safety strap are essential when working in high places. The safety belt, strapped around the waist, contains pockets for small tools. The safety strap is a nylon-reinforced leather belt that is placed around the item to be climbed. It is then attached to the two D-rings on the safety belt.

f. *Ear Protection.* Proper hearing protection is essential when working with or around certain types of power tools. Some tools are capable of producing dangerously high noise levels which, if ignored, can result in serious hearing loss or injury. Use the hearing protection regularly.

5. Conclusion

This task provided information on the safety requirements of selected handtools and power tools. A user must have, choose, and use the correct tools in order to do the work quickly, accurately, and safely. Without the proper tools and knowledge of how to use them, the user wastes time, reduces efficiency, and may face injury. The following lessons will provide the appropriate knowledge for handling and maintaining selected handtools and measuring tools.

PRACTICAL EXERCISE 1

The following items will test your understanding of the material covered in this lesson. Print this page and compare it with the solutions that will be found at the end of this exercise. If you do not understand an answer, review the portion of the instructional material which provides the information.

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1. A mechanic should never operate any power equipment unless he is

2. What is the first thing that must be done before clearing a jammed power tool?

3. What objects are used for support when lifting a vehicle using a jack?

4. When should gloves be worn?

5. What is the safety hazard of using an oily or greasy tool on a job?

LESSON 2
USE AND CARE OF HANDTOOLS

TASK 1: Describe the procedures for the use and care of non-edged handtools.

CONDITIONS: Within a self-study environment and given the subcourse text, without assistance.

STANDARDS: Within three hours

REFERENCES: No supplementary references are needed for this task.

1. Introduction

This task encompasses a large group of general purpose handtools. These tools are termed non-edged handtools because they are not used for cutting purposes and do not have sharpened or cutting edges. They are designed to facilitate mechanical operations such as clamping, hammering, twisting, turning, etc. This group includes such tools as hammers, mallets, and screwdrivers, which are commonly referred to as driving tools. Other types of non-edged tools covered in this task are wrenches, pliers, clamps, pullers, soldering irons, and many others of a similar nature. Several types of pliers do have cutting edges (exceptions to the rule); they are discussed in the pertinent paragraph with the non-edged pliers, for convenience.

The following paragraphs discuss the types of tools, as indicated by the paragraph title, their description and particular construction, as well as the use and care of each tool.

2. Hammers and Mallets

a. *Purpose.* Hammers and mallets (figure 1and figure 2) are used to drive nails, spikes, drift pins, bolts, and wedges. They are also used to strike chisels and punches, and to shape metals. Sledge hammers are used to drive spikes and large nails, to break rock and concrete, and to drift heavy timbers.

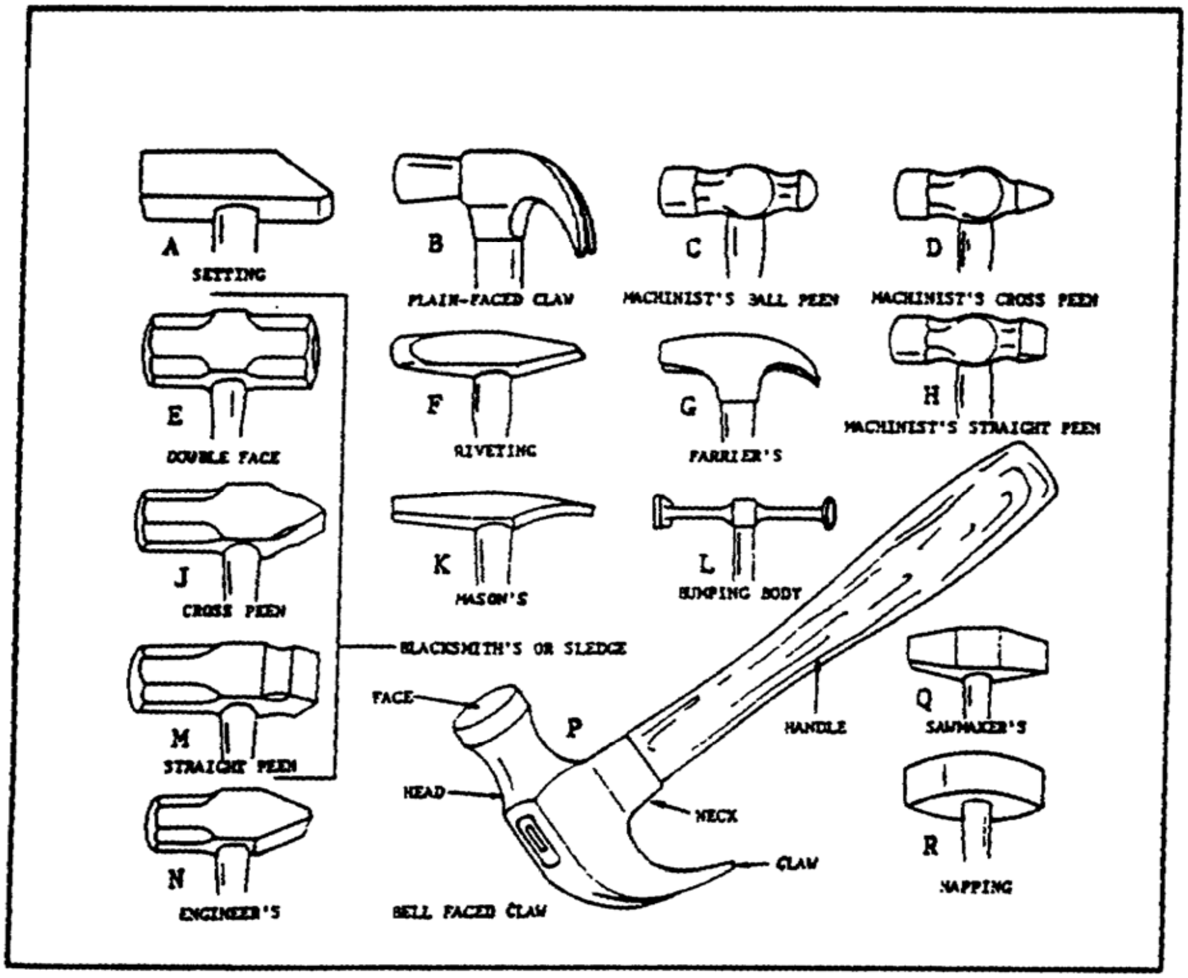


FIGURE 1. TYPES OF HAMMERS.

b. *Types of Hammers.*

(1) *Carpenter's Hammers.* A carpenter's hammer is a steelheaded, wood-handled, nail-driving tool. There are two types of carpenter's hammers. Both types have claws at the back of the hammer head for pulling nails. The difference between them lies mainly in their faces. One type has a flat face (figure 1, view B). The other type has a rounded or convex face and is known as a bell-faced claw hammer (figure 1, view P). Carpenter's hammers are issued in 7 ounce, 10 ounce, and 1 pound sizes.

(2) *Machinist's Peen Hammers.* Machinist's peen hammers are generally used by machine shop personnel and auto mechanics. Machinist's peen hammers are made in several different styles.

(a) *Ball-Peen Hammer.* The most common is the machinist's ball-peen hammer (figure 1, view C). It has a round ball-shaped head and is used for all general purpose work.

Ball-peen hammers are classified according to the weight of the head without the handle. They usually weigh 2, 4, 8, or 12 ounces, or 1, 1 1/4, 1 1/2, 2, or 3 pounds.

(b) *Cross-Peen Hammer.* The machinist's cross-peen hammer (figure 1, view D) has a dull chisel head at right angles to the handle and is used for spreading or drawing out metal. This hammer is issued in 3, 6, 8, 10, and 12 pound sizes.

(c) *Straight-Peen Hammer.* The machinist's straight-peen hammer (figure 1, view R) has a drill chisel head in line with the axis of the handle and is used for spreading and drawing out metal.

(3) *Blacksmith's or Sledge Hammers.* Blacksmith's or sledge hammers are similar to machinist's peen hammers, except that they are made for heavy-duty. Short handled sledge hammers are used to drive bolts, drift pins, and large nails, to strike cold chisels when chipping and small hand rock drills when drilling holes in rock. Long handled sledge hammers are used to break rock and concrete, to drive spikes and bolts, to strike rock drills and chisels, and to drift heavy timbers. The handle is usually made of the best grade clear grain hickory, ash, or maple, completely free from defects. Some sledge hammers have a double face (both sides alike) (figure 1, view E), cross-peen face (figure 1, view J), or straight-peen face (figure 1, view M). They are made in sizes from 6 to 20 pounds, having handles 30 to 36 inches long.

(4) *Bumping Body Hammers.* A bumping body hammer (figure 1, view L) is used for straightening and bumping metal. The hammer shown has one round and one square face and the head is 4 inches long.

Other bumping body hammers may have an offset cross and straight-peen faces, or two round faces, or an offset square face and a cross-peen face.

(5) *Engineer's Hammer.* The engineer's hammer (figure 1, view N) has a cross-peen face and weighs 3 pounds. This hammer is similar to the blacksmith's or sledge cross-peen hammer, only it is lighter in weight and is used on lighter work.

(6) *Jeweler's Hammer.* A jeweler's hammer (figure 2, view D) is used for light hammering and for driving small shafts and pins. This hammer weighs 1 3/4 to 2 ounces and generally has a hardwood handle.

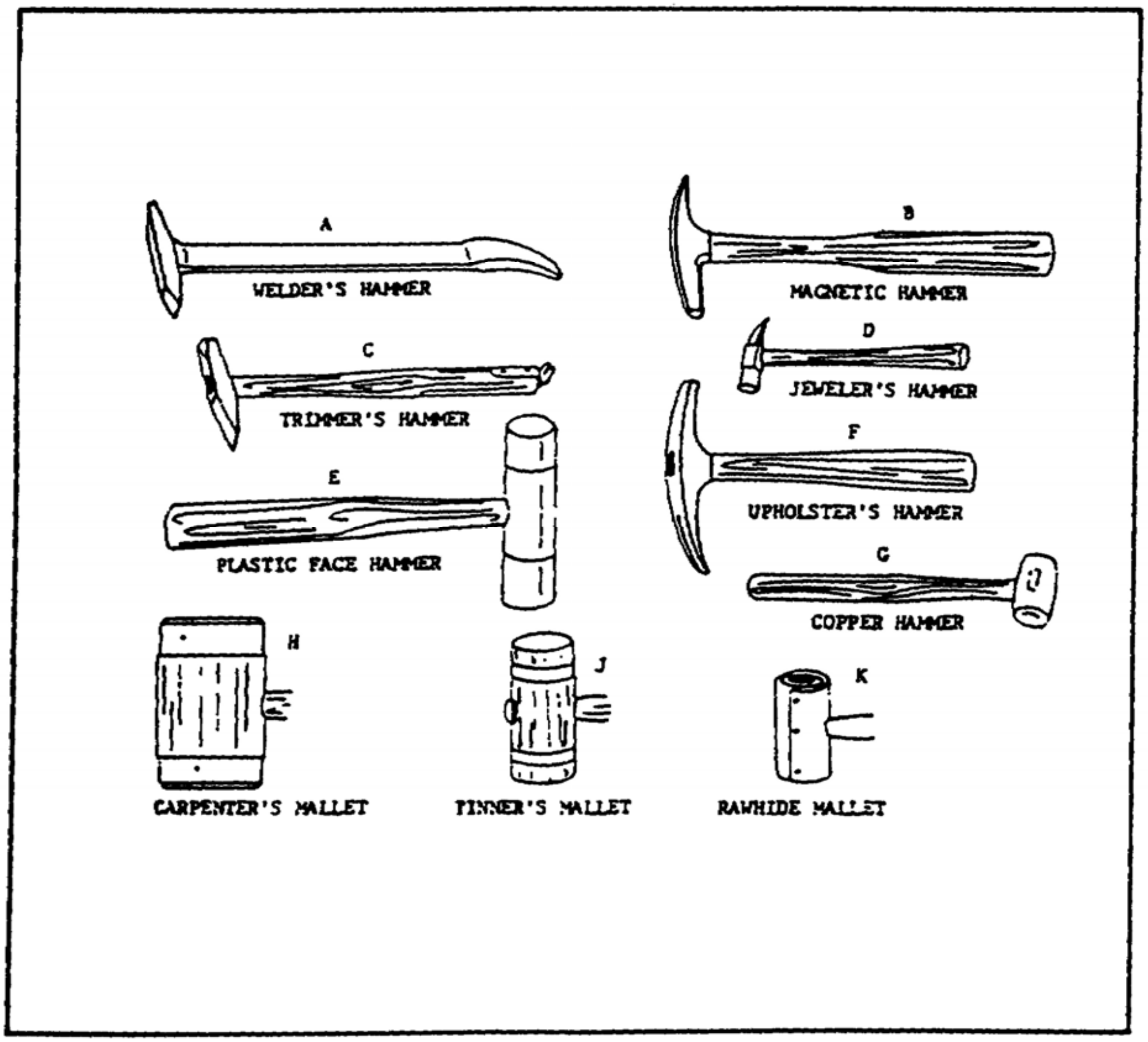


FIGURE 2. MALLETS AND HAMMERS.

(7) *Welder's Hammer.* A welder's hammer (figure 2, view A) is used for chipping welds. The opposite end of the hammer is sometimes equipped with a wire brush for cleaning metals before welding, and for brushing slag away after chipping.

(8) *Soft-Faced Hammers.* Wood-handled, soft-faced hammers are used for striking heavy blows where the steel-faced hammers would bruise or mar the surface of the work. The soft faces are made of rubber, wood, rawhide, copper, lead, or plastic, and the head may vary in weight from 6 ounces to 6 pounds. The Army Ordnance Supply System issues a 3 pound copper hammer (figure 2, view G) and several inserted plastic-face hammers. The plastic-face hammers (figure 2, view G) are supplied with two soft, two medium, two tough, and two nylon replaceable faces.

c. *Types of Mallets.*

(1) *Carpenter's Mallet.* A carpenter's mallet (figure 2, view H) is a wooden, short-handled tool used to drive wooden handled chisels, wooden dowels, or small stakes. The head is cylindrical and has two flat driving faces. It is sometimes reinforced with iron bands at each end. This mallet is also used for smoothing out dents in sheet metal and for turning thin metal edges and seams without cutting the metal surface.

(2) *Rawhide Mallet.* The rawhide mallet (figure 2, view K) is used to form or shape sheet metal where hard-faced or steel hammers might mar or injure the work.

(3) *Tinner's Mallet.* A tinner's mallet (figure 2, view J) is made of wood. It ranges in size from 1 1/4 inch head diameter and 3 inch head length to 3 1/2 inch head diameter and 6 inch head length.

d. *Use of Hammers and Mallets.*

(1) *Using a Carpenter's Hammer.*

(a) *Driving Nails.* The wrist and arm motion, used when driving nails, depends upon the power of the impact required. Small nails require light blows which are struck almost entirely with a wrist motion. Heavy blows required to drive a large nail come from the wrist, forearm, and shoulder. Always strike the nail with the center of the hammer face. Do not strike with the side or cheek. Sometimes the grain of the wood, a knot, or a hidden obstruction will cause a nail to bend slightly when it is being driven. Striking a nail with the face of the hammer at a slight angle will also cause a nail to bend. Changing the angle of the hammer face will help to straighten the nail out. If a nail bends excessively when it is driven, pull it out and discard it. Start another nail in its place. If the second nail also bends excessively, inspect the work for a knot or other obstruction. Drive a new nail in a new position, or drill a hole past the obstruction and try again. Tacks and small nails (brads) can be driven with a magnetic hammer, upholsterer's hammer, or a light carpenter's hammer. The bell-faced claw hammer is used to drive nails flush, and even slightly below the surface of the work, without leaving marks. The basic procedure for driving nails is described in 1 through 5 below.

1 Grip the hammer handle firmly, with one hand, near the end of the handle (figure 3).

2 Hold the nail near its point with the thumb and forefinger of the other hand.

3 Place the point of the nail on the work at the exact spot in which it is to be driven.

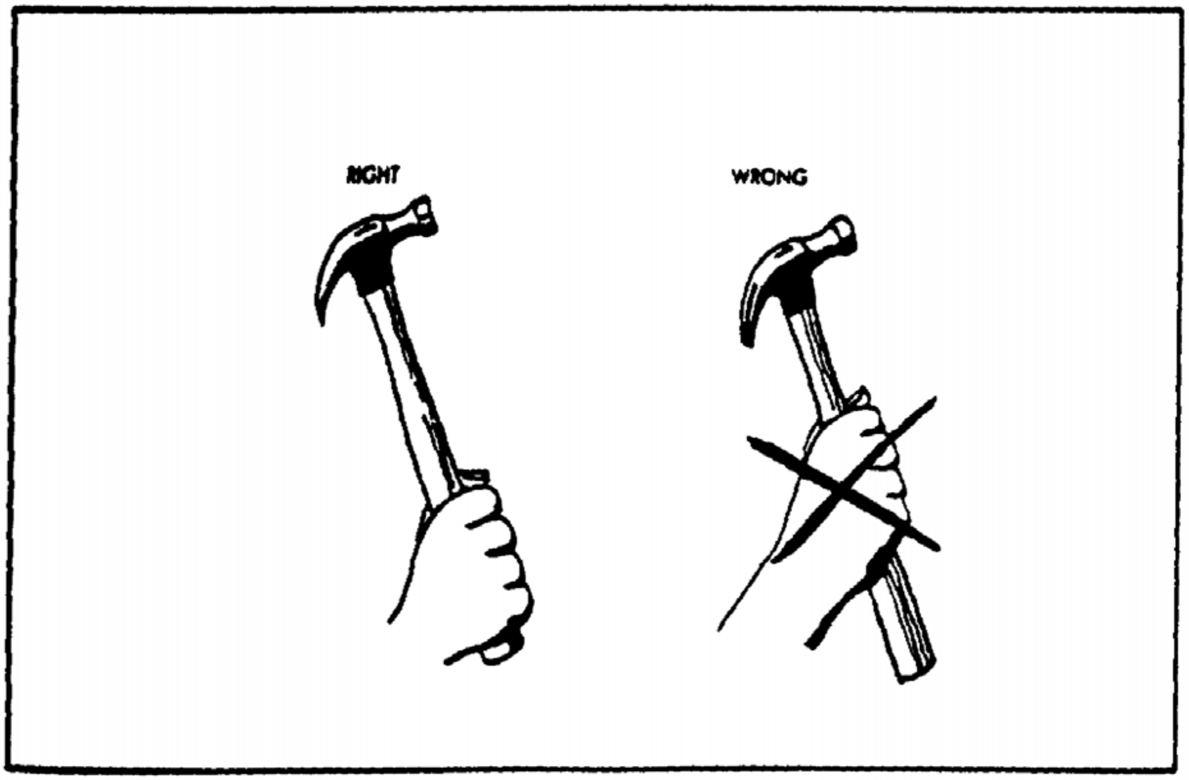


FIGURE 3. HOLDING HAMMER CORRECTLY.

4 To start the nail, tap it squarely, but lightly, until it has penetrated the work to a depth sufficient to hold securely.

5 Remove fingers and drive the nail into the work.

NOTE

When using a plain-faced hammer, the nail head must be parallel to the face of the hammer at the moment of impact. The bell-faced hammer offers a uniform face to the nail head even though the hammer is slightly tipped.

(b) *Pulling Nails.* Slip the claw of the carpenter's hammer under the nail head. Make certain the head of the nail is caught securely in the slot of the claw. Raise the hammer handle until it is nearly vertical. If the nail is short, this will withdraw it from the work. If the nail is long and the hammer handle is pulled past the vertical position, it will mar the work, bend the nail, and enlarge the hole. Most of the leverage is lost when the hammer handle passes the vertical position, requiring a great deal of force to withdraw the nail. To simplify pulling long nails, place a piece of wood under the hammer head so that the handle is again nearly horizontal and the leverage is increased.

(2) *Using a Blacksmith's or Sledge Hammer.* Since a sledge hammer is used for heavy-duty work, it is designed with a longer handle which requires a greater swing, and a

heavy head which supplies a greater impact. Grasp the sledge hammer near the end of the handle with both hands; spread feet apart; raise the sledge hammer up over your head and bring it down. You must practice this swing until you are properly balanced and the work is struck with the least effort. Let the head of the sledge do the work. After raising the sledge hammer over your head, use wrists, forearms, and shoulders to deliver heavier blows. Light blows are struck with a motion of wrist only. Observe the following precautions when using a sledge hammer.

(a) Wear safety goggles when using a sledge.

(b) Do not use a sledge whose head is worn round by overuse; it may glance off the work and cause serious injury.

(c) Make certain the area behind you is clear, so that on the backswing the sledge head will not strike anyone.

(d) Take a practice swing first to help you gage distance, balance, and contact of the sledge with the work to be hit.

(e) Before striking a chisel bar with a sledge, attach a disk to the bar about one-fourth of the distance from the top of the bar. The disk will protect the hands of the helper who holds the chisel.

(f) Keep hammer and sledge faces free from oil or other material that would cause the tool to glance off nails, spikes, or stakes.

(3) *Using a Mallet.* A mallet is swung in the same manner as a hammer. Never use a mallet to drive nails; it will spoil the face of the mallet. Never use a wooden mallet on sharp corners; it will mar the work and the mallet.

e. *Care of Hammers and Mallets.*

(1) *Storage.* If a hammer, mallet, or sledge is used often, it should be stored in a wall rack when not in use. Clean, repair, and oil metal portions of tools before storing them for long periods of time. Store wooden mallets out of direct sunlight and away from all sources of heat, since excessive drying will cause cracking and splitting. A light film of oil should occasionally be placed on wooden mallets to keep a little moisture in the wood.

(2) *Maintenance.* Faces of hammer heads should be regularly dressed to remove battered edges. Hammer and sledge heads should be securely attached to a good solid handle of the proper type. Make sure the steel or hardwood wedges are tight and in place. If wedges work loose, drive them into place. Replace missing wedges. Never use screws or nails as wedges because they may come out or split the handle. Keep the claws of all hammers sharp enough to grip nail heads firmly. See that the handles are in perfect condition and always replace a defective handle to avoid accidents.

f. *Repair and Replacement of Handles.*

(1) *Repair.* Handles on hammers and sledge hammers must be inspected constantly to see that they are tight and to check for split or broken wood. If the handle is loose, seat it into the eye of the hammer head by striking the end of the handle with a mallet (figure 4), and then drive the wedges back into the handle. If the wedges are not tight or do not spread the handle sufficiently to make it tight, add another wedge or use larger wedges, if possible. In an emergency, a loose handle may be temporarily tightened by soaking it in water until the wood swells within the head. If the handle does not become tight, replace the handle.

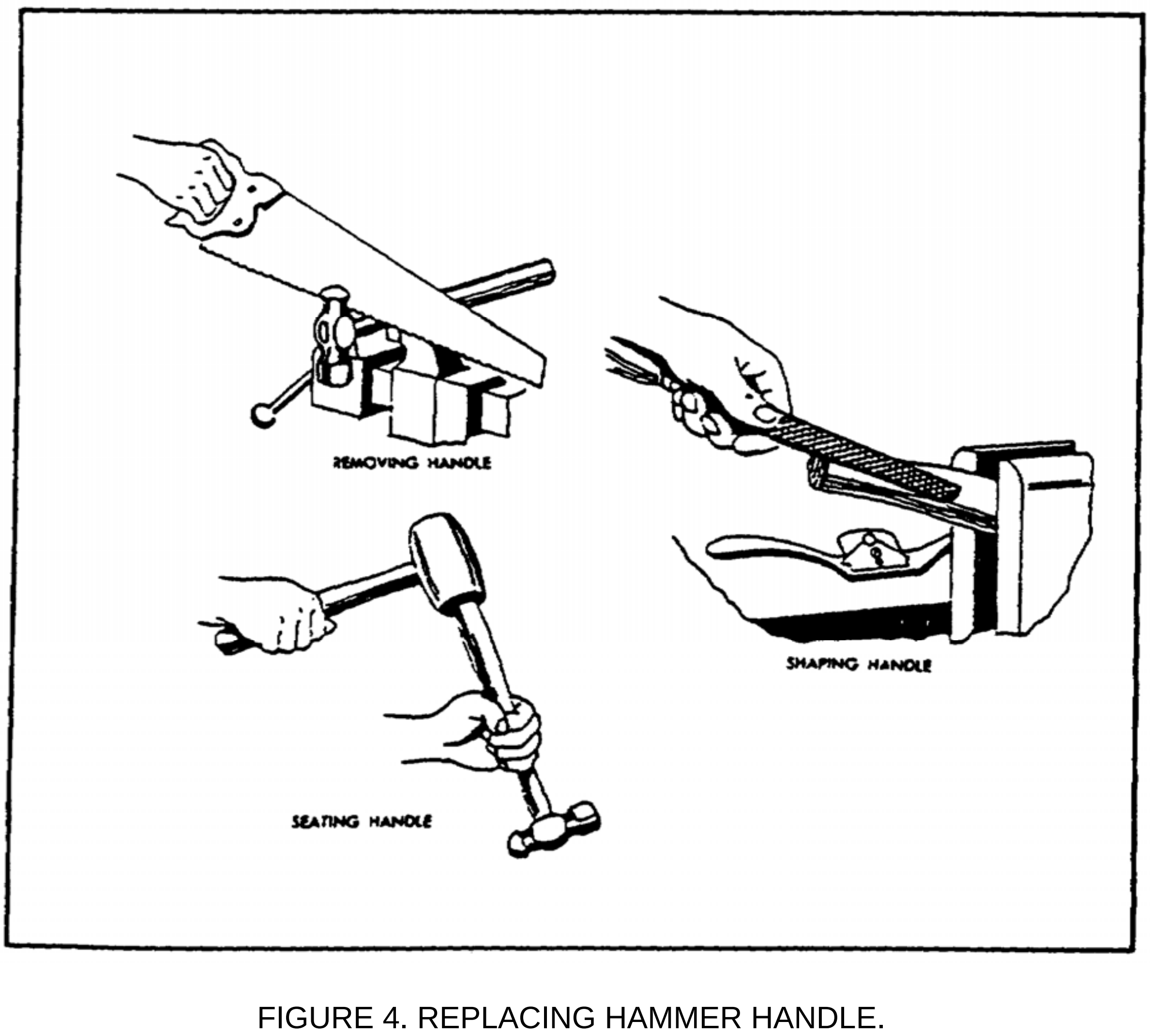


FIGURE 4. REPLACING HAMMER HANDLE.

(2) *Replacement* (figure 4). If a handle is split or broken, remove it from the head of the tool. If the handle is too tight to pull out of the head, saw off the handle close to the head and drive the remaining end out through the large end of the eye. Save the wedges. Shape a new handle from hickory or maple to fit, using a spoke shave or wood rasp. If using a wooden wedge, make a saw cut in the end of the handle, as shown in figure 5.

Wedges may be metal or straight-grained hardwood, but never nails or screws. Seat the new handle and check to see whether the handle fits properly. If it does, saw off the projecting end and drive the wedge(s) into the handle (figure 6). If the handle is tightened with metal wedges, smooth them off by grinding. If the handle is secured with wooden wedges, use a wood rasp to smooth them off.

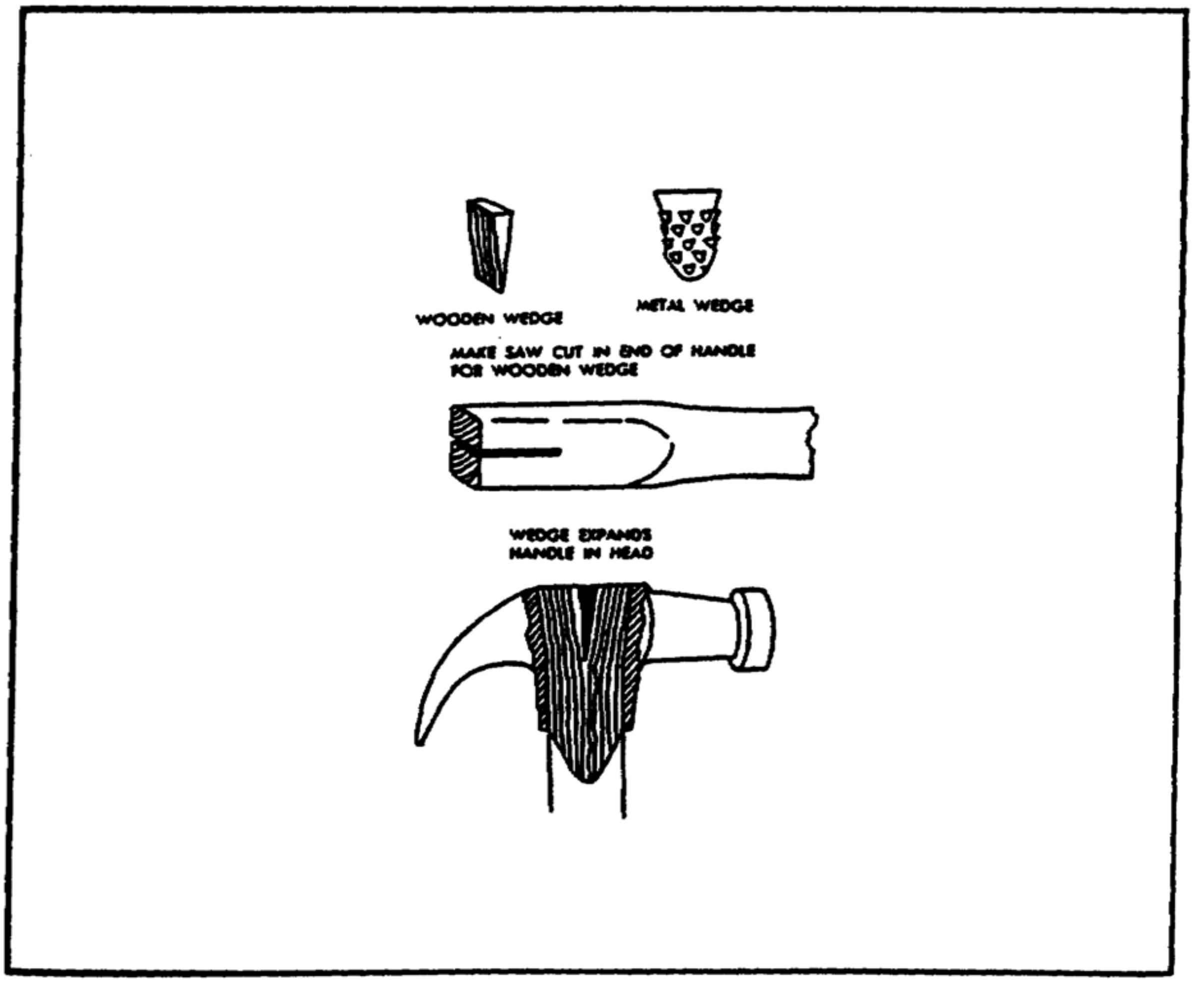


FIGURE 5. HAMMER HANDLE WEDGES.

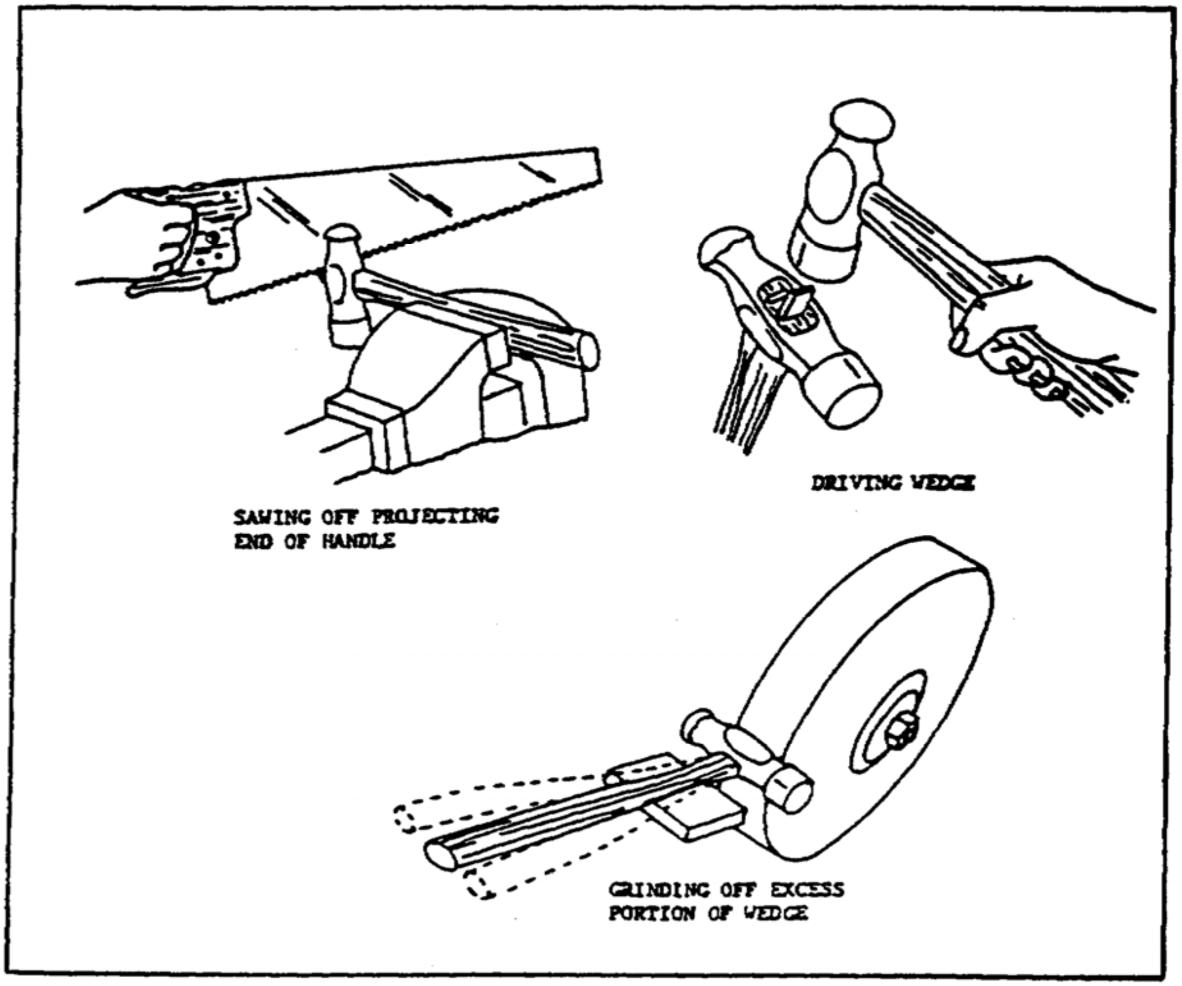


FIGURE 6. INSTALLING WEDGES.

g. *Restoring Worn Faces.* Incorrect or abusive use of hammers and mallets frequently results in uneven face wear. Faces also wear after considerable use and must be restored as described below.

(1) Determine if the face should be flat or rounded by examining the unworn portion of the face, or by comparison with an unworn tool of the same type.

(2) Grind the face to the proper shape. Dip the head in water often to prevent loss of temper through overheating.

(3) When restoring mallets or double-faced hammers or sledges, remove the same amount of material from both sides to preserve the balance.

NOTE

Do not remove any more material than is necessary.

3. Screwdrivers

a. *Purpose.* Screwdrivers are used for driving or removing screws or bolts with slotted or special heads.

b. *Types of Screwdrivers.*

(1) *General.* Screwdrivers are made in various shapes and lengths to perform specific jobs. The size of a screwdriver (figure 7) is indicated by the length of the blade; i.e.; a 6 inch screwdriver has a 6 inch blade. The width and shape of the blade tip vary from a narrow parallel sided tip to a wide tapered tip. Some screwdrivers have special tips for cross-slotted recessed screws or bolts and clutch-bit screws. Special screwdrivers are provided with a ratchet arrangement.

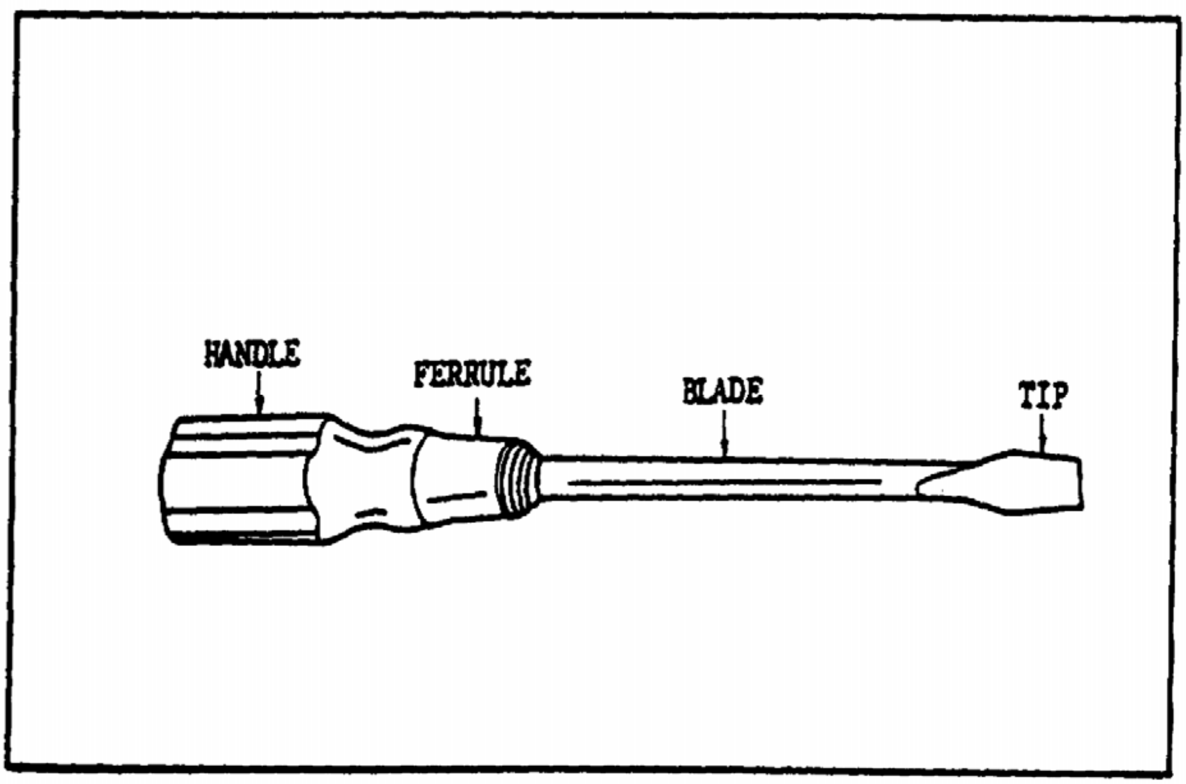


FIGURE 7. STANDARD SCREWDRIVER.

(2) *Common Screwdriver.* The common screwdriver (figure 8) has a round steel blade anchored in a wood or plastic handle. The blade is forged from alloy steel and tempered. The tip is flat, hot forged to size, and heat treated. Common screwdrivers are tapered to give maximum strength. Handles are made of hardwood or plastic composition, usually fluted for a good grip. The blade is anchored in the handle by two or more tongs on the end of the blade and, in the case of a wood handle, the blade is anchored by a pin or rivet through the ferrule, handle, and blade. Some handles are integral; that is, the blade forms an integral part of some of the outside surface of the

handle and is locked in place by rivets. Integral blade screwdrivers are used for heavy-duty work. The blade can be tapped with a hammer to seat the blade tip in rusty screws. Other common heavy-duty screwdrivers have square blades so that a wrench can be used to turn them.

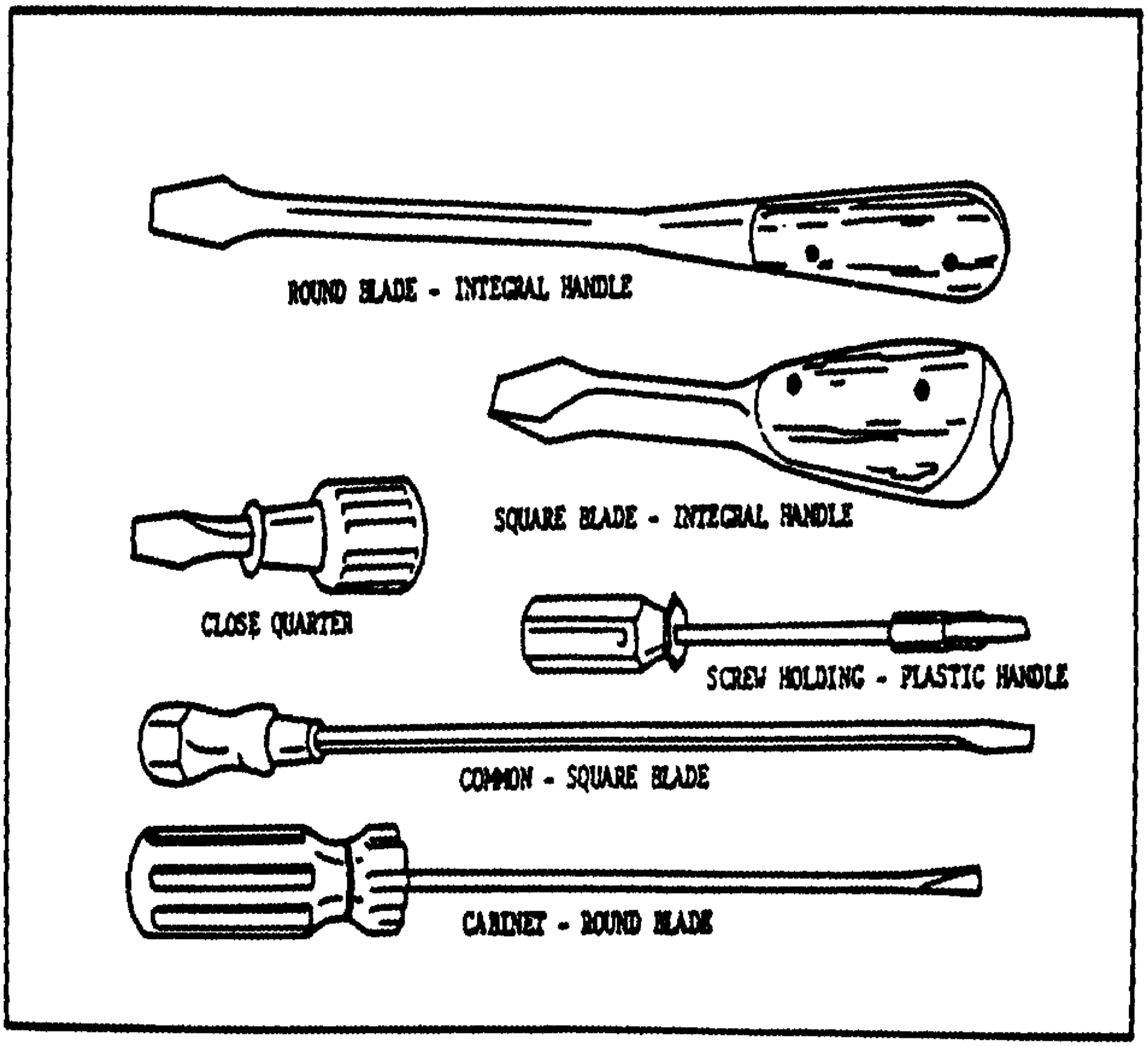


FIGURE 8. COMMON FLAT-TIP SCREWDRIVER.

(3) *Phillips Screwdrivers (Cross-Tip).* The tip of a Phillips screwdriver (figure 9) is shaped like a cross so that it fits into Phillips-head screws. Phillips-head screws have two slots which cross at the center. These screwdrivers are made with four different sized tips. Size 1 will fit No. 4 and smaller size Phillips screws; size 2 will fit Nos. 5 to 9 inclusive; size 3 will fit Nos. 10 to 16 inclusive; and size 4 will fit No. 18 and larger size Phillips-head screws. Phillips screwdrivers also have different length blades ranging from 1 inch to 8 inches.

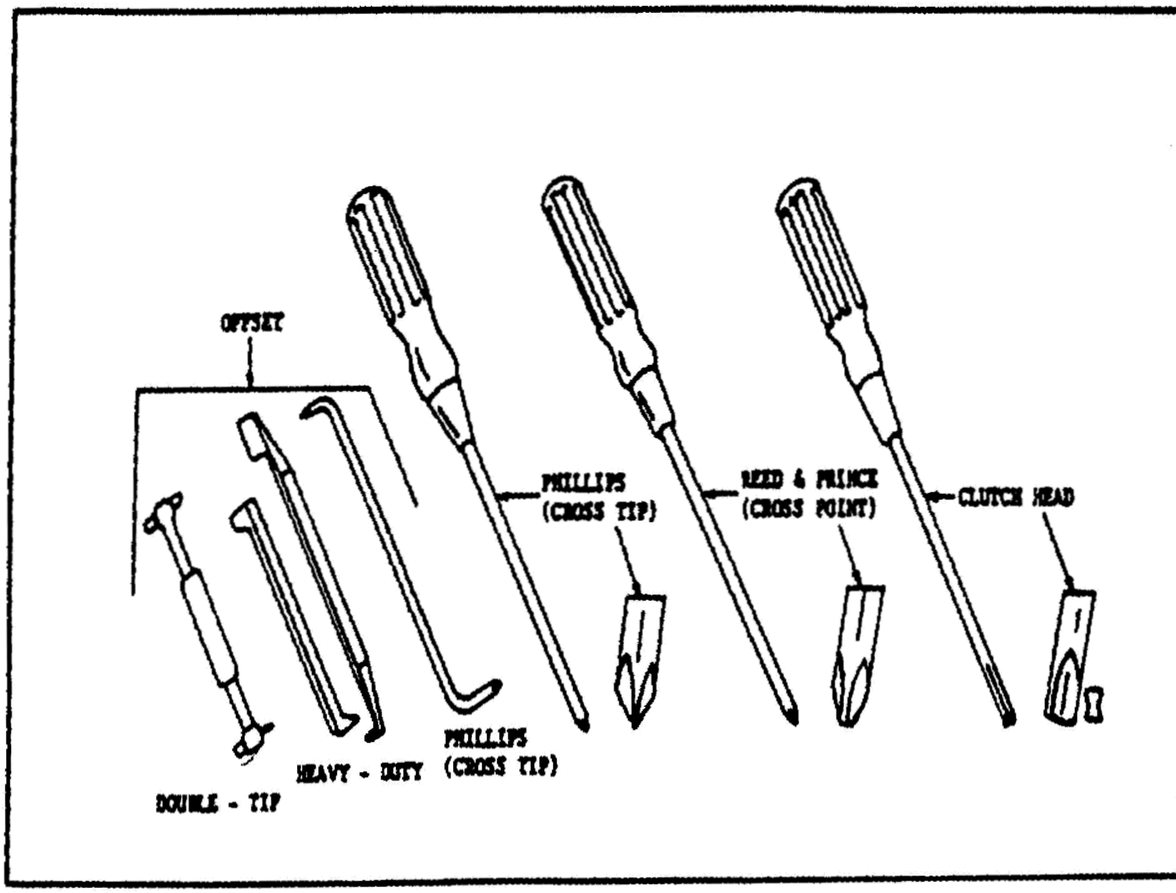


FIGURE 9. SPECIAL TIPPED SCREWDRIVER.

(4) *Reed & Prince Screwdrivers (Cross-Point).* Reed & Prince screwdrivers are similar to the Phillips type; however, do not confuse them, for the tip is different, as shown in figure 9. These screwdrivers are issued in 3 to 8 inch sizes.

(5) *Clutch-Head Screwdrivers.* Clutch-head screwdrivers (figure 9) are used to drive clutch-bit screws. These screws are commonly called butterfly or figure 8 screws and have recessed heads. The clutch-type screwdriver is issued in 3, 4, 5, and 6 inch sizes.

(6) *Offset Screwdrivers.* Offset screwdrivers (figure 9) are designed to drive or remove screws that cannot be lined up with the axis of common screwdrivers, or are located in tight corners. An offset screwdriver is usually made from a piece of steel, round or octagonal in shape, machined so that the end portion is at right angles to its longitudinal axis. They are made in a variety of sizes having different width tips. Some offset screwdrivers are made with two blades, one of different size at each end. A double-tip offset screwdriver has four blades.

(7) *Ratchet Screwdrivers.* Ratchet screwdrivers (figure 10) are used to drive or remove small screws rapidly. The spiral ratchet screwdriver automatically drives or removes screws. It can be adjusted to turn left, right, or to be locked to act as a common

screwdriver. It has a knurled sleeve with a spiral chuck and a control locking device which has three positions: right and left ratchet, and rigid. Some spiral ratchets have a spring in the handle which automatically returns the handle for the next stroke. Another style of ratchet screwdriver has a knurled collar for rotating the blade with your fingers. The spiral type has separate blades that are inserted in the chuck. The plain common ratchet screwdriver is made with one integrally built blade.

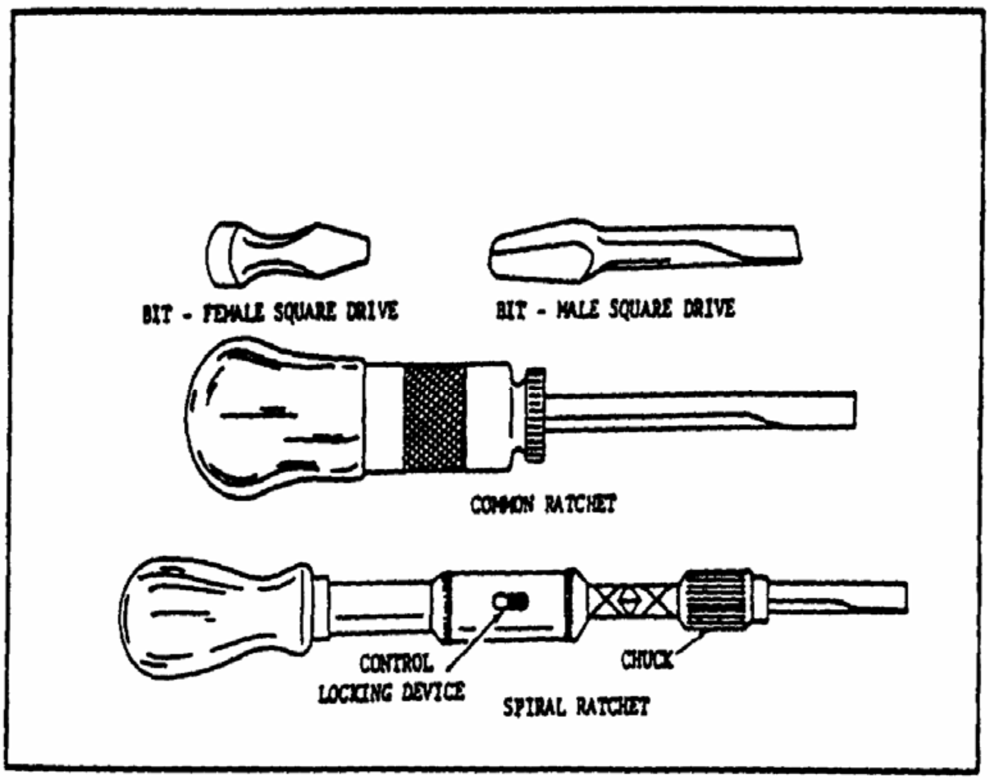


FIGURE 10. RATCHET SCREWDRIVERS AND SCREWDRIVER BITS.

(8) *Screwdriver Bits.* A screwdriver bit (figure 10) is a screwdriver blade with a square, hexagonal (six-sided), or notched shank so that it will fit in the chuck of a breast drill or ratchet bit brace, or on a square drive tool, such as a socket wrench handle. Other screwdriver bits are made with a spiral ratchet screwdriver shank for use with spiral ratchets.

(9) *Jeweler's Screwdrivers.* Jeweler's screwdrivers (figure 11) are made for driving and removing small size screws. The tips range from 0.025 inch to 0.1406 inch wide. They usually have knurled handles, a swivel end finger rest plate, and some have removable blades.

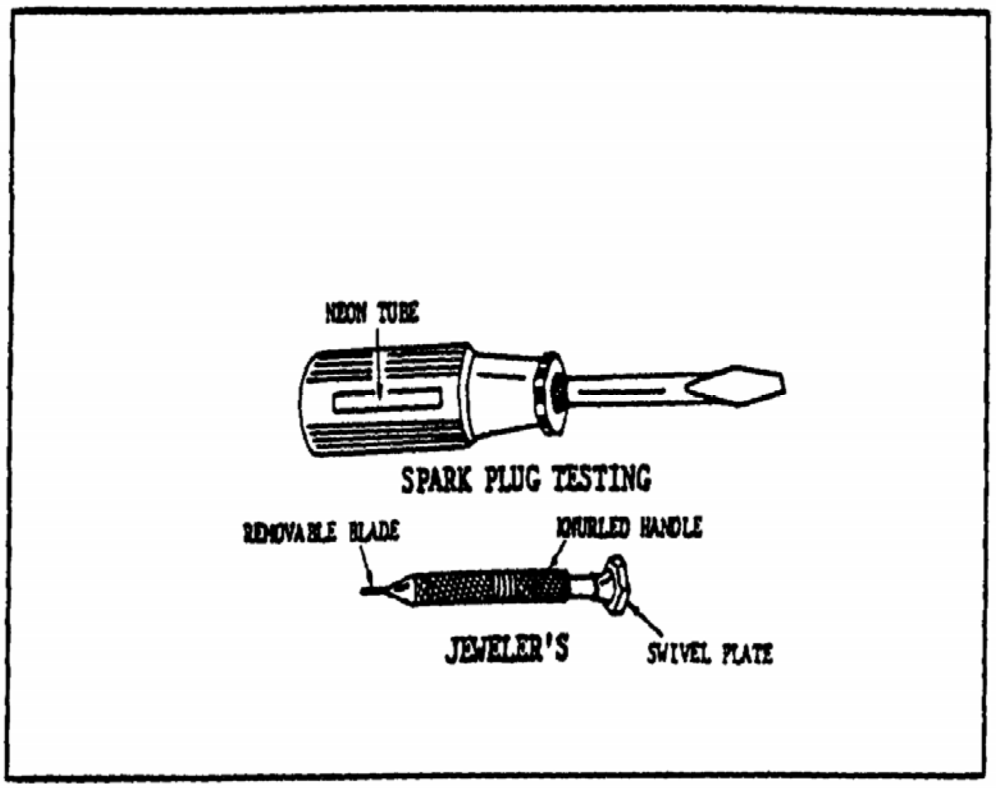


FIGURE 11. JEWELER'S AND SPARK PLUG TESTING SCREWDRIVERS.

(10) *Spark Plug Testing Screwdriver.* A neon tube, inserted in an electric shock proof handle of a common screwdriver, indicates the condition of a spark plug by the type of flash. A brilliant flash means good condition, a thin flash indicates too narrow a gap, and no flash means a short. This screwdriver is equipped with a 2 1/4 inch blade and a pocket clip (figure 11).

(11) *Flexible Screwdriver.* A flexible screwdriver (not illustrated) is available. It has a 1/4 inch wide tip and an overall length of 7 1/2 inches. The spring steel blade is flexible, enabling the user to get around flanges, shoulders, and other parts to drive and remove screws.

(12) *Radio and Pocket Screwdrivers.* A radio screwdriver (not illustrated) has a round blade that is 1 1/2 inches long. The tip is 1/8 inch wide and the overall length is 3 1/4 inches. Its use is in the construction of radio chassis. The pocket screwdriver (not illustrated) is also small. It has a square blade that is 1 3/4 inches long, a 1/4 inch wide tip, and an overall length of 4 inches. It is similar to the close quarter screwdriver shown in figure 8.

(13) *Snap Fastener Screwdriver.* A snap fastener screwdriver (not illustrated) is similar to the standard screwdriver shown in figure 7. They are made by snap fastener manufacturers to fit only their products.

c. *Using a Screwdriver.*

(1) *Driving Screws.* Use the longest screwdriver available which is convenient for the work. The width of the tip should equal the length of the screw slot and the tip must be thick enough to fit the width of the screw slot (figure 12). Hold the handle firmly in one hand with the head of the handle against the palm and grasp the handle near the ferrule with your thumb and fingers (figure 13). Hold the screwdriver in line with the axis of the screw and center the tip in the screw slot. To drive the screw in, press down with your palm and turn the screwdriver clockwise (to the right). When taking a fresh grip on the handle, steady the tip and keep it pressed in the screw slot with your other hand. Relax your other hand when you are ready to turn the screwdriver again. To drive screws easier, rub a little soap into the threads of a wood screw and put a drop of oil or a little graphite on a machine screw. Doing this will also minimize the chance of rust forming on the screws and will make them easier to remove.

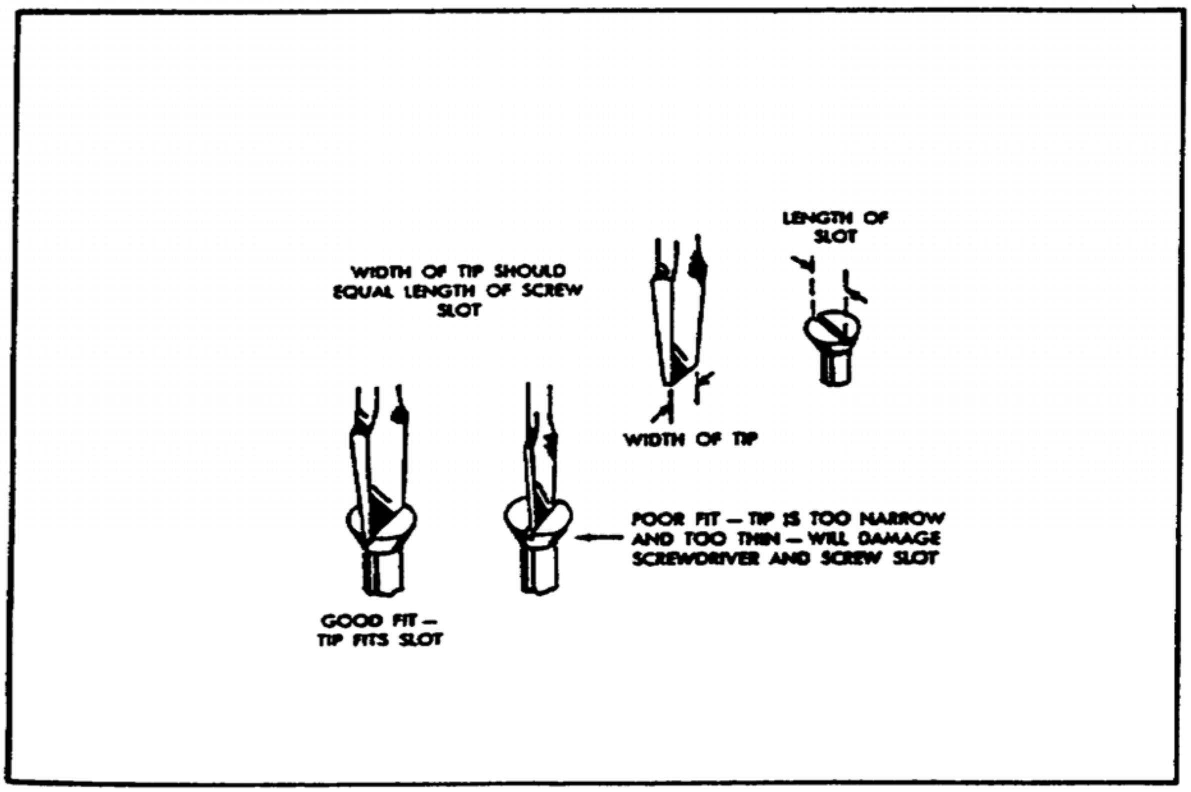


FIGURE 12. PROPER BLADE FOR SPECIFIC SCREW.

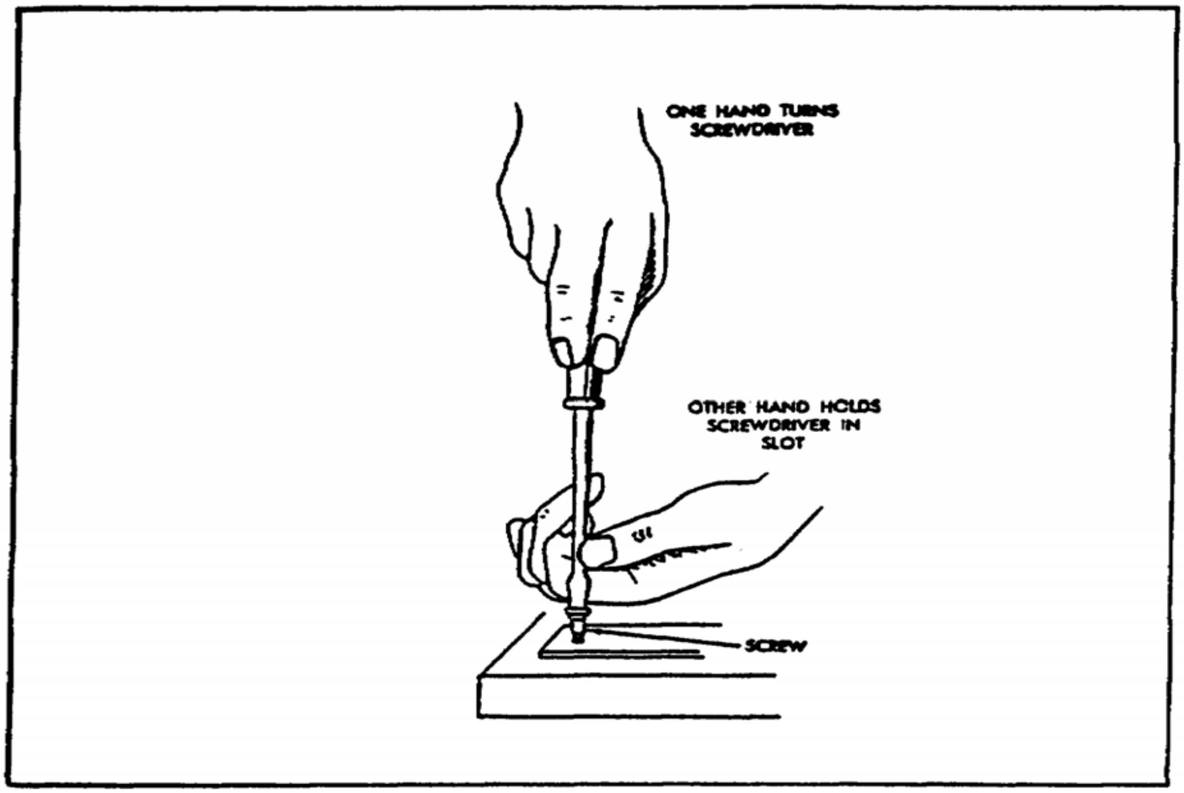


FIGURE 13. HOLDING SCREWDRIVER PROPERLY.

(2) *Removing Tight Screws.* When a screw cannot be turned at the first attempt to remove it, try to tighten it first, then turn the screwdriver in the opposite direction. Sequentially, tighten and loosen the screw until completely removed.

CAUTION

Use a screwdriver that has parallel sides and exactly fits the screw slot. A poorly fitting screwdriver will damage the screw head, slip off the screw, and perhaps cause personal injury.

If a tight screw with a damaged slot can be backed out partially, it is possible to remove it completely with a pair of pliers.

d. *Care of Screwdrivers.*

(1) *Dressing and Shaping.* When a screwdriver becomes nicked, or the edges become rounded, or when other damage occurs so that it does not fit a screw slot, it must be reground or filed. The sides must be parallel to keep the tool from lifting from the screw slot (figure 14) and the tip must be square, at right angles to the sides and to the blade. If using a file, place the screwdriver in a vise.

When using a grinder, adjust the rest to hold the screwdriver against the wheel to produce the desired shape, parallel or concave. Do not grind away more material than necessary to remove nicks or square up the end. After squaring the tip, grind both sides until the tip is the required thickness. Frequently dip the screwdriver into water during grinding to prevent loss of temper by overheating. If the blade discolors (blue or yellow), the temper has been damaged. Retemper by heating about 1 1/2 inches of blade to a cherry red with a torch. Immediately dip about 3/4 inch of the blade in clean cold water. Quickly rub the hardened end with aluminum oxide abrasive to brighten it. Watch the color creep back into the tip from the heated portion of the blade. When the color becomes light blue, dip the blade into water. The tip is now retempered and ready for use.

(2) *Precautions.* Handle the screwdriver carefully. Use the right size screwdriver for the job. Keep the blade clean. Do not carry a screwdriver in your pocket unless it has a pocket clip. Never use a screwdriver for prying or chiseling operations. When difficulty is encountered in driving or removing screws that are hard to turn, do not use pliers to turn the screwdriver. Pliers will damage the screwdriver. For hard to turn screws, select a square bladed screwdriver designed for heavy-duty and a wrench which properly fits the blade.

(3) *Storage.* After use, wipe the screwdriver with light oil and place it in a rack or tool box. For long-term storage, apply rust preventive compound over all metal parts and store in a dry place.

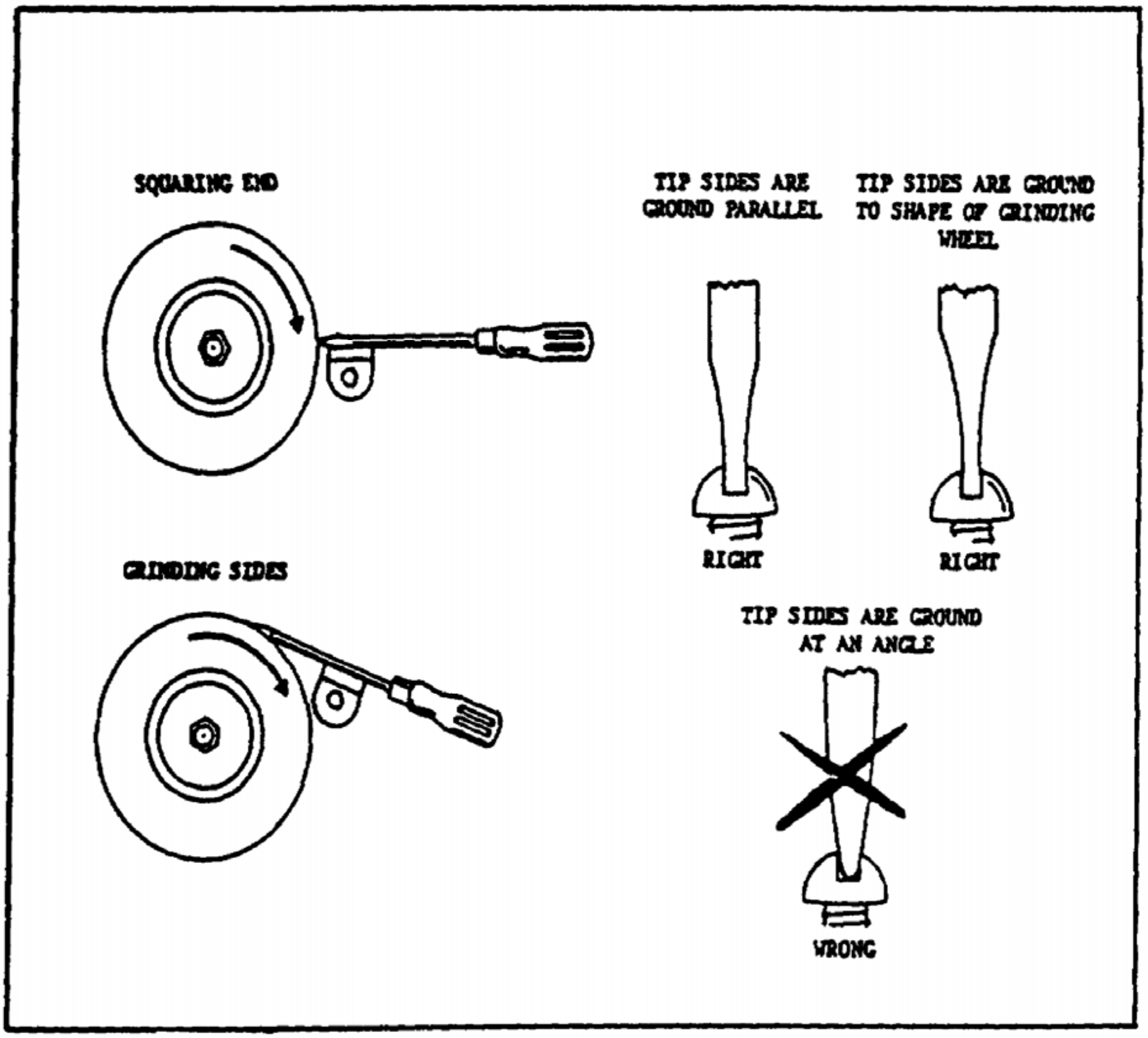


FIGURE 14. GRINDING SCREWDRIVER BLADE TIP.

4. Wrenches

a. *Purpose.* Wrenches are used to tighten or loosen nuts, bolts, screws, and pipe plugs. Special wrenches are made to grip round stock, such as pipe, studs, and rods. Spanner wrenches are used to turn cover plates, rings, and couplings.

b. *Types of Wrenches.* There are many types of wrenches; each type is designed for a specific use.

(1) *Fixed-End Wrenches.*

(a) *Open-End Wrenches.* Various open-end wrenches are shown in figure 15 . They are usually double-ended wrenches, although some have a single open-end. These wrenches are forged from chrome vanadium steel and are heat treated. The size of the opening between the jaws determines the size of the open-end wrench. For example, a wrench with a 1/2 inch opening in one end and a 9/16 inch opening in the other end is called a 1/2 by 9/16 wrench. The size of each opening is usually stamped on the side of the wrench. The openings are from 0.005 inch to 0.015 inch larger than the size marked on the wrench, so that they will easily slip on bolt heads or nuts of that size.

Open-end wrenches are made in many different sizes. Wrench sizes range upward in steps of 1/32 inch, starting with 5/32 inch up to 1 3/4 inches. The common open-end wrench is made with the ends at an angle of 10° to 23° to the body of the wrench, so that the user can work in close quarters. Other special open-end wrenches may have the ends at an angle of 45, 60, 75, or 90 degrees, or a combination of two angles.

The length of the wrench is determined by the size of the opening, since the lever advantage of the wrench is proportional to its length; wrenches with larger openings are made longer and heavier to increase leverage and strength.

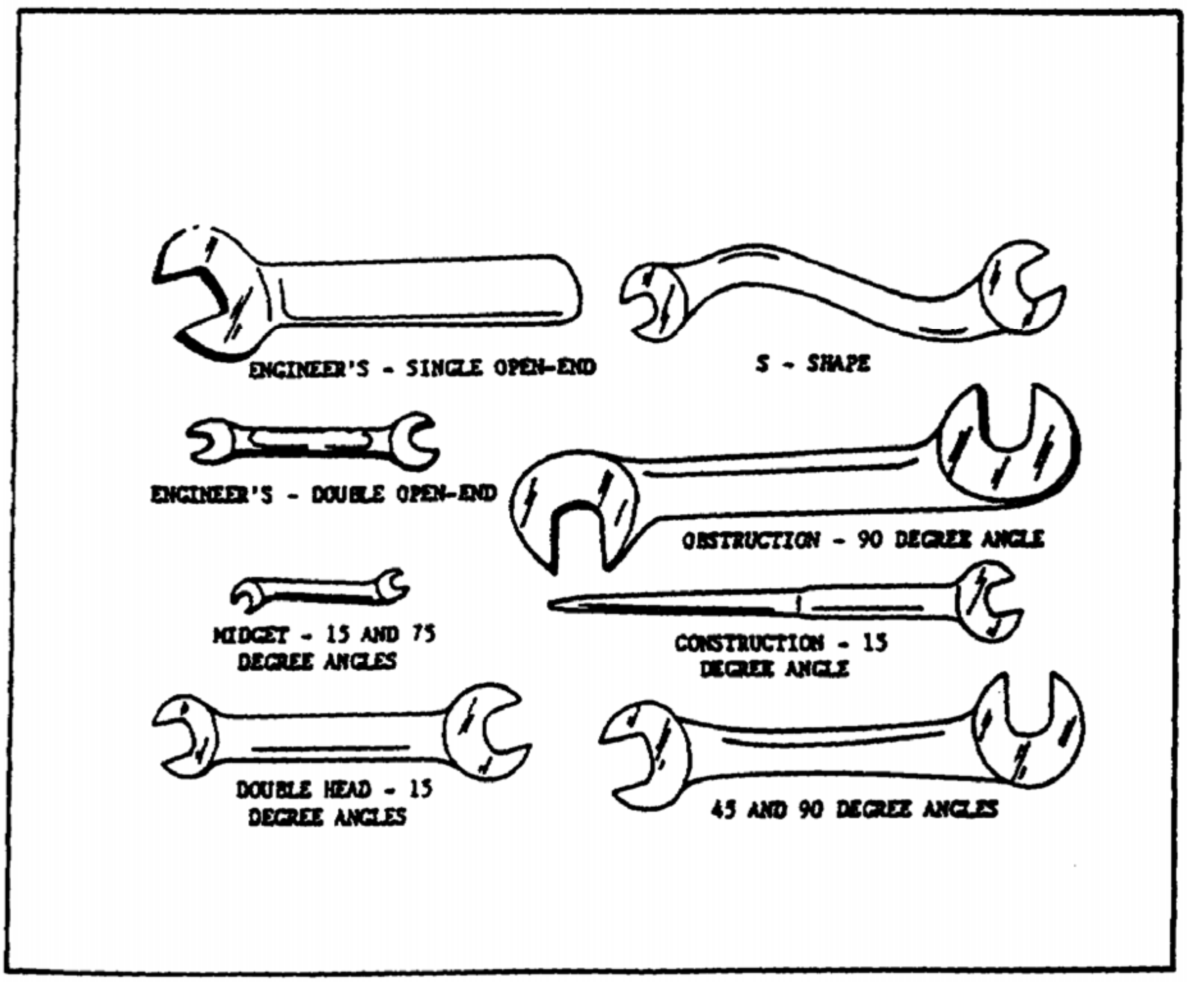


FIGURE 15. OPEN-END WRENCHES.

(b) *Box Wrenches.* Box wrenches (figure 16) are so named because they completely surround or box the bolt head or nut. The opening in a box wrench contains 6 or 12 notches, called points, arranged in a circle. The box wrench is a safer tool than the open-end wrench, since it will not slip off the work. As little as one-twelfth of a turn can be taken at each stroke, if necessary, in close quarters. Box wrenches may have straight handles, they may be offset, or the box end may be offset. Box wrenches are available in the same sizes as are open-end wrenches ((a) above) and usually have two openings; one opening 1/16 inch larger than the other. Some openings may be 1/32 or 1/8 inch larger than the other. A ratchet box wrench (not illustrated) usually has two 12-point openings and is not automatically reversible. However, it can be turned around to perform both tightening and loosening operations. Being of sturdy, thin construction, they are convenient for working in limited spaces. Ratchet box wrenches are issued in four sizes, ranging from 3/8 and 7/16 inch openings to 3/4 and 7/8 inch openings.

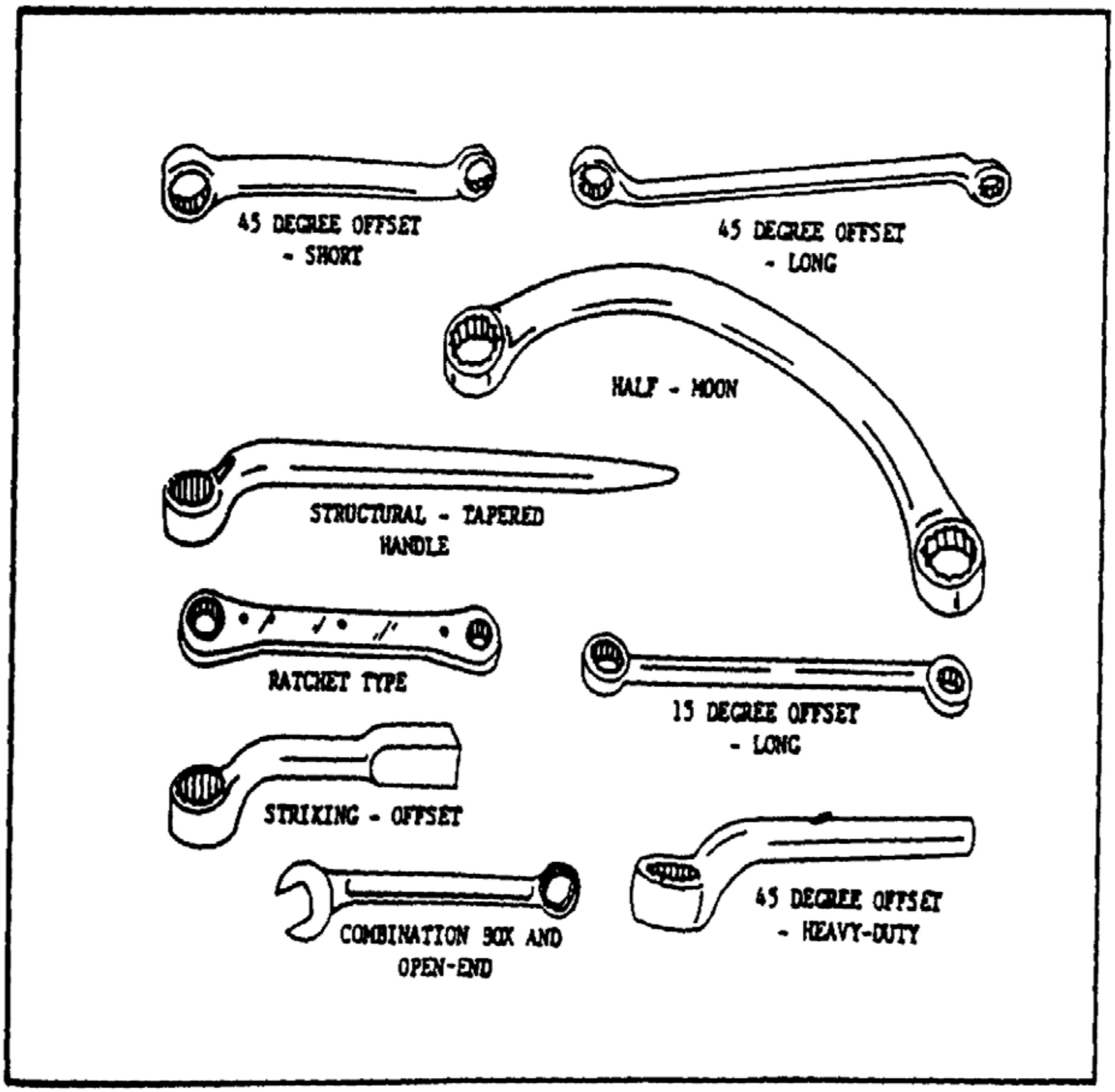


FIGURE 16. BOX AND COMBINATION WRENCHES.

(c) *Combination Open and Box Wrenches.* Combination wrenches (figure 16) have one open-end and a box wrench at the other end. Combination wrenches may be made with any combination of sizes, offsets, and angles, as discussed in (a) and (b) above.

(d) *Socket Wrenches.* The common socket wrench is boxlike and made as a detachable socket (figure 17) for various types of handles. A socket wrench set usually consists of various sized sockets, a ratchet (figure 18), a sliding bar tee, a speeder, a speed tee, a ratchet adapter, a nut spinner, a 3/8 inch drive handle, and extensions. Socket wrenches have two openings, one a square hole which fits the handles and the other a circular hole with notched sides to fit the bolt or screw head or nut to be turned. The square hole is made 1/4, 3/8, 1/2, 3/4, or 1 inch in diameter; each must be driven with the matching drive or speeder handle. The notched opening may have 6, 8, or 12 points. Socket wrenches are the fastest wrenches to use, since the ratchet handle permits the socket to remain on the nut or bolt and the handle does not have to be removed from the socket for turning. Socket wrenches are sized from 5/32 to 3 1/8 inches in steps of 32nds, 16ths, or 8ths of an inch.

(e) *Special Socket Wrenches.* Some socket wrenches are not detachable and are of one piece construction, such as the four-way socket wrench and the 90° offset handle shown in figure 19. Other socket wrenches are of the screwdriver type, having a six-pointed or a square socket. These may be straight or offset and have a T-type or regular screwdriver handle. Two types of stud remover sockets are available that are used with any 3/4 inch square drive socket wrench handle. One type has an eccentric cam which grips soft or hardened studs. The driving shank extends through both sides of the housing to provide a bearing surface on each side of the cam and prevents binding. The cam type has a capacity of 1/4 to 3/4 inch. The heavy-duty wedge-type stud remover socket works on the wedge principle and takes a positive grip which can be released only when the tool is turned in the reverse direction. Two sizes of steel wedge are included with the socket. This type has a capacity of 9/16 to 1 inch.

(f) *Crowfoot Wrenches.* A crowfoot wrench (figure 17) has an open-end in the box containing notches and a square hole which fits the handle. This configuration makes the crowfoot wrench the best wrench to use on a nut located in a very tight place. They are used in conjunction with socket wrench handles having a 3/8 or 1/2 inch square drive. They range in size from 3/8 to 2 1/2 inches.

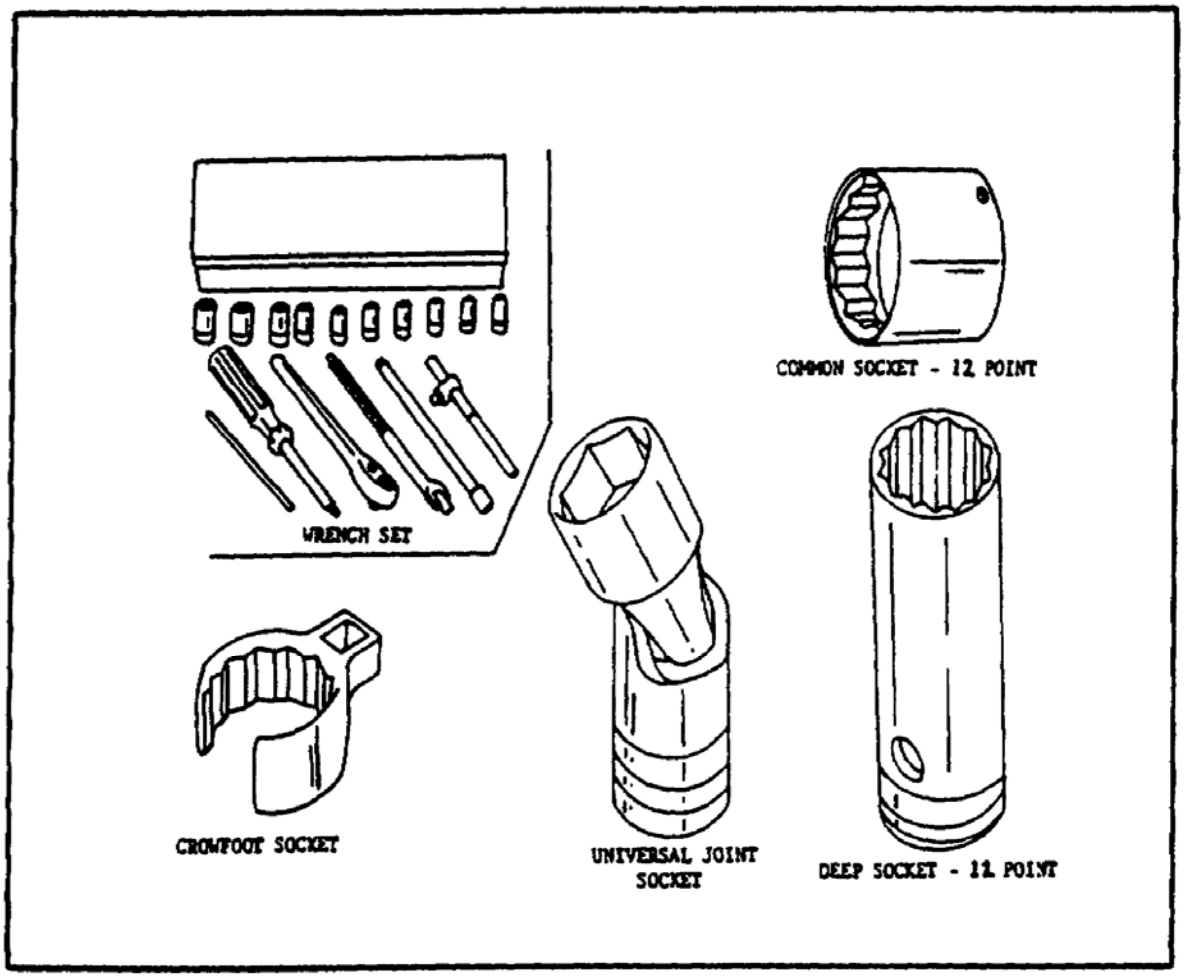


FIGURE 17. SOCKET AND CROWFOOT WRENCHES.

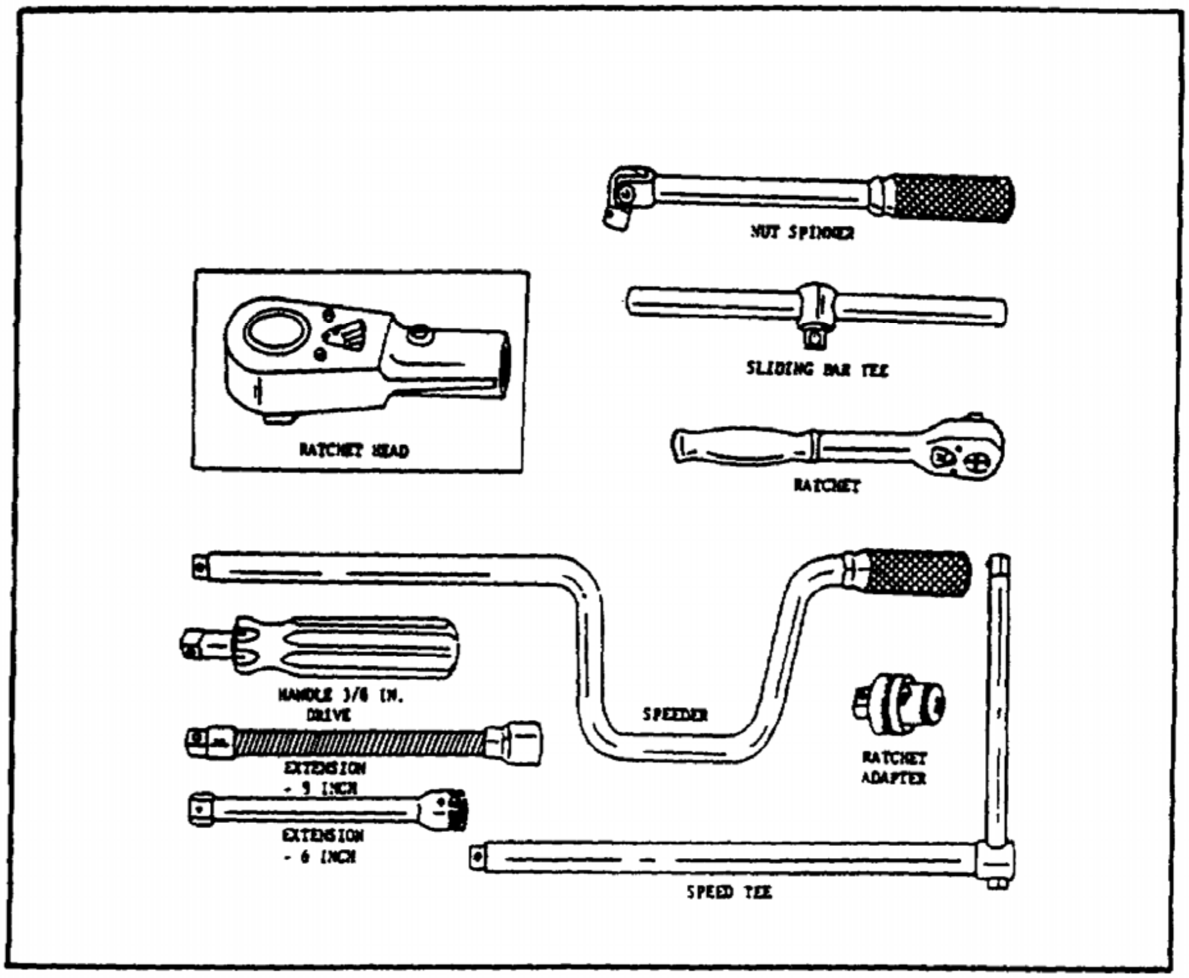


FIGURE 18. SOCKET WRENCH RATCHETS, HANDLES, AND EXTENSIONS.

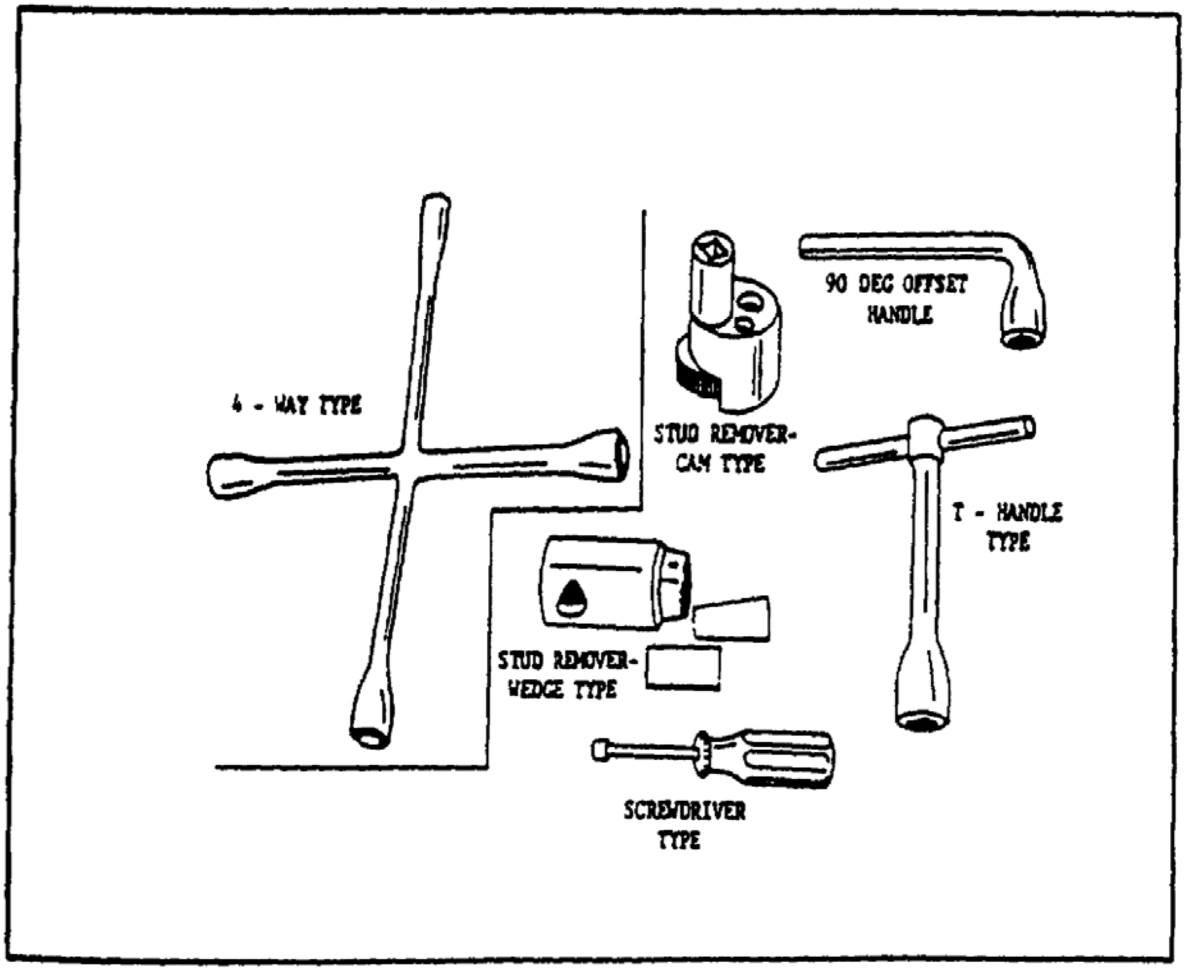


FIGURE 19. SPECIAL SOCKET WRENCH.

(g) *Setscrew and Hollow-Head Capscrew Wrenches.* Most setscrews and hollow-head capscrews have a hexagon (six-sided) socket. The commonly known key (Allen) wrench (figure 20) is L-shaped, made of tool steel having a hexagonal or square section to fit these screws. Splined setscrew wrenches are made of round stock with ends to fit little flutes or splines in headless setscrews. A hollow-head capscrew set is also supplied. This set has detachable sockets which are used with the accompanying handles.

(h) *Plug Wrenches.* A plug wrench (figure 20) is a straight bar having a hexagon or square shape and is available in a range of sizes from 3/8 to 1 inch in width. They are usually 2 inches long. Plug wrenches are also made to fit drain plugs of transmissions, differentials, and all types of gear cases. The multiple plug wrench is a combination type, having several different size and shape ends. Most plug wrenches are made for a specific size plug. There are single-end plug wrenches which range in size from 3/16 to 11/16 inch with a hexagonal or square end. Double-end plug wrenches with square ends are issued for 3/8 and 1/2 inch plugs and 3/8 and 3/4 inch plugs. These wrenches are normally 8 to 12 inches long. Socket plug wrenches have a 1/2 inch square drive to be used with socket wrench handles.

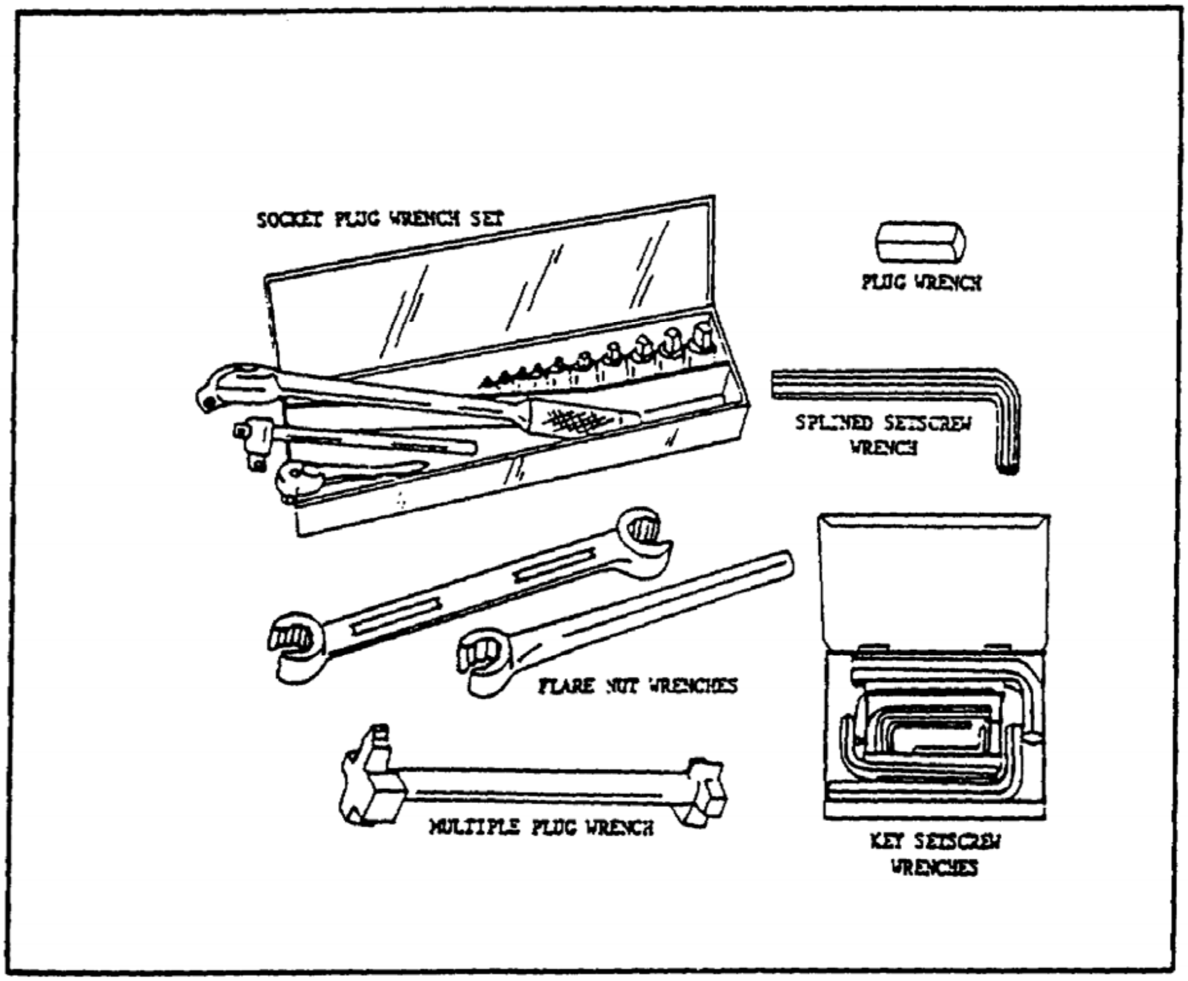


FIGURE 20. SETSCREW, PLUG, AND FLARE NUT WRENCHES.

(i) *Flare Nut Wrenches.* A flare nut wrench (figure 20) is a notched, thin-walled split box wrench especially designed to fit over nuts in very close places. It is ideal for tightening brass tube flare nuts. It grips the nut on five sides; it does not slip or mar the nut. Flare nut wrenches are of 12 point design and have either a single or double end. Openings range in size from 3/4 to 1 5/8 inches.

(2) *Adjustable Wrenches.*

(a) *Single Open-End Wrench.* The single open-end adjustable wrench (figure 21) is similar in shape to the fixed-end nonadjustable open-end wrench, but has one adjustable jaw and one stationary jaw. The adjustable end wrenches issued by the Army Ordnance Supply System have 1 3/8 to 2 7/8 inch jaw openings and are 24 inches long. A knurled nut is rotated to bring the movable jaw up to fit the nut or bolt head.

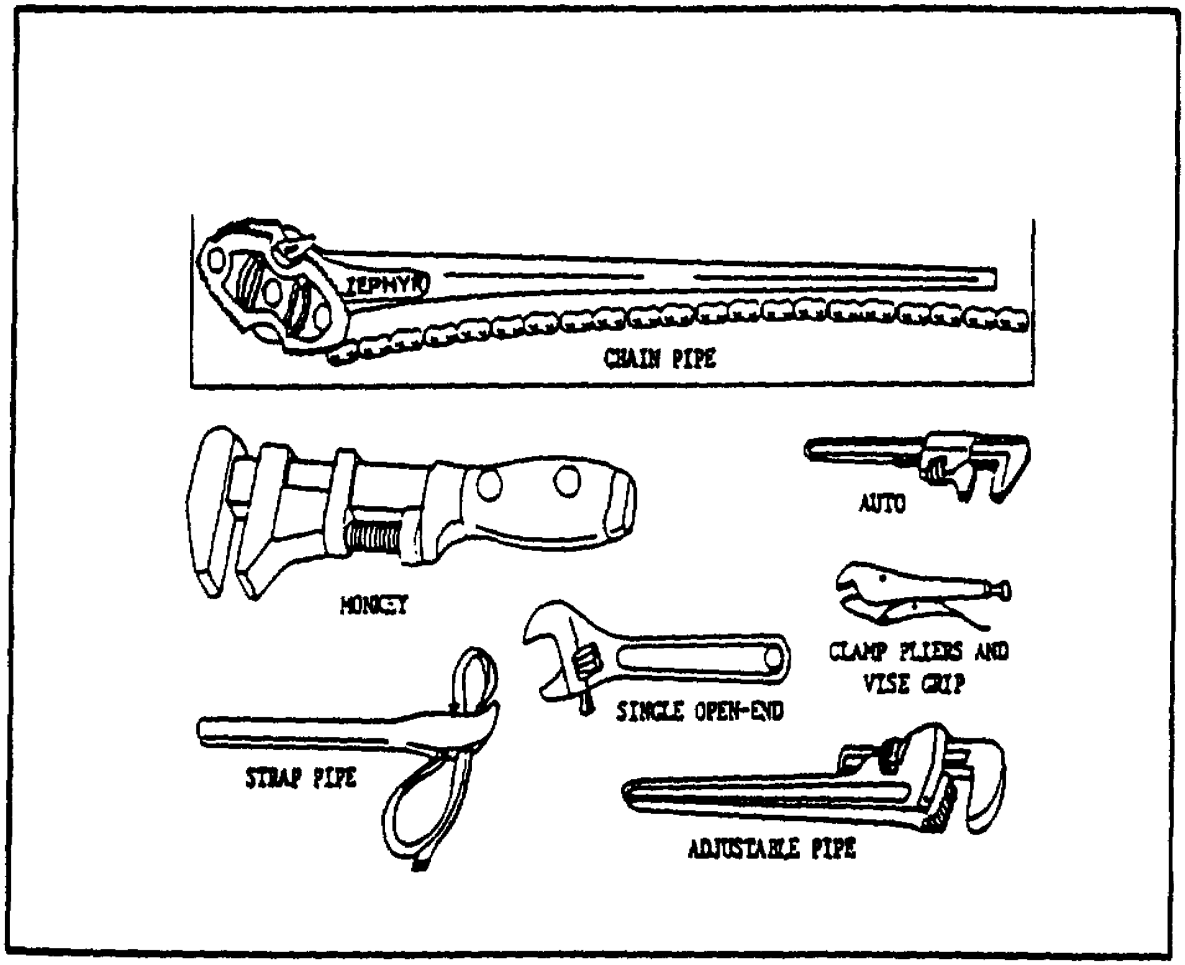


FIGURE 21. ADJUSTABLE WRENCHES.

(b) *Auto and Monkey Wrenches.* The auto and monkey wrenches (figure 21) are similar in design. They are of sturdy construction and are made to fit a wide range of nuts and bolts. They are designed principally for turning odd sized nuts or bolts which the open-end, box or socket wrenches will not fit, and when work requires a sturdy wrench. They are supplied in several sizes, from 5 to 21 inches long.

(c) *Clamp Pliers and Vise Grip Wrench.* The clamp pliers and vise grip wrench (figure 21) has one movable jaw and one stationary jaw. The movable jaw is adjusted by an adjusting screw in the base of the stationary jaw handle. The movable jaw can be clamped around a nut or bolt after setting the jaw to the desired size. This type wrench is issued in two sizes: 1 1/8 inch jaw opening capacity and 7 inches long, and 1 1/4 inch capacity and 10 inches long.

(3) *Pipe Wrenches.*

(a) *Adjustable Pipe Wrench.* The adjustable pipe wrench (figure 21) has two jaws that are not parallel. The outer jaw, which is adjustable, is made with a small amount of play which provides a tight grip on the pipe when the wrench is turned in the direction of the movable jaw. This is the only wrench which will take a bite on round objects. The jaw always leaves marks on the work and should never be used on a nut or bolt unless the corners have been rounded so that it cannot be turned with another type of wrench.

(b) *Strap Pipe Wrench.* The strap pipe wrench (figure 21) is also used to turn cylindrical parts, but will not mar the work because the strap serves as jaws. These wrenches are issued in a 1/8 to 2 inch pipe capacity size and a 1 to 5 inch pipe capacity size.

(c) *Adjustable Chain Pipe Wrench.* The adjustable chain pipe wrench (figure 21) is a long-handled tool with a single jaw and a length of chain that fits around the pipe to be turned and over the connection at the end of the jaw. The chain acts as the other jaw. It is used for gripping rough pipe work on large diameter pipe. These wrenches range in size from 35 to 64 inches long and have a pipe capacity of from 3/4 inch to 12 inches.

(4) *Torque Wrenches.* A torque wrench (figure 22) is used for work requiring a specified force (torque) to tighten bolts, nuts, capscrews, etc., to a desired degree of pressure. A dial or scale calibrated in foot-pounds indicates the degree of torque placed on the work. The pointer moves to the right or left of zero, depending on the bolt (left or right hand threads) being tightened. These wrenches are issued in several sizes; they may have a 1/4, 1/2, or 3/4 inch square drive to receive socket wrenches, and the capacity may range up to 600 foot-pounds.

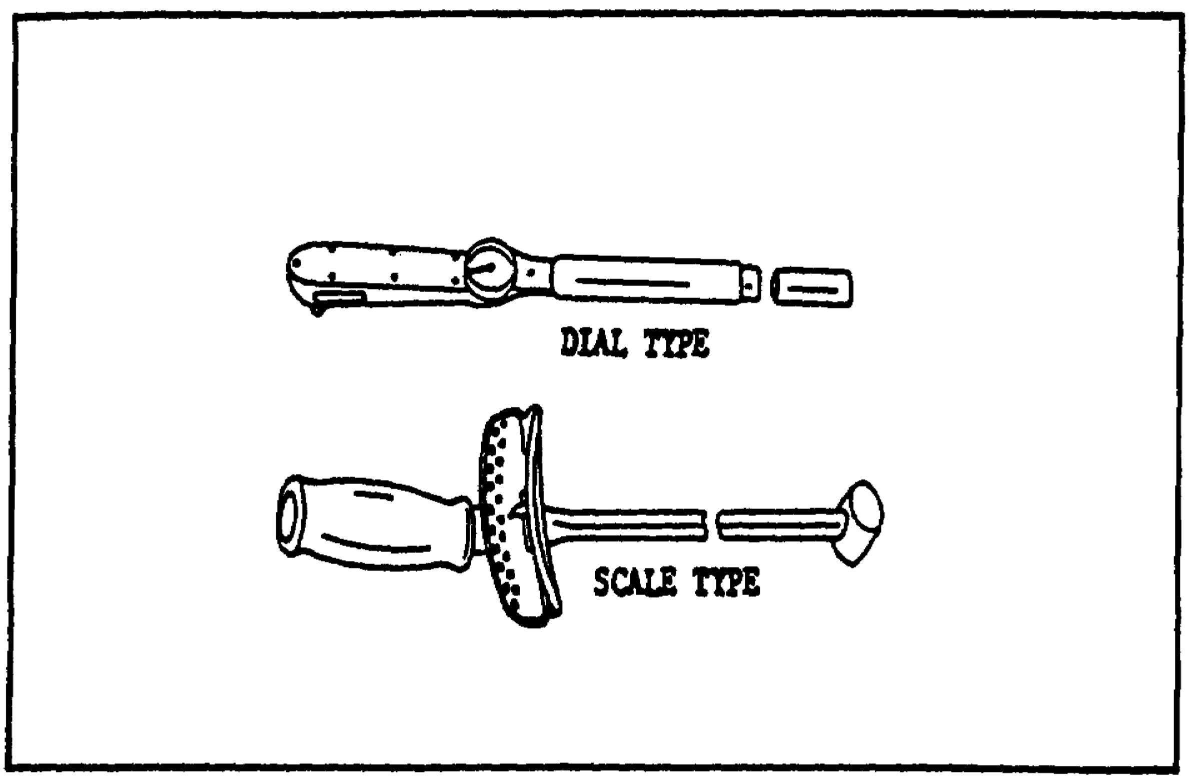


FIGURE 22. TORQUE WRENCHES.

(5) *Spanner Wrenches.*

(a) *Fixed Spanner Wrenches.* Fixed spanner wrenches (figure 23) are used to turn flush type and recessed retaining rings, cover plates, plugs, hose couplings, and parts which have holes or slots for insertion of the wrench pins or lugs. Each fixed spanner wrench is designed for a particular job.

(b) *Adjustable Spanner Wrenches.* An adjustable face spanner wrench (figure 23) has two legs joined together with a pivot pin. The legs can be opened and closed, allowing the pins at the end of the legs to fit the various distances between holes found in many types of cover plates and plugs. Another type of adjustable spanner wrench, shaped like a hook, is called an adjustable hook spanner wrench. The position of the hook can be adjusted to fit different size couplings and other parts.

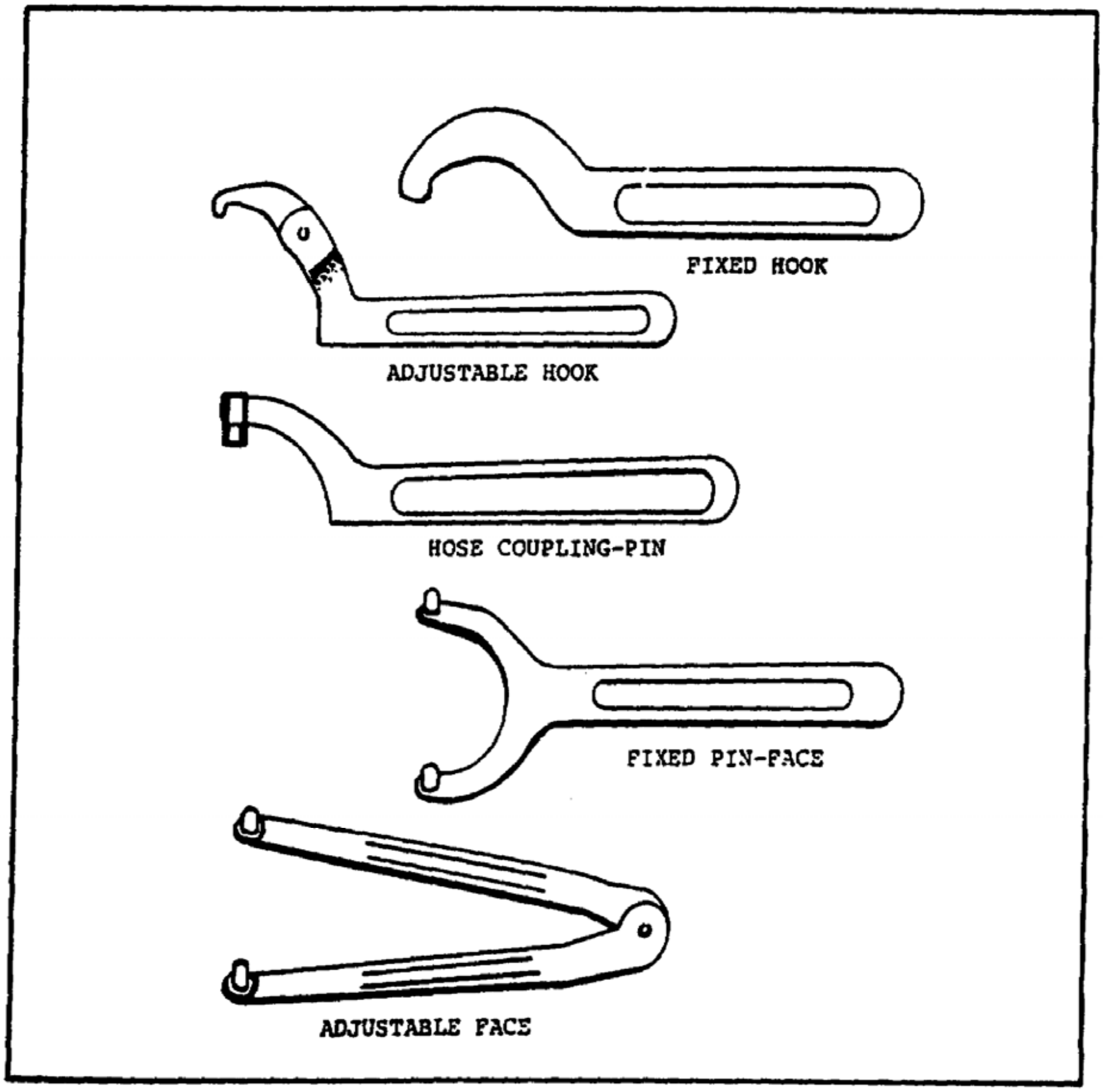


FIGURE 23. SPANNER WRENCH.

c. *Using Wrenches.*

(1) *Open-End Wrenches.* It is important for a wrench to be a snug fit on a nut or bolt head. If it is too loose, the wrench will slip and round the corners. Make certain that the wrench fits squarely on the sides of the nut or bolt head, as shown in figure 24 . Offset open-end wrenches make it possible to turn a nut or bolt that is recessed, and in limited quarters where there is little space to swing the wrench. Turn the wrench over after each swing so that the opposite face is down, and the angle of the wrench opening is reversed, as shown in figure 25 . Always place yourself so that you can pull on the wrench to turn the work in the desired direction. There are times, however, when the

only way you can move the wrench is by pushing it. In this case, do not wrap your fingers around it. Push it with the palm of your hand and hold your hand open.

CAUTION

Do not push on a wrench; if the wrench slips or the bolt breaks loose suddenly, you may skin your knuckles and be thrown off balance.

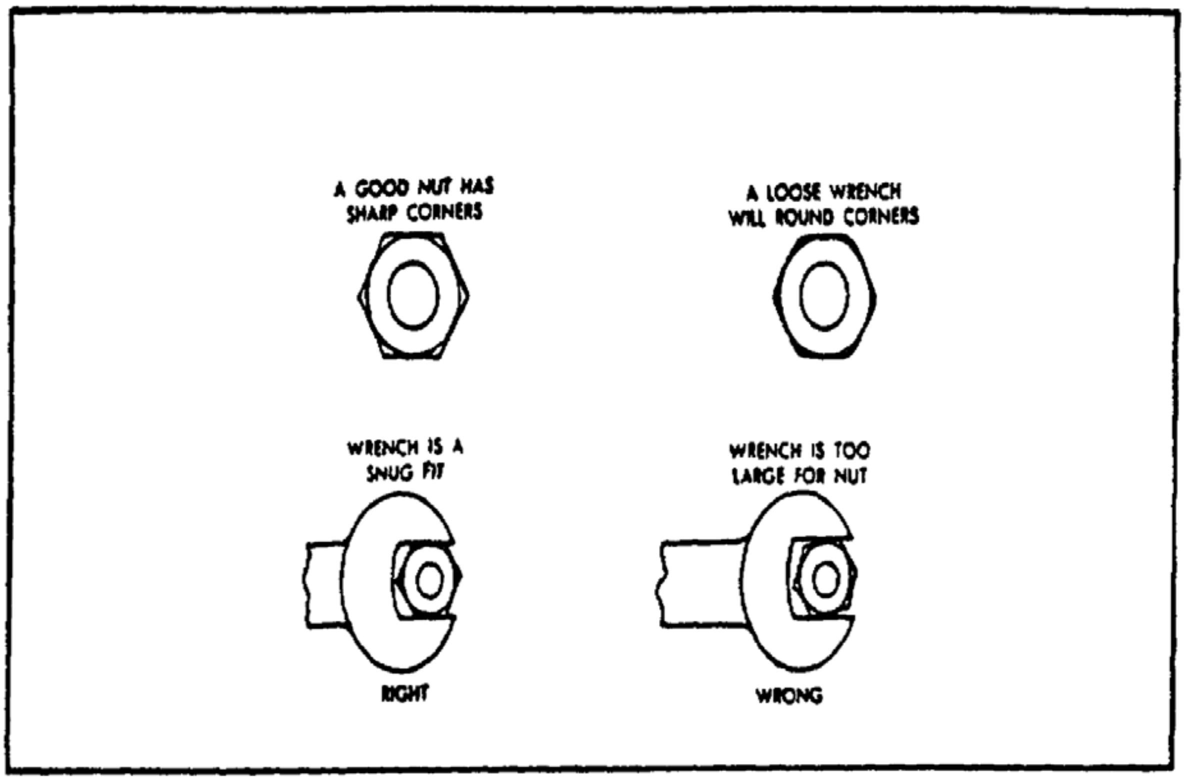


FIGURE 24. FITTING OPEN-END WRENCH.

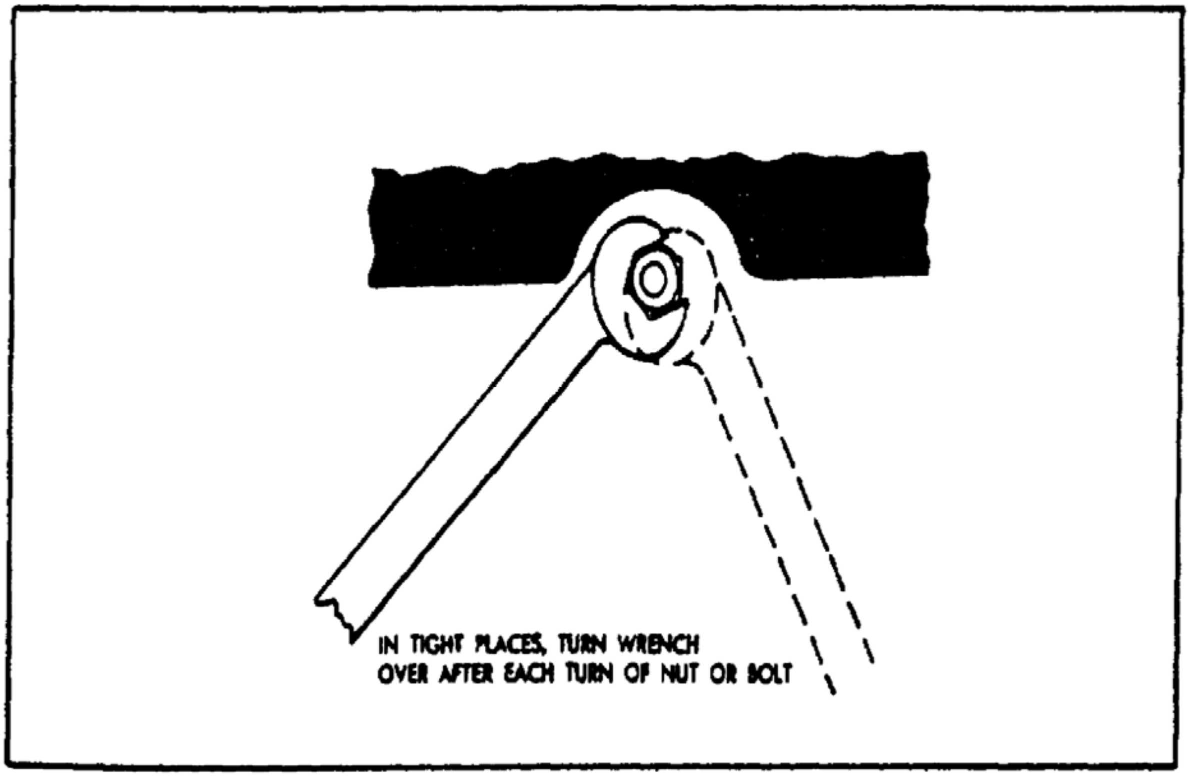


FIGURE 25. USE OF OPEN-END WRENCH.

(2) *Box Wrench.* Always select the size wrench that fits the nut or bolt head. Box wrenches will not slip off and are used in preference to open-end wrenches. A swing through an arc of 15 degrees is sufficient to continuously loosen or tighten a nut or bolt. Unless there is room to swing a box wrench in a full circle, lift it completely off the nut when it comes to the limit of its swing, and place it in a new position which will permit it to be swung again. Since a box wrench cannot slip off a nut, it is ideal for loosening tight nuts and bolts, and for setting them up. To set up means to give already tight nuts or bolts their final tightening. After a nut is started, it can usually be worked more quickly with an open-end wrench than with a box wrench. For this reason, combination box and open-end wrenches are very popular and more convenient; the box end to break loose or set up, and the open-end to do the actual turning.

(3) *Socket Wrenches.* To use a socket wrench, select the size of socket that fits the nut or bolt to be turned and push it onto the handle which is best suited to the job. If there is room to swing it, use the ratchet handle. The handle lay be made to ratchet in one direction for tightening, and in the other direction for loosening work. It is necessary only to swing the handle back and forth in order to turn the nut in the desired direction. The socket need not be raised from the nut at the end of each swing. A nut spinner handle (figure 18) also saves time. When a tight nut is to be loosened or a nut is to be set up, the handle can be swung at right angles to the socket to provide the most leverage. At the point where the nut turns easily, the handle can be swung to a vertical position and twisted rapidly between the fingers in the same manner as a screwdriver. A universal

joint socket wrench (figure 17) makes it possible to turn nuts where a straight wrench could not be used unless some part of the machine or equipment is removed.

(4) *Key (Allen) Setscrew Wrenches.* Select the proper type and size that fits the recess of the screw being worked on. The short end of the wrench is used to give a final tightening or break loose tight screws. The long end of the wrench is used to turn the screw rapidly when very little leverage is needed.

(5) *Adjustable Open-End Wrench.* Always place the wrench on a nut or bolt so that the force used to turn it is applied to the stationary jaw side of the wrench, as shown in figure 26. After placing the wrench in position, straighten the knurled adjusting nut until the wrench fits the nut or bolt head as tightly as possible. If it does not fit tightly, it will slip, which may result in an injury to your hand and which may also round the corners of the nut of bolt head.

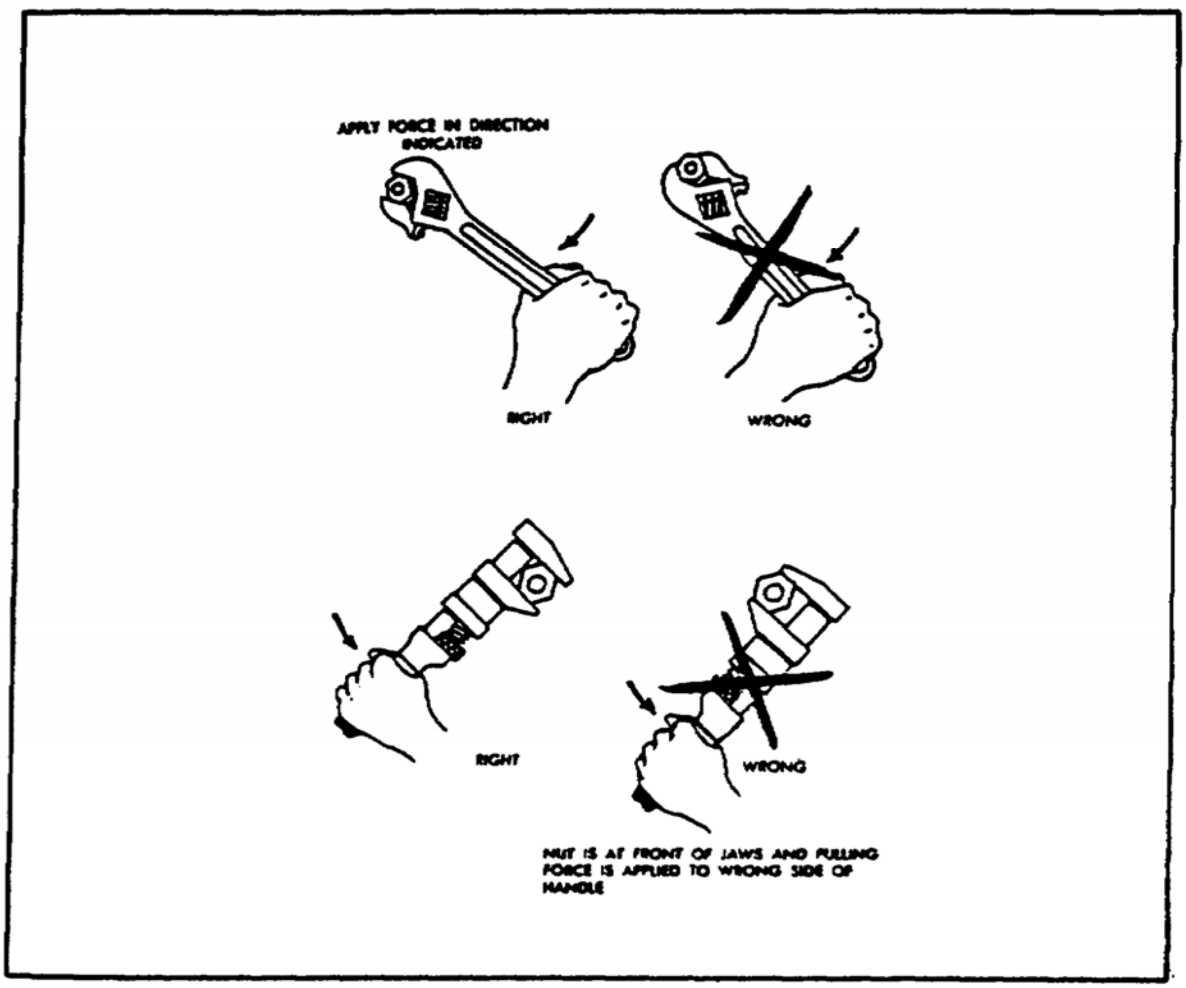


FIGURE 26. USING ADJUSTABLE WRENCHES.

(6) *Auto and Monkey Wrenches.* Use the auto or monkey wrench in the sane manner as you would the adjustable open-end wrench.

NOTE

Always place the wrench on a nut or bolt so that the turning force is applied to the back of the handle; that is, the side of the wrench opposite the jaw opening, as shown in figure 26.

(7) *Pipe Wrenches.*

(a) *Adjustable Pipe Wrench.* The adjustable pipe wrench will work in one direction only. Always turn the wrench in the direction of the opening of the jaws. Apply force to the back of the handle; since the top jaw is capable of a slight angular movement, the grip on the work is increased by pressure on the handle (figure 27).

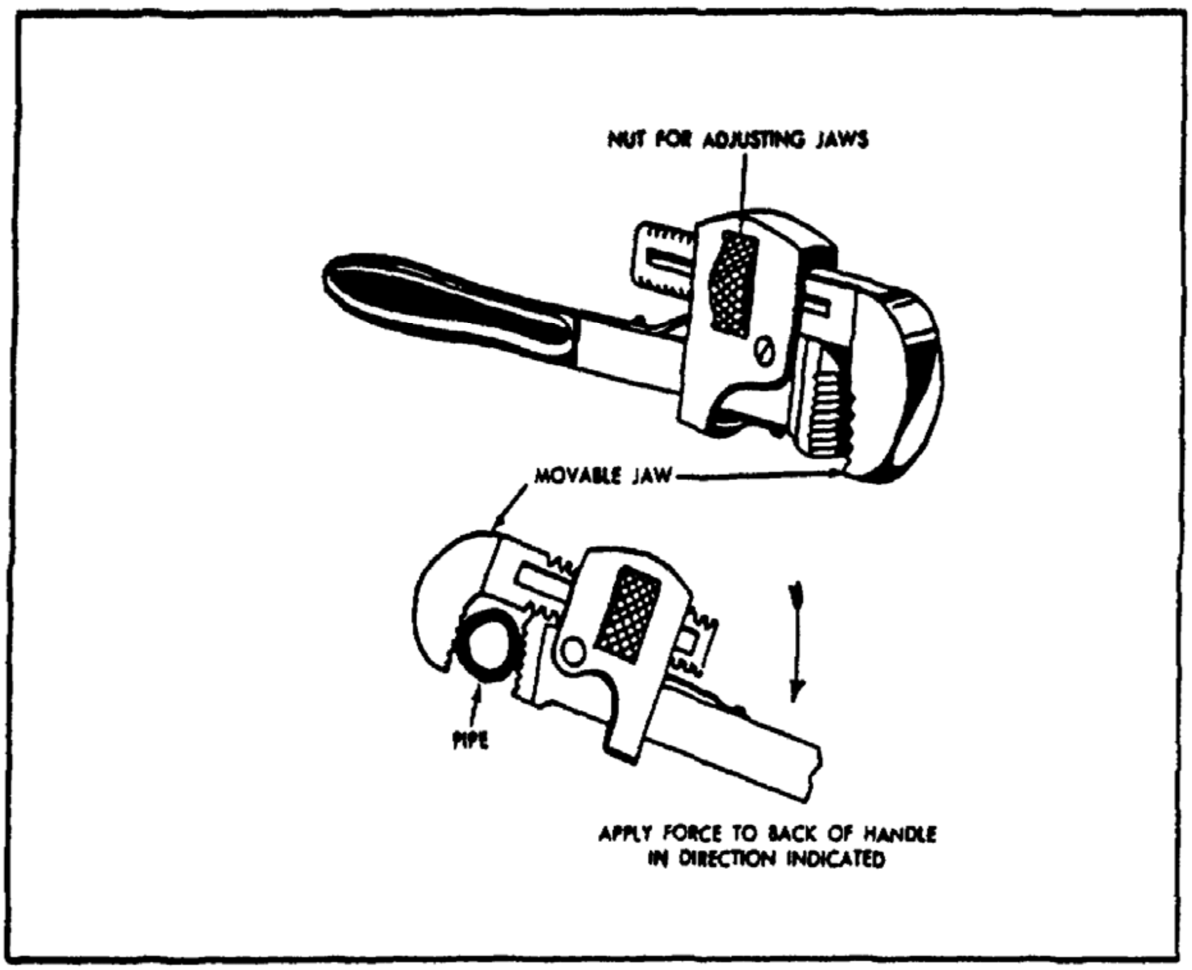


FIGURE 27. USING ADJUSTABLE PIPE WRENCH.

(b) *Adjustable Strap Pipe Wrench.* When using the adjustable strap pipe wrench, loop the strap around the pipe in the opposite direction to that in which the pipe is to be rotated (figure 28). Slip the end of the strap through the shackle and draw it up tightly. Pull the handle to turn the pipe in the desired direction. The jaw at the end of the shackle will seat against the strap, and as the handle is pulled, the strap will tighten and turn the pipe.

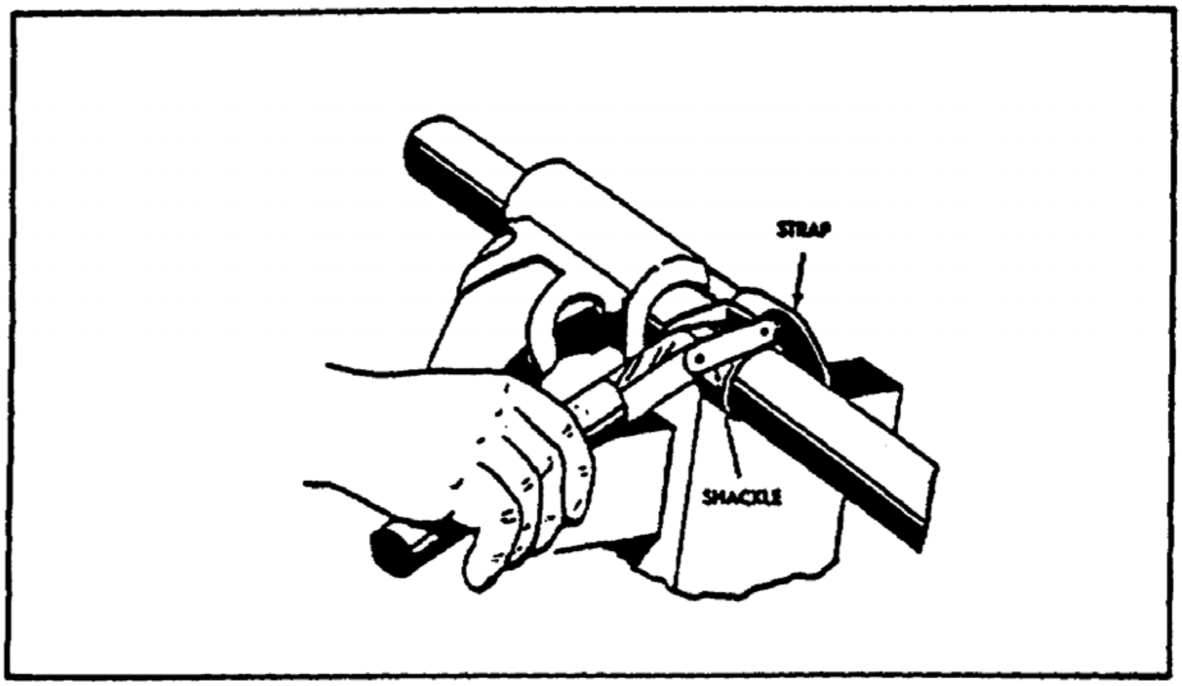


FIGURE 28. USING A STRAP PIPE WRENCH.

(c) *Adjustable Chain Pipe Wrench.* The adjustable chain pipe wrench is used in the same manner as the strap wrench. The chain acts as a jaw when looped around the pipe, gripping the pipe on the entire outer circumference. It is used for rough pipework on very large diameter pipes.

(8) *Torque Wrench.* A torque wrench enables you to set up a nut or bolt when the force applied to the handle reaches the specified limit. Manufacturers' instructions specify these limits of turning force. Cylinder head nuts and bolts, rod bearing cups, and other places on automotive and airplane engines usually require torque wrench limits. Select a proper size socket wrench and attach it to the torque wrench square drive. Place the socket wrench on the work and pull the torque wrench handle in the desired direction to tighten the work. The tightening torque will be indicated on the dial or scale, depending on the type of torque wrench used.

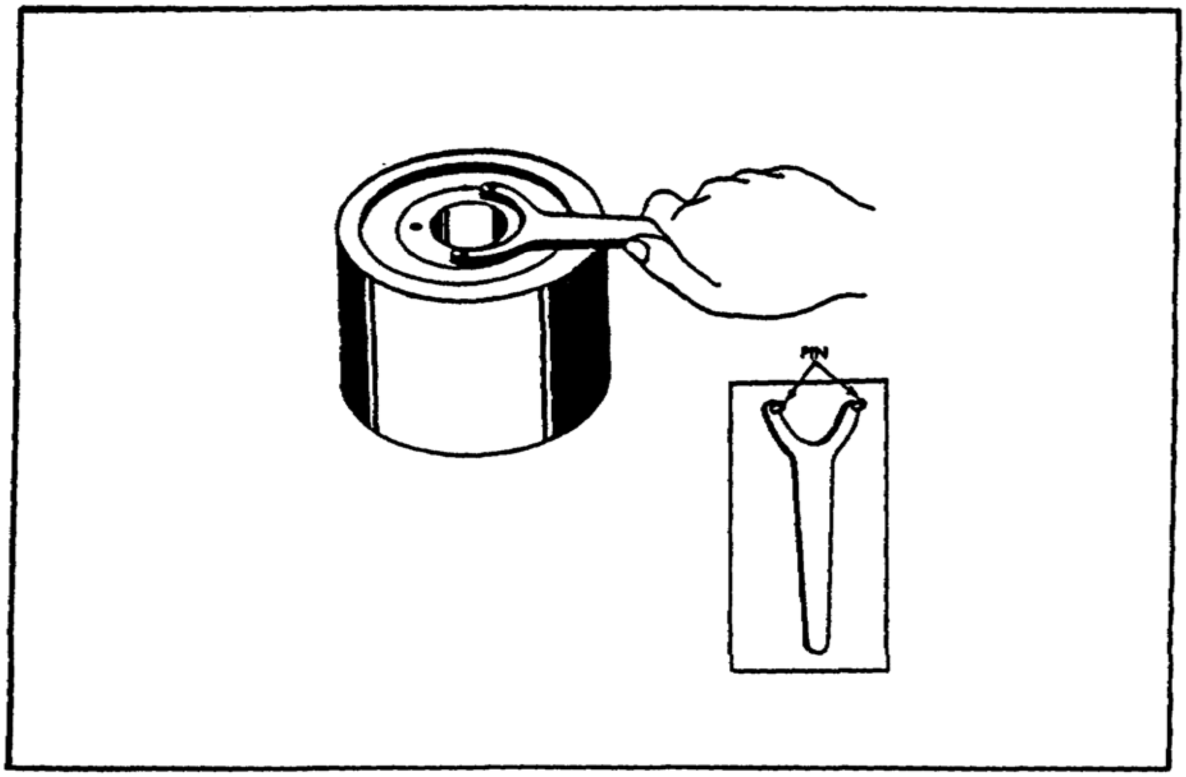


FIGURE 29. USING A PIN FACE SPANNER WRENCH.

(9) *Spanner Wrenches.* When using a pin-face spanner wrench (figure 29), insert the pins or lugs into the pin holes of the part. Keep the pin face of the wrench flush with the part surface and turn the wrench. Exert enough force against the wrench so that the pins do not jump out of the holes. Hose coupling spanner wrenches are shaped so that they fit around the coupling with the pin or lug at right angles to the handle. Insert the pin in the hose coupling pin hole. Pull or push the handle in the direction opposite the hook of the spanner wrench. Make certain the pin fits the hole and that the force is applied with the handle perpendicular to the work. Use of an adjustable spanner wrench is shown in figure 30 .

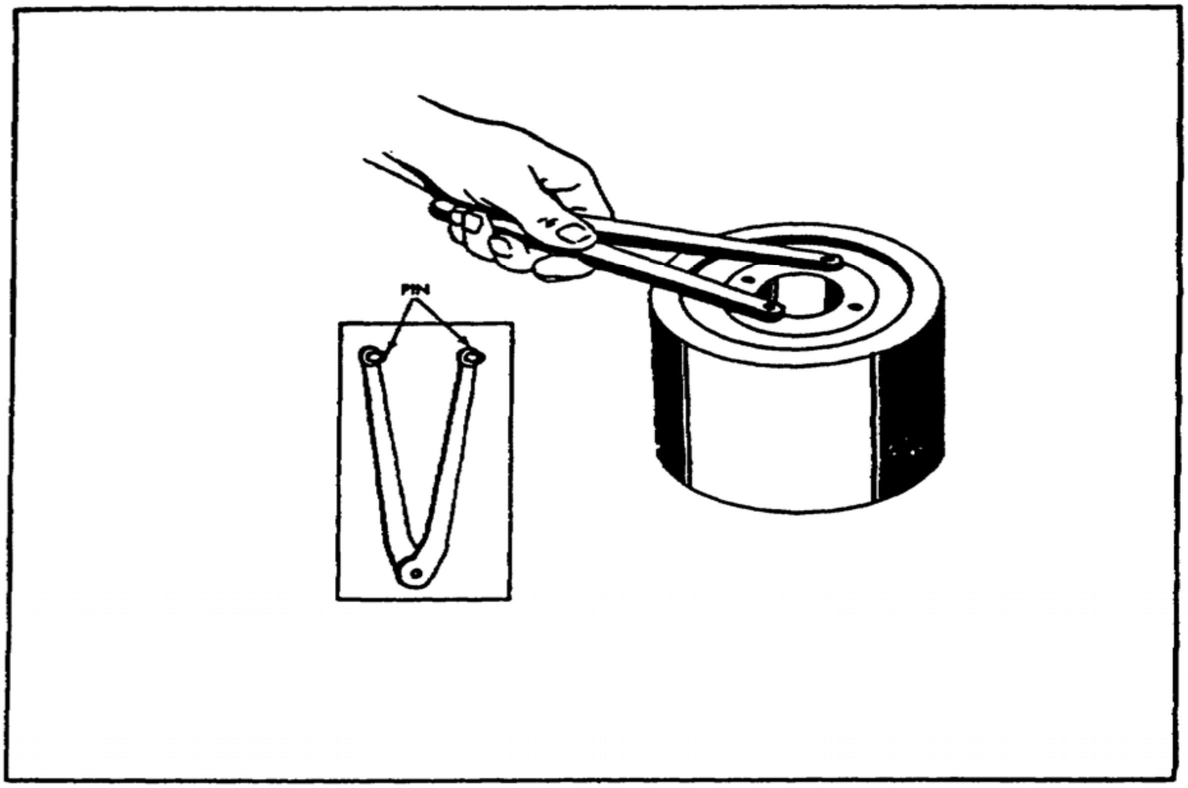


FIGURE 30. USING ADJUSTABLE SPANNER WRENCH.

d. *Care of Wrenches.* Clean all wrenches after use. Apply a thin film of oil to metal parts of all wrenches prior to storing. Wrenches that come in sets, such as socket wrenches, should be returned to their cases after being used. The torque wrench, in particular, must be carefully placed in its box to prevent damage to the dial or scale. For long periods of storage, wrenches should be covered with a rust preventive compound and carefully stored in a dry place.

e. *Safety Precautions.*

(1) Wrenches should fit the nuts or bolt heads they are to loosen or tighten.

(2) Never turn adjustable wrenches so that the pulling force is applied to the adjustable jaw.

(3) Do not use a pipe, or extend the handle in any way, to increase the leverage on a wrench (figure 31).

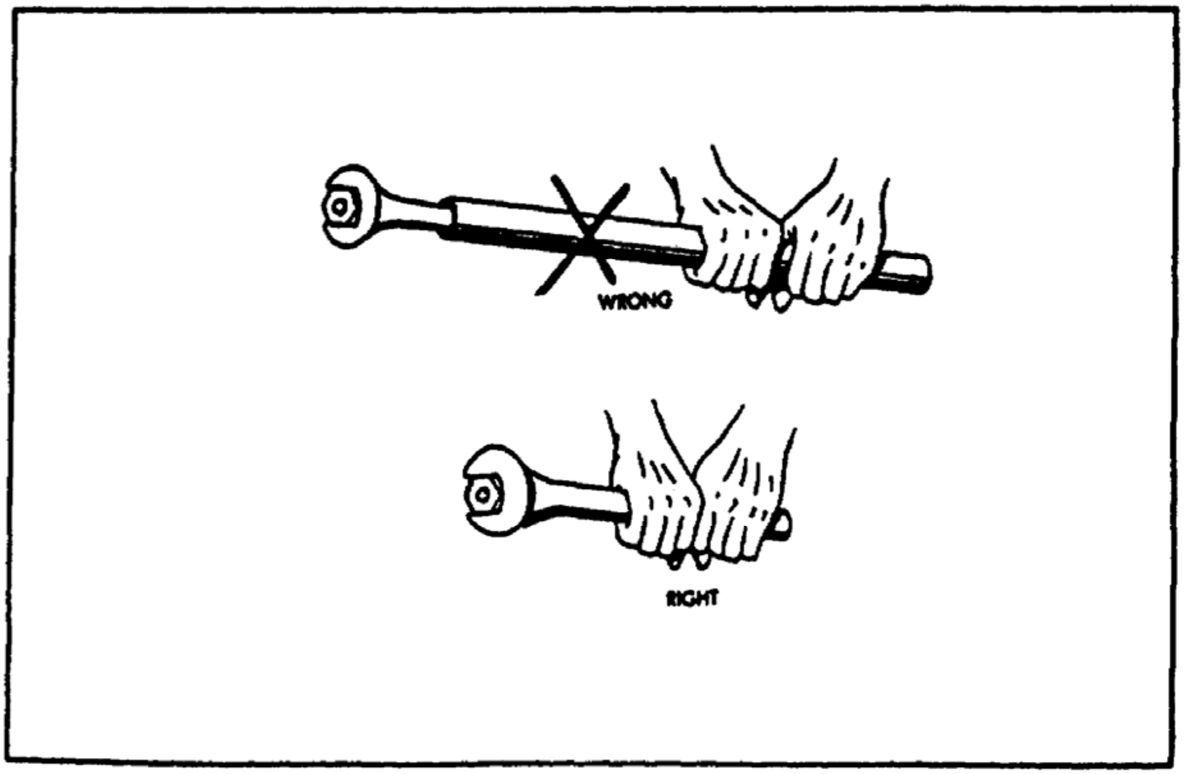


FIGURE 31. APPLYING LEVERAGE ON WRENCH.

(4) Apply penetrating oil to rusted nuts and/or bolts that resist turning. Allow time for the oil to penetrate before attempting to turn.

(5) Do not strike wrenches with hammers to tighten or loosen nuts or bolts.

(6) Do not exert a hard pull on a pipe wrench until it has a firm grip on the work.

(7) Remember to pull on the wrench when possible, in order to protect your knuckles in case the wrench slips.

(8) Always keep the wrench in good condition; clean, and free from oil or grease.

f. *Maintenance of Wrenches.*

(1) *Grinding and Filing Damaged Jaws.* Fixed open-end and adjustable open-end wrenches with damaged jaws can be made serviceable by grinding and/or filing. When attempting this repair, finish-grind or file the jaw opening of the fixed open-end wrench to the next largest standard size. Jaw faces must be flat and parallel. Use a part of the known size or a gage block to test for correct size and parallelism. Dip the jaws in water frequently when grinding to preserve temper which can be lost because of overheating.

(2) *Renewing Jaw Serrations.* To renew the serrations in auto, monkey, pipe, and vise grip wrenches, use a fine triangular or flat tapered file, and carefully deepen the low points between the serrations. Do not remove more material than is absolutely necessary.

(3) *Adjustment for Play.* The movable jaw on adjustable open-end wrenches may not remain parallel to the stationary jaw after prolonged use. In most cases, the trouble is due to wear and to the worm spring having weakened. To increase spring resiliency, remove the axle screw from the wrench and separate the adjustable jaw, worm, and worm spring from the handle (figure 32). Stretch the worm spring if the spring is not cracked and is in good condition. Stretching the spring will increase its tension and help keep the adjustable jaw from tipping. Reassemble the wrench and prick punch the wrench adjacent to the tightened axle screw to lock it in position.

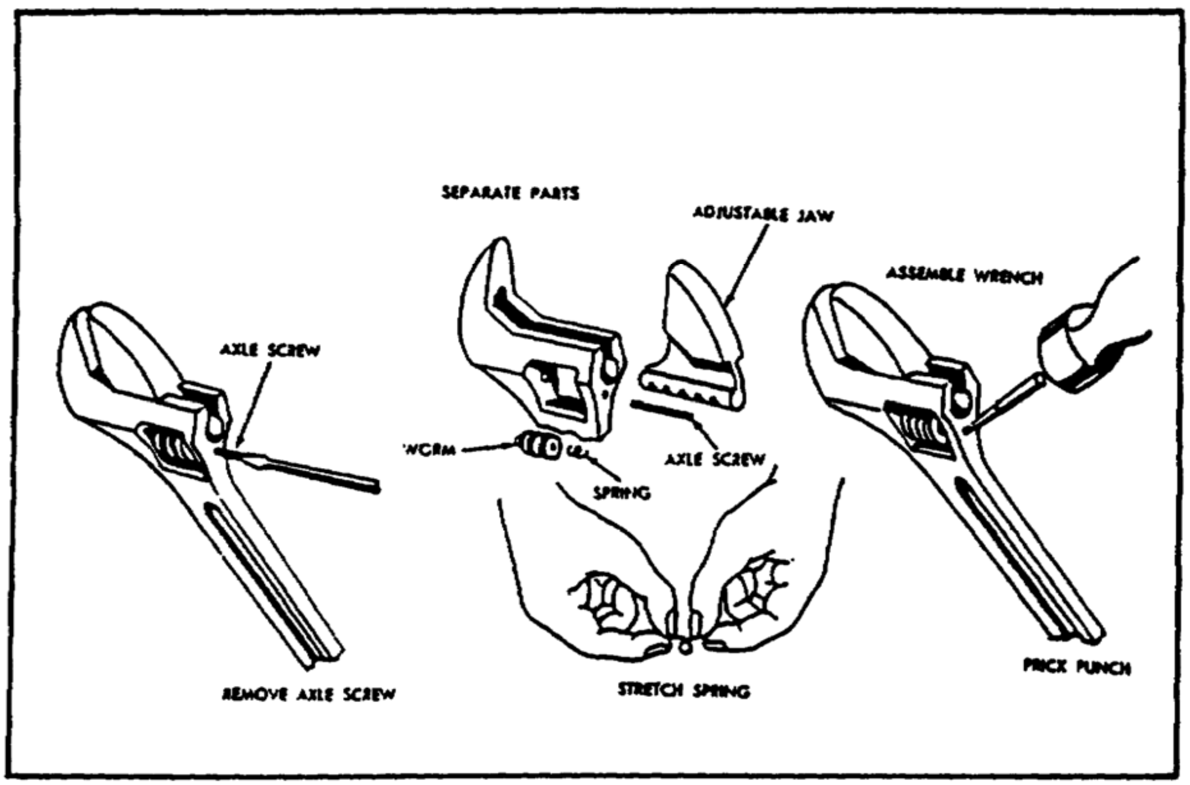


FIGURE 32. ADJUSTING FOR PLAY IN ADJUSTABLE WRENCH.

5. Pliers and Tongs

a. *Purpose.* Pliers are used for gripping, cutting, bending, forming, or holding work, and for special jobs. Tongs look like long-handled pliers and are mainly used for holding or handling hot pieces of metal work to be forged or quenched, or hot pieces of glass.

b. *Types of Pliers.* Pliers basically consist of a pair of jaws shaped for a specific purpose, a pivot or hinge, and a pair of handles. They are made in many shapes and sizes to handle a variety of jobs. The size is determined by the overall length, which usually is 5 to 10 inches.

(1) *Slip Joint Combination Pliers* (figure 33). Slip joint combination pliers are most commonly used to hold or bend wires, small bars, and a wide variety of miscellaneous items. Some have short cutting edges near the hinge for cutting wire. The slip joint permits adjustment and wider opening of the jaws. The jaws have serrations or teeth for gripping.

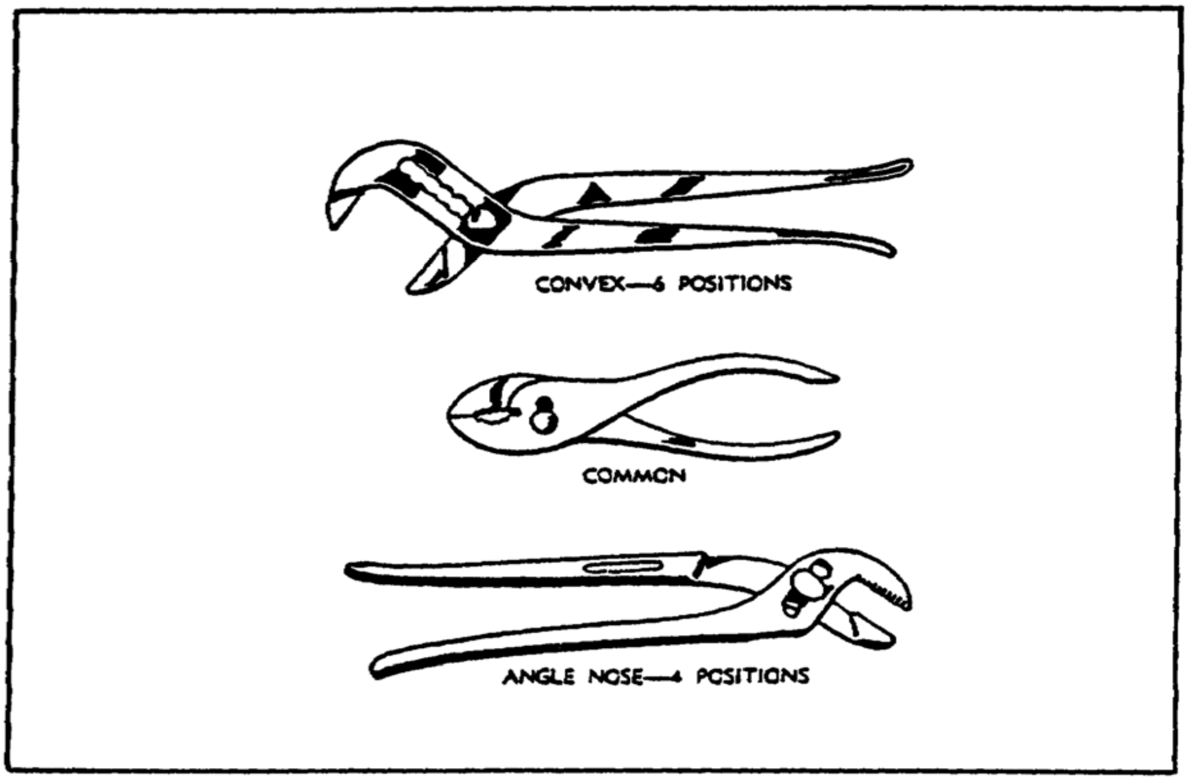


FIGURE 33. SLIP JOINT COMBINATION PLIERS.

(2) *Diagonal Cutting Pliers* (figure 34). Diagonal cutting pliers have short jaws with the cutting edges at a slight angle. They are used for cutting soft wire and stock and for removing cotter pins. They are also used for cutting cotter pins to desired lengths and for spreading the ends after the pin is inserted through a hole.

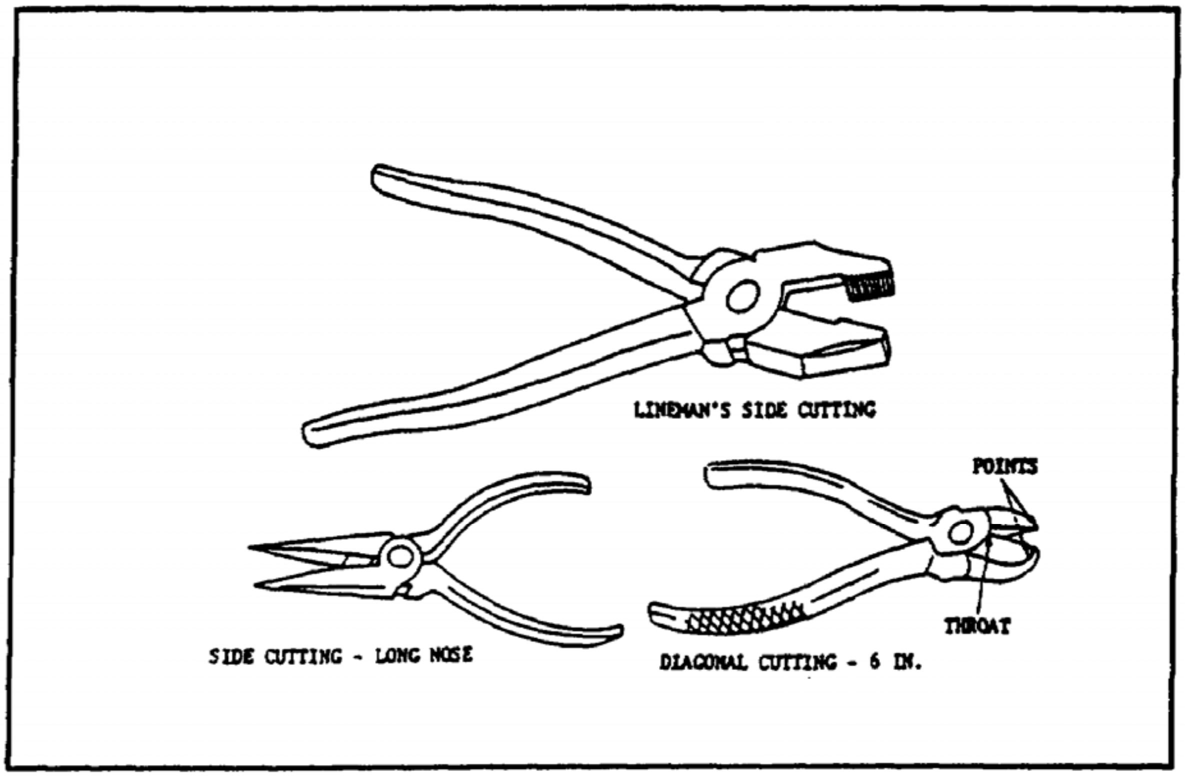


FIGURE 34. DIAGONAL AND SIDE CUTTING PLIERS.

(3) *Lineman's Side Cutting Pliers* (figure 34). Lineman's side cutting pliers are used for cutting wire and peeling insulation. The flat serrated jaws are also used to twist wire ends together in making splices.

(4) *Parallel Jaws, Flat, and Round Nose Pliers* (figure 35). These pliers are used to bend or form metal into various shapes and to work in limited spaces. The nose is made in a variety of widths and lengths. The parallel jaws pliers are supplied with or without side cutters.

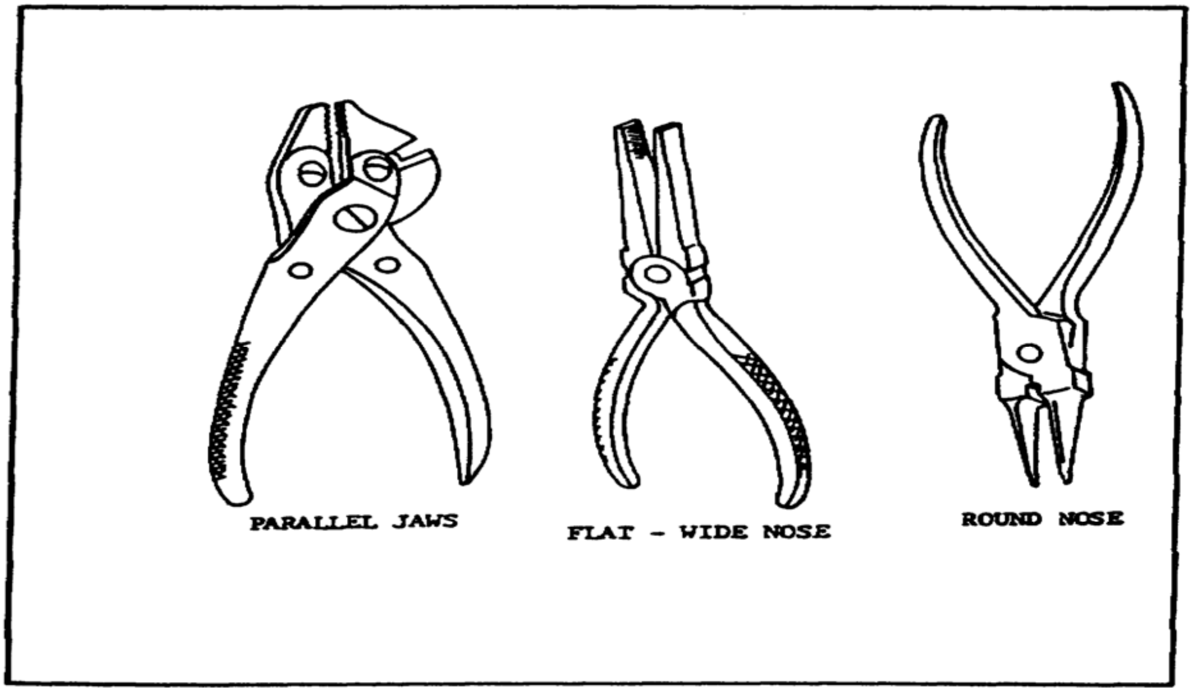


FIGURE 35. PARALLEL JAWS, FLAT, AND ROUND NOSE PLIERS.

(5) *Special Purpose Pliers* (figure 36). Some pliers are made for specific jobs, such as the brake spring pliers, glass holding and breaking pliers, ignition pliers, battery terminal pliers, and brake key and snap ring pliers.

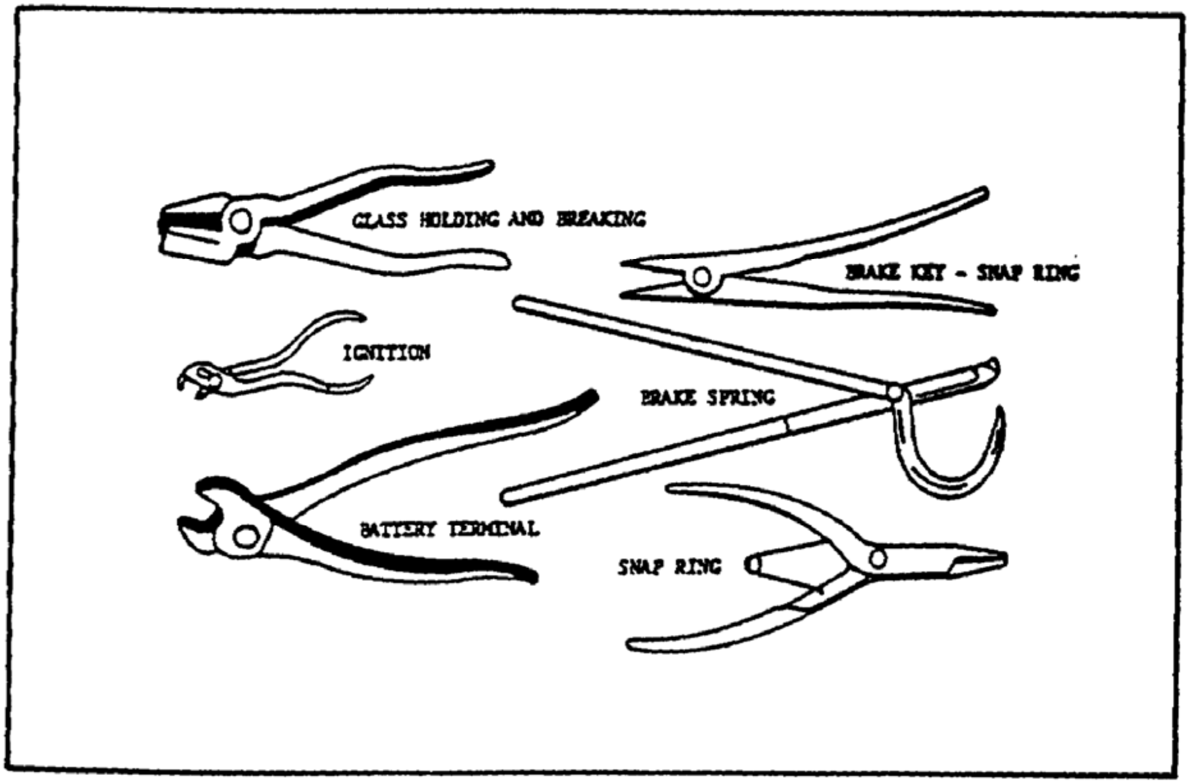


FIGURE 36. SPECIAL PURPOSE PLIERS.

(6) *Tongs* (figure 37). Tongs differ according to their use. The blacksmith's tongs are used for picking up and holding hot metal. The straight lip, flat jaw tongs are used to hold bearings and bearing inserts, while setting them in place.

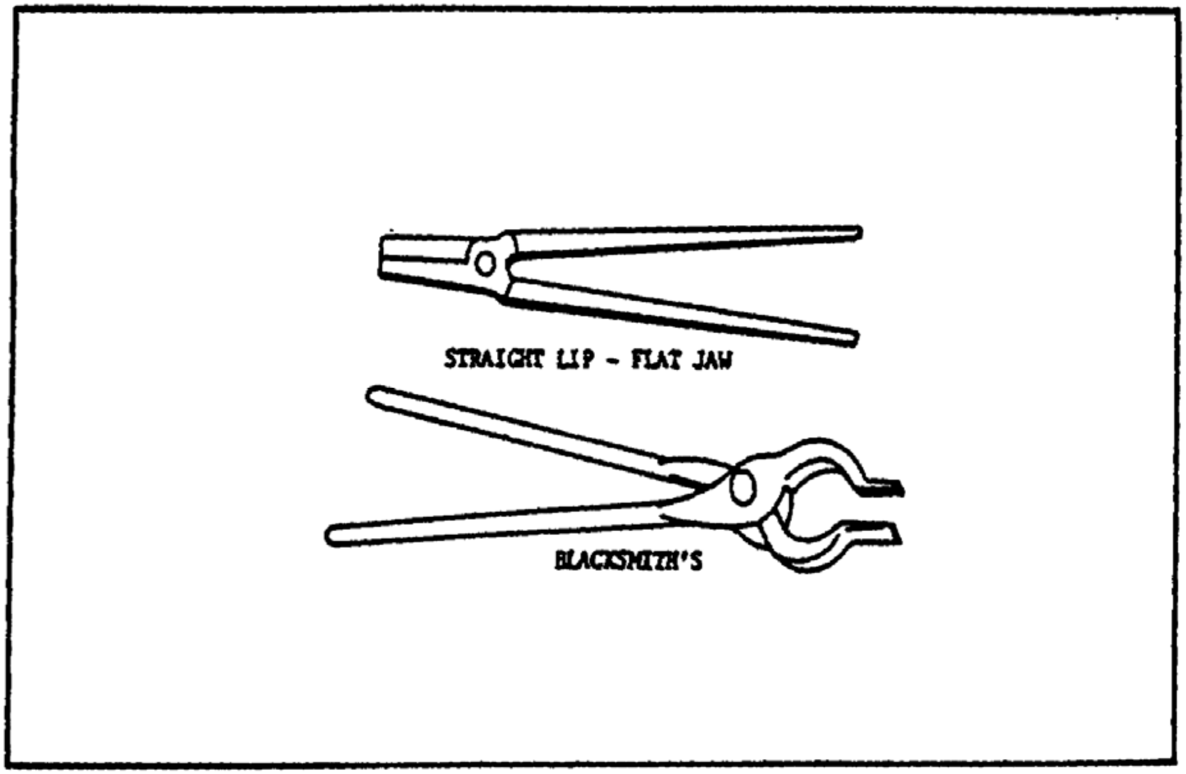


FIGURE 37. TONGS.

c. *Use of Pliers and Tongs.*

(1) *Pliers.* When using pliers, keep your fingers away from the jaws and cutting edges. Make sure the hinge or joint is tight before using pliers. Insulate handles of pliers when using them in electrical work with several thicknesses of friction tape, rubber tape, or specially manufactured rubber grips. When cutting large material within the capacity of diagonal cutting pliers (figure 34), cut with the throat of the jaws, not with the points. The tendency of misaligning the jaws will be greatly reduced. Once the jaws are misaligned (sprung), it will be impossible to cut fine wire. To preserve the life of slip joint combination pliers (figure 33), do not use them on very hard metal. Hard metal will wear off the teeth and the pliers will lose their grip. Use pliers only for the purpose for which they are intended. Do not try to increase the leverage of their handles by lengthening them with sections of pipe or other extensions.

(2) *Tongs.* Light tongs should not be used to handle heavy work, since the heavy material may cause a bending or springing of the jaws. Keep the jaws in line when handling work. When handling hot metal, hold the metal securely and keep the tongs away from your body. Make certain all joints are tight before use.

d. *Care of Pliers and Tongs.*

(1) *Maintenance.* When the serrations of plier jaws become damaged or worn, or when the cutting edges become dulled or nicked, they must be repaired. The jaw serrations must be either ground on a V-shaped wheel or filed with a V-shaped or triangular shaped file.

(a) *Grinding Serrations.* Separate the jaws of the pliers by removing the nut and screw, if so designed, and place one plier jaw in a grinding vise. Use a narrow grinding wheel that has an included angle of 60° (30° on each side of the centerline) (figure 38) and grind the serrations.

(b) *Filing Serrations.* Place the pliers in a vise protected with soft jaws and file the serrations with a triangular shaped file.

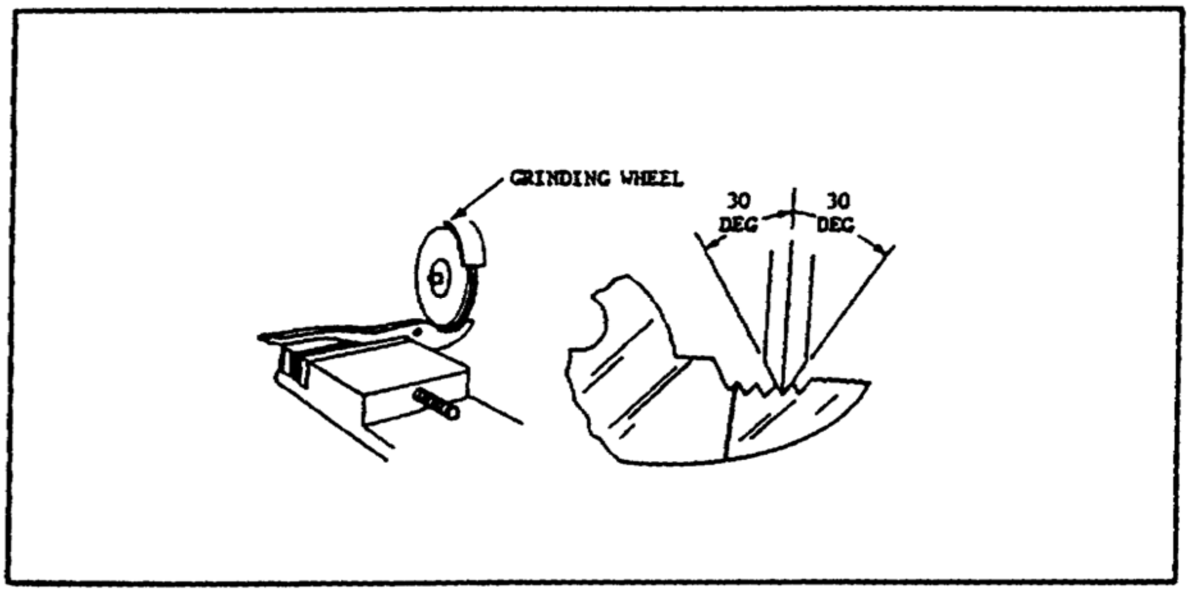


FIGURE 38. RECONDITIONING PLIER JAWS.

(c) *Sharpening Cutting Edges.* Some side cutting pliers are designed so they can be reground. Examine pliers carefully to see if the design will permit them to close completely if material is ground from the cutting edges. Do not attempt to sharpen pliers not designed to be ground, such as diagonal cutting pliers. Separate pliers, if possible, and place in a vise. Grind the cutting edges so that the ground bevel is at right angles with the inside machined bevel (figure 39). Grind the same amount of stock from both jaws, but no more than necessary to remove nicks. Use extreme care to retain the temper of the cutting edges, dipping the jaws in water frequently. After sharpening, reassemble pliers and make certain the cutting edges meet and that the hinge is secure.

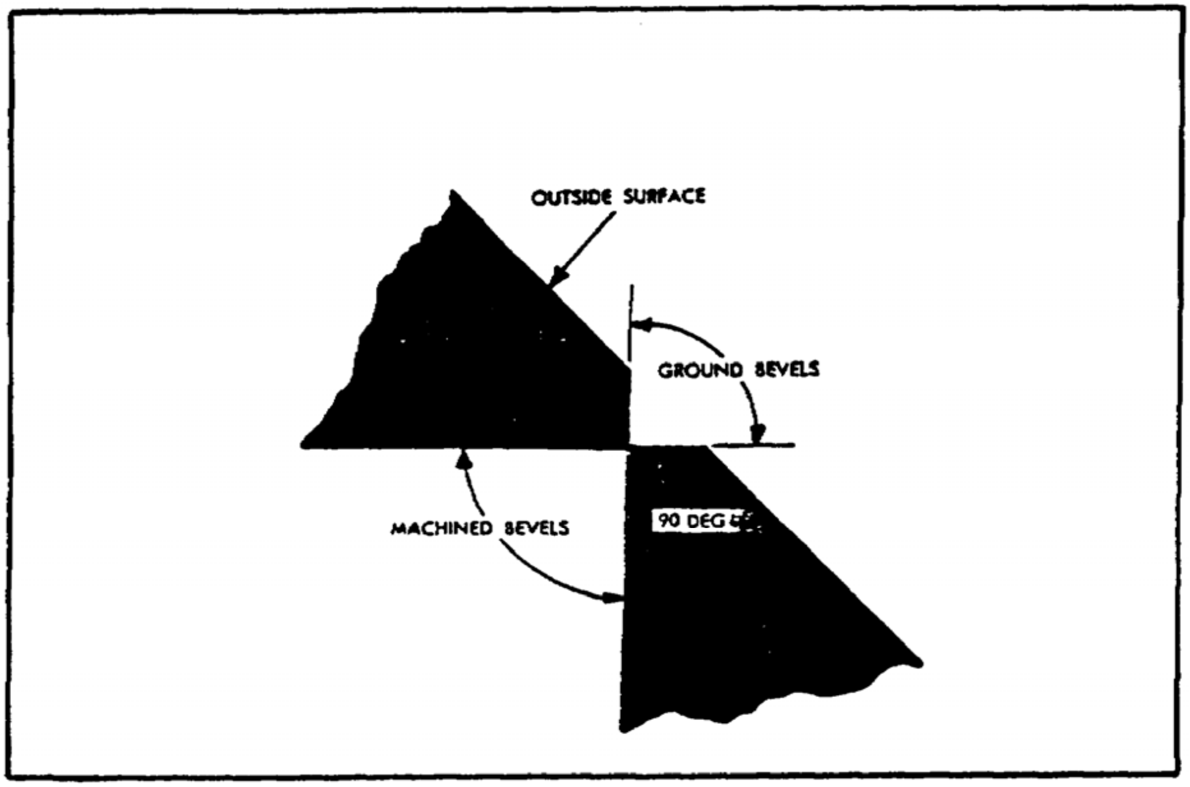


FIGURE 39. GRINDING ANGLE WHEN SHARPENING PLIER CUTTING EDGES.

(2) *Care.* Pliers and tongs should be kept free from dirt and grease; otherwise they may slip, damaging the work and causing injury. Apply a thin film of light oil and place carefully in a tool box when not in use. Make certain the cutting edges do not strike other metal or hard objects that would nick or dull them. Cover pliers and tongs with rust preventive compound and hang in a dry place if they are to be stored for long periods of time. Never use pliers to turn nuts or bolts, and do not use them for prying.

6. Clamping Devices

a. *Purpose.* Vises are used for holding work on the bench when it is being planed, sawed, drilled, shaped, sharpened, riveted, or when wood is being glued. Clamps are used for holding work that cannot be satisfactorily held in a vise because of its shape or size, or when a vise is not available. Clamps are generally used for light work.

b. *Types of Vises.*

(1) *Machinist's Bench Vise.* A machinist's bench vise (figure 40) is a large steel vise with rough jaws that prevent the work from slipping. Most of these vises have a swivel base with jaws that can be rotated, while others cannot be rotated. A similar light duty model is equipped with a cutoff. These vises are usually bolt-mounted onto a bench.

(2) *Bench and Pipe Vise.* The bench and pipe vise (figure 40) has integral pipe jaws for holding pipe from 3/4 inch to 3 inches in diameter. The maximum working main jaw opening is usually 5 inches, having a jaw width of 4 to 5 inches. The base can be swiveled to any position and locked. These vises are equipped with an anvil and are also bolted onto a workbench.

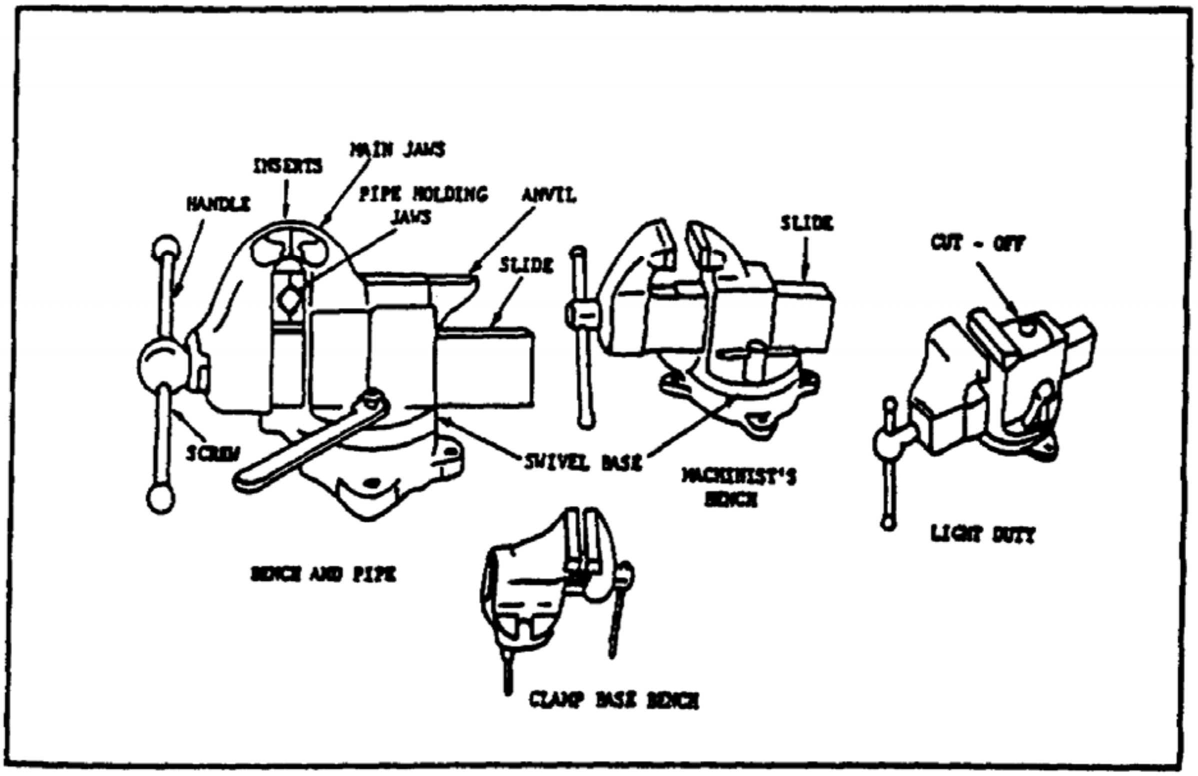


FIGURE 40. TYPE OF VISES.

(3) *Clamp Base Bench Vises.* The clamp base bench vise (figure 40) usually has a smaller holding capacity than the machinist's or bench and pipe vises and is clamped to the edge of a bench. Holding capacity is generally 1 1/2 to 3 inches. These vises normally do not have pipe holding jaws.

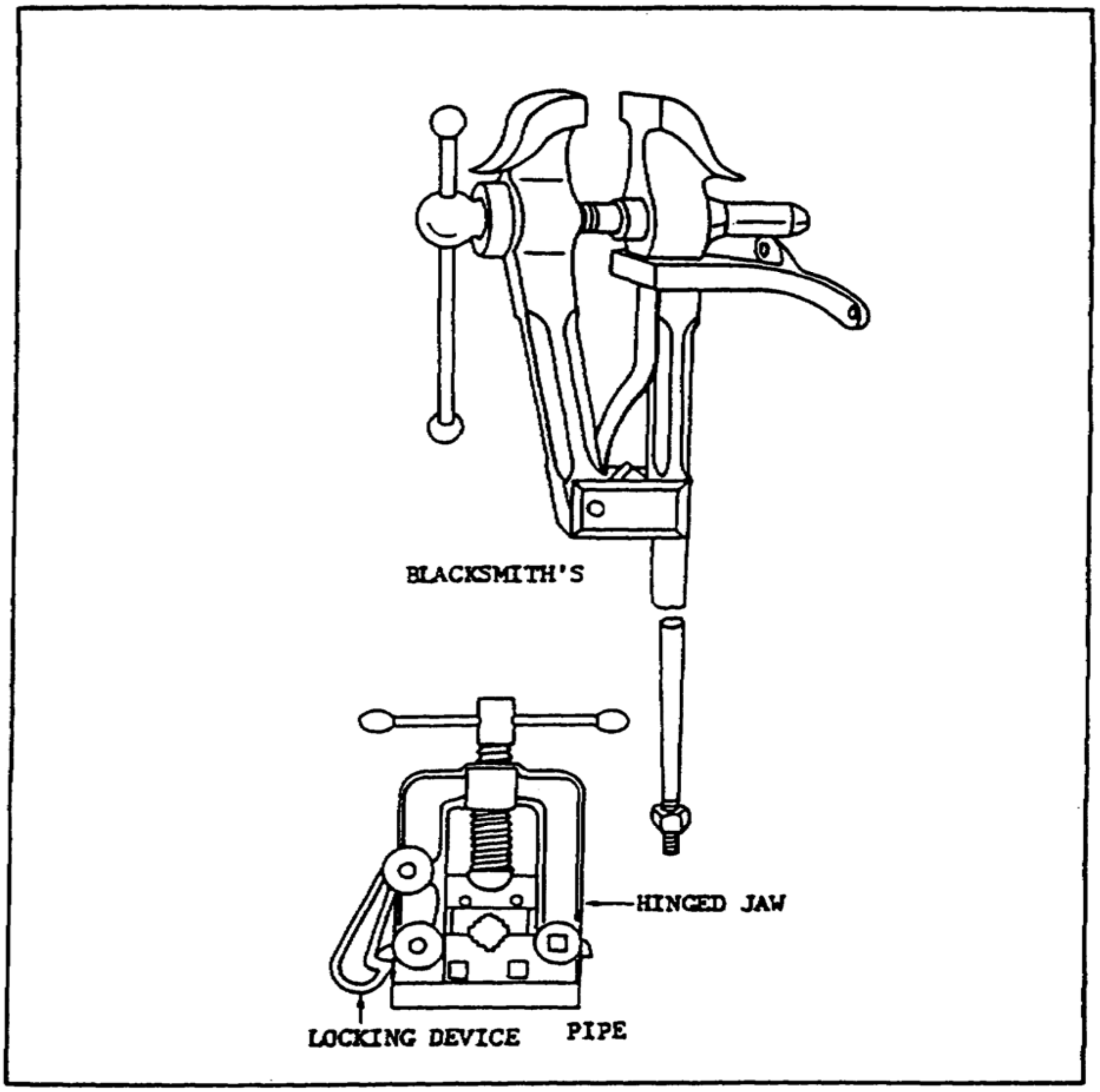


FIGURE 41. BLACKSMITH'S AND PIPE VISES.

(4) *Blacksmith's Vise.* The blacksmith's vise (figure 41) is used for holding work that must be pounded with a heavy hammer. It is fastened to a sturdy workbench or wall, and the long leg is secured into a solid base on the floor.

(5) *Pipe Vises.* A pipe vise (figure 41) is specifically designed to hold round stock. The vise shown has a capacity of 1 to 3 inches. One jaw is hinged so that the work can be positioned and the jaw then brought down and locked. This vise is also used on a bench. Some pipe vises are designed to use a section of chain to hold down the work. Chain pipe vises range in size from 1/8 to 2 1/2 inch up to 1/2 to 8 inch pipe capacity.

(6) *Machine Table Vise.* The machine table vise (figure 42) is constructed so that it may be secured on a machine table and hold work for subsequent machining operations. These vises either have a 3 1/2 inch jaw width and a 3 inch jaw opening, or a 6 inch jaw width with a 6 inch jaw opening.

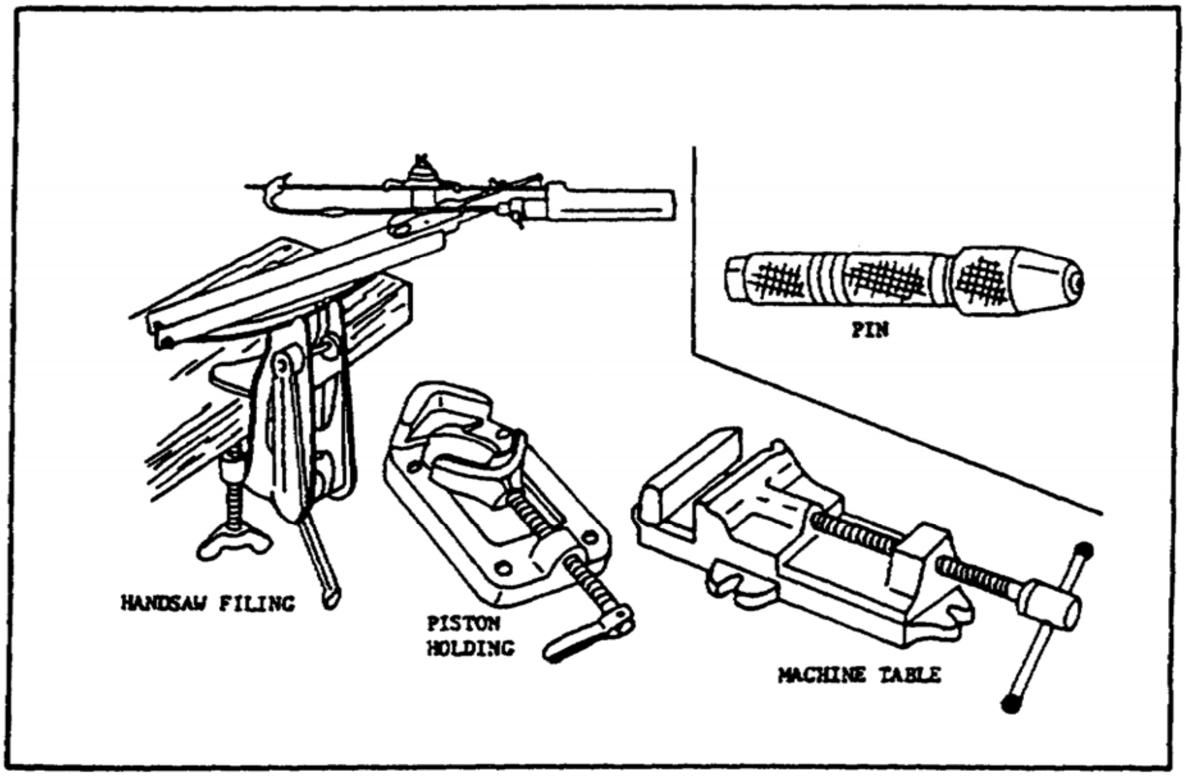


FIGURE 42. SPECIAL PURPOSE VISES.

(7) *Pin Vise.* A pin vise (figure 42) is held in the hand. Its overall length is usually about 4 inches. It has a chuck-type jaw capable of holding small stock from 0 to 0.187 inch in diameter.

(8) *Piston Holding Vise.* The piston holding vise (figure 42) is designed to hold engine pistons up to and including 5 1/2 inches in diameter. This vise can be bolted onto a bench or machine table.

(9) *Handsaw Filing Vise.* The handsaw filing vise (figure 42) is another specially designed vise. It has a 9 1/2 to 11 inch jaw width which holds handsaws in the correct position for sharpening their teeth, and an attachment for holding the file at a definite constant angle.

c. *Types of Clamps.*

(1) *C-Clamps.* A C-clamp (figure 43) is shaped like the letter C. It consists of a steel frame threaded to receive an operating screw with a swivel head. They are made for light, medium, and heavy service in a variety of sizes.

(2) *Hand Screw Clamps.* A hand screw clamp (figure 43) consists of two hard maple jaws connected with two operating screws. Each jaw has two metal inserts into which the screws are threaded. These clamps are also issued in a variety of sizes.

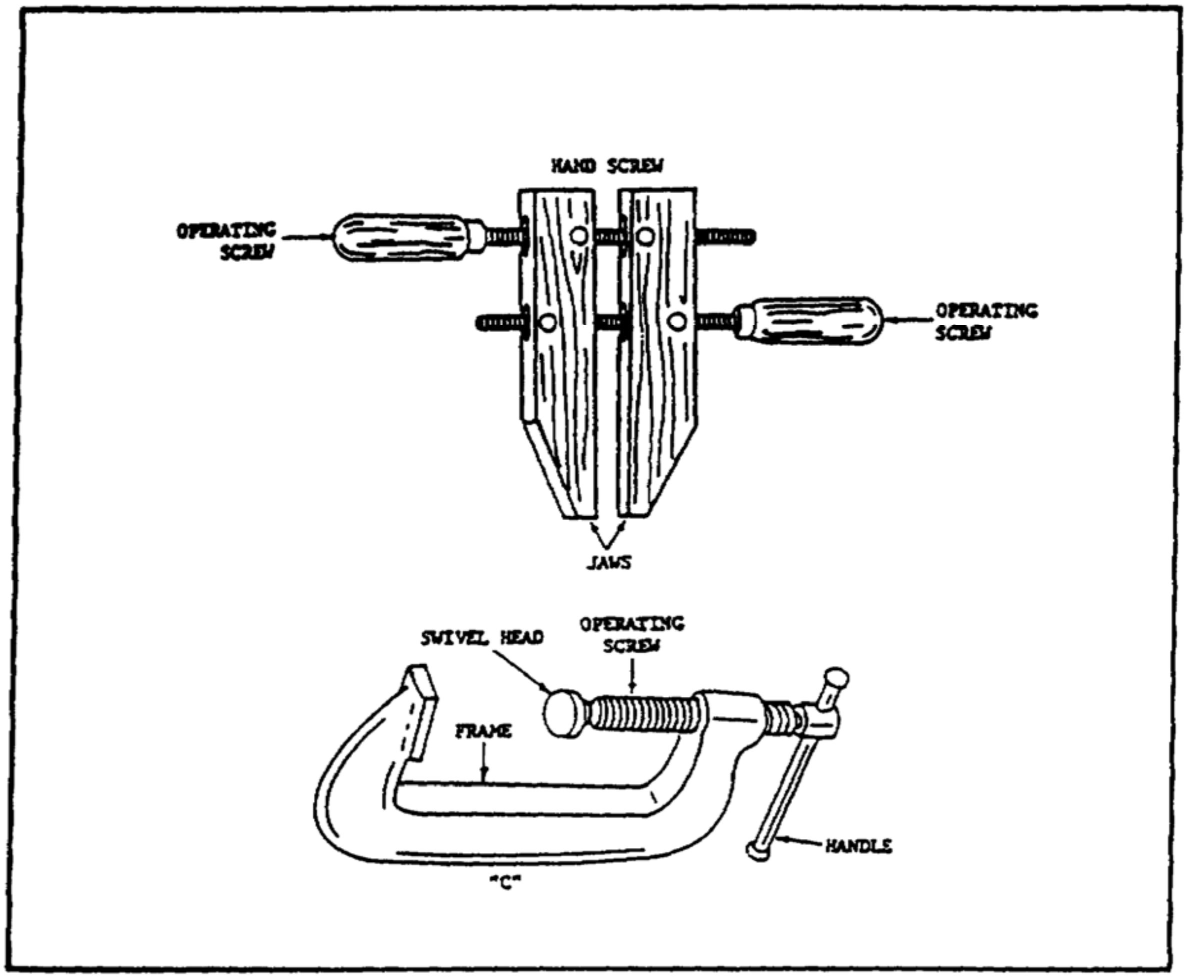


FIGURE 43. TYPES OF CLAMPS.

d. *Use of Vises.*

(1) When holding soft metal in a vise, material softer than the workpiece must be used in the jaws to prevent damage to the work. The work should be held securely to prevent it from slipping, but not so tightly as to cause damage.

(2) When holding hard material, turn the screw of the vise up tight and tap the end of the handle sharply for the final tightening.

(3) To hold irregularly shaped work in a vise requires a little thought. Make certain the jaws grip on a firm even surface of the work. The swivel jaw type of vise (not illustrated) is especially suited to hold tapered or irregular work, since one jaw can be swiveled. A tapered pin must be removed before the jaw can be swiveled.

(4) Cylindrical work can be held between straight jaws; however, it is better to insert V-cut jaws over the straight jaws for this work.

(5) Finished work should be held between jaws of soft metal, such as copper, brass, lead, or plastic. A piece of rawhide or soft leather laid over the vise jaws will prevent damage to highly polished surfaces.

e. *Use of Clamps.*

(1) When using the hand screw clamp, keep the jaws parallel to apply even pressure along the work and to properly hold the pieces of work together (figure 44).

(2) When soft material can be damaged by the jaws, soft material should be placed over the face of each jaw.

(3) Use rawhide or soft leather to protect highly polished surfaces.

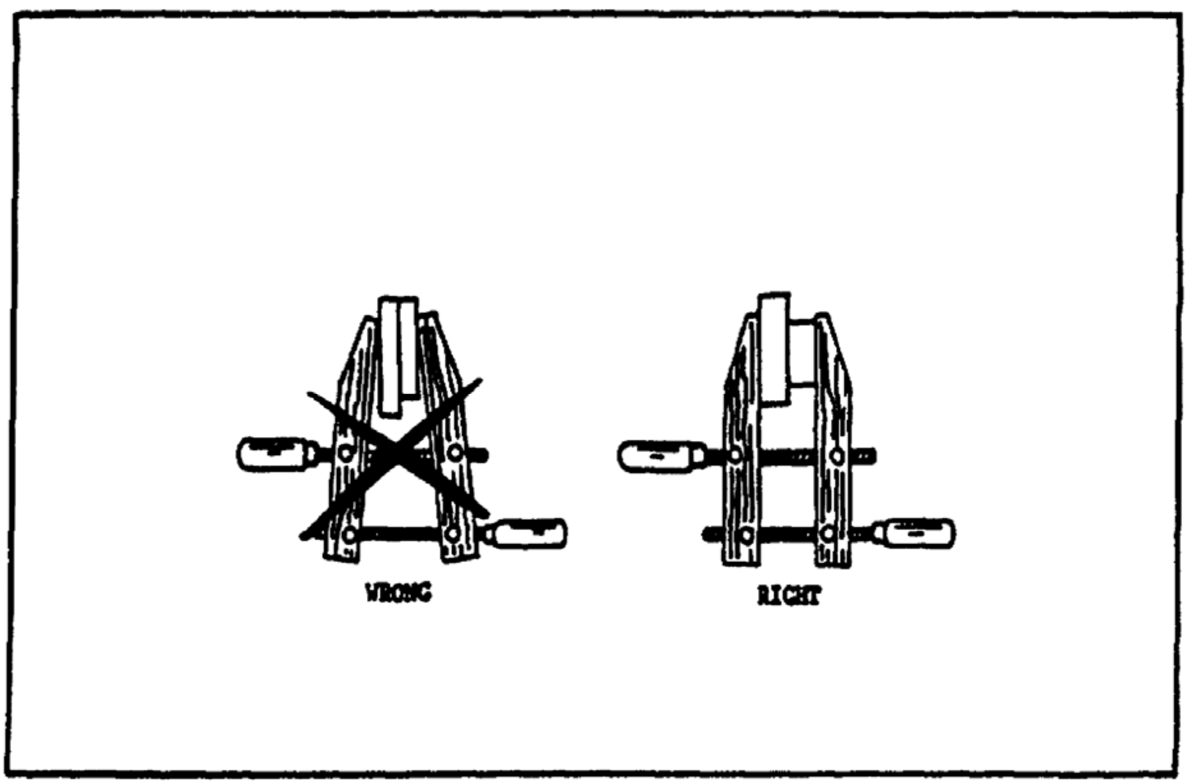


FIGURE 44. USING HAND SCREW CLAMPS - JAWS PARALLEL.

(4) Never use the hand screw clamp on material other than wood. Other materials may damage the wooden jaws.

(5) A C-clamp may be used on any kind of material. When holding glass or work with a high polish or paint finish, provide protection by using brass shims or wooden blocks on each side of the work.

(6) Clamps should be screwed up tight, but not so tight that the pressure will spring the clamp.

(7) Use hand pressure to tighten clamps; never use wrenches or bars (figure 45).

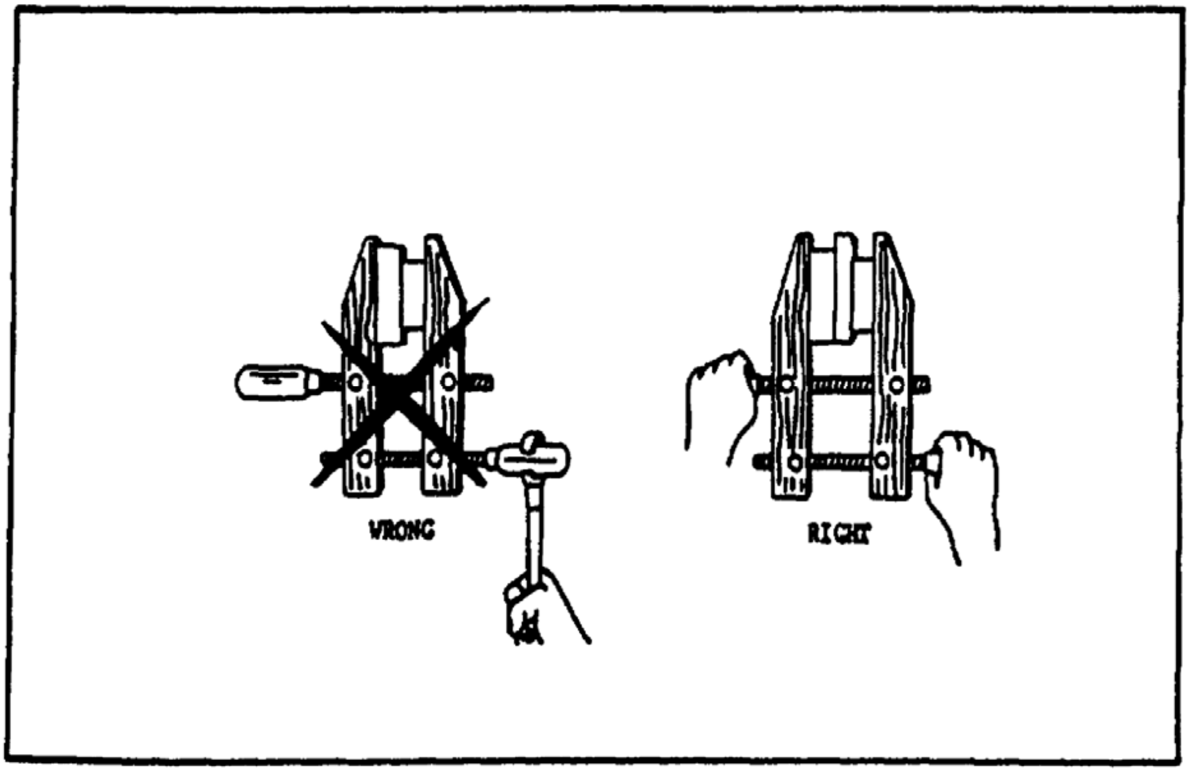


FIGURE 45. USING HAND SCREW CLAMPS - HAND TIGHTENED.

(8) Always use the right size clamp and observe clamps for signs of undue strain when using them.

f. *Care of Vises and Clamps.*

(1) *Vises.* Keep vises clean at all times. They should be cleaned and wiped with light oil after using. Never strike a vise with a heavy object and never hold large work in a small vise, since this practice will cause the jaws to become sprung or will otherwise damage the vise. Keep the jaws in good condition and oil the screws and the slide frequently. Never oil the swivel base or swivel jaw joint; its holding power will be impaired. When

the vise is not in use, bring the jaws lightly together, or leave a very small gap and leave the handle in a vertical position.

(2) *Clamps.*

(a) *C-Clamps.* Keep the threads of C-clamps clean and free from rust by oiling properly. The swivel head must kept clean, smooth, and grit free. If the swivel head becomes damaged, replace it as follows: Pry open the crimped portion of the head and remove the head from the ball end of the screw (figure 46). Replace with a new head and crimp securely on the ball. Oil screw threads regularly. For short storage, oil clamps with a light coat of engine oil and wipe them off before they are hung on racks or pins, or carefully placed in a tool box. For long storage, apply a rust preventive compound to the C-clamp.

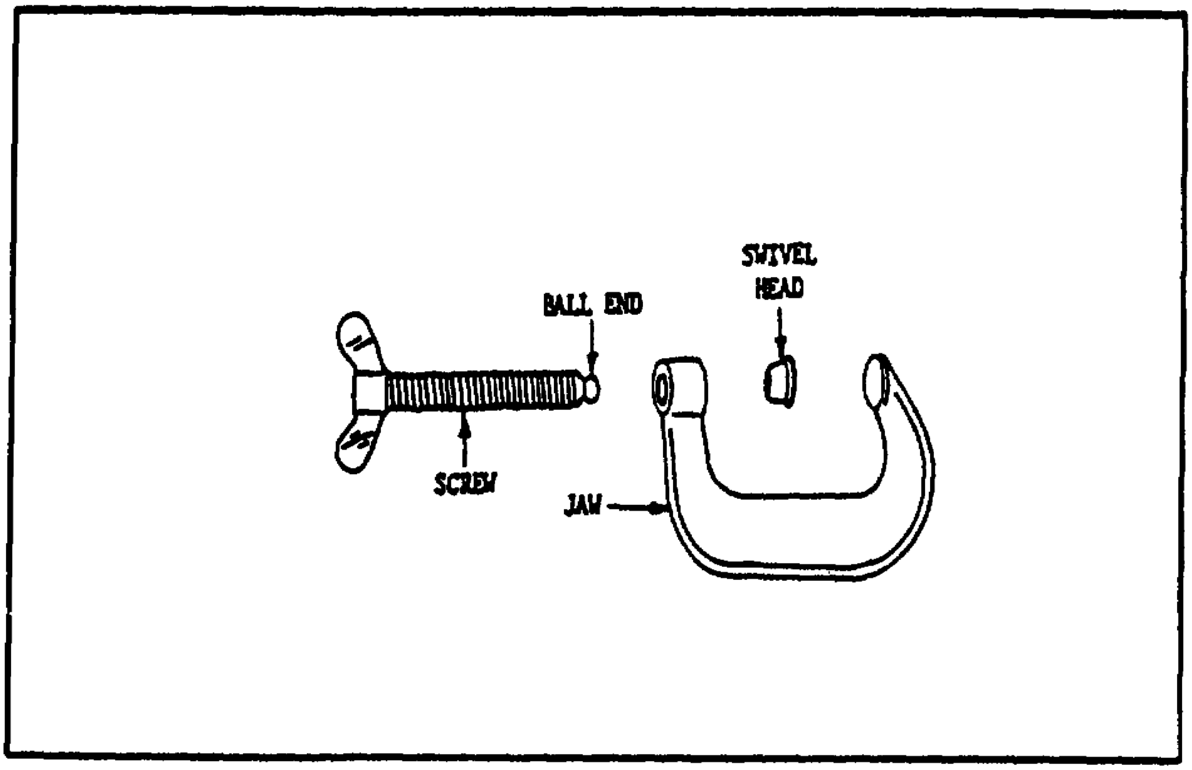


FIGURE 46. C-CLAMP, EXPLODED VIEW.

(b) *Hand Screw Clamp.* The screws of these clamps may break or become damaged, the inserts may become worn, or the wooden jaws may split or warp. When necessary to replace any of these parts, disassemble the clamp (figure 47). Remove handles from screws by filing off peened ends of attaching pins and drive out the pins. Turn both screws from the inserts and remove the inserts from the jaws. Replace damaged screws, inserts, and handles. Install inserts in jaws and turn the screws into position in the two jaws. Turn the new screw into the handle or the old screw into the new handle, depending on which part is being replaced. Align holes and tap in a new pin. Peen end of the pin to secure screw in the handle. Keep screws lubricated with a few drops of light oil. Apply a light coat of linseed oil to wood surfaces to prevent them from drying out. If the finish of wooden jaws is worn and bare wood is exposed, coat jaws with varnish. Hang clamps on racks or pins, or carefully place them in a tool box, to prevent damage when not in use. Wipe clean before storing.

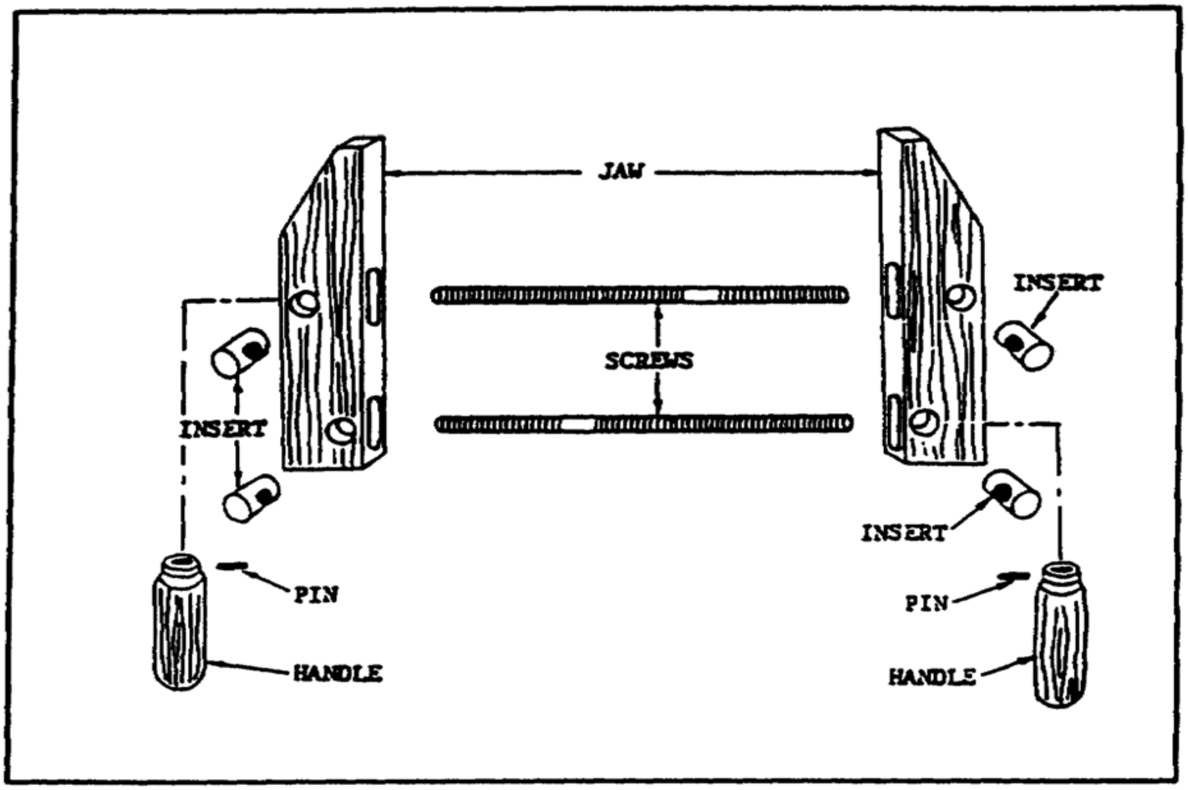


FIGURE 47. HAND SCREW CLAMP, EXPLODED VIEW.

g. *Safety Precautions.*

(1) When closing the jaw of a vise or clamp, avoid getting any portion of your hands or body between the jaws, or between one jaw and the work.

(2) Use care to keep from being pinched between the end of the handle and the screw.

(3) When holding heavy work in a vise, place a block of wood under the work as a prop to prevent it from sliding down and falling on your foot.

(4) Do not open the jaws of a vise beyond their capacity, as the movable jaw will drop off, possibly causing personal injury and/or damage to the jaw.

7. Jacks

a. *Purpose.* Jacks are used to raise or lower work and heavy loads short distances. Some jacks are used for pushing and pulling operations, or for spreading and clamping.

b. *Types of Jacks.* Jacks are available in capacities from 1 1/2 to 100 tons. Small capacity jacks are operated through a rack bar or screw, those of large capacity are usually operated hydraulically.

(1) *Screw Jacks.* The vertical screw jack (figure 48) is operated by hand through a collapsible handle which is inserted in a socket. The screw moves up or down, depending on the direction of rotation in which the handle is turned. Some screw jacks are equipped with a ratchet for automatic lowering. Mechanical screw jacks are issued in several capacities having different contracted and extended heights. Another type of screw jack is called an outrigger jack. It is equipped with end fittings which permit pulling parts together or pushing them apart and has a capacity of 10 tons.

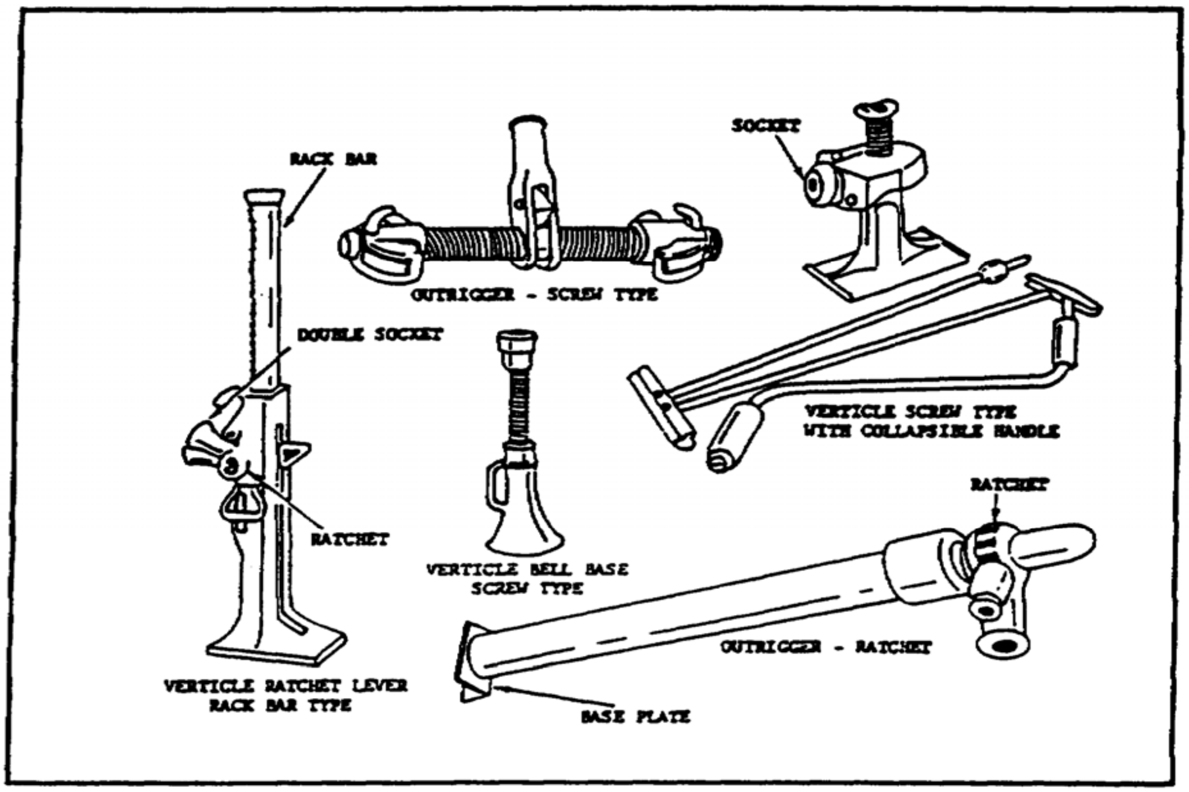


FIGURE 48. MECHANICAL JACKS.

(2) *Ratchet Lever Jacks.* A vertical ratchet lever jack (figure 48) has a rack bar that is raised or lowered through a ratchet lever. Some of these jacks are equipped with a double socket; one for lowering, one for raising. Others have one socket as well as an automatic lowering feature. An outrigger ratchet jack is ratchet-operated and has an extra reverse ratchet handle and a base plate.

(3) *Vertical Hydraulic Jacks.* A hydraulic jack (figure 49) operates through pressure applied to one side of a hydraulic cylinder which moves the jack head. These jacks are automatically lowered or released by releasing the pressure. Vertical hydraulic jacks are issued in a variety of types, in capacities from 3 to 100 tons, having different extended heights.

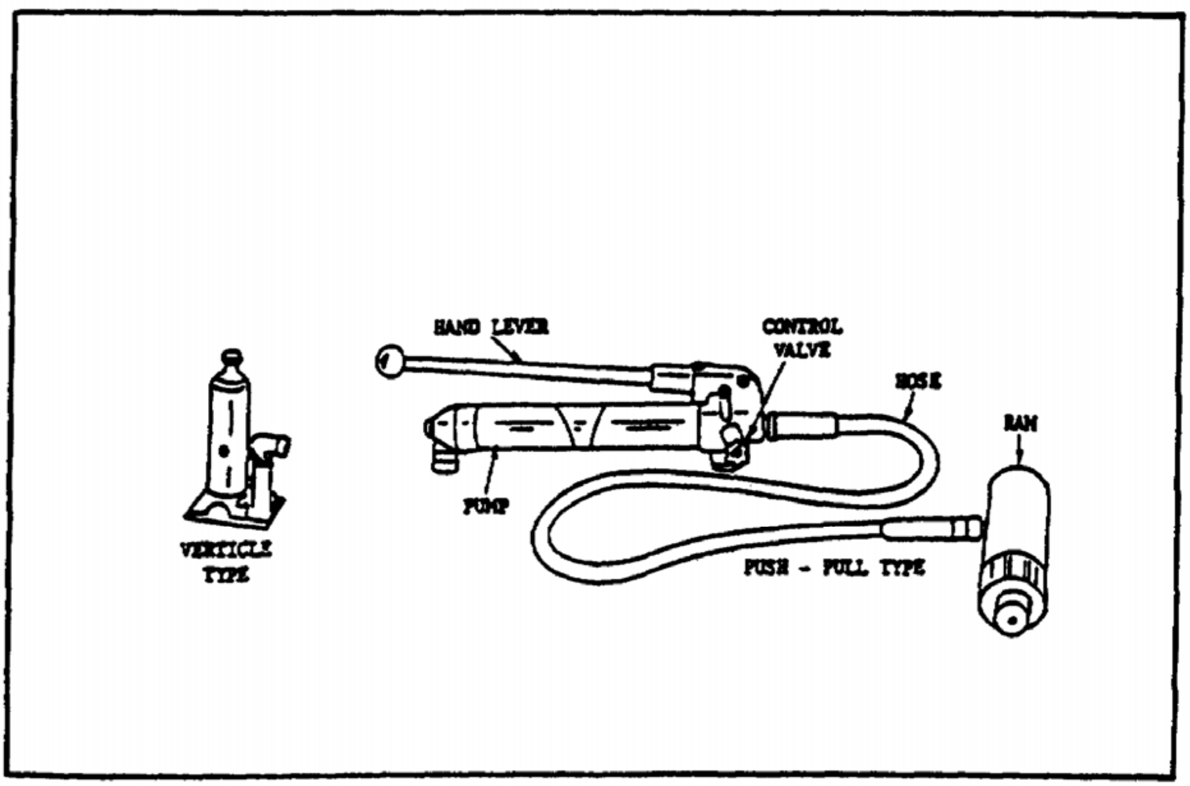


FIGURE 49. HYDRAULIC JACKS.

(4) *Push-Pull Hydraulic Jacks.* A push-pull hydraulic jack (figure 49) consists of a pump and ram connected by a hydraulic or oil hose. These jacks are rated at 3, 7, 20, 30, and 100 ton capacities and have diversified applications.

c. *Using Jacks.*

(1) *Lifting Vehicles.* Vertical jacks are used to lift one side or the end of a vehicle to permit removal of the wheel or tires, or to effect repairs that would not be possible with the vehicle standing on its wheels. The jack can be used on each side alternately by jacking up one side of the vehicle, blocking it, and moving the jack to the other side, continuing this operation until the vehicle has been raised to the desired height.

(2) *Miscellaneous Lifting.* The jack can also be used to raise heavy crates, small buildings, or other items too heavy to be raised by prying with wrecking bars. It is essential that the jack be placed on solid ground or on a plank to spread the weight so that it will not give way or tip when being used.

(3) *Push-Pull Hydraulic Jacks.* The push-pull hydraulic jacks are furnished with an assortment of attachments enabling performance of a variety of pushing, pulling, lifting, pressing, bending, spreading, and clamping operations. The pump is hand operated. Turn the control valve (figure 49) on the side of the pump clockwise, stroke the hand lever up and down and the ram will extend. The 6 foot flexible hydraulic or oil hose allows the ram to operate in any desired position and from a safe distance. The ram retracts automatically by turning the control valve counterclockwise. The attachments can be threaded to the end of the plunger, to the ram body, or into the ram base. Figures 50 through 53 illustrate some standard combinations of the push-pull hydraulic jack attachments for various operations, including a specially designed spread ram.

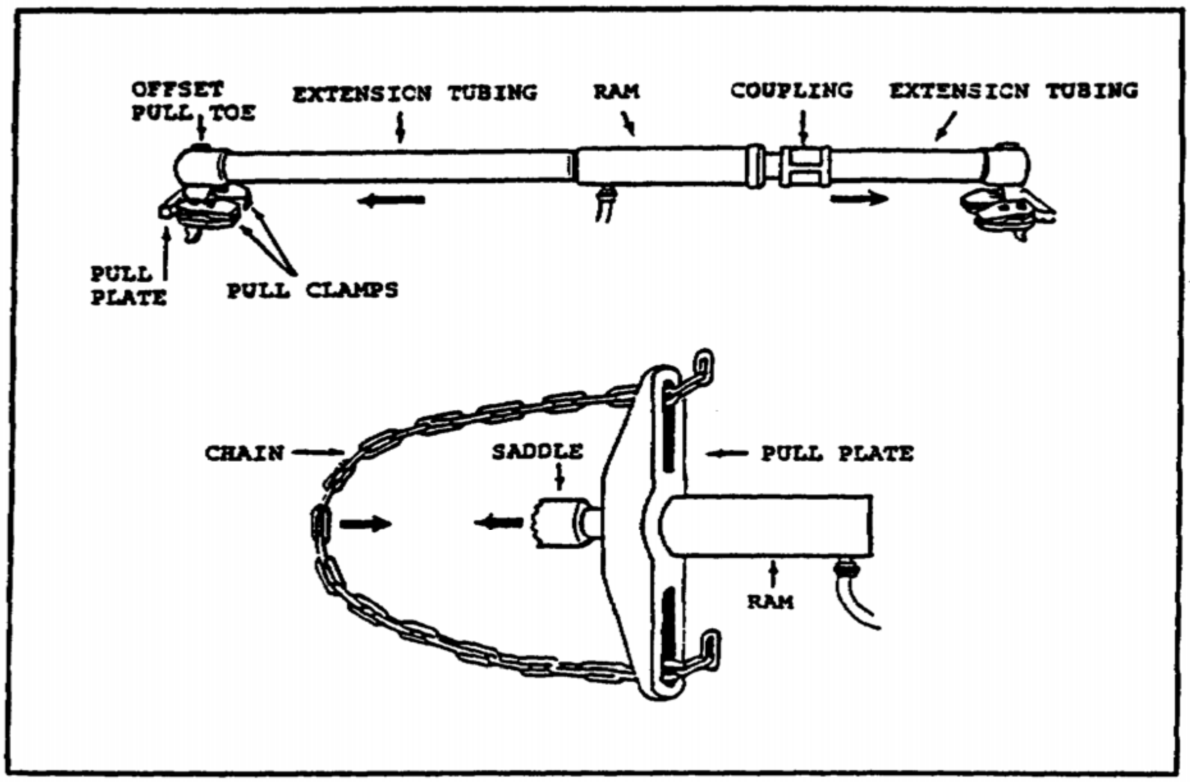


FIGURE 50. JACK PULLING COMBINATIONS.

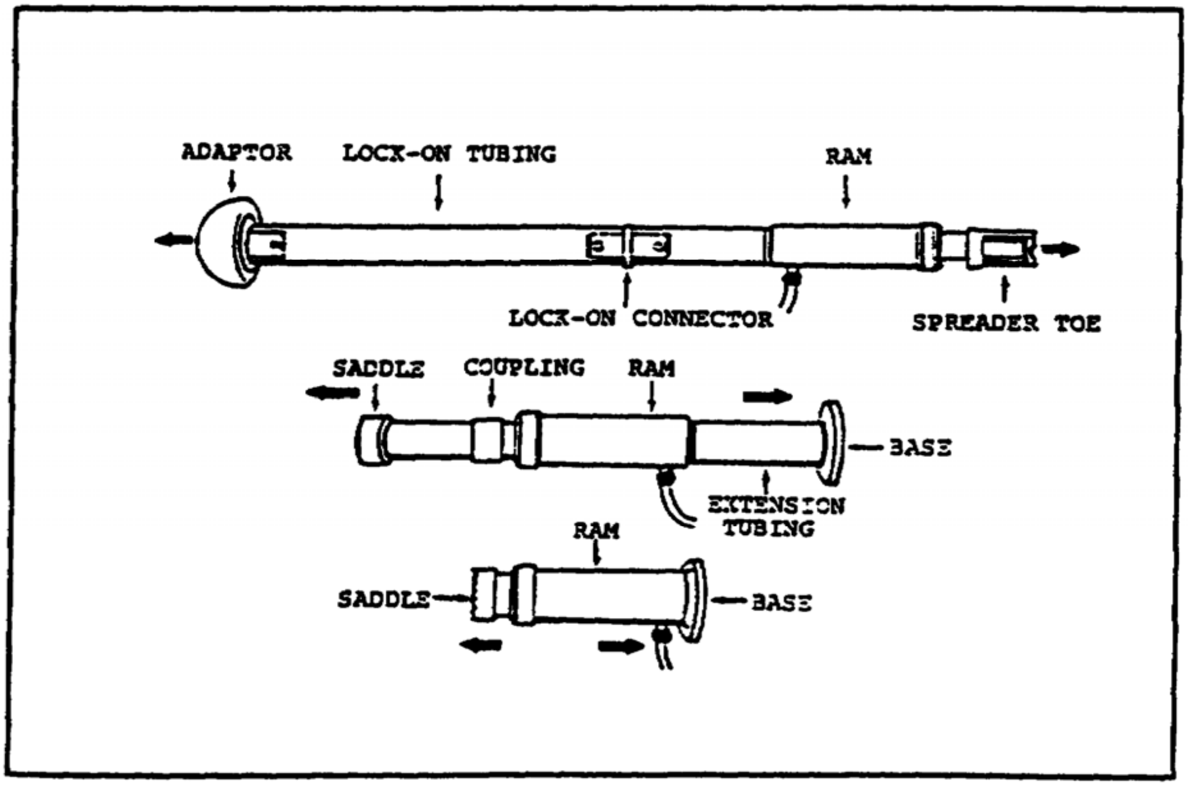


FIGURE 51. JACK PUSHING COMBINATIONS.

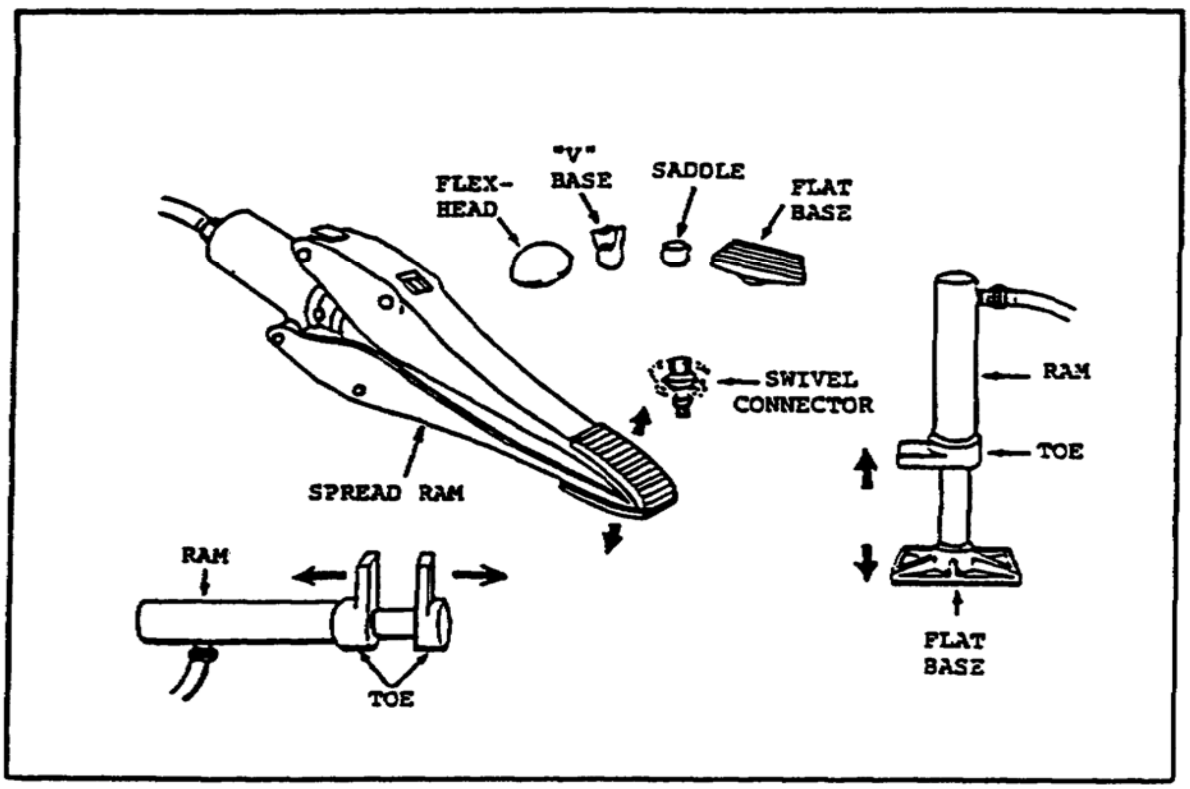


FIGURE 52. JACK SPREADING COMBINATIONS.

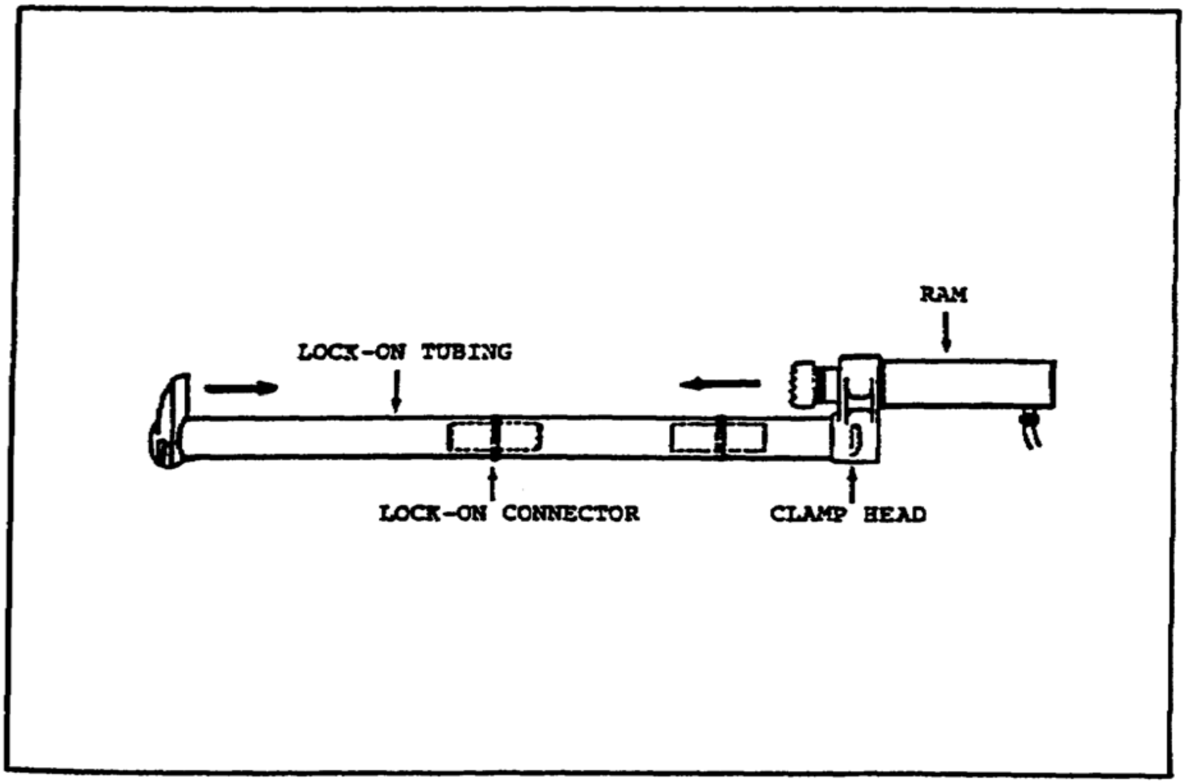


FIGURE 53. JACK CLAMPING COMBINATIONS.

d. *Care of Jacks.* Coat all surfaces with a thin film of light oil when not in use. For a long period of storage the jacks should be covered with a rust preventive compound and stored in a dry place. Periodically, check hydraulic pump fluid level in push-pull hydraulic jacks. They are equipped with a fill plug and it is necessary to stand the pump on end before filling. Make certain the ram is in the retracted position when checking the level of oil and when filling.

e. *Precautions.* Keep fingers away from all moving parts. When jacking up vehicles make certain no one is under the vehicle to be raised. Place blocking or other supports under the vehicle when it is raised to the desired height to prevent it from dropping if the jack fails. Make certain hydraulic jacks are filled with oil and that there are no visible oil leaks before using.

8. Bars and Mattock

a. *Purpose.* Bars are heavy steel tools used to lift and move heavy objects and to pry where leverage is needed. They are also used to remove nails and spikes during wrecking operations. The mattock is used for digging in hard ground, cutting roots underground, and to loosen clay formations in which there is little or no rock. The mattock may also be used for light prying when no bars are available.

b. *Types of Bars and Mattock.*

(1) *Crowbar.* The crowbar (figure 54) is made of high grade steel, has a slightly bent wedge point at one end, and tapers a little throughout its length. The wedge end is used for prying or for moving heavy timbers and other objects. The blunt end is used for loosening rock formations. Crowbars are available in 4 and 5 foot lengths, with diameters of 1 or 1 1/4 inches.

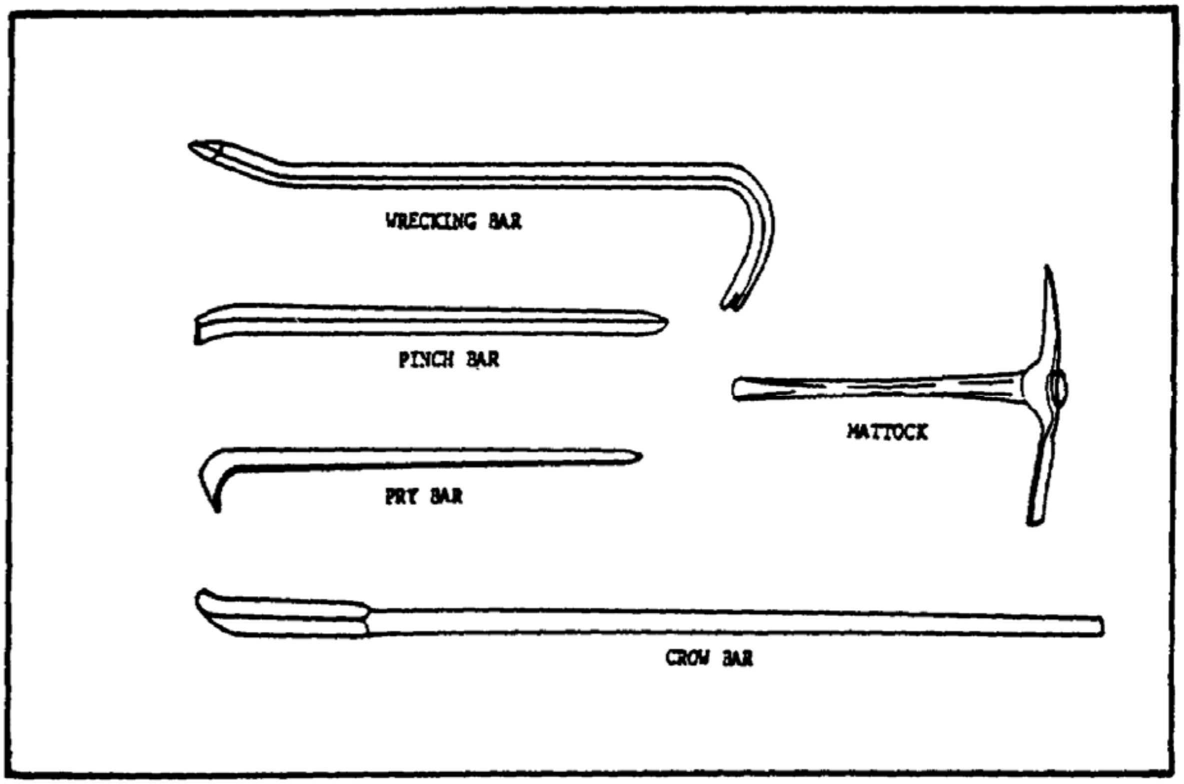


FIGURE 54. BARS AND MATTOCK

(2) *Pinch Bar.* The pinch bar (figure 54) has one end bent slightly to a chisel or pinch point and has a tapered point at the other end. Another type has a pinch point at one end and a claw at the other. Pinch bars range in size from 1/2 to 1 inch in diameter and from 12 to 36 inches long. The pinch bar is used in general as the crowbar is used, except for lighter work; in addition, it is used to pull spikes and nails, and for light prying.

(3) *Pry Bar.* The pry bar (figure 54) is 16 inches long and has one end tapered to a point. The opposite end is offset 90 degrees to the bar. It is a combination aligning and prying bar. The tapered point can be used for lining up work, and the offset end can be used for prying out gears, bushings, etc., since the offset point provides a great amount of leverage.

(4) *Wrecking Bar.* The wrecking bar (figure 54) has a gooseneck claw at one end and a pinch point at the other end. Other types may have two gooseneck ends, one with a

claw and one with a straight point. Another variation is one gooseneck end with a claw and the other end offset, with a wedge shape. Wrecking bars range in size from 12 to 60 inches long and 1/2 to 1 1/8 inches in diameter. They are used in the same manner as the crowbar and the pinch bar.

(5) *Mattock.* The head of the mattock (figure 54) has two ends. One end is rectangular in cross section and tapers to a point like a pick. The other end has a finely tempered 4 inch wide blade that has a double bevel. The mattock head weighs 5 pounds and is supplied with a wood handle.

c. *Use of Bars and Mattock.*

(1) *Bars.* To use a crowbar, operate it as a simple lever (figure 55). It is mostly used in a position where the weight of the body is exerted downward on the narrow end of the bar. The pinch and wrecking bars are used in the same manner for prying and wrecking. The claw is used as you would a carpenter's claw hammer to remove nails and spikes. When prying, be careful that the bar does not slip and cause personal injury. Wrecking bars are exceptionally heavy and care must be taken to keep them from falling and striking someone. Do not use bars for extra heavy work, since they will bend.

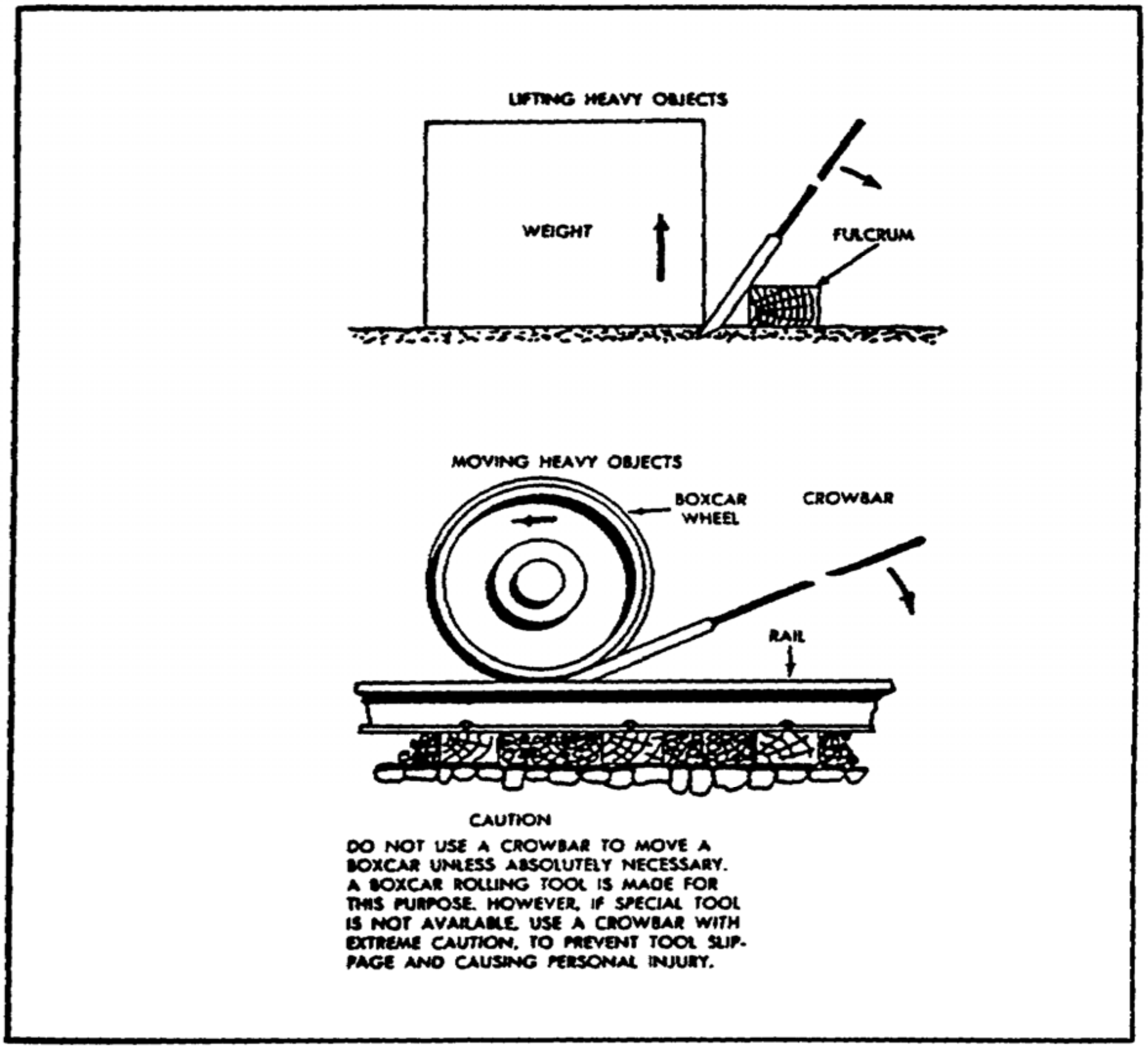


FIGURE 55. USING A CROWBAR.

(2) *Mattock.*

(a) When using the mattock, it is important to have a firm footing and correct posture to prevent the mattock from glancing and striking the feet or legs if the mark is missed. Distribute body weight equally on both legs; the knees should be set but not tense, and feet should be spread apart at a comfortable distance. Body should be relaxed and free to swing and bend from the hips. Practice using the mattock either with the right-hand or the left-hand leading in order to prevent tiring quickly. With the right-hand leading, the left foot should be brought slightly toward the work. To start the swing, hold the handle at the end with the left-hand and near the center with the right-hand. Raise the mattock over the right shoulder. Swing the mattock down toward the work allowing the right-hand to slide back along the handle toward the left-hand so that, at the finish of the swing, the hands are close together.

(b) With the left-hand in the center of the handle, the mattock is swung in the same manner, except that the positions are reversed.

(c) Light swings are accomplished with wrist motion only, allowing the head of the mattock to do the work. Use the wrists, forearms, and shoulders for heavy swings.

(d) Slight prying may be done with the mattock; however, this must be done cautiously to prevent breaking the wood handle.

CAUTION

Do not swing a mattock until you are sure that no one will be endangered by the swing, by a possible loose head, or by a possible glancing of the tool.

d. *Care of Bars and Mattocks.*

(1) *Bars.*

(a) *Storage.* Bars are sturdy tools which require little maintenance, but they should be thoroughly cleaned after use and covered with a light film of oil before placing them on a rack. For long term storage, they should be covered with a rust preventive compound and stored in a dry place.

(b) *Shaping.* When misused or used extensively, bars may lose the shape of their ends and must be reshaped. Normally, the chisel end or pinch point can be filed and kept sharp so that it can properly engage the nails or spikes that are to be pulled.

(2) *Mattock.*

(a) *Storage.* Store the mattock so that the head will not be struck against metal or other hard surfaces. The mattock should be placed against a wall on its head, or hung on a rack. For long term storage, coat the head with a rust preventive compound and store in a dry place in a rack or box with the cutting edges protected. Thoroughly clean the mattock after use and before short or long term storage.

(b) *Sharpening.* The point of the mattock can be sharpened with a file or on a grindstone. If the point becomes too dull to be sharpened with a file or grindstone, it should be heated in a charcoal fire and hammered to shape on an anvil, after which it must be tempered. If properly forged, the point should not require grinding. The head must be removed from its handle before tempering and before the blade can be sharpened on a grindstone or abrasive wheel. Hold the head of the mattock and tap the opposite end of the handle on a solid surface to loosen the head. Slide the head from the top of the handle. Remove nicks from the blade by moving it back and forth across a grindstone. Make sure the edge is square across the head. Grind the double bevel on the mattock blade by adjusting the rest on the grinder; hold the blade against the rest and move the blade down onto the abrasive wheel; do one bevel at a time and grind to the original bevel. Dip the head in cold water frequently to prevent burning or loss of temper. After sharpening, slide the head over the bottom end of the handle and into approximate position at the top of the handle. Tap the head end of the handle on a solid surface to tighten the head on the handle.

9. Soldering Irons

a. *Purpose.* Soldering is joining two pieces of metal by adhesion. The soldering iron is the source of heat for melting solder and heating the parts to be joined to the proper temperature.

b. *Types of Soldering Irons.* There are two general types of soldering irons, electric heated and nonelectric heated. The essential parts of both types are the tip and the handle. The tip is made of copper.

(1) *Electric Soldering Iron.* The electric soldering iron (figure 56) transmits heat to the copper tip after the heat is produced by electric current flowing through a self-contained coil of resistance wire, called the heating element. Electric soldering irons are rated according to the number of watts they consume when operated at the voltage stamped on the iron. There are two types of tips on electric irons: plug tips, which slip into the heater head and are held in place by a setscrew, and screw tips which are threaded, and which screw into the heater head. Some tips are offset and have a 90 degree angle for soldering joints that are difficult to reach (not illustrated).

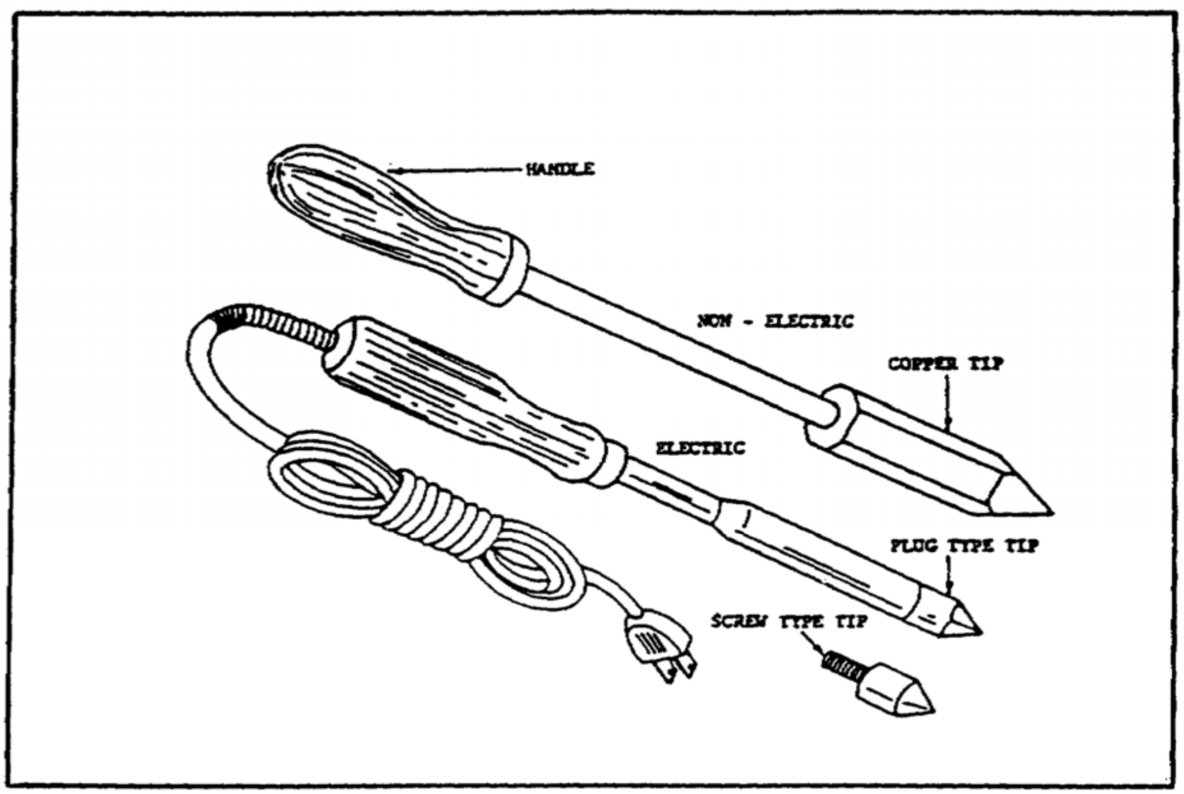


FIGURE 56. SOLDERING IRONS.

(2) *Nonelectric Soldering Iron.* A nonelectric soldering iron (figure 56) is sized according to its weight. The commonly used sizes are the 1/4, 1/2, 3/4, 1, 1 1/2, 2, and 2 1/2 pound irons. The 3, 4, and 5 pound sizes are not used in ordinary work. Nonelectric irons have permanent tips and must be heated over an ordinary flame, or with a blowtorch.

c. *Use of Soldering Iron.*

(1) *Tinning.* Before any soldering iron can be used, the faces of the tip must be filed smooth and tinned (coated with solder). For ordinary work, a soldering iron is tinned on all four faces. For work where the iron is held under the object to be soldered, as when soldering wire splices, only one face is tinned (figure 57). Molten solder on a tip with all faces tinned will not remain on the upper face, but will run to the bottom, forming a drop. When only one face is tinned (that face turned up), solder melted upon it will not drip off. Tin an electric soldering iron as indicated in (a) through (d) below.

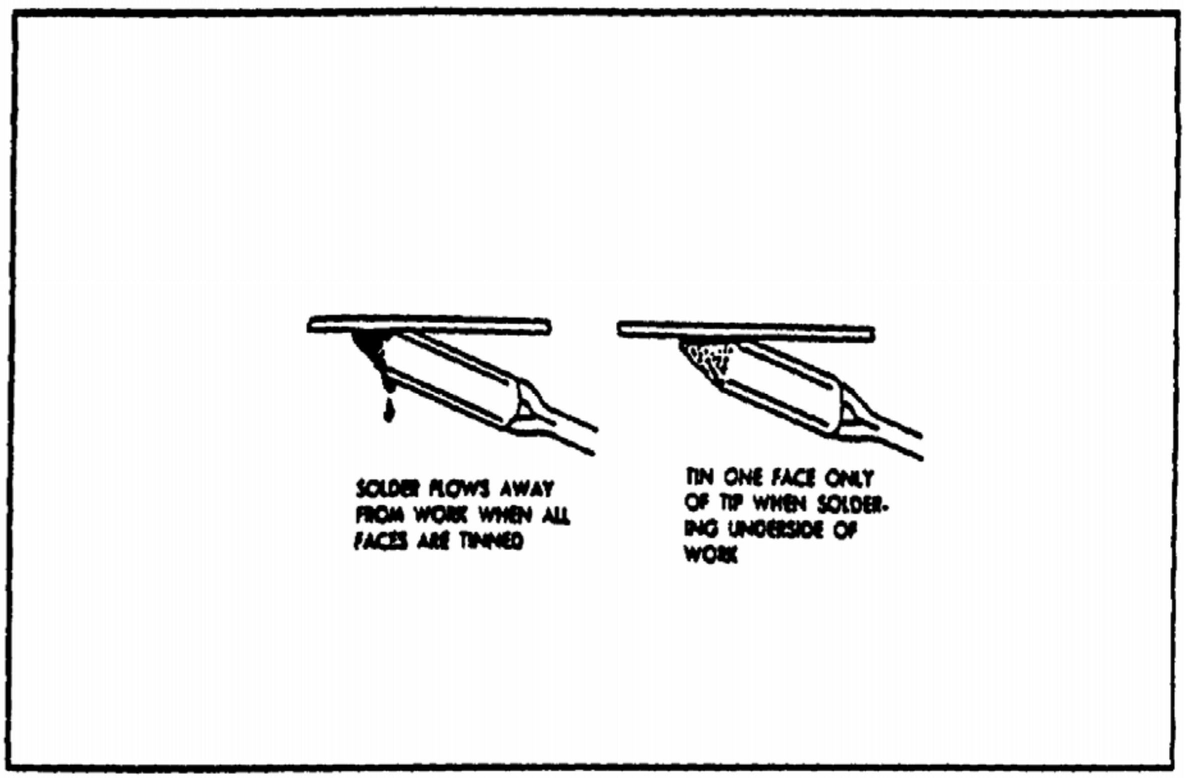


FIGURE 57. PROPER TINNING OF SOLDERING IRON.

(a) Clamp the iron in a vise and file the tip faces bright while the iron is cold (figure 58).

(b) Remove the iron from the vise. Plug the electric cord into the outlet and, as the iron heats up, rub flux core solder over the tip faces every 15 or 20 seconds. At first, the iron will not be hot enough to melt the solder.

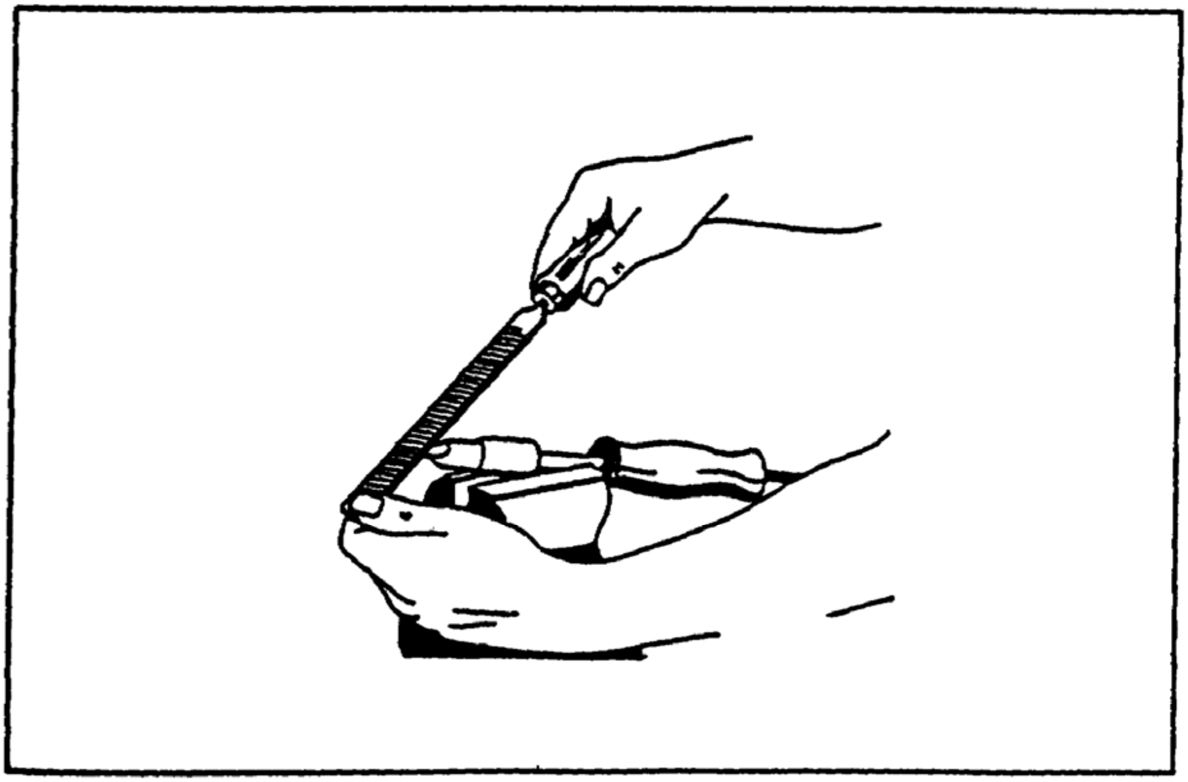


FIGURE 58. FILING TIP OR IRON.

(c) As soon as the temperature has risen sufficiently, the solder will spread smoothly and evenly over the faces. The purpose of this procedure is to do the tinning as soon as the copper is hot enough to melt the solder and before it has had a chance to oxidize.

(d) When the tinning is completed, wipe the tip with a rag while the solder is hot and molten. This will expose an even, almost mirror-like layer of molten solder on the tip faces.

NOTE

If the iron is large, either acid core or rosin core solder may be used. Small irons used for soldering electrical parts and wiring should be tinned only with rosin core solder or solid solder and rosin.

(2) *Regulating Temperature of Electric Soldering Iron.* Electric soldering irons are designed for continued use. Once connected, they develop heat so rapidly that the tip becomes overheated and oxidized, corroding rapidly if the iron is not used constantly. It is often convenient to have a hot iron ready for use without having to wait to heat it up.

This can be done by connecting the iron in series with a light bulb and a switch, as shown in figure 59 . The resistance of the lamp reduces the amount of current flowing through the iron, thereby preventing it from developing its maximum temperature. When the switch is open so that the current flows through both the iron and the lamp in series, the iron may be left connected to the power line with no danger of overheating. When the iron is to be used, close the switch to short circuit out the lamp. This increases the current flowing through the iron to its normal value, permitting it to develop maximum heat. The size of the lamp will depend upon the size of the iron and the desired temperature while waiting and will have to be determined by experiment. It should be rated (number of watts rating) to permit the flow of that amount of current which is required to keep the iron just hot enough to melt solder, or somewhat below that temperature, if desired.

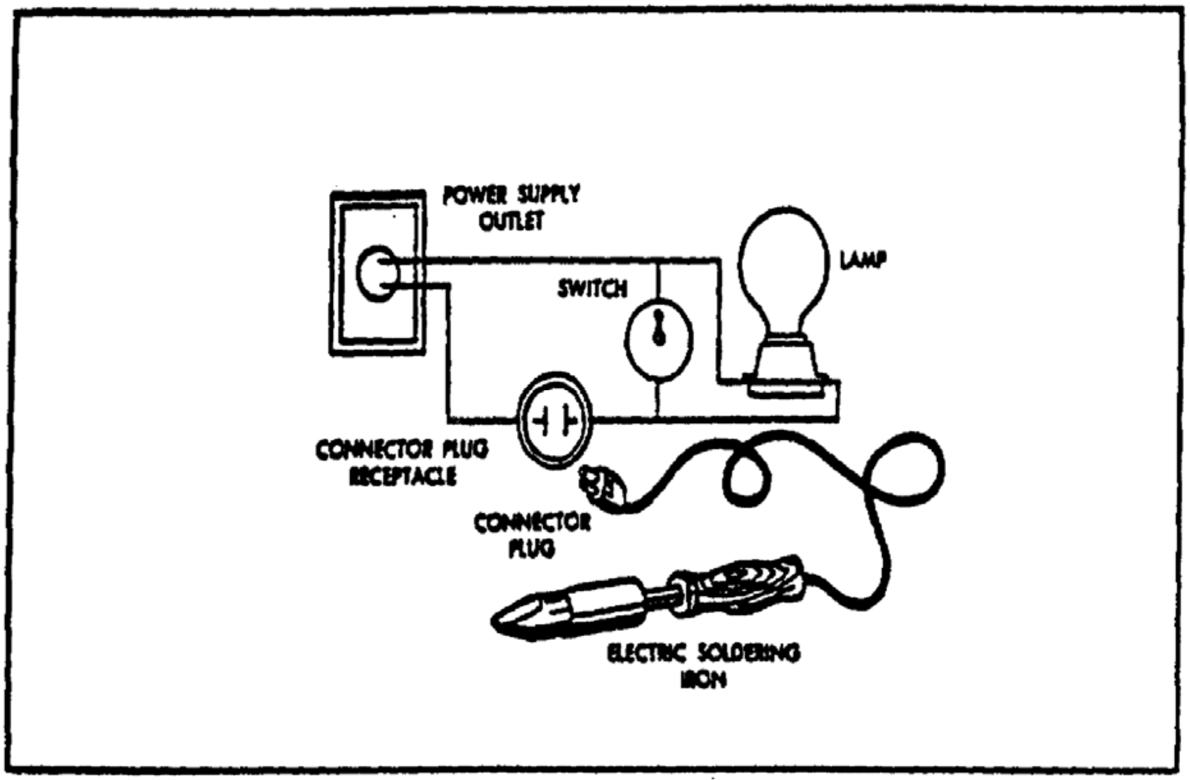


FIGURE 59. ELECTRICAL CIRCUIT TO PREVENT OVERHEATING IRON.

(3) *Using Fluxes.* It is almost impossible to solder without a flux. Metal surfaces, at the point where they are to be joined together, must be absolutely clean and bright so that the solder will adhere to them. A thin layer of oxide forms on bright surfaces in a few seconds, as soon as they are heated by the iron. To remove the oxide coating, apply flux. Fluxes are chemicals; the most common in use for soldering are rosin and zinc chloride. Zinc chloride is an acid flux. Rosin fluxes are noncorrosive and nonconductive and are the best fluxes to use when soldering metals, copper, old tinware, electrical connections, radios, telephones, fine instruments, and small parts. Zinc chloride or paste solder is corrosive and is commonly used in heavier work on untinned copper,

brass, bronze, monel metal, nickel-plated parts, galvanized iron, zinc, steel, and German silver. Since it is corrosive, all traces of it should be washed off the work after soldering. The only disadvantage of using rosin flux is that rosin is adhesive. Consequently, a joint which may appear to be well soldered may actually be held together by the adhesive properties of the rosin and not by the solder. To prevent this, the soldering iron must be hot enough to cause the rosin to burn and must be held against the joint until it smokes. Be constantly on the alert to avoid "rosin joints" when making electrical connections.

(4) *Using Solder.* There are two types of soldering, soft and hard. Soft soldering uses solder which melts at temperatures under 700°F. Soft solders are alloys of lead and tin. Hard solders melt at higher temperatures and are mechanically stronger than soft solders. Solder is made in bar, ribbon, and wire form. Wire solders may be either solid or cored. Cored solder is a hollow tube containing a core of flux. The flux is usually either rosin or an acid substance. Ribbon and wire solder are used with small irons on small work. Bar solder is used with large irons on heavy work.

(5) *Using a Soldering Iron.* There are many rules to follow in order to perform a successful soldering job, but the six most important are described in (a) through (f) below.

(a) The work which is to be soldered must be perfectly clean. All oxide, corrosion, paint, grease, dust, and foreign matter must be scraped off or the solder will not stick. A steel scratch brush, emery paper, steel wool, file, knife, emery wheel, or scraper may be used, whichever works best for the particular job, to clean the metals and produce the required bright surface.

(b) The proper flux must be used; it must wet the entire surface to which the solder is to adhere. Too much flux will interfere with soldering. Rosin flux may be applied in the form of a powder which is sprinkled on, or it may be dissolved in alcohol and applied with a brush. In soldering small work of brass, copper, and tin-plated items, rosin core solder can be used. In heavy work, it is necessary to apply flux separately. Zinc chloride, or any fluid flux, should be swabbed on. After soldering, all traces of acid and zinc chloride fluxes should be removed by washing with a solution of soap and washing soda in water.

(c) The work must be properly and rigidly supported so that it does not move while the solder is setting. If a joint is moved while the solder is cooling and setting, the solder will be broken or weakened. When holding work in clamps or vises, make sure that the heat is not conducted to the jaws of these holding devices. In most cases, several layers of newspaper or asbestos paper placed between the jaws and the work will provide an effective insulator to prevent the escape of the heat. The best method of securing the work will vary with each job.

(d) The iron must be the right size for the job and must have the proper temperature. When using an iron to melt solder and heat the work, the iron loses its heat very rapidly.

If an electric iron becomes too cool to solder, it is too small and a larger iron should be used. Soldering small, light objects does not draw a great deal of heat from the iron, but large castings, pipe fittings, etc., will cool an iron very quickly so that a torch or flame must be used to preheat the work before the iron is applied. In some cases, soldering can be done with a torch alone, eliminating the iron.

(e) The iron must be kept well tinned and clean. The electric iron must be wiped with a rag frequently, and the nonelectric iron wiped clean after it is removed from the flame.

(f) The work must be heated by the soldering iron so that the solder flows or sweats into the joint. The proper method of holding an iron to pass heat quickly to the work is by establishing sufficient contact surface, as shown in figure 60. When soldering splices in wire, the splice is usually heated by the iron from below and the solder placed above the splice. Figure 61 illustrates the right and wrong methods to make wire splices for soldering.

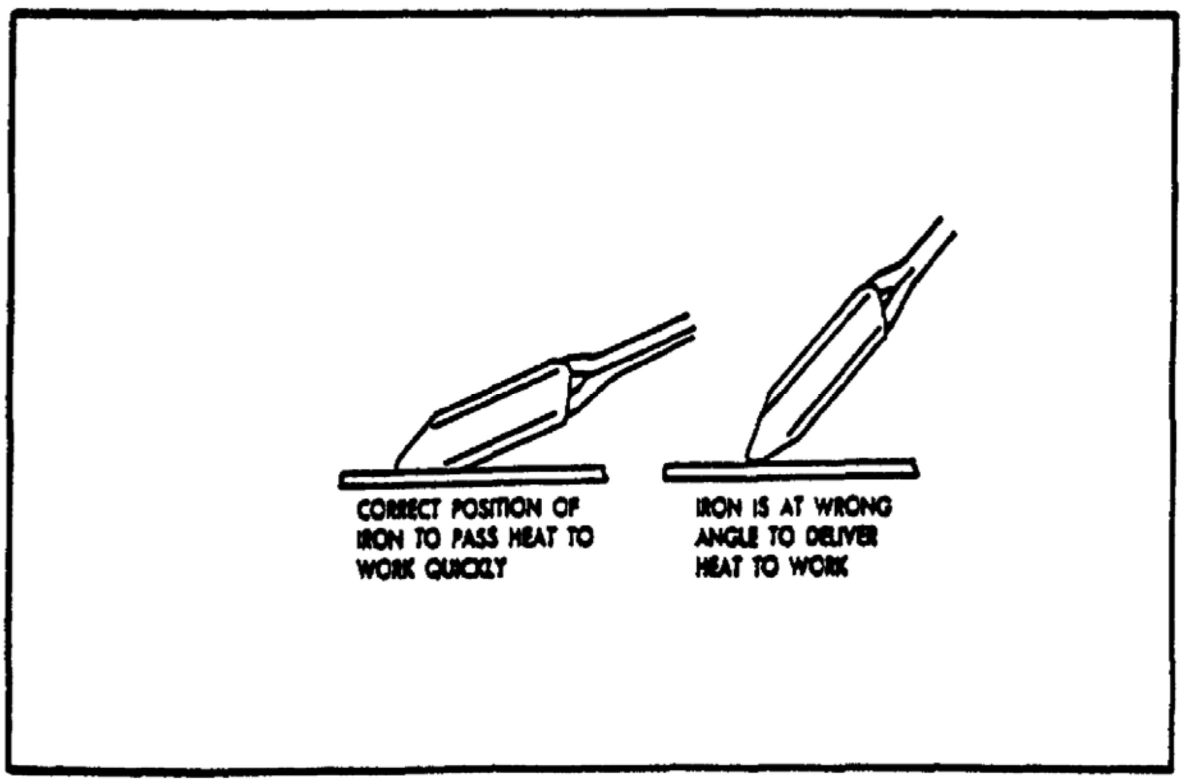


FIGURE 60. POSITION OF IRON TO PASS HEAT.

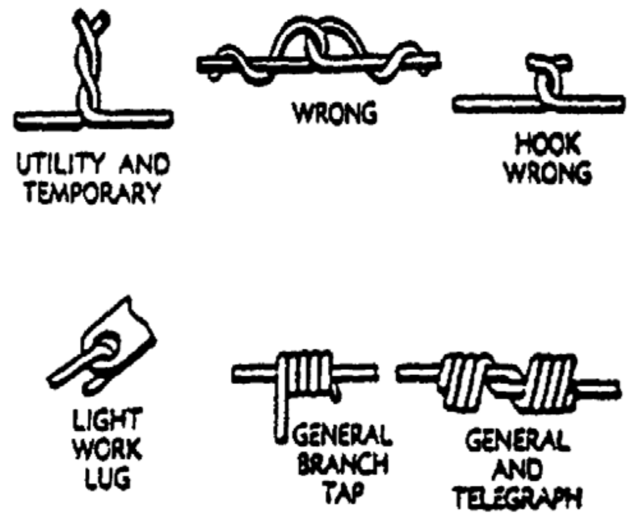


FIGURE 61. WIRE SPLICES FOR SOLDERING.

d. *Care of Soldering Irons.* Electric iron tips must be kept securely fastened in the heater unit, and kept clean and free of copper oxide. Sometimes the shaft becomes oxidized and the tip may stick in place. Remove the tip occasionally and scrape off the scale. If the shaft is kept clean, the tip will not only receive more heat from the heater element, but it can be removed easily when replacement is necessary. After use, hang soldering irons on a rack or place on a shelf; do not throw an iron into a tool box. When storing irons for long periods of time, coat the shaft and all metal parts with rust preventive compound and store in a dry place.

e. *Maintenance of Soldering Irons.*

(1) *Reconditioning Nonelectric Soldering Iron Tip.* To recondition a nonelectric soldering iron tip, perform the operations outlined in (a) through (h) below.

(a) File all old solder and oxide scale from the faces and point of the copper tip.

(b) File the tip to the proper pyramidal shape so that the faces taper back to an efficient working angle, depending on the size of the iron. The point should be slightly rounded.

(c) Use a torch or flame to heat the copper tip to a dull red color. Do not direct the flame at the extreme point; doing so will burn it.

(d) Quench the red-hot tip into cold water to anneal it.

(e) Polish the face of the tip with a fine file so that subsequent tinning will last longer.

(f) Heat the tip so it will just melt solder. Wipe tip clean.

(g) Place a few drops of solder on a bar of ammonium chloride (sal ammoniac) and rub the tip into melted solder and on the bar until the tip is tinned.

(h) Clean the tinned tip each time it is removed from the flame or source of heat. When pits form on the tip, heat the tip and dip it in water to remove the scale.

(2) *Reconditioning Electric Soldering Iron.*

(a) Clean and shape the point by filing and tin the tip. Do not use an external source of heat and do not quench the tip in water.

(b) If an iron does not heat with the plug connected into the power outlet, an open circuit is indicated in the plug, cord, or heater element. Inspect the cord for breaks, and the plug for bent prongs. Feel along the wire for breaks inside the insulation. If an open circuit cannot be found, disconnect the cord from the handle and test the cord and heater element separately with a test lamp. Replace faulty parts.

(c) A blown fuse in the power circuit when the plug of a soldering iron is connected indicates a short circuit. Inspect the plug for loose wire ends and the cord for damaged insulation. Test the cord, plug, and heater element separately with a test lamp. Correct faults and replace faulty parts.

10. Grinders and Sharpening Stones

a. *Purpose.* Grinders are devices designed to mount abrasive wheels that will wear away other materials to varying degrees. Special grinders are designed to receive engine valves. Sharpening stones are used for whetting or final sharpening of sharp edged tools that have been ground to shape or to a fine point on a grinder.

b. *Types of Grinders.*

(1) *Bench Grinder.* A bench grinder (figure 62) is a device with an axle to mount an abrasive wheel and a handcrank that will permit turning the wheel. The grinder is geared so that the wheel spins faster than the crank. This type of grinder is clamped onto a bench and is equipped with a rest for alignment of the work when grinding.

(2) *Mounted Grindstone.* The mounted grindstone (figure 62) is foot-powered. The nonglaze grit stone is 2 inches wide and 22 inches in diameter. A funnel-shaped container of water, which constantly wets the stone during grinding, is suspended over the stone.

(3) *Valve Grinder.* The hand valve grinder (figure 62) is a device that is used to lap engine valves in their seats. It consists of pinion gearing enclosed in a heavy, machined, cast iron housing. An external crank handle drives the gears, which rotates a shaft. The end of the shaft is designed to hold any one of three driving blades for use on slotted valves. Nonslotted valves can be driven by a rubber suction cup, supplied with the grinder, that fits the shaft. Two shafts are furnished; one short and one long.

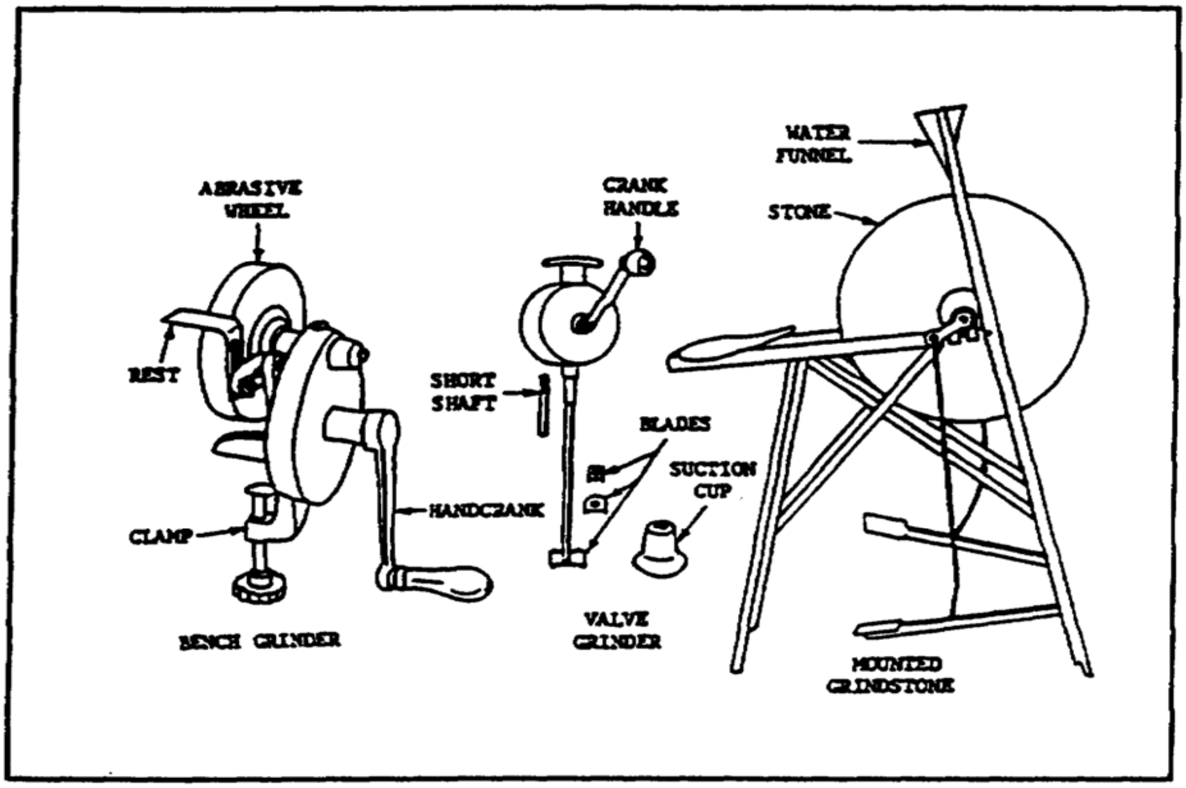


FIGURE 62. GRINDERS AND GRINDSTONE.

c. *Types of Sharpening Stones and Oilstones.* Sharpening stones and oilstones are natural or artificial stones. Most sharpening stones have one coarse and one fine face and are normally made of silicon carbide, aluminum oxide, or natural stone. Natural oilstones have a very fine grain and are excellent for putting razor-like edges on fine cutting tools. Some stones are mounted and the working face of some of the sharpening stones is a combination of coarse and fine grains. Stones are available in a variety of shapes, as shown in figure 63.

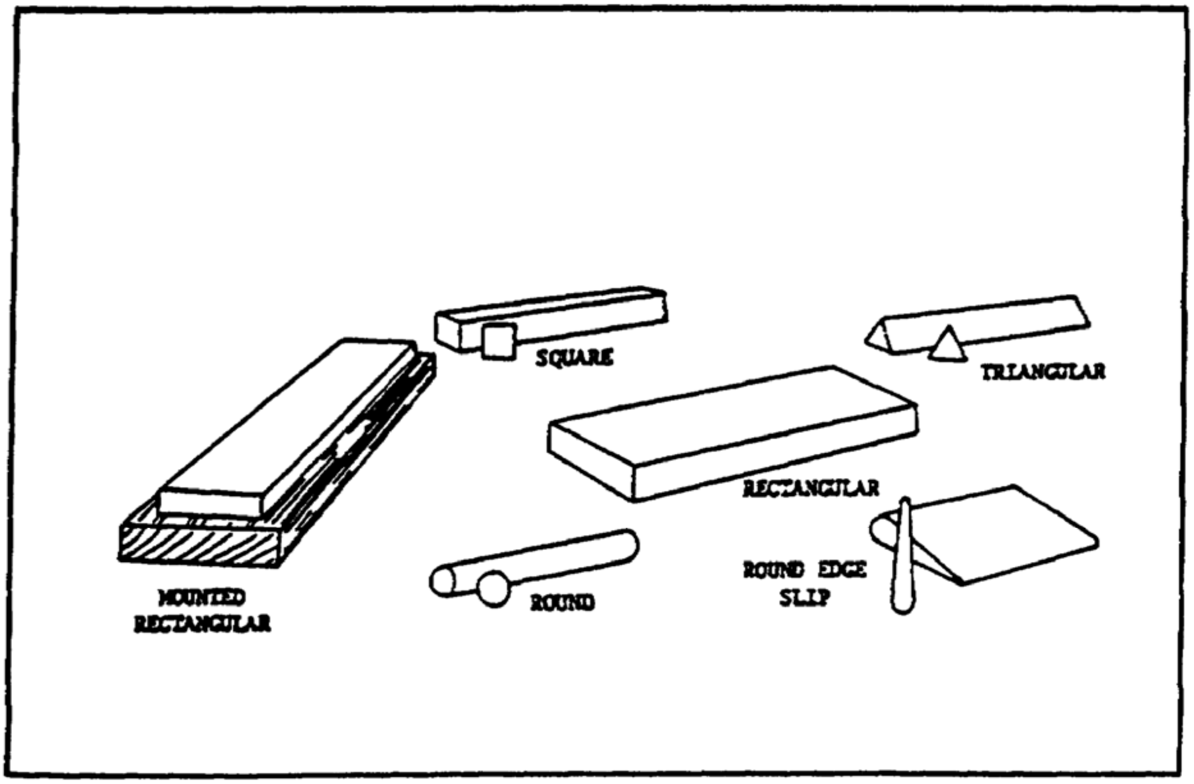


FIGURE 63. SHAPES OF SHARPENING STONES AND OILSTONES.

d. *Using Grinders.*

(1) *Bench Grinder and Grindstone.* Wear goggles when using a bench-type grinder and the grindstone. Use the rest (figure 62) provided on the grinder frames to support the work. Hold the tools that are being shaped so that they will not catch in the abrasive wheel; otherwise, they will slip and injure the operator, or wear the wheel excessively. To grind specific tools, refer to instructions covered in pertinent sections of the technical manual on the particular tool you desire to grind or sharpen. Never use a cracked wheel. Before using a wheel, tap it lightly with a mallet. A ringing sound indicates that the wheel is satisfactory; a dull sound indicates that the wheel may be cracked.

(2) *Valve Grinder.* A hand valve grinder (figure 62) is used for grinding or lapping a valve. By applying a small amount of grinding compound around the valve face and rotating the valve in its seat with the grinder, a perfect lap can be made. The grinder is geared so that the attached blade rotates quickly. One complete revolution of the crank handle advances the blade several revolutions. Check the grinding operation by removing the valve and applying a thin coat of prussian blue on the face of the valve. Reinsert the valve and, with hand pressure on the valve head, rotate the valve about one-quarter turn on its seat. Remove and inspect the impression made on the prussian blue. The impression will indicate the accuracy of the seating. Continue to lap grind the valve face until the entire circumference of the valve seat, without a gap, indicates

contact with the valve face on 90 percent of its area. The grinder shaft mounts a suction cup to hold those valves that have no recessed holes or slots.

e. *Using Sharpening Stones and Oilstones.* Sharpening stones and oilstones (figure 63) are used with a fine oil, sometimes with kerosene, and in some cases are used dry. When a tool has been sharpened on a grinder or grindstone, there is usually a wire edge or a feather edge left by the coarse wheel. The sharpening stones and oilstones are used to hone this wire or feather edge off the cutting edge of the tool. Do not attempt to do a honing job with the wrong stone. Use a coarse stone to sharpen large and very dull or nicked tools. Use a medium grain stone to sharpen tools not requiring a finished edge, such as tools for working soft wood, cloth, leather, and rubber. Use a fine stone and an oilstone to sharpen and hone tools requiring a razor edge.

f. *Care of Grinders.* Keep grinders clean and make certain housing screws are tight. Periodically, drain oil from the bench grinder and regrease the valve grinder. Flush gear housings and gears with the suitable cleaning solvent. Refill with the manufacturer's recommended grade of lubricant. Remove rust from external surfaces with crocus cloth. After use, wipe clean and store in a suitable box or on a rack. Make certain all nuts, screws, and bolts are tight. For long periods of storage, relubricate and spread a rust preventive compound on all metal parts. Wrap the grinder in an oil soaked cloth and store in a dry place.

g. *Care of Sharpening Stones and Oilstones.*

(1) *Cleaning.* Prevent glazing of sharpening stones by applying a light oil during the use of the stone. Wipe the stone clean with wiping cloth or cotton waste after each use. If the stone becomes glazed or gummed up, clean with aqua ammonia or dry cleaning solvent. If necessary, scour with aluminum oxide abrasive cloth or flint paper attached to a flat block.

(2) *Dressing.* At times, oilstones will become uneven from improper use. True the uneven surfaces on an old grinding wheel or on a grindstone. Another method is to lap the surface with a block of cast iron or other hard material covered with a waterproof abrasive paper, dipping the stone in water at regular intervals and continuing the lapping until the stone is true.

(3) *Repairing.* Oilstones are easily broken if they are not handled carefully. Repair a broken oilstone in the manner described in (a) through (f) below. Refer to figure 64 for the repair procedure.

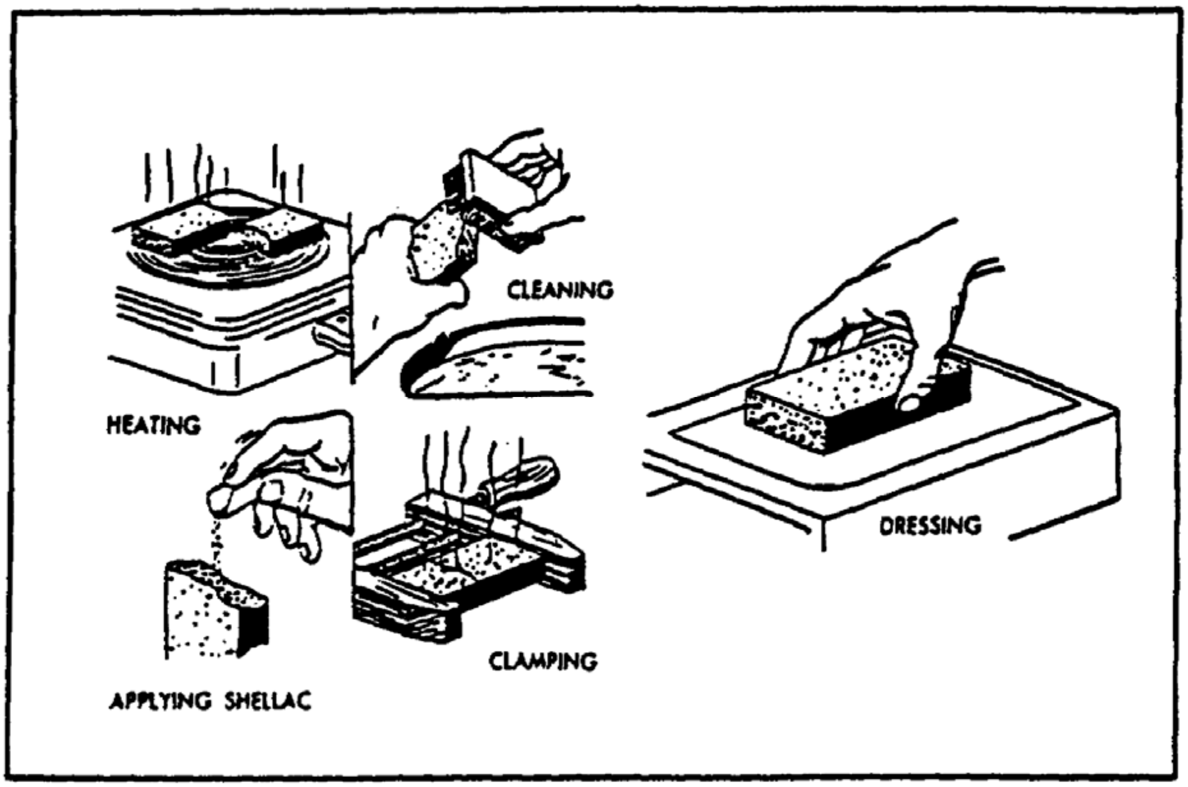


FIGURE 64. REPAIRING BROKEN OILSTONE.

(a) Heat the broken pieces, on a hot plate or in any other satisfactory manner, to drive all oil from inside the stone.

(b) Scrub the broken edges with a dry cleaning solvent to remove gum and dirt.

(c) Dust the broken edges thickly with flaked or ground orange shellac. Carefully work shellac into all cracks and openings.

(d) Press the broken pieces together and reheat to melt the shellac.

(e) Clamp pieces together until cooled.

(f) Dress the stone until the joint is smooth and true.

(4) *Storage.* Oilstones must be carefully put away in a box or on special racks when not in use. Never lay them down on uneven surfaces or place them where they may be knocked off a table or bench, or where heavy objects can fall on them. Do not store in a hot place.

11. Benders and Pullers

a. *Purpose.*

(1) *Benders.* Benders are designed to facilitate bending brass or copper pipe and tubing.

(2) *Pullers.* Pullers are designed to facilitate pulling operations, such as removing bearings, gears, wheels, pulleys, sheaves, bushings, cylinder sleeves, shafts, and other close-fitting parts.

b. *Types of Senders and Pullers.*

(1) *Benders.* Benders (figure 65) issued by the Army Ordnance Supply System are of the spring type sized to fit pipe and tubing ranging from 1/4 to 1 inch in diameter.

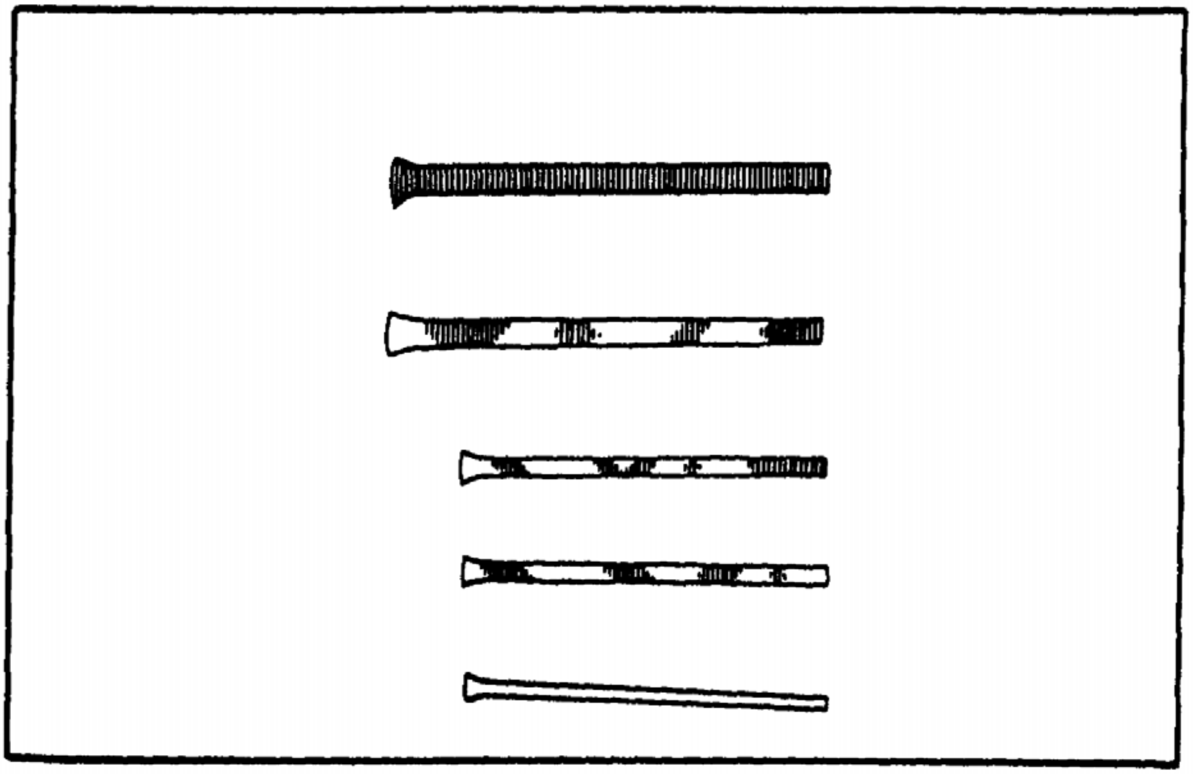


FIGURE 65. HAND PIPE AND TUBE BENDERS.

(2) *Pullers.*

(a) *Universal Gear Pullers.* Universal gear pullers (figure 66) are usually of yoke and screw construction with two jaws. The jaws have from 0 to 14 inches diameter capacity, having a reach from 3 to 16 inches.

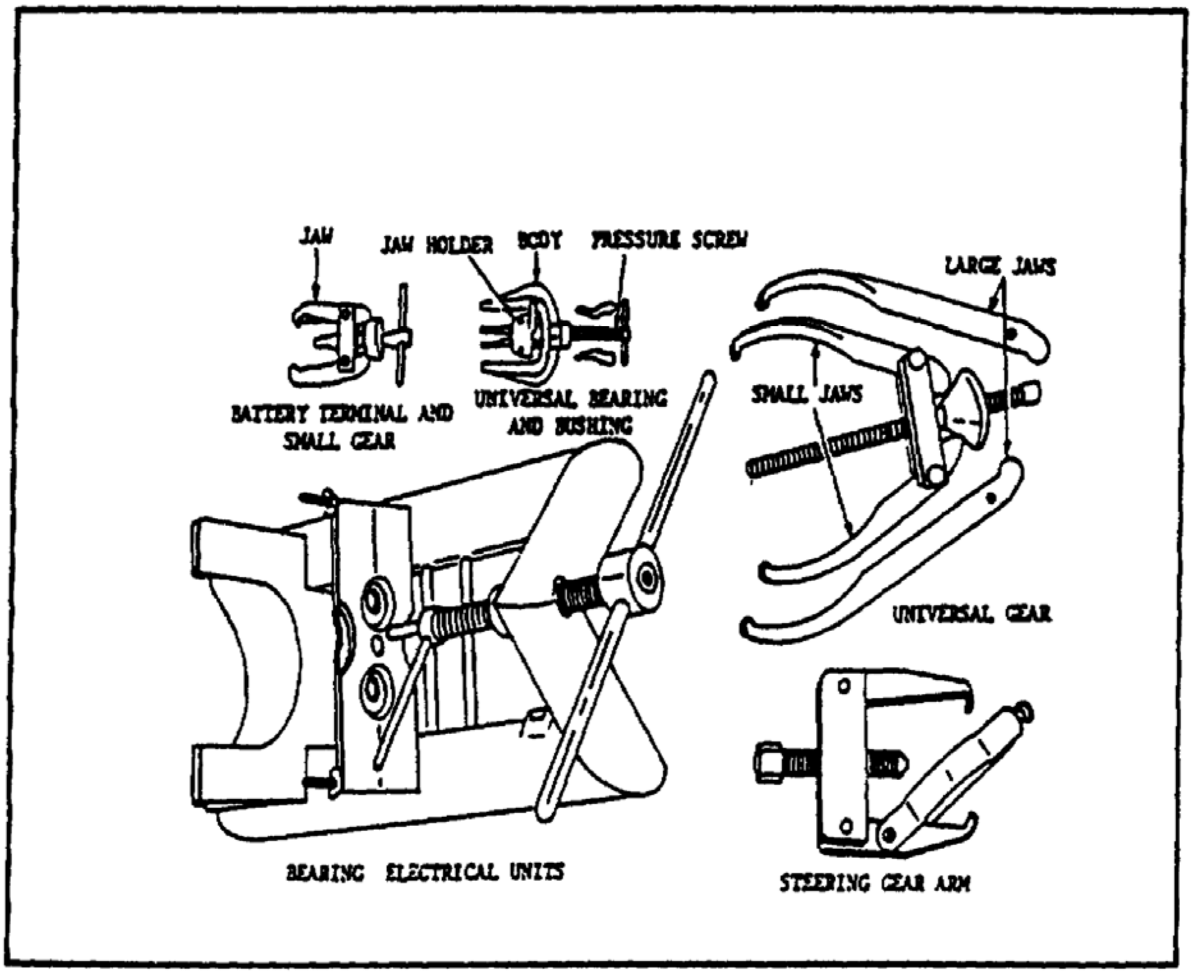


FIGURE 66. BEARING, BUSHING, AND GEAR PULLERS.

(b) *Universal Bearing and Bushing Puller.* The universal bearing and bushing puller (figure 66) has a pulling capacity of 1 1/4 inches. The larger jaws are designed to remove bronze or oilite bushings without crumbling them. The small jaws will pull clutch pilot bearings. This puller consists of a U-shaped body, a jaw holder, two jaw pins, and a pressure screw with slide bar.

(c) *Bearing Puller, Electrical Units.* This type of bearing puller (figure 66) is designed to pull bearings from the shafts of electrical units. It is supplied with plates to fit a variety of unit constructions and to fit behind the particular shaft bearings, etc.

(d) *Battery Terminal and Small Gear Puller.* The battery terminal and small gear puller (figure 66) is of the screw type and is capable of use in close quarters. Besides pulling battery terminals, it is used to pull small gears, bearings, etc.

(e) *Steering Gear Arm Puller.* The steering gear arm or Pitman arm puller (figure 66) can also be used for a wide variety of other jobs. The clamp locks the puller on the arm, leaving both hands free for the actual pulling operation.

(f) *Push and Pull Puller Set.* The push and pull puller set (figure 67) is used in conjunction with a variety of attachments and adapters. The push and pull type puller consists of a 13 1/2 inch steel bar slotted to receive two 9 1/2 inch legs. A pressure screw in the center of the bar is 13 inches long, has a diameter of 1 inch, and is threaded. This puller is a universal and versatile bearing and is designed for use with a pulling attachment, a bearing cup pulling attachment, a sheave puller attachment, threaded adapters, step plate adapters, additional legs, and many other special adapters. The set is capable of removing or replacing bearings, gears, pinions, pulleys, wheels, bushings, and has many other uses. A puller set consisting of a yoke-type puller and push and pull puller, 8 adapters, and 2 attachments carried in a metal case is issued by the Army Ordnance Supply System.

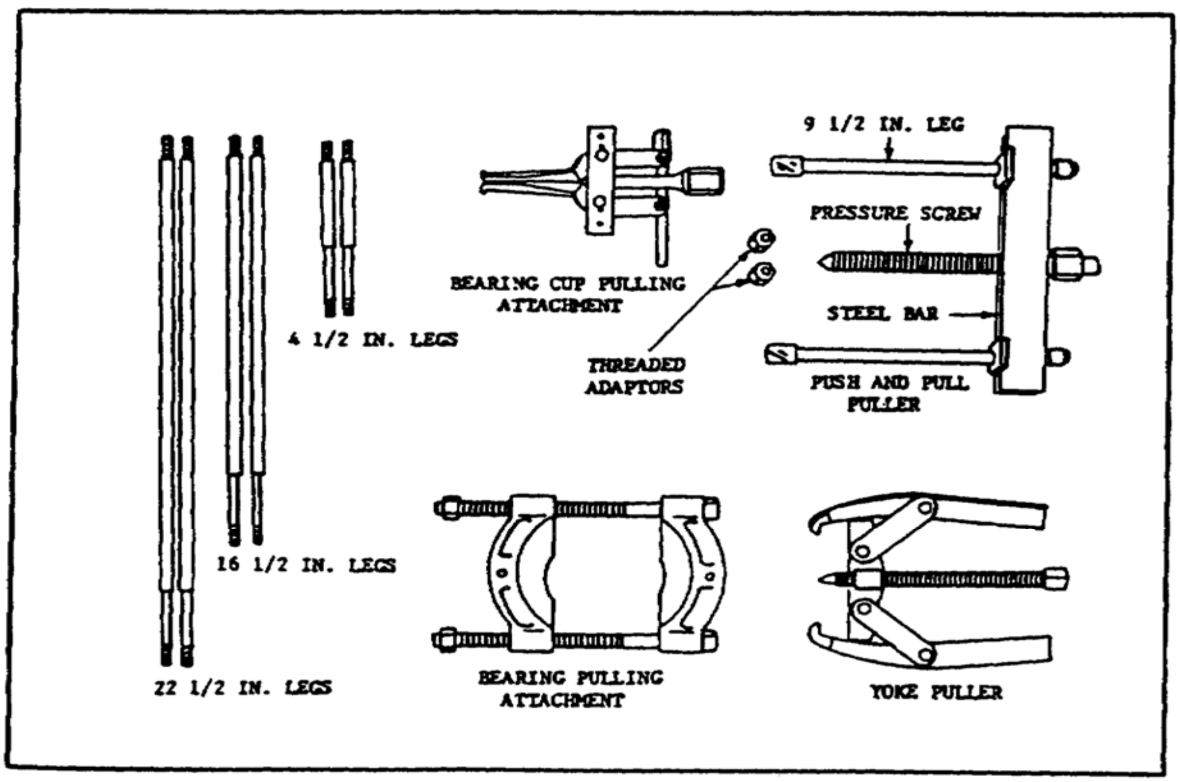


FIGURE 67. PUSH AND PULL PULLER SET.

(g) *Steering Wheel Puller.* A universal-type steering wheel puller is shown in figure 68. The set consists of all the units necessary for removal of steering wheels on all cars and trucks from early models up to the present.

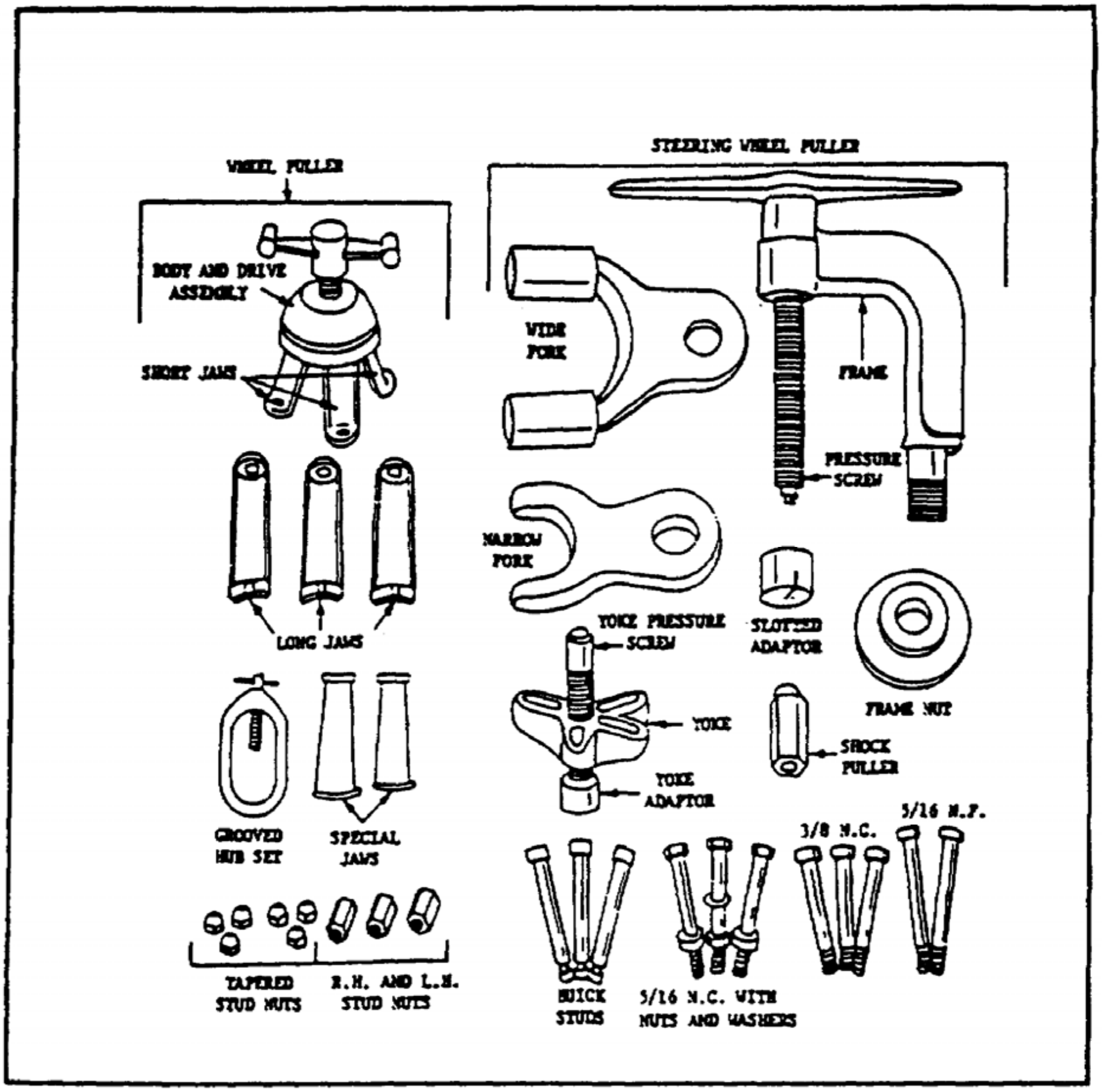


FIGURE 68. STEERING WHEEL AND WHEEL PULLERS.

(h) *Wheel Puller.* The universal wheel puller set (figure 68) consists of a body and drive assembly that receives either three long jaws, three short jaws, or a special grooved hub set for Ford passenger cars. The interchangeable jaws pivot and swing to any desired bolt circle. Tapered, and right- and left-hand threaded stud nuts complete the set, all of which is carried in a metal case. It is capable of pulling any demountable wheel hub for any passenger car, and most light-weight trucks. A chain-type wheel puller is also available that has a 1 ton pulling capacity (not illustrated).

(i) *Cylinder Sleeve Puller.* The universal cylinder sleeve puller (figure 69) will pull the cylinder sleeves on more than 200 makes and models of trucks and tractors. It is adjustable to provide clearance regardless of the position of the cylinder studs and to simplify centering the tool over the bore. This puller is used in conjunction with four adapter plates supplied with the puller. The combination is capable of pulling cylinder sleeves 4 1/4, 4 1/2, 4 3/4, and 5 3/4 inches in diameter.

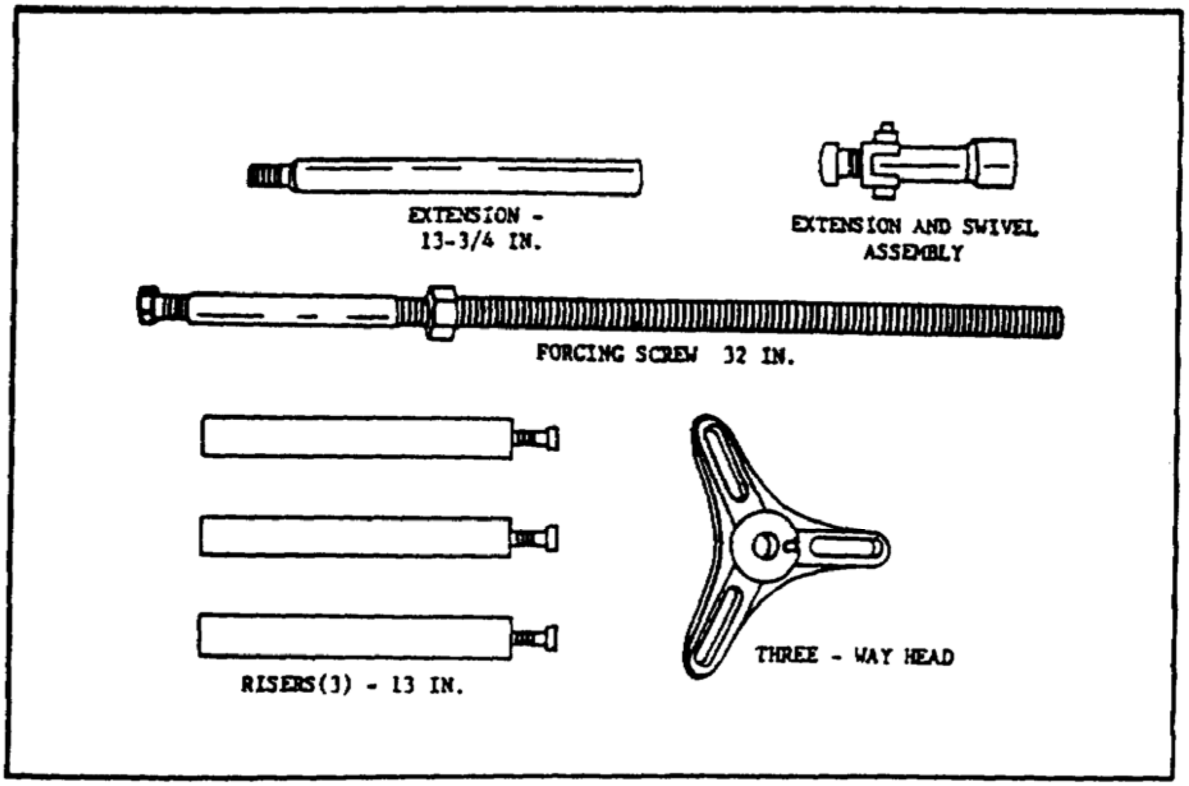


FIGURE 69. CYLINDER SLEEVE PULLER.

(j) *Slide Hammer Puller.* The slide hammer puller set (figure 70) is a universal-type puller equipped with a two- and three-way yoke and three medium jaws for outside pulls, and two small jaws for inside pulling. The small jaws can be inserted through a 1/2 inch opening. The capacity of the medium jaws is 6 1/4 inches. The slide hammer puller is also equipped with a locking feature which holds the jaws open or locks them on the work.

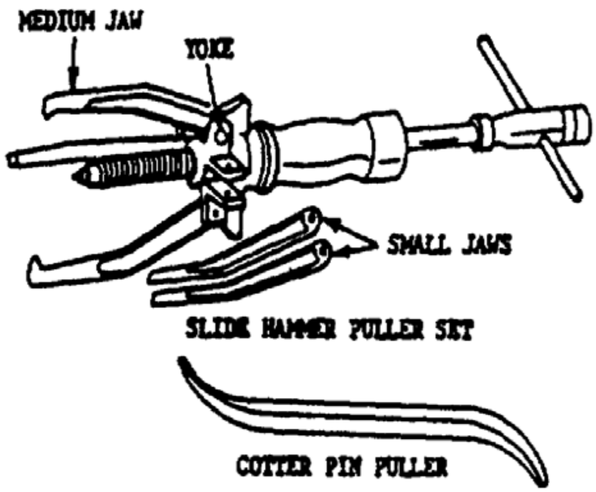


FIGURE 70. SLIDE HAMMER PULLER SET AND COTTER PIN PULLER.

(k) *Cotter Pin Puller.* A cotter pin puller (figure 70) is used to install or to remove cotter pins. It is an S-shaped tool, 7 inches long, one end used to insert through the cotter pins for extracting, the other end used for spreading the cotter pin. The shank is beveled square for easy handling and firm grip.

c. *Use of Pipe and Tube Benders.* A tube bender is used to prevent tubing from kinking or flattening out at the desired bend. To use a bender, push it over the tube until the center portion of the bender is centered over the point in the tube where the bend is to be made. The tube can then be bent by hand to the desired radius. Pull the bender from the tube after bending.

d. *Use of Pullers.*

(1) *General.* Place a puller firmly in position and secure it if locking devices are part of the puller. Make certain the puller will not slip off suddenly while under strain. Check all gripping edges and threads of a puller for damage before using it. Use the proper size wrench for turning the pressure screw or nut to avoid rounding the corners of the nut or of the screw head. Use the proper size puller for the job.

(2) *Slide Hammer Puller.* When using a slide hammer puller (figure 70), lock the jaws with the locking feature and slide the hammer handle up the shaft in the direction of the

pull. The combination yoke provided with this puller enables the mechanic to pull a variety of items by the different combinations and settings of jaws.

(3) *Push and Pull Puller Set.* The universal push and pull puller set (figure 67) is probably the best all around puller combination available. Several combinations of its component parts are discussed and illustrated, in (a) through (d) below.

(a) *Removing and Installing Bearing Cup.* Figure 71 shows the push and pull puller and the bearing cup pulling attachment used to remove a bearing cup from a cage. The same combination is used to install it back in the cage, as shown in figure 72 .

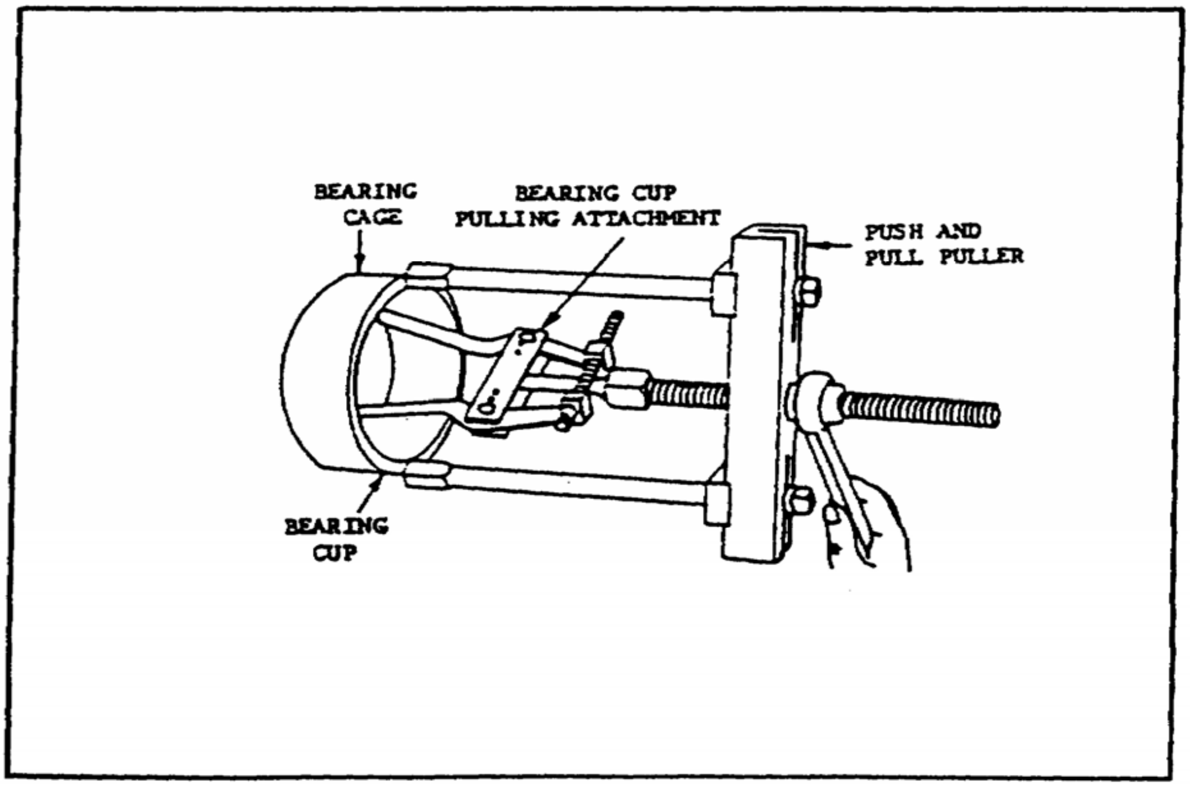


FIGURE 71. REMOVING BEARING CUP.

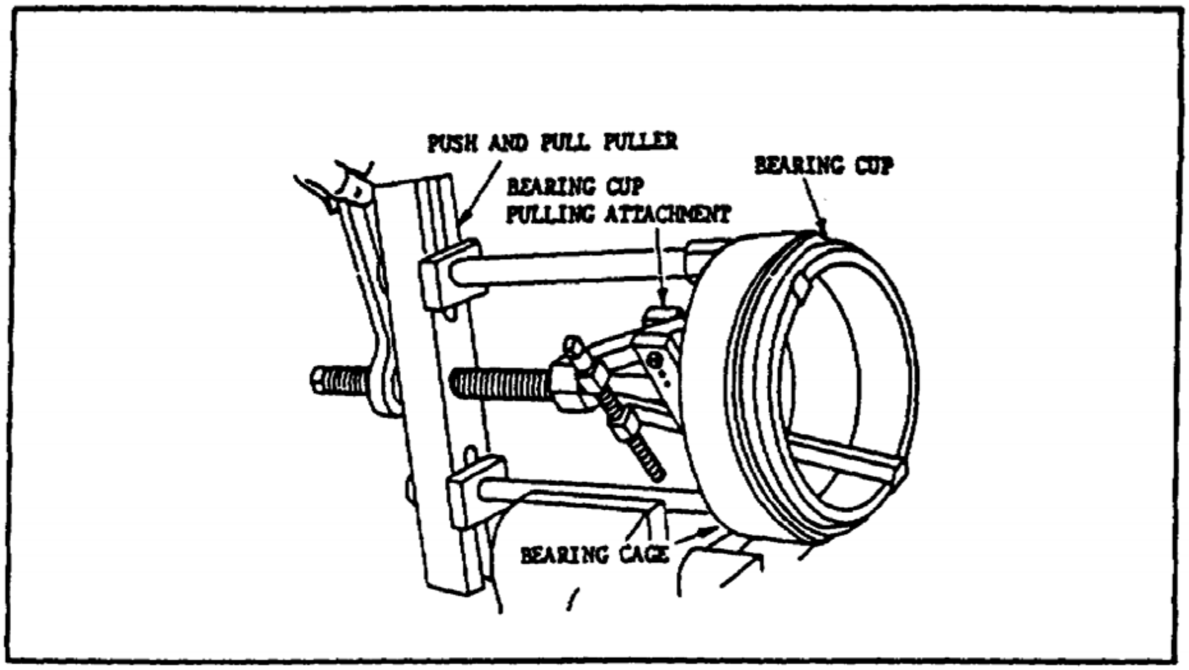


FIGURE 72. INSTALLING BEARING CUP.

(b) *Pulling Camshaft Gear.* The use of the push and pull puller with 9 1/2 inch legs and two adapters is shown in figure 73. Here the camshaft gear is being removed without removing the camshaft from the engine. A protective plate should be used under the forcing screw to protect the end of the camshaft.

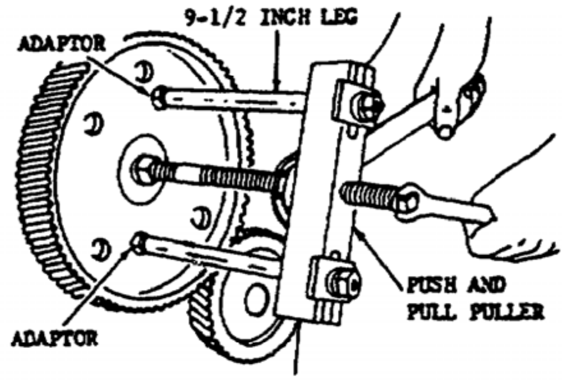


FIGURE 73. PULLING CAMSHAFT GEAR.

(c) *Pulling Bevel Gear Pinion Shaft.* Figure 74 illustrates the use of the bearing pulling attachment and a pair of forcing bolts to remove a bevel gear pinion shaft from a transmission case. The forcing bolts bear against the case and force the pinion shaft out. Tighten the bolts alternately to obtain a uniform even pull to prevent cocking.

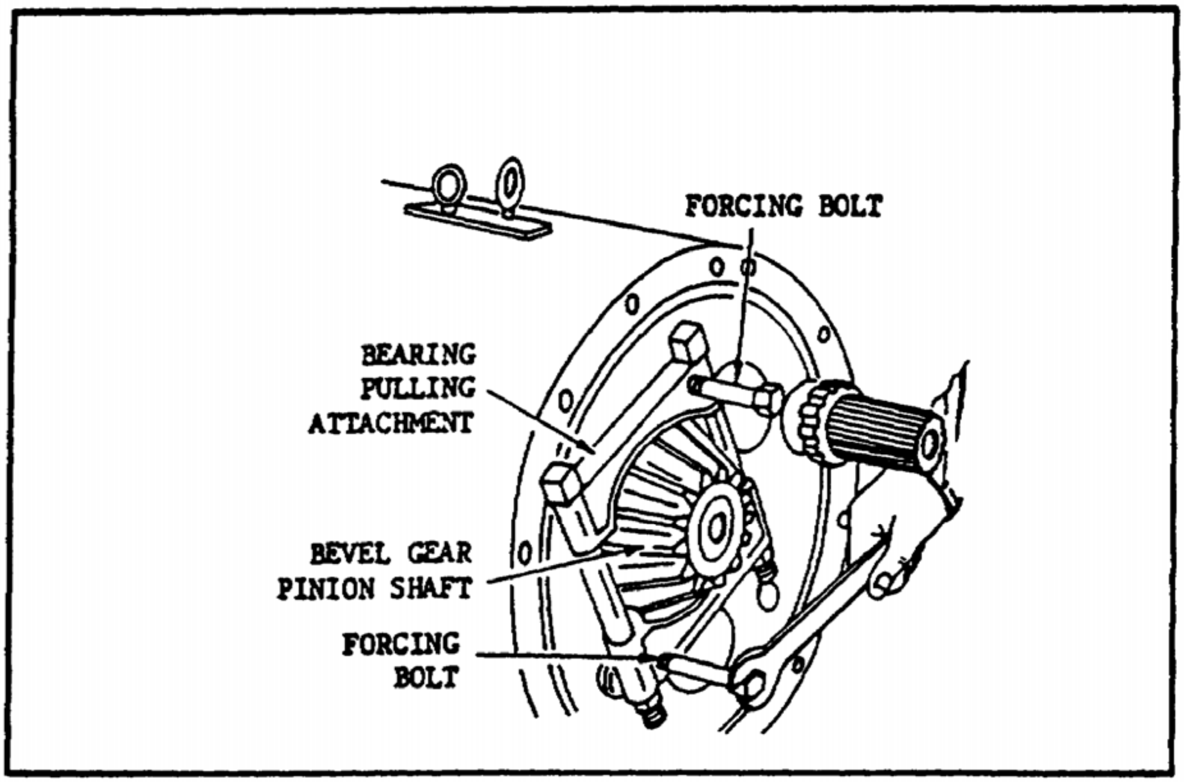


FIGURE 74. PULLING BEVEL GEAR PINION SHAFT.

(d) *Pulling Bearing.* In figure 75 a roller bearing assembly is being removed from a transmission shaft assembly with a combination of the bearing pulling attachment and the push and pull puller.

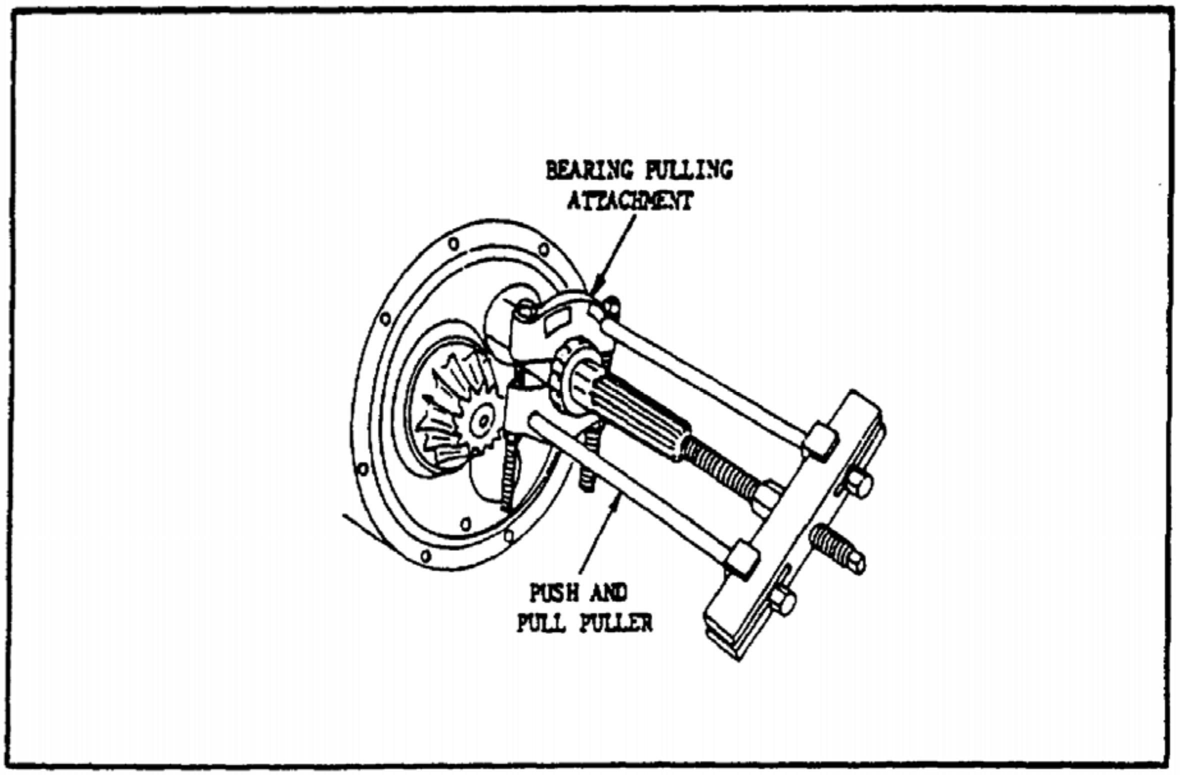


FIGURE 75. PULLING BEARING.

(4) *Steering Wheel Puller.* The steering wheel puller set (figure 76) can be used on all cars and trucks. The yoke puller and its related parts are used to pull the newer models, since they have tapped wheel hubs. The fork puller and its related parts are used on older models. The pressure screw in the frame puller is threaded over its entire length and works through a key. The narrow fork has rubber sleeves to protect the steering column. Adapters protect the shaft from damage. View A of figure 76 illustrates the use of the wide fork and frame puller on older type hubs. View B of figure 76 shows the yoke puller removing a late model steering wheel.

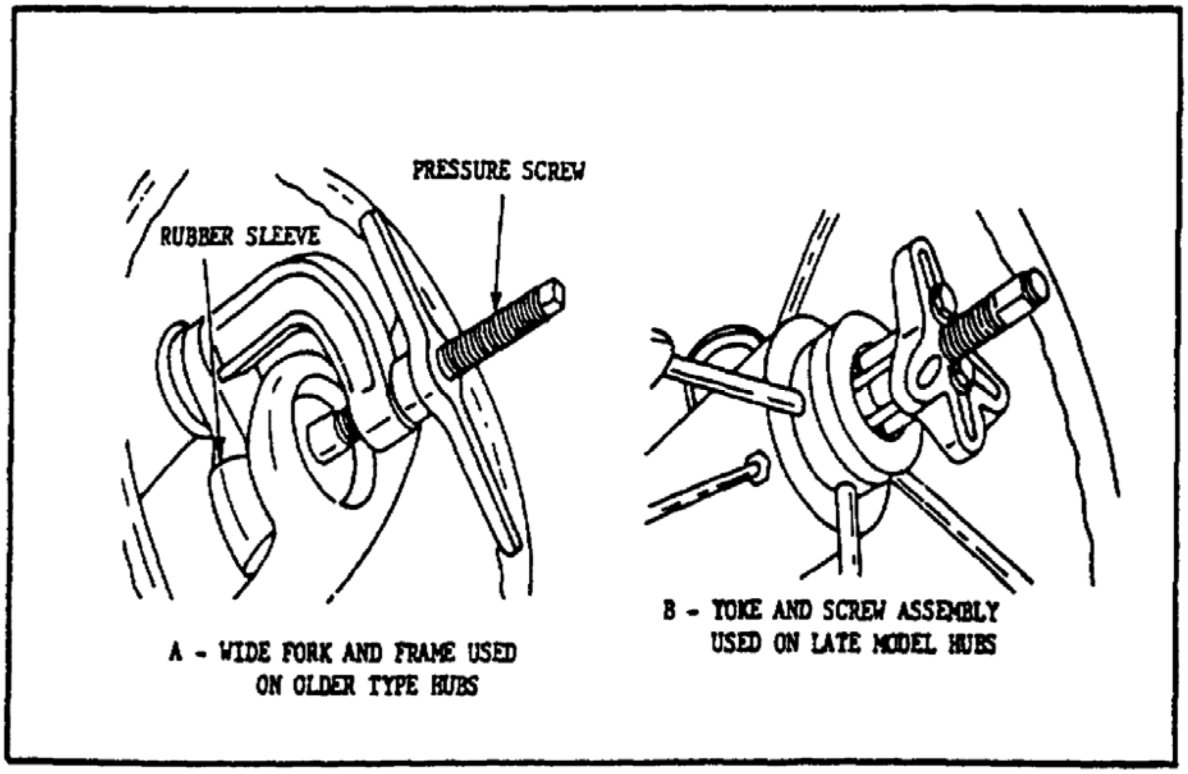


FIGURE 76. USING STEERING WHEEL PULLER SET.

(5) *Wheel Puller.* The universal wheel puller set is quickly assembled by inserting the proper type jaws and attaching the tool to the wheel stud bolts. To interchange the jaws, hold two jaws together, as shown in figure 77 . This depresses the inner sleeve and allows room to remove or insert other jaws. To pull Ford car or truck wheels, use the three long jaws in conjunction with the special Ford grooved hub set, as shown in figure 78.

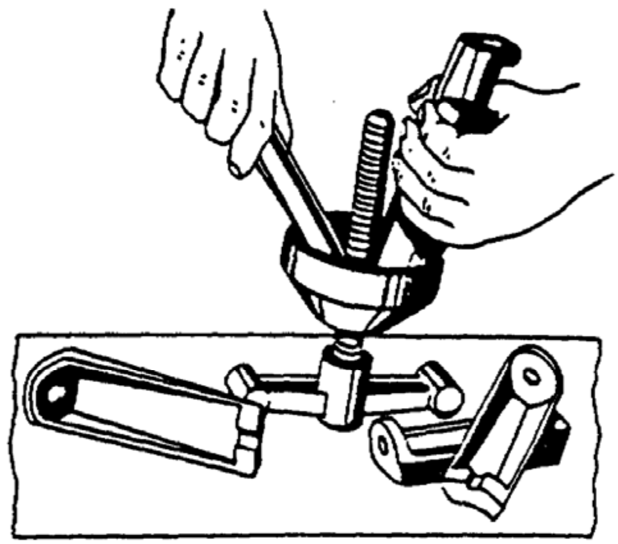


FIGURE 77. INTERCHANGING WHEEL PULLER JAWS.

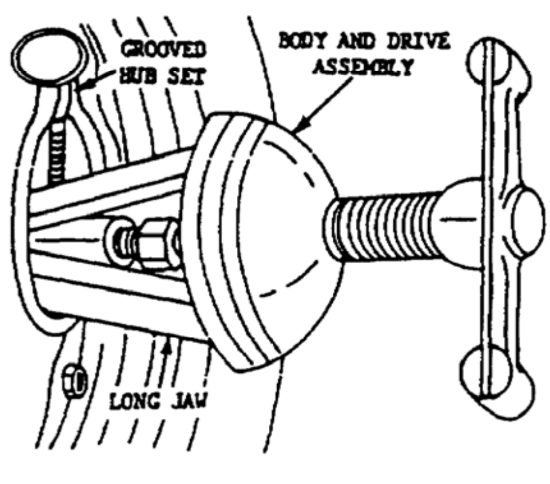


FIGURE 78. USING WHEEL PULLER AND GROOVED HUB SET.

(6) *Cylinder Sleeve Puller.* The cylinder sleeve puller is adjustable to provide clearance regardless of the number or position of the cylinder head studs, and to accurately center the tool over the bore (figure 79). Four adapter plates are supplied with the puller which cover sleeves from 4 1/4 to 5 3/4 inches in diameter. The adapter is positioned so that the cylinder sleeve rests on the edges of the adapter. The puller swivel assembly is inserted from the top and screwed into the adapter. When tightening the forcing screw, a steady force is applied which will pull the sleeve out of the cylinder.

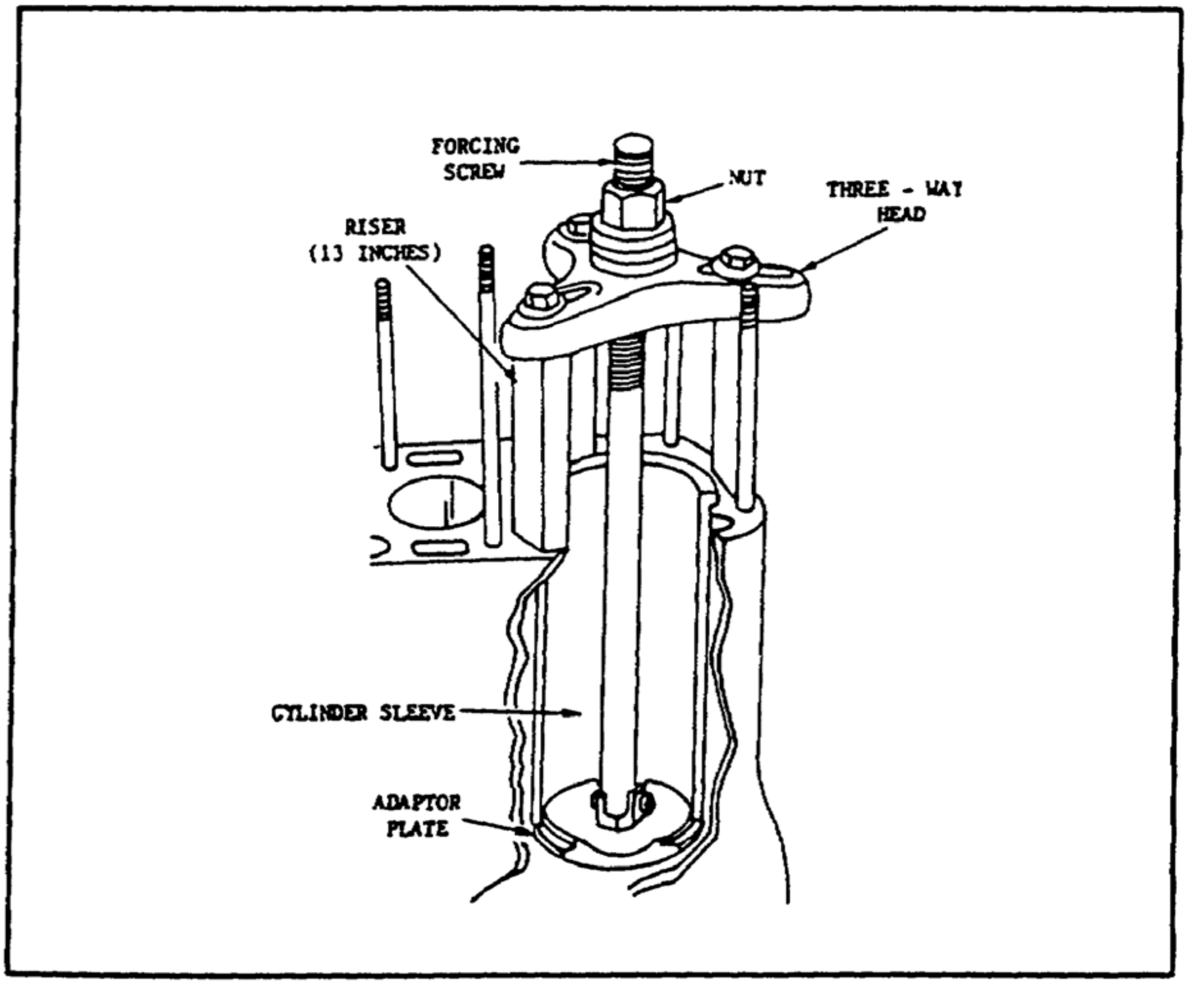


FIGURE 79. USING CYLINDER SLEEVE PULLER.

e. *Care of Benders and Pullers.* Keep benders and pullers clean at all times. Grease or oil on the gripping edges will make the tool slip. Clean all tools after use and store them so that the threads and gripping surfaces will not become damaged. Make certain attachments and adapters are stored with the basic puller and do not become separated.

Oil benders and pullers after use and wipe them clean before storing. When storing for long periods of time, apply a coat of rust preventive compound on tools and store them in a dry place.

12. Conclusion

This task described selected nonedged handtools and the procedures required for their maintenance. The next task will provide information on selected edged handtools, to include procedures for proper maintenance.

LESSON 2

USE AND CARE OF HANDTOOLS

TASK 2:	Describe the procedures for the use and care of edged handtools.
CONDITIONS:	Within a self-study environment and given the subcourse text, without assistance.
STANDARDS:	Within three hours
REFERENCES:	No supplementary references are needed for this task.

1. Introduction

Edged handtools are designed with sharp edges for working on metal, wood, plastic, leather, cloth, glass, and other materials. They are used to remove portions from the work or to separate the work into sections by cutting, punching, scraping, chiseling, filing, etc.

Most edged tools have hardened cutting edges or points and require extreme caution when in use. The tools covered in this task are those currently issued by the Army Ordnance Supply System.

2. Chisels

a. *Purpose.* Chisels are made to cut wood, metal, hard putty, and other materials. Woodworker's chisels are used to pare off and cut wood. Cold chisels are used to chip and cut cold metal. Some blacksmith's chisels are used to cut hot metal. A special chisel is available to cut hard putty so that glass may be removed from its frame channel.

b. *Types of Chisels.*

(1) *Woodworker's Chisels.* Woodworker's chisels (figure 80) are made in a variety of sizes ranging from a 1/8 inch blade width up to 2 inches wide, and with blade lengths from 2 to 6 inches long. Woodworker's chisels have a beveled cutting edge. The construction of woodworker's chisels is of either the socket type or the tang end type. The socket type has the blade and handle socket forged from one piece of high carbon steel. The end of the handle is inserted into the socket. The tang end type is also forged in one piece, but the handle is drilled and the tang is inserted into the handle, which is reinforced with a ferrule or metal band. The socket type is usually used for very heavy work where a hammer may be used to strike the hard end of the chisel handle. Tang-type chisels are usually lighter, have

thinner blades than the socket type, and are normally used with hand pressure.

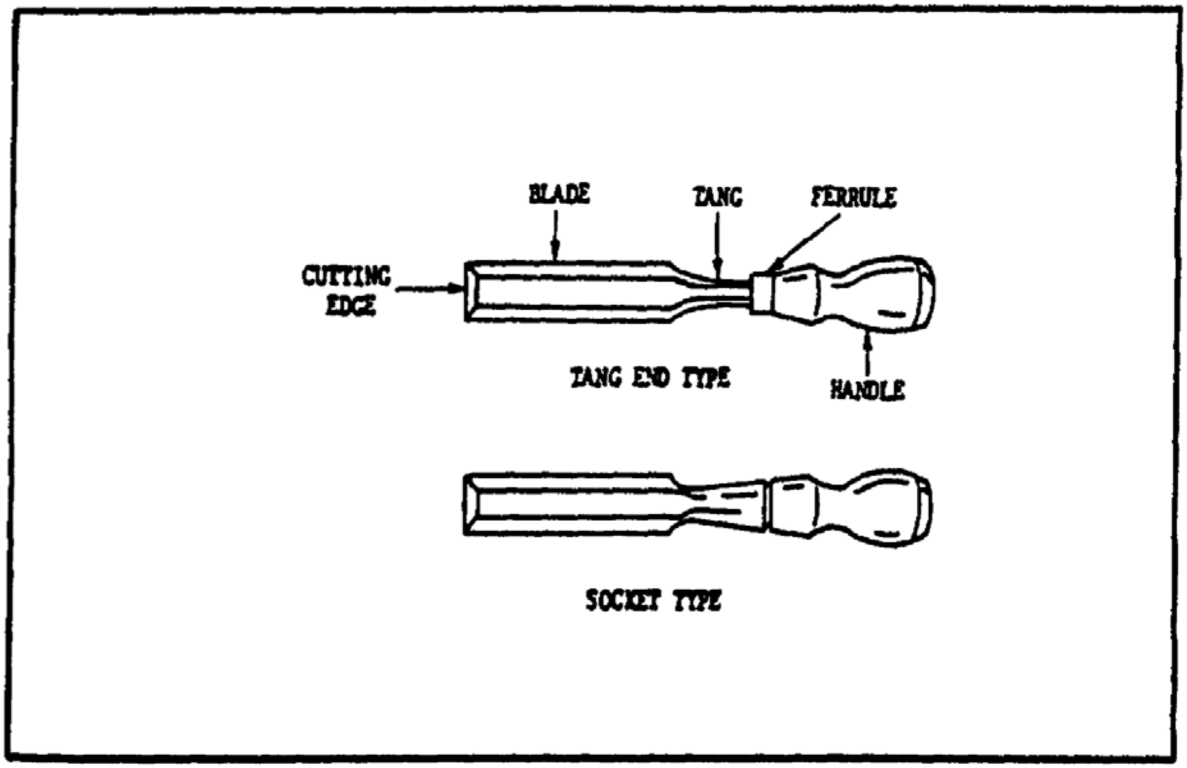


FIGURE 80. WOODWORKER'S CHISELS.

(2) *Machinist's Chisels.*

(a) *Flat or Cold Chisels.* Flat or cold chisels (figure 81) are made of a good grade of steel with a hardened cutting edge on one end and rounded off at the other end. The flat or cold chisel is made in sizes from a 1/4 inch cutting edge up.

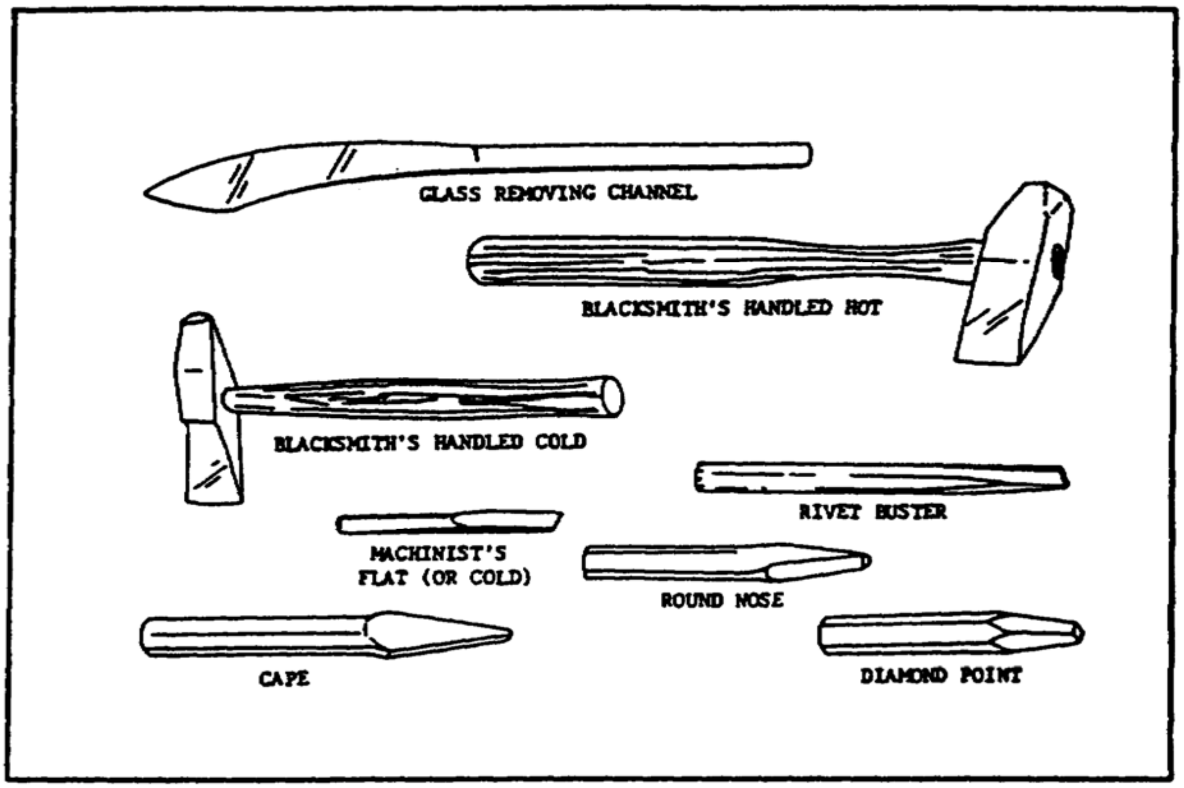


FIGURE 81. MACHINIST'S AND BLACKSMITH'S CHISELS.

(b) *Diamond Point Chisel.* The machinist's diamond point chisel (figure 81) has a solid point and is used to cut V-grooves, for drawing holes, and for cutting holes in flat stock.

(c) *Cape Chisel.* The machinist's cape chisel (figure 81) has a point which is smaller than that of a diamond point chisel. It is used to cut keyways or slots in metal, and also for dividing up work so that a flat chisel can be used for finishing.

(d) *Roundnose Chisel.* The roundnose chisel (figure 81) has its cutting edge ground at an angle of 600 with the axis of the chisel. When roundnose chisels are used to bring drilled holes, just started, concentric with the laid out drilling circles, they are called center chisels. The roundnose chisel is also used for cutting channels, such as oil grooves and similar work. Roundnose chisels are of similar shape to the cape chisel, with one edge ground flat, and the other edge making a round cutting edge. The stock of these chisels is usually octagonal (eight sided) in shape.

(3) *Blacksmith's Chisels.*

(a) *Handled Cold Chisel.* The blacksmith's handled cold chisel (figure 81) is used to cut or chip cold metal on an anvil. These chisels are supplied in two sizes, one with a 1 3/8 inch cutting edge, the other with a 1 3/4 inch cutting edge. The length of the chisel is about five inches. It is provided with a wooden handle.

(b) *Handled Hot Chisels.* The blacksmith's handled hot chisel (figure 81) is used only when hot metal is to be cut. It has a wood handle long enough to keep the hands at a safe distance from the hot metal, and to provide a firm grip, because a heavy hammer or sledge is used to strike the chisel. This chisel is heavier and more rugged than the handled cold chisel.

(4) *Track Chisel.* A track chisel weighs 5 1/2 pounds and has a length of 9 1/2 inches. The handle is 24 inches long. This chisel is used to cut off track bolts and boiler rivet heads, as well as to cut rail where a saw or cutting torch is not available.

(5) *Rivet Buster Chisel.* A rivet buster chisel (figure 81) is 9 inches long and has a 3/4 inch cutting edge. It is designed to reach chassis rivets and those in other difficult places that other chisels cannot reach.

(6) *Glass Removing Channel Chisel.* The glass removing channel chisel (figure 81) is 15 1/2 inches long with a curved blade. It is used to cut away hard putty from around glass and to separate glass from its frame channel.

c. *Use of Chisels.*

(1) *Woodworker's Chisels.* A woodworker's chisel should always be held with the flat side or back of the chisel against the work for smoothing and finishing cuts. Whenever possible, it should not be pushed straight, but should be moved laterally at the same time as it is pushed forward (figure 82). This method ensures a shearing cut, which, with care, will produce a smooth and even surface even when the work is cross-grained. On rough work, use a hammer or mallet to drive the socket-type chisel. On fine work, use your hand as the driving power on tang-type chisels. For rough cuts, the bevel edge of the chisel is held against the work. Whenever possible, other tools, such as saws and planes, should be used to remove as much of the waste wood as possible, the chisel being used for finishing purposes only.

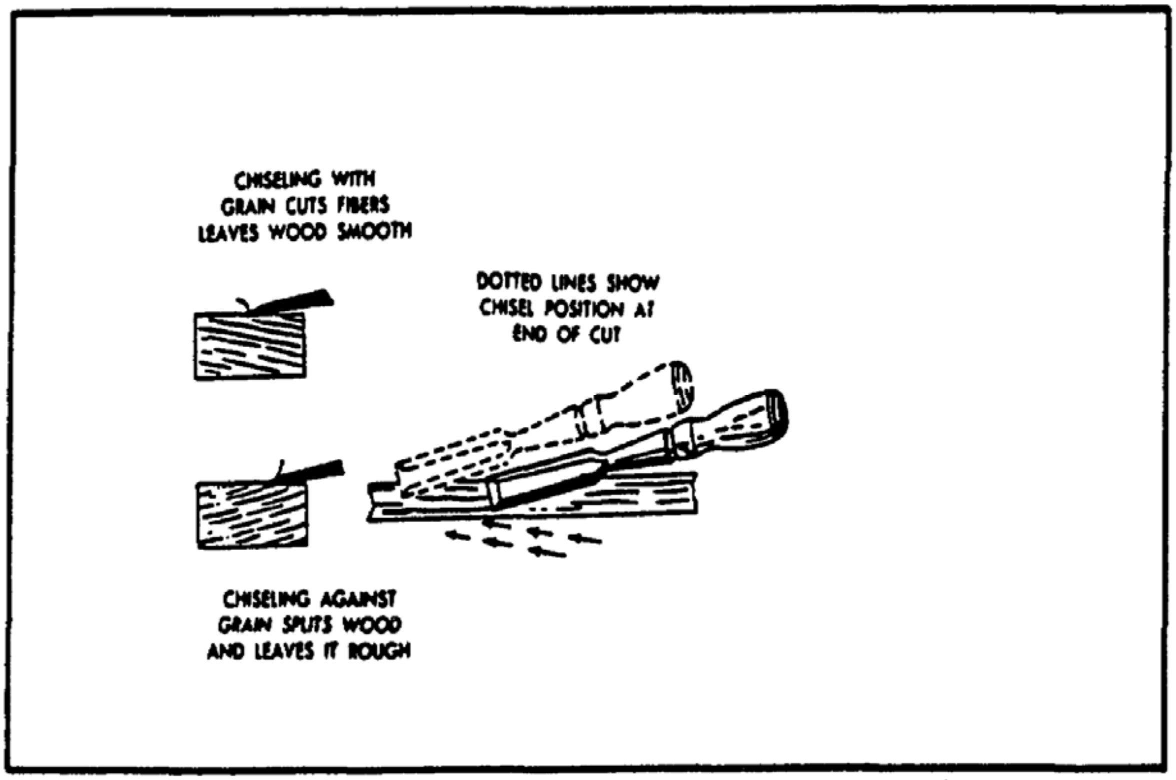


FIGURE 82. PARING OR SHEARING CUT - WOODWORKER'S CHISEL.

(a) *Basic Precautions When Using a Chisel.*

1 Secure work so that it cannot move in any direction.

2 Keep both hands back of the cutting edge at all times.

3 Do not start a cut on a guideline. Start slightly away from it, so that there is a small amount of material to be removed by the finishing cuts.

4 When starting a cut, always chisel away from the guideline toward the waste wood, so that no splitting will occur at the edge.

5 Never cut towards yourself with a chisel.

6 Make the shavings thin, especially when finishing.

7 Examine the grain of the wood to see which way it runs. Cut with the grain (figure 82). This severs the fibers and leaves the wood smooth. Cutting against the grain splits the

wood and leaves it rough. This type of cut cannot be controlled.

(b) *To Cut Horizontally With the Grain.* Grasp the chisel handle in one hand with the thumb extended towards the blade (figure 83). The cut is controlled by holding the blade firmly with the other hand, knuckles up and the hand well back of the cutting edge. The hand on the chisel handle is used to force the chisel into the wood. The other hand pressing downward on the chisel blade regulates the length and depth of the cut. The chisel will cut more easily and leaves a smoother surface when the cutting edge is held at a slight diagonal to the direction of the cut, or is given a slight lateral sliding motion (figure 82). This is done by holding the tool at a slight angle and moving it to one side as it is pushed forward, or by moving it slightly from left to right at the same time you push it forward. With cross-grained wood, it is necessary to work from both directions to avoid splitting the wood at the edges. Do not hurry. Cut only fine shavings. If thick shavings are cut, the tool may dig in and split off a piece of wood which was not intended to be removed.

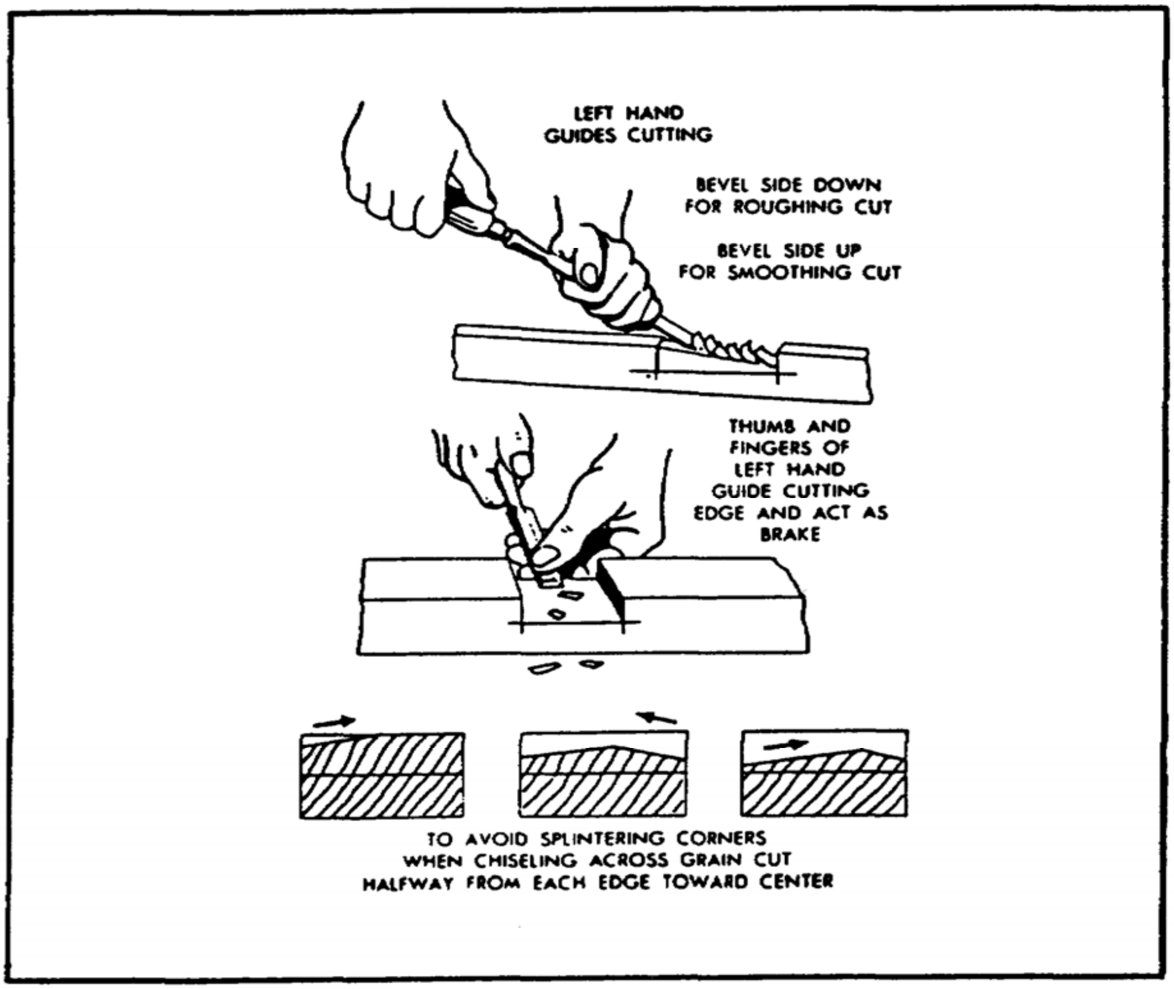


FIGURE 83. CHISEL HORIZONTALLY.

(c) *To Cut Horizontally Across the Grain.* Work must be held in a vise and most of the waste wood is removed by the chisel with the bevel held down. On light work, use hand pressure or light blows on the end of the chisel handle with the palm of the right-hand. On heavy work, use a mallet. To avoid splitting at the edges, cut from each edge to the center and slightly upward, so that the waste wood at the center is removed last (figure 83). Finishing cuts are made with the flat side of the chisel down. Never use a mallet when making finishing cuts, even on large work. One hand pressure is all that is necessary to drive the chisel, which is guided by the thumb and forefinger of the other hand. Finish cuts should also be made from each edge toward the center. Do not cut all the way across from one edge to another or the far edge may split.

(d) *To Cut Diagonally Across the Grain.* To cut a straight slanting corner, as shown in figure 84, as much waste wood as possible is first removed with a saw. Clamp the work in a bench vise with the guideline horizontal. Use the chisel as in cutting horizontally with the grain ((b) above). It is necessary to chisel with the grain and to hold the chisel so that the cutting edge is slightly diagonal to the direction of the cut.

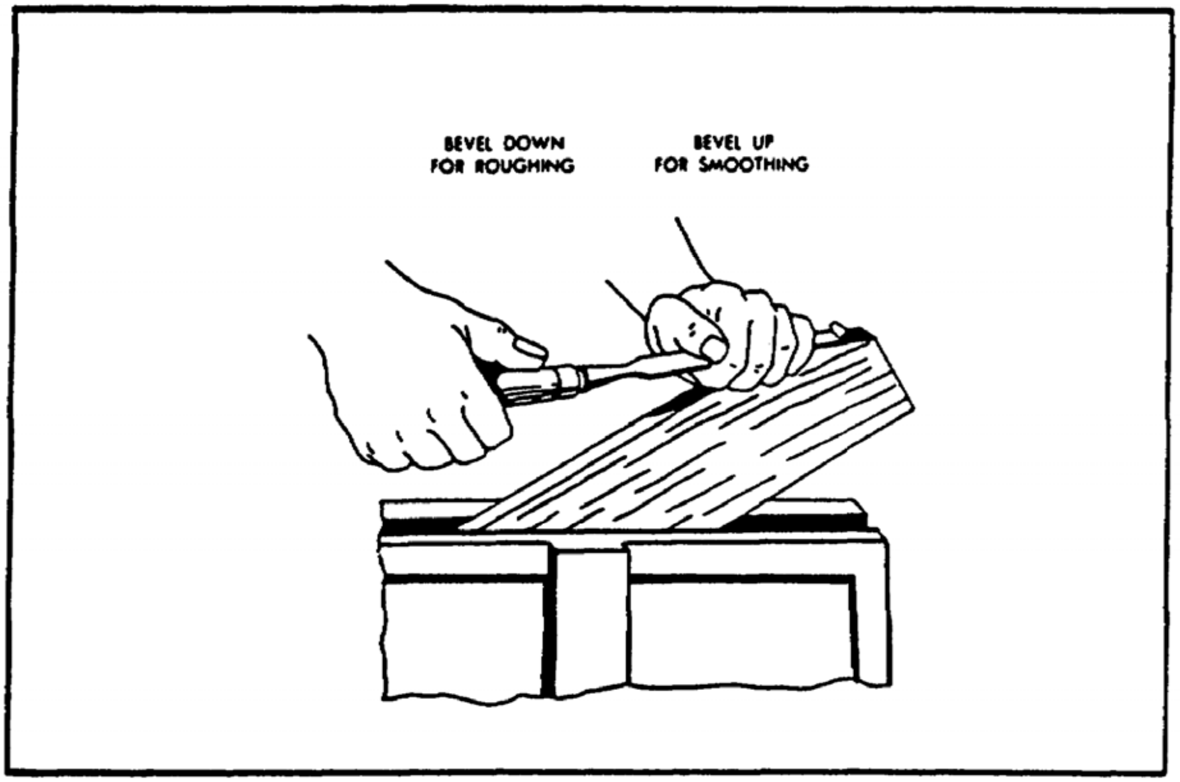


FIGURE 84. CHISELING DIAGONALLY ACROSS GRAIN.

(e) *Chamfering with a Chisel.* A chamfer is made by cutting off and flattening the sharp corner which exists between two surfaces which are at right angles to each other. A plain chamfer runs the full length of the edge and is usually made with a plane. A stopped chamfer does not run the full length of the edge. If a stopped chamfer is long enough, part of it can be planed and the ends finished with a chisel. A short stopped chamfer must be made entirely with a chisel. A chamfer is usually made symmetrically at 45° . Mark guidelines with a pencil; the guidelines for a 45° chamfer will be the same distance back from the edges on both surfaces of the wood (figure 85).

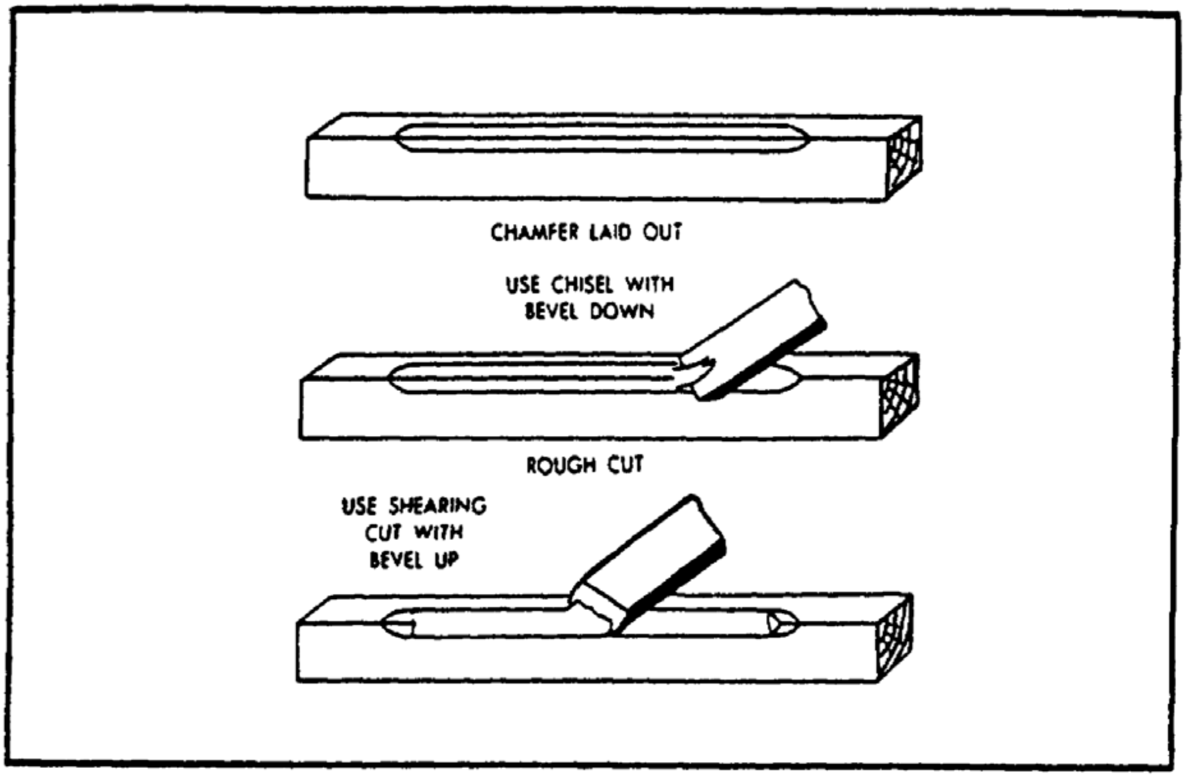


FIGURE 85. CHAMFERING WITH A CHISEL.

NOTE

Do not use a marking gage or knife to make guidelines, since they leave marks in the wood which are difficult to remove.

To cut a stopped chamfer, hold the chisel with the edge parallel to the slope of the chamfer and cut with the grain as in ordinary horizontal paring (figure 82). Begin at the ends and work towards the center. The ends of a chamfer may be either flat or curved. If flat, use the chisel with the bevel up. If curved, keep the bevel down when cutting.

(f) *To Chisel a Round Corner.* To cut a round corner on the end of a piece of wood, first lay out the work and remove as much waste as possible with a saw (figure 86). Use the chisel with the bevel side down to make a series of straight cuts tangentially to the curve. Move the chisel sideways across the work as it is moved forward. Finish the curve by paring with the bevel side up. Convex curves are cut in the same manner as a round corner.

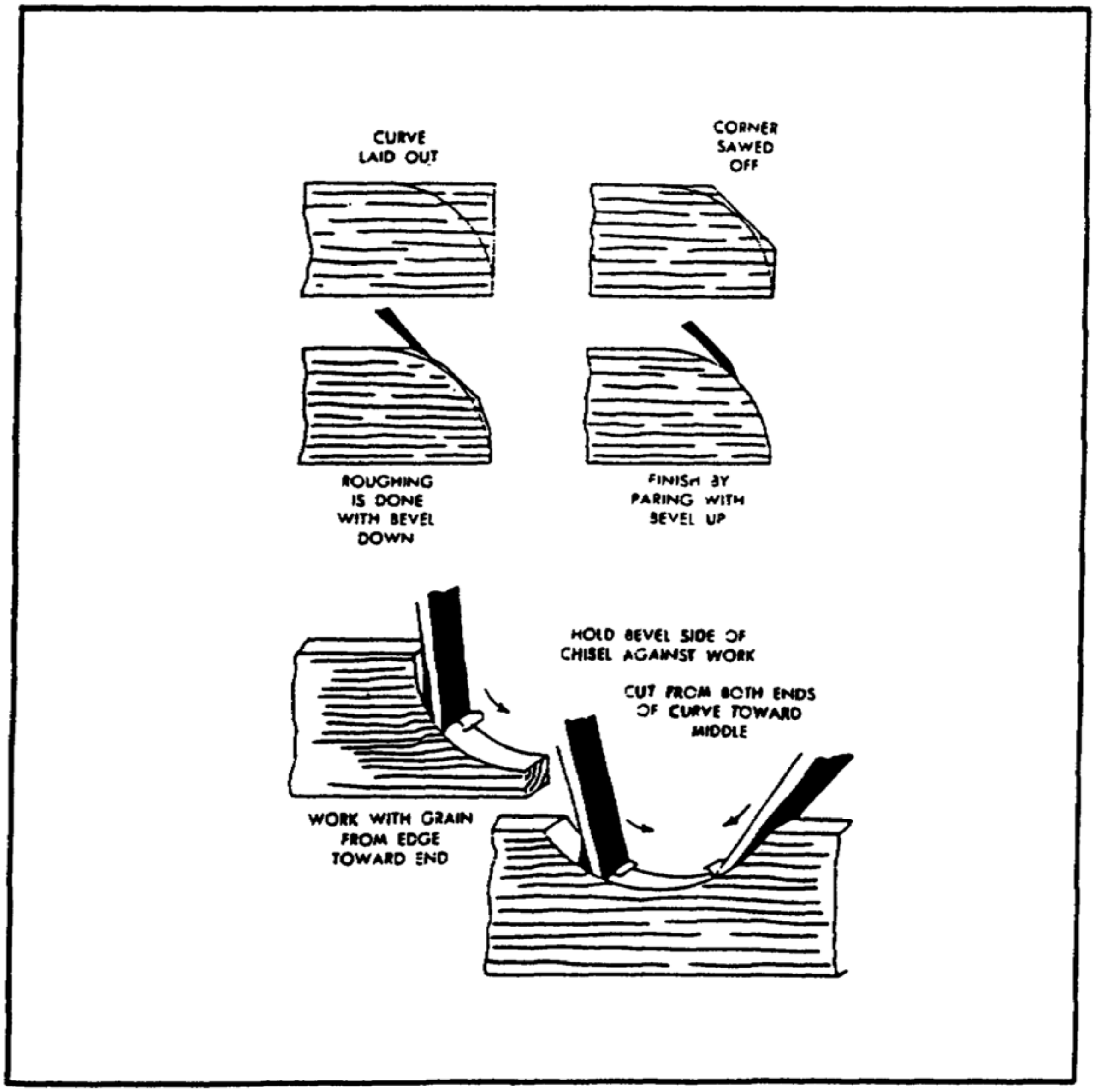


FIGURE 86. CHISELING CORNERS AND CURVES.

(g) *To Cut a Concave Curve.* Remove most of the waste wood with a coping saw or a compass saw. Smooth and finish the curve by chiseling (figure 86) with the grain, holding the chisel with the bevel side down. Use one hand to hold the chisel against the work. Press down on the chisel with the other hand and, at the same time, draw back on the handle to drive the cutting edge in a sweeping curve. Care must be used to take only light cuts or the work may become damaged.

(h) *Vertical Chiseling.* Vertical chiseling (figure 87) means cutting at right angles to the surface of the wood, which is horizontal. Usually it involves cutting across the wood fiber, as in chiseling out the ends of a mortise or making a gain on stopped dado joints. When vertically chiseling across the grain, a mallet may be used to drive the chisel. A mallet is necessary when chiseling hardwood. Use a shearing cut in cutting across the grain. Always cut with the grain whenever possible, so that the waste wood will easily split away from the guide marks. When chiseling on the ends of wood, remove as much waste wood as possible with a saw. Observe the direction of the grain and start to cut at an edge to avoid splitting the wood. Use a shearing cut and make the shavings thin. Thin shavings can be made without the use of a mallet. Grasp the handle of the chisel in one hand with the thumb pressing down on top of the handle. Use the other hand to guide the tool and to supply some of the driving force, if such pressure is required to do the job.

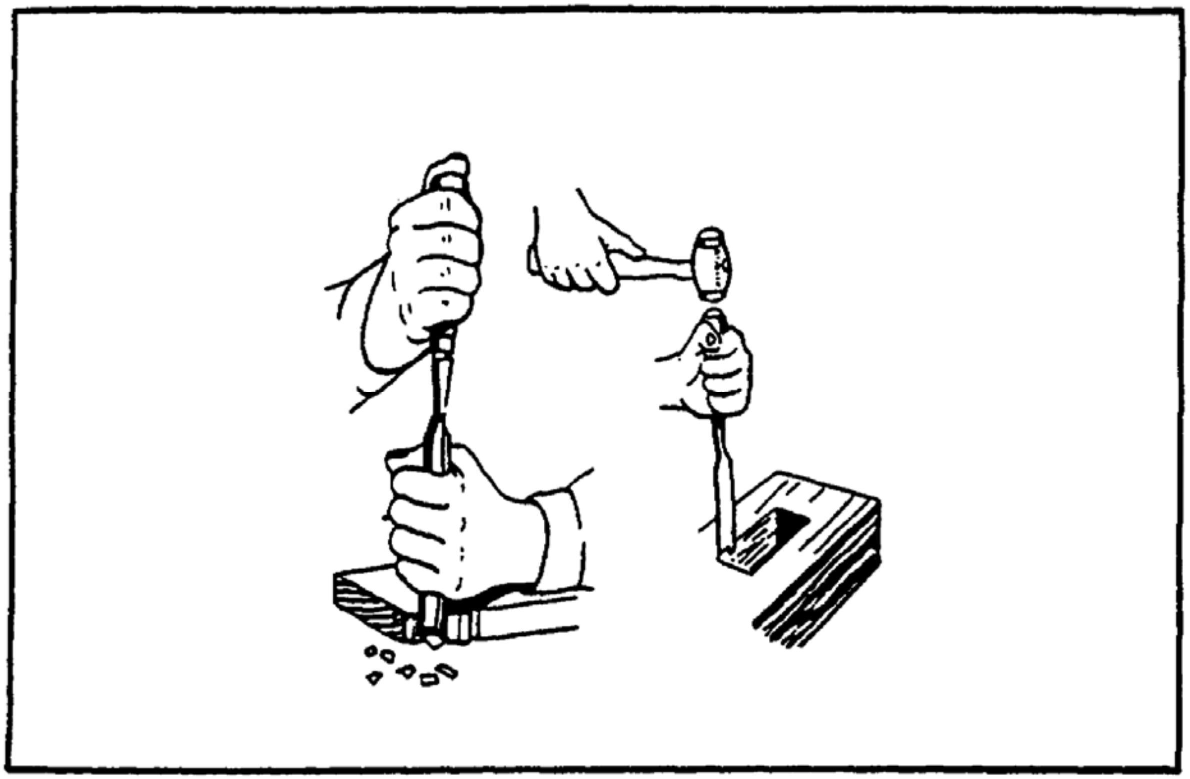


FIGURE 87. VERTICAL CHISELING.

(2) *Machinist's Chisels.*

(a) *Selecting a Chisel.* Best results will be obtained if a chisel is used that was designed for the particular job to be done.

(b) *Chipping.* Chipping is a term applied to the removal of metal with the cold chisel and hammer. The degree of accuracy required varies.

1 Secure the work in a vise, with a block under the work to prevent it from slipping down.

2 Place a canvas chipping guard in front of the work to keep flying chips from hitting men working in front of you. Wear goggles to protect your eyes.

3 For most ordinary chipping with a 3/4 inch chisel, use a 1 pound hammer. Use a lighter hammer for a smaller chisel. Always use a well-sharpened chisel.

4 Grasp the chisel with one hand, holding the cutting edge to the work and striking the other end of the chisel with the hammer, keeping your eyes on the cutting edge to watch the progress of the work. The bevel side of the chisel is the guiding surface and is held at a very slight angle with the finished part of the work the cutting edge is touching. Raising or lowering the shank of the chisel increases or decreases the inclination of the guiding bevel and causes the chisel to take a heavier or lighter cut. If the hand is held too low on the shank, the chisel will run out before the end of the cut; if held too high, progress will be slow, owing to the difficulty of guiding the chisel.

5 When chipping wrought iron or steel, wipe the edge of the chisel with an oil saturated cloth frequently to lubricate the contacting surfaces, and to preserve the cutting edge of the chisel.

6 After every two or three blows, draw the chisel back slightly from the chip. This tends to ease your muscles, giving you better control over the job.

7 When chipping cast metal, begin at the ends and chip toward the center to keep from breaking corners and edges.

8 Take cuts from 1/16 to 1/32 inch. Leave enough stock so that the surfaces may be finished with a file.

9 When chipping keyways with a cape chisel, an ample margin for filing should be left both on the sides and on the bottom.

10 When chipping a rather wide surface, first use a cape chisel to cut grooves, then use the flat chisel to chip the stock between the grooves.

(c) *Cutting Wire or Round Stock.* When a suitable hacksaw is not available to cut round stock, the chisel may be used.

1 Mark off the guideline and place the work on the top face of an anvil or other suitable working surface.

2 Place the cutting edge of the chisel on the mark in a vertical position.

3 Lightly strike the chisel with a hammer and check the chisel mark for the desired cut.

4 Continue to strike the chisel until the cut is made. The last few cuts should be made lightly to avoid damage to the anvil, the supporting surface, or to the chisel.

5 Heavy stock is cut in the same manner, except that the cut is made halfway through the stock, the work is turned over, and the cut finished from the opposite side.

(d) *Cutting Sheet or Plate Metal.* When sheet or plate metal cutters or machines are not available, the chisel may be used. However, using a chisel to cut sheet metal will cause the metal to stretch; avoid this method whenever possible.

1 Mark off the guideline for the cut.

2 Secure work in a vise so that the guideline is even with or below the vise jaws.

3 Use a sharp chisel; start at one edge of the work, holding the chisel perpendicular to the surface. Strike the end of the chisel sharply, keeping the chisel cutting edge firmly held against the work. Always drive the chisel towards the stationary jaw of the vise.

4 Complete the cut along the guideline and finish with a file.

(3) *Blacksmith's Chisels.* The blacksmith's cold chisel is used to cut heavy gage metal which the machinist's cold chisel will not cut. Hold the chisel by the handle with one hand, having the cutting edge perpendicular to the work, and strike the head of the chisel vigorously with a blacksmith's

hammer or sledge. The blacksmith's hot chisel is used in the same manner to cut hot metal. The work is usually placed on an anvil with a piece of scrap metal under the work when the cut is to go completely through the stock.

(4) *Track the Rivet Buster Chisel.* To cut a bolt or rivet head, place the cutting edge of the chisel against the bolt or rivet head where it seats against the track rail or other unit it secures, and strike the chisel head sharply with a heavy hammer or sledge. To cut a rail, place the cutting edge perpendicular to the top of the rail and strike the chisel head with a sledge until a nick or shallow cut has been made in the rail. Pick up the rail and drop it across another rail centered under the cut. The rail should snap at the point where the nick was made.

d. *Maintenance and Repair of Chisels.* Chisels must be kept properly ground and sharpened at all times in order to obtain good workmanship in the finished product. Grinding is necessary when the cutting edge has been badly nicked and the nicks cannot be removed by whetting on a coarse oilstone, or when the bevel has become too short or rounded as a result of frequent or careless whetting.

(1) *Woodworkers's Chisels.*

(a) *Sharpening.* A common oilstone having a coarse and fine grit is used to sharpen a chisel which does not require grinding. It is also used to whet a chisel after grinding.

1 Clamp the oilstone in a vise, or make sure it is otherwise firmly held so that it cannot move.

2 Cover the stone with light machine oil so that the fine particles of steel which are ground off will float; this will prevent the stone from clogging.

3 Hold the chisel in one hand with the bevel flat against the coarse side of the stone.

NOTE

For ordinary work, the bevel is sharpened at an angle of 25° to 35°. For fine cutting and paring, the angle may be slightly less.

4 Use the fingers of your other hand to steady the chisel and hold it down against the stone.

5 Using smooth even strokes, rub the chisel back and forth parallel to the surface of the stone (figure 88). The entire

surface of the stone should be used to avoid wearing a hollow in the center of the stone. Do not rock the blade. The angle of the blade with the stone must remain constant during the whetting process.

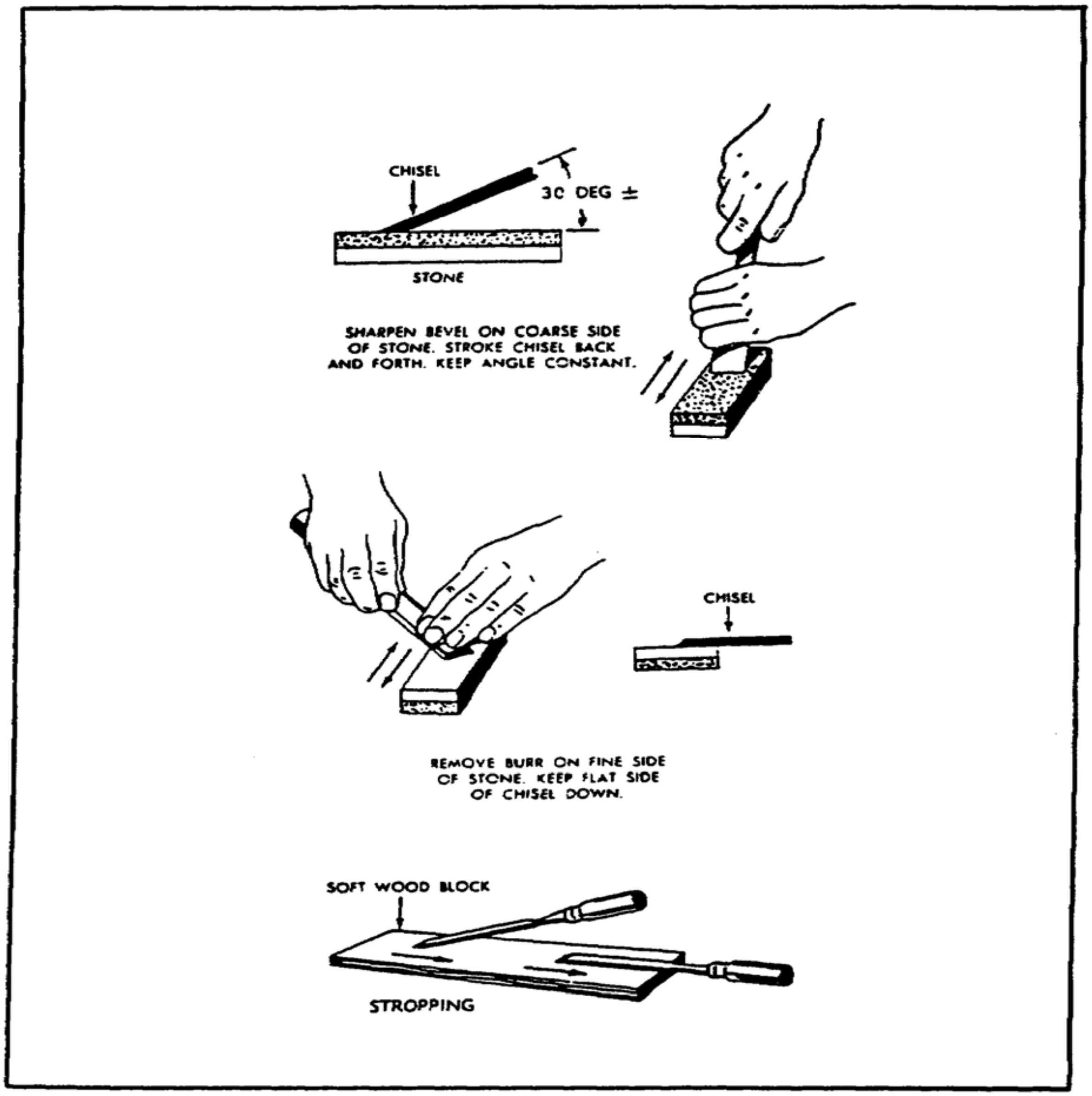


FIGURE 88. SHARPENING A WOODWORKER'S CHISEL.

6 After a few strokes, a burr, wire edge, or feather edge is produced. To remove the burr, first take a few strokes with the flat side of the chisel held flat on the fine grit side of the stone. Be careful not to raise the chisel even slightly and avoid putting the slightest bevel on the flat side; otherwise, the chisel must be ground until the bevel is removed.

7 After whetting the flat side on the fine grit side of the stone, turn the chisel over and place the bevel side down, holding it at the same angle as was used when whetting on the coarse side of the stone. Take two or three light strokes to remove the burr.

8 It may be necessary to take one or two light strokes again on the flat side of the chisel to remove the burr.

9 To get an extremely sharp edge, the chisel must be stropped. This is done by rubbing both sides of the chisel's cutting edge on a soft wood block or on a leather or canvas strap, putting the chisel down and stroking the edge in one direction only, moving the chisel toward the handle end, as shown in figure 88.

10 To test the sharpness of the cutting edge, hold the chisel where a good light will shine on the cutting edge. A keen edge does not reflect light in certain positions. If there are no shiny or white spots in this position, it is a good edge.

(b) *Grinding.* Grind the bevel of a woodworker's chisel concave to the shape of the abrasive wheel used, or to a perfectly flat or straight bevel (figure 89). The length of the bevel should be approximately twice the thickness of the chisel, or slightly longer if the chisel is to be used to cut soft wood.

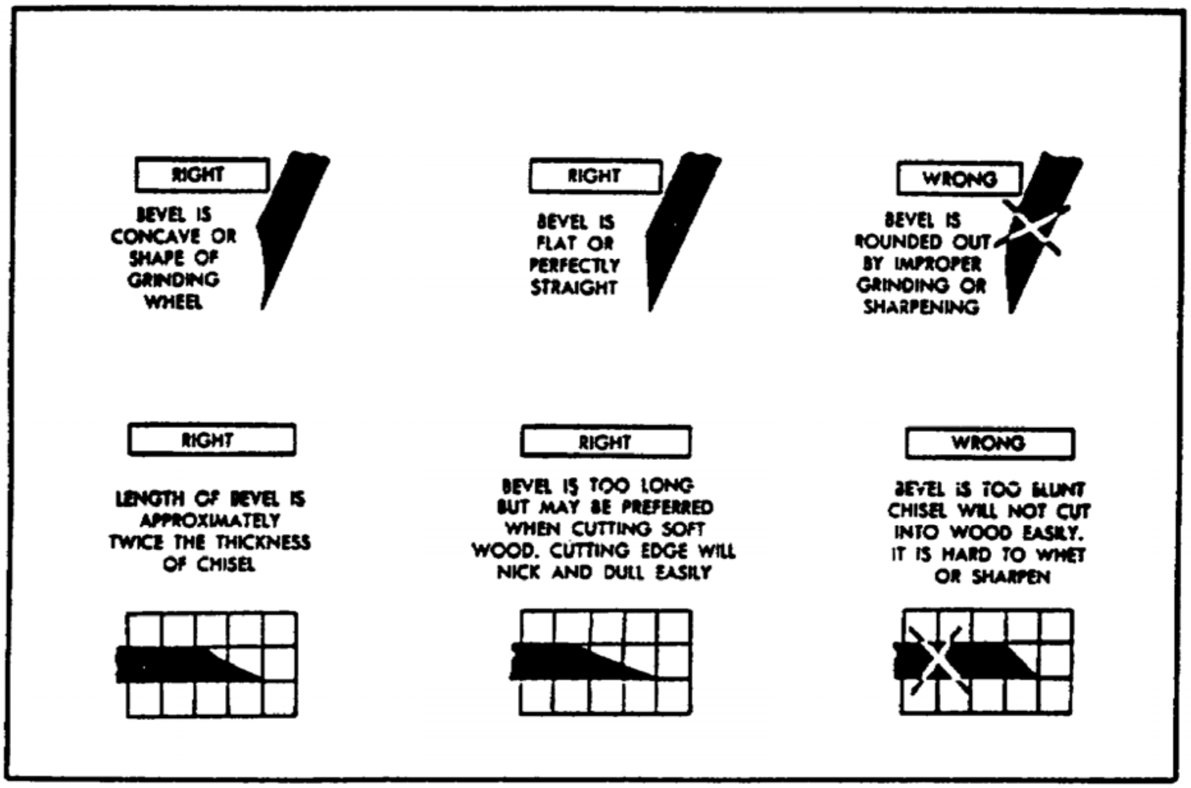


FIGURE 89. RIGHT AND WRONG CHISEL BEVELS.

1 Square the cutting edge and remove nicks. Adjust the grinder tool rest so that when the chisel is held upon it, the edge will be ground at right angles to the length of the chisel (figure 90).

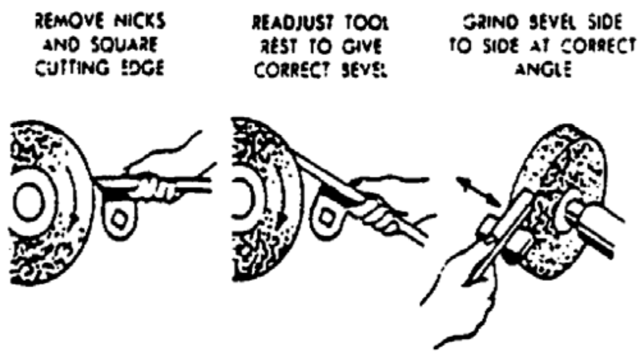


FIGURE 90. GRINDING A WOODWORKER'S CHISEL.

2 After squaring, readjust the grinder rest to the position that will give the correct bevel. Check the bevel angle by looking at it from the side when the grinder is not operating. During grinding the cutting edge must be kept at right angles to the length of the chisel, while the chisel blade rests on the grinder wheel tool rest.

3 When the right position is found, grasp the chisel blade so that the back of the forefinger touches the tool rest. The finger acts as a stop; do not shift its position on the blade until grinding is completed.

4 Hold the chisel lightly against the wheel and move it from side to side evenly across the surface.

5 Frequently dip the chisel in water to prevent loss of temper and softening of the steel. When placing the chisel back on the tool rest of the wheel, use your forefinger as a stop. The grinding angle may be 25° to 35°.

6 After grinding, whet the chisel as discussed above.

(c) *Repairing Damaged Handle Heads.* If the head of a woodworker's chisel becomes mushroomed (figure 91), it can be repaired as described in 1 through 4 below.

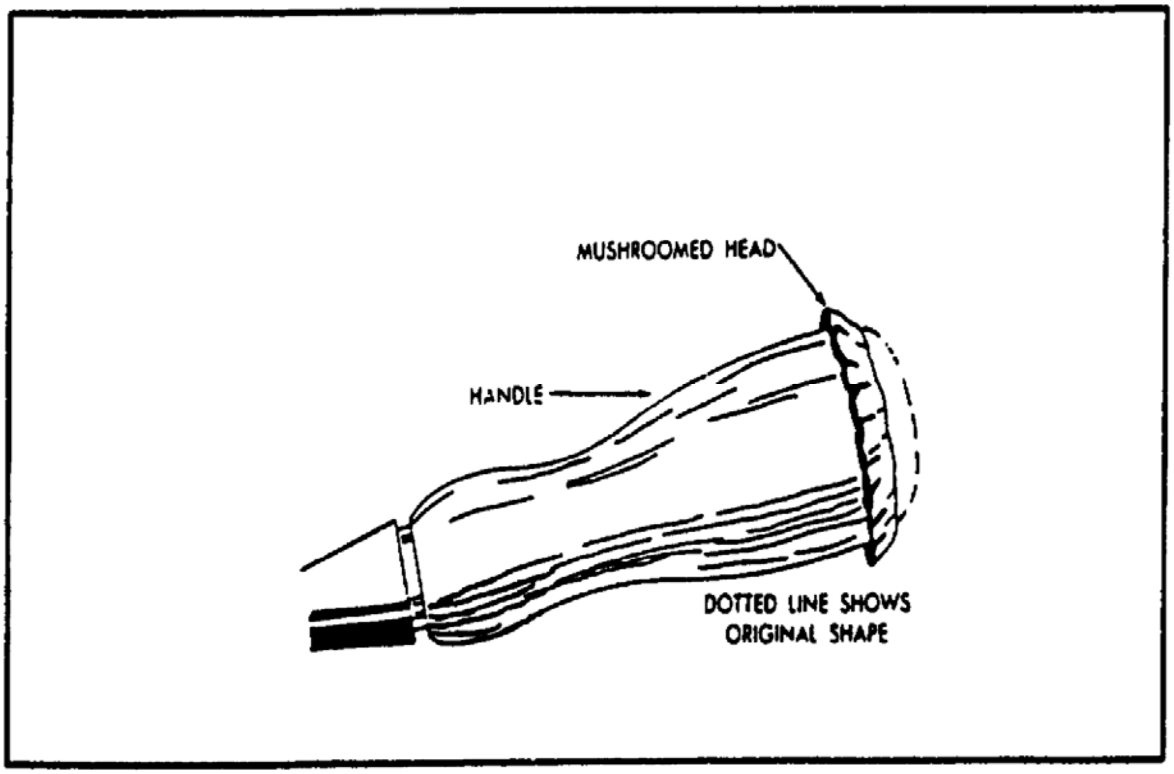


FIGURE 91. MUSHROOMED CHISEL HANDLE.

1 Cut the head of the handle off square (figure 92) with a saw.

2 Using a lathe, turn down about 3/8 inch of the handle length, leaving a tip about 7/16 inch in diameter, as shown.

3 Cut leather or fiber washers to fit snugly over the tip and glue them in place. Use enough washers so their total thickness exceeds 3/8 inch. Their diameter should be greater than the diameter of the handle.

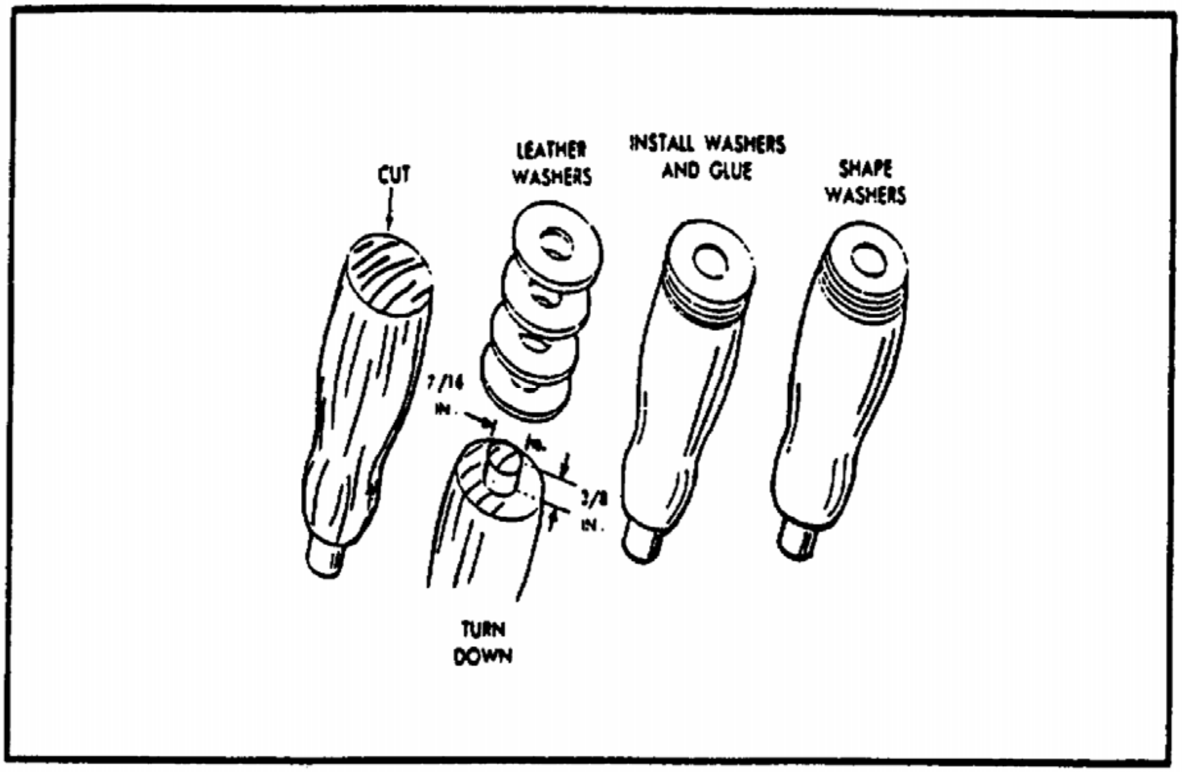


FIGURE 92. REPAIRING MUSHROOMED HANDLE.

4 After the glue dries, reshape the handle end by cutting and sanding the washers to conform to the original rounded shape.

(d) *Replacing Broken Handle.*

1 If a socket-type handle is damaged beyond repair or is broken off in the socket, remove the handle, drilling out the broken ends from the socket if necessary. Shape a new handle to fit snugly in the socket. Secure the blade in a soft-jawed vise and tap the handle to seat in the socket.

2 If a tang-end type handle is damaged beyond repair, or is split, remove the handle. Select a new handle to fit the tang and chisel. Fit a ferrule on the handle by tapping with a soft-faced mallet. Prick punch ferrule to handle and insert the tang in the handle. Tap the back end of the handle on a flat surface until the chisel is properly seated.

(2) *Machinist's and Blacksmith's Chisels.*

(a) *Grinding.* Grind chisels of this type immediately when they become dull. Most of these chisels have two bevels, which form the cutting edge. The included angle formed by the two bevels should be as small as possible without leaving the cutting edge weak. If the angle is too small, the chisel will soon become dull; if the angle is too large, more force will be required to drive the tool. The best included angle for cutting cast iron is about 70°; for wrought iron and mild steel 60° is preferred. Chisels used for cutting extremely hard metal may be ground to 90°.

1 Set the grinder tool rest to give the chisel the desired bevel angle.

2 Hold the chisel (as shown in figure 93) with the left-hand resting on the tool rest.

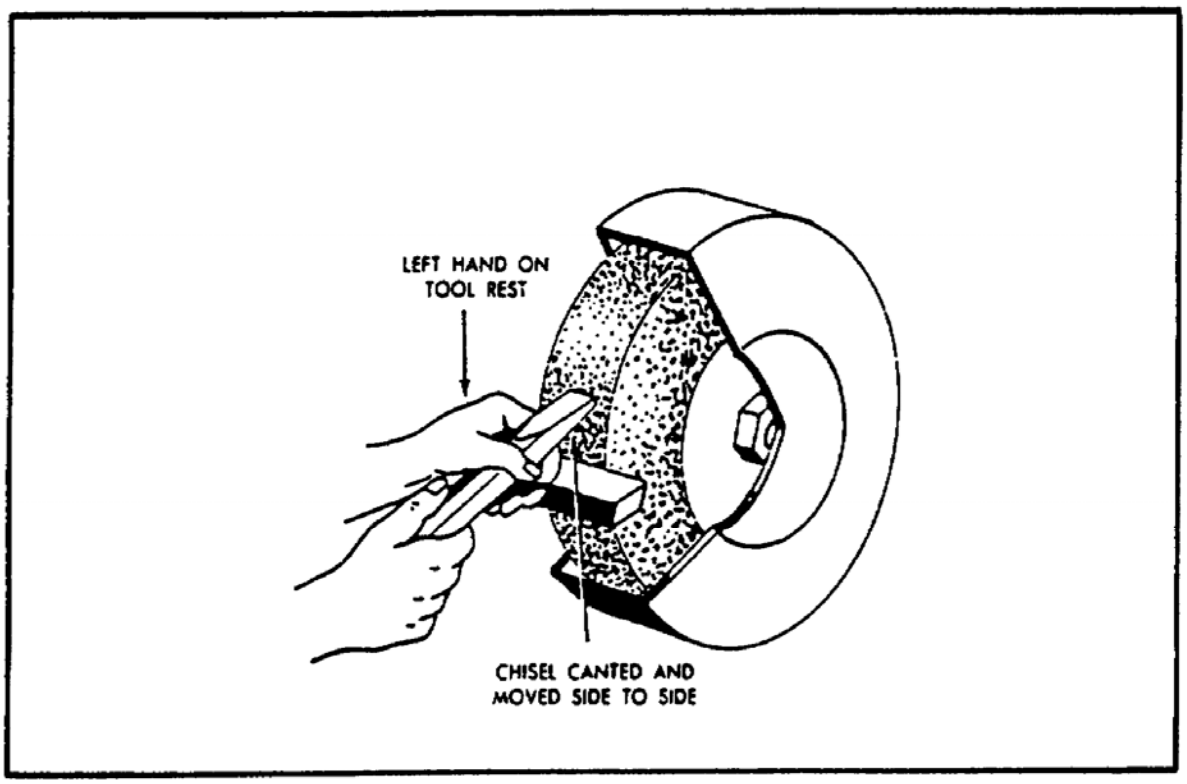


FIGURE 93. GRINDING A COLD CHISEL.

3 Move the chisel slowly back and forth across the face of the grinding wheel at the desired canted angle.

4 Do not hold the chisel against the wheel with too much pressure or the temper will be lost due to overheating.

5 Grind the cutting edge slightly convex, as shown in figure 94. This is done to prevent the corners of the chisel from digging into the work.

6 Dip the chisel in water frequently to cool off, preserving temper.

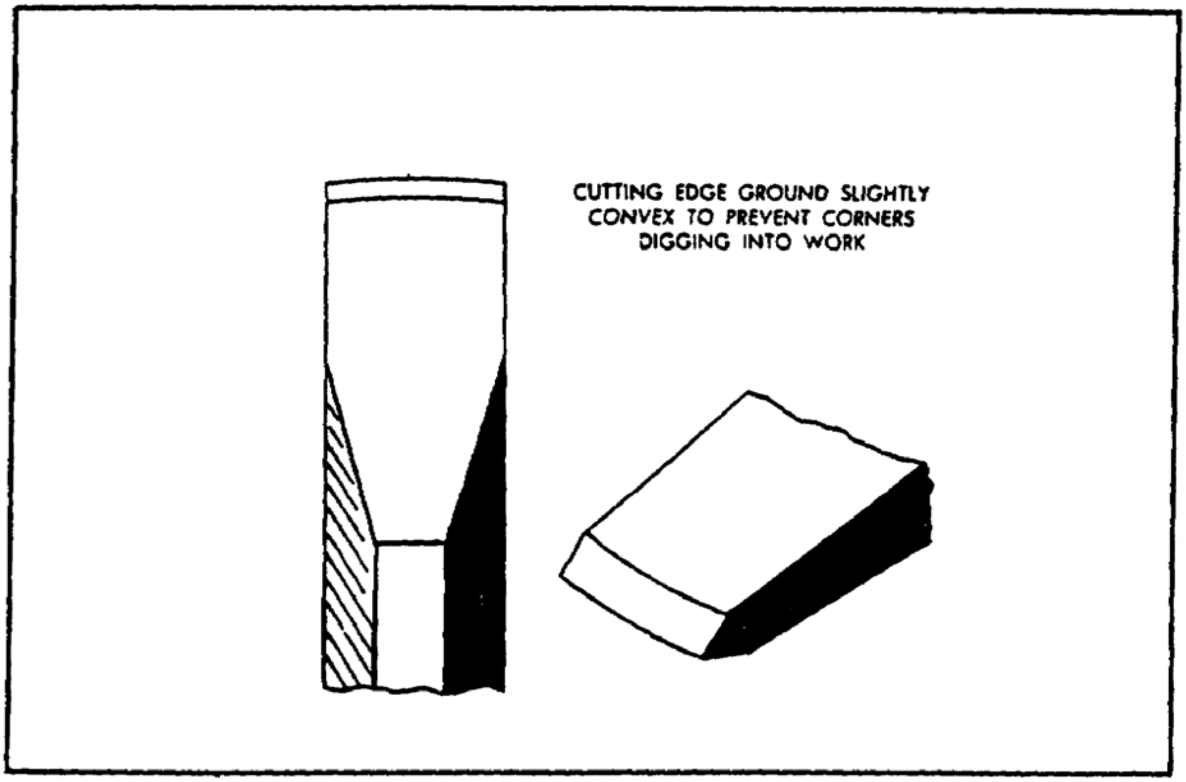


FIGURE 94. CUTTING EDGE OF MACHINIST'S FLAT OR COLD CHISEL.

7 Turn the chisel over to grind the other bevel. The bevels should be ground alike in width and should form equal angles with the centerline of the chisel. The roundnosed chisels have one bevel, like a wood chisel. The standard included angle between the surfaces which form the cutting edge should be the same, whether these surfaces are both bevels, or one bevel and the other flat. In a one bevel chisel, therefore, the angle that the bevel forms with the centerline of the chisel should be twice as large as in a chisel having two bevels.

(b) *Hardening and Tempering.* Machinist's and blacksmith's chisels often require hardening and tempering. To harden a chisel, heat it to a cherry red in a suitable furnace or forge, after removing the wood handle in case of the blacksmith's chisel. Hold the chisel in the center with a pair of tongs and dip the cutting end in cold water to a depth of 1 1/4 inches. Turn the chisel over and dip the chisel head to a depth of 1 inch. Polish the hardened ends with a file or aluminum oxide abrasive cloth. Watch for color to return to the ends from the very hot center section. Every time the cutting end turns purple, dip it. Redip the head every time it turns blue. When the red disappears from the chisel, dip the whole tool to check further drawing of temper. The same procedure is used on the cutting edges and heads of any type chisel or other tool when retempering or hardening is necessary. The process produces a hard cutting edge and head, and a softer and tougher center section, better adapted to withstand shock.

(c) *Reshaping Mushroomed Head.* If machinist's or blacksmith's chisels become mushroomed after much use, the head must be reground to shape on a grinder wheel. The chisel must be hardened after reshaping the head.

(d) *Repairing and Replacing Handles.* Wooden handles on blacksmith's chisels are repaired and replaced as you would a hammer handle.

e. *Precautions When Using Chisels.*

(1) Keep your mind on your work so that you do not strike yourself or someone else with a hammer.

(2) Do not carry chisels in your pockets.

(3) Lay chisels down so that you or others cannot be hurt with the cutting edge.

(4) Be sure chisel shanks and hammers are free from grease or oil.

(5) Keep the cutting edge of chisels away from yourself and others when using them.

(6) Wear goggles when chipping metal and when grinding chisels.

(7) Keep chisel handles in good condition. Do not use chisels having mushroomed heads or handle heads.

(8) Do not exert too much pressure against a grinding wheel when grinding or sharpening chisels.

f. *Storage and Care of Chisels.* To prevent dulling the cutting edges, place the chisels in racks or arrange them so that their cutting edges do not come in contact with other tools or pieces of metal. Chisels used daily should be cleaned and wiped with an oily cloth before putting them away. For long periods of storage, apply a rust preventive compound to all metal parts and store in a dry place.

3. Files

a. *Purpose.* Files are used for cutting, smoothing off, or removing small amounts of metal.

b. *Types of Files.* Files (figure 95) are made in various lengths, shapes, cuts, and teeth-spacing. Every file has five parts: the point, edges, face or cutting teeth, heel or shoulder, and tang (figure 96).

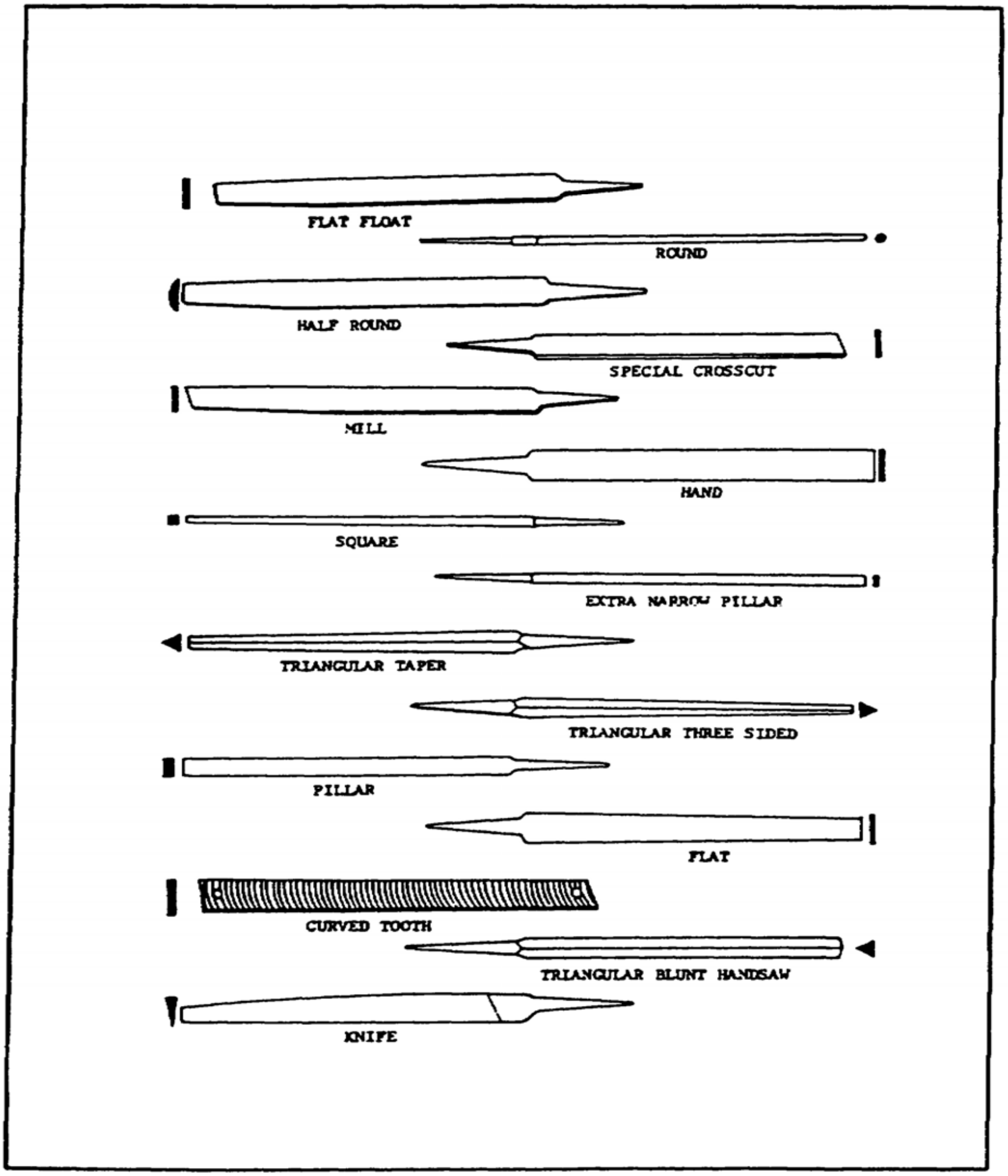


FIGURE 95. TYPES OF FILES.

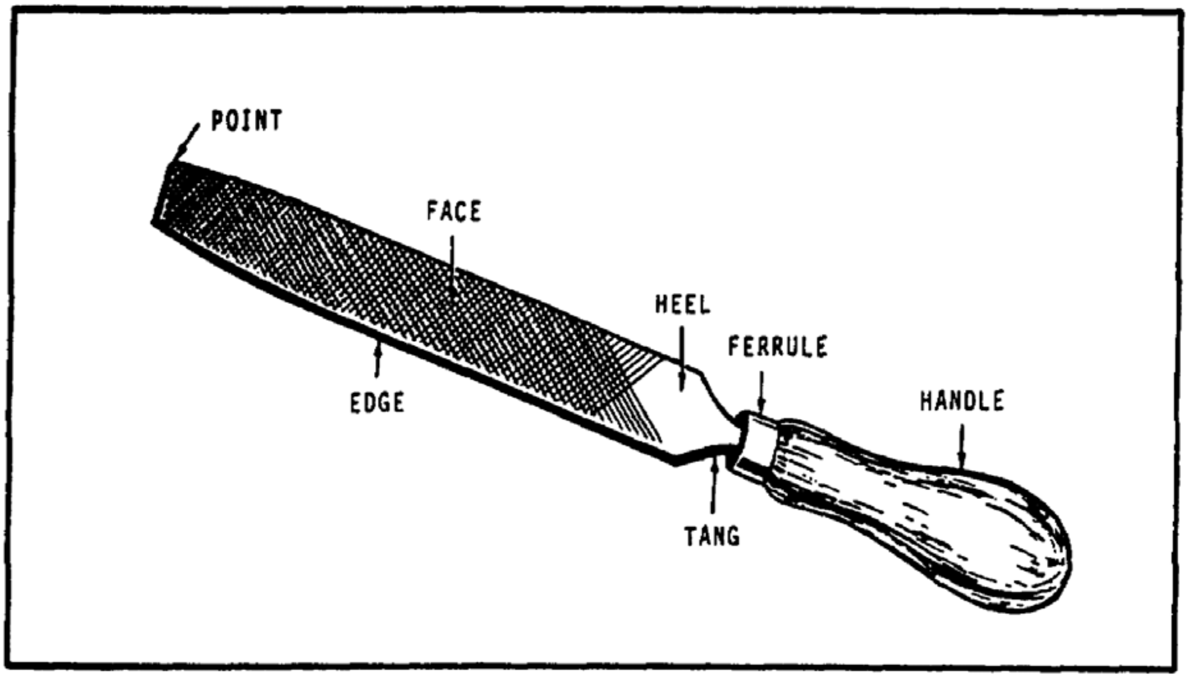


FIGURE 96. PARTS OF A FILE.

(1) *File Teeth Characteristics.* Figure 97 illustrates the different types of file teeth.

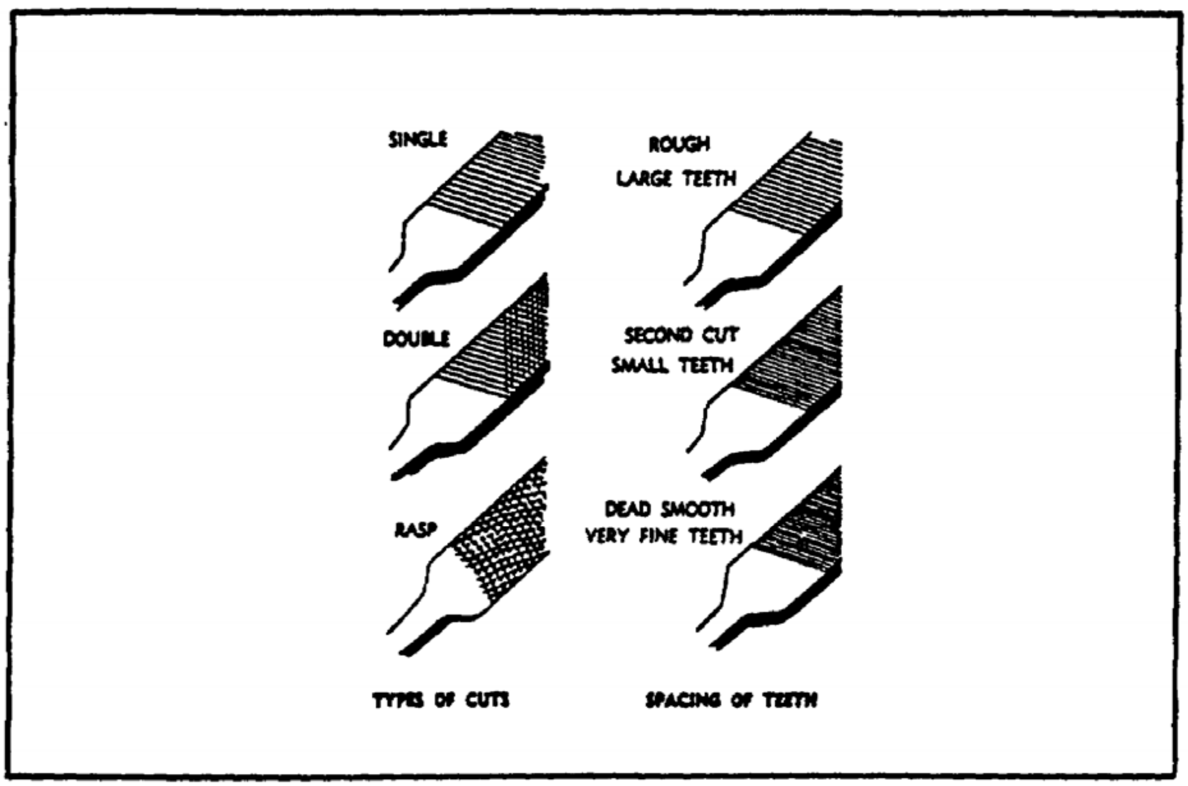


FIGURE 97. FILE TEETH CHARACTERISTICS.

(a) *Single-Cut Files.* Single-cut files have a single set of diagonal rows of teeth. The teeth are parallel to each other throughout the file.

(b) *Double-Cut Files.* Double-cut files have two sets of diagonal rows of teeth. The first set is called the overcut. On top of the overcut set, a second is made crossing the first. The second set is called the upcut and is not as coarse or as deep as the overcut.

(c) *Rasp-Cut Files.* Rasp-cut files are made by a pointed tool or punch which forms each short tooth separately. Teeth are formed consecutively, side by side, to form a line or row of teeth.

(2) *File Teeth Spacing.* The number of teeth per inch of spacing varies slightly with the make of file. The spacing also changes with the file length, increasing proportionately as the length of the file is increased. A file may have rough, coarse, bastard (medium coarse), second cut, smooth cut, and dead smooth grade teeth. For fast removal of metal for rough work, rough, coarse, and bastard files are used. For finishing, second cut (small teeth), smooth cut (smaller teeth), and the dead smooth (very fine teeth) are used.

(3) *File Shapes.*

(a) *Flat Files.* A flat file is rectangular in cross section, is slightly tapered towards the point in both width and thickness, and has double-cut teeth. Both edges are cut.

(b) *Hand Files.* A hand file is similar to a flat file, but is of uniform width and tapers only in thickness. It is double cut with one safe or uncut edge.

(c) *Square Files.* A square file tapers slightly towards the point on all four sides and is double cut.

(d) *Round Files.* A round file tapers slightly towards the point. Bastard cut files, 6 inches and longer, are double cut. Second cut round files, 12 inches and longer, are double cut; all others are single cut.

(e) *Half-Round Files.* A half-round file tapers towards the point in width and thickness. The flat side of all half-round files is double cut and is graded in coarseness like flat files. The round backs of all coarse and bastard half-round files longer than 6 inches are double cut; the backs of 4 and 6 inch files are single cut.

(f) *Mill Files.* A mill file is usually single cut and is tapered in width and thickness for about a third of its length.

(g) *Pillar Files.* A regular or an extra narrow pillar file is similar to a hand file, except that it is narrower. Pillar files are double cut with one safe or uncut edge. Pillar files are of the same coarseness as square files of corresponding lengths.

(h) *Triangular Files.* The taper file tapers toward the point, is usually single cut, and has edges that are set and cut for filing the gullet between saw teeth. The blunt handsaw file is of uniform width and thickness; its teeth are similar to those of the taper file. The three sided file tapers towards the point, is double cut, and has fairly sharp corners.

(i) *Knife Files.* A knife file is shaped like a knife blade and is double cut on both faces.

(j) *Flat Float Files.* Flat float files are slightly tapered in width and thickness and have a coarse single cut.

(k) *Curved Tooth File.* The curved tooth file has single cut, curved, milled teeth.

(l) *Special Crosscut Saw File.* The special crosscut saw file is single cut and of uniform width and thickness.

(m) *Swiss Pattern Files.* Swiss pattern files (figure 98) are small and delicate. The tang is shaped into a handle. They are most often used for fitting parts of delicate mechanisms, for filing work in instruments, and for tool and die work. They are made in seven cuts;

Nos. 00, 0, 1, 2, 3, 4, and 6. They are usually supplied in sets of 8 or 12 assorted files in a box, although individual files are issued. The handles are knurled for a better grip. The Swiss pattern files are designed in twelve shapes.

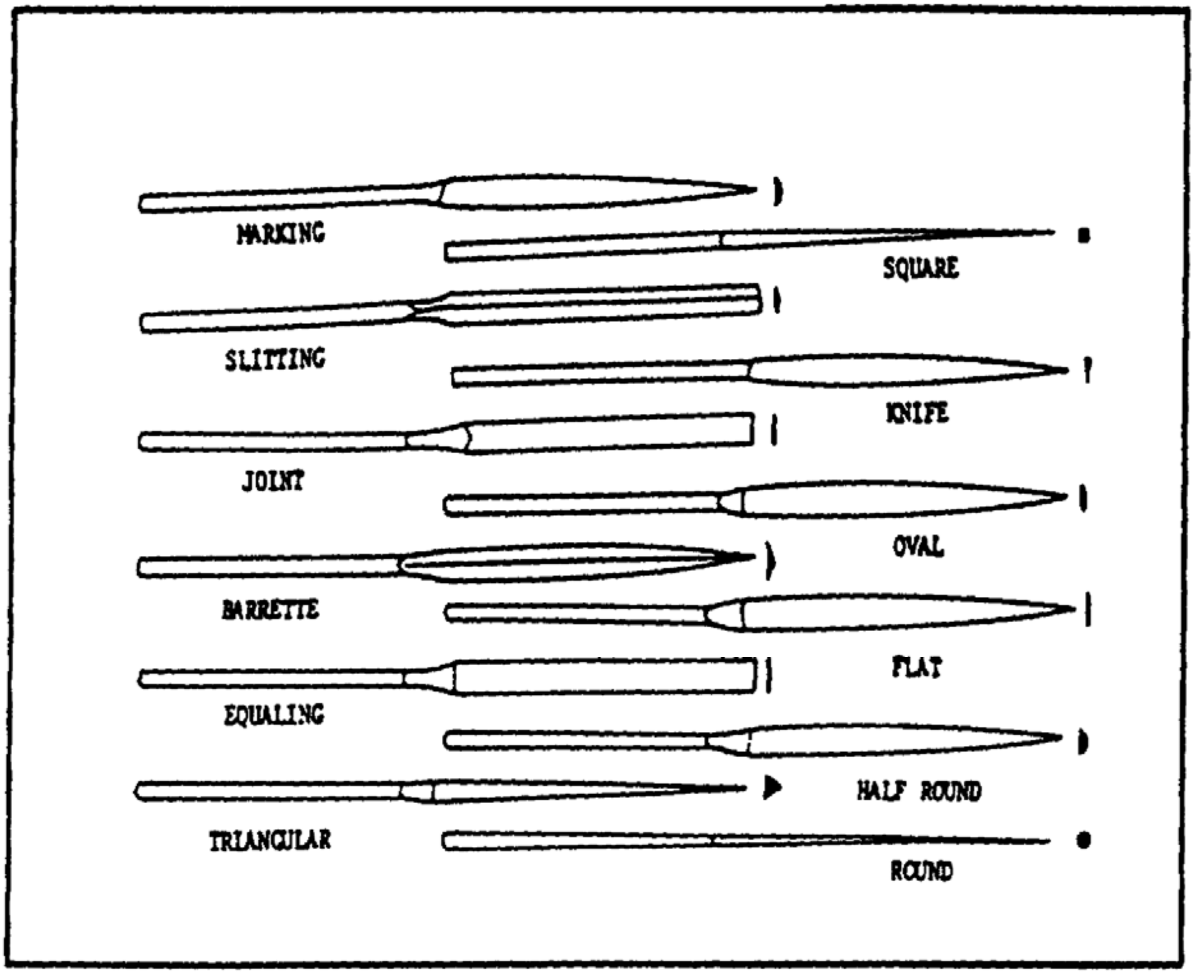


FIGURE 98. SWISS PATTERN FILES.

c. *Use of Files.*

(1) *Selecting the Proper File.*

(a) For heavy, rough cutting, a large coarse, double-cut file is best.

(b) For finishing cuts, use a second- or smooth-cut, single-cut file.

(c) When working on cast iron, start with a bastard-cut file and finish with a second-cut file.

(d) When filing soft metal, start with a second-cut file and finish with a smooth-cut file.

(e) When filing hard steel, start with a smooth-cut file and finish with a dead smooth file.

(f) When filing brass or bronze, start with a bastard cut file and finish with a second- or smooth-cut file.

(g) When filing aluminum, lead, or babbitt metal, use a bastard-cut, curved tooth file.

(h) For small work, use a short file; for medium sized work, use an 8 inch file; for large work, use a file that is most convenient in length.

(2) *Method of Filing.*

(a) Clamp the work securely in a vise so that the area to be filed is horizontal and is parallel to and projecting slightly above the vise jaws.

(b) Hold the file handle in one hand, thumb on top, and hold the tip of the file with the fingers of the other hand, as shown in figure 99).

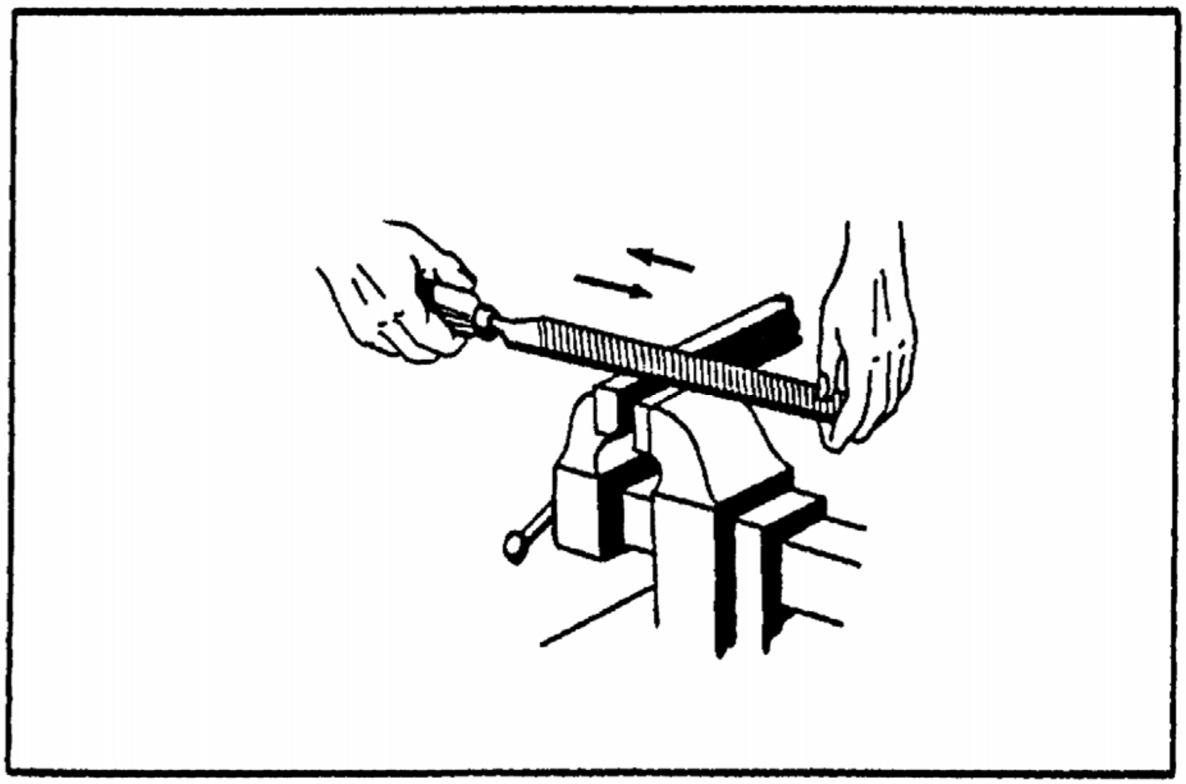


FIGURE 99. NORMAL FILING PROCEDURE.

(c) Apply pressure on the forward stroke only. Unless the file is lifted from the work on the return stroke, it will become dull much sooner than it should. However, when filing soft metals, pressure on the return stroke helps keep the cuts in the file clean of waste metal.

(d) Use a rocking motion when filing round surfaces.

(e) When using a new file, do not apply too much pressure as the teeth may break off.

(f) File slowly, lightly, and steadily. Too much speed and too much pressure causes the file to rock and will round off the corners of the work.

(3) *Draw Filing.* Draw filing is used to produce a very smooth and true surface. To draw file, hold the file at right angles to the direction of the strokes, with your hands close together, as shown in figure 100, to prevent bending or breaking the file. Pressure should not be great and can remain the same on the back stroke, as well as on the draw stroke. The speed of filing is not important. For extra smooth surfaces, wrap a piece of emery cloth around the file and stroke in the same manner.

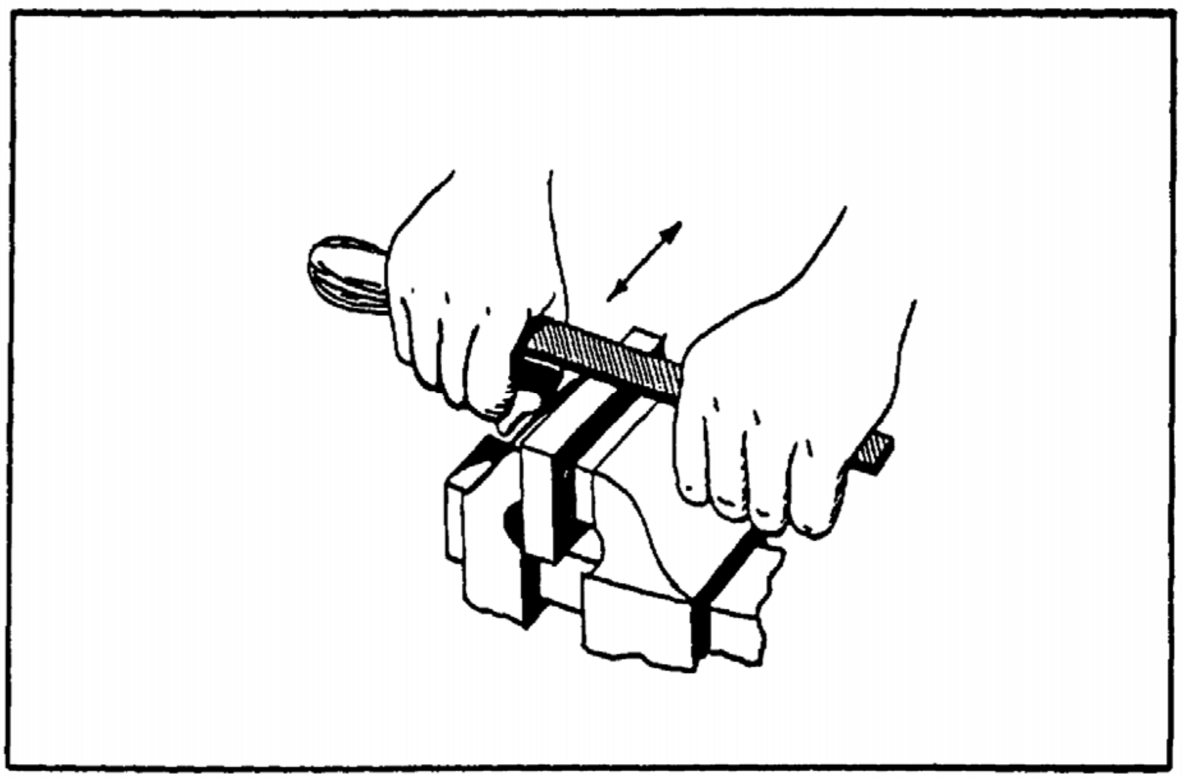


FIGURE 100. DRAW FILING.

d. *Care of Files.*

(1) *Breaking In.* A new file should be broken in by using it first on brass, bronze, or smooth iron. Never use it first to remove the fins or scales on cast iron. Do not use a new file on a narrow surface, such as sheet metal, because the narrow edge of the metal is likely to break off the sharp points on the file teeth.

(2) *Cleaning.* After using a new file, the teeth will clog up with metal filings. Using a clogged file will scratch the work--this condition is called pinning. One way to help prevent pinning is by rubbing chalk between the teeth before filing. However, the best method of keeping a file clean is to use a file scorer and file cleaner brush (figure 101). A scorer is a small pointed metal instrument, often furnished with the file cleaner brush. It is used for cleaning out individual teeth and grooves in the file if they become clogged too tightly with metal to clean with the brush. When cleaning a file with a file scorer, use a pulling motion, holding the file scorer blade parallel to the rows of teeth. Finish cleaning by brushing the file parallel to the rows of teeth with the file cleaner brush.

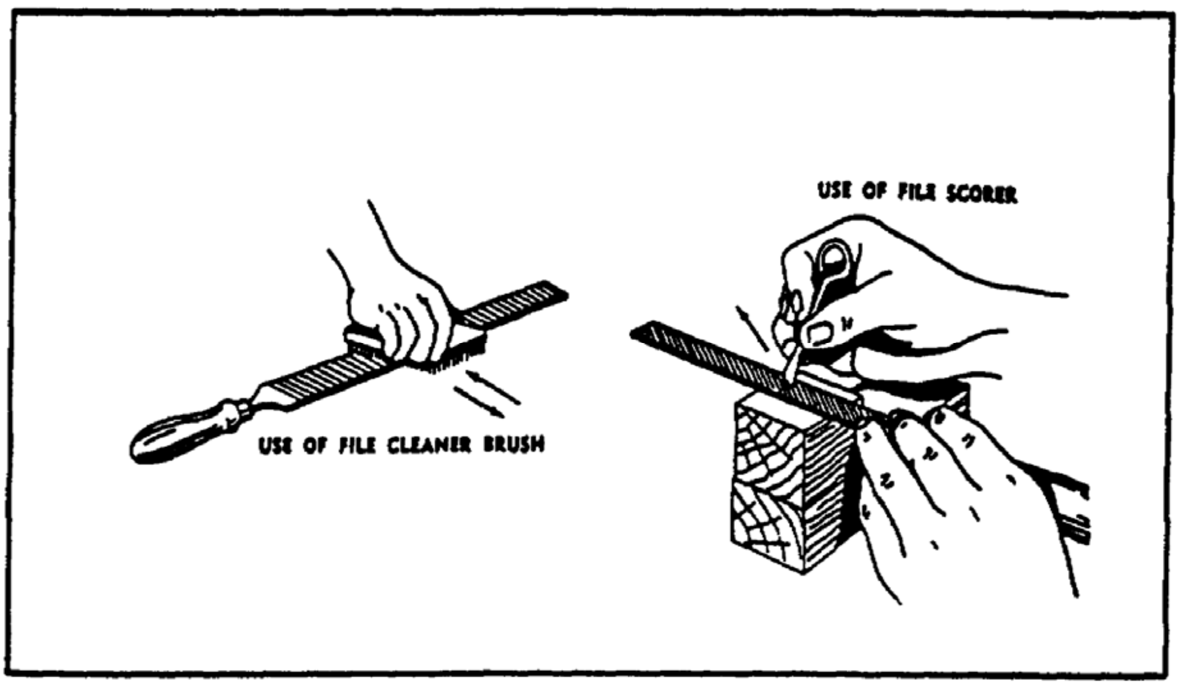


FIGURE 101. CLEANING A FILE.

(3) *Handling Precautions.*

(a) Do not throw files in a drawer or tool box where they can rub against each other, or against other tools. Store them in separate holders, such as clips, straps, or in holes cut in a block of wood.

(b) Use a file as instructed, and clean files often.

(c) Never use a file without a securely attached handle (figure 102) unless it is of the Swiss pattern.

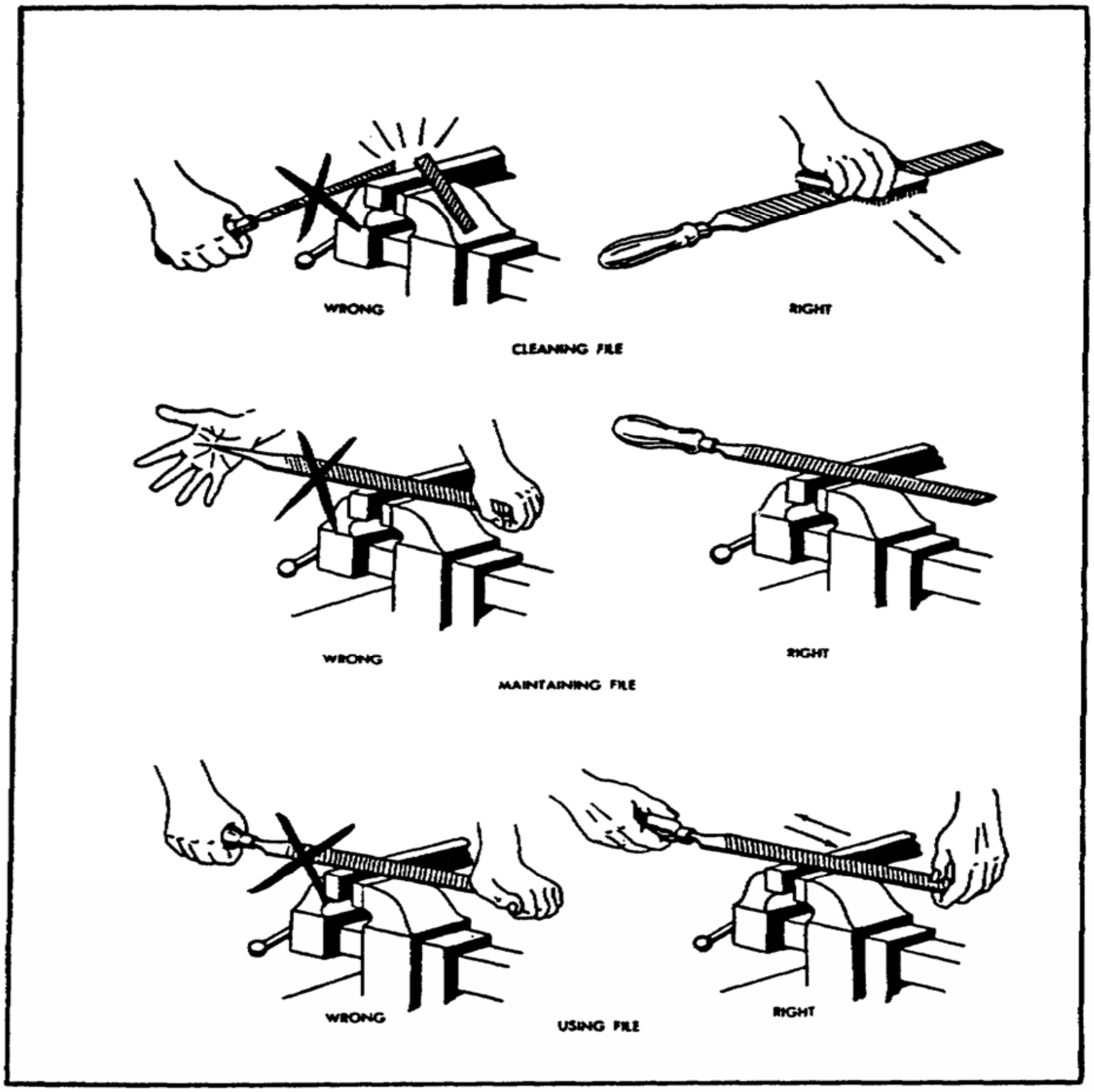


FIGURE 102. FILING PRECAUTIONS.

(d) Do not use files for a purpose other than that for which they were intended.

(e) Do not use oil since this will cause the file to slide across the work, preventing fast cutting.

(f) Never strike the file against a vise or other object to remove filings; use the file cleaner brush.

(4) *Storage.* Never store files with lubricants or rust-preventive compounds on them. Wrap each file in a waterproofed barrier wrapping paper and place the files in racks or boxes so that the faces or edges of the files will not touch each other. Keep files dry.

e. *Replacing Handles.*

(1) To remove a handle, hold the file with one hand and the handle with the other hand; pull the file from the handle while striking the ferrule end of the handle against the edge of a bench, as shown in figure 103.

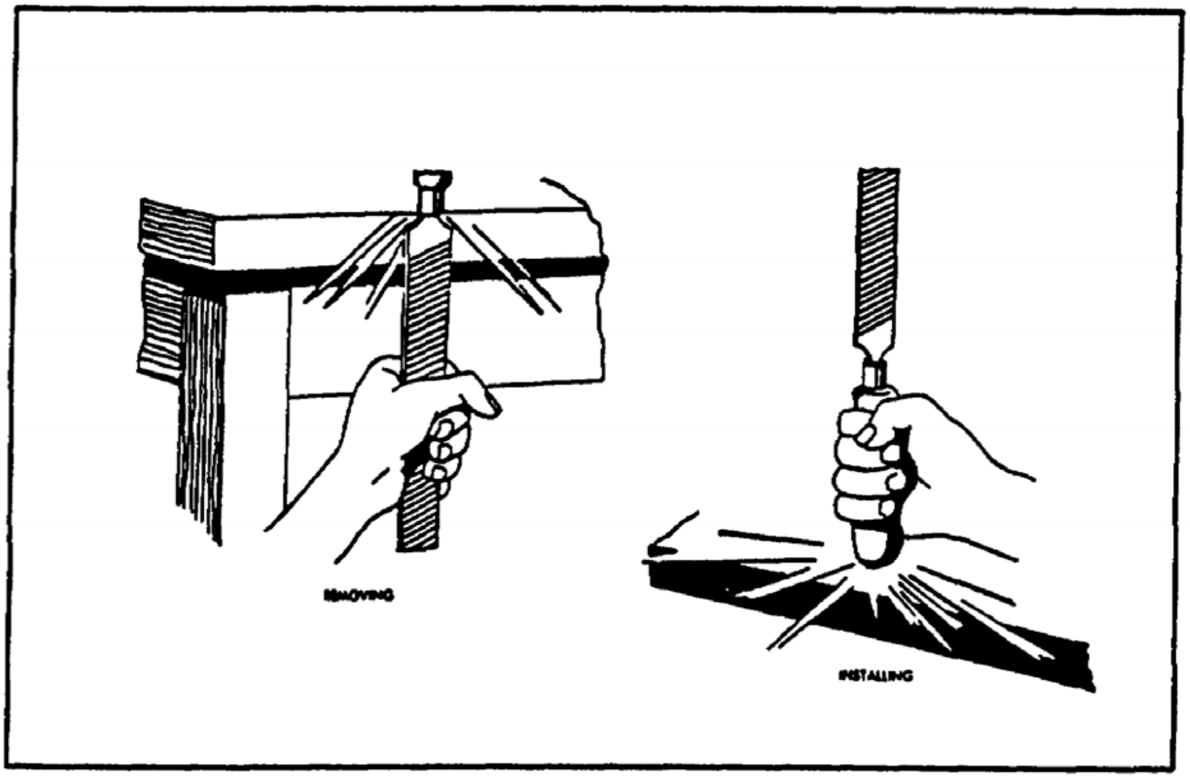


FIGURE 103. REPLACING A FILE HANDLE.

(2) To install a new handle, insert the tang end of the file into the handle socket exerting pressure with your hands. Then tap the handle on the bench top until the file is seated, as shown in figure 103. Do not hammer a file into a handle.

4. Knives

a. *Purpose.* Most knives (figure 104) are used to cut, pare, notch, and trim wood, leather, rubber, and other materials. Some knives, used by glaziers, are called putty knives; these are used to apply and spread putty when installing glass.

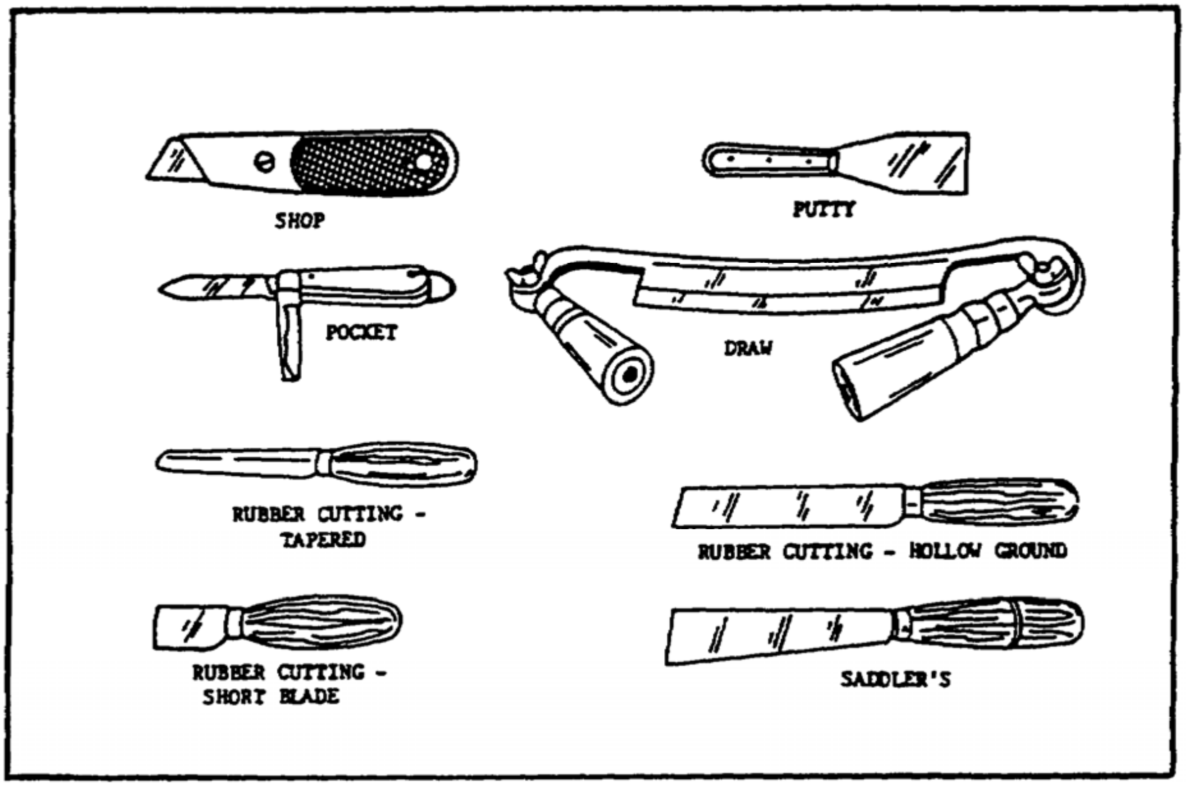


FIGURE 104. TYPES OF KNIVES.

b. *Type of Knives.*

(1) *Rubber Cutting Knives.* Rubber cutting knives are made in several shapes. Some are hollow ground with a 1 x 6, 1 x 8, or 1 1/4 x 10 inch blade. The handle is usually oval in shape. Some rubber cutting knives have a short wide blade, some taper to a blunt rounded point.

(2) *Saddler's Knives.* Saddler's knives are available in three shapes; one having a broad point on a 1 1/8 x 5 inch blade, a second having a 5 inch round pointed blade, and a third having a 5/8 x 3 7/8 inch square point blade. Shoe knives are similar to the saddler's knives; they have 3/4 x 3 1/4 inch blades.

(3) *Shop Knife.* The shop knife can be used to cut wall board, paper, cardboard, linoleum, canvas, and upholstery materials. It has an aluminum handle and is furnished with five interchangeable blades. The extra blades are stored in the 6 inch handle.

(4) *Pocket Knives.* Pocket knives are used for light cutting, sharpening pencils, cutting string, and light whittling. They are unsuited for heavy work. Multi-purpose knives have an assortment of blades designed for forcing holes, driving screws, and opening cans, as well as for cutting. The blades are hinged, contained within the case when not in use, and are spring loaded to keep them firmly in place when open or closed.

(5) *Drawknife.* A drawknife is a flat-edged tool used principally to rough-shape round timber. It should be used to smooth wood after chopping with a hatchet or adze. It consists of a single bevel blade and two wooden handles, one at each end and at right angles to the blade.

(6) *Spoke Shave.* A spoke shave (not illustrated) is used like a drawknife and was originally designed for shaping the wooden spokes of a wheel by hand. The spoke shave has an adjustable blade like a plane and can be adjusted for the thickness of the cut required.

(7) *Putty Knife.* A putty knife is used for applying putty to a window sash in setting in panes of glass. The blade has a wide square point and is available in different lengths and widths.

c. *Use and Care of Knives.*

(1) Always cut away from the body, except when using a drawknife or spoke shave.

(2) To use a drawknife or spoke shave, grasp both handles of the knife, holding the blade at a slight angle to the wood, and pull the knife toward the body. Always work with the grain of the wood. If the grain is irregular, change the direction of the stroke or the position of the work accordingly. Always clamp small work in a vise.

(3) Do not use knives which are larger than can be handled safely. Use knives only for the purpose for which they were designed.

(4) Do not carry open knives in your pocket.

(5) Do not leave knives where they may come in contact with the body, or in such a position that they could cause injury to others.

(6) Carefully put knives away after use, in a sheath or container, to protect the sharp cutting edges from contacting other hard objects.

(7) Before storing, wipe all metal parts with an oily rag.

(8) For long-term storage, apply a thin film of rust-preventive compound on all metal parts, cover the cutting edge, and store in a dry place.

d. *Maintenance of Knives.*

(1) *Sharpening.*

(a) Most knives are sharpened on a medium or fine grade oilstone with a few drops of oil spread on the surface. Hold the handle in one hand and place the blade across the stone. Press down with the fingers of other hand and stroke the blade, following a circular motion as shown in figure 105. After several circular strokes, reverse the blade and stroke the opposite side, using the same type of motion. Avoid grinding the blade; use a light, even pressure. A thin blade overheats quickly and can lose its temper. The wire edge or burr that may be left on a knife blade after sharpening may be removed by stropping both sides on a soft wood block or a canvas or leather strap.

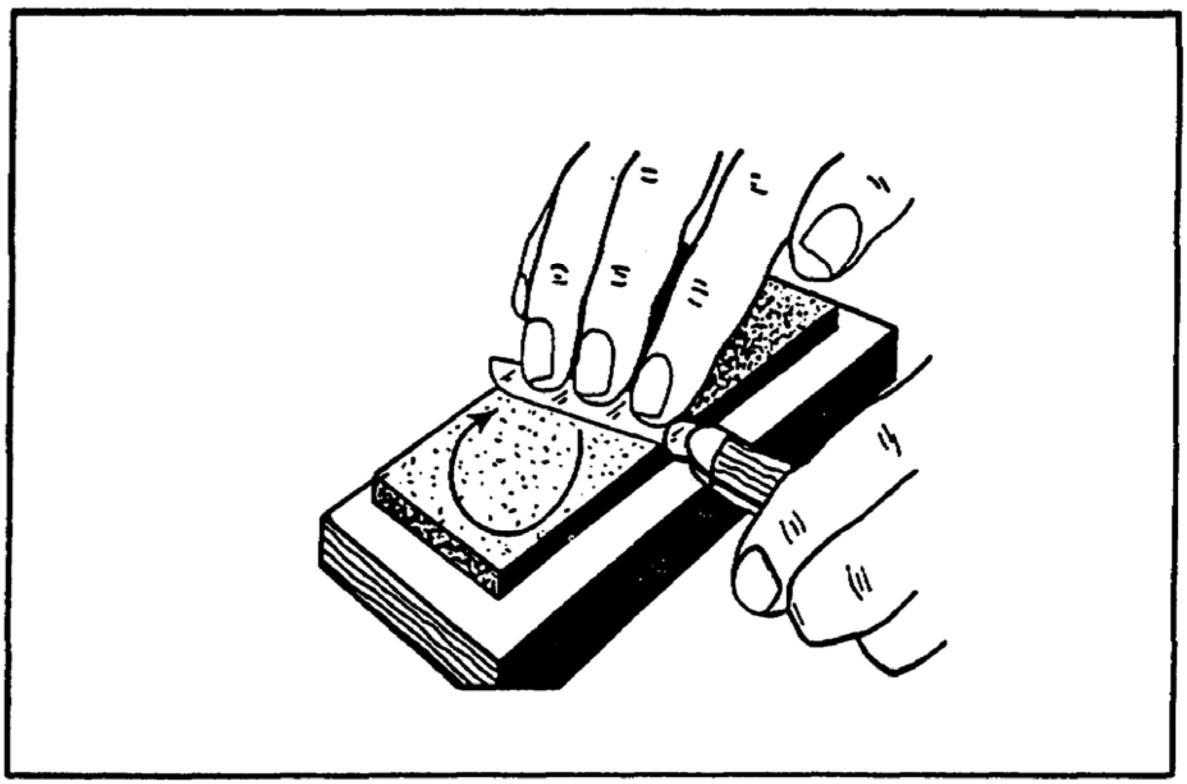


FIGURE 105. SHARPENING A POCKET KNIFE.

(b) To sharpen a drawknife blade, place the knife blade on the oilstone and tilt it so that the bevel edge lies flat on the stone. Make certain the oilstone is high enough on the bench to provide clearance for the knife handles. Use both hands and, following a circular motion, rotate the blade across the stone so that the entire length of the bevel contacts the stone. Repeat the sharpening procedure on the other side of the blade. The wire edge can be removed by stropping both sides on a soft wood block or canvas or leather strap.

(2) *Grinding.*

(a) To reshape a broken blade or to remove nicks, grind knives on a grinding wheel or grindstone. Sharpen and hone on an oilstone after grinding. Dip the blade in water frequently during the grinding process.

(b) A putty knife is ground at right angles against the edge of a grinding wheel to remove nicks and to square up a worn blade. Move the blade from side to side while grinding (figure 106). Do not remove any more metal than is necessary. Remove the wire edge on an oilstone after grinding.

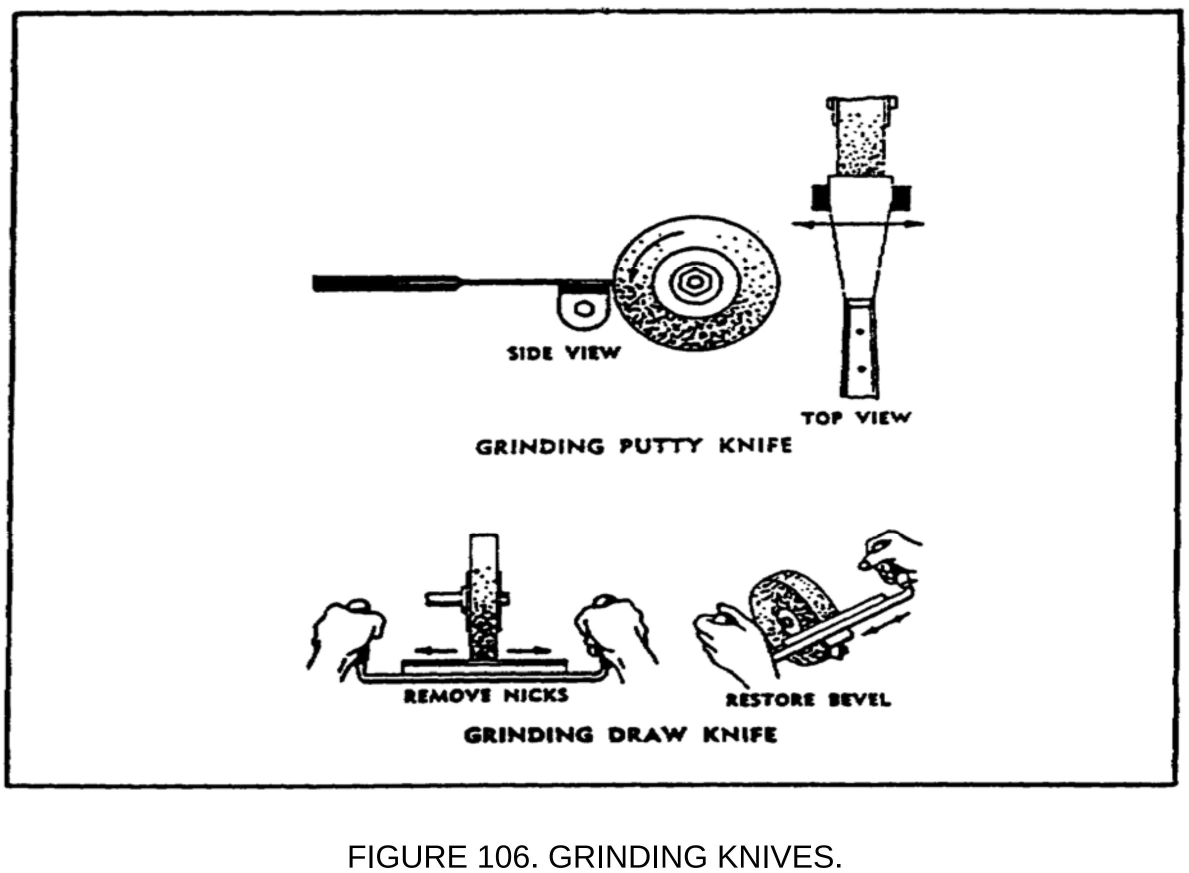


FIGURE 106. GRINDING KNIVES.

(c) The drawknife may be ground with a single or double bevel. The bevel must be restored to its original shape. Determine the original shape of the bevel by examining the unworn portions at the ends of the cutting edge. If the bevel cannot be determined by examination, make the bevel length approximately twice the thickness of the blade at the point where the bevel starts. Correct bevel length and shapes for drawknives are shown in figure 107. The bevel must never be ground convex.

1 Adjust the grinder rest at midpoint of the wheel so that the blade is at right angles against the edge of the wheel. Move the blade back and forth across the wheel until all nicks are removed (figure 106).

2 Adjust the grinder rest toward the top of the wheel to provide the desired bevel. Move the blade back and forth across the wheel until the desired bevel is obtained. Dip the blade in water frequently to preserve temper.

3 If the knife has a double bevel, turn the blade over and grind second bevel.

4 Sharpen the blade on oilstone, as described in paragraph 4d(1)(b).

5 Remove the wire edge by stropping.

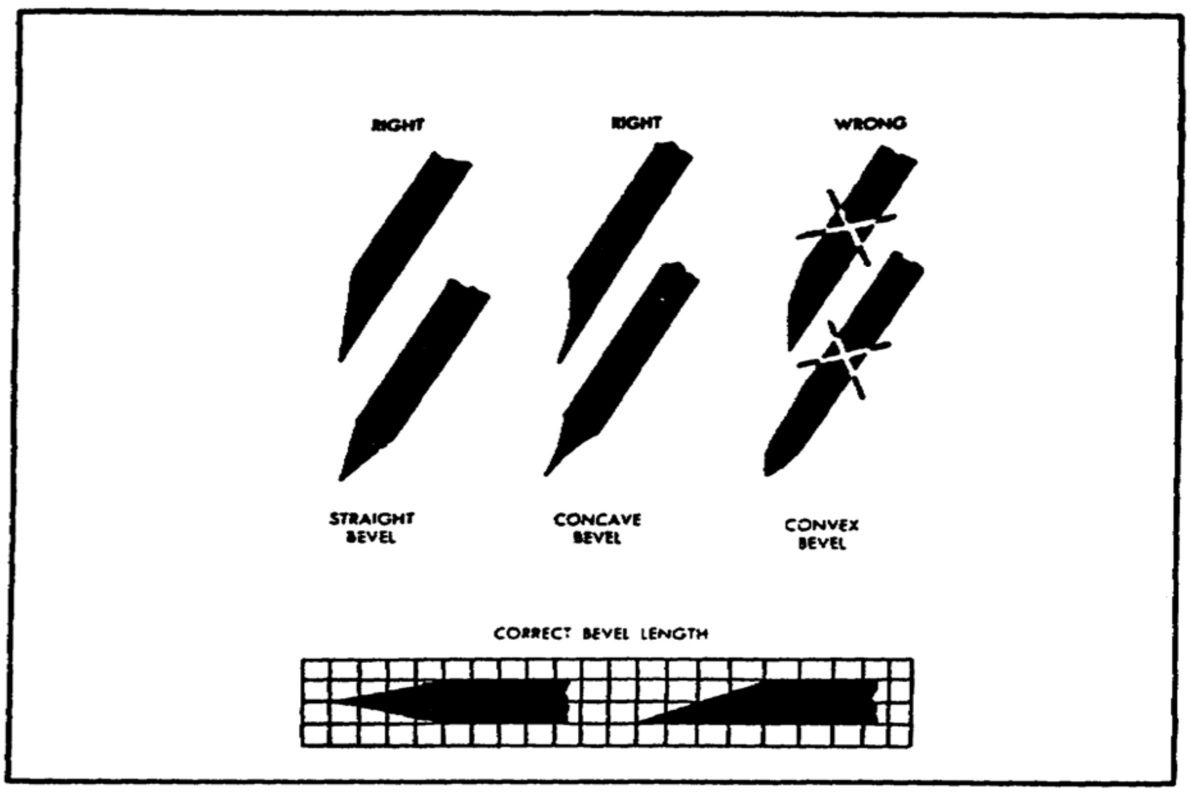


FIGURE 107. DRAWKNIFE BEVEL LENGTH AND SHAPE.

5. Scrapers

a. *Purpose.* Some scrapers (figure 108) are used for trueing metal, wood, and plastic surfaces which have previously been machined or filed. Other scrapers are made to remove paint, stencil markings, and other coatings from various surfaces.

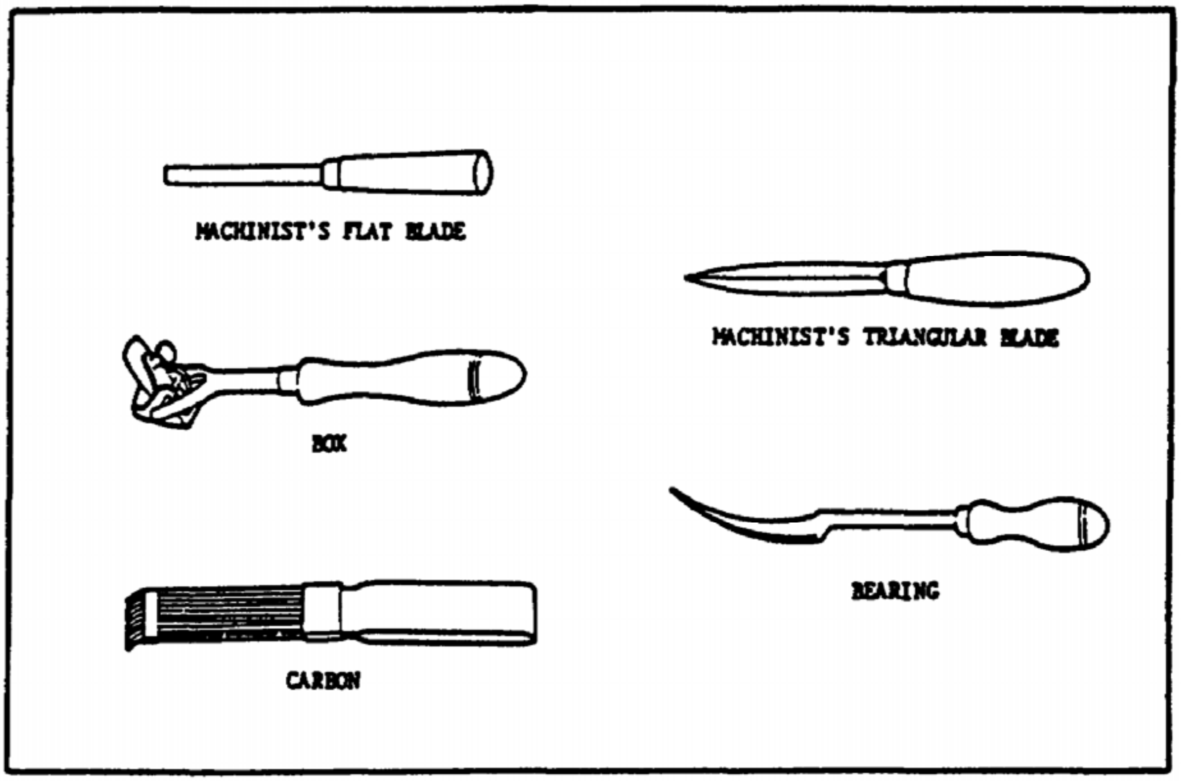


FIGURE 108. TYPES OF SCRAPERS.

b. *Types of Scrapers.* Scrapers are made in several different shapes and for varied work.

(1) *Carbon Scraper.* Carbon scrapers (figure 108) are flexible and have an overall length of 9 inches. The carbon scraper consists of 10 spring steel blades with flexibility controlled by a sliding ferrule.

(2) *Bearing Scraper.* Bearing scrapers (figure 108) are used to scrape the babbitt metal bearings that are used in many Army vehicles and equipment. Bearing scrapers are issued with a 1 1/2, 2, and 4 inch cutting edge.

c. *Use of Scrapers.*

(1) *Preparing Work Before Scraping.*

(a) Do not attempt to scrape off three or four thousandths of an inch of metal on a large surface.

(b) Surfaces that are to be made flat should be checked against a surface plate. A curved surface should be checked against its mating surface. Be sure that both the surface to be scraped and the reference surface are perfectly clean. Apply a very thin film of prussian blue on the reference surface. To determine the high spots on the work, lightly rub the work against the blued reference surface. Remove the work and examine for any blue spots. The prussian blue transferred to the work will indicate where scraping is required. Scrape and rematch the work to the reference surface until the work surface is covered with uniform coating of blue.

(c) Visible burrs should be removed by filing before beginning the scraping process.

(2) *Using a Carbon Scraper.* The carbon scraper is used to clean carbon deposits from cylinder heads, pistons, and other metal surfaces where carbon accumulates. The blades are fairly dull to prevent scoring of a piston and cylinder wall. Slide the ferrule towards the cutting edges when removing heavy deposits; slide it back toward the handle for light scraping.

(3) *Using a Bearing Scraper.* Hold the bearing scraper with both hands, using the hand at the end of the handle to twist, while the other hand steadies the tool. Use a very light pressure and remove a small amount of metal with a twisting stroke. If too much pressure is applied, the scraper will chatter and leave a rough, uneven surface. When scraping a bearing, start at one top side of the bearing cap, go down, then up to the top of the other side. Do not scrape lengthwise.

d. *Precautions.*

(1) Keep work, scraper, and hands free from grease and oil when using a scraper.

(2) When scraping over a surface the second time, scrape at a different angle so that the markings are more easily distinguished.

(3) Keep scrapers sharp at all times (except the carbon scraper) or they will cause an uneven surface, since increased pressure is required to make the scraper cut.

(4) Use scrapers only for purposes for which they are intended.

e. *Care of Scrapers.* To sharpen a bearing scraper, use an oilstone with a rounded edge. Secure or hold the scraper on a bench and rub the rounded edge of the oilstone on the inside bevel of the hollow ground scraper blade. Rub the stone back and forth several times. Use a piece of canvas or leather to remove the wire edge after sharpening.

6. Punches

a. *Purposes.* Punches are used to punch holes in metal, leather, paper, and other materials; to mark metal, drive pins or rivets; to free frozen pins from their holes; and to align holes in different sections of metal. Special punches are designed to install grommets and snap fasteners. Bench-mounted punching machines are used to punch holes in metal one at a time, or up to 12 holes simultaneously.

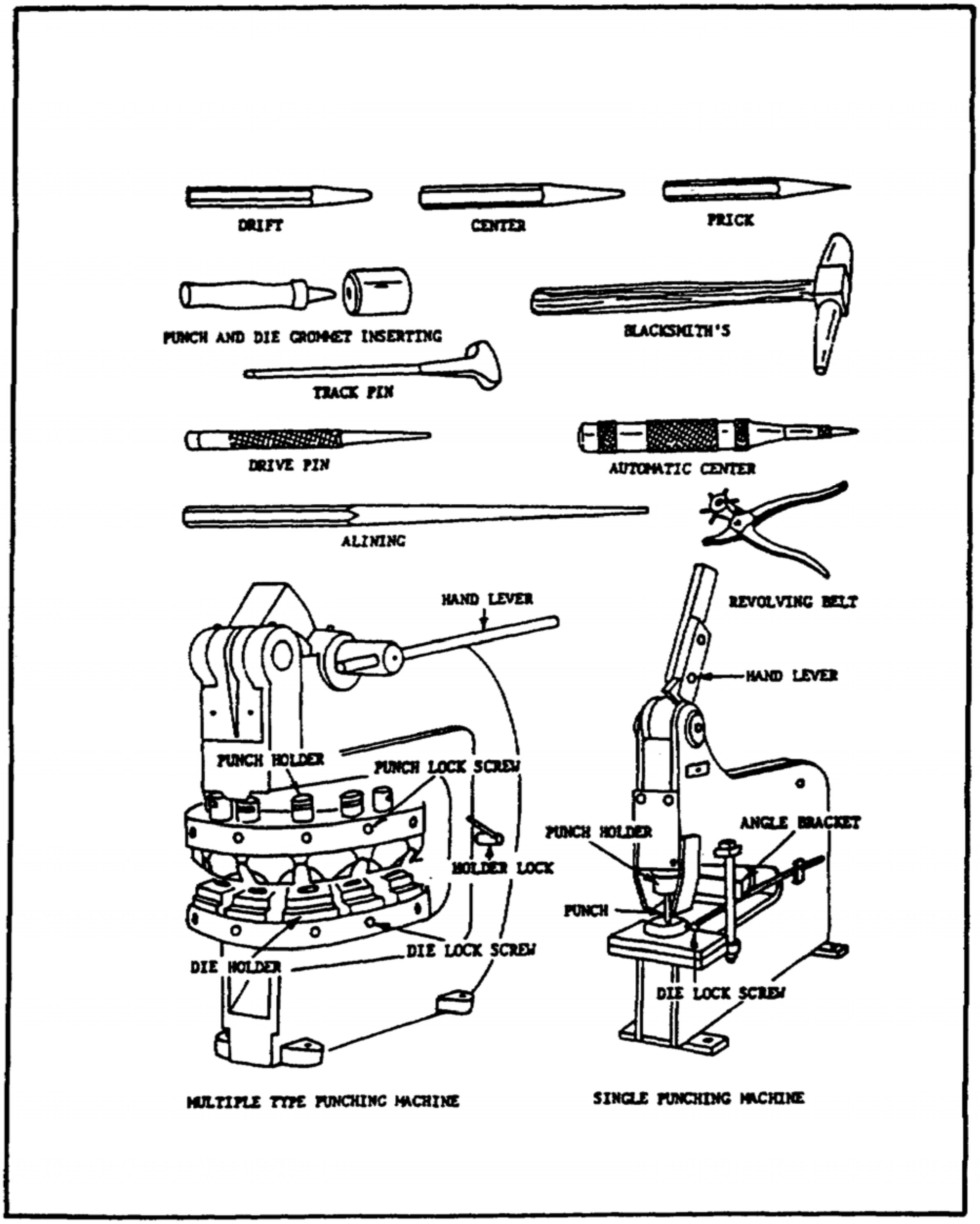


FIGURE 109. SOLID PUNCHES AND PUNCHING MACHINES.

b. *Types of Punches.* The most common punches are the solid punches (figure 109) they have various shaped points. Hollow punches (figure 110) have a circular cutting edge and are sized according to their cutting diameter.

Blacksmiths use solid punches that have handles. Special punches are made for snap fasteners.

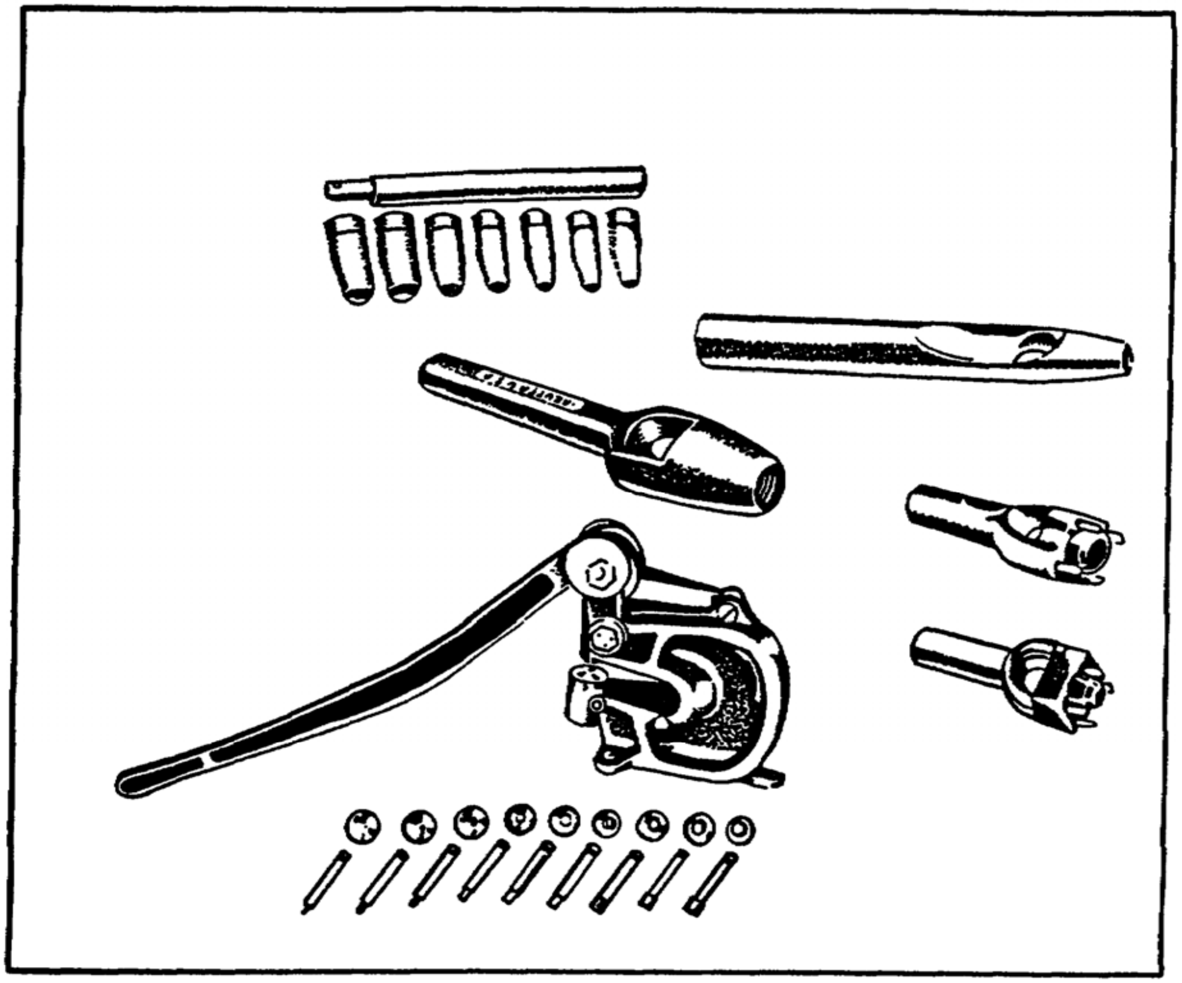


FIGURE 110. HOLLOW PUNCHES AND PUNCHING MACHINES.

(1) *Solid Punches.* Solid punches are made to mark materials, to drive out straight or tapered pins, to mark metal for starting holes to be drilled, to align holes in different sections of metal, and to punch holes by hand in metal that is 1/32 inch to 1/8 inch thick. Punching machines are capable of punching holes in metal that is from 1/16 inch to 1/4 inch thick.

(a) *Center Punch.* A center punch has a narrow cone-shaped point terminating in a sharp 90° conical tip. The stock on a center punch may be octagonal, round, or square in shape, with or without knurling. Center punches range in size from 1/8 inch diameter stock to 5/8 inch with a length of 3 to 6 inches. An automatic center punch is also available. Where other center punches require a hammer blow to mark metal, the automatic center punch contains a mechanism which automatically strikes a blow of the required force when the punch is in the desired position and is pushed forward by hand pressure. It has an adjustable cap for regulating the stroke and the point is removable for regrinding and replacement. Center punches are normally used for starting holes to be drilled.

(b) *Drift and Alining Punches.* Drift and alining punches are normally tapered to a 1/8, 3/16, 7/32, 1/4, 5/16, 3/8, or 1/2 inch point, and range in length from 7 to 15 inches. Drift and alining punches are used to line up holes in metal work.

(c) *Drive Pin Punch.* Drive pin punches are used for driving out straight or tapered pins. The standard drive pin punch tapers to a point ranging in diameter from 0.03 to 1/2 inch. Standard drive pin punches are issued in sets of 9, as well as individually. Some drive pin punches are straight (without taper). The shanks may be knurled for better gripping, or hexagon shaped. Common lengths range from 3 to 6 inches; however, some drive pin punches have long tapers and an overall length of 9 inches.

(d) *Prick Punch.* The prick punch is used for marking soft metal, such as brass, and has a long tapered cone-shaped point terminating in a sharp 30° conical tip.

(e) *Blacksmith's Punch.* A blacksmith's punch is equipped with a handle to protect the user from contact with hot metal, and to provide a better grip when punching holes in hot metal. Blacksmith's punches are issued with a tip having a diameter of 1/4 inch to 1 inch.

(f) *Track Pin Punch.* A track pin punch is especially designed to drive out pins from railroad tracks. It has a 3/8 inch diameter point, is 8 inches long, and has a T-shaped head. The track pin punch is driven with a sledge hammer.

(2) *Hollow Punches.* Hollow punches are made to cut out gaskets, and to cut holes in leather, canvas, paper, and metal. They are made to cut holes from 1/8 to 2 1/2 inches in diameter, and are suitable to cut through work from 1/16 to 1/8 inch thick.

Gasket cutting punches are supplied in a set with one driving madrel and 7 punches, 1/4 to 5/8 inch diameter cut. Each punch is 1/16 inch larger in diameter than the preceding size. Other gasket cutting punches are issued individually.

c. *Using Punches.*

(1) Use a punch only for the purpose for which it is intended.

(a) Center punches are intended to start holes to be drilled with a twist drill.

(b) Prick punches are intended for marking locations on soft metal such as brass.

(c) Pin punches are intended to drive out straight or tapered pins.

(d) Blacksmith's punches are used to punch holes in hot metal.

(2) Hold the punch lightly in the fingers of one hand, approximately in the middle.

(3) Locate the end of the punch at the point to be marked for a pin to be driven, or a hole to be cut, at an angle so that you can see the point. Straighten the punch after locating, so that it is perpendicular to the work. Do not strike the head of a punch with a hammer until the punch is perpendicular.

(4) When punching holes in metal, use a center or prick punch to mark the center. Scribe the desired circle with a pair of dividers. Select the proper size and type punch; locate the punch on the scribed circle and strike the head with a heavy hammer until the hole is cut. Use a solid punch and die in a punching machine for punching holes in metal up to 1/4 inch thick. Use a hollow punch for holes in thin sheet metal and in soft material.

NOTE

To prevent damage to the edge of the punch after it finishes the cut, place a block of wood under the work before cutting out holes with a hollow punch.

(5) When using blacksmith's punches, be sure the hot metal is securely held and cannot be knocked off the bench or anvil. Make certain the handle is tight.

(6) Never use a punch that has a mushroomed head, or whose point or cutting edge is dull.

(7) To use the automatic center punch, turn the cap down or clockwise for work requiring a heavy mark; for work requiring a light mark, turn cap up or counterclockwise. No hammer blow is needed. Place the punch in an upright position on the spot to be marked. A downward pressure releases the internal striking hammer and makes the impression without danger of possible injury to fingers if the hammer slides off the head of the punch.

This punch is primarily used by toolmakers where more accurate and delicate work is required.

d. *Care of Punches.*

(1) After using a punch, wipe it clean and apply a thin film of oil to prevent rusting. Carefully place punches on a shelf, rack, or other suitable place to avoid damaging the points.

(2) For long periods of storage, apply rust preventive compound to all metal parts, protect points and cutting edges, and store carefully.

e. *Grinding and Shaping.*

(1) *Drift, Drive Pin, and Blacksmith's Flat and Punches.* Grind a drift, drive pin, or blacksmith's punch so that the end is perfectly flat and at right angles to the center line of the punch (figure 111). Grind other flat end punches in a similar way.

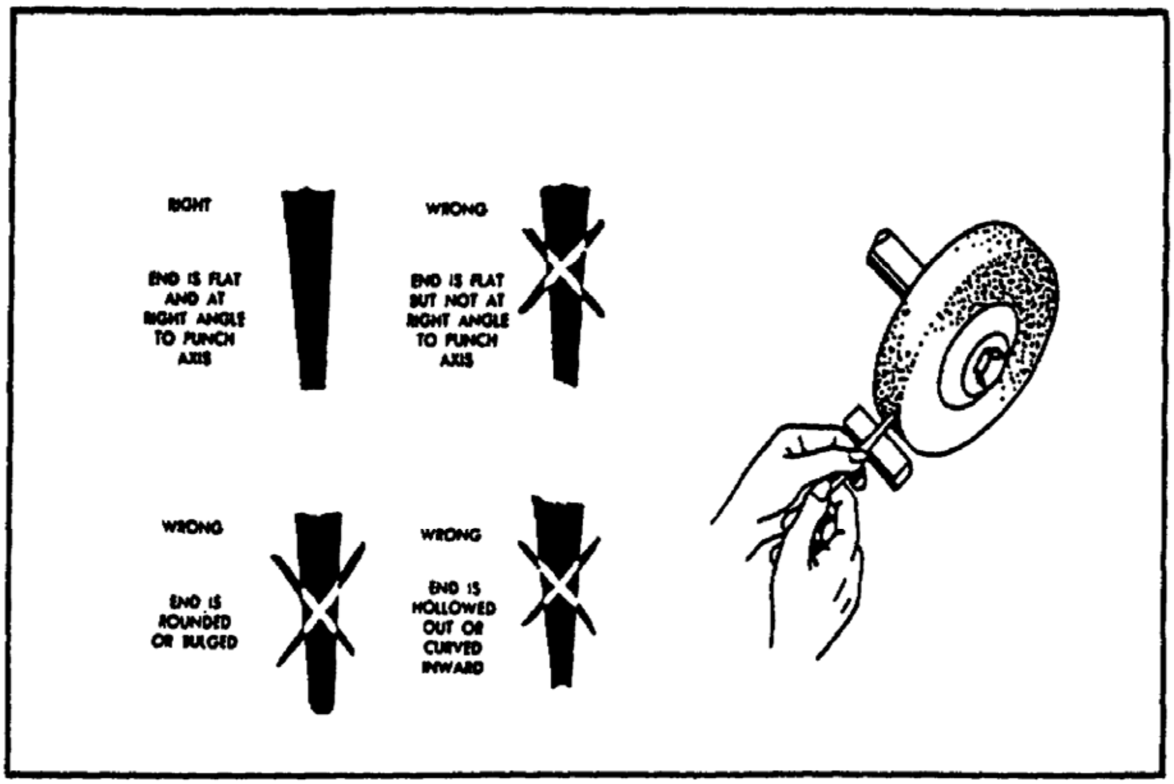


FIGURE 111. GRINDING A FLAT END PUNCH.

(a) Adjust the grinder rest so the end of the punch is opposite the center of the abrasive wheel and can be ground square.

(b) Place the punch on the rest and feed the end of the punch into the wheel. Rotate the punch during grinding to obtain a flat surface.

(c) Dip the punch in water frequently to preserve temper.

(d) Do not grind away more metal than is necessary to obtain a flat, nick-free end.

(2) *Cone Point Punches.* Center and prick punches are ground to cone points. The correct point angle for center punches is 90°; the point angle for prick punches is 30° (figure 112). These angles may be changed for special purposes.

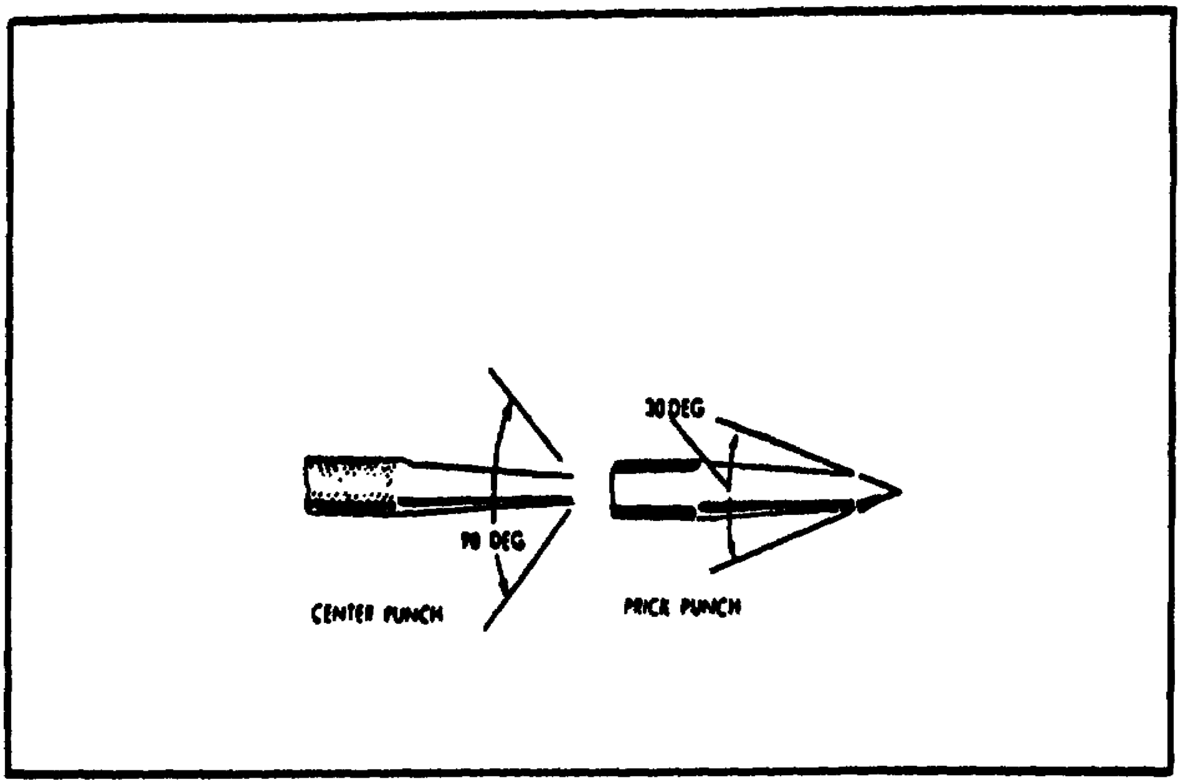


FIGURE 112. CONE POINT PUNCH ANGLES.

(a) Adjust the grinder rest so that the end of the punch will be ground at the desired angle.

(b) Place the punch on the rest and place the point on the abrasive wheel. Rotate the punch during grinding to obtain cone shape (figure 113).

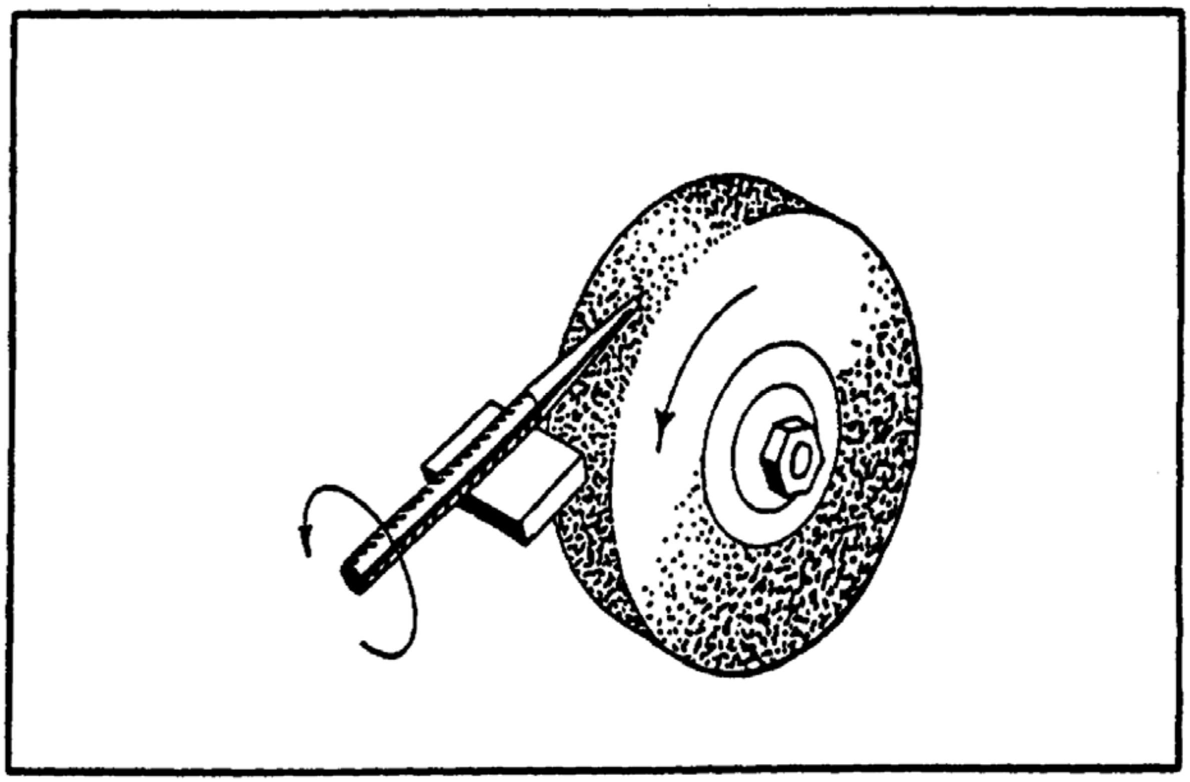


FIGURE 113. GRINDING A CONE POINT PUNCH.

(c) Dip the punch in water frequently to preserve temper.

(d) Do not grind away more metal than is necessary to obtain a sharp cone-shaped point.

(3) *Reshaping Mushroomed Head.* If the head of a punch becomes mushroomed after extended use, grind to the original shape on a grinder wheel. Restore temper after grinding.

(4) *Restoring Temper.* If the point or the flat end of a punch is ground beyond the hardened section, or if the mushroomed head was reshaped or if the punch was overheated in grinding, the punch must be hardened and tempered.

7. Shears

a. *Purpose.* Shears are used for cutting sheet metal and steel of various thicknesses and shapes.

b. *Types of Shears.* Shears are made in a variety of shapes and sizes and are used according to their design and capacity. Hand shears (figure 114) are used for light work and are made with straight or curved cutting blades. Straight bladed shears are used for cutting straight lines and to cut curves in easily accessible locations. Shears with curved blades, such as the hawk bill and the curved blade hand shears, are made especially for cutting short straight lines or curves. They are also used for cutting out small intricate designs in locations where it is advantageous to keep the handles and handle operating hand away from the metal stock. Shears are made for right-hand operators so the cutline is always in full view for accurate cutting when the shears are held in the right hand.

c. *Use of Shears.*

(1) *Straight Cuts.* To make straight cuts, place the sheet metal on a bench with the marked guideline over the edge of the bench; hold the sheet down with one hand. Hold the shears so that the flat sides of the blades are at right angles to the surface of the work. If the blades are not at right angles to the surface of the work, the edges of the cut will be slightly bent and burred. The bench edge will also act as a guide when cutting with the shears. The shears will force the scrap metal down so that it does not interfere with cutting. Any of the hand shears may be used for straight cuts. When notches are too narrow to be cut out with a pair of shears, make the side cuts with the shears and cut the base of the notch with a machinist's cold chisel.

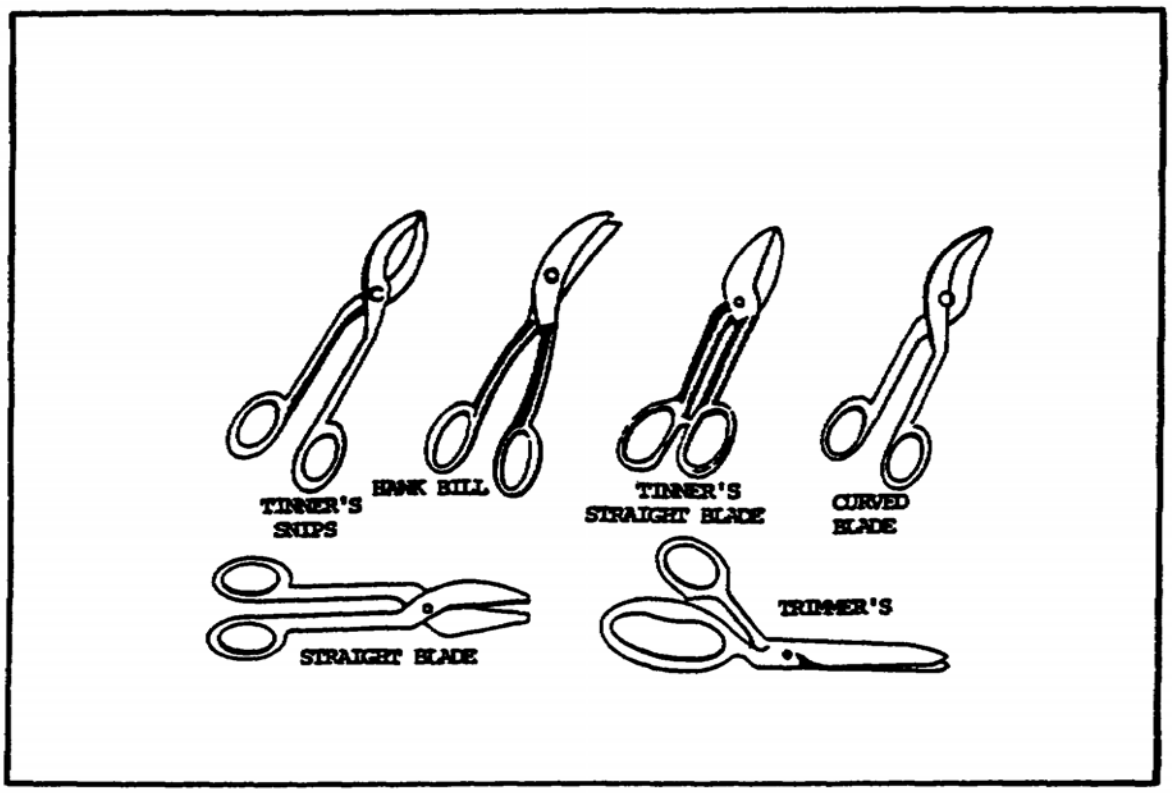


FIGURE 114. HAND SHEARS.

NOTE

When cutting, the sheet metal should be between the blades as far back as it will go and the upper blade must be exactly on the guideline.

(2) *Curved Cuts.* When cutting curves, the cut should be continuous. Stopping and starting at different points on a line results in rough edges and sharp slivers of metal, which may cause an injury. Curved blade and hawk bill shears are generally used for cutting out small, intricate designs, including curves. The offset handles of these shears are convenient to use in tight places. When cutting shapes from sheet metal with straight shears, it is important to make the cuts in the right direction. Figure 115 indicates the starting point by an X, and the arrows show the directions in which the cuts should be made for various shapes. When a hole or opening is to be cut in sheet metal with a pair of shears, lay the metal on a lead or hardwood block. Use a hollow punch or small cold chisel and punch a hole large enough for the point of the curved blade or hawk bill shears to be inserted. Complete the cut with the points of the curved shears.

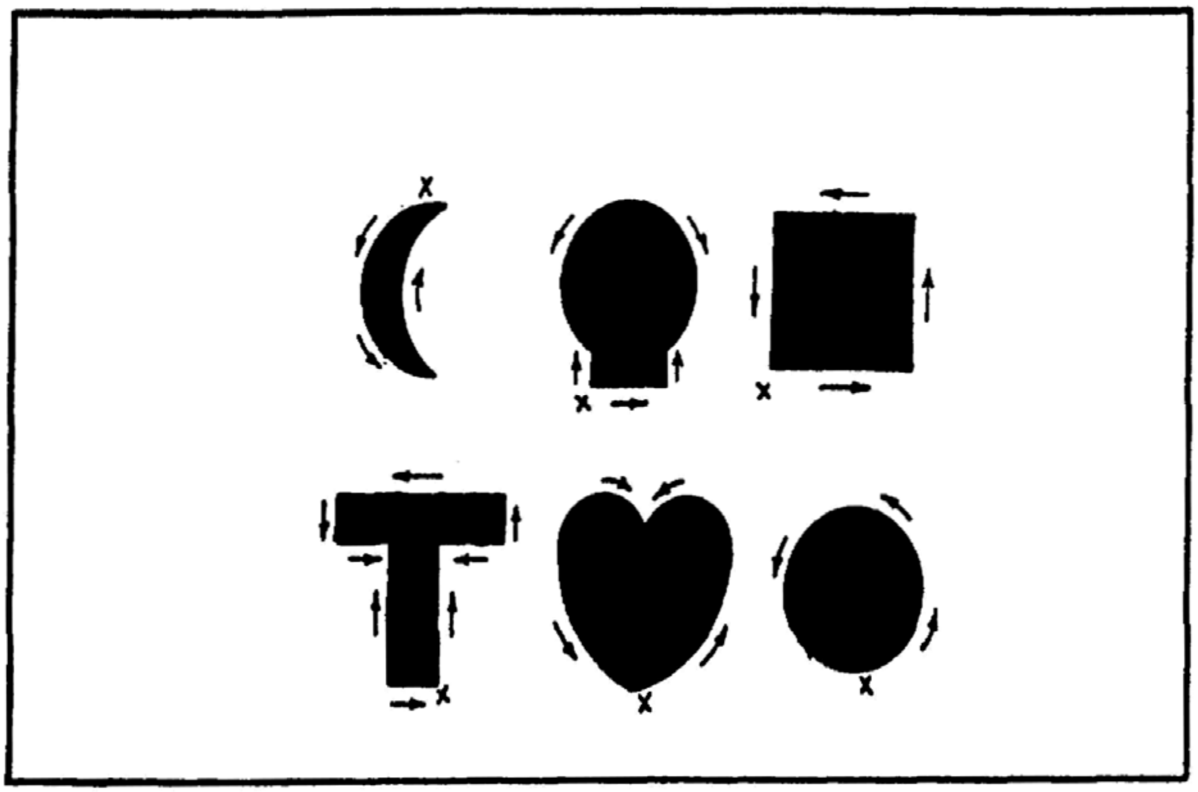


FIGURE 115. DIRECTION OF CUTTING SHAPES WITH SHEARS.

d. *Care of Shears.*

(1) *Care and Cleaning.* Keep tools clean at all times. Lubricate the pivot screw or bolt with a drop of light oil. Remove rust with a fine aluminum oxide abrasive cloth. Apply a thin film of oil on tools to prevent rust. Hang tools on hooks or place them on a shelf when not in use. Never throw tools in a box where the cutting edges may be damaged. Do not attempt to cut material heavier than the tools are designed to handle. Never use shears as a hammer, or as a pry bar, since they are easily damaged. For long periods of storage, coat tools with a rust preventive compound and store them in a dry place where the cutting edges do not come in contact with other metal objects.

(2) *Sharpening.* Dull shears can usually be sharpened on an oilstone or with a file, without grinding. Never grind shears if sharpening will suffice, since most shears become useless after two or three grindings. To sharpen with a file, clamp shears in a vise and use a flat file, as shown in figure 116. The flat file is used on beveled edges only--not on the flat faces of sharp edges. Stroke across the beveled edge using the full length of the file in a diagonal stroke along the entire cutting edge of the blade. Stroke smoothly from heel to tip. Never file the flat face of any tool. To remove the wire edge (burr), place the blade on lightly oiled stone so that the flat face is on the stone with the blade crossing the stone at right angles. Draw the blade across the stone from heel to tip. Start each stroke at the heel of the blade. Repeat the whole process to sharpen the other blade.

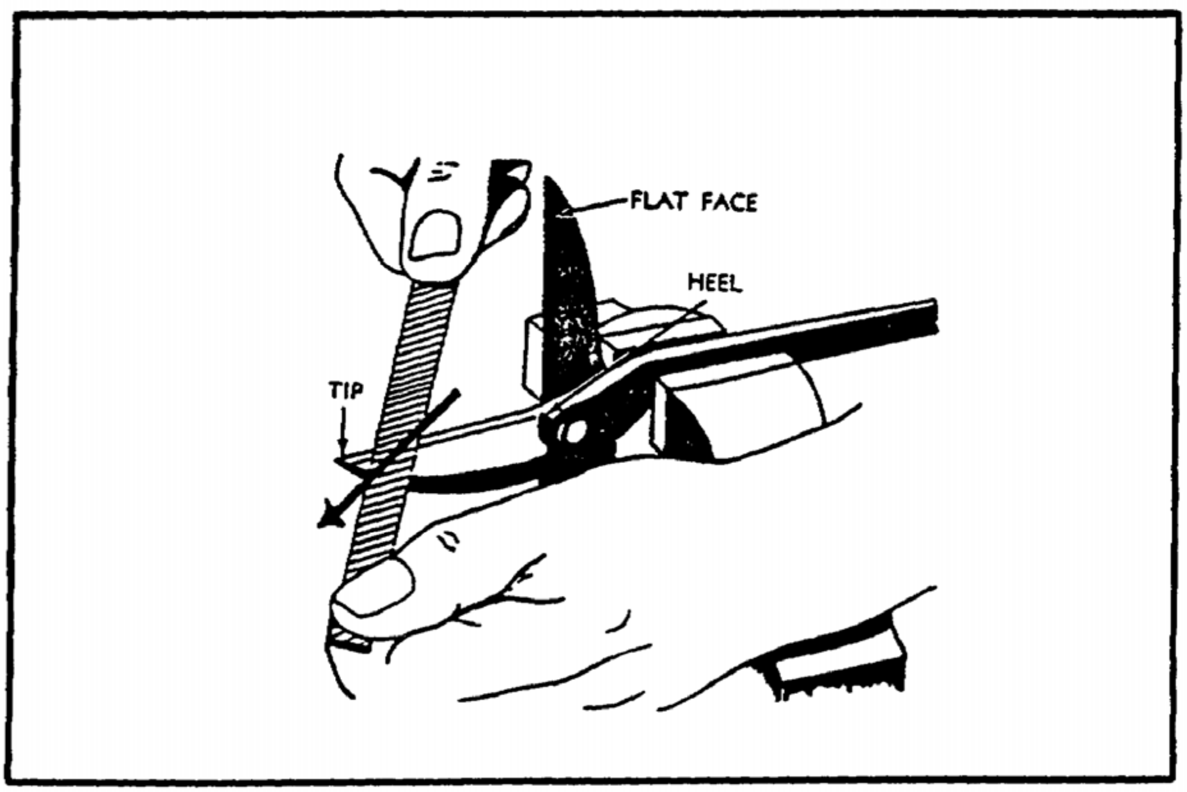


FIGURE 116. SHARPENING BEVELED EDGE SHEARS.

(3) *Grinding.* If the blades of shears are nicked, damaged, or if the bevel is distorted by improper sharpening or prolonged use, it is necessary to grind them. A single bevel is used; it may be flat or concave, but never convex (figure 117). The bevel angle varies with the type of work for which the shears are used. The bevel usually makes an angle of from 60° to 85° with the flat inside face of the blade. Paper and cloth cutting shears are ground to a bevel of approximately 60°. Metal cutting shears are ground to a bevel of approximately 85°.

Usually the bevel angle can be determined by examining an undamaged portion of the blade, but if the bevel has been distorted for its entire length, an undamaged pair of shears of a similar type should be examined to find the correct bevel. The correct bevel angle could be determined by using the above figures, if it is known specifically what materials will be cut by the shears. When grinding, use a fine grain abrasive wheel, properly dressed. Adjust the grinder rest to a position that will give the correct bevel. Place the shear blade on the rest with the bevel side down and move the blade into contact with the turning wheel. Move the blade from side to side during grinding to ensure a straight cutting edge. Dip the blade in water frequently when grinding to preserve temper; remove any wire edge on the oilstone.

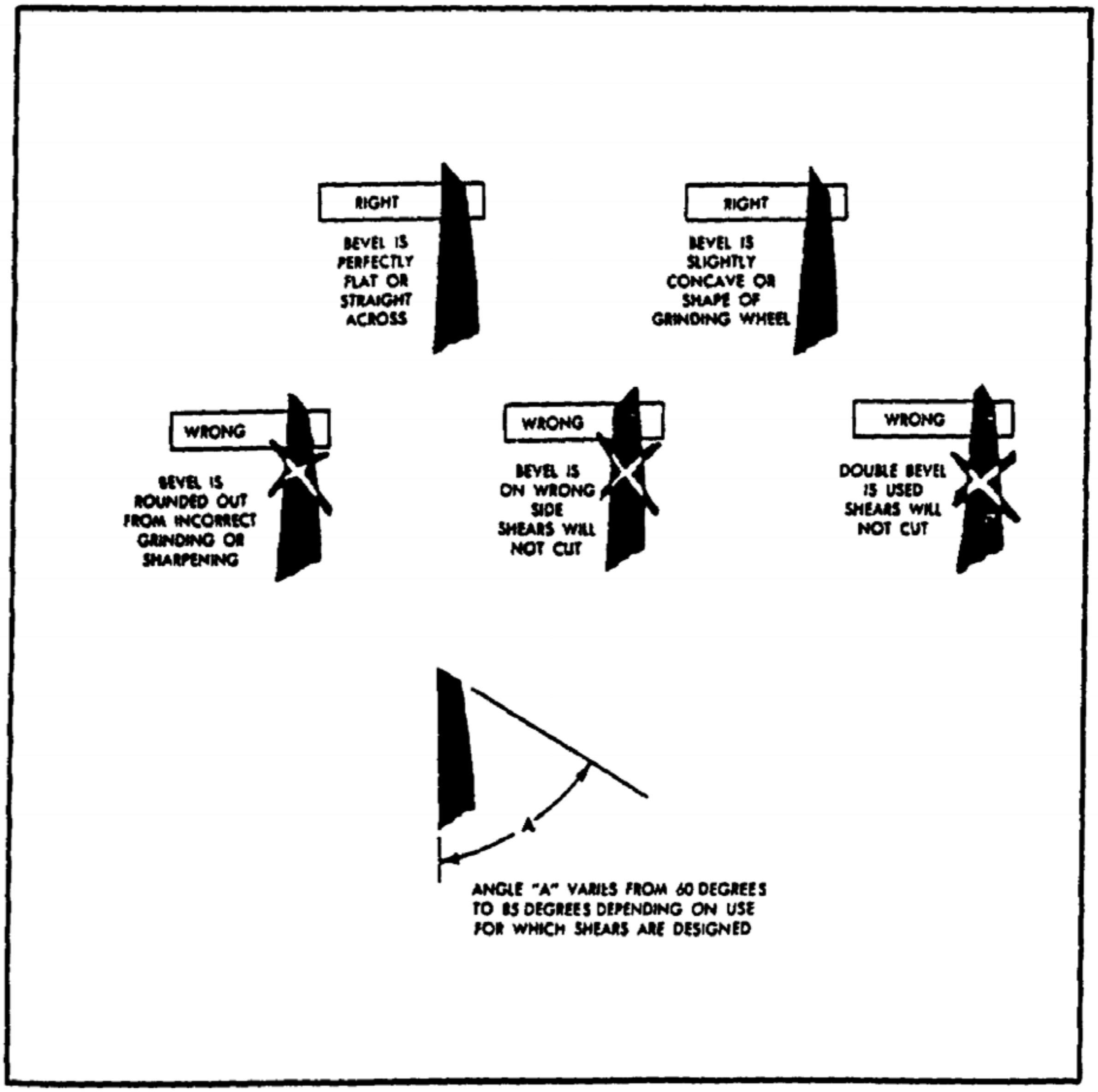


FIGURE 117. GRINDING ANGLES FOR SHEARS.

e. *Precautions.*

(1) Keep fingers away from the cutting edges of all handtools in general, and keep hands and other parts of the body clear of the cutting edges of hand shears.

(2) Do not carry shears in your pocket and do not wave them around.

(3) After use, be sure to hang or store shears so that they will not cut anyone coming in accidental contact with them.

(4) Always steady the work that is about to be cut to prevent the tool from slipping.

8. Bolt, Cable, and Glass Cutters

a. *Purpose.* Cutters or clippers are used to cut bolts, rods, wire rope, cable, screws, rivets, nuts, bars, strips, and wire. Special cutters are made to cut glass.

b. *Types of Cutters.* A bolt clipper or cutter is shaped like a giant shears with short blades and long handles. Different cutting edges are designed for specific applications. Figure 118 illustrates various types of cutting edges. Figure 119 illustrates types of cable cutters. Figure 120 shows the wheel-type glass cutter.

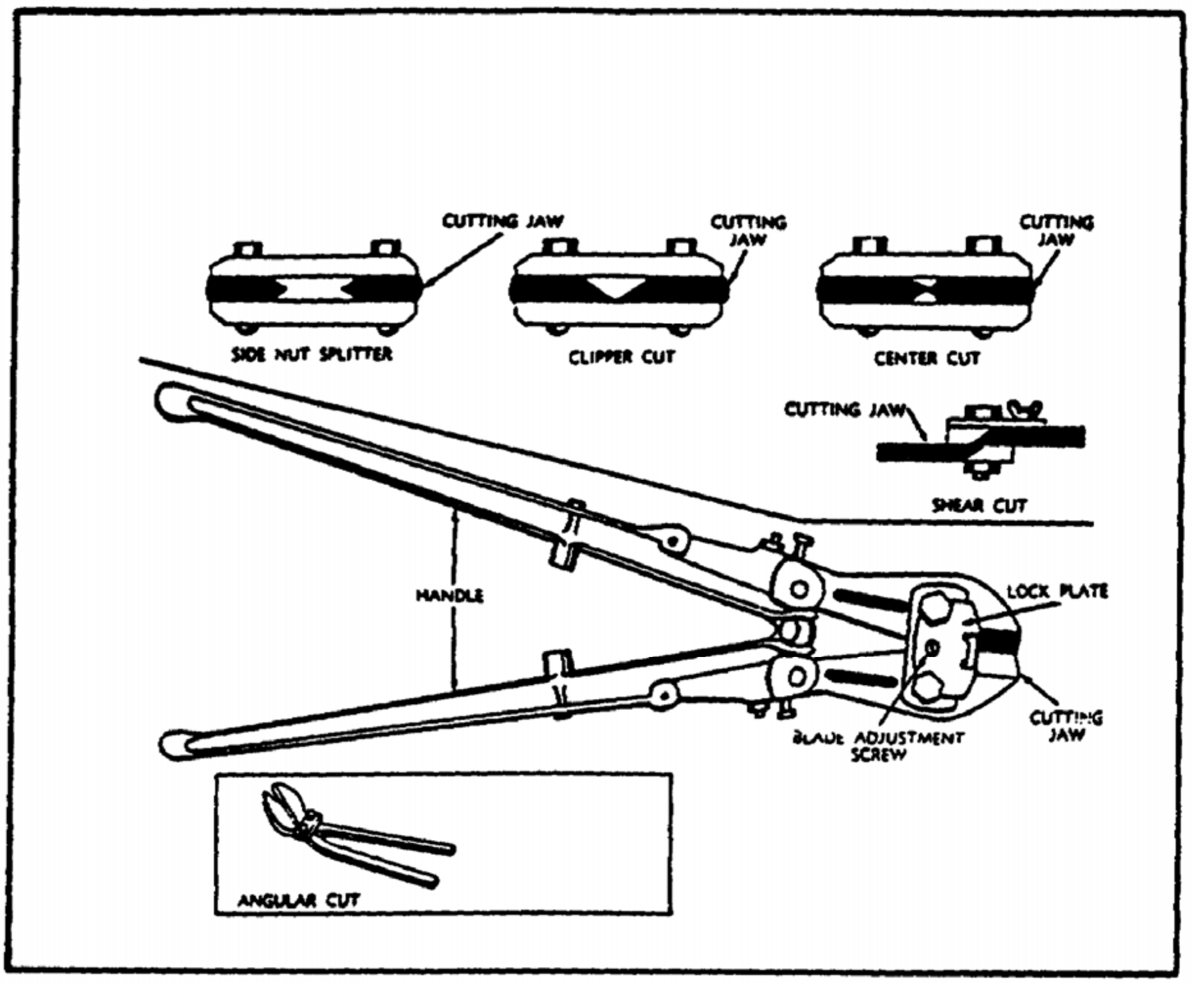


FIGURE 118. TYPES OF BOLT AND NUT CUTTERS.

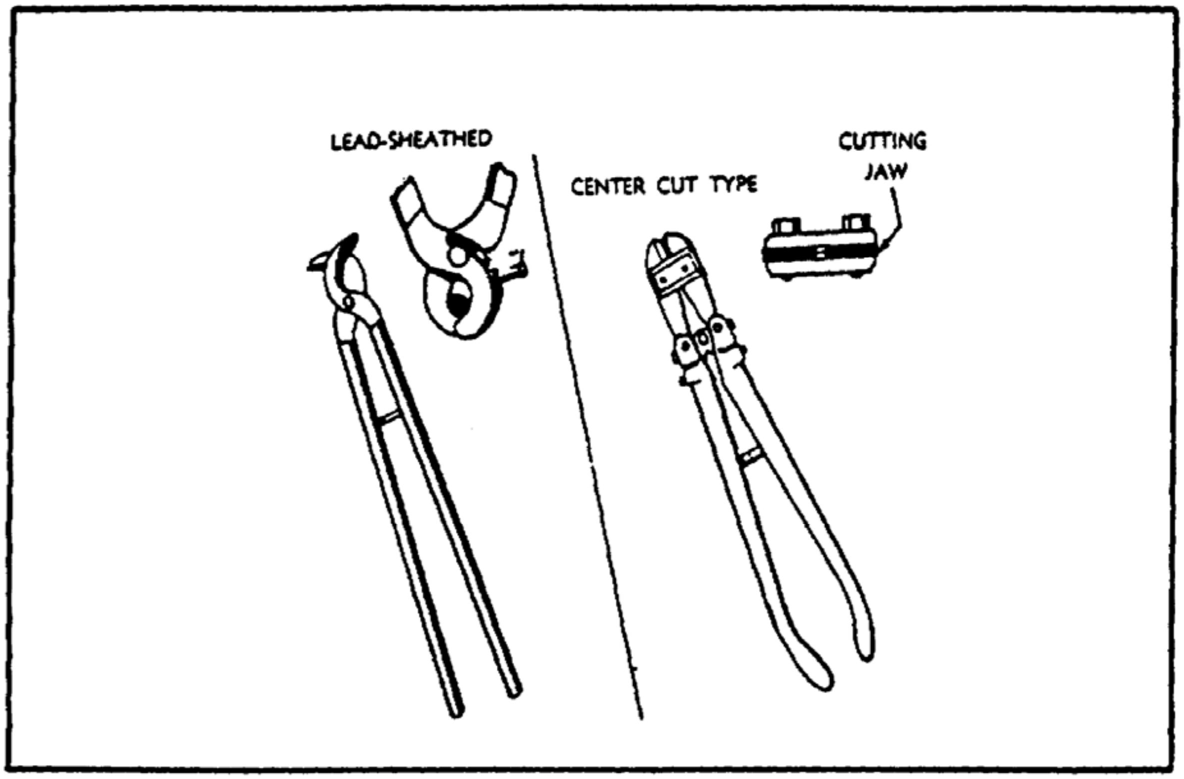


FIGURE 119. TYPES OF CABLE CUTTERS.

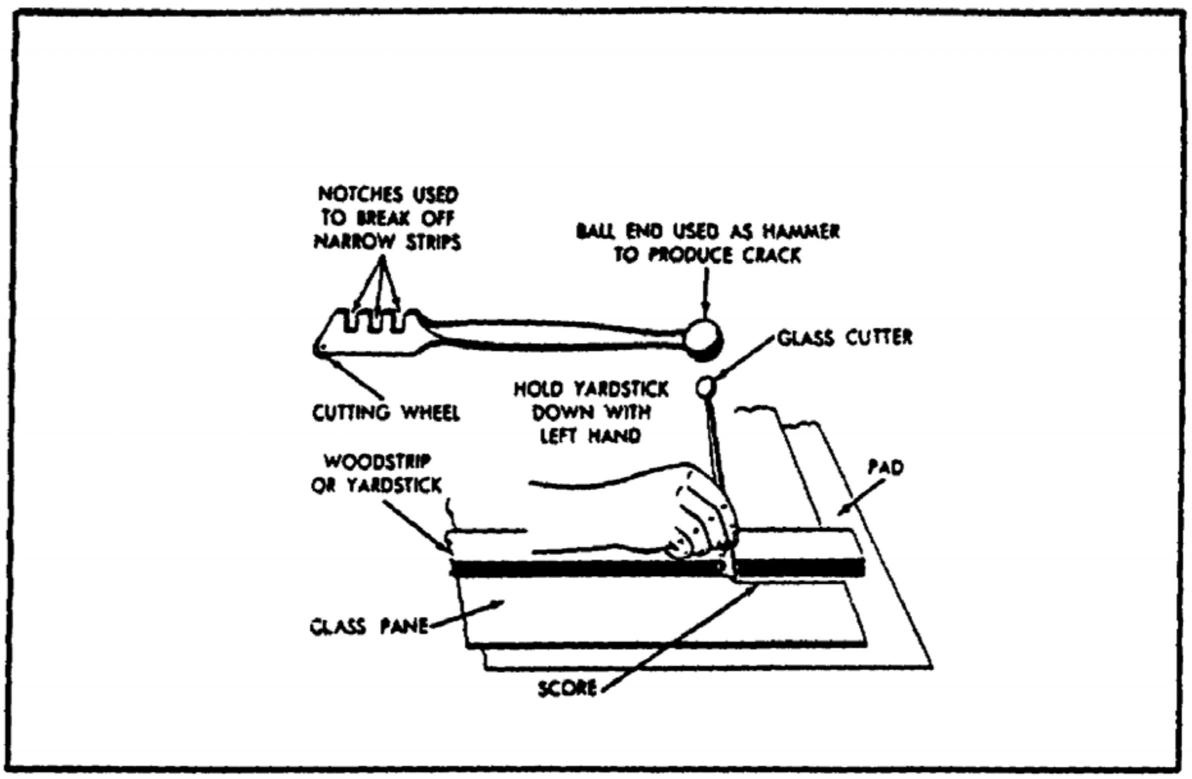


FIGURE 120. USING A GLASS CUTTER.

(1) *Angular Cut Cutters.* Angular cut cutters are used for cutting against large flat surfaces. They are 36 inches long and are capable of flush cutting a 5/8 inch bolt and a 1/2 inch rod. The handles are at a 300 angle to the cutting edges of the jaws.

(2) *Center Cut Cutters.* For all general purpose cutting, center cut cutters are used. The cutting jaws are firmly fixed in line with the handles and the cutting edges are in the center of the jaw, between equal bevels. These cutters come in 18, 36, 42, and 48 inch lengths, having cutting capacities of 5/16 inch bolt and 1/4 inch rod, 5/8 inch bolt and 1/2 inch rod, 3/4 inch bolt and 5/8 inch rod, and 7/8 inch bolt and 3/4 inch rod, respectively. The longer the handles, the greater the cutting capacity.

(3) *Clipper Cut Cutters.* The cutting edges of clipper cut cutters are in line with the handles and beveled almost entirely from one side. These cutters permit very close cutting of projecting ends. They are available in several sizes, providing cutting capacities for 1/2 inch bolt and 3/8 inch rod, 5/8 inch bolt and 1/2 inch rod, and 3/8 inch mild steel.

(4) *Shear Cut Cutters.* Shear cut cutters are used to cut steel cable, strip or flat bar stock. The cutting edges of the jaws pass each other in the manner of scissors, making a complete shear cut. The cutters are available in two capacities: 7/16 inch bolt and 5/16 inch steel cable with a 24 inch long handle, and a 1/2 inch bolt and 3/8 inch steel cable capacity with a 36 inch long handle.

(5) *Side Nut Splitter Cutter.* The side nut splitter cutter has the edges of the cutting jaws in line with the handles. This tool is used to split nuts off bolts with the tool "head on" to the bolt axis without damaging the bolt. When adjusted properly, the cutting edges will remain separated after the nut is split. Cutting capacity is rated at 3/8 inch bolt nut and is adjustable to 5/16 and 1/4 inch capacity. This cutter is 24 inches long.

(6) *Hand Cable Cutters.* Cable and wire cutters are available to cut 2 or 3 wire cables, Nos. 10, 12, and 14 BX cable. These are of the center cut and the shear cut type. Hammer-type cable cutters (not illustrated) are available having a 1/2 inch and 1 inch cutting capacity.

(7) *Lead-Sheathed Cable Cutter.* The lead-sheathed cable cutter has symmetrically shaped hooked jaws that pass each other, providing a shearing action. This cutter is designed to minimize flattening of communication cables and crushing the insulation inside. It has a cutting capacity of up to 1 inch diameter cable and is 23 1/2 inches long.

(8) *Bench Cable Cutters.* Two bench cable cutters (not illustrated) are available, both of the shear cut type. One has a cable holding die and a movable blade that operates on a hydraulic principle (1 1/8 inch capacity). The other bench cutter is bolted onto a bench and has a 36 inch handle with a cutting capacity of 1 inch.

(9) *Glass Cutters.* Two glass cutters are available; one is the single wheel, general purpose type, the other has a 2 to 24 inch circular capacity incorporating a graduated beam (not illustrated).

(10) *Gasket Circle Cutters.* A gasket circle cutter (not illustrated) is available that can cut circles in gasket material from 4 to 20 inches in diameter.

c. *Use of Bolt and Cable Cutters.*

(1) Select the proper cutter for the job. Determine the kind of work to be cut and the hardness and thickness of the material.

(2) Position the work as far back as possible into the jaws to prevent damage to the jaws, and to reduce the pressure required for cutting.

(3) Do not use cable cutters on spring steel wire; to do so will nick the cutting edges and possibly misalign the cutters.

(4) Avoid cutting live electrical cables. When doing work on existing electrical circuits, make certain the handles of the cutter to be used are insulated.

(5) Use extreme caution when using any cutter to avoid catching any part of the body or clothes between the handles as pressure is applied to them.

(6) Be sure to dry hands and handles of cutters before using, to prevent slipping. Keep tools clean.

(7) Make sure to clamp or steady the work before cutting to prevent the cutters from slipping.

d. *Use of Glass Cutter and File.* A glass cutter actually does not cut glass; it splits it. If the wheel is sharp and it is drawn over the glass at the right speed and pressure, it makes a fine score or groove by slightly crushing or pulverizing the glass under the edge of the wheel. The beveled sides of the wheel act as wedges which push against the sides of the groove and pry the glass apart so that a crack is started. If a crack fails to start in the cutting, tap the scratch or score with the ball end of the glass cutter to start a crack. Break off a narrow strip along the edges by placing the strip into a notch in the cutter and using the handle as a lever. Glass tubing or rod is cut by nicking the surface with a triangular file.

(1) *Cutting Glass Pane.* Ordinary window glass comes in two thicknesses, single light and double light. Single light is thinner and the easiest to cut. Plate glass up to 1/4 inch in thickness can be cut in the same manner as ordinary window glass. Safety glass, which consists of two or more glass sheets cemented together by a transparent plastic, requires special cutting equipment.

(a) *Window or Single Light Glass.*

1 Place several layers of newspaper or a piece of carpet on a firm level surface and place the glass pane on the padding.

2 Make certain the glass is clean--dirty glass does not cut well and dulls the cutter.

3 Brush turpentine directly along the line to be cut. This keeps the cutter bearings from gumming and keeps the cutter sharp longer.

4 To make a straight cut, use a straightedge to guide the cutter. A wooden yardstick is ideal, since the wood will not slip as easily on glass as a metal guide would.

5 Lubricate the cutting wheel with a drop of light machine oil. Remove excess oil.

6 Hold the guide with one hand against the glass and hold the cutter in a vertical position in the other hand. Your forefinger should be extended along the back of the cutter with the tip of the finger down near the wheel.

NOTE

The wheel does not cut exactly at the edge of the guide, but makes the groove about 1/16 inch from it. Position the guide accordingly.

7 Start the groove at the far end of the guide and draw the cutter towards you. The correct pressure is important, since too much pressure may crack the pane and both too little or too much pressure may make an unsatisfactory groove. If the correct pressure is applied and the cutter is drawn towards you at the right speed, the wheel will make a scratching sound. If the wheel is dull or too much pressure is

applied, the sound obtained will be more like crunching than scratching.

8 Draw the cutter over the line only once. If it becomes necessary to correct an imperfect groove, do not use a new cutter for this purpose, use an old one. Drawing a sharp cutter over a groove the second time dulls it.

9 Make a continuous mark all the way from one edge to the other. If made properly, a slight crack will be visible the complete length of the mark. The crack may not extend through from one surface to the other. It is best seen from the side opposite the mark.

10 To part the glass, slide the pane over to the edge of the bench or table so that the score mark is parallel to and projecting about 1/8 inch beyond the edge. Hold down the portion resting on the table with one hand and grasp the projecting end between the fingertips and palm of the other hand. Apply a light pressure and the glass will part.

11 To part a narrow section of glass, slip a notch in the cutter head over the projecting end of the glass pane and apply pressure to twist the projecting end down and in towards the bench. A grooved wood block can also be used to make a clean break along the score mark.

(b) *Plate or Double Light Glass.*

1 Plate glass or double light glass will part along the scored line most easily and accurately if a continuous crack is started along the bottom of the groove or the scratch. A sharp cutter and the right pressure will usually start this crack when the groove is scored.

2 If the crack does not appear, it can generally be started by turning the pane over and tapping against the unscored surface with the end of the cutter handle. Tap directly over the line scored on the opposite side. A crack which is not continuous can be extended all the way along the groove by tapping in this manner.

(c) *Cutting Glass to a Pattern.* First lay out a full size drawing on paper, making certain the outline is heavy and distinct. Place the drawing under the pane of glass. Cut circles, ovals, and curves by tracing them through the glass with the cutter wheel. For straight lines, use a guide such as a woodstrip or a yardstick.

(2) *Cutting Glass Tubing and Rod.* Cut glass tubing by nicking it with a triangular file. Hold the tubing in both hands and apply pressure as if to bend the tube. The nick must be on the surface away from you. The tube will crack apart at the nick. Glass rods are cut in the same manner. In cutting large diameter glass tubing or large diameter glass rods, the nick made with the triangular file should be a continuous scratch, extending all around and circling the tubing or rod.

e. *Care of Cutters.*

(1) *Sharpening and Grinding.* Sharpen and grind cutter blades as you would shears. The blades of most cutters are easily removed. Sharpen dull blades with a file and an oilstone. Grind blades that are nicked, have distorted bevels, or are worn beyond a simple sharpening job. Determine bevel or shape of cutting edges and adjust grinder rest to obtain the desired angle. Dip the blade in water frequently to preserve temper. Remove wire edge on an oilstone. Reassemble cutter. After grinding and sharpening, make certain the cutting edges meet perfectly and, in the case of shear cut cutters, the edges must pass each other in a tight fit.

(2) *Adjustments.* Most cutter blades can be adjusted to compensate for small wear by tightening the adjustment screw between the blades. When assembling cutting edges on cutters, make certain attaching bolts are tight and that the bolt lock plate between the blades is in place and secure.

(3) *Storage.* When not in use, apply a light film of oil on cutting edges and store so that the cutting edges do not contact other metals or humans. Wrap the glass cutter wheel in cotton or a small piece of rag saturated with light machine oil. For long periods of storage, coat entire cutter with rust preventive compound and store in a dry place.

9. Pipe and Tube Cutters, and Flaring Tools

a. *Purpose.* Pipe cutters (figure 121) are used to cut pipe made of steel, brass, copper, wrought iron, and lead. Tube cutters (figure 121) are used to cut tube made of iron, steel, brass, copper, and aluminum. The essential difference is that tubing has considerably thinner walls as compared to pipe. Flaring tools (figure 122) are used to make single or double flares in the ends of tubing.

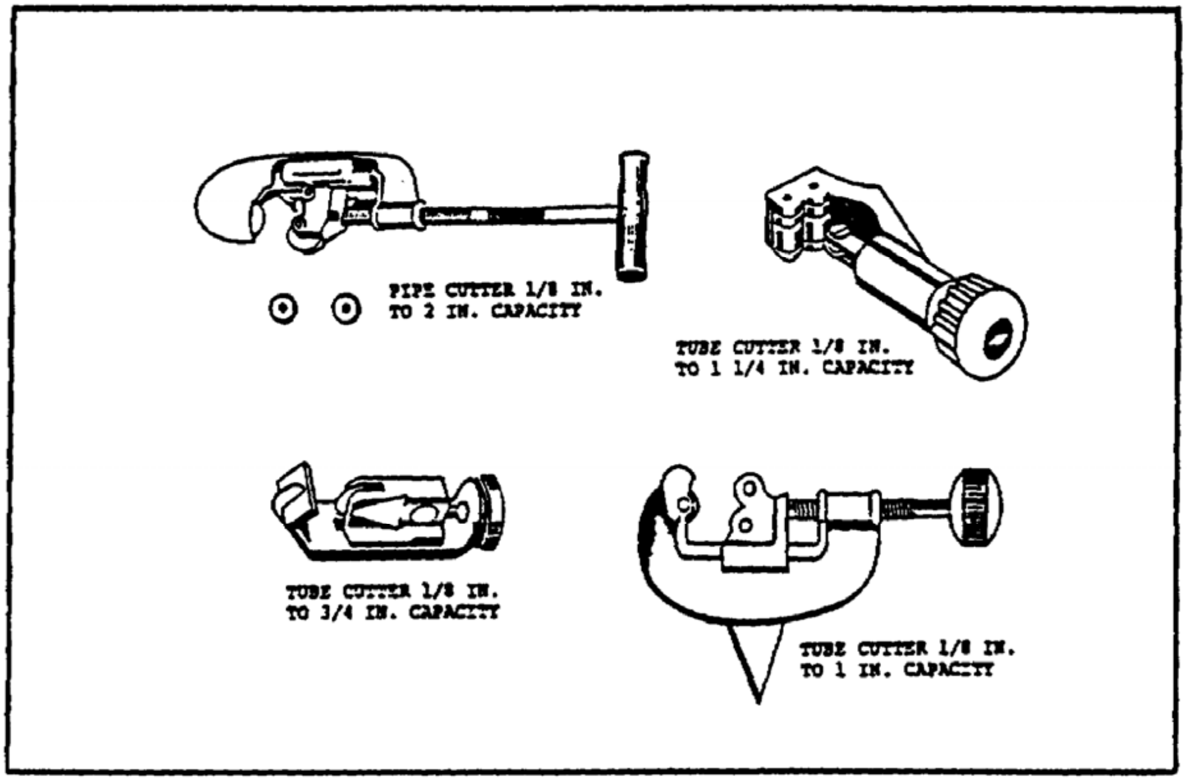


FIGURE 121. PIPE AND TUBE CUTTERS.

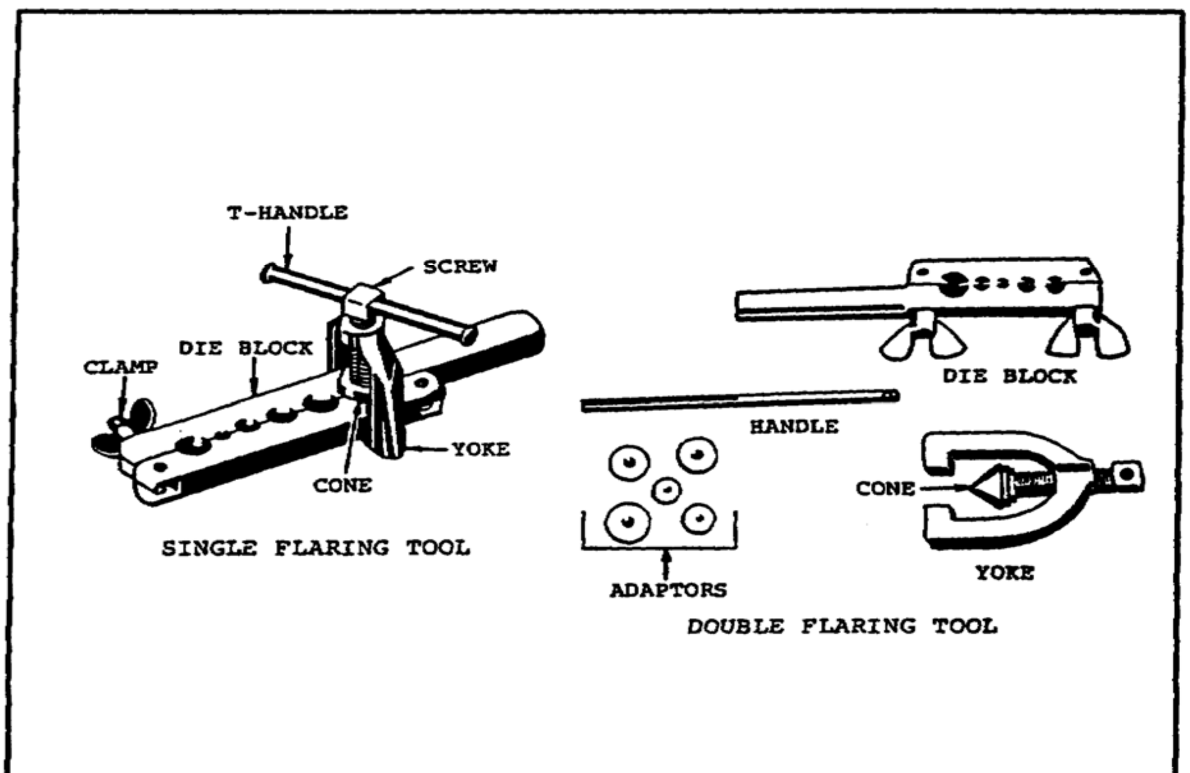


FIGURE 122. FLARING TOOLS.

b. *Types of Pipe and Tube Cutters, and Flaring Tools.*

(1) *Pipe Cutters.* Two pipe cutters are issued; one has a cutting capacity of 1/8 to 2 inches, and the other from 2 to 4 inches. The pipe cutter has a special alloy-steel cutting wheel and two pressure rollers which are adjusted and tightened by turning the handle.

(2) *Tube Cutters.* Some types of tube cutters closely resemble pipe cutters, except that they are of lighter construction. A hand screw feed tubing cutter of 1/8 inch to 1 1/4 inch capacity has two rollers with cutouts located off center, so that cracked flares may be held in them and cut off without waste of tubing. It also has a retractable reamer blade that is adjusted by turning a knob. Other types of tube cutters shown (figure 121) are designed to cut tubing up to and including 3/4 and 1 inch outside diameter (o.d.). Some cutters have the feed screw covered to protect the threads against dirt and damage.

(3) *Flaring Tools.* Flaring tools are used to flare soft copper, brass, or aluminum to make up 45° flare joints. The single-flaring tool consists of a split die block that has holes for 3/16, 1/4, 5/16, 3/8, 7/16, and 1/2 inch o.d. tubing, a clamp to lock the tube in the die block, a yoke that slips over the die block that has a compressor screw, and a cone that forms a 45° flare or a bell shape on the end of the tube. The screw has a T-handle. A double-flaring tool has the additional feature of adapters that turn in the edge of the tube before a regular 45° double flare is made. It consists of a die block with holes for 3/16, 1/4, 5/16, 3/8, and 1/2 inch tubing, a yoke with a screw and a flaring cone, plus 5 adapters for different size tubing, all carried in a metal case.

c. *Use of Pipe Cutters.*

(1) *Measuring Threaded Pipe.* Before you cut pipe, make certain the correct required length is determined. There are three methods of measuring threaded pipe, and you must understand these methods if the pipe is to be cut to the correct lengths (figure 123).

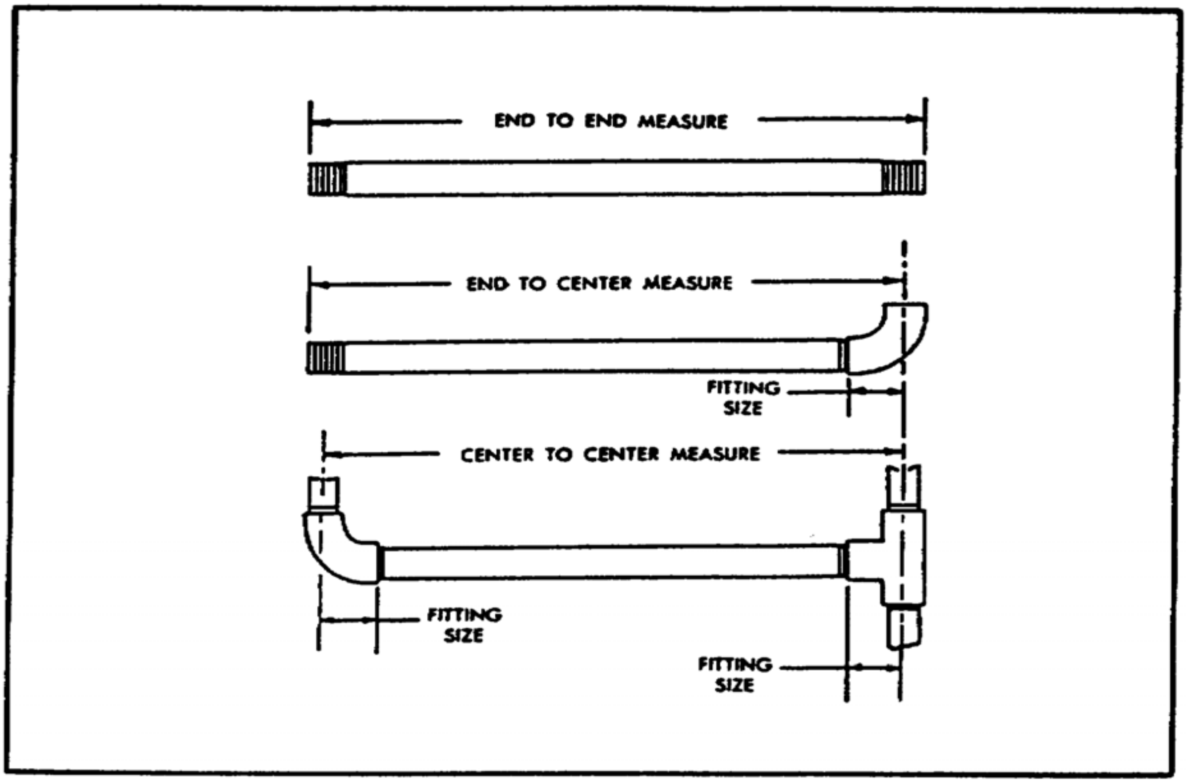


FIGURE 123. MEASURING THREADED PIPE.

(a) *End-To-End Method.* This measurement includes the threaded portions of the pipe. The pipe is measured from end-to-end.

(b) *End-To-Center Method.* This measurement is used on a section of the pipe that has a fitting screwed on one end only. Measure from the free end of the pipe to the center of the fitting at the other end of the pipe.

(c) *Center-To-Center Method.* This measurement is used when both ends of a pipe have fittings. Measure from the center of one fitting to the center of the other fitting at the opposite end of pipe.

(d) *Approximate Thread Lengths.* The approximate length of thread on 1/2 and 3/4 inch wrought iron or steel pipe is 3/4 inch. On 1, 1 1/4, and 1 1/2 inch pipe, it is approximately 1 inch long. On 2 and 2 1/2 inch pipe, the length of thread is 1 1/8 and 1 1/2 inches respectively.

(e) *Determine Pipe Length.* To determine the length of pipe required, compute as outlined in 1 through 4 below.

1 Take measurement of installation such as center to center of pipe, requiring two fittings ((c) above).

2 Measure size of fitting or fittings as shown in figure 123.

3 Subtract total size of the two fittings from measurement obtained in 1 above.

4 Multiply approximate thread length ((d) above) by 2 and add the result to the length obtained in 3 above. This will give the length of pipe required.

(2) *Cutting Pipe.*

(a) Measure the length of pipe necessary (1) and mark the spot where the cut is to be made with a scriber or crayon.

(b) Lock the pipe securely in a pipe vise (figure 124).

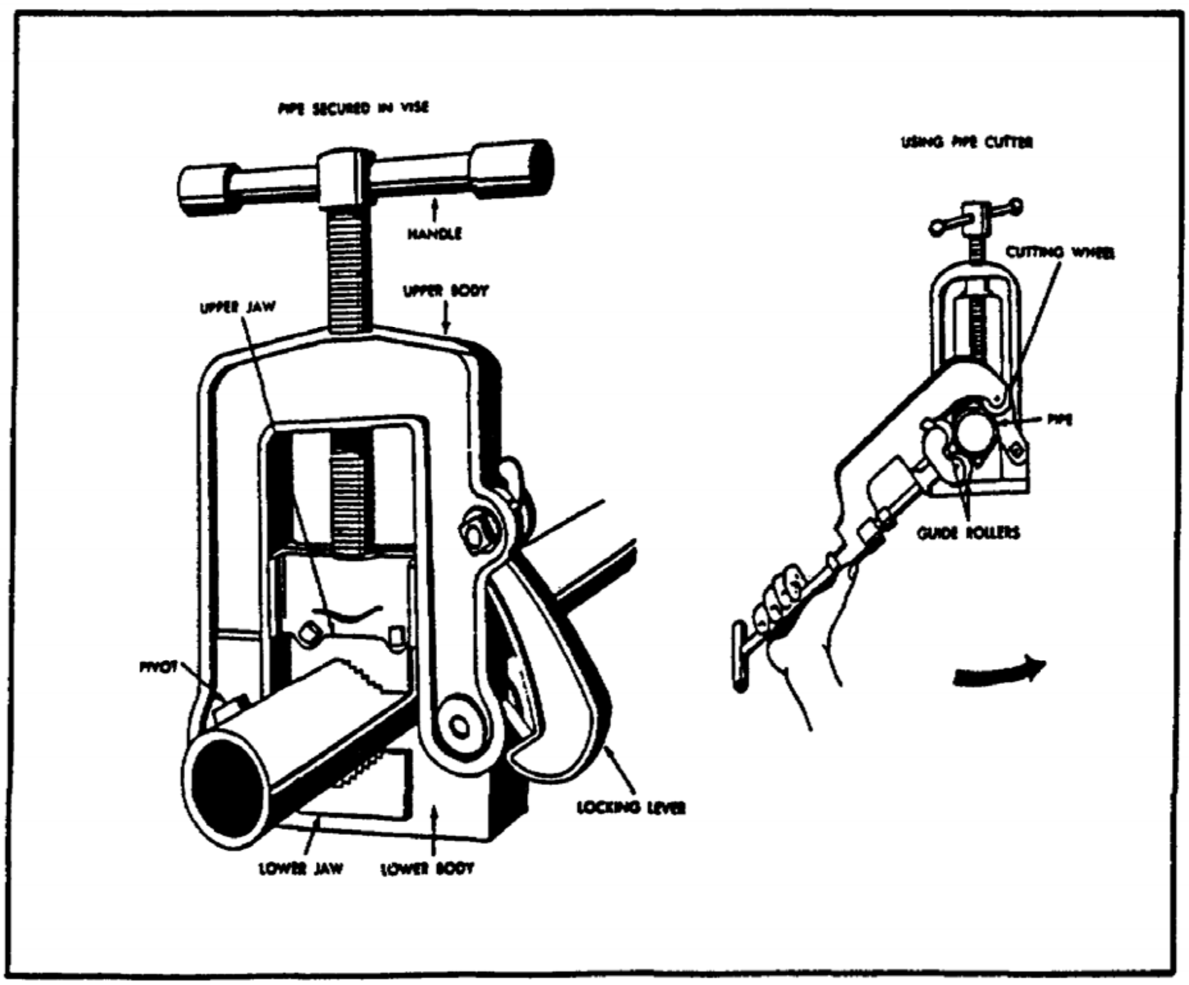


FIGURE 124. CUTTING PIPE.

(c) Inspect the pipe cutter to make sure there are no nicks or burrs in the cutting wheel. Open the jaws of the cutter by turning the handle counterclockwise.

(d) Position the cutter around the pipe at the marked point. Make sure the cutting wheel is exactly on the mark and close the jaws of the cutter lightly against the pipe by turning the cutter handle clockwise.

(e) After making contact, turn the cutter handle clockwise one-fourth of a turn more. This will put a bite on the pipe.

(f) Grasp the cutter handle and rotate the cutter as a whole, one complete revolution, swinging it around the pipe in the direction indicated in figure 124.

(g) Turn the cutter handle clockwise one-fourth of a turn more to take another bite on the pipe and rotate the cutter, as a whole, another complete revolution. Keep the cutter perpendicular to the pipe at all times or the wheel will not track properly.

(h) Repeat (g) above until pipe is cut. Remove the shoulder on the outside of the pipe with a file and the burr on the inside with a reamer.

d. *Use of Tube Cutters.*

(1) *Measurement.* Measure tubing as you would measure pipe.

(2) *Cutting Tubing.* The procedure for using a tube cutter is the same as for pipe cutters, except that for small diameters a vise is not necessary. Tubing is held in one hand and the cutter rotated with the other. For large diameter tubing, using a vise is advisable. Be certain to use soft jaws on the vise to prevent damage to the tubing. Use the reamer blade, with which most tube cutters are equipped, to remove any burrs from the inside diameter of the tube after it is cut.

e. *Use of Flaring Tool.*

(1) *Single Flare.* With the die block clamp screw loose, inset the tube in the corresponding size hole so that the tube extends approximately 1/8 inch above the face of the block. Tighten the clamp screw firmly to hold the tube in place. Slide the yoke over the end of the die block and turn the feed screw clockwise until the flaring cone forces the end of the tube

tightly against the chamfer of the die block. The tube is now flared to a 45° angle. Back out the feed screw, slide the yoke off the die block, and loosen the clamp screw to remove the flared tube.

(2) *Double Flare.*

(a) Insert tubing through the proper hole in the die block, with the end protruding above the block by the thickness of the shoulder on the appropriate adapter. Tighten the wingnuts on the die block and insert the adapter in the tubing. Move the yoke over the adapter and turn the feed screw clockwise until the shoulder of the adapter rests on the die block and a bell shape is formed on the tubing, as shown in figure 125, view A. Loosen the feed screw and remove the adapter from the tubing.

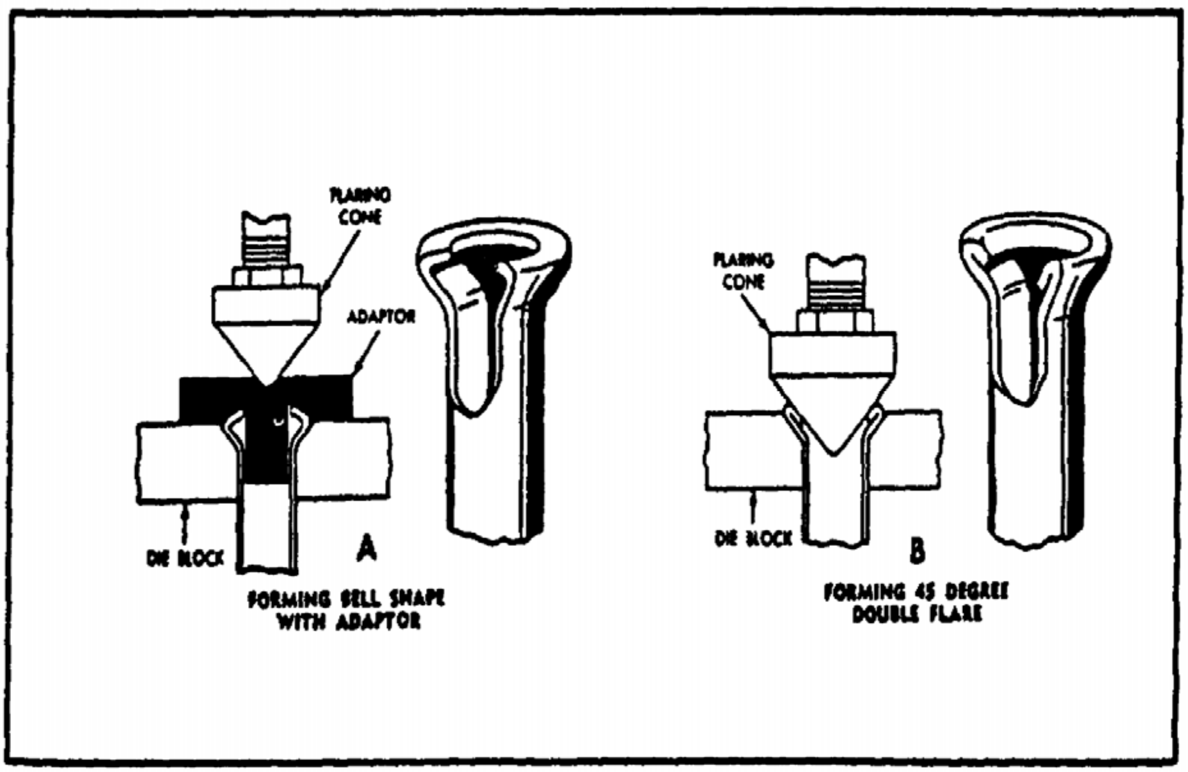


FIGURE 125. DOUBLE FLARING A TUBE.

(b) Flare tube as you would for a single flare (figure 125, view 8).

f. *Care of Cutters and Flaring Tools.*

(1) *Sharpening Cutter Wheels.* The cutting wheel on a pipe or tube cutter must be removed and sharpened when it becomes dulled, nicked, or otherwise damaged. Remove the wheel by tapping out the pin in the

center of the wheel, or by backing out the attaching screw on some types. Secure the wheel in a suitable jig and carefully grind the cutting edge on a grinder abrasive wheel or grindstone. Preserve the temper by frequently dipping the cutter wheel in water during grinding. Any wire edge can be removed on an oilstone.

(2) *Storage.* Clean and wipe cutters and flaring tools with a thin film of oil before putting away after use. Carefully store tools to prevent the cutting wheels from becoming damaged. Close the single flaring tool die block, install the yoke, and turn down the flaring cone until it just lightly touches an opening in the block, before storing. Return parts of the double flaring tool to their case after use. For long periods of storage, coat all parts of cutters and flaring tools with a rust preventive compound; wrap cutter wheels in cotton or a small piece of rag saturated with light machine oil to prevent damage; store in a dry place.

10. Taps and Dies

a. *Purpose.* Taps and dies are used to cut threads in metal, plastic, or hard rubber. The taps are used for cutting internal threads, and the dies are used to cut external threads.

b. *Types of Taps.* There are several types of taps issued by the Army Ordnance Supply System. The most common types are the taper, plug, bottoming, and pipe taps (figure 126). Special purpose taps (figure 127) such as mud or washout taps, boiler taps, and staybolt taps are also discussed in this subparagraph.

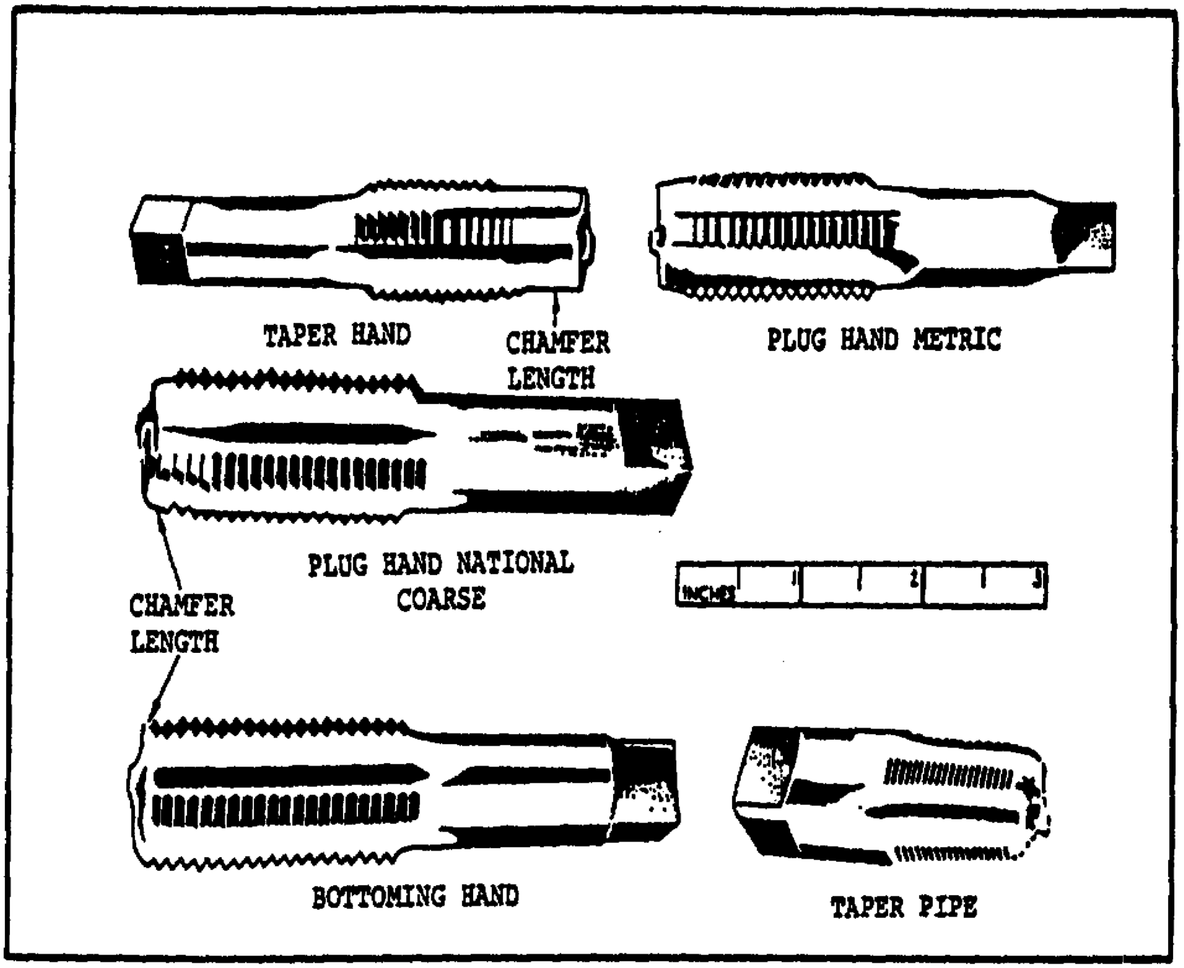


FIGURE 126. TYPES OF COMMON TAPS.

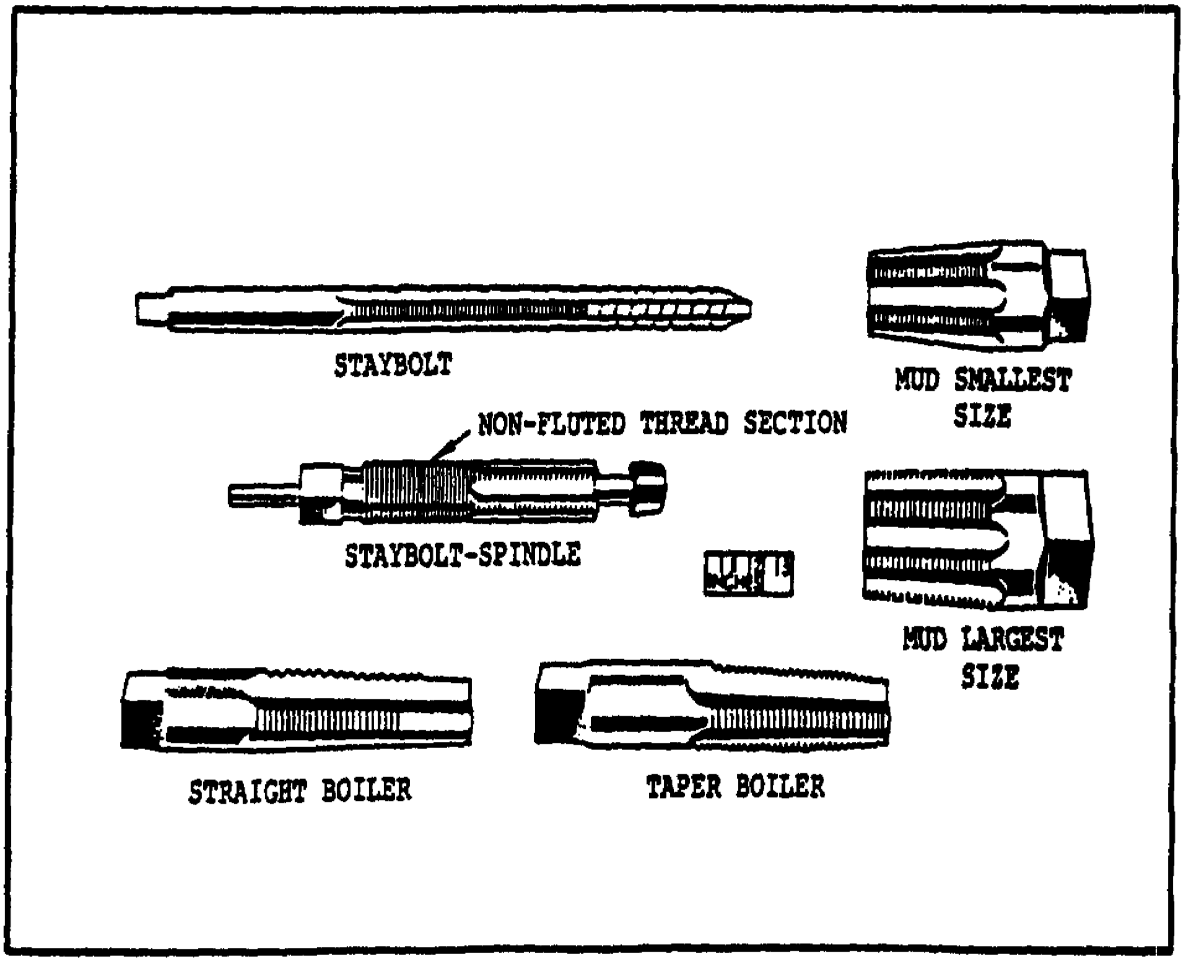


FIGURE 127. SPECIAL PURPOSE TAPS.

(1) *Taper Hand Tap.* The taper or starting hand tap has a chamfer length of 8 to 10 threads. These taps are used when starting the tapping operation, and when tapping coarse threads in through holes, especially in harder metals.

(2) *Plug Hand Taps.* Plug hand taps are designed for use after the taper tap, and in through holes when tapping softer metals or fine-pitch threads. They have a chamfered length of 3 to 5 threads. These taps are the most widely used.

(3) *Bottoming Hand Taps.* Bottoming hand taps are used for threading the bottom of a blind hole. They have a very short chamfer length of only 1 to 1 1/2 threads for this purpose. This tap is always used after the plug tap has already been used, and for hard materials. Both the taper hand and plug hand taps should precede the use of the bottoming hand tap.

(4) *Pipe Taps.* A taper pipe tap is used for pipe fittings and on other places where extremely tight fits are necessary. The tap diameter, from end-to-end of the threaded portion, increases at the rate of 3/4 inch per foot. All threads on this tap cut, as compared to the straight taps where only the non-chamfered portion does the cutting.

(5) *Boiler Taps.* Straight boiler taps range in diameter from 1/2 to 1 1/2 inches. The chamfered portion of the thread simplifies starting. Taper boiler taps have no chamfered portion and the threaded portion is tapered 3/4 inch per foot. The overall and shank diameters are similar to those of straight boiler taps.

(6) *Staybolt Taps.* Staybolt taps are used principally in boiler, locomotive, and railroad shops for tapping the staybolt holes in the outer and inner plates or shells of boilers. The tap must have sufficient length to tap both holes in one operation so the threads in both holes will be in alignment. Staybolt spindle taps are also used for tapping staybolt holes. They have a sliding removable internal spindle with a tapered guide to ensure that both tapped holes are properly lined up. The first hole is tapped, then the spindle is removed, and a non-fluted thread section at the back of the tap guides threading of the second hole.

(7) *Mud or Washout Taps.* Mud or washout taps have 6 flutes with a 1 1/4 inch taper per foot and 12 threads per inch. They are used to cut special American National or V-form threads when tapping mud plug drain holes.

(8) *Fusible Plug Tap.* The fusible plug tap (not illustrated), issued by the Army Ordnance Supply System, is made of carbon steel and has a 1 1/4 inch taper per foot. It has a thread length of 4 3/8 inches, is 1 inch square on the shank, has 4 flutes, and is 7 inches long.

(9) *Pipe Tap and Drill.* A pipe tap and drill (not illustrated) is a combination twist drill and tap. The tap portion follows the twist drill tip. The tool does drilling and tapping in one operation. They are made of carbon steel with a tapered square shank and are sized to drill and tap holes 1/4 - 18, 3/8 - 18, and 1/4 - 14 inches long.

c. *Types of Dies.* Dies are made in several different shapes and are of either the solid or adjustable type.

(1) *Solid Dies.*

(a) *Square Pipe Die.* The square pipe die (figure 128) will cut American Standard Pipe thread only. It is issued in sizes that will cut threads on pipe from 1/8 - 27 to 3 - 8 inches.

(b) *Rethreading Dies.* A rethreading die (figure 128) is used principally for dressing over bruised or rusty threads on screws and bolts. However, it may be used for cutting occasional new threads. It is available in a variety of sizes for rethreading American Standard Coarse and Fine threads. These dies are usually hexagonal in shape and can be turned with a socket, box, open-end, or any wrench that will fit. Rethreading dies are available in sets of 6, 10, 14, and 28 assorted sizes in a case.

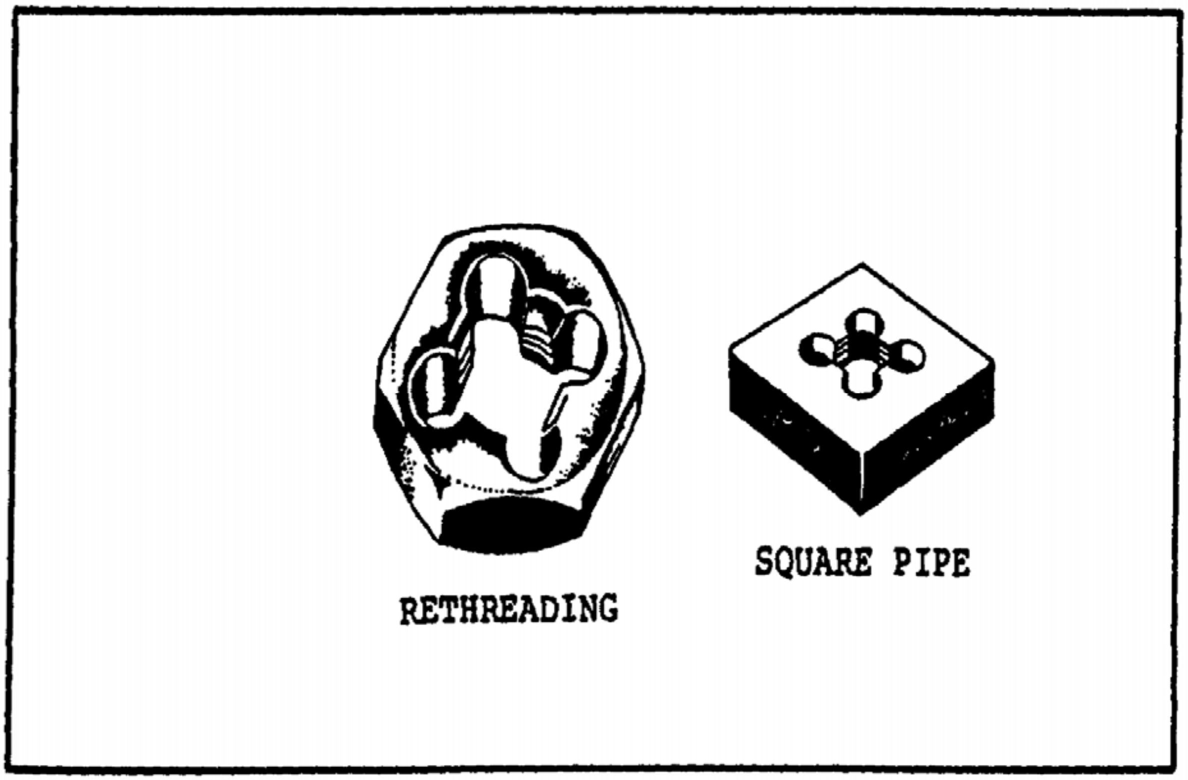


FIGURE 128. TYPES OF SOLID DIES.

(2) *Adjustable Dies.*

(a) *Round Split Adjustable Dies.* Round split adjustable dies (figure 129) are called "button" dies and can be used in either hand diestocks or machine holders. The adjustment in the screw adjusting type is made by a fine pitch screw which forces the sides of the die apart or allows them to spring together. The adjustment in the open adjusting types is made by means of three screws in the holder, one for expanding and two for compressing the dies. Round split adjustable dies are available in a variety of sizes to cut American Standard Coarse and Fine threads, special form threads, and for the standard sizes used in Britain and other European countries. For hand threading, these dies are held in diestocks (figure 130). One type has three pointed screws that will hold round dies of any construction, although specifically made for open adjusting type dies.

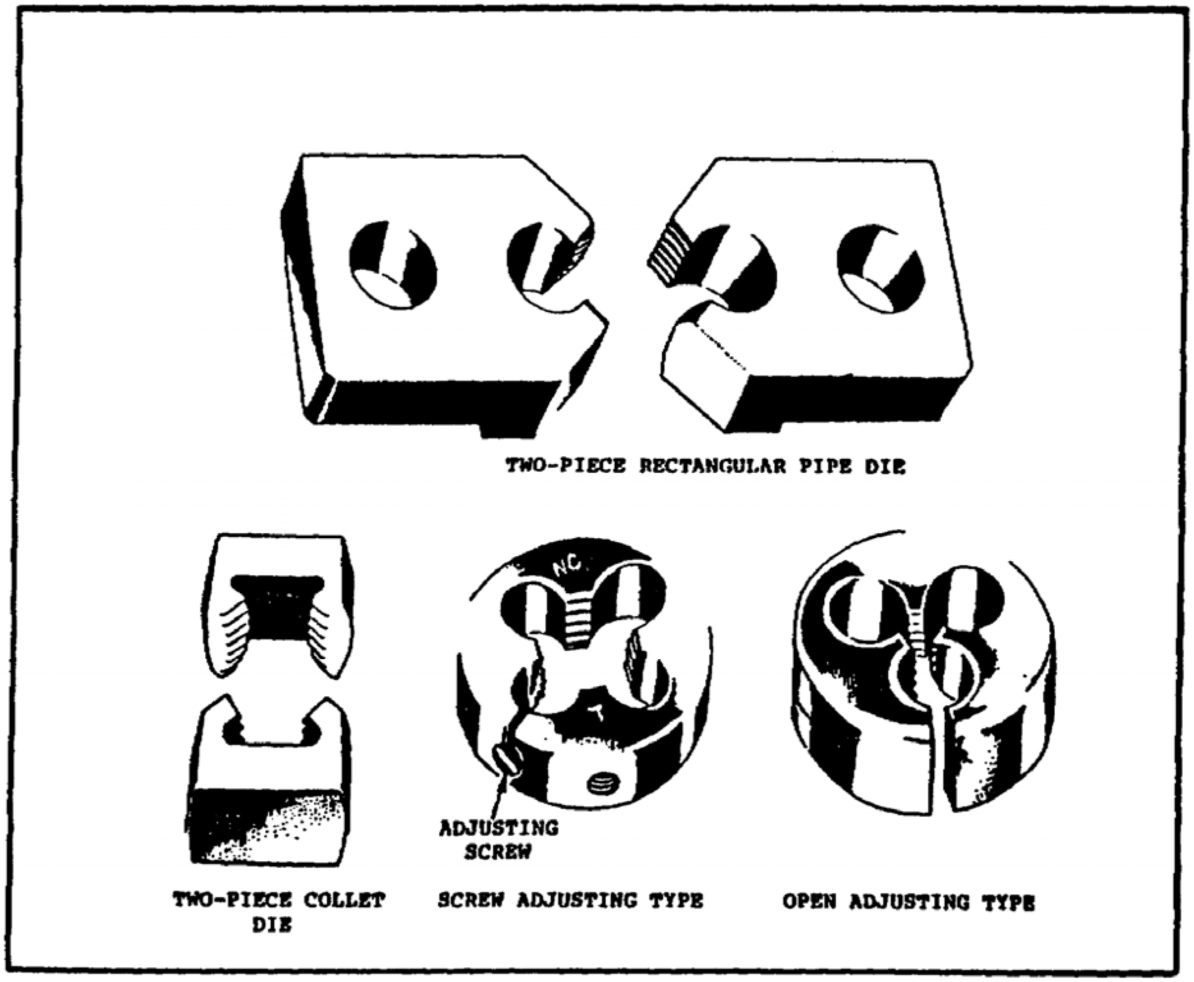


FIGURE 129. TYPES OF ADJUSTABLE DIES.

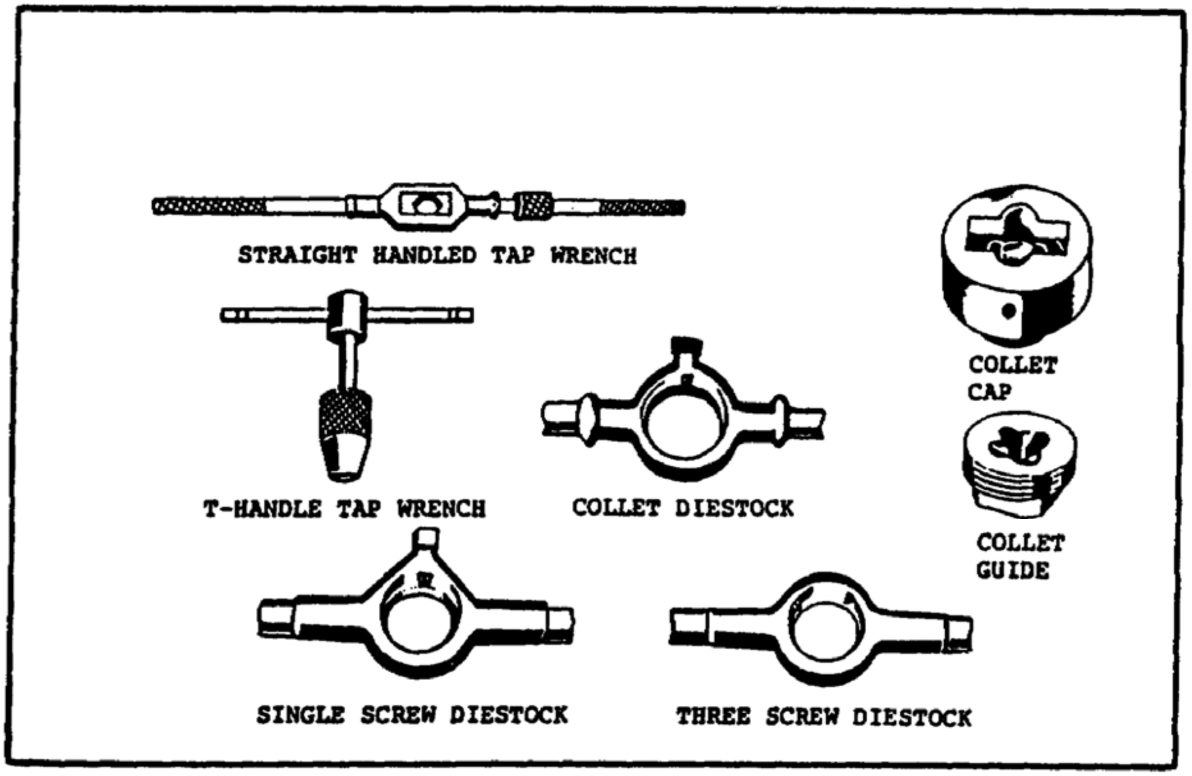


FIGURE 130. DIESTOCKS, DIE, COLLET, AND TAP WRENCHES.

(b) *Two Piece Collet Dies.* A two piece collet dies is used with a collet. The collet consists of a cap and a guide. The die halves are placed in the cap slot and are held in place by the guide which screws into the underside of the cap. The die is adjusted by means of setscrews at either end of the internal slot. This type of adjustable die is issued in various sizes to cover the cutting range of American Standard Coarse and Fine and special form threads. Diestocks to hold collets are issued in three sizes.

(c) *Two Piece Rectangular Pipe Dies.* Two piece rectangular pipe dies are available to cut American Standard Pipe threads. They are held in an ordinary or ratchet type diestock. The jaws of the dies are adjusted by means of setscrews. An adjustable guide serves to keep the pipe in alignment with respect to the dies. The smooth jaws of the guide are adjusted by means of a cam plate; a thumbscrew locks the jaws firmly in the desired position (figure 131). Nonratchet type diestock and plain guides are also available for pipe threading (figure 132).

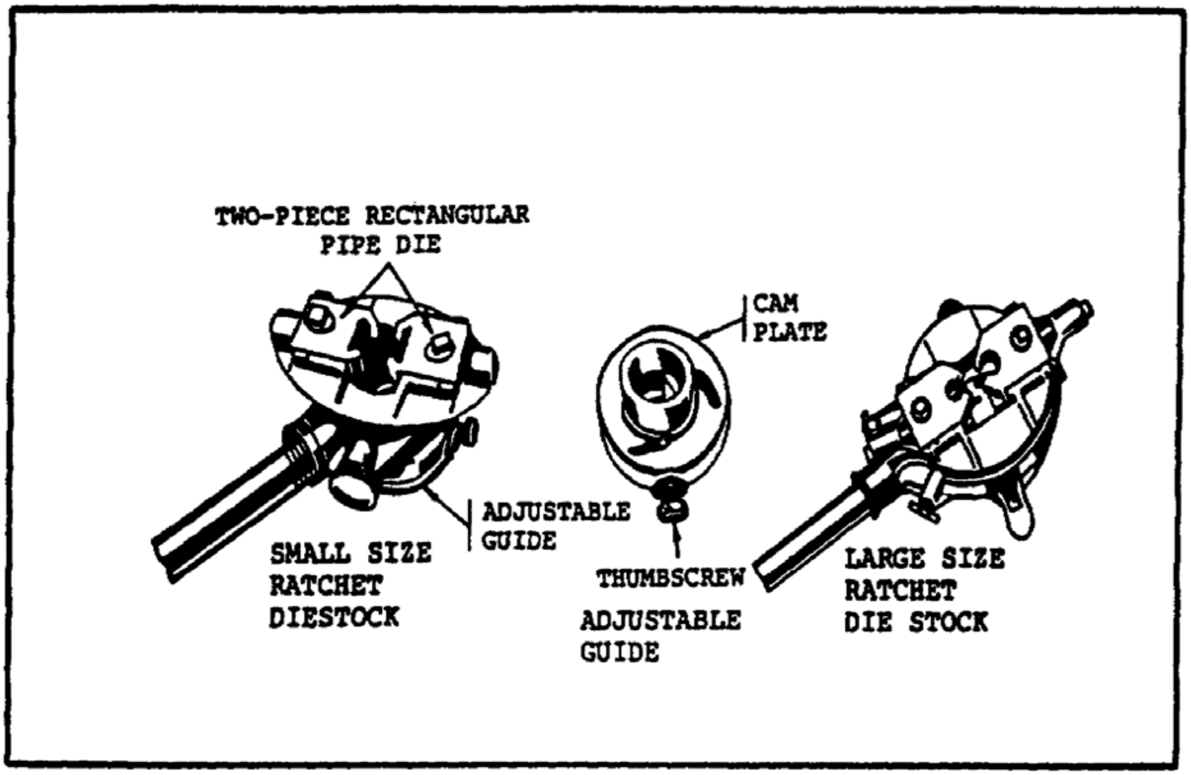
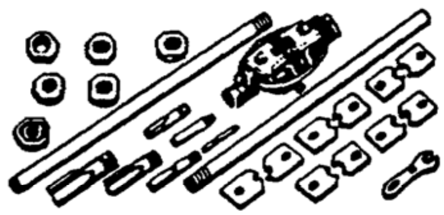
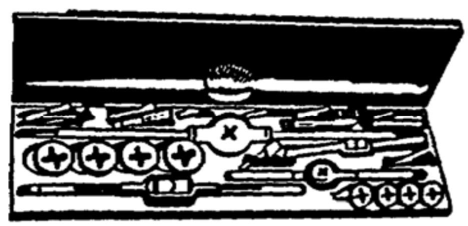


FIGURE 131. ADJUSTABLE DIE GUIDE AND RATCHET DIESTOCKS.



PIPE THREADING SET WITH RECTANGULAR ADJUSTABLE DIES, DIESTOCK, WRENCH, GUIDES AND TAPS



BOLT AND SCREW THREADING SET WITH ROUND ADJUSTABLE SPLIT DIES, DIESTOCKS, TAPS, TAP WRENCHES, AND SCREWDRIVERS

FIGURE 132. THREADING SETS.

d. *Threading Sets.* Threading sets are available in many different combinations of taps and dies, together with diestocks, tap wrenches, guides, and necessary screwdrivers and wrenches to loosen and tighten adjusting screws and bolts. Figure 132 illustrates typical threading sets for pipe, bolts, and screws.

e. *Mechanics of Taps and Dies.*

(1) *General.* Taps and dies are manufactured of regular high speed steel and surface-treated high speed steel. Surface-treated high speed steel taps have a secondary hardening which increases the hardness and wear resistance of the cutting edges without subtracting from the toughness of the body of the tool as a whole.

(2) *Tap Design.* A tap is a threading tool designed to produce a completed internal thread and to make threading possible without a lead screw. A tap is basically a screw in which longitudinal channels or flutes are cut or ground. The flutes permit chips to escape and lubricants to reach the cutting area and threaded metal. Terms used when discussing taps are as indicated in (a) through (s) below (figure 133).

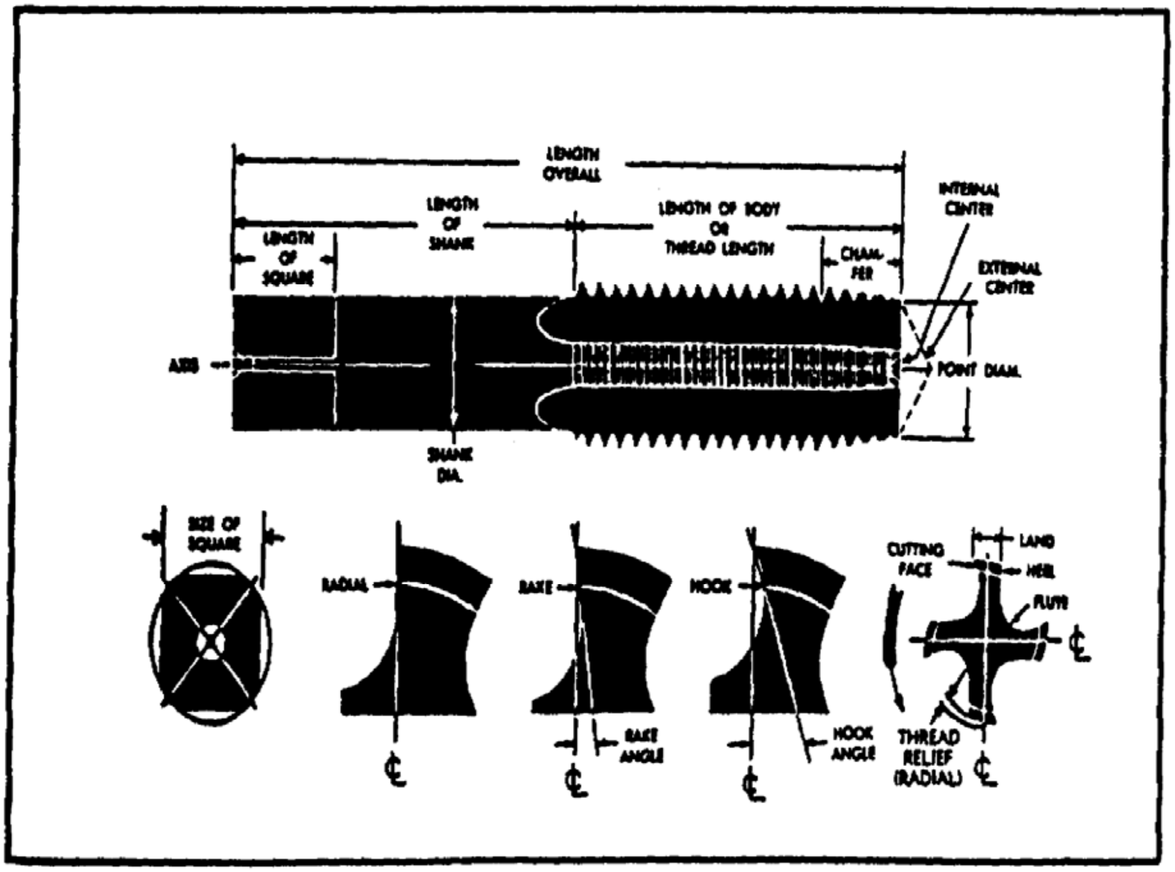


FIGURE 133. TAP TERMS.

(a) *Axis of Tap.* Longitudinal central through the tap.

(b) *Back Taper.* A slight taper on the body of the tap which makes the pitch diameter of the thread near the shank somewhat larger than that close to the point. The pitch diameter equals outside diameter minus the single depth of the thread.

(c) *Body.* The threaded part of tap.

(d) *Chamfer.* The length at the front end of the threaded section, cut or ground tapered and relieved of teeth.

(e) *Cutting Face.* The leading side of the threaded part or land.

(f) *External Center.* The cone shaped front end of the tap. It is necessary for manufacturing purposes and usually at the threaded ends of small taps only.

(g) *Flute.* The portion cut away between the threaded parts of the lands.

(h) *Heel.* The noncutting or following side of the land.

(i) *Hook.* The curved cutting side of the flute. Used when tapping some materials.

(j) *Internal Center.* The small drilled countersunk conical hole at the front end of the tap, made for manufacturing purposes.

(k) *Interrupted Thread.* Taps with every other tooth along the threaded part removed. Used on soft, stringy materials.

(l) *Land.* The threaded part of the tap.

(m) *Point Diameter.* The diameter at the leading end of the chamfered portion.

(n) *Radial.* The straight side of a flute which, if continued, would pass through the center of the tap.

(o) *Rake.* The angle of the cutting side of the flute in relation to an axial plane passing through the center of the tap.

(p) *Relief.* The condition whereby metal is removed from behind the cutting edge to produce clearance and reduce friction. Most taps have the chamfer relieved, but some may not have relief on the external diameter of the threads.

(q) *Shank.* The part behind the threaded section of the tap.

(r) *Square.* The length at the back end of the shank, of square cross section.

(s) *Thread.* The helical or spiral formed grooves and teeth of the tap, with intermittent deep longitudinal flutes, which produce the thread in a tapped hole.

(3) *Die Design.* A die is a threading tool designed to produce an external thread. It accomplishes this operation without a lead screw. A solid die is basically a nut in which flutes have been machined at right angles to the threads, and which have been hardened to provide cutting edges. The round or button die is actually an adjustable split nut. Two piece dies are machined separately. The number of threads in a die is much less than on a tap and the flutes have more of an exit for the escape of the chips of metal. A short chamfer on a die (figure 134) is used for threading close to a shoulder. A long chamfer is used where two or three incomplete threads can be tolerated on the job to be threaded. Equal chamfering on a die provides balanced cutting. The terms usually used in connection with a die are indicated in figure 135. The standard chamfer for the front face of a straight thread die is 2 to 3 threads, or about 15°. The rear face in some dies is chamfered from 1 to 1 1/2 threads. Standard taper thread dies have a front chamfer of 2 to 3 threads and none at the rear face. Long chamfers mean better threading performance.

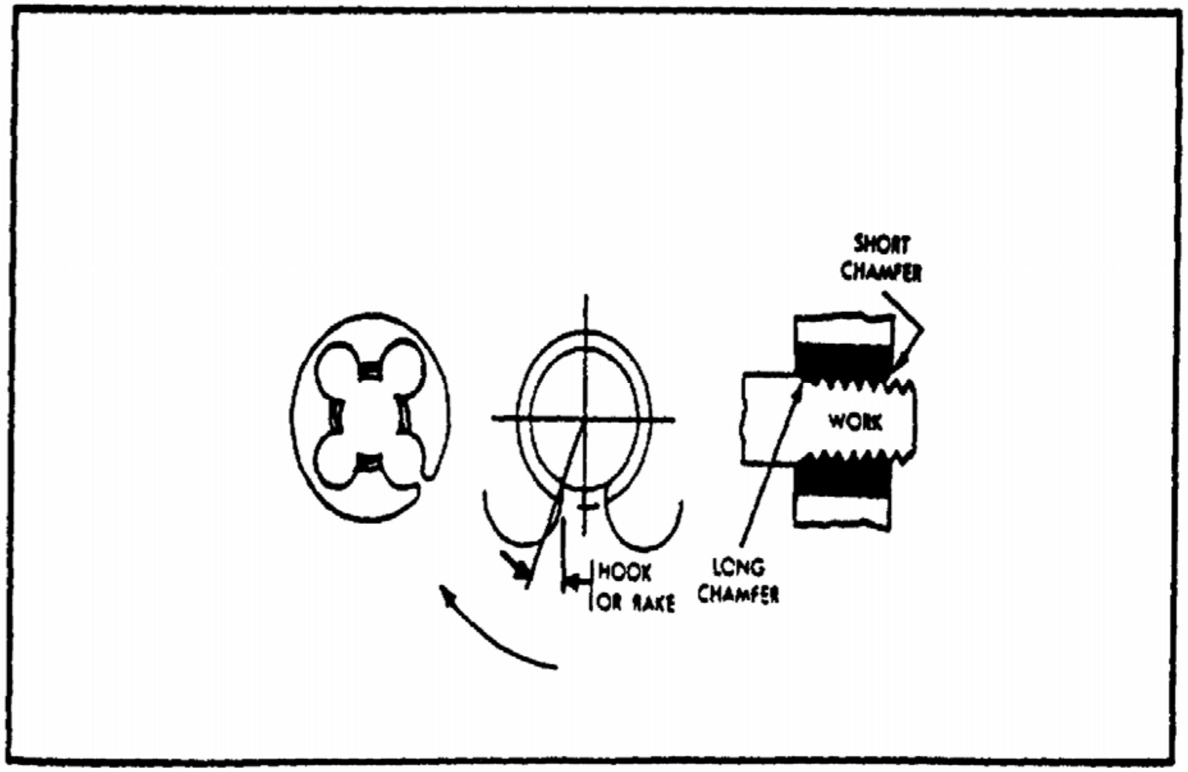


FIGURE 134. DIE CHAMFERS.

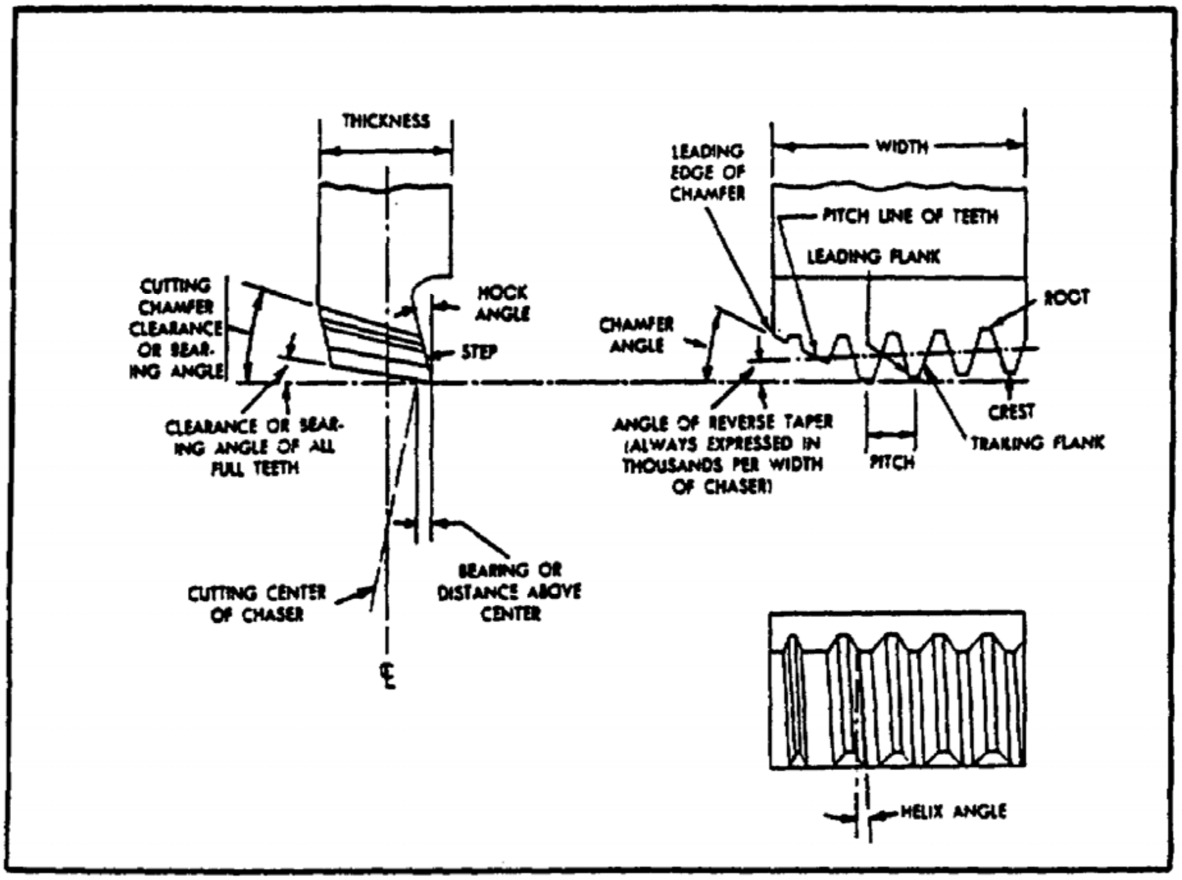


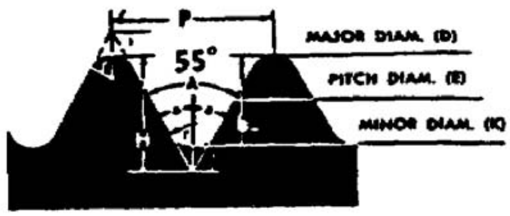
FIGURE 135. DIE TERMS.

f. *Use of Taps.*

(1) *Selecting a Tap Drill.* The size of a tap is the outside diameter of its threads; therefore, theoretically, the hole drilled for tapping could be smaller than the tap by twice the depth of the thread if a full thread is cut. The shape of the thread partly determines the amount to be subtracted from the tap diameter. Figures 136 through 139 indicate the various thread dimensions of British and Metric screw thread standards, American pipe thread standards, and the tap drill size required for each thread. Do not use a tap drill that is too small in diameter as this will cause tapping troubles. A drilled hole should be of sufficient diameter to produce a thread depth of approximately 75 percent. This 75 percent is only an average. Actually, the percentage may vary from 50 to 53 percent for small or deep holes, to a maximum of 83 percent on any size. A definite thread depth for all sizes, under all conditions, is not practical. You must determine which is most suitable by analyzing the following conditions:

diameter of tapped hole, nature of material being tapped, depth of tapped hole, and the pitch.

This form of thread is used almost exclusively in Great Britain and extensively in the British Dominions, Asia and South America. There are two standard series, the British Standard Whitworth which is a coarse thread series and the British Standard Fine. Threads of this form not included in the BSW and BSF series are designated simply Whitworth.

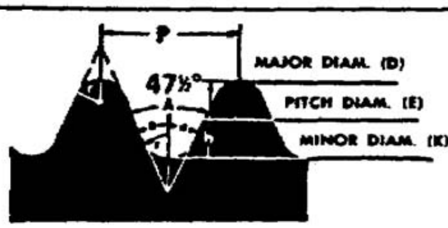


A = 55° = Angle of thread
a = 27½° = ½ Angle of thread
f = 1/6H = Depth of truncation
H = 0.960491p = Depth Theoretical V 55° thread
h = 0.640327p, or 4/6H = Depth Whitworth form thread
n = Number threads per inch
p = 1/n = Pitch
r = 0.137329p = Radius of crest and root

NOMINAL SIZE Inches	D MAJOR DIAM Inches	E PITCH DIAM. Inches	K MINOR DIAM. Inches	COMMERCIAL TAP DRILL to Produce Approx. 75% Full Thread		
				Size	Dec Equiv.	Actual Percent
1/16-60	.0625	.0518	.0412	3/64	.0468	72
3/32-48	.0938	.0804	.0671	5/64	.0781	58
1/8-40	.1250	.1090	.0930	3/32	.0937	96
5/32-32	.1563	.1362	.1162	1/8	.1250	77
3/16-24	.1875	.1608	:1341	9/64	.1406	87
7/32-24	.2188	.1921	.1654	11/64	.1718	86
1/4-20	.2500	.2180	.1860	13/64	.2031	72
26	.2500	.2254	.2008	7/32	.2187	63
9/32-26	.2813	.2566	.2320	1/4	.2500	62
5/16-18	.3125	.2769	.2414	17/64	.2656	65
22	.3125	.2834	.2543	17/64	.2656	79
3/8-16	.3750	.3350	.2950	5/16	.3125	77
20	.3750	.3430	.3110	21/64	.3281	72
7/16-14	.4375	.3918	.3460	3/8	.3750	67
18	.4375	.4019	.3665	25/64	.3906	65
1/2-12	.5000	.4466	.3933	27/64	.4218	81
16	.5000	.4600	.4200	7/16	.4375	77
9/16-12	.5625	.5091	.4558	31/64	.4844	72
16	.5625	.5225	.4825	1/2	.5000	77
5/8-11	.6250	.5668	.5086	17/32	.5312	79
14	.6250	.5793	.5336	9/16	.5625	67
11/16 11	.6875	.6293	.5711	19/32	.5937	79
14	.6875	.6418	.5961	5/8	.6250	67
3/4-10	.7500	.6860	.6219	21/32	.6562	73
12	.7500	.6966	.6434	43/64	.6719	72
7/8- 9	.8750	.8039	.7327	49/64	.7656	76
11	.8750	.8168	.7586	25/32	.7812	79
1- 8	1.0000	.9200	.8399	7/8	.8750	77
10	1.0000	.9360	.8720	29/32	.9062	72
1 1/8- 7	1.1250	1.0335	.9420	63/64	.9843	76
9	1.1250	1.0539	.9828	1 1/64	1.0156	76
1 1/4- 7	1.2500	1.1585	1.0670	1 7/64	1.1093	76
9	1.2500	1.1789	1.1078	1 9/64	1.1406	76
1 3/8- 6	1.3750	1.2683	1.1616	1 7/32	1.2187	72
8	1.3750	1.2950	1.2150	1 1/4	1.2500	77
1 1/2- 6	1.5000	1.3933	1.2866	1 11/32	1.3437	72
8	1.5000	1.4200	1.3400	1 3/8	1.3750	77
1 5/8- 5	1.6250	1.4969	1.3688	1 7/16	1.4375	73
1 3/4- 5	1.7500	1.6219	1.4939	1 9/16	1.5625	72
1 7/8- 4 1/2	1.8750	1.7327	1.5904	1 21/32	1.6562	76
2- 4 1/2	2.0000	1.8577	1.7154	1 25/32	1.7812	76

BRITISH ASSOCIATION STANDARD

This thread is the standard used in the manufacture of small machine screws in Great Britain, and, to some extent, in other countries of Europe. It is sometimes called the Swiss Small Screw Thread system, owing to its origin in the Swiss watch and clockmaking industries.

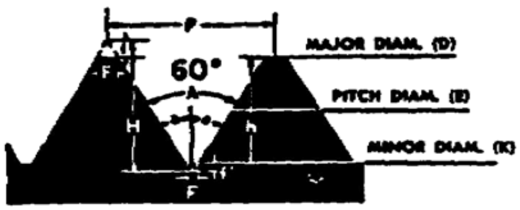


A = 47½° = Angle of thread
a = 23¾° = ½ Angle of thread
h = 0.600p = Depth British Association Thread
p = Pitch
r = 2/11p = Radius of crest and root

SIZE No.	PITCH mm	D MAJOR DIAM. mm	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. Full Thread mm
0	1.00	6.0	5.400	4.80	4.9
1	.90	5.3	4.760	4.22	4.4
2	.81	4.7	4.215	3.73	3.8
3	.73	4.1	3.660	3.22	3.5
4	.66	3.6	3.205	2.81	3.0
5	.59	3.2	2.845	2.49	2.7
6	.53	2.8	2.480	2.16	2.3
7	.48	2.5	2.210	1.92	2.0
8	.43	2.2	1.940	1.68	1.8
9	.39	1.9	1.665	1.43	1.5
10	.35	1.7	1.490	1.28	1.3
11	.31	1.5	1.315	1.13	1.2
12	.28	1.3	1.130	.96	1.0
14	.23	1.0	.860	.72	.7

FIGURE 136. BRITISH THREAD DIMENSIONS.

This thread form is similar to the American National thread form. It is generally designated in two standards, the International Standard and the French Standard, and is used mostly in Continental European countries.



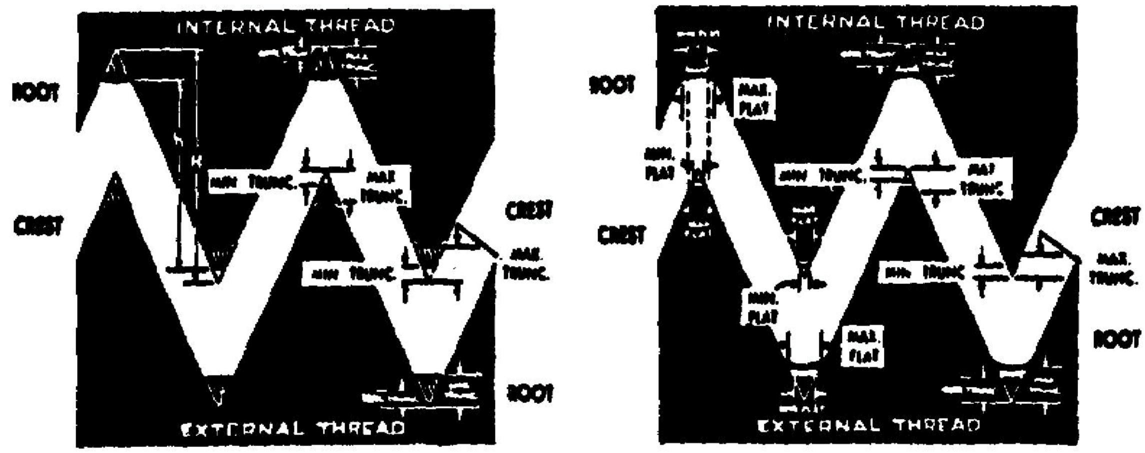
A = 60° = Angle of thread
a = 30° = $\frac{1}{2}$ Angle of thread
F = $\frac{1}{8}p$ = Flat at crest
F' = $\frac{1}{16}p$ = Flat at root
f = $\frac{1}{8}H$ = Depth of truncation at crest
f' = $\frac{1}{16}H$ = Depth of truncation at root
H = 0.866025p = Depth of theoretical sharp V thread
h = 0.70365p, or $\frac{13}{16}H$ = Depth Metric form thread
p = Pitch

D NOMINAL SIZE	PITCH French Std.	PITCH Int. Std. (D.I.N.)	PITCH Optional	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. 75% Full Thread mm
1.5	..	..	.35	1.273	1.05	1.1
2	..	.40	..	1.740	1.48	1.6
2	.45	..	..	1.708	1.42	1.5
2	..	..	.50	1.675	1.35	1.5
2.3	..	.40	..	2.040	1.78	1.9
2.5	.45	..	..	2.208	1.92	2.0
2.6	..	.45	..	2.308	2.02	2.1
3	..	.50	..	2.675	2.35	2.5
3	.60	..	..	2.610	2.22	2.4
3	..	..	.75	2.513	2.03	2.25
3.5	.60	.60	..	3.110	2.72	2.9
4	..	.70	..	3.545	3.09	3.3
4	.75	..	..	3.513	3.03	3.25
4.5	.75	.75	..	4.013	3.53	3.75
5	..	..	.75	4.513	4.03	4.25
5	..	.80	..	4.480	3.96	4.2
5	.90	..	..	4.415	3.83	4.1
5	..	..	1.00	4.350	3.70	4.0
5.5	..	..	.75	5.013	4.53	4.75
5.5	.90	.90	..	4.915	4.33	4.6
6	1.00	1.00	..	5.350	4.70	5.0
6	..	..	1.25	5.188	4.38	4.8
7	1.00	1.00	..	6.350	5.70	6.0
7	..	..	1.25	6.188	5.38	5.8
8	..	..	1.00	7.350	6.70	7.0
8	1.25	1.25	..	7.188	6.38	6.8
9	..	..	1.00	8.350	7.70	8.0
9	1.25	1.25	..	8.188	7.38	7.8
10	..	..	1.25	9.188	8.38	8.8
10	1.50	1.50	..	9.026	8.05	8.6
11	..	1.50	..	10.026	9.05	9.6
12	..	..	1.25	11.188	10.38	11.0
12	..	..	1.50	11.026	10.05	10.5
12	1.75	1.75	..	10.863	9.73	10.5
13	..	..	1.50	12.026	11.05	11.5

D NOMINAL SIZE	PITCH French Std.	PITCH Int. Std. (D.I.N.)	PITCH Optional	E PITCH DIAM. mm	K MINOR DIAM. mm	COM. TAP DRILL to Produce Approx. 75% Full Thread mm
13	..	..	1.75	11.863	10.73	11.5
13	..	..	2.00	11.701	10.40	11.0
14	..	..	1.25	13.188	12.38	13.0
14	..	..	1.75	12.863	11.73	12.5
14	2.00	2.00	..	12.701	11.40	12.0
15	..	..	1.75	13.863	12.73	13.5
15	..	..	2.00	13.701	12.40	13.0
16	2.00	2.00	..	14.701	13.40	14.0
17	..	..	2.00	15.701	14.40	15.0
18	..	..	1.50	17.026	16.05	16.5
18	..	..	2.00	16.701	15.40	16.0
18	2.50	2.50	..	16.376	14.75	15.5
19	..	..	2.50	17.376	15.75	16.5
20	..	..	2.00	18.701	17.40	18.0
20	2.50	2.50	..	18.376	16.75	17.5
22	2.50	2.50	..	20.376	18.75	19.5
24	3.00	3.00	..	22.051	20.10	21.0
26	3.00	..	..	24.051	22.10	23.0
27		3.00	..	25.051	23.10	24.0
28	3.00	.	..	26.051	24.10	25.0
30	3.50	3.50	..	27.727	25.45	26.5
32	3.50	.	..	29.727	27.45	28.5
33	..	3.50	..	30.727	28.45	29.5
34	3.50	..	..	31.727	29.45	30.5
36	4.00	4.00	..	33.402	30.80	32.0
38	4.00	..	..	35.402	32.80	34.0
39	..	4.00	..	36.402	33.80	35.0
40	4.00	.	..	37.402	34.80	36.0
42	4.50	4.50	..	39.077	36.15	37.0
44	4.50	..	..	41.077	38.15	39.0
45	..	4.50	..	42.077	39.15	40.0
46	4.50	..	..	43.077	40.15	41.0
48	5.00	5.00	..	44.752	41.50	43.0
50	5.00	..	..	46.752	43.50	45.0

FIGURE 137. METRIC STANDARD THREADS.

AMERICAN STANDARD PIPE THREADS—NPT   AMERICAN STANDARD DRYSEAL PIPE THREADS—NPTF

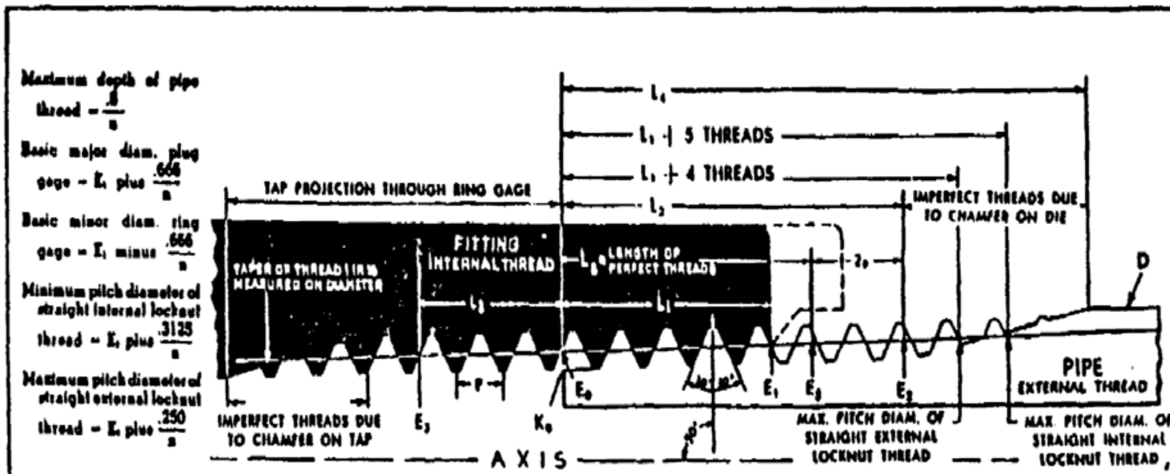


LIMITS ON CREST AND ROOT OF EXTERNAL AND INTERNAL PIPE THREADS—INCHES

THREADS Per Inch		DEPTH SHARP V THREAD H	STANDARD TAPER PIPE THREAD					DRYSEAL PIPE THREAD			
			Depth Taper Pipe Thread "Max" h	Truncation		Equivalent Width of Flat		Truncation		Equivalent Width of Flat	
				Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
27	Crest	.03208	.02963	.0012	.0036	.0014	.0041	.0017	.0035	.0020	.0040
	Root			.0012	.0036	.0014	.0041	.0035	.0052	.0040	.0060
18	Crest	.04811	.04444	.0018	.0049	.0021	.0057	.0026	.0043	.0030	.0050
	Root			.0018	.0049	.0021	.0057	.0043	.0061	.0050	.0070
14	Crest	.06186	.05714	.0024	.0056	.0027	.0064	.0026	.0043	.0030	.0050
	Root			.0024	.0056	.0027	.0064	.0043	.0061	.0050	.0070
11 ½	Crest	.07531	.06957	.0029	.0063	.0033	.0073	.0035	.0052	.0040	.0060
	Root			.0029	.0063	.0033	.0073	.0052	.0070	.0060	.0080
8	Crest	.10825	.10000	.0041	.0078	.0048	.0090	.0052	.0069	.0060	.0080
	Root			.0041	.0078	.0048	.0090	.0069	.0096	.0080	.0110

Note: The major diameter of standard taper pipe plug gages and the minor diameter of standard taper pipe ring gages used for gaging dry-seal threads will be truncated .20p minimum or .28p maximum for all pitches.

FIGURE 138. AMERICAN STANDARD AND DRY SEAL PIPE THREADS.



Basic Dimensions of Taper Pipe Threads — Inches

PIPE SIZE		PITCH		HAND TIGHT ENGAGEMENT		EFFECTIVE THREAD OR WRENCH MAKEUP				TOTAL LENGTH OF THREAD	PERFECT THREADS		SMALL END OF PIPE		INCREASE IN DIAMETER PER THREAD 0.0625/n	*TAP DRILL SIZES
						External		Internal								
Nominal	Outside Diameter	Threads per Inch	Length	Length, also Thickness of Thin Ring Gage and Distance from Gaging Notch to Small End of Plug Gage	Basic Pitch Diam., also Pitch Diam. at Gaging Notch, also Basic Pitch Diam. of Straight Pipe Thread	Length, also Length of Plug Gage	Pitch Diameter	Length Wrench Makeup	Pitch Diameter at Small End		Length	Pitch Diameter of Largest External	Pitch Diameter	Basic Minor Diameter		
..	D	n	p	L_1	E_1	L_8	E_8	L_3	E_3	L_4	L_5	E_5	E_0	K_0	..	..
1/16	.3125	27	.03704	.160	.28118	.2611	.28750	.1111	.26424	.3896	.1870	.28287	.27118	.2416	.00231	..
1/8	.405	27	.03704	.180	.37476	.2639	.38000	.1111	.35656	.3924	.1898	.37537	.36351	.3339	.00231	R
1/4	.540	18	.05556	.200	.48989	.4018	.50250	.1667	.46697	.5946	.2907	.49556	.47739	.4329	.00347	7/16
3/8	.675	18	.05556	.240	.62701	.4078	.63750	.1667	.60160	.6006	.2967	.63056	.61201	.5676	.00347	37/64
1/2	.840	14	.07143	.320	.77843	.5337	.79179	.2143	.74504	.7815	.3909	.78206	.75843	.7013	.00446	23/32
3/4	1.050	14	.07143	.339	.98887	.5457	1 00179	.2143	.95429	.7935	.4029	.99206	.96768	.9105	.00446	59/64
1	1.315	11 1/2	.08696	.400	1 23863	.6828	1 25630	.2609	1.19733	.9845	.5088	1.24543	1.21363	1.1441	.00543	1 5/32
1 1/4	1 660	11 1/2	.08696	.420	1 58338	.7068	1 60130	.2609	1 54083	1 0085	.5329	1.59043	1 55713	1.4876	.00543	1 1/2
1 1/2	1 900	11 1/2	.08696	.420	1 82234	.7235	1 84130	.2609	1 77978	1 0252	.5496	1 83043	1.79609	1.7265	.00543	1 47/64
2	2 375	11 1/2	.08696	.436	2 29627	.7565	2 31630	.2609	2 25272	1.0582	.5826	2.30543	2.26902	2.1995	.00543	2 7/32
2 1/2	2.875	8	.12500	.682	2 76216	1.1375	2 79062	.250	2.70391	1 5713	.8875	2.77500	2.71953	2.6195	.00781	2 5/8
3	3 500	8	.12500	.766	3 38850	1.2000	3 41562	.250	3 32500	1.6337	.9500	3 40000	3 34062	3.2406	.00781	3 1/4
3 1/2	4 000	8	.12500	.821	3 88881	1.2500	3 91562	.250	3 82188	1.6837	1 0000	3 90000	3.83750	3.7375	.00781	3 3/4
4	4.500	8	.12500	.844	4 38712	1.3000	4 41562	.250	4.31875	1.7337	1 0500	4.40000	4 33438	4.2344	.00781	4 1/4
5	5 563	8	.12500	.937	5 44929	1.4063	5 47862	.250	5.37511	1 8407	1.1563	5.46300	5.39073	5.2907	.00781	..
6	6 625	8	.12500	.958	6 50597	1.5125	6 54062	.250	6 43047	1.9467	1.2625	6 52500	6.44609	6.3461	.00781	..
8	8 625	8	.12500	1.063	8 50003	1.7125	8 54062	.250	8 41797	2.1467	1.4625	8 52500	8 43359	8.3336	.00781	..
10	10.750	8	.12500	1.210	10 62094	1.9250	10 66562	.250	10 52969	2 3587	1.6750	10 65000	10 54531	10.4453	.00781	..
12	12.750	8	.12500	1.360	12.61781	2.1250	12.66562	.250	12 51719	2.5587	1.8750	12.65000	12.53281	12.4328	.00781	..

* Methods of inspection vary. Care should be taken to use a tap drill or taper reamer which can meet thread specifications. Sizes given permit direct tapping without reaming the hole, but only give a full thread for the first two or three threads. See columns E_1 and L_1.

FIGURE 139. BASIC DIMENSIONS OF TAPER PIPE THREADS.

(a) *Diameter and Pitch of Tapped Hole.* The coarser the pitch, the larger is the thread depth if a full thread were cut. Try a drill giving 75 percent thread depth first. If tap breakage results, reduce the thread depth gradually by using larger drills until satisfactory performance is obtained.

NOTE

A nut with only 50 percent thread depth will break the bolt before it strips the thread.

American Standard screw threads (Table I) are standardized in two series, coarse and fine. As a tap size becomes smaller, the percentage of double thread depth in relation to basic major diameter of the screw generally becomes larger.

TABLE I. AMERICAN STANDARD SCREW THREADS.

Basic Major Diameter	% Double Coarse	Thread Depth Fine
1.0 inch	16	9
0.750 inch	17	11
0.500 inch	20	13
0.375 inch	22	14
0.250 inch	26	19
No. 5 machine screw	26	24

(b) *Nature of Material Being Tapped.* Soft metals such as copper, aluminum, monel metal, nickel silver, and the low melting point alloys have a tendency to flow towards the root of the minor diameter of the tap while being tapped. The minor diameter of tapped holes in such material will be smaller after tapping. Take this into consideration when selecting the tap drill of sufficient size. Use the smallest thread depth possible on materials that are very tough or of high hardness. This is accomplished by using the largest drill possible, which nevertheless will be smaller than the one used for softer materials under similar circumstances.

(c) *Depth of Tapped Hole.* Larger tap drills giving 50 percent thread depth may be used when holes are deeper than 1 1/2 times the tap diameter. Punched holes often cause binding and tap breakage, especially in thin sheet metal, which creates an "oilcan" effect. When the hole is punched, the metal is flared out. As the tap is reversed after threading, it draws in this flare and binds. Consider this when selecting the punch size. The larger the punched hole, the less tendency for the tap to bind. Holes formed in castings and forgings should be checked for 75 percent depth, and reamed to size if necessary before tapping.

(2) Tapping a Hole.

(a) After the proper size and type hole (figure 140) is drilled and cleaned, secure the tap in a tap wrench.

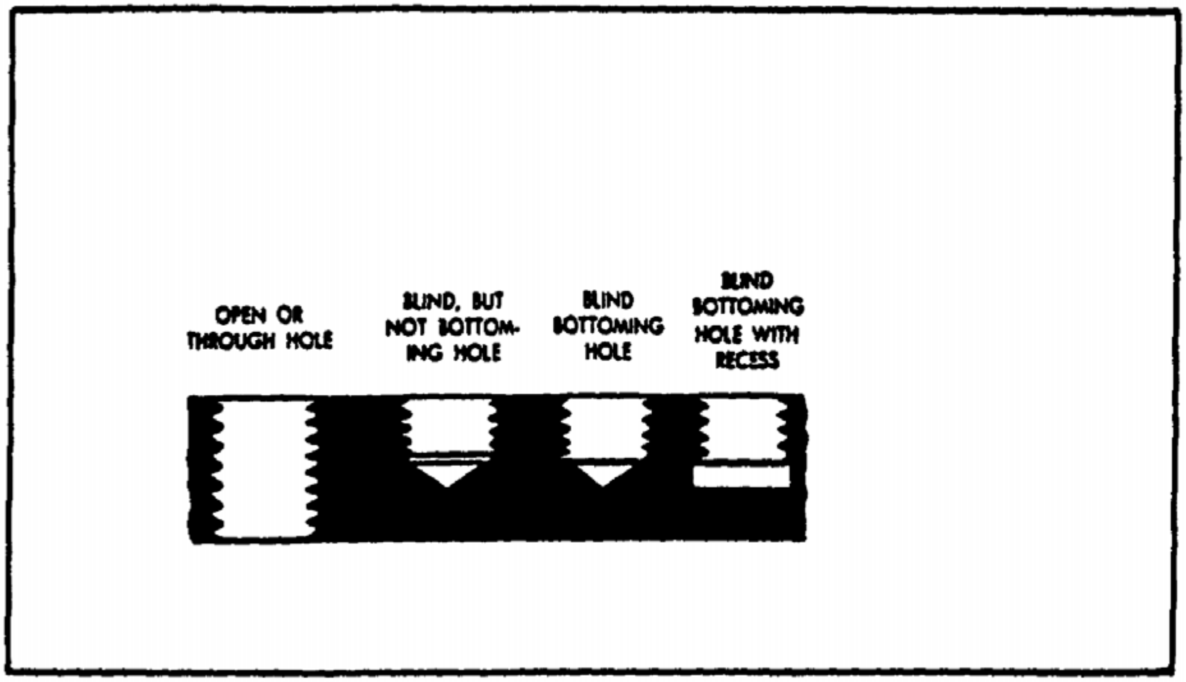


FIGURE 140. TYPES OF DRILLED HOLES.

(b) Apply cutting oil to the tap and to the hole. Place the point of the tap in the hole and rotate the tap (figure 141) clockwise for right-hand threads and counterclockwise for left-hand threads.

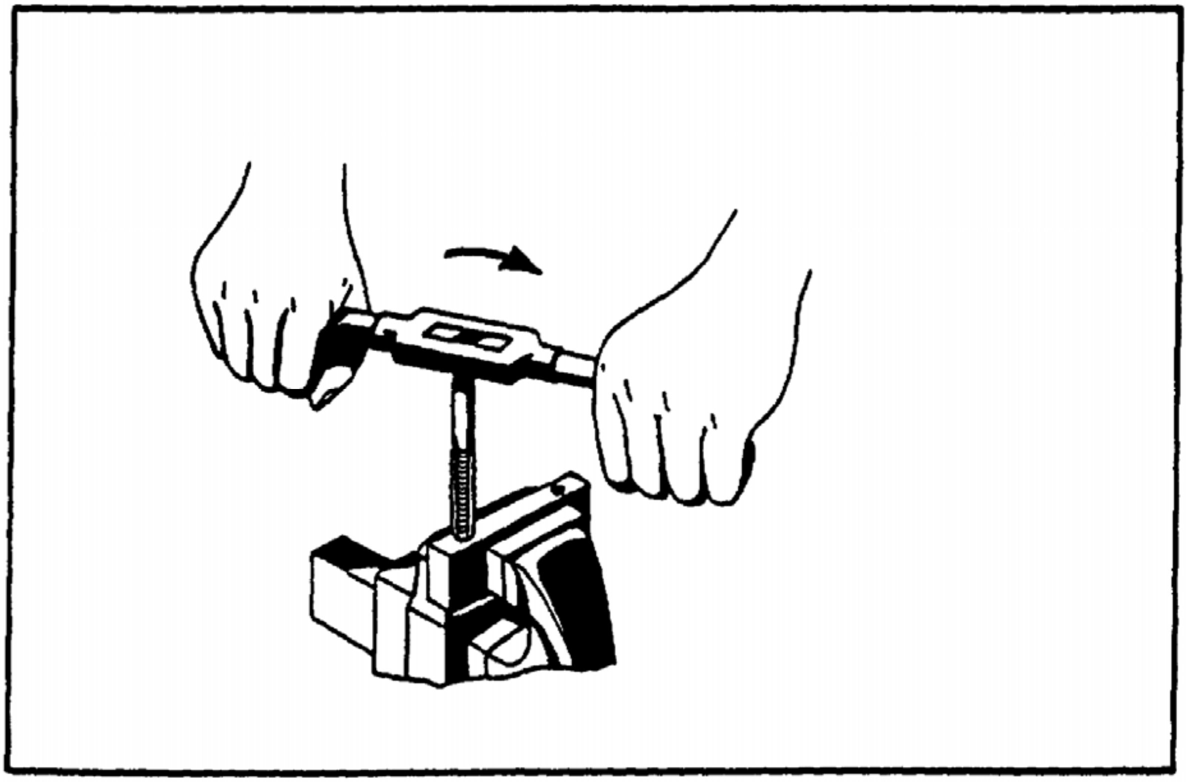


FIGURE 141. USING A TAP AND TAP WRENCH.

(c) Check the tap for straightness in the hole by using a square. Check to see that the tap is in line with the axis of the hole and at right angles to the face of the work. Check at more than one position around the tap.

(d) It is not necessary to feed the tap into the hole with any pressure, as the threads will pull it in at the proper rate. Keep the tap straight ((c) above).

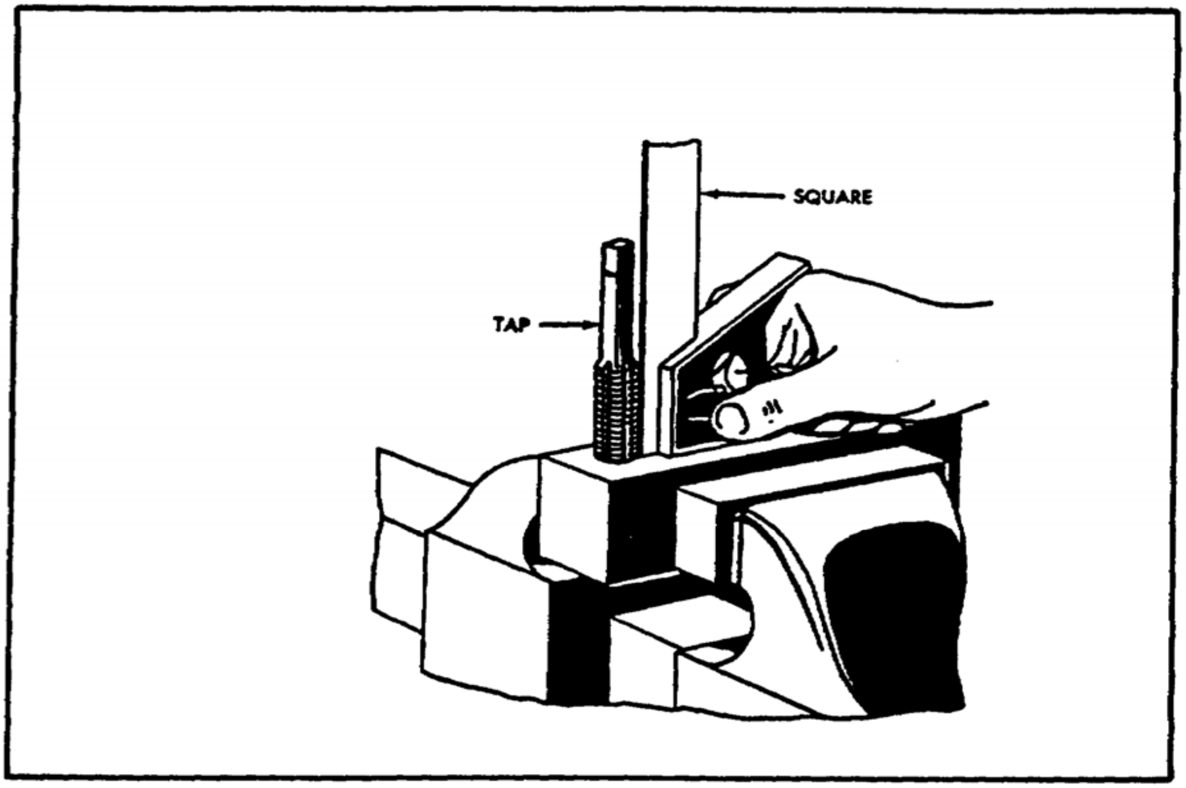


FIGURE 142. CHECKING TAP FOR STRAIGHTNESS.

(e) When tapping rough material, after each half turn of the tap in a forward or cutting direction, rotate the tap a quarter turn back, then a half turn forward, then a quarter turn back, etc., until the hole is tapped. Use pure lard cutting oil to keep the tap well lubricated when tapping.

(f) If the hole to be tapped is a blind hole, use a plug tap and finally a bottoming tap to complete the tapping operation. A bottoming hole is one in which the thread has been tapped as far as the bottom. Use extreme caution to keep the taps from being forced against the bottom of the hole. Check cut threads with the proper screw pitch gage.

g. *Use of Dies.*

(1) *General.* The general procedure for cutting threads by hand is as described in (a) through (g) below.

(a) Make certain the work to be threaded is clean and free from burrs.

(b) Secure the work firmly in a vise (figure 143).

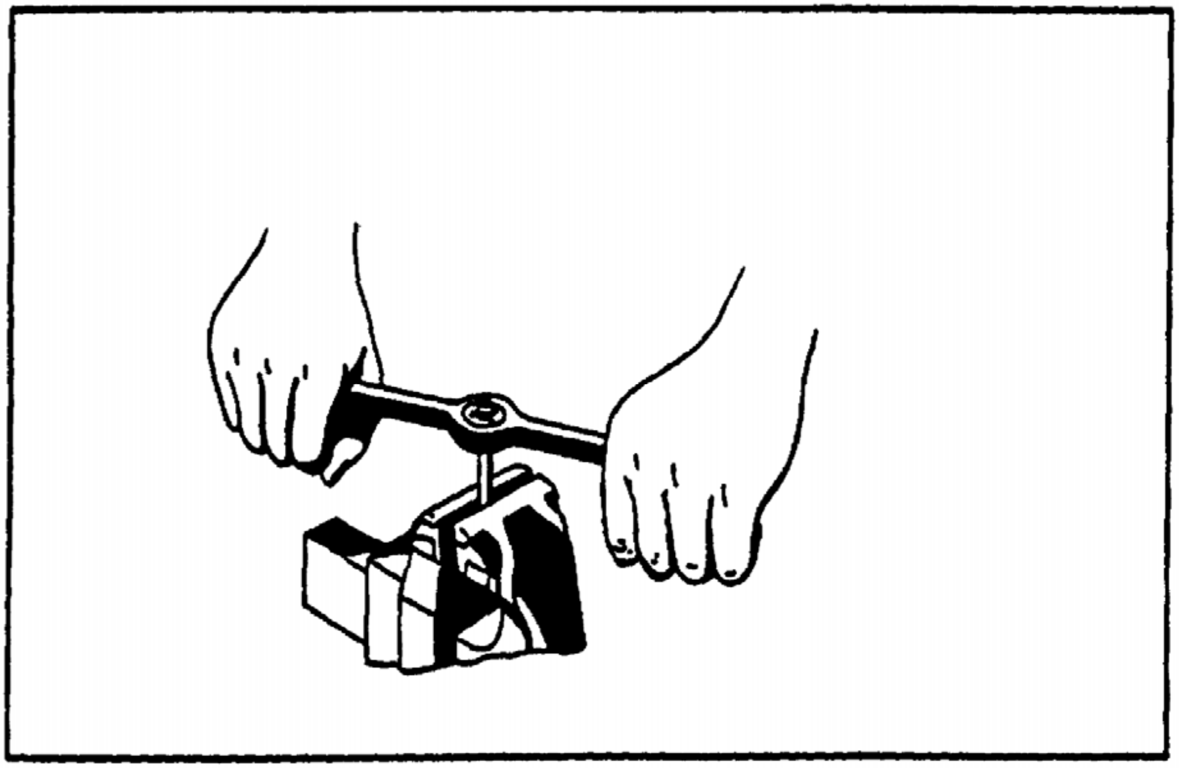


FIGURE 143. USING A DIE AND DIESTOCK.

(c) See that the die is held firmly in the diestock. Set an adjustable die to the desired size before securing it in the diestock.

(d) Drop some cutting oil on the work and the die, and position the chamfer of the front face of the die (side with the longest chamfer) squarely on the work.

(e) Rotate the die slowly, but firmly, until the threads take hold. After cutting several threads, stop to determine if the die is square with the work. Use a tri square or suitable tool to check squareness.

(f) Turn the die back a quarter turn after each forward full turn to prevent teeth from breaking off and for ease of threading.

NOTE

When threading hard materials, use cutting oil liberally.

(g) Back the die off the newly cut thread carefully and check the cut threads with the proper screw pitch gage.

(2) *Adjustment for Pitch Diameter.* The diestock for holding round split open adjusting dies has three screws. A fine pitch screw in this diestock enters the split in the die and forces the sides apart; the other two screws are on the opposite side for compressing. A single screw diestock is used to hold dies of the round split screw adjusting type, that are provided with an adjusting screw which forces the sides apart or allows them to spring together, although this type die will fit in a three screw diestock as well. Two piece rectangular dies are adjusted by the setscrews at either end of the diestock, or of the slot in the collet in which they are placed.

(3) *Threading Pipe.* The procedure for threading pipe is as described in (a) through (l) below.

(a) Lock the pipe securely in a pipe vise (figure 144).

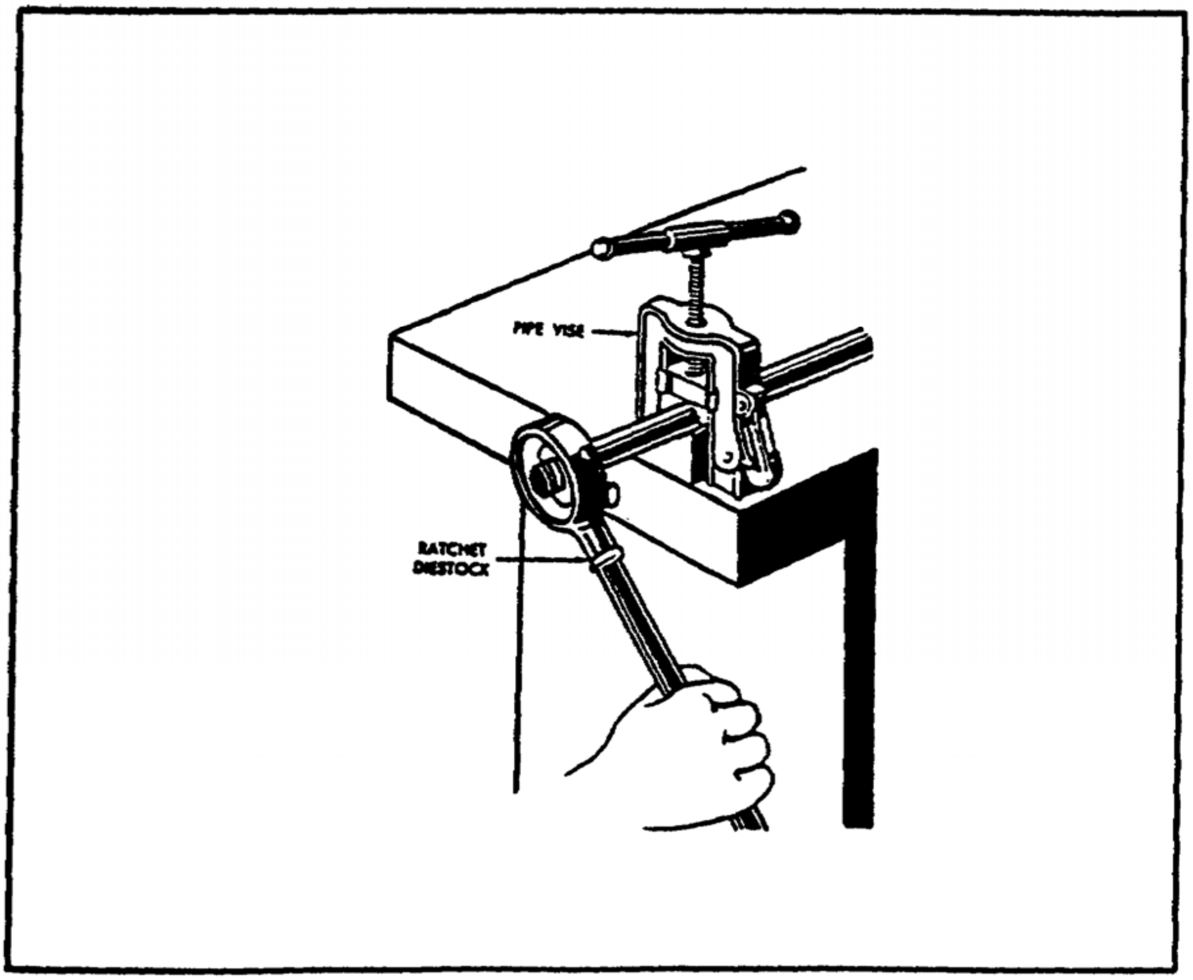


FIGURE 144. THREADING PIPE.

(b) Inspect the dies to see that they are sharp and free from nicks.

(c) Assemble two piece rectangular pipe die on adjustable die guide and ratchet diestock.

(d) Set the die to the desired size.

(e) Apply cutting oil to cutting edges of die and to the pipe to prevent overheating of dies and marring of the cut threads.

(f) Place diestock on the pipe and push lightly with the heel of your hand until the die is up against the end of the pipe. Adjust guide to admit pipe by loosening thumbscrew; rotate cam plate until guide fits pipe; tighten thumbscrew after adjustment.

(g) Rotate the diestock clockwise a few short strokes to start the cut. Lock ratchet and pump handle up and down several strokes.

(h) Recoil die.

(i) Reverse ratchet and stroke frequently to free die of chips.

(j) Thread the pipe until threaded end of the pipe projects 1/4 to 1/2 inch from diestock.

(k) After threading, set ratchet for reverse operation and back off die.

(l) Check for proper length of threaded pipe. For determining the length of threaded pipe for standard fittings and couplings for various size pipe, refer to Table II.

TABLE II. PIPE THREADS DATA FOR STANDARD PIPE.

Metal	Commodity			
	Sheet	Strip	Wire	Tubing
Steel:				
Carbon (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Carbon (cold-rolled)	Mfr's std.	U.S. std.		
Alloy (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Alloy (cold-rolled)	Mfr's std.	U.S. std.		
Stainless	(*)	(*)	SWG	U.S. std.
Copper:	Oz. per sq. ft.	B&S	B&S	BWG#
Copper alloys (brass, bronze).**	B&S	B&S	B&S	BWG
Aluminum	B&S	—	B&S	Studs
Magnesium	B&S	—	—	Studs
Nickel alloys	U.S. std.	U.S. std.	B&S, U.S. std.	Studs

*Eastern warehouses stock cold-rolled stainless in U.S. Standard Gage, whereas Pacific coast and some middle western warehouses follow ASA preferred thicknesses.

#For most sizes.

**The copper and brass industry prefer ASA preferred thicknesses, but most material is still fabricated to customer orders in terms of the Brown and Sharpe gaging system.

h. *Care of Taps and Dies.*

(1) *Maintenance.* Do not attempt to sharpen taps or dies. Sharpening of taps and dies involves several high precision cutting processes where the thread characteristics, chamfer angle and, in some cases, the hook angle and spiral point are involved. These cutting procedures must be accomplished by experienced personnel in order to maintain the accuracy and the cutting effectiveness of taps and dies.

(2) *Cleaning.* Keep taps and dies clean and well oiled when not in use. Store them so that they do not contact each other or other tools.

(3) *Storage.* For long periods of storage, coat taps and dies with a rust preventive compound; place in individual or standard threading set boxes in a dry place.

11. Thread Chasers

a. *Purpose.* Thread chasers are used to rethread damaged external or internal threads.

b. *Types of Thread Chasers.* Thread chasers (figure 145) are threading tools that have several teeth. These tools are available to chase threaded parts having standard threads. The internal thread chaser has its cutting teeth located on a side face. The external thread chaser has its cutting teeth on the end of the shaft. The handle end of the tool shaft tapers to a point.

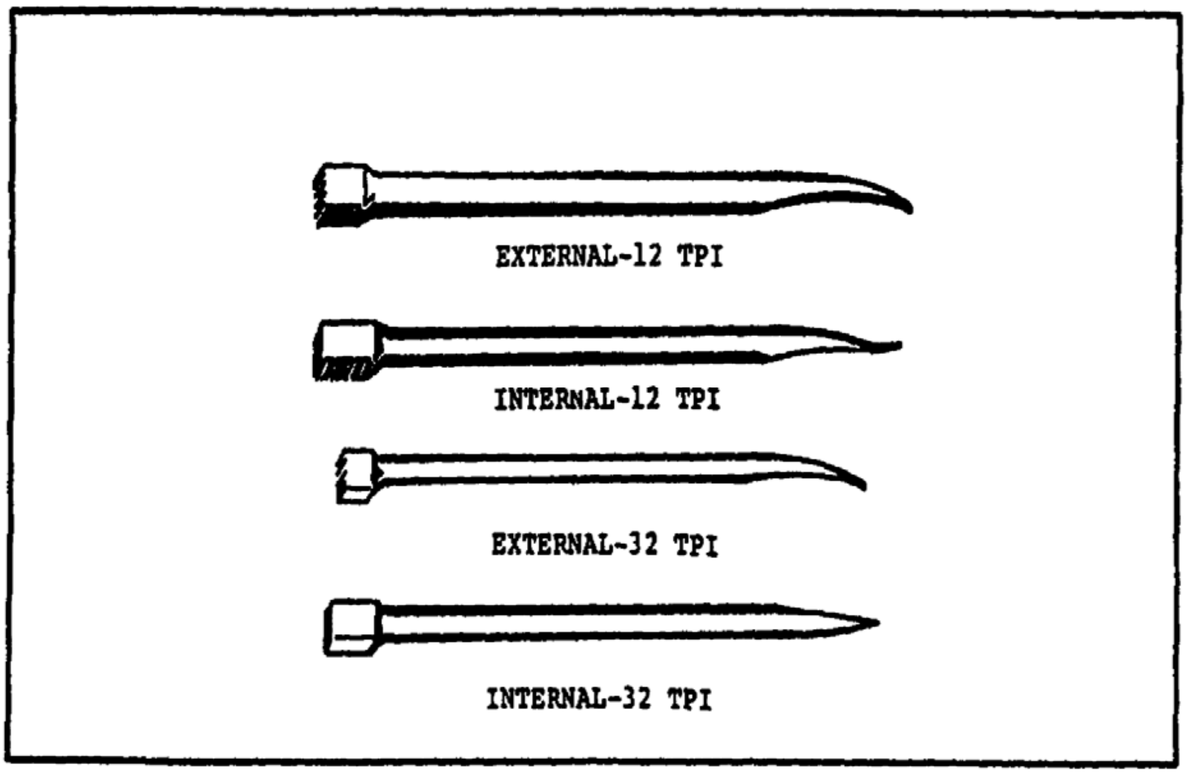


FIGURE 145. THREAD CHASERS.

c. *Use of Thread Chasers.* Select the proper thread chaser for the job. You must know the number of threads per inch on the work. Simply use a rule to measure off a distance and count the threads in the measured distance. If screw pitch gages are available, use them to determine the number of threads per inch. Secure the work firmly in a vise or hold the work in one hand. Hold the chaser in the other hand and run it around the threaded section. Hold the chaser firmly so that the cutting teeth are parallel to the threads in the work, as shown in figure 146. The cutting action will follow the previously cut threads and restore the damaged portion.

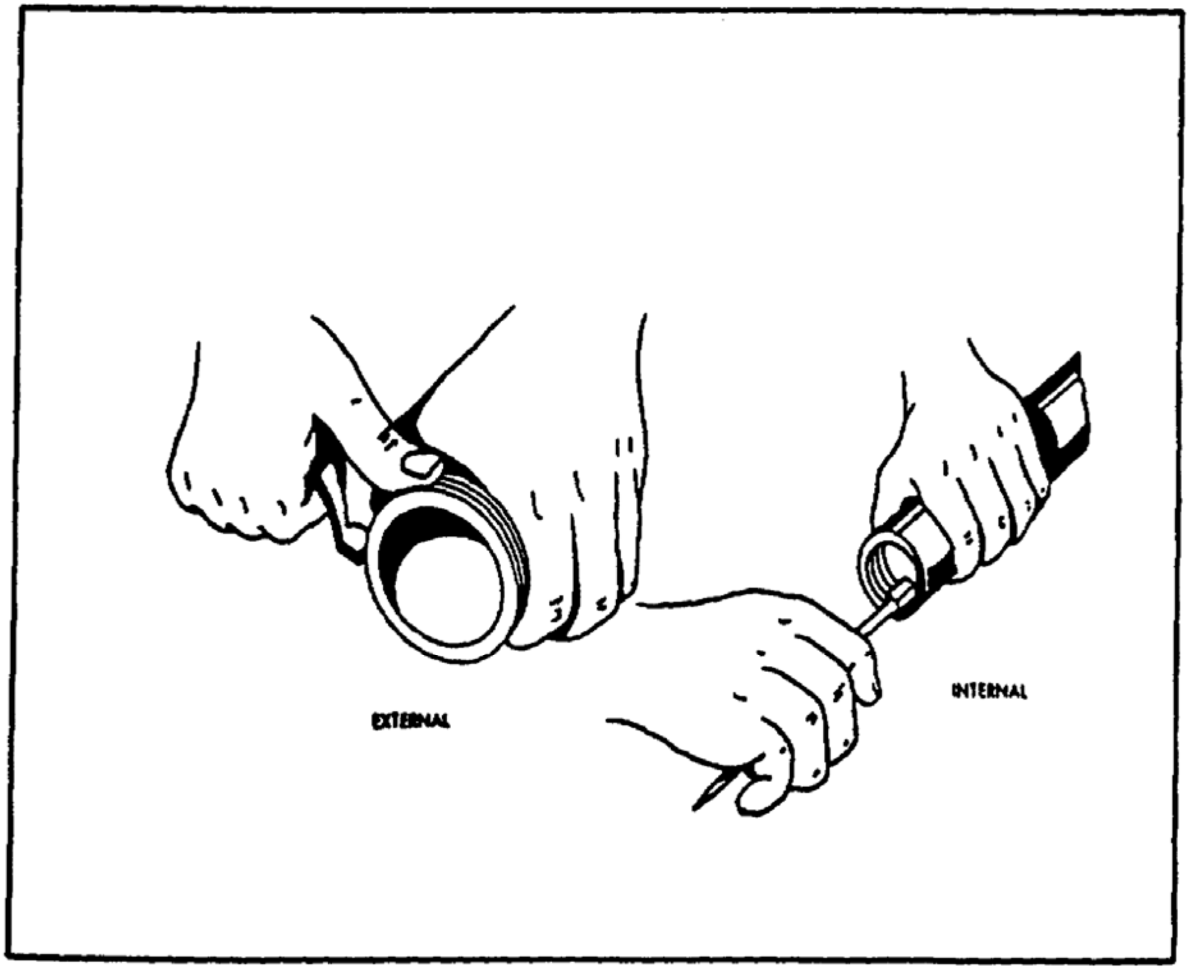


FIGURE 146. USING THREAD CHASERS.

d. *Care of Thread Chasers.* Never attempt to sharpen thread chasers yourself as this is a highly specialized cutting process. It involves precision work on hard tool steel of a shape altogether not suited for simple stroking on an oilstone. Store chasers carefully when not in use. Coat with a light film of oil and rack individually so that the cutting edges do not touch other metal. For long periods of storage, coat chasers with a rust preventive compound and store in a dry place.

12. Screw and Tap Extractors

a. *Purpose.* Screw extractors are used to remove broken screws without damaging the surrounding material or the threaded hole. Tap extractors are used to remove broken taps.

b. *Types of Extractors.* Some screw extractors (figure 147) are straight, having flutes from end to end. These extractors are used with twist drills, drill guides, and turn nuts. This type is issued in sizes to remove screws having 1/4 to 1/2 inch outside diameter. This type is also issued in a set, enclosed in a metal case. Spiral tapered extractors are also available in sets that include twist drills. Spiral tapered extractors are sized to remove screws and bolts from 3/16 inch to 2 1/8 inches outside diameter.

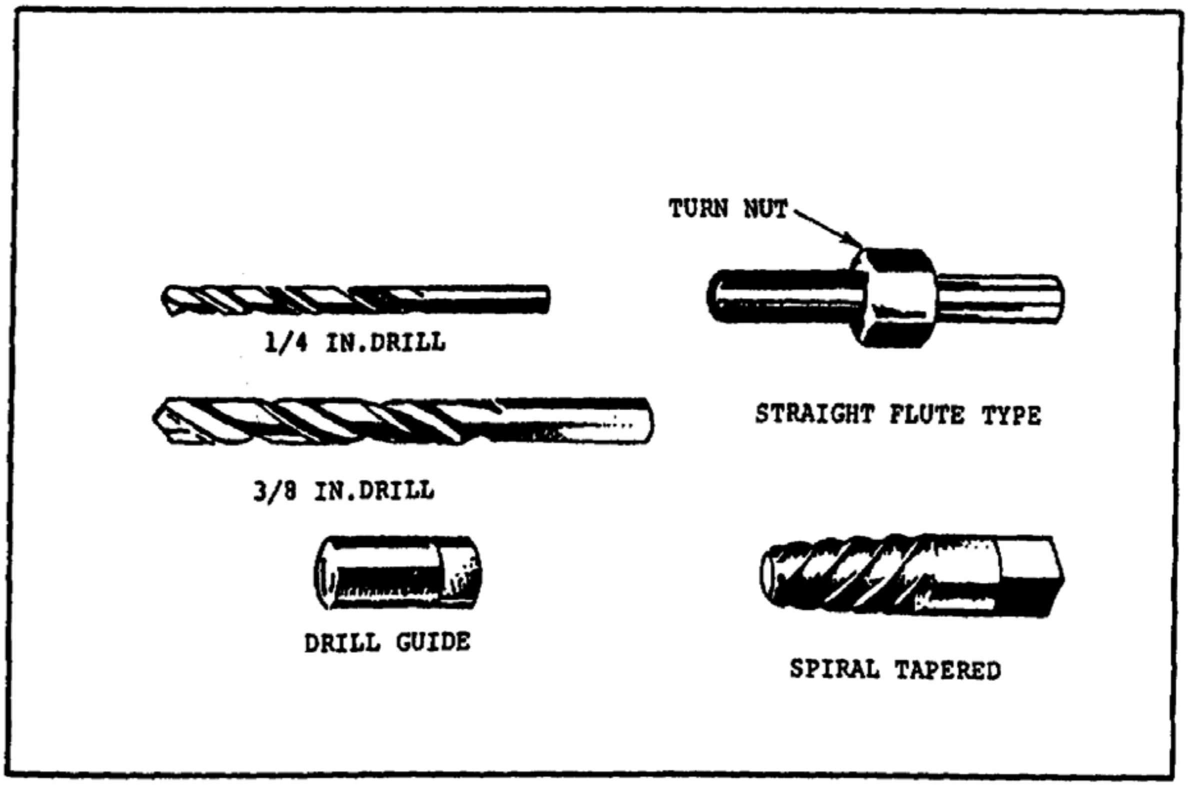


FIGURE 147. SCREW AND TAP EXTRACTORS.

c. *Use of Extractors.*

(1) Before using an extractor, make certain broken chips of screws, bolts, or taps are removed from the hole. A sharp pointed tool, such as a scriber, or a small brush may be used for this purpose.

(2) The use of the straight fluted type extractor (figure 148) requires that a well-centered small hole be drilled in the

broken unit first. Enlarge the hole to receive the extractor tool. The correct drill size is one size less that the extractor size to be used.

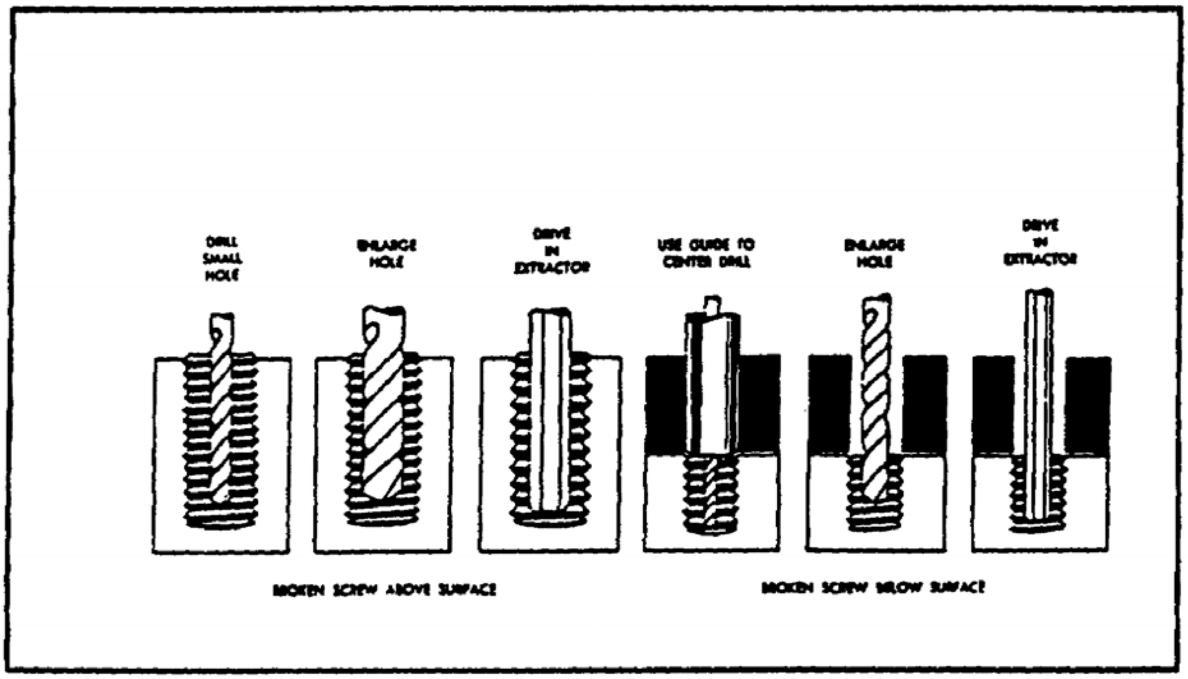


FIGURE 148. USING STRAIGHT FLUTED TAP AND SCREW EXTRACTOR.

(3) Drive the extractor into the hole, slip the turn nut over the extractor, turn it counterclockwise, and turn out the broken unit. The flutes will grip the walls of the drilled unit and remove it without damaging the threads of the tapped hole.

(4) For screws or taps that are broken off below the surface, use the correct size guide to center the drill before drilling the first small hole. Enlarge the hole as before. Remove the drill and insert the extractor into the hole. Slip the turn nut over the extractor and turn out the broken screw or tap.

(5) When using a spiral tapered extractor (figure 149), drill the hole in the broken unit slightly smaller than the diameter of the extractor. Insert the extractor into the hole and turn it counterclockwise.

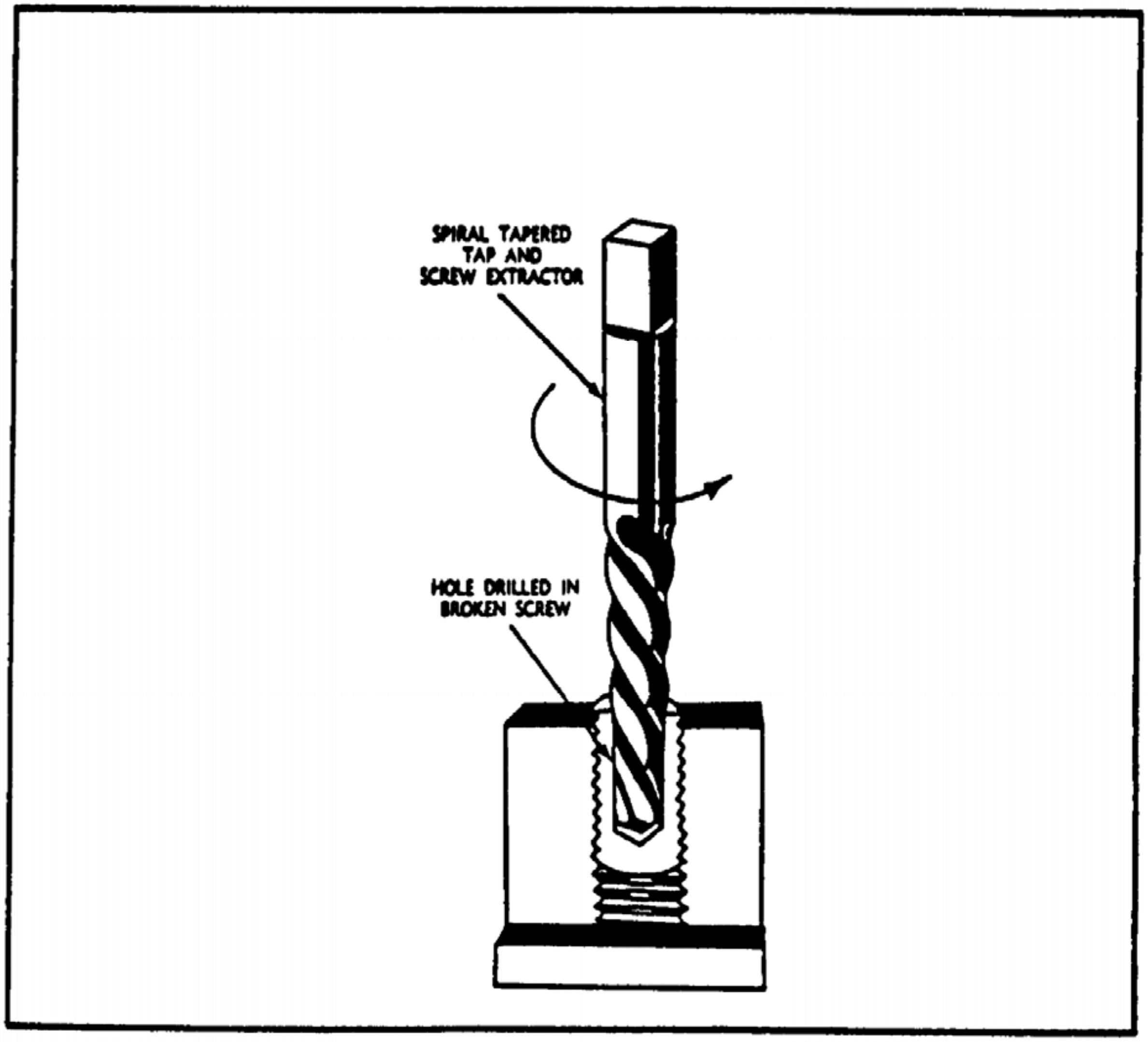


FIGURE 149. USING SPIRAL TAPERED TAP AND SCREW EXTRACTOR.

(6) A tap wrench may be used on spiral tapered extractors and a standard open end wrench on the turn nut of the straight fluted extractor.

d. *Precautions.*

(1) Make certain to select the proper size extractor for the job.

(2) Never attempt to drill a hole in the broken screw or tap without first centering the drill. Use a drill guide whenever possible.

(3) Avoid using too much pressure when backing out the broken screw or tap. Do not apply too much leverage with the wrench as this will break off the extractor.

e. *Care of Extractors.* Keep extractors clean at all times. When not in use, coat with a light film of oil and place in their case or box, or store separately so that they do not contact other tools or metal. For long periods of storage, coat with rust preventive compound and store in a dry place.

13. Conclusion

This concludes the discussion of edged and non-edged handtools. The next lesson will described the use and care of measuring tools.

PRACTICAL EXERCISE 2

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1. Instructions

Read the scenario and respond to the requirements that follow. The following items will test your understanding of the material covered in this lesson. Print this page and compare it with the solutions that will be found at the end of this exercise. If you do not understand an answer, review the portion of the instructional material which provides the information.

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2. Scenario

SSG Harrison is in a jam. There is an inspection in three days and the person in charge of the tool room has been reassigned to another unit.

The tool room is in great need of reorganization and SSG Harrison must find someone who has a lot of handtool knowledge. He decides that the best way to determine who is the most qualified person for the job is to give his mechanics a quiz on edged and non-edged handtools.

3. Requirement

Below is a list of questions that SSG Harrison feels will be the best to use in determining who knows the most about handtools.

a. What are the names of the three machinist's peen hammers?

b. What type of mallet is made of wood ranging in size from 1 1/4 inch head diameter and 3 inch head length to 3 1/2 inch head diameter and 6 inch head length?

c. What indicates the size of a screwdriver?

d. What type of screwdriver is designed to drive or remove screws that cannot be lined up with the axis of common screwdrivers?

e. What is used to drive screws easier?

f. A box wrench is a type of ___________ wrench.

g. Setscrews and hollow-head capscrews have a hexagon socket which means that it is a ___________ __________ socket.

h. What is the function of the long end of a key (Allen) wrench?

i. What type of pliers are most commonly used to hold or bend wires, small bars, and a wide variety of miscellaneous items?

j. What vise is specifically designed to hold round stock?

k. The types of clamps used by the mechanic are the ________________.

l. What component on the push-pull hydraulic jack allows the mechanic to operate the ram in any desired position and from a safe distance?

m. What is the purpose of the mattock?

n. What are the four types of bars?

o. There are two types of soldering irons, ____________ and __________.

p. What are sharpening stones normally made of?

q. What is the pulling capacity, in inches, of the universal hearing and bushing puller?

r. What kind of chisel is used to cut V-grooves, drawing holes, and cutting holes in flat stock?

s. How is a chamfer made with a chisel?

t. What are the five parts of a file?

u. Describe a flat float file.

v. The carbon scraper consists of ________ spring steel blades whose flexibility is controlled by a ____________________________.

w. What shears have curved blades?

x. What is the purpose of shear cut cutters?

y. Taps and dies are used to cut threads in what types of materials?

LESSON 3

USE AND CARE OF MEASURING TOOLS

TASK 1: Describe the procedures for the use and care of measuring tools.

CONDITIONS: Within a self-study environment and given the subcourse text, without assistance.

STANDARDS: Within two hours

REFERENCES: No supplementary references are needed for this task.

1. Introduction

Measuring tools are designed for measuring work accurately. They include level indicating devices (levels), noncalibrated measuring tools (calipers, dividers, trammels) for transferring dimensions and/or layouts from one medium to another, calibrated measuring tools (rules, precision tapes, micrometers) designed to measure distances in accordance with one of several standards of measurement, gages (go and no-go gages, thread gages) which are machined to predetermined shapes and/or sized for measurement by comparison, and combination tools such as a combination square which is designed to perform two or more types of operations.

In this task, five types of measuring tools will be discussed. These types are: scribers; rules or scales; calipers and dividers; micrometers; and miscellaneous measuring gages.

2. Standards of Measurement

a. *Standards of Length.* Two systems, the English and Metric, are commonly used in the design of measuring tools for linear measurements. The English system uses inches, feet, and yards; the Metric system uses millimeters, centimeters, and meters. In relation to each other, 1 inch is equivalent to 25.4 millimeters, or 1 millimeter is equivalent to 0.039370 inch. Refer to figures 150 through 156 to facilitate conversion between systems.

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
1	0.039370	26	1.023622	51	2.007874	76	2.992126
2	0.078740	27	1.062992	52	2.047244	77	3.031496
3	0.118110	28	1.102362	53	2.086614	78	3.070866
4	0.157480	29	1.141732	54	2.125984	79	3.110236
5	0.196850	30	1.181102	55	2.165354	80	3.149606
6	0.236220	31	1.220472	56	2.204724	81	3.188976
7	0.275591	32	1.259843	57	2.244094	82	3.228346
8	0.314961	33	1.299213	58	2.283465	83	3.267717
9	0.354331	34	1.338583	59	2.322835	84	3.307087
10	0.393701	35	1.377953	60	2.362205	85	3.346457
11	0.433071	36	1.417323	61	2.401575	86	3.385827
12	0.472441	37	1.456693	62	2.440945	87	3.425197
13	0.511811	38	1.496063	63	2.480315	88	3.464567
14	0.551181	39	1.535433	64	2.519685	89	3.503937
15	0.590551	40	1.574803	65	2.559055	90	3.543307
16	0.629921	41	1.614173	66	2.598425	91	3.582677
17	0.669291	42	1.653543	67	2.637795	92	3.622047
18	0.708661	43	1.692913	68	2.677165	93	3.661417
19	0.748031	44	1.732283	69	2.716535	94	3.700787
20	0.787402	45	1.771654	70	2.755906	95	3.740157
21	0.826772	46	1.811024	71	2.795276	96	3.779528
22	0.866142	47	1.850394	72	2.834646	97	3.818898
23	0.905512	48	1.889764	73	2.874016	98	3.858268
24	0.944882	49	1.929134	74	2.913386	99	3.897638
25	0.984252	50	1.968504	75	2.952756	100	3.937008

FIGURE 150. CONVERSION CHART - MILLIMETERS TO INCHES.

Fraction of Inch	Decimal of Inch	Millimeters	Fraction of Inch	Decimal of Inch	Millimeters
1/64	0.015625	0.3968	33/64	0.515625	13.0966
1/32	0.03125	0.7937	17/32	0.53125	13.4934
3/64	0.046875	1.1906	35/64	0.546875	13.8903
1/16	0.0625	1.5875	9/16	0.5625	14.2872
5/64	0.078125	1.9843	37/64	0.578125	14.6841
3/32	0.09375	2.3812	19/32	0.59375	15.0809
7/64	0.109375	2.7780	39/64	0.609375	15.4778
1/8	0.125	3.1749	5/8	0.625	15.8747
9/64	0.140625	3.5718	41/64	0.640625	16.2715
5/32	0.15625	3.9686	21/32	0.65625	16.6684
11/64	0.171875	4.3655	43/64	0.671875	17.0653
3/16	0.1875	4.7624	11/16	0.6875	17.4621
13/64	0.203125	5.1592	45/64	0.703125	17.8590
7/32	0.21875	5.5561	23/32	0.71875	18.2559
15/64	0.234375	5.9530	47/64	0.734375	18.6527
1/4	0.25	6.3498	3/4	0.75	19.0496
17/64	0.265625	6.7467	49/64	0.765625	19.4465
9/32	0.28125	7.1436	25/32	0.78125	19.8433
19/64	0.296875	7.5404	51/64	0.796875	20.2402
5/16	0.3125	7.9373	13/16	0.8125	20.6371
21/64	0.328125	8.3342	53/64	0.828125	21.0339
11/32	0.34375	8.7310	27/32	0.843750	21.4308
23/64	0.359375	9.1279	55/64	0.859375	21.8277
3/8	0.375	9.5248	7/8	0.875	22.2245
25/64	0.390625	9.9216	57/64	0.890625	22.6214
13/32	0.40625	10.3185	29/32	0.90625	23.0183
27/64	0.421875	10.7154	59/64	0.921875	23.4151
7/16	0.4375	11.1122	15/16	0.9375	23.8120
29/64	0.453125	11.5091	61/64	0.953125	24.2089
15/32	0.46875	11.9060	31/32	0.96875	24.6057
31/64	0.484375	12.3029	63/64	0.984375	25.0026
1/2	0.5	12.6997	1	1.0	25.3995

FIGURE 151. CONVERSION CHART - FRACTIONS OF AN INCH TO DECIMALS OF AN INCH, AND MILLIMETERS.

Decimals of inch	Millimeter	Decimals of inch	Millimeter	Decimals of inch	Millimeter
0.001	0.02540	0.035	0.88900	0.068	1.72720
0.002	0.05080	0.036	0.91440	0.069	1.75260
0.003	0.07620	0.037	0.93980	0.070	1.77800
0.004	0.10160	0.038	0.96520	0.071	1.80340
0.005	0.12700	0.039	0.99060	0.072	1.82880
0.006	0.15240	0.040	1.01600	0.073	1.85420
0.007	0.17780	0.041	1.04140	0.074	1.87960
0.008	0.20320	0.042	1.06680	0.075	1.90500
0.009	0.22860	0.043	1.09220	0.076	1.93040
0.010	0.25400	0.044	1.11760	0.077	1.95580
0.011	0.27940	0.045	1.14300	0.078	1.98120
0.012	0.30480	0.046	1.16840	0.079	2.00660
0.013	0.33020	0.047	1.19380	0.080	2.03200
0.014	0.35560	0.048	1.21920	0.081	2.05740
0.015	0.38100	0.049	1.24460	0.082	2.08280
0.016	0.40640	0.050	1.27000	0.083	2.10820
0.017	0.43180	0.051	1.29540	0.084	2.13360
0.018	0.45720	0.052	1.32080	0.085	2.15900
0.019	0.48260	0.053	1.34620	0.086	2.18440
0.020	0.50800	0.054	1.37160	0.087	2.20980
0.021	0.53340	0.055	1.39700	0.088	2.23520
0.022	0.55880	0.056	1.42240	0.089	2.26060
0.023	0.58420	0.057	1.44780	0.090	2.28600
0.024	0.60960	0.058	1.47320	0.091	2.31140
0.025	0.63500	0.059	1.49860	0.092	2.33680
0.026	0.66040	0.060	1.52400	0.093	2.36220
0.027	0.68580	0.061	1.54940	0.094	2.38760
0.028	0.71120	0.062	1.57480	0.095	2.41300
0.029	0.73660	0.063	1.60020	0.096	2.43840
0.030	0.76200	0.064	1.62560	0.097	2.46380
0.031	0.78740	0.065	1.65100	0.098	2.48920
0.032	0.81280	0.066	1.67640	0.099	2.51460
0.033	0.83820	0.067	1.70180	0.100	2.54000
0.034	0.86360				

FIGURE 152. CONVERSION CHART - DECIMALS OF AN INCH TO MILLIMETERS.

Inches	Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches	Milli meters
1	25.4	26	660.4	51	1295.4	76	1930.4
2	50.8	27	685.8	52	1320.8	77	1955.8
3	76.2	28	711.2	53	1346.2	78	1981.2
4	101.6	29	736.6	54	1371.6	79	2006.6
5	127.0	30	762.0	55	1397.0	80	2032.0
6	152.4	31	787.4	56	1422.4	81	2057.4
7	177.8	32	812.8	57	1447.8	82	2082.8
8	203.2	33	838.2	58	1473.2	83	2108.2
9	228.6	34	863.6	59	1498.6	84	2133.6
10	254.0	35	889.0	60	1524.0	85	2159.0
11	279.4	36	914.4	61	1549.4	86	2184.4
12	304.8	37	939.8	62	1574.8	87	2209.8
13	330.2	38	965.2	63	1600.2	88	2235.2
14	355.6	39	990.6	64	1625.6	89	2260.6
15	381.0	40	1016.0	65	1651.0	90	2286.0
16	406.4	41	1041.4	66	1676.4	91	2311.4
17	431.8	42	1066.8	67	1701.8	92	2336.8
18	457.2	43	1092.2	68	1727.2	93	2362.2
19	482.6	44	1117.6	69	1752.6	94	2387.6
20	508.0	45	1143.0	70	1778.0	95	2413.0
21	533.4	46	1168.4	71	1803.4	96	2438.4
22	558.8	47	1193.8	72	1828.8	97	2463.8
23	584.2	48	1219.2	73	1854.2	98	2489.2
24	609.6	49	1244.6	74	1879.6	99	2514.6
25	635.0	50	1270.0	75	1905.0	100	2540.0

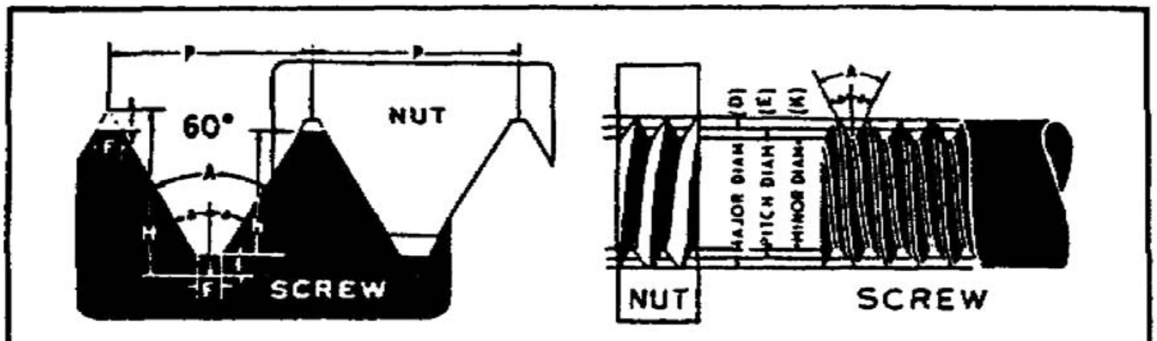
FIGURE 153. CONVERSION CHART - INCHES TO MILLIMETERS.

Feet	Meters	Feet	Meters	Feet	Meters
1	0.3048	35	10.6680	68	20.7264
2	0.6096	36	10.9728	69	21.0312
3	0.9144	37	11.2776	70	21.3360
4	1.2192	38	11.5824	71	21.6408
5	1.5240	39	11.8872	72	21.9456
6	1.8288	40	12.1920	73	22.2504
7	2.1336	41	12.4968	74	22.5552
8	2.4384	42	12.8016	75	22.8600
9	2.7432	43	13.1064	76	23.1648
10	3.0480	44	13.4112	77	23.4696
11	3.3528	45	13.7160	78	23.7744
12	3.6576	46	14.0208	79	24.0792
13	3.9624	47	14.3256	80	24.3840
14	4.2672	48	14.6304	81	24.6888
15	4.5720	49	14.9352	82	24.9936
16	4.8768	50	15.2400	83	25.2984
17	5.1816	51	15.5448	84	25.6032
18	5.4864	52	15.8496	85	25.9080
19	5.7912	53	16.1544	86	26.2128
20	6.0960	54	16.4592	87	26.5176
21	6.4008	55	16.7640	88	26.8224
22	6.7056	56	17.0688	89	27.1272
23	7.0104	57	17.3736	90	27.4320
24	7.3152	58	17.6784	91	27.7368
25	7.6200	59	17.9832	92	28.0416
26	7.9248	60	18.2880	93	28.3464
27	8.2296	61	18.5928	94	28.6512
28	8.5344	62	18.8976	95	28.9560
29	8.8392	63	19.2024	96	29.2608
30	9.1440	64	19.5072	97	29.5656
31	9.4488	65	19.8120	98	29.8704
32	9.7536	66	20.1168	99	30.1752
33	10.0584	67	20.4216	100	30.4800
34	10.3632				

FIGURE 154. CONVERSION CHART - FEET TO METERS.

Meters	Feet	Meters	Feet	Meters	Feet
1	3.28083	35	113.81805	68	222.08534
2	6.56166	36	117.09888	69	225.36617
3	9.84249	37	120.37971	70	228.65700
4	13.12332	38	123.66054	71	231.93783
5	16.40415	39	126.94137	72	235.21866
6	19.68498	40	130.22220	73	238.49949
7	22.96181	41	133.50303	74	241.78032
8	26.24164	42	136.78386	75	245.06115
9	29.52147	43	140.06469	76	248.34198
10	32.80130	44	143.34552	77	251.62281
11	36.08113	45	146.62635	78	254.90364
12	39.36196	46	149.90718	79	258.18447
13	42.64179	47	153.18801	80	261.46530
14	45.92162	48	156.46884	81	265.74613
15	49.20145	49	159.74967	82	269.02696
16	52.48228	50	163.03050	83	272.30779
17	55.76311	51	166.31133	84	275.58862
18	59.04394	52	169.59216	85	278.86945
19	62.32477	53	172.87299	86	282.15028
20	65.60560	54	176.15382	87	285.43111
21	68.88643	55	179.43465	88	288.71194
22	72.16726	56	182.71548	89	291.99277
23	75.44809	57	185.99631	90	295.27360
24	78.72892	58	189.27714	91	298.55443
25	82.00975	59	192.55797	92	301.83526
26	85.29058	60	195.83870	93	305.11609
27	88.57141	61	199.11953	94	308.29692
28	91.85224	62	202.40036	95	311.67775
29	94.13307	63	205.68119	96	314.95858
30	97.41390	64	208.96202	97	318.23941
31	100.69473	65	212.24285	98	321.52024
32	103.97556	66	215.52368	99	324.80107
33	107.25639	67	218.80451	100	328.08190
34	110.53722				

FIGURE 155. CONVERSION CHART - METERS TO FEET.



Adapted by the National Screw Thread Commission and formerly known as "United States Standard" this form of thread is the most common in the United States and one of the most widely used thread forms in the world. There are two standard series in commercial use — NC (National Coarse) and NF (National Fine). Threads of this form not included in the NC and NF series are designated as NS (National Special).

A = 60° – Angle of thread
a = 30° – ½ Angle of thread
F = 0.125000p, or ⅛p – Width of flat at crest and root
f = 0.108253p, or ⅛H, or 1/6h – Depth of truncation
H = 0.866025p – Depth Theoretical V 60° thread
h = 0.649519p, or 6/8H – Depth American National form thread
n = Number threads per inch
p = 1/n, = Pitch

NOMINAL SIZE Inches	D MAJOR DIAM. Inches	E PITCH DIAM. Inches	K MINOR DIAM. Inches	DRILL FOR APPROX. 75% THREAD	DEC. EQUIV. TAP DRILL	ACTUAL % FULL THREAD
1/16-64 NS	.0625	.0524	.0422	3/64	.0469	77
72 NS	.0625	.0535	.0445	3/64	.0469	66
5/64-60 NS	.0781	.0673	.0563	1/16	.0625	72
72 NS	.0781	.0691	.0601	52	.0635	81
3/32-48 NS	.0938	.0803	.0667	49	.0730	77
50 NS	.0938	.0808	.0678	49	.0730	80
7/64-48 NS	.1094	.0959	.0823	43	.0890	75
1/8-32 NS	.1250	.1047	.0844	3/32	.0937	77
40 NS	.1250	.1088	.0925	38	.1015	72
9/64-40 NS	.1406	.1244	.1081	32	.1160	76
5/32-32 NS	.1563	.1360	.1157	1/8	.1250	77
36 NS	.1563	.1382	.1202	30	.1285	77
11/64-32 NS	.1719	.1516	.1313	9/64	.1406	77
3/16-24 NS	.1875	.1604	.1334	26	.1470	75
32 NS	.1875	.1672	.1469	22	.1570	75
13/64-24 NS	.2031	.1760	.1490	20	.1610	78
7/32-24 NS	.2188	.1917	.1646	16	.1770	77
32 NS	.2188	.1985	.1782	12	.1890	73
15/64-24 NS	.2344	.2073	.1806	10	.1935	78
1/4-20 NC	.2500	.2175	.1850	7	.2010	75
24 NS	.2500	.2229	.1959	4	.2090	76
27 NS	.2500	.2259	.2019	3	.2130	77
28 NF	.2500	.2268	.2036	3	.2130	80
32 NS	.2500	.2297	.2094	7/32	.2188	77
5/16-18 NC	.3125	.2764	.2403	F	.2570	77
20 NS	.3125	.2800	.2476	17/64	.2656	72
24 NF	.3125	.2854	.2584	I	.2720	75
27 NS	.3125	.2884	.2644	J	.2770	74
32 NS	.3125	.2922	.2719	9/32	.2812	78
3/8-16 NC	.3750	.3344	.2938	5/16	.3125	77
20 NS	.3750	.3425	.3100	21/64	.3281	72
24 NF	.3750	.3479	.3209	Q	.3320	79
27 NS	.3750	.3509	.3269	R	.3390	75
7/16-14 NC	.4375	.3911	.3447	U	.3680	75
20 NF	.4375	.4050	.3726	25/64	.3906	72
24 NS	.4375	.4104	.3834	X	.3970	75
27 NS	.4375	.4134	.3894	Y	.4040	70
1/2-12 NS	.5000	.4459	.3918	27/64	.4219	72
13 NC	.5000	.4500	.4001	27/64	.4219	78
20 NF	.5000	.4675	.4351	29/64	.4531	72
24 NS	.5000	.4729	.4459	29/64	.4531	87
27 NS	.5000	.4759	.4519	15/32	.4687	65
9/16-12 NC	.5625	.5084	.4542	31/64	.4844	72
18 NF	.5625	.5264	.4903	33/64	.5156	65
27 NS	.5625	.5384	.5144	17/32	.5312	65
5/8-11 NC	.6250	.5660	.5069	17/32	.5312	79
12 NS	.6250	.5709	.5168	35/64	.5469	72
18 NF	.6250	.5889	.5528	37/64	.5781	65
27 NS	.6250	.6009	.5769	19/32	.5937	65
11/16-11 NS	.6875	.6285	.5694	19/32	.5937	79
16 NS	.6875	.6469	.6063	5/8	.6250	77
3/4-10 NC	.7500	.6850	.6201	21/32	.6562	72
12 NS	.7500	.6959	.6418	43/64	.6719	72
16 NF	.7500	.7094	.6688	11/16	.6875	77
27 NS	.7500	.7259	.7019	23/32	.7187	66
13/16-10 NS	.8125	.7476	.6826	23/32	.7187	72
7/8-9 NC	.8750	.8028	.7307	49/64	.7656	76
12 NS	.8750	.8209	.7668	51/64	.7969	72
14 NF	.8750	.8286	.7822	13/16	.8125	67
18 NS	.8750	.8389	.8028	53/64	.8281	65
27 NS	.8750	.8509	.8269	27/32	.8437	65
15/16-9 NS	.9375	.8654	.7932	53/64	.8281	76
1-8 NC	1.0000	.9188	.8376	7/8	.8750	77
12 NS	1.0000	.9459	.8918	59/64	.9219	72
14 NF	1.0000	.9536	.9072	15/16	.9375	67
27 NS	1.0000	.9759	.9519	31/32	.9687	65
1 1/8-7 NC	1.1250	1.0322	.9394	63/64	.9844	76
12 NF	1.1250	1.0709	1.0168	1 3/64	1.0469	72
1 1/4-7 NC	1.2500	1.1572	1.0644	1 7/64	1.1094	76
12 NF	1.2500	1.1959	1.1418	1 11/64	1.1719	72
1 3/8-6 NC	1.3750	1.2667	1.1585	1 7/32	1.2187	72
12 NF	1.3750	1.3209	1.2668	1 19/64	1.2969	72
1 1/2-6 NC	1.5000	1.3917	1.2835	1 11/32	1.3437	79
12 NF	1.5000	1.4459	1.3918	1 27/64	1.4219	72
1 5/8-5 1/2 NS	1.6250	1.5069	1.3888	1 29/64	1.4531	73
1 3/4-5 NC	1.7500	1.6201	1.4902	1 9/16	1.5625	78
1 7/8-5 NS	1.8750	1.7451	1.6152	1 11/16	1.6875	72
2-4 1/2 NC	2.0000	1.8557	1.7113	1 25/32	1.7812	76
2 1/8-4 1/2 NS	2.1250	1.9807	1.8363	1 29/32	1.9062	76
2 1/4-4 1/2 NS	2.2500	2.1057	1.9613	2 1/32	2.0312	76
2 3/8-4 NS	2.3750	2.2126	2.0502	2 1/8	2.1250	77
2 1/2-4 NS	2.5000	2.3376	2.1752	2 1/4	2.2500	77
2 3/4-4 NS	2.7500	2.5876	2.4252	2 1/2	2.5000	77
3-4 NS	3.0000	2.8376	2.6752	2 3/4	2.7500	77
3 1/4-4 NS	3.2500	3.0876	2.9252	3	3.0000	77
3 1/2-4 NS	3.5000	3.3376	3.1752	3 1/4	3.2500	77
3 3/4-4 NS	3.7500	3.5876	3.4252	3 1/2	3.5000	77
4-4 NS	4.0000	3.8376	3.6752	3 3/4	3.7500	77

FIGURE 156. AMERICAN NATIONAL COARSE AND FINE THREAD DIMENSIONS AND TAP DRILL SIZES.

b. *Standards of Screw Threads.* There are several screw thread systems that are recognized as standards throughout the world. All threaded items for Ordnance used in the United States, Great Britain, and Canada are specified in the Unified

System. However, the existing inch measure screw thread systems should be understood despite the existence of the Unified System.

(1) *Inch Measure Systems.*

(a) *Whitworth.* Introduced in England in 1841. The thread form is based on a 55° thread angle, and the crest and roots are rounded.

(b) *American National.* The American National screw thread system was developed in 1933. This system is based on 60° thread angle and flat crests and roots; it includes the following series:

1 Coarse thread sizes of 1 to 12 and 1/4 to 4 inches.

2 The fine thread series in sizes 0 to 12 and 1/4 to 1 1/2 inches.

3 The extra fine thread series in sizes 0 to 12 and 1/2 to 2 inches.

4 The 8 pitch series in sizes from 1 to 6 inches.

5 The 12 pitch series from 1/2 to 6 inches.

6 The 16 pitch series from 3/4 to 4 inches.

(c) *Classes of Fit.* The American National screw thread system calls for four regular classes of fit.

1 Class I. Loose fit, with no possibility for interference between screw and tapped hole.

2 Class II. Medium or free fit, permitting slight interference in the worst combination of maximum screw and maximum nut.

3 Class III. Close tolerances on mating parts may require this fit, applied to the highest grade of interchangeable work.

4 Class IV. A fine snug fit, where a screwdriver or wrench may be necessary for assembly.

NOTE

An additional Class V, or jaw fit, is recognized for studs.

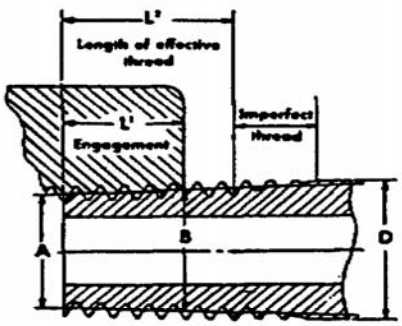
(2) *Unified System.* Since the Whitworth and American National thread forms do not assemble because of the difference in thread angle, the 60° thread angle was adapted in 1949. However, the British may still use rounded crests and roots and their products will assemble with those made in United States plants. In the unified system, class signifies tolerance, or tolerance and allowance. Fit is determined by the selected combination of classes for mating external and internal threads. New classes of tolerance are listed below: 3 for screws, 1A, 2A, and 3A; and 3 for nuts, 1B, 2B, and 3B.

(a) *Classes 1A and 1B, Loose Fit.* A fit giving quick and easy assembly, even when threads are bruised or dirty. Applications: Ordnance and special uses.

(b) *Classes 2A and 2B, Medium Fit.* This fit permits wrenching with minimum galling and seizure. This medium fit is suited for the majority of commercial fasteners and is interchangeable with the American National Class II fit.

(c) *Classes 3A and 3B, Close Fit.* No allowance is provided. Applications are those where close fit and accuracy of lead and thread angle are required.

(3) *Tables.* Thread dimensions as shown in figures 156 and 157 are the most commonly used in the United States. The additional columns of tap drill sizes are included for quick reference.



Taper 3/4 in. per foot on diameter

A Pitch Diameter of thread at end of pipe

B Pitch Diameter of thread at gauging notch

D Outside Diameter of pipe

L1 Normal engagement by hand between external and internal thread.

Nominal Size Inches	No. of Threads per Inch	Pitch Diameter		Length		Pipe O. D. D Inches	Depth of Thread Inches	Tap Drills for Pipe Threads	
		A Inches	B Inches	L2 Inches	L1 Inches			Minor Diameter Small End of Pipe	Size Drill
1/8	27	.36351	.37476	.2638	.180	.405	.02963	.33388	R
1/4	18	.47739	.48989	.4018	.200	.540	.04444	.43294	7/16
3/8	18	.61201	.62701	.4078	.240	.675	.04444	.56757	37/64
1/2	14	.75843	.77843	.5337	.320	.840	.05714	.70129	23/32
3/4	14	.96768	.98887	.5457	.339	1.050	.05714	.91054	59/64
1	11 1/2	1.21363	1.23863	.6828	.400	1.315	.06957	1.14407	1 5/32
1 1/4	11 1/2	1.55713	1.58338	.7068	.420	1.660	.06957	1.48757	1 1/2
1 1/2	11 1/2	1.79609	1.82234	.7235	.420	1.900	.06957	1.72652	1 47/64
2	11 1/2	2.26902	2.29627	.7565	.436	2.375	.06957	2.19946	2 7/32
2 1/2	8	2.71953	2.76216	1.1375	.682	2.875	.10000	2.61953	2 5/8
3	8	3.34062	3.38850	1.2000	.766	3.500	.10000	3.24063	3 1/4
3 1/2	8	3.83750	3.88881	1.2500	.821	4.000	.10000	3.73750	3 3/4
4	8	4.33438	4.38712	1.3000	.844	4.500	.10000	4.23438	4 1/4

FIGURE 157. AMERICAN NATIONAL PIPE THREAD DIMENSIONS AND TAP DRILL SIZES.

c. *Standards of Wire and Sheet Metal.* Sheet metal, strip, wire, and tubing are produced with thickness diameters or wall thicknesses, according to several gaging systems, depending on the article and metal. This situation is the result of natural development and preferences of the industries that produce these products. No single standard for all manufacturers has been established, since practical considerations stand in the way of adoption. In the case of steel, large users are thoroughly familiar with the behavior of existing gages in tooling, especially dies, and do not intend that their shop personnel be burdened with learning how preferred thicknesses behave. Another important factor is the sum total of warehouse stock manufactured with existing gages. You must keep abreast of any change in availability of metals in these common gaging systems, as opposed to simplified systems. For example: in the brass industry, the American Standards Association (ASA) numbers are said to be preferred for simplicity of stocking, but actually most of the metal is still made to Brown and Sharpe (B&S) gage numbers. Until single standards are adopted, selecting the right gaging system and the proper decimal equivalent of the gage numbers is simplified by Table III, the index of gaging systems used for various metals and commodities, and the conversion chart--wire and sheet metal gages in inch equivalents (figure 158). It is good practice to use the inch equivalent in decimals to at least the third digit, and not a gaging system number, since the gaging system numbers have different inch equivalents, depending on the article and metal.

TABLE III. INDEX OF GAGING SYSTEMS USED FOR VARIOUS METALS AND COMMODITIES.

Metal	Commodity			
	Sheet	Strip	Wire	Tubing
Steel:				
Carbon (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Carbon (cold-rolled)	Mfr's std.	U.S. std.		
Alloy (hot-rolled)	Mfr's std.	BWG	SWG	BWG
Alloy (cold-rolled)	Mfr's std.	U.S. std.		
Stainless	(*)	(*)	SWG	U.S. std.
Copper:	Oz. per sq. ft.	B&S	B&S	BWG#
Copper alloys (brass, bronze).**	B&S	B&S	B&S	BWG
Aluminum	B&S	—	B&S	Studs
Magnesium	B&S	—	—	Studs
Nickel alloys	U.S. std.	U.S. std.	B&S, U.S. std.	Studs

*Eastern warehouses stock cold-rolled stainless in U.S. Standard Gage, whereas Pacific coast and some middle western warehouses follow ASA preferred thicknesses.

#For most sizes.

**The copper and brass industry prefer ASA preferred thicknesses, but most material is still fabricated to customer orders in terms of the Brown and Sharpe gaging system.

NUMBER OF GAGE	AMERICAN OR BROWN AND SHARPE	WASHBURN AND MOEN OR AMERICAN STEEL AND WIRE CO.	BIRMINGHAM OR STUBS IRON WIRE	MUSIC WIRE	TWIST DRILL SIZES	IMPERIAL WIRE GAGE	UNITED STATES STD. FOR PLATE
0000000	----------	0.4900	----------	----------	----------	0.5000	0.5000
000000	----------	0.4615	0.5800	0.004	----------	0.4640	0.4688
00000	0.500	0.4305	0.5165	0.005	----------	0.4320	0.4375
0000	0.454	0.3938	0.4600	0.006	----------	0.4000	0.4063
000	0.425	0.3625	0.4096	0.007	----------	0.3720	0.3750
00	0.380	0.3310	0.3648	0.008	----------	0.3480	0.3438
0	0.340	0.3065	0.3249	0.009	----------	0.3240	0.3125
1	0.300	0.2830	0.2893	0.010	0.2280	0.3000	0.2813
2	0.284	0.2625	0.2576	0.011	0.2210	0.2760	0.2656
3	0.259	0.3437	0.2294	0.012	0.2130	0.2520	0.2500
4	0.238	0.2253	0.2043	0.013	0.2090	0.2320	0.2344
5	0.220	0.2070	0.1819	0.014	0.2055	0.2120	0.2188
6	0.203	0.1920	0.1620	0.016	0.2040	0.1920	0.2031
7	0.180	0.1770	0.1443	0.018	0.2010	0.1760	0.1875
8	0.165	0.1620	0.1285	0.020	0.1990	0.1600	0.1719
9	0.148	0.1483	0.1144	0.022	0.1960	0.1440	0.1563
10	0.134	0.1350	0.1019	0.024	0.1935	0.1280	0.1406
11	0.120	0.1205	0.0907	0.026	0.1910	0.1160	0.1250
12	0.109	0.1055	0.0808	0.029	0.1890	0.1040	0.1094
13	0.095	0.0915	0.0720	0.031	0.1850	0.0920	0.0938
14	0.083	0.0800	0.0641	0.033	0.1820	0.0800	0.0781
15	0.072	0.0720	0.0571	0.035	0.1800	0.0720	0.0703
16	0.065	0.0625	0.0508	0.037	0.1770	0.0640	0.0625
17	0.058	0.0540	0.0453	0.039	0.1730	0.0560	0.0563
18	0.049	0.0475	0.0403	0.041	0.1695	0.0480	0.0500
19	0.042	0.0410	0.0359	0.043	0.1660	0.0400	0.0438
20	0.035	0.0348	0.0320	0.045	0.1610	0.0360	0.0375
21	0.032	0.0317	0.0285	0.047	0.1590	0.0320	0.0344
22	0.028	0.0286	0.0253	0.049	0.1570	0.0280	0.0313
23	0.025	0.0258	0.0226	0.051	0.1540	0.0240	0.0281
24	0.022	0.0230	0.0201	0.055	0.1520	0.0220	0.0250
25	0.020	0.0204	0.0179	0.059	0.1495	0.0200	0.0219
26	0.018	0.0181	0.0159	0.063	0.1470	0.0180	0.0188
27	0.016	0.0173	0.0142	0.067	0.1440	0.0164	0.0172
28	0.014	0.0162	0.0126	0.071	0.1405	0.0148	0.0156
29	0.013	0.0150	0.0113	0.075	0.1360	0.0136	0.0141
30	0.012	0.0140	0.0100	0.080	0.1285	0.0124	0.0125
31	0.010	0.0132	0.0089	0.085	0.1200	0.0116	0.0109
32	0.009	0.0128	0.0080	0.090	0.1160	0.0108	0.0102
33	0.008	0.0118	0.0071	0.095	0.1130	0.0100	0.0094
34	0.007	0.0104	0.0063	0.100	0.1110	0.0092	0.0086
35	0.005	0.0095	0.0056	0.106	0.1100	0.0084	0.0078
36	0.004	0.0090	0.0050	0.112	0.1065	0.0076	0.0070
37	--------	0.0085	0.0045	0.118	0.1040	0.0068	0.0066
38	---------	0.0080	0.0040	0.124	0.1015	0.0060	0.0063
39	---------	0.0075	0.0035	0.130	0.0995	0.0052	--------
40	----------	0.0070	0.0031	0.138	0.0980	0.0048	--------

FIGURE 158. WIRE AND SHEET METAL GAGES IN INCH EQUIVALENTS.

(1) *Sheet Metal Gaging Systems.* Several gaging systems are used for sheet and strip metal.

(a) *Manufacturer's Standard Gaging System (Mfr's Std).* This gaging system is currently used for carbon and alloy sheets. The system is based on steel weighing 41.82 pounds per square foot (psf), 1 inch thick. Gage thickness equivalents are based on 0.0014945 in. per oz. psf; 0.023912 in. per lb. psf (reciprocal of 41.82 psf per in. thick); 3.443329 in. per lb. psf.

(b) *U.S. Standard Gaging System (U.S. Std).* This gaging system is obsolete except for stainless steel sheets, cold rolled steel strip (both carbon and alloy), stainless steel tubing, and nickel alloy sheet and strip.

(c) *Birmingham Wire Gaging System (BWG).* This gaging system, also called the Stubs iron wire gaging system, is used for hot rolled steel carbon and alloy strip and steel tubing.

(d) *Brown and Sharpe, or American Wire Gaging System (B&S or AWG).* This gaging system is used for copper strip, brass and bronze sheet and strip, and aluminum and magnesium sheet.

(2) *Wire Gaging Systems.*

(a) *Steel Wire Gaging System (SWG) or Washburn & Moen Gaging System.* This gaging system is used for steel wire, carbon steel mechanical spring wire, alloy steel spring wire, stainless steel wire, etc. Carbon steel or music wire (wire used in the manufacture of musical instruments) is nominally specified to the sizes in the American Steel & Wire Company music wire sizes, although it is referred to by a number of other names found in steel catalogs.

(b) *Brown & Sharpe (B&S) or American Wire Gaging System (AWG).* This gaging system is used for copper, copper alloy, aluminum, magnesium, nickel alloy, and other nonferrous metal wires used commercially.

(3) *Rod Gaging Systems.* The Brown & Sharpe gaging system is used for copper, brass, and aluminum rods. Steel rods are nominally listed in fractional sizes, but drill rods may be listed in Stubs steel wire gage or the twist drill and steel wire gage. It is preferable to refer to twist drill sizes in inch equivalents rather than by the Stubs or twist drill numbers.

d. *Standards of Weight.* The two most commonly used standards of weight are the Metric and English weight measures.

(1) *Metric Standards.* The principal unit of weight in the Metric system is the gram (gm). Multiples of grams are obtained by prefixing the Greek words deka (10), hekto (100), and kilo (1000). Divisions are obtained by prefixing the Latin words deci (1/10), centi (1/100), and milli (1/1000). The gram is the weight of 1 cubic

centimeter of pure distilled water at a temperature of 39.2° F; the metric ton is the weight of 1 cubic meter of pure distilled water at a temperature of 39.2° F.

(2) *English Standards.* The basic unit of weight in the English system is the grain (gr.). We are more familiar with the ounce (oz.), which is equal to 437.5 grains. Refer to figure 159 below for the conversion chart of Metric and English weight measures.

METRIC MEASURES OF WEIGHT		
10 milligrams (mg)	=	1 centigram (cg)
10 centigrams	=	1 decigram (dg)
10 decigrams	=	1 gram (gm)
10 grams	=	1 dekagram (dkg)
10 dekagrams	=	1 hektogram (hg)
10 hektograms	=	1 kilogram (kg)
1000 kilograms	=	1 ton (T)
ENGLISH MEASURES OF WEIGHT		
437.5 grains (gr)	=	1 ounce (oz)
16 ounces	=	1 pound (lb)
100 pounds	=	1 hundredweight (cwt)
2000 pounds	=	1 ton
2240 pounds	=	1 long ton
1 ton = 20 cwt = 2000 lbs. = 32,000 ozs. = 14,000,000 grs.		
CONVERSIONS OF METRIC AND ENGLISH		
1 gram	=	15.432 grains
1 kilogram	=	2.2046 pounds
1 metric ton	=	0.9842 ton of 2240 pounds
1 metric ton	=	19.68 hundredweight
1 metric ton	=	2204.6 pounds
1 grain	=	0.0648 gram
1 ounce	=	28.35 grams
1 pound	=	0.4536 kilogram
1 ton	=	1.016 metric tons
1 ton	=	1016 kilograms

FIGURE 159. CONVERSION CHART - METRIC AND ENGLISH WEIGHT MEASURES.

e. *Standards of Temperature.* The universal standard measuring temperature is 68° F, or 20° C. At this temperature, the standard 1 inch equals 2.54 centimeters, which is also a universal conversion factor for measuring length ((1) above). The Fahrenheit and Centigrade measuring standards are used throughout the world; however, there is a third temperature measuring system called the Reaumur which is rapidly becoming obsolete. For our purposes, refer to figure 160 for converting Fahrenheit to Centigrade and vice versa. The temperature conversion formulas used are as described in (a) through (c) below.

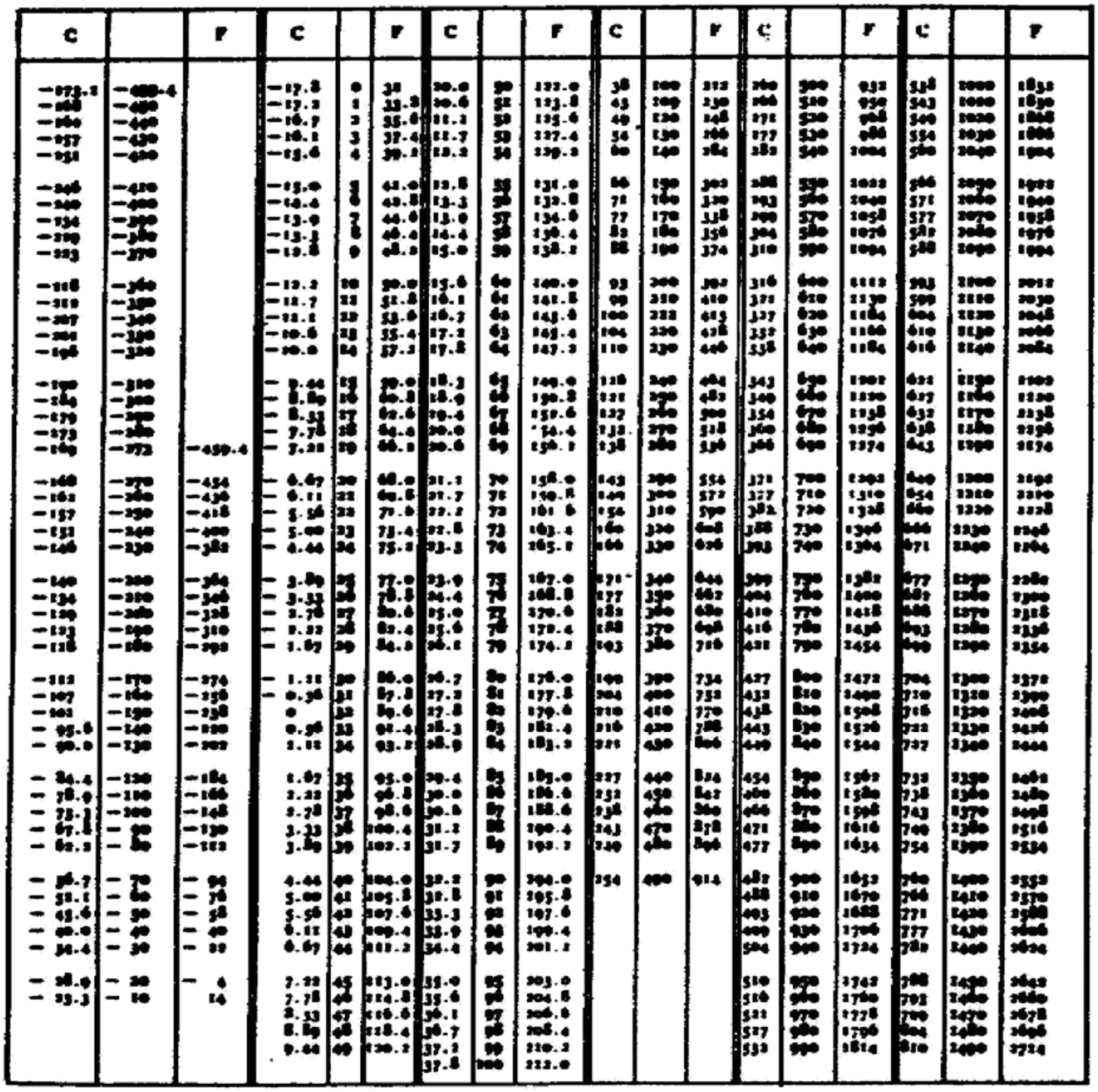


FIGURE 160. TEMPERATURE CONVERSION CHART.

(1) To convert Centigrade to Fahrenheit, multiply the temperature in Centigrade by 9/5 and add 32° to the result; F = (9/5 x ° C) + 32° .

(2) To convert Fahrenheit to Centigrade, subtract 32° from the Fahrenheit temperature and multiply the result by 5/9; C = (° F - 32°) x 5/9.

(3) The boldface numbers on the temperature conversion chart refer to temperatures that are to be converted from Fahrenheit (F) to Centigrade (C), or vice versa. For example, what is Fahrenheit equivalent of 60° C? At boldface 60, look to the F column and read 140.0°.

3. Scribers

a. *Purpose.* Scribers are used to mark and lay out a pattern of work to be followed in subsequent machining operations. Scribers are made for scribing, scoring, or marking many different materials such as glass, steel, aluminum, copper, etc.

b. *Types of Scribers.*

(1) *Machinist's Scribers.* Machinist's single point pocket-type scribers (figure 161) have a scriber point made of tempered high grade steel and a handle of nickel plated steel tubing. The point is reversible, telescoping into the knurled handle when not in use. This type of scriber usually has a 1/4 or 3/8 inch diameter handle with a point length of 2 3/8 or 2 7/8 inches. Bent point scribers are usually 8 to 12 inches long with one straight point, and one long or one short bent point. Some of these scribers are threaded and can be engaged in either end of the handle. The long bent point is designed for reaching through holes beyond a lip or ridge. Portions of these scribers are knurled for firm grip.

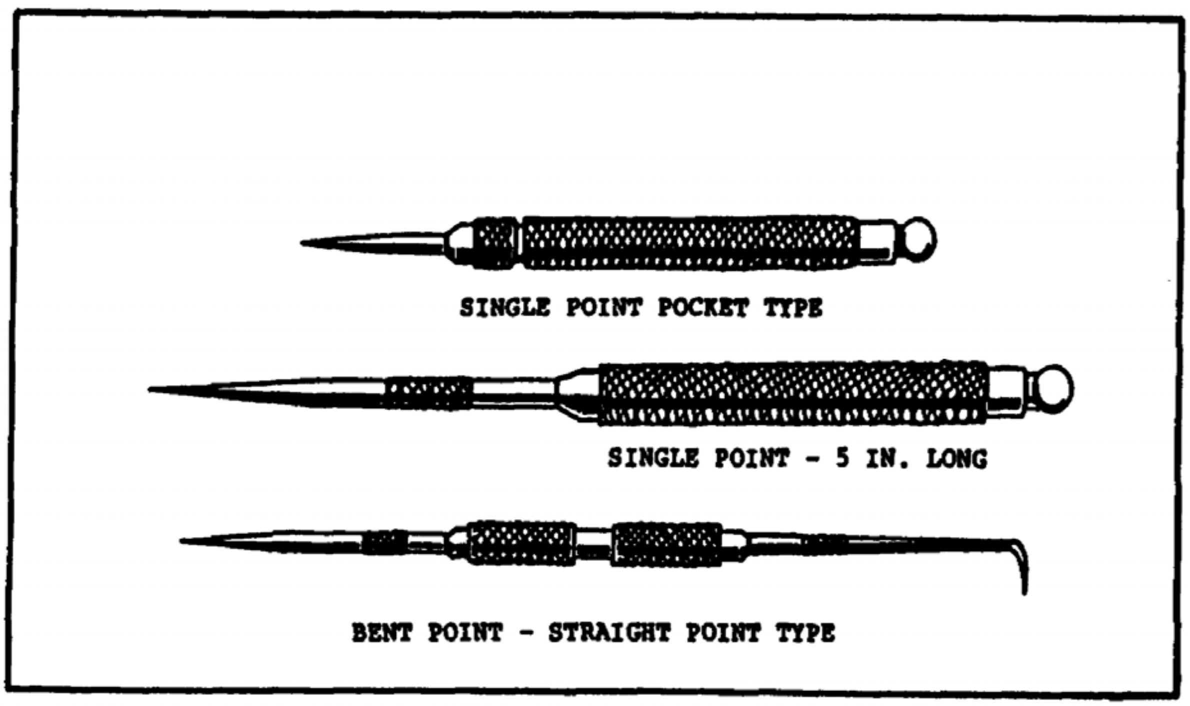


FIGURE 161. TYPES OF MACHINIST'S SCRIBERS.

(2) *Tungsten Carbide Scribers.* Tungsten carbide scribers are used to lay out lines on very hard materials, such as hardened steel and glass. The scriber point is made of tungsten carbide, a long wearing material, which makes it possible to scribe sharp, well defined lines on the hardest materials. Some of these scribers are used, with an extension, in conjunction with a Vernier height gage, which allows measurements to be taken from the top to the bottom side of the gage jaws. This type scriber is hardened, ground, and lapped to a point so that a line or series of lines may be accurately drawn and spaced as required in laying out dies, and other high precision work.

c. *Using the Scribers.*

(1) Make sure the point of the scriber is sharp. To sharpen, rotate the scriber between thumb and forefinger while moving the point back and forth on an oilstone.

(2) Clean work surfaces of all dirt and oil.

(3) Place a steel rule or straightedge on the work beside the line to be scribed.

(4) Use the fingertips of one hand to hold the rule in position and hold the scriber in the other hand as you would a pencil (figure 162).

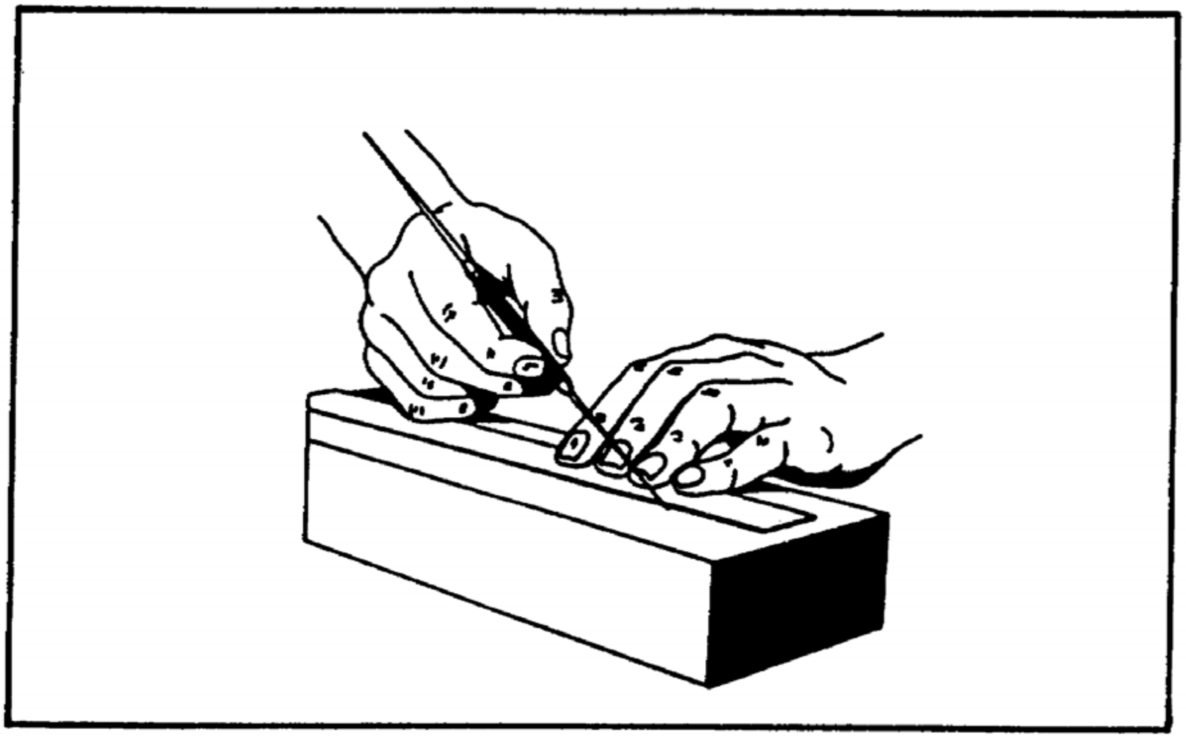


FIGURE 162. USING THE SCRIBER.

(5) Scribe the line by drawing the scriber along the edge of the rule, at a 45° angle and tipped outward and slightly in the direction in which it is being moved.

d. *Care of Scribers.* Place a cork or soft wood over the point of a scriber when not in use. Coat the scriber with rust preventive compound before storing. Do not throw scribers in a drawer with other tools. This practice can cause damage to scribers and injury to personnel. Rack properly or stow in a suitable box. Do not use scribers for purposes other than those intended.

4. Rules or Scales

a. *Purpose.* All rules (scales) are used to measure linear dimensions. They are read by a comparison of the etched lines on the scale with an edge or surface. Most scale dimensions are read with the naked eye, although a magnifying glass can be used to read graduations on a scale smaller than 1/64 inch.

b. *Types of Rules.*

(1) *Steel Rules.* Steel rules (figure 163) are available from a fraction of an inch in length up to 4 feet or more; in machine shops, the 6

inch pocket rule is the one most commonly used. There are also several standard systems of graduations. In the English system, rules are graduated in 10ths, 20ths, 50ths, and 100ths; 12ths, 24ths, and 48ths; 14ths, and 28ths; 16ths, 32nd, and 64ths of an inch. In the Metric system, rules are graduated in millimeters and one-half millimeters. Some steel rules have four scales, two on each side (one graduated in 32nds and the other in 64ths), with the scales on the reverse side running in the opposite direction. There are rules which have both an inch scale and millimeter scale, making this type rule adaptable to work involving both systems of measurement. Another feature on some rules is a scale etched across the end of the rule, facilitating measurement in restricted places.

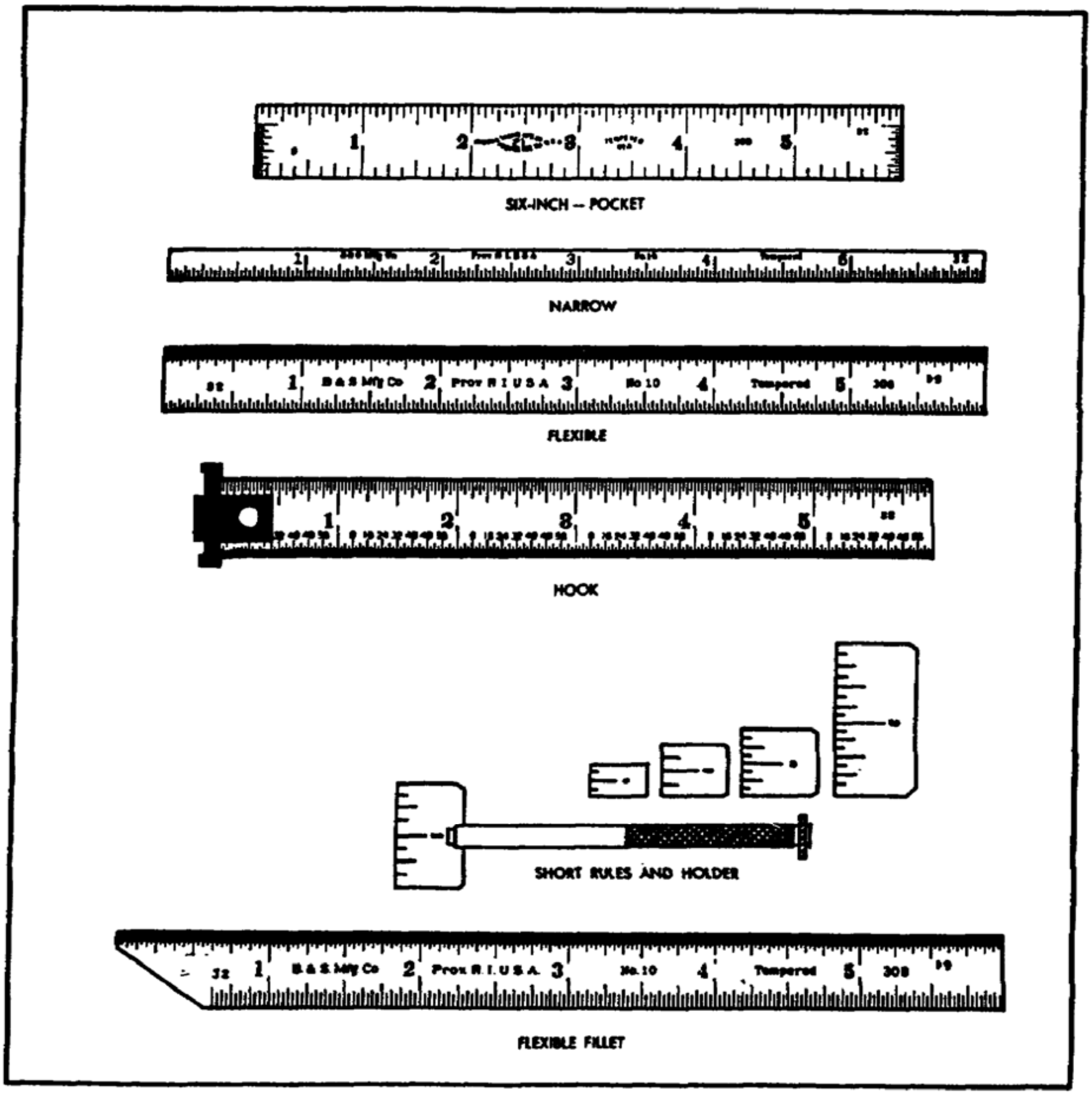


FIGURE 163. TYPE OF STEEL RULES.

(a) *Flexible Rule.* A flexible rule is made of thin, tempered spring steel, permitting it to be bent over a rounded surface.

(b) *Hook Rule.* A hook rule has a sliding hook which facilitates measuring from a shoulder, particularly if the end of the rule is hidden so that it cannot be lined up with the shoulder. The sliding hook is also convenient in setting calipers and dividers.

(c) *Short Rules and Holders.* Short rules with a holder are available for measuring in a recess or in a restricted area.

(d) *Flexible Fillet Rule.* A flexible fillet rule is used to span fillets and corner fills which are frequently in the way when measuring flanges, shoulders, etc.

(e) *Key Seat Clamps.* Key seat clamps (figure 164) are made of steel, are case hardened, and weigh 1 ounce each. They are designed to transform any straight steel rule into a rule that can be used to lay out keyways on the cylindrical surface of a shaft.

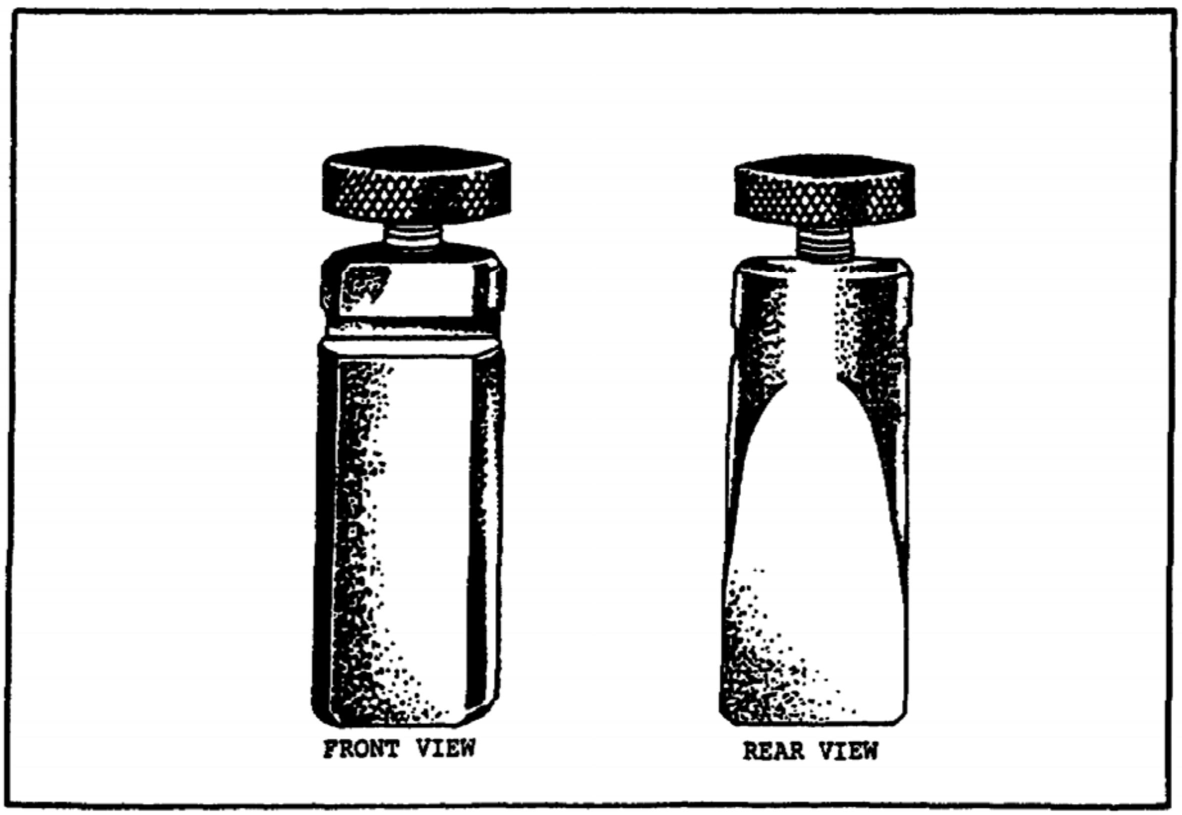


FIGURE 164. KEY SEAT CLAMP.

(2) *Shrink Rule.* The shrink rule (figure 165) resembles an ordinary rule, except that its scale automatically compensates for the shrinkage in castings. In the manufacture of a casting, molten metal is poured into a cavity formed in sand by a wooden or metal pattern of the part. The impression in the sand is that of the pattern and is of the same size and shape. The molten metal fills the cavity, solidifies, and cools. As all metals expand when heated and contract when cooled, the casting shrinks as it cools, and becomes smaller than the cavity. To compensate for this shrinkage so that the casting will be the correct size when it cools, the pattern must be made larger than the part itself. So, in making the pattern, using the blueprints of the part, it is necessary for the patternmaker to add just the correct amount to every dimension to take care of shrinkage. Rather than calculate this shrinkage, the patternmaker uses a shrink rule, which automatically compensates for it.

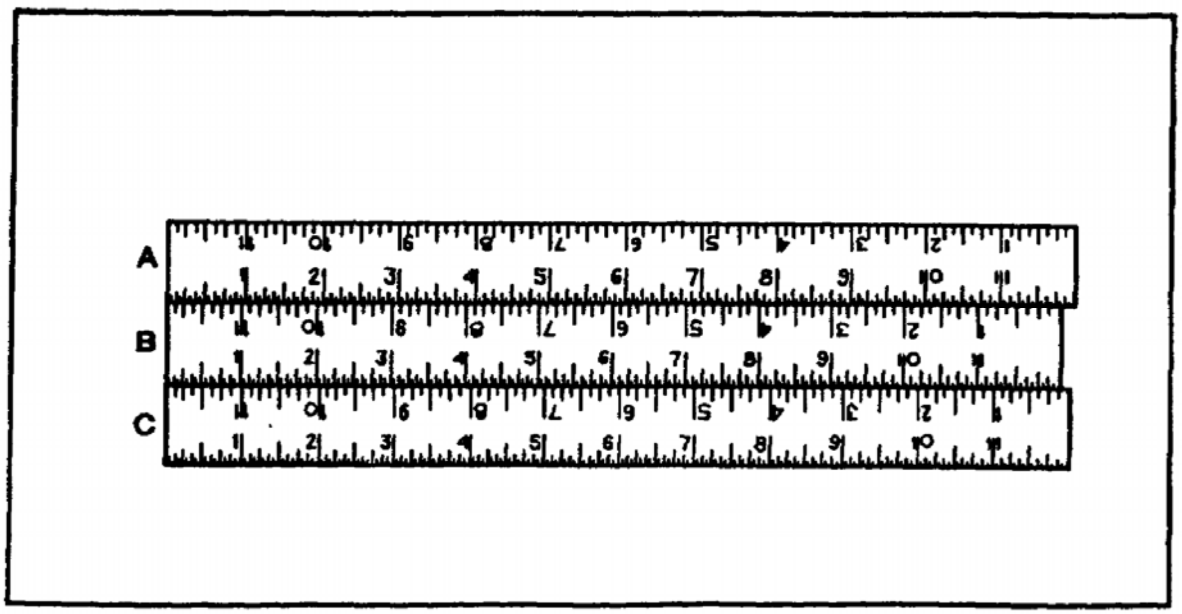


FIGURE 165. SHRINK RULES COMPARED TO STANDARD RULE.

Every metal has its specific shrinkage value; the expansion or contraction for each degree change in temperature is not the same. Shrinkage for the two most common casting metals are: iron - 1/8 inch per foot; brass - 3/16 inch per foot. A special shrink rule is required for each of these casting metals. In figure 165, two shrink rules, A for brass and C for cast iron, are shown in comparison with a standard foot rule, B. Note that the inch marks on the shrink rule do not match the corresponding marks on the standard rule, and that this variation increases with the length of the rule until the total length of the shrink rule exceeds that of the standard by the amount of shrinkage per foot required.

(3) *Folding Rules.* Folding rules (figure 166) are obtainable in wood or metal, having 4 to 12 folds, from 2 to 6 feet in total length. See figure 166 for examples of variation in folding rules. These rules cannot be relied on for extremely accurate measurements because a certain amount of play develops at the joints after they have been used for a time.

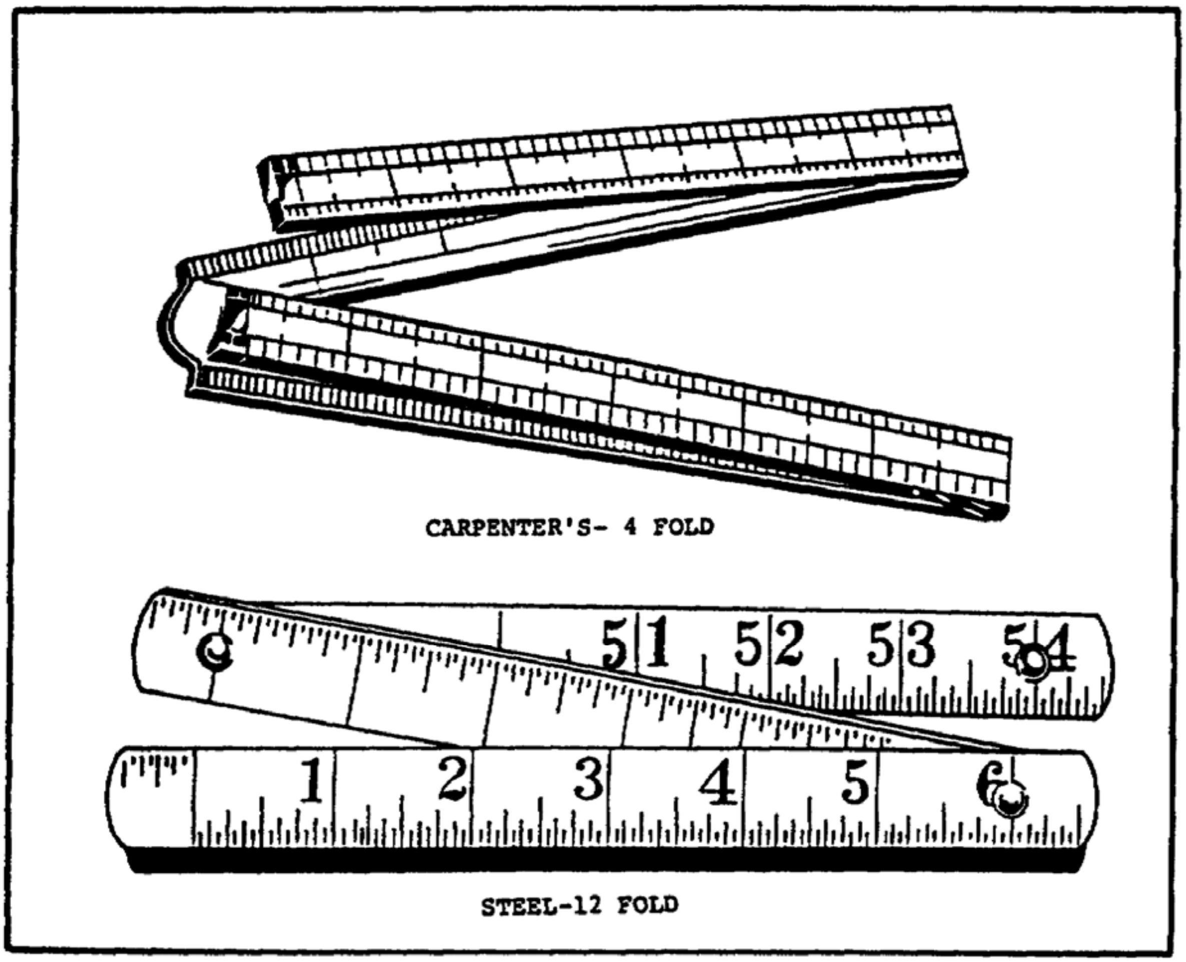


FIGURE 166. TYPES OF FOLDING RULES.

(4) *Circumference Rule.* The circumference rule (not illustrated) supplied by the Army Ordnance Supply System is 36 inches long, 1 1/4 inches wide, 1/16 inch thick. Both sides are marked with graduations of 1/16 inch on one edge and 1/8 inch on the opposite edge. This rule is capable of measuring a 36 inch diameter and 113 inches maximum circumference reading, using a conversion scale.

(5) *Glazier's Rule.* A glazier's rule (figure 167) is used primarily for measuring glass and has a lip, similar to a hook rule. The lip is non-adjustable and is used as a rest. It is held against the glass edge when measuring. This rule is normally 5 feet long, 5/16 inch thick, and 2 inches wide.

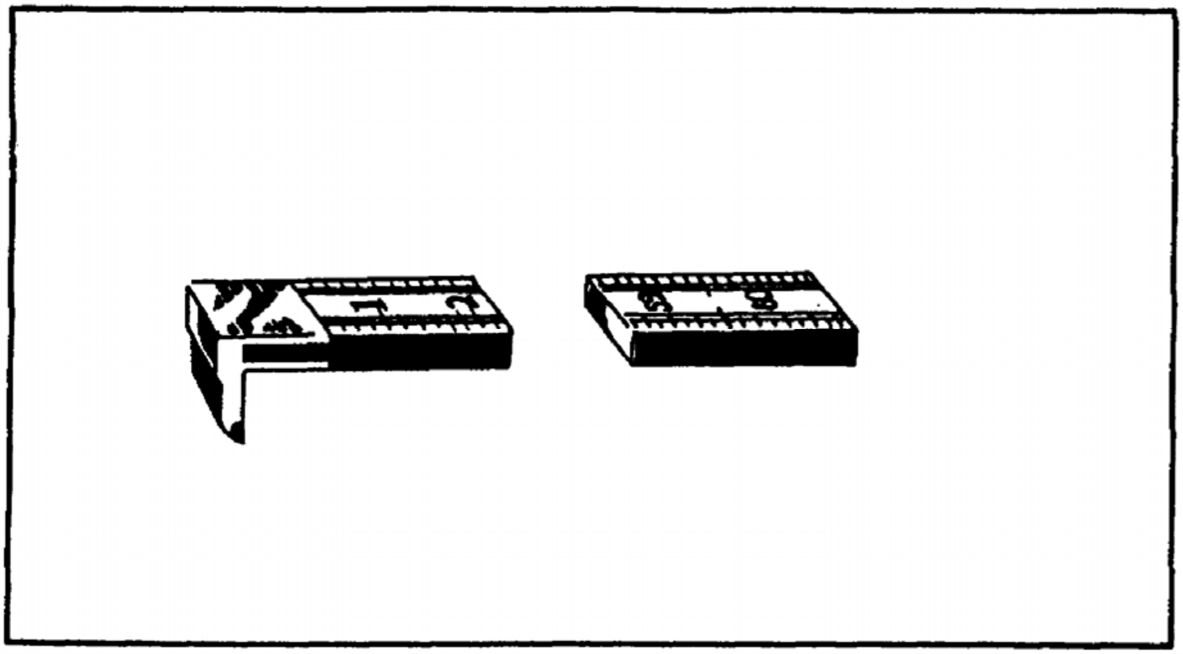


FIGURE 167. GLAZIER'S RULE.

c. *Using the Rule.*

(1) *Select Proper Scale.* When using a rule to check a dimension, the proper graduated scale should be used to control the reading of the dimension (figure 168, view A). If the work being measured lines up between two graduations on the scale, as shown in views B and C, in figure 168, and it is not possible to read this dimension to a 1/16 on a 1/16 inch scale, a 1/32 inch scale should be used. If it is still impossible to read a dimension to a 1/32, a 1/64 inch scale should he used.

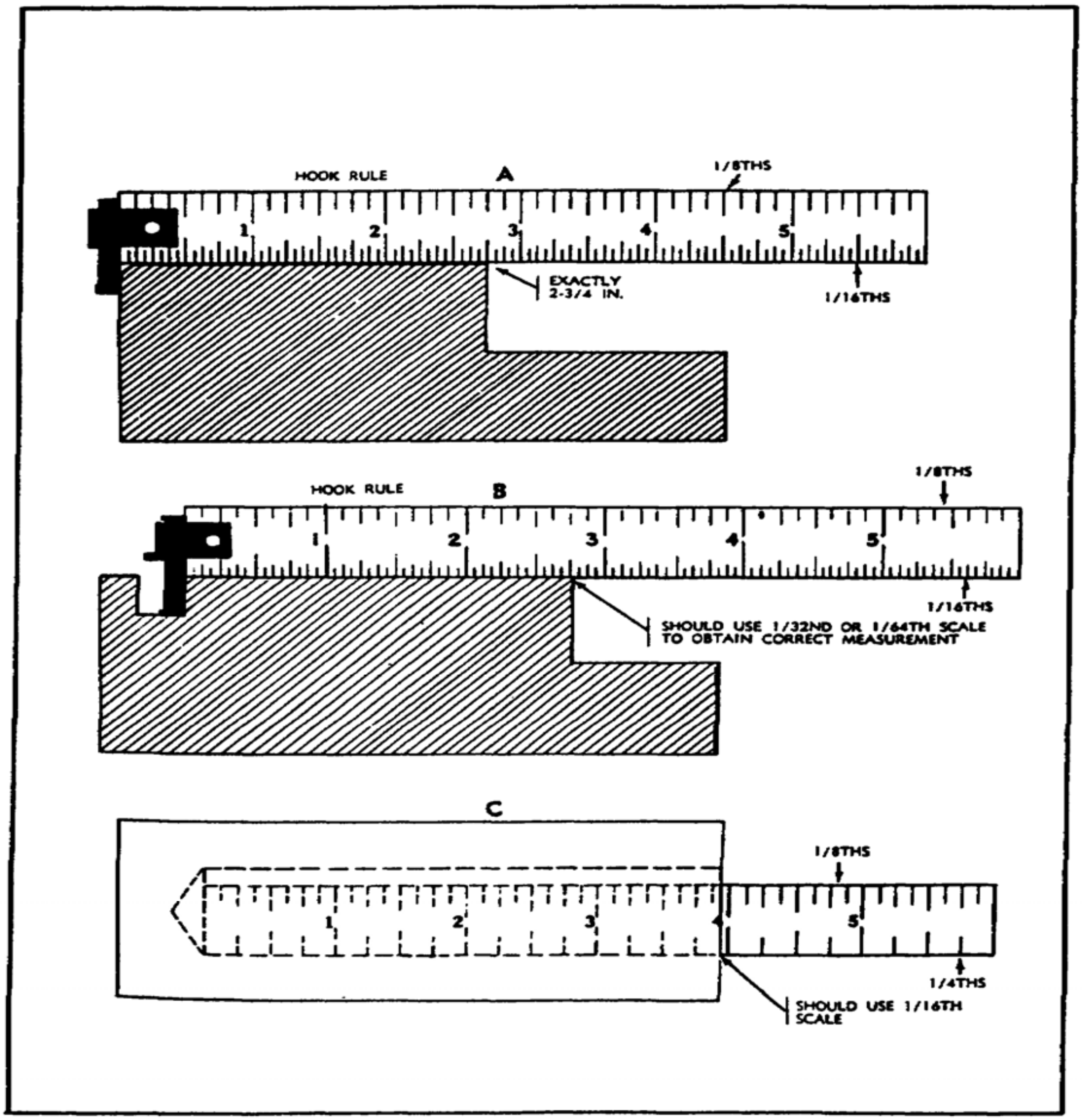


FIGURE 168. DETERMINING PROPER GRADUATED RULE.

(2) *Applications.*

(a) *Six Inch Rule.* It is good practice to carefully line up the end of the rule with the surface from which the measurement is to be taken. Figure 169 shows the mechanic holding the part and the rule firmly against an angle block. This allows the user to devote his entire attention to reading the scale correctly. Figure 170 illustrates the use of a rule in checking the location of a gaging surface from a surface plate. The surface plate in this case serves as a common base and locates the rule in relation to the surface on the part measured.

NOTE

Always measure stock at right angles.

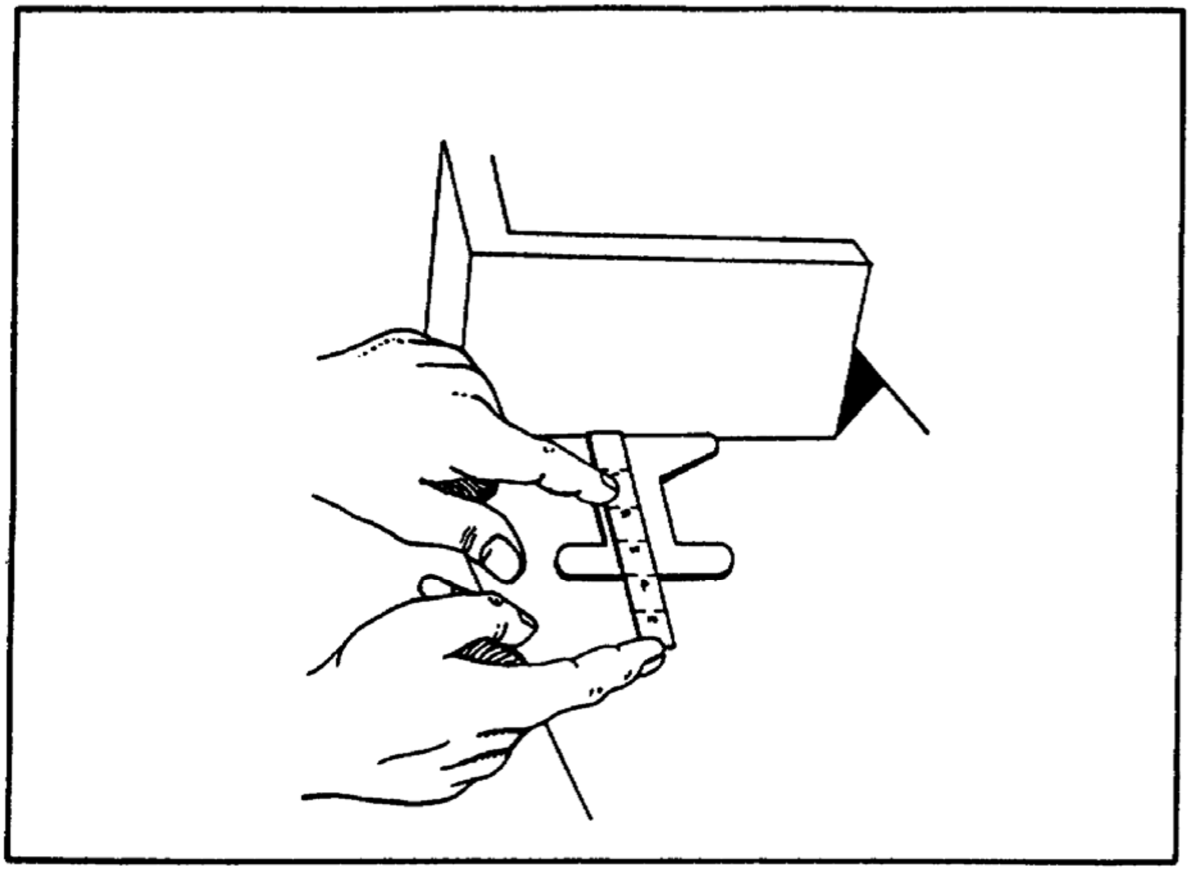


FIGURE 169. USING A 6 INCH RULE.

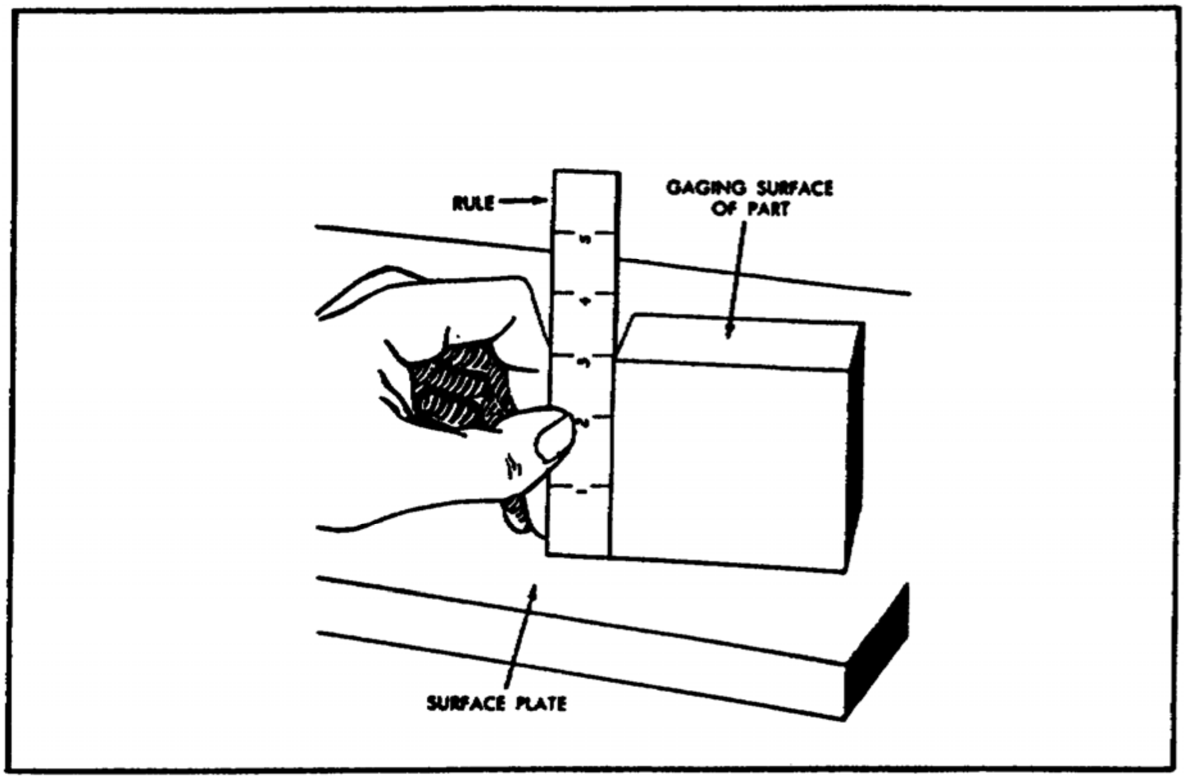


FIGURE 170. USING RULE ON SURFACE PLATE.

(b) *Short Rule and Holder.* Figure 171 shows how a short steel rule with holder may be usefully applied to a measurement in a recess inaccessible to the longer type rule.

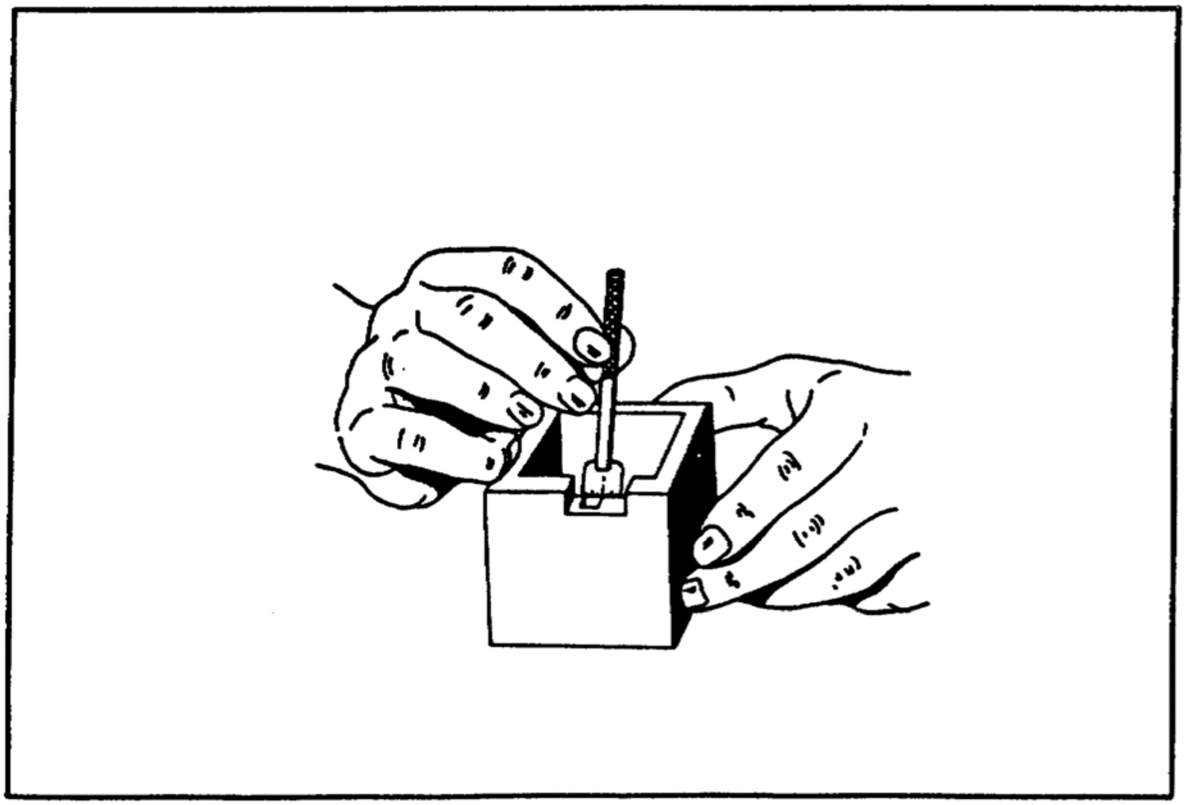


FIGURE 171. USING SMALL RULE AND HOLDER.

(c) *Narrow Rule.* The narrow rule is used to advantage in measuring the depth of a narrow slot (figure 172).

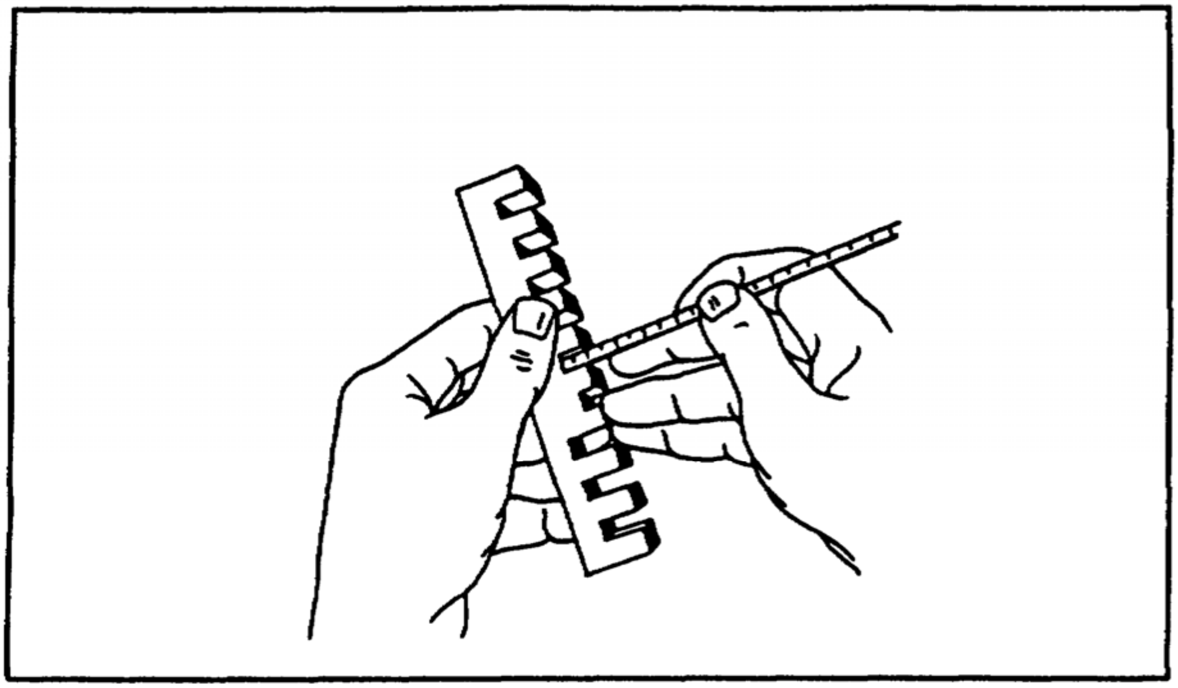


FIGURE 172. USING A NARROW RULE.

(d) *Hook Rule.* Figure 168 shows applications of the hook rule. In one case, the hook serves to line up the end of the rule with the edge of the shoulder from which the measurement is taken; the other case shows the hook being used from the square edge of a part.

(e) *Shrink Rule.* A shrink rule is used to check a dimension on a pattern, as shown in figure 173, and at the same time to automatically compensate for the amount of shrinkage of the metal after casting or molding.

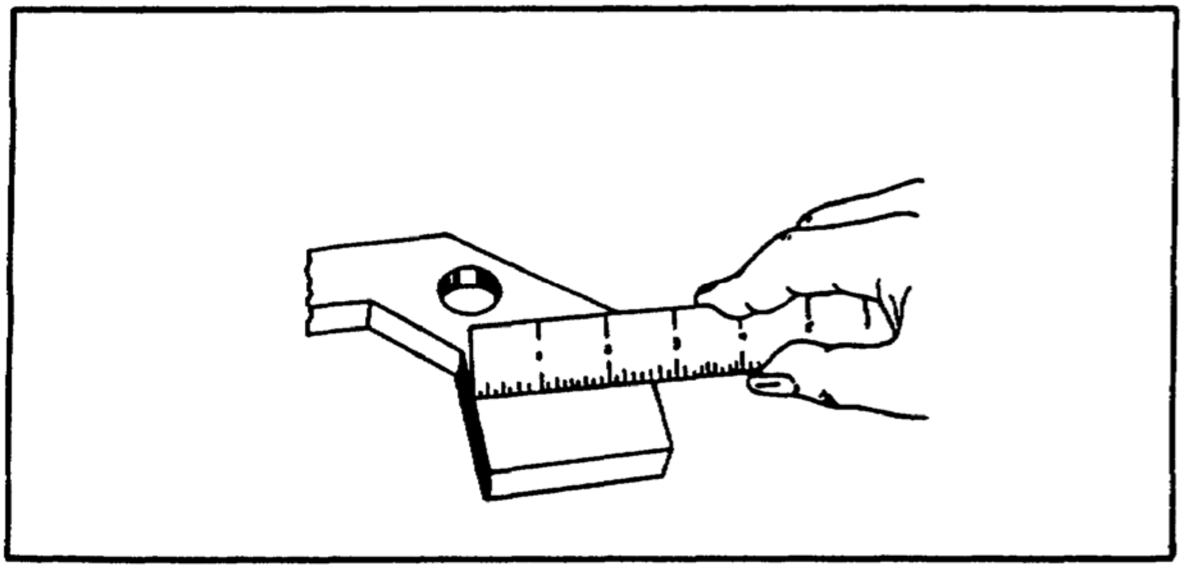


FIGURE 173. USING A SHRINK RULE.

(f) *Key Seat Clamps and Rule.* Figure 174 illustrates the method of scribing a line on cylindrical stock, using key seat clamps and a rule.

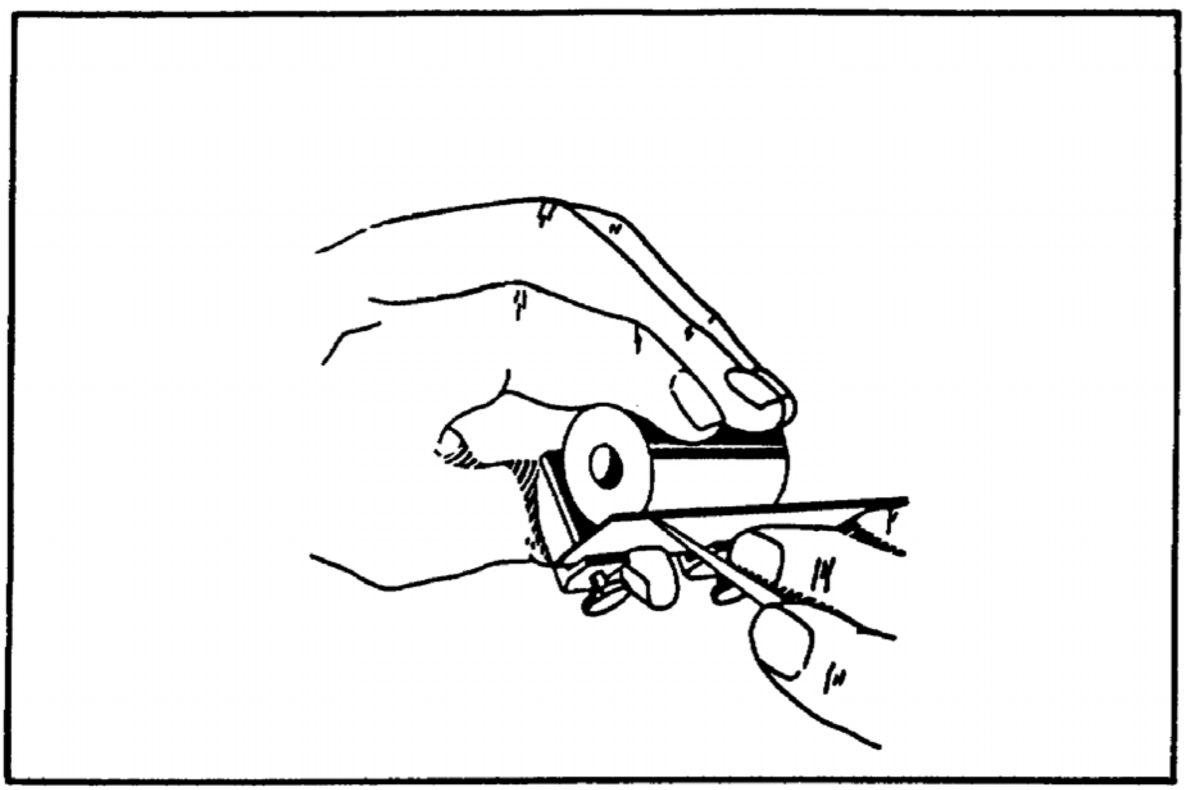


FIGURE 174. USING KEY SEAT CLAMPS, RULE, AND SCRIBER.

d. *Care of Rules.* Coat steel rules with a rust preventive compound or oil before storing. Make certain wood rules are stored in a dry place and are properly wrapped to preserve the wood. Clean rules before and after use, so graduations are always legible. Periodically, check straightedges against a master surface plate for accuracy. The slightest nick can result in an incorrect reading. Do not use rules for purposes other than those intended.

5. Calipers and Dividers

a. *Purpose.* Dividers are used for measuring distances between two points, for transferring or comparing measurements directly from a rule, or for scribing an arc, radius, or circle. Calipers are used for measuring diameters and distances, or for comparing dimensions or sizes with standards, such as a graduated rule.

b. *Types of Calipers and Dividers.*

(1) *Dividers.*

(a) *Spring Divider.* A spring divider (figure 175) consists of two sharp points at the end of straight legs, held apart by a spring and adjusted by means of a screw and nut. The spring divider is available in sizes from 3 to 10 inches in length.

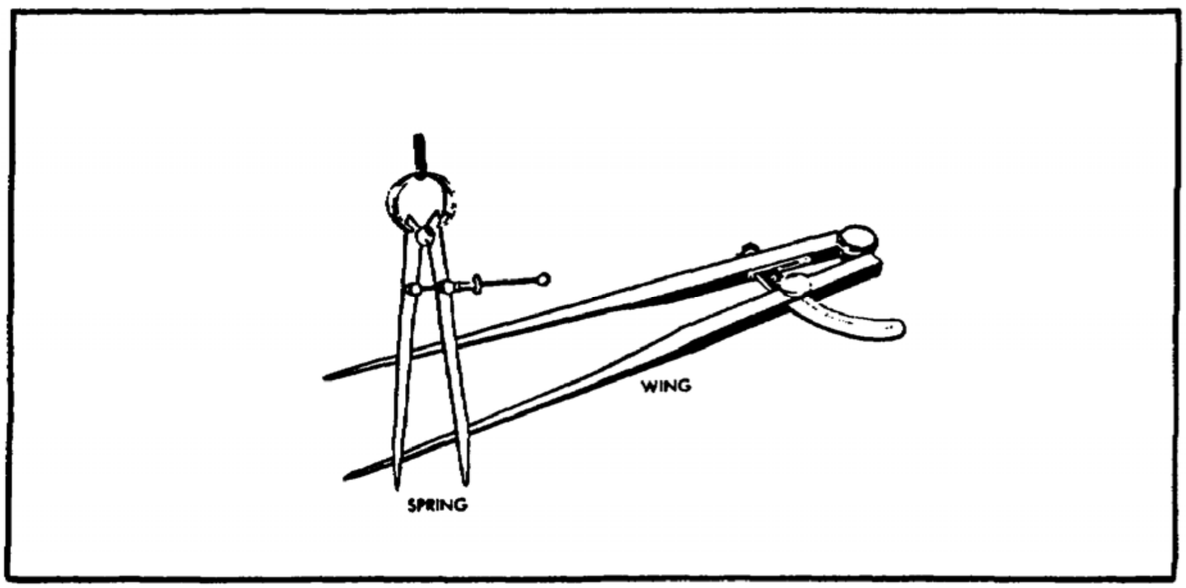


FIGURE 175. DIVIDERS.

(b) *Wing Divider.* A wing type divider (figure 175) has a steel bar that separates the legs, a locking nut for securing a rough measurement, and an adjusting screw for fine adjustments. The wing-type divider is available in 6, 8, and 12 inch lengths. An improved version of this type has the tip of one leg removable so that a pencil can be inserted.

(2) *Outside Calipers.* Outside calipers (figure 176) are used to measure distances over and around adjacent surfaces, and to transfer the measurements to a rule. Several types are made in several sizes to accommodate a wide range in measurement. The size of the caliper is expressed in terms of the maximum dimension it is capable of measuring. A 3 inch caliper, for example, will measure a distance of 3 inches. Actually, the maximum capacity of the caliper will be greater, often as much as one third. This means that a 3 inch caliper will actually measure up to 4 inches. It is not recommended that you use a 3 inch caliper to measure 4 inches, since you may spring the legs, resulting in an inaccurate measurement.

NOTE

Never set a caliper on work that is revolving in a machine. The contact of one leg of a caliper on a revolving surface will tend to draw the other leg over the work because of the friction between the moving surfaces. Only a slight force is necessary to spring the legs of a caliper so that measurements made on moving surfaces are never exact.

(3) *Inside Calipers.* Inside calipers (figure 176) have the same general function as outside calipers except that the inside caliper is used for measuring distances between inside surfaces. The points are rounded so that they are slightly ball shaped. This ball shape establishes the point of contact. This is important in inside calipering; where the surfaces are likely to have an inside curvature, error might occur if the radius of the hole being calipered were less than the radius of the points. Some inside calipers are equipped with an adjusting screw on one leg which provides a fine adjustment of the caliper legs.

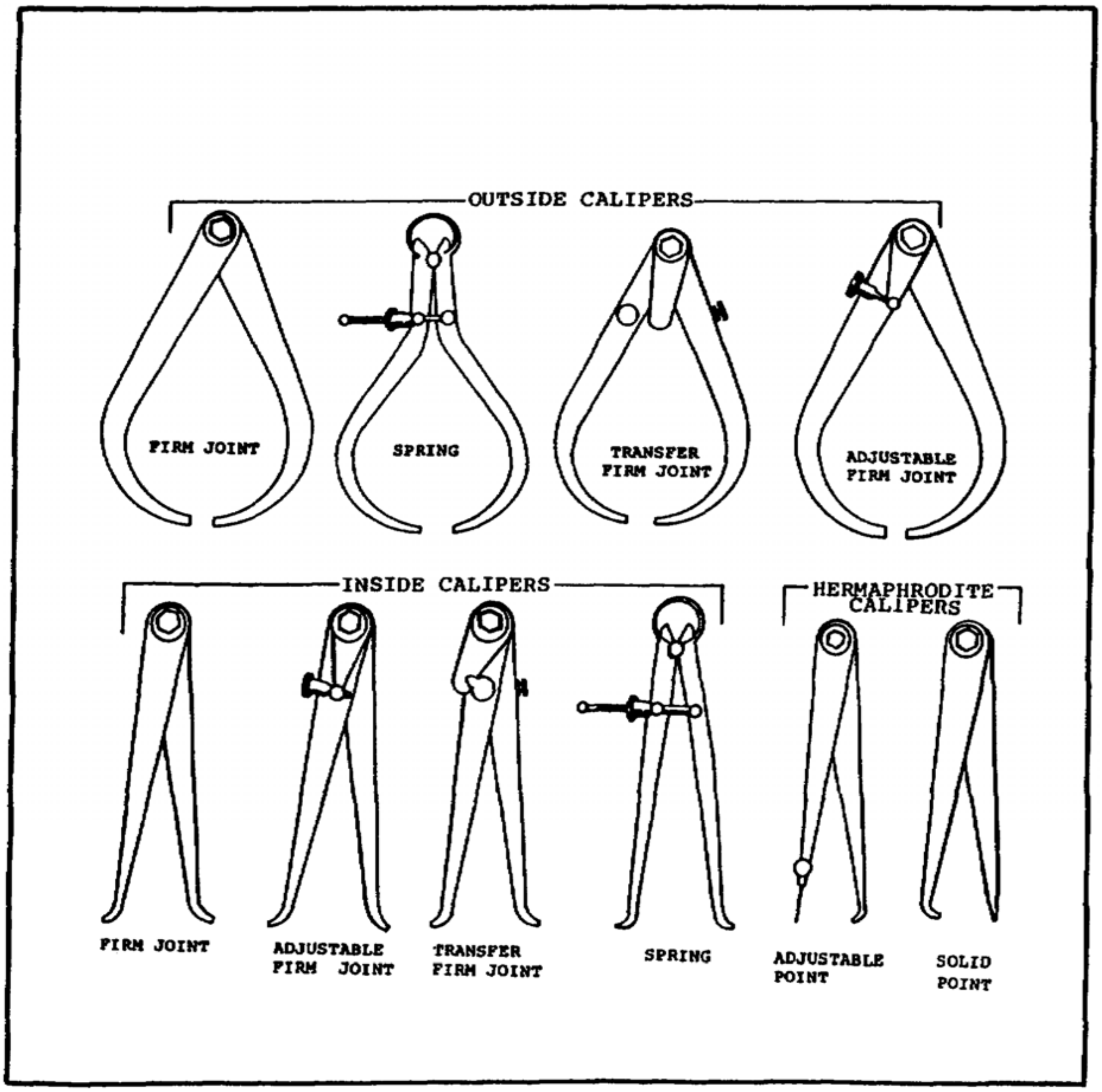


FIGURE 176. CALIPERS - NONCALIBRATED.

(a) *Spring Caliper.*

1 The spring caliper is available in sizes from 2 to 8 inches. The friction of the adjusting nut and screw works against the tension of the spring which holds the legs in any set position. This type of inside caliper is known as the toolmaker's spring caliper.

2 Thread spring calipers are used to measure diameter and distances in tapped holes. The ends of the legs of thread

calipers are shaped to a fine point so that exact contact may be made between threads.

(b) *Firm Joint Caliper.* The firm joint type is available in a number of sizes from 3 to 24 inches. This type of caliper is equipped with a nut and stud that provides sufficient friction to hold the legs in any set position. Some variants of this type of caliper are equipped with an adjusting screw for fine adjustments.

(c) *Transfer Firm Joint Caliper.* Inside transfer firm joint calipers are shaped for inside measurements and are used for measuring recesses where the setting cannot be transferred to a scale directly because the legs must be collapsed to remove them from the work.

(4) *Hermaphrodite Calipers.* Hermaphrodite calipers (figure 176) are a cross between a divider and an inside caliper, having one leg of each. These calipers are used for scribing parallel lines from an edge, or for locating the center of cylindrical work. Some are equipped with an adjustable point.

(5) *Trammels.* A trammel is a tool used for the same purposes as a divider or caliper, but usually for distances beyond the range of either of these instruments. A steel beam trammel with all of the attachments required in measuring and layout work is shown in figure 177. The instrument consists of a rod or beam to which trams may be clamped. These steel beams will range in length from 9 to 20 inches, but may be increased further through the use of extensions. Longer beams are often made of wood. The trams carry spring chucks in which divider points, caliper points, and ball points may be inserted so that the trammel may be readily converted from a divider to an outside or inside caliper or to a hermaphrodite caliper. Ball points are used to position a tram in the center of a hole. By using different size balls or V-points, it is possible to position the tram in any size hole up to 1 1/2 inches in diameter. On top of the trams are knurled handles which swivel so that the handles may be gripped firmly when describing a circle or an arc. An adjusting screw is provided on one of the trams which permits a fine adjustment of the points.

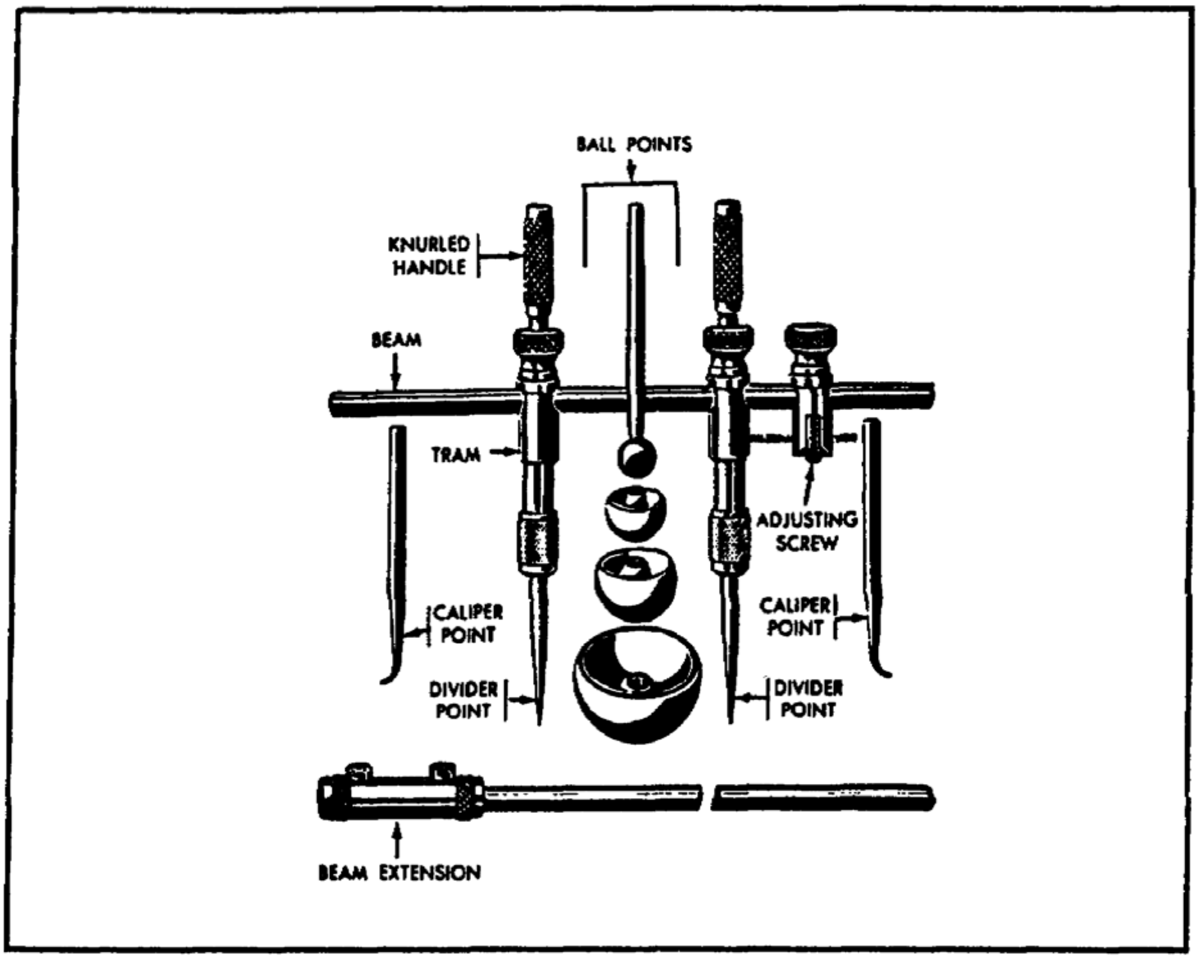


FIGURE 177. TRAMMEL SET.

(6) *Vernier Calipers.* This type of caliper uses the Vernier scale. The Vernier scale consists of a short auxiliary scale usually having one more graduation in the same length as the longer main scale. The Vernier caliper (figure 178) consists of a L-shaped frame, the end of which is a fixed jaw; the long arm of the L is inscribed with the main true scale or fixed scale. The sliding jaw carries the Vernier scale on either side. The scale on the front side is for outside measurements; the scale on the back is for inside measurements. On some Vernier calipers, the metric system of measurement is placed on the back side of the caliper in lieu of a scale used for inside measurements. In such cases, add the thickness of the nibs to the reading when making inside measurements. The tips of the jaws are formed so that inside measurements can be taken. The thickness of the measuring points is automatically compensated for on the inside scale. The length of the jaws will range from 1 1/4 inches to 3 1/2 inches, and the minimum inside measurement with the smallest caliper is 1/4 inch or 6 millimeters. Vernier calipers are made in standard sizes of 6, 12, 23, 36, and 48 inches, and 150, 300, 600, and 900 millimeters. The jaws of all

Vernier calipers, except the larger sizes, have two center points, which are particularly useful in setting dividers to exact dimensions.

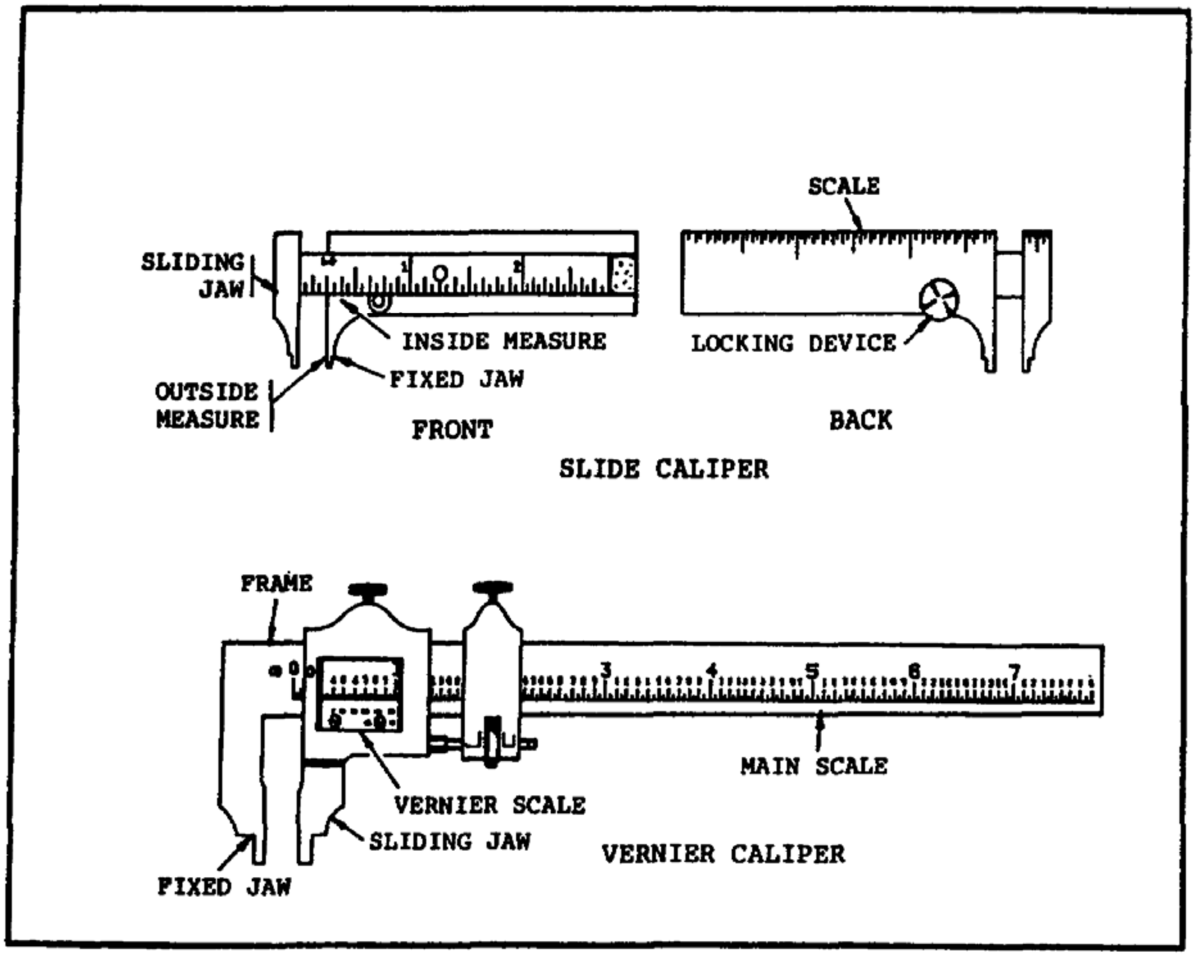


FIGURE 178. CALIPERS - CALIBRATED.

(7) *Slide Calipers.* The slide calipers (figure 178) have one fixed jaw and one sliding jaw. When the two jaws are brought in contact with surfaces to be measured, the distance between the surfaces may be read from the scale. The ends of the jaws are so shaped that it is possible to measure both inside and outside surfaces. Slide calipers are usually available in 3 inch sizes, although larger size calipers are made. The standard 3 inch slide caliper will measure from 0 to about 2 inches outside, and from 1/8 inch to a little more than 2 inches inside. The caliper shown has a mark or graduation line on the fixed jaw, which enables the user to read the inside measure, while the outside measure can be read directly from the inner edge of the fixed jaw. If these marks were not on the slide caliper, it would be necessary to add the thickness of the nibs to the reading when using it as an inside caliper. All slide calipers are equipped with a locking device

which makes it possible to hold the jaws in any desired position. On the other side of the instrument is an ordinary rule.

c. *Use of Dividers.* In setting a divider to a dimension on a scale, the usual procedure is to locate one point in one of the inch graduations of the rule and to adjust the nut or screw so that the other point falls easily into the correct graduation (figure 179, view A). Make sure certain points of the divider are not blunt (figure 179, view B).

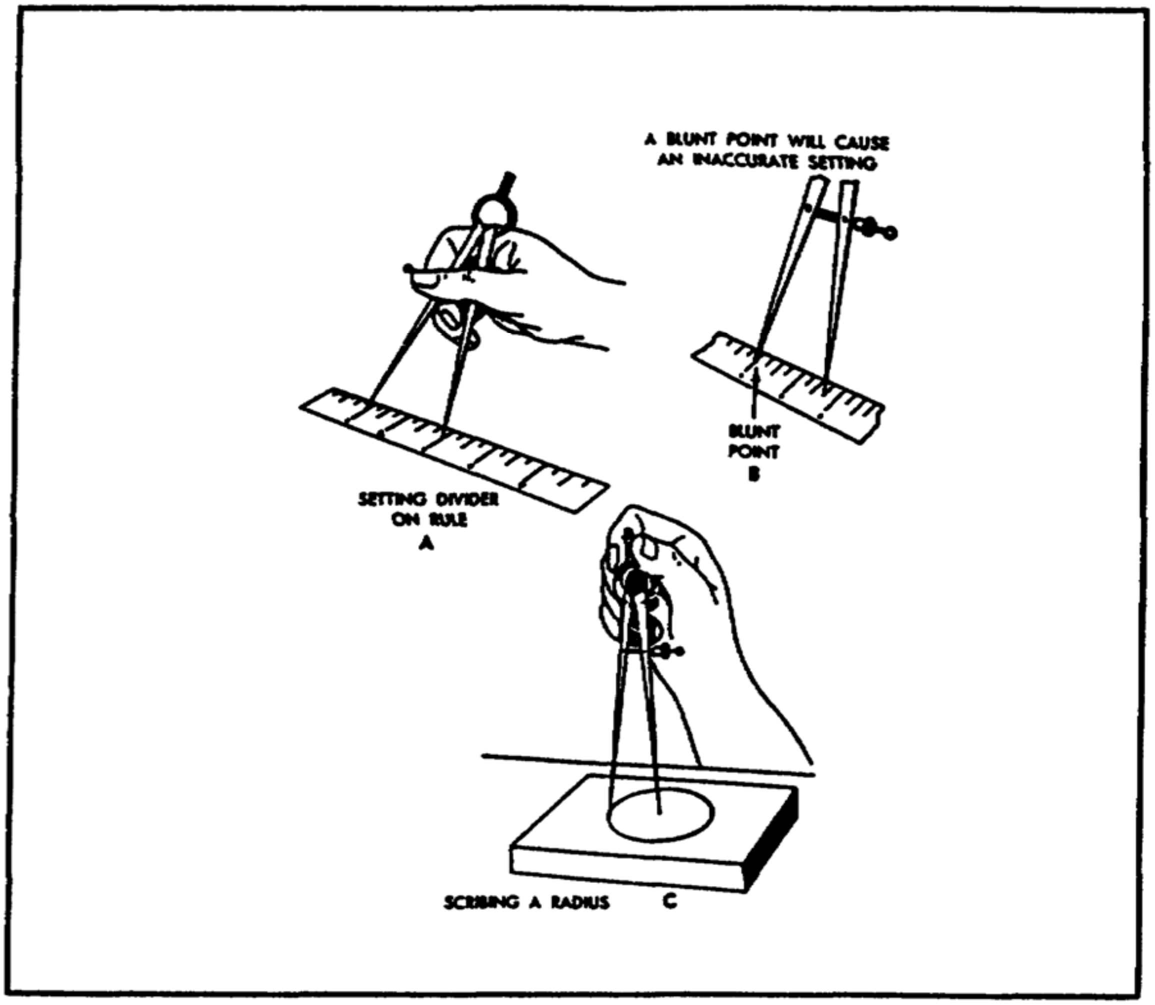


FIGURE 179. USING DIVIDERS.

NOTE

Do not set to the end of a rule.

When transferring a dimension from a part or tool to the scale on a rule, use the same care in adjusting the points of the dividers, making sure there is no pressure tending to spring the points either in or out. Illustrated in figure 179, view C, is a mechanic scribing a radius on a die block he is laying out. It will be seen that no pressure is being applied to the legs of the dividers.

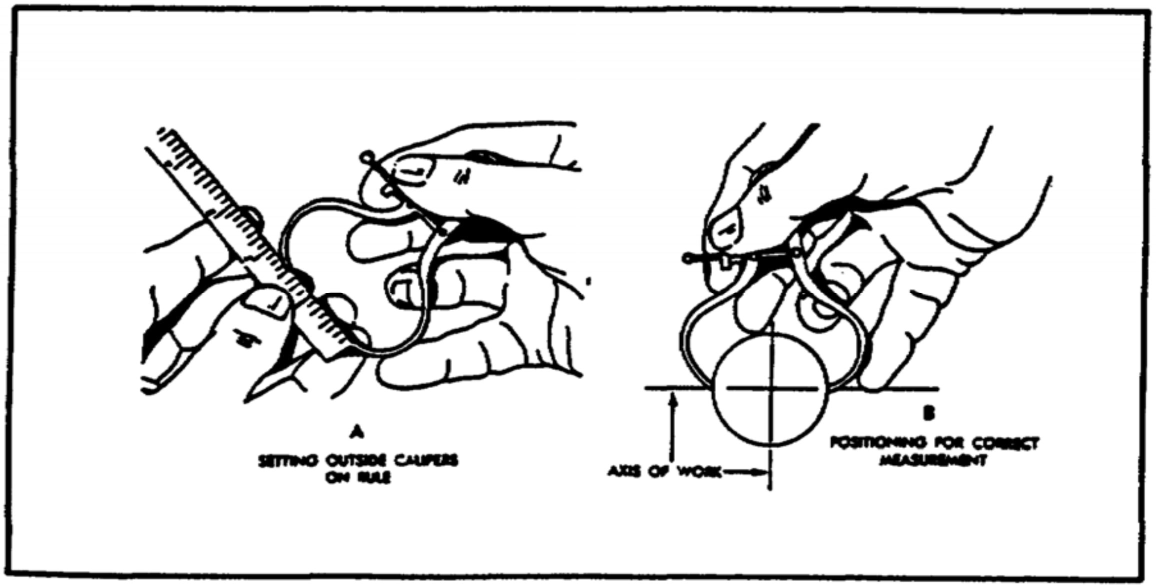


FIGURE 180. USING OUTSIDE CALIPERS.

d. Use of Calipers.

(1) *Outside Calipers.* A caliper is usually used in one of two ways. Either the caliper is set to the dimension of the work and the dimension transferred to a scale, or the caliper is set on a scale and the work machined until it checks with the dimension set up on the caliper. To adjust an outside caliper to a scale dimension, one leg of the caliper should be held firmly against one end of the scale and the other leg adjusted to the desired dimension, as shown in figure 180, view A, on the previous page. To adjust the outside caliper to the work, a sense of feel must be acquired. This comes through practice and care in using the tool to eliminate the possibility of error. Always position the caliper properly on the axis of the work, as shown in figure 180, view B.

NOTE

Never set a caliper on work that is revolving in a machine. The contact of one leg of a caliper on a revolving surface will tend to draw the other leg over the work because of the friction between the moving surfaces. Only a slight force is necessary to spring the legs of a caliper so that measurements made on moving surfaces are never accurate.

(2) *Inside Calipers.* The inside caliper is set to a dimension by placing the end of a scale and one point of the caliper against a solid surface and

adjusting the other leg to the proper graduation, as shown in figure 181, view A. The spring caliper is shown being used to check the inside diameter of a bored hole in figure 181, view B. Figure 182 illustrates the correct and incorrect positioning of the calipers with relation to the axis of the work.

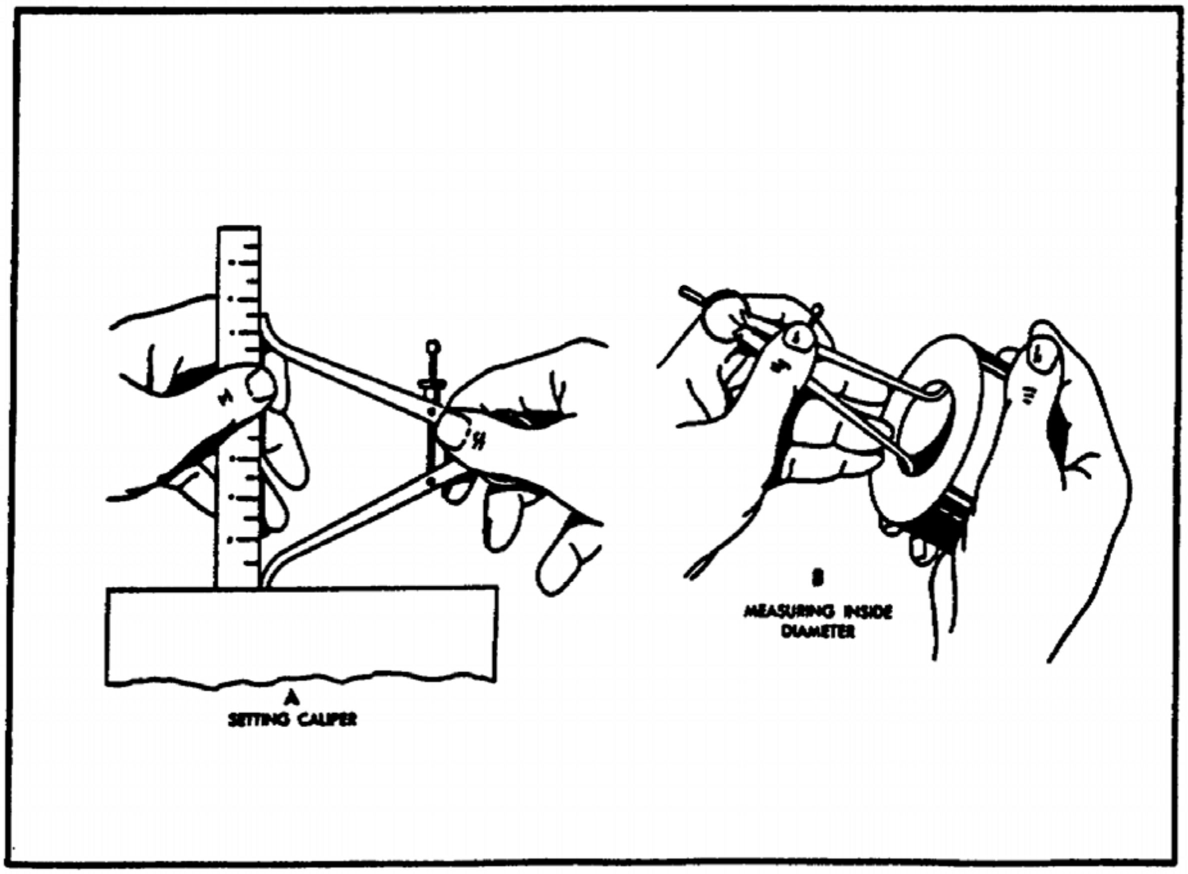


FIGURE 181. SETTING AND USING INSIDE CALIPER.

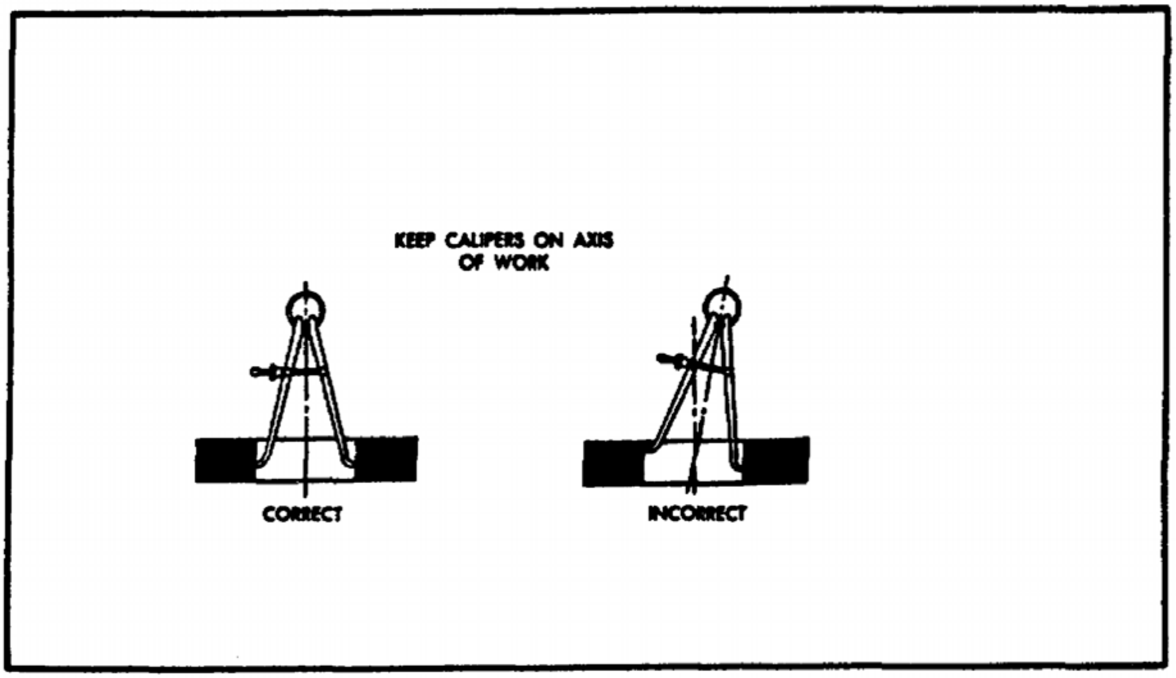


FIGURE 182. POSITIONING OF INSIDE CALIPERS.

The transfer feature of the caliper is illustrated in figure 183. Note that the diameter being measured is recessed and that the setting cannot be transferred to a scale directly because the legs must be collapsed to get them out of the work. The setting must be reproduced after the calipers are removed. Figure 184 shows how a micrometer can be used to transfer a dimension from an inside spring caliper.

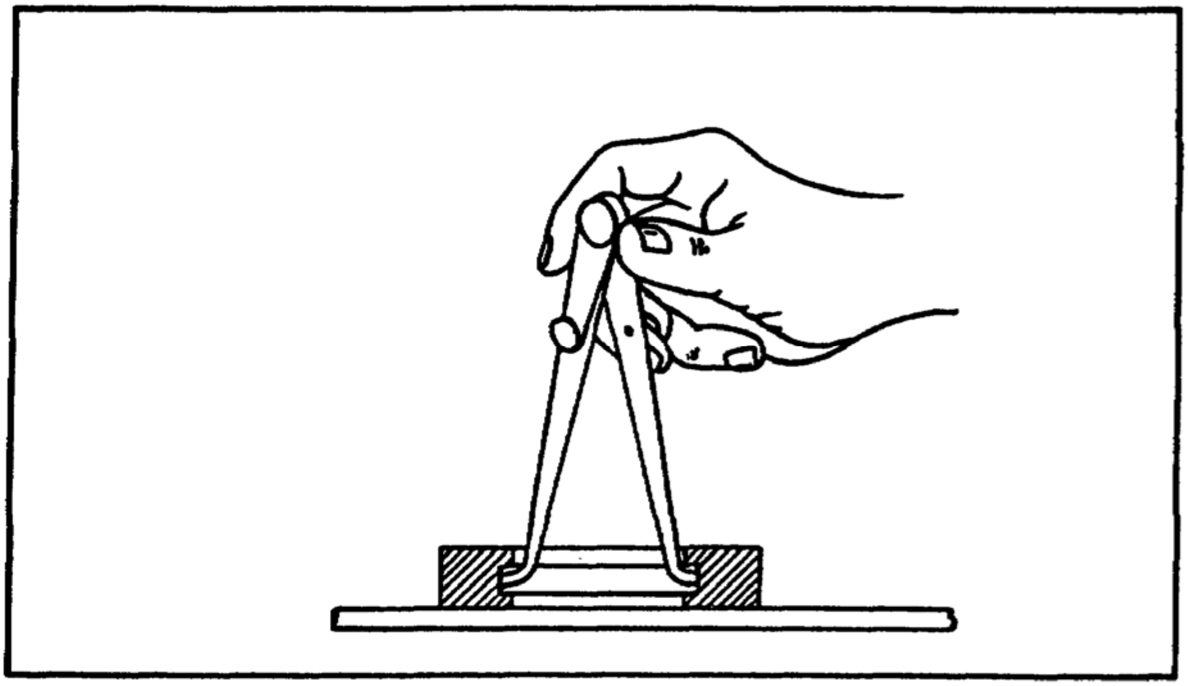


FIGURE 183. USING A TRANSFER CALIPER TO MEASURE A RECESSED DIAMETER.

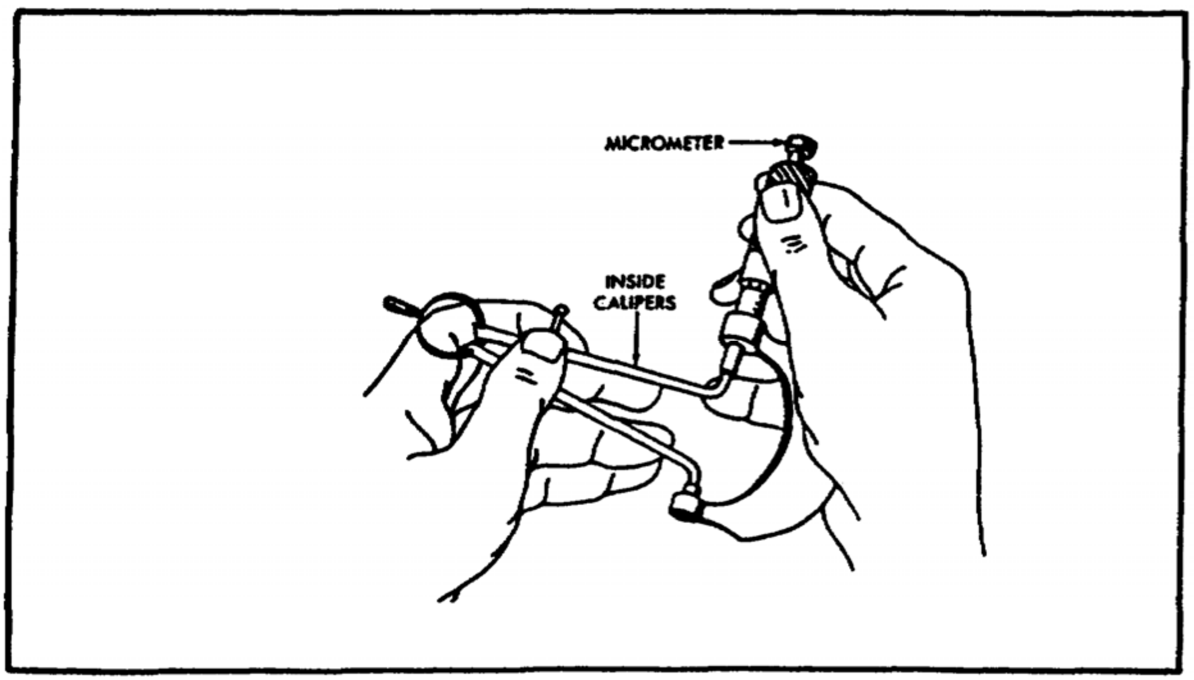


FIGURE 184. TRANSFERRING DIMENSION TO MICROMETER.

(3) *Hermaphrodite Calipers.* The hermaphrodite caliper is adjusted and set in the same manner as the outside and inside caliper, depending on the position and intended use of the caliper leg, as shown in figure 185.

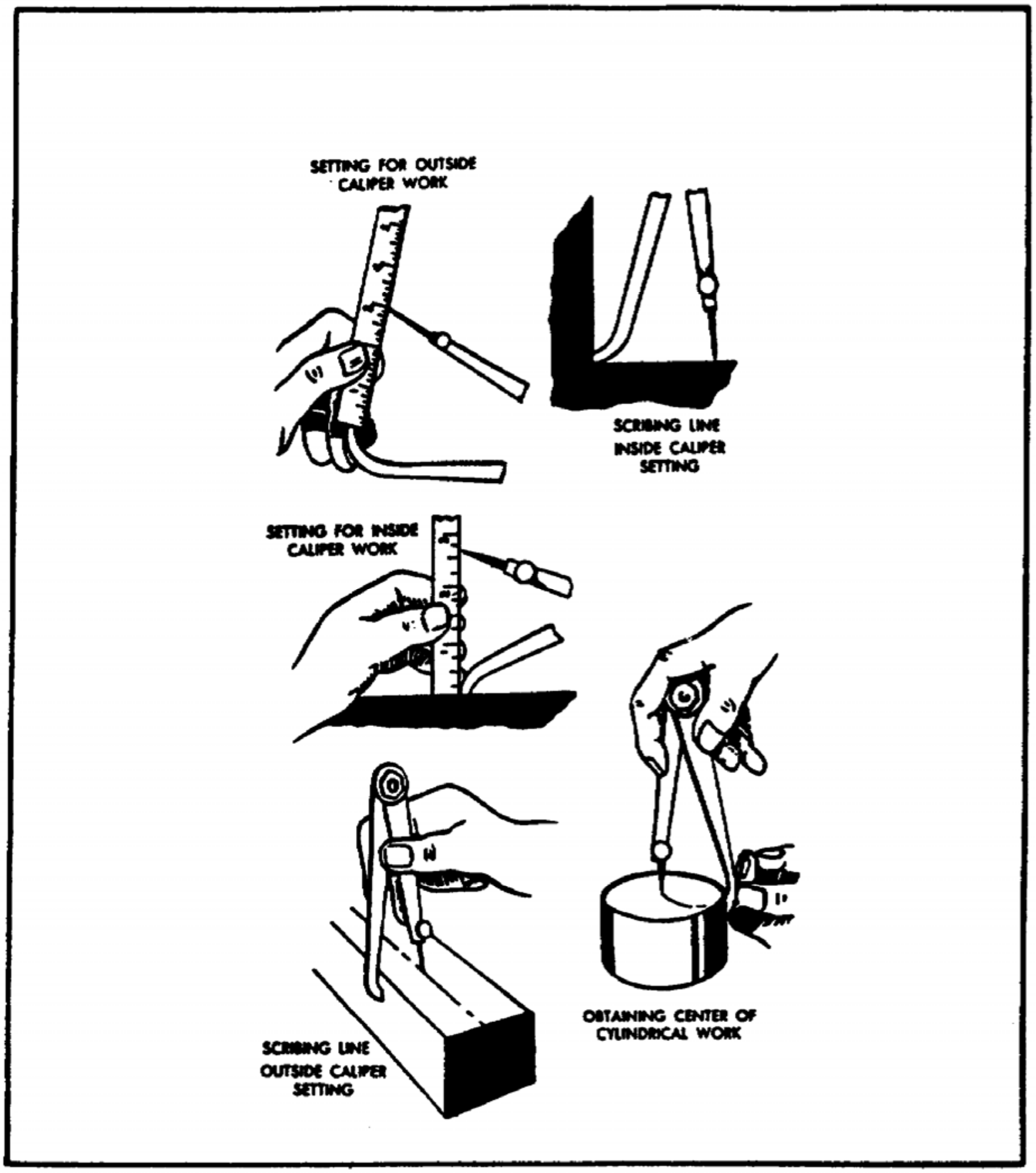


FIGURE 185. SETTING AND USING A HERMAPHRODITE CALIPER.

(4) Trammel. The trammel set is used for the same purposes as a divider or caliper, but usually for distances beyond the range of either one.

Figure 186 shows the trammel with a caliper point scribing an arc or establishing a dimension from the edge of a machined part. The divider point and ball point are illustrated in use in figure 187. Here, the machinist is scribing distances from the precise center of the hole, already drilled.

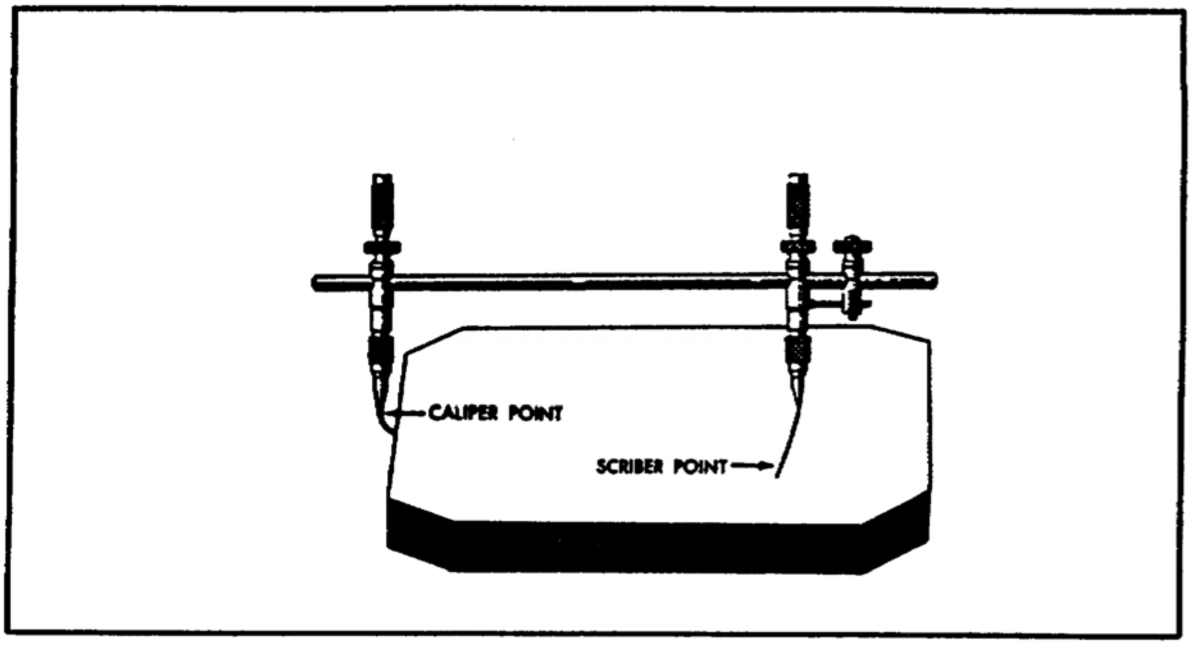


FIGURE 186. USING TRAMMEL WITH CALIPER AND SCRIBER POINTS.

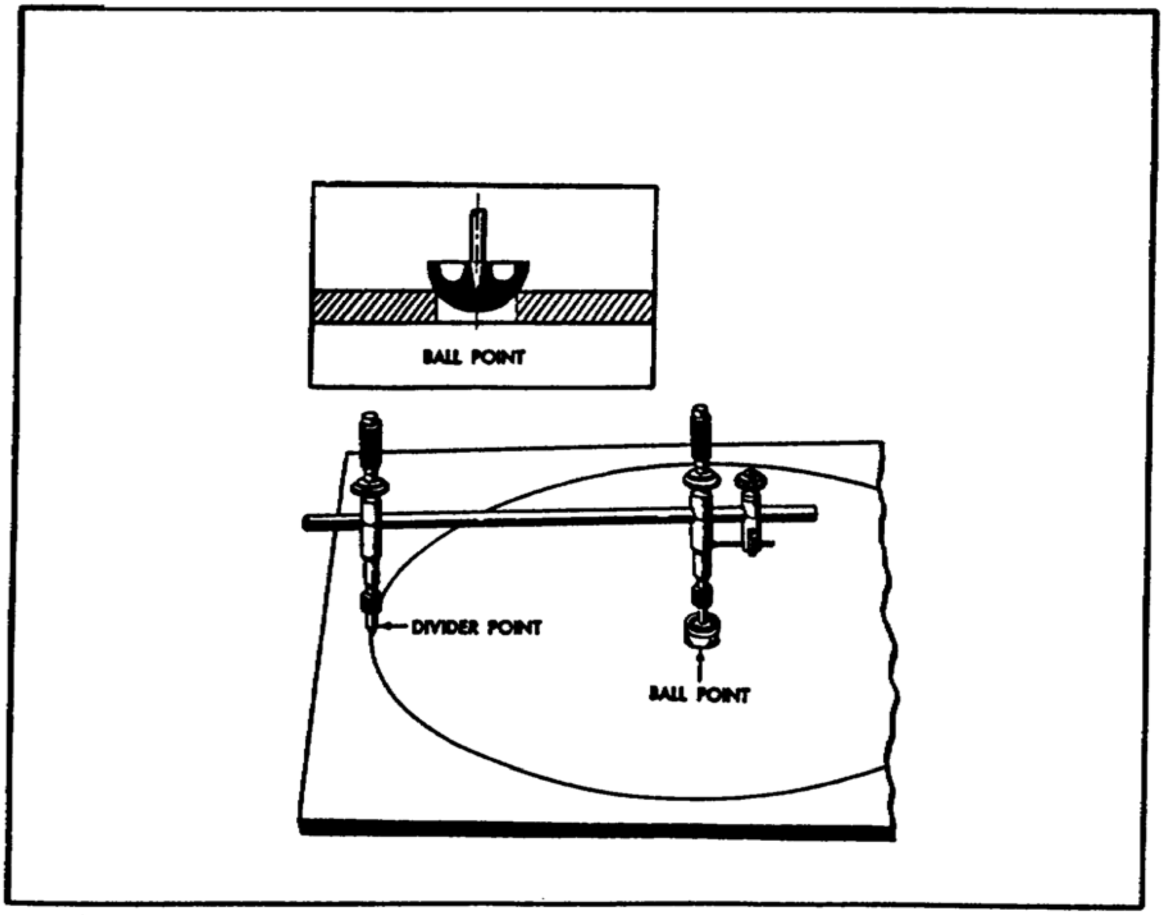


FIGURE 187. USING TRAMMEL WITH DIVIDER AND BALL POINTS.

(5) *Vernier Caliper.*

(a) *Reading Vernier Caliper.* The Vernier caliper permits precise, accurate readings by means of the graduated steel rule and the movable jaw which carries the Vernier scale. In order to use the Vernier caliper, a thorough understanding of the Vernier scale and how to read it is essential.

1 The steel rule of the caliper is graduated in fortieths or 0.025 of an inch. Every fourth division, representing a tenth of an inch, is numbered, as shown in the enlarged view in figure 188. The Vernier scale is divided into 25 parts and numbered 0, 5, 10, 15, 20, and 25. These 25 parts are equal to and occupy the same space as 24 parts on the rule. The difference between the width of one of the 25 spaces on the Vernier scale and one of the 24 spaces on the rule is 1/25 of 1/40, or 1/1000 of an inch. If the tool is set so that the 0 line on the Vernier coincides with the 0 line on the rule, the line

to the right of 0 on the Vernier scale will differ from the line to the right of 0 on second line by 2/1000 of an inch; and so on. The difference will continue to increase 1/1000 of an inch for each division until the line 25 on the Vernier scale coincides with the line 24 on the rule. To read the scales, note how many inches, tenths (or 0.100), and fortieths (or 0.025) the mark 0 on the Vernier scale is from 0 mark on the rule; then note the number of divisions on the Vernier scale from 0 to a line which exactly coincides with a line on the rule.

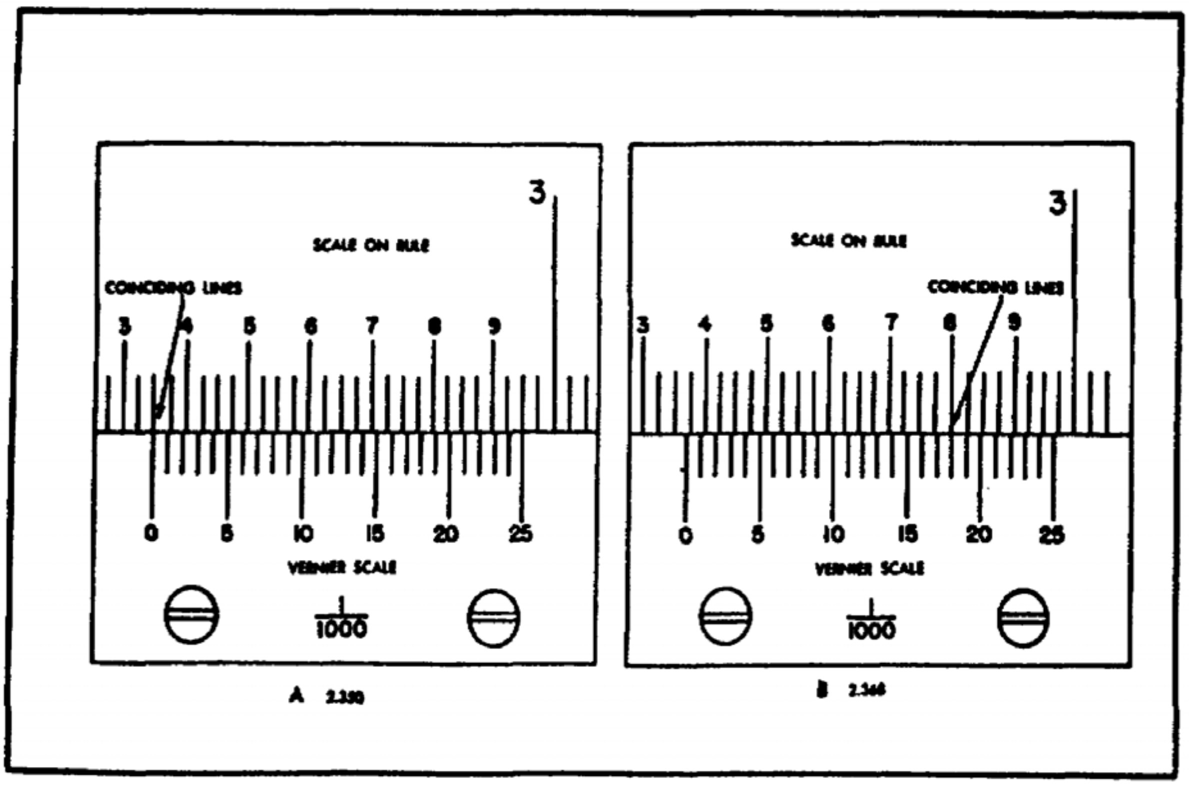


FIGURE 188. READING VERNIER SCALE.

2 For example, figure 188, view A, shows the 0 mark of the Vernier scale coinciding with a line on the rule. In this case, the Vernier scale is not necessary, since there is no fractional part of a space to determine. The reading is 2.350. The 0 mark on the Vernier scale, as shown in figure 188, view B, coincides with a fractional part of a space on the rule. The reading is 2.35 plus a fraction of the space on the rule. In order to determine what fractional part of a whole rule division, or how many thousands are to be added to the 2.35 reading, it is necessary to find the line on the Vernier scale that exactly coincides with the line on the rule. In this case, the line coincides at the 18th mark. This indicates

18/25 of a whole space. Since each space on the rule equals 0.025 inch, this part of a space is equal to 0.018 inch, and the total reading is 2.34 plus 0.018, or 2.368 inches.

NOTE

Vernier scales are not necessarily 25 divisions long; they may have any number of units. For example, the ten thousandths micrometer has a Vernier scale of only ten divisions.

(b) *Applications.* The Vernier caliper has a wide range of measurement applications, and the shape of the measuring jaws and their position with respect to the scale makes this tool more adaptable than a micrometer. However, the Vernier caliper does not have the accuracy of a micrometer. In any 1 inch of its length, a Vernier caliper should be accurate within 0.001 inch. In any 12 inches, it should be accurate within 0.002 inch and increase about 0.001 for every additional 12 inches. The accuracy of measurements made with a Vernier caliper is dependent on the user's ability to feel the measurement. Because the jaws are long, and because there is the possibility of some play in the adjustable jaw, especially if an excessive measuring pressure is used, it is necessary to develop an ability to handle the Vernier caliper. This touch may be acquired by measuring such known standards as gage blocks and plug gages. Applications of the Vernier caliper are shown in figure 189. In view A, a machinist is checking the outside diameter of a part. One hand holds the stationary jaw to locate it, while the other hand operates the adjusting nut and moves the sliding jaw to the work. The same procedure is used in view B in checking the inside dimension.

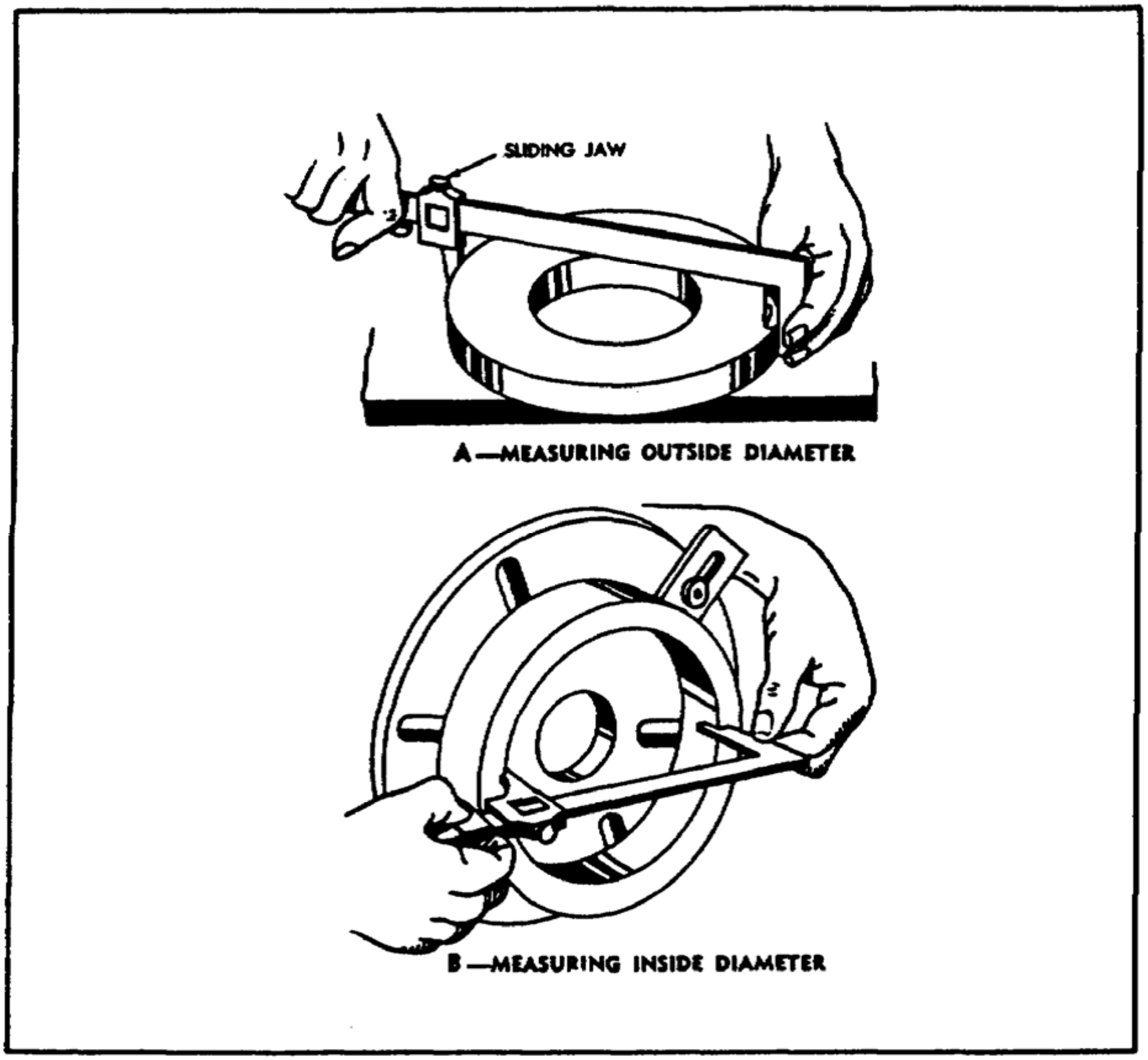


FIGURE 189. USING A VERNIER CALIPER.

(6) *Slide Caliper.* All slide calipers are equipped with a locking or clamping device, which makes it possible to hold the jaws in any desired position. Outside dimensions are taken off the graduated scale line that matches the inner edge of the fixed jaw. Inside dimensions are read opposite the mark or graduation line on the fixed jaw.

e. *Care of Dividers, Trammels, and Calipers.* Never use a divider, trammel, or caliper for a purpose other than that for which it was intended. Never pile these tools in a drawer. Never force dividers and calipers beyond their capacity or setting. Never use these tools incorrectly--changing settings by hammering instead of by loosening a clamping screw or nut, bearing down too hard when scribing with a divider or trammel, wearing measuring surfaces unnecessarily by using a heavy measuring pressure. Apply a protective film of oil to tools when not in use.

f. *Care of Vernier Calipers.* The accuracy of the Vernier caliper depends on the condition of fit of the sliding jaw, and the wear and distortion in the measuring surfaces. The fit of the sliding jaw should be such that it can be moved easily and still not have any play. It may be adjusted by removing the gib in the sliding jaw assembly and bending it. The function of the gib is to hold the adjustable jaw against the inside surface of the blade with just the right pressure to give it the proper friction. Wear on the jaws of the Vernier caliper is mostly at the tips where most measurements are made. Some of this wear may be taken up by adjusting the Vernier scale itself. This scale is mounted with screws in elongated holes which permit it to be adjusted slightly to compensate for wear and distortion. When the error exceeds 0.0002 inch, either in parallelism or flatness, the caliper should be returned to the manufacturer for reconditioning. Wear on the jaws can best be checked by visual means and by measuring rolls or rings of known dimensions.

6. Micrometers

a. *Purpose.* Micrometers are used for measurements requiring precise accuracy. They are more reliable and more accurate than the calipers discussed in the preceding paragraph.

b. *Types of Micrometers.* Micrometers are made in various shapes and sizes, depending upon the purpose for which they are to be used. They all have a precision screw adjustment offering great measuring accuracy.

(1) *Micrometer Caliper.*

(a) The micrometer caliper (figure 190) is the most common type. It has a range of 0 to 1 inch and is graduated to read in thousands of an inch or in units of the Metric system, from 0 to 25 millimeters by hundredths of a millimeter. It may or may not have:

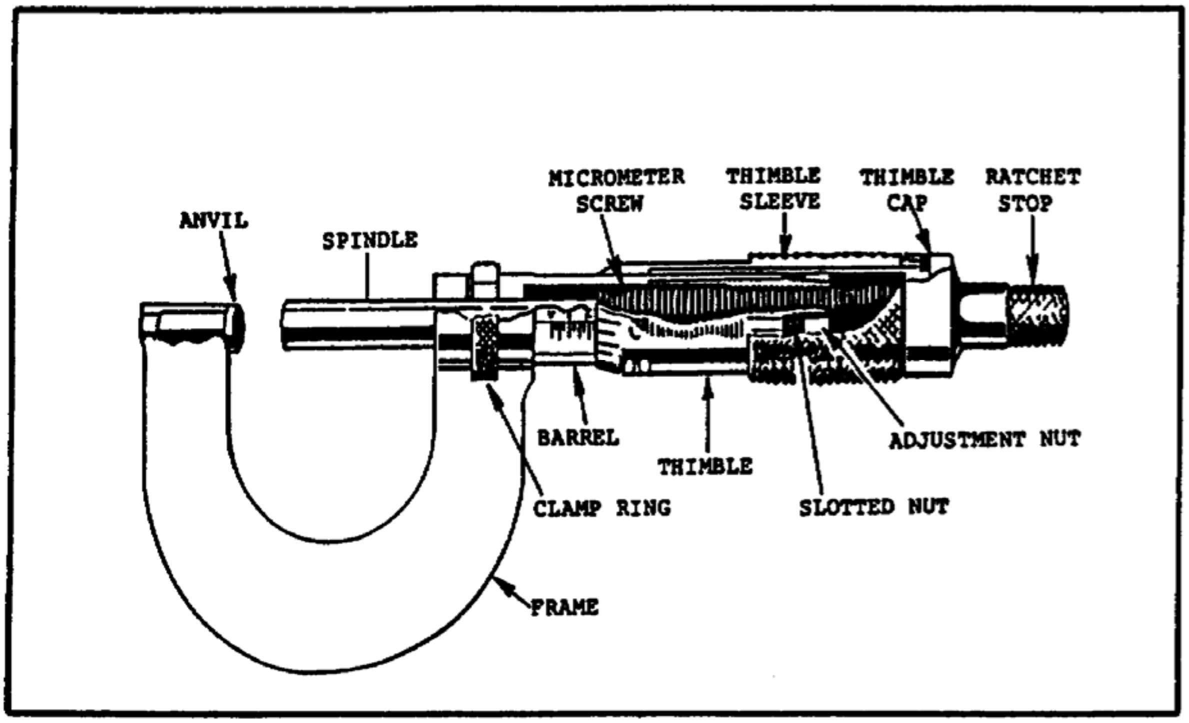


FIGURE 190. MICROMETER CALIPER, CUTAWAY VIEW.

1 A stainless steel frame to resist corrosion or tarnish.

2 A ratchet for applying a constant measuring pressure.

3 A special vernier scale for reading tenths of thousandths of an inch.

4 A clamp ring or locknut for clamping the spindle to hold a setting.

5 Cemented carbide tips on the measuring anvils to reduce wear.

(b) The frame can be smaller to the extent that the range of the caliper is only 0 to 1/2 inch or 0 to 13 millimeters, or it can be larger so that the range is 23 to 24 inches. The head has a constant range of 0 to 1 inch. The shape of the frame may be varied to adapt it to the physical requirements of some types of work. For example:

1 The frame back of the anvil may be cut away to allow the anvil to be placed in a narrow slot.

2 The frame may have a deep throat to permit it to reach into center sections of a sheet (sheet metal or paper gage).

3 The frame may be in the form of a base so that the gage can be used as a bench micrometer.

4 The frame may have a wooden handle and may be of extra heavy construction for use in a steel mill for gaging hot sheet metal.

(c) The spindle and anvil may vary in design to accommodate special physical requirements. For example:

1 The spindle and anvil may be chamfered so that the gage can slide on and off the work easily, as when gaging hot metal.

2 The ball-shaped anvil is convenient in measuring the thickness of a pipe section of small diameter.

3 The V-shaped anvil is necessary on the screw thread micrometer caliper to mesh properly with the screw thread. The spindle of the screw thread micrometer is cone shaped. This micrometer measures the pitch diameter.

4 Interchangeable anvils of various lengths make it possible to reduce the range of the caliper. A micrometer having a range from 5 to 6 inches can be changed to one having a 4 to 5, or 3 to 4 inch range by inserting a special anvil of the proper length.

(2) *Inside Micrometers.* Inside micrometers are used to measure inside dimensions. The minimum dimension that can be checked is determined by the length of the unit with its shortest anvil in place and the screw set up to zero. It consists of an ordinary micrometer head, except that the outer end of the sleeve carries a contact point attached to a measuring rod. The typical inside micrometer set (figure 191) has a range that extends from 2 to 10 inches. The various steps in covering this range are obtained by means of extension rods. The micrometer set may also contain a collar for splitting the inch step between two rods. The collar, which is 1/2 inch long, extends the rod another half-inch so that the range of each step can be made to overlap the next. The range of the micrometer screw itself is very short when compared to its measuring range. The smallest models have a 1/4 inch screw, the average have a

1/2 inch screw, and the largest inside micrometers have only a 1 inch screw.

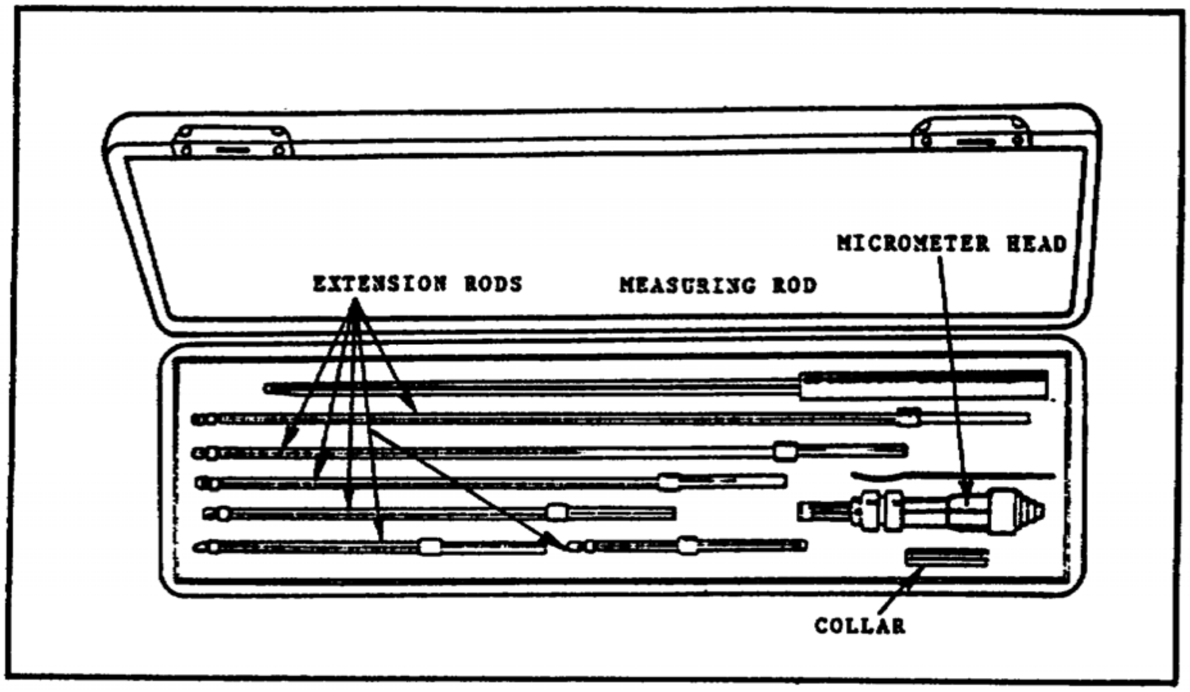


FIGURE 191. INSIDE MICROMETER SET.

c. *Mechanics of Micrometers.*

(1) *Design.* The micrometer makes use of the relation of the circular movement of a screw to its axial movement. The amount of axial movement of a screw per revolution depends on the thread, and is known as the lead. If a circular nut on a screw has its circumference divided into 25 equal spaces, and if the nut advances axially 1/40 inch for each revolution, then if it is turned one division, or 1/25 of a revolution, it will move axially 1/25 x 1/40, or 1/1000 of an inch. In the micrometer, the nut is stationary and the screw moves forward axially a distance proportional to the amount it is turned. The screw on a micrometer has 40 threads to the inch, and the thimble has its circumference divided into 25 parts, so 1 division on the thimble represents an advancement of 1/1000 of an inch axially.

(2) *Construction.*

(a) The steel frame is U-shaped, one end of which holds the stationary anvil. The stationary anvil is a hardened button either pressed or screwed into the frame.

(b) The steel spindle is actually the unthreaded part of the screw. It is the spindle that advances or retracts to open or close the open side of the U-frame. The spindle bearing is a plain bearing and is part of the frame.

(c) The hollow barrel extends from this bearing; on the side of the barrel is the micrometer scale, which is graduated in tenths of an inch, and which is, in turn, divided into subdivisions of 0.025 inch. The end of the barrel supports the nut which engages the screw. This nut is slotted, and its outer surface has a taper thread and a nut which makes it possible to adjust the diameter of the slotted nut, within limits, to compensate for wear.

(d) The thimble is attached to the screw, and is a sleeve that fits over the barrel. The front edge of the thimble carries a scale broken down into 25 parts. This scale indicates parts of a revolution, while the scale on the barrel shows the number of revolutions. The thimble is connected to the screw through a sleeve that permits it to be slipped in relation to the screw for the purpose of adjustment. The inner sleeve is sweated to the screw. The outer sleeve is clamped to the inner one by the thimble cap. Loosening the cap allows it to slip one in relation to the other.

(e) On top of the thimble cap there may be a ratchet. This device consists of an overriding clutch held together by a spring in such a way that when the spindle is brought up against the work, the clutch will slip when the correct measuring pressure is reached. The purpose of the ratchet is to eliminate any difference in personal touch and so reduce the possibility of error due to a difference in measuring pressure. Not all micrometers have ratchets.

(f) The clamp ring or locknut is located in the center of the spindle bearing on those micrometers equipped with it. This clamping makes it possible to lock the spindle in any position to preserve a setting.

d. *Use of Micrometers.*

(1) *Reading Standard Micrometer.* Reading a standard micrometer is only a matter of reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution. The micrometer screw has 40 threads per inch. This means that one complete and exact revolution of the micrometer screw moves the spindle away from or towards the anvil exactly 0.025 inch. The lines on the barrel (figure 192) conform to the pitch of the micrometer screw, each line indicating 0.025 inch, and each fourth line being numbered 1, 2, 3, and so forth. The

beveled edge of the thimble is graduated into 25 parts, each line indicating 0.001 inch, 1/25 of the 0.025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch. Read measurement shown in figure 192 as indicated in (a) through (d) below.

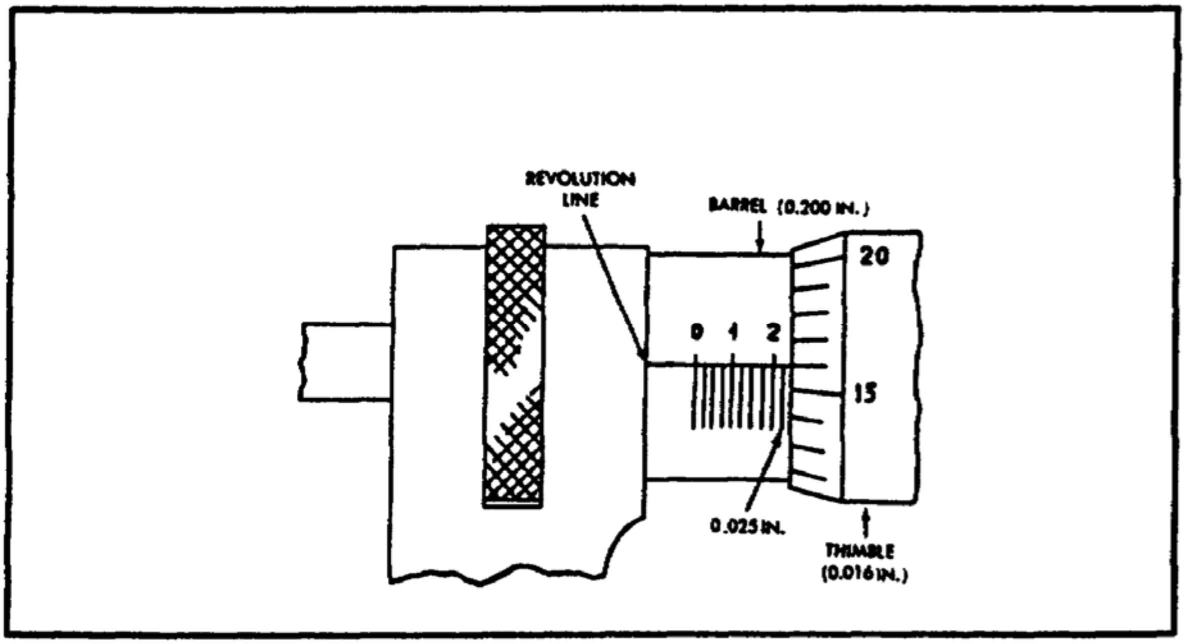


FIGURE 192. READING STANDARD MICROMETER SCALE.

(a) Record highest figure visible on barrel 2 = 0.200 in.

(b) Number of lines visible between the No. 2 and thimble edge 1 = 0.025 in.

(c) The line on the thimble that coincides with or passed the revolution or long line in the barrel 16 = 0.016 in.

(d) Measurement reading TOTAL = 0.241 in.

(2) *Reading Metric Micrometer.* The same principle is applied in reading the Metric graduated micrometer, but the following changes in graduations should be noted to avoid confusion:

(a) The pitch of the micrometer screw is 0.5 mm. One revolution of the spindle advances or withdraws the screw a distance equal to 0.5 mm.

(b) The barrel is graduated in millimeters from 0 to 25; it takes two revolutions of the spindle to move 1 mm.

(c) The thimble is graduated in 50 divisions with every fifth line being numbered.

(d) Rotating the thimble from one graduation to the next moves the spindle 1/50 of 0.5 mm, or 1/100 mm. Two graduations equal 2/100 mm, and so forth.

(3) *Adjusting Micrometer Caliper to Work.*

(a) Figure 193, view A, shows the proper way to hold a micrometer caliper in checking a small part. Hold the part in one hand. Hold the micrometer in the other hand so that the thimble rests between the thumb and the forefinger. The third finger is then in a position to hold the frame against the palm of the hand. The frame is supported in this manner which makes it easy to guide the work over the anvil. The thumb and forefinger are in position to turn the thimble, either directly or through the ratchet, and move the spindle over against the work.

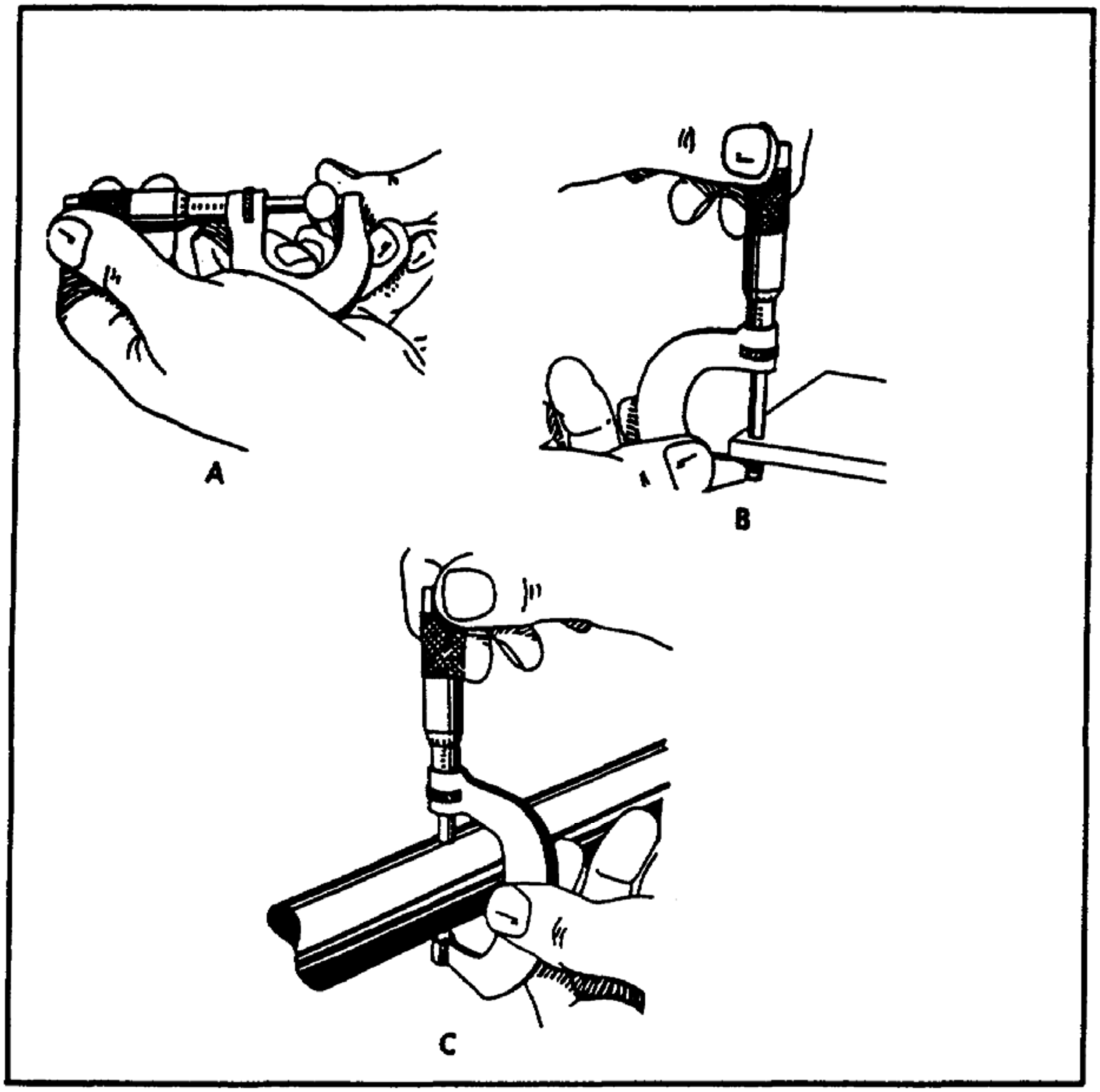


FIGURE 193. USING OUTSIDE MICROMETER.

(b) On larger work, it is necessary to have the work stationary and positioned to permit access to the micrometer. The proper method of holding a micrometer when checking a part too large to be held in one hand is shown in figure 193, view B. The frame is held by one hand to position it and to locate it square to the measured surface. The other hand operates the thimble, either directly or through the ratchet. A large flat part should be checked in several places to determine the amount of variation.

(c) To gage a shaft as shown in figure 193, view C, the frame is held by one hand while the thimble is operated by the other. In gaging a cylindrical part with a micrometer, it is necessary to "feel" the setting to be sure that the spindle is on the diameter, and to also check the diameter in several places to determine the amount of out-of-roundness.

(d) For measuring very large diameters, micrometer calipers are made in various sizes up to 168 inches. Figure 194 shows a pulley being checked with a micrometer whose range has been reduced by a special anvil which has been screwed into the frame. A set of different length anvils permits the use of this micrometer over a wide range of sizes; yet the spindle only moves 1 inch. This micrometer has been lightened in weight by the I-section construction and by boring holes in the frame.

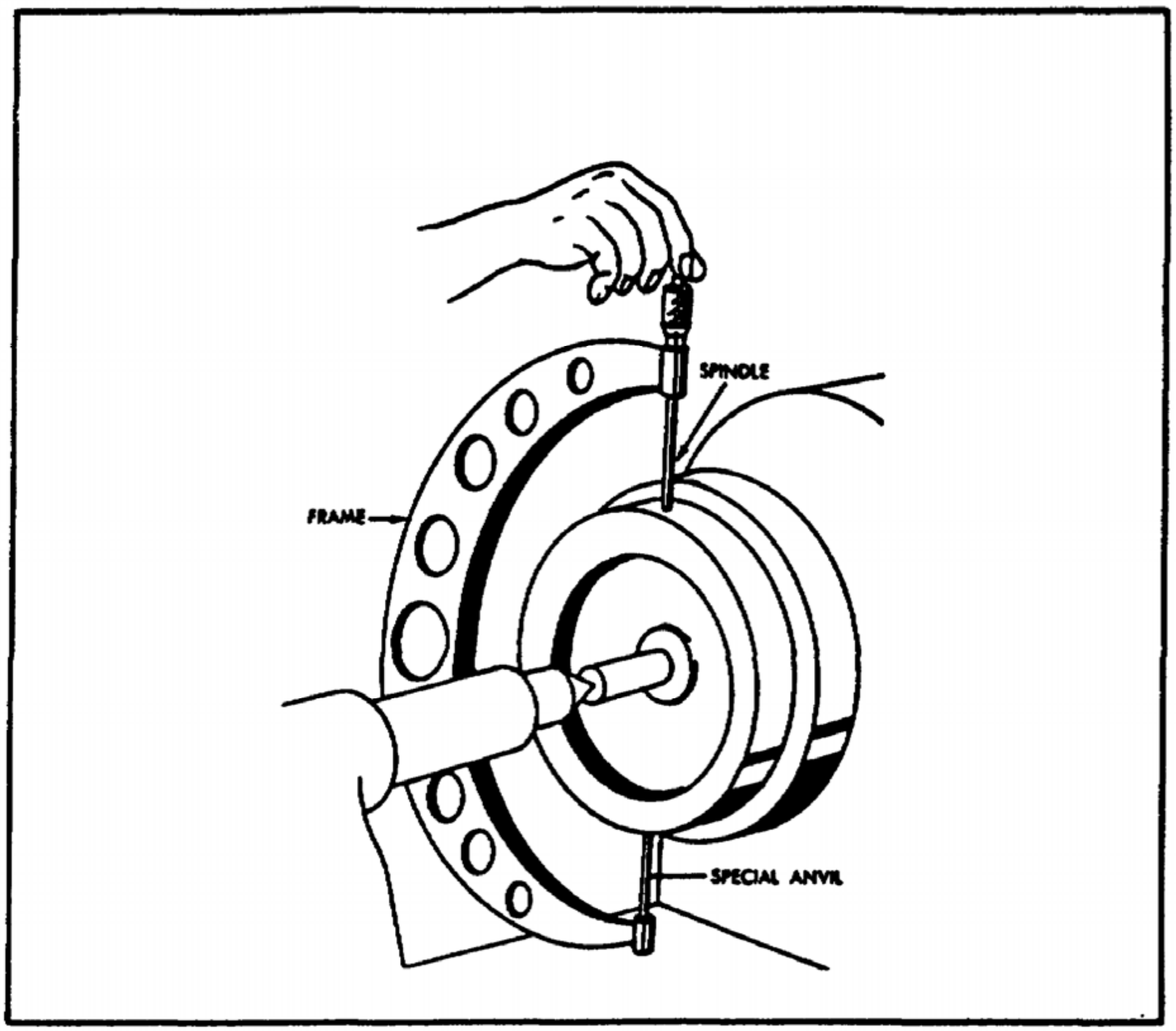


FIGURE 194. CHECKING DIAMETER OF PULLEY.

(4) *Using Inside Micrometer.* The normal procedure when using an inside micrometer is to set it across a diameter or between the inside surfaces, remove it, and then read the dimension. For this reason, the thimble on an inside micrometer is much stiffer than on a micrometer caliper--it holds the dimension well. It is good practice to verify the reading of an inside micrometer by measuring it with a micrometer caliper.

(a) Figure 195 shows an inside micrometer with extension rod being used to check the diameter of a bored hole. Note the arrows which indicate the directions of movement as the operator feels for the largest dimension horizontally and the smallest dimension vertically. Inside micrometers have spherical contact points which require more practice to "feel" the full diametrical measurement. One contact point is generally held in a fixed position and the other rocked in different directions to be sure the tool is spanning the true diameter of a hole or the correct width of a slot.

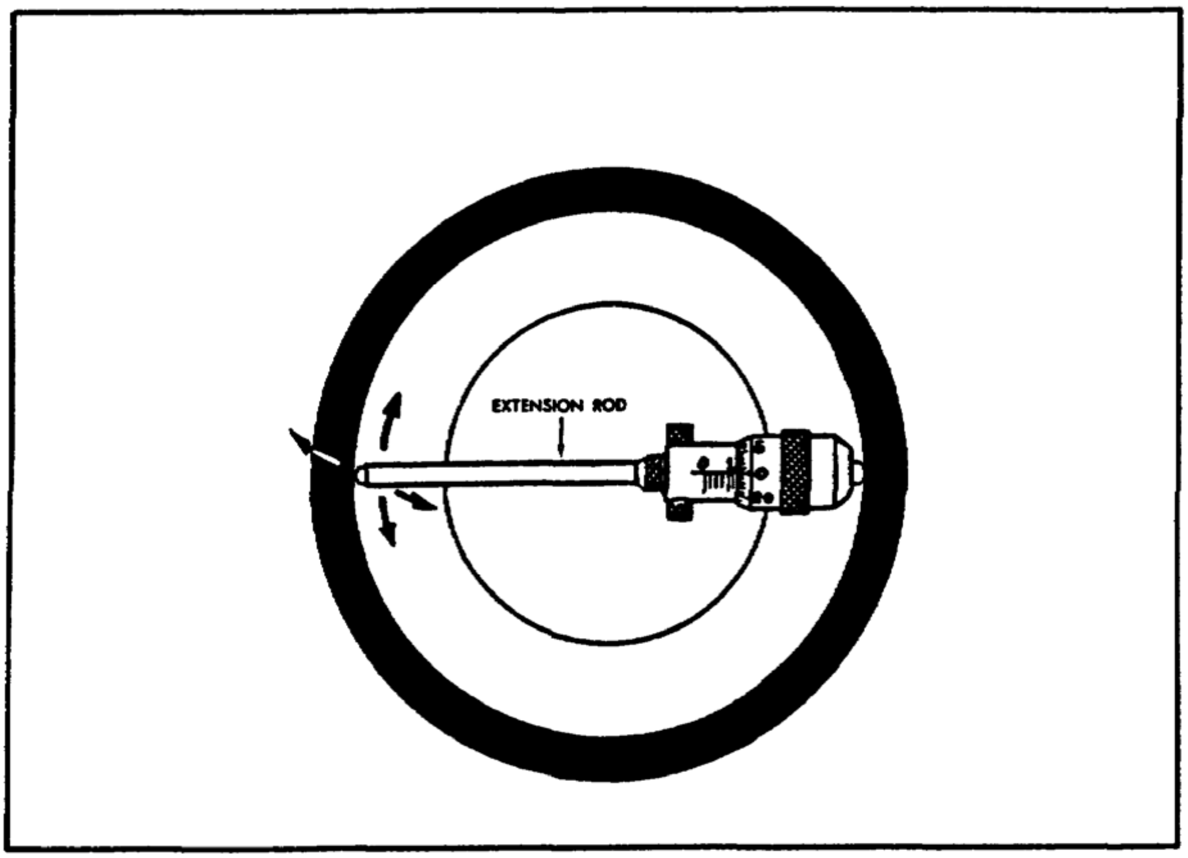


FIGURE 195. USING INSIDE MICROMETER WITH EXTENSION ROD.

(b) For probing a deep hole or in a restricted place, a handle attachment may be used. The handle clamps on to the body of the micrometer.

(5) *Transferring Measurements From Inside Caliper or Inside Micrometer to Micrometer Caliper.*

(a) After setting the inside caliper or inside micrometer to the work, hold the micrometer caliper in one hand and the inside tool in the other hand.

(b) Turn the thimble of the micrometer caliper with the thumb and forefinger until you feel the inside tool legs lightly contact the anvil and spindle of the micrometer caliper.

(c) Hold the tips of the inside tool legs parallel to the axis of the micrometer caliper spindle.

(d) The micrometer caliper will be accurately set when the inside tool will just pass between the anvil and spindle by its own weight.

e. *Care of Micrometers.* To maintain a micrometer in good condition and to preserve the accuracy of its measurements, observe the following rules of good practice and adjusting procedures:

(1) Never store a micrometer with its anvil and spindle closed. Flat surfaces wrung together for any length of time tend to corrode. Leave a small gap between the anvil and spindle when storing.

(2) Oil the micrometer in only one place--the micrometer screw; and only with a very light oil. If storing for long periods of time, cover the micrometer with a light film of oil and wrap it in oiled paper.

(3) Never roll the thimble along the hand or arm. This practice, like holding the thimble and twirling the frame to open or close the micrometer, will cause excessive wear on the screw.

(4) Before using a micrometer, wipe it off and pull a piece of paper between the anvil and the end of the spindle.

(5) The micrometer should operate freely with no play in its travel. If a micrometer has play, or if it binds, it should be returned to the manufacturer for reconditioning. This condition is caused by abuse or uneven wear.

(6) Check the micrometer screw periodically with a precision gage block in at least four places other than zero to verify its accuracy. Simply measure a selected group of blocks ranging from 0 to 1 inch.

(7) Clean the micrometer mechanism whenever it becomes gummy, contains abrasive grit, or whenever it is to be adjusted. Use an approved cleaning agent.

(8) When the faces of the spindle and anvil become worn and they are no longer flat and parallel to each other, the error should not exceed 0.0002 inch on a micrometer which is graduated to control measurements to a limit of 0.001 inch, and should not exceed 0.00005 inch on a micrometer which is graduated to control measurements to a limit of 0.0001 inch. Measuring a ball at several points over the surface of the anvils will show up any error in parallelism. Parallelism can be tested by means of two balls mounted in an aluminum holder. If the anvils are in error more than the allowable maximum, the micrometer should be returned to the manufacturer for repair.

(9) In adjusting a micrometer to read correctly, the thimble is not set to 0, when the anvil is in contact with the spindle, but is set at some other dimension, to distribute the error. For example, if a micrometer screw had an accumulated error of 0.0003 inch in the length of its travel, and it were set correctly at 0, it would be off 0.0003 at 1 inch. However, if the micrometer were set correctly in the center of its travel, it would be 0.00015 under at 0 and 0.00015 over at 1 inch, which is a much better condition. Because a micrometer does not return exactly to 0 when anvil and spindle contact does not mean that it is not adjusted properly. Turn the friction sleeve with a small spanner wrench to compensate for minor wear on the anvil and spindle or on the screw, as shown in figure 196.

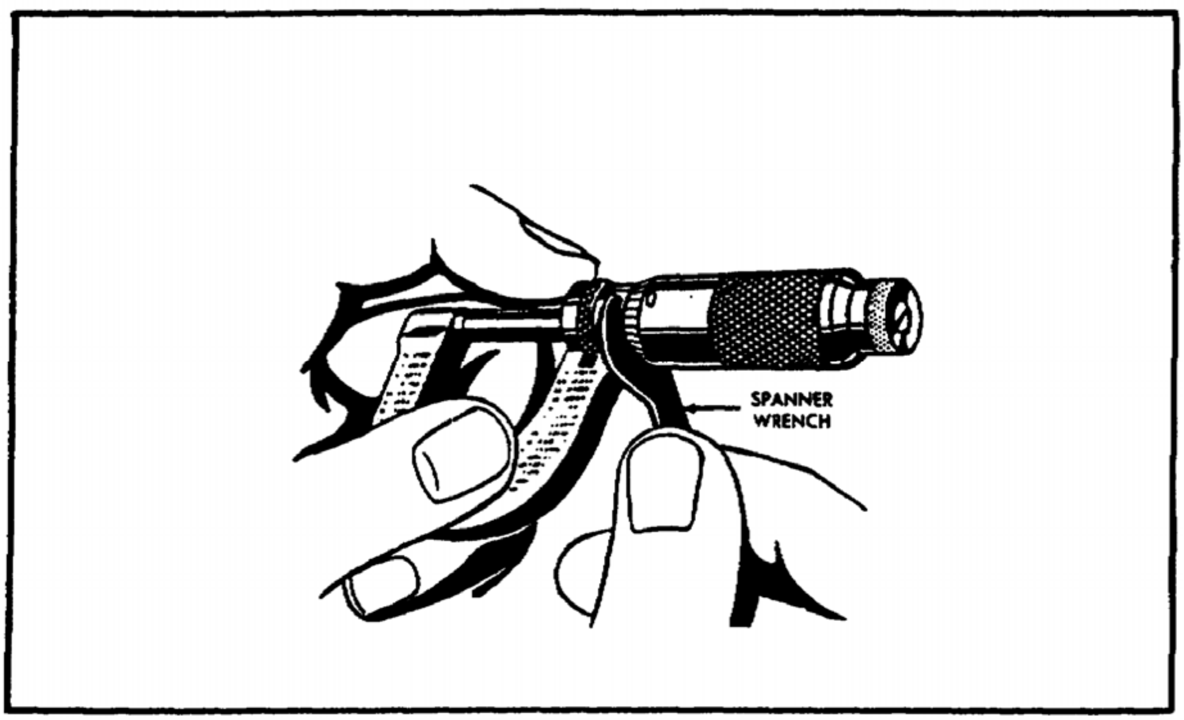


FIGURE 196. MICROMETER ADJUSTMENT.

7. Miscellaneous Measuring Gages

a. *Description and Purpose.*

(1) *Thickness (Feeler) Gages.* These gages are made in leaf form, which permits the checking and measuring of small openings, such as contact points, narrow slots, etc. They are widely used to check the flatness of parts in straightening and grinding operations and in squaring objects with a tri square.

(2) *Wire and Drill Gages.* The wire gage is used for gaging metal wire; a similar gage is used to check the size of hot and cold rolled steel, sheet and plate iron, and music wire. Drill gages determine the size of drill and indicate the correct size of drill to use for a given tap size. Drill number and decimal size is also shown in this type gage.

(3) *Drill Rods or Blanks.* Drill rods or blanks (not illustrated) are used on line inspection work to check the size of drilled holes in the same manner as with plug gages. They are also used for setup inspection to check the location of holes.

(4) *Thread Gages.* Among the many gages used in connection with the machining and inspection of threads are the center gage and the screw pitch gage.

(a) *Center Gage.* The center gage is used to set thread cutting tools. Four scales on the gage are used for determining the number of threads per inch.

(b) *Screw Pitch Gage.* Screw pitch gages are used to determine the pitch of an unknown thread. The pitch of a screw thread is the distance between the center of one tooth to the center of the next tooth.

(5) *Small Hole Gage Set.* This set of 4 or more gages is used to check dimensions of small holes, slots, grooves, etc., from approximately 1/8 to 1/2 inch in diameter.

(6) *Telescoping Gages.* These gages are used for measuring the inside dimension of slots or holes up to 6 inches in width or diameter.

(7*) Thread Cutting Tool Gages.* These gages provide a standard for thread cutting tools. They have an enclosed angle of 29° and include a 29°

setting tool. One gage furnishes the correct form for square threads and the other for Acme standard threads.

(8) *Fillet and Radius Gages.* These gages are used to check convex and concave radii in corners or against shoulders.

(9) *Drill Point Gage.* This gage is used to check the accuracy of drill cutting edges after grinding. It is also equipped with a 6 inch hook rule. This tool can be used as a drill point gage, hook rule, plain rule, and as a slide caliper for taking outside measurements.

(10) *Marking Gages.* A marking gage is used to mark off guidelines parallel to an edge, end, or surface of a piece of wood. It has a sharp spur or pin that does the marking.

(11) *Tension Gage.* This type of gage (not illustrated) is used to check contact point pressure and brush spring tension in 1 ounce graduations.

(12) *Saw Tooth Micrometer Gage.* This special gage (not illustrated) checks the depth of saw teeth in thousandths of an inch from 0 to 0.075 inch.

b. *Types of Thickness (Feeler) Gage.* Thickness (feeler) gages are made in many shapes and sizes; usually 2 to 26 blades are grouped into one tool and graduated in thousandths of an inch. Most thickness blades are straight, others are bent at the end at 45° and 90° angles. Some thickness gages are grouped so that there are several short and several long blades together. Thickness gages are also available in single blades and in strip form for specific measurements. For convenience, many groups of thickness gages are equipped with a locking screw that locks the blade to be used in the extended position. Figure 197 shows several types of thickness gages supplied by the Army Ordnance Supply System.

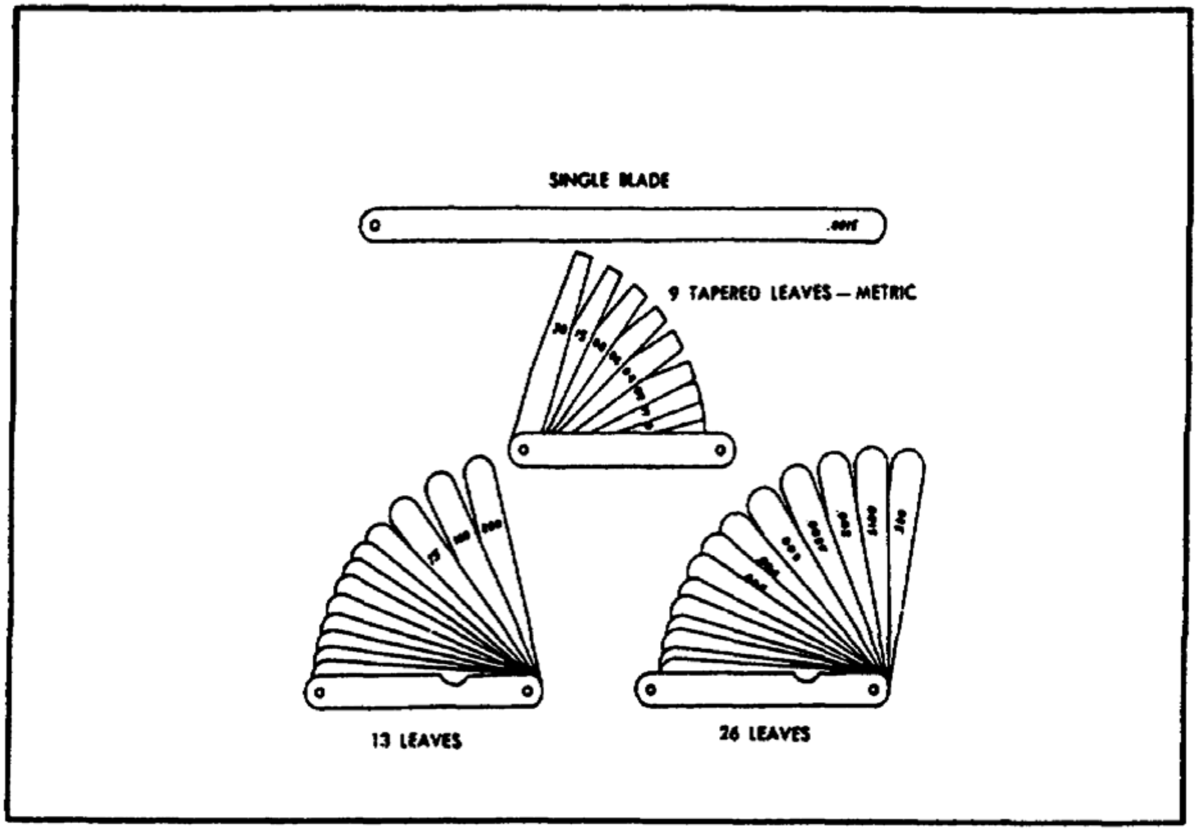


FIGURE 197. THICKNESS (FEELER) GAGES.

c. *Types of Wire and Drill Gages.*

(1) *Twist Drill and Drill Rod.* The twist drill and drill rod gage (figure 198) has a series of holes with size and decimal equivalents stamped adjacent to each hole. One gage measures drill sizes Nos. 1 to 60; the other measures drill sizes 1/16 to 1/2 inch, by 1/64 inch intervals.

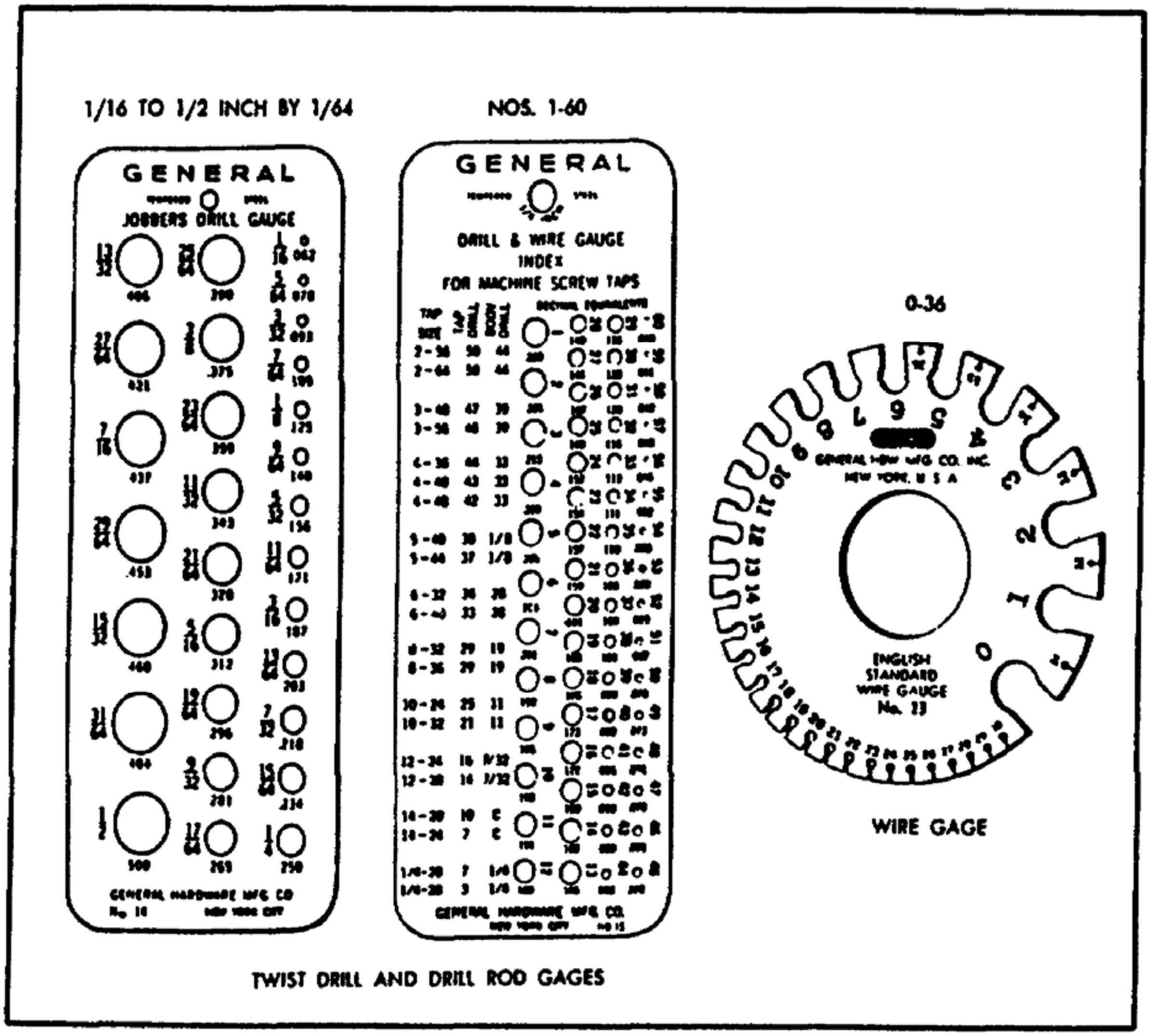


FIGURE 198. DRILL AND WIRE GAGES.

(2) *Wire Gages.* A wire gage (figure 198) is circular in shape with cutouts in the outer perimeter. Each cutout gages a different size wire, from 0 to 36 of the English standard wire gage. A separate gage is used for American standard wire and another for U.S. standard sheet and plate iron and steel.

d. *Types of Thread Gages.*

(1) *Center Gage.* The center gage (figure 199) is graduated in 14ths, 20ths, 24ths, and 32nds of an inch. The back of the center gage has a table giving the double depth of thread in thousandths of an inch for each pitch. This information is useful in determining the size of tap drills. Sixty degree angles in the shape of the gage are used for checking Unified and

American threads as well as for older American National or U.S. standard threads, and for checking thread cutting tools.

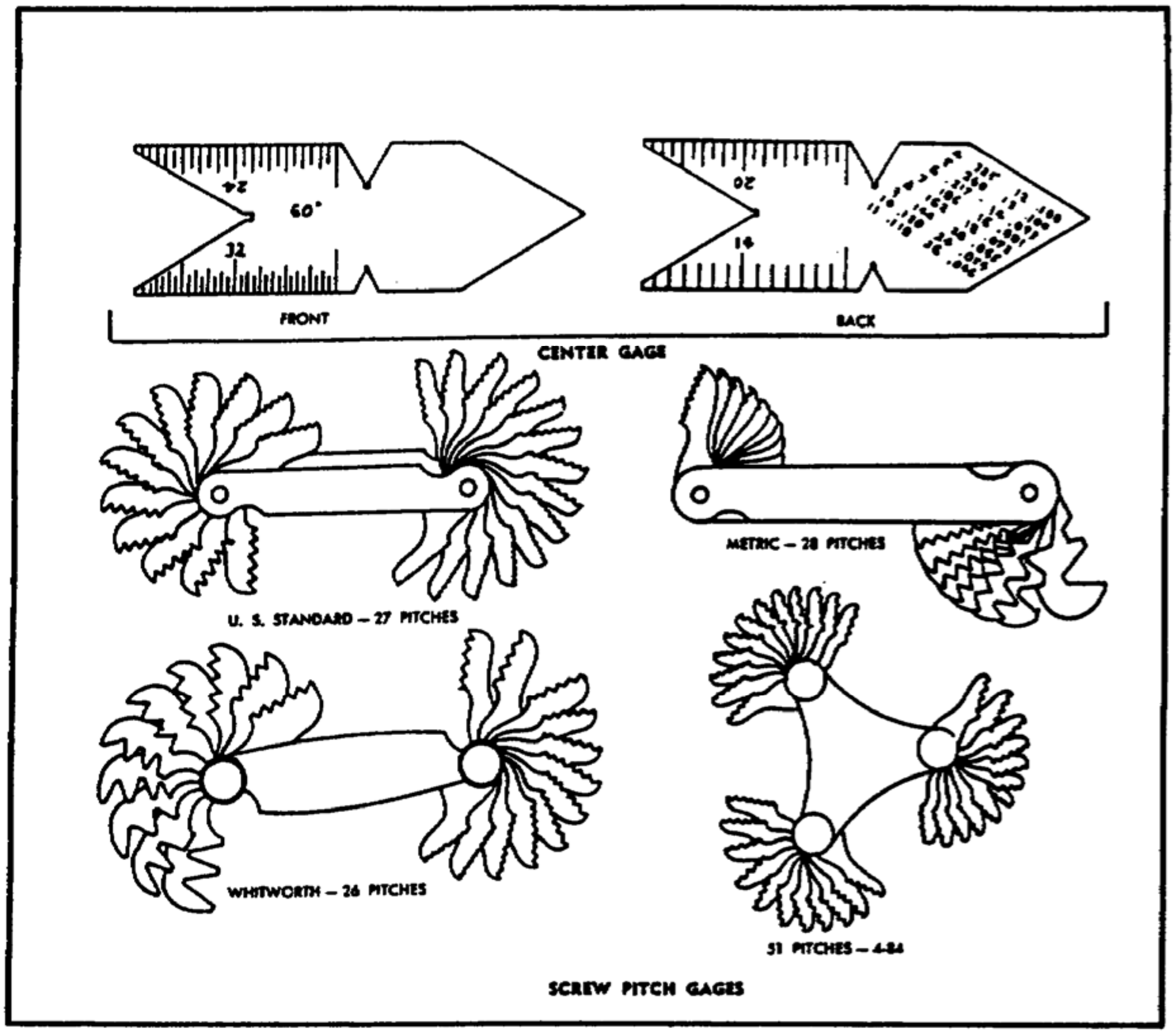


FIGURE 199. CENTER AND SCREW PITCH THREAD GAGES.

(2) *Screw Pitch Gages.* Screw pitch gages (figure 199) are made for checking the pitch of U.S. Standard, Metric, National form, V-form, and Whitworth cut threads. These gages are grouped in a case or handle, as are the thickness gages. The number of threads per inch is stamped on each blade. Some types are equipped with blade locks. The triangular shaped gage has 51 blades covering a very wide range of pitches, including 11 1/2 and 27 threads per inch for V-form threads.

e. *Types of Small Hole and Telescoping Gages.*

(1) *Small Hole Gages.* Small hole gages (figure 200) are adjustable, having a rounded measuring member. A knurled screw in the end of the

handle is turned to expand the ball-shaped end in small holes and recesses. A micrometer caliper is used to measure the ball end. Maximum measuring capacity is 1/2 inch.

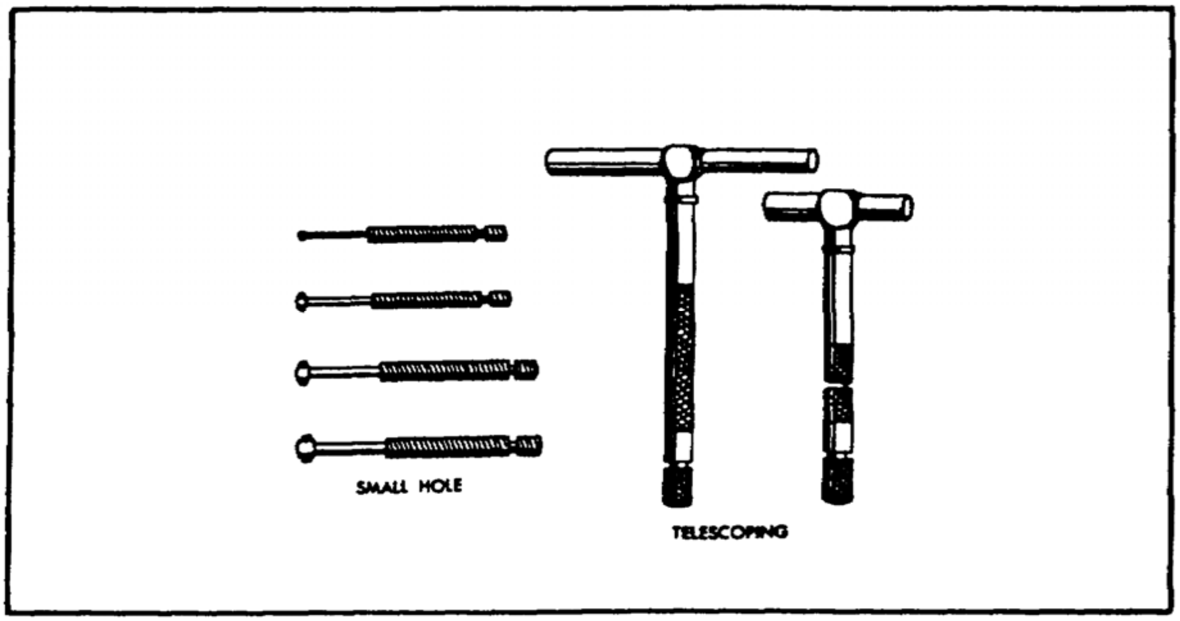


FIGURE 200. SMALL HOLE AND TELESCOPING GAGES.

(2) *Telescoping Gages.* Telescoping gages (figure 200) are used to gage larger holes and to measure inside distances. These gages are equipped with a plunger that can be locked in the measuring position by a knurled screw in the end of the handle. Maximum measuring capacity is 6 inches. Measurements must be calipered on the gage by a micrometer, as in the case of the small hole gages.

f. *Types of Thread Cutting Tool Gages.* Thread cutting tool gages (figure 201) are hardened steel plates with cutouts around the perimeter. Each cutout is marked with a number that represents the number of threads per inch. A 29° angle, included with each gage, is used to set the thread cutting tool. One gage is used for Acme standard threads and the other for square cut threads.

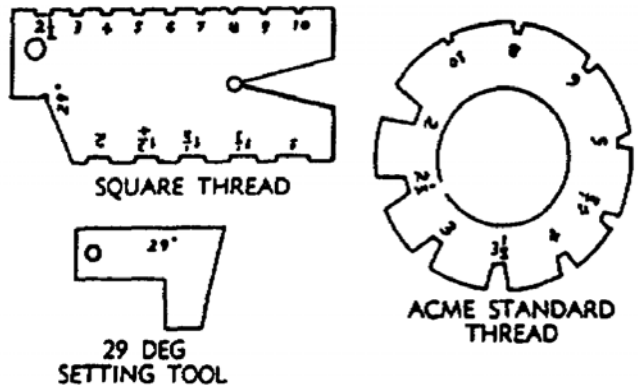


FIGURE 201. THREAD CUTTING TOOL GAGES.

g. *Types of Fillet and Radius Gages.* The blades of fillet and radius gages are made of hard rolled steel. The double ended blades of gage (figure 202, view A) have a lock which holds the blades in position. The inside and outside of the same radii are on one blade. The other gage (figure 202, view B) has separate blades for inside and outside measurements. Each blade of each gage is marked in 64ths. Gage A, figure 202, has a range of sizes from 17/64 to 1/2 inch. Gage B, figure 202, has a range of sizes from 1/32 to 17/64 inch. Each gage has 16 blades.

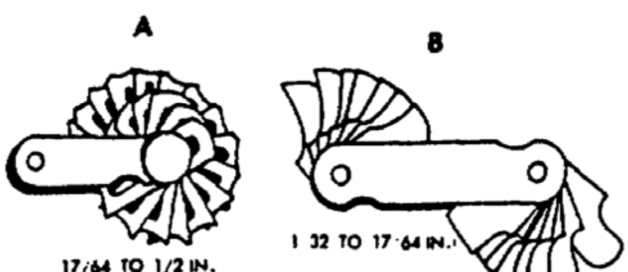


FIGURE 202. FILLET AND RADIUS GAGES.

h. *Types of Drill Point Gages.* The drill point gage (figure 203) consists of a 6 inch hook rule with a 59° head that slides up and down the rule. The sliding head can be locked at any position on the rule. The sliding head is graduated in 1/32 inch.

i. *Types of Marking Gages.* Marking gages (figure 204) are made of wood or steel. They consist of a graduated beam about 8 inches long, on which a head slides. The head can be fastened at any point on the beam by means of a thumbscrew. The thumbscrew presses a brass shoe tightly against the beam and locks it firmly in position. A steel pin or spur marks the wood. The spur projects from the beam about 1/16 inch.

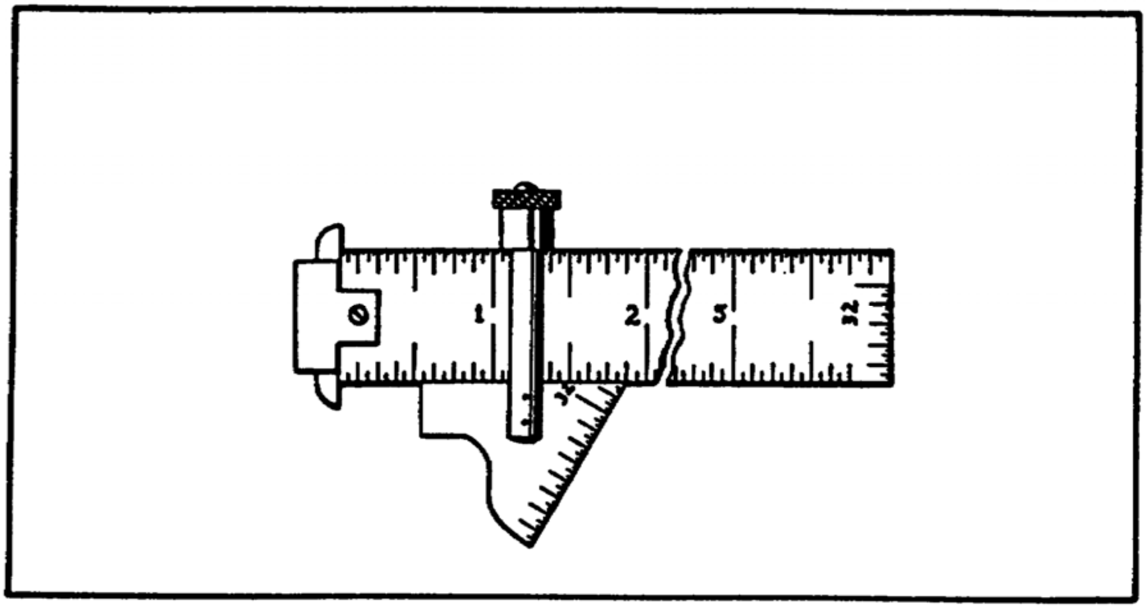


FIGURE 203. DRILL POINT GAGE.

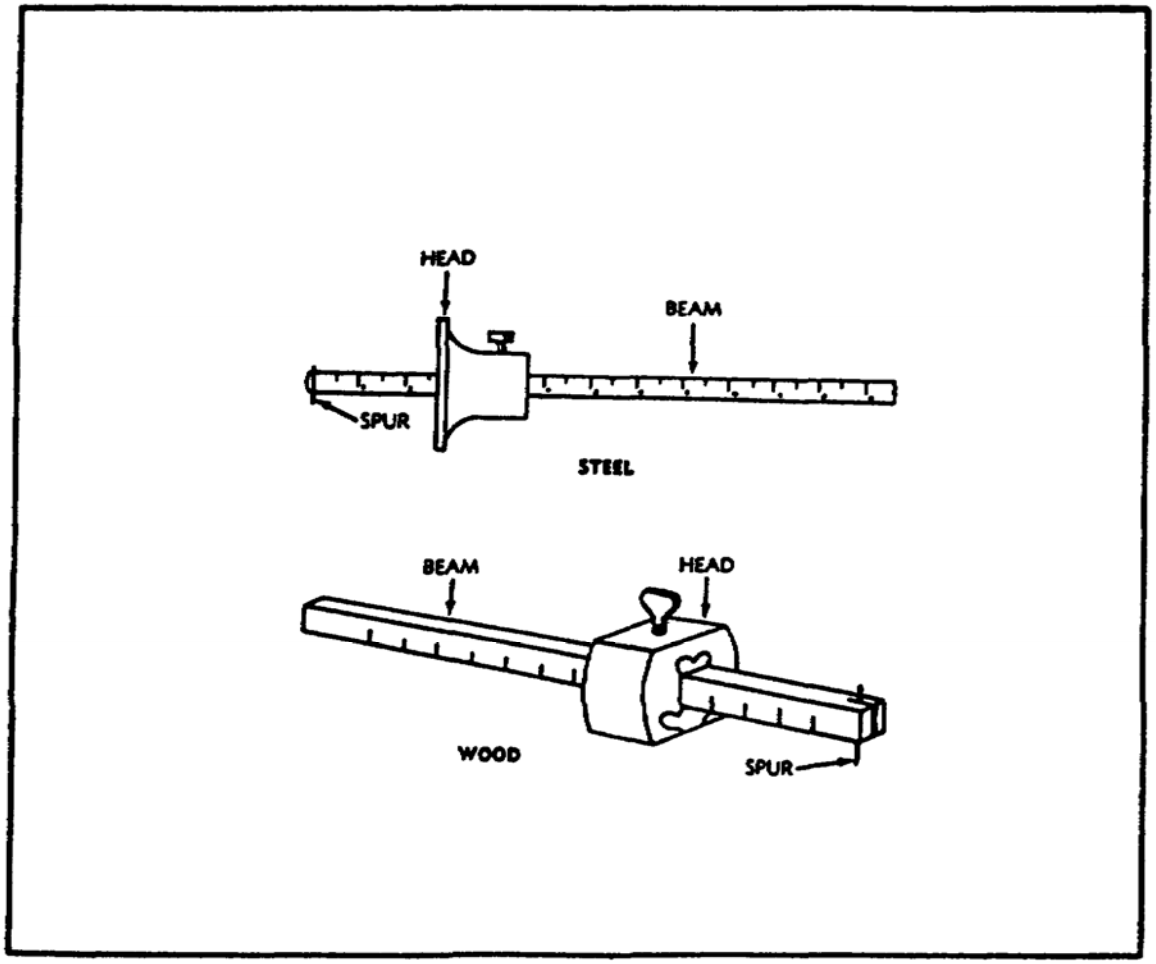


FIGURE 204. MARKING GAGES.

j. *Use of Thickness (Feeler) Gages.* Thickness (feeler) gages are used in one of two ways, as a means for determining a measure or a means for adjusting to a definite limit. Figure 205, view A, shows a thickness gage being used to check piston ring gap clearance in a cylinder bore. A long blade thickness gage is being used to determine the fit between large mating surfaces in figure 205, view B. By combining blades it is possible to obtain a wide variation of thicknesses.

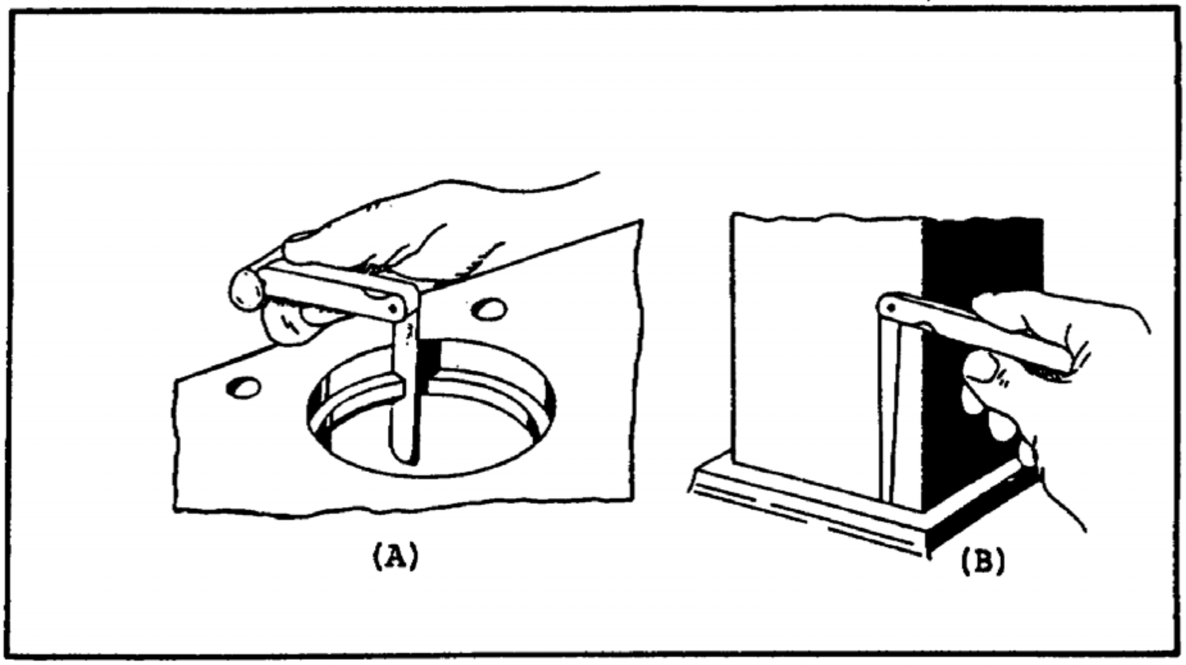


FIGURE 205. USING THICKNESS (FEELER) GAGES.

k. *Use of Wire and Drill Gages.* The use of a drill gage is shown in figure 206, view A. The size of a drill is being determined; the drill size or number and decimal size are stamped on the gage beside each hole. A chart on the gage indicates the correct size of drill to use for a given tap size. Determine the size of both sheet stock and wire by using a correct sheet and plate or wire gage, as shown in figure 206, view B.

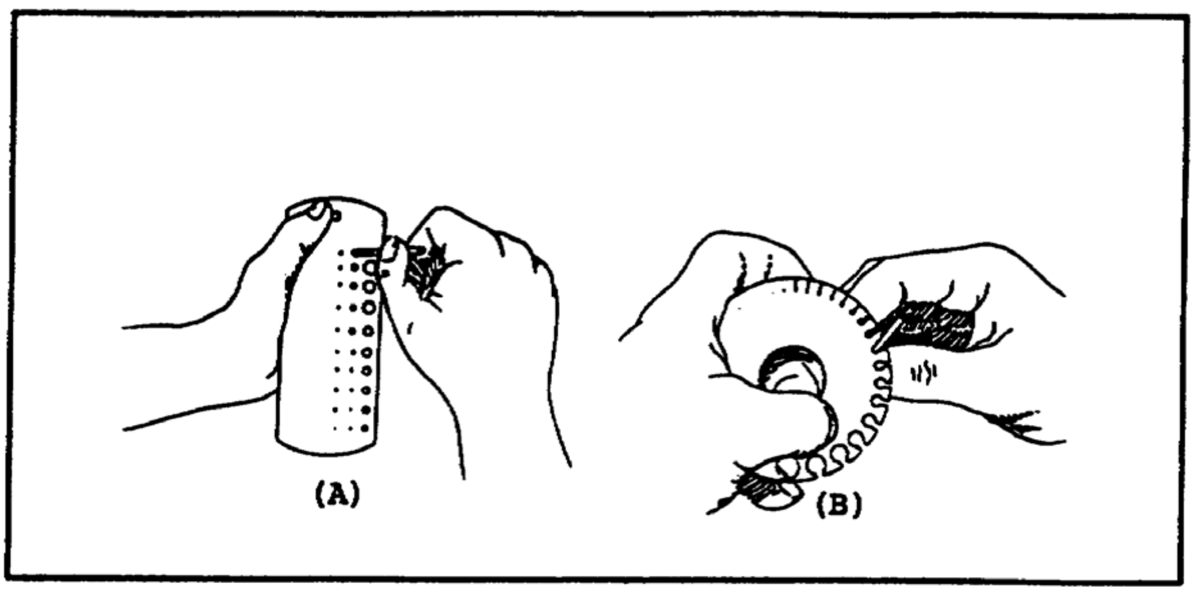


FIGURE 206. USING DRILL AND WIRE GAGES.

l. *Use of Thread Gages.*

(1) *Center Gage.* Check the angle of thread cutting tools as shown in figure 207. The gage is also used to check cut threads and the scales are used to measure threads per inch.

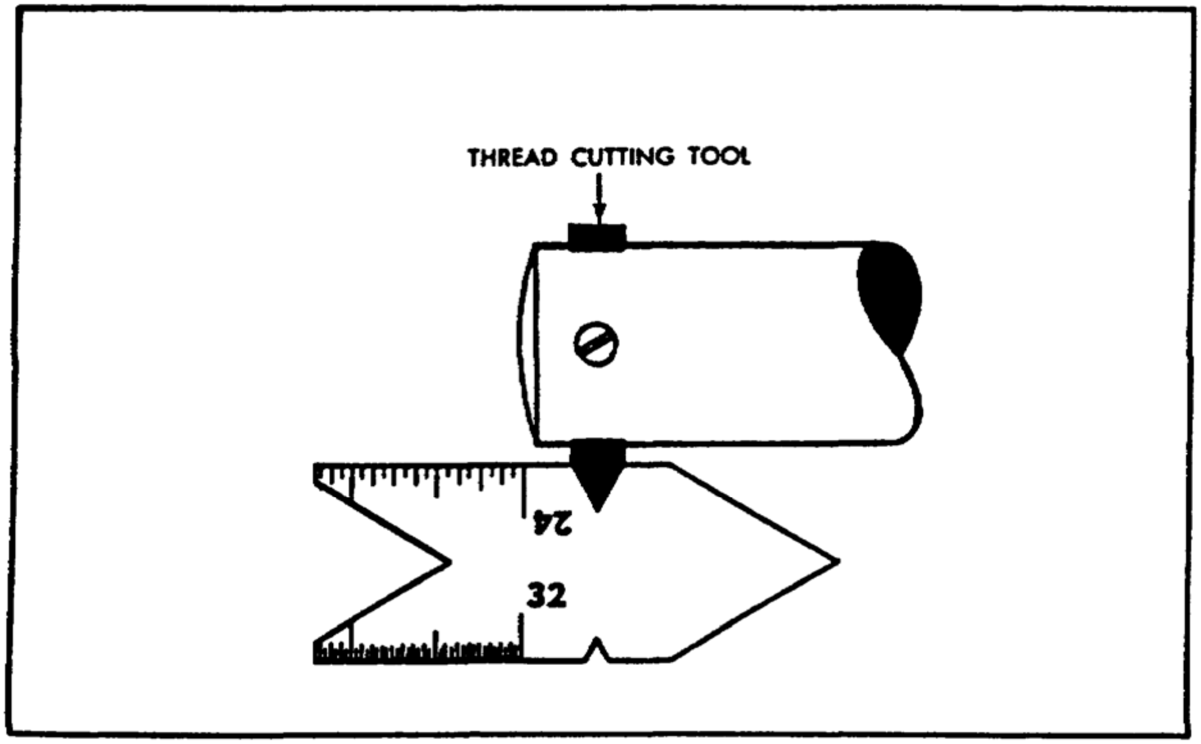


FIGURE 207. USING CENTER GAGE.

(2) *Screw Pitch Gages.* If the pitch of a thread is not known, it can be determined by comparing it with the standards on the various screw pitch gages. Place a blade of a gage over the threads, and check to see whether it meshes; if not, successively check each blade of the gage against the thread until it meshes. The pitch can be read off the correct blade. The blades are made pointed so that they can be inserted in small nuts to check inside as well as outside threads. Refer to figure 208 for use of the screw pitch gages.

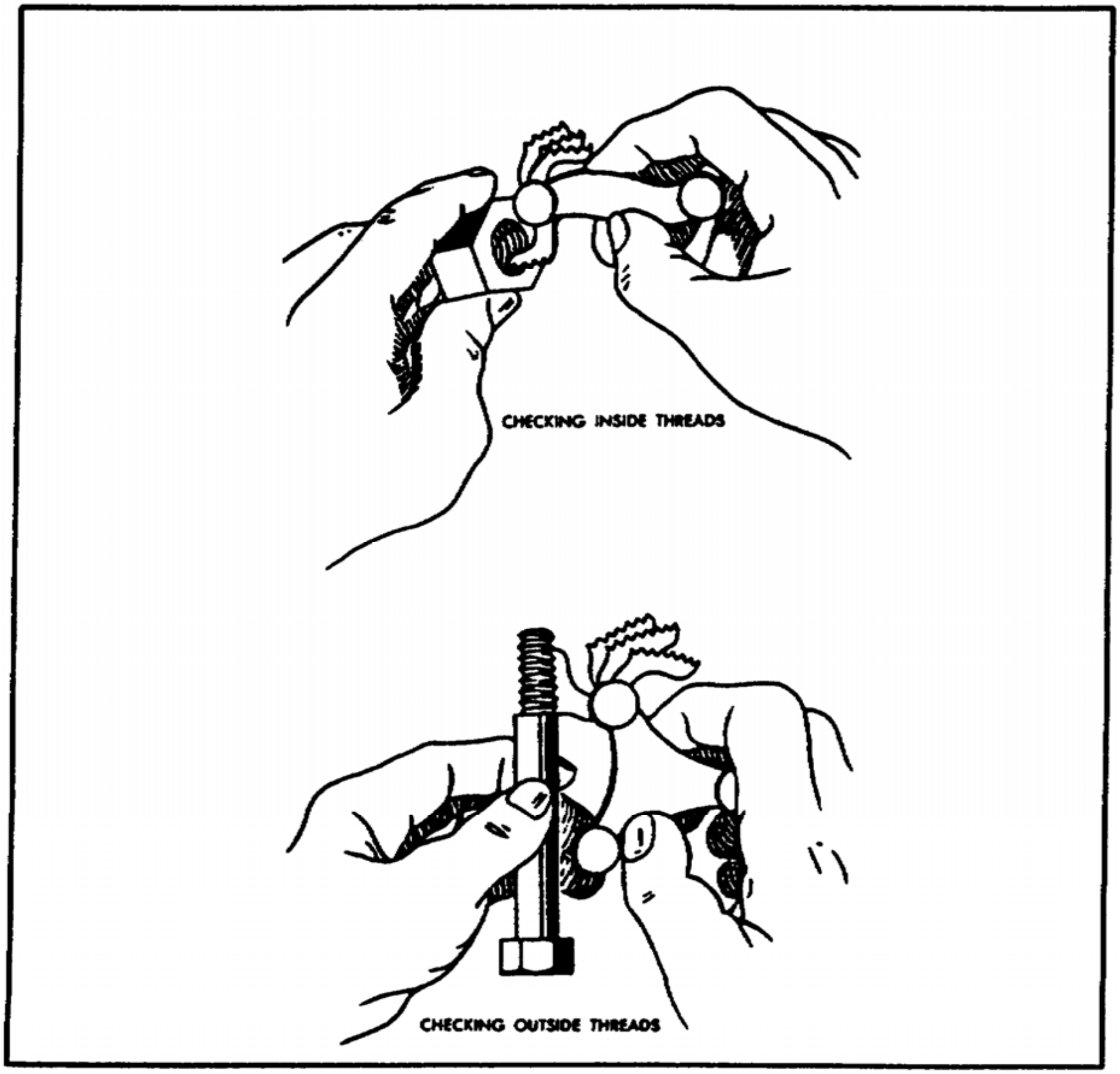


FIGURE 208. USING SCREW PITCH GAGES.

m. *Use of Small Hole and Telescoping Gages.*

(1) These gages are used when measurements cannot be taken with a standard micrometer, or for which there are no plug gages available. Telescoping gages are particularly adaptable for rough bored work and odd sizes and shapes of holes. Compress plungers and lock by turning the handle screw. Insert gage in hole; (figure 209) release lock; the plunger expands to exact size of the hole. Lock the plunger by turning the handle. After locking, remove the gage and check the measurement with a micrometer.

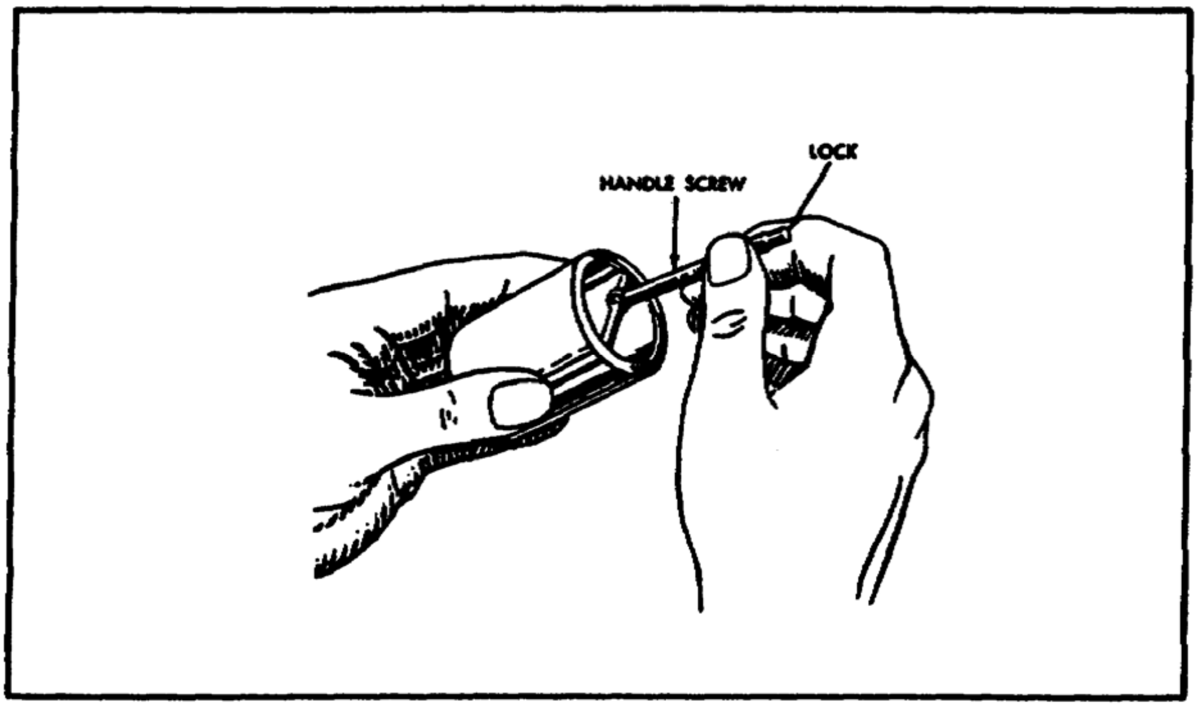


FIGURE 209. USING TELESCOPING GAGE.

(2) The small hole gages perform the same function as telescoping gages, except that they are used in smaller work. Fit the ball-shaped point into the hole or slot as shown in figure 210, view A; expand the ball-shaped end by turning the screw at the end of the handle. Use a micrometer to gage the measurement, as shown in figure 210, view B.

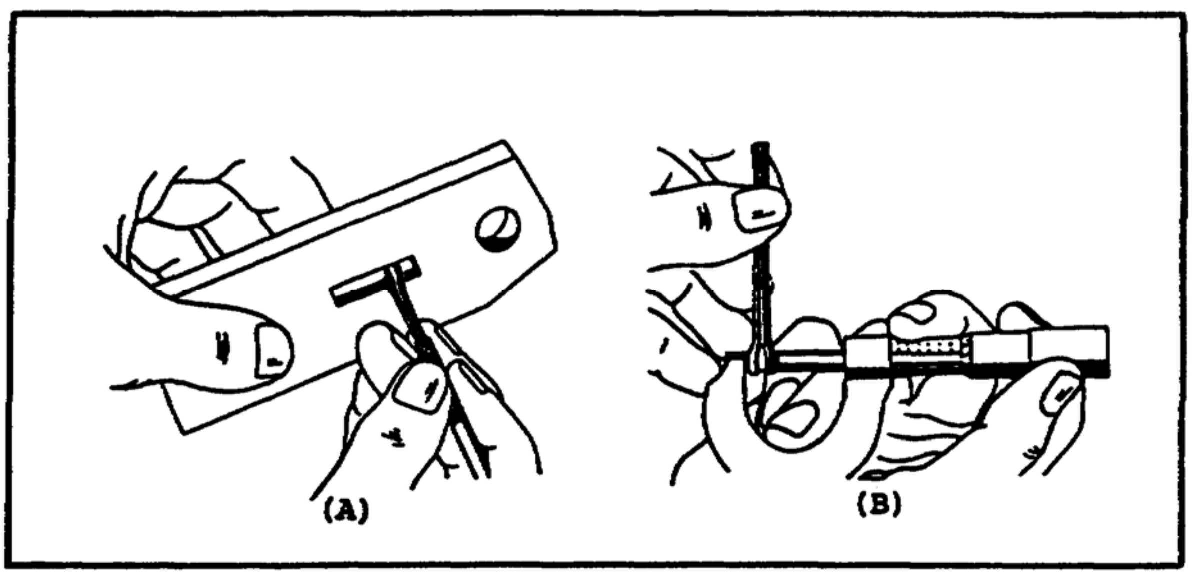


FIGURE 210. USING SMALL HOLE GAGE.

n. *Use of Thread Cutting Tool Gages.* To check the correct form of a thread cutting tool, place the proper gage over the tool, as shown in figure 211. The Acme standard gage is used here. The tool must mesh properly with no light showing between the tool and the gage. Use 29° angle as a guide when grinding the cutting tool. After the tool fits the angle, the point should be ground off to fit the proper place on the gage for the particular number of threads per inch to be cut.

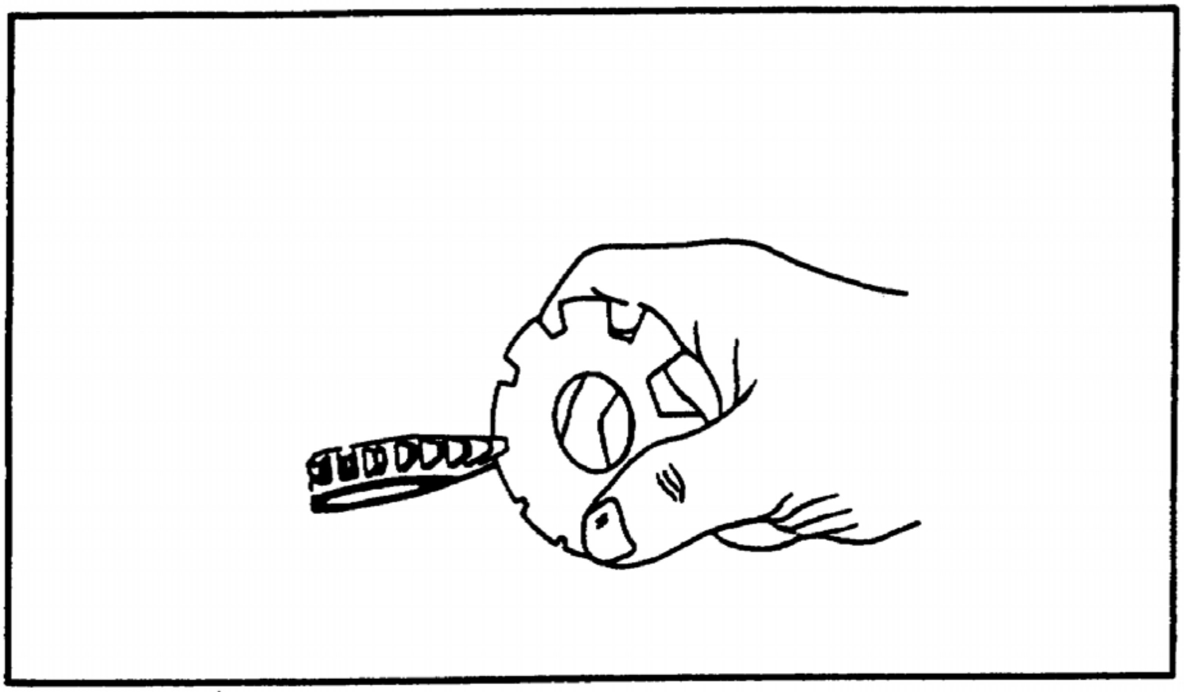


FIGURE 211. USING THREAD CUTTING TOOL GAGES.

o. *Use of Fillet and Radius Gages.* A double-ended radius blade being used to check the inside corner or fillet of a machined part is shown in figure 212, view A. Each blade can be locked in position by tightening the clamp. These gages can be used in any position and at any angle for both inside and outside radii (figure 212, view B).

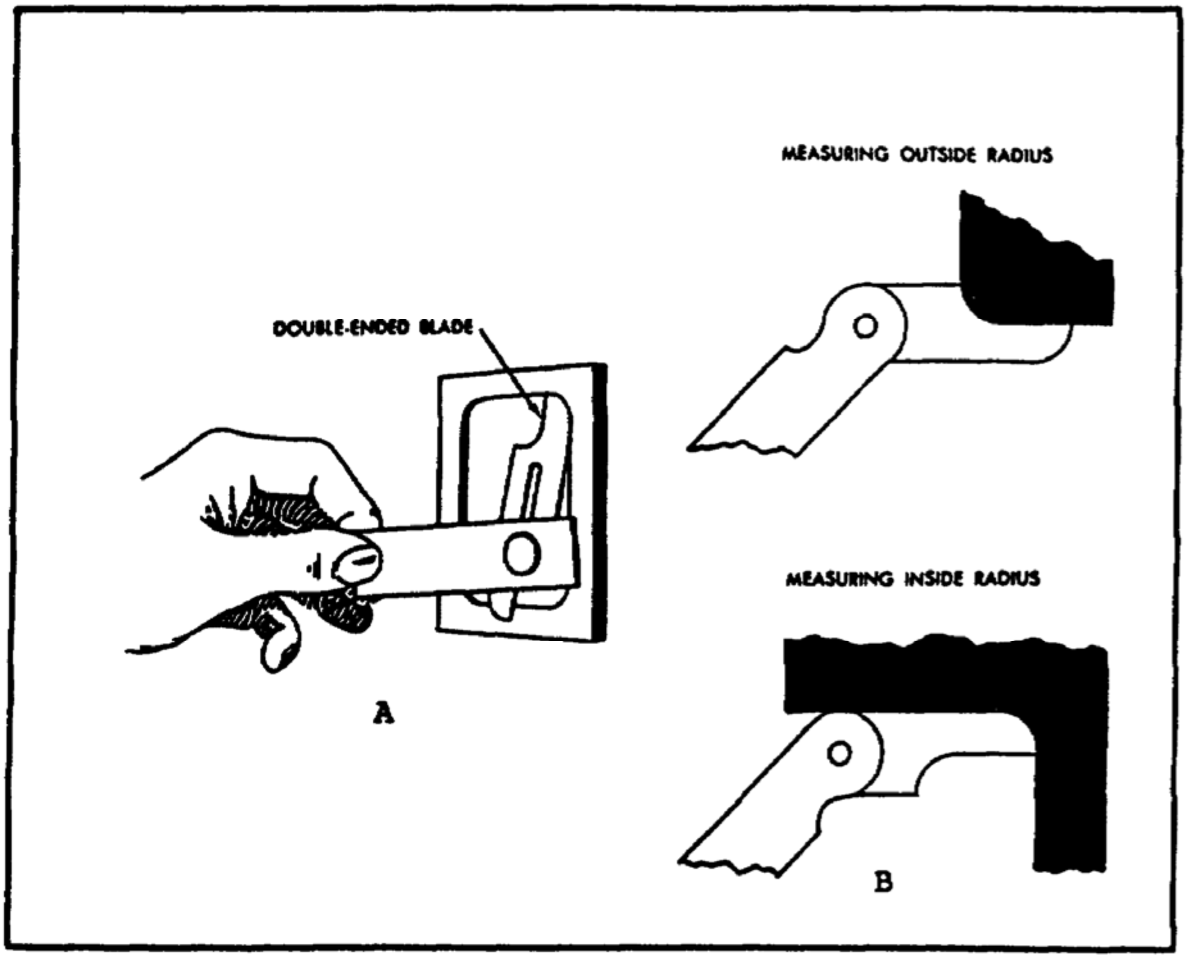


FIGURE 212. USING FILLET AND RADIUS GAGES.

p. *Use of Drill Point Gage.* The method of sharpening the cutting edges of a drill is to do one lip at a time. Each lip must have the same length and the same angle in relation to the axis of the drill. Set the sliding head securely on the rule at the mark equal to the length of the drill. Place the drill vertically against the rule so that the drill lip contacts the 59° angle of the sliding head. Hold up to the light; the correct angle is obtained when no light is seen between the gage and the drill.

q. *Use of Marking Gages.* A marking gage must be adjusted by setting the head the desired distance from the spur. Although the bar of a marking gage is graduated in inches, the spur may work loose or bend. If this occurs, accurate measurement with a rule should be made between the head and spur (figure 213, view A). To draw a line after setting the gage, grasp the head with the palm and fingers (figure 213, view B); extend the thumb along the beam towards the spur.

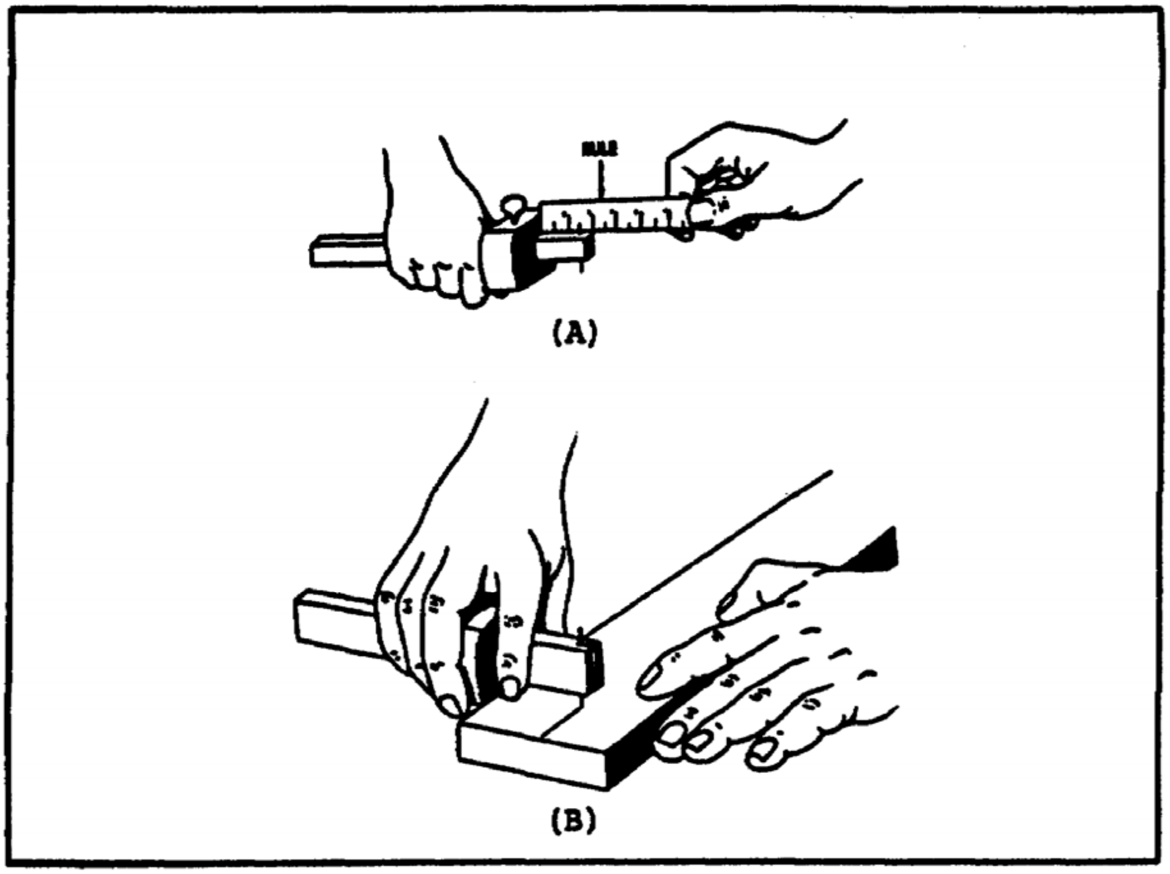


FIGURE 213. USING MARKING GAGE.

Press the head firmly against the edge of the work to be marked and, with a wrist motion, tip the gage forward until the spur touches the work. Push the gage along the edge to mark the work, keeping the head firmly against the work.

r. *Care of Gages.*

(1) Exercise care when using thickness gages to measure clearance of knives and cutters on machines. Do not lower a knife on a thickness blade and then try to remove the gage, since the blade may be shaved off if it is too tight. Never use gages for cleaning slots or holes. When blades are damaged or worn, they should be replaced. Blades in a case are removed by loosening the clamp and sliding out the damaged blade. Install a new blade and tighten the clamp.

(2) Always coat metal parts of all gages with a light film of oil when not in use to prevent rust. Store gages in separate containers. Do not pile gages on each other. Always return the blades of leaf-type gages to the case after use. Keep graduations and markings on all gages clean and legible.

Do not drop any gage; minute scratches or nicks will result in inaccurate measurements.

8. Conclusion

This lesson and the subcourse contain general descriptions of the handtools and measuring tools that would be used by the mechanic. When actually using handtools and measuring tools, the mechanic should refer to TM 9-243 for proper operation.

PRACTICAL EXERCISE 3

The following items will test your understanding of the material covered in this lesson. Print this page and compare it with the solutions that will be found at the end of this exercise. If you do not understand an answer, review the portion of the instructional material which provides the information.

1. An inch in the English system is equivalent to how many millimeters?

2. The American National screw thread system is based on what degree thread angle?

3. What is the universal standard measuring temperature?

4. What is the purpose of scribers?

5. What type of scriber is used to lay out lines on very hard materials, such as hardened steel and glass?

6. A flexible rule is able to bend over rounded surfaces because it is made of ____.

7. What item is designed to transform any straight steel rule into a rule that can be used to lay out keyways on a cylindrical surface of a shaft?

8. What function does a divider perform?

9. What type of caliper is used to measure diameter and distances in tapped holes?

10. Micrometers are used for measurements requiring _____________________.

11. How is a standard micrometer read?

12. Where is the only place that a micrometer should be oiled?

13. In what form is the feeler gage made?

14. What are the two thread gages that are used in connection with the machining and inspection of threads?

15. What is the maximum measuring capacity of the small hole gage?