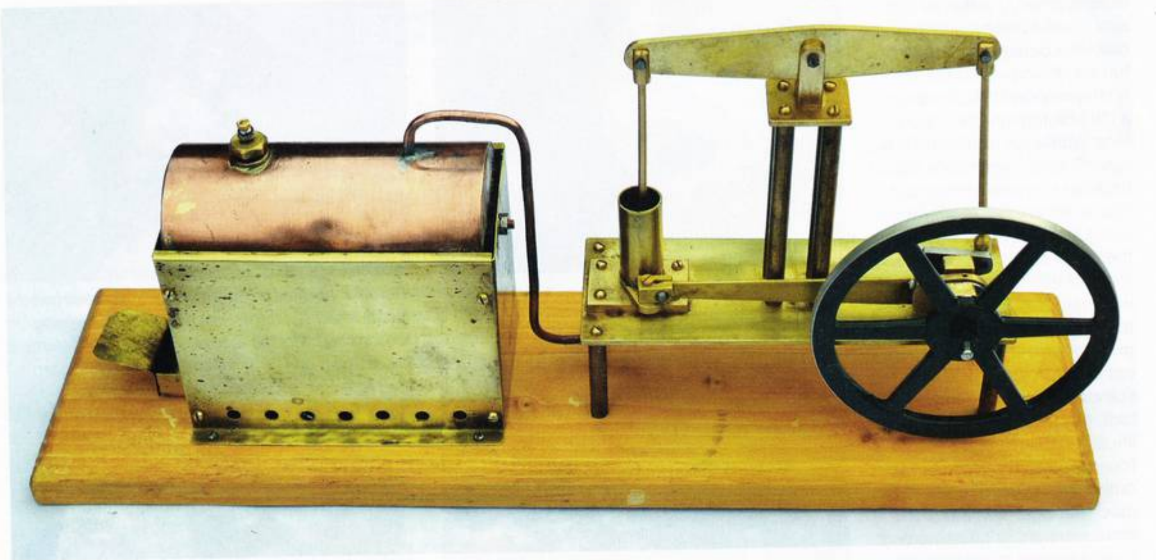


A Simple Beam Engine... With a Twist

Would you like to build a simple beam engine that requires no expensive castings? Yes? Well this could be the article for you.

Tony Wright designs a simple, yet unusual, beam engine.

Despite the apparent simplicity of the model, the design took quite a long time to gestate. The valve arrangements took the longest to figure out; originally the intention was to have a piston valve which would let a puff of exhaust steam out. But I could not think of a simple and neat arrangement. I decided to figure it out retrospectively once I had actually built the model. I had also decided that the engine would be single acting, thus I could do away with any requirements for parallel motion and the piston rod could move in the style of an I/C engine.

I had made good progress in the build, when I had my *Eureka* moment. I had been reading about the development of a four stroke I/C engine where the whole cylinder rotates to give the valve events. I thought I would do the same! Back to the drawing board I tried to figure out a method of rotating the cylinder. Yet again my mind went blank. Then came the simplest of design solutions: make the cylinder oscillate in the vertical axis. How simple? As the cylinder twists the ports would open and shut just as they do in an oscillating engine.

Solving a problem, however, always leads to another and in this case it was the question of how to drive the cylinder back and forth. (Yes I know all of you reading this article are now thinking ... is he stupid? It's obvious *now* how to move the cylinder - it is now you see it. But it wasn't obvious at the time.)

The main problem was the slight movement of the valve rod in relation to the eccentric. I was worried that the eccentric would bind. I had envisaged pivots at both ends of the valve rod. Again I was not happy with the arrangement so I opted just to pivot the rod at the cylinder end. The minute moment on the eccentric caused no problem so if you build this engine

Solving a problem always leads to another and in this case it was the question of how to drive the cylinder back and forth.

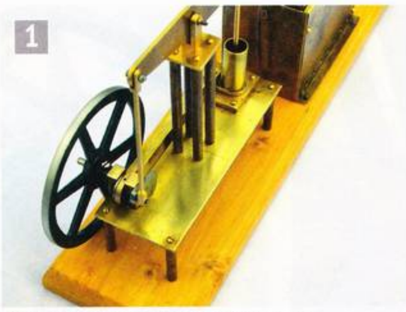
don't go for a wring fit on the eccentric. Incidentally, if I have re-invented the wheel I do apologise but I have searched on the Internet and I can't see any thing similar. Maybe readers know otherwise?

On with the build

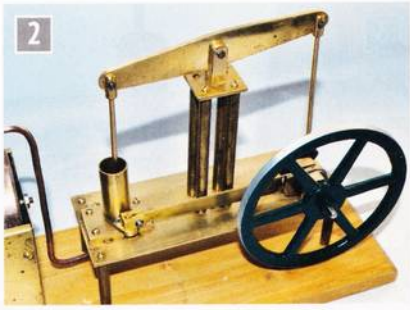
Start with the base (**part 1**) and mark this out as accurately as possible (**photo 1**). A few words for beginners might be appropriate here. Cut the base to shape but remember when cutting brass that you will need to use tools that have not been used on steel. You will find that they won't cut neatly but will just rub. Also, be careful when drilling brass as it tends to snatch, which is not a big problem with the smaller hole but if you intend drilling larger holes you can use the old dodge of putting a small flat on the face of the drill bit. Let me explain. Hold the drill bit vertical, then, with a piece of emery on a stick, rub the face of the cutting edge. This small flat will prevent drill from snatching. Make sure you hold the parts down with clamps. DON'T HOLD THE PARTS IN YOUR BARE HAND - not unless you fancy a trip to the hospital. The top bearing mount (**part 2**) and the port block (**part 3**) should also be prepared at this time. Using double sided tape or Superglue, affix these parts to the base. Use them as a jig to mark out the matching holes in the base. Mark through then remove.

The vertical columns are next on the list (**parts 4** and **5**). Making these is a simple and enjoyable turning job. Cut the four long ones and four shorter base legs to length. If your lathe has a depth stop it's plain sailing to get the lengths all the same. If not it's out with a rule and a scribe. Face all ends, drill and tap 8BA.

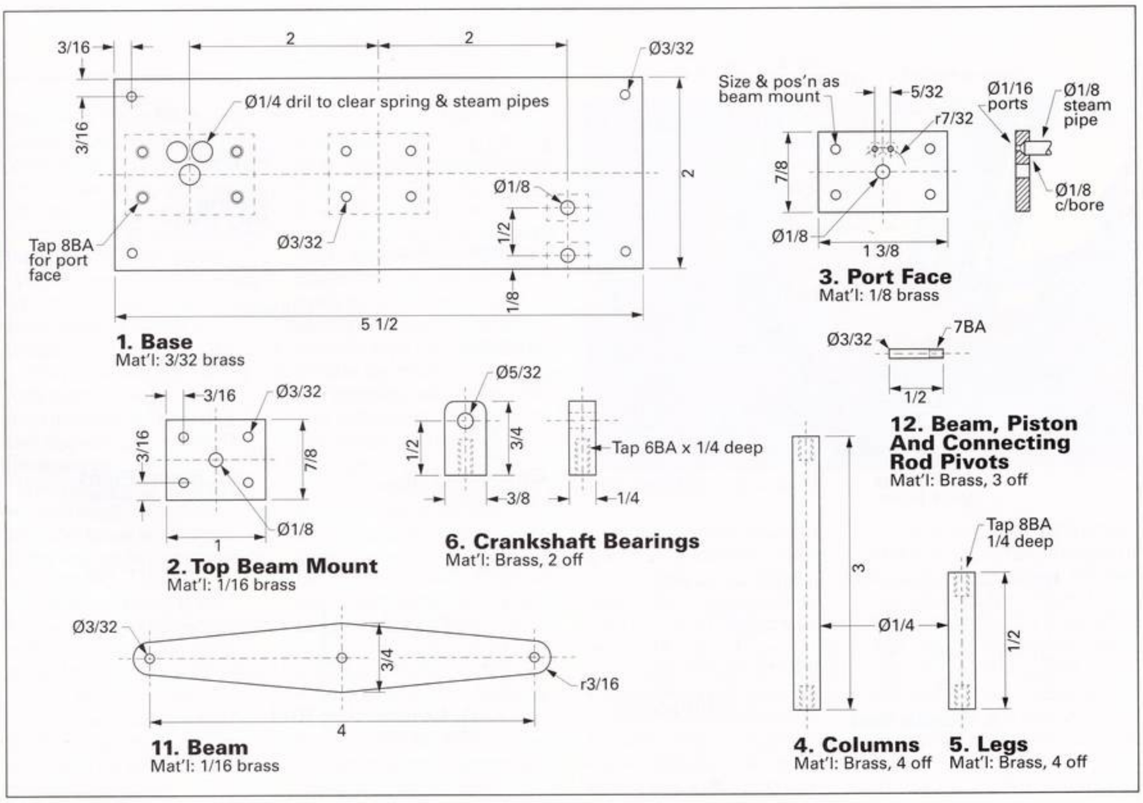
The next parts to make are the crankshaft bearings (**part 6**). Take a length of ⅜ x ¼ inch brass and mark out two bearings. Before cutting to length, drill and ream 5/32 inch. Cut to length. Now, unless you are an absolute wizard with a file I would suggest you cut a short length of 5/32 inch round and mount the two bearings onto it. Place in the four jaw chuck and face to size. Whilst the four jaw is out you might as well use it to assist in drilling and tapping the end of the bearings (one at a time). The main beam bearing (**part 6a**) is made in the same way as the crankshaft bearings, except that it has a slot for the beam (**photo 2**). There are several ways to cut this slot. You could

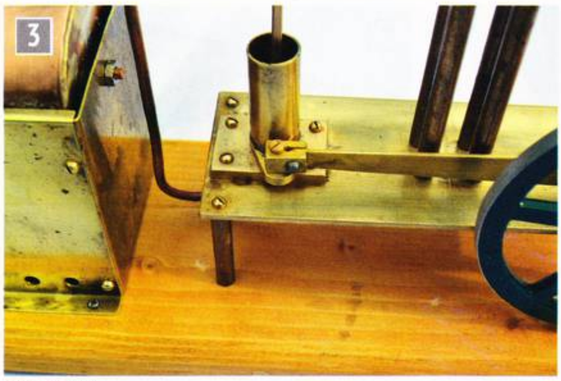


The base plate and the top bearing mount.

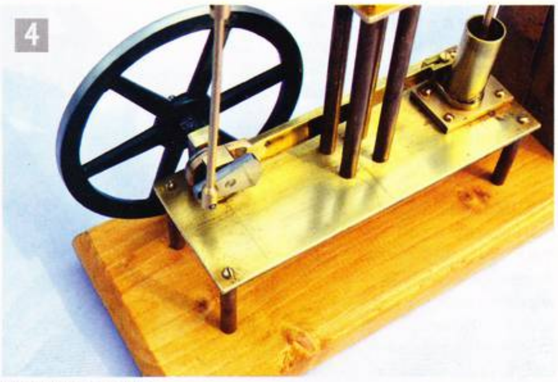


The main beam bearing.





The clyinder.



The crank assembly.

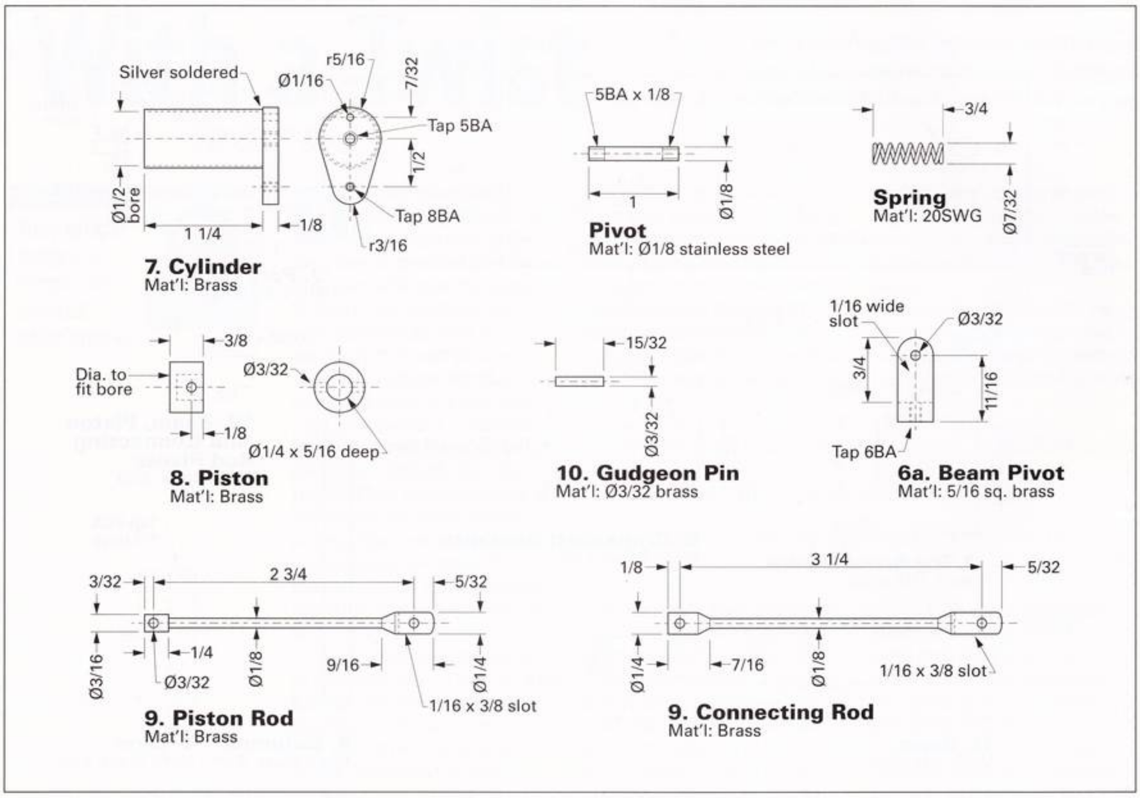
use a slitting saw in the lathe or mill, cut it by hand or with a band saw which is the way I did it.

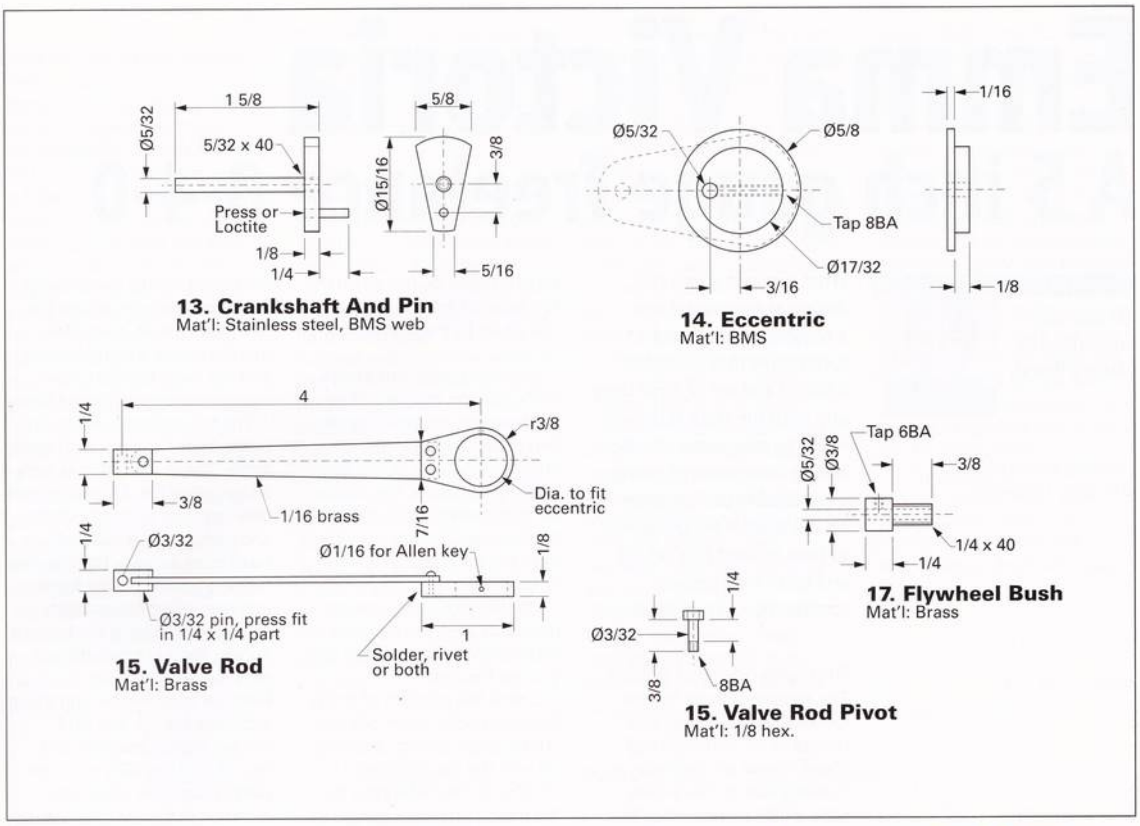
Moving on to the parts that move

Starting with the cylinder assembly (**part 7**). This is just a length of smooth bore brass tube, cut to length and finished in the lathe (**photo 3**). You can, of course, carve the cylinder out of the solid. The cylinder end is cut out of ⅛ inch brass sheet. Don't drill any of the holes just yet. The cylinder and the end are silver soldered together. Next, a delicate operation; because of the silver soldering the cylinder will be quite soft so, if we put the cylinder straight into the three jaw chuck we aren't going to end up with a round bore. I would suggest you turn a length of brass round to fit the cylinder bore, just a light push fit. Put it in the cylinder, then we can chuck the part in the lathe. Don't go mad with the chuck key!

Now we can mark out the three holes in the base of the cylinder. With the cylinder base horizontal, so to speak, scribe a line using a lathe tool across the bottom of the cylinder. Next, start up the lathe. With the smallest centre drill you have, just lightly mark the centre of the base. We can now use this as a reference point to mark the position of the steam port and the linkage hole. Next drill and tap the pivot hole 5BA. The pivot itself is just a length of ⅛ inch diameter stainless round, threaded each end 5BA.

With the cylinder removed from the lathe, drill the steam port. Drill and tap the linkage





hole. Next, the piston (**part 8**). Chuck a suitable length of brass round. Face off and centre drill. We can now open up the piston rod hole with a ¼ inch drill and, to finish, a ¼ inch end mill. Turn the outer until it just fits the cylinder bore. Finish with emery for a nice sliding fit. Part off to length and drill 3/32 inch for the gudgeon pin.

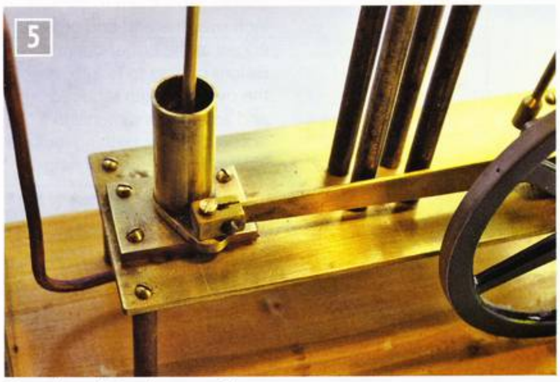
The piston and connecting rods (**part 9**) can be turned from the solid or fabricated. Drill and slot as described in the drawings.

The gudgeon pin (**part 10**) is just a length of 3/23 inch diameter brass or stainless round and no further comment is necessary.

The beam (**part 11**) is a simple job to mark out, drill and cut to shape, finishing it off with a file. Whilst the 5/32 inch round is to hand you might as well prepare the beam pivots which are simply three lengths with a 7BA thread at each end.

The crankshaft (**part 13**) is another length of 5/32 inch round stainless steel with one end threaded 5/32 inch x 40 ME (**photo 4**). Cut the crank web from a suitable piece of mild steel and drill and tap for the crankshaft. The hole for the crank pin is drilled 3/32 inch for a Loctite fit or slightly under for a press fit. After the crankshaft is fitted to the crank web you can tidy up the round parts of the web in the lathe - light cuts at high speed. You can now fit the crank pin.

The eccentric (**part 14**) is a simple turning job. Starting with a piece of round bar in the three jaw, turn to size then part off. The hole for the crankshaft should be tackled next. After carefully marking the position of the hole you could drill it on your drill press but I did mine in the four jaw. Don't forget to protect the 'working part' of the eccentric when you grip it. The eccentric needs to be drilled and tapped 8BA.

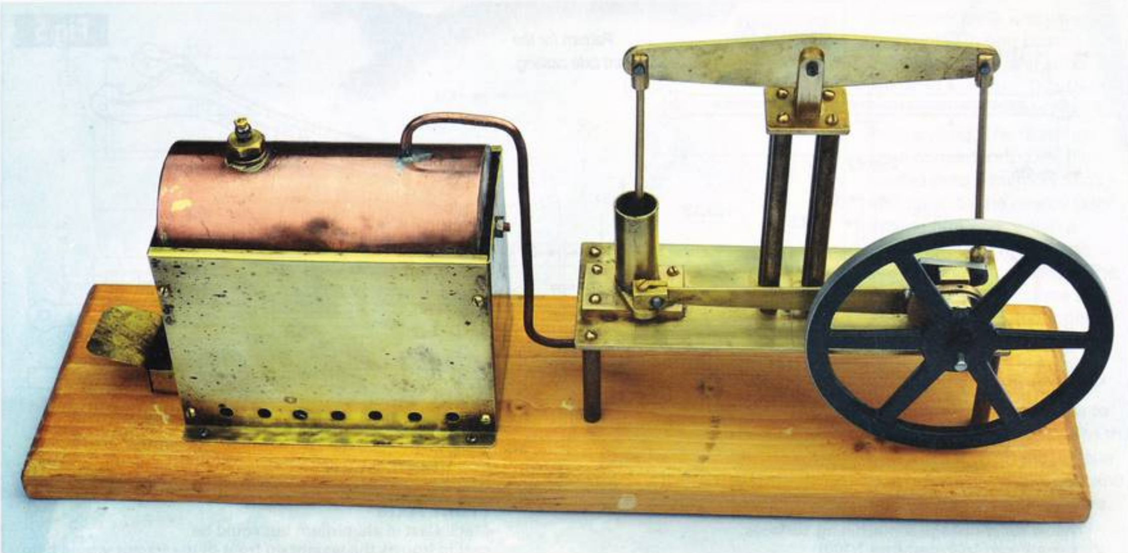


Close view of the valve assembly.

For the valve rod assembly (**part 15**) the eccentric sheave is made from ⅛ inch sheet brass cut to shape. We then need to bore it: I would suggest you do it in the four jaw. Centre drill, then drill and finish off with a small boring tool - just a nice running fit on the eccentric. A couple of thou' clearance is okay. Note the hole for the access to the 8BA grub screw.

The universal joint is a small block of brass. Take a length of brass square; slot and drill then cut to length. It's a fiddly job to make if you cut it to length first. (You have been warned!) We will have to wait until the engine is erected before we make the link from the eccentric to the universal block (**photo 5**).

● To be continued.



A Simple Beam Engine... With a Twist PART 2

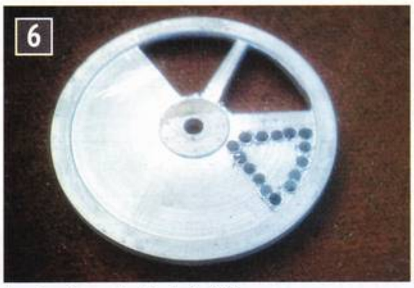
Would you like to build a simple beam engine that requires no expensive castings? Yes? Well this could be the article for you.

Tony Wright designs a simple, yet unusual, beam engine.

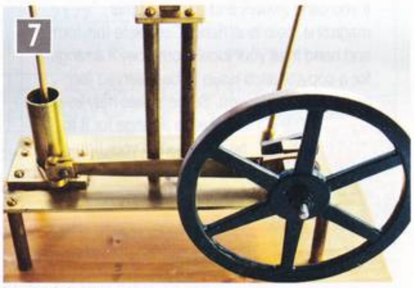
Continued from p.827
M.E. 4509, 29 May 2015

The flywheel (**part 16**) is cut from a piece of 3⁄16 inch thick aluminium. With your dividers set, scribe the diameter required, drill the centre of the blank ¼ inch. Now cut the circle by whatever means. I used my trusty band saw. We will be dressing the fly wheel on the lathe so you don't have to be too accurate. To mount the flywheel in the lathe we need a mandrel. Any material will do - I used a short end of 1 inch diameter bright mild steel. Turn a ¼ inch spigot onto which you can mount the flywheel and put a ¼ inch x 40 ME thread on the end of the spigot. Secure the flywheel with a suitable nut re-threaded ¼ inch x 40 ME. Turn the outside diameter and form the recess front and back. We can use the three jaw chuck as a simple dividing head to mark the positions of the flywheel spokes. Set the number one jaw horizontally to the lathe bed. Measure the distance between and cut a length of wood to suit the gap. We now have a dividing head. Scribe across the flywheel with a lathe tool.

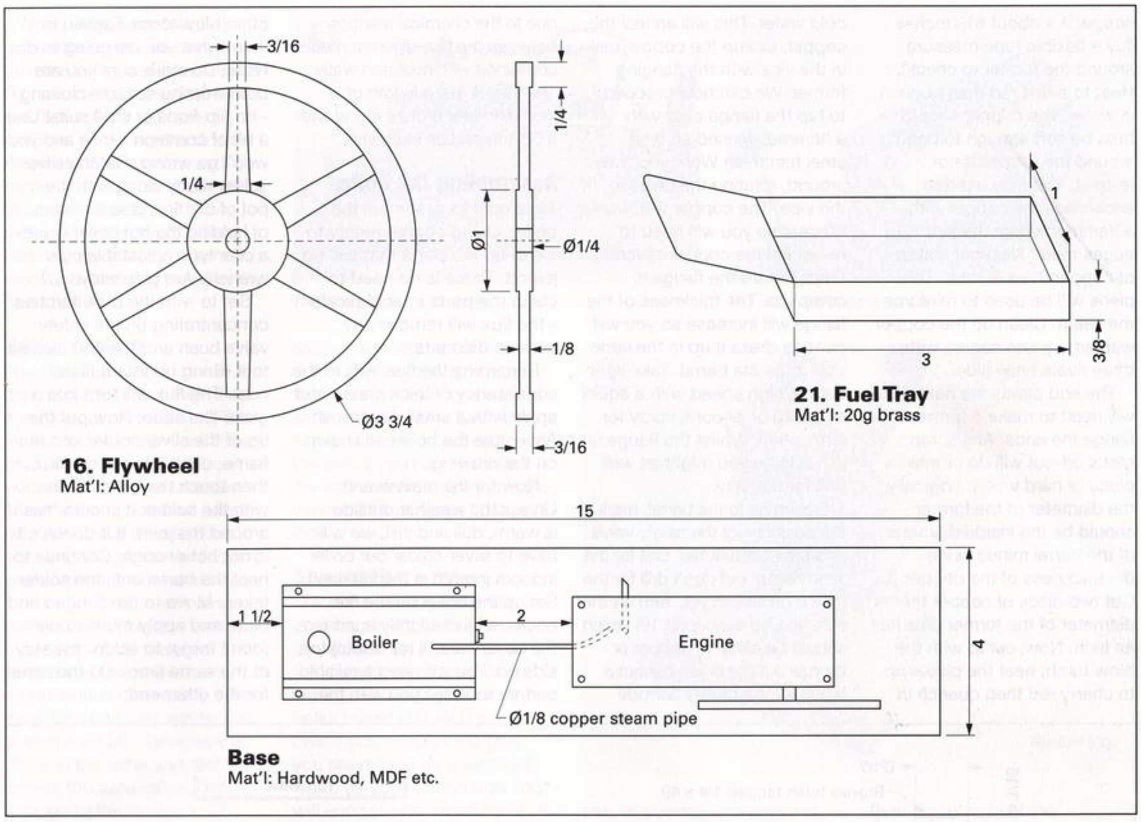
Remove the length of wood and rotate by hand the three jaw chuck. Using the length of wood, put number 2 jaw in the horizontal position. You can guess the rest. Remove the flywheel from its spigot and finish marking out the spokes. To remove the waste between the spokes I chain drilled them then set to with a file (**photo 6**). All good fun! To mount the flywheel onto the crankshaft (**photo 7**) we will need to turn a mounting bush (**part 17**). Chuck a length of ⅜ inch diameter brass and face off; turn to ¼ inch diameter to the



Forming the spokes by chain drilling.



The finished flywheel.



required length. Thread ¼ x 40 ME. Centre drill, followed with a 5/32 inch drill then part off to length. Drill and tap for the 6BA grub screw.

Putting it together

We should have enough parts to build our beam engine now, apart from the valve rod link, which we will come to later.

First fit the port block (we will fit the steam pipes later) followed by the crankshaft bearings. Now, if we lay a 6 inch rule on the flat we can measure the distance between the port block pivot hole and the middle of the crankshaft bearing hole. Note this down. This is the finished size required between the eccentric sheave centre and the universal block, upright hole centre. I hope that makes sense?

Cut a piece of brass sheet for the valve rod link. This is now screwed or riveted to the side of the eccentric. Mark the position of the 3/32 inch hole at the other end, so the distance corresponds with the measurement you took previously. We can now build the engine.

Start by fitting the cylinder pivot; secure and seal with Threadlock. Introduce it to the port block; it is held in place by a ¾ inch x 7/32 inch spring and a suitable nut. Next fit the upper and lower columns. To the top bearing mount, add the beam bearing, securing it to the upper columns. Now we can fit the piston rod to the piston with the gudgeon pin. Slip it into the cylinder. Fit the beam with one of the 3/32 inch pins (**part 12**).

Connect the rod to the beam with another 3/32 inch pin (part 12). Assemble the crankshaft, eccentric, eccentric sheave and the flywheel bush (**part 17**). The eccentric position should be… how can I say?... the fat end should be directly opposite the crankpin.

The easiest way to set the valve events is as follows: tighten up the grub screw, connect the valve rod to the universal block then to the cylinder with a shouldered bolt (sorry I forgot to tell you to make that part but I'm sure if you've got this far that won't be too taxing for you produce). Fit the connecting rod. Fit the flywheel and that's it!

Now, if I've done my job correctly in describing this engine's construction and the right sizes appear on my drawings you should be able to invert the engine and rotate the flywheel; the ports will open and close at the correct time. With the piston at TDC the exhaust port will just about to open. Similarly with the piston at BDC the steam port will be just about to open.

Lets build a boiler (part 18)

With the price of materials sky high at the moment, let's see if we can keep the costs down. If we buy a sheet of copper 6 x 12 inches we can make a full boiler without buying a length of tubing. We can 'roll our own', as they say. It's not that difficult to form a barrel. You can, of course, use ready formed tubing but I am trying to reduce the costs. Anyway let's begin.

To satisfy the heating requirements, two DIY torches will suffice as long as you use the mixed gas type (propane-butane). You will need a couple of fire bricks to support the boiler. If you contact any of the model engineering suppliers and ask for Easyflo No. 2 replacement I am sure they will come up with the goods, together with a suitable flux to boot. You will also need a few 3/32 inch copper rivets and a 5 inch length of ⅛ inch diameter bronze rod.

First find yourself a suitable former about 2 inches diameter. An old rolling pin would do nicely. Cut a piece of » copper 4 x about 6⁵⁄₁₆ inches (lay a flexible tape measure around the former to check). Heat to a dull red then quench in water. The copper should then be soft enough to bend around the former. If not, re-heat. You may need to encourage the copper with a hammer where the two edges meet. Next cut a strip of copper 3½ x ¾ inch. This piece will be used to reinforce the seam. Clean up the copper with emery and secure with three rivets each side.

The end plates are next. You will need to make a former to flange the ends. Any scrap metal off-cut will do or even a piece of hard wood. Logically, the diameter of the former should be the inside diameter of the barrel minus twice the thickness of the copper. Cut two discs of copper the diameter of the former plus half an inch. Now, set to with the blow torch; heat the plates up to cherry red then quench in cold water. This will anneal the copper. Clamp the copper disk in the vice with the flanging former. We can now proceed to tap the flange over with a hammer. (I used an 8 oz. steel hammer.) Work your way around, rotating the piece in the vice. The copper will 'work harden' so you will need to re-anneal the copper several times before the flange is complete. The thickness of the flange will increase so you will need to dress it up in the lathe until it fits the barrel. Take light cuts at high speed with a squirt of WD40 or silicone spray for lubrication. Whilst the flange is in the lathe you might as well drill for the stay.

Returning to the barrel, mark the positions of the safety valve and the steam outlet. Drill for the safety valve but don't drill for the steam outlet just yet. Turn up the safety valve bush (part 19) which should be either of copper or bronze but not brass because brass will eventually corrode due to the chemical reaction between the two different metals combined with heat and water. The stay is just a length of ⅛ inch diameter bronze round with a 5BA thread on each end.

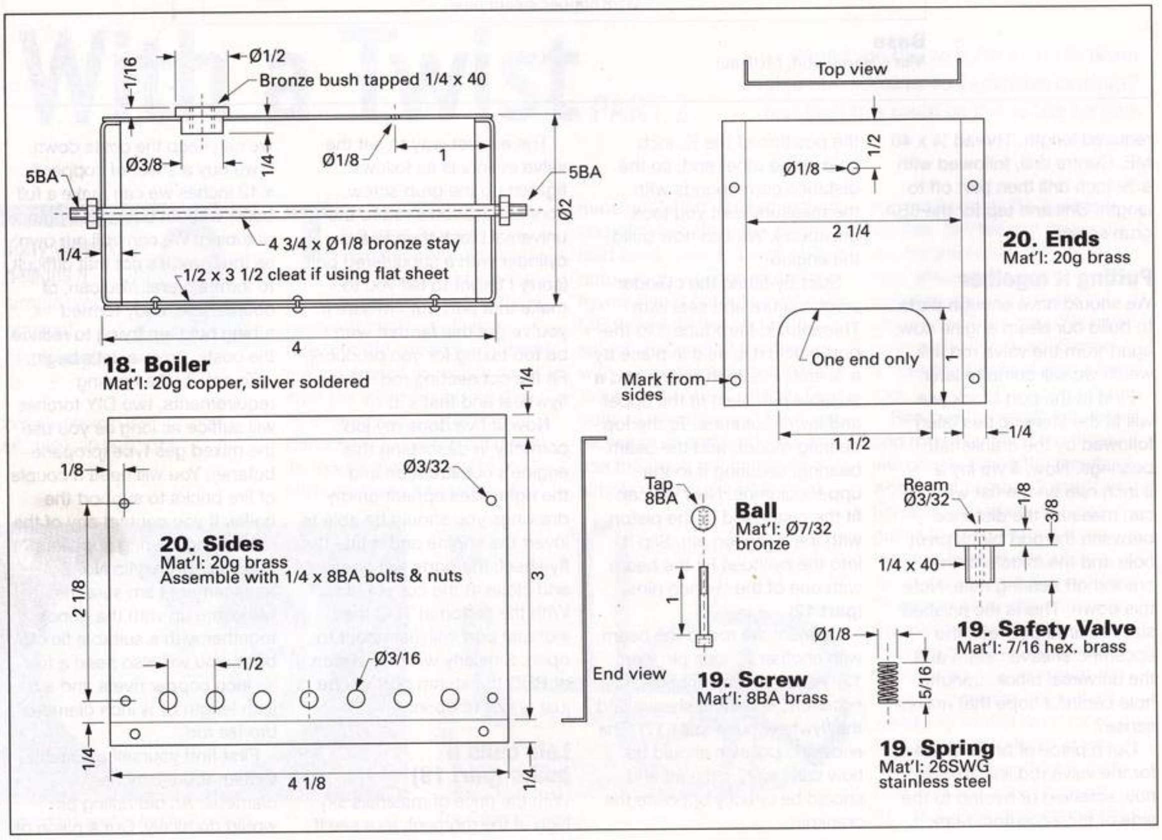
Assembling the boiler

Time now to assemble the boiler. Using coarse emery to clean up the parts that will be joined. There is no need to clean the parts in acid pickle - the flux will remove any surface oxidants.

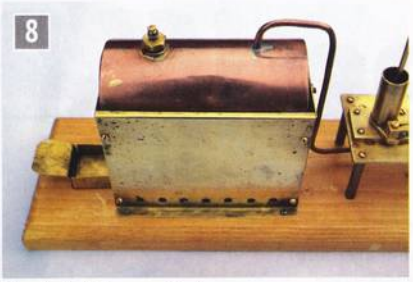
Regarding the flux, mix to the consistency of thick cream and apply with a small paintbrush. Assemble the boiler as shown on the drawing.

Now for the main event! Unless the weather outside is warm, dull and still, we will have to silver-solder our boiler indoors (no not in the kitchen!). Set up the boiler on the fire bricks set just slightly apart (so the boiler cannot roll about) top side up. You will need a reliable partner to assist you with the other blow torch. Explain to them what you are going to do. **Note:** Do make sure you are both wearing suitable clothing - no flip-flops or shell suits! Use a bit of common sense and you won't go wrong. Get the silver solder ready along with the pot of dry flux, also a means of holding the hot boiler (I use a plier type adjustable pipe wrench). Are you ready ... ?

Set to with the blow torches concentrating on the safety valve bush and the end closest to it. Bring up to a dull red heat. The flux will turn into a glass-like state. Now put the tip of the silver solder into the flame, dip it into the dry flux then touch the boiler bush with the solder. It should 'flash' around the joint. If it doesn't it is not hot enough. Continue to heat the barrel until the solder takes. Move to the flanged end plate and apply more solder (don't forget to solder the stay at the same time). Do the same for the other end.



Now, using your tongues or whatever you are using, turn the boiler seam side up. By now the boiler will be nice and hot so you will have no problem soldering the double thickness of the boiler and it's reinforcing strip, don't forget to add a touch of solder to the head of the rivets. After cleaning up the boiler (wire wool and scouring powder) we must test it.



The simple boiler completed.

The boiler sits in its metal box.

Boiler testing

The simple method I use is to first plug the boiler, then drop it in to a pot of hot water. The air inside will expand with the heat. If you have a leak you will see a stream of bubbles in the water. If you find a leak, re-solder - but the chances are, with this simple boiler, you wont have any such problems.

Now for an hydraulic test. Get yourself a bicycle inner tube and cut off the valve stem. Next take a piece of brass, round ⅜ inch diameter x 1 inch long, turn one end and thread ¼ inch x 40 ME. Reverse the piece in the lathe and drill to accept the tube valve. Drill through to the ¼ inch x 40 end. Glue the valvė in with cyanoacrylate (Superglue). Fill the boiler with water, screw the tube valve into the boiler (with a suitable sealing washer). Then, with a car foot pump, take it up to about 40psi. If nothing dramatic happens you have a safe boiler.

Safety valve (part 19)

Now if you don't feel confident making your own safety valve use a Mamod safety valve. You will, of course, need to alter the thread in the boiler bush but it's very easy to make your own, starting with the valve body. Refer to the drawing.

Chuck a short length of brass hex.; face, then turn to suit a ¼ inch x 40 thread x ⅜ inch long. Drill and ream $^{3}/_{32}$ inch and part off to length.

Grip the ball in the three jaw and just lightly face off so that you can centre drill then drill and tap 8BA. The spring is 22 swg stainless steel, ⅝ inch long, ⅛ inch diameter. Assemble the safety valve with an 8BA brass screw. Tighten the screw to remove any free play then add an extra half a turn. Lock the screw with a lock nut on top of the ball. If you have followed the instructions to the letter the valve will lift at about 10 lbs/sq inch.

Almost there now

The boiler casing (**part 20**) is just a simple sheet metal box (**photo 9**). If you follow the drawings you cannot go wrong. For drilling the vent holes I used a ¼ inch centre drill; if you support the part you are drilling on a piece of wood as you drill through you will end up with round holes. If you use a twist drill, the holes will be anything but round. On one of the end pieces you will have to solder the fixing nuts in place at the top because there is very little room, even for the tiniest fingers to hold the nuts in place. The burner tray (**part 21**) requires no further description (**photo 10**).

The fuel tray.

The base on my model is a piece of varnished wood .You can, of course, use anything you like. The final stage is the plumbing but I suspect that if you've got this far you won't need me to tell you how to do that.

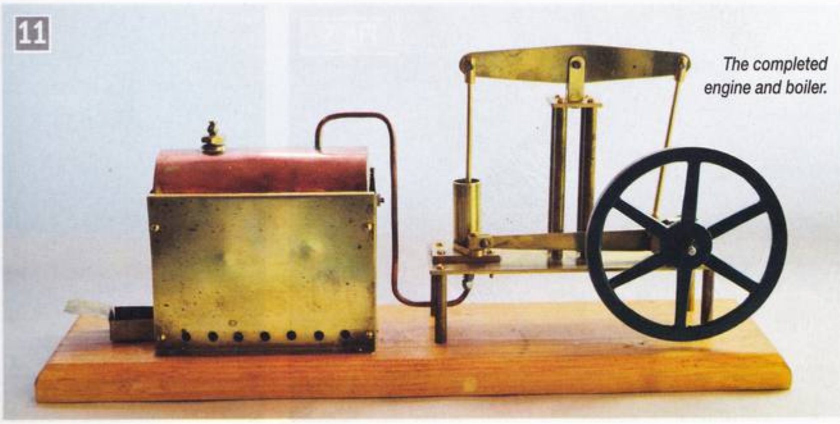
Now the best bit: load up the burner tray with two fuel tablets and half fill the boiler with hot water. Set the fuel on fire and wait a few minutes.

Give the flywheel a few turns to remove the condensate, then if you've built the engine to these instructions you should have a runner. **Photograph 11** shows the completed engine and boiler.

I hope you have a go at building it. If you do and you have any problems please contact me at **thepufango@gmail.com**

Next time I will be describing a simple marine plant.

ME



The completed engine and boiler.