Supervisors Training Centre,
South Central Railway

ISM - 06

DIESEL THEORY (MDT – 03)

September 2020

INDEX

1.Power pack

Power pack components

- **Engine Base**
- **Engine Block**
- **Crank Shaft**
- **Camshaft**
- **Liner**
- **Piston & Piston Ring**
- **Connecting Rod**
-
- **Cylinder Head & Valves**

Engine base:

When diesel engines were of low speed and low horsepower the engine base and blocks were made of heavy cast iron casting. In older types engines one of the main functions of the base was to take the crank shaft. In the modern engines the crank shaft is underhung from the engine block.

The engine base of ALCO Locos WDM2, WDM4 are made from weldable quality steel to specification IS-2062 with 0.2% of carbon.

The engine bases of ALCO Locos have following functions.

It has to -

a) Support the engine block

b) Serve as oil sump

c) Accommodate lube oil main header

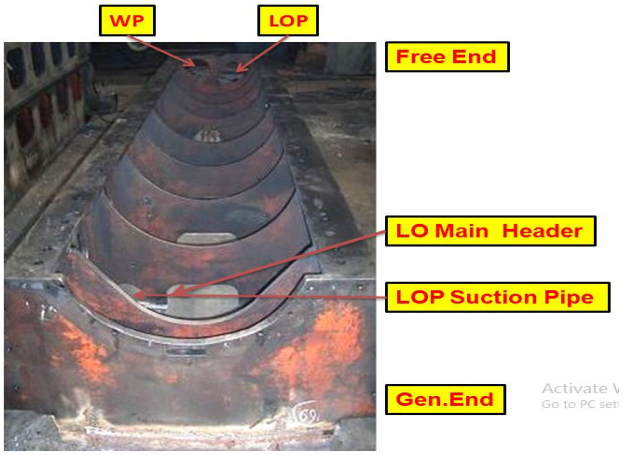
d) Take lube oil pump and water pump at the free end

e) Allow openings for crank case inspection

f) Take fitment of crank case explosion cover

g) Foundation pads are provided for transmitting load to the chassis and als to take lower blots of the main generator magnet frame.

A perforated screen is fitted to the base to prevent foreign matter like pieces of metal etc. getting access to the sump. The top face of the base which takes the engine block is machined smooth and a sealing compound is applied before fitting the block to make the crank case air tight so that crank case vacuum can be maintained.

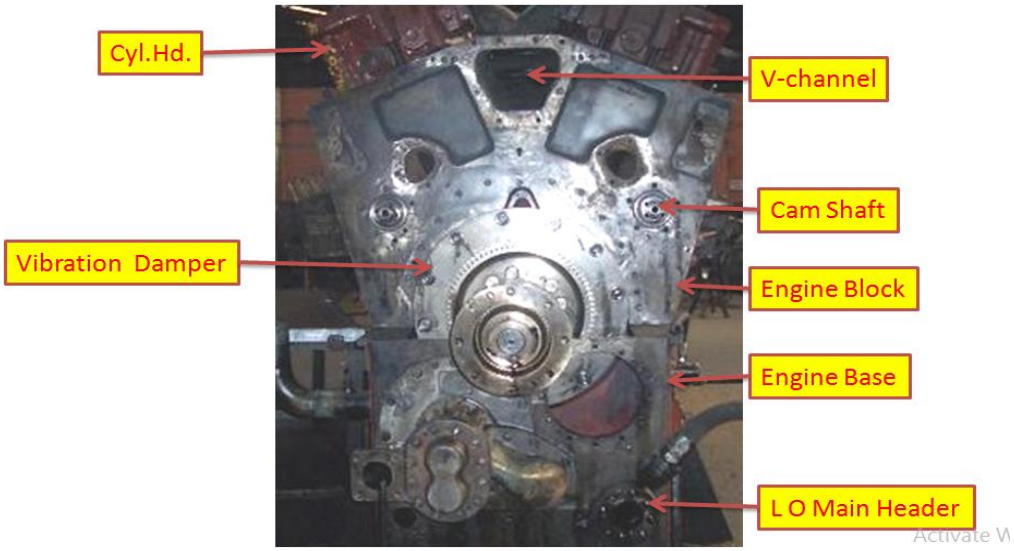


Engine base

Engine block

The engine block is the most important and very highly stressed structure on which are fitted a number of important fittings like crank shaft, cam shaft, cylinder heads**,** cylinder liners, pistons**, c**onnecting rods, fuel injection pumps and cross-head, turbo support, governor etc to form a complete Power pack.

This structure is fabricated from low carbon steel to specification IS-2062. The saddle, however, is a forging out of steel to specification IS-1875.



Engine Base & Block

Crank shaft

It is the medium of transforming reciprocating motion to rotary motion.

The ALCO crankshafts are manufactured from chrome-molybdenum steel equivalent to SAE 4140. The process of forging is such that continuous grain is maintained.

The standard Locomotives of Indian Railways are with single-piece crankshaft with welded counter weights.

Output of the engine is collected from crankshaft (T/Gen mounted on it converts Mechanical energy into electrical energy).

It gives mechanical drive to Camshaft, Expressor, Radiator Fan and other allied components like water pump, lube oil pump, Tr. Motor Blowers etc.

Counter weights are provided for dynamic balancing of the crankshaft; they are welded.

The portions of crank shaft which form the axis of rotation are called main journals where it is housed in the engine block through main bearings

The eccentric portions where piston is connected through connecting rod are called crankpins

Crankshaft of WDM2 type engine has 9 main journals and 8 crankpins to accommodate 16 pistons in a V shaped engine.

It is only removed for maintenance in POH Schedule.

Crank shaft gear

- Mounted at Power- take-off end and meshes with Camshaft Gear.
- Made in 2 halves, accurately fitted and keyed to the crankshaft.
- Gear is held in place by 4 bolts and has locating dowel to position the halve as they are assembled.
- Gear is 4 pitch straight Spur type.

Note:i) Spilt Gear is statically balanced and halves are not interchangeable

ii) Replacement must be in matched pairs.

ii) Metal to Metal joint formed by both halve of gear to be checked using Feeler Gauge.

iv) It should not be possible to insert Feeler gauge more than 1/4".

Crank shaft split gear

Crank web deflection*:* Checking of crank web deflection is one of the major works while assembling engine.

Main generator is coupled at one end of the crankshaft, whose other end is supported on a bearing housed at the magnet frame. As such, due to mislocation of magnet frame, if axis of armature does not completely align with the axis of the crankshaft, the unbalanced mass of armature will cause uneven loading on crank web at different angular positions during rotation. This causes deflection on crank web, which will be changing at various positions of crankshaft during rotation. Such kind of continuous cyclic variation of load leads to main bearing seizure and breakage of crankshaft.

Correction is made by adding or subtracting shims at the mountings of magnet frame with engine block. The magnet frame is mounted at two locations with the engine block and at two locations at the base. Adjustable shims are provided at the mountings of the magnet frame with the block.

Cam shaft

In diesel engine the cam shaft performs the vital role of opening and closing inlet and exhaust valves and allowing timely injection of fuel inside the cylinder. Usual practice is to provide 3 cams for each cylinder the two outer cams being for exhaust and inlet valves and the central cam being for fuel injection. Like most of the Diesel engine manufacturers, ALCO engines have cams integral with camshaft. Each camshaft section takes care of two cylinders.

The rifle hole is made in the center of the shaft for lubrication of cam bearings. Lubrication to

cam lobes is provided by oil coming from valve lever mechanism via the push rod.

- Opening and closing of Inlet & Exhaust valves and to operate FIP timely.
- Providing speed information to Governor
- Driving OST for tripping & engine shutdown in case of high speed
- 3 Cams are provided for each Cylinder.
- Lubrication delivered to bearings through an internal drilled hole .
- Rollers for Fuel pump cross head lifters and Valve push rod lifters ride on cams,
- Cam lobes and rollers are lubricated through gravity fed oil dropping from cylinder head through push rod holes.
- Lateral movement of Camshaft restricted by Thrust bearing, located at free.

  Camshaft Thrust : 0.006” - 0.012”(New), 0.022” (Limit)

Backlash : 0.006” - 0.010”

- Camshaft Bearings (Bi Metal):
  - Examine for pitting, shelling and wear.
  - ID : 4.511”(limit)
  - Running Dimensional checks:

2. SUPER CHARGING

REQUIREMENT OF AIR SUPER CHARGING SYSTEM

Diesel engine Uses chemical energy to generate Heat energy. This heat energy will be later converted into Mechanical energy. To produce the heat energy, fuel is burned inside the combustion chamber. For efficient burning more oxygen is required. For supplying more fuel, SUPER CHARGING is required. In this process air is introduced into the engine cylinder at a density more than ambient. This will produce more power than a naturally aspirated engine for the same bore and stroke dimension. Super charging causes better scavenging also.

ADVANTAGES OF SUPER CHARGING

- Better cooling of components.
- Saves them from failure due to thermal stresses.
- Enhances the service life.
- Better fuel efficiency.
- Power to weight ratio is much more.

METHODS OF SUPERCHARGING

- **Separately driven air compressor:**

  This type of supercharging used on four wheel drive military vehicles. This method provides high SFC.

- **Blowers driven by exhaust gas.**

  Here turbocharger uses the energy of waste Exhaust gas. This is a very efficient & economical method. Blowers run by the exhaust gas driven turbine.

AIR BRAKE SYSTEM

INTRODUCTION

IRAB – 1 brake system is a complete air brake version, in which only compressor unit is used instead of Expresser for creating air pressure in the brake system and all the brake valves are panel mounted.

SALIENT FEATURES OF IRAB – 1 SYSTEM

1. Locomotives Brakes can be applied and released through independent brake valve SA9, independently.

2. Formation brakes can be applied & released through Automatic brake valve A9.

3. Locomotive brakes are applied automatically when formation brakes are applied.

4. It is suitable for MU operation also, with which the brakes of trailing units are controlled from leading unit.

5. Brakes in the rear loco are synchronized with lead loco brakes.

6. Emergency brake application is available to have minimum possible braking distance, from any control stand and any loco.

7. Safety devices are incorporated to bring the engine to idle in case of emergency brake application and train parting.

8. In case of train parting between the locos, both the locos will have automatic brake application.

9. Automatic brake and Dynamic brakes are inter locked. So that, Auto Brake will be released automatically when the DB is applied.

10. The system can work either with single pipe / dual pipe.

AIR BRAKE SYSTEM VALVES

SL. NO	DESCRIPTION	PURPOSE
1.	A9. Automatic Valve	Brake application for Loco as well as formations.
2.	SA 9 Independent Brake Valve	Brake Application for Loco alone
3.	MU – 2B	M.U. Operation, used as gate valve
4.	F 1 – Selector	M.U. Operation, used as gate valve
5.	$C_{2.}$ W. or Additional $C_{2.}$ Valve	Feeding B. P. Pressure to the formation
6.	24 A. Double Check Valve	This will allow only one operation at a time.
7.	$C_{3.}$ W. Distributor Valve	Proportionate Brake valve application during A9. application.
8.	$C_{2.}$ Relay Valve	For Locomotive Brake.
9.	Pressure Switch	Loco will be brought to idle during A9 emergency application.
10.	D1. Emergency Valve	For Emergency brake application.
11.	D1. Pilot air valve	During Dynamic brake Loco brake will be released.

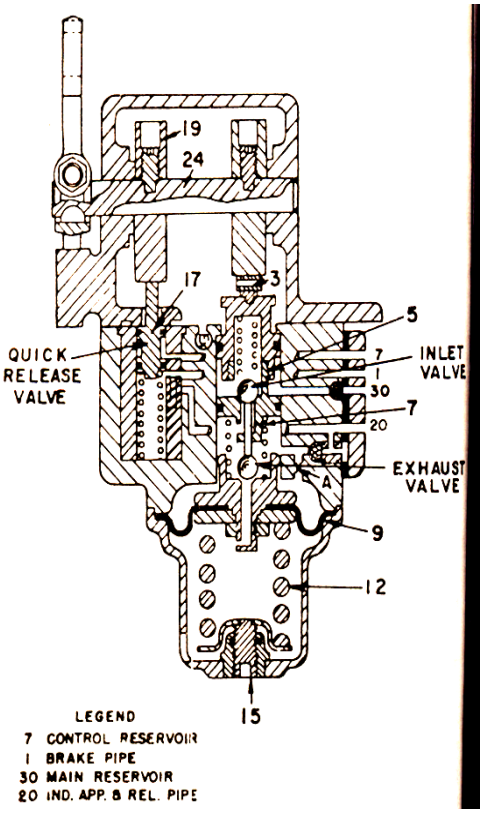
12.	Pressure Limiting Valve	Pilot air to C_2 Relay valve for synchronized brake application is Limited to 2.5 kg / Cm^2
13.	M. R. Safety Valve	When M. R. Pressure goes beyond 10.5 kg / Cm^2 This valve will operate and release excess pressure from MR.
14.	Duplex Check Valve Set at 6 kg / Cm^2	This valve will connect MR1 with feed valve when MR pressure exceeds 6 kg / Cm^2
15.	D 24 – Feed Valve	For Feed pipe Pr: 6 kg / Cm^2.

IMPORTANT VALVES PROVIDED IN IRAB – 1 SYSTEM.

SA 9 INDEPENDENT BRAKE VALVE:

It is a variable pressure-reducing valve, sends pilot air to C2 relay valve to charge brake cylinder for application and release of loco brake independently. The outlet pressure can be varied from 0 to max (3.0 Kg / Cm2) by moving its handle. Its handle has three distinct positions.

1. Application
2. Release
3. Quick release – In IRAB, this position is not active.

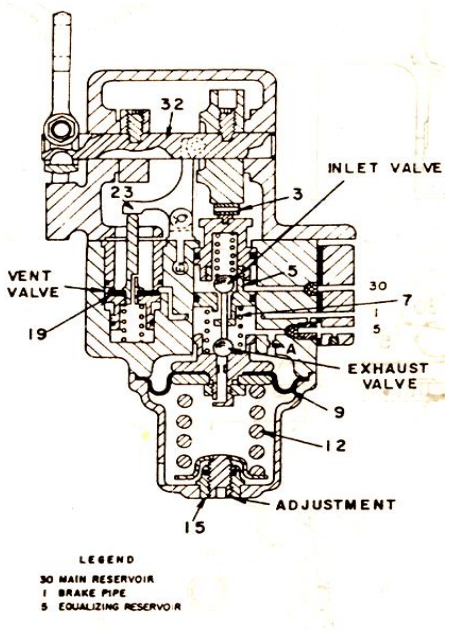


SA9 INDEPENDENT BRAKE

The output pressure is zero at release position and the pressure is max (3.0 Kg / Cm2) at application position. The handle can be placed at any position between release and application to have desired out let pressure(i.e., brake cylinder pressure)

A9 – AUTOMATIC BRAKE VALVE

The valve is also a variable pressure-reducing valve. Its duty is to send pilot air for charging/ exhausting B.P. pressure through C2W relay valve for releasing and application of loco and formation brake. In release condition it charges BP up to 5.0 Kg/cm^2(max). The BP pressure can be varied by moving its handle.

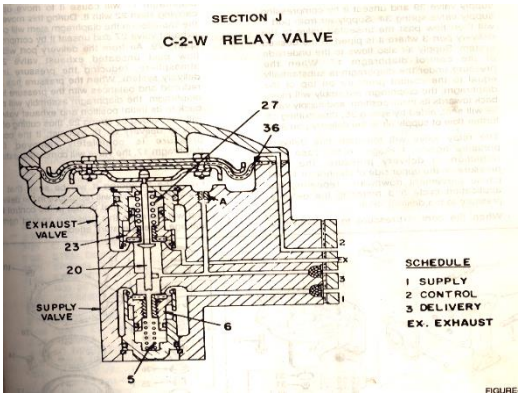


The handle has 5 distinct positions.

1. Release (BP= 5 Kg/cm^2)
2. Minimum release (BP = 4.5 to 4.3 Kg/cm^2, BC = 0.5 to 0.7 Kg/cm^2)
3. Full service (BP = 3.2 to 3 Kg/cm^2, BC = 2.5 Kg/cm^2)
4. Over reduction (BP = 2.5 Kg/cm^2, BC = 2.5 Kg/cm^2)
5. Emergency (BP = 0 Kg/cm^2, BC = 2.5 Kg/cm^2)

The outlet pressure (Brake pipe) is maximum i.e. 5Kg/ cm^2 when the handle is at release position. The pressure will reduce when the handle is moved to application zone. The BP pressure will correspond to the position of the handle between Min and Full service and will be zero at emergency.

C_2 RELAY VALVE



It is a high capacity relay air valve.

It gets pilot air from SA9/ A9 and supply MR air to the brake cylinders at a pressure equal to the pilot air pressure at a higher rate. Thereby it applies and releases the brake.

C_2 W – Relay VALVE: It is similar to C_2 relay valve with some additional features. It is connected to the BP charging/ exhausting system. It gets pilot air from A9 brake valve and it charges/ exhausts BP accordingly. As compared to C2 relay valve it is having an additional diaphragm and pusher pin above the main diaphragm. If air is charged above this diaphragm, it pushes the main diaphragm and increases the pressure setting for the main diaphragm with the same pilot air from A9. This increment is limited by another arrangement so that the outlet pressure cannot build up more than 5.4 Kg/Cm^2. This function is called as overcharging function. It helps to release the brake binding in any of the variable from the locomotive cab.

C_3W- Distributor VALVE

It is an automatic brake application valve. It is used for conjunction brake application in the locomotive in proportion to the formation brake. It is having two air chambers. Control

reservoir (CR) and Brake Pipe (BP). If BP ≥ CR, Brake is released, i.e. BC = 0 and when BP < CR brakes are applied. The difference between CR and BP pressure will decide the amount of BC pressure. As BP is common in the train and locomotive hence according to the BP drop page the brake application and release will be synchronized in the formation and locomotive.

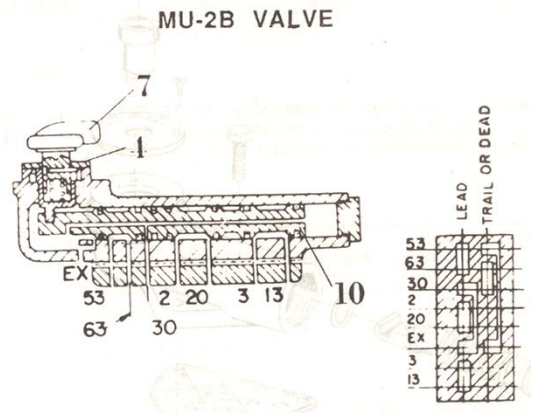
MU – 2B: -

It is manually operated change over valve. It makes the system to be controlled from the same unit or the leading unit. It also isolates the drivers control for application and release of brakes in trailing loco.

The knob of this valve has 2 positions.

1. Lead
2. Trail or Dead.

There are many ports in this valve and their connections are changed as under:



Lead	2,20	3,13	63,53	60 – Exhaust
Trail or Dead	--	--	63 - 30	53 – Exhaust

F1 – SELECTOR: -

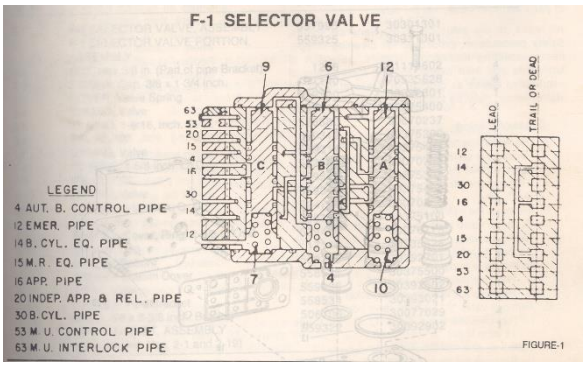
This valve is also a change over valve.

It has 2 positions:

1. Lead
2. Trail or dead.

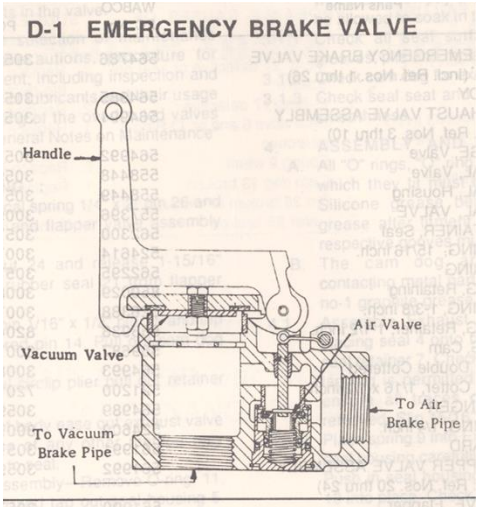
The position is changed automatically according to the position of MU2B valve. Port 30 from MU2B is piped to this valve. When there is no pressure in this port F1 selector will assume, lead position. If air pressure is supplied from the port, F1 selector will assume Trail or dead position.

This valve also has many ports and the connections are given below.



Lead	4-16	30 – 14
Trail or dead	14-16-20	

In co-ordination with MU2B, this valve makes the system to operate as a lead unit or trail unit.



D1 – EMERGENCY VALVE:-

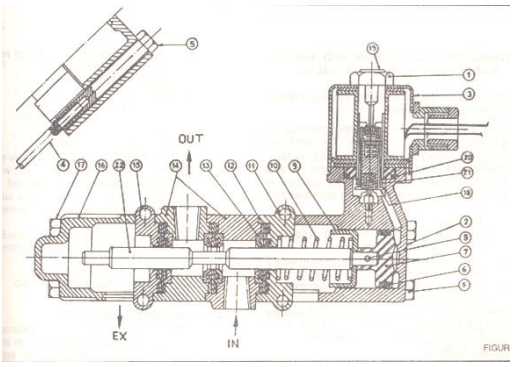
This valve is a flap valve with suitable lever. It is connected directly with the Brake pipe. If this valve is opened, BP drops to Zero at the faster rate and thus brake application is made very fast with maximum braking effort and minimum braking distance.

1. In case of emergency, when the assistant driver notices any obstruction / defect in track which the driver could not notice, the assistant driver can operate independently.

2. When the normal application of brakes is not possible or not affected, the driver or assistant driver can use this valve to stop the train.

D1. PILOT AIR VALVE CUM BRAKE ISOLATING VALVE

It is an electrically operated solenoid valve. Whenever Dynamic Brake is applied it disconnects the supply from C3W Distributor valve and connects it to Exhaust. Thus it nullifies the loco brake application through A9 when dynamic brake is applied.



D1. PILOT AIR VALVE CUM BRAKE ISOLATING VALVE

PRESSURE LIMITING VALVE :-

This will control the Output pressure of C_3 W valve to

the desired level. This valve is fitted at the outlet of C3W valve to limit the Brake Cylinder pressure to 2.5Kg/Cm^2.

PRESSURE LIMITING VALVE

24-A DOUBLE CHECK VALVE :

This connects two inlet passages in a common outlet. At a time it connects only one of the two inlet passages with the outlet by isolating the other.

24A-DOUBLE CHECK VALVE

AIR FLOW MEASURING VALVE

This valve indicates charging rate of BP / the leakage of BP pipe through an indicator, which is calibrated in term of No of wagons. Indicator is located at driver's control stand. MR air is connected to C2 W relay valve through Air Flow Measuring valve.

Construction:

MR air is connected to C2 W relay valve through inlet and outlet passages of AFM valve. Disc valve controls inlet and outlet passage of AFM valve. Disc valve has two small ports, one connects MR air to the top chamber of Disc Valve and other connects MR from top chamber of disc valve to Additional C2 Relay valve. Top chamber of Disc valve is the bottom of main diaphragm. Disc valve is pressed down through a follower & spring on its seat. Choke B is provided to connect MR air to top chamber of main diaphragm. Choke C is provided to supply `main diaphragm top chamber air' to indicator, when diaphragm moves down word. Choke D is provided regulate air supplied through choke C towards indicator.

Working:

When the brake pipe is fully charged with air and the air brake is in the release condition, the air flowing from the main air supply through the Airflow measuring valve and to the brake pipe is that necessary to overcome leakage. In this condition the disc valve is closed as shown in diagram and air from the main supply passes through choke A in to the top chamber of disc valve and out to the Additional C2-Relay valve. It also passes in to the chamber under the diaphragm via the space around the follower. At the same time, air from the main supply passes through a filter and choke B in to the chamber above the diaphragm.

So long as the pressures above and below the diaphragm are equal, the diaphragm floats against the choke C. As brake pipe leakage occurs, the pressure at the outlet port and under the diaphragm falls and the diaphragm is moved down away from the choke C and permits air entering the chamber above the diaphragm via choke B, to flow through choke C to an indicator and through choke D to atmosphere.

Choke D is smaller than choke C and an intermediate pressure builds up in the passage between them and registers on the indicator. This intermediate pressure is related to the flow of air through choke C that is controlled by the diaphragm reacting to the pressure under it. As the pressure under the diaphragm depend upon the fall of pressure at the outlet port relative to the main supply pressure, being guided by the flow rate towards BP to make good the leakages during run. It also determines the flow of air through choke A. The indicator therefore provides a visual indication of the amount of air flowing to the brake pipe.

During initial charging or release of brakes, when a large quantity of air passed to the brake pipe, the pressure at the out let port and in spring chamber reduces sufficiently. It allows the supply pressure to lift the disc valve off its seat and permit unrestricted flow of air to the brake pipe through C2 W-Relay valve. Under these conditions a high intermediate pressure builds up in the passages between chokes C and D, and the indicator indicates a high rate of airflow.

Choke D is variable to facilitate calibration and may be altered by means of an adjusting screw, turning the screw clockwise reduces the aperture and turning it anticlockwise enlarges it.

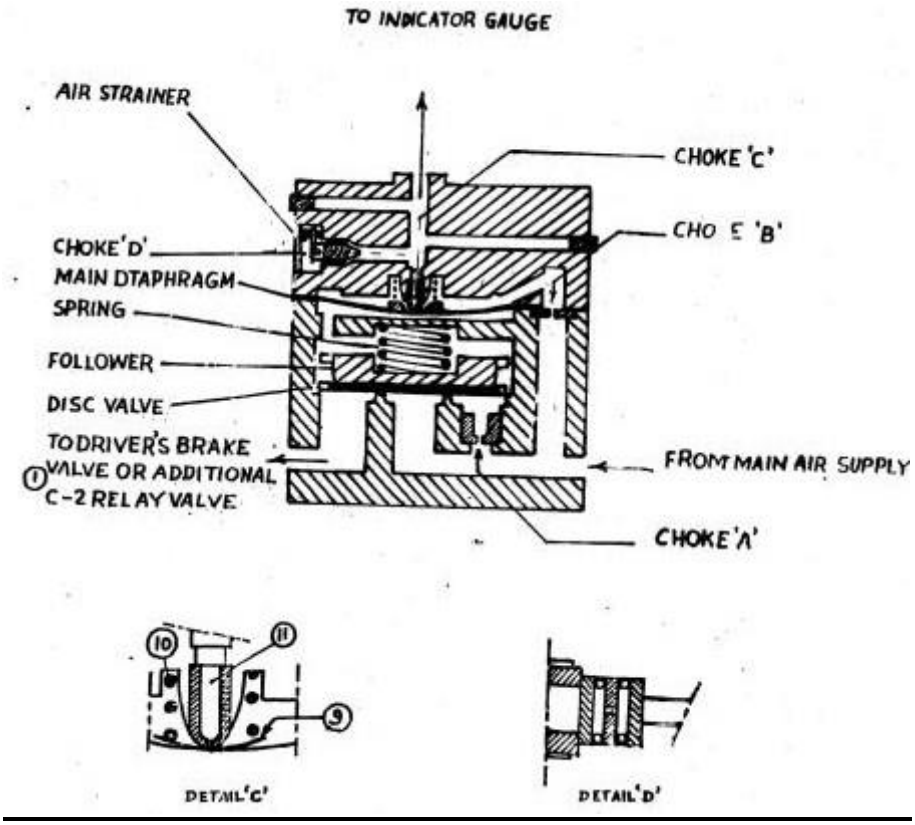
Calibration

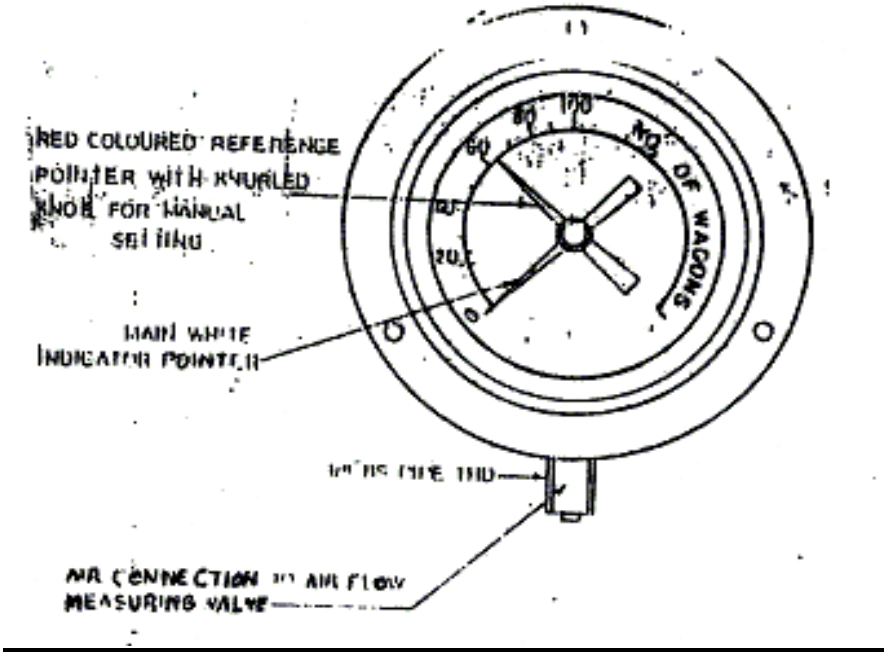
The Airflow measuring valve includes a calibration choke enclosed by a vent plug. This feature is provided to facilitate the calibration of the equipment on the vehicle.

There is a test stand, where the needle valve setting is calibrated on 130 psi charging line. Where AFM valve indicator gauge reads 70 psi/ 100 wagons reading.

AIR FLOW INDICATOR

It is an air pressure gauge with two pointers. Red pointer is called reference pointer, which is attached to a knurled knob and protrudes through the dial glass, so that it can be set manually in any desired position, where as the other pointer (White) moves on the scale depending up on the air flow. The indicator is connected to the measuring valve through R-6 relay valve. The scale on the gauge is calibrated in terms of number of wagons. The 60 marks correspond to the maximum rate of airflow that can be accepted to overcome leakage on a 60 wagon train and so on





AIR FLOW INDICATOR

INDEPENDENT BRAKE-APPLICATION AND RELEASE.

Independent brake application and release is controlled through SA9 Brake handle. When SA9 handle is kept in released position, Brakes are in released condition. When SA9 handle is moved to application zone, it supplies pilot air to C2 relay valve through Port No: 20 to Port No: 2 of MU2B. In lead loco or single unit loco MU2B is kept in lead position. In this, Port No 2 & 20 are interconnected and air from MU2B will come out through port 20. This air acts as Pilot air for C_2 relay valve, entering at Port No 2 (Pilot port) through a double check valve. This pressure acts at the top of main diaphragm of C_2 relay valve. (In trailing loco the MU2B is kept in trail position, port No 2 & 20 are isolated hence brake cannot be applied from the trailing loco).

C2 relay valve in turn will supply air to the Brake Cylinder through port 3 at a pressure equal to pressure at port 2.

There are two Brake cylinders in locos. The outlet air from C2 relay valve goes to the brake cylinders and applies the brakes.

One branch from C_2 relay outlet is connected to F1 selector port 30. Since MU2B is in lead, F1 selector also will be in lead and hence the air at port 30 comes out through port 14 and charges the brake cylinder-equalizing pipe. Normally the COCs at both the ends of BC equalizing pipe are in closed condition. This pipe will be coupled to the trailing loco in MU operation to apply the brakes in trail loco.

If the SA9 handle is moved to release position, the pilot air supplied to C2 relay port 2 will be withdrawn and exhausted through SA9 exhaust port. In turn, C_2 relay valve will withdraw the brake cylinder pressure and exhaust it through exhaust port, till the Brake cylinder pressure is equal to pilot air pressure at port 2. (In this case 0). The pilot air for Brake cylinder pressure will be proportionate to the position of SA9 handle during application and release. A gauge pipe is connected after the front truck Brake cylinder COC to indicate the BC pressure to the driver's control stand.

AUTOMATIC BRAKE APPLICATION AND RELEASE.

BP CHARGING:

The charging and exhausting of BP is done through A9 Brake handle for application and release of formation brake in conjunction with Loco Brake. When the A9 handle is kept in release position, it supplies pilot air at 5 Kg/Cm^2 to the port 2 of C_2W relay air valve through MU2B port 3 and 13. A volume reservoir is also connected at this line to dampen fluctuation of pressure. C_2W valve thus charges the BP equal to the pilot pressure. At the outlet of C_2W valve, a ¾" COC is fitted which should be open in single unit / lead unit and closed in trailing unit.

At the inlet to C_2W relay valve, an airflow-measuring valve is fitted which is connected to an Air Flow Indicator Gauge situated at Driver's Cab. The indicator indicates the rate of MR airflow through C_2W relay valve i.e. rate of charging of BP. This arrangement is used to find the condition of brake pipe. If the leakage in B Pipe is high, the indication will show a higher valve. If there is no leakage the indicator show zero.

MONITORING OF BP CHARGING:

While starting a train after coupling and charging the Brake pipe, the driver should check the indicator reading. It should be less than the number of vehicles in that train. (The graduations are in 'No of wagons') and turn Red needle and align with the white needle. While working, if BP starts leaking, the white needle will overshoot the red needle. This is the indication of a problem / leakage in Brake pipe. On getting this indication, the driver should stop, investigate the reason for BP leakage and rectify.

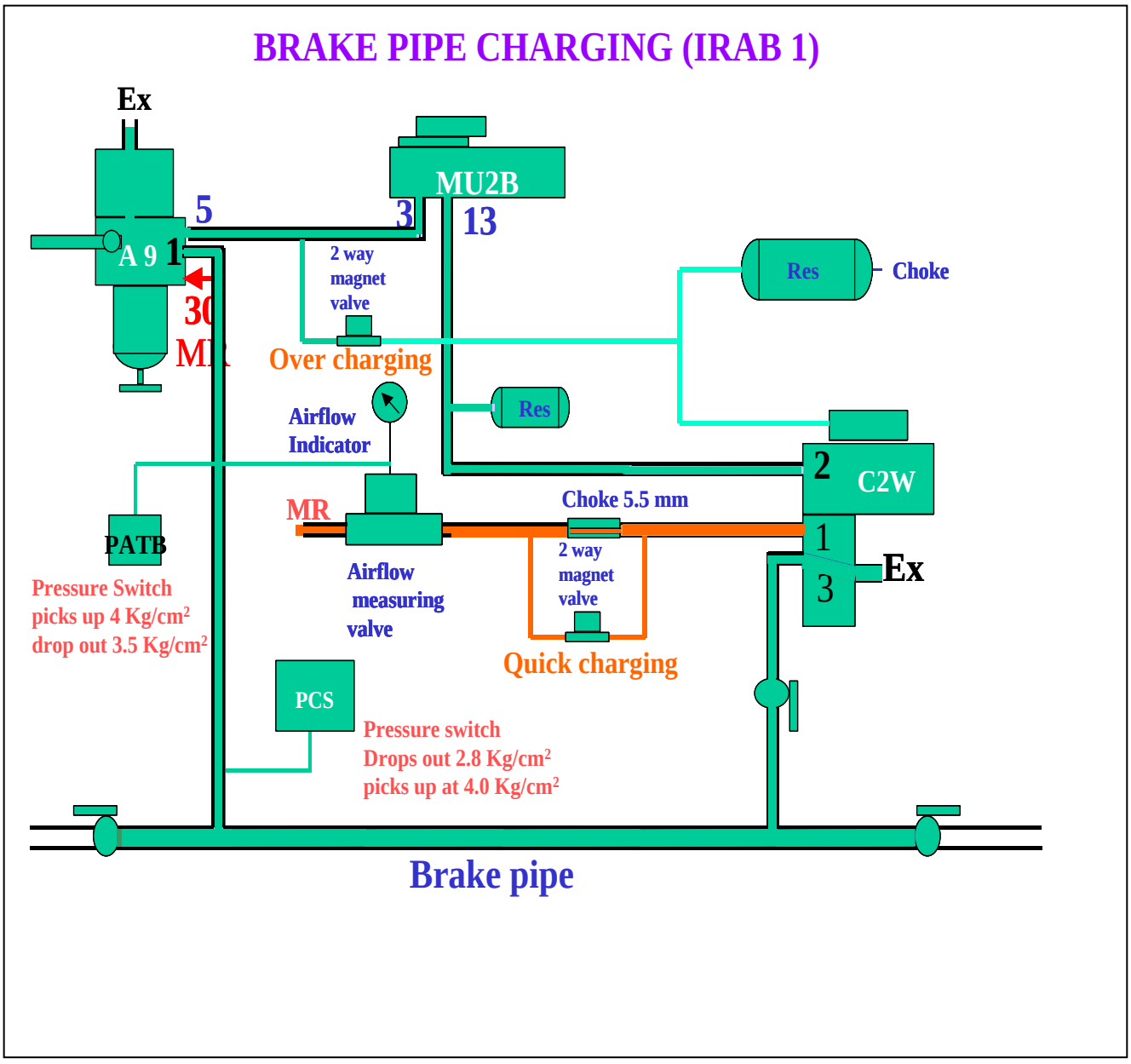
When the A9 valve handle is moved to application zone i.e. to min. reduction, or more, A9 valve reduces the pilot air to C2W and hence C2W also reduces the brake pipe pressure (BP charging rate drops to zero).

When A9 handle is kept in Emergency, the Brake pipe drop to zero immediately causing emergency brake application in formation (BP charging rate drops to zero).

During release the rate of charging of BP is very high and the white needle deflection of Airflow indicator shoots up and then stabilizes, which should not be misunderstood as defect in Brake pipe.

AUTOMATIC / CONJUCTION BRAKE IN LOCOMOTIVES:

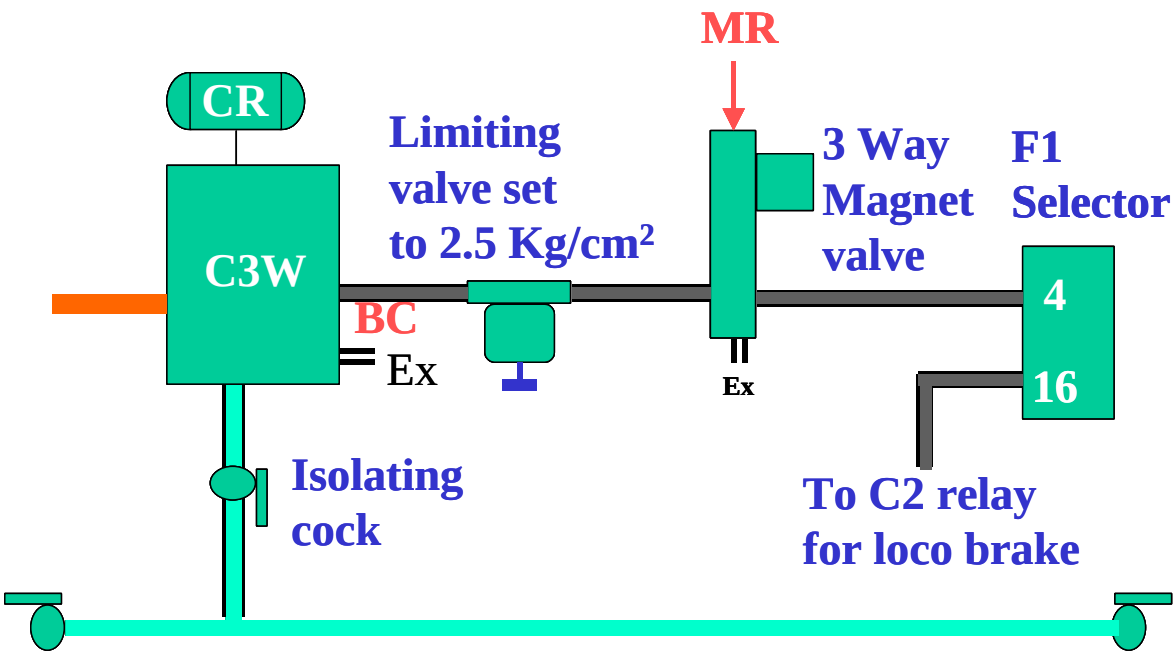
The arrangements of valves are shown in sketch.



avoid delay due to brake binding, the brake pipe is charged more than 5 Kg/cm^2 (i.e.,5 Kg/Cm^2 max). By doing so, the C3W valves of all the vehicles will be forced to release the brakes, because as per general logic brake releases when BP is equal to or more than CR. This is done by the overcharging function in this system.

For overcharging, the crew should press overcharging button, in certain cases switch. This switch energizes the 2-way magnet valve, supplying BP pilot air to C_2W relay valve. This pressure increases the setting of C_2W valve to 5.4 Kg/Cm2 (this is done by charging the top diaphragm to an additional value). The overcharging continues till the button/ switch hold pressed. It is advisable not to allow the BP to rise more unnecessarily long time to resume the normal operation. The switch should be released as soon as the BP rises to 5.2 Kg/Cm^2.

CO-ORDINATED BRAKING APPLICATION



QUCIK CHARGING FUNCTION:

Normally to meet the leakages in the BP line during running condition a 5.5 mm choke is provided at the inlet to the C2 relay valve, the purpose of providing choke is just to meet the loss of BP during run. Otherwise excess rate of charging will not reduce the BP for application of brake and indication in case of Chain pulling / guard's brake application. But during initial charging and releasing of brake BP need to be charged faster. To charge the pipes faster, a bypass for this choke is provided with a 2 way magnet valve. On energizing the magnet valve, the choke is bypassed to normal opening ¾", resuming the normal capacity of C_2W relay valve. This should be used to avoid auto flasher to switch ON during releasing the brakes (which takes place if the charging time is more than 60 sec).

SAFETY DEVICES

These safety devices are shown in the sketches.

A9 EMERGENCY:

The A9 emergency is applied BP will be reduced to zero. When the pressure is less than 2.5Kg/Cm^2 the PCS operate and brings the engine to idle.

TRAIN PARTING:

When train parting occurs, air leaks out heavily through the brake pipe causing Airflow indicator to shoot up. When the reading goes beyond 80 wagons (4.0 Kg/cm^2) at the indicator pipe, the PCS operates and brings the engine to idle. If the trouble is rectified and the reading reduces to 70 wagons, (3.5 Kg/ Cm^2 at the indication pipe) this PCS resets and allow the engine to rise.

DIESEL LOCOMOTIVE TWIN PIPE DUAL BRAKE SYSTEM

INTRODUCTION

Diesel locomotives of Indian Railways are equipped with brake system designed by either M/S WABCO/ USA or M/S KNORR Germany or IRAB-1 Indian Railways or M/S KNORR Brake (NYAB). Initially locomotives were equipped with M/S WABCO, USA designed 28LV-1 Brake system for use in vacuum brake train only. In 80's locomotives were switched over to 28LAV-1 Brake system for use both in vacuum and air braked Trains.

In 90's some of the locomotives were equipped with IRAB-1 brake system, which are suitable for only air-braked trains. Recently acquired WDG4 and WDP4 locomotives are equipped with CCB (computer control brake) system designed by KNORR BRIMSE (NYAB), which are suitable for air braked train only.

Important feature of the 28LAV-1 brake system

1. Locomotive brakes may be applied with any desired pressure between the minimum and maximum. This pressure will be maintained automatically in the locomotive brake cylinders against normal leakage from them.
2. The locomotive brakes can be graduated on & off with either the automatic or the independent brake valve.
3. It is always possible to release the locomotive brakes with the independent brake valve, even when automatically applied.
4. The maximum braking position emergency, ensuring the shortest possible stops distance.
5. It is always possible to haul both vacuum / air brake trains.
6. Automatic brake application and power cut off with idle rpm of engine is always possible during train parting.
7. Multiple unit operation is also possible.

INDEPENDENT BRAKE SYSTEM (LOCO BRAKE)

Introduction:

Loco brake system is provided to stop the Locomotive, whenever it runs as light engine. It is purely compressed air brake system known as independent brake system. For this separate air circuit is provided in 28LAV-1 & IRAB-1 Brake system which is independent to other air circuit. SA9 Independent brake valve is provided in driving control stand for application & release of loco brake. Valve has three positions i.e. quick release, release and application.

Purpose of this system:

Independent Brake System is designed to apply and release brake on locomotive only, especially when the locomotive is moving independently.

System brake valves:

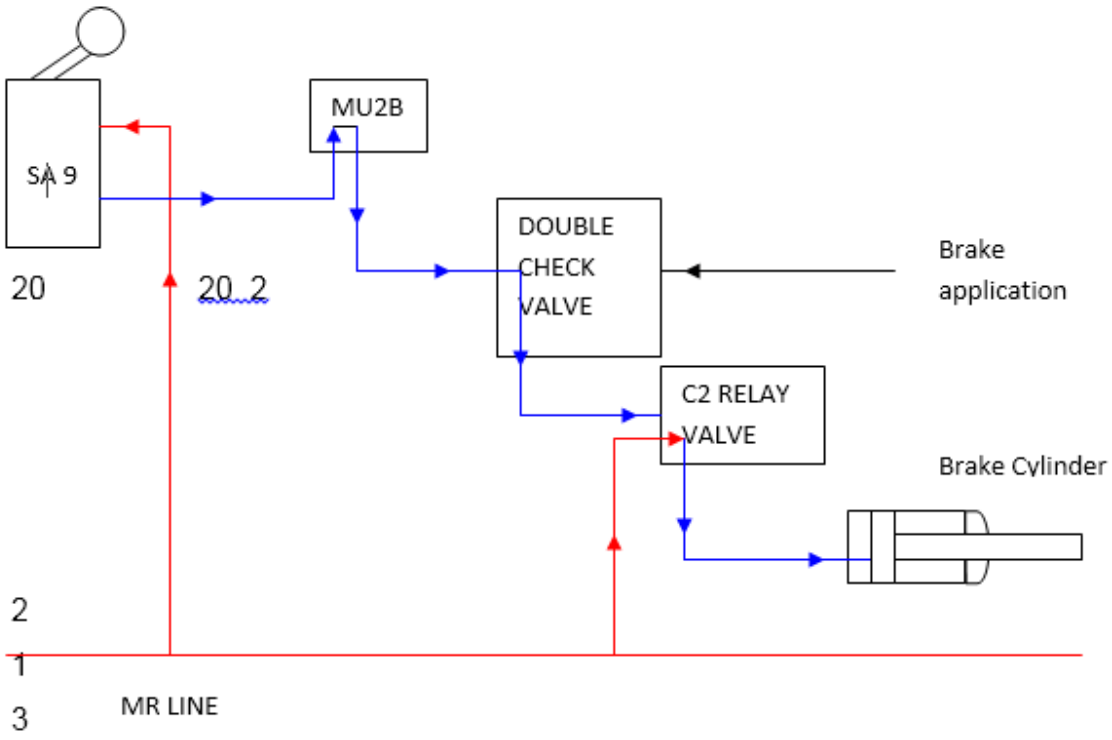
System consists of SA9 Independent Brake valve, Double check valve and C2-Relay valve.

Description of loco brake (Independent brake) system

The SA9 Valve handle is kept normally in release position (right side). MR air is always available at port no.30 of SA9 valve. When handle is brought in application potion (left side) than SA9 port 30 connects port 20 and starts supplying pilot air to C2-Relay air valve. The pilot air passes through MU2B Valve port no. 2&20 and inters to C2-Relay at port no.2. See the line diagram of loco brake system. The pilot air pressure depends upon the handle position; in full application it is 3.5kg/cm2. The C2-relay air valve actuates after getting pilot air and connects MR pressure to brake cylinders of locomotive through port no.1&3. The brake cylinder pressure depends upon pilot air pressure, supplied into C2-Relay

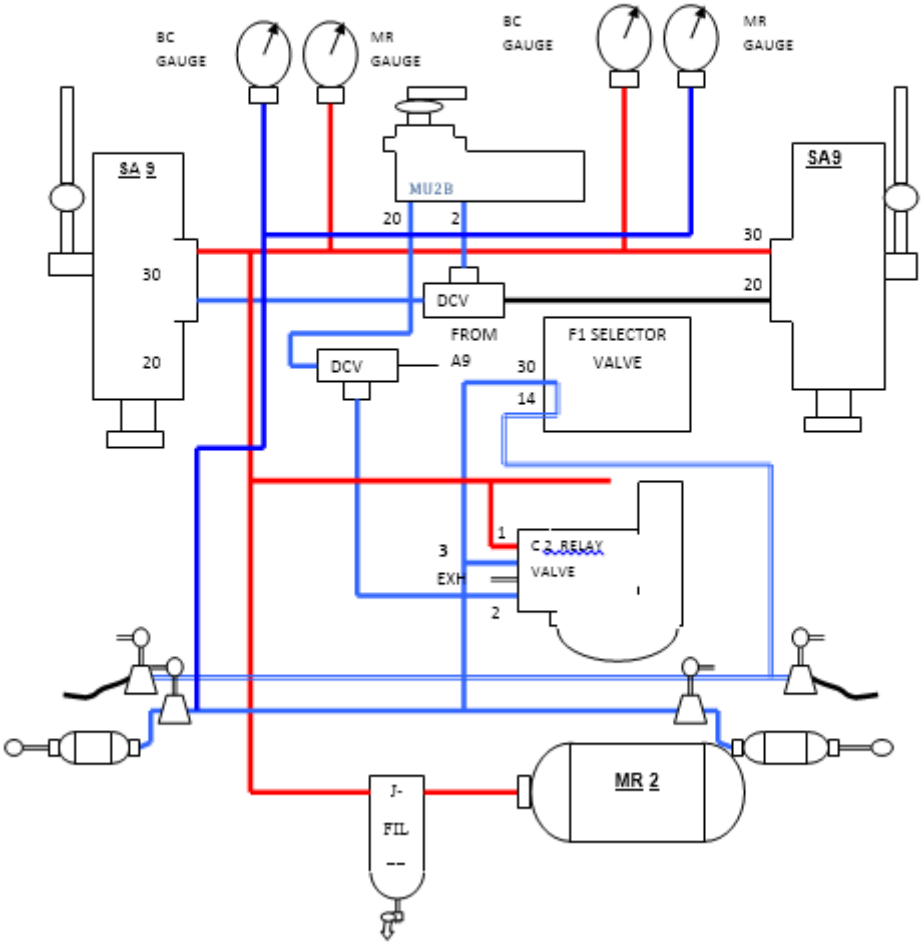
chamber through port no.2. For full brake application SA9 handle is moved to maximum travel position. In this way independent brake/loco brake is applied. Gauge line connection is taken from BC pipe near front truck of locomotive to the driver's control stand for indicating brake cylinder pressure. When SA9 handle is placed in release position, loco brakes are released. For detailed understanding see the internal function of the SA9 valve & C2-Relay valve.

SA9 Brake valve handle is normally kept in release position. It can be applied to any desired pressure between the minimum and maximum through SA9 valve handle. This pressure will be automatically maintained in the locomotive brake cylinders against normal leakage from them. The locomotive brake can be graduated on and off with either the automatic (A9) or the independent brake valves (SA9). It is always possible to release the locomotive brake with SA9 valve.



INDEPENDENT BRAKE APPLICATION

INDEPENDENT BRAKE SYSTEM LAYOUT



VACCUM BRAKE SYSTEM

INTRODUCTION

Indian Railway runs both the trains vacuum and air brake. In vacuum brake train brakes are controlled through vacuum of train pipe. After coupling the locomotive with the vacuum brake train the vacuum hoses are connected to obtain vacuum in train pipe. The exhauster unit of the locomotive is connected with vacuum train pipe through a vacuum control valve (VA1A/ VA1B), to create the vacuum in the train pipe as well as the Vacuum cylinders of each coach/wagon. A9 automatic brake valve is provided in driving control stand through which vacuum is controlled for application and release of brake. Normally valve handle is kept in release position.

PURPOSE OF THIS SYSTEM

This system is designed to apply and release brakes on vacuum brake train. Which is achieved through A9 Automatic Brake valve.

VACUUM BRAKE SYSTEM VALVES

System consists of A9 Automatic Brake valve, VA1B Control valve and HS4 Control valve.

DESCRIPTION OF VACCUM BRAKE SYSTEM

Locomotive and train has a long vacuum brake pipe, in which 56cm vac. is maintained through an exhauster unit and a vacuum control valve (VA1A/ VA1B). A9 automatic brake valve is provided in driving control stand to apply vacuum brake in the train. When A9 handle is placed in application zone, train pipe vacuum drops and brakes are applied through vacuum cylinders of coaches.

The function of A9 valve is to supply Brake Pipe pressure in 28 LV1 system or to provide control air pressure to Add.C2-Relay valve for charging Brake Pipe in 28 LAV1 system. The function of VA1B control valve is to control vacuum according to control air pressure of Brake Pipe. The function of HS4 valve is to supply 1.7kg/cm2-air pressure to bottom chamber of VA1B control valve at port no.1. Other valves are provided in this circuit for MU operation. See line diagram of vacuum brake circuit.

CHARGING OF SYSTEM

Air at 8 to 10kg/cm2 pressure is charged at different valves through MR-2 (See the line diagram of vacuum system) i.e. at port no.30 of A9 valve, port no.1 of Add.C2-Relay valve and port no.1 of HS4 control pressure valve. A9 valve handle is kept at release position normally. In release position, A9valve will supply control pressure to additional C2-Relay valve through MU2B valve. After getting supply of control pressure, Add.c2-relay valve will charge BP according to control Air Pressure. BP pipe is connected to VA1B control valve top chamber at port no.3. At port no.1 control pressure at 1.7kg/cm2 is supplied through HS4 control valve. VA1-B control valve maintains 56cm vacuum in train pipe by connecting it to Expressor.

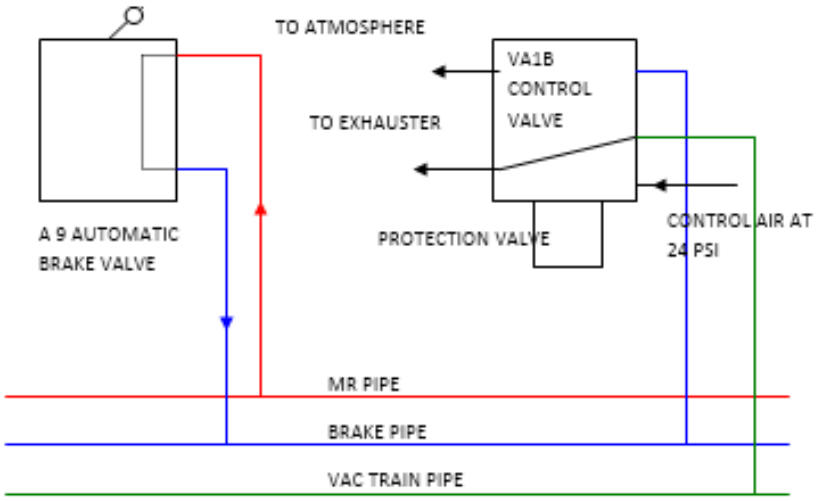
APPLICATION OF BRAKE

A9 handle is moved in application zone for brake application. A9 reduces Control pressure to Add.C2 Relay valve. Add. C2 Relay reduces BP pressure in proportion to control pressure droppage. BP pressure drops to zero if A9handle is moved at over reduction position. If handle is placed at emergency position BP will drop to zero immediately within 3 sec. Due to dropping BP pressure, brakes are applied in train through distributor valve in case of air brake train. In case of vacuum brake train, control pressure at the top chamber of VA1B control valve is dropped, which causes movement of spool valve connecting train pipe to atmosphere and applies brake.

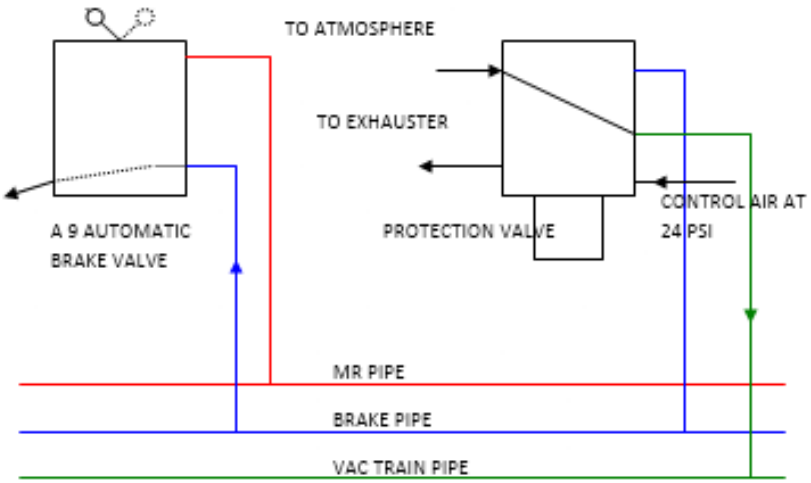
RELEASING OF BRAKE

When handle is moved to release position, A9 valve starts supplying full control pressure to additional C2 Relay valve, which in turn charges Brake Pipe. When pressure increases to 5kg/cm2 and brakes are fully released.

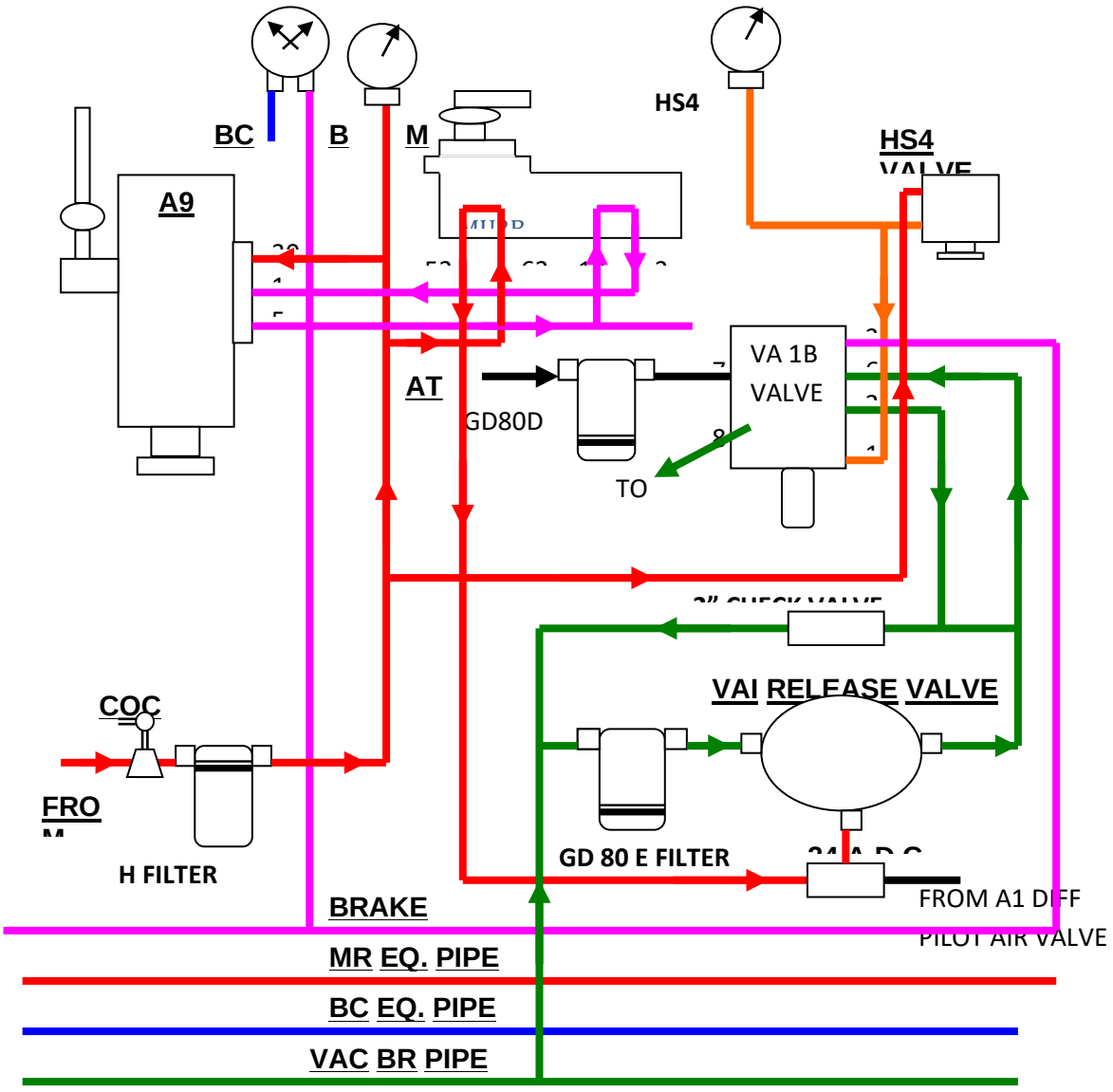
VACUUM BRAKE RELEASE POSITION



VACUUM BRAKE APPLICATION POSITION



VACUUM BRAKE SYSTEM



VACUUM TROUBLE IN TRAIN

Following test are recommended:-

1. BLOCKAGE TEST: Remove one end of the vacuum hose pipe and raise it upwards. If more than 8cm vacuum is created, there is a blockage in the system.

2. EFFICIENCY TEST: Against an 8 mm leak disc, the loco should create 53 cm vacuum.

3. LEAKAGE TEST: Vacuum on dummy and on leak disc should not vary more than 3 cm.

The Board has therefore standardized the vacuum level in engine and brake van for all Railways in both the traction.

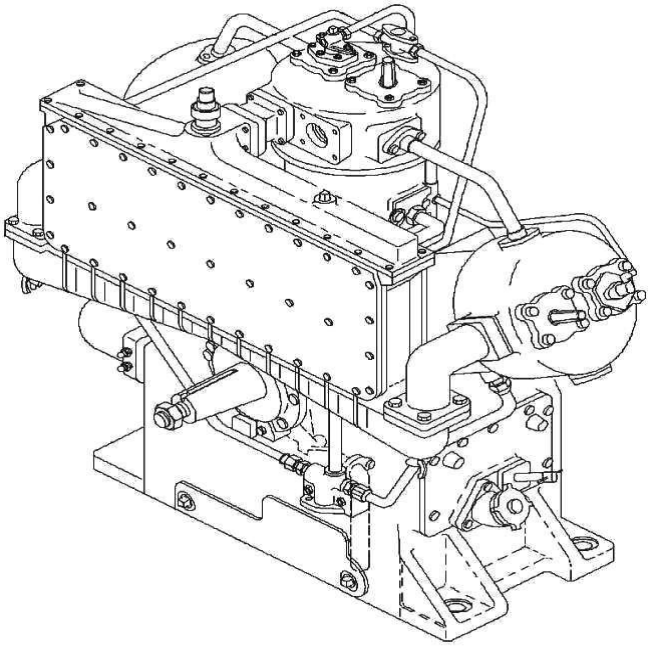
Type of service	Engine	Brake van	Average
M/E	53	47	50
Passenger	50	44	47
Goods	46	38	42

3. COMPRESSORS:

WORKING OF COMPRESSOR

Compressed air in HHP locomotive is used for the locomotive brake system as well as for auxiliary systems such as sanders, bell, horn, windshield wipers, rail lube systems, and radar head air cleaner.

The HHP locomotive uses WLNA9BB model three cylinder air compressor which is a two stage (low-pressure and high-pressure) compressor. The compressor is water-cooled. The compressor is mechanically driven by a driveshaft from the front or accessory end of the locomotive engine. This driveshaft is equipped with flexible couplings to couple the compressor.



WLNA9BB - AIR COMPRESSOR ASSEMBLY

The compressor is equipped with three cylinders, two low pressures and one (in the center) high pressure. Air is sucked through two dry pamic type air filters and compressed by the two low pressure cylinders. After that the low-pressure compressed air passed through an

intercooler. The intercooler reduced the compressed air temperatures. A pressure relief valve is provided on the intercooler for intercooler safety. After this the compressed air moves on to the high-pressure cylinder where it is again compressed to main reservoir pressure. Between the compressor and main reservoir an after cooler cooling coil is provided to reduce the air temperature.

The compressor has its' own internal oil pump and pressure lubricating system with an oil filter. The oil level is checked during running by means of the dipstick mounted on the side of the compressor crankcase. When adding oil in the compressor it must be in stop position.

At idle speed and normal operating temperature, the oil pressure should be between 18-25 psi. A plugged opening is provided for installation of an oil pressure gauge

AIR COMPRESSOR MAINTENANCE

The compressor oil level should be checked regularly using the dipstick, and the oil level should be kept at the full mark. The compressor oil and compressor oil filter should be changed at the scheduled maintenance intervals.

The compressor air filters should be changed out at the scheduled maintenance intervals. Remove the filters by first removing the nuts attached to the clamps on the filter housing. Swing the clamps to the side and remove the retainer screen. The filter housing and screen should be cleaned whenever the filter elements are change out. When the application of test gauges are required for maintenance ensure that the gauges are removed and the proper sized plug inserted and tightened before returning the locomotive to service.

Air compressor change out and overhaul should be done at the scheduled maintenance intervals.

AIR COMPRESSOR CONTROL

The standard air compressor on a GT46MAC locomotive is coupled directly to the diesel engine through a driveshaft and when the engine is running, the air compressor is being

driven. Therefore an unloader assembly, mounted on the compressor, is required to control when the compressor is actually pumping air.

The intake or suction valves of the compressor contain unloaders that block the valve open when pneumatically activated. With the intake valves blocked open the compressor is incapable of compressing, whether it is rotated or not. These unloaders are controlled pneumatically, through the unloader magnet valve.

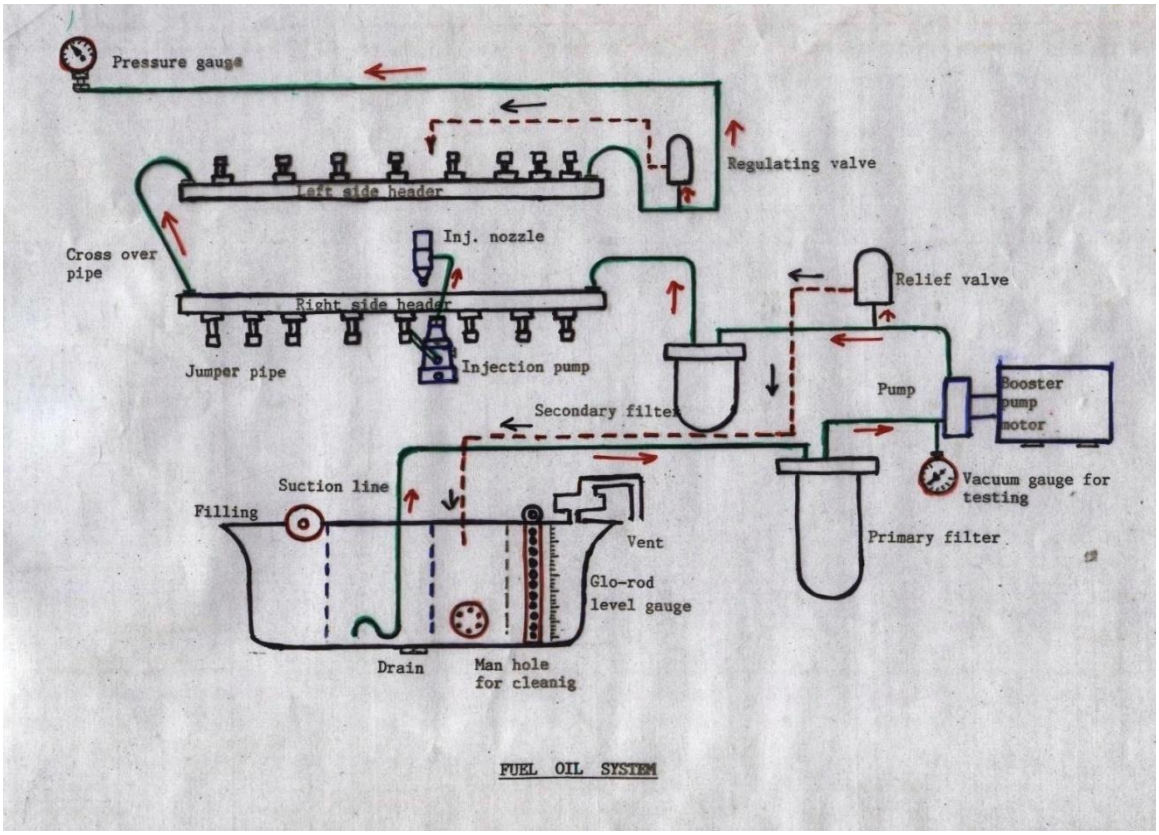
This valve is called the MV-CC, or Magnet Valve Compressor Control.

The locomotive computer, the EM2000, controls the MV-CC in turn. When the locomotive is started, the computer picks up the MV-CC, allowing main reservoir air through to activate the unloaders. When the computer, monitoring main reservoir pressure, notes that the pressure is below the required pre-programmed maximum pressure it drops out the MV-CC. This releases the unloaders causing the compressor to load.

4. FUEL OIL SYSTEM

INTRODUCTION

All locomotive units have individual fuel oil system. The fuel oil system is designed to introduce fuel oil into the engine cylinders at the correct time, at correct pressure, at correct quantity and correctly atomized. The system injects into the cylinder correctly metered amount of fuel in highly atomized form. High pressure of fuel is required to lift the nozzle valve and for better penetration of fuel into the combustion chamber. High pressure also helps in proper atomization so that the small droplets come in better contact with the fresh air in the combustion chamber, resulting in better combustion. Metering of fuel quantity is important because the locomotive engine is a variable speed and variable load engine with variable requirement of fuel. Time of fuel injection is also important for better combustion.



FUEL OIL SYSTEM

The fuel oil system consists of two integrated systems.

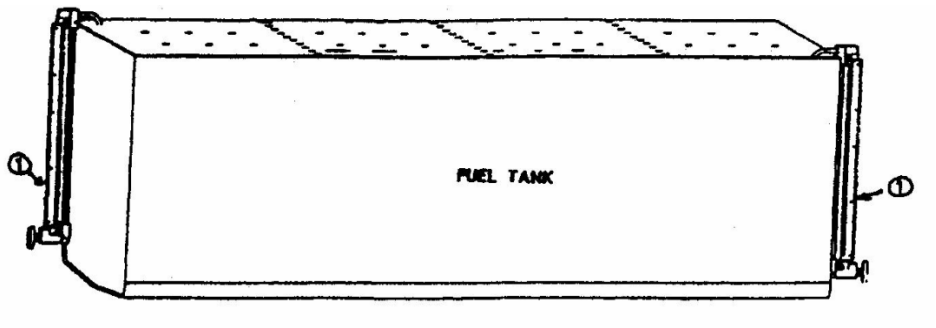
- Fuel feed system.
- Fuel injection system.

FUEL FEED SYSTEM AND ITS ASSOCIATE COMPONENTS

Fuel feed system provides the back-up support to the fuel injection pumps by maintaining steady supply of fuel to them at the required pressure so that the fuel pump can meter and deliver the oil to the cylinder at correct pressure and time. The fuel feed system includes the following:-

Fuel oil tank:

A fuel oil tank of required capacity (normally 5000ltrs), is fabricated under the superstructure of the locomotive and located in between the two bogies. Baffle walls are used inside it to arrest surge of oil when the locomotive is moving. A strainer filter at the filling plug, an indirect vent, drain plug, and glow rod type level indicators are also provided.

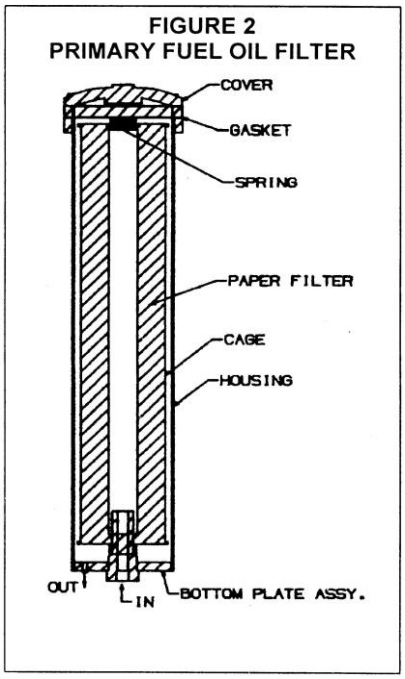


FUEL OIL TANK

Fuel primary filter:

A filter is provided on the suction side of the fuel transfer pump to allow only filtered oil into the pump. This enhances the working life of the fuel transfer pump. This filter is most often a

renewable bleached cotton waste packed filter, commonly known as socks type filter element. These socks type filters are coarse filters and have a greater ability to absorb moisture, and are economical. However, in certain places, it has been replaced by paper type filter, which have longer service life.



PRIMARY FUEL OIL FILTER

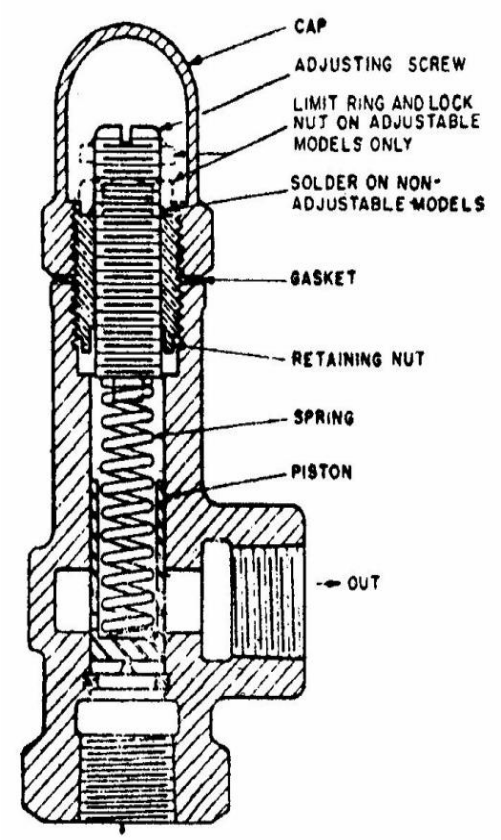
Fuel transfer pump or booster pump:

The fuel feed system has a transfer pump to lift the fuel from the tank. The gear type pump is driven by a dc motor, which is run by storage batteries through a suitable circuit. The pump capacity is 14 litres per minute at 1725 rpm at pressure 4 to 4.8 kg/sq.cm.

Fuel relief valve:

The spring- loaded relief valve is meant for by passing excess oil back to the fuel tank, thus releasing excess load on the pump and on the motor, to ensure their safety. It is adjusted to

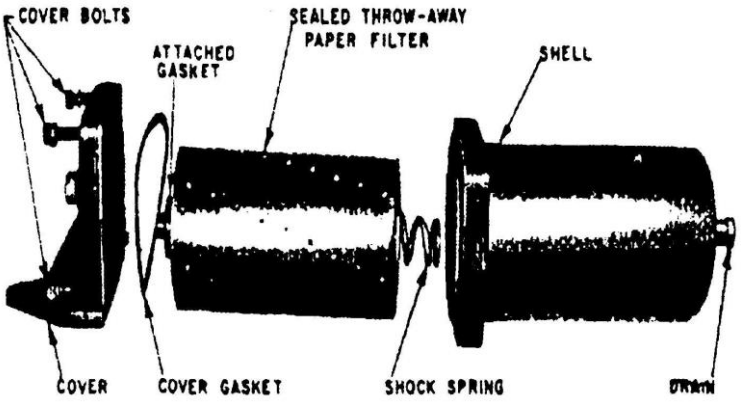
a required pressure (normally 5 kg/cm^2), and it by- passes the excess fuel back to the oil tank. It also ensures the safety of the secondary filter and the pipe lines.



FUEL RELIEF AND REGULATING VALVE

Fuel secondary filter:

The fuel secondary filter is located after the booster pump in the fuel feed system. The filter used is a paper type filter, cartridge of finer quality, renewable at regular intervals. This filter arrests the finer dirt particles left over by the primary filter and ensures longer life of the fuel injection equipment.



SECONDARY FUEL OIL FILTER

Fuel regulating valve:

The fuel-regulating valve is spring-loaded valve of similar design as the fuel relief valve. It is located after the secondary filter in the fuel feed system. This valve is adjusted to the required pressure (3 kg/cm^2), and always maintains the same pressure in the fuel feed system by releasing the excess oil to the fuel oil tank. There is no by-passing of oil if the pressure is less than the adjusted level.

FUNCTIONING OF FUEL FEED SYSTEM

The fuel booster pump or transfer pump is switched on and the pump starts sucking oil from the fuel oil tank, filtered through the primary filter. Because of variable consumption by the engine, the delivery pressure of the pump may rise increasing load on the pump and its drive motor. When the rate of consumption of the fuel by the engine is low, the relief valve ensures the safety of the components by releasing load, by- passing the excess pressure back to the tank. Then oil passes through the paper type secondary filter and proceeds to the right side fuel header. The fuel header is connected to eight numbers of fuel injection pumps on the right-bank of the engine, and a steady oil supply is maintained to the pumps

at a pressure of 3 Kg./ sq. cm. Then the fuel oil passes on to the left side header and reaches eight fuel injection pumps on the left bank through jumper pipes. The regulating valve remaining after the left side fuel header, takes care of excess pressure over 3 Kg/cm Square by passing the extra oil back to the tank. A gauge connection is taken from here leading to the driver's cabin for indicating the fuel oil feed pressure. Thus the fuel feed system keeps fuel continuously available to the fuel injection pumps, which the pumps may use or refuse depending on the demand of the engine.

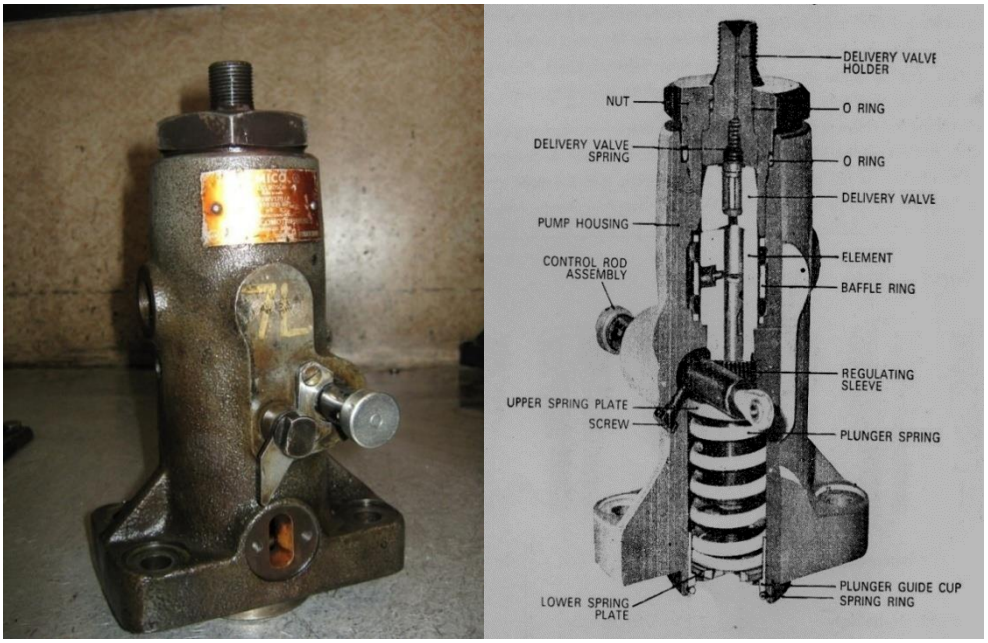
FUEL INJECTION SYSTEM

When diesel engine is started, all fuel injection pumps start functioning. According to firing order all F.I. pumps start discharging fuel oil at high pressure to their respective nozzles through high pressure line tube. Fuel injection nozzle injects fuel oil to combustion chamber at 4000 psi. The internal function of F.I. pump and nozzle are described below.

Fuel Injection Pump:

It is a constant stroke plunger type pump with variable quantity of fuel delivery to suit the demands of the engine. The fuel cam controls the pumping stroke of the plunger. The length of the stroke of the plunger and the time of the stroke is dependent on the cam angle and cam profile, and the plunger spring controls the return stroke of the plunger. The plunger moves inside the barrel, which has very close tolerances with the plunger. When the plunger reaches to the BDC, spill ports in the barrel, which are connected to the fuel feed system, open up. Oil then fills up the empty space inside the barrel. At the correct time in the diesel cycle, the fuel cam pushes the plunger forward, and the moving plunger covers the spill ports. Thus, the oil trapped in the barrel is forced out through the delivery valve to be injected into the combustion chamber through the injection nozzle. The plunger has two identical helical grooves or helix cut at the top edge with the relief slot. At the bottom of the plunger, there is a lug to fit into the slot of the control sleeve. When the rotation of the engine moves the camshaft, the fuel cam moves the plunger to make the upward stroke. It may also

rotate slightly, if necessary through the engine governor, control shaft, control rack, and control sleeve. This rotary movement of the plunger along with reciprocating stroke changes the position of the helical relief in respect to the spill port and oil, instead of being delivered through the pump outlet, escapes back to the low pressure feed system. The governor for engine speed control, on sensing the requirement of fuel, controls the rotary motion of the plunger, while it also has reciprocating pumping strokes. Thus, the alignment of helix relief with the spill ports will determine the effectiveness of the stroke. If the helix is constantly in alignment with the spill ports, it bypasses the entire amount of oil, and nothing is delivered by the pump. The engine stops because of no fuel injected, and this is known as 'NO-FUEL' position. When alignment of helix relief with spill port is delayed, it results in a partly effective stroke and engine runs at low speed and power output is not the maximum. When the helix is not in alignment with the spill port throughout the stroke, this is known as 'FULL FUEL POSITION', because the entire stroke is effective. Oil is then passed through the delivery valve, which is spring loaded. It opens at the oil pressure developed by the pump plunger. This helps in increasing the delivery pressure of oil. it functions as a non-return valve, retaining oil in the high pressure line. This also helps in snap termination of fuel injection, to arrest the tendency of dribbling during the fuel injection. The specially designed delivery valve opens up due to the pressure built up by the pumping stroke of plunger. When the oil pressure drops inside the barrel, the landing on the valve moves backward to increase the space available in the high-pressure line. Thus, the pressure inside the high-pressure line collapses, helping in snap termination of fuel injection. This reduces the chances of dribbling at the beginning or end of fuel injection through the fuel injection nozzles.



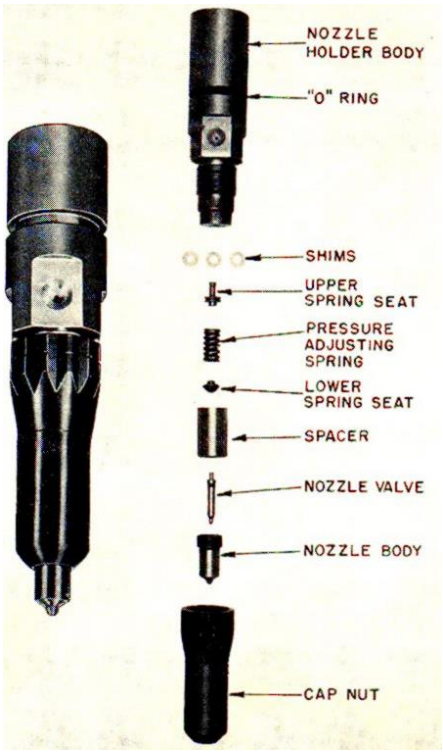
FUEL INJECTION PUMP

Fuel Injection Nozzle:

The fuel injection nozzle or the fuel injector is fitted in the cylinder head with its tip projected inside the combustion chamber. It remains connected to the respective fuel injection pump with a steel tube known as fuel high pressure line. The fuel injection nozzle is of multi-hole needle valve type operating against spring tension. The needle valve closes the oil holes by blocking the oil holes due to spring pressure. Proper angle on the valve and the valve seat, and perfect bearing ensures proper closing of the valve.

Due to the delivery stroke of the fuel injection pump, pressure of fuel oil in the fuel duct and the pressure chamber inside the nozzle increases. When the pressure of oil is higher than the valve spring pressure, valve moves away from its seat, which uncovers the small holes in the nozzle tip. High-pressure oil is then injected into the combustion chamber through these holes in a highly atomised form. Due to injection, hydraulic pressure drops, and the valve returns back to its seat terminating the fuel injection, termination of fuel

injection may also be due to the bypassing of fuel injection through the helix in the fuel injection pump causing a sudden drop in pressure.



INJECTOR

SUMMARY:

Fuel Feed System is responsible for supply of clean oil with adequate quantity at required pressure to Fuel Injection System, to meet the requirement of fuel oil of the engine at rated output. In Fuel Feed System, Fuel tank acts as reservoir of HSD oil of the engine; Primary and Secondary filters maintain cleanliness of oil in the system. Fuel Booster Pump works for generating pressure and maintaining adequate supply of fuel in the system; Relief and Regulating Valves maintain constant pressure in the feed system.

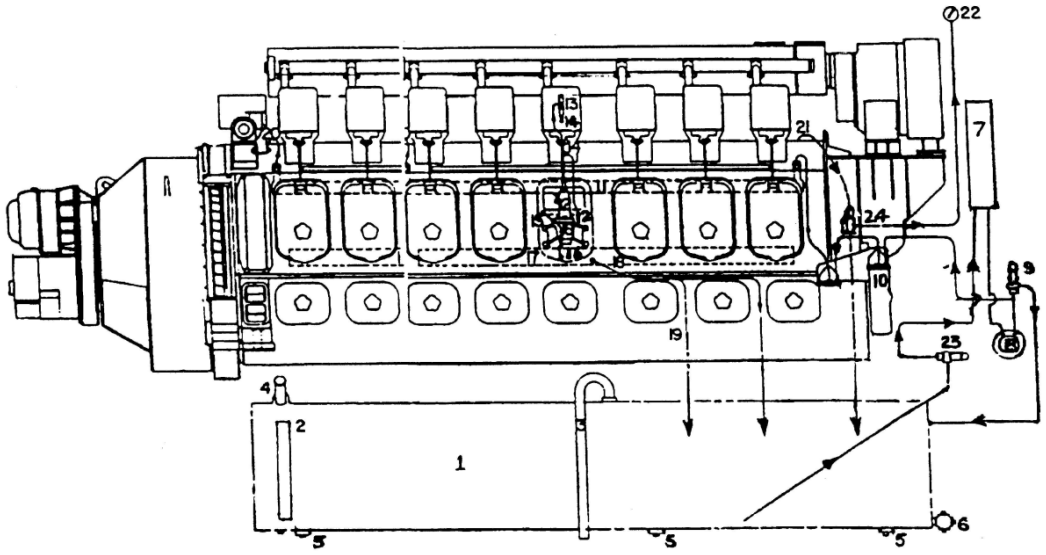
Fuel Injection System comprises of mainly two components.

(a) Fuel Injection Pump.

(b) Fuel Injection Nozzle.

Fuel Injection Pump is a plunger type Pump having constant stroke with variable delivery. The quantity of fuel delivered is decided by the position of the helix groove that varies with the twisting of the plunger according to the fuel rack position. Hence it is responsible for supplying correct quantity of pressurized fuel up to the nozzle. Nozzle is responsible for delivering pressurized fuel in atomized form into the combustion chamber. The breaking pressure i.e. the final pressure at which fuel is released into the combustion chamber is decided by the setting of Nozzle Valve Spring pressure.

FIGURE 1
NUMBERING SEQUENCE INDICATES OIL FLOW THROUGH THE SYSTEM



Numbering sequence indicated oil flow through the system

1–Fuel Tank
2–Fuel Level Gauge
3–Vent
4–Filter Pipe
5–Washout Plug
6–Condensation Drain
7–Primary Filter
8–Fuel Booster Pump
9–Pressure Relief–Valve (75 psi)
10–Secondary Filter
11–Fuel Oil Header
12–Injection Pump
13–Injection Nozzle
14–Nozzle Leaknut
15–Drain From Control Shaft Compartment
16–Drain From Fuel–Pump
17–Drain Channel
18–Drain to Tank (RS)
19–Drain to Tank (LS)
20–Header Crossover Line
21–Fuel Oil Rectum
22–Pressure Gauge
23–Fuel Trap
24–Pressure Regulating–Valve (35 psi)