Shay Plumbing VIII - Steam Turret & Associated Plumbing

Nelson Riedel Nelson@NelsonsLocomotive.com

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Note: This page has been revised several times to reflect advice from readers and experience from initial tests. The more significant changes are noted in the text.

The layout of the steam, water and burner controls on and around the boiler backhead proved to be quite a challenge. A number of different live steam locomotives were examined and probably 50 different variations were sketched (a good way to kill time on long flights). Near the end of this process an organization of the controls and gauges into functional groups evolved. The following lists this organization.

- The steam turret is located on the top rear of the boiler. The turret contains cutoff valves that supply steam to the whistle valve, to the steam brake valve, and to a manifold for the blower and atomizer valves. There is also a port for the steam pressure gauge and spare ports for possible later use to supply steam to a steam water pump and/or injector.
- The water controls are on the left side of the boiler. These controls are a valve to adjust the axel pump output and a test valve to verify that the axle pump is working. The water gauge is on the left side of the backhead and the steam pressure gauge is in front of the backhead next to the water gauge.
- The blower & atomizer valves are mounted on a manifold near the floor to the right of the boiler. The blower pipe runs through the right stay tube to the smoke box. The atomizer valve serves an on/off function to supply the atomizer regulator located under the platform that covers the reversing gear lever. The manifold is fed steam through a cutoff valve from the steam turret. The manifold is also fed compressed air via a quick connect fitting under the right side of the cab floor. There is a cutoff valve and check valve in series with this air supply. There are pressure gauges for both

the blower and atomizer located above the platform that covers the reversing gear lever.

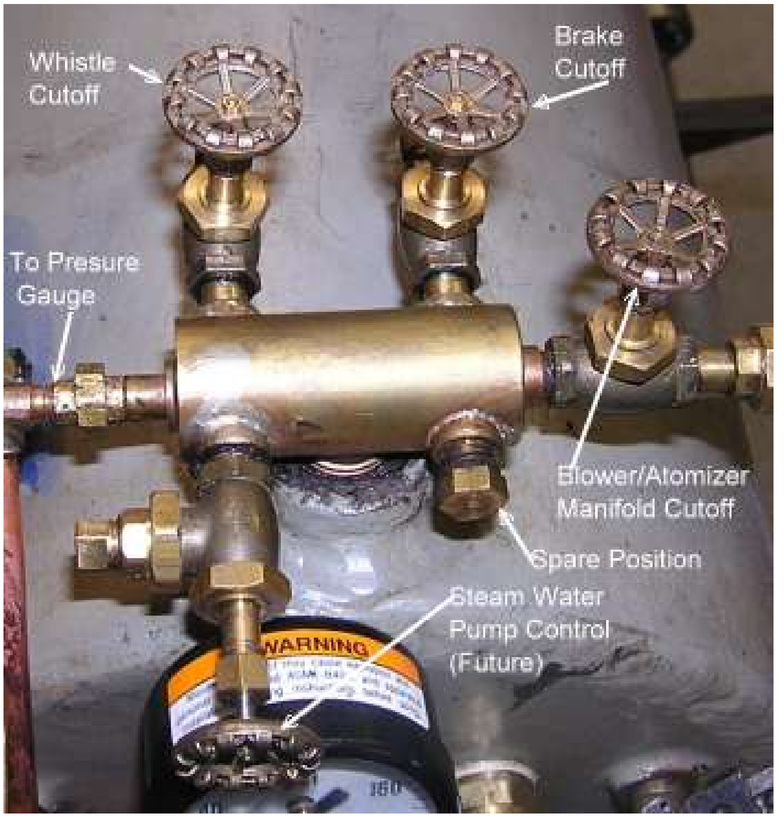
- The steam brake valve and whistle valve are located on the shelf above the rear cylinder.
- The oil feed valve is located in the oil tank with the knob at the top of the tank.

Cass 10 Turret: This is the steam turret on Cass No 10. The turrets are hard to photograph on the operating locomotives because of all the clutter. The turret shown here is very similar to Kenneth's design.

Turret Layout: This photo shows the turret layout. The ports in the back and right end are 1/4" MTP and the two ports at the front are 5/16" MTP. The port on the left end is 3/16" MTP.

The initial plan had been to put a cutoff valve between the boiler and the turret as recommended by Jim Buchanan. However, I didn't like the looks of that arrangement.

This is a revised layout; the earlier version has the top of the water gauge connected to the turret.



Turret Fabrication: This is actually the 4th or 5th turret made. One problem was getting the fittings to seal in the rounded sides. This was solved by making little bosses on the sides. Another problem was that some of the holes were tapped too large; **the MTP taps should only be screwed in about 40% of the tap length**. If the hole proves too small, the tap can be used again to make it slightly larger. (Unfortunately, nothing can be done to make a hole smaller.)

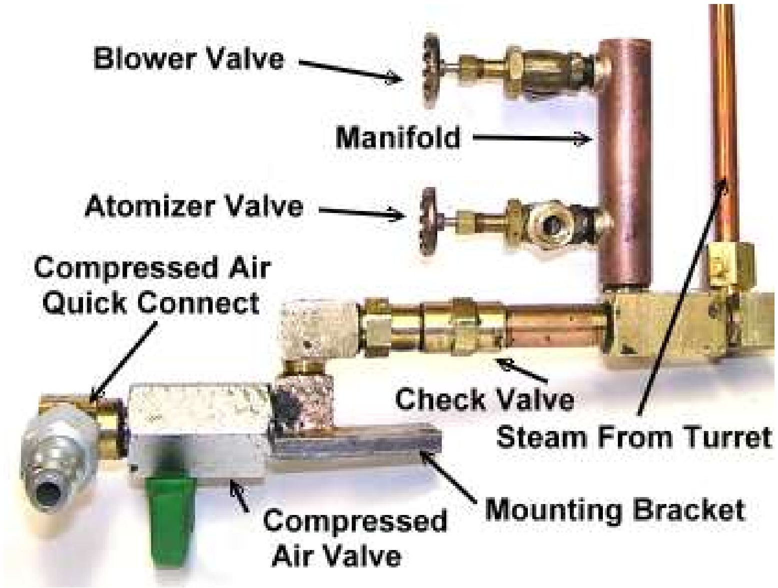
The turret body (upper rod) is 3/4" diameter. The holes are 1/2" for the nipple and 3/8" diameter the side ports. The holes in the body were drilled undersize and then reamed. The ports were tapped 5/16" MTP at one end 1/4" MTP at the other. The end of the nipple was turned down to 1/2". It would have been better if the rod was drilled lengthwise before drilling the holes through the side.

The nipple and ports were positioned and then silver soldered. The length was then drilled 5/16". (As mentioned above, it works better to drill the rod lengthwise before cross drilling it.) The next step was to position and silver solder the end plugs shown in the photo. The left end plug is tapped 3/16" MTP and the right plug is tapped 1/4" MTP.

This photo shows the finished and cleaned turret. It does have some resemblance to the turret on Cass 10.

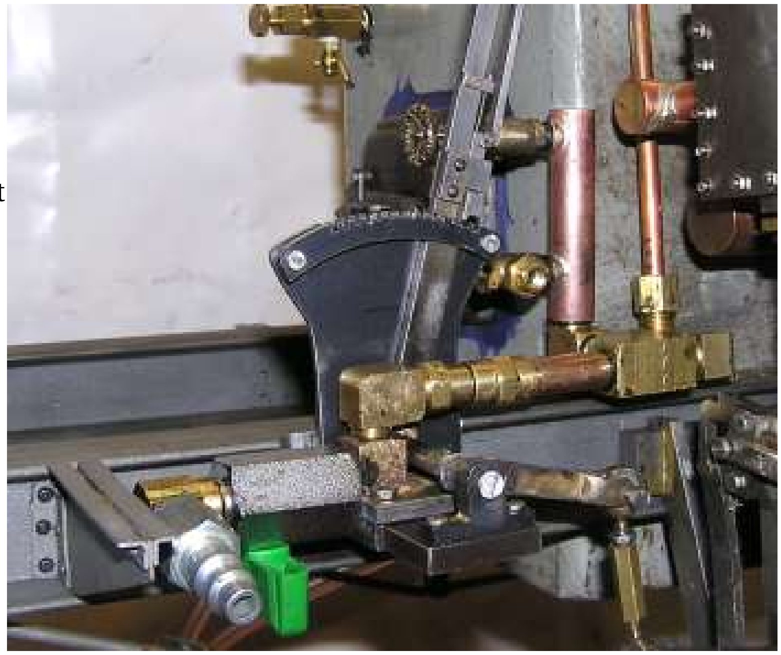
Blower & Atomizer Manifold: This is the manifold with the compressed air feed. The manifold is made from a 1/4" pipe nipple. A plug was silver soldered in the top and the bottom was tapped 1/8' NPT. The blower and atomizer ports are 5/16" MTP and made like the ports on the side of the turret. The valve outputs are 1/4" MTP. The air feed components across the bottom of the photo are all 1/8" NPT.

The support bracket is silver soldered to the elbow to the right of the compressed air valve. The bracket screws into the reverse lever mounting bracket.



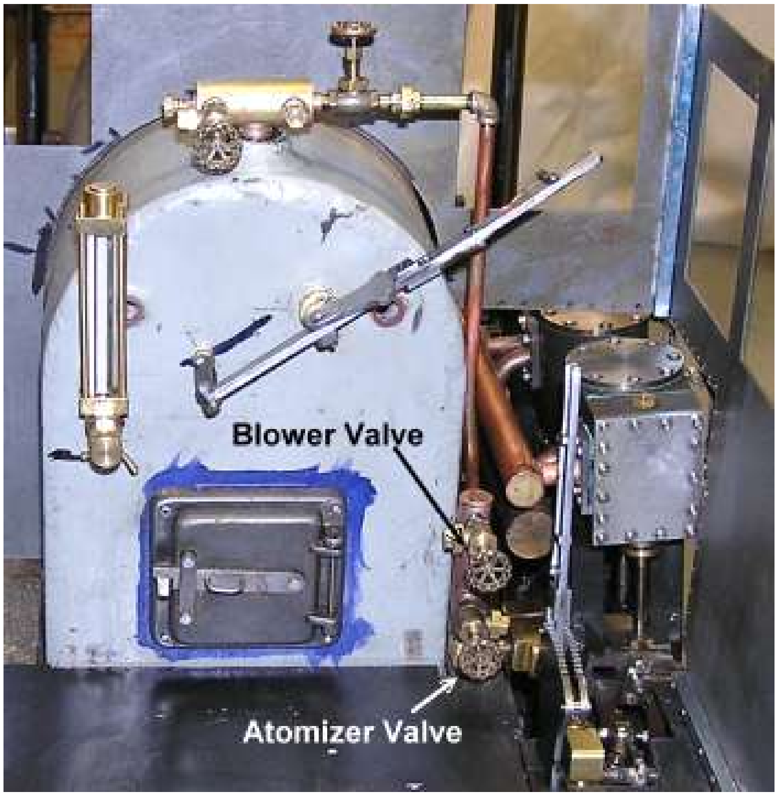
This shows the installed manifold and associated compressed air hardware. The reverse lever bracket was moved out 3/8" and up 3/8" to give a little more room for the valves. The quick connect and compressed air valve are under the cab floor. The rest of 1/8" pipe and fittings are under the platform covering the reversing gear lever.

The compressed air valve is rated for 250 degrees F (McMaster-Carr 4264K44) and the check valve is rated for 400 degrees (McMaster-Carr 7775K61). The check valve will normally prevent steam from exiting via the quick connect after the air line has been disconnected. The hand valve serves as a backup for the check valve. (That green knob has to go!)



This photo was taken with the cab and cab floor in position. The bottom of the manifold is about 1/4" off the floor. The right side water feed pipe will come out of the floor and over the frame I beam under the manifold.

The manifold is along the edge of the cover for the back side of the rear cylinder making it more or less inconspicuous.



Pressure Gauge: Initially the pressure gauge was located in the top left front corner of the cab. When I got to looking at the possible roof lines I realized very little roof would be possible with the gauge in that position. Then I remembered that Dan Staron had said that he was going to position his pressure gauge in the top center of the backhead. Then I remembered that Cass No 11 had the pressure gauge in the center of the backhead as shown in photo on the right. So, decided to move the pressure gauge to top of backhead.

This shows the second (and hopefully final) location of the pressure gauge. The pipe from the turret to the gauge is 3/16". The union at the turret end is a SuperScale with a male end on the turret side. The street elbow between the union and the pipe is TrueScale. The fitting on the gauge end is 3/16" compression to female 1/8" NPT. The pipe was formed by heating red hot and then quenching and then bending around a steel rod.

The gauge is supported only by the 3/16" tube. It seems very stable since the left side of the tube rests against the backhead.

Water Gauge: Jim Buchanan had advised that the water gauge not be connected to the turret because the water level would fluctuate when the steam supplied to other turret ports varied. I decided to try it on the turret anyway. (*This reminds me of a story told by a female engineer colleague. She said that male engineers are like little boys, about 5% will listen to good advice while the other 95% will pee on an electric fence*.)

Murry Curtis of Melbourne sent along a couple comments after this page was first posted. He says that the small boiler code down under specifies a separate boiler port for the water gauge because even small pressure differentials can cause a large change in water level (remember that atmospheric pressure at ~ 15 psi will raise a water column ~ 30 feet). He also said that the pipe from boiler to water gauge must be straight so that a rod can be pushed through it to show it's not plugged by scale.

I also found that when testing with compressed air, opening the blower valve caused the water level to increase maybe 25% of the glass height giving a very false reading. So, I moved the top to a dedicated boiler port..

The photo shows the redone water gauge. The bottom of the water gauge screws directly into a 1/8" NPT in the backhead. The top port of the gauge is threaded 1/4"-40 but apparently not tapered; otherwise it matches MTP 1/4"-40. The cutoff valve (LSM 1/4") connects to the boiler via a 1/4" nipple. The pipe between the valve and top of the gauge is also 1/4" tube threaded MTP each end. The connection at the top of the gauge didn't leak even though only the male part was tapered. Maybe the Permatex No2 used on all the joints helped. The union that is part of the valve together with the valves at each end of the gauge permits the glass to be replaced without reducing boiler pressure.

The test cock at the bottom permits both pipes from the boiler to be verified open.

Safety Valves: The last thing before pressure testing was to install the pair of safety valves in the top of the steam dome. The holes were tapped 1/8" NPT. These valves are brass body with stainless steel ball intended for air service. It's not clear if the spring is stainless steel. It'd probably be wise to buy a package of suitable stainless steel springs.

Murry also had some comment about the exhaust capability of the safety valves. He describes a test of the safety valves as follows (both safety valves working) : *For the coal fired locos we're required to build up a good fire, water at the top nut and put the blower full on. The pressure (on a calibrated gauge) must not exceed the working pressure by more than 10% for the time it takes the water to reach the bottom nut, 5-10 minutes. It's interesting that a lot of the designs published in England will fail on this requirement I've been told. Usually because the steam can get past the valve seat fast enough but then can't get out of the safety valve body. Some designs call for a couple of nicks in the side of the adjusting nut, that's all! No wonder the steam can't get out.*

Update 4/24/04: The safety valves worked OK in a number of steam tests. One problem is that about 15 psi pressure drop is required before the valves shut off. At some point I'll make least least one valve that requires only a couple psi drop to shut off. I made the deflectors shown in the lower photo to deflect the relief steam upward. The bottom of the deflector has a hole for the 1/8" pipe safety valve and the inside is just large enough to clear a 1/2" deep socket. The outside is slightly less than 7/8". The valves could have been located a little further apart such as on 1.25" centers. **End of Update**

Testing With Air: The next step was to connect the air line as shown in the photo. The regulator has quick connects on both sides. The pressure was set for about 50 pounds and then the most obvious leaks fixed ------ a few open valves and drain holes not plugged. The pressure was then increased to 100 psi and the safety valves adjusted to go off at 100 psi. The throttle was opened and the engine tested. The air supply to run the engine is limited since it must go through the 1/4" OD tube between the air input and the steam manifold. The engine did run but fairly slowly.

Testing For Leaks: The next step was to brush a soap solution (liquid dishwashing detergent in water) on the joints. The photo shows a few problems. (There seems to be bubbles everywhere ---- did every joint leak? That's an unknown since all haven't been tested yet.) The joints were tightened a bit and the leaks stopped. There are also leaks around the steam dome top and two of the upper heads. Those joints have gaskets but will try a bit of Permatex No 2 to see if that helps. One pretty significant leak is the test cock at the bottom of the water gauge. That cock uses a tapered plug. Think I'll test it in boiling water ---- friend Dan Staron says those cocks seal better when hot. Of course, there is some hope that steam is thicker than air and won't leak as easily.

Another comment from Murry Curtis: *Testing any steam appliance with air is sure to give you heart ache. Air squirts past things that hot steam/water won't even dribble out of. I first tested my copper boiler under water with air pressure and nearly died when the water bubbled like a spa. The boiler inspector just laughed at me and pumped up the boiler with water - not a drop.*

From Murray's comments it appears that steam is thicker than air. Now need some steam which requires water and fire so it's on to the water plumbing and burner.

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