The following are several articles on brake valves. Some are for steam, some for air. Whether one designed for steam would work on air or vice-versa is up to you to decide. According to Jack Bodenmann, steam valves require larger ports, and a lap position doesn't work well on steam. The last two, from Nelson Riedel, are included with version 2 first as Riedel wrote that version 1 did not work out as planned. But that version 1 set is included for reference.

Gould valve, source: Live Steam, July 1992, p.15 ff.

PART 2

Putting the Brakes On

By William L. Gould

Photos and drawings by Author

Engineer's Brake Valve

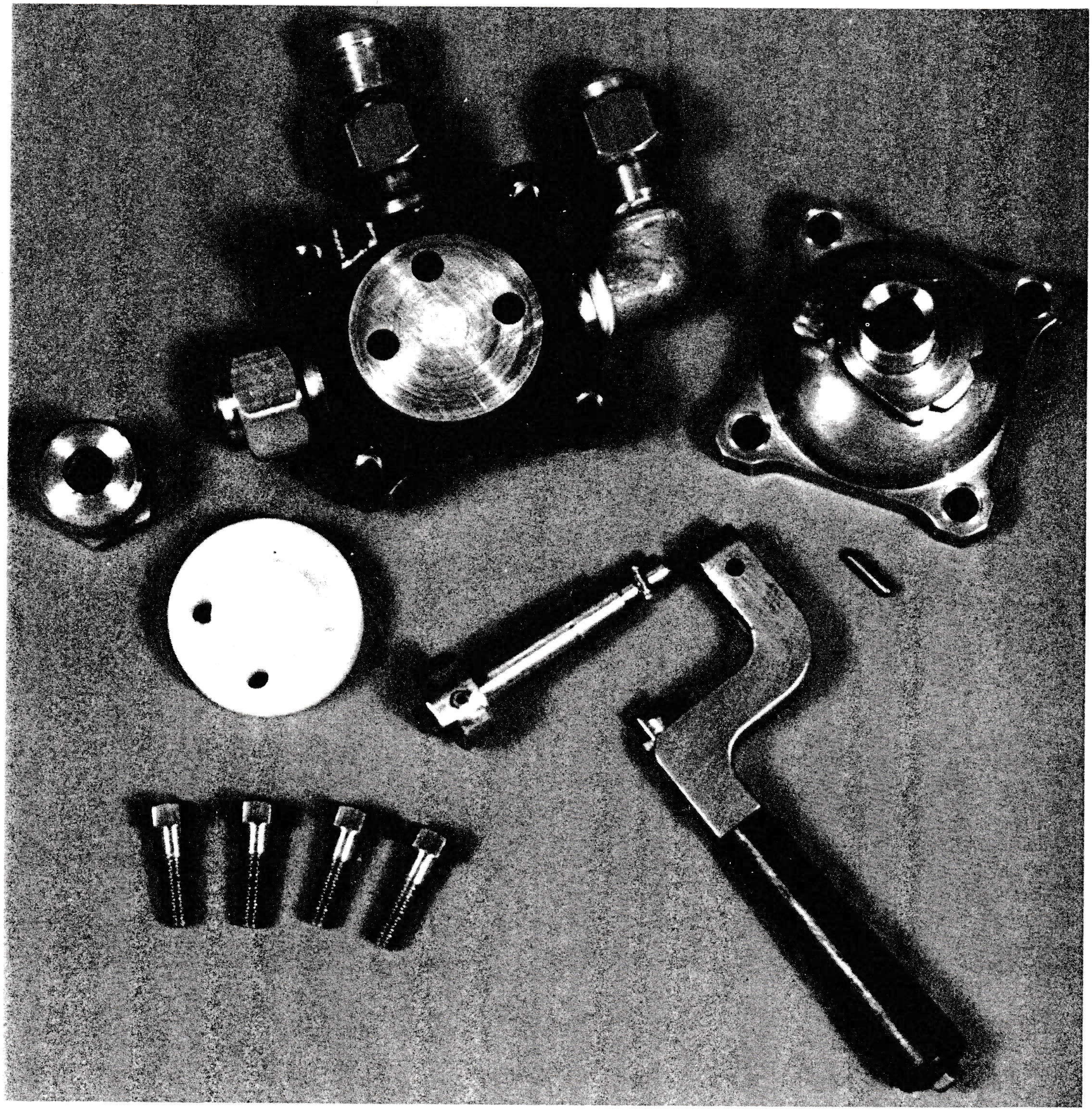
In the previous article we discussed the addition of equalized steam brakes to small locomotives such as Allen Models *Chloe*. The steam brake valve described here can be used with almost any locomotive, however, regardless of scale or prototype. Several suppliers offer a suitable brake valve, but I wanted one that "looked" right, and had *lap, application* and *release* functions. The "look" was important because I plan to mount it above the boiler backhead, off the turret, a real focal point when looking into the cab. Although I made mine to 3" scale, it is really not too large for the bigger 1-1/2" locos; of course, you can also make it smaller – the construction is just a bit more tricky.

The steam brake valve is reliable, works like a champ, and the machining is straightforward – all important. Operation is smooth and easy under pressure, due to the use of *Teflon*® for the valve disk, and it will hold "on-lap" for a considerable period of time.

The body is brass, the disk and spindle gland *Teflon*, the spindle 303 stainless, and, of course, the unit has a rosewood handle.

The drawings should be self-explanatory, but I'll give some construction details

The brake valve parts.



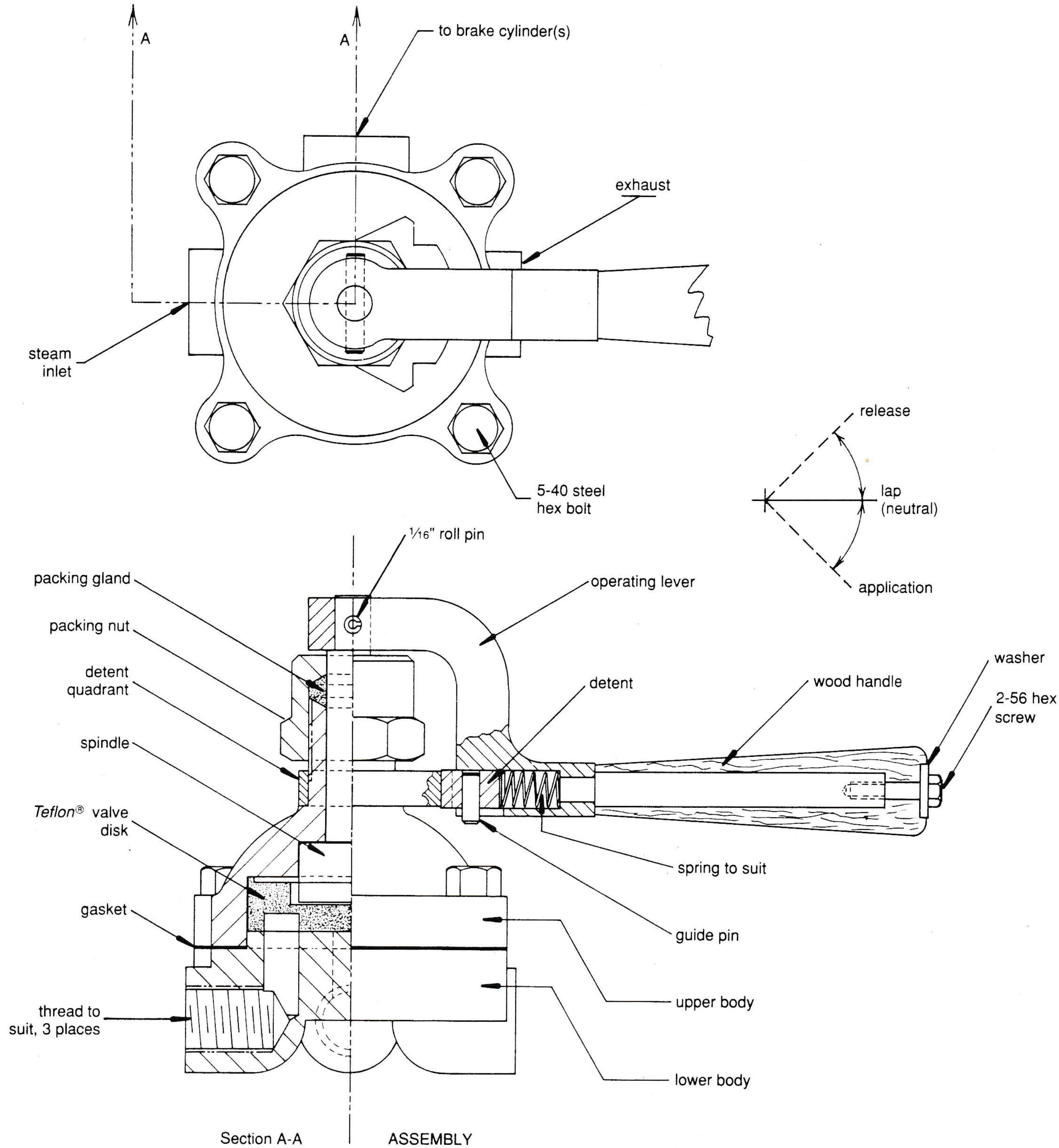
to assist you. Feel free to redesign or rescale to suit your specific need. Note that the input/exhaust ports are reversible simply by rotating the disk 180° as drawn.

Operation

The design uses a rotative disk valve, with porting to provide the functions of application, lap, and release. Steam is always applied to the top face of the disk, thus providing constant seating under pressure. As the disk is rotated to the *application* position, steam is directed through the porting to the brake cylinder ("emergency" or "slow-on" is a function of how quickly the valve is rotated), thus applying the brakes at full available pressure. The center neutral position, or *lap*, holds the brake "on-lap" until steam pressure bleeds off due to leakage (minimal) or condensation in the brake line creates a hydraulic system. The *release* position, of course, seals the valve against steam pressure, and redirects the brake pressure to exhaust, with, I might add, a very convincing "whoof" under the cab. Following release, the valve should be returned to the center, or lap position, ready for the next application. As I said, the operation is very smooth and subtle; it is easy to finesse the brakes for various track and speed conditions. I would like to thank Rudy Van Wingen for his suggestions on the use of *Teflon* and the porting concept I used.

Valve Body

Make the Base from a short length of brass, about 2" long. Face off, turn the locating spigot (allow for gasket thick-



ness) and flange surface; follow with a fine facing cut, as this will be the operating face after polishing on 600 paper. Do not part off yet.

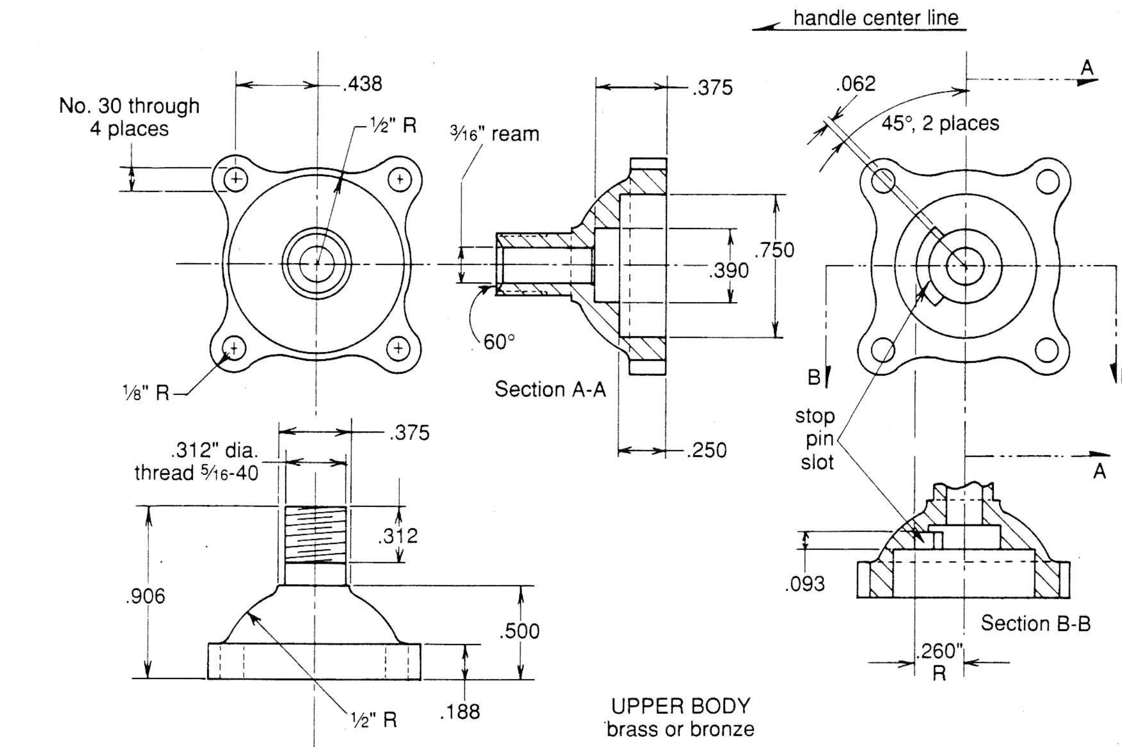
Now turn up the Body, also of brass. Turn the outside and ball-shaped contour, but leave the neck about 1/2" too long. Cut the threads to suit, drill and ream for the spindle, then part off, leaving stock for cleanup.

Chuck up a piece of scrap bar, drill and tap (or screw-cut) to fit the neck and mount the body. Face to dimension; bore the two counterbores, making the large diameter a tight fit to the spigot on the base.

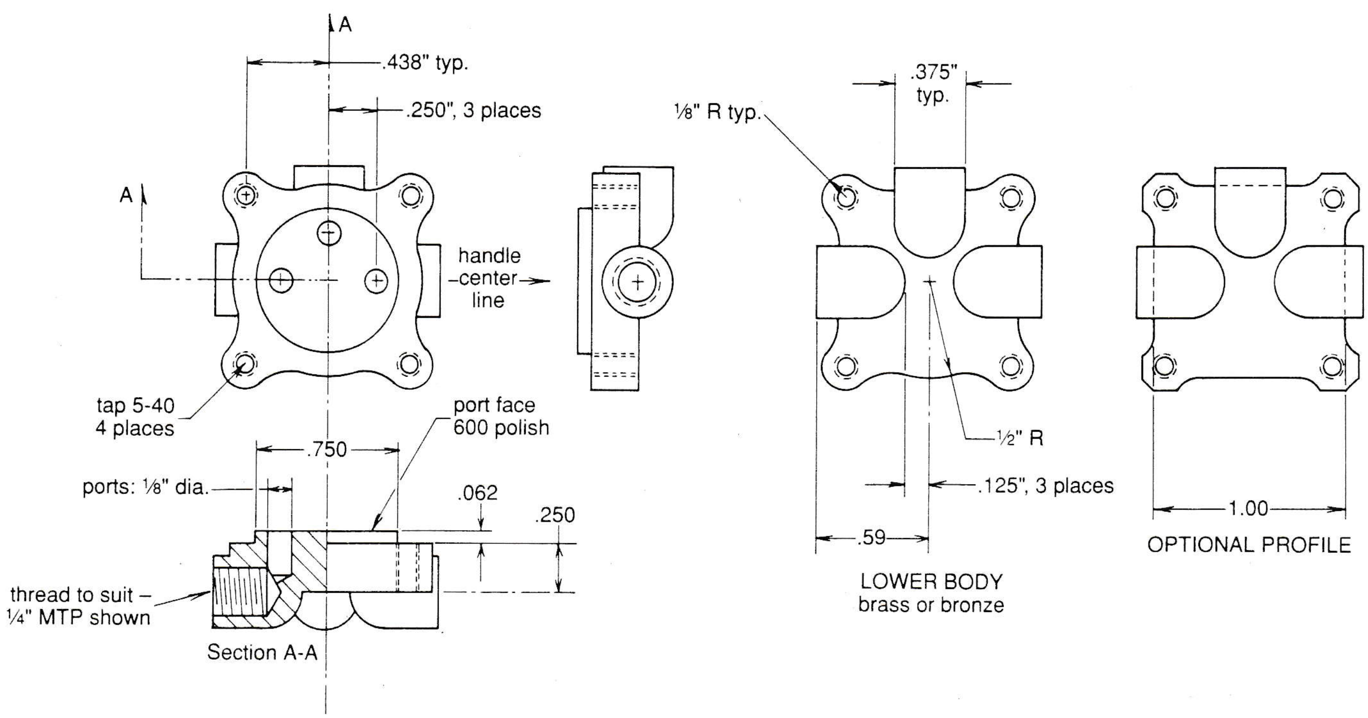
Now mount the base vertically in the mill vise, or use a V-Block. Indicate to the center, and then press the body onto the base. Using the offset formula (Part 1, June issue), drill bolt clearance holes through the body, spotting into the base. Remove the body. Drill and tap the body into the base blank; make sure to tap deep enough into the blank to allow assembly of the body to the base without removing the latter from the vise. Bolt the body to the base.

Now square up the assembly, and contour the profile to suit. Remove, disassemble and part the base from the stock, again leaving enough material for cleanup. Reverse the base in the lathe and face off to the dimension.

Clamp the base, bottom side up, in your mill vise, and indicate to the center. Using a 3/8" ball end mill, cut "slots" for the pipe bosses .188" deep. Turn up three 3/8" diameter bosses, each with a ball end; a trick here is to use the trusty *SpinDex* fixture and a 3/16" radius corner rounding

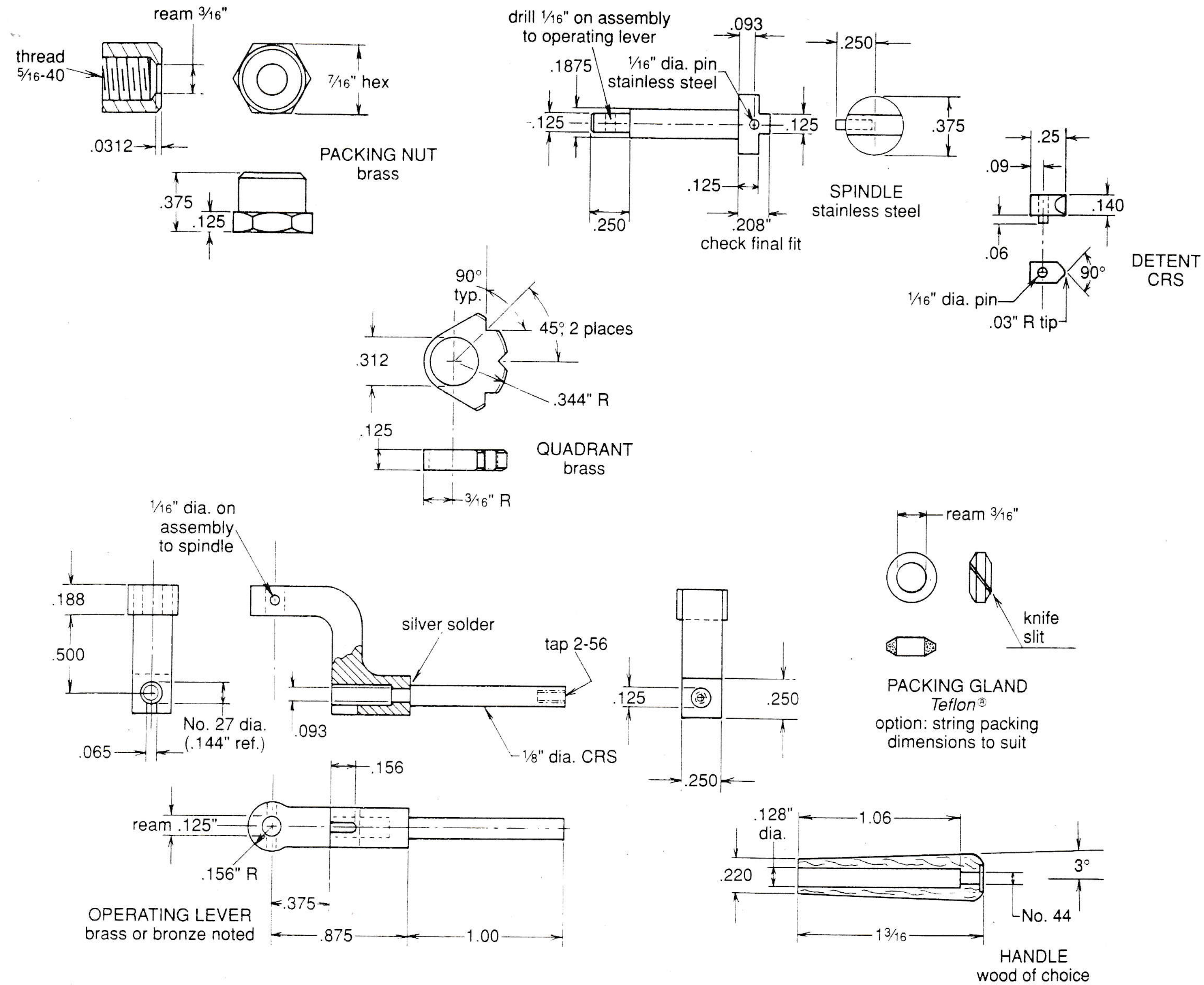


UPPER BODY
brass or bronze



LOWER BODY
brass or bronze

OPTIONAL PROFILE



cutter. Simply rotate the index head by hand, feeding *against* the cut. Drill and tap for the pipe fittings; I used 1/4 MTP, but 3/16 MTP is fine. Silver-solder the bosses in place, clean up, and then drill the three ports through the port face into the bosses.

Now, chuck up the body, trim the neck to proper length, and countersink 45° for the packing gland.

Spindle, Handle, and Detent

The Spindle should be made from 303 stainless steel, turned to a nice smooth fit in the body. The large diameter should be a loose fit in the counterbore; be careful to accurately center the tang, as it must not have any slop in the keyslot of the valve disk. I did not want to rely on the detent ring for stops, so I milled a circular segment in the body, and added a stainless stop pin to the spindle, thus providing a positive stop inside.

Make the Detent Sector from brass, and solder it to the body. Now make up the operating lever (brass) and the rosewood or ebony handle, as well as the spring-loaded detent. This detent does not actually "stop" the rotation, but does provide a prototypically tactile feel. Make the Packing Gland Nut to fit, and turn up a Packing Gland from *Teflon*, slit diagonally to allow sealing. At this point, it is wise to test-assemble everything to adjust fits prior to making the Valve Disk.

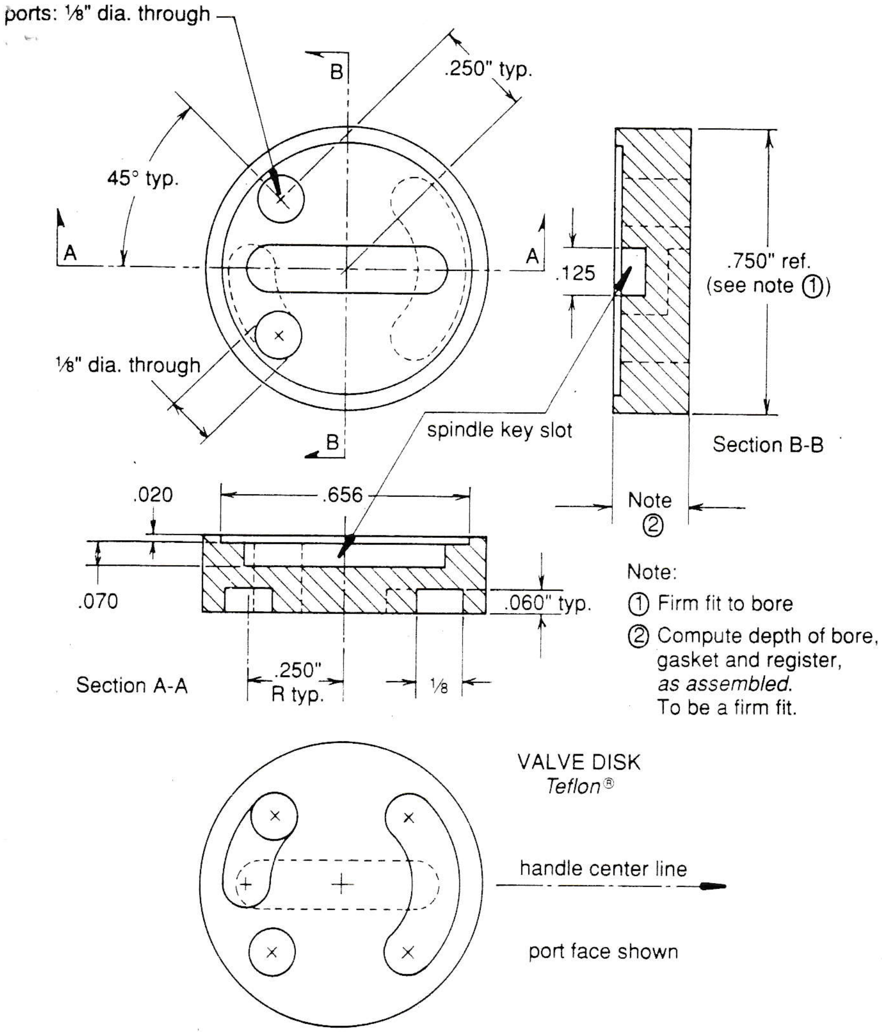
Valve Disk

As you know by now, the valve disk is of *Teflon*, which is the secret to smooth, leak-free operation. In this application it will not be affected by temperature, and no lubrication is necessary.

A word of caution: *Teflon* dust is toxic if burned. *Teflon* dust should NOT be ingested. If you smoke, DON'T DO IT WHEN MACHINING *TEFLON*. And be careful to wash up immediately when finished.

First, we must determine the space available for the valve disk. Carefully measure the dimension between the polished port face and the top of the counterbore in the body, as well as the locating spigot and gasket thickness. What we want is the *as assembled* thickness of the valve disk. Turn up the disk to be a firm but smooth diametrical fit in the body. Part and face off to be a tight fit on the thickness. Recess the top face of the disk as shown to give a bit of a steam chamber. Mount the blank vertically in a V-block, indicate the center, and mill the key slot to be an accurate fit to the spindle key. Rechuck and part off. Reverse the piece (use a bush if necessary) and face off to be a tight fit, by dimension, on thickness. You can fine tune it later on 600 paper.

Now make a simple recessed fixture on the rotary table, using finger clamps. As the ports must register to the keyslot, mill another "keyslot" centered in the bottom of the recess, make a small dummy key, and assemble the disk to the fixture. Clamp it lightly. Locate and drill the ports, and cut the circular connecting joints. Remove, and deburr with a *sharp* modeler's knife. Follow up with a polish on wet 600 wet/dry paper.

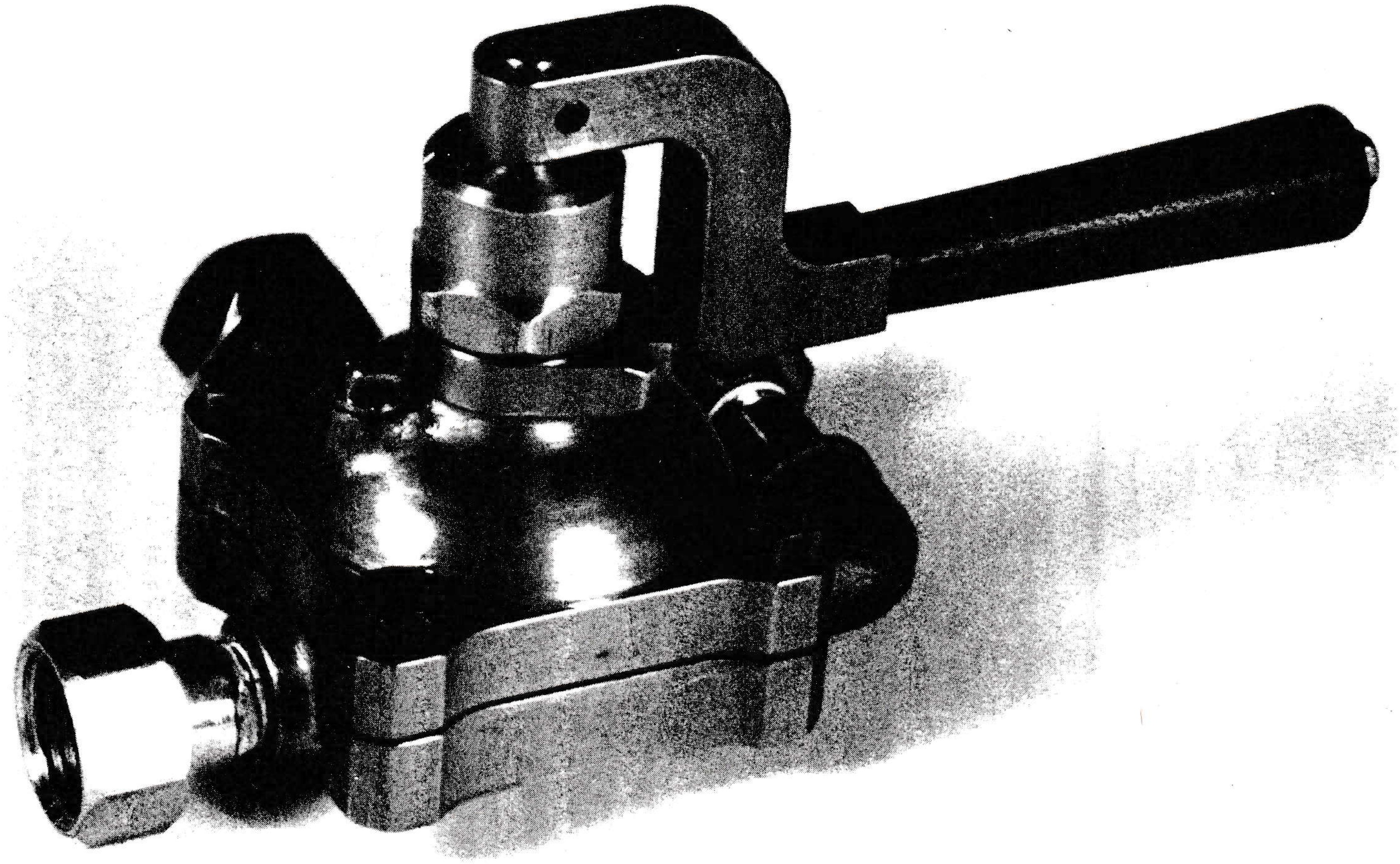


Assemble all, including the gasket, and test for action. The valve disk should be firm, yet easily operated. If all is okay, clean, paint and do your final assembly. Gasket goop should not be necessary.

I added a check valve in the steam line ahead of the brake valve to prevent suck-back of oil from the brake cylinder on cool-down, as well as a fitting in the brake line to add several drops of oil to the system prior to each day's run. Thanks to Tom Rhodes (Fitchburg Northern series) for this pointer. It is also wise to wrap the brake line to help minimize condensation.

Although a bit of work, this little valve was a lot of fun, and works as expected. I think you will be as pleased as I am.

The assembled brake valve.



Phillips valve. Source: Australian Model Engineering, date unknown

A Brake and Drain Cock Valve

by Les Phillips

I can just hear you – not another b----- brake valve! Well, yes, but I hope someone out there will be interested! When I wrote about the Rosebud grate I thought there was one other item that might be useful, the brake and drain cock operating valve. I hope that is the case, so here goes.

On the full size 38 class locos the drain cock operating valve is located on the cab side just in front of the driver's knees – very handy but it did present me with a problem with the models as it didn't give me a lot of room if I wanted to duplicate it. As I was pondering on this I remembered an article many years ago in the English *Model Engineer* on a valve which was fairly compact. My filing system came good so it was then just a case of adapting it to my needs. The original concept by Ian Rowbottom of South Africa was very ingenious and had a tapered cock arrangement – I simply changed it to a parallel spindle incorporating an 'O' ring for simplicity and to save time. I haven't got enough years left to muck about! The drawing tells most of the story.

The main criteria was for a fairly small body. The result was a neat, compact valve which I hope will fulfil a need. On 3807 and 3808 the one for the drain cocks is mounted as full size, whilst the one for the engine brake is mounted under the floor and operated by the handle of the brake stand. In use it does give some modicum of control as you make a partial application by moving the handle part way.

The mounting bracket is silver soldered to the end in my case but obviously can be adapted to suit your situation. Using the 'O' ring as a seal, your turning has to be reasonably accurate. However, it is all straight forward and the sketches should be sufficient, which I hope have all the necessary measurements. If you have any complaints with the drawing, don't contact me, contact my draftsman! That will be alright as he won't take any notice of you anyway. I would make one or two comments which may help.

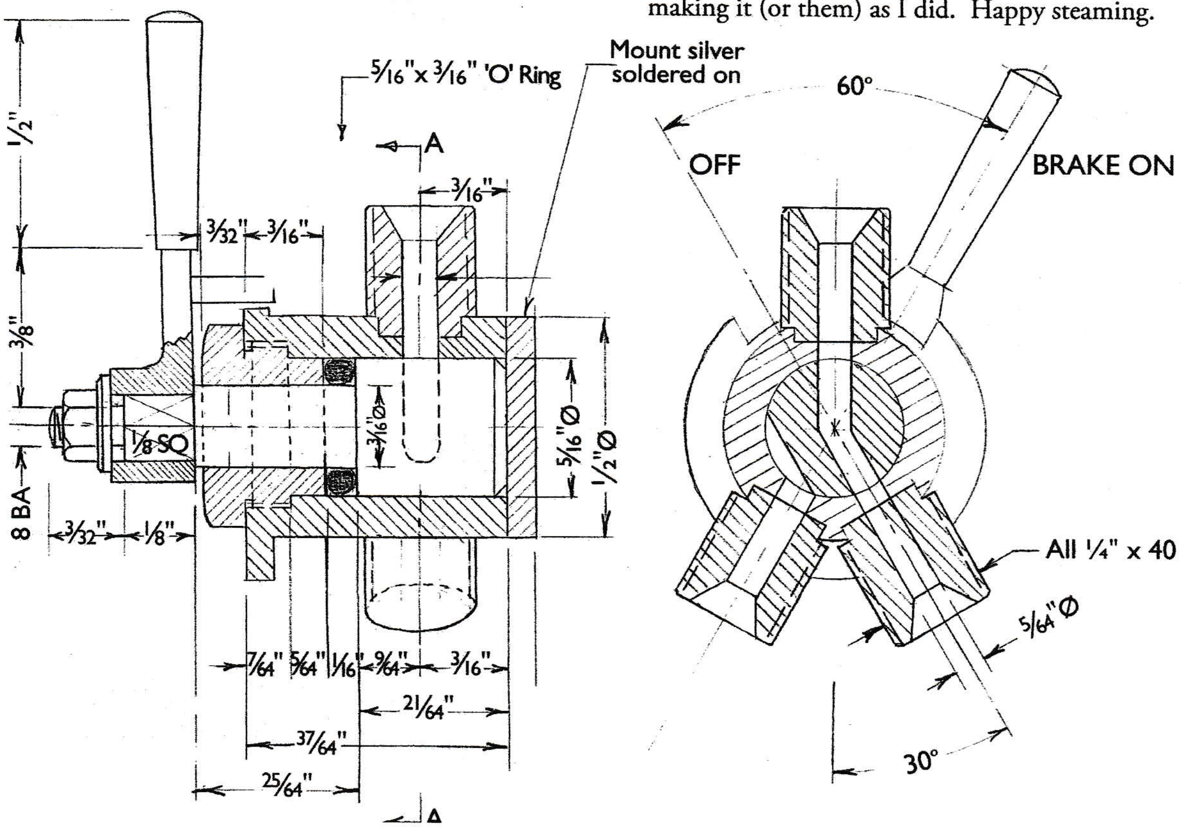
It is made of bronze, brass and stainless steel and you should have the specified sizes in your rack. I made one recently for my *Nigel Gresley's* new vacuum brake when I shopped it for a major overhaul after thirty years of hard work.

The body is a straight "boring job" (notice the play on words) and should cause no problem. However, it is important to stick to the 60 degrees stipulated for both the body connections and the hole through the spindle. Preferably the holes through all components should be done in a rotary table or dividing head, including the spot holes in the body to take the nipples. Make sure the latter don't go right through initially as you don't want any silver solder in the bore – they can be drilled through afterwards. Also give some thought so that you drill the angle the right way through the spindle, otherwise it will be off when it's on and on when it's off, if you know what I mean! One other small point, the spindle should have no shake. It should rotate freely but be a neat fit in the body.

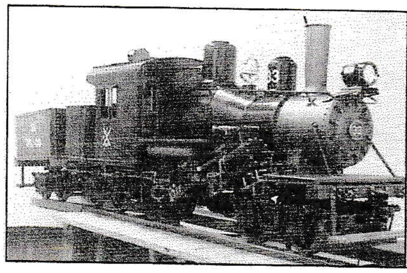
Now, the stops for the handle can be done two ways, (a) leave a ring on the end when turning the body and machine or file away to suit or (b) silver solder on two good sized lugs and make final adjustments with a file, which is probably more fiddly.

To establish the correct position for the groove to obtain exhaust, put the spindle into the body in the appropriate position, i.e. with the handle in the shut position, and spot with a drill onto the spindle through the two holes for the threaded nipples. Then simply machine or file a groove between the two. And that's about all there is to it.

However, one very last thing. If you would like to make it smaller, rest assured it can be done. My mate John "no compromises" Brown has done it! And by about a third! Anyway, go to it. I hope you get as much enjoyment out of making it (or them) as I did. Happy steaming.



Reedy valve. Source: Live Steam, Nov./Dec. 2003 p. 46 ff.

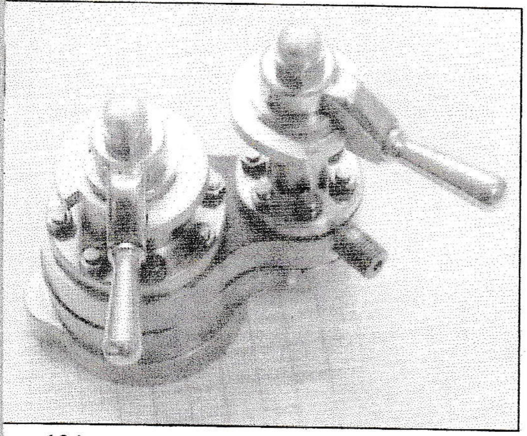


PART 15

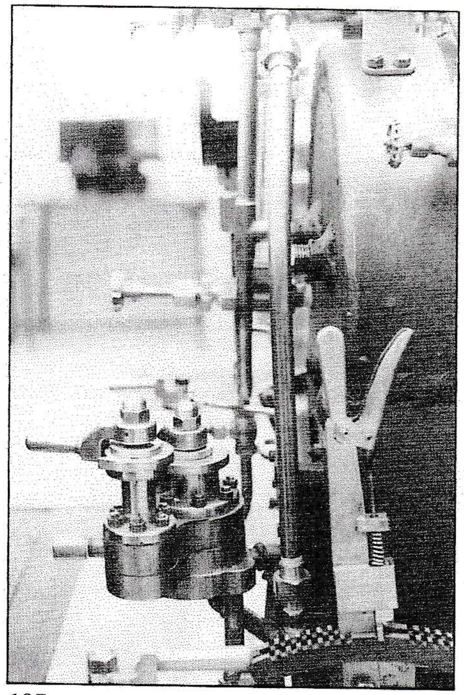
Three-truck Climax

By Bob Reedy

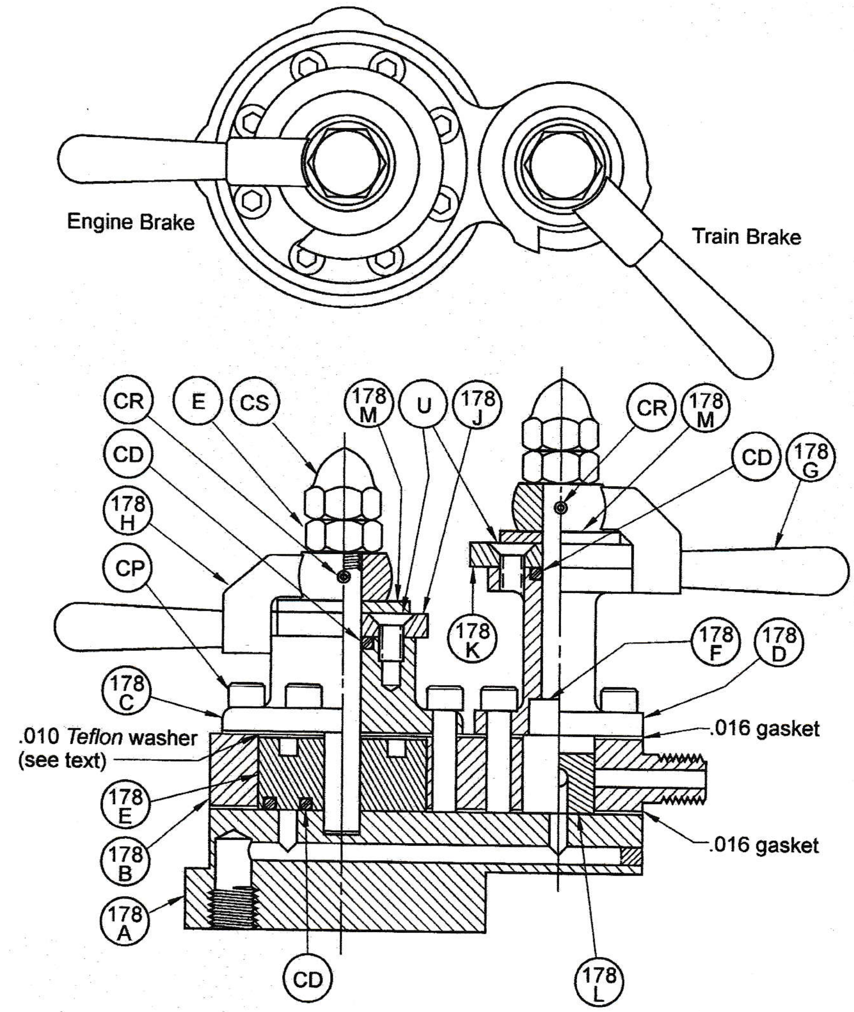
Photos by Author
Drawings by Neil Knopf



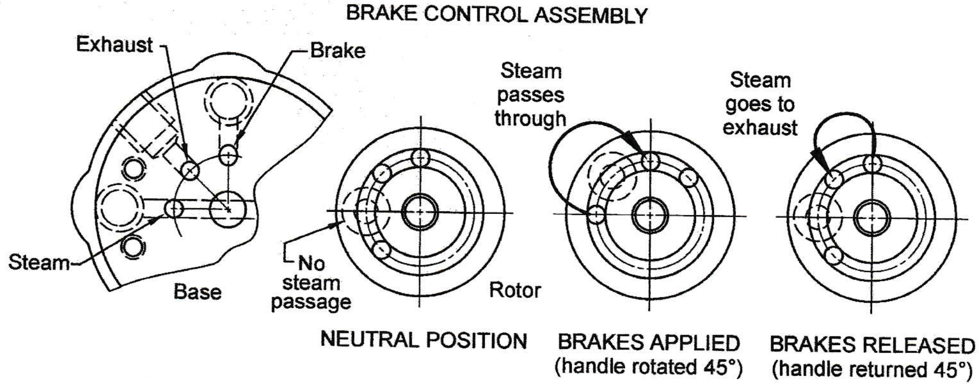
104



105



BRAKE CONTROL ASSEMBLY



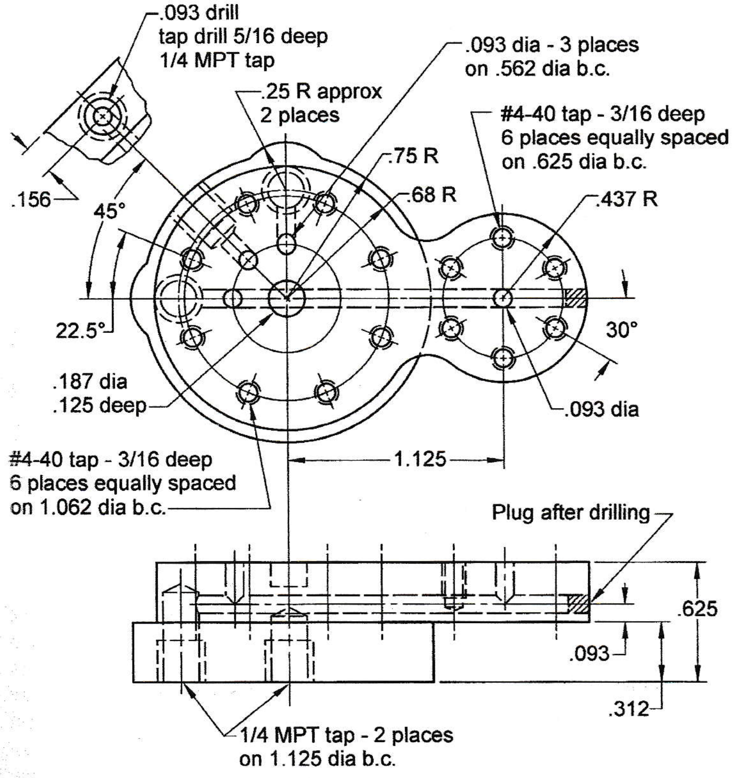
ENGINE BRAKE VALVE DIAGRAM

The brake control valves are constructed from detail drawings **178A** through **178M**. Close-up views of the valves may be seen in **Photos 104** and **105**. The idea came from the brake valves shown in **Photo 106**. Although these valves are not on the Climax, they were used extensively on engines of this period.

The larger of the two valves on the model is for the engine brakes and the smaller one is for the train brakes. At this time, the train brake valve is not in use. The operating principle for the engine brake is very simple. When in the inactive position, a blanked-off O-ring covers the steam inlet hole; and when the brake is activated, the O-ring is moved to cover the exhaust hole. When in this position, steam can now pass up into a circular groove in the rotor (Detail 178E), around and down to the pipe leading to the brake cylinders.

When finished with the brake, the lever is returned to the off position, stopping the steam and uncovering the exhaust passage. The principle is illustrated in the Engine Brake Valve Diagram.

The valve for the train brake operates on the principle of a rotary plug. The plug has a hole in the bottom that leads to a cross hole coming out of the side. There is



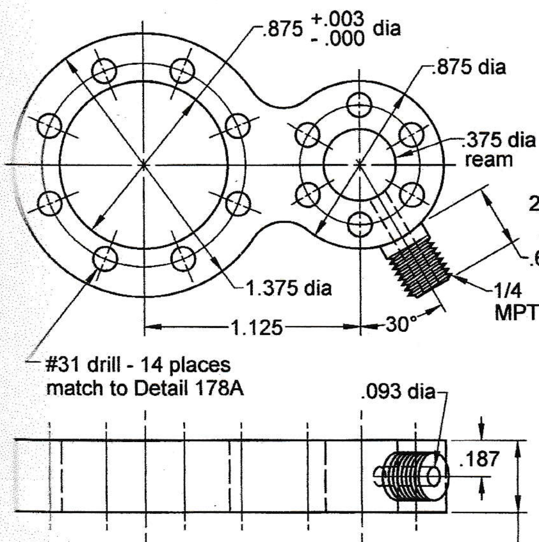
178A BASE PLATE
mat'l - brass
1 required

BILL OF MATERIALS – *BRAKE CONTROL VALVES*

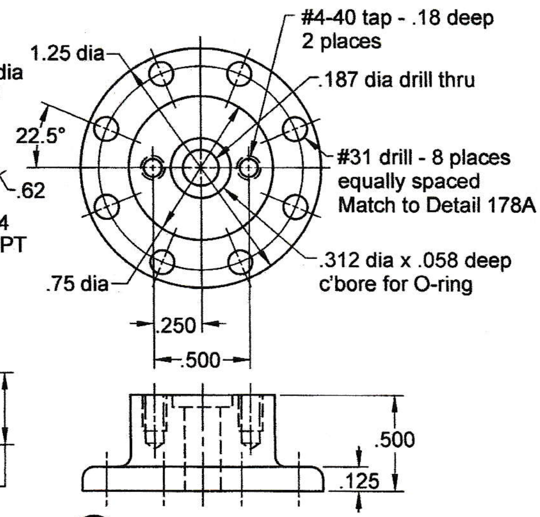
ITEM NO.	QTY.	DESCRIPTION	MATERIALS/NOTES
178A	1	Base plate	brass, 2.0 × 2.5 × .625"
178B	1	Body	brass, 1.375 × 2.5 × .375"
178C	1	Brake valve top	brass, 1.25" dia. × .500"
178D	1	Valve casing	brass, .875" dia. × .875"
178E	1	Rotor	303 stainless steel, .873" dia. × .397" .186" dia. × 1.610"
178F	1	Valve stem	303 stainless steel, .186" dia. × 1.625" .060 × .370 × .090" .300" dia. × .180"
178G	1	Train brake handle	brass
178H	1	Engine brake handle	brass
178J	1	Stop plate	brass, 1.00" dia. × .125"
178K	1	Stop plate	brass, .938" dia. × .125"
178L	1	Valve spool	brass, .372" dia. × .402"
178M	1	Washer	brass, .687" dia. × .062

BILL OF MATERIALS – *HARDWARE*

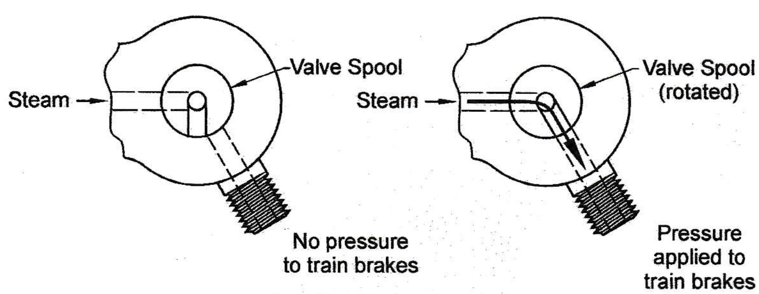
ITEM NO.	QTY.	DESCRIPTION	MATERIALS/NOTES
CP	8	Socket head cap screw	No. 4-40 × 3/4" long
CR	2	Roll pin	1/16 × 1/2" long
CS	2	Acorn nut	brass, No. 10-32



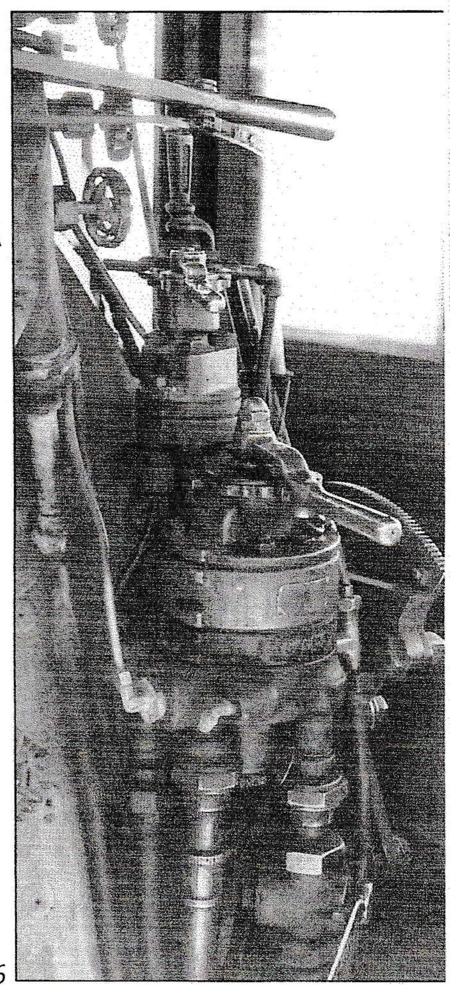
178B BODY
mat'l - brass
1 required



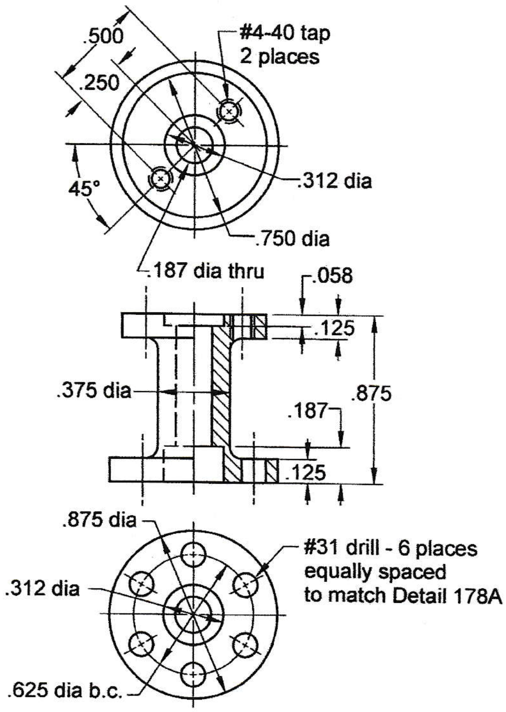
178C BRAKE VALVE TOP
mat'l - brass
1 required



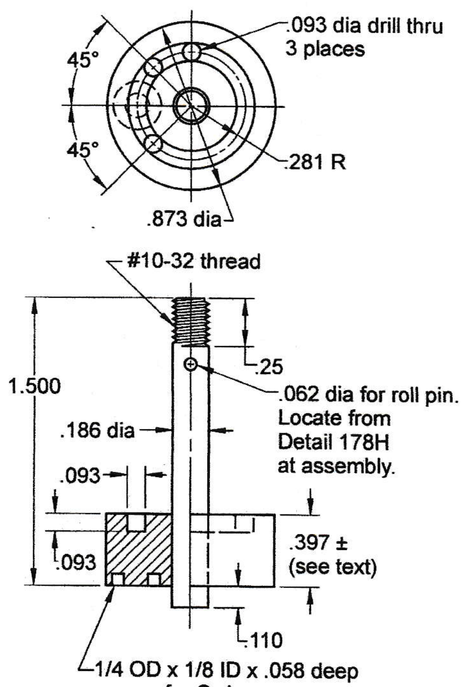
TRAIN BRAKE VALVE DIAGRAM



106

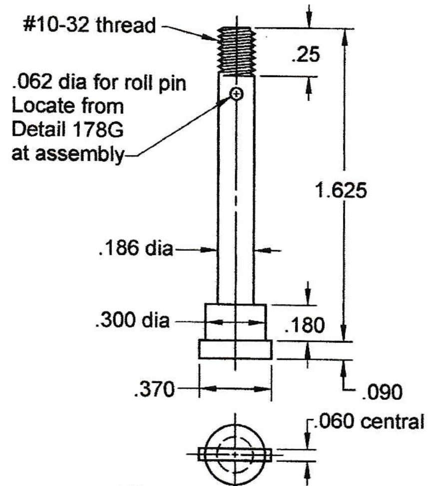


178 D VALVE CASING
mat'l - brass
1 required

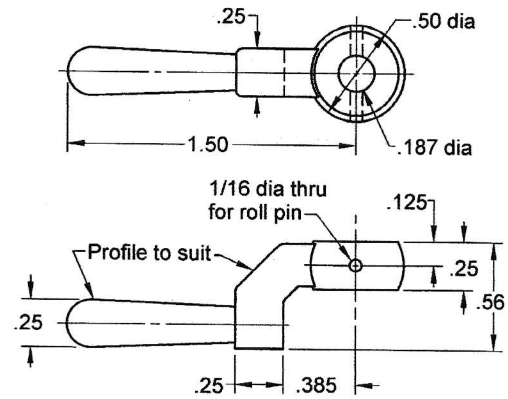


178 E ROTOR
mat'l - 303 stainless steel
1 required

a corresponding hole in Detail 178A. When the brake is off, the holes do not line up. When the brake is activated, the plug is rotated to line up the holes, sending the steam to a vacuum injector or a brake cylinder. This plug is made from *Teflon* which expands with heat. The idea is to give enough clearance when cold so, when heated by steam, the plug will expand to give a good fit. The plug is small, so it will



178 F VALVE STEM
mat'l - 303 stainless steel
1 required

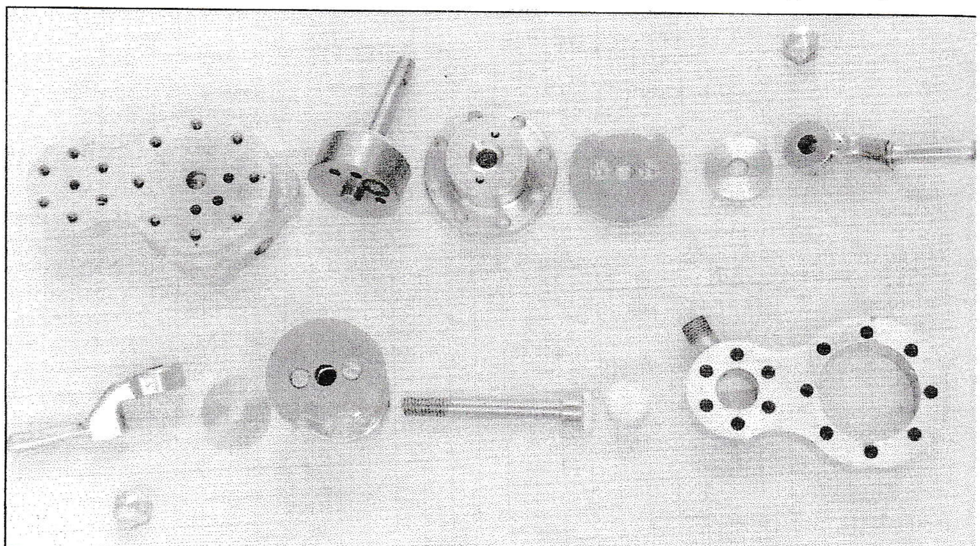


178 G TRAIN BRAKE HANDLE
mat'l brass
1 required

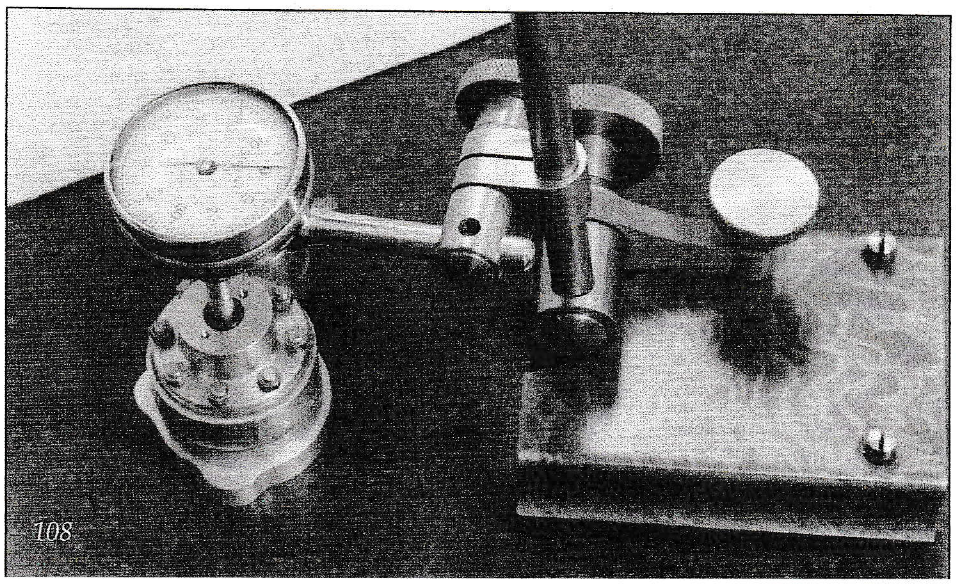
expand to a good fit quickly.

Photo 107 shows all the parts laid out.

It is important to get the correct thickness on the rotor (Detail 178E). A *Teflon* washer with a thickness of .010" was used on the upper side to reduce friction. When calculating the correct thickness for the rotor, the thickness of the gaskets and the washer must be taken into account. The height of an installed O-ring above the rotor face must also be considered. The O-ring needs a few thousandths compression in order to seal. The rotor clearance can be checked after machining to determine if the thickness is correct by assembling the complete unit, except for the O-ring, with gaskets



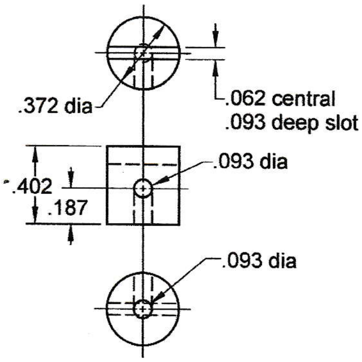
107



108

and washer. The clearance can be checked by placing a dial indicator on the top of the rotor shaft. The shaft is then lifted until the rotor is against the top. There should be only a few thousandths of motion. **Photo 108** shows this operation. The surface the O-ring slides on must be polished and the edges of the holes must be smooth to avoid shearing.

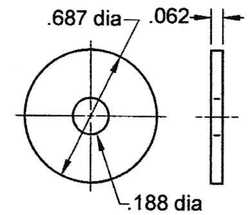
A simple tool can be made for machining the O-ring groove by turning a piece of oil-hardening tool steel to the correct OD and drilling a hole in the end to match the ID of the O-ring. Harden and draw the steel. Grind away all but enough to form a single tooth. Give the tooth plenty of back rake and use plenty of cutting oil.



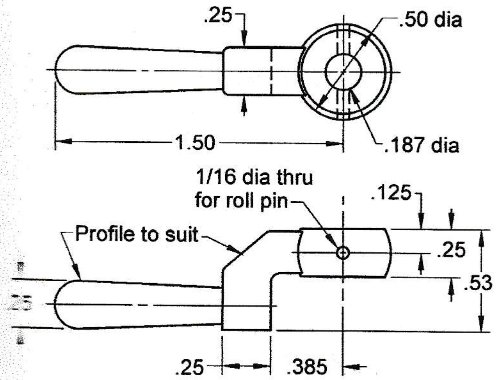
(178 L) VALVE SPOOL
mat'l - brass
1 required

Details 178E and 178F are made from 303 stainless steel. The remaining components are made from brass.

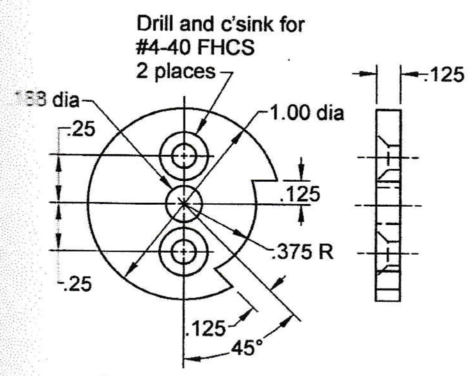
Next time, we'll work on the throttle.



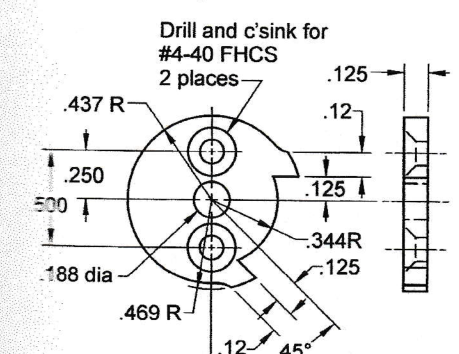
(178 M) WASHER
mat'l - brass
1 required



(178 H) ENGINE BRAKE HANDLE
mat'l brass
1 required



(178 J) STOP PLATE
mat'l - brass
1 required



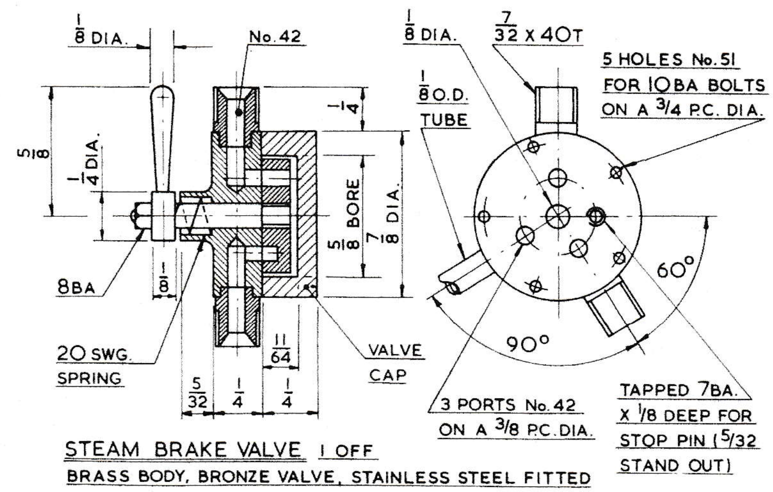
(178 K) STOP PLATE
mat'l - brass
1 required

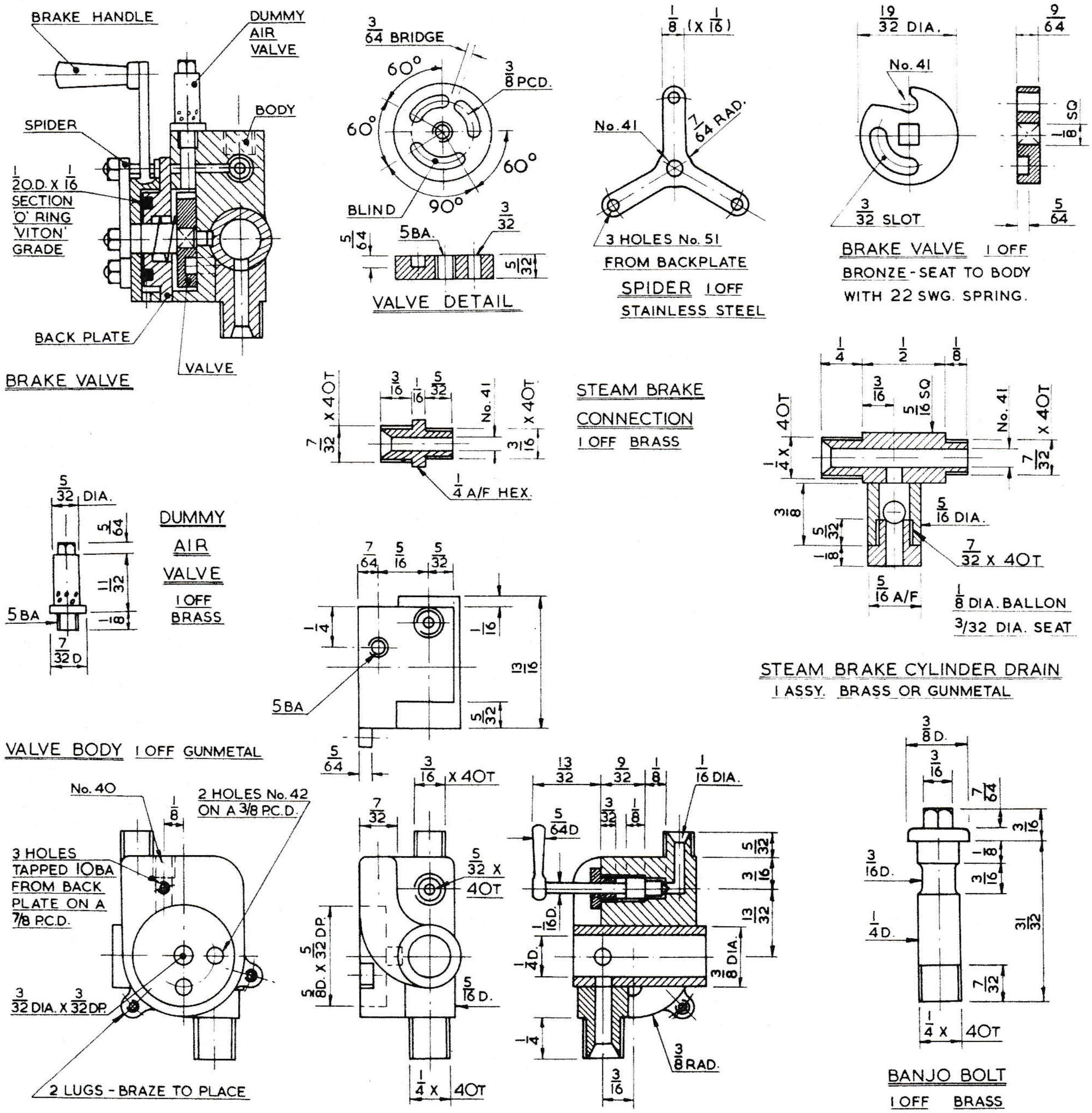
Don Young valve. Source: Live Steam, Feb. 1980

Lanky

by Don Young

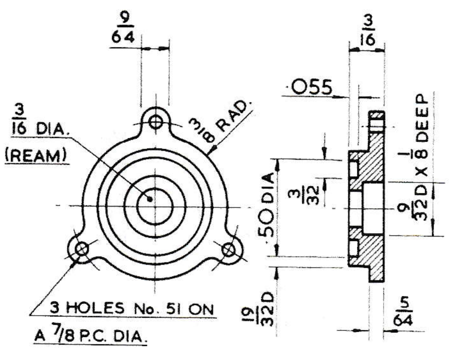
Part 26 — Steam Brake Valve



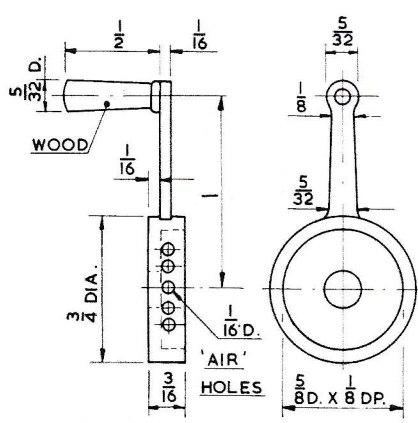


Full size, the brakes were vacuum operated, and there is no reason why **Super Lanky** cannot be so fitted. However, the function of the valve as detailed has been changed from vacuum to steam operation, to control the brake cylinder on the engine. The **Dummy Air Valve** and **Banjo Bolt** to attach to the boiler will cause no problems, so let us get stuck into the **Valve Body** right away.

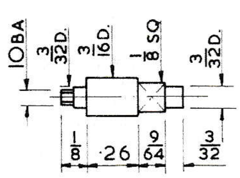
Start with a 1″ machined length from ¾″ square gunmetal bar and at ⅝″ from the top on the vertical center line, center pop. Set this pop mark running true when chucked in the 4 jaw, lightly



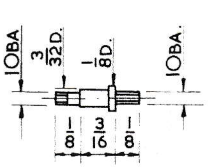
BACKPLATE 1 OFF BRASS



BRAKE HANDLE 1 ASSY. BRASS



SPINDLE 1 OFF
STAINLESS STEEL



COLLAR STUD 3 OFF
STAINLESS STEEL

face off, then drill 3/32″ diameter to about ¼″ depth. Next bore out to ¾″ diameter and 5/32″ depth to form the valve seat. The 3/32″ hole in the center will help you get this nice and flat. Scribe a half circle at ⅜″ radius to represent the bottom shape of the body before removing from the chuck.

Next, mark on the position of the sleeve to accept the banjo bolt, drilling the body at ⅜″ diameter to accept same. Mill down the body thickness to 37/64″ before completing the profile with saw and files, plus milling in the area where the steam brake valve is to be fitted. Turn up the sleeve and slide it into the remains of the ⅜″ hole. Then turn up the outlet connection to the brake cylinder, scalloping to suit the sleeve. To complete the assembly ready for brazing, we need the two lugs to accept the spider studs; I suggest these be made oversize in the first instance, and once tapped out, their final shape can be established. Oh, and there is just one more item, the inlet union, which I suggest be turned to a press fit in the body rather than be produced integral as I have shown. Braze up, pickle, clean and inspect.

To machine the **Valve Body** for the **Steam Brake Valve,** bolt through the sleeve to the vertical slide. Mark off the center and align with the headstock, then drill 1/16″ diameter to ½″ depth. Follow up with an ⅛″ 'D' bit to 13/32″ depth and tap 5/32 x 40T as deep as possible without ruining the seat just produced. The valve, 'gland' and handle are all similar to parts previously made, so you can pass quickly on and complete the drilling of the passage from the inlet connection, down into the hole ahead of the valve spindle. Next, mark off and drill the hole for the dummy air valve (it is a passage really into the valve chamber), the dummy air valve acting as a plug. To complete the passage from the valve to the chamber, a No. 55 hole is required, and I have located this as an extension of the 10BA tapped hole at the side, for securing the back plate. Merely make a note of its position for the moment.

The **Backplate** starts life as a lump of 1⅛″ diameter brass bar. First chuck in the 3 jaw. Face, center, drill No. 13 to at least ½″ depth and follow up with a 7/32″ 'D' bit to ⅛″ depth. Ream it out at 3/16″ diameter. Lightly scribe in circles at ¾″ and ⅞″ diameter to locate the profile and bolting circle, then part off at 13/64″ thickness.

Reverse in the chuck, checking that the 3/16″ bore is running true; if not, then use the 4 jaw and set carefully. Turn the outside and machine the groove for the 'O' ring. Next, mark off and drill the three No. 51 fixing holes and then profile the outer flange to complete. For the lugs, I would case-harden two 10BA plain steel washers and bolt one each side of the lug, carefully filing on the radius. For the remainder of the profile, chuck a length of ¾″ diameter mild steel bar, bore out for about 3/16″ depth to a tight fit over the 19/32″ diameter spigot, part off an ⅛″ slice, case-harden this, and use as a simple filing jig. Locate the backplate on the body, spot through, drill and tap the three 10BA holes, and complete the other pair of lugs.

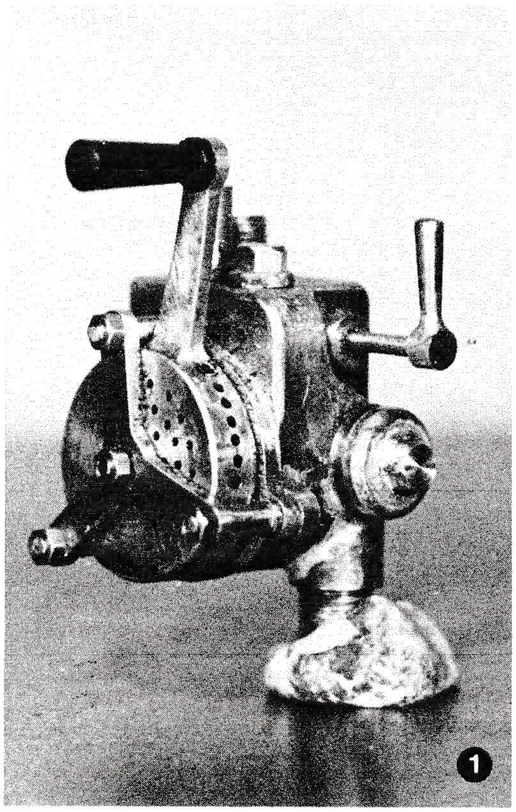
The **Spider** starts life as a piece of 1/16″ stainless steel sheet. Drill centrally at No. 41, then turn up the center spindle to locate on the backplate before drilling the three No. 51 holes. Now it is simply a matter of completing the profile to drawing. The **Collar Studs** are easy, which brings us to the **Brake Valve** itself.

Chuck a length of ⅝″ diameter bronze bar, reduce to 19/32″ diameter for about 5/16″ length. Face the end, center and drill No. 32 before parting off a 9/64″ slice. Drill four No. 41 holes on a ⅜″ pitch circle diameter to 5/64″ point depth to start forming the blind slot, gripping in the machine vise to complete the slot freehand. Drill another No. 41 hole right through on the same pitch circle at the position shown. Then broach the ⅛″ square hole to suit the spindle. Locate in the body, deepening the spindle hole as necessary. Then drill off the other two ports specified. The one at the bottom is for exhaust and is open to atmosphere. Shape the valve roughly as shown to allow gradual application of the brake, then grind the valve onto its seat, using a bit of stout rubber tube over the projecting spindle for ease of rotation.

The **Brake Handle** adds the finishing touch, so first chuck a length of ¾″ brass bar. Face, center and drill No. 13 to ⅜″ depth. Bore out to ⅝″ diameter for ⅛″ depth, getting a really good surface finish in way of the 'O' ring, then part off at 13/64″ thickness; reverse and clean up. The 1/16″ 'air' holes add a touch of authenticity, though they achieve nothing. Cut the arm from ¼″ x 1/16″ brass strip, fit a ⅝″ length of 1/16″ rod at the top, and braze the three pieces together. Complete with a wooden handle, turned from oak or ebony, lightly peening the 1/16″ rod over to secure it in place. A 10BA plain brass washer would look good at both ends of the wooden handle, and make peening a lot easier.

Assembly is a little tricky, as the spindle has to be a tight fit in the handle to prevent steam leakage; fit this first, slide into the backplate, with its 'O' ring in place, then add the 22 s.w.g. bronze spring, followed by the valve. The spring only has to be strong enough to retain the valve lightly on its seat, so the valve should not jump off the spindle during assembly. Next, fit the collar studs, followed by the spider, when you can check operation of the valve. I made a deliberate omission in the earlier text about correct orientation of the handle on the spindle, for now I can explain how the whole thing works.

With the handle in the 'off' position, almost vertically upwards and hard against the top collar stud, the blind port must span both ports in the



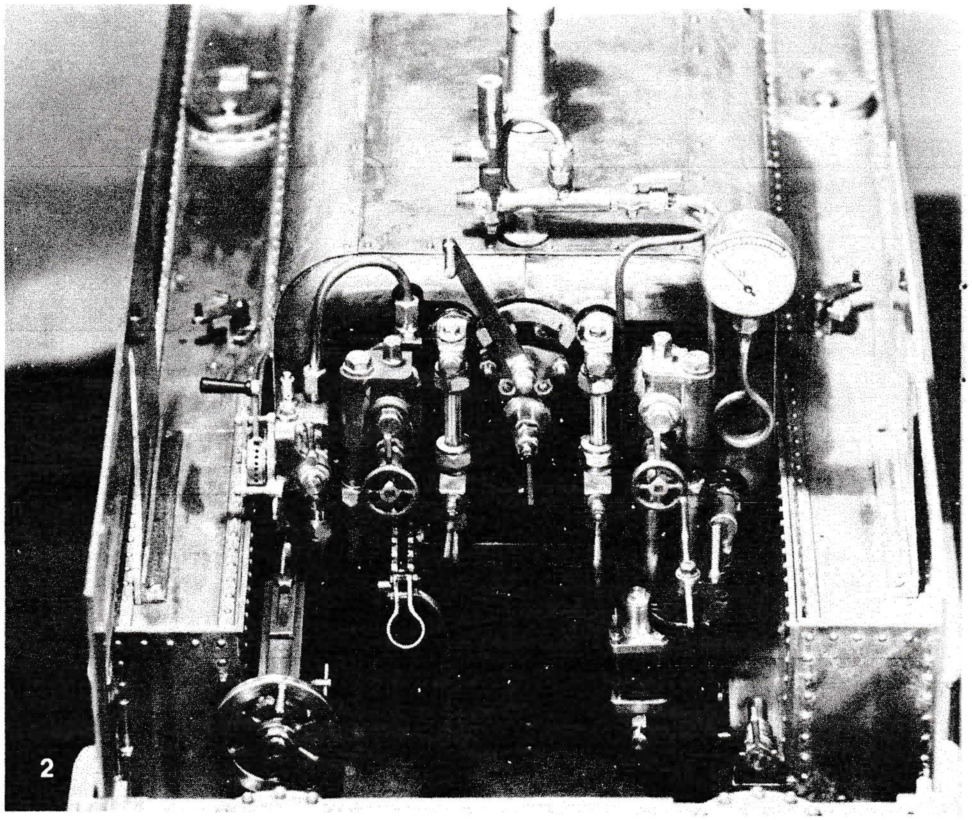
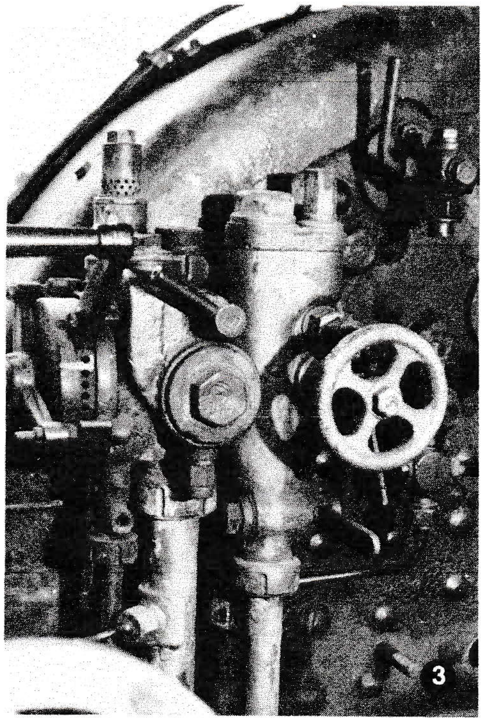


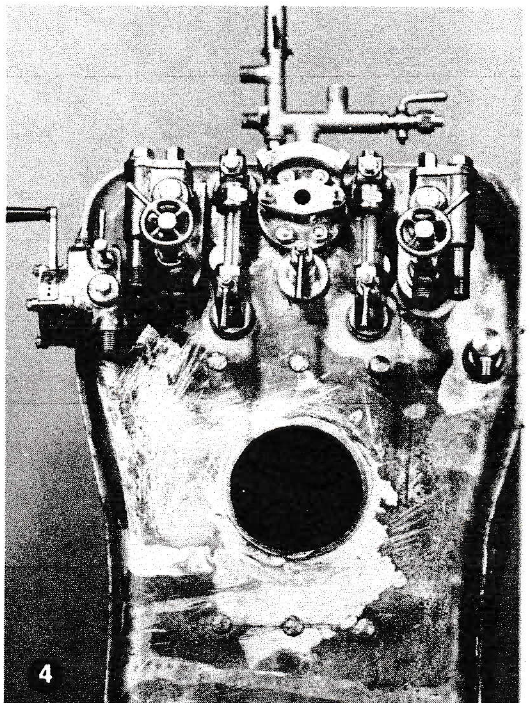
Photo 1 shows the brake valve in good detail. The brake valve is shown in its permanent location at the left end of the control assembly in **Photo 2.** The prototype for the Lanky brake valve is pictured in **Photo 3. Photo 4** offers another view of the fittings for the model across the backhead.



body, so that the brake cylinder is exhausting to atmosphere. Pulling the brake handle down to the 'on' position, when it strikes the front collar stud, brings the open No. 41 hole in line with the steam port in the body. This is what you have to achieve, and I suggest that you lightly tap the handle over the valve spindle in the first instance, and check operation by lung pressure before pressing the spindle home.

Condensation in the brake pipe causes 'hydraulic lock,' so that when the brakes are applied, nothing happens! I learned this fact rather painfully more than 30 years ago now. When Gordon Chiverton and I had finished our first steam Locomotive (a joint effort, though I was very much the junior partner) we had need of a track. Search of the local dump produced some angle iron and we laid this with wooden sleepers at ground level. We were eager to run, so the driving truck consisted of a flat board and four wheels running in plain brass bushes. At one end of the track was an old cast iron gas oven in which Gordon stored coal, wood and paraffin, all the fuel we needed for running. Now this novice only knew two positions for the regulator, fully open and closed, so came hurtling down the track, truck first, closed the regulator and applied the steam brake. The truck went straight through the heavy side of the oven and I was deposited on the hot plate. What we did not know at the time was that a simple 'automatic' drain valve would have prevented this accident. The only design feature deserving mention is that the size of the ball must be kept small so that it tends to float upwards on the condensate and so release same. Manufacture is straightforward, the complete valve being screwed into the steam brake cylinder.

Next time we will deal with problems and solutions regarding backhead fittings.



Nelson Riedel's brake valve, v.2. This version revises an unsatisfactory version 1 in which the ports were too small.

These pages were downloaded from a single web page. While the content is in order the page breaks may not be logical.

Source: Nelsonslocomotive.com, no longer online, check the Wayback machine

Another Shay Steam Brake Valve

Nelson Riedel NARiedel@Adelphia.net

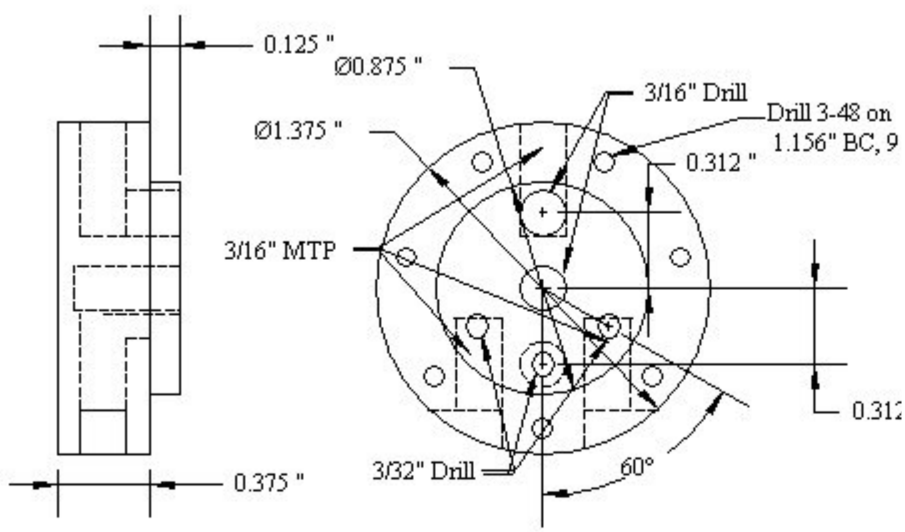
Initial: 1/30/2004 Last Revised: 02/26/2006

I was not happy with the valve described in the brake valve section Shay Steam Brake Valve because th passages were too small. The valve worked OK on compressed air but sometimes would not pass steam, especially under lower pressure such as less than 50 psi. I modified the the valve by drilling the passage larger. This fixed the blockage problem but the clearances were reduced with the larger passages and the developed a small leak. One solution was to make a new valve designed with larger passages. A valve 3/32" passages would be satisfactory and this size passage could probably be achieved reliably with a 3/8 plug.

I had recently finished building an air compressor/pump that used O-Ring seals and was very happy with Rings. I had also made a blowdown valve using an O-Ring seal and was happy with that design. With t successes I decided to try to make a brake valve using O-Rings. The O-rings will seal against a rotating just like the blowdown valve. Recall that the valve must make two connections at once: the steam input end of the cylinder and the other end of the cylinder to the exhaust. The passages connecting the betwe valve inputs and outputs will be within the rotating disk. (This was the view in January 2004).

Update 2/26/2006: I made the O-Ring valve and it worked fine for a few weeks and then started to leak one of the O-Rings tore on the disk. I replaced the O-Ring and then another tore in a week or so. It turn this design didn't work very well. After two summers with seldom working brakes I decided to design a valve using a rotating disk on a thin sheet of Teflon. The disk is spring loaded and the entire valve is pressurized and sealed. This valve uses some of the concepts of a brake valve sold by LocoParts. The LocoParts valve is an excellent value and I recommend it. Unfortunately that valve controls only one en brake cylinder and is not applicable to the double ended cylinders used on the early Shays. I deleted the description of the O-Ring based valve from this page and replaced it with the description of the disk-Tefl valve which really works.

Brake Valve Base: The drawing on right shows the valve base. The base is made of 1.375" diameter brass rod. The nine outer holes tapped 3-48 are for attaching the top to the base. I drilled the holes in the top first and then used the top as a pattern to drill the holes in the base. Steam enters the base through the 3/16" MTP hole in the back and then up through a tension pin forced into the 3/16" vertical hole. The center 3/16" hole is for the shaft. The three 3/32 holes near the front are the steam ports. The middle port is for exhaust and goes out the bottom. The other two ports intersect 3/16" MTP holes out the front that go to each end of the brake cylinder.



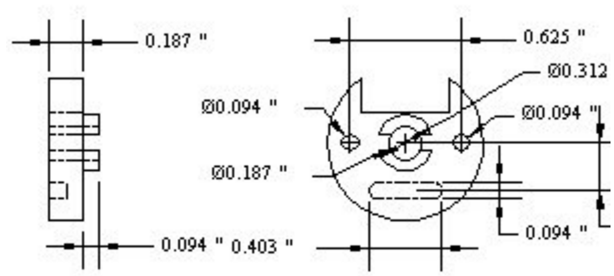
Brake Valve Base

This shows the top of the base with the two output pipes connected. The black plate out the back is from the previous valve and is used to attach the valve to the shelf above the rear engine cylinder. The stub of the tension pin near the rear of the top is hollow which allows the steam to flow into the valve. The pin together with a slot in the disk limits the rotation of the disk. (The stainless steel tension pins were trimmed to the proper length with a Dremel cutoff disk.)

This is the under side of the base. A recess (not shown on the drawing) was milled in the base for the attachment plate. The plate is screwed to the base with a pair of 4-40 FH screws. The tension pin out the bottom is to carry the exhaust through the shelf. The lower part of the exhaust port is enlarged to 3/16" to accept the short expansion pin.

Teflon Seal: This photo shows the 0.015" thick Teflon seal in position on the base. The Teflon is available from McMaster-Carr. The Teflon was cut with an hobby knife. The seal is held in place by the tension pin and the shaft.

Valve Disk: The drawing shows the valve disk that is turned from 7/8" diameter brass rod. The shaft runs through the hole in the disk center and into the center hole of the base. The slot in the back fits around the the the tension pin that sticks up from the base. The slots limits the disk rotation to 30 degrees each side of the center. When the disk is centered. the slot is over the exhaust port (the middle port). When the disk is rotated 30 degrees, the slot is over both the exhaust port and one of the ports leading to the brake cylinder allowing that end to exhaust. One of the holes though the disk is over the port leading to the other end of the brake cylinder allowing the steam to flow from above the disk through the hole to the port and on to the brake cylinder. When the shaft is rotated to the other extreme the opposite ends of the cylinder are powered and exhausted.

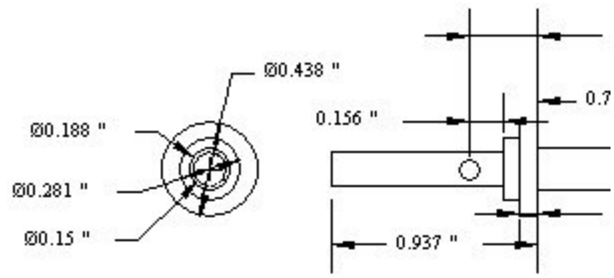


Brake Valve Disk

This is the top view of the disk. I didn't make the slot in the back quite like the drawing. Instead, I drilled 3/16" holes at a 5/16" radius from the center and 30 degrees each side of the center line. I then opened up the slot with a saw and filed the edges such that the disk rotated freely. The slot in the shoulder on the top is 3/32" wide to accept the pin through the shaft.

I had the disk in the rotary table so I milled a curved slot rather than the straight slot shown on the drawing. The slot is 3/32" wide at a 5/16" radius from the center and covers a 30 degree rotation each side of center.

Valve Shaft: The shaft is 3/16" stainless steel rod. The washer was turned from 1/2" stainless steel rod and silver soldered on the the shaft. The hole is for a 3/32" tension pin that fits in the slot in the to of the disk.

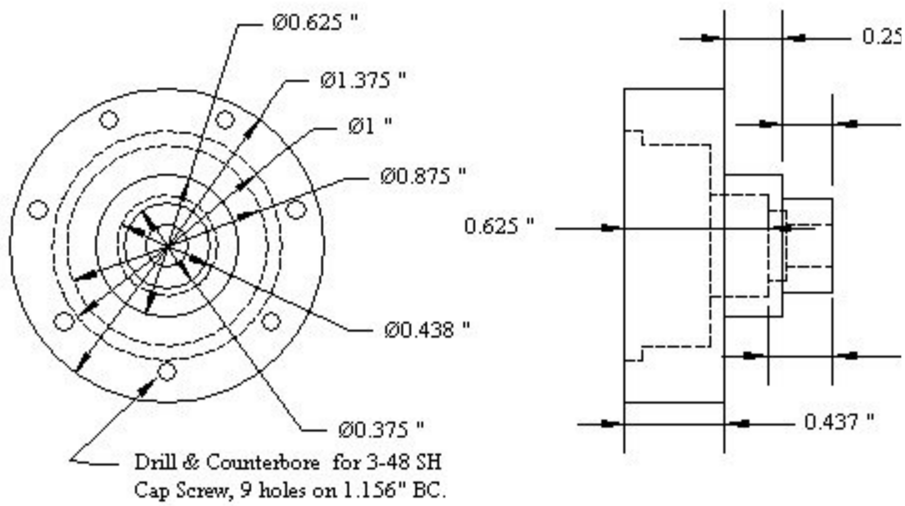


Brake Valve Shaft

Valve Shaft & Spring: Photo shaft the valve shaft & Spring. The spring is 9/16" long cut from, a 7/8" long, 0.42" OD, 0.047" wire diameter stainless spring (McMaster-Carr #9435K93).

This photo shows the shaft, spring, disk & base positioned for the placement of the top. Not that the disk is held against the Teflon by both the spring and steam pressure.

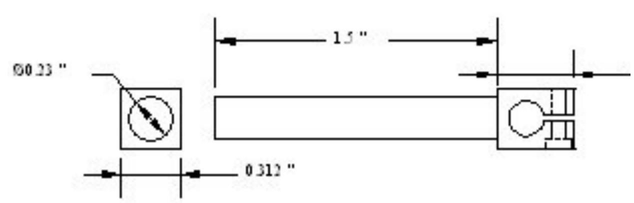
Valve Top: The valve top is turned from the same 1.375" diameter brass rod as was the base. The recess on the bottom edge is for a 7/8" ID - 1" OD (#020) Viton O-Ring seal. The recess near the top is for a 3/16" ID - 5/16" OD (#008) Viton O-Ring seal.



Brake Valve Top

This shows the underside of the finished top. The O-Ring looks bigger that the 1/16" thick ring specified on the drawing. It is in fact a 3/32" cross section O-Ring that I ordered by mistake. I made the recess deeper to accommodate the thicker cross section.

Valve Handle: Valve Handle: The valve handle is turned from 5/16" square brass. After the handle was turned I remembered how hot the handle on the old valve got so I changed the design. I turned the end of the handle part down to 3/16" and threaded it 10-32. I then tapped the end of a piece of 1/4" plastic rod (I think it was Delrin) 10-32 and threaded it on the brass.



Brake Valve Handle

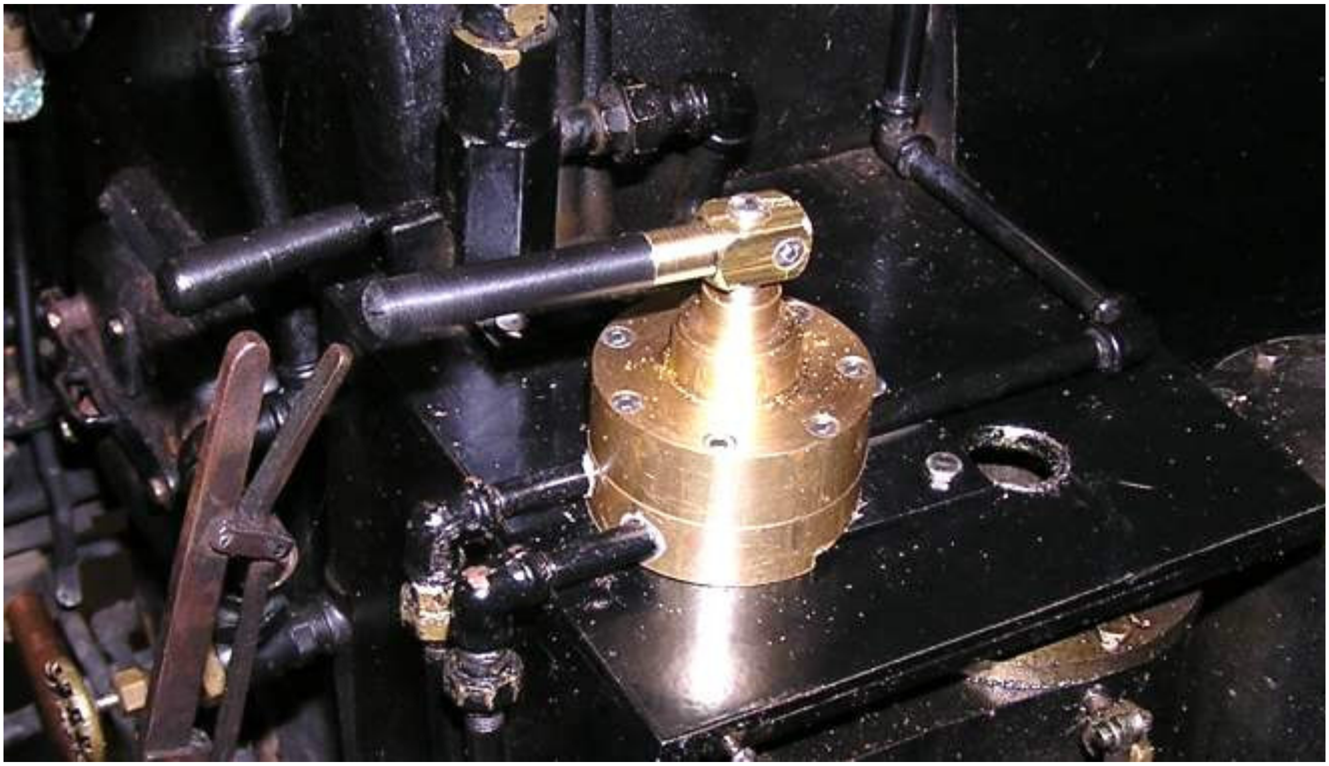


Photo above shows the finished valve installed on the shelf over the rear cylinder. The cab was off when photo was taken.

[Shay Home](#)
[NLW Home](#)

Nelson Riedel’s brake valve, version 1, superseded by v.2

In V.2 Riedel writes that he was not happy with this version as the passages were too small. See V.2.

These pages were downloaded from a single web page. While the content is in order the page breaks may not be logical.

Source: Nelsonslocomotive.com, no longer online, check the Wayback machine

Shay Steam Brake Valve

Nelson Riedel Nelson@NelsonsLocomotive.com

Initial: 10/26/2003 Last Revised: 06/05/2004

Update 10/28/2003: The day after I published this page Mike Green from up in Ontario emailed and pointed out that I had the steam and air brake controls on Cass 5 backwards. I've corrected the following to reflect Mike's input.

Cass 5 Brake Valves: This photo shows the two brake valves on Cass No 5. The valve on the right controls the locomotive steam brakes and the valve on the left controls the train air brakes.

Note that the air brake valve is located under the throttle handle and beside the reversing lever.

This is another view of the Cass 5 air brake valve. One thing is sure, there is clutter everywhere.

This shows the bases of the two brake valves on Cass 10. Note the pipes below the air brake valve. It's not clear if the valve is supported by the pipes or if there is some sort of support bracket.

Mike Green also was able to shed light on the air brake mounting bracket. The photo on right taken by Gordon Carlson shows the mounting bracket on Shay #3345, the last narrow gauge shay built by Lima and the one that Mike is modeling.

A closer view of the air brake base.

The November/December 2003 issue of Live Steam has a neat brake valve design for a three-truck Climax. The design by Bob Reedy is really two valves, a locomotive steam brake valve and a smaller train air brake valve. The locomotive brake uses O ring seals whereas the train brake uses a Teflon plug. I decided to use a physical appearance similar to Reedy's locomotive brake but try a Teflon sleeve similar to the design used for the cylinder cocks. ***Recall that I had the steam and air valves reversed so I modeled the air brake valve thinking it was the steam brake.***

Test Model: The first thing was to make the model shown on the right. The plug has two holes at a 90 degree rotation of the plug that go half way through. The body has three holes at 90 degree rotations. The plug has three positions ---- in the first position the plug holes line up with the steam supply and brake cylinder holes --- this is the brakes applied position. Rotating the plug 45 degree counterclockwise puts the plug holes between the body holes ---- brake hold position. Rotating a further 45 degrees lines the plug holes up with the brake cylinder and exhaust holes --- the brake release position.

The model worked and made a pretty good seal. Next, a model was made using a 3/4" sleeve OD and a 7/16" plug OD. The valve worked pretty well, leaked slightly at room temperature with 125 psi air applied and leaked only a little in boiling water. The handle was a little hard to turn. Tried another sleeve with a smaller ID to put more pressure on the sleeve and body ---- no difference in force or small leak. Tried yet again with similar results.

Many years of engineering experience have taught that there is a time to leave the lab and do a bit if thinking about the engineering principles ---- and that time had arrived for the brake valve. Some thought yielded the following:

1. **Teflon is pliant:** Teflon is a very tough material, hard to tear and slippery which are properties that make it good for sealing. Another property is that it is pliant which is also necessary for a good seal. However, the pliability means that as pressure is applied on the sleeve between the body and plug, the Teflon tends to ooze out the ends of the body. That is why no improved sealing was achieved by forcing the plug into a smaller ID sleeve --- the extra Teflon oozed out the ends of the body. The maximum pressure is related to the sleeve thickness ----- the thinner the sleeve, the greater the maximum pressure. The cylinder cocks sealed pretty well with a 1/32" sleeve thickness. Several different brake valve sleeve thicknesses were tried. A thickness of 1/64" worked but was touchy; sometimes the sleeve tore. A thickness of 1/16" didn't seal very well at 125 psi. Conclusion --- 1/32" is a good workable choice. (A different approach would be to seal the ends of the body so that the Teflon couldn't ooze out. That was not used because there was no obvious way to accommodate sleeve swelling under higher temperatures.)
2. **Pressure maintains the seal:** The seal is maintained by pressure, not force. That's sort of obvious --- the steam pressure is tending to compress the Teflon and the resilience of the Teflon is pushing back. The area of the seal is less important except that a larger area will reduce leaks due to small imperfections.
3. **Plug Rotating Force is Proportional to Plug Surface Area:** The same sealing pressure is required to maintain a seal independent of the plug size. The friction force between the plug and the sleeve is proportional to the pressure on the surface multiplied by the surface area. The plug surface area and hence the friction force is proportional to the plug radius (and diameter).
4. **Torque:** The plug is rotated by a lever so the force of interest is a rotating force or torque. The torque required for a given force on the sleeve-plug interface is proportion to the plug radius (also diameter). Hence when 3 & 4 are combined, the torque to rotate the plug is proportional to the square of the plug diameter.
5. **Pressure Between Sleeve and Body:** The total force (pressure X surface area) between the plug and sleeve is the same as between the sleeve and the body. On one model with a 3/4" OD sleeve and 3/8" there was a leak between the sleeve and body. After trying several sleeves a little thought revealed that the sleeve OD area was nearly twice the ID area hence the sealing pressure on the OD was roughly half the sealing pressure on the ID. No wonder the the sleeve-body interface was the most likely to leak.

After thinking about the above points, , the following dimensions were selected:

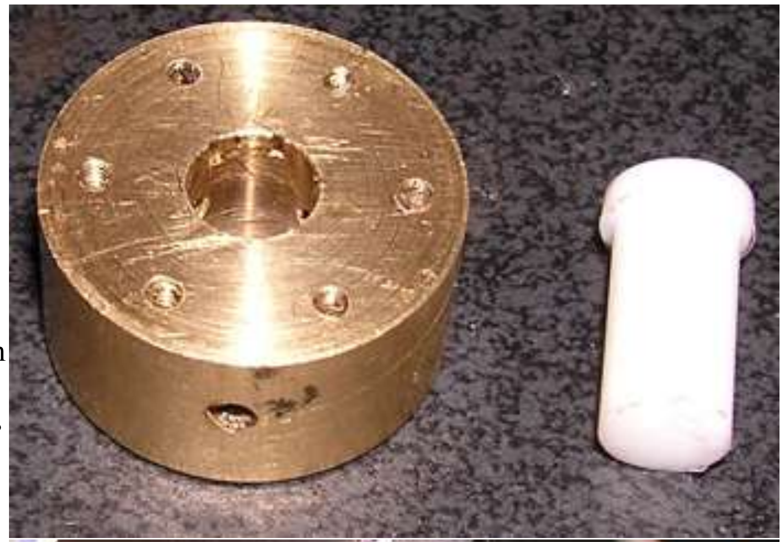
- 1/4" plug diameter (smaller is better but limited by hole diameter)
- 5/16" hole in body (this is sleeve OD which gives a 1/32" sleeve thickness)

- 1/2" long plug working surface (this size looks good)
- 5/64" holes in plug and sleeve
- holes in body and plug at 120 degrees instead of the 90 degrees of first model
- 1" body OD.

Plug: The plug was made from 1/4" diameter 303 stainless steel. The stem is 3/16" diameter and the end is 0.133" partially threaded 6-32. The holes are 5/64". The body was initially made with a 1/4" hole and the plug put in the body and the holes in the plug partially drilled using two of the holes in the body as a guide. After the holes were drilled to the plug center, the surface around the holes was smoothed with a fine file and then the plug was polished with 400 Emory cloth.

The three holes in the body that access the plug were drilled 3/32" and threaded 1/8" MTP and plugged with pipe plugs. The three ports are in the bottom and drilled up to meet the three horizontal holes. The input and exhaust ports are 3/16" MTP and the exhaust port is 1/8" MTP. The holes for attaching the top are 2-56.

The body ID was bored to ~ 0.305" and an old 5/16" reamer driven in the hole ~ 1/8" to score the hole to keep the sleeve from rotating. The sleeve was turned from 3/8" Teflon rod to a diameter of ~ 0.320" leaving a head on one end. The sleeve was then driven into the body with a hammer.



A 3/16" hole was drilled in the sleeve and then 5/64 access holes drilled through the 3/32" holes in the body.

The body was then bored to 0.010" less then the plug OD. (The pug was 0.249" so the sleeve ID was 0.239") A handle was attached to the plug and the plug forced into the sleeve (by hand) while the body was rotating very slowly. After the initial insertion, the plug was removed and the ends of the sleeve trimmed flush using a utility knife. The plug was then inserted again (easy the second time).

This is the body with sleeve. Note the 1/8" plug in the side hole. The input port below is fitted with a 3/16" MTP nipple and a 1/4" to 3/16" bushing. This was used to test the seal.

The top was also turned from 1" brass and is about 1/2" high. The 6 holes were drilled in the top first and then the top was used as a guide to drill the mating holes in the body. The upper part of the hole for the plug shaft is 3/16" The lower part is drilled 1/64" larger to minimize binding.

The top was later notched to allow rotation of the handle while providing stops to limit rotation.

The (air brake) valve on Cass 5 is mounted at about the height of the top of the rear engine cylinder which scales to about 4" above the cab floor. That height was tried and looked awkward so the valve was lowered to about 2" off the floor as shown on the right.

A brass rod screwed into the input port is the support bracket. The tee was silver soldered on the rod and the top part of the rod was drilled and outside threaded 3/16" MTP. As a result, the top part of the rod is actually a pipe while the bottom part is a fake pipe serving as the mounting bracket. The lower end of the rod is tapped 4-40 and held by a flat head screw on the under side of the floor. The copper pipe pointing into the camera is the input pipe that will connect to the steam turret.

The vertical copper pipe to the right of the input pipe is from the cylinder port. The pipe goes through the floor and connects to a pipe running across under the frame I beams to the cylinder.

This view is from the left side of the back of the valve. The valve handle is in the **BRAKES ON** position.

The smaller copper pipe on the rear side is from the exhaust port. The pipe goes through the floor and has an open end.

The valve and cylinder were temporarily connected with 3/16" plastic hose and the system tested using compressed air. Everything worked as expected.

OK, now that I've learned I had the two brake valves mixed up what a I going to do? I have a valve that can be used to control the steam brakes but is in the air brake position. Of course, it can control an injector for train vacuum brakes. I think I'll make another valve ---- at least another valve mounting arrangement in the more correct position for the steam brake. But there is more to it than just the valve location. The following is part of the note that Mike Green sent describing the steam brake operation:

Just opened up your site today and noticed that you have added the Brake Valve installment. Having ridden on #5 in the past I think that you have the two brake valves reversed in your captions for the first pictures. The valve with the long stem directly in front of the Engineer is the loco steam brake. The larger valve unit under the throttle lever is the Westinghouse valve for the train air brake control. I didn't follow the three pipes descending from the steam valve but one applies the brakes, while another feeds the back side of the cylinders to keep the brakes off, the third one is the exhaust. The Engineer was constantly moving the valve probably because of a disc leak at that time and the application side was showing some pressure. The horizontal pipe would be the steam supply leading up to the stop valve on the main manifold. The reason I was told for the extended valve spindle was to keep the heat of the hot valve from getting into the handle and allow a machinist to be able to re-pack the top gland without dismantling the whole thing, with the gloves of today, the hot handle wouldn't be too much of a concern.

I haven't seen any models that use steam release (backoff) of the brakes. My brakes hang up a bit on release and was thinking of using heavier return springs. However, the thought of using steam release is really intriguing........

Mike also sent a copy of Lima Instruction Sheet No 10 that describes the operation of the Lima Steam Brake. Turns out that I also had a copy. Both our copies came from a booklet of Lima Instruction Sheets published by Kyle Neighbors of Cass WV. The following is a scan of the two page Instruction Sheet No 10.

LIMA LOCOMOTIVE WORKS, Incorporated

Lima, Ohio

GENERAL SALES OFFICE
17 East 42nd Street
New York

SERVICE DEPARTMENT
Lima, Ohio

LIMA STEAM BRAKE

The Lima steam brake equipment for Shay locomotives consists of the following parts:

(1) *Steam Brake Valve*—Same on all size engines.

(2) *Brake Cylinder*—On two truck engines both ends the same size; on three truck engines, one piston and cylinder larger, which is to take care of the additional truck.

(3) *Pipe Connections*—Same for all size engines.

(4) *Brake Rigging*—Built to suit class of engine on which used.

General Arrangement—Steam is piped from the main turret to the steam brake valve. In this line a lubricator pipe is cut in just ahead of the steam brake valve. Three pipes lead out of the brake valve.

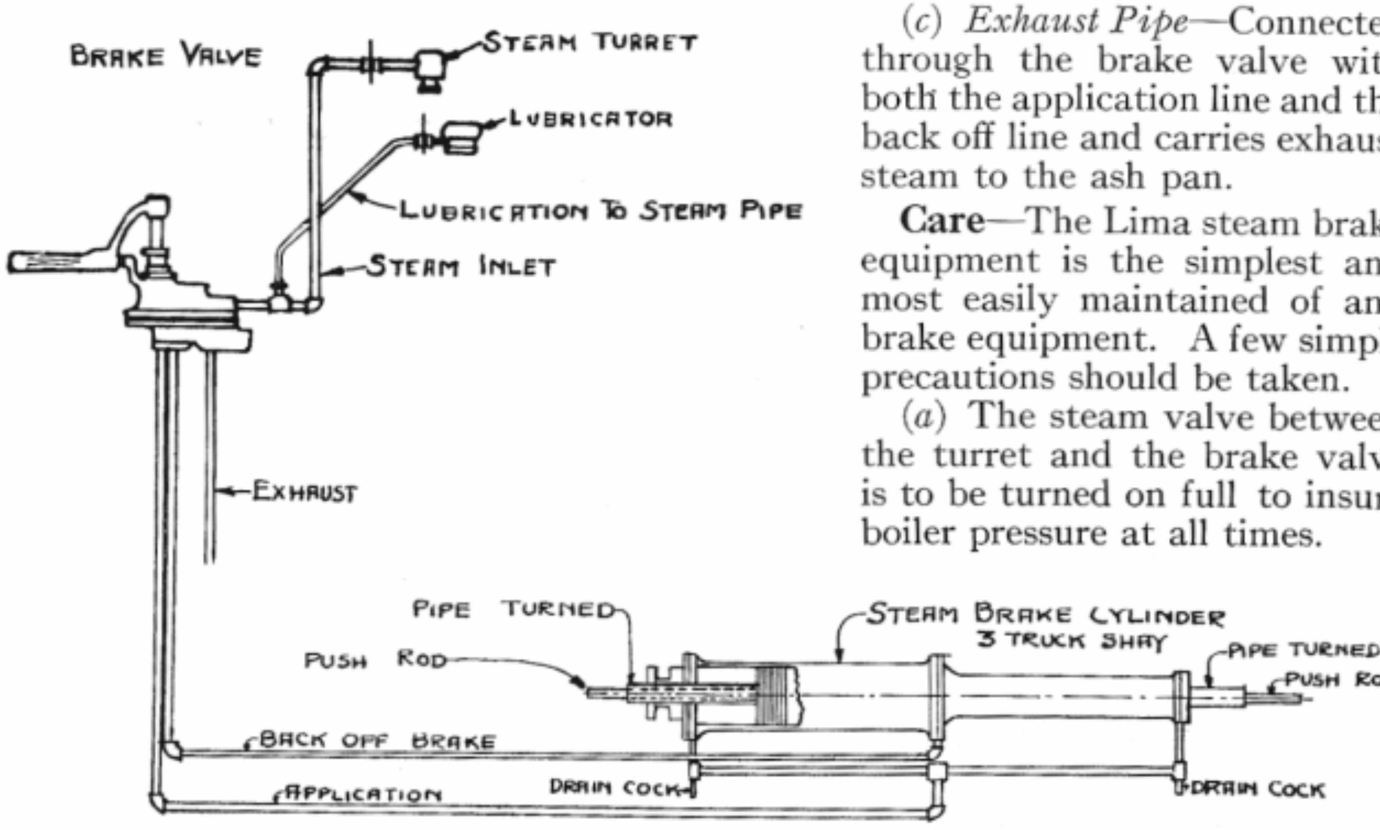
(*a*) *Application Pipe*—Carrying steam to a tee through which the steam is carried to each end of the brake cylinder at each end of which is applied a drain cock.

(*b*) *Back Off Pipe*—Carrying steam to the center of the brake cylinder which introduces steam between the pistons to back off the brakes.

(*c*) *Exhaust Pipe*—Connected through the brake valve with both the application line and the back off line and carries exhaust steam to the ash pan.

Care—The Lima steam brake equipment is the simplest and most easily maintained of any brake equipment. A few simple precautions should be taken.

(*a*) The steam valve between the turret and the brake valve is to be turned on full to insure boiler pressure at all times.



(*b*) Give the lubricator feed to the brake valve enough valve oil so it will work easily and does not stick.

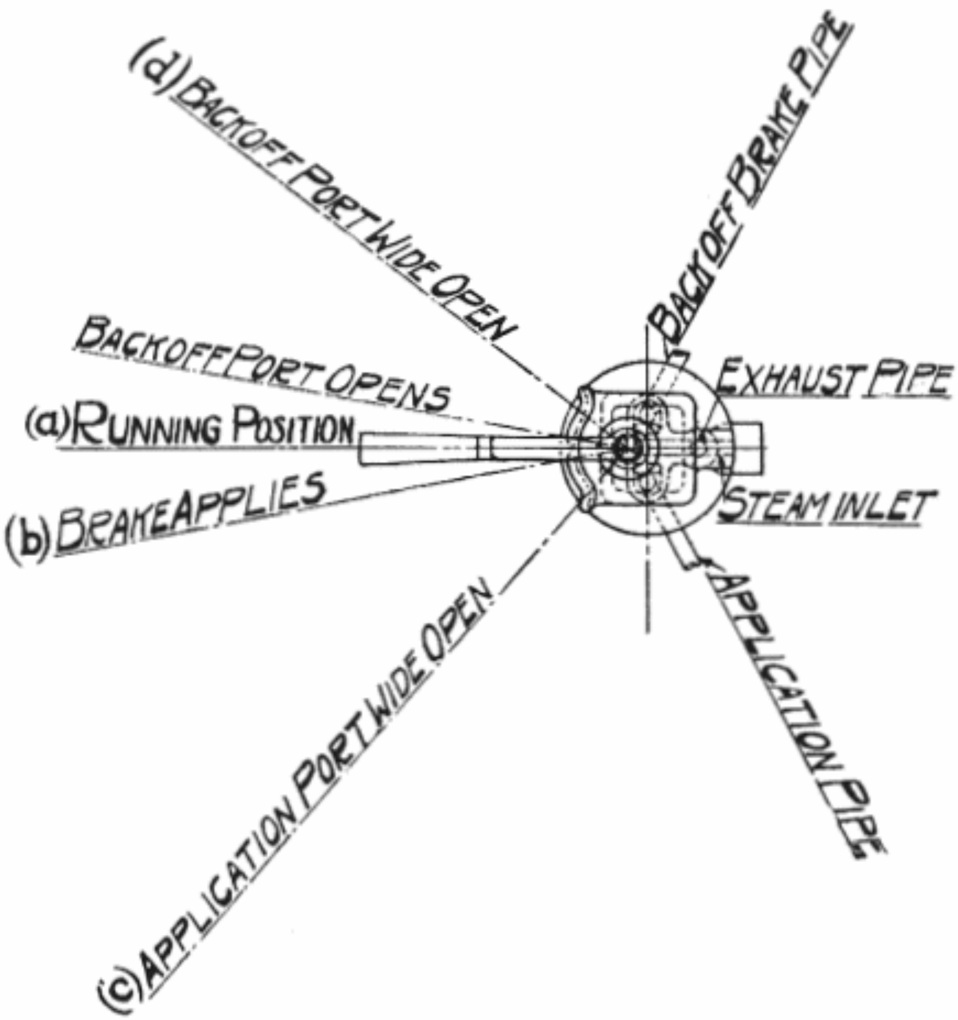
(*c*) See that drain cocks are working—these will take care of condensation.

(*d*) In winter keep steam turned on to prevent freezing.

Operation—On the Lima steam brake live steam is used both to apply and release the brakes. The operation of the brake valve is as follows:

(*a*) *Running Position*—In running position the brake handle is in central position.

(*b*) *Service Application of Brakes*—Move the handle to the extreme left. This will blow the condensation out of the pipes and cylinder. Then back to the right to service application and keep working the handle about half way between running position and emergency application.

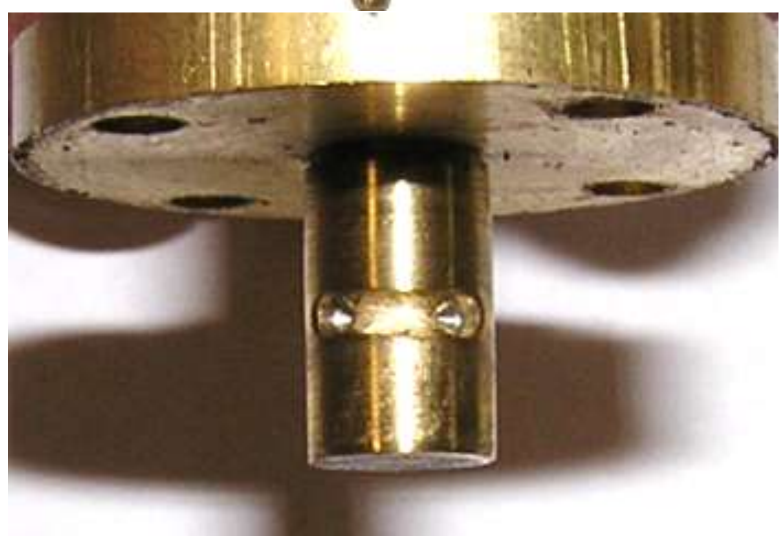


(*c*) *Emergency Application of Brakes*—Move the handles as in service application and then bring around slowly to the extreme right position and work handle between full application and service application.

(*d*) *To Release Brakes*—Move handle to the left as far as it will go on full release then back to central or running position.

Update (12/12/03): I fabricated a steam brake valve along the lines of the valve describe above shortly after Mike pointed out my errors on the first try. I delayed updating this page until the valve was installed and operating the cylinder. The boiler arrived in the mean time so I was off working on getting it installed and plumbing the water and steam. The locomotive is about ready for the first run at the track and assuming that it actually gets moving, brakes might be a nice feature to help stop it. So, hooked up the brakes.

Correct Steam Brake Valve: The photo on right shows the partially disassembled more correct steam brake valve. The stem is longer like on the prototype. The base has a Teflon insert and four ports equally spaced around the base (90 degree angles)



Holes were drilled through each port about 1/32" deep into the plug. The plug was then removed from the body and the slots made between adjacent holes on each side of the plug using a Mototool with cutoff disk and then smoothing with small files. The photo shows one of the slots. There is an identical slot on the other side.

The plug is a brass tube silver soldered to a stainless steel shaft; much less effort than turning one piece from steel.

A top view of the valve. The top pipe is the steam supply and the bottom pipe is the exhaust. The left pipe goes to the outside ends of the brake cylinder (apply brakes) and the right pipe goes to the center of the brake cylinder (backoff or release brakes). The handle is in the brakes "full on" position. In this position one plug slot connects the top and left pipes (steam to outside ends of the cylinder) and other slot connects the bottom and right pipes (exhaust the center part of the cylinder). When the handle is in the left most or other extreme position steam is applied to the right pipe (backoff) and exhaust is connect to the left pipe (exhaust outside ends of the cylinder). When the handle is centered, the plug slots are centered on the upper and lower pipes and there is no connect between any of the pipes.

This photo shows the valve mounted on the shelf. The valve is off center to the right side of the shelf to minimize interference with the reverse and throttle levers. The plan is to also mount the whistle valve on the shelf --- to the left of the brake valve.

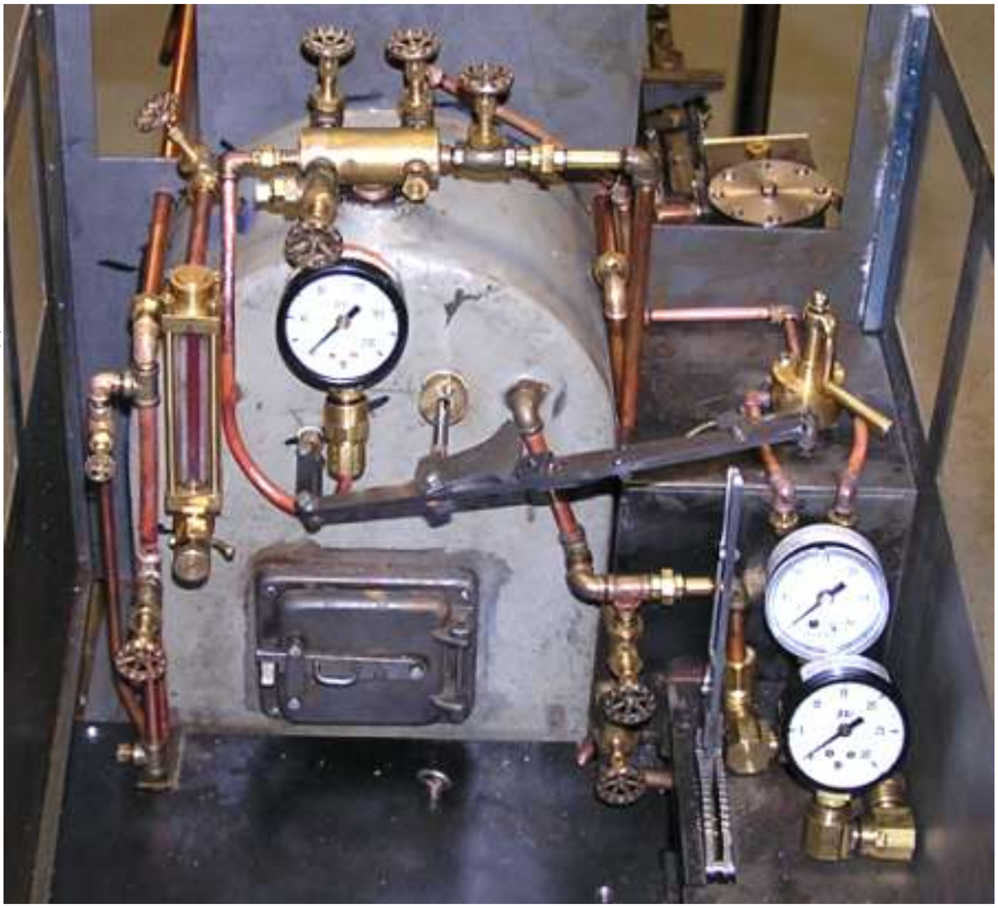
Brake Pipe Routing: The pipes run from the valve on the top of the shelf down the shelf front, through notches in the platform top and then bend and go under the frame just behind the firebox to the brake cylinder on the left side. The pipes are identified on the photo on right.

The photo below of the left side shows the cylinder and the other end of the pipes. The pipe to the cylinder center is 3/16" The other pipe is 3/16" to the tee at the big end where it converts to two 1/8" pipes. There is a drain cock at the end of the small cylinder. The union in the upper pipe appears to be oversize and in fact is a 1/4" union. I had run out of 3/16" unions so the 1/4" union is a temporary substitute.

This photo shows the cab interior with the installed brake valve.

The valve works great! The return springs on the brakes were removed. (The return spring on the park brake lever was left in place.) It takes about two seconds for the brake pistons to move after the brakes are applied. The speed is controlled by the pipe and valve size. This speed is probably good; we weren't designing a steam catapult. On the test stand it's possible to control the braking force by moving the valve on and off. It'll be interesting to see how the brakes work on an engine and string of cars with a little momentum.

Thanks to Mike Green for steering me to this neat design.



Update 1/30/2004: The valve worked OK on compressed air but sometimes would not pass steam, especially under lower pressure such as less than 50 psi. I modified the the valve by drilling the passages larger. This fixed the blockage problem but the clearances were reduced with the larger passages and the valve developed a small leak. One solution would be to make a new valve designed with larger passages. A valve with 3/32" passages would be satisfactory and this size passage could probably be achieved reliably with a 3/8" valve plug. Another solution would have been to ignore the leak. Instead, I tried a different design using O-Rings that worked pretty well. That valve is described in webpage titled [Another Shay Brake Valve].

[Shay Home]
[NLW Home]