B.R. 33057/16
D.T.S. 81

BRITISH RAILWAYS - WESTERN REGION

THE DAVIES & METCALFE DUAL AIR BRAKE

CLASS 47 LOCOMOTIVES

CM & EE TECHNICAL TRAINING CENTRE
THE MILL, B.R.E.L.
BRISTOL STREET
SWINDON

BRITISH RAILWAYS WESTERN REGION

THE DAVIES & METCALFE DUAL AIR BRAKE
CLASS 47 LOCOMOTIVES

This publication is intended for students attending courses at C.M. & E.E. Training Units, and is a precis of the lectures given. Subsequently alterations may be made and it entails upon the person concerned to suitably up-date the information.

SPECIAL NOTE :

The Class 47 is used for the initial brake course, before conversion to other types. The publication has been suitably simplified and contains items of equipment which it may not be necessary to explain in detail, on subsequent conversion courses.

CONTENTS

DUAL AIR BRAKE SYSTEM (METCALFE)

Brake Diagram Colour Schemes

Main Reservoir Pressure 118 - 140 p.s.i.	(BLUE)
Brake Feed/Reservoir Equalising Pipe pressure 100 p.s.i.	(LIGHT GREEN)
Auto Air Brake Pipe pressure 72.5 p.s.i.	(PURPLE)
Auto Air Brake Pipe pressure below 72.5 p.s.i.	(LIGHT PURPLE)
Control Air pressure 72.5 p.s.i.	(TERRA COTTA)
Vacuum Train Pipe 21"	(RED)
Vacuum Train Pipe below 21"	(RED STRIPED)
Vacuum Chamber 21"	(YELLOW)
Triple Valve to Relay Valve - pressure 0 - 50 p.s.i.	(DARK GREEN)
Direct Air Brake Valve to Relay Valve	(SIENNA BROWN)
Relay Valves to Brake Cylinder (variable)	(SIENNA BROWN STRIPED)

Colours for training purposes only - pipework on locomotives may not be coloured as above.

DAVIES AND METCALFE DUAL AIR BRAKE CLASS 47 LOCOMOTIVES

During the changeover period from Vacuum to Air Braking on the rolling stock, a locomotive may have to deal with 4 types of train :-

(a) Vacuum Goods (Unbraked)

(b) Vacuum Passenger (Braked)

(c) Air Passenger

(d) Air Goods

When working a vacuum braked train two exhausters and one compressor will be required to operate, but when working an air braked train, two compressors will be required and no exhausters. In addition various emergency equipment will require to be operated to give the appropriate emergency brake application on the type of train that is being worked. All this is taken care of by a four position Brake Selector Switch.

These locomotives are fitted with TWO Automatic Brake Pipes :-

(1) Vacuum Train Pipe

Identical in principle to the usual vacuum train pipe.

(2) Air Brake Pipe

This pipe is norminally charged to 72.5 p.s.i. when the following conditions prevail :-

(a) Vacuum Braked Trains with the exhausters running, train pipe vacuum will rise to and be maintained at 21".

(b) Air Braked Trains the train air brakes will be released.

If the Air Brake Pipe pressure is reduced to any value between 72.5 p.s.i. and 50.5 p.s.i. the following will occur :

(i) Vacuum Braked Trains there will be a reduction in Train Pipe Vacuum proportional to the reduction in Air Brake Pipe pressure and a proportional air brake application on the locomotive.

(ii) Air Braked Trains : There will be a locomotive air brake application and a train air brake application proportional to the reduction in Air Brake Pipe pressure.

If the Air Brake Pipe pressure is reduced to 50.5 p.s.i. Train Pipe Vacuum is reduced to zero when working vacuum braked trains and a full air brake application is applied when working air braked trains.

Therefore the following forms of brake application can be made :-

(1) Locomotive Straight Air Brake

Used when light locomotive and controlled by the Drivers Straight Air Brake Valve.

(2) Locomotive Proportional Air Brake

Which controls the locomotive air brake application in proportion to the degree of brake application on the train, whether it be air or vacuum fitted.

(3) Vacuum Braked Trains

An Automatic Vacuum Train Pipe is provided to control the braking of vacuum fitted stock, brake release is obtained by two exhausters in the normal manner.

(4) Air Braked Trains

An Automatic Air Brake Pipe is provided which, when kept charged at 72.5 p.s.i. maintains the brakes of an air braked train in the release position and when pressure in the Auto Air Brake Pipe is released the brakes are applied. The system thus "fails safe", and to ensure quick release of the brakes a second compressor together with additional air capacity is provided.

A four position switch is provided, together with visual indications in each cab, so enabling the driver to select a position corresponding to the type of train.

The switch has four positions, two for operating vacuum braked trains and two for operating air braked trains, these are :-

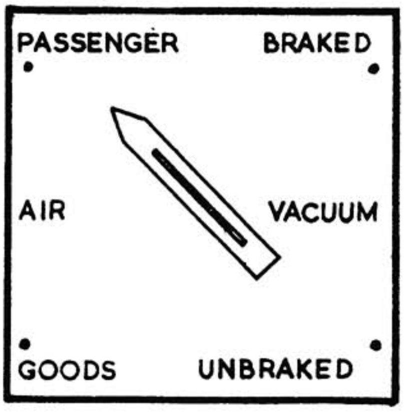


FIG. 1. BRAKE SELECTOR SWITCH

(1) AIR PASSENGER - selected when working Air Braked Trains with a maximum permitted speed above 60 m.p.h.

In this position both compressors will run, but both exhausters will be stopped and since there will be no vacuum the Vacuum Control Governor is "shorted-out". The Triple Valve will only sense variations in Auto Air Brake Pipe Pressure.

The Passenger/Goods E.P. Valve is energised and therefore closed. On operation of the A.W.S. or D.S.D. a 12-15 second delay occurs, before the brake application commences.

(2) AIR GOODS - selected when working Air Braked Trains with a maximum permitted speed of 60 m.p.h. and below

Conditions as in (1) apply excepting that the Passenger/Goods E.P. Valve is de-energised and therefore open to give a 20-29 second delay before a full A.W.S. or D.S.D. brake application is achieved.
NOTE :- There is also a similar delay in a drivers normal brake application.

(3) VACUUM BRAKED - selected when working Vacuum Braked Trains with a maximum permitted speed of 60 m.p.h. and above

Only No. 1 compressor will run, together with both exhausters and the Vacuum Control Governor will be operative.

The Braked/Unbraked Magnet Valve is energised and therefore open. On operation of the A.W.S. or D.S.D. a 12-15 second delay occurs, before the brake application commences.

(4) VACUUM UNBRAKED - selected when working Vacuum Braked Trains with a maximum permitted speed of 60 m.p.h. and below

Conditions as in (3) apply excepting that the Braked/Unbraked Magnet Valve is de-energised and therefore closed, the Braked/Unbraked E.P. Valve is energised and therefore open so that together these valves will give a 30-40 second delay before a full A.W.S. or D.S.D. brake application is achieved.

This is the only position in which the Braked/Unbraked E.P. Valve is open, in the other 3 positions the valve is de-energised and therefore shut.

When the diesel engine has been started :-

Brake Selector Switch in either Air position

Both compressors will run under the control of the compressor governor and will be stopped when a pressure of 140 p.s.i. has been reached. A time delay relay prevents both compressors starting together thus protecting the Auxiliary Generator from high current surge. When a maximum pressure has been reached the compressors will not restart until the pressure has dropped to 118 p.s.i.

Brake Selector Switch in either Vacuum position

No. 1 compressor will run.

Emergency Compressor Switch

This switch has been progressivley fitted so that should a compressor fail when working vacuum braked trains the other compressor can be used by turning the switch from NORMAL to EMERGENCY i.e. No. 2 Compressor.

BASIC FUNCTIONS OF MAIN VALVES

DRIVERS AUTO AIR BRAKE VALVE

(1) To charge the Auto Air Brake Pipe at 72.5 p.s.i. in the running position

(2) To reduce the Auto Air Brake Pipe pressures when making brake applications.

(3) To charge the Auto Air Brake Pipe to 78.5 p.s.i. in the release position.

(4) This valve is made inoperative in the non-driving cab by pegging it in the neutral position.

TRIPLE VALVE

AIR POSITION

In this position this valve senses a reduction in Automatic Air Brake Pipe pressure and initiates a proportional locomotive air brake application through the medium of the Auto Air Brake Relay Valves situated over each bogie.

VACUUM POSITION

In this position this valve senses a reduction in Train Pipe Vacuum and initiates a proportional locomotive air brake application through the medium of the Auto Air Brake Relay Valves situated over each bogie.

AIR/VACUUM ISOLATING VALVE

VACUUM POSITION

In this position the valve automatically ensures that the Triple Valve is only sensitive to Train Pipe Vacuum. Variations in Auto Air Brake Pipe pressure are sensed by the Air/Vacuum Relay Valve which in turn destroys the vacuum which then operates the Triple Valve.

AIR POSITION

In this position the valve automatically ensures that the Triple Valve is only sensitive to Air Brake Pipe pressure and that the Triple Valve is not affected by lack of vacuum.

AIR/VACUUM RELAY VALVE

This valve controls the reduction of Train Pipe Vacuum in direct proportion to a reduction of Auto Air Brake Pipe pressure. If there is no Auto Air Brake Pipe Pressure the Vacuum Train Pipe will remain open to atmosphere.

It can be appreciated from the above that when working vacuum fitted stock a Locomotive Proportional Brake Application is achieved in the folliwng manner :-

(a) Driver reduces Auto Air Brake Pipe Pressure through his Drivers Auto Air Brake Valve.

(b) Air/Vacuum Relay Valve opens the Vacuum Train Pipe to atmosphere, the valve then 'laps' itself to give a reduction in Train Pipe Vacuum which is proportional to the reduction in Auto Air Brake Pipe pressure.

(c) The Triple Valve then senses the reduction in Train Pipe Vacuum and allows controlling air to pass to the Auto Air Relay Valve over each bogie.

(d) The Auto Air Relay Valve then allows air to flow from the Auxiliary reservoirs so that a pressure, proportional to the initial drop in Auto Air Brake Pipe pressure, is built up in the brake cylinders.

FEED CUT OFF VALVE (D.S.D.)

The Feed Cut off valve isolates the main air supply to the Drivers Auto Air Brake Valve ensuring that a D.S.D. brake application can take place if the D.S.D. pedal is released.

BRAKE VALVE ISOLATOR (A.W.S.)

The Brake Valve Isolator (A.W.S.) isolates the Drivers Auto Air Brake Valve from the Auto Air Brake pipe, to ensure that an A.W.S. initiated brake application can take place.

BASIC FUNCTION OF AUXILIARY EQUIPMENT

AUTO AIR (BRAKE PIPE) GOVERNOR

This governor is always in operation (i.e. when working Air Braked and Vacuum Braked trains). Its function is to prevent power being applied until the Auto Air Brake Pipe Pressure is above 60 p.s.i. and it will ensure that power is cut off when the brake pipe pressure drops below 45½ p.s.i. (i.e. when an Emergency brake application is made).

COMPRESSOR GOVERNOR

Two sets of contacts to control both compressors, provided with isolating cock.

CONTROL CIRCUIT GOVERNOR

Opens at 65 p.s.i. due to loss of main reservoir pressure, causing loss of power. Closes at 87½ p.s.i. to regain power.

VACUUM CONTROL GOVERNOR

Opens at 12.5" causing loss of power due to loss of train pipe vacuum, closes at 15" to regain power. It is 'shorted-out' when the brake selector switch is in either of the air braked positions.

EQUIPMENT GOVERNOR E.T.H.

Opens at 50 p.s.i.. Closes at 60 p.s.i. to ensure 50 p.s.i. is available to the Train Heating Contactors (HC1 & HC2).

VACUUM RELEASE VALVE

One in each cab but only one need be used. Destroys vacuum in Triple Valve vacuum control reservoir to release brake, and also allows the Air/Vacuum Isolating Valve to change from VACUUM to AIR position.

MAIN RESERVOIR ISOLATING COCK

Isolates main reservoir from all except safety valves and compressor governor.

EXHAUSTER CHOKE VALVE

Energised when in RELEASE position to remove choke in train pipe so that exhausters may re-create train pipe quickly.

COMBINED SNIFTER, CHECK VALVE AND STRAINER

Limits train pipe vacuum to 21", prevents dirt from system being drawn into the exhauster.

AIR QUICK RELEASE VALVE

Admits air to triple valve air control reservoir to release air brake application.

A.W.S. EXHAUST VALVES (2)

Apply drivers safety device if A.W.S. operates in either cab.

BRAKE/UNBRAKE CHANGEOVER VALVE (11)

Controls rate at which atmospheric air destroys vacuum in Triple Valve, when working partially fitted or unbraked stock.

D.S.D, E.P. VALVE

Energised from drivers pedal to prevent D.S.D. brake application when direction controller is in FOR or REV.

PASSENGER/GOODS CHANGEOVER VALVE

This is the equivalent of the brake/unbrake changeover valve for use when working air braked trains.

ANTI-SLIP MAGNET VALVE

Gives a 12-15 p.s.i. brake application on the locomotive through controller push button.

D.S.D. EDHAUST VALVE

If pedal is released this valve opens to pass brake pipe air to the D.S.D. Valve.

D.S.D. ISOLATING COCK

Prevents operation of the D.S.D. in event of defect.

D.S.D. VALVE

Operated by brake pipe air pressure from one of the three exhaust valves i.e. 2 for A.W.S., 1 for D.S.D. and releases air from air brake pipe to give secondary application at a rate controlled by timing reservoir(s).

Auto Air Brake Relay Valve Straight Air Brake Relay Valve	) Supplied from main reservoir) pipe at 118-140 p.s.i. but) operated by a control pressure) 0-50 p.s.i. to feed 0-70 p.s.i.) to locomotive brake cylinders.

PRESSURE CONTROL VALVE

Reduces main reservoir pressure from 118/140 p.s.i. to 100 p.s.i. for Brake Feed Reservoir pipe supply to air braked trains.

AUTO BRAKE VALVE ISOLATING COCK

Isolates drivers auto air brake valve from main reservoir (for maintenance testing purposes).

THE DRIVERS AUTOMATIC BRAKE VALVE (Fig.2)

The Automatic Brake Valve has the following operating positions:-

RELEASE POSITION

In which the automatic Air Brake Pipe is rapidly charged to approximately 78.5 p.s.i. to ensure a complete and rapid release of the air brake throughout a train, and is used by the driver in accordance with his intructions. When working vacuum braked trains, the exhausters are speeded up and the exhauster choke valve is energised and therefore fully open. (Release position).

RUNNING POSITION

Maintains the Automatic Air Brake Pipe at a nominal 72.5 p.s.i. so releasing the Automatic Air Brake if in use or, when working vacuum braked trains, evacuating the Automatic Vacuum Train Pipe to 21" when the vacuum brakes will be released.

INITIAL APPLICATION POSITION

When a brake application is to be made, the brake valve handle should be moved to this position initially. The Automatic Air Brake Pipe pressure is then reduced to 66.5 p.s.i. and brake distributors on the train 'set' the air brakes to give a light brake application in preparation for further braking effort.

The handle MUST BE MOVED DIRECTLY TO THIS POSITION from the RUNNING position. IT MUST NOT be held in an intermediate position between RUNNING and INITIAL APPLICATION.

When working vacuum braked trains train pipe vacuum is reduced to approximately 15-17" by Air/Vacuum Relay Valve.

FULL SERVICE POSITION

In which the Automatic Air Brake Pipe pressure is reduced to 50.5 p.s.i. which gives a full air brake application when working air braked trains and train pipe vacuum is reduced to zero when working vacuum braked trains.

Between the INITIAL APPLICATION and FULL SERVICE positions there will be a reduction in Automatic Air Brake Pipe pressure between 66.5 p.s.i. and 50.5 p.s.i. according to the degree of movement of the brake valve handle and on air braked trains an air brake application proportional to the reduction in brake pipe pressure. No lap position is provided as the valve is self lapping anywhere between the INITIAL APPLICATION and the FULL SERVICE positions both in application and release.

When working vacuum braked trains there will be a reduction in train pipe vacuum poportional to the reduction in Automatic Air Brake Pipe pressure between 72.5 p.s.i. and 50.5 p.s.i. through the air vacuum relay valve which is self lapping both in application and release.

EMERGENCY POSITION

Vents the Automatic Air Brake Pipe direct to atmosphere and brake pipe pressure is rapidly reduced to zero resulting in a full and rapid air brake application throughout air braked trains.

When working vacuum braked trains the valve admits atmospheric air DIRECTLY into the vacuum train pipe ensuring a full and rapid vacuum brake application.

NEUTRAL

This position can only be obtained by raising a spring loaded locking pin. It is important that the AUTOMATIC BRAKE VALVE IS SECURED IN THIS POSITION IN ALL NON-DRIVING CABS.

OPERATION OF THE AUTOMATIC BRAKE VALVE

The Automatic Brake Valve consists, basically, of a small Regulating Valve directly controlled by the movement of the brake valve handle and a Relay Inlet/Exhaust Valve, which is sensitive to pressure as dictated by the Regulating Valve. The proportions of the Relay Inlet/Exhaust Valve are much greater than those of the pressure regulator and it is therefore capable of controlling large volumes of air with the minimum time lag.

RUNNING POSITIONS.

With the driver's control handle in this position, the brake pipe is charged and maintained at the normal running pressure, i.e. 72.5 p.s.i.

When the control handle, which is connected to the camshaft, is in the 'RUNNING' position, the camshaft is in its lowest position in valve body due to the camshaft spigot operating against inclined Cam Face thus the pressure regulating spring is compressed and pushes downwards on the diaphragm seating so that the regulating valve is opened by the tip of the valve stem and allows compressed air to flow from the main reservoir into the chamber of the pressure regulator, into the control reservoir, port No. 3 and also to the underside of diaphragm A. As soon as control reservoir air pressure, acting on the underside of pressure regulating diaphragm C, is equal to the opposing pressure of the spring loaded valve it will close, so preventing any further increase in control air pressure. At the same time however, the stem of the regulating diaphragm seating remains pressed against the face of valve so preventing control air from passing up the hollow stem and so escaping to atmosphere via choke F.

The Cam on the Camshaft holds the sealing valve from its seat, while a throttle washer controls the flow of air into the air brake pipe, in this way the Brake Valve capacity is maintained at a suitable value to overcome normal leakage, but will be sensitive to any excess leakage, through defect or emergency application, outside the drivers control.

Control air pressure in the Relay Valve acts on the underside of diaphragm A which lifts the hollow stem valve causing it to open the Relay Inlet/Exhaust Valve. This two part valve consists of a pilot valve which opens for small increases in air pressure and a main valve which opens for large increases in air pressure to give rapid release of the train brakes, furthermore the Inlet/ Exhaust Valve is pneumatically balanced so as to ensure maximum sensitivity.

When the Inlet/Exhaust Valve is opened by the hollow valve stem, as described above, compressed air from the main reservoir flows via the port and the sealing valve, into the air brake pipe Port No. 2. As pressure in the brake pipe rises, it acts in the chamber on the upper side of diaphragm A, consequently as soon as pressure in the pipe has risen to equal the control air pressure, diaphragm A, being subjected to equal pressures on either side, allows valve stem to move down and permit the Inlet/Exhaust Valve to close. At the same time the tip of the stem remains seated against the face of Inlet/ Exhaust Valve, preventing air from the brake pipe escaping via the hollow valve stem and so to atmosphere via exhaust Port No. 6.

In the event of Brake Pipe leakage, pressure is maintained due to the accurate and sensitive operation of the hollow valve stem and the balanced Inlet/Exhaust Valve.

SERVICE BRAKING

To make a brake application, the Drivers control handle is moved anti-clockwise from the RUNNING position towards the FULL SERVICE brake position, the Camshaft is moved upwards by the action of the spring causing the Camshaft spigot to follow the inclined surface, thus the compression of the pressure-regulating spring is reduced, and control air pressure operating in the chamber on the under-surface of diaphragm C lifts the regulating diaphragm seating, so that the stem parts from the face of the regulating valve, thus air from the control reservoir and chamber below diaphragm A and flows through the hollow stem valve and escapes to atmosphere via choke F.

As soon as the control air pressure falls to a value equivalent to the newly adjusted compression spring, the stem is again re-seated on the face of the regulating valve, preventing any further loss of control air pressure. The reduced pressure acting in the chamber on the underside of diaphragm A is correspondingly lower than the brake pipe pressure in the chamber above diaphragm A, consequently the hollow valve stem is moved downwards so that its tip leaves the underside of the Inlet/Exhaust Valve allowing air from the brake pipe to escape to atmosphere, through the hollow valve stem and exhaust port 6. The flow of air to atmosphere continues until pressure in the chamber above diaphragm A has fallen to a value equivalent to the control air pressure acting on the underside of the diaphragm. At this point the hollow stem valve will re-seat on the underside of the Inlet/Exhaust Valve preventing a further fall in the Auto Air Brake Pipe pressure. The sensitive operation of the Relay Valve ensures that brake pipe pressure is rapidly reduced to the required value.

GRADUAL RELEASE OF THE BRAKES

To make a gradual release of the brakes the drivers control handle is moved clockwise in the braking sector towards the RUNNING position, from the foregoing description it will be understood that this movement will cause control air pressure to be proportionally increased, and consequently the Inlet/Exhaust Valve will operate as previously described to re-charge the train pipe to a corresponding pressure.

RELEASING IN THE RUNNING POSITION

If the drivers control handle is moved directly to the RUNNING position, the valves will be in the positions shown on diagram Fig. The fill valve remaining closed, while the Sealing Valve Lift is such that Throttle Washer limits the flow of air through the seating into the brake pipe.

RELEASE POSITION OVERCHARGE

Referring to diagram Fig. 2 in RELEASE or OVERCHARGE position the cam opens the sealing valve to its maximum so that the throttle washer is moved outside the bore of the seat. Also in this position, due to the increased lift of the sealing valve, the stem of the valve contacts and opens the Fill Valve. This allows compressed air to flow through the Fill valve seat and operate on Fill release valve diaphragm D, so closing Fill Release Valve and preventing air escapaing to atmosphere through this valve. At the same time, the reduction reservoir is charged via the port No. 4 and a choke, in addition it will be seen that air also passes into brake valve chamber via choke E, which restricts the flow of air. Due to the escape to atmosphere from this chamber through the choke F there is a small increase in pressure within the chamber which, acting on the upper surface of regulating diaphragm C, augments the force provided by the spring, so that there is consequently a controlled and limited increase in control air pressure, causing the regulating valve to increase the pressure to 79.5 p.s.i. to be followed likewise by the Inlet/ Exhaust Valve charging the Auto Air Brake Pipe to 78.5 p.s.i.

When the drivers control handle is moved from the RELEASE position to the RUNNING position, the valves assume positions shown on diagram, the Fill valve being closed, there is consequently no further flow of air into the reduction reservoir which now maintains a flow of air into brake valve chamber via choke E. Subsequently, due to the escape of air to atmosphere through the choke valve F, the pressure is gradually reduced to atmospheric and consequently the control air pressure is reduced proportionally to the normal running pressure. This slow fall in the control air pressure, operating in the chambers causes the Inlet/Exhaust valve to operate, and gradually reduce brake pipe pressure to the normal running pressure of 72.5 p.s.i. The rate at which control air pressure falls is controlled by the choke bores, so that the rate at which the brake pipe pressure is reduced is maintained, thus ensuring that there is no re-application of the train brakes during the reduction of the overcharge, this takes 2 to 4 minutes.

In order that the brake pipe pressure is returned to the running pressure in the shortest possible time, the flow of air through choke valve F is augmented during the final stages as follows:- When air pressure in the reduction reservoir has fallen to a relatively low value the release valve spring is able to open the fill release valve so that air may now additionally flow to atmosphere through its hollow stem.

NOTE :- The escape of air to atmosphere via choke valve F provides the driver with an audible indication and warning that the Control Handle is in the RELEASE position. This position should be held for one minute to complete the release of the brakes.

EMERGENCY BRAKE POSITION

When the drivers control handle is placed in the EMERGENCY brake position the cam profiles allow the sealing valve to close and the emergency valves are simultaneously opened by the appropriate cam formed on the shaft. Thus the air brake pipe is vented directly to atmosphere through the emergency valve and a rapid application of the brakes achieved and, provided that vacuum has been created due to the locomotive brake selector switch being in a vacuum position, a rapid application of the brakes will also be achieved by the total destruction of the vacuum, through its emergency valve.

EMERGENCY BRAKE APPLICATION FROM THE TRAIN

If with the drivers control handle in the RUNNING Position or in any of the service brake positions, an emergency brake application is made from the train, either by the guard or by operation of the passengers emergency brake equipment, or additionally due to the train parting etc. then the ability of the Brake Valve to re-charge the train pipe under this condition is automatically limited as follows :-

Referring to diagram Fig. 2 the Sealing Valve is open in the RUNNING position, but the effective area through the seating is limited by the Throttle Washer, consequently air flow into the brake pipe is controlled by the annular space around this washer.

Thus the large capacity of the Drivers Auto Air Brake Valve is effectively prevented from influencing an emergency brake application made in the train.

NEUTRAL POSITION

This position is obtained by moving the drivers control handle in an anti-clockwise direction from the RUNNING position, lifting the stop pin to clear the stop formed on the brake valve body. The handle should be moved until resistance is felt from an internal stop formed inside the brake valve. In this position the cam allows the sealing valve to close and as the emergency valve also remains closed the brake pipe is completely isolated from the main reservoir and no air can pass through the brake valve to atmosphere.

THE AIR/VACUUM RELAY VALVE FIG. 4.

The purpose of this valve is to regulate Train Pipe Vacuum according to the pressure in the Auto Air Brake Pipe as follows :-

(a) When the nominal pressure of 72.5 p.s.i. is available in the Auto Air Brake Pipe there will be 21" of Vacuum in the Vacuum Train Pipe.

(b) When the pressure in the Auto Air Brake Pipe is reduced to 50.5 p.s.i. train pipe vacuum will be reduced to zero.

(c) Any reduction in Auto Air Brake Pipe pressure between 72.5 and 50.5 p.s.i. will cause a proportional drop in Train Pipe Vacuum.

When chamber J is charged at 72.5 p.s.i, chamber P and the control air reservoir will also be at 72.5 p.s.i. since the air control diaphragm will be forced downwards against the light spring. Provided the exhausters are running, chambers M, L, N and the control vacuum reservoir will all be at 21" of vacuum due to the vacuum control diaphragm being pulled upwards. There will be no forces exerted on the stem valve and the inlet valve will remain closed.

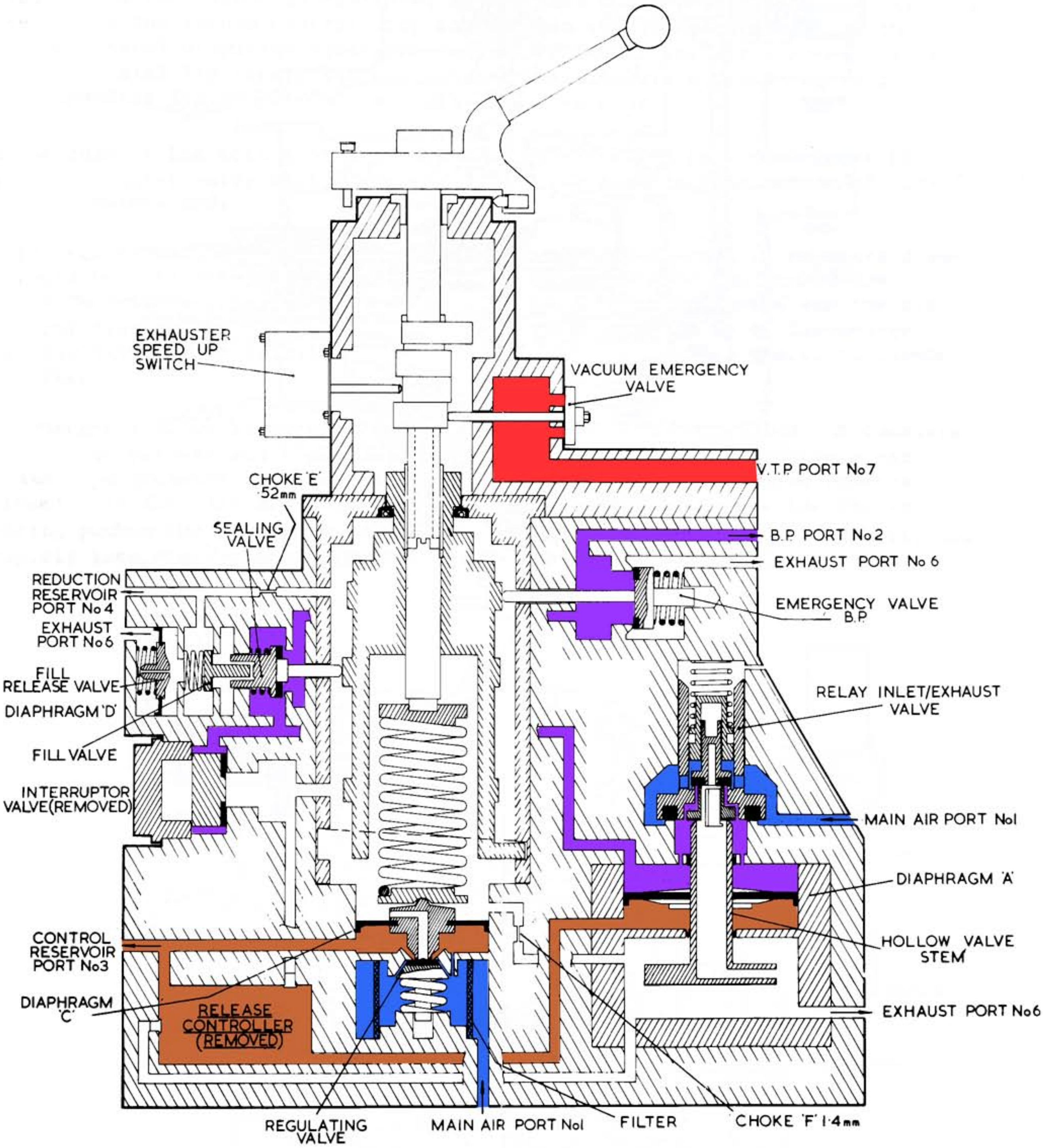


FIG.2 DRIVERS AIR BRAKE VALVE

FIG. 5 - BRAKE APPLICATION (VACUUM)

Consider that Auto Air Brake Pipe pressure in chamber J drops to 66.5 p.s.i. there will then be an upwards differential force of 6 p.s.i. since chamber P remains constant at 72.5 p.s.i. The stem valve then moves upwards opening the inlet valve and atmospheric air commences to destroy the train pipe vacuum Fig. 5 As the vacuum is destroyed in chambers M and L so a downward force is exerted on the vacuum control diaphragm. When the downwards force of the vacuum control diaphragm equals the upwards force of the air control diaphragm the valve will lap itself and the inlet valve will close resulting in a corresponding Train Pipe Vacuum of 15-17" of vacuum.

If because of the action of the exhausters the train pipe vacuum tends to rise, the inlet valve will immediately open and a train pipe vacuum of 15-17" will be maintained.

With Drivers Auto Brake Valve in the Fill position pressure in chambers J and P would tend to rise above 72.5 p.s.i. and when the Auto Air Brake Pipe pressure returns to 72.5 p.s.i. only chamber J will be affected and the air control diaphragm will be unbalanced. This is prevented by an Overcharge Release Valve which releases any pressure in excess of 72.5 p.s.i. in chamber P. Fig.3

An Emergency Valve is incorporated in the Air/Vacuum Relay Valve, it consists of an air cylinder and a piston attached to a valve. So long as Auto Air Brake Pipe pressure is in excess of 40 p.s.i. the Emergency Valve remains closed. If Auto Air Brake Pipe pressure drops below 40 p.s.i. the return spring pushes the Emergency Valve off its seat, thus admitting atmospheric air rapidly into the Vacuum Train Pipe through the inlet and emergency valve.

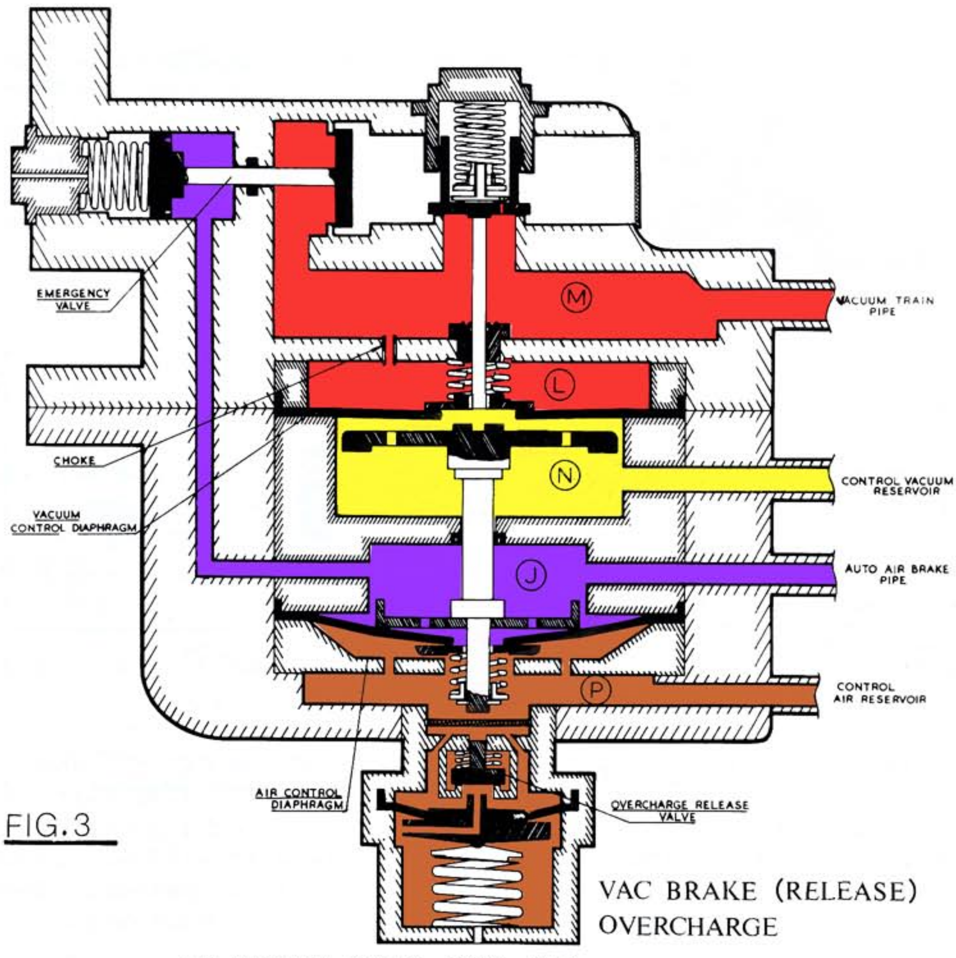


FIG.3

VAC BRAKE (RELEASE) OVERCHARGE

AIR VACUUM RELAY TYPE D.V.2

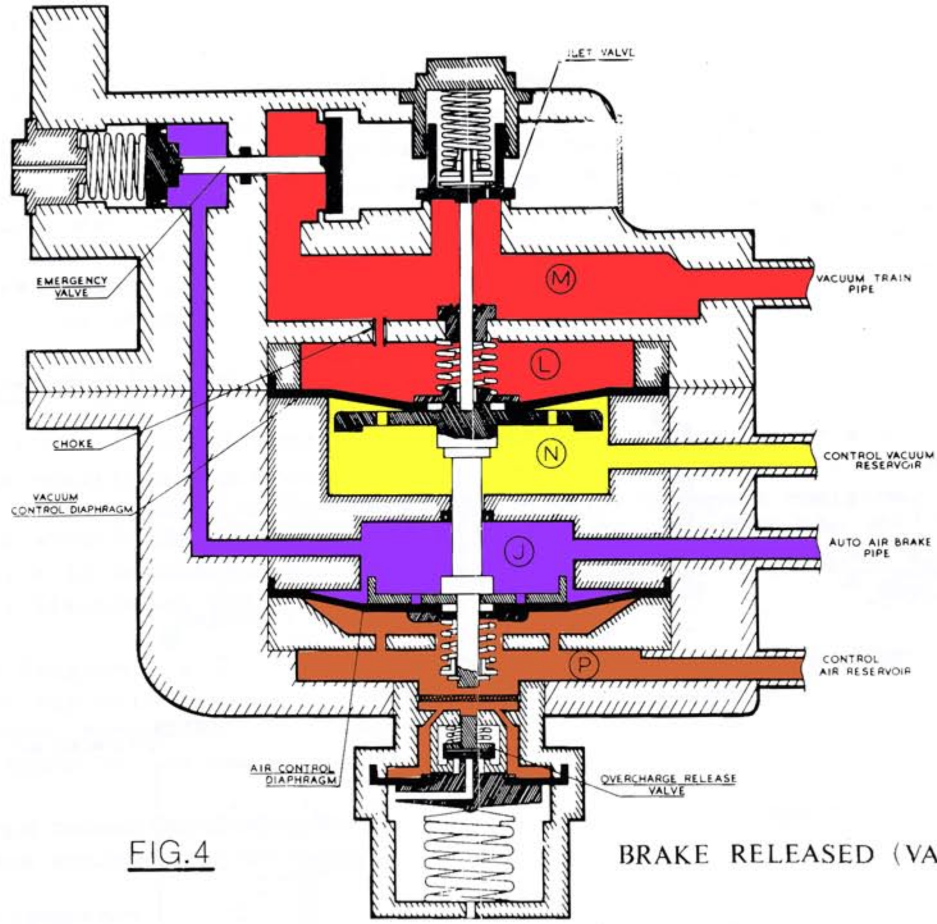


FIG.4

BRAKE RELEASED (VAC)

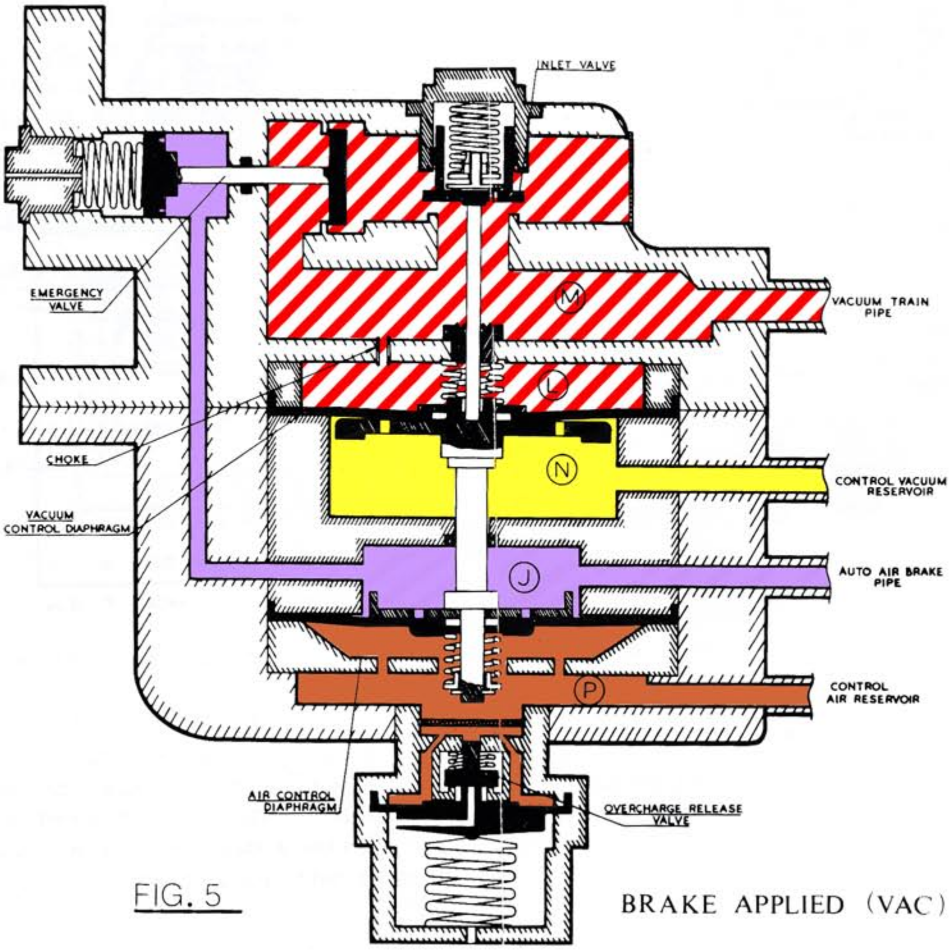


FIG. 5

BRAKE APPLIED (VAC)

The Emergency Valve will guard against failure of the Air/Vacuum Relay Valve, and the possibility that Train Pipe Vacuum will not be destroyed when a brake application is made.

AIR/VACUUM ISOLATING VALVE Air Condition Fig.6

When working air braked trains the Brake Selector Switch must be in the AIR PASSENGER or AIR GOODS position. In these positions the exhausters will not run and hence there will be no vacuum in the Vacuum Train Pipe, Vacuum Train Pipe (Expansion) Reservoir and, providing the vacuum has been destroyed by operating the Vacuum Release Valve, the Vacuum Control Reservoir and chamber K of the Air/Vacuum Isolating Valve.

Because there is no vacuum in chamber K, the spring above the Control Diaphragm pushes the Double Stem Valve down until its lower tip seats on top of the Lower Sealing Valve, isolating the Auto Air Brake Pipe Expansion Reservoir from the Air Control Reservoir. At the same time the upper tip of the Double Stem Valve leaves the Upper Sealing Valve, connecting the Vacuum Train Pipe (Expansion) Reservoir and Vacuum Control Control Reservoir via the hollow stem of the Double Stem Valve. Thus the Vacuum Control Diaphragm A in the Triple Valve is in a balanced condition and is ineffective.

In the Air condition, diaphragm B in the Triple Valve is the controlling diaphragm.

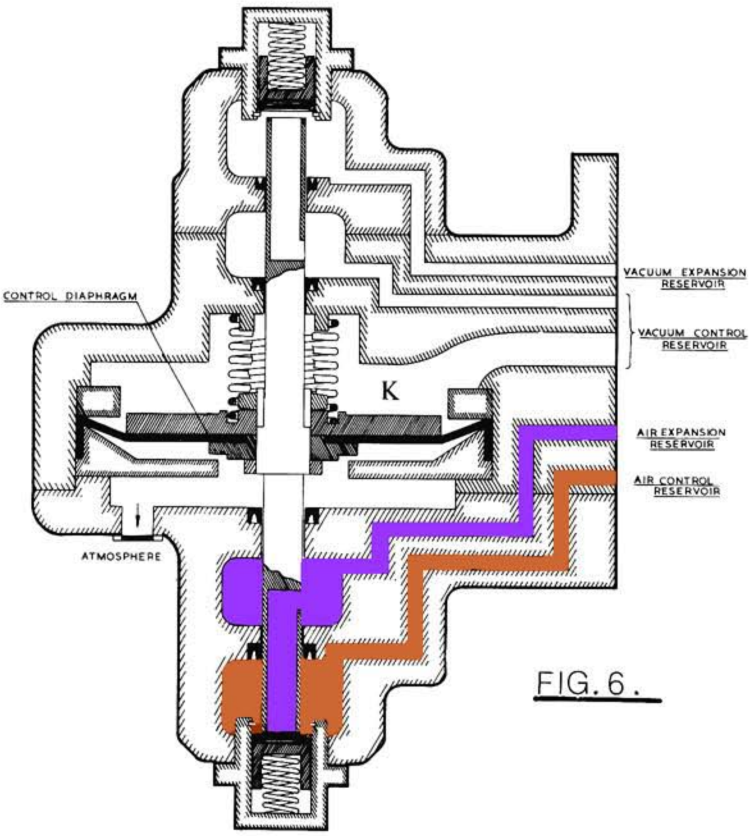


FIG. 6.

AIR-VACUUM ISOLATING VALVE

(air condition)

Vacuum Condition (Fig. 7.)

When working Vacuum Braked Trains the Brake Selector Switch must be in the VACUUM BRAKED OR VACUUM UN-BRAKED POSITION. In either of these positions the exhausters will run, creating vacuum in the Vacuum Train Pipe, Vacuum Control and Vacuum Train Pipe (Expansion) Reservoirs and in vacuum chamber K above Control Diaphragm, in the Air/Vacuum Isolating Valve. With vacuum above the diaphragm, atmospheric pressure will force the diaphragm and the Double Stem Valve up until its upper tip seats on the Upper Sealing Valve, isolating the Vacuum Train Pipe (Expansion) Reservoir from the Vacuum Control Reservoir.

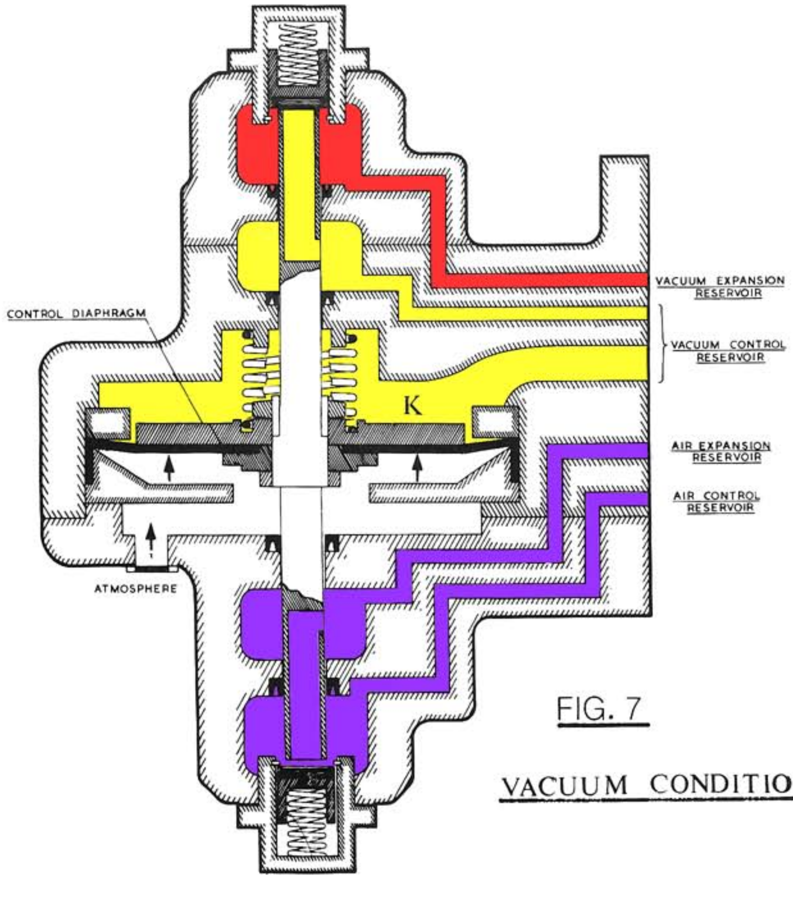


FIG. 7

VACUUM CONDITION

THE TRIPLE VALVE

Triple Valve (Fig.8)

The purpose of this valve is to operate the locomotive air brakes in proportion to the degree of braking effort applied to the train i.e.

(a) In proportion to the reduction in Auto Air Brake Pipe pressure when working air braked trains.

(b) In proportion to the reduction in train pipe vacuum (which is proportional to the reduction in Auto Air Brake Pipe pressure when working vacuum braked trains.

DESCRIPTION

The valve consists of six main sections :-

(1) A hollow stem valve, balancing diaphragm, anti-slip brake diaphragm and main inlet valve.

(2) A vacuum control diaphragm A which is sensitive to change in Train Pipe Vacuum when working vacuum braked trains.

(3) An air control diaphragm B which is sensitive to change in Auto Air Brake Pipe pressure when working air braked trains.

(4) The sealing and maximum pressure limiting valves.

(5) The braked/unbraked changeover valve.

(6) The passenger/goods changeover valve.

OPERATION (AIR BRAKED TRAINS).

It should be appreciated that only the control diaphragm appropriate to the type of brake system in use on the train will be operative. The control diaphragm not applicable to the system must be maintained in a balanced and non-operative condition. This is achieved by the Air/Vacuum Isolating Valve, see fig.6

Air from the Auto Air Brake Pipe passes to the top of diaphragm B via the Release Choke Valve, Choke 5, Goods Passenger Changeover Valve and Chokes 4 and 8, Sealing Valve and Maximum Pressure Limiting Valve and Choke 7, also via a choke 6 to the underside of diaphragm B. When pressure above and below are at the normal running pressure of 72.5 p.s.i. diaphragm B is in a balanced condition.

Consider a reduction in auto Air Brake Pipe pressure to 62.5 p.s.i. pressure above diaphragm B falls to 62.5 p.s.i. but at that instant, because of the restriction offered by the small choke 6 in the sealing valve, pressure below the diaphragm remains at approximately 72.5 p.s.i. A pressure differential of 10 p.s.i. therefore acts on the underside of diaphragm B so lifting the hollow stem valve to first seal off the chambers above diaphragm E from atmosphere, then open the inlet valve to allow air to pass to the Auto Air Relay Valves.

At the same time air also passes from the chambers above diaphragm E to diaphragm G of the sealing valve, forcing the diaphragm and valve down to close the passage to choke 6, pressure below diaphragm B is therefore maintained at approximately 72.5 p.s.i.

As pressure builds up in the chamber above diaphragm E via inshot choke 3 a downwards force will be exerted on this balancing diaphragm E and when this equals the upward force exerted by the air control diaphragm B the inlet valve will close under the action of its return spring, cutting off the air supply to the auto Air Relay Valves. Any reduction of Auto Air Brake Pipe pressure between 72.5 p.s.i. and 50.5 p.s.i. will result in a corresponding brake pressure between 0 and 70 p.s.i.

MAXIMUM PRESSURE LIMITING VALVE

The purpose of this valve is to prevent the locomotive air brake cylinder pressure exceeding 70 p.s.i. (or such other figure required according to design of - locomotive) if the Auto Air Brake Pipe pressure should be reduced to zero e.g. an emergency application.

A maximum locomotive brake pressure of 70 p.s.i. is achieved when the Auto Air Brake Pipe pressure is reduced to 50.5 p.s.i. the resultant differential pressure of 22 p.s.i. acting on the air control diaphragm B.

It is therefore necessary to limit this differential to 22 p.s.i. when the Auto Air Brake Pipe pressure falls below 50.5 p.s.i. This is achieved by closing the port and non return valve by means of a spring loaded diaphragm and valve whenever the differential in the chamber above diaphragm H exceeds 22 p.s.i. The springs keep the port open for any differential less than 22 p.s.i.

PASSENGER/GOODS CHANGEOVER VALVE

The purpose of this valve is to delay braking during an A.W.S. D.S.D. or drivers brake application on a partially fitted air braked train.

When operating in the Passenger position and the E.P. valve is energised and therefore shut, diaphragm F remains in a balanced condition and air can pass out of the triple valve through chokes 4 and 8.

Consider now an A.W.S, D.S.D. or drivers brake application in the Goods position, the E.P. valve will be de-energised and therefore pass air to the underside of diaphragm F forcing the diaphragm and valve up to close choke 8, thus delaying the build up of brake pressure by allowing a slower reduction of Auto Air Brake Pressure from above diaphragm B through choke 4.

OPERATION OF THE TRIPLE VALVE (VACUUM BRAKED TRAINS)

As already explained the air control diaphragm is in a balanced condition and therefore ineffective.

With the exhausters running, atmospheric air will be drawn out of the chamber below diaphragm A via choke 1 and the release valve, the vacuum control diaphragm will be pulled downwards thus allowing a vacuum to be created in chamber above the diaphragm. In this condition the vacuum control diaphragm is balanced. Consider a drop of vacuum in chamber below diaphragm A, the vacuum above the diaphragm will remain at 21" due to the sealing action of the vacuum control diaphragm and there will therefore be an upward force on the vacuum control diaphragm lifting the hollow stem valve to first shut off chambers above diaphragm E from atmosphere and allow air from the inlet valve to pass to the Auto Air Relay Valves.

As pressure builds up in the chamber above diaphragm E a downward force will be exerted on the balancing diaphragm and when this force equals the upward force exerted by the vacuum control diaphragm the inlet valve will close under the action of its return spring so cutting off air supply to the relay valves. The valve is therefore self lapping, any reduction in train pipe vacuum between 21" and 0" resulting in a corresponding braking pressure between 0 and 70 p.s.i.

BRAKED/UNBRAKED CHANGEOVER VALVE

When an A.W.S, D.S.D. or Drivers brake application is made in the unbraked position, the magnet valve is de-energised and the large choke 2 remains closed. The atmospheric air passing into chamber will then only be able to pass through the small choke 1, resulting in a delay in the building up of braking pressure. It should be noted that in the unbraked position the total delay of 30-40 seconds is achieved in conjunction with another E.P. valve (brake/unbraked E.P. valve).

ANTI-SLIP DEVICE

When the anti-slip E.P. valve is energised as a result of the Driver pressing the button on the end of the controller, control air at 72.5 p.s.i. is fed into the chamber below diaphragm C. This results in the hollow stem valve lifting and a brake application of 12-15 p.s.i. being achieved in the normal manner.

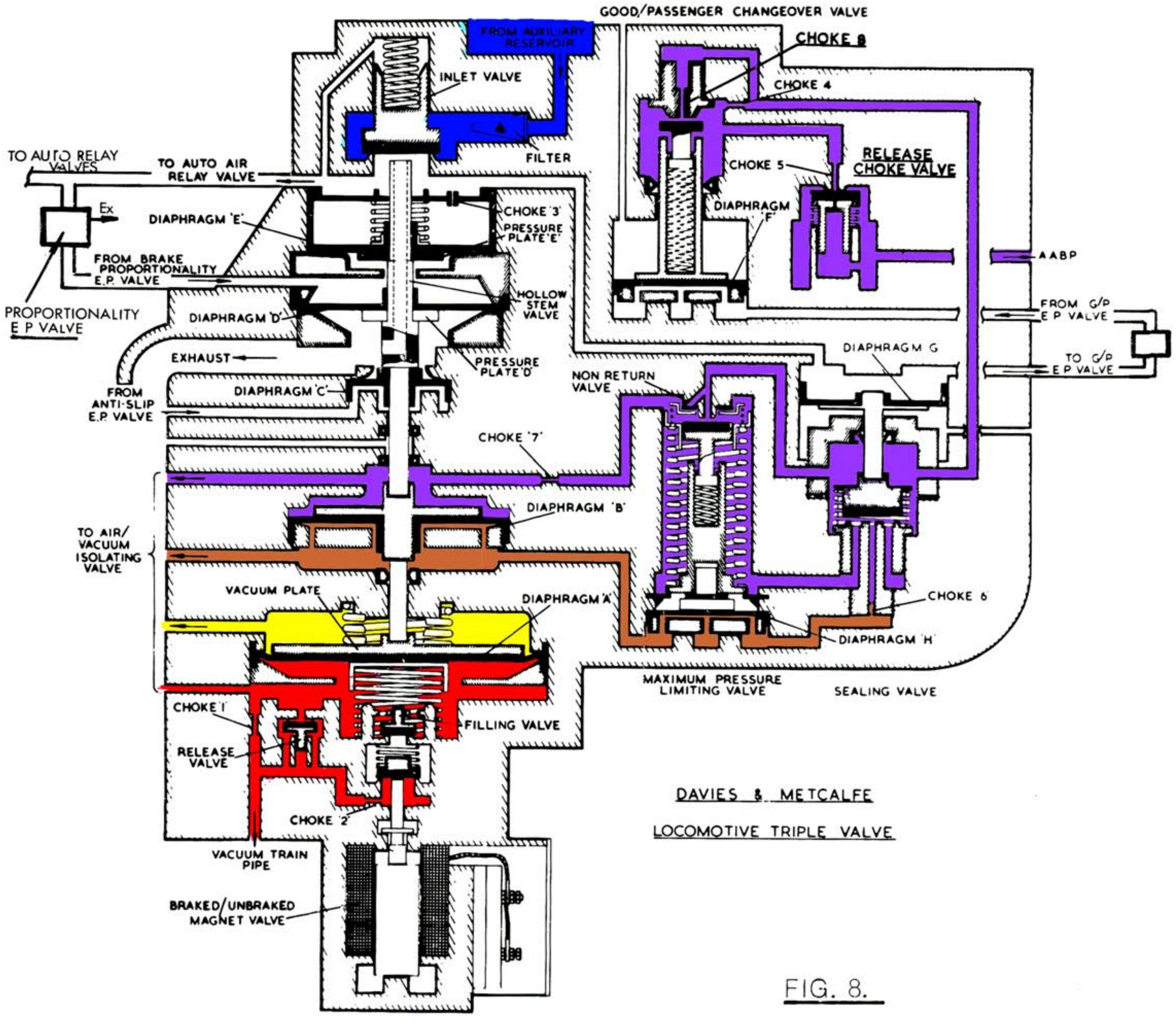
The following table gives the vacuum and appropriate brake cylinder readings for the various degress of braking.

Train Pipe Vacuum	Brake Cylinder Pressures.	Loco. Fitted with Unmodified Triple Valve - Brake Cylinder Pressures.
15" Hg	0 - 5 p.s.i.	14 - 20 p.s.i.
10" Hg	21 - 27 p.s.i.	30 - 37 p.s.i.
5" Hg	42 - 48 p.s.i.	47 - 54 p.s.i.
0" Hg	67 - 73 p.s.i.	67 - 73 p.s.i.

BRAKE PROPORTIONALITY

In order to reduce the brake application on the locomotive in the early stages of braking, and still obtain the maximum brake application at full service, on vacuum braked trains only an additional diaphragm D was fitted, which had a pressure plate with a smaller diameter than that of diaphragm E. A proportionality E.P. valve which was energised and open in both the VACUUM BRAKED and UNBRAKED position, allowed air, which acted on diaphragm E when a brake application was made, to pass to the underside of this diaphragm, thus balancing and cancelling out its reaction, at the same time diaphragm D was brought into use. The additional spring which was also fitted above the vacuum control diaphragm A, retarded the lift of the stem in the early stages of train braking causing the train to share more of the braking effort in the early stages of braking, because of the smaller diameter of pressure plate D the full braking of the locomotive was achieved in the final stages of a brake application. This major modification involved adding an extra section to the valve pile and thus became the Mark 7.

It has since been decided that it would be an advantage to have brake proportionality on air braked trains as well, and the locomotive Triple Valve Mark 8 was introduced, dispensing with the proportionality E.P. valve and the section of the pile containing diaphragm D. The additional spring was retained to retard the lift of the stem in the early stages of braking, and the pressure plate of diaphragm E suitably reduced to give the full braking in the final stages of the brake application.



DAVIES & METCALFE

LOCOMOTIVE TRIPLE VALVE

FIG. 8.

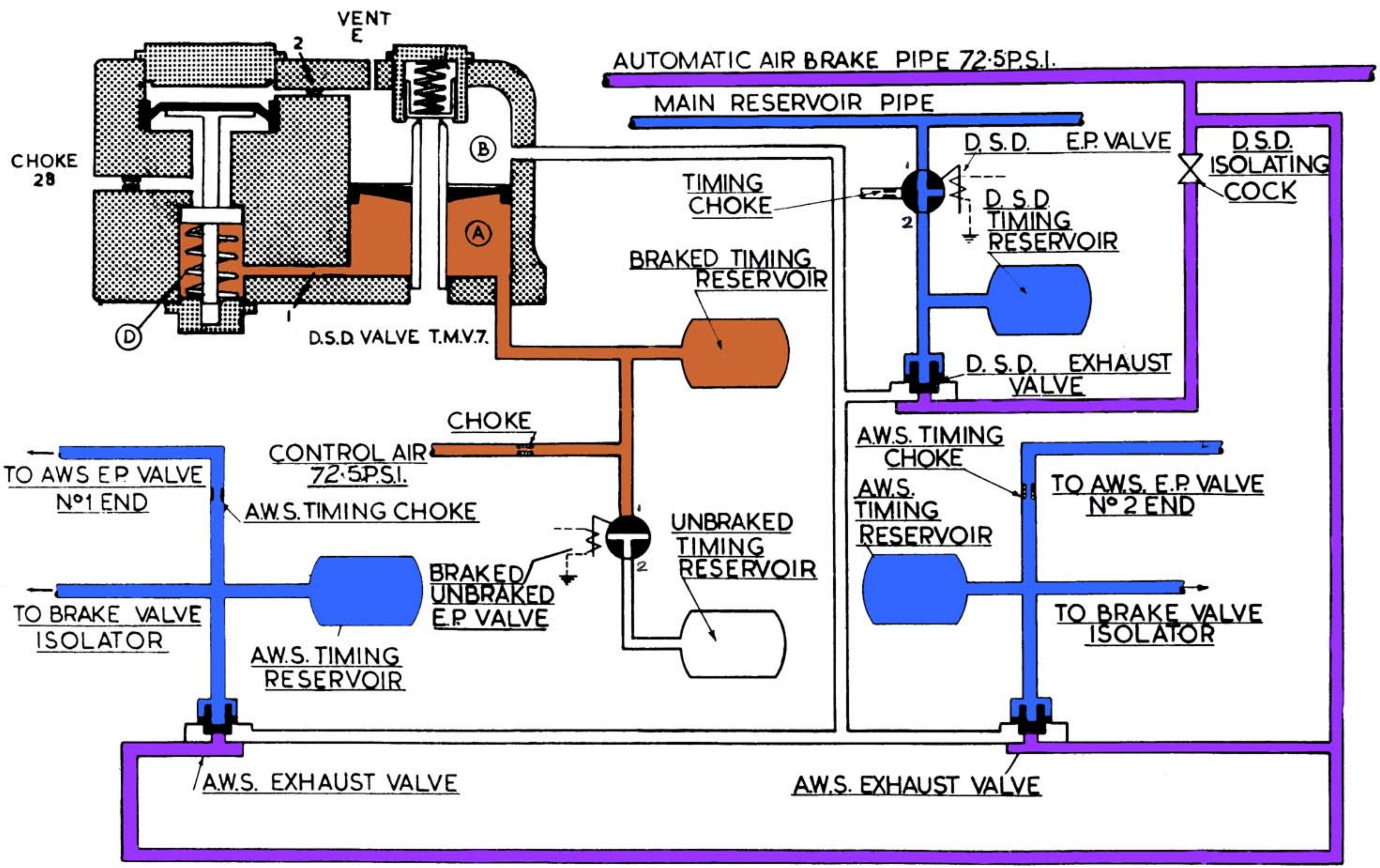


FIG. 9. RUNNING POSITION OF A.W.S. & D.S.D. EQUIPMENT

D.S.D. VALVE (T.M.V.7)

The purpose of this valve is to provide a controlled rate of pressure drop in the Auto Air Brake Pipe during a brake application initiated either by the A.W.S. or releasing the D.S.D. pedal.

The valve consists of two elements i.e. Control and Application. Chambers A of the control element and D of the application element are supplied with control air at a pressure of 72.5 p.s.i. via port No. 1. Chamber B is connected to the Auto Air Brake Pipe through Exhaust Valves in the D.S.D. and A.W.S. systems and is also in communication with Chamber C of the control element.

RUNNING POSITION OF D.S.D. AND A.W.S. EQUIPMENT (Fig.9)

When the direction selector is at E.O. or OFF or when the D.S.D. pedal is depressed in FORWARD or REVERSE, the D.S.D. E.P. Valve will be energised open allowing air from the main reservoir pipe at 118/140 p.s.i. to fill the D.S.D. Timing Reservoir and hold the D.S.D. Exhaust Valve on its seat.

In the driving cab the A.W.S. Change-end Switch will be in the ON position which will energise the A.W.S. E.P. Valve, this in turn supplies air at main reservoir pressure to the appropriate A.W.S. Timing Reservoir via an A.W.S. Timing Choke and to the A.W.S. Exhaust Valve to hold it on its seat. In the non-driving cab, the A.W.S. Change-end Switch will be OFF and in this position a continuous supply of air is available to the appropriate A.W.S. Timing Reservoir, via a A.W.S. Timing Choke and A.W.S. Exhaust Valve which is held on its seat, thus the A.W.S. equipment in the cab remains inoperative.

Thus with the D.S.D. and A.W.S. Exhaust Valve held on their seats, pressure in the Auto Air Brake Pipe will be maintained.

With the Brake Selector switch in the VACUUM GOODS position, control air at 72.5 p.s.i. is fed into both the Braked Timing Reservoir and Unbraked Timing Reservoir. In the other 3 positions of the switch, control air is only fed into the Braked Timing Reservoir. It also enters chamber A of the D.S.D. Valve and passes through port No. 1 to chamber D keeping the spring loaded and hollow stem valves on their seats.

D.S.D. BRAKE APPLICATION (Fig.10)

If the D.S.D. pedal is released when the direction selector is in FORWARD or REVERSE position, the D.S.D. E.P. Valve will be de-energised. This will allow air from the D.S.D. Timing Reservoir to exhaust to atmosphere through the Timing Choke, which gives a 5-7 seconds delay before the pressure in the Auto Air Brake Pipe lifts the D.S.D. Exhaust Valve, air will then flow into chamber B and via port No. 2 to chamber C of the D.S.D. Valve. There will be some loss of air in chamber B through vent E, so that initially the control air pressure in chamber A will be greater, keeping the hollow steam valve on its seat.

Immediately air enters chamber C it acts on the diaphragm, causing it to deflect and move the spring loaded valve off its seat, thus allowing control air to flow to atmosphere through choke 28. Pressure in chambers D and A now falls at a controlled rate, determined by whether one or both timing reservoirs are in operation. When pressure in chamber A falls below the pressure in chamber B, the diaphragm will move down unseating the hollow steam valve, allowing the Auto Air Brake Pipe to vent to atmosphere while the choke in the control air connection prevents excessive loss of air from the system.

It should be noted that when the D.S.D. pedal is released, the Feed Cut-off Valve is de-energised, this cuts off the main air supply to the Drivers Auto Air Brake Valve and prevents the Brake Valve charging the Auto Air Brake Pipe during a D.S.D. application.

It will therefore always be necessary to keep the D.S.D. pedal depressed to energise the Feed Cut-off Valve even when the D.S.D. Isolating Cock has been closed for some defect.

A.W.S. BRAKE APPLICATION

When the A.W.S. operates for the Warning condition, the E.P. Valve will be de-energised and remain so unless the RESET button is depressed. In this de-energised condition air is admitted to the horn and exhausted from the A.W.S. Timing Reservoir through the A.W.S. Timing Choke, which will give a 3 seconds delay, after which the A.W.S. Exhaust Valve will be pushed up by Auto Air Brake Pipe pressure, which can now pass to the D.S.D. Valve causing it to function exactly as in a D.S.D. Brake Application.

Note that Main Air Pressure will also be exhausted from the Brake Valve Isolator, which closed to prevent the Auto Air Brake Pipe being recharged from the Drivers Auto Air Brake Valve.

RELEASE

Depression of the D.S.D. pedal or A.W.S. Reset Button allows main air pressure to seat the appropriate Exhaust Valve. As soon as the D.S.D. or A.W.S. Exhaust Valve has closed, the Auto Air Brake Pipe is sealed off from chambers B and C and will be recharged by the Drivers Auto Air Brake Valve.

Air which may be still in chambers B and C of the D.S.D. Valve will pass to atmosphere through the open hollow stem valve and vent E. The loss of air pressure in chamber C will allow the spring loaded valve in chamber D to close, allowing the Control Air Pressure to build up in chambers D and A closing the Hollow Stem Valve. The D.S.D. Valve is now back in the position as in the Running position diagram. (Fig.9)

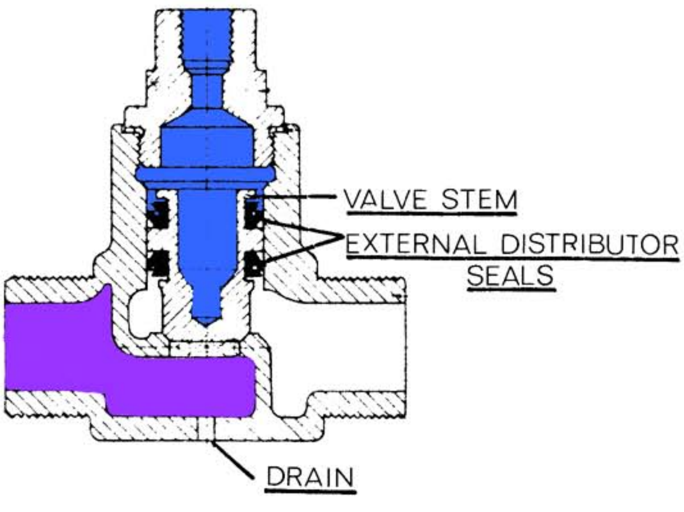


FIG.11. D.S.D./A.W.S. EXHAUST VALVE

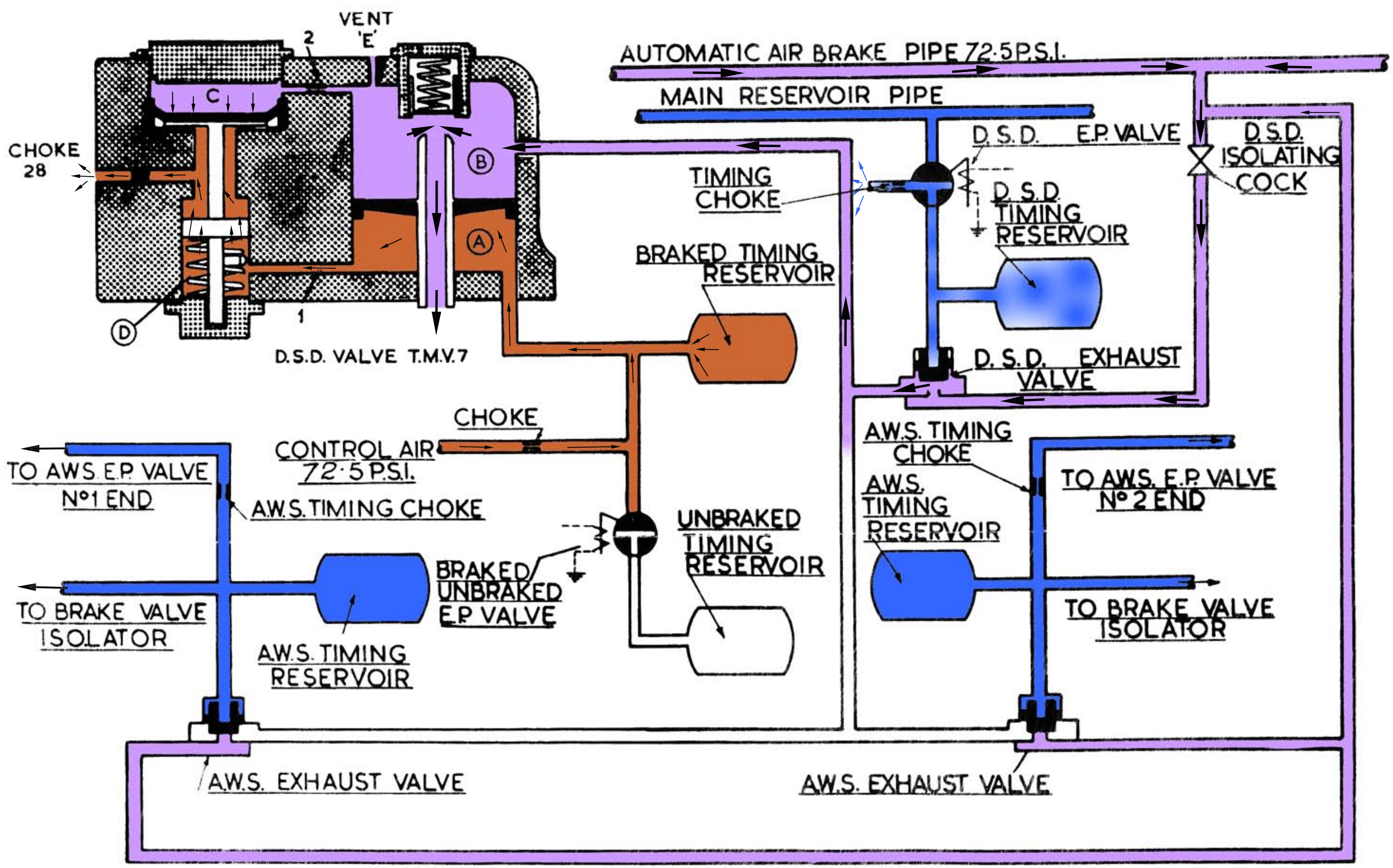


FIG.10. D. S. D. BRAKE APPLICATION

FEED CUT-OFF VALVE (D.S.D.)

The function of the Feed Cut-off Valve is to ISOLATE the Drivers Auto Air Brake Valve from the main air supply so ensuring that a D.S.D. brake application can take place when the D.S.D. pedal is released.

Air from the main reservoir pipe enters the Feed Cut-off Valve at A passing to:-

(1) Inlet Valve of Magnet Valve

(2) Through Strainer to Valve B

When the Magnet Valve is energised the Inlet Valve opens and the Outlet Valve closes and air from the main reservoir pipe passes to the underside of the piston which lifts to open Valve B. Main reservoir air can now pass to the Drivers Auto Air Brake Valve.

Should the D.S.D. pedal be released or main air pressure fall below 65 p.s.i. the Magnet Valve will be de-energised. The Inlet Valve will then close and the Outlet Valve will open so allowing air from the underside of the piston to escape to atmosphere. Valve B will then close thus preventing main air passing into the Drivers Auto Air Brake Valve.

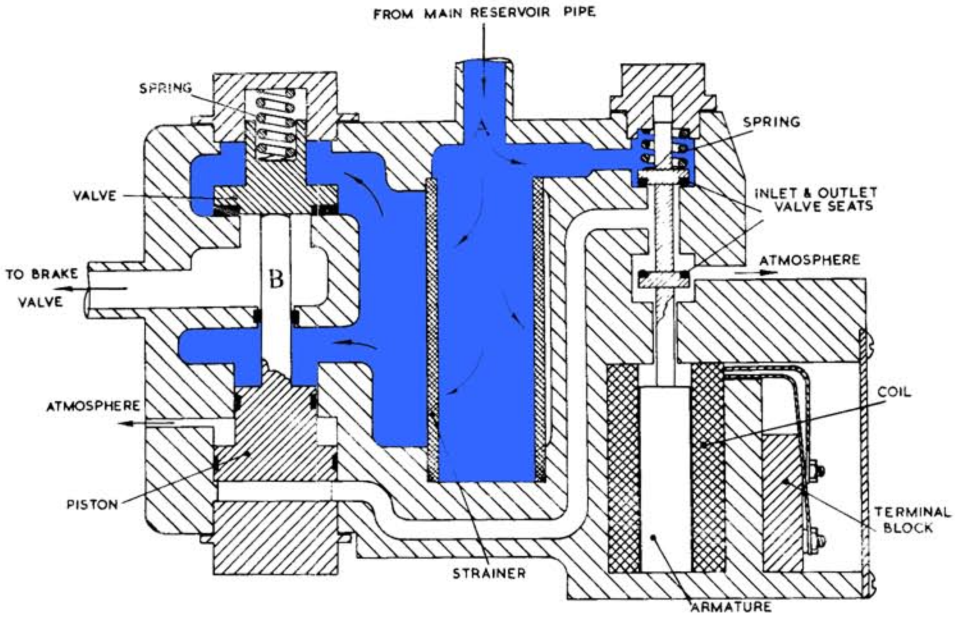


FIG.12. FEED CUT-OFF VALVE. (D.S.D.)

BRAKE VALVE ISOLATOR (A.W.S.)

The function of the Brake Valve Isolator is to prevent air from the Drivers Auto Air Brake Valve passing to the Auto Air Brake Pipe and ensure that an A.W.S. initiated brake application can take place.

Air from the Drivers Auto Air Brake Valve enters the Brake Valve isolator at A, passing through the Strainer to Valve B. If air at main reservoir pressure is available from the A.W.S. this will lift the piston to open Valve B and allow air from the Drivers Auto Brake Valve to flow into the auto Brake Pipe.

Operation of the A.W.S. will exhaust the air from the underside of the piston allowing Valve B to close, cutting off the air supply between the Drivers Auto Air Brake Valve and the Auto Air Brake Pipe.

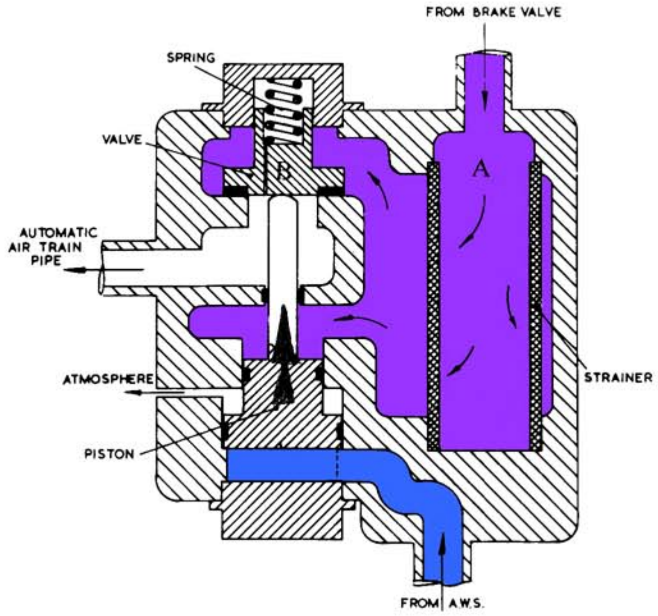


FIG. 13. BRAKE VALVE ISOLATOR (A.W.S.)

PRESSURE CONTROL VALVE

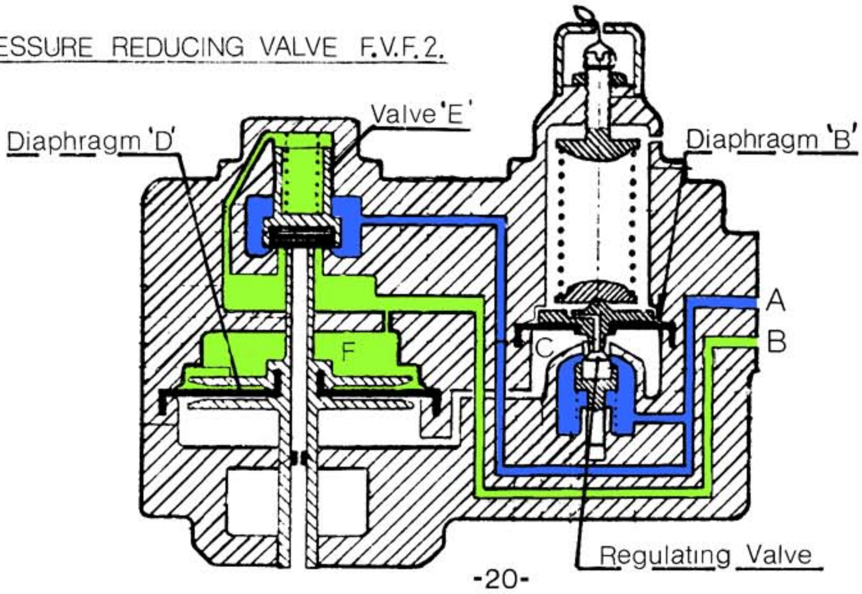
This valve reduces main reservoir pressure from 118/140 p.s.i. to 100 p.s.i. for Brake Feed/Reservoir Pipe supply to air braked trains.

Air at main reservoir pressure enters the valve at A, flows through the open Regulating Valve into chamber C. When pressure in chamber C and the underside of diaphragm B reaches 100 p.s.i. diaphragm B moves up compressing the spring and allowing the Regulating Valve to close.

When pressure in chamber F falls below 100 p.s.i. diaphragm D will be lifted by the pressure in chamber C and open valve E. Air at main reservoir pressure will then flow into chamber F and the Brake Feed/Reservoir Pipe until a pressure of 100 p.s.i. is reached, diaphragm D will then move down allowing valve E to close.

If pressure in chamber C should exceed 100 p.s.i. because of a leaking Regulating Valve diaphragm B will lift, allowing air to flow to atmosphere via the hollow stem valve. Equally if the pressure in Chamber F above diaphragm D exceeds 100 p.s.i. because of a defective valve E, the hollow stem valve will leave its exhaust seat and vent air via the choke and exhaust port.

FIG.14.PRESSURE REDUCING VALVE F.V.F.2.



THE 'NORTHEY' ROTARY EXHAUSTER (Fig.15 &16)

The exhausters are capable of running at two speeds :-

(a) A normal speed of 1250 R.P.M. to create and maintain the required degree of vacuum in the train pipe.

(b) At a higher speed of 1850 R.P.M. to rapidly create vacuum for quick release of the brakes.

The principle of the Northey Rotary vacuum pump differs radically from most others. Two balanced rotors mounted on parallel shafts within the body rotate within a working chamber shaped like a figure 8. At one end the shafts are geared together to maintain correct relationship between the rotors. There are no valves and the air flow is controlled by the movement of the rotors past ports in the end covers. The rotors have no actual rubbing contact with each other or the walls of the chamber.

NOTE : The inlet port shown on the diagram is connected to the Vacuum Brake Train Pipe whilst the delivery port discharges to atmosphere via a silencer.

In position 1 the Delivery (left-hand) Rotor tip has swept out the induction Rotor 'gap', a partial vacuum has been created in space I which materially assists the induction from the train pipe just about to commence. Compression of air already removed from train pipe is commencing in space C.

Position 2 shows commencement of delivery to atmosphere from space C through the rapidly opening delivery port whilst introduction is well advanced in Space I.

In position 3 delivery has been completed and as the inlet port is sealed from Space I induction ceases with a small quantity of air, removed from the train pipe, trapped in Space C.

Position 4 illustrates the changeover position, the seal between the rotors is broken so releasing the small amount of undelivered air which expands into the rotor chamber. The cycle now recommences at position 1. During the transition period from position 4 to position 1, when the rotors 'mesh', the inlet and delivery ports are closed thus isolating the train pipe from atmosphere.

NOTE : Modification on Northey Exhauster - Elimination of oil feed to rotor chamber.

COMMENCEMENT OF CYCLE

(A) Inlet port about to open into induction space I.

(B) Compression commencing in space C.

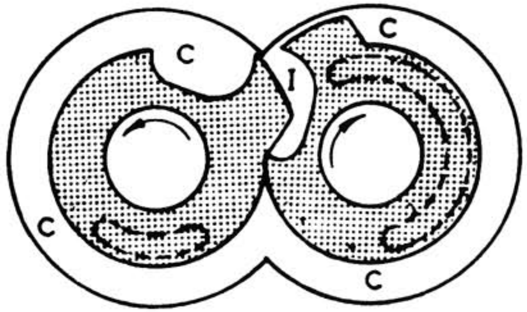
(A) Induction well advanced in space I.

(B) Delivery commencing from space C.

(A) Induction complete, inlet port shut off from space I.

(B) Delivery complete, small portion of compressed charge trapped in space C.

(1)

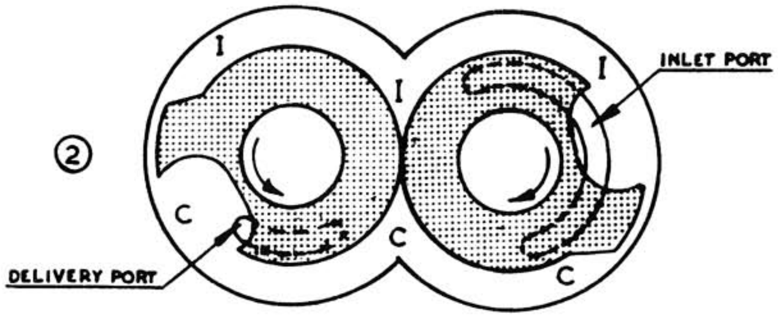


COMMENCEMENT OF CYCLE

(A) Inlet port about to open into induction space I.

(B) Compression commencing in space C.

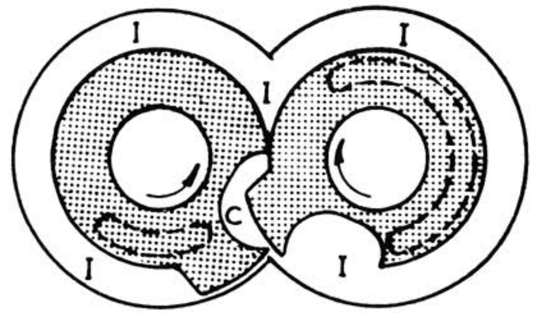
(2)



(A) Induction well advanced in space I.

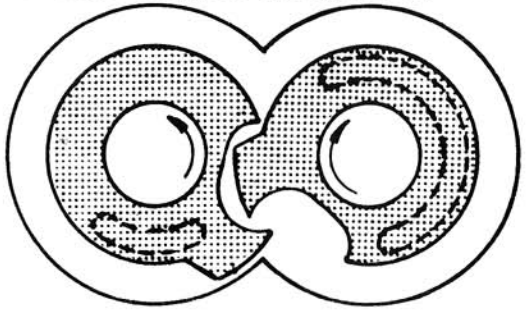
(B) Delivery commencing from space C.

(3)



(A) Induction complete, inlet port shut off from space I.
(B) Delivery complete, small portion of compressed charge trapped in space C.

(4)



"Change-over" position, seal broken bet:een rotors, freeing undelivered air into induced charge.
Cycle recommences at I, with induced charge now transferred to "compression side" of rotor tips.

FIG. 15. THE PRINCIPLE ON WHICH THE NORTHEY ROTARY VACUUM PUMP OPERATES

"Change-over" position, seal broken between rotors, freeing undelivered air into induced charge.

Cycle recommences at 1 with induced charge now transferred to "compression side" of rotor tips.

REAVELL VACUUM BRAKE EXHAUSTER (Fig.17.)

This machine is a sliding-blade, air-cooled, rotary exhauster which again has two operating speeds, a high speed to rapidly create vacuum for quick release of the brakes, and a normal speed to create and maintain the required degree of vacuum in the train pipe.

DESCRIPTION OF EXHAUSTER

The accessories for use with this exhauster include a pipeline filter in the pipe leading to the exhauster inlet, a check valve in the same pipeline which will close when the exhauster is not running and prevent atmospheric air from leaking into the vacuum system, and a snifting valve for limiting the vacuum in the pipeline.

The combined rotor and shaft (2) is mounted eccentrically in the casing on roller bearings and the eccentricity being such that at one position the rotor almost touches the casing bore. The slots in the rotor are provided with fabric blades (3) which, when the rotor is revolving, are kept in contact with the casing, dividing the space between the rotor and the casing into unequal cells. Air is drawn into each cell from the vacuum train pipe on the inlet side of the casing at a position where the volume of the cell is greatest. As volume of the cell decreases, the air is compressed and then expelled from the exhaust port via the exhaust pipe to the separator. The rotor is located in a longitudinal direction by ball bearing. A seal is provided at the point where the shaft projects from the casing cover in order to prevent leakage of atmospheric air into the exhauster, which would tend to reduce the vacuum.

A fan mounted on the driving end of the shaft blows air over the radial cooling fins, which are cast on the outside diameter of the casing to take away some of the heat generated when compressing air inside the exhauster.

LUBRICATION

A combined separator and oil tank (4) is mounted above the exhauster. Oil is contained in the lower portion of the tank and when the exhauster is running the difference in pressure between the atmosphere and the vacuum in the machine is made to force oil to two lubrication points in the exhauster.

The motion of the rotor against the two cover faces distributes the oil to the blade slots and to the bore of the casing. Some oil passes through the clearance between the rotor shaft and the cover at the driving end and lubricates the bearing but, in addition, there is a grease feed which directly lubricates these bearings and the sealing lip of the seal. The lubrication system is therefore one in which the same oil is being constantly re-circulated, resulting in a very small oil consumption.

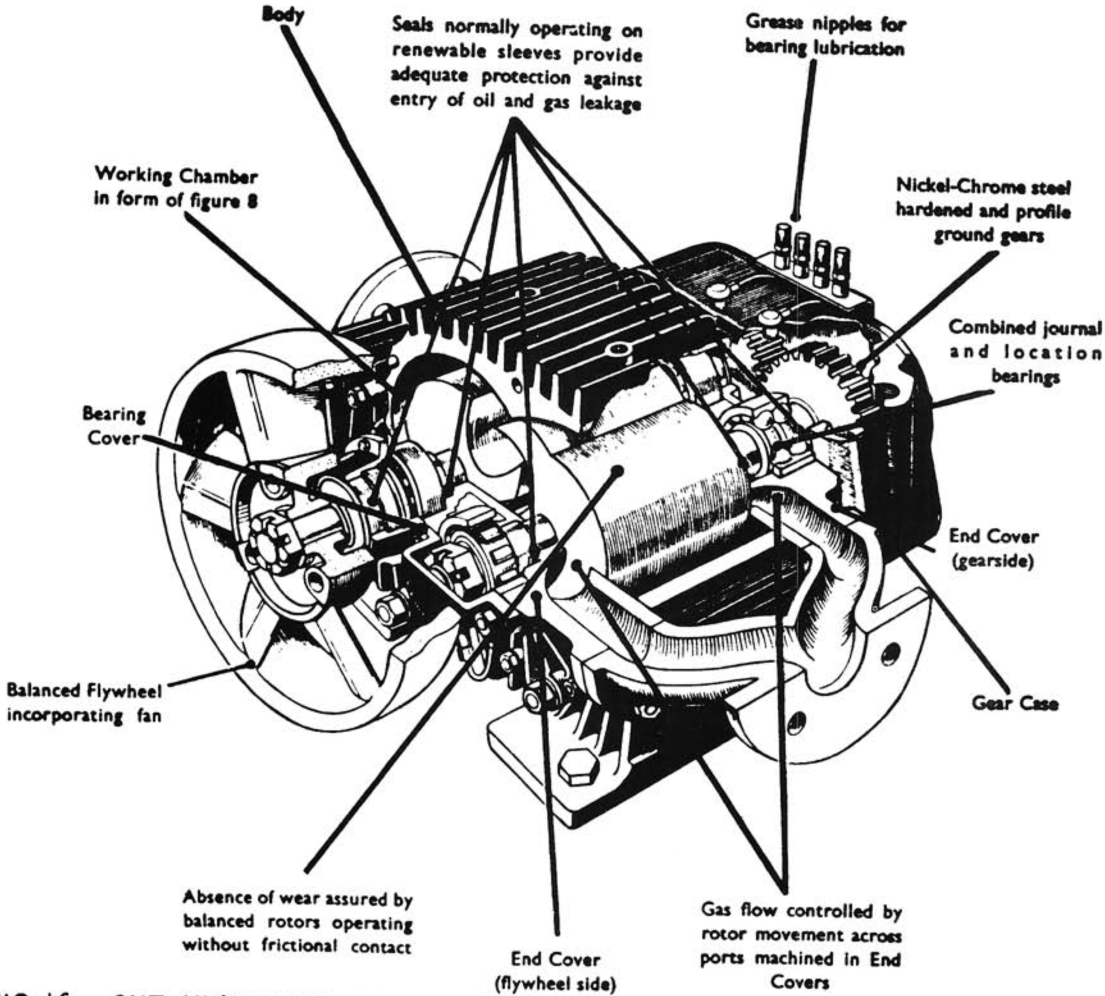


FIG. 16. CUT-AWAY VIEW OF TYPICAL NORTHEY EXHAUSTER

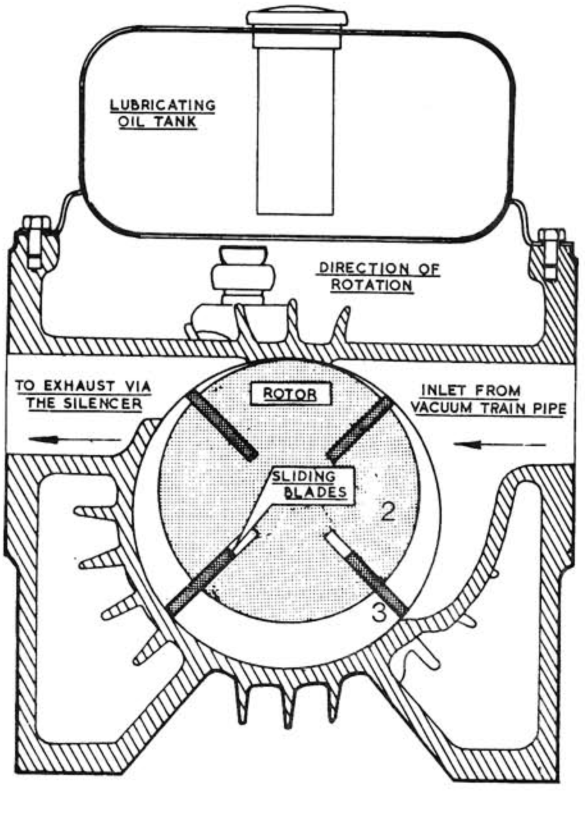
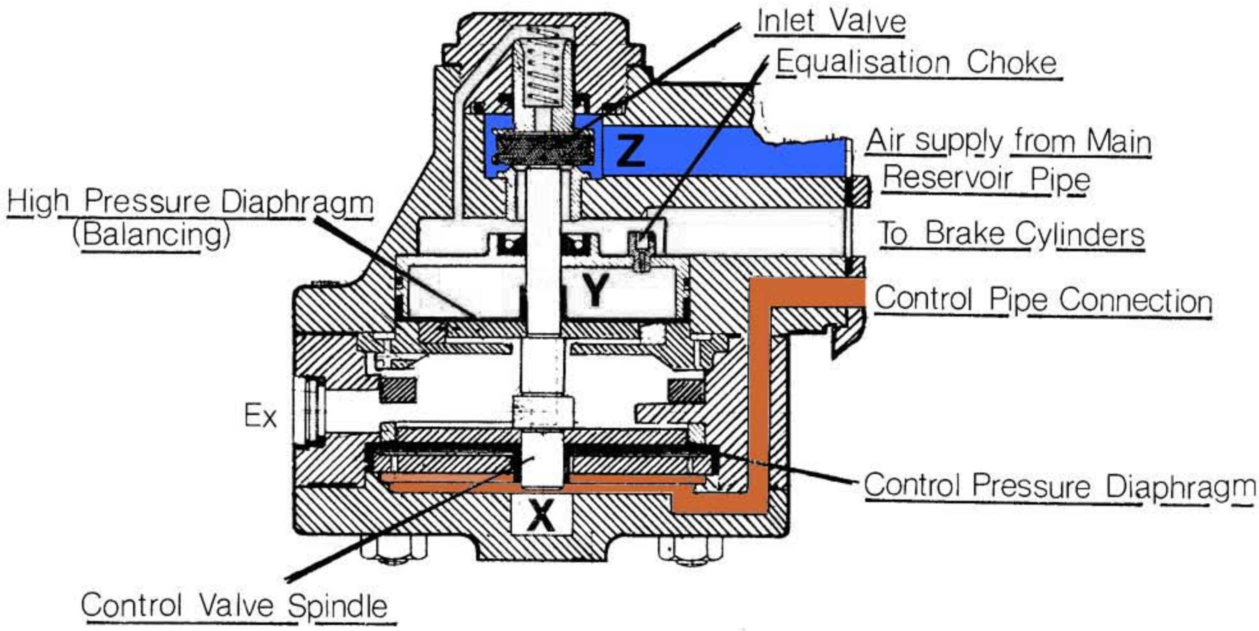


FIG. 17. REAVELL ROTARY EXHAUSTER

THE RELAY VALVE.

The purpose of the relay valve is to relay the pressure dictated by the straight air brake valve directly from the main reservoir supply to the locomotive brake cylinders.

The relay valve consists of a centrally positioned hollow stem valve, the lower end of which is attached to the control pressure diaphragm; below this diaphragm is chamber 'X' which is in communication, via the connecting pipe, with chamber 'B' of the straight air brake valve. Near to the upper end of the stem valve is attached the high pressure balancing diaphragm, the upper side of which will be subjected to any air present in chamber 'Y'; chamber 'Y' being in direct communication with the locomotive brake cylinders. The upper end of the stem valve is located beneath the inlet valve which controls the passage of air from chamber 'Z' (supplied with air from the main reservoir pipe) into chamber 'Y'. The hollow stem valve is open to atmosphere at a point between the two diaphragms.



Straight Air Brake Relay Valve Fig.18.

Braking.

The desired braking pressure will be dictated by the straight air brake valve, pressure being transmitted from chamber 'B' of that valve to chamber 'X' of the relay valve. The control diaphragm will be forced upwards by air pressure in 'X' causing the upper open end of the stem valve to bear on the under side of the inlet valve, sealing 'Y' from atmosphere. Further movement will then lift the inlet valve off its seat to allow air to pass from 'Z' into 'Y' and thence to the brake cylinders.

As air pressure builds up in 'Y', and also in the brake cylinders, it will exert a downward force on the high pressure balancing diaphragm. When this downward force slightly exceeds the upward force of the control diaphragm the stem will move down allowing the inlet valve to seat, thus cutting off the flow of air from 'Z' to 'Y' and hence the brake cylinders. When brake cylinder pressure falls because of leakage, the downward force on the high pressure balancing diaphragm will also be reduced and the upward force of the control diaphragm will exceed the downward force of the balancing diaphragm; the stem valve will now rise to unseat the inlet valve and restore pressure in 'Y'.

Releasing.

Should the pressure dictated by the straight air brake valve be reduced, the upward force on the control diaphragm will be correspondingly reduced. The higher pressure existing above the high pressure balancing diaphragm will force the stem valve downwards causing the inlet valve to seat and the upper end of the stem valve to part from the underside of the inlet valve, allowing air in 'Y' and the brake cylinders to be released to atmosphere. When air pressure in 'Y' falls slightly below the new pressure in 'X', the stem valve will again rise to the underside of the inlet valve lifting it iff its seat to allow pressure in 'Y' to rise to the new pressure dictated by the brake valve.

If it is desired to release the brake completely, the brake handle is moved to the release position, air will then exhaust from chamber 'B' of the brake valve and chamber 'X' of the relay valve, thus removing the upward force on the control diaphragm. Pressure in 'Y' will force the high pressure balancing diaphragm and stem valve downward, the inlet valve will seat and the upper end of the stem valve will part from the underside of the inlet valve to allow air to escape to atmosphere from 'Y' and the brake cylinders.

Inshot Pressure.

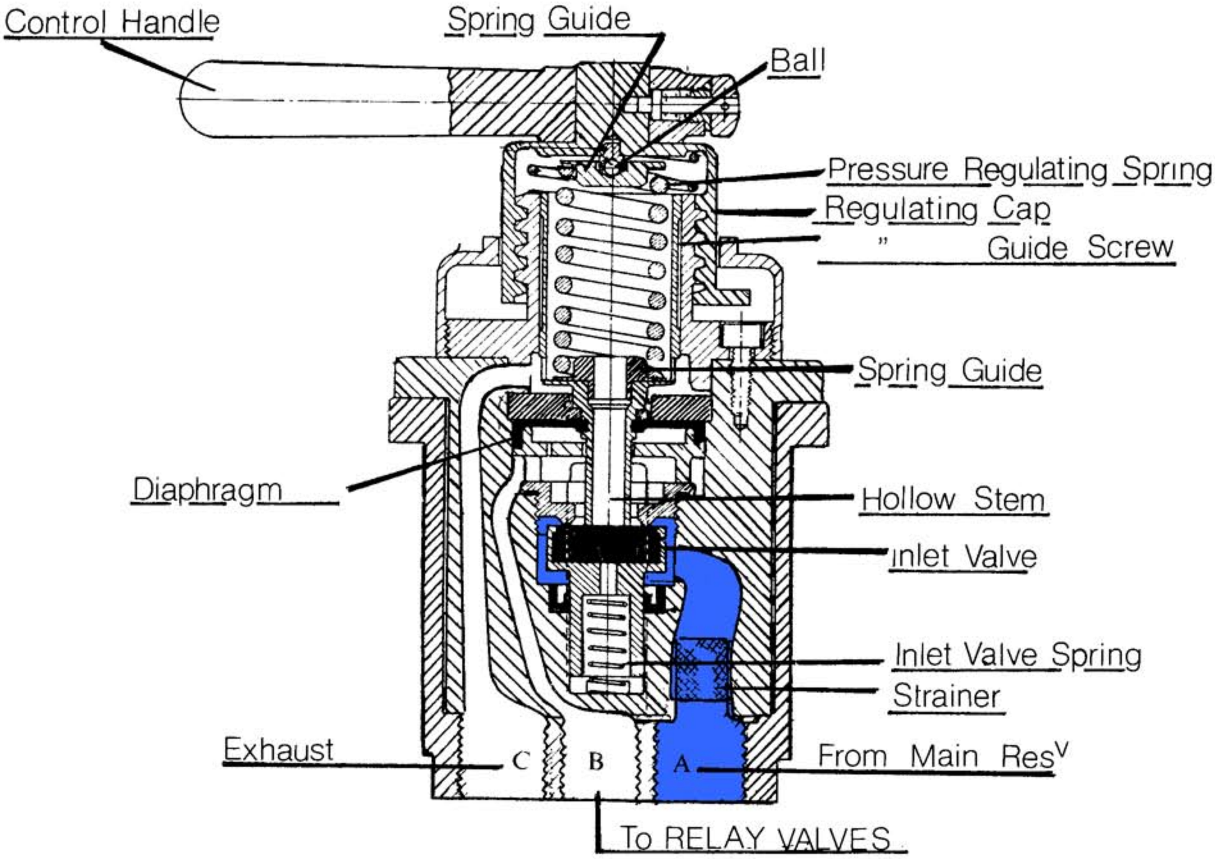
It can be seen that during the initial stages of brake application a relatively large volume is passed rapidly to the brake cylinders to ensure that the brake blocks quickly make light contact with the tyres before braking force is increased under the direct control of the driver. This ensures that the clearances in brake rigging, brake blocks and wheel tyres are quickly taken up. This feature is particularly important when brake piston travel is extended due to brake block wear, so ensuring smooth and accurate braking.

The relay valve is provided with an extremely simple inshot pressure system and consists essentially of a equalisation choke which, during the early stages of a brake application, delays the rise in pressure above the balancing diaphragm. This allows the stem valve to hold the inlet valve fully open to allow a large volume of air to flow into the brake cylinders. The choke is shown in the diagram.

The Straight Air Brake Valve.

The straight air brake valve supplies air brake pressure to the locomotive brake cylinders via two relay valves, one above each bogie.

Fig.19. Straight Air Brake Valve



The reason the straight air brake valve does NOT supply air directly to the brake cyliners is that the capacity of all the brake cylinders and the connecting piping is considerable and, if the air required to fill this system had to pass through the driver's air brake valve, there would be a considerable time lag before the desired brake cylinder pressure was reached.

To reduce this time lag the air brake valve supplies air through a connecting pipe, (the capacity of which is very low compared with that of the brake cylinders) to two much larger RELAY VALVES, situated over each bogie. When a brake application is made these valves relay air (at a pressure dictated by the position of the brake valve) direct from the main reservoir pipe to the brake cylinders.

The air brake valve has only to pass sufficient air to control the larger relay valves, which can rapidly fill the brake cylinders to the desired pressure. Similarly, a rapid release of air from the brake cylinders is obtained when the brake is released.

The Self-lapping Straight Air Brake Valve.

The control handle attached to a regulating cap which runs in a thread formed in the regulating screw drive, as shown in Figure 19 As the handle is moved in an arc from the release position towards the braking position, the thread will cause the regulating cap to move downwards; similarly as the handle is moved towards the release position the thread will cause the regulating cap to move upwards.

The regulating cap bears on the ball support of a control spring and will, according to the position of the brake valve handle, compress the spring, i.e. a downwards movement (caused by the brake handle being moved towards 'Braking') will increase the force of the spring and conversely, as the brake handle is moved towards 'Release' the shaft will move upwards to reduce the force in the spring.

The lower end of the control springs bears on to the upper end of a hollow stem valve which is attached to the diaphragm supporting plate, the lower end of the stem valve seats on the upper surface of the inlet valve, while the upper end is open to atmosphere.

In the body of the valve are three chambers, the lower one 'A' is fed from the main reservoir pipe, the centre one 'B' is fed from the relay valve, and 'C' is open to atmosphere.

Braking Position.

When the brake valve handle is moved towards the braking position the downwards movement of the regulating cap will impose on the control spring a compressive force proportional to the movement of the regulating cap. The lower end of the hollow stem valve will bear on the upper surface of the inlet valve thus sealing off 'B' from 'C'. At the same time the inlet valve is pushed off its seat to allow air from the main reservoir pipe to pass from'A' into 'B' and thence to the relay valve. As air pressure rises in 'B' it will exert an upward force on the diaphragm opposing the downward force of the control spring. When this upward force on the diaphragm slightly exceeds the downward force of the control spring, the diaphragm will rise and cause the inlet valve to seat and cut off the air supply to 'B'. When pressure falls in 'B' because of leakage, the upward force on the diaphragm will be reduced allowing the control spring to again push the inlet valve off its seat to restore pressure in 'B'.

Thus, for any position of the brake valve handle there will be a force imposed in the control spring and, therefore, air pressure in 'B' will be proportional to the spring force which will remain constant irrespective of leakage. This 'self-lapping' feature of the brake valve allows any braking pressure between zero and maximum to be obtained by setting the brake valve handle to the desired position.

Release Position.

Moving the brake valve handle to the release position causes the regulating cap to move upwards and so reduce the compressive force of the spring and thus the downward force of the diaphragm. Air pressure in 'B' will now lift the diaphragm and the inlet valve will close, cutting off 'A' and 'B'; but air pressure still exisitng in 'B' will lift the diaphragm further, causing the hollow stem valve to part from the upper surface of the inlet valve. Chamber 'B' will now be in communication with chamber 'C' via the hollow stem valve, allowing air in 'B' to escape to atmosphere.

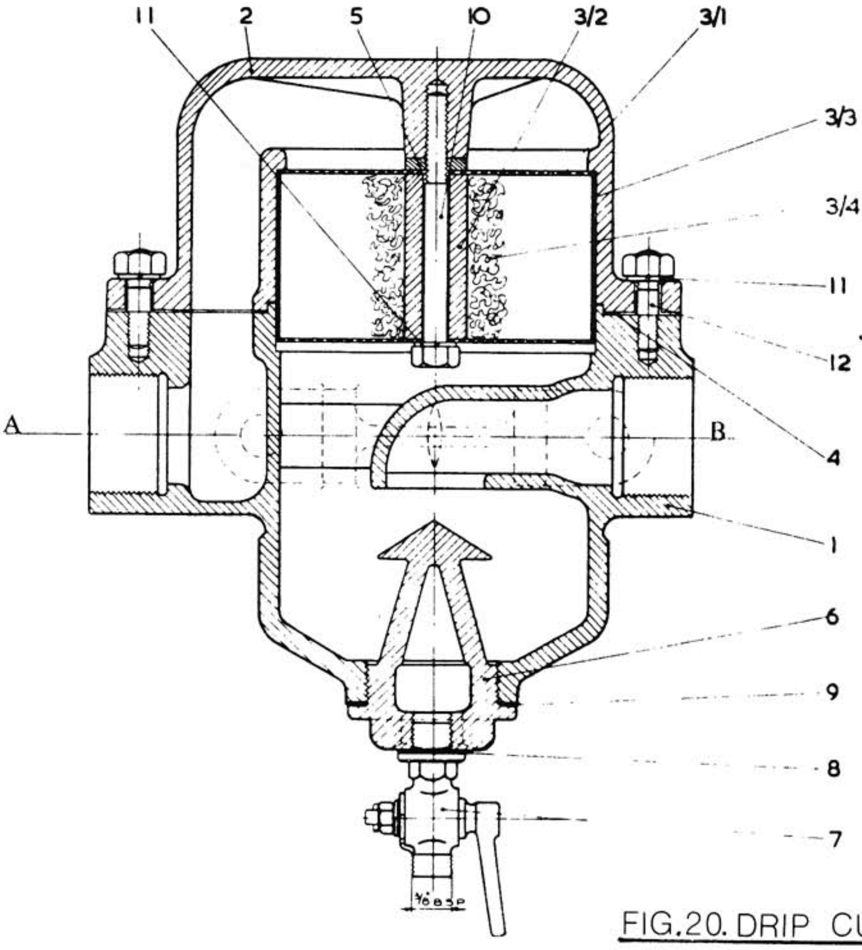
Should it be necessary to reduce, though not to completely release brake cylinder pressure, the brake handle is moved towards the release position thus reducing the force imposed by the control spring. This will cause the diaphragm to lift and the hollow stem valve to part from the inlet valve; air will escape from 'B' to atmosphere until pressure in 'B' falls slightly. The force now existing in the control spring will move the diaphragm and stem valve downwards until the lower end of the stem valve seats on to, and then opens, the inlet valve to restore pressure in 'B' to the new setting.

DRIP CUP

Collects condensate, oil and other foreign matter.

Air enters as port 'A' and baffle piece (6) deflects air towards the sides of the body, so that accumulated condensate and foreign matter in the lower part of the body and chamber formed on the baffle piece will not be disturbed by the air flow which rises via filter (3) to port 'B'.

The drain cock is provided to remove all accumulated condensate and foreign matter from the body.



List of parts.

Item No.	Description
1	Body
2	Cover
3	Strainer, Complete
3/1	Cover
3/2	Distance Piece
3/3	Outer Cover
3/4	Filter
4	Gasket
5	Nut
6	Screwed Baffle Piece
7	Drain Cock
8	Joint
9	Joint
10	Bolt
11	Spring Washer
12	Stud and Nut

FIG.20. DRIP CUP

RUBBER SEATED CHECK VALVE

Purpose

Used for retaining pressure in air reservoirs.

Air flows from Port A to B via valve 4, lifting off valve seat 2. Air cannot flow from Port B to A because valve 4 will close.

DOUBLE CHECK VALVE FIG

The function of the double check valve is to enable two alternative sources of air to be used to operate, for instance, one set of brake cylinders. There are two air inlets, A and B and one air outlet, C; the former are at either side of valve 5, which slides in the bush (6) and is further guided in the valve seat (3). The valve will slide under the influence of air pressure entering at either inlet.

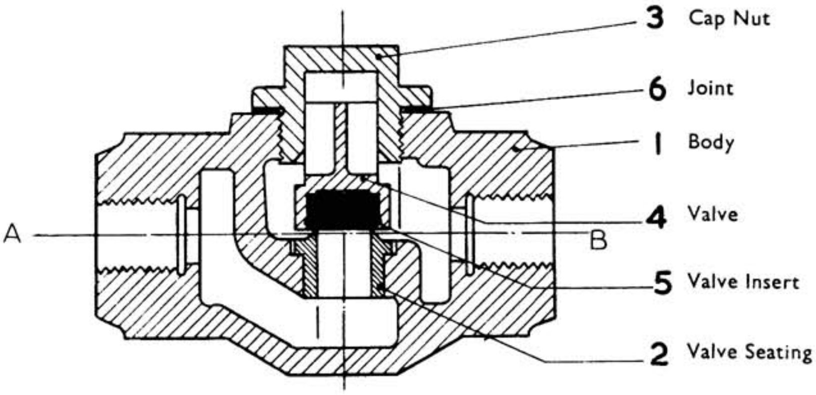
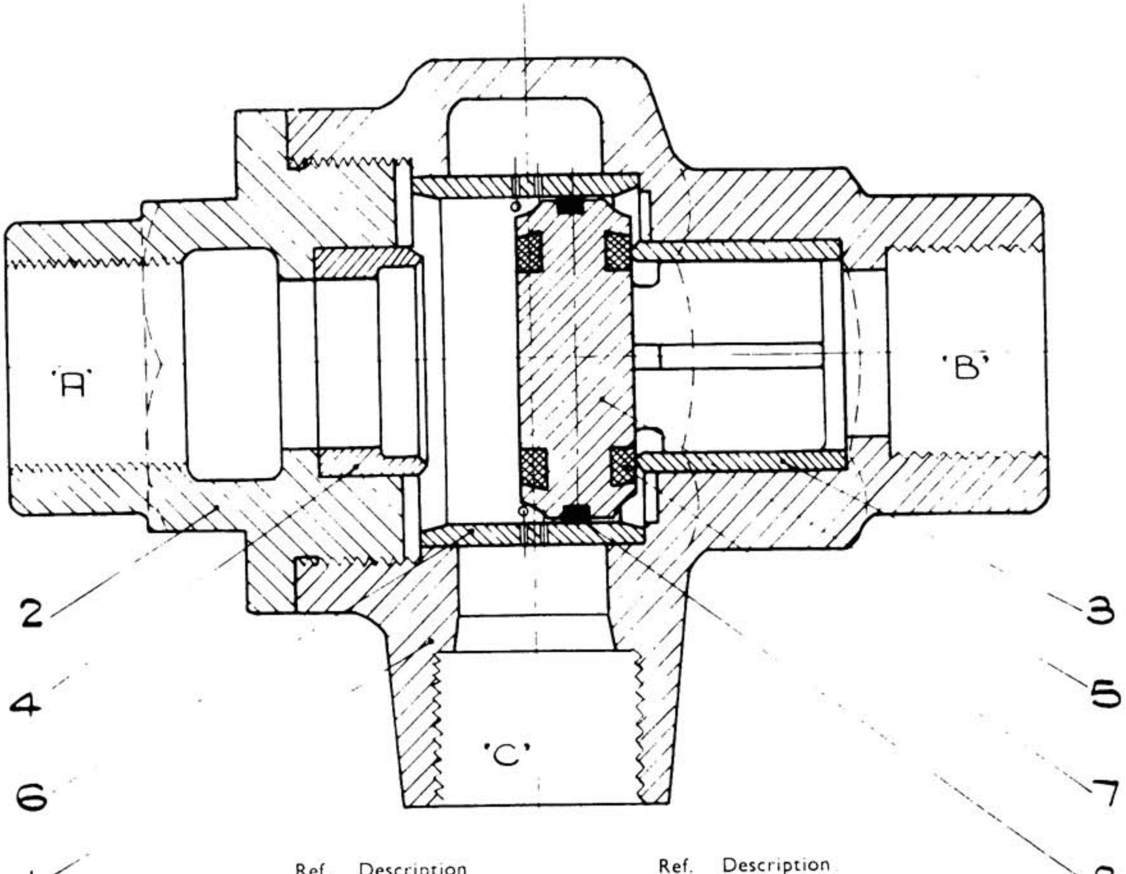


FIG. 21 RUBBER SEATED CHECK VALVE

If air enters at inlet connection 'A' the valve will travel to the right, due to differences in air pressure on either side of the valve head, until the rubber seat(7) is pressed against the seating formed on the end of the valve seat (3), when the outlet 'B' on the right hand side is completely isolated free from the air supply and outlet 'C'.

At the same time it will be seen that the valve head uncovers holes drilled in bush (6), which connect with a passage formed in the body of the valve leading to the outlet connection 'C'. Similarly air may also return through the outlet connection when required, e.g. to release air from the brake cylinders.



Ref.	Description	Ref.	Description
1	Body	5	Valve
2	Cap Nut	6	Bush
3	Valve Seat	7	Rubber Seat
4	Valve Seat	8	Piston Ring

FIG.22.DOUBLE CHECK VALVE.

DUPLEX CHECK VALVE

Used to protect an air reservoir or supply from loss of pressure below a specified limit.

Compressed air flow from inlet connection A flows through the strainer 1, and via passage 2 underneath, diaphragm B acting upwards against the downward pressure of pre-set spring 8. It also flows via passage 5 under spring loaded valve 6 and helps to keep valve 6 closed.

The pre-set pressure of spring 8 can be adjusted by adjusting screw 9.

When the air pressure acting on the underside of diaphragm B is greater than the downward pressure of spring 8, valve 3 will open and allow air to flow from chamber 2 to passage 4 via strainer 7 to outlet connection C. This will continue as long as the upward pressure remains greater than the downward spring force. Should for any reason the inlet pressure be reduced less than the spring 8 pressure, valve 3 will close isolating the inlet connection A from the outlet connection C.

Non-return valve 6 allows a flow back of air through the duplex check valve from connection C to connection A. Thus the duplex check valve is a two-way valve. This would only happen if the air supply at connection A was reduced or cut off for any reason.

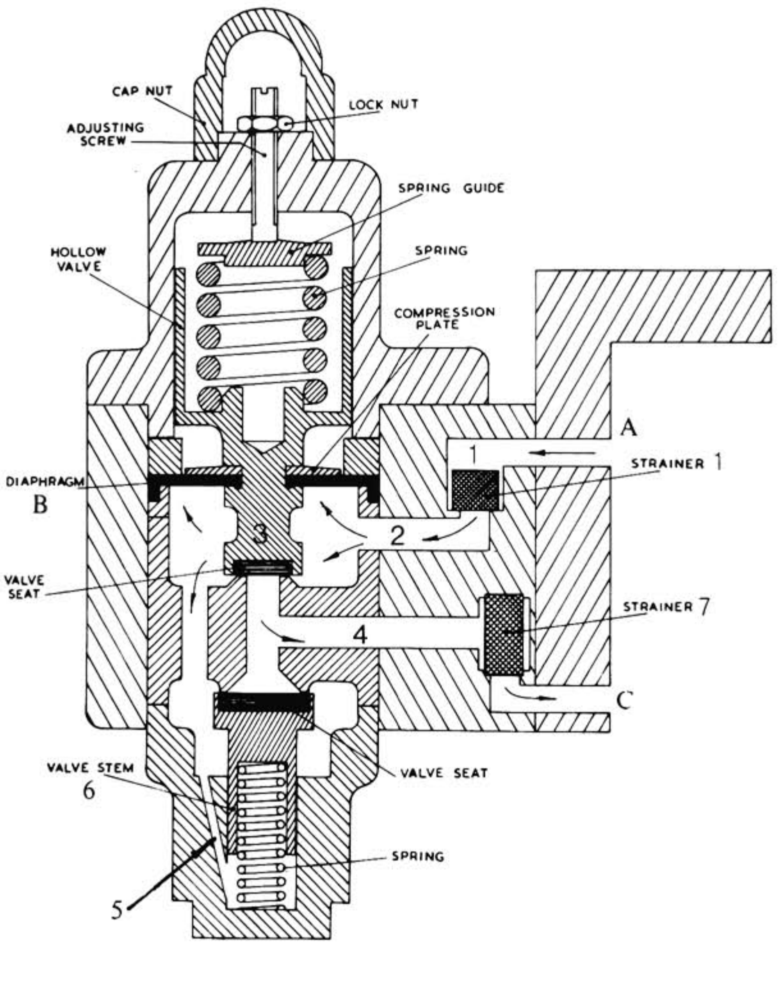


FIG. 23. DUPLEX CHECK VALVE

POSITION OF BRAKE EQUIPMENT

EQUIPMENT ROOM

ITEM	POSITION
Compressors (2).	L.H. side of equipment room facing engine room.
Main Reservoirs.	Under compressors, one behind cab bulkhead, two being triple pump and serck tank.
Check Valves (for compressors).	One on bodyside by safety valve, one under drip cup.
Pre-start compressor governor.	Behind compressors. Only Locomotives with air operated starting contactors.
Drip cups (2) for Main Reservoir supply.	Engine room end adjacent No. 2 compressor.
Duplex Check Valve.	Behind drip cup. Only locomotives with air operated starting contactors.
Safety Valve (150 p.s.i.)	Behind frame holding brake valves.
Feed cut-off valve (D.S.D. brake valve isolator).	On frame at side of door leading to engine room.
Pressure control valve (100 p.s.i.)	- ditto -
Auto Air Brake Relay Valve (No. 1 end).	- ditto -
Straight Air Brake Relay Valve (No. 1 end).	- ditto -
Manual push button for overcharge release of Air/Vacuum Relay Valve.	Above Air/Vacuum Relay Valve.
Compressor Governor.	Under Air/Vacuum Relay Valve.
Control Circuit Governor.	- ditto -
Auto Air Brake Pipe Governor.	- ditto -
Vacuum Control Governor.	- ditto -
Equipment Governor (E.T.H.)	L.H. side of Air/Vacuum Relay Valve.
Drip Cup (main reservoir pipe).	Above Triple pump and in front of Governors.
Feed cut-off valve isolating cock.	Behind frame.
D.S.D. Valve (T.M.V.7).	Behind No. 1 cab bulkhead.
A.W.S. Brake Valve isolator (No. 1 end).	- ditto -

D.S.D. and A.W.S. Exhaust Valves.	- ditto -
D.S.D. isolating cock.	- ditto -
Braked/Unbraked E.P. Valve	Above No. 1 Traction Motor Blower.
Antislip E.P. Valve.	- ditto -
Passenger/Goods Changeover Valve.	Above No. 1 Exhausters.
D.S.D. E.P. Valve.	- ditto -
2 Chamber Reservoir.	Under No. 1 Traction Motor Blower.
Triple Valve.	Above No. 1 Traction Motor Blower.
Vacuum Operated Isolating Valve.	- ditto -
Auxiliary Reservoir.	Above No. 1 Fuel Tank.
Exhauster Choke Valve.	Above No. 2 Exhauster.
Vacuum Relief Valve.	- ditto -
Exhauster Filters.	- ditto -
Air Quick Release Valve.	- ditto -
Air/Vacuum Relay Valve.	Above end of Triple Pump.
Air/Vacuum Relay Valve Isolating Cock.	On 2" pipe above Triple Pump.

ENGINE ROOM

Automatic Drain Valve.	Adjacent Battery Isolating Switch.
Control Air Pressure Gauge.	Above door leading to Boiler Room.
Straight Air Brake Double Check Valve.	Adjacent to Engine same side as B.I.S.
Brake Selector Switch and Changeover Switch.	On Bodyside near B.I.S.

BOILER ROOM

2 Chamber Reservoir (No. 2 End).	On bulkhead above door leading to No.2 cab.
Control Air Reservoir.	- ditto -
Combined Reducing Valve and Check Valve.	On bulkhead at side of door leading to No. 2 cab.
Control Air Isolating Cock.	On bulkhead at side of door leading to No. 2 cab.

Feed Cut-off Valve.	On Frame above No. 2 Traction Motor Blower.
Auto Air Brake Relay Valve (No. 2 End).	- ditto -
A.W.S. Brake Valve Isolator.	- ditto -
Straight Air Brake Relay Valve (No. 2 End).	- ditto -
Feed Cut-off Valve Isolating Cock.	- ditto -
Auxiliary Reservoir.	Near roof.

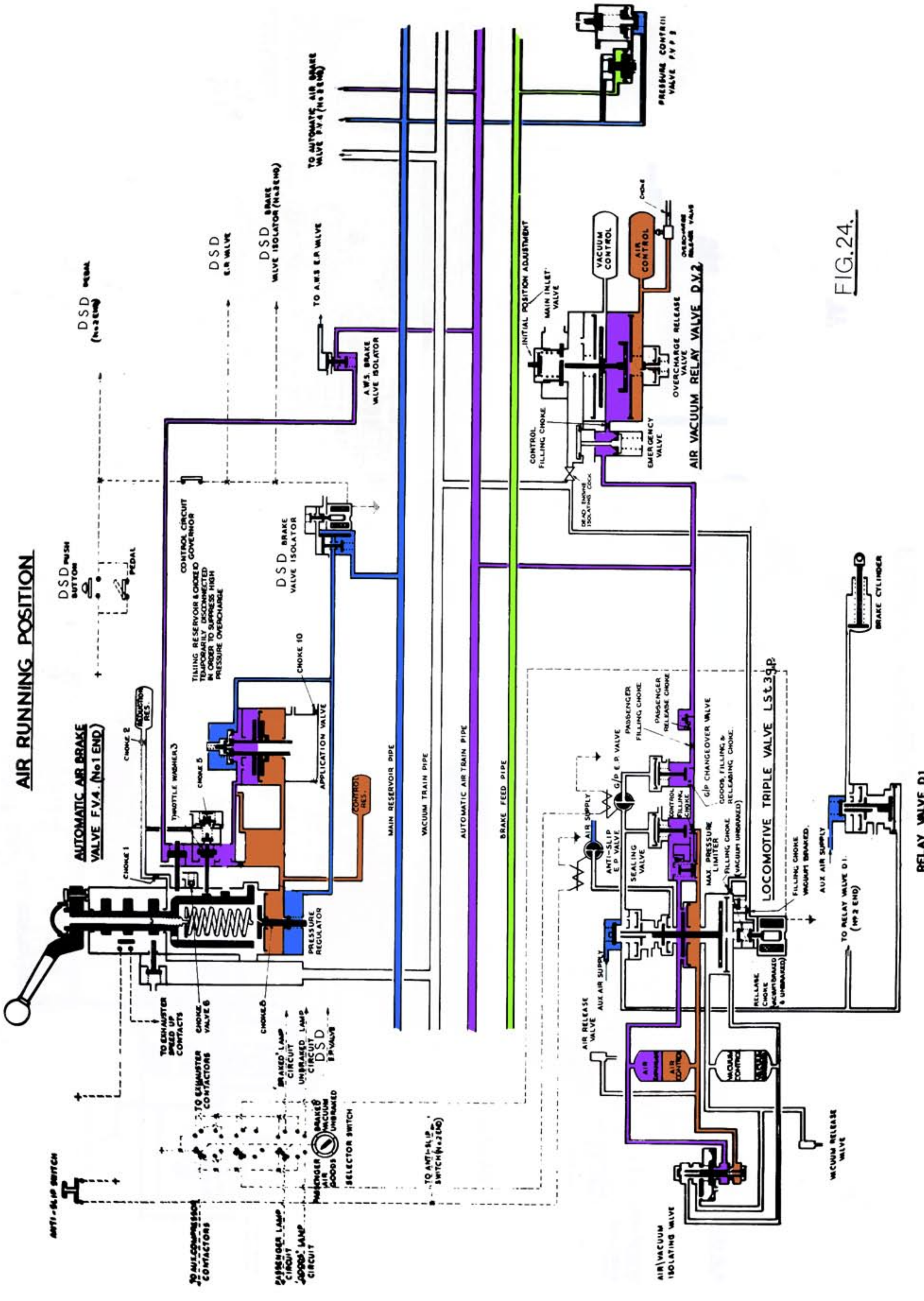

AIR RUNNING POSITION
AUTOMATIC AIR BRAKE VALVE F.V.4. (No 1 END)
MAIN RESERVOIR PIPE
VACUUM TRAIN PIPE
AUTOMATIC AIR TRAIN PIPE
BRAKE FEED PIPE
AIR VACUUM RELAY VALVE D.V.2
LOCOMOTIVE TRIPLE VALVE L.St.3P
RELAY VALVE D1 (No 1 END)
PRESSURE REGULATOR
APPLICATION VALVE
BRAKE CYLINDER
SELECTOR SWITCH
ANTI-SLIP SWITCH
VACUUM RELEASE VALVE
AIR/VACUUM ISOLATING VALVE

FIG.24.

AIR BRAKING POSITION

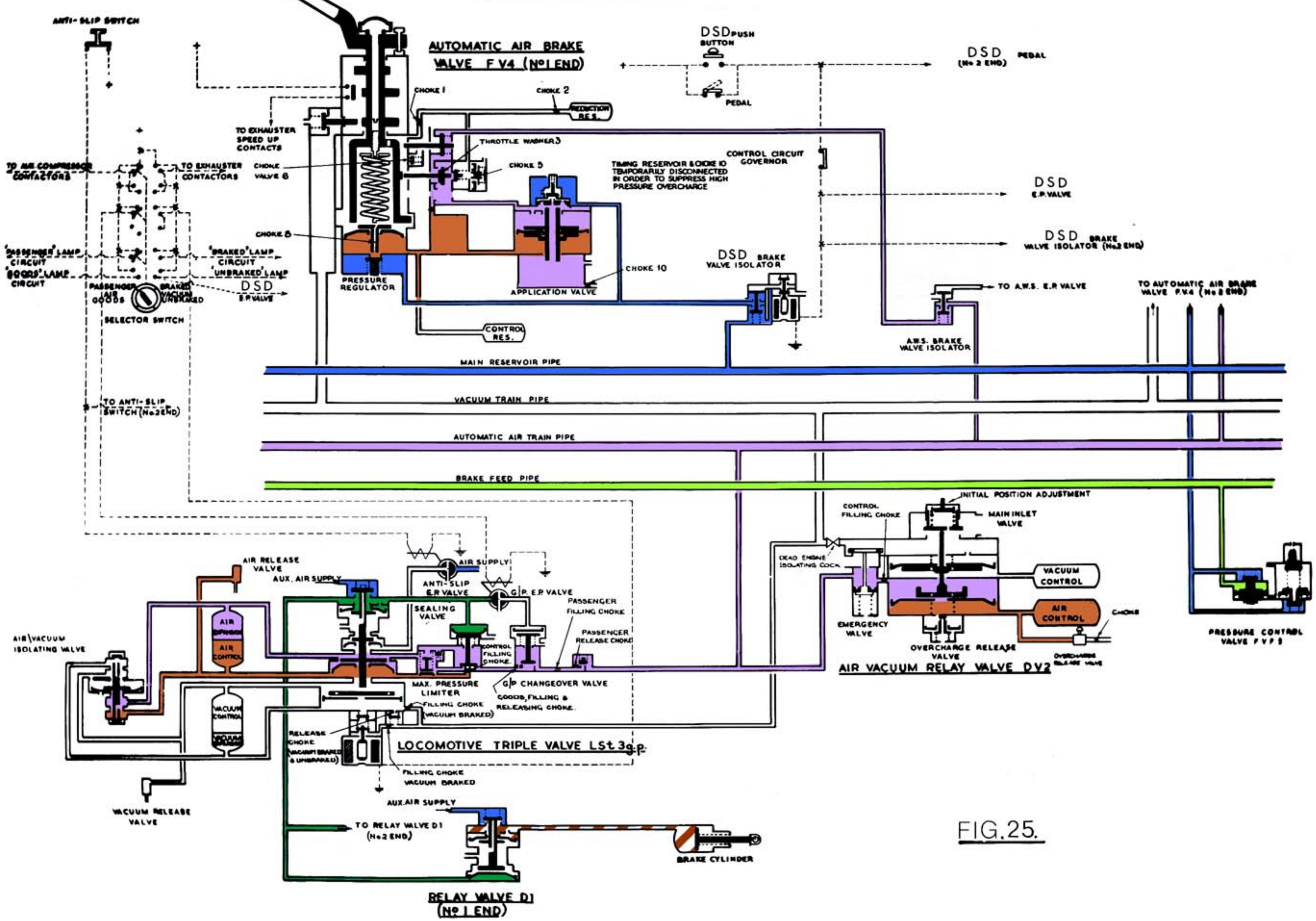


FIG.25.

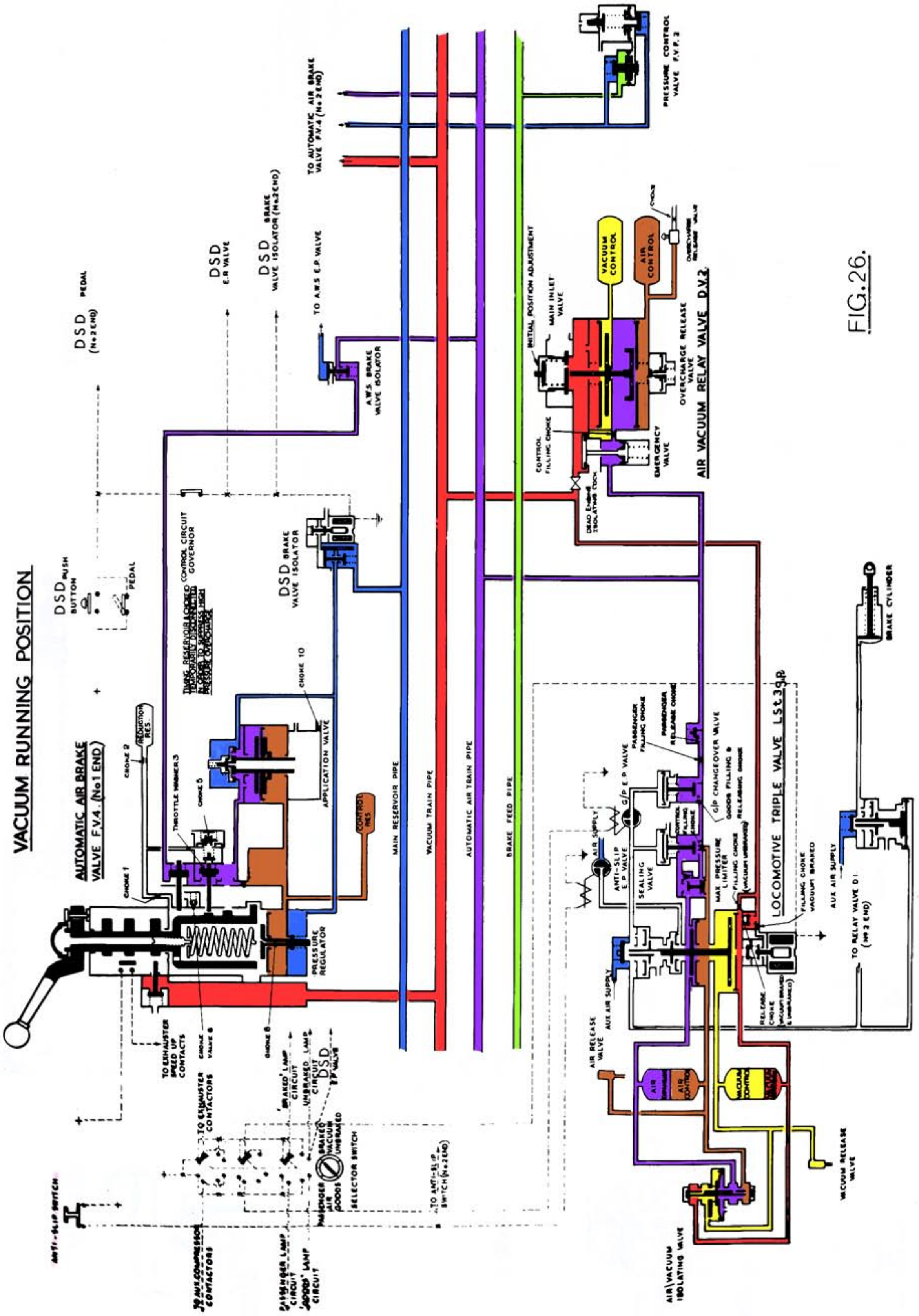
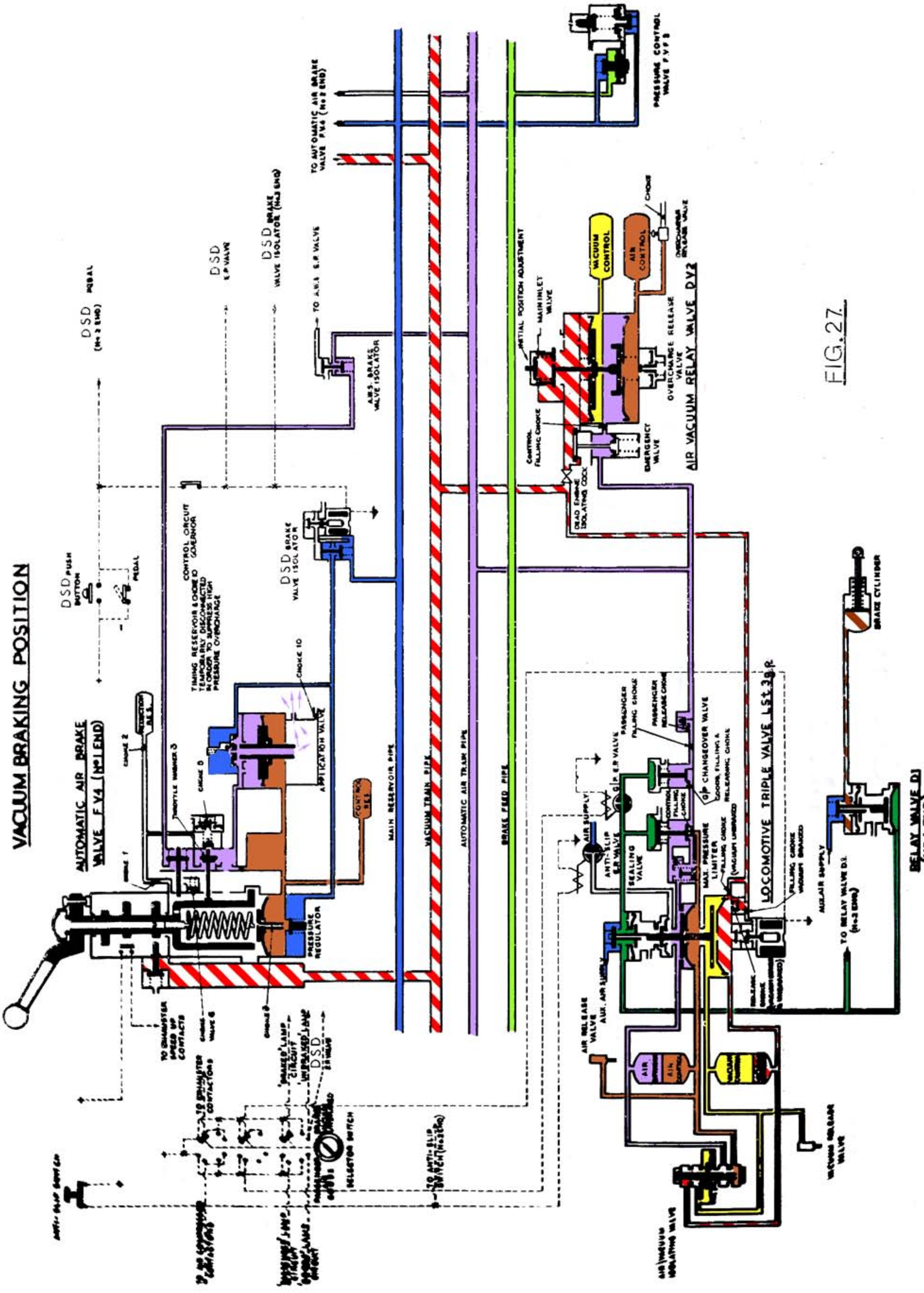

VACUUM RUNNING POSITION
AUTOMATIC AIR BRAKE VALVE F.V.4. (No 1 END)
MAIN RESERVOIR PIPE
VACUUM TRAIN PIPE
AUTOMATIC AIR TRAIN PIPE
BRAKE FEED PIPE
APPLICATION VALVE
PRESSURE REGULATOR
CONTROL RES
DSD BRAKE VALVE ISOLATOR
A.W.S. BRAKE VALVE ISOLATOR
TO AUTOMATIC AIR BRAKE VALVE F.V.4 (No 2 END)
PRESSURE CONTROL VALVE F.V.P.2
AIR VACUUM RELAY VALVE D.V.2
VACUUM CONTROL
AIR CONTROL
EMERGENCY VALVE
OVERCHARGE RELEASE VALVE
LOCOMOTIVE TRIPLE VALVE L.S.t.3.p.
BRAKE CYLINDER
RELAY VALVE D1 (No 1 END)
SELECTOR SWITCH
AIR/VACUUM ISOLATING VALVE
VACUUM RELEASE VALVE
AIR RELEASE VALVE
ANTI-SLIP SWITCH

FIG. 26.


VACUUM BRAKING POSITION
AUTOMATIC AIR BRAKE VALVE FV4 (No 1 END)
DSD PUSH BUTTON
DSD PEDAL
DSD BRAKE VALVE ISOLATOR
DSD E.P. VALVE
TO A.B.S. E.P. VALVE
A.B.S. BRAKE VALVE ISOLATOR
TO AUTOMATIC AIR BRAKE VALVE FV4 (No 2 END)
PRESSURE CONTROL VALVE P.V.P.8
CONTROL CIRCUIT GOVERNOR
TIMING RESERVOIR & CHOKE 10 TEMPORARILY DISCONNECTED IN ORDER TO SUPPRESS HIGH PRESSURE OVERCHARGE
CHOKE 10
APPLICATION VALVE
PRESSURE REGULATOR
MAIN RESERVOIR PIPE
VACUUM TRAIN PIPE
AUTOMATIC AIR TRAIN PIPE
BRAKE FEED PIPE
VACUUM CONTROL
AIR CONTROL
MAIN INLET VALVE
INITIAL POSITION ADJUSTMENT
OVERCHARGE RELEASE VALVE
EMERGENCY VALVE
CONTROL FILLING CHOKE
DEAD ENGINE ISOLATING COCK
AIR VACUUM RELAY VALVE DV2
BRAKE CYLINDER
RELAY VALVE D1 (No 1 END)
LOCOMOTIVE TRIPLE VALVE L5t 38 R
G/P CHANGEOVER VALVE
MAX. PRESSURE LIMITER
SEALING VALVE
ANTI-SLIP E.P. VALVE
AIR SUPPLY
AUX. AIR SUPPLY
AIR RELEASE VALVE
VACUUM RELEASE VALVE
AIR/VACUUM ISOLATING VALVE
SELECTOR SWITCH
TO ANTI-SLIP SWITCH (No 2 END)
TO RELAY VALVE D1 (No 2 END)
ANTI-SLIP SWITCH
FIG. 27.