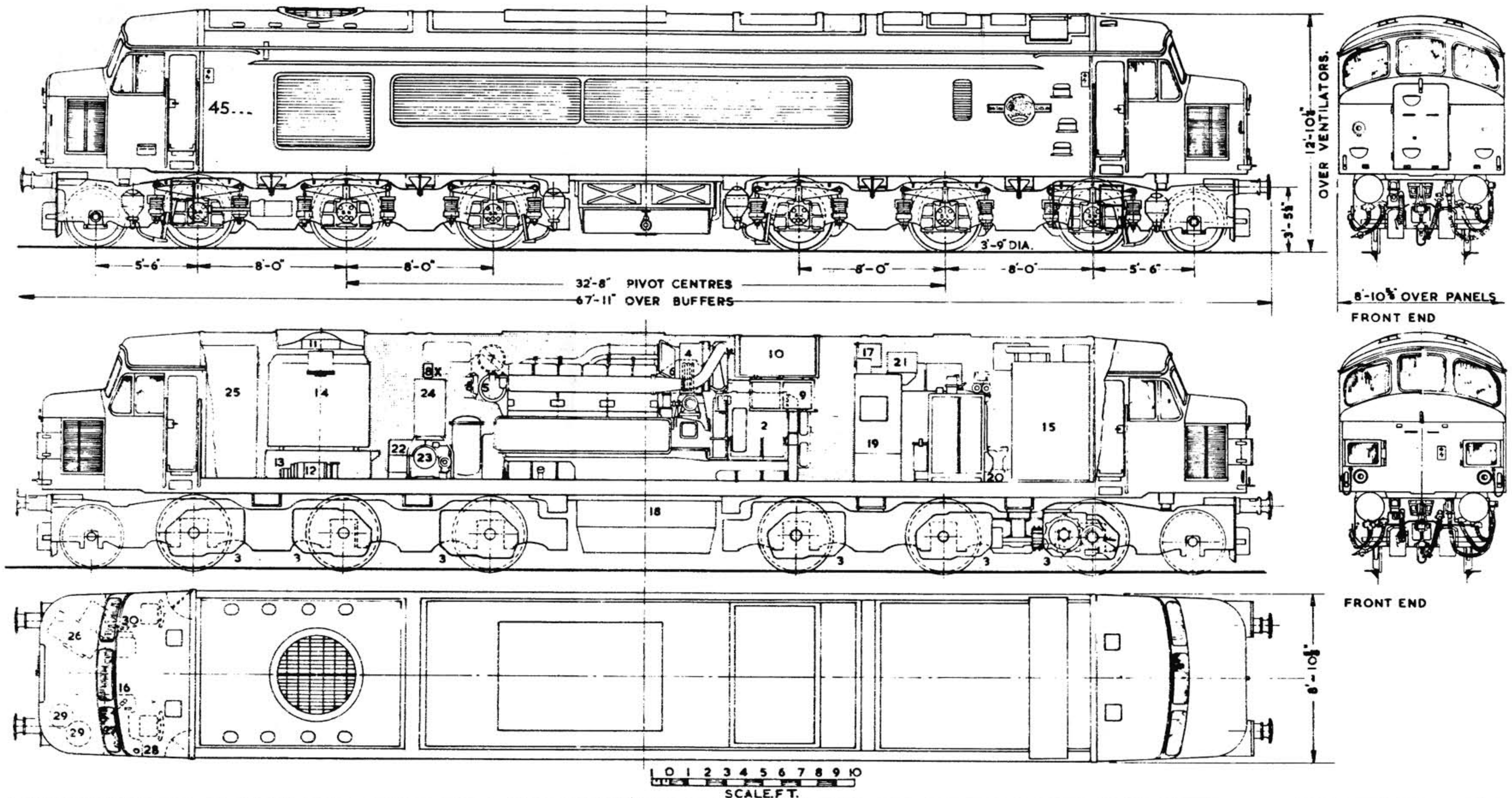
B.R. 33057/16
D.T.S. 46

BRITISH RAILWAYS - WESTERN REGION

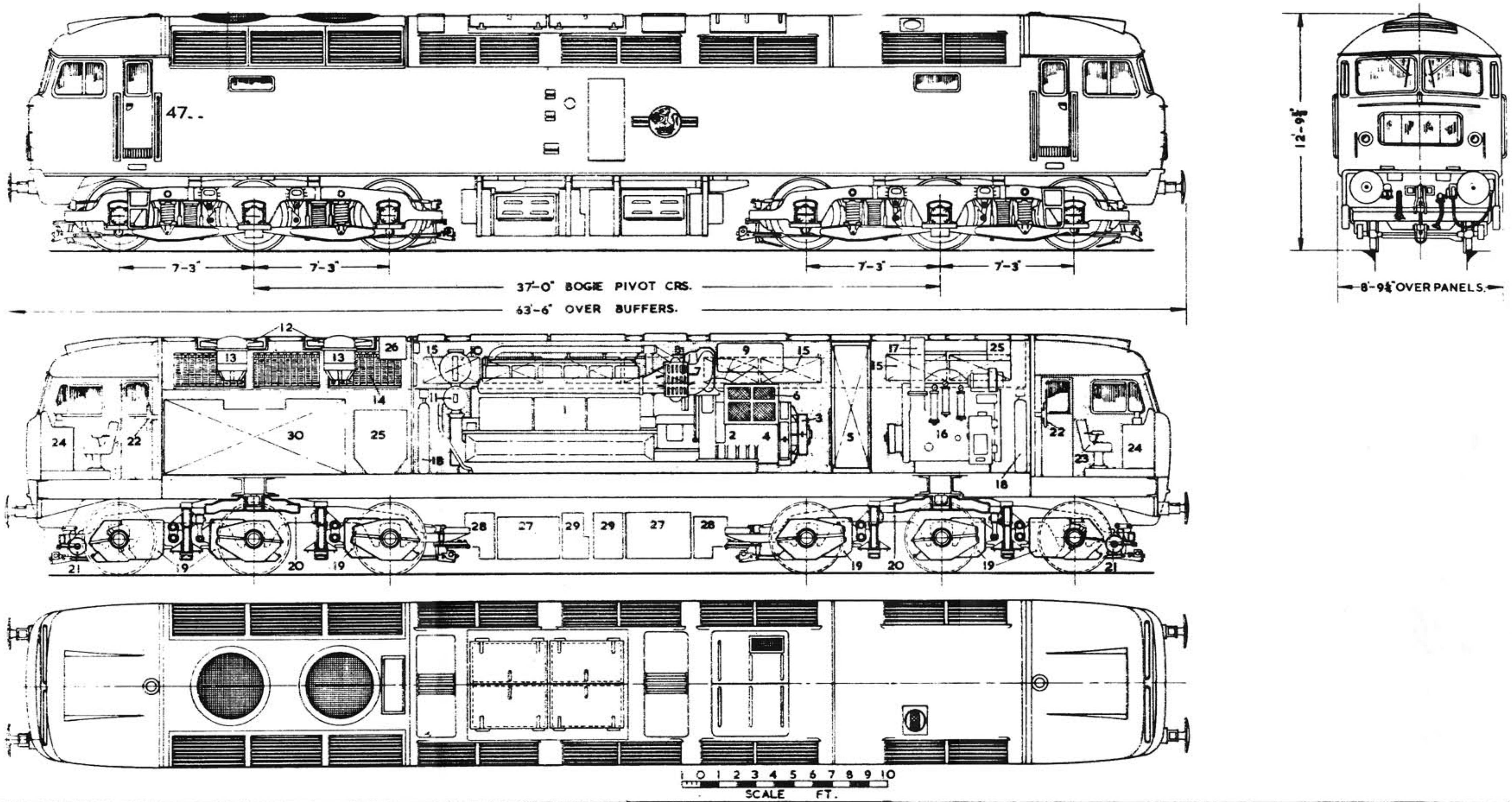
SULZER ENGINES AND SYSTEMS. CLASS 45, 46, AND 47 LOCOMOTIVES.

M. & EE. Training Unit,
SWINDON
December 1974
1st Edition



1. DIESEL ENGINE.	6. INTERCOOLER. D11.ETC.	11. RADIATOR FAN.	CLASS 45&46	16. MASTER CONTROLLER.	21. RESISTANCE FRAMES.	26. TRACTION MOTR BLOWER.
2. MAIN & AUX GENERATORS.	7. HEAT EXCHANGER. " "	12. COMBINED PUMP SET.	DIESEL	17. VOLTAGE REGULATOR.	22. AIR COMPRESSOR.	27. VACUUM BRAKE VALVE.
3. TRACTION MOTORS.	X8. ENGINE INST. PANEL. " "	13. CONVERTOR SET.	ELECTRIC LOCOMOTIVES	18. BATTERY BOXES	23. EXHAUSTER.	28. AIR BRAKE VALVE.
4. PRESSURE CHARGER.	9. ENGINE AIR FILTER.	14. RADIATOR PANELS.		19. MAIN CONTROL CUBICLE	24. BRAKE GEAR CUBICLE.	29. AIR RESERVOIRS.
5. LUB. OIL FILTER.	10. EXHAUST SILENCER.	15. BOILER WATER TANK.		20. W.C.	25. MAIN FUEL TANK.	30 HAND BRAKE.

FIG I



1. SULZER MAIN ENGINE.	6. AIR INLET FILTER BOX.	11. LUB: OIL FILTER.	CLASS 47	16. TRAIN HEATING BOILER.	21. AIR BRAKE CYLINDERS	26. RADIATOR HD'R TANK.
2 MAIN GENERATOR.	7. TURBOCHARGER.	12. RADIATOR FANS.	DIESEL	17. BOILER FLUE OUTLET.	22. HANDBRAKE.	27. BATTERIES.
3 AUX	8. CHARGE AIR INTERCOOLER.	13. ELECTRIC MOTORS FAN.	ELECTRIC LOCOMOTIVES	18. FIRE EXT. CO_2 BOTTLES.	23. DRIVERS SEAT.	28. FUEL OIL ENG: FEED TANK.
4. TRAIN HEATING GENERATOR.	9. SILENCER & EXHAUST OUTLET.	14. ROOF MT'D RADIATORS.		19 TRACTION MOTORS.	24. DRIVERS CONTROL DESK.	29. BOILER WATER TANK.
5 MAIN CONTROL CUBICLE.	10. LUB: OIL HEAT EXCHANGER.	15. AIR FILTER PANELS.		20. CAST STEEL BOGIES.	25. RESISTOR UNITS.	30. MAIN FUEL TANKS.

FIG 2

B.R.33057/16
D.T.S.46.

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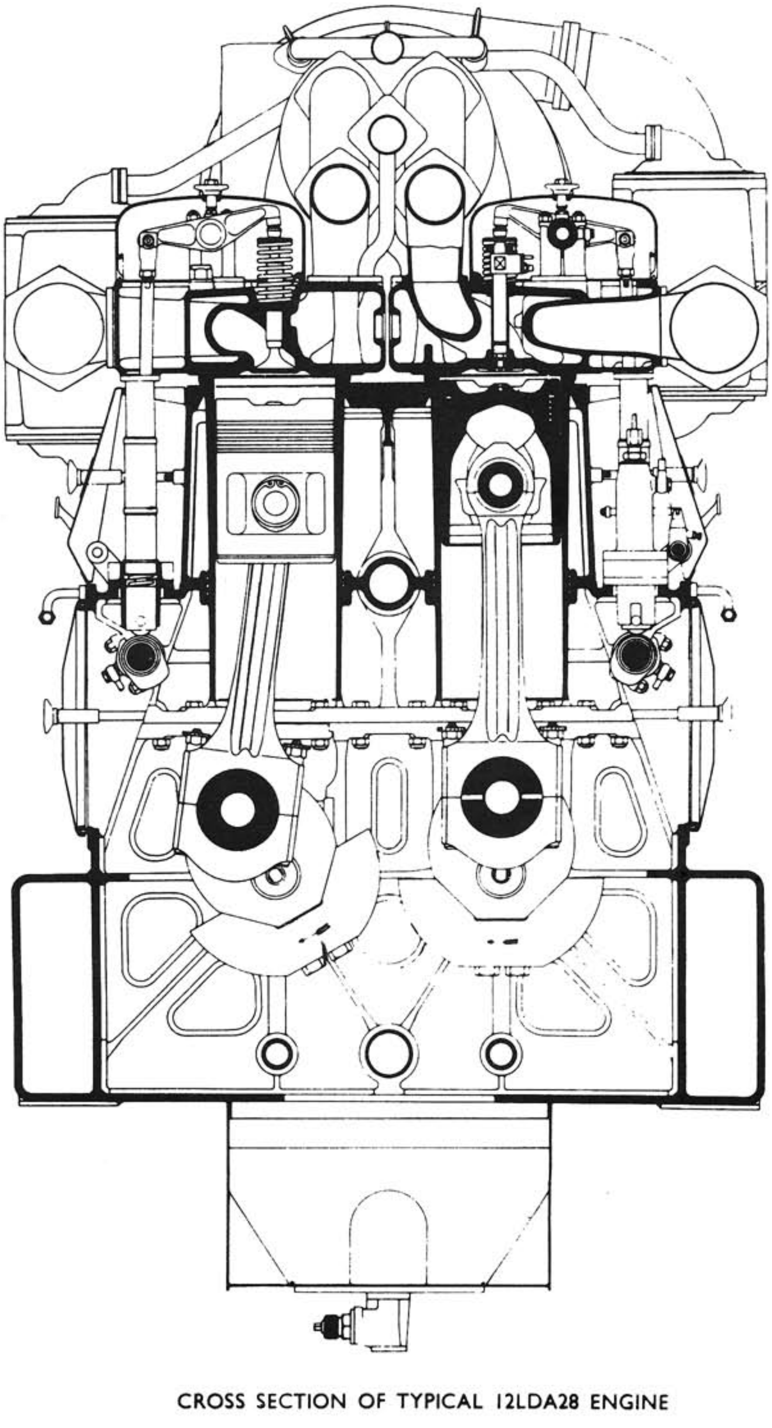
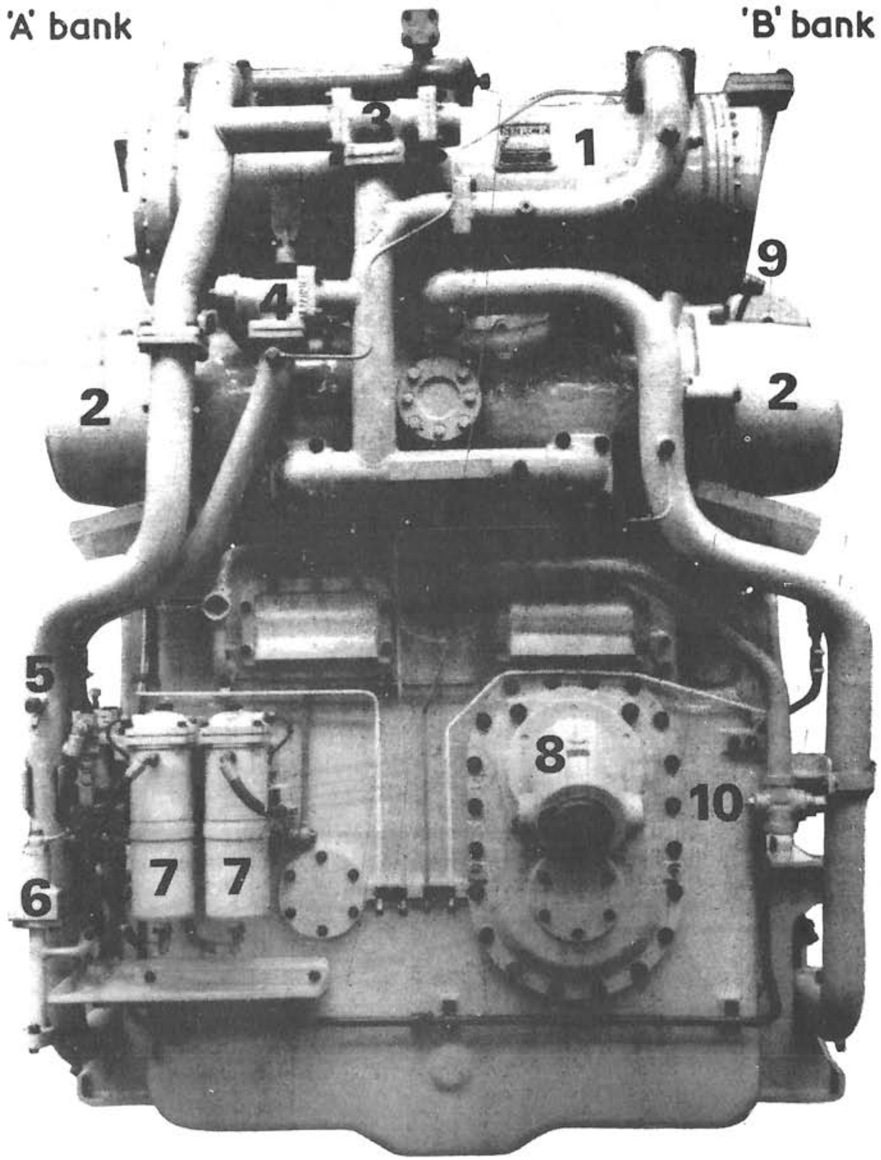


CROSS SECTION OF TYPICAL 12LDA28 ENGINE

Fig. 3.

1. Heat Exchanger.
2. Combined lubricating oil filter
3. Heat exchanger lubricating oil by-pass valve
4. Lubricating oil safety valve
5. Lubricating oil sample cock
6. Lubricating oil priming relief valve
7. Fuel fine filters
8. Hydrostatic pump.
9. Heat exchanger coolant drain
10. Coolant filiing and drain cock
11. Air inlet manifold
12. Exhaust manifold
13. Fuel pump gallery
14. Crankcase
15. Lubricating oil sump
16. Charge air intercooler
17. Pressure charger
18. Governor
19. Engine stoplever.
20. Synchronising gear casing
21. Dipstick
22. Lubricating oil filler
23. Overspeed trip
24. Main generator
25. Auxiliary generator
26. Inductor alternator



I2LDA28C ENGINE. VIEW ON FREE-END

Fig. 4.

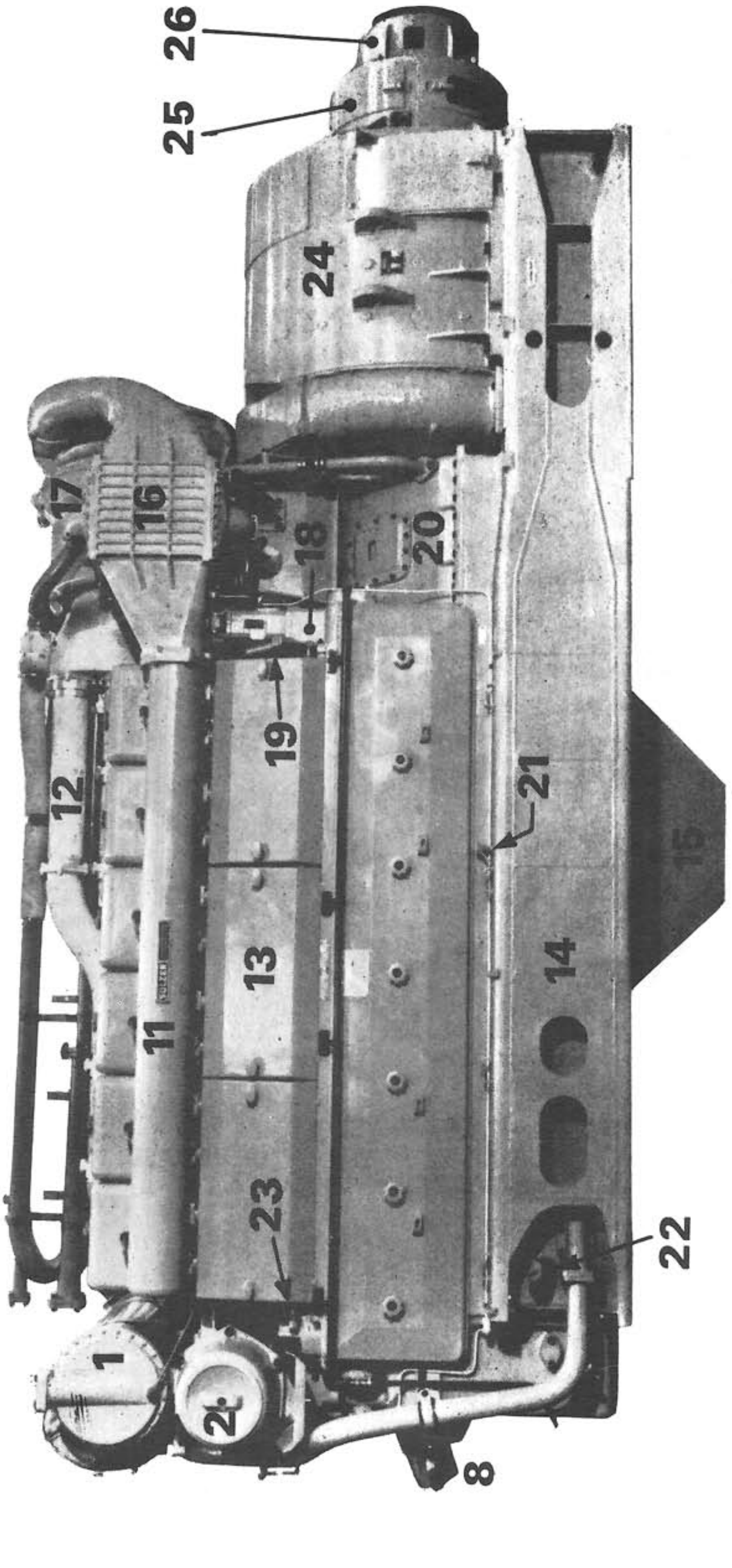
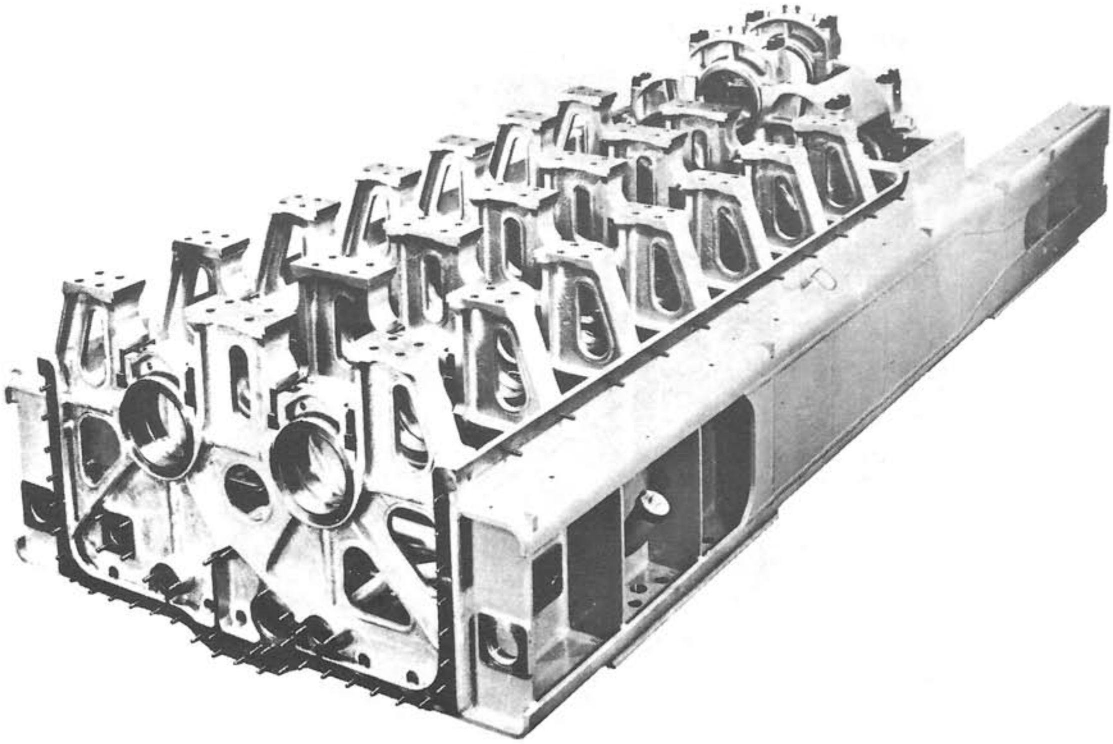


Fig 5. 12LDA28C ENGINE. SIDE VIEW



FREE-END VIEW OF CRANKCASE.

Fig. 6.

THE SULZER 12 LDA 28 B & C ENGINE.

The 12 cylinder engine is arranged in two vertical banks of six cylinders, each with its own crankshaft, which drives a common output shaft through straight spur gearing with a step up ratio of 1 - 1.44. The two crankshafts are positioned as close together as the balance weight arcs will allow.

The principal constructional feature of the Sulzer traction oil engine is the method of frame construction. The welded steel integral structure of transverse diaphragms and bedplate combine to give an engine generator underbed of exceptional lateral and base stiffness. Combining with this unit, the welded cylinder block, when bolted to the crankcase, is also of such shape and so matched to the crankcase structure, that all the combustion forces are transmitted in straight lines through the framing without the necessity of fitting long through bolts.

Lateral stiffness is further developed in the following manner. Firstly, the transversals of the crankcase carrying the main bearings are rigid steel castings, welded to the framing side plates. The top bearing caps are then locked into the main framing so that they act as transverse bridge pieces above the 'U' shape of the lower framing which is shaped to take the main bearing. A special wedge device locks bearing and cap within the crankcase, which dispenses with any form of stud fixing.

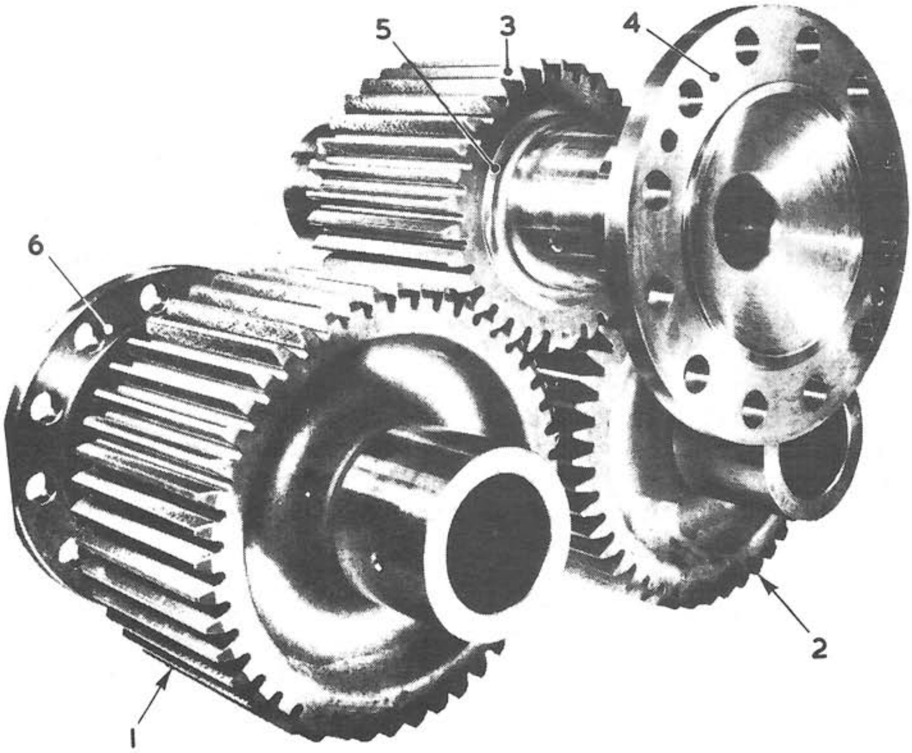
The welded fabrication of crankcase and cylinder block from simple steel transverse castings and longitudinal side plates, results in a light but rigid structure, while the entire diesel/generator group is formed into a compact rigid assembly unified through the extension of the crankcase framing.

Additional strength is provided by incorporating all the main water and oil pipes as integral internal parts of the frame assembly and not as separate pipes. This form of bracing is illustrated in the cross-sectional view of the double row-type frame (Fig. No. 6 , page 6). The main oil rail provides longitudinal stiffening at sump level and the cooling water inlet pipe provides similar bracing between the cylinders at approximately mid-cylinder barrel level. In addition to adding to the structural strength, integral pipework eliminates the chance of vibrational loosening of the conventional type separate pipe systems.

The cylinder block is constructed to carry wet type liners and has a heavy section top plate rigidly locating the top section of the liner while the cooling water integral pipe assembly provides the liner support at the lower level.

The pistons are forged in a special high duty lightweight alloy and are machined overall. They have a special form of oil cooling, and for this purpose the ring carrying section of the piston is formed by a sleeve which is made separate from the main body and is fixed by shrinkage of the collar on to the body.

This system of incorporating oil cooling annular grooves within the piston crown to form a heat barrier between the crown and the ring carrying grooves causes the heat flow to be lessened at that point. This, of course, considerably improves the working conditions of the ring carrying section and improves piston ring groove durability.



1. Lower synchronising gear (crankshaft **B**)
2. Lower synchronising gear (crankshaft **A**)
3. Upper synchronising gear
4. Generator coupling flange
5. Upper synchronising gear thrust face
6. Crankshaft (No. 1) coupling flange

CRANKSHAFT SYNCHRONISING GEARS.

Fig. 8.

The oil supply for this purpose is conveyed from the normal gudgeon pin supply via oilways in the body of the gudgeon pin (not from the hollow of the pin), and oil drillings connecting the gudgeon pin bearings to the circumferential oil lands. Return of oil from these annular grooves to the sump is via vertical drillings in the piston skirt.

The two sections of the piston are referred to as the body and collar. The body carries the gudgeon pin bearing and the lower oil scraper ring, while the collar carries the upper oil scraper and three gas type rings.

The crown or top of the assembled piston is then machined to form a circular depression with a raised centre suitably relieved opposite the inlet and exhaust valve location. This combined with the shape of the cylinder cover, produces a combustion space in which the degree of turbulence ensures good combustion of the fuel.

The connecting rods are forged in chrome nickel steel. They are of I section and are machined all over. The rods are drilled throughout their length to convey the oil supply from the crankshaft for small end bearing lubrication and piston ring cooling.

The large end bearings are of the "tri-metal" type, that is, a steel backed shell supporting a lead bronze lining, which is protected by a two thou. electro deposited soft metal running surface. The shells are carried directly by the saddles of connecting rod and cap, requiring no shim adjustment or hand fitting.

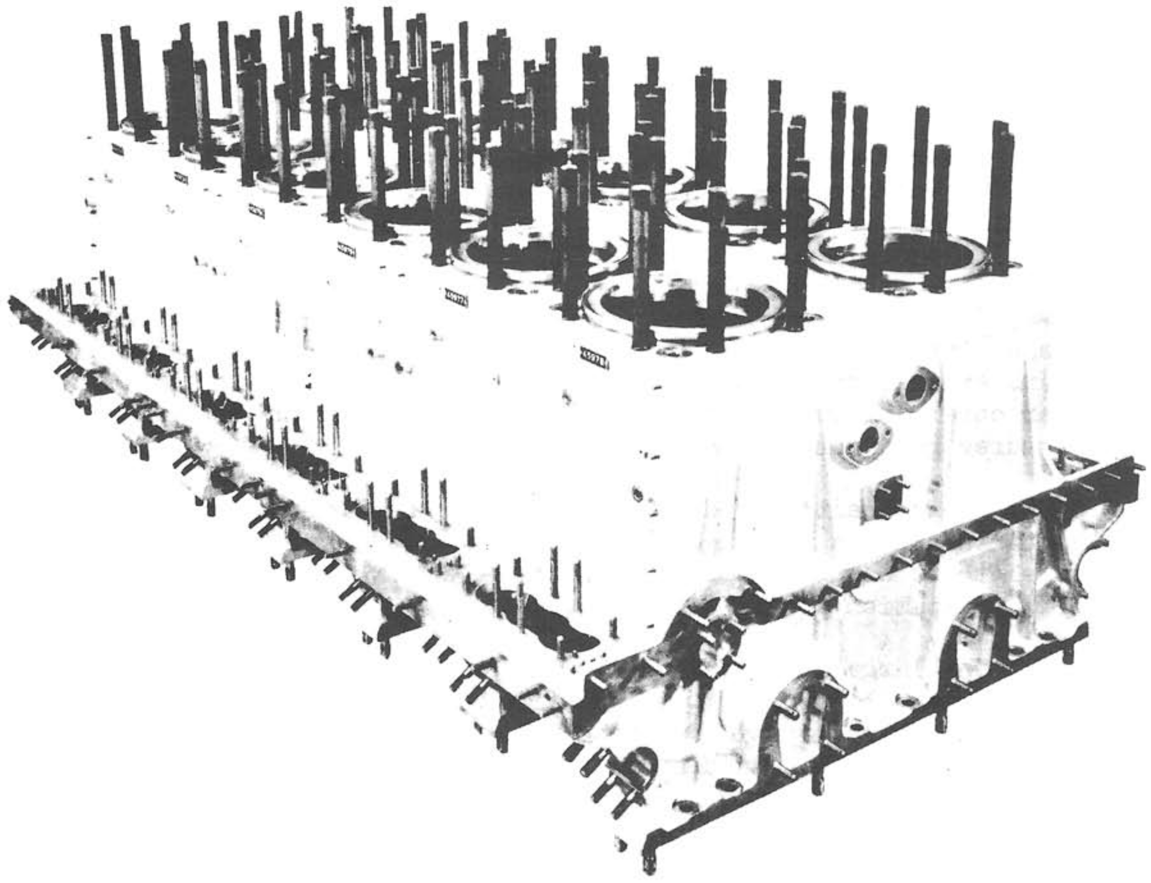
The cylinder liners are of the separately inserted wet type, being located in the normal fashion in the cylinder block top plate, sealing to the plate being by means of a soft iron ring held beneath the liner top lip. Longitudinal expansion of the liner is catered for by the sliding joint at the lower support point, this being formed by oil resisting rubber rings carried in grooves machined on the liner periphery. These rings also form the water seal between liner and crankcase.

The individual cast iron cylinder heads carry one exhaust and one inlet valve which seat directly into the head, there being some valve seat inserts but no valve cage arrangements. The valves are interchangeable, being of identical dimension and material.

Situated between the valves, and centrally in the cylinder head, is the fuel injector, giving direct injection into the combustion chamber formed by the circular depression within the piston head which corresponds to a slight recess machined on the cylinder head pressure area. A port is also provided through to the top of the head (normally sealed by a screwed plug) which provides a means of decompressing the cylinder and allows indicator gear to be fitted if required.

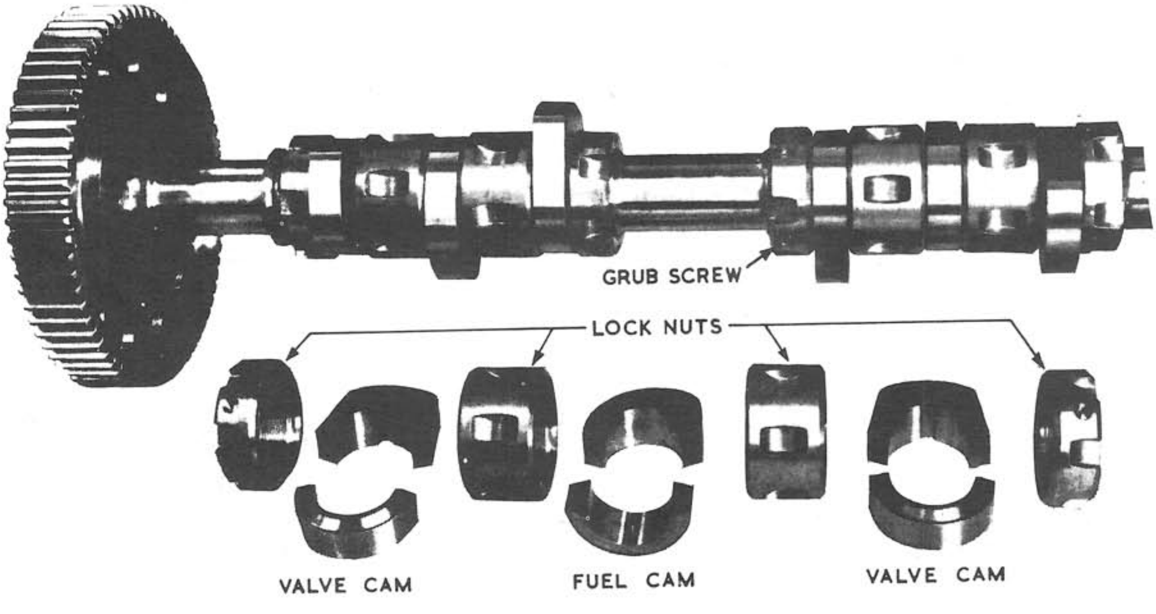
The flow of cooling water to the cylinder head is by way of four passages of approximately 1" diameter, grouped equidistant around the head face. The actual water connection between cylinder block and cylinder head is in each instance formed by a hollow rubber distance ring fitted with an outer steel tube guide which centralises and supports the distant piece.

Flow of fuel oil to the injectors is by way of a special extension stalk, thereby minimising chance of fuel dilution due to pipe failure, all pipe connections being external to the cylinder head.



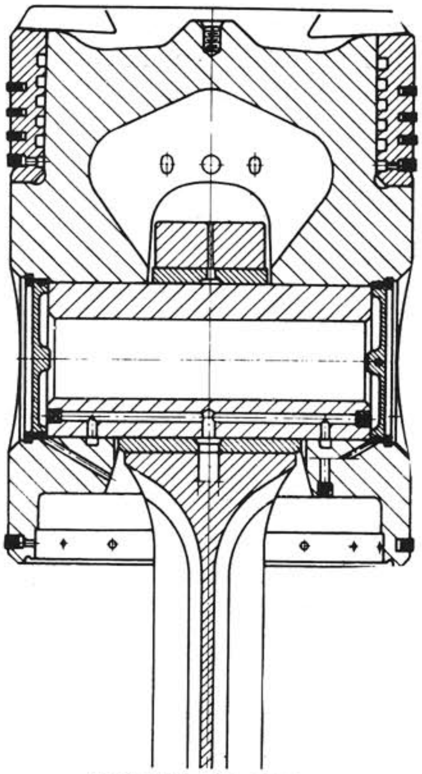
SULZER 12LDA.28 CYLINDER BLOCK.

Fig. 10.

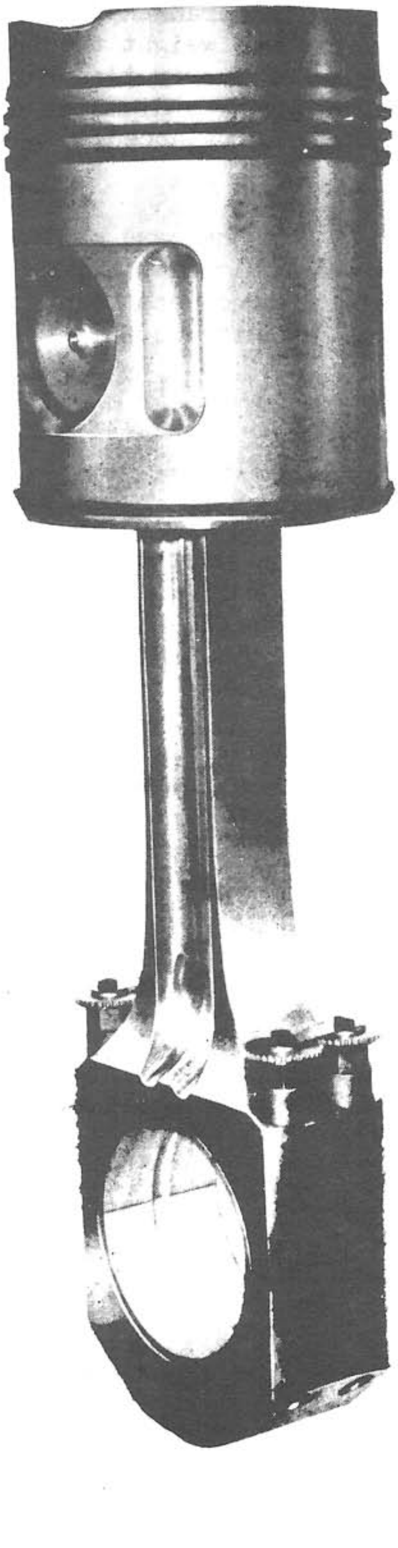


CAMSHAFT AND CAMS.

Fig. 11.



SECTION THROUGH PISTON
SHOWING GUDGEON PIN AND RING
COOLING ARRANGEMENT.



ENGINE PISTON AND CONNECTING ROD.

Fig. 12.

Fuel spill is conducted away to the fuel pump gallery through another extension stalk while lubricating oil supply to rocker gear is introduced from an external supply pipe via a similar extension piece.

The crankshaft is forged in alloy steel and is not surface hardened. To reduce weight the shaft is hollow bored, this bore being used as an oil duct for lubrication supply. This shaft is of large diameter, journals and pins having a diameter of about 70% or more of the cylinder bore. Each crankthrow is balanced by a counter weight.

In the case of the double row 12 cylinder version, there are two synchronising gear bearings to be considered additional to the normal, and in this instance each crankshaft (6 throws) has eight main bearing points. Balance weights are fitted to each crank throw.

The crankshafts rotate in an anti-clockwise direction looking on the generator end.

The camshaft of the 12 cylinder engine is supported by seven bearings. The bearings are Glacier type white metal on steel shell and are pressure lubricated. Camshaft drive is taken from the upper synchronising pinion. Double shaft engines with clockwise crankshaft rotation derive clockwise camshaft rotation.

The bronze guide pistons which work within the cam follower assembly in each case carry the cam rollers which are copper plated internally and run on hardened steel pin. Within the guide piston a pushrod is fitted on which the spring loaded ball ended push rods locate.

Rubber pushrod tubes, or sleeves, fitted over the spring housings and held in place by jubilee type clips ensure that lubricating oil returning from the cylinder head to the camshaft gear, is kept separate from the fuel oil gallery. Drive from the central piston in the group is given to the pump via an extension stalk which locates similarly to the pushrod cup within the piston.

Designation of Cylinders.

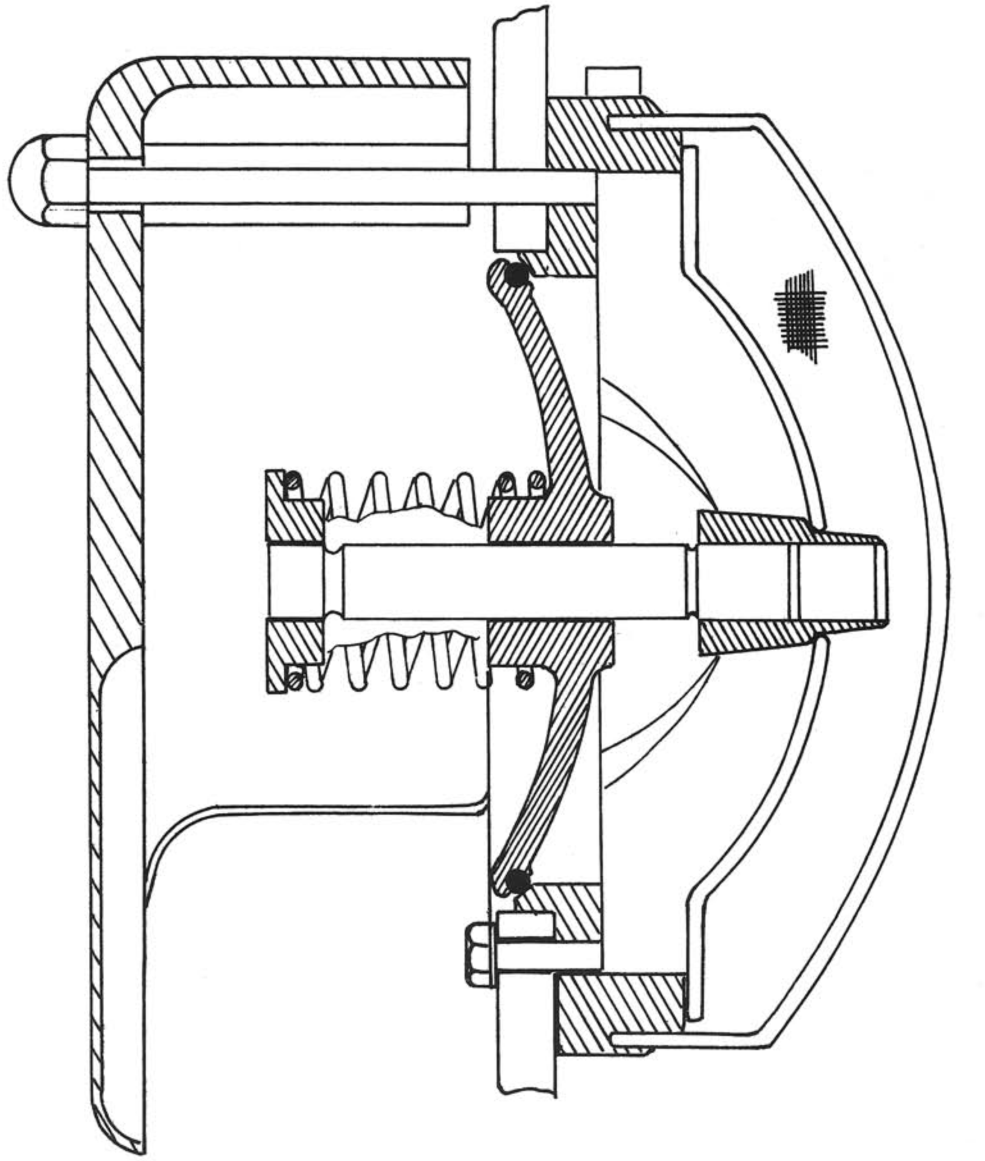
The cylinders of each bank are numbered consecutively from No. 1 to 6, starting at the free end of the engine in each case.

The firing order is as follows:-

Bank 1 (or B) - Left hand side of locomotive 1.5.3.6.2.4.

Bank 2 (or A) - Right hand side of locomotive 2.4.1.5.3.6.

(Right hand bank looking on free end of engine is No. 1 or B Bank).



BICERA EXPLOSION RELIEF VALVE.

Fig. 13.

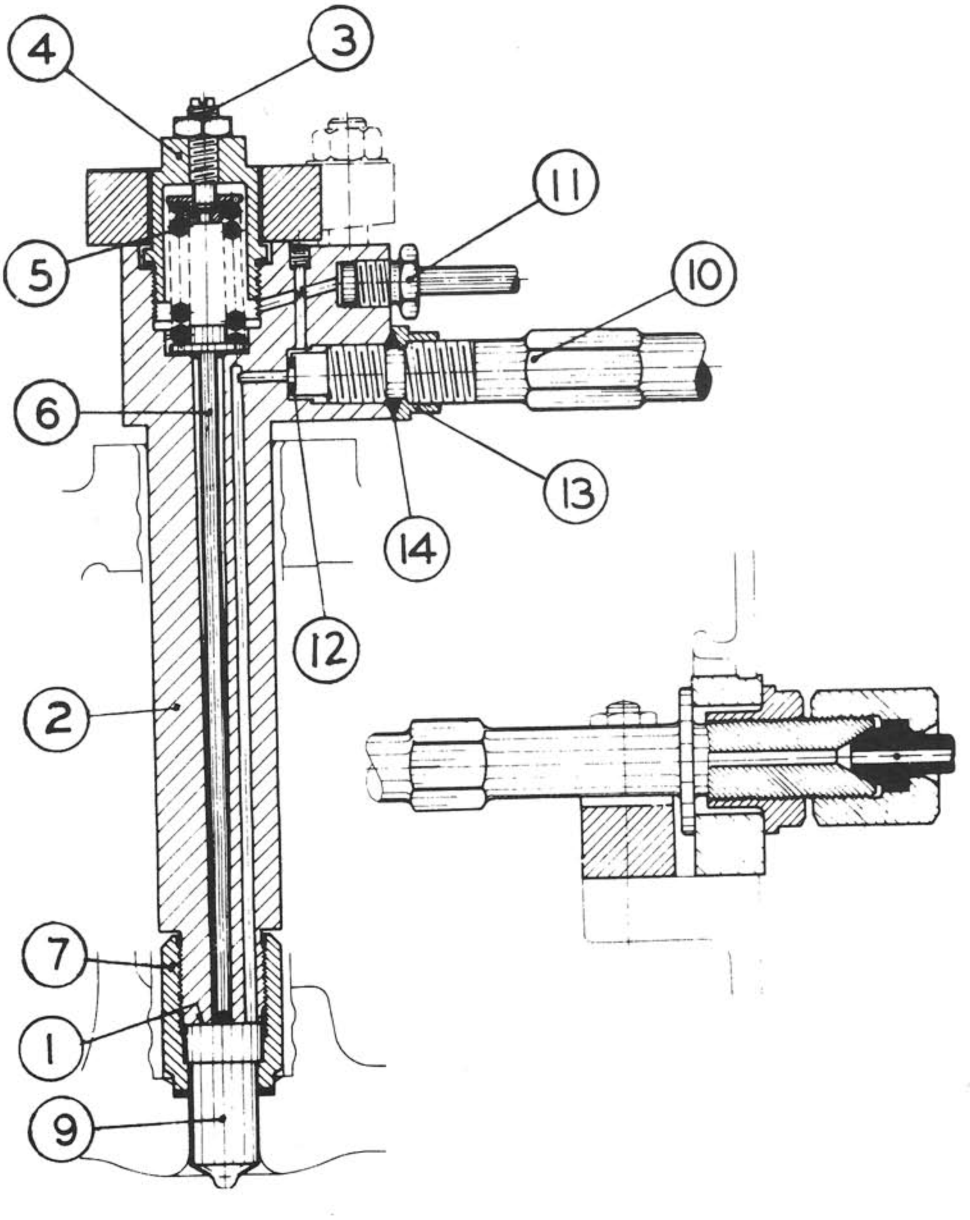
Fitted at each cylinder position in the crankcase doors are Bicera explosion valves (Fig.13).

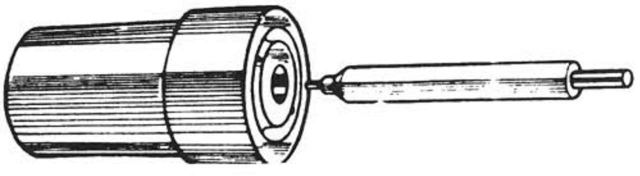
Should crankcase pressure increase to a dangerous level, or a bearing run hot and ignite the crankcase gases, these valves will relieve the pressure to atmosphere of any resultant explosion and minimise damage as far as possible.

The valves consist of a wire mesh mounted on the inside of the crankcase door (this is to stop excessive oil being thrown out should an explosion occur), a spring loaded disc valve with a rubber seat and round cover, secured to the crankcase door by four bolts.

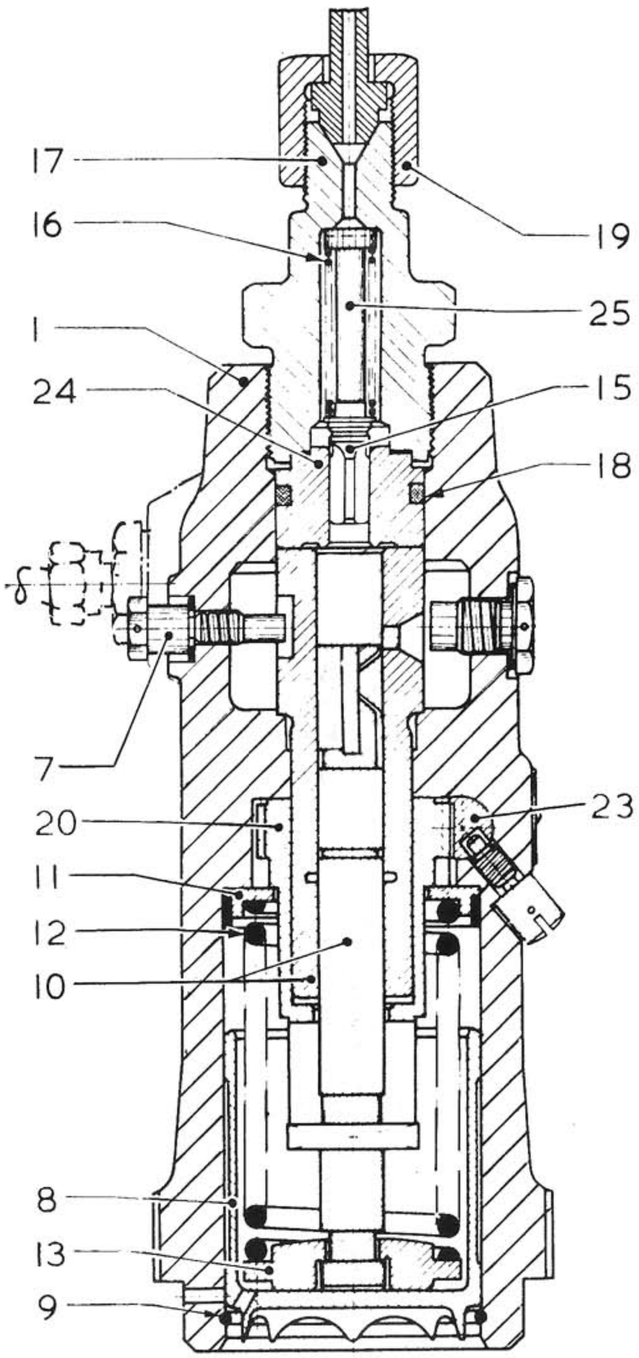
SECTIONAL VIEW OF C.A.V. MULTI-HOLE INJECTOR.

Fig. 14.





1. Pressure face
2. Nozzle holder
3. Compression screw
4. Spring cap nut
5. Valve spring
6. Valve spindle
7. Nozzle cup nut
8. Nozzle valve
9. Nozzle body
10. Fuel inlet connection
11. Leak-off connection
12. Soft iron joint
13. Lock nut
14. Rubber seal



SECTIONAL VIEW OF FLANGE MOUNTED C.A.V. FUEL PUMP.

Fig. 15.

1. Housing
7. Locking pin and joint
8. Plunger guide
9. Spring ring
10. Pump element (plunger and barrel)
11. Spring plate, upper
12. Helical spring for plunger
13. Spring plate, lower
15. Delivery valve
16. Delivery valve spring
17. Delivery valve holder
18. Joint for delivery valve holder
19. Delivery nipple nut
20. Regulating sleeve
23. Control rod
24. Delivery valve seating
25. Delivery valve spring peg

DIESEL ENGINE EMERGENCY OVERSPEED TRIPS.

Large engines are normally fitted with an emergency overspeed trip which, on operation at a speed higher than the normal pre-set maximum governed speed of the engine, cuts off fuel oil supply to the engine cylinders, either by forcing the fuel injection pumps control rod to the STOP position or by cutting off the fuel oil supply before it reaches the fuel pumps.

Possible causes of overspeeding the diesel engines:-

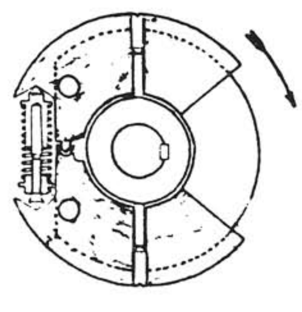
(1) Sticking or damage in the normal governor.

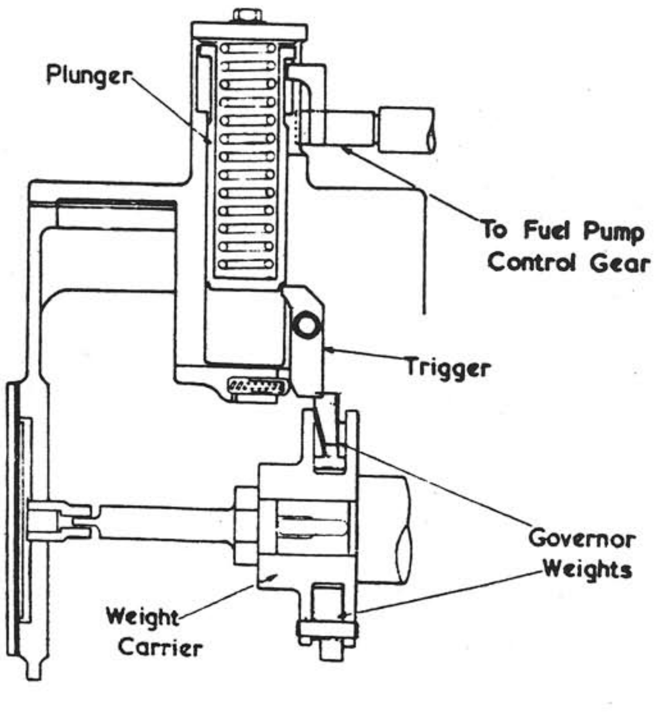
(2) Irregularities in the fuel pump and its control gear.

(3) Notching up too rapidly on the Power Controller.

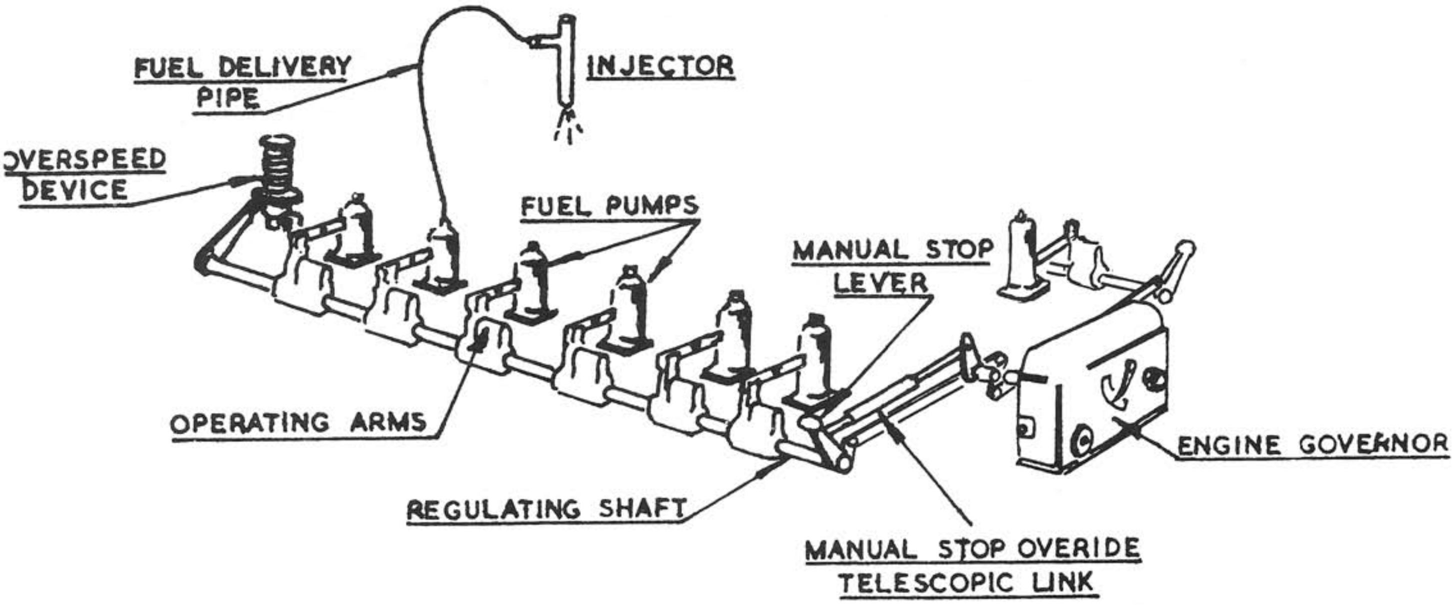
(4) Returning the Power Controller to OFF too quickly.

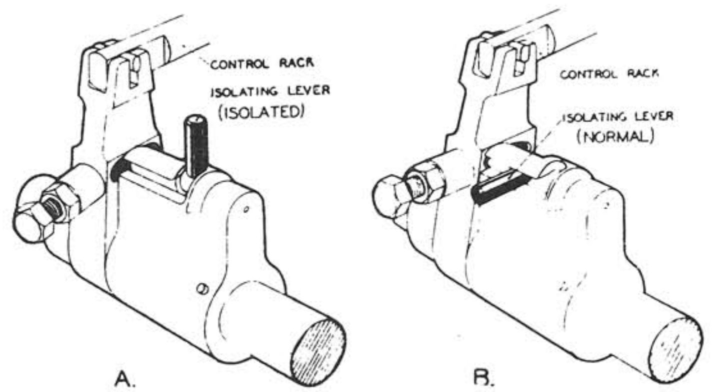
(5) Sudden throwing off of the generator load by the traction motors, such as the operation of the 'overload' relay, earth fault relay or should vacuum be destroyed when the power controller is open. Normally these conditions are catered for by the normal governor.

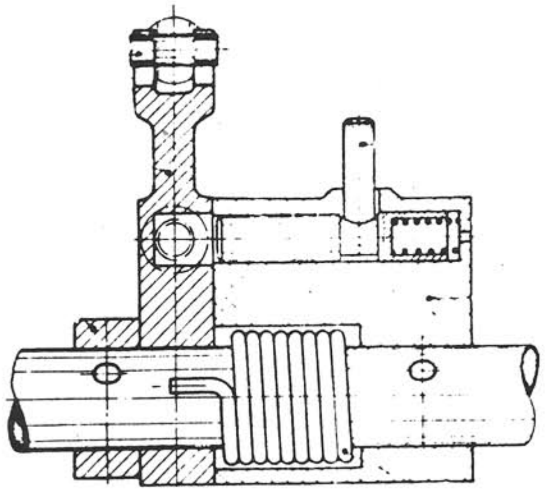




The weight carrier assembly is rotated from the 'free' end of one camshaft. Two weights are used and are held back in the carrier by a spring which counteracts the centrifugal force produced by the weights when they are rotated by the carrier assembly.

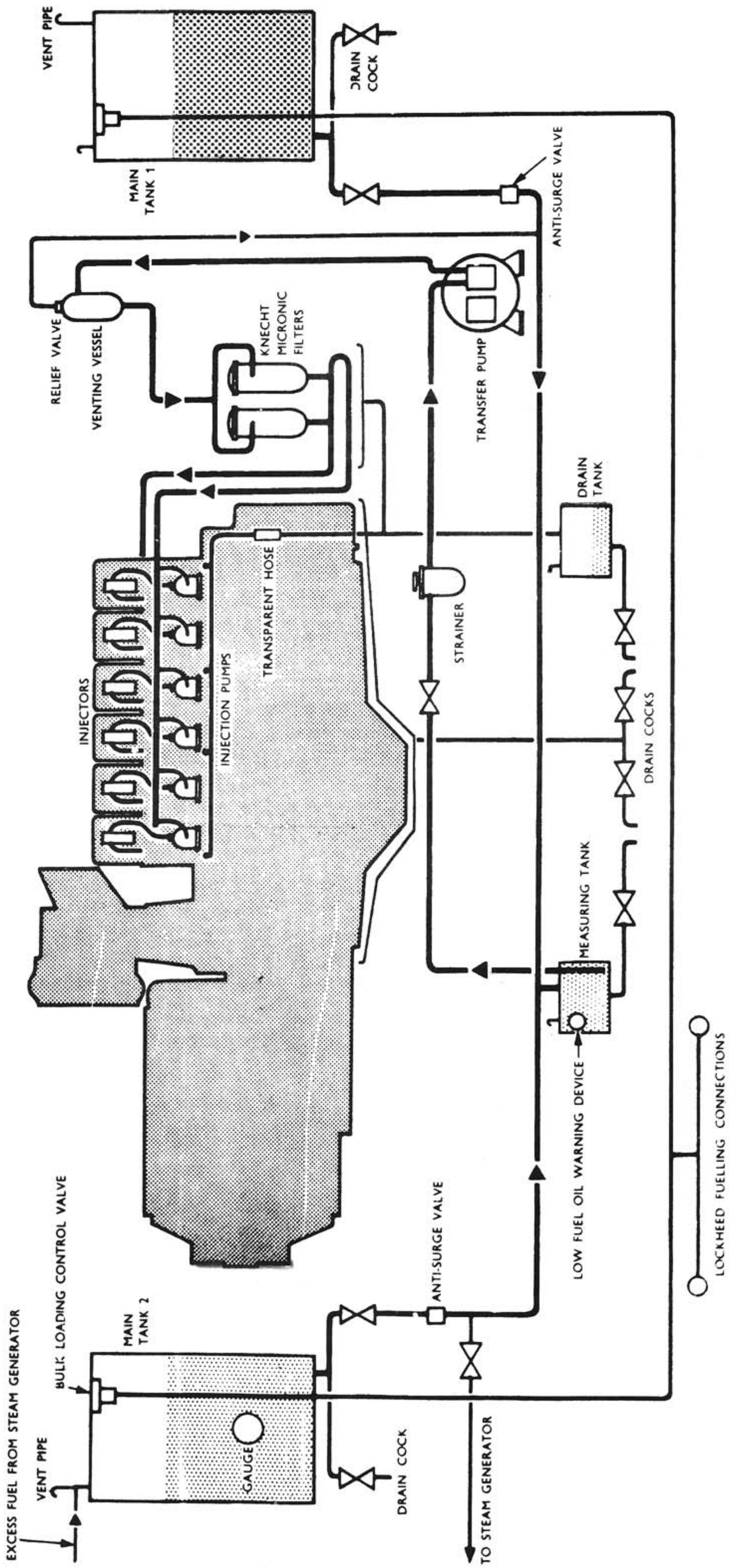

FUEL DELIVERY PIPE
INJECTOR
OVERSPEED DEVICE
FUEL PUMPS
MANUAL STOP LEVER
OPERATING ARMS
ENGINE GOVERNOR
REGULATING SHAFT
MANUAL STOP OVERIDE TELESCOPIC LINK


CONTROL RACK
ISOLATING LEVER
(ISOLATED)
A.
CONTROL RACK
ISOLATING LEVER
(NORMAL)
B.



If the engine speed rises to 850 r.p.m. (normal 750 r.p.m.) the additional centrifugal force produced by the weights will overcome the spring and cause the weights to move outwards. One weight is of tapered section, progressively increasing in width from its leading edge and on moving out will, by means of the 'wedge' action of the tapered edge, operate the 'trigger'. The 'trigger' releases the spring loaded plunger which moves down to engage on a lever attached to the fuel control shaft, turning this shaft to the 'no fuel' position.

To re-set the trip, the spring loaded plunger has to be lifted upwards from the lever on the fuel control shaft until the trigger re-engages beneath the plunger. The plunger is raised by means of a special re-setting lever which is carried as part of the locomotive tool equipment. Drivers must be sure they have this lever when taking charge of locomotives with Sulzer engines, except on engines that now have the lever fitted permanently.



CLASS 47 FUEL OIL SYSTEM.

Fig. 18.

THE FUEL OIL SYSTEM.

The fuel oil supply is carried in two main tanks and a measuring tank.

One main tank is situated in the radiator compartment and the other in the boiler compartment. The measuring tank is at a lower level than the main tanks and is underslung beneath the main frame at a point mid-way between the bogies. The main tanks are connected to the measuring tank to which the oil feeds by gravity.

There are filling and drain points common to the main tanks, but separate cocks enable either tank to be drained independently.

Each main tank is provided with a supply cock which allows either to be isolated from the measuring tank. It is important that these cocks are open during normal operation. The combined capacity of the main tanks is 720 gallons and that of the measuring tank 50 gallons, giving a total capacity of 770 gallons.

Path of the Fuel Oil.

The fuel oil transfer pump, one of the three units in the triple pump set, draws oil from the measuring tank, through an Auto Kleen strainer (mounted on the Serck/Behr oil reservoir) and is then delivered to the venting vessel; this vessel, provided with a relief valve set at approximately 45 p.s.i., ensures that adequate pressure is available at the engine fuel pumps. The capacity of the fuel transfer pump is in excess of the maximum demand of the engine and excess fuel is by-passed through the relief valve to the measuring tank. From the venting vessel, oil then passes through two Knecht micronic filters before finally feeding the engine fuel pumps.

A Mobrey float switch in the measuring tank operates a warning light should the fuel oil level fall to approximately 38 gallons (this is sufficient for about 25 miles running). In the event of the low fuel level warning being given, the boiler, if in use, should be shut down and the locomotive driven clear of the main line within 25 miles.

Spillage from the engine fuel pumps and injectors drains into a special drain tank.

Fuel Oil Consumption.

A reasonable figure is 1¼ miles per gallon without the boiler in operation.

The boiler can use up to 26 gallons per hour according to operating conditions.

LOAD CONTROL SYSTEM FOR THE "SULZER" 6S OR 12 LDA.281 ENGINE.

Since the individual characteristics of Diesel Engine, Main Generator and Traction Motors vary, some method of matching is required in order that Diesel Engine and Generator Output may at all times be sufficient to meet the requirements of the Traction Motors in providing locomotive power.

This need is met by the Engine Governor which incorporates provision for Load REGULATION or CONTROL.

The Governor ensures that the engine is correctly loaded to match the speed at which it is running, but output at each engine speed is varied to accommodate changing conditions of load thus ensuring that fuel is used economically throughout the speed range of 325 to 750 r.p.m. So, for a particular engine speed, the governor may cause the load regulator to increase or decrease the main generator field thereby loading or unloading the engine to the required value.

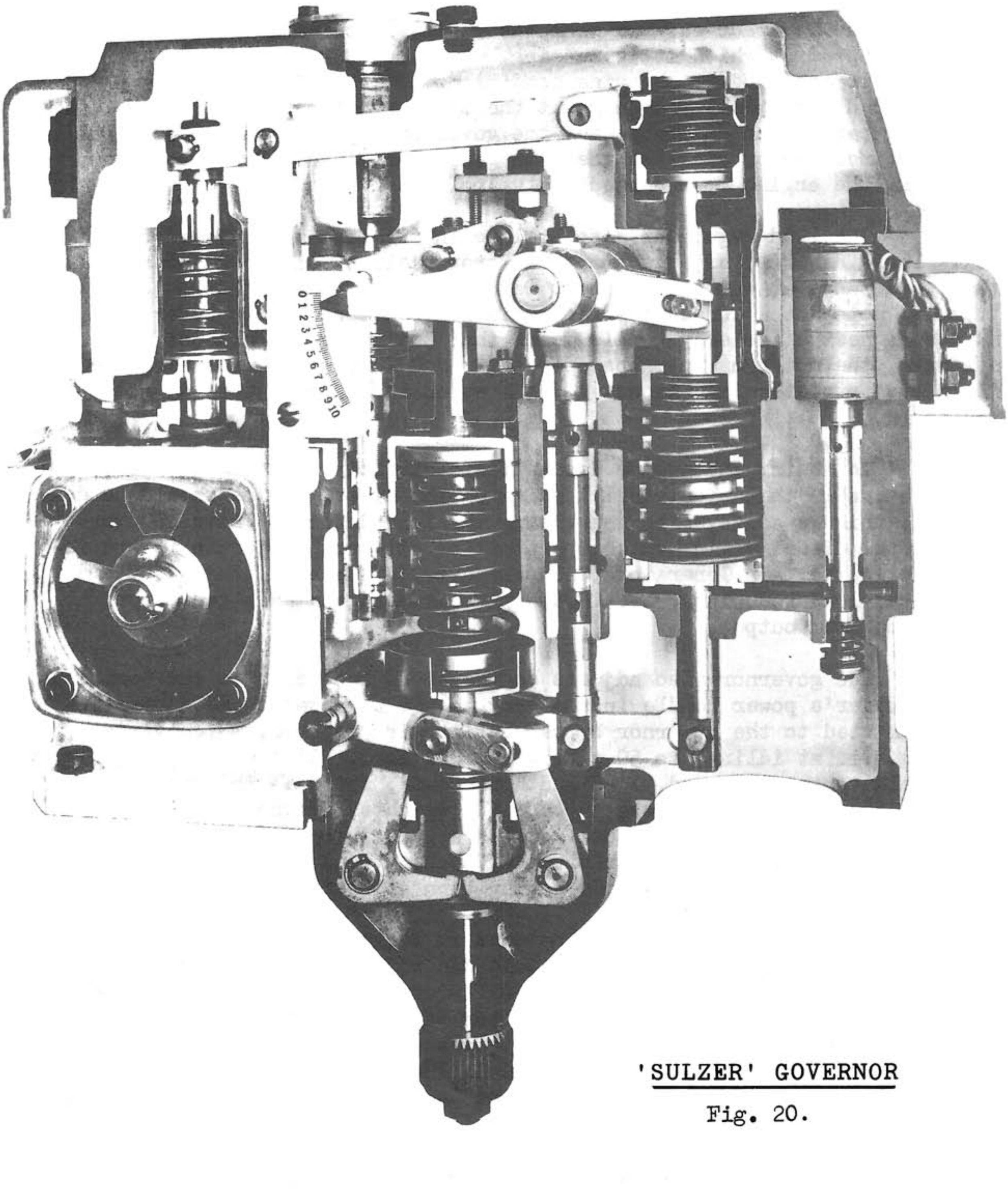
The load regulator also assists in traction motor field diverting. These diverts vary the traction motor field strength and consequently the speed range at which the motors may operate. The speed range of a traction motor at a constant strength is limited possibly to 20 or 30 m.p.h. at its highest efficiency. This means that while at one value of field strength, the motor may perhaps operate from 0 - 30 m.p.h. altering the field by a predetermined amount gives a speed range from 30 to 45 m.p.h. and so on.

To assist the engine during field diverting on traction motors, it is desirable that electrical loading on the diesel engine should be decreased; this is achieved by energising the Load Reducing Valve or overloading the diesel engine which operates the oil servo motor to insert resistance in the Main Generator field circuit. After each stage of field divert the load reducing valve is de-energised and the main generator reaches maximum output.

The governor also adjusts engine speed according to the position of the driver's power handle in that any change of power handle position is transmitted to the governor by regulating air pressure, which varies from 0 p.s.i. at idling, to 50 p.s.i. at full load. Of the three rigidly fixed relationships, speed, load and horsepower, speed is the one that the governor senses. This it does through fly weights, driven by the engine camshaft. The governor therefore accepts a certain condition of any load for speed, and maintains it, for example, should the locomotive run into a gradient without the power handle having been altered.

Protection devices are included in the governor which incorporates an electro-magnetic Engine Run Solenoid which must be energised for the engine to run. Low water and low oil pressure switches are included in the circuit to this solenoid and either can break the feed to de-energise the solenoid and stop the engine. The governor also includes a device to limit the fuel injected at starting and during acceleration since the pressure charger takes time to accelerate and deliver the necessary amount of air for complete combustion.

Locomotives fitted with alternators for electrical train heating have had their engines uprated, i.e. speed range 380 - 800 r.p.m.



'SULZER' GOVERNOR

Fig. 20.

OPERATION OF THE GOVERNOR.

Control air entering the speed control cylinder from the Control Air Valve will balance a rubber diaphragm against spring load to lift the speed control piston (A) and oil from the engine lubricating system is available at the middle section of slide valve (D). Movement of piston (A) between position '0' and '10' will, through B, C, and E linkage, move slide valve (D), admitting oil to the top of speed control servo-piston (F) thus causing it to move until slide valve (D) again is in the 'all ports closed' position. By means of this feed-back linkage, speed control servo-piston (F) will always move according to the movement of the piston (A) in the speed control cylinder.

The governor spring combination is designed to balance the lifting force of flyweights (U) which are driven from the engine camshaft through bevel gears. With increasing control air pressure, speed control servo-piston (F) will move downwards, at the same time depressing speed regulating link (T). This causes fuel servo-piston (N) to move upwards, increasing fuel injection and therefore engine speed. The linkage between speed regulating link (T) slide valve (R) and fuel servo-piston (N) again forms a servo-system transmitting any motion of speed regulator link (T) into a power stroke of fuel servo-piston (N). This servo-mechanism enables the diesel engine to maintain any speed set by the speed control servo-piston (F), since the slightest unbalance of the flyweights (U) against the force of the springs will move regulating link (T) and thus cause an increase or decrease of the fuel injection through the operation of fuel servo-piston (N).

Under normal conditions, oil pressure forces fuel control piston (M) to rest in the upper position within fuel servo-piston (N) as shown. Therefore, every movement of fuel servo-piston (N) is transmitted to the engine fuel pumps.

ADJUSTMENT OF GENERATOR LOAD TO ENGINE OUTPUT.

During acceleration or deceleration of the locomotive, a continuous balance of generator electrical load and diesel engine output is required. This load adjustment is achieved by inserting a vaiable resistance in the separate field of the main generator. Contacts for these resistances are arranged in the load regulator which is driven by servo-motor (V) and hydraulically actuated in either direction by slide valve (H). As the required engine torque depends upon engine speed, the linkage of slide valve (H) is connected on one side to speed control servo-piston (F) and on the other to fuel servo-piston (N) via lever (K).

An increase in main generator output, e.g. by running into a steeper grade, results in an overload of the diesel engine causing its speed to drop. Since the position of piston (F) has not changed, the governor spring will force speed regulating link (T) downwards due to the reduced centrifugal force of the flyweights. This movement causes slide valve (H) to be pulled downwards, i.e. out of its natural position, thus allowing oil to lift servo-piston (N), so increasing the quantity of fuel injected.

The diesel engine will then increase speed and movement of fuel servo-piston (N) will, through lever (K), push slide valve (H) downwards from its original neutral position. This causes load regulator servo-motor (V) to rotate in a clockwise direction and the load regulator will therefore rotate towards the maximum resistance position causing additional resistance to be introduced into the generator separate field and reducing the generator load. Increase of fuel injection and reduction of generator load therefore causes a rapid recovery of engine speed.

As speed increase, fuel servo-piston (N) will fall, taking with it fuel control piston (M) and raising slide valve (H). This action will continue until slide valve (H) is in the 'both ports closed' position and engine speed and torque will be the same as before the adjustment took place.

The load regulator will come to rest as well, but the new position does not need to be the same as the original one. Engine power and speed are therefore independent of locomotive speed, apart from small ranges at high locomotive speed where there is a slight fall of engine output due to limitation in generator capacity.

To avoid hunting due to simultaneous alterations of injection quantity and generator load, a sliding choke is placed in the passageway between slide valve (H) and the load regulator servo-motor.

The choke (Z) imposes a lag on the movement of the load regulator servo-motor (V) which effectively prevents any overswing. Control of the speed of the load regulator is effected by throttle screws.

PRESSURE CHARGING PROTECTION.

Charging pressure is applied to the air pressure chamber, lifting the air piston sleeve against a spring force to a position corresponding to the pressure in the air inlet manifold. As long as the relief ports are closed by the piston sleeve, no fuel reduction will occur. However, should charging pressure drop below the design value, the control edge of the piston sleeve will uncover the relief ports. This results in reduction of oil pressure inside fuel servo-piston (N) causing fuel control piston (M) to be forced downwards by spring force until relief ports are covered again. The orifice enables pressure to be maintained under fuel control piston (M) unless the relief ports are open.

The full movement of servo-piston (N) therefore will be transmitted to the fuel pumps as long as there is sufficient pressure to keep relief ports closed.

A drop in charging pressure below design value will cause the fuel rack settings governed by fuel control piston (M) to be lower than that required by the governor.

With this depressed fuel rack position, the engine will loose speed. This in turn will cause fuel servo-piston (N) to rise. This reaction will be transmitted through linkage (K) (J) to the load regulator slide valve (H). This will cause the load regulator to run back, reducing the generator separate field.

This action will continue until engine speed has been restored to normal and the slide valve (H) is in its neutral position, causing the load regulator to stop.

When starting or accelerating the engine, the inherent characteristic of the governor would normally cause the fuel pump racks to go to their fullest position. This procedure is bad for any engine, causing

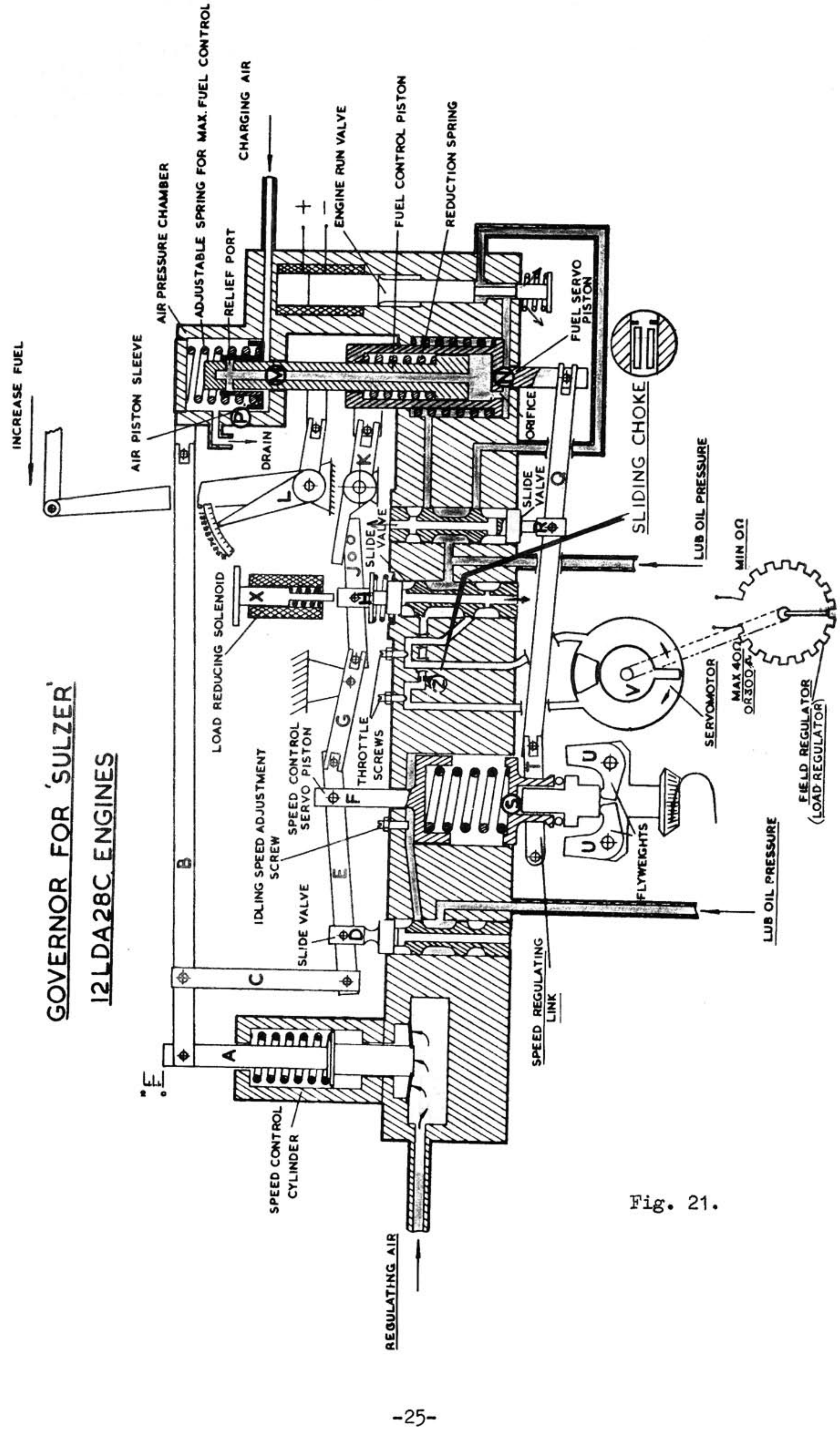

GOVERNOR FOR 'SULZER'
12LDA28C ENGINES
INCREASE FUEL
AIR PISTON SLEEVE
AIR PRESSURE CHAMBER
ADJUSTABLE SPRING FOR MAX. FUEL CONTROL
RELIEF PORT
CHARGING AIR
ENGINE RUN VALVE
FUEL CONTROL PISTON
REDUCTION SPRING
FUEL SERVO PISTON
ORIFICE
DRAIN
SLIDE VALVE
SLIDING CHOKE
LUB OIL PRESSURE
MIN Ω
SLIDE VALVE
LOAD REDUCING SOLENOID
SERVOMOTOR
MAX 40Ω OR 300 A
FIELD REGULATOR (LOAD REGULATOR)
THROTTLE SCREWS
SPEED CONTROL SERVO PISTON
IDLING SPEED ADJUSTMENT SCREW
FLYWEIGHTS
LUB OIL PRESSURE
SLIDE VALVE
SPEED REGULATING LINK
SPEED CONTROL CYLINDER
REGULATING AIR

Fig. 21.

excess stresses and incomplete combustion due to lack of charging air until the pressure charger has had a chance to build up speed.

With the Sulzer governor, the fuel racks are prevented from opening further than the value allowed by the height of the air piston sleeve. This prevents increases of rack opening beyond a predetermined value until charging air pressure has reached a value which would provide sufficient air to burn the fuel efficiently.

Stopping the Engine.

Until the run valve is energised, oil is prevented from filling the fuel servo cylinder and the fuel racks will remain at '0'. With the valve energised, the drainway is blocked and oil can pass to raise servo piston (N). This is used as a method of stopping the engine both normally and in the case of a failure of cooling water or lubricating oil pressure.

FIG. 21.

SPEED CONTROL GROUP.

A Piston and Diaphragm
B Lever
C Connecting Link
D Slide Valve
E Feed Back Lever
F Piston

POWER PISTON AND P.P.U. GROUP.

L Fuel Rack Lever
M Fuel Control Piston
N Fuel Servo Piston
P Pressure Protection Unit (P.P.U.)
Q Feed Back Lever
R Slide Valve

LOAD REGULATOR GROUP.

G Lever
H Slide Valve
J Double Fulcrum Lever
K Lever
V Servo Motor
X Load Reducing Valve
Z Sliding Choke

GOVERNOR FLY-WEIGHT GROUP.

S Governor Sleeve
T Drag Lever
U Fly-weights

SHUT DOWN GROUP.

W Shut Down Valve and Magnet (Engine Run Valve).

COOLING WATER SYSTEM CLASS 47 (UNMODIFIED).

Two radiator panels connected in series, and two cooling fans are provided; these are mounted in the roof section of the locomotive between the diesel engine and No. 1 driving cab. The radiator panels drain into a single common tank in the radiator compartment which is below the radiators. The drain tank has a sight glass housed in a metal protective sleeve with two openings provided to indicate the maximum and minimum water levels.

Water pressure and temperature gauges are provided on the engine instrument panel mounted on the bulkhead separating engine and radiator compartments.

Cooling water is circulated by an electrically driven pump forming part of a combined lubricating oil, priming and fuel oil transfer pump set.

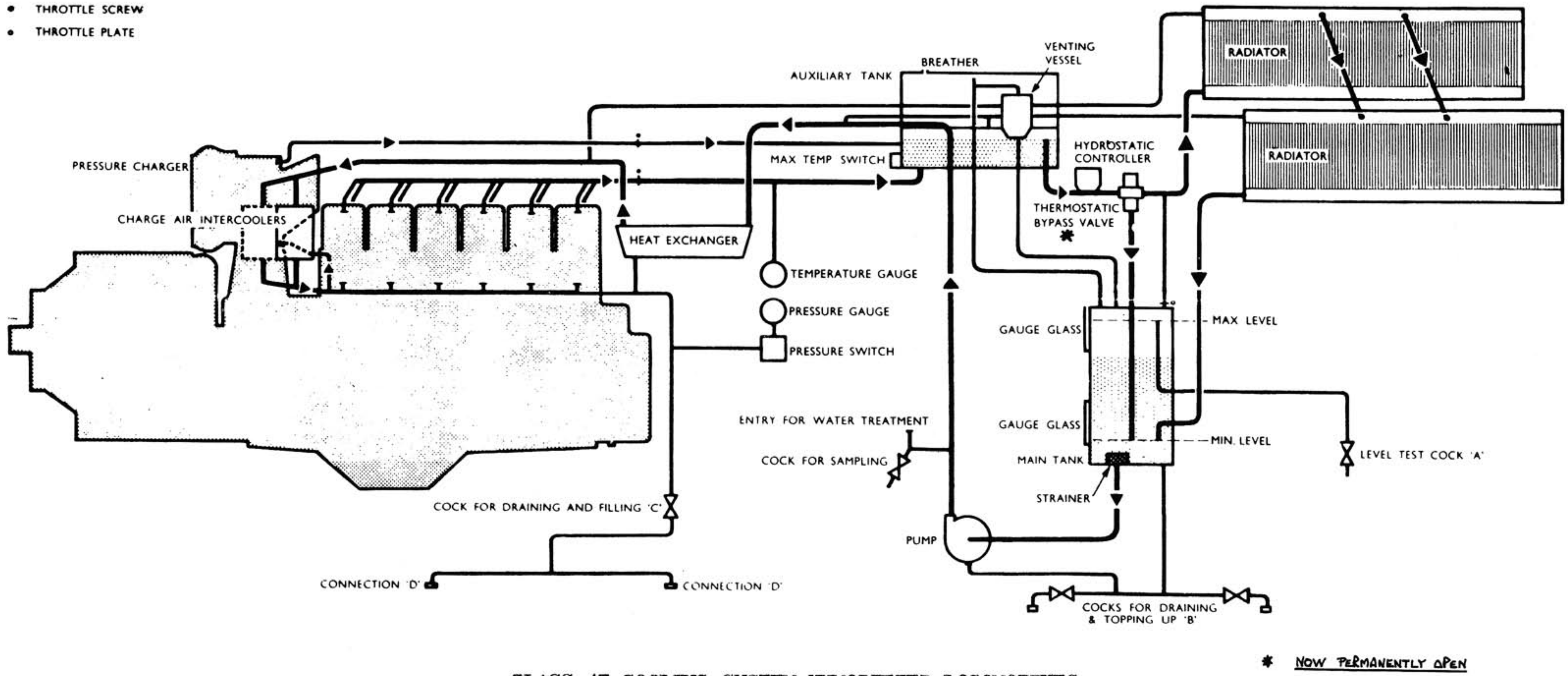
The water pump normally maintains a water pressure of approximately 15 p.s.i. when the engine is running and approximately 10 p.s.i. with the engine stopped. If the pressure falls much below these values the cause should be investigated. A water pressure switch stops the engine should the water pressure fall to about 4 p.s.i.

The arrangement of the system is such that as soon as the pump stops and circulation ceases, the radiator panels are automatically drained into the tank.

An auxiliary or header tank is fitted to serve as an expansion chamber for water in the circuit. Mounted upon it is the maximum temperature switch, which gives warning in case of high cooling water temperature (185°F). Fine temperature control is then provided by the Serk/Behr hydrostatic fan control.

PATH OF THE COOLING WATER.

The TRIPLE PUMP draws water from the radiator drain tank and passes through an inverted 'U' pipe to the HEAT EXCHANGER. The 'U' pipe acts as a non return valve. From the HEAT EXCHANGER the water passes through the INTERCOOLERS and then to the engine cylinder block, rising through the cylinder heads. From there it goes to the HEADER TANK where the WATER TEMPERATURE SWITCH is located. The BYPASS VALVE now permanently open allows the water to pass through the two RADIATOR PANELS which are coupled in series. From there it goes back to the RADIATOR DRAIN TANK.



CLASS 47 COOLING SYSTEM UNMODIFIED LOCOMOTIVES.

Fig. 22.

PRESSURE COOLING SYSTEM CLASS 47 LOCOMOTIVES.

In the light of the rapid evolution in diesel engine power, pressurisation of coolant systems has led to much greater efficiency. The advantages can be summed up breifly as follows.

Operationally the use of pressure cooling very appreciably reduces the need for topping up because of evaporation, and this in turn reduces the incidence of corrosion and silting of coolant passages. The previous use of drain tanks required additional weight and space, and the draining of coolant everytime the engine stopped allowed atmospheric air to assist corrosion and encouraged aeration on starting.

Pressurisation also causes a rise in temperature at which the coolant will boil, and in this respect greater efficiency of the engine can be achieved by running it at a higher ambient temperature, without risk of boiling. When deterioration of equipment occurs the warning and fault lights brighten at 200°F instead of the usual 185°F. It then logically follows that the size of the cooling group can be further reduced because a lesser degree of temperature drop is necessary in the passage of the coolant through the radiator. This means that the radiator can be reduced some 65 - 70 per cent of the original size, or alternatively the power required to drive the fan can be reduced by 30 - 50 per cent of the original value.

Coolant Path.

Water delivered by the triple pump passes into the heat exchanger where it cools the engine lubricating oil. After the heat exchanger, the flow is divided between the two intercoolers; from the intercoolers the water is fed to the cylinder block of the engine, the cylinder heads and leaves the engine via the outlet manifold.

Water also passes from the cylinder block to the turbo charger. The combined flow from the engine and turbo charger join at the outlet from the engine.

Attached to the outlet pipe are the maximum water temperature switch set at 200°F., the water temperature gauge, and a water pressure safety valve set at 30 p.s.i.

The coolant then passes through the Serck controller into the left hand radiator panel then into the right hand panel, thence it passes to the suction side of the triple pump.

Return vents to the header tank run from the engine and turbo charger outlet and from the discharge side of the circulation pump. The header tank keeps the water circulation pump supplied via a make-up pipe on the suction side.

To ensure reasonably quick build up of engine temperatures and to protect the radiator elements in frosty weather, four sets of shutters operated by hydraulic rams in the Serck System are fitted across the radiator air intakes.

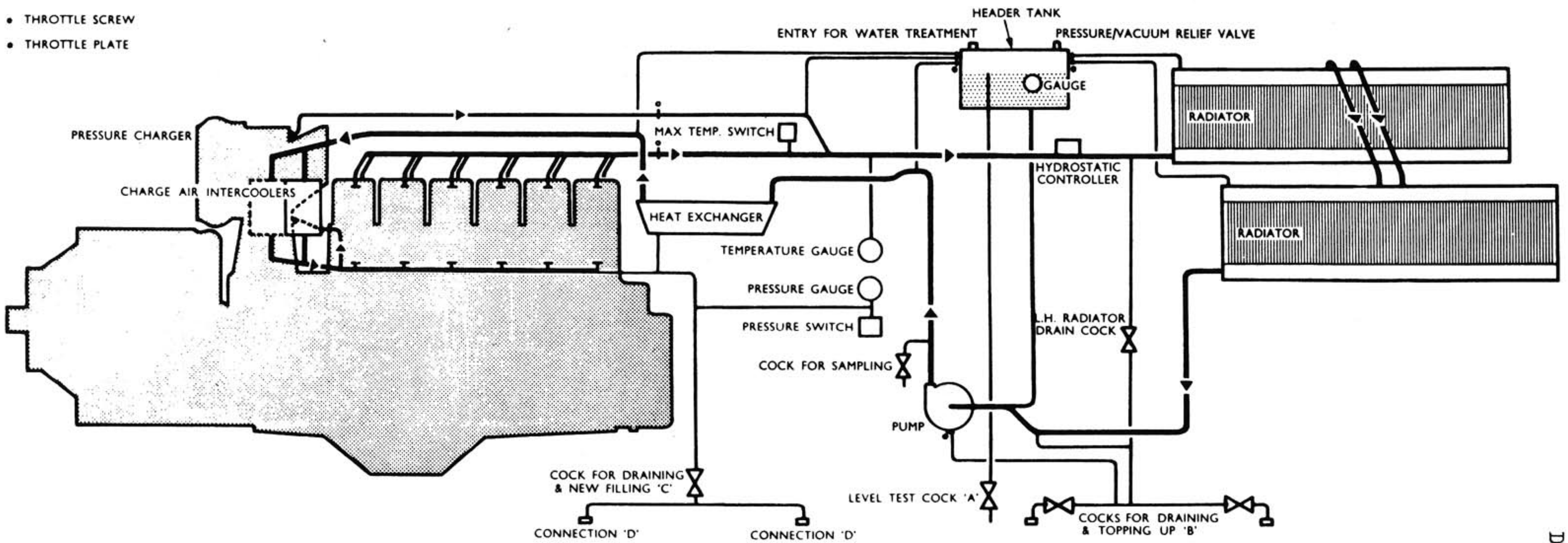
The Serck controller regulates the opening of these shutters so that they open 10°F. before the fans begin to rotate. It is still necessary to have the try cock (situated on one side of the locomotive only) open when filling the cooling system otherwise water will discharge from the relief valve situated on the header tank.

There is an additional safety device in the form of low water level switch fitted to the header tank which, if it should operate, will cause the general alarm and the Low Water Pressure/Level Light to become bright. This will indicate that there is a loss of water from the system and only 12 gallons remain in the header tank to "make-up" any subsequent losses.

Note that if the header tank empties completely the diesel engine will be stopped through the water pressure switch operating at 4 p.s.i; this would also brighten the low water pressure/level fault light on the control cubicle. A Pressure/Vacuum relief valve also fitted in the header tank set at 6 p.s.i., 1½" vacuum, limits the pressure in the system, and the formation of vacuum as the water cools and contracts by approximately 12 gallons within the header tank.

CLASS 47 PRESSURISED COOLING SYSTEM.

Fig. 23.



THE SERK/BEHR HYDROSTATIC COOLING FAN DRIVE.

The Serk/Behr hydrostatic fan drive automatically controls the speed of the cooling fan in relation to the temperature of the engine cooling water (coolant).

The drive consists of a hydraulic pump mounted on the free end of the engine and gear driven from the crankshaft. This pump is coupled hydraulically (i.e. through connecting pipes) to hydraulic motors which drive the radiator fans.

A control unit, sensitive to coolant temperature, regulates the supply of oil to the fan motors.

The oil used in the hydraulic circuit is contained in a reservoir situated in the equipment room. After passing through the circuit the oil is cooled in cooling elements which are positioned in the stream of cooling air passing through the radiator panels.

When the engine is started the hydraulic pump rotates, drawing oil from the reservoir and delivering it at a very high pressure to the Control Unit.

The Control Unit, which senses the coolant temperature, governs the starting and varies the speed of the fans. It contains a wax element, submersed in the coolant return from the engine, which is very sensitive to temperature change. Coupled to the wax element is a spring valve, which is fully open when the coolant temperature is below 168°F. allowing oil delivered from the pump to by-pass the fan motors and return to the reservoir. Thus, pressure is prevented from building up at the fan motors which therefore remain stationary.

When the coolant temperature exceed 168°F., the wax element expands and progressively closes the Control Unit by-pass. At first only part of the oil flow will be diverted to the fan motors causing them to rotate at a relatively low speed, but as the coolant temperature continues to rise, the Control Unit by-pass further restricts the amount of oil by-passing the fan motors and causes the pressure at the fan motors to increase in proportion to the rise in coolant temperature. In this manner, the speed of the fan motors is regulated so that the flow of cooling air is sufficient to maintain the desired coolant temperature in the engine.

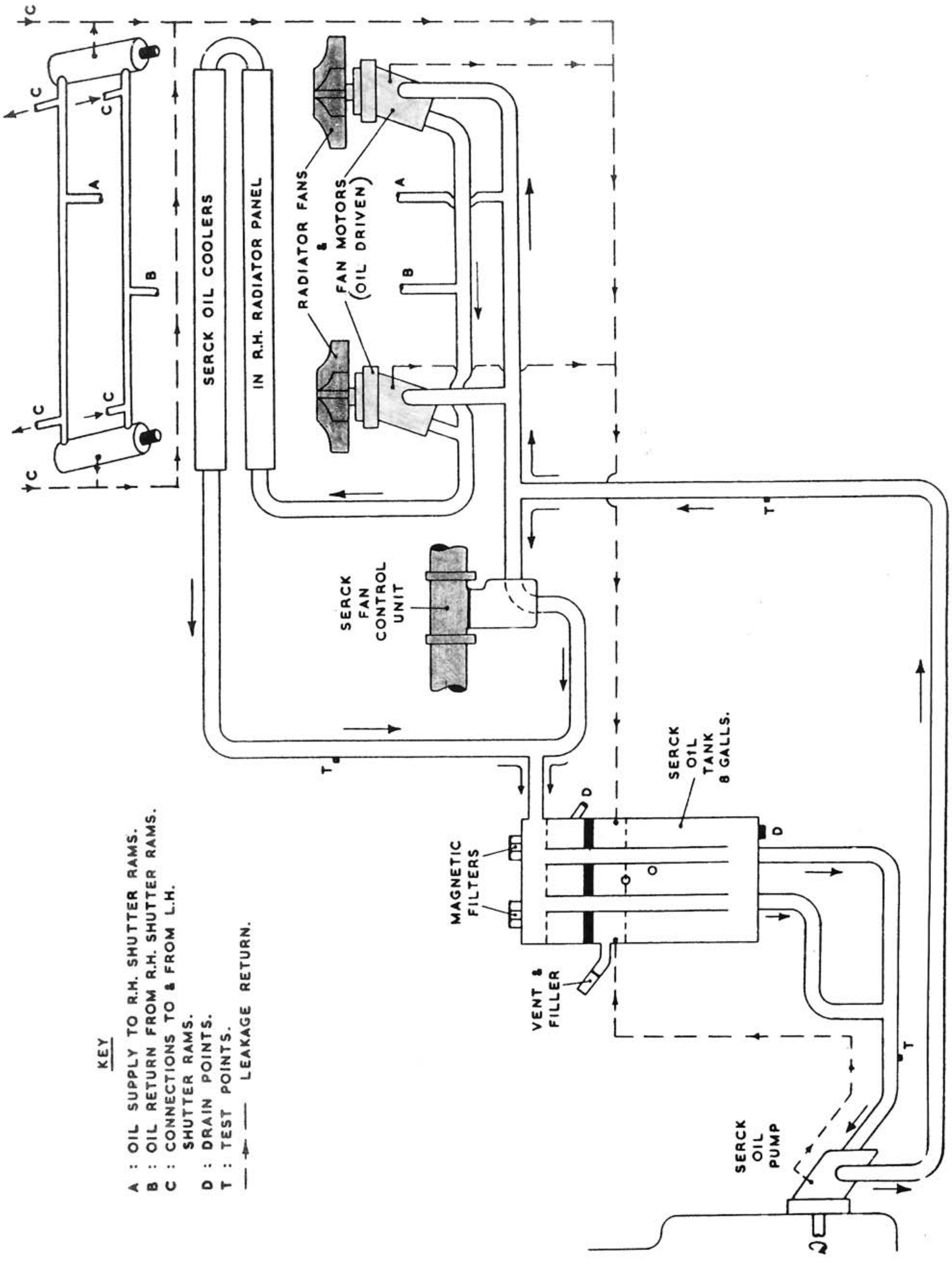
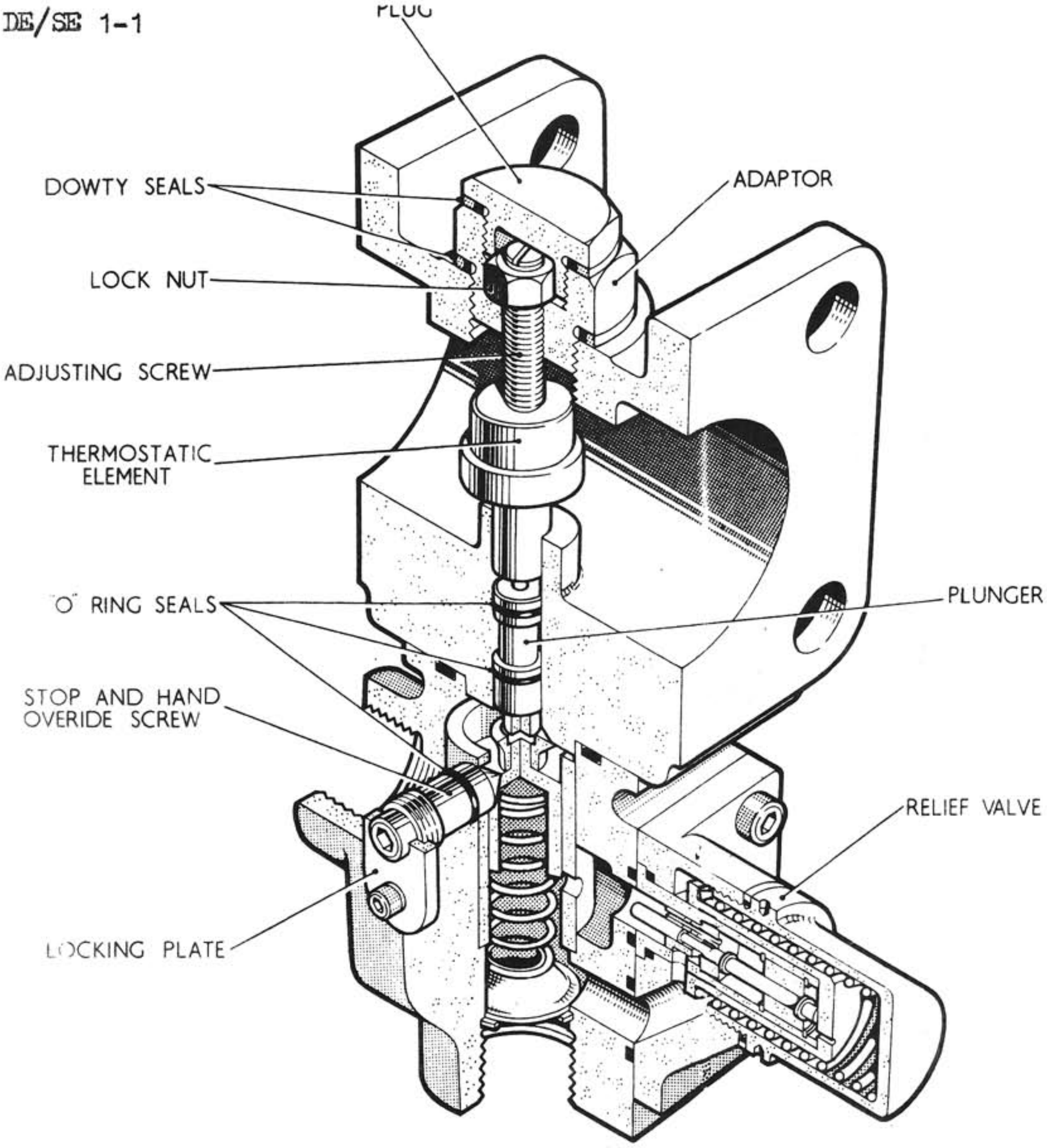

SERCK OIL COOLERS
IN R.H. RADIATOR PANEL
RADIATOR FANS
&
FAN MOTORS
(OIL DRIVEN)
SERCK FAN CONTROL UNIT
SERCK OIL TANK 8 GALLS.
MAGNETIC FILTERS
VENT & FILLER
SERCK OIL PUMP
A
B
C
D
T
KEY
A : OIL SUPPLY TO R.H. SHUTTER RAMS.
B : OIL RETURN FROM R.H. SHUTTER RAMS.
C : CONNECTIONS TO & FROM L.H. SHUTTER RAMS.
D : DRAIN POINTS.
T : TEST POINTS.
—→— LEAKAGE RETURN.

Fig. 24.


PLUG
DOWTY SEALS
ADAPTOR
LOCK NUT
ADJUSTING SCREW
THERMOSTATIC ELEMENT
"O" RING SEALS
PLUNGER
STOP AND HAND OVERIDE SCREW
RELIEF VALVE
LOCKING PLATE

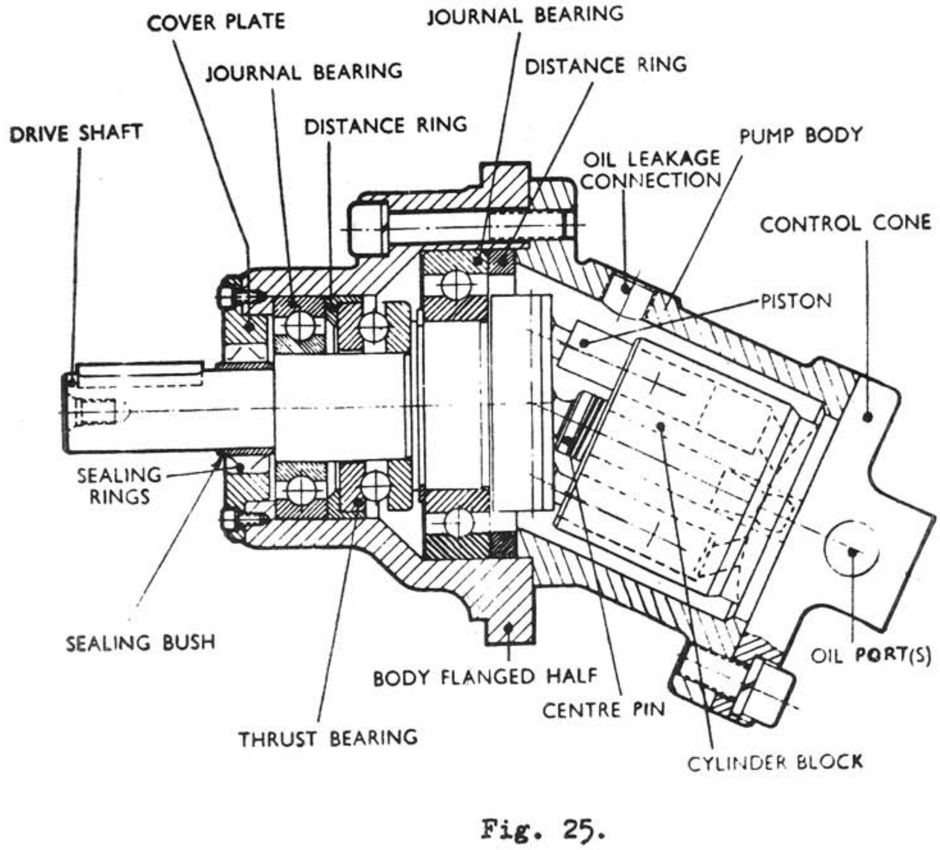

COVER PLATE
JOURNAL BEARING
JOURNAL BEARING
DISTANCE RING
DISTANCE RING
DRIVE SHAFT
PUMP BODY
OIL LEAKAGE CONNECTION
CONTROL CONE
PISTON
SEALING RINGS
SEALING BUSH
OIL PORT(S)
BODY FLANGED HALF
CENTRE PIN
THRUST BEARING
CYLINDER BLOCK

Fig. 25.

THE LUBRICATING OIL SYSTEM.

Two lubricating oil pressure pumps are incorporated in the system:-

1. The Priming Pump (one of the three pump units which make up the combined or triple pump set). This pump enables the engine lubricating system to be primed before the engine is started, and for oil circulation to be maintained for a time when the engine is stopped, to ensure an even cooling of pistons and bearings. This pump also supplies oil directly to the engine governor via a special filter, and a spring loaded pressure valve will ensure rapid build up of oil pressure at the governor so causing the fuel racks to move to the correct position for engine starting. Pressure in excess of the valve setting is then circulated to the engine system.

2. The Main Engine Driven Pump which supplies the system after the engine has been started.

Two oil pressure switches are provided:-

1. The Run Oil Pressure Switch (R.O.P.S.). This switch operates to stop the diesel engine should oil pressure fall to 12 p.s.i.

2. The Start Oil Pressure Switch (S.O.P.S.). This switch causes the RED Engine Stopped Light to dim when, after the diesel engine has been started, the lubricating oil pressure has built up to 20 p.s.i. It has been provided to obviate 'false' engine starts.

The normal oil temperatures are	160/175°F.
Maximum running temperature	185°F.

The diesel engine should not be run if the oil temperature reaches 200°F. If this temperature is reached, the diesel engine MUST be stopped and the reverser left in 'E.O.' until the temperature has fallen to approximately 170°F.

Checking the Lubricating Oil Level in the Engine Sump.

If the diesel engine stops and the oil pressure fault light on the Control Cubicle is BRIGHT, check the level of the oil in the sump before attempting to restart the diesel engine. The correct method is as follows:-

(a) Leave the reverser in 'E.O' for two minutes.
(b) Remove the dipstick and wipe it with a clean cloth.

(c) Replace the dipstick fully home into dipstick housing.
(d) Remove the dipstick and take the reading.

NEVER CHECK THE SUMP OIL LEVEL WHEN THE ENGINE IS RUNNING.

If the oil level indicated is between the MIN and MAX marks (due allowance to be made if the locomotive is not on a level track) then the engine may be restarted.

If the engine restarts, check the oil pressure at idling speed. If it is less than 16 p.s.i. proceed, but report fault and inform any relief driver.

The normal oil pressures are:-

Engine idling	16 - 30 p.s.i.
Engine running above idling speed	16 - 50 p.s.i.

On initially starting from cold, oil pressures will exceed these values.

Lubricating Oil Path.

With the REVERSING HANDLE in 'E.O.' the TRIPLE PUMP runs and draws oil from the engine pump, and passes it through a delivery pipe, a branch of which goes through a filter unit to the ENGINE GOVERNOR. At the GOVERNOR the oil makes the necessary adjustments to the FUEL RACKS ready for starting.

The main delivery pipe then passes oil to the STARTING VALVE which remains in the closed position until a pressure of 45 p.s.i. is obtained. Oil in excess of this pressure now passes via the HEAT EXCHANGER to a FILTER UNIT. Connected to this pipe, between HEAT EXCHANGER and FILTER UNIT, is an OIL TEMPERATURE GAUGE and two VALVES.

(a) BY-PASS VALVE.
(b) SAFETY VALVE.

The BY-PASS VALVE allows oil to by-pass the HEAT EXCHANGER if the differential pressure across the HEAT EXCHANGER exceeds 20 p.s.i.

The SAFETY VALVE allows oil to escape to the sump if the pressure in the system exceeds 60 p.s.i.

The FILTER UNIT consists of two FILTERS. A coarse wire mesh filter through which all the oil passes and a fine gauge filter through which a proportion of the oil passes.

From the FILTER UNIT the oil now passes through two pipes:-

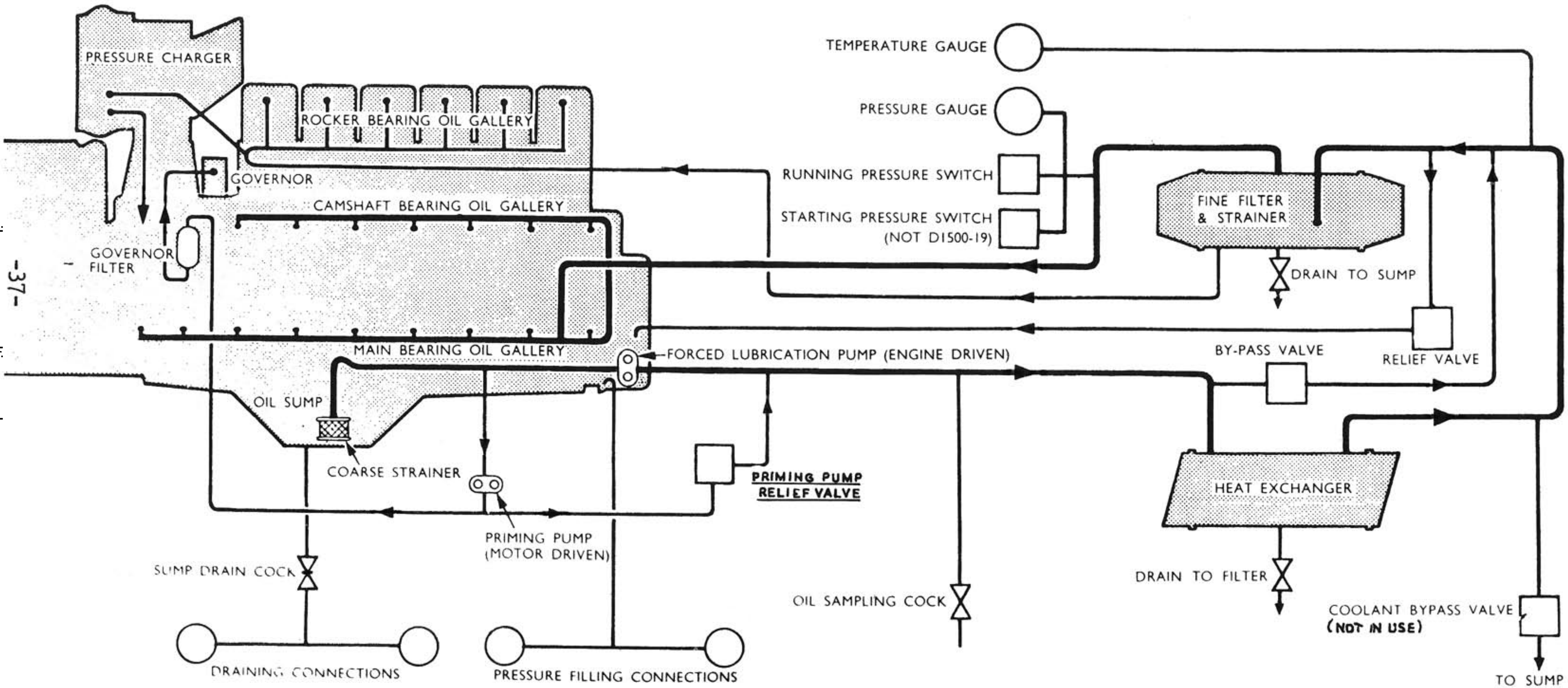
(a) To the main bearings, large ends, small end gudgeon pins, piston cooling and camshafts. There is a feed taken from this pipe to the PRESSURE SWITCHES AND PRESSURE GAUGE.

(b) This line feeds the rocker gear and turbocharger.

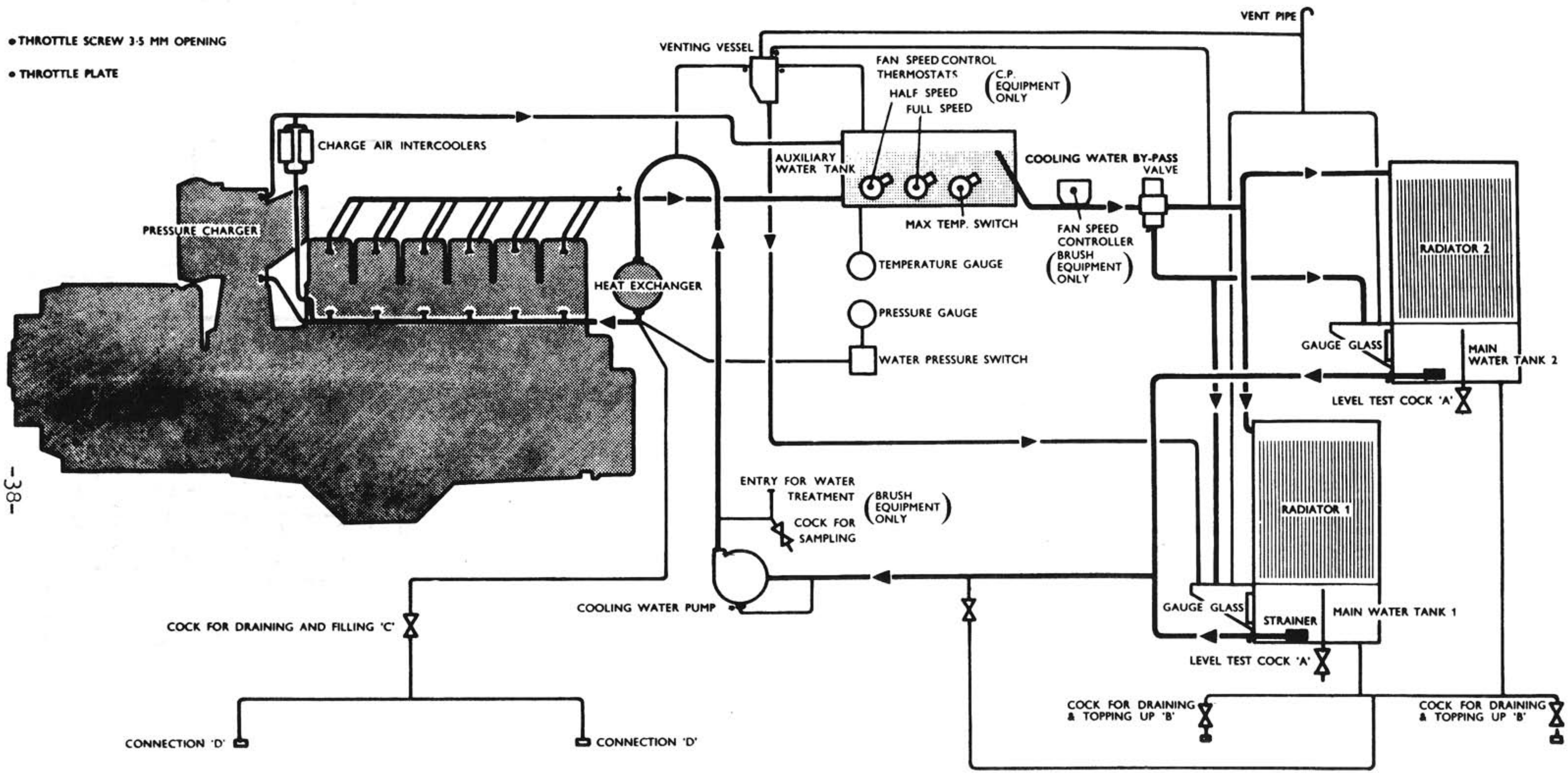
When the engine is running, the gear driven pump (driven from the crankshaft) delivers oil from the sump into the system at a point between the STARTING VALVE and HEAT EXCHANGER.

ULZER 12 LDA28 LUBRICATING OIL SYSTEM.

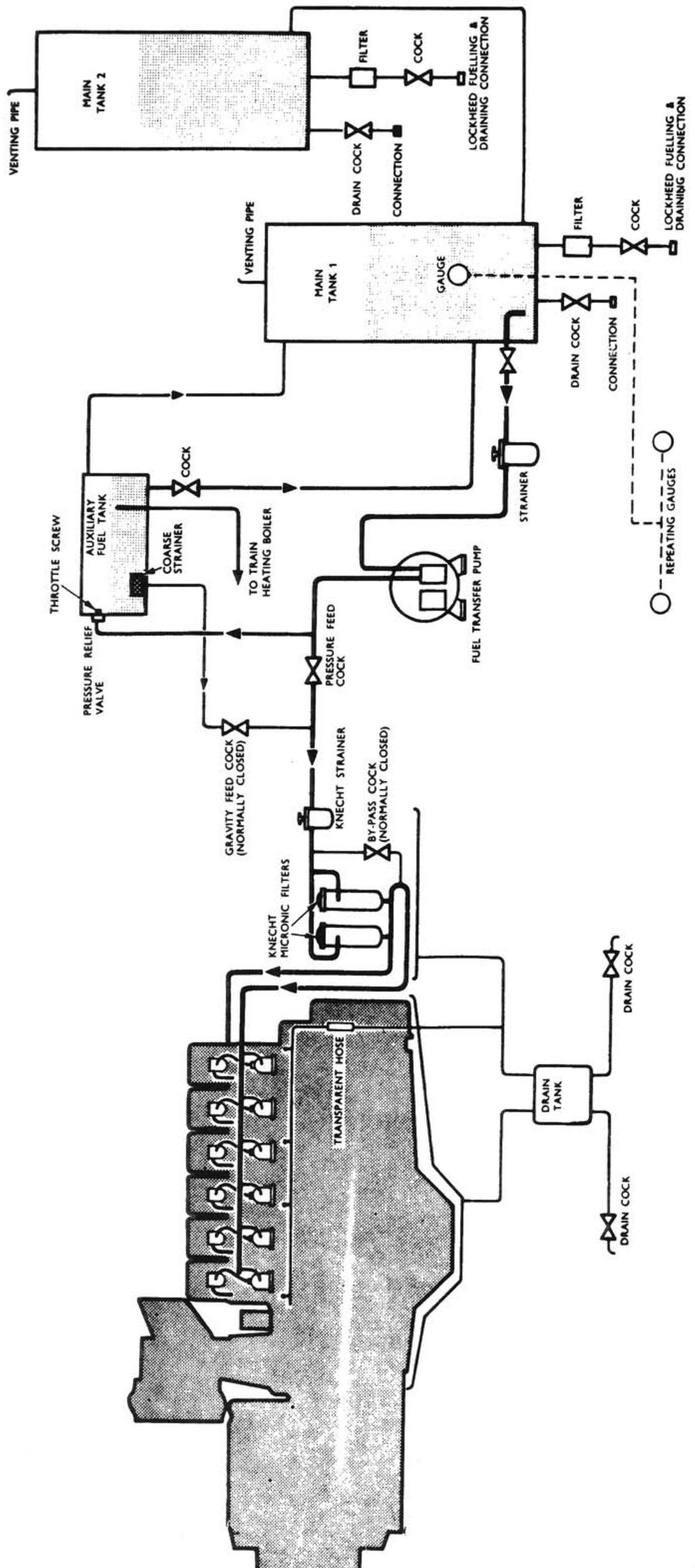
Fig. 26.



CLASS 45 AND 46 COOLING WATER SYSTEM. Fig. 27.



THE COOLING WATER BYPASS VALVES ARE NOW NOT OPERATIVE, I.E. THE COOLANT PASSES CONTINUOUSLY THROUGH THE RADIATOR.



CLASS 45 AND 46 FUEL OIL SYSTEM.

Fig. 28.

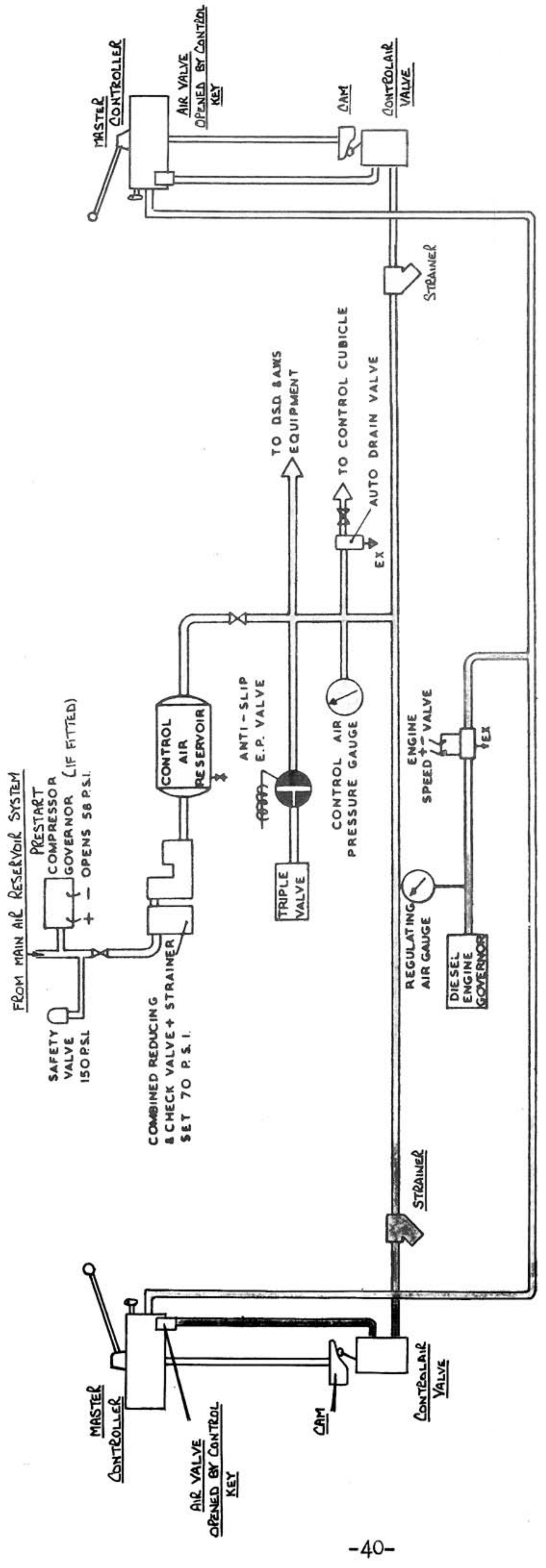


FIG 29 REGULATING & CONTROL AIR SYSTEM

The Regulating Air System.

This system supplied from the main reservoirs through a Pressure Reducing Valve set at 70 p.s.i., feed the controller valve in each cab.

The main controller is locked and cannot be operated in the driving cab until the Master Control Key is inserted and turned. This movement also opens an air valve but has no electrical function.

When the power controller is opened, a cam at the end of the controller shaft operates the "CONTROLAIR" valve and allows air to pass through the air valve to the engine speed valve and diesel engine governor on the manned locomotive, and any others which may be coupled in multiple. The valve is so designed that with the Power controller fully opened it allows a maximum of 50 p.s.i. to pass as ENGINE air, thus any slight losses in control air pressure through incorrect setting of the Pressure Reducing valve, will not affect ENGINE air.

The Engine Speed Valve (E.S.V.) is energised in the 1st notch position of the Power Controller and beyond; when the controller is returned tc OFF the E.S.V. is de-energised to exhaust ENGINE air from the diesel engine governor while ENGINE air between controller and E.S.V. exhausts through the CONTROLAIR valve. This ensures that the engine immediately returns to idling under normal and fault conditions.

NOTE:- It is necessary to carry out the correct preparation duties thus operating the controls in each cab before leaving the depot. If it should be possible to fully insert and turn the Master Control Key in the non-driving cab, it must be appreciated that the CONTROLAIR valve in this cab will allow air to pass straight to exhaust. Engine r.p.m. will then be with a consequent reduction in power.

Operation of Controlair Valve. (Fig. 30, Page 42).

As the controller is opened the cam pushes down the valve assembly, unseating the top inlet ball valve as shown in the APPLICATION diagram, so providing a through passage from 'supply' to 'delivery', i.e. for ENGINE regulating air. This air, at a pressure determined by the position of the controller cam, will also act on top of the diagram and when this balances the upward force of the spring below, the small spring above the inlet ball valve will push them both down (they are joined by a spindle). Thus both ball valves remain seated and closed, and the valve becomes 'lapped'; it is this feature which limits the ENGINE air to a maximum of 50 p.s.i. when the controller is fully open and allows any pressure from 0 - 50 p.s.i. to be available for governor operation.

When the controller is closed, the cam releases the valve assembly which can now rise and the exhaust ball valve is unseated as shown in the RELEASE diagram. ENGINE regulating air is now released to exhaust through the hollow stem and the engine returns to idling.

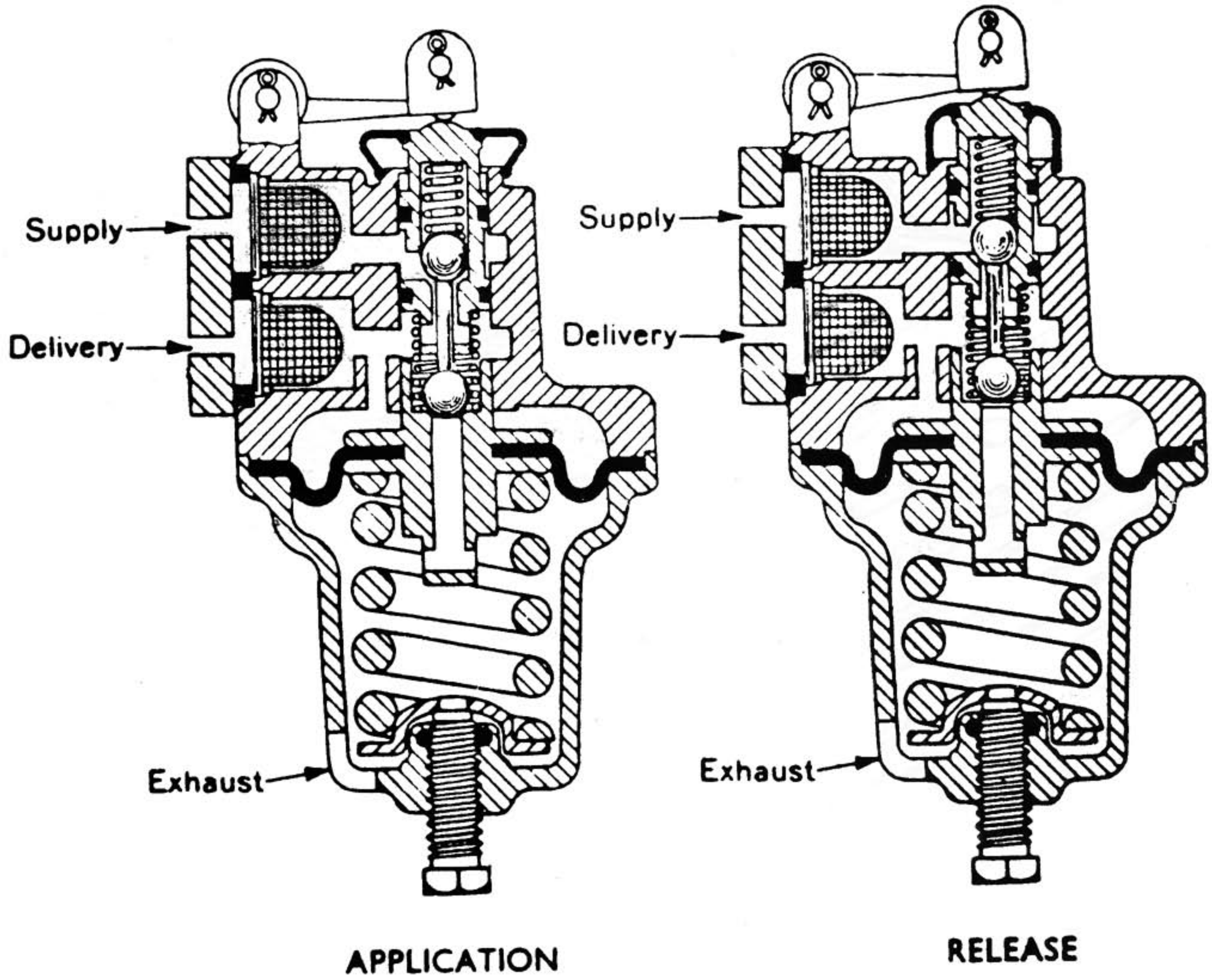


FIG 30 CONTROLAIR VALVE