The "DAVID" Steam Engine

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The David steam engine is a simple oscillating steam engine, many plans for which are around. It makes an excellent "first project" for the lathe and mill.

The material requirements for the engine are small, requiring only a small amount of aluminum and brass stock. The scrap box supplied mine. Materials are not critical, and substitutions may be made if desired.

Machining and assembly instructions

Base

Start by making the base from a 2.25" x 2.25" square of 1/4" aluminum plate. A single 8-32 countersunk hole (0.1770") in the bottom is required. This will secure the upright.

Upright

Make the upright next from a piece aluminum 1/2" square bar stock. Cut and finish it to the required 2.75" length. Layout all holes first, with the two 1/16" holes being drawn on an arc from the center of the pivot hole. Scribe a line parallel with the side of the upright to intersect the arc (both sides). The intersections will be locations of the two steam passages.

Drill and ream the 3/16" hole for the trunion (pivot) near the top. This hole, and the crankshaft bore need to be parallel to the face. They can be drilled in the lathe (4-jaw chuck) or the mill.

Two blind holes are next drilled for the steam ports (intake and exhaust), and tapped 1/4 - 32 (or 1/4 - 28) on the sides. Don't drill too deep, or they will connect!

Two 1/16" holes (steam passages) are drilled on the face side to intersect the steam ports. Drill them accurately, as they must align with the passage in the cylinder block.

The crankshaft hole is drilled and reamed to 1/4". The last hole to be drilled and tapped is 8-32, on the end for mounting. Watch the depth, as this must also be a blind hole.

After drilling the upright, mill the recess for the crank disk in the face. Clean and debur the part, insuring that the face with the two steam passage holes is clean. This face will be in contact with the cylinder block.

Cylinder Block

The cylinder block is made from a similar piece of aluminum, although brass would work as well. Start by drilling and reaming the matching .1875" pivot hole. The upright and cylinder can also be clamped and drilled/reamed together, if desired. You may also wish to drill the 1/16" steam passage at this time.

Next comes the tricky part. Clamp the stock upright, carefully center and drill it to the required depth. Finish by boring or reaming to size. The exact diameter in not important, as the piston will be turned to fit. The cylinder bore needs a square bottom. I was able to do this with a 3/8" endmill.

The final cut on this part is the slot. Cut it with a 1/4" endmill, through both sides of the cylinder block. Clean and debur as before.

Trunion
The trunion bolt, made of steel is next. 3/16" Drill rod is good for this. Cut to length, and thread both ends 3/16-32 as described. Clean and debur.

You may now check the fit of the trunion bolt in the pivot holes of the two parts just made. It should be a smooth running fit. It might be helpful to run the trunion in a spindle at low speed to polish it. A little rouge polishing compound can be used to get the trunion smooth running in the holes as well. The two aluminum parts should now seat together squarely, in order to obtain a good valve action with the steam passages. Watch for any burrs.

Piston
Make the piston next, brass is good for this. Turn it to a good running fit in the cylinder. Drilling and reaming the wrist pin hole first may be a good idea, to aid getting it in and out of the blind cylinder bore. To drill the wrist pin hole, set up the stock on a V-block. It needs to be drilled accurately square and centered on the stock. Lap the piston in with rouge polish and a little oil or water.

Crank Disk
Turn the crank disk on the lathe from brass. It has a small shoulder. Drill and ream the center 1/4" hole for the shaft. Before drilling it, mark the 1/2" diameter bolt circle to determine the location of the wrist pin. The wrist pin may be drilled in the lathe by offsetting in a 4-jaw chuck, or by drilling in the mill. Insure the wrist pin hole is parallel to the crankshaft hole.

Crankshaft
The crankshaft is made from drill rod, and silver brazed (see brazing instructions below) into the crank disk. It can also be soft soldered or pressed into the crank disk. As before, lap it into its bore in the upright. Also lap the wrist pin into the piston. All should be smooth running.

Wrist Pin

The wrist pin can also be made from drill rod. Cut to appropriate length, clean and debur. Polish as necessary. Assemble wrist pin, crank disk and crank shaft, braze or solder as desired. Keep the parts square. Insure the crankshaft and wrist pin ends do not extend past the disk. These parts could also be assembled by taping and threading, although accurately square threaded parts are a little more difficult to make.

Flywheel
The prints show a really nice flywheel, made up from three brass parts. It was an experiment. A much simpler flywheel can be made from a simple brass or aluminum disk. 2" diameter by 1/2" thick would be suitable.

The "fabricated" flywheel ring is made from bearing stock that was on hand. Turn the inner diameter and step. The step will be used to aid in positioning the hub. Turn the ring to the proper width and finish the faces.

Brass Disk
The brass disk is made from 1/8" brass plate. The holes don't have to be this fancy, four, five, or six holes can be drilled instead. The cutouts can be milled or cut by hand. See examples in the Sherline rotary table documentation.

Brass Hub
The brass hub is a lathe project, a simple turning of the larger diameter, and a loose fit of the smaller diameter into the brass disk. Drill and ream for the 1/4" shaft.

Set up the stock on V-blocks to drill and tap for the 6-32 setscrew. You might want to do this before turning the outer diameter (uneven diameters make it harder!).

The stock can also be clamped in the vice and drilled for the setscrew. Use a steel scale balanced on the diameter, and held by the point of a tap (or something similar) to determine the center for drilling, or touch off on a side, and "clock over" using the calibrated feed.

Brazing
As this operation uses a propane torch, high temperatures (1100 degrees F. or more), it can be dangerous if not done with care. Do not attempt unless you are familiar with the procedure to be described. For that reason, these instructions are "*AT YOUR OWN RISK*". Follow the manufacture's directions for the brazing products.

Insure the surfaces to be brazed are clean and degreased. Apply flux, to these surfaces, and assemble the three parts, ring, disk, then hub in that order on fire brick to silver braze (they can be soft soldered as well). I cut pieces of silver brazing (also called silver soldering) wire, and lay them along the joints to be brazed. The flux will aid in holding them in place. Heat the parts evenly. The flux will first boil, and then reduce to a liquid. When the brass is near or at red heat, the brazing wire will melt and flow into the joints. Remove heat, and let cool for a short time. Dump the flywheel (HOT!) into hot water, or an acid pickle, and allow the flywheel to soak for 5-15 minutes, as necessary to remove scale. Rinse the flywheel, dry, and clean off the "copper" with a emery paper.

Trunion nuts
Two nuts are required to tension and retain the spring on the trunion. The small nut is simple enough, made from brass or steel hex rod, 1/2" across flats. It is a simple exercise to drill and tap it 3/16-32. The larger nut (3/8" across flats) has a slight shoulder to keep the spring centered. Turn the shoulder to fit the spring you have. This nut is threaded 3/16-32 as well.

Spring
You'll probably want to buy the spring, I found mine in an "assortment box" at a local hardware store. You can also wind one from .016" steel piano wire. Use a length of 3/16 rod held in the lathe's chuck, and apply tension while allowing the wire to wind up. Keep the turns evenly spaced.

Plumbing
The last parts are two pieces of aluminum tubing used for the intake and exhaust pipes. Brass could be used as well. Copper is too soft and difficult to thread, and was avoided. 1/4-32 (or 1/4 - 28) threads are called for here. Use a tailstock die holder in the lathe if you have one.

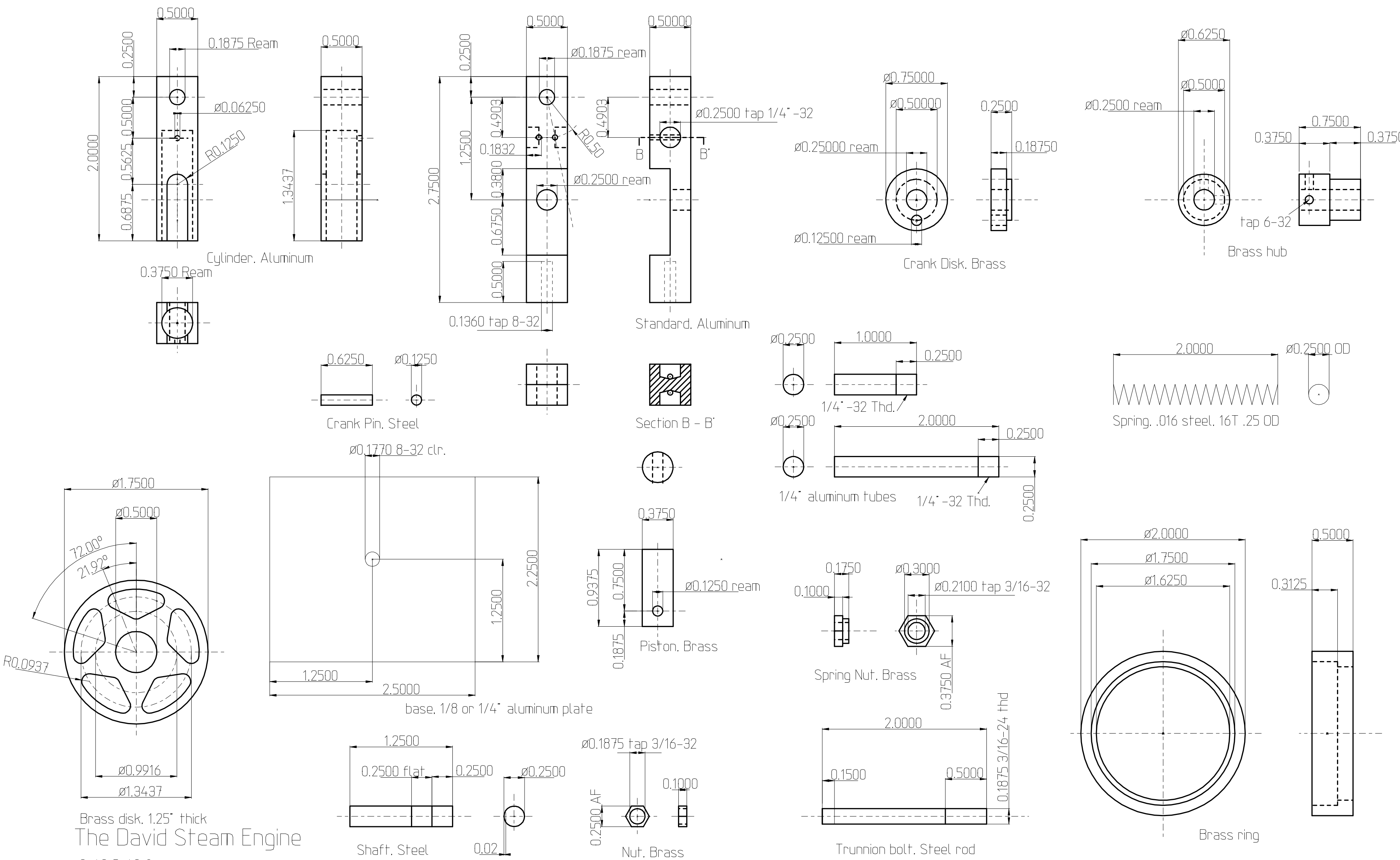
ASSEMBLY
Start assembly by first fitting the crankshaft into the upright (crank disk goes into the cutout), and securing the flywheel to shaft on the other side. Leave it just loose enough to turn freely, but not too loose.

Next install the trunion into the pivot holes as before. The short threaded end goes on the flywheel side. Slip the spring over the trunion after the cylinder block is in place (steam passages go together), and secure with the shouldered nut.

You'll notice that the cylinder block can be slid back on the trunion, allowing the piston to be inserted into the cylinder and the wrist pin to be engaged in the piston. The flywheel should be adjusted to allow it rotate freely, and the cylinder block should slide easily back and forth on the face of the upright. The shouldered nut allows for the adjustment of tension, which should be at the minimum needed to keep the two valve faces together.

Mount the upright on the base, screw in the steam pipes, and your engine is completed! You'll need a 1/4" copper tubing compression fitting to attach a length of 1/4" clear plastic tubing (for air). The engine can be ran it either direction, depending on which steam pipe gets the air.

CONGRATULATIONS, YOU'VE GOT IT! Add a little oil to the moving parts, and turn on the air or steam! Enjoy your little engine, my little nephew David sure does!



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