VICTORIAN RAILWAYS.

INSTRUCTION BOOK

Concerning

The

Locomotive

and the

Westinghouse Brake

FOR ENGINE CLEANERS.

720—45

Melbourne, April, 1945.

R. Gordon
144 Bay Rd
Sandringham
58

PREFACE

This Book is printed for the purpose of assisting Engine Cleaners to gain a knowledge concerning certain of the duties required of Firemen.

Every Cleaner before being allowed out as a Fireman will be subjected to an examination on the Rules and Signals, and on Questions 1 to 65 herein, and after completing 2295 hours firing, will, in addition to re-examination in the above, require to pass an examination in Questions 66 to 119.

A. C. AHLSTON,
Chief Mechanical Engineer.

PRACTICAL QUESTIONS AND ANSWERS ON THE LOCOMOTIVE AND WESTINGHOUSE BRAKE THAT ENGINE CLEANERS WILL BE REQUIRED TO KNOW BEFORE BEING ALLOWED TO ACT AS FIREMEN.

1. Q. **What is the general form of a Locomotive Boiler?**

A. The front portion of a locomotive boiler is cylindrical and is known as the barrel. The back portion, which contains the firebox, is rectangular in shape with a flat or curved top. The tubes extend from the firebox through the barrel to the smokebox which is attached to the front of the barrel.

2. Q. **What is the general form of a firebox?**

A. The firebox is rectangular in form, having an outer and inner shell. The outer shell is joined to the boiler barrel by a saddle or throat plate. The inner shell is of rectangular shape and is made either of copper or steel. When the inner firebox and the tubes also, are made of steel the boiler is referred to as an "All Steel Boiler."

The inner firebox contains the Brick Arch and the Firegrate.

The space between the inner and outer shell is known as the steam and water space, and in order to prevent collapse owing to the pressure of steam, the plates of the inner and outer shells are attached to each other by means of stays which are usually about four inches apart. Stays are located in the sides and also in the crown of the firebox. Cross stays are also provided and these extend through the steam space from each side of the outer shell.

3. Q. **What are the uses of tubes?**

A. The tubes connect the firebox with the smokebox and carry away the hot gases from the fire. They have a large heating surface, and are surrounded by the water inside the boiler. The heat of the gases is given up to the water, and helps to generate steam quickly. They also act as stays for the tube plates.

A Superheater Boiler is provided also with Superheater Flue Tubes in which the Superheater Elements are located. The elements convey the saturated steam from the saturated chamber of the Header through the flue tubes, where the steam is superheated and returned to the superheated chamber of the Header, and thence to the steam chest for distribution through the steam cylinders.

4. **Q. What is the object in making the exhaust steam pass through the chimney?**

A. To provide the draught necessary for combustion.

5. **Q. Explain how the exhaust provides this draught.**

A. The steam exhausting up the chimney draws the gases from the smokebox, creating a partial vacuum in the smokebox. When this takes place the atmospheric pressure forces the air through the open damper and the fire bars, thus providing the draught.

6. **Q. What is it that, in conjunction with the fuel, makes the fire burn?**

A. Oxygen.

7. **Q. Where does oxygen come from?**

A. The atmosphere.

8. **Q. Is it necessary for a great quantity of air to go through the grate to make the fire burn properly?**

A. Yes.

9. **Q. Why?**

A. Because oxygen forms only one-fifth of the total volume of the atmosphere, consequently a large quantity of air has to go through the grate in order to get enough oxygen to make the fire burn properly.

10. **Q. What occurs when coal is placed on the fire?**

A. To produce heat in a locomotive firebox, three conditions are necessary, viz.—(*a*) proper supply

of fuel, (*b*) sufficient quantity of air, and (*c*) the air and fuel must be brought together at a temperature at which they will burn.

Coal is composed of carbon, volatile matter and ash. When coal is placed on the fire the volatile matter or gases are driven off. Both the carbon and the gases will burn if supplied with sufficient air at the igniting temperature.

With the three conditions of fuel, air and proper temperature present, proper combustion will occur, and due to a chemical change during the process of burning, the fuel will disappear with the exception of the ash and dirt which remain on the grate.

11. **Q. What is black smoke?**

A. A mixture of various gases and carbon. The carbon is the black part and once formed will not burn.

12. **Q. Explain how black smoke can be prevented.**

A. The carbon of the coal is released when a fresh fire is put on and if, at the moment of release, it can be mixed with the proper quantity of air and kept at a sufficiently high temperature, it will ignite and burn. The best preventative is to fire " light," that is, to supply a small quantity of fuel at a time and maintain a bright even fire.

13. **Q. How do you build up a fire?**

A. Great care must be exercised in building up the fire to ensure a good supply of steam on the journey. A great deal depends upon the first layer of coal being well burnt through, as to add coal to a fire that is black on the top is to court trouble on the journey. When the coal already put in the firebox is burnt through more should be added and the fire should thus be gradually built up until there is a sufficient body of it, thickest in the back corners and under the door.

14. **Q. Why is it, if you have a thin fire, and a hole is made in it, steam pressure will fall at once?**

A. The air entering through the damper is cold and passes through the hole in the fire direct through the firebox to the tubes, cooling the firebox and tubes and causing a fall in temperature. In order to produce the best results the air must be thoroughly mixed with the gases given off by the incandescent fuel.

15. **Q. What adverse effect would it have on the boiler if holes through the fire permitted large quantities of cold air to pass through the tubes.**

A. It would reduce the temperature of the tubes and cause unequal contraction which may result in the tubes leaking at the tube plate.

16. **Q. What action would you take to prevent this strain on the boiler tubes?**

A. Build and maintain a heavier fire.

17. **Q. What is the use of a baffle plate?**

A. To prevent the cold air impinging direct on the tube plate when the fire door is open and to assist combustion by directing the air to the top of the fire.

18. **Q. What are the purposes of the brick arch in a locomotive firebox?**

A. To also prevent cold air passing directly on to the tube plate. It lengthens the journey of the gases from the fire to the tubes and so promotes better combustion.

19. **Q. What is the use of the damper?**

A. To regulate the quantity of air passing through the fire when the regulator is closed.

20. **Q. What would you do to prevent black smoke when the locomotive is rolling with steam shut off?**

A. Put on a slightly heavier fire in sufficient time before shutting off so that the fuel will have begun to burn and thus not give off black smoke when the supply of air is reduced. If the regulator is shut unexpectedly

at any place where it is desired to prevent smoke, open the fire door, close the damper and start the blower, which will generally prevent it.

21. **Q. What is the effect of opening the fire door when the locomotive is at work?**

A. Opening the fire door slightly allows air to enter the firebox above the fire and the oxygen of the air mixing with the gases released from the fire results in their complete combustion, and prevents the emission of black smoke which is unconsumed carbon going to waste through the chimney.

The amount of door opening which is necessary varies with the nature of the fuel, a gaseous coal such as Maitland, requiring more door opening than a less gaseous coal such as State Mine. Generally speaking, the door should be left in the lowest notch and then gradually closed as the volume of black smoke diminishes until the door is in the last notch.

Leaving the door wide open affects the draught through the firebox itself, and instead of all the air passing through the burning fuel, a large quantity of air passes through the fire door and thence through the firebox direct to the tubes, cooling down the gases and also cooling down the tubes, and in this way the efficiency of the boiler is decreased. In addition, the cold air striking the tubes is likely to produce unequal contraction and cause the tubes to leak. The practice of leaving the fire door open should be avoided, therefore, as much as possible.

22. **Q. What should be the condition of the fire on arriving at a station where a stop is made?**

A. Bright and clear, so that little smoke will issue from the chimney.

23. **Q. What should be avoided before arriving at a station where a stop is to be made?**

A. (i) Avoid putting on a fire just before a stop.

(ii) As far as possible avoid all duties that will distract attention from the signals and the track.

24. Q. **What should be the condition of the fire when the locomotive tops the summit of a long grade?**

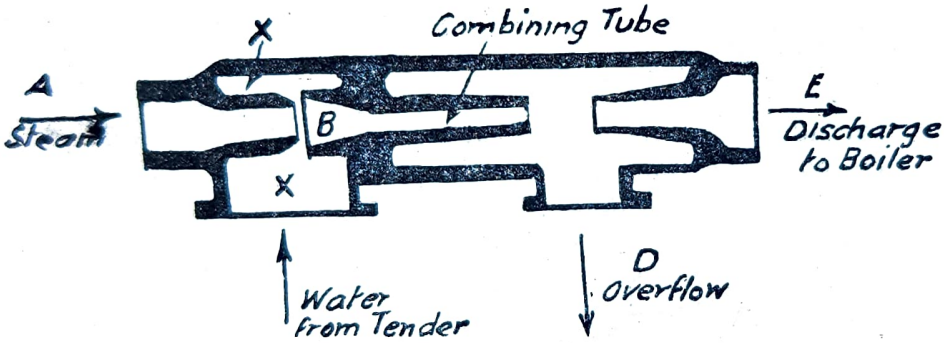
A. The same as for a station stop.

25. Q. **What is an injector?**

A. A device for feeding the boiler with water.

26. Q. **Explain the principle of the injector.**

A. There are numerous forms of injectors in use, but they are all developments of the arrangement of parts shown in the following illustration.



Steam at a high velocity passes from the boiler into the tube A, and striking the feed water at B is itself condensed. It, however, imparts a momentum to the water and sends it rushing along the delivery pipe E with sufficient force to raise the check valve against the boiler pressure and pass into the boiler. As the current of water could not at once be started into rapid motion against the constant pressure on the check valve, an overflow opening is provided in the injector through which the water can flow unchecked until the necessary momentum is obtained, when the overflow ceases. In a lifting injector the parts are so designed that, in starting, a jet of steam passes through the combining tube B at sufficient velocity to create a partial vacuum in the water chamber X, and atmospheric pressure then forces the water into this chamber from the feed pipe; the steam jet then striking the water starts it into motion through tube B. If too much steam is admitted for the quantity of water passing, air will be drawn in through the overflow

opening, mixing with the water and reducing its compactness, while some uncondensed steam will pass through with the water. This will reduce the force of impact of the feed water upon the check valve, and when it becomes so light that the momentum of the feed water is no greater than the boiler pressure on the check valve, the water will break and discharge through the overflow. On the other hand, when the quantity of water supplied is too great for the steam, part will escape through the overflow.

27. **Q. Explain how much water should be carried in a boiler.**

A. Sufficient water should be carried to cover the crown of the firebox and the front end of the tubes on "up" grades and to cover the crown of the firebox on "down" grades. Generally speaking, half a gauge glass should be showing on "down" grades and three-quarters of a gauge glass on "up" grades, with the exception of H, S, X and N class locomotives, which must have at least $\frac{7}{8}$ of a gauge glass of water when negotiating the rising ruling grades.

It must be appreciated that the water level is affected by changes in gradient, the water rising in the gauge glass when the locomotive is on a rising gradient and falling when the locomotive is on a decending gradient.

Under no circumstances must the water be out of sight at the bottom of the gauge glass.

28. **Q. Can too much water be carried?**

A. Yes. The carrying of too high a water level is harmful as priming is likely to take place, resulting in water being carried over to the cylinders with the steam, and for this reason the water must not be allowed to get out of sight at the top of the glass. Water in the cyclinder may result in damage to the cylinders, cylinder covers, pistons, or rods.

On superheater locomotives, water would be carried over to the elements and this would result in a reduction of the temperature of the steam.

The lubrication on the cylinder walls and valve faces would be washed off and excessive internal friction result,

which in turn causes greater wear on the rings and walls of the cylinder and valve chambers.

These harmful effects would also result in an increase in the amount of coal and water used.

29. **Q. (*a*) What is a fusible plug and what is its use? (*b*) How many plugs are fitted in the firebox crown plate?**

A. (*a*) A fusible plug is a gun metal plug with a hole in the centre filled with lead. It is fitted in the crown of the firebox, and so long as there is water over the plug, it is kept at a low temperature, but if the water does not cover the crown of the firebox, the heat in the firebox will melt the lead and steam and water will be permitted to pass through the plug to the fire and give warning that the water is too low, and that the fire must be drawn. These plugs are therefore supplied as safeguards against the burning of crown sheets on account of shortness of water, and which may cause a boiler explosion. The lead in the plugs must be renewed at every periodical Boiler Examination. (*b*) Two fusible plugs are fitted, one towards the front of the firebox crown plate just above the brick arch and the other towards the back of the firebox crown plate. 3 fusible plugs are fitted in the firebox crown of S & X class boilers and 4 in the H class boiler.

30. **Q. Describe the instructions that must be observed in regard to the washing out of locomotive boilers.**

A. The instructions are as detailed hereunder :—

(*a*) The boiler of every locomotive at a Depot or Outstation must be washed out as often as is directed by the Officer-in-Charge.

(*b*) Every Officer-in-Charge must make the necessary arrangements for a locomotive which is to be washed out to be left in such a position as will permit washing out to be performed without the necessity of moving it.

(*c*) Every boiler which is to be washed out must, if practicable, be allowed to stand until the water in the boiler has become cold. The blow-off cock is then to be opened and the water run off. The boiler must

then be washed out in accordance with clauses "g" to "n" of these Instructions.

(*d*) When sufficient time is not available for the water in the boiler to become cold and facilities for washing out with hot water are not provided, the following method of cooling down the boiler must be adopted :—

The Injectors must be put on and the boiler filled as high as possible. The steam pressure must be reduced to zero by allowing the steam to escape through the steam valves of the Injectors ; the Blower must not under any circumstances be used for the purpose of reducing the steam pressure.

The boiler must then be allowed to stand for as long as possible, but the minimum period must not be less than 12 hours for H., S., and X. class locomotives, 6 hours for Superheater locomotives of other classes, and 4 hours for all other locomotives, before cooling down is commenced. After this period of time has elapsed and the brick arch is reasonably cool, cold water may be gradually added through the top wash-out plug hole until the boiler is full, and must be allowed to flow out continuously through the Injector overflow pipes until the boiler is cold. Any other method of cooling down a boiler is prohibited.

Water must not be permitted to get below the crown of the firebox until the boiler is cold. Washing out must then be carried out in accordance with these Instructions.

(*e*) At any Depot where facilities for washing out with a hot water engine are provided it is not necessary for the boiler which is to be washed out to stand until it is cool, but the Injectors must be put on and the boiler filled up as high as possible. The steam pressure must be reduced to zero by allowing the steam to escape through the steam valves of the Injectors. The Blower must not under any circumstances be used for reducing the steam pressure. When the steam pressure has been reduced to zero the top wash out plug must be removed and the nozzle of the hose from the hot water engine

inserted. The boiler is then to be washed out in accordance with there instructions.

After washing out has been completed and the boiler has been inspected and passed by a Boilermaker or Officer-in-Charge, the plugs must be at once replaced and the boiler filled with hot water.

(*f*) Before any washing out is commenced the Big Ends, Side Rod Bushes, and Driving and Trailing Axle Boxes must be covered with a bag or piece of tarpaulin. The Rubber Hose or other protective devices must be also placed in position.

(*g*) The washout plugs which must be removed on the occasion of each washout and through which washing out must be carried out are indicated below :—

Location of Washout Plug.	At each Washout.	
	H, S and X.	Other Classes.
Arch Tubes ...	Removed (at every AB exam.)	Not fitted
Syphons	Removed ...	Not fitted
Firebox Plugs in Cab.		
Back Plate Corners, Upper	Removed ...	Removed on E and Y
Back Plate Corners, Lower	Removed ...	Removed. (E & Y excepted)
Back Plate Centre, Upper	Not fitted ...	Removed on D4, E, and Y.
Back Plate, Centre Lower	Removed where fitted	Removed. (D4, E, and Y excepted)
Firebox Crown	Removed ...	Removed
Firebox Filler	Removed ...	Removed
Plugs outside Cab.		
Boiler Barrel, near top of Firebox ...	Removed X class so fitted	Not fitted
Firebox Crown	Removed where fitted	Not fitted
Firebox Shoulder	Removed ... where fitted	See operation No. 4
Firebox at Hand Rail Level	Removed ...	Removed
Combustion Chamber ...	Removed ...	Not fitted
Side Water Space	Removed ...	Removed
Throat Plate	Not fitted	Removed
Front Corner	Removed ...	Removed
Bottom of Boiler Barrel ...	Removed ...	Removed where fitted
Top of Leading Course of Barrel	Removed ...	Removed (E, T, and Y excepted)
Smoke Box Tube Plate	Removed ...	Removed

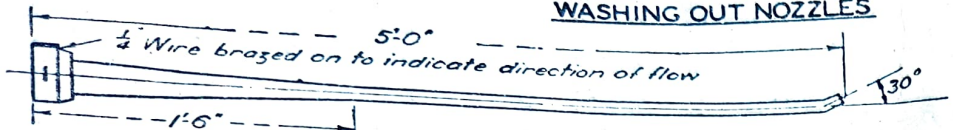
(*h*) The Rotary Cleaner must be regularly used in each Arch tube at every ABC examination, and also at intervening examinations if the condition of the interior of the tubes in regard to the presence of scale demands it.

The Rotary Cleaner must be used before washing out is commenced, and care must be taken to see that the rotary portion of the Cleaner always remains within the tube while it is being used.

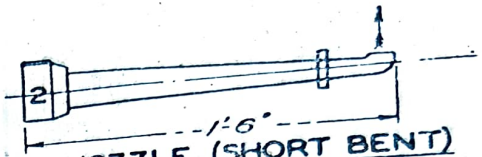
(*i*) The nozzles which are to be used for washing out are as follows (see diagrams on pages 12 and 13 :—

Number of Nozzle.	Description of Nozzle.	Where Used.
No. 1 ...	Long Bent Nozzle 5′ 0″ long, angle of bend 30°	Washing down Firebox crowns ; Syphons ; back of Smokebox tube plate and bottom of tubes from Smokebox ; Boiler Barrels
No. 2 ...	Short Bent Nozzle	Washing out back water spaces ; Firehole ring (Top and Bottom); Combustion Chambers ; Side Water spaces ; Front water space at Throat Plate
No. 3 ...	Short Straight Nozzle 1′ 6″ long	Side water spaces ; Crown of firebox ; filling up boiler
Nos. 4 and 5	R. and L.H. Boiler Barrel Nozzle 5′ 6″ long	Boiler barrel from plug holes at bottom of boiler barrel "N," "H," "S," and "X" class locomotives
No. 6 ...	Special Bent Nozzle 13″ long, angle of bend 90°, bend 4″ long	Back corners "D4" locomotives
No. 7 ...	Long Straight Nozzle 10′ 0″ long	Boiler Barrel from Smokebox end if barrel is found to be blocked up
No. 8 ...	Double Bent ...	Boiler Barrel from Smokebox on locomotives with Self-cleaning Smokeboxes. To be used if No. 1 Nozzle caannot be used
No. 9 ...	Special Nozzle, end set at angle of 30°	Side water spaces on boilers with plugs close to footplate
No. 10	Long straight Nozzle 3′ 9″ long	Firebox Syphons

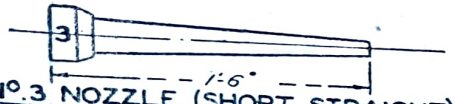
LOCOMOTIVE BOILERS
WASHING OUT NOZZLES



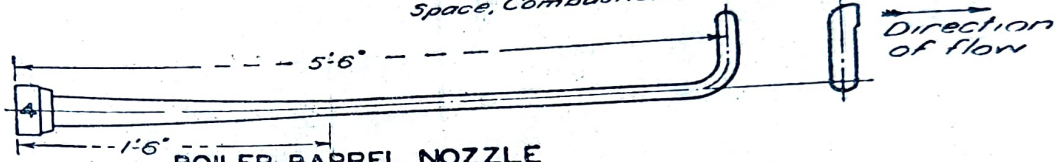
Nº.1 NOZZLE (LONG BENT)
Used for Washing Down Firebox Crown, Boiler Barrel from Smokebox



Nº.2 NOZZLE (SHORT BENT)
Used for washing out Back Water Space, Firehole Ring, Side Water Space, Combustion chamber, Throat Plate



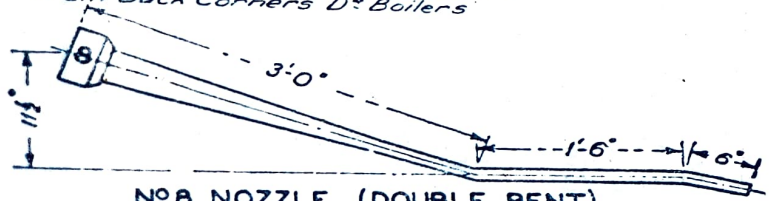
Nº.3 NOZZLE (SHORT STRAIGHT)
For washing out Side Water Spaces from inside Cab, Arch tubes, firebox Crown from outside Cab



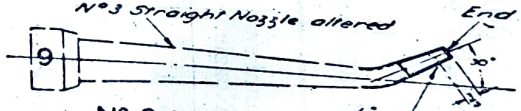
BOILER BARREL NOZZLE
Nº.4 R.H. Nº.5 L.H.
For washing out Boiler Barrels from Washout Plugs, located at Bottom of Barrels of H.S.N.X Engines. R or L to be used which suits location of Millcock

Nº.6 NOZZLE SPECIAL BENT
For washing out Side Water Spaces from Back Corners Dª Boilers

Nº 7 LONG STRAIGHT NOZZLE.
To be used for Clearing Barrel when Blockage is found to have taken place

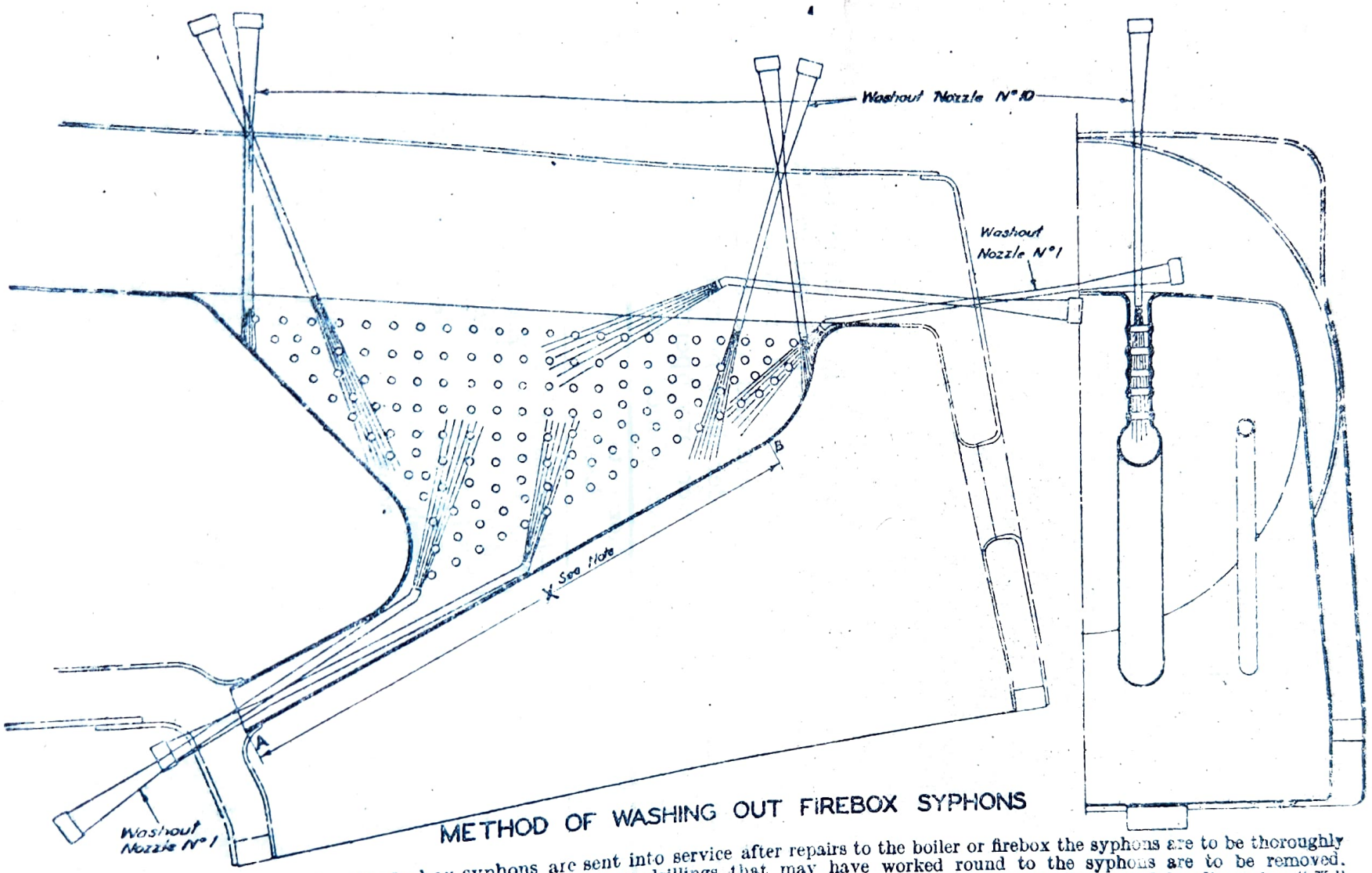


Nº.8 NOZZLE (DOUBLE BENT)
For Boiler Barrel from Smokebox, Improved Front End Engines. if Nº1 cannot be used



Nº 9 NOZZLE
For washing out Side Spaces on those A Engines (Stephenson Gear) with plug close to footplate. This nozzle to be used only when Nº 2 Short Bent nozzle cannot be used.

Traced M.C.T. 8-9-35



METHOD OF WASHING OUT FIREBOX SYPHONS

When engines fitted with firebox syphons are sent into service after repairs to the boiler or firebox the syphons are to be thoroughly inspected after each trip for the first three trips and any drillings that may have worked round to the syphons are to be removed. The syphons are to be thoroughly washed out whenever the boiler is washed out. The lower portion designated by dimension "X" between points "A" and "B" should receive special attention because of solids settling along this surface and its nearness to the hottest part of the fire. Washout holes are provided in the crown, back, and throat plates of the boiler for inspection and the insertion of nozzles. Washout nozzles Nos. 1 and 10 are to be used as shown on this diagram.

In order to wash down as large an area as possible, the Bent Nozzles, Nos. 1 and 2, must be given a rotary movement, and at the same time moved slowly backwards and forwards.

A mark has been provided on the screwed portion of the bent nozzles in order to indicate the direction of the flow of water.

(*j*) A Brass Rod must be used in the front firebox corner plug holes during each washing out operation for the purpose of removing scale and sludge.

(*k*) At every AB examination the Boilermaker making the Boiler examination must work the Long Brass Rod, which is specially provided for the purpose, through the bottom wash-out plug holes in the smokebox tube plate to ensure that there is no accumulation of scale and sludge in the barrel, particularly about the throat stays to the firebox tube plate.

(*l*) Every employe engaged in washing out a boiler must see that all scale and dirt is removed from the boiler barrel, the crown of the firebox and the water spaces.

The method of washing out and the sequence of operations as set out hereunder must be carried out on every locomotive except where any operation is shown to be limited to certain classes of locomotives.

Operation No.	Section of Boiler.	Nozzle to be Used.	Where Used.
		Firebox—From inside Cab.	
1	Firebox Crown	No. 1 (Long Bent) See page 13 for method of washing out Syphons	Each washout plug hole located in the back plate at the firebox crown level The scale and sludge to be washed towards the side water spaces. On A1, A2, D1, D2, and D4 boilers, the filler plug holes
2	Top of Fire-hole ring	No. 2 (Short Bent)	Each of the arch tube cap holes or the washout plug holes in the back plate at the firebox crown level. The water must be directed on to the top of the firehole ring

Operation No.	Section of Boiler.	Nozzle to be Used.	Where Used.
	Firebox—From inside Cab.		
3	Bottom of Fire-hole Ring and and Back water space	No. 2 (Short Bent)	Each of the back corner plug holes. The water to be played across the back water space towards the opposite side, & towards the bottom of the fire-hole ring
4	Firebox Crown	No. 3 (Short Straight) See page 13 for method of washing out Syphons	On H, S & X classes all plug holes above the hand rail commencing from that nearest to the cab & working towards the smokebox. On other classes the plug holes at the hand rail level or where these holes cannot be used the shoulder plug holes. The water to be played on to the crown of the firebox towards the opposite side
5	Top of side water spaces & barrel	No. 2 (Short Bent)	In each of the plug holes and in the same order as laid down in Operation No. 4 and the water played in all directions. From the front plug holes the water is to be directed along the top of the tubes towards the smokebox for at least two minutes on each side
6	Side Water Spaces	No. 2 (Short Bent)	Each side water space plug hole situated at about footplate level. The water to be played in all directions

Operation No.	Section of Boiler.	Nozzle to be Used.	Where Used.
7	Leading Course of Barrel	No. 2 (Short Bent) No. 3 (Short Straight)	Each nozzle to be inserted in the plug holes above the hand rails at the front end of the boiler barrel. The bent nozzle is to be given a rotary movement
8	Combustion Chamber (H, S, and X Classes)	No. 2 (Short Bent)	The plug hole located in the barrel in front of the throat plate and towards the bottom of the boiler. The water to be played in all directions
9	Barrel & Tubes from Smokebox End	No. 1 (Long Bent) or No. 8 (Double Bent)	Each of the smokebox washout plug holes. The nozzle must be moved slowly backwards and forwards, and also given a combined rotary and side movement for the purpose of cleaning out as large an area as possible
10	Boiler Barrel (Boilers with plugs in the bottom of the barrel)	Nos. 4 and 5 (Boiler Barrel)	The nozzle with the outlet facing towards the firebox must be inserted in each of the plug holes located at the bottom of the boiler barrel commencing with the plug hole nearest the smokebox and working towards the firebox. The screwed end of the nozzle must be given as much fore and aft movement as possible

Operation No.	Section of Boiler.	Nozzle to be Used.	Where Used.
11	Boiler Barrel blocked up	No. 7 (Short Straight)	Each plug hole in the smokebox
12	Arch Tubes (H, S, and X classes)	No. 3 (Short Straight)	Before the washing out of the arch tubes is commenced the front arch tube plug caps must be replaced The nozzle must be inserted in each of the arch tubes and the tubes thoroughly cleaned out
13	Front Water Space at Throat Plate (Except H, S, and X classes)	No. 2 (Short Bent)	Each plug hole in the throat plate (where fitted). The water to be played in all directions
14	Side Water Spaces from Cab	No. 3 (Short Straight) (On D4 engines Special Bent nozzle No. 6)	Each of the lower corner plug holes holes in the back plate or on E. and Y class boilers, the upper plug holes. Any scale or sludge deposited during washing out to be washed forward towards the front corner plug holes
15	Replacement of Plugs & Filling up	No. 3 (Short Straight)	After the boiler has been washed out in the manner laid down & has been inspected by a boilermaker, or Employe in charge, the wash out plugs and the syphon and arch tube plugs must be greased, replaced & tightened up. The boiler must then be filled to half a gauge glass of water

(*m*) When any boiler is left empty the employe concerned must hang on the cab front of the boiler a plate bearing the words "Boiler Empty' and also notify' his Supervising Officer who must take the necessary action to ensure that all concerned are advised accordingly.

(*n*) The boiler, after washing out has been completed, must be inspected by a Boilermaker, or where a Boilermaker is not available, by the Officer or Employe-in-Charge, who must satisfy himself that the crown of the firebox, boiler barrel, and water spaces and syphons (where fitted) are thoroughly clean, and the threads on the plugs and in the plug holes are clean and in good order.

At every AB examination the interior of each arch tube must be inspected by a Boilermaker for signs of denting, pitting or bulging.

(*o*) **Care must be taken to see that the Washout Plugs are not replaced crossthreaded.**

The Plugs must be greased before replacement, and after being screwed home they should be eased back about a quarter of a turn.

The blow-off cock must be free of scale, and before it is shut off finally, it should be opened and closed several times in order to clear any scale which may have become attached to the faces during the washing out operations.

31. Q. **What care must be taken of boiler washing out equipment?**

A. All equipment such as spanners, nozzles, and washout rods, must be gathered up after use and placed in a locker. Hoses must not be left lying about the Engine Shed, but should be coiled and placed around the washout hydrants, or on racks provided for the purpose. The Rotary Cleaner, after use, must be cleaned, inspected, oiled, and placed in the box provided, and returned to the Leading Hand Fitter's Store.

All equipment must be regularly inspected by the Officer-in-Charge, and maintained in good condition, particular care being exercised to see that leakage of water through faulty joints does not occur.

32. Q. **Explain the method and procedure which must be followed out when lighting up a locomotive boiler.**

A. In order to prevent damage to boilers and engine cabs during the process of lighting up and raising steam, it is necessary that the methods set out below must be strictly observed.

(1) **Equipment.**

Every employe engaged in lighting up a locomotive must have the following equipment :—A Shovel, Bannister Brush and Slush Lamp.

(2) **Examination and Tests before Lighting Up.**

(*a*) Before an employe commences to light up a locomotive, either cold or under steam, he must inspect the gauge glasses, pipes and connections, and see that they are in good order ; must see that about half a gauge glass of water is showing in both gauge glasses and then test the water level in each gauge glass as shown in sub-clauses (*b*) or (*c*) hereunder :—

(*b*) **Boilers not under Steam.**

(i) See that the steam valve on top of the boiler is fully opened.

(ii) Turn the water valve handle clockwise as far as possible and as the water in the boiler is then shut off, the water in the gauge glass should disappear and escape through the drain pipes.

(iii) Turn the water valve handle counter clockwise as far as possible and the water should again rise smartly in the gauge glass. If it rises slowly the water passage is partially blocked.

(iv) See that the water level in each gauge glass is about the same.

(v) When steam has been raised the test as shown for "Boilers under Steam" (sub-clause "c") must be carried out.

(*c*) **Boilers under Steam.**

(i) Close the steam valve on top of the boiler.

(ii) Turn the water valve handle clockwise about half a turn. This permits water to flow from the boiler direct to the drain pipe and assist in keeping the water passage clear.

(iii) Turn the water valve handle clockwise as far as possible.

(iv) Open the steam valve on top of the boiler and allow steam to blow through the glass to the drain pipe and so assist in keeping the glass clean.

(v) Turn the water valve handle counter clockwise as far as possible when the water should rise smartly in the glass. If it rises slowly this indicates a partial blockage of the water passage ; if it rises high in the glass and then settles back slowly the steam passage is partially choked.

(vi) See that the water level in each glass is about the same.

(vii) On " H," " S " and " X " class boilers the drain valve of the water column must also be opened for about five seconds in order to prevent any accumulation of sediment.

(*d*) He must see that the Regulator is closed, the reversing lever is in mid gear, the hand brake screwed on and the Release Cocks open ; see that the Injector Steam Valves, Blower Valve, Turbo Steam Valve, Lubricator Steam Valve and Air Compressor Steam Valve are closed ; examine the firebox, brick arch, baffle plate, firebars and grate, and see that they are in good condition ; try over the damper to see that it works freely, but leave it in the closed position.

(*e*) He must then get down from the cab and proceed to the smokebox along the left hand side of the engine but on the way must see that the damper is closed, and that the ashpan slides are closed and properly secured either by the pawl or locking device.

(*f*) He must thoroughly clean all spark arresting appliances in the smokebox with the wire brush and closely examine them for defects ; remove any ashes from behind the door flame plate ; clean the smokebox ring against which the door closes and screw the door up as tightly as possible by hand.

(*g*) He must then return towards the cab along the right hand side of the engine and see that the ashpan slides on that side are properly closed and secured. If the engine is standing over a pit the examination of ashpan slides must also be made from the pit.

(3) **Reporting of Defects.**

Any defects which have been observed, particularly in regard to the water gauge glasses and the spark and ash arresting appliances, must be reported immediately to the Officer-in-Charge, and he must take any action necessary to ensure that the locomotive is in a safe and proper condition before lighting up is commenced.

(4) **Method of Lighting Up.**

The Lighter Up must then proceed to light up the boiler in the following manner :—

(*a*) A Layer of selected lumpy coal must be placed around the four sides of the grate leaving the centre portion uncovered.

(*b*) A few pieces of lighting up wood are then to be placed in the centre portion of the grate, the kindling material ignited and placed on the wood, the remainder of the wood placed in position over the ignited kindling material and the fire allowed to burn in that condition **with the damper closed and the fire door open.**

(*c*) If necessary, additional wood may be used to raise sufficient steam pressure to enable the blower to be used.

(*d*) The blower valve may then be opened slightly and coal put on in small quantities and at such intervals as required to maintain a bright fire and to ensure that the boiler will have approx. 100 lb. of steam when the crew is due to sign on. **When the blower is being used the fire-door must be closed and the damper opened slightly.**

(*e*) In emergency cases coal may be added to the fire before the boiler has generated sufficient steam to work the blower of the locomotive provided the air blower is used. While the air blower is being used **the fire door must be closed and the damper opened slightly**

(*f*) Particular care must be taken to see that all lighting up wood is completely consumed before the locomotive leaves the Shed.

(5) **Early Lighting Up to be Avoided.**

In order to prevent wastage of fuel, boilers must not be lit up earlier than is necessary and the practice of lighting up in anticipation of the locomotive being ordered should be avoided.

(6) **GENERAL.**

During the whole of the time the Lighter Up is maintaining the fire, he will be responsible for keeping the spark arresters clear, the footplate swept clean and for seeing that smoke and flame do not enter the cab.

The presence of flame or smoke in the cab indicates that either the draught through the ashpan is excessive that the spark arresters require cleaning or the smoke-box door is not tightly closed.

33. Q. What are a Fireman's duties at the commencement of a shift?

A. Every Fireman must come on duty punctually at the time appointed, strictly sober and as clean and tidy as his duties will allow.

He must sign on, peruse the Sheet and Notice Boards, obtain his stores, and go to the locomotive.

He must first examine the pressure gauges, then test each of the water gauge cocks in order to ascertain if there is sufficient water in the boiler.

He must then examine the inside of the firebox to see that the tubes are not burred, that the brick arch and baffle plate are in good order, and that no firebars are missing.

The smokebox must then be examined, the spark arresters cleaned with the wire brush provided for the purpose, and the joint of the smokebox door cleaned and greased.

The fire should then be attended to in the following manner :—Starting with slow burning coal the fire should be so built up that a bright bed of coke may be formed in the firebox, which will permit of the subsequent charges of coal, placed on the fire, burning through completely.

After the fire has been built up, its temperature should be controlled by careful use of the damper and blower.

The guiding principle is to think well ahead of the work in hand in order to conform to the laws of combustion which cannot be unduly hastened in locomotive boilers without damage to boiler, losses in heat, shed maintenance, and damage to buildings, etc., with soot-laden gases.

When the steam pressure permits, both Injectors must be tested.

The Fireman must see that the locomotive is equipped with a full set of fire irons, and that these are placed safely on the tender ; also that it is fully equipped with lamps, properly cleaned, and in good order. The engine and tender hand brakes where provided must be cleaned and oiled, the footplate swept, and the windows of the cab, and the front of the firebox cleaned.

When the Driver is ready to move on to the turntable, the Fireman, if men are employed to turn the table, must see that it is in its proper position. If no men are so employed, the Fireman must place the turntable in the proper position, then stand on the Driver's side on the end of the turntable nearest the locomotive in order to bring the wheels on that end down on to the circular track.

34. **Q. If a Fireman finds that the water is low in the boiler, or that the boiler is likely to be late in steam, what should he do?**

A. After taking the necessary steps to ensure the safety of the boiler, he should call the attention of the Driver and the Officer-in-Charge to the matter at once.

35. **Q. Do you understand that the Fireman is entirely subordinate to the Driver, and must carry out whatever instructions are given him, cheerfully and respectfully?**

A. Yes.

36. **Q. Do you also understand that the Fireman is not relieved of any responsibility in regard to Signals, and that he must always be on the alert to act on his own responsibility?**

A. Yes.

37. **Q. What are the Fireman's duties after leaving the shed and when on the road?**

A. After leaving the shed the Fireman must time his firing so that he will be able to keep a good lookout for fixed and other signals, and he must, at all times, draw the Driver's attention to anything he considers is not safe.

When the locomotive is moving about in yards, either shunting or going to and from trains, he must keep a good lookout for Points, Point Indicators, Discs and Fixed Signals which are within his view.

When the locomotive has set back on to the train, the Fireman must promptly couple it to the train, screw up the coupling as far as possible, connect the Hose Coupling Pipes, and open both the Brake Pipe Cocks.

When starting away from any platform, the Fireman must exchange hand signals with the Guard, as laid down in the Rules and Regulations, and look back until the last vehicle has passed the platform. When leaving a Yard or, in the case of a Goods Train when re-starting after stopping, the Fireman must exchange hand signals with the Guard when he is in the Van.

If he does not receive a signal from the Guard he must immediately so inform the Driver.

When firing, coal must be broken up into lumps not larger than 4 in. cubes, the fire must be kept bright and wedge-shaped, sloping towards the tube plate, the firing must be regulated to minimise the waste of steam through the safety valves, and when standing at or passing Stations the fire door must be opened sufficiently to prevent the formation of black smoke.

When approaching a Station where it is intended to clean a fire, the following procedure should be adopted :—

The fire should be worked as low as possible consistent with keeping steam ; but there should always be a sufficient body of fire in each back corner to permit a bank of new coal placed therein being kindled ready for spreading. Care is to be taken not to bank the coal under the fire door, otherwise the pricker will become overheated while the fire is receiving attention.

Upon arrival at the Station, the pricker should be used to push the dirt and clinker forward, including that under the two banks of coal previously referred to, The two banks should then be ready for spreading, but care should be exercised to see that as much as possible of the dirt and clinker is pushed out through the dump grate into the pan before the new fire is spread.

If this practice is adopted, a good starting fire will always be assured.

After cleaning the fire it must be spread, and where there is no pit accommodation, any live ashes, etc., must be quenched with water before leaving.

In order to prevent warping of the ashpan, the ashpan sprinklers (when fitted), must be used every time the fire is cleaned, and in addition every 15 miles when the engine is running on a Goods train and every 30 miles when the engine is running on a Passenger train.

Any spare time at roadside Stations must be occupied in cleaning the lamps and cab, and trimming the coal on the tender.

At Caretaker and No-one-in-Charge Stations, or at any other specified Stations, the fireman must assist with the shunting and van goods when required.

When any break-down or block takes place, the Fireman must carry out all instructions from the Driver, as provided for in the Book of Rules and Regulations, etc.

When exchanging the Staff at Staff Stations, either by hand or with the Auto. Staff Exchanging Apparatus, the Fireman must do so as prescribed in the Book of Rules and Regulations, and as laid down in the General Appendix. The Staff, when it is received, must be immediately examined in order to make certain that it applies to the section the train is about to enter. The Driver must be handed the Staff by the Fireman who must at the same time call out the names of the Stations marked thereon.

38. Q. **What are the duties of a Fireman from the time the train reaches the Terminal till the locomotive is put away?**

A. On arrival at the Terminal, and when instructed to do so by the Driver, the Fireman must close both Brake Pipe Cocks and disconnect the Hose Coupling Pipes, uncouple the locomotive from the train, and, where provided, couple the dummy coupling to the Hose Coupling Pipe.

When returning to the Engine Shed the same duties with regard to keeping a lookout, apply as when leaving it prior to commencing the trip.

The Fireman must bear in mind that the trip is practically completed, and do any firing required accordingly.

All ash and cinders must be removed from the smokebox and from between the flame plate and the smokebox door, and must be swept off the front footplate and the steps of the cow catcher. The Air Compressor must not be working while the smokebox is being cleaned.

On arrival over the pit, the water must be just showing in the top of the gauge glasses, and, unless otherwise ordered, the pressure of steam should be high.

The water tank must be filled, the filler hole lid placed in position, and the Water Crane left properly secured.

The Damper, Slides, Ash Arrester and Dump Grate must be opened in the order shown, and the fire must then be thoroughly cleaned out or banked.

Banking of fires, at the completion of a shift, must only be done on the authority of the Rolling Stock Officer-in-Charge.

The blower must then be shut off and the Dump Grate closed. The Ash Pan must then be thoroughly cleaned out, after which the Ash Arrester, Damper and Slides must be properly closed and secured.

If no Fuelmen or Cleaners are employed on the coal stage, the Fireman must assist in coaling the locomotive.

When the locomotive is placed in its allotted position at the Depot, the Fireman must screw the hand brake hard on, assist to fill sand boxes, put away the engine kit, return to the store all oil containers, and, when given permission by the Driver, sign off.

WESTINGHOUSE AIR BRAKE.

39. **Q. What power is used to operate the continuous brakes on Locomotive sand trains?**

A. Compressed air.

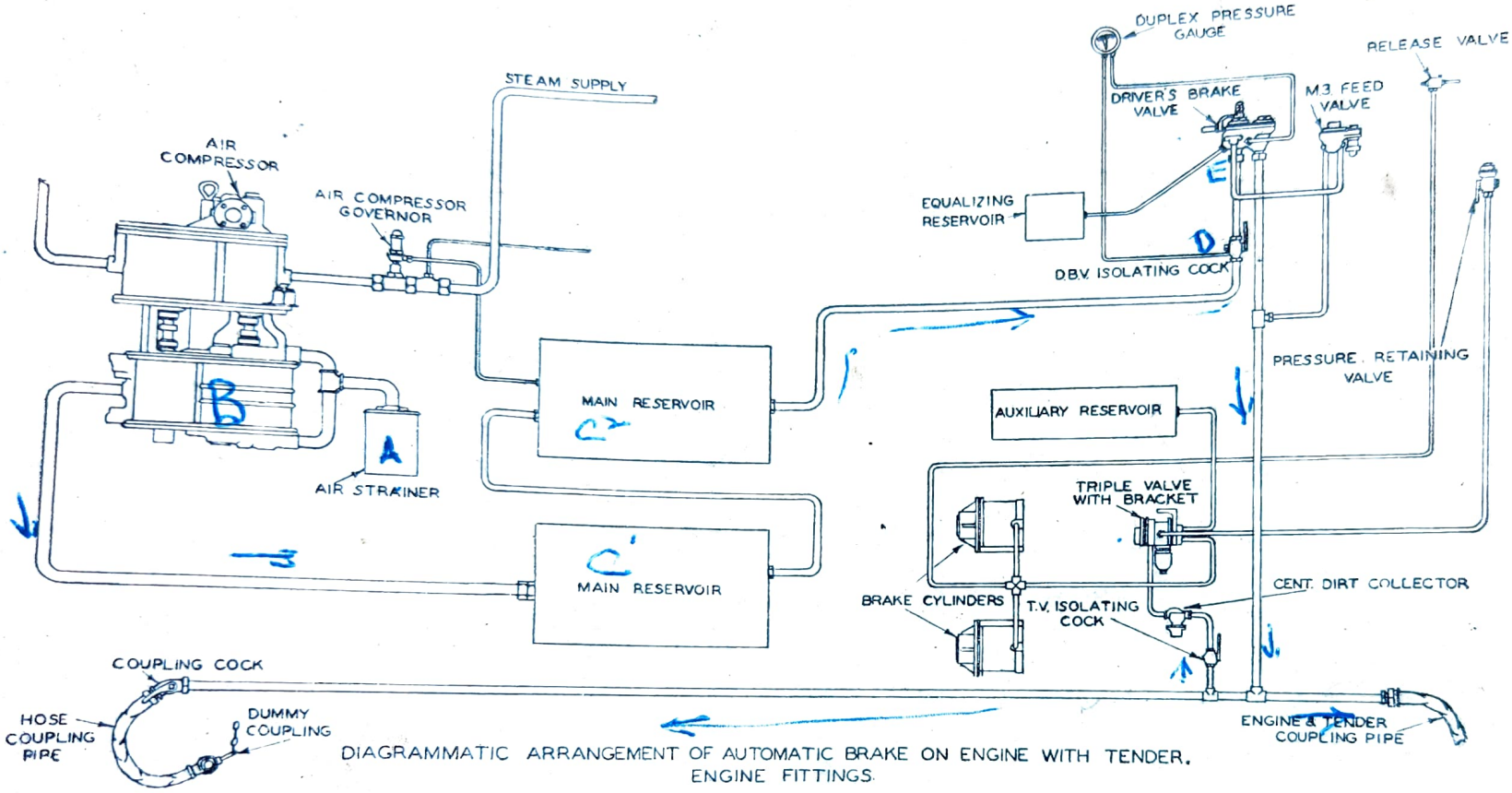
40. **Q. How is the compressed air obtained?**

A. The air is compressed by an Air Compressor attached to the locomotive.

In the case of a steam locomotive, the Air Compressor is driven by steam from the boiler, and on electric locomotives by an electrically-driven motor. In all cases the air is compressed in the air cylinders of the Air Compressor and forced into the Main Reservoir.

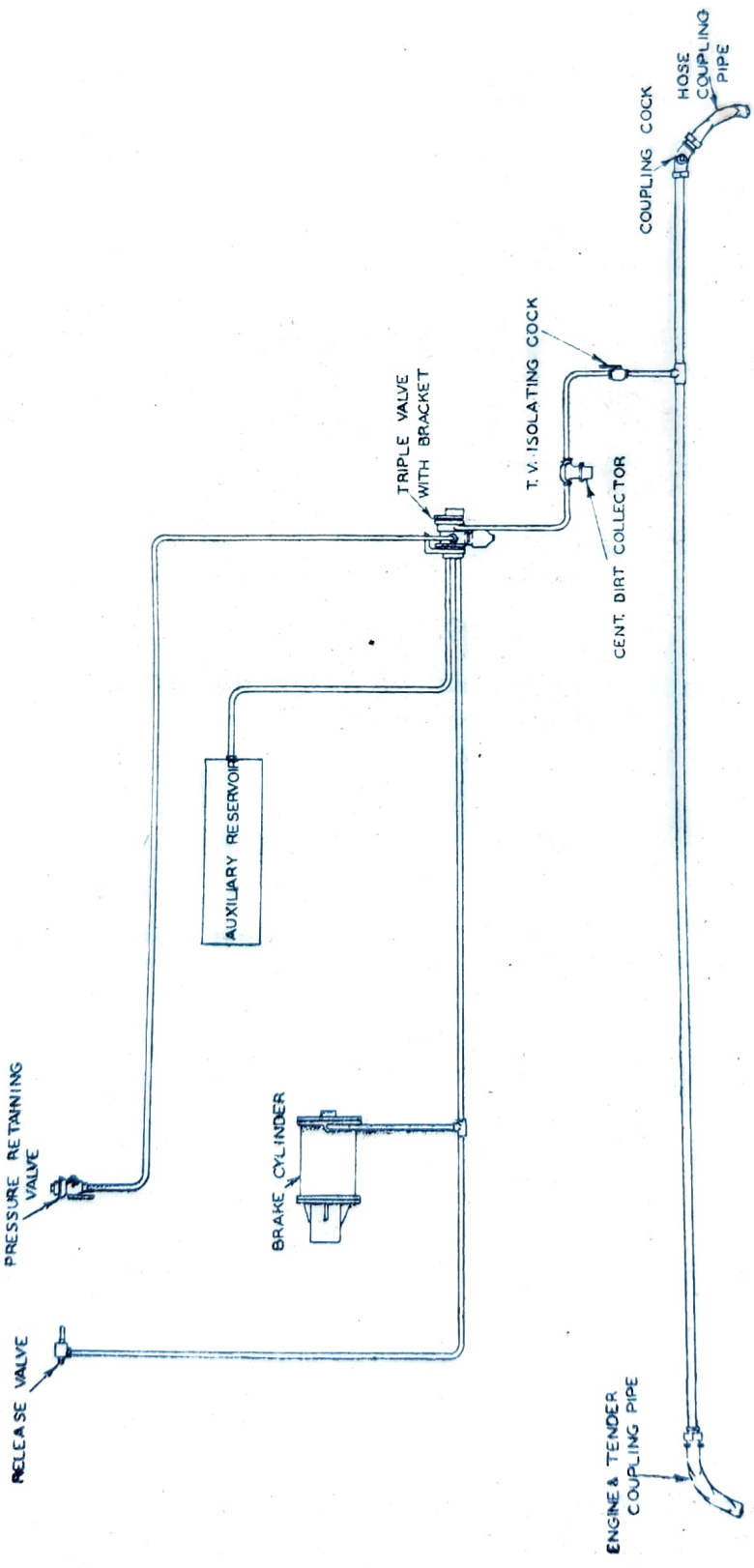
41. **Q. How does the compressed air apply the brakes?**

A. The compressed air is stored in an Auxiliary Reservoir on each vehicle, and when a reduction of pressure occurs in the Brake Pipe the piston of the Triple Valve causes the air to flow from the Auxiliary Reservoir to the Brake Cylinder. The Brake Cylinder contains a piston and piston rod which is forced outwards by the compressed air and by means of suitable levers and rods, forces the brake blocks against the wheels.



DIAGRAMMATIC ARRANGEMENT OF AUTOMATIC BRAKE ON ENGINE WITH TENDER. ENGINE FITTINGS.

FIG. 1.



DIAGRAMMATIC ARRANGEMENT OF AUTOMATIC BRAKE ON ENGINE WITH TENDER.
TENDER FITTINGS.

FIG. 2.

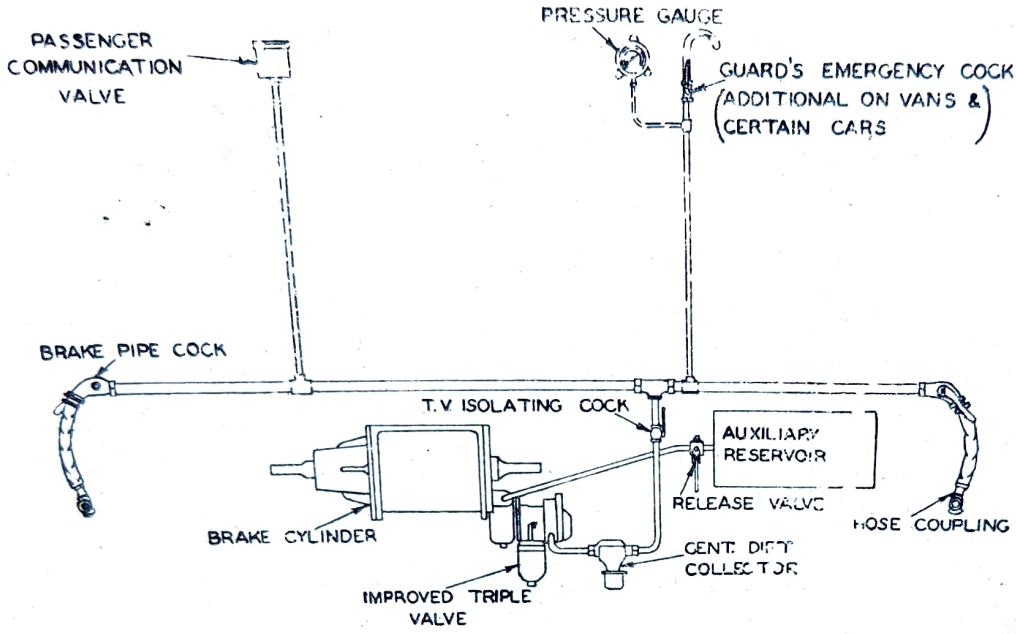


FIG. 3.

Diagrommatic Arrangement of Automatic Brake on Passenger Vehicle.

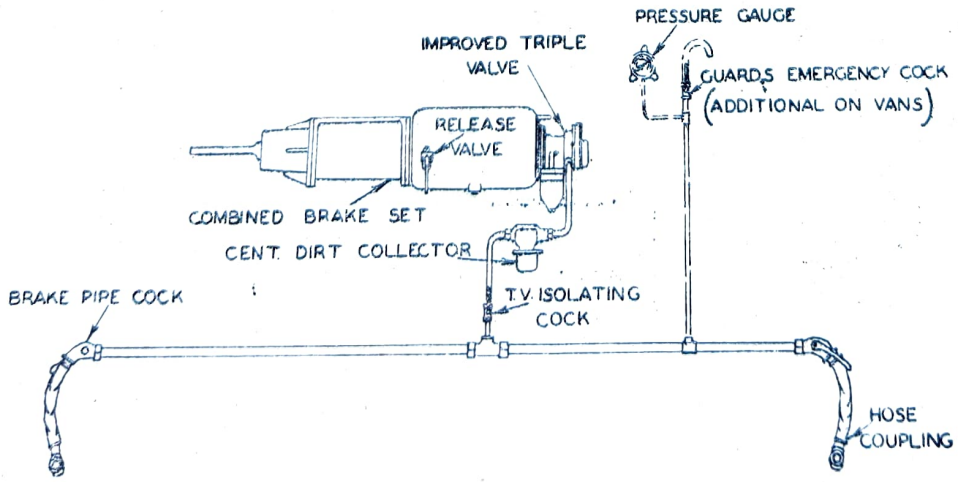


Fig. 4.

Diagrammatic Arrangement of Automatic Brake on Goods Vehicle.

42. **Q. Describe the principle of the Westinghouse Automatic Air Brake.**

A. It is a compressed air system operating as a continuous brake throughout the train. The reducing or increasing of the air pressure in the Brake Pipe controls the application or release of the brakes respectively.

43. **Q. Name the principal parts of the Air Brake equipment on the Locomotive.**

A. Air Compressor, Main Reservoir, Driver's Brake Valve, Brake Pipe, Triple Valve, Auxiliary Reservoir, Brake Cylinder, related air pipes and fittings, and brake rigging. The Straight Air Brake is also fitted to some locomotives.

All recently constructed locomotives are provided with A-6-ET locomotive brake equipment.

44. **Q. What are the principal parts fitted on tenders and other vehicles in a train?**

A. Brake Pipe, Triple Valve, Auxiliary Reservoir, Brake Cylinder, related air piping and brake rigging.

45. **Q. What is the Main Reservoir used for?**

A. To store sufficient compressed air to charge the Brake Pipe and release the brakes, and to operate other pneumatic devices on the locomotive.

46. **Q. What is the Driver's Brake Valve used for?**

A. To control the flow of compressed air from the Main Reservoir to the Brake Pipe, and from the Brake Pipe to the atmosphere.

47. **Q. What is the Brake Pipe used for?**

A. It forms the continuous brake connection throughout the train and conveys the compressed air from the Driver's Brake Valve to the Triple Valves throughout the train.

By controlling the pressure of the compressed air in the Brake Pipe the Driver is enabled to apply or release the brakes as desired.

48. **Q. What are the functions of the Triple Valve?**

A. To charge the Auxiliary Reservoir and to admit and release air to and from the Brake Cylinder for the purpose of applying and releasing the brake.

49. **Q. Why is an Auxiliary Reservoir necessary on each vehicle?**

A. Because it is a compressed air storage reservoir located on each vehicle, and furnishes the power that applies the brake on that vehicle.

50. **Q. Explain how the compressed air is supplied to the Auxiliary Reservoir on each vehicle.**

A. Compressed air flows from the Main Reservoir on the locomotive to the Driver's Brake Valve, then through the Driver's Brake Valve when in Release or Running position to the Brake Pipe, which extends throughout the train.

Rubber Hose Coupling Pipes are fitted between the engine and tender and also between all vehicles on the train to provide flexibility. A Brake Pipe Cock is also fitted on the ends of each vehicle, and when all the Hose Coupling Pipes are coupled together and all the Brake Pipe Cocks are open, a continuous Brake Pipe connection extends from the Driver's Brake Valve to the rear of the last vehicle on the train.

A branch pipe fitted with a cut out cock leads off the Brake Pipe on each vehicle and conveys the compressed air from the Brake Pipe to the Triple Valve. The compressed air forces the Triple Piston to Release position and passes through the feed grooves to the Auxiliary Reservoir charging it to Brake Pipe pressure.

51. **Q. What is the function of the Brake Cylinder?**

A. It transmits the expansive force of the compressed air from the Auxiliary Reservoir through the brake rigging to the brake blocks, forcing them against the wheels.

52. **Q. How is the pressure in the Brake Cylinder controlled?**

A. By decreasing or increasing the pressure in the Brake Pipe which controls the movements of the Triple Piston and permits the air to flow from the Auxiliary Reservoir to the Brake Cylinder, or from the Brake Cylinder to the atmosphere.

53. **Q. How are the Automatic Brakes applied?**

A. By a reduction of Brake Pipe pressure produced :—

(*a*) **Purposely.**

(i) By the operation of the Driver's Brake Valve.

(ii) By the opening of a Brake Pipe Cock at the front or rear of a train or the cock in the Guard's van.

(iii) By the opening of the Passenger Communication Valve on a passenger car.

(*b*) **Accidentally.**

(i) By the train dividing.

(ii) By a Burst Hose Coupling Pipe.

(iii) By any other air pipe rupture between the Air Compressor and the Triple Valve on any vehicle in the train.

54. **Q. Explain how the Air Brakes are applied from the locomotive.**

A. The handle of the Driver's Brake Valve is turned towards the right to the "Service" application or "Emergency" position. This cuts off the Main Reservoir from the Brake Pipe and the compressed air in the Brake Pipe is discharged through the exhaust port in the Driver's Brake Valve to the atmosphere.

The resultant reduction of Brake Pipe pressure permits the Auxiliary Reservoir pressure on each vehicle, which is now greater than that in the Brake Pipe, to force the Triple Valves to the applied position and the Auxiliary Reservoir pressure is then permitted to flow into the Brake Cylinder, applying the brake blocks to the wheels.

55. **Q. How are the Air Brakes released?**

A. By returning the handle of the Driver's Brake Valve to the left or Release position. This reopens the connection between the Main Reservoir and Brake Pipe. Air now flowing from the Main Reservoir increases the pressure in the Brake Pipe above that remaining in the Auxiliary Reservoir with the result that the Triple Valves are forced to Release position, which permits the air to escape from the Brake Cylinder to the atmosphere and thus releases the brake blocks from the wheels. At the same time the Auxiliary Reservoirs are again charged to Brake Pipe pressure through the Triple Valve Feed Grooves.

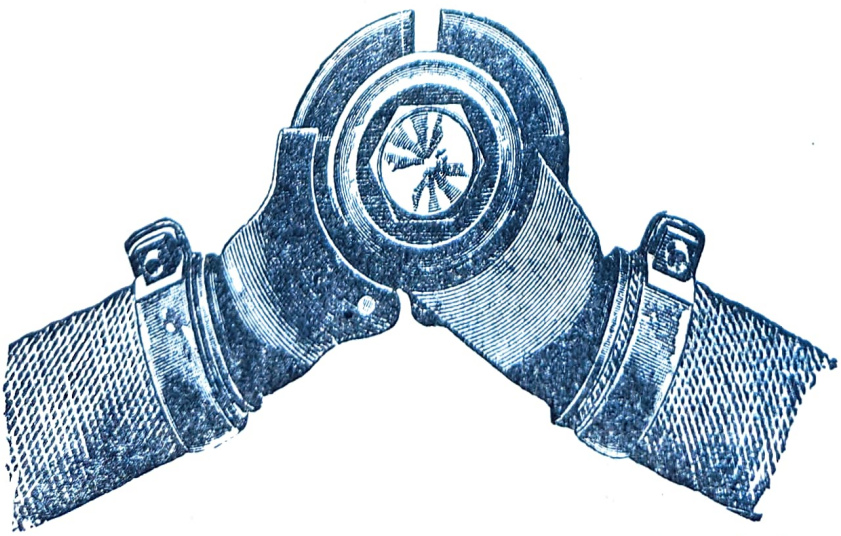
56. **Q. How is the Air Brake on each vehicle released by hand?**

A. By pulling the release wires connected to the sides of a vehicle or operating the hand release valves in the cab of a locomotive.

57. **Q. How is the continuous Brake Pipe connected between vehicles?**

A. By flexible rubber Hose Pipes attached to the Brake Pipe Cocks by a screwed nipple at one end, and having a metal coupling head at the other, so arranged that they can be readily coupled or uncoupled.

Hose Coupling Heads



Position of Coupling Heads before they can be united.

58. **Q. How are the Hose Coupling Pipes between vehicles united and made air-tight?**

A. By placing the coupling heads face to face almost at right angles, and then turning the projecting lugs into the corresponding grooves of the coupling heads. The two coupling heads are exactly alike, each being provided with a rubber packing ring, so arranged that when the coupling heads are united, the packing rings are forced together by the air pressure and make an air-tight seal.

59. **Q. Where are the Brake Pipe Cocks located on each vehicle ?**

A. At each extreme end of the Brake Pipe, and form the connection between the air Hose Coupling Pipe and the Brake Pipe.

60. **Q. For what purpose are Brake Pipe Cocks provided?**

A. To close the Brake Pipe on both sides of air Hose Coupling Pipes which have to be parted when dividing the train, and to close the Brake Pipe at both ends of the train.

61. **Q. Describe the position of the Brake Pipe Cock Handle in relation to the Brake Pipe when in the open and in the closed position.**

A. The Handles of the Brake Pipe Cocks will point across the Brake Pipe when closed and in line with the Brake Pipe when open.

Any doubt as to whether the Cock is open or closed can be determined by observing the cut which is provided on the plug and extended across on to the Handle.

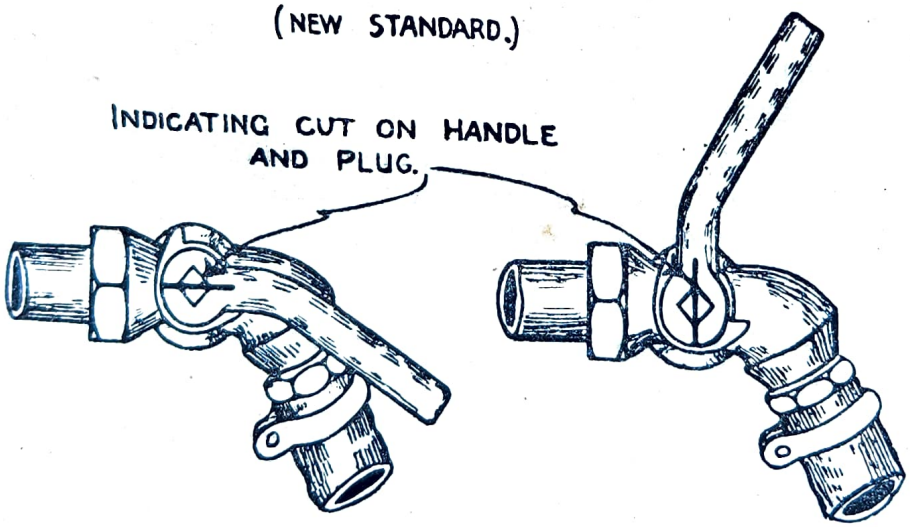
In every case when the Cock is open the cut will be along the Brake Pipe, and when closed the cut will be across the Brake Pipe.

62. **Q. How many kinds of Brake Pipe Cocks are there?**

A. Generally two; the new standard Brake Pipe Cocks which have horizontal stop plugs with the handle on the side of the Cock, as illustrated below, and those with vertical stop plugs which have the handle on top of the Cock.

BENT BRAKE PIPE COCK.

(NEW STANDARD.)



63. **Q. What must be done after the Hose Coupling Pipes between two vehicles have been connected together?**

A. The corresponding Brake Pipe Cocks must be fully opened to allow a free passage for the compressed air through the Brake Pipe.

64. **Q. Before disconnecting the Hose Coupling Pipes between two vehicles, what must be done?**

A. The corresponding Brake Pipe Cocks must always be closed.

65. **Q. What must be done with the Brake Pipe Cock on the tender immediately before connecting the Hose Coupling Pipe to that on the first vehicle of the train?**

A. It should be opened momentarily to give the Brake Pipe of the locomotive a good blow out to remove grit and other foreign matter.

NOTE.—IN ADDITION TO THE FOREGOING, CLEANERS MUST HAVE A KNOWLEDGE OF THE USE OF FIXED, HAND AND LAMP SIGNALS AS LAID DOWN IN THE RULES AND REGULATIONS, AND A GENERAL KNOWLEDGE OF THE RULES AND REGULATIONS LAID DOWN FOR THE GUIDANCE OF ENGINEMEN.

PRACTICAL QUESTIONS FOR ACTING FIREMEN BEFORE BEING CLASSIFIED AS FIREMEN.

66. **Q. Trace the passage of the steam from the time it leaves the boiler until it reaches the atmosphere; (*a*) Saturated locomotives; (*b*) Superheated locomotives.**

A. (*a*) On Saturated engines, the regulator valve being opened, the steam passes from the dome into the internal steam pipe in the boiler, then into the steam chest, and is admitted to the cylinder by the piston or slide valve opening the steam port. After doing its work in the cylinder, the steam returns through the same port into the cavity of the slide valve, where such valves are fitted, or into the exhaust chamber in the steam chest, where piston valves are fitted. From the cavity in the slide valve or the exhaust chamber in the steam chest, as the case may be, the steam passes to the exhaust pipe, and up the chimney to the atmosphere. (*b*) On Superheated locomotives, the regulator valve being opened the steam passes from the dome into the internal steam pipe in the boiler, then to the saturated compartment of the header or steam collector fitted in the smokebox. From the header or steam collector, the steam passes through the elements in the large flue tubes and re-

turns as superheated steam to the superheated compartment of the header or steam collector. From the header the superheated steam passes to the steam chest and is admitted to the cylinder by the piston valve opening the steam port. After doing its work in the cylinder, the steam returns through the same port to the exhaust chamber in the steam chest and thence to the exhaust pipe and up the chimney to the atmosphere.

67. **Q. Describe (*a*) the gauge glass and its mounting. (*b*) The method to be carried out in testing the water level in the boiler.**

A. (*a*) The gauge glass consists of a two-piece gun metal mounting bolted together, into which is fitted a rectangular shaped glass. One side of the mounting is slotted to enable the glass to be seen. The mounting is provided with a screwed nipple at the top and bottom and the gauge glass with its mounting can be readily removed when occasion arises.

From the top nipple a pipe is taken to a steam valve which is located on the top of the boiler and under ordinary working conditions this valve must be kept fully opened, otherwise a false indication of the water level is obtained in the gauge glass.

The bottom nipple is connected to the gauge glass boiler mounting, one part of which is permanently fixed to the boiler face. A hole is drilled through the boiler plate and this communicates with a chamber inside the gauge glass boiler mounting. A spindle having a square thread is provided in the outside portion, that is, the part which can be detached from that portion which is permenently attached to the boiler. This is necessary in order to carry out repairs to the valve faces in the chamber inside the boiler mounting. The end of the spindle is provided with two valve faces, the front one of which is tapered towards the boiler, while the back face is tapered away from the boiler.

When the spindle is turned in a clockwise direction the front valve face of the spindle makes contact with the valve face on the mounting fixed to the boiler and the water from the boiler is then shut off. A free passage is then left for the steam to flow through the steam cock

on the top of the boiler through the space behind the glass, through the boiler mounting and thence to the drain pipe and to the ash pan.

When the spindle is turned in a counter clockwise direction the back valve face of the spindle seats on the screwed portion of the mounting, the flow of steam from the steam cock on top of the boiler through the gauge glass to the drain pipe is shut off, a free passage through the opening in the boiler is provided and water rises in the gauge glass until it reaches the level of that in the boiler. If the steam valve on top of the boiler is closed, the water will rise up in the glass until out of sight owing to there being no steam pressure on the top of the water.

(*b*) Testing Water Levels.

On taking over a locomotive under steam the level of the water in both glasses should be inspected in order to see that they agree. On some occasions a slight difference may be noticed, however, owing to the irregularities in the road level.

Each gauge glass must be tested separately in the following manner :—

(1) See that the steam cock on top of the boiler is fully opened.

(2) Turn the handle on the spindle in a clockwise direction as far as possible. The water will then be shut off and the steam will blow direct from the boiler through the gauge glass and drain pipe to the ash pan.

(3) Turn the handle of the spindle as far as possible in a counter clockwise direction and the water should rise smartly in the glass.

If the water rises slowly it indicates a partial blockage of the water way.

If the water rises high in the glass and then settles back slowly it indicates that the steam passage is partially choked.

When hostling a locomotive the Driver must test each gauge glass separately in the following manner :—

(1) Close the steam cock on top of the boiler.

(2) Turn the handle of the spindle about half a turn in a clockwise direction.

This will permit water to flow through the hole which is drilled in the boiler plate, thence through the chamber in the mounting and so to the drain pipe and ash pan, the water way thus being freely blown through.

(3) Turn the handle of the spindle in a clockwise direction as far as possible.

(4) Open the steam valve on top of the boiler whereupon steam will flow through the glass and thence to the drain pipe and pan, resulting in the steam passage being blown clear.

(5) Turn the spindle as far as possible in a counter clockwise direction when the water should rise smartly in the gauge glass.

68. **Q. What defects will cause a false indication of the water level?**

A. Leakages of steam at the union nuts or excessive leakage at the gauge glass joints or blockages of steam or water passage ways.

69. **Q. If a variation in water levels is found, what should be done?**

A. The attention of the Officer-in-Charge must be immediately drawn to the defect.

70. **Q. What special precautions should be taken when a variation of water level in the two gauges is observed when a locomotive is in service?**

A. The water level in both glasses should be tried over in order to see if any blockage has taken place and if one is found defective it must be shut off.

In any case where the test indicates that the water and steam ways are clear but that for some reason a variation still exists, the gauge glass showing the lesser water level must be worked to and precautions must be taken to see that the water level is maintained as high as possible consistent with the work to be done.

71. **Q. What is the reason for fitting Release Cocks to the cylinders and steam chests?**

A. Release Cocks are fitted to enable the steam chest and cylinders to be drained of water which may accumulate when a locomotive is standing, or which may be carried over when the boiler primes or when the water is carried too high in the boiler and the regulator is suddenly opened.

72. **Q. What harmful effects are likely to occur if the water in cylinder and steam chests is not carefully blown out?**

A. As water is incompressible, the ends of the cylinders are likely to be knocked out. Damage to cylinders, pistons and piston or connecting rods is also likely to result.

73. **Q. How are cylinder and steam chest release cocks controlled?**

A. They are controlled by the operation of a lever in the engine cab.

74. **Q. How many positions has the release cock operating lever, and describe the operation of the release cocks?**

A. Two—open and closed.

Open position.—When the lever is moved to the open position the valve in the release cock body is opened through the movement of a tapered rod. Although there is pressure on top of the valve when steam is admitted to the cylinder the valve cannot seat itself owing to the presence of the rod.

Closed position.—When the lever is moved to the closed position the valve is no longer held open by the tapered rod and it can then be closed by steam pressure in the steam chest or cylinder, as the case may be. A small spring is fitted beneath the stem of the valve, and this keeps the valve off its seat when the locomotive is standing and so allows the cylinder and steam chest to drain. As soon as the regulator is opened the steam pressure in the cylinder forces the valve down against the small spring, the valve seats itself and the escape of steam and water is cut off.

On some of the older types of locomotives plug release cocks are provided, and these consist of a tapered plug provided with a hole which in the open position provides a free passage from the cylinders and steam chest.

75. **Q. In what way must the locomotive be left in regard to the release cocks when it is put away or left unattended?**

A. The release cock operating lever in the engine cab must be left in the open position.

76. **Q. What precautions in regard to the release cocks should be observed by an employe responsible for the lighting up or care of a locomotive boiler?**

A. He should see that the release cocks are in the open position and that they remain in this condition all the time the locomotive is under his charge.

77. **Q. Why is it not sufficient to rely upon the position of the release cock operating lever in the cab in order to decide if the release cocks are open?**

A. Because there may be defects in the operating mechanism, and it is therefore always necessary to examine the release cocks and the tapered rod.

78. **Q. Describe how a locomotive should be started from rest in order to prevent damage to the cylinders owing to the possible presence of water.**

A. During the time the locomotive has been standing the release cocks should have been open, but before starting the Driver must assure himself that the release cocks are open. The locomotive must be moved slowly so that all the water can be expelled through the release cocks and they must not be closed until all signs of water have disappeared from the release cocks or chimney. Under no circumstances should the release cocks be closed until the locomotive has moved at lease four locomotive lengths.

79. **Q. When should the release cocks be opened during the trip?**

A. The release cocks should be opened when there are any signs of priming or water being carried over with the steam to the cylinders. Also, when it is known that the duration of a stop will exceed ten minutes the release cocks should be opened immediately the locomotive stops.

80. **Q. What parts require special attention in the examination of a locomotive?**

A. Connecting and side rods, big and little ends and side rod bushes, all valve gear, springs and spring gear, all air and hand brake equipment, release cocks and gear, bye-pass valves and connections, all spark and ash arresting appliances, smokebox and internal fittings, firebox, tubes, baffle plate, grate and brick arch, all union nuts, bolts, set screws, cotters, split pins, etc.

81. **Q. Is it necessary to go underneath the tender as part of the regular examination, before leaving the shed?**

A. Yes; the brake gear, the springs, pins, the couplings between engine and tender, etc., are liable to be defective.

82. **Q. What if the effect of filling the boiler too high at starting?**

A. When the regulator is opened, wet steam instead of dry steam may be drawn through the internal steam pipes to the cylinders. With Superheater locomotives the elements may become filled with water and this water has to be evaporated before the full benefit of superheating can be obtained. The wet steam also affects the oil film on the cylinder walls and valve faces, and this increases the internal frictional resistance to be overcome, which means more power must be absorbed leaving less available to draw the train. The presence of water in the cylinders may also result in breakage of the covers or damage to the cylinders themselves.

83. **Q. Is it good management to have the boiler blowing off when waiting for a train?**

A. No; this can be altogether avoided if the Fireman takes care in the matter, and uses the dampers and Injectors with judgment. All steam blown off through the Safety Valves is so much fuel wasted and should be avoided at all times.

84. **Q. What is the best way to work an Injector?**

A. When adjustable, it should be set to supply as much water as the boiler is using so to be kept almost constantly at work; this is important on long runs. If an Injector has been shut off, it should not be put on just before firing, but the boiler should be fired first, and the Injector put on afterwards. It is important also to keep the Injector steam cock closed when the Injectors are not in use, otherwise the steam remains in contact with the Injector, thus injuring the cones and increasing the risk of failure through overheating. The Injectors must be worked alternately to ensure both being kept in working order.

85. **Q. Explain the action of the Sight Feed Lubricator. (*a*) Ordinary; (*b*) Detroit; (*c*) Mechanical Lubricator.**

A. (*a*) The action of the ordinary Sight Feed Lubricator which operates on the hydrostatic principle, is as follows:—When steam is admitted into the lubricator it is condensed in the globe, at the same time it is condensed in an internal pipe in the globe, and charges the sight feed glass with water. On opening the water valve the pressure is admitted to the bottom of the oil chamber, and forces the oil through an internal pipe to the sight feed valve. By then opening the retention valve a jet of dry steam is admitted to the cylinders, and by opening the sight feed valve the oil being lighter than water passes through the water in the sight feed glass to the retention valve. Here it is met by the jet of dry steam which mingles with the oil and forces it away in the form of a spray to the steam chest and cylinders, where it lubricates the valves and pistons.

(*b*) In the Detroit Lubricator the principle employed is also hydrostatic, which is explained as follows:—A drop of water admitted to a tank, containing a lighter fluid must, owing to its greater weight or specific gravity, displace an equal volume of that fluid. A column of water exerting its weight to displace a lighter fluid is the force which operates the lubricator. This force is measured by the height of the column of water and is not affected by the steam pressure, as the steam pressure on top of this column and at the point of discharge of oil from the sight feed chamber are equal. When a lubricator is in operation in service, the pressure within the oil reservoir is equal to the boiler pressure, plus the weight of the column of water in the condenser, while the condenser, equalising tubes, sight feed chambers, and delivery pipes are under boiler pressure only. The water from the condenser, therefore, under the pressure of a practically constant head enters the oil reservoir through the water valve, displacing the oil and forcing it drop by drop through the sight feed chamber to the point of discharge to lubricate the valves, pistons, etc.

(*c*) The Mechanical Lubricator is worked on the same principle as a pump. A rectangular-shaped oil reservoir, bolted to the footplate, contains a number of pump barrels, the outlets of which run to the various points of distribution.

The pumping action is obtained from the crosshead or quadrant from which suitable links are taken to the driving arm of the lubricator. The arm is attached to a ratchet mechanism with a ratchet wheel keyed to the driving eccentric shaft. The shaft passes through a packing gland and runs from one side of the oil reservoir to the other. With a Wakefield Lubricator the eccentrics are located between the pump barrels and the movement of the crosshead or quadrant causes the driving eccentric shaft to rotate and the pump barrels are thus given a reciprocating motion. This action against the pump plungers results in the oil being forced along the pipes.

Check valves and oil test plugs are provided in the pipe lines.

Adjustment of the feed is obtained by the provision of oil adjustment plugs.

A strainer is fitted to the oil reservoir in order to prevent the entry of any material which would result in blockage of the plungers, barrels or piping.

The setting of Mechanical Lubricators is made by a member of the shed staff, and no alteration should be made unless under exceptional circumstances. The Officer-in-Charge should be immediately notified of any alteration.

86. **Q. What is the purpose of a Safety Valve on a locomotive boiler?**

A. To relieve the boiler from over-pressure of steam.

87. **Q. What should be done to prevent waste of steam through safety valves?**

A. The firing should be so regulated when the locomotive is working that the steam will not rise to the blowing off point when steam has to be shut off unexpectedly. Blowing off may be prevented by closing the dampers, opening the firebox door a little, and keeping the Injector operating.

88. **Q. Describe a Blower, and its use and abuse.**

A. A Blower is a device designed for the purpose of directing small jets of steam up the chimney in order to induce an artificial current of air and so increase the draught on the fire. Its proper use is to prevent smoke when the locomotive is not working, to draw the fire gases away so that they do not pass into the cab, and to stimulate the fire when necessary. The abuse of the blower is drawing cold air through the tubes, and by forcing the fire when it is not necessary, causing waste of steam through the safety valves.

89. **Q. What advantage is it for the Fireman to know the grades of the lines and the location of the Stations?**

A. This enables him to regulate the firing to suit the fluctuating work the locomotive is required to do.

WESTINGHOUSE AIR BRAKE.

90. **Q. What two Air Brake Systems are employed on modern locomotives?**

A. Automatic and Straight Air.

91. **Q. On what vehicles is the Automatic Air Brake used?**

A. On all locomotives and on practically all cars, vans, and wagons.

92. **Q. Where is the Straight Air Brake used?**

A. On certain steam locomotives, electric locomotives, rail motors, electric parcels coaches and certain electric motor coaches.

93. **Q. Where is the compressed air stored that applies the Automatic Brake?**

A. In the Auxiliary Reservoir fitted on each vehicle.

94. **Q. Where is the compressed air stored that releases the brakes?**

A. In the Main Reservoirs on locomotives and motor coaches.

95. **Q. Where is the compressed air stored that applies the Straight Air Brake?**

A. In the Main Reservoirs on the locomotives and motor coaches.

96. **Q. What types of Air Compressors are in use on steam locomotives.?**

A. Two; one such as the "D" class which is a double acting compressor with one steam cylinder located above the air cylinder, and the other known as the Cross Compound Compressor with two steam and two air cylinders arranged side by side respectively, the small or high pressure steam cylinder being above the large or low pressure air cylinder and the large or low pressure steam cylinder above the small or high pressure air cylinder.

97. **Q. Are the Air Compressors used exclusively for supplying compressed air for the Air Brake systems?**

A. On modern locomotives compressed air is also required for the operation of auxiliary devices, such as Air Sanding equipment, Fire Doors, Ashpan Slides and Reversing Gear.

98. **Q. What device is employed to maintain a constant Main Reservoir pressure?**

A. An Air Compressor Governor which is fitted on the steam supply pipe to the Air Compressor. It is controlled by Main Reservoir pressure in such a manner that the Governor automatically stops or starts the Air Compressor as required to maintain a constant Main Reservoir pressure.

99. **Q. What is the authorised Main Reservoir pressure on steam locomotives?**

A. 100 lb. per sq. inch. Ordinary brake equipment.
95 lb. to 120 lb. per sq. inch; A-6-ET equipment.

100. **Q. What Brake Pipe Pressure should be carried on steam service trains?**

A. Passenger trains ... 75 lb. per sq. inch.
Mixed and Goods trains 70 lb. to 75 lb. per sq. inch.

101. **Q. What means are provided on modern locomotives to maintain a constant pressure in the Brake Pipe?**

A. An automatic Feed Valve which maintains a constant Brake Pipe pressure whilst the Driver's Brake Valve is in running position.

102. **Q. What is meant by Reserve Pressure.**

A. Reserve pressure is the pressure that is carried in the Main Reservoir in excess of that carried in the Brake Pipe.

70 lb BRAKE PIPE = 20 lb
100 " MAIN RESERVOIR RESERVE PRESSURE

103. **Q. What is the use of Reserve pressure?**

A. The increased pressure when passed into the Brake Pipe through the Driver's Brake Valve in Release position, assists to force the Triple Valves to Release position and to recharge the Auxiliary Reservoirs.

104. **Q. How much reserve pressure is usually carried?**

A. From 25-35 lb., according to the adjustment of the Automatic Feed Valve and Governor, where provided.

105. **Q. What is a Pressure Retaining Valve?**

A. It is a valve loaded to approximately 15 lb. per sq. inch and attached to the exhaust ports of the Triple Valves on locomotives not fitted with the Straight Air Brake. When the handle of the retaining valve is turned to the closed position, it retains about 15 lb. per sq. inch pressure in the Brake Cylinder for the purpose of retarding the locomotive whilst the train brakes are releasing and the Auxiliary Reservoirs are recharging.

106. **Q. What particular attention must the Driver give to Air Compressors?**

A. He must see that they are efficiently lubricated.

107. **Q. What particular daily attention must the Driver give to Main Reservoirs?**

A. He must drain all Main Reservoirs by opening the drain cocks to ensure that they are kept free from accumulated water and that the connecting pipes are not blanked.

108. **Q. What causes the Automatic Air Brake to apply on a vehicle?**

A. A reduction of Brake Pipe pressure below that of the Auxiliary Reservoir.

109. Q. **What causes the Automatic Air Brake to release on a vehicle?**

A. Increasing the Brake Pipe pressure above that of the Auxiliary Reservoir by means of the Driver's Brake Valve, or reducing the Auxiliary Reservoir pressure below that of the Brake Pipe by means of the hand Release Valve.

110. Q. **Why is it important to maintain all air brake apparatus free from leakage?**

A. In order to get efficient service from the air brakes and economy in compressed air consumption, and also to prevent undesired automatic application of the air brakes as a result of Brake Pipe leakage.

111. Q. **Why is it important before starting a train to know that the Brake Pipe cocks are fully open throughout the train with the exception of those at the front and rear of the train?**

A. Because otherwise the train would not be under full control as all brakes at the rear of any closed Brake Pipe cock would be inoperative.

112. Q. **How can it be determined that the necessary Brake Pipe cocks are open and the Brake Pipe continuity complete before the train is started?**

A. By ensuring that the regulation Air Brake tests are carried out before departure.

113. Q. **What are the functions of the Improved Triple Valve?**

A. To control the flow of compressed air from the Brake Pipe to the Auxiliary Reservoir, from the Auxiliary Reservoir to the Brake Cylinder, from the Brake Cylinder to the atmosphere, and also from the Brake Pipe to the bulb, and from the bulb to the atmosphere.

114. **Q. What is the function of the Triple Piston in the Triple Valve?**

A. To operate the graduating valve and slide valve, and to open and close the feed grooves.

115. **Q. What controls the movement of the Triple Piston?**

A. The difference of air pressure on each side of the piston.

116. **Q. What two pressures influence the movement of the Triple Piston?**

A. Brake Pipe pressure on one side and Auxiliary Reservoir pressure on the other.

117. **Q. What is the function of the Triple Valve Slide Valve?**

A. To control the flow of compressed air from the Auxiliary Reservoir to the brake cylinder, the brake cylinder to the atmosphere. the Brake Pipe to the bulb, and the bulb to the atmosphere.

118. **Q. What is the function of the Graduating Valve?**

A. To regulate the flow of compressed air from the Auxiliary Reservoir to the Brake Cylinder.

119. **Q. What is the function of the bulb on the Improved Triple Valve?**

A. It ensures a more simultaneous action of the brakes throughout the train by providing a local reduction of Brake Pipe pressure in conjunction with the reduction made by the Driver's Brake Valve.