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C.M. & E.E.
TRAINING SECTION

COURSE NOTES AND DRAWINGS
DIESEL MULTIPLE UNITS
(ARTISAN STAFF)

T4-121
OCTOBER 1973

SECTION ONE

MECHANICAL EQUIPMENT

INDEX

A.E.C. 150 H.P. HORIZONTAL ENGINE

No. of cylinders, 6.
Cylinder dimensions, 5.12 ins. bore x 5.59" stroke
Max. Torque, 490 lb/ft. @ 1300 r.p.m.
Firing Order, 1, 5, 3, 6, 2, 4 - No. from Free-end.
Compression Ration, 16 : 1
Maximum Governed Speed, 1,800 r.p.m.
Weight, 15¾ cwts.

The engine is built up of four main parts.

1. CYLINDER HEADS (High Grade Cast Iron)

Two detachable heads each covering three cylinders. On them are mounted the inlet and exhaust valves, rocker gear, injectors and exhaust manifolds. The joint between the cylinder head cylinder block is made with a steel backbone asbestos gasket. A cooling water passage is also incorporated with removable covers for cleaning purposes. Care must be taken when fitting individual heads that the correct pulling down procedure is adhered to, this will ensure a good seal across the three cylinders.

2. CYLINDER BLOCK AND CRANKCASE (High Grade Cast Iron)

Integrally cast to which an engine extension and sump are bolted. The cylinder block houses the cylinder liners (dry), which can be removed, these being made of high grade centrifugally cast iron. A cooling water jacket is incorporated in the cylinder block casting, with removal covers for cleaning purposes. Pistons of aluminium alloy are housed in the cylinder bores and are attached by fully floating gudgeon pins to the connecting rods, which are attached to the crankshaft by the big end bearings and fastenings. The crankshaft is also housed in the crankcase and held in position by the main bearings and caps.

3. EXTENSION PIECE, of Aluminium Alloy is bolted to bottom of crankcase, this collects lubrication oil returning from the engine working parts and it is from the extension piece that the scavenge pump draws oil.

4. SUMP, of Aluminium Alloy is bolted to the extension piece, this is really the oil reservoir and it is from the sump that the pressure pump draws draws its oil.

Piston and Connecting Rod Assembly

These are of the 'Alfin' type, being constructed of aluminium-alloy with a special ring carrying section of case iron. There are three compression rings, the top ring being chromium-plated, and other rings being of cast-iron. Two oil-scraper rings are fitted one above the gudgeon pin and one below. These piston rings are fitted with the gaps in line with the crankshaft at a distance of 180° from each other, this ensures that there is no gap fitted on the thrust face.
The gudgeon pins are fully floating, free to move in the small end of

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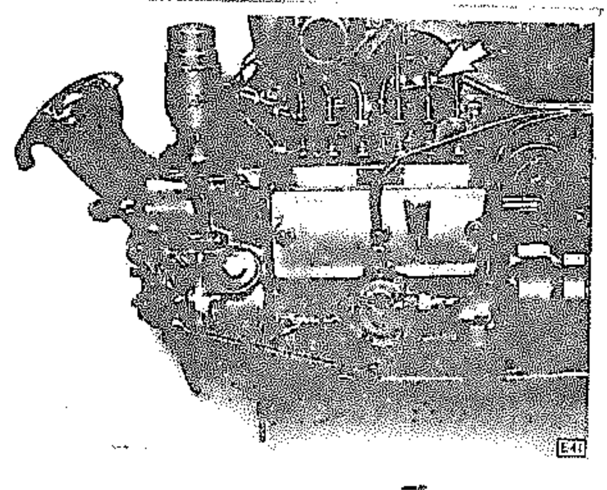
the connecting rod and the piston. The gudgeon pin is located by two circlips which are fixed in machined grooves in the piston. The connecting rods are marked to denote the cylinder they should be fitted to, also the big-end part of the connecting rod and the bottom cap are marked and should always be kept in matched pairs. The big-end bearings are of the tri-metal type, steel-backed copper bronze with a soft lead flash finish.

Crankshaft and Main Bearings. The Crankshaft is supported by seven main-bearings, No. 1 main bearing is the thrust-bearing, all the bearings are of the tri-metal type. The main bearing caps are in numerical sequence so the position must be noted when they are removed and replaced. The crankshaft was hollow pins and drilled journals forming passages through which oil passes under pressure from the oil pump to both main and big end bearings. The main-bearings can be removed without removing the crankshaft, the lower half of the bearing can be removed by inserting a screw into oil-hole on the main journal and by barring the crankshaft round the lower half is ejected. No vibration damper is fitted.

Camshaft is constructed of cast-iron and is carried in seven bushes in the engine casing, the cam-faces are "chill" hardened to reduce wear rate. The camshaft is driven at ½ engine speed by bevel drive and idler gear from the crankshaft. The camshaft in turn provides a drive for the fuel-injection pump and engine speed indicator generator. The opening and closing of the respective inlet and exhaust valves is controlled by the camshaft valve cams through pushrods, cam-followers and valve rocker gear. Lubrication of the camshaft and its associated parts is done by a special metering device incorporated in the pressure pump, this delivers a small quantity of oil at low pressures.

Valves and Valve Rocker Gear. The inlet and exhaust valve are not interchangeable, the inlet valve being of the " masked" type with a restraining spline on the valve stem. Inner and outer valve return springs are used to operate both valves and it is advisable when refitting valves that they are fitted to the same position from where they were removed. The valve heads are numbered. Tappet clearance is the same for both valves .010 - .012 and should be set when the engine is "hot". The valve rocker arms are carried on a rocker shaft which in turn is carried in three supporting brackets per cylinder head.



ENGINE NUMBER.

LEYLAND 150 H.P. HORIZONTAL ENGINE

No of cylinders, 6.
Cylinder Dimensions, 5.0 in. bore x 5.75 in. stroke
Maximum Torque, 450 lbs/ft @ 1,100 rpm
Firing Order, 1,5,3,6,2,4, No. from the Free-end
Compression Ration, 16:1
Maximum Governed Speed, 1,800 rpm
Weight, 15¾ cwts.

The engine is built up of three main parts.

1. CYLINDER HEADS (High Grade Cast Iron)

Two detachable heads, each covering three cylinders. On them are mounted the inlet and exhaust valves, rocker gear, injectors and exhaust manifolds. The joint between the cylinder head and the cylinder block is made with a steel asbestos gasket. A cooling water passage is also incorporated, no access is provided for cleaning purposes. Care must be taken that the correct pulling down procedure is adhered to, this will ensure a good seal across the cylinders.

2. CYLINDER BLOCK AND CRANKCASE (High Grade Cast Iron)

This forms a monoblock casting to which the two part sump is bolted. The cylinder block houses the cylinder liners which are renewable, these being made of high grade, centrifugally cast iron. A cooling water jacket is incorporated in the cylinder block casting with removable covers for cleaning purposes. Pistons of aluminium alloy are housed in the cylinder bores and are attached by fully floating gudgeon pins to the connecting rods, which are attached to the crankshaft by the big-end bearings and fastenings. The crankshaft is housed in the crankcase and held in position by the main bearings and caps.

3. SUMP, of Aluminium Alloy, consisting of an inner and outer sump, the outer sump acts as an oil reservoir and it is from the sump that the pressure pump draws its oil. The inner sump carries the engine breather and internal oil pipes, etc.

Pistons are constructed of special aluminium alloy fitted with three compression rings, the top ring being chromium plated and two oil-scraper rings, one above and one below the gudgeon pin. A toroidal cavity in the piston crown forms the combustion chamber, this being offset and fitted to the same side as the camshaft. The pistons are stamped in numerical order to correspond with cylinder numerical order.

Piston Rings are fitted with a gap at 90°, the gaps are arranged 180° from each other in line with the crankshaft, no gaps being on the thrust face.

Gudgeon Pin and small end bearings. These locate the piston and connecting rod together. The gudgeon pin is fully floating and is allowed to move within the piston assembly and small end bearing. The pin is held by two circlips which are located by a machined groove in the piston body.

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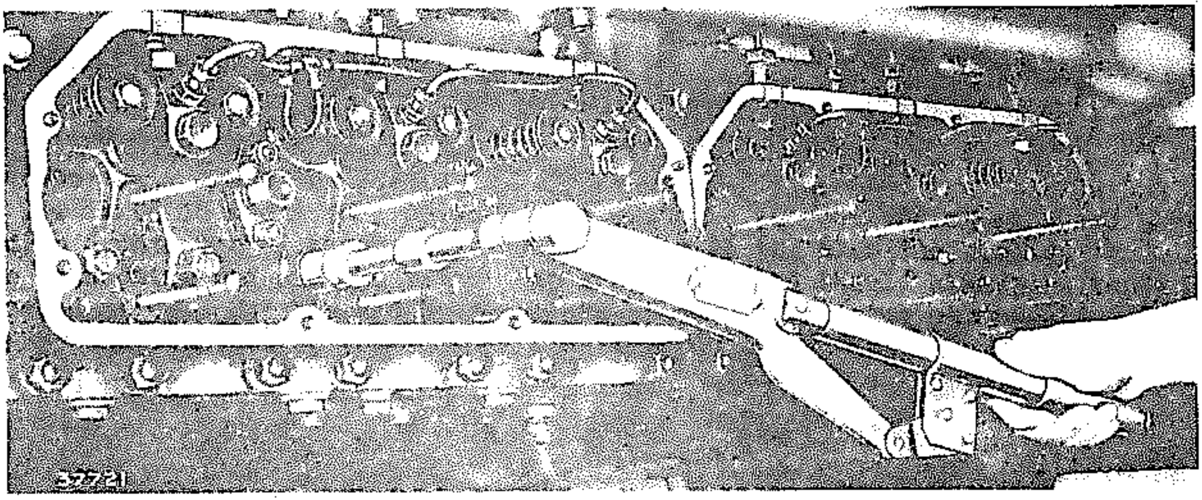
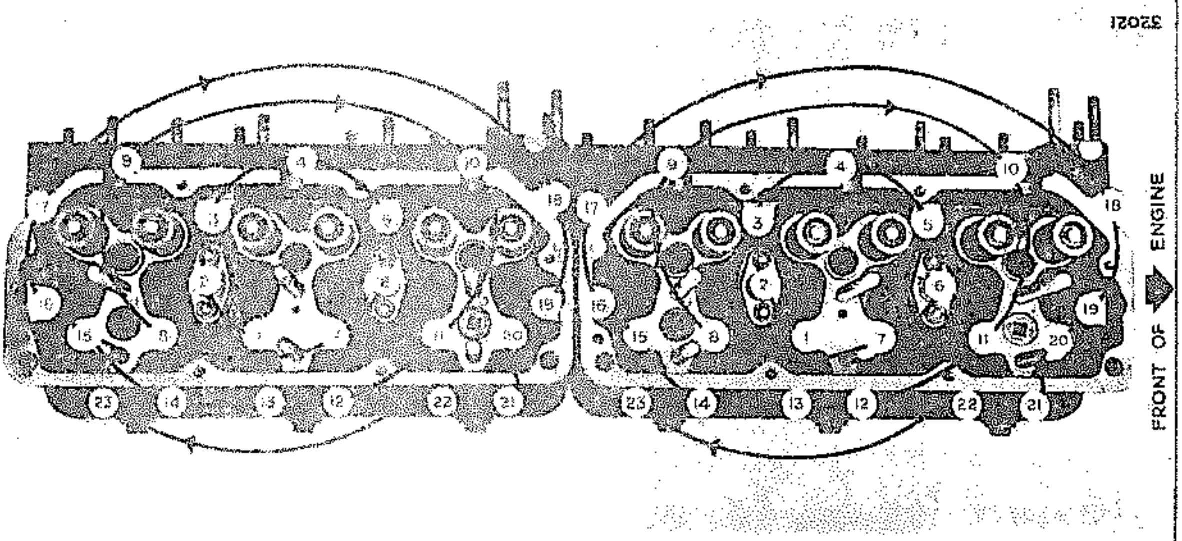
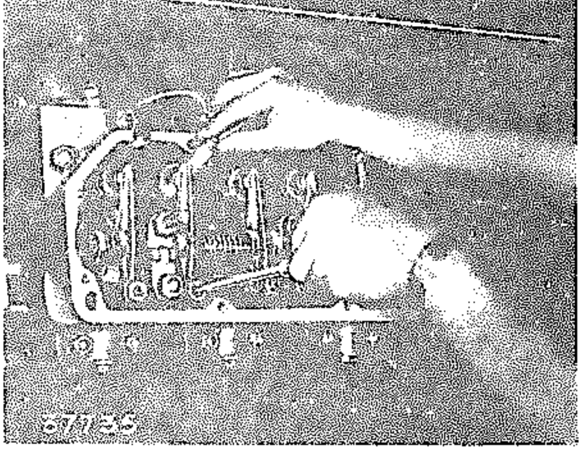


Tightening head nuts with torison spanner.



Correct sequence of tightening head nuts.



Adjusting the tappets.

LUBRICATING OIL SYSTEMS

(a) BUT 'L' TYPE ENGINE

Engine lubrication is on the wet sump system, the oil being circulated by a gear-type oil pump. As shown on the attached diagram.

Oil is drawn from the outer sump well through a suction filter and pressure fed by the pump into the main lubrication system via an oil cooler situated at the front of the crankcase. A by-pass centrifugal oil filter is incorporated in the system.

The crankshaft main bearings, big-end bearings, idler-gear for camshaft drive, and camshaft bearings, are supplied with oil through oilways drilled in the engine block.

A supply is tapped off the front main bearing to lubricate the idler-gear transmitting drive to compressor and injection pump drive gear. The cylinder walls and gudgeon-pin bushes are lubricated by splash and intermittent spray from oilways drilled in the crank-pins and connecting-rod big ends.

The rocker gear is also lubricated by an intermittent feed from the second and fifth camshaft bearings via horizontal oilways drilled in the engine-block heads, through the centre rocker shaft support bracker on each head, along the tubular rocker shafts to the rocker levers. A hole drilled in each rocker level carries a supply of oil to the top of the rocker in order to lubricate the contact surfaces between the valve cap and rocker lever. Oil is returned from the valve operating gear via two external pipes, running from the tappet gallery bottom covers to the inner sump.

The output oil pressure from the main pump is monitored by an oil pressure switch for visual indication, and by a second switch for engine shut-down.

The system is provided with a relief valve mounted on top of the engine block at the rear left-hand side; it consists simply of a spring-loaded valve provided with an adjusting screw. Oil by-passed by this valve spills back into the main sump well.

Crankcase breathing is effected by vent pipes fitted to the valve rocker covers.

(b) BUT 'A' TYPE ENGINE

Engine lubrication is on the dry sump system, as shown on the attached diagram.

Oil to lubricate engine parts is drawn from the sump by the High Pressure Pump which gives two pressurised feeds to the engine as follows :-

1. 50 PSI to Main Bearings and via drillings in the Grankshaft to connecting rod big ends. Gudgeon pins and cylinder walls are lubricated by splash from the crankshaft.

2. 5 PSI to rocker shaft bearings and valve stems.

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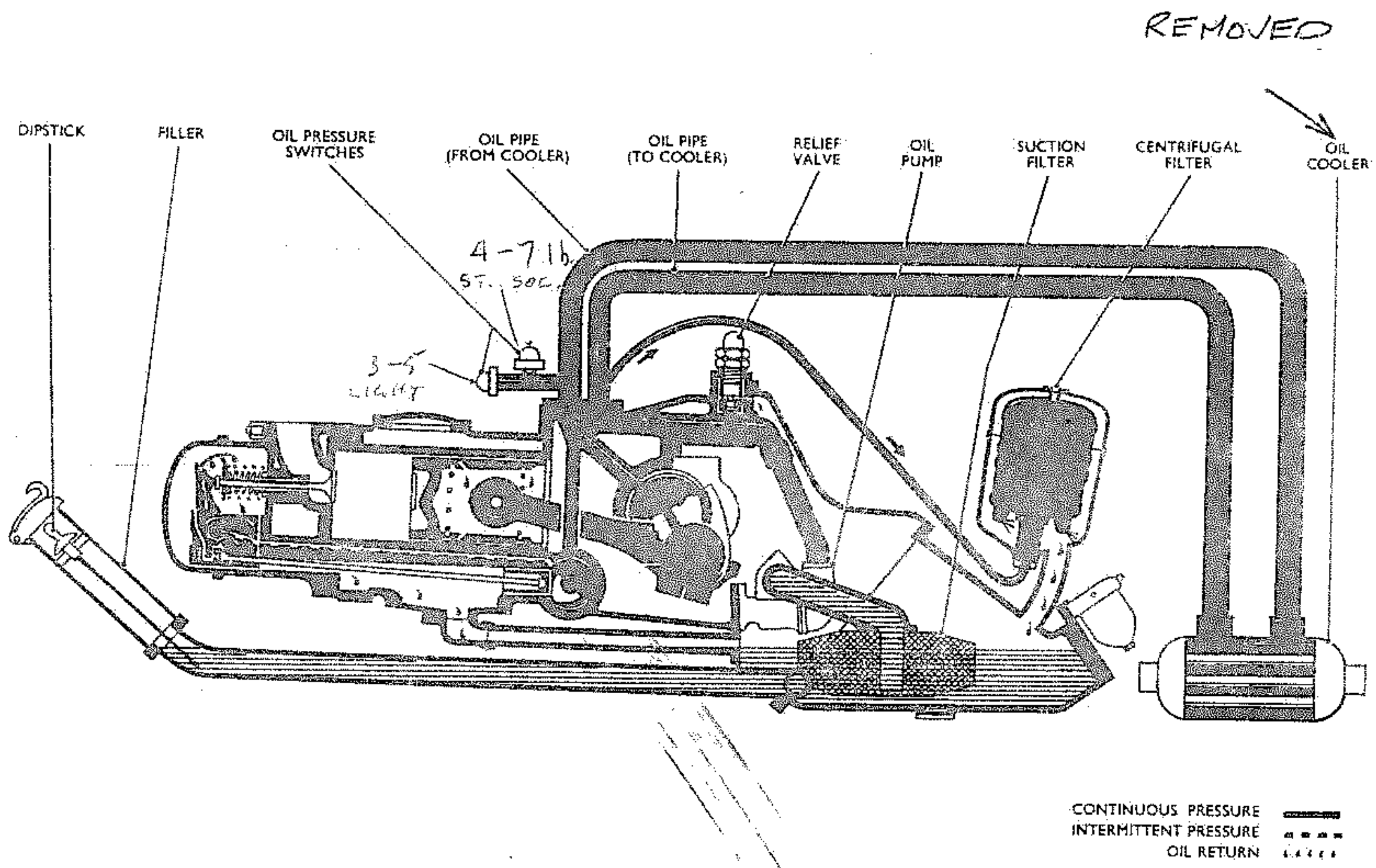


Engine oil circulation diagram.

ENGINE COOLANT SYSTEM (PRESSURISED)

Water is driven by the pump through the oil cooler and passes direct into the engine block for circulation through the cylinder water jackets. After leaving the block the water enters a cored passage in the top of the casing and is then directed through drilled holes into the cylinder heads.

A thermostat fitted in the water outlet pipe allows hot water to flow through the thermostat to the radiator, or cool water to return to the suction side of the pump through a by-pass.

An additional return pipe fitted on the top of the crankcase allows the water round the cylinders to pass to the water outlet pipe. A separate header tank is incorporated in the system.

Water cooling is effected by an eight-bladed fan enclosed in a cowl which is bolted to the radiator. The drive to the fan is taken from a small right-angle drive gearbox, belt-driven from a pulley at the front end of the crankshaft.

WATER PUMP

The impeller-type water-pump, mounted on the timing gear case at the front end of the engine-block, is gear-driven from the camshaft gear. A spring-loaded self-adjusting, carbon seal unit carried on the driving shaft, completely isolates the impeller chamber from the ball and roller bearings. The bearings are lubricated by splash from the camshaft gear. An oil seal prevents oil from penetrating to the impeller chamber.

THERMOSTAT VALVE

The thermostat consists basically of a gas-filled metal bellows which expands and contracts at pre-determined temperatures, thereby operating a valve which is housed with the bellows in a metal frame.

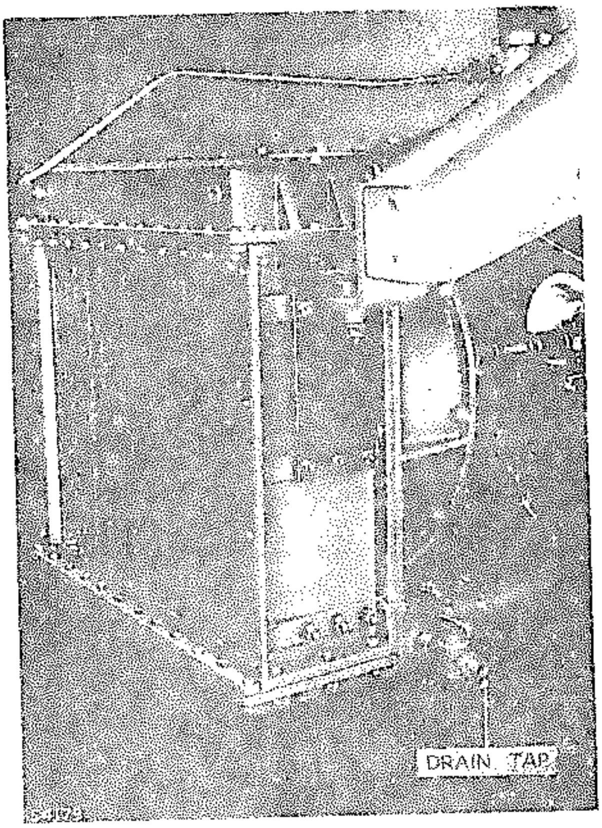
The thermostat valve should begin to open at 160°F to 170°F (71.1°C to 76.6°C) and normally should be fully open at 200°F (93.3°C).

The minimum lift of the valve is $\frac{1}{2}$ in. (12.7 mm).

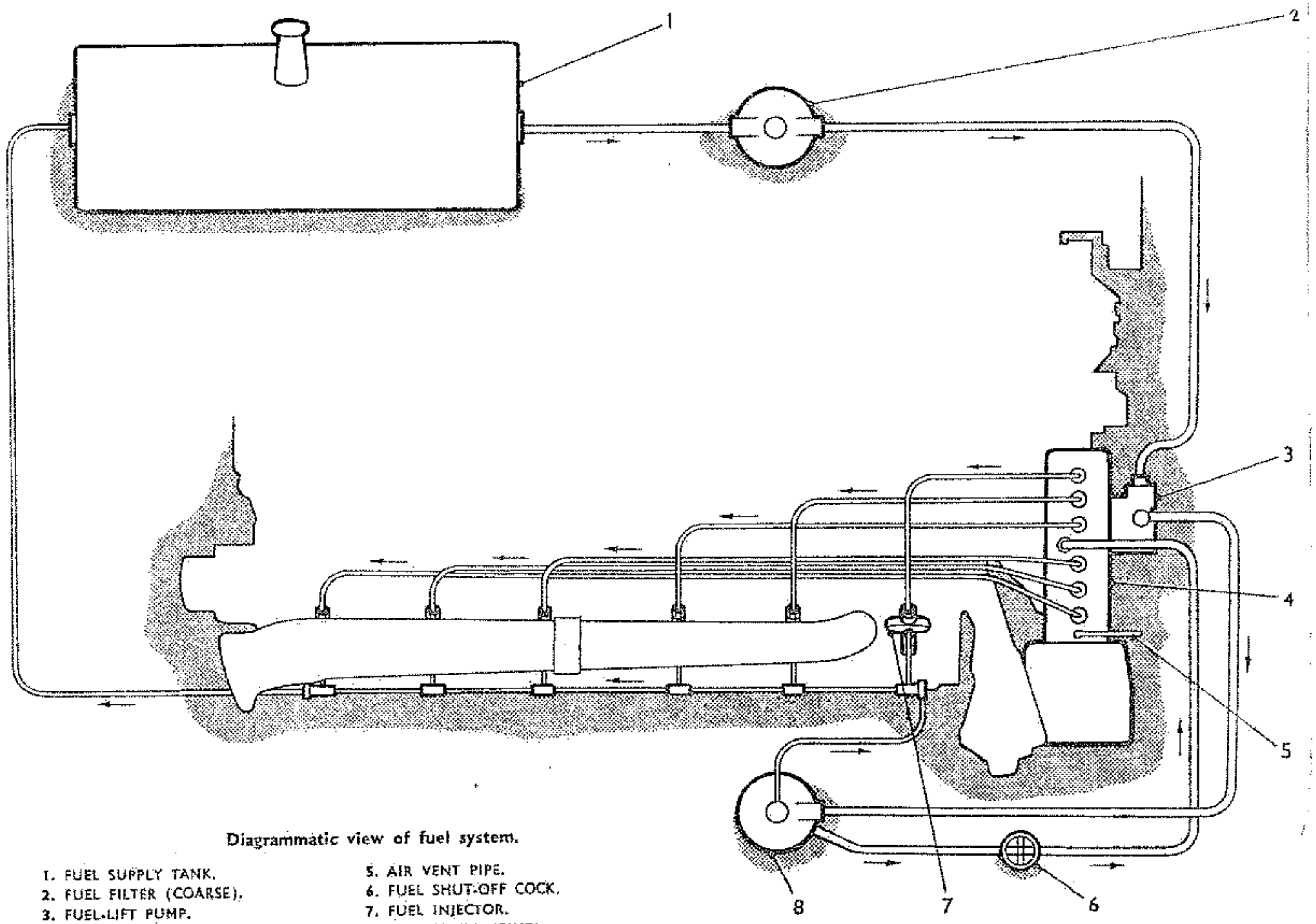
If the thermostat does not function correctly, do not attempt to repair or adjust it, but fit a new one.

NOTE:

In most instances, the thermostat valve has been removed to give increase coolant flow, check with relevant instructions before fitting, or re-fitting the valve.

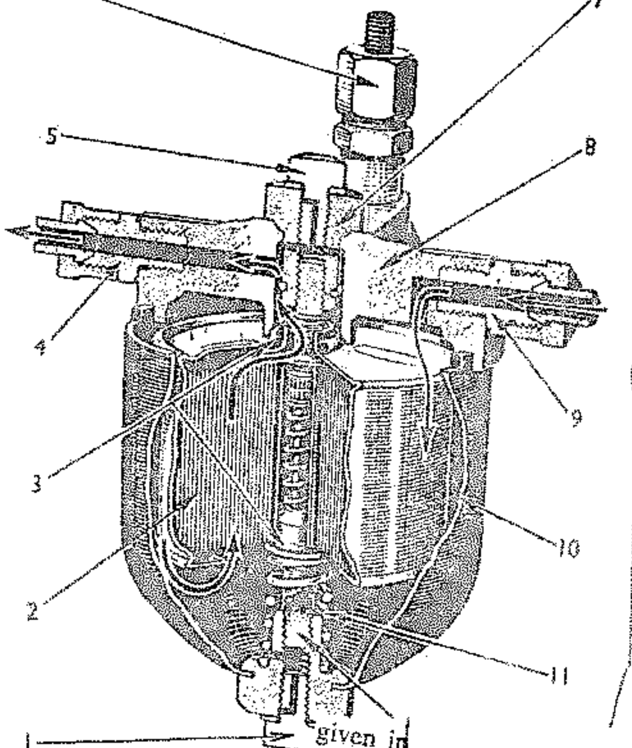


Radiator showing position of drain tap.



Diagrammatic view of fuel system.

1. FUEL SUPPLY TANK.
2. FUEL FILTER (COARSE).
3. FUEL-LIFT PUMP.
4. FUEL-INJECTION PUMP.
5. AIR VENT PIPE.
6. FUEL SHUT-OFF COCK.
7. FUEL INJECTOR.
8. FUEL FILTER (FINE).



Key to Number

1. DRAIN PLUG
2. PAPER ELEME
3. OIL SEALS.
4. OUTLET CO
5. AIR VENT P
6. AIR RELEAS
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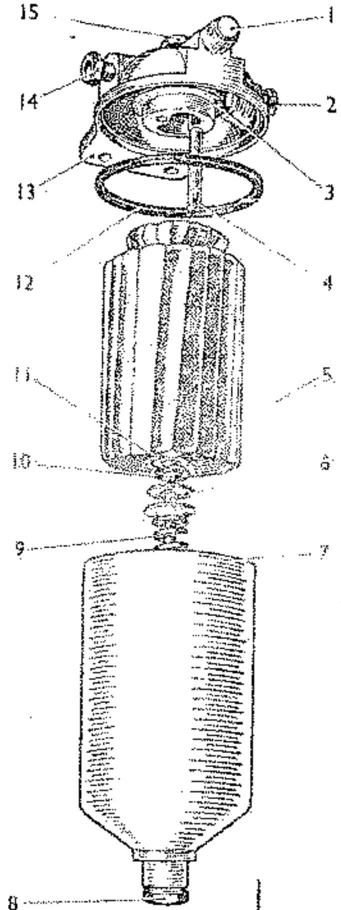
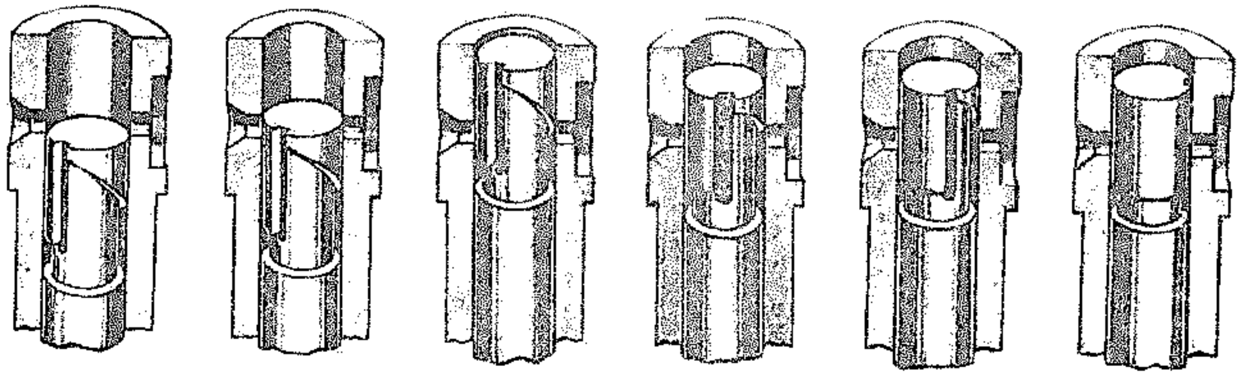


Exploded view of main fuel filter cloth element type).

1. AIR RELEASE SCREW
2. FUEL OUTLET.
3. FELT WASHER.
4. SUCTION PIPE.
5. FILTER CLOTH.
6. FELT WASHER
7. FILTER BOWL.
8. BOTTOM PLUG.
9. SPRING.
10. FELT INSERT.
11. FILTER CLOTH SECURING NUT.
12. RUBBER WASHER.
13. TOP COVER.
14. FUEL INLET.
15. CENTRE NUT.



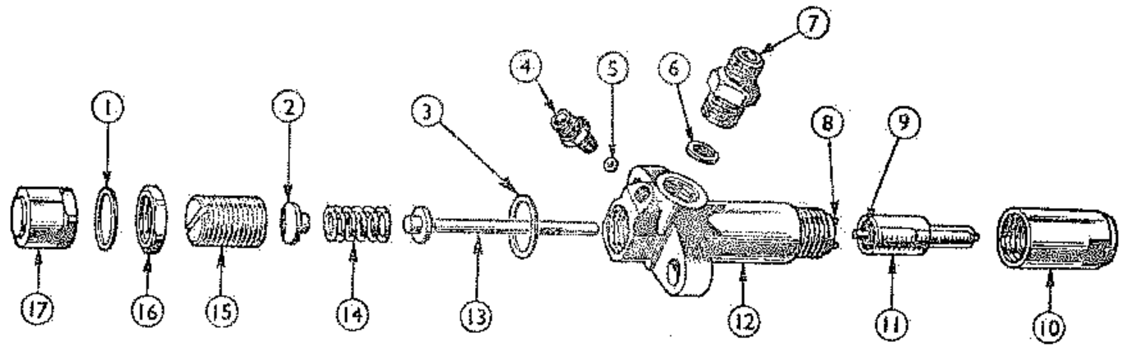
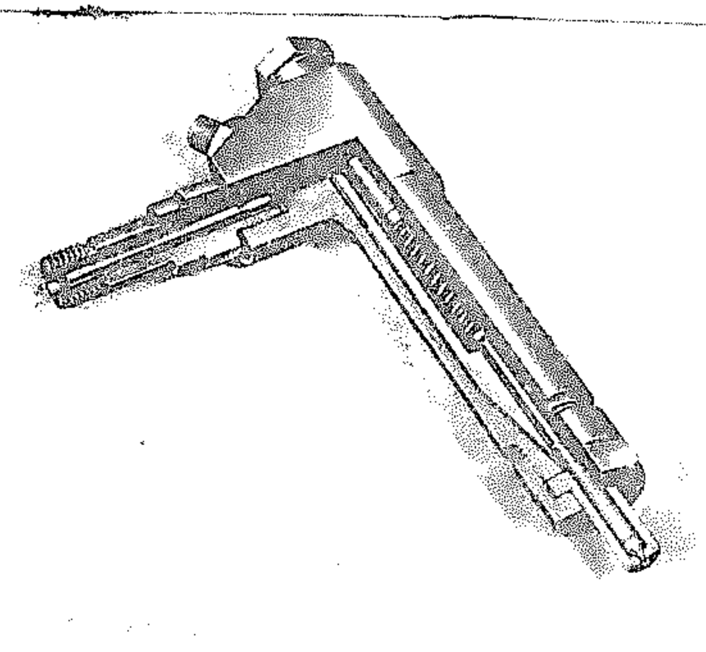


Fig. 24. Exploded view of injector.

1. COPPER WASHER.
2. SPRING PLATE.
3. COPPER WASHER.
4. DRIBBLE PIPE CONNECTION.
5. COPPER WASHER.
6. DISC FILTER.
7. INLET CONNECTION.
8. DOWELS.
9. NOZZLE VALVE.
10. NOZZLE CAP NUT.
11. NOZZLE BODY.
12. INJECTOR BODY.
13. NOZZLE VALVE ROD
14. SPRING.
15. SPRING CAP.
16. LOCKNUT.
17. END CAP.



An injector unit sectioned.

DIESEL ENGINE GOVERNORS.

MECHANICAL TYPE - RAILCAR ENGINES.

All diesel engines, unlike petrol engines, require some form of governor. The latter engines induce their fuel/air mixture through a carburettor containing a choke or venturi which at high speeds of operation of the engine results in some throttling of the mixture. If a petrol engine "runs away" a speed is reached at which increased friction and windage, combining with this throttling effect, result in a balancing speed being reached before centrifugal forces cause the engine to "burst". When idling, the engine draws its mixture past a "closed" throttle resulting in low pressures (a partial vacuum) in its inlet ports and the charges of mixture are of low density. When "ticking over" there is thus a self regulating characteristic present which causes a steady speed to be maintained.

The diesel has no self-regulating characteristics either when running away or ticking over so a governor is essential:

(i) to guard against overspeed by regulating the fuel supply

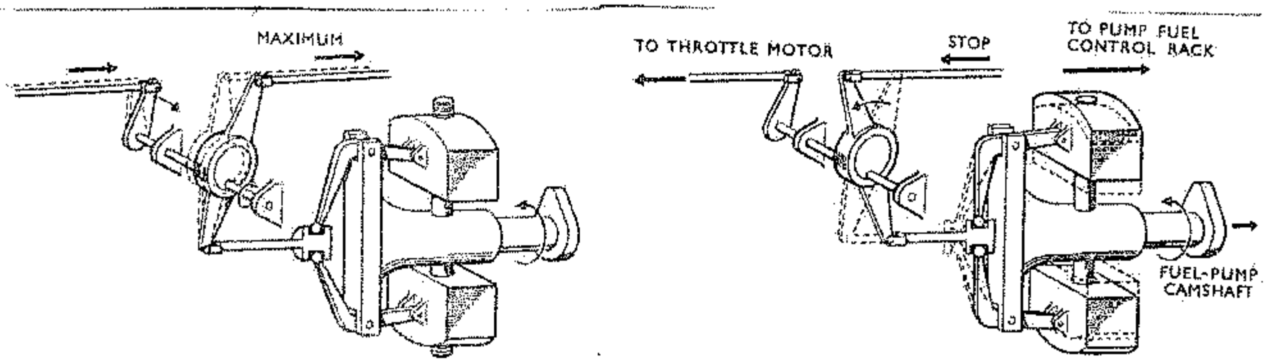
(ii) to regulate the idling speed, preventing "stalling" of "racing".

In many applications of the diesel engine it can be left to the driver to regulate the fuel supply or engine torque to suit the load between these two limits. A diesel propelled vehicle with mechanical transmission is one such application.

In its simplest form the governor will have two weights so mounted in a rotating carrier that they hinge about fulcrum pins, a spring load is provided to hold the weights in their innermost position. The carrier is rotated at increasing speed as the engine speeds up and centrifugal force acting on the weights forces them apart. This movement is transmitted to the fuel injection pump control rods to reduce the fuel input to the engine.

Continued..........

The control rod stop is also set and sealed. Whilst the control lever is held in the full fuel position and the engine is turning on the electric starter motor, the control rod will contact its screwed stop. When the engine fires and speeds up, the governor weights move apart, pulling the fuel control rod into a reduced dual setting. The extra fuel injected whilst starting is called the excess fuel for starting, the amount is controlled by the control rod stop screw.



<u>IDLING DAMPER</u> An idling damper is fitted. A spring loaded plunger bears against the governor floating lever whilst the latter is in the idling setting, damping out quick movements to prevent hunting whilst idling. To adjust, check and set correct idling speed, then screw in the damper slowly until idling speed increases. Unscrew the damper again to restore the normal idling speed, retract it a further half turn and lock up. Test by revving up engine and then checking whether the speed drops back to a steady idling value. Check whether engine can be stopped.

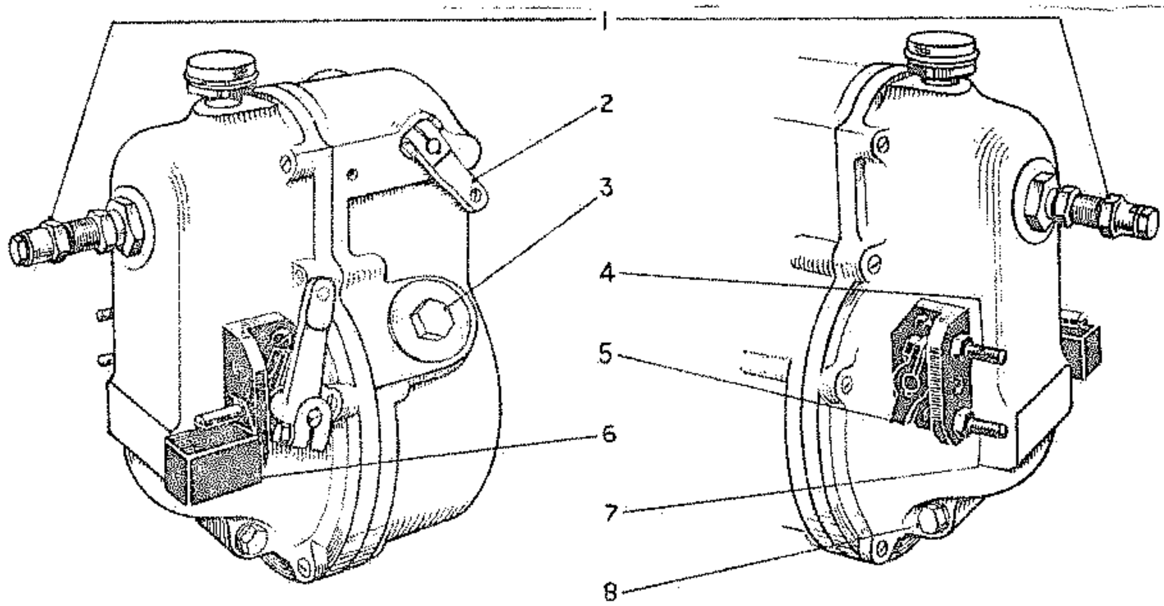


Fig. 79. The governor.

1. AUXILIARY IDLING DAMPER.
2. STOPPING LEVER.
3. OIL FILLER PLUG.
4. IDLING SPEED STOP.
5. BEARING PAWL.
6. MAXIMUM FUEL STOP COVER.
7. SECONDARY MAXIMUM FUEL STOP.
8. OIL LEVEL PLUG.

Continued.........

MECHANICAL TRANSMISSION DIESEL MULTIPLE UNITS

This transmission comprises of the following components:-

(1) The Fluid Coupling which fulfils the following functions:-

(a) To connect and disconnect the engine from the remainder of the transmission.

(b) To take up the drive from the engine smoothly and to absorb any shock loading.

(2) The Free Wheel Unit. This takes up the drive from the fluid coupling when the speed of the input shaft exceeds that of its output shaft. Should the speed of the output shaft exceed that of the input shaft, then no drive is transmitted back to the fluid coupling and engine, i.e. it 'free wheels'. This allows the engine speed to be at idling r.p.m. whilst the remainder of the transmission from the free wheel is rotating at a considerably higher speed during coasting.

(3) The Four Speed Gearbox Unit. This is a mechanical torque multiplying device enabling the engine torque to be considerably increased for starting and accelerating the train. Because of the large masses that have to be accelerated in train haulage, it is not practicable to use sliding mesh gears, therefore, constant mesh gears are invariably used. The various gear ratios being determined by the engine minimum and maximum speed and the maximum rail speed.

(4) The Final Drive Gearbox Unit. This unit fulfils the following functions:-

(a) To convert the longitudinal drive from the gear box through 90° to a transverse drive at the roadwheel axle.

(b) Provides the means of reversing the direction of travel.

(c) Has a permanent speed reduction between input and output giving a constant multiplication of engine torque.

(d) Provides the means of isolating the road wheels from the remainder of transmission.

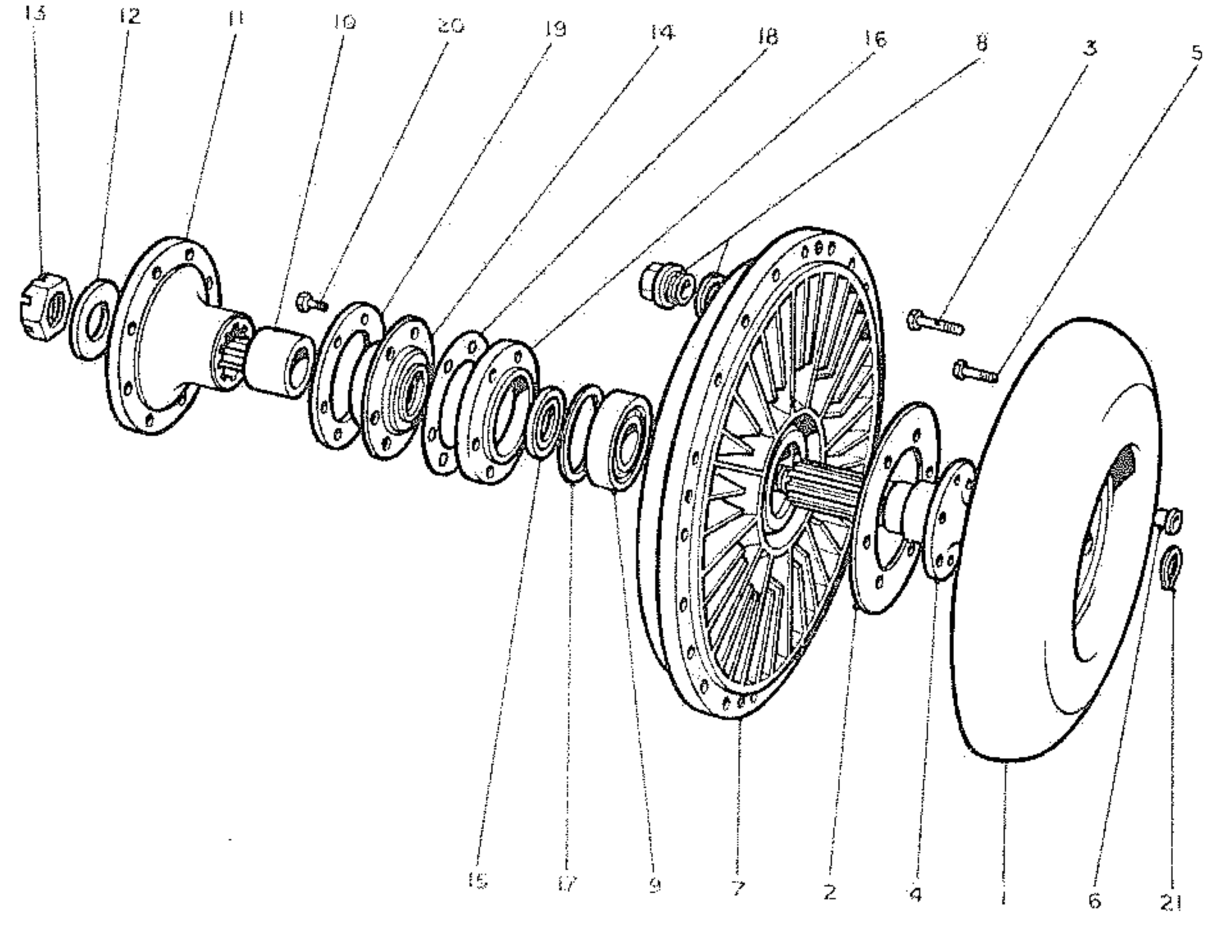
(5) The shafts connecting the engine to the road wheels between the following components:-

Fluid Coupling - Free Wheel - Gearbox - Final Drive

Construction (Cont'd)

The impeller is bolted to the engine crankshaft flange whilst the runner is bolted to a flange on a hollow stub shaft having a spiggoted bearing within the hub of the impeller. The impeller body has a dish shaped housing bolted to its periphery which encloses the runner, the stub shaft of the latter passing through a suitable sealing gland in the housing and is connected by a short shaft to the free wheel.

The coupling contains a fluid which should occupy about 75-80% of the total volume. Type of fluid used is detailed in the oil and grease section at the rear of the notes.



Exploded view of fluid coupling (L - type).

1. RUNNER.
2. BAFFLE PLATE.
3. BOLT.
4. RUNNER SHAFT.
5. BOLT.
6. FERRULE.
7. REAR CASING.
8. PLUG.
9. BEARING.
10. DISTANCE PIECE.
11. COUPLING FLANGE.
12. WASHER.
13. NUT.
14. OILSEAL.
15. RUBBING WASHER.
16. SPACER RING.
17. JOINT.
18. JOINT.
19. STIFFENING RING.
20. SETSCREW.
21. CIRCLIP.

The former is used when it is required to engage and disengage the drive irrespective of speed.

The latter is used when the diesel engine is only required to pick up the drive as it accelerates to working speed. The action in this case being that at engine idling speed no appreciable torque is transmitted and therefore no load is put on the engine, but as the input speed is increased the load is picked up gradually and shocklessly until the full output speed is obtained.

Irrespective of the type of coupling if the load on the engine becomes too great the output shaft slows down (slip increases) but the torque is maintained. In fact the full engine torque can be maintained against the installed output shaft. But of course when this occurs the whole power of the engine is put into the fluid which of course rapidly heats up.

DRAG

Although no appreciable torque is transmitted at idling speed there is a little drag and the runner (output) tends to turn which may be a nuisance with certain types of transmission. This is obviated to a great degree by an "anti drag baffle" which destroys the fluid vortex at low speeds. It has little effect at working speeds since centrifugal force throws the vortex outwards away from the axis of rotation and thus away from the baffle.

CARE IN SERVICE

(1) A hydraulic coupling should not be allowed to run for long with a high degree of slip taking place since the slip represents energy being put into the fluid and causing it to heat up.

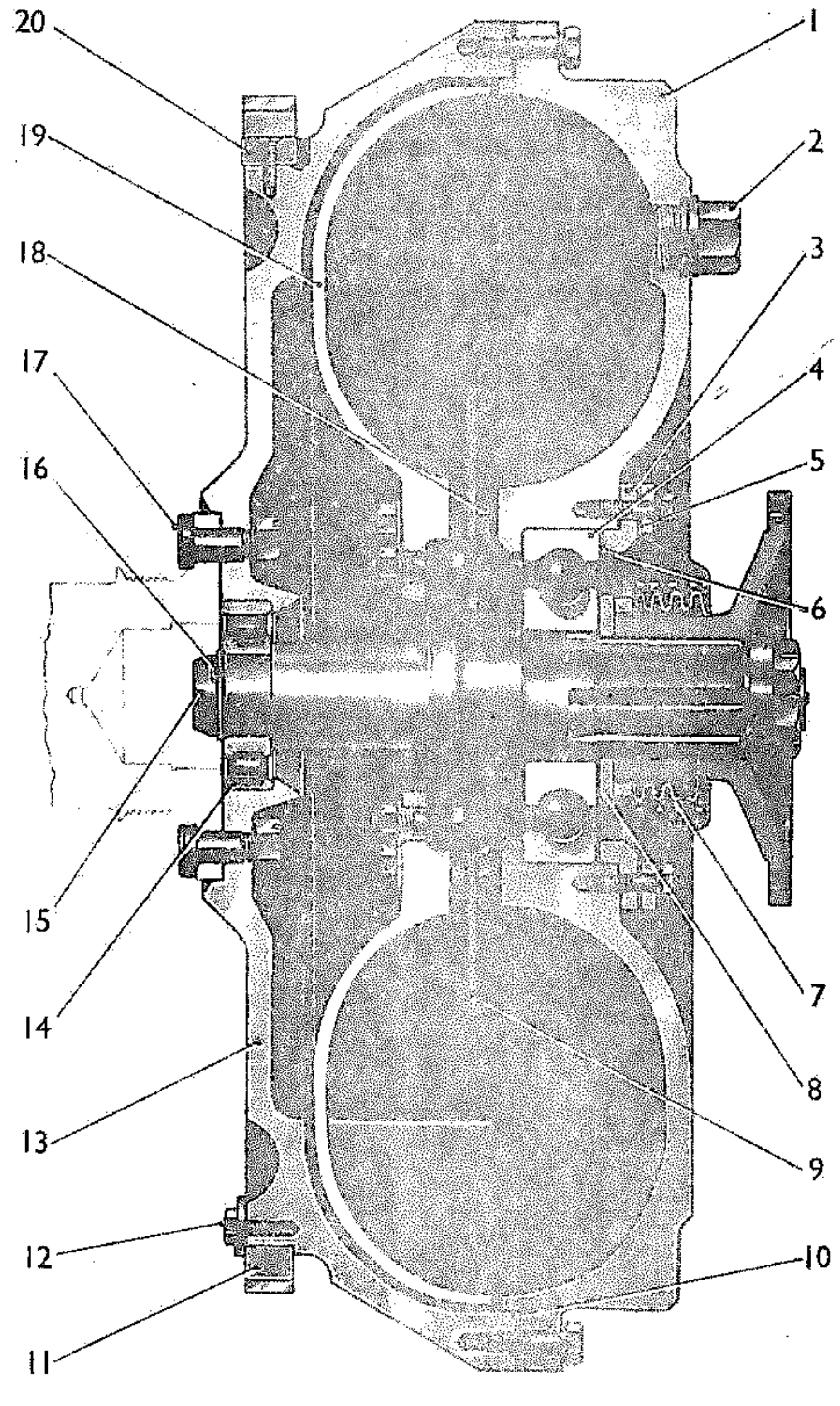
(2) A traction type coupling should always contain the correct amount of fluid. If it is under-filled excessive slip takes place and over-heating results.

It is equally important that the coupling should not be overfilled, as this would not allow for expanion of the fluid when its temperature is raised in service causing leaking seals or even bursting of the coupling. To prevent the coupling being over-filled the filling plugs are positioned at some distance below the outer periphery so that fluid in excess of this level cannot be added.

(3) If the coupling is allowed to overheat the fluid seal on the output shaft may be damaged on the main joint between the two halves of the coupling. Failure of either of these would cause serious fluid leaks and put the coupling out of action. Such leaks may also be dangerous since the hot fluid spraying out may cause burns. Extreme caution should be taken if the fluid has been thrown from the coupling as it will give off a toxic vapour when hot.

The unit must be left to stand until all heat has been dispersed before work should be carried out.

N.B. : See relevant instructions issued to deal with this situation.



Section through fluid coupling (A - type).

1. DRIVING MEMBER.
2. FILLER AND DRAIN PLUG.
3. ADAPTER RING.
4. RUNNER SHAFT BEARING.
5. PAPER JOINT.
6. PAPER JOINT.
7. BELLOWS GLAND.
8. RUBBING RING.
9. OIL DEFLECTOR PLATE.
10. PAPER JOINT.
11. STARTER RING.
12. STARTER RING RETAINING SETSCREW.
13. FLYWHEEL.
14. RUNNER SHAFT SPIGOT BEARING.
15. RUNNER SHAFT.
16. RUNNER SHAFT SPIGOT BEARING CIRCLIP.
17. CRANKSHAFT FLANGE BOLT.
18. OIL DEFLECTOR PLATE RETAINING BOLT.
19. DRIVEN MEMBER.
20. STARTER RING KEY.

THE WILSON FOUR SPEED EPICYLCIC GEARBOX

In the lesson on the fluid coupling it was mentioned that there is no complete break in the coupling effect between the impeller and the runner even at engine idling speed, resulting in some 'drag' drive being transmitted to the gearbox, which precludes the use of sliding mesh gears even if synchromesh is employed. Some form of gearing is necessary with which changes of ratio can be made irrespective of complete freedom of drive between engine and transmission during the change. This requirement is met by the use of epicyclic planetary gears which requires no gear shifting, since all gears are in constant mesh.

There are many forms of gearbox used on diesel locomotives and multiple-unit trains, but the Wilson gearbox is used in all mechanical multiple-units. It has the following main characteristics:-

(1) It is simple to control because of:-

 (a) its constant-mesh epicyclic gearing

 (b) its power-operated gear change

(2) Each indirect gear has its own epicyclic gear trains and suitable compounding of these gear trains varies the output ratio. The 1st, 2nd and 3rd ratios are engaged by compounding the gear trains, whilst the fourth gear is a direct drive.

(3) As the gearbox is used in conjunction with a fluid coupling there is no need for an external clutch.

(4) The controls are electro-pneumatic, which ensures that a number of gearboxes make the same gear change at the same time.

The gearbox is based on constantly-meshed gear trains which can be coupled in different ways to give different output speeds, as explained below.

The duty of the gear trains is to transmit power from the engine input shaft to the output shaft; there are three ranges of speed, and also a direct drive making the fourth range.

The simple epicyclic train is composed of an internally toothed annulus, two or more planet wheels and a sunwheel. The planet wheels are in mesh with the sunwheel and the internally toothed annulus, and are carried on a planet wheel carrier. The sunwheel is driven by the input shaft. If the planet carrier is held the annulus will revolve and if the annulus is held the planet carrier will revolve.

EPICYCLIC GEAR TRAIN : PRINCIPLE OF OPERATION

From the diagrams showing the general principle, it will be seen that the driving shaft is revolving clockwise, causing the sunwheel to revolve in the same direction which, in turn, drives the planet wheels in an anti-clockwise direction. The planet carrier is not revolved when the planet wheels are revolving round their own axes and the brake band is not applied on the annulus; in this case the annulus revolves in the same direction as the planet wheels, i.e. anti-clockwise, and no power is transmitted in neutral gear.

The position is changed when the brake band is applied to the external surface of the annulus (see the lower diagram). The driving shaft transmits the anti-clockwise movement to the planet wheels through the sunwheel, but as the annulus is now locked the planet wheels revolve round their own axes, while their teeth, engaging in the stationary teeth of the annulus, force their centres to move in the clockwise direction. As the three planet wheels are held together by the planet carriers the planet carrier is revolved in the clockwise direction and power is transmitted. The rotary direction of travel of the various parts when the brake band is applied is shown (arrowed).

FIRST SPEED

Fig. 64 represents the first-speed gear train in schematic form and explains the operation of the first gear. It is assumed throughout these explanations, for all speeds, that the input shaft is revolving. It will be seen that the input shaft is connected direct to the sunwheel.

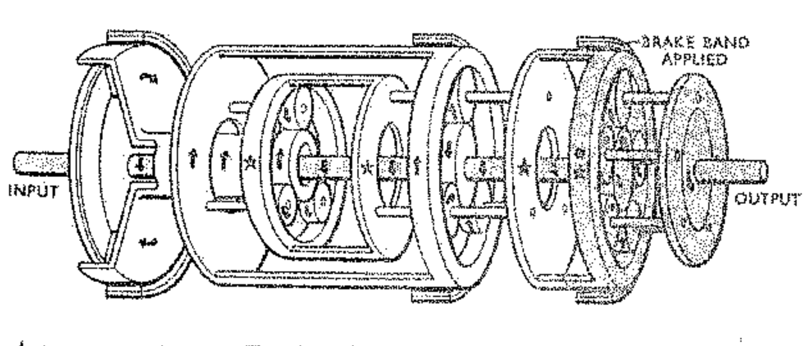


Fig 64 **Epicyclic Gear Train: First Speed**

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

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

THIRD SPEED

Third speed (Fig. 66) is obtained from the added motion which the third-speed train passes to second speed and on to first speed. Summarising: Second gear is used to speed up first gear for second speed range. Third gear is used to speed up second gear which in turn will further speed up first gear for third speed range.

As the sunwheel of the third train is smaller than the sunwheel of the second train, the effect is to increase the speed at which the second-train planet wheel runs round the second-train sunwheel. It follows as a direct consequence of this that the speed at which the first-gear planet wheels rotate around their sunwheel is also increased, thus causing the output shaft to revolve faster for the same number of engine revolutions as before.

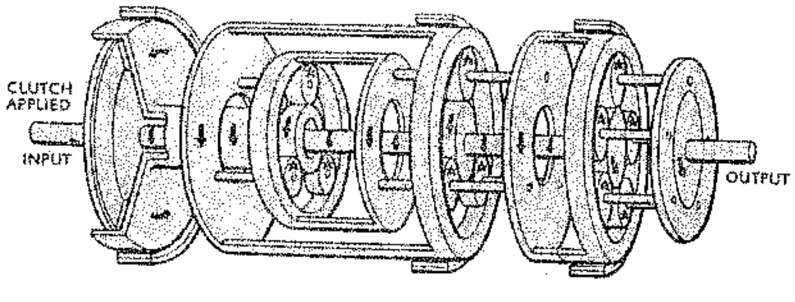


Fig. 67 Epicyclic Gear Train: Fourth Speed

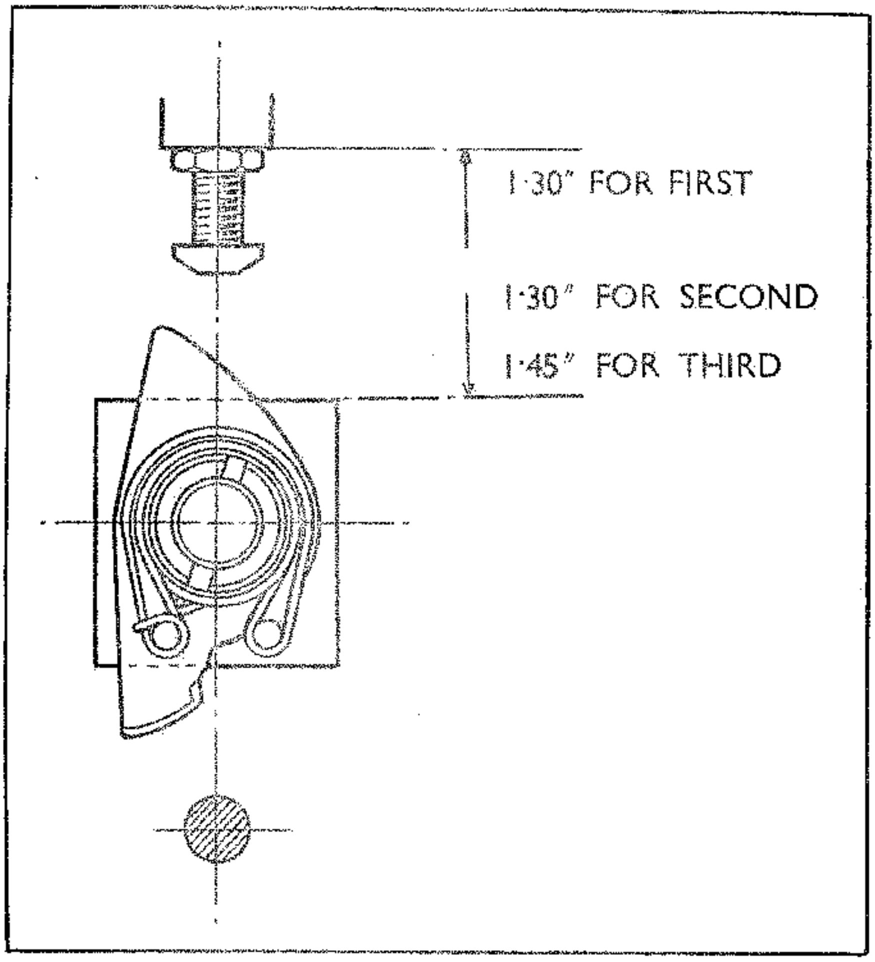
FOURTH SPEED

In Fig. 67 the fourth-speed gear is not engaged by applying a brake band but by means of a clutch which connects the sunwheel of the third-speed train to the input shaft and thus locks all the running gears together, which then revolve with the main shaft. It should be noted that there is no rotation of any of the planet wheels about their pins. This arrangement gives a very efficient drive in top gear.

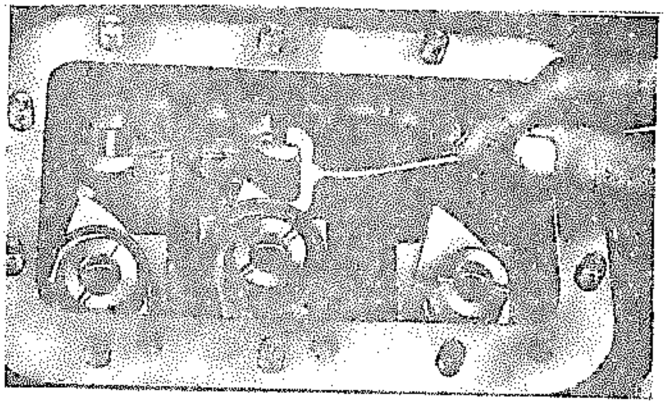
OPERATION OF BRAKE BANDS AND ASSOCIATED MECHANISM

From the previous notes it will be appreciated that the various gear ratios are obtained by restraining one element in each gear train by means of a contracting brake band. These are anchored to the gearbox casing to provide the necessary reaction point. For direct drive (4th speed) a multiplate clutch is used.

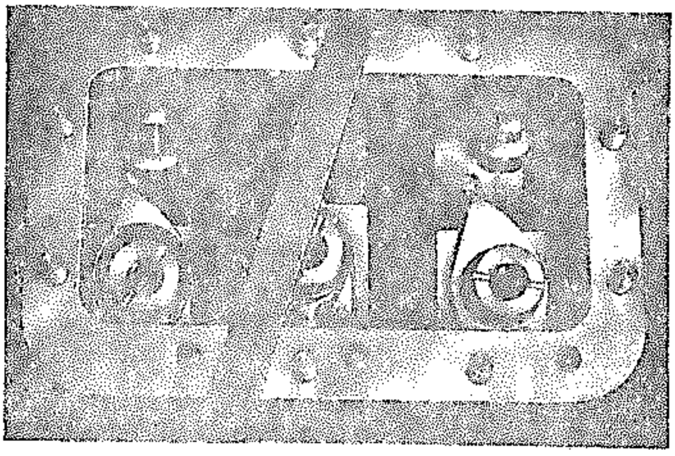
The brake bands and clutch are operated by air pistons working in cylinders mounted in the gearbox casing. Compressed air is supplied via a reducing valve from the units air system. The admission and release of air from a cylinder being controlled by an electro-pneumatic valve (E.P.V.) which in turn is electrically controlled by the drivers' gear selector. When the gear selector is moved into a gear engaged position air flows from the appropriate E.P.V. to its associated cylinder. When a different gear is selected, air is exhausted from the previous cylinder through its E.P.V. and air admitted to the cylinder of the gear selected from its associated E.P.V.



Brake Setting Dimensions.



GAUGE APPLICATION. This shows where the gauge should be applied.



Checking Movement of Adjuster Nut

Operating sequence of Brake Bands

The operating mechanism is shown in the diagrams opposite. The upper diagram shows the brake band released.

When a gear is selected air is admitted to the brake cylinder (21) forcing the piston (22) upwards. This movement applies an upward force to the thrust pad (12) which pivots about its knife edge on the hooks, thereby raising the adjuster mechanism (7, 8, and 9) and with it the pull rod (11). Since the pull rod is attached to the lower end of the outer band (3) (the upper part of which is anchored by the hooks) this action constricts the brake band.

The arrangement of the band brake and its operating gear are of great interest, much care and thought having been expended thereon.

It features are as follows:-

(a) Application of the brake band does not involve any load on the shaft or shaft bearings.

(b) The bands are self centralising and therefore come off uniformly when released and thus do not rub on the drums.

(c) The brake bands are automatically adjusted for wear and kept at the correct setting.

These features are ensured by the following means:-

(i) The bands are floating and are supported only by anchorage depending on friction so that the position taken up by the band when "OFF" is that necessary having regard to the state of wear of the brake bands at the time.

(ii) Brake band consists of two concentric bands whose friction linings are situated side by side. The outer band when constricted by the brake mechanism closes the inner band both linings being brought into contact with the drum.

(iii) A torque link prevents rotation of the combined band assembly under the influence of the torque reaction.

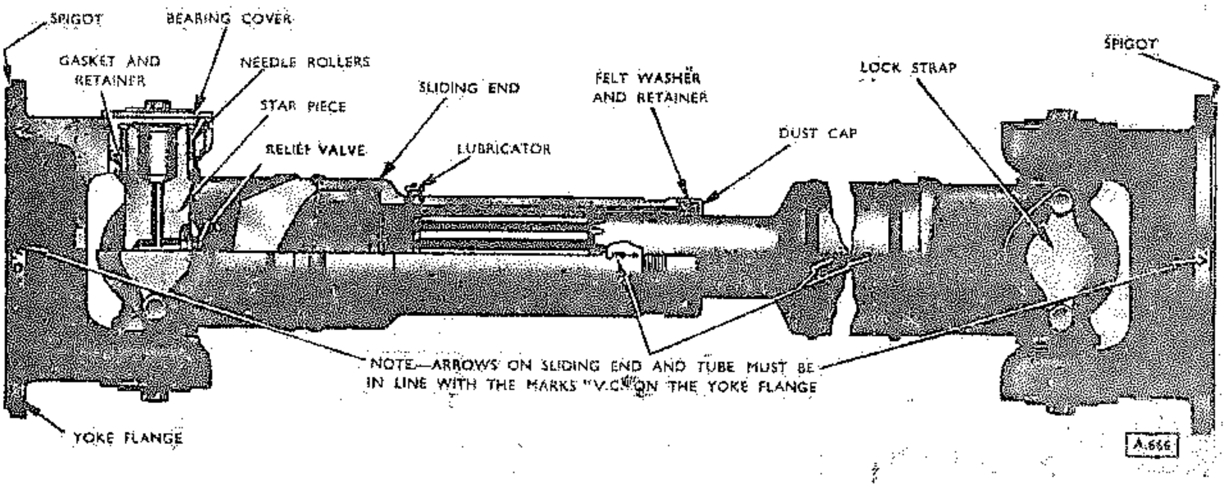
(iv) Continuous automatic adjustment is obtained as described on the previous pages.

AIR PRESSURE

Since air pressure is relied on, not only to engage a gear, but also to hold it in engagement, it is imperative that the air should be maintained at the prescribed figure. If not the bands and multi-plate clutch will slip, causing heat and excessive wear.

Restrictors are fitted in the pipe lines supplying 1st, 2nd and 3rd air cylinders. The purpose of these is to control and synchronise the application and release of the brake bands.

PROPELLER SHAFTS.



Section through propeller shaft—needle roller bearing type joints.

FINAL DRIVES

The gearbox, by means of which the cardan shaft running longitudinally in the frame is connected to the axle, is usually referred to as the final drive.

In diesel mechanical transmissions for diesel trains the final drive usually fulfils the following functions:-

(1) changes the plane of the drive from longitudinal to transverse.

(2) provides means of reversing direction of travel.

(3) provides a reduction gear

(4) provides a means of isolating the rest of the transmission from the road wheels.

The bevel type of final drive is very popular because in addition to changing the plane of the drive through 90° (Item 1 above) it also provides a ready means of reversing the direction of travel (Item 2 above) and at the same time affords a means of isolating the rest of the transmission from the road wheels (Item 4 above).

A bevel type of final drive can be arranged in two basic ways, viz:-

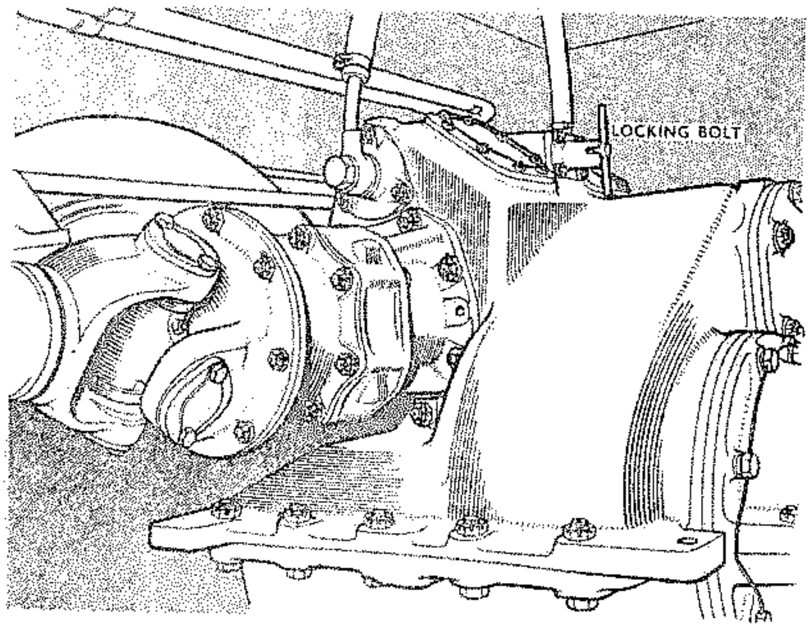
(a) A bevel pinion fixed to the input shaft which is in constant mesh with two bevel gears mounted freely on the driven shaft but so arranged that either can be "clutched" thereto.

(b) Two bevel pinions mounted freely on the input shaft but so arranged that either can be "clutched" to it, these two bevel pins being in constant mesh with a gear fixed to the driven shaft.

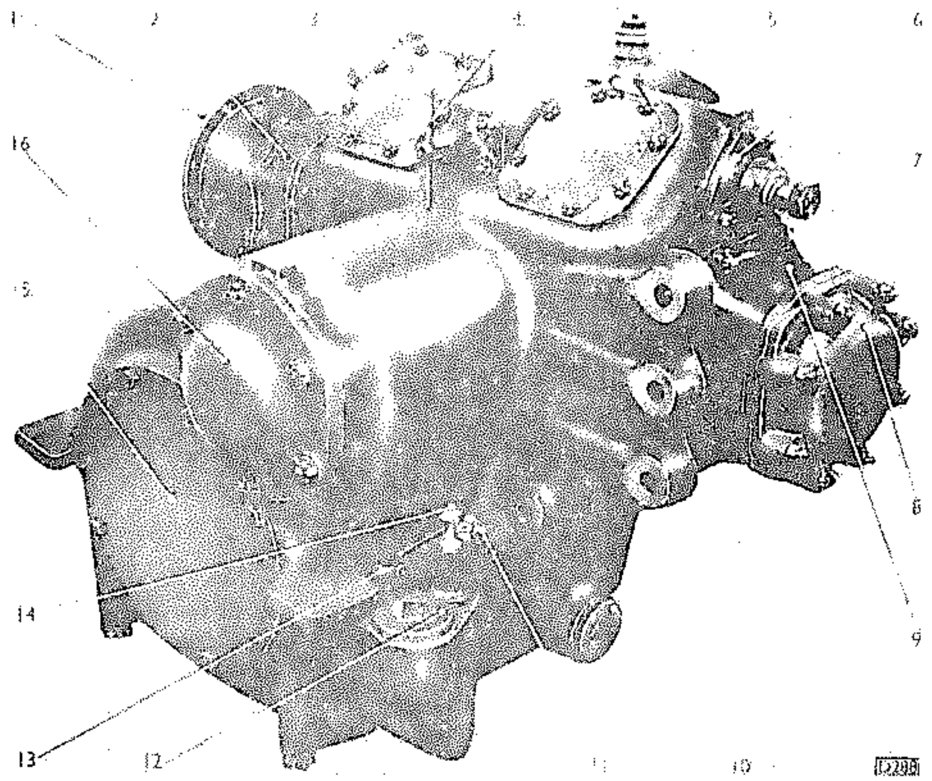
B.U.T. RAIL CAR FINAL DRIVE

This, is a double reduction gearbox the first reduction being in the right angle spiral bevel drive, the second in a spur wheel and pinion to the axle. This gives a total reduction of 2.81 to 1 for the complete unit.

The gearbox is carried on the axle on parallel roller races, location being by a ball race.

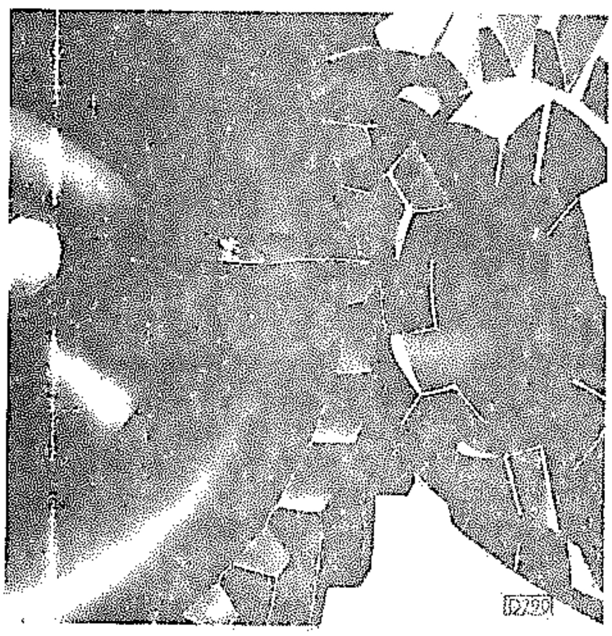


Diesel Railcar: Final Drive and Reversing Mechanism

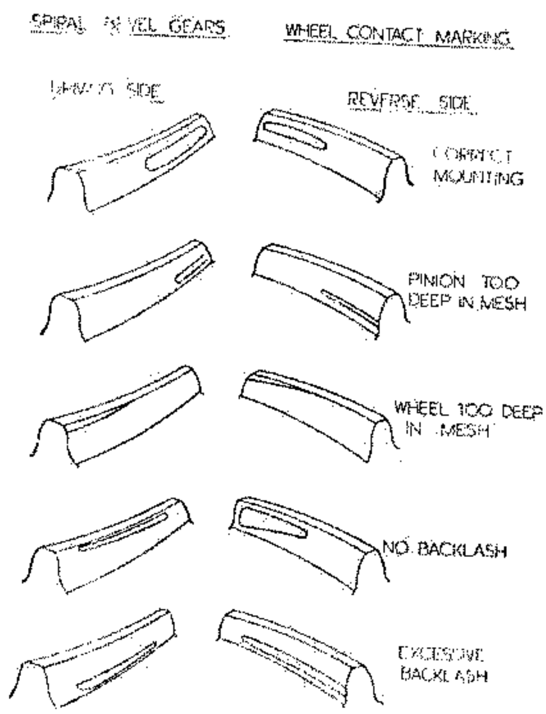


1. DRIVING SHAFT COUPLING FLANGE.
2. PRIMARY BEVEL PINION BEARING HOUSING.
3. INSPECTION COVER.
4. " NEUTRAL " LOCKING PLUNGER.
5. AXLE BREATHER.
6. AIR CYLINDER.
7. AIR SUPPLY PIPE BANJO PIN AND PISTON STOP BOLT.
8. REVERSE BEVEL PINION BEARING COVER.
9. REVERSE BEVEL PINION HOUSING.
10. OIL DRAIN PLUG.
11. FINAL DRIVE CASING BOLT.
12. OIL FILLER PLUG.
13. FINAL DRIVE CASING SET-SCREW.
14. OIL DIPSTICK.
15. TEMPORARY COVER.
16. BEVEL WHEEL BEARING COVER.

Final drive unit. (The indicator switch is not shown in this illustration).



Method of measuring bevel wheel and pinion backlash



Marking on teeth of spiral bevel wheel.

SECTION TWO

ELECTRICAL EQUIPMENT.

INDEX

INTRODUCTION TO ELECTRICAL EQUIPMENT ON DIESEL RAIL CARS

Unlike the main line locomotive which has only to provide the motive power and in certain cases train heating for hauling standard rolling stock, the diesel railcar, in addition to these requirements, has to provide the room for the passengers and their luggage.

In order to provide the maximum amount of space for the conveyance of the passengers, the power units, transmission etc. are mounted beneath the underframe of the railcar.

It should be noted that for ease of identification all components mounted on the left hand side of the railcar or driven from the engine on that side are referred to as No. 1 component e.g. No. 1 Gearbox, while those mounted on the right hand side are referred to as No. 2 component.

Diesel Rail Cars are of two types, namely, Power Cars which contain diesel engines and transmission gear, and trailer cars which do not. A 'set' comprises one Power Car coupled to one Trailer Car 1 x 2 car set or two Power Cars with a centre Trailer Car to form 1 x 3 car set.

Each Power and Trailer Car (1 x 2 Car set), has a driving cab and these are arranged to enable the train to be driven from one end or the other. The control of the train from the selected driving cab is arranged electrically by means of 'train wires' which run from one end of the train to the other. The connections between adjacent cars being made by multicore flexible cables with plugs at each end and which are known as jumpers. The function of the 'train wires' and associated electrical circuits is to enable the driver at the selected cab to exercise remote control and receive information in connection with the following items:-

1. Selection of Forward or Reverse gears on the final drive axles of each power car.

2. Indication of direction of the above gears, i.e., evidence by means of an indicator lamp that the gears are actually in mesh, and that adequate air pressure is available.

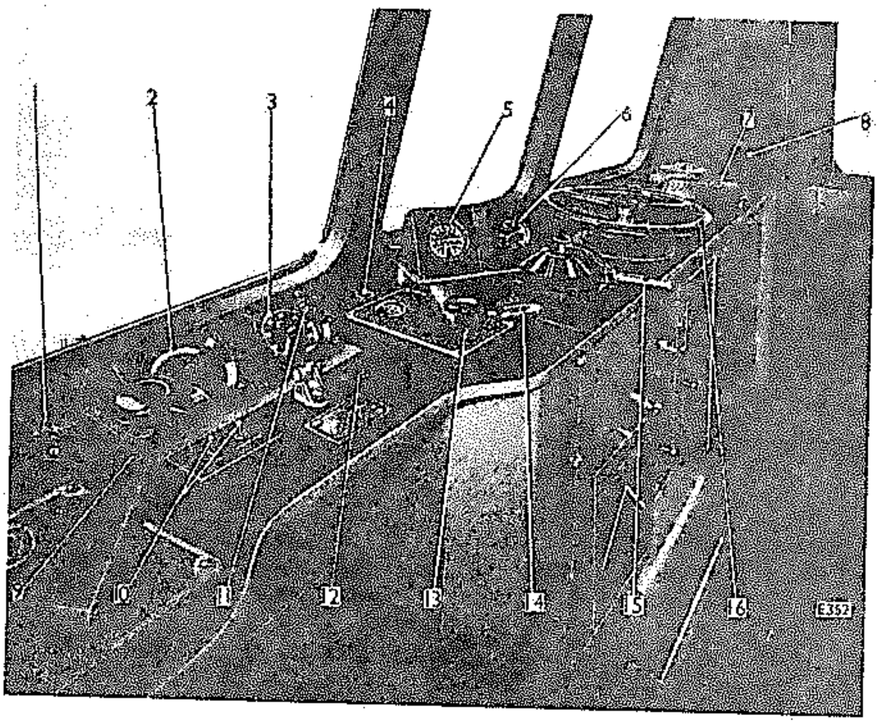
3. Selective starting of the diesel engines throughout the length of the train - an electrically operated starter motor is fitted to each engine.

4. Indication that each diesel engine has 'fired' and is operating with adequate oil pressure.

5. Stopping of all engines - i.e. one 'Stop' press button which enables all engines to be stopped simultaneously.

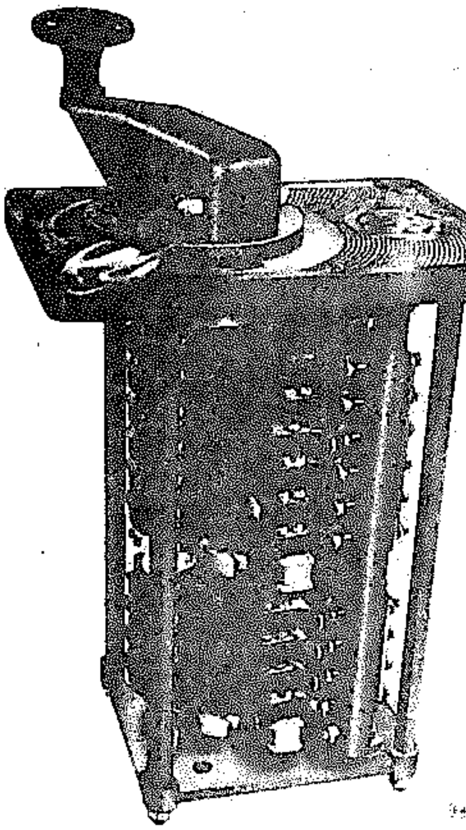
6. Control of engine throttle settings by means of 4 electro-pneumatic valves per Power Car.

7. Selection of gears by means of 4 electro-pneumatic valves.

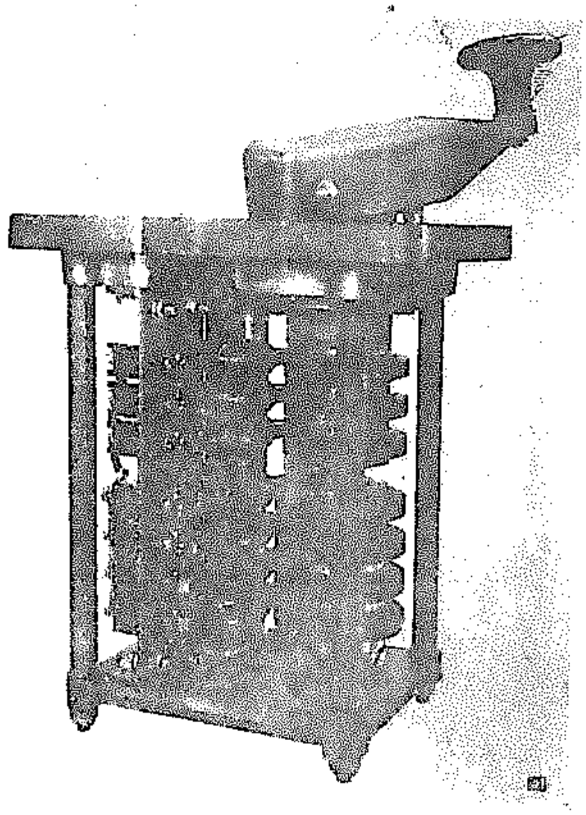


Driver's controls (Metropolitan Cammell).

1. WINDSCREEN WIPER VALVE.
2. ENGINE SPEED INDICATOR.
3. SPEEDOMETER.
4. EMERGENCY LIGHT SWITCH AND SOCKET.
5. VACUUM GAUGE.
6. AIR PRESSURE GAUGE.
7. GUARD'S BRAKE CONTROL VALVE
8. D.S.D. SWITCH.
9. THROTTLE CONTROLLER.
10. { ENGINE SPEED INDICATOR CHANGE OVER SWITCH (RIGHT). PANEL LIGHT SWITCH (LEFT).
11. HORN SWITCH.
12. BUZZER BUTTON.
13. GEAR CHANGE LEVER.
14. FORWARD AND REVERSE LEVER.
15. VACUUM BRAKE LEVER.
16. HANDBRAKE WHEEL.



Gearbox and final drive controllers showing contacts.



Throttle controller showing contacts.

C.A.V. "AXIAL" TYPE STARTER MOTOR

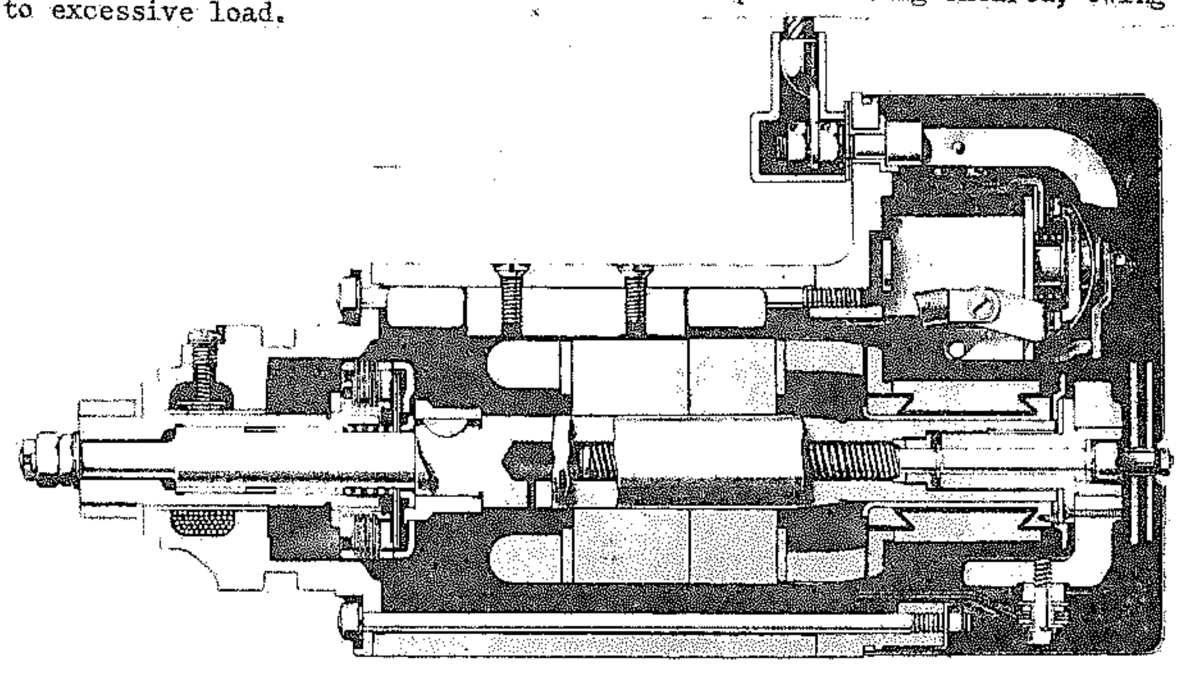
This starter, known as the "Axial" type, is so termed because the armature with its shaft is capable of an axial movement in its bearings and when extended it engages the pinion with the teeth on the flywheel. It is held in a disengaged position by means of a coil spring fitted inside the shaft at the commutator end, the armature being thus kept out of complete register with the pole shoes.

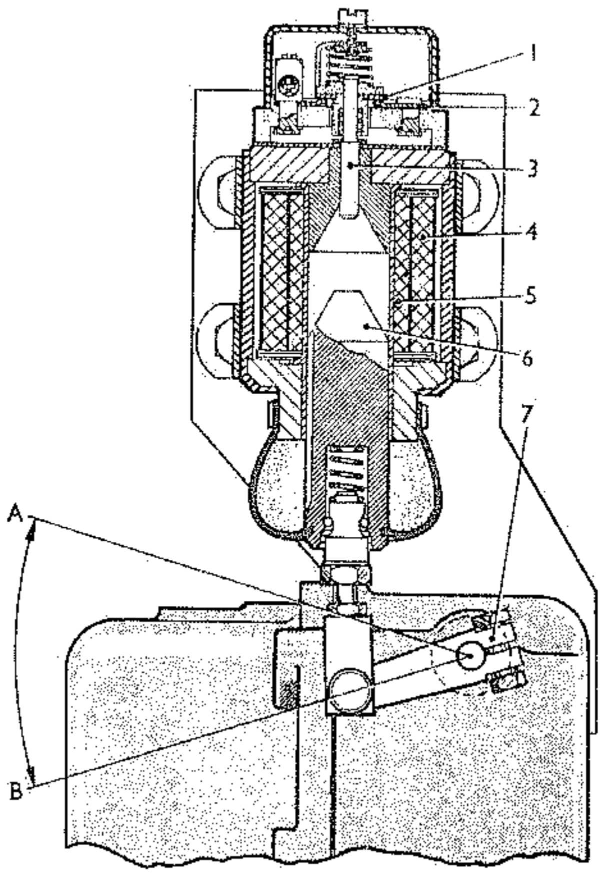
The field winding of this machine consists of the main series winding, the auxiliary series winding and auxiliary shunt winding. When the two-stage starter solenoid switch is energised its first stage set of contacts close immediately causing a small current to flow through the auxiliary windings, causing the armature to rotate slowly.

Simultaneously, the magnetic field set up pulls the armature forward, which brings the pinion gently into mesh with the engine flywheel teeth. This movement of the armature also causes the tripping disc to operate the tripping lever which releases the second stage contacts of the solenoid switch and these close so completing the main circuit. The full current from the battery then flows through the armature and series field winding, and the motor exerts its full torque on the engine. In "Axial" starters with straightforward windings, directly the engine gets under way, the motor current is greatly reduced, the magnetic field is decreased in power, the tension of the spring overcomes the force exerted by the magnetic field and the pinion automatically disengages. This is not so, however, on machines fitted with "holding on" windings, in which case the pinion is held in mesh with the flywheel teeth until the starter button is released.

On diesel railcars where a number of starter motors are brought into operation together by the driver pushing one start button, it is necessary to use a form of automatic cut out and isolating of each starter motor whenever its particular engine has actually fired and started, and for this purpose use is made of the engine speed tacho-generator as the sensing device.

A very special feature of Axial starters is a unique overload device, preventing damage occurring owing to engine backfire. This is a simple screw and spring-loaded clutch arrangement which has a slipping torque about three times the lock torque of the starter, but is below shearing strength of the pinion teeth. This device works extremely well and is a positive safeguard against the teeth of the pinion being sheared, owing to excessive load.





Section through engine shut-down solenoid.

A. STOP POSITION.
B. RUN POSITION.

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

The shut down solenoid is self re-setting, and consists of two coils:-

1. "Make" coil, of approximately 2 ohms res. This should be in circuit only during the initial "lift" of the solenoid plunger, which when fully lifted switches the "make" coil out of circuit.

2. Hold coil, of approx. 44 ohms res. This is of sufficient ampere turns to hold the solenoid plunger up when the plunger has been fully lifted.

To avoid "burn-out" of these solenoids ensure that they are correctly adjusted i.e. with the plunger fully lifted.

1. The engine can be shut-down from full R.P.M.

2. The safety contacts are open and that only the hold coil is in circuit.

BATTERY CHARGING AND LIGHTING CIRCUIT

D.C. GENERATOR

On certain railcars this is based on the use of a shunt wound totally enclosed dynamo which, in conjunction with a regular panel, enables the battery to be charged at a constant current until the battery is almost charged (approx. 30 volts) after which constant voltage charging is arranged which gives a taper or reduction in current as the battery voltage continues to rise. This arrangement has the following merits:-

(a) batteries can be recharged at a fast rate.

(b) the final taper current characteristic prevents undue gassing and temperature rise.

(c) size and weight of dynamo is a minimum when charging current is held constant.

(d) the voltage variations produced at the lamps under varying battery charge and speed conditions are relatively small.

The following disadvantages also apply : (a) Charging only available when vehicle is moving. (b) High maintenance costs.

A typical schematic diagram of electrical connections is shown.

The dynamo is belt driven from either a road wheel (Trailer Car) axle or from the engine gearbox output shaft (Power Car) and when the train is accelerating the voltage generated first energises (at approx. 16 volts) the Regulator Relay which connects in circuit the operating coil of the voltage regulator and the voltage coil of the cut-out relay. At approx. 27 volts the cut-out relay energises and connects the cut-out contactor in circuit, which in turn, connects the dynamo to the battery via a swamp resistance (also the current coils of the cut-out relay and current regulator).

At the same time a lamp resistance is connected in series with the battery feed to the lamps.

The swamp resistance helps to maintain a steady charging current and the lamp resistance helps to maintain steady voltage across the lamps when charging is in progress.

Two carbon type regulators are provided, one working on current and the other on voltage change. The combined effects of the two regulators being such that the maximum rated charging current is held reasonable constant up to approximately 30 volts after which the generator voltage is held constant giving a taper current characteristic.

The voltage regulator has several resistances connected in series with its operating coil acting as follows:-

(a) The voltage dividing resistance (VDR) is a means of pre-setting the degree of response to a change in generated voltage and the response is a maximum in position 1 and a minimum in position 4.

(b) The voltage adjusting resistance (VAR) enables a final adjustment of the regulator to be made.

(c) The lamp voltage selected resistance (LVS) is a means of selecting the required voltage when the dynamo is charging and the lamps are in circuit, i.e. extra (valts and) amps if lamps are in circuit.

(d) The voltage selecting resistance (VSR) is a means of varying the difference in voltage obtainable with or without lamps in circuit.

The cut-out relay is provided with a resistance (TCR) which has a negative co-efficient of resistance to compensate for the increase in resistance occurring in the voltage coils of this relay.

Motoring Resistances (MTR) may be provided to enable the dynamo to be checked by running it as a motor (belt removed).

On trailer cars the dynamo has brush gear which is rotated through 90° according to direction of travel, this acting as an automatic reversing switch and ensures that the dynamo polarity is unaffected by a change in direction of rotation.

The lights can be switched on or off throughout the train by means of 3 train wires which in conjunction with 2 small relays (one 'ON and one 'OFF') control the operation of the main lighting contactor L.C. L.C. has two coils, one a 'making coil' which is controlled by the 'ON' relay, and the other a 'hold in' coil which is controlled by the 'OFF' relay.

A.C. ALTERNATOR

Description

Where an A.C. Alternator is used this is driven from the freewheel (motor coach) or axle (trailer coach).

The generator is a 24V 50 amp 3-phase totally enclosed machine designed to charge railcar batteries at a steady rate under all loading conditions. The alternating output is fully wave rectified via silicon type rectifiers mounted away from the alternator in a convection air-cooled box. In addition to housing the rectifiers, the box also houses the current and voltage regulators and the protection unit which safeguards the charging system from damage in the event of a rectifier diod failing.

Merit of Alternator
(a) Charge whilst engine is idling.
(b) Reduced maintenance cost.
(c) Steady charge and current.

Field Coil and Rotor

The self-exciting field circuit normally obtains its energising current from the rectified output of the alternator. But in the initial build up period after the field is placed in circuit, by the operation of the driver's control relay, the field current is supplied by the batteries. However, once the rectifier output reaches charging potential the field current is supplied from the output.

At all times the field currents are fully regulated by the current and voltage regulators in the rectifier box.

Protection Unit

Any rectifier diode breakdown in the generator output circuit will cause an unbalance in the 3-phase supply from the alternator, will seriously overload the machine, and will drastically reduce the amount of d.c. current available for battery charging.

To safeguard the system against such a contingency an automatically operated protection unit consisting of a type 312-25 relay, a green testing light and push operated test button is incorporated with the rectifier unit.

This relay normally operates with the contacts closed, and as long as a balanced current from the positive and negative lines of the rectifier unit flows through the two opposite wound coils of the relay's common bobbin, the contacts will remain closed.

In the event of a failure of any diode of the rectifier these contacts will open and the green test light will no longer function. When this occurs a diode failure condition is indicated.

D.M.U. RAILCARS
RECTIFIERS AND ALTERNATORS - MAINTENANCE

RECTIFIERS

Insert and place control switch key to ON position in one driving cab.

Press test button on protection unit, where fitted, and check that green lamp is illuminated. If lamp fails to light, check bulb. If bulb satisfactory, rectifier unit is probably faulty.

To verify rectifier failure open protection unit and inspect relays. If one is closed, the rectifier is faulty and must be changed. TEST BOTH ALTERNATORS before fitting a new rectifier unit.

NOTES:-

(a) Alternators must NOT be run if the battery is disconnected from the rectifier unit.

(b) If it should be necessary to replace a faulty rectifier unit, it will be necessary to check the rotor field of both alternators to ensure that they are not short circuited, by disconnecting the rotor field and measuring the resistance of same which should be between 16-20 ohms.

ALTERNATORS

Check that all screws, nuts and terminals are tight. Check condition and clean slip rings, brush holders and brushes. Renew brushes if necessary.

Run alternators at top engine speed and listen for noise that would indicate worn bearings. Change alternator if necessary.

NOTES:-

(a) Alternators must NOT be run if the battery is disconnected from the rectifier unit.

(b) If it should be necessary to replace a faulty rectifier unit, it will be necessary to check the rotor field of both alternators to ensure that they are not short circuited, by disconnecting the rotor field and measuring the resistance of same which should be between 16-20 ohms.

Never allow the electrolyte to come in contact with the body or clothing as it is corrosive and will burn the affected part. If electrolyte is splashed on the skin or clothing the affected parts should be quickly soaked in tap water to limit the burning and further medical attention sought.

MAINTENANCE IN SERVICE (See Current Instructions)

The performance, good or bad, of a battery is largely determined by the treatment it receives in service, i.e. the way it is used and maintained.

In general the battery has been designed for the specific duty of starting the diesel engine.

Further demands on the battery in the form of providing lighting for inspection purposes etc. should be strictly contained and recourse made where possible to a shed supply.

In addition, the following points must receive correct attention:-

Check the electrolyte frequently and see that the level is never allowed to fall below that specified for the type of battery.

Top up with distilled or approved water only. Metal buckets, jugs or funnels must not be used for adding water to the battery.

The proper use of the automatic cell filter will eliminate overfilling and prevent spilling of water on the cell covers, and will make the topping up process simpler and speedier, especially where the cells are not readily accessible.

It is advisable to add the water just before the locomotive goes into service so that the charging current will mix the electrolyte.

If water is added and the battery left standing at very low temperatures the upper layer of the electrolyte may freeze and burst the container.

All cell connectors must be kept clean, tight and in good condition, and should be so installed as to prevent undue strain on the battery terminals and to avoid the cable being trapped between trays and battery compartment, damage to the insulation of the cable will give rise to short circuits.

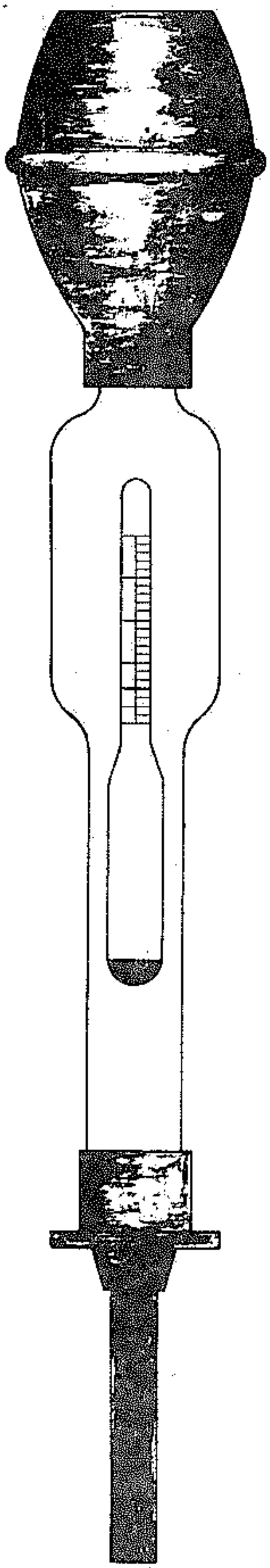
Recharging of the battery is normally carried out by equipment on the unit but supplementary charging may be carried out using depot installed chargers.

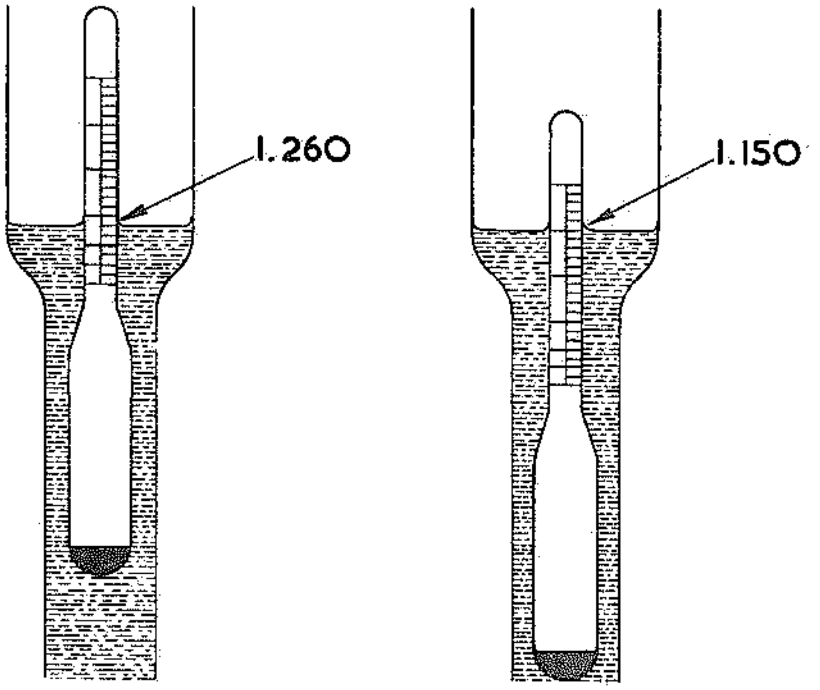
LEAD ACID BATTERIES

OVER-CHARGING

Overcharging produces corrosion of the positive grids and excessive gassing, which loosens the active material, particularly in the positive plates and results in a needless loss of water, requiring constant attention to keep the cell filled to the correct level with electrolyte.

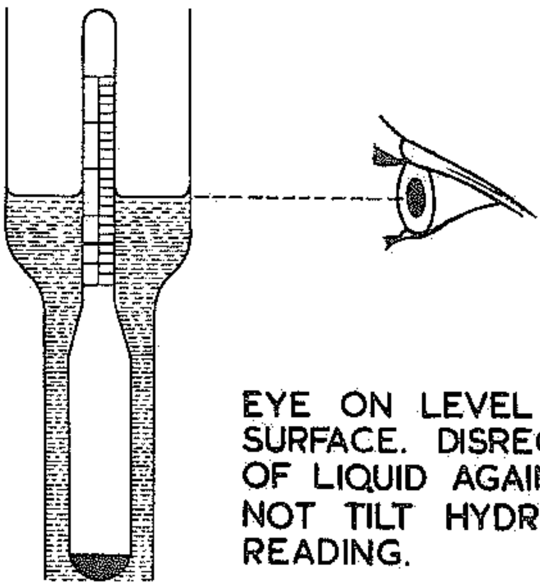
Occasional overcharging is beneficial, but habitual overcharging decreases the period of useful service that the battery can give.





HIGH FLOAT —
HIGH SPECIFIC GRAVITY.

LOW FLOAT —
LOW SPECIFIC GRAVITY.



EYE ON LEVEL WITH LIQUID SURFACE. DISREGARD CURVATURE OF LIQUID AGAINST GLASS. DO NOT TILT HYDROMETER WHILST READING.

USE OF HYDROMETER

ALKALINE, BATTERIES(NICKEL - CADMIUM)

"NIFE" ENGINE STARTING BATTERIES

GENERAL DESCRIPTION

The NIFE cell is constructed chiefly from steel and reference to **Page 74** will show that the Electro-chemical active materials are enclosed in finely perforated flat STEEL tubes, which in turn are assembled into STEEL frames, and securely locked together. This arrangement results in a plate of great mechanical strength. Positive and negative plate groups are insulated by ebonite rods and bolted to STEEL terminals; the complete assembly fits sungly within a STEEL container.

Intercell connectors are of COPPER, bolted to the cell terminals.

All external parts are rust-proofed by a cadmium and nickel plating process. The whole construction is very strong and capable of resisting the severest shocks and vibration.

The active materials are oxides of nickel and cadmium; and the electrolyte is an alkaline solution of potassium hydroxide. The electrolyte does not enter into any chemical union with the active materials, nor is there any local action between the active materials and the perforated steel retaining tubes, or between the electrolyte and the ebonite insulating rods.

Potassium hydroxide is in fact a preservative of steel and ebonite, and the steel tubes and plate frames act simply as metallic conductors for charge and discharge currents.

Electro-chemical action takes place only during charge and discharge; on open circuit there is complete chemical inertness within the cell. These are unique features for a storage battery and mean that it can stand idle without self-discharge or inherent deterioration.

CHARGING THE BATTERY

The battery is usually float-charged across the **dynamo/alternator** which supplies the secondary loads, and as the voltage of this system is controlled within close limits, charging is automatic and on the constant potential system with varying current.

In this sytem the battery accepts only a small current when in a high state of charge but a heavier current when deeply discharged. Values of these currents are given as an example for a type D.L.15 cell.

On this system the battery regulates its own charging current automatically. When in a high state of charge the value of the charging current is appreciably less than when the battery is in a lower state of charge, sufficiently accurate for all practical purposes, is obtained by noting the value of the charging current.

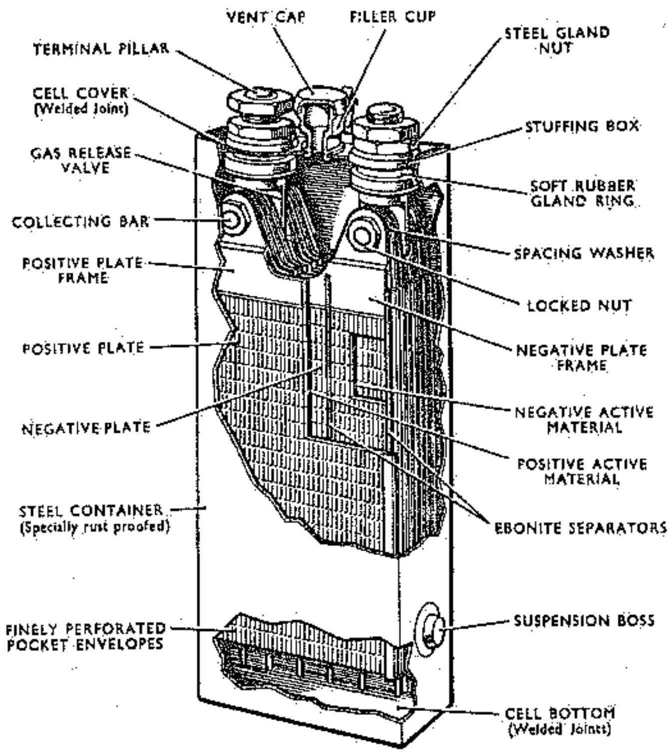
A regular and sufficient consumption of topping up water is, however, the best indication that the battery is being held consistently at a high state of charge, and that the charging equipment is functioning correctly.

SPECIFIC GRAVITY

This does not vary with the state of charge but falls gradually in service. The normal gravity is 1.19 and cells should not be operated with the gravity below 1.160 or above 1.200. Readings should not be taken immediately after topping up but only when the solution has become thoroughly mixed by a few hours charging, and then allowed to stand for some time to allow the gas to disperse.

Low gravities must not be corrected by the addition of electrolyte, but when the lower limit is reached the electrolyte must be completely changed.

N.B. Failure of the battery invariably means failure of the whole unit and therefore much trouble and annoyance can be avoided if correct and regular attention is given to the maintenance of the battery, and so enable it to meet the normal demands made upon it.



Sectional View of an Alkaline Cell

train negative lead, and provides a positive feed to Relay 1 coil. Both 'FAILURE' and 'ISOLATOR' indicator lamps will illuminate on all panels, showing that there is a battery supply to each heater control and that each heater is in a non-operating or failed condition.

4. Press 'START' button.

This action will operate Relays 1 and 3 by completing the negative path in each heater control box and the 'FAILURE' lamps should extinguish on all panels, showing that the heaters are now under the control of the car thermostats. If heat is required, Relay No. 3 is energised and the timer motor in the control box starts to drive a series of four cams, causing the following sequence of operation :-

The solenoid fuel valve and the heater motor are energised and fuel is thus admitted to the combustion chamber. The heater motor is then stopped by the action of a cam and the flow of fuel ceases. The glow plug is next energised by its cam, micro switch and Relay 4 and after 30/45 seconds the fan motor is again started. Fuel is again fed to the heater and since the glow plug is now hot, combustion should occur. The glow plug circuit is broken by Relay 4 when the flame detection thermostat of the heater detects heat and the heater should then continue to run under the control of its thermostat.

Should one or more heaters fail to start the failed heaters and the Guard's panel 'FAILURE' lamps will illuminate. The heater may be put under 'HEAT CYCLING' again by re-pressing the starter button on the Guard's panel; no action can, however, be performed until the timer motor has completed its cycle. When the Guard's 'FAILURE' indicator extinguishes upon pressing the starter button this is an indication that the heater is locked in again on heat cycling control.

After three attempts, should the heaters still not start from the Guard's panel, then it will be necessary to inspect each 'LOCAL CONTROL' in order to identify the failed unit/s; if so desired an attempt can be made to re-start the heater at its own panel purely by pressing the starter button, this will not affect the Guard's control in any way. Guard control is only over-ridden if the local panel isolator is operated.

With the heater operating, the next stage is for the carriage thermostat to break contact. This closes the fuel valve and the heater completes a shut-down cycle. When the heat detector thermostat changes to the cold contact the main air fan motor is de-energised and the heater awaits demand from the carriage thermostat. Both carriage and heat detector thermostats must register cold contact before the heat cycle can commence.

In the event of over-heating, Relay 1 circuit is broken and the circuit trips out as for failure to detect heat.

To switch off all heaters, the Guard's 'ISOLATOR' switch is placed in the 'OFF' position. This will trip out all Isolator Relays (No. 5) all circuits are de-energised, all indicator lamps will extinguish. If a heater is performing a heat cycle the fan motor will continue to run and complete a shut-down cycle.

AIR/FAN/OIL PUMP MOTOR drives the combustion air and clean air fans also the fuel oil pump and fuel slinger.

FLAME DETECTION THERMOSTAT is a 2 way snap action micro switch operated by an expansion rod, the latter detecting the presence (or absence) of combustion.

NOTE : A new type detection unit is now used, incorporating thermistor d detection and transistorised control.

RELAY 2 is a normally de-energised relay which controls the feed to the air/fan/oil pump motor.

FUEL VALVE SOLENOID a two winding solenoid controlling fuel supply to the heater. Both windings must be energised to 'open' the valve - once the valve has 'opened' one winding energised will retain the valve 'open'. Rect. 4 - prevents 'feed back'.

RELAY 4 is a normally de-energised relay which controls the feed to the glow plug.

RELAY 3 is a normally de-energised relay - it initiates the feed to the timer motor.

GUARDS FAILURE INDICATOR when illuminated proves that there is a battery supply to each heater control box and that each heater is in a non operating or failed condition.

GUARDS ISOLATOR INDICATOR proves guard's panel isolator switch position.

RECT. 1 prevents Guard's isolator being fed via drivers panel isolator switch.

RELAY 5 is a normally energised 'isolator relay'. It controls battery feeds to the control box.

RECT. 2 prevents 'feed back'.

DRIVERS ISOLATOR INDICATOR proves drivers panel isolating switch position.

OVERHEAT THERMOSTAT is fitted at the top and at the hot end of the heater and cuts fuel supply if excessive temperature is generated.

NOTE : This also is included in the new modified detection circuit.

RELAY 1 is a 'stick' relay and cuts the fuel supply if combusion ceases.

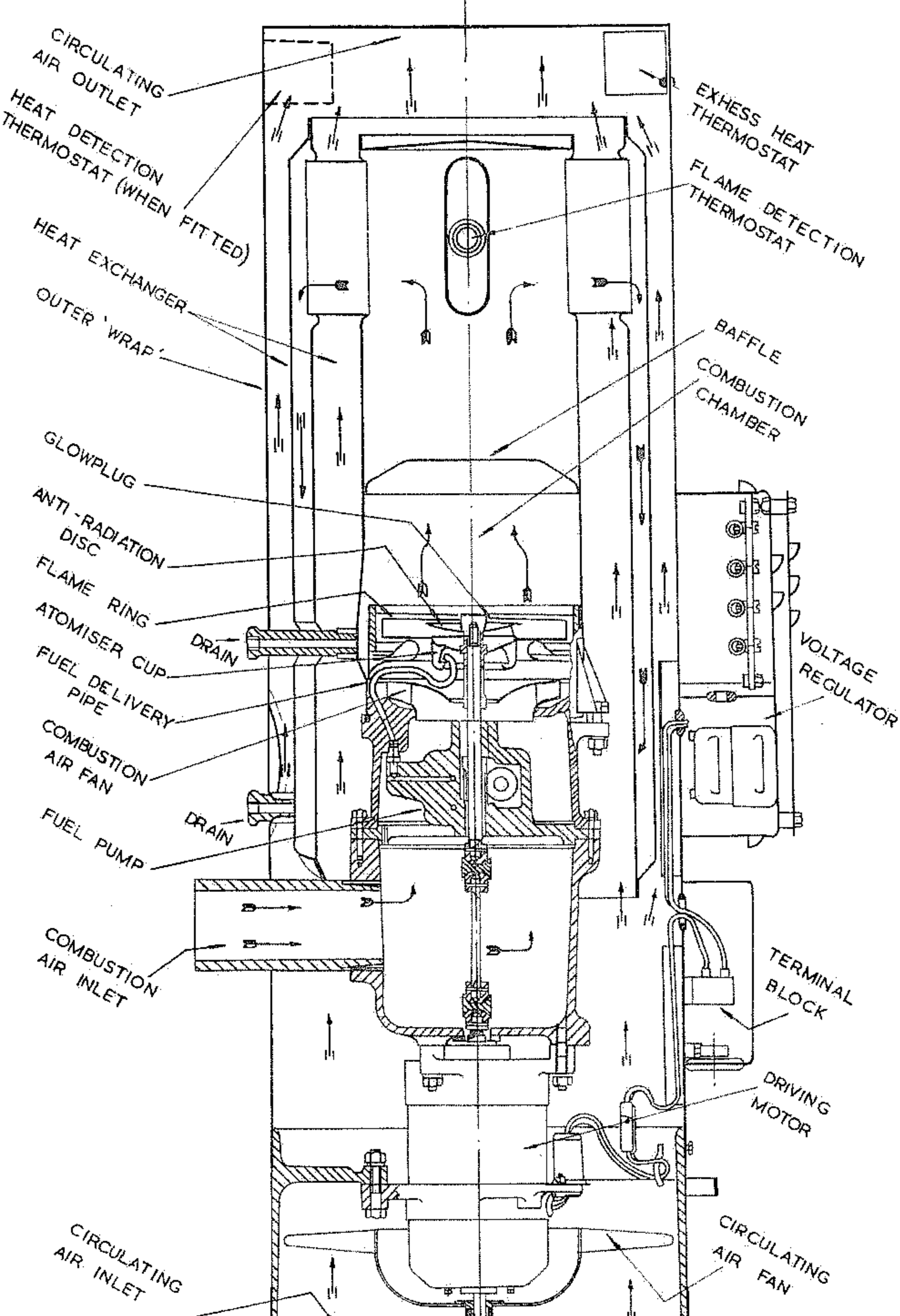
RECT. 3 prevents 'feed back' from other heaters via No. 2 train wire.

DRIVER FAILURE INDICATOR proves that relay 1 is de-energised, i.e. the heater is not working.

TIMER MOTOR a small D.C. motor which drives 4 cam operated switches, the sequence of events being generally as follows :-

Relay 3 contacts, on closing, will energise the timer motor causing all cams to rotate in an anti-clockwise direction. The first movement will be for cam 2 to close its contact for a short interval during which the air/fan/oil pump motor and fuel valve solenoid will energise. Cam 4 will then close its contacts to energise relay 4 and thereby the glow plug. After a delay of approx. 30/45 seconds, cam 2 will again close its contacts to

SECTION - RAILCAR HEATER



SECTION THREE

AIR AND VACUUM SYSTEMS.

1. Compressed Air System
2. Air System Valves
3. Throttle Motor
4. Vacuum Brake System
5. Drivers Safety Device

1. 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 valv valve and an unloaded valve into the air reservoirs.

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.

From diagram included, the different uses made of the compressed air can be noted.

Unloader Valve

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.

Electro-Pneumatic Valves

There are two types: they are "ON" and "OFF".

"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.

3. Engine Speed Control

The method of speed control is electro-pneumatic, using the high pressure air system.

'A' and 'L' Type

The control car battery supplies current through the main, control and reversing switches to the throttle control. Movements 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. A. 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.

Throttle Handle Position	E.P. Valves energised	Throttle Motor cylinders charged with air.	Effect
OFF	-	-	Engine Idles
1	T1	1	Engine speed increases
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 d.s.d. circuit is energised through a switch on the throttle handle.

The 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 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 small.

The Gearbox Control

Movement of the Driver's gear selectrion lever energises an E.P. valve which directs air to the appropriate gear brake air cylinder. This raises the piston through a toggle-mechanism and applies the brake. Gears 1, 2 and 3 are operated this way, but gear 4, the piston operates a clutch instead of brake.

NOTE : In all instances it may be found that the reducing valve set at 65 lbs per square inch has been operationally removed from circuit thus allowing the gearbox to operate at full air pressure.

Direction Control

Direction is controlled by the Driver's Forward and Reverse lever, which when placed in the position required energises the appropriate E.P. valve and allows air to the final drive, and forces the sliding dog into the correct position. In the driving cab a warning light indicates that the sliding dogs are in the correct position with adequate air pressure.

4. RAILCARS - GRESHAM AND CRAVEN
TWO-PIPE QUICK-RELEASE VACUUM BRAKE SYSTEM

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

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. NOTE : The isolating valve should close at 19" to ensure the high vacuum side does not reduce below this setting. 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:-

(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). There is one feed valve in 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.

(c) Automatic isolating valve (see diagram). 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.

DRIVERS SAFETY DEVICE.

One d.s.d valve is fitted in each power car.

Referring to diagram attached.

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 drivers safety device applicatio, the solenoid is de-energised and the atmospheric pressure above the diagram 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 over-come 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 drivers safety device 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 drivers safety device light is fitted which goes out when the throttle lever is released.

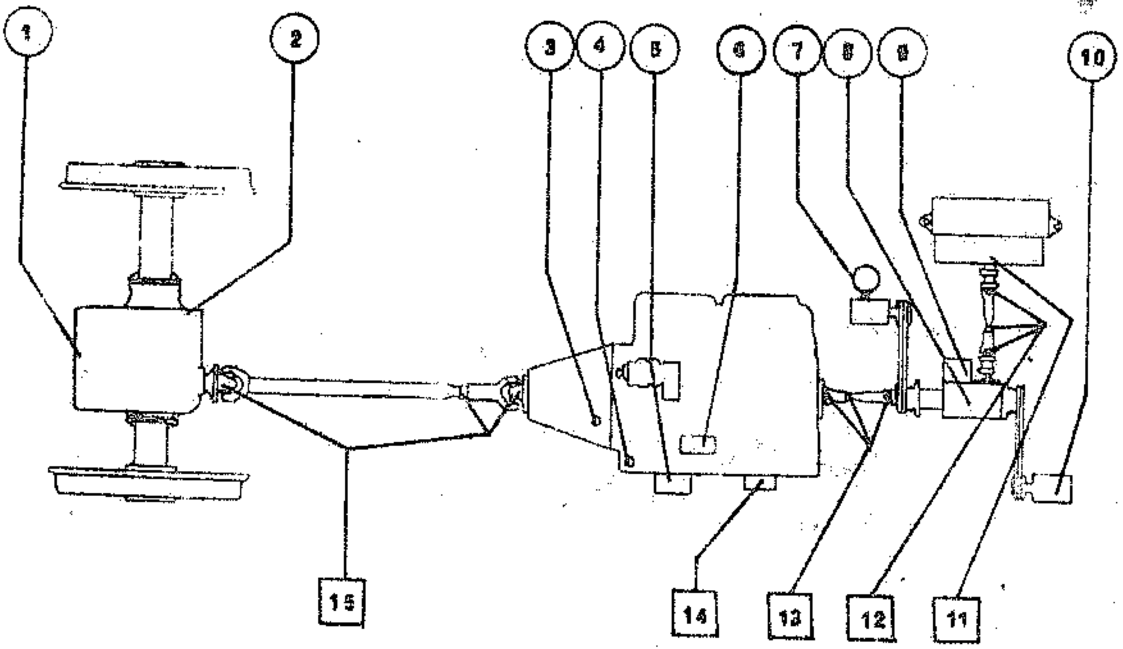
When taking charge of a train the drivers safety device equipment should be tested with the brake valve in the lap position thus avoiding loss of the "high" vacuum.

BR.87264/1
British Railways Board
Revised October 1970
Issued January 1971

SECTION 10

LUBRICATION CHART NO. 2

D.M.U. WITH HYDRAULIC TRANSMISSION



C-A3-4062 . 17th Nov '70

Shell Talona 945 (Cat.No.9/27/20550) or Esso Estor HD30 (Cat.No.9/27/18600)		
Point No.	Job Nos.	Description
2	262,263	Final drive isolating plunger
4	102,152	Engine sump
5	115	Engine air intake oil bathfilter
6	107	Fuel pump mechanical governor
7	321,322	Exhauster
9	431,432	Compressor
10	521	Alternator suspension gear
-	Various	General oil lubrication as specified in Jobs

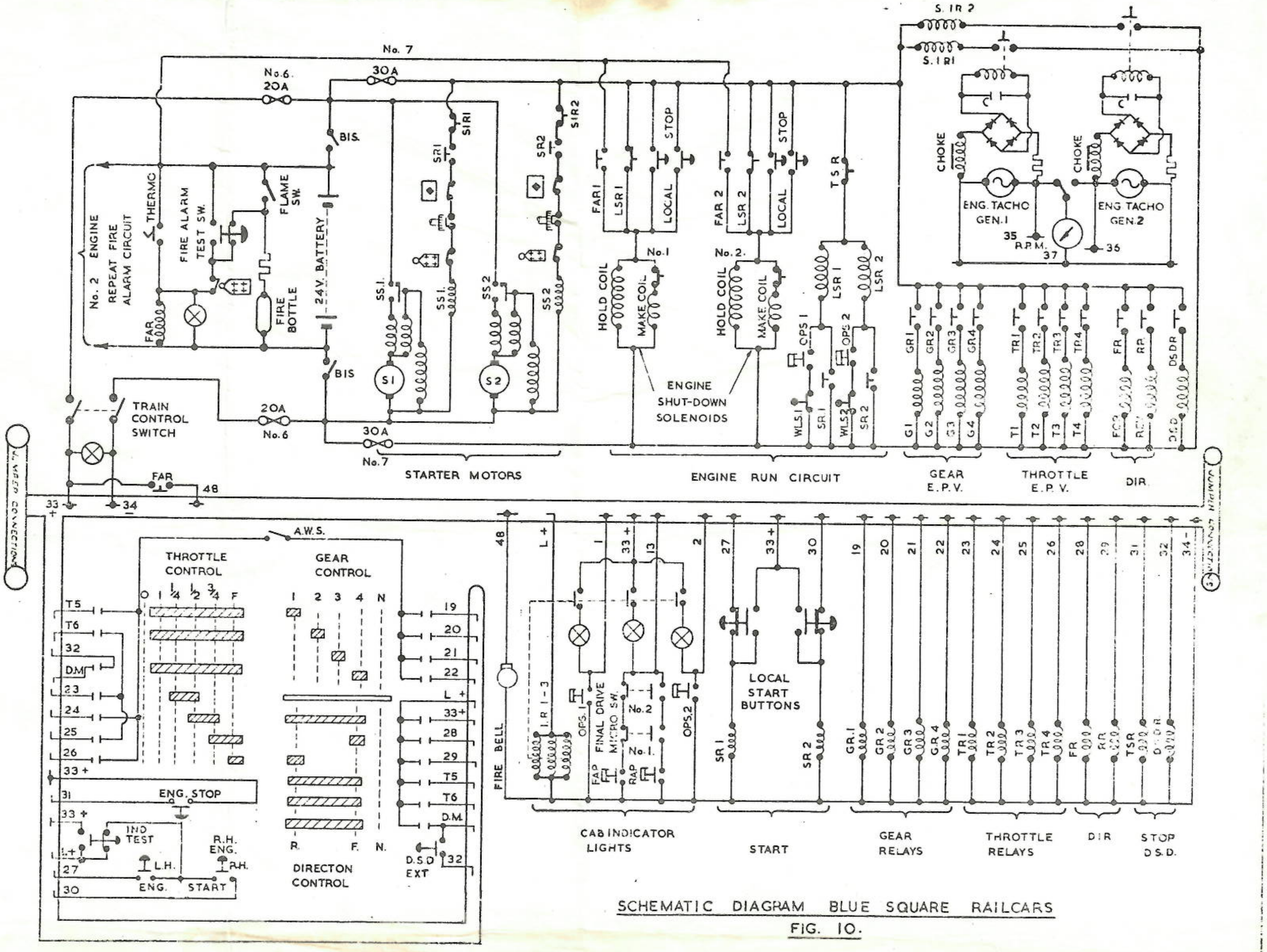
Shell Talona 972 (Cat.No.9/27/20560) or Esso Estor HD 40 (Cat.No.9/27/15765)		
Point No.	Job Nos.	Description
1	251,265	Final drive gearbox *
8	126,127	Radiator fan drive gearbox

*** Until further notice use oil BR Spec. 655 EP 225 (Cat.No.9/27/15060) for Orange Star units.**

Shell Donax T.7. (Cat.No.9/27/18271)		
Point No.	Job Nos.	Description
3	231,235	Torque converter

Grease B.R.B. Spec. 673 (Lithium base) (Cat.No. 9/27/1350)		
Point No.	Job Nos.	Description
11	103	Radiator fan bearing
14	111	Throttle motor, linkage and hand control throttle
-	Various	General grease lubrication as specified in Jobs

Molybdendum disulphide grease (Cat.No.9/27/4150)		
Point No.	Job Nos.	Description
12	103	Radiator fan drive shaft universal joints & splines
13	103	Auxiliary shaft universal joints & splines
15	102	Cardan shaft universal joints and splines

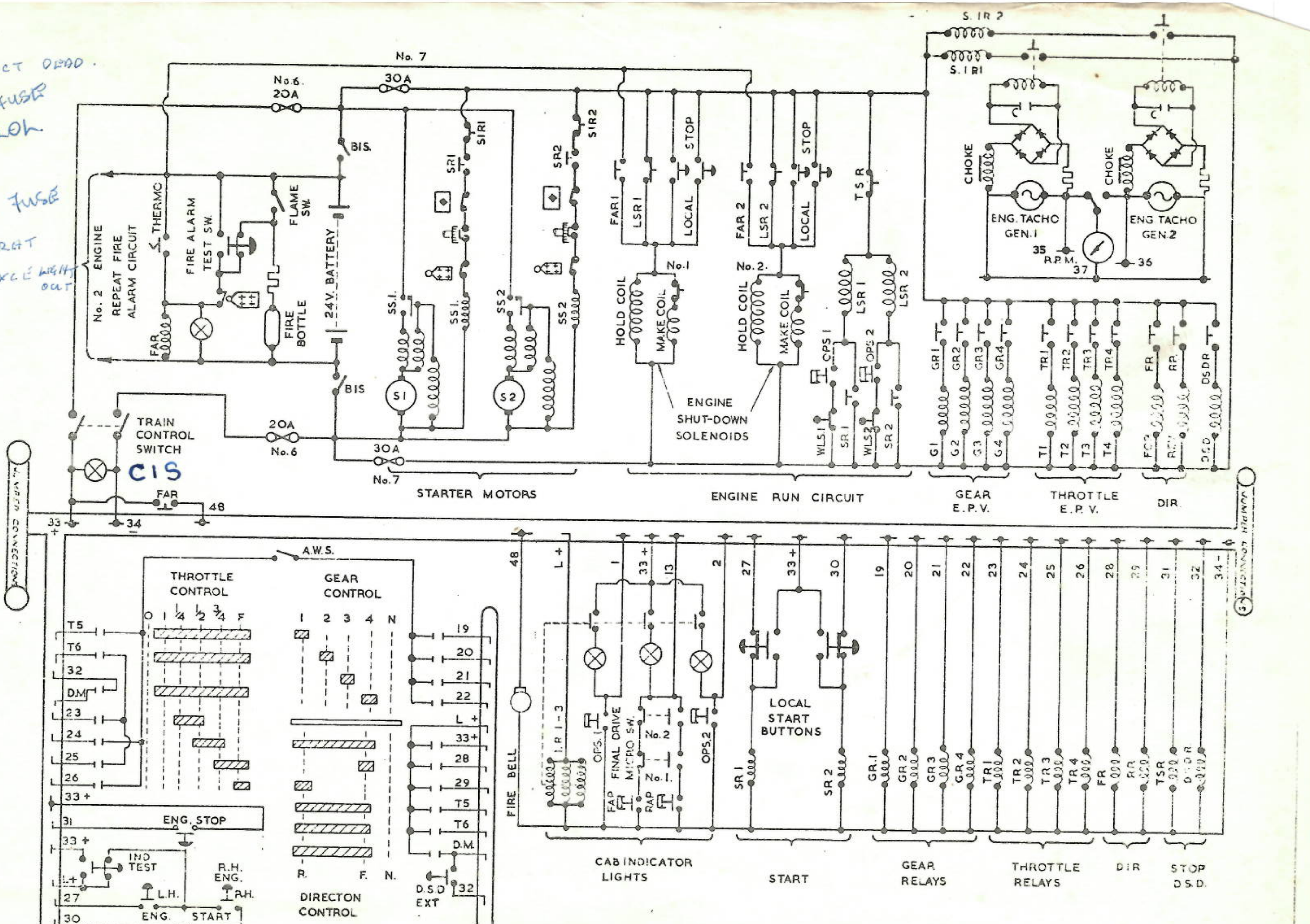


SCHEMATIC DIAGRAM BLUE SQUARE RAILCARS

FIG. 10.

59A

ALL CCT DEAD.
No 6 FUSE CONTROL
No 7. FUSE
DSD OPERAT
AIR & AXLE LIGHT OUT



SCHEMATIC DIAGRAM BLUE SQUARE RAILCARS

FIG. 10.