Air Compressor/Water Pump Part IV
Pilot Valve Stem, Test & Installation

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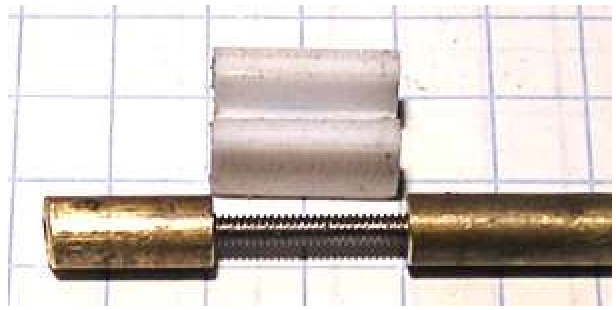
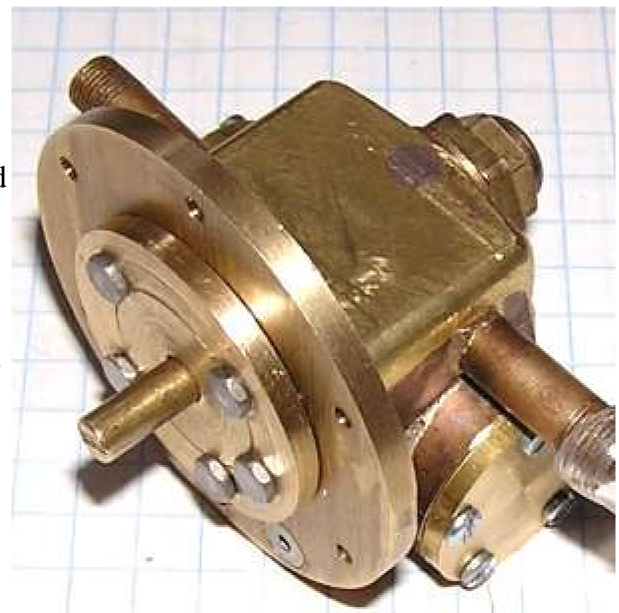
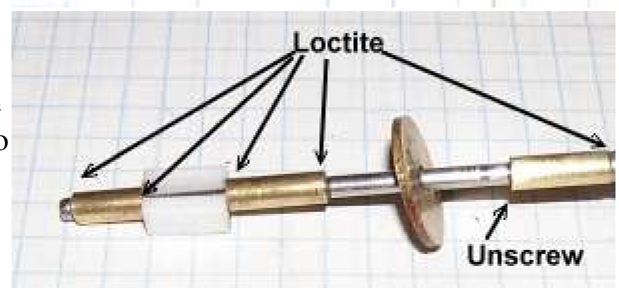


Valve Test: I decided to test the steam valves at this point before going any further with the fabrication. The pilot valve stem assembly in the upper photo was made from 3/16" brass and a 2-56 threaded rod (screw with head cut off). The lower photo shows the valve assembly with the end of one 3/16" brass rod sticking out below the head. Compressed air was then connected via the hose and the valve operation tested by pushing and pulling the 3/16" rod. Well, it didn't work, and there seem to be air leaks everywhere. I took it apart and double checked everything ---- nothing seemed to be amiss. As a last resort I verified that the air was connected to the input port. Damn! Should have checked that first.



Once air was supplied to the input port the valve worked as expected (maybe hoped is more correct). The shuttle operated with some authority with as little as about 15 psi.



Valve Stem: The photo shows the final valve stem. The brass pieces are 3/16" rod. The left piece and left half the middle piece are threaded 2-56, the screw on the left and the stainless threaded rod over the valve are also 2-56. The stainless steel piece on the right is 1/8" OD threaded 5-40 on the ends. The screw in the right end is 4-40 stainless steel. The disk screws to the top of the steam piston.

This photo shows the valve stem position when the the piston is against the stops at the top of its travel. The middle brass piece was cut to the exact length required so that the valve is positioned in the upper extreme position. The screw on the left is cut so that it's all the way in and against the end of the 2-56 threaded rod. The valve is loose in the gap between the two brass pieces.

This shows the valve stem position when the piston is against the stops at the bottom of its travel. The brass piece inside the piston rod was adjusted so that the valve was in the lower extreme position. The screw in the right (lower) brass piece was then cut so that it was all the way in the brass piece and against the end of the 1/8" rod. After the pump was tested and the valve stem adjustment was shown to be correct, #620 (high temperature) Loctite was applied to all the threads except the joint between the brass piece inside the piston rod and the 1/8" rod.

Update 5/16/04: The pump failed several times due to the pilot valve rod and the connection between tl shuttle valve pistons working loose. I finally bit the bullet and took apart each joint and applied high temperature Loctite (620) which seems to have fixed the problem. **End update.**

The valve stem is removed by inserting a hex wrench up through the the lower end of the piston rod and blade screwdriver down through the top of the pilot valve cylinder into the screw head above the valve. ' joint inside the piston rod can then be unscrewed and the stem with the valve can then be pulled up and o top of the pilot valve cylinder.

The pilot valve can be removed using the following procedure:

1. Remove the cap and bushing at the top of the pilot valve cylinder
2. Remove the lower pump cylinder head.
3. Remove the set screw in the bottom of the piston rod.
4. Push the piston to the upper extreme position.
5. Insert a hex wrench or small rod in the piston rod and push the valve stem to the upper position.
6. With both the piston and valve stem in the upper position, much of the valve stem and the valve s out above the top of the pilot cylinder. The valve can then be pulled away from the stem
7. Once the valve has been removed, the upper head can be removed if necessary.
8. This procedure can be reversed to reinstall the valve.

First Steam Test (using compressed air): The steam side of the system was then assembled and tested compressed air. It didn't work very well --- it was very erratic. I then put a little water in the air line anc straightened right and worked pretty well. The water serves to lubricate everything and help the valves s was curious how the system would work with a little lubricant. Petroleum based lubricants are not comp with the EPDM O-Rings but brake fluid is so I tried a half dozen drops in the air line. Wow! The thing t and was really smooth, worked down to a few pounds of air pressure. I let it run for a half hour or so anc worked great, never hung up once. I then installed the water pump cylinder and piston and it continued t operate great.

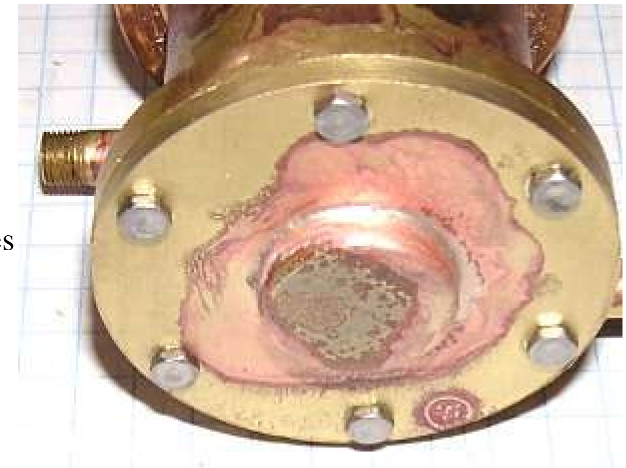
After this successful test I took a break. Later I tried it again and it was erratic again. The valve seemed working but the steam piston seemed to be hanging up. Pulled the piston and found the O-Ring had turn and failed. Then I remembered, McMaster Carr doesn't carry the high temperature EPDM version of the O-Ring so I got a bag of 100 of #121 Buna-N O-Rings for a couple dollars. This test confirmed the O-Ri literature; Buna-N is not compatible with brake fluid.

The plan was to order the correct O-Ring from Marco Rubber once I was sure of the correct size. Marco to have a minimum price of $10 per item. In this case one of the O-Rings is $10 and one can also buy 10 the #121 O-Rings for $10.00. I also need some of the #008 size used for the valve stem seals and can g of these for $10 and 500 for $10.40. (I had a bunch of the #008 in the 200 degree max temperature EPDI I'd used in brake systems. McMaster Carr doesn't carry the #008 size in the higher temperature EPDM ei Guess I'm going to end up with a few hundred spare O-Rings. **Update 2/23/2006:** I changed the O-Rin Viton for everything except the water piston which was changed to Buna-N. I obtained the Viton and B O-Rings from from McMaster-Carr. **End Update**.

The brake fluid lubricant worked great so that I'm considering building a lubricator. Also, a few drops o stuff might loosen up those steam brake pistons a bit --- makes sense, brake fluid for brake cylinders. Ho the polyglycol ether based braked fluids (DOT3, DOT4 & DOT5.1) are some of the most effective paint removers known to man. Don't want that stuff around my locomotive since I hope to paint it someday. brake fluids are soluble in water so the lubrication might also wash off pretty easily. An alternative is the silicone brake fluid (DOT5). The silicone fluid is harmless to paint and isn't soluble in water. So, mayb lubricator that uses the silicone fluid. Some further tests are in order. **Update:2/23/2006:** After changin steam side O-Rings to Viton I was able to use standard steam oil for lubrication. See added lubricator at end. **End Update.**

Lower Head: The lower head on the water pump was the last operational part to be finished. A piece of 3/4" Brass rod was turned to fit inside the pump cylinder (5/8" OD) and a recess bored to accommodate the the nut on that holds the pump piston to the piston rod. This piece was then silver soldered to the head. The photo shows the head with with the short (~.030") shoulder that fits into the pump cylinder.

This photo shows the under side of the head. The pinkish color is strain from the flux used when the pieces were silver soldered together.



It Works! Everything was assembled for a test of the complete pump. The unit seemed very stiff so a few drops of silicone brake fluid was added to the air line ---- it seemed to work even better than with the glycol based fluid. Next the sink was partially filled with water, a hose connected to the water input with the other end in the sink. The air was connected and the pump started up. The output sputtered for a couple seconds and then shot a stream about 20 foot across the room. (Fortunately I was using the workshop sink; she'd have killed me if she caught me doing something like this in her kitchen sink.) About as much water came out around the pump heads as the output pipe. The heads were attached with only two screws.

Mount: The last major task was to make the mount. A 3/8" wide slot was milled in the back of the steam cylinder and the 1/4" X 3/8" mounting bar was soldered in the slot. The holes in the ends of the mount are for 6-32 screws.

Gaskets were then made for the cylinder heads, shuttle valve heads

and between the upper head and the steam valve assembly. The shuttle valve head screws were replaced with studs and nuts. All the head screws were then installed and the pump tested again. The gaskets and screws seemed to fix the leaks.

Further tests are required under steam pressure pumping water against 100 psi boiler pressure. However, don't think there will be a problem.

This shows the finished pump. The pump will have to be partially disassembled later to install the correct EPDM O-Rings on the steam cylinder piston and for the valve stem seals. The socket head cap screws connecting the tie piece to the two cylinders will be replaced with hex head screws at that time. The socket head screws are easy to install and remove using a ball end hex wrench which was convenient when multiple assemblies and disassemblies were required during the fabrication. The hex head screws are more time consuming to install since an open end wrench is used.

This pump has been one of the most rewarding parts of the shay project. It would be a good project for one to do prior to attempting a locomotive since a number of different skills are required yet the project is fairly small and the finished pump can function as a self contained unit.

Installation: A 1/2" wide 1/4" thick steel mounting plate was welded to the boiler. The pump mounting bar screws to the mounting plate. The pump is positioned lower than the pump on Cass 5 because the steam pipes are higher than on the Westinghouse unit. The pump didn't look right when positioned about an inch higher as on Cass 5. The front top pipe is the steam exhaust that goes over the smoke box and down to the engine exhaust pipe. The lower front pipe is the water pump output that goes to the inside of the frame I beam and then down under the left mud ring and then under the cab floor where it ties into the hand pump output.

This shows the two pump input pipes. The steam input comes off the valve directly above the pressure gauge. There is a union next to the valve and then three elbows before the pipe leaves the cab above the feed water pipe on the way to the top of the pump. There is a second union in this pipe at the pump. The water input connects to a tee in the axel pump return pipe and then goes via an elbow and union and then along the walkway to another union next to the pump. The pump output pipe is visible under the boiler just to the inside of input pipe.

The output pipe goes under the left side mud ring and up to a compression elbow that connects to center port of the tee between the two rubber hoses in the photo. The tee was inserted in the pipe that ran from the hand pump to the right side feed water pipe. The tee is silver soldered to a bracket that is in turn screwed to the right side frame I beam. There are spring loaded poppet check valves (McMaster-Carr # 7768K55) in the two inputs to the tee. These check valves prevent a faulty check valve in one pump from effecting the other pump.

I dug out this photo of Cass 5 to show how the pump steam exhaust goes over the top of the smoke box and down to the engine exhaust pipe This is a color photo but the color is wasted on this object.

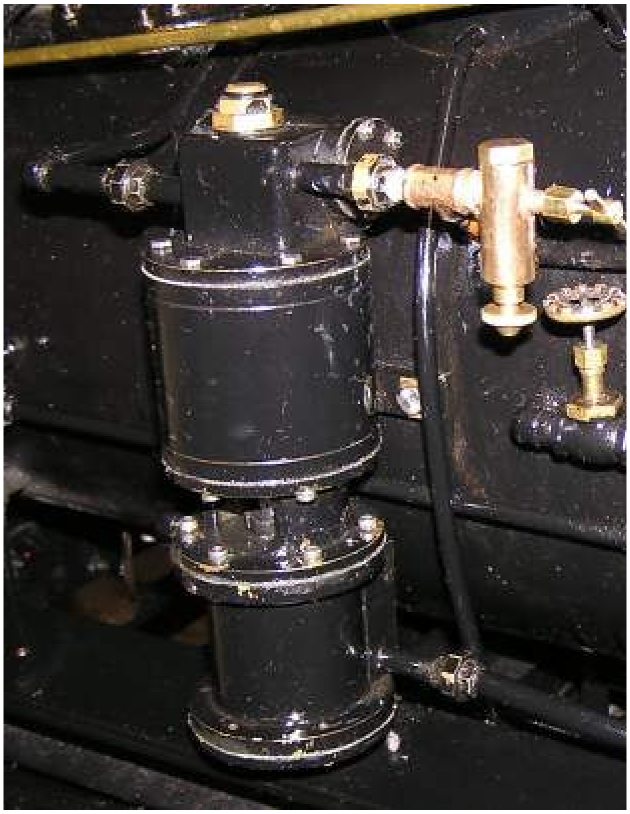
This shows how the pump exhaust is connected to the engine exhaust pipe. The street elbow is screwed into the exhaust pipe and then soldered using 550 degree soft solder to make a solid connection.

Update 1/30/2004: Yesterday (1/29/2004) I used the pump on compressed air to fill the boiler and then wheeled the locomotive outside in the 15 degree (F) weather to do a steaming test. The pump worked on just as it did on compressed air. With the cold temperature it was easy to spot two steam leaks. One lea from the slot I milled for the mounting bar. This milled slot cut through the steam passage from the shut valve to the bottom of the steam cylinder. The mounting bar was silver soldered in place which sealed th steam passage except for a pin hole. The other leak was from the joint between the valve case and the up head. The pump was disassembled later and the pin hole was soldered shut. A high spot was found that the valve case from seating on the head. After the high spot was filed off the valve case/head joint sealec

There was no problem starting the pump. The pump was started and then stopped and allowed to cool a l dozen times. There was clearly condensate in the valves and cylinder that didn't seem to interfere with s even at very low pressure. After the two leaks were fixed the pump was submerged in water to allow the cylinder and valves to fill with water. The pump started on less than 50 pounds pressure every time, ever water . This thing is reliable!

Update 6/6/04: The pump started to run really slow. A few drops of silicone brake fluid in the steam lin speeded it up for a few minutes but then it slowed down again. A lubricator seemed like a real pain. The was disassembled and the steam piston was found to be hard to push. A little water made it easier to push still pretty tight. The depth of the gland was according to specifications --- but that was for a tight seal. this application a slight leak is tolerable so the gland depth was increased to 0.100" --- a loose seal for the 0.103" O-Ring cross section. The pump has run flawlessly after this fix and the application of Loctite to valve joints.

Update 2/23/2006: As mentioned previously, the EPDM O-Rings became sticky after a couple years of use so I changed to Viton O-Rings on the steam piston, steam valves and rod seals. I also added the displacement lubricator shown on the right. The lubricator was obtained from American Model Engineering Supply, model DLU4. The unit seems to run a bit freer than before.



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