Air Compressor/Water Pump Part III
Making the Steam Valves

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The cylinders pistons and water valves were completed in Part II. I could have stopped at that point and the parts as a fake air compressor. However, its still cold outside so might as well try to make the thing v So, on to the tough part --- the steam valves. The pilot valve cylinder was done first, then the shuttle va cylinder and then the two were joined. After that, a few minor details such as the little valves, the shuttle pistons, shuttle valve heads, etc.

Pilot Valve Cylinder: The pilot valve cylinder is made from 5/8" diameter brass rod. The inside is bored 7/16" and the upper end tapped 1/2-20. A section is milled out half way through the rod. The rectangular piece is milled with a 5/16" wide slot for the sliding valve. The valve ports in the rectangular piece are 3/32" diameter spaced on 3/16" centers. The holes in the sides of the rectangular piece are for the two 0-80 screws. The screws hold the rectangular piece to the rod during the multiple silver soldering operations.

This shows the cylinder after the rectangular piece has been joined and silver soldered. The left end of the rod has excess length to chuck the cylinder and turn down the excess part of the rectangular piece to 5/8" OD.

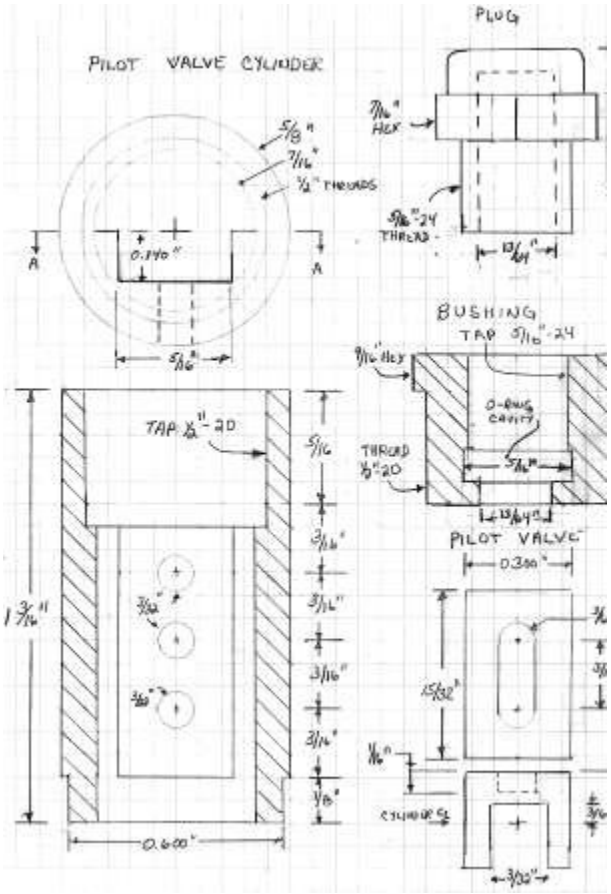
This is the finished cylinder The bushing from 9/16" hex rod is threaded 5/16" on the outside and 1/2" on the inside. The end of the bushing is closed except for a 13/16" hole. The bushing retains the O-Ring seal. The end cap is turned from 7/16" hex rod and bored 13/16"

for the 3/16" end of the valve stem.

This is the end view of the parts

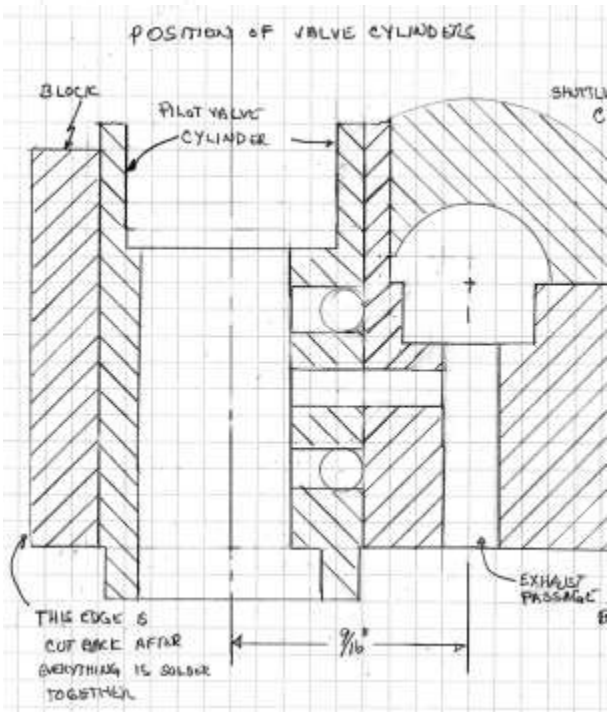
The assembled pilot valve cylinder. The left end is turned to 0.600" and fits into a mating hole in the head.

This is the drawing I used to make the the pilot valve cylinder. Well, it's really a copy since the original had a couple coffee rings. Sorry I'm too lazy to sketch in the threads; life is too short.....



Shuttle Valve Cylinder: The shuttle valve cylinder and pilot valve cylinder are made as a single casting on the prototype. I'm going to try to built up the combination much like the casting pattern might have been built. The parts on the left side of the photo are the pilot valve cylinder described above and the head. The rectangular block in the upper right corner is made from two 1/2" thick pieces silver soldered together. The block will contain the shuttle valve ports (the three little holes). The larger hole holds the pilot valve cylinder. The rod in the lower right side will be notched and fit over the rectangular block to form the the shuttle valve cylinder.

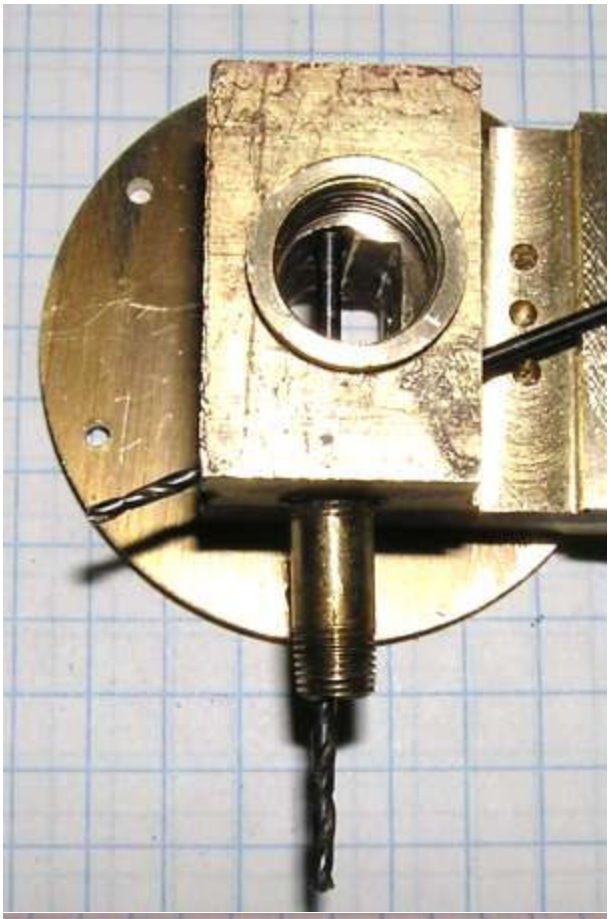
This shows how the head, pilot valve cylinder and block fit together. The cylinder was initially drilled 3/8"



The block controls the relative position of the two valve cylinders. This drawing is a section taken vertically through the valve assembly. The section cuts through all the pilot valve ports and through the shuttle valve exhaust port. The relative positions was designed to enable the easy interconnection of both the input and exhaust paths.

The slot for the shuttle valve was machined in the block first. Then, passages for the input steam steam were drilled. The drills show the passages. The drill from the lower left at an angle up to the right is a 5/32" horizontal passage for steam to the shuttle cylinder that comes out above the shuttle valve. The left end of this hole will be plugged. The input is via the 1/4" nipple. The drill through the nipple shows that there is a also a passage

from the input to the pilot valve cylinder opening to the left of the pilot valve.



This shows another view of the input passages. The two holes intersect directly behind the nipple.

The rod was then notched to mate with the block.

This shows the shuttle valve cylinder in position. There is still considerable excess material. The cylinder stubs will be used to chuck the cylinder to bore the inside. These stubs will be cut close to the block after the boring operation. This is the back view. The block will be cut back to the pilot valve cylinder on the front side and the edges of the block will be rounded.

The next step was to make the exhaust passage for the center port of the valve cylinders to the exhaust nipple. The exhaust passage is contained in the block similar to the steam input. That is the exhaust nipple in the photo. The center line of the center pilot valve port is in line and 0.1" below the center port on the shuttle valve. A hole was drilled through the block in the position of the exhaust (middle) hole in the pilot valve cylinder. This hole intersects the exhaust hole (middle hole in the block) for the shuttle valve. The pin sticking out the

right side is through this hole.

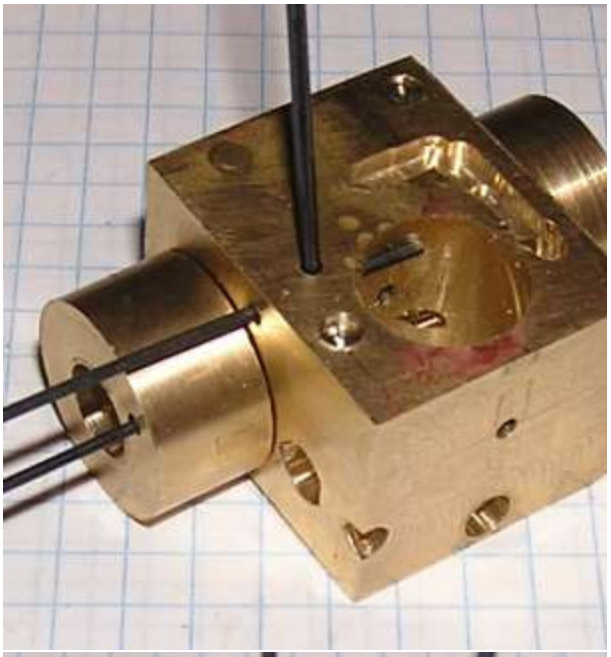
This is the under side of the block. The shuttle valve exhaust hole was drilled down all the way through the block. The passage was then milled from this hole to under the exhaust nipple and then a hole was drilled up to the nipple. The open exhaust channel will be sealed by the top of the head.

The hole is the lower right side is for a #2 screw to hold the shuttle valve to cylinder to the bock

This shows another screw to hold the cylinder to the block. The two holes in the front surface and the hole on the right edge will be plugged when everything is soldered together.

This photo shows the holes in the pilot valve cylinder. The upper hole on the left is the steam input. The slot in the side is part of the steam passage to the shuttle valve cylinder. The bottom hole is the lower steam port that goes to the steam passage to one end of the shuttle valve cylinder. This passage goes out the side. The second hole from the bottom is the exhaust port and goes directly out and connects to the shuttle valve exhaust port. The third hole from the bottom is the upper steam port that goes to the steam passage to the other end of the shuttle valve cylinder. This passage is also out the side.

This photo shows the underside of the block. The little hex wrench shows the direct passage from one end of the shuttle valve cylinder to the upper steam steam port from the pilot valve. The relative location of the pilot valve cylinder and the shuttle valve cylinder was designed so that both the exhaust port and this port were aligned with the mating position in the shuttle valve cylinder.



The lower pilot valve steam port is lower than the required position of the hole to the end of the shuttle valve cylinder so there must be a jog in the passage. The hex wrenches shows the position of the two horizontal and the one vertical passage. The bottom of the vertical passage and the hole out the side will be plugged with #4-40 set screws.

The photo shows the routing of the last passages ---- for the shuttle valve output ports. The hex wrench on the left shows the easy one, the hole goes straight down through the head to the upper end of the steam cylinder. The right hole is offset through a horizontal hole and then down through the side of the steam cylinder to the bottom end of the cylinder. The hole out the side will be plugged with a #8-32 setscrew.

For reference, the hole directly behind the left hex wrench is the steam input passage to the shuttle valve cylinder. The upper hole in the middle is for one of the screws that hold the shuttle cylinder to the block. The right vertical hole near the front of the photo is for the second screw to attach the shuttle cylinder to the block. The left vertical hole near the front of the photo is for one of the screws holding the the head to the steam cylinder (head bolt).

The next step was to fit the block to the head. The head fits over the end of the pilot valve cylinder that that hangs below the block. The bock is at the top of photo

with the head below the block. The disk below the head has a stub that fits into the end of the pilot valve cylinder. The disk has a recess to retain the valve stem sealing O-Ring. The washer retains the O-Ring in the disk. The OD of the disk is a snug fit into the steam cylinder so that it serves to align the head with the cylinder.

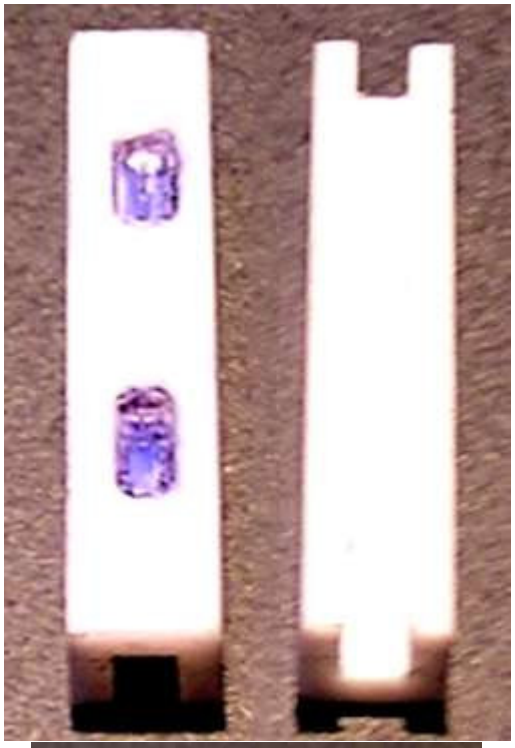
This is the underside of the head with all the parts screwed together. The hex head screws retain the washer in the the disk and hold the disk to the head and the head to the block. The two flat head screws on the right side hold the head to the block.

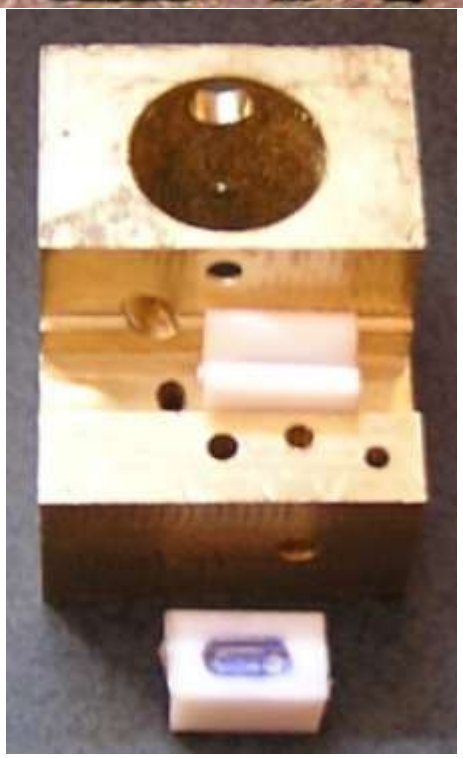
Valve: The little valves were fabricated before soldering the valve cylinder and block together.

Both the pilot and shuttle valve cylinders have a 5/16" wide slot for their valves. Before deciding on the valve width a 0.280" thick (at room temperate) piece of Teflon was submerged in boiling water for about 5 minutes and the thickness measure again and found to have increased

by 0.004". The operating steam temperature will be about 300 degrees, so a total room temperature clearance of 0.12" seemed appropriate.

A piece of round Teflon rod was milled to a 0.25" X 0.300" rectangular shape. Next, 9/32" long 0.050" deep slots were milled in one side. These slots are shown in the left side of the photo. The upper slot for the shuttle valve is about 5/32" wide and the lower slot for the pilot valve is about 1/8" wide. The other side was notched for the valve stem.





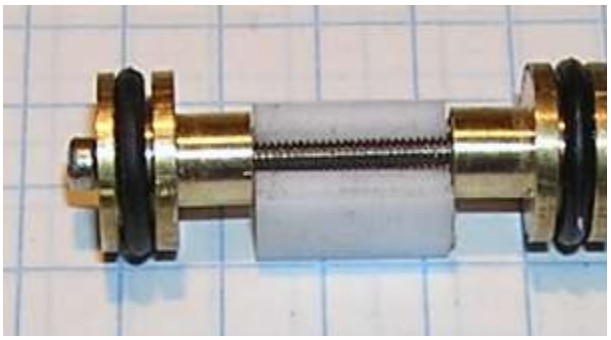
This shows the valves after they were separated and trimmed to the correct length.

Shuttle Valve Cylinder: The next step was to silver solder the block, pilot valve cylinder and the shuttle valve cylinder together. The photo shows the combination mounted in the 4-jaw chuck. I tried the 3-jaw chuck but the end was off about 0.010". The next step was to bore the ends of the cylinder. The slot in the block for the valve was made much longer than necessary and was be cut back during the boring operation. The drill bit in the photo is through one of the

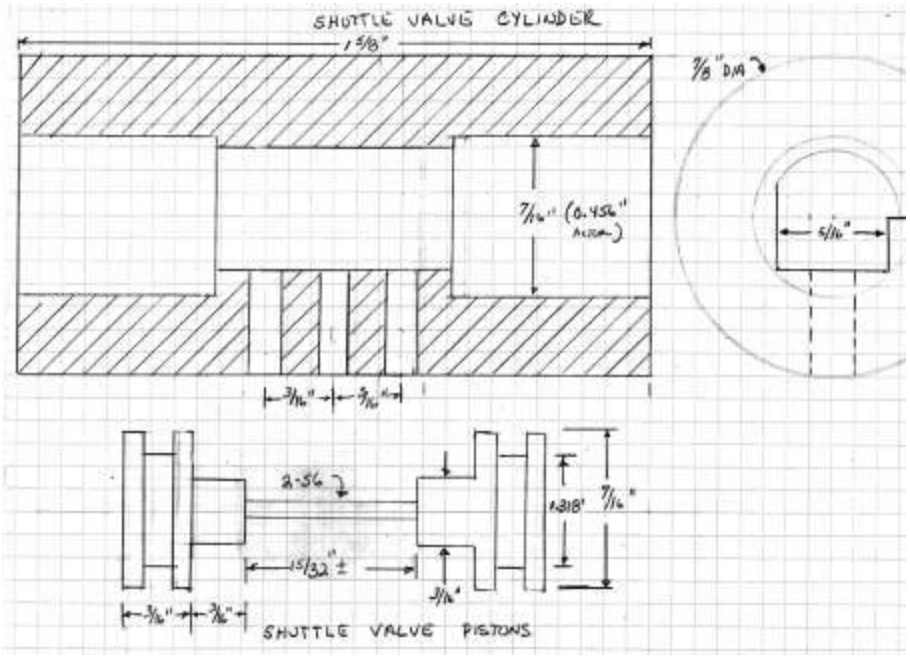
valve ports to serve as an index point for the caliper to determine the position of the valve port relative to the end of the cylinder enabling the correct depth of the boring to be calculated.

This shows the end view of the shuttle valve cylinder. The guide for the valve is clearly visible. The length of the guide was shortened to exactly match the the tack of the valve. The guide is smaller then the cylinder ID and serves as a stop for the shuttle valve pistons

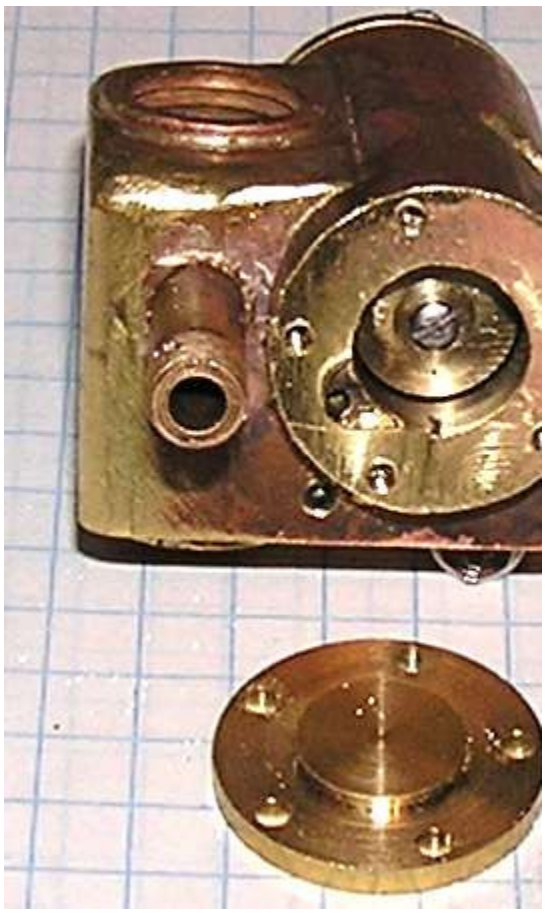
Shuttle Valve Pistons: This photo shows the shuttle valve pistons and the shuttle valve. The pistons are connected with a 2-56 threaded rod. There are 2-56 screws in the end of the pistons to serve as stops for the threaded rod. After everything has been checked out, these end screws will be secured with hi temperature Loctite. The screw head can then be used to take apart the two pistons. The grove in the pistons was cut to make the O-Ring fit looser then normal so there pistons slide fairly easily. The cylinder bore was 0.456" and the O-Ring grove diameter was 0.320". **Update 2/23/2006:** I replaced the EPDM O-Rings with Viton O-Rings. When I did that I found the fit loose --- no seal at all. I remade the piston with a groove ID of 0.335" which worked but slid very easily. It might be best to start with a depth if 0.34" and then reduce it if the piston is too tight**. End Update.**



This drawing shows the shuttle valve cylinder and the pistons. Recall that the lower half of the middle part of the cylinder is part of the block.



Shuttle Heads: The shuttle heads were turned from 7/8" diameter rod. A stub was turned on the inside to help with alignment. Yes, there are 5 attachment screws, and it wasn't another miscalculation. The first choice was 4 screws but the location of the steam feed required that the screws not be align with the horizontal or vertical and I thought it'd look sloppy. The prototype used 5 holes and with 5 holes, any alignment looks OK.



The upper photo shows the cylinder end with one of the shuttle valve pistons. The lower photo shows an installed head. The screws are 2-56 and will be replaced with studs and 2-56 hex nuts later.

This is a good point to end this part. The project is finished in Part IV.

Shay Project

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