

BRITISH RAILWAYS L.M. REGION  
MOTIVE POWER DEPARTMENT  
DIESEL TRAINING SCHOOL, DERBY

LECTURE NOTES  
AND DRAWINGS

DIRECTOR OF TRAFFIC SERVICES

Motive Power Office  
EUSTON HOUSE

Reprinted *October 1959*

**INDEX TO NOTES**  
**RELATING TO MULTIPLE UNIT DIESEL RAILCARS**

NOTE	SUBJECT
1	Description and layout of equipment
2	The four-stroke cycle
3	Description of typical diesel engine and valve operation
4	Description of A.E.C. engine ("A" type)
5	Description of Leyland engine ("L" type)
6	Description of Rolls-Royce engine
7	Fuel injection system
7A	B.U.T. Cars. Max./Min. Governor (Mech.)
7B	Rolls-Royce Cars—Hydraulic Governor.
7C	Engine shut down solenoid.
8	Fuel filters
9	Fuel lift pump
10	C.A.V. fuel injection pump. "N" type
11	Fuel injectors
12	Engine cooling systems
13	Fluid coupling
14	Free wheel
15	Hardy Spicer coupling
16	Wilson 4-speed epicyclic gearbox
16A	The Torque Converter (Rolls-Royce)
17	Final drive gearbox
18	Electro-pneumatic control system
19	Compressed air system
20	Engine speed control
21	Vacuum brake system: (a) Exhauster (b) Feed valve (c) Isolating valve
22	Deadman arrangements
23	Fire-fighting equipment
24	Faults and remedies

**INDEX TO DRAWINGS**  
**RELATING TO MULTIPLE UNIT DIESEL RAILCARS**

NO.	DESCRIPTION
1	Equipment layout. Power car
2	Railcar coupling symbols
3	The four-stroke cycle
4	Operation of valve gear
5	Section through A.E.C. engine
6	Lubrication system (A.E.C. engine)
7	Cut-away view of Leyland 6-cyl. engine
7A	Lubrication system (Leyland engine)
7B	Gear type oil pump
7C	Lub. oil filter
7D	Lub. oil cooler
7E	Lubrication system Rolls-Royce engine
8	Fuel injection system
8A	Principle of max./min. weight type governor
8B	Section through governor springs
8C	Principle of hydraulic governor
8D	Shut down solenoid
9	Fuel filters
10	Fuel lift pump (diaphragm type)
11	N-type fuel pump
12	Pump element and plunger
13	Pump elements
14	Section through C.A.V. fuel injector
15	Cooling system, "A" type,
16	Cooling system, "L" type
16A	Cooling system pressurised
17	Fluid flywheel
18	Freewheel coupling
19	Epicyclic gearbox. Cross-section through gear train
20	Sectional view of epicyclic gearbox
20A	Diagrammatic view of epicyclic gear train
20B	R14 gearbox. Section through first speed band with brake off
20C	As fig. 20C—Brake on
20D	R14 gearbox. Operation of automatic adjuster
20E	Torque converter (Rolls-Royce)
21	Final drive gearbox
21A	Final drive. Longitudinal section through bevel pinions
22	Electrical system, "A" type
23	Electrical system, "L" type
24	Gearbox control, "A" type
25	Gearbox control, "L" type
26	Engine speed control, "A" type
27	Engine speed control, "L" type
28	Direction control, "A" type
29	Direction control, "L" type
30	Electro-pneumatic valves
31	Compressed air system
32	Reducing valve
33	Diverter valve
34	Unloader valve
35	Throttle motor, "A" type
35A	Throttle motor and linkage "L" type
36	Vacuum system
37	Vacuum brake operation
38	Vacuum exhauster
39	Auto-feed valve and isolating valve
40	Deadman and emergency valve
41	Automatic fire-extinguishing system

## DIESEL TRACTION NOTE No. 1

**DIESEL MULTIPLE UNIT TRAINS. DESCRIPTION, AND LAYOUT OF EQUIPMENT**

Diesel Multiple Units, as the name implies, are designed to run in sets comprising powered vehicles and trailer cars. The usual arrangements are for a two-car set, comprising a power car and a trailer car, with a driving compartment at each end, or 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 either eight or twelve engines in one train, i.e. four or six power cars. The number of power cars which can be included in a train is dependent on the control system design and layout.

The general layout of the power unit, transmission, etc. for a two engine-gearbox car is shown in diagram No. 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.

Although some new cars have torque converters fitted instead of gearboxes and some are fitted only with a single engine on each power car, the most common arrangement is as shown in diagram 1. 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. On A.E.C. and Leyland engines the air compressor is gear driven; on Rolls-Royce 6 cyl. engines it is belt driven and on their 8 cyl. engines it is gear driven from the auxiliary gearbox. Vacuum exhausters and generators are belt driven.

Two types of electro-pneumatic control system are in use and these are described in other notes. They have been termed the "A" and "L" types. Whilst again these letters originally referred to the make of engines fitted, this is not true today. All makes of engine, including Rolls Royce, can be found fitted to cars operating on the "L" type control system. The letters "A" and "L" have been retained to distinguish the two control systems. Cars with the "A" type control systems come under the "yellow diamond" or "red triangle" coupling code whilst the "L" type system is covered by all the other coupling codes.

The coupling codes are provided as an indication as to which types of cars may be coupled together for multiple working. For reasons of varying control systems and transmissions, cars bearing dissimilar coupling codes must not be coupled together.

Details of the coupling codes are shown in diagram 2 and the cars to which they apply are as follows:

Red Triangle.	79000 series. Derby "lightweight" cars with Leyland Hydro-Mechanical transmission. Nos. 79000-7 and 79500-7 (Not on L.M. region)
Yellow Diamond	Derby "lightweight" cars. 79000 series. Metropolitan-Cammell cars. 79000 series. Craven parcel vans. M. 55997-9.
White Circle.	Swindon built Inter-City. 79000 series.
Blue Square.	All 50000 series cars except Craven parcel vans and Nos. E. 50000-49 and E. 56000-49.
Blue Square. with Cream Stripe.	Nos. E. 50000-49. E. 56000-49.
Orange Star.	Twin engine Rolls-Royce cars with torque converters.

Details of the purpose and method of operation of the transmission and control systems are dealt with in other notes under their respective headings.

*Drawing References*

1. EQUIPMENT LAYOUT. POWER CAR.
2. RAILCAR COUPLING SYMBOLS.

FIG. 1

EQUIPMENT LAYOUT - POWER CAR

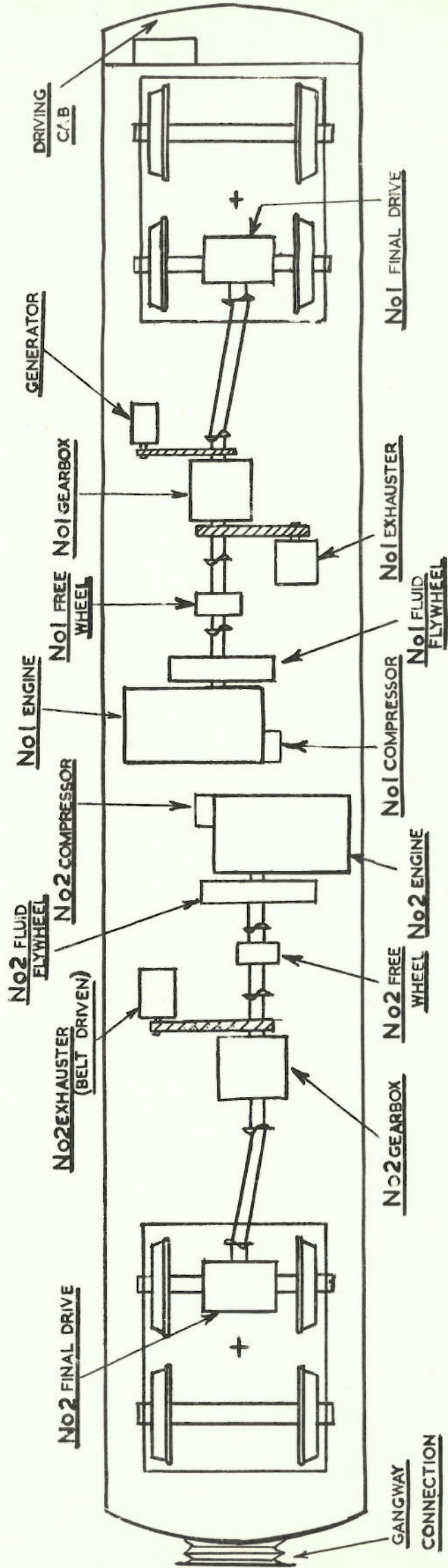
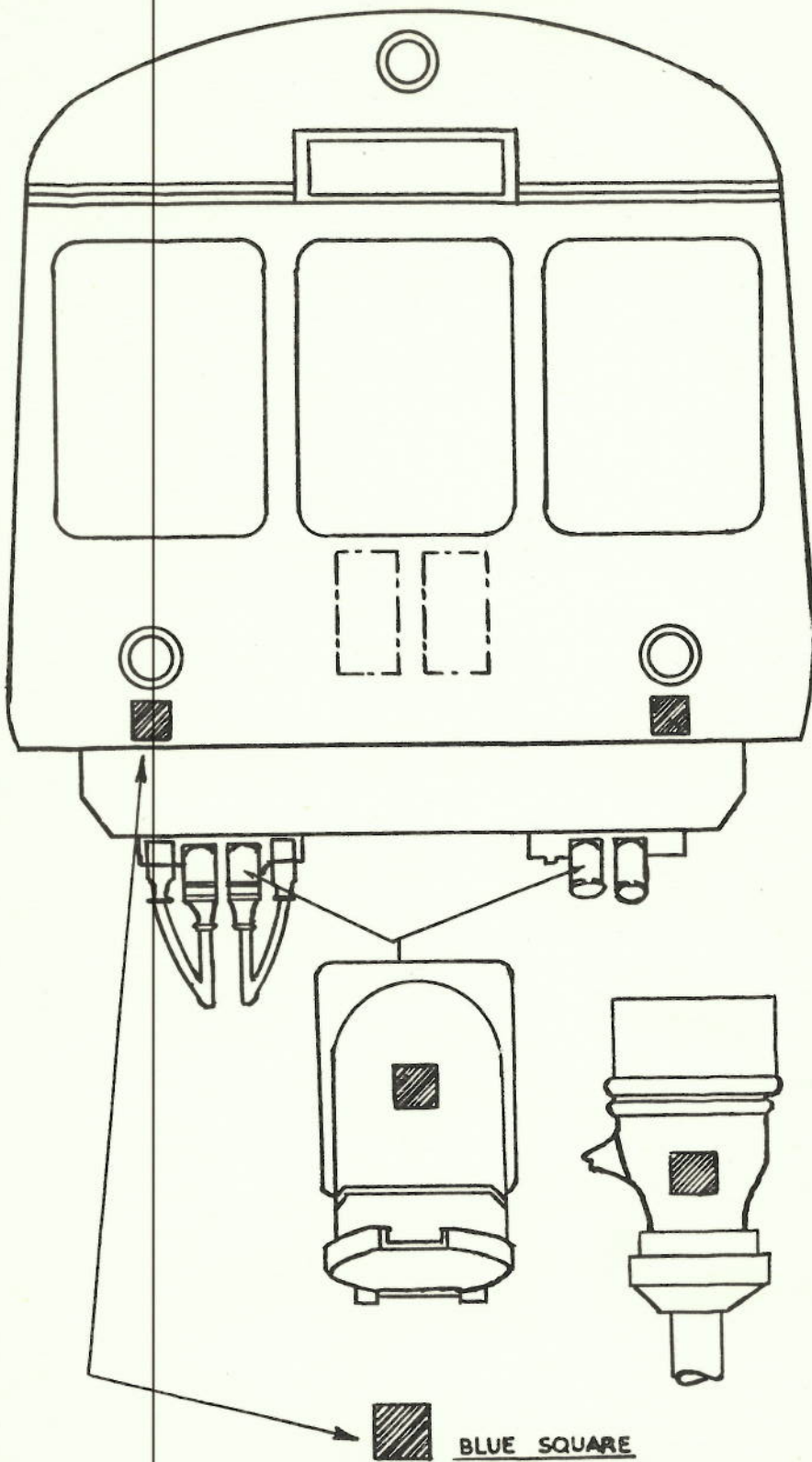
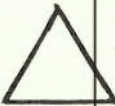


FIG.2


RAILCAR COUPLING SYMBOLS



OUTLINE OF CAR AND JUMPER COUPLINGS SHOWING 'BLUE SQUARE' COUPLING CODE. OTHER COUPLING CODE SYMBOLS ARE :-

  
RED TRIANGLE

  
YELLOW DIAMOND

  
WHITE CIRCLE

**DIESEL TRACTION NOTE No. 2**

**DIESEL ENGINES—THE FOUR-STROKE CYCLE**

When air is compressed quickly in a cylinder by means of a piston its temperature rises, and it is this final high temperature of the compressed air which ignites the fuel oil and which is the main characteristic of the compression ignition engine.

There are two basic types of engine, the four-stroke and the two-stroke. All railcar engines are four-stroke.

In every four strokes of the piston from one end of the cylinder to the other, one is a working (or power) stroke.

Diagram 3 shows the four strokes, which are as follows:—

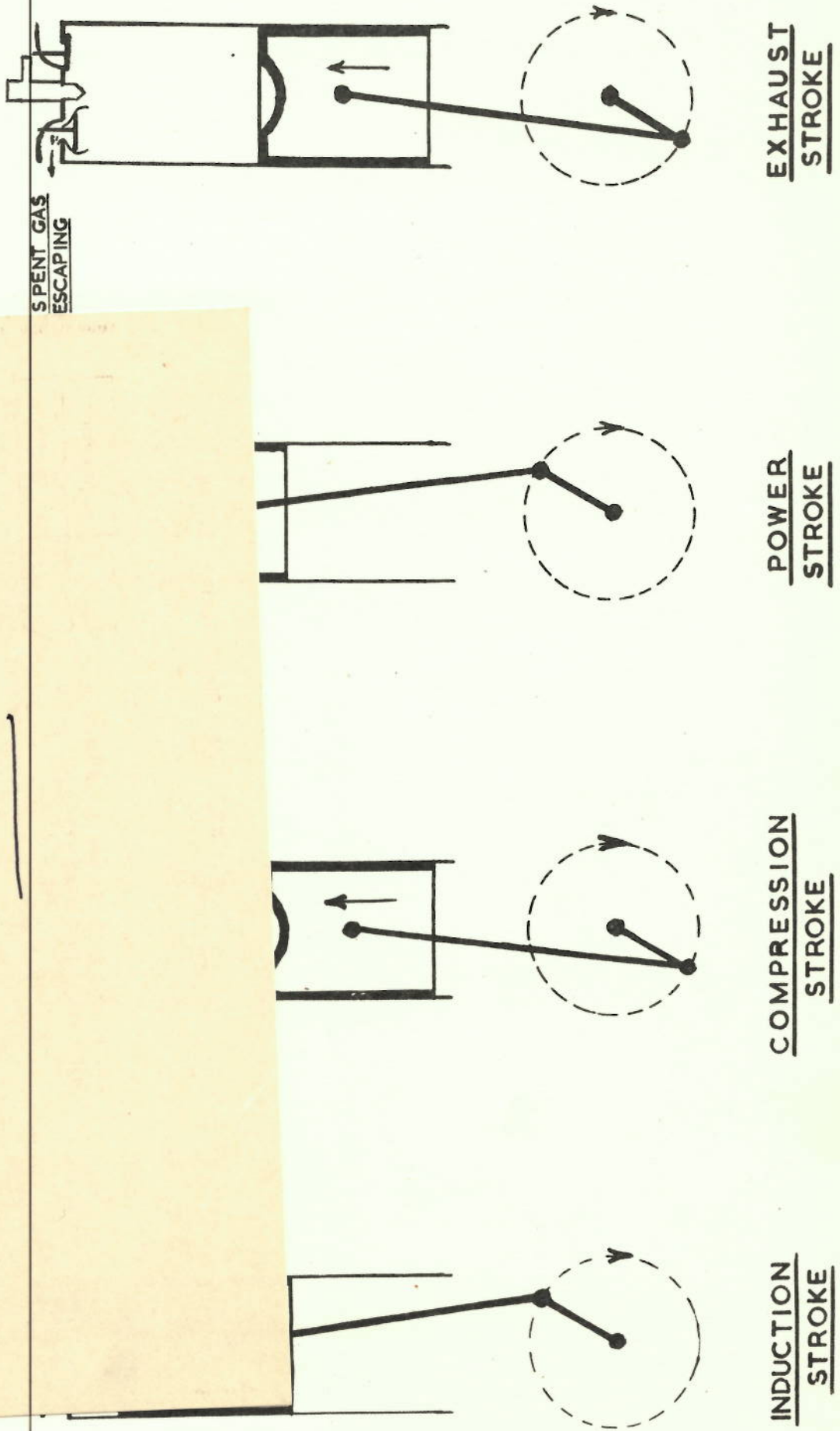
- (1) Induction stroke. Clean air is drawn into the cylinder through an inlet valve, by the piston moving along the cylinder liner.
- (2) Compression stroke. At the end of the induction stroke the inlet valve closes. Both valves are now closed, and as the piston moves back along the cylinder the air is compressed to about 700 lb. per square inch.
- (3) Power stroke. Just before completion of the compression stroke, oil is sprayed into the cylinder at a pressure of approx. 2,500 lb. sq. in. (varying with different engine designs). This mixes with the hot compressed air and ignites since the temperature is well above the spontaneous ignition temperature of the fuel oil. As the fuel burns, the pressure in the cylinder rapidly rises and the piston is forced down on its working or power stroke.
- (4) Exhaust stroke. Just before the piston reaches the end of the power stroke the exhaust valve opens and on the return stroke the piston pushes the waste gas out of the cylinder through the exhaust valve.

The inlet valve opens just before the end of the stroke, the exhaust valve closes just after T.D.C. and the cycle repeats. There is thus one working stroke in every four strokes, or two revolutions of the crank-shaft.

*Drawing References*

3. THE FOUR-STROKE CYCLE

FIG. 3



**DIESEL TRACTION NOTE No. 3**

**DESCRIPTION OF TYPICAL DIESEL ENGINE**

Engines fitted to railcars are 6-cylinder horizontal four-stroke single acting direct injection type, incorporating push rod operated overhead valves. There are two detachable cylinder heads, each covering three cylinders. The valve rocker gear, valves and the fuel injectors are carried in the cylinder heads.

Diagram No. 4 shows a typical layout of a diesel engine, cylinder, valves, camshaft, etc.

In the diagram it will be seen that the piston acts through the connecting rod to turn the crankshaft. At one end of the crankshaft, drive is taken out to the wheels through the transmission. At the other end (known as the free end) a pinion on the crankshaft drives the camshaft through gearing. On the camshaft, as its name implies, are cam lobes which rotate with the camshaft and operate against tappets. There is one exhaust valve and one inlet valve to each cylinder. The motion given by the tappets is transmitted through push rods to the rockers on the top of the cylinders, the rockers depress the valves to open. Springs close the valves. Particulars of opening and closing the valves are given under the notes on the four-stroke cycle. The valves are timed accurately to open and close at the exact moment required by the design of the engine.

The fuel injector is in the cylinder head and is supplied with fuel oil from the fuel injection pump.

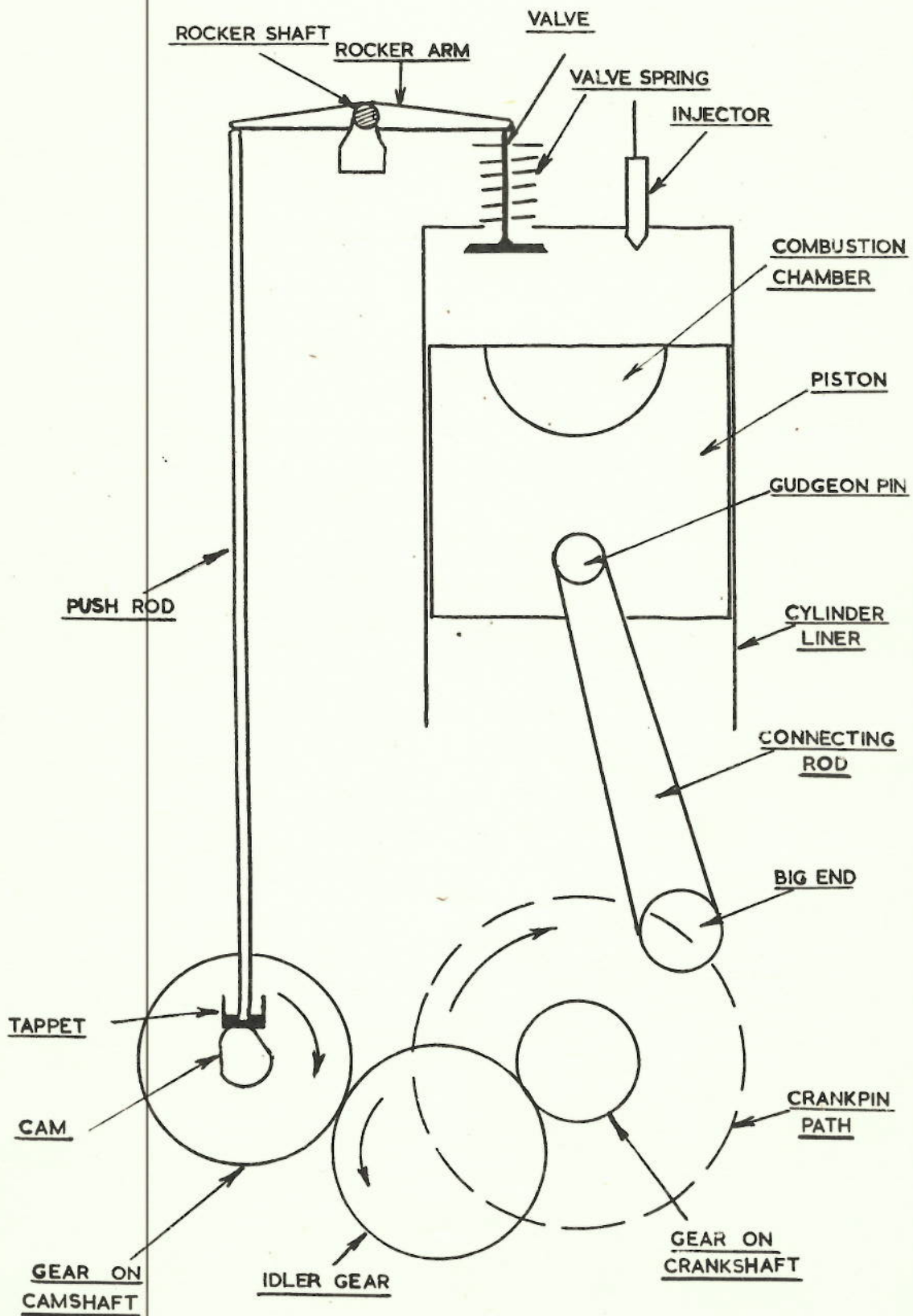
The cavity in the top of the piston is a combustion chamber. This arrangement of injector and combustion chamber is known as "direct injection".

*Drawing Reference*

**4. OPERATION OF TYPICAL DIESEL ENGINE**

FIG 4

OPERATION OF VALVE GEAR



**DESCRIPTION OF A.E.C. 150-H.P. HORIZONTAL ENGINE**

Diagram No. 5 shows a section through a 150-h.p. A.E.C. engine with key to part numbers (see below)

Engine data:—

- Number of cylinders, 6.
- Cylinder dimensions, 5.12 ins. bore × 5.59 ins. stroke.
- Cubic capacity, 11.3 litres (690 cu. ins.).
- Maximum torque, 490 lb./ft. at 1,300 r.p.m.
- Firing order, 1, 5, 3, 6, 2, 4.
- Compression ratio, 16:1.
- Lubrication system, dry sump.
- Lubricating oil capacity, 6½ galls.
- Maximum governed speed, 1,800 r.p.m.
- Approximate weight, 15¾ cwts.

The engine is built up of four main parts:—

- (1) Cylinder heads (High-grade cast iron).
  - (2) Cylinder block and crankcase (High-grade cast iron).
  - (3) Extension piece (Alloy).
  - (4) Sump (Alloy).
- (1) Cylinder heads. Two heads are fitted, each covering three cylinders. On them are mounted the inlet and exhaust valves, rocker gear, injectors and exhaust manifolds. The joint between the cylinder block and the cylinder head is made with a copper asbestos gasket.
  - (2) Cylinder block and crankcase. The cylinder bores are fitted with dry liners, made of high-grade centrifugally cast iron. The pistons of aluminium alloy are attached by fully floating gudgeon pins to connecting rods, the big ends of which are attached to a crankshaft which is also housed in the crankcase.
  - (3) Extension piece. This collects the oil returning from the working parts of the engine, and it is from this extension piece that the scavenge pump draws oil.
  - (4) Sump. The sump is really the oil reservoir of the engine and it is from the sump that the pressure pump draws its oil. On the back of the sump is mounted a filter containing a felt element.

**LUBRICATION.** Lubrication is of the dry sump type. It can be divided into two sections, scavenge and pressure.

- (1) Scavenge system. The scavenge pump sucks oil from the bottom of the extension piece and passes it through an oil cooler and filter before delivering it to the sump.
- (2) Pressure system. The pressure pump draws oil from the sump and delivers it to the main bearings of the crankshaft, and through drillings in that shaft to the big ends. The cylinder walls and gudgeon pins are lubricated by splash and mist. Through a metering device in the pressure pump we get low-pressure lubrication for the rocker gear and valve stems. The oil pump is driven from the free end gear train.

A schematic layout of the lubricating system is shown in diagram No. 6.

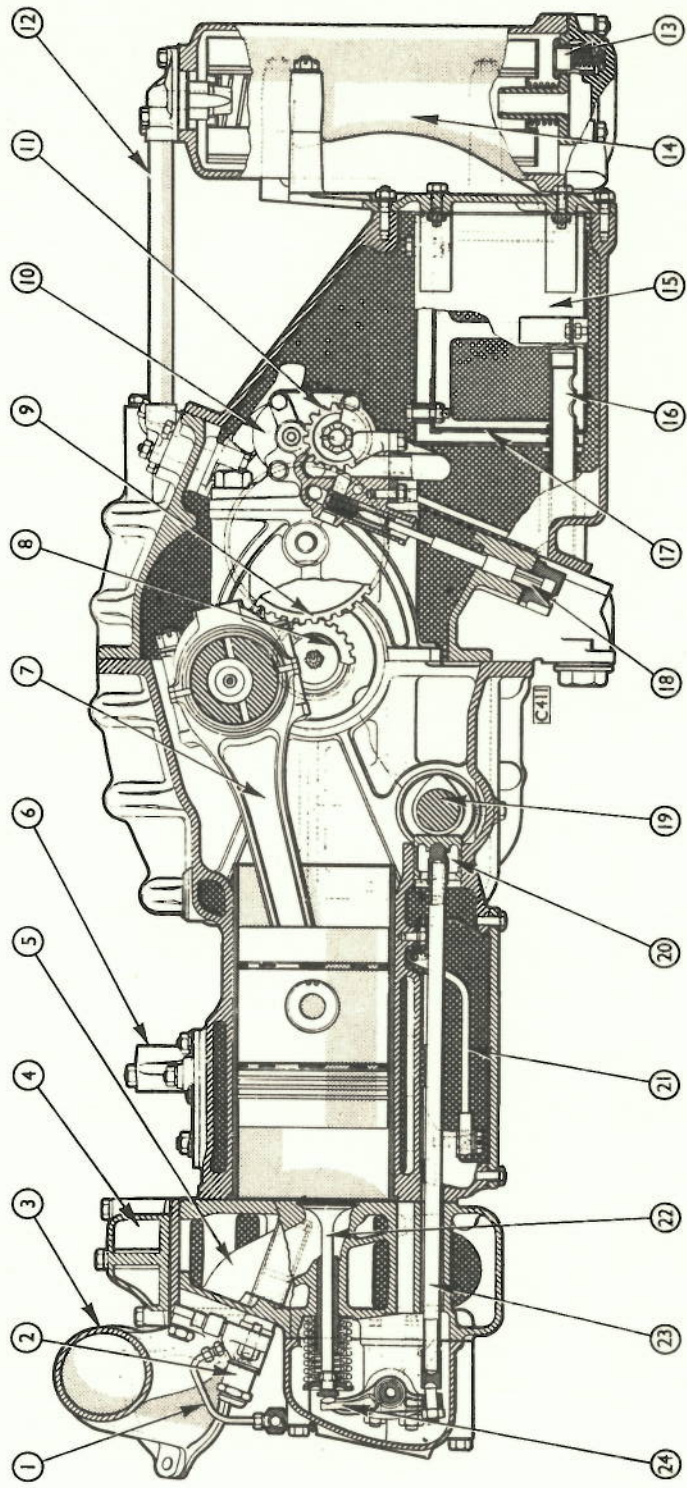
*Key to part numbers. Diagram No. 5*

- |                             |                                      |
|-----------------------------|--------------------------------------|
| 1. Fuel return pipe         | 13. Oil filter pressure relief valve |
| 2. Fuel injector            | 14. Oil filter                       |
| 3. Exhaust manifold         | 15. Oil strainer cover               |
| 4. Water passage            | 16. Oil suction pipe to oil pump     |
| 5. Exhaust pipe             | 17. Oil strainer                     |
| 6. Restraining link bracket | 18. Oil pressure relief valve        |
| 7. Connecting rod           | 19. Camshaft                         |
| 8. Crankshaft gear          | 20. Tappet                           |
| 9. Idler wheel              | 21. Oil feed to rockers              |
| 10. Oil pump                | 22. Exhaust valve                    |
| 11. Oil pump gear           | 23. Push rod                         |
| 12. Oil pipe to filter      | 24. Rocker                           |

*Drawing Reference*

5. SECTION THROUGH A.E.C. ENGINE
6. LUBRICATION SYSTEM (A.E.C. ENGINE)

FIG. 5



DIESEL TRACTION NOTE No. 5

**DESCRIPTION OF LEYLAND 6-CYLINDER HORIZONTAL DIESEL ENGINE**

Diagram No. 7 shows a cut-away view of a Leyland 6-cylinder engine.

The Leyland or B.U.T. "L" type is similar to the B.U.T., A.E.C. "A" type, and is of 150 h.p. at 1,800 r.p.m.

*Engine Data:*

Number of cylinders, 6  
Cylinder dimensions, 5.0 in. bore × 5.75 in. stroke.  
Cubic capacity 677 cu. in.  
Maximum torque, 450 lb. ft. at 1,100 r.p.m.  
Firing order, 1, 5, 3, 6, 2, 4.  
Compression ratio, 16:1  
Lubrication system, wet sump, gear type pump.  
Lub. oil capacity, 5½ gals.  
Approximate weight, 15¾ cwt.

The engine can be divided into three main parts:

- (1) Cylinder heads. High-grade cast iron.
- (2) Crankcase and cylinder block. High-grade cast iron.
- (3) Sump. Alloy.

(1) Cylinder heads. These differ from the A.E.C. type heads in that Leylands fit their own injectors instead of C.A.V. equipment and these injectors are under the rocker covers out of sight. Decompressors are fitted to assist in turning the engine over by hand.

(2) Cylinder block and crankcase. This varies mainly from the A.E.C. type in that the oil feeds to bearings, etc. are carried in cored passages and drillings in the crankcase instead of through pipes. The big ends and main bearings are fitted with Vandervell shell bearings.

(3) Sump. The sump is mounted on the back of the crankcase and has a suction filter inside. The fuel injection pump and fuel filter are mounted on the sump together with the "Glacier" centrifugal lubricating oil filter (7c).

Lubrication (7A). There is only one pump (7B) in the Leyland engine and it is driven from the driving end of the camshaft. Oil is drawn from the sump and passed through an oil cooler (7D) before being delivered to the crankshaft main bearings. The rocker gear is lubricated from the second and fifth camshaft bearings; a drilling in the crankcase coincides with a drilling from the centre of the camshaft, so that a feed of oil goes to the cylinder heads once per revolution of the camshaft. In this way we get low-pressure lubrication to the rocker gear. A bleed is taken from the line between the pump and cooler and feeds the oil to the centrifugal filter (7c). After filtration the oil returns to the sump.

*Drawing References*

7. CUT-AWAY VIEW OF LEYLAND 6-CYL. ENGINE
- 7A. LUBRICATION SYSTEM. B.U.T. "L" TYPE ENGINE
- 7B. OIL PUMP (GEAR TYPE)
- 7C. LUBRICATING OIL FILTER (LEYLAND)
- 7D. LUBRICATING OIL COOLER

## DIESEL TRACTION NOTE No. 6

## DESCRIPTION OF ROLLS-ROYCE 8-CYLINDER DIESEL ENGINE. MODEL C8. NFLH

Explanation of engine type code letters is as follows:

- C Oil engine division
- 8 Number of cylinders
- N Normally aspirated
- F Ferrous crankcase
- L Left hand engine
- H Horizontal.

A normally aspirated 4-stroke, direct injection compression ignition engine.

*Engine Data:*

Rated power and speed:	238 b.h.p. at 1,880 r.p.m.
Bore:	5.125 in.
Stroke:	6.0 in.
Compression ratio:	16:1
Firing order:	1, 6, 2, 5, 8, 3, 7, 4
Direction of rotation:	Clockwise, viewed from front of engine.

*Fuel System:*

Pressure:	10-12 p.s.i. maintained by C.A.V. piston-type lift pumps.
Injection:	C.A.V. equipment ("N" type pump) Fuel injector lifting pressure—175 atmospheres (2,570 lb. per sq. in.)
Lub. oil Capacity:	12½ gals.
Lub. oil Pressure:	Max. 75 p.s.i. Normal 40-60 p.s.i. Minimum 10-15 p.s.i.

*Main features:*

*Crankcase:* Nickel chrome iron alloy. The cylinder block is cast integrally with the crankcase and is fitted with "wet" centri-cast liners.

*Crankshaft:* Forging in Hydro steel and nitride hardened. At the front end an externally mounted viscous torsion damper effectively reduces crankshaft oscillations over the full working range.

*Connecting Rods:* H-Section nickel steel forgings.

*Bearings:* Main and big end bearings are steel backed lead bronze shell type, lead flashed to provide a surface for running in. A coating of indium prevents corrosion of the lead and also increases its tensile strength.

*Pistons:* Aluminium alloy castings, incorporating a straight-sided cavity combustion chamber. Each piston carries three compression rings and one oil scraper ring.

*Cylinder Liners:* Centri-cast and are a press fit into the block. Two rubber rings around the skirt of the liner make a seal to prevent coolant entering the crankcase.

*Lubrication:*

The gear-type pressure pump is driven from the free end gear train. Oil is drawn from the sump through a gauze strainer and delivered via a pack type heat exchanger to the main relief valve. Spill from here re-enters the sump. The remaining oil is piped via the two full flow filters to the gallery pipe feeding the crankshaft main bearings, and then through drillings in the crankshaft webs to the sludge traps in the crank pins; from here it lubricates the big end bearings. The connecting rods are drilled longitudinally and oil from the big end bearings is forced through the drillings to lubricate the small end bushes. The camshaft bearings receive an individual supply of oil via drillings in the main bearing webs.

Tappings off Nos. 1 and 9 main bearings provide low-pressure lubrication for the rocker gear and valve stems; the feed to the hollow rocker shafts is via two hollow steel studs in each cylinder head. The studs provide a restricted passage for the oil which therefore reaches the rocker shaft bearings at a reduced pressure. Tappings from Nos. 1 and 5 camshaft bearings and the main gallery provide lubrication for the free end gear train.

Oil from the main bearings, big ends, cylinders and valve gear drains by gravity back to the sump. Surplus oil from the free end gears and bushes in the wheelcase falls into the wheelcase drain chamber. This oil is returned into the sump by the scavenge pump.

*Drawing Reference*

7E. LUBRICATION SYSTEM ROLLS-ROYCE 8-CYLINDER ENGINE

**FIG. 6**  
**LUBRICATION SYSTEM BUT A TYPE 11.3 LITRE ENGINE**

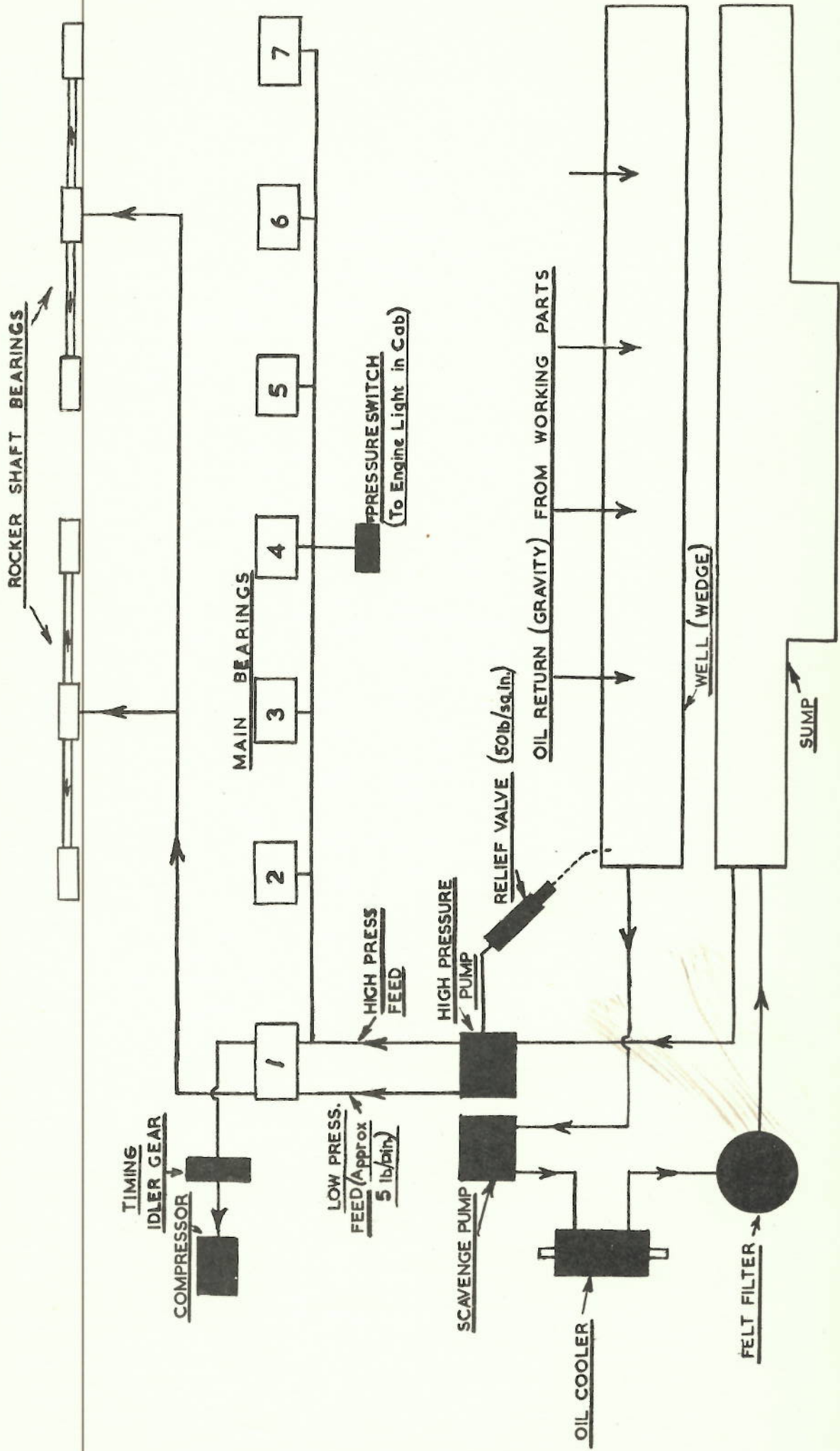
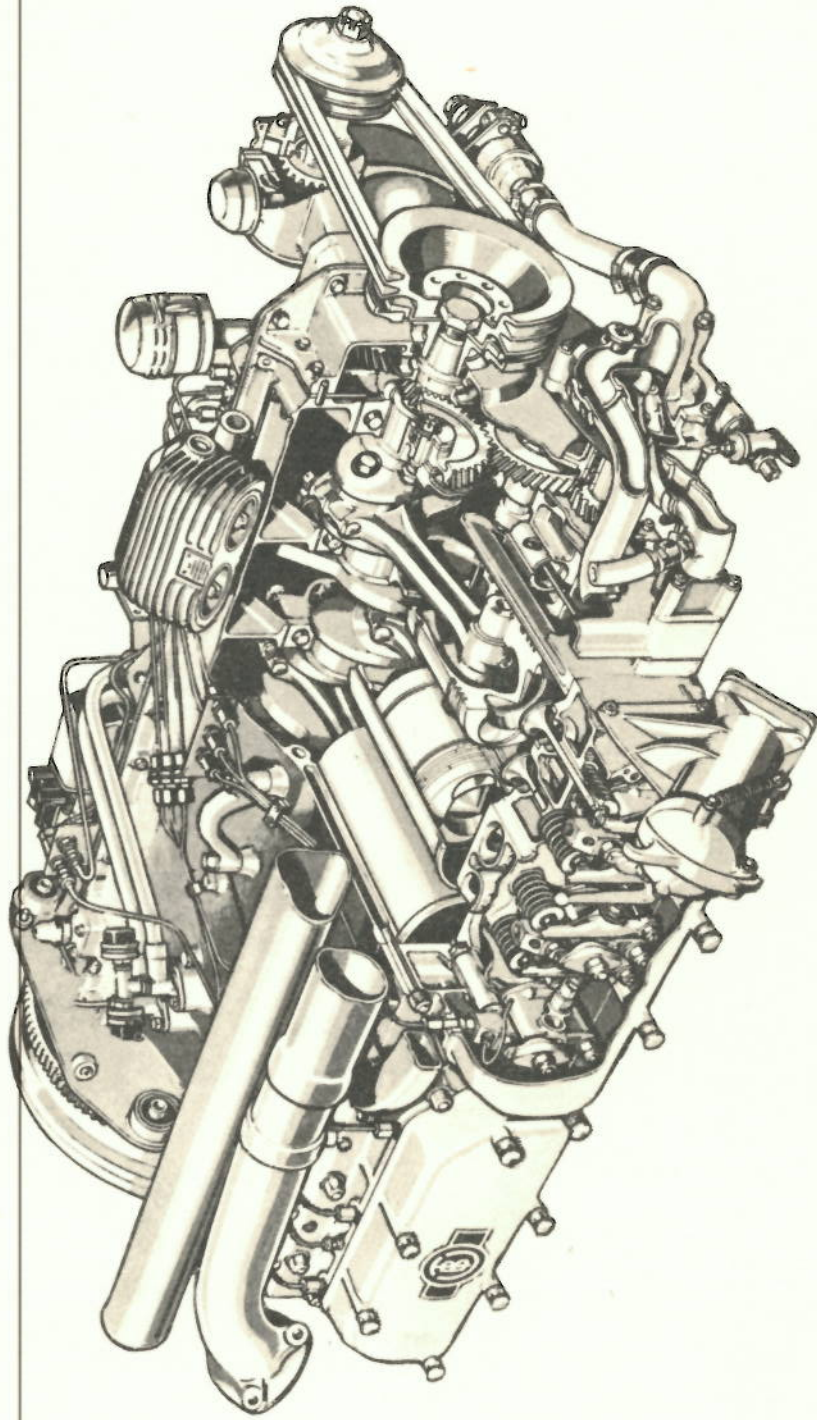


FIG. 7



# LUBRICATION SYSTEM B.U.T. "L" TYPE 11.1 LITRE ENGINE

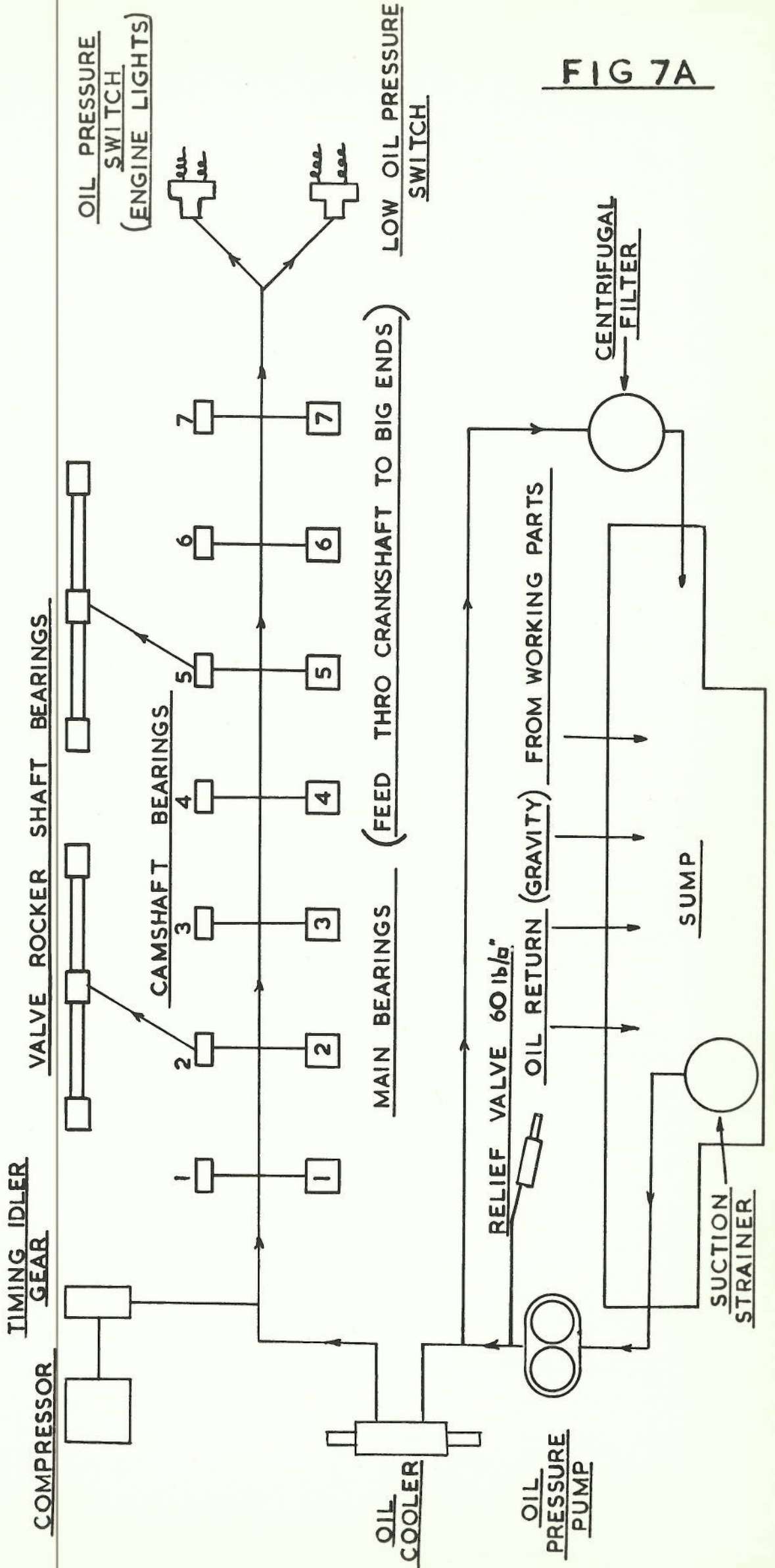


FIG 7A

OIL PUMP (GEAR TYPE)  
(PRINCIPLE)

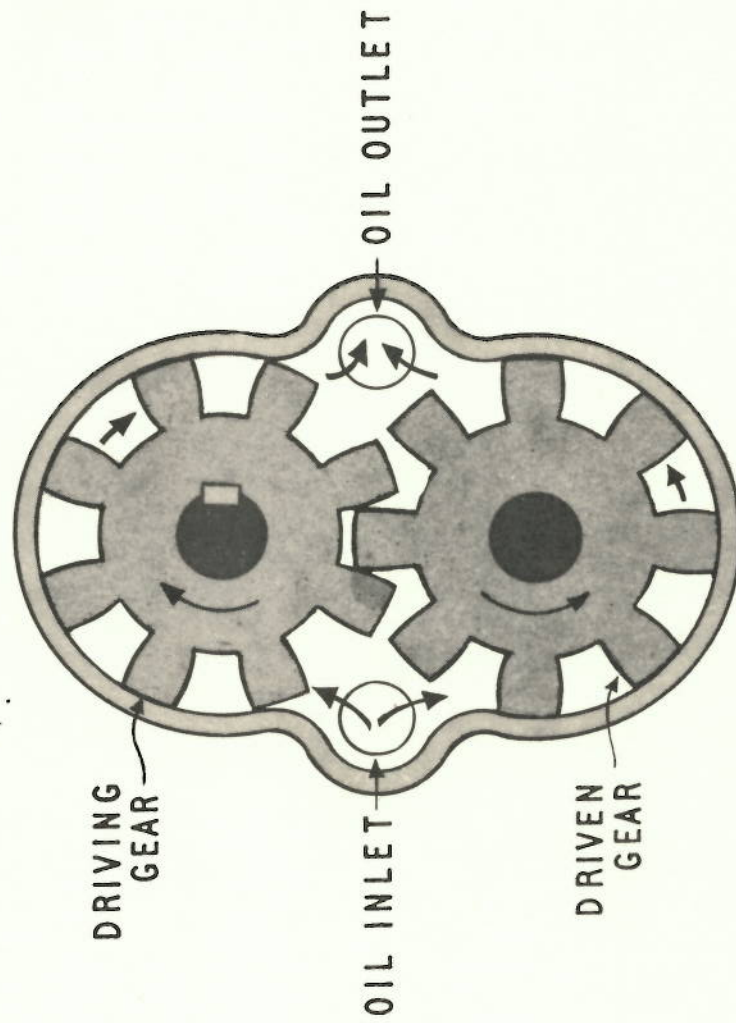
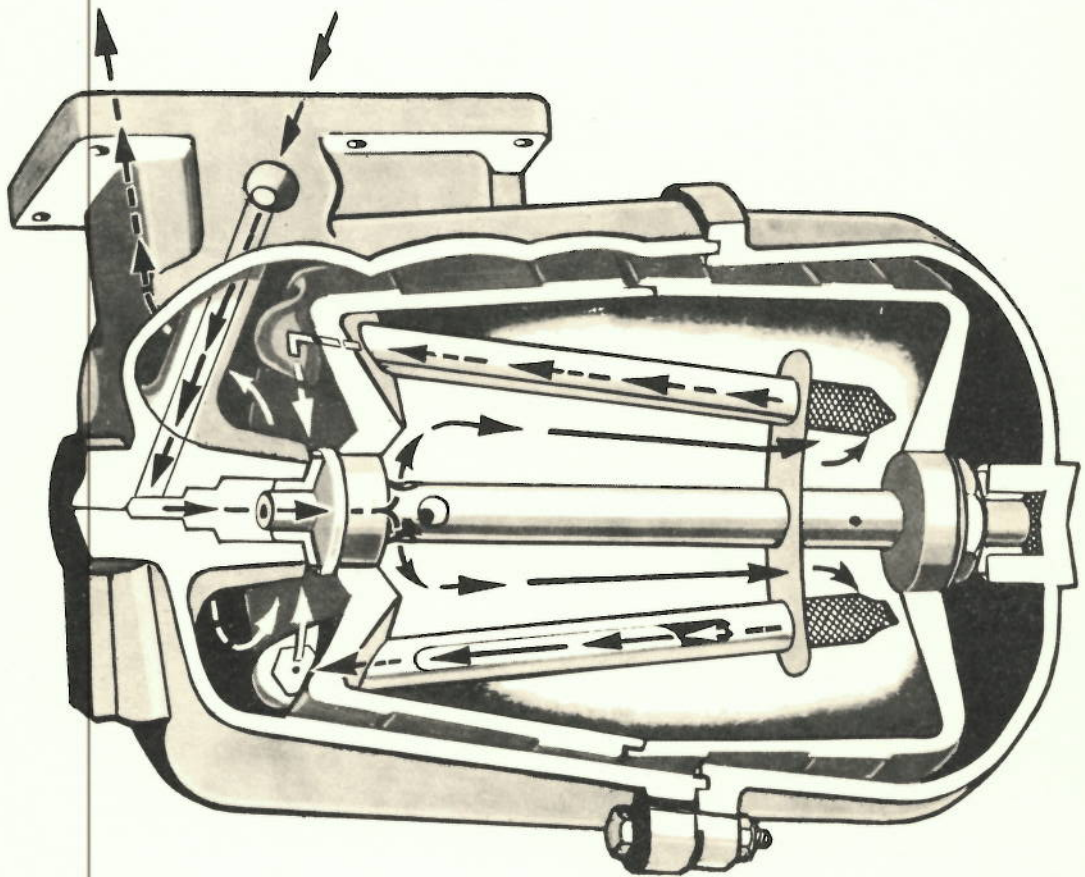


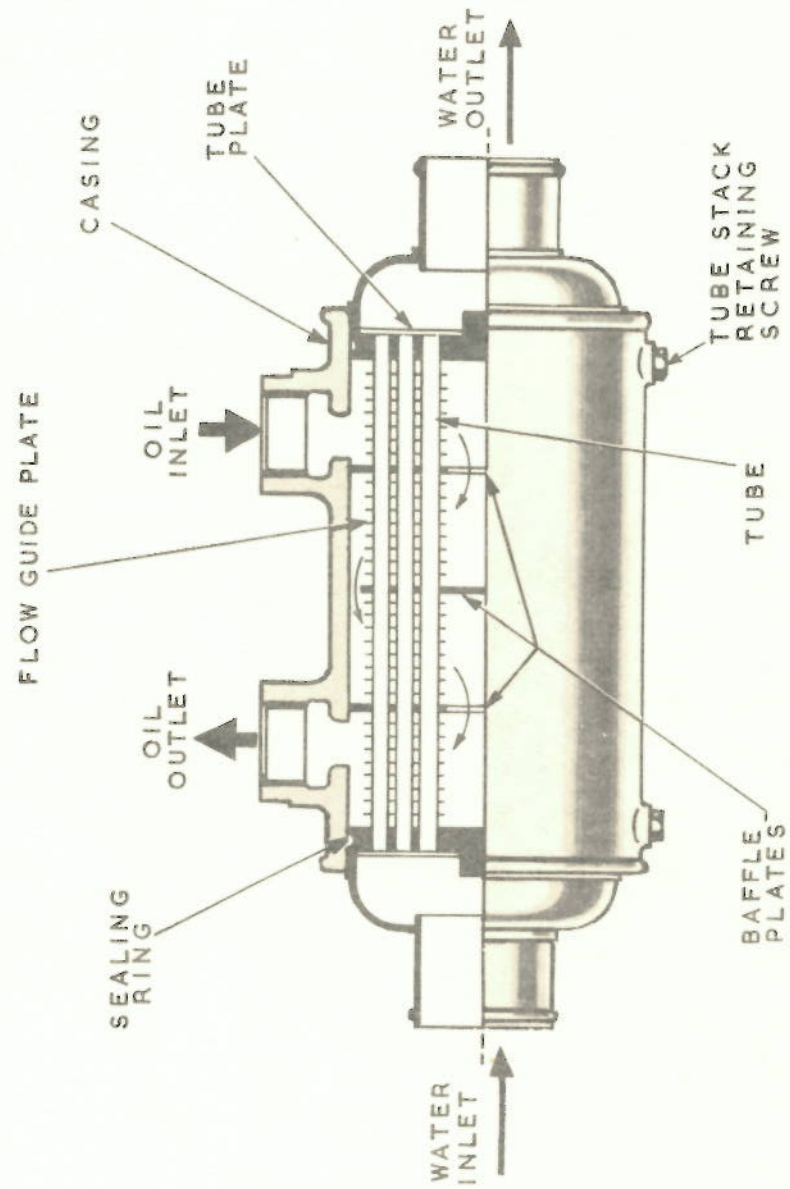
FIG. 7<sup>B</sup>

FIG. 7c



LUB. OIL FILTER (LEYLAND)

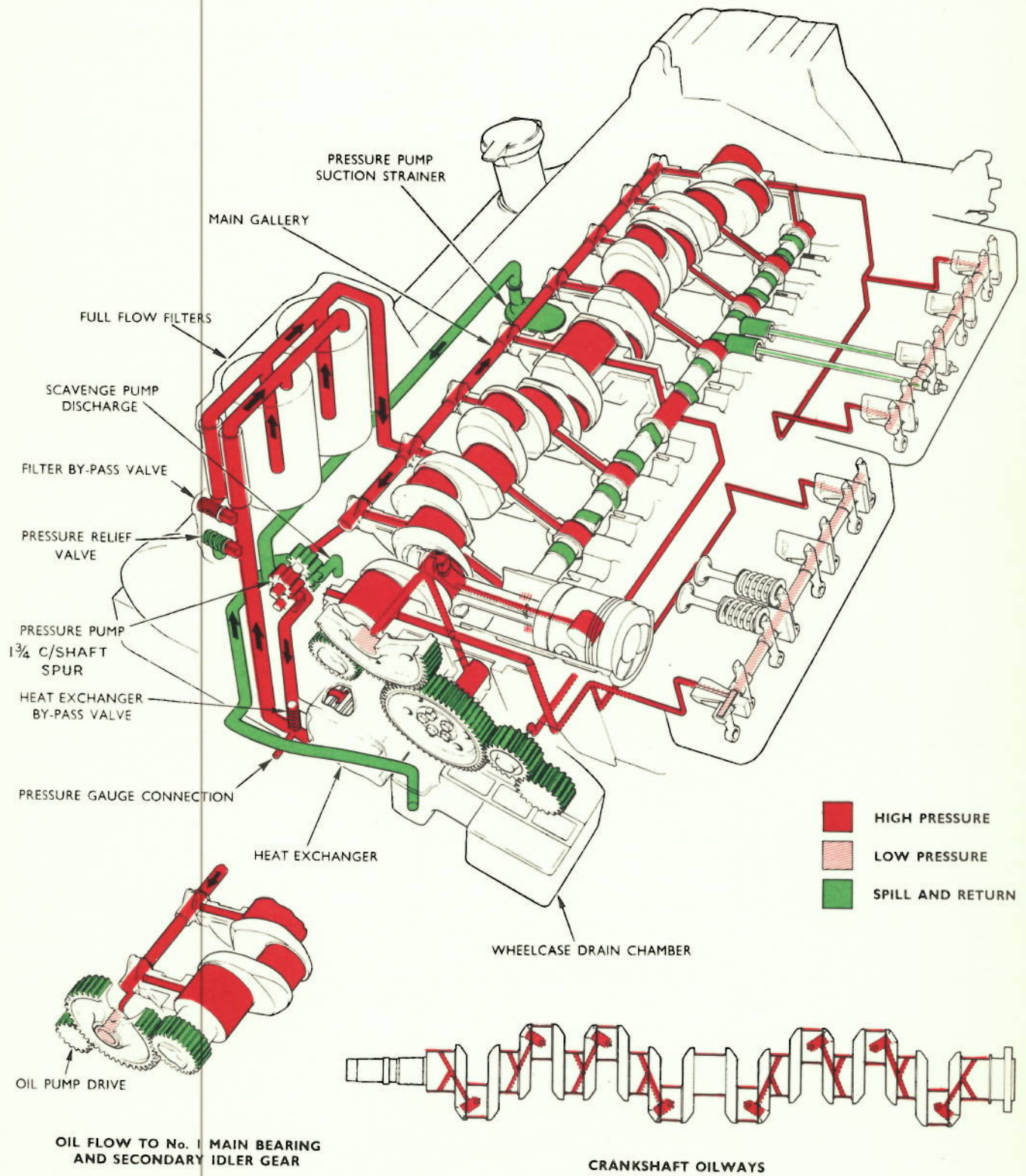
FIG. 7D



LUB. OIL COOLER

**FIG. 7E**

**8 CYL. ENGINE**



**LUBRICATION SYSTEM**

**DIESEL TRACTION NOTE No. 7**

**RAILCARS—FUEL INJECTION SYSTEM**

Each power car is fitted with two engines and there is a complete fuel injection system for each engine.

Fuel is drawn from the fuel tank through a primary filter by a lift and feed pump which passes the fuel through two secondary filters to the fuel pump gallery in the fuel injection pump. The fuel injection pump delivers fuel to the fuel injectors in the correct quantity at the correct time.

The amount of fuel delivered to the engine cylinders is controlled on the fuel injection pump by the throttle motor operated by the driver's throttle handle in the cab.

A governor is provided on the fuel injection pump to control the minimum and maximum engine speeds.

From the injection pump there are fuel lines to each fuel injector in the cylinder heads.

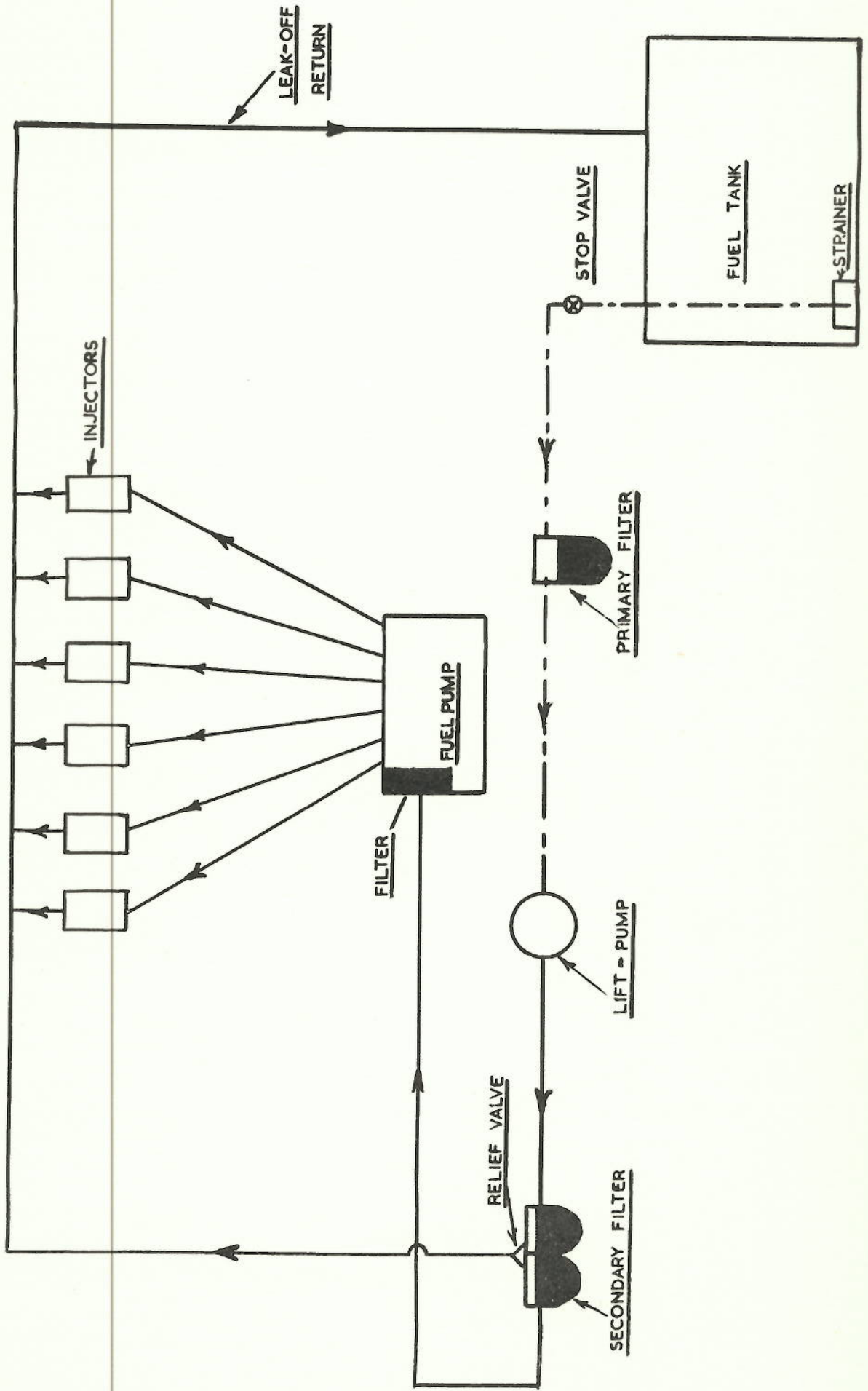
A schematic layout of the fuel system is shown in diagram No. 8.

*Drawing Reference*

8. FUEL INJECTION SYSTEM

# FUEL INJECTION SYSTEM

FIG. 8



**B.U.T. RAILCARS—MAX./MIN. SPEED MECHANICAL GOVERNOR****CONSTRUCTION** (see diagrams Nos. 8A and 8B)

The governor is enclosed in a housing bolted directly to the injection pump. Two flyweights (12) are supported by the pump camshaft and are mounted on spring loaded pillars. Each weight operates against an outer spring which controls the idling speed, and two strong inner springs which control the maximum speed. Two bell crank levers are attached to the weights at one end and a guide bush at the other. This in turn is connected to the swing link (16). The swing link is carried on an eccentric (14) and is connected at the top to the control rack (7). The eccentric can be rotated by the control lever (15) which in turn is connected to the throttle motor by the linkage (22).

A maximum fuel stop is incorporated at the front end of the pump.

**OPERATION** (see diagram 8A)**(a) Starting** (See Fig. A)

When starting the engine the control lever is moved to the right towards the maximum fuel position. The eccentric (14) causes the swing link (16) to pivot about (21) since the flyweights (12) are almost immovable at this instant. This causes the control rack (7) to move towards its maximum delivery position as in Fig. B.

The engine fires and begins to run up to speed. If the control lever is brought back into the idling position the governor will come into operation and hold the engine R.P.M. to a pre-determined speed as follows: When the control lever is moved to the idling setting, the governor assumes a position as shown in Fig. A. Should the R.P.M. try to increase, it causes the centrifugal loading on the weights to rise and the swing link will now pivot around the eccentric (held fixed by the control lever setting) to bring the rack into a reduced delivery position.

Should the R.P.M. try to fall the flyweight loadings are reduced, causing the swing link to pivot around the eccentric (but in an opposite direction to when R.P.M. tries to rise), and thus moves the control rack to an increased delivery position.

**(b) Accelerating** (See diagrams 8A and 8B)

When the control lever (15) is moved from the idling position, the eccentric (14) moves the swing link (16) to the right, pivoting about (21). This causes an increased rack travel to permit more fuel to the engine and allow it to accelerate.

The R.P.M. obtained is determined solely by the control lever position and not by governor control, as will be seen from diagram 8B Fig. B, the weights due to the two strong inner springs cannot move beyond this position until the maximum R.P.M. is reached. Conversely the weights cannot move from diagram 8B Fig. B. position to Fig. A position until the engine R.P.M. has fallen to idling speed.

It will, therefore, be understood that should a gradient be encountered, the R.P.M. will immediately start to fall, unless it is corrected through the throttle control.

**(c) Maximum Speed Control** (See diagram 8A)

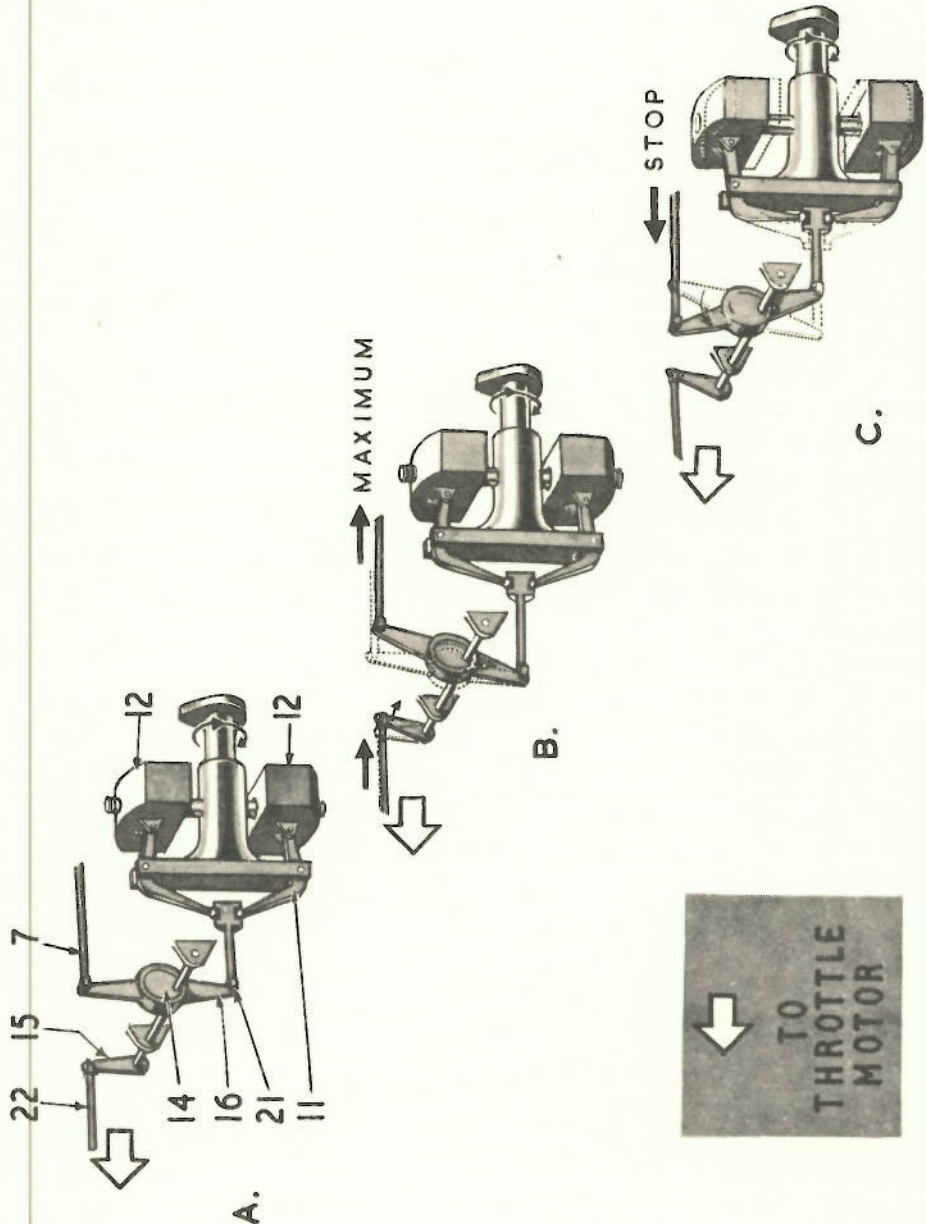
Should the control lever be opened to a position where the fuel pump delivers more fuel than the engine requires for the load, the engine speed will tend to exceed the pre-determined limit. This will cause the centrifugal force on the weights to increase sufficiently to overcome the strong inner springs (diagram 8B Fig. C). The weights will now travel further outwards and through the action of the bell crank levers, pivot the swing link about the eccentric to pull the control rack to a reduced fuel delivery position and hold the engine speed at the pre-determined maximum, irrespective of the control lever being too wide open.

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

*Key to Diagram 8A.*

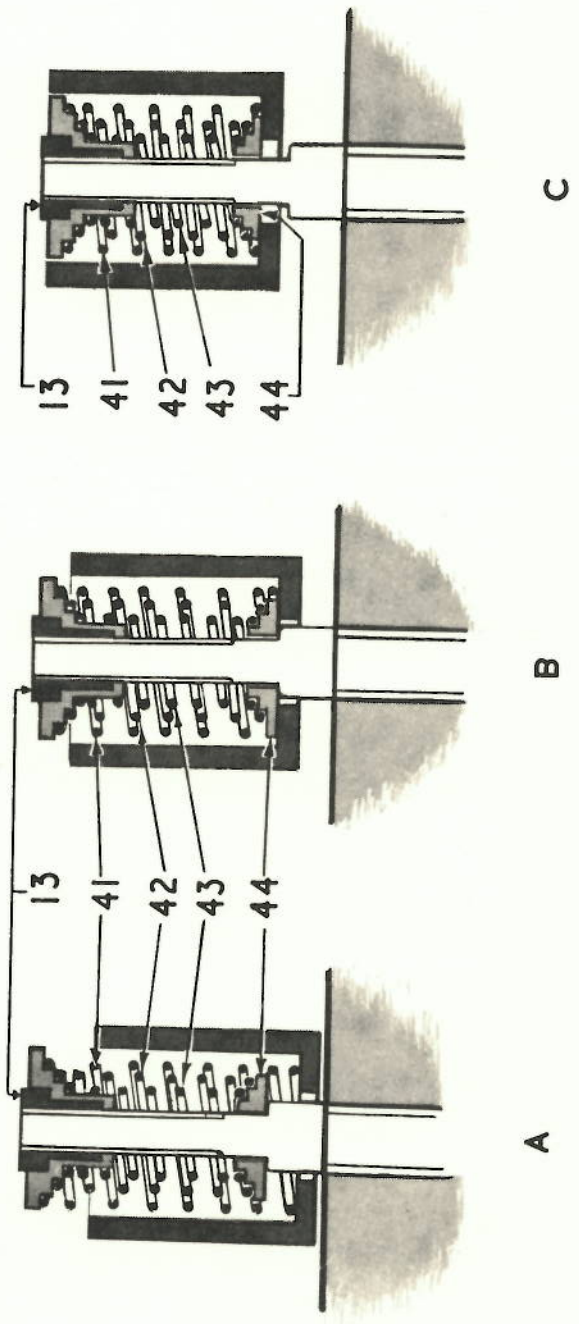
Throttle motor linkage	22
Control lever	15
Control rack	7
Eccentric	14
Swing link	16
Coupling pin	21
Bell crank levers	11
Flyweights	12

FIG. 8A



PRINCIPLE OF MAX / MIN WEIGHT  
TYPE GOVERNOR

FIG. 8<sup>B</sup>



SECTION THROUGH GOVERNOR SPRINGS.

## ROLLS ROYCE CARS—HYDRAULIC GOVERNOR

### CONSTRUCTION (See diagram 8c)

The unit is enclosed in an aluminium casting attached directly to the injection pump.

The rack, *J*, is attached to a drag link *K*, pivoting at point *V*, on the governor lever. At the top of this lever a swing link, *L*, is connected to the servo piston, *G*, which is spring loaded on one side.

A gear type pump is driven from the camshaft by a self-aligning coupling, and receives its fuel supply from the injection pump gallery and delivers it to an amplifier piston, *F*. The amplifier piston has a metering hole in the crown allowing fuel to pass to the servo piston, *G*, moving it against spring *H*, thus moving the rack to an increased delivery position.

The stem of the amplifier valve, *E*, is in contact with the underside of the amplifier piston. The head of the valve is in contact with a spring loaded plunger whose rating can be altered by movement of the operating lever, *Y*, within the limits of its maximum stop, *X*, and minimum stop, *Z*.

Two relief valves, *B* and *C*, limit the fuel pressure on each side of the servo piston.

An idling valve, *N*, is loaded by spring, *M*, to the pump casing on one side and to a spring-loaded plunger, *P*, in contact with the slow-running screw, *Q*, on its other side.

Two bleed points, *A1*, are provided on the top of the governor casing to bleed either side of the servo piston, this operation should be carried out when the engine is running.

### OPERATION

On starting, the operating lever is moved to full travel, thus loading the amplifier valve and keeping it on its seat. The engine is now rotated by the starter motor and the gear pump begins to deliver fuel to the governor. The quantity of fuel flowing is small at this speed, and the pressure drop across the orifice of the amplifier piston is also very small; in consequence no appreciable end thrust is developed. Thus the amplifier valve stays closed and the fuel oil is trapped against the servo piston. As the opening pressure rises, the servo piston forces the rack open and fuel is delivered to the engine. This continues until the engine fires.

As the engine gathers speed, the increased flow of fuel oil sets up a pressure difference across the amplifier piston which thrusts against and opens the amplifier valve. This admits fuel oil to the "closing" side of the servo piston which moves to operate the rack and reduce the fuel supply to the engine. If the operating lever is now closed the spring force holding the amplifier valve towards its seat is reduced. The amplifier valve will now open further, allowing more fuel oil to flow past it, resulting in a higher closing pressure and a lower opening pressure. This will cause the servo piston to move the rack to a position to give idling fuelling and the idler valve will now be in control to hold the R.P.M. steady.

On opening up, the engine speed will respond to the operating lever movement, again causing a load to be put on the amplifier valve via the spring loaded plunger. This closes the valve completely or partially, depending on the amount of operating lever movement. This cuts off or reduces the fuel passing to the spring side of the servo piston ("closing pressure"), causing a sharp rise of pressure on the "opening" side of the servo piston. As a result the servo piston moves rapidly to the "open" position, moving the rack to an increased delivery position until the engine reaches the speed selected.

At this point the pressure difference across the amplifier piston has increased, moving the amplifier valve off its seat. This causes the "opening" pressure to fall and closing pressure to rise allowing the servo piston and rack to move towards the "decrease fuel" position.

The servo piston is halted when the closing pressure has reached a quantity where the low pressure valve opens and bleeds back to the pump and out of the circuit, the same quantity of fuel which is passed into the circuit by the pump.

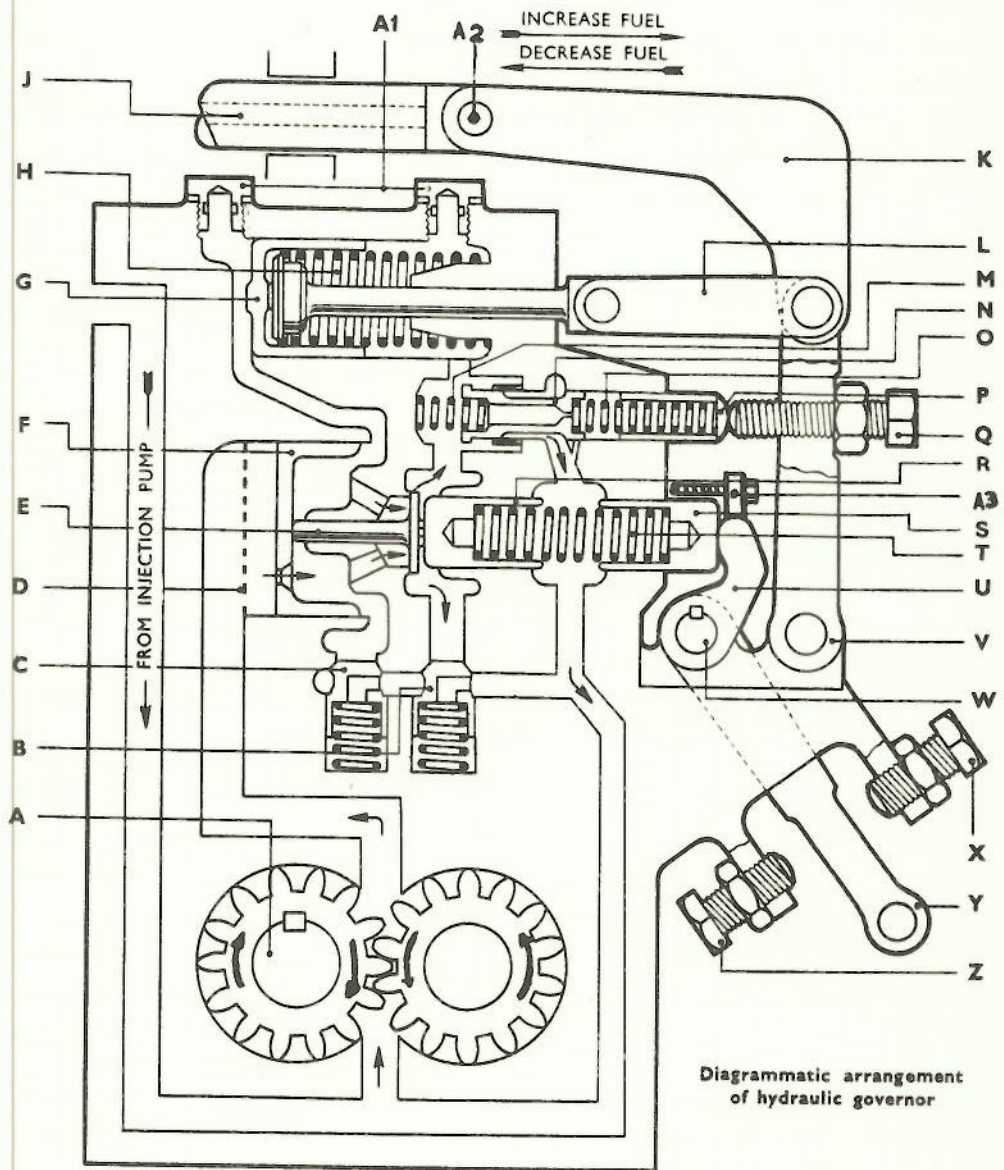
### THE IDLING VALVE

In order to reduce the effective permanent rate of the governor so that for any change of load or resistance at idling its effect on the R.P.M. will be small, an idling valve is incorporated to sample the "closing" pressure. The valve functions as follows: An adjusting screw, *Q*, or the governor lever, *V*, is in contact with a spring-loaded plunger, *P*. Movement of the plunger will impart a movement to the idling valve. The valve is fluted so that as it moves to the right the bleed from the spring side of the servo piston is decreased and vice versa.



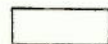
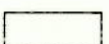
### Drawing Reference

8C HYDRAULIC GOVERNOR. FUEL INJECTION PUMP.

**HYDRAULIC GOVERNOR - FUEL INJECTION PUMP**



Diagrammatic arrangement of hydraulic governor

- |  |   |
|--|---|
|  FUEL OIL AT GOVERNOR DELIVERY PRESSURE |  FUEL OIL AT "OPENING" PRESSURE                 |
|  FUEL OIL AT "CLOSING" PRESSURE         |  FUEL OIL AT PRESSURE OF INJECTION PUMP GALLERY |

**KEY**

- |                              |                                 |
|------------------------------|---------------------------------|
| A — Gear Pump                | P — Steel Plunger               |
| B — L.P. Relief Valve        | Q — Idler Valve Adjustment      |
| C — H.P. Relief Valve        | R — Control Lever Inner Plunger |
| D — Diffuser Plate           | S — Control Lever Outer Plunger |
| E — Amplifier Valve          | T — Coil Spring                 |
| F — Amplifier Piston         | U — Control Lever Pawl          |
| G — Servo Piston             | V — Pivot Point Governor Lever  |
| H — Servo Return Spring      | W — Pivot Point Control Lever   |
| J — Control Rack             | X — Control Lever Max Stop      |
| K — Governor Lever           | Y — Control Lever               |
| L — Connecting Rod           | Z — Control Lever Min. Stop     |
| M — Idler Valve Inner Spring | A1 — Bleed Points               |
| N — Idler Valve              | A2 — Clevis Pin                 |
| O — Idler Valve Outer Spring | A3 — Internal Stop              |

**DIESEL TRACTION NOTE No. 7C**

**ENGINE SHUT-DOWN SOLENOID**

The engine shut-down solenoid is mounted on a bracket directly above the stopping lever and its purpose is to stop the engine when (a) the stop button is depressed, (b) engine lubricating oil pressure is low, (c) low cooling water level, and (d) 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, and when in the running position it is in the down position. If the engine is stopped by any of the above mentioned causes, an electric current is passed to the coils surrounding the armature and the magnetic field induced causes the armature to be lifted.

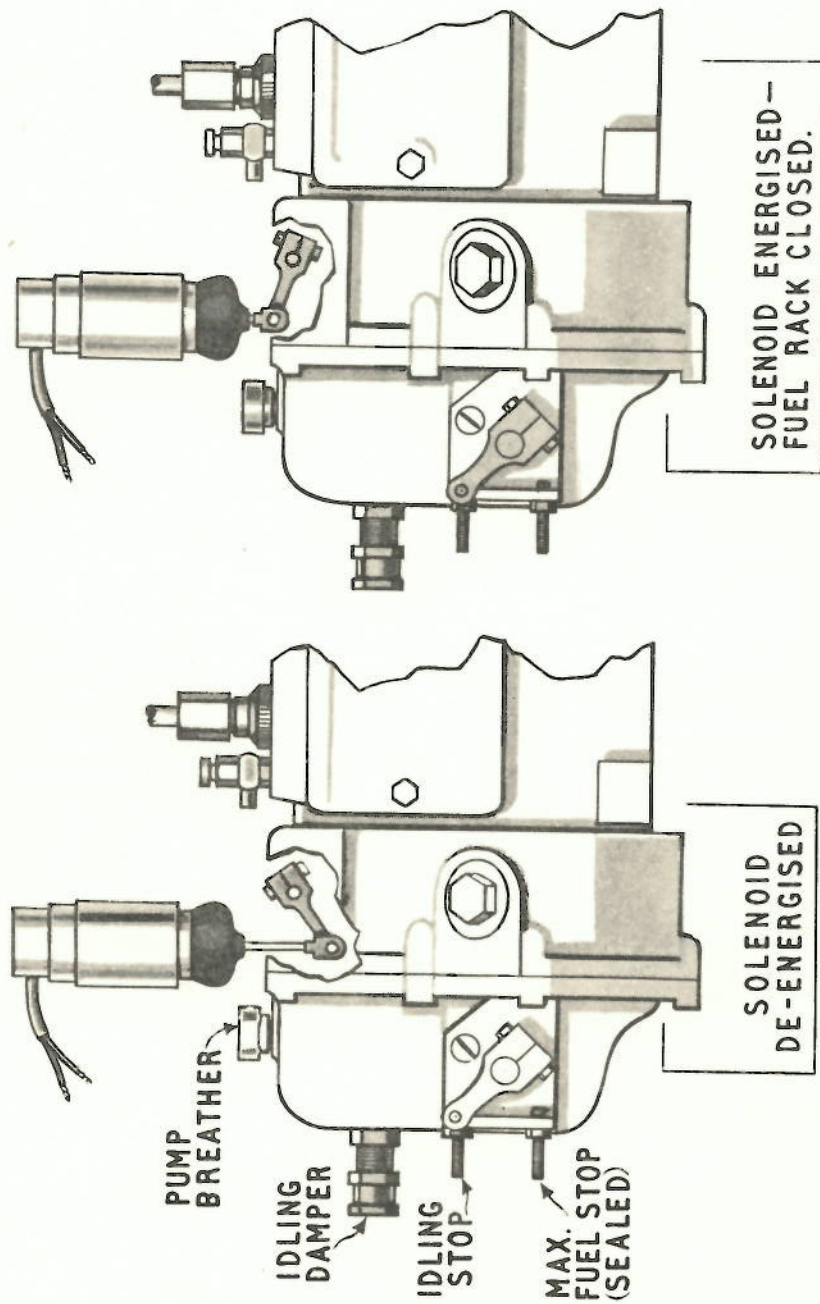
The shut-down solenoid is continuously rated and has two operating coils, one of them is only used for pulling in the armature, and the other one is to hold the armature in the shut off position. The pull-in coil is isolated when the armature core rises against an actuating plunger and opens a moving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

*Drawing Reference*

8D ENGINE SHUT-DOWN SOLENOID

**ENGINE SHUT-DOWN SOLENOID**



**FIG. 8D**

**DIESEL TRACTION NOTE No. 8**

**FUEL FILTERS**

The primary filter fitted between the fuel tank and the lift pump is a cloth-type filter. It is shown in diagram No. 9. The fuel, on entering through the inlet connection, passes through the finely woven cloth (5) which is stretched over a spiral wire framework. The fuel then flows up through the stand-pipe (7) and out into the main pipe line via the outlet connection.

*Key to diagram:* 1, Housing; 2, Cover; 3, Cap nut; 4, Air vent screw; 5, Filter cloth; 6, Sludge plug; 7, Stand pipe; 8, Closing plug; 9, Pressure spring.

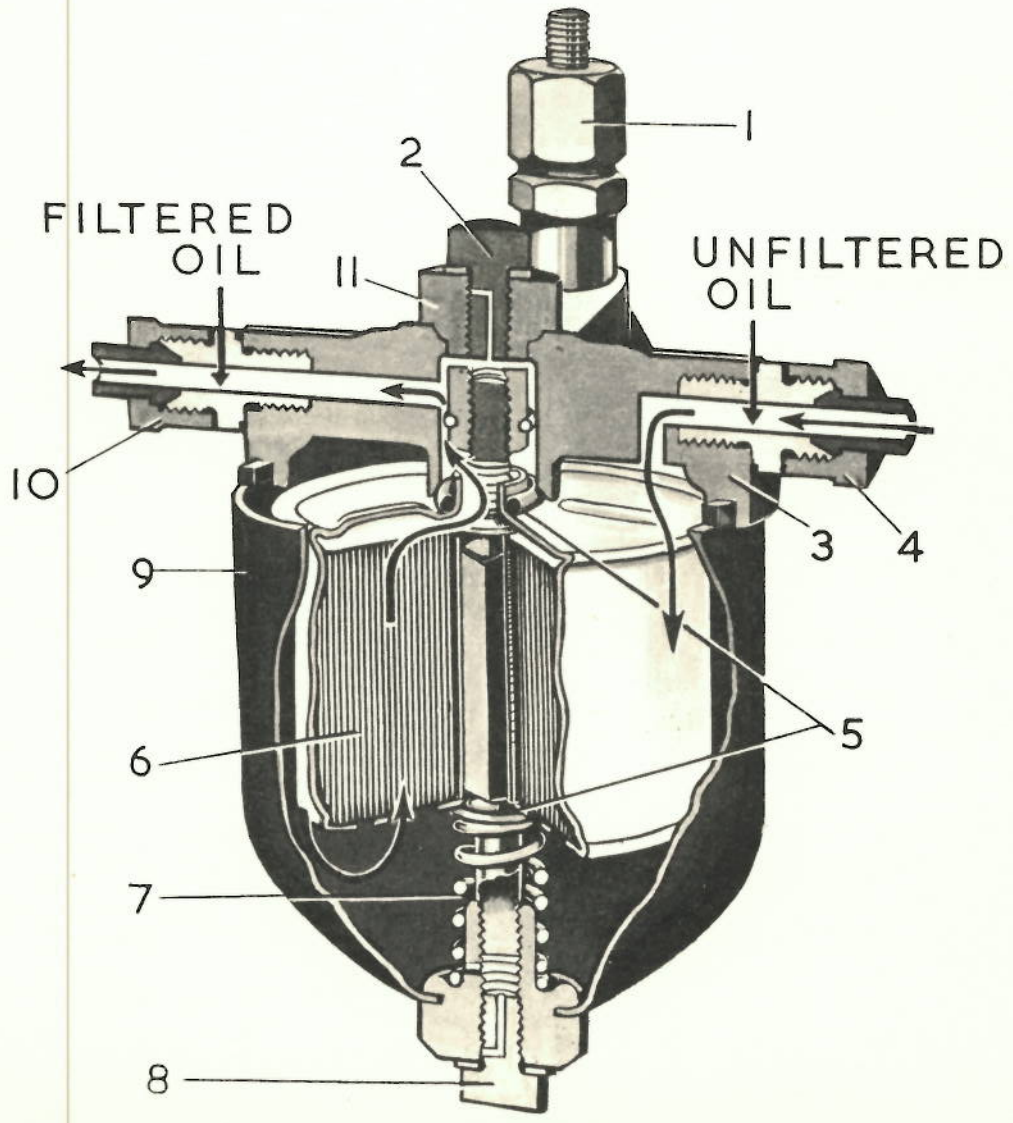
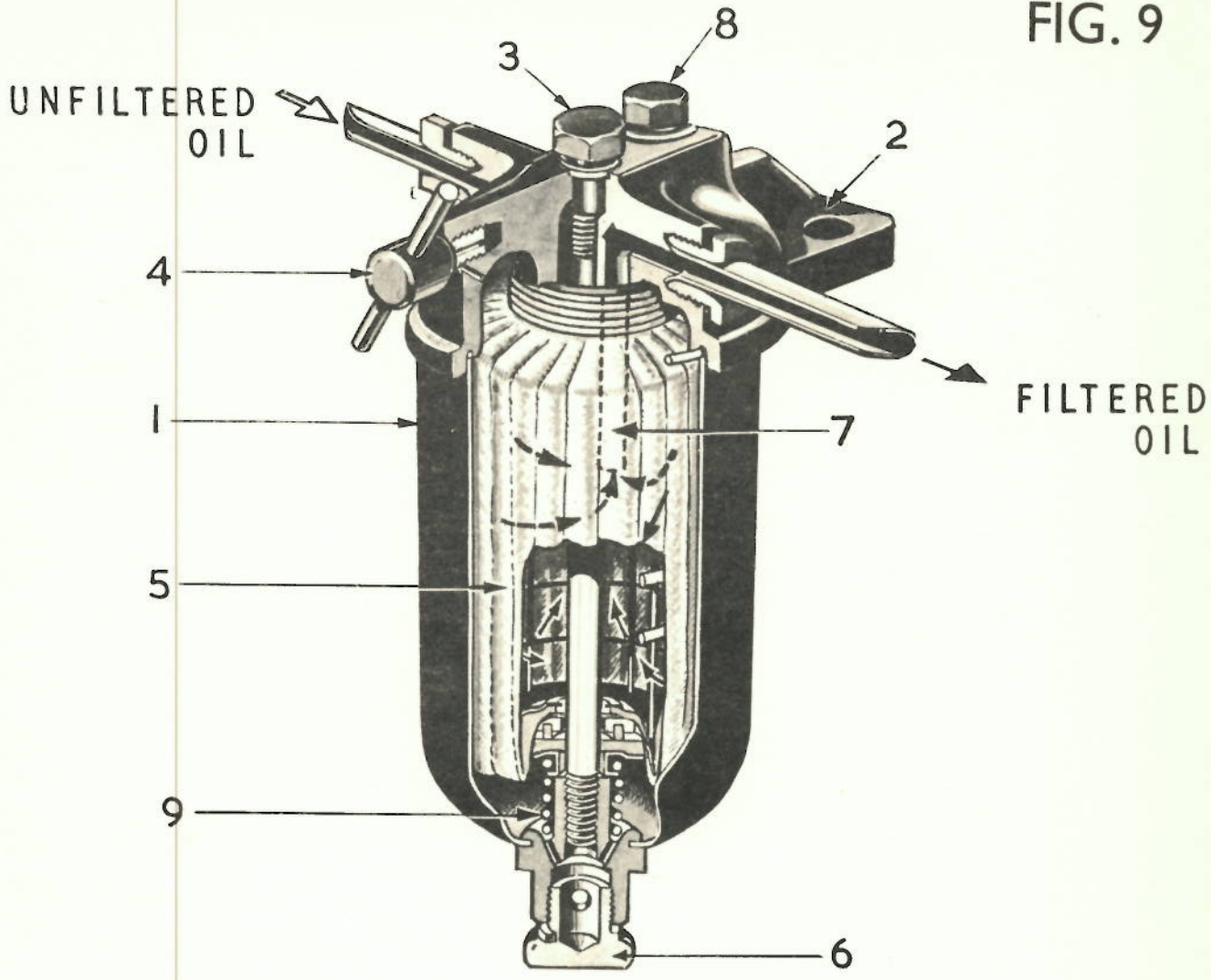
Fitted between the lift pump and the injection pump are two paper-element-type secondary filters. These are C.A.V.-type "F" filters. The general arrangement is shown on diagram 9. The filter is of the cross-flow type. Fuel enters the filter through connection (4), passes down outside the element container, then up through the element and finally emerges via the central outlet at the top of the element and so out through the outlet connection. Two filters are fitted, in parallel.

*Key to diagram:* 1, Gravity vent valve; 2, Air vent plug; 3, Cover; 4, Inlet connection; 5, Oil seals; 6, Paper element; 7, Pressure spring; 8, Drain plug; 9, Filter bowl; 10, Outlet connection; 11, Cap nut.

*Drawing Reference*

9. FUEL FILTERS (PRIMARY AND SECONDARY)

FIG. 9



DIESEL TRACTION NOTE No. 9

**FUEL SYSTEM—THE FUEL FEED PUMP. DIAPHRAGM TYPE**

C.A.V. type DFP 2 diaphragm lift and feed pumps are fitted on B.U.T. engines.

Mounted on the side of the injection pump, the diaphragm lift and feed pumps provide an uninterrupted supply of fuel oil at the injection pump inlet.

An eccentric on the fuel-pump camshaft operates a diaphragm through a bell crank lever. As the camshaft revolves a thrust is imposed on the lever which, by the action of the fork at the opposite end of the lever, displaces the diaphragm. The return stroke is controlled by a spring which replaces the diaphragm to its former position and allows fuel oil to be pumped from the cavity. 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 limited action decreases the flow of fuel oil until the delivery pressure falls. The pumping stroke of the diaphragm varies according to the amount of fuel required by the injection pump under varying engine loads.

The feed pump draws fuel from the fuel tank through a primary filter and pumps it through the secondary filter to the injection pump.

A mechanism for hand-priming the fuel system before starting up or in the event of air getting into the system is incorporated.

*Hand Priming.* Depression of the small lever, 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 cam. When this is so, the engine should be turned a full turn before priming the fuel system.

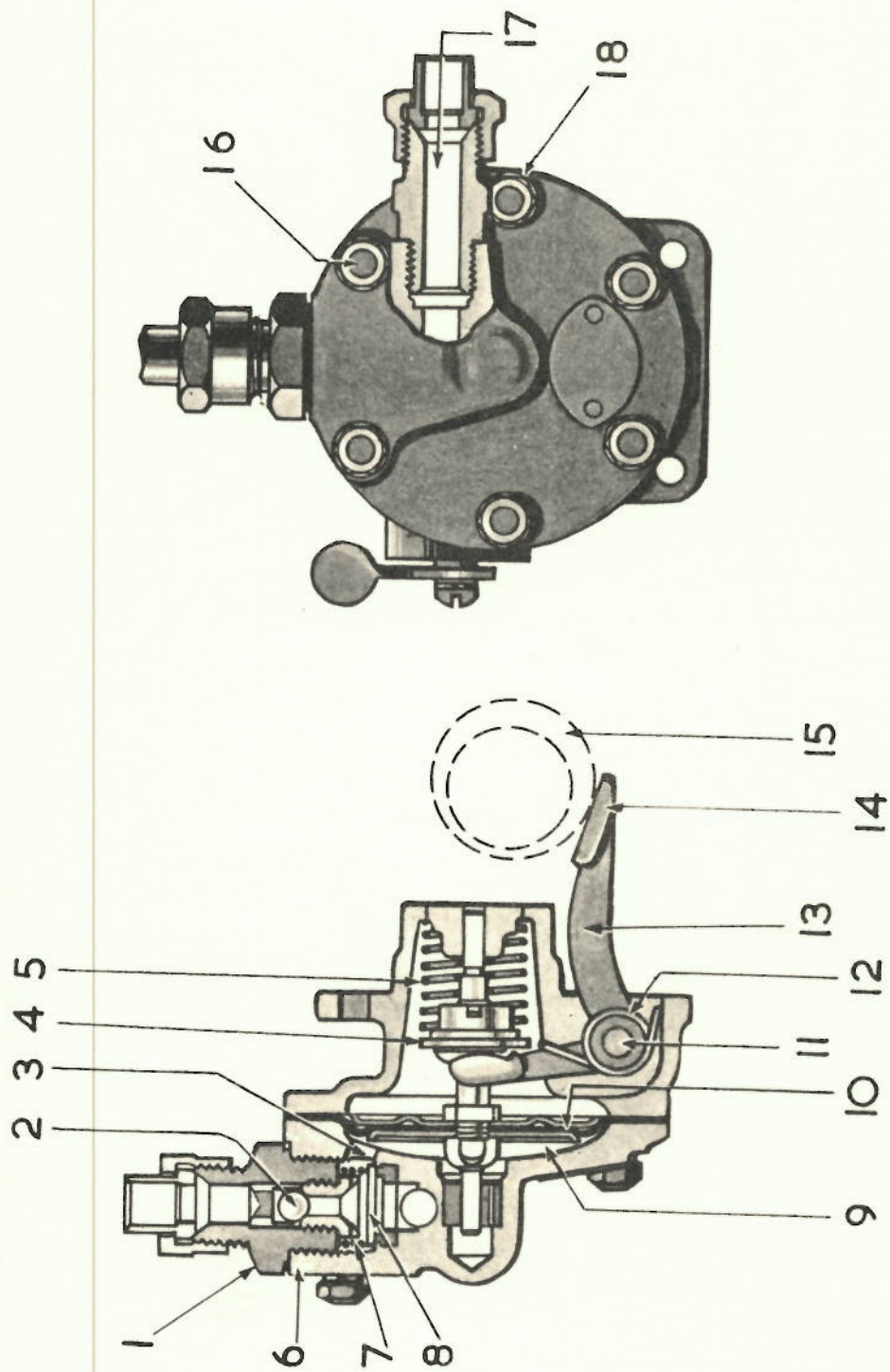
The feed pump is shown in diagram No. 10.

*Key to diagram:* 1, Air bell; 2, Stand pipe; 3, Air bell base; 4, Bell valve; 5, Spring plate; 6, Pump casing; 7, Spring for plate valve; 8, Plate valves; 9, Pump chamber; 10, Diaphragm; 11, Rocker arm spindle; 12, Rocker arm return spring; 13, Rocker arm; 14, Contact pad; 15, Injection pump camshaft; 16, Diaphragm spring; 17, Suction passage from fuel supply; 18, Nut; 19, Stud.

*Drawing Reference*

10. FUEL LIFT PUMP (DIAPHRAGM TYPE)

FIG. 10



## FUEL SYSTEM—THE FUEL INJECTION PUMP

*Refer to diagrams 11, 12 and 13*

The C.A.V. fuel injection pump is a cam-operated, spring return, plunger pump, with a separate pumping element for each engine cylinder. The "N"-type pump is fitted to rail car engines.

Each pump unit comprises the following essential components:—

- (a) Pump element (Barrel and plunger)
- (b) Delivery valve and seating.

Barrel and plunger, valve and seating are all of highly ground and hardened steel, finished to the *finest limits* and with the *highest degree of precision* to permit of accurate operation at high speeds and pressures.

Fuel is supplied to the pump by the lift and feed pump. It can then be drawn into the pumping chambers of the various elements through the two lateral ports provided in each barrel. To enable the pump to vary the quantity of fuel delivered per stroke, the plunger is provided with a vertical channel extending from its upper edge to an annular groove, the top edge of which is cut in the form of a helix. By means of the pump rack and quadrant the plunger can be rotated in its barrel during operation.

**OPERATION.** Referring to diagram 13. When the plunger is at bottom dead centre (a), fuel can enter through the barrel ports. As the pump plunger rises, a certain amount of fuel is pushed back through the barrel ports, until the plunger reaches the position (b) where the top of the plunger has closed both ports. The fuel above the plunger is then trapped, and its only outlet is through the delivery valve to the injectors. This continues until the plunger reaches the position shown at (c). Here, the lower edge of the helix has uncovered the barrel port, allowing fuel to pass back to the fuel gallery, the delivery valve closes. The plunger stroke is always constant, but that part of it which is actually pumping is variable. It is possible to make the point of cut-off earlier or later in the stroke. By means of the control rack and quadrant the plunger can be rotated in its barrel and the point of pump cut-off is varied by the helix which is cut in the plunger. Compare positions shown at (c), (d) and (e) which shows full load, half load and idling respectively. To stop the engine, the plunger is turned so that the vertical slot coincides with the port (f) during the whole of the plunger stroke, thus no fuel is delivered.

**Anti-Dribble Device.** Incorporated in the delivery valve is an anti-dribble device. The delivery valve is an ordinary mitre-faced valve with a guide which has a circular groove cut in it, dividing the guide into two parts. The upper part of the guide forms a small piston. Immediately the pump plunger releases pressure in its barrel, the delivery valve resumes its seat causing the small piston part to sweep down with a plunger action, thus increasing the space in the delivery pipe before the valve actually seats itself. This suddenly reduces the pressure in the pipe line to the injector so that the injector nozzle valve can "snap" to its seat and instantaneously terminate the spray of fuel to the cylinder entirely without dribble.

If the fuel system has been opened at any time, say, for overhaul, it is necessary to ensure that all air is removed before starting. This is done by opening the "bleed" screw on the top of the pump and operating the hand-priming lever on the feed pump until fuel flows out freely without any air bubbles.

### *Drawing References*

11. N-TYPE FUEL PUMP
12. PUMP ELEMENT AND PLUNGER
13. PUMP ELEMENTS

FIG. 11

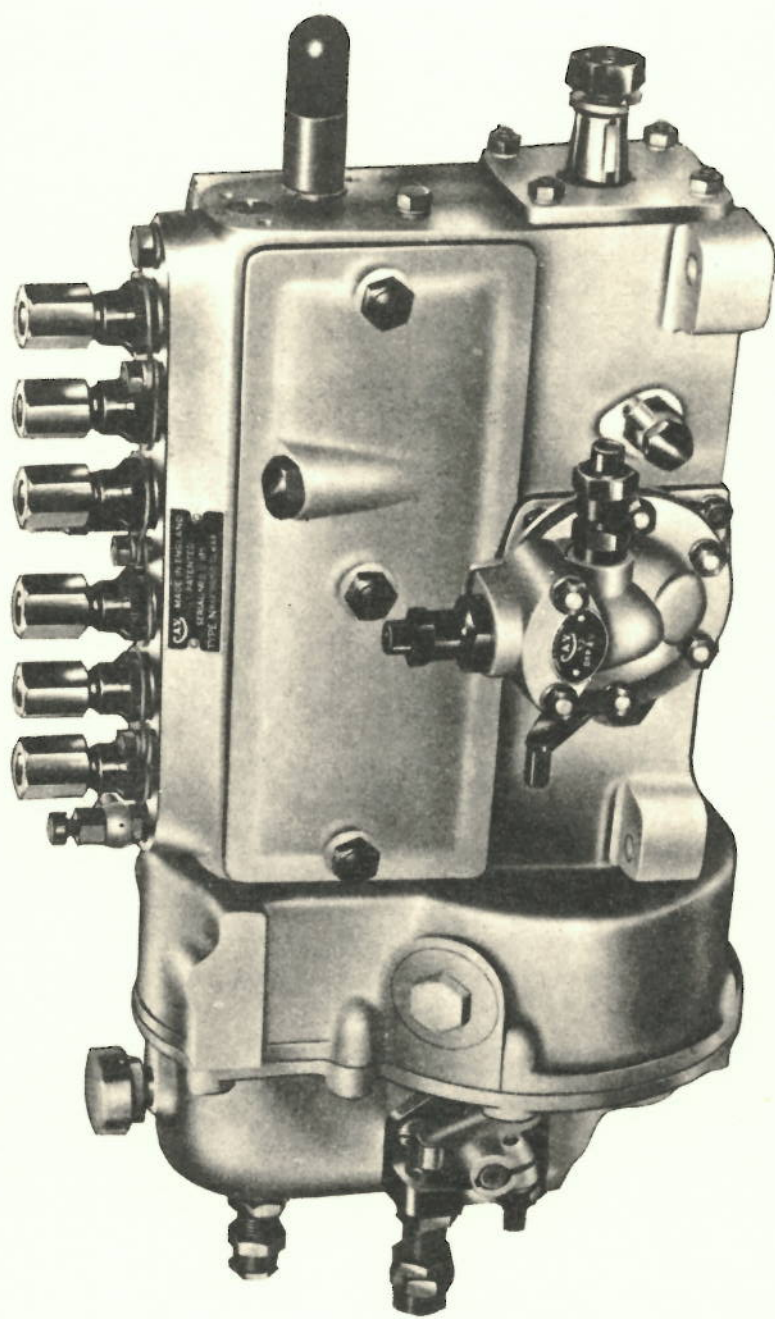
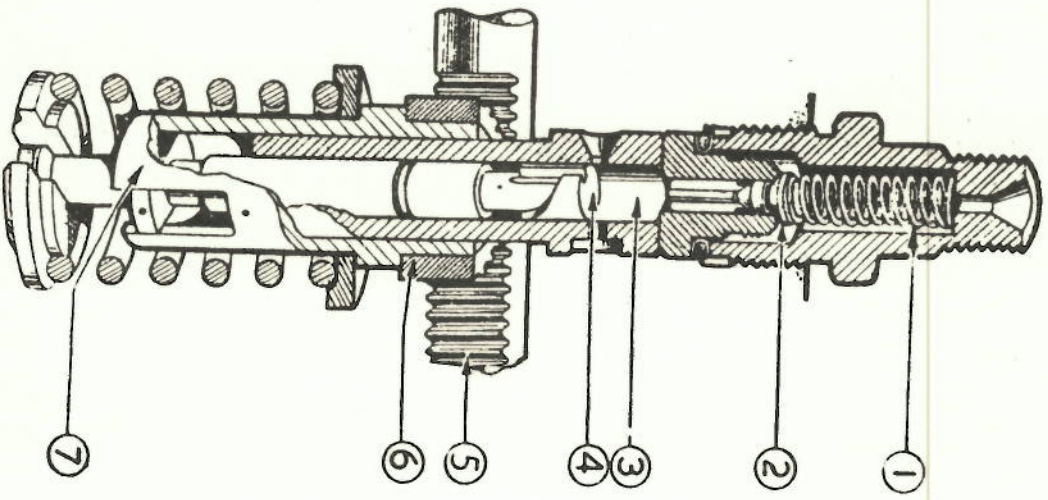


FIG. 12



- 1—Valve spring
- 2—Delivery valve and seat
- 3—Pump barrel
- 4—Pump plunger
- 5—Control rod
- 6—Toothed quadrant
- 7—Control sleeve

Fig. 2—  
Pump Element in Section

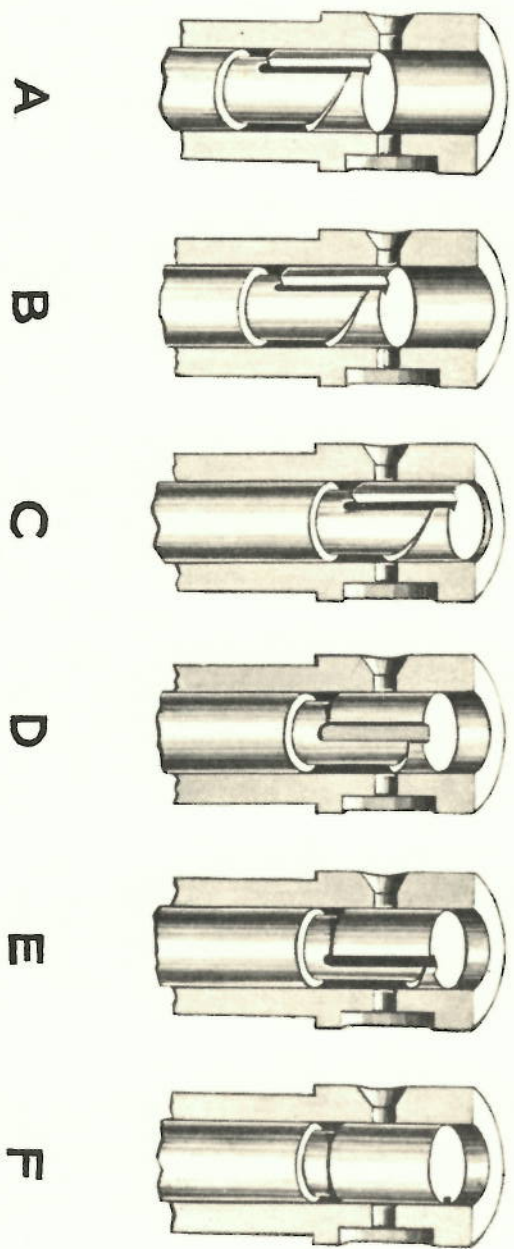


FIG. 13

**DIESEL TRACTION NOTE No. 11**

**FUEL INJECTORS**

It is important that the cylinder should receive each charge of fuel in a condition such that it can be completely burnt, without causing smoke in the exhaust. This, briefly, is the function of the injector nozzle, which is held in position in the cylinder head by the nozzle holder. The nozzle may have to deal with many hundreds of fuel charges per minute, with widely varying conditions of pressure and temperature, therefore the exact precision necessary in the manufacture and repair of these parts will be appreciated.

Refer to diagram 14. In the injector a steel needle valve is spring loaded on to a seat. The spring is housed in the body of the injector and loads the valve via a push rod. The fuel, when supplied under pressure by the injection pump, must exert sufficient force to lift the needle against an adjustable spring before it can escape from the annular space formed by a reduction in diameter of the needle. Once the needle is off its seat, an additional area is acted on by the fuel pressure and the needle shoots up to full lift. The fuel can then escape through a number of small holes into the combustion space in the cylinder. High velocities are produced and atomisation of the fuel results.

The diameter of the fuel injection holes is .008 in. Injection pressure is 175 atmospheres on A.E.C. and Rolls-Royce engines and 140-145 atmospheres on Leyland engines.

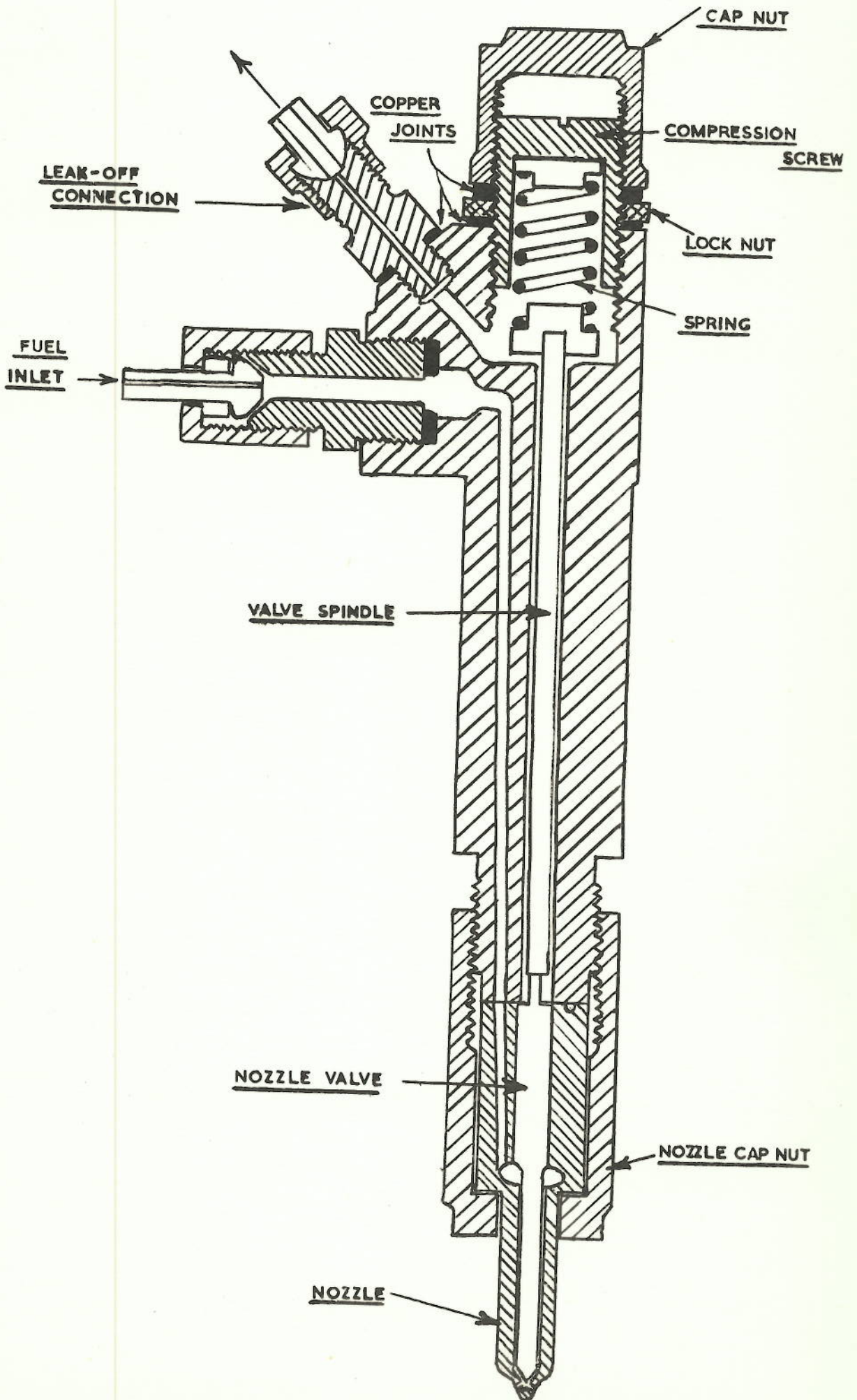
Lubrication of the injector is by "back leak" past the needle valve.

*Drawing Reference*

14. SECTION THROUGH C.A.V. FUEL INJECTOR

SECTION THROUGH C.A.V. INJECTOR

FIG 14



**DIESEL TRACTION NOTE No. 12**

**ENGINE COOLING SYSTEMS (DIESEL RAILCARS)**

Three cooling systems are in use, the "A" and "L" types and pressurised, which latter is fitted to later built cars. They are shown in diagrams 15, 16 and 16A respectively. They are essentially similar and consist basically of:

- (1) A low-pressure pump to circulate the water through the engine and radiator.
- (2) A fan to blow air over the radiator elements.
- (3) A temperature controlled valve (thermostat) to allow the cooling water to by-pass the radiator when the engine is cold.
- (4) A header tank or reservoir.
- (5) A device for shutting down the engine if the cooling water falls below a safe level.

The "A"-type system includes a separate tank for each water-level switch, below floor level: two header tanks, and an expansion tank in the car roof. Water capacity is 50 galls. per power car.

The "L"-type system uses one header tank for each engine incorporating the water level switch. There is no expansion tank. Water capacity is 24 galls. per power car.

The pressurised system has recently been introduced to provide a totally enclosed system to reduce coolant losses. The normal pressure in the system is about 2 lb. per sq. in. and the relief valves on the header tank are set to lift at 5 lb. per sq. in. and that on the expansion tank at 7 lb. per sq. in.

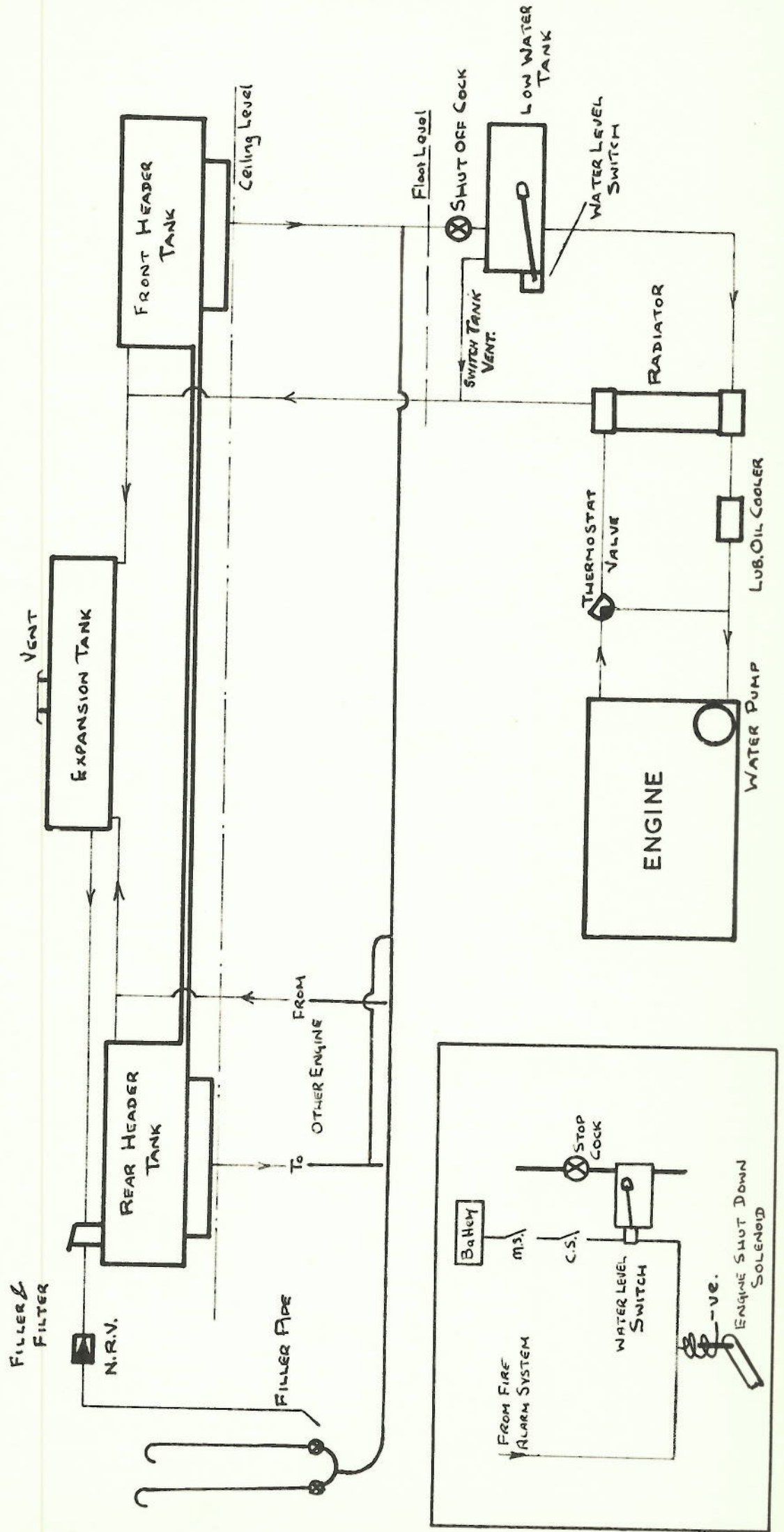
Anti-freeze solution and corrosion inhibitors are used in all railcar cooling systems, during the period November to March.

*Drawing References*

15. COOLING SYSTEM. "A" TYPE
16. COOLING SYSTEM. "L" TYPE
- 16A. COOLING SYSTEM PRESSURISED TYPE. (BY-PASS SYSTEM)

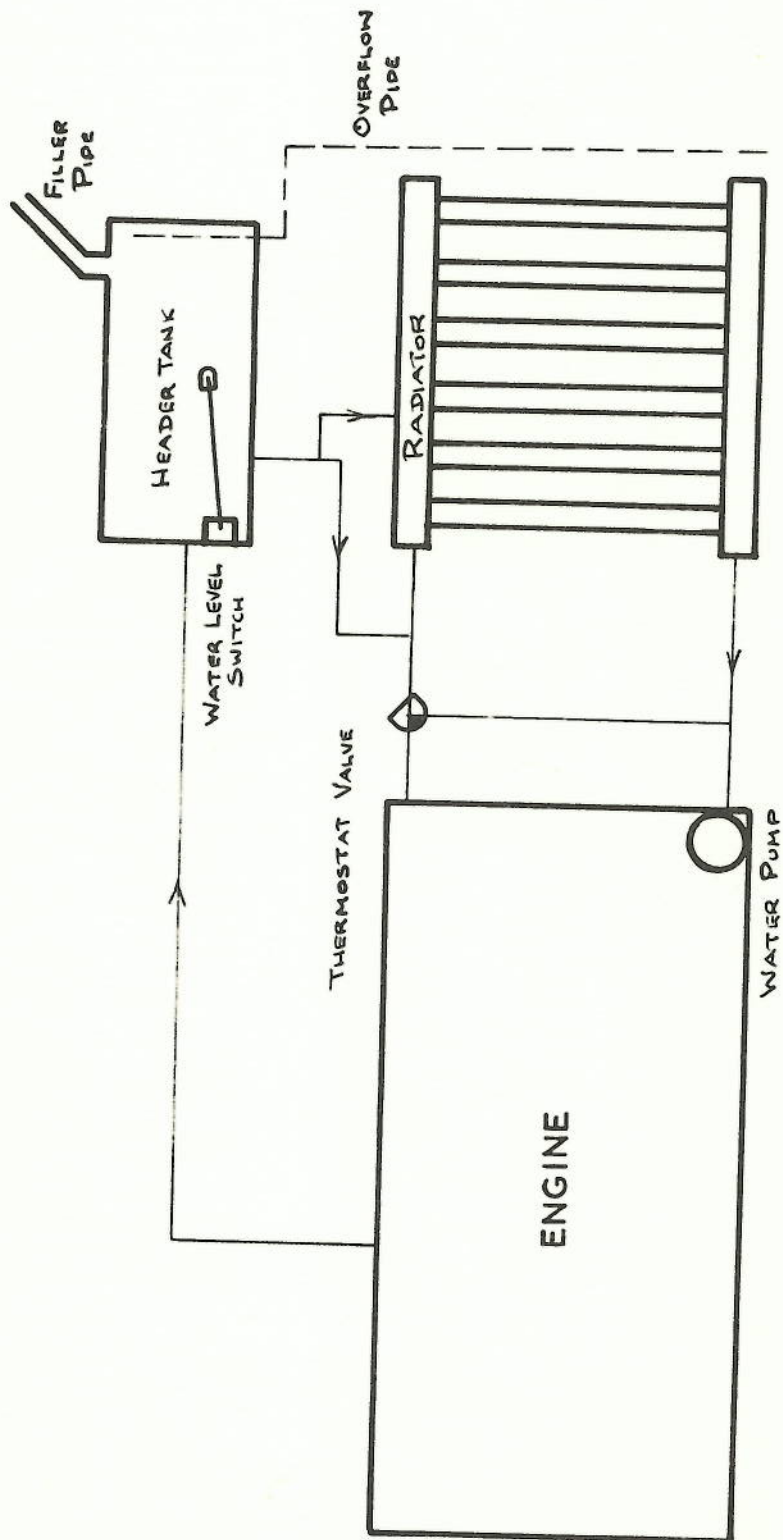
# ENGINE COOLING SYSTEM A TYPE

FIG. 15



# ENGINE COOLING SYSTEM 'L' TYPE

FIG.16



# TYPICAL PRESSURISED ENGINE COOLING SYSTEM

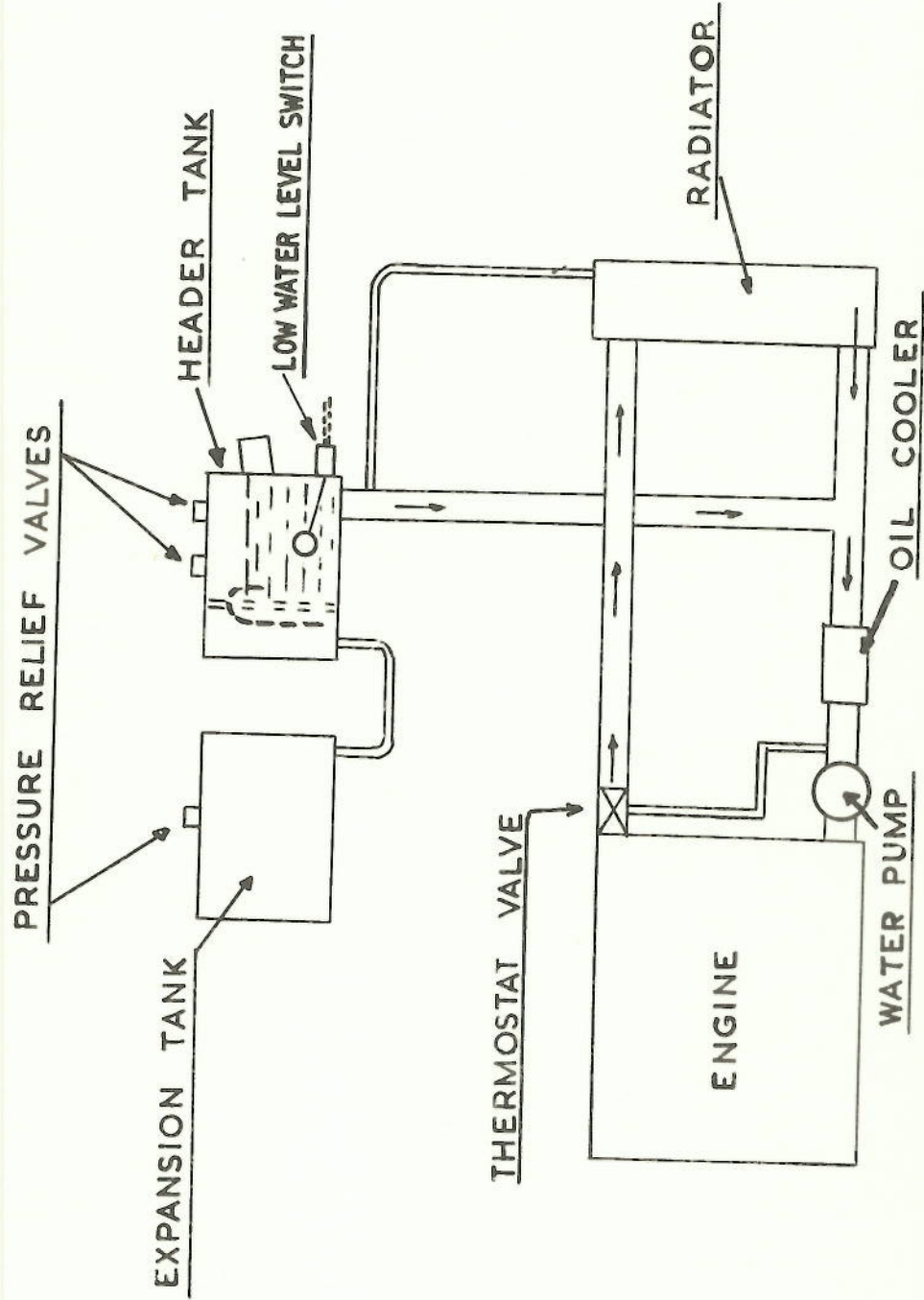


FIG 16A

**DIESEL TRACTION NOTE No. 13 (REVISED)**

**DIESEL RAILCARS—THE FLUID COUPLING (B.U.T.)**

The purpose of the fluid coupling is to enable the drive from the diesel engine to be smoothly taken up for transmission to the road wheels.

Arrangement of the fluid coupling is shown in diagram 17.

The principle of a fluid coupling is briefly as follows:

Oil which is flung out by centrifugal force, established by the rotation of the driving blades, impinges on and moves the blades of the driven member.

The fluid coupling fitted to B.U.T. A- and L- type engines consists in each instance of two parts:

The rear casing which is secured to the engine flywheel (which in turn is secured to the crankshaft) and the runner, which is free to rotate within the outer casing (formed by the flywheel and the rear casing) and is coupled to the joint flange of the free wheel unit.

The rear casing and the runner are each provided with a series of pockets separated by radial webs formed on their inner surfaces.

A self-adjusting bellows-type packless gland oil seal is fitted to the outer side of the rear casing.

The space within the casing is almost full of engine oil. When the casing is rotated by the engine the oil is forced under centrifugal pressure into the pockets of the "runner" which itself is forced to rotate until both members are rotating together.

The only contact between the two sections is through the oil which is immediately "tearable" should any seizure of the transmission occur. This prevents serious damage but the fluid coupling will not permit of misuse; for instance a car must not be held with the brakes on whilst in gear for more than a few seconds. Any "tearing" of the oil generates heat which may be sufficient to fuse the oil seal. Should this happen, the oil would escape and no power could then be transmitted.

On the bellows gland oil seal it is important that the bellows and the highly polished faces of the rubbing ring and the bellows gland seal ring are not damaged; the slightest scratch across these faces will destroy the efficiency of the seal.

The oil capacity of the fluid couplings are as follows:

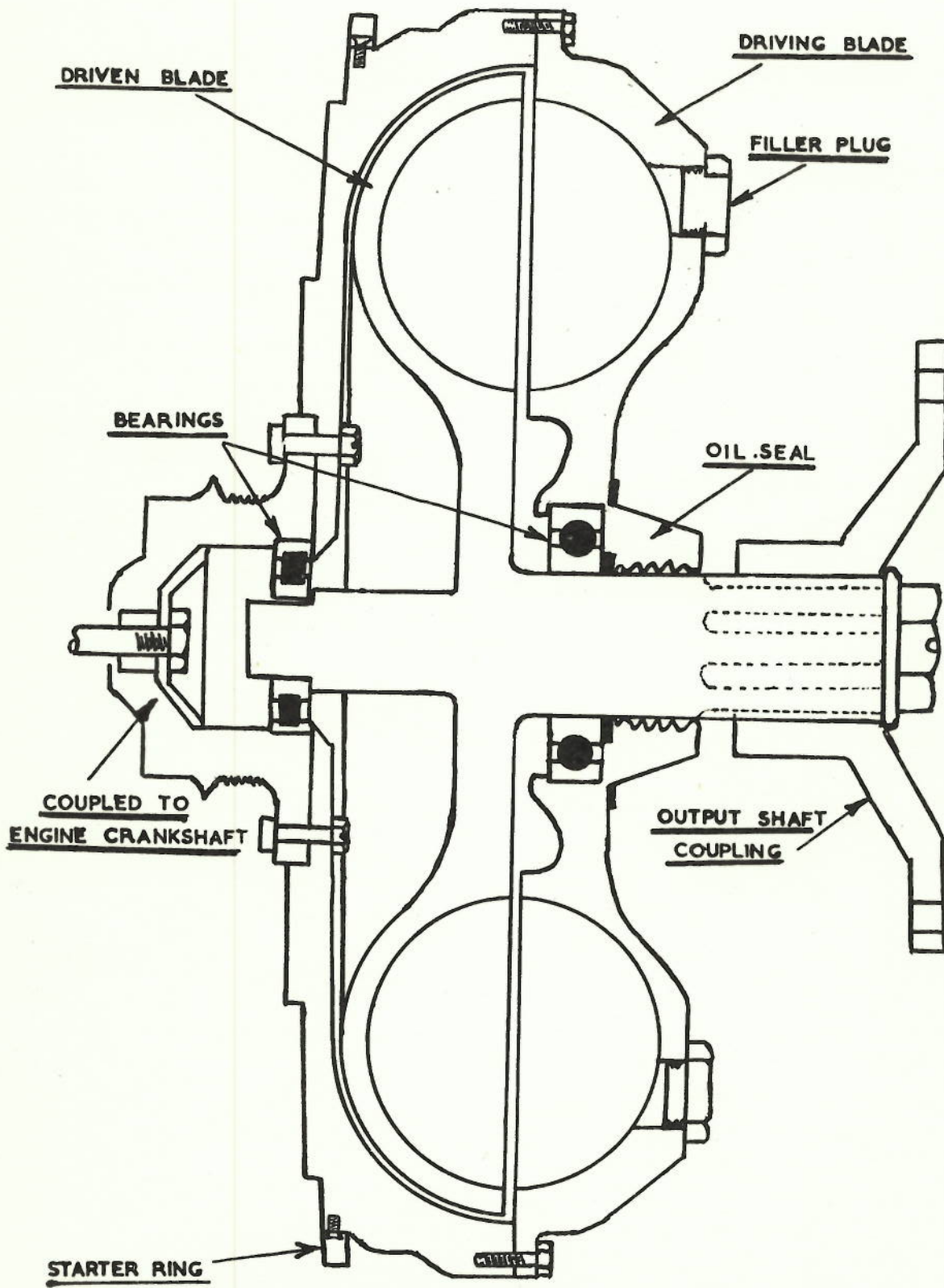
A-type engine 4½ gallons  
L-type engine 4½ gallons

*Drawing Reference*

17. FLUID COUPLING

FIG.17

FLUID FLYWHEEL



**DIESEL TRACTION NOTE No. 14**

**DIESEL RAILCARS—THE FREE WHEEL**

The free wheel is fitted between the engine fluid coupling and the gearbox. It prevents the transmission or road wheels from driving the engine and permits coasting at high speeds.

It consists of two concentric members: an outer member, and an inner member having a series of ramps around its outer surface. There is a roller in the space between each ramp and the outer member.

When the engine is driving the road wheels, the inner member rotates to such a position that the rollers are wedged between the inner and outer members and transmit power. The arrangement is shown in diagram No. 18.

When road wheel speed exceeds engine speed, i.e. during coasting, the rollers are freed as the outer member rotates faster than the inner, no drive is transmitted.

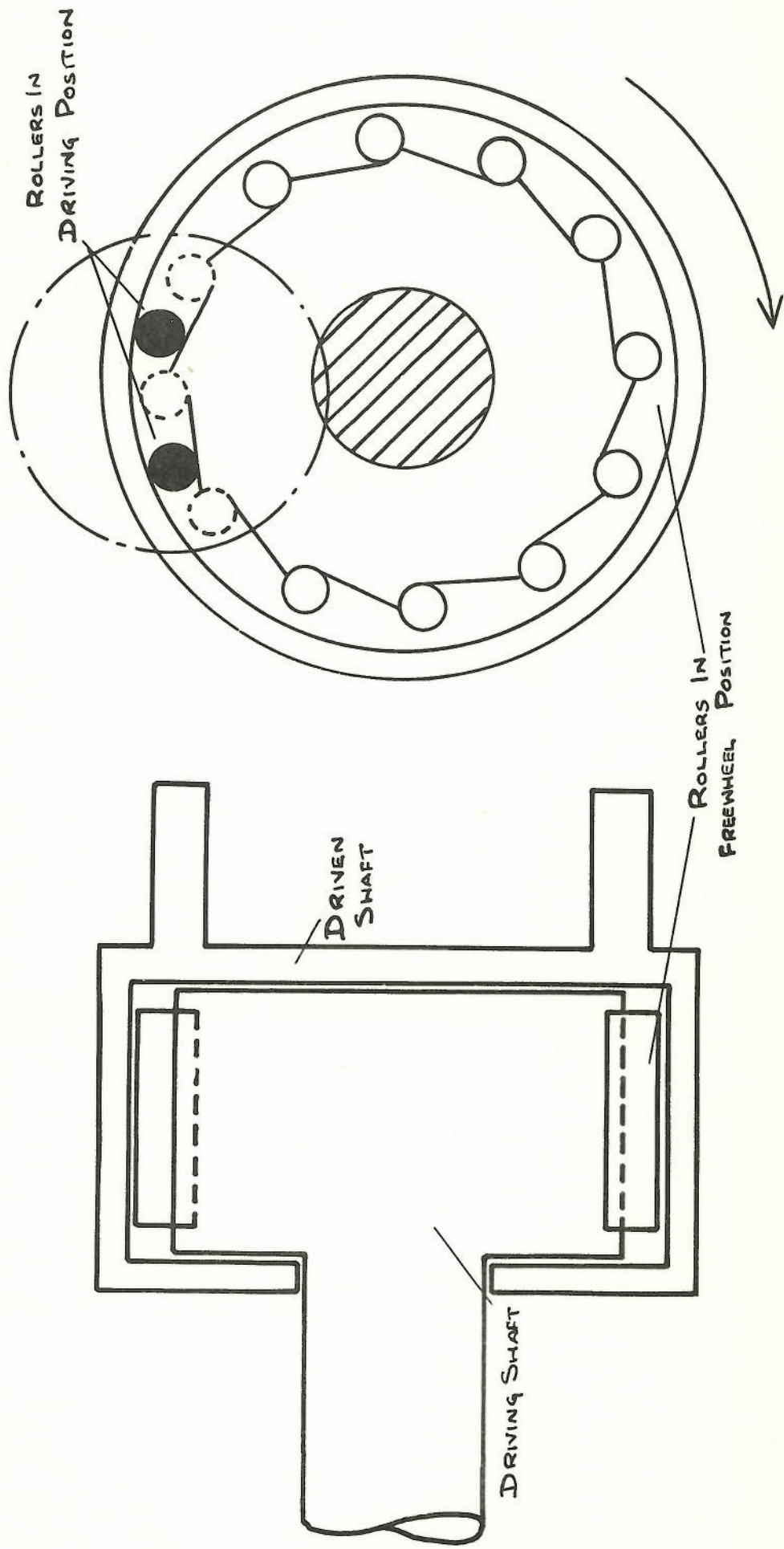
As the free wheel is fitted between the engine and gearbox, the gearbox is driven by the road wheels when coasting and for this reason it is essential to coast only in top gear when all gear trains are locked together. This is referred to under the gearbox.

*Drawing Reference*

18. FREEWHEEL COUPLING

# FREEWHEEL COUPLING

FIG. 18



## **DIESEL TRAINS—PROPELLER SHAFTS**

The drive from the engine and fluid coupling to the driving axle is transmitted by means of two propeller shafts:—

- (1) From fluid coupling to gearbox
- (2) From gearbox to final drive

The first shaft incorporates the free wheel and on early cars is fitted with two types of universal joint, the one at the engine end being a plain bearing type and the other the needle roller bearing type. On later cars, both universal joints are of the needle roller type.

The second shaft has a sliding universal joint at one end and both joints are of the needle roller bearing type.

A propeller shaft is fitted between the engine and the radiator cooler fan. It has a sliding universal joint at one end and the joints are of the needle roller bearing type.

DIESEL TRACTION NOTE No. 16

**DIESEL RAILCARS—TRANSMISSION. THE GEARBOX. MESSRS. S.C.G. R14 TYPE**

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-h.p. 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.

Messrs. Self Changing Gear Co.'s "R14"-type epicyclic gearbox is fitted to the majority of British Railways railcars.

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 by regarding the first speed gear train as being the basic train. Referring to Fig. 19, 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.

The gearbox utilises air reduced to 65 lb./sq. in. pressure, from the main compressed-air supply.

Lubrication is by means of a gear-type oil pump.

Procedure for changing gear is given in the driving instructions for the various types of train. The need to pause for TWO SECONDS after selecting gear before opening the throttle is stressed. From what has been stated above, 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 selecting the gear concerned at least six times; this has the effect of "toggling up" the affected brake band adjusting mechanism. When "toggling up," the engines should be stopped and the throttle handle held out of the deadman's position. Two seconds pause is, of course, necessary between each movement of the gear-selection lever.

*Drawing References*

19. EPICYCLIC GEARBOX. CROSS SECTION THROUGH GEAR TRAIN
20. SECTIONAL VIEW OF EPICYCLIC GEARBOX
- 20A DIAGRAMMATIC VIEW OF EPICYCLIC GEAR TRAIN
- 20B SECTION THROUGH FIRST SPEED BAND WITH BRAKE OFF
- 20C SECTION THROUGH FIRST SPEED BAND WITH BRAKE ON
- 20D R14 GEARBOX. OPERATION OF AUTOMATIC ADJUSTER

# 4 SPEED EPICYCLIC GEARBOX (PRINCIPLE)

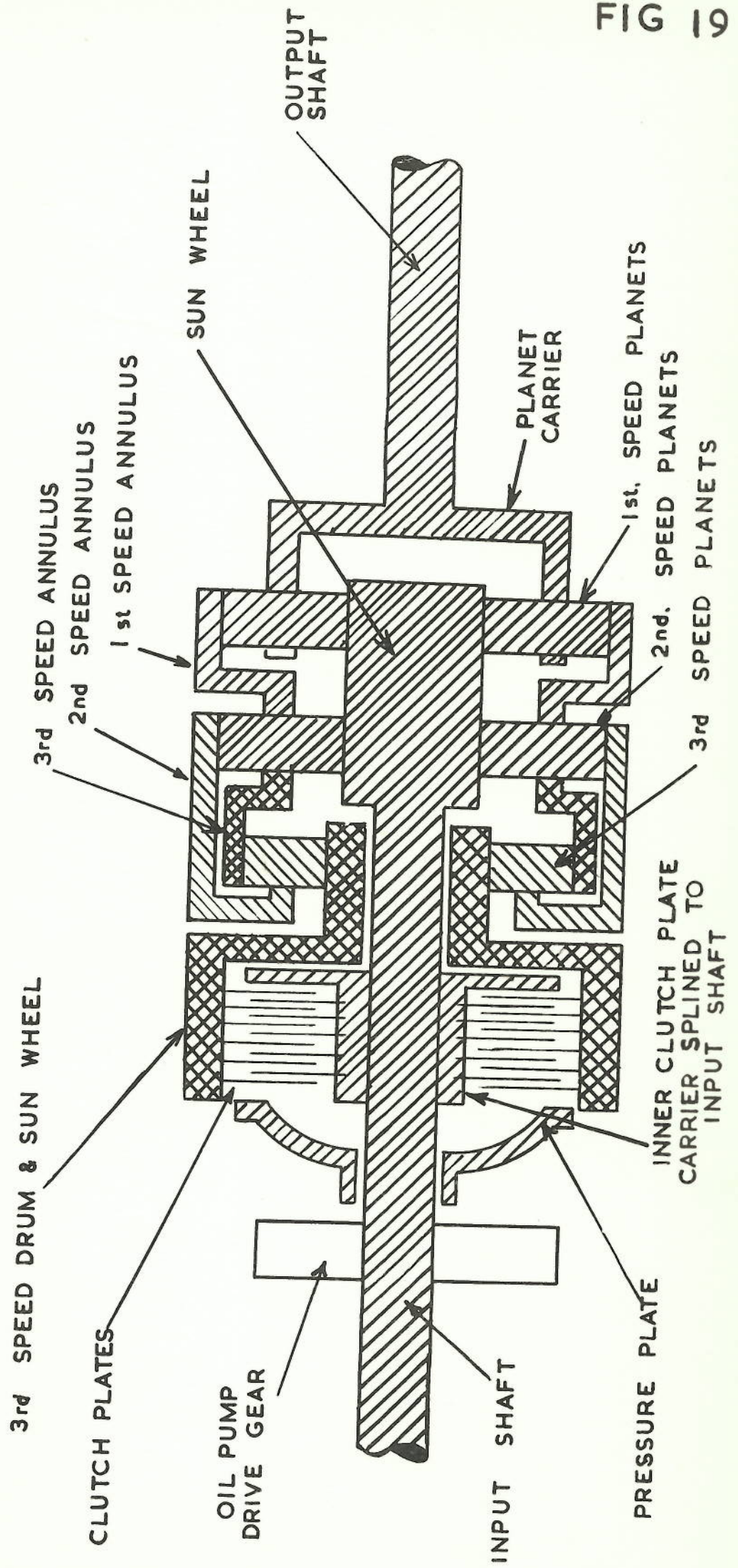
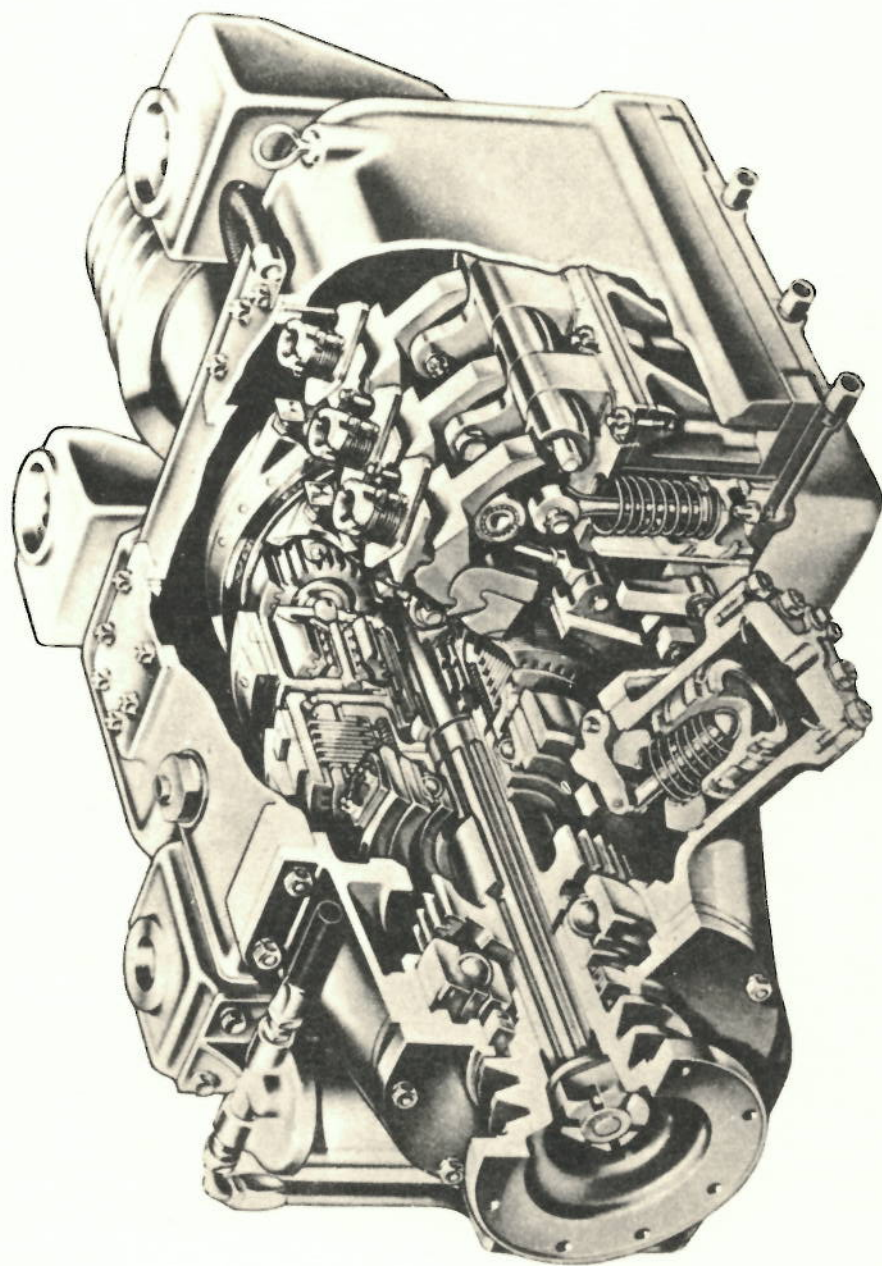


FIG 19

FIG. 20



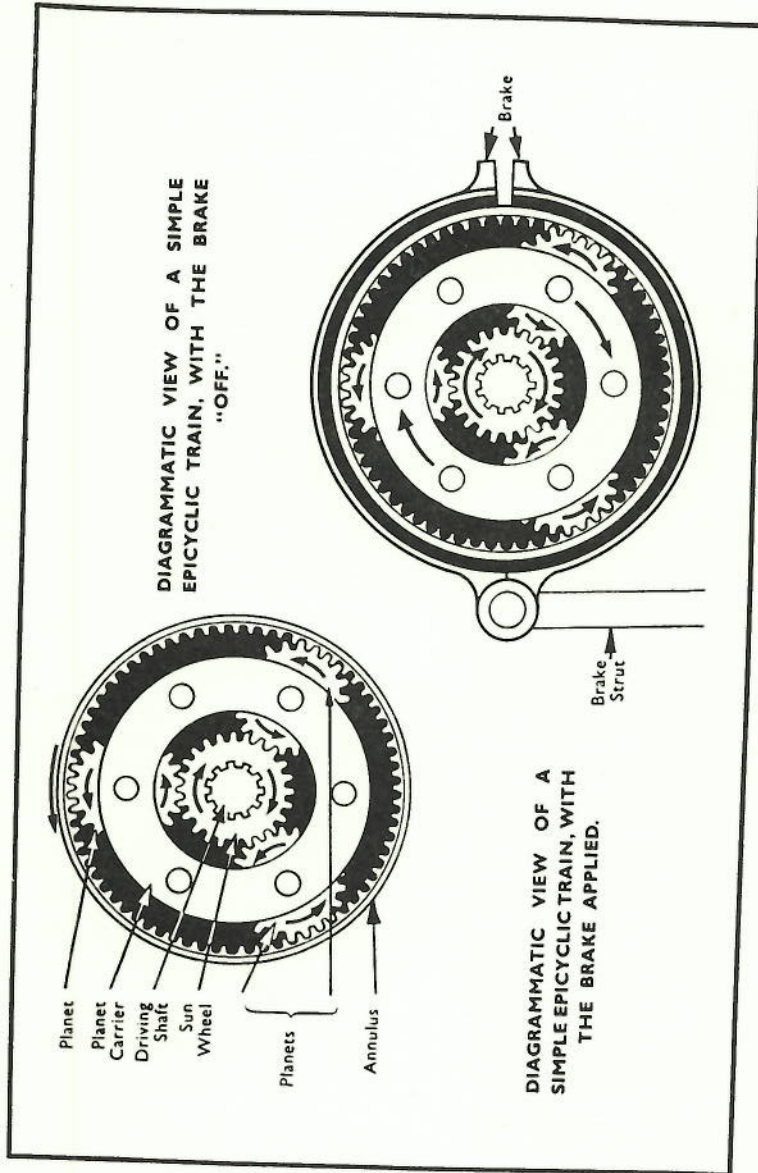
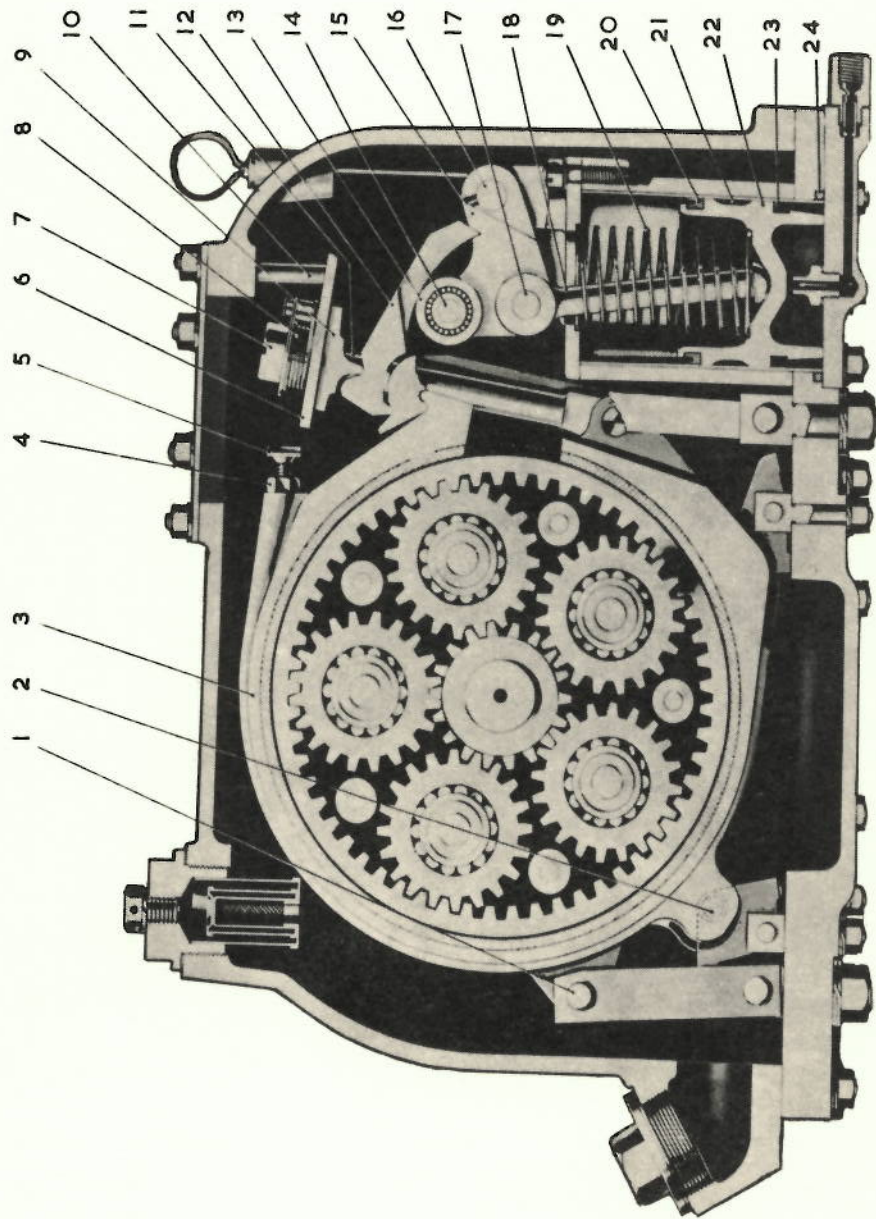


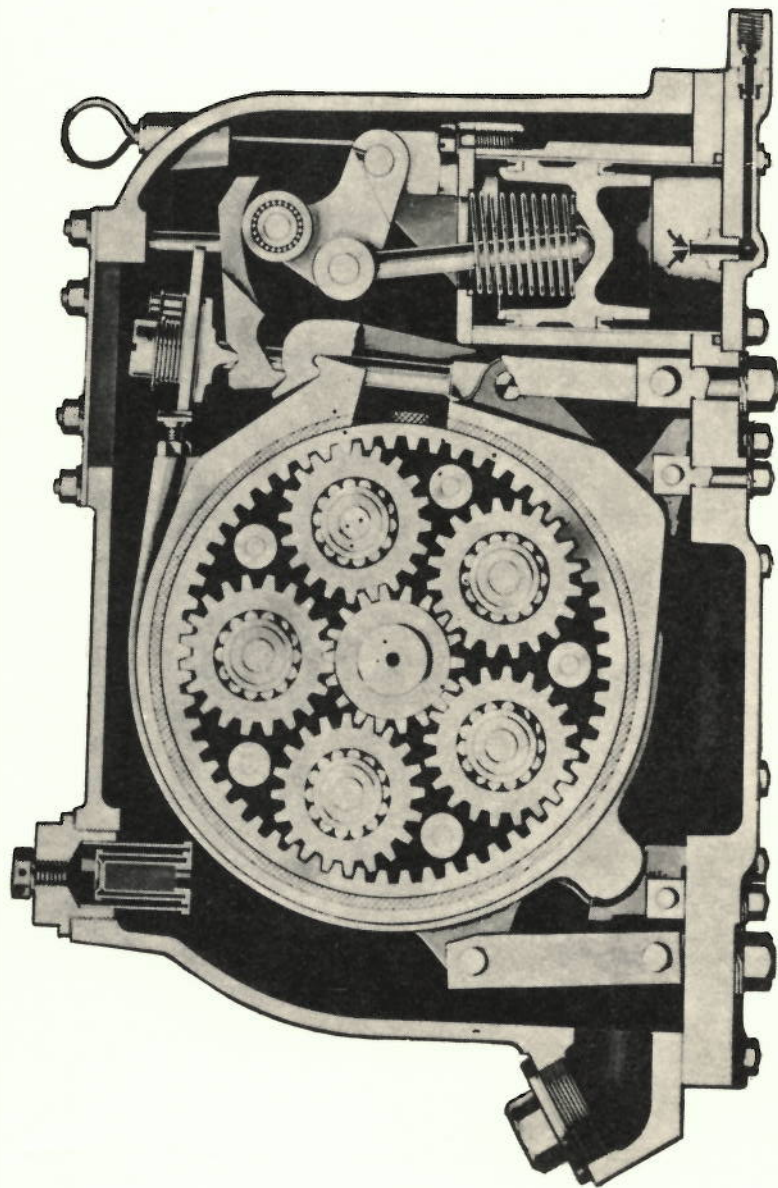
Fig. 8. Diagrammatic View of Epicyclic Gear Train.

FIG. 20B



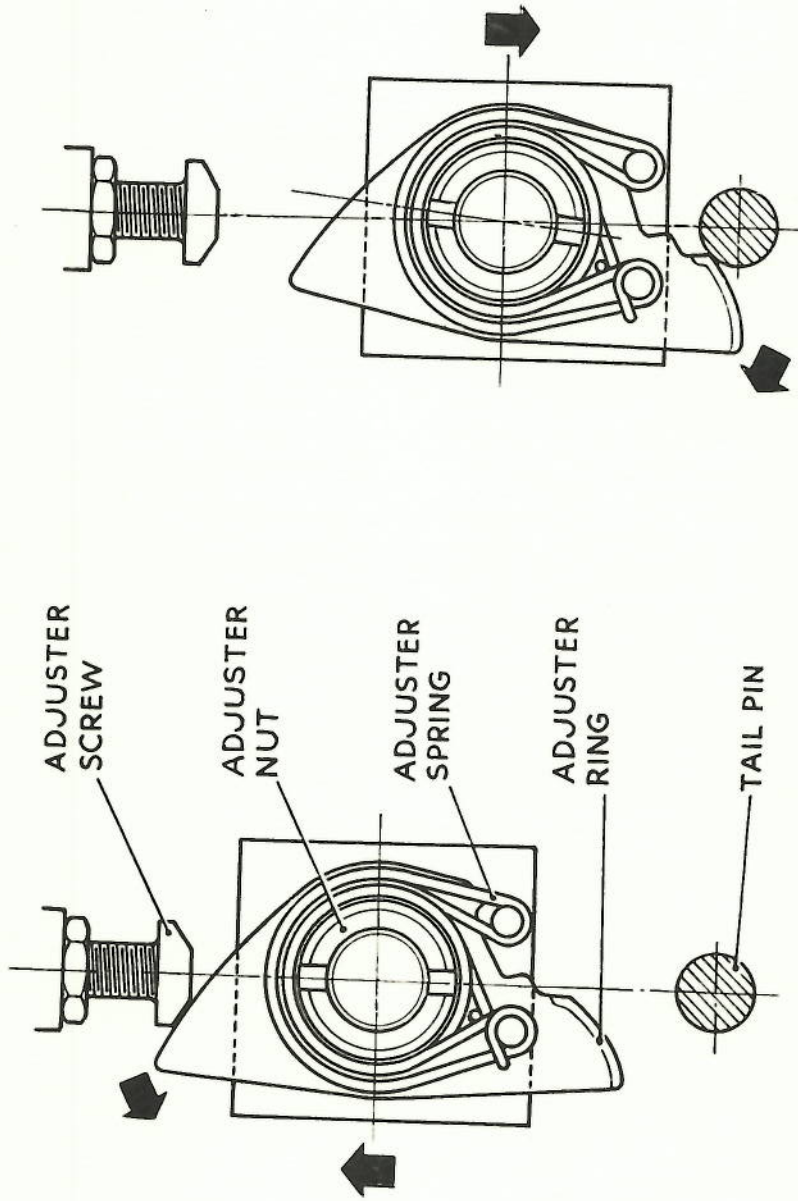
R 14 GEARBOX. SECTION THROUGH FIRST SPEED  
BAND WITH BRAKE "OFF".

FIG. 20c



R14 GEARBOX. SECTION THROUGH FIRST SPEED  
BAND WITH BRAKE "ON"

FIG. 20<sup>D</sup>



DIESEL TRACTION NOTE No. 16A

## THE TORQUE CONVERTER (ROLLS-ROYCE)

The object of the torque converter is to perform a function similar to that of a gearbox.

A gearbox provides only a small number of fixed ratios, whereas the torque converter provides a continuous variation of ratios from the lowest to the highest.

On railcars a torque converter can be substituted for the fluid coupling free wheel and gearbox on the usual layout.

The drive is by fluid similar to a fluid coupling. It differs in one important aspect from the fluid coupling, namely, in having three principal components instead of two.

Torque converters all consist of:

1. The driving element or impeller which is connected to the engine crankshaft.
2. The driven element or turbine which is connected to the propeller shaft.
3. The reaction member or stator blade assembly which is fixed to the frame.

It is item 3 which makes it possible to obtain a change of torque between the input and output shafts.

Under normal running conditions the action of the impeller causes the turbine blades to turn and the fluid passes through the converter easily and quickly, striking each blade at a very slight angle. When a load is encountered the turbine slows down and the fluid strikes the turbine blades at a greater angle giving an increase in output torque.

A three-stage converter is used, having three separate sets of blades each receiving fluid in turn. By this means a torque multiplication as much as 5.3 times input torque can be achieved when the turbine is at stall.

The output shaft is capable of being driven by the turbine, or directly by the engine. An outer clutch connects the engine to the impeller giving a conventional drive through the converter to the output shaft.

An inner clutch connects the engine directly to the output shaft, enabling engine power at crankshaft speed to be used and advantage to be taken of the higher maximum speed now possible.

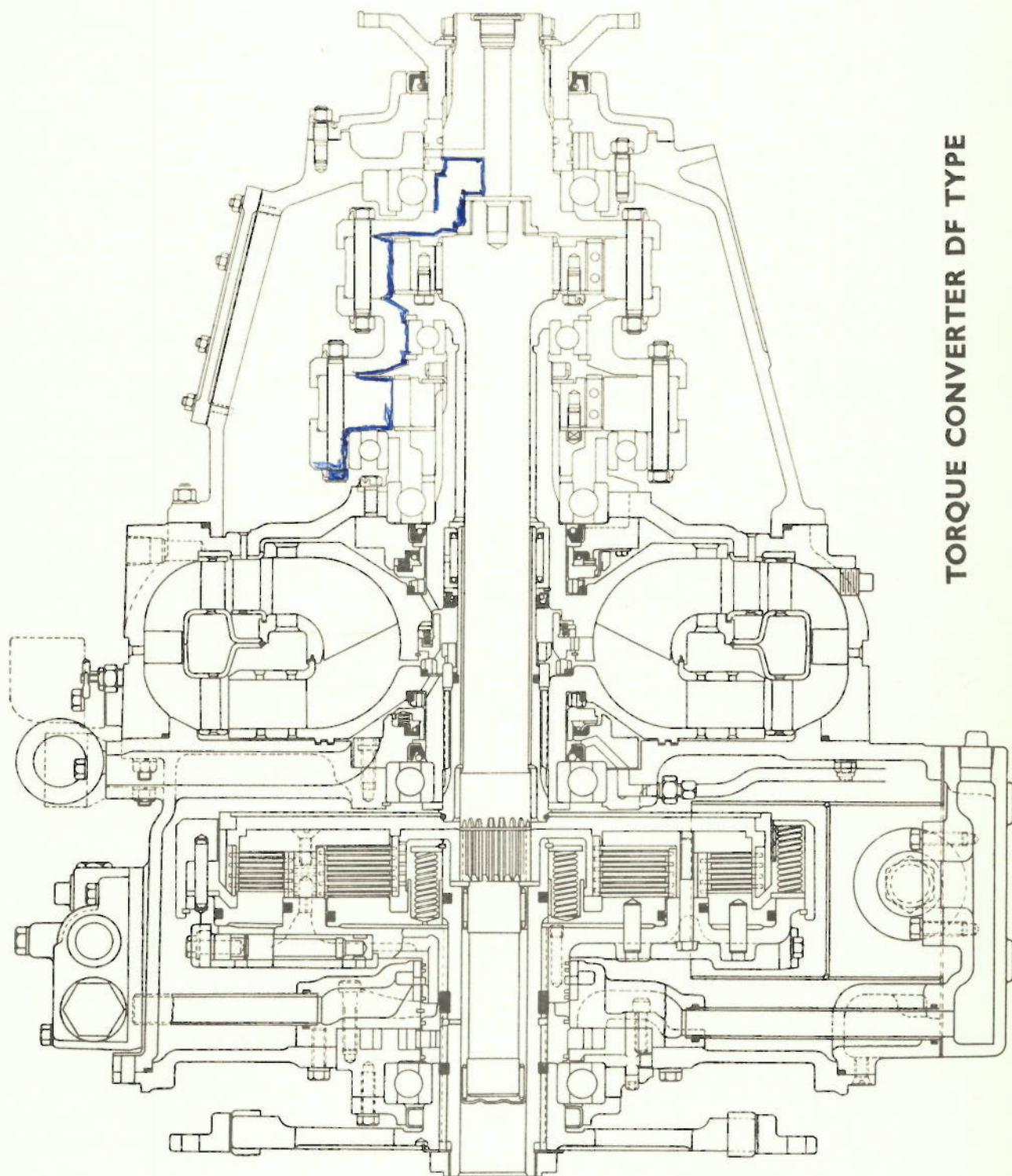
Two free wheels are incorporated, one to allow the rail car to coast without over-running the engine when in direct drive. The other allows the turbine to drive the output shaft in "converter drive", but prevents the output shaft from wasting energy by driving the idle turbine during direct drive.

The fluid used in the converter is fuel oil. Clutch engagement is by a sliding valve, air actuated, and under the control of a lever in the driving cab. The change from converter drive to direct drive is automatic at 47 m.p.h.

### *Drawing Reference*

20A TORQUE CONVERTER (ROLLS-ROYCE)

FIG. 20<sup>E</sup>



TORQUE CONVERTER DF TYPE

**DIESEL TRACTION NOTE No. 17**

**RAILCARS—THE FINAL DRIVE GEARBOX**

A railcar differs from a road vehicle in that it requires to run at all speeds in both directions. On railcars it is necessary to have a step-down gear, and this and the reversing mechanism are incorporated in the final drive gearbox on the inner bogie axle. Reversing is achieved by employing a sliding dog in the final drive gearbox. By referring to diagram No. 21 it will be seen that there are two bevel gears which are free to rotate on their carrying shafts. The sliding dog is controlled by pistons which are supplied with compressed air through electro-pneumatic valves.

When the direction required is selected by the driver, air is supplied to the appropriate piston, and the sliding dog moves and engages with the bevel gear.

The sliding dog is splined to the driving shaft and the power is transmitted through the bevel gears and a set of spur gears to the axle.

When it is necessary to reverse, air is released from one cylinder and admitted to the opposite cylinder, and the dog moves across to engage with the opposite bevel gear. When the gear is engaged an electrical connection is made and a circuit completed to illuminate the "air and final drive" light in the driver's cab.

To avoid damage to the striking fork, sliding dog and pinion teeth when changing direction, the engines must be at idling speed.

Should an engine or transmission become defective it can be isolated from the road wheels by centralising the sliding dog in the final drive in the "neutral" position. To do this the isolating plunger is drawn out and turned through 90 degrees. When released it is forced by a spring to locate in a groove in the sliding dog, thus holding it in the central position disengaged from both bevel gear wheels. When the driver has isolated his defective engine and transmission on the axle he also has to operate an electrical switch to disconnect the starter motor, the train can then be driven normally but of course it will have less power available. To get the sliding dog into the central position it must be moved across by making use of the driver's reversing handle or by operating the "forward" and "reverse" E.P. valves manually.

To check that the drive has in fact been isolated the propeller shaft must be turned by hand, before the train is moved.

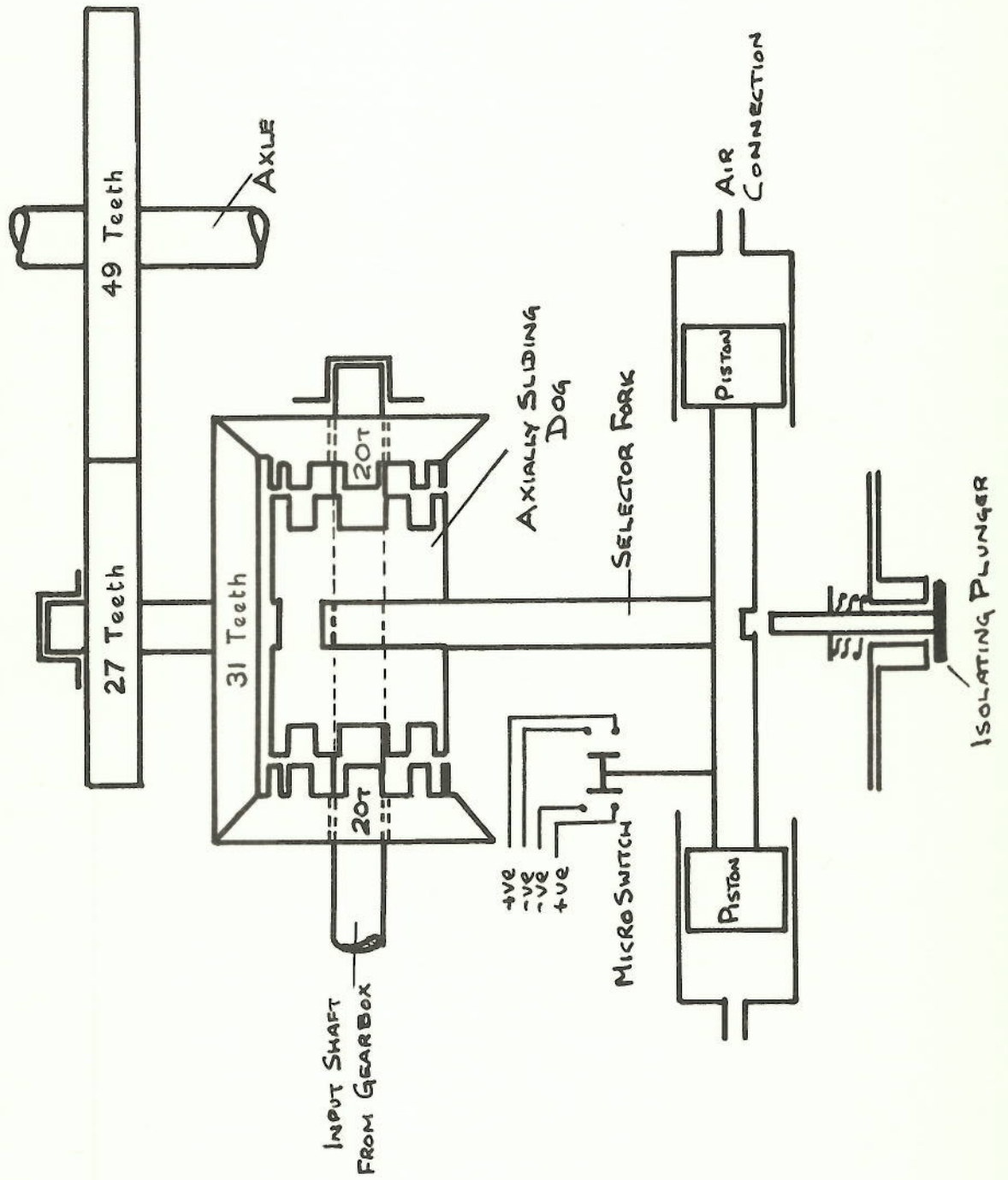
*Drawing References*

21. FINAL DRIVE GEARBOX

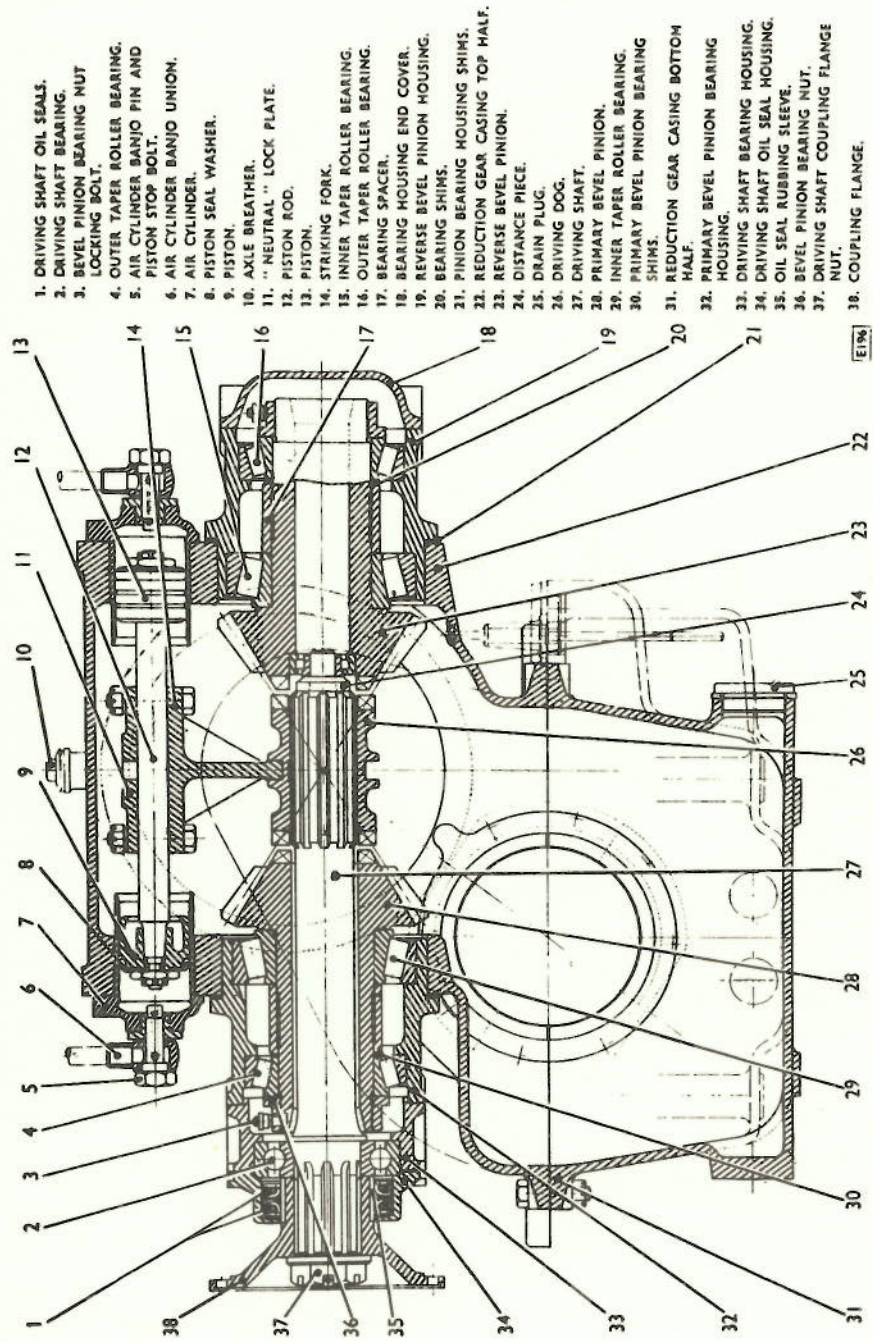
21A. LONGITUDINAL SECTION THROUGH BEVEL PINIONS

# FINAL DRIVE GEARBOX

FIG. 21



**FIG. 21A**



**RAILCARS—ELECTRO-PNEUMATIC CONTROL SYSTEM**

For various reasons an electro-pneumatic control system is used on railcars. 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 in one of two ways, i.e. the "A"-type and "L"-type systems.

In earlier cars ("A" type) the control car battery supplied electric current to all the E.P. valves in a train, but it was found that four power cars could not be reliably worked in multiple and a revised ("L" type) system has been brought into use. 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 control car battery.

Diagrams, as follows, show the layout of the electrical system and control systems:—

- |                          |          |
|--------------------------|----------|
| 22. Electrical system    | "A" type |
| 23. Electrical system    | "L" type |
| 24. Gearbox control      | "A" type |
| 25. Gearbox control      | "L" type |
| 27. Engine speed control | "A" type |
| 27. Engine speed control | "L" type |
| 28. Direction control    | "A" type |
| 29. Direction control    | "L" type |

The control car battery is the battery on the car in which the control switch is closed.

**ELECTRO-PNEUMATIC VALVES**

There are two types: they are "ON" and "OFF," and are shown in drawing No. 30.

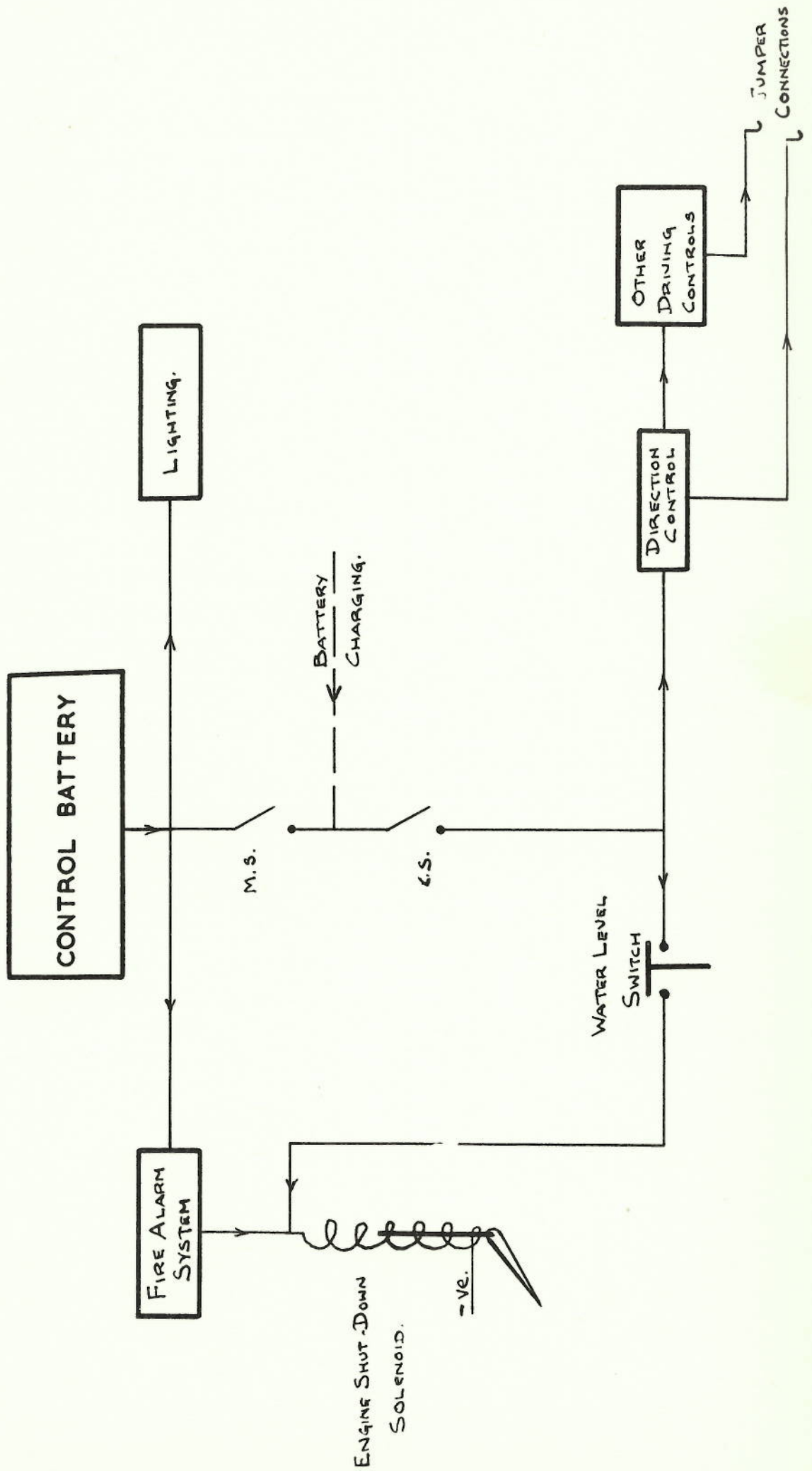
*"ON" type.* When an electrical current is supplied to the coil, a magnetic force is set up in the soft-iron core. This attracts the hinged plate which unseats the air valve and causes the main valve to close the exhaust port. Compressed air is therefore allowed to flow to the particular service, which is served by that E.P. valve. When the current is switched off the coil is de-energised and the valve falls under its own weight, closing the air valve and allowing the air, already supplied, to exhaust.

*"OFF" type.* With this type of valve air is supplied to the service whilst the coil is de-energised. When a current is passed to the coil the hinge plate lifts and seats the air valve and at the same time allows the air, already supplied, to exhaust.

For test purposes a button is fitted under the hinged plate; this is mainly for maintenance staff use. When isolating a final drive the reversing piston can be moved by pressing the buttons of the forward and reverse E.P. valves alternately.

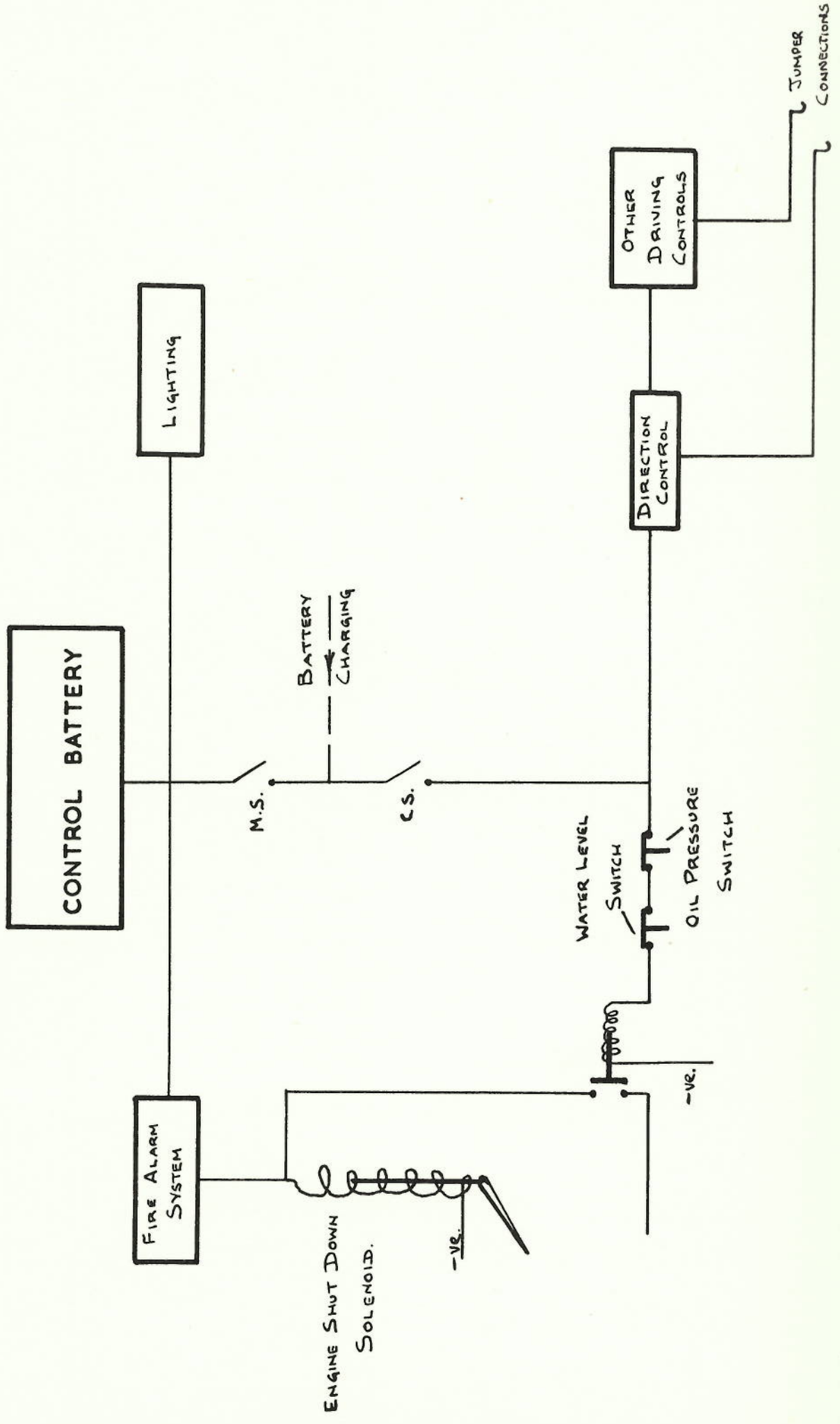
# ELECTRICAL SYSTEM 'A' TYPE

FIG. 22



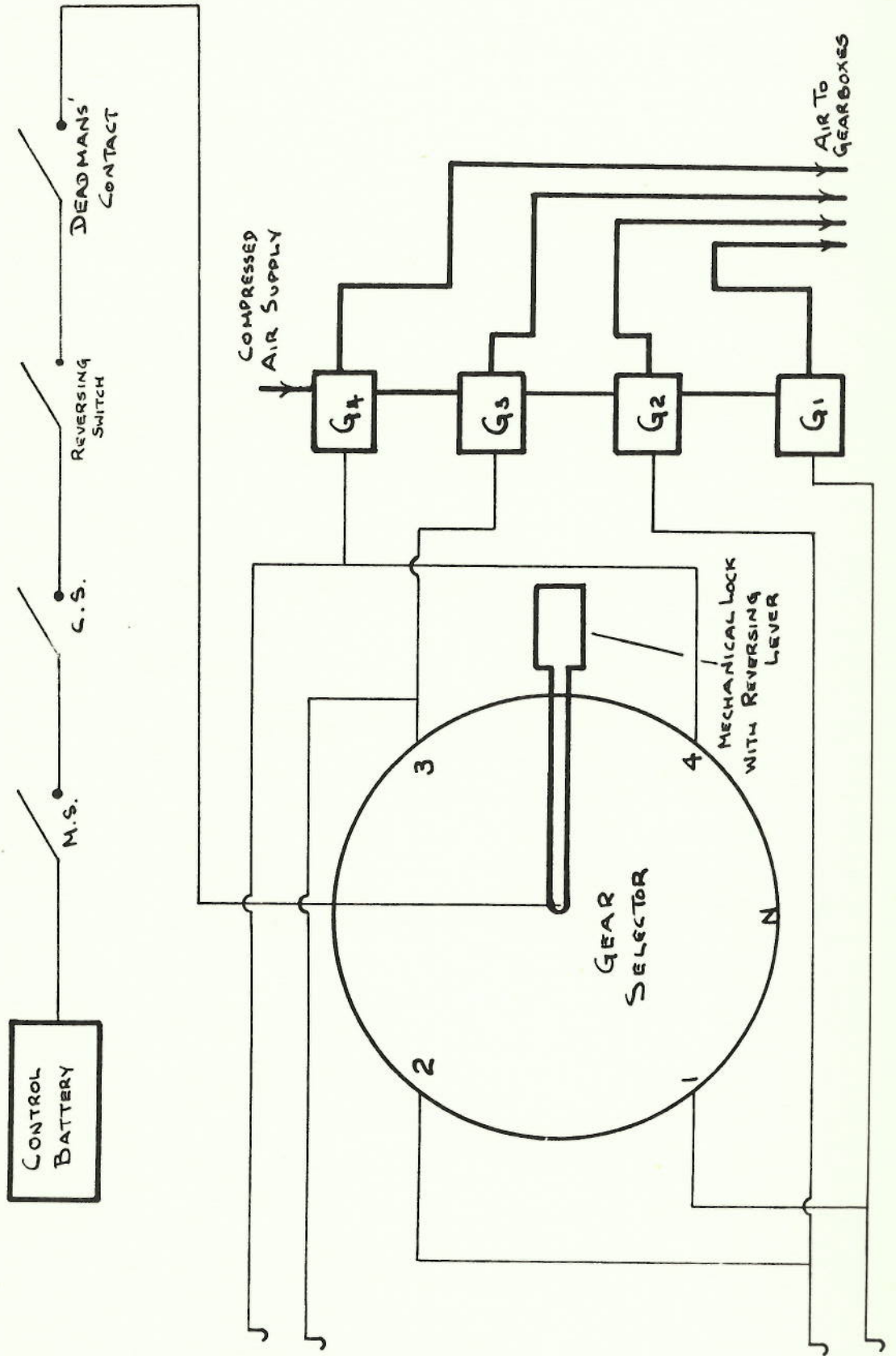
# ELECTRICAL SYSTEM 'L' TYPE

FIG. 23



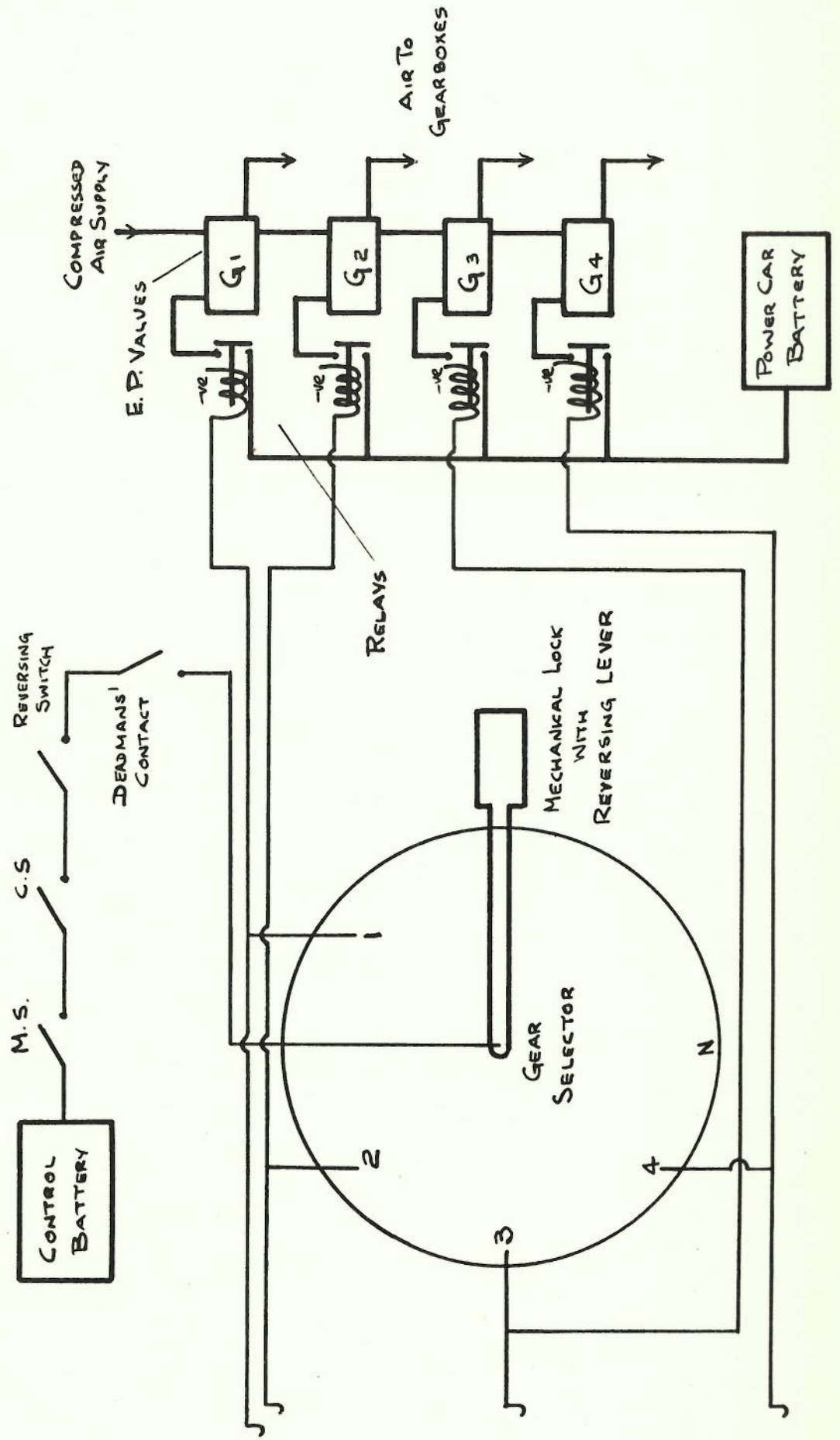
# GEARBOX CONTROL A TYPE

FIG. 24



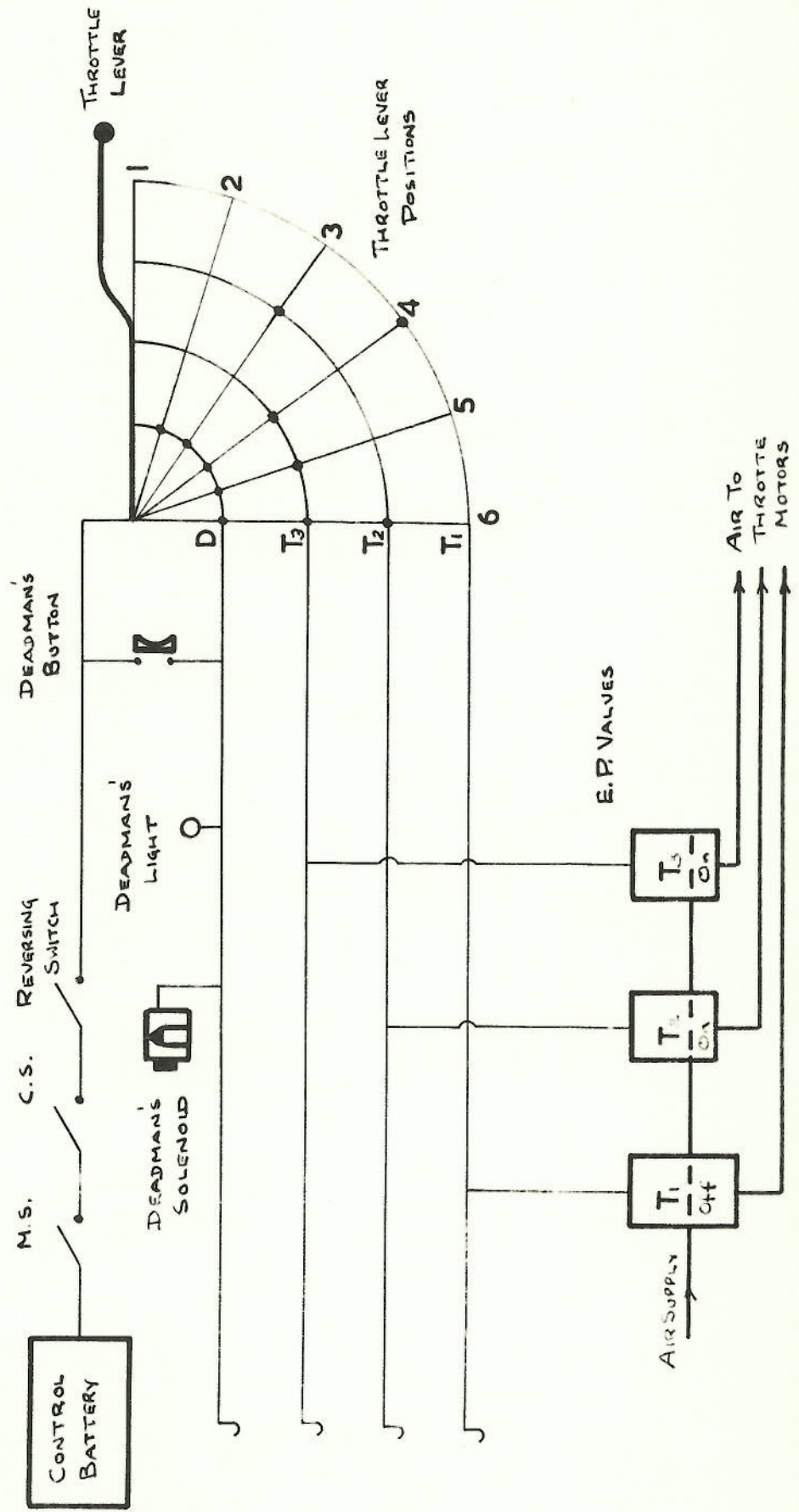
# GEARBOX CONTROL 'L' TYPE

FIG. 25



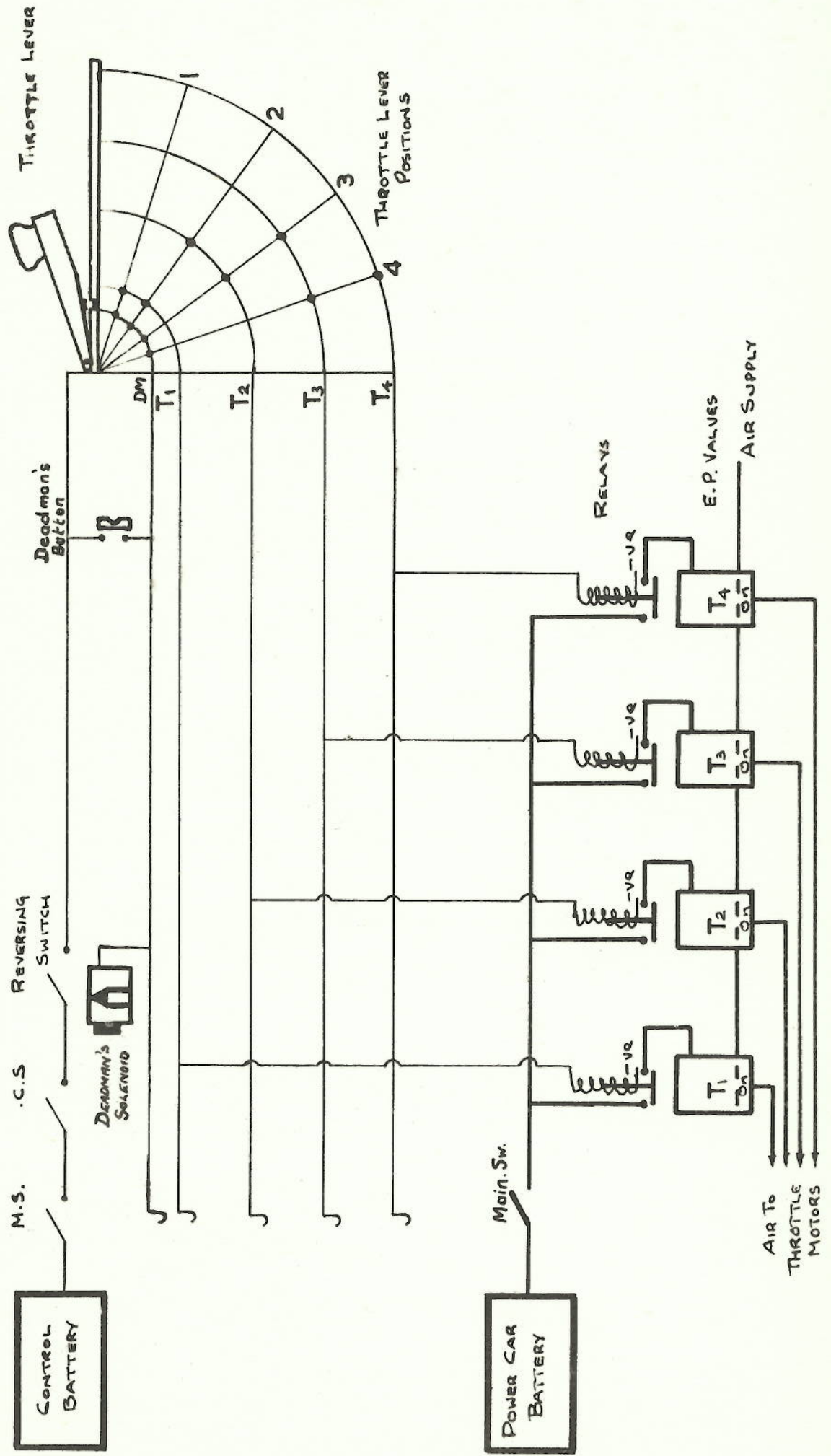
# ENGINE SPEED CONTROL 'A' TYPE

FIG. 26



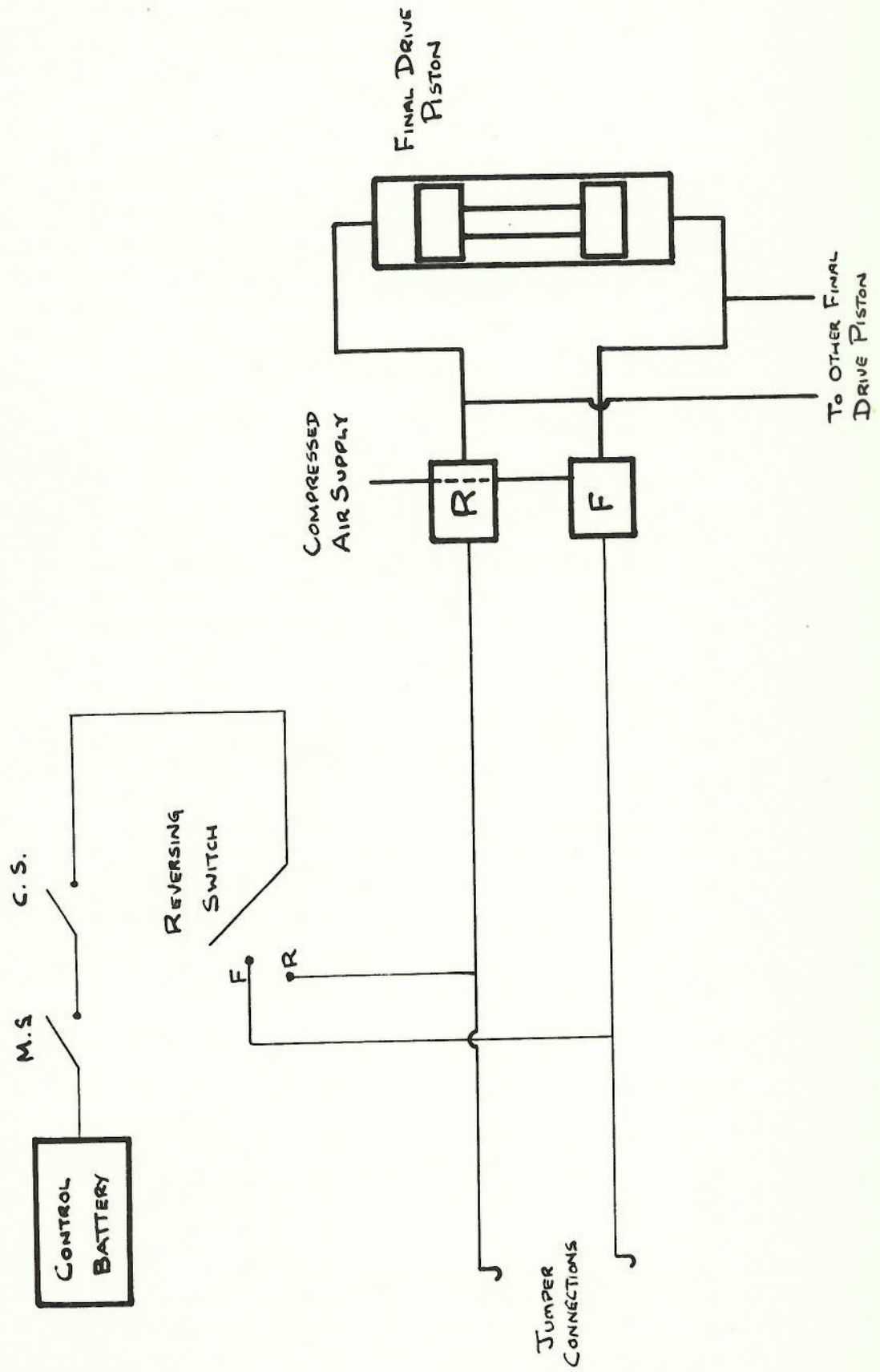
# ENGINE SPEED CONTROL 'L' TYPE

FIG. 27



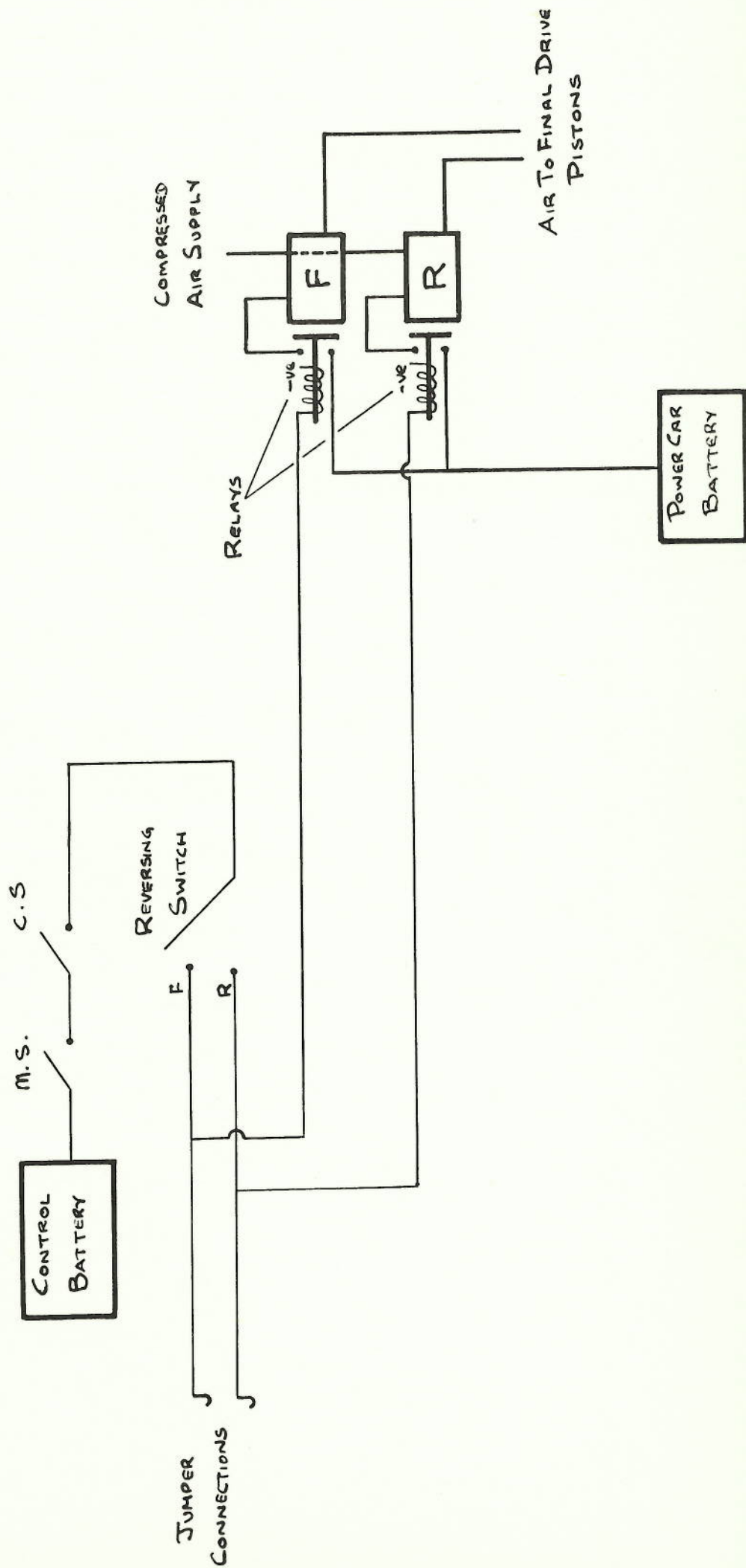
# DIRECTION CONTROL 'A' TYPE

FIG. 28



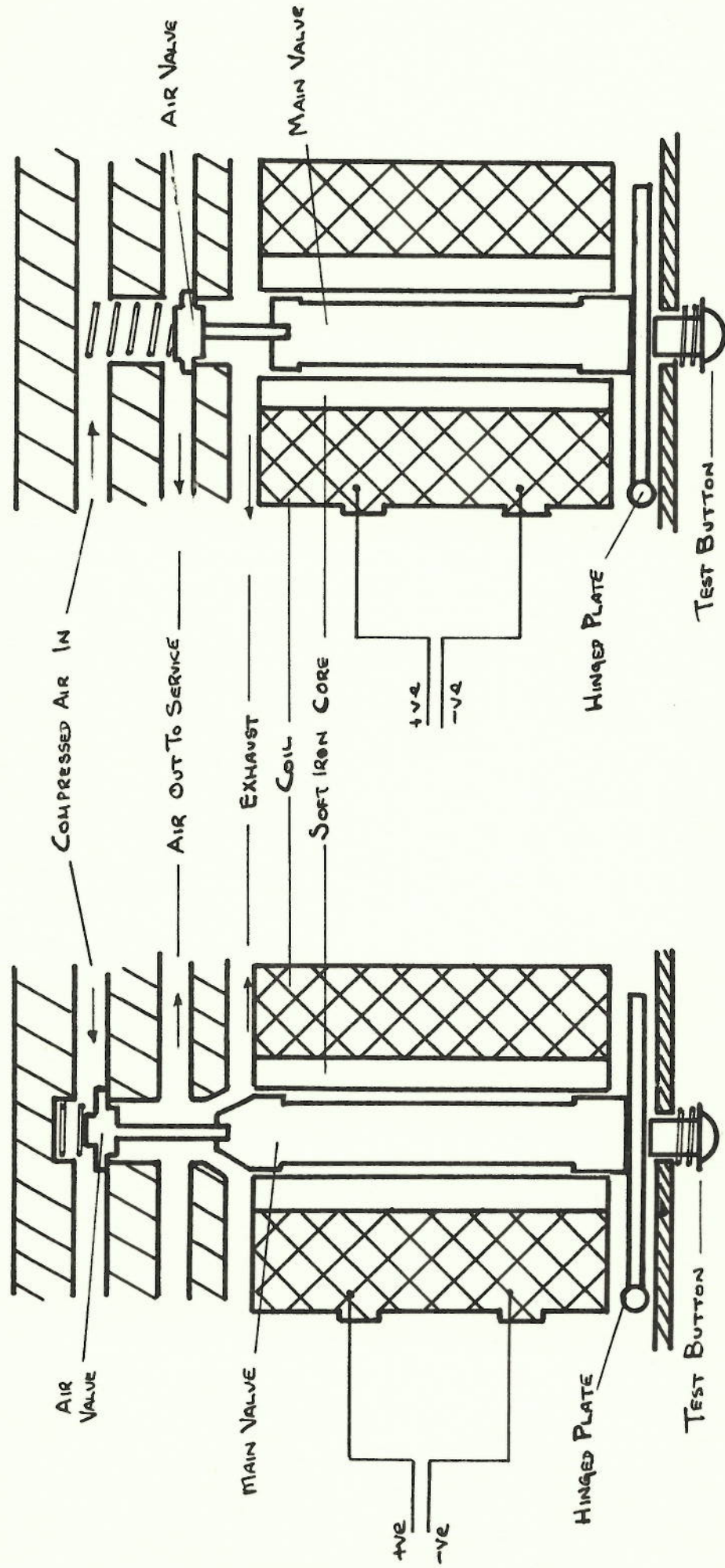
# DIRECTION CONTROL L TYPE

FIG. 29



# ELECTRO - PNEUMATIC VALVE

FIG. 30



'ON' TYPE

'OFF' TYPE

## RAILCARS—THE COMPRESSED AIR SYSTEM

Each engine is provided with a twin cylinder reciprocating-type air compressor to supply air for the various fittings which are pneumatically operated. On B.U.T. engines the compressor is gear driven from the engine crankshaft, on Rolls-Royce 6 Cyl. engines the compressor is belt driven and on their 8 cyl. engines it is gear driven from the auxiliary gear box.

Air from the atmosphere is drawn through a filter and anti-freeze unit into the compressor. The compressed air then passes through a non-return valve and an unloader valve into a small reservoir, where the pressure builds up to 50 lb./sq. in. before the diverter valve opens and the main reservoirs are charged.

When the pressure in the system reaches 95 lb./sq. in. the unloader valve opens to atmosphere, so allowing the compressor to run light. It does not close again until the pressure has dropped to 80 lb./sq. in.

The diverter valve allows air to flow back to the small reservoir should the pressure on that side of the valve drop below the pressure in the main reservoirs.

The design of the gearbox requires air supplied at constant pressure, but the reservoir pressure varies between 80-95 lb./sq. in., so use is made of a reducing valve to reduce air pressure for the gearbox to 65 lb./sq. in.

From diagram No. 31 the different uses made of the compressed air can be noted.

*Reducing Valve.* Shown in diagram No. 32.

Supplies air at 65 lb./sq. in. to operate gearbox. Mounted in the pipe line between an air filter and the gearbox E.P. valve block. As shown in the diagram, the valve consists of a reaction head containing a filter, inlet valve, release valve and reaction piston, together with a main body housing the control spring which is fitted in a pre-loaded condition.

*Diverter Valve.* Shown in diagram No. 33. (Applicable to 79000 series cars, only.)

This valve is mounted on the first large reservoir and ensures that the small reservoir is charged to 50 lb./sq. in. before pressure is allowed to build up in the large reservoirs beyond.

Air from the compressors and small reservoir enters the valve and passes through the flutes of the valve stem to the upper chamber. When pressure in the small reservoir has built up to the diverter valve setting (50 lb./sq. in.), air compresses the bellows, causing them to contract against the control spring and lift the valve from its seat. Air then passes under the valve to the large reservoirs.

A non-return valve allows a feedback of air from the large reservoirs should the pressure in the small reservoir fall below 50 lb./sq. in. for any reason.

*Unloader Valve.* Shown in diagram No. 34.

This valve relieves the compressors of most of the pumping load, when the reservoirs are charged to operating pressure. When pressure in the reservoir is below that of the unloader setting, the valve remains closed and air flows through a filter and non-return valve into the small reservoir. The valve is held on its seat by spring tension plus air pressure which flows to the spring chamber through a balancing passage.

Reservoir pressure is communicated to the inside of a metal bellows, situated below the valve. When the reservoir pressure reaches 95 lb./sq. in. the air action on the larger surface area of the bellows forces them up, overcoming the resistance of the spring and spring chamber air pressure, thus lifting the valve off its seat. When this occurs, air from the spring chamber and compressor is passed through the silencing chamber to atmosphere. Reservoir pressure inside the bellows will now only have to overcome spring tension, so the valve will remain open until reservoir pressure has fallen to 80 lb./sq. in.

# COMPRESSED AIR SYSTEM

FIG. 31

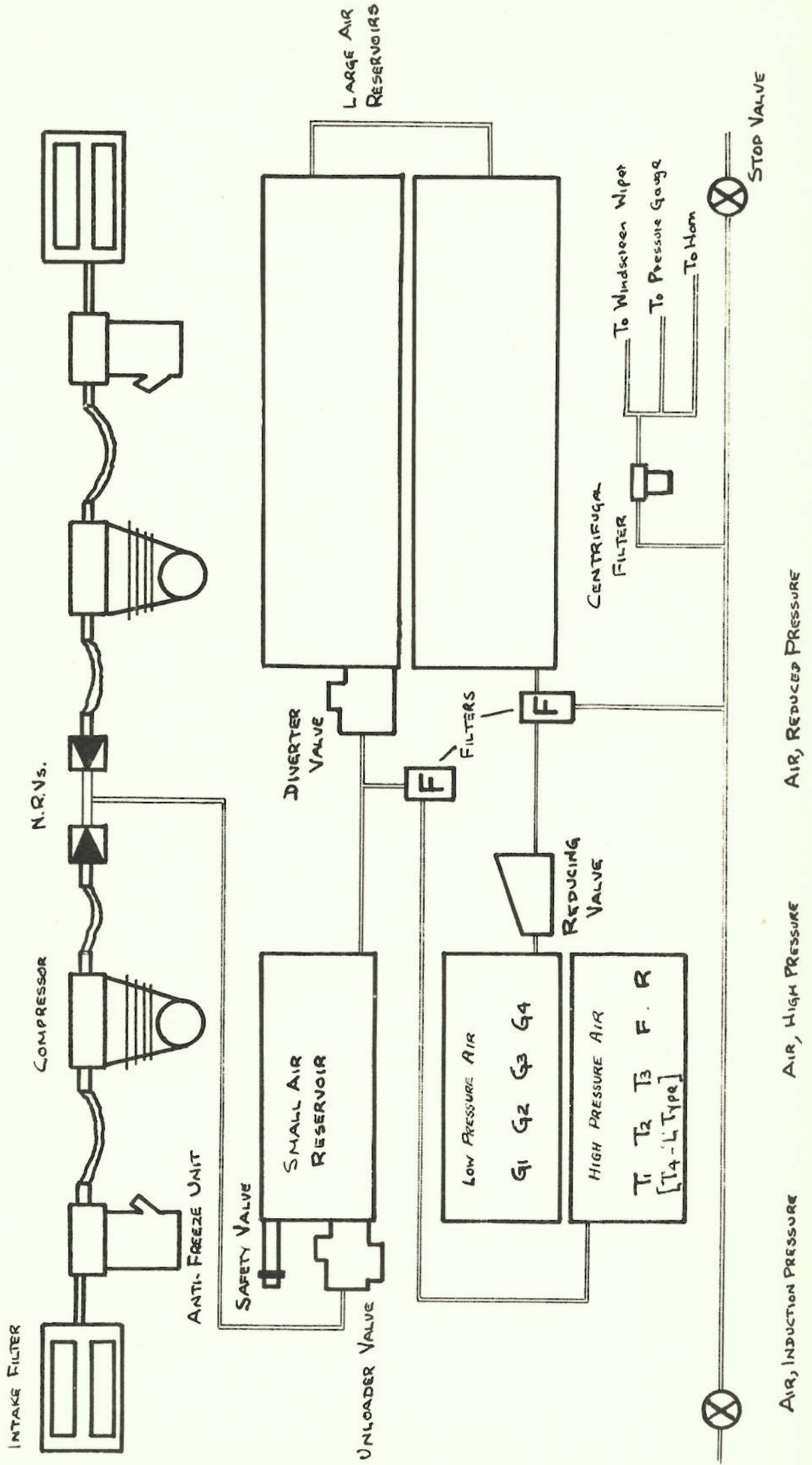


FIG 32

REDUCING VALVE

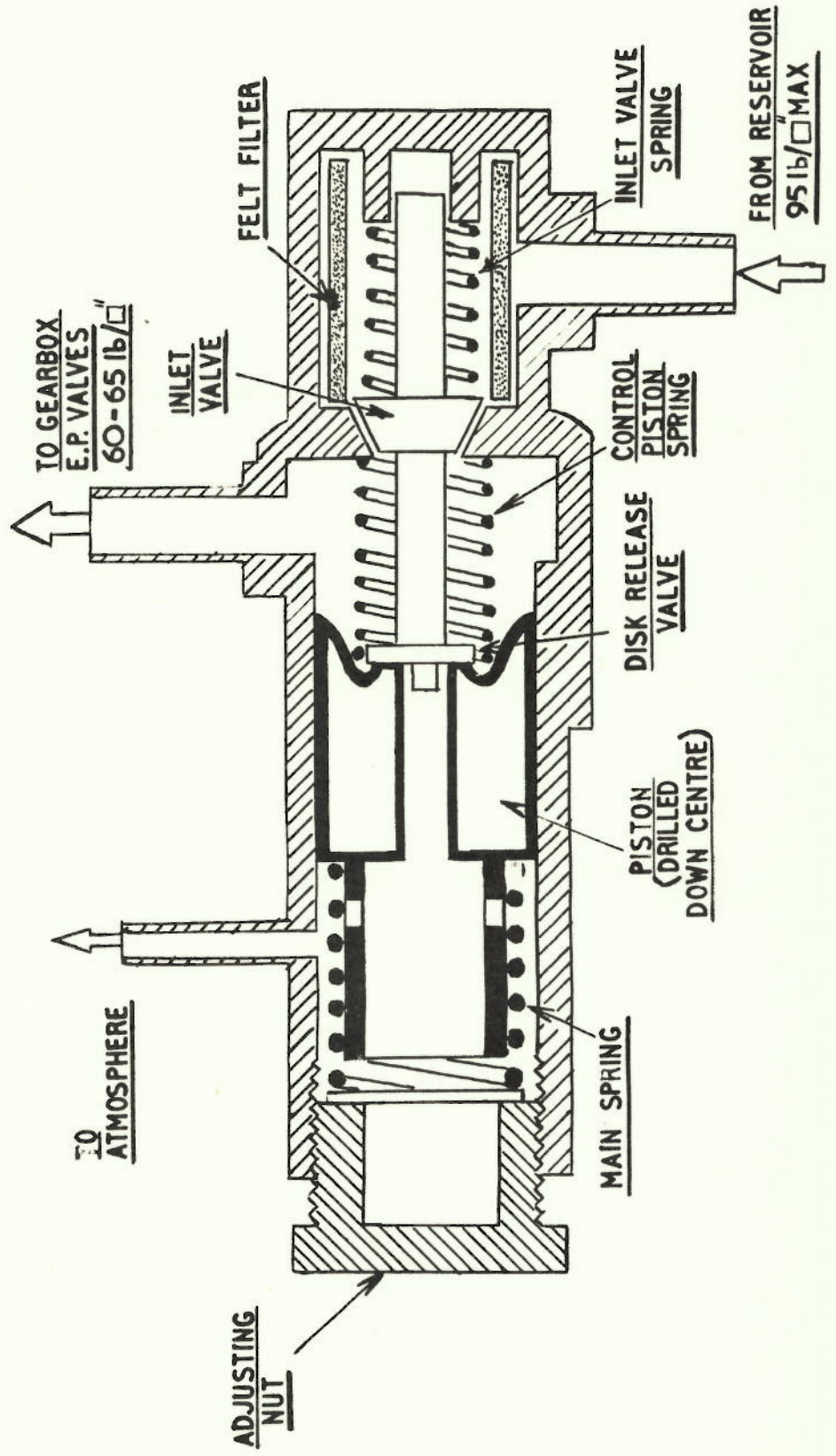


FIG. 33

DIVERTER VALVE

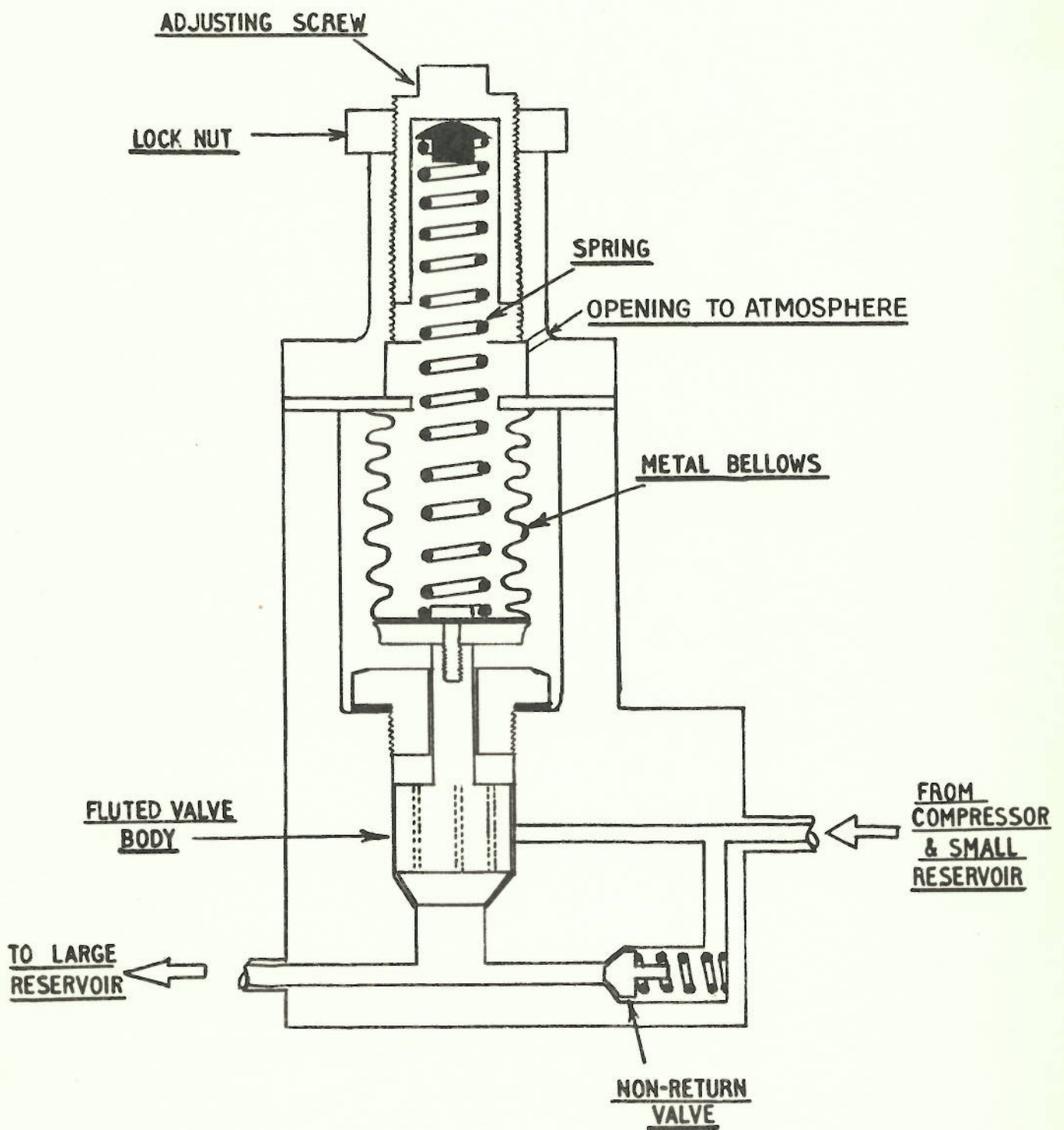
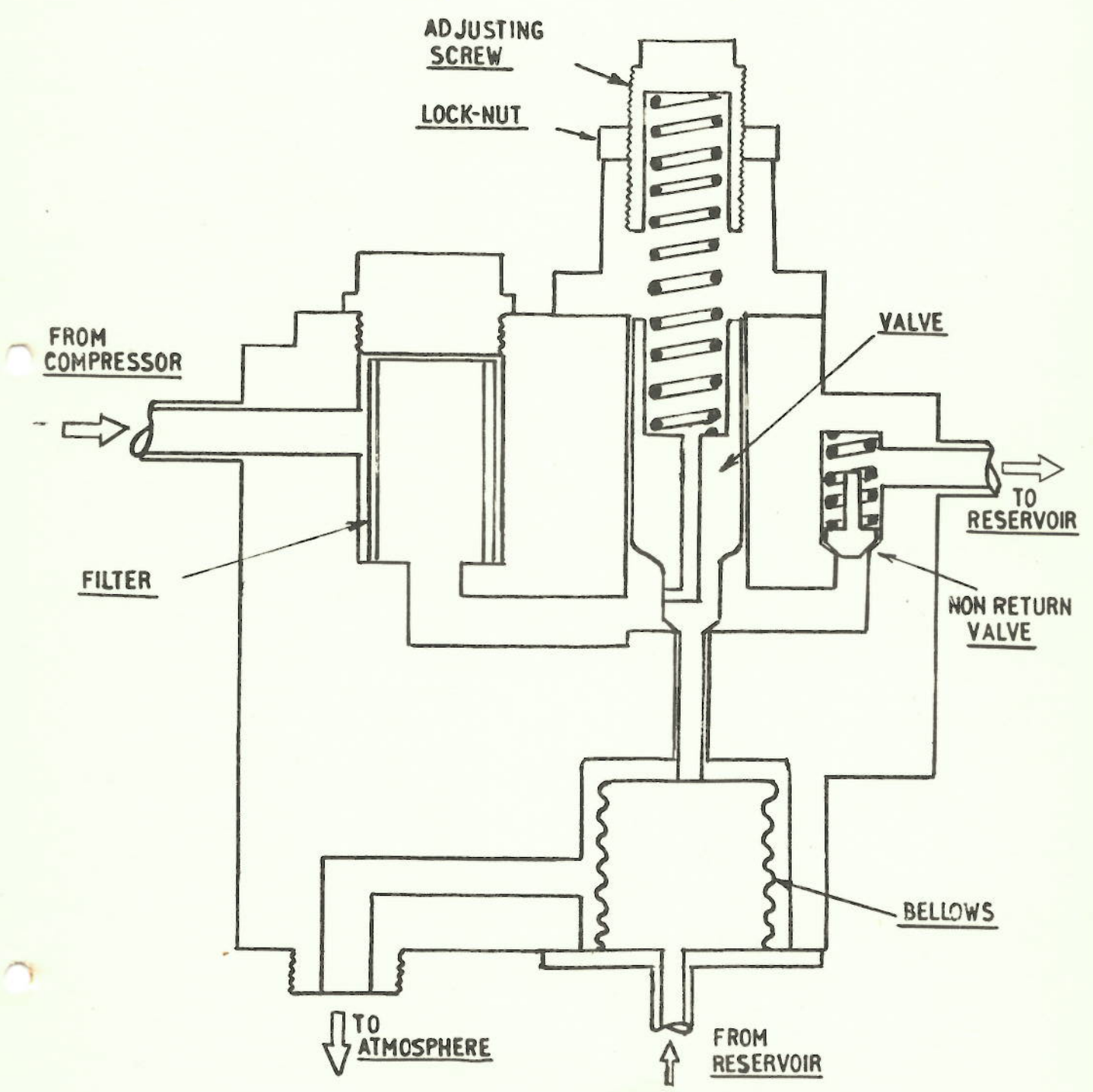


FIG. 34

UNLOADER VALVE



## DIESEL TRACTION NOTE No. 20

## RAILCARS—ENGINE SPEED CONTROL

There are two methods of engine speed control and, as with other equipments, they are known as the "A" and "L" types.

"A" type. Diagram No. 26 shows schematically the electrical connections between the control car battery and the engine speed control electro-pneumatic valves. When the main control and reversing switches are closed there is a supply of current to the throttle control. Movement of the driver's throttle handle controls the supply of current to the throttle E.P. valves and the deadman circuit in a particular sequence.

The figures 1 to 6 down the right-hand side of the arc, in the diagram, represent the six throttle handle positions, and a black dot where the arcs cut the straight radial lines indicates an electrical connection made in that position of the handle.

The table below shows which connections are made in each of the six positions and the effect.

<i>Throttle handle position</i>	<i>Circuits energised</i>	<i>Throttle motor cavities charged with air</i>	<i>Effect</i>
1	—	1st	Deadman de-energised. Engine idles.
2	D	1st	Deadman energised. Engine idles.
3	D T2	1st, 2nd	Deadman energised. Engine speeds up.
4	D T1, T3	3rd	Deadman energised. Engine speeds up.
5	D T3	1st, 3rd	Deadman energised. Engine speeds up.
6	D T2, T3	1st, 2nd, 3rd	Deadman energised. Engine speeds up.

The "A"-type throttle motor is shown diagrammatically in diagram No. 35. As indicated above, it is compressed air operated. The diagram interprets the effect on the throttle motor of the details given in the above table as the driver opens the throttle control handle and energises the speed control circuits. The shaded portions represent the compressed air. When the compressed air is allowed to exhaust by the electro-pneumatic valves, a strong spring returns the pistons to the left side of the cylinder.

"L" type (Diagram No. 27). The control car 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 as shown in Fig. 35A. An overlap is provided to produce a smooth increase in engine speed.

All throttle E.P. valves in this system are the "ON" type.

The table below shows the connections made in each throttle handle position and the effect.

<i>Throttle handle position</i>	<i>E.P. valves energised</i>	<i>Throttle motor cylinders charged with air</i>	<i>Effect</i>
1	T1	1	Engine idles.
2	T1 T2	1 2	Engine speed increases.
3	T2 T3	2 3	Engine speed increases.
4	T3 T4	3 4	Engine speed increases.

With this type of control the deadman circuit is energised through a switch on the throttle handle.

The "L"-type throttle motor consists of a rectangular box with four small air cylinders attached to it. Across the box is a shaft carrying four independently mounted arms. These arms will rotate

**DIESEL TRACTION NOTE No. 20—continued**

the shaft if operated from the cylinder side of the box, but are free on the shaft if moved from the other side.

These arms, though free on the cross shaft, have lugs which engage the shaft and turn it by a predetermined amount when compressed air is applied to a cylinder and forces the piston against the arm until contact is made with a threaded adjustable stop. By progressively reducing the height of the stop for each cylinder the shaft can be made to rotate a fixed amount as air is applied to each cylinder in turn.

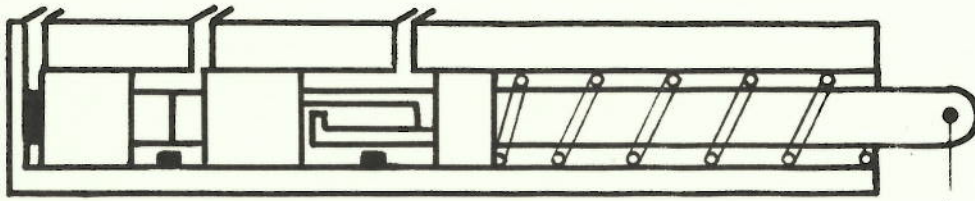
It should be noted that in the "L" system the control car battery supplies, and the jumper cables carry, only the current required to operate relays and as this is small compared with the current required by electro-pneumatic valves the load on the control car battery is reduced as compared with the "A" system.

*Drawing References*

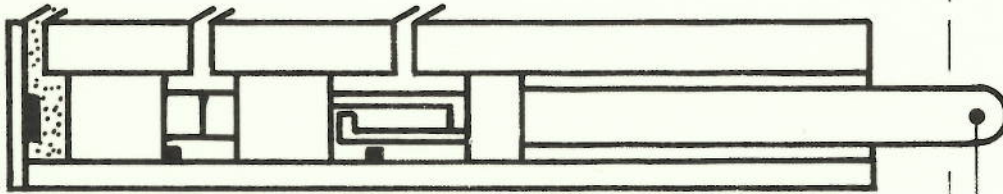
Fig. 35. "A" TYPE THROTTLE MOTOR

Fig. 35A. "L" TYPE THROTTLE MOTOR AND LINKAGE

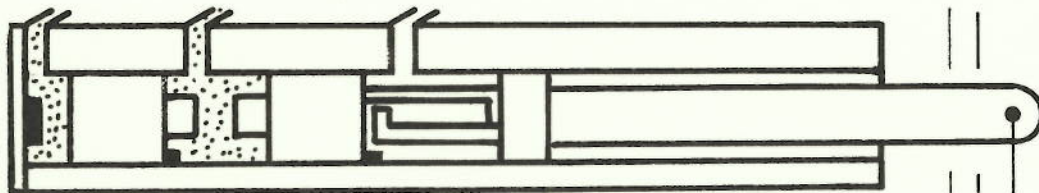
# THROTTLE MOTOR 'A' TYPE



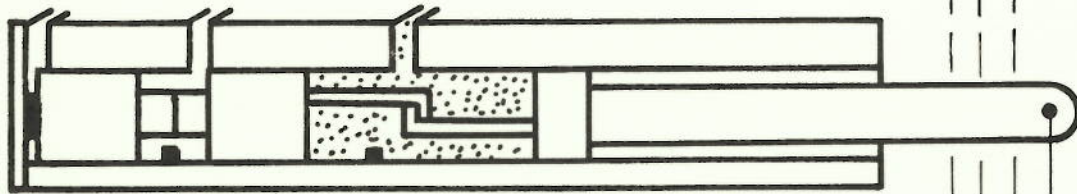
NO AIR - ENGINE STOPPED



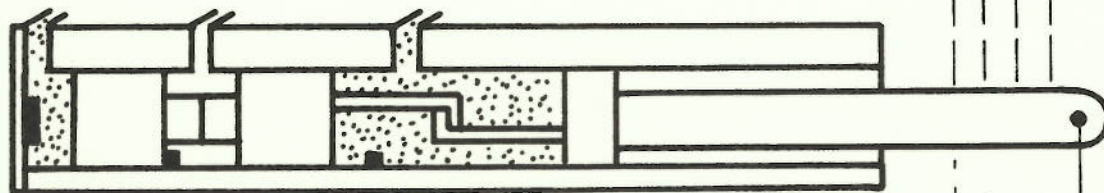
NOTCHES 1 & 2 - DEADMAN'S ENERGISED ON 2.



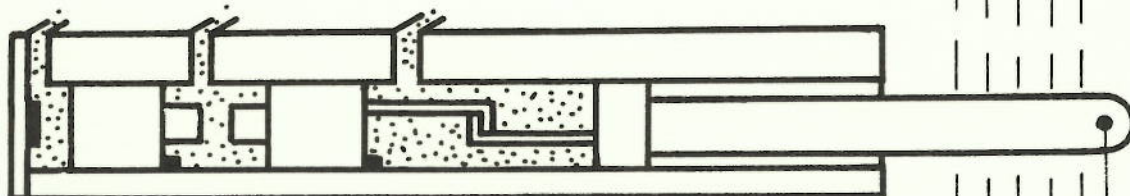
NOTCH 3 - T2 ENERGISED



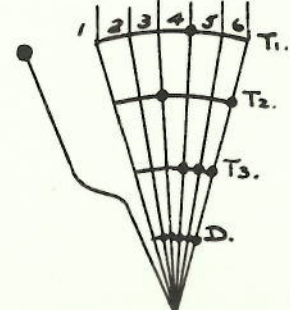
NOTCH 4 - T1 & T3 ENERGISED



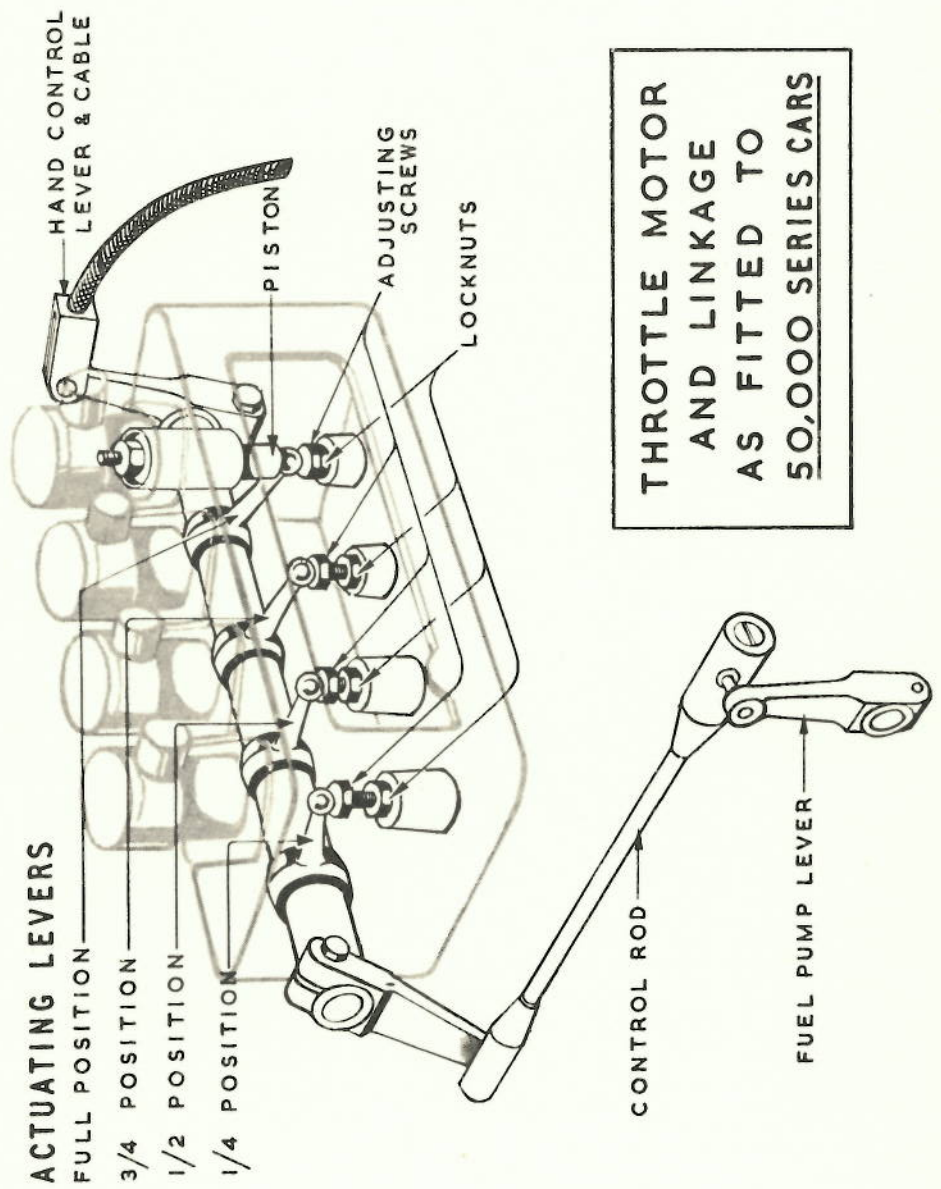
NOTCH 5 - T3 ENERGISED



NOTCH 6 - T2 & T3 ENERGISED



**FIG. 35A**



**RAILCARS—GRESHAM AND CRAVEN****TWO-PIPE QUICK-RELEASE VACUUM BRAKE SYSTEM**

The general layout is shown on diagram No. 26.

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.

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 diagram No. 36. They are as follows:—

- Exhauster. Belt driven from either the input shaft of gearbox or from the output end of the auxiliary gearbox.
- Feed valve
- Driver's brake valve
- Isolating valve
- Standard brake cylinder

Operation is as follows (referring to diagram 37).

(1) Running. Car in motion and exhauster running at maximum speed. The feed valve prevents train-pipe vacuum from rising above 21 ins. To do this it does not admit air like an ordinary relief valve, but shuts down at 21 ins. train-pipe vacuum, thereby isolating the exhauster from the rest of the system. The exhauster then creates up to 28 or 29 ins. 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.

(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 ins. 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; 19 ins. of vacuum is maintained in the reservoir, although the vacuum in the rest of the system has fallen below that figure. This greatly reduces re-charging time.

*Brake System Components*

(a) Exhauster. The layout of the exhauster is shown in diagram No. 38. It is belt driven from the input side of the gearbox. It will be seen that as the rotor revolves the clearance between the blades alternately increases and decreases. A vacuum is created as the clearance increases, causing the space to be filled with air from the reservoir and oil from the separator. The air and oil are then compressed before being forced into the oil separator. As the name implies, the air and oil are separated in this unit, the air passing to atmosphere and the oil falling into the reservoir ready to be used again.

(b) Automatic Feed valve (see diagram No. 39). There is one feed valve to each driver's brake valve fitted between the brake valve and the release pipe. It regulates the train pipe vacuum to 21 ins. and maintains this as long as the release pipe vacuum is above 21 ins.

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

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

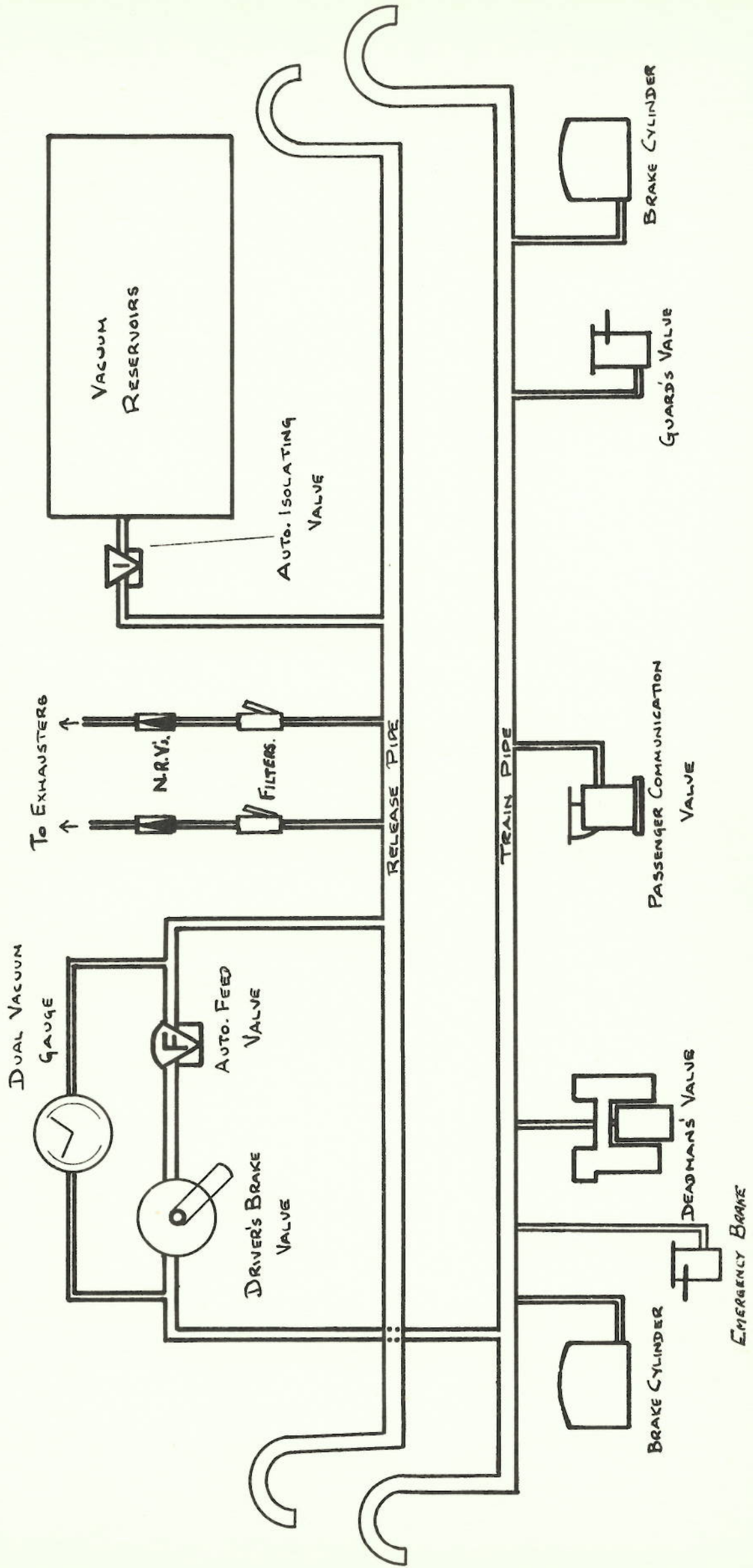
When changing ends a difference in the train pipe vacuum may be noticed, and this means that one of the adjustable feed valves needs resetting. Such cases should be reported when booking off duty.

(c) Automatic isolating valve (see diagram No. 39). There is one fitted to each set of reservoirs, positioned between the reservoirs and the release pipe. Its purpose is to maintain 19 ins. 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.

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 reservoirs. When the vacuum above the diaphragm reaches 19 ins., atmospheric pressure under the diaphragm overcomes the spring tension, lifts the spindle and continues to hold the N.R.V. off its seat.

# VACUUM SYSTEM

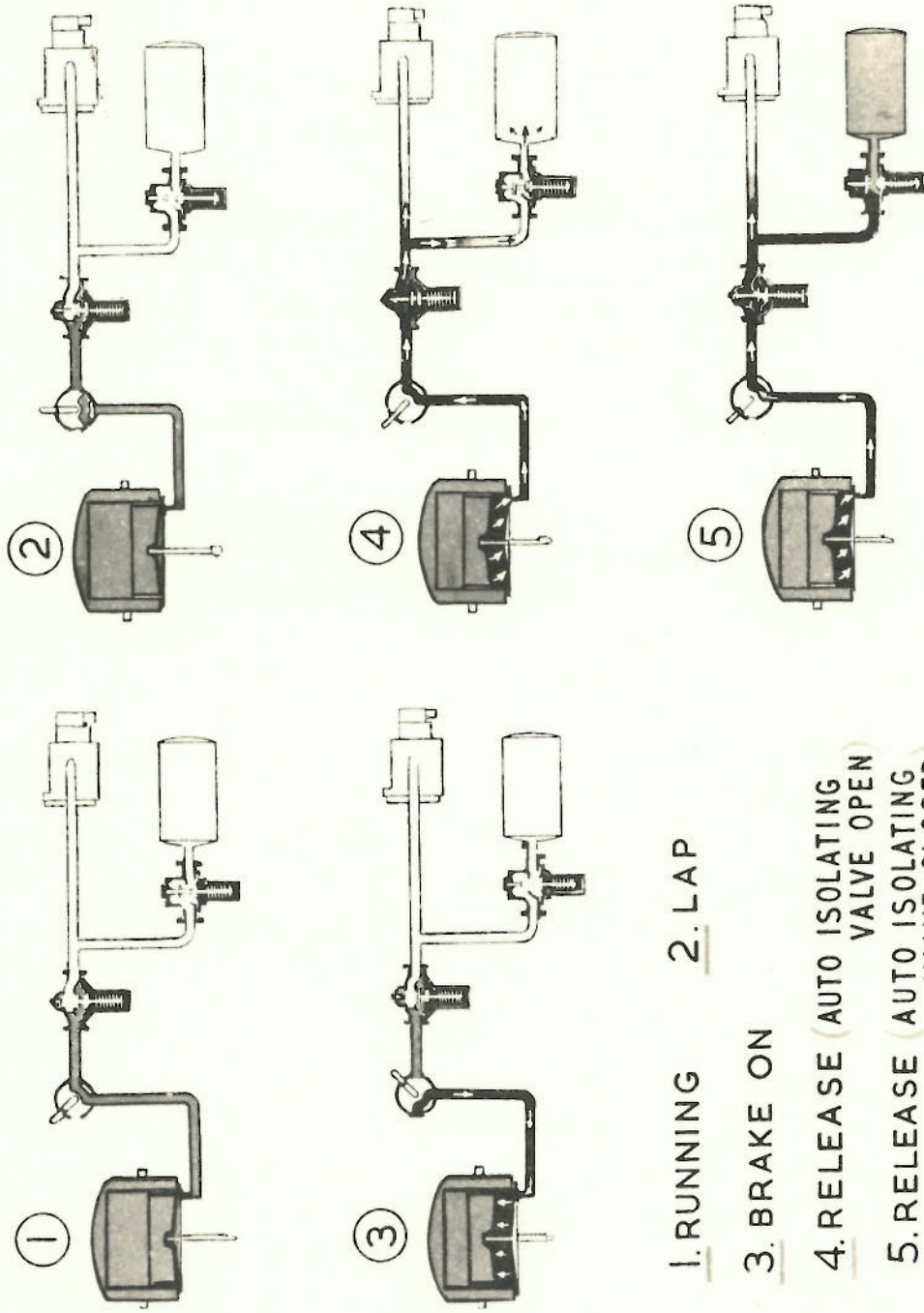
FIG. 36



FRONT

REAR

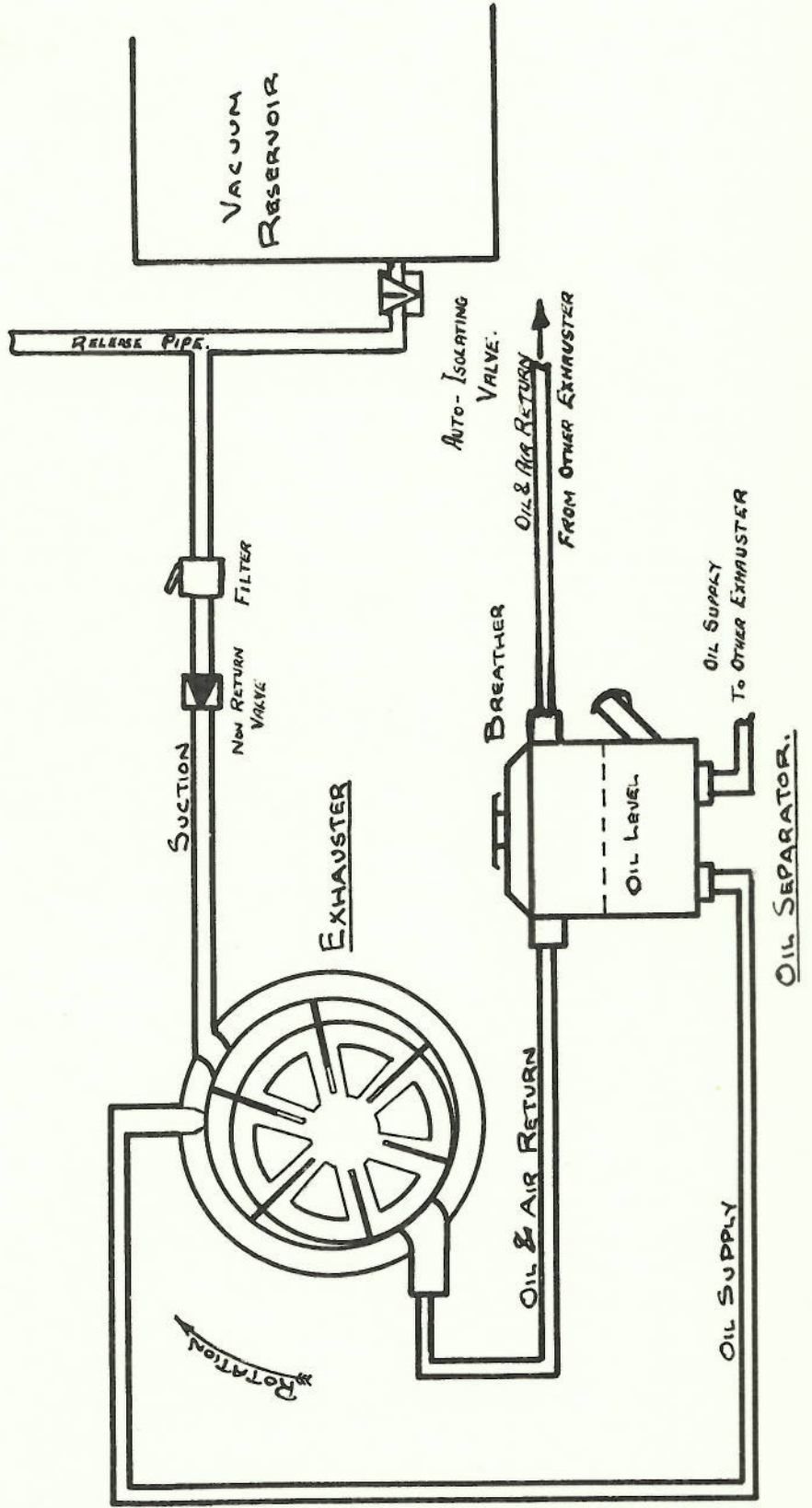
FIG. 37



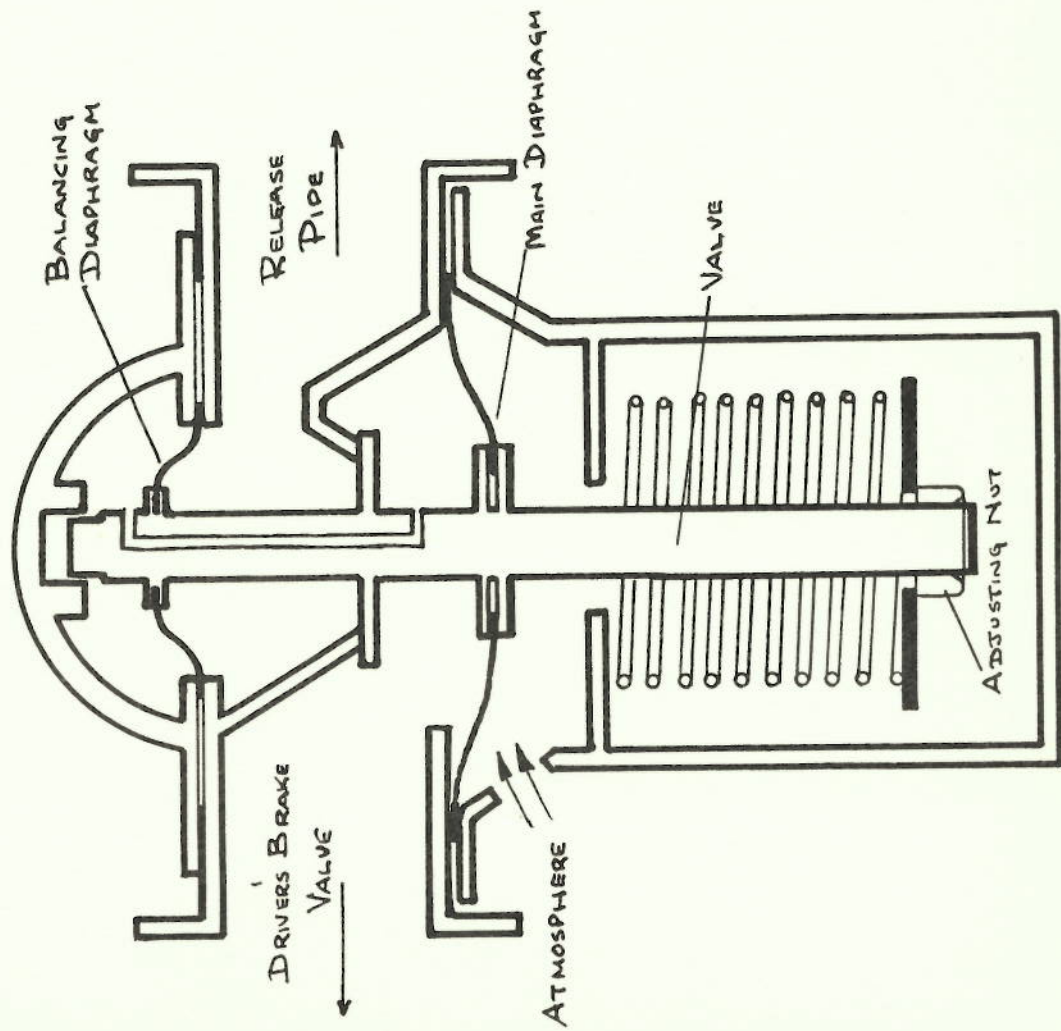
1. RUNNING    2. LAP  
3. BRAKE ON  
4. RELEASE (AUTO ISOLATING VALVE OPEN)  
5. RELEASE (AUTO ISOLATING VALVE CLOSED)

# VACUUM EXHAUSTER.

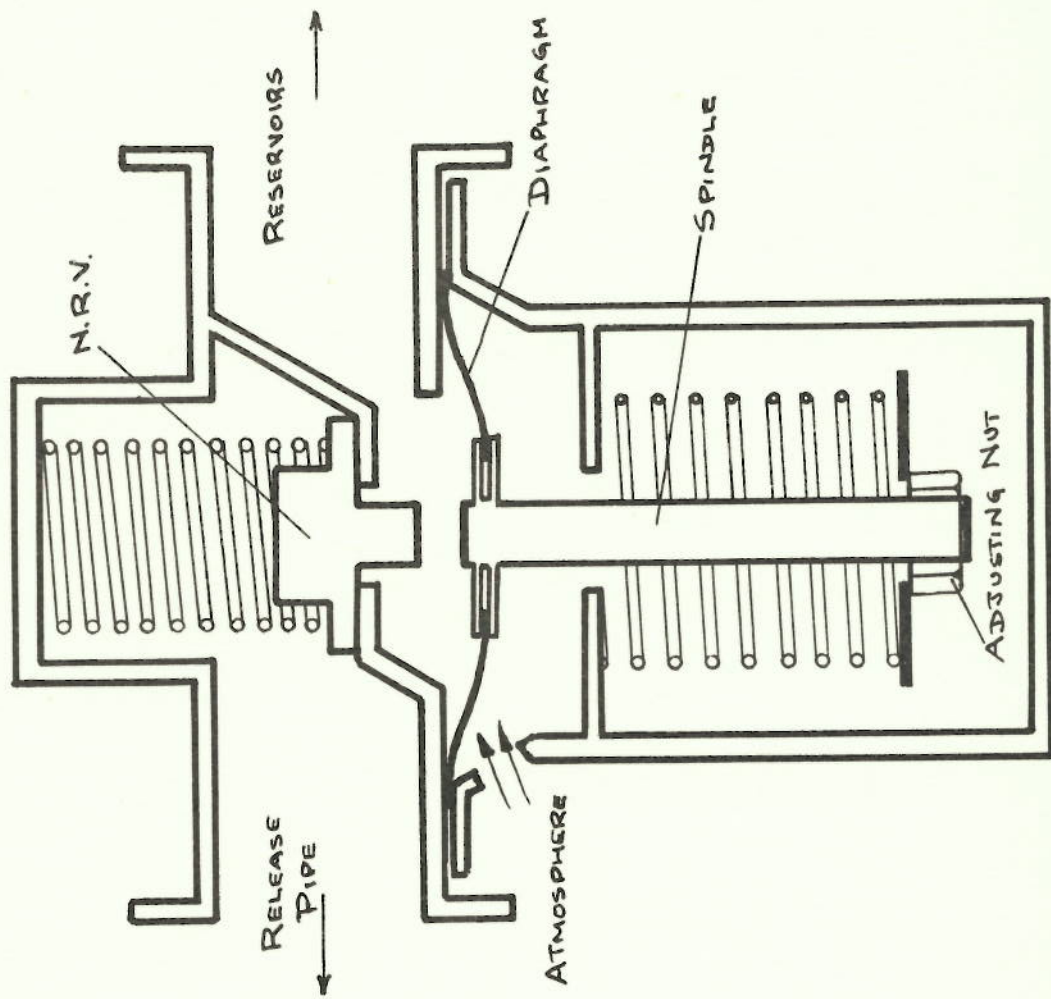
FIG. 38



AUTO. FEED VALVE



AUTO. ISOLATING VALVE



## DIESEL RAILCARS—DEADMAN ARRANGEMENT

One deadman valve is fitted in each power car.

Referring to diagram No. 40.

When running, the operation of the throttle lever closes a switch so that current is passed to the solenoid, which is then energised. The lower valve is lifted on to its seat so isolating the control valve from the 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.

In the case of a deadman application, the solenoid is de-energised and the 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. The air cannot get direct into the train pipe because the upper seat of the control valve is covered.

As the air pressure builds up under the emergency valve diaphragm, the spring pressure is overcome and air is admitted direct into the train pipe through the emergency valve. When the 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 the vacuum can be recreated in the train pipe. There will be approximately 3 ins. of vacuum showing on the train pipe gauge due to the action of the spring.

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

Should the valve become defective, e.g. the diaphragm becoming punctured, etc., the valve can be isolated. This is done by moving the isolating handle to the position indicated.

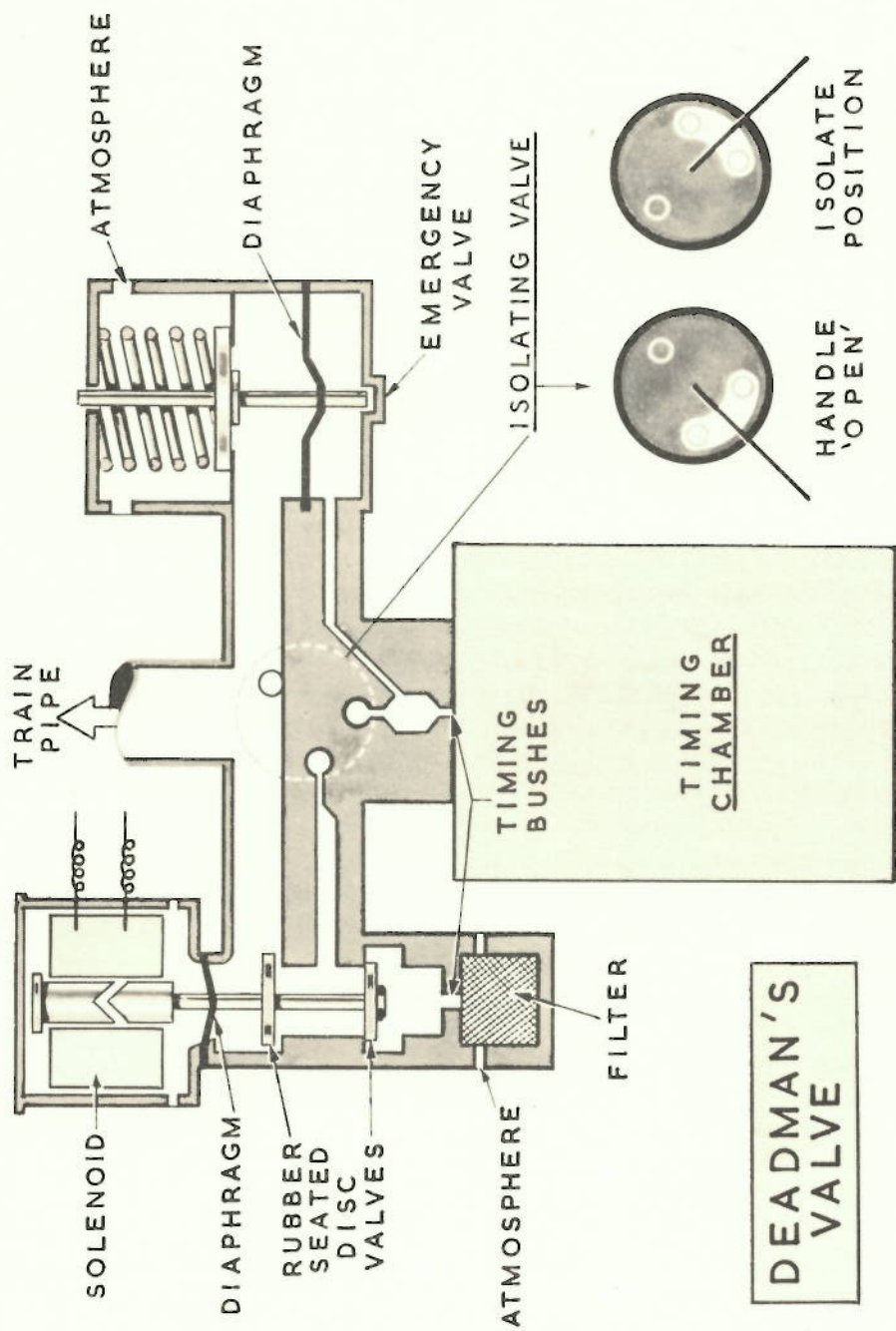
When the deadman is operated the gearbox is returned to neutral and the engine to idling speed by cutting the current to the appropriate E.P. valves. On some cars a deadman light is fitted which goes out when the throttle lever is released.

When taking charge of a train the deadman equipment should be tested with the brake valve in the lap position thus avoiding loss of the "high" vacuum.

### *Drawing Reference*

Fig. 40. DEADMAN AND EMERGENCY VALVE.

FIG. 40



## DIESEL TRACTION NOTE No. 23

**DIESEL RAILCARS—FIRE FIGHTING EQUIPMENT**

Two types of Fire Fighting Equipment are used on Railcars, namely, hand equipment and automatic equipment.

1. *Hand Equipment.*

Each vehicle in a diesel train is provided, where applicable, with the following hand-operated equipment.

1. 2 CO<sub>2</sub> (Gas) extinguishers in each driving cab.
2. 1 CO<sub>2</sub> (Water) extinguisher at the lobby end of each non-brake vehicle (contents 2 galls.).
3. 1 CO<sub>2</sub> (Water) extinguisher in each brake compartment (contents 2 galls.).

2. *Automatic Equipment*

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

Referring to the schematic diagram No. 41 of this equipment, it will be noted there is a constant supply of current from the battery to one side of the flame switch. The other side of this switch connects to two separate circuits

- (a) Detonator on extinguisher bottle
- (b) Fire Alarm relay system

Whenever the flame switch closes (1) a current operates the detonator under the fire bottle, and releases a heavy inert gas (chlorobromomethane), which blankets the engine, smothering the fire, and (2) 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 in two ways:—

- (1) By hand
- (2) 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, and in order to stop the fire bells ringing, the alloy tab plate on the fire-control relay panel must be pulled off and the 2-pole switch operated. This puts out the light and stops the bells ringing but isolates the starter relays 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.

**FIRST AID TREATMENT FOR PERSONS KNOWN TO HAVE BEEN IN CONTACT WITH CHLOROBROMOMETHANE LIQUID**

*Note.*—Chlorobromomethane is an efficient agent for extinguishing fires, but contact with heat materially increases the toxic nature of the liquid.

If the automatic extinguishing apparatus has been operated, staff must avoid inhaling a concentration of the gas and avoid touching the liquid with the skin or clothes.

The agent is heavier than air and will fall to the ground. There is very little perception of smell, though it can be faintly distinguished.

*Treatment*

1. Remove the patient from discharge area.
2. Summon medical aid as soon as possible, notifying the doctor that the patient has been in contact with chlorobromomethane and that oxygen therapy will probably be required.
3. If contaminated with liquid ALL clothing, wrist watches, rings, etc., must be removed and the patient washed freely.
4. Contaminated clothing should be removed for later disposal.
5. Fresh air is essential and artificial respiration may be necessary. Oxygen therapy, if available, should be started at once.
6. If a quantity of chlorobromomethane enters eyes or nose, wash the affected parts with a sterile, saturated, sodium bicarbonate solution of 1 part sodium bicarbonate to 15 parts of water. If sodium bicarbonate is not available use plain water freely.

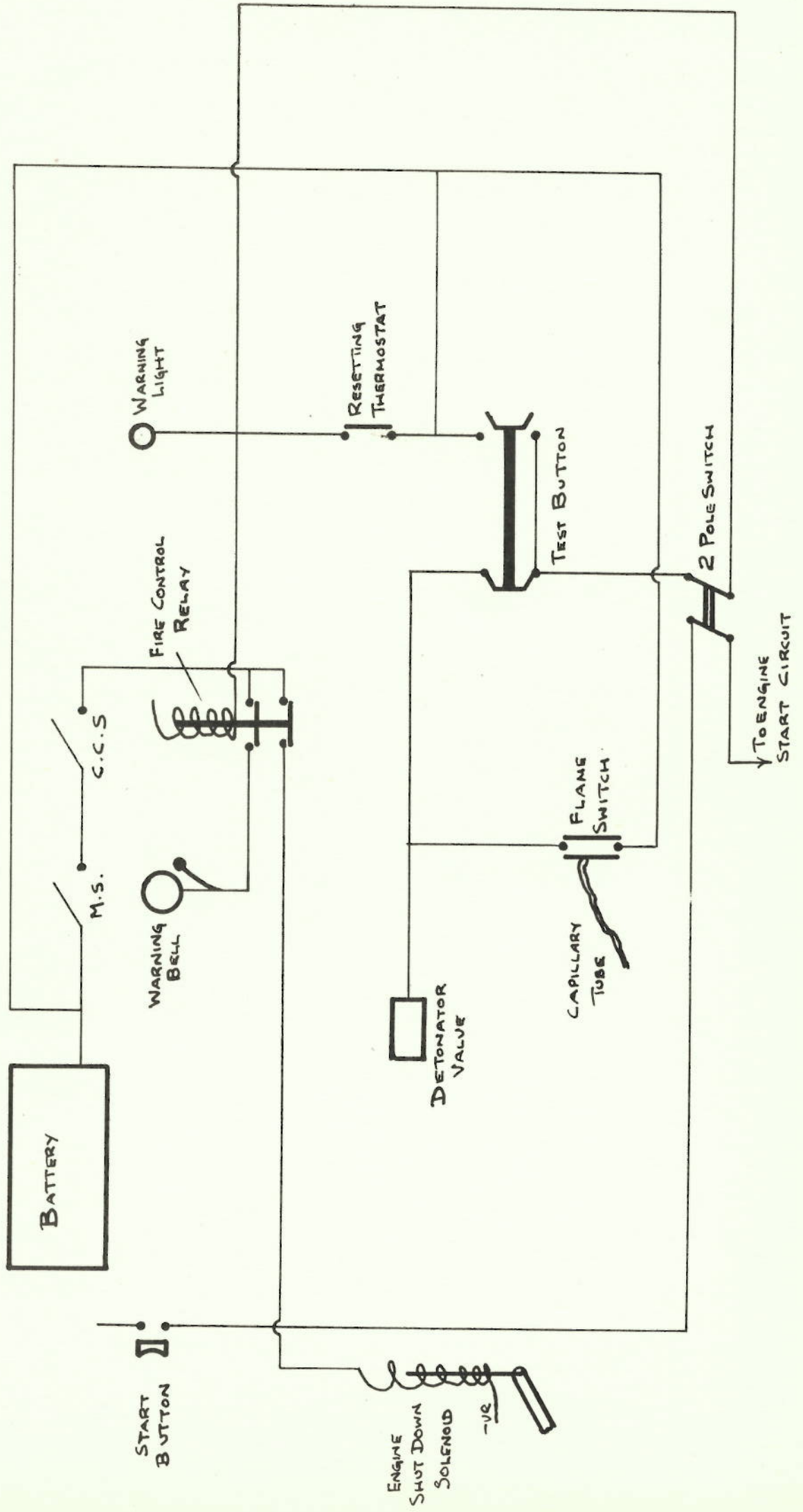
**DIESEL TRACTION NOTE No. 23—continued**

7. If a quantity of chlorobromomethane enters the mouth or is swallowed, an emetic, of at least one pint of sterile saturated solution of sodium bicarbonate of 1 part sodium bicarbonate to 15 parts of water, should be given immediately, and the patient treated as for shock whilst a doctor is contacted. The solution may also be used as a neutralising wash, for cleansing parts contaminated by this agent, on the condition that the skin is not broken or damaged by burns or scalds.
8. There may be certain delayed effects of chlorobromomethane poisoning, and every case of contamination must therefore be referred to the Regional Medical Department for observation.

The automatic fire-extinguishing system is shown in diagram 41.

# AUTOMATIC FIRE EXTINGUISHER SYSTEM

FIG. 41



## DIESEL TRACTION NOTE No. 24

## RAILCARS—FAULTS AND REMEDIES

These notes are intended to be used as a guide to drivers on the action to be taken should faults develop on diesel railcar trains when in their charge. These notes do not in any way supersede the requirements of the Rule Book, and General and Sectional Appendices and other similar instructions.

In all cases of delays, failure, etc., drivers must submit reports before signing off duty and, where necessary, repair cards indicating the repair required.

*FAULTS OCCURRING AT STABLING POINTS, SIDINGS, ETC.*

<i>Defect</i>	<i>Action to be taken</i>
1. Engine will not start on pressing local starting button on side of car.	(a) Check that battery isolating switch is in the "ON" position. (b) Check that the engine starter isolating switch on side of car is in the "ON" position.
2. Engine starter turns engine sharply but engine will not start.	(a) Lack of fuel. Check that there is sufficient fuel in tank and also the fuel cock is open. (b) Check coolant level in cooling system. (c) Check engine sump oil level.
3. Engine will not start on pressing starter button in driving compartment.	(a) Start engine by local starter button on side of car.
4. Engine fails to start owing to insufficient fuel oil, sump oil or coolant.	(a) Top up, if possible, and report action taken. (b) If unable to top up, isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce cars Nos. 51591 to 51650.
5. Engine fails to start for no apparent reason.	(a) Check for air in fuel system. "Bleed" system by opening "bleed" screw on fuel pump and operating hand-priming lever. (b) Isolate final drive and turn engine starter isolating switch to "OFF" position. Operate over-ride switch to "OFF" position on Rolls-Royce torque converter cars.
6. Engine indicator light fails.	(a) Check bulb is secure in holder. (b) Check that the engine is running; if so, proceed and report light defective. (c) If engine stopped, attempt to restart; if unable to do so take action as per Items 2, 3 and 5.
7. Air pressure and axle indicator lights fail.	(a) Check bulb is secure in holder. (b) Check air pressure in driving compartment of car indicated. (c) Remove trap door covering the final drives of car indicated and check that the pointers are in the correct position for direction of travel, i.e. pointer in opposite direction to that of travel. (d) If air pressure in car indicated is over 60 lb./sq. in. and final drive pointers are in correct position, proceed. (e) If air pressure is below 60 lb./sq. in. see Item 8. (f) If final drive pointer is in wrong direction see Item 9.
8. Lack of air pressure.	(a) Examine unloader and if discharging below 60 lb./sq. in. remove blank nut from stud adjacent to the unloader valve and fit it on to the escape connection of the valve after unscrewing protection cap. (b) Examine air system for leakage. (c) If (a) and (b) ineffective on trains having more than one power car, isolate both final drives and turn both engine starter isolating switches to the "OFF" position on car concerned. Also close air line stop cocks on ends of car. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.

DIESEL TRACTION NOTE No. 24—*continued*

<i>Defect</i>	<i>Action to be taken</i>
9. Final drive indicator pointer is not in correct position for direction of travel.	(a) Isolate final drive and turn corresponding engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce Car Nos. 51591-51650.
10. Pronounced knock on engine.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce Car Nos. 51591-51650.
11. Excessive smoke from exhaust pipe.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.
12. Over-heating or leaking fluid coupling.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.
13. Engine repeatedly stopping.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.
14. Broken or defective cardan shaft.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.
15. Defective or leaking gearbox.	(a) Stop engine. Isolate final drive and turn engine starter isolating switch to the "OFF" position.
16. Gears slipping.	(a) On arrival at terminal station, ensure that air pressure is in the region of 80 lb./sq. in. Stop engines, hold throttle handle out of deadman position, and select the gear which is slipping alternately with the next higher or lower gear, pausing in each gear position for at least three seconds. Repeat until air pressure drops to 60 lb./sq. in. If gear continues to slip, stop engine, isolate final drive and turn engine starter isolating switch to the "OFF" position.
17. Unable to maintain sufficient vacuum.	(a) Check communication cord, deadman's device and vacuum system on train. (b) If deadman's device defective, isolate.
18. Brake applies through deadman's device when throttle handle is held open (i.e. failure of No. 7 fuse).	(a) Electrical fault on car in which deadman's device has operated. Stop engines, isolate deadman's device and final drive and turn engine starter isolating switches to the "OFF" position on defective car. Turn over-ride switch to "OFF" position on Rolls-Royce car Nos. 51591-51650.
19. Brake applies through deadman's device, indicator lights extinguished and no response by train to driver's controls (i.e. failure of No. 6 fuse).	(a) Electrical fault on car from which driver is operating controls. Place the control switch key in the next car and turn it to the "ON" position.

**FAULTS OCCURRING WHILE WORKING A TRAIN**

<i>Defect</i>	<i>Action to be taken</i>
1. Engine indicator light fails.	(a) Proceed to next stopping point and carry out procedure as in Item 6 of "Faults occurring at stabling points, etc."

**DIESEL TRACTION NOTE No. 24—continued**

*Defect*

*Action to be taken*

- |  |  |
|--|--|
| 2. Air pressure and axle indicator lights fail.  | (a) Reduce speed to 25 m.p.h. to next stopping point, and carry out procedure as in Item 7 of "Faults occurring at stabling points, etc."  |
| 3. Gears slipping.   | (a) Refrain from using defective gear as much as possible and on arrival at terminal station carry out procedure as in Item 16 of "Faults occurring at stabling points, etc."  |
| 4. Brake applies with brake handle in release position and throttle handle open.   | (a) Stop train, call guard by use of bell code and ascertain if communication cord has been pulled.<br>(b) If communication cord has not been pulled, press engine stop button and if engine indicator lights remain lit on any one car, an electric fault is indicated on that car. Carry out procedure as in Item 18 of "Faults occurring at stabling points, etc."<br>(c) If all engine indicator lights go out when engine stop button is used, check all deadman's devices and vacuum system for leakage. |
| 5. Brake applies through deadman's device when throttle handle is held open (i.e. failure of No. 7 fuse).  | (a) Stop train and carry out procedure as in Item 18 of "Faults occurring at stabling points, etc."  |
| 6. Brake applies through deadman's device, indicator lights extinguished and no response by train to driver's controls (i.e. failure of No. 6 fuse). | (a) Stop train and carry out procedure as in Item 19 of "Faults occurring at stabling points, etc."  |

- N.B.—1. Should an engine on any power car fail, or final drive for that engine be isolated, the maintenance staff should be notified immediately.
2. If unable to isolate final drive on journey proceed at not more than 25 m.p.h. to nearest point, where disabled train can be taken out of traffic, advising maintenance staff accordingly.