B.R. 33057/16
D.T.S. 76

BRITISH RAILWAYS - WESTERN REGION

DIESEL MECHANICAL MULTIPLE UNIT TRAINS

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SWINDON

BRITISH RAILWAYS WESTERN REGION

DIESEL MECHANICAL MULTIPLE UNIT TRAINS

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.

C.M. & E.E. Training Centre
SWINDON

2nd Edition
June 1982

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<u>DIESEL MULTIPLE UNIT TRAIN. DESCRIPTION, AND LAYOUT OF EQUIPMENT</u>

Diesel Mechanical Multiple Units, as the name implies, are designed to run in sets comprising powered vehicles and trailer cars. The usual arrangements are for two powered cars with a trailer car in the middle. Any other train formation is possible with a limitation within a set or multiple unit train, of up to twelve engines in one train, six power cars. The number of power cars which can be included in a train is dependent on the control system design.

The general layout of the power unit, transmission, etc. for a two engine-gearbox car is shown in Fig.1 No. 1 engine and transmission is always on the driver's left-hand side when sitting in the driver s seat, and No. 2 engine and transmission on the right-hand side. This information, together with the power car number, should always be shown on the repair card when reporting defects.

The diesel engine is of the horizontal type, resiliently mounted on the underside of the car frames with the gearbox similarly mounted. To allow for independent movement of the units, and for the pivoting of the bogies when rounding curves, Hardy Spicer universal couplings are fitted to the shafts which couple the engine and gearbox, and the gearbox and final drive unit.

Engine speed, gear change and forward and reverse are all controlled electro-pneumatically, the air compressor is gear driven, Vacuum exhausters and Alternators or Generators, are belt driven. Each power car having 2 x 150 HP engines and weighing 35 tons, the trailer 30 tons (these are approximate weights), gives the set 600 horsepower for 100 tons weight, a power weight ratio of 6 hp per ton.

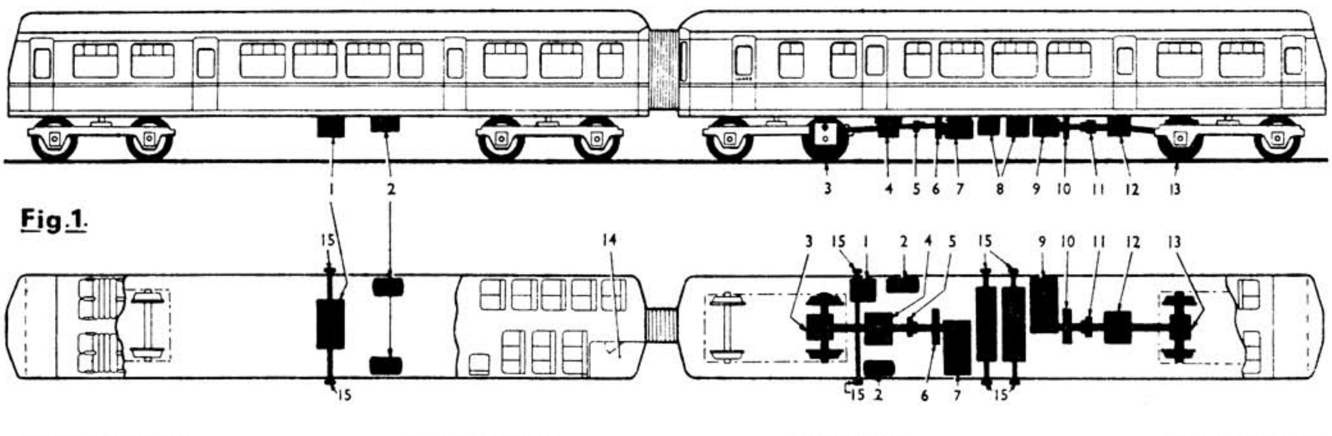


Fig.1.

1 HEATER FUEL TANK
2 HEATERS
3 No. 2 FINAL DRIVE
4 No. 2 GEARBOX
5 No. 2 FREEWHEEL
6 No. 2 FLUID COUPLING
7 No. 2 ENGINE
8 FUEL TANKS
9 No. 1 ENGINE
10 No. 1 FLUID COUPLING
11 No. 1 FREEWHEEL
12 No. 1 GEARBOX
13 No. 1 FINAL DRIVE
14 LAVATORY
15 TANK FILLERS

<u>Cross Country</u>

Designed for semi-fast passenger work. Each set consists of three vehicles i.e. two power and one trailer car.

Each power car has a full width driving compartment with corridor connections between power and trailer cars, the set is therefore complete in itself. The seating in this type of unit is of the open plan arrangement.

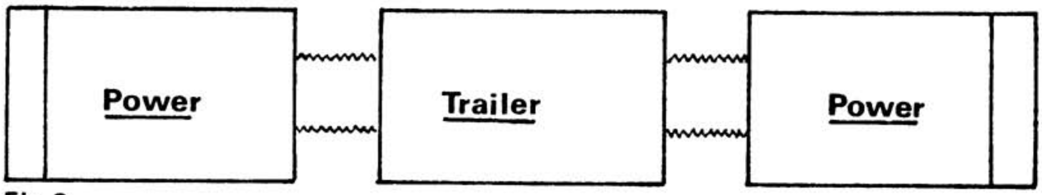


Fig.2.

Suburban

Designed for local passenger work. Each set consists of three vehicles i.e. two power and one trailer car.

Each power car has a full width driving compartment, but there were no corridor connections between any of the cars, no first class seating or toilets. High density seating is provided with extra compartment doors, to speed up the loading and un-loading of passengers. (These trains have now been suitably modified).

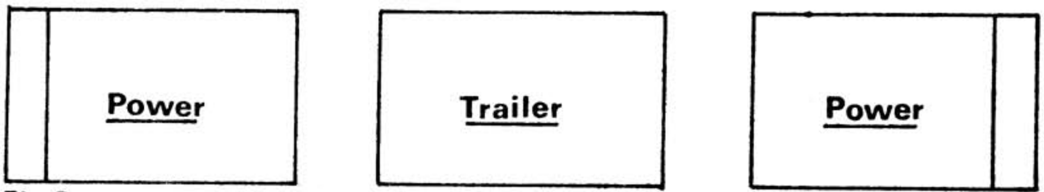


Fig.3.

Single Power Car and Driving Trailer

Designed for local branch line work. The power car has a full width driving compartment at each end of the vehicle.

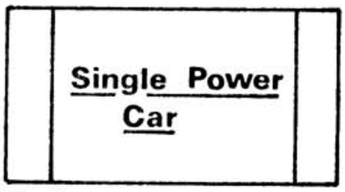
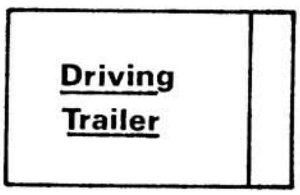


Fig.4.

A driving trailer, with a full width driving compartment is provided which, though not fitted with power equipment, can be attached to a single power car to form a two car set or if required, to a three car set to form a four car set.

Fig.5.



The seating in these vehicles is the same as in the suburban type cars.

Fig.6.

Parcels Cars

Designed to deal with parcel traffic only. Parcel cars are a single power car, with a half width cab at each end of the vehicle, because they have corridor connections at each end.

ENGINE TECHNICAL DETAILS	11.1 Litre LEYLAND 680/-
Rating	150 H.P.
Operating Speed Max :	1800 R.P.M.
Min : 410-430	~~375/400~~ R.P.M.
Cylinder Formation	Horizontal Inline
Number of Cylinders	6
Bore	127 MM - 5"
Stroke	146.05 MM - $5^3/_4$"
Compression Ratio	15.75:1
Aspiration	Normal
Firing Order	1.5.3.6.2.4.
Engine Rotation	Anti-clock Flywheel End
Camshaft Rotation	Anti-clock Flywheel End
Fuel Pump	Multi-element C.A.V.
Injectors	Leyland or C.A.V.
Governor	C.A.V.
Pump Timing	30° BTDC
Injector Pressure	140/145 Atmos. or 2060/2135 p.s.i.
Max Governed Speed	1900/2000 R.P.M.
Oil Capacity	$5^1/_2$ gallons
Operating Oil Pressure	55/60 p.s.i.

B.U.T. 'L' TYPE LEYLAND ENGINES

The B.U.T. 'L' type 11.1 litre horizontal engine has six cylinders of 5.0 inches diameter, a piston stroke of 5.75 inches, and develops 150 B.H.P. at 1800 r.p.m.

The sump of the 'L' type engine is bolted to the crankcase and carries the fuel injection pump which is mounted parallel to the crankshaft. The cylinder heads Fig. 9. are fitted with fuel injectors which are underneath the rocker cover. Decompressors are also fitted which assist when turning the engine over by hand. The crankshaft, an alloy steel forging hardended by nitriding, is carried in seven indium-coated lead-bronze steel shell bearings with a rubber bonded vibration damper bolted to the pulley at the free end. A forged steel hollow camshaft, mounted in seven bearings, is driven by helical gears from the crankshaft, as is also the fuel injection pump water pump, compressor and engine tachometer.

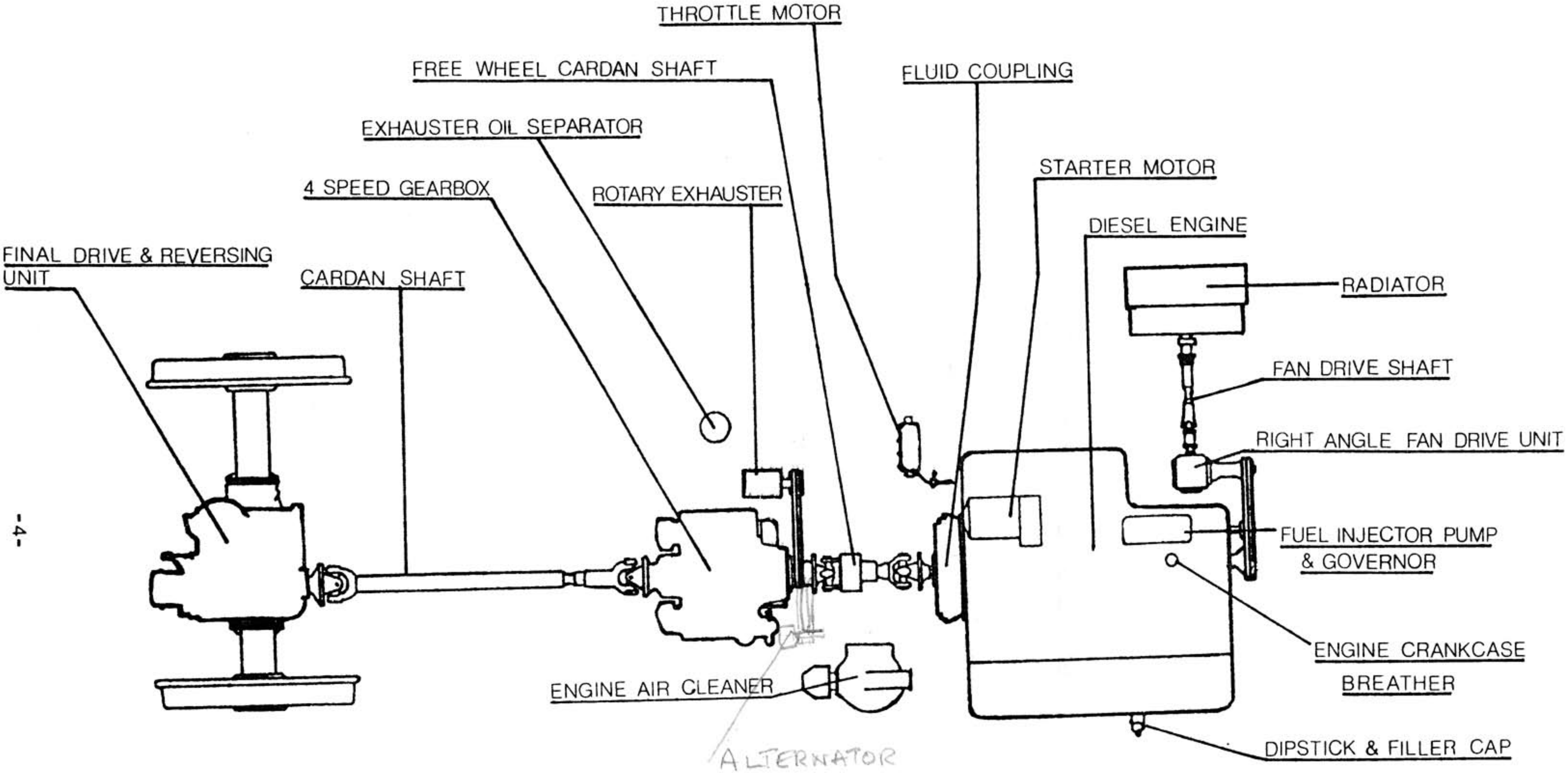


FIG. 7. LAYOUT FOR 'L' TYPE TRACTION UNIT

Fig 8 Cut–away view of the Leyland Engine

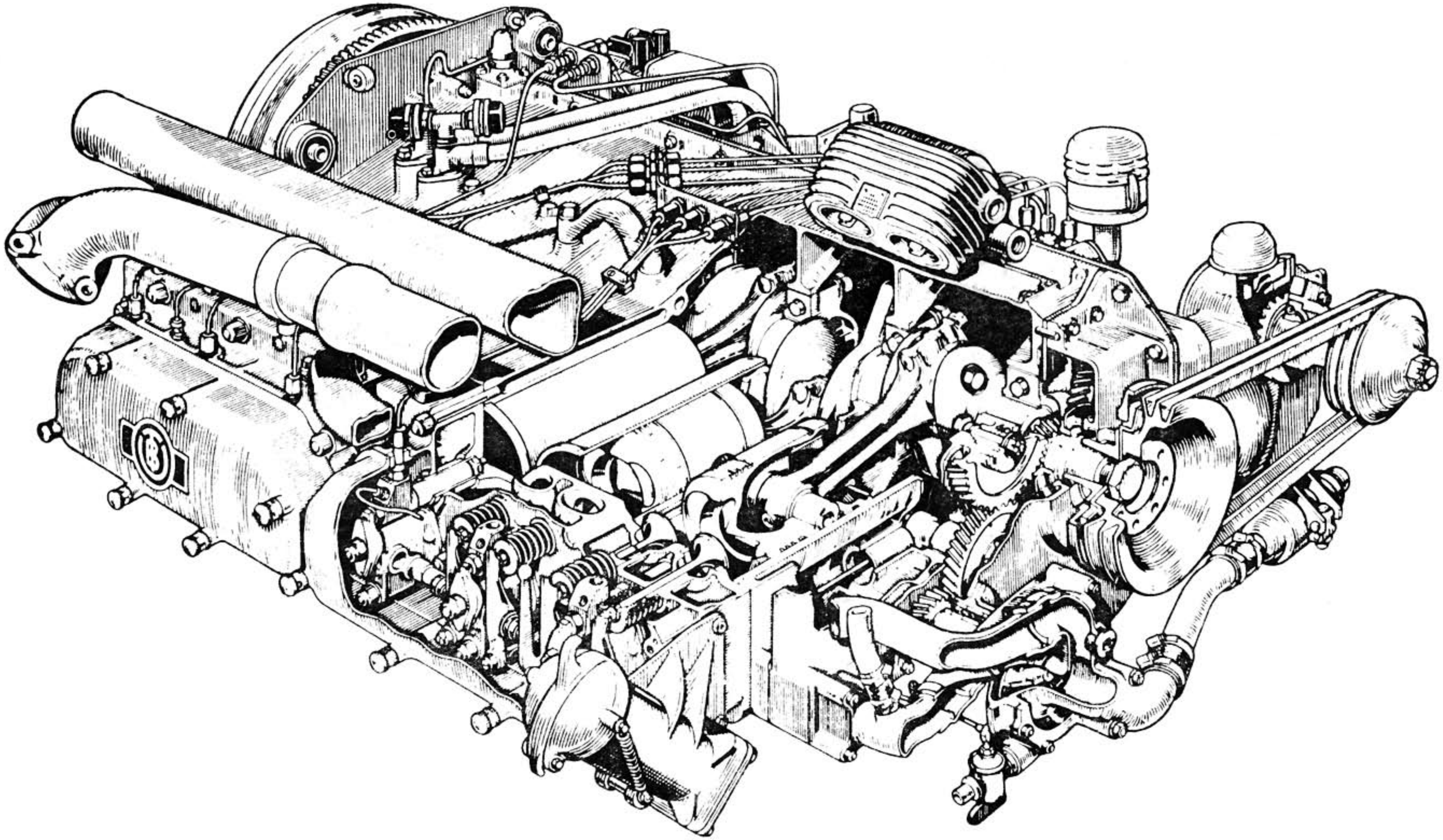
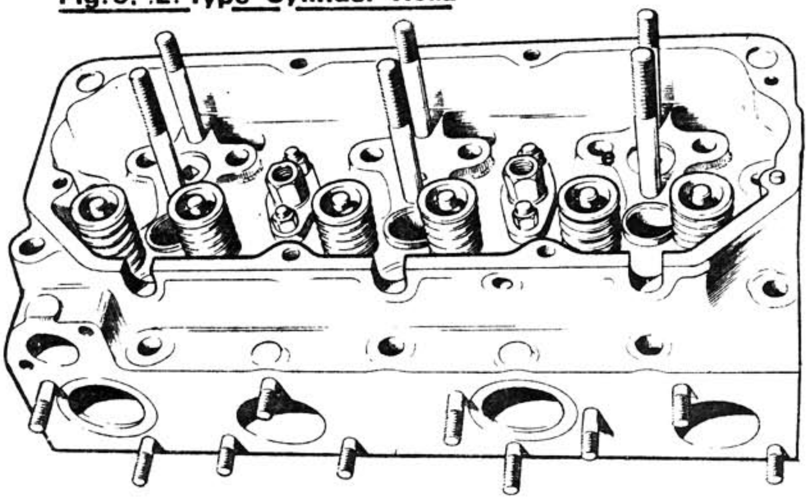
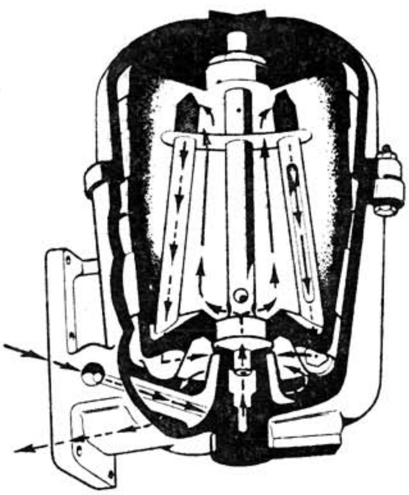


Fig. 9. 'L'. Type Cylinder Head



The engine lubrication system is of the 'wet sump' type and employs one gear type oil pump driven from the camshaft at the drive end of the engine.

Fig 10 Section through the Centrifugal Oil Filter



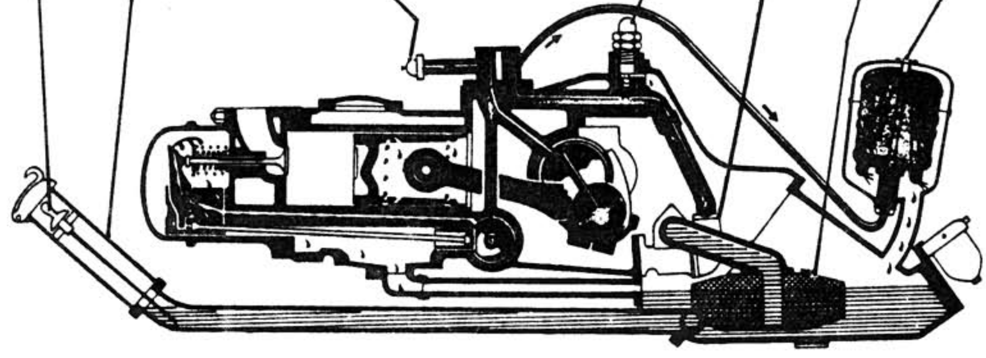


Fig. 11. Cross- Section of Lubricating Oil System

Oil, after passing through the engine returns by gravity to the sump, and is delivered by the oil pump via a suction strainer to the main bearings, and hollow camshaft. Between the pump and the main bearings is a relief valve and a bleed-off to a centrifugal filter Fig. 10 which after filtering the oil, passes it back into the sump. A branch taken from the main gallery feeds the timing idler gears at the free end of the engine and the air compressor. From the second and fifth camshaft bearings two feeds provide an intermittent oil supply to the valve gear.

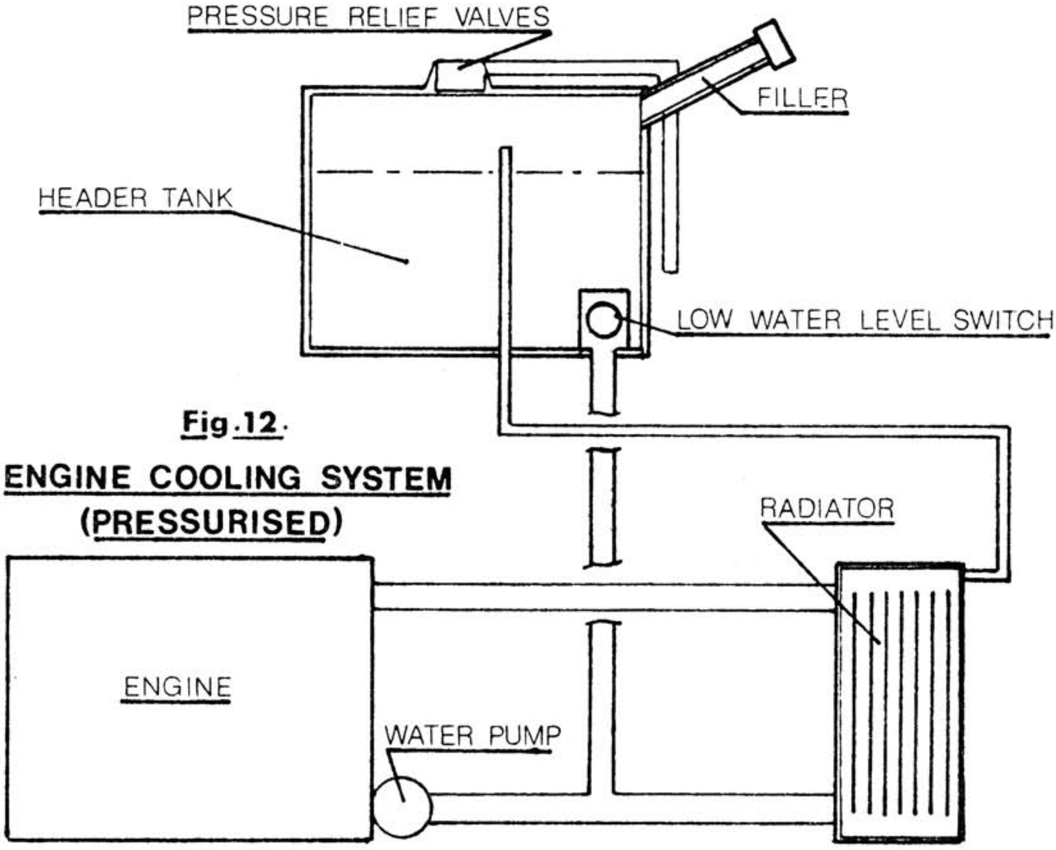


Fig.12.

ENGINE COOLING SYSTEM (PRESSURISED)

The 'L' type system uses one header tank incorporating a water level switch for each engine.

The pressurised system provides:

a totally enclosed system to reduce coolant losses, normal pressure in the system is approximately 2 p.s.i. and relief valves on the header tank are set to lift a 5 p.s.i.

(1) A low-pressure pump to circulate water through the engine and radiator.

(2) A fan to blow air over the radiator elements.

(3) A header tank or reservoir.

(4) A device for shutting down the engine if the cooling water falls below a safe level, a loss of $4^1/_2$ gallons.

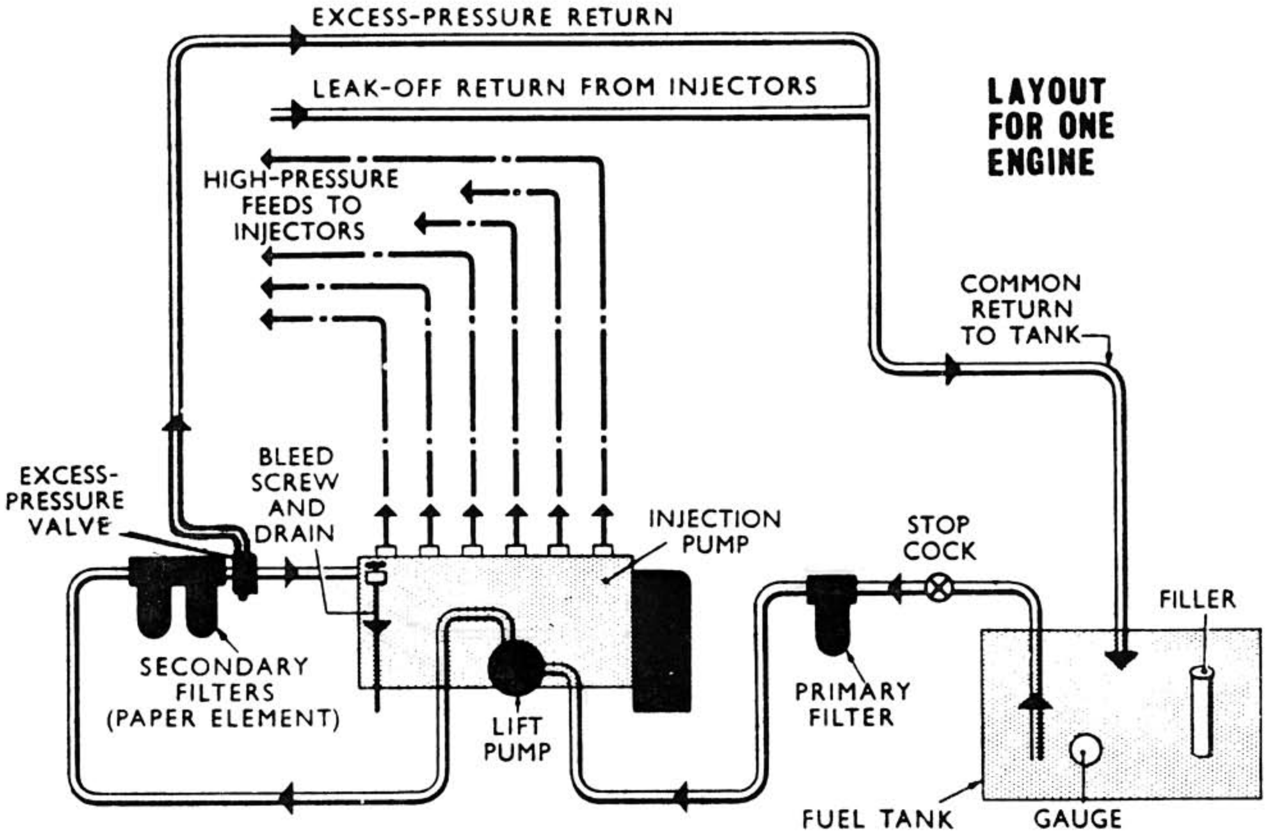


Fig. 13. Fuel Injection System

FUEL SYSTEM

The layout of fuel injection components is shown in Fig.13 and it can be seen that the lift pump draws fuel oil from the main storage tank via the primary filter bowl which has no element, and delivers it to the injection pump gallery or suction chamber by way of the secondary filters which are equipped with a pressure relief valve enabling surplus oil to be returned to the storage tank, the secondary filters have a renewable element of paper.

THE FUEL FEED PUMP - DIAPHRAGM TYPE (Fig.15)

The function of the fuel feed or lift pump is to draw fuel from the storage tank and deliver it to the injector pump and a small diaphragm-type unit bolted directly to the multi-element injection pump.

An eccentric on the fuel-pump camshaft operates the diaphragm through a bell crank lever as the camshaft revolves movement is transmitted to the lever which, by the action of the fork at the opposite end of the lever, displaces the diaphragm.

The action of displacement on the diaphragm causes a depression above the inlet plate valve which is then able to overcome its spring and, in consequence, to lift: allowing fuel to be drawn into a cavity through two passages. The return stroke is controlled by a special spring which returns the diaphragm to its former position and allows fuel oil to be pumped from the cavity, through the passages and ball valve to the fuel filter and onto the fuel gallery of injection pump. A constant pressure should be maintained in the fuel gallery, and when this has been reached the spring controlling the return stroke of the diaphragm ceases to function and the restricted action decreases the flow of fuel oil until the delivery pressure falls i.e. the pumping stroke of the diaphragm varies according to the amount of fuel required by the injection pump under varying engine loads.

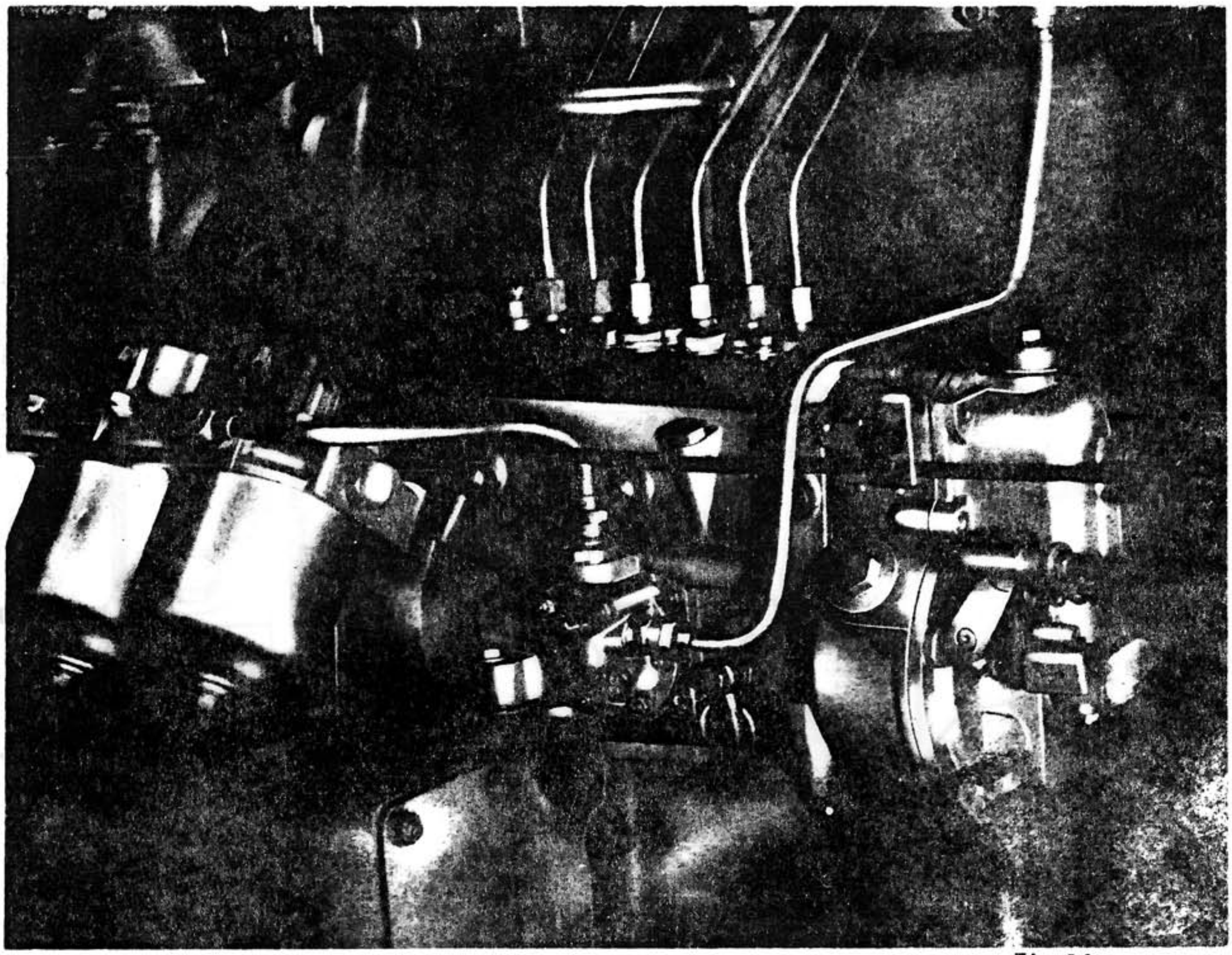


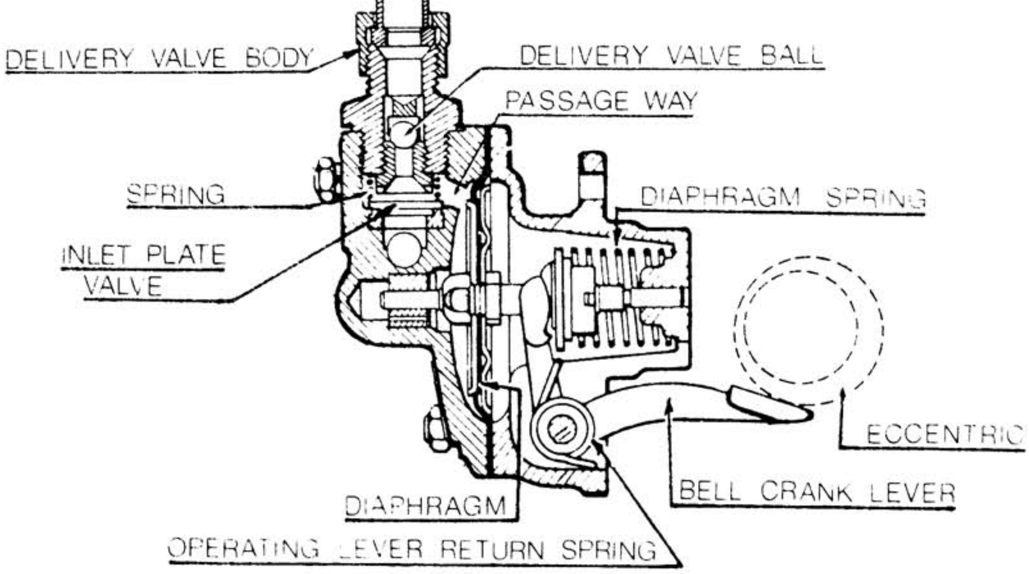
Fig.14.

HAND PRIMING

Depression of the priming lever, not shown, on the left hand side of the feed pump, displaces the diaphragm a full stroke as in normal running. The small lever is spring loaded to keep the priming mechanism out of engagement during normal operation of the pump.

The priming mechanism will not work when the foot of the bell crank is on the lobe of the eccentric, when this happens the engine should be turned a full turn before priming the system.

FIG.15. THE C.A.V. DIAPHRAGM FEED PUMP



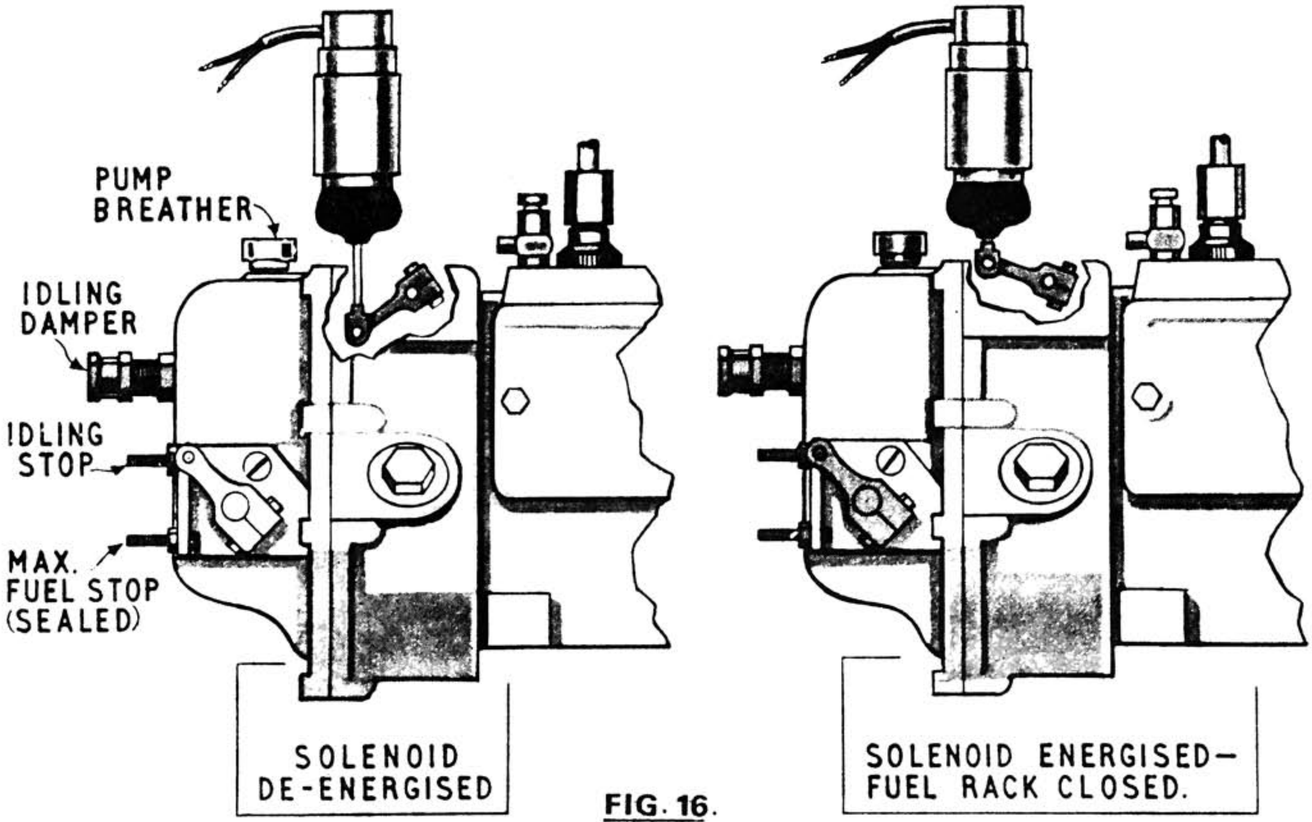


FIG. 16.

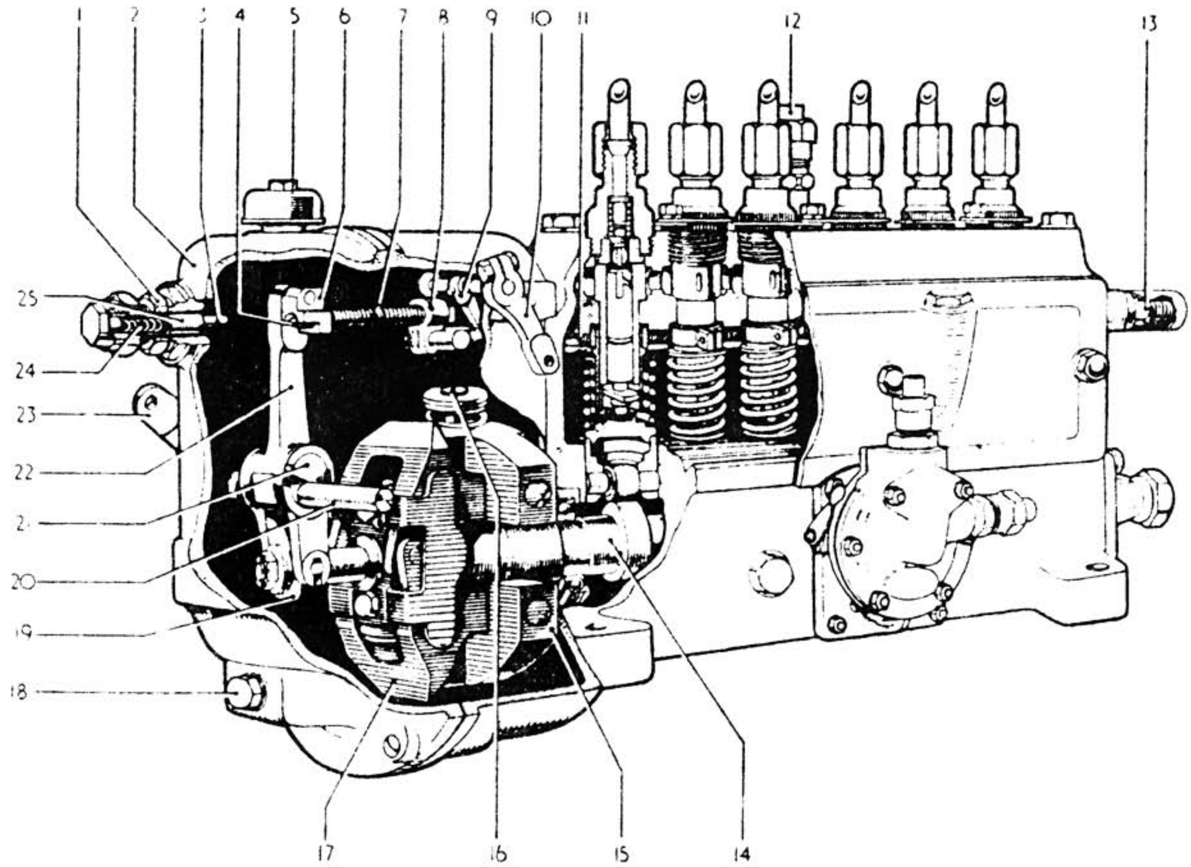
ENGINE SHUT-DOWN SOLENOID Fig.16

The engine shut-down solenoid is mounted on a bracket directly above the stopping lever and its purpose is to stop the engine when the stop button is depressed, low cooling water level and in the event of fire. The solenoid must be capable of shutting the engine down even when the throttle lever is held in the maximum fuel position.

The armature of the solenoid is directly connected to the stopping lever by means of a fork-ended rod, which in the running position is in the down position. Any of the above mentioned conditions will cause the engine to stop as the solenoid will be energised, the induced magnetic field will then cause the armature to lift and operate the stopping lever.

The shut-down solenoid is continuously rated and has two operating coils, one of them is only used for pulling in the armature, and the other holds the armature in the shut off position. The pull-in coil is isolated when the armature core rises against an actuating plunger and opens a moving contact.

If the armature core is prevented from rising sufficiently to open the moving contact, even though the engine does shut down, the solenoid will overheat and its coil will be burnt out in a very short time.



1. Auxiliary idling stop locknut.
2. Cover.
3. Auxiliary idling stop valve.
4. Link screw.
5. Air breather.
6. Lever link.
7. Link springs.
8. Link block.
9. Stop pawl.
10. Stopping control lever.
11. Control rod.
12. Fuel inlet.
13. Control rod stop.
14. Camshaft.
15. Fly-weights.
16. Spring adjusting nut.
17. Bell crank levers.
18. Drain plug.
19. Crosshead.
20. Shaft.
21. Eccentric.
22. Floating lever.
23. Control lever.
24. Auxiliary idling stop spring.
25. Auxiliary idling stop sleeve.

Fig.17. The C.A.V. 'LW' Governor fitted to type 'N' Fuel Injector Pump

B.U.T. RAILCAR MAX/MIN SPEED MECHANICAL GOVERNOR

The governor is enclosed in a housing bolted directly to the injector pump and its operation is shown diagrammatically in Fig. 18 It will be seen that two spring-loaded fly-weights (8) are mounted on an extension of the fuel pump camshaft, and to these weights are attached bell crank levers (7) which, in turn, are connected through a coupling rod floating lever (5) to the fuel pump control rod (3).

Starting (See Fig. 18 (A))

When starting the engine control lever (2) is moved to the right toward the maximum fuel position. This causes eccentric (4) and floating lever (5) to pivot about coupling pin (6). Since the fly-weights (8) are almost immoveable at this instant, this causes control rod (3) to move towards its maximum delivery position as in Fig. (b).

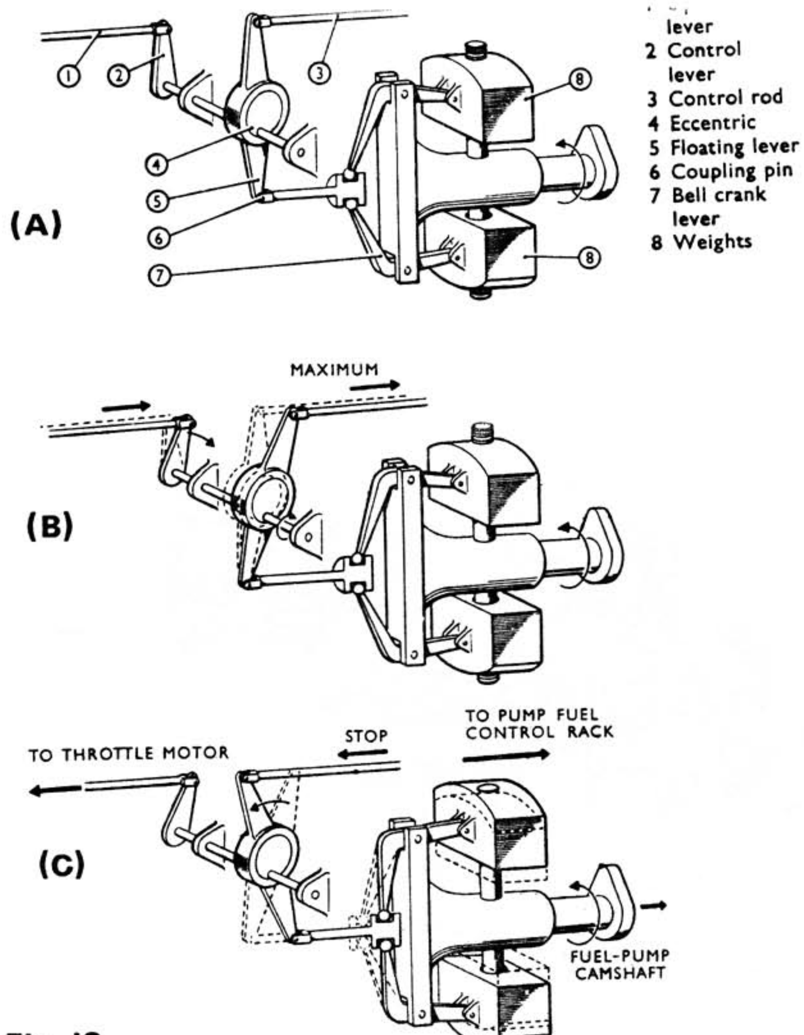


Fig.18

The engine fires and begins to run up to speed. If the control lever is brought back into the idling position the governor will take charge and hold the engine R.P.M. at a pre-determined value as follows :-
Fig. (A). Should the R.P.M. tend to rise the centrifugal loading on the weights will increase and cause the floating lever to pivot around the eccentric (held fixed by the control rod setting) and bring the rack into a reduced delivery position. Should the R.P.M. tend to fall the centrifugal loading is reduced, causing the floating lever to pivot around the eccentric in the opposite direction, and this moves the control rod to an increase delivery position.

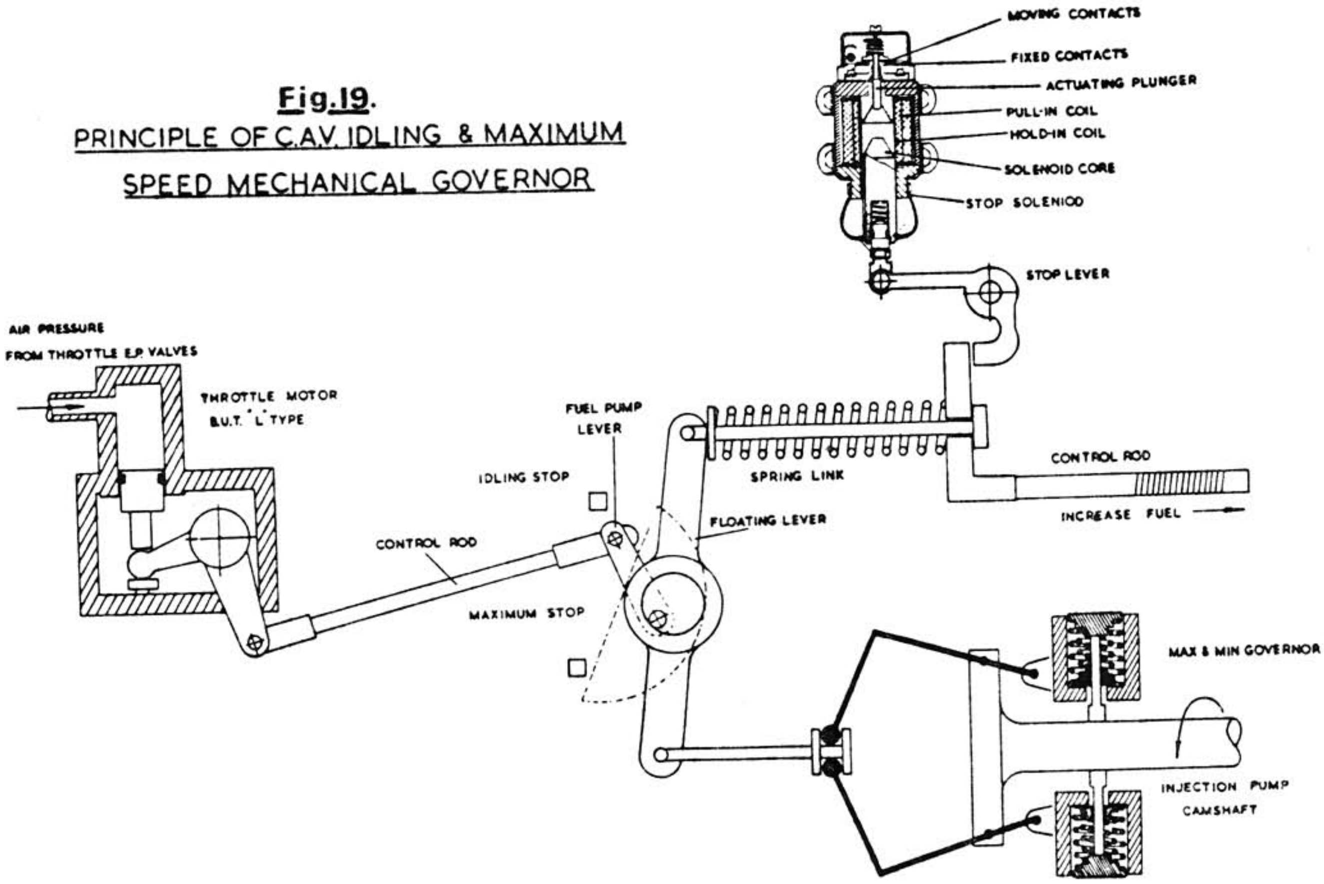
Accelerating (See Fig. 18 and Fig. 20)

When control lever (2) is moved from the idling position eccentric (4) moves floating lever (5) to the right, pivoting about coupling pin (6), so increasing rack travel to admit more fuel to the engine and allow it to accelerate.

Engine speed is determined solely by the control lever position and not by governor control. It will be seen from diagram Fig. 20 that due to the two strong inner springs the weights cannot move beyond this position until the maximum R.P.M. is reached. Conversely the weights cannot move from the position shown in diagram Fig.18 until R.P.M. has fallen to idling speed.

It will, therefore, be appreciated that when climbing a gradient R.P.M. will start to fall unless corrected through the throttle control.

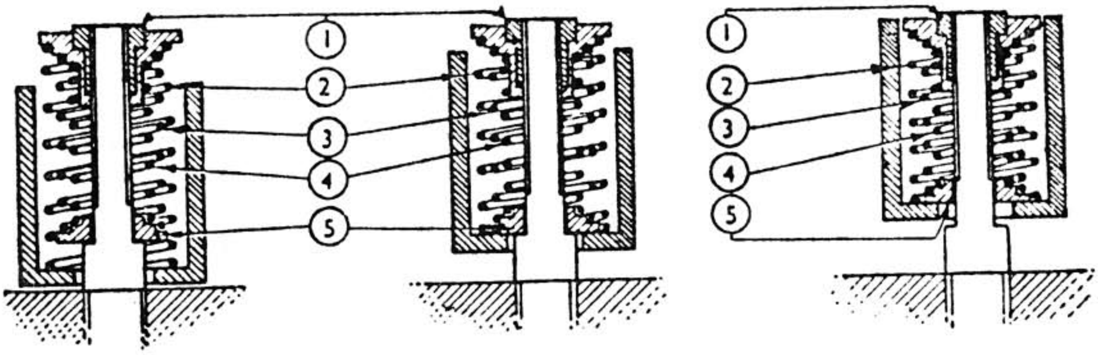
Fig.19.
PRINCIPLE OF C.A.V. IDLING & MAXIMUM SPEED MECHANICAL GOVERNOR



Maximum Speed Control (See Fig 18)

Should the control lever be opened to a position where the fuel pump delivers more fuel than the engine requires for the load, engine speed will tend to exceed the pre-determined limit. This will increase the centrifugal loading on the weights sufficiently to overcome the strong inner springs (Diagram Fig.18(C)). The weights will now travel further outwards and through the bell crank levers, pivot the floating lever about the eccentric to pull the control rod and bring the rack into a reduced fuel delivery position holding engine speed at a pre-determined maximum, irrespective of the control lever position.

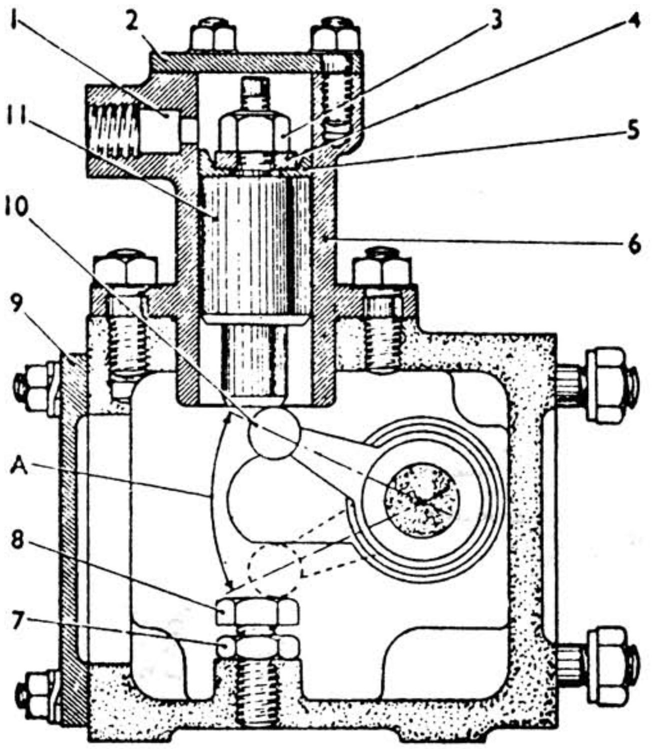
The maximum R.P.M. is therefore determined by the rating given to the inner springs.



1. Spring retaining nut.
2. Light outer spring.
3. Strong inner spring.
4. Strong inner spring.
5. Spring plate.

Fig 20

Section Through Throttle Control Motor



Section through throttle control motor showing travel of actuating lever at full throttle

Fig.21.

A. MAXIMUM TRAVEL 47° — FULL THROTTLE
1. AIR INLET PORT
2. CYLINDER COVER
3. RETAINING NUT FOR PISTON SEAL
4. RETAINING WASHER
5. PISTON SEAL
6. AIR CYLINDER
7. LOCKNUT
8. ACTUATING LEVER ADJUSTING SCREW
9. COVER PLATE
10. ACTUATING LEVER
11. PISTON

The throttle motor consists of four air cylinders (one of which is shown (6) in the cross section) attached to a box section casting. Each cylinder has a combined piston and rod (11) fitted with a synthetic rubber washer or seal (5).

A spindle carried in bushes passes through the length of the casing and has an operating lever at one end and an alternative clamped lever at the other end. Four ball-ended levers (10) are loosely mounted on the spindle together with four bosses which are keyed to the spindle. The connecting faces of the ball-ended levers and bosses are so constructed that any movement of the levers carried out by the action of the air on the piston rotates the spindle, the degree of this movement (A) being limited by four stop-screws (8) set at varying lengths in the bottom of the casting.

Air enters the appropriate cylinder through the inlet port (1) via the associated electro-pneumatic valve selected by the throttle controller and pushes the piston down until the controller is moved to another position.

THE FLUID COUPLING

This replaces the conventional clutch and also serves as a flywheel in evening the power transmitted from the engine and cushions irregularities in the power output. It consists of two main parts. The driving member is secured to the flywheel casing which, in its turn, is bolted to the engine crankshaft. The driven member, which is free to rotate within the outer casing formed by the flywheel, is bolted to the output shaft. The driving and driven members are each provided with a series of cup shaped pockets separated by radial webs and the interior of the coupling is filled to a chosen level with fluid. When the engine starts to run the driving member

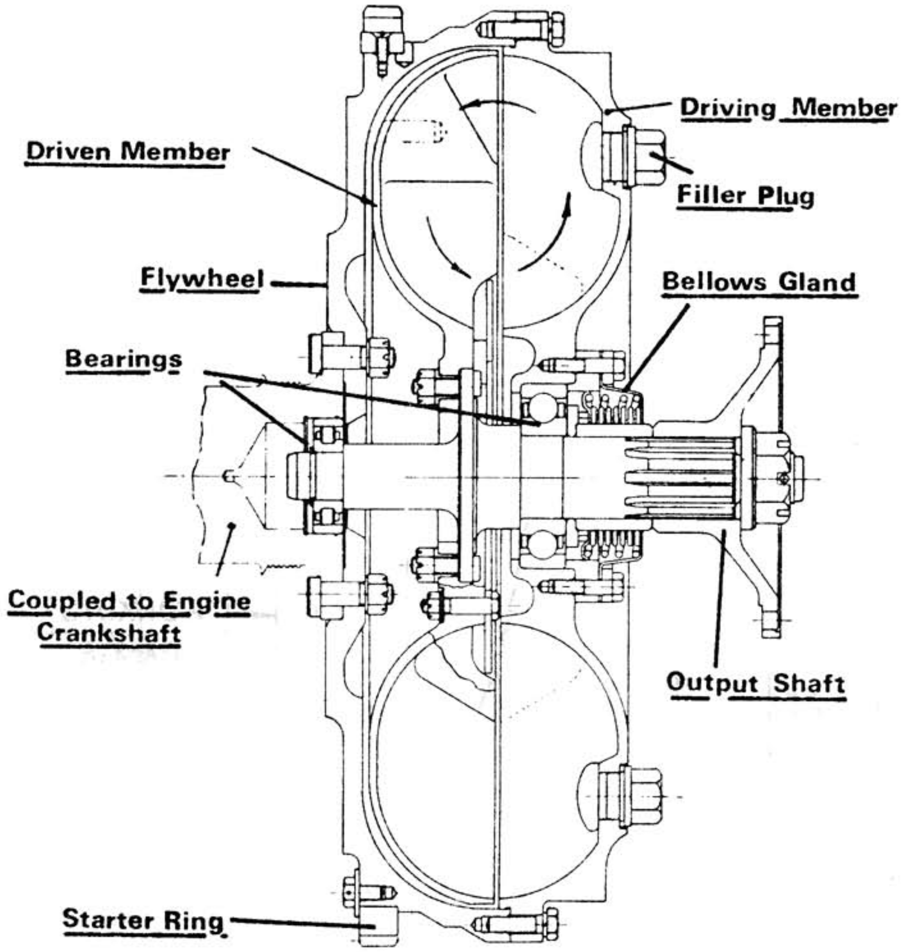


Fig 22 Fluid Coupling

of the coupling begins to rotate and fluid in the pockets is carried around with that member, gaining in centrifugal force as the speed rises. Under the action of this force the fluid will tend to move outwards from the centre of rotation, and the form of the cup shaped pockets deflects oil into the path of the driven member from which oil will be displaced and circulate in a direction indicated by the arrows. When engine rotation is slow the value of centrifugal force is at a minimum and the circulating fluid will have insufficient force to move the driven member.

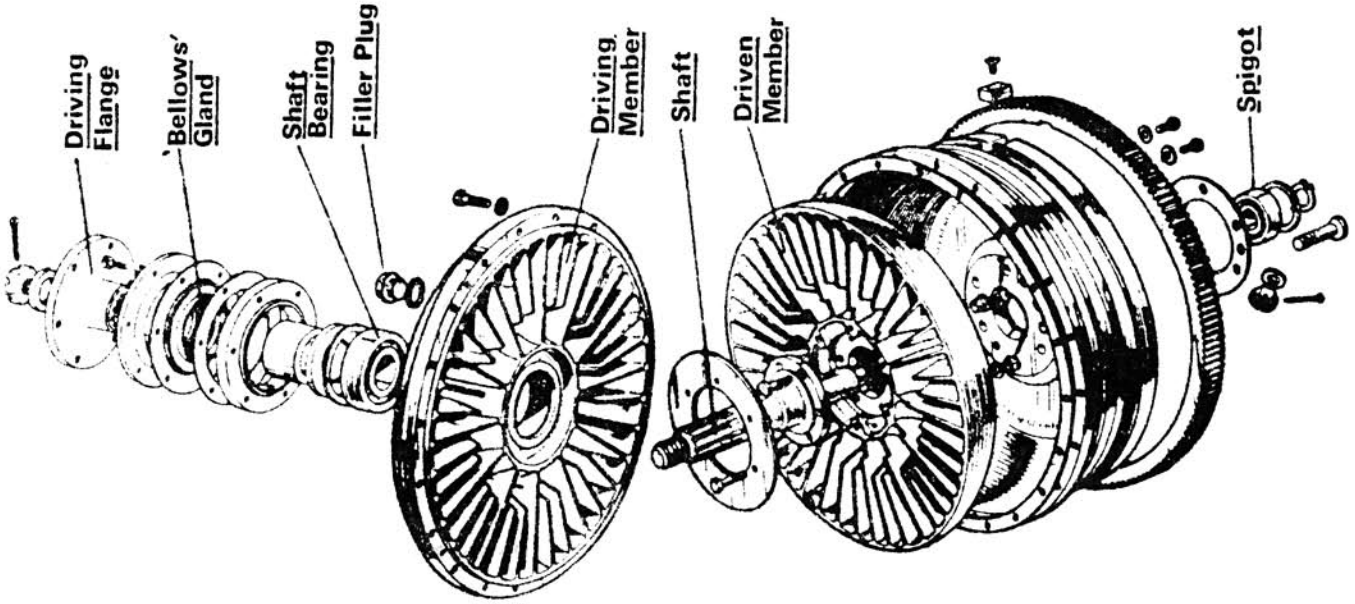


Fig.23. Exploded view of B U T Fluid Coupling

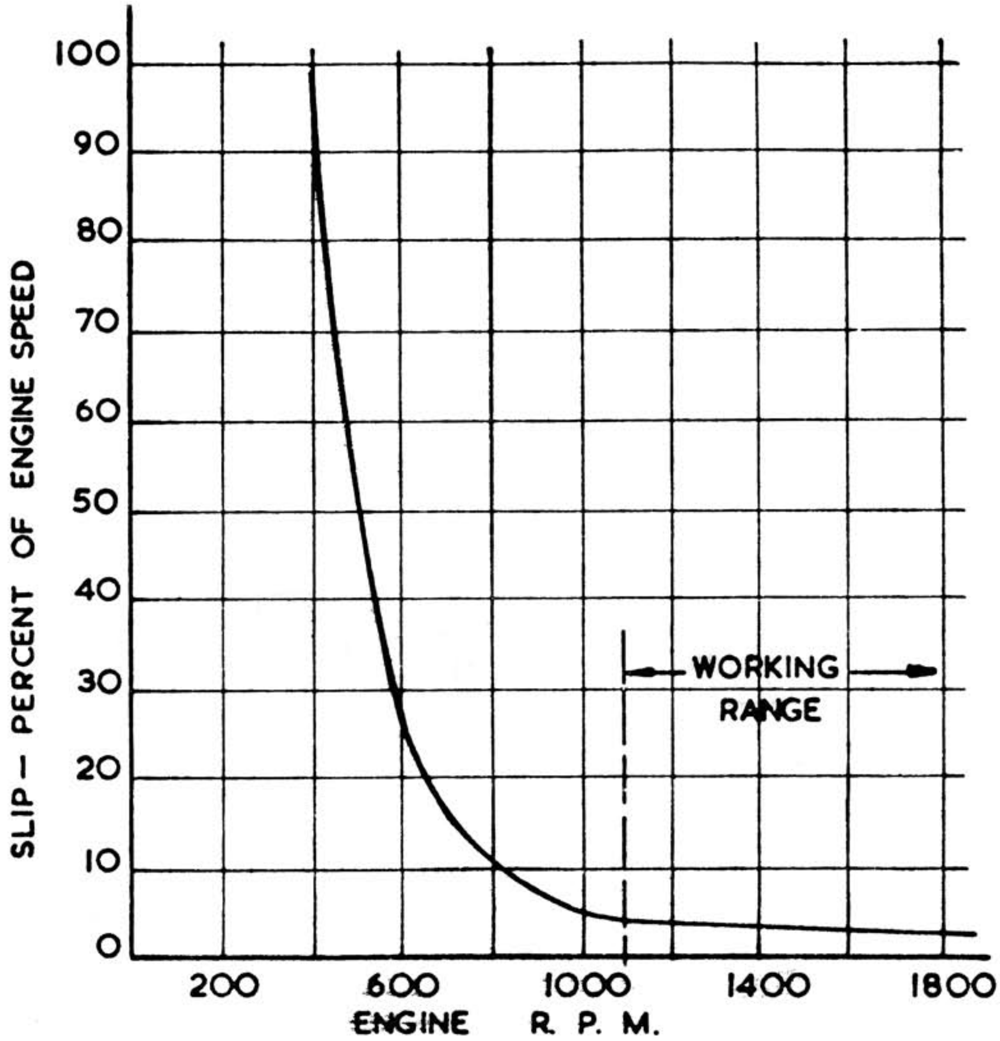


FIG. 24. Typical Slip Curve for Fluid Coupling.

As engine speed increases, so does the centrifugal force of the fluid, and circulation of this fluid will impart motion smoothly to the driven member until the best condition of drive results in which the output coupling has approximately 3% slip and rotates nearly at engine speed. Since oil is the driving medium, should one part of the coupling be brought sharply to rest by a failure occurring on either input or output side of the coupling, the fluid will be severely churned and heated up, but mechanical damage is unlikely to result. A typical slip curve for the coupling is shown Fig.24. and it is essential, when such a device is fitted, that engine revs. when driving are maintained in the operational range of the coupling or serious overheating will result.

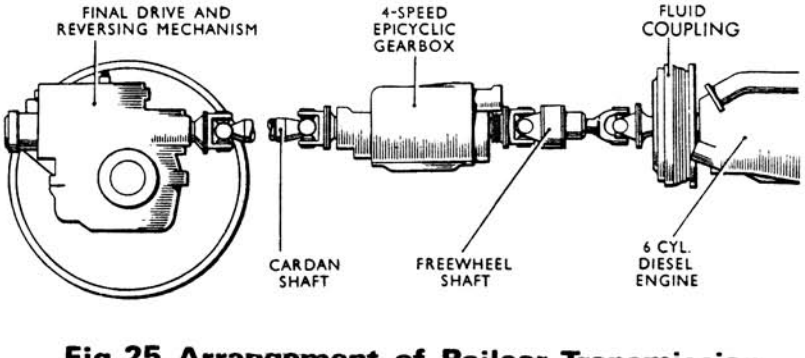


Fig.25. Arrangement of Railcar Transmission

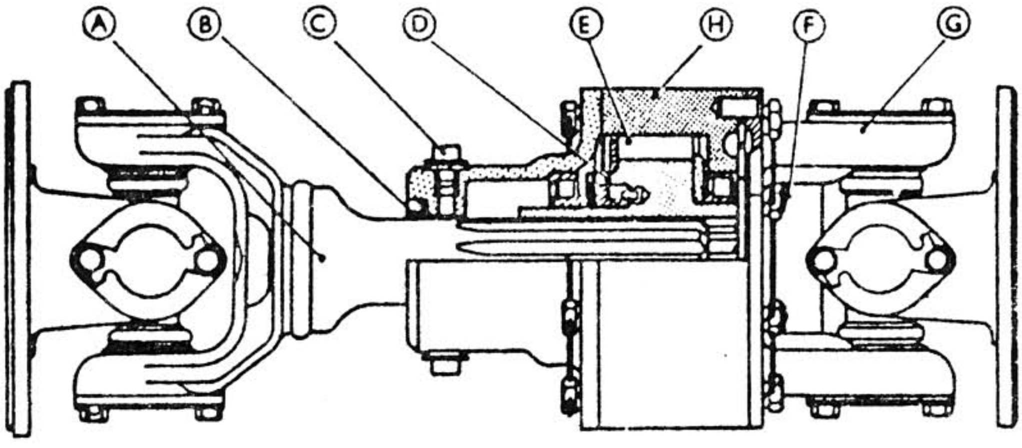


Fig.26. Propeller Shaft used between Fluid Coupling and Gearbox incorporating Freewheel. (B.U.T.)

A. Propeller Shaft; B. Seal; C. Lubricating Plug; D. Freewheel Cam; E. Freewheel Rollers; F. Lubricator; G. Universal Joint Assembly; H. Freewheel Cage.

FREEWHEEL

The principle of the freewheel is shown in Fig.27 It consists of a specially formed driving shaft not unlike a ratchet wheel, while the outer driven cage has a plain cylindrical interior. Resting on the "notches" of the driving shaft are hardened steel rollers. When the input driving shaft is rotated clockwise the steel rollers ride up the inclined planes and are trapped between the cage and shaft causing the cage to rotate. If the cage rotates faster than the driving shaft the rollers come out of engagement with the outer cage and no drive results. The hardened rollers will only engage the outer cage so long as the input shaft is tending to revolve faster than the driven shaft. If, on the other hand, the driven member, when coasting or changing gear, tends to revolve faster than the driving shaft, the rollers disengage automatically and roll out of the locked position.

The drive is now transmitted through a splined propeller shaft and Hardy Spicer coupling to the 4 speed gearbox.

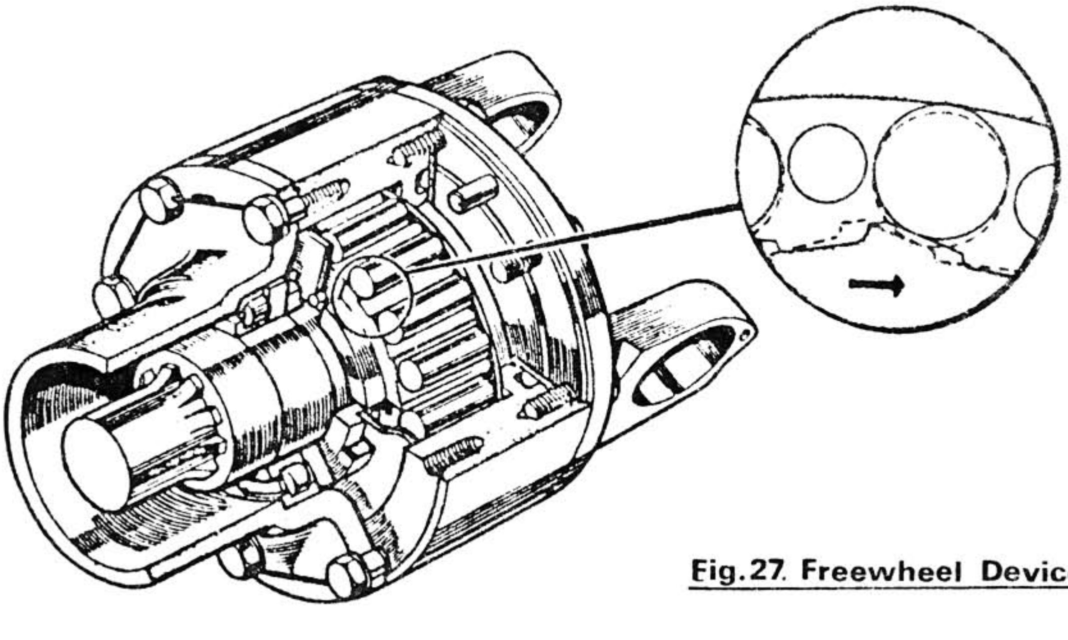


Fig.27. Freewheel Device

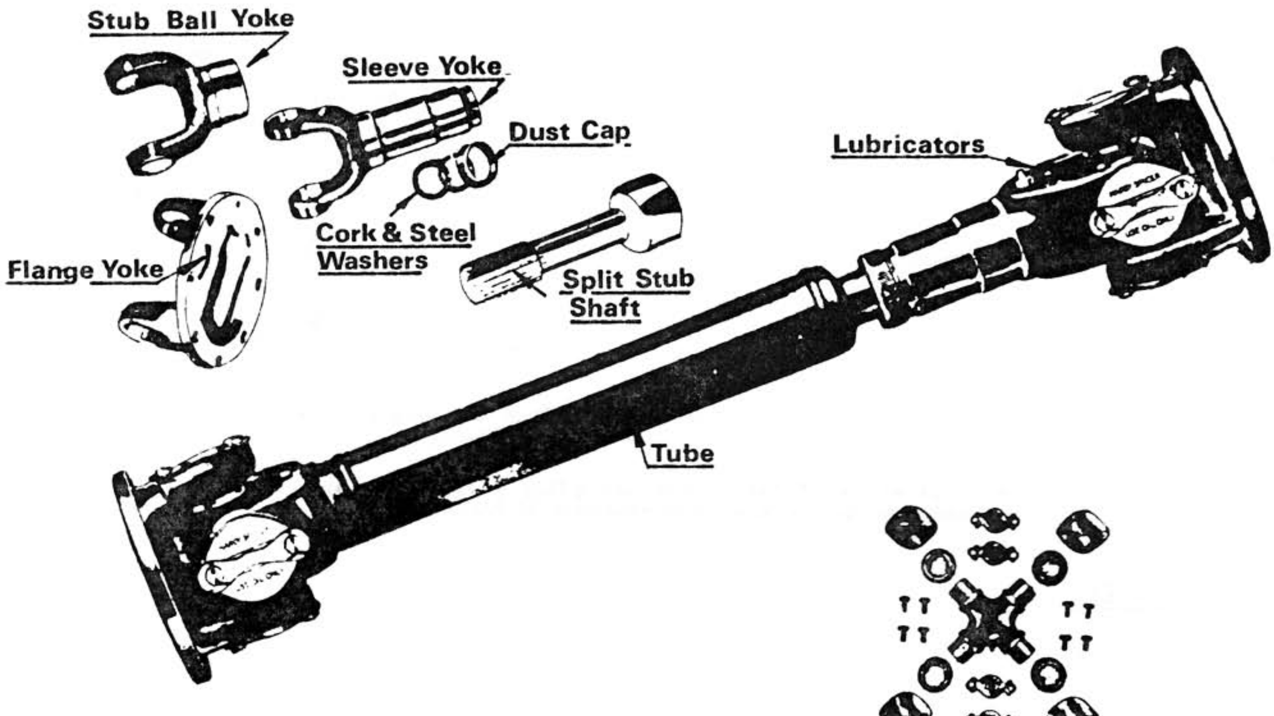


Fig. 28. The Cardan Shaft

INTRODUCTION TO THE GEARBOX

A high-speed internal combustion engine cannot be directly coupled to the rail wheels for the following reasons :-

1. It cannot start from rest when under load.
2. It will stall at a certain minimum speed of revolution.
3. Insufficient torque is produced at low rotational speeds.

To overcome the above difficulties a gearbox (or other equipment not described here) is interposed between the engine and the connection to the road wheels.

The gearbox ensures :-

1. The full engine output is available over its designed working speed range. In the case of B.U.T. 150 hp engines 1,100 r.p.m. to 1,800 r.p.m.
2. High torque is available at starting.
3. The torque is capable of smooth variation.
4. Minimum duration of loss of tractive effort when changing gear.

In short the gearbox provides a method of obtaining from the engine the right power at the right speed to work the train. (See graph Fig. 29).

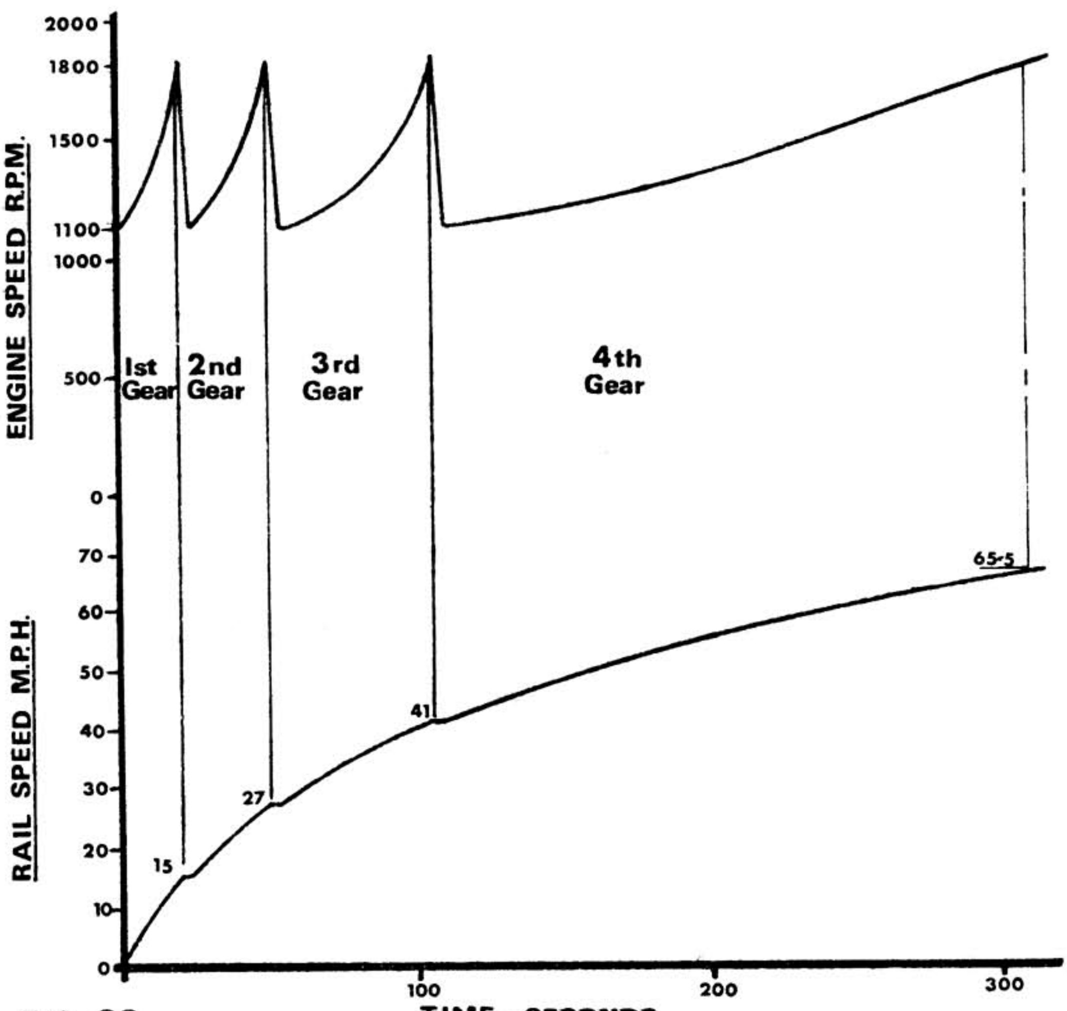


FIG. 29.

Four gear ratios and "neutral" may be obtained with this gearbox. Top (or fourth) gear involves all the gearing rotating as one unit, the other three gears being indirect, i.e. through gear trains.

Each indirect gear has its own air piston-operated balanced brake, which consists of two concentric bands, one within the other. They are wrapping in action, i.e. the friction of the brakes on the drums tends to increase their grip.

The running gear is what is known as the compound epicyclic type; this is best understood regarding the first speed gear train as being the basic train. Referring to Fig.30 the sun-wheel of this train is integral with the input shaft and meshes with the planets which are carried on a flange on the output shaft, known as a planet carrier. The planet wheels in turn mesh with the first speed annulus.

When this is held stationary by its brakeband, and input shaft is driven, the planets are caused to roll around inside the annulus, carrying with them the output shaft at a speed determined by the reduction ratio of this gear train.

By means of the other epicyclic trains the annulus of the basic train is caused to rotate at certain fixed increments of input speed, which has the effect of producing the other ratios.

Movement of the driver's gear selection lever energises an electro-pneumatic valve which directs air to the appropriate brake air cylinder. This raises the piston and through a toggle-mechanism applies the brake. The pistons for Nos. 1 - 3 gears are of varying size, according to the torque which each brake has to restrain.

The brake linings wear slightly, but this is compensated by an automatic adjuster.

Top (or fourth) gear is obtained by a clutch which locks together two of the running gear elements and causes all the gearing to rotate as one unit. In top gear there is no wear in the intermediate gear trains, and this is one reason why coasting should always be done in top gear.. The drive in top gear is direct from input to output. It is also important to note that to run in neutral would cause the compounding of the gear trains in the opposite direction, thus overspeeding gear three.

The gearbox utilises air pressure, from the main compressed air-supply.

Lubrication is by means of a gear-type oil pump on the input side.

Procedure for changing gear is given in the driving instructions, but the need to pause for TWO SECONDS after selecting gear before opening the throttle is stressed. From what has been explained, it will be appreciated that on selecting a gear the appropriate electro-pneumatic valve will be energised; this will allow air to act on the piston for that gear; the piston applies the brake band and the desired gear is obtained. TWO SECONDS is necessary for this sequence of operations, i.e. for air to operate the piston and the annulus to be stopped before the throttle is opened and torque applied.

It is possible in certain circumstances for wear on a brake band to occur faster than the automatic adjuster can overcome it. In such cases engine racing will occur when accelerating in the affected gear. If the tachometer persistently shows "change up" before the correct rail speed for that gear has been attained it is likely to be due to a slipping brake band. This can be corrected by the toggling procedure as described in the Driving Instructions.

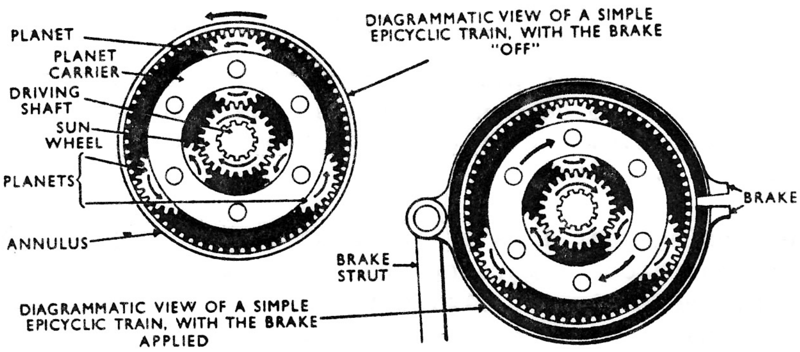


FIG.30. Simple Epicyclic Gear Train

First Gear

Fig.31 represents the first speed gear train in schematic form and explains the operation of the first gear. In the following explanations it has been assumed that the input shaft is revolving in all speed conditions. It will be seen that the input shaft is connected direct to the sunwheel marked No. 1.

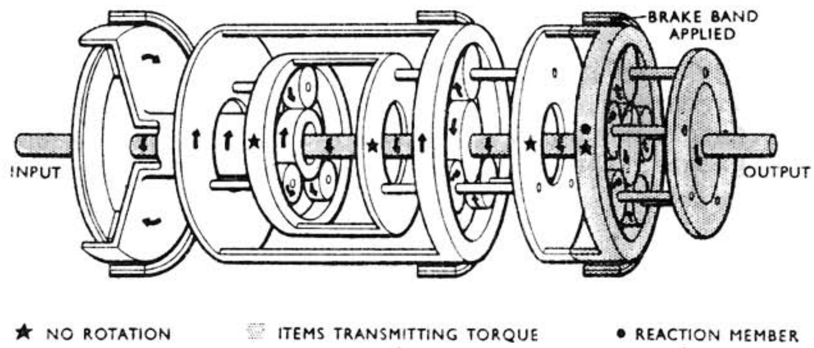


FIG. 31. Epicyclic Gear Train FIRST SPEED

With the annulus locked by the brake band and No. 1 sunwheel rotating, the planet wheels attempt to spin but are prevented by the locked annulus. By using the internal teeth of the annulus they can spin only by rolling and thus the planet spindles cause rotation of the planet carrier, which forms part of the output shaft, this now rotates in the same direction as the input shaft.

The speed of the output shaft in relation to the input is governed by the designed ratio, e.g. 4.28:1, which means that the input shaft revolves 4.28 times for each revolution of the output shaft.

The figure also shows what is taking place in the other gear train when the No. 1 brake band is applied.

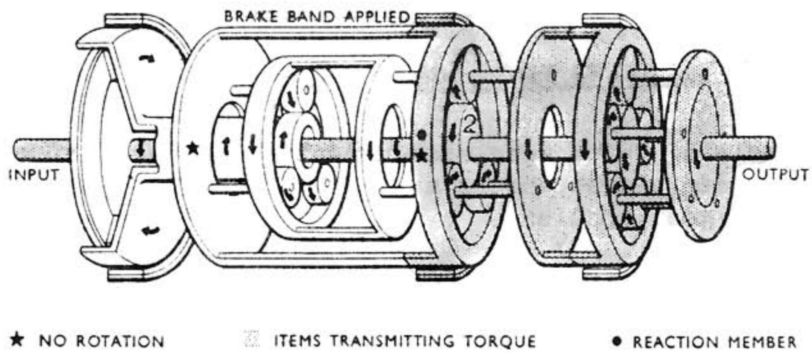


FIG. 32. SECOND GEAR

Second Gear

In this case the second gear brake band is applied after the brake band for the first gear has been released as shown in Fig. 32 When the second brake band is applied the following happens :-

(1) The first gear annulus is released.

(2) The second gear annulus is stopped.

(3) The sunwheel for No. 2 gear is rotating.

(4) The three planet wheels of No. 2 gear are rotating in the opposite. direction to that of the input shaft.

(5) As the annulus is stopped, but with the sunwheel revolving, the planet wheel carrier revolves.

(6) As the planet wheel carrier, which is directly connected to the annulus of the first gear, revolves, it causes the No. 1 gear annulus to revolve.

(7) As the first gear annulus and first gear sunwheel are already revolving in the same direction, this added rotation causes No. 1 gear planet wheels to rotate more quickly, this in turn causes the output shaft to rotate at a greater speed than in first gear.

Third Gear

Third Gear Fig.33 is obtained from the added motion which the third gear train passes to second gear and on to first gear. Summarising: Second gear is used to speed up first gear for second gear range. Third gear is used to speed up second gear which in turn will further speed up first gear for third gear range.

When third gear is selected a brake band stops the third gear drum to which is attached the third gear sunwheel.

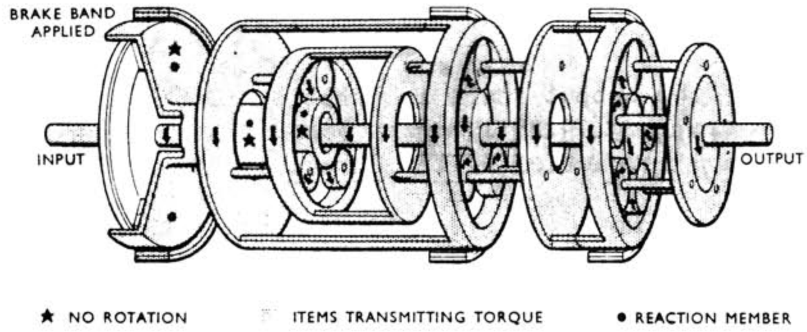


FIG.33. THIRD GEAR

The planet wheels of third gear are connected to the annulus of second gear and the second gear planet wheels are connected to the third gear annulus as well as to first gear annulus.

Rotation of sunwheel No. 2 will cause second gear planet wheels to rotate about their own axis. They in their turn will cause the second gear annulus to rotate, which in its turn will cause third gear planet wheels to roll round the stationary third gear sunwheel. This will cause the third gear annulus to rotate, causing second gear planet wheels to roll round second gear annulus.

The combined movements of the third and second gear annulus will cause the second gear planet wheels to move faster, thus the first gear annulus will revolve faster which in its turn increases the speed of the output shaft.

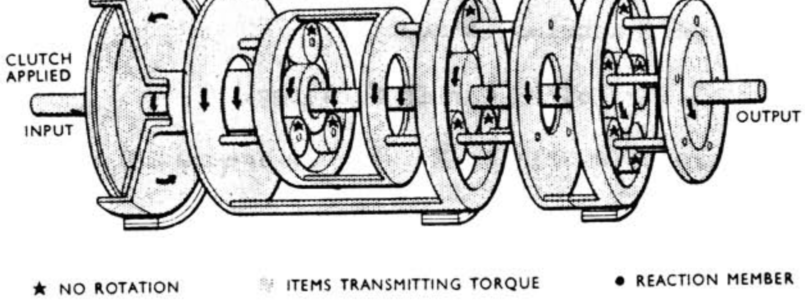


FIG.34. FOURTH GEAR

Fourth Gear

In Fig. 34 the fourth gear is not engaged by applying a brake band but by means of a clutch which connects the sunwheel of the third gear train to the input shaft and thus locks all the running gears together, which then revolve with the main shaft. It should be noted that there is no rotation of any of the planet wheels around their pins. This arrangement gives a "straight through" drive in top gear.

The following are the gear ratios :

1st Gear 4.28 : 1	3rd Gear 1.59 : 1
2nd Gear 2.43 : 1	4th Gear 1.1 : 1

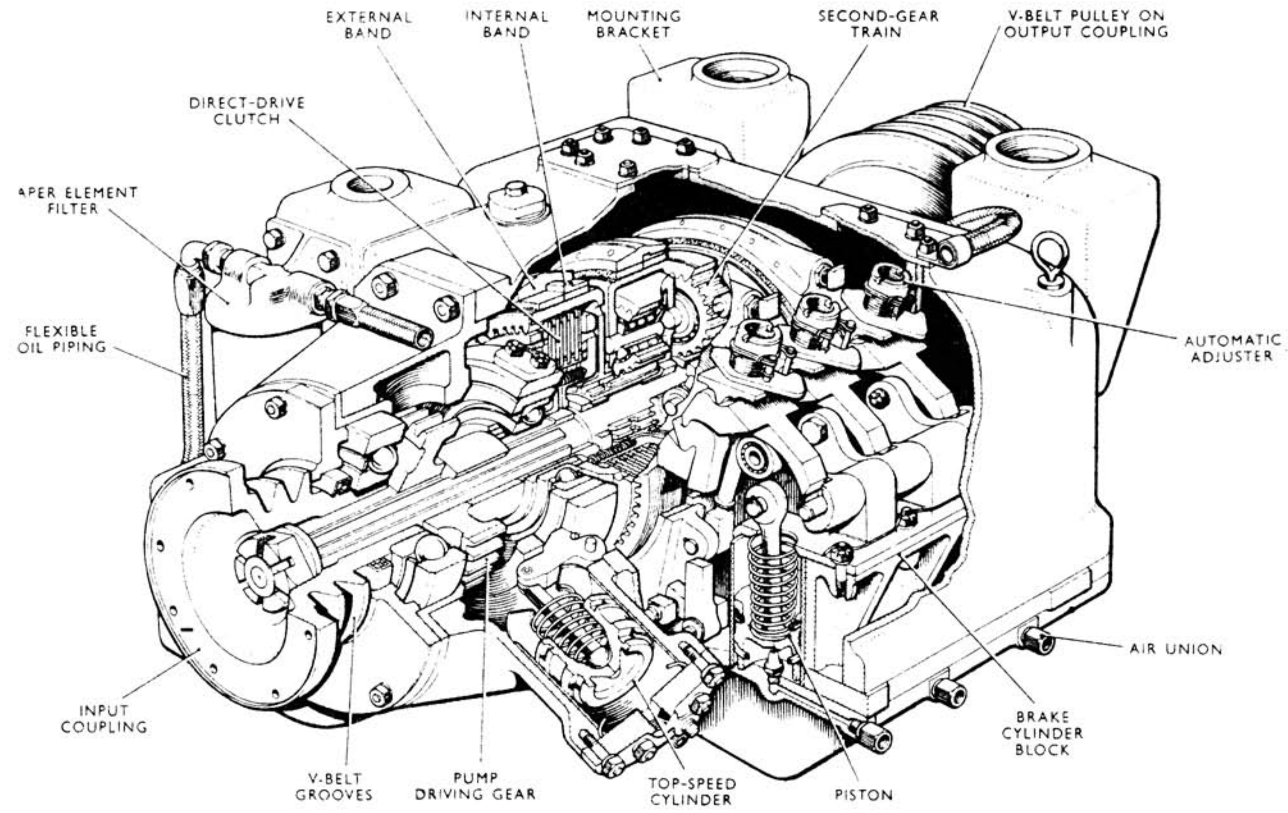


FIG. 35. AIR OPERATED R 14 GEARBOX

THE GEARBOX (Fig. 35)

From the part sectioned view of this gearbox the assembly of the various components may be followed and, looking along the main shaft from left to right, the direct-drive top speed clutch with its multi plate assembly is in the centre followed by the third, second and first speeds. Below this running gear can be seen the brake cylinder block containing three air cylinders and pistons operating brake bands for the three indirect speeds.

The pistons are of varying size according to the load transmitted which varies for each gear. "Vee" belt pulleys are provided on the input and output couplings and these are used to drive an exhauster and generator.

A sectioned view of the top speed clutch operation piston, cylinder and linkage is shown at lower left of diagram. The multi plate clutch operates so as to lock together the running gear elements and by preventing rotation of the gear trains relative to each other, causes all the gearing to rotate as one unit thus providing a direct drive from the input shaft to the output shaft. From Fig.35 it will be seen that air is admitted to the top speed operating cylinder forcing the piston upward and with it the piston rod, which in turn is linked to a lever pivoted on a pin. This lever, acting on a trunnion ring, converts movement of the piston into movement parallel to the input shaft and this applies the clutch.

Admission of air at main reservoir pressure to each of the gearbox cylinders is by the medium of E.P. valves operated by the gear change controller in the driving compartment.

The Gearbox is lubricated internally by a gear type oil pump mounted on the front casing and oil, delivered under pressure through an external feed pipe, passes to an oil "muff" fitted on the output shaft from whence it is delivered to the gear trains and bearings. A lubricating oil filter of the paper-element type is also provided.

The combination of a self-change gearbox and fluid coupling provides a highly efficient means of transmission and the operation of a number of gearboxes from one control is simple. The driver moves his gear controller to the desired position and thus energises the appropriate E.P. valve which will allow air to operate the piston for a particular gear, this piston then applies the brake band and the required gear is engaged.

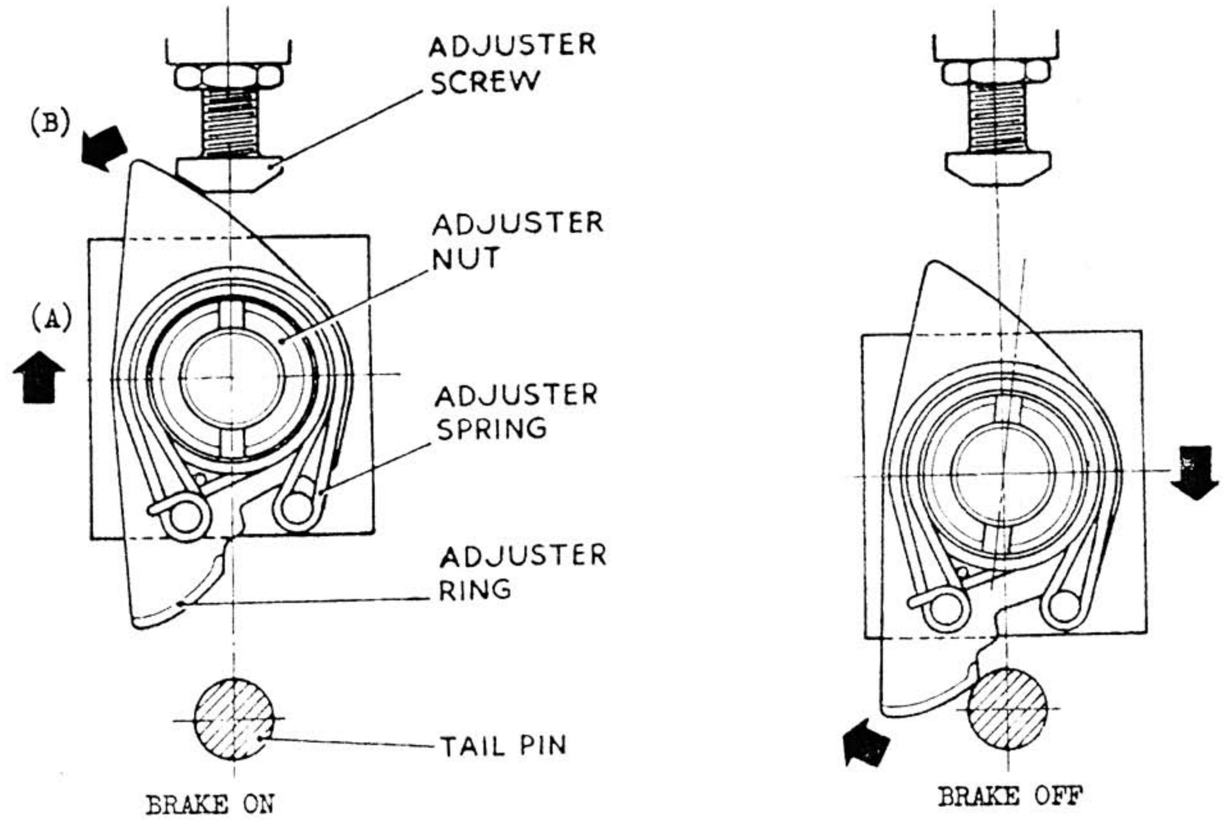


FIG.36.OPERATION OF THE AUTOMATIC ADJUSTER

THE AUTOMATIC ADJUSTER

The cross section of the R14 gearbox, Fig.37 shows the brake operating mechanism arranged to function when compressed air is directed into the cylinder. since the sunwheel is driven at all times the annulus is therefore rotating when in neutral gear, changing into gear by the application of the brake involves bringing the annulus to rest with consequent wear of the brake band. For such an arrangement to be satisfactory, automatic adjustment for brake band wear is desirable and this is provided by the "Toggling" gear.

As each brake is applied, the adjuster mechanism swings towards the brake band (arrow A) bringing the adjuster ring into contact with the adjuster screw. The faces of these components in contact is shown; in Fig.36 as the brake linings wear the adjuster ring is deflected when the brake is applied (arrow B) loosening the special spring formed round the adjuster nut.

When the brake is next released the spring tightens round the nut holding the adjuster ring in this position until the ring is partially rotated by striking the tail pin affixed to the gearcase.

This screws down the adjuster nut so shortening the effective length of the bolt by the correct amount and maintains the proper brake setting.

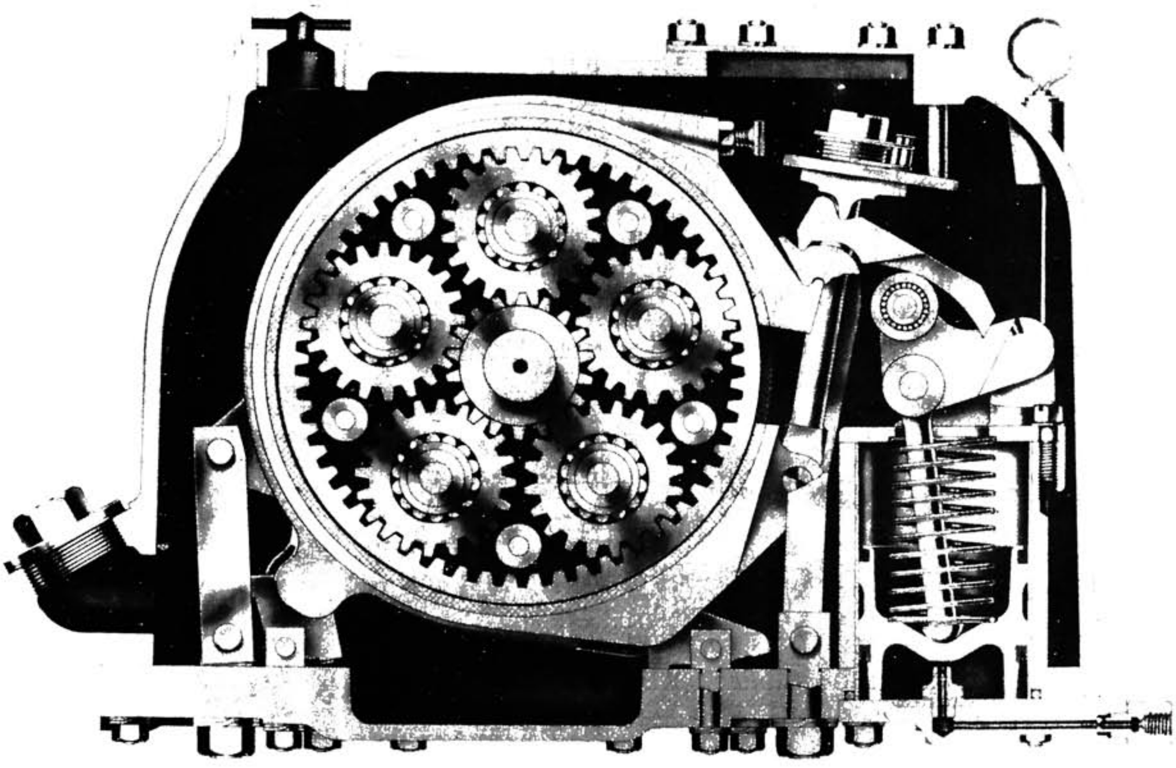


FIG.37. CROSS SECTION OF THE R.14.GEARBOX

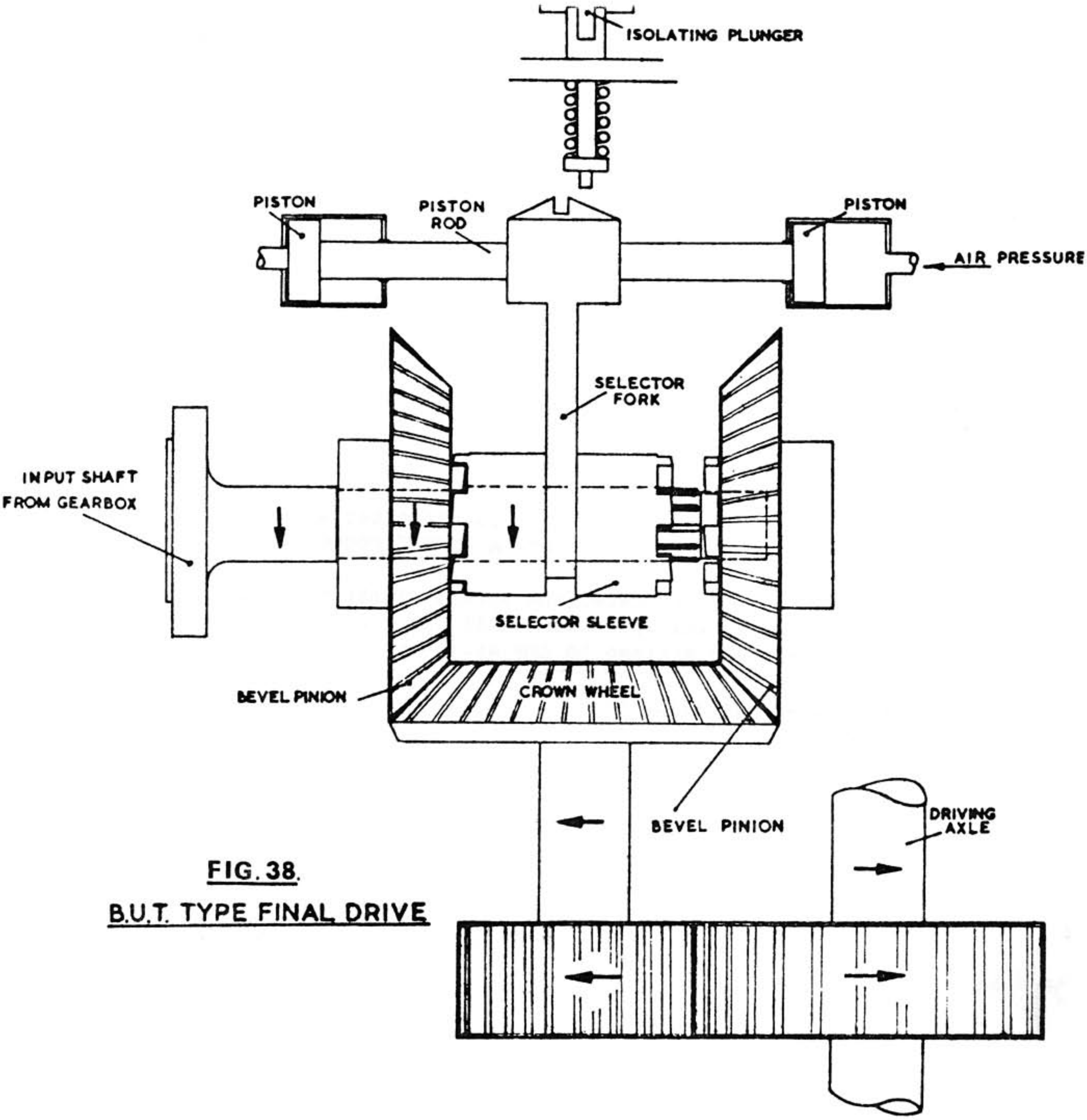
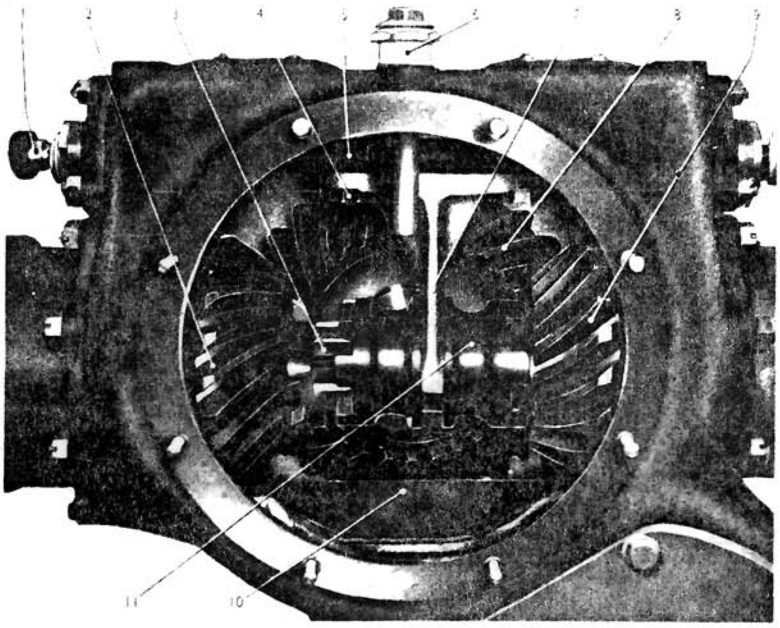


FIG. 38.

B.U.T. TYPE FINAL DRIVE

Final Drive Units

A final drive and reverse gearbox of the type, in use is shown in Fig. 38, from this it can be seen that the drive from the propeller shaft is transmitted to the splined input shaft on which is mounted the direction selector sleeve. This sleeve can be moved to left or right by the action of compressed air in the appropriate cylinder. The movement of the selector sleeve is controlled by the driver when he operates his Direction Selector Controller. From the diagram it can be seen that the splined selector sleeve has dog teeth out on its ends and that freely mounted axially are two bevel pinions also with dog teeth. If the selector sleeve is moved to the left it will engage the L.H. bevel pinion. Both of these pinions are in permanent mesh with a crown wheel. The input shaft is always rotating in the same direction and the bevel pinions will each have this direction of rotation given to them. However, the effect is that because the bevel pinions are relatively rotating in opposite directions, a reversed drive will be given to the crown wheel when the drive is transferred from L.H. to R.H. bevel. The continuation of the drive is through a spur gear train to the driving axle of the vehicle.



1. AIR SUPPLY PIPE BANJO PIN AND PISTON STOP BOLT.
2. PRIMARY BEVEL PINION.
3. DRIVING SHAFT.
4. STRIKING FORK SET-SCREW.
5. PISTON ROD.
6. BREATHER.
7. ENGAGEMENT DOG STRIKING FORK.
8. BEVEL WHEEL.
9. REVERSE BEVEL PINION.
10. BEVEL WHEEL OIL TROUGH.
11. ENGAGEMENT DOG.

FIG.39. FINAL DRIVE SHOWING ENGAGEMENT DOG IN FORWARD SPEED

When faults occur (see drivers fault guide) the selector sleeve should be locked in a neutral position to enable a defective transmission to be isolated and the set of vehicles moved without the damaged parts being driven. In this event the local stop button should be pressed to stop the diesel engine and the engine isolation switch turned to 'OFF' to ensure that this engine will not start until repairs have been made.

Since the final drive is mounted around the axle a restraint in the form of a torque arm is provided which by its spring seating allows a certain amount of movement to take place during travelling thus absorbing shocks etc.

Reversing The Final Drive Fig.40.

Referring to the diagram which is drawn for the forward position, air will flow from the 'forward' E.P. through the airline to push the final drive selector sleeves to their respective positions of 'SNAP' and 'LOCK'. Providing each one moves to its fully engaged position to toggle the final drive indicator switches, and the air pressure is sufficient to close the contacts of the air pressure switch for the forward direction, the circuit will be complete and the air and axle light will illuminate.

When a reverse direction is selected the same thing would apply, and any failure of either of the final drives to take up direction or the reverse pressure switch not making contact would mean that the air and axle light would not illuminate, and the specific instructions laid down in the Drivers fault guides and other publications should be strictly carried out.

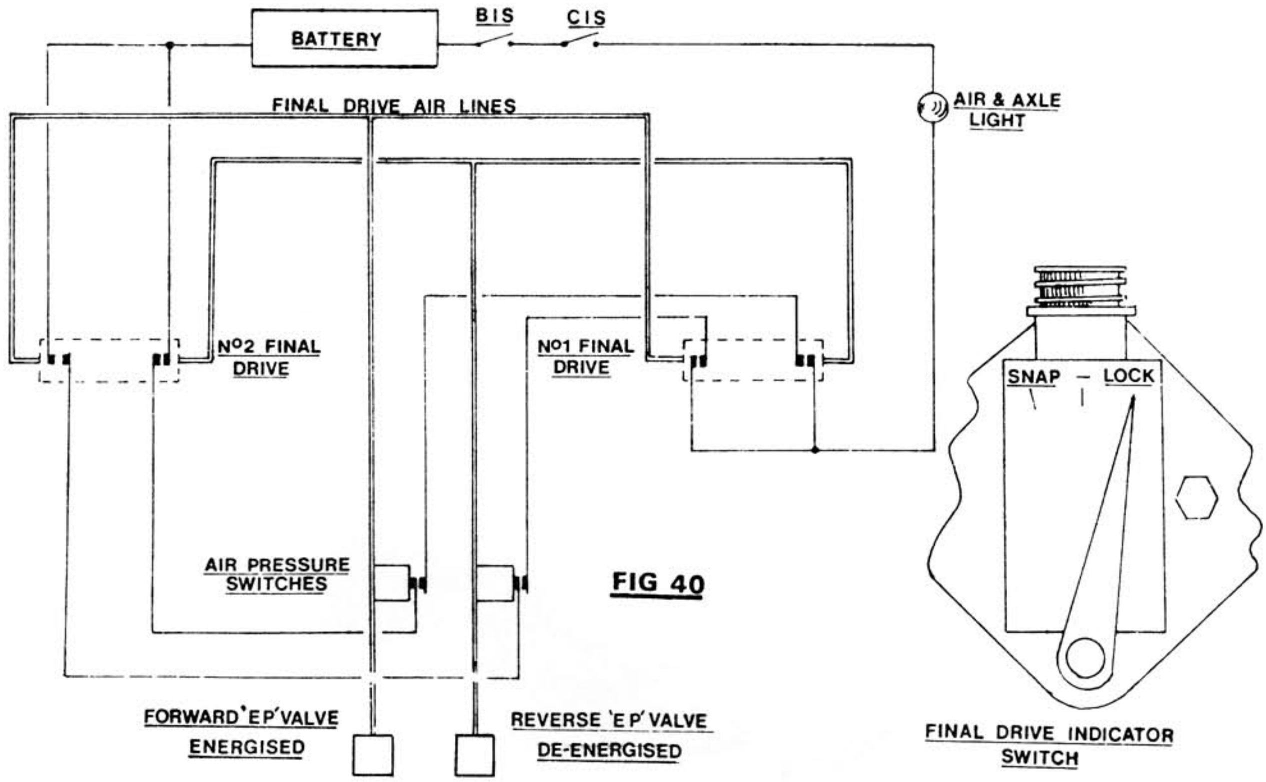


FIG 40

FINAL DRIVE INDICATOR SWITCH

THE COMPRESSED AIR SYSTEM FIG.41.

Each engine is fitted with an air compressor which feeds into a common reservoir and E.P. valve system. Air lines from the E.P. valves feed the appropriate cylinders of each throttle control motor, gearbox and final drive unit of the power cars.

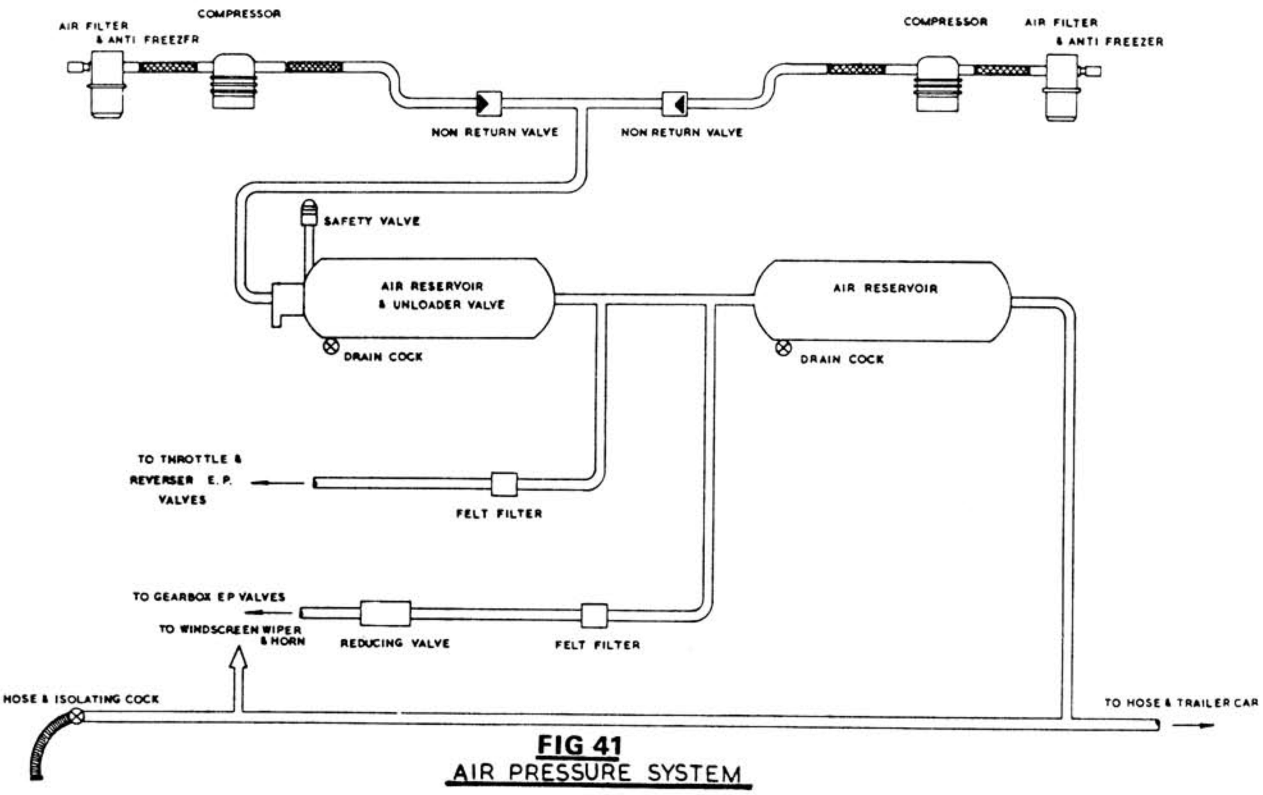
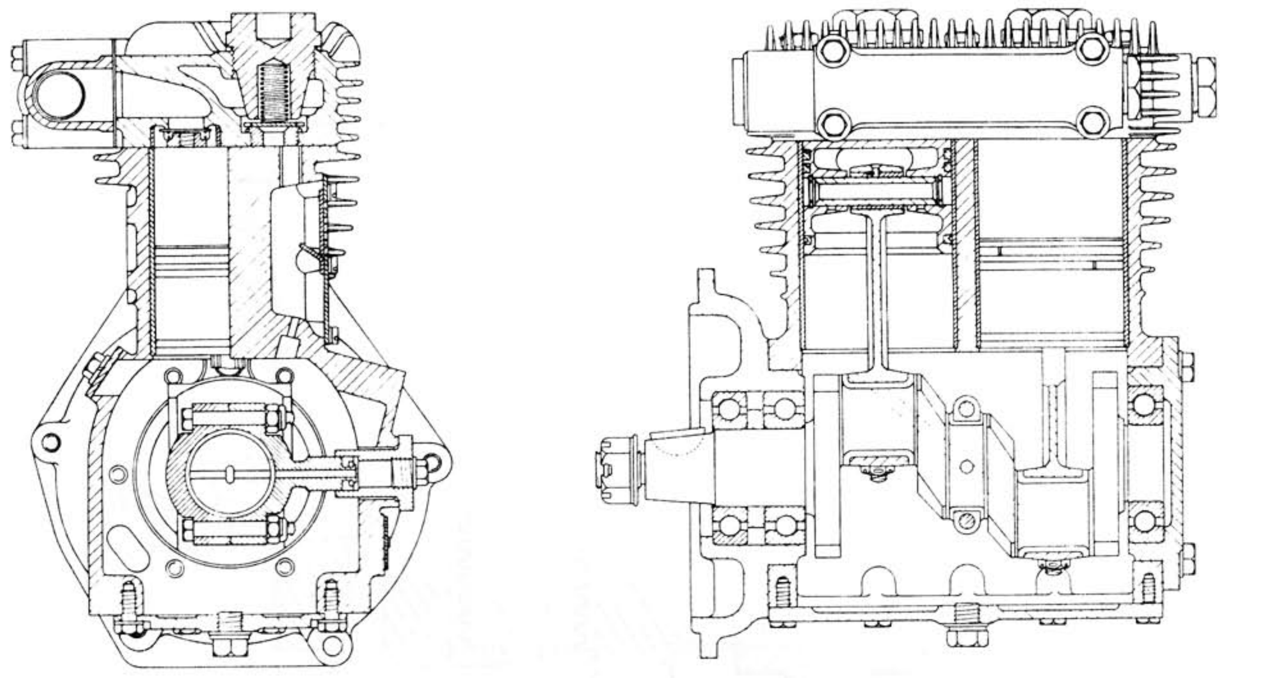


FIG 41
AIR PRESSURE SYSTEM

FIG. 42. SECTIONED VIEW OF AIR COMPRESSOR



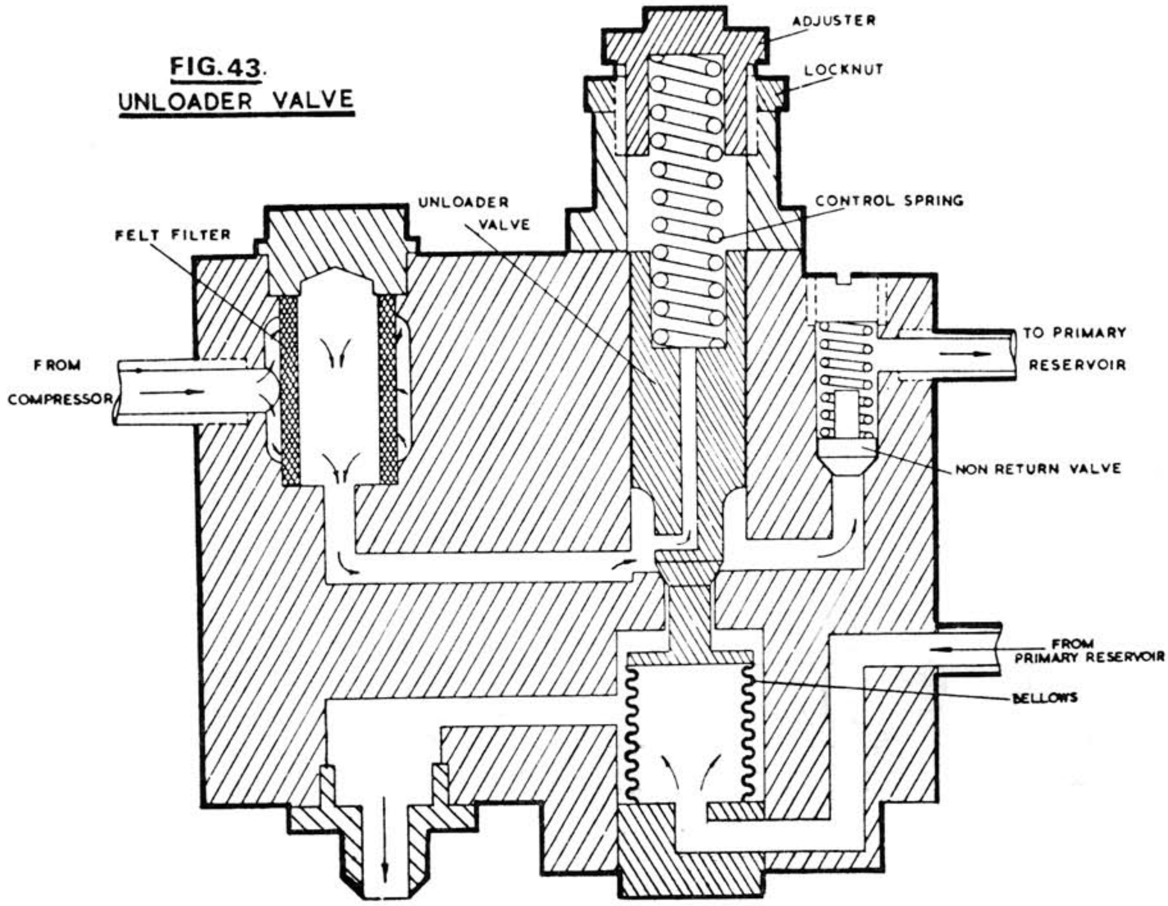
Intake air is drawn through a felt filter and enters the venturi of the Anti-freezer. Some of the air is made to pass into a container holding the anti-freeze, which evaporates and passes with the air back into the main stream to the compressor. This mixture of air and vapour has a very low freezing point and ice accumulations in the air lines are thus avoided during cold weather. The container is only filled with the Anti-freezing fluid during exceptionally cold weather.

The Compressor is an air-cooled twin cylinder reciprocating type machine, mounted on and directly driven by the diesel engine which also supplies oil for lubrication. The trunk type pistons are provided with two compression rings and one oil scraper ring. The cylinder head embodies the inlet and delivery valves which are of the spring loaded disc type. The compressed air is passed through non-return valve before joining the common feed to the reservoir system.

The Unloader Valve Fig.43.

No provision is made for disconnecting the drive to the compressor, which runs all the time when the diesel engine is running, so the compressed air is passed to the unloader valve before it enters the air reservoirs. This valve is designed so that when the reservoir reaches 95 p.s.i. admission of air is stopped and the compressor is allowed to exhaust direct to atmosphere and thus run lightly loaded. From the diagram it can be seen that air entering the valve body is forced through a felt filter past the spring closed unloader valve, past the non return valve, into the reservoirs. The unloader valve stem is attached to a bellows the interior of which is in communication with the reservoir. When pressure reaches 95 p.s.i. the load acting inside the bellows is sufficient to overcome the spring and the unloader valve rises, providing an escape path for the air via the silencing chamber to the atmosphere. The non return valve seals off the air in the reservoir. As the reserve of air is used up, pressure within the reservoir and bellows chamber is reduced and at about 75 p.s.i. the unloader valve can seat and air is again allowed to charge the reservoir.

FIG. 43.
UNLOADER VALVE



In the event of the unloader valve becoming defective a blanking nut is provided adjacent to the unloader valve and can be used to seal off the exhaust to allow the train to proceed.

The pressure in the system will now be limited to about 100 p.s.i. by the spring loaded safety valve fitted on the reservoir and the unloading feature of the system will not operate. Use of the blanking nut must be reported at the earliest opportunity.

From the reservoir system air is distributed to the E.P. valves for throttle and direction control and gearboxes.

THE ELECTRO - PNEUMATIC CONTROL SYSTEM

For various reasons an electro-pneumatic control system is used. This provides for compressed air operation of the gearbox, final drive and engine speed control. The supply of air to these services is governed by electrically operated air valves. These air-operated (E.P.) valves are controlled from the driver's desk. By using electrical relays, one for each E.P. valve, the battery on each power car is now made to operate the E.P. valves on that car, and the relays only are supplied with current from the controlling cars battery.

After looking at the principles of an 'E.P.' valve, the following simplified schematics namely 'gearbox' 'throttle' and 'reversing control' will help you to understand more clearly the principles involved. For example in the case of engine speed control the controlling cars battery supplies current through the main, control and reversing switches to the throttle control. movement of the driver's throttle handle passes this current, in sequence, to one or more relay coils. These relay coils, when energised, close contacts which pass current from the power car batteries to the related electro-pneumatic valves, and in turn the E.P. valves admit air to the appropriate throttle motor cylinder. An overlap is provided to produce a smooth increase in engine speed.

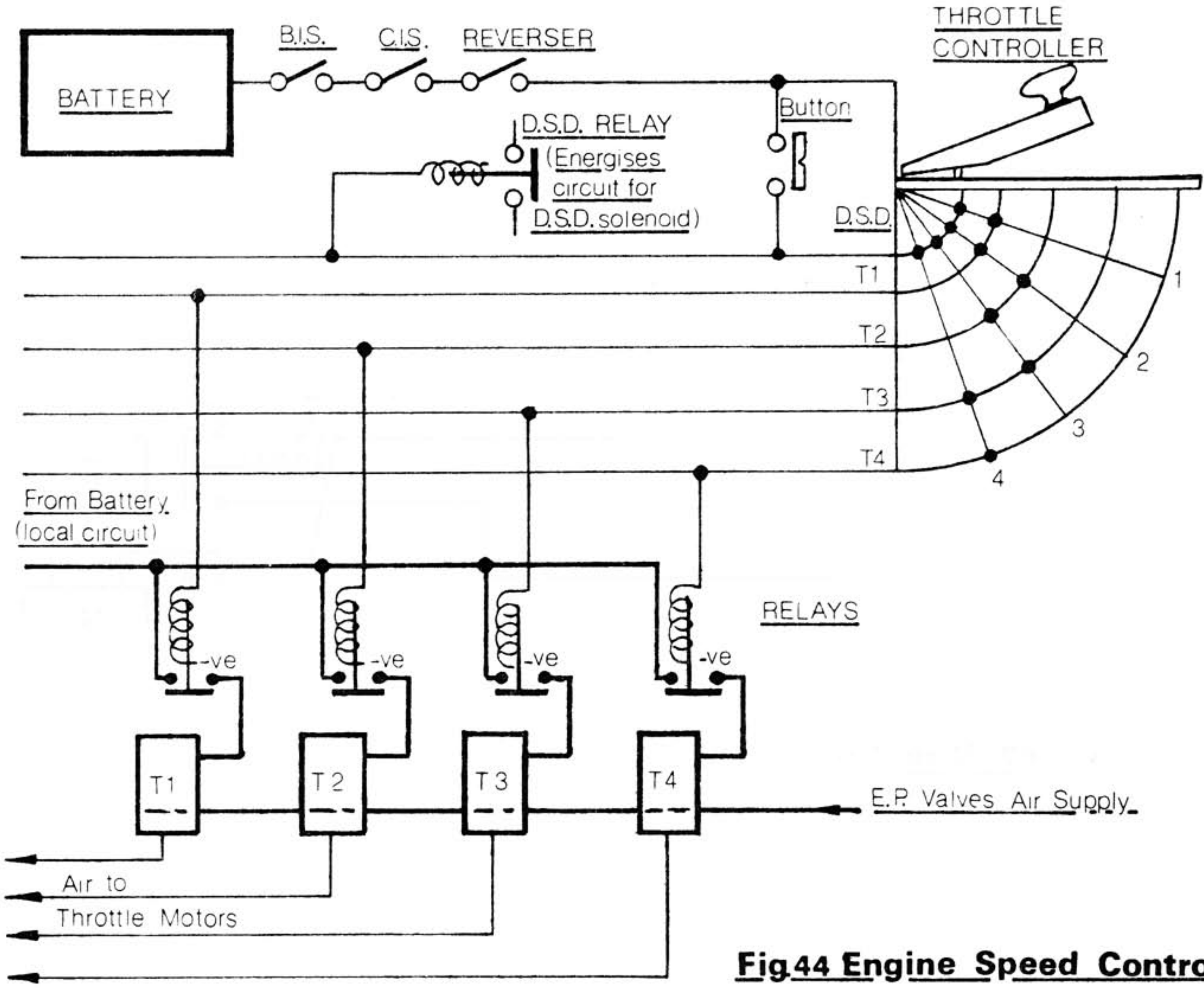


Fig.44 Engine Speed Control

FIG.45. THROTTLE CONTROLLER

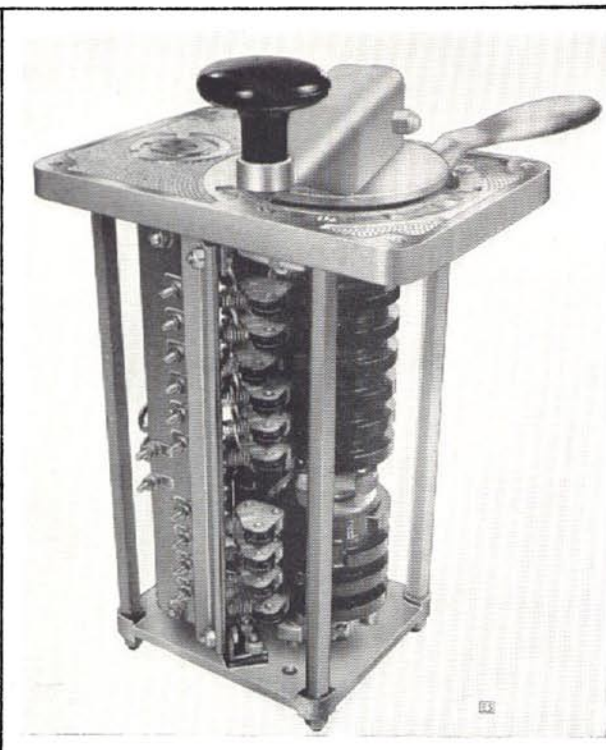


FIG.46 GEARBOX & DIRECTION CONTROLLER

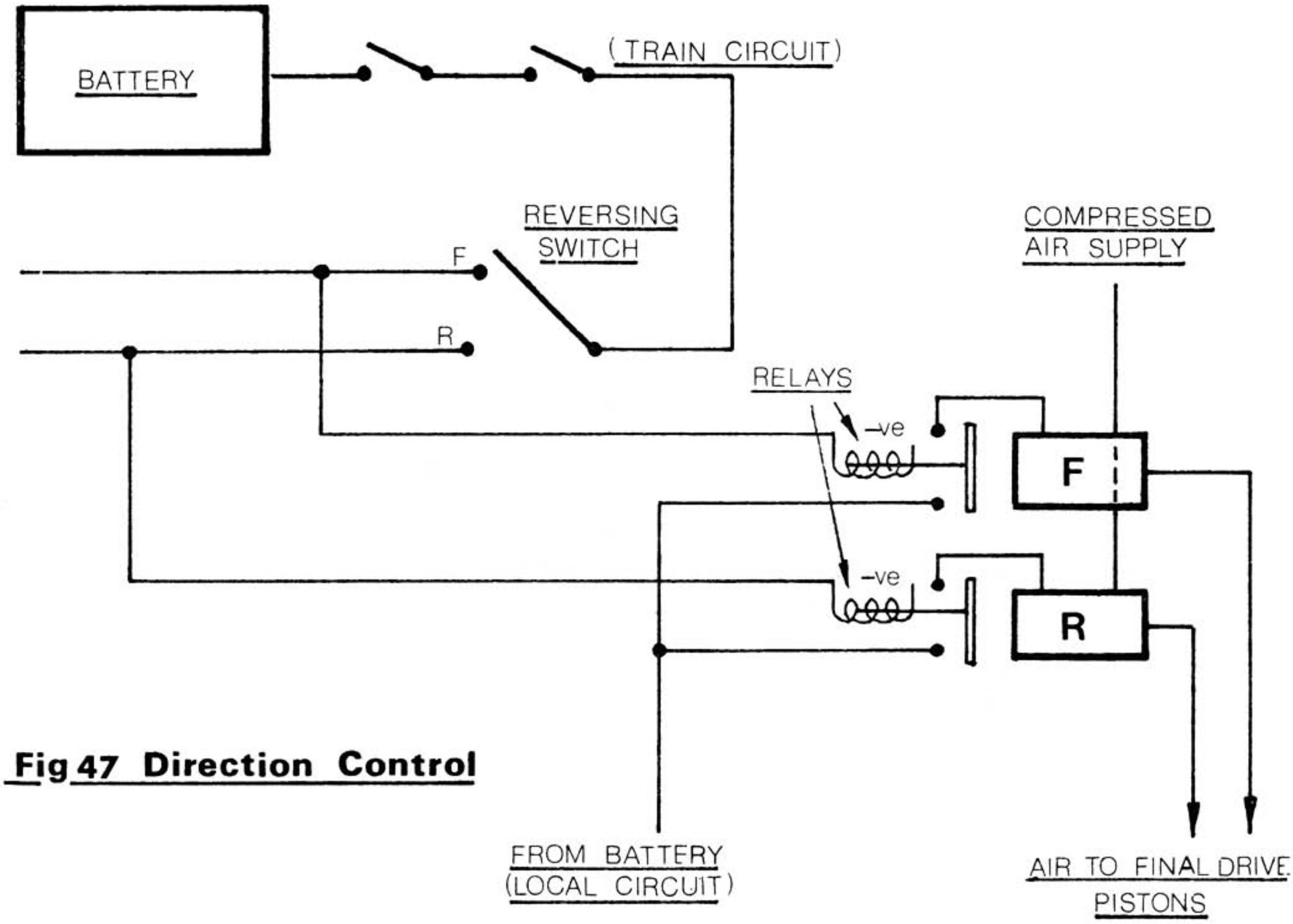


Fig 47 Direction Control

Solenoid operated valves Fig.49.

An electrically operated valve for use with a compressed air system. It is called a Magnet Valve or Electro-pneumatic (E.P.) valve.

When the current passes through the operating coil of the valve, magnetic force attracts the armature to the core. A valve which normally closes the air delivery lines is operated by the armature and when lifted gives passage to the compressed air so long as the switch remains closed. On opening the switch, the magnetic field collapses and the valve is returned by its weight, and the assistance of a spring, the supply of compressed air ceases.

They are used in controlling the throttle motors, reversing the final drives, and gear changing.

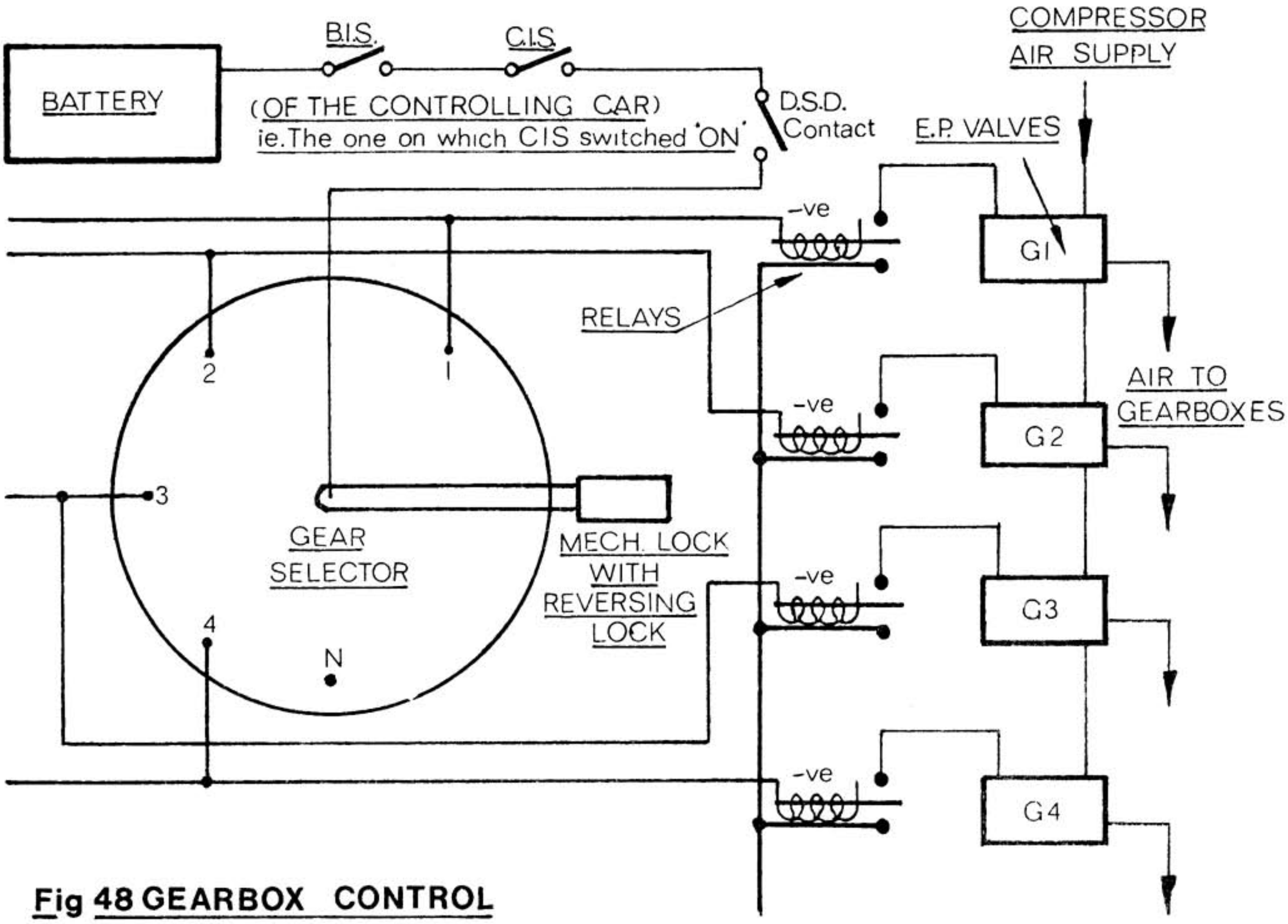


Fig 48 GEARBOX CONTROL

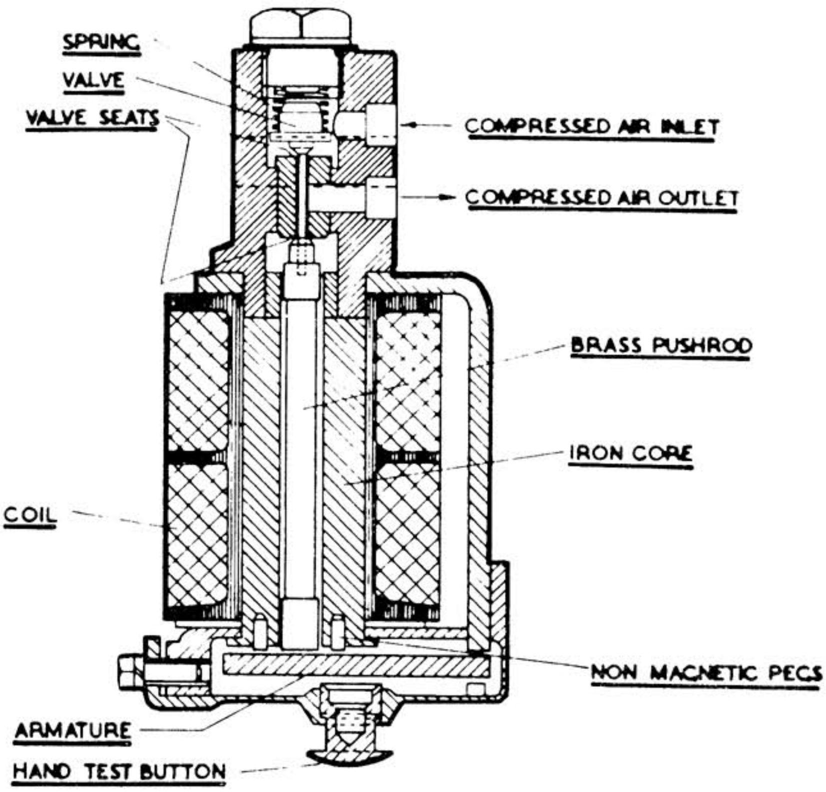
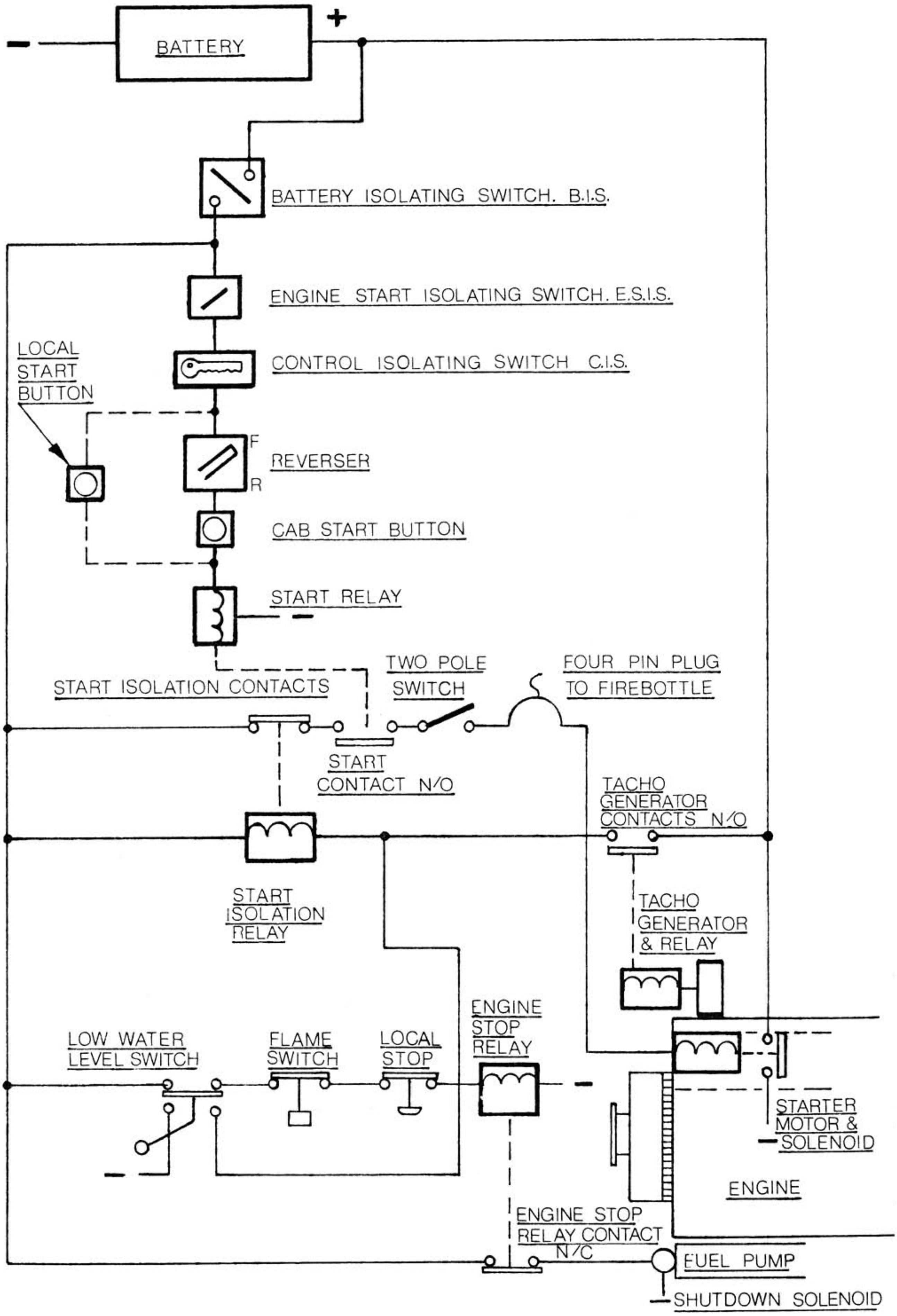


FIG.49. MAGNET AIR VALVE

FIG.50. PRINCIPLE OF A D.M.M.U. STARTING CIRCUIT



Battery Charging Arrangements

The vehicles are fitted with battery charging facilities which operate automatically as the battery discharges and are driven from the engine when equipped with alternators, (one for each engine) and vehicle movement when a generator is provided (output from gearbox)

The Engine Start Circuit Fig.50.

The simplified set of symbols has been assembled to show that when the 'battery isolating switch' B.I.S. is turned to 'ON' the 'engine stop relay' is energised, its normally closed contacts will, then open breaking the circuit to the engine shutdown Solenoid. The shutdown solenoid when de-energised will allow the fuel pump to be opened in preparation for the engine start, either by hand throttle local start, or throttle controller, (air pressure above 60 p.s.i.).

If it is desired to make an engine start, this can be done providing the B.I.S. is at 'ON' the engine has not been isolated E.I.S., and the 'control isolation switch' C.I.S. is switched 'ON'. A 'local start' can now be made, but the 'Forward' or 'Reverse' must be selected to make a cab start.

Start Sequence

When the start button is depressed, this will energise the start relay and its normally open contacts will close, and providing the two pole switch has not been operated, the four pin plug has been connected to the fire bottle, the circuit will be complete via the normally close contacts of the 'start isolation relay to the starter motor solenoid. The engine will now motor up to firing speed, and continue to run when the start button is released. The lubricating oil pressure switch, previously explained, will make the circuit to the engine indicator light above the desk.

The starter motor solenoid has two sets of contacts and a special trigger mechanism, so that when the armature of the starter motor moves axially to engage the starter pinion in the starter ring, the axial movement actuates the trigger to allow the main contact to 'make', so that after the gentle engagement of the pinion, the main field of the motor is energised to motor the engine up to firing speed.

With the engine now running the tachogenerator will record the engine revolutions on the tachometer, and also energise the tachogenerator relay, whose normally open contacts will close, this will in turn make the circuit to energise the start isolation relay whose normally closed contacts will open.

From this you will see that if an attempt is made to start an engine from the cab for instance, when other engines in the same bank are already running, the starter motor will not attempt to engage on the already running engines.

From this basic explanation it can be seen that each switch and control must be in its correct position to enable an engine to be started, and that if the two pole switch has been operated after a fire, or the fire bottle is disconnected, the engine will not start.

Stopping Engine

If with the engine running the coolant level becomes low, the flame switch is operated through a fire occurring, or a stop button is depressed. The circuit to the engine stop relay is opened thus causing the relay to close its normally closed contacts, and in turn energising the shutdown solenoid and stopping the engine.

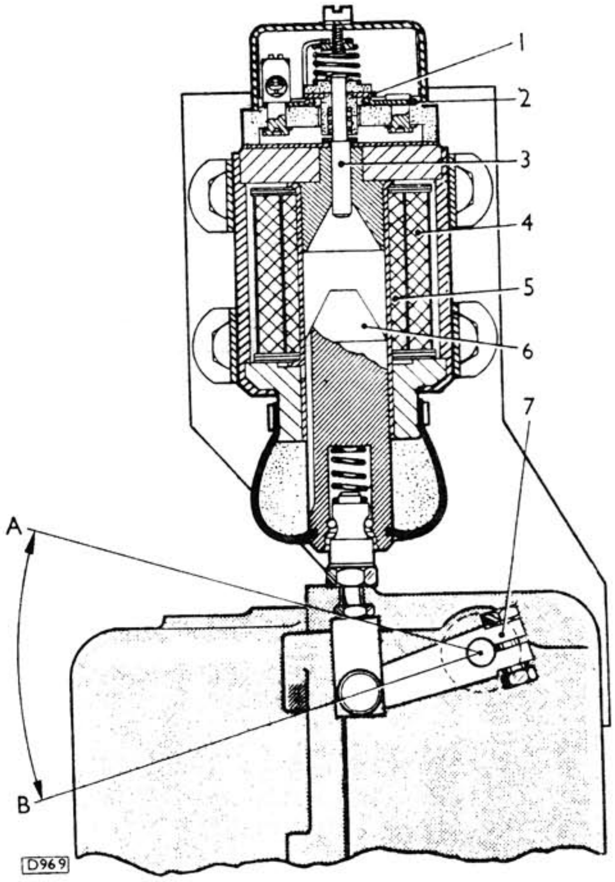
If the engine is stopped through fire, and the two pole switch is operated as well as resetting the fire control relay the other set of contacts will prevent the engine from being started. If it were low coolant level, the low level float switch as well as stopping the engine would make the circuit to the start isolation relay whose contacts would again open preventing the engine from being motored. The local or train stop button when released, would again make contact energising the stop relay causing its contacts to open and de-energising the shutdown solenoid.

A. STOP POSITION.
B. RUN POSITION.

1. MOVING CONTACTS.
2. FIXED CONTACTS.

3. ACTUATING PLUNGER.
4. PULL-IN COIL.
5. HOLD-IN COIL.
6. SOLENOID CORE.
7. FUEL-INJECTION PUMP STOP LEVER.

FIG. 51. THE ENGINE SHUTDOWN SOLENOID



THE ENGINE SHUTDOWN SOLENOID

This consists of a coil, and movable iron core (6) is positioned so that when current is allowed to flow, a magnetic field is set up around the solenoid (4) which attracts the core and causes it to be drawn up into the solenoid. The linkage attached to the core operates the engine shut down device, and when current is switched off springs return the core to release the shut down device.

Speed Indication Devices

It is necessary that the driver should be aware of the speed at which his train is moving and also the speed at which his oil engines are rotating. Since more than one oil engine is involved the distance from engine to cab may be long and mechnically operated indicators are not suitable for this purpose. To overcome this, electrically operated speedometers and tachometers are installed. These consist of an electric generator fitted to a revolving member and an indicating meter fitted near to the driving position. It is a fact that for a given electric generator the pressure or voltage which is developed depends directly on the speed at which it is rotated. It is possible therefore to couple the tacho-generator to a meter and to calibrate the meter face to read either in M.P.H. or R.P.M., the driver is then able to read directly from the speedometer in M.P.H. or from the tachometer in R.P.M.

Automatic Fire Equipment Fig.52.

In addition to the normal hand-operated equipment, a "GRAVINER" type automatic extinguisher system is fitted on the under frames of the power coaches.

Referring to the schematic diagram of this equipment, it will be noted there is a constant supply of current from the battery to one side of the flame switch, and one side of the resetting thermostat. The other side of the switches connects to the detonator on the fire extinguisher bottle, and other circuitry to the fire control relay, and the red warning indicator lamp.

Whenever the flame switch or fluid coupling thermostat closes, a current operates the detonator under the fire bottle, and releases a heavy inert gas BCF, which blankets the engine, smothering the fire, and a current flows through the 2-pole switch, illuminating the warning light on the fire control relay panel and energising the fire control relay. This relay in turn allows current to ring the fire bells in each cab and energises the engine shut down solenoid.

The flame switch can be operated:-

By hand (button), fluid coupling thermostat 140°C

By the action of excessive heat (over 250°C) on the Pyro-technic cord (explosive wick) within the capillary tube.

When the fire has been extinguished move the double pole switch to 'OFF' this extinguishes the light and stops the bells ringing, providing the thermostat has reset, and isolates the start relay from the starter button for that engine, making it impossible to restart.

In the event of subsequent over-heating or fire, the resetting thermostat will close, causing the bell to ring and the appropriate light to be illuminated, but in this case the bells will continue to ring until the fire has been put out with the hand-operated equipment. See current B.R. Instructions 33056/7 for specific procedures to be adopted when a fire bell rings.

The Simplified Diagram to Explain No.6 and No.7 Fuses Fig.53.

This diagram has been designed as an exercise in explaining the principle of the 'Train' and 'Local' circuit, and the effects of rupturing one of the fuses, in conjunction with the procedures laid down in the current fault guide.

THE GRESHAM AND CRAVEN TWO-PIPE QUICK-RELEASE VACUUM BRAKE SYSTEM

The quick-release vacuum brake system is essentially for use on diesel railcars on which the vacuum exhauster is mechanically driven from the diesel engine. Under these conditions the engine and therefore the exhauster will only be operating at minimum speed when the car is standing in a station and the exhauster is not available for release of the brakes.

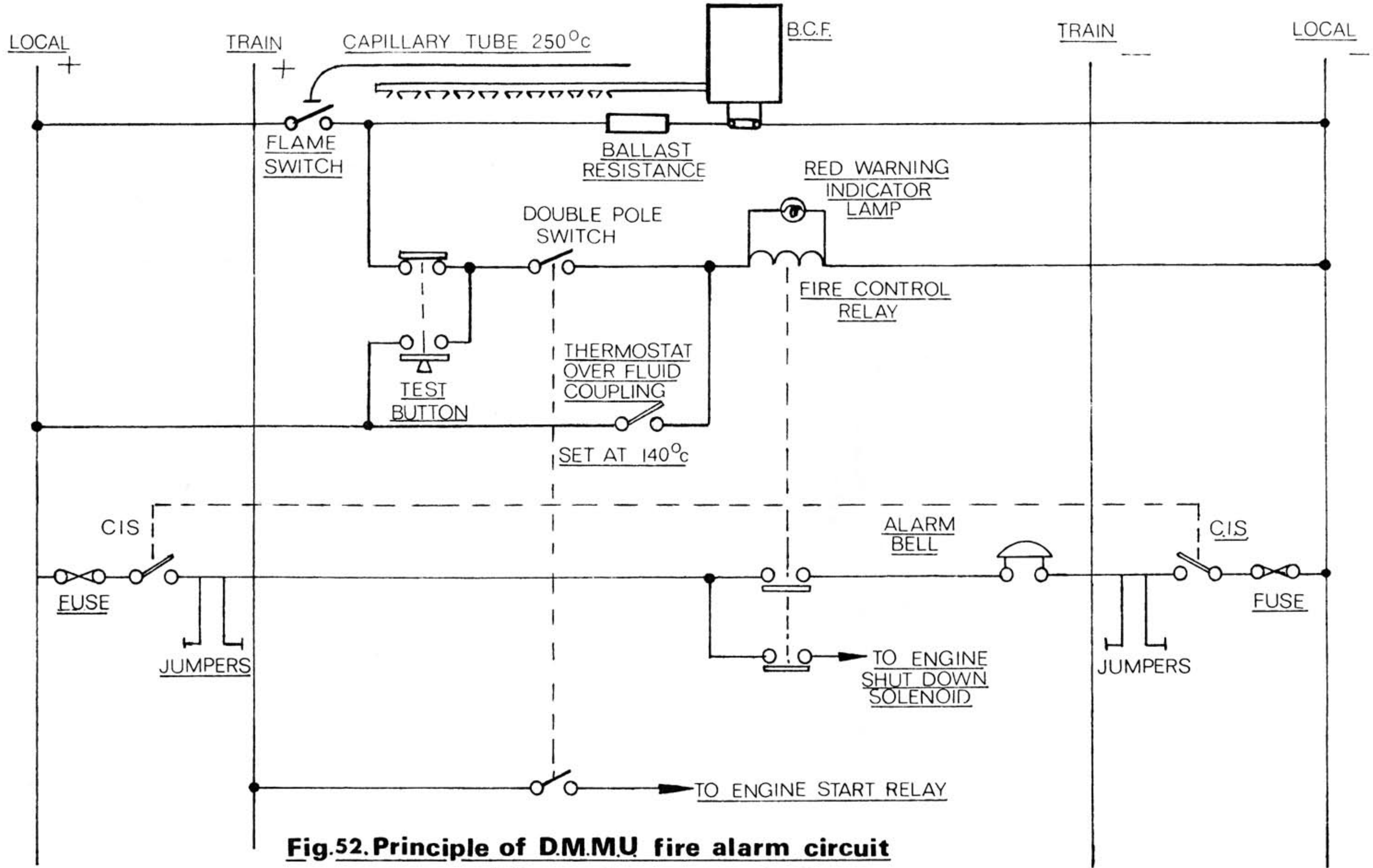


Fig.52. Principle of D.M.M.U fire alarm circuit (shown for one engine)

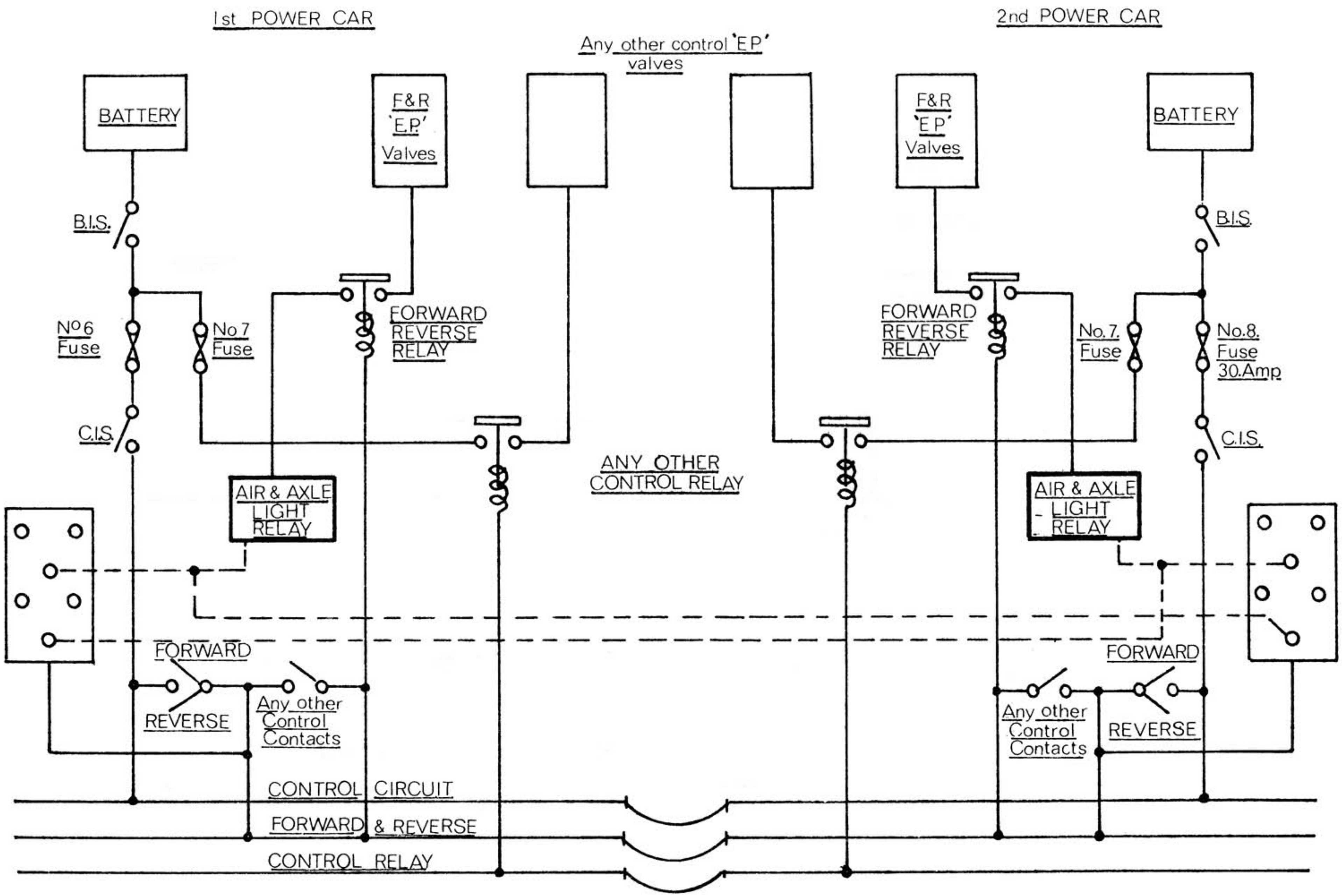
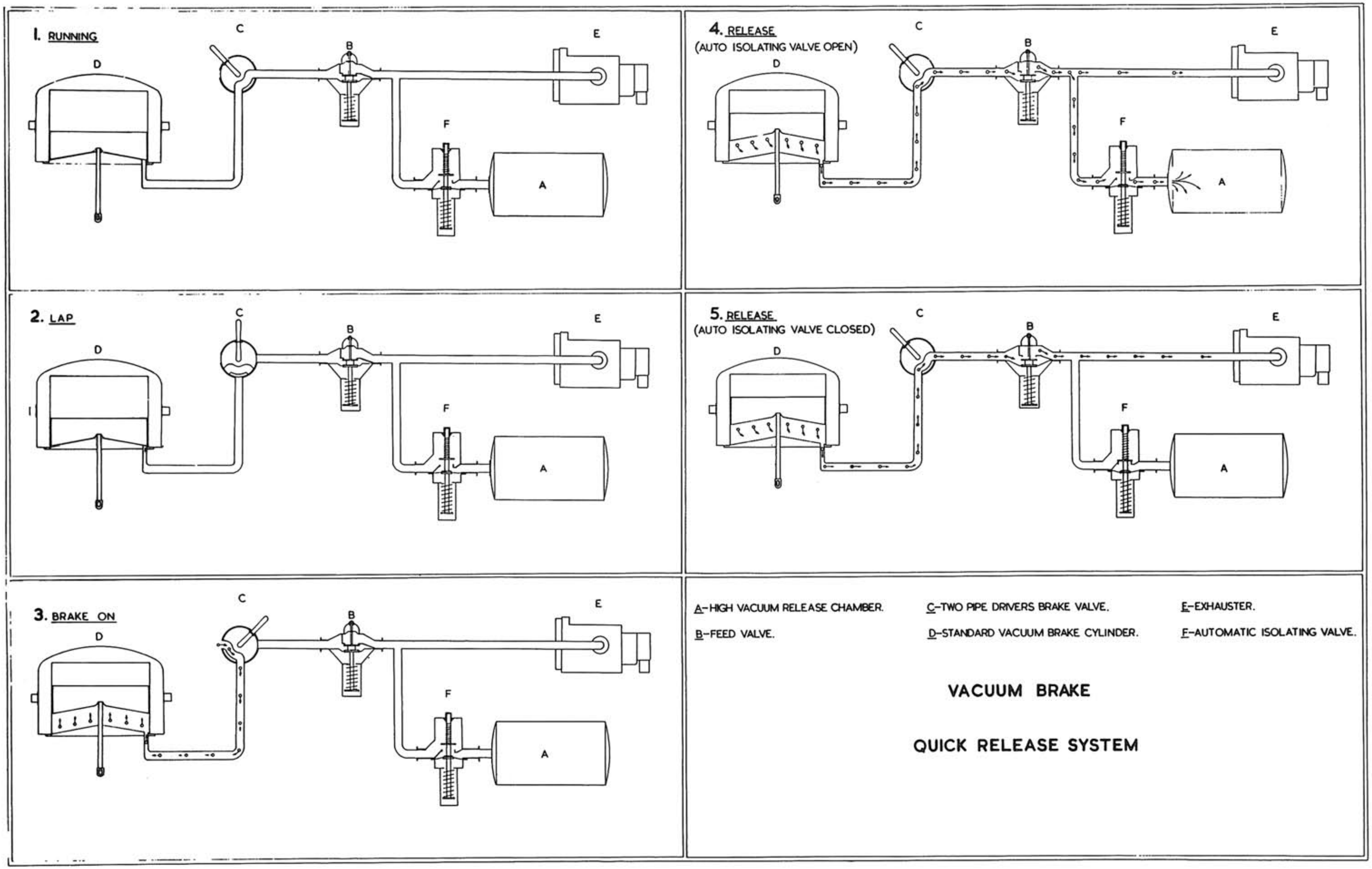


Fig.53. Simplified Electrical Diagram for No 6 & No 7 Fuses


1. RUNNING
2. LAP
3. BRAKE ON
4. RELEASE
(AUTO ISOLATING VALVE OPEN)
5. RELEASE
(AUTO ISOLATING VALVE CLOSED)
A
B
C
D
E
F
A–HIGH VACUUM RELEASE CHAMBER.
B–FEED VALVE.
C–TWO PIPE DRIVERS BRAKE VALVE.
D–STANDARD VACUUM BRAKE CYLINDER.
E–EXHAUSTER.
F–AUTOMATIC ISOLATING VALVE.
VACUUM BRAKE
QUICK RELEASE SYSTEM

Release of the brakes is entirely independent of the exhauster speed and is obtained through the medium of a "release-reservoir" which is exhausted while the car is running.

The main features of the equipment are shown in Fig. 54

They are as follows:-

Exhauster — Belt driven from input shaft to gearbox

Feed Valve

Driver's brake valve

Isolating Valve

Standard brake cylinder

(1) Running

Car in motion and exhauster running at maximum speed. The feed valve prevents train-pipe vacuum from rising above 21 inches. To do this it does not admit air like an ordinary relief valve, but shuts down at 21 inches train-pipe vacuum, thereby isolating the exhauster from the rest of the system. The exhauster then creates up to 28 or 29 inches of vacuum in the release pipe and reservoir, giving storage capacity for subsequent brake releases. The driver's brake handle is in the off position.

(2) "Lap"

Driver's brake handle is in the lap position. The train-pipe is isolated from the feed valve and release pipe. Train pipe is also isolated from the atmosphere. In this position a partial brake application can be held, (drivers handle can only be removed in this position).

(3) Brake "ON"

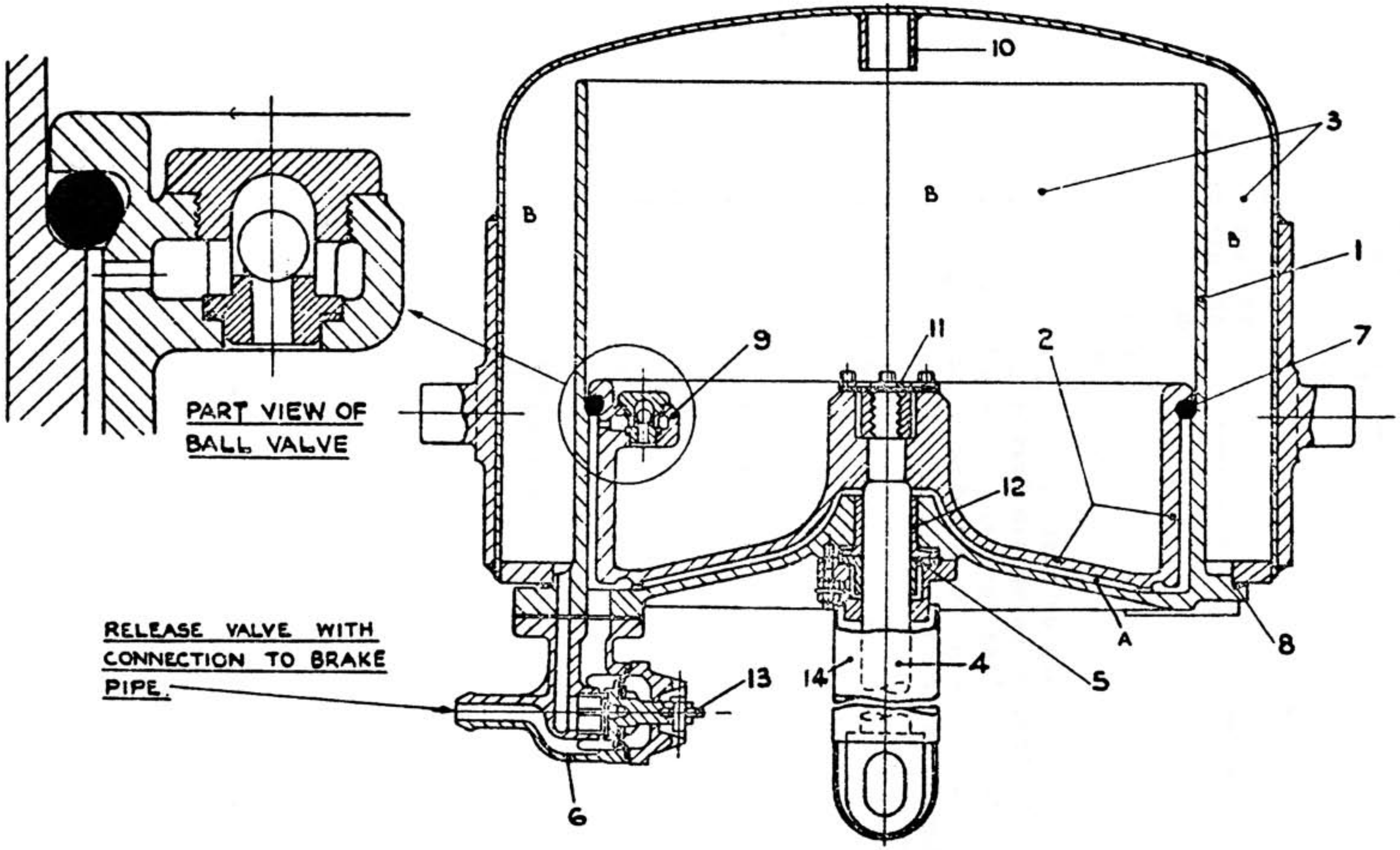
Direct admission of air from atmosphere into train-pipe to apply the brake. High vacuum via feed valve sealed off and thus preserved. Partial applications can be maintained by returning the handle to the lap position.

(4) Brake Release

The driver's brake valve now links the train-pipe with the release reservoir via the feed valve. Air from below the vacuum brake piston and from the train pipe flows rapidly through the feed valve into the reservoir which is of sufficient volume to absorb all the air in the system. Immediately 21 inches is reached in the train-pipe, the feed valve closes as before. The auto-isolating valve is open.

(5) Brake Release

The auto-isolating valve is closed and 19 inches of vacuum is maintained in the reservoir.



DESCRIPTION OF PARTS

1. VACUUM CYLINDER
2. PISTON HEAD
3. TOP SIDE SPACE
4. PISTON ROD
5. PISTON ROD GLAND & PACKING
6. RELEASE VALVE
7. ROLLING RING
8. SEALING RING
9. BALL VALVE
10. STOP FOR PISTON
11. PISTON ROD CAP
12. PISTON ROD GUIDE BUSH
13. RELEASE VALVE LEVER
14. PISTON ROD SLEEVE

Fig 55 Type E1 Brake Cylinder

The Vacuum Brake Cyliner Fig.55.

This is a rolling ring E1 type which is now standard on British Railways. These cylinders are of the combined type and consist of an outer steel shell which forms the top-side space and an inner cast-iron cylinder. The piston fits easily into the cylinder and has a deep head with a relieving groove to take the rolling ring in the "brake off" position. The groove keeps the rolling ring in alignment and prevents permanent distortion of the ring when the cylinder stands for a long time with the piston in the OFF position.

The piston carries a ball valve fitted in a cage with a direct communication between the underside of the ball and the top-side space, and with a passage from above the ball to the outside of the piston, and thus to the underside of the rolling ring in the OFF position

The piston rod passes out of the cylinder through a gland box, which forms an air tight joint on the rod when the cylinder is under vacuum. The bottom end of the piston rod has a slotted hole for the pin which connects to the brake levers. The brake gear is arranged to come against a stop release, so that the piston can fall the extra distance permitted by the slot. When making a brake application the first $^1/_2$" or so of piston movement can thereby take place freely, which helps the piston ring to move out of its groove evenly.

When vacuum is created in the train-pipe, air passes freely from the bottom side of the piston, which will then fall by its own weight when an equal vacuum exists on both sides of it. With the piston in the "brake off" position, air can be withdrawn from the top side through the ball valve, until a working vacuum is attained on both sides.

When the brake is applied, air enters the bottom side of the cylinder from the train- pipe and presses down on the ball valve, thereby preserving the vacuum on the top side. The piston therefore rises due to the difference in vacuum and the brakes are applied. The ring rolls between the piston and the cylinder wall, preserving an air-tight seal and also cutting off communication between the top side of the piston and the bottom side space. This prevents loss of top-side vacuum due to leakage past a worn or damaged ball valve seat.

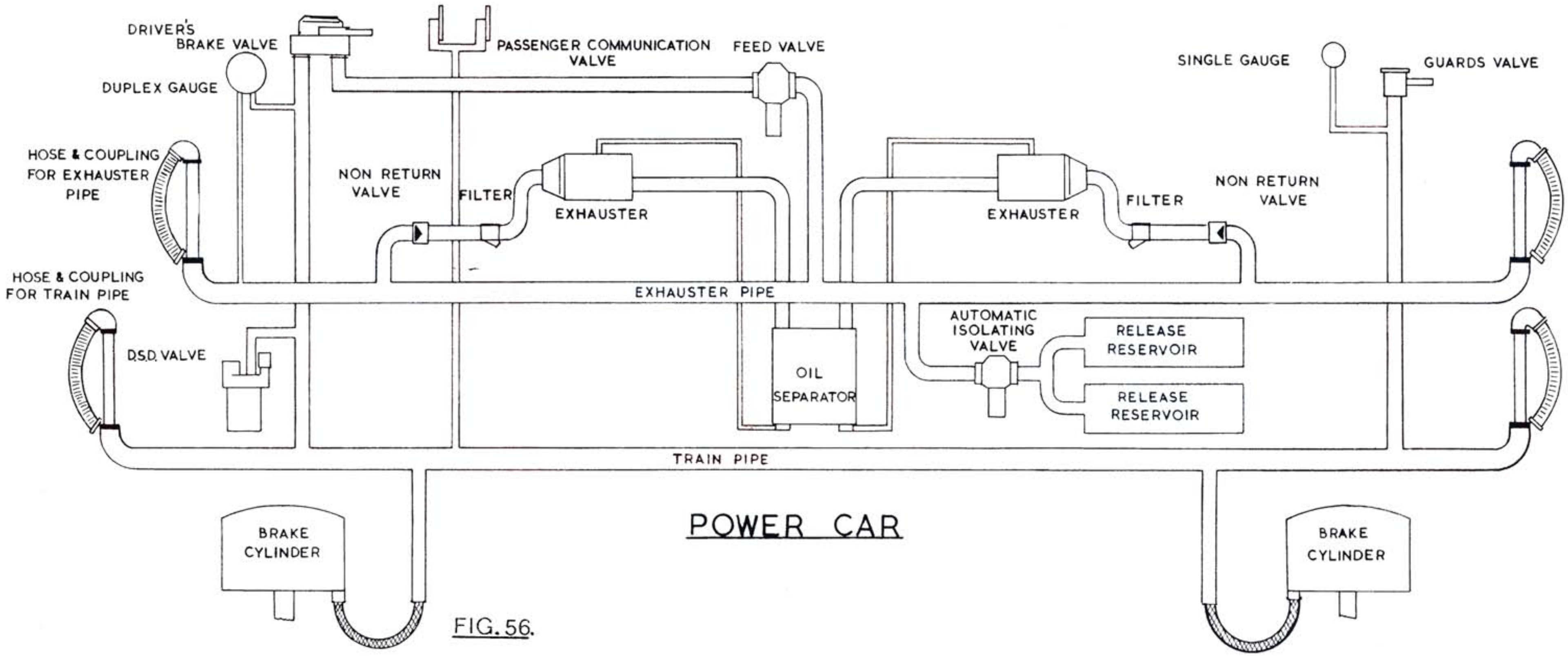


FIG. 56.

QUICK RELEASE VACUUM BRAKE SYSTEM

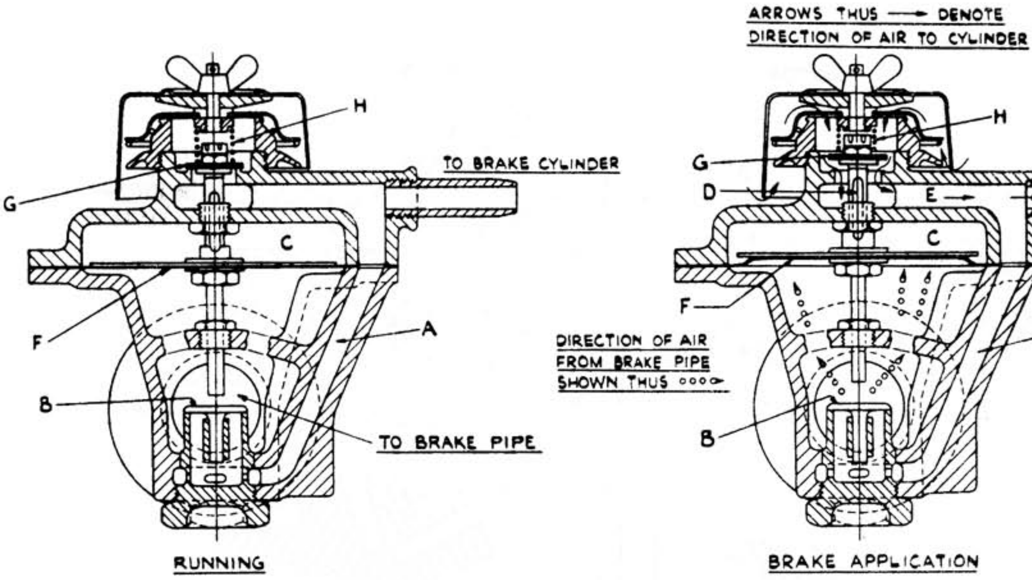


FIG. 57. Direct Admission Valve

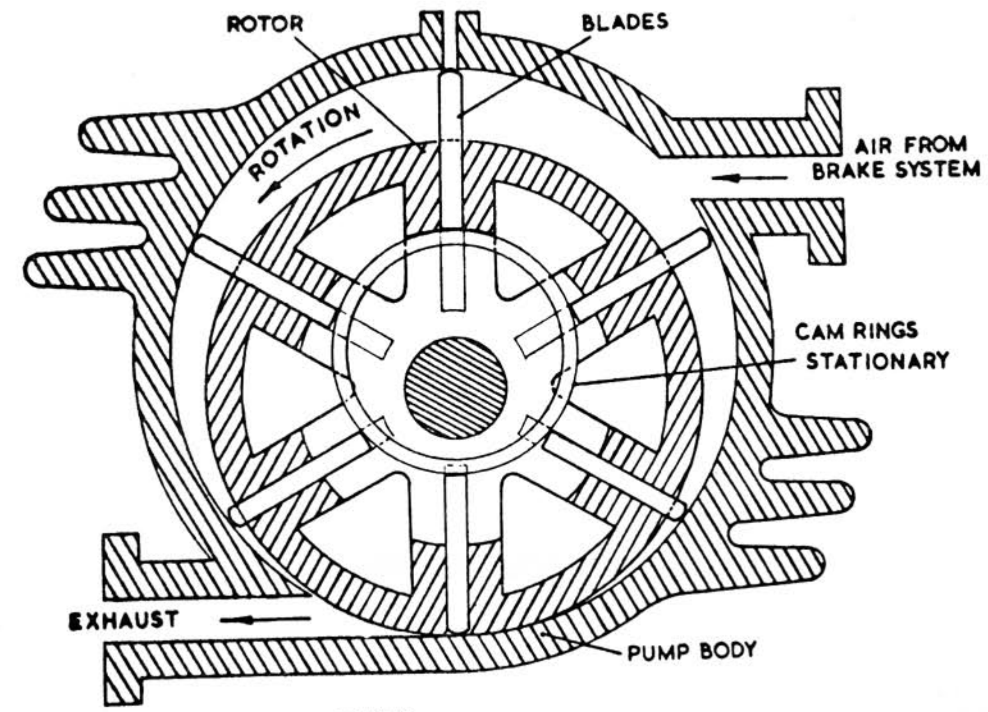
Direct Admission Valves

As the length of a vauum-braked train increases, the greater delay in the application of the brake at the rear becomes a serious disadvantage, and in order to speed up the application of the brake various devices have been employed, one of the best known being the Direct Admission Valve (D.A. valve)

The principle employed is to use the air from the driver's brake valve during a brake application to fill the train-pipe and operate the D.A. valves only, while the air which operates the brake cylinders is admitted locally by the D.A. valves. The application of the brake along the train is thus greatly speeded up, as each brake cylinder has in effect its own independent air supply. Brake release takes place through a non-return valve, hence speed of release is the same as for a simple vacuum brake train without D.A. valves. When vacuum is created in the train-pipe for the initial brake charging or for release after brake application, air is drawn from the brake cylinder through passage A, lifting non-return valve B, into the train-pipe. At the same time vacuum is created in chamber C, by air being drawn past the flat D on the spindle and along passage E. When release is complete the whole valve is under vacuum and the brake off, see sketch marked "Running".

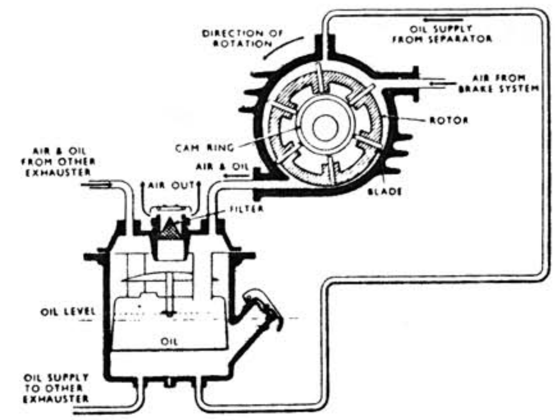
When the brake is applied, see diagram, "Brake Application", air from the train-pipe enters the D.A. valve body, raising the diaphragm F, and keeping valve B shut. The diaphragm opens air valve G, thereby admitting atmospheric air through the filter and valve G to the brake cylinder along passage E. When sufficient air has been admitted to reduce the vacuum in chamber C (by entering the flat D on the spindle) to equal train-pipe vacuum, the diaphragm is again in equilibrium and is moved downwards by spring H, thus closing valve G. (In practice, on an emergency brake application the D.A. valve also feeds some air back to the train-pipe, as valve B will lift if the pressure in passage A is higher than that in the valve body).

In the event of a defective D.A. valve failing to close and causing a continual leak to the train-pipe, the valve can be put out of action by 'blanking off'



ROTARY EXHAUSTER

FIG. 58.



THE ROTARY EXHAUSTER

The Rotary Exhauster is belt driven from the input end of each gearbox and is a vane type pump consisting of a body fixed to the vehicle underframe which has inside it a rotor mounted eccentrically within the bore of the body casting. The rotor has a number of radial slots cut in it and vanes or blades slide in these slots. The eccentric positioning of the rotor and the length of the blades are arranged so that the tips of the blades can at all times contact the inner surface of the bore. To ensure that the blades do maintain this contact when the rotor is stationary, or only slowly rotating, a cam ring concentric with the bore is provided upon which the inner edges of the blades ride. The action can be seen by following the motion of the blade which is at 6 o'clock position in the drawing. As the rotor commences to revolve the cam ring will maintain the blade in contact with the bore but it will be noticed that the outer surface of the rotor will be moving about its own centre and away from the bore. The following blade will perform an exactly similar cycle as it is rotated. The space between these two blades will thus be seen to increase to a maximum at the 12 o'clock position and then decrease as the space again approaches the 6 o'clock position. The pump is provided with an inlet port where the air space is increasing and an outlet port where the space is decreasing as shown. The inlet port connects with the vacuum reservoir and as the rotor revolves air is drawn into the pump body. As the following blade passes the inlet port the air is trapped and will be subject to some compression before the leading blade uncovers the exhaust port. To provide air seals between the blades and the body, oil is supplied into the interior and some of this oil will be carried over with the exhaust air into an oil separator where it is recovered and re-circulated. The exhauster is efficient at idling speeds and can thus restore vacuum conditions when a vehicle is at rest after a brake application has been made. When the pump is running at speed, centrifugal force will ensure that the radial blades bear firmly against the inner surface of the bore and the cam rings will thus be necessary only at low engine speeds.

For the efficient operation of the exhauster it is necessary for sufficient oil to be supplied to the exhauster bearings and also into the body of the exhauster to provide an effective seal between the blades and the bore of the body. The air exhausted, therefore, contains a considerable proportion of oil and it is necessary to force this through an oil separator unit before allowing it to escape to atmosphere.

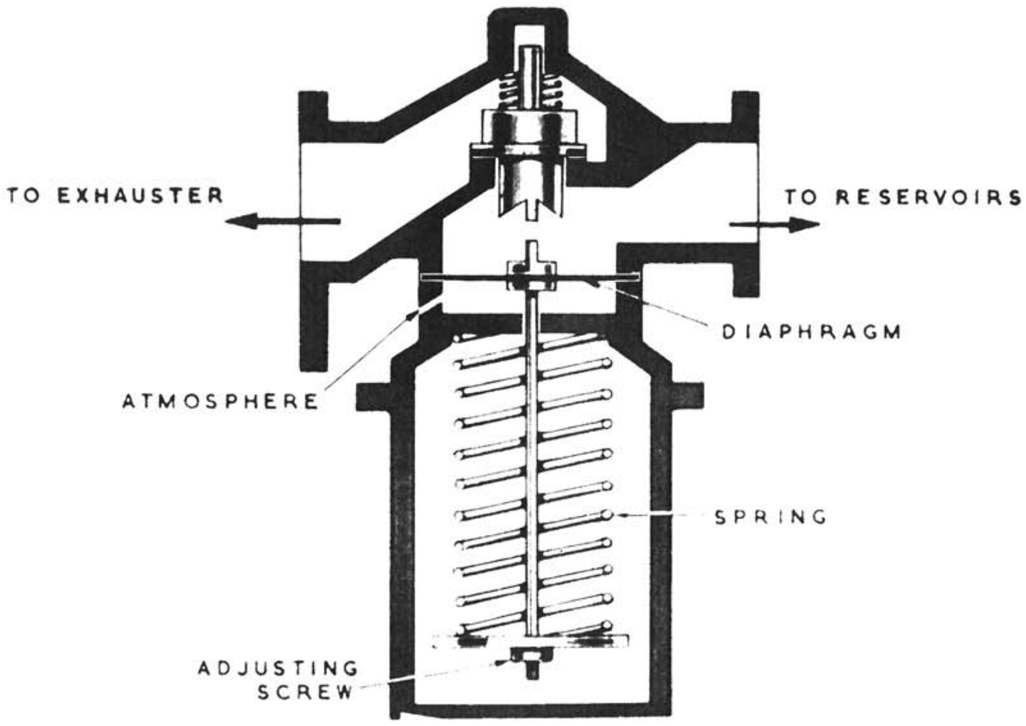


FIG.59. Automatic Isolating Valve

THE AUTOMATIC ISOLATING VALVE

One valve is fitted to each set of reservoirs, positioned between the reservoirs and the release pipe. Its purpose is to maintain 19 inches of vacuum in the reservoirs even though the vacuum in the rest of the system falls below that figure; this greatly reduces re-charging times.

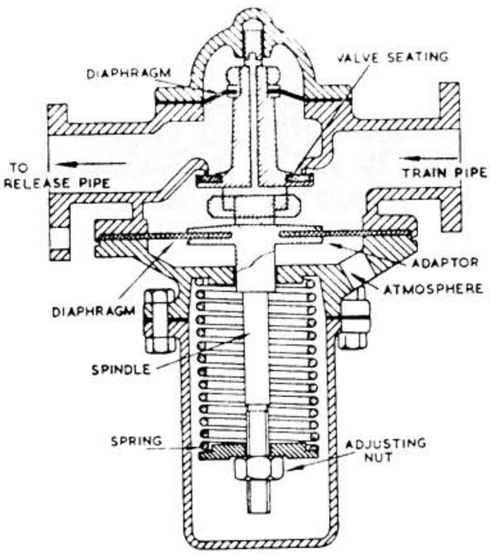


FIG.60. Automatic Feed Valve

When the system is initially charged, the vacuum created on the exhauster side of the valves lifts the N.R.V. off its seat, allowing the air to be withdrawn from the release side reservoirs. When the vacuum above the diaphragm reaches 19 inches atmospheric pressure under the diaphragm overcomes the spring tension, lifts the spindle and continues to hold the N.R.V. off its seat. Conversely when the vacuum is destroyed, and falls to 19 inches and below, the atmosphere above the diaphragm will assist the spring to expand and draw the diaphragm down thus allowing the spring of the N.R.V. to push it onto its seat holding 19 inches in the reservoir/s.

THE AUTOMATIC FEED VALVE

There is one feed valve for each driver s brake valve fitted between the brake valve and the release pipe. It regulates the train pipe vacuum to 21 inches and maintains this so long as the release pipe vacuum is above 21 inches.

Initially the valve is held off its seat by spring tension and vacuum is allowed to build up in the train pipe. When vacuum above the main diaphragm is 21 inches atmospheric pressure overcomes spring tension and seats the valve. Any air that enters the train pipe will increase the pressure above the diaphragm, so opening the valve, air is now extracted by the exhausters and the valve closes again at 21 inches.

The smaller diaphragm is to balance the pressure under the valve.

When changing ends a difference in the train pipe vacuum may be noticed, and this means that one of the adjustable feed valves needs resetting.

D.S.D. CONTROLS

When running, depression of the throttle controller closes a contact so that current is passed to the solenoid, which is then energised. The lower valve B is lifted on to its seat so isolating the control valve from atmosphere. With the exhausters running air is extracted from the timing chamber and the underside of the emergency valve diaphragm. There is then vacuum above and below the emergency valve diaphragm and the emergency valve is held on its seat by the spring.

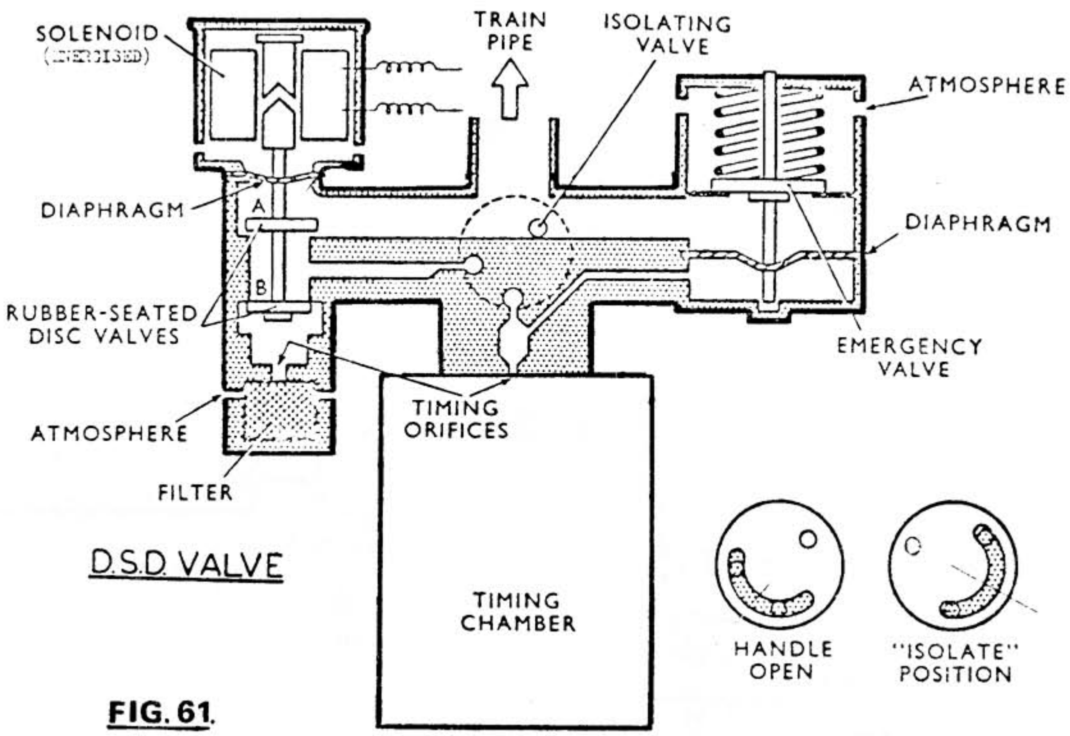


FIG. 61.

In the case of a D.S.D. application, the solenoid is de energised and atmospheric pressure above the diaphragm forces the lower valve off its seat. Air is admitted through the gimp filter into the timing chamber, and the lower half of the emergency valve. Air cannot pass directly into the train-pipe because the upper seat of the control valve is covered

As air pressure builds up under the emergency valve diaphragm, spring pressure is overcome and air is admitted direct into the train pipe through the emergency valve. When train pipe vacuum has been destroyed, the emergency valve diaphragm is in balance, with atmospheric pressure above and below. Therefore the valve is closed under the action of the spring so that vacuum can be recreated in the train-pipe. There will be approximately 3 inches of vacuum showing on the train-pipe gauge due to the action of the spring.

The delay period before brakes are applied is 5-7 seconds after release of the throttle, and this represents the time taken to build up pressure in the timing chamber and emergency valves.

Should the valve become defective, it can be isolated. This is done by moving the isolating handle to the position indicated.

When the D.S.D. operates the gearboxes return to neutral and the engines to idling speed by de-energising the appropriate E.P. valves.

PASSENGER COMMUNICATION AND GUARDS EMERGENCY VALVE

When operated, these valves admit air into the train-pipe, giving a full brake application with no time delay.

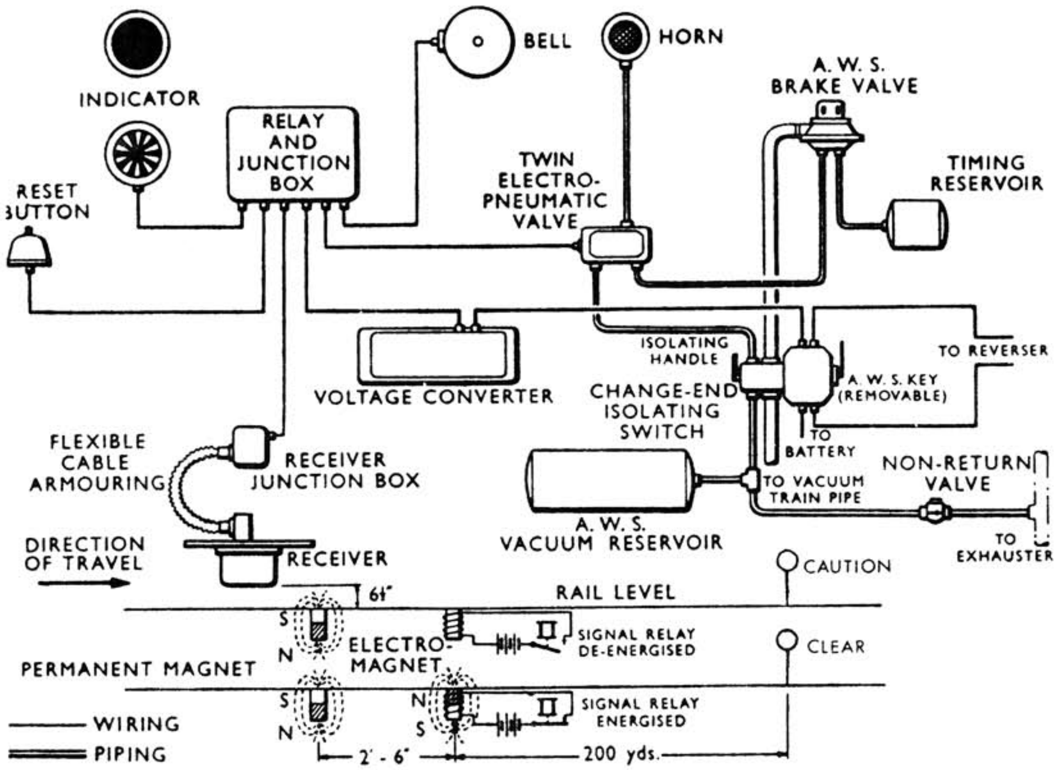


FIG. 62.

THE A.W.S. SYSTEM

MAIN FEATURES

The British Railways system works on the principle of magnetic induction. When a distant signal is at 'caution', the permanent magnet situated between the running rails alters the receiver setting on the diesel locomotive or diesel train, causing the horn to sound and the initiation of a full brake application after a short delay. Cancelling or acknowledging the 'caution' indication by means of the 'reset' button provided, silences the horn and causes the visual indication to change from all black to yellow and black. If the distant signal is at 'clear' the electro magnet is energised, which restores the receiver setting to its normal position, the action of which causes a bell to ring in the driving comparment for three seconds.

METHOD OF OPERATION

In this system Fig 62 two magnets are fixed centrally between the rails, 2ft 6 in. apart, generally 200 yd. on the approach side of distant signal. The first contains a permanent magnet with its south pole uppermost, and the second is an electro-magnet. The electro-magnet is 'dead' when the distant signal is at Caution and 'alive' with its north pole uppermost when the signal has been pulled to Clear. The pole faces of the magnets are at rail level.

In addition to the above, permanent 'caution' magnets are provided in the outlet roads from the depots to test the equipment before going into service.

The vacuum in the AWS reservoir of the multiple-unit train is created by exhausters operating through a non-return valve. When the change-end switch is in the 'on' position the change-end switch connects the main batteries to the voltage converter which supplies 12 volts d.c. to the AWS circuit. The change-end switch also connects the train line to the contacts of the reverser key. The horn is operated by vacuum and controlled by an electro-pneumatic valve.

The upper side of the diaphragm in the AWS brake valve is connected direct to the vacuum train pipe. The underside is connected to the vacuum timing reservoir and controlled by the Electro-pneumatic valve. In the normal position the brake valve is balanced by vacuum on both sides of the diaphragm, and a light coil spring is fitted on top of the valve to assist it to close. When the brake is applied through the action of the AWS, air is admitted to the underside of diaphragm, at a controlled rate, which upsets the balance and causes the valve to lift, admitting air to the trian pipe with a resultant brake application.

The receiver consists of a small permanent magnet pivoted at a central point and carrying contacts which act as a two-way switch. When running between signals the receiver N contact is in its normal closed position, forming a circuit to the electro-pneumatic valve which controls the vacuum and atmosphere as described above. When the distant signal is at 'caution' the receiver passes over the south pole of the permanent magnet the receiver N contact opens, and after one second the electro-pneumatic valve is de-energised and operates to connect the horn to the vacuum reservoir, thus causing it to sound; also air is admitted through a restriction in the electro-pneumatic valve to the timing reservoir and brake valve. Then the AWS brake valve operates and admits air to the train pipe. The horn can be silenced and any brake application cancelled by operating the 'reset' button, which restores the receiver contact to its normal position (N contact) and resets the solenoid in the electro-pneumatic valve.

When approaching a distant signal in the 'clear' position the electro-magnet is energised, creating a N magnetic field. In this case the receiver contact changes over as before through the influence of the permanent magnet, and then changes back again through the influence of the electro-magent. If travelling at more than $1^1/_2$ m.p h. less than one second will elapse between changes of the receiver contact, and the solenoid in the electro-pneumatic valve would not be de energised to cause the sounding of the horn or apply the brakes, but the changeover of the receiver contact picks up relays which, in turn, cause the bell to ring for 2 seconds.

In addition to the audible signals of horn or bell a visual indicator is provided. When the receiver passes over the permanent magnet, current passes to the indicator to turn it to, or keep it at, all black. If the distant signal is at 'caution' and the 'reset' button operates to silence the horn, the indicator automatically changes to display yellow and black spokes, and this is maintained until reaching the next set of magnets in the track, which is a constant reminder to the driver that the last signal passed was in a 'caution' position.

It should be noted that the operation of the 'reset' button will only change the indicator from black to yellow-and-black after receiving a 'caution'warning.