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Boiler & Engineering Skills Training Trust

Steam Locomotive Repair and Overhaul

Module LM8

Pipework & Fittings

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Module BESTT LM8

Pipework & Fittings

Aim

This unit will give learners an understanding of Locomotive Pipework & Fittings and how to examine for wear.

The learner will consider: -

* Different Braking Systems
* Different types of Bogies and trucks
* Different types Radial Axles and boxes
* Examination and reporting

Learning Outcomes

LO1: Smoke Box Items

LO2: Smoke Box Items (2)

LO3: Footplate Topics

LO4: Injectors

LO5: Inspection

BESTT MECHANICAL MODULE LM8

PIPEWORK & MISCELLANEOUS FITTINGS

INTRODUCTION

Although previous modules have covered the majority of vital parts, there are important and some safety critical items that we need to sweep up so that the whole set of modules are comprehensive in their coverage of the subject of steam locomotive building, repair, inspection and maintenance.

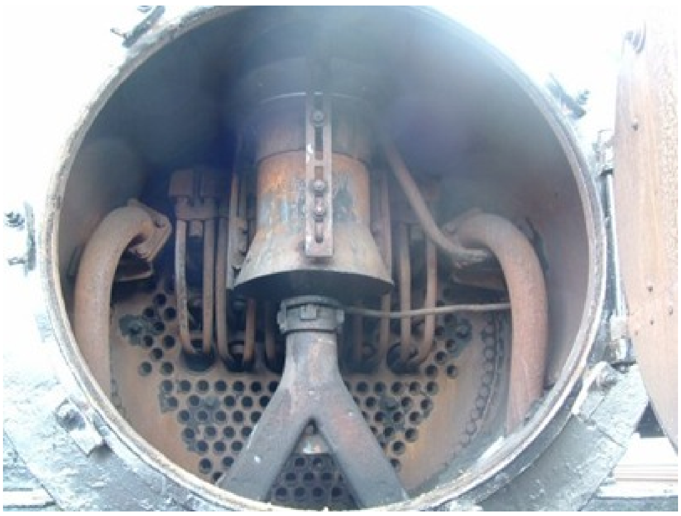
This module will attempt to cover the vital components such as pipes that link the various major sections covered by previous modules and attempts to sweep up loose ends left out in the process by trying to sub divide this expansive subject into viable and freestanding sections. HRA Guidance Document HGR 9007 relates but there are some topics not covered

It might seem that module LM8 is a blend of unrelated topics, but this approach is inevitable if we are trying to cover the whole subject appropriately.

We can group the various topics loosely not covered so far under two main headings.

Those associated with the SMOKEBOX and those associated with the FOOTPLATE plus a few which do not fit easily with either.

SMOKEBOX RELATED TOPICS



STEAM PIPES BETWEEN BOILER AND CYLINDERS

Although these pipes are not strictly part of the pressure vessel they need special attention during any sort of assessment or inspection. This is because any failure of these highly stressed components can be life threatening to the crew. A rupture of one of these pipes with the locomotive under load can tend to throw the fire back out through the firehole door and engulf the crew They are generally steel (sometimes copper) are subject to full boiler pressure, across a wide temperature range and because they are bent up from thick walled pipe there is generally thinning of the outside surfaces during the bending process which stretches the outer surfaces on the bend and compresses the inner surfaces. In addition the abrasive nature of the char from the fire passing the outer surface of the pipe at high speed tends to abrade the already thinned pipe wall. All of that is on top of the acidic attack from the highly corrosive atmosphere from the sulphuric acid, which is prevalent in a smokebox during and after running.

Visual inspection is inadequate to get a full picture of the condition of these items and a thorough ultrasonic survey of the pipes at overhaul or heavy exam periods is essential. In addition, during erection of the locomotive after overhaul a hydraulic test to twice working pressure is recommended so that any weakening during the ensuing life of the pipes is catered for.

Additionally seen in the image above, are the copper or steel pipes which feed the blower ring around the blast pipe seen coming in from the right and the brake ejector exhaust pipe seen feeding up into the chimney petticoat. These pipes too generally made of copper need to be regularly inspected and replaced if weakened for the same reasons given above.

SNIFTING OR ANTI VACUUM VALVES

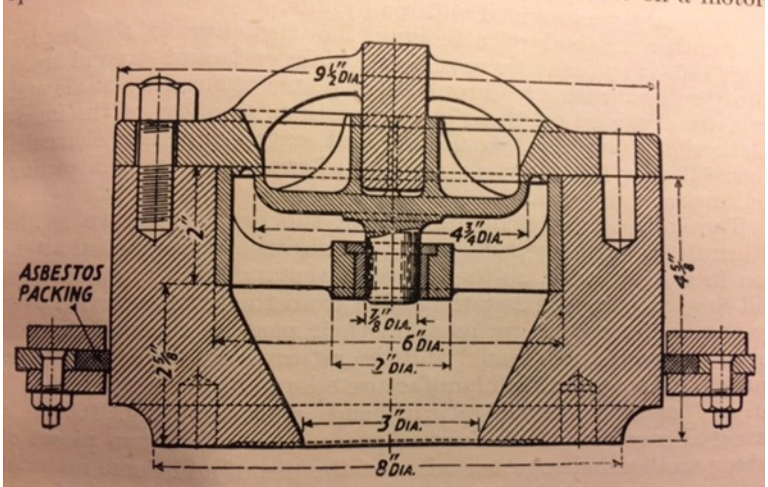


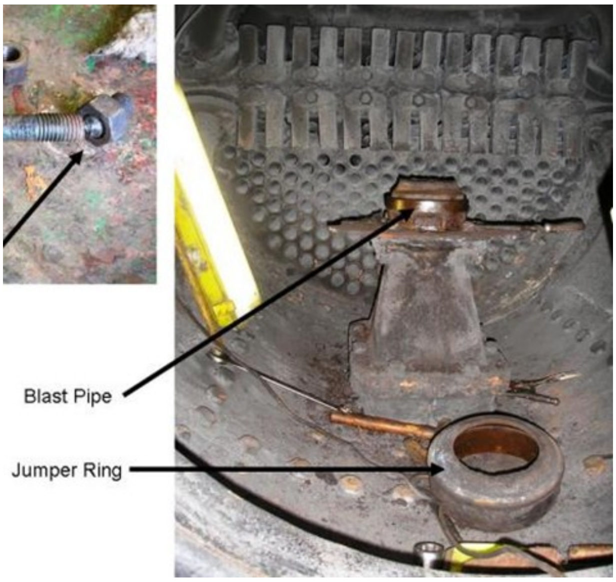
FIG. 163.—ANTI-VACUUM VALVE, L.N.E.R.

When a steam locomotive is running, and steam is shut off by the driver closing the regulator, the pistons within cylinders continue to sweep the same volume and expel all the steam that is left in the steam pipes and the super-heater. In effect the engine becomes a vacuum pump and three disadvantageous things happen within the steam circuit Firstly the super-heater elements are emptied of any steam, which might protect them from overheating as the heat from the fire continues to heat up the elements. Secondly the vacuum created within the super-heaters and steam chests slows the locomotive down as resistance is felt in maintaining the vacuum. Thirdly the vacuum created within the cylinder block can inevitably lead to ash and cinders being drawn down the open blast pipe into the cylinder block which is clearly bad news and will lead to premature wear.

In order to prevent these things happening an anti-vacuum valve or “snifting valve” as it is sometimes known is fitted to the top of the super-heater header so that as soon as the pressure in the steam pipes subsides the valve opens to atmosphere and cold air is drawn through the super-heater elements and down into the cylinders. This ensures free running, cool super-heater elements and no ingress of char from the smokebox.

The valve can be seen in the photograph, sitting about a metre behind the chimney of *Tornado* in the photograph is shown in diagrammatic form in the drawing. The valve can often be heard shutting with a metallic clink when the locomotive starts from rest after the regulator is first opened. The description above applies to Ex LNER locomotives, Ex LMS and Ex BR Standard Locomotives had anti-vacuum valves fitted at either end of the cylinder assembly under the running board, which performed the same function apart from letting air in to cool the superheaters when coasting.

BLAST PIPE JUMPER RING



Whilst still on with smokeboxes we need to cover the automatic blast-pipe jumper ring which was introduced by G.J. Churchward on the GWR to avoid excessive back pressure forming at the blast orifice.

In ordinary working locomotives which use part of the exhaust steam in the injectors or for other purposes need a smaller blast pipe orifice than they would otherwise have. But on the other hand when the locomotive is being pressed to work hard, the blast may easily become too fierce and the back pressure on the pistons be increased correspondingly. When the locomotive fitted with this particular type of blast pipe comes to a gradient or causes more than a pre-determined amount of steam to pass through the cylinders out up the chimney, the heavy jumper ring rises and remains up until the exhaust steam is reduced when it falls back to its original position. The rising of the “Jumper” increases the area of the blast pipe by 9 square inches thus softening the blast and reducing backpressure.

It will be seen that by automatically increasing the capacity of the blast pipe as with the “jumper” top and ring, a free outlet for the exhaust is available under normal and maximum load conditions.

Other railways tried adjustable blast pipe mechanisms so the size of the blast orifice can be varied by the driver according to the work that is being performed, but they are liable to get out of order through the ashes and coal dust choking up the working parts.

BLAST PIPE “JIMMY”

Following on from the Jumper top described above this item is related but comes from a really unusual angle.

Some locomotives were poor steamers for a variety of reasons and the crew were faced with trying to keep to time when the locomotive would not perform as expected.

In order to liven up the fire to make more steam the locomotive crew devised and had made this illegal device which they were able to apply to the inside of the blast-pipe nozzle. The adjustable jaws fitted down into the mouth of the blast pipe and the sharp edge of the square bar lay across the orifice. This had the disruptive effect of dividing the blast from the exhaust into two diverging flows, which thus increased the speed of the exhausting steam and caused the exhaust to completely fill the petticoat pipe and created more vacuum in the smokebox. Of course the Railway Management didn’t approve as the use of Blastpipe Jimmys increased coal consumption of the locomotive. The crews had to be careful to make sure the devices were removed before the locomotive returned to its shed. These items were kept hidden in the crew’s toolboxes and this particular one was presented to the management upon the retirement of a famous driver.

It is interesting that the more sophisticated design of blast pipes developed by French and other locomotive designers echoed the method used here. Learners should research KYALA and CHAPELON’s work as well as LEMPOR. The A4’s like Mallard were fitted with Kychap (derived from the first two names together) blast arrangements, which were created to markedly improve blast pipe and smokebox performance

SMOKEBOX STEAM LANCE

In order to help cleaners and firemen get their locomotives ready and dispose them at the end of the day there was a fitting on the lower right hand side of the smokebox which was connected to the boiler pressure by a pipe inside the smokebox. This allowed the crew to attach a steam lance on the end of flexible piping so as to be able to loosen and clean some of the soot and debris from the parts in the smokebox before shovelling it out.

FOOTPLATE BASED TOPICS

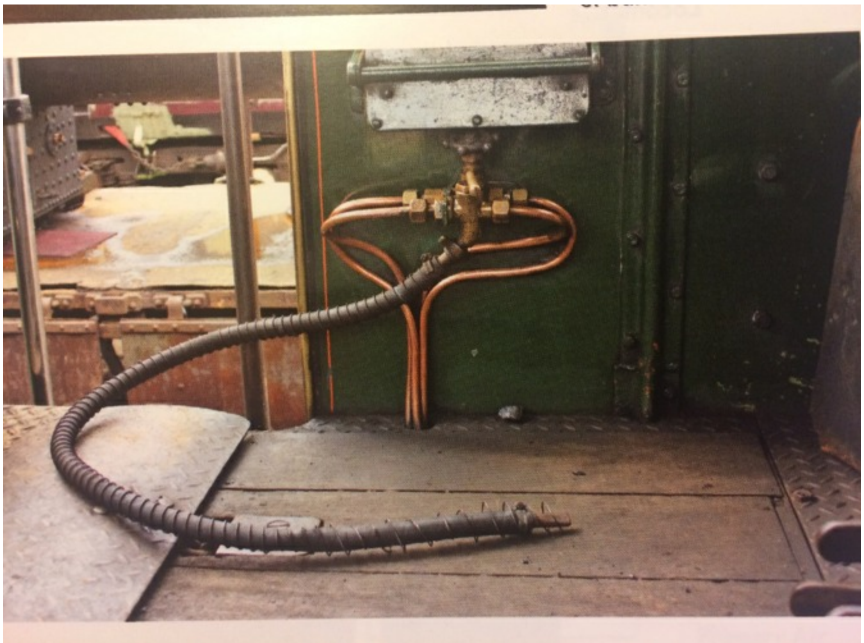
COPPER PIPES

During overhaul all copper pipes must be examined for defects and annealed fully so that any hardness which had formed within the copper would be removed / The so called “Red book “ covering boilers and pipework is a mine of really useful information and makes special reference to the issues governing pipe fastenings with four hole fastenings for joints between pipes with flared ends. This covers ex LNER and LMS locomotives and it important learning. A further useful resource for those dealing with copper pipework on the back-head of the locomotive is to read the full accident report on the accident at Chapel -en-le Frith on 9th February 1957where a Class 8F locomotive pulling a heavy unfitted freight train ran away at high speed killing the driver John Axon. From the learning viewpoint this report by the Government Inspector is very significant and revealing.)

A steam leak on the main copper pipe to the steam brake had been reported as leaking before the train departed from Buxton. A fitter came out from the shed and tightened the union on the pipe with a large spanner unwittingly realising that in applying further turning to the union, the brazing of the copper pipe to the union fitting sheared completely leaving the end of the pipe effectively unattached.

When an attempt to apply the steam brake was made at the start of a big descent the pipe with over 200 psi of steam blew clear and made the footplate inaccessible as the train ran away out of control for several miles before crashing into the rear of a preceding freight train.

FOOTPLATE SLACKER PIPE

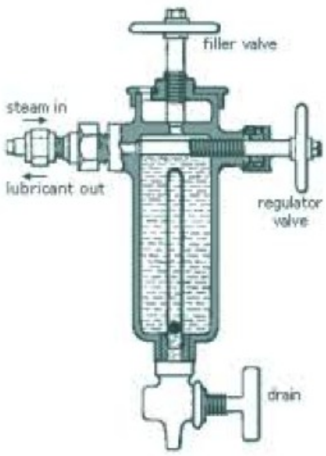


In order to keep the dust from the coal being used and effectively managed, steam locomotive footplates are equipped with a flexible hose called a slacker pipe or pet pipe which is fed with water from the live steam injector and has its own control .The jet of water can be used to damp down the coal in the tender or bunker to minimise flying coal dust and also can be used on the boards of the wooden footplate to keep it clean and help to keep conditions on the footplate bearable in hot weather. Remember it only works when the live steam injector is operating.

STEAM HEATING VALVE or MASON VALVE


Locomotives fitted with steam heating apparatus are generally equipped with a Mason Valve, generally low down on the footplate. The valve limits the pressure of steam that is drawn off the locomotive's system by means of a pressure-reducing valve. The steam is fed to the carriages in the train through steam heating pipes, which are equipped with, shut off cocks. The hoses should be hung on the hooks provided so that the steam heating hose does not sustain damage from hanging down

CYLINDER LUBRICATION FROM THE FOOTPLATE



Although we have covered the topic of lubrication of rotating parts in the Axlebox module, there is a whole new topic to be covered in steam cylinder lubrication and the Learner would be well advised to visit Morris's Oils websitehttps://www.morrislubricants.co.uk/

The essential requirements in a steam locomotive are to present the moving parts within the cylinders with an oil that will not emulsify and become the sort of mayonnaise that we have all seen inside the rocker covers of a car engine when we come to top up with oil.

The Steam Cylinder oil that is marketed for non -superheat or for superheat steam locomotives will not emulsify and thereby provides excellent lubrication within the moving parts of the steam system.

Early simple locomotives used displacement lubricators as shown above where the Roscoe type lubricator, would be connected in to the steam supply near to the steam chest. As steam was admitted the steam entered the oil filled chamber and because the lubricator body was relatively cold, some of the steam condensed in the chamber as a droplet of water. Because oil floats on water the oil in the lubricator forced the water droplet to the bottom and this droplet joining the chamber forced a droplet of oil in turn out through the connection that initially brought the steam in.

This process continued until all the oil in the body of the lubricator had been forced back into the steam chests of the engine and the lubricator chamber was left full of water. By running this water off to drain at some convenient point the lubricator could be temporarily isolated whilst a new charge of steam oil was added to the lubricator and process starts off all over again. The valve on the right-hand side of the lubricator could be used to regulate the flow of oil and such devices managed extremely well until steam temperatures started to climb with the advent of superheating when something more positive was required. There was a tendency for the Hydrostatic lubricator to deliver very little oil when the throttle was wide open then to gulp a large proportion of the oil into the steam chest after all the hard work was finished.

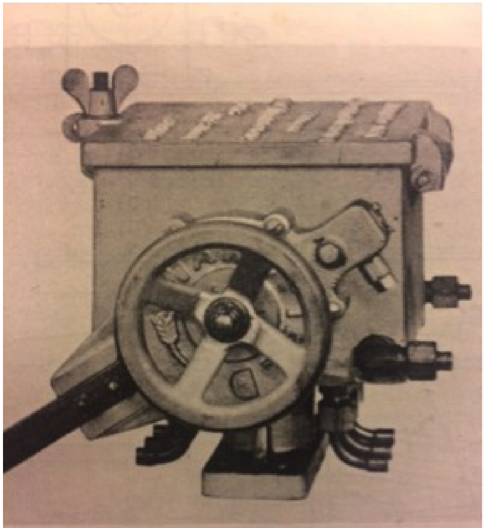


Fig. 215.—Wakefield No. 7 Pattern Mechanical Lubricator.

Mechanical oil pumps which meter a small fixed amount of oil with each stroke were introduced like the Wakefield pump shown above. Sometimes the drive to the lubricator from the valve gear of the locomotive was arranged in such a way that the movement of the valve spindle determined the quantity of oil delivered. So if the locomotive was in full gear working hard the stroke of the lubricator would be delivering a substantial amount of lubrication whereas if the locomotives was notched up and running fast the movement passed on to the lubricator drive would be minimal.

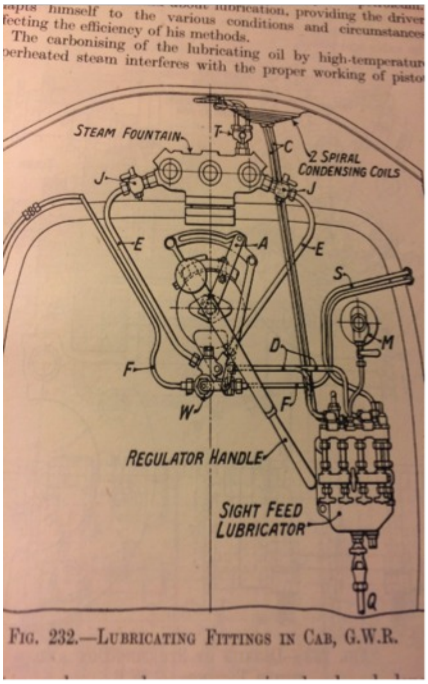


FIG. 232.—LUBRICATING FITTINGS IN CAB, G.W.R.

For the GWR there was a problem with running with the throttle closed (drifting) on their hydrostatic system that only delivered oil to the front end of the locomotive when the throttle was open. They perfected a system of hydrostatic lubrication whereby a small steam bleed was led off to an atomiser, which delivered a mist of steam and oil when the locomotive was working but none when the throttle was closed.

Learners must study all the different ways that the various railway companies got oil to the pistons and cylinders to prolong the life of the locomotive.

INJECTORS

In the early days of steam locomotive operation the boilers were fed from mechanically operated pumps, which drew the water from the tanks or tender and fed it to the boiler at a pressure greater than the boiler operating pressure.

Mechanical pump fed locomotives suffer from two drawbacks.

1. The pump absorbed mechanical energy the whole time it was running whether the boiler needed water or not.
2. The pump delivered cold water to the steam boiler when it was pumping, which was not ideal and encouraged internal corrosion. Ideally a boiler should be fed with hot water, which allows less oxygen to be retained in solution, and is inherently less corrosive.

   A Frenchman named Henri Giffard invented the injector in 1859 and pump fed steam locomotives became a rarity.

There is a mystique surrounding the operation of steam injectors, which is not helped by well meaning explanations on U tube and on the web. Beware the explanations, which suggest that the water is forced into the boiler purely by the high velocity of the steam. I have looked at a number of You Tube films and written explanations, which are clearly posted without a full understanding of what is going on with Giffards invention.

The key information that is missing from so many of the current explanations is the conversion of the heat energy that is contained in the incoming steam into velocity energy in accordance with Bernoulli ‘s theorem. Only the Wikipedia entry listed below seems to get it spot on right. The rest seem to fudge the issue and obfuscate!

https://en.wikipedia.org/wiki/Injector#Well_pumps

The Learner would do well to look at all the available material to judge for themselves. Please beware! But you must end up being able to explain to others convincingly how it works

https://youtu.be/4wsiXPgfdII is a particularly good example of a fudge.

Two types of typical injector are shown below and as with Brake Valves discussed earlier, access for the learner to Mutual Improvement Class examples of steam injectors that have been sectioned for clarity are an essential part of learning how they work and how they can be unreliable

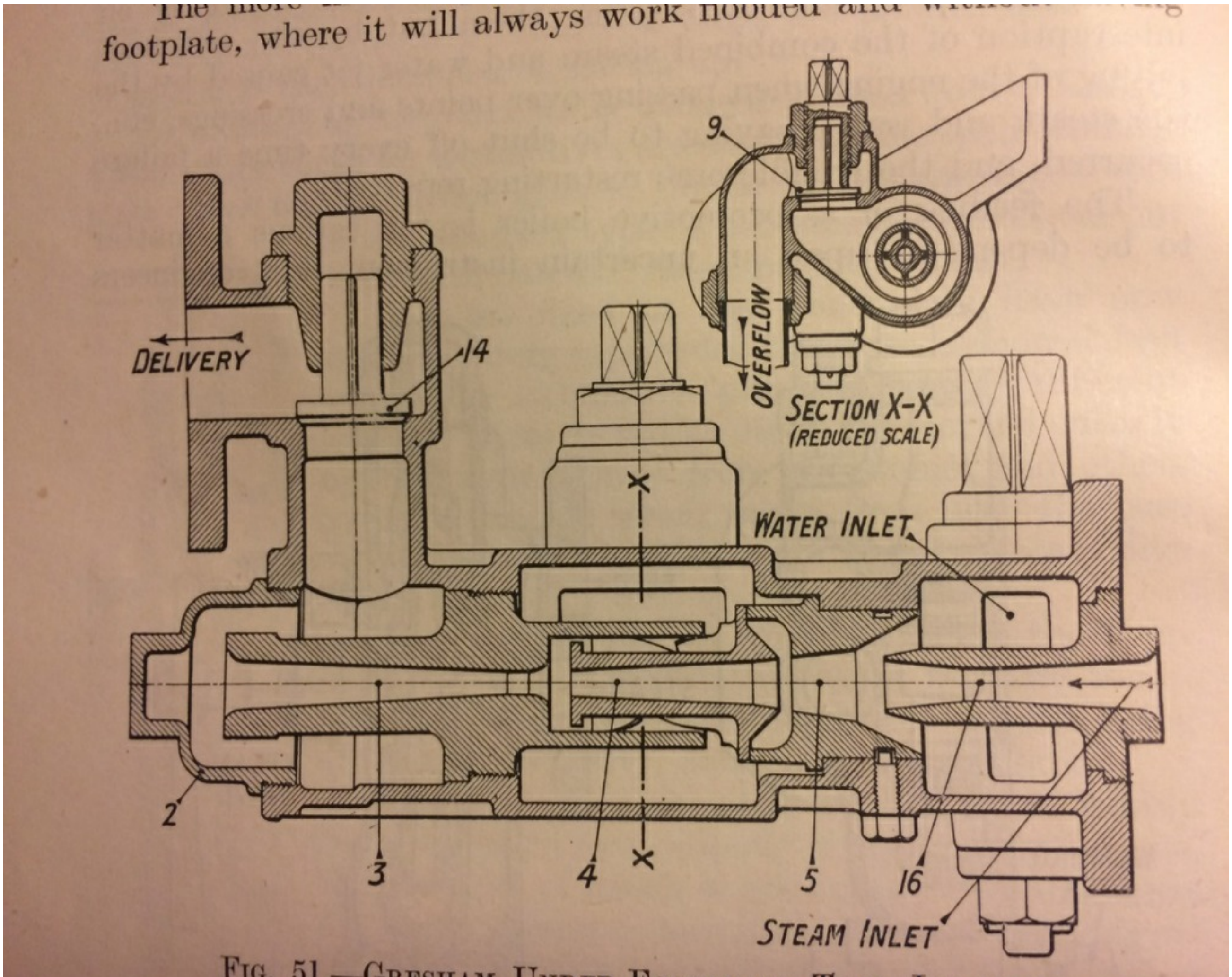


Fig. 51.—Gresham Under-Footplate Type Injector.

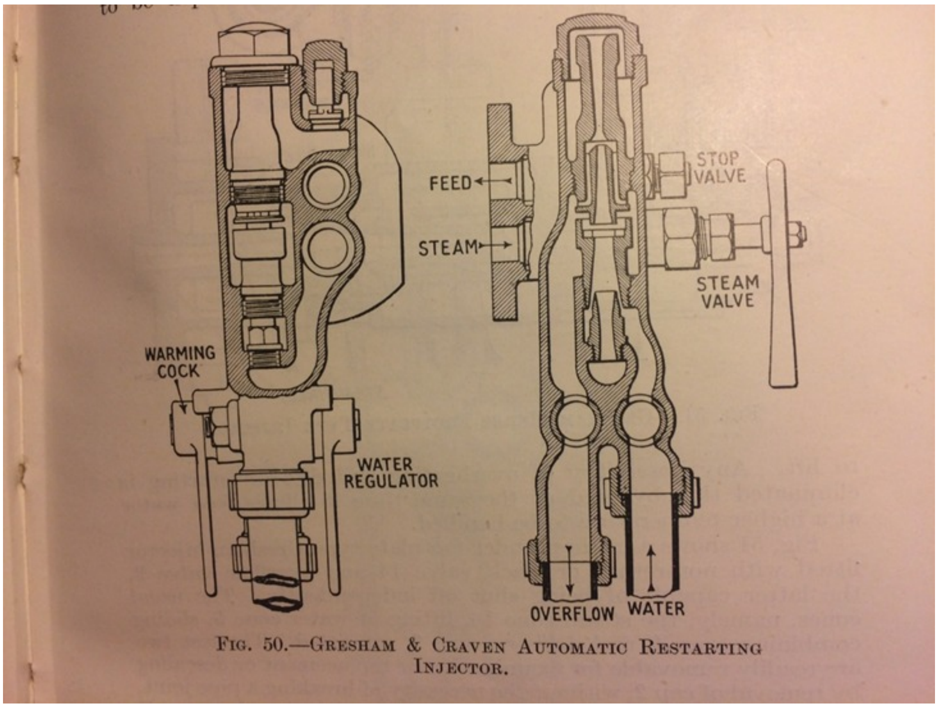


Fig. 50.—Gresham & Craven Automatic Restarting Injector.

The photograph shows an installation of two injectors side by side on the fireman's side of the locomotive

The beautifully crafted sweeping copper bends, which are so prominent, are an essential feature of the installation to reduce pipe friction and create a smooth path for the feed water.

LOW LEVEL TENDER WATER FILLERS ON MAIN LINE LOCOMOTIVES

Steam locomotives that are intended to work on the main line as well as on Heritage lines need to be equipped with low-level access for filling their tenders with water. Climbing up on the tender under the 25KV electric wires presents a totally unacceptable hazard and is rightly forbidden. Tenders are therefore filled with fire hose type couplings at or about at platform height. In the photograph above the filler can be seen in orange just between the second and third safety barrier from the right-hand side. Obviously the pipes must feed internally to the very top of the tender tank so no water is lost when filling is completed. There will be one such filler on each side of the locomotive.

FLEXIBLE STEAM CONNECTIONS BETWEEN LOCOMOTIVE AND TENDER

On locomotives where steam brakes are fitted on engine and tender there is a requirement for flexible pipes to be fitted between engine and tender. These pipes need to be capable of carrying the correct pressure and temperature to feed the steam brake. Usually the modern equivalent of this pipe is a PTFE lined pipe with Stainless Steel braiding on the outside such as those made by ARCO (Usual disclaimer)

It is ESSENTIAL that rotary swivel joints are provided between engine and tender to accommodate the movement that happens when these two vehicles travel on the track.

LO1: Smoke Box Items

1. Boiler and Cylinder
2. Hydraulic Test
3. Smokebox
4. Pipework
5. Testing

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO1 1	Between Boiler and Cylinder	What pressure are these pipes subjected to?	Classroom	
LO1 2	Hydraulic Test	What pressure should a hydraulic test be carried out at?	Classroom	
LO1 3	Smokebox	What acid is present in the smokebox and why?	Classroom	
LO1 4	Pipework	What other pipes are required to be inspected in the smolebox?	Classroom	
LO1 5	Testing	What other method of testing the pipework could be used?	Classroom	

LO2: **Smoke Box Items (2)**

1. Regulator
2. Snifting Valve
3. Blast Pipe Jumper Ring
4. Jimmy
5. Kychap and LEMPOR
6. Steam Lance

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO2 1	Closing the regulator	If the driver closes the regulator with the locomotive moving what occurs in the superheater and steam chests”	Classroom	
LO2 2	Snifting Valve	Was does a snifting or anti-vacuum device do?	Classroom	
LO2 3	Blast Pipe Jumper Ring	What is the function of a ‘Blast Pipe Jumper ring’?	Classroom	
LO2 4	Jimmy	What is a Blast Pipe Jimmy?	Classroom	
LO2 5	Kychap and LEMPOR	What do these terms refer to?	Classroom	
LO2 6	Steam Lance	What is the purpose of a Steam lance	Classroom	

LO3: Footplate Topics

1. Copper Pipes
2. Data
3. Slacker Pipe
4. Steam Heat
5. Lubrication
6. Displacement Lubricators
7. Mechanical Lubricators
8. Lubrication

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO3 1	Copper Pipe	What is annealing and how do you carry out the operation?	Classroom	
LO3 2	Data	Where would you find the information regarding 4 hole pipe fastenings with flared ends?	Classroom	
LO3 3	Slacker Pipe	What is the slacker pip used for? And where does it draw its supply from?	Classroom	
LO3 4	Steam Heat Valve	What does the Steam Heat Valve do?	Classroom	
LO3 5	Lubrication	What is emulsification of oil? Why use Steam Oil?	Classroom	
LO3 6	Displacement Lubricator	Draw a section through a displacement lubricator and describe its operation	Classroom	
LO3 7	Mechanical Lubricators	Describe the action of a mechanical lubricator	Classroom	
LO3 8	Lubrication	Study a locomotive in your workshop and explain the lubrication system with emphasis on pistons and cylinders	Classroom & Workshop	

LO4: Injectors

1. Mechanical Pumps
2. Injector
3. Giffard Injector
4. Principles
5. Tender Fillers
6. Tender Steam connectors

LO	Objectives	Assessment Criteria	Delivery	Date achieved and Supervisors signature
LO4 1	Mechanical pumps	What are the drawbacks of mechanical feed pumps?	Classroom	
LO4 2	Injector	What are the advantages of an Injector?	Classroom	
LO4 3	Giffard Injector	Draw an annotated section through an injector	Classroom	
LO4 4	Principles	Explain the principle of how an Injector operates.	Classroom	
LO4 5	Tender Fillers	Why are tender fillers arranged to be at about platform height?	Classroom	
LO4 6	Tender Steam Connections	What must be provided between loco & tender for steam connections for steam brakes? Draw an example.	Classroom	

LO5: **Inspection**

1. Smoke Box
2. Cab Fittings
3. Steam Test
4. Steam Test

LO	**Objectives**	**Assessment Criteria**	**Delivery**	**Date achieved and Supervisors signature**
LO5 1	Smokebox	Carry out inspection as detailed in MT267 2.11	Workshop	
LO5 2	Cab Fittings	Carry out inspection as detailed in MT267 2.12	Workshop	
LO5 3	Steam Test	Carry out inspection as detailed in MT267 2.16	Workshop	
LO5 4	Steam Test	Carry out inspection as detailed in MT267 2.20	Workshop	

Assessment

Learners could demonstrate competence in this unit by:

- Documental evidence
- Photographic evidence
- Witness statements e.g. written or verbal statement from a competent person stating that they have completed tasks satisfactorily.
- Underpinning knowledge questions e.g. written questions, multi choice answer sheets, on-line tests, and assignments.
- Practical training tasks

BESTT Locomotive repair and overhaul - Module LM8 – Pipework & Fittings

Assessment Record for: **Training Centre:** **Year:**

LO1	**1**	**2**	**3**	**4**	**5**					
Supervisor Initials and date										
LO2	**1**	**2**	**3**	**4**	**5**	**6**				
Supervisor Initials and date										
LO3	**1**	**2**	**3**	**4**	**5**	6	7	8		
Supervisor Initials and date										
LO4	1	2	3	4	5	6				
Supervisor Initials and date										
LO5	1	2	3	4						
Supervisor Initials and date										

Witness Statement: The trainee has completed the Learning outcomes to a satisfactory standard

Supervisor signature: **Print Name:** **Date:**

Verified by BESTT Assessor **Name:** **Assess**