BRITISH RAILWAYS – WESTERN REGION
C. M & E E's Department

DIESEL RAIL CARS

AN INTRODUCTORY DESCRIPTION OF THE POWER TRANSMISSION COMPONENTS AND THE PRINCIPLES INVOLVED

BRITISH RAILWAYS - WESTERN REGION

Chief Mechanical & Electrical Engineer's Department

THE MULTIPLE-UNIT DIESEL RAIL CARS

An Introductory description of the Transmission Components

and principles involved

SWINDON

July, 1956

CONTENTS

General

The diesel rail cars which this booklet describes, are designed to run in sets comprising powered vehicles and trailer/s. Engines and transmissions are provided only on the power cars, and arrangements are included to enable up to six power cars to be coupled together and driven from the driving cab of the leading vehicle.

Each power car is provided with a diesel engine and transmission system for each of the two bogies of the car, and one driver's compartment from which all the engines and transmission items of this set or all the train can be controlled Some trailer cars will be provided with a driving compartment from which control of the power car/s can be exercised.

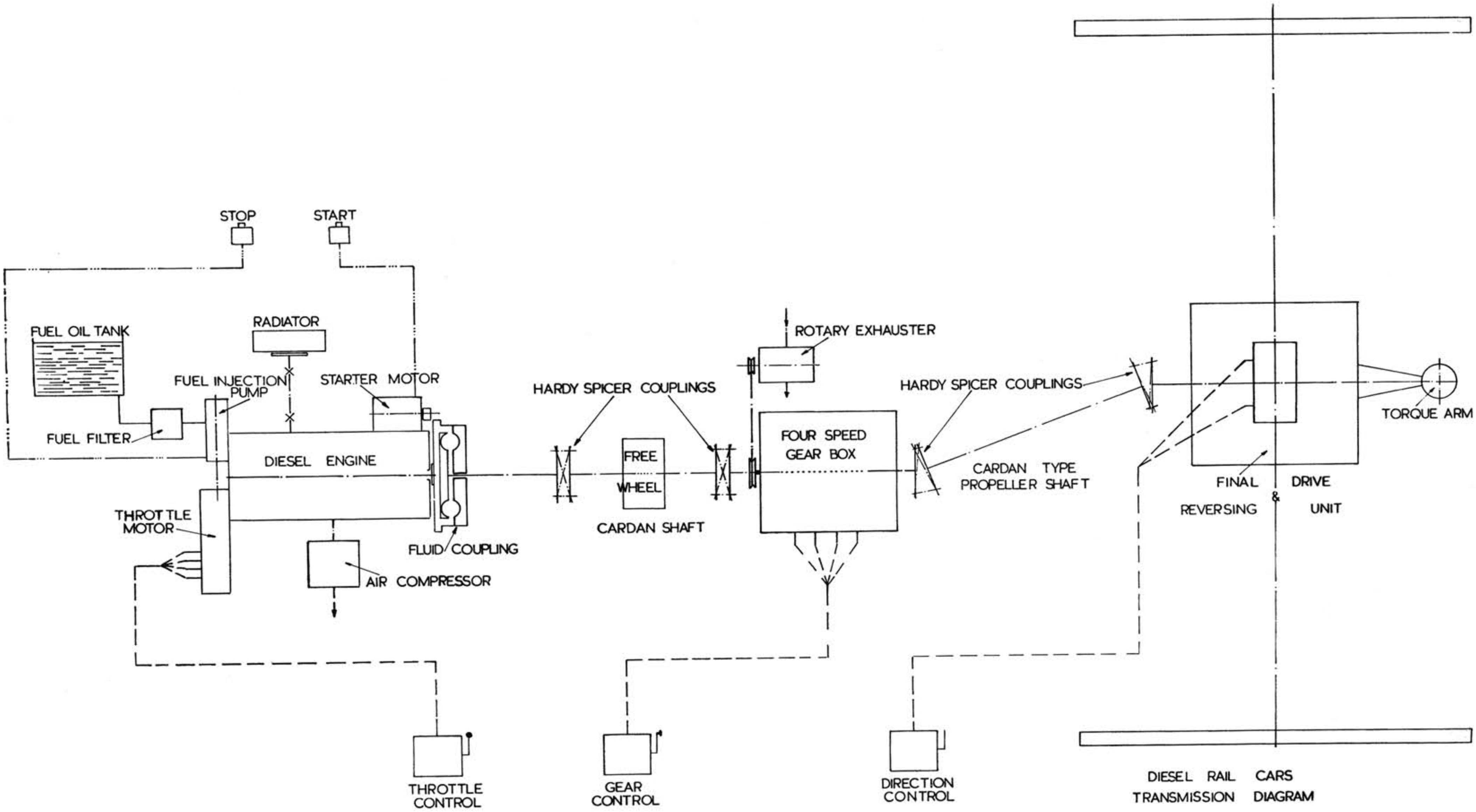
Layout of transmission components Page (2)

This layout shows diagrammatically the way in which the power is transmitted and controlled. The engine is supplied with filtered fuel oil by the fuel injection pump at the correct time and in the correct quantity to suit the conditions existing at any moment. The engine drive is taken through the fluid coupling to the gearbox, passing through a freewheel unit. Since the fluid coupling and gearbox are separate units secured to the underframe, use is made of a Hardy Spicer type of universal joint with sliding connection known as a Cardan Shaft, to take care of possible misalignments. From the gearbox the drive is again taken through a Cardan type propeller shaft with Hardy Spicer couplings to the final drive and reversing unit mounted around the axle on the bogie.

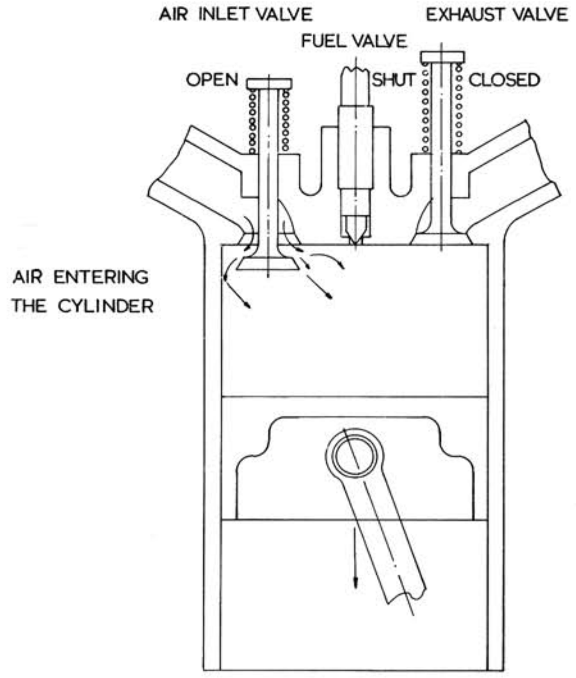
The control of the engine, gearbox, and final drive is by remote means using electrical and compressed air circuits.

The engine is started and stopped by electrical means; gear and direction changes, as well as throttle (acceleration) control use Electro-pneumatic methods and thus involve electrical circuits to control compressed air operated valves and pistons.

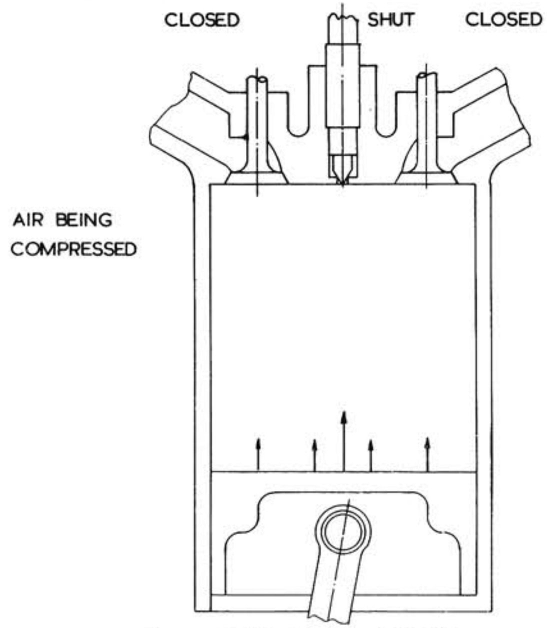
In order that the Driver may know the state of the engines and reversing units, when running in multiple formation indication by pilot lamp is provided in the cab, for all power units, up to a total of six power cars.



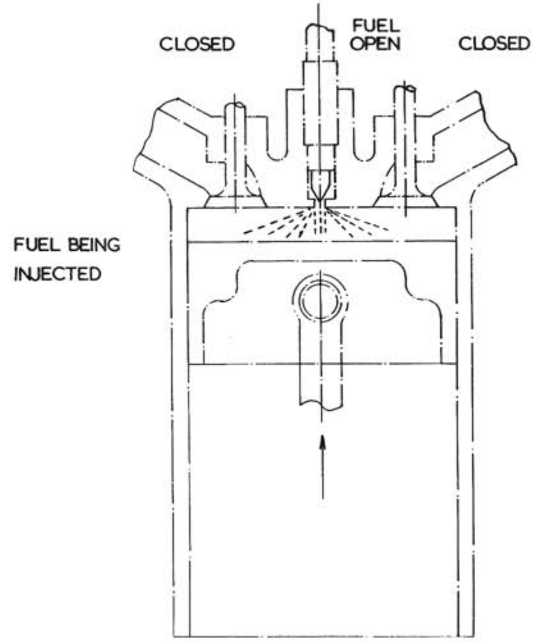
DIESEL RAIL CARS
TRANSMISSION DIAGRAM



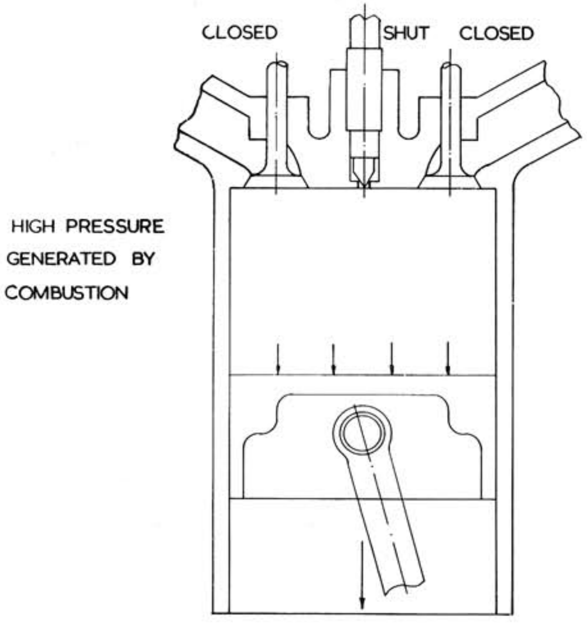
INDUCTION STROKE



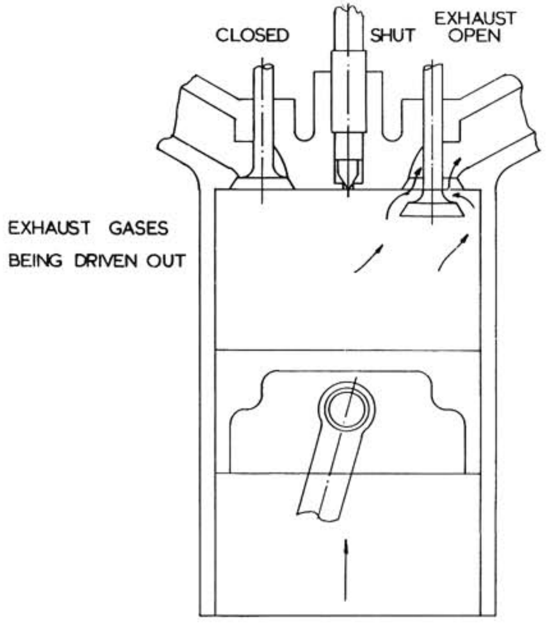
2 COMPRESSION STROKE



2A FUEL INJECTION & IGNITION



3 FIRING STROKE



4 EXHAUST STROKE

PRINCIPLE OF THE FOUR-STROKE CYCLE
FOR
DIESEL ENGINES

Principle of the four stroke oil engine (Commonly called a Diesel Engine)

As in the case of the steam engine the requirements are for a cylinder with valves, piston, connecting rod, cranks etc., to translate the sliding motion of the piston into rotation of the driving wheels. The design is different in that the piston is driven on one side only and also acts as the crosshead and piston rod. The valves are of the poppet type driven by tappet rods from a camshaft which is timed and geared to suit the cylinders and the firing order. Diag. Page 5.

The particular engine adopted in this instance is a horizontal engine which operates on the four stroke cycle. This cycle is shown in diagrammatic form on Page 3 and is explained as follows.

1st Stroke — Induction stroke, with only air inlet valve open, filtered air is sucked into the cylinder as the piston moves outwards.

2nd Stroke — Compression stroke, with all valves shut the piston moves inwards and compresses the air to about 1/16th of its original volume. The air gets hot and a temperature in the region of 1000°F can be expected at the end of the stroke.

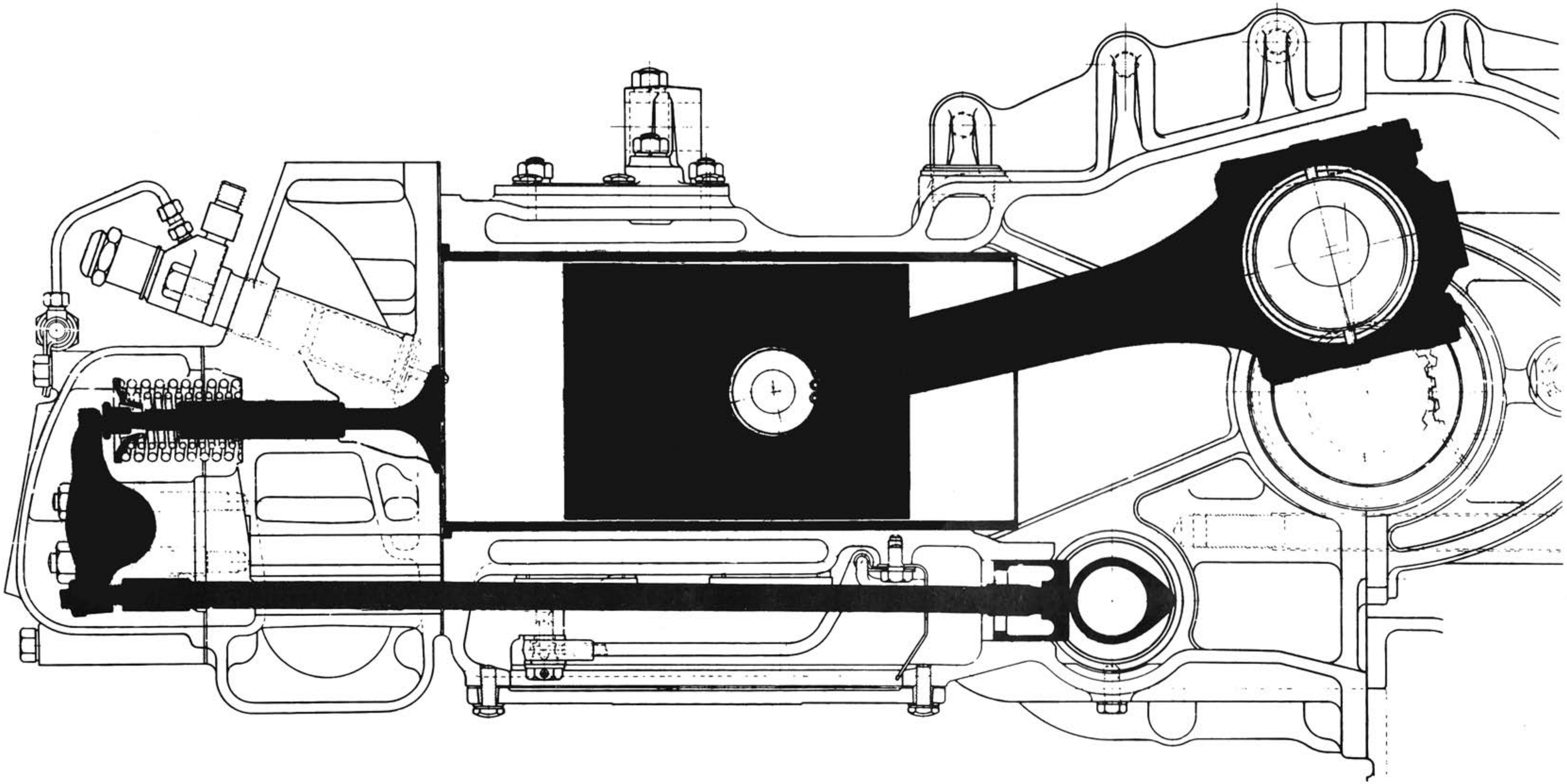
2A — Just before the end of the compression stroke fuel oil under pressure is injected into the cylinder. Fuel oil has the property that if held at a high enough temperature, it will ignite itself without any external means of ignition. The temperature in the cylinder is higher than this flash point and the oil burns in the air present.

3rd Stroke — Firing stroke — On burning in the air, gases are produced and these try to expand. In order that they can expand they must force the piston out of the cylinder giving a driving stroke to the crankshaft. Just before the end of this stroke the exhaust valve opens and the pressure in the cylinder is reduced.

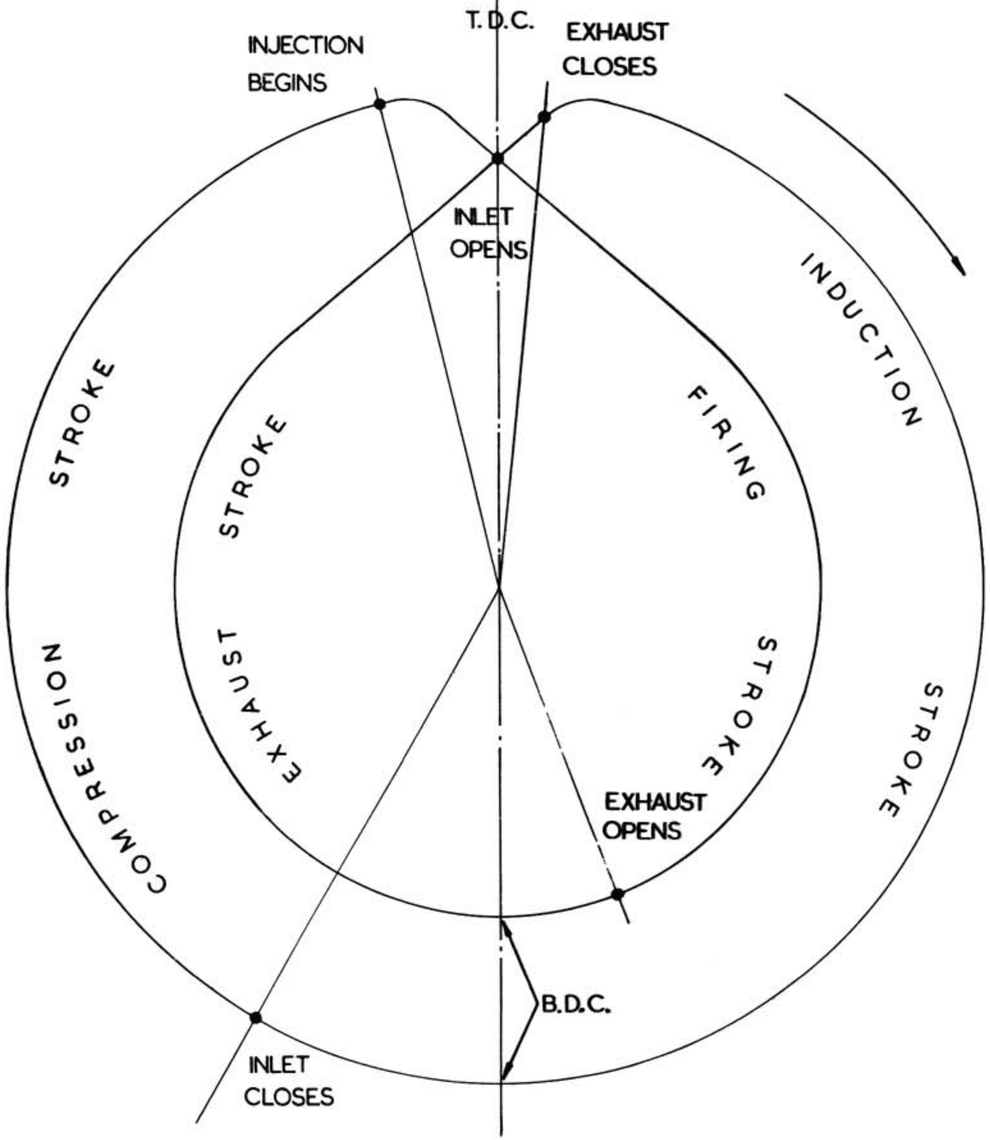
4th Stroke — Exhaust stroke — With the exhaust valve still open the piston again moves inwards and pushes out the exhaust gases.

Page 6 shows a typical valve timing diagram indicating the valve events which take place during the four strokes.

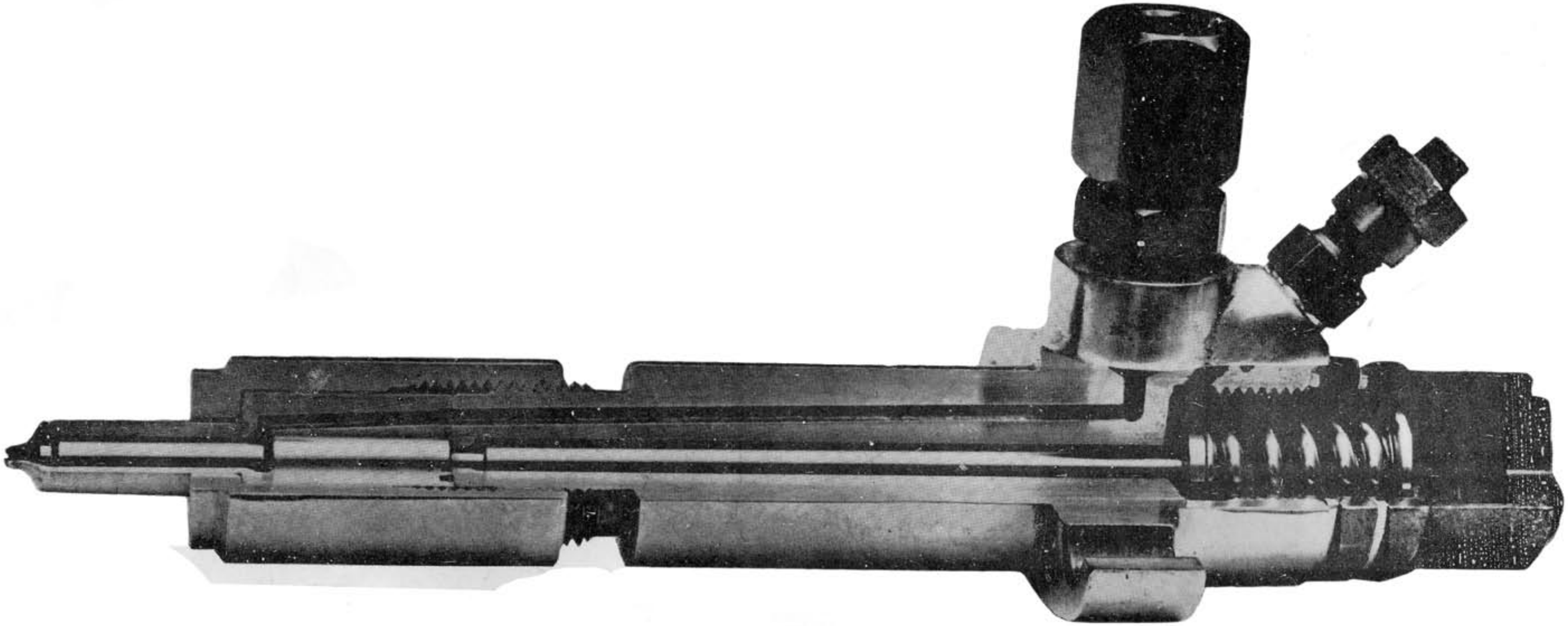
It will be appreciated that the four stroke cycle has produced only one power stroke in two revolutions of the crank shaft. The energy produced in this stroke has to be sufficient to supply the power to create the other 3 strokes and to leave a surplus for driving purposes. The power output must be smoothed out and a flywheel is used in this connection. A multi-cylinder engine enables a smoother output to be achieved since each cylinder fires during each 2 revolutions of the engine crankshaft, and also adds to the power output of the engine since a higher average output can be obtained than with a single cylinder engine of equivalent power.



ARRANGEMENT OF HORIZONTAL OIL ENGINE.



TIMING DIAGRAM FOR FOUR STROKE OIL ENGINE



SECTIONED C.A.V. FUEL INJECTOR NOZZLE & HOLDER

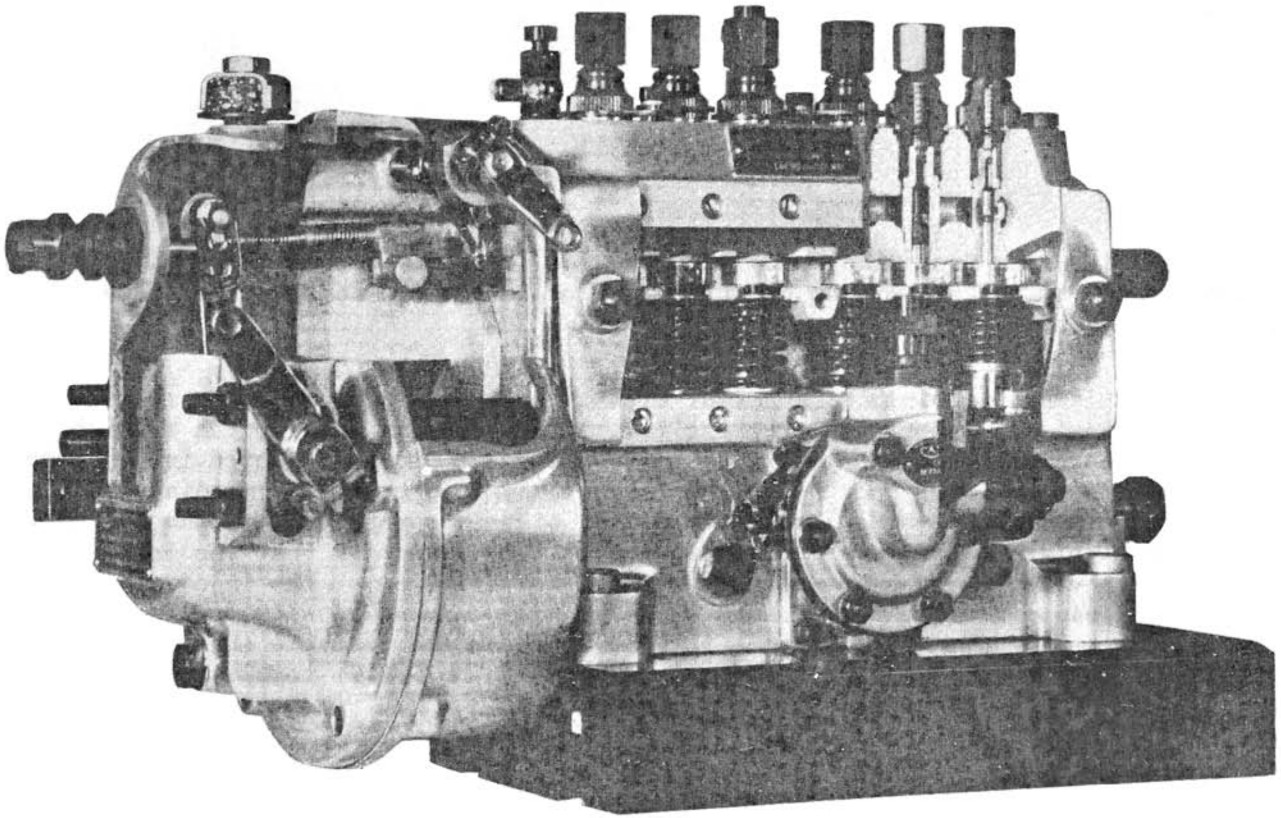
Fuel System The fuel oil is drawn from the supply tank and fed to the fuel pump where it is filtered, the quantity required is determined and at the appropriate time is fed to the injector valve or nozzle in the head of the cylinder.

Injectors The nozzle equipment consists of a holder with a spring and a needle type of valve. The principle of operation is that oil under high pressure is led to a chamber near to the orifice and when the appropriate pressure has been built up, the oil will lift this valve and be injected into the cylinder. The pressure immediately drops and the valve closes, only to open again immediately as pressure is regained. Thus the valve oscillates and a broken stream of oil - a spray - enters the cylinder to mix with the air already at high temperature and pressure. It is essential that the initial opening and final closing of the valve takes place sharply without any dribble. The injector is very accurately made and dirt will cause inefficient working, as also will carbon deposits on its orifices in the cylinder. It is thus necessary from time to time to remove, clean and test the injectors to ensure efficient operation of the engine. Page 7 shews a section of the C.A.V. nozzle and nozzle holder.

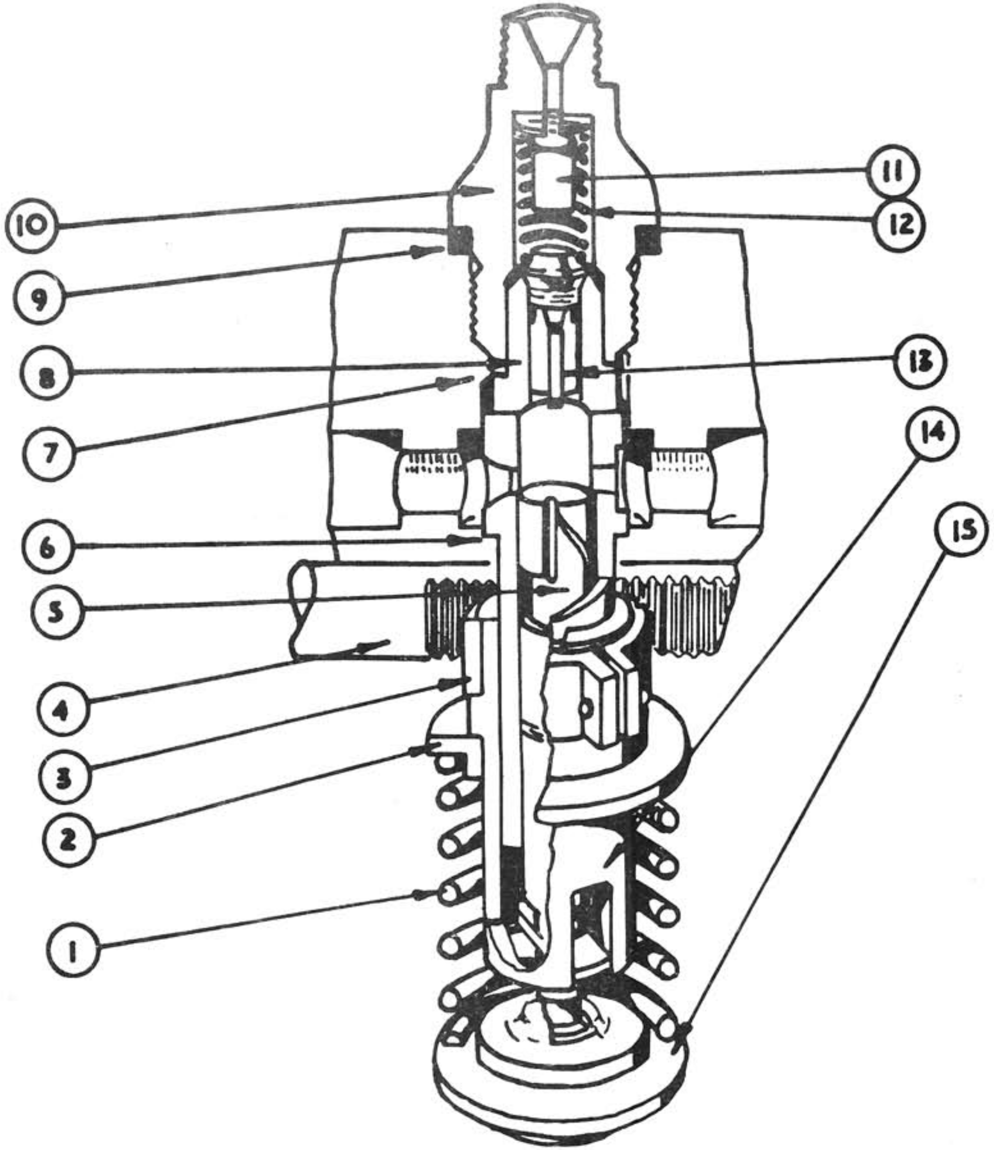
DANGER

It must be pointed out that the spray from an injector is at such a pressure (2,250 lb/sq.in) that it will penetrate through the skin and cause painful skin trouble.

ALWAYS TEST SPRAYS AWAY FROM THE BODY.



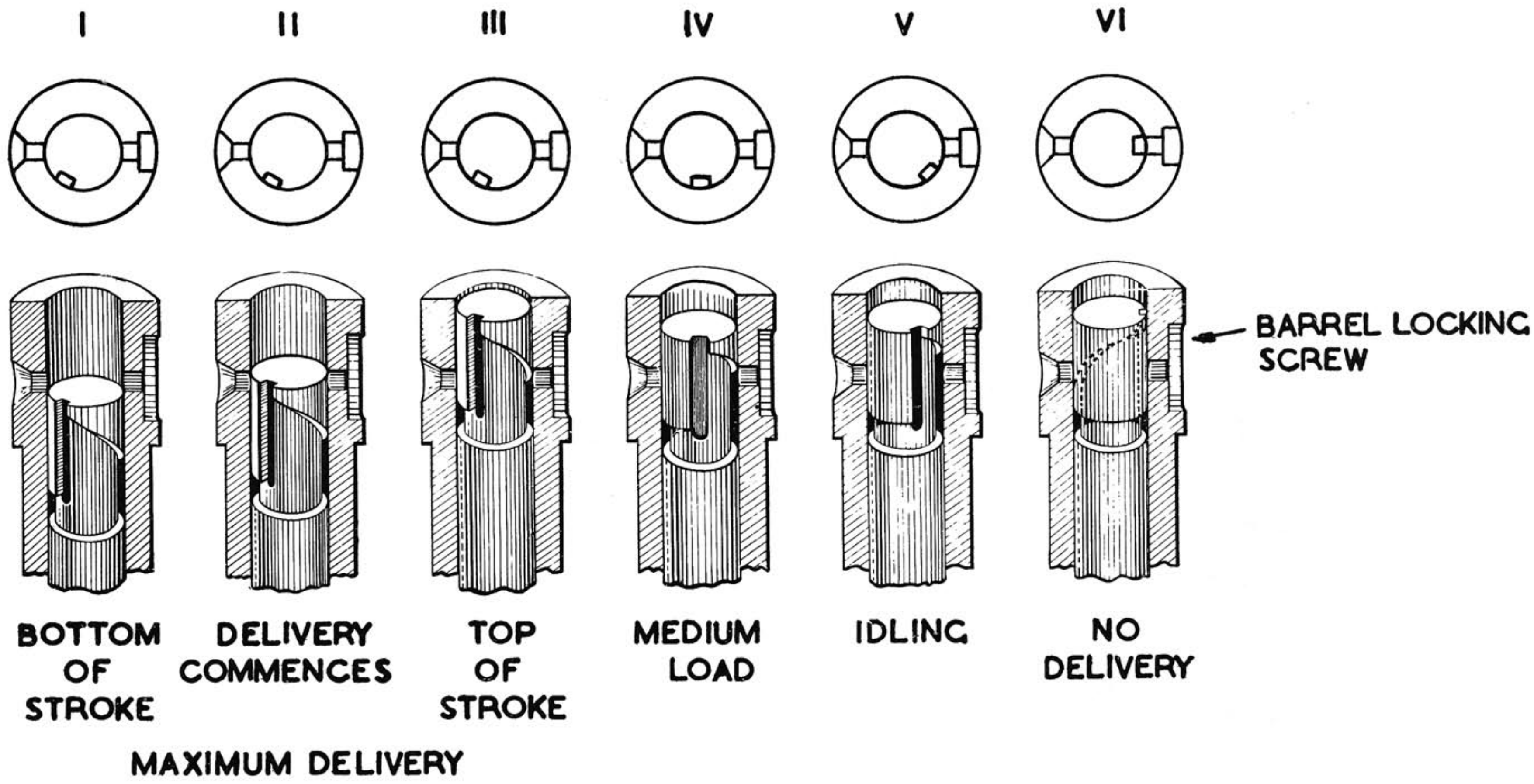
SECTIONED C.A.V. 'N' TYPE FUEL INJECTION PUMP



KEY

1.– PLUNGER SPRING
2.– PUMP UPPER SPRING PLATE
3.– CONTROL QUADRANT
4.– CONTROL ROD
5.– PLUNGER
6.– BARREL
7.– HIGH PRESSURE JOINT
8.– DELIVERY VALVE SEAT
9.– LOW PRESSURE SEAL
10.– DELIVERY VALVE HOLDER
11.– DELIVERY VALVE SPRING PEG
12.– DELIVERY VALVE SPRING
13.– DELIVERY VALVE
14.– CONTROL SLEEVE
15.– PUMP LOWER SPRING PLATE

PUMP ELEMENT & METHOD OF CONTROL



PRINCIPLE OF FUEL METERING

Fuel Injector Pump Pages 9, 10 and 11. Figures in ( ) refer to diag. Page 10.

The fuel injector pump used in this application is a 6 cylinder pump which is driven by the engine and is timed to suit the firing order. In principle it is a "jerk" pump in that the fuel is "jerked" to the injectors when required by a cam driven plunger with a head of special design, working in a cylinder. Page 9 shows a sectioned view of the whole pump and Page 10 shows a line diagram of one pump unit.

The method of operation is, that with the fuel supply on, the whole of the fuel pipes etc., full of oil, rotation of the camshaft by the engine causes the plunger (5) to move in its cylinder or "barrel" (6). The head of the plunger is as shown on Page 11 and the barrel has ports by which oil may enter and leave the chamber.

Page 11 also shows the sequence of events for the element in views i to vi. The pumping stroke is determined by the top of the plunger and the helical lower edge of the head. The pumping stroke commences when, on an upward stroke, the top of the plunger seals off the oil inlet port and finishes when the lower edge of the helix uncovers the port. The top and bottom of the plunger head are interconnected by a vertical slot which allows the pressure above and below the head to equalise. The length of the stroke is of constant value, but the pumping stroke can be varied by rotating the plunger and so altering the distance from plunger top to helix edge and thus vary the volume of oil pumped. Rotation of the plunger is carried out by the fuel rack under the control of the Throttle controller or the governor, and the quantity of oil delivered to the cylinder through the injector is varied to suit load and speed conditions for the engine. To stop the engine the plunger is rotated so that the vertical slot is opposite the intake port and no pressure can develop to give delivery.

Injection must begin and end deliberately with no pre-release or "dribble" and to this end no air can be allowed in the oil lines or it will compress and both oil volume and delivery will be affected. Air venting valves are provided and venting or "bleeding" of the system is necessary after initial filling or when disconnections have been made for maintenance purposes.

To ensure that delivery ends sharply a special delivery valve (13) is situated above the plunger, this is a spring loaded non-return valve having a narrow piston accurately ground on its diameter which is a plunger fit in the delivery valve seat sleeve (8). Thus, when the element commences to rise on the pumping stroke, pressure builds up and raises the delivery valve (13) allowing the oil in the delivery lines and injector to build up sufficient pressure to cause injection. As soon as the stroke ends and the pressure drops the delivery valve reseats and the piston entering its sleeve acts as one unloading device which ensures that the pressure at the injector drops sharply and the injector closes instantaneously without "dribble".

Fuel Feed Pump

The fuel oil is drawn from the storage tank and fed to the injector pump by a small diaphragm type pump which is cam driven from the injector pump crankshaft.

Fuel oil Filter Diagram Page 14.

As the component parts of the fuel pump and nozzle are of necessity very accurately ground the presence of any grit or dirt in the oil would soon score the parts or cause them to stick and it is of paramount importance that the fuel used is filtered free of solid matter. After leaving the supply tank the oil passes through a Fuel oil filter with a Paper element. This is shown diagrammatically on Page 14 and is self explanatory. The oil has to pass through the paper and dirt is left behind on the paper element. The spiral arrangement of the paper gives a large area to carry out the filtering. When the element is choked it can be simply replaced by a new one which is supplied in a special canister. The used filter is discarded, no attempts being made to reclaim it.

The 'N' type fuel pump also has a final felt filter included to ensure that the oil is clean before it enters the barrel for injection.

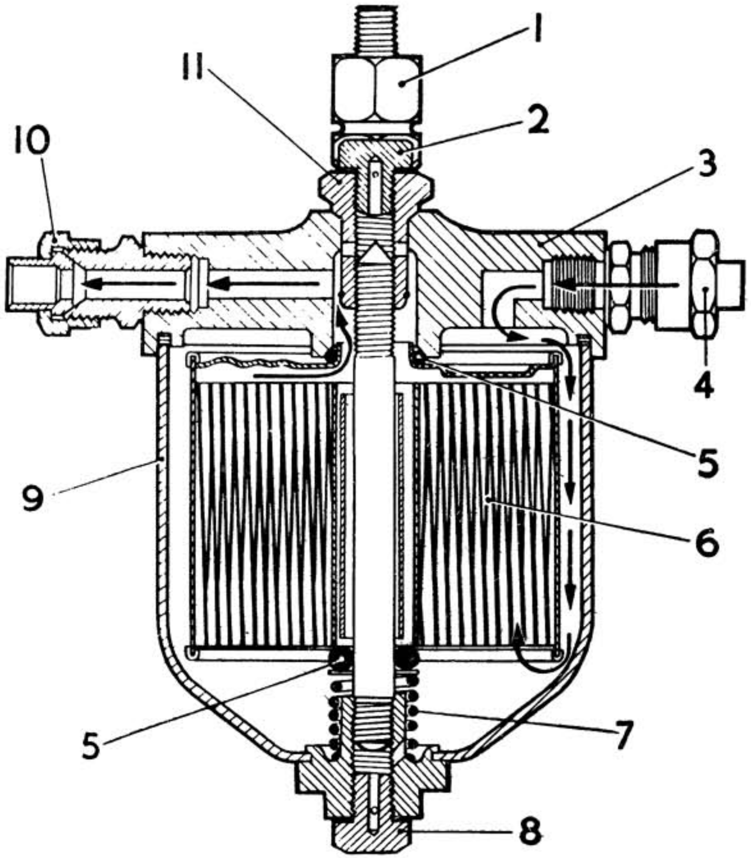


Fig. 1. *Filter in section*

1. Gravity vent valve
2. Air vent plug
3. Cover
4. Inlet connection
5. Oil seal
6. Paper element
7. Pressure spring
8. Drain plug
9. Filter bowl
10. Outlet connection
11. Cap nut

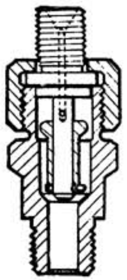
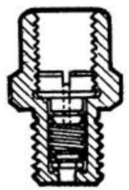
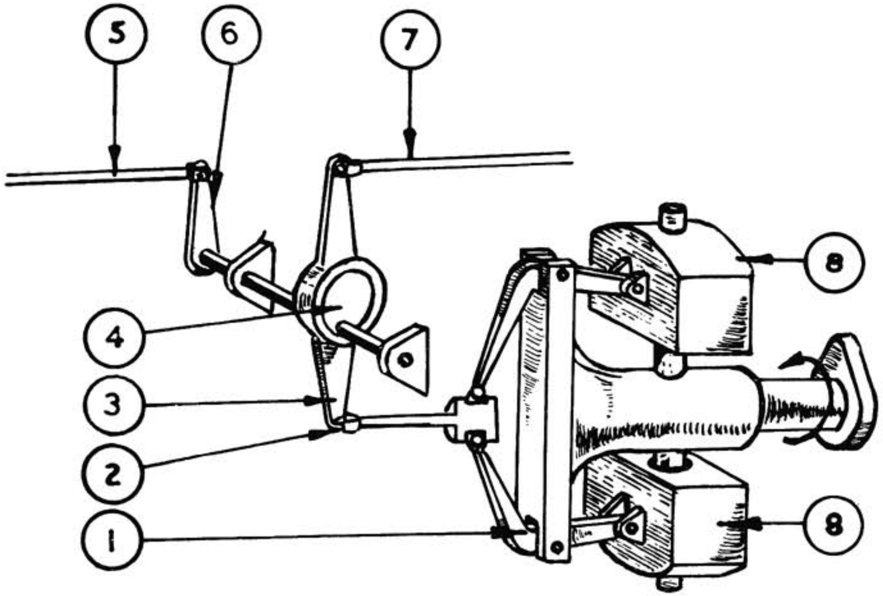
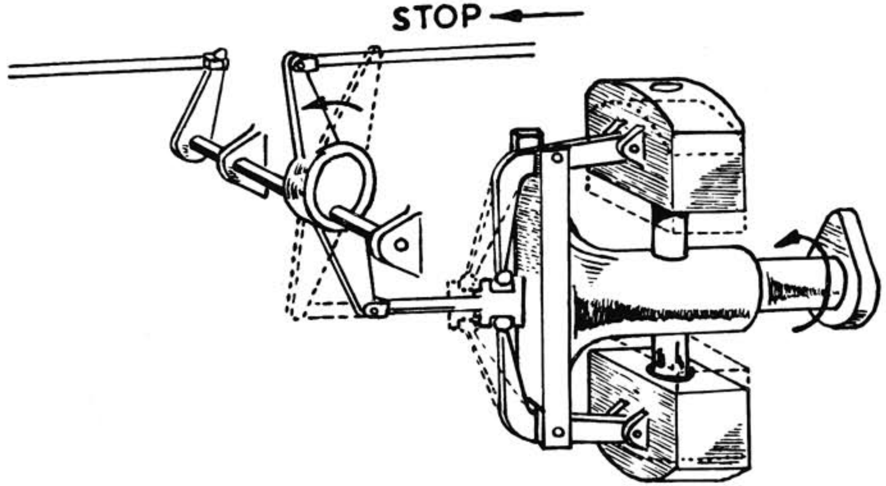
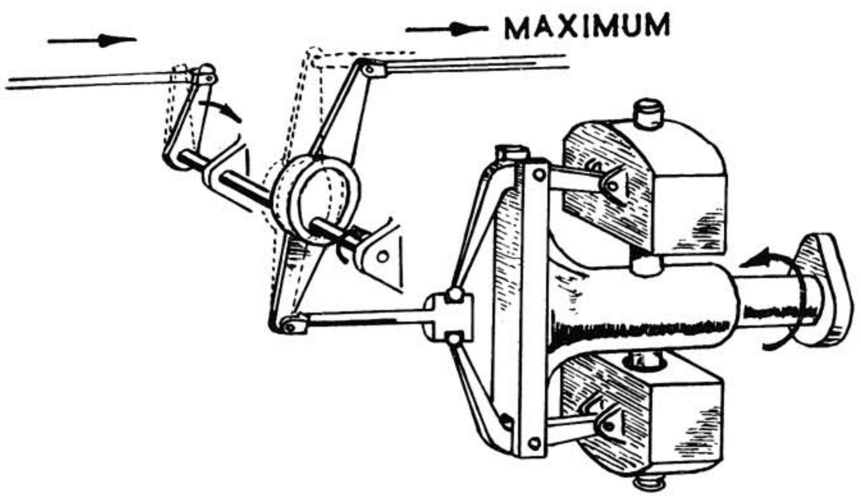


Fig. 2. (*left*) *Gravity vent valve and* (*right*) *Pressure reliej valve.*









KEY

1 BELL CRANK LEVER	5 THROTTLE MOTOR SPINDLE
2 COUPLING PIN	6 CONTROL LEVER
3 FLOATING LEVER	7 CONTROL ROD
4 ECCENTRIC	8 WEIGHTS

PRINCIPLE OF THE GOVERNOR

Governing and Throttle Control of fuel supply

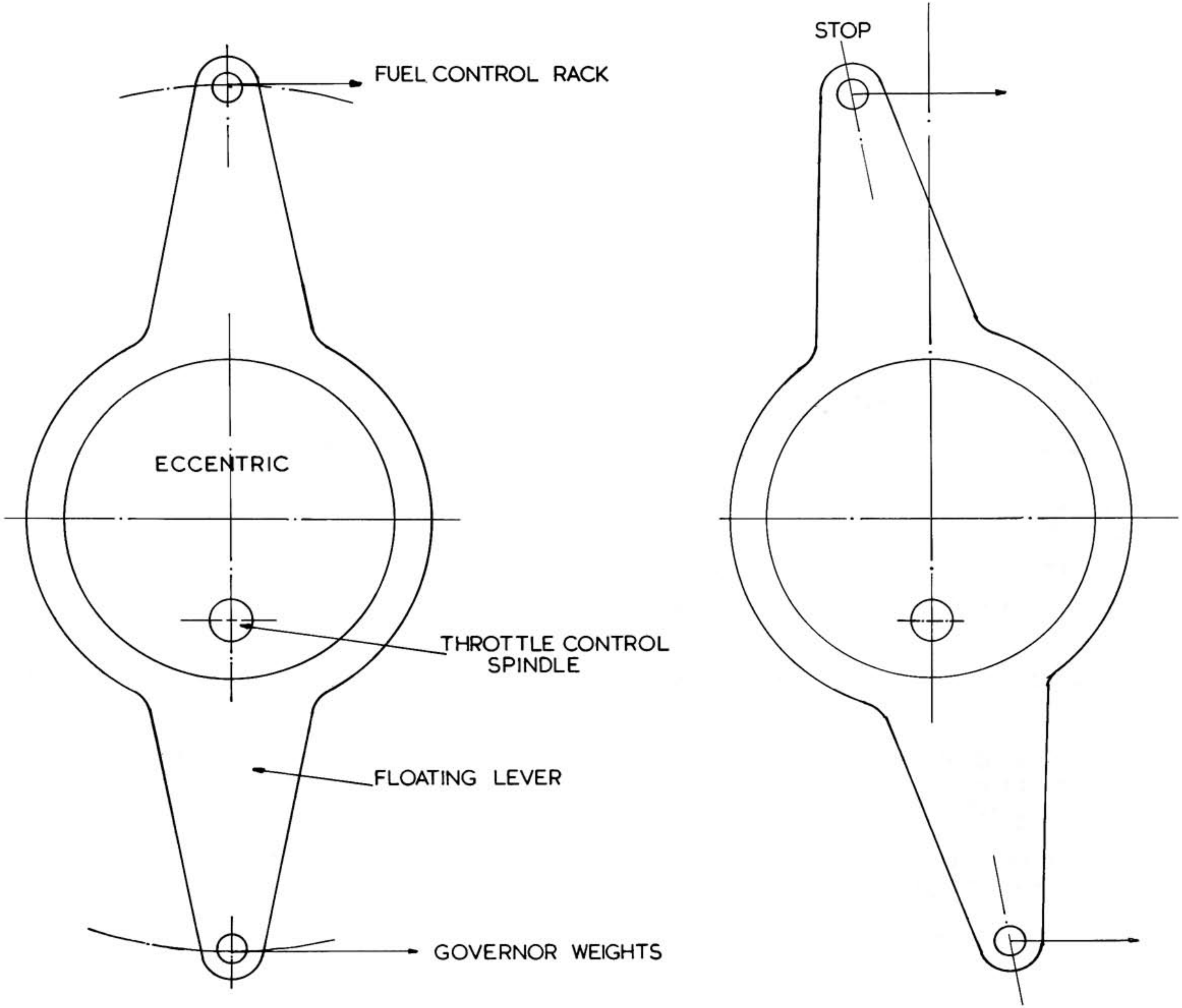
To enable the engine to be run according to the power required the control must allow three conditions:-

1. Allow for an 'Idling Speed' which will operate when the throttle is closed so that the engine will continue to tick over slowly without stopping.
2. Ensure that the engine can never run so fast that it will damage or exceed a pre-determined road speed.
3. Allow the driver to obtain the desired power output to haul his load at the appropriate speeds throughout the journey.

The principle of the governor is shown on Page 15 and the operation under weight and/or throttle control on Pages 17, 18 and 19.

It is a mechanical governor of the Idling and Maximum speed type. Page 15 shows the linkage involved. The principle of weight governing is that, as speed increases the weights are thrown further away from the centre of the spindle by centrifugal force, deflecting the floating lever and pulling the fuel rack towards the stop position, Page 17. The forward position of the floating lever is determined by contact with a preset maximum speed stop and at Idling by the throttle motor. These three conditions are outside the driver's control. The accelerator, or in this case the throttle control operates through the spindle and eccentric boss as shown on Page 18.

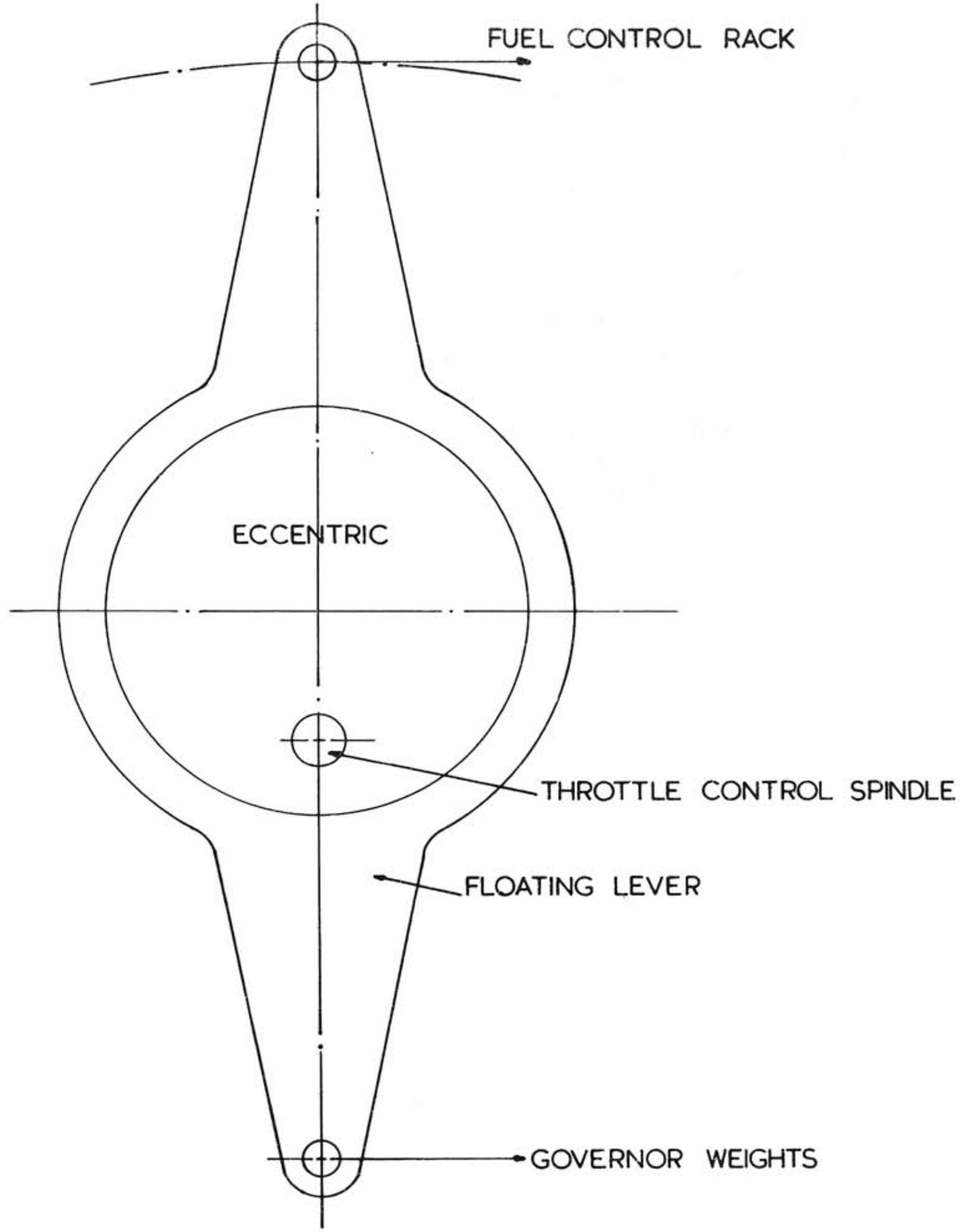
When the throttle control is at maximum and the speed rises to overcome the spring controlling the weights, they move outwards bringing the floating lever to 'stop' without affecting the throttle controller position, Page 19.



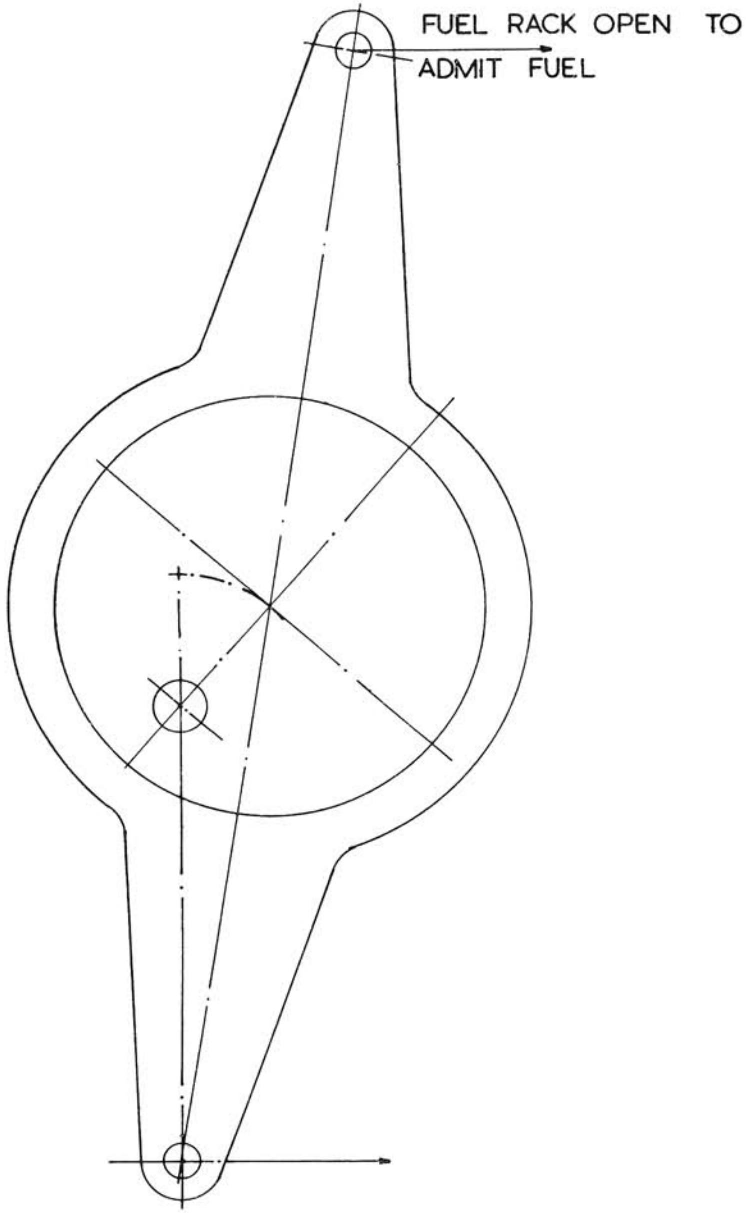
1 WEIGHT CONTROL IDLING

2 WEIGHT CONTROL MAXIMUM SPEED

C A V IDLING & MAXIMUM SPEED GOVERNOR

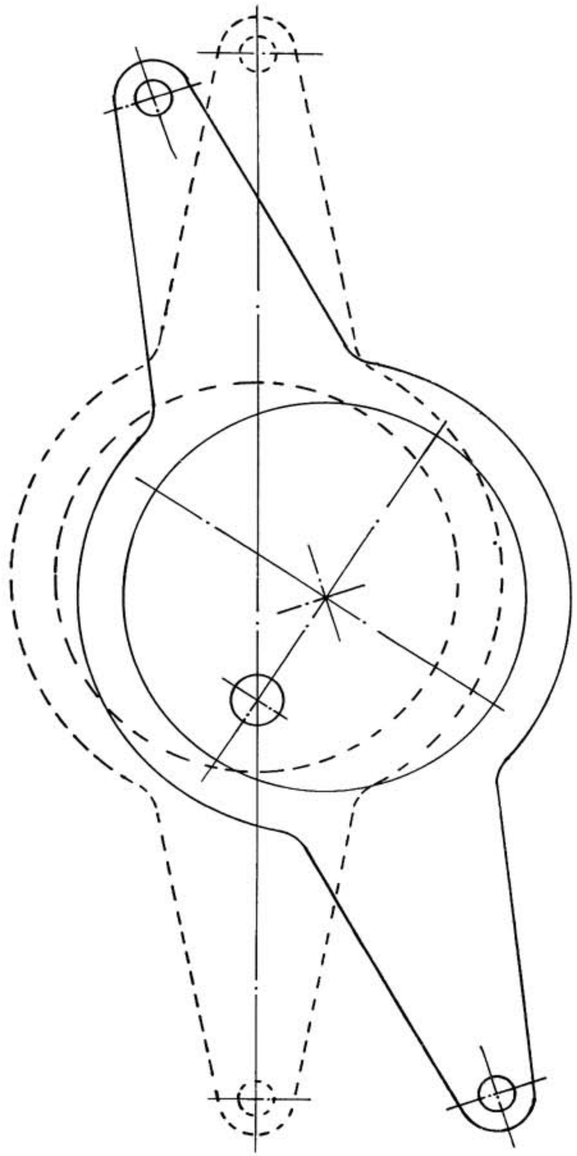


3 THROTTLE CONTROL IDLING



4 THROTTLE IN OPERATION

C A V IDLING & MAXIMUM SPEED
GOVERNOR



5 COMBINED WEIGHT & THROTTLE CONTROL

LEGEND

1 MECHANISM IN IDLING POSITION

2 SHEWS ACTION WHEN WEIGHTS ARE OPENED BY EFFECT OF SPEED FUEL RACK IS PULLED TOWARDS POSITION OF 'NO FUEL SUPPLY'

3 MECHANISM IN IDLING POSITION

4 SHEWS ACTION WHEN THROTTLE IS OPENED AND FUEL RACK IS PUSHED TO INCREASE FUEL SUPPLY TO ENGINE

5 SHEWS CONDITION WHEN, WITH THROTTLE OPEN AND ENGINE AT MAXIMUM SPEED, GOVERNOR WEIGHTS OPEN TO PUSH FUEL RACK TO REDUCE AMOUNT OF FUEL SUPPLIED TO ENGINE

C A V IDLING & MAXIMUM SPEED GOVERNOR

Exhaust system

To pass the exhaust gases to atmosphere they are collected from each cylinder by the exhaust manifold and travel along the exhaust pipe to the baffle box or silencer. Here the pipe is of larger diameter and baffle plates are fitted which effectively reduce the noise of the explosions before the gases pass to atmosphere.

Cooling water system

The temperatures which occur in the cylinder are of such an order that seizing of the piston would occur unless some cooling system is employed. This takes the form of water jacketing of the cylinders and the heated water 120 - 180°F is conducted to a fan cooled radiator to lose heat before returning to the cylinder block for re-use. The fan is driven from the engine by a shaft fitted with universal joints.

Air Compressor

To supply compressed air to operate the pneumatic valves etc., a small piston type air compressor is fitted to the engine, driven from the crankshaft. In principle this compressor works similarly to the diesel engine cycle except that at the end of the compression stroke the air is passed to a reservoir and every inward stroke is a compression stroke.

NOT USED ON "W.R" CARS

Throttle Motor See Diag. Page 22

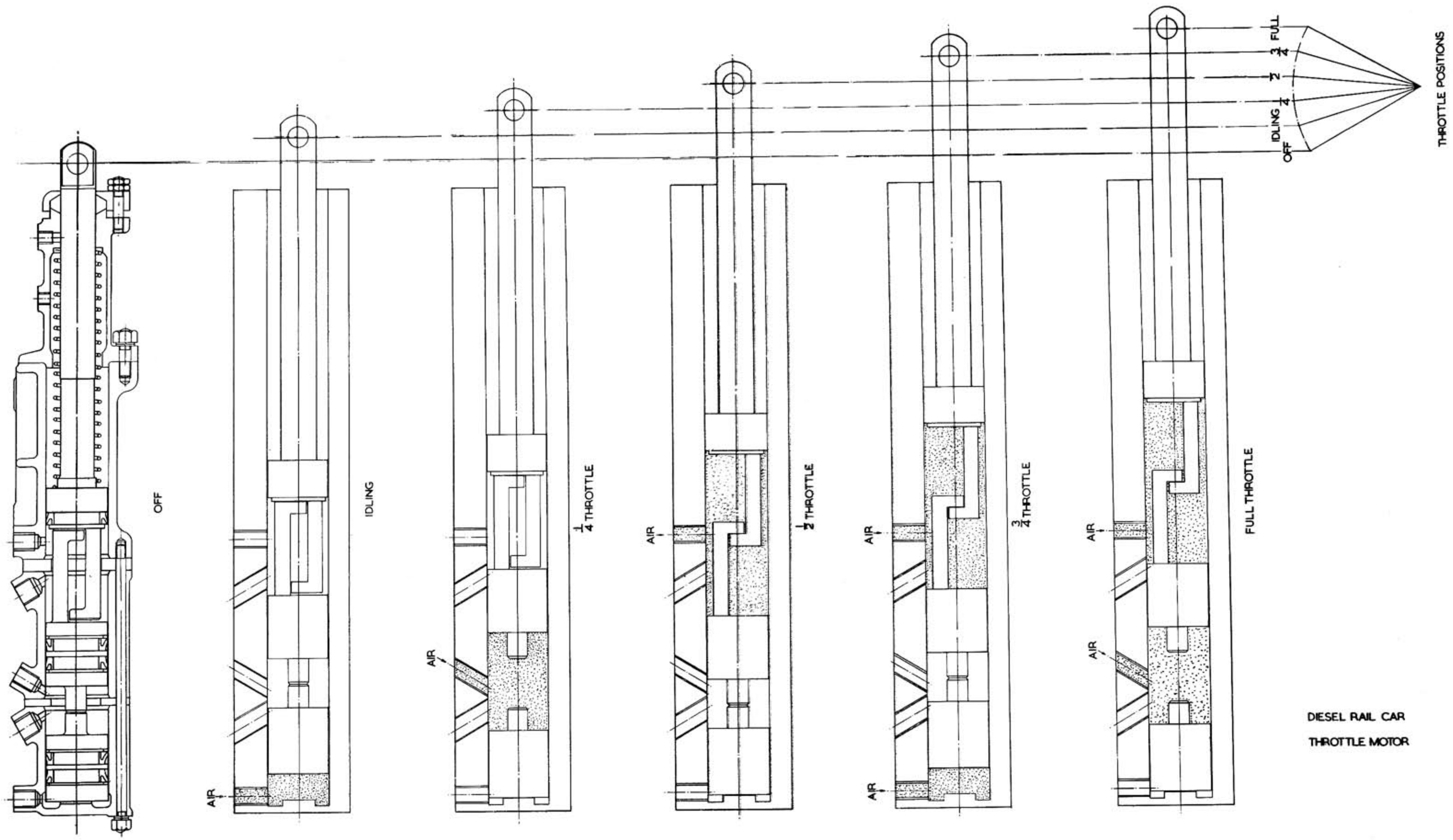
To enable the driver to control the position of the fuel rack an accelerator or throttle control has to be provided. For the driver this takes the form of a rotary controller which is arranged to give OFF, IDLING, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and FULL throttle positions. These positions are considered sufficient to enable the cars to operate under service conditions.

The Throttle Controller electrically controls the compressed air supply to the several ports of the throttle motor. This device shown in diagrammatic form on Page 22 consists of a cylinder having 3 independent pistons to each compressed air may be fed when the driver selects the appropriate position on his throttle controller.

Also incorporated in the throttle controller is a Dead Man's switch which will apply the brakes when the controller is in the OFF position. The handle of the controller is spring loaded to return to OFF and if the Driver releases it during his journey, application of the brakes will begin after a delay of 6 seconds.

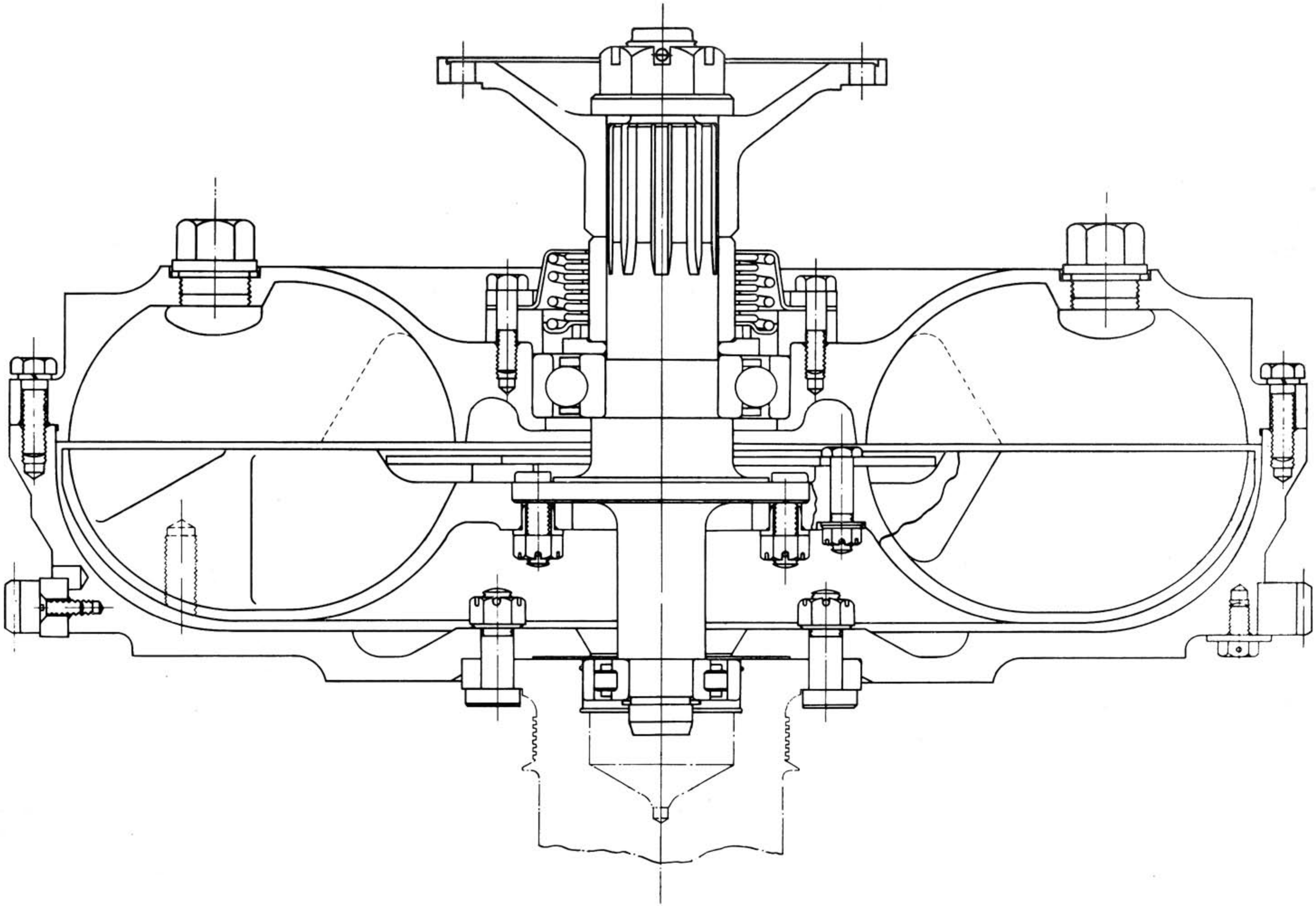
The operation of the pistons is clearly shown in the diagrams of Page 22. This design of throttle motor will not be found in later cars as a more simple rotary system will be used which has four valves each giving the desired movement from IDLING of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and FULL throttle positions.

If no air pressure is available, then the spring in the throttle motor will push all pistons to stops as shewn in the top diagram Page 22 and the fuel rack will be at STOP. To start an engine when no air pressure is available, use LOCAL start button and open throttle by hand lever provided. As air pressure builds up the throttle motor will move to the IDLING position as shewn on Page 22, enabling the throttle lever to be released.



DIESEL RAIL CAR

THROTTLE MOTOR



FLUID COUPLING

Fluid Coupling Shown Page 23.

This replaces the conventional clutch and also serves as a flywheel in evening the power transmitted from the engine and cushions irregularities in the power output. As shown on Page 23 it consists of two parts, the flywheel which is bolted to the engine crankshaft, and the driven member or runner which is free to rotate within the outer casing and by which the power is transmitted to the Cardan Shaft.

Both the Driving and Driven members are provided with a series of cupshaped pockets separated by webs. The whole unit is filled with oil which is the means of transmission in the following way.

If the vehicle is stationary and the engine is allowed to turn, the oil in the Driving web pockets is caused to flow outwards into the pockets of the driven runner. If the engine is idling no power will be transmitted as the oil will not be able to impart sufficient force to the runner to cause it to rotate and will simply churn. When the engine speed rises, however, the oil transmits sufficient force to rotate the runner and commence to drive. At low engine speeds slip occurs up to 100% but decreases smoothly to about 3% at normal road speeds. This slip i.e. churning is the means by which smoothness of transmission is produced and also gives no drive at idling speeds.

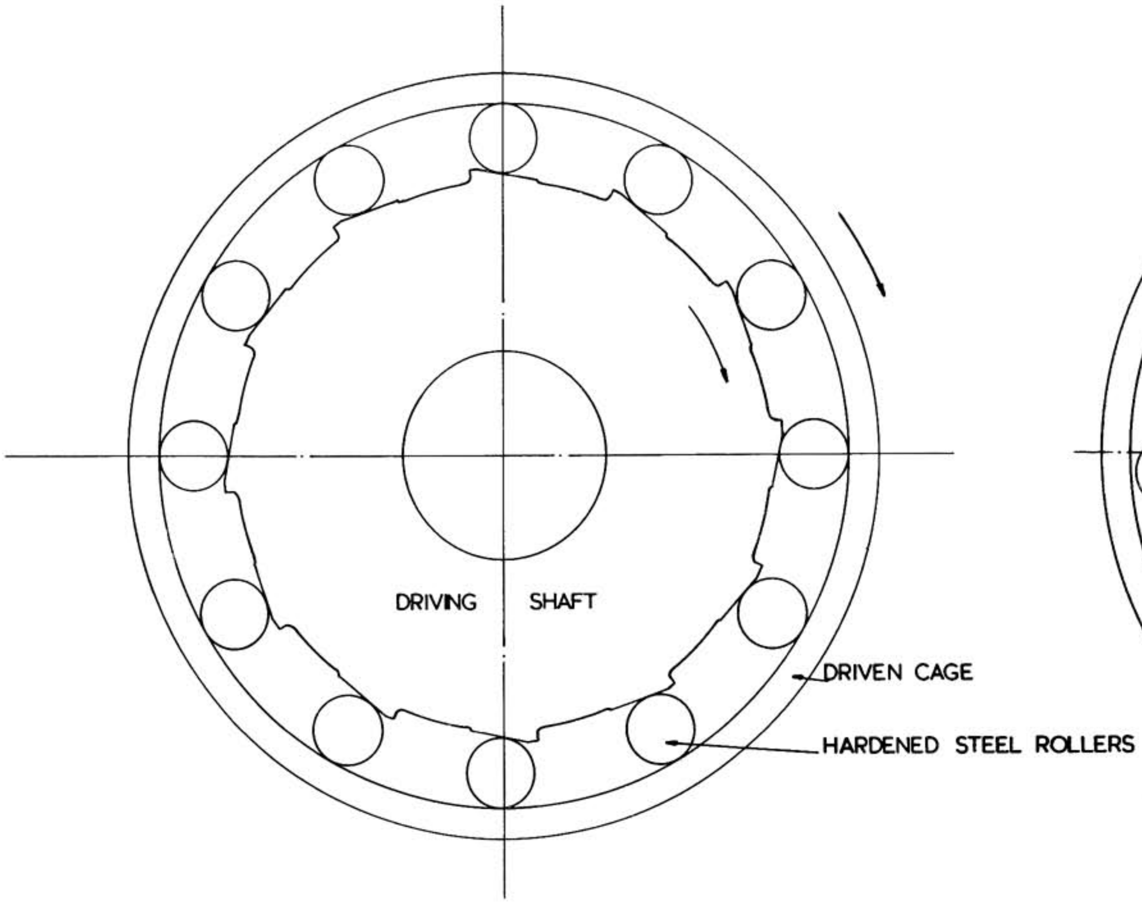
Churning of the oil causes heat to be generated in the fluid coupling and this will happen if excessive slip occurs through incorrect use of gears. It is essential that the engine is used with the proper gears engaged so that the engine revolutions do not fall below or rise above the yellow band on the tachometer dial.

Referring again to the transmission diagram on Page 2 the power is now transmitted by means of a special form of Universal joint called a Hardy Spicer coupling and through the Splined sliding connection of the Cardan Shaft to the 4 speed gearbox, passing through the freewheel.

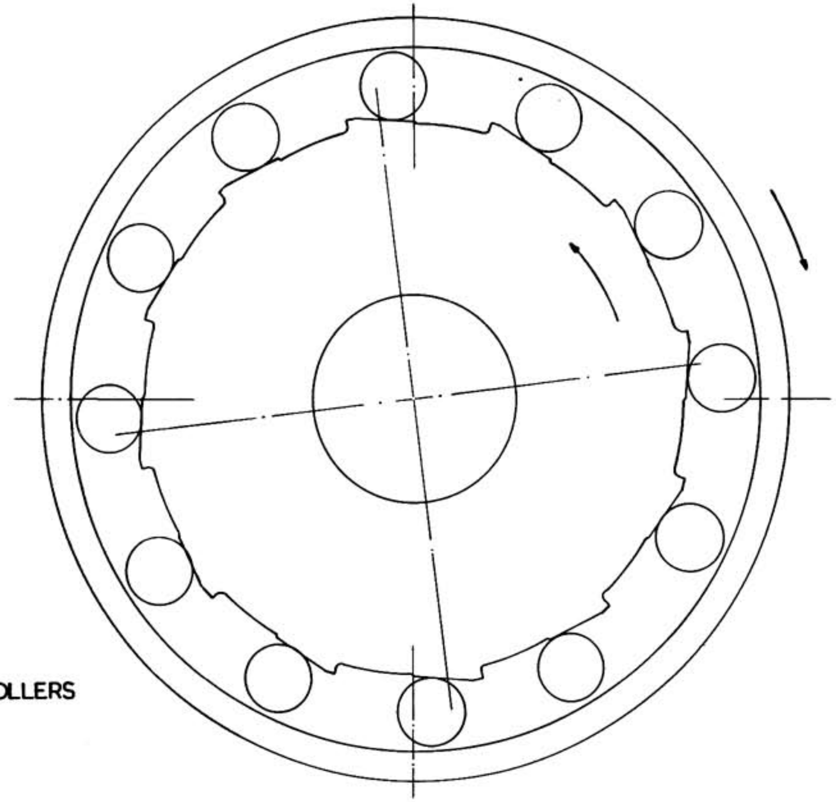
Freewheel

The principle of the freewheel is shown on Page 26. It consists of a specially formed driving disc not unlike a ratchet wheel. The outer cage has a plain cylindrical interior. Resting on the "notches" of the driving disc are hardened steel rollers. When the input driving disc is rotated clockwise the steel rollers ride up the inclined planes and are trapped against the cage and cause the cage to rotate. If the cage rotates faster than the driving disc the rollers come out of engagement with the outer cage and no drive results. The hardened rollers will only engage the outer cage if the initial rotation comes, in one direction only, from the driving motor.

The drive is now transmitted through a further Cardan sliding coupling and Hardy Spicer couplings to the 4 speed gearbox.



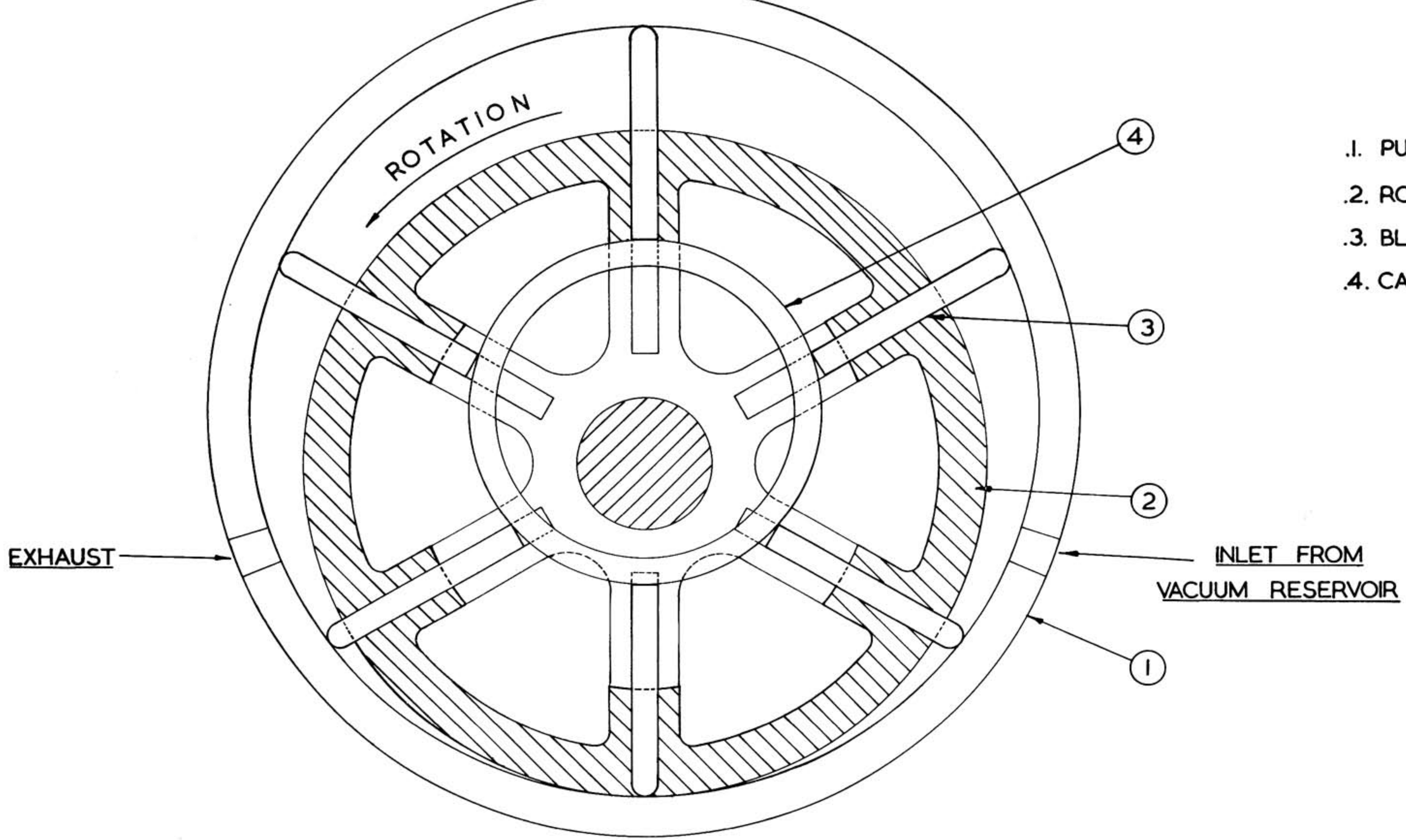
DRIVING



FREE WHEELING

PRINCIPLE OF FREEWHEEL

DIESEL RAIL CARS



KEY

.1. PUMP BODY

.2. ROTOR

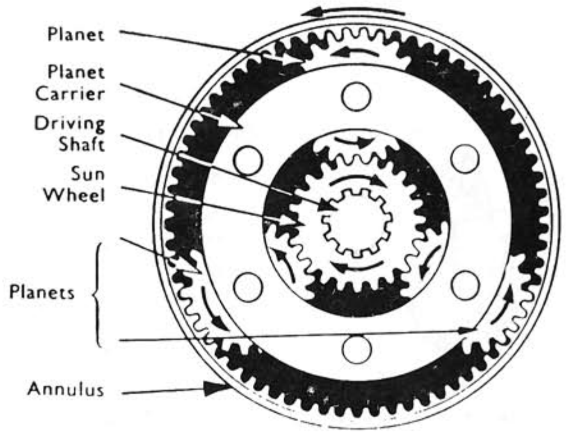
.3. BLADES

.4. CAM RINGS (STATIONAF

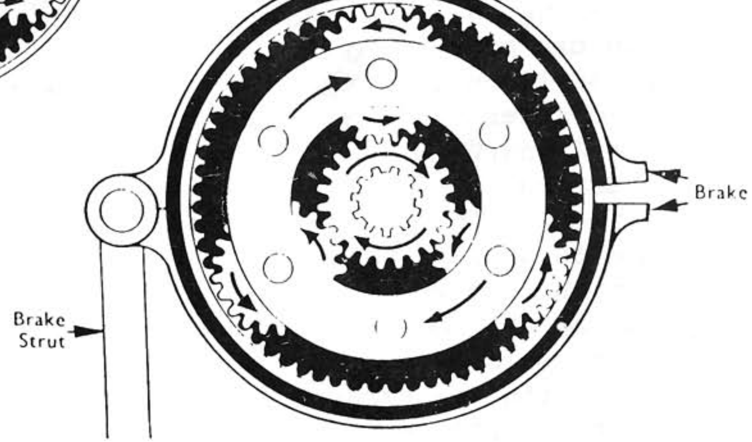
ROTARY EXHAUSTER FOR DIESEL RAILCARS

<u>The Rotary Exhausters</u> are belt driven from the input end of each gearbox and are used to provide the vacuum conditions necessary to hold off the train brakes. The principle of operation is as described below and a section through the exhauster is shown on Page 27. The exhauster is a vane type pump consisting of a body (1) which is fixed to the vehicle underframe and has inside it a rotor (2) which is mounted eccentrically within the bore of the body casting. The rotor has a number of radial slots cut in it and vanes or blades (3) slide in these slots. The eccentric positioning of the rotor and the length of the blades are arranged so that the tips of the blades can at all times contact the inner surface of the bore. To ensure that the blades do maintain this contact when the rotor is stationary, or only slowly rotating, a cam ring concentric with the bore is provided upon which the inner edges of the blades ride. The action can be seen by following the motion of the blade which is at 6 o'clock position in the drawing. As the rotor commences to revolve the cam ring will maintain the blade in contact with the body bore but it will be noticed that the outer surface of the rotor will be moving about its own centre and away from the body bore. The following blade will perform an exactly similar cycle as it is rotated. The space between these two blades will thus be seen to increase to a maximum at the 12 o'clock position and then decrease as the space again approaches the 6 o'clock position. The pump is provided with an inlet port where the air space is increasing and an outlet port where the space is decreasing as shown in the diagram. The inlet port connects with the train vacuum reservoir and as the rotor revolves air is drawn into the pump body. As the following blade passes the inlet port the air is trapped and will be subject to some compression before the leading blade uncovers the exhaust port. To provide air seals between the blades and the body, oil is supplied into the interior and some of this oil will be carried out with the exhaust air into an oil separator where it is recovered and re-circulated. The exhauster is efficient at idling speeds and can thus restore vacuum conditions when a vehicle is at rest after a brake application has been made. When the pump is running at speed centrifugal force will ensure that the radial blades bear firmly against the inner surface of the core and the cam rings will thus be necessary only at low engine speeds.

PRINCIPLE OF GEARBOX OPERATION



DIAGRAMMATIC VIEW OF A SIMPLE EPICYCLIC TRAIN, WITH THE BRAKE "OFF."



DIAGRAMMATIC VIEW OF A SIMPLE EPICYCLIC TRAIN, WITH THE BRAKE APPLIED.

<u>The Gear Box</u> Pages 29, 32 and 33

For Railcar work the gearbox need have no reversing gear within it since all speeds are required for travelling in both directions. Further, since no clutch as such is being used the conventional box as used in road vehicles is not the most suitable. The box used in this case is of the compound epicyclic type. The great advantage of this box is that gears are changed by the application of brake bands and no gears have to be taken into or out of mesh during the changes. Reference to Page 29 gives a simple diagram showing the principle of an epicyclic train of gears and explanation of the action is as follows.

The input shaft has the spur gear 'S' the sun wheel cut upon it. In mesh with the sun wheel is a series of planet wheels 'P'. The spindles on which these planets revolve are mounted on a plate which is known as the planet carrier 'C' and this is formed into the output shaft for the gear train. In mesh with all the planet pinions is the internally toothed epicyclic gear ring known as the annulus 'A'. All these gears are permanently meshed and remain so. The annulus is also a brake drum whose brake is applied by the driver through his gear controller, when he wishes to use the gear.

To provide the four gears, three interconnected epicyclic gear trains and a clutch are provided as described below, and as shown on Page 32.

To simplify the explanation of the action of the gears a system of letters with suffixes will be used as follows.

1st Gear train sun wheel = S1 Planets = P1 Carrier = C1 Annulus = A1

2nd and 3rd gear components take the numerical suffix of their gear thus :-

Carrier 3rd gear is C3

First Gear

Consider first the action which takes place when S1 is turned and the brake is off. As S1 rotates P1 must commence to move. If C1 is held stationary, say by the fact that the vehicle is stopped, then P1 merely spin on their spindles and A1 which meshes with each planet pinion itself begins to rotate.

Now apply the brake to A1 and S1 is still being driven, therefore, P1 must rotate. The planets P1 are prevented from spinning because they cannot move A1 since it is held stationary by its brake. The motion will be converted into rolling of P1 around A1 taking C1 around and thus rotating the output shaft. This condition is that for the first gear.

Second Gear

From the diagram Page 32 it will be seen that 1st and 2nd gear trains are driven from a common sun wheel serving them both, the set of planets P2 are mounted on a carrier plate C2 which is an extension of 1st gear annulus. Another annulus surrounds the gear train and the second gear brake band is arranged to engage this annulus A2.

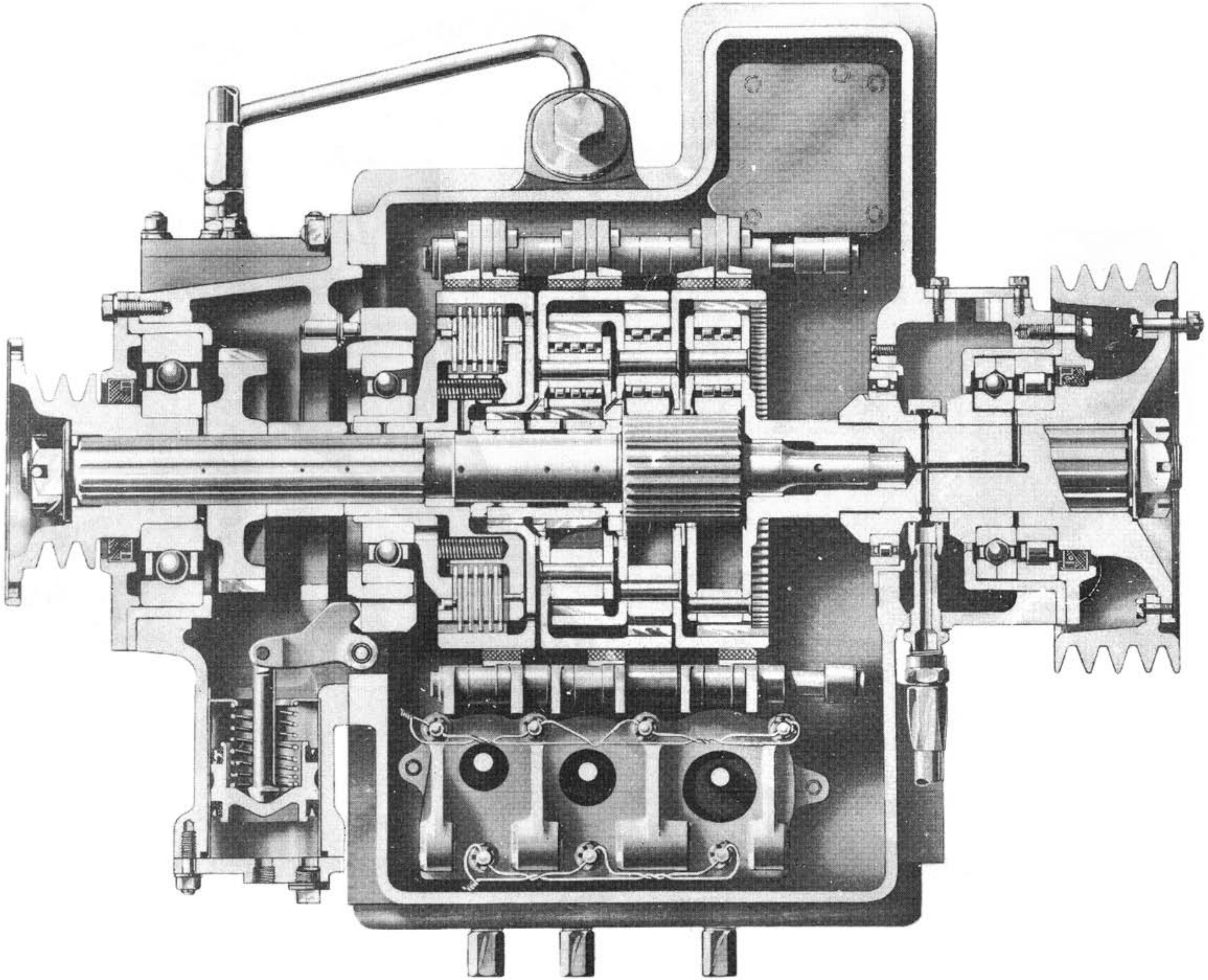
Second gear is obtained by speeding up the 1st gear carrier in the following way.

The drive is taken from the common S2 and S1 and the second gear planets P2 try to spin but A2 is held by its brake; C2 then rotates. Meanwhile first gear planets P1 are also trying to rotate and can only do so by rolling around A1 which is being rotated by the second gear planets through C2. If directions of rotation are worked out for second gear position it will be found that with S2 and S1 clockwise and A2 stationary, P2 anti-clockwise pushes C2 clockwise. P1 will be rotating anti-clockwise and if A1 were stopped C1 would be driven clockwise. However, C2 is taking A1 clockwise already, so that this will cause C1 to rotate at a faster speed than it did in gear one condition since it is given additional speed by the 2nd gear train.

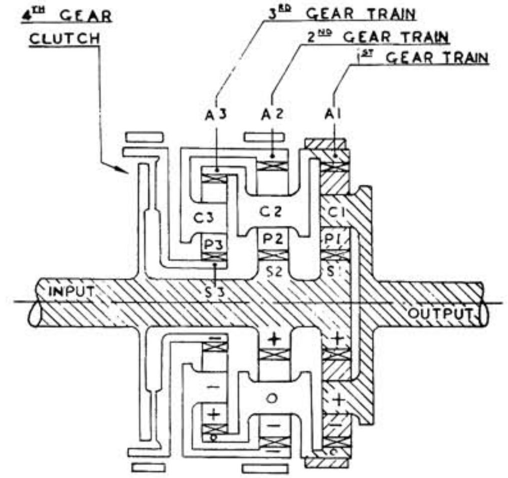
Third Gear

The third gear position involves additional compounding of the gears of the first two trains and as seen on Page 32 the third gear brake drum is attached to the third gear sun wheel S3. C3 is integral with A2 and A3, C2 and A1 are also one with each other. To engage 3rd gear the brake is applied and S3 is prevented from rotating. The input is again through S2 and S1 and following the motion through P2 these planets will cause A2 to rotate - taking C3 with it. Rotation of C3 causes the third gear planets P3 to roll round the stationary S3 and causes A3 to rotate. A3 moves C2. The combined movements of A2 and A3 causes C2 to move faster. Thus A1 will move faster than it did in 2nd gear position thus adding more speed still to the output carrier 1. The result is that the output shaft speed will be nearer to that of the input shaft.

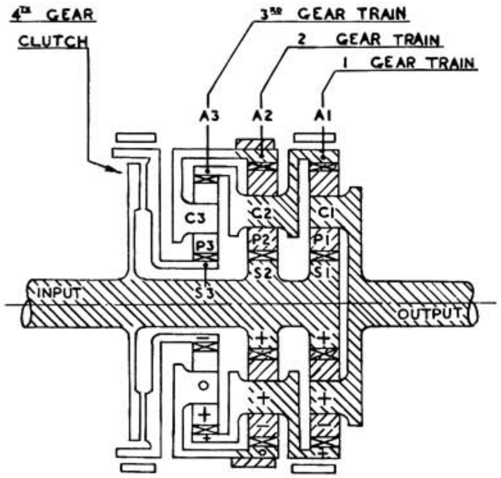
To obtain fourth or "top" gear a clutch is engaged which causes S1, S2 and S3 to rotate with equal speed, the gear trains being locked solidly together. The drive is thus straight through with no reductions i.e. a 1:1 drive.



LONG^L SECTION 'R.14' GEAR BOX



1ST GEAR ENGAGED



2ND GEAR ENGAGED

KEY

PORTIONS SHOWN HATCHED INDICATE TRANSMITTING TORQUE.

PORTIONS SHOWN WHITE INDICATE NOT TRANSMITTING TORQUE.

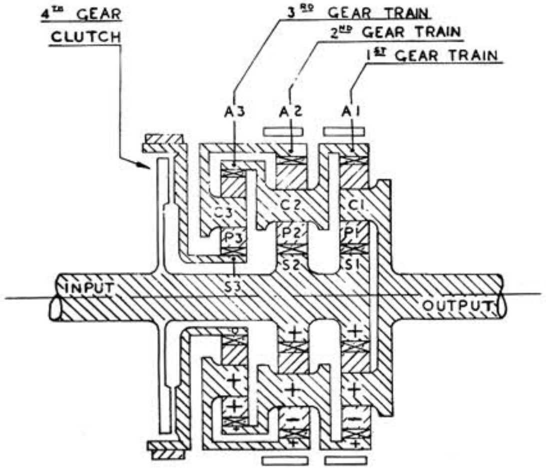
ROTATION

+ = CLOCKWISE LOOKING ON INPUT

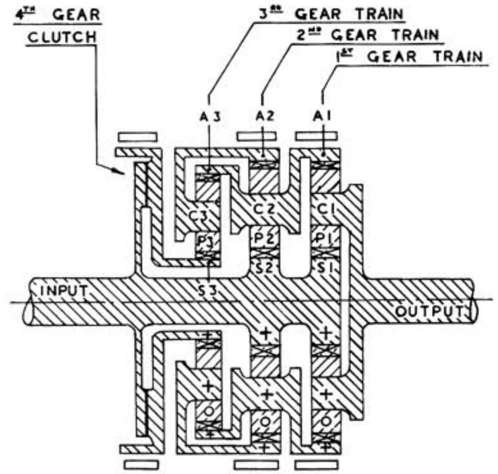
— = ANTI-CLOCKWISE LOOKING ON INPUT

o = NO ROTATION

GEAR	3RD	2ND	1ST
ANNULUS	A3	A2	A1
CARRIER	C3	C2	C1
PLANET	P3	P2	P1
SUN	S3	S2	S1



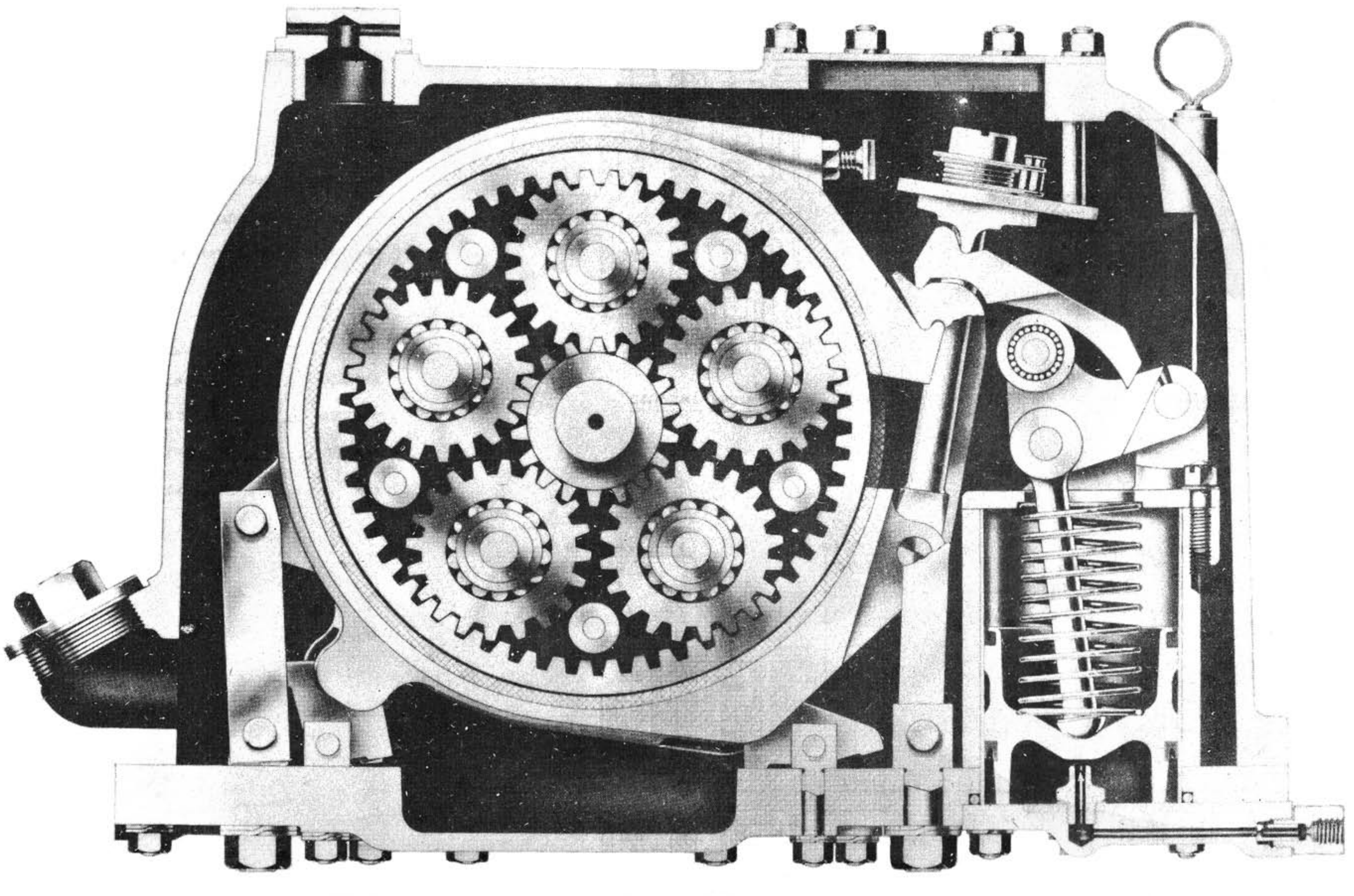
3RD GEAR ENGAGED



4TH GEAR ENGAGED

GEARBOX

TORQUE TRANSMISSION DIAGRAM



CROSS SECTION 'R.14' GEAR BOX

Neutral gear is a condition in which no brake or clutch is engaged and the effect of the input is merely to allow planets P1 and P2 to spin and annuli A1 and A2 to rotate causing A3, P3 and S3 to rotate freely. Since no part of the gearbox is held stationary to provide a reaction, no drive can be transmitted. If the vehicle is moving when neutral condition exists the carrier of the first gear will rotate and will result in 3rd gear parts rotating at about 3 times normal speed. It is possible that this high revving will cause damage to the gear trains. Hence NEVER COAST IN NEUTRAL. For coasting the driver should stay in top gear and should not engage any other gear until his road speed has dropped to that appropriate for the gear, as indicated by his tachometer dial.

The Band brakes see Page 33 surrounding the annuli are one for each of the 3 gear trains, and are operated by air pistons controlled through Electro-pneumatic valves by the Drivers gear controller. The electrical system allows the one controller to control all gear boxes in the sets of vehicles forming the train. Wear of the brake shoes is automatically taken up by the toggle plate and spring Page 33 which constantly adjusts for wear as soon as it takes place. The gear box has a very low oil level below the annuli and a self contained pump and filter enable cleaned oil to be directed along the spindle to lubricate the running gear. The absence of churning of the oil results in very high efficiency being obtained in the gear box.

The clutch used for fourth gear is of the multi plate type made up of alternate steel and bronze plates which engage with the 3rd speed brake drum and with the inner member of the clutch assembly which is splined to the input shaft. Engagement is made through electro-pneumatic valves and an air piston in a similar way as for gears 1, 2 and 3. Wear of the clutch plates is catered for automatically by increased travel of the operating piston.

<u>Gear Ratios</u> 1st Gear, 4.28 : 1 2nd Gear, 2.43 : 1 3rd Gear, 1.59 : 1 4th Gear, 1 : 1

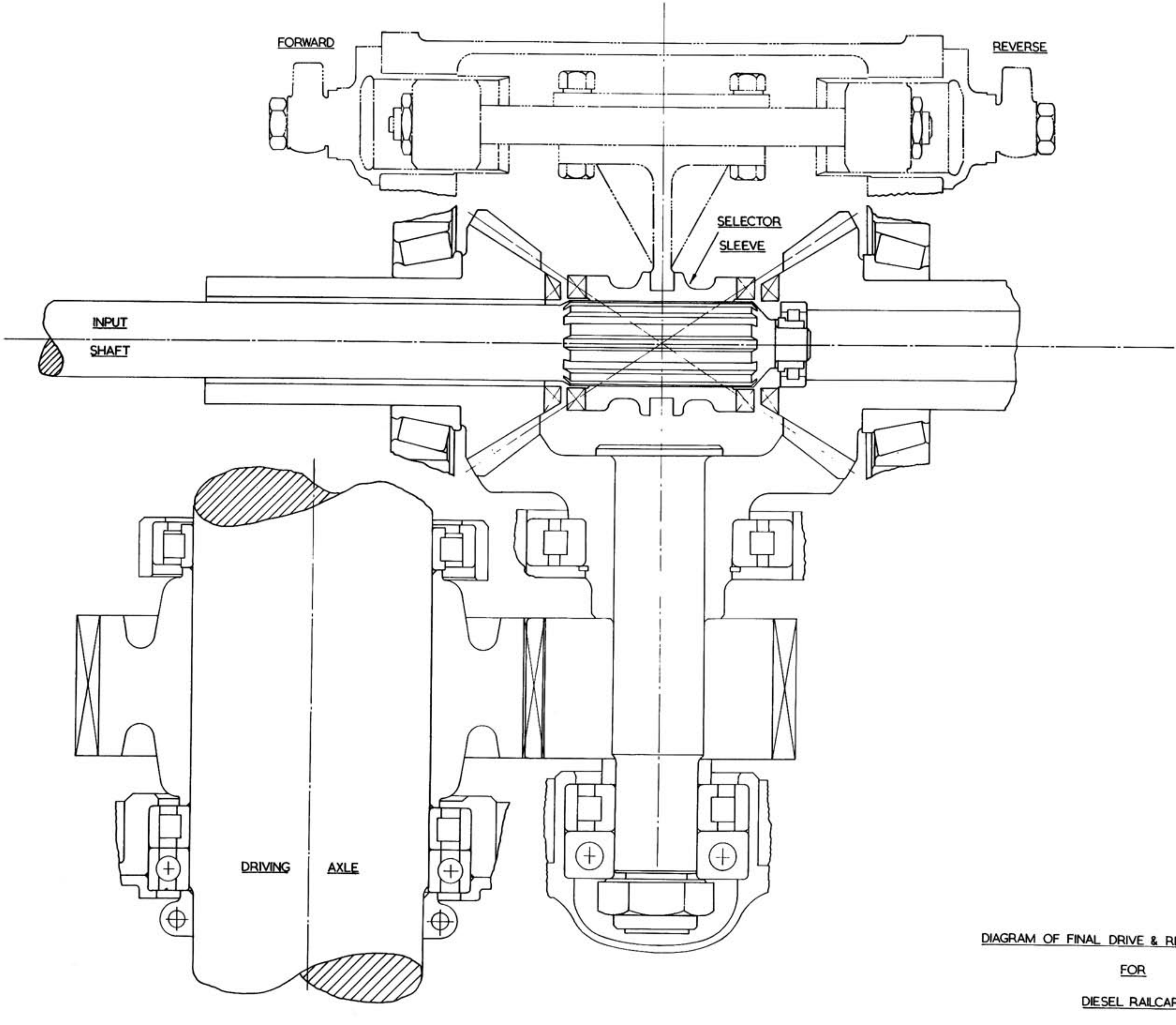


DIAGRAM OF FINAL DRIVE & REVERSING GEAR

FOR

DIESEL RAILCARS

The drive from the gear box is taken now by a Cardan type propeller shaft with Hardy Spicer couplings at each end, to the Final Drive unit carried around the driving axle on the bogie. The sliding Cardan coupling and Hardy Spicer couplings are necessary to take up the movement of the bogie in negotiating curves and the effects of springing.

The Final Drive See Page 35. also includes the reversing unit and the action is as follows.

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

For emergency use the selector sleeve can be locked in a neutral position to enable a crippled transmission to be isolated and the set of vehicles moved without the damaged parts being driven. In this event the local stop button should be pressed to stop the diesel engine and the engine isolation switch opened to ensure that this engine will not start until repairs have been made.

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

Final gear ratio = 2.81 : 1 thus overall gear ratio = Gear box ratio x 2.81

<u>Electro-Pneumatic</u> (E.P.) <u>Valves</u> (or Magnet Valves) are used to operate the air pistons of the throttle motor, gear brakes and reversing unit. The valve is shewn in section on page 38.

The operation of the valve is as follows :-

(1) <u>Electrical operation</u>. Is by a solenoid, comprising operating coil, iron core and armature, and passing through the hollow iron core is a brass push rod. When current is passed through the operating coil, lines of magnetic force are induced in the iron core and the armature is attracted towards the core. In moving, the armature lifts the brass push rod.

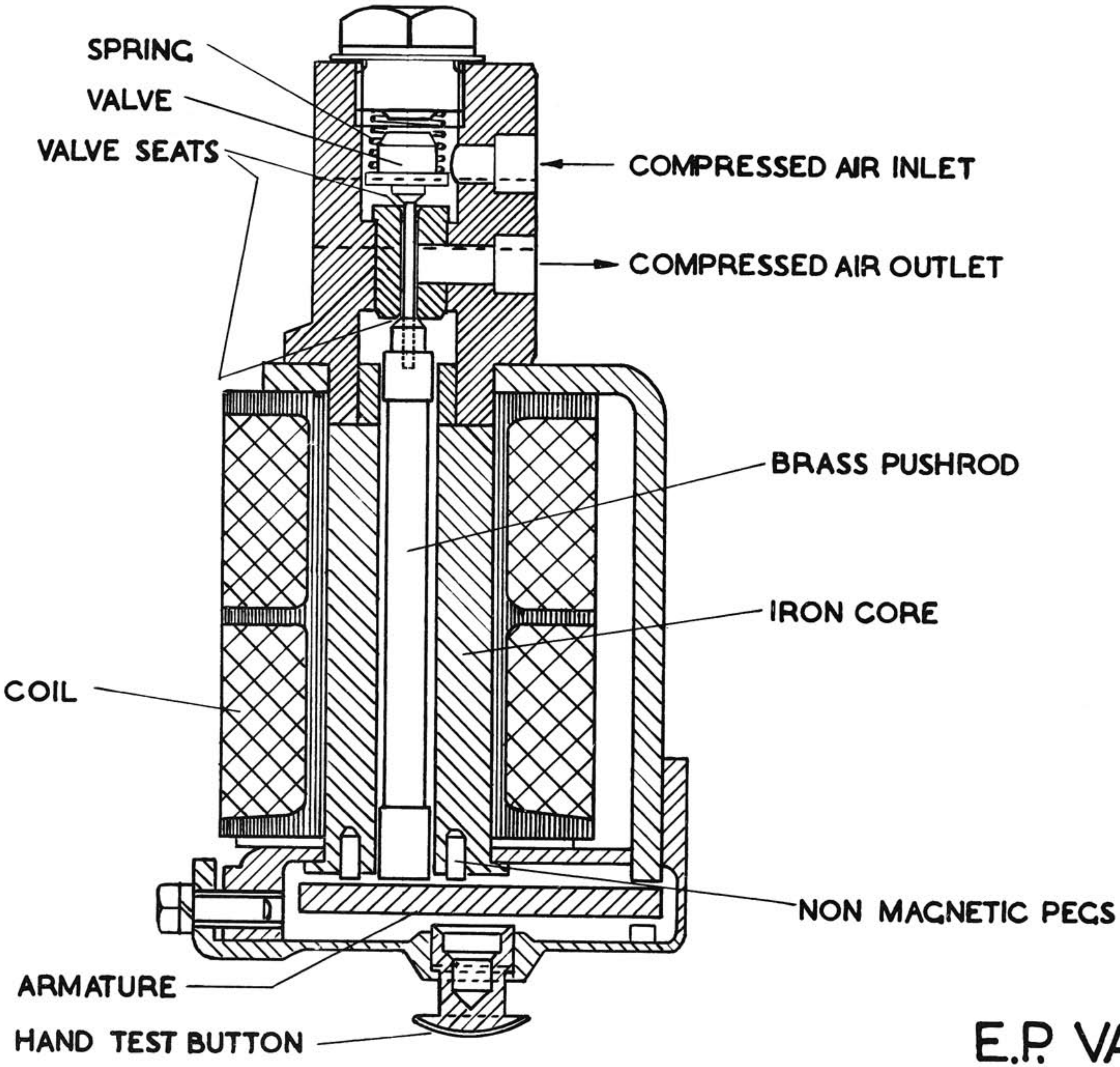
(2) <u>Compressed air valve operation.</u> The valve shewn on the drawing is normally seated by the spring and also by the air pressure acting on it. When the solenoid is energised and the brass push rod lifts, the valve is raised from its seat and air passes to the lower chamber and is led to the appropriate air cylinder.

When the current is shut off the solenoid is de-energised and the air pressure closes the valve.

This type of valve is described as an 'ON' type valve since it only admits air when the current is 'ON' to the solenoid. By varying the arrangement of the air valve so that it admits air when the solenoid is de-energised an 'OFF' type valve is produced. The rail car uses both types of valve.

It will be noted from the diagram that the core has non-magnetic pegs shewn in its base, these prevent the armature contacting the core and so ensure that when the current is switched off the armature will not be held up by residual magnetism of the core.

In order that testing of the air valve can take place a hand test button is provided as shewn, and this enables the armature to be moved and the valve opened without energising the solenoid. The valve should open and close quickly and this can be observed by listening when the hand test button is smartly depressed.



E.P. VALVE. 'ON' TYPE

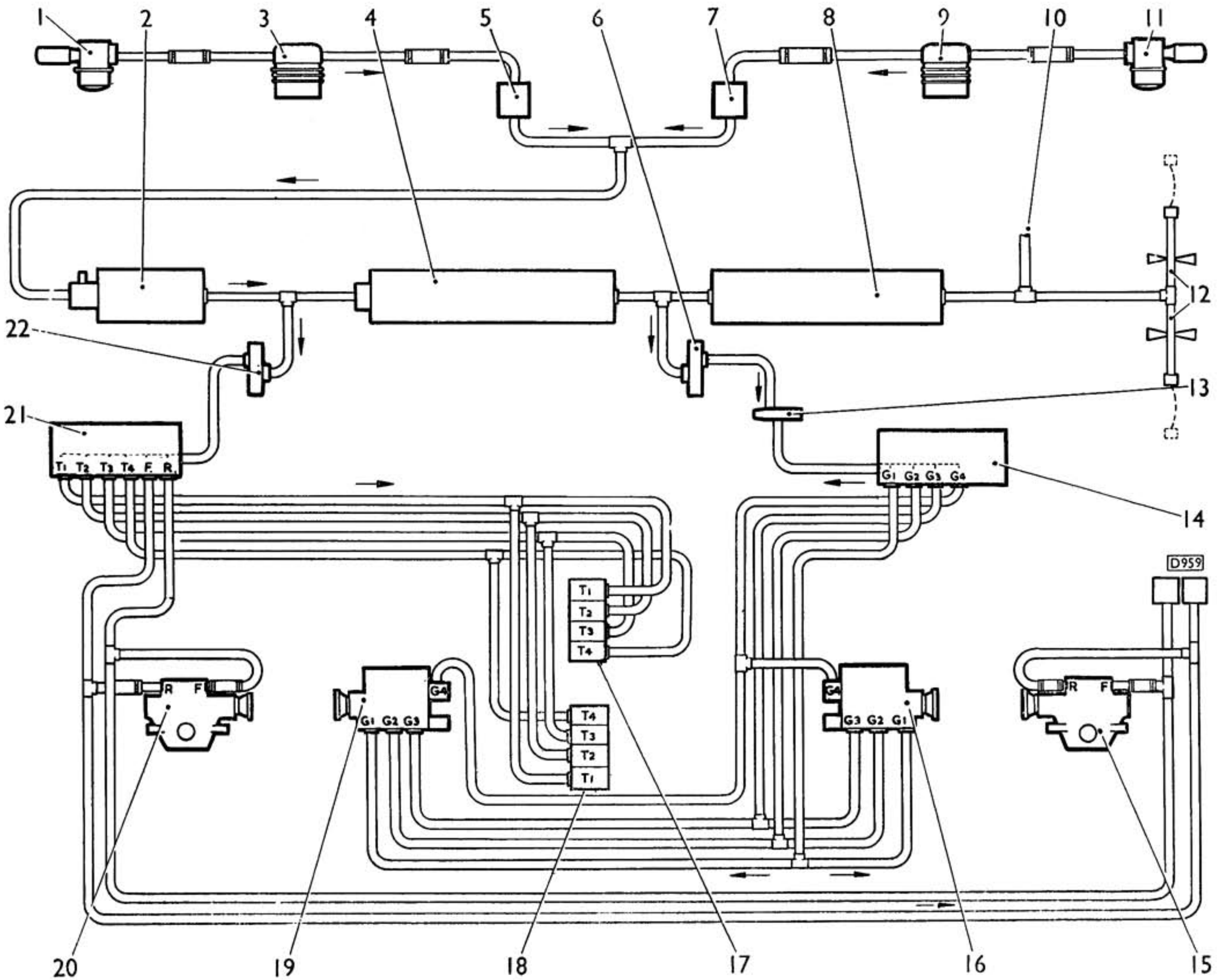


Fig. 1. Diagrammatic layout of air pressure system.

1. AIR FILTER AND ANTI-FREEZER.
2. AIR RESERVOIR WITH UNLOADER AND SAFETY VALVES.
3. AIR COMPRESSOR.
4. AIR RESERVOIR AND DIVERTER VALVE.
5. NON-RETURN VALVE.
6. PIPE LINE AIR FILTER.
7. NON-RETURN VALVE.
8. AIR RESERVOIR.
9. AIR COMPRESSOR.
10. PIPE LINE TO AIR PRESSURE GAUGE AND AUXILIARIES.
11. AIR FILTER AND ANTI-FREEZER.
12. PIPE LINE TO COUPLING COCKS AND HOSE COUPLING AT REAR OF CAR.
13. AIR REDUCING VALVE.
14. ELECTRO-PNEUMATIC VALVES — GEARBOX OPERATION.
15. FINAL DRIVE UNIT.
16. EPICYCLIC GEARBOX.
17., 18. } THROTTLE CONTROL MOTORS.
19. EPICYCLIC GEARBOX.
20. FINAL DRIVE UNIT.
21. ELECTRO-PNEUMATIC VALVES — THROTTLE CONTROL AND FINAL DRIVE OPERATION.
22. PIPE LINE AIR FILTER.

ALL ~~Inter-City~~ Diesel Rail Cars

The Compressed Air System.

This is shewn in simplified form on the attached diagram. Each engine is fitted with an air compressor which feeds into a common reservoir and E.P. valve system. Air lines from the E.P. valves feed the appropriate cylinders of each of the throttle control motors, gearboxes and final drive units of the power cars.

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

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

The Unloader Valve

No provision is made for disconnecting the drive to the compressor, which runs at all times when the diesel engine is operating. The compressed air has to pass the unloading valve before it can enter the Primary air reservoir. This valve is designed so that when the Primary reservoir reaches 95 p.s.i. admission of air is stopped and the compressor is allowed to exhaust direct to atmosphere and thus run lightly loaded. From the diagram it can be seen that air entering the valve body is forced through a felt filter (12) past the spring closed unloader valve (4) past the non return valve (7) into the primary reservoir.

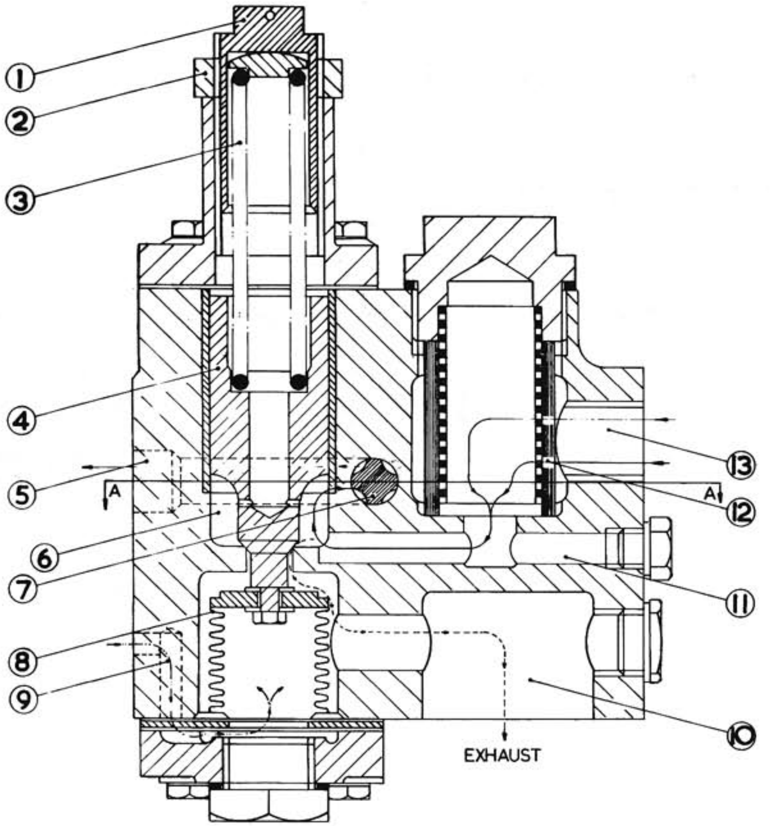
The unloader valve stem is attached to a bellows (8) the interior of which is in communication with the primary reservoir. When the primary reservoir pressure reaches 95 p.s.i. the load acting inside the bellows is sufficient to overcome the spring and the unloader valve rises, providing an escape path for the air via the silencing chamber (10) to the atmosphere. The non-return valve seals off the air in the reservoir. As the reserve of air is used up the pressure within the reservoir and bellows chamber is reduced and at about ~~85~~ p.s.i. the unloader valve can seat and air is again allowed to charge the primary reservoir. 75-80

In the event of the unloader valve sticking in the open position re-charging of the system would be prevented and control of the vehicle would be lost. A blanking nut is provided adjacent to the unloader valve and can be used to seal off the exhaust to allow the train to proceed.

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

From the primary reservoir two air paths exist, one to the E.P. valves for throttle and direction control and the other to the Secondary reservoir system.

The Secondary reservoirs are arranged in tandem for space reasons and the first reservoir has attached to it the <u>Diverter Valve</u>. On starting engines locally to build up air pressure it is necessary to hand operate the throttle control at the fuel injection pump, and, to minimise the time before train control from the cab can be obtained, the diverter valve remains closed until the primary reservoir is charged to 50 p.s.i. Pressure is thus built up more quickly and air is available at the throttle control motor and final drive but not at the gearbox, allowing cab control of throttle but not of gears. Thus the vehicles cannot be moved under power until correct air pressure is available in the gearbox. As can be seen from the diagram the diverter valve (9) is spring loaded (3) and air can pass over flutes on the stem to act on a bellows (4) causing valve movement when delivery pressure exceeds 50 p.s.i. which allows air to pass the cone valve to the secondary reservoir (8). A non-return valve (7) is incorporated in the valve body in a bypass passage and this allows air to feed back to the primary system in the event of primary pressure loss and thus use can be made of all the air stored in the event of a failure.



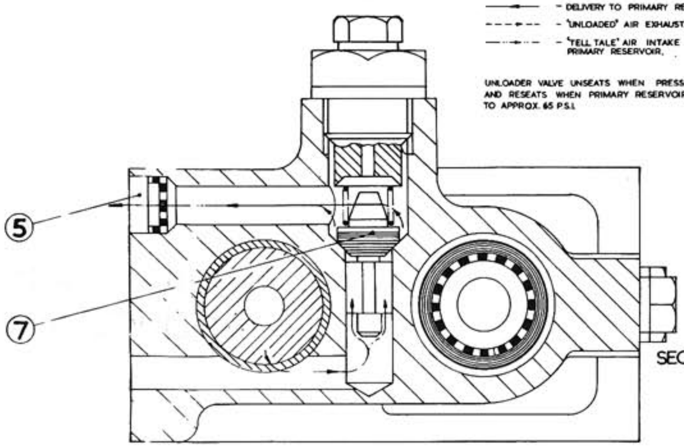
KEY

1 ADJUSTER
2 LOCKNUT
3 CONTROL SPRING
4 UNLOADER VALVE
5 AIR ENTRY TO PRIMARY RESERVOIR
6 UNLOADER VALVE AIR CHAMBER
7 NON-RETURN VALVE
8 BELLOWS
9 AIR PASSAGE FROM PRIMARY RESERVOIR
10 SILENCING CHAMBER
11 AIR PASSAGE
12 FELT FILTER
13 INLET PORT FROM COMPRESSOR

AIR FLOW

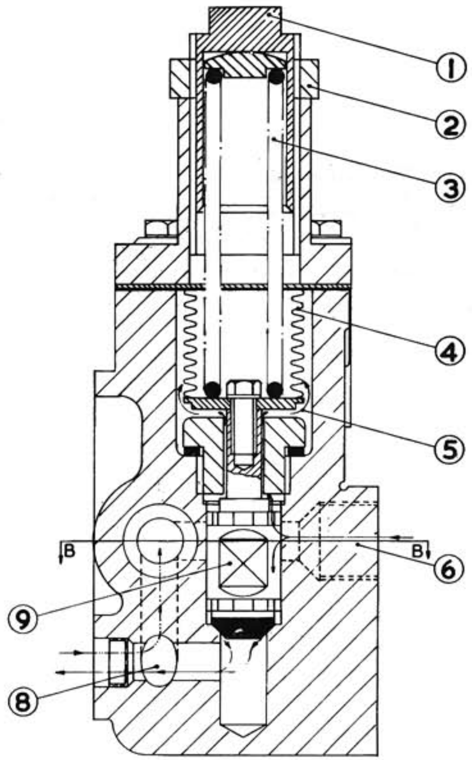
- DELIVERY TO PRIMARY RESERVOIR.
- 'UNLOADED' AIR EXHAUST.
- 'TELL TALE' AIR INTAKE FROM PRIMARY RESERVOIR.

UNLOADER VALVE UNSEATS WHEN PRESSURE REACHES 85 P.S.I. AND RESEATS WHEN PRIMARY RESERVOIR PRESSURE REDUCES TO APPROX. 65 P.S.I.



SECTION 'AA'

UNLOADER VALVE



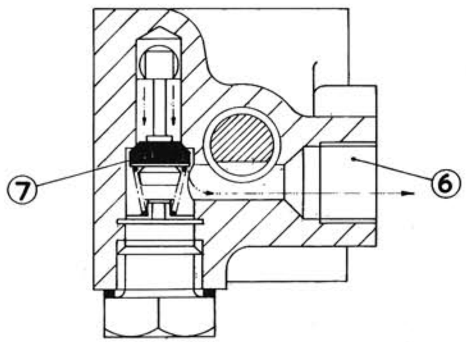
KEY

1 ADJUSTER
2 LOCKNUT
3 CONTROL SPRING
4 BELLOWS
5 AIR CHAMBER
6 AIR ENTRY FROM PRIMARY RESERVOIR
7 NON-RETURN VALVE
8 PASSAGE TO SECONDARY RESERVOIR
9 DIVERTER VALVE

AIR FLOW

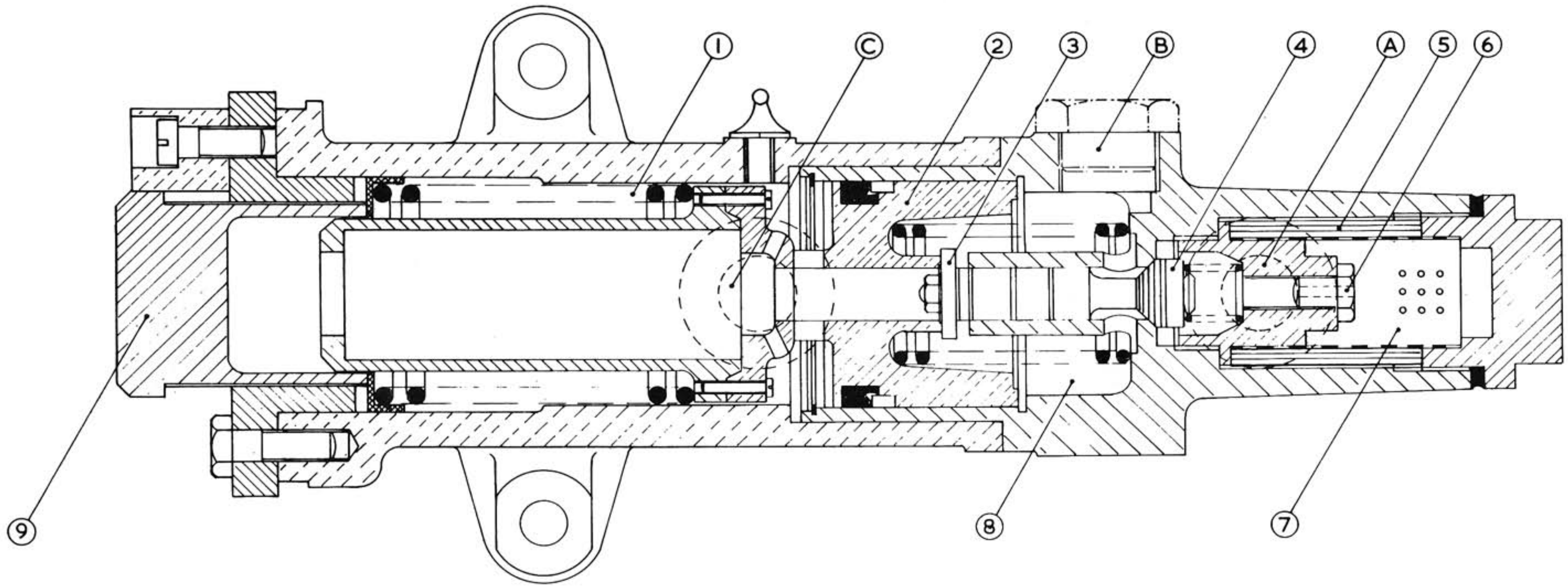
DELIVERY TO SECONDARY RESERVOIR.
FEED-BACK TO PRIMARY RESERVOIR.

VALVE OPENS TO PASS AIR TO SEC^{DY} RES. WHEN DELIVERY PRESSURE EXCEEDS 50 P.S.I.
FEED-BACK OCCURS IF PRIMARY PRESSURE IS BELOW THAT IN SEC^{DY} SYSTEM.



SECTION 'BB'

DIVERTER VALVE



KEY

1	CONTROL SPRING	7	AIR CHAMBER
2	REACTION PISTON	8	AIR CHAMBER
3	DISC TYPE RELEASE VALVE	9	ADJUSTING SCREW
4	CONICAL INLET VALVE	A	INLET PORT
5	FELT AIR FILTER	B	OUTLET PORT TO GEAR 'E.P.' VALVES
6	RESTRICTOR TO PREVENT SURGE	C	EXHAUST PORT TO ATMOSPHERE

AIR PRESSURE REDUCING VALVE

Reducing Valve

The gearbox used can also be obtained in road vehicle form and has been designed to operate at a pressure of 65 p.s.i. usual on road vehicles. In order that this pressure can be obtained with the railcar equipment a reducing valve is included in the line from the secondary system to the Gear E.P. valves. The diagram shews that this valve includes a spring loaded reaction piston (2) and a double ended valve (3 and 4) as well as an air filter (5). With the system at low pressure the control spring (1) pushes the piston to the right and the spindle of the double ended valve is moved to open the cone valve (4). Air entering through port (A) passes the felt filter and surge restrictor (6) over the cone valve and into the chamber (8) from where it can flow to the gear E.P. valves through port (B). The air in the chamber also acts upon the reaction piston (2) and when the pressure exceeds 65 p.s.i. the piston will overcome control spring (1) and move to the left. The double valve will move with the piston and cone valve (4) will close and prevent intake of further air. If piston movement to the left continues the disc valve (3) will be unseated and air from chamber (8) can pass through the piston to the atmosphere through port (C). As pressure reduces, control spring (1) resumes control and exhaust closes and inlet opens to maintain pressure in the chamber (8) at 65 p.s.i. with the minimum of waste.

Line filters Gauze line filters enclosed in special bodies are included in the system as shewn in the diagram.

Notes.

(1) Since two compressors are used to charge the common reservoir system, failure of one compressor does not necessarily mean failure of the compressed air system on that car.

(ii) The compressed air system is ~~not~~ coupled throughout the train ~~but is self contained on each power car.~~

(iii) If the compressed air system does fail, the transmission of that car cannot be controlled and should be mechanically and electrically isolated as laid down in Driving Instructions. In a leading car this would mean that the control desk is still available to control the train but that air horns and windscreen wipers will not be working.

(iv) Prolonged coasting with engine idling means that charging of the air system will be negligible. It may prove necessary in some cases, particularly if windscreen wipers and air horns are in heavy use, to open the throttle to recharge the system.

(v) Only one pressure gauge is provided and this records primary system pressure. If pressure reading exceeds 70 p.s.i. it is assumed that gearbox will be receiving 65 p.s.i. via the reducing valve. When testing the operation of the gearbox it is advisable to maintain the gauge reading at 75 p.s.i.

(vi) The anti-freezer should only be filled when frost conditions are expected and local instructions will be issued to cover this point.

Vacuum Brake Quick Release system. The operation of the Standard Vacuum brake is dependant on the creation and maintenance of a suitable vacuum in the brake cylinder above and below the piston when the brake is released. When a brake application is required air is admitted below the piston and the difference in pressure created in the cylinder provides the force to apply the brake. When the brake is to be released the air recently admitted has to be exhausted from the cylinder and train pipes. The exhausting devices used are the steam ejector and the vacuum pump. The ejector also functions as the brake valve and as long as steam is available brake release can take place.

When this brake system is applied to the Diesel rail car no steam ejector can be used and exhausting has to be done by a special form of vacuum pump called an exhauster which is a vane type pump driven by the diesel engine. When the rail cars are stationary the Diesel engine is running at 'Idling' speed and the exhauster is working at a low rate, consequently it is not able to quickly exhaust the air from the brake system, and the brakes will not be speedily released. To avoid having to run the engines at a fast rate to release the brakes, particularly when standing in stations, the Standard brake system has been modified to include a quick release feature.

The modified brake system includes the addition of a High Vacuum reservoir (A) a feed valve (B) and an isolating valve (F) and these are arranged as shown in the diagrams on page 18.

The principle of operation which can be followed by reference to the 5 diagrams is as follows:-

Running Position. (Figure 1) With the exhausters (E) running at normal speed, vacuum conditions are maintained throughout the system and the feed valve (B) ensures that the pressure in the train pipe side is reduced to 21" Mercury at which pressure it closes. No vacuum relief (snifting) valve is provided and the exhauster continues to create the maximum vacuum it can produce, which is about 27"-28" Mercury.

"Lap Position". (Figure 2) Shows the position of the Driver's brake valve (C) to "Hold" a partial brake application.

Brake 'On'. (Figure 3) Turning brake valve (C) as shown, admits air to the train pipe and brake cylinders only, preserving high vacuum in the release chamber (A). By returning the brake valve to "lap" this degree of braking can be maintained.

"Quick release position". (Figure 4) Brake valve (C) is returned to the running position and the air pressure causes feed Valve (B) and Isolating valve (F) to open. The air from the brake cylinder and train pipe flows rapidly through the open valves (B) and (F) to the release chamber (A) which is large enough to accept all the air in the system. As soon as the pressure on the train pipe side of valve (B) reaches 21" Mercury (B) closes. It will be seen that during this release the exhauster was not used and therefore, did not affect the speed of brake release. Since the brake is now released the train can move away and the exhauster can re-create the 27"-28" Mercury Vacuum in the release chamber during the journey.

Figure 5. Shows the operation of the isolating valve (F) which prevents the vacuum in the release chamber falling below 18" or 19" Mercury. This, in effect, reduces the time taken to recharge the chamber.

From the above it can be seen that the high vacuum release reservoir is the means by which quick release of the brakes is made possible. It is therefore, important to avoid "frittering away" this high vacuum by making repeated partial applications and releases when stopping.

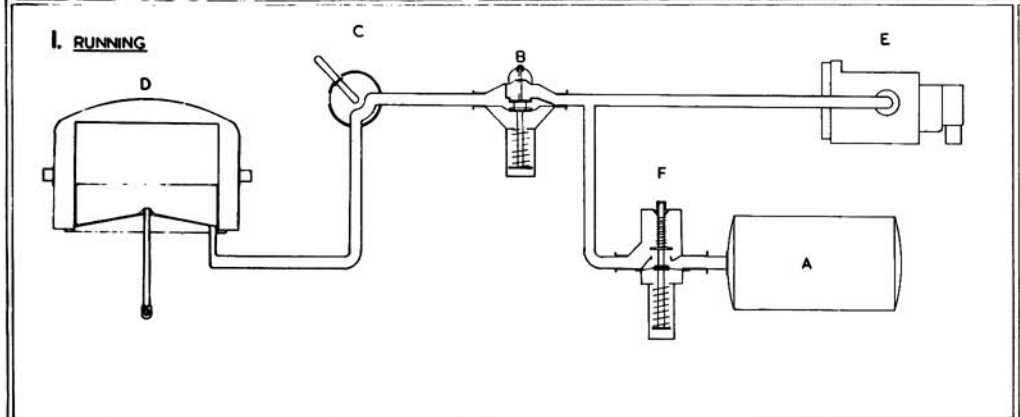
The "lap" position enables the driver to hold any degree of braking without passing air back to the exhauster.

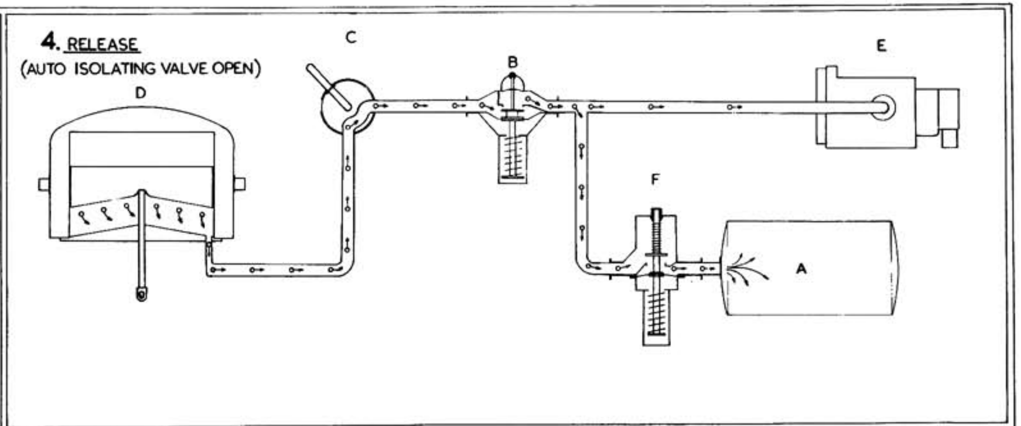
Drivers should drop the train pipe pressure to a pressure dependant upon circumstances and experience and move the brake valve handle back to lap to hold the brake application. Moving beyond 'lap' to 'release' floods the reservoir with air.

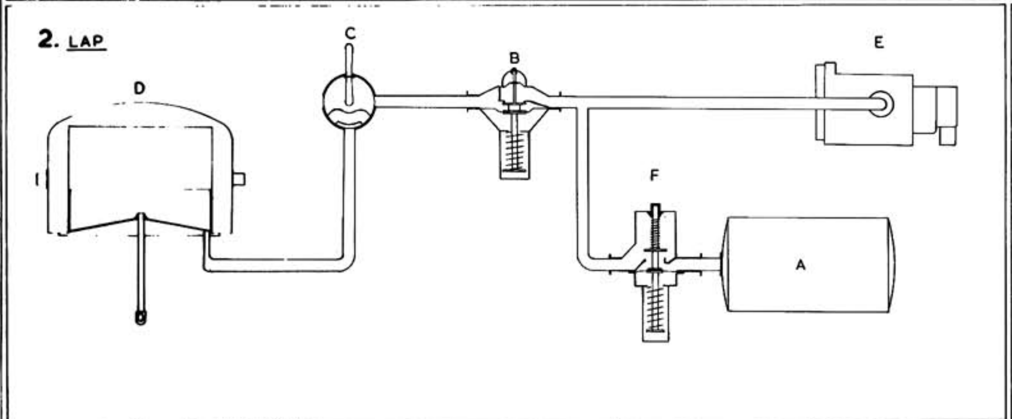
The correct procedure will result in 28"-29" high vacuum being preserved until the moment when it is desired to ease the brake off just before stopping.

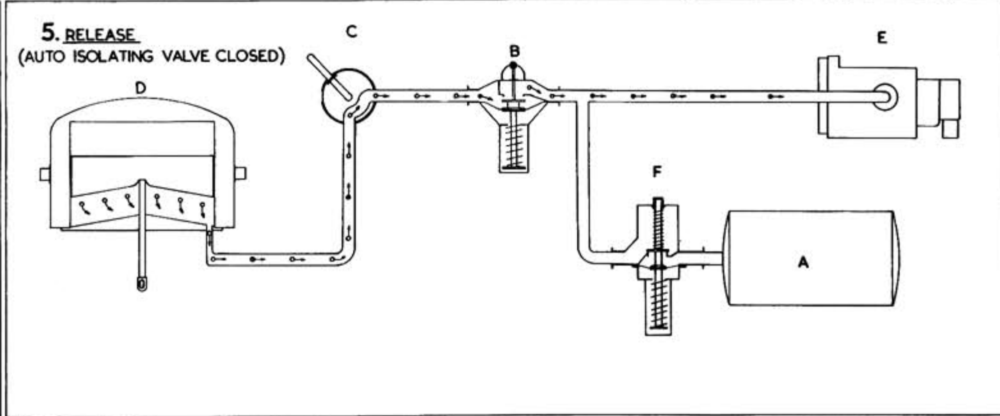
Provision is made in the brake system to give Deadman operation of the brake, through release of the throttle lever energising and electrically operated valve and also the usual facility of the Passenger operated emergency braking.

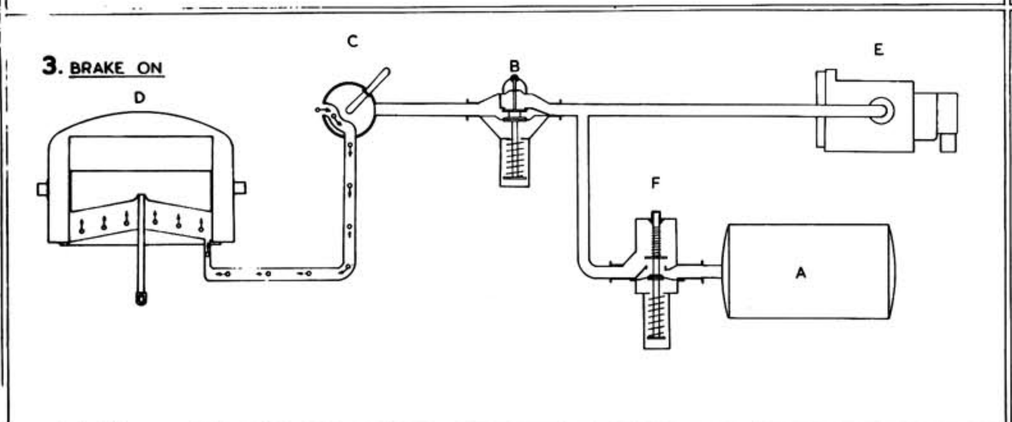
In order that the driver may move to the other side of his cab to observe signals, etc., the Deadman's brake application is delayed for 5 seconds after releasing the throttle lever by a dashpot device. At the other side of the cab a push button is provided which whilst depressed prevents the brake application from taking place. After releasing the button a 5 second delay allows the driver to return to his seat and resume driving. Whilst the throttle handle is released the engine will continue to run at idling speed, the freewheel operating and car speed altering according to load and gradient.











A-HIGH VACUUM RELEASE CHAMBER.
B-FEED VALVE.
C-TWO PIPE DRIVERS BRAKE VALVE.
D-STANDARD VACUUM BRAKE CYLINDER.
E-EXHAUSTER.
F-AUTOMATIC ISOLATING VALVE.

VACUUM BRAKE

QUICK RELEASE SYSTEM

B R I T I S H   R A I L W A Y S

WESTERN REGION

Chief Mechanical & Electrical Engineer's Dept.

M U L T I P L E   U N I T

D I E S E L   R A I L   C A R S

Supplementary Notes on Inter-City, Cross Country
and Suburban Rail Cars

SWINDON

January, 1958

Introduction

This supplement to the Diesel Training School notes on Multiple Unit rail cars is issued to shew differences between the various types of car used on Western Region.

All Multiple Unit rail cars for this Region are designed to run as 3 car sets and the control equipment provided has capacity to control a maximum of 6 power cars in a train with up to 3 trailer coaches arranged in any order.

Three types of Multiple Unit rail cars are used and each is designed for a particular type of passenger duty, as will be seen from the arrangement of seating and other facilities.

The three types are :-

1. Inter-City Rail Cars :-

Designed for long distance express passenger services, are fitted with buck-eye couplings, have corridor communication throughout and include a buffet car. The vehicles can be arranged in 3 car sets comprising leading and trailing sets and intermediate set. Corridor communication is not provided forward from the leading vehicle nor rearwards from the trailing vehicle, allowing full width driving compartments at the ends. The intermediate set has a corridor gangway at each end and thus all intermediate driving compartments are to one side of the corridor gangway.

Division of the train is possible and each set can be controlled and travel as a separate train, if required.

2. Cross Country Cars:-

Designed for fast passenger services with more frequent stops. Each three car set has a connecting corridor, but has no communication forward or rearward. Each set has buffet facilities and a full width driving compartment at each end. Screw type couplings are fitted to this type of car.

3. Suburban Cars :-

Designed to operate stopping train services radiating from major stations. The vehicles are not corridor connected but are vestibule stock - with bulkhead partitions in some instances, ample doors being provided to speed up loading and unloading of passengers. Screw type couplings are fitted to this type of car.

Common features of the Transmission Equipment

Basically all three types of rail car are similar in that British United Traction oil engines and transmission equipment with similar electrical and pneumatic circuits are used to power and control the cars. The engines are all of the 6 cylinder 150 B.H.P. horizontal type manufactured by A.E.C. or Leyland, they are not immediately interchangeable because of differences in suspension arrangements and auxiliaries, but a kit of conversion equipment will be made available if such changes become necessary. Fuel injection equipment is by C.A.V. but Leyland injectors will be fitted to Leyland engines. Starter motors are of the axial type and may be of C.A.V. or Simms manufacture. Gearboxes, Final Drives, Cardan Shafts, Compressed Air and Vacuum equipment are similar on all B.U.T. type railcars.

Items and Features which differ on the three types of railcars

Fluid coupling

18" diameter couplings are fitted to Inter-City power cars and 20" diameter couplings to Cross Country and Suburban type cars.

Compressed Air System

On Inter-City cars each power car has a separate compressed air system which is self-contained on the car, maintained at 85 - 90 p.s.i. (gearbox 65 p.s.i).

Cross Country and Suburban sets have similar compressed air equipment for the pneumatic circuits, but maintained at 95 - 100 p.s.i. (gear box 65 p.s.i.) with the air systems of each car coupled together by an air train pipe.

Throttle Control Motor

On Inter-City rail cars this item is operated by 3 electro-pneumatic (E.P.) valves, one "OFF" type valve and two "ON" type valves as described in the notes. A new type throttle motor has become available and is fitted to both Cross Country and Suburban vehicles. It is a simple device containing four pistons each controlled by an "ON type E.P. valve. The travel of each piston is limited by a pre-set stop so that the four throttle openings are obtained by movement of the appropriate pistons and not by the combined movements of several pistons as was previously the case. Fuel rack openings are thus more positively obtained.

Final Drive

Reversing Procedure

The "Inching In" procedure described in the original notes is now discontinued as an unnecessary drain on the batteries resulted. If an indicator light fails to respond, the reason must be sought as laid down in the driving instructions, before moving off. Switch "OFF" all engines before reversing.

Isolation of a transmission

This is accomplished by (a) Isolation of the final drive at the bogie
and (b) Electrical Isolation of the engine by means of the Engine Isolation Switch

Final drive isolation. Access to Spring loaded locking bolt.

Inter-City and Cross Country Cars

A manhole is provided in the vehicle flooring giving access to this bolt.

Suburban Cars

Access can be obtained over the bogie from ground level using the claw ended rod carried in the Guards' Compartment.

If air pressure has been completely lost the final drive gear cannot be neutralised by use of the Forward and Reverse Controller.

On Suburban Cars no further means of isolation of this drive is available to the Driver who will comply with Driving Instructions, and proceed at reduced speed.

On Inter-City and Cross Country Cars a screwed plug fitted to the cover plate of the final drive gearbox on the opposite side to the locking bolt can be removed. By obtaining the oil level dipstick from the final drive gearbox and inserting it through the plug hole, it can be used as a lever to prize the gear to its neutral position to engage the locking bolt.

When a final drive gear has been isolated, or an unsuccessful attempt to isolate has been made and the driver intends to continue at reduced speed, it is essential that the associated engine shall be stopped and also isolated by means of the key operated switch positioned adjacent to each engine.

Control Desk

The photographs included in the original notes are of Inter-City power cars. On both Cross Country and Suburban cars the layout will be different and new type controllers, panel, train switch etc. are used as shewn in the illustrations in this supplement.

Throttle Controller and Dead Man's Brake Switch

Inter-City type: Throttle controller handle is spring loaded so that when released it returns to "OFF" in which position a Deadman brake application takes place after 5 - 6 seconds delay. The engine reverts to idling speed and the train halts with gear still engaged.

Cross Country and Suburban type:- Throttle controller handle is of the depression type and when released in any position will cause a brake application after 5 - 6 seconds delay. Release of the handle also breaks electrical circuits to reduce the engine speed to "Idling", disengage the gear, and return the gearbox to neutral position. Control can be regained by returning the throttle control handle to the stop, depressing and opening again. Before re-opening the throttle, care must be taken to ensure that the appropriate gear is engaged.

Gear Controllers

Inter-City type:- Gear and direction controllers are operated from two adjacent spindles which are mechanically interlocked as previously described.

The direction controller handle acts additionally as a master switch and is removable in the "OFF" position.

Inter-City gear controller notches are disposed so that complete rotation of the handle from any position is possible in either direction.

Cross Country and Suburban type:- The gear and direction controllers are mounted co-axially with interlocking arranged to give the same protection as Inter-City type.

The gear controller handle is restricted to rotate through a limited arc to select 1st, 2nd, 3rd, 4th and Neutral. In returning the handle from Neutral to 1st gear, cams will close contacts as intermediate gears are passed, the handle must thus be operated smartly, but not so as to damage the controller. Slow return of the handle would cause each gear to attempt to engage and it is important that after moving from Neutral to 1st gear a proper pause be allowed before opening the throttle.

Train Switch

The domestic type switch used on the Inter-City cars has been replaced by a miniature cylinder lock key switch mounted on the desk of the Cross Country and Suburban cars. Once the key has been turned and the switch is "ON", the key is "locked in" as in the Inter-City type switch. An indicator light is in circuit with this switch proving that the switch is either "ON" or "OFF".

Engine, Air and Axle Indicator Panel

Is provided in all driving compartments of each type of car.

Inter-City cars:- All panels shew signal lights when the vehicle is operating, but only the indication in the leading vehicle is in correct car sequence. Intermediate panels give a scrambled indication, but the total number of lights should be correct.

Cross Country and Suburban cars:- By introducing an 18-way relay panel into the circuit, indicator lights are controlled by relays energised only when train switch and direction switch have been operated. Lights will appear only on the panel of the cab selected for driving purposes, but a test button is provided in every cab and on depressing this, the lights will indicate on the panel in that cab as long as the button remains depressed.

Local Start

A "Local start" and "Local stop" push button station is provided adjacent to the engines on all power cars.

Inter-City cars:- The "Local Start" button can be used if the Battery isolating switch is closed

Cross Country and Suburban cars:- The "Local Start" circuits have been revised and are now dependent on the Train Switch and Battery Isolation switches being closed. This alteration ensures that start isolation relay protects the starter motor whenever starting is attempted by "local" or "train" start button.

Start Isolation Relay

Inter-City cars:- Operated by pressure switch in the engine lubricating oil pressure line.

Cross Country and Suburban cars:- Operated by engine tachometer.

Local Stop

Inter-City cars:- An engine started locally must be stopped locally

Cross Country and Suburban cars: As train switch must be closed before any start button is operative, engines started locally can be stopped by train stop button.

N.B. Use of Start Buttons:- If an unsuccessful attempt has been made to start an engine fitted with a fluid coupling, care must be exercised when re-starting and adequate time allowed before the start button is pressed again. Failure to observe this precaution will result in damage to starter pinion. This time delay is longer with 20" diameter couplings than with 18" diameter couplings.

Jumper Cables:- It is essential that all 4 Jumper cables are pushed fully home in their receptacles and that the spring lid is closed to position the lugs correctly so locking the jumper in position. Jumpers not in use at the ends of the train must be secured to the dummy and not left free. Disconnected or loose jumpers will cause loss of "through" control.

Marker Lights

Inter-City cars:- use an illuminated letter head code in place of the usual arrangement of lamps.

Cross Country and Suburban cars:- are provided with electrically operated marker lights each of which is fitted with two lamps controlled from three position (centre "off") switches. To switch a lamp "OFF", the switch is moved to the central position. To change from one lamp to the standby, the switch must be returned to "OFF", released, and then moved again to its other position. Two pressures are necessary for complete change-over with this type of switch. Each marker lamp is controlled by a similar switch and all are repeated by indicators on the desk.

N.B. The control circuits, jumper cables and buffer beam arrangements of Cross Country and Suburban cars are similar and if required by operating considerations, these two types may be coupled together and driven in normal manner.

Single Power Cars:-

1. B.U.T. type:- Will be basically similar to Suburban power cars; but will have a driving cab at each end. They will be capable of Multiple Unit working with other single cars, Cross Country and Suburban Units up to a maximum of 6 power cars and 3 trailers. Driving trailer coaches will also be provided to work with these cars forming "Twin-sets".

2. Rail Buses:- will be simple four wheeled power cars built by various manufacturers, which are not intended to work in multiple formation. Further details are awaited and will be published later.

Electrical Control systems

Coloured signs will be seen painted on the body above the jumper receptacles and also on the jumper cables and receptacles. The form of sign, which may be a yellow diamond, red triangle or blue square, indicates the control system used. Cars must only be electrically coupled to other cars of the **same** colour code, using jumpers bearing the same code.

Inter-City cars have no colour code but are easily distinguished by the Buck-eye coupling, seating arrangement and the inscription "Inter-City" which will be found painted on the solebar. The other Multiple-Unit railcars mentioned in this supplement are all of the BLUE SQUARE type and can thus work coupled together with up to six power cars in a train formation. Cars of the three colour codes are working on other Regions.

Jumper connecting cables

In addition to the remarks on page 6 and above, **one** jumper receptacle of each pair is painted white and the other black. In coupling, white must connect to white and black to black. The white and black sockets are in opposite positions on Inter-City and "Blue square" cars and if coupling two railcars makes it necessary to cross the jumpers in order to insert white in white, then these cars have different control systems, which is also proved by the colour code symbols, and electrical coupling must NOT take place.

Single Car Diesel Trains (Gloucester Built)

These power cars, with driving compartment provided at each end, follow very closely the Suburban (Derby built) power cars in the arrangement of traction and control equipment but use the B. U. T. 'A' type engine.

Each engine draws fuel oil from separate fuel tanks, but the two Smiths' Combustion Heaters take fuel from a common heater fuel tank.

Head code arrangements differ from previous cars and the illustration on page 27 shews that a combined head-code and route description system is used in addition to a destination indicator.

Battery charging arrangements are different from those provided on previous B. U. T. railcars and are as follows.

An alternator, belt driven from the pulley on the input shaft to each gearbox, feeds a metal rectifier carried on the underframe. This is an advantage particularly on a vehicle which will operate stopping train services where high speeds will not normally be reached. The alternator will be driven at speeds proportional to engine speed irrespective of which gear is in use. Thus the batteries will be kept charged even though the car will be operating at medium speeds. Isolation of one engine will stop one alternator, but the other will continue to operate and charge the battery. On previous railcars where one generator was driven from the axle side of a gearbox, prolonged slow speed running could result in "flat batteries" although the engine may have been running at speed when driving through the lower gears.

Deadman Isolating Valve

One valve only is provided as in all other power cars and this will be found below the desk at the leading end, i.e. the end opposite to that at which the exhaust pipes can be seen.

Passenger Communication Brake resetters and Heater Control Units will also be found in the leading driving compartment.

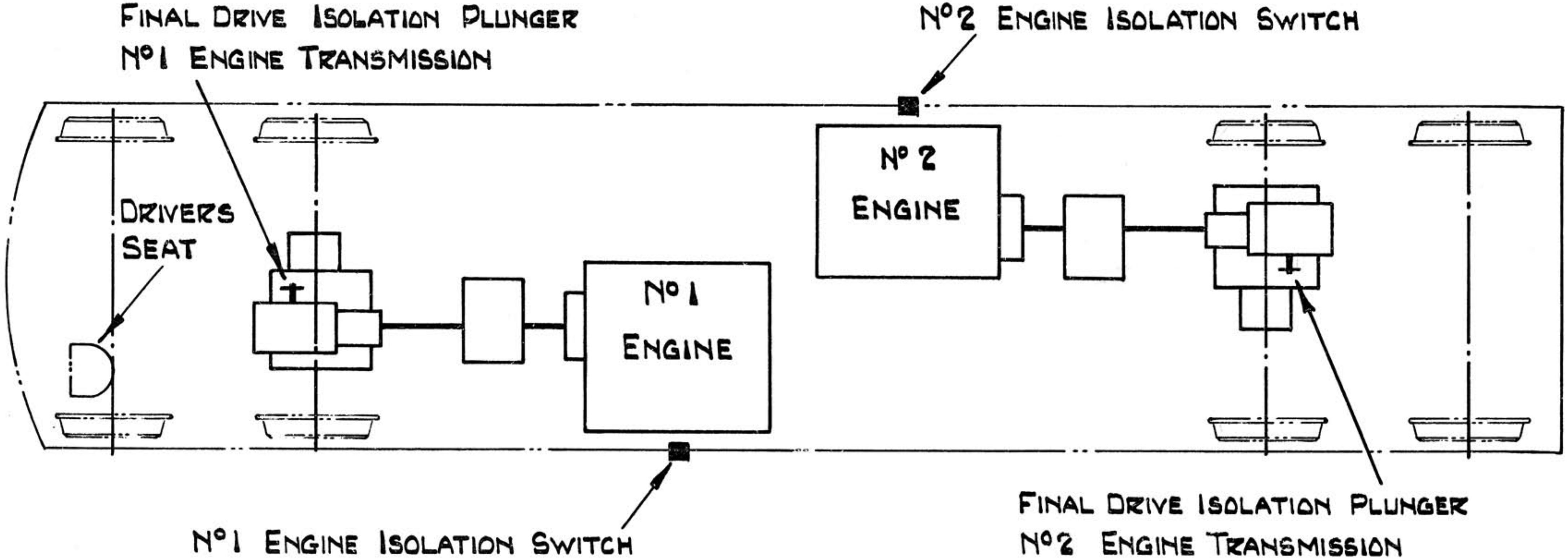
Battery Isolation switch will be found on No. 2 engine side of the Power Car, inside the box labelled "Electrical Control Box" and access is gained through the hole normally covered by a circular plate.

Final Drive

Reversing Procedure

As a result of further experience in this matter it has been decided that all previous instructions regarding reversing are cancelled and from 3rd February, 1959 the procedure to reverse now is -

Stop train, ensure engines are idling and change direction. Engines are not stopped.



TYPICAL DIAGRAM OF POWER CAR

SHEWING Nº1 & Nº2 ENGINE & AXLE ISOLATION ARRANGEMENTS