SECTION 7

LUBRICATION

Lubricating oil is used to keep the bearing surfaces apart and permit easy running and reduced wear and tear. This is brought about by forming a film or layer of oil between the bearing and shaft or between the sliding surfaces to prevent metallic contact. When oil is allowed to spread over a clean metallic surface it forms a thin film of great stability. This film may be only 100,000th of an inch in thickness, but it adheres strongly to the metal and two such films, one on each surface, slide over each other and protect the metals from contact and wear. "Oiliness" is the property of a liquid which enables it to form a powerful lubricating film when spread as a layer between the two surfaces.

When a locomotive is working, the chief kinds of motion are:—

(1) Rotating—as in axle and big-end bearings.
(2) Sliding—as in pistons, crossheads and valves.
(3) Rocking—as in parts of a valve gear and little-end bearings.

In the first of these types it is easier to maintain a fluid film as the rotation assists the distribution of the oil, but in the other two cases it is more difficult. For example, a piston slows down and stops at the end of each stroke and reverses direction; again, a small end has only a limited amount of movement. Under these conditions, which are unfavourable to the maintenance of a fluid film, we depend upon the "oiliness" of the lubricant to prevent metallic contact.

Methods of Lubrication

A. *Hand Lubrication*

Example: Hand brake gear, firedoor slides, screw couplings, etc.
Description: Oil is applied by a hand oil feeder daily or as required.

B. *Pad Lubrication (Worsted)*

Example: Chiefly used in underkeeps of axleboxes.
Description: The worsted pad is supplied with oil by tail feeders attached to the pad and dipping into a bath of oil in the underkeeps.

C. *Syphon Lubrication*

Example: Axleboxes, slide bars, horn cheeks, etc.
Description: The oil is fed to the bearing or surface from an oil box by means of a worsted tail trimming (see Fig. 55).

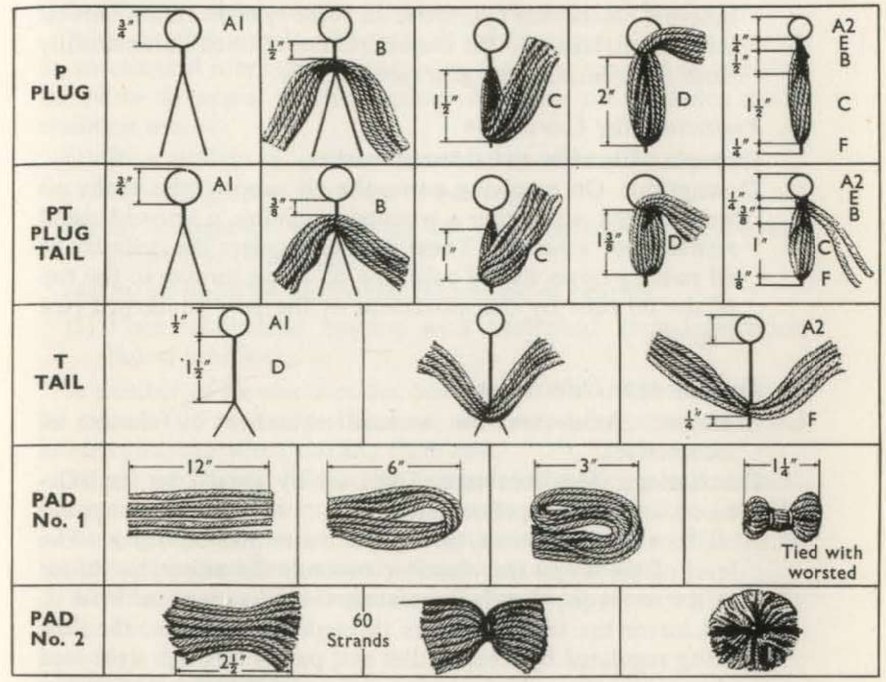


Fig. 55 **WORSTED TRIMMINGS**
Details of Preparation

D. *Mechanical Lubrication*

Example: Axleboxes, pistons, valves and cylinders, etc.
Description: Lubrication is effected by means of a mechanical pump (see Figs. 56 and 57).

E. *Hydrostatic Sight Feed Lubrication*

Example: Valves, pistons and cylinders.
Description: Lubricators of this type work on the principle of the displacement of oil by means of condensed steam (see Fig. 58).

F. *Atomised Lubrication*

Example: Valves, pistons and cylinders.
Description: With both mechanical and sight feed lubricators the oil is atomised with steam and sprayed through a choke

before it reaches the cylinders. In some systems of mechanical lubrication, steam to the atomisers is controlled automatically from the cylinder cock gear (see Fig. 59).

G. *Restrictor Plug Lubrication*

Example: Big ends and side rod bushes.

Description: On revolving parts, the oil supply tube in the oil well is fitted with either a worsted trimming, a screwed metal restrictor or a needle. These devices regulate the quantity of oil passing down the oil tube, the oil being thrown to the top of the oil tube by the movement of the part concerned (see Fig. 60).

H. *Fountain-type Lubrication*

Example: Axleboxes on a small number of classes of locomotives.

Description: This lubricator feeds oil by gravity to the axleboxes and consists of an airtight oil reservoir which supplies oil to a feed chamber through a main shut-off valve. The level of the air in the chamber controls the admission of air to the reservoir, thereby regulating the delivery of oil from it. Oil leaves the feed chambers through drip nozzles, the flow being regulated by feed needles and passes through sight feed glasses into the oil pipes, thence by gravity to the axleboxes (see Fig. 61).

I. *Grease Lubrication*

Example: Ball and roller bearings, return crank, motion parts, brake gearings, water pick-up gearings, pony trucks, reversing screw, etc.

Description: Grease nipples are screwed into each lubricating point, being sealed with a spring-loaded valve to prevent dirt getting into the hole. A grease gun is used to force lubricant through the nipples to the point of lubrication.

Lubrication of Axleboxes

Locomotive axleboxes can be divided into two types, viz. (*a*) dead load bearings as fitted to bogie, pony truck, bissel trucks and tenders; (*b*) dead load-power bearings, as on the driving and coupled wheels, which in addition to taking the dead weight are also called upon to transmit a considerable proportion of the piston thrust to the locomotive frames to form the tractive force.

On modern locomotives the former type of bearing depends entirely on oil supplied by the underfeed keep pad, and care must be taken during preparation to check the underkeep oil level.

With coupled wheels, although oil can be supplied to the bearing by mechanical lubricator or trimming feed, the method of applying the oil to the actual bearing surface varies, but the following are in common use:—

(1) By a straight oil groove cut on crown of bearing.

(2) By oval groove on crown of bearing.

(3) By straight oil grooves at 45° on each side of the vertical centre line of bearing.

(4) By oil holes on horizontal centre line of bearing.

(5) Plain whitemetal bearing with underfeed keep lubrication (latest practice).

A number of locomotives are being fitted with roller bearings on all axles. The advantages of these are lower lubricating costs and lower resistance when starting from rest.

Where mechanical lubrication is employed a spring-loaded back-pressure valve is fitted on the axlebox, whose function is to keep the oil supply pipe full whilst the locomotive is standing, so that the oil supply commences immediately the locomotive moves.

With bearings as described in item (5) the oil supply is mechanically fed to the underkeep.

Mechanical Lubricators

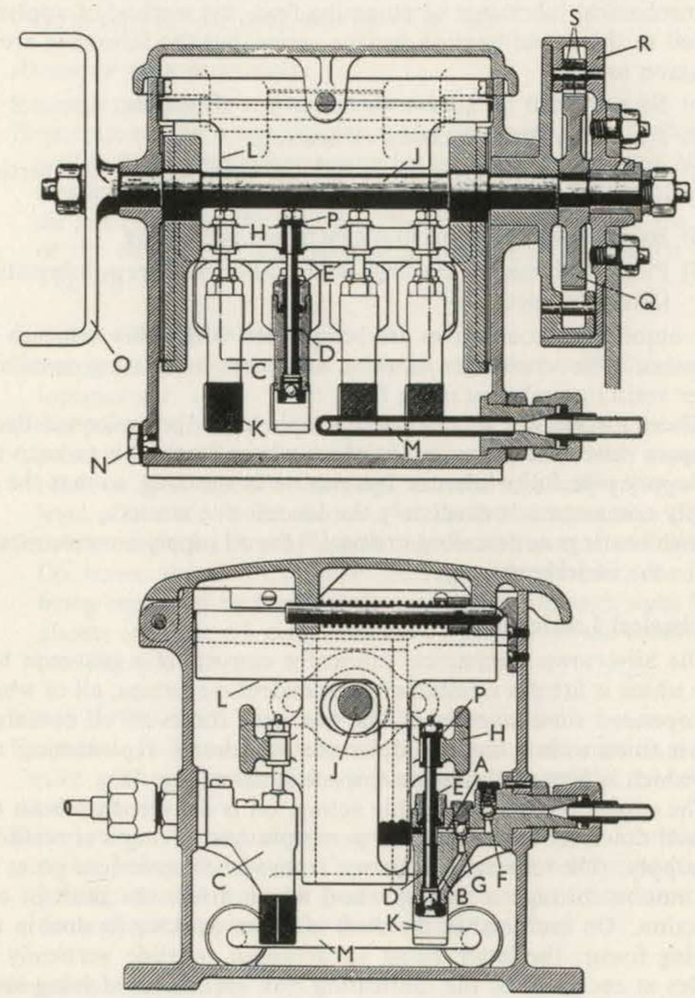
The Silvertown mechanical lubricator consists of a cast-iron box into which is fitted a number of independent oil pumps, all of which are operated simultaneously. The box itself forms an oil container and is fitted with a hinged lid for the purpose of replenishing the oil, which is filtered through a fine-mesh sieve (Fig. 56).

The supply pumps are double acting, oil is delivered on both the up and down movements of the pump plunger, giving a continuous oil supply. The lubricator is driven from some convenient point on the motion through a ratchet wheel which drives the shaft in one direction. On each end of the shaft is a cam working in slots in the driving frame, the latter being so arranged to slide vertically in guides at each end of the lubricating box. When the driving shaft revolves a reciprocating motion is given to the frame which is connected to the pump plunger by means of thimbles.

The action of the pump is as follows:—

On the upward movement of the plunger, oil is drawn via a small sieve past a ball valve, thus filling the space below the plunger. During the downward movement of the plunger the ball valve is held on its seat and the oil is forced up the passage past the ball valve, half of the oil filling the cavity on the top of the plunger and the

Fig. 56 SILVERTOWN MECHANICAL LUBRICATOR



A. CAVITY
B. PASSAGE
C. SUPPLY PUMPS
D. PUMP PLUNGER
E. PACKING
F. BALL VALVE
G. BALL VALVE
H. DRIVING FRAME
J. SHAFT
K. SMALL SIEVE
L. FINE-MESH SIEVE
M. WARMING PIPE
N. DRAIN PLUG
O. DRIVING SHAFT HANDLE
P. THIMBLES
Q. DRIVING WHEEL
R. FIXED WHEEL PLATE
S. PAWL

remaining oil being forced past the ball valve into the lubricating system. It will be seen that on the upward movement, in addition to the oil being drawn into the lower passages of the pump, the oil remaining in the cavity is also forced past the ball valve, during which operation the ball valve is held on its seat. Special packing is provided to prevent leakage of oil from the top side of the plunger.

The rotary movement of the shaft is obtained by six spring-loaded pawls fitted to the outer case of the ratchet box and engaging in teeth on the outside edge of the driving wheel which is keyed to the main shaft, so that when the case is moving in one direction the driving wheel is rotated, but in the return direction is held in position by means of the six retaining pawls provided in the fixed wheel plate.

Each pump feeds approximately 2 oz. per 100 miles.

On the opposite end of the driving shaft a handle is fitted which can be turned by hand to operate the pump independent of the action of the locomotive. This handle should be rotated a few times before leaving the shed.

These lubricators can be used to supply oil to the axleboxes or to the cylinders. When used for the latter purpose, as a thick oil is used for cylinder lubrication, it is necessary to provide means for preventing the oil from congealing in cold weather and this is achieved by fitting a warming pipe through which a supply of steam is passed. This supply of steam can be cut off during the summer weather. When necessary the oil can be drained from the lubricator through a drain plug.

Hydrostatic Displacement Lubricator

The principle of the hydrostatic displacement lubricator is the utilisation of condensed steam from the condenser coil, which on entering the oil reservoir displaces the oil causing it to overflow into the feed passages. Oil is controlled by the oil-regulating valve and, after passing this point, it rises through the water in the sight glass into a delivery chamber from which it is carried by steam through the lubricator pipes to the choke which is inserted in the lubricator pipe near the delivery point on the main steam pipes. The choke plug gives a constant resistance to the lubricator and so prevents the feed being affected by variations of pressure in the steam chest.

On the former G.W.R. locomotives the oil is atomised by passing through a small orifice from the delivery chamber.

The usual rate of feed should be two to three drops per feed per minute, according to the class of work performed.

A Detroit hydrostatic lubricator is shown in Fig. 58. This is a four-feed lubricator and the working instructions are as follows:—

To fill: Turn oil control valve to closed position. Shut water valve and steam valve, open the drain plug in order to empty water from oil-reservoir and release pressure, next remove filling plug slowly. (The reason for removing this plug slowly is to allow any pressure which may have built up in the reservoir to escape past the threads.) Close the drain plug and fill reservoir with clean oil; if there is insufficient oil on hand use water to fill reservoir completely. (Some lubricators of this type are not fitted with oil control valve; in this case when filling close all feed regulating valves.)

To start: Fully open the steam valve and allow three or four minutes to elapse in which to fill the condenser and sight feed glasses with water, then fully open water valve, turn oil control valve to "open" position and regulate the oil feed valves.

To shut down lubricator: For short stops shut down oil control valve only; for long stops close oil control valve, water valve, and lastly steam valve.

Note: Always start the lubricator ten minutes before leaving the shed.

Fig. 57 WAKEFIELD MECHANICAL LUBRICATOR

No. 7 Pattern

HOW THE LUBRICATOR WORKS

When the pump plunger **D** and sleeve valve **E** are at the outer end of the stroke, oil flows into the pump barrel **C** through the ports **F**. As soon as the ports **F** are covered by the plunger and sleeve valve on the return stroke, the oil in the pump barrel is forced away under pressure to the outlets **K**. If the oil regulating plug **G** is screwed right down, the pumps are working at their full capacity. One full turn outwards of the oil regulating plug **G** decreased the oil pumped by one-fifth as follows:—

Plug **G** screwed right down = full feed.
Plug **G** screwed one turn out = four-fifths feed
Plug **G** screwed two turns out = three-fifths feed
Plug **G** screwed three turns out = two-fifths feed
Plug **G** screwed four turns out = one-fifth feed
Plug **G** screwed five turns out = feed cut off

TO OPERATE

When starting the Lubricator for the first time when newly fitted—

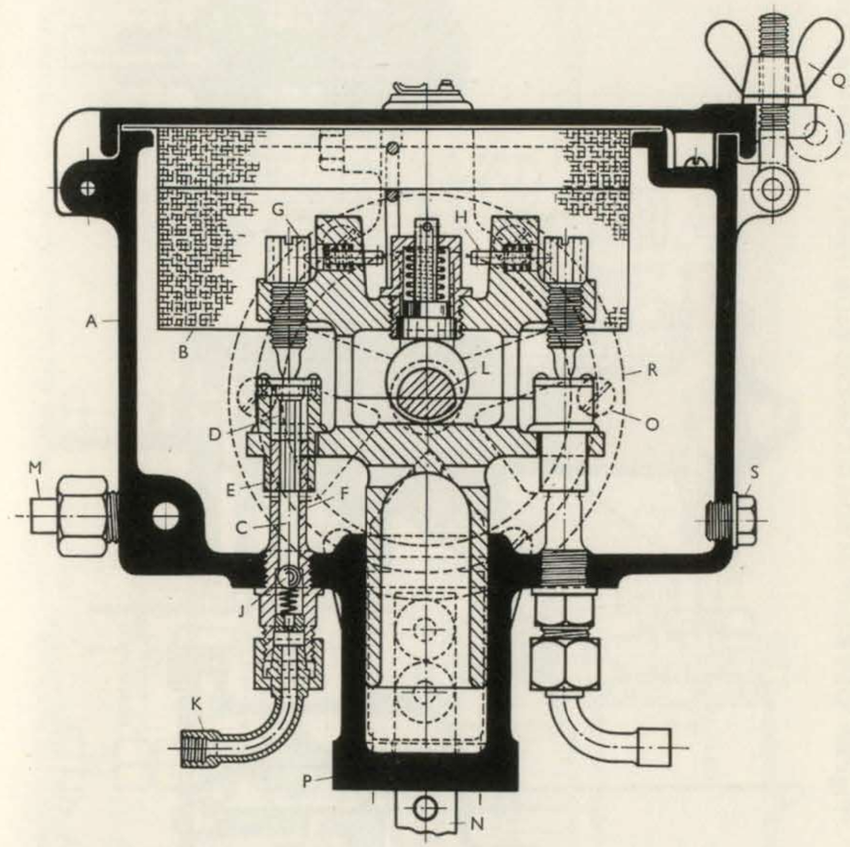
(1) See that each of the oil regulating plugs **G** is screwed right down.
(2) Fill the oil reservoir, taking care to pass the oil through the strainer.
(3) Open the oil-test plug on the combined check valve and oil-test plug.
(4) Work the Lubricator by turning the flushing wheel until the oil is seen at the oil-test plug.
(5) Close the oil-test plug and work the Lubricator a few more times to make sure that the oil-delivery pipes are quite full.

The above operations are essential when the lubrication is first fitted up. The lubrication system is then in working order.

It is advisable before leaving the shed, with the engine going into traffic, to examine the test plugs and make sure the oil is there by giving the flushing wheel a few turns.

The level of the oil in the reservoir must never be allowed to fall below the ports **F** in the pump barrels or no oil will be delivered.

The oil MUST pass through the sieve. It is advantageous to WARM the cylinder oil before filling the lubricator.

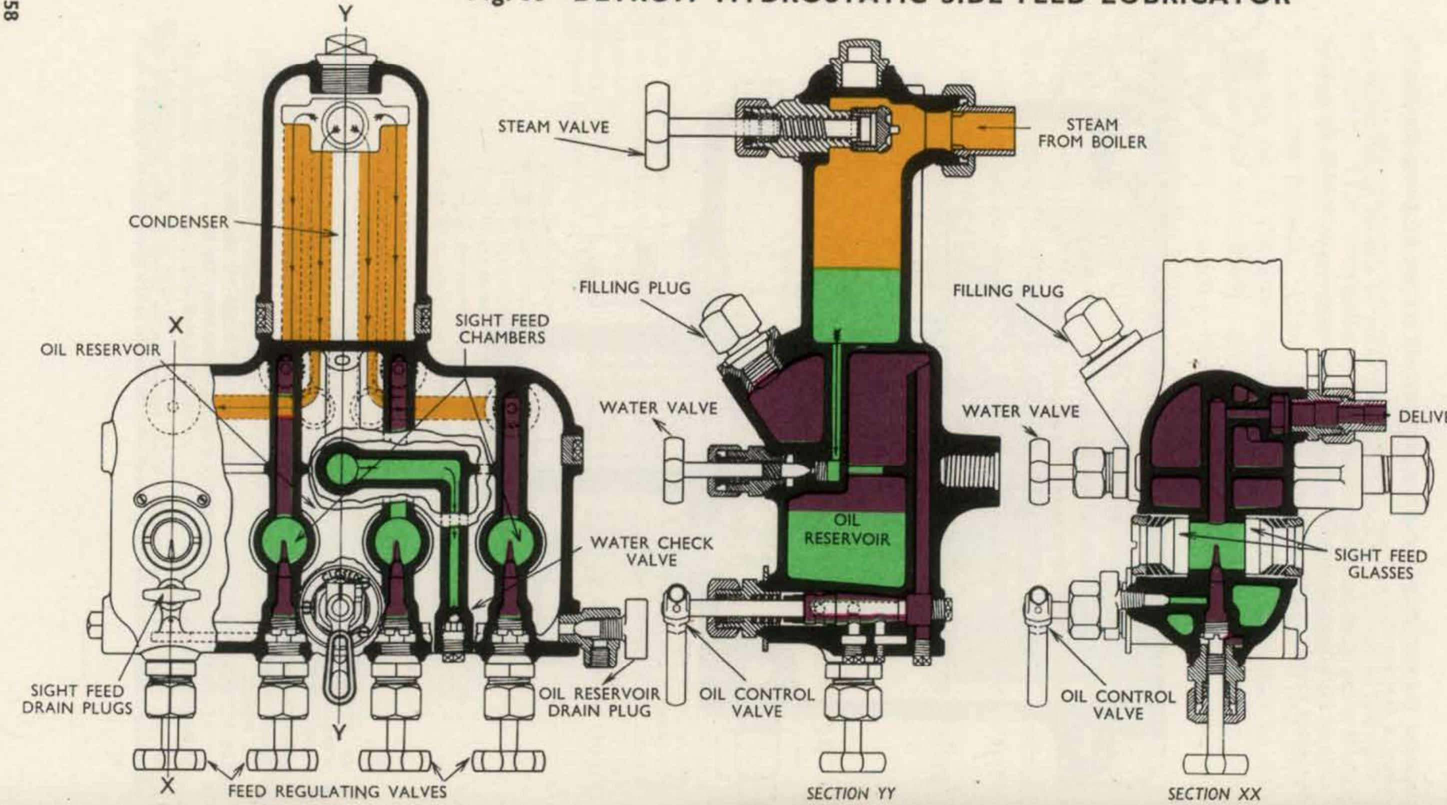


SECTIONAL ELEVATION

A. OIL RESERVOIR
B. WIRE GAUZE STRAINER
C. PUMP BARREL
D. PUMP PLUNGER
E. SLEEVE VALVE
F. OIL PORTS
G. OIL REGULATING PLUG
H. OIL REGULATING LOCKING PEG
J. NON-RETURN VALVE
K. OIL OUTLETS
L. DRIVING ECCENTRIC SHAFT
M. OIL WARMING PIPE
N. DRIVING ARM
O. RATCHET DRIVE AND GEAR CASE
P. FIXING LUGS
Q. FLY BOLT TO SECURE LID
R. FLUSHING WHEEL
S. DRAIN PLUG

NOTE.—No. 7 (a) pattern operates in a similar manner to the above, but the oil outlets K lead out from the sides of the oil reservoir, level with the centre of the driving eccentric shaft L.

Fig. 58 DETROIT HYDROSTATIC SIDE FEED LUBRICATOR



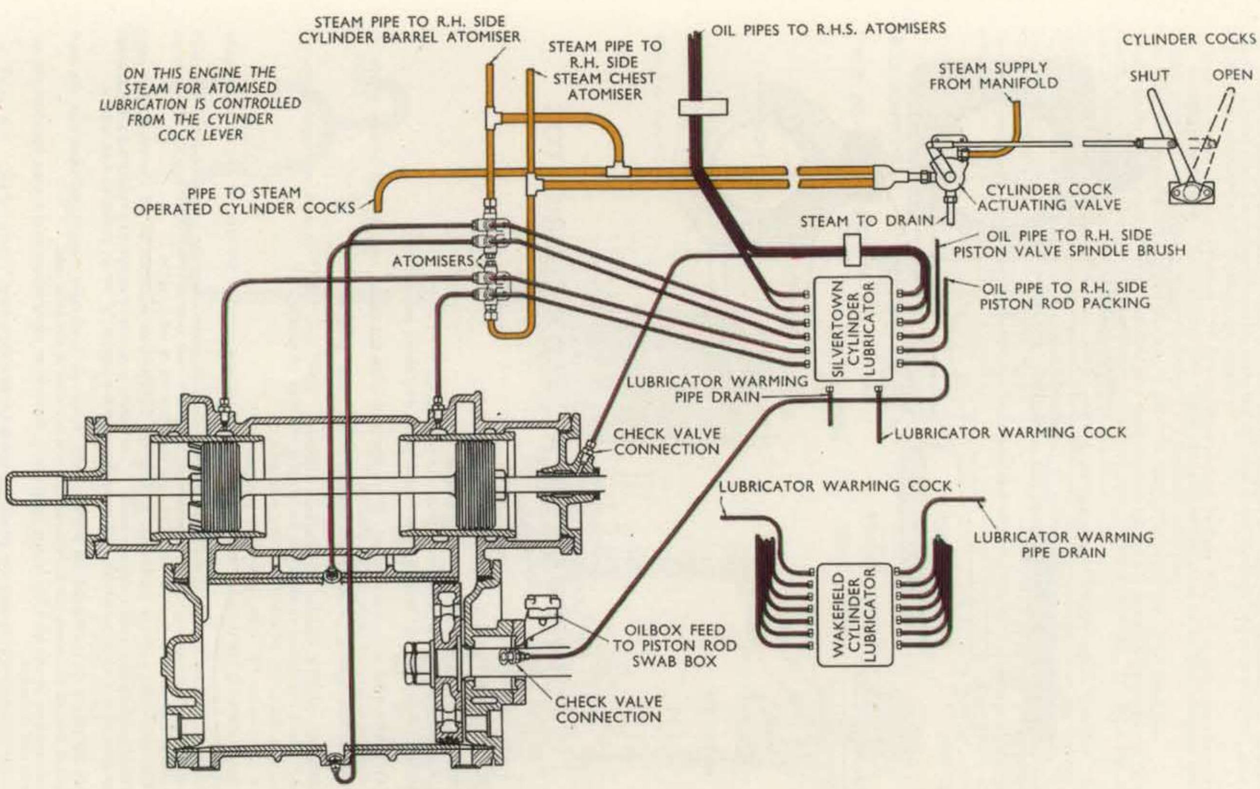
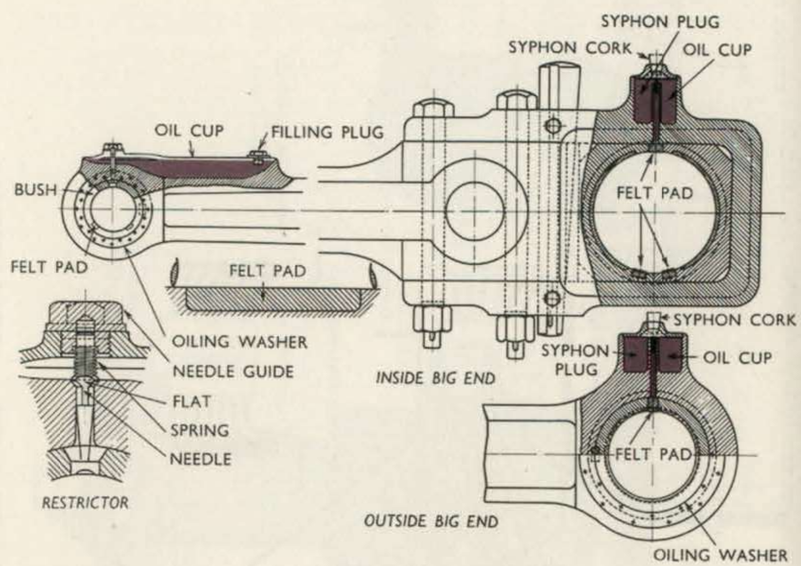


Fig. 59 ARRANGEMENT OF ATOMISER LUBRICATION

Fig. 60 CONNECTING ROD LUBRICATION



FOUNTAIN-TYPE AXLEBOX LUBRICATOR

INSTRUCTIONS FOR OPERATING

TO FILL Set handle "P" in "OFF" position.
Remove filling plug "B" and fill reservoir with *clean* oil.
Replace filling plug "B" making sure that it is screwed down and air tight.

TO OPERATE Examine needles "J" to see that they are clean, and that no foreign matter is accumulated around or in the nipples "V."
Then replace needles "J" and move handle "P" to "ON" position.

SPECIAL NOTE Handle "P" has two positions, "ON" and "OFF." It does not regulate the oil feed. Feed regulation is obtained by varying the size of needle "J."
NO OIL MUST BE POURED INTO CHAMBER "F."
Lid on chamber "F" is for inspection purposes only.
Move handle "P" into "OFF" position when running into terminal stations, or during any lengthy stoppage.
Do not move handle "P" into the "ON" position until the steam regulator is again opened. The small quantity of oil accumulating in each chamber "G" from feed chamber "F" flows quickly down the oil pipes to the journals immediately the Lubricator is set to work again.
When shunting, operate Lubricator at intervals sufficient to maintain an oil film on the journals.
Should an Axle-box heat, remove needle "J" of the Axle-box feed concerned to temporarily increase the oil delivery until conditions improve, then replace needle "J" or fit a smaller size needle.

TO DETECT STOPPAGE IN PIPE LINE Should oil flood sight glass, it indicates that the feed pipe is choked between the Lubricator and the air inlet in the pipe line.
If oil appears at the air inlet in the pipe line it denotes an obstruction in the pipe between the air inlet and Axle-box.
Air inlets should be periodically examined and kept free from dirt.

HOW IT FUNCTIONS When handle "P" is set in the "ON" position, oil from the reservoir "A" passes through main shut-off valve "C" and along passage "D" into feed chamber "F," where it rises to a level just above top of outlet passage "D" and is fed through the nozzle "L" in drops regulated by the needle "J" fitted in the nipple "V."

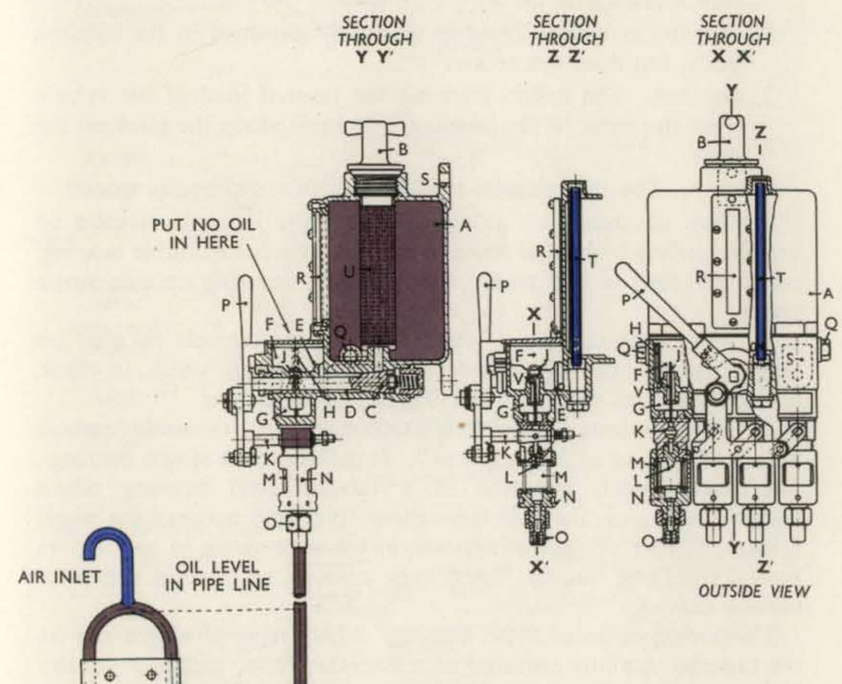
As soon as the oil level in chamber "F" drops below top of passage "D," air enters the reservoir "A" through the air tube "T," destroys the partial vacuum, permits the oil to flow through until it again rises to a level above the top of passage "D" and cuts off the air.

This cycle of operations is repeated the whole time the handle "P" is in the "ON" position.

When handle "P" is in the "OFF" position, the main shut-off valve "C" and shut-off valves "K" are closed, and oil in the chamber "F" continues to feed to each auxiliary chamber "G" until the oil level in chamber "F" falls to the level of the top of the nipple "V."

Immediately handle "P" is set in the "ON" position the oil accumulated in each chamber "G" quickly flows down the pipes to the journals, while the cycle of operations between the reservoir "A" and chamber "F" has allowed the level in chamber "F" to rise and feed oil past the needle "J." The air tube "T" regulates the expansion or contraction, due to variation of temperature in reservoir "A."

By strictly observing the above instructions, an appreciable economy in oil consumption will be effected.



A. OIL RESERVOIR
B. FILLING PLUG
C. MAIN OIL SHUT-OFF VALVE
D. OIL OUTLET FROM RESERVOIR TO FEED CHAMBERS
E. BAFFLE
F. OIL FEED CHAMBER
G. AUXILIARY OIL CHAMBER
H. AIR VENT
J. FEED REGULATING NEEDLE
K. SHUT-OFF VALVE
L. DRIP NOZZLE
M. SIGHT FEED GLASS
N. SIGHT FEED FITTING
O. OIL OUTLET
P. OPERATING HANDLE
Q. DRAIN PLUGS
R. OIL LEVEL GAUGE GLASS
S. FIXING LUG
T. AIR INSET TUBE
U. WIRE GAUGE STRAINER
V. FEED NIPPLE

Fig. 61 FOUNTAIN-TYPE AXLEBOX LUBRICATOR

Roller Bearings

With a view to obtaining economies brought about by more trouble-free running and increased mileages between shop repairs, roller bearings are being fitted to locomotives in increasing numbers, especially to axlebox bearings.

Roller-bearing Axleboxes

Fig. 62 illustrates typical inside and outside journal roller-bearing axleboxes. The bearings used in these axleboxes consist of four main components as follows:—

1. CONE (inner race). The cone is pressed on the axle and therefore rotates with the axle.
2. CUP (outer race). The cup is loosely mounted in the axlebox body, but does not rotate.
3. ROLLERS. The rollers transmit the journal load of the vehicle from the outer to the inner race and roll along the track on the cone.
4. CAGE. The cage ensures that the rollers are correctly spaced.

A. This illustrates an axlebox for outside journals as used on certain trailing truck and tender axles. It includes a double bearing, which in effect is two single sets of rollers running on two single cones.

B. This illustrates an axlebox for outside journals as used on certain tender axles. It includes a double bearing, which, in effect, is two single sets of rollers running on a double cone.

C. This illustrates a cast-steel axlebox as used for inside journals and is known as a "cannon box". It includes two single bearings, one per journal, mounted in a tubular steel housing which entirely surrounds the axle throughout its length between the wheel bosses. Earlier designs of cannon boxes were made in two halves bolted together, but the latest type consists of a solid one-piece tubular casting.

The construction of these bearings, where tapered rollers run on the tapered working surfaces of a cone and cup, makes it equally suitable for handling loads at right-angles to the axle (radial loads such as spring loads, brake loads and piston loads) and thrust loads set up along the axle when the vehicle is negotiating curves in the track. Only the upper rollers carry radial load, whereas all the rollers carry thrust load.

The bearings are lubricated by oil which is automatically circulated in the axlebox by the action of the tapered rollers. Oil level, which is checked with a gauge, should be topped up with the correct grade of oil when the level is down to the lower mark on the gauge.

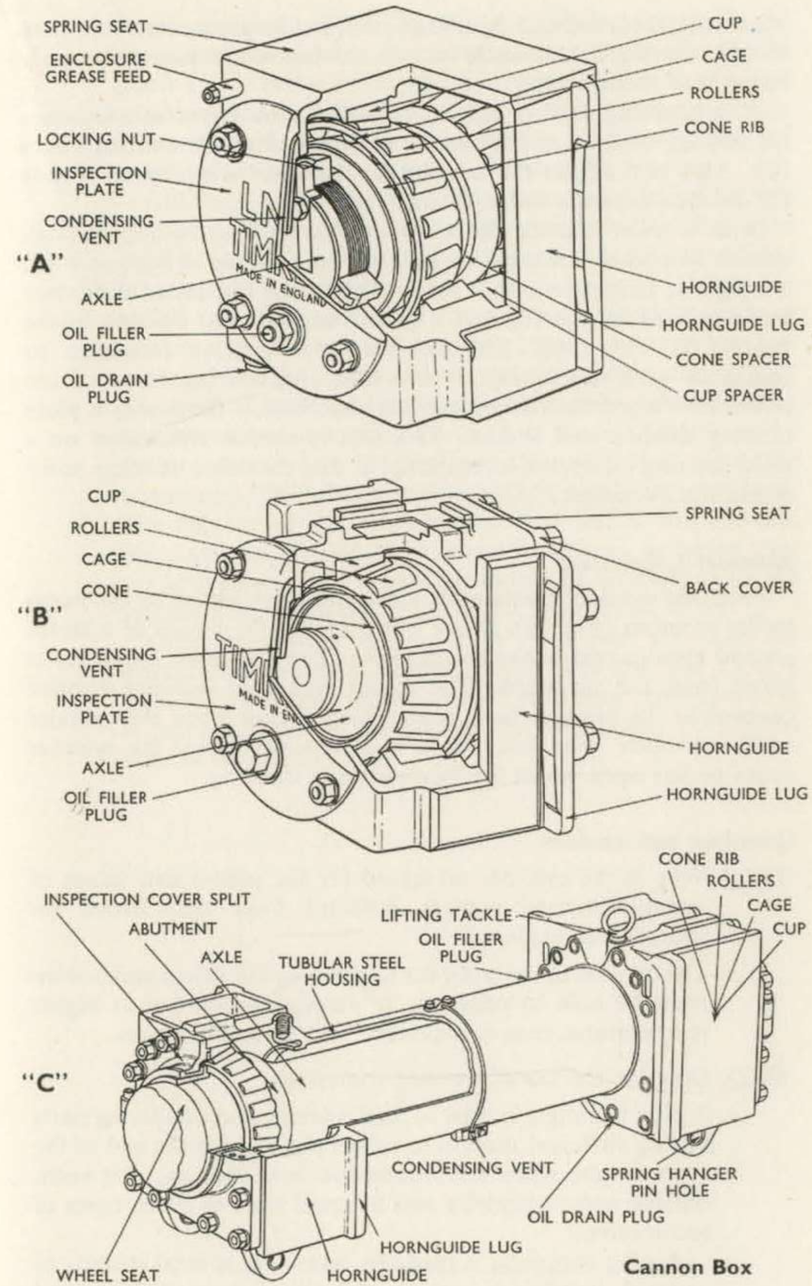


Fig. 62 TYPES OF ROLLER-BEARING AXLEBOXES

This work is carried out by artisan staff, but Enginemen should note that the entry of dirt or water into the axlebox would prove extremely harmful to the bearings.

A condensing vent is cast in the inspection cover of axleboxes (A and B), whilst a condensing vent pipe is fitted to cannon boxes (C). This vent allows the axlebox to "breathe" when the air inside the axlebox expands and contracts.

With a roller bearing the loads are handled on rolling surfaces similar to a wheel rolling on a rail, not on a sliding surface as when a weight is dragged along a road. This is the important difference between a roller bearing and a plain bearing. The friction in the bearing is very small and therefore the tractive resistance or resistance to free running is very low. At starting some of the power developed by a locomotive is absorbed as friction in a plain bearing axlebox and is lost. This loss is almost eliminated on a roller-bearing-equipped locomotive; it can therefore develop more useful tractive effort.

Atomiser Lubrication

From the cylinder mechanical lubricator oil is forced by the pump to the atomiser (Fig. 59), where it is atomised by means of a steam jet and then passed to the steam chest. The steam for atomisers is taken from the manifold. The steam pipe also includes a valve coupled to the cylinder cock gear, which is shut when the cylinder cocks are open. For this reason it is imperative that the cylinder cocks be left open whilst the locomotive is standing.

Questions and Answers

(1) *Q*. Why is the cylinder oil issued for the piston and valves of non-superheated engines different from that issued for superheated engines?

A. The oil used in the latter for lubricating the valves and pistons must be able to retain its lubricating properties at higher temperatures than is necessary with saturated steam.

(2) *Q*. Describe the use of worsted trimmings.

A. A plug trimming is used to feed rotating and oscillating parts having sufficient motion to splash the oil over the end of the syphon tube when the locomotive is in motion. Big ends, outside rods, eccentrics and in small ends of older types of locomotives.

A plug trimming is made by wrapping several strands of worsted lengthwise over a length of twisted wire and forming a plug, which should be a comfortable fit in the syphon tube, and when in position the top of the plug should reach a little below the top of the syphon tube to form a well to accommodate a small quantity of oil above the trimming. The extreme length of the plug should be shorter than the length of the tube to obviate it touching the bearing.

Although, within certain limits, the amount of oil fed will vary according to the number of strands in the plug, care must be taken to adhere to the standard as too many strands may restrict the passage of oil to the bearing.

Tail trimmings are used for non-rotating parts such as axleboxes, piston and valve spindle glands, etc., and they are made of the same material as plug trimmings, the strands being left of sufficient length to fit the syphon tube and hang into the oil box to syphon the oil from the oil chamber to the syphon tube when in position, the oil falling from the trimming in the tube by gravity to the point to be lubricated. The number of strands, within certain limits, will increase the supply of oil with the increase in strands, provided they are kept clean. Tail trimmings should be removed from the syphon tube, when not required, to avoid waste of oil.

Other trimmings in the form of a pad are used for expansion die blocks, expansion link pins and side blocks; these pads being saturated with oil each time the locomotive is prepared, the oil lubricating the part slowly during the time of working.

SECTION 8

BRAKES

The function of the brake is to absorb by friction the momentum of the train; in other words, the energy stored in the moving train is converted to heat at the brake blocks when the brakes are applied.

In the working of freight and mineral trains not made up of power-braked vehicles, the braking of the train is dependent upon the brakes of the locomotive together with the screw hand brake on the guard's brake van, supplemented on certain sections of the line, where there are severe gradients, by stopping the train and applying the hand brake on a number of vehicles before descending the incline.

For the working of passenger trains it is necessary, in order to comply with an Act of Parliament passed in 1889, that (1) the brake on the train should be continuous and capable of being applied to every vehicle of the train; (2) be instantaneous in action and capable of being applied by Driver and/or Guard; (3) be self-applying in the event of the train becoming divided.

These conditions are fulfilled by the two main braking systems in common use to-day, namely, the "automatic vacuum brake" and the "Westinghouse automatic air brake".

The "automatic vacuum brake" is used almost exclusively on steam-hauled trains in this country and makes use of the atmospheric pressure.

The system consists essentially of an exhausting device on the engine known as the vacuum ejector, which has a large ejector used to create quickly the regulation amount of vacuum in the train pipe, connections and reservoir and both sides of the brake cylinder pistons throughout the train, together with a small ejector to maintain the vacuum. Some locomotives are fitted with a vacuum pump which serves a similar purpose to the small ejector.

The pressure of the atmosphere is approximately 15 lb. per sq. in. and the vacuum is measured in inches of mercury. A perfect vacuum corresponds to approximately 30 in. of mercury, i.e. 0 lb. per sq. in. pressure. This varies slightly with the atmospheric pressure as measured by a barometer. Therefore, it will be evident that each 2 in. of vacuum represents approximately 1 lb. per sq. in. of atmospheric pressure.

The regulation vacuum for working the brakes is 21 in. on all Regions except the former G.W.R., where the amount is 25 in.

To apply the brakes, air is admitted to the train pipe and train pipe connections so that the vacuum on the lower side of each brake piston is partially or completely destroyed. The vacuum on the reservoir and upper sides of the brake pistons, however, is retained, being sealed off by a ball valve.

In a normal application of the brakes the Driver can admit the desired amount of air to the train pipe by way of the ports in the Driver's application valve, the quantity of air admitted regulating the power of the application. Full power is utilised when the vacuum in the train pipe is totally destroyed.

Some arrangements of the automatic vacuum brake are worked in conjunction with steam brakes on the engine and tender or in conjunction with the steam brake on the engine only and vacuum brake on the tender.

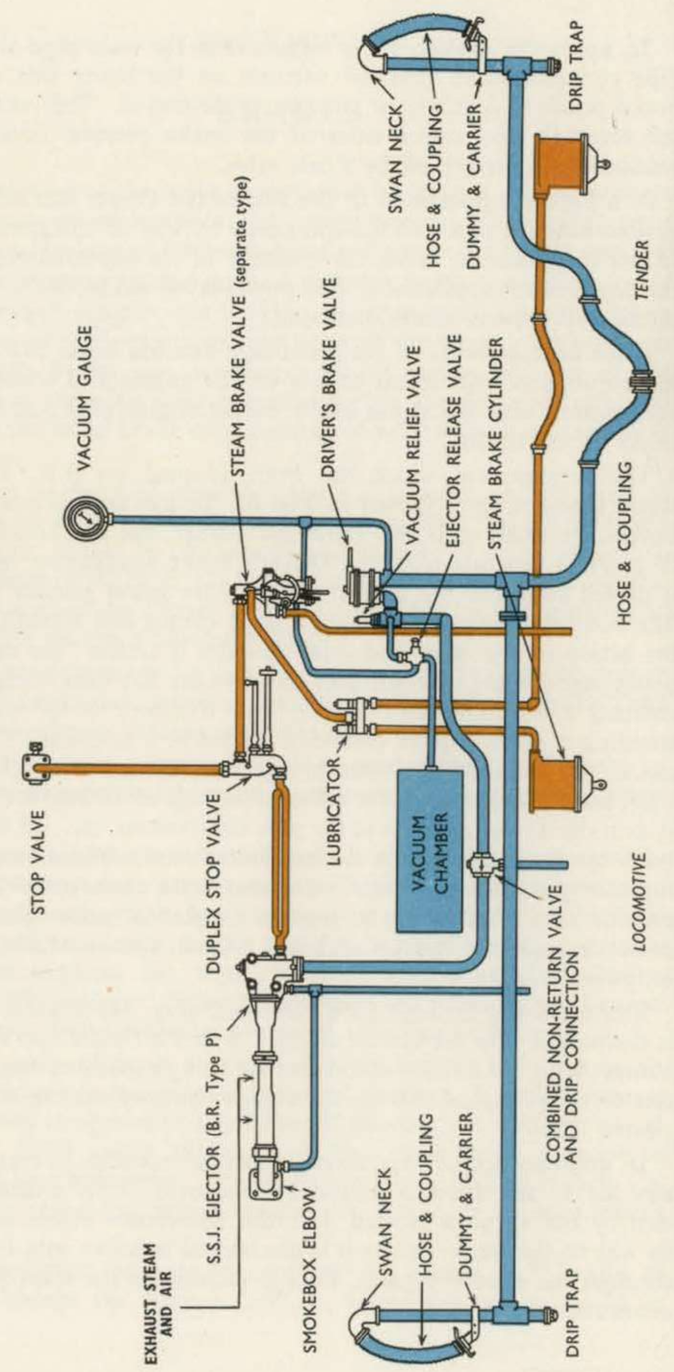
The arrangement which has been adopted on B.R. standard steam locomotives is shown in Fig. 63. In this arrangement steam brakes are fitted to both engine and tender, the combined ejector (Fig. 64) is separate from the Driver's brake application valve and is placed alongside the left-hand side of the boiler outside the cab. The body contains two ejectors, a large ejector and a small ejector, the action of the large and small ejectors is similar, the difference being that the large ejector uses more steam and thus is capable of creating a vacuum more quickly and therefore is for use when standing or when a quick release of the brake is essential. The small ejector is provided for maintaining the vacuum throughout the train and for overcoming the effect of leakage of air into the vacuum system due to faulty joints at the pipe connections, etc., on the train. Each ejector is fitted with a non-return valve. These two valves, together with the non-return valve and drain connection (Fig. 63), provide an air lock so as to prevent smokebox gases being drawn back through the ejector exhaust. Each ejector works in the following manner:—

Steam passing through the steam cone (Fig. 64) at great velocity is discharged into the ejector air cone where it comes into frictional contact with the air, the steam and air being exhausted through the ejector exhaust pipe and up the engine chimney via the smokebox elbow.

In consequence of this action a partial vacuum is created and any air in the train pipe and connections, in its endeavour to destroy the vacuum created, lifts the non-return valves and finds its way to the ejector where it is discharged together with the steam through the ejector exhaust, thus a vacuum in the train pipe and connections is created.

Fig. 63 **GENERAL ARRANGEMENT OF VACUUM AUTOMATIC BRAKE ON ENGINE AND TENDER**

B.R. Standard Arrangement



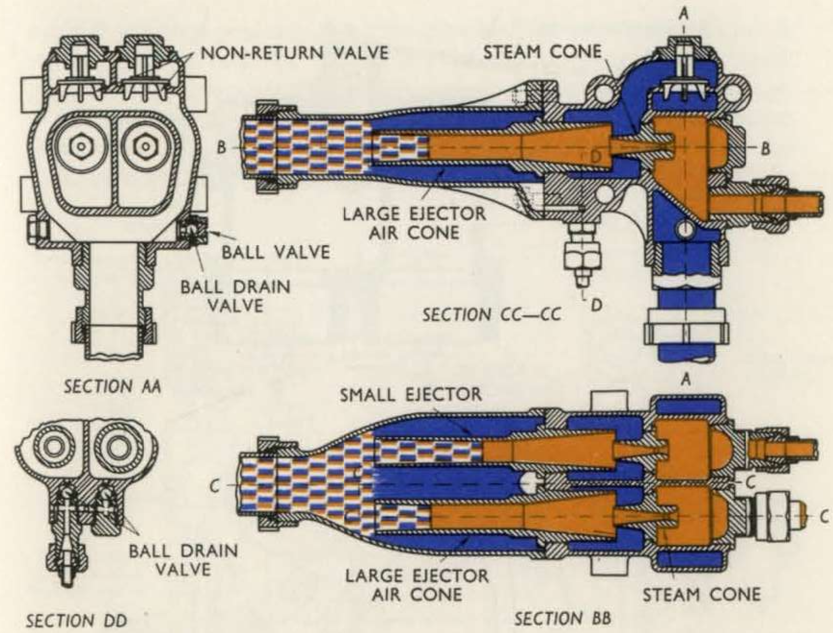


Fig. 64 S.S.J. EJECTOR

Under each ejector, ball drain valves are provided; whilst the ejectors are in use the ball is forced to its seating, preventing air entering; when the steam supply is shut off, the ball falls away from the seating and allows any condensation to drain away. A ball valve is provided so that in the event of leakage taking place in either of the non-return valves, the ball valve will open to the atmosphere and smokebox gases will not be drawn back through the ejectors when they shut off, but the vacuum maintained in the train pipe.

Driver's brake application valve is shown in Fig. 65 and is designed to admit air into the train pipe so as to reduce or destroy the vacuum. It has only two handle positions, "off" and "on".

Vacuum-operated graduable steam brake valve. This arrangement is shown in Fig. 66 and is designed to admit steam to the steam brake cylinders as the train pipe vacuum is reduced or destroyed and to release the steam from the steam brake cylinders as the train pipe vacuum is restored; in action the brake is applied on the engine and tender slightly later and released slightly earlier than the vacuum

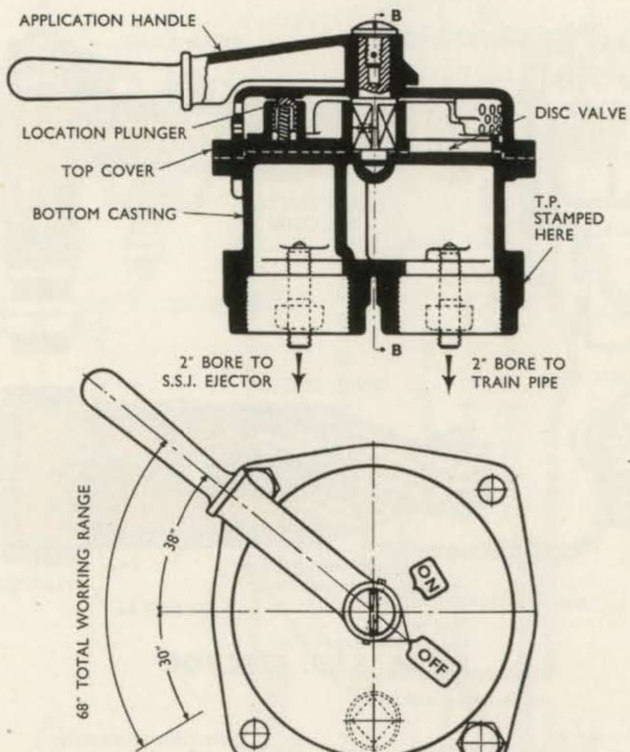


Fig. 65 DRIVER'S BRAKE APPLICATION VALVE
B.R. Standard Locomotive

brake on the train in order to minimise bunching of the carriages and strain on the engine and tender draw-gear; moreover, the pressure of steam in the steam brake cylinder is proportional to the amount by which the vacuum in the train pipe is reduced.

Vacuum relief valve. This is provided to prevent the regulation vacuum being exceeded (see Fig. 63). It consists of a spring-loaded valve which lifts and allows air into the train pipe if the ejectors create more than 21 in. of vacuum (25 in. in the case of the former G.W.R.).

Operation. The operation of brake arrangement as fitted to B.R. standard locomotives (see Fig. 63) is as follows: when in the

normal running position the train pipe will be registering 21 in. of vacuum, which will be maintained at this amount by the small ejector. Any over-creation which the small ejector might manage, if not satisfactorily adjusted, will be taken care of by the vacuum relief valve. There will be the normal train pipe vacuum below the vacuum cylinder piston (Fig. 66) due to the direct connection of the

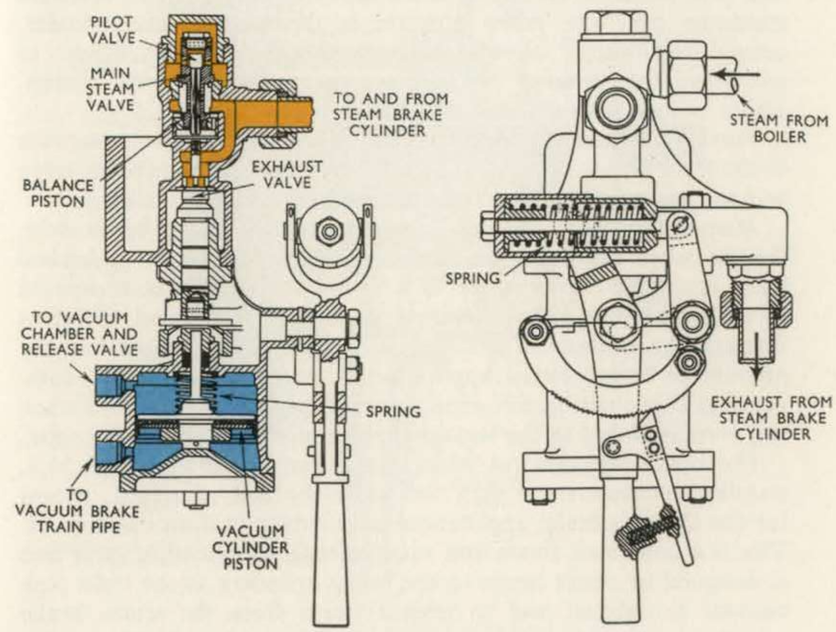


Fig. 66 VACUUM-OPERATED GRADUABLE STEAM BRAKE VALVE
(Mark IV)

bottom of the vacuum cylinder to the train pipe. On the upper side of the piston there will also be a normal vacuum due to the connection of the upper portion of the piston with the vacuum chamber through the ejector release valve, and the piston will be at its lowest position due to the action of the spring. Steam at boiler pressure is supplied to the chamber above the two valves and the steam brake cylinders are empty of steam, the cylinders being open to atmosphere past the exhaust valve.

When the Driver's brake valve is moved towards the "on" position, the vacuum in the train pipe is reduced due to air being admitted through the brake valve. This also admits air to the underside of vacuum cylinder piston which moves upward, causing the steam brake cylinder exhaust valve to close. Further movement next raises the pilot valve to admit steam below the balance piston which causes it to lift, thus allowing the main steam valve to open and pass steam direct to the steam brake cylinder. This condition continues until the steam pressure in the steam brake cylinder, acting downwards on the exhaust valve, is just sufficient to overcome the upward pressure on the vacuum cylinder piston, which is then forced down until the valves close.

Further downward movement of the air piston, when the vacuum in the train pipe is re-created, permits the steam brake exhaust valve to open and release steam from the brake cylinders to exhaust.

Manual Operation. Manual operation of the steam brake only, for use when running light engine or when working an unbraked train, is carried out by means of a lever and quadrant incorporated in the brake unit. The operating lever gives movement to valves through the medium of a compression spring so arranged that the amount of steam brake application is proportional to the compression of the spring, full application of the brake is obtained when this lever is placed in the last notch, the spring box then being solid.

The brake arrangement which was fitted to the former L.M.S. standard locomotives is very similar to the B.R. standard, except for the Driver's brake application valve, which is shown in Fig. 67. This is a combined steam and vacuum brake application valve and is designed to admit steam to the brake cylinders as the train pipe vacuum is reduced and to release steam from the steam brake cylinders as the vacuum is restored. The normal or "off" position is when the small ejector is in operation and a vacuum is maintained in the train pipe and on the inner side of the air piston, the opposite side of the air piston being under atmospheric pressure entering through the hollow piston rod, the air pressure holding the piston in the "in" position which, through the fulcrum lever, maintains the steam brake supply plug in the closed position and at the same time allows the exhaust passage and ports to be in communication with the pipe to the steam brake cylinders.

A movement of the application valve handle to the "on" position admits air into the train pipe through the holes in the application valve disc and to the inner side of the air piston, the air piston then being in equilibrium, the steam behind the steam plug exerts a pressure, forcing the steam plug out. The movement of the steam plug spindle closes the passage and ports, preventing the steam

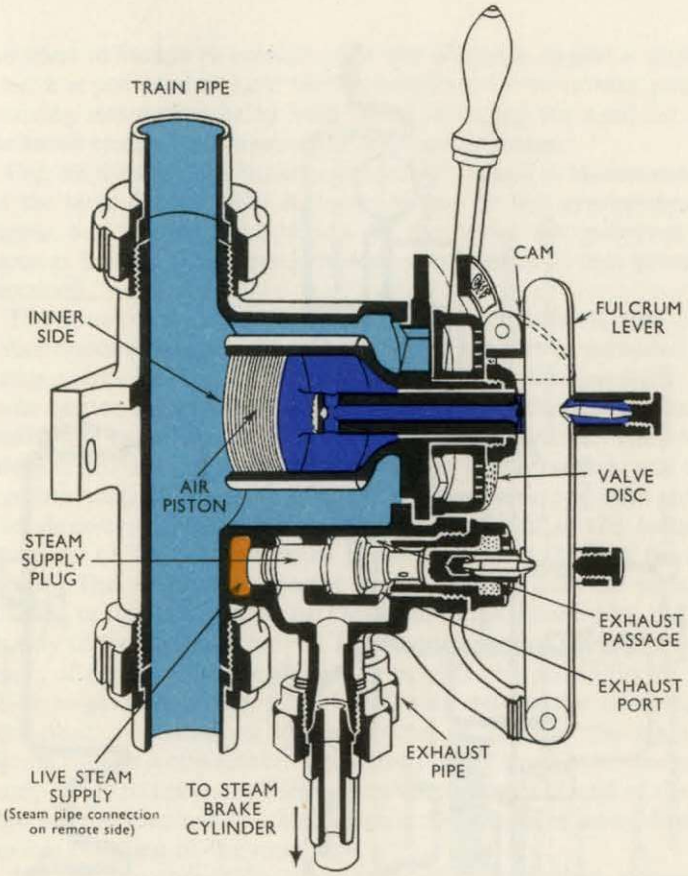


Fig. 67 DRIVER'S BRAKE VALVE

passing out to exhaust and at the same time, through the fulcrum lever, forces the air piston out. Steam from the plug passes down the steam pipe to the engine and tender steam brake cylinders. A cam, which is part of the application valve disc, ensures the positive movement of the lever to open the steam plug as the vacuum is being destroyed.

Replacing the application valve to "off" position, the vacuum will be restored in the train pipe and inner side of the air piston. The atmospheric pressure acting on the outer side of the air piston will exert a pressure to force the piston in and through the fulcrum lever, close the steam plug, and allow the steam in the steam brake

Fig. 68 BRAKE ARRANGEMENT ON ENGINE AND TENDER

Former Great Western Railway

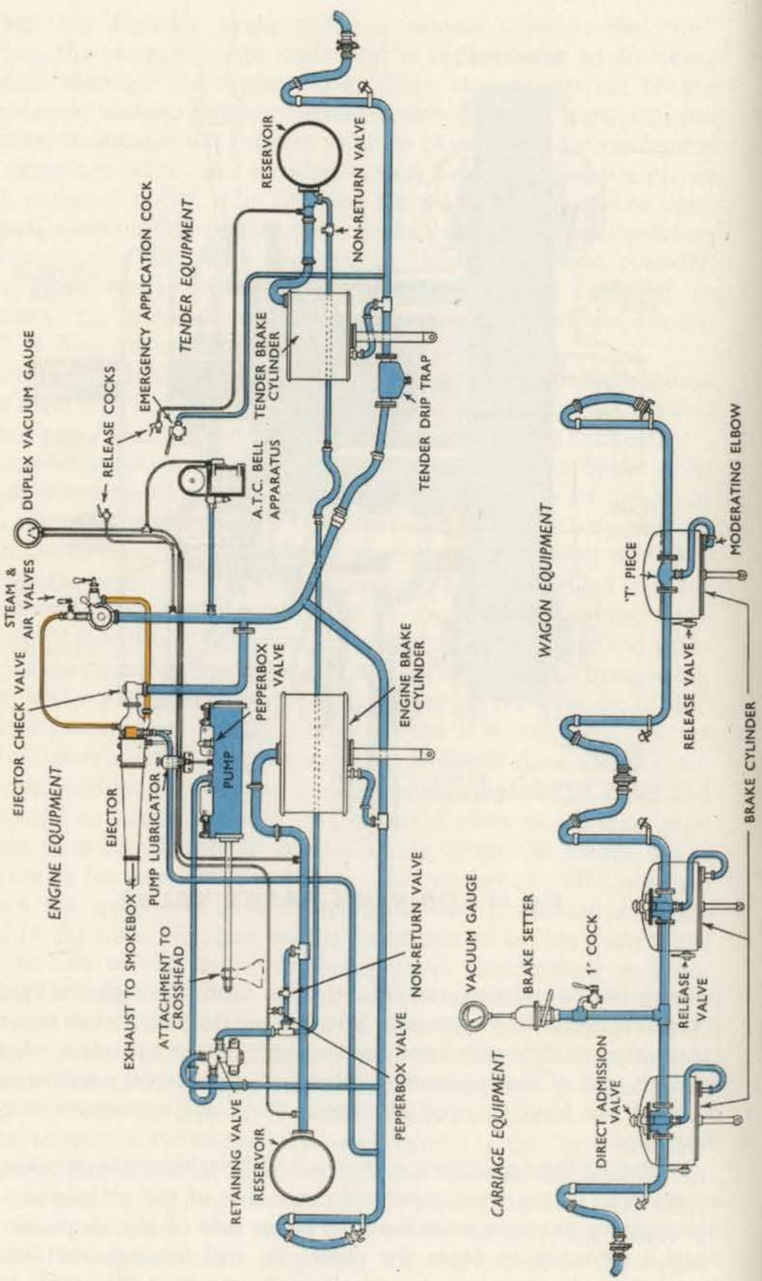


Fig. 68

cylinders to escape to exhaust. For use when the engine is standing, a hook is provided to hold the fulcrum lever in the inward position, ensuring steam plug being held closed, avoiding the need for using the small ejector and resulting in a saving of steam.

Fig. 68 illustrates a brake arrangement which is in common use on the large former G.W.R. locomotives. In this arrangement the engine and tender, in addition to the train, are provided with vacuum brakes. The arrangement is very similar to that previously described.

The four-cone ejector is located on the right-hand side of the boiler outside the cab. The steam to the ejectors is provided from steam valves located on the Driver's brake application valve. The main ejector steam valve supplies steam to the three cones and the small valve supplies steam to the remaining single cone. The vacuum pump is provided to maintain the vacuum when running, and this is supplemented as necessary by the single-cone ejector (small ejector). The three-cone ejector (large ejector) is coupled to the train pipe extension to the Driver's brake application valve through the check valves. The single-cone ejector (small ejector) and the pump are coupled to the train pipe at the front end of the locomotive, the latter by way of the retaining valve. The arrangement of these pipes is the result of protracted experiments to obviate the possibility of water which might accumulate in the flexible train pipe connections through condensation caused by the admission of air into the train pipe during cold or wet weather. The action of the small cone ejector and pump tends to draw any moisture towards the front end of the train pipe on the locomotive, thus keeping the moisture away from the flexible coupling of the train pipe.

The vacuum pump (Fig. 69) consists of a piston which reciprocates

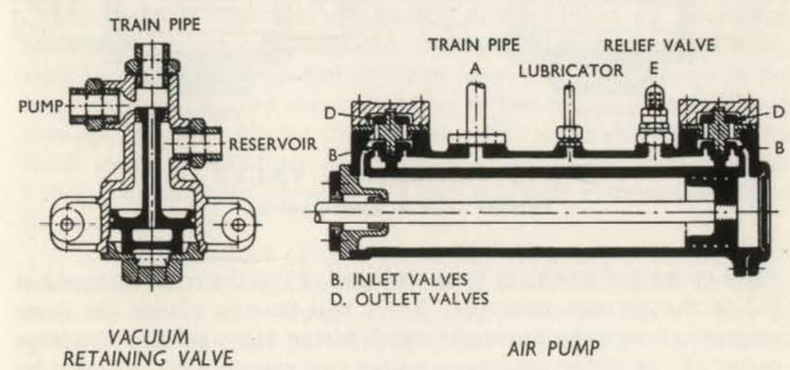


Fig. 69 VACUUM PUMP

Former Great Western Railway Locomotives

in the cylinder, being driven directly from one of the locomotive piston crossheads. A chamber extends above the cylinder and flat clack valves (B) are fitted between the chamber and the cylinder, one at each end. Similar flat clacks (D) are also fitted at each end of the cylinders which lift to provide access to the atmosphere. Train pipe (A) provides communication to the retaining valve.

As the piston travels from the left-hand cover air is induced from the chamber and pipe (A), past clack (B), clack (D) being held on its seating by the pressure of the outside atmosphere. On the return stroke the air previously induced into the cylinder is expelled from the cylinder past clack (D) into the atmosphere, valve (B) being held on its seating by the air being expelled. The pump is double acting so that when air is being induced from the train pipe on one side of the piston, the air induced during the previous stroke is being expelled at the other side.

The retaining valve is shown in Fig. 70. Position 1 shows the

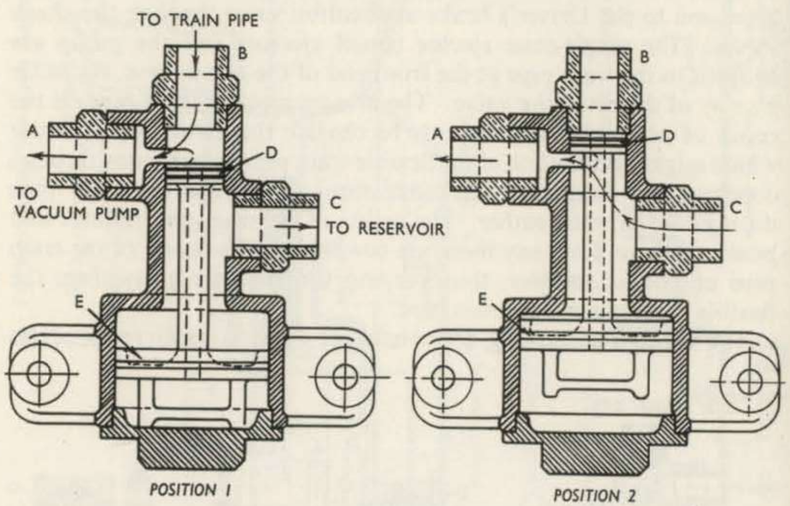


Fig. 70 RETAINING VALVE
Former G.W.R. Locomotives

valve connected at (A) to the pump and (B) to the train pipe and at (C) to the vacuum reservoir. There will thus be always the same amount of vacuum above the small piston (D) and also the large piston (E) as in the train pipe, as the two pistons are connected by means of a hole through the piston rod. In the space between the

piston heads there will be the same amount of vacuum as in the reservoir. When running, air is extracted from the train pipe by the vacuum pump.

When the brake is applied air enters the train pipe and then flows underneath the large piston (E) and raises the pistons to the position shown in *Position* 2. It will be noted that the piston (D) seals the passage (B) and being raised above the passage (A) opens communication between the latter and the passage (C), and the effect of the pump being transferred to maintaining the vacuum in the reservoir.

The vacuum relief valve or pepper-box valve on the connecting pipe prevents the vacuum in the reservoir from rising to an excessive amount and preventing the brake pistons from returning to their normal position when the brake is released. The relief valve is set to lift at 23 in. vacuum.

Returning to Fig. 68, when the brake is applied air is admitted to the train pipe and from there to the undersides of the brake pistons on the engine, tender and train. This action of the retaining valve transfers the effect of the pump to the reservoir side of the brake cylinders, therefore maintaining the reservoir vacuum.

When the brake is released the single-cone ejector should be used, whereas the three-cone ejector (large ejector) should only be used when it is necessary to create the vacuum quickly. By avoiding the use of the three-cone ejectors a considerable amount of steam will be saved.

Another brake arrangement in common use is shown in Fig. 71.

A combined ejector and Driver's brake application valve is fitted; this may be of the Dreadnought or solid jet type. (Fig. 72.)

A diagrammatic view of the Dreadnought type of combined ejector and brake valve is shown in Fig. 73.

The diagram illustrates the ejector in the "brake off" position, i.e. the brakes are being released, the cam on the main shaft being raised to open the large ejector steam valve and admit steam to the large ejector. At the same time steam passes to the small cone through the small ejector steam valve. This valve should be set by hand so as to withdraw and reduce the steam pressure to about 120 lb., which is the pressure at which this cone is designed to give its greatest efficiency.

Under the influence of both cones air is drawn rapidly from the train pipe past the large ejector air clack, the small ejector air clack, main air clack, and through cavity (D) in the air disc by way of ports (C and B), these ports being in full register in this position of the handle. At the same time air is drawn from the vacuum chambers on engine and tender past release valve.

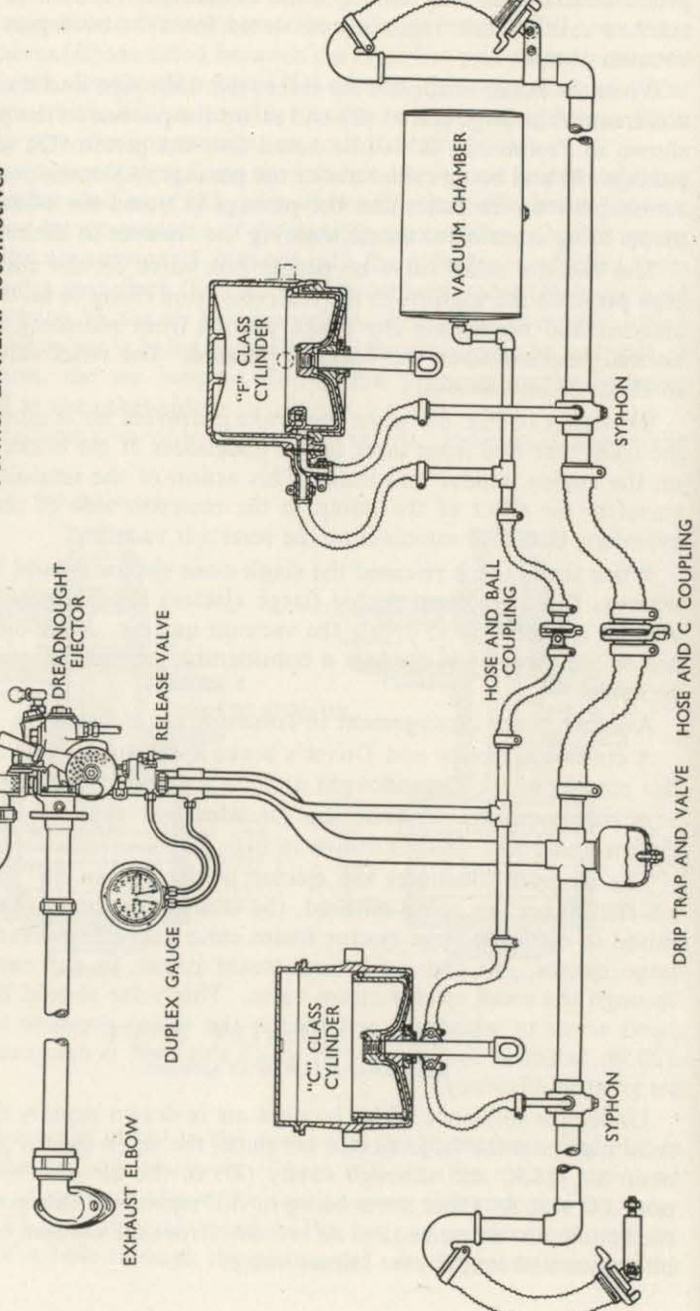


Fig. 71 ARRANGEMENT OF VACUUM BRAKE ON ENGINE AND TENDER

Former L.N.E.R. Locomotives

Fig. 71

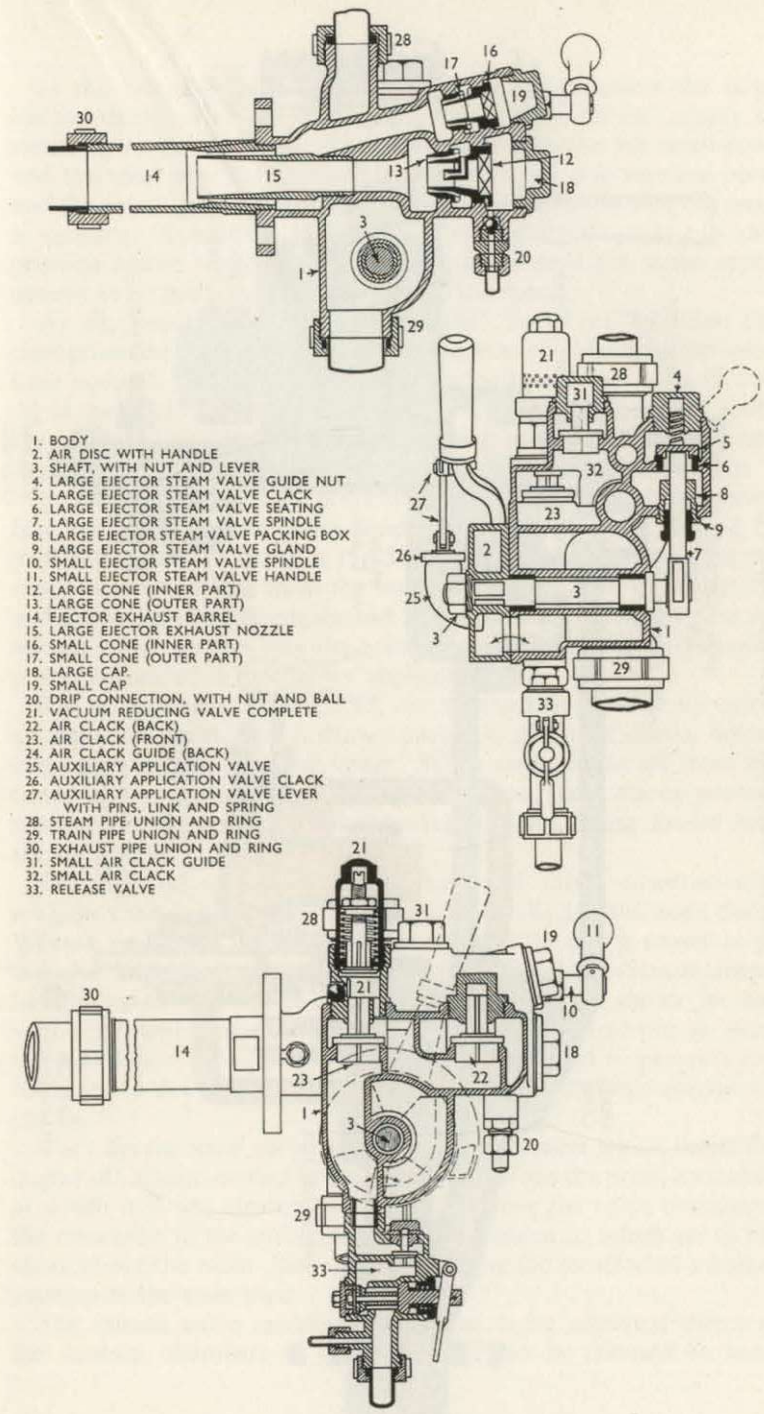


Fig. 72 DREADNOUGHT EJECTOR

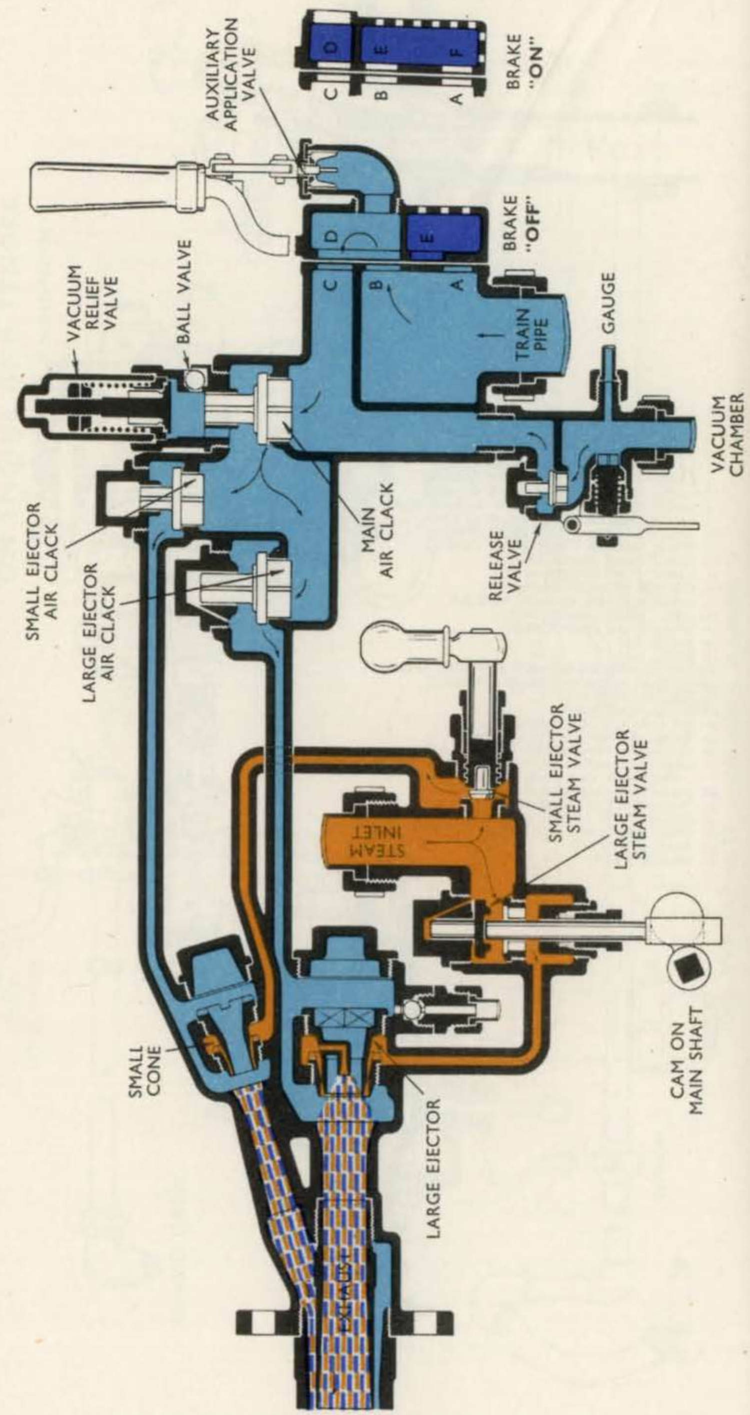


Fig. 73 WORKING DIAGRAM OF DREADNOUGHT VACUUM EJECTOR AND DRIVER'S BRAKE VALVE

In the "running position" of handle, the cam lowers the large ejector steam valve on to its seat, thus cutting off the supply of steam to the large ejector. The connection between the small cone and the train pipe through cavity (D) in the air disc remains open and the small ejector maintains the working vacuum whilst the train is running. Operation of the auxiliary application valve in this position admits air to the train pipe and enables light brake applications to be made for controlling the train speed.

As the handle is moved towards the "brake on" position the connection through the cavity (D) is progressively closed. At the same time ports (E and F) in the air disc gradually uncover ports (B and A) in the ejector face and air is admitted to the train pipe to apply the brake. This air is prevented from passing to the engine and tender vacuum chambers by the non-return valve in release valve.

In the full "brake on" position ports (A and B) in the ejector face are completely open to atmosphere through ports (F and E) in the disc and the brake is rapidly applied. At the same time the small cone is isolated from the train pipe by the wall of cavity (D) and draws only on the engine and tender vacuum chambers past the release valve. In this way the maximum possible locomotive brake power is assured in emergency applications.

The air passages in the ejector are so arranged that, in all cases, air from the train pipe is drawn past two gunmetal clacks before coming in contact with the steam. When steam is cut off from the cones and a vacuum is left in the train pipe, these clacks prevent moisture, and more especially smokebox gases, being drawn into the train pipe.

The ball valve, located below the relief valve, communicates with the chamber between the two ejector clacks and the main clack. When a vacuum is created in the instrument the ball is drawn to its seat, but falls off as soon as steam is shut off and the vacuum drops. Should ejector air clacks be leaking it provides an outlet for any vapour or steam. Should the main air clack leak, it admits air from the atmosphere being drawn into the train pipe and so prevents any tendency to draw vapour and smokebox gases through ejector air clacks.

The vacuum relief valve is a spring-loaded valve which limits the degree of vacuum carried in the train pipe. When the point is reached at which it is set, atmospheric pressure above the valve overcomes the resistance in the spring and the valve opens to admit air to the space above the main clack, thus preventing the creation of a higher vacuum in the train pipe.

The release valve enables atmosphere to be admitted direct to the vacuum chambers so that the brake can be released by hand

Fig. 74 WORKING DIAGRAM OF S.J. VACUUM EJECTOR AND DRIVER'S BRAKE VALVE

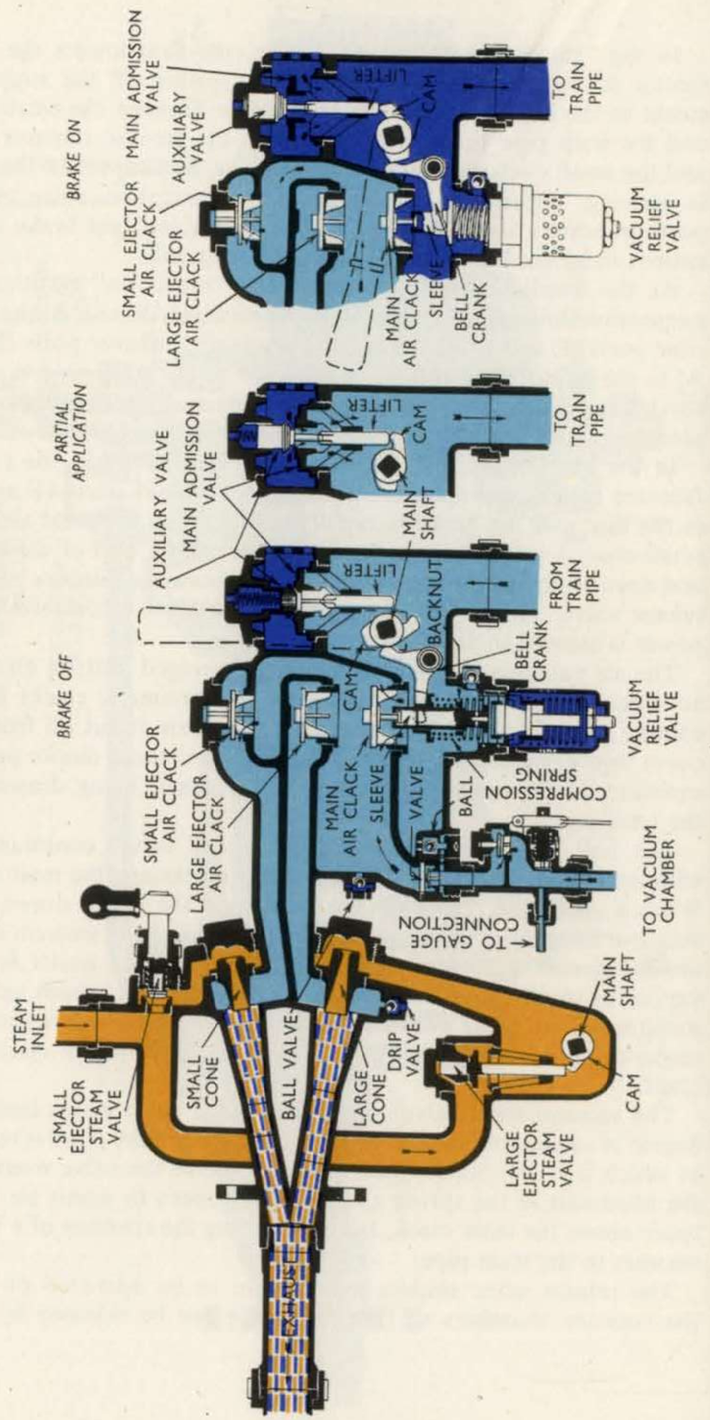


Fig. 74

when the locomotive is uncoupled and when steam is not available.

Fig. 74 shows a diagrammatic arrangement of the solid jet type combined ejector and brake valve.

The left-hand illustration is of the ejector in "brake off" position, the cam on the main shaft being raised to open the large ejector steam valve and admits steam to the large cone. At the same time steam passes to the small cone through the small ejector steam valve which is opened just sufficiently to admit the quantity of steam necessary to maintain the required vacuum.

Under the influence of both cones air is drawn rapidly from the train pipe past the air clacks, also from the chambers on the engine past the valve and the ball.

In the "running position" of the Driver's handle, the cam lowers the large steam valve on to its seat and the working vacuum is maintained throughout the running train by the small cone only, which is prevented from drawing back on the exhaust branch of the large ejector by air clack closing down.

The "partial application" shows the first admission of air as the Driver's handle is moved towards the "brake on" position. The finger on cam engages the lifter to open an auxiliary valve, and after this valve has attained its full lift the shoulders on the wing of the lifter come in contact with the main admission valve.

To effect isolation of the main train pipe from the action of the small ejector in the full "brake on" position, the main air clack is provided with a spindle extension actuated by the sleeve. Bell crank, worked from the cam, is operated increasingly as the Driver's handle comes to the "full on" position. In the "full on" position illustrated the arm of the bell crank has fully depressed the sleeve, taking with it the main clack, so shutting off the small ejector connection from the train pipe. The actual holding down of the main air clack is through the compression spring, which is capable of adjustment as regards tension by means of the backnut. The light spring only serves the purpose of holding this assembly together to prevent chatter.

When the brake is applied and the small ejector is left drawing upon the cavity below the small air clack, the large air clack remains closed and the main air clack is held closed by the bell crank, the valve lifts and connects the engine chambers to the ejector. In this way the maximum possible locomotive brake power is assured in emergency applications. To provide against the creation of an excessive vacuum in the top side of the brake cylinders the main air clack is held down by the bell crank through the tension of the compression spring which is so arranged that, when the brake is "full on" and the cavity all round the bell crank and the train pipe is in a state of atmospheric pressure, the creation of anything exceeding 21 in. above the main air clack will cause the atmospheric pressure under it to overcome the resistance of the compression spring and so allow the main air clack to lift, and this acts as an internal relief valve, obtaining its air from the train pipe which is in a state of atmospheric pressure due to the main admission valve being open.

A ball valve is located in the cavity between the two ejector clacks and the main clack, and is drawn to its seat when a vacuum is created, but falls off as soon as steam is shut off and the vacuum drops. Should the small and large air clacks be leaking, it provides an outlet for any vapour or steam. Should the main air clack leak, this ball valve prevents any tendency to draw vapour and smoke box gases through the small and large air clacks. The ball above the relief valve serves to allow any moisture to escape.

For the purpose of maintaining the brake operative on a "dead engine" which requires moving and may have vacuum brake cylinders without ball valves, the ball is provided within the ejector. By this means, when a vacuum is created in the train pipe, air is also drawn from the chambers of the dead engine, thus created in the train pipe; air is also drawn from the chambers of the dead engine, thus creating a vacuum above and below the brake pistons. This necessitates that the Driver's handle on the dead engine ejector is in the "running position".

The vacuum relief valve is a spring-loaded valve which limits the degree of vacuum carried in the train pipe. When the point is reached at which it is set, the atmospheric pressure below the valve overcomes the resistance of the spring and the valve opens to admit air to the space below the main clack, thus preventing the creation of a higher vacuum in the train pipe.

The release valve operates in the usual manner.

Fig. 75 shows the brake arrangement on ex-L.N.E.R. A.3 Pacific locomotives.

The combined ejector and Driver's brake valve is of the combined type and the vacuum brake cylinders are of the combined "C" class without release valve.

On the arrangement Figs. D and A illustrate the normal running position with the brakes "off" and the small ejector maintaining the vacuum in the train pipe and vacuum cylinder. Figs. F and B illustrate the position when the brake is in the "on" position.

It will be noted that air has entered the train pipe through the Driver's control handle and has acted on the underside of the brake cylinders causing the brakes to be applied. The effect of the small

ejector has been cut off from the train pipe and its whole effect transferred to maintaining the vacuum in the vacuum chamber on the top side of the brake cylinders so as to overcome any slight leakages which might decrease the vacuum.

Vacuum Brake Cylinders

Figs. 76-79 show four types of vacuum brake cylinder which are in common use on British Railways. Fig. 76 illustrates the combined "C"-type cylinder which is in general use on carriage and wagon stock as no vacuum chamber is required, this being incorporated in the design. The piston is rendered airtight by means of a rubber rolling ring (9).

Fig. 79 illustrates a similar cylinder, but the piston is fitted with a slipping rubber band instead of a rolling ring, and this type was adopted as standard for British Railways stock.

With rolling ring cylinders the vacuum chamber side vacuum is obtained either through a non-return ball valve in the piston or in an external fitting on the cylinder. These allow air to flow from the chamber side and shut when the brake is applied, so as to maintain the vacuum in the vacuum chamber.

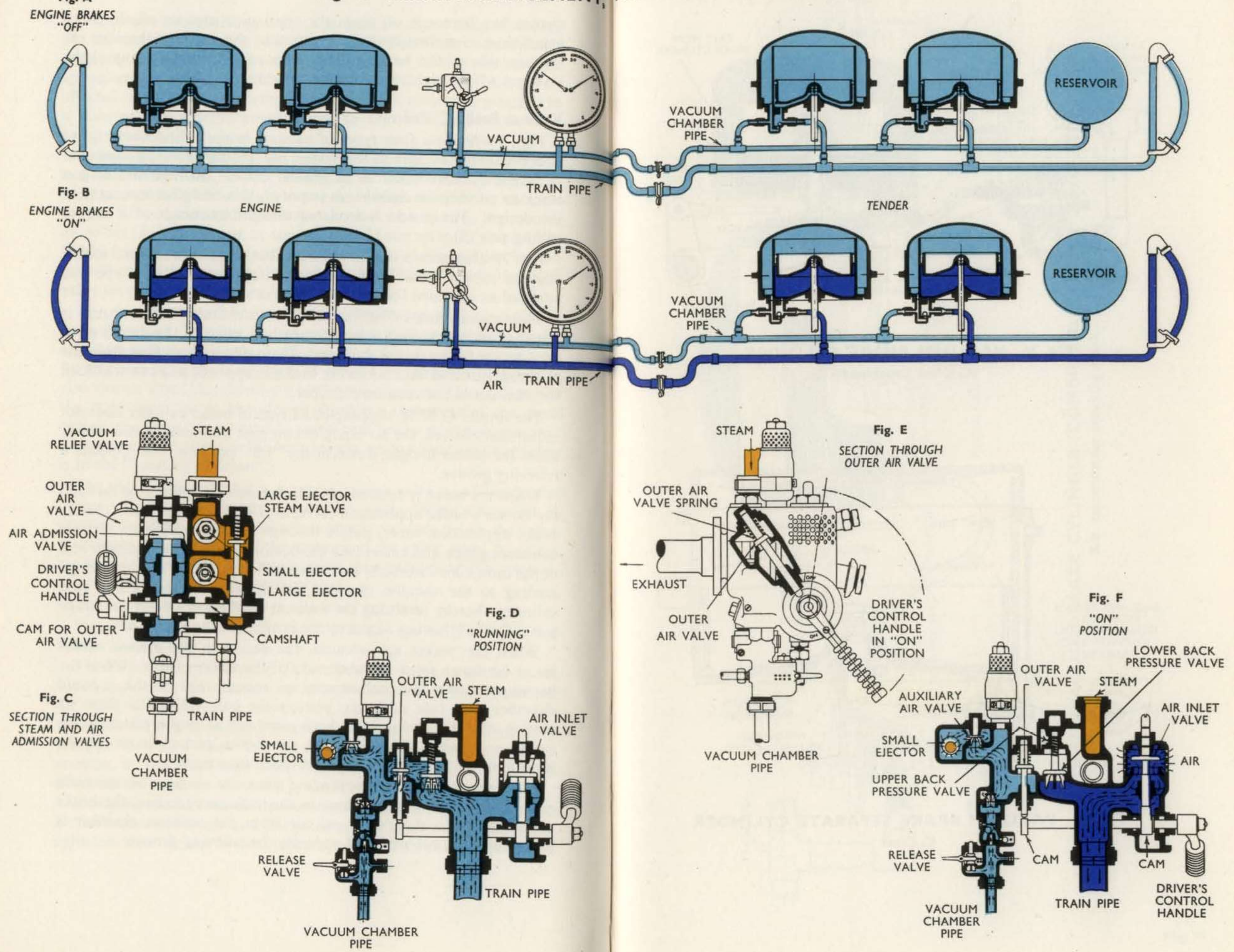
The former G.W.R. slipping-band type of brake cylinder does not require ball valves, the air being drawn past the rubber band which, when the piston is right down in the "off" position, lies opposite a relieving groove.

When the brake is applied, air which enters the train pipe through the Driver's brake application valve, or, for that matter, the Guard's brake application valve, passes through the brake cylinder flexible connecting pipe and enters into the bottom of the brake cylinder and at the same time forces the ball valve on to its seating on the passage leading to the vacuum chamber, in the case of the rolling ring cylinder, thereby retaining the vacuum on the top side of the brake piston, the air having access to the bottom of the piston only.

When the brakes are released, the action of the ejector causes air to be drawn from the underside of the brake piston. When the vacuum reaches and commences to exceed that in the vacuum chamber (top side of brake piston) the ball valve lifts from its seating until the vacuum on both sides of the brake piston is the same, and being in equilibrium the brake piston drops to the bottom of the brake cylinder by virtue of its weight.

With the slipping-band cylinder, when the vacuum in the train pipe commences to exceed that in the vacuum chamber, the brake piston drops to the "off" and air from the vacuum chamber is drawn past the rubber band opposite the relieving groove.

Fig. 75 BRAKE ARRANGEMENT, Former L.N.E.R. A.3 Pacific Locomotive



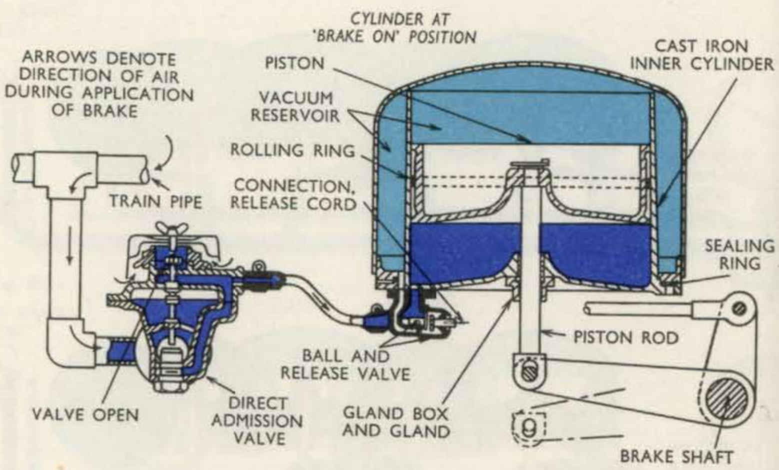


Fig. 76 VACUUM BRAKE CYLINDER

C. Class Combined

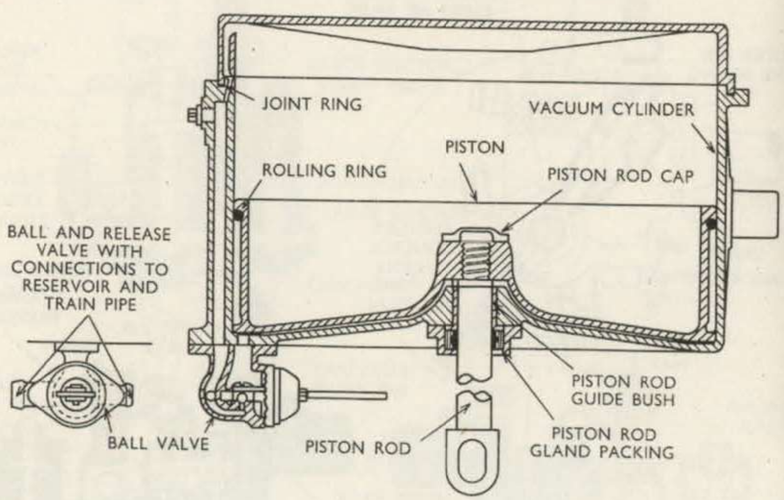


Fig. 78 VACUUM BRAKE SEPARATE CYLINDER

C. Class

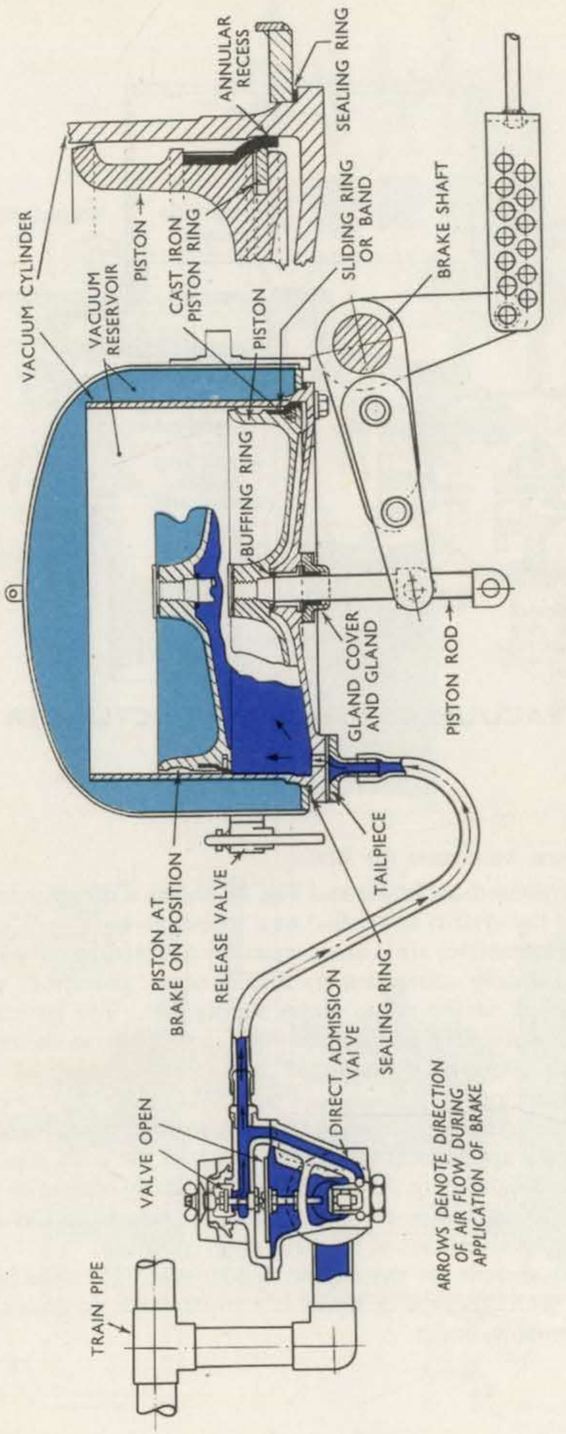


Fig. 77 VACUUM BRAKE CYLINDER (COMBINED) SLIPPING-BAND TYPE

B.R. standard for coaching stock

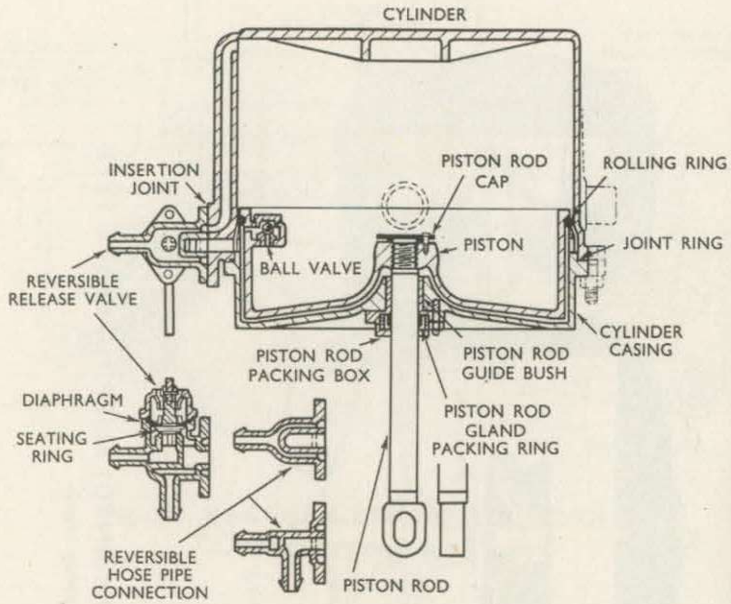


Fig. 79 VACUUM BRAKE SEPARATE CYLINDER

F. Class

The Westinghouse Automatic Air Brake

This is a compressed-air brake and Fig. 80 shows a diagrammatic arrangement of the system as applied to a locomotive.

On a steam locomotive, air is compressed by a steam-driven pump which is automatically controlled by means of a "governor" (see Fig. 81) positioned on the pump steam supply line. The governor is usually set to maintain a pressure of 90 lb. per sq. in. in the main reservoir, which pressure is indicated by the red hand of the duplex air pressure gauge.

The compressed-air supply from the main reservoir passes through the Driver's brake application valve (Fig. 82) into the train pipe by means of the feed valve (Fig. 83) which automatically maintains the air pressure in the train pipe at 70 lb. per sq. in. when the Driver's brake application valve is set in the "running" position.

The brake equipment on the engine, tender and each vehicle of the train fitted with this type of brake is a triple valve, auxiliary air reservoir and brake cylinder.

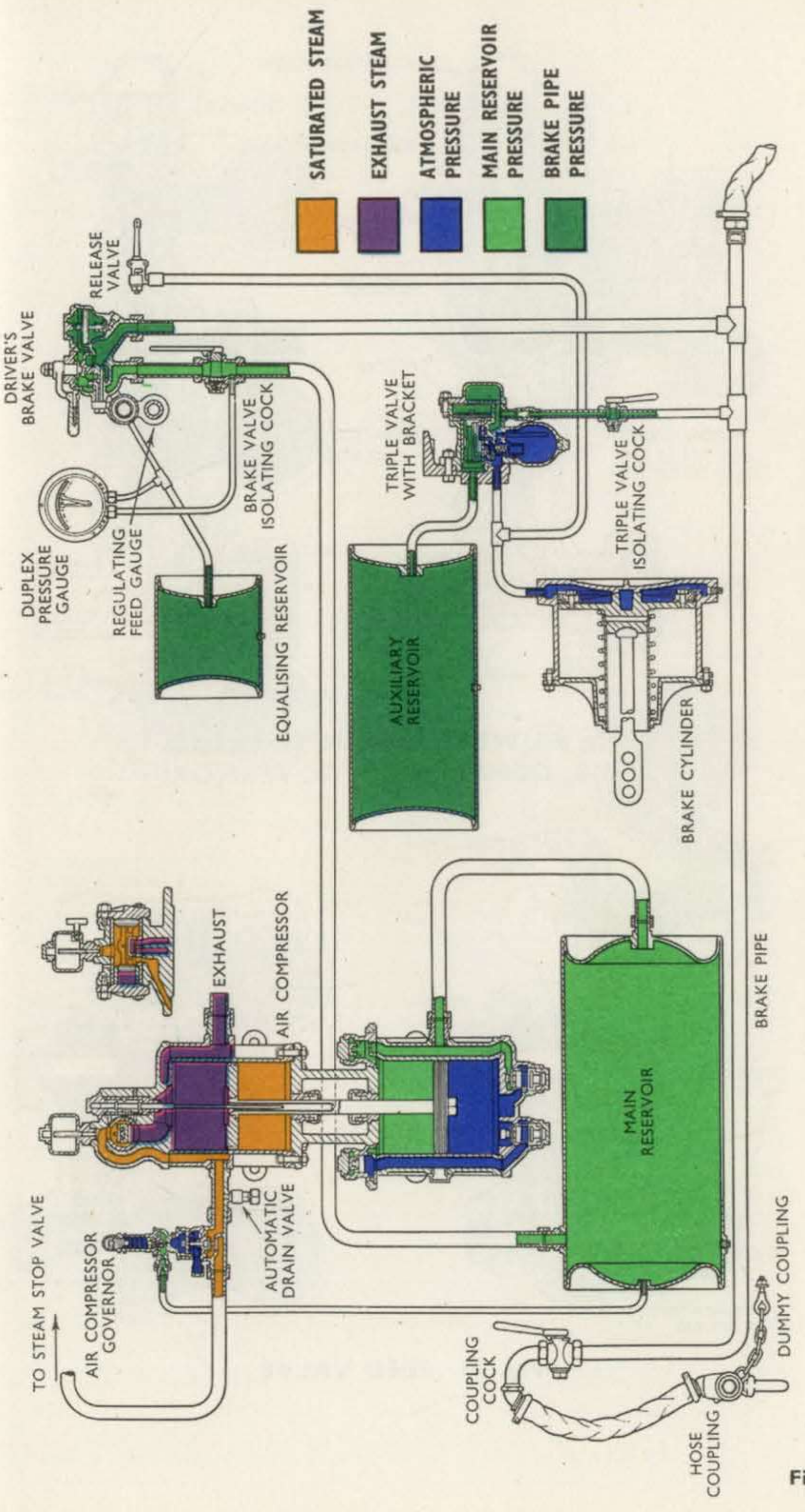


Fig. 80 DIAGRAM OF WESTINGHOUSE AUTOMATIC BRAKE

Fig. 80

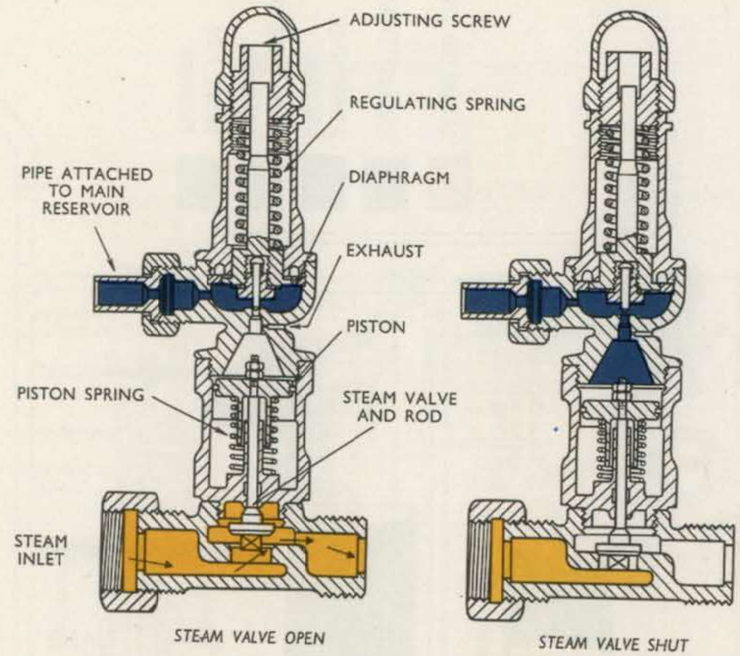


Fig. 81 WESTINGHOUSE BRAKE AIR COMPRESSOR GOVERNOR

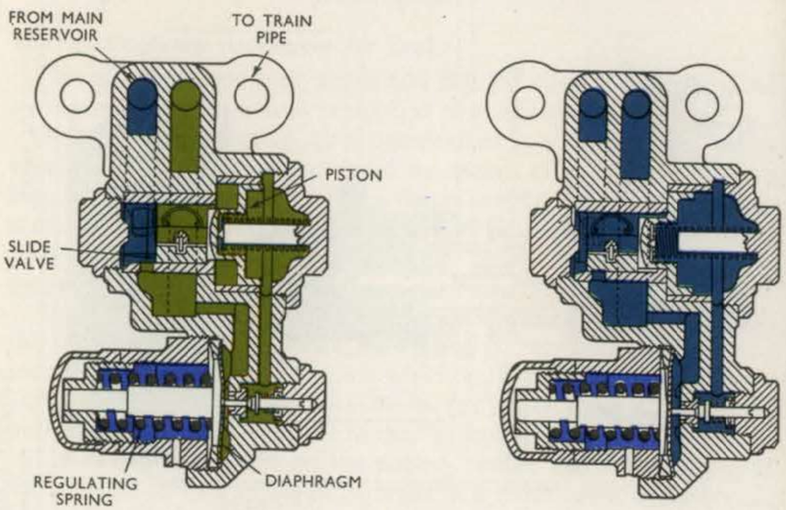


Fig. 83 FEED VALVE

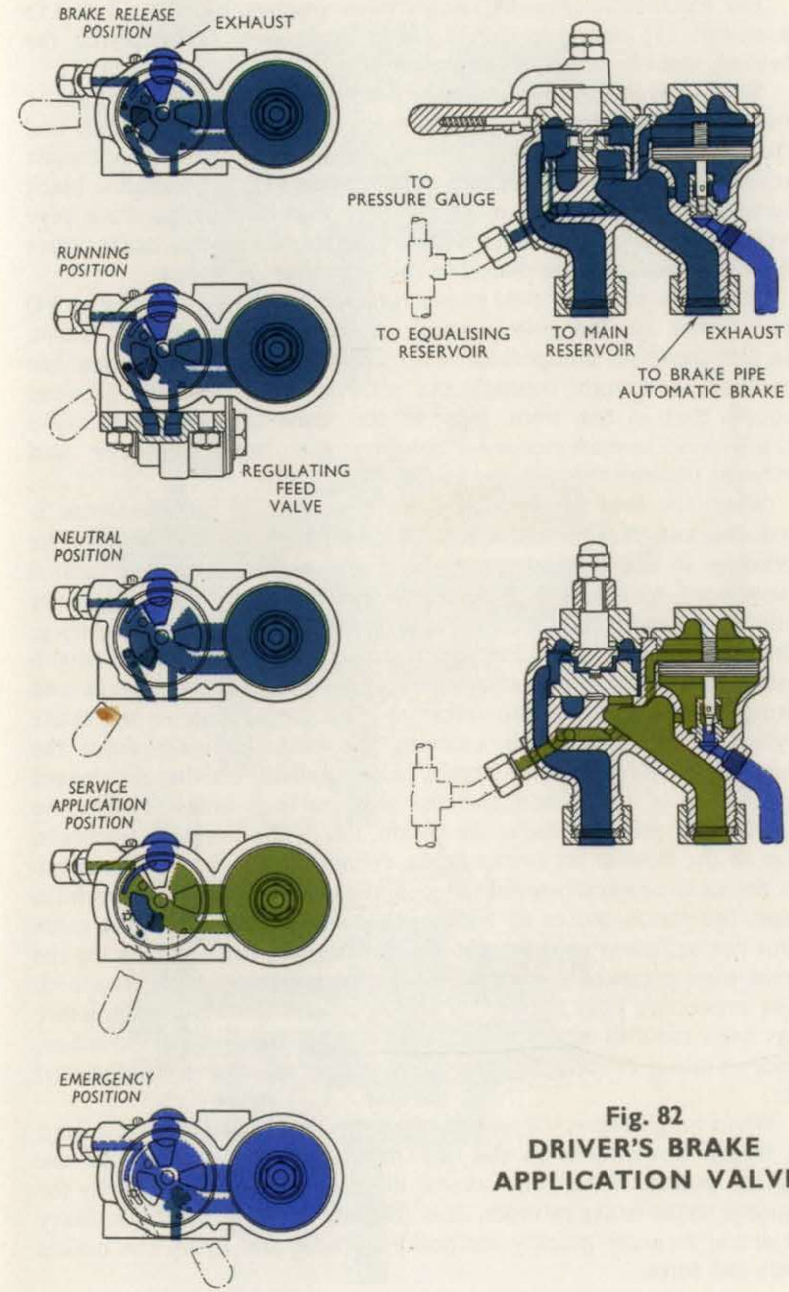


Fig. 82 DRIVER'S BRAKE APPLICATION VALVE

The triple valve (Fig. 84), as the name implies, has three duties to perform: (1) charging the auxiliary reservoirs, (2) applying the brakes, and (3) releasing the brakes.

When the locomotive is coupled to the train, air is admitted to the train pipe after the cocks between the locomotive (tender) and the train have been opened. Driver's brake application valve handle is then placed in the "release" position (see Fig. 82) until the black hand of the duplex air gauge indicates that the normal train pipe working pressure has been reached, after which the brake valve handle should then be placed in the "running" position.

The air in the train pipe passes into each triple valve (see Fig. 84) and forces up the piston which is connected to a slide valve. In this position compressed air from the train pipe charges the auxiliary reservoirs through the grooves until the air pressure equals that in the train pipe, at the same time the slide valve establishes communication between the brake cylinder and exhaust passage through the cavity.

When the brake is applied the air pressure in the train pipe is reduced and the piston is moved downwards by the greater air pressure in the auxiliary reservoir. The piston, having a limited movement, without acting on the slide valve, closes the feed groove and at the same time moves the graduating valve from its seating, thus opening the port. Further downward movement of the piston takes with it the slide valve which closes the exhaust passage and brings the port into communication with the passage to the brake cylinder, resulting in air entering the brake cylinder from the auxiliary reservoir and the brakes being applied. Further downward movement of the piston and the slide valve is arrested with the decrease of pressure above the piston, i.e. in the auxiliary reservoir, due to the flow of air to the brake cylinder, and when the pressure in the auxiliary reservoir is reduced slightly below that in the train pipe, the piston moves up sufficiently to close the graduating valve (but not sufficient to move the slide valve). By further reducing the train pipe pressure any degree of brake pressure can be attained. The brakes are fully applied, however, when the train pipe pressure has been reduced by 25 lb. per sq. in., and any further reduction, under normal braking conditions, is merely a waste of compressed air.

When an emergency application of the brake is made, the piston is forced downwards to the limit of its stroke and seats on the leather gasket. When this occurs, the slide valve uncovers fully the passage to the brake cylinder, thus allowing the air from the auxiliary reservoir to enter quickly the brake cylinder and apply the brakes with full force.

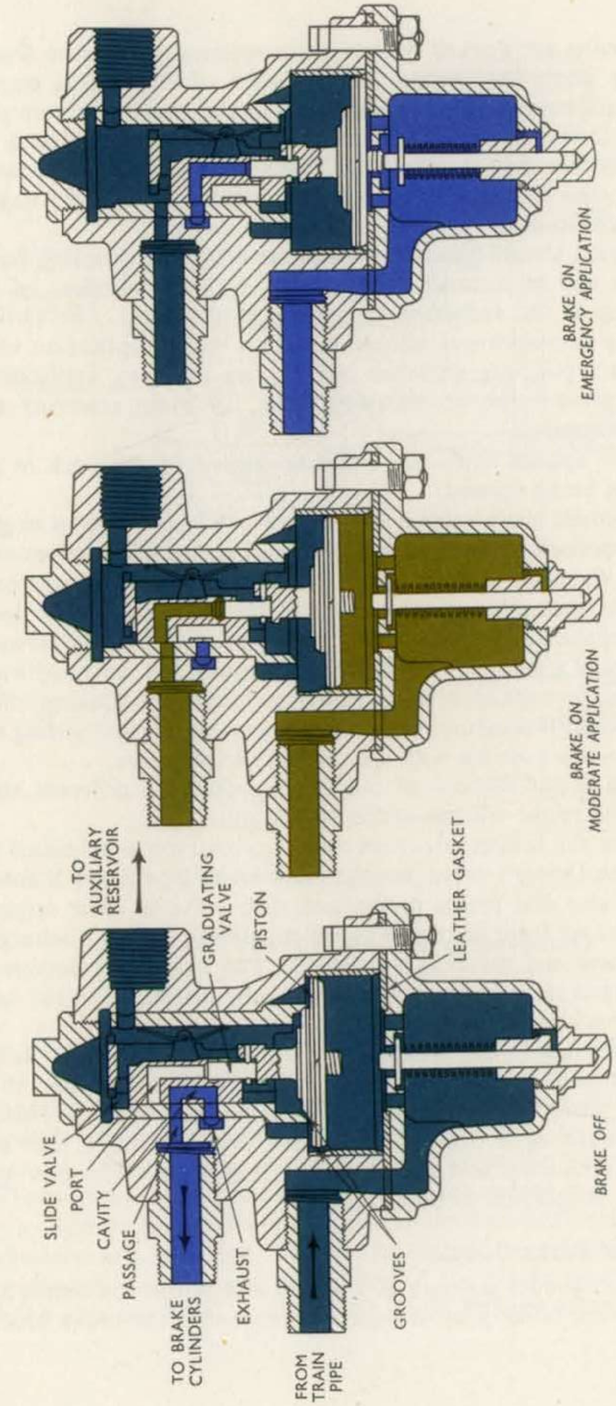


Fig. 84 TRIPLE VALVE (Ordinary)

Fig. 84

When trains are worked with two locomotives, the brakes should be entirely under the control of the Driver of the leading engine. On the train engine the isolating cock to the main reservoir pipe under the Driver's brake application valve must be closed and the brake valve placed in the "release" position. Care should be taken to ensure that this isolating cock is opened on the train engine whenever the leading engine is uncoupled.

If the train should become divided, or a flexible coupling burst, the brakes will be automatically applied on both portions of the train owing to the reduction in train pipe pressure. The Driver, under these circumstances, should move his brake application valve to the "on" position, as when making an ordinary application. This will prevent the air escaping from the main reservoir and assist the stopping.

The same applies when the brake is applied by the cock in the guard's van being opened.

The improved triple valve is shown in Fig. 85; its object is to give a closer approach to simultaneous action of all the triple valves on a train when the slide valve is moved by applying the brakes, the bulb is closed to atmosphere and opened to the train pipe. The local reduction of the train pipe pressure thereby produced by the forward triple valves of a train causes an earlier action of the rearward triple valves, which results in a more nearly simultaneous braking effect being produced throughout the train in every case of first setting the brakes than was possible with the ordinary triple valve.

The bulb at the bottom of the valve is made in different sizes proportioned to the volume of the vehicle train pipe.

To release the brakes, air from the main reservoir is admitted by means of the Driver's valve into the main brake pipe where it enters the triple valve and forces piston and slide valve to their original position; the air from the brake cylinders of bulb is then discharged to atmosphere and the brakes released. The auxiliary reservoir is then recharged through the grooves, past the piston, as in the case of the ordinary triple valve.

Fig. 86 illustrates the brake arrangement of a dual-fitted locomotive; whilst the brakes on the engine are Westinghouse, it is possible to work coaches equipped with vacuum brakes. This is done by means of a proportional valve, which ensures that the degree of application and release of the brakes on the engine and train are in proportion to each other.

Westinghouse Brake Cylinder

The brake cylinder consists of a piston and piston rod which are attached to the brake gear in such a manner that the brake blocks

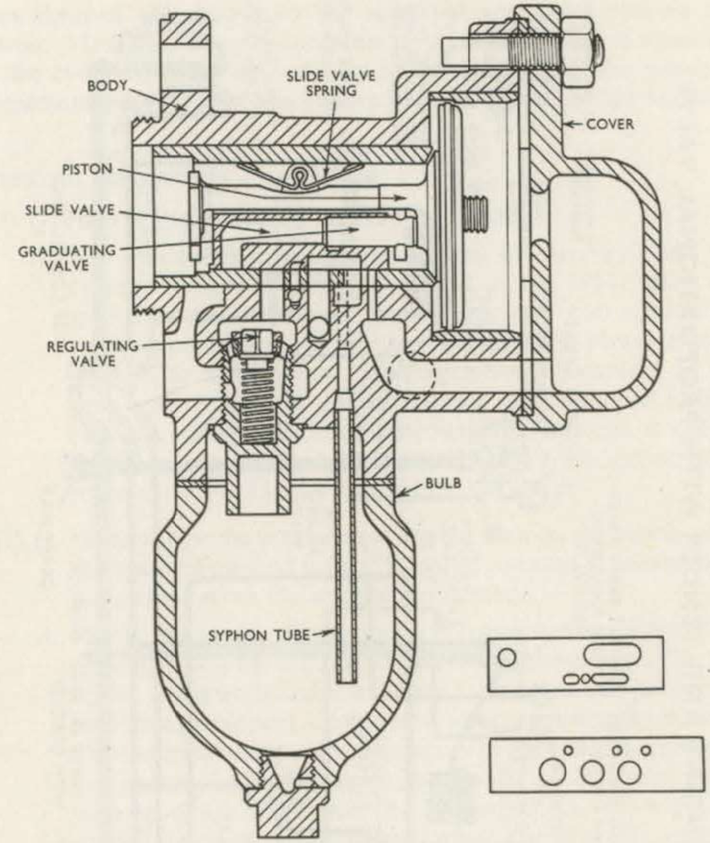


Fig. 85 TRIPLE VALVE (Improved)

are pressed against the wheels when the piston is moved in the brake cylinder by air pressure. A spring is fitted which is compressed when the brake is applied, and when the brake is released the spring expands and returns the piston and brake gear to their original position, thus releasing the brake blocks from the wheels.

To prevent the application of the brakes, which might be caused by a slight leakage in the brake pipe to the brake cylinder, the brake cylinders are provided with a small groove which establishes communication between both sides of the piston when the brake piston is in the "off" position. If a slight leakage occurs the air will

Fig. 86 WESTINGHOUSE BRAKE DIAGRAM

AUTOMATIC BRAKE ON ENGINE AND TENDER WITH PROPORTIONAL VALVE

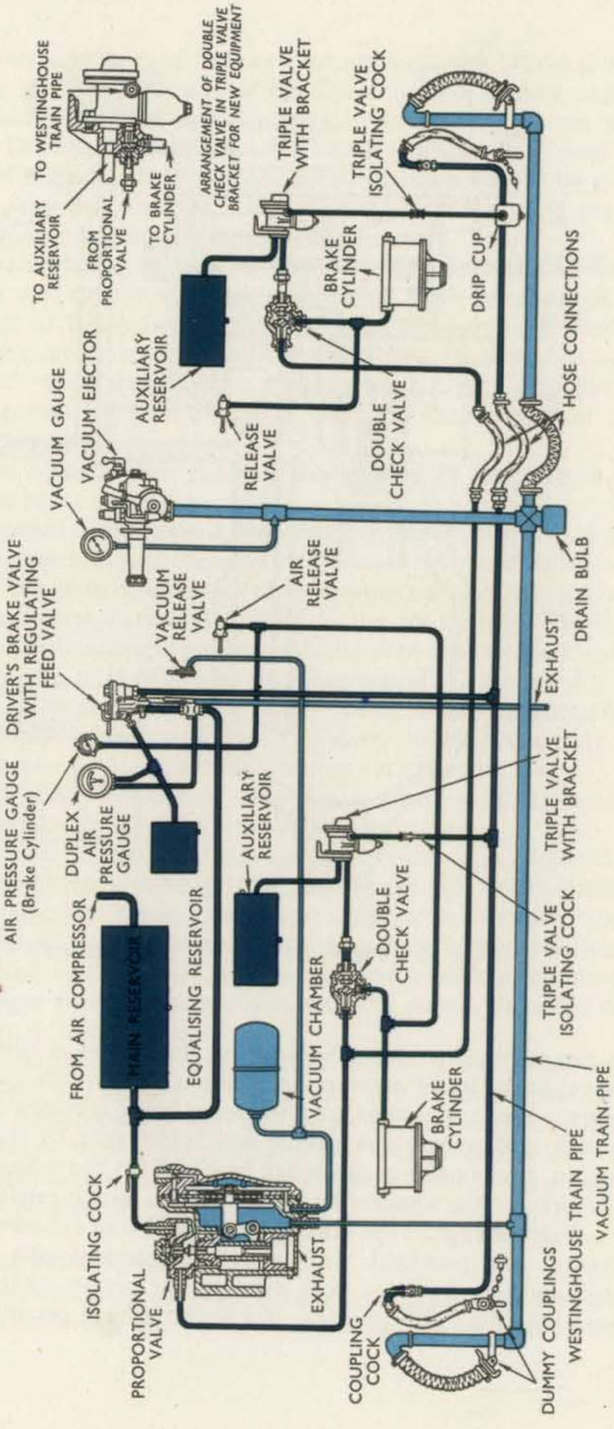


Fig. 86

pass through the groove to the atmosphere without moving the piston. However, when a considerable quantity of air is admitted to the cylinder, as by an ordinary brake application, the piston is immediately forced past the groove and the escape of air sealed.

Questions and Answers

(1) *Q*. How is the train pipe vacuum measured?

A. The vacuum is measured in "inches of mercury" and the vacuum gauges on the engine and in the brake vans are graduated in inches. A perfect vacuum corresponds to approximately 30 in. of mercury, atmospheric pressure or no vacuum to zero inches. The regulation of vacuum in the train pipe to 21 in. of mercury, which it is important to bear in mind, along with other intermediate readings, is only a partial vacuum. Each 1 lb. pressure of air extracted is represented by 2 in. of vacuum on the gauge.

(2) *Q*. What will be the pressure per square inch on the piston when the brake is applied fully if 21 in. of vacuum is recorded on the gauge before the application is made?

A. $10\frac{1}{2}$ lb. per sq. in. Atmospheric pressure or the weight of air pressing upon the earth's surface is approximately 15 lb. per sq. in. at sea level and it has been found that this pressure is sufficient to support a column of mercury nearly 30 in. high. Consequently every inch of mercury in the column represents a pressure of $\frac{1}{2}$ lb. per sq. in., so that 21 in. indicated in the vacuum gauge represents $10\frac{1}{2}$ lb. per sq. in. which can be exerted upon the piston head when the brake is applied. Some idea of the power available can be obtained by considering a 20-in. diameter cylinder. The area of the piston is 314 sq. in. and the pull produced on the brake piston rod would be $10\frac{1}{2} \times 314$ lb., which equals 3,297 lb. or more than 1 ton.

(3) *Q*. How does the combination ejector create vacuum?

A. A jet of steam issuing at high velocity from a cone of special shape within the ejector (see Fig. 64) carries the surrounding air forward by frictional contact through a second and larger cone, known as the air cone, to exhaust in the smoke-box.

The removal of air in this manner from the space in the immediate vicinity of the steam jet sets up a partial vacuum inside the ejector; air, in its endeavour to fill this space, flows past the non-return valve from the train pipe and other portions of the brake apparatus connected to it.

In this way it is possible to maintain the desired amount of vacuum at will in the train pipe and connections so long as the ejector is kept at work and the brake is not applied. The combination ejector contains two separate ejectors constructed on the above principle, each one independent of the other and possessing its own non-return valves.

(4) *Q*. What purpose do the non-return valves serve?

A. The non-return valves and the air lock chamber are for the purpose of preventing loss of vacuum through the ejector cones when the ejector is shut down, and also to guard against steam and smokebox gases being allowed to enter the train pipe and connections.

(5) *Q*. How is the train pipe vacuum prevented from rising above the regulation amount of 21 in.?

A. A vacuum relief valve is provided for the purpose. This is a spring-loaded valve capable of being adjusted so that it will open and admit air to the train pipe as soon as the regulation vacuum of 21 in. has been exceeded. The relief valve is generally mounted inside the cab in an accessible position and contains a fine-gauge filter to prevent entry of dust and dirt into the train pipe. This filter requires to be cleaned and examined periodically by the Shed Staff. If the filter or the air holes become choked with dirt or any other obstruction, free passage of air to the relief valve is prevented and may result in an excessive amount of vacuum being created in the train pipe.

(6) *Q*. Describe one type of vacuum brake cylinder in common use.

A. A type of vacuum brake cylinder frequently used on passenger and freight vehicles is illustrated in Fig. 76.

It will be seen to consist of a vacuum reservoir and cylinder combined, the cylinder proper being open at the top and enclosed within the reservoir. The brake piston is of fairly deep section and is kept airtight within the cylinder by a rubber rolling ring nipped between the piston head and the cylinder wall. The piston rod passes through the bottom of the cylinder and is kept airtight by a gland.

The brake cylinder is connected to the train pipe by a small flexible hose attached to the ball valve housing at the base of the vacuum chamber.

The purpose of this ball valve is to control the movement of the brake piston in accordance with the variations in the train pipe vacuum, and also to provide a means of releasing the brake by hand when necessary.

This ball valve can close the vacuum chamber port, or it can place the lower side of the brake piston and the vacuum chamber in communication with each other and with the train pipe when off its seating.

Running with the brake off, the ball valve is unseated, leaving the train pipe in communication with both sides of the piston, which will then be in equilibrium and resting by its own weight at the bottom of the cylinder. Immediately air is admitted to the train pipe it passes up the connecting pipe and forces the ball valve to its seating on the port leading to the vacuum chamber, thereby retaining the vacuum on the top side of the piston. The port to the underside of the piston is, however, left open, and the air accordingly flows into the bottom of the cylinder, lifts the piston and applies the brake.

Restoration of the train pipe vacuum extracts the air from below the piston until the vacuum below equals that in the chamber above, after which the piston, being equalised, will sink to the bottom of the cylinder by its own weight, allowing the brake to release. At the same time the ball valve will drop away from its seating on the chamber port, leaving both sides of the piston in communication with the train pipe, ready for the next brake application.

The hand release arrangement is effected by a ball valve enclosed inside a sliding cage connected to an external lever, as shown in Fig. 76. When the release cord is pulled, the cage is displaced, forcing the ball valve away from the vacuum chamber port, thereby placing both sides of the brake piston in communication with the train pipe.

(7) *Q*. Passenger vehicles are fitted with a communication cord which, when operated, gives an indication to the Driver in order to stop the train in case of emergency. Describe how the arrangement operates.

A. The communication cord consists of a chain passing through each compartment of the coach and connected at the end of the vehicle to the passengers' alarm valve and indicating disc.

The alarm valve, when operated by the chain being pulled, opens and allows air to enter the vacuum train pipe, causing a reduction in vacuum of 5 to 10 in., which is sufficient to apply the brake with moderate force and to attract the Driver's attention.

(8) *Q*. Describe the brake action on a train fitted throughout with the vacuum automatic brake.

A. The brake is applied by the pressure of air being admitted through the ports of the Driver's application valve, passing down the train pipe from the engine to the train.

During release, the blocks on the leading vehicles will be freed first and for this reason the small ejector only should be used for release purposes when the train is in motion, in order to avoid surging and shocks on the drawgear caused by the early release in front and continued retardation of the rear portion of the train, which would be intensified if the large ejector was used.

(9) *Q*. How should the brake be handled to obtain the best results?

A. In the case of "service application", in which full brake power is not called for, the Driver should begin by destroying 7 to 10 in. of train pipe vacuum and should hold this application until he feels the slight check which will indicate the brake has taken hold. This is known as "setting the brake"; after this, the brake block pressure can be varied at will by regulating the train pipe vacuum to suit requirements of the stop.

To make a full-power application, the Driver would put the application valve right over to "full on" position in a single movement, destroying all train pipe vacuum, and would leave it thus until speed was reduced sufficiently to permit the application to be somewhat eased.

(10) *Q*. Name a few bad faults to be avoided when handling vacuum-fitted trains.

A. Do not "see-saw" the brake handle between "running" and "brake on" positions several times when commencing an application. This practice retards the action of the brake cylinder ball valves and will increase the time required to "set" the brake.

In all normal cases avoid the use of the large ejector to release the brake except when the train is stationary.

Do not bring the train to rest with all the train pipe vacuum destroyed and the brake applied with full power.

Ease the application in the final stages by allowing the train pipe vacuum to build up slowly to about 12 in., which will prevent complete release of the engine brake and also the risk of locked wheels on the train.

(11) *Q*. How would the Driver carry out his test of the brake on an engine fitted with the automatic steam and vacuum brake?

A. He would test for obstruction in the engine train pipe by applying the large ejector with first the front and then the rear hose bag off the stopper; in neither case should the vacuum gauge show more than 3 in. of vacuum. If the gauge shows an appreciable amount of vacuum with either pipe off the plug, an obstruction in the train pipe is indicated and must be located and removed. Having replaced the hosebags on the stoppers he should then create the full 21 in. of vacuum in the train pipe, using the small ejector for the purpose; shut off the ejector and note the time taken for the vacuum to fall to 12 in. on the gauge.

If this is less than 20 seconds the train pipe leakage is excessive and should be located.

The large ejector should be tested and the brake worked once or twice by the application valve to prove the mechanical parts of the apparatus.

(12) *Q*. If bad leakage on the train pipe is indicated by this test, what points should be looked at to find the fault?

A. See that both vacuum hose pipes are properly on the stop plugs and that the rubber washers are good. Test the drip valves for leakage and all joints in the train pipe, using the torch-light flame for the purpose. See that the disc of the application valve is not sticking away from the face and check all the train pipe connections on the footplate. If no leakages are disclosed, suspect the non-return valves in the combination ejector. Whilst making the above test the small ejector should be kept at work and the brake valve should be left in "running" position.

(13) *Q*. How would you test engines fitted with the vacuum brake before leaving the shed?

A. Examine the flexible train pipes and see that the couplings fit properly on the plugs. Then put the brake handle to the "on" position, close the auxiliary release valve and open the small ejector steam valve slightly. This will extract air from the top sides of the pistons and admit air to the bottom sides and train pipe and will also deposit in the smokebox any water which may be in the exhaust pipe instead of throwing it out over the boiler, as may be the case if the large ejector was suddenly opened after the engine had been standing for some time. Close the small ejector and watch the chamber side needle on the gauge, which will fall if the ball valve leaks. If the needle remains stationary, then test the train pipe side by creating 21 in. with the application valve in "running" position, close the steam valve and watch the gauge. If the vacuum is rapidly destroyed, the defect must be located and made good.

The large ejector must be tested separately, preferably outside the shed, whilst the small ejector remains shut. Then test the train pipe on the engine by taking first the front hosepipe and afterwards the rear hosepipe off the plugs separately, and opening the large ejector fully and then closing it; if any vacuum is registered on the train pipe side of the gauge when the ejector is closed whilst either of the hosepipes is off the plug, a stoppage or obstruction in the train pipe is indicated, which must be put right.

(14) *Q*. On engines fitted with vacuum brake only, how would you decide if a chamber-side leakage was internal or external?

A. Create a vacuum on both sides, close the small ejector and leave the application valve in "running" position. If the chamber-side pointer should fall it will be an external leakage.

(15) *Q*. How would you test for a faulty ball valve, burst diaphragm or faulty rolling ring?

A. Create 21 in., close the small ejector and apply the brake quickly, returning the application valve into "running" position. A fault will be shown by the chamber-side needle falling and the train pipe needle rising until equal.

(16) *Q*. Is it possible to have a defect without indication on the engine vacuum gauge?

A. Yes, an obstruction in the train pipe might prevent the creation of vacuum in the train, but the engine gauge would show the correct amount of vacuum. It would be necessary to test the engine with the vacuum hosepipe off the plug, as previously explained. (It should be borne in mind that the vacuum gauge shows the degree of vacuum but can give no indication of the quantity of air the ejector can eject to overcome leakage. The small ejector may maintain 21 in. of vacuum on the engine alone, but when coupled to the train is unable to create or maintain the requisite vacuum. The test for this is by the use of a disc with a standard size leak-hole; this is carried out by the Fitting staff at the shed or by C. & W. staff when in traffic. See General Appendix and Supplement "Working of Vacuum Brake".)

(17) *Q*. How should the brake be operated when two engines, coupled together, are attached to a vacuum-fitted train?

A. It is the duty of the Driver of the leading engine to create and maintain the vacuum and to operate the brake. The ejectors on the second engine must be kept closed, but the Driver of the second engine is not relieved from responsibility of the due observance of all signals affecting the working of the train and in case of need he must apply the brake.

(18) *Q*. How does the compressed air used in the Westinghouse brake system apply the brake?

A. By the air being admitted to a brake cylinder and forcing the piston out, which by means of connecting rods and levers forces the brake blocks against the wheels.

(19) *Q*. What essential parts of the brake are fitted to engine and tender carriage or other vehicle?

A. An auxiliary reservoir, triple valve and brake cylinder.

(20) *Q*. Where is the pressure which supplies the brake cylinder stored?

A. In the auxiliary reservoir under each vehicle fitted with the brake.

(21) *Q*. How much main reservoir pressure should be carried?

A. 90 lb. per sq. in.

SECTION 9

AUTOMATIC TRAIN CONTROL

Automatic train control is the name given to the various systems which give an audible and, in some cases, a visual indication in the engine cab of the position of a distant signal, followed by a brake application where necessary. There are three systems in operation in this country:—

(*a*) The former Great Western Railway system in use on the Western Region (Fig. 87).

(*b*) The system in use on the Eastern Region (London, Tilbury and Southend section) (Fig. 88).

(*c*) The British Railways system (Fig. 89).

The B.R. system which has been developed during the past five years will be adopted as the standard for use on all British Railways.

The methods of operation of the three systems are described in the following pages, but it may be helpful to outline the main features of each arrangement.

Former Great Western Railway System

In this system a fixed ramp about 44 ft. long is situated in the 4-ft. way. This makes contact with a shoe on the locomotive, and when the distant signal is at Caution the ramp lifts the shoe operating a switch on the engine, causing a siren to sound in the cab and applying the brake after a short delay. The indication can be cancelled by the operation of a handle. When the distant signal is in the Clear position the ramp is electrified. The lifting of the shoe operates the switch as before, but the current picked up from the electrified ramp causes a bell in the cab of the engine to ring for a short period instead of the siren and without any subsequent brake application.

Eastern Region—London, Tilbury and Southend System

This is operated by magnetic induction. When the distant signal is at Caution a permanent magnet in the 4-ft. way operates the apparatus, sounding a horn and applying the brakes after a short delay. Cancelling or acknowledging by means of a handle provided changes the visual indicator from black to yellow. If the distant signal is at Clear, an electro-magnet is energised which cancels the effect of the permanent magnet, allowing the horn to sound for a short time only and with no subsequent brake application.

British Railways System

The British Railways system also works on the principle of magnetic induction. When a distant signal is at Caution, the permanent magnet operates the receiver on the locomotive, sounding the horn and applying the brake after a short delay. Cancelling or acknowledging the indication by means of a handle provided changes the visual indicator from all black to black and yellow. If the distant signal is at Clear an electro-magnet is energised which cancels the effect of the permanent magnet and causes a bell to ring in the engine cab for a short period.

FORMER GREAT WESTERN RAILWAY SYSTEM

General Description

The primary object of this system is to give audible warning on the engine when the train is approaching a distant signal, or passing a lower distant signal fixed below a "Stop" signal, and the distant signal being in the "On" (proceed with caution) position, also, in the event of this warning being disregarded, to apply the brakes automatically, so as to ensure the train being pulled up before it reaches the home signal.

Another and distinctive audible indication is also given on the engine when the distant signal is "Off" (proceed).

The audible signals given are the sounding of a siren, indicating "be prepared to stop at the appropriate 'Stop' signal", and the ringing of a bell, indicating "proceed normally".

The point at which the audible signals are given is usually about 440 yd. (200 yd. in multiple aspect signalling areas) before the distant signal is reached. Where, however, the distant signal is a lower arm on a "Stop" signal, the audible signals are given just as the "Stop" signal is passed.

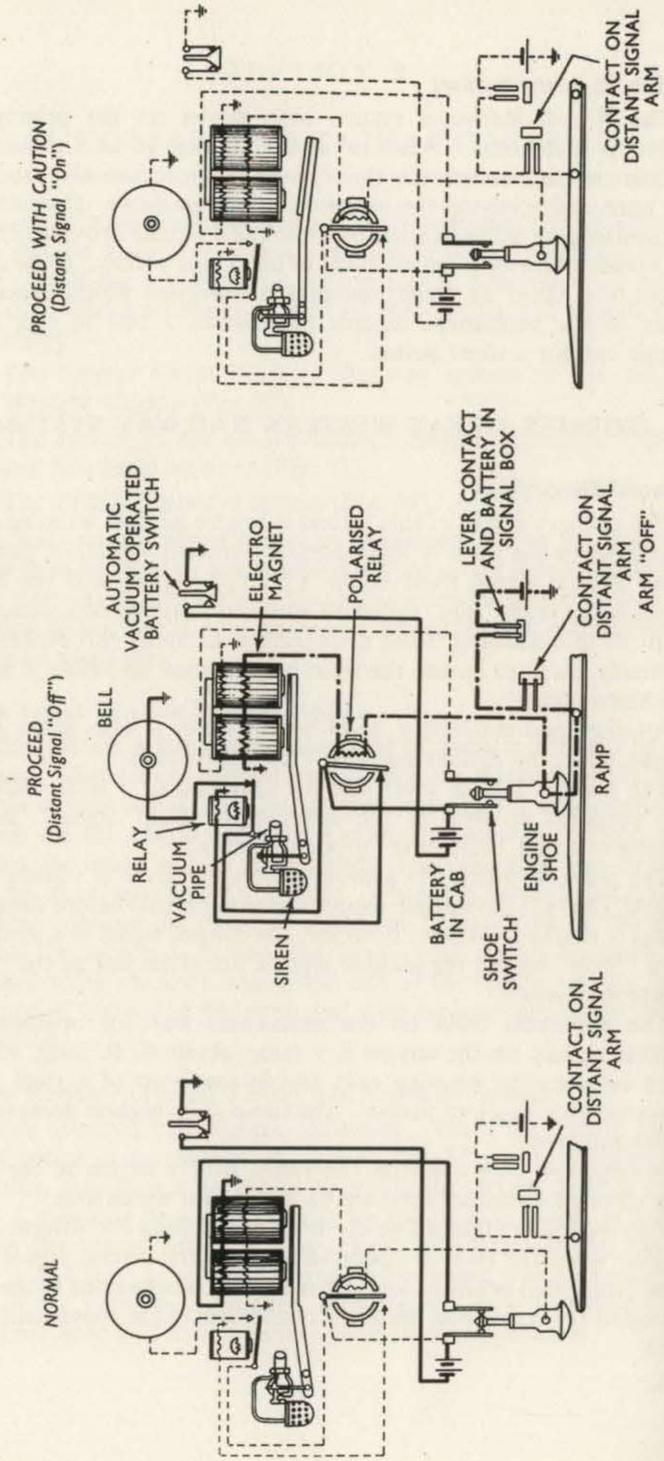
The apparatus fixed on the permanent way for operating the audible signals on the engine is a ramp about 40 ft. long, which is fixed between the running rails and is made up of a steel ⊥ bar mounted on a baulk of timber. The ramp at its highest point is $3\frac{1}{2}$ in. above rail level.

A telegraph wire connects the ramp with a switch in the Signal Box through a contact attached to the distant signal arm.

This switch is attached to the lever controlling the distant signal, so that when the lever is operated to place the distant signal to the "Off" (proceed) position, an electric battery is connected to the ramp, provided the signal has correctly responded to the movement of the lever.

Fig. 87 AUTOMATIC TRAIN CONTROL

Former Great Western Railway System



When the lever is replaced to restore the signal to the "On" (proceed with caution) position, the battery is disconnected from the ramp.

The ramp is, therefore, electrified when the distant signal is "Off".

When the distant signal is "On", the ramp is electrically "dead", as is also the case in the event of the battery failing, or the arm not responding correctly to the lever, or the telegraph wire breaking.

The apparatus on the engine comprises a contact shoe with switch, an electrically-controlled combined brake valve and siren, and an electric bell, in the engine cab.

The contact shoe is fixed in the centre line of the engine and projects to within $2\frac{1}{2}$ in. above rail level, in which position it is held by gravity assisted by a powerful spring. It is capable of being raised vertically, and being in line with the ramp it is lifted 1 in. whenever a ramp is passed over. This lift of 1 in. is utilised for effectively opening a switch attached to the contact shoe. The switch is connected with the electrically-controlled brake valve and siren in such a way that whenever it is opened it results, except as hereafter described, in air being admitted through the siren and the brake valve to the train pipe, sounding the siren and applying the automatic brake on the train. This happens when an engine passes over an unelectrified ramp. The Driver, by acknowledging the warning given by the siren, can stop the siren sounding and stop the application of the brakes. This he does by raising a handle provided for the purpose.

When the ramp is electrified by the distant signal being placed in the "Off" (proceed) position, the brake valve is not released by the engine passing over the ramp, but the bell on the engine rings instead. The contact shoe is lifted as before, but the current is picked up from the electrified ramp, the effect of which is to cut out, or render inoperative, the switch attached to the contact shoe; so that although the switch is opened it does not release the valve admitting air through the siren to the train pipe.

When an engine is at a stand and remains thus for more than half an hour, the automatic battery switch operates and cuts the battery off from the cab apparatus, thus economising battery power. This battery switch is operated by the vacuum maintained in the engine reservoir or train pipe. When the vacuum is restored by the Engineman the automatic switch pulls up and closes the battery circuit and energises the cab apparatus.

In the event of a failure to pick up the electric current when a ramp is passed over, the effect on the engine apparatus is the same as though the ramp was not electrified, that is, the valve admitting air through the siren to the train pipe is opened, and the automatic brake is applied on the train, thus ensuring that any failure of the electrical apparatus shall produce the warning indications irrespective of the position of the signals.

EASTERN REGION, LONDON, TILBURY AND SOUTHEND SYSTEM

Track Equipment

Two magnets are fixed in the centre between the rails, 10-15 yd. apart and approximately 200 yd. on the approach side of a distant signal (or outer signal only when more than one is provided). The first contains a horizontal permanent magnet with its north pole at the trailing end and the second contains an electro-magnet. The electro-magnet is "dead" when the distant signal(s) is at Caution and "alive" with its south pole at the trailing end when the signal(s) has been pulled to Clear. The tops of the magnets are 1 in. above rail level.

In addition to these, permanent magnets are provided in the outlet roads from sheds to test the equipment before going into service.

Engine Equipment

The equipment consists of a magnetic receiver, horn valve, vacuum horn, brake valve, re-setting magneto and indicator.

The receiver is operated magnetically from the track magnets, its internal permanent magnet changing its position and operating an air valve as it passes over the north pole of the permanent magnet or the south pole of the electro-magnet. The re-setting magneto is provided to change it from the position taken up after passing a permanent magnet if the electro-magnet is "dead", as at a Caution signal.

The admission of air through the valve in the receiver operates the horn valve which connects the horn to the vacuum reservoir and causes it to sound and admits air through a restriction to the timing reservoir and lower side of the brake valve.

The upper side of the brake valve is connected to the train pipe so that the valve is normally balanced and kept closed by a spring. The admission of air to the under side upsets this balance and, after 3 seconds, the valve opens to admit air to the train pipe, lowering its vacuum, and the valve assumes a new position of balance such that the fall in vacuum in the train pipe corresponds to the fall in vacuum in the timing reservoir. The fall of vacuum in this reservoir is calculated to reach 5 in. in about 15 seconds.

This action occurs whenever the distant signal is at Caution and

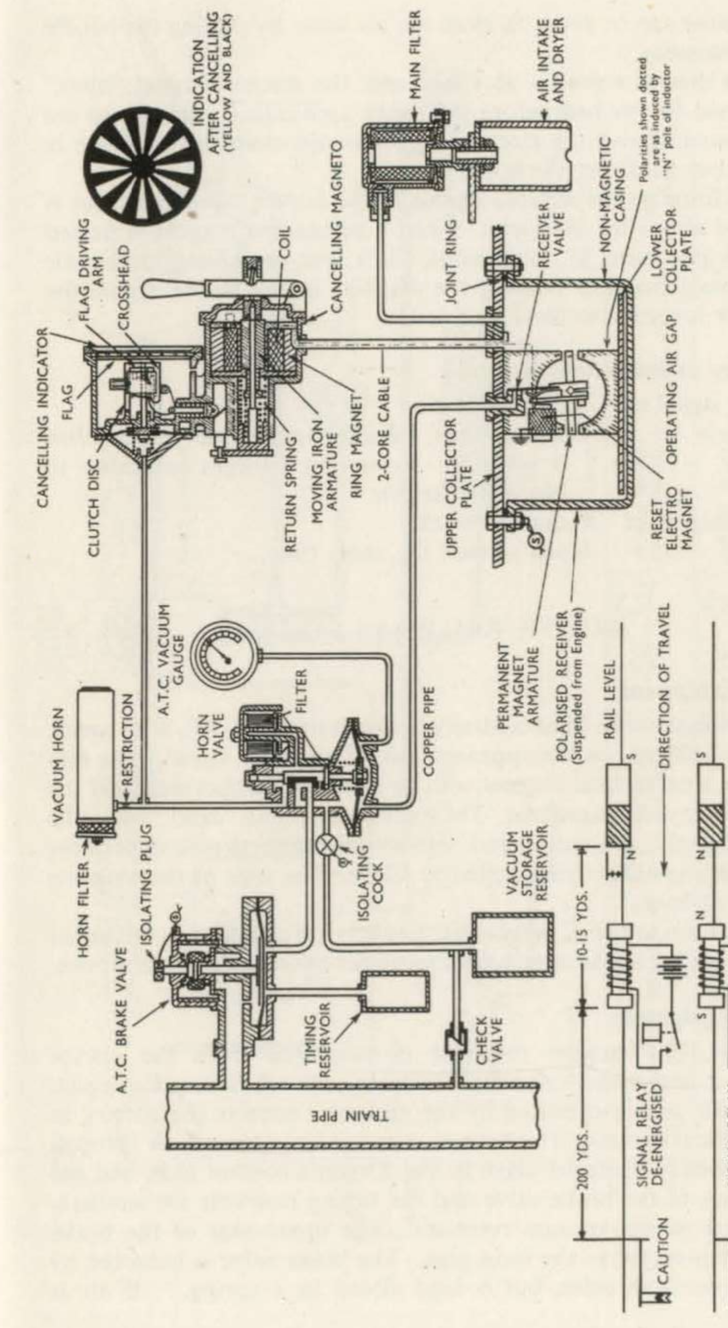


Fig. 88 AUTOMATIC TRAIN CONTROL
L.T. & S. (E.R.) System

Fig. 88

the receiver can be re-set to close the air valve by pulling the handle of the magneto.

If the distant signal is at Clear and the electro-magnet "alive" this would be reached before the brake application started and the act of passing over the electro-magnet would close the air valve in the receiver to silence the horn.

In addition to the audible signals of the horn a visual indicator is provided above the magneto. When a permanent magnet is passed the indicator turns to, or remains, black, but on pulling the handle of the magneto after passing the magnets at a Caution signal the indicator is turned to black and yellow.

Summary of Indications Received

Distant signal at Caution	Indicator black. Horn sounds. Brake application starts after 3 seconds. Re-setting changes indicator to black and yellow.
Distant signal at Clear	Indicator black. Horn sounds for short time.

BRITISH RAILWAYS SYSTEM

Track Equipment

Two magnets are fixed centrally between the rails, 2 ft. 6 in. apart, generally 200 yd. on the approach side of a distant signal. The first contains a permanent magnet with its south pole uppermost and the second is an electro-magnet. The electro-magnet is "dead" when the distant signal is at Caution and "alive" with its north pole uppermost when the signal has been pulled to Clear. The tops of the magnets are at rail level.

In addition to these, permanent magnets are provided in the outlet roads from the sheds to test the equipment before going into service.

Engine Equipment

The A.T.C. vacuum reservoir is exhausted from the ejector through a non-return valve and isolation cock which is sealed open. An electric switch operated by the vacuum connects the battery to the electrical circuits. The horn is connected to atmosphere through an electrically-operated valve in the Driver's control unit, and the under side of the brake valve and the timing reservoir are similarly connected to the vacuum reservoir. The upper side of the brake valve is connected to the train pipe. The brake valve is balanced by vacuum on both sides, but is kept closed by a spring. If air is

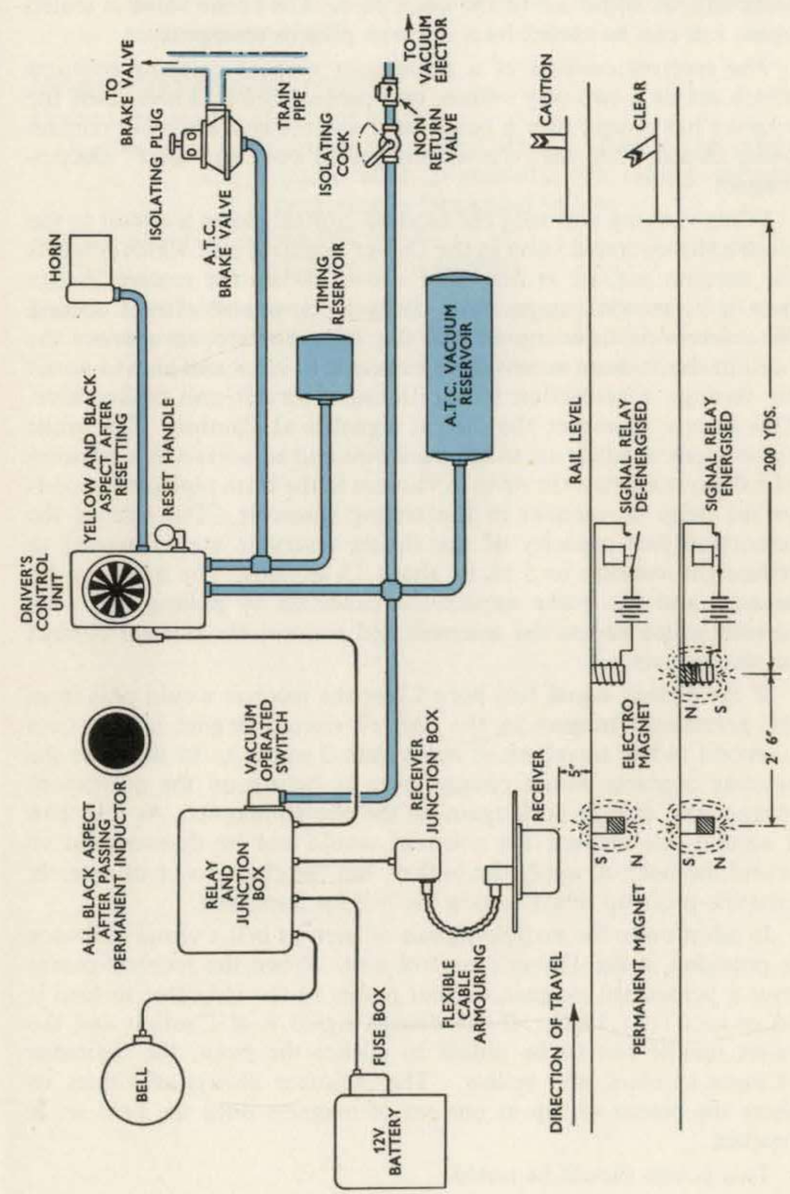


Fig. 89 AUTOMATIC TRAIN CONTROL
British Railways System

admitted to the under side of the valve, the balance is upset and the valve lifts to admit air to the train pipe. The brake valve is sealed open, but can be closed by a screwed plug in emergency.

The receiver consists of a permanent magnet carrying contacts which act as a two-way switch, one contact being closed when the receiver has passed over a permanent magnet and the other contact being closed when the receiver has passed over an "alive" electro-magnet.

When running normally the receiver contact closes a circuit to the electrically-operated valve in the Driver's control unit which controls the vacuum and air as described above. When the receiver passes over a permanent magnet the contact opens and after 1 second the solenoid is de-energised and the valve operates to connect the horn to the vacuum reservoir and cause it to blow and also to admit air through a restriction to the timing reservoir and brake valve. This occurs whenever the distant signal is at Caution. The brake valve opens to admit air to the train pipe and assumes a new position of balance such that the drop in vacuum in the train pipe corresponds to the drop in vacuum in the timing reservoir. The size of the restriction and capacity of the timing reservoir are calculated to reduce the vacuum to 5 in. in about 15 seconds. The horn can be silenced and the brake application cancelled by pulling the re-set handle, which re-sets the solenoid and restores the normal contact on the receiver.

If the distant signal had been Clear the receiver would pass from the permanent magnet to the "alive" electro-magnet in less than 1 second (when travelling at more than 2 m.p.h.). In this case the receiver contacts would change over as before on the permanent magnet and change back again on the electro-magnet. As less than 1 second has elapsed the solenoid would not be de-energised to sound the horn or apply the brakes, but the changeover of receiver contacts picks up relays to ring the bell for 2 seconds.

In addition to the audible signals of horn or bell a visual indicator is provided in the Driver's control unit. When the receiver passes over a permanent magnet, current passes to the indicator to turn it to, or keep it at, black. If the distant signal is at Caution and the re-set handle has to be pulled to silence the horn, the indicator changes to black and yellow. The indicator always continues to show the colour set up at one set of magnets until the next set is reached.

Two points should be noted:

(1) Pulling the re-set handle when not required to silence the horn will apply the brakes.

(2) Pulling the re-set handle will only change the indicator from black to black and yellow after passing the magneto at a Caution signal.

Summary of Indications Received

Distant signal at Caution	Indicator black. Horn sounds after 1 second. Brake application starts after 3 seconds. Re-setting changes indicator to black and yellow.
Distant signal at Clear	Indicator black. Bell rings for 2 seconds.

NOTE.—On both the L.T. & S. Section and British Railways systems the complete magnet and housing which actuate the receiver on the locomotive is referred to as an "inductor".

SECTION 10

THE RULE BOOK

Rules are drawn up for the purpose of ensuring method and order in all movements and operations.

METHOD and ORDER provide SAFETY.

We all know the story of the man who observed two trains approaching one another on the same line, his comment being that it seemed to him a funny way to run a railway!

Railways are the safest means of transport.

The Rule Book has been compiled on the basis of long experience and of common sense. Most of the rules have come into existence on the "case" method, that is, as the result of mishaps and of near-mishaps.

If you find the Rule Book hard to digest you must apply the case method to your study. Visualise a station with which you are familiar, for instance, and imagine a derailed wagon blocking one line. What should be done to ensure protection of the line and how do the rules apply?

It is an axiom that it takes two people's mistakes to create a dangerous situation. Rules aim at preventing misunderstandings. Each man concerned has a definite duty laid down for him to perform.

Any subject may be considered dull when studied in textbooks. Interest is aroused when your reading can be applied to real life and to real situations. Firstly, then, be prepared to visualise.

Secondly, it is helpful to have a proper arrangement in one's mind of the various groups of rules. Sub-divided in this way the Rule Book will appear less formidable and the rules applying to one's particular calling, such as that of Enginemen, can be given special attention.

We can proceed to divide the groups of rules as follows:—

Rules 1 to 16 cover matters of discipline and procedure. Discipline implies a standard of behaviour which is essential to good order in any organisation.

Rules 17 to 33 cover the working of stations.

Rules 34 to 49 describe the various patterns of fixed or permanent signals. Their working and application are, of course, an important part of an Engineman's knowledge.

Rules 50 to 54 lay down the authorised hand signals. Hand signals must be properly given and properly interpreted to avoid misunderstandings.

Rules 55 and 56 are very important safety rules, to ensure that a train standing on a running line is not forgotten.

Rules 57 to 60 cover the use of detonators, which are a form of audible warning signal used where other methods of attracting a Driver's attention are not practicable or need supplementing. A supply of detonators must be on every engine, with two red flags (see Rule 127).

Rules 61 to 76, covering the working of points and signals, must be understood by Enginemen, as they have a joint responsibility in their correct operation. Note Nos. 69 and 70 (*b*), (*c*).

Rules 77 to 80 refer to precautions imposed when signals are under repair, etc., and Rules 81 to 83 cover similar precautions when points and signals are defective. Certain paragraphs are directly applicable to Enginemen.

Rules 84 to 95 ensure the running of trains in safety under the adverse weather conditions of fog and falling snow (see also the special instructions issued in a separate booklet to the staff).

Rules 96 to 98 apply to the movements at stations.

Rules 99 to 107 apply to the working of level crossings.

Rules 108 to 118 cover shunting, where a thorough knowledge of hand signals is essential. Enginemen must observe certain precautions when not accompanied by a Shunter.

Rules 119 to 125 cover the use of lamps. Enginemen are responsible for headlamps and disc-boards and for tail-lamps when light engine.

Rules 126 to 176 cover the normal working of trains. Nos. 126, 127 and 128 are especially directed to Enginemen. Being train-operating rules, the whole of this group concerns Enginemen in their everyday duties.

Rule 177. Reporting of Accidents. This rule introduces the section of the rule book dealing with abnormal occurrences and requires careful study.

Rules 178 to 188. When the abnormal occurs, it is vital to preserve order in the face of emergency. Hence:—

Rules 178 to 181 set out the system of protection.

Rule 182 deals with "Trains divided."

Rules 183 to 185 deal with the systematic removal of an obstruction.

Rules 187 to 188 cover defects on a train.

Rules 189 to 208 deal with the setting up of single-line working. Great care is necessary in this operation and Enginemen should note particularly Nos. 192, 196, 197, 202, 203, 204 and 206.

Rules 209 to 239 cover the precautions to be taken when work is done on the line by the Civil Engineering staff. Enginemen must be familiar with Rule 216, Ballast Train Working, and Rules 217 and 218 in regard to speed restrictions.

Rule 240 should be studied, having in mind the fact that Enginemen, as well as others, are concerned with the conveyance of dangerous traffic.

Certain of the rules are amplified by instructions in the General Appendix, which should be carefully studied.

INDEX

(NOTE: Typical questions and answers are placed at the end of each section—these are not covered in the Index.)

NOTES