CONTROLS

CHAPTER P2

CONTENTS

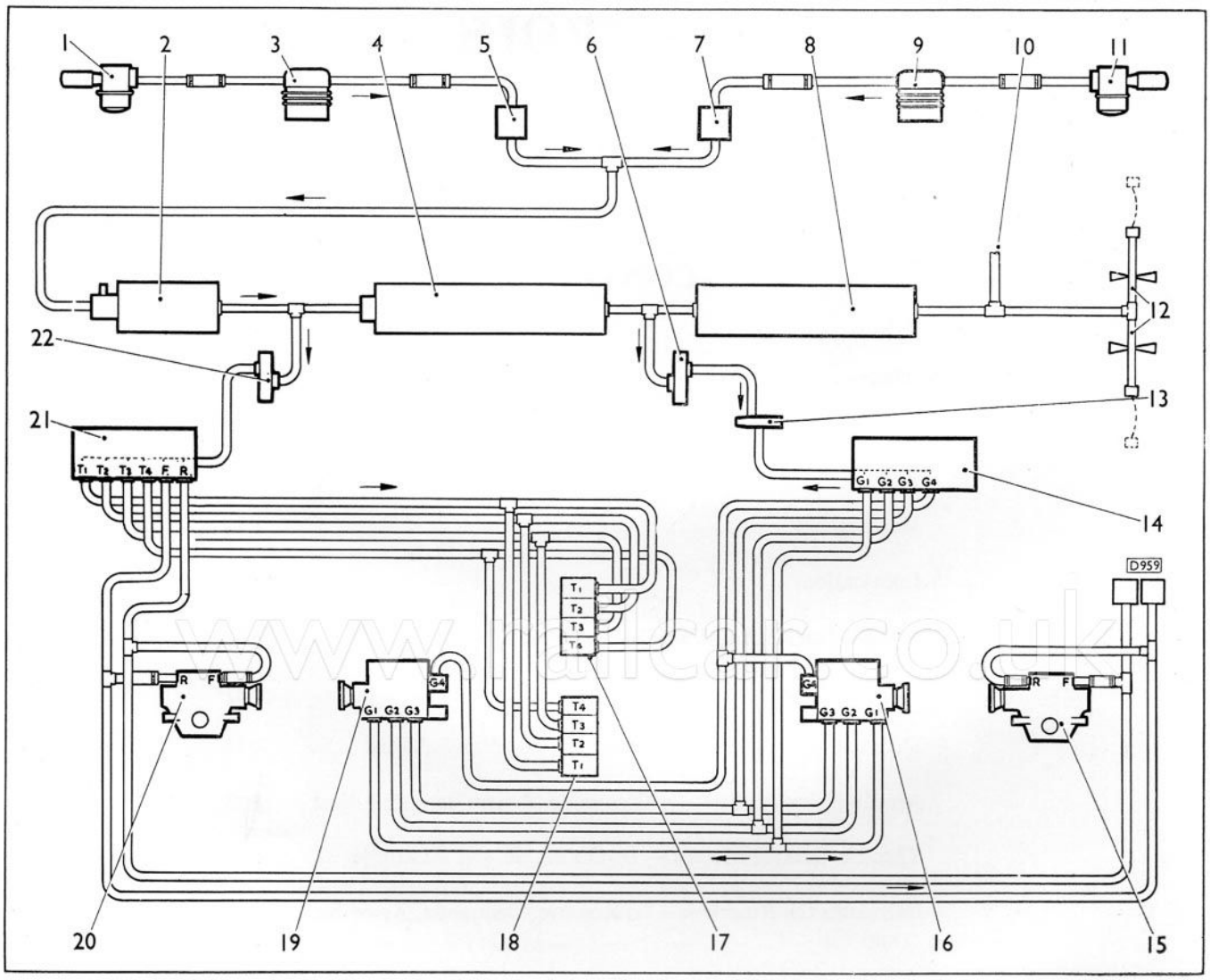

Fig. 1. Diagrammatic layout of air pressure system

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

Section P1 CONTROLS—DESCRIPTION

(See Figs. 2 and 3)

GENERAL

The hand controls in the driver's cab consist of a combined throttle control and " deadman's " handle, mounted on the left of the driver, and a forward and reverse lever and a gear change lever mounted on the control table to the right of the driver.

These levers, through the media of electro-pneumatic (E.P.) valves, operate the throttle control motors, forward and reverse gears in the final drive units and the epicyclic gearbox pistons.

The throttle lever is also the " deadman's " handle; and when released, returns the engine to idling speed, the gearbox to neutral and automatically applies the brakes.

In addition to the hand controls, the following are also mounted in the driver's cab; a driver's brake valve, a speedometer, an engine speed indicator, air pressure and duplex vacuum gauges and a control panel containing starter buttons and indicator lights. The cab layout is shown in Figures 2 and 3.

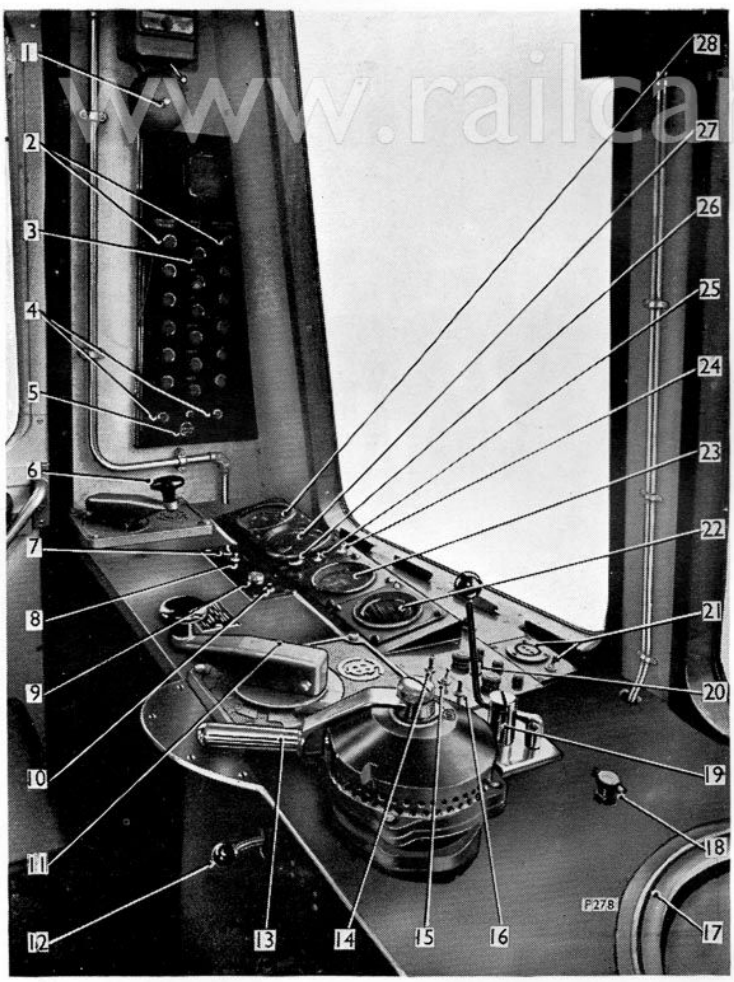

Fig. 2. Driver's controls—power car (Derby built)

1. FIRE ALARM BELL
2. ENGINE OIL PRESSURE INDICATOR LIGHTS
3. AIR PRESSURE AND AXLE INDICATOR LIGHTS
4. ENGINE START BUTTONS
5. ENGINE STOP BUTTON
6. THROTTLE CONTROLLER
7. TEST SWITCH—AIR AND OIL PRESSURE LIGHTING INDICATORS
8. DEMISTER SWITCH
9. MAIN KEY SWITCH
10. BUZZER BUTTON
11. GEARBOX CONTROLLER
12. HORN LEVER
13. VACUUM BRAKE VALVE LEVER
14. LEFT-HAND HEAD CODE LIGHT SWITCH
15. ROUTE HEAD CODE INDICATOR LIGHT SWITCH
16. RIGHT-HAND HEAD CODE LIGHT SWITCH
17. HANDBRAKE WHEEL
18. WINDSCREEN WIPER VALVE
19. WINDSCREEN WASHER PUMP LEVER
20. DESTINATION INDICATOR LIGHT SWITCH
21. EMERGENCY LIGHT SOCKET AND SWITCH
22. AIR PRESSURE GAUGE
23. VACUUM GAUGE
24. PANEL LIGHT SWITCH
25. ENGINE SPEED INDICATOR CHANGE-OVER SWITCH
26. MAIN SWITCH INDICATOR LIGHT
27. ENGINE SPEED INDICATOR
28. SPEEDOMETER

AIR PRESSURE SYSTEM

Two air compressors, one mounted on each engine, provides air for operating the throttle control motors, epicyclic gearbox pistons and forward and reverse pistons in the final drive units.

Air is dawn by the compressors through the air filter and anti-freezer units and passed through non-return valves; at this point the combined output from both compressors passes, via an unloader valve, to a small capacity reservoir. This permits a rapid build-up of pressure, thus enabling the throttle control motor E.P. valves, the forward and reverse selector in the final drive units and the air pressure switches to be operated.

When pressure in the small capacity reservoir reaches a pre-determined figure, a diverter valve, mounted on the second reservoir, opens and allows air to pass to the second and third reservoirs which are of larger capacity.

Air from the main reservoirs passes, via an air filter, through a reducing valve to the E.P. valves which operate the epicyclic gearbox pistons and via an air filter to the E.P. valves which operate the pistons in the final drive unit and the throttle control motors.

A further pipeline from the reservoirs supplies air pressure for the pressure gauge in the driver's cab and the auxiliaries.

Note.—For a description of the revised air pressure system see " SUPPLEMENT TO CHAPTER P2."

The air compressors are described in the Engine Chapter.

Air filter and anti-freezer (*see Fig.* 4)

The air filter, which is an integral unit with the anti-freezer, consists of a cylindrical gauze on which is mounted a felt filter; the felt is surrounded by a slotted cover, cylindrical in shape and closed at one end. The cover is secured by one nut at its closed end. The anti-freezer consists of a reservoir above

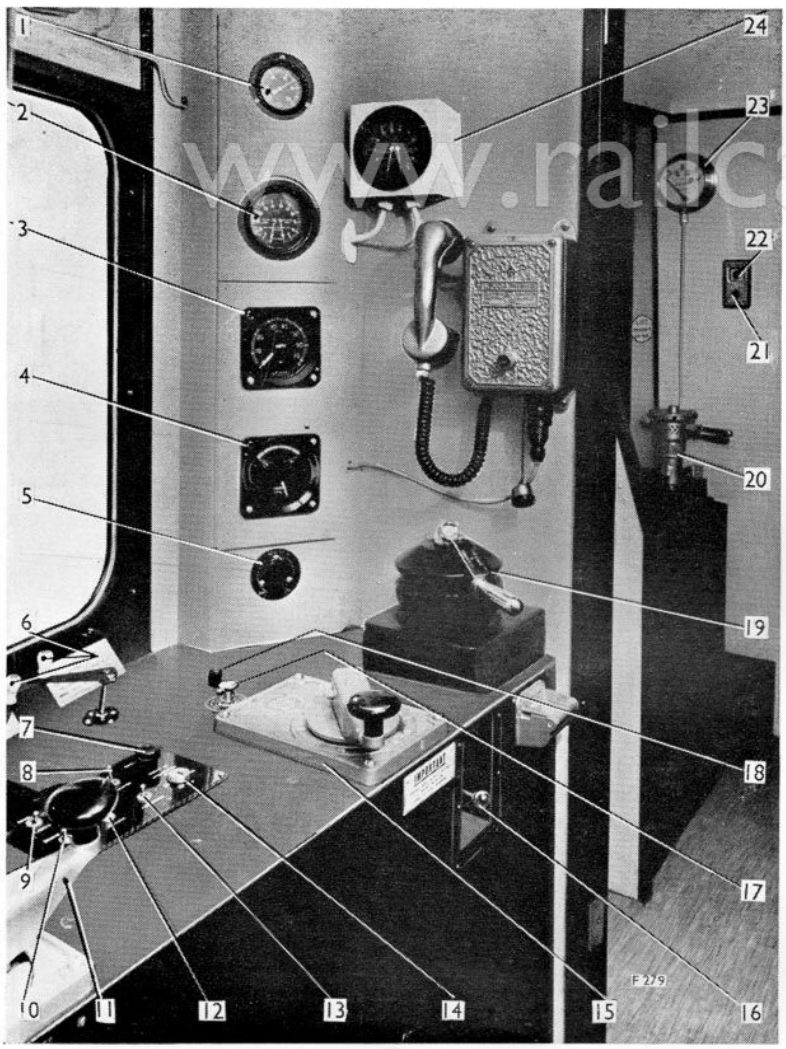

Fig. 3. Driving compartment—Western Region parcels car (Gloucester Carriage and Wagon)

1. AIR PRESSURE GAUGE
2. VACUUM GAUGE—TRAIN AND RELEASE PIPE
3. SPEEDOMETER
4. ENGINE SPEED INDICATOR
5. DIMMER SWITCH—PANEL LIGHTS
6. HEAD CODE ROLLER BLIND HANDLES
7. MAIN SWITCH LIGHT INDICATOR
8. ROUTE HEAD CODE INDICATOR LIGHT SWITCH
9. PANEL LIGHTING SWITCH
10. ENGINE SPEED INDICATOR CHANGE-OVER SWITCH
11. THROTTLE CONTROLLER
12. BUZZER BUTTON
13. DEMISTER SWITCH
14. MAIN KEY SWITCH
15. GEARBOX CONTROLLER
16. HORN LEVER
17. WINDSCREEN WIPER VALVE
18. SANDING BUTTON
19. DRIVER'S BRAKE VALVE
20. GUARD'S EMERGENCY BRAKE VALVE
21. CAB LIGHT SWITCH
22. DEADMAN'S CANCELLATION BUTTON
23. VACUUM GAUGE—TRAIN PIPE
24. VACUUM GAUGE—No. 1 AND No. 2 VACUUM CYLINDERS

which a venturi tube is mounted ; the reservoir communicates with the extremes of the venturi tube by means of two drillings. A proportion of the air, drawn through the venturi tube by the compressor, by-passes (down the first drilling) into the reservoir, there mixing with the alcohol vapour present. The mixture then passes up the second drilling to mix with the main air stream.

Air reservoirs (*see Fig.* 5).

Three reservoirs are provided for storing compressed air, supplied by the compressors, at a convenient pressure for operating the air equipment.

The reservoirs are of welded steel construction and are protected against corrosion by an external and internal finish of stove-baked enamel.

Facilities for draining are provided by two plugs or cocks fitted to the underside of each reservoir.

Unloader valve (*see Fig.* 7)

The purpose of the unloader valve is to relieve the compressors of the pumping load when the reservoirs are charged to operating pressure.

Air from the compressors enters the unloader valve through an inlet port and passes through a felt filter along a passage into the unloader valve chamber.

When the pressure in the reservoir is below that of the unloader, the spring-loaded valve remains closed and air flows via a non-return valve into the reservoir. The non-return valve retains the pressure built up in the reservoir when the compressor is not operating.

Reservoir pressure is communicated to the inside of a metal bellows, situated below the valve.

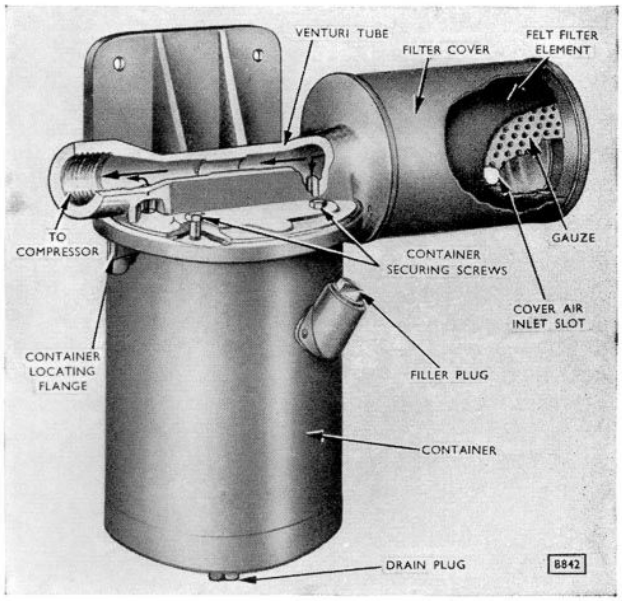

Fig. 4. Combined air filter and anti-freezer

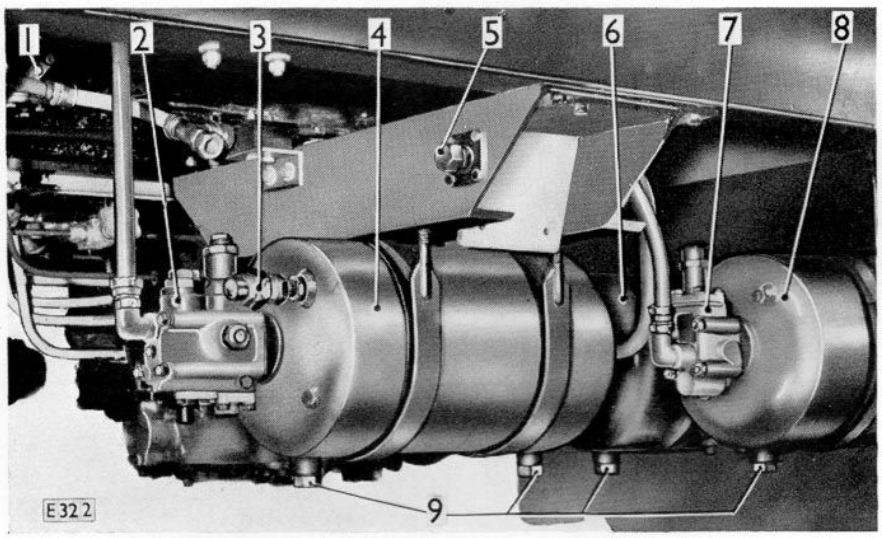

Fig. 5. Air reservoirs, unloader and diverter valves

1. PIPE LINE AIR FILTER
2. UNLOADER VALVE
3. SAFETY VALVE
4. FIRST RESERVOIR
5. BLANKING NUT FOR UNLOADER VALVE IN STORAGE POSITION
6. THIRD RESERVOIR
7. DIVERTER VALVE
8. SECOND RESERVOIR
9. RESERVOIR DRAIN PLUGS OR DRAIN COCKS

When the reservoir pressure exceeds that of the unloader, the bellows are forced up, thus overcoming the resistance of the spring and lifts the valve off its seat.

Air continuing to enter the unloader valve from the compressor is then diverted to atmosphere.

Safety valve *(see Fig. 6)*

The safety valve, which is in permanent communication with the interior of the reservoir, is provided to prevent excessive pressure rise should the unloader valve fail to operate at the correct pressure. It is a simple spring-loaded valve with a metal seat and is set to blow-off at a pressure slightly above the normal maximum working pressure in the reservoir.

Non-return valve (*see Fig.* 8)

The non-return valve is mounted in the air pipe line between the reservoirs and the compressors.

It is designed to prevent air escaping from the reservoirs back to the compressors whilst the engines are idling or stationary.

The rubber faced valve is held in position on the valve seat by a light coil spring and is contained within a brass body.

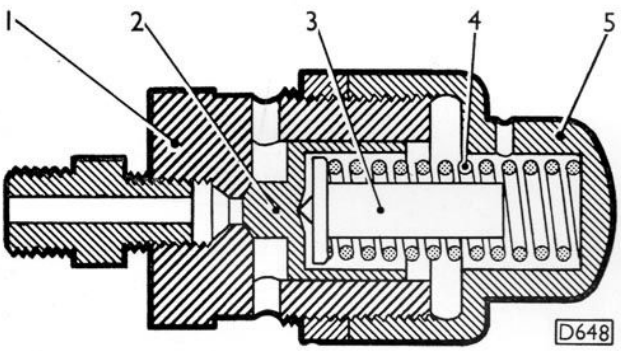

Fig. 6. Safety valve

1. SAFETY VALVE BODY
2. VALVE
3. PLUNGER
4. SPRING
5. ADJUSTING END CAP

Air from the compressor enters the non-return valve through the inlet port, overcoming the effort of the coil spring and moving the valve off its seat and passes through the air passage and out through the outlet port.

When the air flow ceases, the pressure in the reservoir, assisted by the action of the spring, forces the valve on to its seat, thus preventing air escaping back to the compressor.

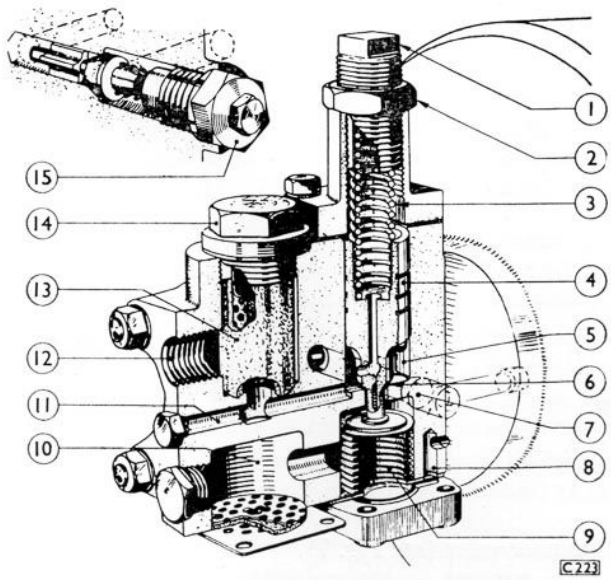

Fig. 7. Unloader valve

1. ADJUSTING NUT
2. LOCKNUT
3. SPRING
4. VALVE
5. UNLOADER VALVE CHAMBER
6. VALVE SEAT
7. NON-RETURN VALVE
8. AIR PASSAGE
9. BELLOWS
10. SILENCING CHAMBER
11. AIR PASSAGE
12. INLET PORT
13. FELT STRAINER
14. PLUG FOR FELT STRAINER
15. PLUG FOR NON-RETURN VALVE

Throttle control motors (*see Fig.* 10).

The throttle control motors are mounted on the car adjacent to the fuel-injection pumps and are operated by air via the E.P. valves.

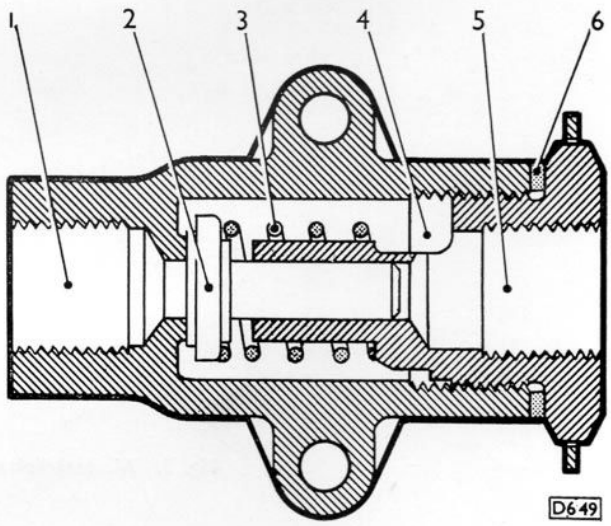

Fig. 8. Non-return valve

1. INLET PORT.
2. VALVE
3. SPRING
4. AIR PASSAGE
5. OUTLET PORT
6. COPPER WASHER

They are connected by linkage to the fuel-injection pump control levers, thereby enabling the fuel delivery, and thus the engine speed, to be remotely controlled by the throttle lever inside the driver's cab.

The pistons in the throttle control motors operate the actuating levers, which in turn operate the control levers on the fuel-injection pumps, in a series of steps which correspond to the steps felt when moving the driver's throttle control lever.

Adjustment of the actuating levers is provided by four screws and locknuts.

Pipe line air filters (*see Fig.* 11)

Air filters are mounted in the pipe line between the reservoirs and the air reducing valve, also between the reservoirs and the E.P. valve block for the throttle motors and final drive units.

The purpose of the filters is to provide an additional safeguard against foreign matter entering the E.P. valves.

Each filter consists of a felt element encased in a perforated cylinder and contained within a brass body.

Diverter valve (*see Fig.* 9)

The diverter valve is connected to the main compressed air supply. Its purpose is to ensure that the primary system is charged to at least the pressure quoted in Section P2 before pressure is allowed to build up in the system beyond the valve. This valve will however, permit the reverse flow of air if for any reason, the pressure in the main system should fall below that in the secondary reservoir.

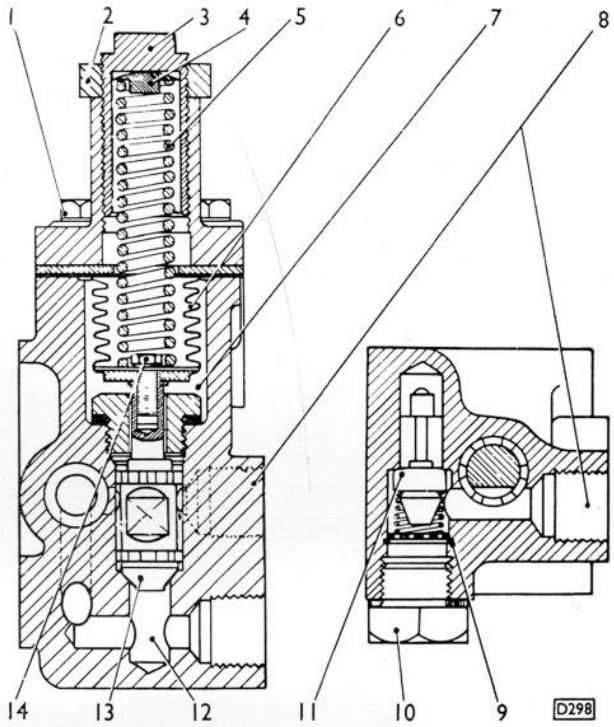

Fig. 9. Sectioned view of diverter valve

1. SET-SCREWS SECURING TOP COVER
2. LOCKNUT
3. ADJUSTER
4. CONTROL SPRING BUTTON
5. CONTROL SPRING
6. BELLOWS
7. AIR CHAMBER
8. INLET PORT
9. CIRCLIP SECURING PERFORATED PLATE AND SPRING
10. HEXAGON PLUG FOR NON-RETURN VALVE
11. NON-RETURN VALVE
12. CORED PASSAGE TO RESERVOIR
13. VALVE
14. SETSCREW FOR SECURING BELLOWS

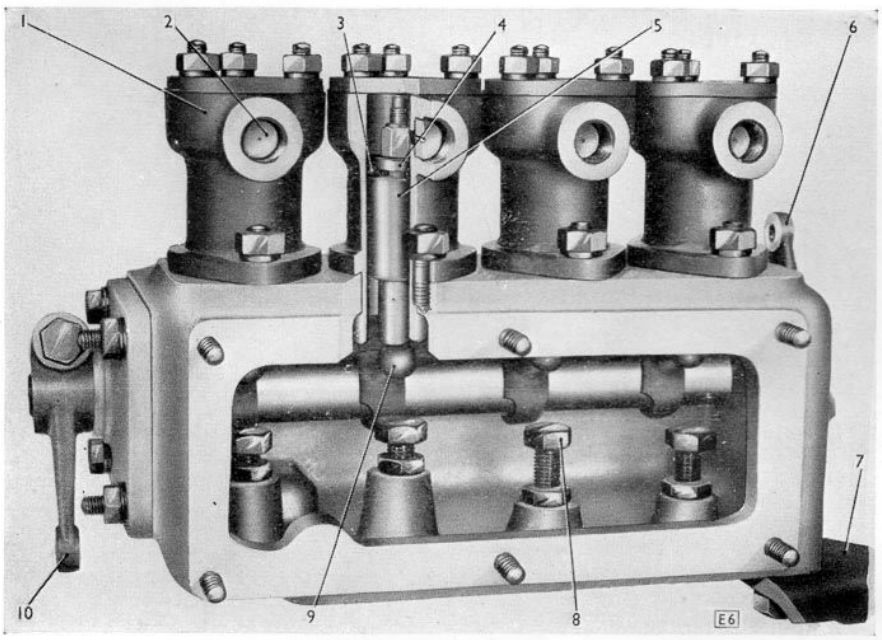

Fig. 10. Throttle motor showing adjusting screws

1. AIR CYLINDER
2. AIR INLET PORT
3. PISTON SEAL
4. PISTON SEAL RETAINING WASHER
5. PISTON
6. CONTROL LEVER TO FUEL-INJECTION PUMP (WHEN FITTED)
7. CONTROL CABLE ANCHOR BRACKET (WHEN FITTED)
8. ACTUATING LEVER ADJUSTING SCREW
9. ACTUATING LEVER
10. CONTROL LEVER (WHEN FITTED)

Reducing valve (*see Fig.* 12)

The function of the reducing valve is to maintain a supply of air at the necessary pressure to operate the epicyclic gearbox.

An adjusting screw is provided for setting the valve to obtain the desired air pressure (*for air pressure see Section* P2).

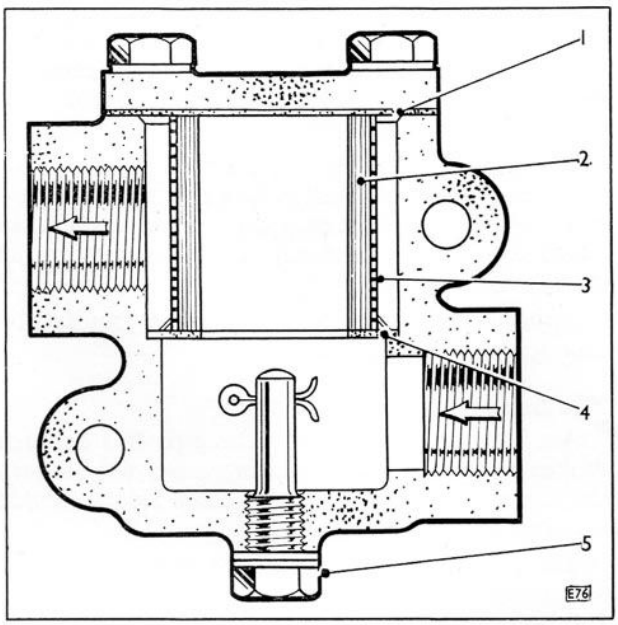

Fig. 11. Pipe line air filter

1. COVER JOINT
2. FELT ELEMENT
3. PERFORATED CYLINDER
4. WASHER
5. DRAIN PLUG

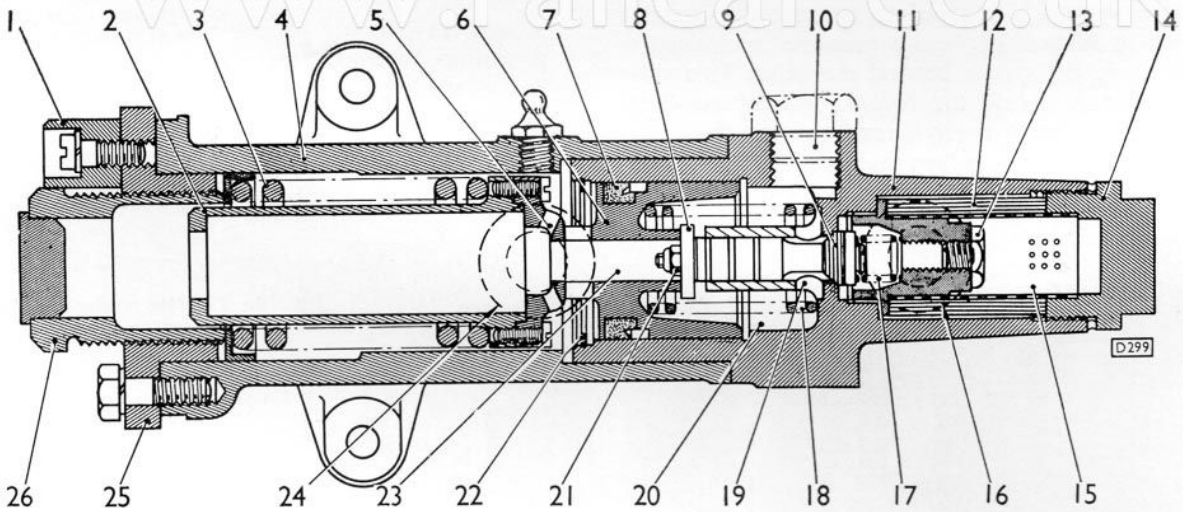

Fig. 12. Sectioned view of air reducing valve

1. LOCKING PIECE
2. CONTROL SPRING GUIDE
3. CONTROL SPRING
4. VALVE BODY
5. AIR HOLE
6. REACTION PISTON
7. SEALING RING
8. DISC TYPE RELEASE VALVE
9. CONICAL INLET VALVE
10. OUTLET PORT TO GEARBOX ELECTRO-PNEUMATIC VALVES
11. VALVE HEAD
12. FELT FILTER
13. RESTRICTOR TO PREVENT SURGE
14. END CAP
15. AIR INLET CHAMBER
16. INLET PORT
17. SPRING FOR INLET VALVE
18. SPRING FOR CONTROL PISTON
19. AIR SPACE UNDER INLET VALVE
20. AIR REACTION CHAMBER
21. NUT FOR DISC VALVE
22. CIRCLIP
23. AIR PASSAGE
24. EXHAUST PORT TO ATMOSPHERE
25. ADJUSTING SCREW CARRIER
26. ADJUSTING SCREW

ELECTRICAL SYSTEM (*see Plate* O 102 *at the end of this Section*)

The driving controls are electro-pneumatic in operation, the air flow being regulated by a number of solenoid operated valves through switchgear housed in the driver's control table.

An engine speed indicator is operated by generators mounted one on each engine and indication of the speed of either engine may be obtained by movement of the indicator switch provided (*see Fig.* 26).

A water level switch causes the engines to be stopped when the water in the header tank reaches a low level.

Facilities for starting or stopping the engines are provided by push buttons mounted on the control panel situated in the driver's cab ; auxiliary start and stop buttons are provided adjacent to each engine.

Also mounted on the control panel are the indicator lights for oil and air pressures and " deadman's " indicator (*see Fig.* 3).

The starter motor and engine speed indicator generator are described in the Engine Chapter.

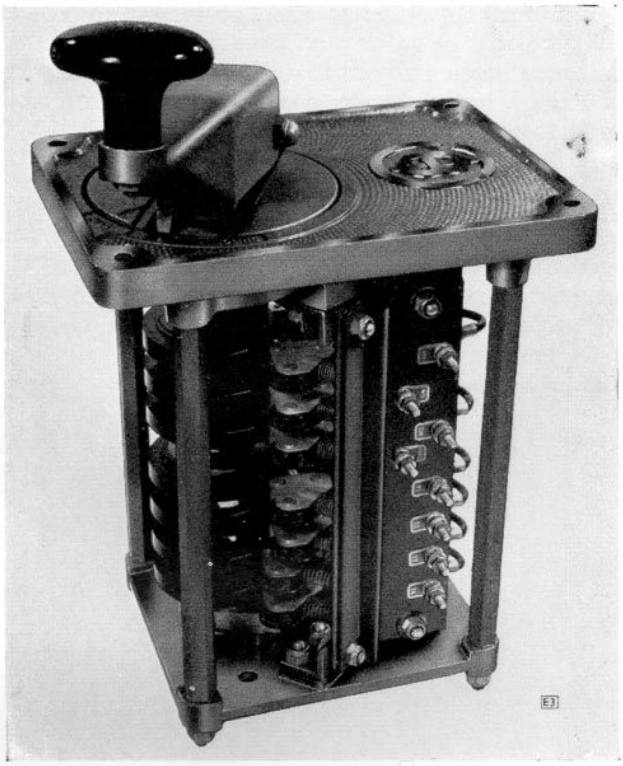

Fig. 14. Throttle controller

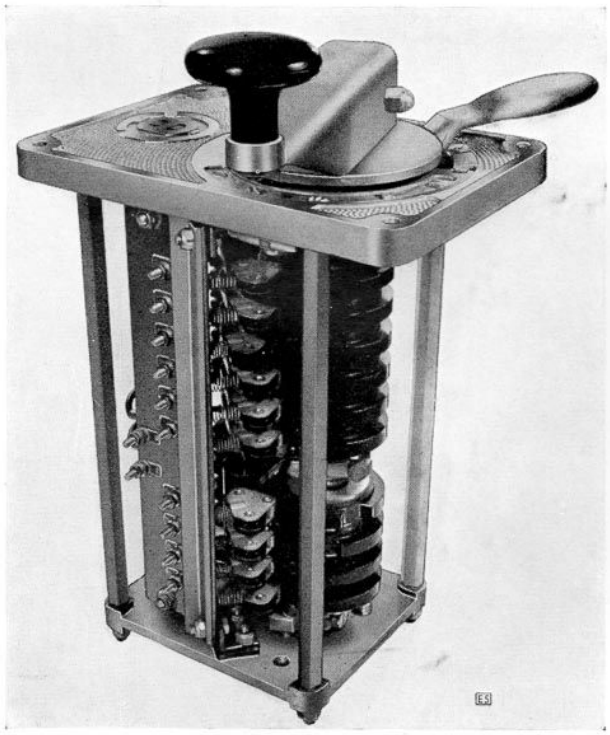

Fig. 13. Gearbox and final drive controller

Engine control relay panel

The engine control box contains three Tonum type relays mounted on an ebony insulated panel and may be readily identified, the specification numbers being stamped on plates attached to each unit.

The relays are mounted horizontally so that the contact faces are in a vertical plane, thereby ensuring that no dust will collect on the faces.

One relay (specification T3633) consists of one pair of normally open main contacts and two pairs of normally open auxiliary arcing contacts which are connected in series.

These are often referred to as the " sparking tips " and are accordingly arranged to " make " a fraction **before** and " break " a fraction **after** the main contacts.

The two other relays (specification T3500) consist of one pair of normally closed main contacts.

E.P. control relay panel (*see Fig.* 17)

The E.P. control relay box contains an insulated panel on which are mounted thirteen Tonum type relays of three different specifications ; the specification is stamped on a plate attached to each unit.

One relay (specification T3500) consists of one pair of normally closed main contacts. This unit is mounted horizontally so that the contact faces are in a vertical plane, thereby ensuring that they do not collect dust.

Two relays (specification T3501) each consist of two pairs of normally open main contacts, in the centre of which is located one pair of normally open auxiliary arcing contacts. These are often referred to as the " sparking tips " and are accordingly arranged to " make " a fraction **before,** and " break " a fraction **after** the main contacts.

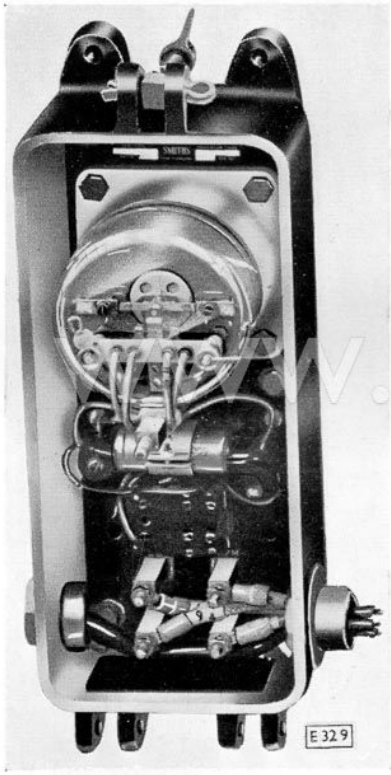

Fig. 15. Starter motor isolating relay

The remaining ten relays (specification T3502) are similar to specification T3501, except that they have only one pair of normally open main contacts and one pair of normally open auxiliary contacts.

Starter motor isolation relay (*see Fig.* 15)

This relay, which is actuated by the engine speed indicator generator, is provided to safeguard the starter motor should an attempt be made to operate it while the engine is running.

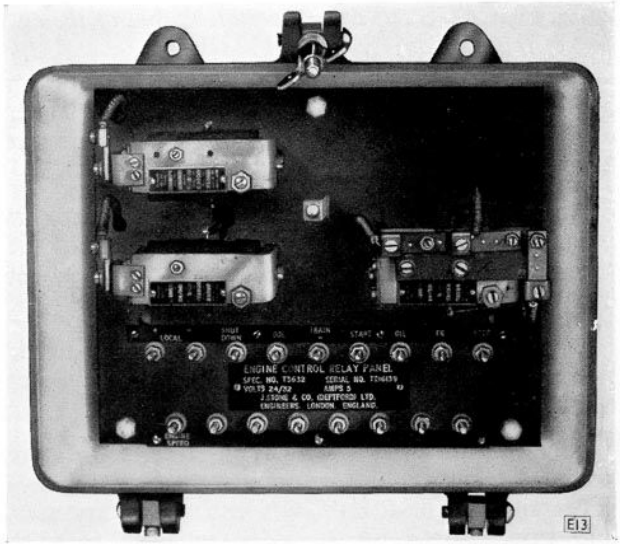

Fig. 16. Engine control relay panel

When the generator reaches a predetermined speed, the relay operates to interrupt the starter motor circuit, thus preventing the starter motor being operated.

To avoid possible errors in the tripping speed, the relay is mounted on the car in a vertical position selected to avoid excessive heat, not exceeding 50 deg. C. (122 deg. F.).

Relay-operated switch panel (*see Fig.* 20)

The purpose of this unit is to isolate the engine lights and the air indicator lights in the trailing driving cabs.

The unit consists of three relays mounted on a bakelite base. The relays are either four or six pole and are brought out to twelve or eighteen terminals below the relays (*see Figs.* 31 *and* 32).

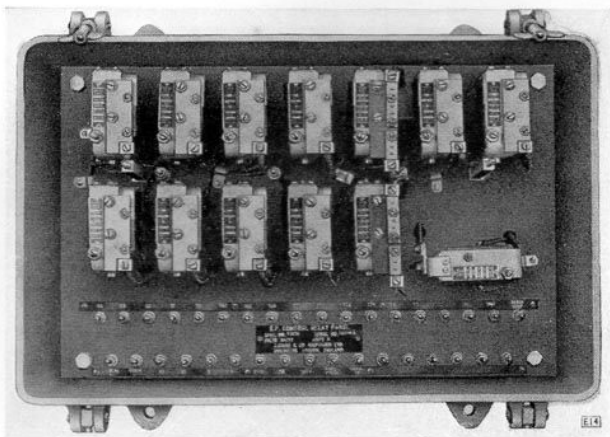

Fig. 17. E.P. control relay panel

Combined throttle controller and "deadman's" control (*see Figs.* 14 *and* 19)

The throttle control lever is connected by linkage to a shaft which carries a number of cams. Each cam closes an electrical contact, when in the appropriate position (depending on the position of the control lever), which in turn operates the solenoid in the corresponding E.P. valve, thus actuating the throttle control motors.

The "deadman's" control valve consists mainly of a solenoid operated control valve, an emergency control valve and a timing chamber. The timing chamber is designed to allow a delay of approximately six seconds before the brakes are applied.

For details of the "deadman's" control valve see Gresham and Craven's handbook "Instructions for Gresham's Quick Release Vacuum Brake Equipment on British Railways Railcars."

Gearbox and final drive controller (*see Figs.* 13 *and* 18)

The gearbox controller is similar in construction to the throttle controller. There are two camshafts, one for the operation of the gears in the epicyclic gearboxes and one to actuate the forward and reverse gears in the final drives. Each cam closes an electrical contact, thereby operating the appropriate E.P. valve, which in turn engages the selected gear.

Only when the forward and reverse lever is in the OFF position, can it be removed from the controller.

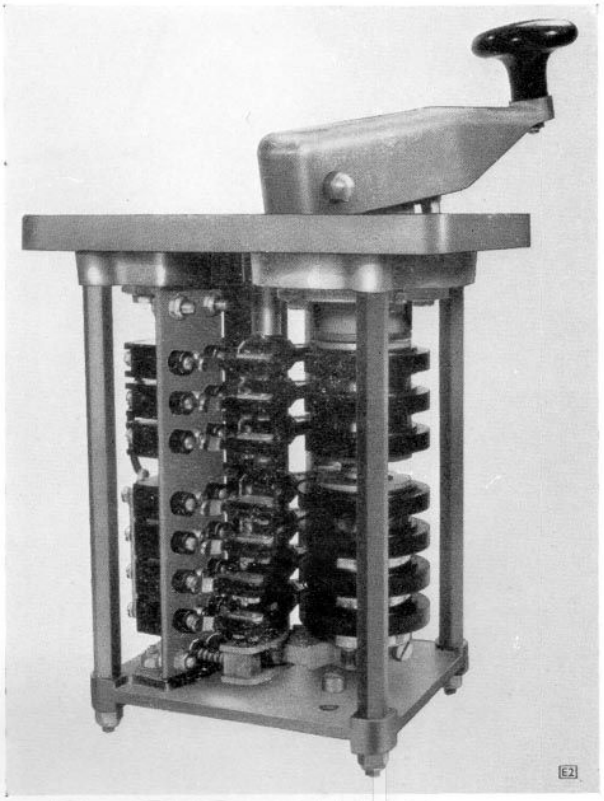

Fig. 19. Throttle controller showing contacts

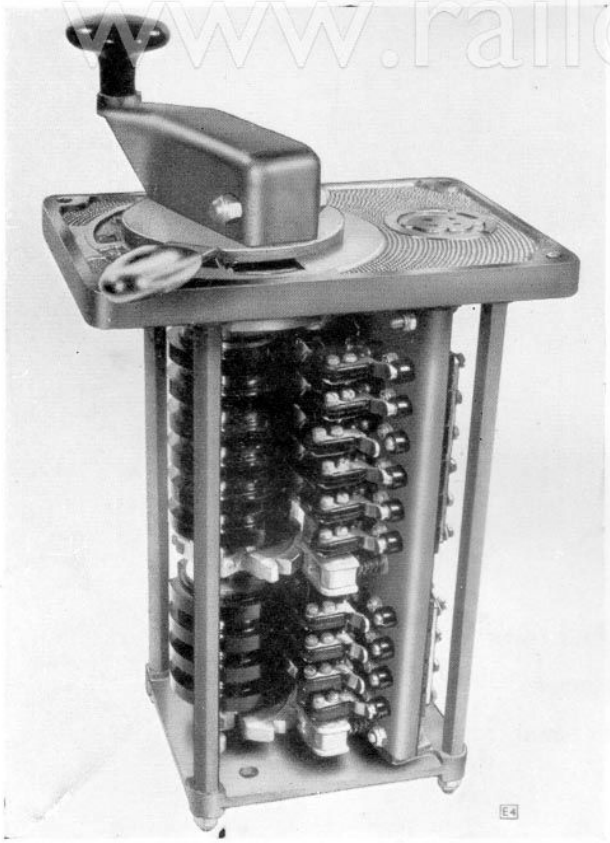

Fig. 18. Gearbox and final drive controllers showing contacts

Electro-pneumatic valves (*see Figs.* 21 *and* 23)

Each car is provided with a number of E.P. valves; these control the supply of compressed air to the actuating mechanism for gear selection and engagement, the engine throttle control motors and the engagement of forward or reverse gears in the final drive units.

These valves are of the "ON" type and will pass air when the solenoid is energised.

A push button is provided on the underside of the valve to enable the valve to be tested by hand.

Each E.P. valve embodies a needle valve which opens a short passage connecting an air feed pipe to a delivery pipe which leads to the actuating mechanism concerned. The needle valve is operated

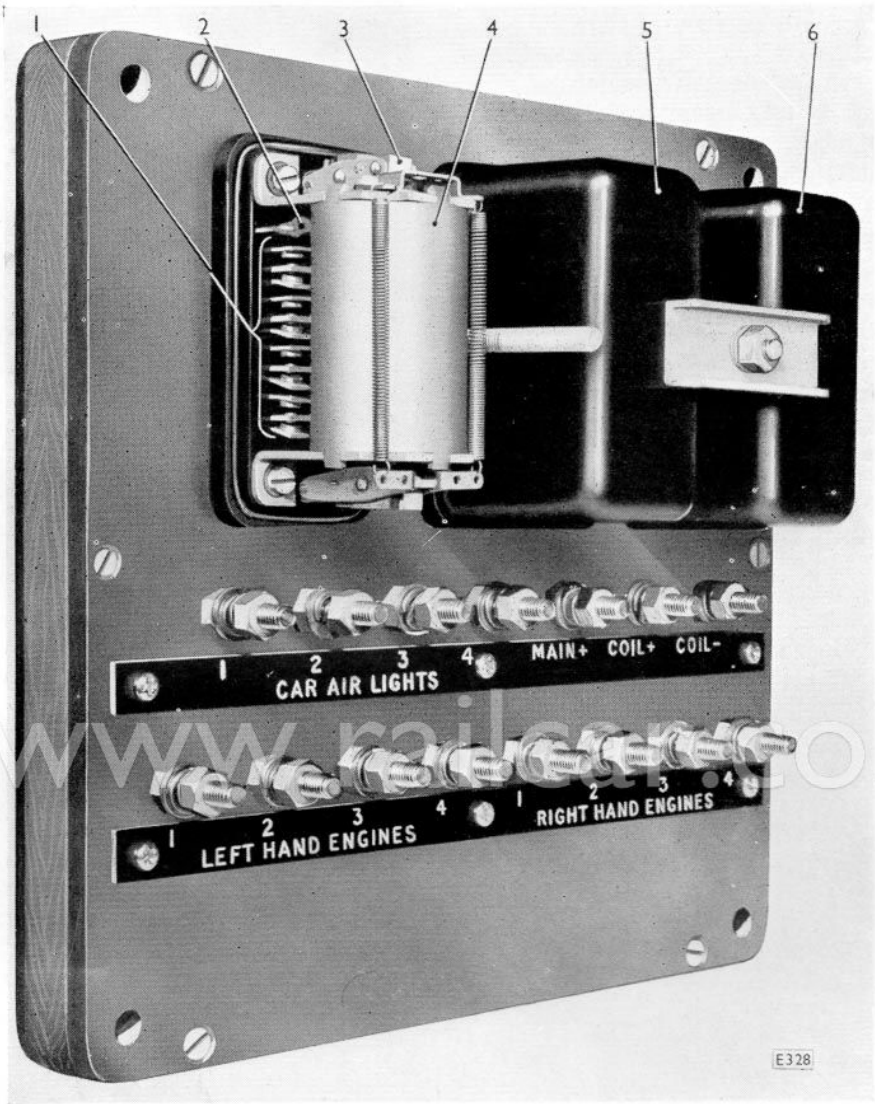

Fig. 20. Relay-operated switch panel (12-way)

1. CONTACTS
2. COIL CONNECTIONS
3. PLUNGER MECHANISM
4. RELAY FOR CAR AIR LIGHTS (WITH COVER REMOVED)
5. RELAY FOR LEFT-HAND ENGINE LIGHTS
6. RELAY FOR RIGHT-HAND ENGINE LIGHTS

by a loosely fitting plunger inside the core of a solenoid whenever the latter is energised, and works against the pressure in the air line in addition to that exerted by a small coil spring. The design of the connecting passage and the plunger top is such that any air leaking past the valve is discharged to atmosphere.

Air pressure switches (*see Fig.* 22)

The air pressure switch indicates electrically, by means of a light on the driver's control panel that a minimum safe air pressure is available.

The indicator light will not be switched on until the final drive is properly engaged and the correct air pressure is obtained (*for air pressures see Section* P2).

The switch is a totally enclosed unit with a small trigger, which is integral with the switch, projecting from one side of the casing. This trigger can be operated manually, if required, to test the circuit between the switch and lights.

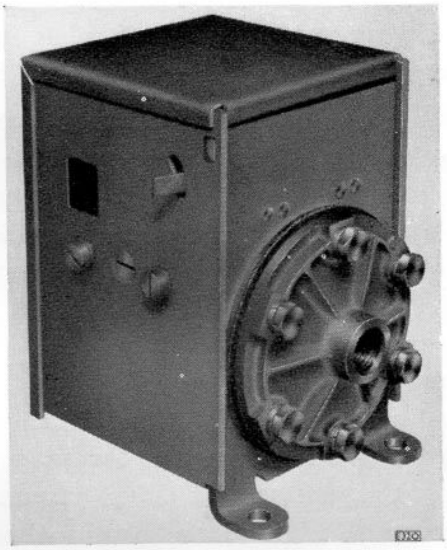

Fig. 22. Air pressure switch

Water level switch

The water level switch is mounted on the header tank and is attached to a float ; when the water in the tank reaches a low level, this float magnetically operates the switch, thereby actuating the engine shut-down solenoid and stopping the engine.

Incorporated in the float assembly is a permanent magnet which is opposed by a similar magnet in the switch assembly.

The adjacent poles of the two magnets repel one another, and by this method the switch contacts are made to change over with a snap action.

Engine shut-down solenoid (*see Fig.* 30)

The shut-down solenoid is mounted on a bracket attached to the fuel-injection pump, and when energised cuts off the supply of fuel to the engine.

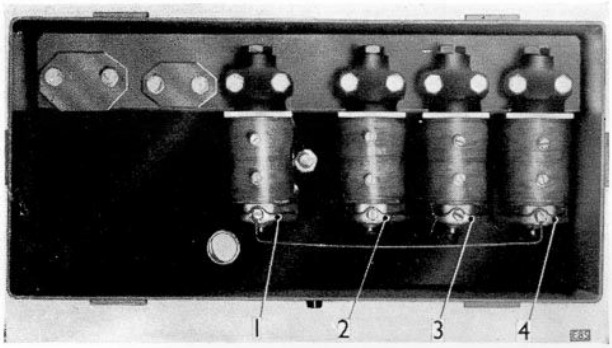

Fig. 21. Electro-pneumatic valves for gearbox

1. FIRST SPEED GEARBOX E.P. VALVE
2. SECOND SPEED GEARBOX E.P. VALVE
3. THIRD SPEED GEARBOX E.P. VALVE
4. FOURTH SPEED GEARBOX E.P. VALVE

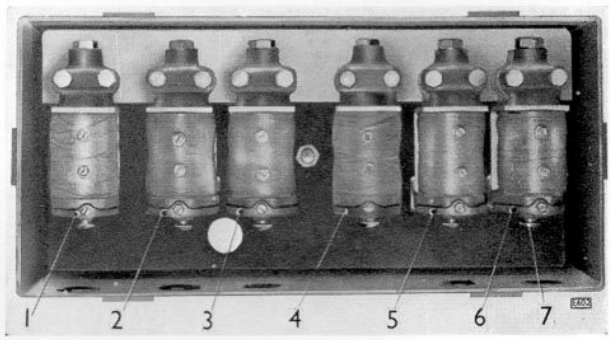

Fig. 23. Electro-pneumatic valves for engine and final drive

1. THROTTLE MOTOR E.P. VALVE — NO. 1
2. THROTTLE MOTOR E.P. VALVE — NO. 2
3. THROTTLE MOTOR E.P. VALVE — NO. 3
4. THROTTLE MOTOR E.P. VALVE—No. 4
5. FINAL DRIVE E.P. VALVE — FORWARD SPEED.
6. FINAL DRIVE E.P. VALVE — REVERSE SPEED
7. HAND-TESTING BUTTON

This unit is continuously rated and consists of a " pull-in " coil and a " hold-in " coil in which a solenoid core is free to move.

On energising the " pull-in " coil the solenoid core rises against the actuating plunger and breaks the moving contact. This action brings into circuit the " hold-in " coil, which has a low current consumption and is designed to hold the solenoid in the stop position.

Oil pressure switch

A double pole switch in the form of two standard single pole units is mounted on the engine casing extension. One pole operates the oil pressure warning lights on the driver's control panel and the other, in the event of low oil pressure, operates the engine shut-down solenoid.

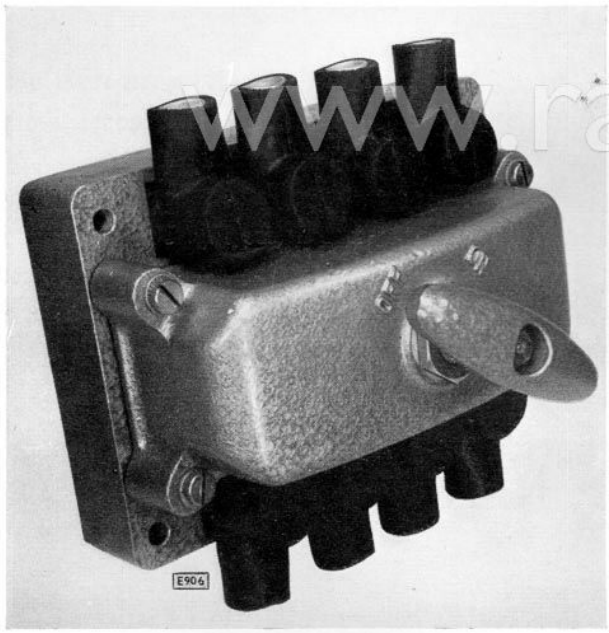

Fig. 24. Dual battery isolating switch.

Each switch consists of a diaphragm and electrical contacts enclosed in a sealed casing.

Oil pressure on the diaphragm causes the contacts to close, thus completing the electrical circuit to the indicator lights or the engine shut-down solenoid (*for oil pressure see Section* P2).

Fig. 25. Engine local control box

Dual Battery isolating switch (*see Fig.* 24)

The dual battery isolating switch is located on the underframe and is a heavy duty switch designed to take the high loading imposed by twin starters fitted to the engine.

It is a four-pole switch, that when open, isolates the battery from the remainder of the electrical equipment of the car.

Note.—This is not a circuit-breaker, therefore all other switches on the car should be opened before it is operated.

The switch requires no adjustment apart from the occasional inspection to see that all connections are secure.

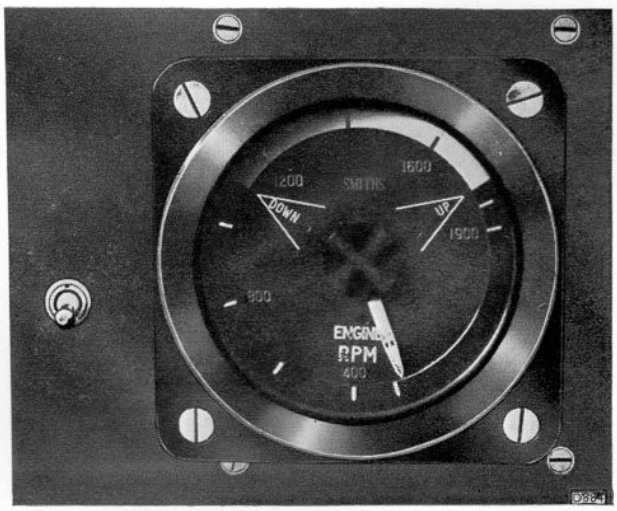

Fig. 26. Engine speed indicator and switch

Engine isolating switch (*see Fig.* 28)

This switch is of the tumbler type and is operated by a standard railway carriage key when for any reason it becomes necessary to isolate an engine.

Each engine is provided with a switch, which is waterproofed and requires no maintenance.

Direction switch (*see Fig.* 38)

A direction switch is mounted on each final drive casing.

This unit is a single pole change over switch operated by actuation of the striking lever in the final drive unit.

It indicates electrically, by means of a light on the driver's control panel, whether the final drive is properly engaged (*see also " Air pressure switches" in this Section*).

Engine local control box (*see Fig.* 25)

This unit is provided to facilitate starting or stopping the engine or engines from the side of the car.

It has two push button switches for starting and two for stopping the engines, and also an emergency lighting socket.

One control box is mounted adjacent to each engine.

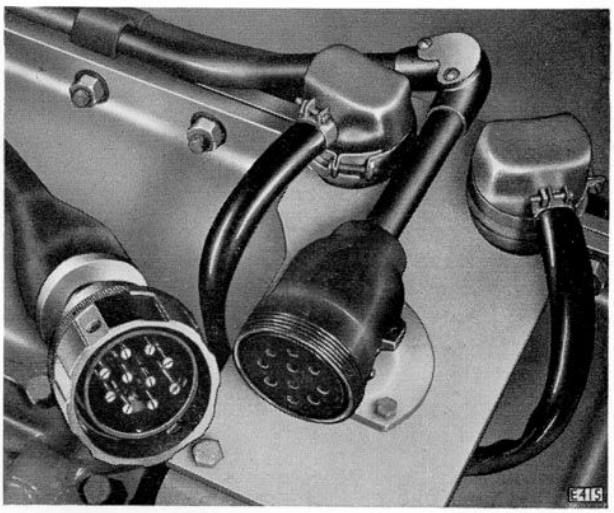

Fig. 27. Engine plug and socket

Engine plug and socket (*see Fig.* 27)

Certain engines are fitted with a plug and socket, designed to provide a common connection for the cables to the oil pressure switches, engine speed indicator generator and the engine shut-down solenoid. This obviates the necessity of disconnecting cables at three points when removing an engine from a car.

The cable is carried in steel conduit which is secured to the engine by brackets and clips.

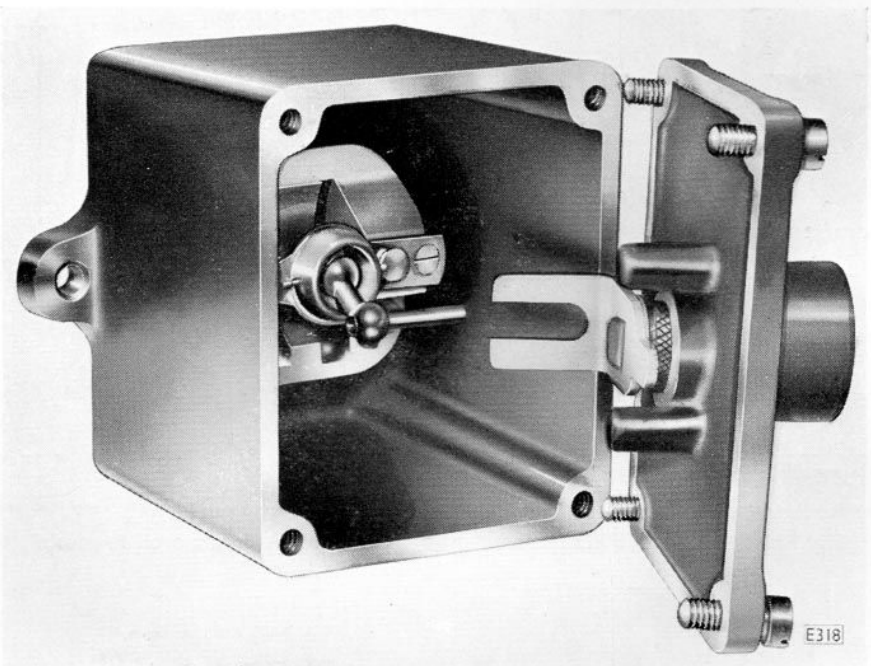

Fig. 28. Engine isolating switch

VACUUM SYSTEM

Exhausters (*see Figs.* 29 *and* 35)

The two exhausters are of the rotary sliding vane type, and contain within the body, a rotor, heavy duty bearings, and spring-loaded sealing plates. The rotor carries six blades and rotates about an axis which is eccentric to the body. The volume of space between the blades, rotor and body thus increases and decreases as rotation occurs so that air is drawn in at low pressure and expelled at a higher (atmospheric) pressure.

The body ends are sealed by plates, loaded axially by means of six small springs housed in pockets in the end covers. The sealing plates are located in recesses in the end covers and a peg riveted to the plate fits into one of the spring pockets to prevent the sealing plates turning with the rotor.

To maintain efficiency at all speeds cam rings are fitted at each end of the rotor, which contact the inside edges of the blades and force them to move out radially in their grooves to maintain contact with the bore of the body. The cam rings are a " push " fit in the sealing plates.

The rotor shaft is mounted on a roller bearing at the drive end and a ball bearing at the rear end; these are located in the end covers. The roller bearing takes the drive loading and is held in position by a hardened steel collar. The direction of rotation is **anti-clockwise** looking at the driven end.

During operation, the pressure inside the exhauster is below atmospheric, since the mean pressure of the working spaces is below atmospheric. Alternatively, on starting with the vacuum system at atmospheric pressure, the exhaust pressure is above atmospheric and for a few seconds, until a sufficient vacuum is generated, there is a tendency to blow out oil at the shaft end. For this reason a double seal is fitted, which bears on the hardened shaft collar.

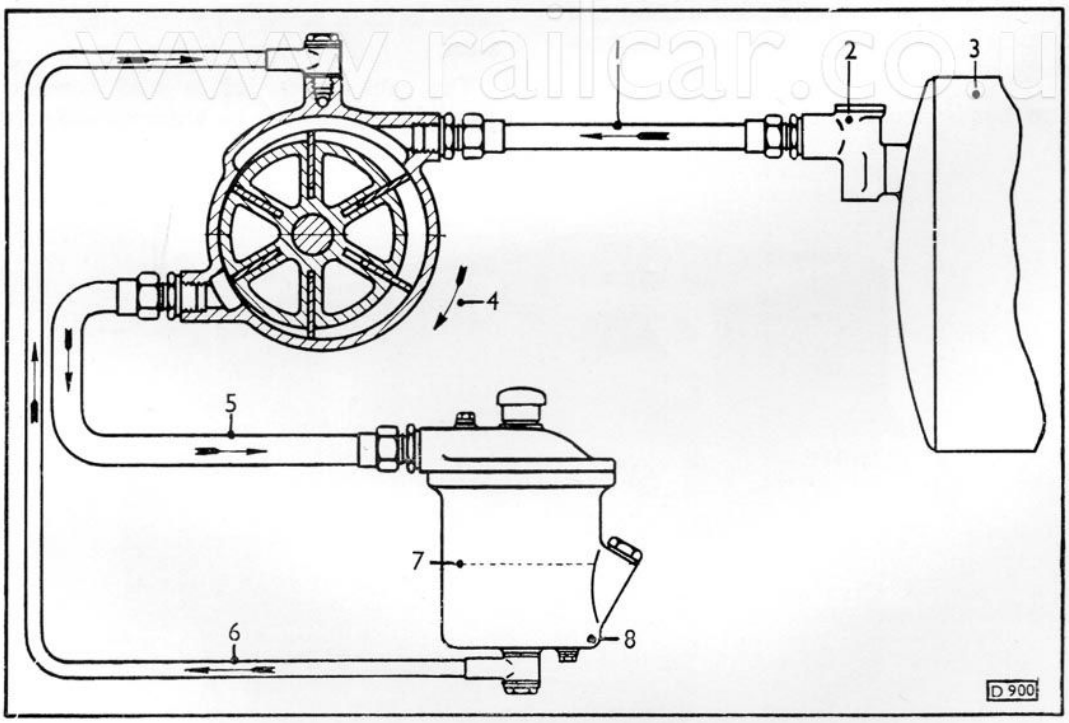

Fig. 29. Diagrammatic illustration showing lubrication by separate oil reservoir

1. SUCTION
2. NON-RETURN VALVE
3. VACUUM RESERVOIR
4. ROTATION OF EXHAUSTER ROTOR
5. OIL AND AIR RETURN
6. DIRECTION OF OIL FLOW
7. OIL LEVEL
8. OIL RESERVOIR

Exhauster oil reservoir (*see Fig.* 36)

The exhauster oil reservoir provides lubrication for the exhausters, in an enclosed system.

By the action of the exhauster rotor blades, oil is drawn through the reservoir bottom filter into the exhauster. It is then ejected through a port in the base of the exhauster and returned to the reservoir through the inlet port.

The oil passes into the ports in the top plate and through the top filter in the strainer, thus completing the circulation.

Oil from the exhauster is combined with air, drawn from the brake system ; a breather is provided to allow this air to escape, the oil being retained in the reservoir. Oil leakage through the breather is prevented by a baffle plate.

A drain plug is fitted to facilitate cleaning.

The reservoir requires no maintenance other than topping-up the oil level (*see Section* P4).

Section P2 CONTROLS—DATA

Reservoir (first)		
Capacity.	1,414 cu. in.	23·2 litres.
Unloader valve—Cut-out pressure.	95 lb. per sq. in. (approximately)	6·7 Kg. per sq. cm.
Cut-in pressure.	75 to 80 lb. per sq. in.	5·3 to 5·6 Kg. per sq. cm.
Safety valve—Blow off pressure.	Set to blow-off between 98 to 100 lbs. per sq. in.	6·9 to 7 Kg. per sq. cm.
Reservoir (second).		
Capacity.	3,600 cu. in.	59·0 litres.
Diverter valve—Cut-in pressure.	47·5 to 52·5 lb. per sq. in.	3·33 to 4·03 Kg. per sq. cm.
Reservoir (third).		
Capacity.	3,600 cu. in.	59·0 litres.
Air reducing valve pressure.	62·5 to 67·5 lb. per sq. in.	4·4 to 4·7 Kg. per sq. cm.
Air pressure gauge maximum pressure.	85 lb. per sq. in.	6·0 Kg. per sq. cm.
Air pressure switch—Cut-out pressure.	60 lb. per sq. in.	4·9 Kg. per sq. cm.
Cut-in pressure.	75 lb. per sq. in.	5·3 Kg. per sq. cm.
Anti-freezer capacity.	3 pints.	1·7 litres.
Exhauster oil reservoir capacity.	10 pints.	5·67 litres.
Engine control relay panel.	Specification No. T3632.	All relays to energise at 7·4 volts cold.
E.P. control relay panel.	Specification No. T3631.	Shunt coil resistance, 101·5 ohms, ±5%, at 20 deg. Centigrade, 24/30v.

NOTES

Section P3 CONTROLS—MAINTENANCE

AIR PRESSURE SYSTEM

The following points require attention at periods quoted in Railway Standing Instructions.

1	Drain the moisture from the reservoirs (*see instructions in the following paragraphs*).
2	Check the level of methyl alcohol in the containers of the anti-freezers (*see instructions in the following paragraphs.*)
3	Clean or if necessary renew the felt element in the combined air filter and anti-freezers (*see instructions in the following paragraphs*).
4	Check all air pipe unions for leakage and tighten if necessary (*see "To check for air leaks"*).
5	Check the unloader valve, safety valve and throttle control motors for air leakage (*see instructions in the following paragraphs and "To check for air leaks"*).
6	Lubricate the throttle motor air cylinders and the air reducing valve (*see Section* P4).
7	Clean or if necessary renew the felt filter element in the air reducing valve (*see instructions in the following paragraphs*).
8	Clean the felt filter element in the pipe line air filters (*see instructions in the following paragraphs*).

Air filter and anti-freezer (*see Fig.* 4)

Air filter

The felt element of the air filter must be kept clean and free from obstruction or a slow pressure build-up in the air reservoir will be experienced and undue wear of the compressor will occur.

At intervals quoted in the chart at the beginning of this Section clean the felt element as follows :—

Remove the nut from the end of the filter cover and draw off the cover. Slide the felt element off its gauze, wash it thoroughly in paraffin, allow it to drain and then refit. A new felt element should be fitted when the compressor becomes due for overhaul.

Anti-freezer

In cold weather the reservoir of the anti-freezer should be filled to the level of the filler plug hole with Methyl Alcohol.

Note.—Methyl Alcohol is toxic in both the liquid and vapour state and has a very low flash point. The following precautions should, therefore, be observed :—

Do not fill the anti-freezer in an enclosed space, unless a good and free circulation of air is available.

The use of naked lights and smoking must be strictly forbidden.

All alcohol contains a small percentage of water which does not evaporate as quickly as the alcohol, and therefore as the alcohol is consumed the percentage of water increases, and this decreases the efficiency of the anti-freezer. To prevent the water content reaching too high a value it is, therefore, advisable to run the anti-freezer until it requires refilling and drain away the residual alcohol and water by removing the drain plug, rather than to keep topping-up the anti-freezer with fresh Methyl Alcohol.

Ensure that the two drillings between the venturi tube and the reservoir are clear.

Air reservoirs (*see Fig.* 5)

Empty and drain the air reservoirs as follows: —

Slowly open the drain plugs or cocks while the reservoirs are still under pressure in order to blow out any condensate or oil that may have collected.

On no account unscrew a drain plug or cock more than two or three turns unless the reservoir has been exhausted of air.

Routine draining of the reservoirs is most important during frosty weather, as neglect of this precaution may result in the collected condensate freezing and preventing correct operation of the valves.

Unloader valve (*see Fig.* 7)

Check, by observing the air pressure gauge in the driver's cab, that the compressor cuts in and out at the correct pressures, and if necessary, adjust as follows :—

The unloader cut-out pressure is adjusted to the figure given in Section P2 by slackening the locknut and turning the adjusting thimble **clockwise** to **increase** and **anti-clockwise** to **decrease** the pressure. When increasing the pressure it is desirable to screw down the thimble just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. Tighten the locknut and recheck the setting.

There is no adjustment for the cut-in pressure, and if this is low, it should be reported.

With the compressor charging, check at the exhaust port for piston valve leakage, and with the compressor at rest, check for valve leakage ; if leakage is detected it should be reported (*see " To check for air leakage " at the end of this Section*).

The inlet filter should be cleaned by unscrewing its cap and washing the element in paraffin.

Safety valve (*see Fig.* 6)

Check the safety valve and if leakage is detected it should be reported (*see " To check for air leakage " at the end of this Section*).

Non-return valve (*see Fig.* 8)

The non-return valve requires no maintenance ; if it should fail it should be removed for overhaul and a new or reconditioned valve fitted.

Diverter valve (*see Fig.* 9)

The diverter valve should not be interfered with ; if it should fail in service, the matter should be reported immediately.

Air reducing valve (*see Fig.* 12)

At intervals quoted in the chart at the beginning of this Section clean the filter as follows (*see under " Air reservoirs "*).

Release the pressure in the system (*see under " Air reservoirs "*). Remove the end cap and withdraw the felt element. Temporarily refit the plug to prevent entry of dirt.

Wash the element in clean paraffin and allow it to drain ; then refit.

Throttle control motors (*see Figs.* 10 *and* 33)

The construction of the throttle control motors is such that very little maintenance is required.

Check all joints for oil leakage and pipe unions for air leakage (*see " To check for air leakage " at the end of this Section*).

Lubricate the air cylinders (*see Section* P4)

Pipe line air filters (*see Fig.* 11)

Remove and clean the felt element and the perforated cylinder in the pipe line filters as follows: —

Drain the air system *(see " Air reservoirs " in this Section).*

Unscrew the filter drain plug to drain off any condensate ; the drain plug cannot be removed from the body as it is retained by a split pin on the inside.

Unscrew the top cover bolts, remove the cover and withdraw the filter assembly.

Wash all parts in clean paraffin and assemble the filter reversing the procedure for dismantling.

If either the felt element or the perforated cylinder is damaged it should be renewed.

Fit the assembly into its body and fit the joint and top cover.

Screw in the drain plug.

To check for air leakage

To check joints suspected of leakage, apply a solution of soap and water ; leakage may then be detected by the appearance of bubbles.

ELECTRICAL SYSTEM

The following points require attention at periods quoted in Railway Standing Instructions.

1	Check all electrical connections for security.
2	Check manually the engine shut-down solenoid for correct operation (*see instructions in the following paragraphs*).
3	Inspect the electro-pneumatic valves *(see instructions in the following paragraphs*).
4	Inspect and if necessary adjust the air pressure switch *(see instructions in the following paragraphs*).
5	Clean the contacts in the following:—throttle controller, gearbox and final drive controller, water level switch, air pressure switches, engine shut-down solenoid switches, engine and E.P. control relays (*see instructions in the following paragraphs*).

Note.—Before attempting to clean the contacts or carry out any adjustments to the engine control or E.P. control relays, isolate the batteries by means of the battery isolating switch.

Engine and E.P control relays (*see Figs.* 16 *and* 17)

Carefully clean the relay contacts with a clean rag moistened with petrol.

Apart from this, no further maintenance is required. If however, the contacts are found to be burnt or pitted, they should be renewed and adjusted.

Starter motor isolation relay (*see Fig.* 15)

Apart from the following tests no maintenance is required.

Start the engine and check that the relay contacts close below engine idling speed.

When the engine is warm stop the engine, then restart it without exceeding idling speed and note whether the relay operates.

It is possible to check if the contacts " make " by observing whether the secondary relay moves.

Before attempting to test the wiring insulation, all equipment should be disconnected, unless a low output tester such as a D.C. " Megger " is used.

Check the insulation between the cable conductors and to earth at 500 volts D.C. when the insulation resistance must not be less than 20 Megohms.

It is advisable to mark the terminals in the junction boxes and jumper connections, to distinguish the measuring circuit from the control circuit. This avoids damage to the equipment by routine insulation tests using high power testers. The maximum loop resistance between the generator and the relay must not exceed 3 ohms.

To maintain accuracy, the correct number of instruments and only instruments having the correct codes, must be connected to the relay. If two instruments are specified, they must be connected in parallel.

Electro-pneumatic valves (*see Figs.* 21 *and* 23)

When it becomes necessary, each valve should be removed from the car and serviced as follows :—

Dismantle and wash all parts in paraffin.

Inspect the conical portions of the needle valve and plunger and the corresponding valve seats for signs of wear. If wear is apparent, either " lap in " the existing valve and seat, using a fine grinding paste, or renew the parts.

Inspect the rubber or cork composition washer at the base of the coil and renew if necessary.

Re-assemble and apply a fresh coating of shellac to the coil.

Refit the valve to the car with a new gasket between the valve and its mounting plate to make the joint airtight.

Test for air leaks, and " earthing " of the electrical wiring.

Engine shut-down solenoid (*see Fig.* 30)

Check the mounting bolts on both the solenoid and the bracket and tighten if necessary.

The solenoid should stop the engine from full speed running; check this, and when the engine has stopped,

remove the terminal cover from the solenoid and ensure that there is a minimum air gap of 0·039 in. 1·0 mm.) between the fixed and moving contacts.

If necessary adjust the fork-end to obtain this gap by removing the clevis pin and energising the solenoid to the stop position.

Lift the lever to the "stop'' position, slacken the locknut, and adjust the fork until the lower portion of the lever shows 0·039 in. (1·0 mm.) above the eye of the fork.

Lower the lever to bring the holes into line and refit the clevis and split pin, finally tighten the locknut.

Retest the stop solenoid by ensuring that the engine is shut-down at **full throttle.**

Refit the terminal cover.

Examine the rubber bellows for damage or deterioration, and renew if necessary.

Clean the contacts by wiping them with a rag moistened with petrol.

Gearbox and throttle controllers (*see Figs.* 13 *and* 14)

Clean the contacts by wiping them with a clean rag moistened with petrol. Apart from this the controllers require no maintenance.

At overhaul periods lightly smear all working parts with lubricant.

Relay-operated switch panel (*see Fig.* 20)

The diagrams in Figures 31 and 32 indicate which relay operates each group of indicator lights, and also shows which contact makes the circuit to each terminal.

The 12-way relay panel is provided with a pair of contacts for each circuit, whilst the 18-way panel has a common connector as shown schematically in Figure 31, therefore a faulty contact on this panel will cause all lights in this group to fail.

Should any of the lights fail to indicate, check that the lamps are in order, then test as follows :—

(a) Using either a test lamp or a voltmeter, check that the car voltage appears across the relay terminals marked " Coil + " and " Coil − ".

(b) Apply a minimum of 18 volts between the terminals marked " Coil + " and " Coil − ", then by alternately switching the voltage on and off the relays should operate.

(c) With the relays switched on, and using a test lamp or voltmeter in turn between the terminal marked " Coil − " and each lamp circuit terminal, the test lamp should light or the voltmeter give the same reading as between " Coil + " and " Coil − ".

Should the above tests disclose a failure in any complete group of lights, a visual check should be made to see whether the solenoid plunger operates as the car voltage is applied. If the plunger fails to operate the relay panel should be renewed.

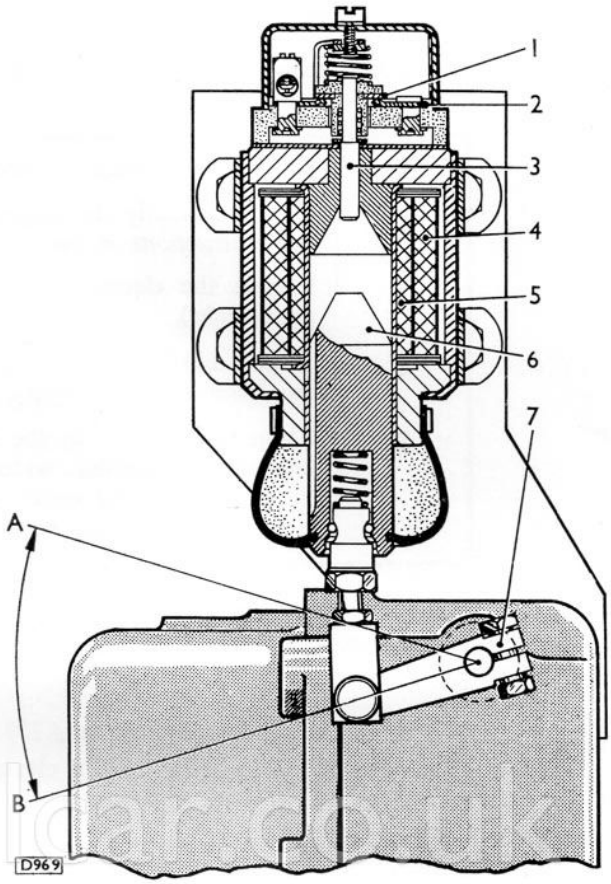

Fig. 30. Section through a typical engine stop solenoid

A. STOP POSITION
B. RUN POSITION

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

It is possible for a relay which appears to operate correctly, to have defective contacts, in this case the contacts should be cleaned with very fine glass paper and afterwards wiped with a clean rag moistened with petrol.

If cleaning the contacts does not rectify the fault, the relay panel should be renewed.

Battery isolating switch (*see Fig.* 24)

This requires no adjustment apart from occasional inspection to see that all connections are secure.

Air pressure switches (*see Fig.* 22)

To adjust the air pressure, unscrew the retaining set-screw situated at the rear of the unit below the type number plate, and remove the cover from the switch.

Slacken the locknuts, rotate the spring retaining screw in a **clockwise** direction to increase the cut-in pressure and vice versa.

To clean the contacts wipe them with a clean rag moistened with petrol ; fit the cover.

Examine the rubber joint at the air inlet for deterioration and renew if necessary.

Water level switch

Remove the terminal cover by unscrewing its retaining set-screws. Disconnect the leads from the terminals and remove the earthing screw and circlip.

Remove the switch assembly from the body and clean each of the contacts by wiping them with a clean rag moistened in petrol.

Refit the parts in the reverse order to their removal.

Direction switch (*see Fig.* 38)

Check that the direction switches are operating correctly and if necessary, adjustment should be made following the instructions given in Section P13.

To clean the contacts wipe them with a clean rag moistened with petrol.

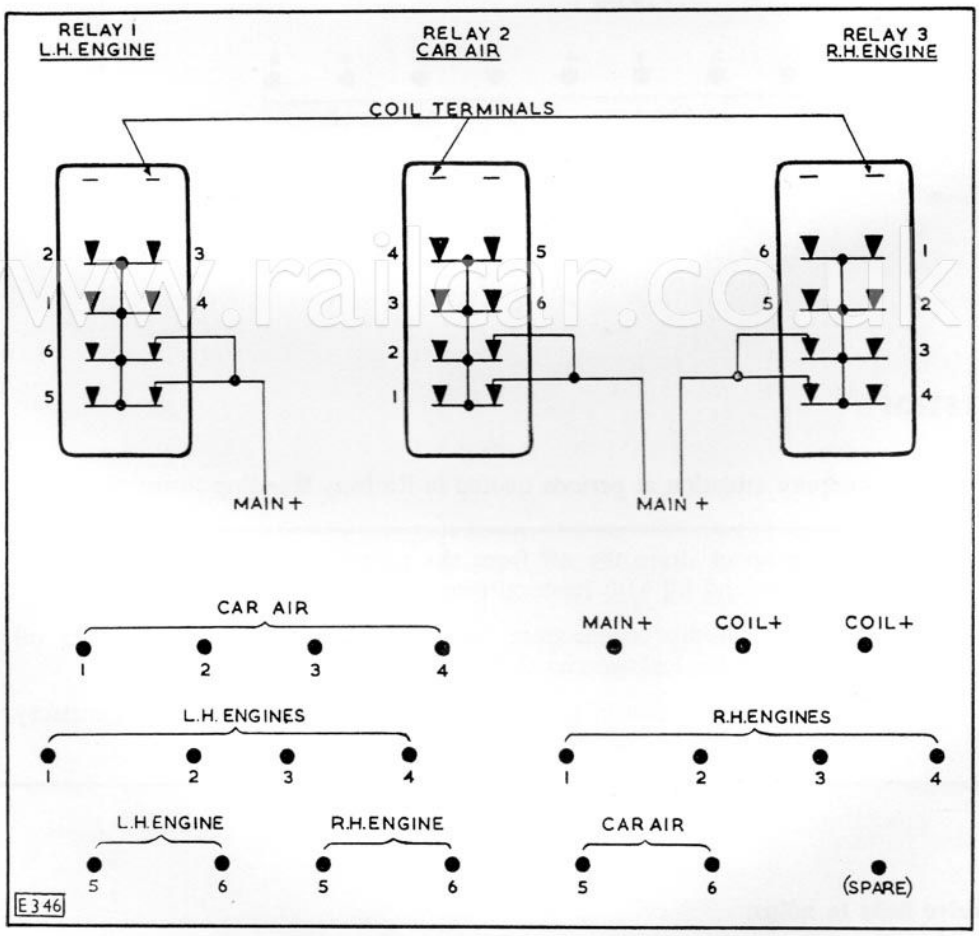

Fig. 31. Diagram of 18-way relay operated switch panel

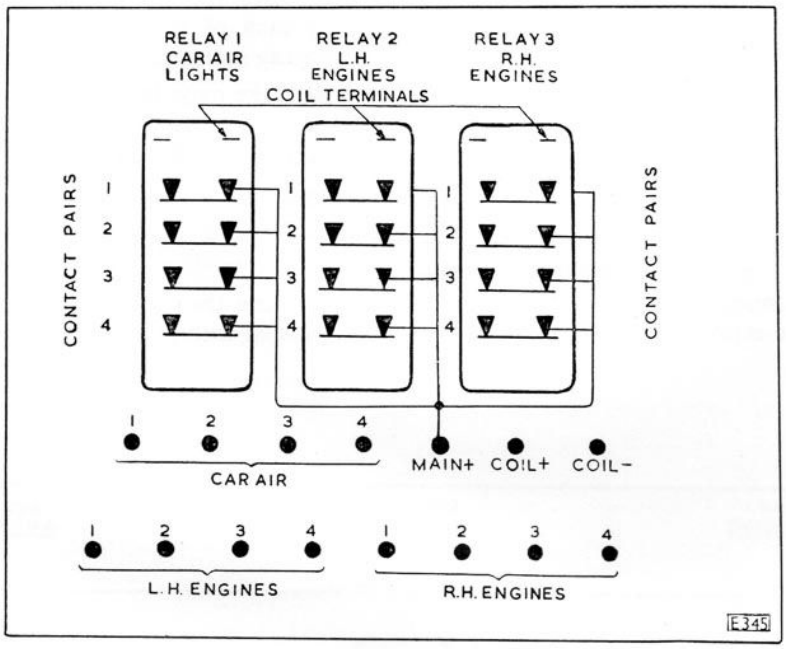

Fig. 32. Diagram of 12-way relay operated switch panel

VACUUM SYSTEM

The following points require attention at periods quoted in Railway Standing Instructions.

1	Top-up or drain the oil from the exhauster oil reservoir, clean the filters and fill with fresh oil (*see Section* P4).
2	Check all pipe connections on the exhauster and the exhauster oil reservoir for leakage and tighten if necessary.
3	Check the tension of the exhauster drive belts and adjust if necessary (*see instructions in the following paragraphs*).

Exhausters—drive belts to adjust

The exhausters are pivoted on brackets fitted to the underframe.

To adjust the drive belt tension, slacken the locknut at the exhauster end of the adjusting rod and turn the rod by means of the welded hexagon nut.

Turn the rod **clockwise** to tighten the belts and vice versa.

When correctly adjusted, there should be from 1½in. to 2in. (38 mm. to 51 mm.) vertical movement at the centre of the belts.

Alignment of the belts should be checked by placing a straight edge across the face of the pulleys; adjustment can be made at the exhauster pivot.

Section P4 CONTROLS—LUBRICATION

This Section should be read in conjunction with the Lubrication Chart

Item	Attention required
Air Reducing Valve	Lubricate through the nipple provided (*see below.*)
Exhauster Oil Reservoir	Lubricate through the filler tube (*see below.*)
Throttle Control Motor	Lubricate through the nipples provided (*see below.*)

Air reducing valve (*see Fig.* 12)

Lubricate the reducing valve piston with an oil gun, through the lubricator provided.

Exhauster oil reservoir (*see Fig.* 36)

Drain the exhauster reservoir and fill with fresh oil as follows :—

Place a suitable container in position, remove the drain plug and drain the oil from the reservoir.

Refit and tighten the drain plug.

Fill the reservoir to the level of the filler cap hole.

Note.—After the running of an exhauster a drop in the oil level will occur. This is of no consequence and is due to the hollow rotor in the exhauster absorbing an amount of oil equivalent to the amount indicated by the drop in the level.

Throttle control motors (*See Fig.* 33)

Lubricate the pistons with an oil gun, through the lubricators provided.

Note.—It is essential that the throttle motors are not over-lubricated.

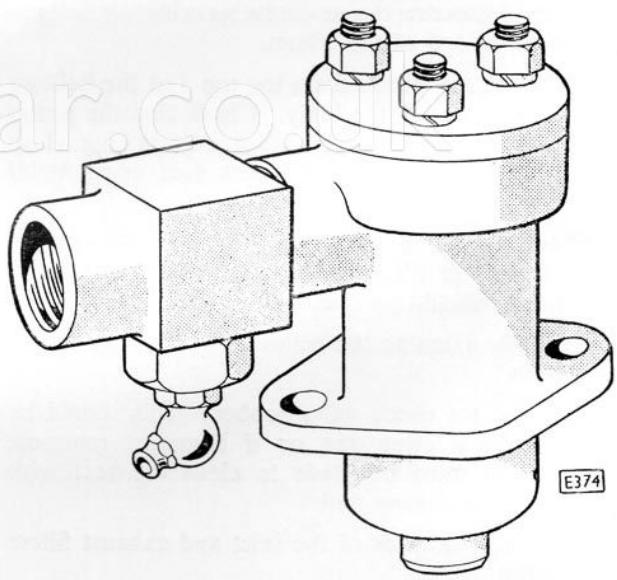

Fig. 33. Throttle control motor piston and cylinder assembly showing lubricator

Section P5 UNLOADER AND SAFETY VALVES —TO OVERHAUL, TEST AND ADJUST

(See Figs. 6 and 7)

Air units must only be dismantled and assembled by a competent mechanic and the work done on a clean bench in a dry and dust free atmosphere.

Scrupulous attention to cleanliness will avoid undue wear and unreliable operation due to the entry of dirt.

To Overhaul

Unloader valve

Remove the unloader valve from the reservoir.

The valve is dismantled by removing the screwed caps retaining the filter and the check valve. Unseal and remove the top cover containing the piston spring adjuster ; care is necessary during this operation as the spring is under compression. Take out the piston spring.

Remove the cover below the bellows.

Hold the piston from rotating by means of the two slots at the top and use a $\frac{1}{8}$ in. Whitworth box spanner to unscrew the set-screw securing the bellows to the lower end of the piston.

Draw out the piston from the top and the bellows from the bottom of the body. Check that the piston works smoothly in its bore without any sticking. Lap the piston valve lightly on to its seat using metal polish.

Check the piston spring and the check valve spring. If any signs of distortion or corrosion are present, the springs should be renewed.

Carefully examine the bellows for deterioration or distortion.

Examine the check valve rubber. This should be wiped with a clean rag or if damaged renewed. No attempt must be made to clean the seat with abrasive or a cutting tool.

Wash the felt pads of the inlet and exhaust filters in paraffin.

The various jointing gaskets and washers if in other than perfect condition must be renewed.

Assemble by reversing the procedure for dismantling, noting the following points :—

Lightly oil all moving parts.

A copper washer is fitted under the head of the set-screw securing the bellows to the lower end of the piston and another between the bellows and the piston.

After assembly, test and adjust as indicated in the following paragraphs.

Fuel oil must NOT be allowed to come into contact with any valve or piston seal.

Safety valve.

Dismantle and clean all parts.

If necessary, lightly lap the valve on to its seating, using a fine grinding paste.

Examine the spring for corrosion and renew if necessary ; lightly oil it on assembly.

After assembly, test and adjust as described in the following paragraphs.

To Test

Unloader valve

Charge the reservoir by running the compressor or by admitting air from the shop air line. The unloader valve should be adjusted to unload when the reservoir pressure gauge indicates the figure given in Section P2. If a test gauge has been fitted in the air supply line, it should give a zero or very low reading **after** the unloader valve has unloaded.

Slowly lower the reservoir pressure by opening the drain plug or cock. The unloader valve should cut in again at the pressure indicated in Section P2.

Close the drain plug or cock and charge the reservoir to the unloader cut-out pressure, checking meanwhile that there is no escape of air through the exhaust silencer, or from any of the joints round the unloader valve.

Safety valve

The safety valve should be removed from the reservoir, tested for correct operating pressures (*see Section* P2) and adjusted if necessary. It should close between 80 and 90 lb. per sq. in. (5·6 and 6·3 Kg. per sq. cm.) and should be tested with soap and water at maximum unloader valve cut-out pressure (*see Section* P2) when no leakage must occur.

To Adjust.

Unloader valve

The unloader valve cut-out pressure is adjusted to the figure given in Section P2 by slackening the locknut and turning the adjusting thimble **clockwise** to

increase and **anti-clockwise** to **decrease** the pressure. When increasing the pressure it is desirable to screw down the thimble just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. Tighten the locknut and check the setting.

There is no adjustment for the cut-in pressure, and if this is low, the unloader valve must be dismantled again and checked. It is important that the reservoir pressure does not fall below the cut-in pressure given in Section P2 but it does not matter if the actual cut-in pressure is a little higher.

Safety valve

Break the seal if one is fitted, then slacken the locknut and screw the spring thimble **clockwise** to **increase** the blow-off pressure or **anti-clockwise** to **decrease** the pressure. When the correct pressure is obtained, tighten the locknut.

Section P6 NON-RETURN VALVE—TO DISMANTLE AND ASSEMBLE

(*See Fig.* 8)

To Dismantle

Remove the non-return valve from the car and proceed as follows :—

Unscrew the hexagon headed valve guide and remove it from the body together with the spring and valve.

To Assemble

Wash all parts in clean paraffin.

Examine the rubber face of the valve and if worn or damaged, it should be renewed.

Assemble the parts reversing the procedure given for dismantling and renew the copper washer ; then fit the valve to the car.

Section P7 DIVERTER VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST

(*See Fig.* 9)

To Dismantle

Remove the diverter valve from the reservoir and proceed as follows :—

Note.—The locknut and adjuster in the top cover must not be disturbed or the valve setting will be altered.

Remove the set-screws securing the top cover ; care should be taken as the cover will be under spring pressure. Remove the top cover together with the adjuster and locknut.

Withdraw the control spring and button.

Remove the set-screw securing the bellows to the valve stem ; prevent the valve from rotating by inserting a tommy-bar through the inlet port.

Remove the bellows, hexagon plug and washer ; withdraw the valve.

Unscrew the hexagon plug of the non-return valve and remove its washer.

Release the circlip and extract the perforated plate, spring and non-return valve.

To Assemble

Reverse the order of dismantling, giving attention to the following points :—

All moving parts should be smeared with oil.

If the packing joint between the bellows and the body has been disturbed or is damaged, fit a new one.

The copper washers fitted each side of the bellows plate must be carefully fitted to prevent air leaking past the set-screw which secures the bellows to the valve.

To Adjust

If the valve setting has been disturbed, mount the valve on to the reservoir and connect the air pressure pipe lines.

Charge the air pressure system to the diverter valve setting then stop the compressor.

Slowly unscrew the diverter valve adjuster until a sudden drop is registered on the air pressure gauge. Secure the locknut at this adjuster screw setting.

Release the pressure from the system ; run the compressor and verify that the diverter valve opens at the correct pressure quoted in Section P2.

Section P8 AIR REDUCING VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST

(*See Fig.* 12)

To Dismantle

After the valve has been removed from the car, remove the set-screws retaining the valve head ; the valve head assembly will come away as a unit.

The control spring guide, control spring and end plate can then be removed.

Unscrew the end cap and remove the felt filter element.

Unscrew the adjusting screw carrier and with suitable pliers extract the circlip ; withdraw the piston. Care must be taken to avoid damage to the sealing ring and also to the flat annular face of the release valve.

Unscrew the nut securing the release valve seat.

To Assemble

Wash all parts in paraffin. Assemble the reducing valve reversing the procedure given for dismantling, observing the following points :—

Inspect the faces of the valves and the sealing rings for wear or deterioration and renew if necessary.

Inspect the bore and piston for scoring.

Lightly coat all inner surfaces with engine oil before assembly. **Fuel oil must NOT be allowed to come into contact with any valve or piston seal.**

To Adjust

Before fitting the reducing valve to the car it must be tested as follows :—

Connect to the inlet port an air supply pipe and a gauge capable of registering pressures up to 85 lb. per sq. in. (6·0 Kg. per sq. cm.).

Connect to the outlet port an accurate gauge, capable of reading up to at least 70 lb. per sq. in. (4·92 Kg. per sq. cm.).

The setting of the control spring should then be adjusted by means of the adjusting screw so that there is constant pressure as quoted in Section P2.

To **increase** the pressure, **screw in** the adjusting screw ; **unscrew** to **decrease** the pressure.

Finally, lock the adjusting screw.

Section P9 THROTTLE CONTROL MOTORS—TO DISMANTLE AND ASSEMBLE

(*See Figs.* 10 *and* 34)

To Dismantle

Remove the throttle motor from the car and proceed as follows :—

Remove the side cover.

Unscrew the two nuts securing each air cylinder to the casing and detach the cylinders by gently prising with a screwdriver.

Unscrew the nuts, remove the cylinder cover and withdraw the piston assembly from each cylinder.

Unscrew the nut and remove the retaining washer, shim (if fitted) and seal from the piston.

Remove the control levers and keys from the shaft, unscrew the nuts and detach the end cover and bush, then withdraw the actuating shaft assembly from the casing.

Retain the shims fitted to the shaft between the bush and distance piece at the cover end.

To Assemble (*see Fig.* 34)

Reverse the procedure given for dismantling noting the following points :—

Examine the cylinder sleeves, if excessively scored or worn a new or reconditioned cylinder assembly should be fitted.

Examine the shoulders on the keyed distance pieces and actuating levers ; if excessively worn the parts should be renewed.

Examine the shaft bushes for wear, renew if necessary.

Renew all paper joints and lightly smear all working parts with engine oil.

Ensure that the shims are fitted between the bush in the cover and the distance piece (*for thickness of shims available see Section* P15).

Examine the piston seals for wear or deterioration and renew if necessary.

When renewing piston seals the retaining nut should be tightened so that the retaining washer seats on the register on the piston and the seal is just nipped but **not distorted.**

To achieve this result it may be necessary to fit a shim between the seal and the piston (*for thickness of shims available see Section* P15).

In order to centralize the piston seal the retaining nut should be left slack whilst the piston assembly is being fitted, then finally tightened when the assembly is in position in the cylinder.

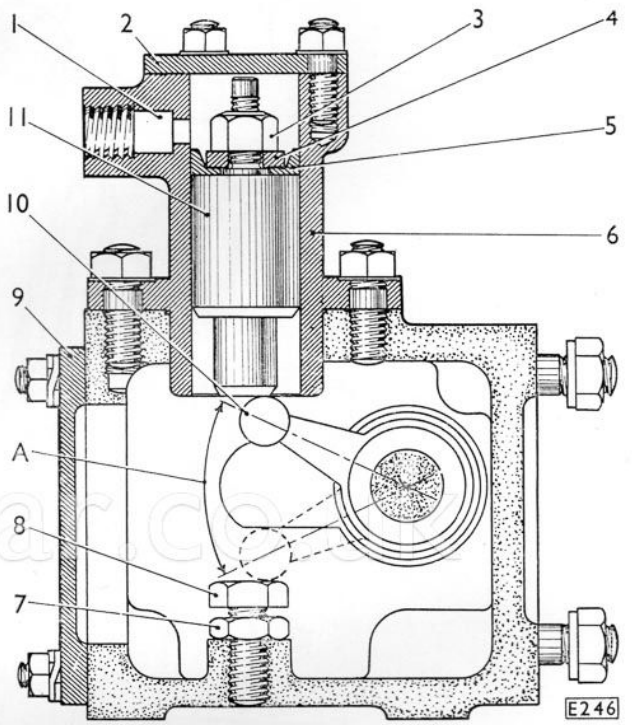

Fig. 34. Section through throttle control motor showing travel of actuating lever at full throttle

A. MAXIMUM TRAVEL 47° — FULL THROTTLE
1. AIR INLET PORT
2. CYLINDER COVER
3. RETAINING NUT FOR PISTON SEAL
4. RETAINING WASHER
5. PISTON SEAL
6. AIR CYLINDER
7. LOCKNUT
8. ACTUATING LEVER ADJUSTING SCREW
9. COVER PLATE
10. ACTUATING LEVER
11. PISTON

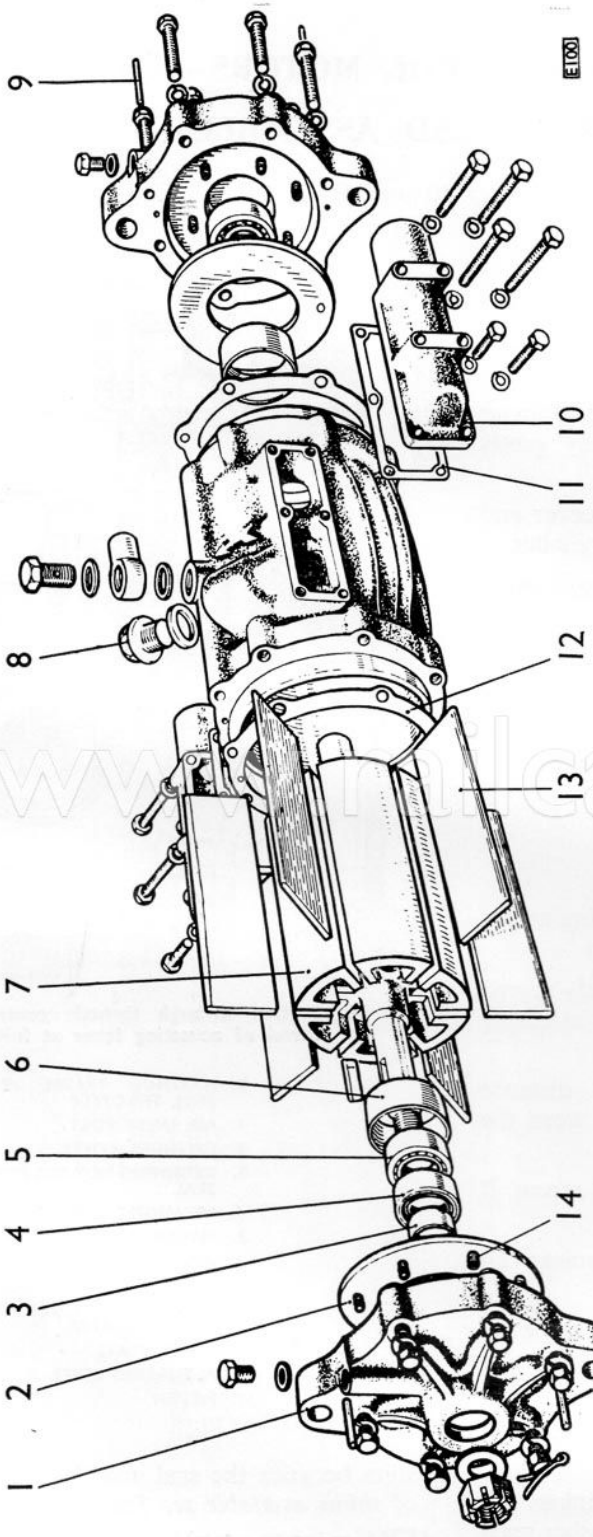

Fig. 35. Exploded view of exhauster

1. DRIVE END COVER
2. SEALING PLATE WITH PEG
3. SHAFT COLLAR
4. METAL INSERT SEAL
5. ROLLER RACE
6. FLOATING CAM RING
7. ROTOR AND SHAFT
8. PLUG $\frac{1}{4}$" B.S.F.
9. END COVER LOCATING PEG
10. MANIFOLD
11. MANIFOLD JOINT
12. END COVER JOINT
13. ROTOR BLADE
14. SEALING PLATE SPRING

Section P10 EXHAUSTER OIL RESERVOIR —TO REMOVE, DISMANTLE, ASSEMBLE AND FIT

(*See Fig.* 36)

To Remove

Drain the oil by removing the drain plug (*see Section* P4).

Disconnect the oil pipes and seal off the pipes and unions to prevent ingress of foreign matter.

Remove the nuts from the base and the top flanges, then lift the reservoir from its bracket.

To Dismantle

Unscrew the nuts securing the top cover and remove the cover and gaskets.

Unscrew the breather.

Remove the inner top plate and strainer complete

Unwire and remove the bottom filters.

To Assemble

Wash all parts thoroughly in clean paraffin.

Reverse the procedure given for dismantling.

To Fit

Reverse the procedure for removal, then fill with fresh oil (*see Section* P4).

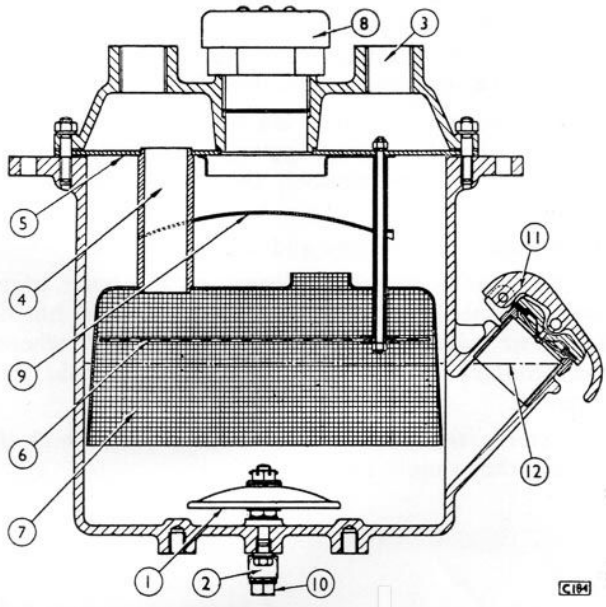

Fig. 36. Section through exhauster oil reservoir

1. BOTTOM FILTER
2. OUTLET PORT
3. INLET PORT
4. TRANSFER PORT
5. TOP PLATE
6. TOP FILTER
7. STRAINER
8. BREATHER
9. BAFFLE PLATE
10. DRAIN PLUG
11. FILLER CAP
12. OIL LEVEL

Section P11 EXHAUSTERS—TO DISMANTLE AND ASSEMBLE

(*See Fig.* 35)

To Dismantle

Remove the exhauster from the car.

Unscrew the set-screws securing the end covers and detach the covers together with the oil seal, the outer race of the roller bearing and the sealing plate springs.

Should it be necessary to remove the oil seal and the roller bearing outer race from the cover, care should be exercised to ensure that they are not damaged.

Remove the sealing plates and withdraw the rotor assembly from the body.

Further dismantling of the rotor should only be carried out if it is necessary to renew any of the parts.

Remove the bearings by means of a suitable withdrawal tool, the shaft collar will be removed with the roller bearing; the cam rings can then be removed.

To Assemble

Before commencing to assemble the exhauster, examine all parts, and if worn or damaged they should be renewed.

Examine the bore of the body which may show markings in the form of lines or ripples running longitudinally and coinciding with the port openings. This condition is usually attributed to the exhauster having been operated without an adequate oil supply.

Providing the markings are only slight, the body may be used for further service. If however, the markings are pronounced, the body should be renewed.

Examine the bearings and renew if worn.

The rotor blades usually wear on the outer edge and a certain amount of wear is permissible, but if the inner edges are appreciably "stepped" where they contact the cam rings, the blades should be renewed.

Examine the faces of the sealing plates and if scored, they should be renewed.

Assemble the exhauster, reversing the procedure for dismantling and noting the following points:—

Ensure that the bearings run freely, when fitted.

To avoid damaging the oil seal when fitting the drive-end cover, a guide sleeve should be used.

Ensure when fitting the sealing plates, that the springs are fitted in the end covers and that the sealing plate peg is located within one of the springs.

Fit the rear end cover first, stand the assembly on its end, then fit the rotor blades.

Smear the end covers with grease before fitting new joints.

Before fitting the exhauster to the car, check to ensure that the rotor rotates freely.

To Test

See Railway instructions for testing the vacuum system.

Section P12 ENGINE CONTROL RELAY PANEL AND E.P. CONTROL RELAY PANEL—TO ADJUST CONTACTS AND CALIBRATE RELAYS

(*See Fig.* 37)

Before fitting or adjusting new contacts to the relays, ensure that the batteries are isolated by means of the battery isolating switch.

If correctly fitted, the contact faces will meet squarely, when the armature is fully home, and should be aligned so that when they are closed it should not be possible to insert a 0·005 in. feeler gauge.

The distance between the faces of any pair of contacts must not exceed 0·031 in. (0·8 mm.).

To adjust the armature hinge gap

Slacken the screws securing the hinge spring and adjust the spring so that it is square with the armature, then tighten the screw securing the spring to the armature.

With the armature core gap at 0·010 in. (0·254 mm.) adjust the armature hinge gap to 0·040 in. (1·016 mm.); the hinge gap must be parallel in the direction across the yoke. Tighten the screw to secure the hinge spring to the yoke, making sure that the clamping plate is the correct way round.

In the case of relays with normally closed contacts, as in specification T3500, fit the hinge spring so that the slots are to the rear, to avoid fouling the fixed contacts support.

The armature core gap should be measured across the centre of the core.

If an armature adjusting screw is fitted, as in specification T3500, this should be locked by means of the locknut.

To adjust the normally closed contacts (as in specification T3500)

Adjust these contacts by means of the adjusting screw so that when they are closed, the armature core gap is 0·050 in. (1·270 mm.), then lock securely by means of the locknut.

To adjust the normally open main contacts (as in specifications T3501, T3502 and T3633)

Adjust these contacts, by means of the adjusting screw, until the faces just meet and the armature core gap is 0·010 in. (0·254 mm.).

On relays to specifications T3501, T3502 and T3633, adjust the armature core gap to 0·050 in. (1·270 mm.), with the main contacts open.

Lock the contacts by means of the locknuts.

To adjust the normally open auxiliary contacts (as in specifications T3501, T3502 and T3633)

Adjust these contacts by means of the adjusting screw, until the faces just meet and the armature core gap is 0·030 in. (0·762 mm.) ; this setting ensures that compared with the main contacts, the auxiliary contacts will " make " first and " break " last.

Lock the contacts by means of the locknuts.

To Calibrate The Relays

The relay coil should be adjusted from zero up to the normal working voltage of the relay.

The energising voltage is given in Section P2, and the control spring adjusting screw should be set so that the relay " cuts-in " at this voltage. Always ensure that the locknut on the adjusting screw is tightened after making an adjustment.

Actuation of the relay should be rapid and decisive when both opening and closing. If this is not the case, it must be assumed that the contacts have not been correctly set and should again be checked and re-adjusted where necessary.

In circumstances where a relay has been renewed or is suspected of faulty operation, it should be adjusted.

After having made the necessary adjustments, ensure that the control boxes are re-connected to the battery.

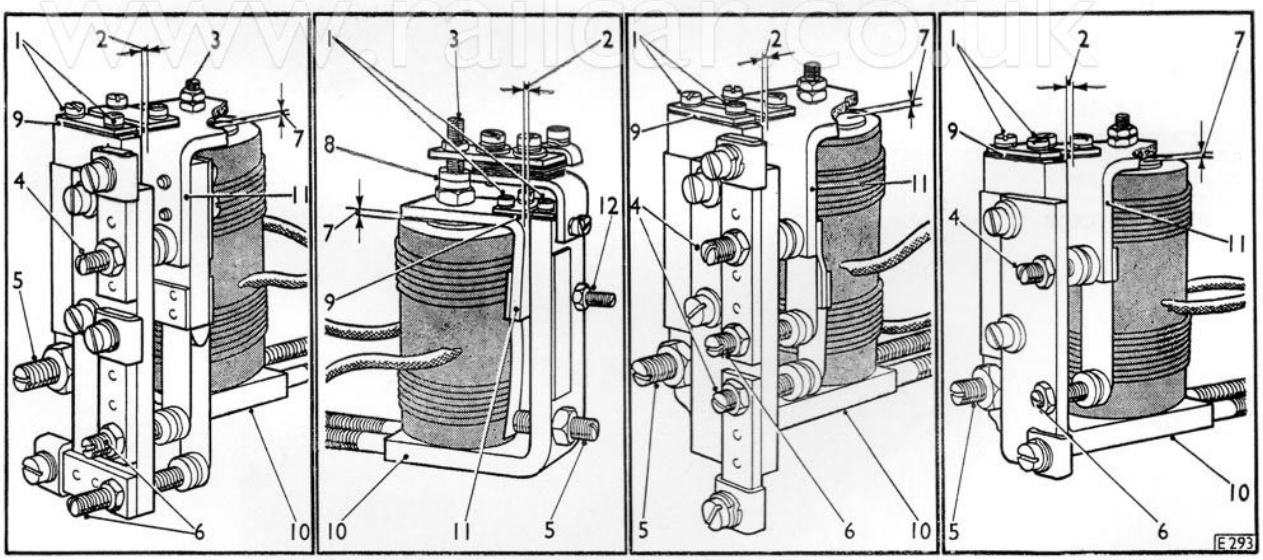

Fig. 37. Diagrams for setting control relays

A. TONUM TYPE RELAY SPECIFICATION T3633

B. TONUM TYPE RELAY SPECIFICATION T3500

C. TONUM TYPE RELAY SPECIFICATION T3501

D. TONUM TYPE RELAY SPECIFICATION T3502

1. ARMATURE HINGE FIXING SCREWS
2. ARMATURE HINGE GAP 0·040in
3. NORMALLY CLOSED MAIN CONTACTS SETTING SCREW
4. NORMALLY OPEN MAIN CONTACTS AND ARMATURE SETTING SCREW
5. CONTROL SPRING ADJUSTING SCREW
6. NORMALLY OPEN AUXILIARY CONTACTS SETTING SCREW
7. ARMATURE CORE GAP 0·010in
8. NORMALLY CLOSED MAIN CONTACTS
9. HINGE SPRING
10. YOKE
11. ARMATURE
12. ARMATURE SETTING SCREW

Section P13 DIRECTION INDICATOR SWITCH —TO FIT AND ADJUST

Ensure that the driving dog is locked in the "neutral" position, by means of the hand operated locking plunger situated on the final drive casing.

Fit the indicator switch to the final drive casing, ensuring that the actuating pin is located in the slot provided in the "neutral" lock plate, then secure it with the set-screws and washers.

Remove the adjusting screw cap to expose the adjusting screw, and slacken the locknut.

Turn the eccentric shaft with a screwdriver until the indicator points to the "neutral" mark stamped on the indicator plate, then tighten the locknut and fit the cap locknut.

Return the hand operated locking plunger to its original position.

To check whether the switch is operating correctly, remove the indicator plate and select in turn, both forward and reverse. The switch should operate when the driving dog is two thirds engaged with either the forward or reverse bevel pinion.

Connect the leads to the switch.

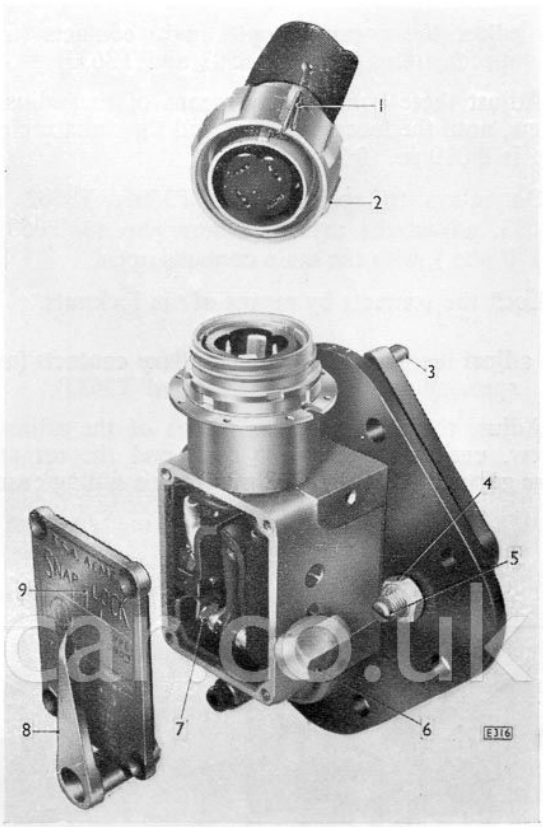

Fig. 38. Direction indicator switch

1. LOCKING SPLIT PIN
2. PLUG
3. ACTUATING PIN
4. LOCKNUT
5. ADJUSTING SCREW
6. CAP FOR ADJUSTING SCREW
7. CONTACTS
8. POINTER
9. INDICATOR AND COVER PLATE

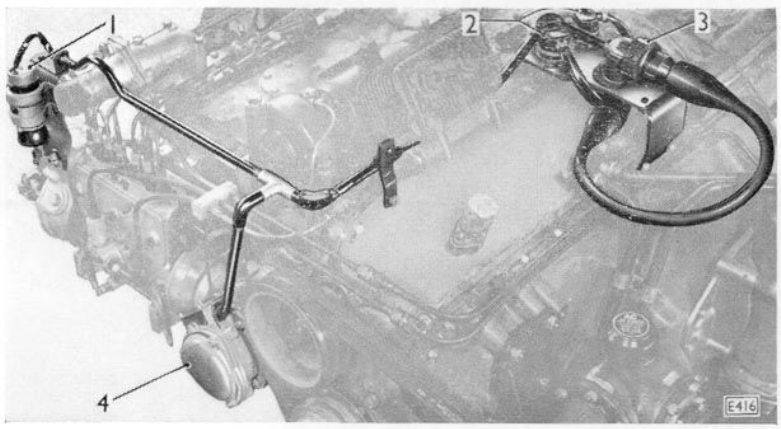

Fig. 39. Engine plug and socket, harness and conduit

1. ENGINE SHUT-DOWN SOLENOID
2. OIL PRESSURE SWITCHES
3. ENGINE PLUG AND SOCKET
4. ENGINE SPEED INDICATOR GENERATOR

Section P14 ENGINE PLUG AND SOCKET —TO REMOVE AND FIT

(*See Fig.* 39)

To Remove

Remove the plug from the socket and disconnect the leads from the oil pressure switches.

Disconnect the leads from the engine shut-down solenoid and remove the bolts securing the conduit bracket to the solenoid bracket.

Disconnect the leads from the engine speed indicator generator.

Remove the bracket and clip securing the conduit to the engine casing extension.

Remove the bolts securing the socket to its bracket.

Withdraw the conduit from the engine speed indicator generator then remove the socket, harness and conduit assembly from the engine.

To Fit

Reverse the procedure given for removal ensuring that the conduit is sealed with compound where it enters the engine speed indicator generator.

Section P15 SIZES OF SHIMS AVAILABLE

Part	Part No.	Thickness
Throttle control motor shaft	Z4/46517	0·005 in. (0·127 mm.)
	Z4/46518	0·010 in. (0·254 mm.)
	Z4/46519	0·015 in (0·381 mm.)
Throttle motor piston seal	Z4/46549	0·003 in. (0·076 mm.)

SUPPLEMENT

TO CONTROLS CHAPTER P2

CONTENTS

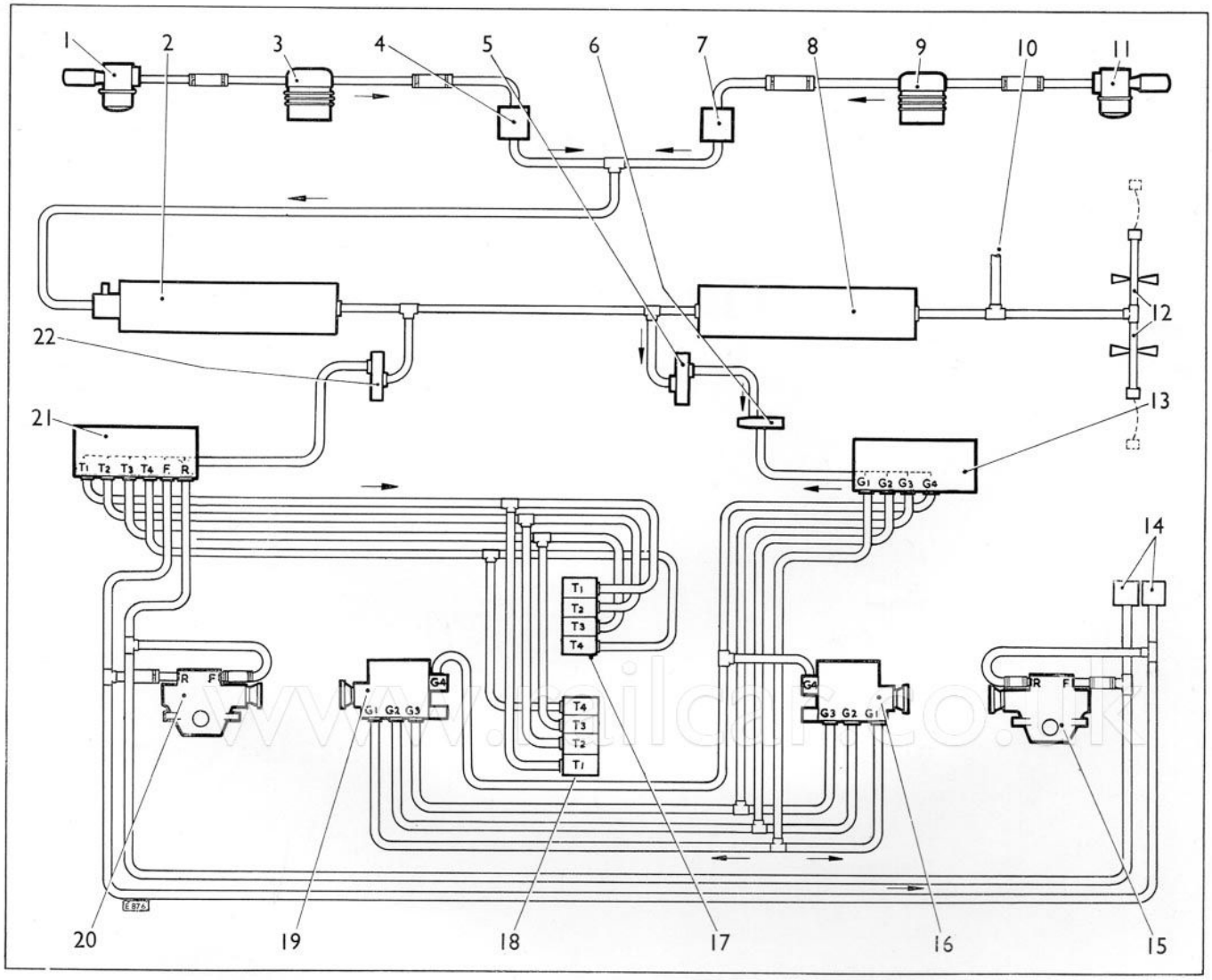

Fig. P1S Diagrammatic view of air pressure system

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

Section P1S CONTROLS—DESCRIPTION

(*See Figs.* P1S, P2S *and* P5S)

AIR PRESSURE SYSTEM (*see Fig.* P1S)

On late cars the air pressure system has been revised by using the unloader and safety valve with a large capacity reservoir. The use of the diverter valve with second reservoir has been omitted.

With the revised system, air is passed through the unloader valve and stored in the main and auxiliary reservoirs. Thus, an air supply of predetermined pressure is available to the electro-pneumatic valves controlling the throttle control motors, gearboxes, and the forward and reverse engagement dogs in the final drive units.

The operation of the air pressure reducing valve and functions of the remainder of the system is unchanged.

Note:—For a description and diagrammatic layout of the air pressure system on early cars, see **" CHAPTER P2."**

ELECTRICAL SYSTEM

COMBINED STARTER ISOLATION AND FIRE CONTROL UNIT (*see Figs.* P2S *and* P5S)

The combined starter isolation and fire control box contains a number of control relays and electrical switches. These are arranged for the protection of the starter motor and operation of the automatic fire extinguisher equipment.

The fire protection equipment consists of a fire detector, cancellation switch and warning indicator light. A test button is provided for testing the circuit for the alarm and warning indicator light, also an isolating switch to isolate the engine from the remainder of the equipment.

In the event of fire, a warning light on the side of the combined control box indicates the engine affected, and also sounds the fire alarm bell in the driver's cab. The engine is automatically shut-down by the firm alarm relay and the extinguisher bottle detonated.

To ensure that the fire has been extinguished the driver must leave the cab and proceed to the affected engine. After the fire has been extinguished, the small metal tab on the cover of the combined control box must then be removed to uncover the alarm cancellation switch. This switch should be operated, to stop the alarm bell ringing and also extinguish the warning indicator light.

Using a standard carriage key, the engine should be isolated from the remainder of the equipment by turning the isolating switch to the " OFF " position, and, in order to prevent possible restarting of the engine through the transmission, the final drive should also be isolated.

Major components in the control box are as follows:—

Control relays (*see Fig.* P5S)

The engine start, starter motor isolation, engine stop and fire alarm, are each controlled by a Tonum type relay (specification T4013). These four relays are mounted on an insulated panel so that the contact faces are in a vertical plane thereby ensuring that no dust will collect on the faces.

Each relay incorporates one pair of normally closed and one pair of normally open main contacts. The latter contacts form a separate circuit from the former and they are insulated from each other.

Starter motor isolation relay (*see Fig.* P5S)

This unit, which is actuated by the engine speed indicator generator, is provided to safeguard the starter motor should an attempt be made to operate the starter while the engine is running.

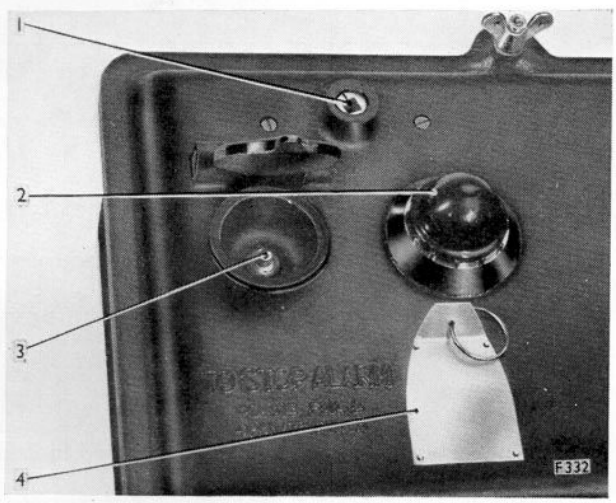

Fig. P2S Location of switches etc., on cover of combined starter isolation and fire control unit

1. ENGINE ISOLATING SWITCH
2. FIRE WARNING INDICATOR LIGHT
3. TEST BUTTON SWITCH—ALARM AND INDICATOR LIGHT CIRCUIT
4. PROTECTION TAB—ALARM CANCELLATION SWITCH

When the generator reaches a predetermined speed the relay trips to interrupt the starter motor circuit, thus preventing the starter motor being operated.

The unit is mounted in a vertical position in the control box and, to prevent the magnetic system attracting metalic particles, is protected by a perspex cover.

Flame switch (*see Figs.* P3S *and* P5S)

The flame switch is a detector designed for use in potential fire zones where the normal ambient temperature does not exceed 110° C. (230° F.). The detector responds rapidly to flame or temperature in excess of 250° C. (482° F.).

The detector consists of a steel capillary which houses a pyrotechnic cord. This cord, which contains a wick impregnated with black powder and nitrocellulose, terminates at the switch.

The application of naked flame to any point in the length of the capillary ignites the pyrotechnic cord and the resultant pressure developed inside the tube closes the flame switch contacts. These are connected to the cartridge firing unit and when operated detonates the extinguisher bottle.

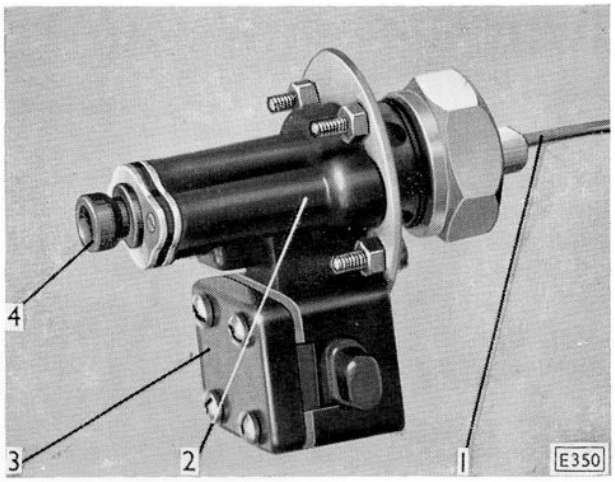

Fig. P3S Flame switch.
Photograph by Graviner

Key to Numbers:—

1. CAPILLARY TUBE AND PYROTECHNIC CORD
2. SWITCH BODY
3. TERMINAL BLOCK
4. TEST BUTTON

Section P2S CONTROLS—DATA

COMBINED STARTER ISOLATION AND FIRE CONTROL UNIT		
Tonum type relays	Specification No. T4013	All relays to energise at 7·4 volts cold (not to exceed 9 volts hot); Shunt coil resistance, 101·5 ohms, ± 5% at 20° C. (68° F.) 24/32 v.
Starter Motor isolation relay	Type TRB 5/5	
Calibrated relay	Type TRB 622/10	

The following components are used with the Combined starter isolation and fire control unit:—

Engine speed indicator generator	Type MDG.3
Engine speed indicator	Type RMC 58/2

Section P3S CONTROLS—MAINTENANCE

ELECTRICAL SYSTEM

The following points require attention at intervals quoted in Railway Standing Instructions.

1	Check all electrical connections for security.
2	Clean the electrical contacts on the control relays.
3	Test the flame switch circuit.

Note:—Before attempting to clean the contacts or carry out any adjustments to the Tonum type relays, isolate the battery by operating the battery isolating switch.

Control relays (*see Figs.* P4S *and* P5S)

Carefully clean the relay contacts with a diamonded spatula file. Apart from this, no further maintenance is required. If, however, the contacts are found to be burnt or pitted, they should be renewed and adjusted.

Flame switch (*see Fig.* P3S)

To test the flame switch circuit, disconnect the cable socket from the cartridge unit on the fire extinguisher and insert a suitable plug and 24 volt test lamp into the free end of the cable socket.

Test the circuit by depressing the rubber covered button on the flame switch. This will effect closure of the switch contacts, and also operate the test and fire warning indicator lights.

Section P4S CONTROL RELAYS—TO ADJUST CONTACTS AND CALIBRATE RELAYS

(*See Fig.* P4S)

Tonum type relay—Stone's Specification T4013

Before fitting or adjusting new contacts to the relays, ensure that the battery is isolated by operating the battery isolating switch.

If correctly fitted, the contact faces will meet squarely when the armature if fully home and should be aligned so that, when they are closed, it should not be possible to insert a 0·005 in. (0·127 mm.) feeler gauge between them.

The distance between the faces of any pair of contacts must not exceed 0·031 in. (0·8 mm.).

To adjust the armature hinge gap

Slacken the locknut and screw out the control spring adjusting screw until there is no pressure applied to the spring.

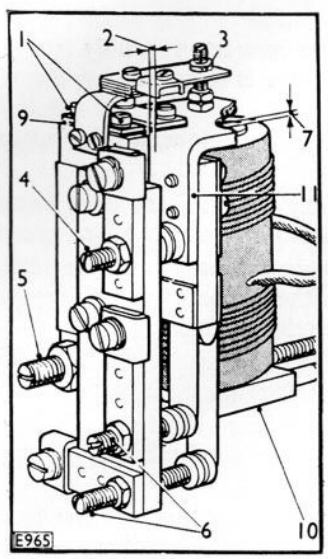

Fig. P4S Diagram for setting control relays

1. ARMATURE HINGE FIXING SCREWS
2. ARMATURE HINGE GAP 0.040 in.
3. NORMALLY CLOSED MAIN CONTACTS SETTING SCREW
4. NORMALLY OPEN MAIN CONTACTS AND ARMATURE SETTING SCREW
5. CONTROL SPRING ADJUSTING SCREW
6. NORMALLY OPEN AUXILIARY CONTACTS SETTING SCREW
7. ARMATURE CORE GAP 0·010 in.
9. HINGE SPRING
10. YOKE
11. ARMATURE

Remove the screws securing the fixed contact assembly of the normally closed main contacts, and detach the assembly from the yoke.

Slacken the screws securing the hinge spring and adjust the spring so that it is square with the armature, then tighten the screws.

With the armature core gap at 0·010 in. (0·254 mm.) adjust the hinge gap to 0·040 in. (1·016 mm.); the hinge gap must be parallel in the direction across the yoke. Tighten the screws to secure the hinge spring to the yoke.

The armature core gap should be measured at the centre of the core.

Screw in the control spring adjusting screw to apply pressure to the spring, and lock the screw with the locknut.

Refit the fixed contact assembly to the yoke and tighten the securing screws.

To adjust the normally closed contacts

Adjust these contacts by means of the setting screw so that when they are closed, the armature core gap is 0·050 in. (1·270 mm.), then lock securely by means of the locknut.

To adjust the normally open main contacts

Adjust these contacts by means of the setting screw until the faces just meet and the armature core gap is 0·010 in. (0·254 mm.). Check that the armature core gap is 0·050 in. (1·270 mm.) when the main contacts are open.

Lock the contacts by means of the locknuts.

To adjust the normally open auxiliary contacts

Adjust these contacts by means of the setting screw until the faces just meet and the armature core gap is 0·030 in. (0·762 mm.); this setting ensures that, compared with the main contacts, the auxiliary contacts will " make " first and " break " last.

Lock the contacts by means of the locknuts.

To calibrate the relay

The relay coil should be adjusted from zero up to the normal working voltage of the relay.

For energising voltage of the relays (*see Section* P2S).

To set the control spring adjusting screw, so that the relay " cuts-in " at the energising voltage, turn the screw in a **clockwise** direction to increase cut-in voltage and vice versa. Ensure that the locknut on the adjusting screw is tightened after making an adjustment.

The action of the relay should be rapid and decisive when both opening and closing. If this is not the case, it must be assumed that the contacts have not been correctly set and should again be checked and re-adjusted where necessary.

In circumstances where a relay has been renewed or is suspected of faulty operation, it should be adjusted.

After having made the necessary adjustments, ensure that the combined starter isolation and fire control unit is re-connected to the battery.

Section P5S STARTER MOTOR ISOLATION RELAY—TO TEST

(*See Fig.* P5S)

Note:—The complete assembly is referred to as the starter isolation relay, the actual relay, identifiable by the transparent cover is referred to as the " calibrated relay."

Apart from the following tests no maintenance is required.

Start the engine and check that the calibrated relay contacts close below engine idling speed.

When the engine is warm, stop the engine, then restart it without exceeding idling speed and note whether the relay operates.

It is possible to check if the contacts " make " by observing whether the secondary relay moves.

If it is inconvenient to run the engine, the following test may be made to check the " tripping speed " of the calibrated relay.

Isolate the car battery from the remainder of the equipment by operating the battery isolating switch.

Disconnect the leads from the engine speed indicator generator output terminals and substitute a 60 volt D.C. battery and variable resistance having a capacity of 22,000 ohms.

The battery and variable resistance should be connected to the generator end of the cables, thus including the wiring in the test. If this is inconvenient, the generator can be isolated at the end of the cable by disconnecting the generator cable from the relay unit terminals and connecting the battery and variable resistance to the terminals direct. Connect also the following relay supply to the appropriate terminals.

With the variable resistance connected as a poten-

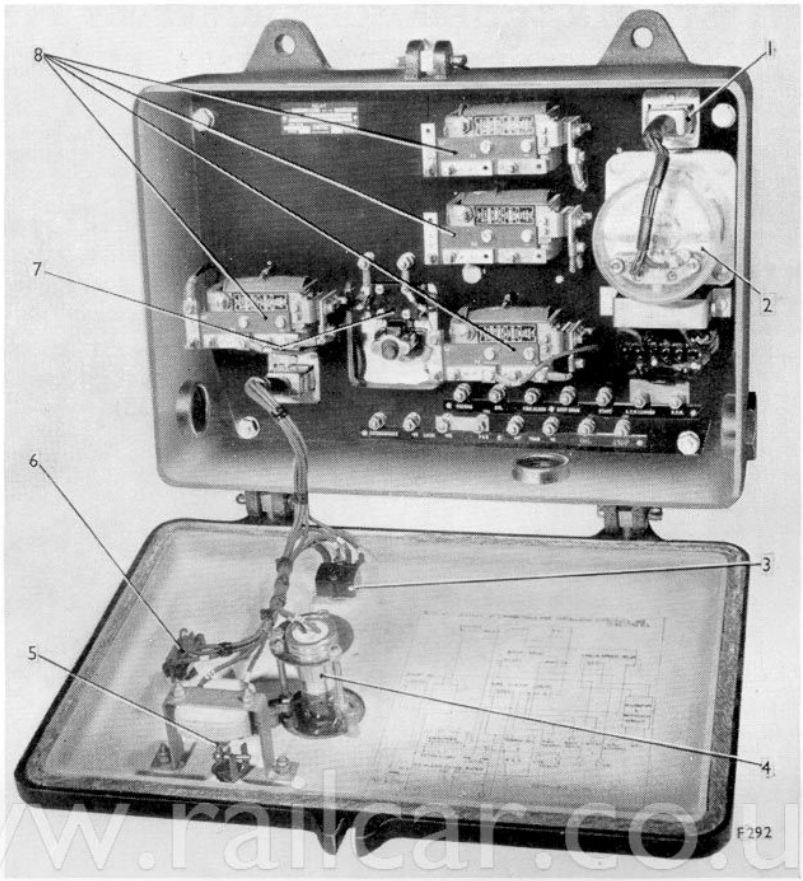

Fig. P5S Combined starter isolation and fire control unit

1. PLUG AND SOCKET
2. STARTER MOTOR ISOLATION RELAY
3. ALARM CANCELLATION SWITCH
4. FIRE WARNING INDICATOR LAMP
5. ENGINE ISOLATING SWITCH
6. TEST BUTTON SWITCH—ALARM AND INDICATOR CIRCUIT
7. FLAME SWITCH
8. CONTROL RELAYS

tiometer and set to minimum, switch on the battery. If when the resistance is adjusted to increase the voltage, no reading is obtained on the engine speed indicator and the calibrated relay does not " trip," then the wiring should be checked (*see under* " *Insulation test* ").

When the relay tripping speed has been reached and the relay tripped, the resistance should not be taken higher since this may result in damage to the rectifier or capacitor.

If the engine speed indicator registers at approximately 160 r.p.m. and the calibrated relay contacts fail to " make " then the relay is defective and should be removed from the panel and renewed (*see Section* P6S " *STARTER MOTOR ISOLATION RELAY—TO REMOVE AND FIT* ").

Insulation test

Before attempting to test the wiring insulation, all equipment should be disconnected, unless a low output tester such as a D.C. " Megger " is used.

Check the insulation between the cable conductor and to earth at 500 volts D.C. when the insulation resistance must not be less than 20 megohms.

It is advisable to mark the terminals in the junction boxes and jumper connections, to distinguish the measuring circuit from the control circuit. This avoids damage to the equipment by routine insulation tests using high power testers. The maximum loop resistance between the engine speed indicator generator and the starter motor isolation relay must not exceed 3 ohms.

To maintain accuracy, it is important that the engine speed indicator and generator of the correct type are connected to the starter motor isolation relay (*for* " *DATA* " *see Section* P2S). If two indicators are specified, these must be connected in parallel.

Section P6S STARTER MOTOR ISOLATION RELAY —TO REMOVE AND FIT

(*See Fig.* P5S)

To Remove

Disconnect the cable plug connecting the calibrated relay with the terminal plug on the combined control box.

Turn each of the four screw fasteners one quarter of a turn to the left and remove the relay from the panel.

To Fit

Reverse the procedure given for removal ensuring that the wording " calibrated relay " inscribed on the transparent cover is positioned the right way up, or errors will be introduced in the tripping speed.

When the relay is secured to the panel, reconnect the cable plug with the socket and retest the equipment (*see Section* P5S).