## Building a vertical wobbler

I wanted to build a simple steam engine that would also run on compressed air. At Chris Heapy's website (http://easyweb.easynet.co.uk) I found drawings of a small double acting wobbler. This engine had no crosshead guide, but I found that Elmer Verburg (http://www.john-tom.com/html/ElmersEngines.html) had plans for a slightly larger wobbler with crosshead guide. The crosshead guide reduces wear on the packing gland at the bottom of the cylinder. Elmer's \#36 has a $5 / 8 \mathrm{in}$. ( 16 mm ) bore and $3 / 4 \mathrm{in}$. ( 19 mm ) stroke. I decided to make an engine based on Elmer's ideas but with a slightly smaller bore, and since I didn't need reversing I skipped the reversing mechanism. I didn't always follow Elmer's drawings or building advice either, more about that later. I mainly used bits and pieces I found lying around in my workshop.

## Materials

The piece of cast iron (CI) that I found in my scrap
 box was to small for a bore of $5 / 8 \mathrm{in}$. so I used a bore of 13 mm (since I had a 13 mm reamer) and a stroke of 19 mm . The piston and crosshead was also made from small pieces of CI left over from another project. I used steel for the column and base and for the cylinder head (outboard head) and the crosshead guide. I also found a few pieces of steel rods that I used. 4 mm dia. for piston rod - this is slightly thicker than what Elmer used. For the pivot shaft I used a 5 mm dia. steel rod and 6 mm dia. for the crankshaft. These shafts came from an old printer. The picture above shows the wobbler with a flywheel from another engine. Later I made a smaller flywheel from a 40 mm dia. steel bar when I found that the engine could be made to run without a flywheel. I bought some M3 stainless steel screws for the cylinder head and crosshead guide.

## Column

I started with the column as I assumed that drilling the two long steam holes from the top of the column about 32 mm deep would be an operation with a great risk of breaking the

thin drill. The column started as a $87 \times 31 \times$ 15 mm piece of black mild steel. It was first squared up in the milling machine and the two large faces were given a finishing cut with a face mill (above photo).
Then the hole positions were marked and the work clamped in the 4-jaw so I could use the lathe to drill the two long vertical holes from the top of the column. Elmer drilled these holes $5 / 64 \mathrm{in}$. (almost 2 mm ). I find it difficult to drill so small holes over 32 mm deep so I started with a 2 mm drill
and drilled to about half the depth frequently removing the drill and clearing the swarf. I then used a 2.5 mm dia. drill to open up the hole. Then drilling deeper with the 2 mm drill, this way I managed to drill both holes to a depth of over 32 mm without trouble. The top 5 mm of these two holes were tapped M3. I don't think that increasing these steam passage holes to 2.5 mm dia. will influence the running of the engine very much. The other holes were drilled as advised by Elmer. The 2 mm dia. holes drilled from the sides of the column were opened up to 2.5 mm to a depth of 5 mm and tapped M3 so they can be plugged. One of these holes were opened to 4.3 mm and tapped M5, you can se that in the photo at the top of the first page (used to supply steam). At the bottom two 5 mm holes were drilled and tapped M6, these will be used to bolt the column and base together.
I could now make the drill jig (see below) and use it to drill pilot holes for the pivot shaft bearing and the main bearing. The pilot holes were opened up to 5 mm for the pivot bearing hole and 6 mm for the main bearing hole. I inserted some pins and used the jig to drill the four port holes ( 2 mm ). This does not follow Elmer's advice but worked well for me as I had 5 and 6 mm pins that were tight fits in these holes. The column was now mostly finished.
There is a drawing at the end of this document that show the column, drill jig and cylinder block that I used. The tapped steamholes mentioned above is not indicated in the drawing, and the pivot shaft is not drawn to correct length. Have a look at Elmer's drawings and adjust to your requirements.

## Drill jig

The drill jig was made from 1 mm thick sheet metal and I used the dials on the milling machine to get the spacing of the holes correct. I started with a small centre drill and then drilled through with a 2 mm drill. Since my engine has metric
 dimensions the drill jig dimensions differs a bit from Elmer's, see drawing at the end of this document.



Here are a couple of pictures showing the drill jig in use to drill the pilot holes for the pivot shaft bearing and the main bearing. The drill jig was clamped to the column and the first pilot hole drilled, in fact before the bearing holes in the drill
jig were opened up. The other picture shows the drilling of the port holes, the main bearing hole is opened up to 6 mm . I found it easier to spot the holes with a small diameter drill. This worked well, everything lined up nicely.

Here is the column so far, the pivot hole and the hole for the main bearing must be opened up and some of the steam passages will be drilled 2.5 mm and tapped M 3 so these can be plugged.

## Main bearing

The main bearing was turned from a piece of square stock from my scrap box.


There is a square section that will be used to bolt it to the column. A hole was drilled through and then a small boring tool was used to bore the hole to receive two brass bushes (since I didn't have any suitable bronze pieces). A small recess about 1 mm deep and about 1 mm wider was bored at each end of the main bearing. The bushes will have a corresponding collar.

The brass bushes were turned from
 a small piece of 10 mm rod, drilled through and reamed to 6 mm . The bushes are a light press fit in the main bearing housing and protrude slightly outside.


The hole for the bearing was bored so the main bearing could be pushed in, the pictures shows the bored column and the almost finished main bearing. I drilled 43 mm holes in the main bearing and used them to spot the 2.5 mm holes in the column and

tapped them M3. M3 is a bit larger than Elmer used but it was just room for M3 countersunk screws.

## Crosshead guide

The crosshead guide was fabricated from an old piece of 16 mm steel rod, some square steel and a piece of brass silver soldered together.

The 16 mm steel bar was held in a "finger collet" and a pilot hole drilled through. The hole was then opened up to 11.8 mm and reamed to 12 mm .


This picture shows the parts after silver soldering and brushing in water. The part of the brass not visible was threaded for the packnut before silver soldering.
I did not make an inboard head as Elmer did but decided to make the crosshead guide do that job as well.

Four 3 mm holes were drilled in the end plate so the crosshead guide can be clamped to the cylinder. I also used this as a drill jig when drilling 2.5 mm holes in the cylinder.


I had a 12 mm mandrel that I mounted in the 4 -jaw and adjusted to a TIR of approximately 0.01 mm at the outer end. I drilled a 4 mm hole in the crosshead guide (this part will be milled away later) and a 3.3 mm corresponding hole in the mandrel. This hole was tapped M4 and a M4 socket head screw used to clamp the crosshead guide to the mandrel. Right photo shows the setup before pushing the crosshead guide fully home on the mandrel. This way I could turn the end of the crosshead guide to 13 mm to fit in
 the cylinder. Later when the piston is finished the hole for the piston rod can be spotted when the crosshead guide is screwd to the cylinder. Just put a drill through the piston so it touches the top of the crosshead guide. Finally the crosshead guide was clamped to the milling table using my finger plate and an extra clamp and the oval openings milled so the crankpin can access the crosshead.

The crosshead was turned from a piece of cast iron. One part turned to a close sliding fit in the crosshead guide. The other part turned to just under 10 mm diameter. A 3.3 mm hole was drilled at this end and tapped M4.The crosshead still mounted in the
 chuck - was then moved to the dividing head on the milling machine and two flats milled and a 4 mm hole drilled (for the crankpin).

## Cylinder

The CI piece was first squared using a face mill. The port face was lapped on fine emery paper.
Then the hole for the pivot pin was marked and drilled 4.2 mm to correct depth. You don't want to drill too deep or the hole will penetrate into the cylinder. The upper 5 mm were then opened up to 5 mm and the bottom was threaded M5.
The pivot pin was made from 5 mm steel rod threaded M5 in each end. A drop of Locktite was used before screwing the pivot pin into the cylinder.
The centre of the cylinder was then marked on the cylinder block.

The block was then transferred to the lathe faceplate and mounted on an angle plate. The pivot pin can be used as part of the clamping. I used a small square to line up the cylinder block before tightening the nut on the pivot pin (right photo). Another clamp and two round

balancing weights and the cylinder was ready to be drilled, bored and reamed to 13 mm .
Then the drill jig was used to drill the port holes to a depth of $3-4 \mathrm{~mm}$. Then the cylinder block was mounted tilted in the vice and the port holes drilled from the end into the already drilled holes.


The last pieces to make was the piston and cylinder cover. The piston was finish turned on the piston rod to a tight fit in the cylinder. With the piston rod clamped in the lathe chuck the cylinder got a few drops of oil and with the lathe running as slowly as possible the piston was introduced into the cylinder and soon the piston was moving more freely
For the first test runs I used a flywheel from another engine. The engine was hooked up to a small compressor and the flywheel given a push and the engine started running.


