AGC TWIN

NOTES FOR DRAWINGS

Before I start working through the drawings, there are a few points that should be made.
The first is that it's getting on for fifty years since I did any tech drawing and I haven't been too fussy as to whether the drawings follow first or third angle conventions – sometimes within the same drawing! I hope the meaning is clear.
The second point to bear in mind is that the flywheel is probably the most difficult thing to make given the method of construction. It needs a rotary table or dividing head to accurately drill the holes in the hub and the rim. A further complication is that given the outside diameter it is right at the limit that a Sieg SC4 lathe will handle. I would therefore suggest that the flywheel be tackled first.
The flywheel is based on a piece of 5” schedule 80 pipe (122.3mm ID x 141.3 OD) because there was an offcut of this at the steel merchants. I would suggest that if you're going to make this engine that you replace it with 4” schedule 80 pipe (97.1mm ID x 114.3mm OD) which will be a lot easier to handle with a small lathe and rotary table. I am sure the reduced inertia won't affect the engine operation to any great extent.
The third point is that the materials used are largely determined by what I had lying around and what I could source. They are therefore not set in stone and can in most cases be altered to suit your circumstances.
Although I normally work in metric, some of my materials and all my reamers are imperial so if you see the following metric dimensions, they probably refer to the imperial equivalents.

mm	Imperial
1.6	1/16”
3.2	1/8”
4.8	3/16”
6.4	1/4”
9.5	3/8”
12.7	1/2”

Drawings 1 and 2 are the side elevation and plan general assembleys and are self explanatory.

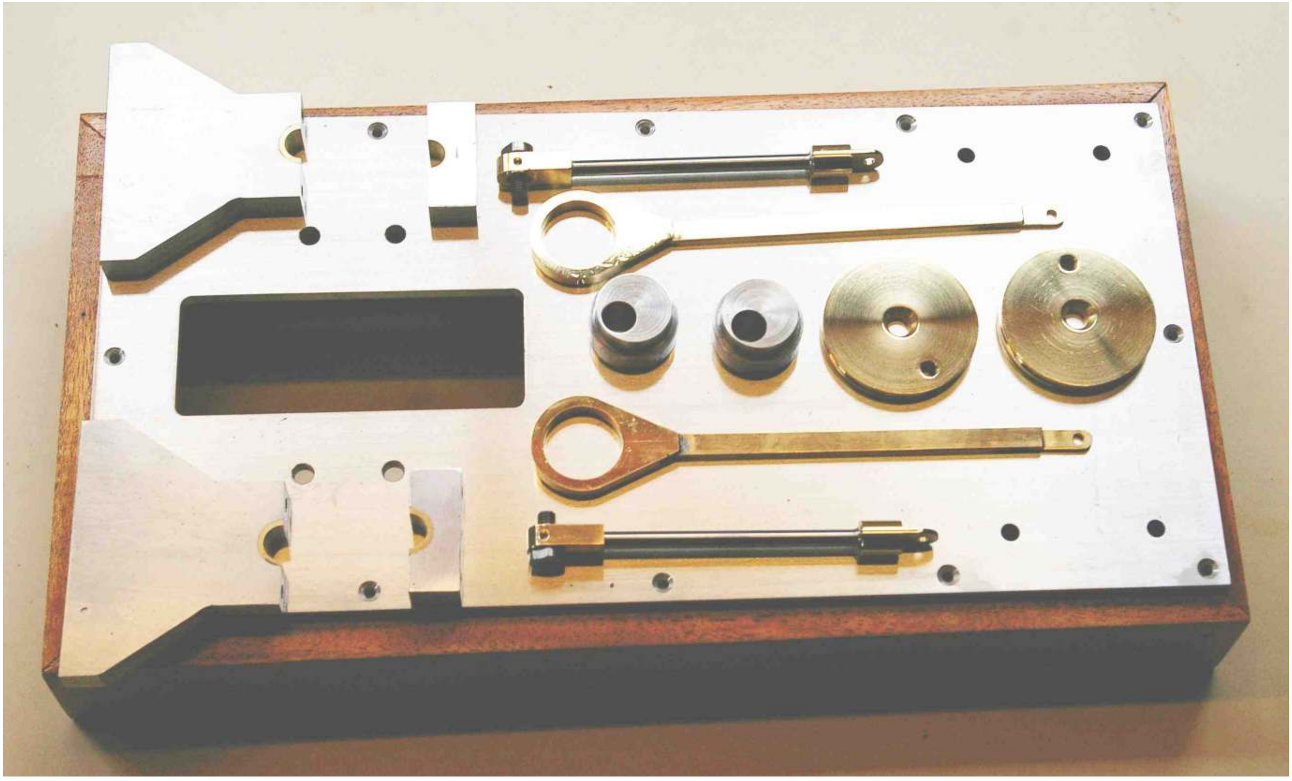
Sheet 3: PLINTH

The plinth is necessary because the flywheel protrudes 10.5mm below the baseplate. I made it 40mm high for aesthetic reasons and out of 20mm mahogany because I had some lying around. I constructed it using simple

mitre joints held together with PVA glue and brass nails.
An alternative would be to fit the base plate with 4 x 1/2" aluminium legs say 20mm long. It depends on what you like.

Sheet 4A: BASE - CUTTING GUIDE

This shows the outside dimensions of the base plate together with the flywheel cut out. I managed to source some 150mm x 5mm aluminium flat bar. I was a bit worried the 5mm thickness wouldn't be stiff enough but it is fine.
The ends were milled square to the final dimension.
The flywheel cut out was milled out using a 6mm slot drill giving the 3mm radius corners.



Sheet 4B: BASE – MOUNTING HOLES

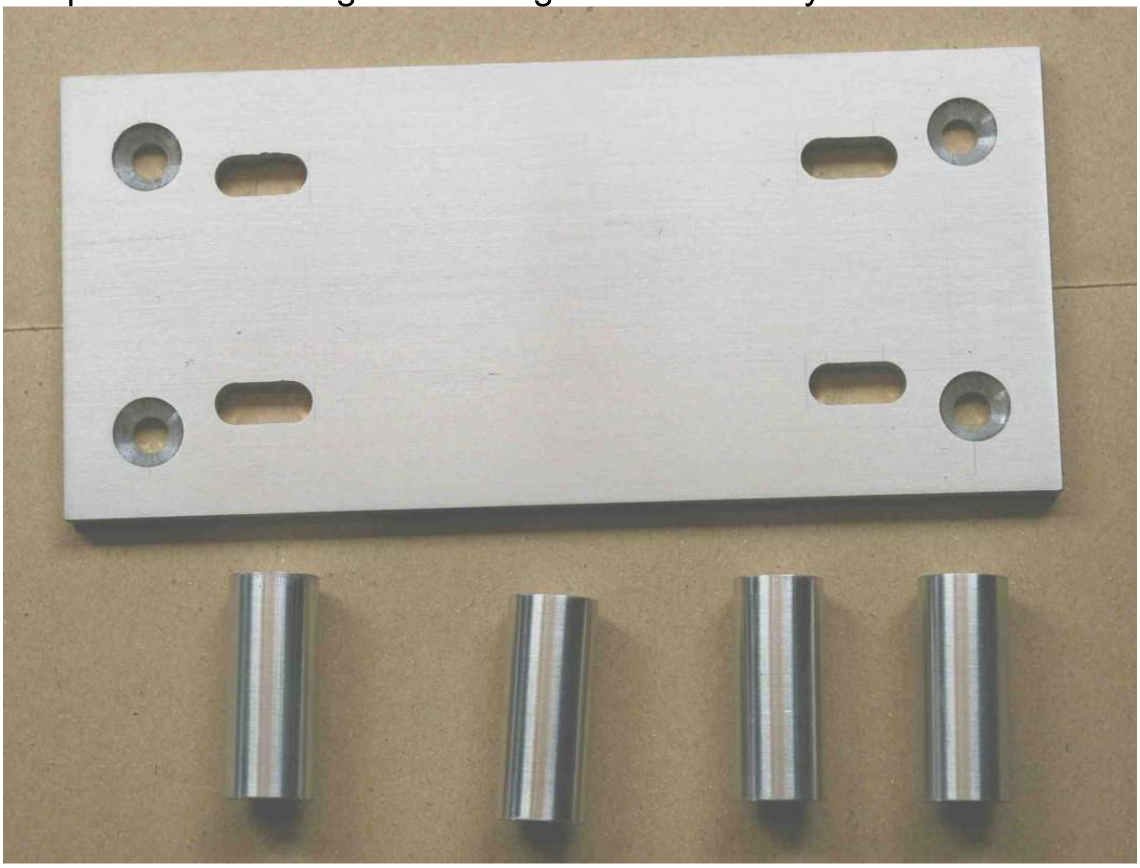
The position of the mounting holes for the flywheel supports and mezanine floor supports are shown.
The holes for the flywheel supports are just plain oversize holes for the 5mm screws.
The holes for the mezanine floor supports are countersunk with a 10mm spotting drill from the bottom to firmly locate the mezanine floor in the centre of the baseplate using 5mm csk screws.

Sheet 5: MEZANINE FLOOR SUPPORTS

These are made from 1/2” aluminium round bar to the dimensions shown.
The taps I have wouldn't reach all the way through so I needed to tap from each end to the middle.

Sheet 6: MEZANINE FLOOR

This is the platform the cylinders sit on. It is made from 5mm thick aluminium.
The holes for fixing the supports are countersunk on the top using a 10mm spotting drill. By using countersunk screws top and bottom of the supports means the platform is automatically fixed in relation to the baseplate.
The oversize (6.4mm) slotted holes for the 5mm cap screws and washers used to fix the cylinders in place allow the cylinders to be precisely aligned with the piston connecting rods during final assembley.



Sheet 7A & B: BEARING STANDS – CUTTING GUIDE

The bearing stands are made from 10mm aluminium bar stock. I have drawn these as I made them i.e. with a split bushing. The idea behind this was that if the bushing was fixed, the whole assembley fixed to the flywheel shaft would need to come off it each time the flywheel was taken off the supports. In practise, the split bushing didn't offer up much in the way of convenience so if I was doing it again I wouldn't bother and would instead go for a simple fixed bush or (if I could find them less than 10mm thick) go for 3/8” bearings.
I shall however describe the procedure for making the supports with split bushes.

Sheet 7A shows the dimensions for the support blanks which includes a 6mm cutting allowance for separating the top from the bottom. The 3.5mm holes are drilled before the two parts are separated to ensure the two parts fit precisely together.
Each support is cut at the indicated point and each side milled to the correct size. It is reccommended that the left and right supports be clamped together during this process to ensure they are identical.
The mounting holes on the top of the supports are then drilled out to 4mm while the holes below them are tapped for m4.0.
Both sides of the supports are then screwed together using m4.0 cap screws.
A 1/2" hole is then reamed through each support as indicated.
A length of 1/2" brass rod is then fitted to the lathe (preferably using a collet) and drilled with a 9mm drill to give a tube which is about 55mm long. This is cut into 4 pieces each about12mm long.
Each of these is then cut along its length so that one side is more than half of the cylinder.
Each of the larger sides is then glued into the reamed half holes in the tops and bottoms of the supports. (I wish I had taken some photos of this – I fear this written account is clear as mud).
I initially used a cheap generic cyano-acrylate glue for this (I can't make head or tail of which of the 3 million loctite products I should use) but it didn't stand up to the subsequent milling so I ended up using an araldite epoxy glue.
The glued in brass bushing halves were milled down until they were flush with the aluminium supports – (top and sides.)
The two sides of the supports were then fastened together with the shank of a 9mm drill held in the bushing to ensure they were lined up and the 9mm hole was then reamed out to 3/8".

Sheet 8: FLYWHEEL SHAFT

The flywheel shaft is made to the dimensions shown in the drawing. The threaded holes in each end should be countersunk to near the edge to accommodate the screw holding the crank disc in place.

Sheet 9: CRANK & CONNECTING SCREW

The crank disc was made from 6mm brass while the screw was made from steel. Don't make the disc any thicker without changing the offset on the valve rod (see sheet 13B.)

Sheet 10: VALVE ECCENTRIC

There are at least three different ways of making an eccentric – this is the easiest.
A length of 1" steel is centred in a 4 jaw chuck and the 21mm dia. step is

machined. The work is then positioned 5mm off centre and the 3/8” hole is drilled and reamed. The work is then fitted to a three jaw chuck and parted off.

Sheet 11A: FLYWHEEL

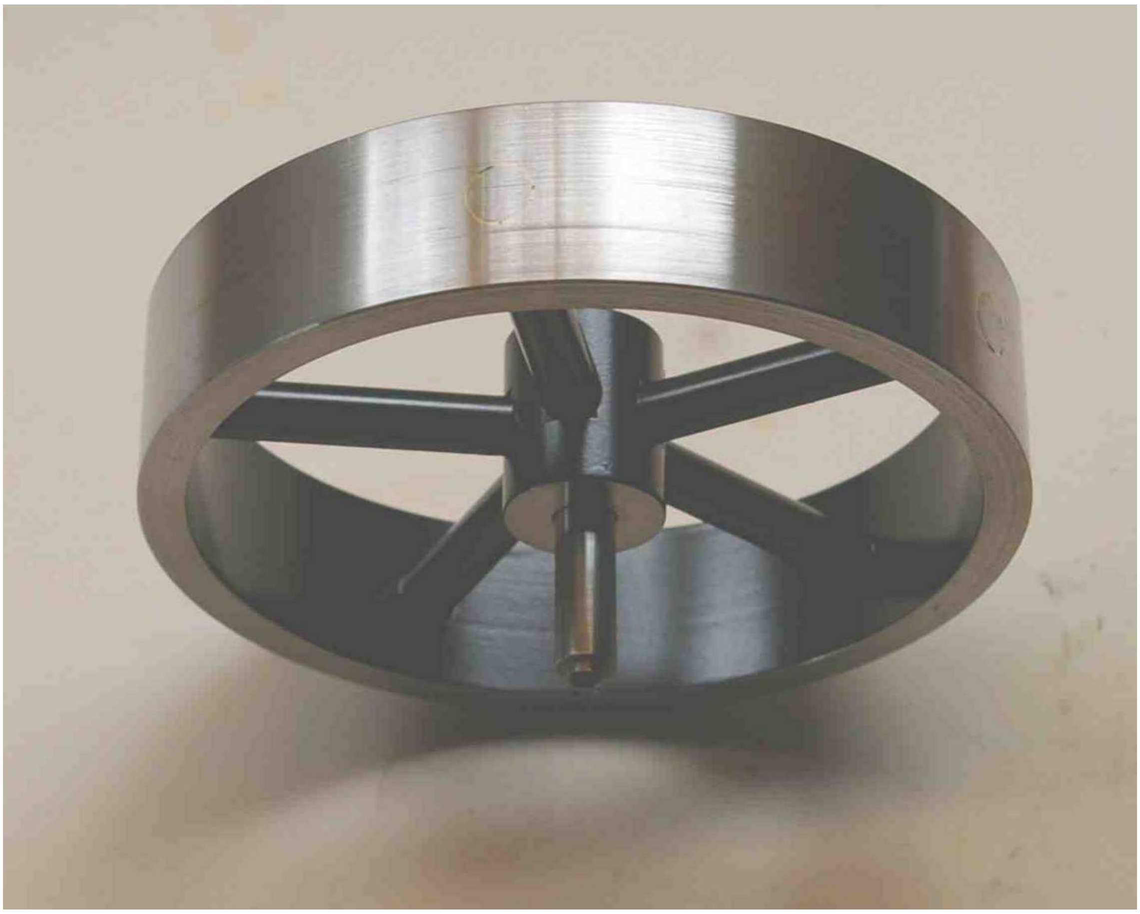
A side view of the finished flywheel.
This method of making a flywheel is very dependent on the accuracy with which the holes are drilled and the threads on the struts are formed. Once the struts are screwed into the hub, the whole assembley becomes rigid and if the hub is not concentric to the rim, it is difficult to do anything about it.This is also the advantage of this method of construction as all the bits are held firmly in place when the struts are brazed onto the rim.

Sheet 11B: FLYWHEEL RIM

The flywheel rim was made from a piece of 5” schedule 80 black iron pipe. This has a nominal OD of 141.3mm and a nominal ID of 122.3mm. I cut a 33mm piece off a longer length using an angle grinder fitted with a 1mm cutting disc. It took two discs to complete the job.
I then centred the piece as best I could with a DTI (the surface is pretty rough) in a 4 jaw chuck, machined the end flat and took the outside surface down until Iit was showing bare metal all round. Using a boring bar I did the same to the inside surface.
I then reversed the work in the chuck and centred it using a DTI on the section of machined surface which extended beyond the jaws. Again the end and inside and outside diameters were machined to give smooth surfaces.
I have an old Myford 4 jaw chuck which screws onto my dividing head and which was big enough (just) to accept the work.
The 5 holes for the struts were then drilled and reamed to 3/8” in the centre of the rim at 72° intervals. As I was going to use bronze (which doesn't flow as well as silver solder) to braze the struts in place I also countersunk the holes a small amount.

Sheet 11C: FLYWHEEL STRUTS

These were fabricated from steel. It is important that the threads are accurately aligned and central to the struts so the threads were cut to nearly the full depth on the lathe and only finished off with a thread nut. They are made about 10mm over length to allow the part sticking out from the rim to be used to tighten the struts onto the hub.



Sheet 11D: FLYWHEEL HUB

A length of 1” steel was centred in the 4 jaw chuck on the dividing head and 5 x 5mm holes were drilled 1/2” deep 72° apart and then tapped m6 x 1.0.
A 10mm endmill was then used to create 10mm x 10mm flats centred on the holes.
The hub was then parted off and the grub screw holes drilled and tapped at the positions shown.
Note – the central hole is not drilled at this stage.

ASSEMBLING THE FLYWHEEL

Each of the 5 struts were inserted through a hole in the rim and screwed hand tight into the hub. When all 5 were in place they were tightened by holding the bits sticking out in the vise and twisting the flywheel. At this point the hub is fixed and won't move. Hopefully it is reasonably central to the rim!
I brazed the struts onto the outside rim using bronze and an oxy/LPG flame. If I were doing it again, I think I would use silver solder.
As much of each of the protruding struts as could be removed without marking the rim was then hacksawed off and the flywheel centred in a 4 jaw chuck in the lathe using a DTI on the outside of the rim.
What was left of the protruding struts was then machined off and the central hole was then drilled and reamed through the hub.

The flywheel was then fitted on to a piece of 3/8" steel rod which was centre drilled in one end. It was clamped in place using grub screws with bits of 1/8" bronze brazing rod between them and the shaft. (Note – if you fasten a grub screw directly onto a shaft held in a reamed hole the burr which is raised will make getting the shaft out again really difficult.)
One end of the rod was then held in the lathe with a collet while the other end was supported on the tailstock centre. The sides and surface of the rim were then given light skim cuts until all the surfaces ran true. This setup is prone to resonate so it's important that the cutting tool is sharp, the rotational speed is low and that you stop at the first sound of any ringing noise.
I finished the flywheel off by spray painting the inner rim, struts and hub with a matt black paint.

Sheet 12: PISTON CON RODS

The crank end clevise is made fom 1/4" brass bar, the shaft from 3/16" diameter steel rod and the piston end clevis from 3/8" brass rod.
The drawing shows a small (0.4mm) relief provided on the crank end clevis to minimise the rubbing contact area between the clevis and the crank disc.
The three parts are joined together using the type of resin cored soft solder normally used for electronics and "Duzall" flux.
It is important that the axes of the reamed holes at either end of the connecting rod are parallel with each other.

Sheet 13A: VALVE ROD – BIG END

This was made from 5mm brass.
A centre was punched into a piece of the material which was large enough to be conveniently held on a faceplate on the lathe and the shape of the piece was scribed onto it.
The piece was then attached to a faceplate and the 21mm hole bored out until it was a close sliding fit on the valve eccentric. The piece was then cut and filed to the final shape and the slot in the end cut using a 1/16" slitting saw.

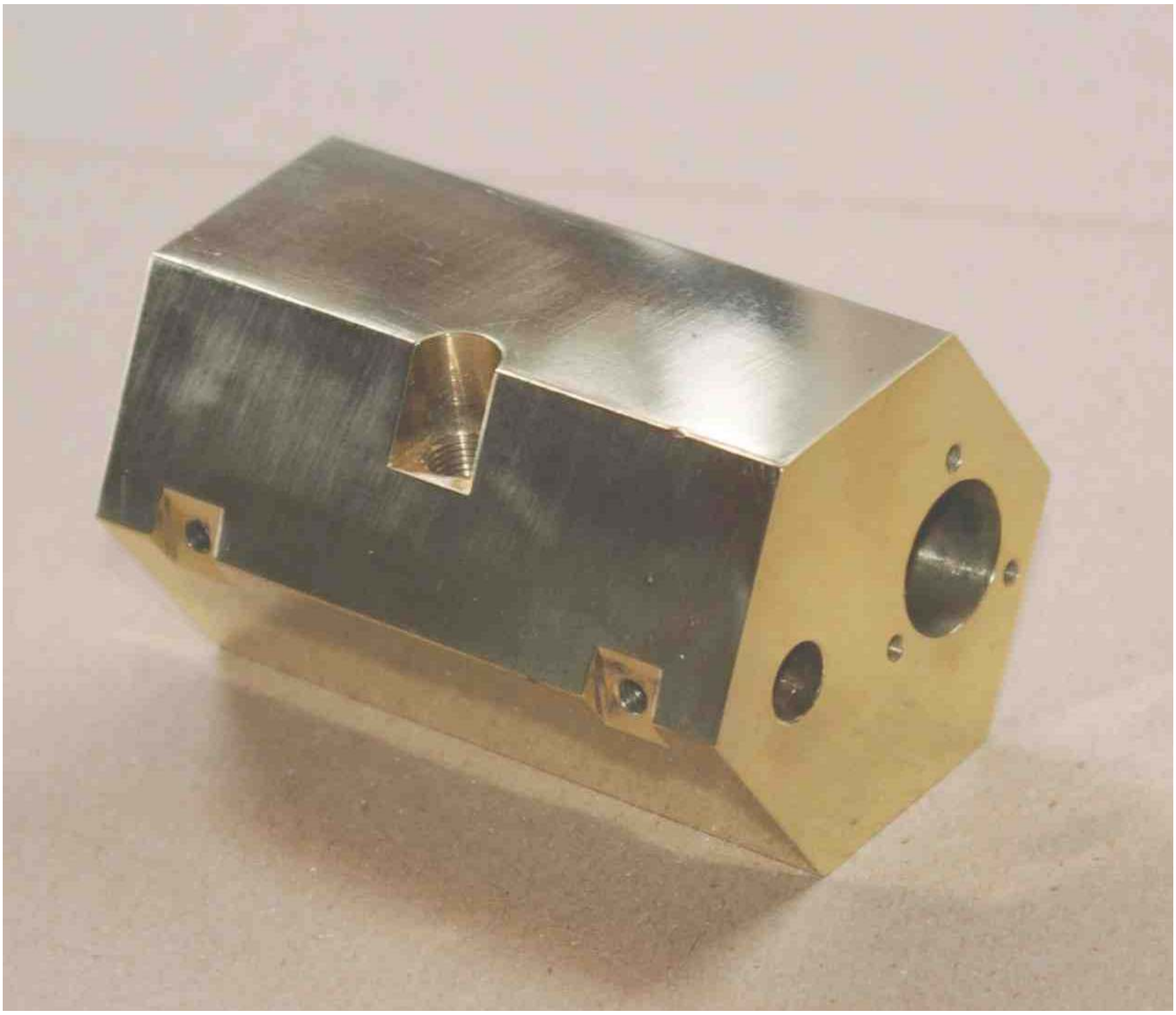
Sheet 13B: VALVE ROD

The main section of the valve rod was made from 1/16" brass to the dimensions shown in the drawing. It is soldered into the slot cut into the big end.
The section providing the offset required for the rod to line up with the valve in the cylinder was made from a piece of 1/8" brass bar.
There is no overall length shown on the drawing. This is best determined during final assembley when the two pieces are soldered together.
The oil hole should not be drilled until after the final assembley as the two

rods are mirror images of each other and it is too easy to end up with an oil hole at the bottom instead of the top of the big end.

Sheet 14: CYLINDER BLOCKS

The cylinders are made from 1 1/2” a.f. hexagonal bar. The reason for this is that I purchased some of this from a scrap metal dealer at a good price. There is no reason why another form (say 1” x 1 3/4” flat bar,) can't be used although if you do, you may need to alter the height of the mezanine floor to keep the centres of the cylinders in line with the centres of the crank discs.
Two pieces of the hex bar were machined to length and the positions of the main and valve cylinders were marked out and centre punched.
Ideally I would like to have mounted these in a 4 jaw chuck and drilled and reamed them on the lathe. However, because of where the holes were located and the geometry of the set-up, 2 of the jaws would need to be tightened on inclined faces which I didn't want to do.
I therefore drilled and reamed them on my mill after clamping them to the base. I was worried about the two holes being parallell but they turned out OK.
Using a 1/4” end mill 2 x 6.4mm squares were machined on the side of each cylinder block at the locations shown in the drawing. 2mm holes were then drilled from the centres of these squares through the valve cylinder and on through to the main cylinder. These provide the passages for the air/steam to get from the valve to the main piston.
The hole from the outside of the block to the valve cylinder was then drilled out to 2.5mm and tapped 1/8”ww. This was then sealed with a 1/8”ww brass screw with a teflon washer. The idea behind using a screw was that when it came to setting the position of the piston the screw could be removed and the shank of a 2mm drill inserted through the back hole to the main cylinder. The piston could then be pushed down the cylinder until it hit the drill at which point it was at bottom dead centre. As it turned out, I found it was just as easy to take the back end cap off and see when the piston was at that point. So it would probably be OK to soft solder a plug into the hole from the outside to the valve cylinder rather than go to the bother of tapping it.
Each of the cylinder blocks was fitted to a mandrel mounted on a rotary table and the 3 holes at each end of the main cylinders drilled and tapped as shown in the drawing. This was not done until the end caps had been fabricated and the holes in these were drilled at the same time without disturbing the rotary table position with relation to the drill.



Sheet 15: CYLINDER BLOCKS - DETAILS OF AIR/STEAM INLETS

A flat was milled into the side of each of the cylinder blocks to the dimensions shown in the drawing. A 4mm hole was drilled through to the valve cylinder. This was enlarged to 5mm dia. to a depth of 5mm and threaded m 6.0.

Sheet 16: CYLINDER CAPS

The easiest way to machine the rear caps is to mount a length of 1” brass in the lathe, turn it down to 23mm dia. and then machine the 12.7mm section, using the cylinder as a gauge. Part it off a little oversize, reverse it in the chuck and machine it to the right size.
As far as the front cap is concerned, a length of 1” brass should be turned down to 9.5mm dia. over 19mm. The work should then be parted off to give an overall length of 40mm (1mm oversize.) The 9.5mm dia. section is then mounted in the lathe chuck and the piece machined to the dimensions shown in the drawing, again using the cylinder as a gauge when machining the 12.7mm dia. section. The central hole is then drilled and reamed. Doing the

job in this order means the central hole will be concentric with the cylinder when the front cap is in position. This is important as both the piston and the piston shaft are both close sliding fits in the cylinder and central hole in the front cap respectively.
The 3 mounting holes in the cap flanges should be drilled while the parts are held in a rotary table and done at the same time as the cylinder blocks.

Sheet 17: VALVE PISTON

The valve pistons are machined from 1/4” steel to the dimensions shown in the drawing. It is very important that the lengthwise dimensions are accurate as they will determine how the valve piston and the holes in the valve cylinder interact to feed air/steam to the power cylinder.
It is as well that the shaft be made a little overlength and trimmed to size during the final engine assembley.

Sheet 18: PISTON

It is critical that the piston head and shaft are concentric and it is therefore desirable that the shaft be held in a collet.
A 12mm length of 5/8” dia. phosphor bronze was centrally drilled to 3/16” in the lathe and silver soldered to a length of 3/16” dia. steel.
The shaft was held in a collet in the lathe and the head machined to a bit more than 1/2”. The diameter was then slowly reduced until the head was a close sliding fit in the cylinder. The final diameter reduction was done with fine emery paper after a tight fit in the cylinder had been achieved. The ends of the head were then machined to give the required length of 10 mm.
It is as well that the shaft be made a little overlength and trimmed to size during the final engine assembley.

Sheet 19: PISTON AND VALVE CLEVIS

These were constructed from 3/8” brass rod to the dimensions shown in the drawing. The slots were cut with a 1/16” slitting saw and the rounded ends achieved by filing in the lathe (the exact profile isn't important).

Sheet 20: AIR/STEAM INLET PIPES

These were made from 2 parts.
The first is a 19mm length of brass pipe (6mm OD x 4mm ID) made by boring out a piece of 6mm dia. brass rod on the lathe. An m6.0 thread is cut into the outside over a length of 5 mm.
The second element was made from a male 3/16” brass compression fitting. The male thread was turned off the fitting and the diameter reduced to 8mm.The hole through the centre of the fitting was bored out to 6mm dia. to a depth of 4mm and the brass pipe inserted as shown in the drawing.
As it was intended to tighten the fitting in the cylinder block by using a spanner on the hexagonal upper section, the two pieces were silver soldered together instead of using soft solder.
Teflon tape was used to ensure a leak proof connection.

Sheet 21: AIR/STEAM MANIFOLD

This item shouldn't be made until the engine has been fully assembled and the cylinder blocks are fastened in their final positions.
It was made from a length of 3/8” OD 1/4” ID brass tube - because I had some available. It could just as well have been 3/8” or 10mm rod bored out on the lathe.
One end was plugged as shown in the drawing. Compression rings were tightened onto the ends of two lengths of 3/16” copper tube and they were fitted into the compression fittings of the inlet pipes screwed into the cylinder blocks.

The centre - centre distance between the two was determined and two 3/16” holes drilled in the brass tube the correct distance apart.
The two copper tubes were then removed from the inlet pipes and soldered into the brass tube - ensuring they were level.
The thread was then turned off another 3/16” compression fitting which was soldered into the end of the brass manifold tube. Alternatively, it could be screwed in if a piece of bored rod with a relatively thick wall was used instead of thin walled brass tube.

ASSEMBLEY

The first task is to fit the flywheel supports. It is assumed that the end of the base plate is square to the length.
The outside edge of one of the supports is marked with a pencil on the baseplate. The two mounting screws are loosely screwed in, and the support is positioned against a square held along the back edge of the baseplate. The mounting screws are then tigthtened down.
The flywheel shaft is inserted through the bushing of the support already installed and the second support bushing. The second support is then positioned to give a small ammount (say .5mm) of overhang of the flywheel shaft to provide clearance for the crank discs. The second support is then screwed down.
Because of the close tolerances between the reamed bushings and the steel shaft, the shaft will probably not rotate freely at this point, and one of the the bushings needs to be reamed again to ensure they are perfectly in line. This was achieved by making a reamer from a piece of 3/8” rod in the manner shown in the picture below.

It was made by milling 3 flats into a piece of 3/8” rod and chamfering the end. The reamer is inserted through the first bushing and brought to bear against the second bushing. Oil is applied through the oil hole in the first bushing. The reamer is then fitted into the chuck of an electric drill and rotated (slowly) while it is pushed through the second bushing. When the cutting edges have

cleared the second bushing the drill is stopped and the reamer removed from the chuck before being removed from the bushings. Don't try withdrawing the reamer while it is still under power. The flywheel shaft should now rotate freely in the supports with little or no play.
If you have made the supports with split bushings, the flywheel is now positioned in the centre of the shaft and fastened in position with the grubscrews (don't forget to put a bit of 1/8” brass rod between the screws and the shaft.)
The valve eccentrics (with the valve rods in place) are installed on the shaft but not tightened down at this stage.
The 2 crank discs are positioned on the ends of the shaft and are fixed in position by the countersunk screws. Use 2 Allen wrenches in opposition to each other - the screws need to be tight as one of them will be subjectected to a torque which will tend to unscrew it when the engine is running. The crank pins should be offset by 90° (by eye is good enough). The piston con rods are then fastened to the crank discs using the crank pins.
The shaft is then placed onto the bottom half of the bushing and the top half fastened into place.
If you have opted to go for a one piece bushing or bearings, you will need to thread the shaft components on as the shaft is inserted through them.
The legs of the mezanine floor are then attached and the cylinder blocks (complete with front caps, pistons and piston clevises but not the rear caps) are loosely screwed on. This assembley is then screwed onto the base.
Each of the piston blocks is then aligned with its con rod by shifting it sideways until the con rod clevis slides freely through the piston clevis. This is done while the block is held against a square which in turn is held against the back of the mezanine floor. When the block is aligned it is tightened on the mezanine floor. I used cap screws to mount the blocks but it was a bit awkward getting the Allen wrench engaged - if I was doing it again, I would probably use hex head bolts. Don't forget to use a plain washer to stop the block from shifting as it is tightened down.
Once the cylinder blocks are fixed in position, the valve pistons can be fed in from the back and connected to the valve rods via the clevises.
The next task is to get the power pistons and the valve pistons to travel over the correct ranges within their cylinders.
At the extreme end of its travel, (i.e. the crank pin at its closest to the cylinder block) the bottom of the power piston should be adjacent to, but not covering the 2mm hole between the valve and power piston cylinders. This can either be observed through the back of the cylinder or the shank of a 2mm drill inserted in the air/steam hole and the piston pushed up against it. The screw holding the clevis onto the piston shaft is slackened off while this adjustment is carried out and is tightened again afterwards.
The valve piston is adjusted after the valve eccentric is temporarily tightened onto the flywheel shaft. If all the dimensions of the cylinder block and the valve piston are crack on the end of the valve piston should sit 0.5mm from

the end of its cylinder at its extreme position. It may however be better to adjust it so that the piston oscillates symmetrically within the cylinder as determined by observing the ends of the pistons at each end of its travel.
Again, this adjustment is carried out by sliding the shaft of the valve piston within the clevis and locking it in position with the screw.
Once the travels of the power and valve pistons have been set, the timing of the air/steam pulses can be set.
I found this to be easier if each cylinder block is treated separately. To this end, one of the cylinder blocks is disconnected by pulling the pins from the valve and piston clevises.
An air supply (5 - 10psi) is supplied to the cylinder to be timed. The air/steam manifold should not be in position at this time.
The valve eccentric is slackened off on the flywheel shaft and rotated so that it is offset 90° to the crank pin i.e. if the crank pin is in the horizontal position, the eccentric should be in the vertical position. It is then clamped to the flywheel shaft with the grubscrew.
Turn on the air supply.
At this point, (if, unlike me, you've remembered to put the back cylinder caps on) the engine should run if you give the flywheel a bit of a turn.
The next step is to optimise the offset to give the best performance (i.e. the engine runs with the least air pressure.) This is achieved by making small adjustments to the eccentic/crank pin offset either way until the optimum position is determined. Note which way the flywheel is turning.
The procedure is repeated for the other cylinder with care being taken that the flywheel is rotating in the right direction. If it doesn't, rotate the eccentric 180°.
The air/steam manifold is installed. With both cylinders operating, the engine should self start when air is applied.

Good Luck