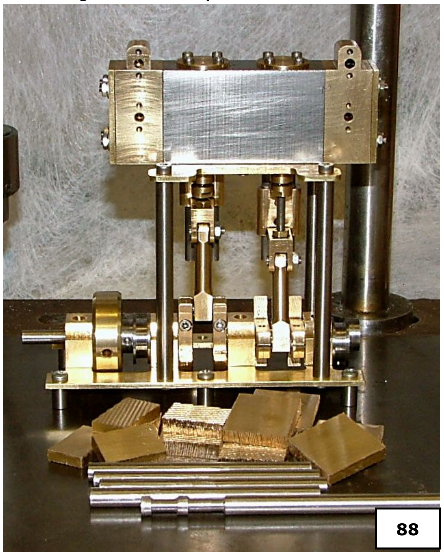
CHAPTER 4

Initial Assembly

That brings me onto this post. Only one Pic (88) tonight (the drawing mentioned last time will come later); the engine built up as far as I have reached with a pile of raw material to carry out the next task. That is to make the spool valves, and the eccentric straps.



The crankshaft is already timed for running, with pistons and eccentrics in the right positions (or so close it will not matter). If you remember when I showed how to make the eccentrics and I scribed a line on the back when I drilled the thru hole; well the trick worked a treat. You can align everything very accurately by eye rather than having to use a DTI to find max lift. So if you can, put that line on; if you need to know how, just ask.

Now the bad news. For the next week or so I am going to be very busy outside of the workshop and won't have time to prepare the posts. So what I intend doing is to get in the shop as much as I can and get the engine to a running state (no control valve, just fill it full of air). This part of the engine build is the most critical bit and hopefully should go fairly smoothly as I have already planned most of the machining stages. Making the bits is easy - it is the fine tuning to get them to all run in unison that takes the time.

Comment – Conversion to Horizontal

Talking with a few colleagues & one suggested... if drawings (CAD) are in electronic format, then would be simple to redesign:

1) the base plate to place the crank to piston axis on a 30 degree diagonal to the horizontal,
2) the cylinder mounting block as above, and
3) bigend bearing blocks similarly modified [so the oil didn't fall out both North or South of the Equator]

& Hey! Presto! A paddle engine!

Response – Conversion to Horizontal

It is still in the early stages yet but I think he is doing it in CAD, so supposedly it will have the facility to be modified. The problem is that he cannot visualize some of my sketches so I will have to redraw them.

I definitely considered turning this engine into a horizontal, but the sheer width of it has put me off the idea. It would be better, if you can imagine it, to cut the main cylinder block in two, and rather than having two steam control blocks just have one between the now sawn in two cylinder block, with a dual eccentric in the middle of the crankshaft. Doing it this way a saving on width of at least a third could be achieved.

But there would have to be a redesign on the crankshaft to get it into a narrower package and I think this would be, for the moment, beyond the skill of the people this article is aimed at. But if they manage to complete one of these with such bad sketches, I'm sure that with a little bit more encouragement they could trespass into the realms of one piece cranks (not from a single billet, but built up as these are and silver soldered together).

Let's get this one finished first.

Tip – Reamers

Ever since S…. did his post on here about deep hole drilling it has been gnawing on what little mind I have left about the difference between hand and machine reamers; should have mentioned it without someone else having to remind me!

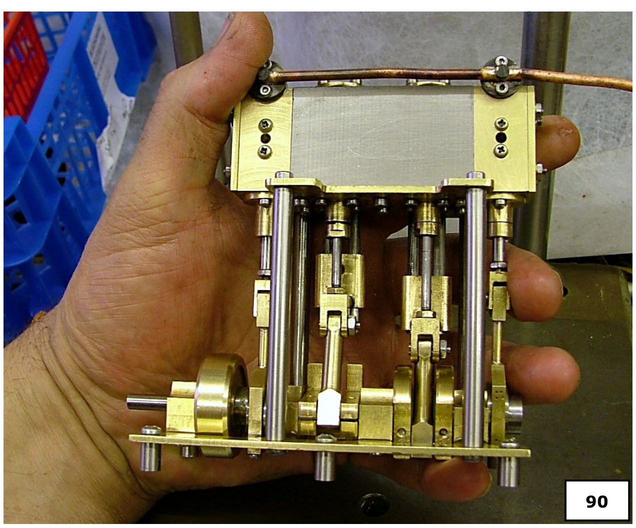
So I have decided the easiest way is to show you where you can get machine reamers at a very reasonable cost. It is here - http://www.tracytools.com/reamersassorted.htm

Pic 89 shows my imperial set that I obtained from them, 1/8" to 1/2" in 1/32" increments for about £70. They aren't all the same design but they all are good quality and function well. I think they do metric machine sets as well. The best way to order is to give them a call and tell them what you need, as the website is a bit confusing at times.

Another thing to note when you are just starting out is that the machine costs are negligible compared to the tooling costs. Only buy what tooling you require to do the job and over the years you will eventually end up with everything you require to complete most jobs.

Car boots and private ads are a good way to buy tooling. A chap on a boot sale was selling brand new metric milling cutters (I didn't ask where they came from), various sizes for £1 each, I offered him £30 for the box and ended up with over 100 cutters. Went to a model boat show and a chap was selling what he thought were 2mm re-sharpened solid carbide drills for £1 for a pack of 10, they were in fact HSS 2mm slot drills, I bought the three packs he had left (some of his previous customers were in for a shock when they tried to use them for drilling). So keep your eyes open all the time and your machining can get a lot cheaper.

Prepared for 1st Run



Back again at last. Many thanks to D for waking me up. Haven't got the paper or pencils yet so I have got a piccy to show you.

It shows the engine prepared for its first main run, You can tell the size of this monster by comparing it to my gorilla sized hand.

It has been assembled just from the made components with no rings, gland packing or sealant. Also the timing has only been quickly done (near enough).

So really this engine is leaking air from most of the joints and so is most probably only running at about 50% of its capabilities.

I will be posting soon all the components that have been made over the last week or so. Some like the spool valves I will dedicate a complete post to, like I did about the eccentrics, they are really easy to do once you get the correct machining sequence.

Anyway, have a look at Pic 90, then go here for a quicky video to show you that it does work.
http://www.youtube.com/watch?v=QwOhxvGc5VY

Comment – Regulator/Throttle, Video

> *Will you be taking us through the complexities of making a steam regulator/throttle for the engine once you've caught up with all the other bits you've made over the last week?*
>
> *How big is the video? It would be nice to have it stored on Paddleducks so it's always available here - I never trust third party sites as you have no control over them and things can go missing. Maybe you could send it to me via email and I can put it online for you? admin@paddleducks.co.uk has a 20Mb inbox.*

Response – Video, Throttle

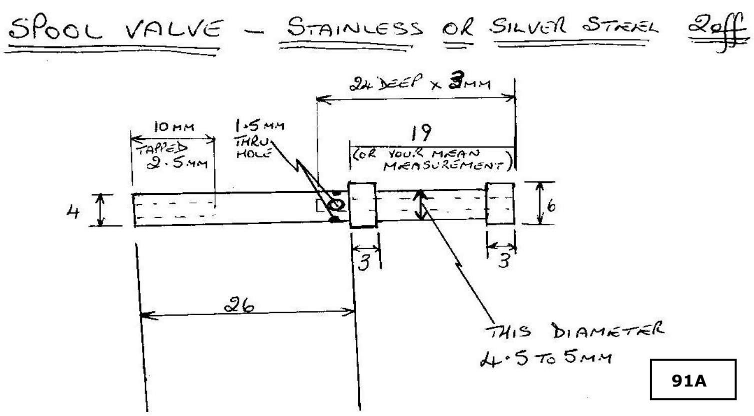
The video is in fact nearly 53mb, but I suppose I can get a program to reduce the size below 20mb, but you will lose quality, as it has already done so on YouTube.

Yes, I have got the design of the speed control valve in my head. It's just a matter of getting it made and working, it isn't my design but a modified one to make it easier to produce.
It will take me about a week to catch up, but I am feeling a lot more confident now that the design has been proved.

I would like to take this opportunity to thank Sandy of ACS for the help he gave me in explaining the operation of the valve gear, which enabled me to get it all to work in unison.

What do you mean Derek, 1/8" copper temporary. This is finished product, all my pipework looks like this, gives it a 'used' look.

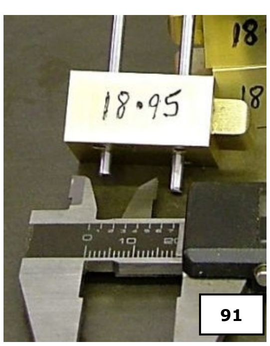
Spool Valves



91A

And now, the 'easy way' to make your spool valves. This is a rather lengthy post but it goes thru step by step how to get useable spool valves. See sketch Pic 91A for overview of what we're going to do.

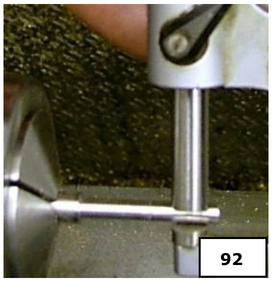
The first thing to do before anything else is to look at Pic 91. Put two pieces of close fitting rod thru the two steam port holes. Now measure close to the block, to the outside of both rods on each side and take a mean measurement, that is if one side measures 18.96 and the other 18.98 the mean is half way between the two 18.97mm.



91

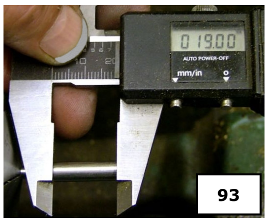
I decided from my four readings to go for 19mm; on no account go for anything shorter than the largest of your mean reading. This is going to be the distance between the ends of your spool valve.

There is no picture of the next step. Cut a length of bar to 46mm and just face both ends. While the bar is still un-machined and rigid drill the two end holes one 24mm deep by 3mm diameter and the other 10mm deep by 2mm diameter, and tap the 10mm end out to 2.5mm.

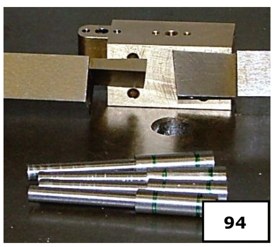

92

Put the untapped end into the chuck (Pic 92). (I would recommend making a split brass collet to protect the finish on the bar) leaving about 28mm protruding from the chuck. Using VERY sharp tooling turn down the end for a length of 26mm to a diameter of about 4.05mm. The last job with the cutting tool is to face the end closest to the chuck. These corners must be kept really sharp and if they need to be deburred use only very worn emery or fine steel wool.

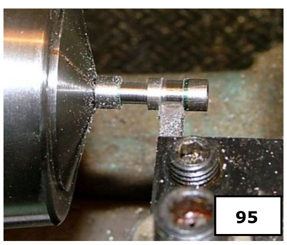
Finish down to size with fine emery (if you look at Pic 99 they look rough as old boots but in fact they are totally smooth like the one laying horizontal).


93

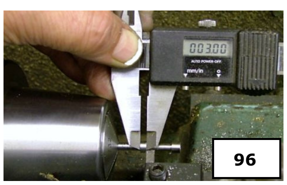
Now remount the rod with the 4mm end in the chuck (again protect if possible) with enough of the 4mm end protruding so you are able to get your measuring device on comfortably, as in Pic 93. Now very gently face off the end until you get to the measurement you obtained back in Pic 91.


94

While still in the chuck get a felt tip and mark off 3.5mm in from the end of each spool face. If you look at Pic 94 it shows my spools marked up and in the background are two grooving tools of the type I used; you could use a right and left turning tool if you are careful.


95

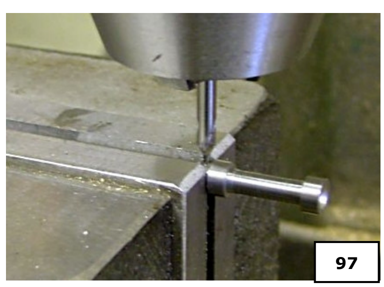
The land between the two spools is not critical and can be any size from 4.5mm to 5mm, and the surface finish just isn't critical. Push the large end of the rod right up to the chuck as in Pic 95 to give as much support as possible and rough out between the spools to the marks you made in the previous step.

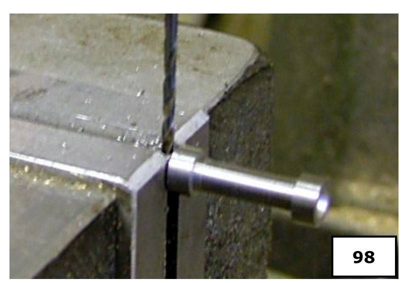

96

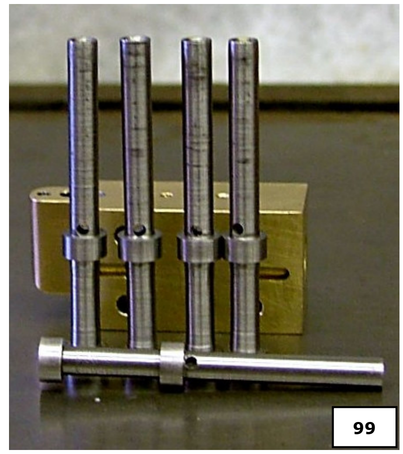
Remount the spool again to have it protruding for getting in with your measuring instrument as in Pic 96 and very carefully face the end of the spool until you reach the 3mm required. Push the spool you have just done right up to the chuck and carry out the same on the spool at the other end. Deburr as mentioned before.

The spools are now finished; now we just have to put in a steam transfer port.

The hole for the steam port is drilled just below the bottom port face; see Pics 97 & 98. Make sure you don't touch the edge of the bottom spool and touch on with a small centre drill to give you a drilling detent. Then drill right through with a 1.5mm drill, turn the spool thru 90 degrees and drill another cross hole the same size.


97


98



99

Carefully deburr the holes and you should now have finished spool valves as in Pic 99.

It has most probably taken longer to write this post than actually make them.

I would like to thank Sandy of ACS for the design of this type of spool valve - it has saved hours design time

Next time we will be making the bits to join the spools to the eccentric.

Explanation – Valve Operation

The way I wrote the last post was supposed to make it easy; just follow it step by step and you should end up with a good spool valve.

The easiest way I can explain the operation is that the two 3mm wide bits (the spools) act as small gateways, blocking two holes, one to the top of the cylinder and one to the bottom. The eccentric to which they are connected say, for example, moves down; then, because there are two holes, they open two at the same time: the top hole say lets steam into the top of the cylinder thus pushing the piston down, while the bottom spool at the same time connects from the bottom of the cylinder to allow for exhaust.

As the eccentric moves thru 180 deg it then does the opposite and lets steam in at the bottom and connects the top to exhaust. And because there are two cylinders at 90 deg apart, there is always a cylinder on power stroke; because of this the engine should always self start and run in reverse if the inlet and exhaust are swapped over.

Now that you have gone cross eyed, do you really want me to carry on, or will you just believe me that it works?

Just a little update on the monster that is running. It has now been on air for over 10 hours and hasn't missed a beat as far as I know in this time, I check every hour and it is still running.

I have fitted a restrictor in the air line and it ticks over very slowly indeed. However, it runs better in one direction than the other which suggests the timing is out.

I will finish the runs tonight and carry on with building a speed control for it.

Comment – Variation in Engine Speed

There are many reasons for an engine to run slower in one direction than the other and, certainly, valve timing is one of them. Another, and a very important one, is.... steam/exhaust passage port dimensions... specifically the cross sectional area. I did a few quick sums on your ports John and I would like to suggest the following:

Your main steam ports are 3mm dia = 7.097 sq mm cross section area.

Turning to your PISTON VALVE (Spool valve as you call it).... a couple of changes would be beneficial.....

1. The bore through the valve(to feed steam to the bottom port) is 2mm dia = 3.161 sq mm cross section area. This bore should be increased to 3mm dia.

2. The 1.5 mm cross hole has and cross section area of only 1.935 sq mm so, since this goes right through, this would total only 3.87 sq mm.
Increase this cross hole size to 2.3 mm dia. (4.1 sq mm cross section area x 2 = 8.2 sq mm total)

In order to accommodate these changes, the reduced dia (4mm) will need to be increased to 4.5 mm or the wall thickness may be a little thin.

In the cross hole area, and to avoid changes to the bottom gland, the increase in dia need only be long enough to accommodate the cross hole... the rest can stay at 4mm, hopefully this will still leave length to allow the spindle through the gland and with enough length for movement.

OK... if you think about what is happening... when the piston valve moves downwards, thus opening the top port, then the steam has direct access to a 3mm dia port.... on the other hand, when it goes to the top of its stroke, uncovering the bottom port, then the steam must first pass through the restricted centre bore, then through the restricted cross holes, before it gets to the 3mm bottom port..... QED less steam in a given time.

When you reverse the ports (for reversing) then the steam is entering via the centre area (between the spools) and has equal access, and ample cross sectional area to move through... thus no restriction to the incoming steam.

A similar issue occurs with the exhaust side if you think about it... and the same really should apply as far as port/passage cross section area.

Incidentally, making the reduced OD 4.5mm instead of 4mm will still give approx 13sq mm cross section area between the spools... so no problem here.

One thing I forgot to mention, when I sent you the valve info John.... the piston valve should really be lapped into the bore to give a very close running /sliding fit since this is how the steam is prevented from bypassing the spool and disappearing up the exhaust... tricky with a blind bore... I agree.

This type of valve was developed for steam locomotive use, and the full size ones are hollow to permit steam transfer between the ends, however, they are fitted with sprung rings to seal the bore.

Ok John... that's my 1 pence worth.... hope you find it helpful.... just observations and suggestions.

Response – Speed Variations

Hi S…,

Many thanks for your input; it's nice having someone on the team who is a specialist in this field. As you know, I make things to work and put fixes in along the way. This afternoon I will try your mods on a spare valve I have made and make the adjustment to drawing and prose to suit. I think that the 2.3 dia at the bottom should be meaty enough around there to do without changing the diameter, but I will reassess when I have carried out the mods.

The valves were tight in the bores as was and I lapped them in with a bit of t-cut (not as coarse as metal polish) and I have no leakage to talk about.

Many thanks for your input yet again; with all this help we should get a very good running engine.

Mods all done, except rather than 2.3 hole at the bottom, I have used two cross drilled at 1.5, 90 deg apart. This only gives a slightly lower reading but it does allow it to be modded without having a larger diameter.

I took the opportunity to seal the engine up whilst doing these mods so all packing glands are packed and piston rings are in, all mating faces are Hylomar sealed, no leaks at all

Now to the results.

Tried both directions, now both the same operationally even down to the raised tickover (but this is due to the engine being tight because of rebuild and rings). The speed is unbelievable on 40 psi, much faster than my oscillators. I think this must be because of a slight increase in efficiency, and maybe a little less friction.

So S…, you were right yet again, I am running out of thanks very fast.

Video of modified engine - http://www.youtube.com/watch?v=I8UCWr_BeqE

Glad you like it, but it still isn't finished.
Hopefully two or three more posts will see it done.

Hit a bit of a problem yesterday, came to get all the junk and bits to make the speed control and the o-rings I thought I had, I hadn't. So ordered some from my supplier - http://www.blackgates.co.uk/body_index.html they should be here today or tomorrow; then I can carry on.

Comment – Running on Compressed Air

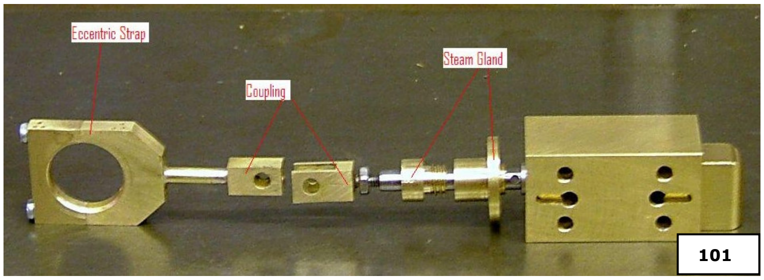
One point.... now that you have fitted the piston rings and steam glands.... don't run the engine to much on compressed air, since this is very abrasive and the o-rings will wear very quickly. Better to run on low pressure steam, with a suitable displacement lubricator in the line... these also don't work on compressed air.

Response – Compressed Air

When running on air I always fill up the engine with diesel multigrade by injecting into the airline just upstream of the engine at least once an hour. I have to pull you up on the use of a displacement lubricator with air; my compressor produces so much water it is like running on cold saturated steam anyway (just joking of course).

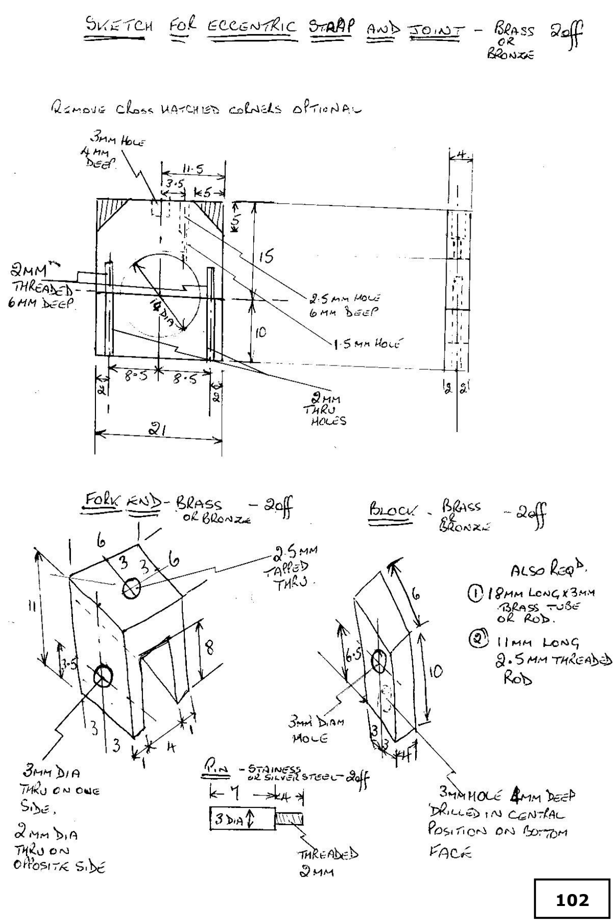
Eccentric Straps

Will be posting sometime today about the eccentric straps & related bits as shown in Pic 101.

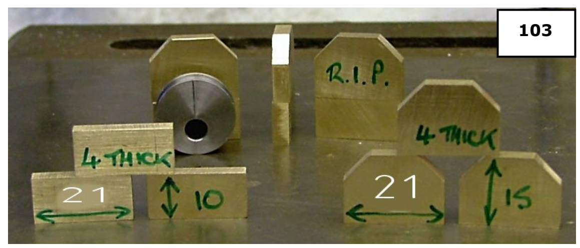


101

The sketches (Pic 102) show what is needed to connect the eccentrics to the valve blocks. They look complicated but as usual I think that this is my sketch that is causing the problem; if you refer to the pictures all becomes clear.

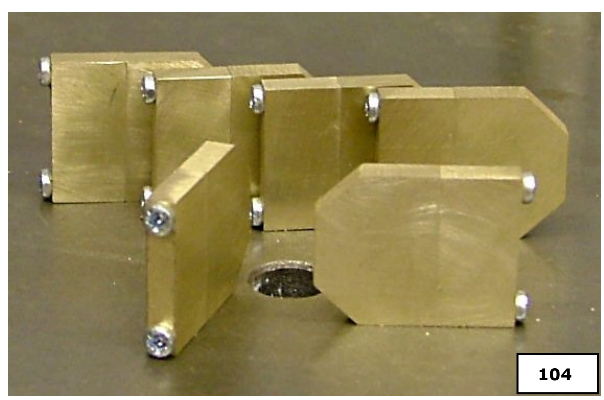


102



103

Pic 103 shows the block sizes required for the eccentric straps. You will notice that there is a measurement change on them. These pictures were taken before the large holes were bored. I actually lost two of these sets because my boring was very slightly out and I broke into the joining screw holes. So I increased the width just slightly to give a bit more room for error.

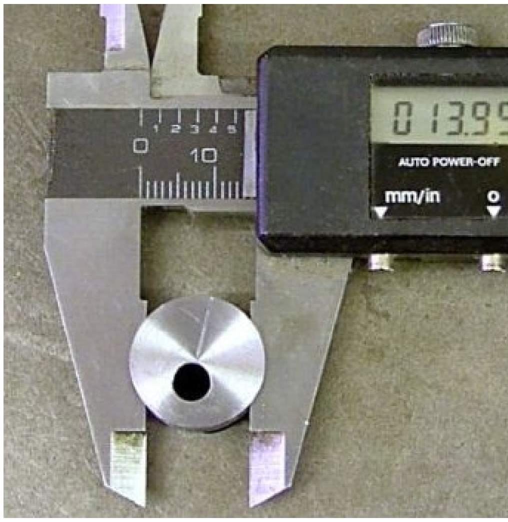


104

The corners of the top blocks are removed purely for cosmetic effect, it will make no difference if you leave them on, but they will look a lot more bulky.

You will see on Pic 104 that the plates are screwed together. Mark them up so that they stay as pairs and always go together the same way.

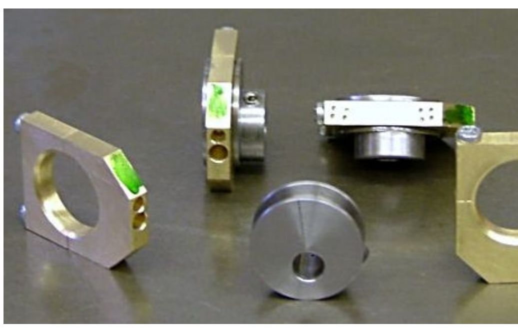
To make sure they are nice and flat toogever, tighten them up really well and put on a flat surface and welly them with a gert big yammer an' a bit o' protective wud.



105

Now measure your diameter of eccentric at the bottom of the groove, as in Pic 105. Mine were all the same at 13.95 (I had used the same setting on the lathe for the depth of all of them). This worked out perfectly for me as I wanted 0.05mm running clearance. So this gave me 14mm exact.

I don't have a 14mm machine reamer so the thought of boring six holes didn't enthuse me at all. Then a bright idea hit me! Remember a bit back about the step drills I bought from Aldi. One of the sizes was 14mm. So out with a bit of scrap plate and duly wacked the drill thru. - 14mm exactly, not 14.02 or anything else. 14mm bob on.


106

All six holes were drilled in less than ten minutes, all spot on, except for the fact I had drilled two slightly off centre and broke into the screw holes, so it pays to make a couple extra, just in case.

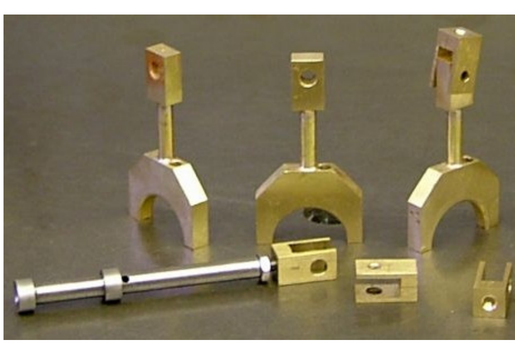
So in Pic 106 you end up with half the metal gone.

On the sketches it isn't too clear but there are two holes in the top of the plates - one (3mm) is for joining to the joint block and the other is an oiling hole for the eccentric, and thru use it has shown to work very well.

Eccentric Connecting Joint

The joints don't need much explanation, just make as is. One thing you might like to try is to cut the 4mm wide slot in a slightly wider piece of metal then bring it down very gently to 1mm either side. The reason for this is that unless you can support all the side to full depth it will spring apart at the top of the cut and you will end up with tapered width sides.

Even if you do get full support, when you take it out of the vice it will spring apart. A little later you will be silver soldering the length 2.5 screwed rod into the top of this fork, after the rod is screwed to the bottom of the tapped hole. After soldering the fork will be soft; just put the matching block into the slot and GENTLY squeeze together in a vice - this will realign the sides.


107

On Pic 107 it shows the blocks joined to the eccentric straps. This is done by silver soldering the 18mm tube or rod between the block and the strap (after it has been fed into the two holes). *(I will go into silver soldering maybe on the next post - some people think it is a black art and expensive, no such thing, just wait and see.)*

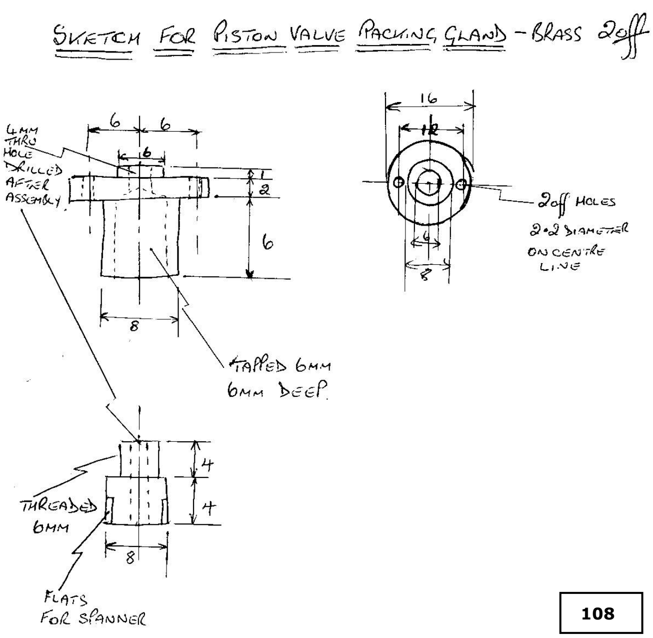
What I did to stop it all falling apart before soldering is to squeeze the tube at the ends in the vice to make them slightly oval and tight in the holes. This will also give the required joint width for the silver solder to penetrate correctly. Then put the assembly on a flat surface and get the strap and block level on the same plane.

I will explain why I used brass tube (or rod). This is to give me/you a bendy, twisty, straightening fiddle just in case your measurements when you make the top and bottom parts of this engine are just not quite spot on. For a short time after silver soldering this tube will be fairly soft and can be fiddled to get this top block perfectly in line with the fork which is attached to the bottom of the piston valve rod. I didn't need any on mine; maybe I was lucky!

The design of the joining pin is the same as the one used for joining the conrod to the crosshead but slightly smaller. I designed them this way because bolts have a nasty habit of tightening up by themselves, and if this was to happen it would lock up the forked end.

You can drill right thru the forked end and put a bolt thru but you must make sure that the bolt is free to rotate, that it has a smooth portion as a bearing surface, and that the nut is locked.

Piston Valve Packing Gland



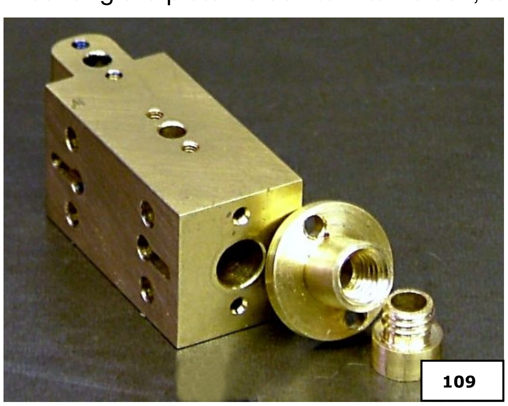
108

Now onto the second sketch (Pic 108), which hopefully shows all the dimensions required. As for the glands used on the piston rods, they are made in the same sequence.

The "screwy-in" bit is made first, then the bottom bit of the top bit is drilled and tapped. The two bits are assembled and the 4mm hole is bored thru them both (keep as matched pairs). Then the top bit is parted off, the screwy bits are put in the chuck and the top bit of the top part is turned to fit the piston valve hole. Two mounting holes are drilled in the positions as shown.

This brings us to Pic 109. The reason for only two mounting holes is because of all the cross drilled holes in the block it will be attaching to.

Look at the picture and it shows the position of the two screwed holes. Stick the gland to the bottom of the valve (as previously done) and spot thru with a drill. These holes can be drilled until they penetrate the cross drilled holes used for mounting the piston block to main block, and tap out to 2mm.


109

So now you have all the bits to assemble and run this engine if you want to; this is as far as I have got. The next post will only be a small one, about making flanges and silver soldering.

If I have got all my calculations right we will only have to bend one little bit of pipe, the rest will all be straight (like the ones D…. picked me up on before).

I suppose you lot will also want a displacement lubricator as well. (Get your tiny drills ready!)

Comment – Live Steam

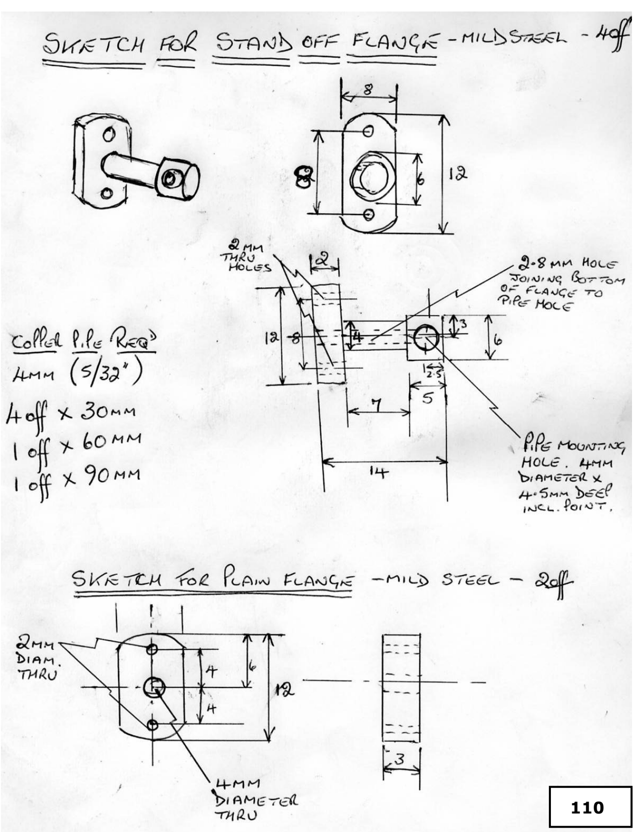
> *Here in Oregon, live steam is not allowed at model shows and most all model steam engines are run on air. To combat the lubrication problem I placed a 1/4 pipe T in the air line. To the top of the T, I installed a drip oiler.*
>
> *To prevent the air from blowing back into the oiler, I soldered a piece of tubing, in the end of the inlet hose fitting, so that it extended past the bottom of the oiler. I drilled a very small #60 hole in the tube just before the oiler just to allow a very little air to blow the oil into the main stream. I thought about building a vortex but was afraid it might suck all the oil out of the oiler.*

I have been looking at the pipework and came to the conclusion 1/8" pipe would be a little restrictive in the bore, so have decided to use 4mm (5/32") instead. But this entailed a redesign of the steam flanges plus a change of material to give the strength to couple it all together, and of course I designed the control valve around the smaller pipe.

So sorry - no posts for a couple of days, at least. And I was hoping to get the whole lot finished within the next week!

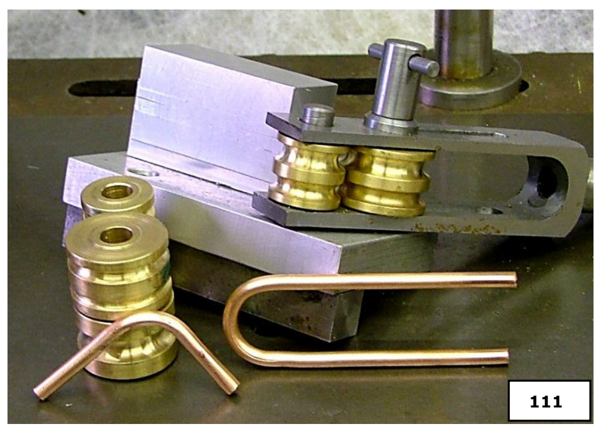
Steam Flanges - General

I will be splitting this post about the steam flanges over two posts, the main reasons are that there are a lot of small operations to be done and the other reason, I haven't totally finished the machining yet.



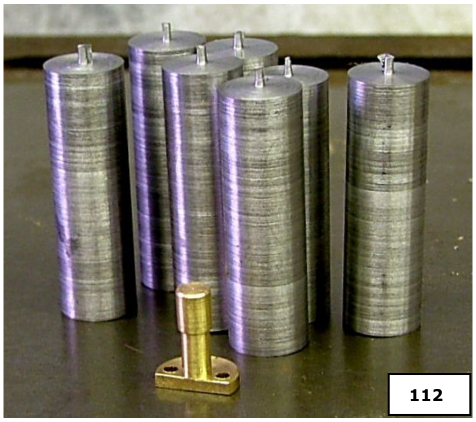
110

The sketch of what we need to produce is at Pic 110.


111

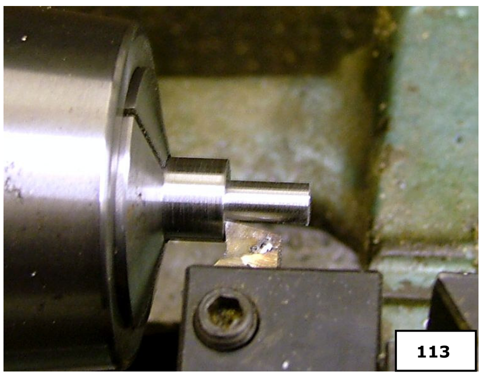
First off is what we want to avoid! Pic 111 shows the dreaded bent pipes and the little machine you use to do it. If you haven't got one of these, doing pipework can be a bit of a nightmare. If you want to make one, I can help - PM me. This one only took about half a day but really requires, unless you are a great tool grinder, a rotary table with a mounted chuck.

The good news is that I have now got it so that no bends will be required at all.


112

Picture 112 shows the reason for the delay. The brass flange, because of the thin wall on the waisted portion, just wasn't strong enough to take the rigours of machining and I didn't think it would be able to support the weight it would be carrying. So I have decided to make them out of a space age product called EN1a, otherwise known as free cutting mild steel, obtainable everywhere and CHEAP.

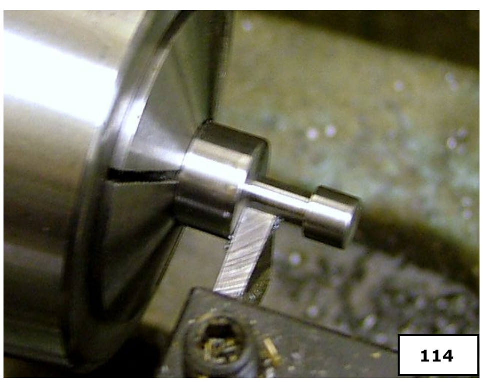
Because I didn't want to be continually changing tooling, I decided to set it up like a production line. So I cut off billets to make one on each end and the bit that was left from the middle would make the second type of flange required. The billets in the picture have already been turned down to 12mm diameter and are about 45mm long.


113

Pic 113 shows turning one end of the bar down to 12mm long by 6mm diameter. Once one end is done, turn the bar round and do the other end the same. Do this until you have enough for your engine, 4 required but I would make 6 just in case.

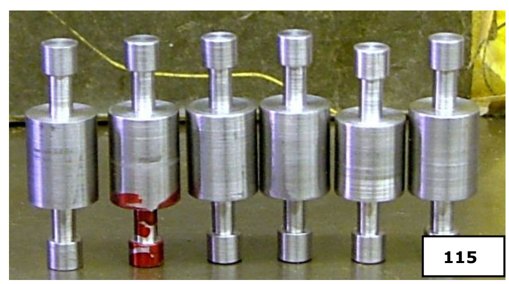
The next op as shown in the shaky Pic 114 is to turn down a waisted portion for 7mm long by 4mm diameter, using the same method as was used for the spool valves.

The diameter of 4mm is fairly critical, too much larger and your bolts won't fit, any narrower and you will be weakening the structure of the flange.


114

The components in Picture 115 is what you should end up with at this stage.

The end marked in red is a reject that will be discarded.

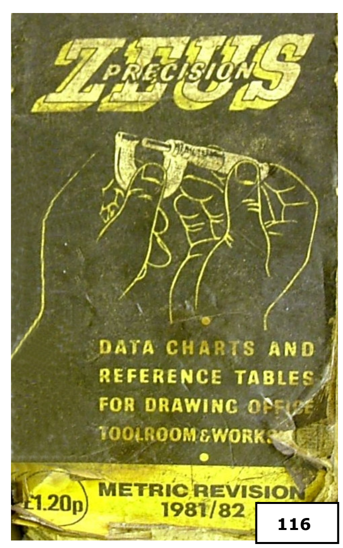

115

Here is a little book called a ZEUS book (Pic 116).

If you are doing any machining, especially if your are making metric bits on an imperial machine (as I do) or vice versa, this is an instant help, because it gives you direct conversion charts plus loads of info like drill sizes for tapping etc. I use mine all the time.

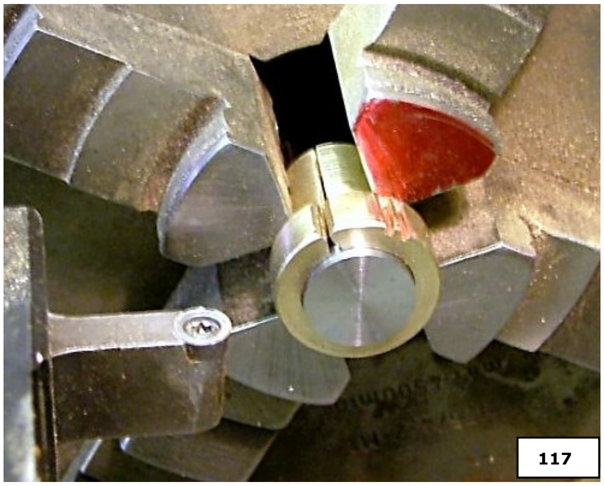
I've had this one for 25 years and it's getting worn out, but being so tight I don't want to shell out the £4:75p that a new one will cost.

Buy one now if you haven't got one.



116

There is no picture for the next bit, but all the operation is that each part is parted off, and the flange ends machined to a thickness of 2mm, DO NOT DRILL THE MAIN HOLE UP THE MIDDLE YET; if you do the part will not be strong enough to go thru the next machining procedures. The bit that is left from between the components is used to make the 3mm thick plain flanges.


117

That takes us onto Pic 117.

Rather than boring out the soft jaws I use on my chuck I decided to make a split bush to hold the small discs. All this is is a piece of soft metal that has a thru hole (I made mine 9mm).

Then bore to a depth shallower than the component part to a diameter where the part only just pushes in.

Then mark one of your jaws with a marker and physically mark the bush adjacent to this jaw.

Now mark the bush at a position half way between two jaws.

Remove the bush from the chuck and where you marked between the jaws cut all the way thru with a hacksaw or bandsaw.

Clean off any burrs, put your component into the bored bit of the bush and remount into the chuck, aligning the mark on the bush with the marked jaw. You can now face and drill to your hearts content, and as long as you always realign the mark on the bush and chuck jaw, all should be ok. Discard the bush after use because it cannot be re-bored to use again.

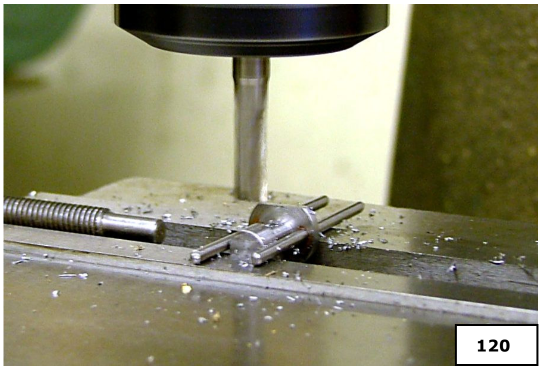

118

You should end up with what is on Pic 118. These took me about 3 hours. Being new to it if you can make half this qty in that time you will be doing well.

Steam Flanges – Holes and Tubes

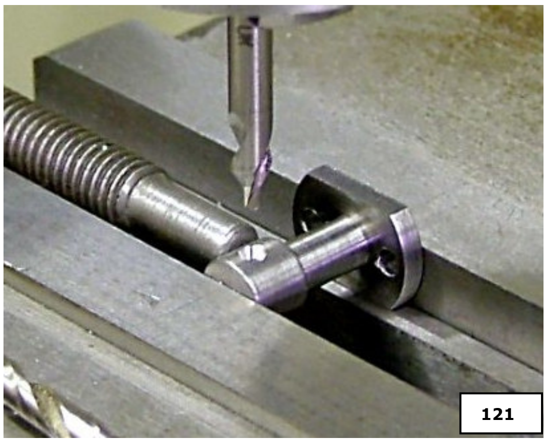

119

Picture 119 shows the flange base being drilled. Centre the flange to the chuck and use machine offset to locate the two 2mm mounting holes.



Once you have the two mounting holes you can then do as I have done in Pic 120. Put two pieces of rod thru the holes and locate them down to the top of the vice, then machine down 2mm.

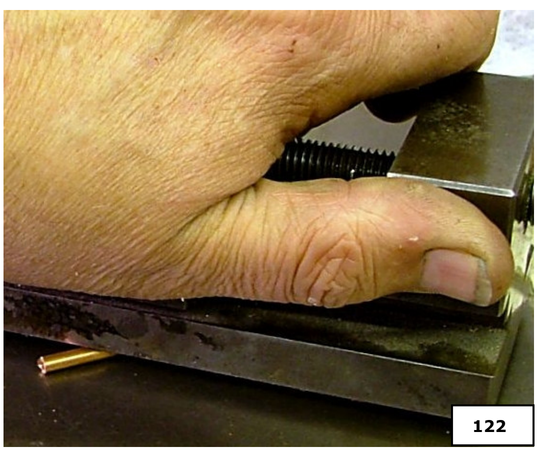
Turn it over and do the same to other side. Be careful; only nibble away downwards not from the side, otherwise it WILL lift the piece out of the vice.



In Pic 121, I show that I have used the flange face resting on a parallel to keep the hole square to the flange. First I centre drilled, then went down with a 3mm drill to a depth of 4.5mm, then followed up with the 4mm required to the same depth.

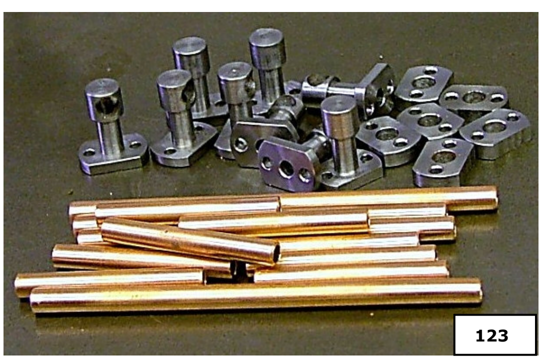
This is the stage at which the brass flanges failed, they couldn't take the pressure applied by the vice and duly buckled.

After the last stage, remount into the lathe and drill up the centre of the flange with a 2.8mm drill(the internal size of the copper pipe) to join into the hole for the pipe at the top.



Picture 122 is how I get bent tubing straight again. The annealed tube is rolled like a using a rolling pin between two hard surfaces.

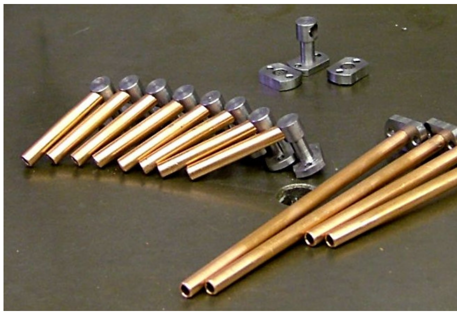
Make sure your copper tube is squared at the ends and deburred on inner and outer faces.



All the finished bits are shown in Picture 123.

For the copper pipe, you will require:

- four (4) X 4mm (5/32") by 30mm long,
- one (1) X same dia by 60mm long, and
- one (1) X same dia by 90mm long.


124

Pic 124 shows all the bits assembled for silver soldering. I need to point out here that for silver soldering to work correctly the parts should NOT BE A TIGHT FIT together, There must be a very slight gap for the solder and flux to penetrate into to form a good joint. If you use a 4mm drill for this pipework all should be ok, as 4mm is very slightly larger than the 5/32" pipe being used.

The way I get the bits to hold together while handling is to slightly flare the end of the tube, so that the tube is held in the hole by the flare but still allows solder flow.


125

To put my mind at rest I silver soldered one of the rejected parts - after drilling the main centre hole in it - to a bit of copper tube. I then tried to break it by putting the flange in a vice and using mole grips to try to put enough force by twisting the pipe to break either the waisted portion on the flange or the copper/steel joint.

As you can see in Pic 125, I failed miserably on both counts, but at least it proves that the flanges are strong enough.

Just a word about failure rate. I started to make 12 flanges: one was rejected after turning, one was used to set up the drilling stages, and a third got damaged during drilling because I hadn't tightened the vice enough. That is a 25% attrition rate, so always make a few spares.

Next time, a post about silver soldering, then onto the control valve, which I am just making and proving.

I wanted to get this out of the way so that I can concentrate on getting the control valve done. These only came out of the pickle bath an hour ago.