Entablature Steam Engine based on Muncaster

By Thor Hansen

Edgar T. Westbury published some articles about "The Muncaster Steam Engine models" in Model Engineer (starting 21 February 1957) and the Entablature engine (from 16 May 1957) that inspired me to make my own version, I didn't follow the drawings. I decided to use a Trunk Guide for the Crosshead since I find it easier to get things to line up using a Trunk Guide. And I didn't use an overhung crankshaft.

Many thanks to Graham Meek for his advice.

Materials

The Cylinder is Gunmetal, I used Aluminium for the Soleplate and Cast Iron, Brass and mild steel I found in my scrap box or in a skip nearby, some mild steel rods, the free-cutting stainless steel, M3 threaded rod, screws and nuts were purchased.

Crankshaft

I decided to start with the Crankshaft that I silver soldered (brazed) together from some pieces of mild steel that I had lying around. The webs were made from 6mm thick black steel and I used a hacksaw to cut them to shape. I could then mark out the centre and use the dials on the handwheel on my milling machine to space the two holes 9.5mm apart. The holes were then drilled 8.5mm – right photo.

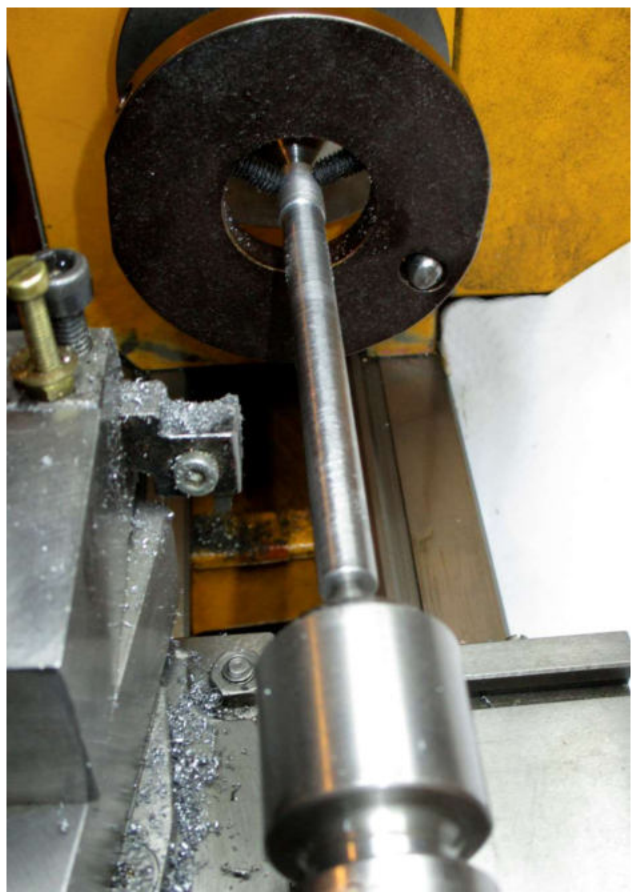
The webs were clamped in a jig in the lathe and the outer diameter turned – left photo. It was easy to measure the diameter of the webs and get each web to the same diameter.

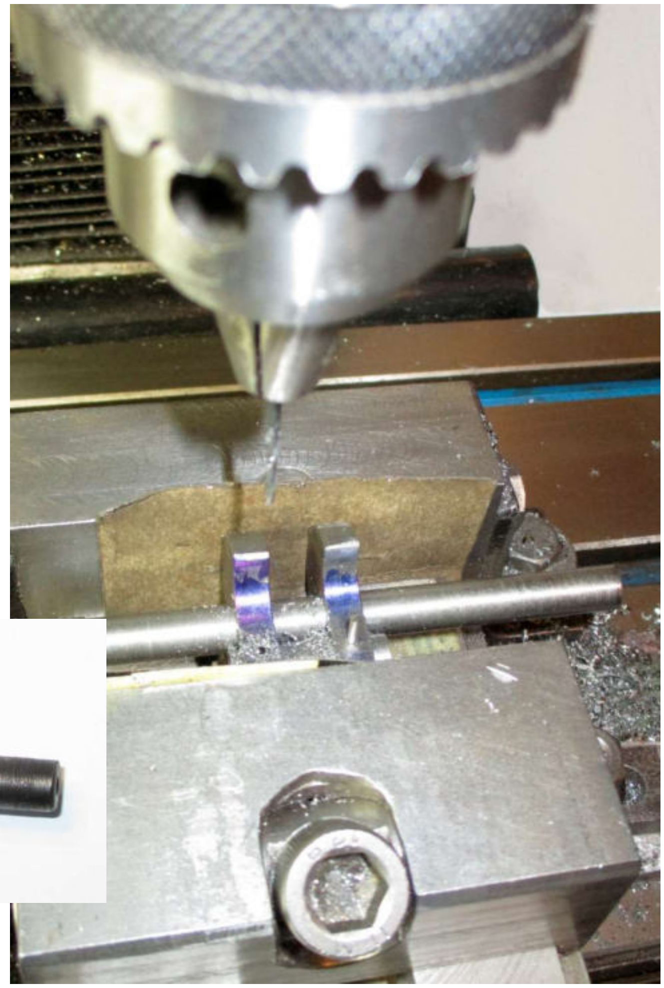
Then the webs were then clamped together in another jig and milled to shape – right photo.

The Crankshaft was turned from a 10mm dia. mild steel rod, first I centre drilled each end so I could turn the rod between centres – right photo.

It was then turned down to a sliding fit through the centre holes in the webs, this leaves the Crankshaft slightly oversize so it can be finished to size after silver soldering (brazing).

Another piece of this 100mm rod was turned for the Crankpin.

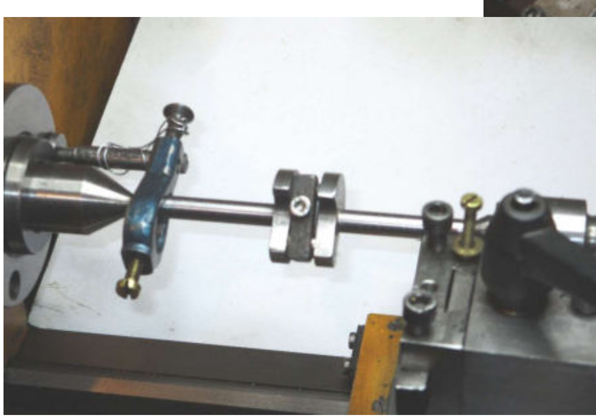




To make sure the Webs didn't move during the silver soldering I drilled some 1.5mm holes through the Webs and Crankpin and inserted small steel pins – right photo.

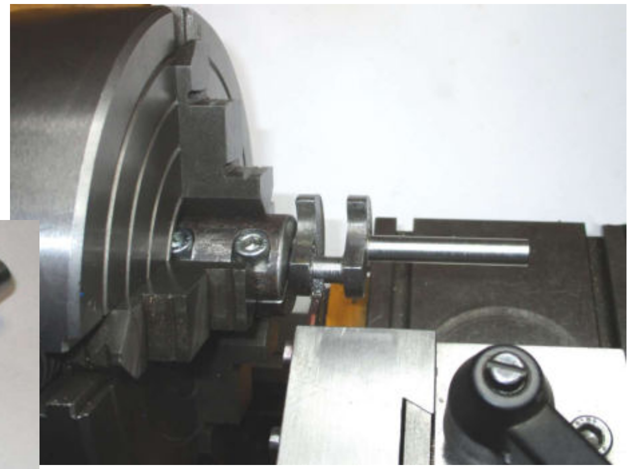
Then the parts were fluxed and silver soldered (brazed) – photo above.

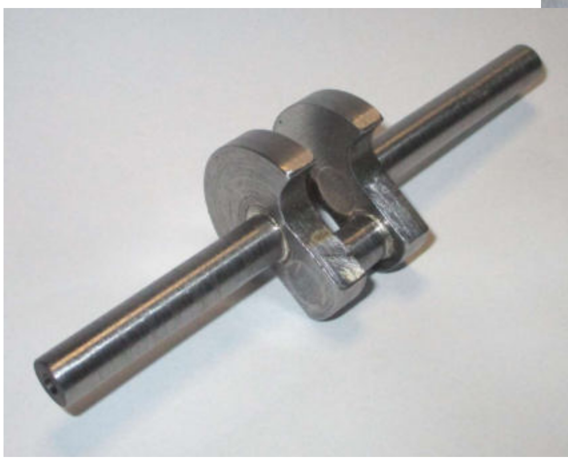
The Crankshaft was then mounted between centres and the "wobble" introduced by the heat, cleaned up, the shaft was still slightly oversize – right photo.



The shaft was cut between the webs and a distance piece clamped between the webs so I could mount the shaft between centres and finish turn the Crankshaft to 8mm – left photo.

The next job was to turn the Crankpin down to 8mm, I used a small eccentric jig and a parting off tool to do that – right photo.
I don't mind the centre holes in each end of the Crankshaft.



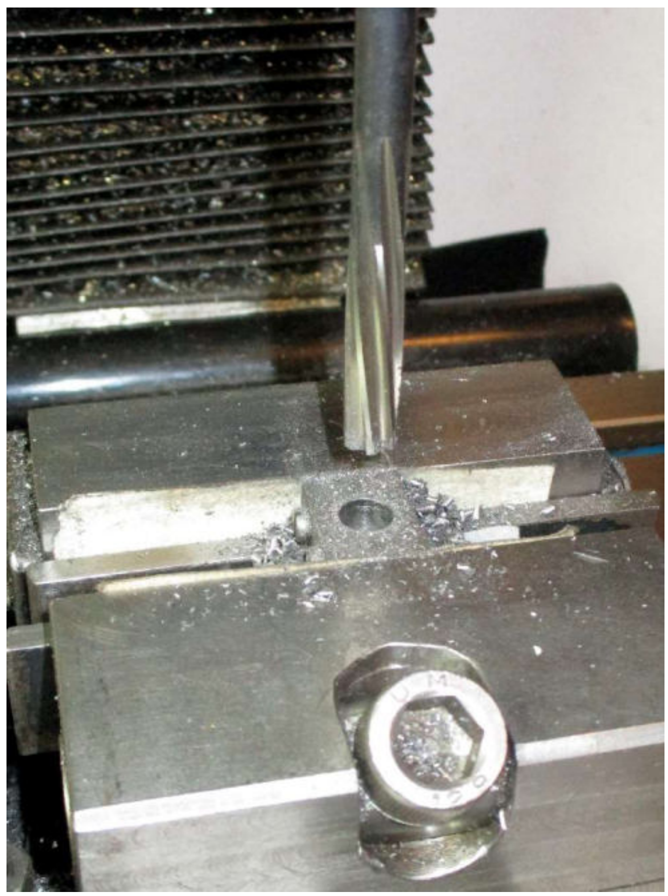


Left – the finished Crankshaft.

Conrod – Big End Bearing

The next part I made was the Big-end bearing on the Conrod, I will make the Conrod from several pieces. I used Cast Iron as bearing material since I get it for free from the garage that service my car – used disc brakes.

Since this must be a split bearing I used a hacksaw to cut two oversize pieces and milled the ends to dimension and clamped them together and drilled a 7.8mm hole through and then reamed to 8mm – right photo.

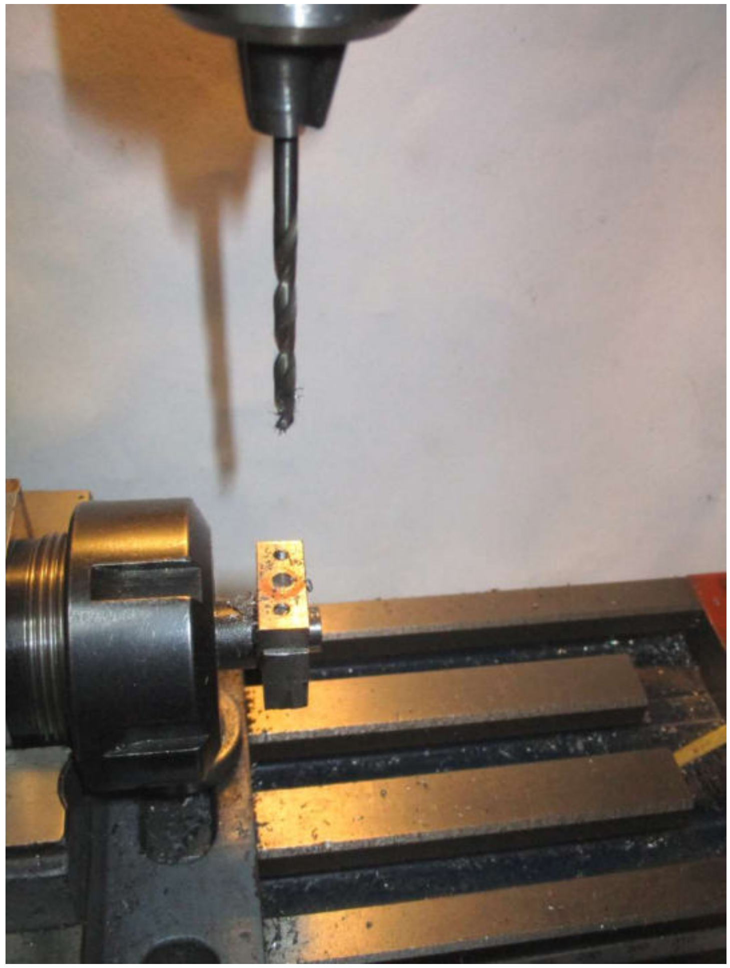


I also drilled two 3mm holes at 90 deg. to the 8mm hole so the two pieces can be clamped together.

I then made a small steel piece with two 2.5mm holes at the same centre distance as the 3mm holes in the bearing. The 3.5mm holes were tapped M3, I could now clamp the big end bearing on a slightly oversize mandrel and turn each side – photo above left.

The mandrel and work was then mounted on the milling machine using a ER collet block – right photo. This way I could drill a 3.3mm hole for the middle part of the Conrod. The 3.3mm hole was then tapped M4.

The rest of the Conrod was made later when Crankshaft bearings, columns etc. were finished.



Crankshaft Bearings

I used mild steel for the bearing blocks and Cast Iron as bearing material – right photo.

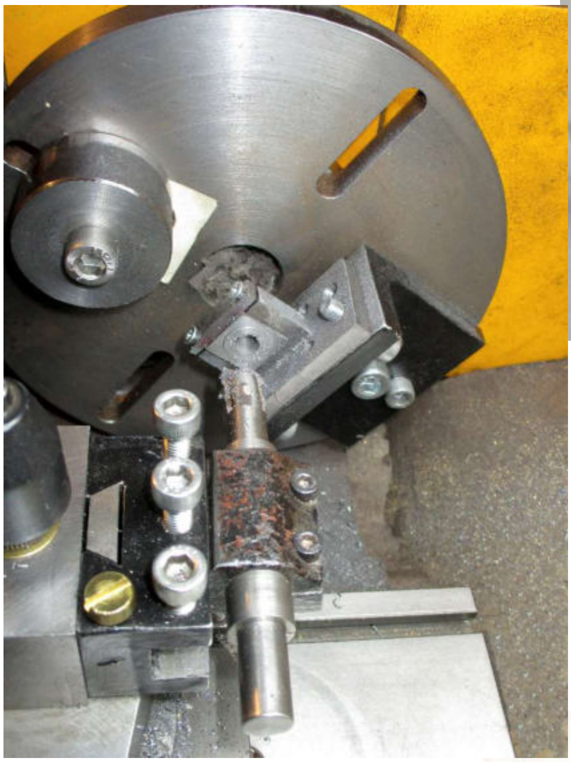
I made split bearings so it will be possible to adjust for wear.

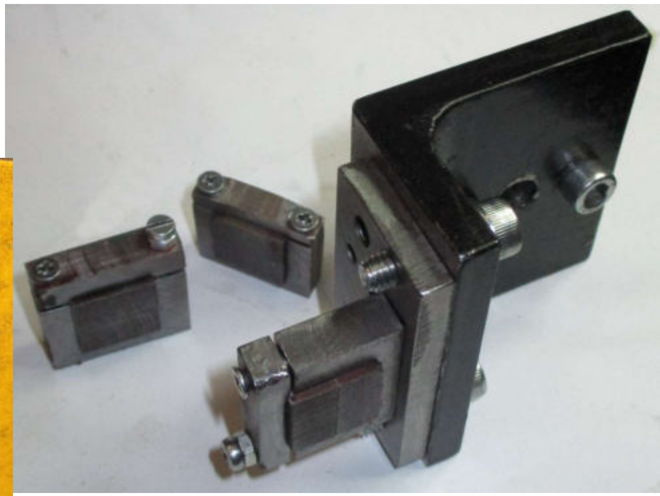
I milled a slot in each bottom part of the Bearing Blocks so each part of the bearing could slide into it. Each bearing part was also milled – photo below.

I also drilled 3.3mm holes in the bottom part of the Bearing Blocks and tapped M4 through so I could clamp the bearing together – left photo.

I didn't quite follow my drawing as I found it would be easier to mount the Crankshaft with split bearings.

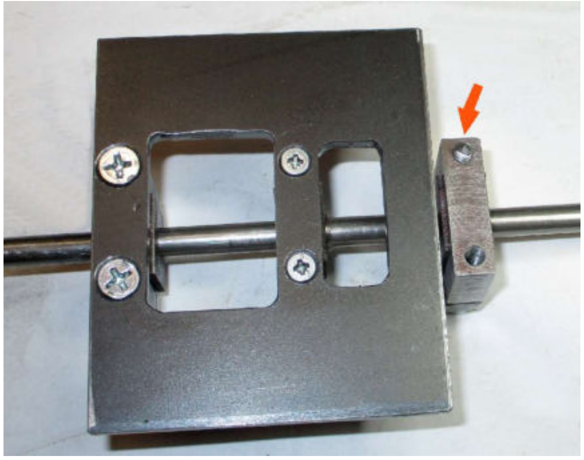
I could now clamp each bearing to a jig plate and the hole to a small angle plate that I could clamp to the lathe faceplate – right photo.





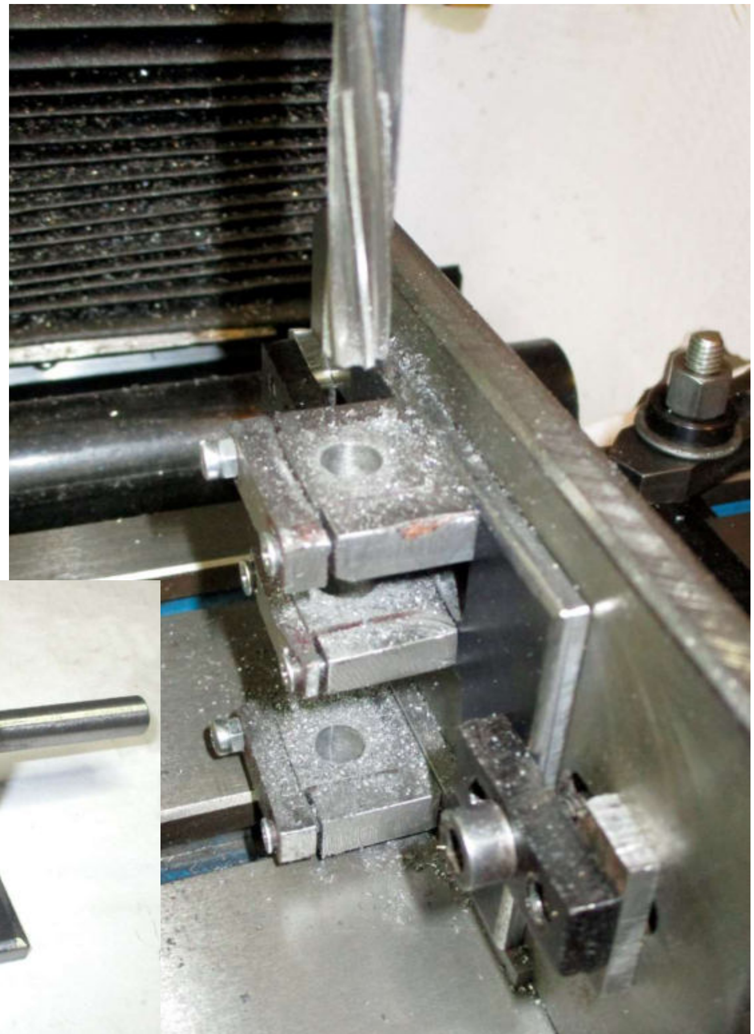
This way I can drill and bore each bearing (slightly undersize) and be sure that the height from the underside of the Bearing Block to the centre of the Crankshaft hole is the same for all three bearings – left photo.

The next job was to make the plate the Bearing Blocks will be mounted on. I used a piece of 4mm thick mild steel and milled the edges to dimension and marked out the position for the two holes. One so the Conrod could be connected to the Crankshaft and the other hole for the eccentric system. I drilled some holes and used a Junior hacksaw to cut out the material – right photo.



The rough sides of the holes were then milled to dimension.
To be able to mark out the position of the 3mm holes that will clamp each Bearing Block to the plate I used some pointed M4 set-screws – red arrow in left photo. I used a rod to line up the bearings. Since the middle bearing was narrower than the others, I used M3 screws for that.

The next operation was to mount the Bearing Blocks to the Top Plate and put a reamer through all three holes – right photo. This way all three bearings will line up.



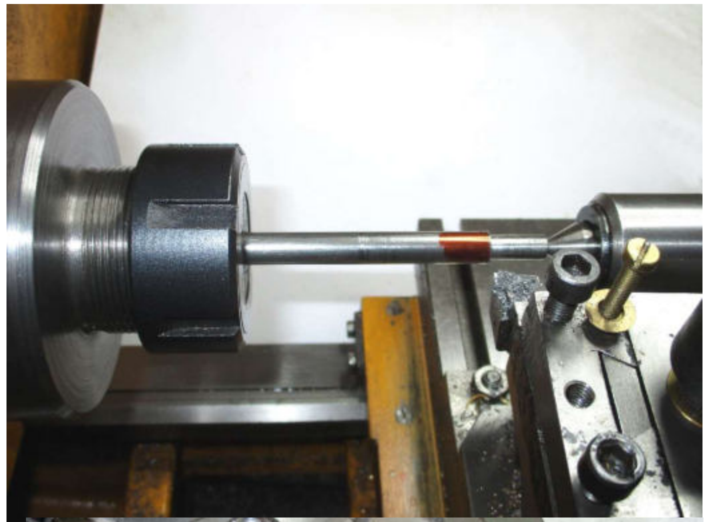
Bottom or Base Plate

I found an old piece of 4mm thick Aluminium alloy in my scrap-box that I used for the bottom (or base) plate. It was over length and the surface was pitted so I had to mount it on the milling table and use a face-mill to clean up – right photo.

I cut off the length needed for the Bottom Plate using a hacksaw, and milled the sides to clean up. The left over piece was just big enough to be used to make the Bottom Cylinder Cover.

Columns

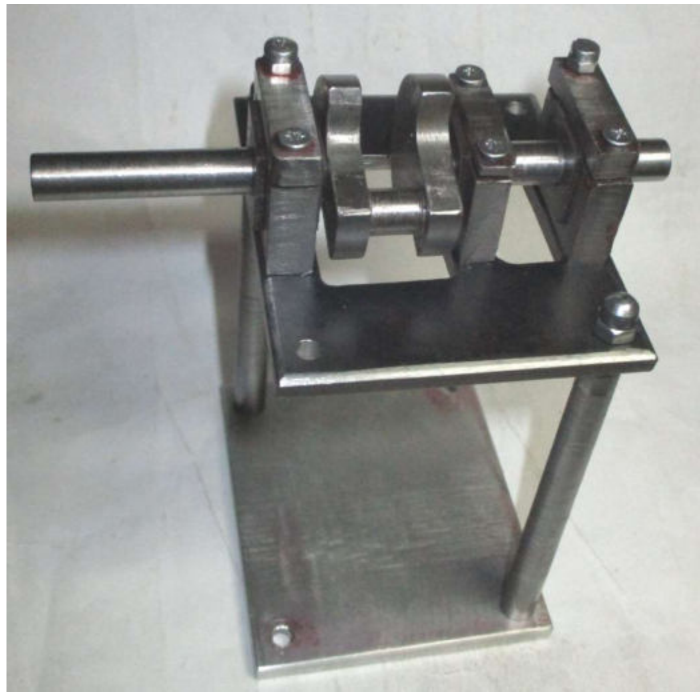
The Columns were made from 8mm dia. mild steel rod.
First I faced the ends and centre drilled, then I turned down one end to 6mm for a length of about 15mm.
I used the ER collet chuck to hold one end and supported the other end with a centre – right photo.



To turn the Columns tapered I used my larger lathe with a Boring Head in the Tailstock. Instead of a Boring Tool I have a small centre that fit instead of the boring tool. By using the feed-screw of the Boring Head I could offset the centre to get the slight taper needed for the Columns – right photo.
The Columns goes from 6mm dia. at the upper end down to 8mm at the bottom. There is a parallel part both at the top and bottom of the Columns, later I will turn the "beads" that go at the top and bottom and just glue them in place.

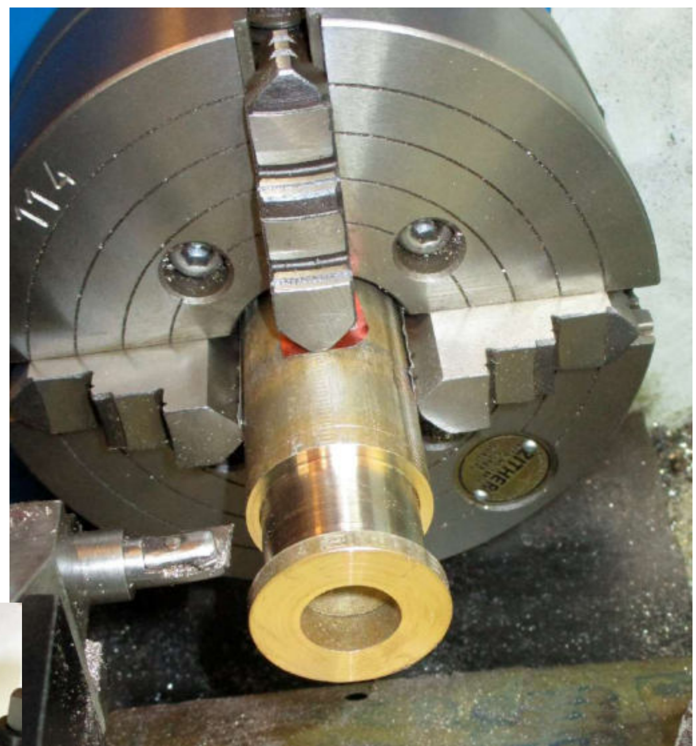
Then back to the small lathe to turn part of the 6mm end down to 4mm and thread M4. I used my home made fixed steady to support the outer end – left photo.

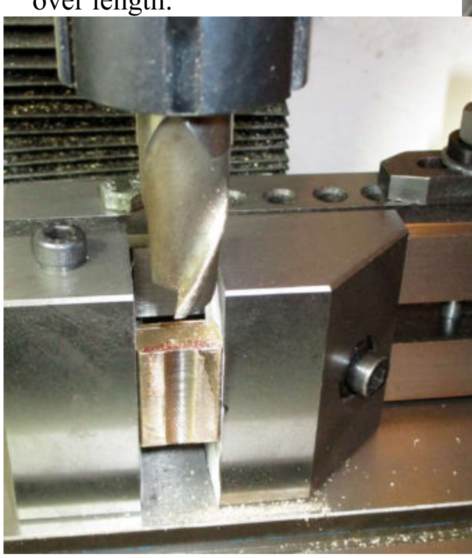
The holes for the Columns were marked out on the Top Plate and drilled 4mm dia. The Top Plate could then be used as a drill jig for the Base.
Here is a photo of the Crankshaft with bearings and two of the Columns mounted.
The Crankshaft moves fairly freely.



Cylinder

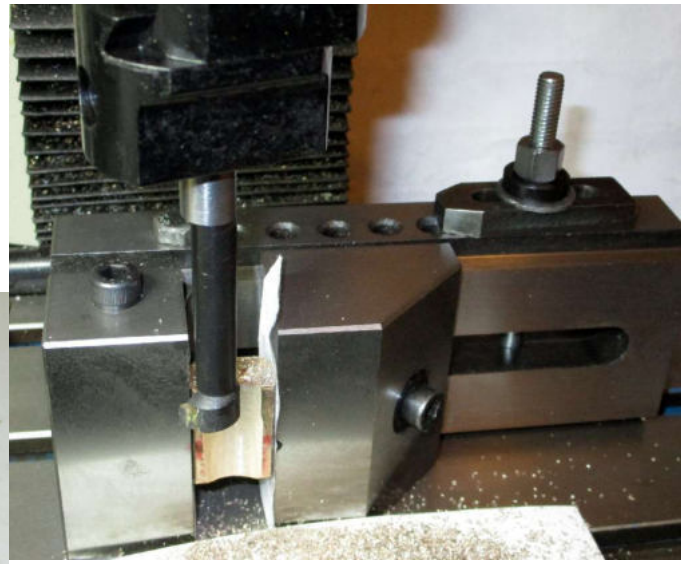
The next job was to make the Cylinder, I had managed to source a thick-walled tube of leaded gunmetal so I used that for the main part of the Cylinder, the Portface was made from another piece of gunmetal and the two parts silver soldered (brazed) together.
I started with the gunmetal tube. The work was mounted in the 4-jaw and the end faced and the Cylinder turned down to dimension except for the flanges – right photo.
The work was then parted off over length.



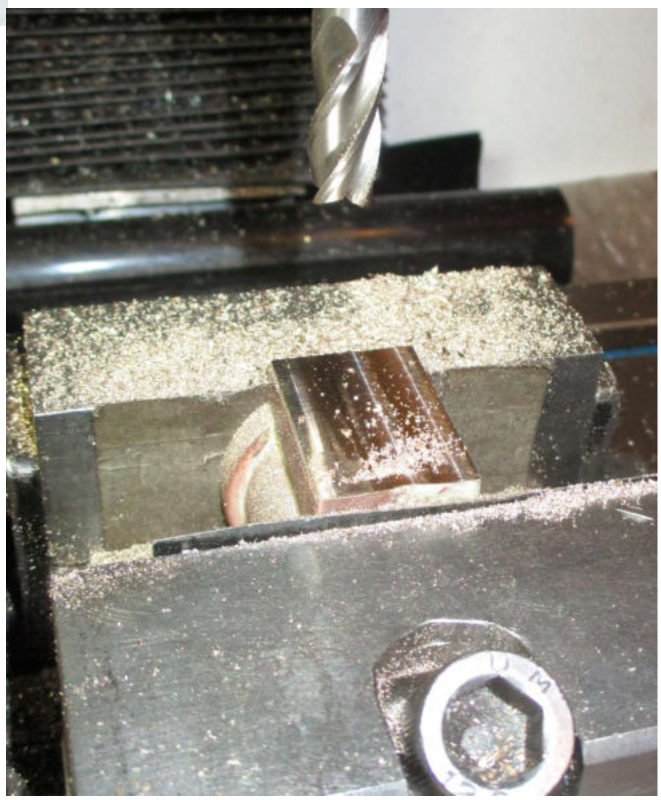


The Portblock was made from a left over piece of gunmetal. I mounted the work in my toolmakers vice lying on its side on the milling table – left photo.
I could then use a 20mm slot drill to start milling a shallow curve on the face that will be soldered to the Cylinder. The piece of gunmetal used for the Portblock was larger than needed but this made it easier to clamp in the vice.

For the last cuts I used my home-made boring head adjusted so the curve of the cut gave a good fit with the Cylinder – right photo.



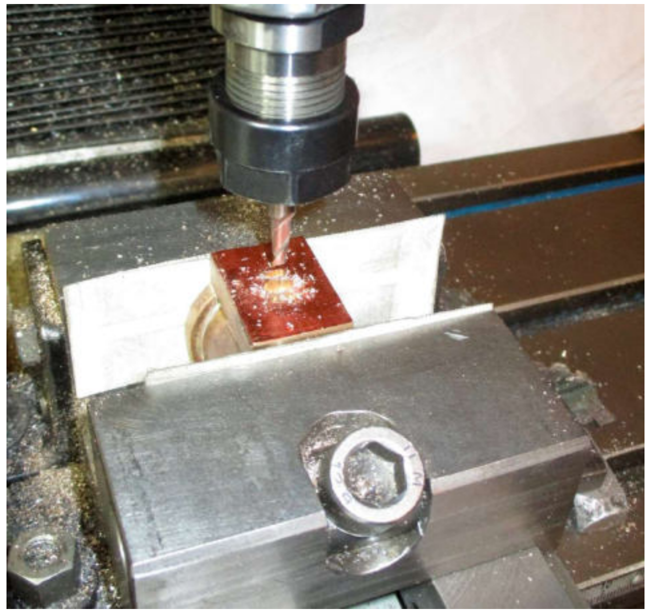
At the top and bottom of the Portblock I cut away more material so the flanges on the Cylinder would fit – left photo.



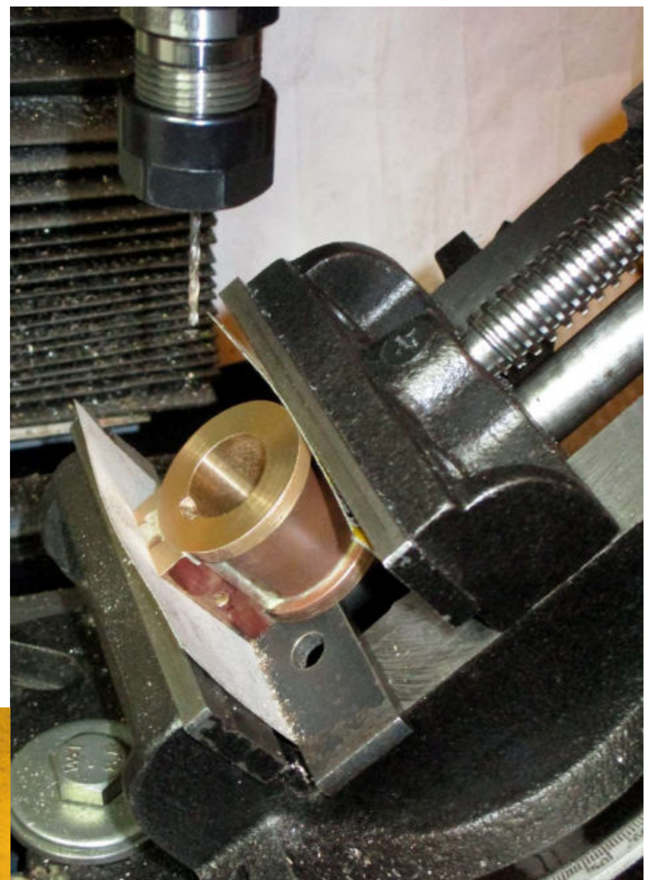
The parts were then silver soldered (brazed) together and pickled in Citric Acid solution.
The next job was to mount the Cylinder in the vice and mill the Portface – right photo.
Unfortunately, I forgot that the Portblock was a few mm too thick so I just cleaned up the Portface. When I later discovered this it was too late to remove more material as I had already milled the steam ports and drilled from the Cylinder end and into the steam ports. I could have made a new Cylinder, but took the easy way out and bent the eccentric rod.

With the Portface milled the Cylinder was mounted in the 4-jaw and the end faced and the Cylinder bored to dimension – left photo. The Cylinder bore should now be parallel to the Portface.
The end that was faced was marked, it will be the Trunk-guide end.

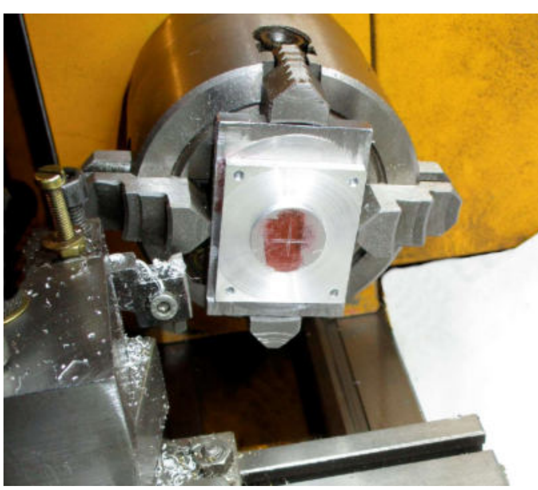
The Cylinder was moved back to the milling machine and the position of the steam ports marked out. I first drilled some (under size) holes, the first (3.5m m) in the centre of the Portface and the used the milling table dials to move 5mm towards a Cylinder flange before drilling a second hole with a 1.5mm drill. It seems to me that it is a bit easier on the small slot drills to do it this way.
I used a 4mm slot drill for the Exhaust port – right photo – and a 2mm slot drill for the Steam ports.



To drill the steam passages from the Cylinder end and into the steam port I mounted the Cylinder in a tilting vice. I had marked the position of the steam ports on the side of the Portblock.
I first milled a flat and then used a 2mm drill to drill two holes into each steam port – right photo.
I also drilled a 1.6mm hole in the bottom flange almost into the Cylinder bore. I then used a 1mm drill to drill into the bore. The 1.6mm part was tapped M2. I will use this for a drain plug.

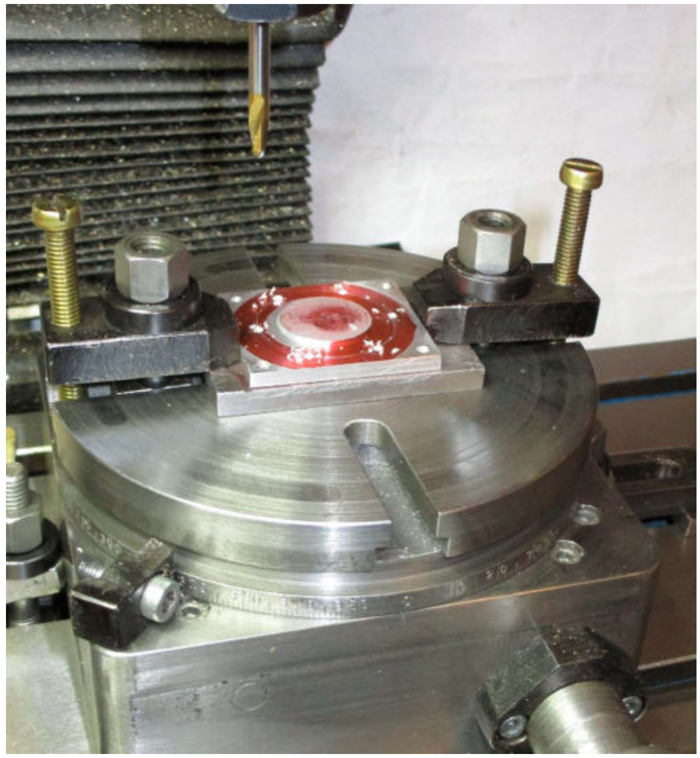


Bottom Cylinder Cover



The next job was to make the Bottom Cylinder Cover from the material left over from making the Base. After machining to dimension in the milling machine and marking the centre of the Cylinder I drilled and tapped four holes for M3. One hole in each corner so I could clamp the cover to a small jig using countersunk M3 screws and turn the spigot to fit the Cylinder bore – left photo.

The cover (and jig) could then be mounted on my home made rotary table and six 3mm holes drilled 60 deg. apart – right photo.
The holes were then countersunk on the underside. The cover was then used as a drilling jig for drilling 2.5mm holes in the bottom flange of the Cylinder and tapping them M3.



Trunk Guide

The Trunk Guide was fabricated from a piece of brass tube (18mm OD and 16mm ID) silver soldered (brazed) to a piece of 4mm thick brass.
I also put a piece of 12mm dia. brass rod in the centre of the brass piece, this will become the gland for the Piston Rod.

The Trunk Guide was then clamped in an ER 32 collet so I could turn the outside to dimension and turn the spigot to fit the Cylinder – right photo. I also drilled a pilot hole through the centre and reamed it for the Piston Rod.

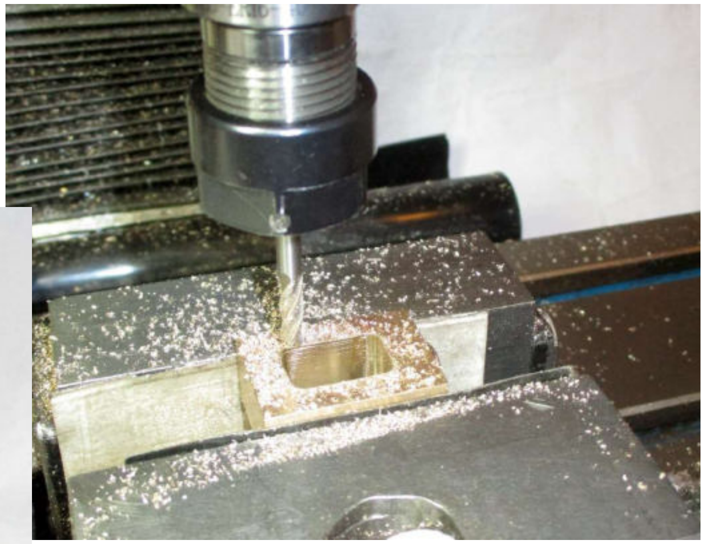
The work was then moved to the milling machine and six 3mm holes drilled 60 deg. apart – left photo. The Trunk Guide was then used as a drilling jig for the 2.5mm holes in the top Cylinder flange, the holes were then tapped M3.

The work was then mounted in the milling vice so I could mill the openings on each side – right photo.

The last operation was to use a tapping drill for the fine thread in the gland and then tap it – left photo.

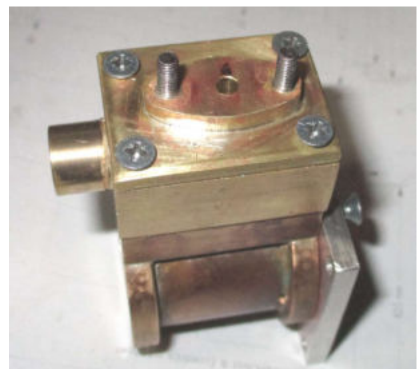
Steam Chest

The Steam Chest was made from a leftover piece of brass. I driklled a hole and used a mini hacksaw to make a hole that could then be milled to size – right photo.



The brass piece wasn't large enough to turn a spigot for the Valve Rod gland so I decided to silver solder (braze) a piece of brass rod to the end – left photo.

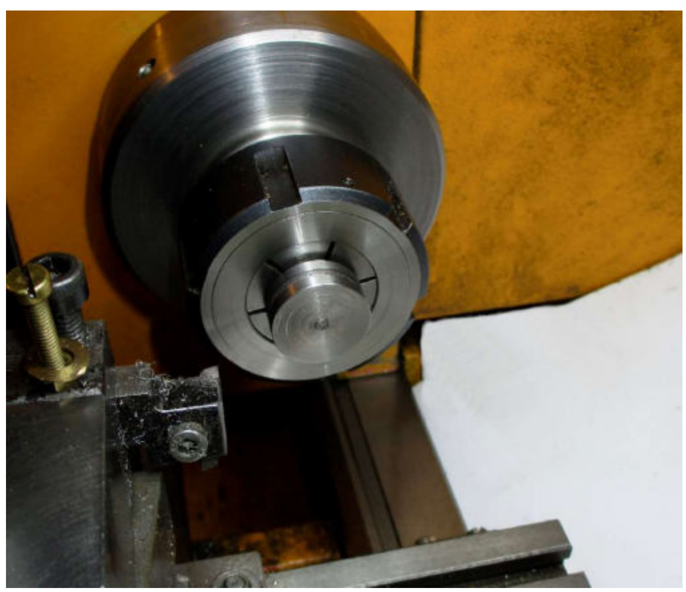
I placed the steam in on the Steam Chest cover – right photo.



Piston and rod

The Piston was turned from a piece of free-cutting stainless steel (303), I used the same material for the Piston Rod (4mm). The steel rod for the Piston was chucked and turned slightly oversize. I used a parting off tool to turn the groove for the packing.

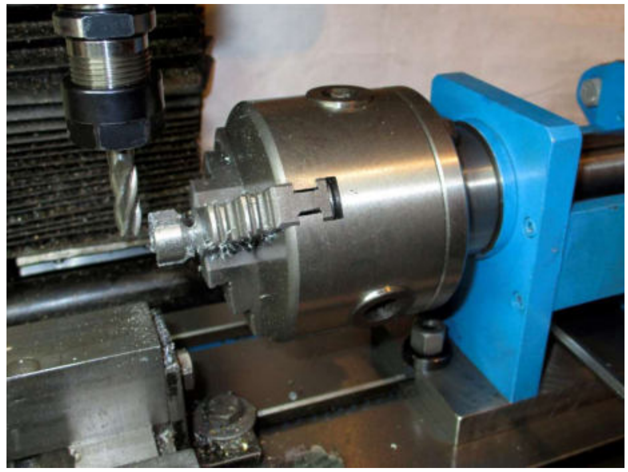
I drilled a 3.2mm hole and opened that up to 4mm for a depth of about half the thickness of the Piston. The Piston Rod was threaded M4 at the end and the Piston screwed onto the rod so I could mount the Piston in a collet and turn the outside of the Piston to a nice fit in the Cylinder – right photo.



Crosshead

The Crosshead was made from a piece of mild steel rod. The rod was chucked in the 3-jaw and the end faced. I drilled a 3.2mm hole and tapped M4 for the Piston Rod. The outside was turned to a nice, sliding fit in the Trunkguide. I also tried to turn a curve at the opposite end of the thread.

The work was then moved to the indexer on the milling machine for milling to shape – right photo.

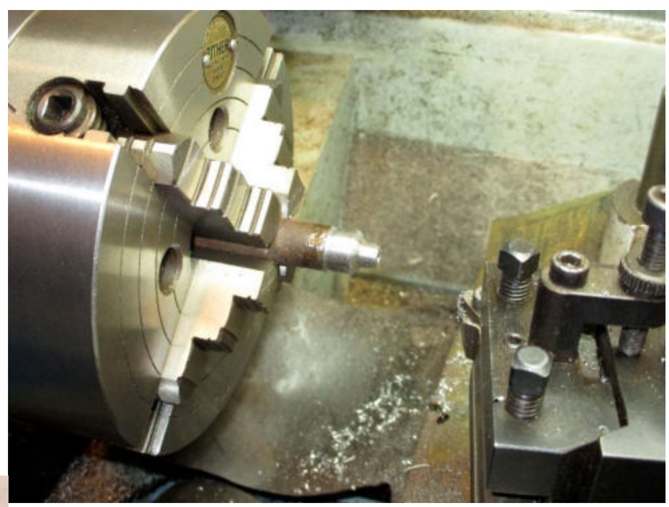


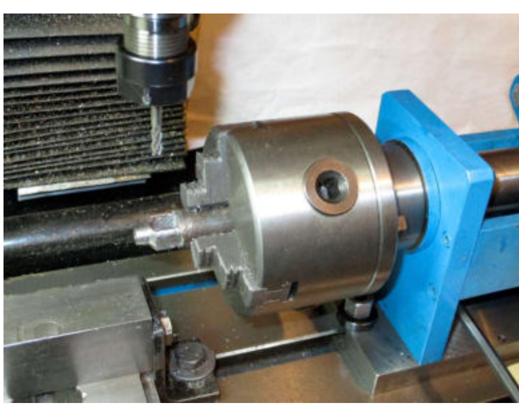
A 3mm hole was drilled at 90 deg. to the thread and the work moved back to the lathe and the Crosshead parted off.

The left photo shows the Crosshead and Trunkguide mounted in place.

Finishing the Conrod

I could now mount the engine parts and make the rest of the Conrod, a 4mm dia. rod threaded M4 at each end and the little end. The little end started as a rusty mild steel rod that was turned to shape and a M4 threaded hole – right photo.





The work was then moved to the indexer in the milling machine and a hole drilled at 90 deg. to the M4 threaded hole. I could then mill to shape – left photo.

The back to the lathe to part off.

Slide valve

The Slide valve was made from free cutting stainless steel (303) rod. The rod was centred in the 4-jaw and faced. I used a slot drill in the tailstock to start the hollow part at the centre – right photo.

The work was then transferred to the milling machine and the round rod mounted in the indexer and the valve part milled rectangular. Two 3mm holes were drilled at 90 deg. to each other to give rounded bottoms in the slots that will be milled later.

The work was returned to the lathe and the valve parted off.

Then back to the milling machine to mill the hollow part more rectangular – left photo.

The work was turned around and two 3mm slots at 90 deg. to each other were milled. One for the Valve rod and the other for the Valve nut.

Eccentrics

I used mild steel for the Eccentric. The rod was chucked in the 3-jaw and faced and a small mark made at the centre. I then used a parting off tool to turn the groove for the Eccentric Sheave and finally parted off.

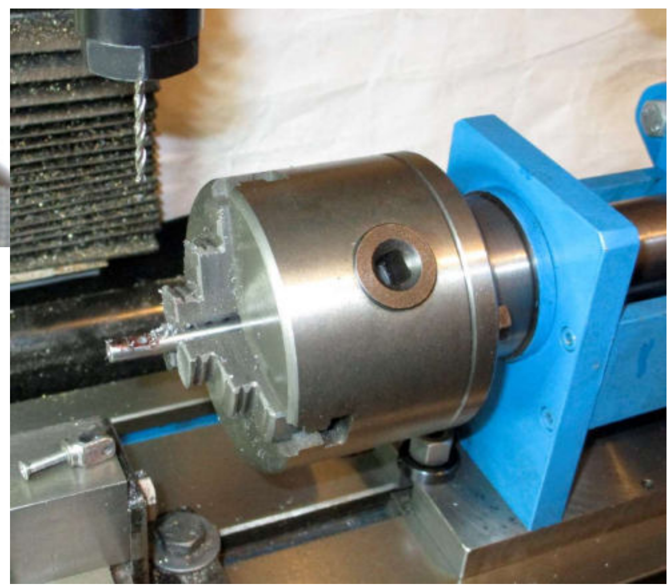
The work was then transferred to the milling machine and the milling spindle placed at the centre of the work using a pointer. I used the handwheel graduations to move the spindle the required offset and drill and ream a hole for the Crankshaft – right photo. A hole for a grub screw was drilled and tapped.

The Eccentric Sheave was made from two rectangular pieces of brass. I glued them together and drilled a 2.5mm hole through. The pieces were then split and in one the 2.5mm hole was opened up to 3mm, in the other piece the 2.5mm holes were tapped M3.

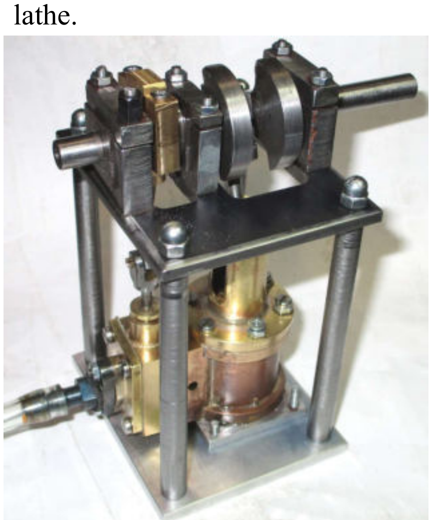
The two pieces were clamped together with two M3 screws and milled to dimensions. The centre was marked.

The work was then transferred to the 4-jaw so I could drill a hole through the centre and bore the hole to fit the sheave – left photo.

The work was turned and mounted so the end where the Eccentric Rod would fit was facing outwards and a 2.5mm hole was drilled and tapped M3 for the rod. At the same time the threaded part was turned to make a spigot around the tapped hole.



The Valve Rod was threaded M3 at each end, and needed a slight bend to fit. The Eccentric Link was made from mild steel rod and milled using my indexer and finish turned and parted off in the lathe.



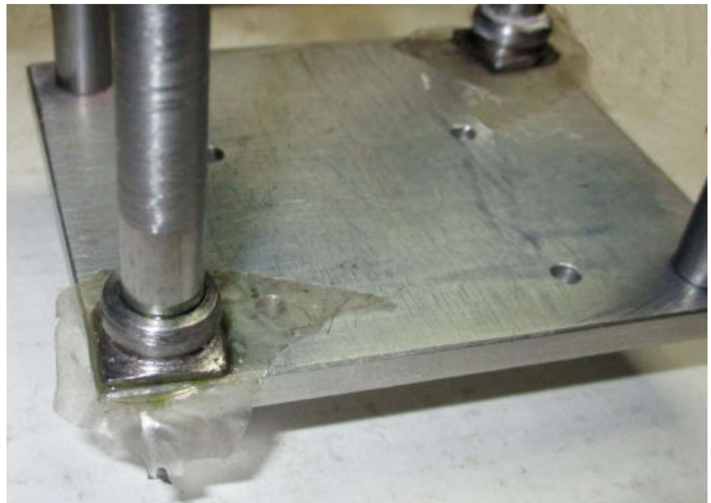
I now mounted the various parts and "borrowed" a flywheel from another engine to see if it would run. After adjusting the Eccentric the engine started running on compressed air. The left photo shows the engine at this stage – except for the flywheel.

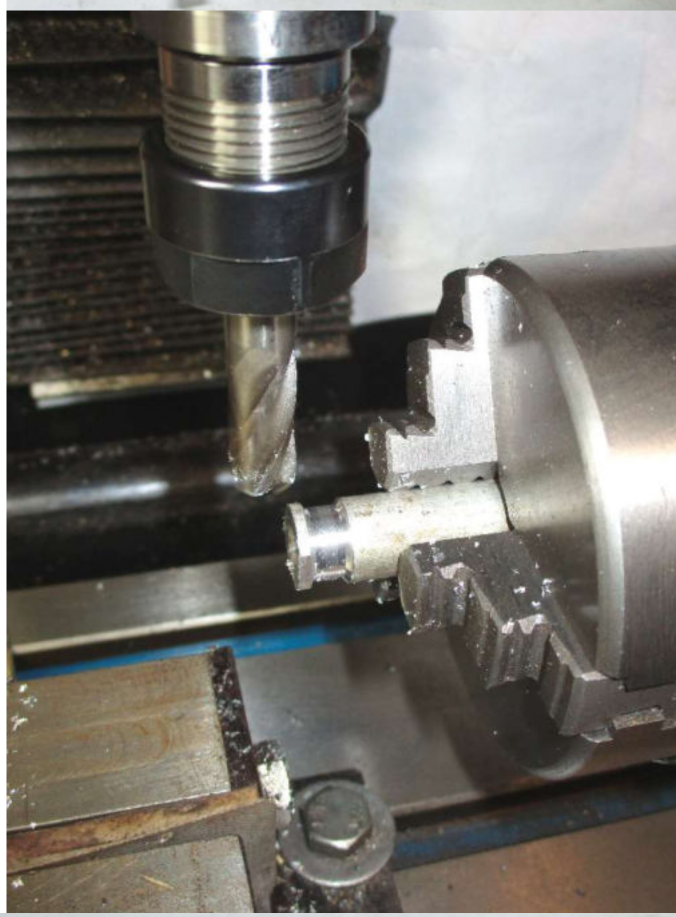
The next jobs will be the beads at the top and bottom of the Columns and to make a flywheel.

Column beads

The Columns have beads at the top (Capitals) and bottom. I decided to try and make a form tool from a piece of an old file. The form tool was filed to form and then heated to about boiled carrot colour and quenched in water and tempered to light straw.

I had a short piece of square steel rod and decided to try and make the bottom beads, the task was demanding for my make-shift form tool but I managed to make four. The beads were glued to the Columns using anaerobic glue, and to make sure they lined up and weren't glued to the base I put some plastic film between them and the base – right photo.





Since my square steel rod was too short and it was so difficult to get good results with my form tool cutting steel I decided to make the top beads from round light alloy rod. I sharpened the form tool first, and it was much easier to cut the beads in the light alloy and get an acceptable result. Since I was using a round rod this time it was necessary to clamp the rod in my indexer and mill the top part square – right photo. Then back to the lathe to finish and part off.

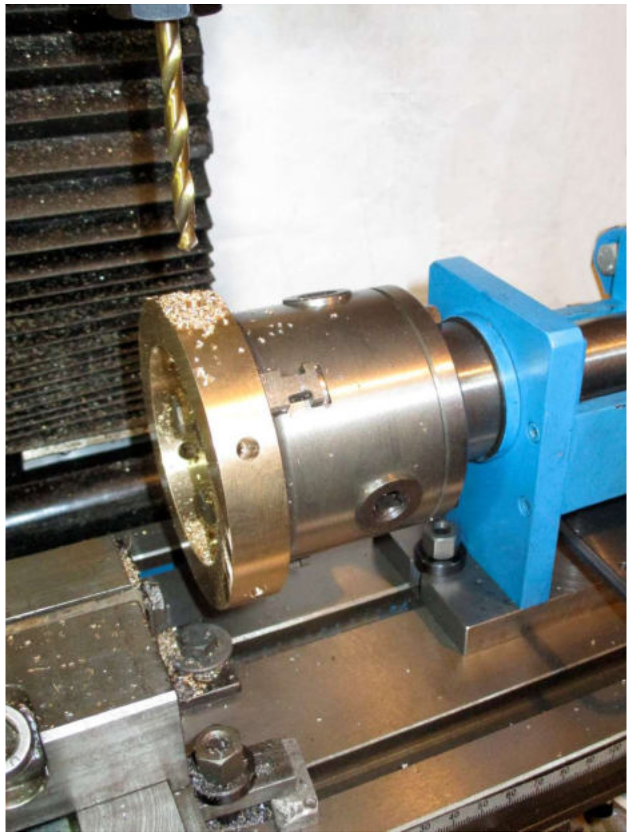
The four top beads were glued in place the same way and the Columns given a coat of primer and painted Grey – right photo.

Flywheel

A friend gave me a short piece of 90mm OD brass pipe, with a 4mm thick wall. Later he gave me a similar piece of brass pipe but with a much thicker wall, so I decided to use that instead.

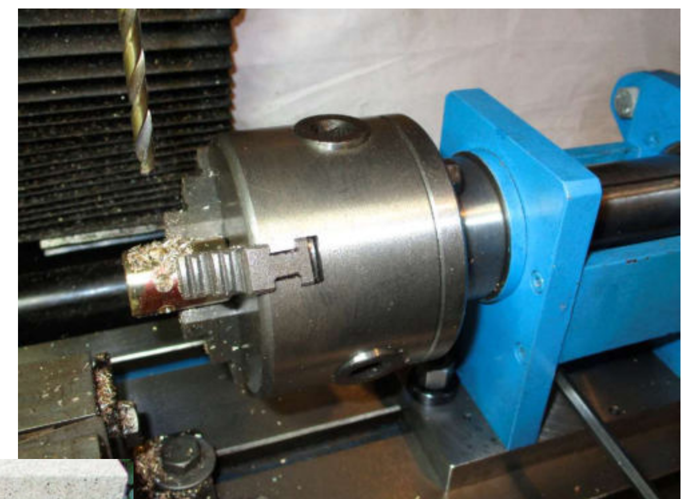
I clamped (on the outside) the piece in the 4-jaw and turned the inside and faced the front, the work was then turned around and the other side faced. The work was then gripped on the inside so I could clean up the outside.

The work was then transferred to the indexer and six points marked out 60 deg. apart using a spotting drill. Next six holes were drilled using a 6mm twist drill were the cutting edge was stoned so the drill wouldn't grab – right photo.



I used a piece of 20mm brass rod for the hub and used the indexer to mark out six points 60 deg. apart with a spotting drill. This time a 5mm twist drill was used to drill six holes to a depth of 5mm, the holes were then tapped M6 – right photo.

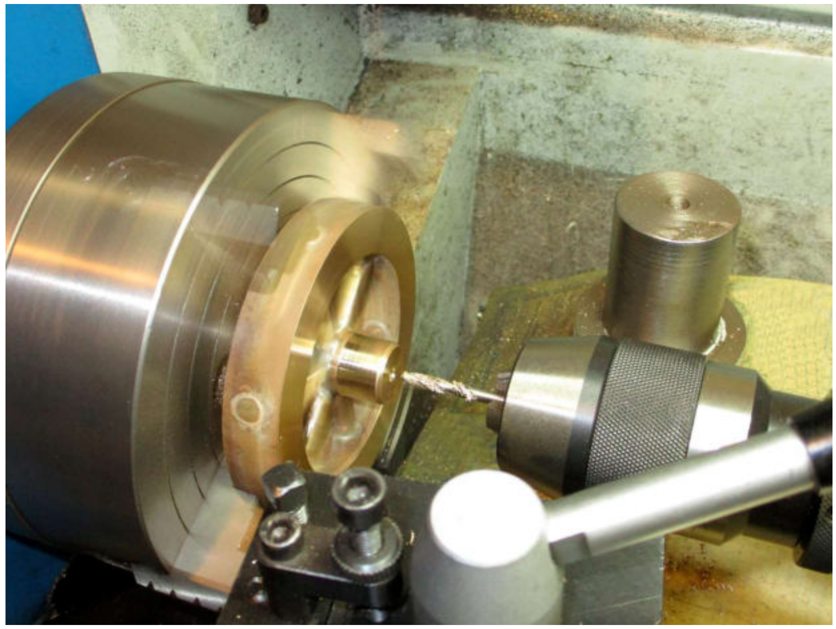
The six spokes were made from 6mm free-cutting brass rod, one end of the rods were threaded M6 for a few millimetres at one end so they would screw into the tapped holes in the hub.



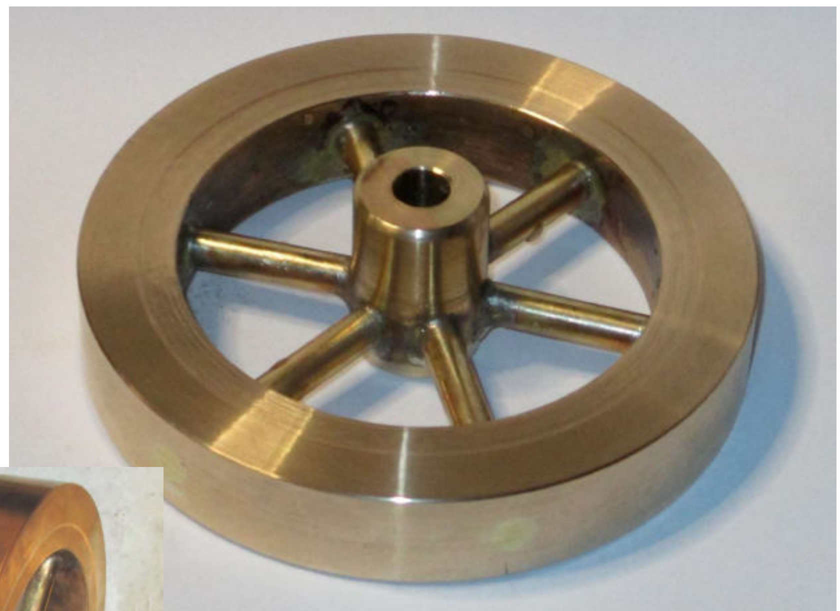
The parts were cleaned and fluxed and then silver soldered (brazed) in my makeshift hearth using my home made Reil burner – left photo. I let the flywheel cool slowly and then pickle it in a solution of Citric Acid for a few hours.

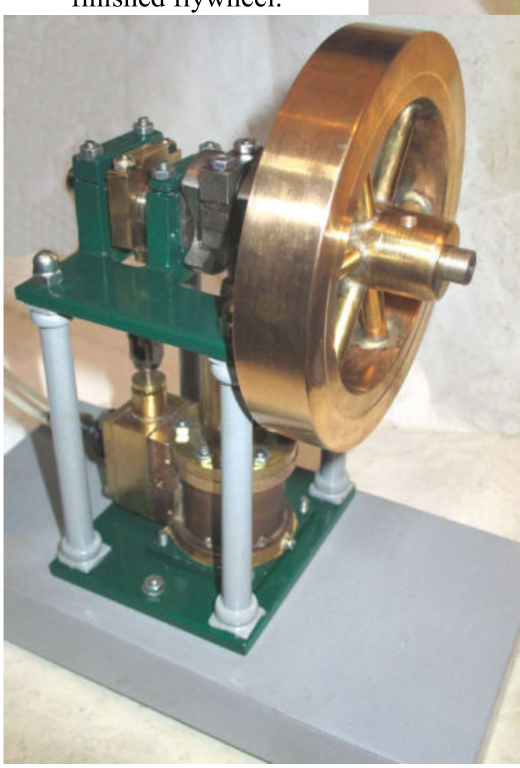
After pickling the flywheel was mounted in the 4-jaw independent and centred on the inside of the rim. I used a spotting drill to mark the centre of the hub and drill through with a pilot drill. The hole was then opened up to 7.5mm and finally a 7.8mm drill before reaming to 8mm – right photo.

A 3.3mm hole was drilled in the hub into the reamed hole and tapped M4 for a grub screw.

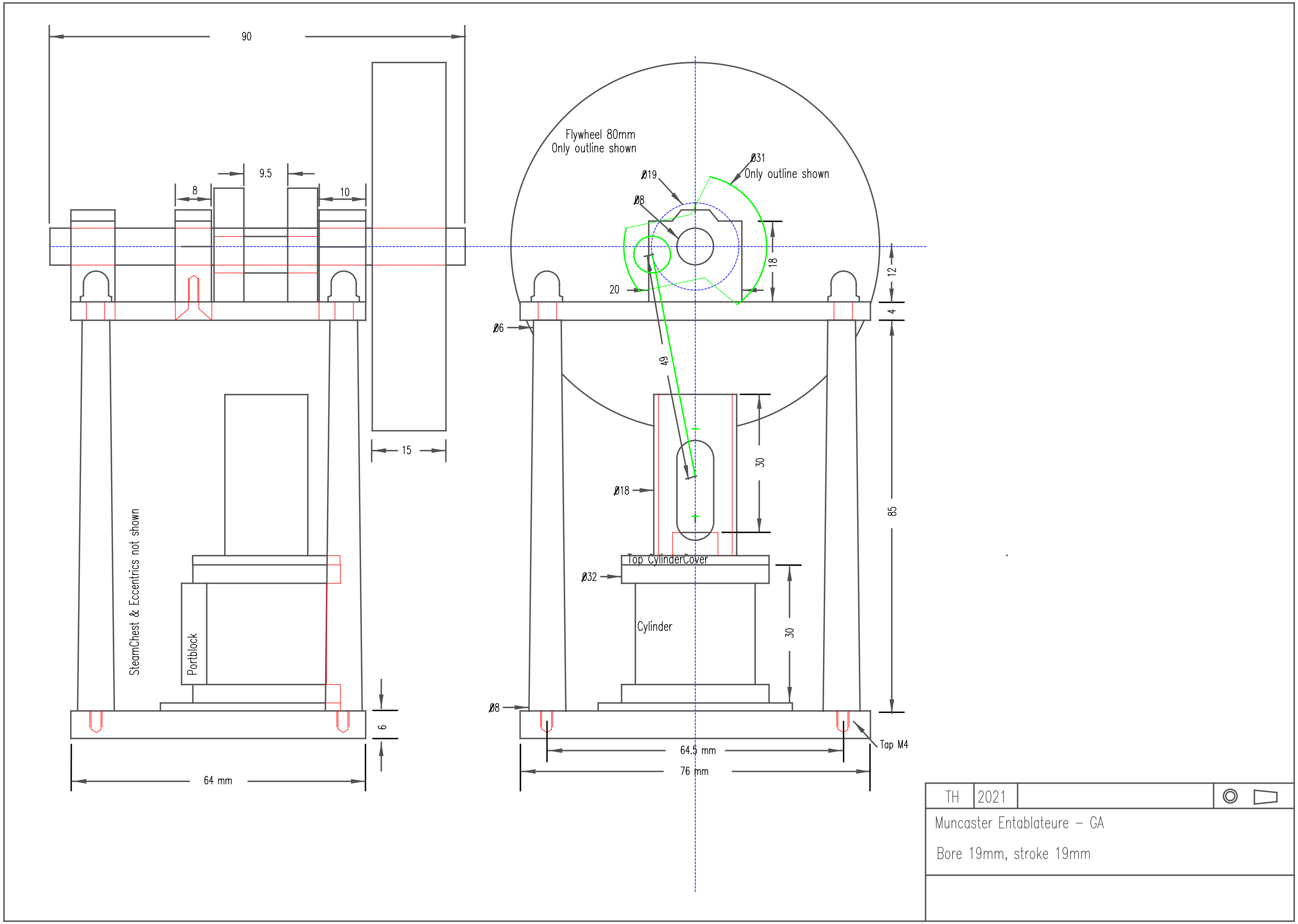


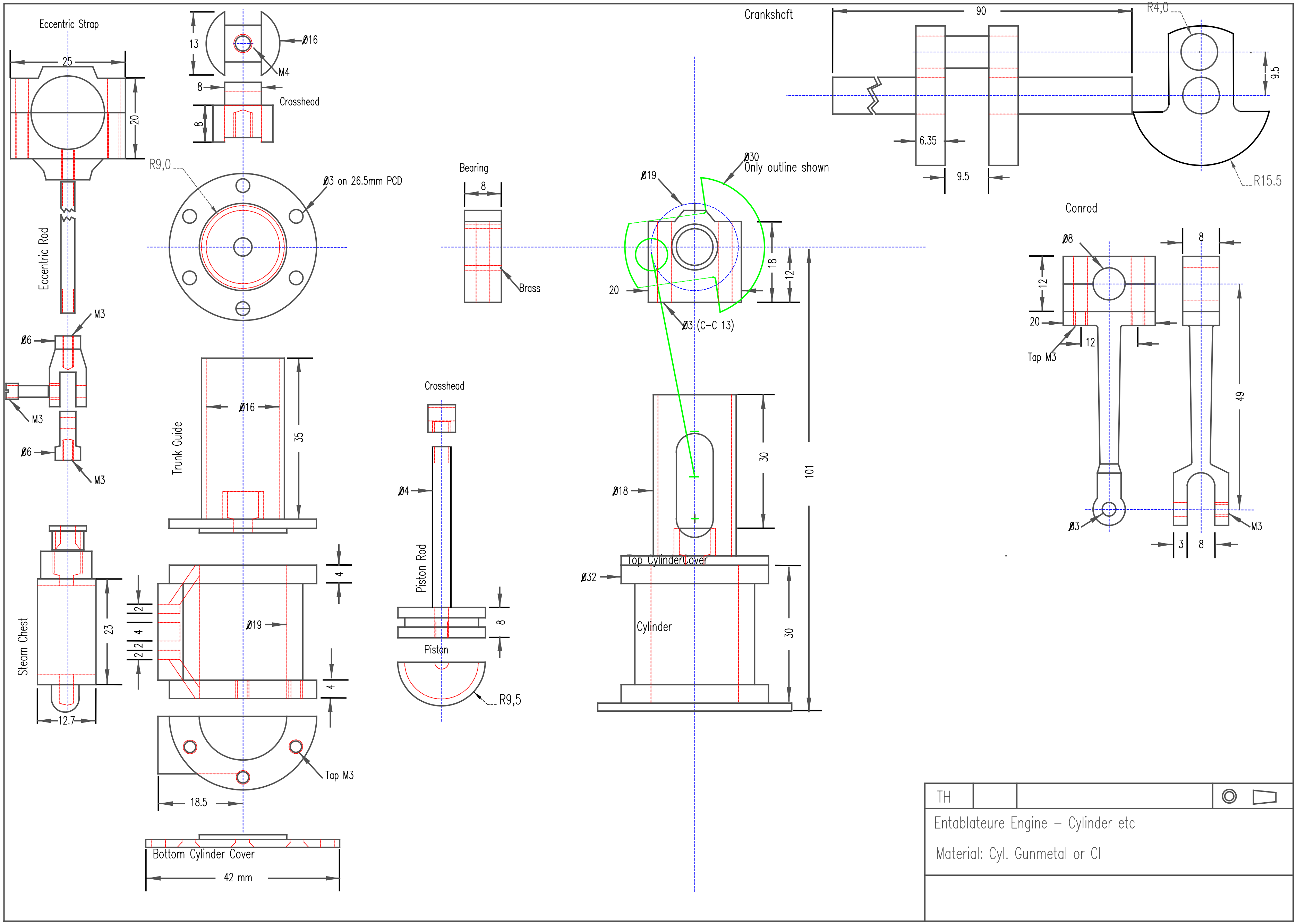
The flywheel was then mounted on a mandrel between the lathe centres and finish turned on the outside and sides. The right photo shows the finished flywheel.

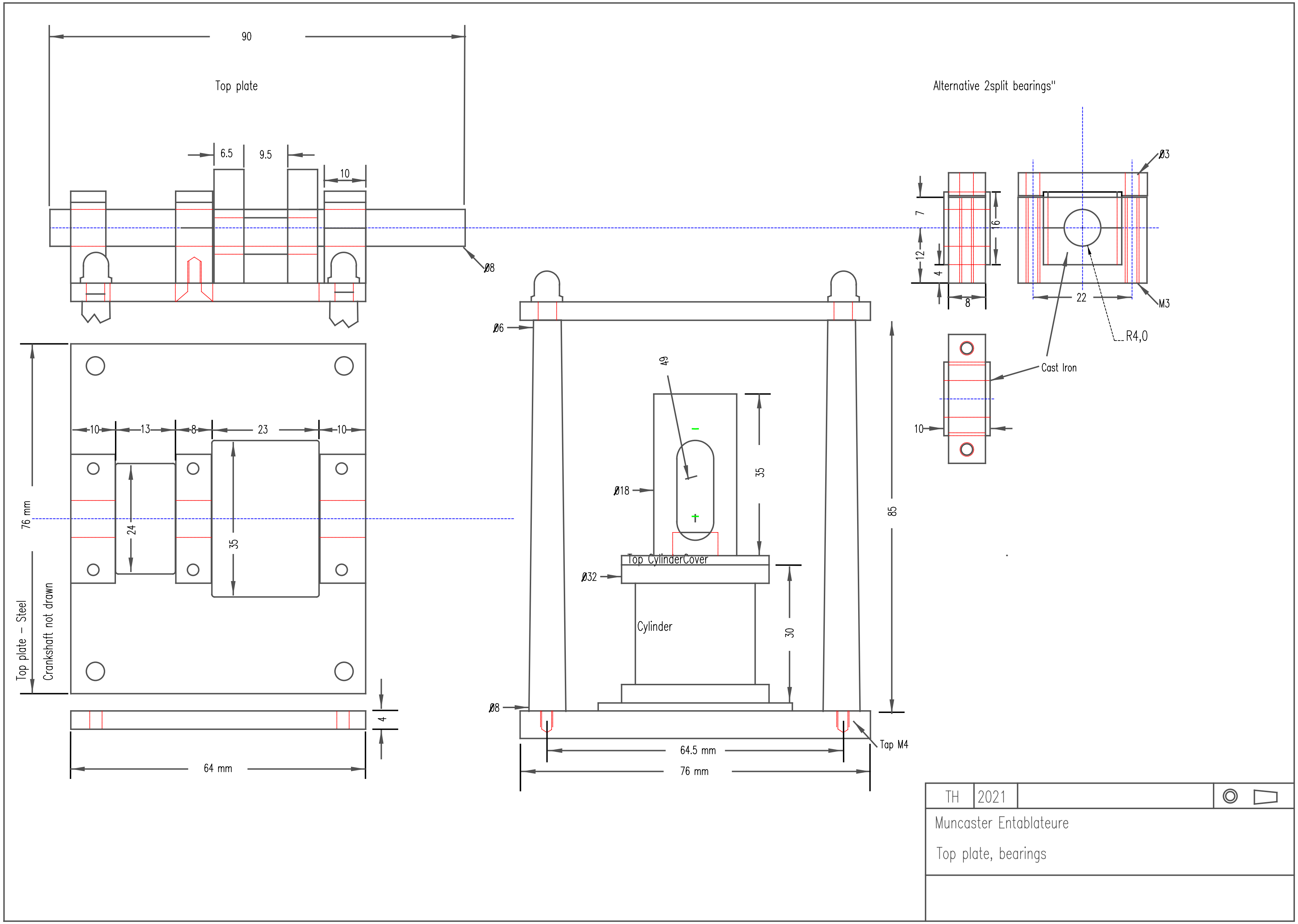




The finished engine.


90
9.5
8
10
15
Flyweel 80mm
Only outline shown
Ø31
Only outline shown
Ø19
Ø8
20
18
12
4
Ø6
49
30
Ø18
85
Top CylinderCover
Ø32
Cylinder
30
SteamChest & Eccentrics not shown
Portblock
6
Ø8
Tap M4
64.5 mm
76 mm
64 mm
TH
2021
Muncaster Entablateure – GA
Bore 19mm, stroke 19mm


Eccentric Strap
25
20
R9,0
Eccentric Rod
M3
Ø6
M3
Ø6
M3
Steam Chest
23
12.7
13
Ø16
M4
8
Crosshead
8
Ø3 on 26.5mm PCD
Trunk Guide
Ø16
35
4
2
4
2
Ø19
4
Tap M3
18.5
Bottom Cylinder Cover
42 mm
Bearing
8
Brass
Crosshead
Ø4
Piston Rod
8
Piston
R9,5
Ø19
Ø30
Only outline shown
20
18
12
Ø3 (C-C 13)
Ø18
30
101
Top CylinderCover
Ø32
Cylinder
30
Crankshaft
90
R4,0
9.5
6.35
9.5
R15.5
Conrod
Ø8
8
12
20
12
Tap M3
49
Ø3
M3
3
8
TH
Entablateure Engine – Cylinder etc
Material: Cyl. Gunmetal or CI


90
Top plate
6.5
9.5
10
Ø8
Alternative 2split bearings"
Ø3
7
16
12
4
8
22
M3
R4,0
Cast Iron
10
Ø6
49
Ø18
35
85
Top CylinderCover
Ø32
Cylinder
30
Ø8
Tap M4
64.5 mm
76 mm
10
13
8
23
10
76 mm
24
35
Top plate - Steel
Crankshaft not drawn
4
64 mm
TH
2021
Muncaster Entablateure
Top plate, bearings