# Shay Cylinder Cocks

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Steam condenses when it enters a cold cylinder. The cylinder cocks are valves located at each end of each cylinder that are opened to drain this condensate (water). The next photo (courtesy of friend Murry Mercier) shows the cylinder cocks on Cass No 5. The escaping steam indicates that the cocks are open --- maybe to warm the cylinders.

The photo on right shows the cocks on one cylinder in more detail. All 6 are ganged together and operated by a single lever in the cab.

Apparently cocks are not required on the 1.5" scale shay engine. However, cocks make the engine look authentic and steam coming out of the open cocks looks neat!

I was unable to find manufactured cocks that look like these. The closest is Coles' straight nose cocks. However, the handles would need to be modified to gang the six together and the output is straight out rather than down.

The cocks are quite simple, consisting of a body and a plug. When the cock is open there is a hole from the input in the body , through the plug and then through the output from the body. The cock is closed by rotating the the plug. The challenge is to make a reasonably tight seal when the cock is closed. The full sized cocks use a tapered plug with a matching taper in the body. There is an adjustment to hold the plug securely in the body.

I checked out Kozo Hiraoka'a three books on building the Shay, the Climax and the Heisler. He used both straight and tapered plugs. In the last of the three books he said that he favors the straight plug because it is easier to fabricate and more reliable.

Last year I tried to make some cocks ---- and they leaked really bad. A few months later tried again. A second set of failures. I was testing with125 psi air and not looking for a 100% seal, but 98% or so was a reasonable objective ---- and the best that could

be achieved was a perceptible difference in flow when the cock was moved from open to close. Shutting off the flow was a fantasy at that point.

After some months of thought I concluded that I couldn't make tapered plugs that would seal since both the plug and a reamer with identical taper had to be fabricated. The standard taper pins were tried and found that they would seize --- the taper is too shallow. So, it has to be straight plugs.

The next task was to find a way to make a tight seal with a straight plug. Teflon was selected; the idea was to surround the plug with Teflon and to make the hole for the plug undersize. The Teflon is slippery so the plug should turn easily relative to the tightness of fit. Also, Teflon has some give so it should maintain pressure on the plug. Teflon can tolerate temperatures up to 400 degrees F so temperature shouldn't be a problem.

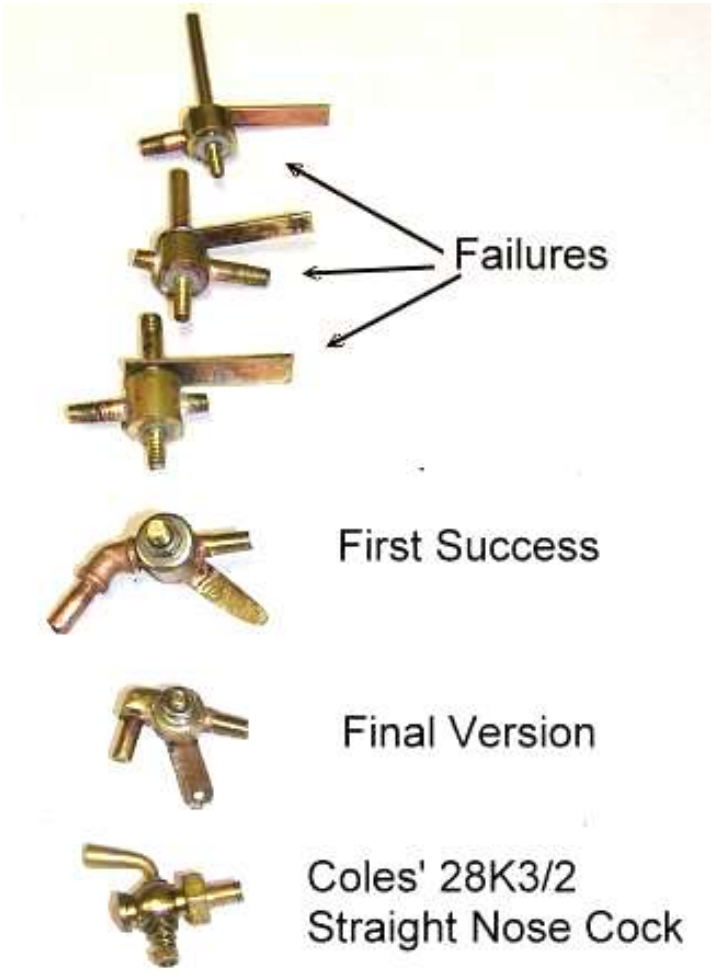
**Models:** On this, the third attempt, a number of models were made over a a several day period. Some of these models are shown on the right. The handles and plugs weren't trimmed on the early models --- the challenge was to find a way to make a good seal.

It was found that the cock would seal initially but after a few operations would start to leak. The hole though the body and plug had been drilled after the cock was assembled. It was found that the hole through the plug left a burr that tore the Teflon after a few operations.

The solution to this was to drill the hole in the the plug in a separate operation and to smooth the the plug before pressing it into the Teflon sleeve. The first successful model continues to seal after several hundred complete revolutions of the plug.

The final version is a reduced size model of the successful model using the same size plug and Teflon sleeve with a smaller body and output pipe.

The smallest Coles Straight Nose Cock is shown for comparison. It uses a tapered plug and spring to keep it tight in the body. A nice design if you can make reasonably precise repeatable tapers.



This shows the final version mounted on the cylinder. The nut is 2-56 that is 5/32" across the flats (industry standard small pattern nut) . The modeler's 2-56 nut that is 1/8" across the flats would look better ---- make the cock look smaller.

Also, a slightly longer discharge pipe would be closer to the prototype.

This shows the disassembled cock. The parts of the body are silver soldered together. The handle and plug are also silver soldered together. Note the Teflon sleeve pressed into the body.

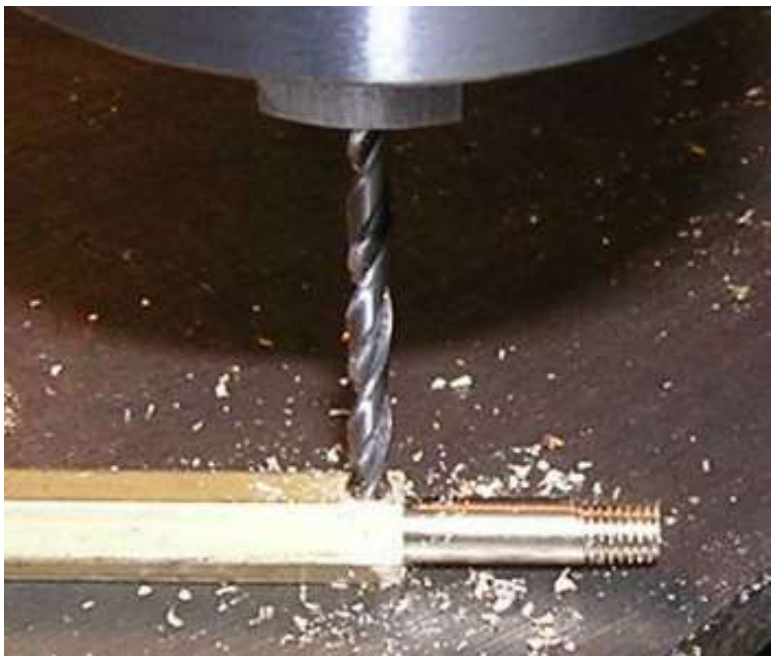
**Design:** The following are the particulars of the design used.

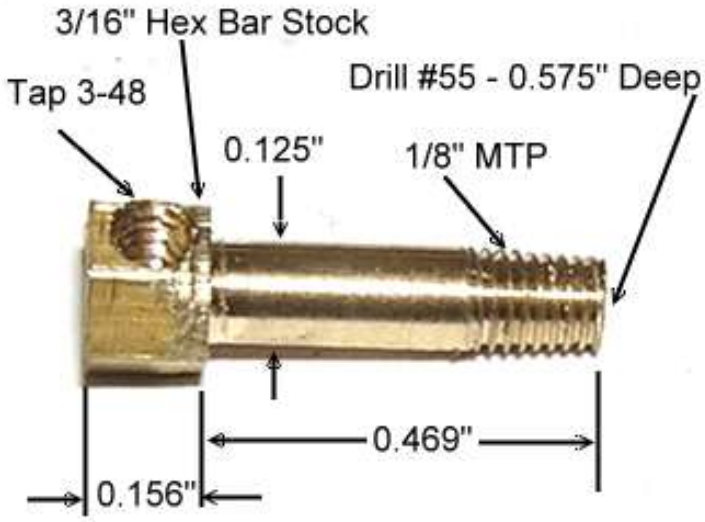
- The Teflon Sleeve is 3/16" OD pressed into a 0.182" (#14 drill) hole in the body that is scored to keep the sleeve from rotating.
- The Plug is 1/8" OD brass pressed into a 7/64" hole in the sleeve.
- The output pipe is 3/23" OD 1/16" ID brass tube threaded 3-48.
- The flow hole through body and plug is 0.052" (#55 drill)
- The central part of the body is made of 1/4" brass rod with a width of 0.187"
- To insure alignment, the input and output pipe are made as one piece and soldered into the central part of the body and then the hole for the Teflon sleeve is drilled separating the input and output pipe.
- The input pipe is threaded MTP 1/8"
- The end of the plug is threaded 2-56
- When the plug is forced into the sleeve some of the Teflon is squeezed out beyond the faces of the body.
- The plug length is about 0.010" greater than the body width.

- The nut and the side of the lever apply a small pressure on the ends of the sleeve that are squeezed out of the body.
- The lever is made of 5/32" wide 0.50" thick stainless steel.
- The effective lever length is 3/8"
- The hole in the plug is drilled in a separate fixture and all burrs on the plug smoothed before being pressed into the sleeve.

**Fabrication Process:** The fabrication process is as important as the design -------- the process must yield good results using the relatively low tolerance workshop machines. Since the setup is a significant part of the chore, some spare cocks were made for future replacements. Also, the jigs were kept to allow easy future setup.

**Input & Output Ports:** The ports are turned from 3/16" hex stock. The first part was done in the lathe---- outside turned, inside drilled and end threaded. One set of ports was turned on each end of the ~ 12" hex rod. The next step was to drill the hole for the output tube as shown on the right. That hole was then tapped 3-48 and the rod mounted in the lathe again and the ports cut off with a parting tool.

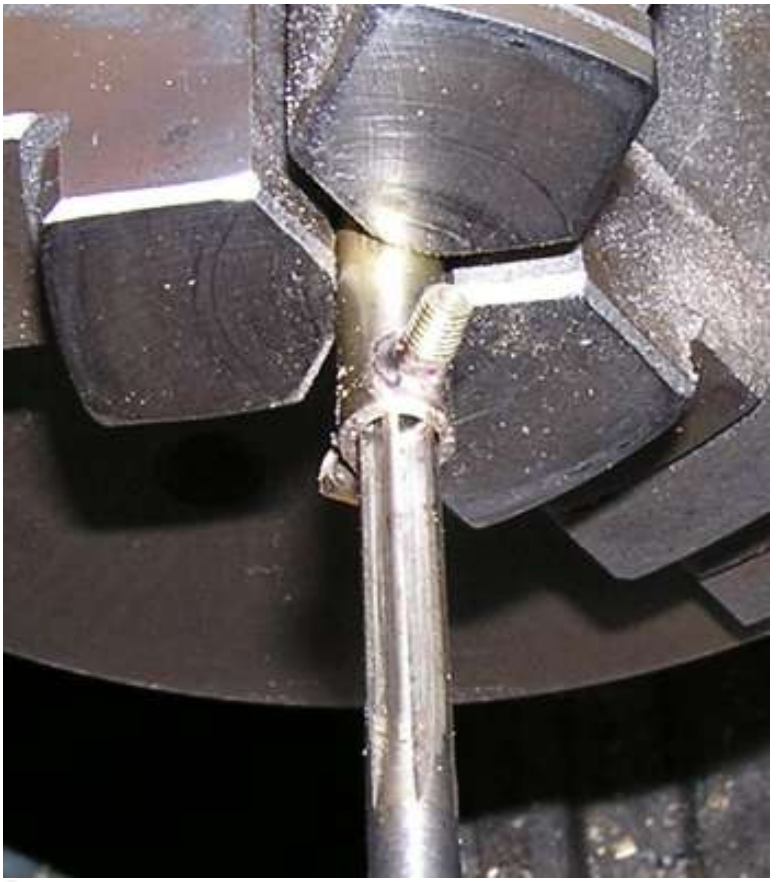





This shows the dimensions on the finished ports. None of the dimensions are critical except of course the holes shouldn't be drilled too deep and run through the other side of the piece.

**Body:** The center part of the body was made from 1/4" brass rod. The end of the rod was drilled 1/8" to a depth of about 3/8". The rod was then crossed drilled 1/8" about 1/8" from the end. (The hole in the center of the rod helps center the bit when the cross hole is drilled.) Next, the input/output ports were silver soldered into the rods as shown on the right. Solder was applied around the output port to fill the void between the hex end of the port and the curvature of the 1/4" rod.

The output port was filed into the final shape at this time. The rod was clamped into a vise to hold everything steady.



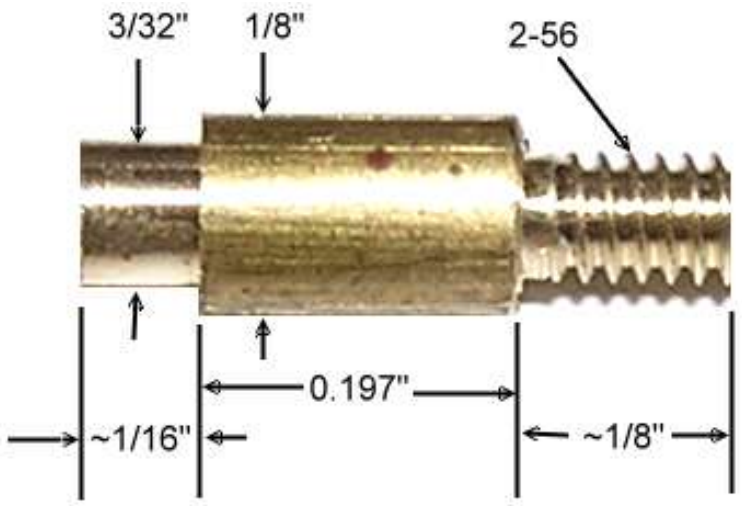
Next, the rod was chucked in the lathe and the end drilled out with a 1/8" drill. This cleaned out the solder and cut the input/output port. The center was than drilled again with a #14 (0.182") drill. The next step was to use the tail stock to force an old 3/16" reamer into the hole **with the body piece stationary** -- see photo. This scored the side of the hole to keep the Teflon sleeve from rotating. The outer end was then faced with the width from the end to the center of the ports 3/32". The inner edge of the end was rounded slightly with a hand held countersink to ease the entrance of the Teflon sleeve. The piece was then parted off with a 3/16" width.

Next, the center of a piece of 3/16 OD Teflon rod was drilled 3/32" and a 1/4" piece cut off with a utility knife. The piece was then forced into the body and the ends trimmed flush with the side of the body.

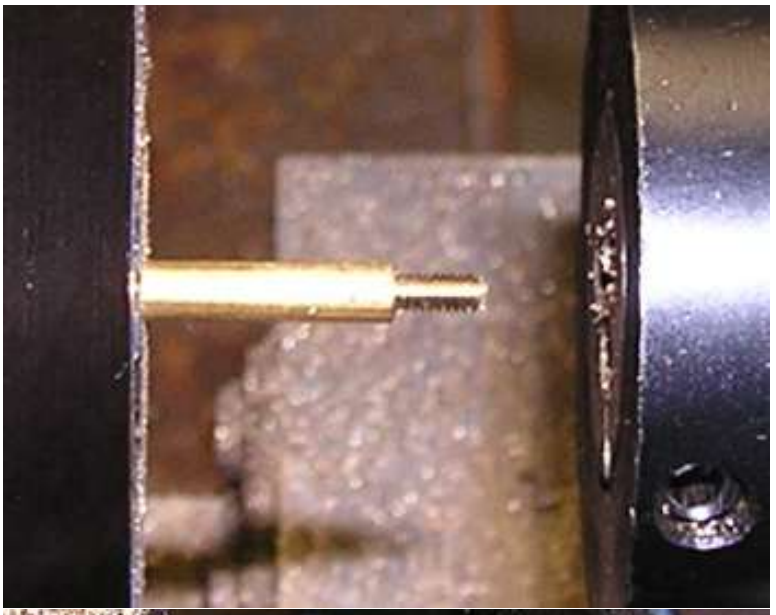

A # 55 drill was run through output port to the input port to make holes through the Teflon sleeve. The sleeve was then reamed 7/64". The photo shows a finished body.

**Plugs:** The plugs were made from 1/8" brass rod. One end was turned down and threaded 2-56 and the other end turned down to 3/32" The only critical dimension is the 0.197" length of the

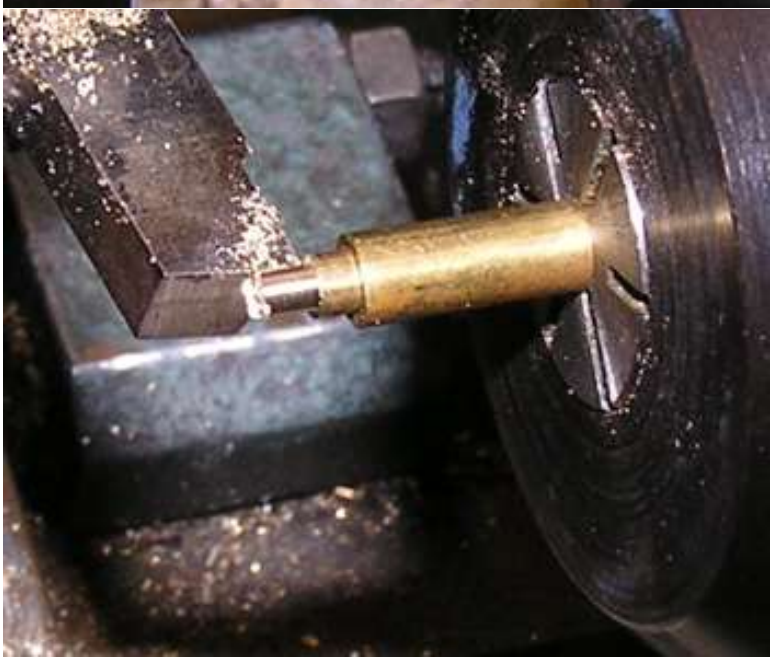
middle part. The 1/16" part will be soldered into the lever and trimmed after the soldering. The threaded part will be filed down to the length that looks best after assembly.




The first step was to turn the end to be threaded and thread with 2-56 die. The rod is held in the lathe collet chuck and the die holder slides on a rod held in the tailstock chuck.



A fixture was made to hold the threaded end of the plug. The lever end of the plug was then turned to 3/32" with the length of the middle section 0.0197" Once the stops were set correctly, it took only a few minutes to turn the ends of 9 plugs.



The lever was made from 5/32" wide, 0.050" thick stainless steel. The distance between the holes is 3/8". The plug was soldered into one hole and a brass tube in the other hole. The tube was made from 3/32" rod with the about 1/8" at the end turned down to 5/64" and drilled #49. The photo on right shows the plug just after the soldering.

The lever was shaped with a file before the 3/32" rod was cut off.

After the 3/32" rod was cut from the handle, the hole in the little tube was tapped 0-80.

The plug-handle combination was then mounted in a fixture to drill the #55 hole through the plug. The fixture is similar to the cock body except it has a 1/8" hole to match the plug diameter and no Teflon sleeve. The fixture has a hole for a 0-80 screw into the end of the plug lever to hold it pointing up at a 45 degree angle.

After the hole was drilled through the plug, the burr at each end of the hole was removed by hand turning a 5/64" drill into opening of the hole. The plug was then smoothed with 400 grit Emory cloth (cloth wrapped around plug and held firmly while lever rotated. ) This was repeated a half dozen times to get a bright smooth finish. From the looks of plug at the right, it could use some more smoothing.

A tapered assembly tool was made from a 1" length of 1/8" diameter brass rod by drilling a 1/4" deep # 44 hole in one end and filing the other end to a point forming a taper. The tool is shown on the right between the plug and the body.

The body was placed over a plate with a 1/8" hole and the assembly tool lubricated with a little petroleum jelly and then inserted through the Teflon sleeve into the hole. The threaded end of the plug was inserted onto the tapered assembly tool and the plug and tool pushed through the sleeve. The tapered tool eases the entry of the plug into the sleeve to avoid cutting the sleeve.

The plug was rotated 20 or 30 times to loosen it up a little.

The cock was then tested with 125 psi compressed air using fixture on right. The end was submerged in water to verify no leaks.

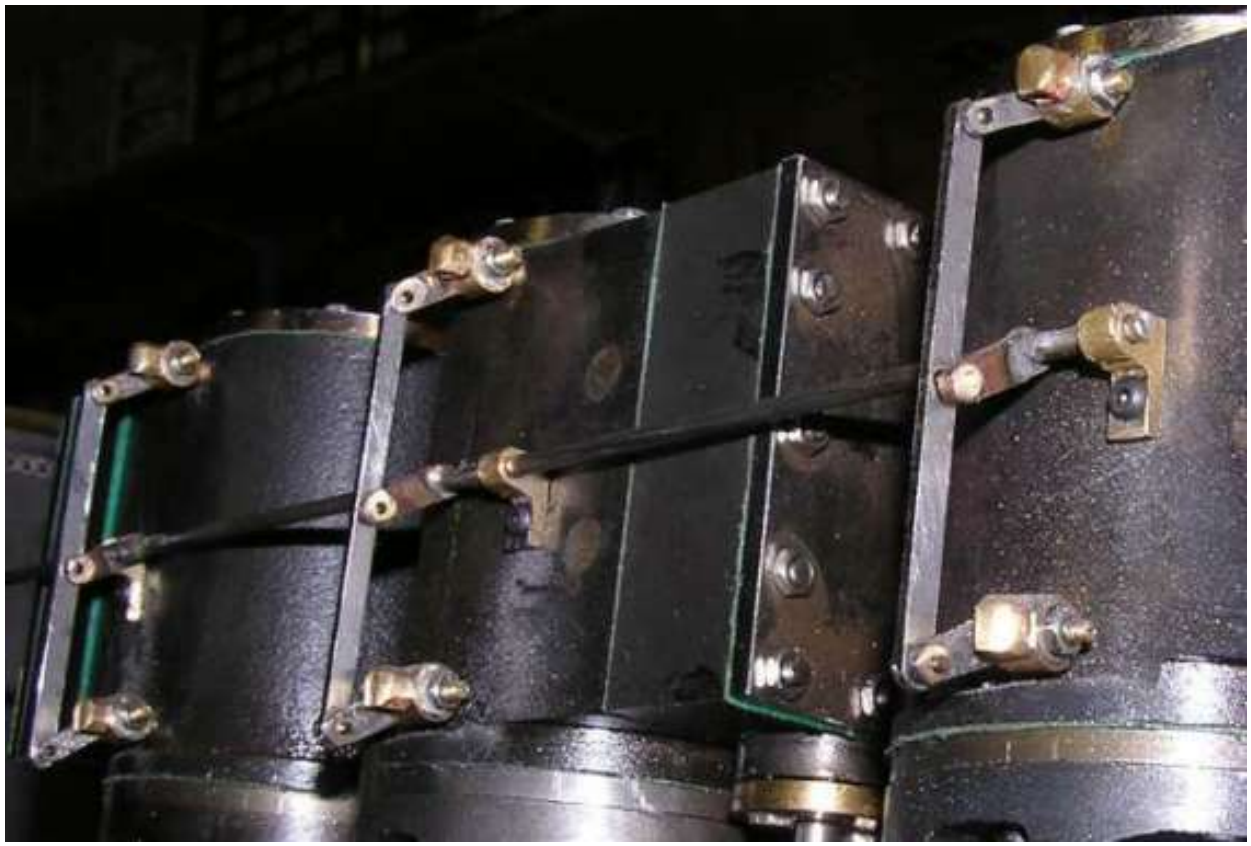
One additional test was done --- several of the cocks were submerged in boiling water and there was no noticeable effect --- they continued to seal. Also a cock with a small leak ( about 4 bubbles per second) was submerged in the boiling water and the leak stopped within a few tens of seconds. When it was placed in cold water it started to leak again within a few 10s of seconds. This was repeated a half dozen times, sometimes rotating the pug a couple revolutions between submerging. Same results. Suspect that the Teflon swells when hot making a better seal.

The cocks haven't been tested on steam yet but expect good results based the boiling water tests.

Several of the cocks leaked slightly so the plug was removed and smoothed again with the Emory cloth and a new Teflon sleeve installed. That fixed it every time.

The photo on right shows a finished plug with the an output tube.

This was my first use of the MTP 1/8-56 die. When I used the die I found the resulting threads too big to thread into elbows. The die as manufactured is not adjustable. I cut a slit in one side using a Dremel cutoff disk and then used it in a die holder where the retaining screws squeeze the die slightly making a smaller OD thread. That fixed the problem. Care was taken when taping the holes in the cylinder to not run the tapered tap in too far making the hole too big.



The photo above shows the six cocks mounted in the cylinders. The shaft linking the three cylinders is 3/32" stainless steel. The levers on the shaft are identical to the levers on the cocks. The little bearing blocks are made from 1/8" thick brass and retained by one 2-25 screw per bearing. Note that I've decided not to use the tubes on the discharge side --- at least for now.

**Update:** The next photo shows the view from the rear of the engine. This is an updated photo that shows the cock operating lever. It was decided to leave the operating lever outside the cab rather than trying to develop some sort of a linkage. Some of the prototypes used a similar lever located inside the cab, in a location that is hard to reach for the engineer of scale model. This outside lever tucks in front of the cab side when the cocks are off and is turned nearly horizontal when the cocks are opened.

(The shaft and little levers haven't been cleaned after the silver soldering.  The flux residue will be removed and the shaft polished when the engine is disassembled for painting.)

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