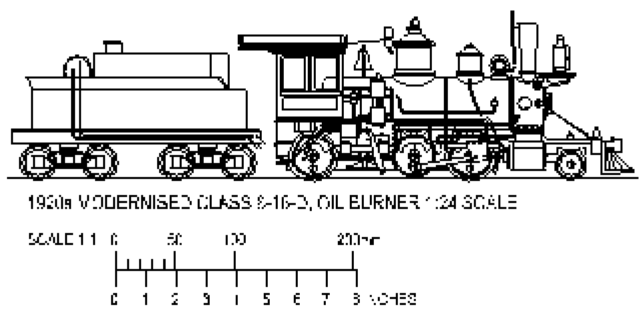
Masters-2001

Build a Baldwin 8-16-D 2-6-0

A Locomotive Adventure
By David Fletcher
Melbourne, Australia
Color Photography by the Author

Chapter 6 - Plumbing

Background - Construction - Detail



Welcome back. We're about to have some of the most fun in all of this MasterClass, the plumbing chapter - injectors, compressors, pipe work and valves. Man it doesn't get any better than this! The quality of a model is not based just on the quality of the finish, but the understanding and appropriate fitment of the components. A loco is a sum of its parts, and never more obviously is it demonstrated than in the pipe work and backhead on a model locomotive. Here is where the men are separated from the boys!! It is here that you really prove you know what you are doing! Sure its easy to copy a photo and make a good looking model that wins all the prizes, but take a look in the cab, or follow all those pipes and you know right off if the guy really knows anything about steam locomotives! Many models have I seen with completely ridiculous pipe work attached in an attempt to make the model look 'detailed'. Every pipe, valve and gauge must have a purpose. Getting it right makes a locomotive really 'complete'. You know its right, and folks in the 'know' will look at your model and say, 'yes' this guy knows, he's one of the brethren!

I liken the accurate modeling of locomotive pipe work and devices to the correct rigging of a model sailing ship. It's not just as bunch of ropes going in all directions. Every rope does a job, and goes from point A to point B. It looks like a 'mass' of lines that one could never understand, but in reality its merely one line at a time, and after you've done that simple step a couple of hundred times, you're left with an accurately rigged, highly detailed sailing ship model, and better still, you know the purpose of every one of those ropes, you can see order in that 'mass' of lines.

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The lesson of the sailing ship is also this: You learn that the ropes are 'remote control' cables to unreachable ship systems. Once a sailing ship's sails are unfurled, the whole sailing operation can be controlled from the deck. ***No one*** has to climb back into the rigging to control the sails.

After learning the content of this chapter, some of you might like to go back and detail your commercial locos. I know the Bachmann 4-6-0s could use a lot of what this chapter has to offer!

Background

We'll examine the purpose and fitting of all the major steam loco systems. While this 2-6-0 is a based on 1870s technology, the principles of the plumbing for this loco are also appropriate to most American locomotives to the end of steam. What you can expect in locomotives after the 1870s is merely an addition to the systems described here. The typical cab back head can get very complex with system on top of system. Sometimes there are several devices in the cab that perform the same task. In order to ensure as little confusion as possible, we'll be looking at the back head in its most basic form, a form typical of the 1870s-1900. In many of the photos within this section you will find knobs and fittings with functions I don't describe. The reason is that these extra fittings are not crucial to the operation of a locomotive, were not seen on 'all' locomotives, and in many cases were later retro fit items which is some cases duplicate some of the basic systems. I should also point out that the back head size of this 2-6-0 is about the smallest back head you will ever have to model in large scale. There is difficulty fitting everything into such a small area. Keep it simple, fit every major system typical of the prototype and leave off the frills. Should you wish to know the function of the any of the extra gizmos you might find in the photos, just drop me a line and we'll talk about them.

Construction

With a very minimum of materials, we'll be fabricating all the pipe work and devices used to operate a steam locomotive including the following:

- Sanding lines
- Injectors and feed water lines
- Air Compressor, steam and air lines
- Steam lines to the Dynamo
- Water glass, and tri-cocks
- Throttle and Johnson Bar
- Main piston hydrostatic Lubricator
- Air Compressor Lubricator
- Main Steam Turret in cab
- Automatic air and direct air brake stands and handles
- Boiler Pressure gauge
- Train air and engine air pressure gauges
- Oil can hot plate & Shelf
- Blower valve and blower steam line

Detail

There will be no 'detail' section in this chapter. Why I hear you ask? Well all of the construction section is 'detail', there is no getting out of it!

Never loosing sight of our prototype locomotive, the D&RG Class 40, or 8-16-D; fellow modeler Steve J of Florida, sent is this great shot taken in the late 1870s on the D&RG. A Class 40 2-6-0 double heading with a Class 42 4-4-0. (The Class 40 2-6-0 is on the head). Taking into account perspective, and the fact that the rear loco should look smaller than the lead, note how the Class 40's cab is lower than the 4-4-0's cab! This 2-6-0 was indeed a small loco.

"....Always mindful of Obstruction, Do your duty, never fail, keep your hand upon the throttle, and your eyes upon the rail..." Life is Like a Mountain Railroad!

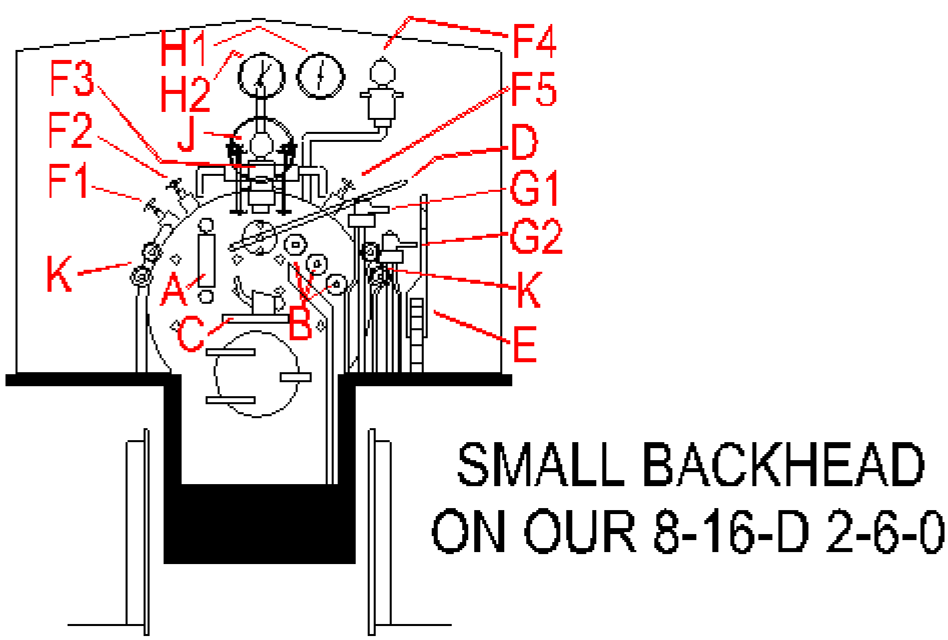
Background

(Ex loco Scientia)
From the locomotive- Knowledge

Pipes, Knobs & Levers:
Taming the Horse from the Footplate.

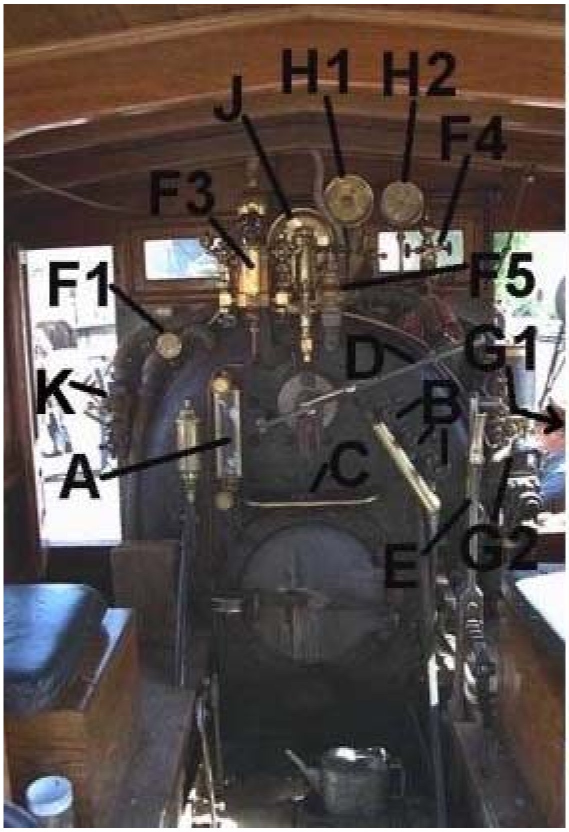
The easiest way to come to terms with a locomotive's pipe work and systems is to start within the cab and follow the pipes back to their source from there. The control panel in the cab is called a 'back head', and is literally the rear bulkhead of the boiler. The purpose of the back head is to provide the engineer and fireman the control of the whole iron horse from within the cab.

Refer to the following tagged diagram and photos as we describe the function of each lever, valve and pipe. The diagram is literally the back head we'll be making for the 8-16-D 2-6-0. In some instances, controls are shown on top of each other, I have not hidden the controls behind, so it's a sort of X-ray view! Bear with me!



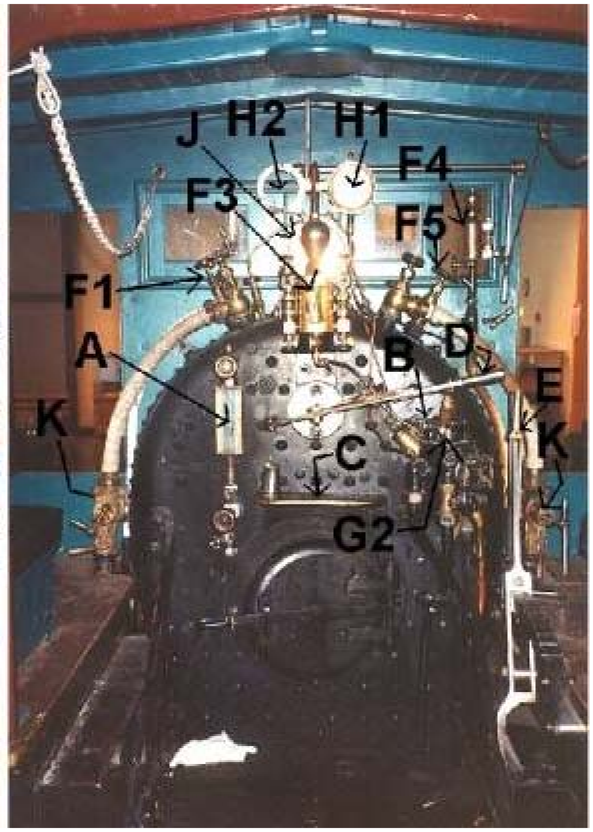
In order to give this diagram some context in reality, compare our 2-6-0 back head with the somewhat slightly modified back heads of locos also from 1875, both of which have all their parts in place, both restored to full operating condition. The two locos are:

1875 Baldwin 8-18-C 4-4-0 'Eureka' restored by Dan Markoff of Las Vegas



A view inside the cab of the 1875 8-18-C 4-4-0, "Eureka" The 'letters' denote the various systems and controls described below. Photo Taken by Matt Hutson, Silverton Colorado.

1875 Baldwin 4-4-0 V&T #22 Inyo, restored by the Nevada State RR Museum



While slightly different from Eureka, the back head of the 1875 Baldwin, 'Inyo'
Has the same basic features. Some of the 'add-on' systems on Eureka are not present on the Inyo.

Parts

A - The Water Glass

This is about as simple as it gets, this is an external glass tube, protected on 4 sides by flat panes of glass. The glass tube is connected to the boiler via copper pipes. The glass indicates the water level in the boiler. The fireman must maintain the water level within the glass length. The perfect water level is exactly half way up the glass. If the water is too high, there is a loss of steam area within the boiler, and loss of efficiency. If the water level is too low, the crew risk exposing the crown sheet above the firebox and the whole boiler could blow. Given the boiler pressure is up around 120 PSI, the little glass tube is under quite some pressure. It could shatter, throwing glass around the cab as boiling water squirts out. For this reason the 4 flat sheets of glass enclose the glass tube and the danger to the crew is minimized. There are small shut-off valves at the top and bottom of the glass, used to isolate the water glass should it burst or leak.

B- The Tri-Cocks

The Tri-cocks are a cluster of three valve handles or 'cocks' that pre-date the water glass. These are also used to check boiler water level. Typically the Tri-cocks remained in use till the end of steam, as a back-up to the water glass. An engineer could open each cock to see if steam blew out, or if water dripped out. If water dripped out, he knew the boiler water was higher than the cock level. If you look closely at the tri-cock layout, you'll see the positions of the three cocks align horizontally with the water glass. Thus the tri-cocks are arranged about the desired boiler water level. Many an engineer, always mindful of boiler water level, would leave the middle and lower cocks open to slowly drip water. If steam began to seep out, he'd know immediately that the water level was dropping and kick the fireman's butt!!

The alignment of the water glass & Tri-cocks is evident in this photo, indicating the max upper and lower boiler water levels. Compare this photo taken in Eureka's cab 2 months ago with the cab photo taken by Matt Hutson a year ago at the beginning of this section. Note the added water glass, pipes and valves to the left of the main water glass. Dan must have recently added these features as a backup

C- The Oil Can Shelf

The oil can shelf is a detail one should not forget, it is as important as any other control. Bachmann have always been very good to detail the can shelf, along with the oil cans and all, Kudos to them. The oil can shelf is not a shelf that is put anywhere, it is a hot plate, and is always located directly above the firedoor. The shelf is made from iron and is directly attached to the firebox metal. If you ever take a cab ride, do not leave your camera on this convenient little shelf, or it'll come out looking like steam oil! The purpose of the shelf is to heat up the steam oil used to lubricate the locomotive cylinders and moving parts. Steam oil is a very gooey, thick oozy substance that only becomes runny after being heated. This is important, because the oil is designed to be the perfect lubricating substance on HOT surfaces such as within the steam chests and cylinders or in the rod bearings. The engineer will always keep his oil can nice and hot on the back head oil can shelf.

D- The Throttle

This one everyone knows...the throttle is a bar fixed to the back head, and is used to open or close the throttle valve within the steam dome of the loco. By pulling back on the throttle, the steam valve is opened to direct steam down into the cylinders, and away we go. At any one time, the engineer usually has one hand on the throttle and the other on the train brake valve.

E- Johnson Bar

This is the forward and reverse lever. There is a half moon style ratchet at the cab floor, with a vertical lever running along the ratchet. When the lever is vertical, centered about the ratchet, the locomotive is in 'neutral' and will not go anywhere! When the lever is moved forward, the locomotive is set for forward motion, likewise when the lever is moved to the rear, the locomotive is set for reverse. The lever actually lifts and lowers the Stephenson valve mechanism, adjusting the valve timing to the cylinders. The same lever was able to lift and lower the radius rod about the reverse link on a Walschaert valve gear.

When an engineer opens the throttle and steams out of the depot, with the Johnson bar in 'full forward', maximum steam is admitted to the cylinders via the valve timing. As the train picks up speed, and momentum builds up, less steam is needed to keep the train in motion. The engineer then brings the Johnson bar back a few notches toward the neutral position, admitting less steam to the cylinders, maintaining motion and conserving steam and fuel.

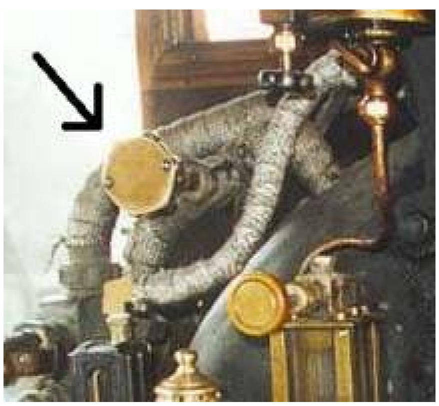
F- The Turret

The area above the boiler water level is filled with steam. This area around the top of the back head is called the 'Turret'. In later locomotives the Turret was quite literally a box fitted to the top of the back head where all kinds of steam appliance lines were manifolded. On the older locos the Turret was less obvious. Basically any appliance that needed steam to operate, would have a steam pipe running back to the Turret area to be plugged into the boiler steam supply. On our 1870s-1930s NG loco, the following appliances were connected to the Turret for supply steam, and each has a shut-off valve at the Turret:

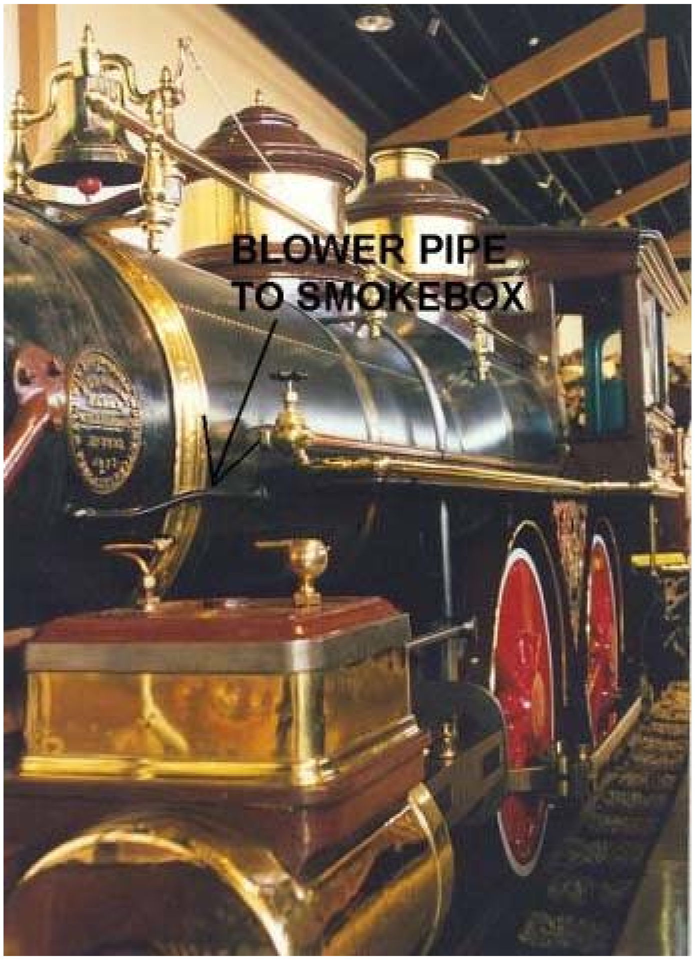
- The Blower Pipe
- The left and right injectors
- The air compressor
- The dynamo
- The Hydrostatic Lubricators

In later years, many additional steam operated appliances were connected to the turret such as additional steam powered lubricators, Feed water heaters, steam operated bells, etc. The turret area ended up looking like a crazy Octopus of steam lines!!

F1- The Blower valve



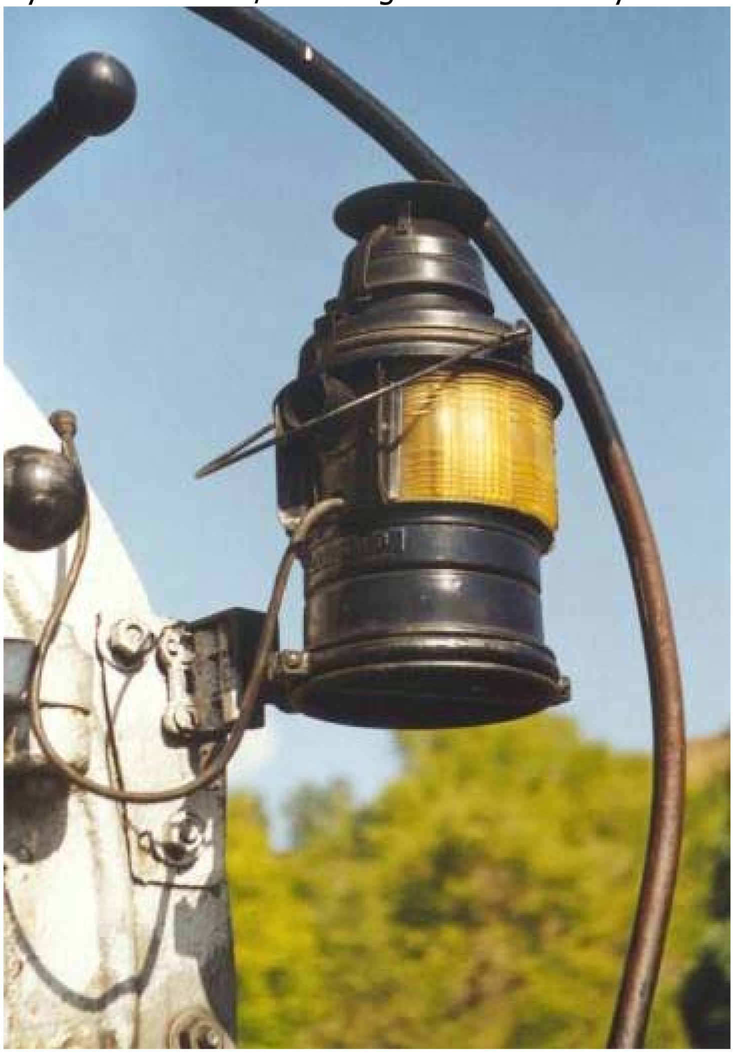
The Blower valve is a simple shut-off valve plugged into the Turret. The Blower pipe runs from the turret down to the cab floor and then proceeds under the floor along the boiler side on the fireman's side. This steam line then enters the smoke box side and wraps around the blast pipe within the smoke box. We've discussed how the blast pipe was used to draw up the fire for better steaming when a loco was in motion. When a loco is stationary, and there is no piston chuffing to draw up the fire, the engineer can turn on the Blower. Steam runs from the turret, along the pipe and into the smoke box. There a steam jet is formed around the idle blast pipe, simulating the effect of the blast pipe of a loco in motion. The fire can be drawn up in this manner. Before a train leaves the depot, the engineer might turn on the blower to draw up the fire and build up steam before departing. Once in motion, the blower is turned off. The Blower valve is on the Fireman's side.



The Blower pipe from the cab on 'Inyo'
Nevada State RR Museum

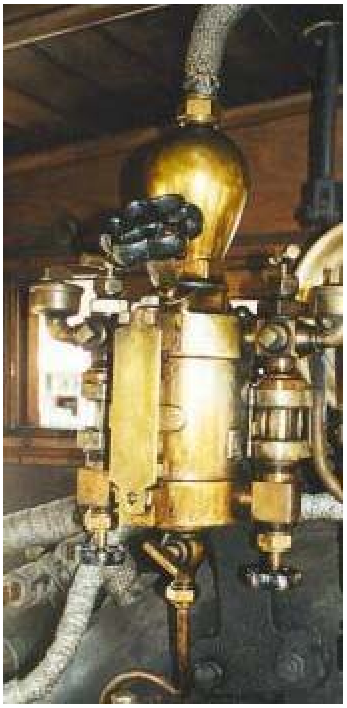
F2 - The Dynamo Valve

This is the shut-off valve, which supplies the steam from the Turret via boiler mounted pipe to the Dynamo or steam/electric generator. On my version of the 8-16-D 2-6-0, the Dynamo is mounted behind the stack and there is a long steam pipe running from the cab to the dynamo along the fireman's side of the boiler. From the Dynamo, a number of small electrical wires run to the electric lights on the front of the loco.

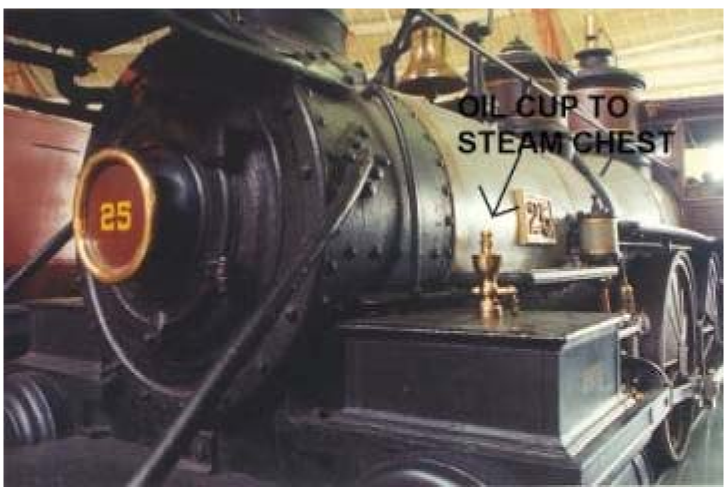


Note the thin electrical cord running to the electric marker light of this D&RGW C-19, #346. This cord has come directly from the dynamo. In many cases the electrical wiring is concealed and protected within the boiler mounted hand rails, exposed only at the connection point to the electrical fitting.

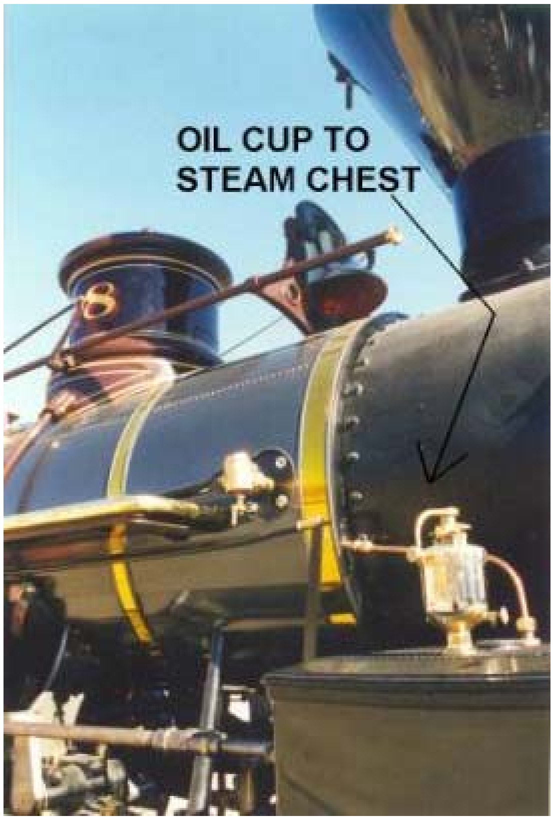
F3 - The Primary Hydrostatic Lubricator



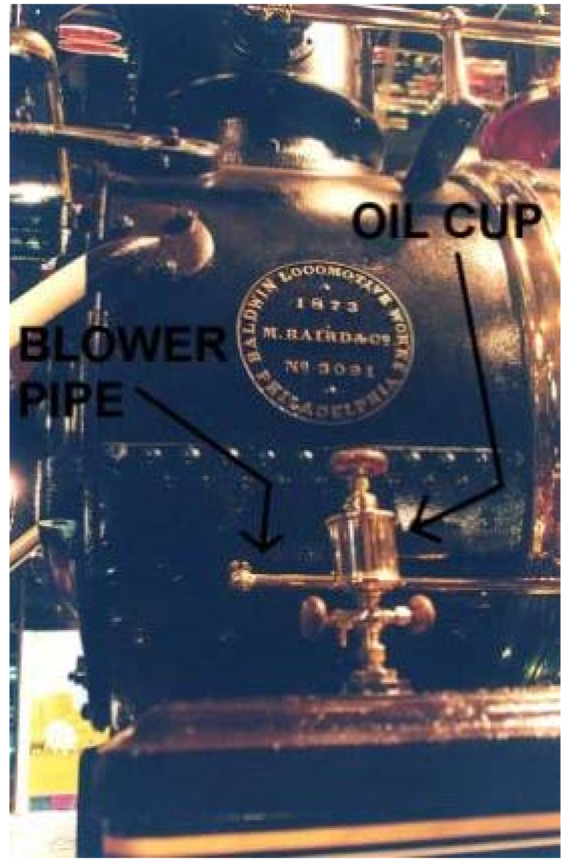
Lets talk about lubricating locomotives first. During the early days of steam, leading through to the 1870s, the engineer would do a walk around his loco and fill the many brass oil cups with his hot oil can to lubricate all the moving parts. The brass cup mounted at the top of the steam chests demanded the most attention. Here steam oil would seep down into the slide valves and pistons. The heat of the steam within the cylinders would quickly burn off the lubricants and run dry. It was necessary to stop the train every five miles or so and fill the steam chest oil cups again. You can imagine the need to stop and fill these oil cups was tedious and time consuming. Some more courageous engineers would turn the command of the loco over to the fireman. They would then grab their hot oil can and climb out onto the loco side boards via the cab's forward doors. With the loco in motion, they'd climb down onto the steam chest tops and fill the oil cups....and then do it again five miles further down the tracks!!



The Oil Cups on the steam chests of 'William Mason'
B&O Mt Clare Museum, Baltimore



Dayton's stylish brass oil cups, V&T Museum
Nevada State RR Museum



The fancy oil cup and brass blower pipe on the V&T #13, 'Empire'
Baldwin 1872, California State RR Museum

Thank God for the Hydrostatic Lubricator

This was a device mounted within the cab, and fed by steam from the Turret. A brass oil filled canister would be fed steam. The steam would condense inside the canister forming water. The oil would float on top of the water. As the water pressure built up inside the canister, the oil was forced out the top into a network of copper tubes or lube lines. The oil tubes then ran directly to the cylinders and steam chests. The oil cups on the steam chests were no longer required as the engineer now filled the oil canister within the cab, and the hydrostatic pressure of the water within the canister fed this oil to the cylinders. At intervals the engineer would drain the water out of the unit and re-fill the oil canister.

The lubricator line to the steam chest. Lubricants supplied under pressure
From the Hydrostatic Lubricator inside the cab, 1875 'Eureka' 8-18-C 4-4-0,
Shot taken at Rockwood Col, 2001.

F4 - The Air Compressor Hydrostatic Lubricator

First note that the Westinghouse air compressor mounted to the boiler side is a steam powered machine used to compress air. The top cylinder is a steam piston which compresses air in the lower cylinder. The lower piston is used to draw in air and compress this air into the big air brake reservoirs or air tanks.

Virtually identical to the primary Hydrostatic Lubricator, the Compressor Lubricator was used to feed oil to the steam piston component of the Westinghouse air compressor. This steam piston was again a component that needed constant lubricants, with the steam heat burning off the oils. Similar to the steam chest oil cups, the Westinghouse air compressor initially had external oil cups too. These oil cups were made redundant by the Compressor Lubricator; providing the means to top up the compressor lubricants from within the cab. This Hydrostatic Lubricator was only used to feed hot steam oil to the steam piston of the compressor. The piston used to compress air at the lower half of the compressor was not fed oil from the Hydrostatic lubricator, and an oil cup remained fitted to the outside of the air compressor for this purpose. Typically there is a small Hydrostatic Lubricator mounted to the cab wall on the side where the compressor is mounted. An oil cup is also to be provided on the lower 'air' cylinder.

The primary lubricator and special air compressor lubricator as described above are shown in their original 1870s-1900 appearance and a style consistent with our 1875 2-6-0. After the turn of the century, the lubricators were rationalized a bit more. It was normal for the cab hydrostatic lubricator to be one large unit comprising many small lubricator chambers. This one unit would feed all the equipment needing lubricants.
The above photo demonstrates a multi-chamber lubricator typically found on post 1900 style locomotives, known as a 'Nathan Bullseye Lubricator. This lubricator has 3 chambers, 2 for the 2 cylinders and one for the air compressor. D&RGW 2-8-0 #583, Colorado State RR museum.

F5 - The Air Compressor valve

This is a valve used to supply steam to drive the air compressor. When a train is about to leave, the engineer has to pressurize the brake lines and release the brakes. This is done by turning on the compressor and filling the air reservoirs/tanks. The brake lines down the length of the train are pressurized to around 90 PSI, while the loco's main air tank is pressurized to around 120 PSI. As the departure time approaches, the engineer opens the steam valve at the turret that starts the compressor into motion. Once the train is under way, the engineer leaves the compressor valve open. From here on the 'compressor governor' will automatically drive the compressor to maintain brake pressure in the lines, turning the compressor on and off automatically as required.

The 'compressor governor', fitted to the steam supply line to the compressor is an odd-looking brass bunny ear thing. These are two small air operated valves. The 1st brass bunny ear is a valve connected via a tiny brass air line to the main air tank. Air pressure is used to keep the governor valve closed. If the tank air pressure drops below 120 PSI, the governor valve begins to open, and steam is admitted to the air compressor. The compressor bursts into life, pumping the tank pressure back up, forcing the governor valve closed again. Thus the air pressure in the tank is used to turn the compressor on and off as required.

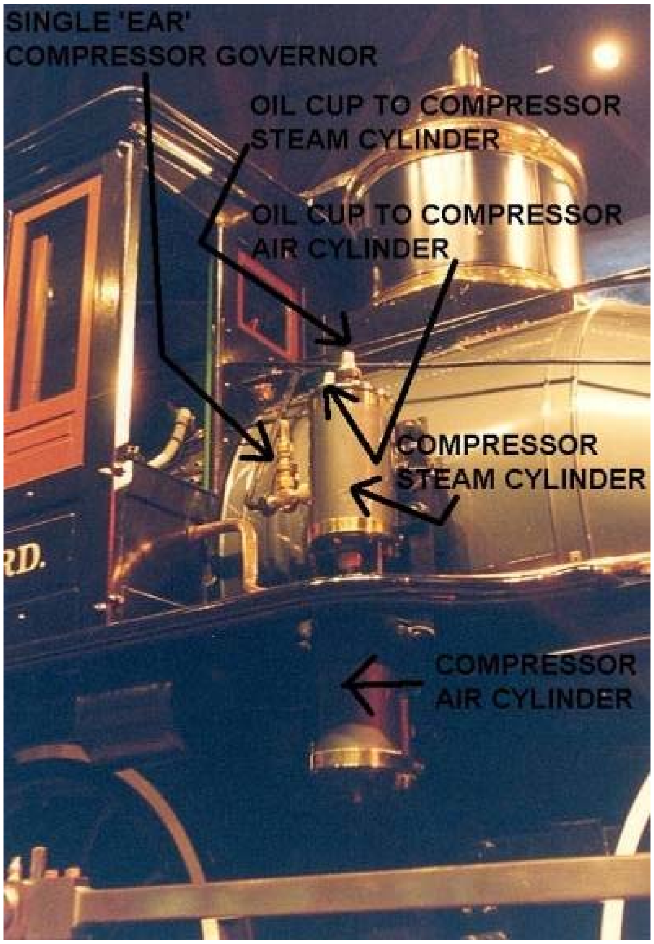
The 2nd bunny ear of the governor is an air-operated valve connected via a tiny air line to the train brake handle in the cab. When the engineer brings the brake on, air is purged from the brake lines. This action guarantees the need for more air in the near future to release the brakes again. Thus when the engineer brings the brakes on, and air is purged, air is also lost from the Compressor governor 2nd valve. Automatically the air compressor is brought to life pumping air into the tank in readiness for the need to release the brakes. The 2nd valve merely pre-empts the drop in tank pressure measured by the 1st valve.

All in all this bunny ear gizmo automatically turns the compressor on and off as the braking requirements of the train dictate. It also saves the engineer from constantly watching the brake pressure gauge, and manually turning the steam turret valve to the compressor on and off all the time.

The fittings to a post 1900 style Westinghouse air compressor
V&T #27, Baldwin 1913, Nevada State RR Museum

You might notice many older loco's only have one valve in the Compressor Governor, ie only one bunny ear. This is the older style governor, and is only driven by the tank pressure. The compressor only comes on when the governor detects a drop in air tank pressure. The action of the brake handle is not measured. The twin valves in the later era Governors are just more efficient.

Typically the 1870s locos had only one valve in the governor. Post 1900 versions would have the full bunny ear twin valves in the governor.



Fittings to early Westinghouse Air Compressor
Gov Stanford, 1869, Cal State RR Museum

Note the brass oil cup mounted to the left side, midway up of this 1880s style air compressor on Eureka. The oil cup has a copper lube line running down to the lower air cylinder. You can also see the 'single ear' Compressor Governor fitted to the steam line at the upper left of the compressor. The brass air filter inlet to the compressor is seen fitted to the left of the lower 'air' cylinder.

The air cylinder oil cups are mounted to the top rim of these twin air compressors on the classic D&RGW C-16 #268, at Gunnison Colorado. Note the long lube lines running down from the oil cups to the lower air cylinders. You can also see the air intake filters mounted to the left side of the air cylinders.

G - The Brake stands

The Brake stands are the brake handle assembly. The brake handle itself is a horizontal brass lever, mounted atop a steel pole. There are copper air lines connected to the brake handle, clamped to the sides of the steel pole. As the Brake lever is moved, valves at the top of the air

lines are opened and closed, either purging air pressure in the system to bring the brakes on, or closing the air lines to maintain air pressure and keeping the brakes off. Refer to the diagram of the brake system to see how the compressor, air tanks and brake stands all tie into the one air system.

There are two brake stands in the cab:

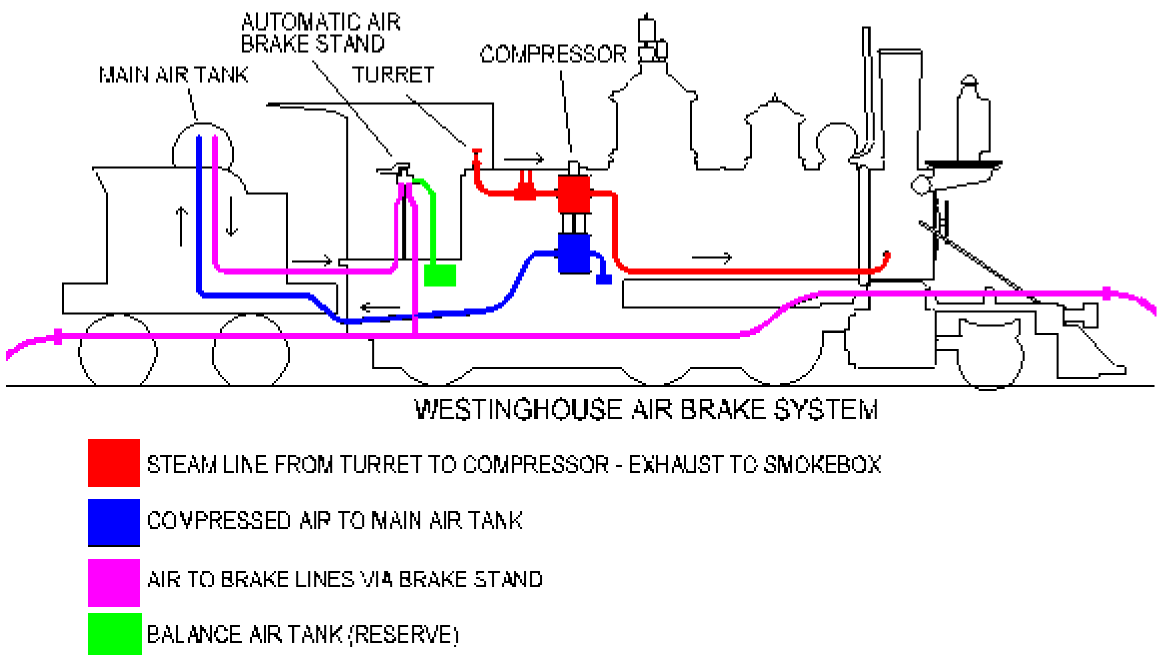
-The direct air locomotive brake handle
-The Automatic air train brake handle

On many locomotives the two brake stands are similar in appearance, and are fitted next to one another to the left of the engineer's seat. On the Eureka (where our photos are used as examples) the engine brake is a vertical lever to the right of the engineer's seat, while the automatic brake is a traditional horizontal brake lever to the left of the seat.

G1 - The direct air-locomotive brake handle, used to control the engine brakes only. 	**G2 - The 2nd brake stand is the automatic air, train brake, used to control the brakes of the whole train.** 

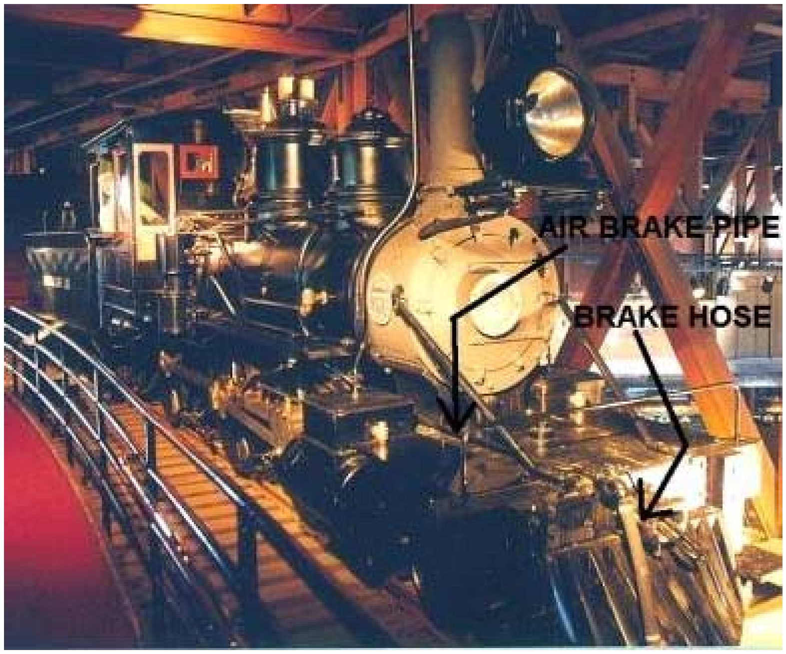
As discussed in previous chapters, the direct air, engine brake uses air pressure to 'push' the engine brakes on, while the automatic air, train brake, uses a drop in air pressure to bring the brakes on. During normal train operations, the engineer will only use the train brake. When doing yard work or driving the loco light, the engineer might use the direct air brake. On 1870s loco's, the engine brakes were fitted to the tender only, there were no brakes on the drive wheels. The direct air brake stand only controlled the tender brakes. After the 1880s, the loco's were fitted with brakes to the drive wheels as well, and the direct air brake stand controlled the drive wheel and tender brakes together. The automatic air brake stand did not control the locomotive brakes at all.

Summary of the typical Automatic Air Brake System



1. Steam from the Turret is directed to the top cylinder of the air compressor (red)
2. The steam used to drive the air compressor is then exhausted into the smokebox and up the stack (red)
3. Air is drawn into the air compressor lower cylinder via a small air filter (Blue)
4. The air is compressed by piston pumping action within the compressor and forced directly to the main air tank (Blue) (fitted on the tender or under the loco's side boards)
5. When the engineer opens the brake valve at the cab brake stand, air leaves the main air tank and is directed to the train's air lines.. pressurizing the entire train via the numerous flexible brake hoses between the cars, the brakes come off and the train is free. (Cyan)
6. There is a small balance tank or 'equalizer' tank mounted under the cab floor used to absorb pressure surges from the main tank (green).

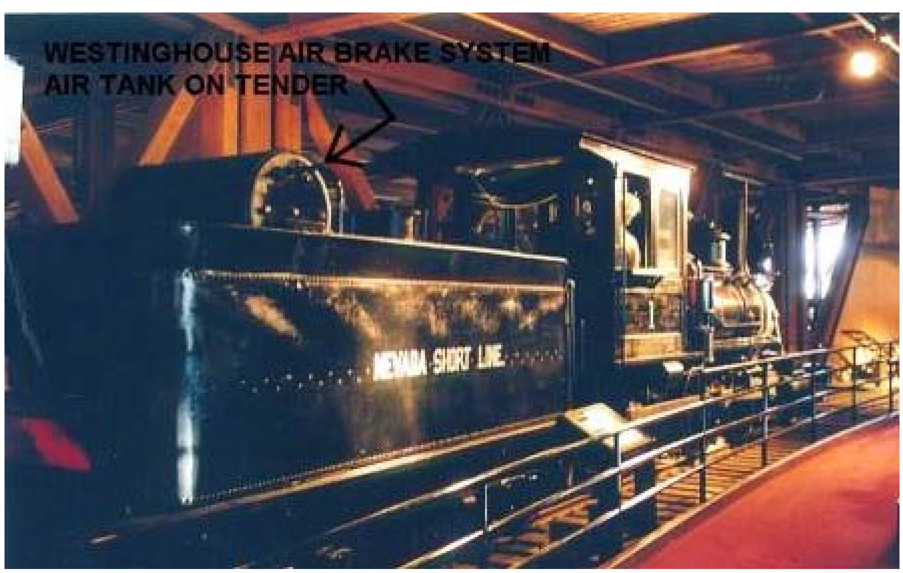
When the engineer rotates the brake lever to 'brakes on' position, a valve is opened on the brake stand, releasing the line pressure in the train, bringing the brakes on. All the while, the line from the main air tank is shut-off maintaining tank pressure.



The air brake lines from the cab running under the side boards to the brake hose on the loco's draw beam, seen on the 8-16-D 2-6-0.

In early locomotives, the Westinghouse air brake system was a retro-fit device, and the necessary pipe work, compressors and tanks were made to fit where possible. On smaller NG locomotives, getting everything to fit was some task. That is one of the reasons why the main air tank was often found mounted on the tender of the smaller locos.

Another reason for fitting the air tank to the rear of the tender was to remove it from the compressor as far as possible. Compressed air is initially very hot. After the air leaves the compressor and begins to cool, it contracts in proportion to the temperature. Contraction in the air pipe or tank can give a false indication of the available brake pressure. It is important to cool the air so that it enters the tank at a stable pressure. This cooling is done by running the compressed air though long runs of external pipe work between the compressor and air tank. On the early locos, this was a long run of air pipe from the compressor to the rear tender deck where the air tank was mounted.



The main air tank retro-fitted to the rear of the tender top, seen on this 8-16-D 2-6-0.

On later era locos, where air tanks were mounted near the compressors under the sideboards, 'radiator' pipes were used. Long lengths of air pipe were wrapped back and forth in a zig-zag pattern, providing the necessary pipe length to cool the compressed air before it entered the air tank.

H- The Brake Pressure Gauges

These two brass gauges provide the engineer information about the status of the brake pressure for both train and engine brakes. There are two gauges mounted to the cab wall:

H1 - The Duplex Air Brake Gauge	**H2 - The Direct Air Brake Gauge**
	
This is a two-in-one air gauge, with two pointers or needles in the glass. The red pointer shows main air reservoir pressure on the engine. The black pointer indicates the automatic air, train brake pipe pressure.	This is a single pointer gauge that indicates air pressure in the pipe to the locomotive's brakes only.

J- The Boiler Pressure Gauge

This one everyone knows, a big gauge that points to the boiler pressure in Pounds/sq inch. Keep the needle away from the red zone at the high end of the gauge! The fireman uses this gauge to keep boiler pressure up and start fueling the loco if the pressure begins to drop.

K- The Injectors

The injectors are the device used to pump water from the tender into the boiler, against the back pressure within the boiler, quite some trick! There are two injectors, one mounted to either side of the back head. Both the fireman and engineer can operate the Injectors. It is however the Fireman's duty to maintain the boiler water level.

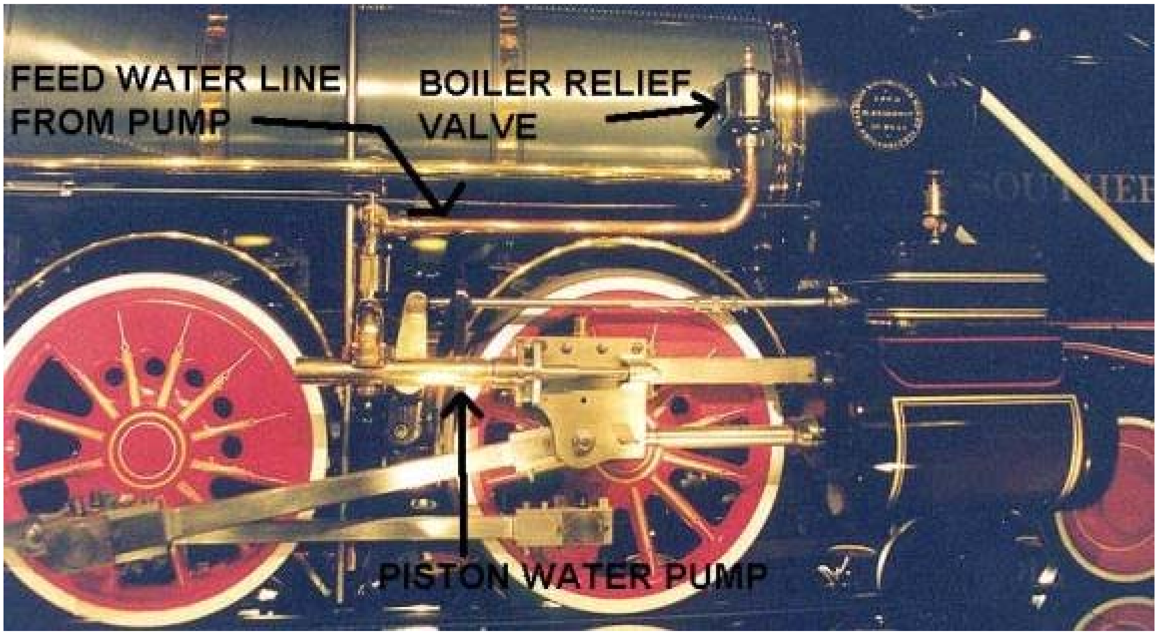
A little background first:

In the early years of steam, water was pumped into the boiler using all means of mechanical devices. The problem was simple; keep filling the boiler with water at a rate just above the rate in which the locomotive used this water as steam. Failure to do so could result in a boiler explosion. Additionally one had to fill the boiler while the loco was in operation and fully pressurized. Forcing water into a pressure vessel is not easy. The water wants to squirt out!

Initially simple hand pumps were used. Every few minutes the fireman would have to get pumping. If the water level within the boiler was dropping at a faster rate than the guy could pump, the crew would damp down the fire and wait for the guy to catch up.

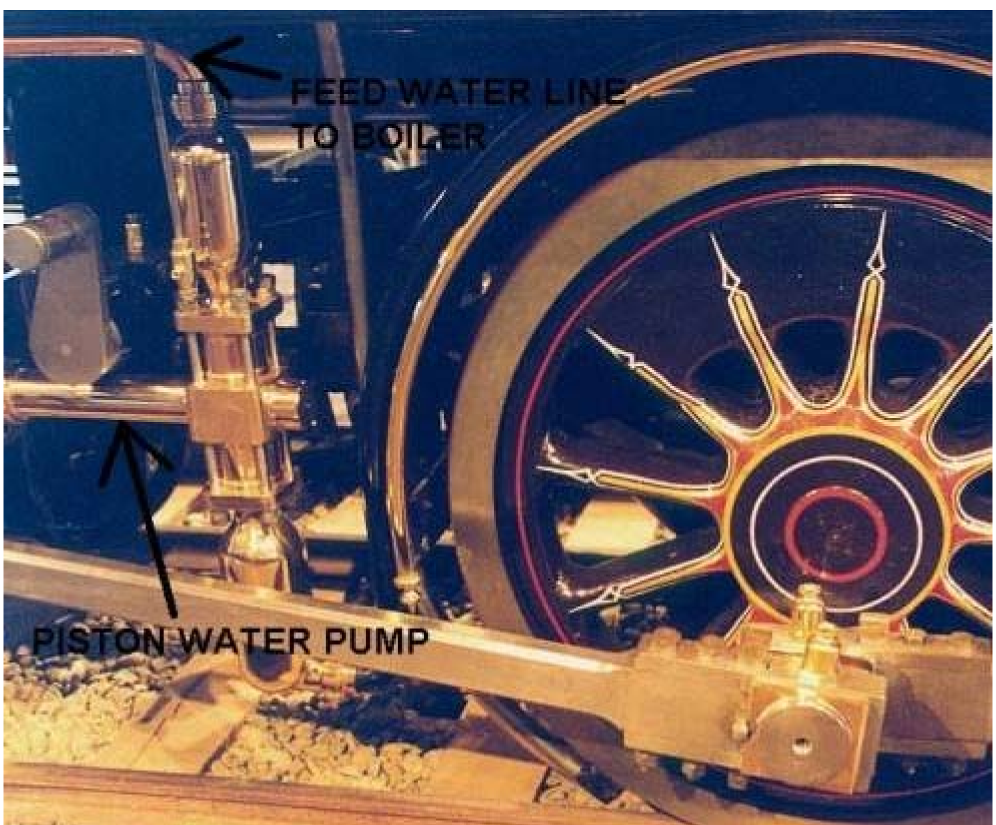
Axle pumps were also tried, where as the loco moved, the pumps connected to the wheel axles would start pumping water into the boiler. The hand pumps were still used for stationary work.

Piston pumps were very popular during the 1850s -1870s. These were a brass water pump connected to the locomotive's piston cross head. The pure torque of the piston would thrust the water pump and force water into the boiler. The fireman would control the water flow rate with a valve in the cab. If no more water was needed in the boiler, the pumps would keep running with no water flowing through. While the piston water pumps were leaky and maintenance intensive, they were very successful in providing a constant water flow into the boiler at rates similar to steam usage. There are railroads today in South America and Cuba that still run 1920s outside frame 2-8-0s and 2-8-2s fitted with piston water pumps...and Injectors as well...the best of both worlds so to speak. Interesting to note too, those living in Florida and familiar with the Disney World RR at the Magic Kingdom will notice the 4-4-0s, 2-6-0s and 4-6-0s running on the line around the park all have piston water pumps with Injector back-up.



The piston water pumps fitted to V&T #13, 'Empire', Baldwin 1872, Cal State RR Museum.

There are stories from the D&RG of the 1870s, where a crew would just make a water tower with low water in the boiler, and little water left in the tender. The time taken to fill the tender and then start filling the boiler again with the piston pump would bring the loco dangerously close to running the boiler dry. Crews had become adept in overcoming this difficulty. As the loco drifted up to the water tower, the fireman would run ahead of the loco and grease the rails. When the loco came under the tower, the engineer would slam down the loco's tender brakes, stopping the train, but leaving the drive wheels turning over, spinning on the grease, keeping the piston water pumps working throughout the time needed to fill the tender.



The piston water pumps fitted to the 1876 4-4-0 'Sonoma' - Cal State RR Museum

There was no more a significant invention for the purpose of pumping water into the boiler than the Injector. The injector is one of the great locomotive Miracles! It uses steam pressure to draw water from the tender, and pump that water into the boiler against the very same boiler pressure that drives the injector in the first place! It's almost a perpetual motion machine! The injector has virtually no moving parts, no wear and can replenish boiler water even when the loco is stationary.

The injector is the result of some very lateral thinking of celebrated French Balloonist Henri Giffard (1825 - 1882). After inventing the Injector in 1859, Giffard was awarded the prize for mechanics from the Academie des Sciences in Paris. In 1863 Giffard was made a Knight of the Legion of Honour. The Injector was first used on US locomotives in 1860.

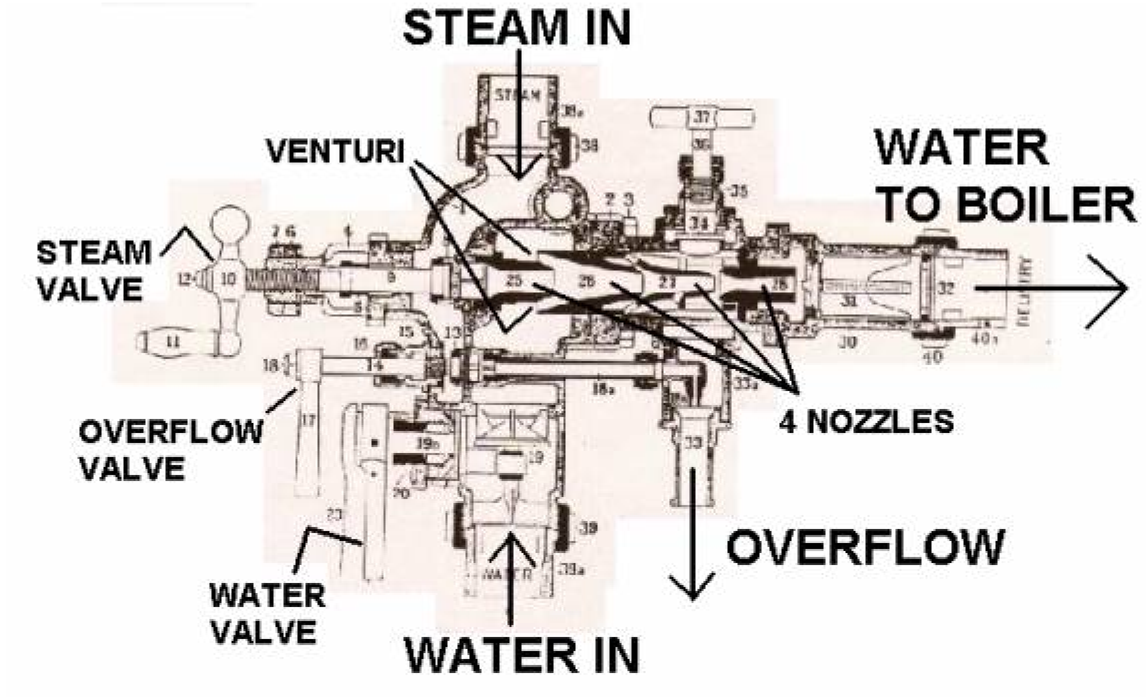
To describe the workings of an injector is fraught with difficulty. To Physicists, the correct use of the appropriate terminology in describing its workings is the key to understanding how the thing works...something I'm frankly hopeless at!! So I'll describe its workings in my own way!

Over the many years of steam locomotive development, there have been many varied versions of the Injector, what I shall describe is the most common type, known as the 'lifting Injector'. So named because of its ability to lift water to the injector level, higher than the tender water level. On our 8-16-D 2-6-0, along with most pre-1900 locos in the US, this type of Injector was made by Edna, and is called an 'Early Edna Lifting Injector'. There were other injectors too, made by Nathan and Handcock.

Very basically the Injector works exactly like a modeler's Air Brush. The action of passing gases (steam) over a nib, creates a vacuum that draws up water to the nib. From there the water is mixed with the gases in a jet flow (this is called a Venturi effect). We use that jet flow to paint models with. The Injector goes a lot further than that. Steam is taken from the Turret and run into the injector. As the steam leaves the boiler at the turret, it begins to expand, producing an increase in energy. This steam energy is then used to draw up the water via the tender water pipe in a Venturi within the injector. The water is mixed with the steam in a jet stream...which is then forced though 4 progressive nozzles of decreasing size. As the steam cools and expands, the steam/water mix gains speed and pressure as it is forced through the 4 ever constricting nozzles. The water/steam mix then runs forward along the feed water pipe to the boiler relief valve and has the necessary added pressure to overcome the boiler's back pressure and fill the boiler with water. In fact this system is such that the water enters the boiler some 50 PSI higher than the actual boiler pressure. Hands up anyone who doesn't know what I'm trying to say??

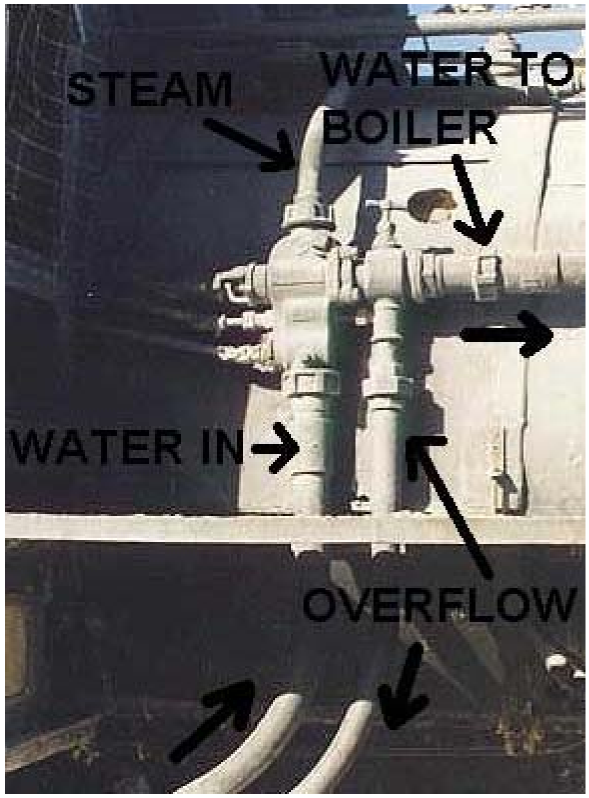
- There are 4 pipes running into the box-like Injector.
- The steam line from the Turret
- The water line from the tender
- An overflow pipe at the far end of the injector
- The main feed water pipe to the boiler from the Injector.

You can see the 4 pipes, the Venturi and the 4 nozzles within the injector in this cut-away view.



We have described how three of those four pipes are used in the workings of the Injector, I will now explain the over flow pipe.

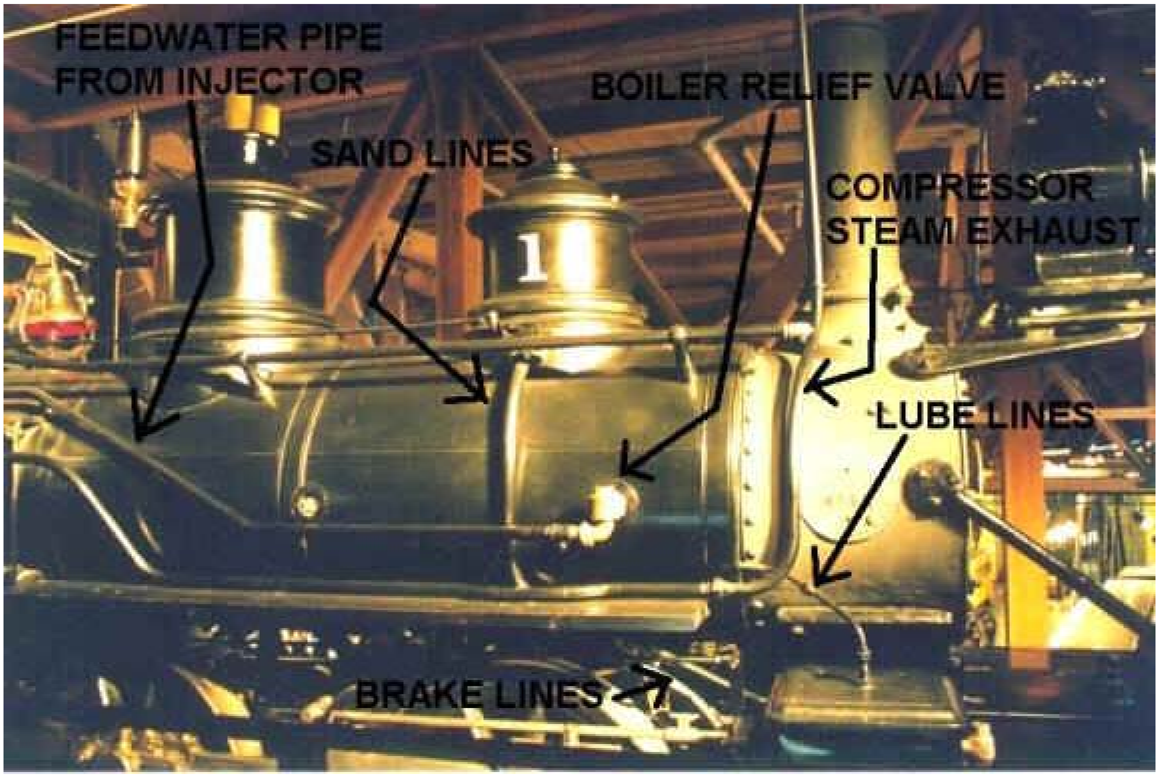
The overflow pipe is critical to the 'priming' of the injector when first getting it working. Obviously until boiler pressure is gained, during the warming up of a locomotive, the injectors will not work. Once steam pressure is beginning to rise, the crew might turn on the steam and water valve to the injector to start the water flow. Two things need to happen, first residual water condensed within the injector has to be expelled, i.e. flushing the system. This is done by opening the overflow valve. The old water is pushed out by the steam pressure behind it. The 2nd activity is the need to get the Venturi within the injector working, and start drawing water up the pipe into the injector. Because the steam pressure is low, the injector at this time cannot work to overcome the rising boiler pressure. The crew opens the overflow valve to run the tender water through the injector and straight out the overflow pipe. This is how you prime the injector. The Venturi is working, the water is flowing up into the injector and the injector pressure is increasing. No water is yet running into the boiler from the Injector. When all the air bubbles are out of the system, and the injector is running efficiently, the crew close the overflow valve and the water is then pressed forward into the boiler proper.



The early Edna Lifting Injector fitted externally to a 1909 Baldwin 4-6-0
The Slim Princess, Laws California.

The boiler relief valves, sometimes called 'check valves' are themselves 'one-way' valves designed to prevent boiler back pressure running down the feed water pipes to the injector. They are usually a stylish brass fitting. Look at previous pictures of Empire or Sonoma for examples of some of the polished variety. Below is a shot of the more rudimentary yet neat boiler relief vales fitted to the 1875 Eureka.


The Eureka's boiler relief valves. Note the polished copper feed water pipe beyond.

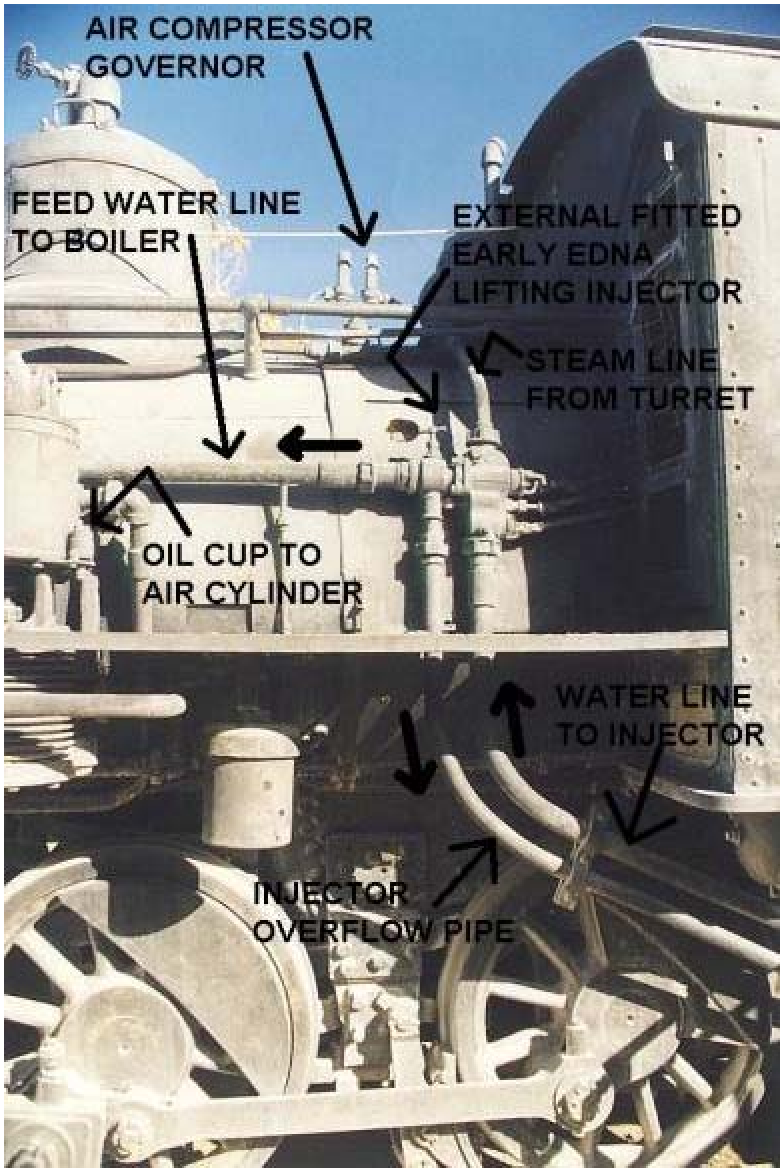


The pipework clearly demonstrated on our prototype 8-16-D 2-6-0, Cal State RR Museum. Note on this version of the 2-6-0, the air compressor outlet pipe does not enter the smokebox to be discharged up the stack. Instead the outlet pipe is mounted externally to the stack.

By the 1920s, the Early Edna lifting Injectors were being replaced by a non-lifting type, sometimes called an 'Inspirator' These worked in a very similar principle to the Injector described above, but with one advantage. Water was fed to the injector using gravity. The injector was fitted to the loco at a level lower than the tender water level. Thus no energy was wasted in lifting the water to the higher level before being forced into the boiler. The non-lifting types were also a two-part affair, where the steam control component was mounted within the cab, while the water feed part was under the cab. The original lifting injectors would be turned on and worked at that given rate. The newer non-lifting types could be throttled. It was possible to set the injector flow rate to suit the steam usage of the loco, and just leave it run. On locomotives such as the NYC Hudsons etc, sometimes both lifting and non-lifting Injectors were used, with the non-lifting type fitted to one side of the loco and the lifting type to the other.

A final note about injectors is that while they have no moving parts and are not susceptible to wear, they can overheat while in constant use, resulting in a drop in pumping efficiency to the point where the injector stops working. This is one reason why never fewer than two injectors are fitted to any loco, with one injector doing most of the work, and the 2nd one brought on line if the first begins to overheat. Those familiar with the fabulous ride up the Cumbres Pass on the Cumbres & Toltec Scenic RR, will know the ride is a double headed train up 14 miles of 4% grades. During that push up the grade, the crew run the loco with one injector turned on, and that injector remains in operation for the full 14 miles. When the train reaches the summit at Cumbres Pass, this Injector is overheating. The crew switch over to the other Injector for the ride down hill allowing the original to cool.

The Injectors are usually mounted to the sides of the backhead within the cab, however, many NG locos by the 1920s had the Injectors moved to an external position forward of the cab, with control linkages back to the cab. I don't know why this was done, but it could be for reasons of providing more space in the cab, and it could also be to allow the injector to cool more easily in the outside air. My 1920s version of the 2-6-0 has external mounted early Edna lifting Injectors.



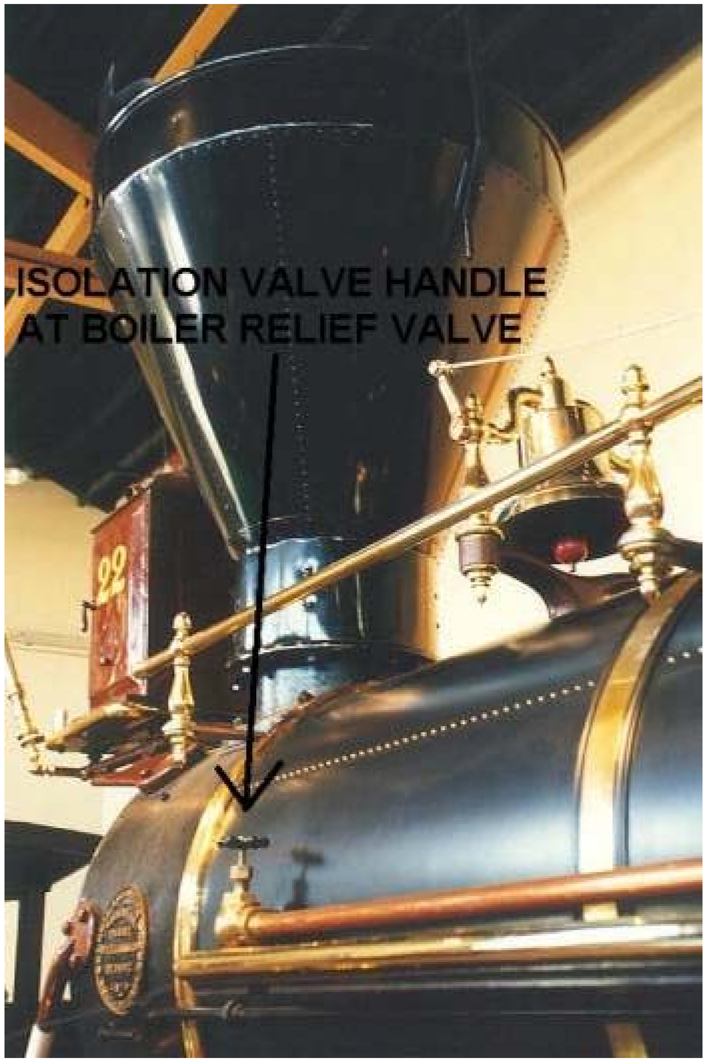
Injector Fittings to the Baldwin 4-6-0, Laws California.

Note the flexible hose connection between the tender water tank and the injector feed water pipe. You can also see the injector overflow pipe terminating near the drive wheel hub. D&RG T-12 #168, Colorado Springs.

Pipework and Valves

As a very general overview of locomotive pipework, modelers should be aware that the pipework and valves described above are common to most US locomotives. In addition to this, there are isolation valves fitted in the pipelines between the control valve in the cab and the fitting's connection point somewhere down the locomotive's side. Generally locomotives of the 1870s had clean pipelines straight from the control valves in the cab. Few other isolation valves were provided and as such if there was a pipe rupture or leak, the crew could do little about it other than to shut off the system from the cab and leave it.

As time progressed and railroads became more adept at fixing problems en-route, more and more isolation valves were fitted to the pipelines. By the 1920s virtually every appliance, and every section of pipe could be independently shut off, repaired or replaced with the loco at full steam pressure. Every pipe would have a control 'on-off' valve in the cab, another isolation valve at the point where the pipe left the cab, and an isolation valve at the end of the pipe where it either connected to an appliance such as the air compressor or connected to the boiler. When modeling your 2-6-0, depending on chosen era, the cab fittings will be virtually identical as shown above, but there is a great range in the number of isolation valves to be fitted to the pipework running along the loco's sides.



Note the added valve handle to the boiler relief valve on the 1890s version 'Inyo'
Nevada State RR Museum

Note the large number of isolation valve handles to all the pipes running in and out of the twin air compressors of this 1952 version D&RGW C-19. Note also the oil cups mounted to the top of the air compressors feeding oil to the air cylinders at the base of the compressors. Knotts Berry Farm, California.

Note the isolation valve in the blower steam line to the smokebox on this D&RGW C-16 #268. Also note the copper lube lines running into the steam chest top. Gunnison Colorado.

Without further delay, lets now put all these valves and pipes to work on our cute lil 8-16-D 2-6-0 model.

Construction

Pipes 'n Stuff

Please review the entire contents of this chapter before proceeding with the work. Really, check it all out. This is a complex chapter, not helped by the fact that I built the prototype model in a different order from how I describe the work!!
The arrangement and locations of the pipework in the model demonstrated here can be varied. There are no 'firm' rules as to exactly where pipes should run on a locomotive. The common rules are these:

1. The pipes usually begin at point A and end at point B in much the same locations on most locomotives
2. The pipe routes are based on 'most direct route from point A to B' principles, without clashing with other pipes, or compromising crew safety. i.e. loading up the sideboards with pipes in a NO NO!!
3. Easy access to the major pipework is desirable. i.e. no hiding pipes.

The way I've routed the pipework along the model is very 'typical' and can be followed for most of your models.

Unlike previous chapters, where I say cut such-n-such so big and stick it there, in this chapter, it's best to follow Steven J's modeling philosophy...follow the pics and all will work out right. For the pipework of your models, this is probably the best approach.

Some Basics

You will be using the following materials almost constantly:

- 1.5mm dia Brass rod, (welding rod or similar)
- 1.5mm dia Copper piping (used on 1870s version only)
- 1.0mm dia plastruct rod...this is a styrene rod with a wire core in the center... You MUST get the rod with the wire center in it.
- 2mm styrene dia (Evergreen) rod. This is a 2mm solid rod.
- 3.2mm dia Styrene Plastruct tube. This is a hollow tube with a hole running through the middle exactly 1.5mm wide...perfect fit for the brass 1.5mm rod to run through. Get the plastruct tube, not the Evergreen. The Evergreen tubes have a hollow in them too large for our purpose.

- 20 or so 5mm dia metal press-studs. These are the tiny metal press-studs used in dress making, found in most fabric shops...get the ones that are round, metal and as tiny as possible...we use these as valve handles. The Press-studs come in two halves, the outer part is usually larger and domed or rounded a little. The 2nd half is the base, this is a flat disc with a central pimple on it. This 2nd part is the useful part. Make sure this gizmo is no larger than 5mm..preferrably even smaller.

Now before you get off on what a totally cool idea using taylor's press-studs as valve handles is, I should point out that this idea didn't come from me!! Traditionally I had used all kinds of HO scale freight car brake wheels as largescale valve handles and this works fine, it might cost a bit and sometimes obtaining HO scale brake wheels can be tricky. It was during my visit with Tiny in Nevada back in '99 that he pointed out what a good idea press studs were. I jumped right into it. I think the idea may have originated here in Auz..when visiting Phil Creer in Adelaide earlier in the year I was surprised at how far he'd taken the press-stud concept...his backheads were loaded with the lil gizmos, but they were also found in varying sizes on his home made freight cars. Phil is the press-stud KING!! My thanks to Phil and Tiny for showing me this little trick.

Generally the pipework running along the side of the boiler is in horizontal runs. Take the utmost care to ensure you do fix your pipes to the model in absolutely horizontal runs. Make sure your pipes are parallel to the sideboards, boiler and hand rails. On the real prototypes, the pipework could be a little off level, especially in later years, but on a model some rather nasty illusions occur if the pipework is not level. If the pipes are running up or down out of level, it will make your loco look like the boiler is not sitting level on the chassis. This is a very nasty illusion, and you will be scratching your head for months trying to figure out how you got your model looking so awkward. The secret is to ensure your pipes are absolutely level...use small chocks resting on the side boards to hold the pipes in place while you pin them. Just take care OK?

When viewing the construction drawings below, note that the pipework is seen in elevation flat from the side-on. In reality you will be bending pipework around the boiler. The diagrams also use some symbols and blacked in solid areas. Each drawing shows the whole model, with the pipework/valves etc totally blacked in to indicate the direction of the pipe from backhead to loco side. There are 'bubble' details attached which show the construction of the components more clearly, containing the following symbols:

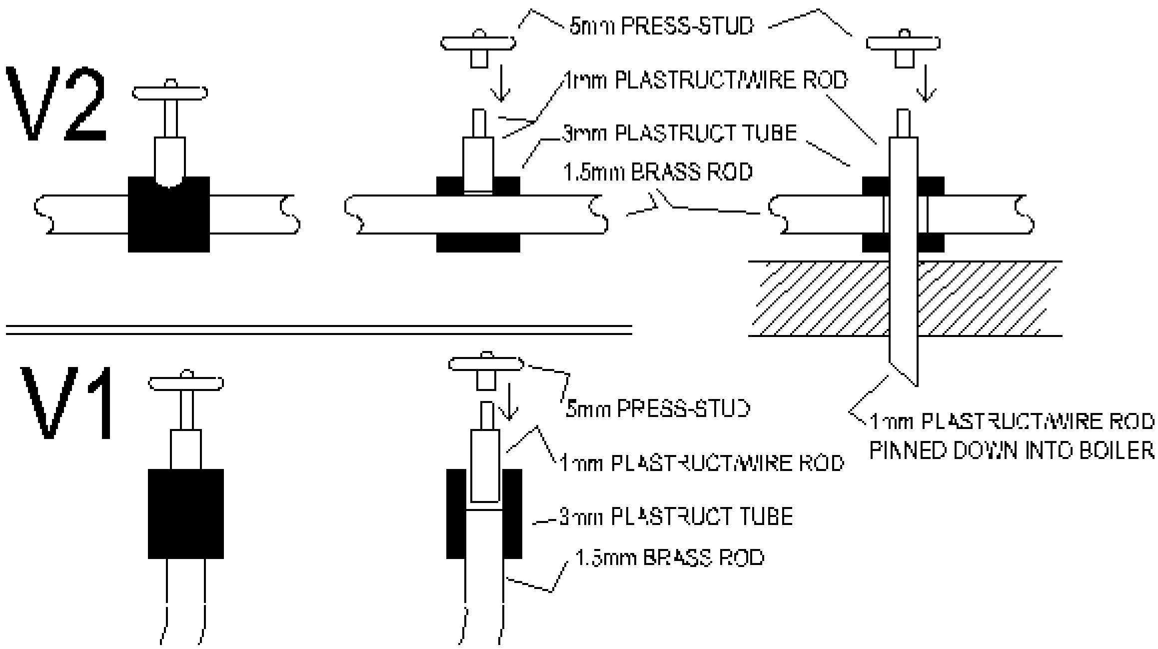
- The blacked in solid areas in the details 'bubbles' represent 3.2mm styrene rods
- The clear/white areas denote 1.5mm brass rod (or copper rod for 1870s models)
- The V1 and V2 symbols represent the two types of valves to be made for this model.

The Two Types of Valve to make

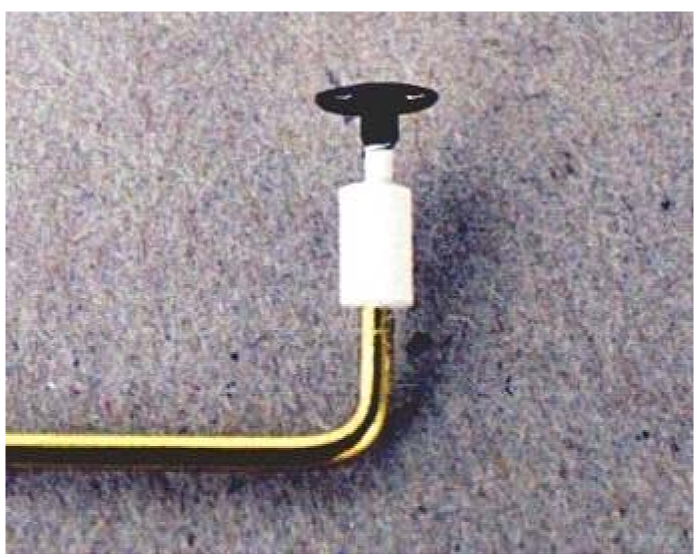
There are only two types of valves to be made for this model, denoted on the diagrams as V1 and V2 (I was always a fan of Von Braun...loved his book entitled "How we aimed for the stars but hit London on the way"). The V1 valve is more a 'plug' valve or a valve at the end of a pipe run. The V2 valve is more an isolation type 'in-line' valve.

As pointed out in the 'Background' section of this chapter, the number of 'in-line' V2 valves is up to you, there is nothing wrong with placing one of these valves near the beginning and end of every pipe run in addition to the V1 termination valve. Generally the more modern the loco, the more V2 isolation valves used.

The two types of valves are made like this:



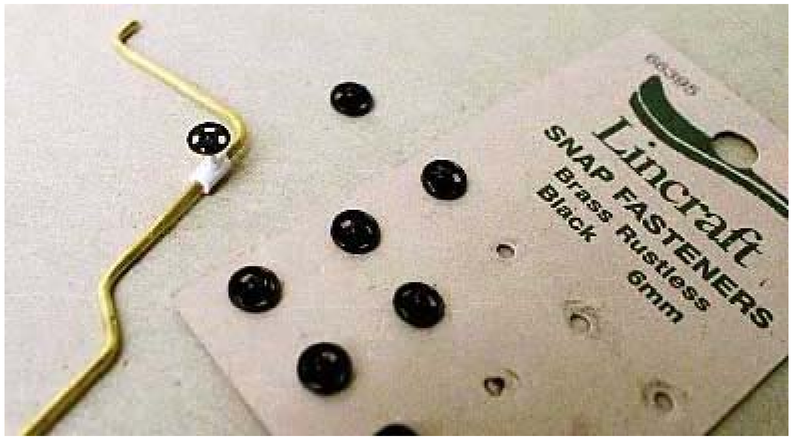
The V1 valve is a 4-5mm long 3.2mm styrene tube slotted onto the end of a brass 1.5mm rod. You cut a 3-4mm length of 1.0mm styrene rod and strip off the styrene lagging to the top 1mm of the rod, exposing the wire core of this plastruct rod. The 1.0mm plastruct rod is then placed into the open end of the 3.2mm tube. Take a 5mm metal press-stud and drop it down onto the wire core of the 1.0mm plastruct rod. You will notice there is a neat 0.7mm hole in the central pimple part of the press-stud. Its fits neatly onto the 1mm rod core wire. Sit the press-stud down with the pimple facing down, and fix into place with CA cement.



The V1 type valve at the end of a pipe run.

The V2 Valve is a 4-5mm long 3.2mm styrene tube slid onto the 1.5mm brass rod. You will have to pre-drill a 1.0mm hole in the top middle of the 3.2mm rod. Insert a 3-4mm length of 1.0mm plastruct rod into the 3.2mm tube side, resting hard into the brass rod within, with a 1mm length of wire core exposed at the top end of the 1.0mm rod, insert a metal press-stud in the same manner as a V1 valve.

In some cases, near the end of a pipe run, you can use the V2 valve as a means to bolt the pipe and valve to the boiler side. This is done by running the 1.0mm plastruct rod right though the 3.2mm valve housing into a pre-drilled 1.0mm hole in the boiler side. This will then hold the pipe and valve to the boiler...this cute fixing method is then finished off with a valve handle and no one will ever know the valve is in reality a bolt. (Shown on the far RHS of the V2 Diagram).



You can see the press-studs and the V2 type valve fitted to this length of brass rod.


The finished, painted V2 valve

The Order of Work

Similar to previous chapters, the order in which you carry out the work is up to you, however I do have a recommendation. When rigging a sailing ship model, I always work from the centerline of the ship outward...installing the rigging along the middle of the ship first, and working outward until the lines on the very outer tips of the yard arms are done last. This way I have clear access to the inner ship areas without having to weave my hands into the ships innards though a mass of lines. We build our loco the same way. Install all the inner most pipes first, and finish with the outermost. The order in which I describe the fitting of the pipes to the model WILL be in the desired order. If you install outer pipes first, and then try to weave an inner pipe in behind, you will most likely scratch the Russia Iron boiler paint work.

Another important aspect is how you fix the pipes to the boiler. You will most likely have to drill small 1.0mm and 1.5mm holes in the boiler side and smokebox side where pipes penetrate. These holes will hold the pipes in place. But it is here where you must take GREAT CARE. Do not let the drill skim across the boiler side, scratching all your great paint work. Take care, do it slowly, hold the parts firmly. Even tap in a notch in the boiler side where the hole is to be drilled, and use this notch as a guide to stop the drill going wild over your boiler. IT IS DIFFICULT drilling a clean hole in the side of a polished curved boiler side so take care.

The instructions show the fitting of the pipe and the termination of this pipe on the backhead all in one instruction. This is the clearest way to show the story of the whole pipe. When I built my model however, I put all the pipes onto the boiler first, with the ends of the pipes cut at the cab wall. After all the 'outside' work was done, I then went into the cab and fitted the valves and pipes within the cab, with those pipes cutting off at the cab wall inline with the outside pipes. I do not run the whole pipe direct from backhead to boiler side, but rather install this pipe in two halves...the inside cab half and the outside cab half. This I've found to be the easiest and most effective way of mounting all these curved, and bent bits of pipe onto the loco. Once the cab is fully fitted in place, you will never know the pipe is in fact cut at the cab wall.

OK lets get into it!

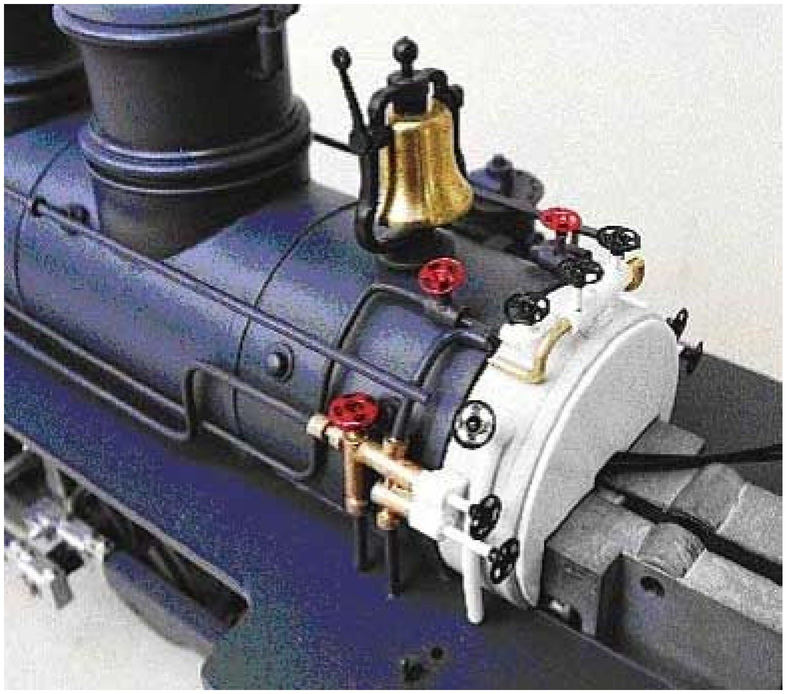
Making the Backhead

The backhead is simply an extension of the boiler pipe inside the cab.

Step 1
Take your old 43mm diameter PVC pipe and cut a neat 10mm length of it. Cut the bottom of it off so this 10mm length of pipe will sit over the Aristo motor block, and line up neatly with the boiler outside the cab.

Step 2
Trace this pipe profile onto some 1mm styrene sheet and cut out the back face of the backhead. I made the back face curvature 1mm smaller than the edge of the pipe. This indicates the boiler lagging thickness on the backhead sides. The back face also has a chunk cut out the bottom to allow it to fit over the Aristo block, and also a small slot above that, to allow for the power cable connection to the tender to pass. Do not glue this backhead in place. You will fit most of the backhead details on this unit, free from the locomotive....Do not glue the backhead assembly to the loco until the end of this chapter.

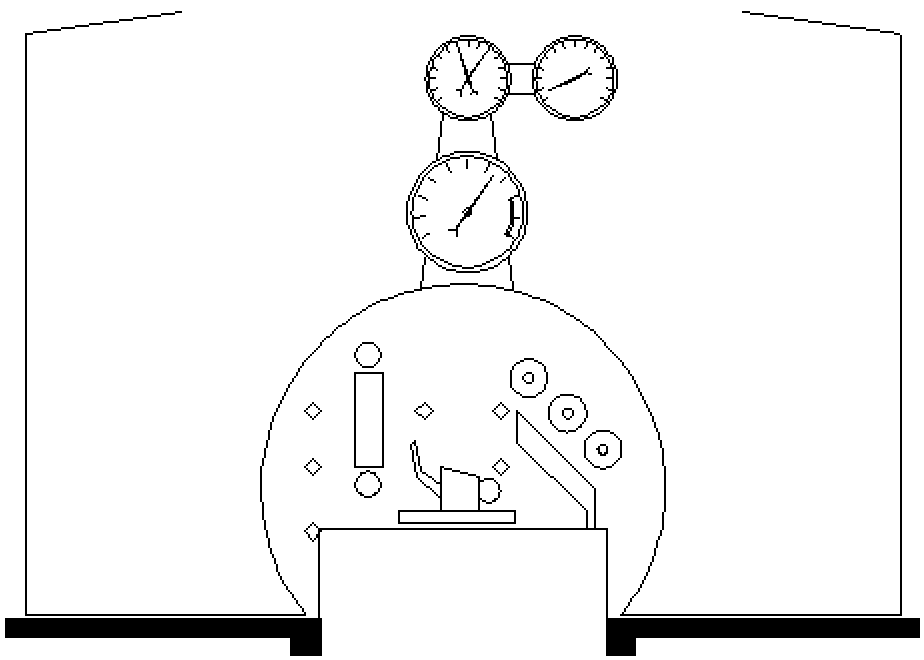
Note the 10mm length of PVC pipe used as the backhead extension. The 1mm styrene back face is cut 1mm shy of the PVC pipe edge, providing the 'step' that occurs with the boiler lagging to the sides. Ignore all the valve handles at this time, that all comes later!



Here you can see the PVC pipe backhead extension shown aligned with the external boiler pipe...this is just sitting loose here!

The Water Glass, Tri-cocks and Basic Backhead Details

Follow the diagram below for the fitting of the Water Glass, Tri-cocks, Oil can shelf and Pressure Gauges.



The Water Glass

Cut a 6mm length of 3x3mm styrene SHS rod (water glass), fix in the vertical alignment as shown above. Cut two 3mm slithers of 2mm styrene rod, and weld into place one above and one below the Glass forming the small valve handles above and below the glass. Paint the glass chrome silver to simulate shiny glass, and paint the valve handles red (modern) or Brass (1870s).

The Tri-cocks

In the same horizontal alignment as the water glass, drill 3, 1mm holes in a 45 deg line and insert 1mm plastruct rods. With the ends of the rods stripped to reveal the wire core, fit 3 press-stud valve handles in place. Take caution to place the three cocks far enough apart so the valve handles don't clash with one another. Fabricate the drain below the tri-cocks using flat 0.5mm styrene sheet. Paint the drain a Brass color, and the valve handles either Brass, red, black or Chrome.

The Backhead Washout Plugs

Using the diagram above cut some 2mm x 2mm squares of 1mm styrene and weld into place, around the tri-cocks and water glass.

The Oil Can and Shelf

Cut a 13mm long, 4mm wide rectangle of 1mm styrene. Weld in place directly above the Aristo block area, weld on edge, forming a shelf. The Oil Can, can be a casting, or some jug like junk from your junk box. I made the oil can on my model using a 5mm length of 4mm styrene tube, with a 2mm styrene rod inserted in the top (as a lid). The spout is a length of 1.0mm plastruct rod bent into shape.

The Pressure Gauges

There are 3 gauges to be installed.

- The Boiler Pressure gauge (needed on all models)
- The Automatic Air, Duplex gauge (needed on all models)
- The Direct Air locomotive Brakes (Needed on most models, where air brakes are assumed fitted on either loco or tender). Not all 1870s version locos will have this Gauge.

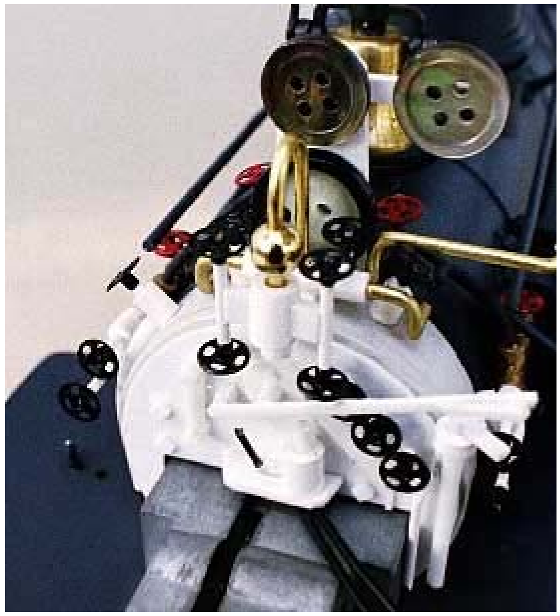
We make the gauges out of Buttons. Find flat like buttons with a raised lip around the edge. Checkout the fabric shops again. The Boiler Pressure gauge is a13mm dia button. Both Brake gauges are 11mm dia buttons.

Cut a 25mm length of 1mm styrene sheet, tapered from 10mm down to 8mm. Fix the 13mm button onto the lower face of the styrene backing, with the Duplex gauge, 11mm button above.

Fix the 3rd 'Direct Air 'Button to the side of the 'Duplex' Button, by gluing it to a 20mm length of 1mm styrene, and fixing the other end behind the Duplex button.

Paint the whole gauges assembly brass, and using 5min epoxy, glue the unit to the very front edge of the backhead, to rest hard up against the cab wall.

Using a fine black pen, draw the pressure gauges onto white paper, follow the above diagram for the 'right' appearance, and also refer the gauges in 'Background' section. Cut out the paper disks and glue onto the buttons using PVA white glue.



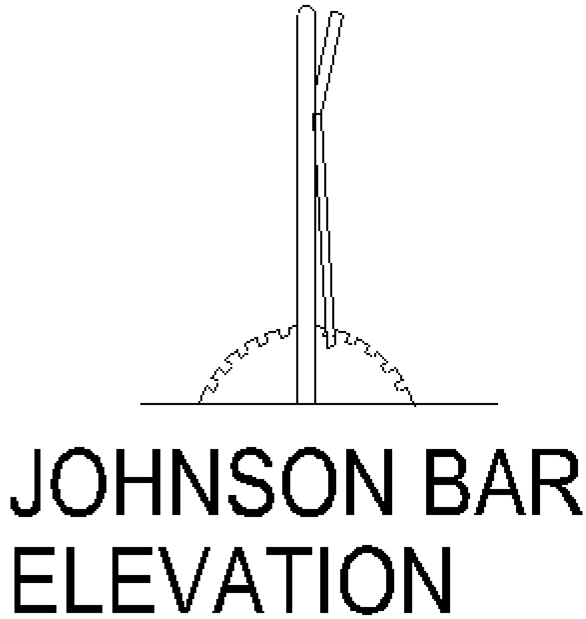
Ignore the many added pipes and valves on this view of the backhead. We'll get to those. Note the Water Glass, Tri-cocks, boiler washout plugs and Button air gauges.

The Painted Pressure gauges with white paper inserts

Johnson Bar and Throttle

The Johnson bar

The Johnson bar is made from 1mm styrene. Cut a 25mm long semicircle of styrene to form the ratchet. Cut in the teeth using either a knife or files. The bar is a 1mm x1mm rod, 30mm tall, with a 1mmx1mm, 7mm long squeeze handle at the top. Use a length of out trusty rivet rod (0.5x0.75mm rod) to make the handle linkage into the ratchet. Weld the unit to the cab floor mid way down the cab floor length (or inline with the cab central window mullion). The Fabrication is as shown here:



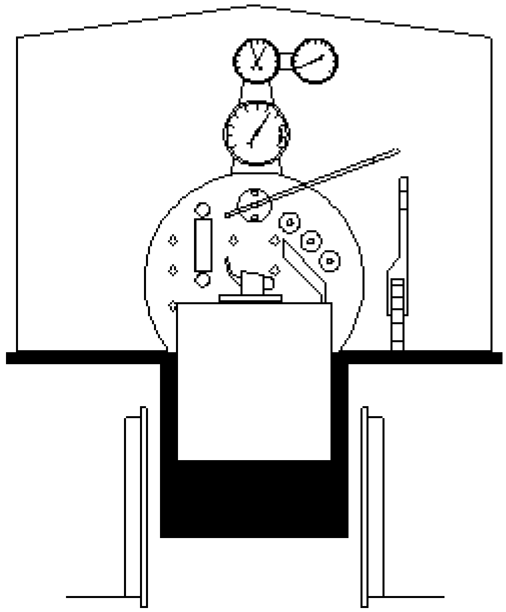
Paint the johnson bar silver. You may like to paint the upper handle part red.

A view of the Johnson Bar in location. There are two brake stands and handles seen beyond.

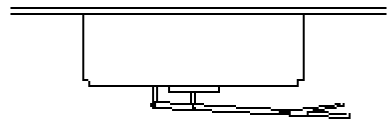
The Throttle

Made in the same manner as the Johnson bar, make a 35mm long lever out of 1mmx1mm styrene rod. Again fit a squeeze handle to the end made from a 7mm long piece of 1x1mm rod.

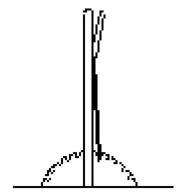
Cut a 6mm round circle of 0.5mm styrene sheet, and weld to the upper central area of the backhead. Weld two rivet heads to the 6mm dia circle, one at the top, one at the bottom. Use the trusty rivet rod, and cut cube rivets as per earlier chapters. Fit Throttle lever rod to the rear face of the back head, on top of two 1mmx1mm stub rods. One welded to the very center of the 6mm dia plate, the other to the very end of the throttle lever. Weld the lever into place, on an incline angle of around 25 deg from horizontal.



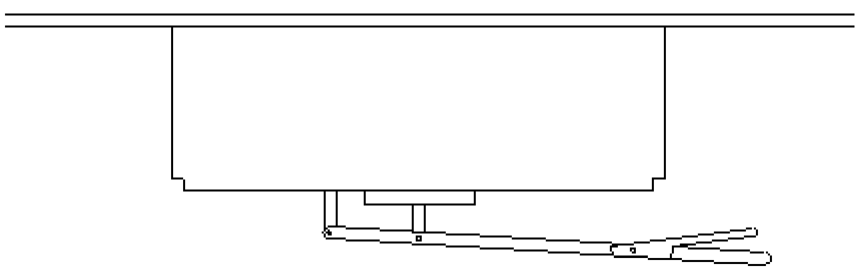
BACKHEAD DETAILS - THROTTLE LEVER



THROTTLE
PLAN -LOOKING DOWN



JOHNSON BAR
ELEVATION



THROTTLE
PLAN -LOOKING DOWN

Note the Pressure Gauges, Water Glass, Oil Can shelf, tri-cocks and drain, Johnson bar and Throttle in this painted backhead view. Again Ignore all the added junk to be discussed later in the chapter.

Onward pipework...

From the inside face and working outward, the closet pipes to the boiler sides are the sand lines.

The Sand Lines

These are made from the 1.5mm brass rod, bent around the boiler from the sand dome base down to the leading edge of the 1st driver. Where the brass rod enters the dome side, form a right-angle bend in the pipe and press the pipe in from the side.

- Drill a 1.5mm hole into the side of the dome base (repeat on other side)
- Bend 1.5mm brass rod from dome though hole drilled in side board in chapter 4
- Bend rod around leading edge of wheel

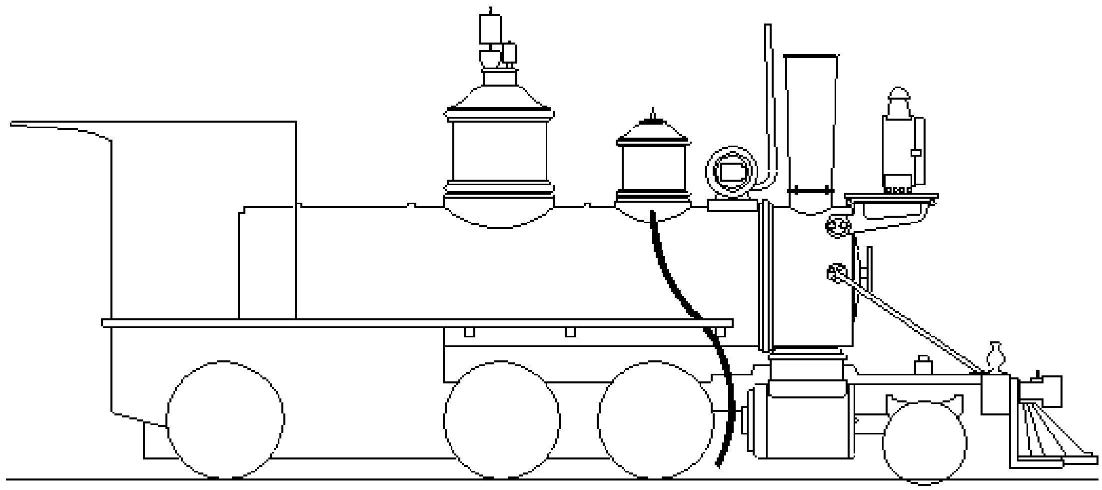
This is a tricky bit of bending to do. The sand lines not only bend forward from the sand dome, and then bend back again in a smooth 'S' shape down to the rail head, but the whole pipe also has to curve around the boiler and then run vertically down to the leading edge of the wheel. Here more than anywhere you must take care not to scratch the boiler sides with the cut ends of the brass rod. Use some easy bendy solder wire to test the sand line form, then copy the solder wire form in brass rod.

For Chris and others fitting two sand domes on their model (a practice consistent with more industrial locos where the loco was likely to run in reverse as often as forwards), your rear dome sand lines will run down and curve around the rear face of the middle driver on this 2-6-0. The 3rd driver is too far under the cab to successfully run a gravity fed sand line.

Painting:

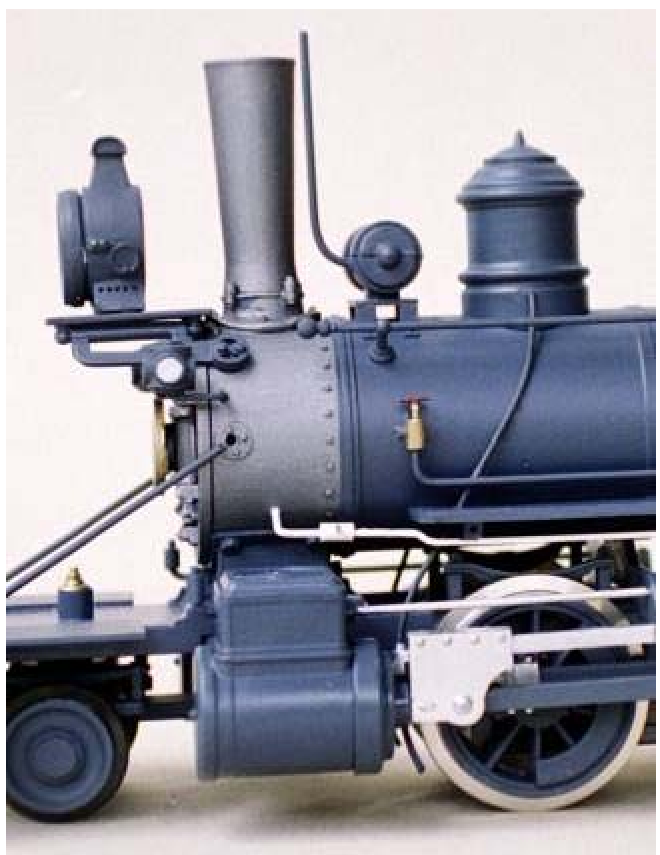
1870s-80s era - Polished Brass
1900- Painted out with boiler (Black)

The sand lines should look like this:



INSTALLATION OF SAND LINES

Note where the sand lines penetrate the side boards. We will have drilled a small hole in this region during chapter 4.



Note the sand lines in this view bending around the boiler and down to the wheels. You can see the 2nd sand line on the other side of the loco though the air gap.

The Feed water lines and Injectors

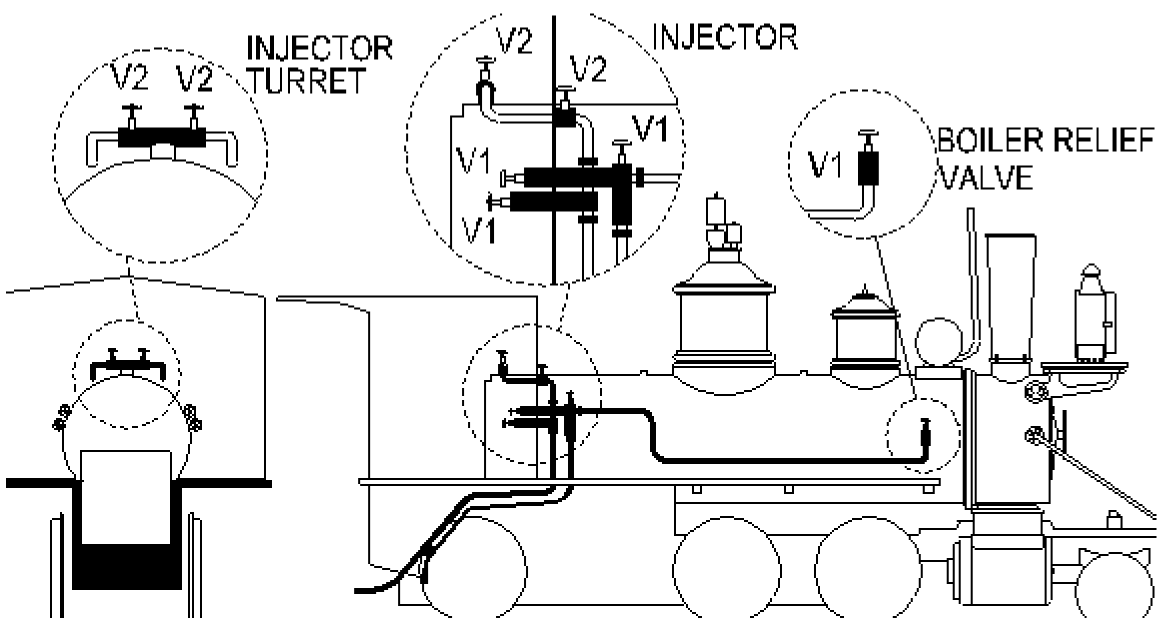
This where it gets exciting!

As indicated in the 'Background' section, the Injectors can be mounted within the cab, or mounted outside on the boiler side. Generally the externally mounted Injectors are post 1900 practice, although there are exceptions.

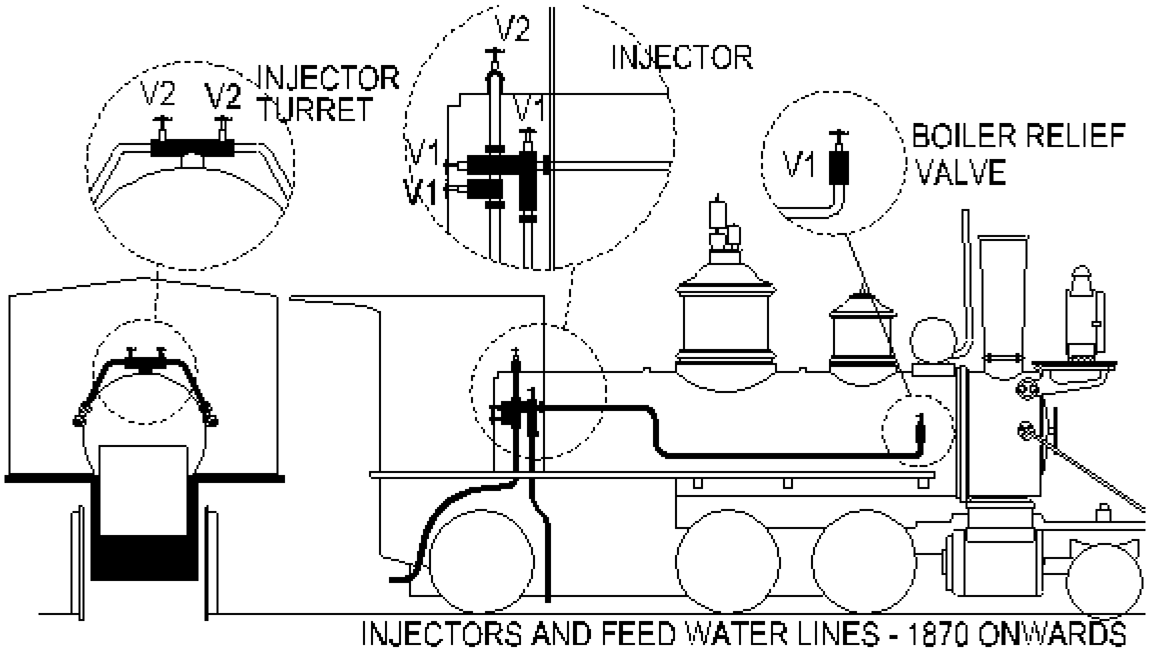
We make the injectors using the 3.2mm plastruct tubing, with brass rod though the inside. Note also the use of 1mm slithers of the 3.2mm tubing simulating flanged pipe joints.
Fabricate the 'Turret' on the top of the backhead using a length of 3.2mm tube with 'L' shaped brass rods running in from each side. Two V2 type valves are fitted above the 3.2mm turret tube.
Remember to drill a 3rd hole in this turret tube, directly between the two V2 valves. Drill the 3rd hole as a 1.5mm hole, in preparation for the steam pipe for the Hydrostatic Lubricator (see end of chapter).

Fabricate and install the feed water pipes and Injectors as shown in the diagram below:
Remember the blacked in areas shown in the detail bubbles represent where the 3.2mm tube is used, the non bolded pipes are the brass or copper 1.5mm rod. Also note where the V1 and V2 valves are used. Either pin or glue the pipework in place with 5min epoxy. Take great care not to slop glue over the boiler sides or paint work. Do not 'slide' the parts into the correct position by greasing the parts and glue along the boiler sides. The boiler relief valve up near the smokebox is to be fitted exactly to the side center line of the boiler.
Painting:

- 1870s-80s - Copper feed water pipes and overflow pipes, brass injector unit and boiler relief valve. (what is seen in these model photos as brass, will be copper, and what you see in white styrene will be brass: clear??!!)
- 1900 - Painted feed water lines, and pipes (Black) with either brass colored injector and relief valve OR everything black.



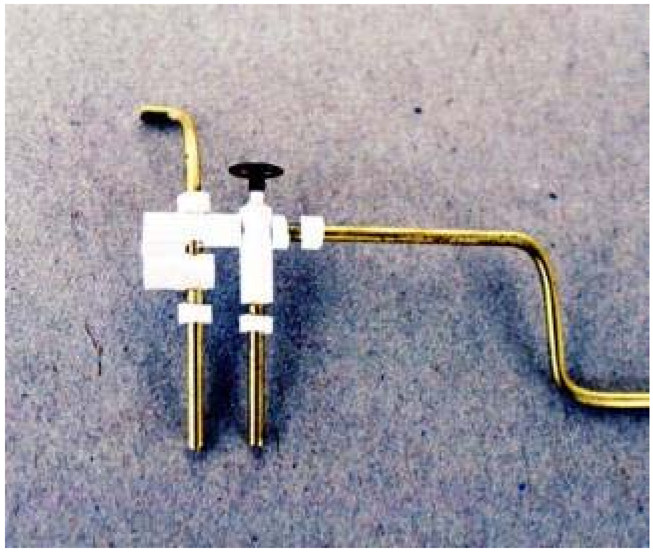
INJECTORS AND FEED WATER LINES - 1880 ONWARD (OPTIONAL)



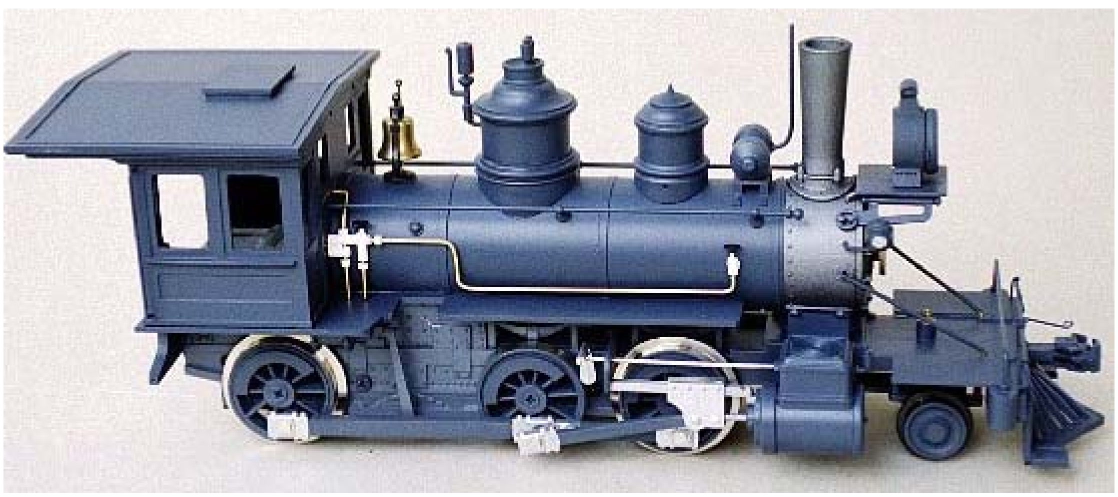
To aid with the fabrication and installation of this complex bit of pipework, I break the pipework at the cab wall, and also break the pipes at the cab floor or sideboards. Thus the feed lines to the injector and overflow pipe (the two vertical pipes running up to the Injector) are cut at the cab floor and continued again below the floor.

Note also the pipework must curve around the boiler, and the pipes below the floor will need to take a dog-leg and be bent outward to a location far enough away from the drive wheels to prevent the side rods banging the pipes.

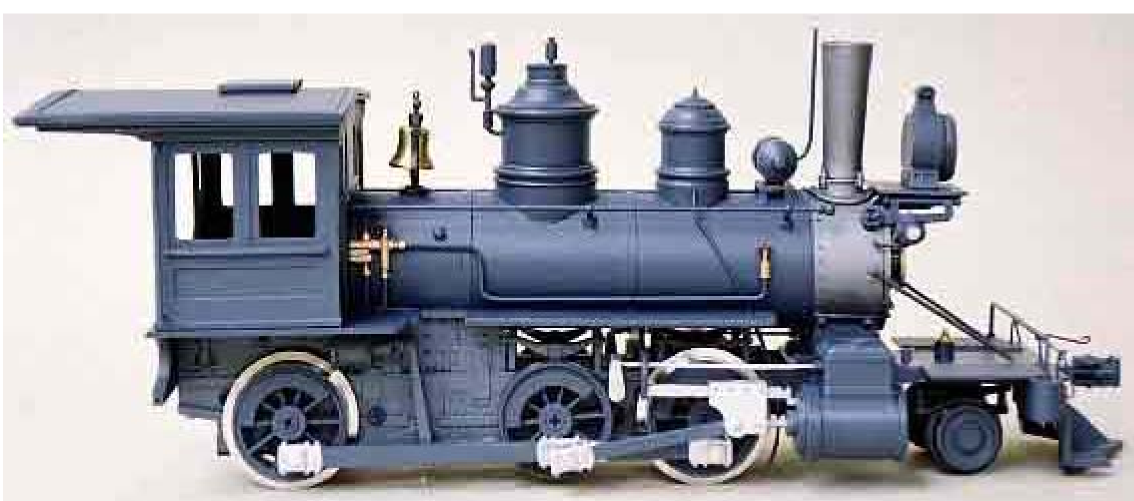
This view shows the full Injector to Boiler Relief valve with pipework between.



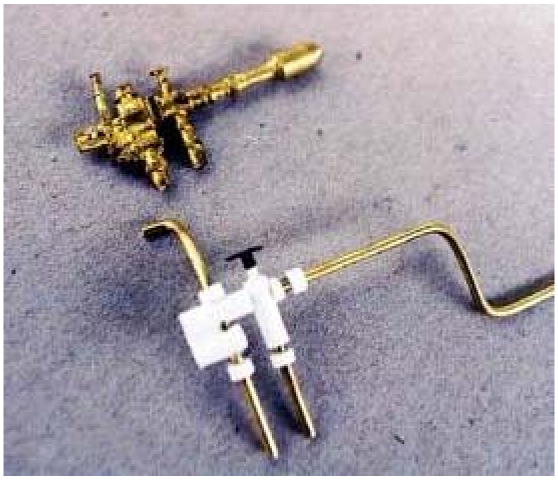
Here is a close-up of the Injector. Note the use of 3.2mm tube slithers to represent flanged joints in the pipework. There is also a 1mm thick slither of styrene between the two styrene tubes to the LHS of the injector. Weld the two tubes together with this packer.



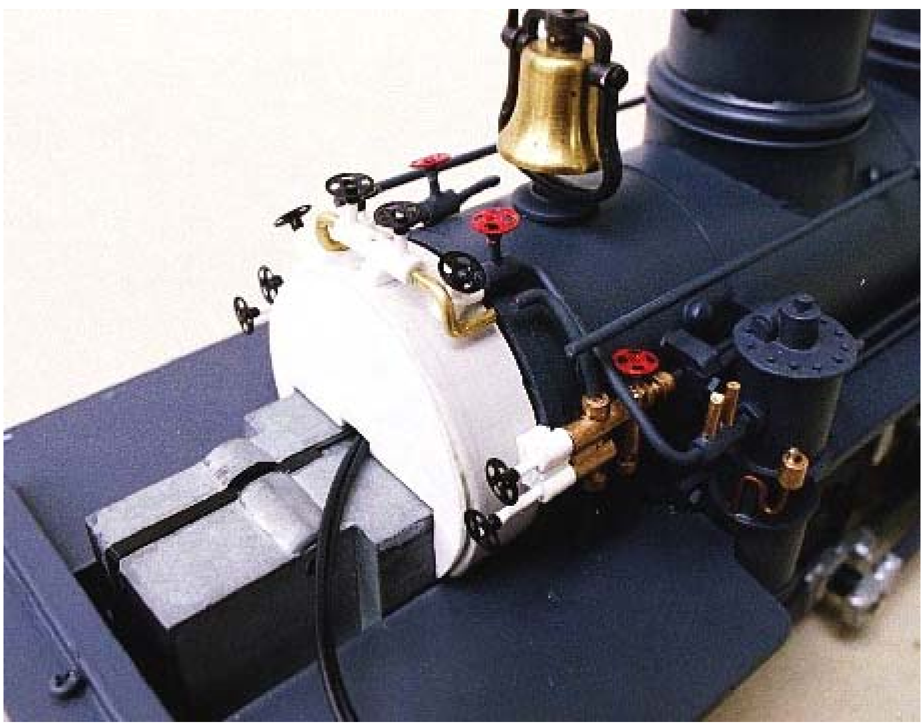
Here is the Injector, Feed water pipe and Boiler Relief valve fitted to the Loco, Repeat this step to both sides of the loco. Painted the injector and feed water pipe looks like this:



There are commercially available Edna Lifting Injector parts. I listed one such part in chapter 1. These are much better formed than our home made injector, but are harder to fit onto the loco. Here's a comparisons between the commercial and home made Injector.

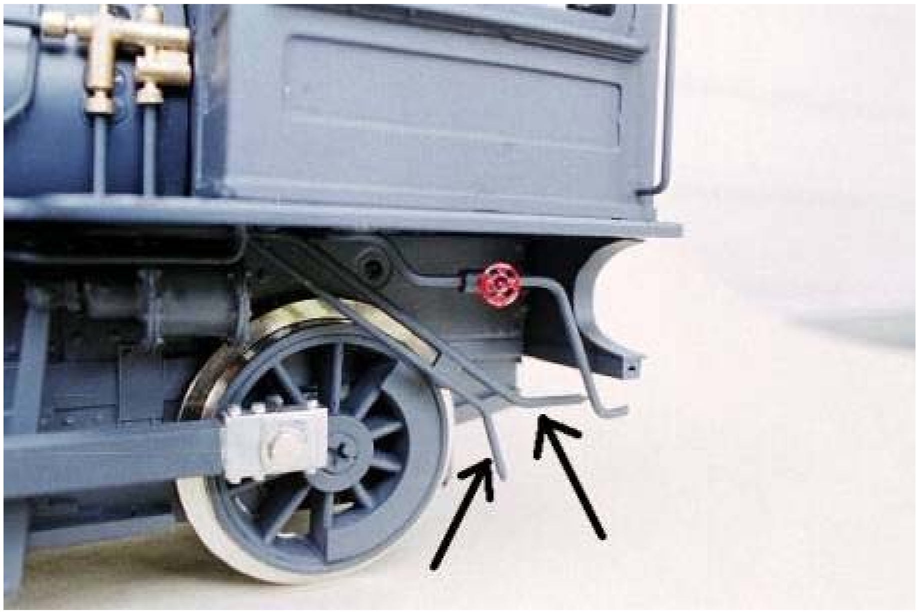


Inside the cab we finish off the Injectors with some 3.2mm tube extensions, and mount V1 type valves to the end. These represent the steam and water valves to the injector. Hidden between these two valves is a tiny brass lever which controls the overflow pipe. Note the two V1 valves are shown as circular handles. These valve handles were often simply lever bars or star type handles.

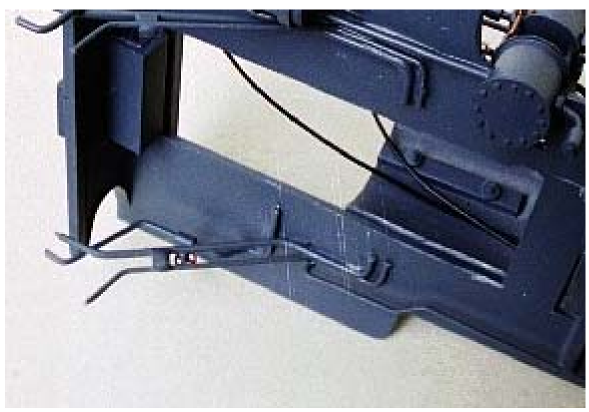


Note the Injector extensions on the side of the backhead, with V1 type valves on the end. Also note the turret on top of the backhead. Try to separate the Compressor Pipework in this view to get a clearer view of the Injector features. The rear extensions of the injectors are packed out on the side of the backhead in order to align with the brass injector on the side of the loco...this also helps to lift the injector V1 valves away from the backhead side.

The feed water pipes to the injectors, (connection from the tender) and the overflow pipes are made from 1.5mm brass or copper rod and mounted separately, under the cab floor. The pipes run clear of the drive wheel rods, and at the cab floor run flat under the floor back to the base of the pipe inlet points below the injector. Glue these pipes to the underside of the floor with 5min araldite. Use a 3x3mm styrene packer as a 'divider' to hold the two pipes together toward the rear end of the pipe run. Check the photos:



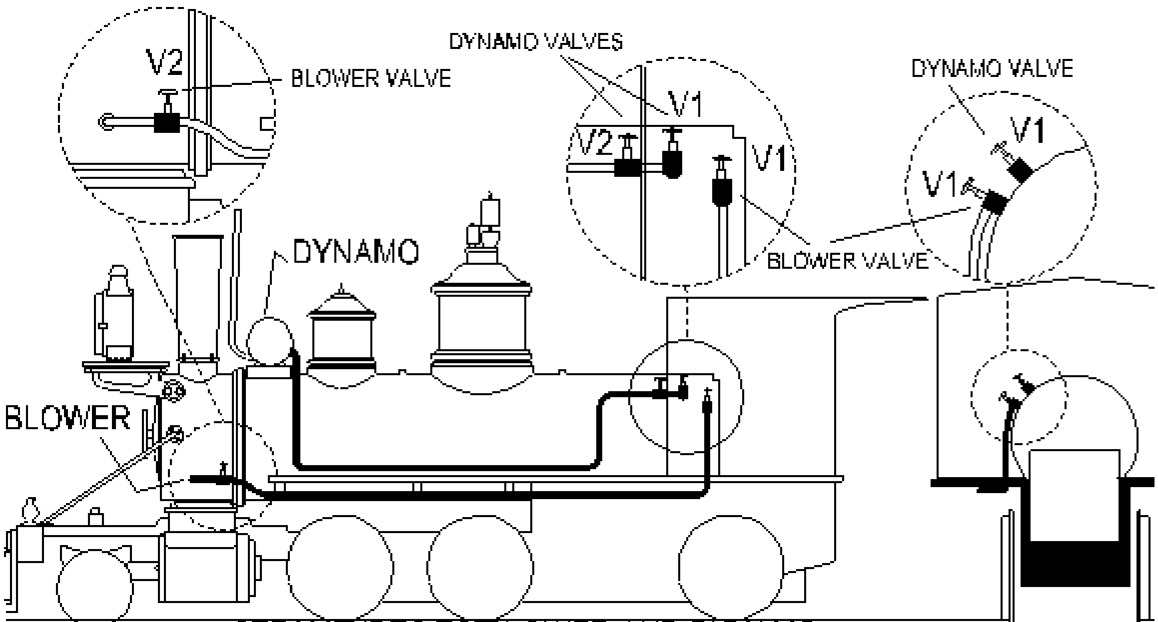
The Feedwater pipe and overflow pipes fitted below the cab floor, running back to the injector intake points, just in front of the cab.



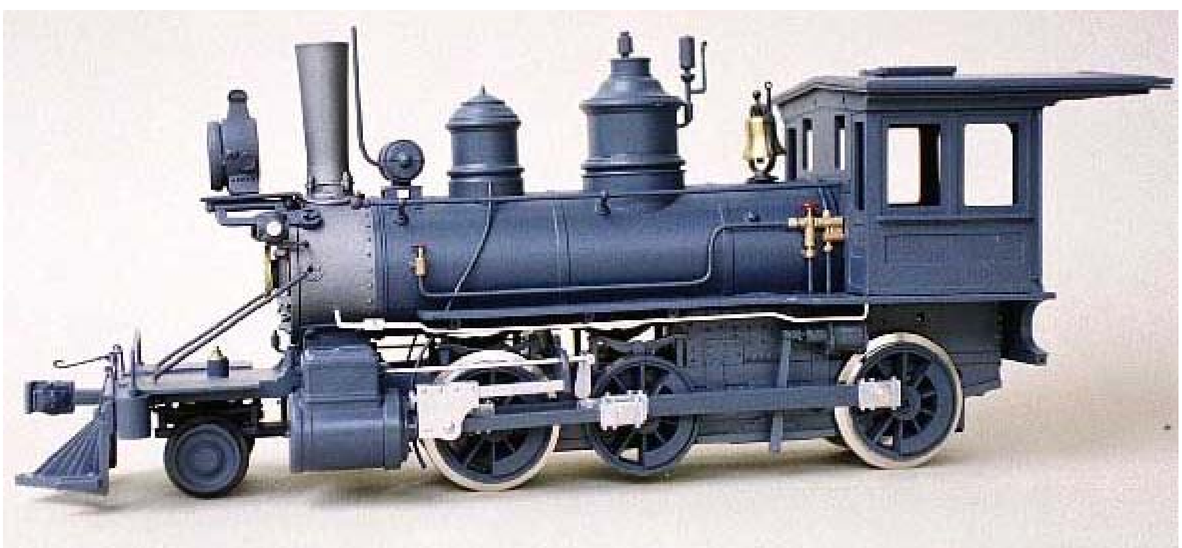
The above view shows the underside of the cab floor and sideboards. Note the feedwater and overflow pipes mounted to the floor, with pipes running flat against the underside of the floor back to the Injectors.

The Blower Pipe and Dynamo Steam Pipe

Install the blower and dynamo pipe as follows:
Note some optional use of V2 isolation valves in these pipes.

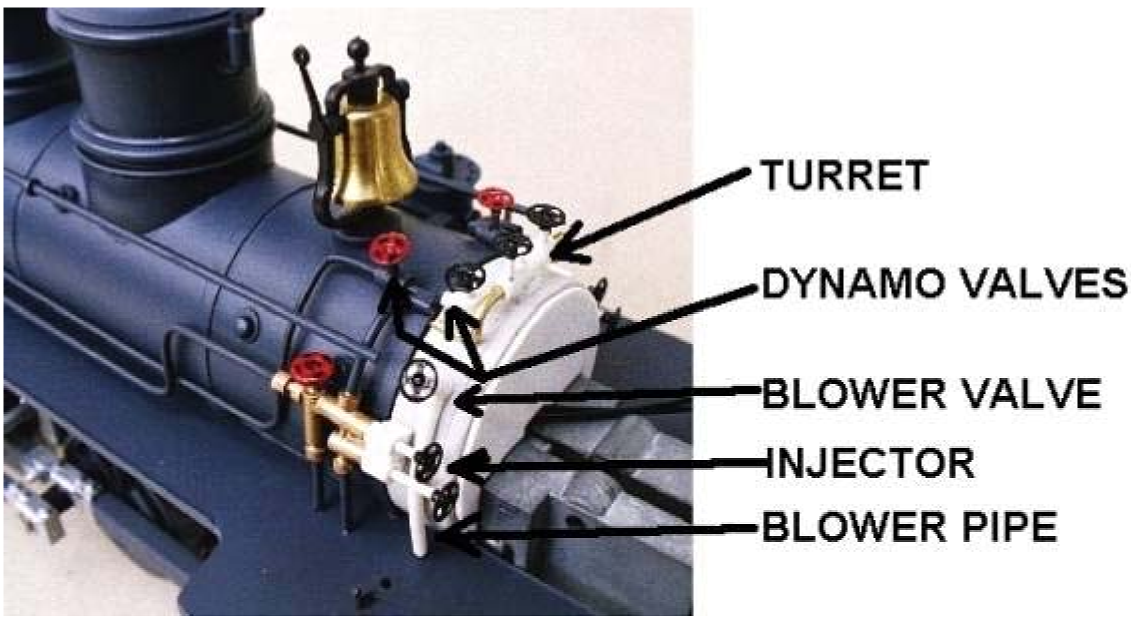


These pipes are only fitted to the Fireman's side of the loco. Note also how we use the Side Board braces as 'hanger's for the support of the blower pipe. Under the cab floor the blower pipe steps outwards to align with the outer edge of the sideboards.



Note the blower pipe slung under the sideboards running from the cab to the smokebox. A V2 type valve is in the making next to the smokebox. Also note the Injector, feed water pipe and sand lines all shown in this view.

Note the Blower pipe with V2 isolation valve near the smokebox, and the fitted dynamo steam pipe with V2 isolation valve next to the cab wall.



The above view illustrates the full injector, blower pipe and valve running up the side of the backhead, and the dynamo pipe running onto the backhead above the injector...with a V1 valve inside the cab and a V2 valve directly outside (painted red).

The Westinghouse Air Brake System - Modelled at last!

Making the Air Compressor

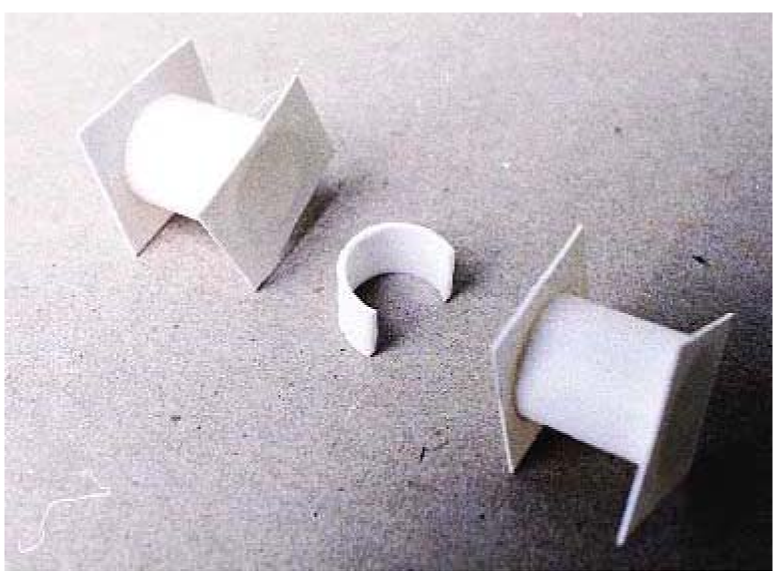
Those of you who have purchased a commercial casting or detail part compressor, will not need to make their own, just add all the necessary pipe work and details covered later in this chapter.

We will now describe how to make your own stylish air compressor out of styrene.

Step 1

Cut two 14mm lengths of Evergreen 12mm dia styrene tube
Cut an 8mm length of the same 12mm dia tube.
Slice the 8mm length vertically such that just under half is removed
Weld rough top and bottom plates onto both ends of the 14mm tubes.

Your parts should look like this:



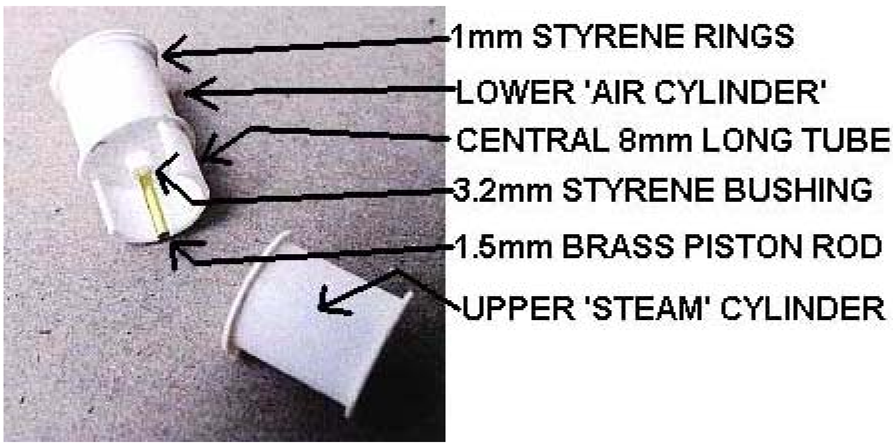
Two capped 14mm long tubes, and a 8mm long tube with side cut off.

Step 2

Using your scissors, carefully trim around the end plates of the 14mm long tubes, cut 0.5mm clear from the tube edges such that a 0.5mm lip is left. Choose which of the two 14mm tubes will be the lower (air cylinder) of the compressor Slice another two 1mm slithers of 12mm styrene tube from your stock. Split these two 1mm rings at one side. Stretch the two rings to slide over your bottom 14mm long tube. Weld the rings into place directly against the top and bottom plate of the tube.

Weld the 8mm long tube onto the top of one of the 14mm long tubes. Drill a 1.5mm hole in the center of the 14mm tube top plate, and a 2nd hole in the bottom plate of the other 14mm tube. Insert a 25mm length of brass rod into one of the tube plates (compressor piston), and apply a 1mm slither of 3.2mm rod over the brass rod to form a base or 'flange' to the compressor piston.

Your Compressor should look like this:



Next weld the top 'steam' cylinder into place, pressing the brass piston rod though the 1.5mm hole in the bottom plate.

I should point out that the lower 'air cylinder' was often formed with an air cooled series of horizontal rills. While the upper steam cylinder was smooth. It was also common practice to have smooth sides to both the top and bottom cylinders. If you want the grilled air cooled look to your lower cylinder, then just slice another 6 or so 1mm rings of 12mm tube. Split them and stretch them over the air cylinder in a uniform set out, forming the grilled look.

Step 3

Choose the rear side of your compressor, this will be the location where the compressor gets mounted to the boiler. This will be the side where the joints in your rings around the lower cylinder occur from step 2.

Now cut a 5mm length of 4.5mm styrene rod and weld vertically into place on the top centre of the steam cylinder. Cut a 6mm long length of 4.5mm styrene rod, cap the ends with 0.5mm styrene patchs and weld the thing flat against the rear side of the vertical 4.5mm tube (what would be parallel with the boiler). Insert a 6mm length of 2mm rod into the top of the 4.5mm vertical tube.

Next get hold of your trusty rivet stick, the 0.5mmx0.75mm styrene strips, and get cutting rivet cubes again. Weld one rivet around the top perimeter of the steam cylinder, at each 'hour' position around a clock face....that is - weld one rivet at 12 o'clock, one at 6, then weld one at 3 and 9 o'clock, then at 1&2, 4&5, 7&8, and 10&11. You will have 12 neatly arranged rivets around the top plate of the steam cylinder. Repeat the rivets procedure around the bottom plate of the air cylinder. Your air compressor should look like this:

Note the rivets around the top and the two 4.5mm styrene tubes at the top.

Step 4 - Adding the Air Cylinder Lubricator Cup and Lube Line.

This is a coooool detail I love putting onto model locos, and is a detail almost totally ignored my most model manufacturers. You wont even find 'em on the expensive brass models!! But believe it or not, there is not one real life compressor anywhere that is without an oil cup somewhere.

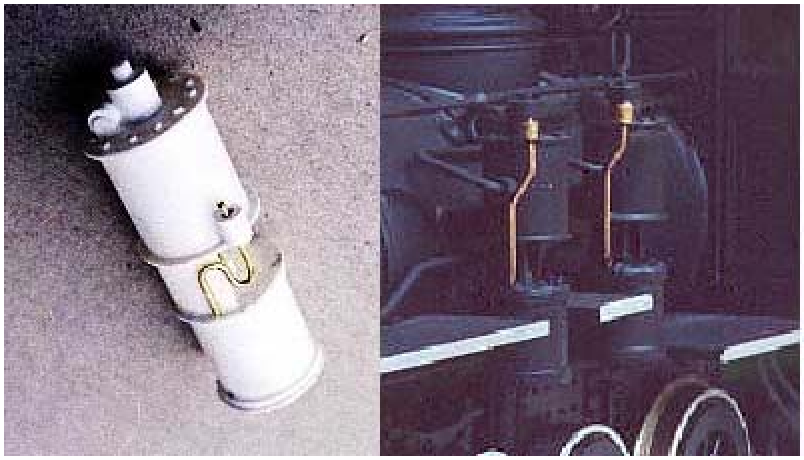
Based on the info in the 'background' section, all air compressors have a lubrication cup clamped to the side of the air compressor used to lubricate the lower 'air' cylinder. This cup can be fixed either to the bottom rim of the steam cylinder or at the top rim. You can go either way, as its done equally both ways. Check some of the photos in 'Background'.

Note if you're modeling an early version 1870s loco and you've got oil cups to the main locomotive steam chests, above the cylinders, then your loco will not have a 'Hydrostatic' lubricator in the cab...if this is the case you will need to mount two oil cups to your air compressor: one to lube the lower cylinder, and one to lube the upper cylinder. This upper oil cup is mounted directly next to the vertical 4.5mm tube on the top of the steam cylinder.

If you will have lube lines into those steam chests on the main locomotive cylinders, then you'll have the said Hydrostatic lubricators fitted in the cab...thus your upper steam cylinder of the compressor will also be hooked up to a lubricator and NO oil cup is needed to the upper cylinder. You WILL still need a cup to lube the lower 'air' cylinder.

We make the oil cup out of 3.2mm plastruct tube, welded directly to the side of the compressor. Run a fine brass wire from within the oil cup down to the top edge of the lower 'air cylinder'. This is your lube line to the air cylinder. There are usually bends in the lube line, sometimes even an 'S' bend.

Check the photos here for two ways to mount the oil cup and lube line:



Note the two locations for the oil cup and lube lines to these different versions of the air compressor. The unit to the left has the oil cup mounted to the bottom of the steam cylinder, with a short lube line down to the air cylinder. The units in right picture have the oil cups mounted at the top of the steam cylinder with long lube lines running down to the lower air cylinder. An additional brass oil cup would be seen next to the top 4.5mm tube atop the compressor if no Hydrostatic lubricator is to be fitted in the cab. No visible lube line is needed for this additional cup, as it drained directly into the top of the steam cylinder.

Step 5 - The Mounting Bracket

This is a detail almost exclusively ignored by most large scale loco manufacturers. The down side of this lack of detail, is that inevitably the compressor is mounted too close to the boiler side, and with it, a loss of apparent 'bulk' in the compressor. The bracket is a series of metal straps that hold the compressor to the boiler. The bracket is big, thick and chunky. It has to withstand the constant pounding of the compressor in operation. Our model will have a bracket, and with it, the compressor will sit well proud of the boiler side.

Cut a strip of 3mm wide, 1mm thick styrene. Our bracket is made only from this strip. Fabricate a rectangle of strips, 17mm wide by 22mm tall, overlap the corners. Cut some 2mmx2mm squares of 1mm styrene and weld onto the corners forming large bolts. Sit this frame on the sideboard across the compressor 'hole' we cut in our sideboards back in chapter 4. Rest the frame back against the boiler and injector feed water pipe. Measure the distance from the top of the frame back to the boiler side horizontally. Cut an additional couple of strips to fill this gap. Do not as yet glue the frame to the boiler!

Your frame should look something like this:

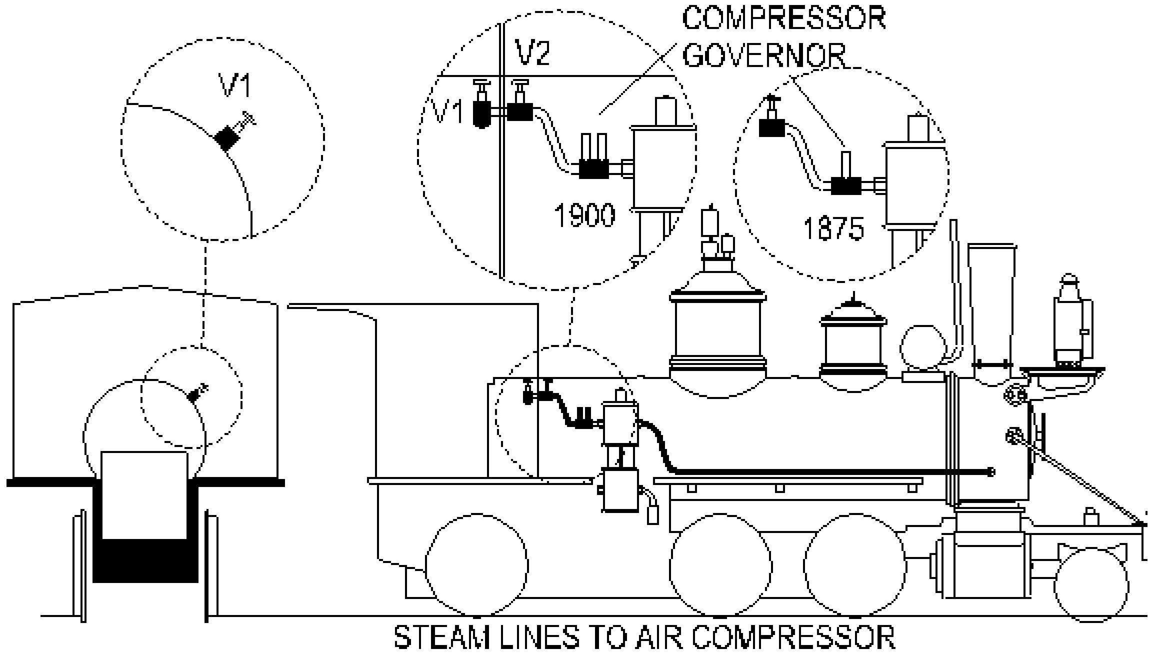
Note I've also added a further 3mm strip flat along the bottom of the frame as a base to sit flat on the side board. The top two strips are chamfered at the front edge simulating bent metal. The rear edge of these will rest against the boiler.

Step 6 - The Steam Pipes to the Compressor

Drill four 1.5mm holes in the middle sides of the two compressor cylinders....these holes are directly 90 deg from the rear and front line of the compressor. The steam and air pipes will be connected to these points.

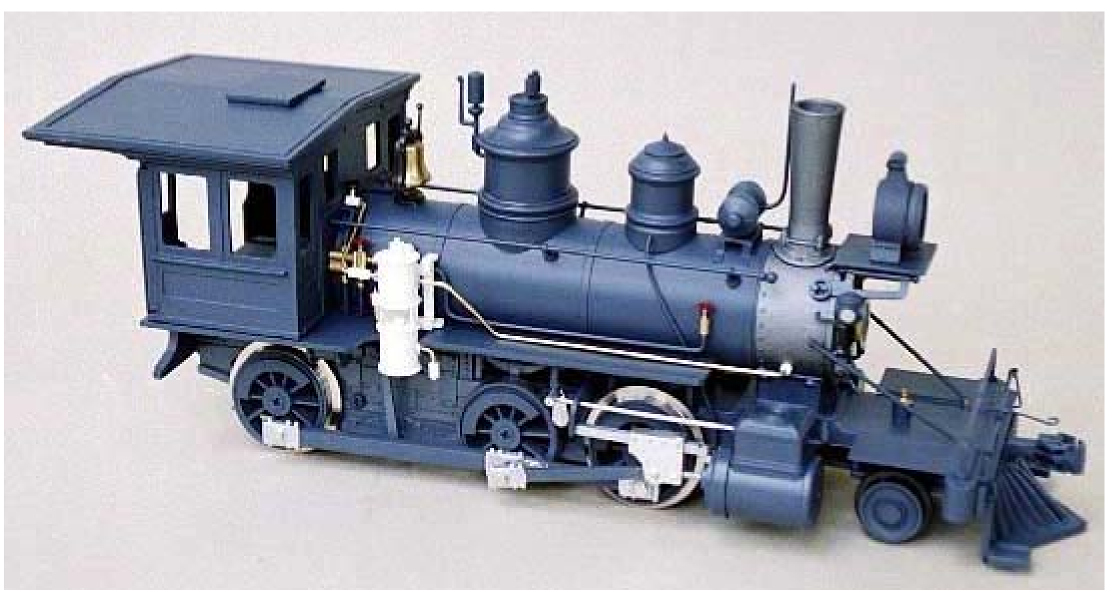
Weld the air compressor to the bracket - rest the bracket on the sideboards, and set the location of the compressor vertically such that the holes in the sides of the lower cylinder are just below the side boards...your air lines will enter and leave the compressor below the side boards.

Next follow the diagram below and fit the steam lines to and from the air compressor. Where ever the pipes enter the steam cylinder in the side holes, insert a small nut (as in nut and bolt nut), to simulate the threading of the steam pipes to the compressor. The steam pipes are brass 1.5mm rod (post 1900) or copper 1.5mm tube (1870s-80s). The steam exhaust pipe runs along the rear back edge of the side board to the smokebox center line. Drill a 1.5mm hole in the smoke box at this point and run the rod through a 90 deg bend into the smokebox side. Insert either a 'nut' or a 1mm slither of 3.2mm styrene tube over the brass rod at the interface with the smokebox (hides the hole also!)



Insert the V1 and V2 valves into the brass 1.5 rod as shown above. On the steam inlet pipe to the compressor (to the left of the compressor), insert a 'compressor governor' - a 6mm long length of 3.2mm tube with two (or one -1870s) 1.5mm brass rods into the top (governor ears)...this governor is made in a similar way to a V2 valve, only without a valve handle. Also square off the tops of the brass governor 'ears'.

You can test the compressor, and pipe work attachment to the loco without gluing any of it at this time. You assembly of steam pipes and compressor should look like this:



Note the metal nuts used at the point where the steam pipes enter the compressor.

Note the 'twin ear' compressor governor on the steam inlet pipe to the compressor.

Here's a close up:

Step 7 - Painting & Installation

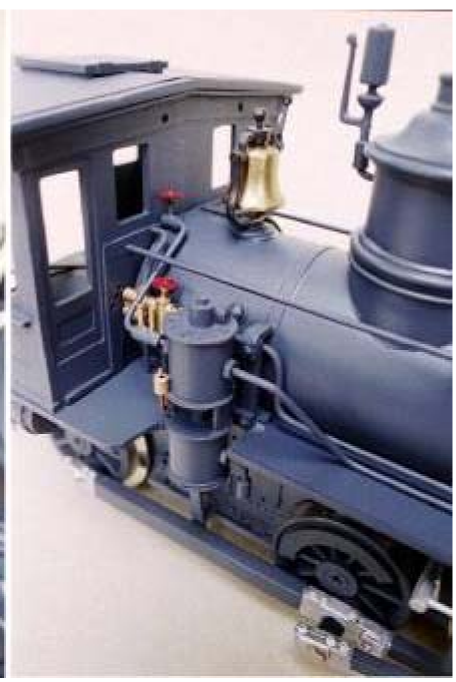
- 1870s-80s, black compressor with Russia Iron cylinder side jackets, (both air and steam cylinders) If your compressor as the air cooled grill on the lower cylinder, then only the upper steam cylinder has Russia Iron jacket, while the lower grilled cylinder is black. Copper pipes to in and out of compressor.
- 1900- All black compressor and pipework. Compressor governor is black with brass bunny ears, to all versions. Brass oil cups and copper lube lines.

Ok here's where you have to be careful. Make sure your pipework is not pushing the compressor around, or lifting it off the boiler side, the compressor must rest easy on the loco side with pipework attached.

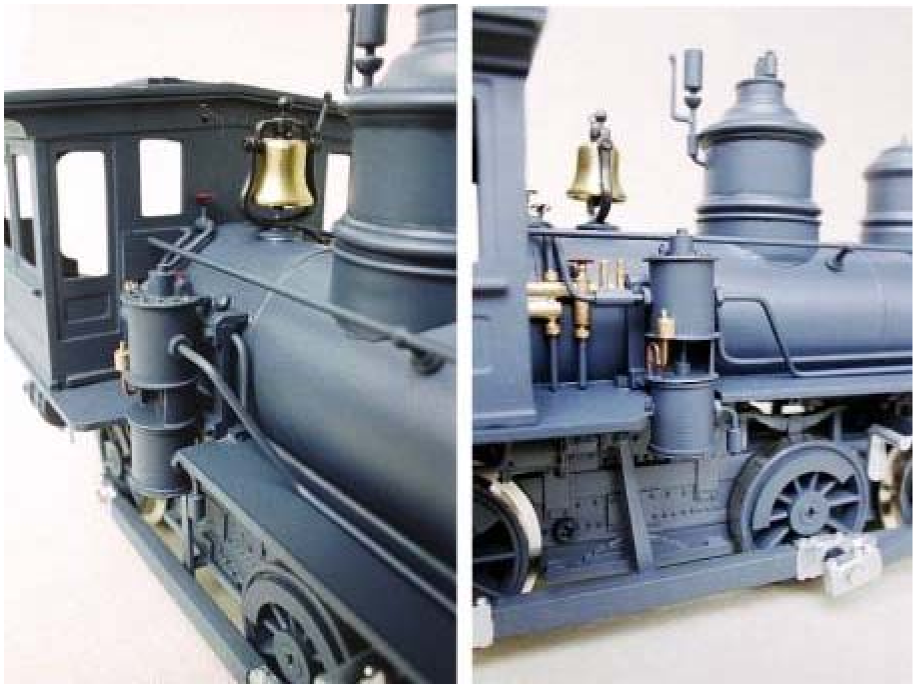
Using 5 min araldite glue the compressor to the boiler side by applying a dob on the bottom edge and on the top two ends of the bracket. Place the compressor and pipework into place. Apply a drop of araldite at the smokebox insert point.

OK your loco with compressor, governor, and isolation valves should look like this:

Note the steam pipe running from the compressor to the smokebox. There is a slither of 3.2mm styrene tube over the pipe at the smokebox entry.



Note how the steam inlet pipe runs from a location near the top of the boiler at the cab wall, with an isolation valve at the wall.

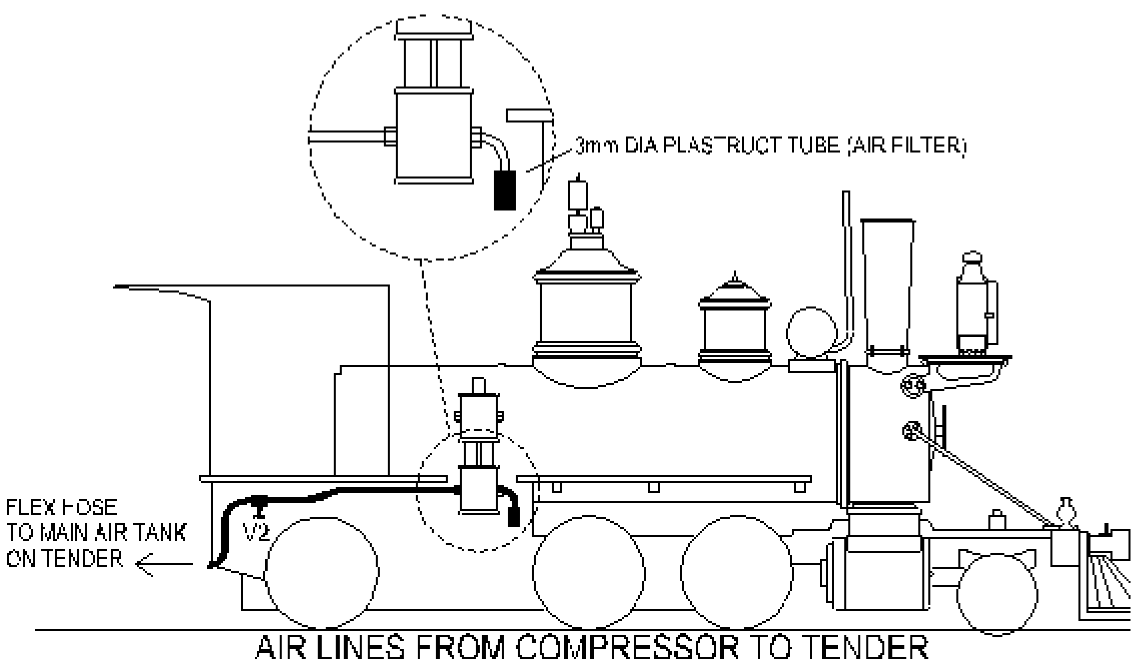


Note the compressor bracket, oil cup and lube line, and compressor governor.

Step 8 - The Compressor Air Pipes

Now we connect air pipes to the two holes in the lower compressor cylinder, under the sideboards. Use the 1.5mm brass rod again, or 1.5mm copper tube (1870s-80s) for the air lines. Again where the pipes enter and leave the compressor, use a small 'nut' to simulate the threaded connection of the pipes to the compressor.

Follow the diagram for pipe installation:

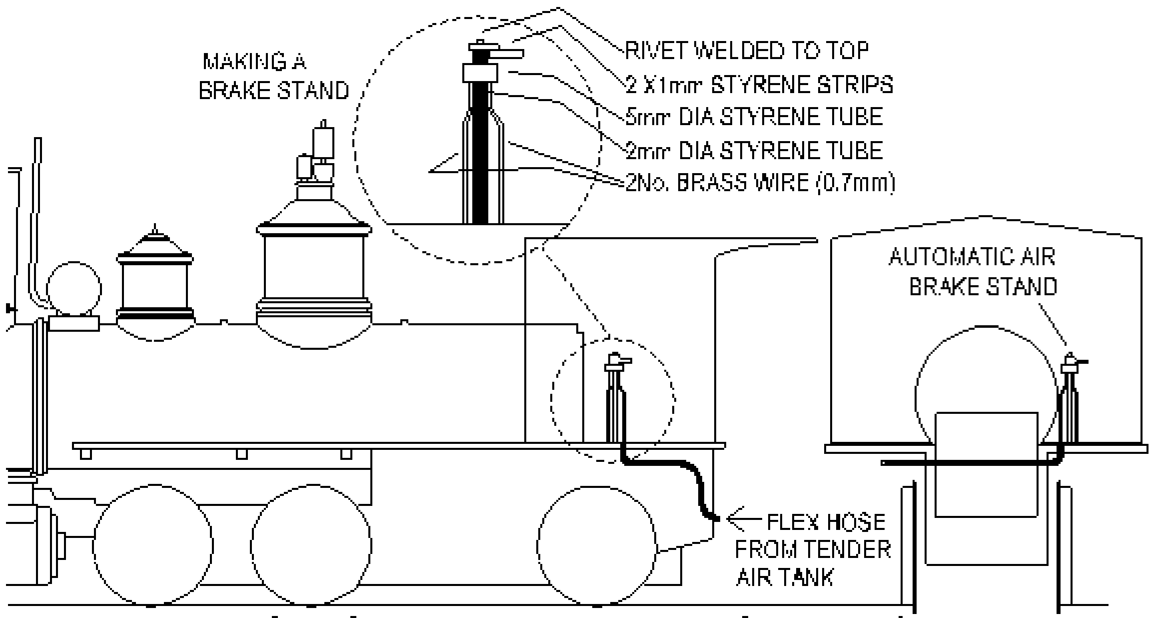


The air filter to the lower right of the compressor is where the air is drawn into the compressor. It is simply a 3.2mm styrene tube mounted on a 'L' shaped length of brass or copper rod. Look at the photos in the previous step for a view of the finished air filter.

The outlet pipe to the left of the compressor runs straight out to the rear of the loco, for connection to the tender air tank. Make this pipe out of brass or copper 1.5mm tube. There is also an isolation valve near the end (optional).

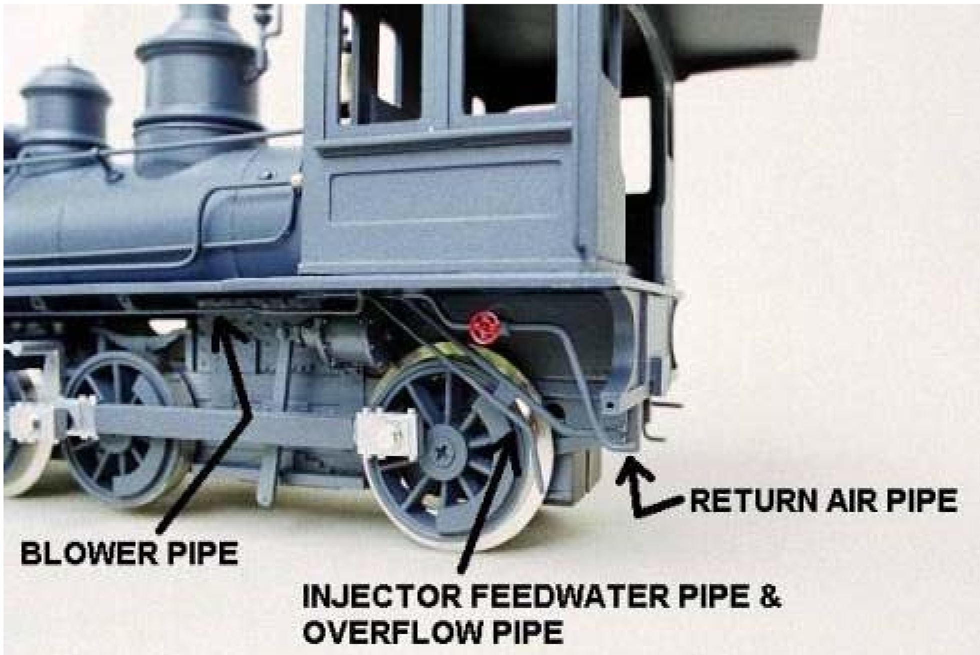
Step 9 - The Return air Pipes from the Tender Air Tank

These are the air pipes returning from the air tank on the rear of the tender. They run back to the locomotive cab and to the brake stand for the engineer to control the braking of the train.
These return air pipes are again brass 1.5mm rod or 1.5mm copper (1870s-80s). Follow the diagram here:



AIR LINES FROM TENDER AIR TANK TO BRAKE STAND

It is not necessary to actually run the return air pipe under the cab floor to the brake stand, just butt the pipe into the fireman's side chassis where the cab floor meets the chassis. Install the brake stand as a separate item directly to the cab floor. You can install an isolation valve in the line if you wish as shown in these photos:



Step -10 - The Brake Stands

There are two brake stands to be made. One for Automatic air (all locos) and one for Direct Air, locomotive Brakes (only locos with loco or tender brakes).

The brake stands are both made in the following way: (refer diagram above also)

- Cut a 35mm length (approx) of 2mm styrene rod. (25mm length for the 2nd brake stand)
- Cut a 2mm slither of 5mm plastruct tube
- Insert the 5mm tube over the 2mm rod and weld into place with a 2mm length of the 2mm rod exposed at the top.
- Cut two 4mm lengths of 1mmx2mm styrene and weld one on top of the other to form the brake handle...Weld the handle to the top of the 2mm rod, above the 5mm tube. Weld a rivet cube to the very top of the assembly. You now have a brake stand with handle.
- Next we need to fit air lines to and from the brake stand. We use two lengths of 1.0mm plastruct rod, bent to fit hard up against the upper end of the 2mm stand. Trim the bottom at floor level. We'll pretend to extend these air pipes below the cab floor later in the chapter.

The two brake stands with brass handles.

Painting - The brake stands are black, with brass handles atop. The air lines to and from the handles are copper.

If you're only making the one brake stand, weld it flat to the engineer's side of the backhead, next to the tri-cocks. No need to attach it to the cab floor.

If making the two brake stands, weld the shorter one to the backhead, and then fix the other to the cab floor, right next to the Aristo block side, and to the left of the Johnson bar.

Note the Fitment of the Johnson bar, Throttle and brake stands on this view of the backhead.

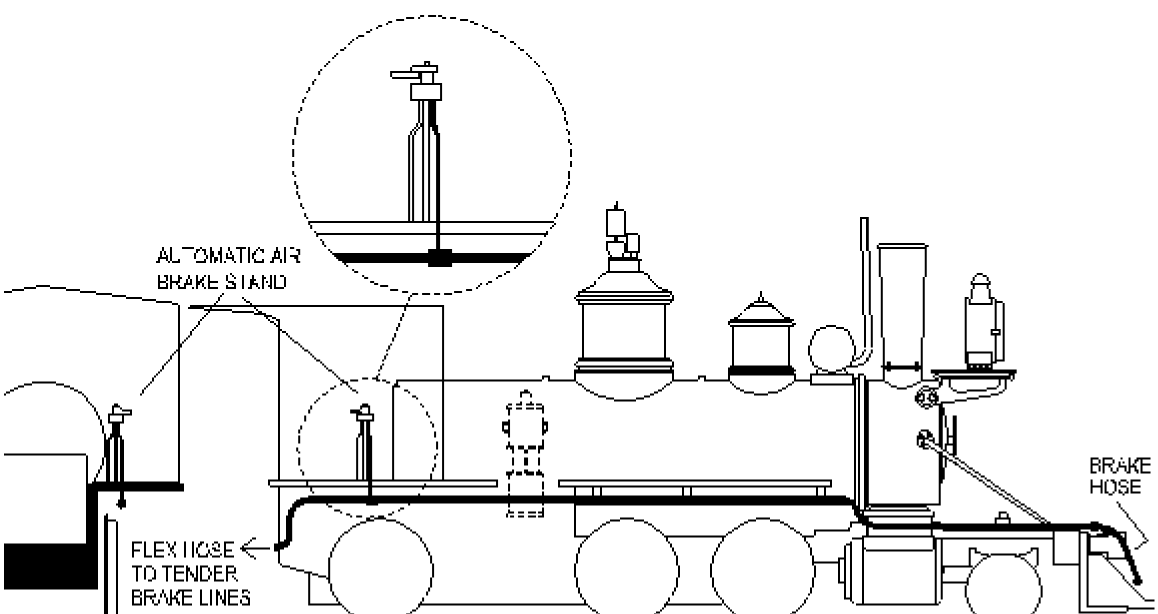
Note the Two brake stands, one fitted hard against the backhead, the other next to the Johnson bar, just back from the 1st brake stand.

Step 11 - The Main Train Brake Air Lines and Hoses

This is the air line that run out of the automatic air brake stand and out to the train. Running both forward to the pilot deck, and rearward to the tender draw beam.

The air lines from the Direct Air brake stand to the locomotive's brake cylinders are concealed and cannot be modeled.

For the automatic air lines, follow this diagram:



AIR LINES FROM BRAKE HANDLE TO TRAIN BRAKE HOSES

Where the 'T' intersection occurs below the brake stand in the cab, we don't actually have to model. Merely run the whole air line from pilot to rear of cab and run part of the pipe hard up against the underside of the cab floor...here it will meet with the brake stand copper air pipe!

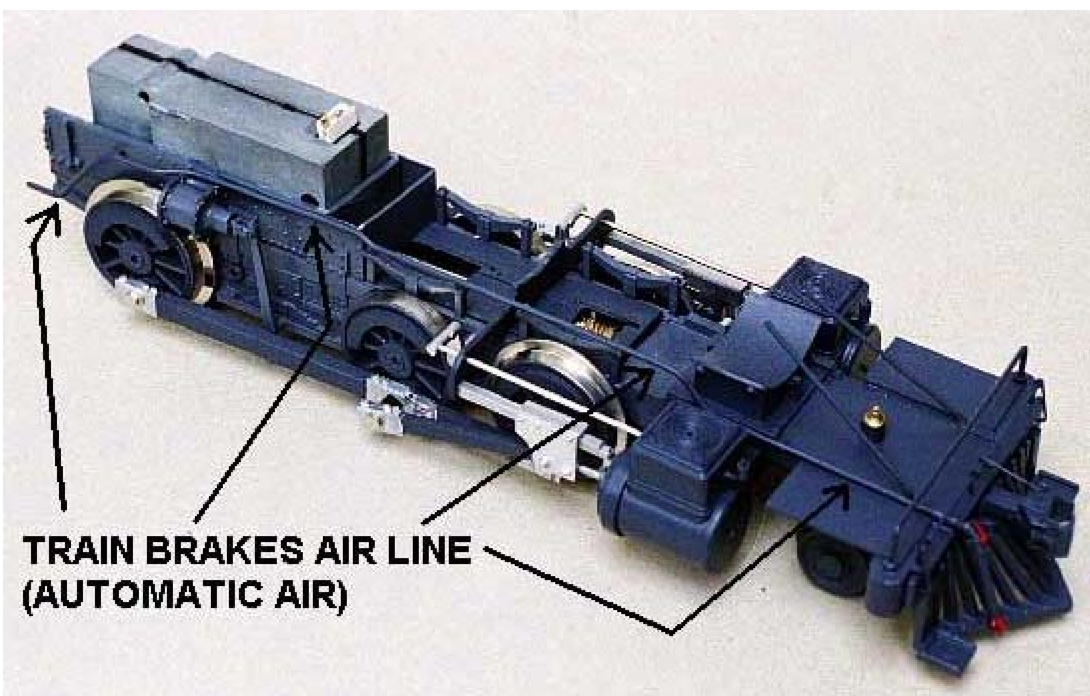
Like the Blower pipe, we can use the sideboard support rods as 'hanger's, appearing to support the pipeline. However in this case, the air line will be fixed to the chassis, and not the superstructure. Fix the pipe back against the chassis side wall, using dobs of araldite in two places:

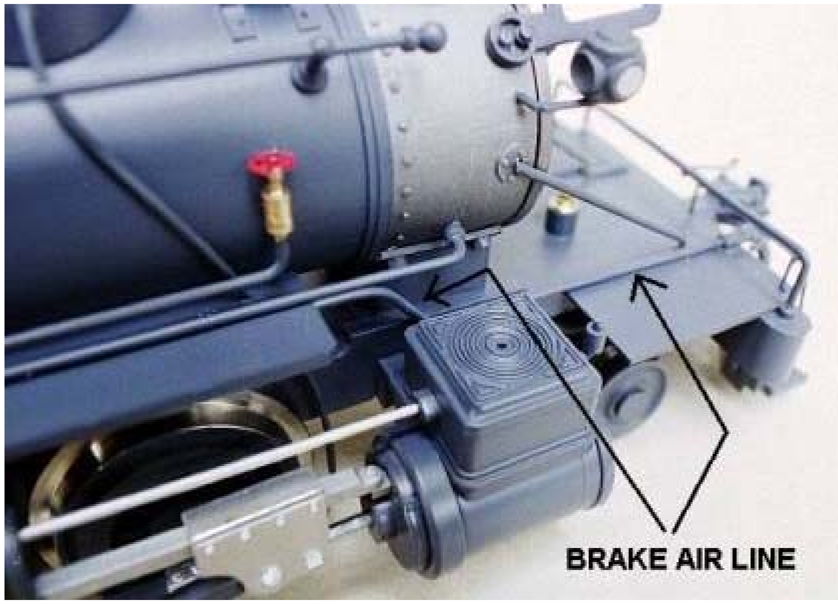
1. At the area above the 3rd driving wheel
2. On the pilot deck.

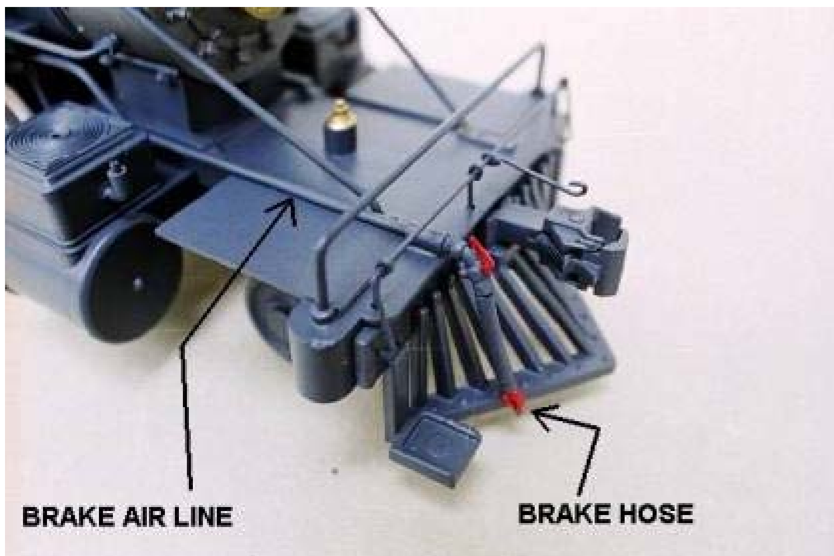
The rest of the pipe can just run free. Where the brake line terminates at the pilot beam, you need to connect an air hose. You can either fit an 'Ozark Miniatures' brake hose with cast heads, or make your own. A home grown air hose is simply made with a straight length of 3.2mm tube, fit the brake line into the top of this 3.2mm hose, and fit a bent bit of bras 1.5mm rod in the base to form the hose coupling.

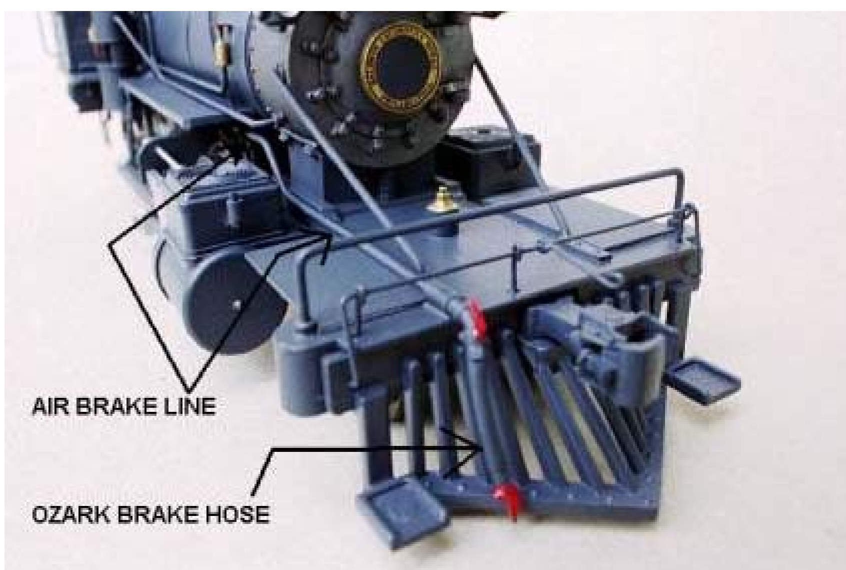
Paint the hose black, with optional red lever and couplings.

The air brake line installation should look like this:









The above model has the 'Ozark' brake hose attached. Previously I made all my own brake hoses, till I tried an Ozark. Mac MacCalla told me "the day you try the Ozark - you'll never go back to your old ways" Absolutely true, I've not made my own air hoses in a while now. Ozarks are that good! Here is the home made type!!

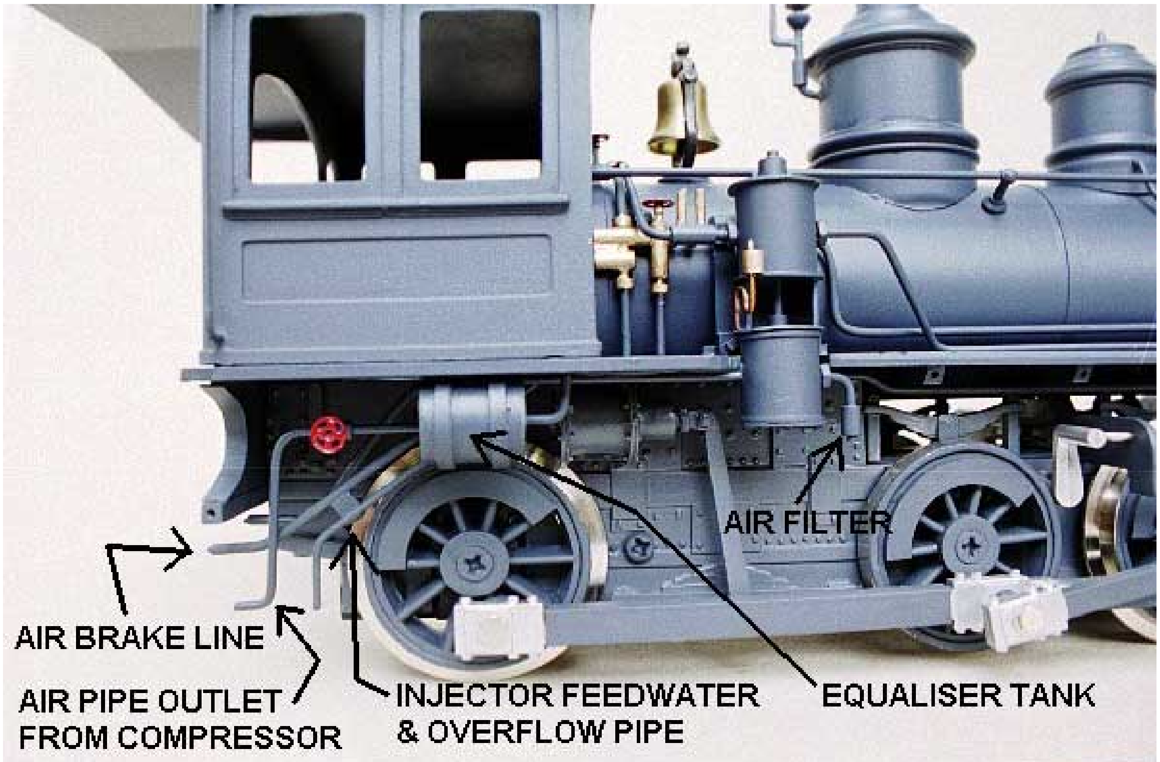
We'll be adding all the air lines on the tender in the next chapter (Chapter 7). This will include the brake hose to the rear draw beam.

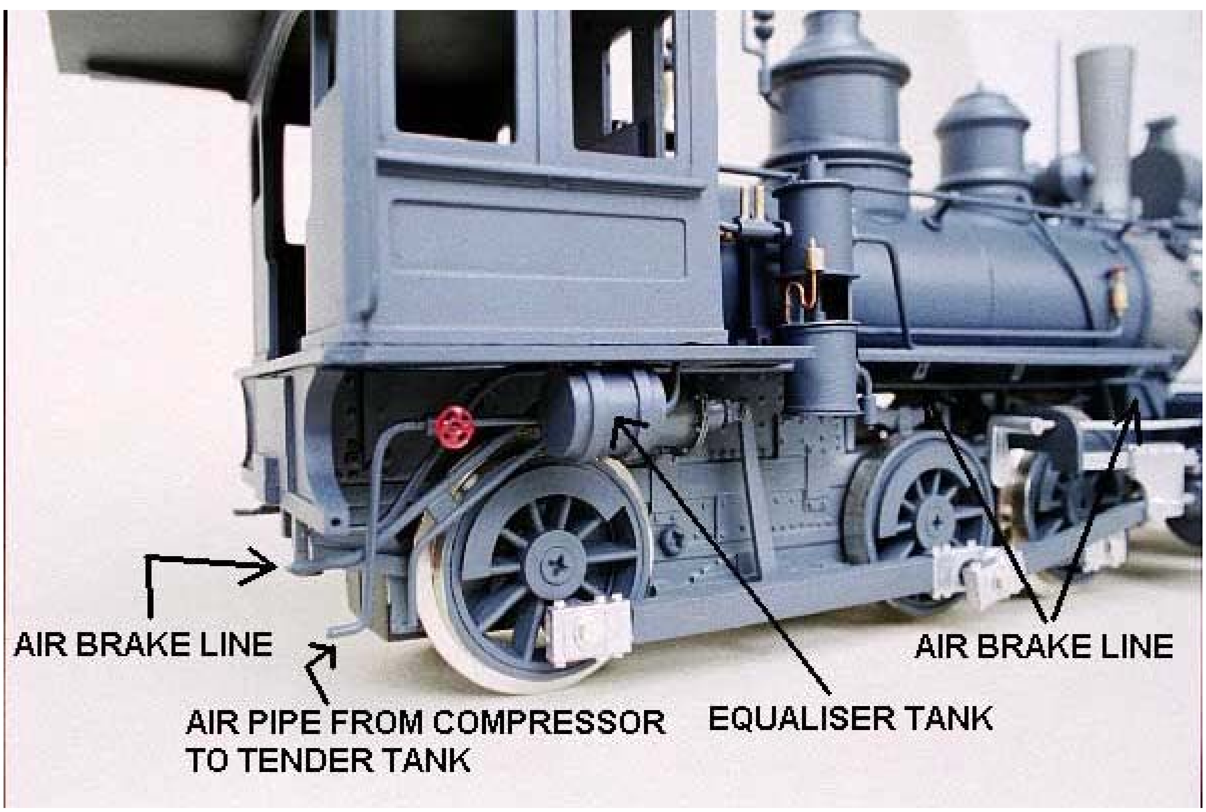
Step 12 - The Equaliser Tank

This is easy - Under the cab floor on the engineer's side, and level with the outer edge of the cab wall is a small air tank. This is a kind of air brake 'Muffler' use to absorb surges in the air brake feed from the tender air tank. There is only one pipe going into the tank, directly from the Automatic Air brake stand in the cab.

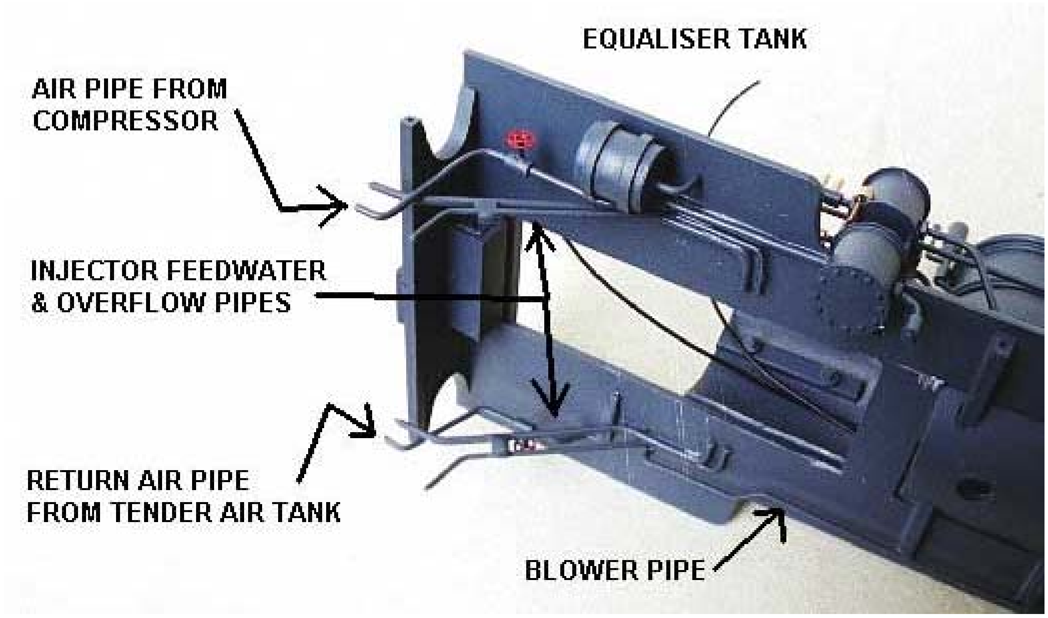
To make it, simply cut a 14mm long length of 12mm dia Evergreen pipe. Cap with ends with 0.5mm styrene. Add two clamp straps near the tank ends by slicing more 12mm dia tube in 1mm slices. Break the 1mm rings on one side, so they can slide over the 12mm dia air tank. The gap in the rings is the side where the tank is glued to the cab floor. On one end of the tank drill a 1.5mm hole and insert a small 'L' shaped 1.5mm rod. This pipe will run from the tank end to the cab floor. Paint the thing black on all versions. Done.

The finished under floor piping on the engineer's side will look like this:



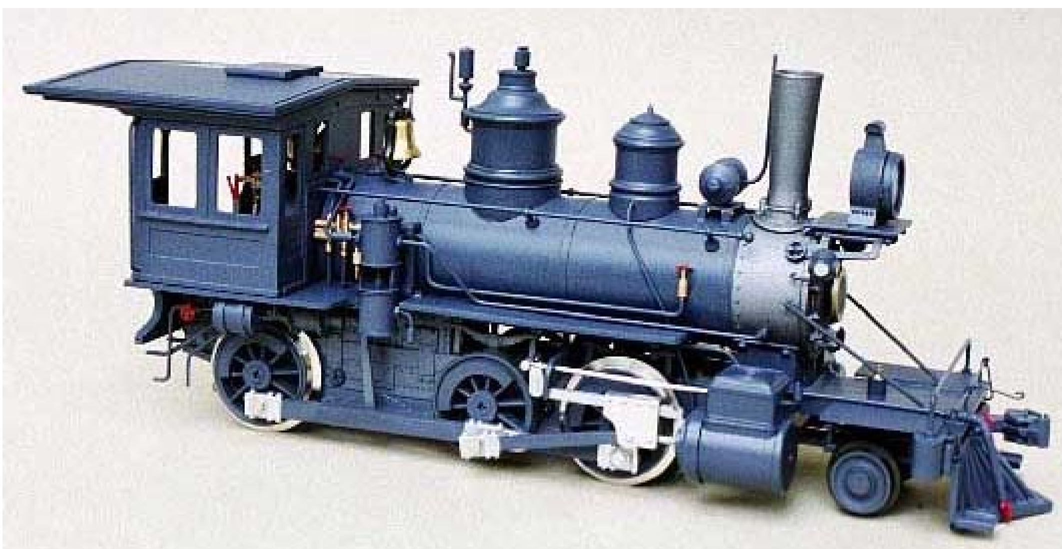


Here is another view of the underside of the cab floor seen below. Note there is no visible air brake line to the brake hoses etc, as this pipe is mounted to the chassis, not the superstructure.



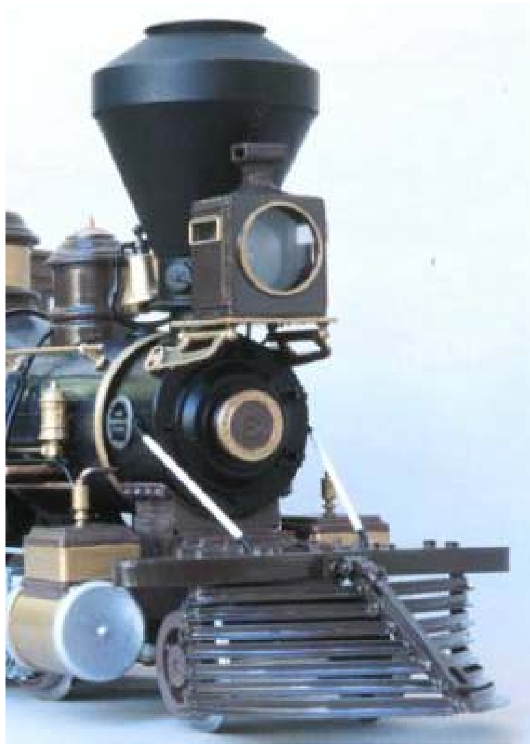
Also note the ring of rivets around the compressor bottom plate.

Your locomotive should look something like this now, with all the pipes in place.



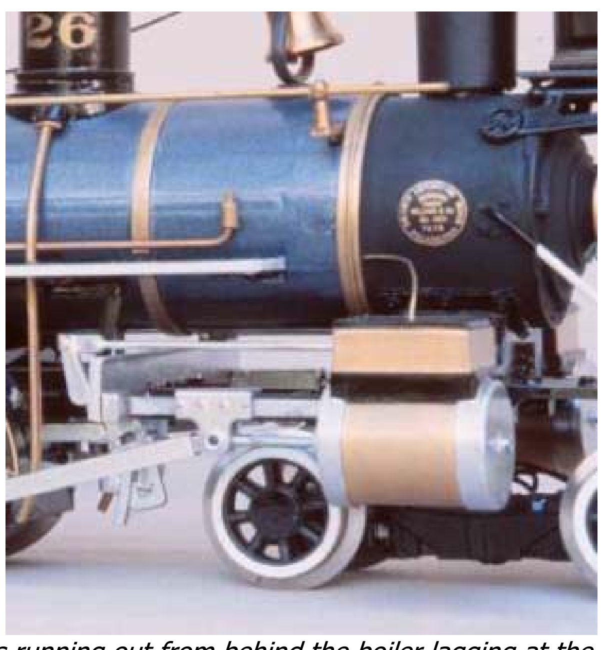
Step 13 - The Hydrostatic Lubricators

If your loco represents an 1870s version, without any hydrostatic lubricators, and your steam chests above the cylinders have oil cups only, then you're basically done for this chapter.   Go to the 'final step' at the end of the chapter to fix the backhead into place. The 1870s style loco with oil cups might look something like this:



Note the brass cups on the steam chest tops.

If your loco is an 1870s loco or later and will have Hydrostatic Lubricators, you will not have oil cups on the steam chests, but rather some small copper or brass lube lines...that look something like this:



Note the small curved lube lines running out from behind the boiler lagging at the smokebox, down to the cylinder heads. This is an 1878 D&RG 4-4-0..which had a lubricator.

Here is another view, this time an 1884 Cooke 2-6-0 of the DSP&PRR.

If your model is to have the Hydrostatic lubricators, then go ahead and make these lil lube lines now. They are made from 0.75mm brass wire, running vertically out of the hole in the top of the steam chests. They then bend in a lazy 'S' curve, bending both toward the rear as well as bending into a horizontal run toward the smokebox side. I only fix these wire lube lines into the steam chest covers with a drop of Araldite. They are not fixed into the smokebox at all. They simply run flat and hard up against the smokebox side. When the superstructure is screwed down into position over the chassis, the lube lines will come to rest in the right place.

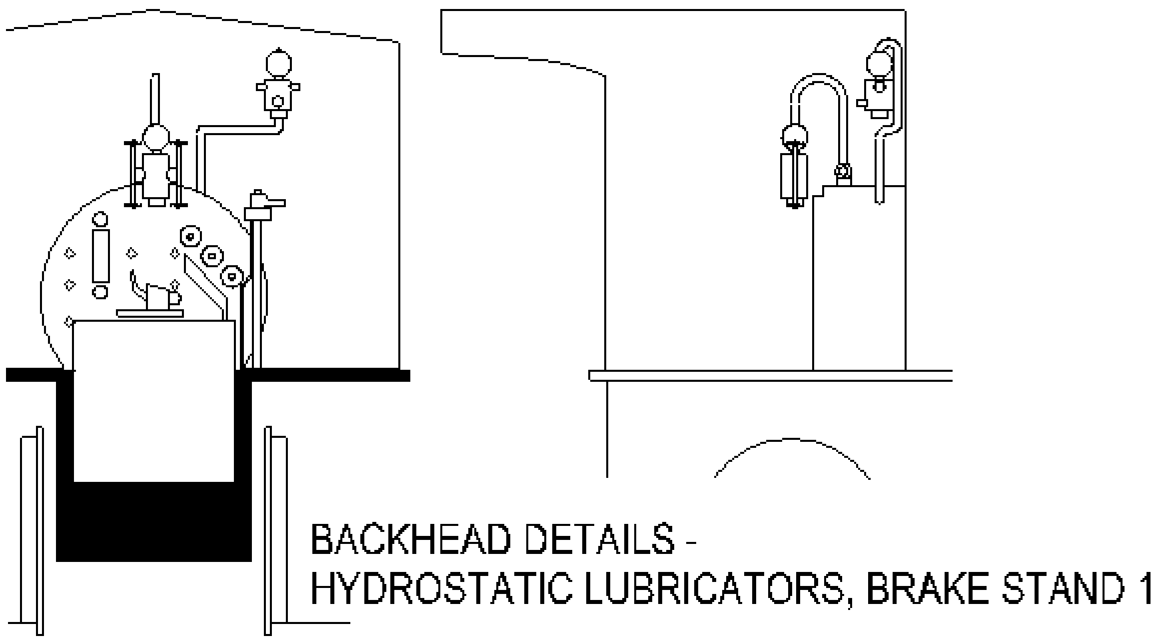
Inside the cab the other end of these lil lube lines is not quite so simple!!

There are two Hydrostatic lubricators to be made for out 8-16-D 2-6-0:

1. A large central lubricator for the loco's cylinders and steam chests
2. A small secondary lubricator for the Air compressor's upper steam cylinder

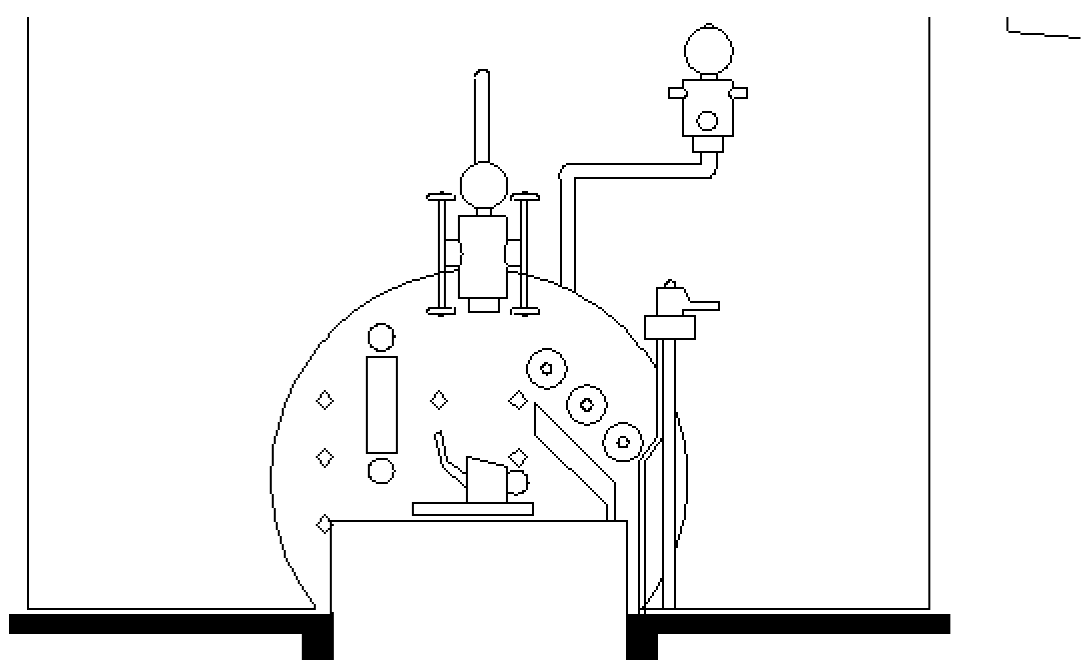
While we'll make both these lubricators, we will not be installing any further visible lube lines on the backhead. The lube lines very quickly ran from the lubricators straight under the boiler lagging and out of view. We only need make the Lubricator units themselves.

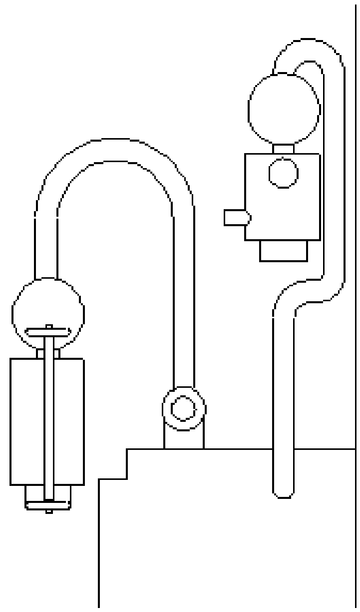
The Lubricators are made as shown on these diagrams:



The unit directly over the top center of the backhead is the main Hydrostatic lubricator. It hangs over the backhead on the end of a goose neck like curved steam pipe, running out of the turret (same part as the injectors connect to).

The 2nd Lubricator is the unit for the compressor steam cylinder, it is mounted to the upper right of the backhead, literally against the cab wall It also hangs on a steam pipe, running out of the top of the backhead. Check the side-on view for the location of both units. Here is a close up of both units:





Making the Main Hydrostatic Lubricator

Cut a 6mm length of 4.5mm styrene tubing. Feed into the bottom of this tube a 5mm length of 3.2mm tubing. It should slide cleanly inside the 4.5mm tube. Leave a 2mm length of the 3.2mm tube exposed at the bottom. Bend a goose neck pipe out of 1.5mm brass rod. Make it long enough to run right into the base of the 3.2mm tubing. Next get hold of a simple plastic or metal bead. This is a bead used in sewing, necklace making etc. Go to a craft store for these. You are after a spherical bead about 4mm in diameter. Feed the bead onto the brass rod above the 4.5mm tube etc. You have now made the oil canister and steam pipe for the lubricator. All you have to do now is make the two oil feed units on the sides of the lubricator, used to control the flow of oil to both steam chests.

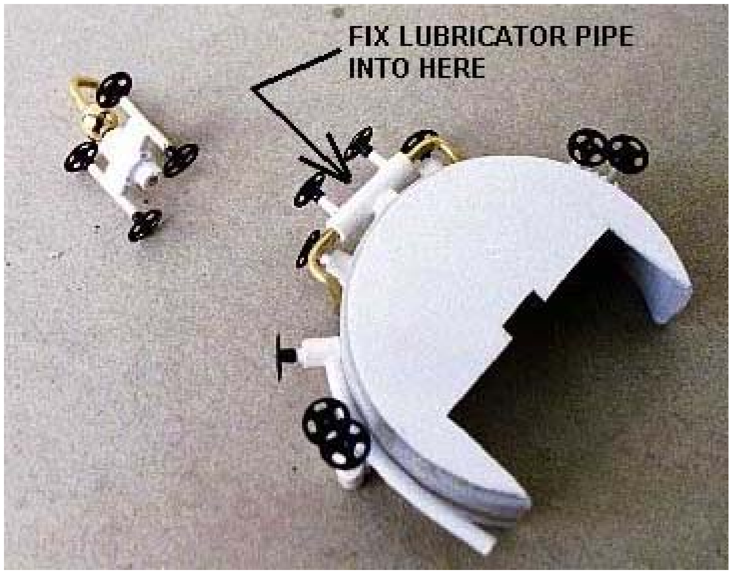
These lubrication feed units are made in this way:

Cut two 12mm lengths of 1.0mm plastruct rod, these are the rods with the wire core. Strip off 1mm of styrene sheath from both the top and bottom of both 12mm rods, in exactly the same way you have been doing for the V1 and V2 valves. Weld the two rods to the side of the lubricator canister using a 2mm wide, 1mm thick styrene packer. Next insert 4 press-stud type valve handles to the top and bottom of both 12mm rods.

The lubricator unit should look something like this:

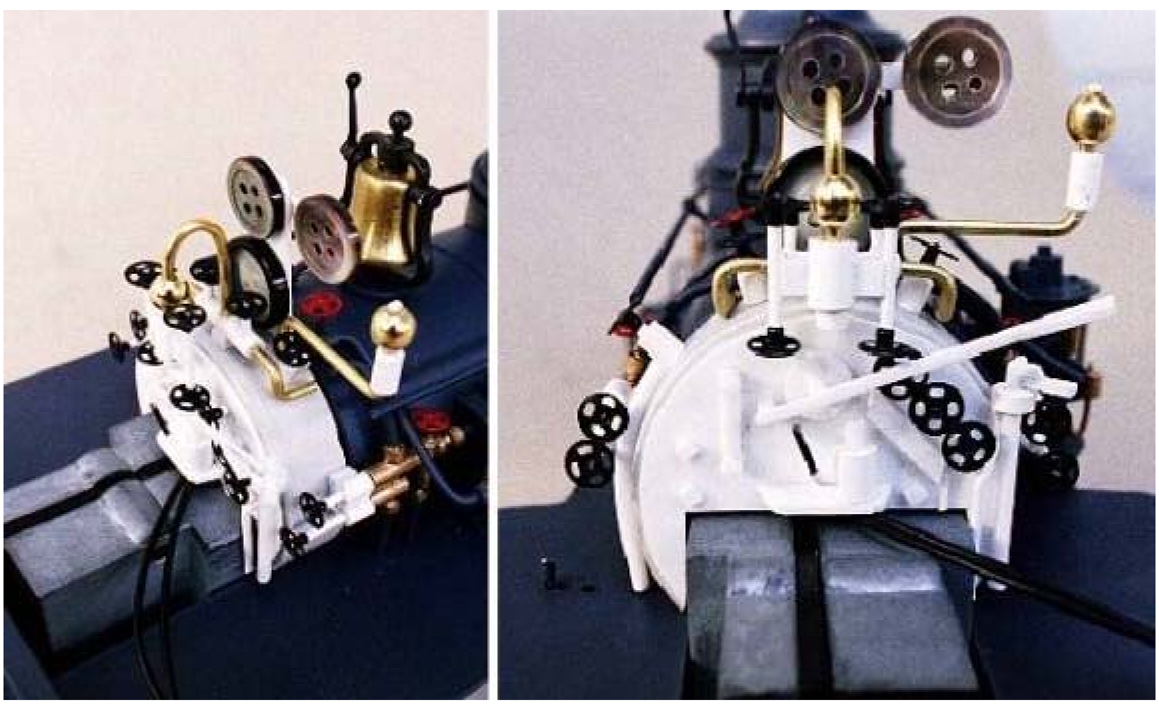
This lubricator unit will fit into the top of the turret, in the 3rd 1.5mm hole you drilled in the 3.2mm turret tube fitted to the backhead during the 'Injector and feed water pipe' section above.

You will fit the lubricator here:



The 2nd Lubricator is a bit simpler. It is made using a 5mm length of 3.2mm styrene tube with a 4mm bead on top. A 1.5mm brass rod runs from the backhead top, sideways and up to the lubricator, running though the bead and into the 3.2mm tube. Fix three 2mm slithers of 2mm styrene rod as the tiny valve handles to this unit. See diagram above. (I ran out of 2mm rod and have not as yet fitted the 3 knobs to the smaller lubricator!!).

The secondary smaller lubricator will look something like this:



Note in these views the fitting of the primary Lubricator into the center of the Turret, the same 3.2mm tube that the injectors connected to. Also note the smaller secondary compressor lubricator out to the right side on a long brass pipe.

Painting

The lubricators shall both be painted a brass color, including all the valve handles. The steam pipes running to the lubricators will be a copper color.

The finished, fully painted lubricators, fitted to a completed backhead and finished locomotive is shown here:




Final Step - Fixing the cab and backhead to the locomotive

Up until now the backhead unit, with all the appliances fitted is a loose item. It was easier being able to do the work on the backhead as a separate assembly. You will have only rested the backhead in place to test pipe alignments with the external pipes. Some of you might have done the work of the backhead with the cab removed as I have done, some might have done it simply with the cab roof removed. Now its time to fix the cab back onto the loco for the last time.

First thing, one minor detail... Cab seats!! You can make the seats up as follows:

Make a styrene box from 0.5mm sheet, 20mm long, 15mm wide and 15mm tall. Paint brown and araldite to the side and rear wall of the cab. The seat should align with the 2nd side window on the cab.

If your fixing angles used to bolt the cab to the floor are in the way of fitting box seats in place, then just fit the seats as a 20x15mm shelf, fixed to the side wall of the cab, 15mm above the floor. You can use a styrene angle to better fix the seats to the walls.

Next make sure you have painted the exposed surfaces of the Aristo motor block a dark or black color.

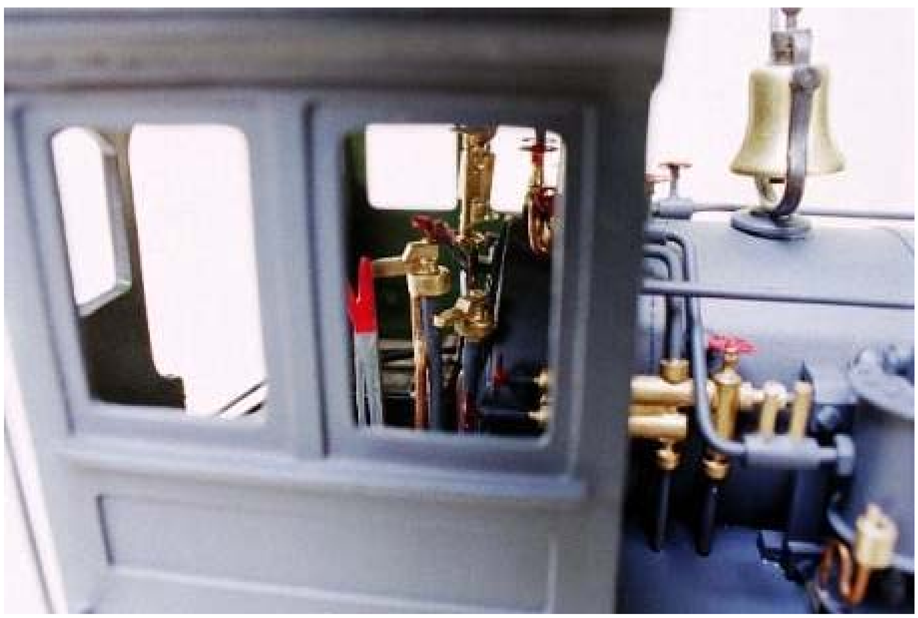
Make sure you have connected your tender electrical connection wires and plug to the Aristo block pin plug inside the boiler. Now to bolt the cab down.

With the backhead removed, fix the cab into place, screwing the cab down to the floor and also screwing the front wall of the cab into the boiler washout SHS rods, all as described in chapter 4 and 5...now comes the hard part.

You will now glue the whole backhead unit to the front wall of the cab with a few drops of 5min araldite You will, in the process, cover over the two screws used to bolt the cab to the boiler via the washout plug SHSs. There will be no removing the cab after this time. From now on, the superstructure of the loco will be removed as a whole, from the chassis, allowing access to the motor block and boiler interior. You should not need to remove the cab again anyway. If you feel you want to keep good access to the two screws bolting into the boiler, and removal of the cab in the future is desirable, then you will need to screw fix the backhead to the cab floor as well, using styrene angles welded to the sides of the backhead PVC pipe.

I simply glued the backhead in place!!

Here is the cab fixed down and the backhead fitted in place. Note the two black wires coming out from under the backhead, these are my electrical connection wires to the tender. You should not try to run this type of loco using track power without additional electrical pick-ups from the tender wheels. The loco just wont run smooth with only 4 driving wheels on the block having any kind of contact with the track.



Ah yes there is nothing so complete as a locomotive with all the right pipework, running in the right directions, connected to the correct backhead valves. This was without doubt the most difficult chapter to write, and probably the one that can benefit you all the most.

When applying these instructions to other locos, such as the Bachmann 4-6-0, or Hartland locos etc, use the systems in the principles as drawn above. Pipework may take different routes, due the appliances being fitted in different places, such as; the air compressors fitted to the fireman's side, air tanks fitted under the loco sideboards and not the tender. The pipe procedures are identical, just run the pipes in the most direct route from the new locations. Where there are two primary air tanks, one on each side of the loco, the air pipe from the air compressor goes directly to one tank, then a second pipe runs from that tank, under (or over) the boiler to the other tank. The return air pipe then runs from the 2nd tank back to the cab's automatic air brake stand. You'll get the idea. If you have any queries about any of this, or how you should adapt it to fit a different type of loco, just drop me a line, or ask the question in the 'Model Making' forum. There would be a number of us who could help.

Well I hope you enjoyed it, this is as good as it gets in locomotive construction.

As always good luck!!

David Fletcher
November 2001.

How much better does it get???