DIESEL TRACTION

BRITISH RAILWAYS

WESTERN REGION

BRITISH RAILWAYS - WESTERN REGION

DIESEL HYDRAULIC LOCOMOTIVES

Section DE1 - 1	Introduction and General Principles
Section DH 1	D 9500 Class
Section DH 2	D 7000 Class
Section DH 3	D 1000 Class
Section DH 4	D 800 Class
Section DH 5	D 833 Class
Section DH 6	D 6306 Class

C.M.&.E.E. Dept.
Diesel Training School,
SWINDON

This book is intended for students attending courses at Western Region Diesel Training Schools, and is a precis of the lectures given. The course covers the basic principles of the oil engine, its auxiliaries and equipment and the application of Hydraulic Transmission for Diesel Traction.

650 H.P. TYPE I DIESEL HYDRAULIC LOCOMOTIVE

D 9500 - D 9555

SECTION DH 1

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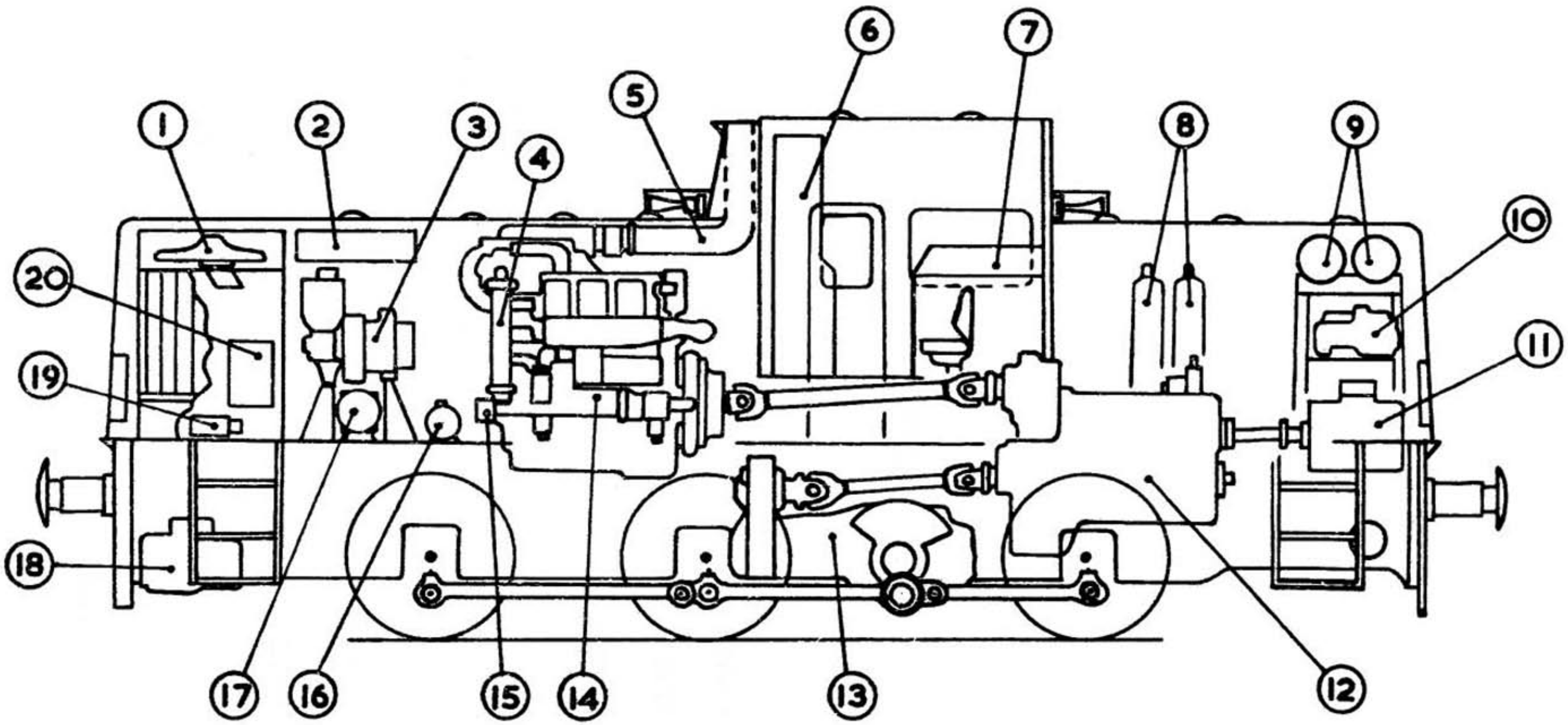


GENERAL ARRANGEMENT 650 HP TYPE I DIESEL HYDRAULIC LOCOMOTIVE

650 H.P. TYPE I DIESEL HYDRAULIC LOCOMOTIVE

GENERAL ARRANGEMENT

1. Serck Radiator, Fan and Fan Motor
2. Fuel Header Tank
3. Vacuum Exhausters (2)
4. Engine Oil Heat Exchanger
5. Exhaust Manifold
6. Control Cubicle
7. Drivers Desk
8. Fire Fighting Equipment
9. Air Reservoirs
10. Air Compressor
11. Auxiliary Generator
12. Voith L217U Transmission
13. Hunslet 650 Gearbox and Jackshaft Drive
14. Paxman Ventura 6YJX Diesel Engine
15. Plessey Hydraulic Pump (Serck System)
16. Lub. oil Priming Pump
17. Transmission oil heat Exchanger
18. Lower Fuel Tank
19. Fuel Oil Transfer Pump
20. Serck Oil Tank

650 H.P. TYPE 1 DIESEL HYDRAULIC LOCOMOTIVE

LOCOMOTIVE DATA

Weight in running order	48 tons. approx.
Wheel base	15ft. 6ins.
Wheel diameter	4ft. 0ins.
Maximum width over all	8ft. 7.9/16ins
Maximum Speed	40 m.p.h.
Fuel Tanks	300 gallons plus 13 gallons.
Engine Lubricating oil sump and heat exchanger	25 gallons
Coolant, total capacity of system	104 gallons
Transmission and heat exchanger	63 gallons

POWER EQUIPMENT

6 cylinder diesel engine	Paxman 6 YJXL
Direction of rotation	Anti-clockwise looking on flywheel
L.H. bank of cylinders (from	1. 2. 3. or A1. A2. A3.
R.H. bank of cylinders free end)	6. 5. 4. or B1. B2. B3.
Cylinder bore and stroke	$7\frac{3}{4}$" x $8\frac{1}{2}$"
Cylinder firing order	1. 5. 3. 6. 2. 4. or A1.B2.A3.B1.A2.B3.
Tappet Clearance (Engine Cold)	0.012"
Injector Timing	28^{o}B.T.D.C.
Pressure at which fuel injector nozzle should be set	3100 p.s.i. (211 atmos.)
Hydraulic transmission	Voith L.217U
Final drive unit	Hunslet 650 gearbox
Lighting and starting circuit	110 volts
Air Compressor (1)	Westinghouse DH.16B
Vacuum Exhausters (2)	Reavell F.R.U. 10S.

ENGINE SPEEDS

Controller Position	Off	600 r.p.m.
	1 energise fill valve	600 r.p.m.
	2 energise engine speed valve	600 r.p.m.
	Notch 2 to maximum	600-1500 r.p.m.
	Engine Overspeed Trip	1710 r.p.m.

TRANSMISSION

Transmission change over speeds

1st to 2nd convertor	16 M.P.H. Approx.
2nd convertor to coupling	32 M.P.H. Approx.
Coupling to 2nd convertor	32 M.P.H. Approx.
2nd convertor to 1st convertor	16 M.P.H. Approx.

Transmission empties in engine only position

Maximum transmission oil temp.	212°F.
Locomotive overspeed operates at	45 M.P.H.

GENERAL

The Paxman engine is of 6 cylinder vee form developing 650 H.P. at 1500 rpm, fitted with a Napier water-cooled turbo-charger. The Voith - G.B. L217U hydraulic transmission consists of 2 torque convertors in series with a fluid coupling, the first convertor being used for starting away and low speeds, the second for intermediate speeds and the coupling for direct drive at speeds above 32 m.p.h.

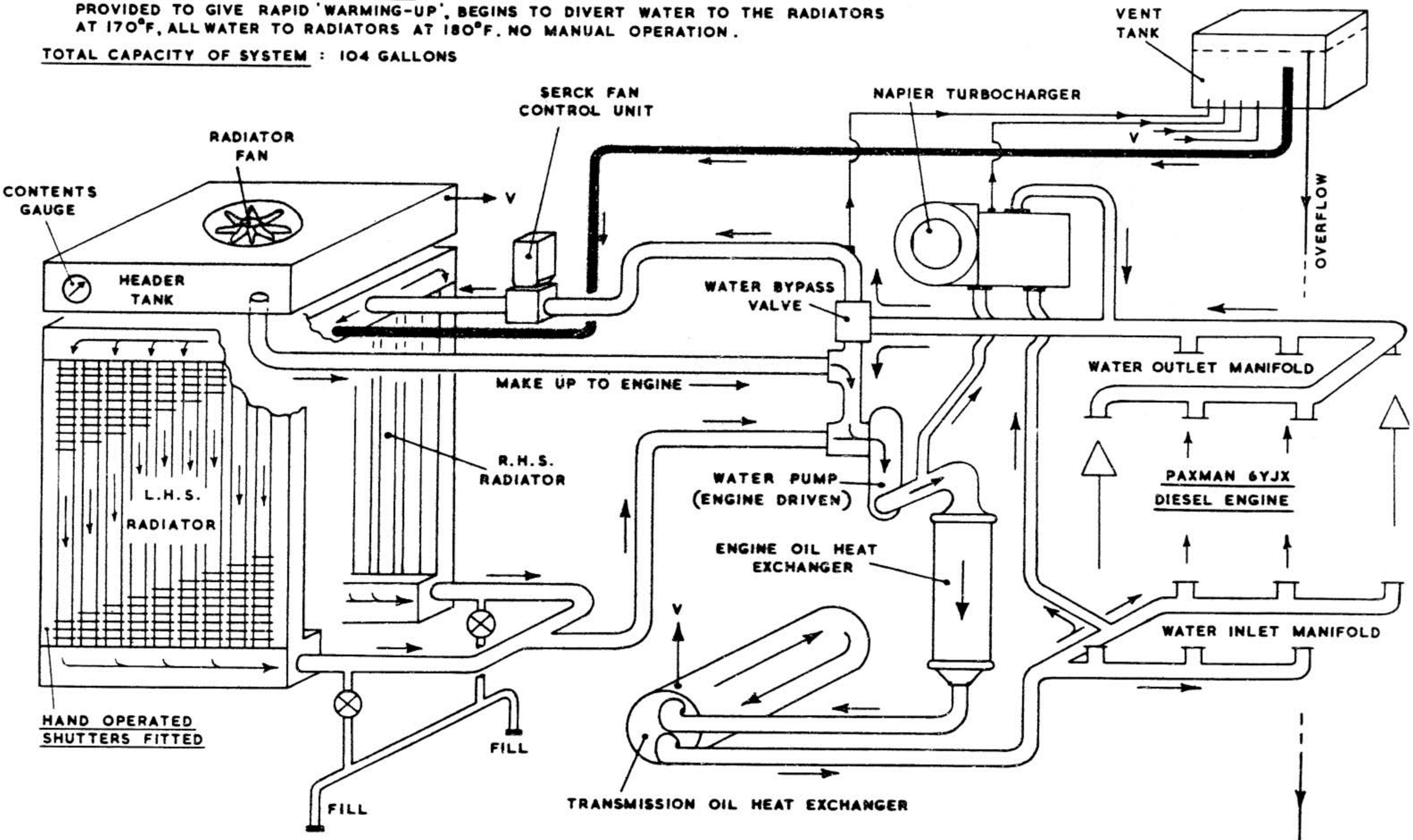
The Hunslett triple reduction and reverse gearbox drives direct to the coupling rods via a jackshaft. The reversing mechanism is incorporated in the second reduction gears and is air-operated, with provision for manual isolation if required.

The auxiliary generator supplies the compressorm exhausters etc. It is NOT used for starting the diesel engine as on other hydraulic locomotives, two C.A.V. starter motors engage teeth on the engine flywheel to turn the engine until it fires.

WATER BYPASS VALVE (THERMOSTATIC)

PROVIDED TO GIVE RAPID 'WARMING-UP', BEGINS TO DIVERT WATER TO THE RADIATORS AT 170°F, ALL WATER TO RADIATORS AT 180°F. NO MANUAL OPERATION.

TOTAL CAPACITY OF SYSTEM : 104 GALLONS



COOLING WATER SYSTEM

Cooling Water System

The System consists of a single engine driven impeller pump which circulates water through the Engine Lub Oil Heat Exchanger, Transmission Oil Heat Exchanger, engine cooling water jacket, Turbo Charger and then either to the radiator, if the cooling water is above 170°F or back to the suction side of the water pump if the water is below 170°F i.e. by-passing the radiators.

This is governed by the cooling water by-pass valve which is thermostatically controlled by two wax elements. The valve acting as a mixing valve to prevent water passing to the radiators when temperature is below 170°F; between 170°F and 180°F only a portion of the cooling water is passed to the radiators and when 180°F is reached the valve directs all the cooling water to the radiators.

The radiator cooling fan is hydraulically driven from the engine and controlled by the water outlet temperature. When water temperature reaches approximately 170°F the fan will start to rotate and stop when the water temperature falls to approximately 160°F.

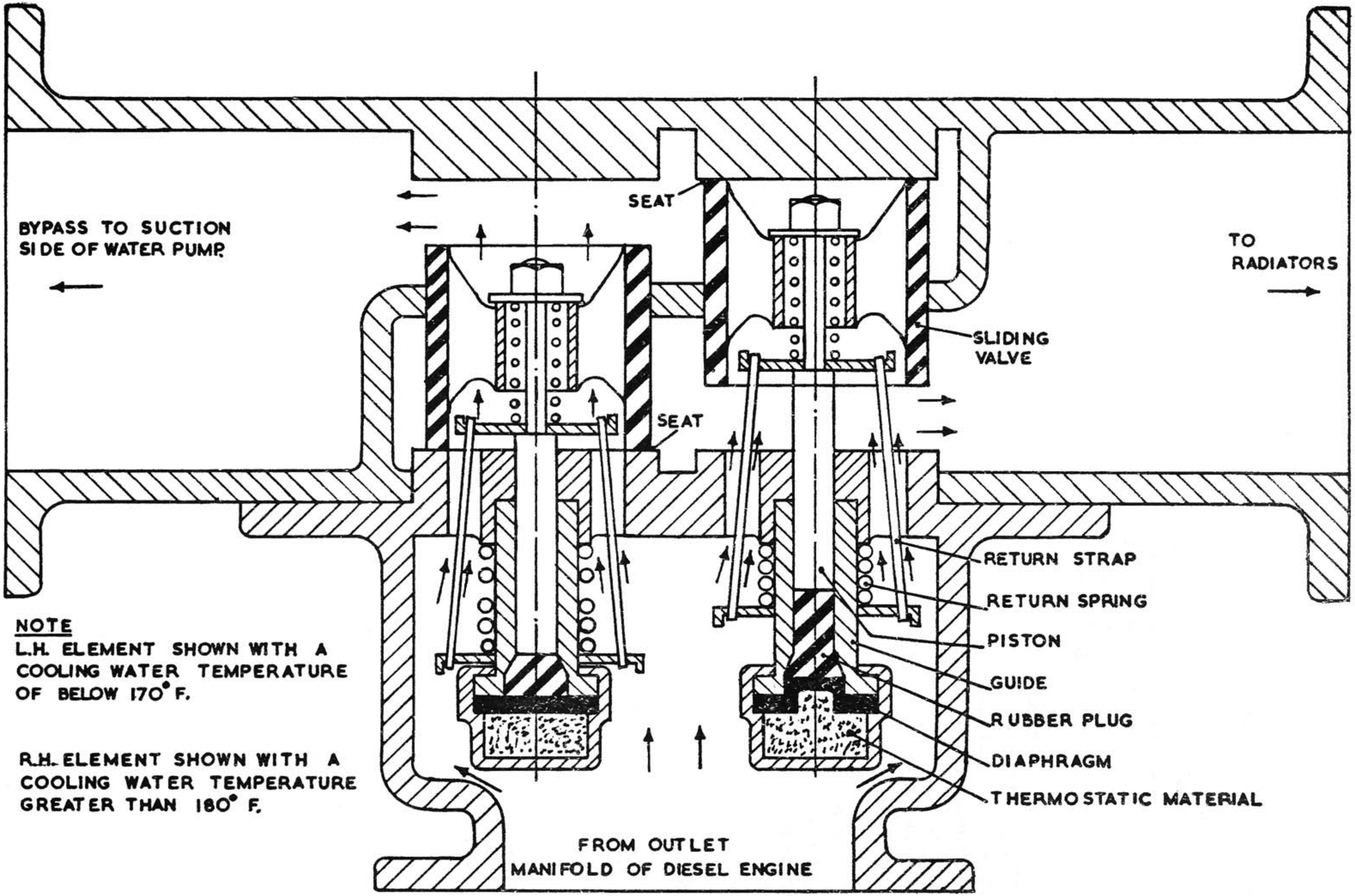
High Water Temperature

If cooling water temperature reaches 195°F, the "High Cooling Water Temperature" and "General Alarm" lamps will become bright and the engine will revert to idling.

The diesel engine should be allowed to idle and cool with the power handle in the off position. The locomotive may be re-powered when the cooling water temperature gauge reads 170°F provided that the re-set button has been pressed which will cause the fault lights to dim.

Low Water Level

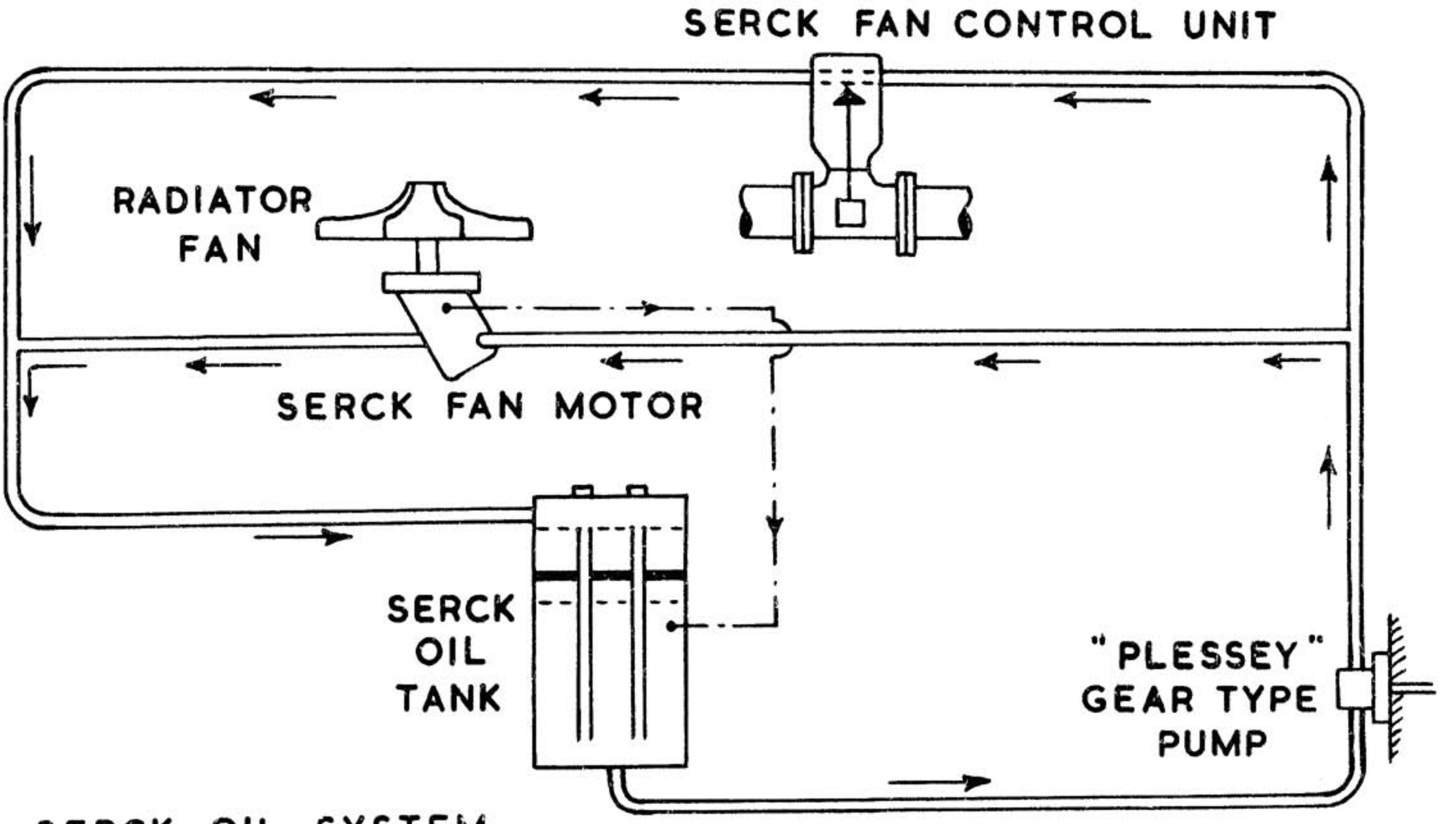
If coolant level reaches the low limit the engine will shut down and the "Engine Stopped", "Low Water Level" and "Battery Charging" lamps will change to bright. The engine cannot then be re-started until the safe working coolant level has been restored.



NOTE
L.H. ELEMENT SHOWN WITH A COOLING WATER TEMPERATURE OF BELOW 170° F.

R.H. ELEMENT SHOWN WITH A COOLING WATER TEMPERATURE GREATER THAN 180° F.

THERMOSTATIC COOLING WATER BYPASS VALVE — D 9500 CLASS



SERCK OIL SYSTEM

The Serck/Behr hydrostatic fan drive fitted to these locomotives is identical to that used on other diesel hydraulic locomotives, except that the Serck Oil Pump has been replaced by a Plessey gear pump.

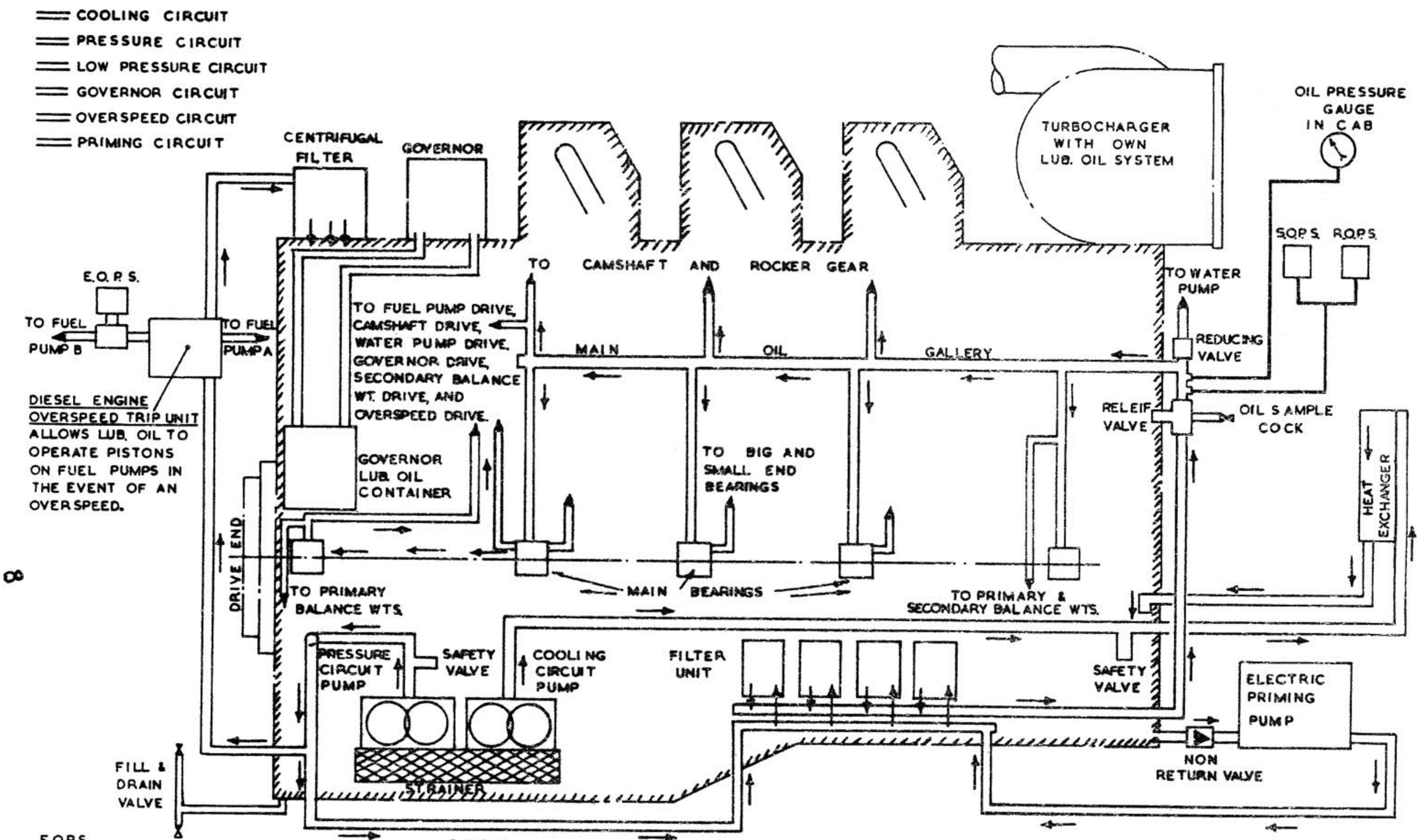
When the engine is started this pump draws oil from the tank to supply the fan motor and fan control unit. If the cooling water temperature is below 170°F the oil will have an unrestricted path through the control unit and back to the tank, under these conditions pressure will be insufficient to drive the fan motor.

When 170°F is reached the wax thermostat in the control unit begins to operate and progressively close the oil passage through the upper portion, back pressure is now built up until it is sufficient to drive the fan motor and hence turn the radiator fan.

The wax thermostat therefore senses the temperature of the cooling water and controls the fan speed so allowing a steady cooling water temperature to be maintained by varying the amount of air drawn through the radiators.

MAXIMUM SPEED OF RADIATOR FAN 2160 R.P.M.

CAPACITY OF SERCK OIL TANK 3 GALLONS



E.O.P.S.
ENGINE OVERSPEED PRESSURE SWITCH
BREAKS 20 PSI RISING & EMPTIES TRANSMISSION.

S.O.P.S.
START OIL PRESSURE SWITCH
MAKES 10 P.S.I. RISING & ALLOWS STARTING CONTACTORS TO MAKE.

R.O.P.S.
RUN OIL PRESSURE SWITCH
MAKES 30 P.S.I. RISING
DIMS ENGINE STOPPED LIGHT, AND STOPS PRIMING PUMP
BREAKS 25 P.S.I. FALLING AND STOPS DIESEL ENGINE

BOTH SAFETY VALVES SET AT 70–80 P.S.I.

MAIN RELIEF VALVE SET AT 55–65 P.S.I.

REDUCING VALVE SET AT 8 P.S.I.

LUB. OIL FILLER & DIPSTICK ON NO 1 CYL. B BANK CRANKCASE DOOR

DIAGRAMMATIC ARRANGEMENT OF LUBRICATING OIL SYSTEMS

D 9500 CLASS

Lubricating Oil System

The Paxman engine contains two gear type pumps both driven from the crankshaft:

Cooling Circuit Pump - takes oil from the sump, passes it through the heat exchanger and returns it to the sump.

Pressure Circuit Pump - takes oil from the sump and delivers to:-

(a) the diesel engine overspeed unit, through a "Glacier" centrifugal filter at the drive end of the engine and then returns to the sump via timing gears.

(b) a series of four filters at the side of the engine to supply the main (crankshaft) bearings, the big and little end bearings, camshaft and rocker gear etc. The lub oil pressure gauge line in the cab is taken from this circuit.

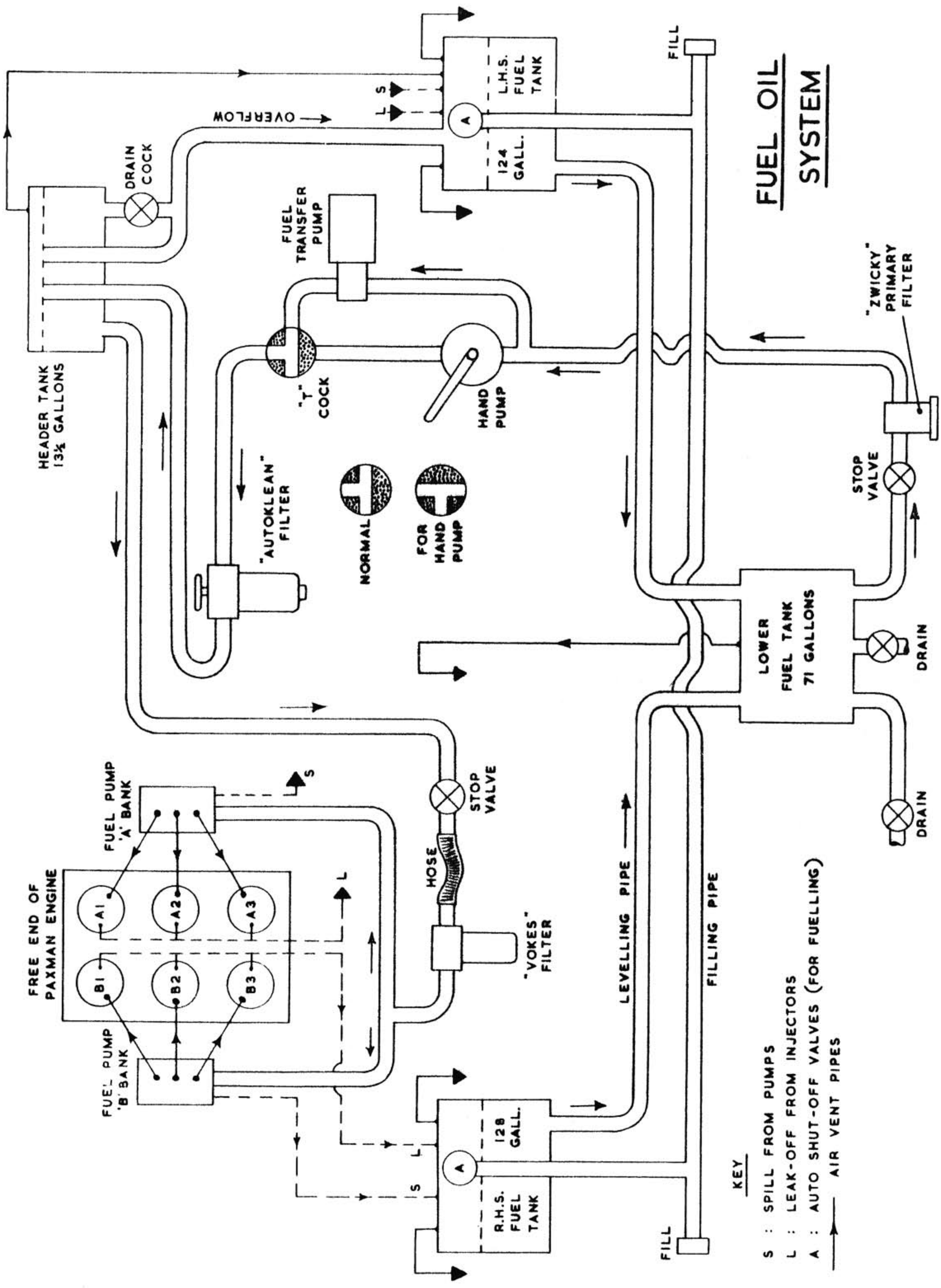
The electrically driven lub oil priming pump enables the Lub oil system to be 'primed' before the engine is started; with the engine running the priming pump will stop when the Run Oil Pressure Switch closes at 30 p.s.i. This R.O.P.S also dims the red "ENGINE STOPPED" light.

A Starting Oil Pressure Switch is also provided, to complete the starting circuit from the battery to the starter motor when priming pump pressure reaches 10 p.s.i.

The diesel engine governor and the Napier Turbo-charger both have independent lub. oil systems.

An engine overspeed pressure switch opens at 20 p.s.i. should the overspeed unit operate, this will cause the transmission to be emptied and thus disconnect the engine (which will stop, see page 13) from the road wheels.

This is necessary as the Fluid Coupling can, in top gear, transmit power on the overrun and the engine is therefore protected against overspeed if 40 m.p.h. is exceeded when coasting down a gradient.


FUEL OIL SYSTEM
L.H.S. FUEL TANK
124 GALL.
FILL
L
S
OVERFLOW
DRAIN COCK
HEADER TANK 13½ GALLONS
FUEL TRANSFER PUMP
"T" COCK
HAND PUMP
"AUTOKLEAN" FILTER
NORMAL
FOR HAND PUMP
"ZWICKY" PRIMARY FILTER
STOP VALVE
LOWER FUEL TANK 71 GALLONS
DRAIN
DRAIN
STOP VALVE
HOSE
"VOKES" FILTER
FUEL PUMP 'A' BANK
FREE END OF PAXMAN ENGINE
A1
A2
A3
B1
B2
B3
FUEL PUMP 'B' BANK
LEVELLING PIPE
FILLING PIPE
128 GALL.
R.H.S. FUEL TANK
FILL
KEY
S : SPILL FROM PUMPS
L : LEAK-OFF FROM INJECTORS
A : AUTO SHUT-OFF VALVES (FOR FUELLING)
AIR VENT PIPES

Fuel Supply to Diesel Engine

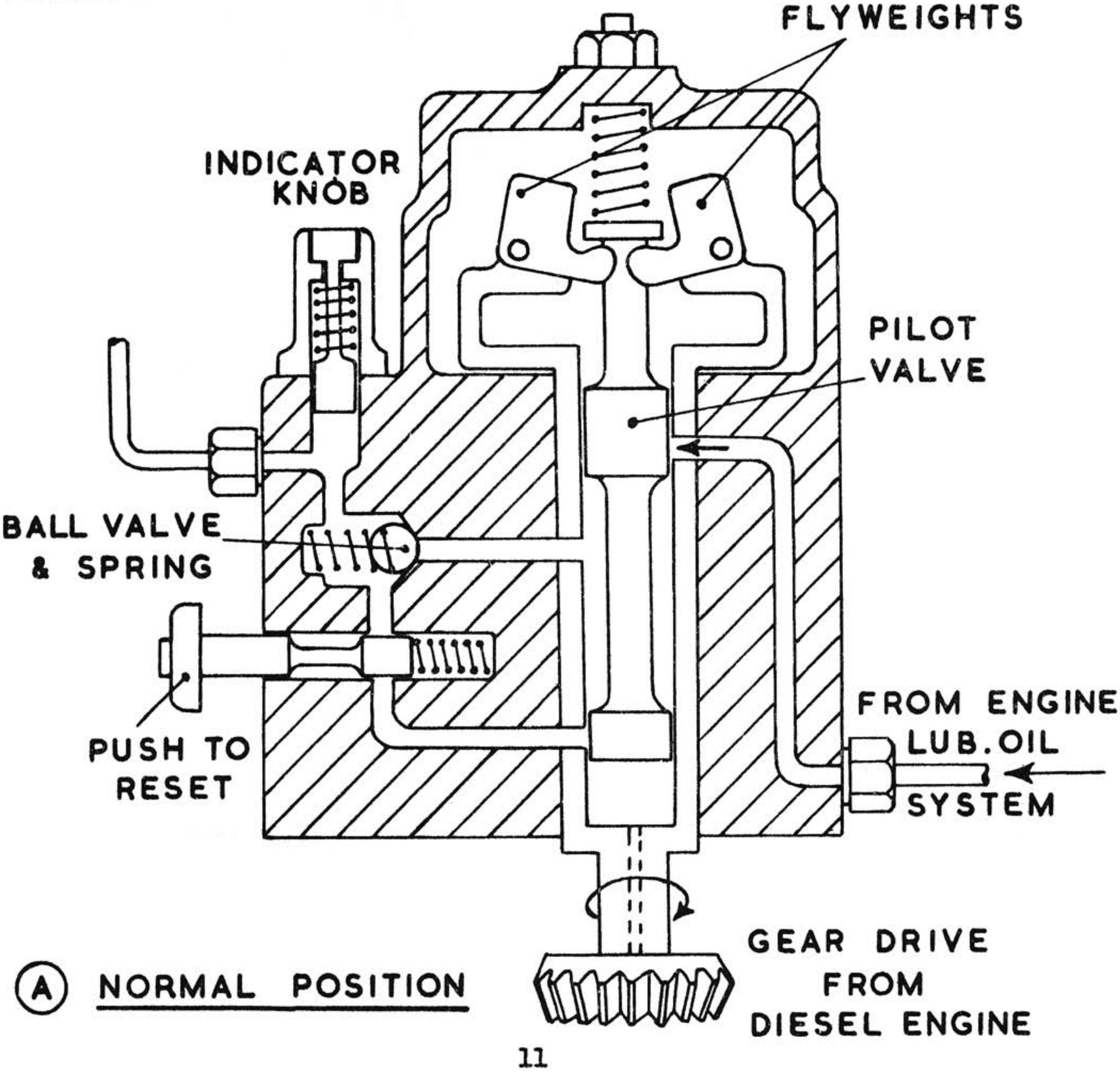
The engine is gravity fed from a service tank which is filled from the main tanks by a fuel transfer pump.

In the event of failure of the electrically driven transfer pump, the service tank may be filled by means of the rotary hand pump fitted under the footstep at the 'A' end of the locomotive behind the panel labelled "Emergency Fuel Pump".

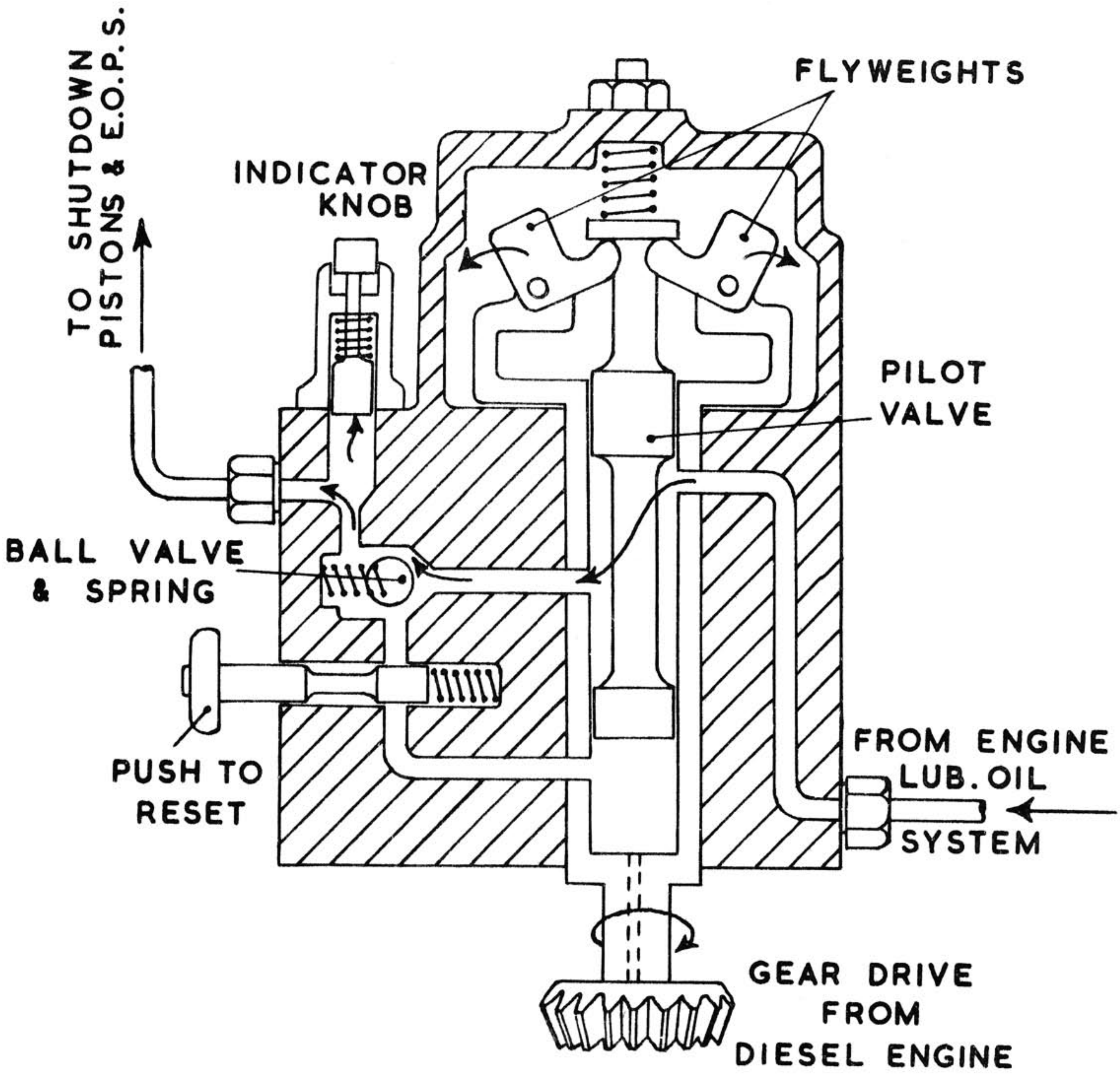
Before operation of the hand pump the three-way cock (access through front panel LHS 'A' end) should be reset to the 'Hand Pump' position.

The service tank is provided with a contents gauge and under normal conditions this should, at all times, read FULL.

Operation of Diesel Engine Overspeed Unit



(A) NORMAL POSITION



(B) TRIPPED POSITION

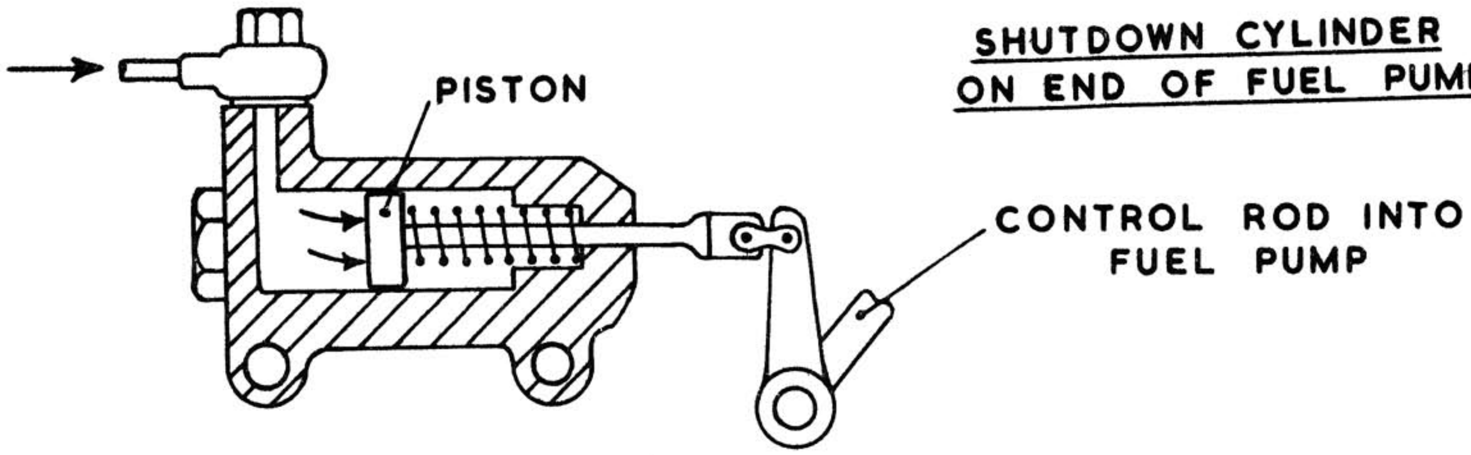
DIESEL ENGINE OVERSPEED PROTECTION UNIT

Diesel Engine Overspeed Protection

The Overspeed Unit contains a pair of flyweights driven by the diesel engine and is supplied with oil under pressure from the engine lub oil system. In the normal position as shown in diagram 'A', the Pilot Valve prevents oil escaping.

Should the diesel engine governor, mounted at the drive end of the engine, fail to keep engine speed to a maximum of 1500 rpm, then the flyweights will begin to move outwards tending to lift the pilot valve; if engine speed reaches approximately 1710 rpm then centrifugal force produced by the rotating flyweights will be sufficient to lift the pilot valve against its' spring (see sketch (B)). This will allow lub oil to move the ball valve off its seat, push up the indicator knob and so provide a feed to the shutdown cylinder of each fuel pump.

Note: The lub oil supply to the shutdown cylinders will also operate the Engine Overspeed Pressure Switch at 20 p.s.i. which will cause the transmission to be emptied.



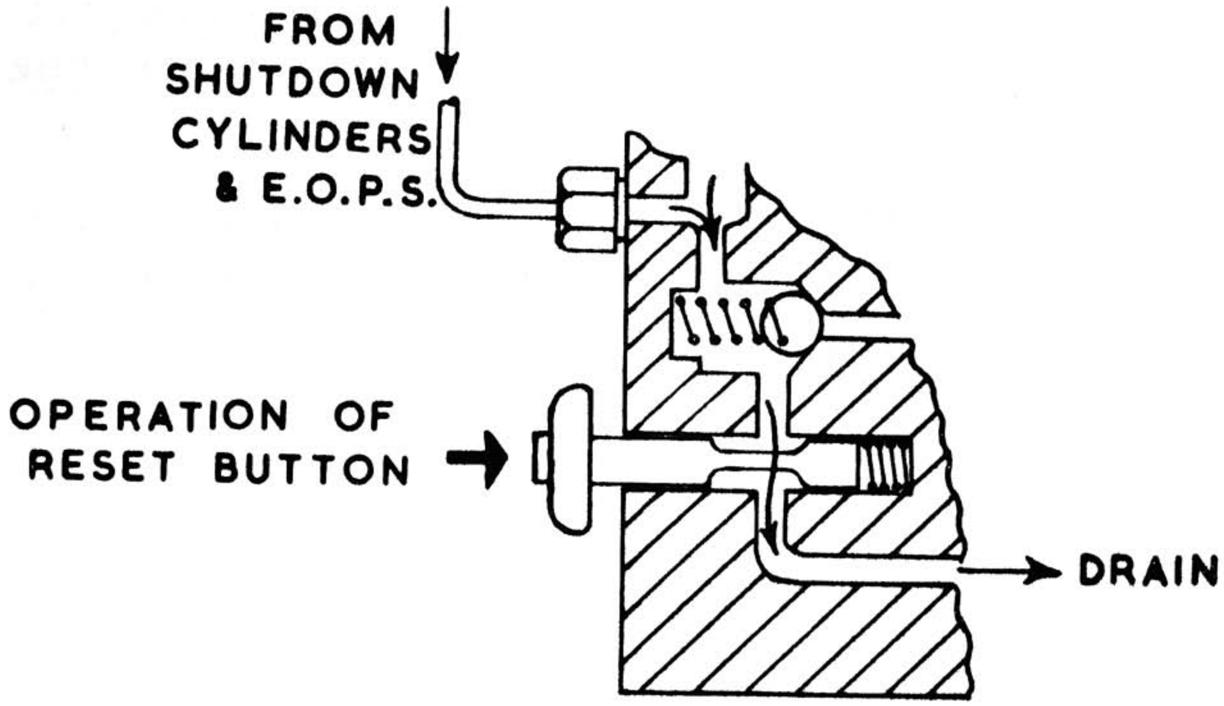
SHUTDOWN CYLINDER ON END OF FUEL PUMP

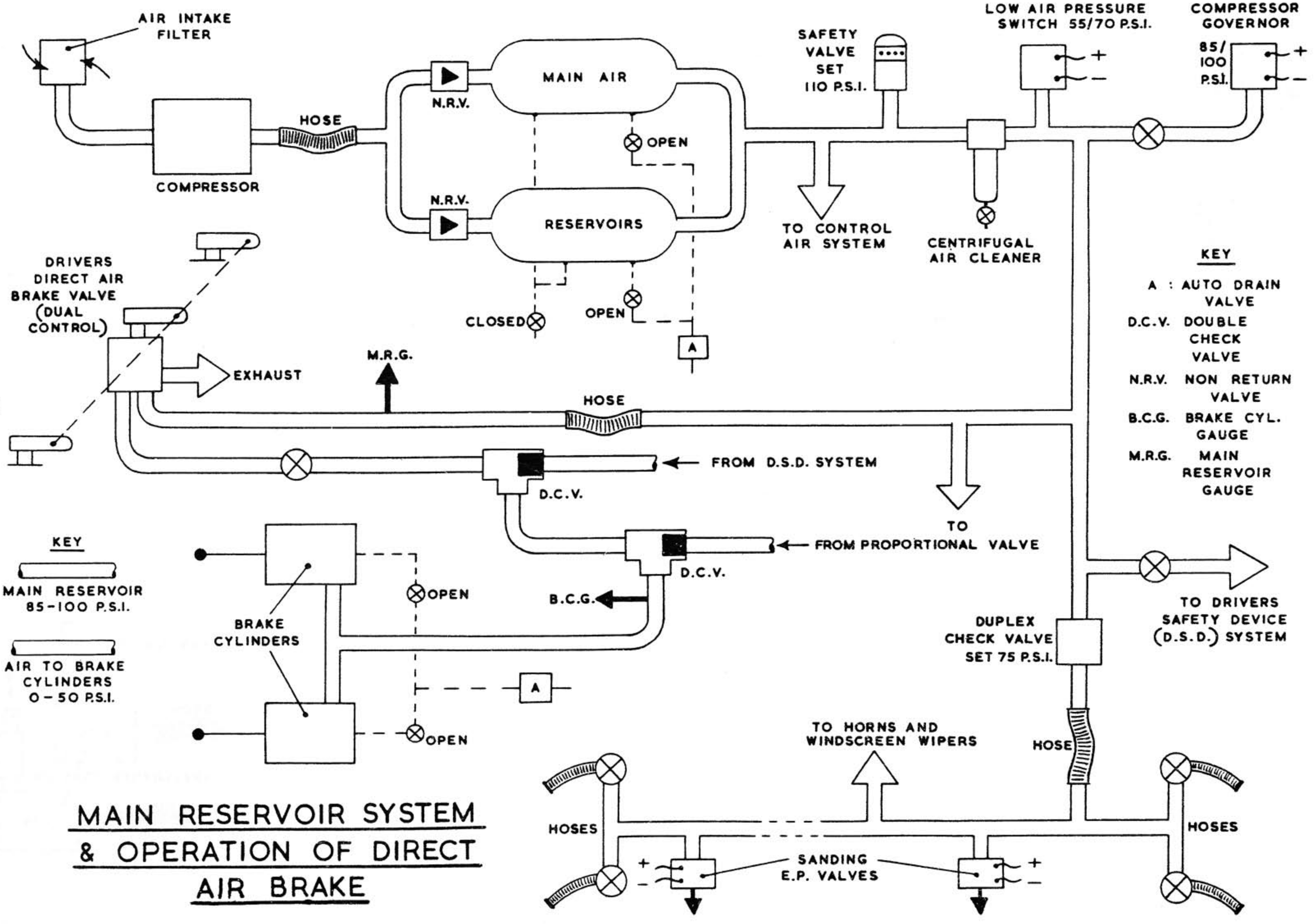
The shutdown cylinders contain pistons which are linked to the control rod passing into the fuel pumps. These operate spring catches which slip beneath each fuel pump plunger (see page 50 of Diesel Traction Manual) to hold them at the top of the stroke thus preventing further injection of fuel. The diesel engine will stop and lub oil pressure will therefore fall but the ball valve will now reseat to trap oil in the shutdown cylinders.

To Reset the Unit the push button at the side must be operated, this will allow the trapped oil to drain away.

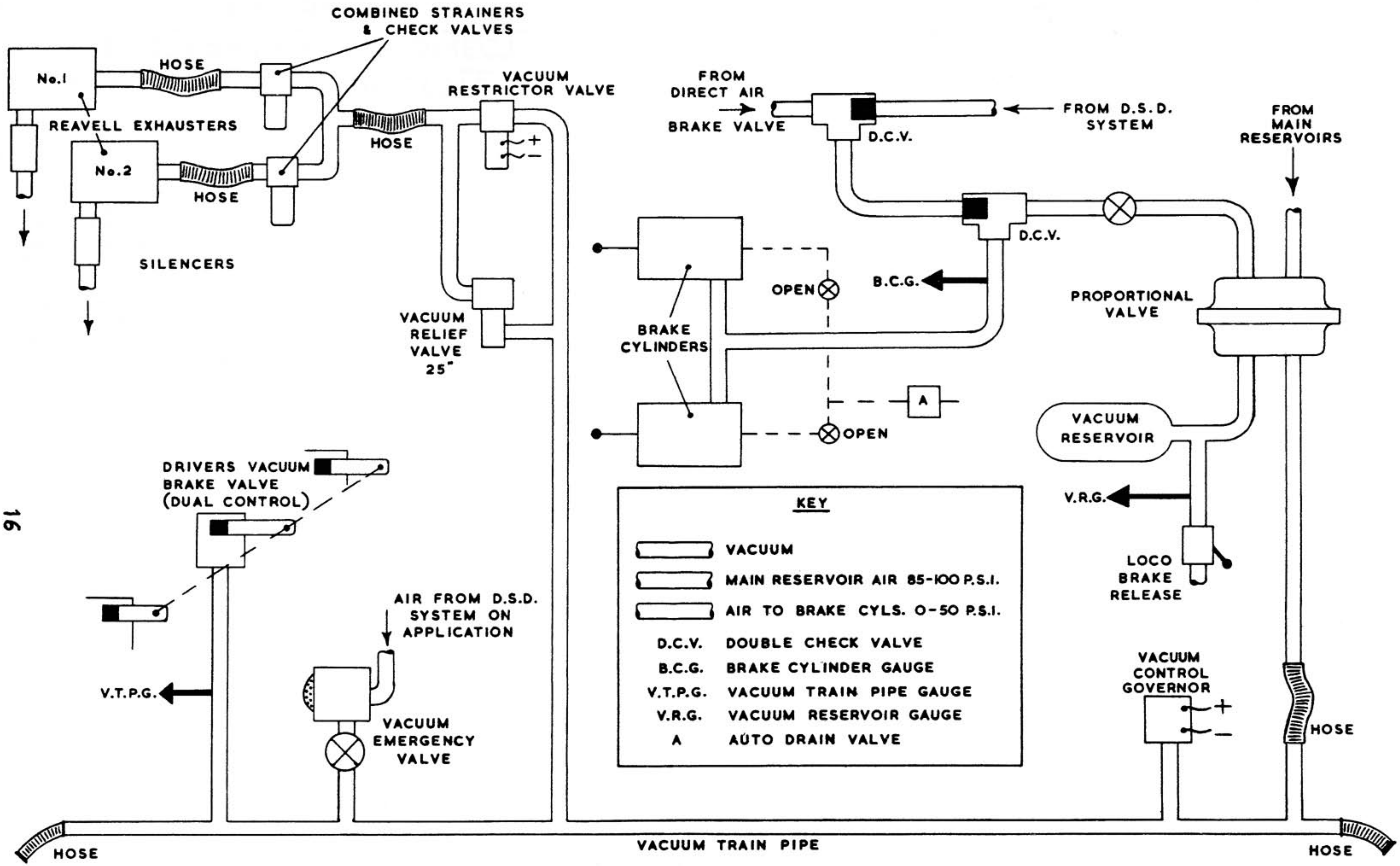
The shutdown pistons will then return to normal and the contacts of the Engine Overspeed Pressure Switch E.O.P.S. will close so that the diesel engine may be restarted. Note that the release of the trapped oil will also return the indicator knob to normal.

AN ENGINE OVERSPEED IS A FAULT. Even though the Unit may be reset and the diesel engine successfully restarted THE MATTER MUST BE REPORTED IN THE USUAL MANNER.





MAIN RESERVOIR SYSTEM & OPERATION OF DIRECT AIR BRAKE



VACUUM SYSTEM & OPERATION OF INDIRECT BRAKE

AIR/VACUUM SYSTEMS

A Westinghouse two stage electrically driven compressor is provided, which is controlled by a compressor governor in the normal manner, air is thus available for:-

(a) Control Air System

(b) Direct Air Brake System

(c) Indirect Air Brake System

(d) D.S.D. Brake System

(e) Horns, Sands, Wipers etc. (through a Duplex Check Valve)

AUTO AIR DRAIN VALVES

Moisture will be drained from both reservoirs and brake cylinders through automatic drain valves via cocks which are normally open.

BRAKES

By means of two double check valves, air can enter the two brake cylinders in three separate ways:-

(i) Direct Air Brake

(ii) Indirect Air Brake

(iii) D.S.D. Brake

DIRECT AIR BRAKE

Air is supplied directly to and released from the brake cylinders by the dual controlled Drivers Direct Air Brake Valve, see Section D.E. 3 - 1 of the Diesel Electric Traction Manual, but note there are no relay valves.

INDIRECT AIR BRAKE

A conventional vacuum system is provided. Air being passed directly to and released from the brake cylinders by means of the proportional valve also described in Section D.E. 3 - 1 of the Diesel Electric Traction Manual.

The vacuum system need not be used if:-

(1) Exhausters are switched off.

(2) Vacuum Control Governor shorted out.

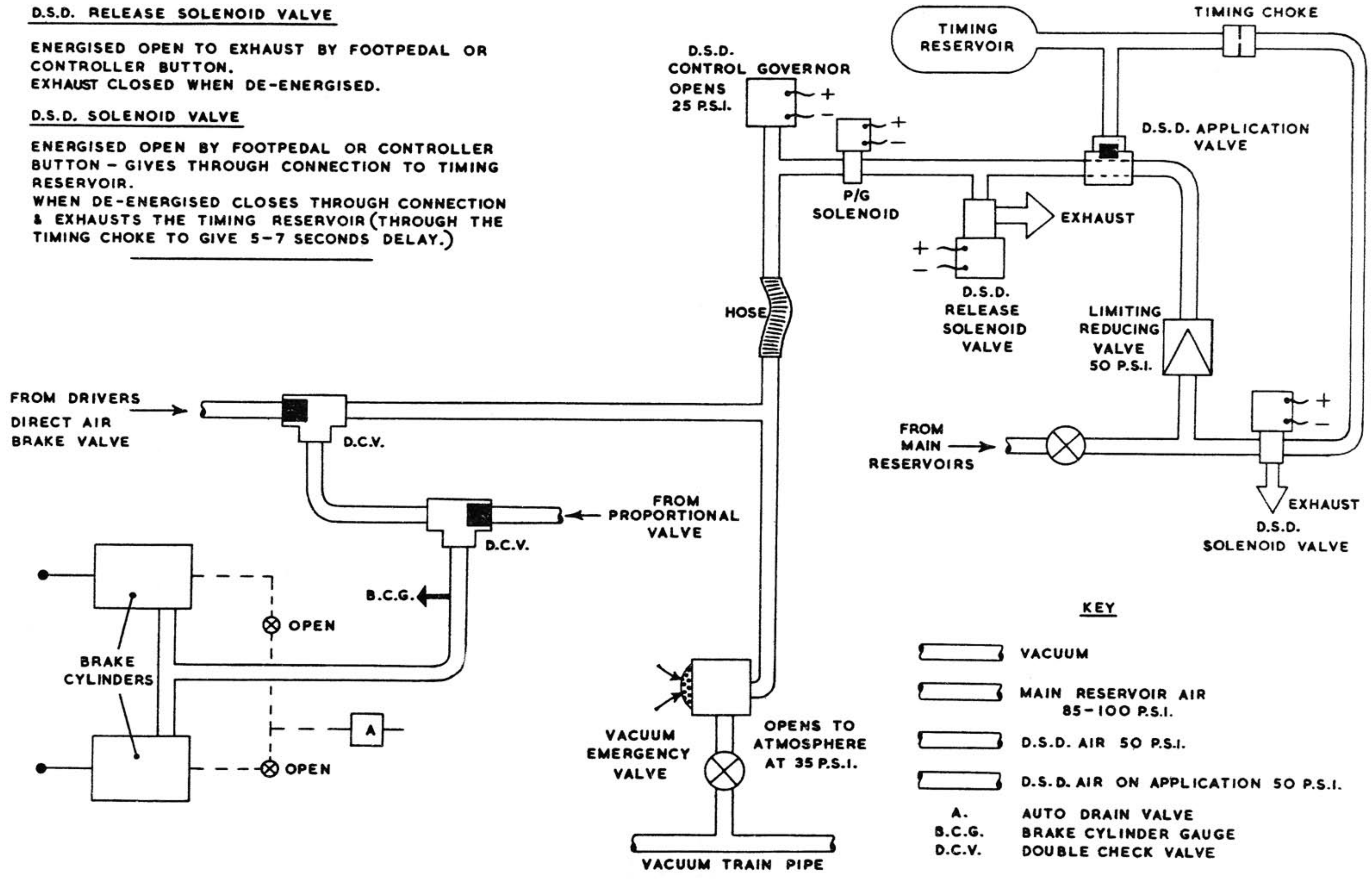
(3) Loco Brake release operated.

D.S.D. RELEASE SOLENOID VALVE

ENERGISED OPEN TO EXHAUST BY FOOTPEDAL OR CONTROLLER BUTTON.
EXHAUST CLOSED WHEN DE-ENERGISED.

D.S.D. SOLENOID VALVE

ENERGISED OPEN BY FOOTPEDAL OR CONTROLLER BUTTON - GIVES THROUGH CONNECTION TO TIMING RESERVOIR.
WHEN DE-ENERGISED CLOSES THROUGH CONNECTION & EXHAUSTS THE TIMING RESERVOIR (THROUGH THE TIMING CHOKE TO GIVE 5-7 SECONDS DELAY.)



DRIVERS SAFETY DEVICE (D.S.D.) SYSTEM

D.S.D. Brake Application

The following events occur when the D.S.D. button or pedal is released and a direction has been selected.

1. The D.S.D. solenoid valve is de-energised and the air in the timing reservoir which has been acting on top of the piston in the D.S.D. Application Valve will be exhausted through the timing choke and out of the D.S.D. solenoid valve.

2. The D.S.D. Release Solenoid Valve is de-energised closed.

3. Air at 50 p.s.i. will pass through the D.S.D. application valve into the brake cylinders after 6 seconds, when the Piston Valve lifts since there is now no air in the Timing Reservoir.

4. Air now passes through the Passenger/Goods Solenoid which is energised in the Passenger Position to give an unrestricted path through the valve. In the Goods Position the valve is de-energised and has a choke effect on the air passing to the Brake Cylinders.

   NOTE: The position of the Passenger/Goods switch has no effect on a normal brake application made by the Driver.

5. When the brake cylinder pressure reaches 25 p.s.i. the D.S.D. Control Governor opens to return the engine to idling and empty the transmission.

6. When it reaches 35 p.s.i. the Vacuum Emergency Valve (see page 23) opens the Train Pipe to Atmosphere and applies the brakes on the train.

D.S.D. Brake Release

The following events occur when the D.S.D. button or pedal is depressed.

1. D.S.D. Solenoid Valve is energised open and allows air to act on top and therefore close the piston valve, in the D.S.D. application valve thus shutting off the supply of air at 50 p.s.i. to the Brake Cylinders.

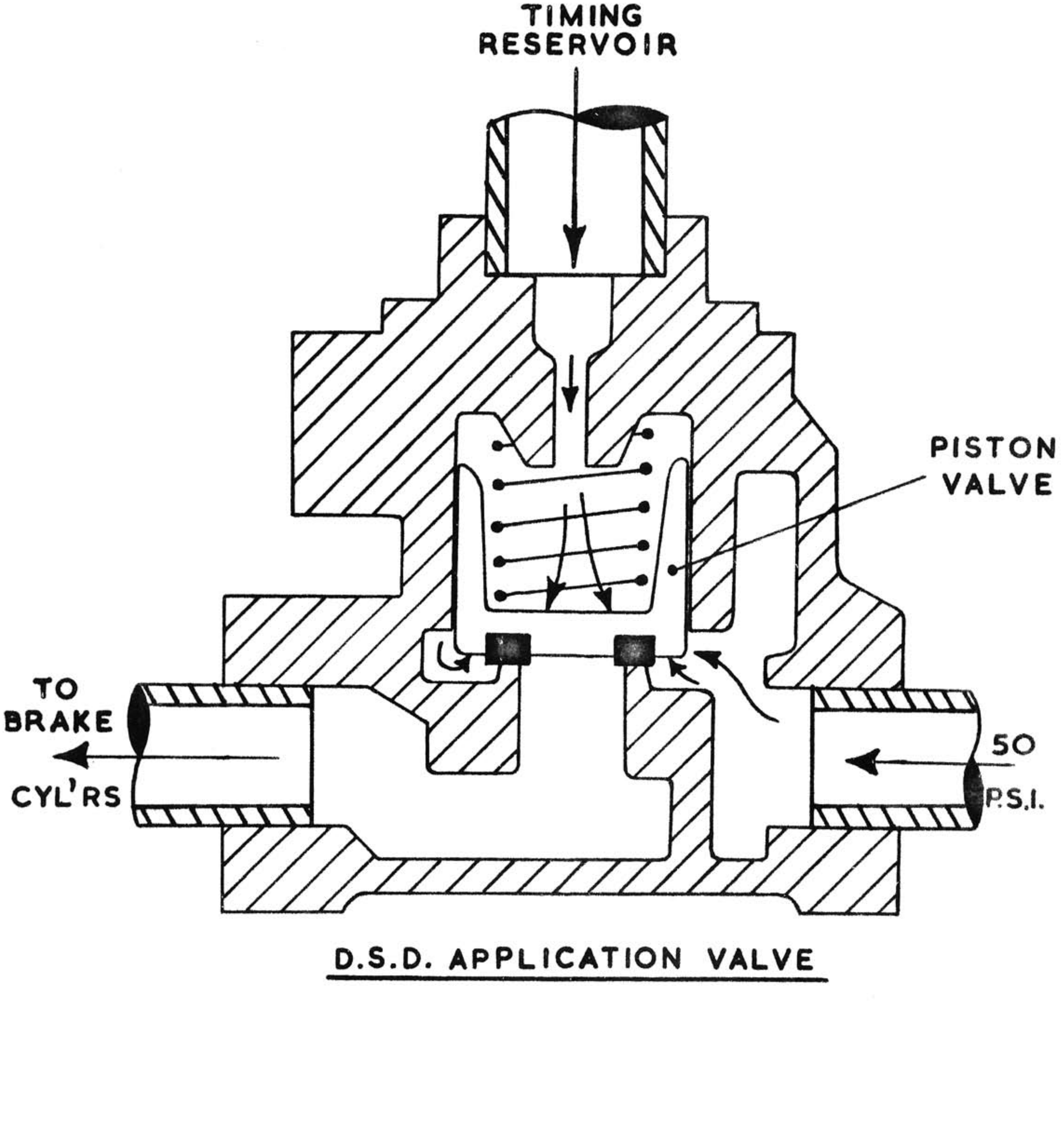
2. The D.S.D. Release Solenoid Valve is energised open and allows the air in the brake cylinder to exhaust to atmosphere.

3. The Vacuum Emergency Valve will close.

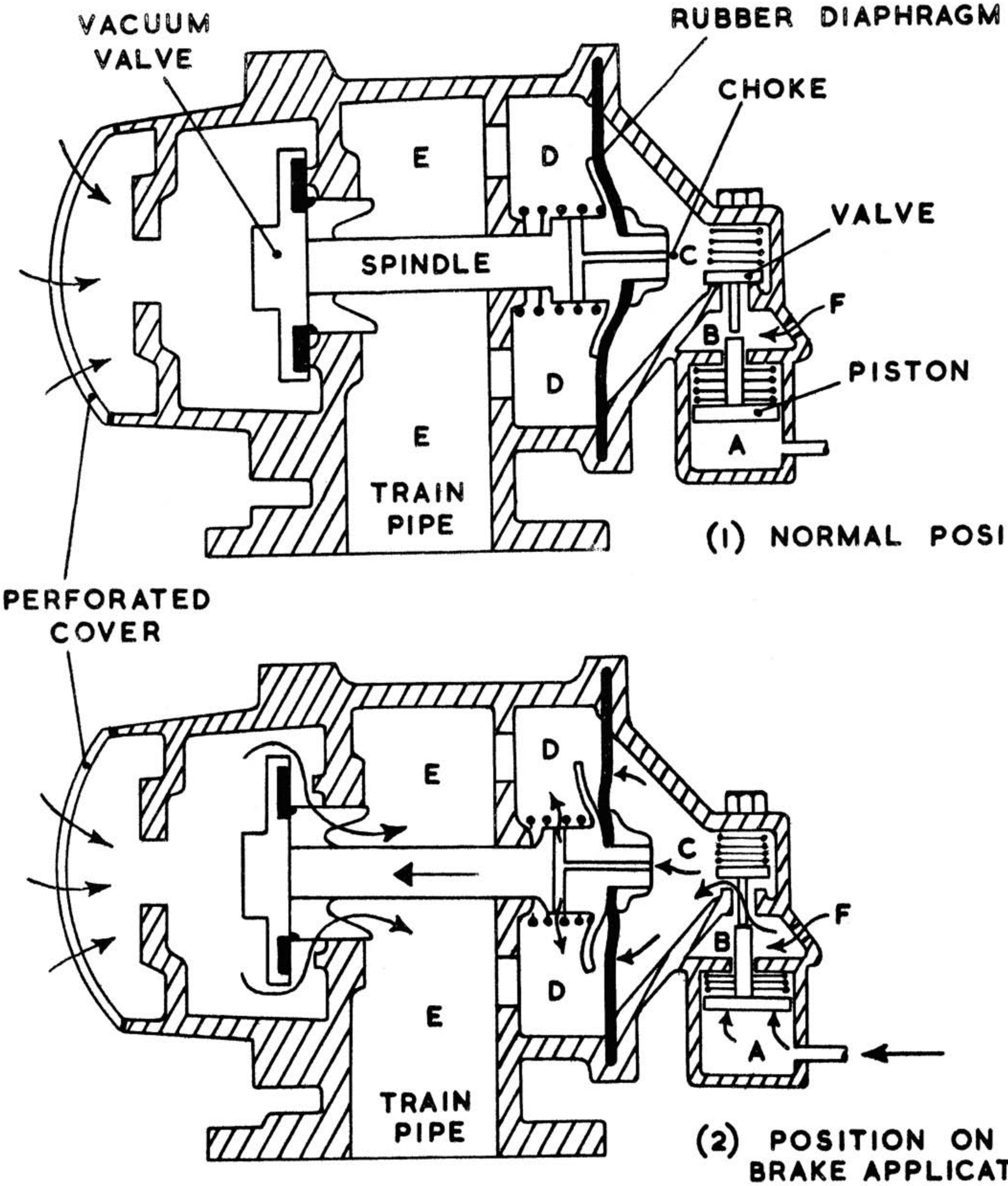
4. When the Pressure in the Brake Cylinders drops to 9 p.s.i. the D.S.D. Control Governor closes and power can be regained.

NOTE:

The D.S.D. brake application of 50 p.s.i. should be followed by a full proportional locomotive air brake application of 60 p.s.i. when working a vacuum fitted train due to the action of the vacuum emergency valve, proportional valve and double check valve. However when making a D.S.D. test during preparation, all vacuum will not be destroyed, or a full brake application of 60 p.s.i. obtained, as Emergency Valve operation is affected by the exhausters.



D.S.D. APPLICATION VALVE



(1) NORMAL POSITION.

(2) POSITION ON D.S.D. BRAKE APPLICATION.

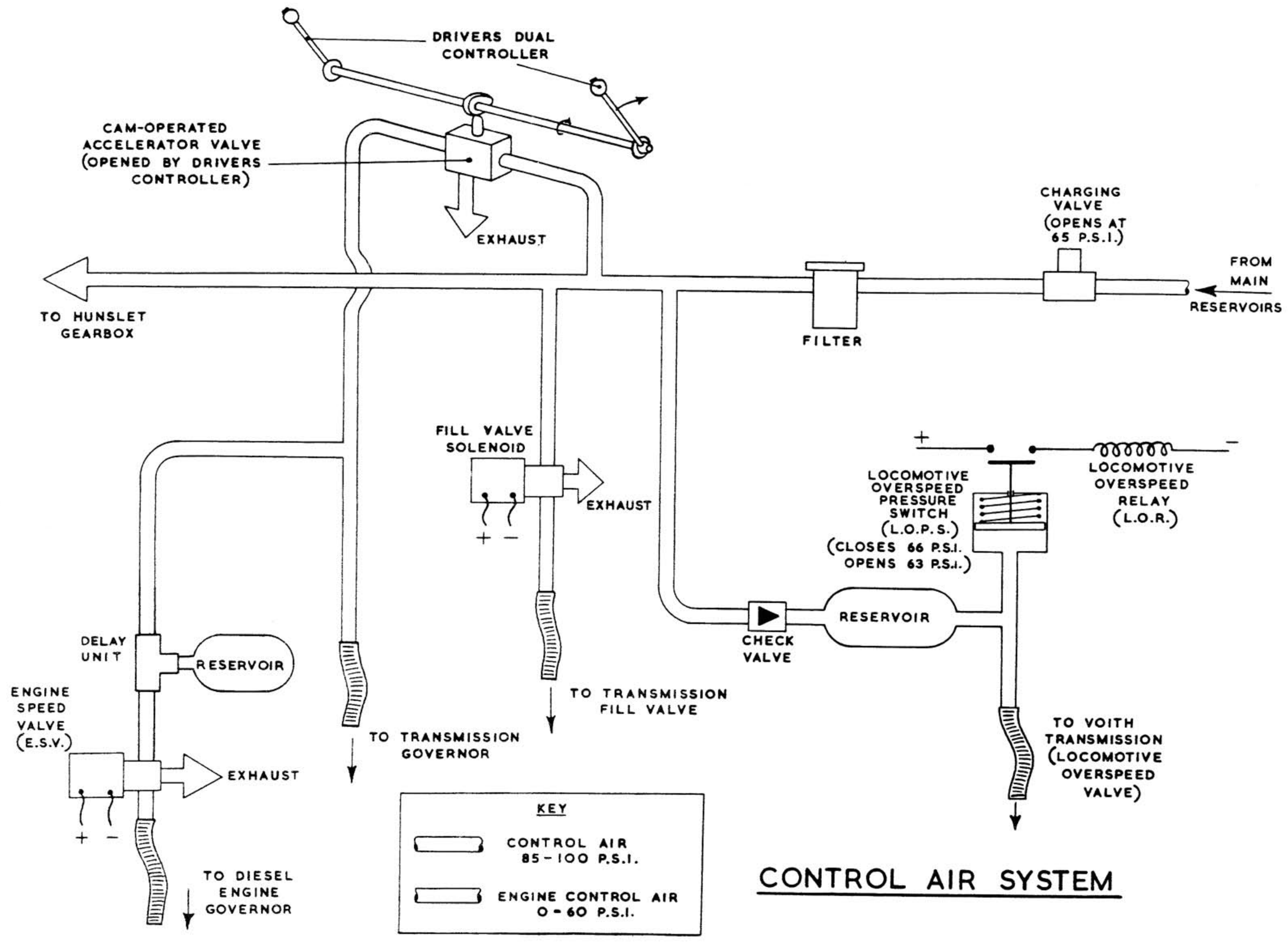
VACUUM EMERGENCY VALVE

OPERATION OF VACUUM EMERGENCY VALVE

When vacuum is created in the train pipe E it is also created in chambers D and C since the vacuum valve is being held on its seat by the spring behind the diaphragm. This condition is shown in Fig (I).

Should air pass to the brake cylinders through a D.S.D. application then it will also feed to chamber A beneath the piston, which will be pushed up when the pressure reaches 35 p.s.i. as shown in Fig (2). The piston and valve will lift and allow atmospheric air to pass from hole F into chambers B and C thus destroying vacuum in C and through the choke gradually destroying vacuum in D, causing the spindle to move across and open the vacuum valve and allow atmospheric air to pass directly into the train pipe to apply the vacuum brakes on the train. It will of course also give an indirect or proportional brake application on the locomotive.

When the D.S.D. brake application is released, air will be withdrawn from A, the valve will reseat and vacuum can be re-created to return the vacuum valve to the NORMAL position.



CONTROL AIR SYSTEM

Control Air System

Air from the main reservoirs feeds to the Charging Valve which opens at 65 p.s.i. to supply the control air system. This valve is fitted so that air is made available for braking purposes before it is fed to auxiliary equipment, and ensures that if a defect occurs on the control air system then at least 65 p.s.i. will be retained in the main reservoir system for braking.

After passing through the wire mesh filter the control air feeds:-

(a) to the Locomotive Overspeed Valve and Fill Valve of the Voith Transmission.

(b) to the Hunslet gearbox for reversing purposes.

(c) to the Accelerator Valve beneath the control desk. When the controller is operated the cam on the controller shaft opens the accelerator valve to supply, via the delay unit and reservoir, engine control air up to 60 p.s.i. for engine governor operation.

The purpose of the delay unit is to prevent sudden increases of engine speed which could be harmful to the engine and cause black exhaust.

NOTE:

Engine Control air supplied to the transmission for primary influence purposes is not affected by the delay unit.

HUNSLETT 650 FINAL DRIVE GEARBOX

General Description

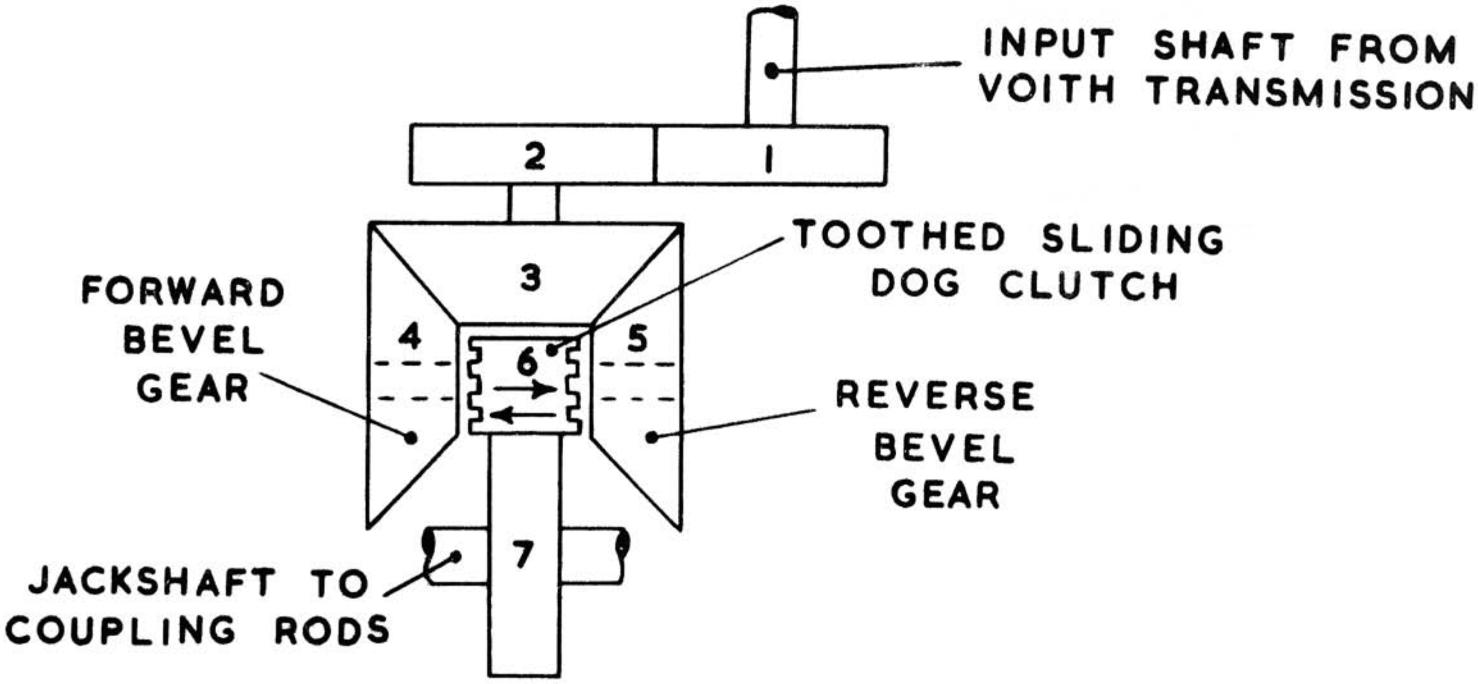
This box is a triple reduction gear box that supplies the power to roadwheels via a jack shaft. In general appearance it resembles the final drive fitted to the 204 H.P. shunter - the drive from the hydraulic transmission to the input shaft of the gear box is through a cardan shaft.

Drive is transferred to a bevel pinion shaft via helical reduction gears (1 & 2). The spiral bevel (3) meshes with the forward (4) and reverse (5) bevel pinion both of which revolve on the reverse shaft. Between the F. & R. bevels a dog clutch (6) slides to and fro on a key, selecting Forward and Reverse by meshing with one or other of the bevel pinions. The sliding dog clutch is a straight toothed gear which meshes with the final drive pinion (7) on the jack shaft.

The gearbox ratio is 6.75:1

The lubrication of the whole unit is by splash feed.

1st reduction	Gear 1	to	Gear 2	
2nd reduction	Gear 3	to	Gear 4	(FOR)
	Gear 3	to	Gear 5	(REV)
3rd reduction	Gear 6	to	Gear 7	



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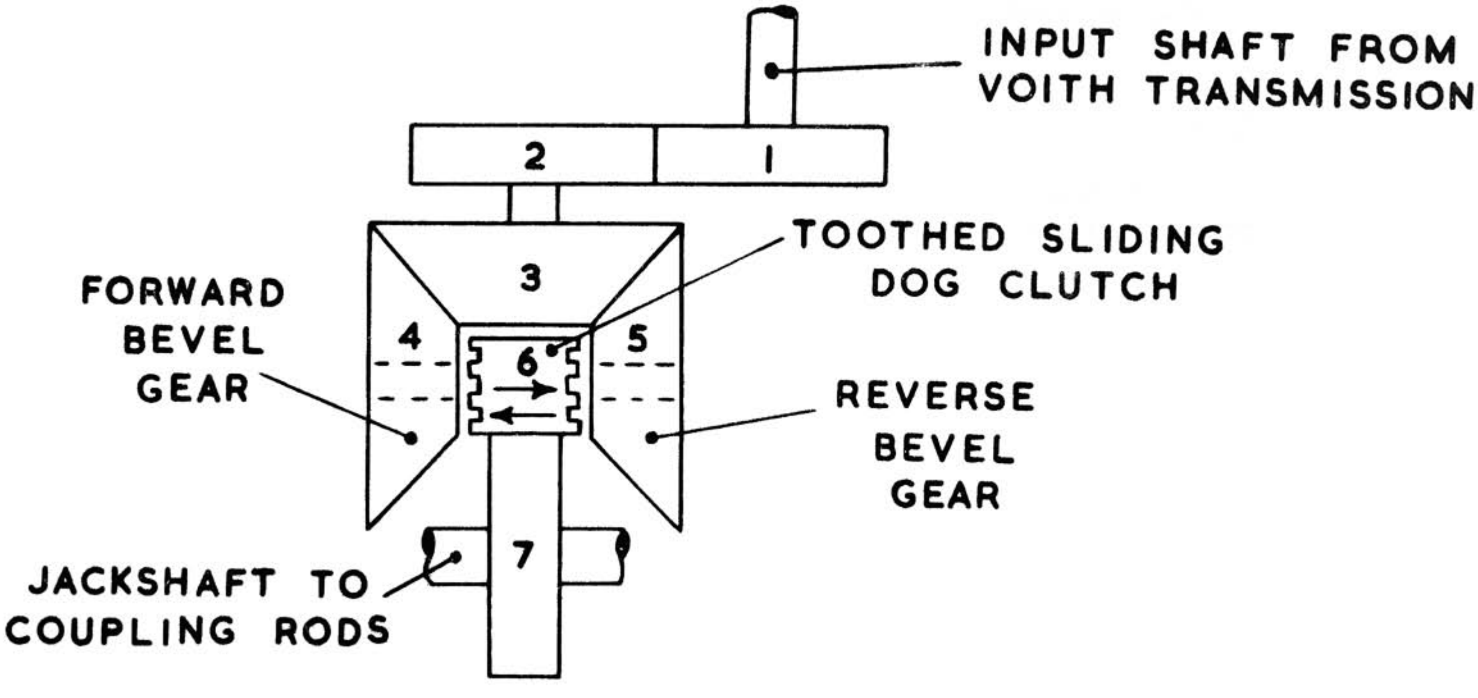
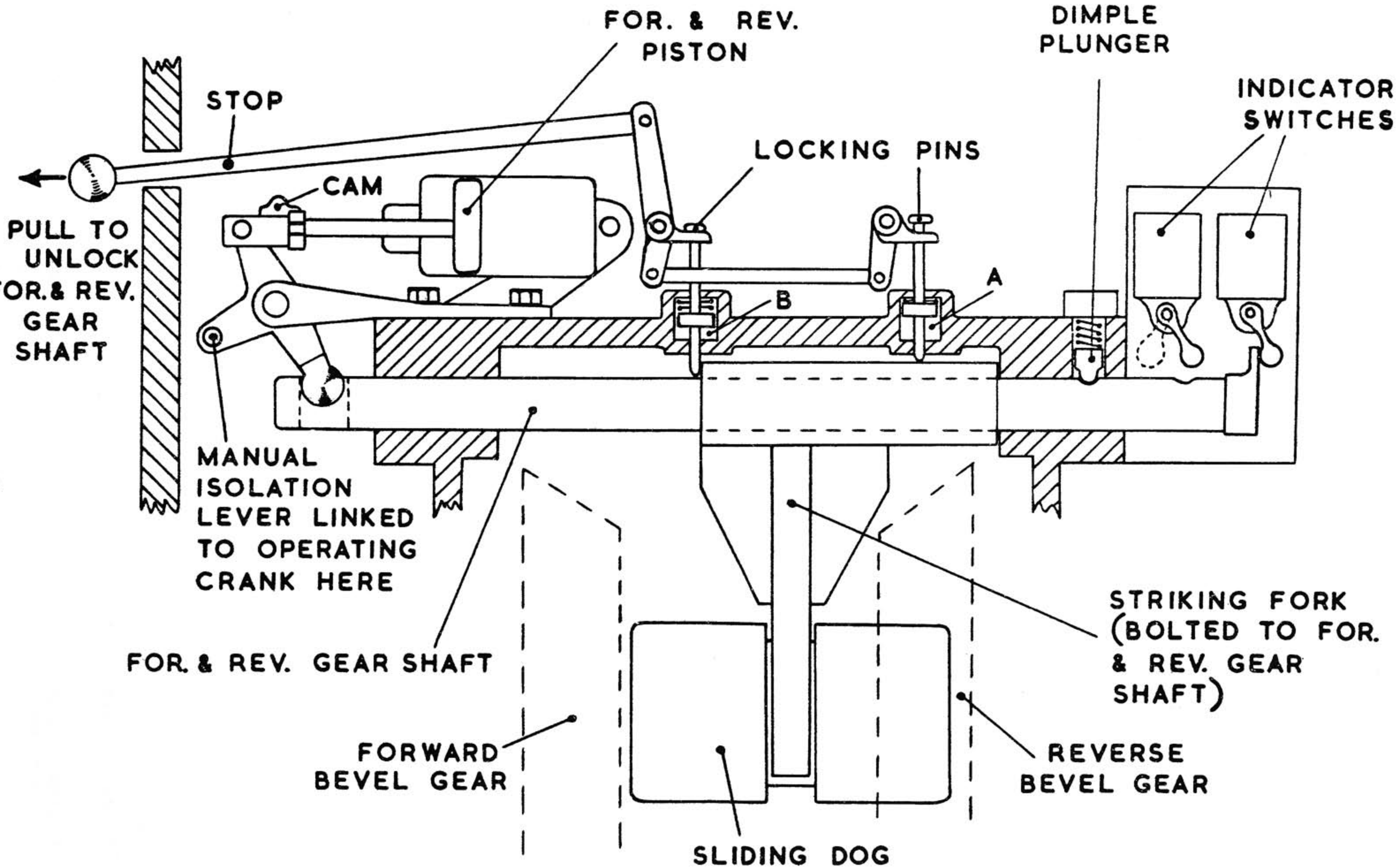
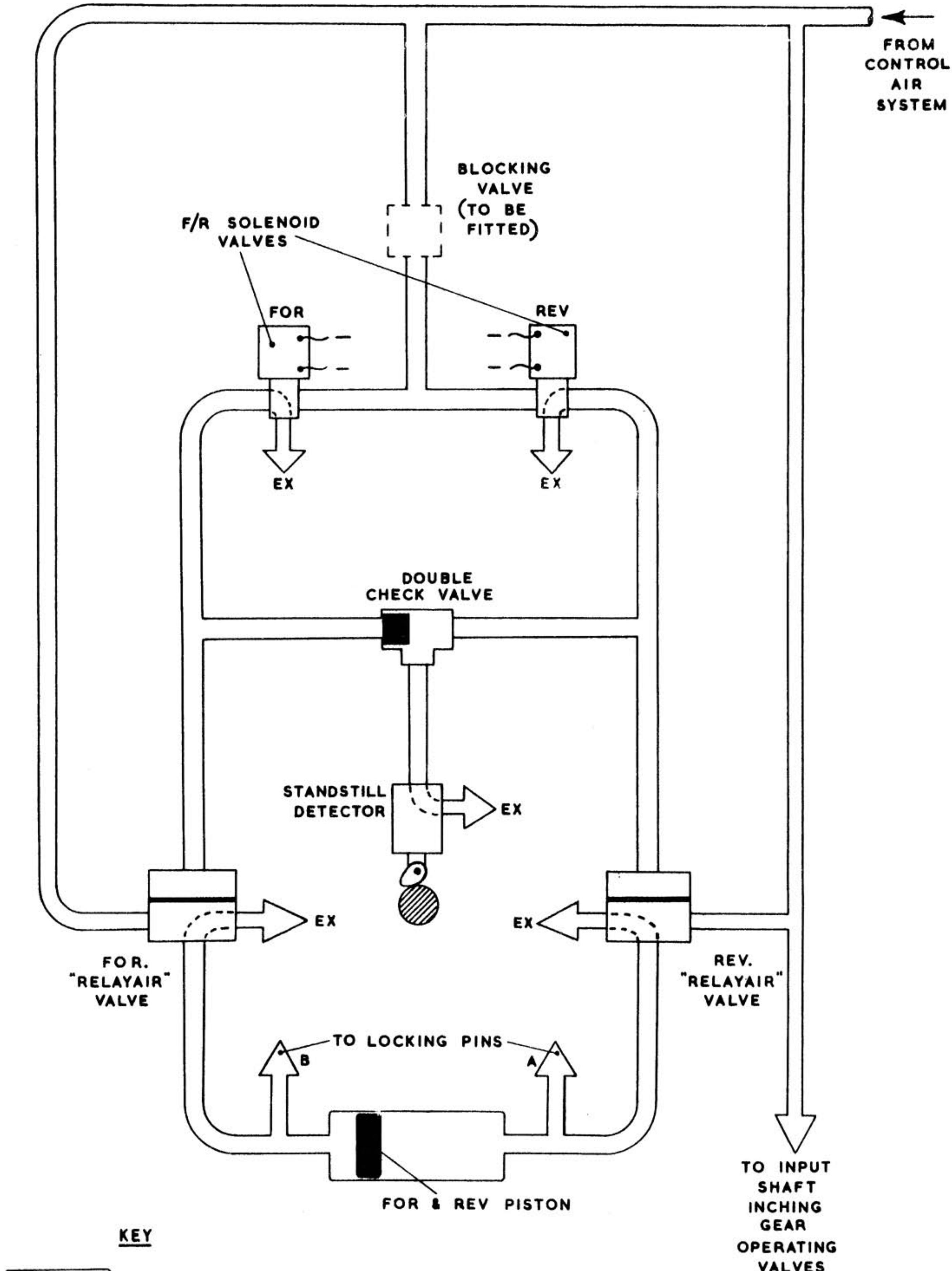
	Gear 3	to	Gear 5	(REV)
3rd reduction	Gear 6	to	Gear 7	





REVERSING MECHANISM
WITHIN HUNSLET GEARBOX



KEY

CONTROL AIR 85 – 100 P.S.I.

OPERATING AIR FROM F/R SOLENOIDS

CONTROL AIR SYSTEM
REVERSING MECHANISM

Description of Reversing Sequence

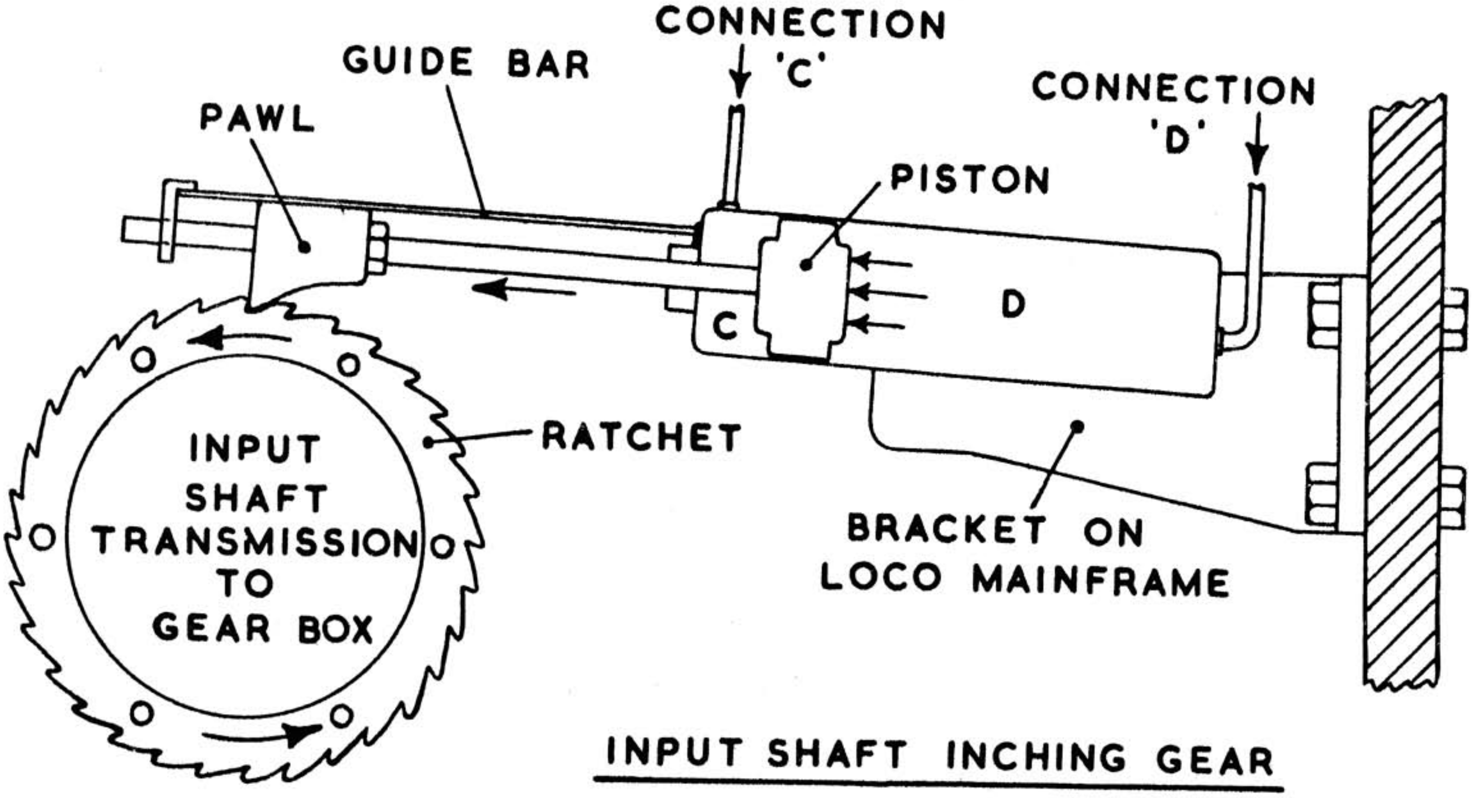
Air from the control system is fed to each RELAYAIR valve and to the FOR and REV solenoids, which are normally de-energised and closed. If REV gear is selected from the cab then the appropriate solenoid valve will be energised and allow air to pass to the corresponding RELAYAIR valve. When operating pressure reaches 50 p.s.i. the valve will open allowing control air to pass to the FOR and REV piston and thus move the sliding dog clutch.

Note that this air is also available to operate the piston of the appropriate locking pin, lifting it clear of the FOR and REV gear shaft to permit movement.

When the clutch has fully engaged in the direction chosen the REV solenoid valve will be de-energised (through the indicator switch which also give cab indication) and operating air pressure at the RELAYAIR valve will be exhausted through the solenoid valve, this will then allow air from the FOR and REV piston to exhaust via the RELAYAIR valve.

To hold the sliding dog clutch in the engaged position a dimple plunger and locking pins are fitted.

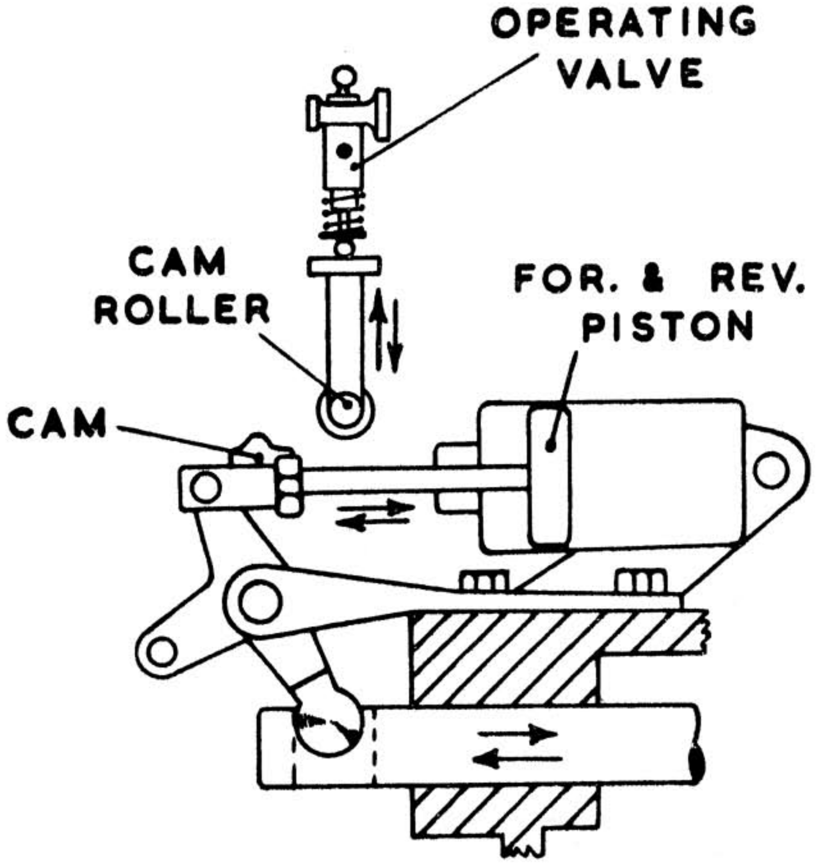
The RELAYAIR valves will not operate if a change of direction should be attempted when the locomotive is moving, since the operating air pressure will be led to exhaust through the standstill detector and cannot reach the required minimum of 50 p.s.i.

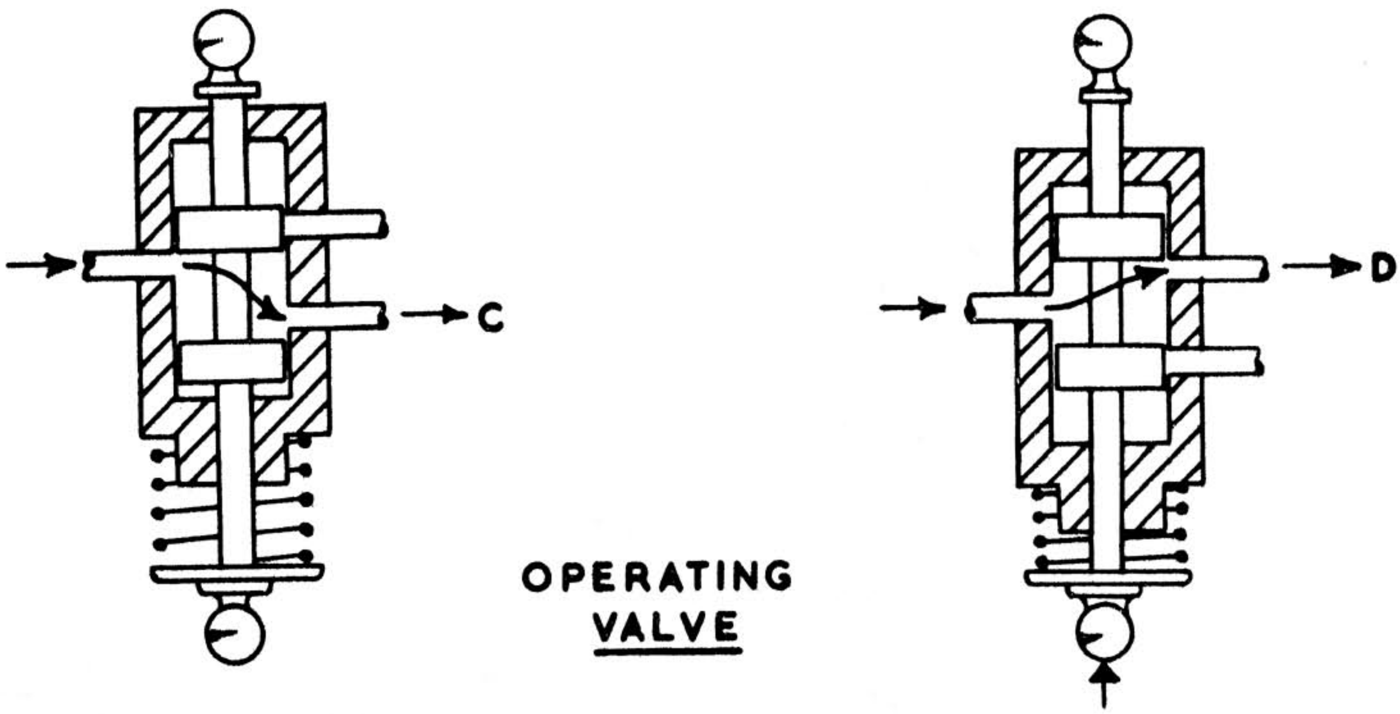


INPUT SHAFT INCHING GEAR

When a direction change is attempted it is possible that a "tooth on tooth" condition may arise, in this event air is admitted to chamber D and the piston is moved out as shown in the above diagram; so that the pawl will engage with the ratchet teeth on the input shaft, turning it sufficiently for the sliding dog clutch in the gearbox to engage in the direction chosen. Once this has taken place, air will be exhausted from chamber D but will be available in chamber C, moving the piston back and releasing the pawl from the ratchet teeth. Should this not happen then there is an EMERGENCY RELEASE PUSH BUTTON in the cab (at the side of the control desk), which should be operated if a "ratchetting" noise is heard just after a change of direction has been made.

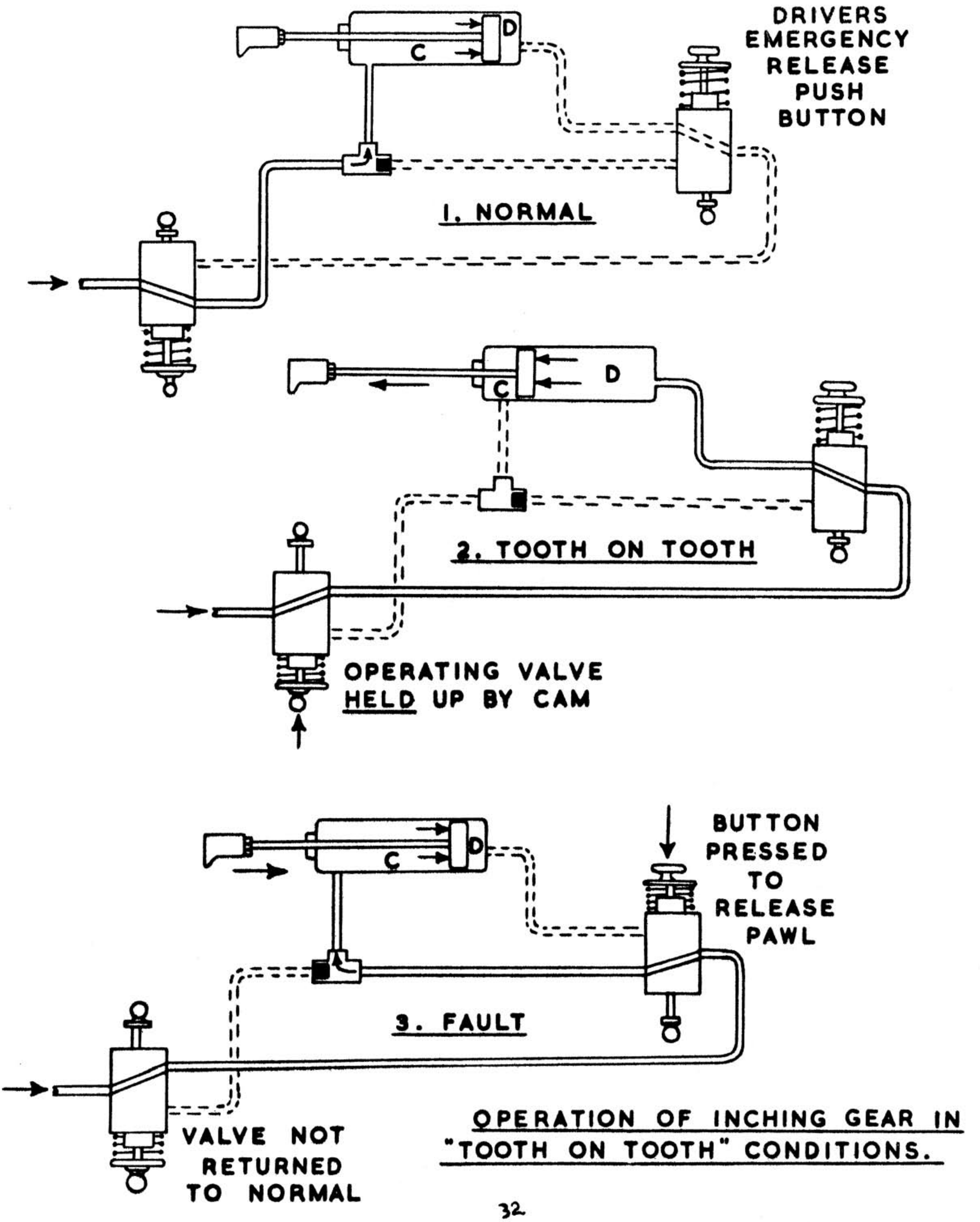
The following diagrams show how the air reaches chambers C and D on either side of the piston.





OPERATING

VALVE



OPERATION OF INCHING GEAR IN "TOOTH ON TOOTH" CONDITIONS.

Operation of Input Shaft Inching Gear

As can be seen from the drawing at the top of page 31 the operating valve is pushed up by the cam each time a direction change is made, but if the sliding dog clutch engages in the required direction at once, then the valve is only pushed up momentarily and air pressure in chamber 'D' is insufficient to move the piston.

Should a "tooth on tooth" condition arise then the operating valve will be held up (see diagram 2 on page 32), allowing air to pass to chamber 'D' moving the pawl outwards to engage the ratchet teeth. The input shaft will therefore turn slightly and the clutch should now engage properly, thus allowing the FOR and REV piston stroke to be completed and release the operating valve which in turn allows air to exhaust from 'D' and to be made available at 'C' so returning the pawl to its Normal position as indicated in diagram I.

If the pawl does not withdraw, possibly due to a 'sticking' operating valve, then use of the emergency release push button will allow air to be exhausted from 'D' and made available at 'C' as shown in diagram 3.

Baulked Condition

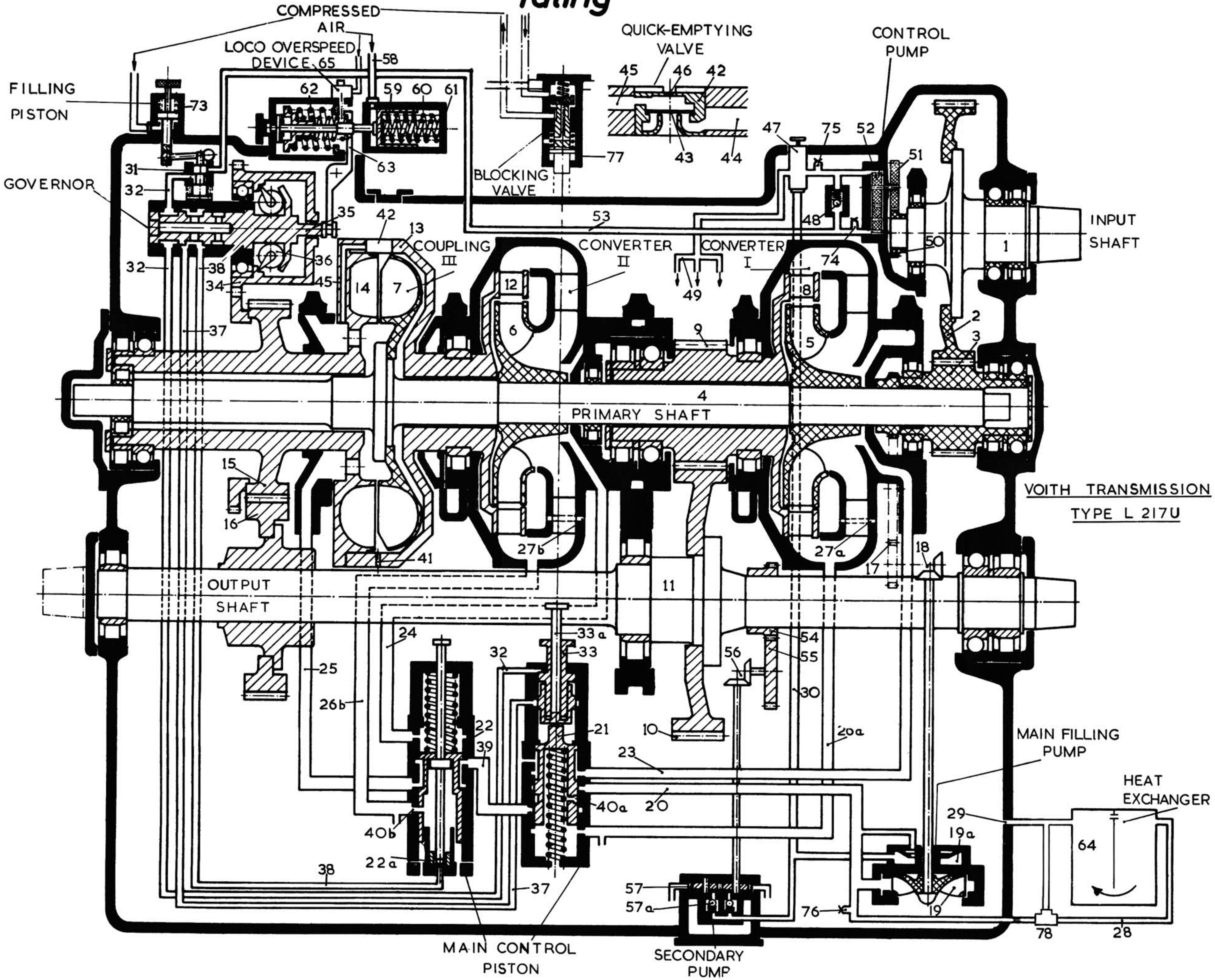
This is the name given to another form of "tooth on tooth" condition in which the sliding dog clutch partially engages with the required bevel wheel, but the pawl is prevented from turning the input shaft because the clutch is being forced into engagement by control air pressure. This can be overcome by the driver pressing the "tooth on tooth" button on top of the control desk, this will energise the other directional solenoid valve (which at the particular instant is normally de-energised so equalising air pressure on each side of the FOR and REV piston; this will free the sliding dog clutch of load and allow the pawl to turn the input shaft.

A timing relay (D.C.T.R.) is provided to ensure that air pressure is only fed to both sides of the FOR and REV piston for $1\frac{1}{2}$ seconds. If the gears still remain 'baulked' after this period then the "tooth on tooth" button must be released and again depressed to repeat the above sequence.

KEY TO VOITH TRANSMISSION - TYPE L 217U

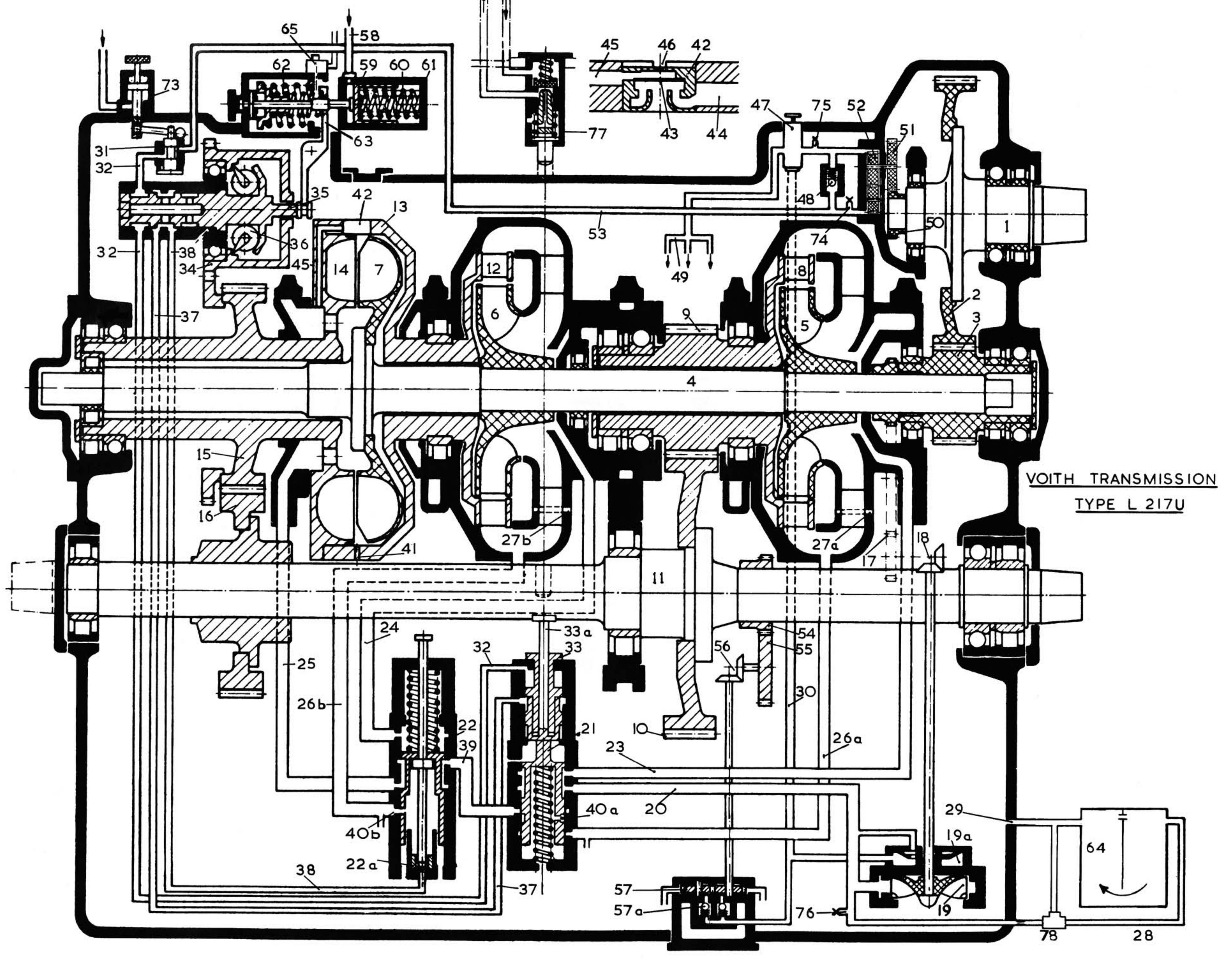
Number	Description
1	Input Shaft
2 & 3	Gears Input and primary
4	Primary Shaft
5	Impellor Torque Converter I
6	Impellor Torque Converter II
7	Primary Wheel Coupling (Stage III)
8	Turbine runner I
9 & 10	Drive Wheels
11	Secondary or Output Shaft
12	Turbine runner II
13	Coupling casing
14	Coupling secondary wheel
15 & 16	Drive Wheels
17 & 18	Drive gears to main oil filling pump
19	Main oil filling pump
19a	Throttling Orifice
20	Oil Supply Line (Main Control)
21 & 22	Control Piston (Main Control)
23	Oil Supply Line to Converter I
24	Oil Supply Line to Converter II
25	Oil Supply Line to Coupling III
26a & 26b	Converter drain liner
27a & 27b	Drains (Heat protection)
28	Oil Line to heat exchanger
29	Oil Line from heat exchanger
30	Oil Line to filter
31	Oil line to fill valve
32	Oil line fill valve to control

Idling



VOITH TRANSMISSION
TYPE L 217U

1st Stage


VOITH TRANSMISSION
TYPE L 217U
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33 & 33a	Pistons (Main Control)
34	Spur Wheel (Governor)
35	Control Pin (Governor)
36	Flyweights (Governor)
37 & 38	Oil liner to main control
39	Oil liner between control pistons
40a & 40b	Piston Orifices
41	Coupling drain (Heat protection)
42	Quick emptying Valve
43	Diaphragm
44	Emptying port
45	Control port
46	Central port
47	Lamellar Filter
48	Overflow Valve
49	Lubricating Line
50 & 51	Drive Gears Control Pump
52	Control oil pump
53	Line to fill valve
54, 55 & 56	Drive Gears
57	Secondary Lubricating Pump
58	Air Line
59	Piston
60	Spring
61	Housing
62	Governor Springs
63	Lever
64	Heat Exchanger
65	Loco Overspeed Device
73	Filling piston
74, 75 & 76	Gauge check points
77	Blocking Valve
78	Thermostatic Bypass Valve

VOITH TRANSMISSION TYPE L 217U

The Voith Hydraulic Transmission is a fluid drive, in which power is transmitted by oil accelerated in a "power-absorbing part" (centrifugal pump), and decelerated again in a "power-delivering part" (turbine). The mechanical energy delivered by the diesel engine to the transmission is absorbed by the fluid in the "power-absorbing part", the power in the fluid is then converted back into mechanical power in the "power-delivering part". The elements used for this purpose are oil circuits based on the Fottinger principle: Torque convertors as stages I and II and a Fluid coupling as stage III. Each hydraulic circuit is associated with a well-defined portion of the total speed range of the locomotive. The arrangement is such that the circuit engaged is automatically that which transmits the power at optimum efficiency. Automatic control is by means of a governor, which is sensitive to rail speed and engine output. In the Voith Turbo Transmission no friction couplings, clutches, pawls, etc. are used. The operation of the Voith Turbo Transmission is entirely hydraulic.

General

Shaft I, which is direct driven by the engine, through gear wheels 2, 3 drives primary shaft 4, on which are attached pump impeller 5 of Stage I torque converter, pump impeller 6 of stage II torque converter, and primary wheel 7 of stage III hydraulic coupling.

The torque developed in turbine runner 8 of the filled torque converter I is transmitted to output shaft II through gear wheels 9, 10. Output shaft II drives the jackshaft via a bevel reverse gear. As long as the converter I stays filled, torque converter II and coupling III are empty and revolve freely.

In stage II, converter I and coupling III are empty, and only converter II is filled. The torque acting on turbine runner 12 of the converter is transmitted to output shaft II through casing 13, secondary wheel 14 and via gear wheels 15, 16.

When coupling III (stage III) is filled, the hydraulic circuits of the stages I and II are empty. At such time, the power is transmitted from primary coupling wheel 7 to secondary coupling wheel 14 and from there to output shaft II through gear wheels 15, 16.

Stage I and II converters are designed for practically the same transmission ratio. In order to obtain two consecutive operating ranges, the transmission ratios of the output gears 9, 10 and 15, 16 are different. The transmission ratios of these gear wheels have been so chosen (about 1.5:1) as to obtain optimum tractive efforts over the entire speed range of the locomotive.

The changeover from one stage to the next is achieved by filling and emptying the oil circuits of the Transmission. With this arrangement, a gentle changeover is provided; with a minimum of shock. Furthermore, the power flow during changeover from one circuit to the next is not interrupted, since - while one circuit is emptying - the next circuit is being filled.

Control

Primary shaft 4, which is driven by the engine, drives filling pump 19 through spur wheels 17 and bevel wheels 18. The filling pump delivers the oil from the bottom of the transmission to the main control valve through line 20. In the main control valve, depending on the position of pistons 21 and 22, the oil is passed through line 23 to converter I, through line 24 to converter II, and through line 25 to coupling III. At the lowest point of the converter, lines 26a and 26b are run to the main control valve. Through these lines the oil can drain from the converters through the openings 40a and 40b when the converters are not in use. The various circuits are shut simply by closing off the associated supply lines 23, 24 or 25 by piston 21 or 22.

When the converters are in operation, a small amount of oil is continuously returned to the sump through openings 27a and 27b. In this way the heat absorbed by the oil is dissipated effectively. On the outer periphery of the coupling casing, small bores 41 are provided, through which also a small amount of oil can drain continuously. As the hydraulic efficiency of the coupling may be as high as 98%, only a very small oil flow is required for the dissipation of the heat losses and these bores are comparatively narrow.

When supply line 25 is cut off, the coupling will empty through these bores. In order to reduce the time required for drainage of the circuit and to speed up the changeover, three quick-emptying valves 42 are provided on the outer periphery of the coupling. These valves disengage a much larger oil passage and, as a result, the coupling empties rapidly as soon as the oil flow through line 25 has been stopped. These quick-emptying valves close automatically as soon as the coupling is being re-filled.

In these valves the only moving part is a hardened thin diaphragm 43 which seals off the discharge port 44, when the coupling is filled. There is some play between diaphragm and valve casing and the diaphragm is controlled exclusively by the oil pressure and the centrifugal force. When the coupling is being filled, oil first flows into the pressure compartment above the diaphragm through control channel 45, forcing the diaphragm against its seat. The internal oil pressure resulting from the coupling being filled, acts only on a small area of the diaphragm, the seat is sealed off as long as the main control piston of the coupling is in the 'filling' position. In the sealing nut of the valve a small central bore 46 is provided through which a small amount of oil can continuously discharge. When the oil flow to the coupling is cut off by the main control piston, control channel 45 discharges its oil through this by-pass bore in the nut. Because of the oil pressure inside the coupling and under the action of the centrifugal force, the diaphragm is lifted from its seat in the outward direction, thus disengaging the large port 44 for quick emptying of the coupling.

When the diesel engine is at a standstill, all oil circuits are empty, there is no pressure in the oil lines, and the control elements are in the position shown on the idling diagram. While the engine is still 'idling', the filling and control pumps produce the pressure required for all control operation.

A control pump 52 (gear pump) driven by the gear wheels 50, 51 supplies the pressure required for the changeover of the main control piston. The pump delivers the oil to the <u>filling</u> valve 31 through line 53. This oil coming from the filling pump through line 30 is cleaned in lamellar filter 47 and kept at the required pressure of 90-120 p.s.i. by overflow valve 48. When the filling valve is moved to the fill position by the action of the fill E.P. valve and filling piston 73, line 32 will become under pressure if the locomotive is at a standstill or when the running speed is low. As a result pistons 33 and 33a are pushed downwards and piston 21 connects line 20 of the filling pump with line 23 of <u>converter I</u> and the converter now starts filling.

<u>The blocking valve 77</u> will, depending upon the position of the main control piston 21, cut off the compressed air for the actuation of the reverse gear. In the idling position of the transmission the main control piston 21 is in the upper position, and the blocking valve is open. Provided that all other safety devices of the locomotive have become effective, the reverse gear can be operated. When main control piston 21 is in the filling position, the blocking valve is closed. At such time, the reverse gear cannot be operated.

The governor driven by the secondary parts of the transmission through spur wheel 34 comprises of a centrifugal pendulum and a control pin 35. When the rail speed increases so does the speed of the pendulum and flyrolls 36 move outwards. The governor of the three-stage transmission is so designed as to become effective at two different speeds (changeover stage I/II and changeover stage II/III). As a result of the movement made by control pin 35, at the first changeover point lines 37 and 38 are filled, and piston 33a and main control piston 21 move to their lower positions, thus establishing a connection between line 20 and 39. At the same time, under the action of the pressure in line 38, piston 22a and therefore main control piston 22 move upwards, thus connecting line 39 with line 24. As a result, converter II will now be filled. At the same time, the passage from outlet line 26a of converter I through openings 40a on main control piston 21a is opened, and the converter can rapidly drain into the oil sump.

If the rail speed and so the speed of the governor continue to rise up to changeover point II/III, the pendulum pushes control pin 35 to a position where the pressure in line 38 can leak away again. As a result, the pressure in the space underneath control piston 22a is released, and main control piston 22 is moved by spring action to the lower position shown in the diagram, thus establishing a connection between line 39 and line 25. Coupling III will now be filled, while converter II empties through line 26b and the bores 40b in main control piston 22.

Primary Control of Oil Circuit Changeover Point of the Governor

For all three stages and all throttle positions optimum tractive efforts are obtained, if the speed at the changeover points is proportional to the engine speed, with the converters engaged.

Primary control of the changeover points of the governor are accomplished by using engine control air through line 58 and acting on piston 59. By moving the drivers controller from full throttle to half throttle the loading on the governor springs will be reduced. This reduction of spring loading effects control pin 35 via lever 63 and as a result, the fly rolls 36 cause a changeover of the hydraulic circuits at lower rail speeds.

This primary control of the changeover point is only effective between full load and a part load for which the engine, with the converters engaged, (normally y = 20 mm) runs at about 67% of its maximum speed. The above engine speeds refer to the rail speeds in the proximity of the changeover points.

If the part loads decrease still further, the speeds at the changeover points do not drop any further; the changeover of the hydraulic circuits is brought about at the same rail speeds. The distance 'y' is inscribed on the front of cylinder 61.

Cooling

With the engine running, filling pump 19 delivers a quantity of oil in excess to that required to the heat exchanger through line 28. A throttling orifice in line 28 adjusts the oil flow to the minimum required to dissipate the heat losses at a maximum oil temperature of 80-100°C under the most severe operating conditions. Because of this throttling of the cooling oil flow, a larger percentage of the total delivery of the filling pump can be made available for the instantaneous filling and the changeover of the hydraulic circuits. At the same time, a constant filling pump pressure is maintained.

Modification to Transmission Lub Oil Circuit

Because the transmission oil heat exchanger 64 is in the closed engine cooling water circuit a slow temperature increase resulted since the engine also had to warm the transmission oil.

A Thermostatic Bypass Valve similar to that shown on Page 6 was therefore fitted in pipe 28 which prevents oil passing to the heat exchanger until transmission oil temperature reaches 175°F.

Lubrication

The gears as well as the bearings of the Turbo Transmission are lubricated through lubricating line 49 by the pressure oil of filling pump 19 through lamellar filter 47. This filter must be operated at least once every day and cleaned at regular intervals.

Secondary Lubricating Pump 57 supplies oil to the lubricating system if the locomotive is hauled with the diesel engine stationary and the final drive not isolated. This pump is driven off the output shaft through spur gears 54 and 55 and bevel gears 56. Two non-return valves 57a are provided to ensure delivery of oil into line 30 for either direction of rotation of the secondary lubricating pump. A throttling orifice 19a is provided to ensure that with the diesel engine stationary the lubricating oil cannot discharge into the sump via stationary filling pump 19.

Transmission

High Oil Temperature

If the oil temperature of the transmission should reach 240°F. the "High Transmission Temperature" and "General Alarm" lamps will come bright and the engine will revert to idling and the transmission will empty.

The power handle should be returned to off and engine allowed to idle and transmission cool.

When the Transmission Oil Temperature gauge reads 205°F. or less press the reset button and the fault lamps will become dim and the locomotive may be re-powered.

Loco Overspeed Detector

Should the secondary parts of the transmission overspeed by 15% the governor lever 63 will operate the overspeed detector 65. The detector opens a valve allowing pressure in a portion of the control air system to drop, this initiates, through a pressure switch, the following safety precautions:-

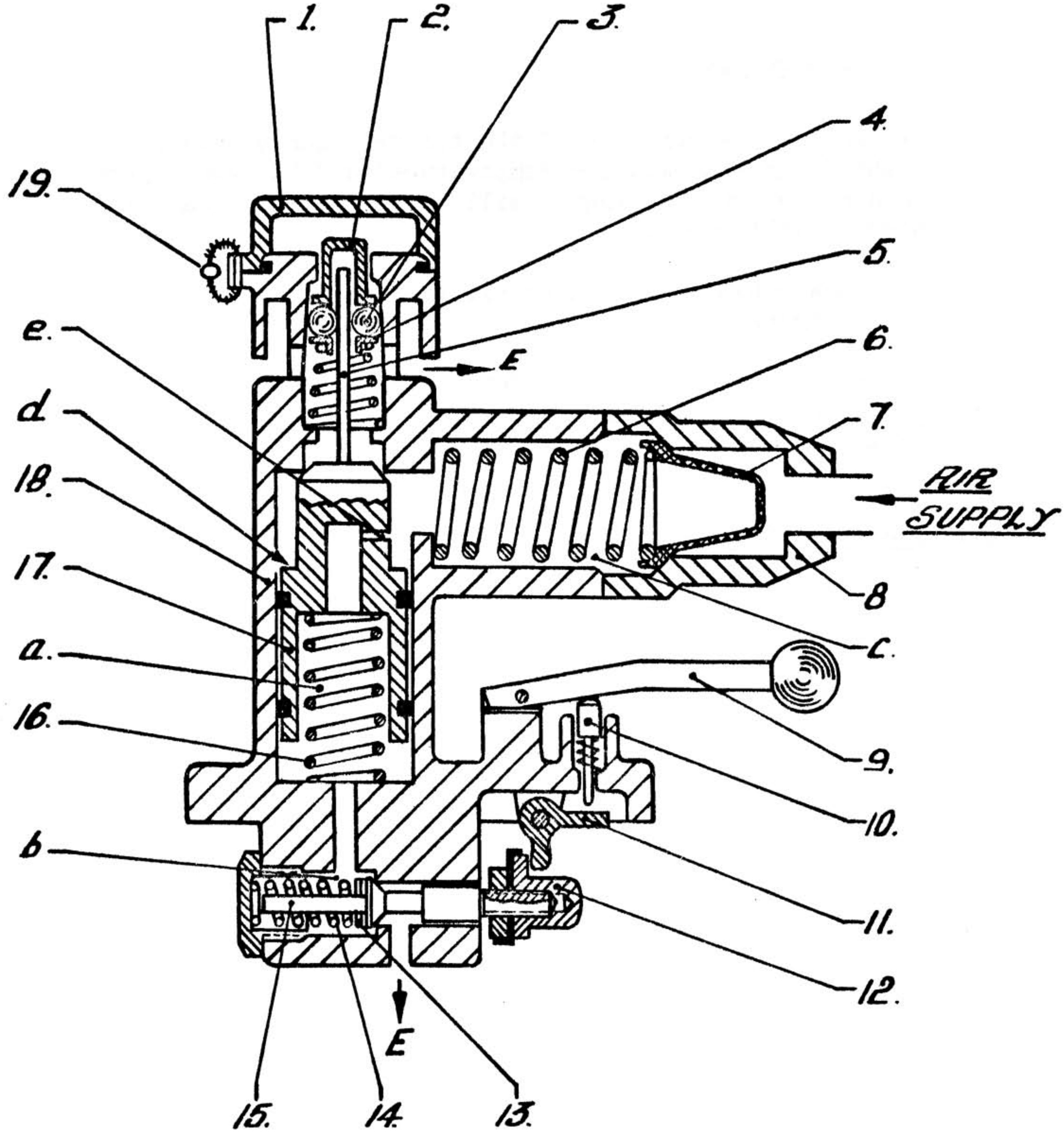
(a) Driver's safety device operates

(b) Diesel engine returns to idling

(c) Fluid coupling empties

(d) Appropriate fault lights become bright

The detector can only be cancelled by depressing the sealed reset button on top of the transmission thus manually closing the valve. The operation of the detector can be checked by operating the hand lever which simulates a loco overspeed.



OVERSPEED VALVE.

VOITH TRANSMISSION