BRITISH RAILWAYS
DIESEL TRAIN
'A' TYPE UNITS
MAINTENANCE MANUAL

BRITISH UNITED TRACTION LTD.

SERVICE MANUAL

(MAINTENANCE)

FOR

B.U.T.

TRACTION EQUIPMENT

FOR TRAINING PURPOSES ONLY

BRITISH RAILWAYS
MULTIPLE-UNIT DIESEL CARS
(Swindon Built Inter-City Cars 79,083-111 & 79,155-168)

BRITISH UNITED TRACTION LIMITED

HANOVER HOUSE, 14, HANOVER SQUARE, LONDON, W.1,

ENGLAND.

Telegrams & Cables: BRITROL, LONDON

Book No. 372-230

T.P.28 100 H & C 9-56

GENERAL INSTRUCTIONS
ENGINE
FLUID COUPLING
GEARBOX
FINAL DRIVE

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FOREWORD.

THIS Service Manual has been compiled to assist those responsible for the maintenance and reconditioning of B.U.T. DIESEL RAILWAY TRACTION EQUIPMENT.

The book is copiously illustrated with reproductions from photographs, specially prepared drawings and diagrams, suitably annotated to give the maximum assistance with minimum searching.

While every care has been taken in the design and manufacture of this equipment in an endeavour to obtain the maximum mileage coupled with the minimum amount of servicing between overhauls, apart from certain essential adjustments and periodic routine maintenance, equipment that is performing satisfactorily should not be tampered with or any part dismantled unnecessarily. A necessary adjustment, however, should never be neglected and should receive attention immediately the need becomes apparent.

As manufacturers we do our part by using the very best materials and workmanship and we are justifiably proud of our products, but once they leave our Works their future depends on the operator; this manual has been compiled to assist to this end.

The Service Department of British United Traction Limited is always willing to assist operators with maintenance problems and maintains a staff of highly trained engineers to give "on the spot" advice to Railway staff.

BRITISH UNITED TRACTION SERVICE MANUAL.

ERRATA

Page C 2. *Para. 4.*
Amend :— " frame " to read " underframe "

Page C 3. *Column 1.*
Reference :— " Important Warning to Drivers " Para. 4
after " Stop the car "
Insert :— " and ensure that the handbrake is firmly applied. If sufficient air pressure is available proceed as follows :—
Pull the hand-operated plunger outwards, then give it a quarter of a turn and release so that it engages in the deep slots in the plunger body, i.e. in the horizontal position.
Move the forward and reverse lever from one position to the other and after a short pause, move it back again.
If the axle has been correctly isolated, it should be possible to rotate the propellor shaft, connected to the final drive, freely by hand, and this test should be carried out before commencing towing operations.
If for any reason the above method of isolating the axle is not possible, one of the following methods should be applied."

Column 2.
Reference :— " On late axles "
Delete :— " the indicator in the driver's cab or "

Page C 7. *Column 1. Para. 1.*
Reference :— After " place "
Insert :— " check the gap."

Page C 8. *Fig. 7.*
Air Reducing Valve.
Reference :— After " 6. Adjusting screw "
Insert :— 7. Set-screw for locking piece.

Page C 15. *Para. 5.*
Amend :— " aluminium " to read " duralumin " (Overhaul Manual only).

Page E 5. *Column 1. Para. 3.*
Reference :— After " Stop the car "
Insert :— " and ensure that the handbrake is firmly applied. If sufficient air pressure is available proceed as follows :—
Pull the hand operated plunger outwards, then give it a quarter of a turn and release so that it engages in the deep slots in the plunger body, i.e. in the horizontal position.
Move the forward and reverse lever from one position to the other and after a short pause, move it back again.
If the axle has been correctly isolated, it should be possible to rotate the propellor shaft, connected to the final drive, freely by hand, and this test should be carried out before commencing towing operations.
If for any reason the above method of isolating the axle is not possible, one of the following methods should be applied ".

Column 2.
Reference :— " On late axles "
Delete :— " the indicator in the driver's cab or "

Page E 6. *Column 2. Para. 1.*
Delete :— Paragraph 1.
Substitute :— " Disconnect the supply pipes from the air cylinders ; ensure that the banjo pins are marked and retained with their washers, so that they can be fitted to their original cylinders when refitting."

Page E 7. *Column 1. Para. 1.*
Reference :— After " ensuring "
Insert :— " that the identification marks on the pin correspond with the marks on the cylinder and ".

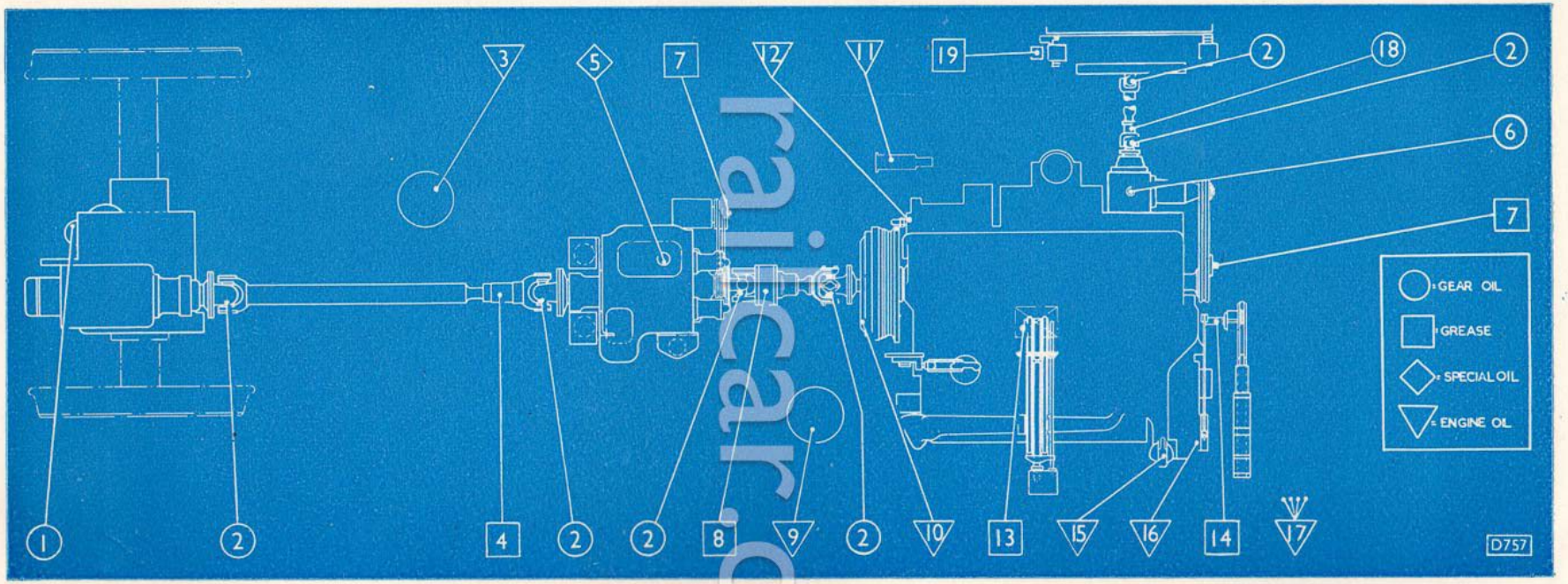
P.T.O.

Page E 9. *Column 1. Para. 4.*
Reference :— After " marked "
Insert :— " and retained with their washers,"

Page E 10. *Column 2. Para. 6.*
Reference :— After " secure "
Insert :— " that the marks on the banjo pins correspond with the marks on the cylinders and that the original number of washers are fitted with each pin."

Overhaul Manual only.

T.S.L. 523—1,500—H & C—3-56



Location Number	Part	Class of lubricant	Number of lubrication points per car	Period	Location Number	Part	Class of lubricant	Number of lubrication points per car	Period
1	Driving axles	Gear oil	2		9	Engine air cleaners	Engine oil	2	
2	Drive shafts universal joints	Gear oil	12		10	Fluid couplings	Engine oil	2	
3	Exhauster oil separator ...	Engine oil	1		11	Air pressure reducing valve	Engine oil	1*	
	Drive shaft splined ends:—				12	Starter motors	Engine oil	2	
18	Small diameter shafts (fan drive)	Gear oil	2		13	Engine lifting gears (if fitted)	Grease	2	
4	Large diameter shafts ...	Grease	2		14	Throttle relay shafts... ...	Grease	2	
5	Gearboxes	Special	2		15	Engines	Engine oil	2	
6	Right-angle fan drive unit ...	Gear oil	2		16	Fuel-injection pump governor casings	Engine oil	2	
7	Pulley bearings	Grease	4		17	Throttle control motors ...	Engine oil	8*	
8	Freewheels	Grease	2		19	Fan bearings	Grease	2	

One stroke of pressure gun only.

THIS CHART SHOULD BE READ IN CONJUNCTION WITH THE APPROPRIATE LUBRICATION SECTIONS.

Lubrication Chart for "A" Type Units (*with right-angle fan drive*).

Plate S81 1,500 H & C 4-56

ENGINE.

CHAPTER A.

CONTENTS.

MAINTENANCE AND OVERHAUL MANUALS.

OVERHAUL MANUAL ONLY.

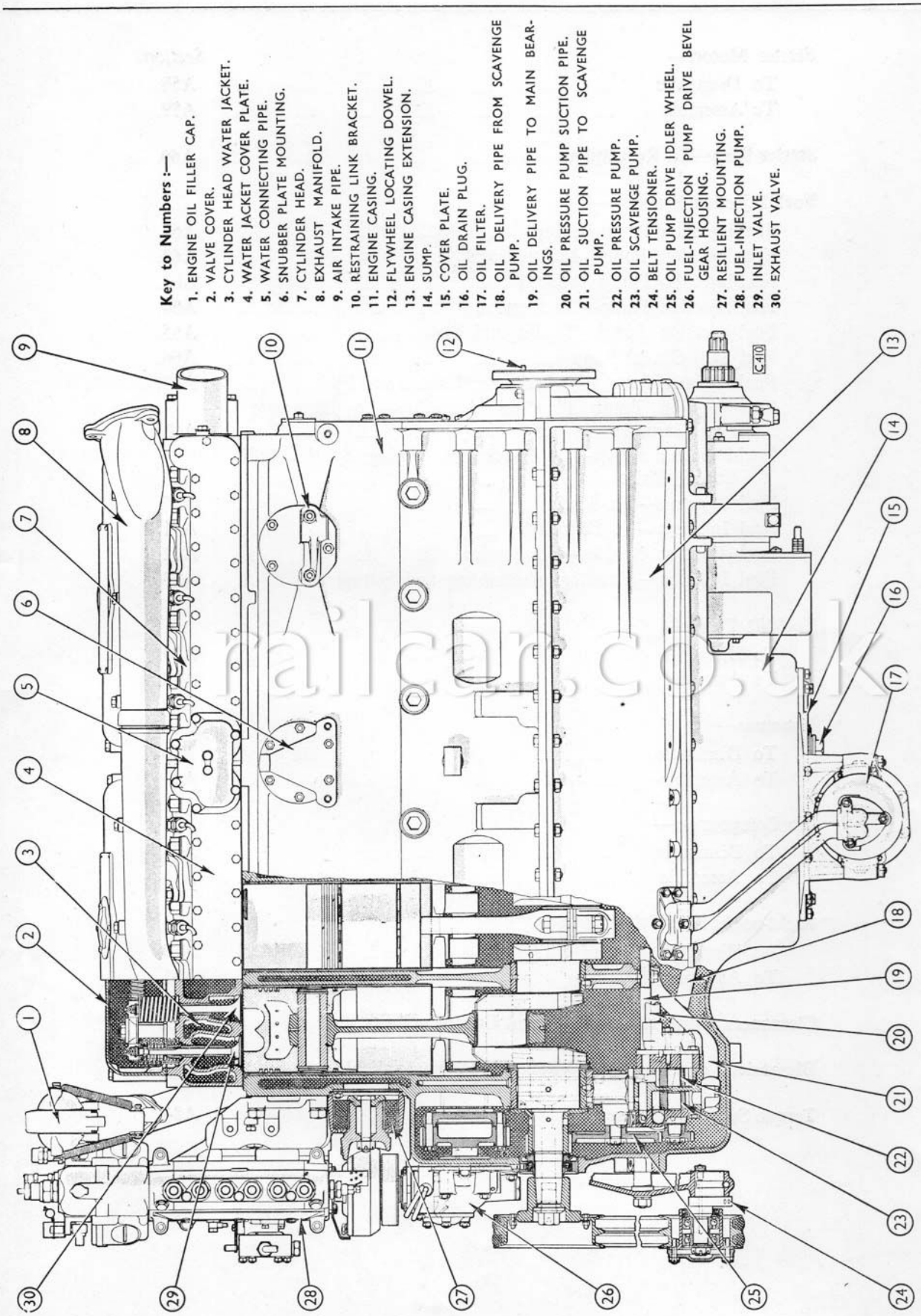


Fig. 1. Longitudinal cross-section of engine.

Sect. A1. ENGINE—DESCRIPTION.

(*See Figs.* 1, 2, 3 *and* 5).

THE B.U.T. 11·3 litre compression ignition horizontal engine is of the four-stroke single-acting direct injection type, incorporating push rod operated overhead valves, and is provided with two detachable cylinder heads each covering three cylinders. The valve rocker gear, valves and the fuel injectors are carried in the cylinder heads, the rocker gear being totally enclosed by two detachable covers.

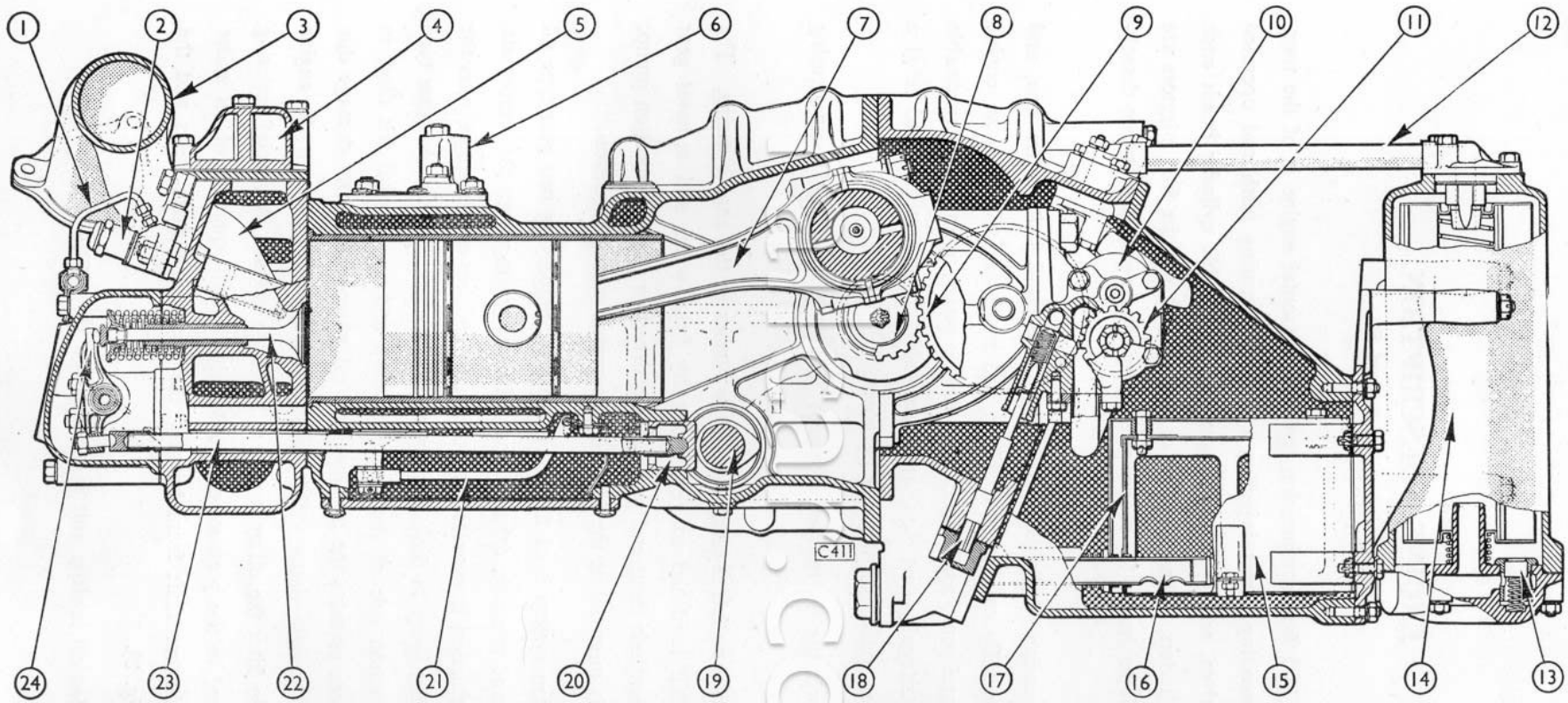
The engine casing is divided vertically at the crankshaft centre line, and comprises an integrally cast cylinder block and crankcase to which an engine casing extension and sump are bolted. The engine casing is fitted with renewable dry liners of centrifugally cast iron, and detachable covers are provided to give access to the water spaces for cleaning purposes.

Crankcase pressure is relieved through a breather on the engine casing extension.

The cast iron camshaft is carried in seven bushes in the engine casing. The cam faces are chill hardened to give immunity from wear, and a bevel gear attached to the camshaft front end provides the drive for the fuel-injection pump; the water pump is mounted at the front of the engine casing extension.

The lubrication system is of the dry sump type, employing two gear-type oil pumps, scavenge and pressure, driven through helical gearing from the crankshaft. Full pressure lubrication is provided for the main and big-end bearings, also the bearings of the idler gears in the oil pump and timing gear drives. A gauze type strainer on the suction side of the pressure pump and an external felt filter in the scavenge system protects the bearings and oil pump gears from damage due to the ingress of foreign matter. Oil grids are also incorporated in the engine casing extension to filter the oil as it returns from the engine. A special metering device, incorporated in the pressure pump, delivers a small quantity of oil under low pressure to the camshaft front bearing, the fuel pump drive gears and the valve gear (*see Fig.* 8).

A water cooled oil cooling unit is mounted on the sump.



Key to Numbers :—

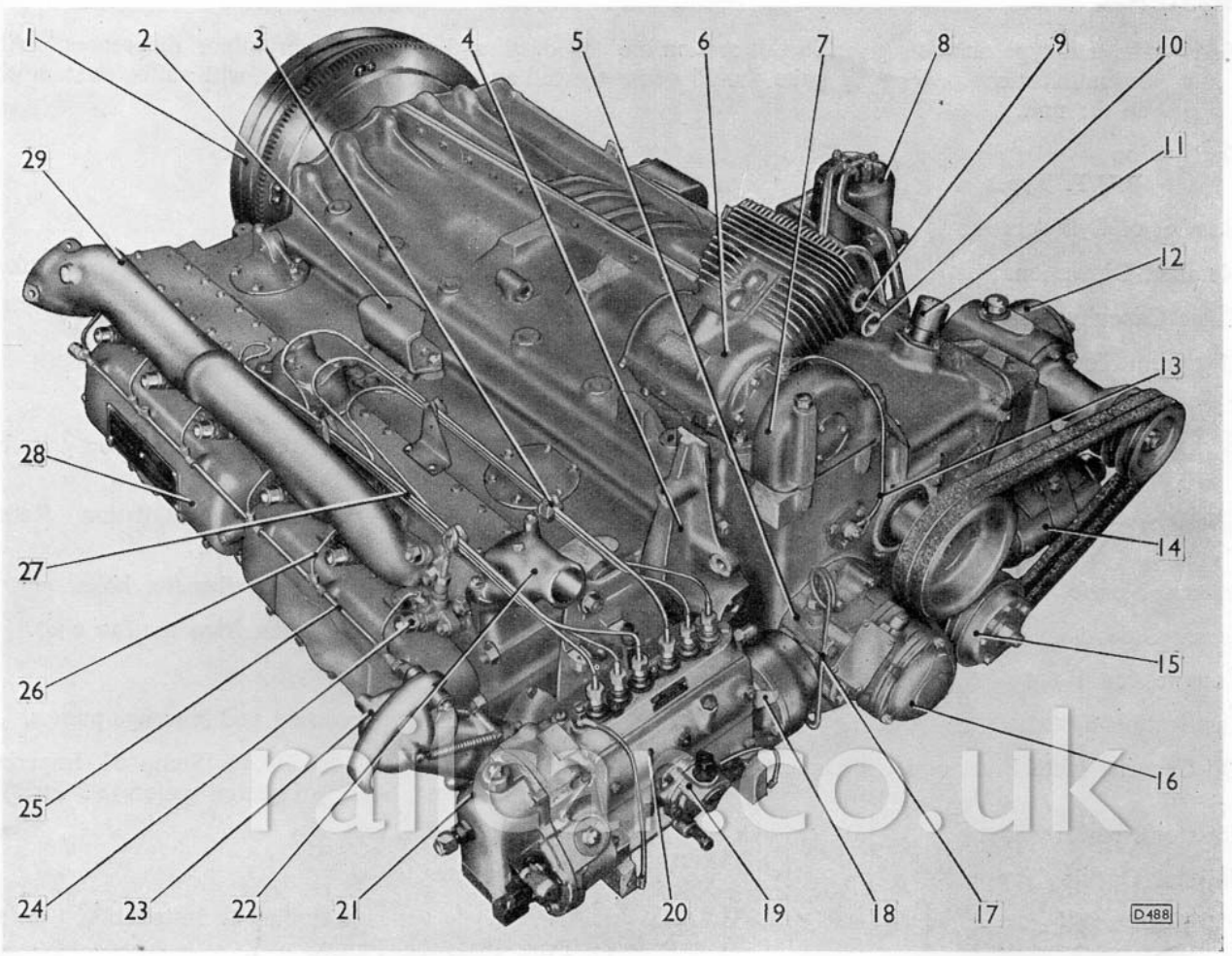
1. FUEL RETURN (OR DRIBBLE) PIPE.
2. FUEL INJECTOR.
3. STANDARD EXHAUST MANIFOLD (DIFFERENT FOR SUPER-CHARGED ENGINES).
4. WATER CONNECTING PIPE.
5. EXHAUST PORT.
6. RESTRAINING LINK BRACKET (NOT FITTED ON SUPER-CHARGED ENGINES).
7. CONNECTING ROD.
8. CRANKSHAFT GEAR.
9. IDLER WHEEL.
10. OIL PUMP.
11. OIL PUMP GEAR.
12. OIL INLET PIPE TO FILTER.
13. OIL FILTER PRESSURE RELIEF VALVE.
14. OIL FILTER.
15. OIL STRAINER COVER.
16. OIL SUCTION PIPE TO OIL PUMP.
17. OIL STRAINER.
18. OIL PRESSURE RELIEF VALVE.
19. CAMSHAFT.
20. TAPPET.
21. OIL FEED PIPE TO ROCKERS.
22. EXHAUST VALVE.
23. PUSH ROD.
24. ROCKER.

Fig. 2. Cross-section through engine.

Sect. A2. ENGINE DATA.

Note.—The unit type numbers given in this section are abridged and do not cover minor differences. All communications concerning units should quote the full and exact type number, with suffix, as stamped on the unit.

Designation B.U.T. Types	A220L, A220S, A220W, A220Y.
Number of Cylinders	6
Nominal Dimensions	130 mm. (5·12 in.) bore × 142 mm. (5·59 in.) stroke.
Cubic Capacity	11·3 litres (690 cu. in.).
Maximum Torque	490 lb. ft. at 1,300 r.p.m.
R.A.C. Rating	62·87 h.p.
Fuel-injection Pump:—	C.A.V. (Type varies according to installation. Refer to Type Plate on Pump).
Governor:—	C.A.V. (Type varies according to installation. Refer to Type Plate on Governor Casing).
Injector Nozzle	C.A.V. BDLL150S.—0·35 mm. diameter holes.
Firing Order	1, 5, 3, 6, 2, 4 (numbers taken from the fan end).
Compression Ratio	16 : 1.
Lubrication System	Dry sump—gear type pressure and scavenge pumps.
Oil Capacity (with Filter and Oil Cooler)	6¼ Imperial gallons (28·3 litres), [Sump 5½ Imperial gallons (25 litres), Filter ¾ Imperial gallon (3·3 litres)].
Injector Nozzle Holder	C.A.V. NLA102S.
Injector Opening Pressure	175 atmospheres.
Fuel-lift Pump	C.A.V. (Type varies according to installation. Refer to Type Plate on Pump).
Combustion Chamber	Direct injection. Toroidal cavity piston.
Valves	Overhead poppet, masked inlet.
Timing Gear and Auxiliaries	Helical gear drive except to fuel-injection pump which has a bevel gear drive.
Water Pump	Centrifugal.
Valve Tappet Clearance	0·010 in. to 0·012 in. (0·25 to 0·30 mm.) (Inlet and exhaust, engine hot).
Maximum Governed Speed (under load)	1,800 r.p.m.
Maximum Runaway Speed (no load)	2,000 r.p.m.
Dynamo	C.A.V. (Type varies according to installation. Refer to Type Plate on Dynamo).
Starter Motor	C.A.V. / Simms (Type varies according to installation. Refer to Type Plate on Starter Motor).
Air Compressor	Clayton Dewandre. (Type varies according to installation. Refer to Type Plate on Compressor).
Engine Speed Indicator Generator	Everett and Edgcumbe B35. Smiths MDG.
Approximate Weight (For lifting purposes)	15¾ cwts. (800 Kg.).



Key to Numbers :—

1. FLUID COUPLING.
2. SNUBBER PLATE.
3. FUEL DELIVERY PIPE CLIP.
4. FRONT SUPPORT BRACKET.
5. BEVEL DRIVE CASING.
6. AIR COMPRESSOR.
7. COMPRESSOR DRIVE HOUSING.
8. OIL FILTER.
9. COMPRESSOR OUTLET PORT.
10. COMPRESSOR INLET PORT.
11. CRANKCASE BREATHER.
12. RIGHT ANGLE DRIVE UNIT—RADIATOR FAN.
13. OIL PIPE TO COMPRESSOR BEARING.
14. OIL COOLER.
15. WATER PUMP PULLEY.
16. SPEED INDICATOR GENERATOR.
17. OIL PIPE—CRANKCASE TO BEVEL DRIVE CASING.
18. FUEL-INJECTION PUMP TIMING POINTER.
19. FUEL-LIFT PUMP.
20. FUEL-INJECTION PUMP.
21. FUEL-INJECTION PUMP GOVERNOR HOUSING.
22. WATER OUTLET CONNECTION.
23. OIL FILLER CAP.
24. FUEL INJECTOR.
25. FUEL INJECTOR GALLERY PIPE.
26. FUEL INJECTOR DRIBBLE PIPE.
27. FUEL DELIVERY PIPES.
28. CYLINDER HEAD COVER.
29. EXHAUST MANIFOLD.

Fig. 3. Three-quarter front view of engine fitted with right-angle fan drive unit.

DYNAMO. (C.A.V.).

DATA.

Make.	Type.	Max. Output.		Dynamo r.p.m.		Brush Spring Pressure.		Field Coils Test.		Drive Ratio.
		watt.	amp.	Cut-in	Max. Output	oz.	gm.	amp.	ohm.	Dynamo Speed / Engine Speed
C.A.V.	G7A24 (as described)	1,320	55	1,150	1,450	12/16	341–454	1·45 at 27 v.	18·6 (Four in series)	1·8 (engine-mounted)

STARTER MOTOR (C.A.V.).

DATA.

Make.	Type.	Lock Torque Test.			Brush Spring Pressure.		Field Coils Test.	
		lb. ft.	Kg.M.	amp.	oz.	gm.	ohm.	Remarks.
C.A.V.	U624 (as described)	65-70	8·9–9·6	1,000 – 1,100	18–24	510 — 680	0·001–0·003	Main field
							1·2	Aux. shunt field
							0·53	Aux. series field

STARTER MOTOR (SIMMS).

DATA.

Make.	Type.	Lock Torque Test.			Brush Spring Pressure.		Coil Test.	
		lb. ft.	Kg.M.	amp.	oz.	gm.	ohm.	Remarks
Simms	SG (as described)	70	9·7	1,000	26–32	737–907	0·005	Each main field coil
							0·205	Engagement solenoid

ENGINE PERFORMANCE CURVES (AT SEA LEVEL AND NORMAL TEMPERATURE) FOR ENGINES FITTED WITH ALL AUXILIARIES EXCEPT FAN.

Power Developed.

Before installation the maximum fuel delivery stop is adjusted to give a minimum of 150 B.H.P. at 1,800 r.p.m., and then sealed. **This stop should not be tampered with in any way.**

Altitude.	Dynamometer test per pint of fuel (568 c.c.) at 1,200 r.p.m.	Hartridge or similar test per 200 pump revolutions at 600 r.p.m.	B.H.P. at 1,800 r.p.m. (minimum).
Sea Level	93 secs.	24·3 ccs.	150
2,000 ft.	97 secs.	23·3 ccs.	140
4,000 ft.	101 secs.	22·4 ccs.	130
6,000 ft.	106 secs.	21·1 ccs.	120

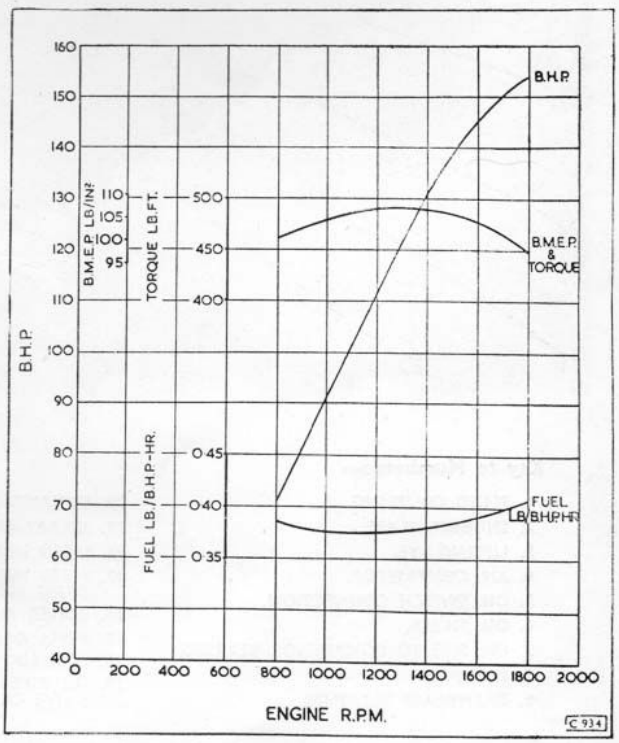


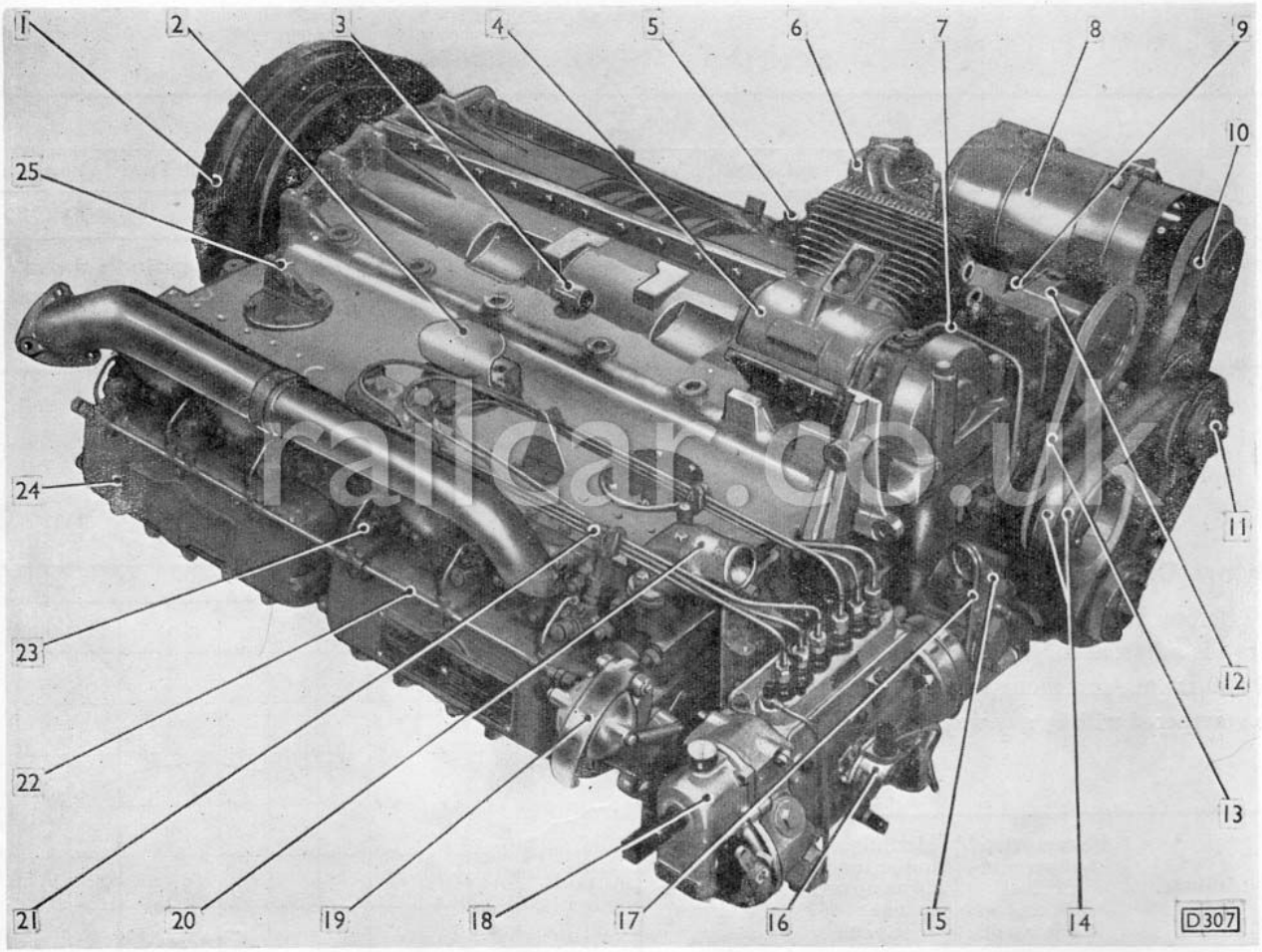
Fig. 4. Average performance curves of 11·3 litre horizontal engine.

ENGINE NUMBER.

(*See Figs.* 3 *and* 5).

The engine number is stamped either on two lugs situated at the front top of the engine midway between the cylinder heads and the engine casing extension or on the lug immediately above the fuel-injection pump securing bracket.

This engine is manufactured in various forms. It is, therefore, important that in all communications the full and exact type number with suffix, is given.



Key to Numbers :—

1. FLUID COUPLING.
2. SNUBBER PLATE.
3. LIFTING EYE.
4. AIR COMPRESSOR.
5. OIL SWITCH CONNECTION.
6. OIL FILTER.
7. OIL PIPE TO COMPRESSOR BEARING.
8. DYNAMO.
9. CRANKCASE BREATHER.
10. DYNAMO DRIVE BELT.
11. JOCKEY PULLEY.
12. SPEED INDICATOR GENERATOR.
13. SPEED INDICATOR GENERATOR DRIVE BELT.
14. WATER PUMP DRIVE BELTS.
15. BEVEL DRIVE CASING.
16. FUEL-LIFT PUMP.
17. OIL PIPE—CRANKCASE TO BEVEL DRIVE CASING.
18. FUEL-INJECTION PUMP.
19. OIL FILLER CAP.
20. WATER OUTLET CONNECTION.
21. FUEL DELIVERY PIPES.
22. FUEL INJECTOR GALLERY PIPE.
23. FUEL INJECTOR.
24. VALVE COVER.
25. RESTRAINT BRACKET.

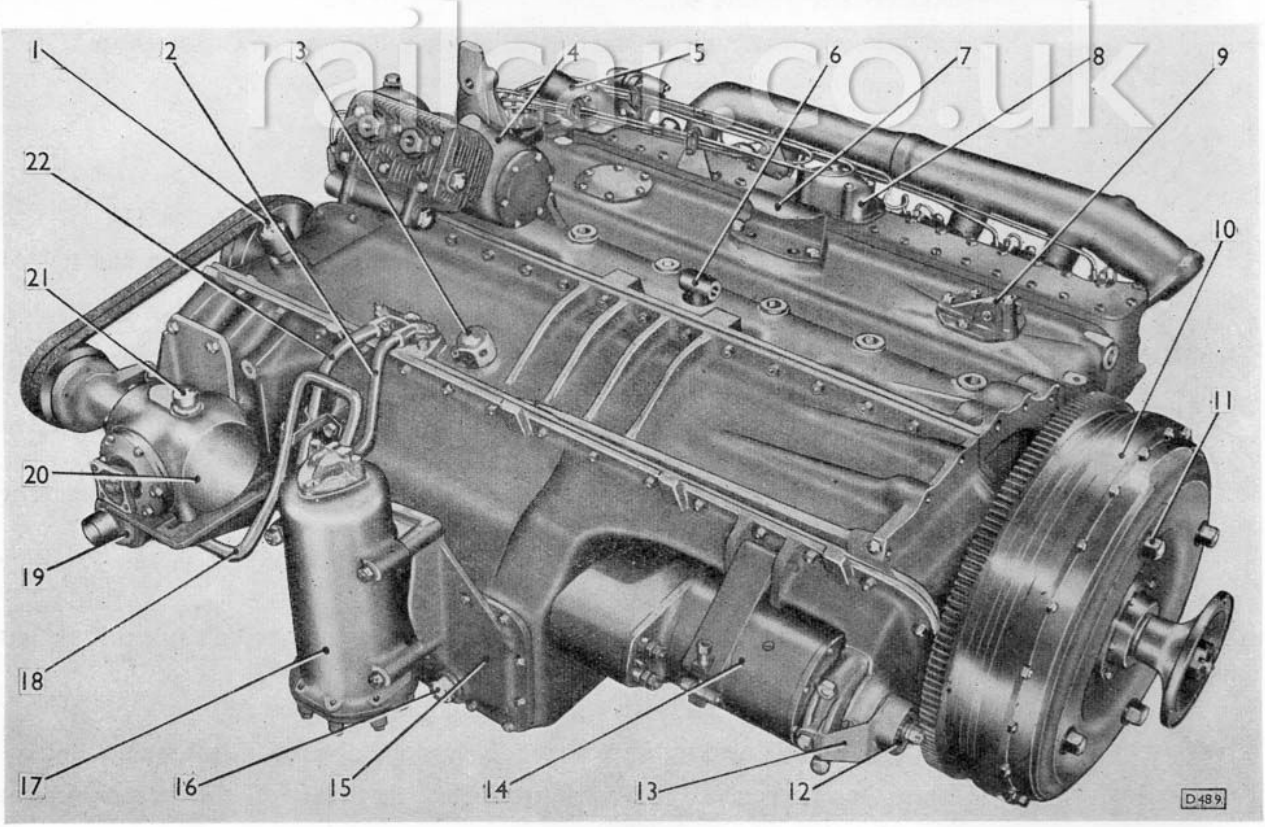
Fig. 5. Three-quarter front view of engine—not fitted with right-angle fan drive unit.

Sect. A3. MAINTENANCE.

Important.—All new or overhauled engines should receive attention, as listed in the first section of the chart below, after the first thousand miles running.

Period.	Attention Required.
AFTER THE FIRST 1,000 MILES (1,500 KM. OF A NEW OR OVERHAULED ENGINE.	Drain the sump, detach the oil strainer, oil cooler and oil filter, clean and refit, (*see Sections* A7, A8 *and* A10).
	Fill the sump and filter with fresh oil; for details of procedure (*see Section* A4).
	Tighten down cylinder heads.
	Check the inlet and exhaust valve tappet clearances (*see Section* A5).
DAILY.	Check level of oil in the sump and, if necessary, top-up to the "Full" mark on the dipstick (*see Section* A4).
	Replenish the fuel tanks.
	Check that the water supply tank is full to ensure a constant supply to the radiator and engine cooling system.
WEEKLY.	Check the level of oil in the fuel-injection pump governor casing, and top-up if necessary to the level plug hole.
	Check the level of oil in the right-angle fan drive unit (if fitted) and top-up if necessary (*see Section* A4).
	Lubricate the water pump and belt tensioner pulley spindles with grease.
	Lubricate the fuel-injection pump control rod linkages.
	Lubricate the fan drive pulley bearings (on early cars).
	Lubricate the water pump pulley bearing.
	Remove, clean, refit and refill the air maze air cleaner (*see Section* 11).
	Examine the air compressor joints and pipe connections for leakage and tighten if necessary.
MONTHLY OR EVERY 5,000 MILES (8,000 K.M.).	Drain the sump, detach the oil strainer, oil cooler and oil filter, clean and refit; fill the sump and filter with fresh oil (*see Sections* A4, A7, A8 *and* A10).
	Drain the right-angle fan drive unit (if fitted) and refill with fresh oil (*see Section* A4).
	Check the tension of the water pump drive belts (*see instructions in the following paragraphs*).
	Check the tension of the dynamo drive belt (*see instructions in the following paragraphs*).
	Check the tension of the drive belts on the right-angle drive unit (*see instructions in the following paragraphs*).
	Check inlet and exhaust valve tappet clearances (*see Section* A5).
	Check all oil, fuel and water pipes for security and absence of leakage.
	Clean the elements in the fuel filters unless they are of the paper element type, and vent the fuel system.
	Lubricate the starter motor bearings (*see Section* A4).

Period.	Attention Required.
EVERY 10,000 MILES (16,000 KM.).	Remove fuel injectors and fit a set of reconditioned ones. Return the old set for servicing (*see Sections* 18 *and* 19). Remove the air compressor cylinder head for examination and withdraw the inlet valve keepers, unscrew the delivery valve caps and withdraw the valve springs and discs. Remove carbon deposits from the valve discs. If the valve discs are ridged or distorted, remove the compressor for overhaul and fit a new or reconditioned unit.
QUARTERLY OR EVERY 15,000 MILES (25,000 KM.).	Check the fuel-injection pump drive coupling rubber for deterioration. Check the fuel-injection pump timing. Check the oil pressure (*see Section* A6). Examine the dynamo and starter motor commutators and brushes (*see following paragraphs*). Renew the elements in the fuel filters and vent the fuel system (*see Sections* A14 *and* A22). Remove the air compressor cylinder head and repeat as for 10,000 Miles but renew the valve discs and springs.
HALF-YEARLY OR EVERY 30,000 MILES (50,000 KM.)	Remove cylinder heads, pistons, etc., carry out general inspection. Examine the teeth of the starter ring and if worn or damaged, report immediately. Remove the air compressor for overhaul and fit a new or reconditioned unit (*see Section* A27). Lubricate the engine lifting gear (if fitted).



Key to Numbers :—

1. CRANKCASE BREATHER.
2. OIL PIPE—FILTER TO SUMP.
3. OIL PRESSURE SWITCH CONNECTION.
4. AIR COMPRESSOR.
5. WATER OUTLET CONNECTION.
6. LIFTING EYE.
7. SNUBBER PLATE.
8. WATER CONNECTING PIPE.
9. RESTRAINT LINK BRACKET.
10. FLUID COUPLING.
11. FLUID COUPLING FILLER PLUG.
12. STARTER MOTOR PINION.
13. PINION GUARD.
14. STARTER MOTOR.
15. OIL SUMP COVER PLATE.
16. OIL SUMP DRAIN PLUG.
17. OIL FILTER.
18. OIL PIPE—OIL COOLER TO FILTER.
19. OIL COOLER.
20. RIGHT-ANGLE DRIVE UNIT—RADIATOR FAN.
21. RIGHT-ANGLE DRIVE FILLER PLUG AND DIPSTICK (IF FITTED).
22. OIL PIPE—SUMP TO OIL COOLER.

Fig. 6. Three-quarter rear view of engine fitted with right-angle fan drive.

Frost Precautions.

If the engine cooling system is not filled with anti-freeze solution and the car is to remain standing in the open with temperatures approaching freezing point, the cooling system must be completely drained.

To Drain the Cooling System.

Close the stop cock fitted to the low water tank and **open** the drain cock fitted to the radiator bottom tank.

Drain cocks should be tested immediately after opening by inserting a piece of wire to ensure that they are clear.

Drain the engine when it is hot and do not leave it unattended until the water has properly drained.

When drained place a notice in a conspicuous place stating that the cooling system is empty and the drain cocks are open.

To Fill the Cooling System.

Ensure that the main water supply tank is full and that the radiator drain cock is **shut.**

Open the stop cock on the low water tank; allow sufficient time for the radiator to fill before running the engine.

Water Pump.

To adjust the drive belts.

Slacken the clamping bolt of the belt tensioner.

To tighten the belts rotate the tensioner in an **anti-clockwise** direction (facing towards the front of the engine) with the aid of a tommy bar in the holes provided.

When correctly adjusted there should be from 1 in. to $1\frac{1}{2}$ in. (25 to 38 mm.) up and down movement in the centre of the **horizontal** run of each belt. Finally re-tighten the clamping bolt.

Right-angle Fan Drive Unit.

To adjust the drive belts.

Slacken the nuts securing the right-angle fan drive unit to its support platform, slide the unit away from the engine and tighten the retaining nuts.

When correctly adjusted there should be from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. (12·7 mm. to 19·1 mm.) up and down movement in the centre of the **horizontal** run of each belt.

Dynamo.

To adjust the drive belt (if fitted).

At periods quoted in the chart at the beginning of this Section check the tension of the drive belts.

The adjustment of the dynamo drive belt should be carried out **after** adjustment of the fan and water pump drive belt has been made (*see above*).

Slacken the nuts securing the dynamo support bracket to the crankcase bottom half.

Raise or lower the support bracket, by means of the jacking screw beneath it, until the correct tension in the belt is obtained. When correctly adjusted there should be from 1 in. to $1\frac{1}{2}$ in. (25 to 38 mm.) slack movement in the belt.

Tighten the securing bolts.

Commutator and brushes.

At periods quoted in the chart at the beginning of this Section the commutator and brushes should be inspected.

To check that the brushes are free in their boxes, hold back the brush springs or triggers and move each brush up and down in its holder by pulling gently on its flexible connections. If movement is not perfectly free, remove the brush from its holder and lightly polish its sides on a smooth file. Always fit the brushes exactly in their original positions. If the brushes are so worn that they do not allow full pressure to be exerted by the spring, new brushes must be fitted.

If the brushes are less than $\frac{3}{8}$ in. (10 mm.) long they should be renewed.

If the commutator is burnt or pitted the dynamo should be removed from the engine for overhaul and a new or reconditioned unit fitted.

After any adjustment has been made the dynamo output should be tested as described below.

Testing in position.

Where the dynamo is belt-driven see that the belts are not slipping by checking their tension.

Remove the terminal box cover and check that the cables are connected to their correct terminals. Sleeves are fitted to the ends of each cable for identification purposes.

Check that these cables are connected to their correct terminals in the control unit.

If the above checks do not disclose an error, see that all lights and accessories are switched off.

Disconnect from the dynamo the three cables marked (+), (−) and (F).

Ascertain the polarity of the terminal(s) marked (F) and then connect a centre-zero ammeter (range 3-0-3) between this terminal and a terminal of opposite polarity.

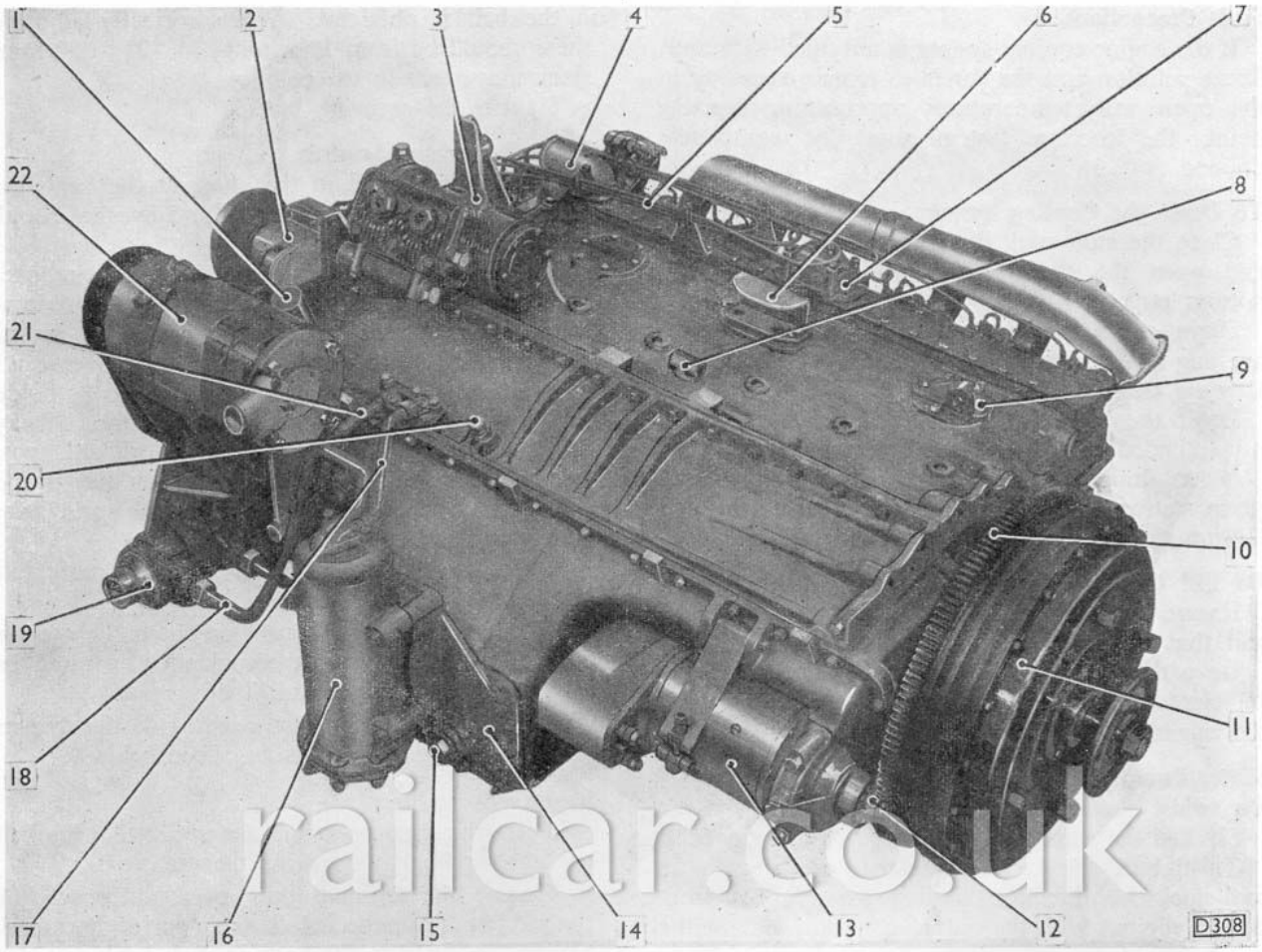
Note.—For split field dynamos with two (F) terminals a test should be made independently from each.

Connect a voltmeter (range 0-30) across the (+) and (−) terminals of the dynamo.

Start the engine and increase its speed until the dynamo terminal voltage is 27. Check that the field current corresponds to that given in Section A2 and take care that the dynamo does not exceed its maximum output speed also given in Section A2.

If the voltmeter remains at zero, check the brush gear and internal connections.

A very low reading throughout the speed rise indicates that the field windings may be faulty. This



Key to Numbers :—

1. CRANKCASE BREATHER.
2. SPEED INDICATOR GENERATOR.
3. AIR COMPRESSOR.
4. WATER OUTLET CONNECTION.
5. FUEL DELIVERY PIPES.
6. SNUBBER PLATE.
7. WATER CONNECTING PIPE.
8. LIFTING EYE.
9. RESTRAINT LINK BRACKET.
10. STARTER RING.
11. FLUID COUPLING.
12. STARTER MOTOR PINION.
13. STARTER MOTOR.
14. OIL SUMP COVER PLATE.
15. OIL SUMP DRAIN PLUG.
16. OIL FILTER.
17. OIL PIPE—FILTER TO SUMP.
18. OIL PIPE—OIL COOLER TO FILTER.
19. OIL COOLER.
20. OIL PRESSURE SWITCH CONNECTION.
21. OIL PIPE—SUMP TO OIL COOLER.
22. DYNAMO.

Fig. 7. Three-quarter rear view of engine, fitted with a dynamo in place of the right-angle fan drive.

will be confirmed by the ammeter reading—if zero, a broken connection is suggested.

In this case, the dynamo should be removed from the car for overhaul, and a new or reconditioned unit fitted.

Starter Motor.

Commutator and brushes.

At periods quoted in the chart at the beginning of this Section the commutator and brushes should be inspected.

To check that the brushes are free in their boxes, hold back the brush springs or triggers and move each brush up and down in its holder by pulling gently on its flexible connections. If movement is not perfectly free, remove the brush from its holder and lightly polish its sides on a smooth file. Always fit the brushes exactly in their original positions.

If the brushes are so worn that they do not bear on the commutator or do not allow full pressure to be exerted by the spring, new brushes must be fitted.

If the commutator is burnt or pitted the starter motor should be removed from the engine for overhaul and a new or reconditioned unit fitted.

Testing in position.

Check the battery to see that it is in a reasonably well charged condition.

See that all cable connections are made securely.

Push the starter button; if the starter motor does not operate, connect a suitable voltmeter, reading up to 24 volts, between the solenoid and the (–) terminals on the starter motor. Push the starter button again; if no reading is indicated on the voltmeter look for a fault in the cables between the button and the starter, or in the windings of the solenoid switch.

Again push the starter button; if the solenoid switch clicks it indicates that this is working on the first contacts only, and full load current is not being applied to the starter motor. A faulty armature adjustment or a worn switch trigger will cause this.

Should the starter motor crash into engagement, inspect the switch trigger and plate for wear on the step and slotted portions respectively.

Intermittent starter motor operation, with the starter button held down, can be caused through second contacts on the solenoid switch being burnt or the starter motor brushes worn. Faulty connections at the starter button or the battery terminal posts or faulty inter-connectors between the batteries are also likely causes.

A worn bearing at the driving end of the starter motor will cause slow engagement and considerable loss of power due to the armature fouling on the pole shoes.

If the starter motor operates but does not turn the engine, possibly the starter motor clutch is slipping or the pinion or flywheel ring teeth are worn. The starter motor itself may have moved in its mounting away from the flywheel, or the battery may be discharged.

Note.—It is impracticable to attempt any adjustments to the starter motor whilst it is in position on the engine.

Sect. A4. LUBRICATION.

The following table gives the details for the lubrication of units.

Item.	Method of Lubricating.	Oil Level.	Type of Lubricant.	Approximate Capacity.
Air Cleaner	Clean and Refill	Level Mark	Engine Oil (*A.E.C. Specification No. L13*)	3 pints (1·7 litres)
Engine	Drain Oil and Refill	Dipstick	Engine Oil (*A.E.C. Specification No. L20*)	6¼ gallons (28·4 litres)
Fuel-injection Pump	Fill on assembly	Overflow Pipe	Engine Oil (*A.E.C. Specification No. L13*)	¼ pint (0·14 litre)
Fuel-injection Pump Governor	Drain Oil and Refill	Level Plug	Engine Oil (*A.E.C. Specification No. L13*)	¼ pint (0·14 litre)
Right-angle Fan Drive (if fitted)	Drain Oil and Refill	Dipstick	Gear Oil (*A.E.C. Specification No. L6*)	½ pint (0·28 litre)
Fan Drive Pulley Bearing	Grease Gun 1 Nipple	—	Grease (*A.E.C. Specification No. L11*)	—
Water Pump Spindle	Grease Gun 1 Nipple	—	Grease (*A.E.C. Specification No. L11*)	—
Lifting Chain Sprocket Spindle (if fitted)	Grease Gun 1 Nipple	—	Grease (*A.E.C. Specification No. L11*)	—
Starter Motor	1 Plug	—	Engine Oil (*A.E.C. Specification No. L13*)	–
Dynamo	Pre-packed bearings	—	Grease (*A.E.C. Specification No. L11*)	—
Engine Speed Indicator Generator	Pre-packed bearings	—	Grease (*A.E.C. Specification No. L11*)	—
Fuel-injection Pump Operating Rod Fork-end Pins	Oil Can	—	Engine Oil (*A.E.C. Specification No. L13*)	—

To Drain the Right-angle Fan Drive unit.

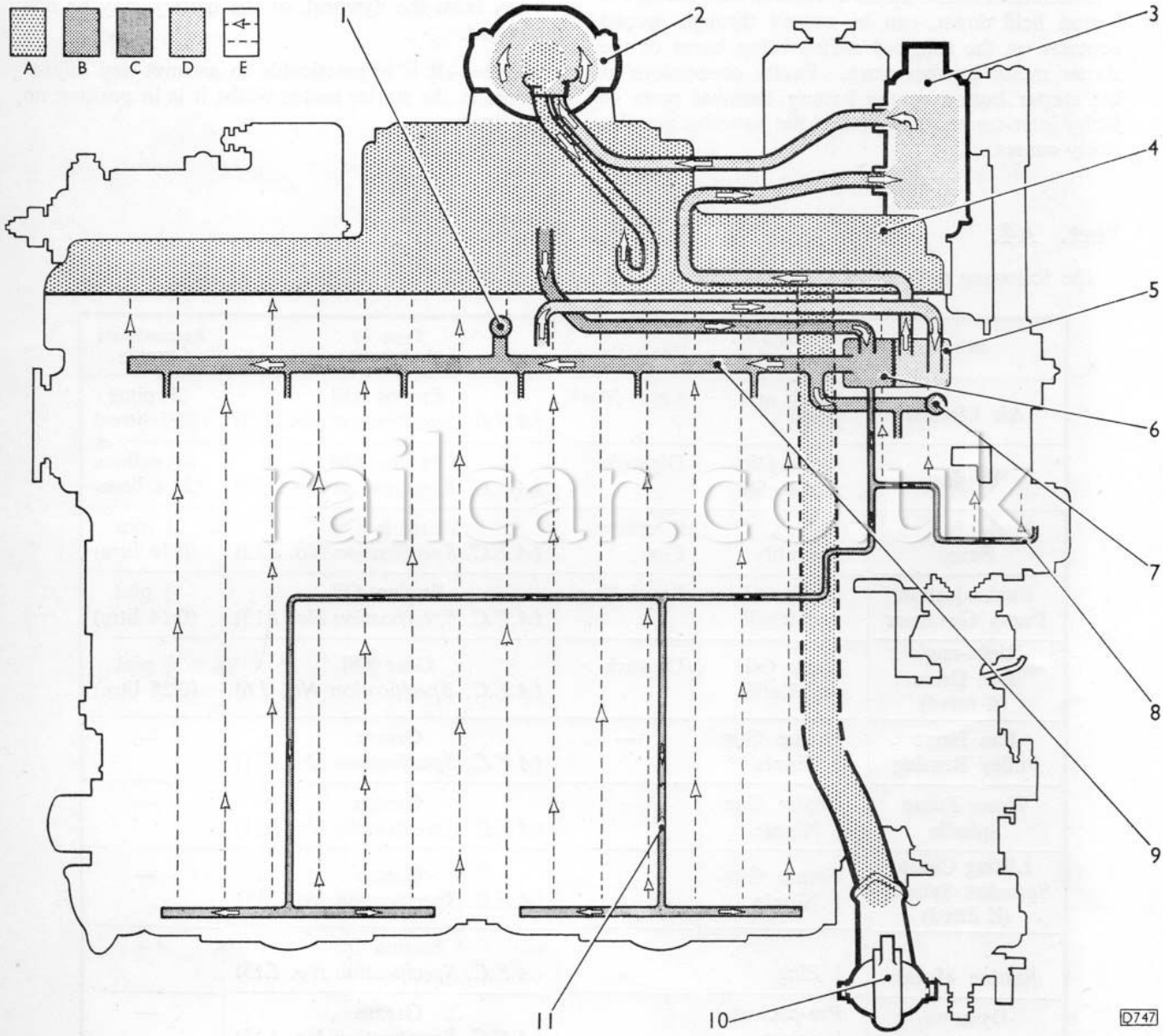
Whenever possible the unit should be drained immediately after the car has completed a run and the oil is warm.

Place a suitable container in position and drain the oil from the unit by removing the drain plug. (*see Fig.* 23).

To Fill the Right-angle Fan Drive unit.

Units fitted with a combined filler plug and dipstick should be filled with oil to the top mark on the dipstick.

Units fitted with a filler plug should be filled to the level of the filler plug hole.



Key to Letters :—

- **A.** OIL IN SUMP.
- **B.** HIGH PRESSURE SYSTEM.
- **C.** LOW PRESSURE SYSTEM.
- **D.** SCAVENGE SYSTEM.
- **E.** " SPLASH."

Key to Numbers :—

1. OIL PRESSURE SWITCH.
2. OIL FILTER.
3. OIL COOLER.
4. SUMP.
5. CIRCULATING PUMP.
6. PRESSURE PUMP.
7. OIL PRESSURE ADJUSTER.
8. PIPE TO BEVEL DRIVE.
9. PIPE TO CRANKSHAFT AND CONNECTING RODS.
10. OIL FILLER CAP.
11. PIPE TO VALVE ROCKER ASSEMBLY.

Fig. 8. Diagrammatic view of engine lubricating system.

To Drain the Engine.

Whenever possible the engine should be drained when the oil is warm i.e., immediately after the car has completed a run.

Place a suitable container in position and drain the oil from the engine by removing the drain plugs from the sump and the lower side of the engine casing extension (*see Figs.* 5 *and* 6).

To Fill the Engine.

Fill the engine sump to a level approximately ¾ in. **below** the "Full" mark on the dipstick **(ensuring first that the car is standing on level ground).** Run the engine at fast idling speed for 5 minutes; then stop the engine, recheck the oil level and, if necessary, top-up to the "Full" mark on the dipstick.

A further check (on level ground) must be made later, **immediately after stopping the engine,** either at the end of the day or at any other convenient time **provided that the engine has been running for over 45 minutes since the first check.** Again top-up, if necessary.

NOTE.—Engine sumps should be filled with an oil to the following engine oil specification (L.20). Other units requiring an engine oil should at all times be filled with an oil conforming to A.E.C. Specification No. L13.

SPECIFICATION OF ENGINE OIL.

(*See note above*).

Detergent Type Oil for use in the engine where the atmospheric temperature is normally between 20° F. (minus 6·7°C.) and 90°F. (32·2°C.).

(*A.E.C. Specification No. L*20).

The **BASE OIL** should be of a type generally similar to that required by A.E.C. Specification No. L18, particularly with regard to viscosity.

The oil should contain the necessary additive(s) as recommended by the oil supplier. To be free from objectionable odour.

When tested by the methods of the American Co-ordinating Research Council, CRC-L4-949 and CRC-L1-545 (with such modifications as may be necessary when applying these methods of test in the United Kingdom) the oils shall meet the acceptance standards required by the United States Ordnance Department's specification MIL-L-2104A.

Oils supplied to this specification shall be compatible with each other.

The additive(s) shall be wholly soluble in the oils and shall remain uniformly distributed throughout them at all temperatures above the specified pour points up to 250° F. (121° C.).

The foaming stability of the oil shall be such that, after allowing ten minutes for the foam to collapse, the residue of foam is not more than 25 ml. when the oil is tested at 200° F. (93·5° C.), and not more than 300 ml. when the oil is tested at 75° F. (24° C.), after cooling from 200° F. (93·5° C.).

Non-detergent Type Oil for use where the atmospheric temperature is normally between 20 F. (minus 6·7° C.) and 90° F. (32·2° C.).

(*A.E.C. Specification No. L*18.).

Description.—To be a pure hydrocarbon oil refined by the Solvent Extraction Process, thoroughly filtered to remove all solid matter. To be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity and objectionable odour. A pour point depressant may be added to ensure compliance with the pour point specified.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

Viscosity (Redwood No. 1) at 140° F. (60° C.)	95—110 seconds (22·0—26·5 centistokes)
Viscosity (Redwood No. 1) at 210° F. (99° C.)	46 seconds minimum (7·8 centistokes)
Viscosity Index	90 minimum
Pour Point	0° F. (minus 17·7° C.) maximum
Closed Flash Point	400° F. (204·4° C.) minimum
Acidity (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·005 per cent. maximum
Carbon Residue (Ramsbottom)	0·3 per cent. maximum

Oxidation Characteristics.—

Viscosity Ratio at 140° F. (60° C.)	1·5 maximum
Increase in Carbon Residue	0·6 per cent. maximum
Asphaltenes in Oxidised Oil	0·05 per cent. maximum

SPECIFICATION OF ENGINE OIL.

For use with units other than the engine.

(*A.E.C. Specification No. L*13).

Description.—To be a pure hydrocarbon oil refined by the Solvent Extraction Process, thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity and objectionable odour.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

Viscosity (Redwood No. 1) at 140° F. (60° C.)	160—175 seconds (39—42·5 centistokes)
Viscosity (Redwood No. 1) at 210° F. (99° C.)	55 seconds minimum (11·0 centistokes)
Viscosity Index	90 minimum
Closed Flash Point	400° F. (204·4° C.) minimum
Pour Point	15 F. (minus 9·4° C.) maximum
Acidity (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·005 per cent. maximum
Carbon Residue (Ramsbottom)	0·5 per cent. maximum

Oxidation Characteristics.—

Viscosity Ratio at 140° F. (60° C.)	1·5 maximum
Increase in Carbon Residue	0·7 per cent. maximum
Asphaltenes in Oxidised Oil	0·05 per cent. maximum

SPECIFICATION OF GEAR OIL.

(*A.E.C. Specification No. L*6).

Description.—To be a pure hydrocarbon oil thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

Specific Gravity	0·950 maximum
Viscosity (Redwood No. 1) at 140° F. (60° C.)	850—950 seconds (205—235 centistokes)
Viscosity (Redwood No. 1) at 200° F. (93·3° C.)	165 seconds minimum (39·5 centistokes)
Pour Point	30° F. (minus 1·1° C.) maximum
Closed Flash Point	490° F. (254·4° C.) minimum
Acidity (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·02 per cent. maximum
Asphaltenes	0·10 per cent. maximum

SPECIFICATION OF GREASE.

(*A.E.C. Specification No. L*11).

Description.—The grease to be a smooth, homogeneous preparation possessing no bad odour. To be suitable for lubrication of roller and ball bearings.

The grease to be prepared from refined and filtered mineral oil together with saponifiable materials of good quality, saponified with a good grade lime. Rosin or rosin oil must not be present. The grease also to be entirely free from mineral filling matter of any kind, or grit. To exhibit no tendency for oil to separate on storage or to emulsify with water.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the grease must conform with the following requirements:—

Soap Base	Lime
Drop Point	203° F. (95° C.) minimum
Worked Penetration	230—260 units
Heat Resistance (*see Appendix A*)	No oil separation or hardening
Copper Strip Corrosion (*see Appendix B*)	Negative
Viscosity of Mineral Oil (Redwood No. 1) at 140° F. (60° C.)	130 seconds minimum (31·5 centistokes)
Colour of Mineral Oil	Pale
Ash (As CaO)	2·0 per cent. maximum
Ash (Sulphated)	4·9 per cent. maximum
Water	1·0 per cent. maximum
Free Alkali and/or Acid	2·0 mgms. KOH per gm. maximum

Appendix A.

Method for Determining Heat Resistance of Grease.

A portion of grease weighing 10—20 gms., contained in a clock glass of suitable dimensions, shall be maintained at 248° F. (120° C.) in an air oven for a period of one hour. The test sample shall then be left undisturbed for twenty four hours at room temperature. At the conclusion of the test period, the sample shall be examined for oil separation, and signs of cracking. Upon being worked with a spatula, the grease shall return to a consistency resembling that of the material prior to heating.

Appendix B.

Corrosion Test for Grease.

The test shall be carried out as described in I.P. 112. It shall be conducted at room temperature, the period of immersion of the copper test piece in the grease being twenty four hours. At the conclusion of the test, the copper strip shall show no signs of discoloration.

Sect. A5. VALVE ADJUSTMENTS.

(*See Figs.* 9 *and* 10).

Valve clearances should always be checked **after** tightening the cylinder head securing nuts.

The running clearance between each valve thimble and rocker pad must be 0·010 in. to 0·012 in. (0·25 to 0·30 mm.) for both inlet and exhaust valves. Clearances must be set when the engine is **hot** and the tappets are on the backs of the cams.

To facilitate turning the crankshaft and to obviate the possibility of the engine starting inadvertently, slacken off the injectors, thus releasing compression from the cylinders, also slacken off the fuel delivery pipe union nuts from the fuel-injection pump.

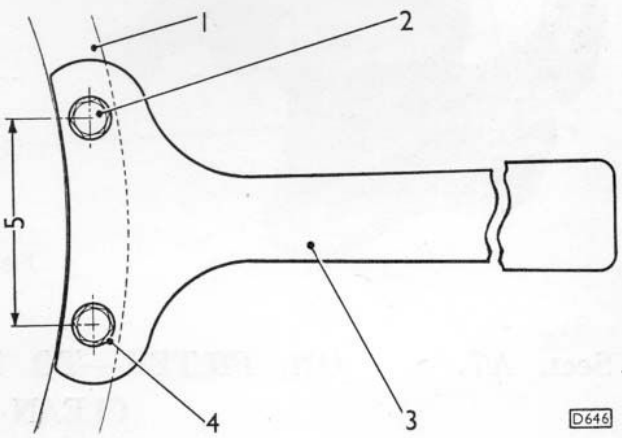
Turn the crankshaft, by using a suitable tool to turn the fluid coupling (*see Fig.* 9), until the valve is open fully, then turn through one complete revolution to bring the tappet on to the back of the cam.

Treat each valve separately in this way.

To adjust the tappet, loosen the locknut, then turn the adjusting screw by means of a screwdriver in the slot provided.

When the correct clearance is obtained, hold the adjusting screw in position with the screwdriver and tighten the locknut at the same time (*see Fig.* 10).

Tighten the fuel delivery pipe unions and injector securing nuts.



Key to Numbers :—

1. DRIVING MEMBER RIM.
2. DRIVING MEMBER RETAINING SET-SCREWS.
3. LEVER FOR TURNING ENGINE.
4. SET-SCREW LOCATING HOLES, 0·75 in. (19 mm.) DIA.
5. 2·98 in. (75·7 mm.).

Fig. 9. Tool for turning engine crankshaft.

Sect. A6. OIL PRESSURE RELIEF VALVE.

(*See Figs.* 2 *and* 8).

The relief valve by-passes oil from the pressure system whenever excessive pressure is reached, particularly in a cold engine.

As a general rule it should be unnecessary to alter the initial adjustment; the correct pressure, with the engine **hot**, should be 50 lb. per sq. in. at the governed speed of 1,800 r.p.m.

Provision is made to fit an oil pressure switch on the engine casing extension (*see Figs.* 6 *and* 7).

Adjustment of the pressure is effected by removing the small domed shaped cover, located on the underside of the engine, lifting off the steel lock washer and turning the square-ended spindle. To **raise** the pressure, screw in the spindle in a **clockwise** direction or vice versa.

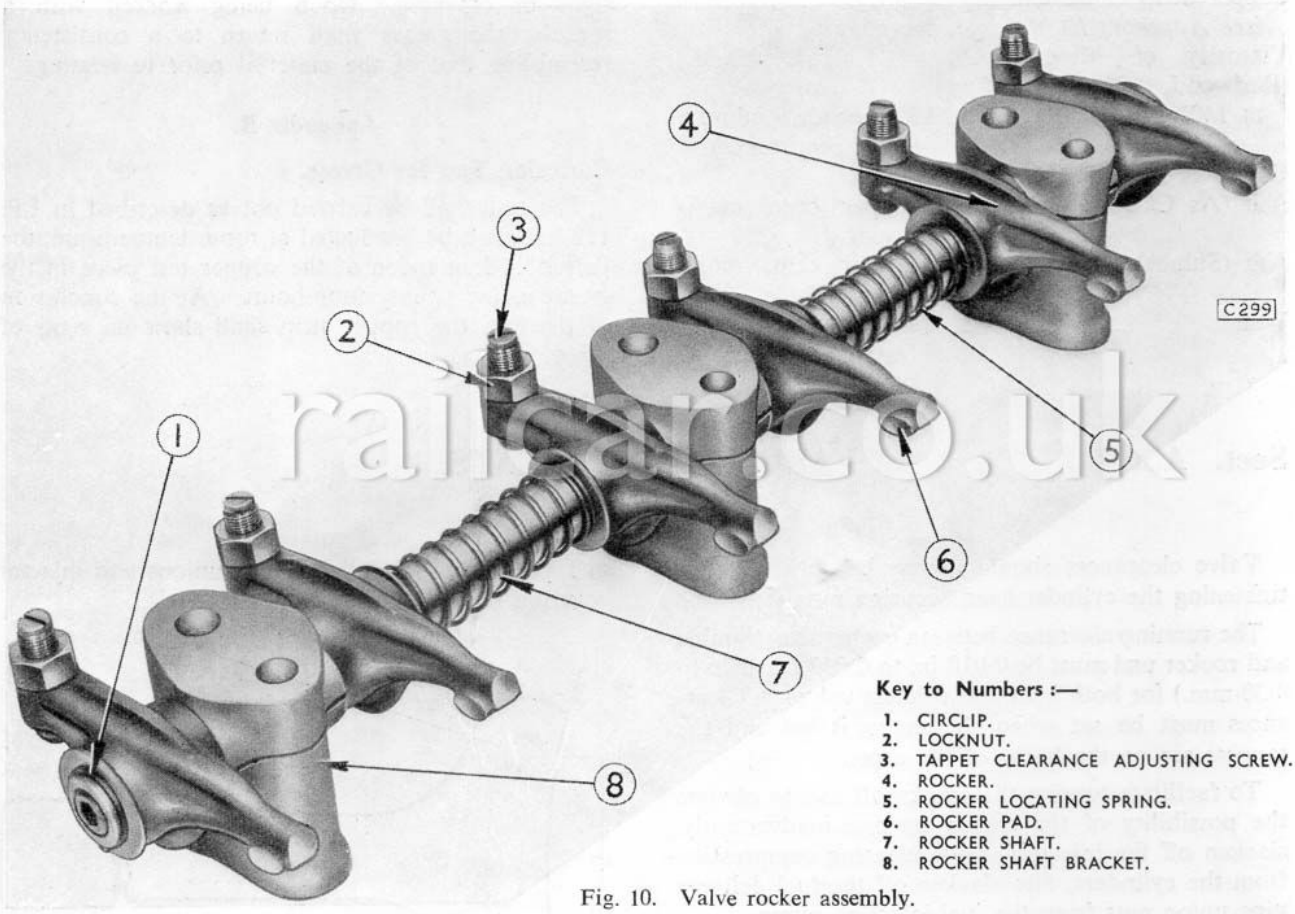


Fig. 10. Valve rocker assembly.

Sect. A7. OIL FILTER—TO REMOVE, DISMANTLE, CLEAN AND FIT.

(*See Fig.* 11).

To Remove.

This operation should be carried out in conjunction with the cleaning of the oil strainer and oil cooler (*see Sections A8 and A9*).

Remove the pipe assembly, connecting the oil cooler and the oil filter to the engine, by unscrewing the retaining nuts and set-screws.

Unscrew the oil filter securing nuts and remove the filter.

Drain out the oil [there will be approximately ¾ gallon (3·4 litres)].

To Dismantle.

Remove the nuts and washers securing the cover to the bottom of the filter body.

Remove the cover and withdraw the element together with the two element retaining plates and the element retaining spring.

To Clean.

Scrape the element to remove the deposit from the serrations, then wash the element in clean paraffin, squeeze it to remove as much of the paraffin as possible, and finally allow it to drain.

Clean out the body of the filter.

Remove the relief valve by unscrewing its plunger guide from the filter cover and withdrawing the plunger and the spring. Clean the passage in the filter cover; clean also the relief valve, plunger guide, plunger and spring.

To Fit.

Soak the element in clean engine oil. Place one of the element retaining plates on one end of the filter element with its boss facing inwards and insert it into the filter body; fit the other element retaining plate to the other end of the element, with its boss facing inwards, and place the retaining spring on the retaining plate.

Refit the relief valve to the filter cover and fit the cover to the body with its **copper and asbestos** joint and lock with a piece of wire.

Fit the filter to the engine by reversing the procedure given for removal.

Check the oil pressure (*see Section* A6).

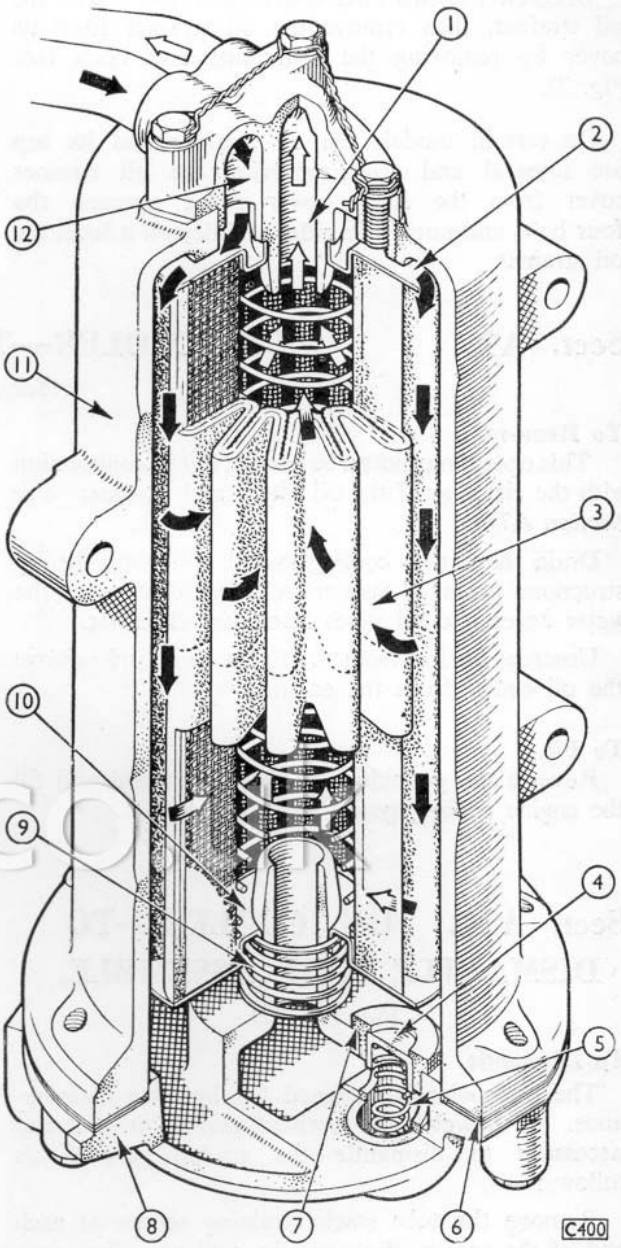


Fig. 11. Cut-away view of oil filter.

Key to Numbers :—

1. OIL OUTLET TO ENGINE.
2. FILTER ELEMENT RETAINING PLATE.
3. FILTER ELEMENT.
4. RELIEF VALVE PLUNGER.
5. RELIEF VALVE SPRING.
6. COPPER AND ASBESTOS JOINT.
7. RELIEF VALVE PLUNGER GUIDE.
8. COVER.
9. FILTER ELEMENT RETAINING SPRING.
10. FILTER ELEMENT RETAINING PLATE.
11. FILTER BODY.
12. OIL INLET FROM ENGINE.

Sect. A8. OIL STRAINER—TO REMOVE, CLEAN AND FIT.

To Remove.

This operation should be carried out in conjunction with the cleaning of the oil filter and oil cooler (*see Section* A7).

Drain the oil from the sump by removing the drain plug from the cover plate (*see Fig.* 6).

Remove the oil filter (*see Section* A7).

Unscrew the nuts securing the cover plate to the sump.

Remove the cover plate together with the oil strainer and oil strainer cover.

Unscrew the nuts and bolts and detach the cover plate from the oil strainer cover.

Unscrew the two nuts and remove the top of the oil strainer, then remove the oil strainer from its cover by removing the four nuts and bolts (*see Fig.* 2).

On certain models the oil strainer and its top are integral and after removing the oil strainer cover from the sump cover plate, unscrew the four bolts and nuts in its sides and detach it from the oil strainer.

To Clean.

Wash the strainer, cover and cover plate thoroughly in clean paraffin and allow to drain.

To Fit.

Fit the parts in the reverse order to their removal ensuring that the oil holes in the oil strainer and its cover are in line.

Fill the engine with fresh oil (*see Section* A4) and check the oil pressure (*see Section* A6).

Sect. A9. OIL COOLER—TO REMOVE AND FIT.

(*See Fig.* 12).

To Remove.

This operation should be carried out in conjunction with the cleaning of the oil filter and strainer (*see Section* A7).

Drain the engine cooling system following the instructions given in Section A3, and disconnect the water hoses and oil pipes from the oil cooler.

Unscrew the nut from the fixing strap and remove the oil cooler from the engine.

To Fit.

Reverse the procedure given for removal and fill the engine cooling system (*see Section* A3).

Sect. A10. OIL COOLER—TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 12).

To Dismantle.

The oil cooler is designed to eliminate maintenance. If however at overhaul periods it is found necessary to dismantle the cooler proceed as follows: —

Remove the tube stack retaining screws at each end of the cooler. Remove the rubber sealing rings by pressing the tube stack out of its housing approximately $\frac{3}{4}$ in. (19 mm.) in either direction.

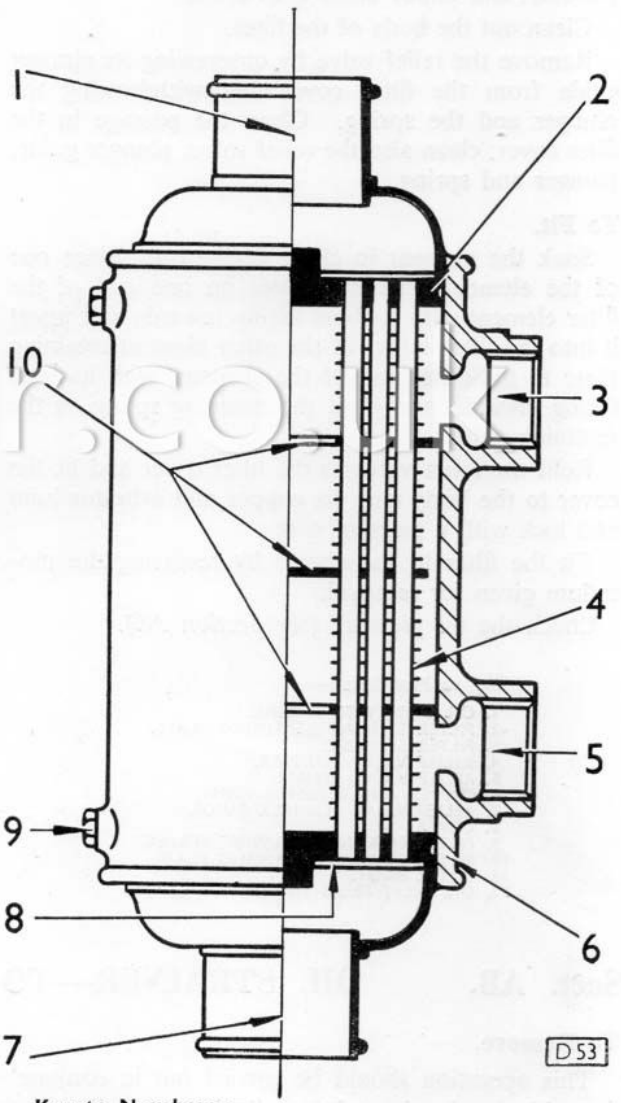
Each movement will expose a rubber sealing ring which must be removed before completely removing the tube stack.

To Assemble.

Wash the parts in clean paraffin and push a rod or wire through each tube to ensure that they are clear.

If an air line is available, apply the nozzle to the unit to clear all traces of dirt or paraffin.

Reverse the procedure given for dismantling, renewing the rubber sealing rings.



Key to Numbers :—

1. WATER INLET.
2. SEALING RING.
3. OIL OUTLET.
4. FLOW GUIDE PLATE.
5. OIL INLET.
6. CASING.
7. WATER OUTLET.
8. TUBE PLATE.
9. TUBE STACK RETAINING SCREW.
10. BAFFLE PLATES.

Fig. 12. Section through oil cooler.

Sect. A11. AIR CLEANER—MAINTENANCE.

(*See Fig.* 13).

Remove the pre-cleaner.

Unscrew the securing bolt which passes through the air cleaner.

Lift off the cleaner complete taking care not to spill the oil contained in the bowl.

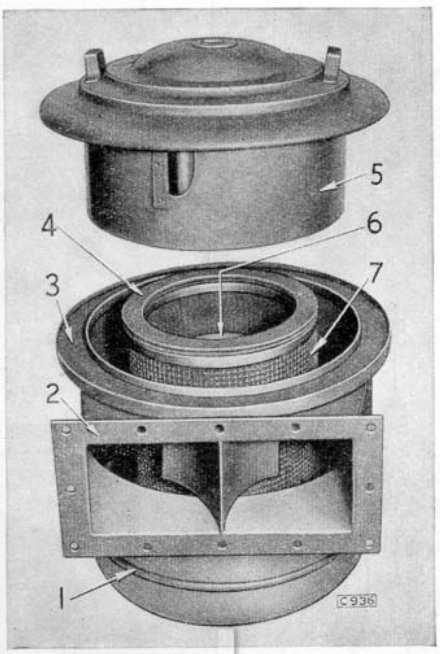
Remove the screens, wash thoroughly in clean paraffin and allow to drain.

Empty the oil from the base portion and wash out any sediment with clean paraffin.

Fill the base portion with clean engine oil up to the level mark just above the bead around the bowl; **do not overfill;** approximate quantity 3 Imperial pints (1·7 litres) (*see Section* A4).

Check that the cork washers are in good condition and in position, then refit the screens, top cover and securing bolt.

Clean and refit the pre-cleaner.



Key to Numbers:—

1. OIL LEVEL MARK.
2. AIR INTAKE WITH PRE-CLEANER REMOVED.
3. CORK JOINT.
4. CORK JOINT.
5. COVER.
6. AIR OUTLET PIPE.
7. FILTER ELEMENT.

Fig. 13. Section through air cleaner.

Sect. A12. STARTER MOTOR—DESCRIPTION.

(C.A.V. TYPE U624) (*see Fig.* 14).

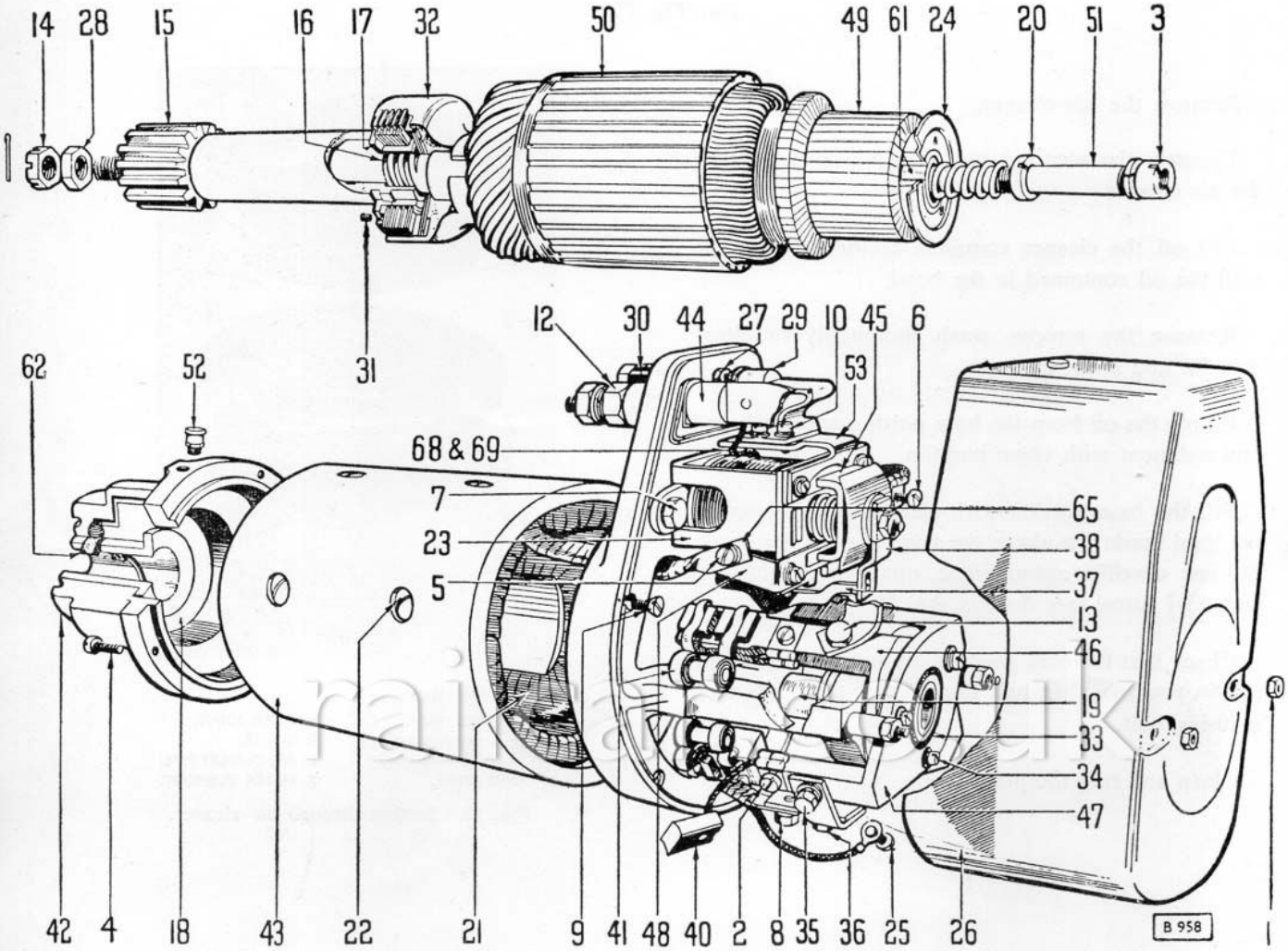
This 24-volt starter motor is of the axial type and provided with a built-in solenoid switch giving two-stage operation.

The field winding is divided into (a) two main series field coils, (b) two auxiliary coils, each made up of an auxiliary shunt coil, and (c) an auxiliary series coil. When the starter button is operated, the magnetic field set up in the switch windings draws in the plunger until the trigger catch plate rests on the step in the trigger. This movement closes the moving contact (long arm) on to the fixed contact; this completes the auxiliary series and shunt field coil circuits, giving the starter armature its axial movement, and gently but positively engages the pinion with the teeth on the flywheel starter ring.

This travel of the armature trips the trigger, permitting the plunger to be drawn further in, closing the contact (short arm) on to the second contact. Thus the circuit through the starter main series coils is completed and the starter develops its maximum power.

A device which prevents damage occurring due to any overload is also fitted. This is a simple screw and spring-loaded clutch arrangement which has a slipping torque greater than the lock torque of the starter, but below shearing strength of the pinion teeth.

The identification symbols are stamped on the nameplate affixed to the driving end frame barrel.



Key to Numbers :—

1. COMMUTATOR COVER NUTS.
2. BRUSH FLEXIBLE CONNECTION SCREW.
3. PLUNGER NUT (OUTER).
4. DRIVING END FRAME SCREWS.
5. MAIN FIELD TERMINAL SCREW.
6. AUXILIARY FIELD TERMINAL SCREW.
7. SOLENOID SWITCH FIXING SCREW.
8. MAIN AND AUXILIARY FIELD TERMINAL SCREW.
9. COMMUTATOR END FRAME FIXING SCREW.
10. POSITIVE TERMINAL CONNECTOR SCREWS.
12. NEGATIVE TERMINAL NUT.
13. NEGATIVE CONNECTOR TERMINAL SCREW.
14. DRIVING PINION SLOTTED NUT.
15. DRIVING PINION AND SLEEVE.
16. PINION SPRING.
17. CLUTCH SLEEVE.
18. DRIVING END BEARING.
19. COMMUTATOR END BEARING
20. ARMATURE PLUNGER NUT.
21. FIELD COILS.
22. POLE SHOE FIXING SCREWS.
23. SOLENOID SWITCH.
24. SOLENOID SWITCH TRIPPING PLATE.
25. AUXILIARY FIELD NEGATIVE TERMINAL SCREWS.
26. COMMUTATOR END COVER.
27. SOLENOID TERMINAL NUT.
28. DRIVING PINION PLAIN NUT.
29. POSITIVE TERMINAL CONNECTION.
30. "SOL." TERMINAL.
31. CLUTCH PRESSURE SPRING.
32. CLUTCH HOUSING.
33. INSULATING BUSH.
34. BRUSH-HOLDER FIXING SCREW.
35. NEGATIVE CONNECTOR FIXING SCREW.
36. NEGATIVE CONNECTOR FIXING SCREWS.
37. SOLENOID SWITCH TRIGGER.
38. TRIGGER CATCH PLATE
40. BRUSHES.
41. BRUSH SPRINGS.
42. DRIVING END FRAME.
43. CARCASE (OR YOKE).
44. NEGATIVE TERMINAL CONNECTION.
45. SOLENOID SWITCH MOVING CONTACT
46. BRUSH GEAR NEGATIVE ARM.
47. BRUSH GEAR POSITIVE ARM.
48. SOLENOID SWITCH FIXED CONTACT.
49. COMMUTATOR.
50. ARMATURE.
51. ARMATURE SPRING PLUNGER.
52. LUBRICATOR.
53. SOLENOID SWITCH FIXED CONTACT.
61. COMMUTATOR END BEARING BUSH.
62. FELT LUBRICATING PAD.
65. MAIN FIELD COIL NEGATIVE TERMINAL.
68. POSITIVE COIL FLEXIBLE CONNECTION.
69. NEGATIVE COIL FLEXIBLE CONNECTION.

Fig. 14. Exploded view of C.A.V. starter motor.

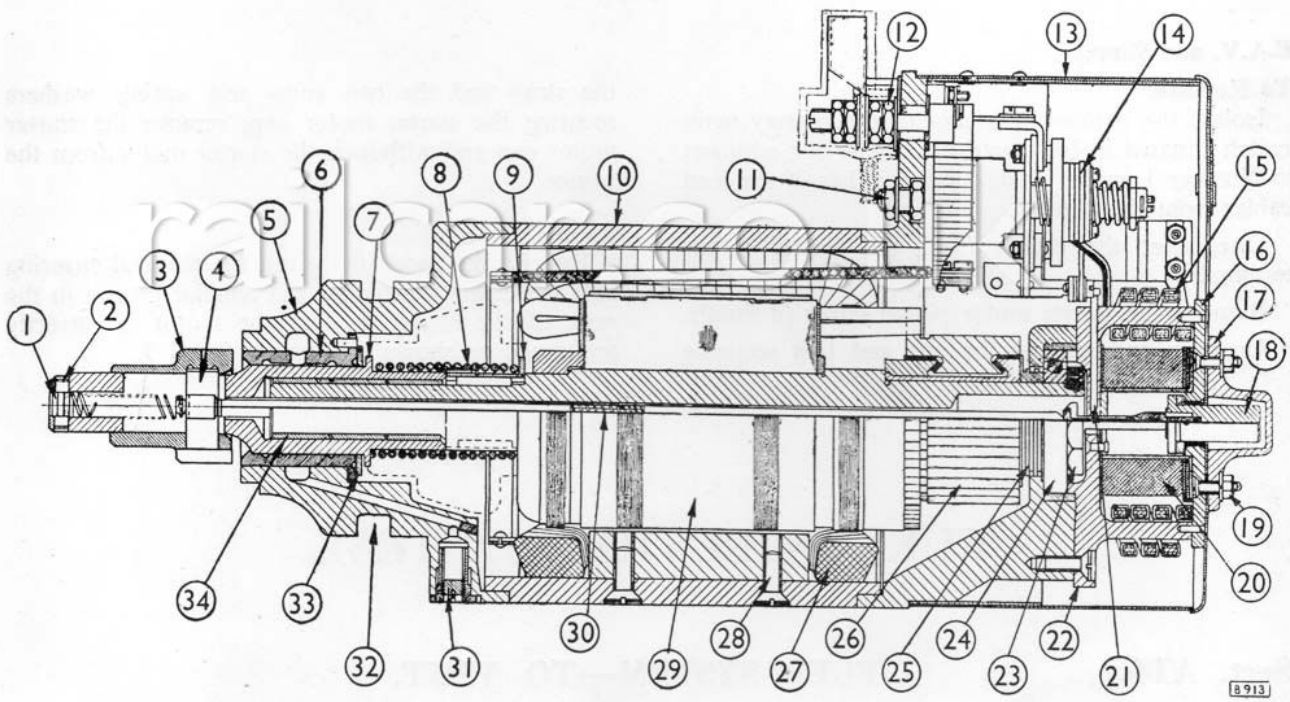
(SIMMS TYPE SG) (*see Fig.* 15).

This 24-volt starter motor is of the axial type and is provided with a built-in solenoid switch giving two-stage operation. The field winding, which is in series with the armature, consists of four coils in parallel connected in pairs to each negative brush.

The pinion shaft is in line with the armature shaft, the drive between the two being transmitted by the spring release clutch to guard against overloads.

The pinion shaft is splined and carries the internally-splined pinion which is brought forward into the engagement position by two push rods passing through the hollow pinion and armature shafts from the solenoid-actuated plunger at the commutator end. The solenoid is wound with the engagement winding and holding-on winding, whilst above the commutator is the two-stage solenoid switch. Between the two push rods is the shock spring, and the hollow nose of the pinion shaft is fitted with a coil spring to hold the pinion in—or return it to—its rest position.

On operating the starter push button the solenoid switch coil is energised and draws in the plunger, closing the first contacts and thereby partially energising the field coils so as to bring the pinion gently into mesh with the flywheel gear ring by an axial movement combined with a slow rotation of the armature. The shock spring safeguards the pinion against jamming, should pinion and flywheel starter ring meet tooth to tooth.



Key to Numbers :—

1. PLUG.
2. CROSS DUMBELL.
3. INTERNALLY SPLINED PINION.
4. CROSS KEY.
5. NOSE.
6. NOSE BEARING.
7. PINION SHAFT.
8. SPRING RELEASE CLUTCH.
9. DRIVING SLEEVE.
10. CARCASS.
11. SOLENOID SWITCH FIXING NUT.
12. SOLENOID TERMINAL.
13. COMMUTATOR END COVER.
14. TWO-STAGE SOLENOID SWITCH.
15. HOLDING-ON WINDING.
16. SOLENOID END PLATE.
17. PLUNGER COVER.
18. SOLENOID ACTUATED PLUNGER.
19. PLUNGER AND COMMUTATOR END COVER FIXING NUT.
20. ENGAGEMENT WINDING.
21. SWITCH TRIGGER OPERATING ROD.
22. SOLENOID FRAME.
23. COMMUTATOR END SHAFT NUT.
24. COMMUTATOR END BEARING.
25. OIL GROOVES.
26. COMMUTATOR.
27. FIELD COIL.
28. POLE SHOE FIXING SCREW.
29. ARMATURE.
30. SHOCK SPRING.
31. TAPPED LUBRICATION HOLE.
32. DOWEL BOLT GROOVE.
33. STEEL THRUST WASHER.
34. SELF LUBRICATING BUSH.

Fig. 15. Section through Simms starter motor.

As soon as the pinion is fully engaged, the switch trigger is tripped and the second contacts of the switch are closed. This action short-circuits the engagement coil and puts into circuit the holding-on winding, simultaneously applying full voltage to the field coils and causing the motor to develop its full power.

When the engine fires, the armature current, and hence the holding-on coil current, is reduced to a minimum. The return spring thereupon overcomes the pull of the "holding-on" coil and returns the pinion smartly to its rest position, where it rotates freely until the push button is released.

The identification symbols are stamped on the plate affixed to the rear of the commutator end cover.

C.A.V. and Simms Starter Motors.—Waterproof tape is used to seal the joints at the commutator end cover to prevent the ingress of water, and a guard is fitted to stop mud and grit accumulating in the starter pinion teeth.

Sect. A13. STARTER MOTOR—TO REMOVE AND FIT.

(*See Figs.* 6 *and* 7).

C.A.V. and Simms.

To Remove.

Isolate the battery by means of the battery main switch situated in the electrical control box adjacent to Number 1 engine or disconnect either of the feed cables from the battery.

Disconnect the cables from the starter motor terminals.

Remove the starter motor pinion cover (if fitted).

Unscrew and remove the nut and bolt securing the strap and the two nuts and spring washers securing the starter motor cap; remove the starter motor cap and withdraw the starter motor from the engine.

To Fit.

Reverse the procedure given for removal ensuring that the dowel bolt enters the annular groove in the nose of the starter so that the motor is correctly positioned as shown in Figures 6 and 7.

FUEL-INJECTION SYSTEM.

Sect. A14. FUEL SYSTEM—TO VENT.

AFTER REMOVAL OF THE FUEL TANK OR **ANY** PART OF THE FUEL SYSTEM, e.g. INJECTORS, PIPES, FILTERS, PUMP, ETC., THE SYSTEM MUST BE VENTED TO EXPEL ALL AIR.

It is essential that all air should be removed from the system as even air bubbles will interfere with the regularity of the fuel-injection.

Proceed as follows:—

Check that there is a supply of fuel in the fuel supply tanks.

Check that the air vent hole adjacent to the filler cap of the fuel supply tank is free from obstruction.

Check that the main fuel filter(s) is/are full of fuel oil.

Unscrew the air release **screw(s)** on the main filter(s) **one turn** (*see Figs.* 18 *and* 20) and operate the hand priming lever of the fuel-lift pump (*see Fig.* 17) until fuel free from air bubbles appears around the air release screw(s); then tighten the screw(s). Open the air vent cock on the driving end of the fuel-injection pump and again operate the

hand priming lever until fuel free from air bubbles flows from the pipe on the air vent cock.

Start the engine and allow it to run at idling speed with the air vent cock open until all trace of air bubbles in the fuel has disappeared, then close the vent cock **whilst the engine is still running.**

If the system is free of air, the engine, when hot, should accelerate rapidly and without hesitation. If this does not occur, then with the engine idling, slacken off each fuel delivery pipe union at the injector end in turn, just sufficiently to allow fuel to seep out, and watch for air bubbles between the pipe and the union nut. Should bubbles be detected, leave the nut slack until air-free fuel appears, then tighten down. Treat each union in turn in this manner and finally open the air vent cock for a few moments.

It is a wise precaution to do this even though the aforementioned acceleration test does indicate that all air has been removed.

Note.—If union nuts are slackened off more than just enough to allow the fuel to seep out, the force with which the fuel issues from the pipe will produce a froth even if no air is present in the pipe.

IT IS A GOOD PLAN TO VENT THE FUEL-INJECTION PUMP PERIODICALLY WHILE THE ENGINE IS RUNNING AND THUS MAKE SURE THAT THE SYSTEM IS KEPT FREE OF AIR AT ALL TIMES.

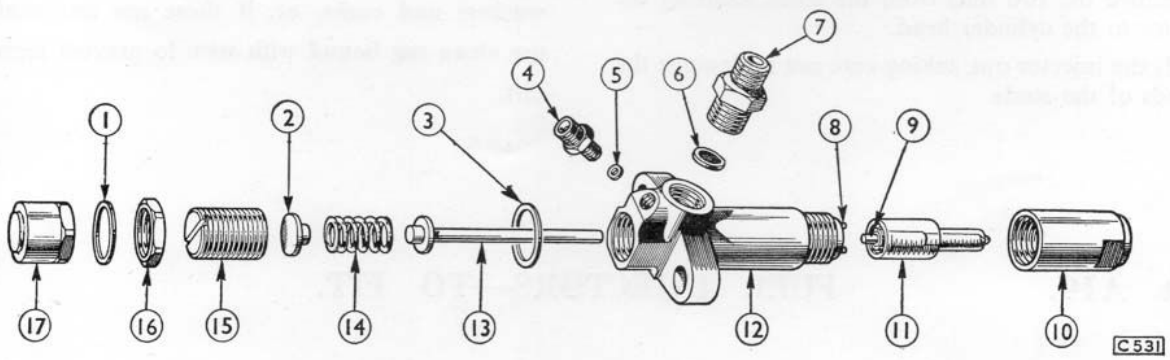
Sect. A15. FUEL INJECTORS—DESCRIPTION.

(*See Fig.* 16).

The fuel injectors fitted to the B.U.T. 11·3 litre direct-injection horizontal oil engine are of the multi-hole type; on no account must they be interchanged with those used on any other make of engine.

The injector is, in effect, a simple spring-loaded valve adjusted to open automatically as soon as the fuel oil reaches a predetermined pressure, the quantity of fuel oil delivered to the injector being controlled by the fuel-injection pump. The slight leakage of fuel which lubricates the nozzle valve and accumulates within the spring chamber is returned through the dribble pipe and gallery pipe, which connects up to the fuel supply tank.

A disc filter is contained in the fuel inlet connection.



Key to Numbers :—

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

Fig. 16. Exploded view of injector.

Sect. A16. SYMPTOMS OF FUEL INJECTOR TROUBLES.

Any troubles experienced with injectors will probably be accompanied by one or more of the following:—

Heavy smoke from the exhaust when the engine is hot and pulling on load.

Pronounced knocking in the affected cylinder.

Complete or intermittent misfiring.

Loss of power.

Sect. A17. FAULTY FUEL INJECTOR—TO LOCATE.

Very often it is possible to locate an injector which is not working correctly, by slackening off the fuel delivery pipe union nut two or three turns at the injector end and allowing the fuel to leak past the threads whilst the engine is running slowly. This prevents fuel passing through the nozzle into the cylinder. If no change is detected in the performance of the engine or sound of the exhaust, it is reasonable to assume that the injector is faulty.

Fit a spare injector and vent the fuel system (*see Section* A14). Blank off the inlet pipe and dribble pipe unions, fit a dust cap to the nozzle of the faulty injector and return it for servicing.

Sect. A18. FUEL INJECTORS—TO REMOVE.

Disconnect the fuel delivery and dribble pipes from the injector.

Remove the two nuts from the studs securing the injector to the cylinder head.

Lift the injector out, taking care not to damage the threads of the studs.

If injectors are not being refitted immediately, blank off the inlet and dribble pipe unions with dust washers and corks, or, if these are not available, use clean rag bound with wire to prevent ingress of dirt.

Sect. A19. FUEL INJECTORS—TO FIT.

Place the injector in the copper sleeve in the cylinder head. **Do not fit a gasket or washer as this sleeve forms the only gasket that is required.**

The injector should drop into place without being forced.

Place the nuts on the studs securing the injector to the cylinder head, **and tighten them evenly, half-a-turn at a time,** to prevent distortion of the injector.

Connect the fuel delivery pipe from the pump to the injector.

Connect the dribble pipe to the injector.

Examine all fuel pipe connections for leaks, correct as necessary, and vent the system as described in Section A14.

Sect. A20. FUEL-LIFT PUMP—DESCRIPTION.

(*See Fig.* 17).

The fuel-lift pump is driven by an eccentric on the fuel-injection pump camshaft and is flange-mounted on the side of the fuel-injection pump. It draws fuel from the supply tank via a filter and forces it at constant pressure via the main filter to the fuel-injection pump. The fuel is lifted by the suction of a diaphragm which is supported on both sides by a thin backing plate.

When the pressure in the pipe line between the lift pump and the injection pump reaches a predetermined figure the diaphragm remains in its depressed position and no further fuel is forced along the line until the pressure drops sufficiently to allow the diaphragm to resume pumping.

The fuel line can be primed by moving the priming lever until the operator feels no resistance to the movement of the lever.

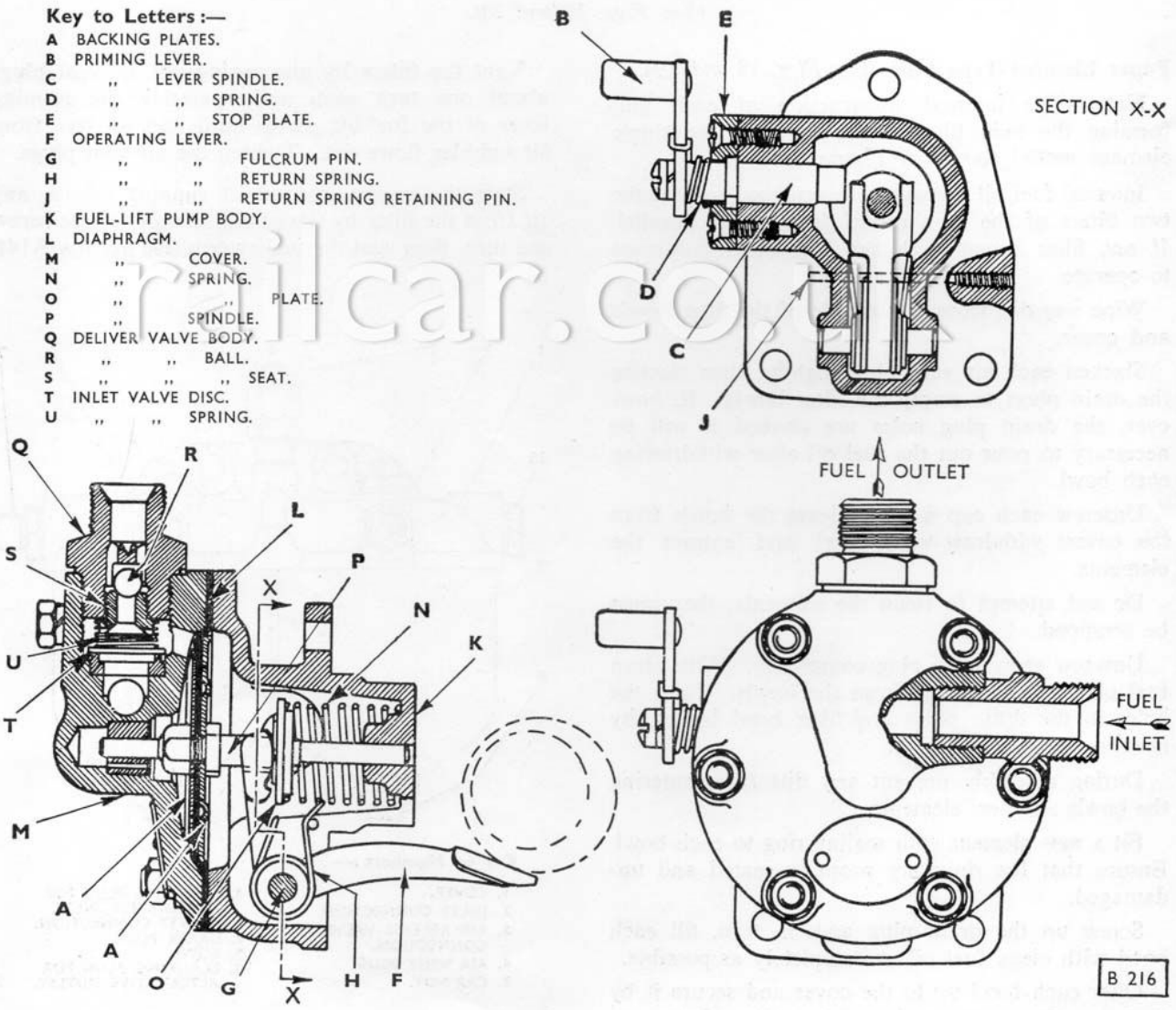


Fig. 17. Sections through C.A.V. fuel-lift pump.

Sect. A21. FUEL-LIFT PUMP—TO REMOVE AND FIT.

(*See Figs.* 3 *and* 17).

The fuel-lift pump is attached to the facing on the injection pump by three nuts.

To Remove.

Disconnect the inlet and outlet fuel pipe connections from the lift pump, then unscrew the three fixing nuts and remove the lift pump from the fuel-injection pump.

To Fit.

Fit a new paper joint to the fuel-lift pump fixing flange, then tighten it down on to the facing on the fuel-injection pump, using jointing compound.

Connect up the inlet and outlet fuel pipes.

Vent the fuel system (*see Section* A14).

Sect. A22. MAIN FUEL FILTERS—MAINTENANCE.

(*See Figs.* 19 *and* 20).

Paper Element Type Filter (*see Figs.* 18 *and* 19).

Note.—The internal construction of each unit forming the twin filter is the same as the single element model shown in Figure 19.

Internal fuel oil passages are arranged so that the two filters of the twin model function in parallel. If one filter becomes choked, the other continues to operate.

Wipe any dirt from the outside of the filter bowls and cover.

Slacken each air vent plug slightly; then slacken the drain plugs to empty the filter bowls. If, however, the drain plug holes are choked it will be necessary to pour out the fuel oil after withdrawing each bowl.

Unscrew each cap nut to release the bowls from the cover; withdraw each bowl and extract the elements.

Do **not** attempt to clean the elements; they must be scrapped.

Unscrew each drain plug completely. With clean fuel oil wash all sludge from the bowls. Clear the holes in the drain plugs and filter bowl bosses, by inserting a piece of wire.

During assembly prevent any dirt from entering the bowls and new elements.

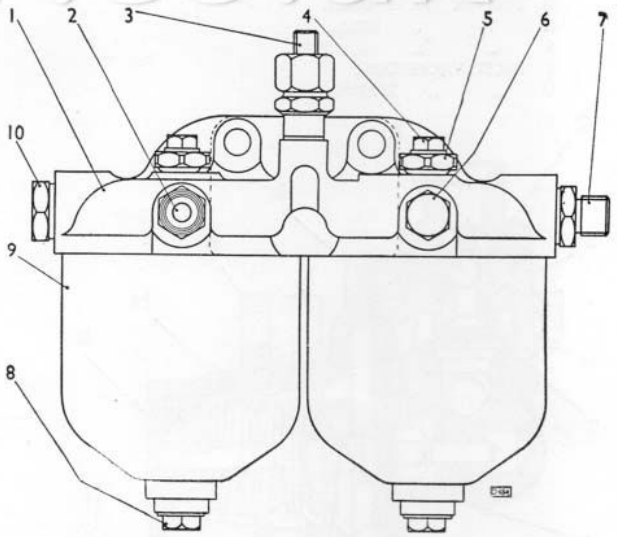
Fit a **new element** with sealing ring to each bowl. Ensure that the rings are properly seated and undamaged.

Screw up the drain plug and, in turn, fill each bowl with clean fuel oil as completely as possible.

Offer each bowl up to the cover and secure it by engaging the centre stud and cap nut. Screw up the cap nuts firmly.

Vent the filters by unscrewing the air vent plugs about one turn each and operating the priming lever of the fuel-lift pump until fuel oil, free from air bubbles, flows out. Tighten the air vent plugs.

Start the engine and whilst running release any air from the filter by slackening the air release screw one turn, then vent the fuel system (*see Section* A14).



Key to Numbers :—

1. COVER.
2. INLET CONNECTION.
3. AIR RELEASE VALVE CONNECTION.
4. AIR VENT PLUG.
5. CAP NUT.
6. BLANKING PLUG FOR ALTERNATIVE INLET.
7. OUTLET CONNECTION.
8. DRAIN PLUG.
9. BOWL.
10. BLANKING PLUG FOR ALTERNATIVE OUTLET.

Fig. 18. Arrangement of fuel filter (C.A.V.) —twin paper element type.

Cloth Element Type Filter (*see Fig.* 20).

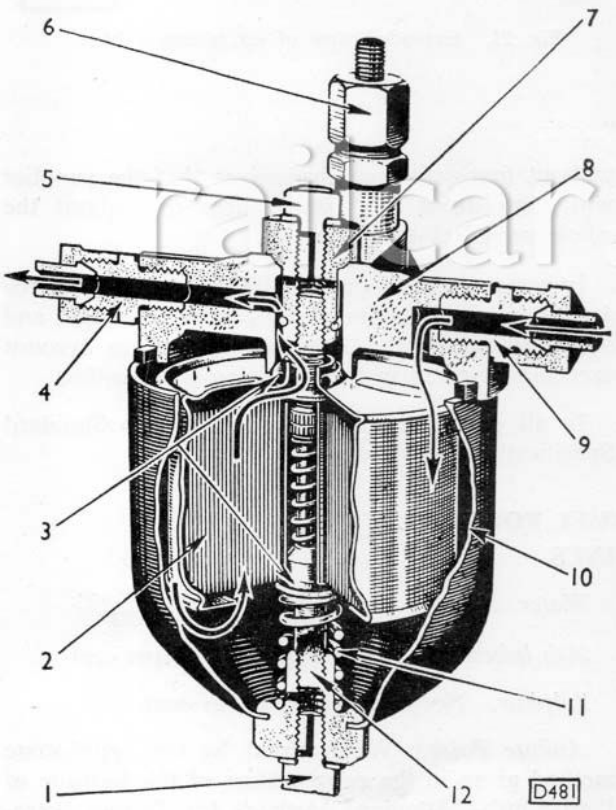
To Clean.

Unscrew the centre nut in the top cover, remove the bowl and extract the element. Fit clean cork plugs in the top and bottom of the element to prevent the ingress of dirt. Swill the element and felt washers in clean fuel oil; remove the bottom plug from the bowl and wash the bowl in clean fuel oil until all the sludge is removed.

When assembling, guard against dirt entering the filter (particularly the inside of the element).

Refit the element.

Check that the rubber washer is in good condition and in position in the top cover.



Key to Numbers :—

1. DRAIN PLUG.
2. PAPER ELEMENT.
3. OIL SEALS.
4. OUTLET CONNECTION.
5. AIR VENT PLUG.
6. AIR RELEASE VALVE CONNECTION.
7. CAP NUT.
8. COVER.
9. INLET CONNECTOIN.
10. BOWL.
11. PRESSURE SPRING.
12. CENTRE STUD.

Fig. 19. Section of fuel filter (C.A.V.) —paper element type.

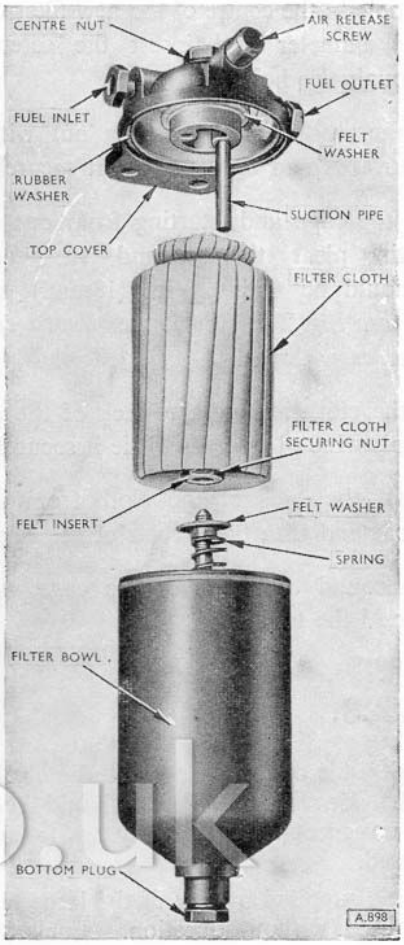


Fig. 20. Exploded view of main fuel filter (C.A.V.) —cloth element type.

Fill the bowl with fuel oil then attach it to the top cover and tighten the centre nut securely. Start the engine and whilst running release any air from the filter by slackening the air release screw one turn, then vent the fuel system (*see Section* 14).

The air release valve does not require attention unless it becomes stuck due to dirt, when it should be detached from the filter, the split pin removed and the parts cleaned and refitted (*see Fig.* 21).

If the filter becomes inefficient, immediately fit a new filter cloth to the element.

To fit a new filter cloth.

Remove the securing nut and washer from the bottom of the cage, cut the twine and remove the old filter cloth.

Cut a hole in the centre of the new filter cloth ½ in. (13 mm.) diameter and insert the screw of the cage through the hole.

Refit the washer and securing nut with its felt insert outwards and tighten the nut securely.

Invert the cage and, starting from one corner of the cloth, pleat this around the cage. The pleats should be about ½ in. (13mm.) wide and uniform (*see Fig.* 20). Tuck the pleated ends down inside the cage throat.

Bind the cloth around the neck of the cage with the special twine provided and tie it securely.

Pull out the ends of the cloth from inside the cage throat and **trim them clear of the cage joint.**

Paint around the neck of the cage with water glass to seal the twine.

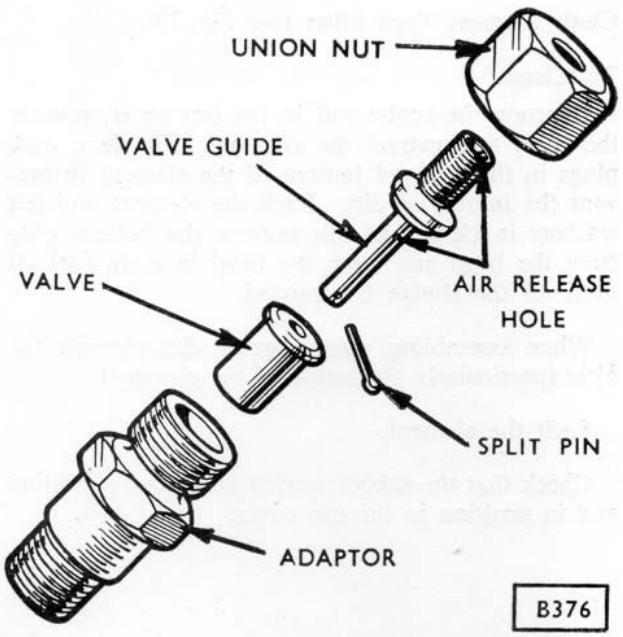


Fig. 21. Exploded view of air release valve.

Sect. A23. FUEL.

A good grade of gas oil or light diesel oil is to be preferred. Heavier diesel oils should be avoided, and on no account should any waste or residual oils be used.

The fuels supplied by any of the large distributors may be used without question. Fuels which are obtained from small local suppliers, who have no fixed source of supply, should be used with caution, and operators are recommended not to enter into arrangements for supplies over an extended period without first satisfying themselves that the supplies will come from the same source throughout the whole period of their contract.

Important factors on the suitability of a fuel for a high speed oil engine, are its source of origin and sulphur content; the latter should on no account exceed that given in the following specification.

In all cases fuels should be to British Standard Specification as follows:—

SPECIFICATION OF FUEL FOR B.U.T. OIL ENGINES.

Description.—The fuel to be a hydrocarbon oil of petroleum and/or shale origin. To be free from mineral acid, grit and other foreign impurities of all descriptions.

Closed Flash Point.—Not to be below 175° F. (79° C.).

Viscosity.—Measured on the Redwood No. 1 Instrument at 100° F. (38° C.), not to exceed 40 seconds.

Cloud and Pour Point.—When tested by the appropriate method given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the pour point of the oil must not exceed 15° F. (minus 9·4° C.), nor the cloud point to exceed 24° F. (minus 4·4° C.).

Water.—Nil.

Ash Inherent.—Not to exceed 0·005 per cent.

Sulphur.—Not to exceed 0·75 per cent.

Aniline Point.—When tested by the appropriate method given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the Aniline Point should preferably be not less than 158° F. (70° C.).

Fuels of lower Aniline Point may, however, be considered providing they satisfy requirements in respect of performance.

Performance.—The fuel must give satisfactory smooth running when tested in the engine.

Sect. A24. DYNAMO (C.A.V. TYPE G7A24). DESCRIPTION.

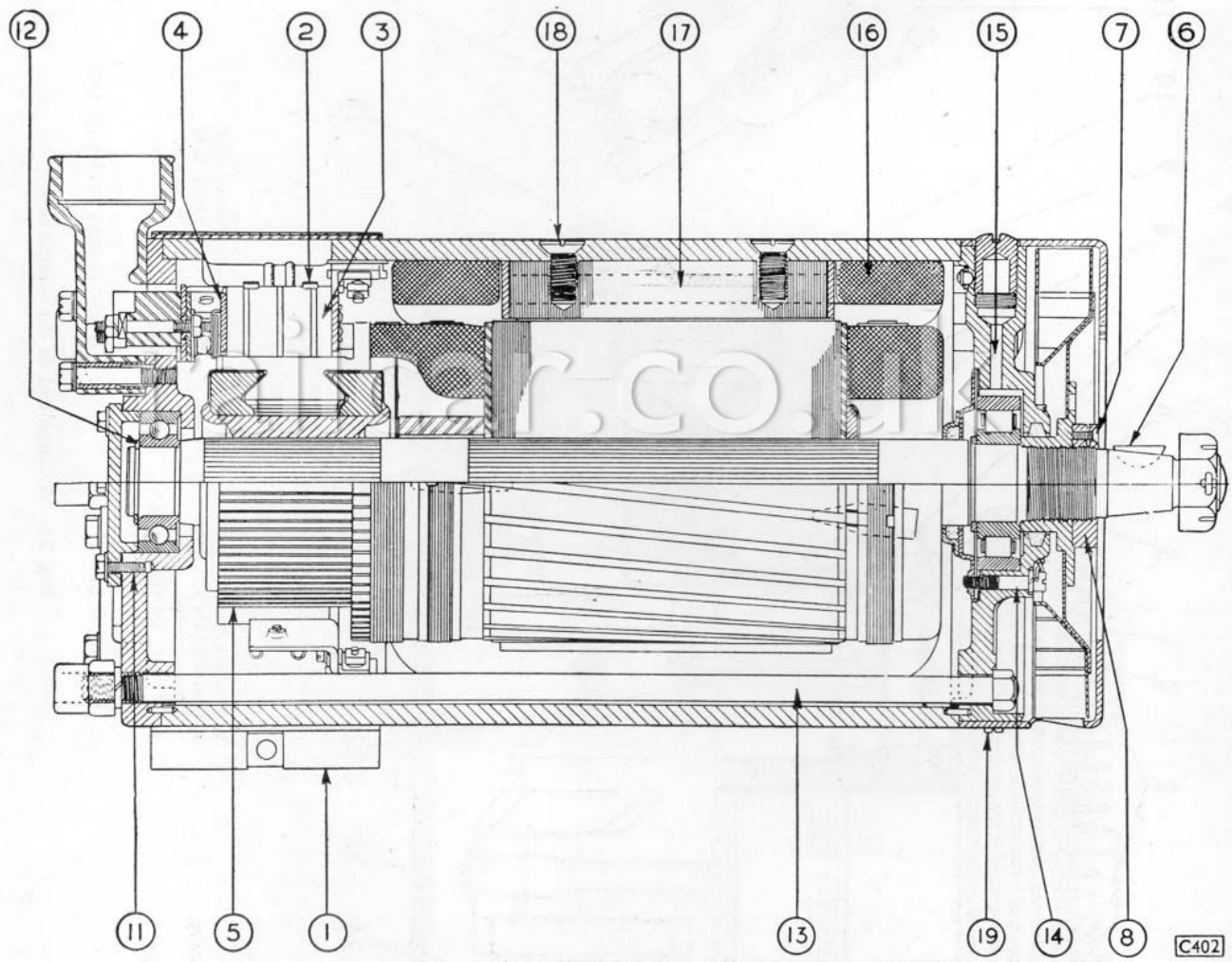
(*See Fig.* 22).

On certain engines a dynamo is mounted on the sump and is driven by a " V " belt from the engine crankshaft pulley.

The C.A.V. type G7A24 dynamo, of 7 in. (178 mm.) nominal diameter and 24-volt rating, is a 4-pole, shunt wound, fan ventilated machine with four field coils in series and a common negative connection for field and armature.

The armature shaft is carried in ball bearings at the commutator end and in roller bearings at the driving end, where it is located.

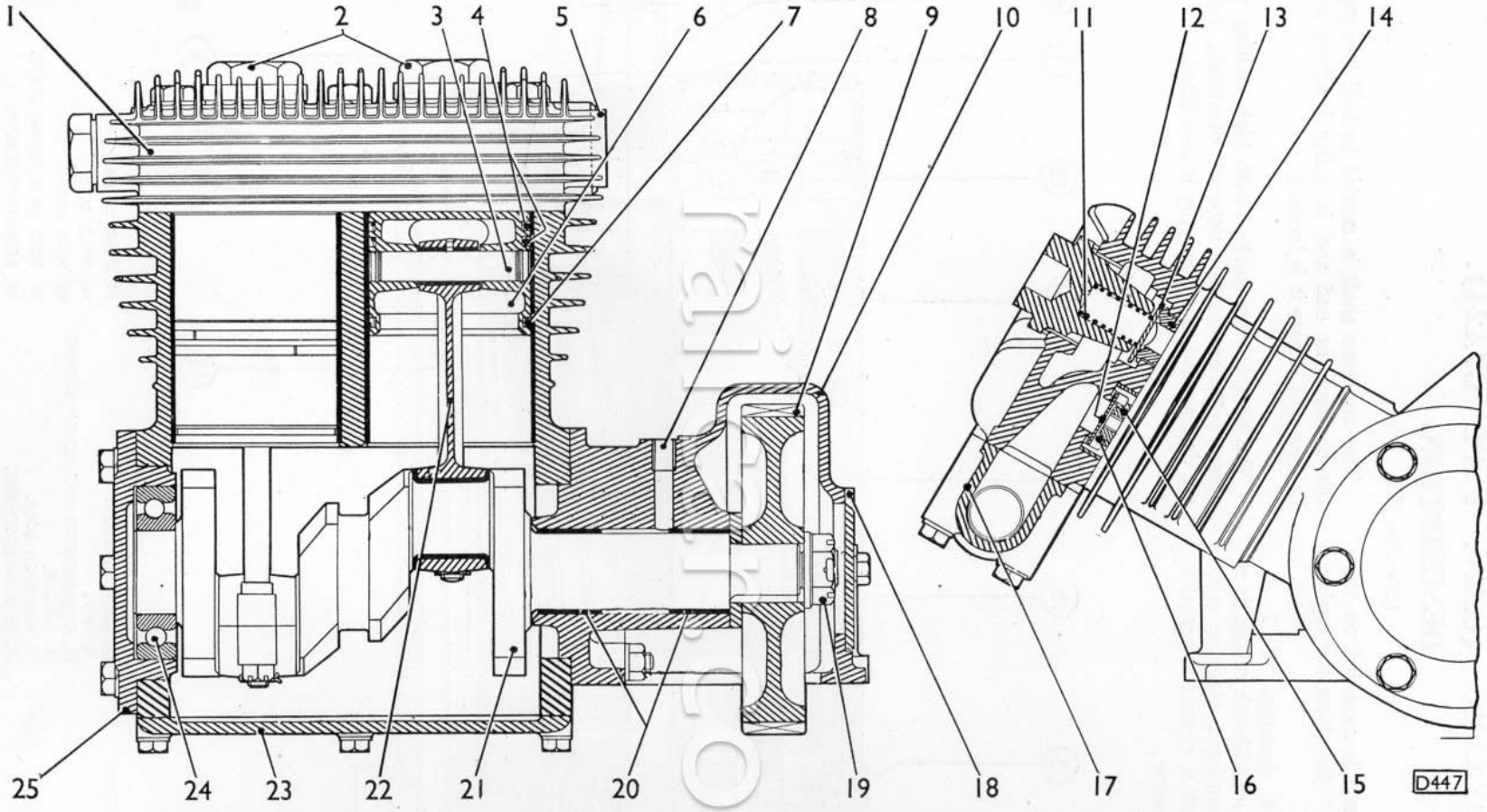
The bearings are packed with **high melting point grease** sufficient to last between overhauls, but, at the driving end, a grease plug is also fitted.



Key to Numbers :—

1. COMMUTATOR BAND COVER.
2. BRUSH SPRINGS.
3. BRUSHES.
4. BRUSH HOLDER.
5. COMMUTATOR.
6. SHAFT KEY.
7. LOCKING SCREW.
8. FAN.
11. COMMUTATOR END COVER SCREWS.
12. CIRCLIP.
13. THROUGH BOLT.
14. RETAINING SCREWS.
15. LUBRICATOR.
16. FIELD COIL.
17. POLE SHOE.
18. POLE SHOE FIXING SCREW.
19. RETAINING SCREWS.

Fig. 22. Section through dynamo.



Key to Numbers :—

1. CYLINDER HEAD.
2. DELIVERY VALVE CAPS.
3. GUDGEON PIN.
4. COMPRESSION RINGS.
5. DELIVERY PORT.
6. PISTON.
7. SCRAPER RING.
8. CRANKSHAFT OIL FEED CONNECTION.
9. COMPRESSOR DRIVE GEAR.
10. COMPRESSOR DRIVE HOUSING.
11. DELIVERY VALVE SPRING.
12. INLET VALVE DISC.
13. DELIVERY VALVE DISC.
14. DELIVERY VALVE SEAT.
15. INLET VALVE KEEPER.
16. INLET VALVE SPRING.
17. INLET MANIFOLD.
18. FRONT END COVER.
19. DRIVE GEAR RETAINING NUT.
20. CRANKSHAFT BUSHES.
21. CRANKSHAFT.
22. CONNECTING ROD.
23. BASE COVER PLATE.
24. CRANKSHAFT BEARING.
25. REAR END COVER PLATE.

Fig. 23. Arrangement of air compressor.

Sect. A25. DYNAMO—TO REMOVE AND FIT.

To Remove.

When the dynamo is fitted to the engine.

Isolate the battery by means of the battery isolating switch situated in the electrical control box adjacent to No. 1 engine or by disconnecting either of the battery cables on the battery.

Remove the dynamo terminal box cover and disconnect the cables.

Slacken the driving belt adjustment (*see Section* A3) sufficiently to allow the belts to be removed from the dynamo pulley.

Release the fixing strap and lift off the dynamo.

To Fit.

Reverse the procedure given for removal.

Sect. A26. AIR COMPRESSOR—DESCRIPTION.

(*See Fig.* 23).

The compressor is an air cooled, two cylinder single acting unit, the bore being 2·625 in. (66·675 mm.) and the stroke 1·75 in. (44·450 mm.), the piston displacement at 1,000 r.p.m. is 10 cu. ft.

The unit is rigidly mounted on the engine casing and is driven by the engine crankshaft timing gear. The cylinder block is inclined at 30° to the horizontal.

Lubrication is by pressure feed from the engine lubrication system supplied via a connecting pipe from the engine crankcase to the compressor drive housing. This supplies oil to the crankshaft front bearings and through a drilled crankshaft to the connecting rod big-end bearings.

The gudgeon pins, pistons and crankshaft rear bearing are lubricated by splash.

Scavenged oil drains direct to the engine sump.

Sect. A27. AIR COMPRESSOR—TO REMOVE AND FIT.

To Remove.

Disconnect the air suction and delivery pipes and the oil connecting pipe from the compressor.

Remove the nut and set-screws securing the compressor drive housing to the engine crankcase and lift the compressor from the engine. Care should be taken not to lose the rubber sealing ring and the coil spring from the oil return connection in the bottom cover.

Retain any shims fitted between the drive housing and the engine crankcase.

To Fit.

Reverse the procedure for removal noting the following points: —

Ensure that the oil sealing ring and the spring is in position on the oil return connection.

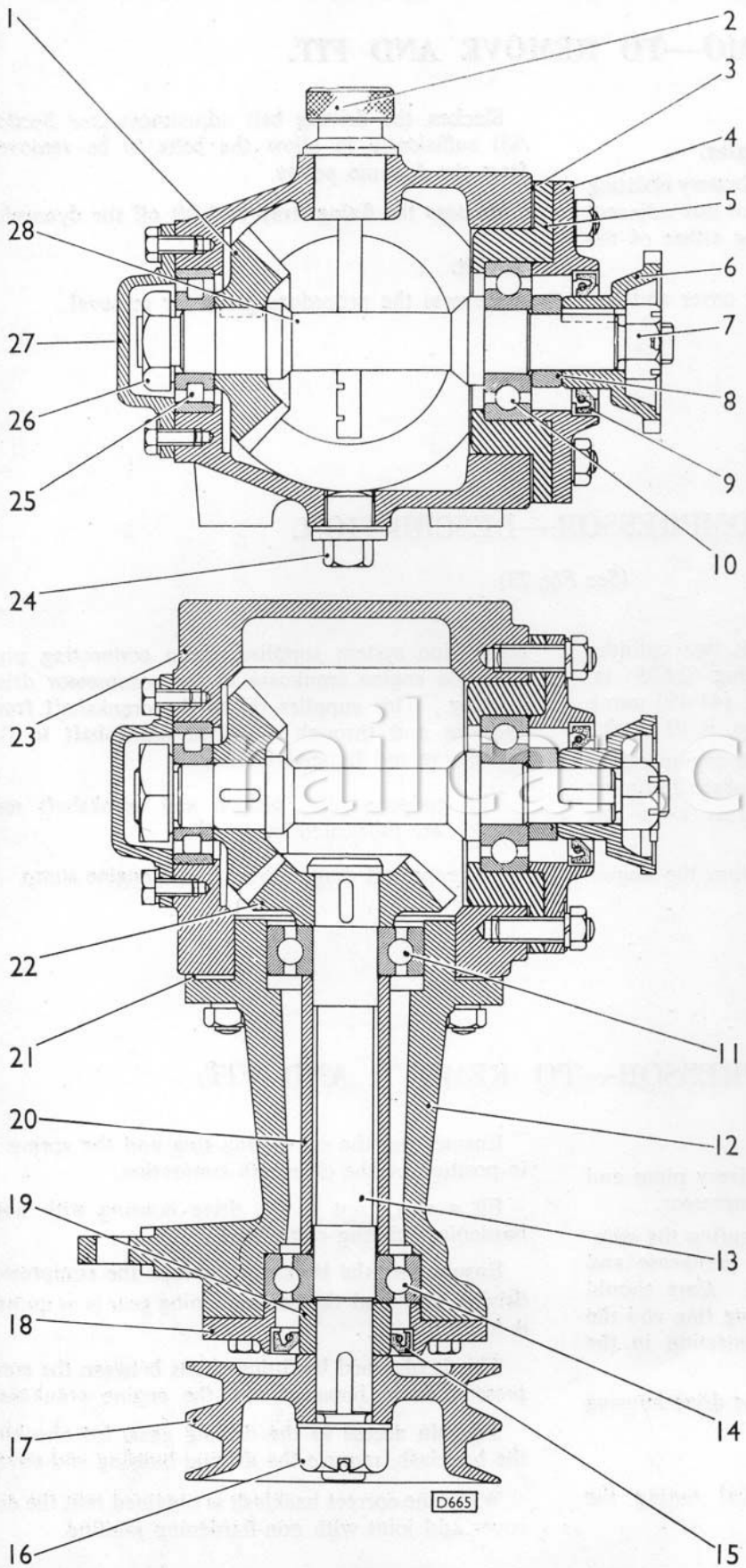
Fit a new joint to the drive housing with non-hardening jointing compound.

Ensure that the backlash between the compressor driving gear and the engine timing gear is as quoted in Section A82.

This is obtained by fitting shims between the compressor drive housing and the engine crankcase.

To gain access to the driving gear, for checking the backlash, remove the driving housing end cover.

When the correct backlash is obtained refit the end cover and joint with non-hardening jointing.



Key to Numbers :—

1. OUTPUT SHAFT BEVEL GEAR.
2. OIL FILLER PLUG WITH COMBINED DIPSTICK AND MAGNETIC OIL FILTER.
3. SHIMS.
4. OIL SEAL HOUSING.
5. BEARING HOUSING.
6. OUTPUT SHAFT COUPLING FLANGE.
7. COUPLING FLANGE RETAINING NUT.
8. DISTANCE PIECE.
9. OIL SEAL.
10. BEARING.
11. BEARING.
12. INPUT SHAFT HOUSING.
13. INPUT SHAFT.
14. BEARING.
15. OIL SEAL.
16. INPUT SHAFT PULLEY RETAINING NUT.
17. INPUT SHAFT PULLEY.
18. OIL SEAL HOUSING.
19. DISTANCE PIECE.
20. BEARING DISTANCE SLEEVE.
21. SHIMS.
22. INPUT SHAFT BEVEL GEAR.
23. CASING.
24. DRAIN PLUG.
25. ROLLER BEARING.
26. BEARING RETAINING NUT.
27. END COVER.
28. OUTPUT SHAFT.

Fig. 24. Arrangement of right-angle fan drive unit.

Sect. A28. ENGINE SPEED INDICATOR GENERATOR —DESCRIPTION.

(*See Figs.* 25 *and* 26).

Two types of speed indicator generators are fitted; on certain engines the generator is mounted on the engine casing extension and is driven by a " V " belt from the crankshaft pulley. On other engines the generator is mounted on the engine bevel gear housing and is gear driven by the fuel-injection pump bevel gear.

For specification of the generator see Section A2.

Should failure occur in the generator it is recommended that the unit be returned to the manufacturer.

Key to Numbers :—

1. LEAD FROM CONNECTION BLOCK TO SPEED INDICATOR.
2. GENERATOR BODY.
3. TERMINAL SCREW FOR (I).
4. TERMINAL SCREW FOR (II).
5. RESISTANCE BOBBIN.
6. LEAD FROM GENERATOR WINDINGS TO RESISTANCE BOBBIN.
7. LEAD FROM RESISTANCE BOBBIN TO CONNECTION BLOCK.
8. CONNECTION BLOCK.
9. TERMINAL SCREW FOR (12).
10. TERMINAL SCREW FOR (7).
11. LEAD FROM RESISTANCE BOBBIN, THROUGH GENERATOR WINDINGS TO CONNECTION BLOCK.
12. LEAD FROM CONNECTION BLOCK TO SPEED INDICATOR.
13. INSULATING DISC RETAINING NUT.
14. INSULATING DISC.

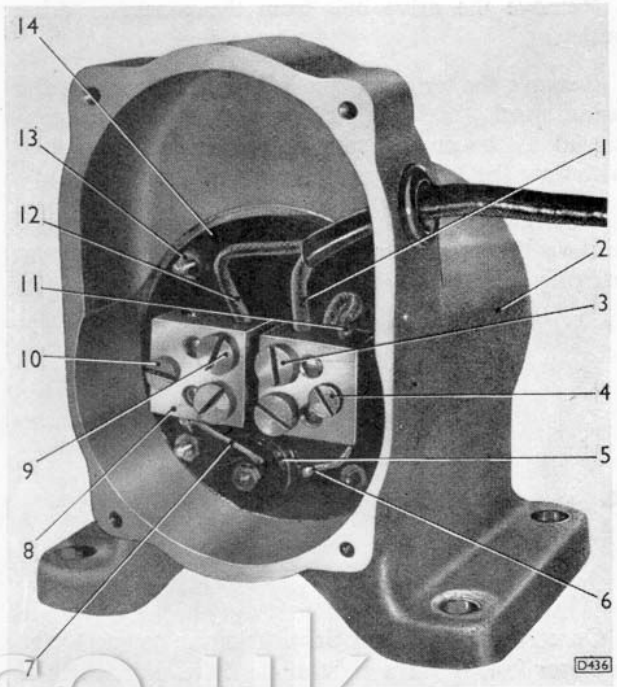


Fig. 25. Engine speed indicator generator (belt driven type).

Sect. A29. ENGINE SPEED INDICATOR GENERATOR —TO REMOVE AND FIT.

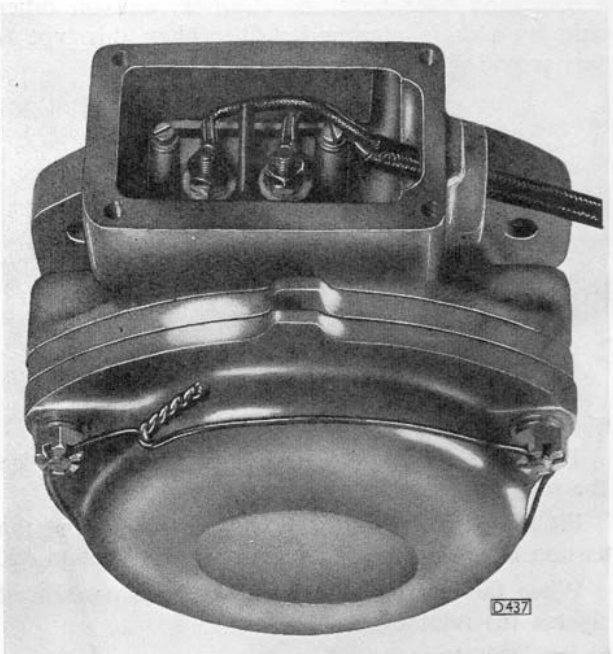


Fig. 26. Engine speed indicator generator—with cover removed (gear driven type).

To Remove.

Gear driven type (*see Fig.* 26).

Disconnect the batteries by means of the isolating switch situated in the electrical control box adjacent to Number 1 engine.

Remove the terminal box cover and disconnect the leads; mark the leads to ensure that they are connected to the correct terminals when refitting, then withdraw the leads from the terminal box.

Refit the terminal box cover.

Unscrew the nuts securing the generator to the engine bevel gear housing and remove the generator. Retain any shims fitted between the generator and the bevel gear housing.

Belt driven type (*see Fig.* 25).

Disconnect the batteries as for the gear driven type.

Remove the drive belt from the generator drive pulley.

Remove the terminal box cover and disconnect the leads; mark the leads to ensure that they are connected to the correct terminals when refitting, then withdraw the leads from the terminal box.

Unscrew the nuts, remove the fixing bolts and remove the generator from its mounting; retain the packing piece.

To Fit.

Gear driven type.

Reverse the procedure for removal noting the following: —

Ensure that there is a backlash between the teeth of the fuel-injection pump drive bevel gear and the generator bevel gear. This is obtained by fitting shims between the joint faces of the bevel gear housing and the generator (*for the correct amount of backlash see Section* A82).

Belt driven type.

Reverse the procedure given for removal.

Sect. A30. RIGHT-ANGLE FAN DRIVE UNIT—DESCRIPTION.

(*See Fig.* 24).

On certain engines the drive from the engine to the radiator fan, is via a right-angle drive unit which is rigidly mounted on a platform attached to the engine sump.

The drive is taken from the engine crankshaft pulley via two "V" belts. Adjustment for the drive belt is provided by elongated slots in the mounting platform.

The right-angle drive unit consists of an input shaft and an output shaft carried in ball and roller bearings contained in a malleable iron casing.

Certain units are fitted with straight bevel gears while on other units they are of the spiral bevel type.

Facilities are provided for draining and fitting the casing with oil; on certain units by a drain plug and a combined filler plug and dipstick, and on other units by a drain plug and a filler plug; this type is also provided with a breather.

Sect. A31. RIGHT-ANGLE FAN DRIVE UNIT —TO REMOVE AND FIT.

To Remove.

Disconnect the propeller shaft from the output shaft coupling flange.

Unscrew the nuts securing the unit to its mounting platform, remove the drive belts and remove the unit from the engine.

To Fit.

Place the unit on the support platform, screw on the retaining nuts but do not **yet** tighten them.

Fit the drive belts to the pulleys and adjust the tension following the instructions given in Section A3.

When the correct adjustment has been established tighten the retaining nuts.

FLUID COUPLING.

CHAPTER B.

CONTENTS.

Sect. B1. FLUID COUPLING—DESCRIPTION.

(*See Fig.* 1).

The fluid coupling consists of two main parts, the driving member, which is secured to the flywheel bolted to the engine crankshaft, and the driven member, which is free to rotate within an outer casing formed by the flywheel and is coupled to the joint flange of the front section of the propeller shaft.

The driving and driven members are each provided with a series of cup-shaped pockets separated by radial webs formed on their inner surfaces.

The runner shaft, which is bolted to the driven member, runs in two bearings, one of which is housed in the bore of the driving member, the other in the rear of the crankshaft. The oil seal on the runner shaft is a self-adjusting bellows type packless gland.

Key to Numbers :—

1. DRIVING MEMBER.
2. FILLER PLUG.
3. RUNNER SHAFT BEARING.
4. ADAPTOR RING.
5. RUBBING RING.
6. JOINT FACE.
7. COUPLING FLANGE.
8. BELLOWS GLAND.
9. OIL DEFLECTOR PLATE.
10. SET-SCREW.
11. STARTER RING.
12. STARTER RING SECURING SET-SCREW.
13. PAPER JOINT.
14. DRIVEN MEMBER
15. RUNNER SHAFT.
16. RUNNER SHAFT SPIGOT BEARING CIRCLIP.
17. RUNNER SHAFT SPIGOT BEARING.
18. RUNNER SHAFT FLANGE BOLT.
19. CRANKSHAFT FLANGE BOLT.
20. FLYWHEEL.
21. STARTER RING KEY SECURING SCREW.
22. STARTER RING KEY.

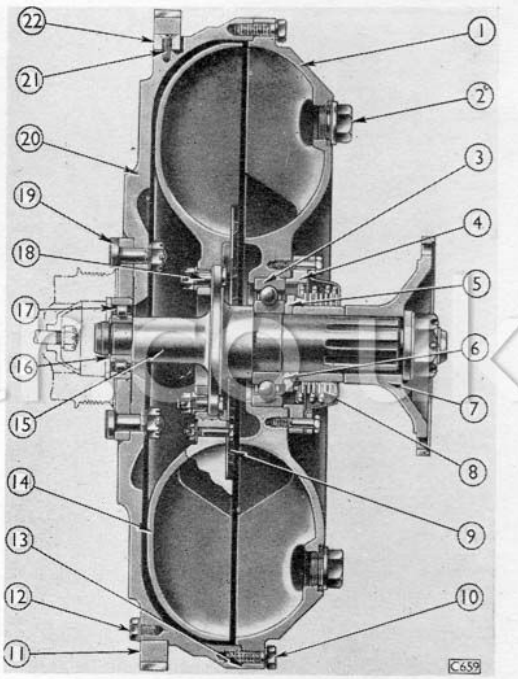


Fig. 1. Section through fluid coupling and bellows gland oil seal.

Sect. B2. FLUID COUPLING—MAINTENANCE.

The following points require attention at intervals quoted below.

Period.	Attention Required.
DAILY.	Check the oil level in the fluid coupling and top-up if necessary (*see Section* B4).
MONTHLY OR EVERY 5,000 MILES (8,000 KM.).	Check the runner shaft bellows gland for oil leaks (*see Section* B3).

Sect. B3. FLUID COUPLING BELLOWS GLAND—TO RENEW.

(*See Fig.* 1).

To Remove.

If the bellows gland is found to be leaking it should be renewed as follows :—

Drain the oil from the coupling (*see Section* B4).

Disconnect the front section of the propeller shaft from the coupling flange on the runner shaft.

Remove the split pin and nut and draw the coupling flange off the runner shaft by means of a suitable draw dog.

Unscrew the set-screws which secure the bellows gland to the coupling driving member, then remove the bellows gland, bolt ring, adaptor ring, sleeve and rubbing ring.

Care must be taken when handling the bellows gland oil seal.

It is important that the bellows and the highly polished faces of the rubbing ring and the bellows gland seal ring are not damaged; the slightest scratch across these faces will destroy the efficiency of the seal.

To Fit.

When fitting the seal, note the following points:—

Smear with non-hardening jointing compound the abutting faces of the adaptor ring and bearing, rubbing ring, sleeve and coupling flange, also the whole of the splined end of the runner shaft and the abutting faces of the coupling retaining washer and nut.

Smear the polished joint face of the seal with clean oil.

Fit a new paper joint between the adaptor ring and the flange of the oil seal and between the abutting faces of the adaptor ring and bearing.

Note.—It is important that the rubbing ring be assembled correctly, i.e., the **polished** face **must** be towards the splined end of the runner shaft, and on no account must jointing compound be allowed to come into contact with this polished face and its mating face.

Fit the coupling flange to the runner shaft and connect the propeller shaft.

Refill the coupling with oil (*see Section* B4).

Sect. B4. FLUID COUPLING—LUBRICATION.

(*See Fig.* 2).

To Drain the Fluid Coupling.

Remove one of the filler plugs in the driving member, then turn the engine by means of a suitable lever until this filler plug hole is at bottom dead centre; allow all oil to drain into a container.

To Fill or Top-up the Fluid Coupling.

Turn the engine by means of a suitable lever until the filler plug hole is at **top dead centre.**

Using a suitable funnel pour oil into the coupling up to the level of the filler plug hole ; ensure that the copper washer is in position on the plug and then refit and tighten the filler plug.

The capacity of the fluid coupling is 3¼ Imperial gallons (14·75 litres) of engine oil to the following specification.

SPECIFICATION OF ENGINE OIL.

(*A.E.C. Specification No.* L13).

Description.—To be a pure hydrocarbon oil refined by the Solvent Extraction Process, thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity and objectionable odour.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's " Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

Viscosity (Redwood No. 1) at 140° F. (60° C.)	160—175 seconds (39—42·5 centistokes)
Viscosity (Redwood No. 1) at 210° F. (99° C.)	55 seconds minimum (11·0 centistokes)
Viscosity Index	90 minimum
Closed Flash Point	400° F. (204·4° C.) minimum
Pour Point	15° F. (minus 9·4° C.) maximum
Acitiry (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·005 per cent. maximum
Carbon Residue (Ramsbottom)	0·5 per cent. maximum

Oxidation Characteristics.—

Viscosity Ratio at 140° F. (60° C.)	1·5 maximum
Increase in Carbon Residue	0·7 per cent. maximum
Asphaltenes in Oxidised Oil	0·05 per cent. maximum

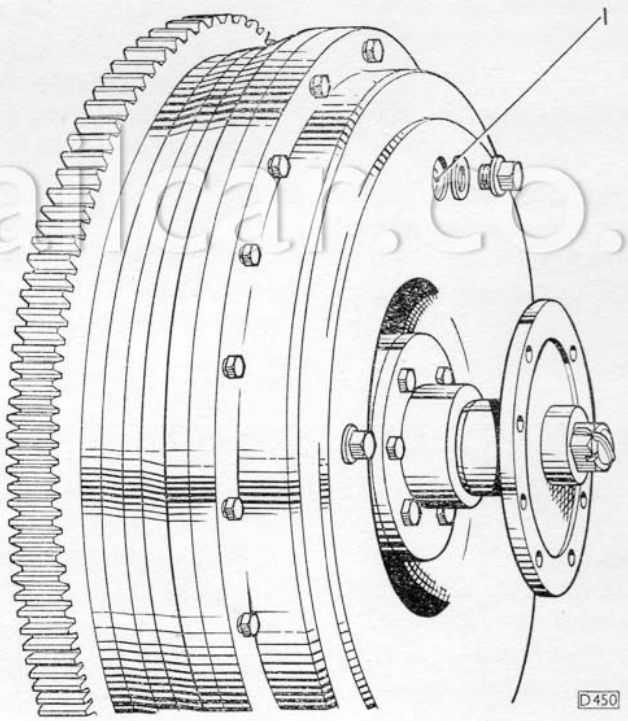


Fig. 2. Position of filler plug hole (1) when filling or topping-up the fluid coupling.

GEARBOX

CHAPTER S

CONTENTS

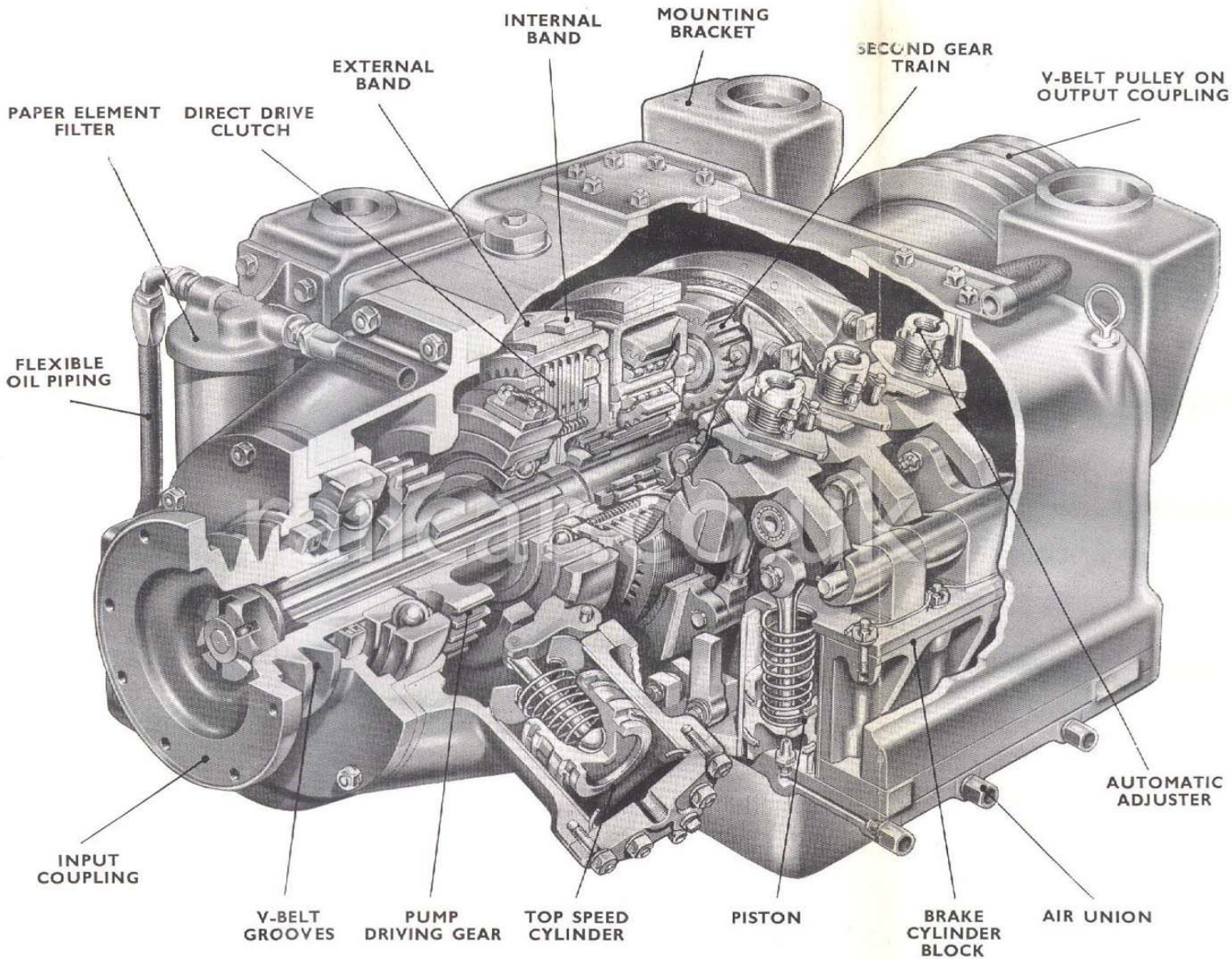


Fig. 1. The Gearbox.

Sec. S1 GEARBOX—DATA

(TYPE R.14)

Type .. .. .. Epicyclic gearbox, 4 forward speeds

Gear Ratios

1st speed	4.28:1	3rd speed	1.59:1
2nd speed	2.43:1	4th speed	1.1

Rotation: Clockwise looking on input end
Mounting: Independent mounting using bearer brackets
Operation: By air pressure at 65 lbs./sq. in. $\pm$ $2\frac{1}{2}$lbs.
Oil Pump: Gear pump driven from input shaft

Brake Setting Gauge Dimensions

First Speed	:	1.30
Second Speed	:	1.30
Third Speed	:	1.45

Sec. S2 GEARBOX—DESCRIPTION

(*See Figs.* 2 & 4)

The gearbox is a four speed independently mounted unit in which three gears 1st, 2nd and 3rd speed are provided by means of compounded epicyclic gear trains. The direct drive top gear is obtained by means of a multi-plate clutch.

All four gears are air-operated each being provided with a separate cylinder. For the reduction gears, air pistons working in cylinders mounted on the bottom cover are used to apply band brakes, whilst an air piston working in a cylinder integral with the front cover is used to apply the direct drive top gear clutch.

When the change speed selector lever is moved into a gear engaged position, air flows through an electro-magnetic air valve and air restrictor (if fitted) into the cylinder required. When a different gear is selected the air pressure is transferred to the newly required cylinder, the air restrictors control the flow of air as the changeover is effected.

Sec. S3 GEARBOX—BRAKE OPERATION

(*See Figs.* 3 & 4)

The brake mechanisms in this gearbox are used to bring into operation the reduction gears (1st, 2nd and 3rd speed) one band brake being provided for each.

When a gear is engaged, the appropriate brake grips the brake drum bringing it to rest, thus providing a reaction so that power is transmitted to the gearbox output shaft.

1. BALL BEARING.
2. BEARING HOUSING.
3. FRONT COVER NUT.
4. TRUNNION RING.
5. SLIDING PANEL.
6. BUSH.
7. INNER PLATE.
8. CLUTCH SPRING.
9. CLUTCH PLATE, INNER.
10. CLUTCH PLATE, OUTER.
11. THIRD SPEED BRAKE DRUM
12. CLUTCH INNER MEMBER.
13. THIRD SPEED GEAR TRAIN.
14. THIRD SPEED SUNWHEEL.
15. SECOND SPEED GEAR TRAIN.
16. ADJUSTING WASHER.
17. GEARCASE.
18. FIRST SPEED GEAR TRAIN.
19. BUSH.
20. BEARING COLLAR.
21. BUSH.
22. COVER PLATE.
23. OIL MUFF.
24. BEARING SLEEVE
25. BALL BEARING.
26. ROLLER BEARING.
27. OIL SEAL HOUSING NUT.
28. OIL SEAL HOUSING.
29. OIL SEAL.
30. OUTPUT COUPLING.
31. O RING.
32. SPLIT PIN.
33. WASHER.
34. COUPLING NUT.
35. BEARING COLLAR.
36. PULLEY.
37. ROLLER BEARING.
38. OIL UNION.
39. BEARING HOUSING.
40. FIRST SPEED BRAKE DRUM.
41. SECOND SPEED BRAKE DRUM.
42. BUSH.
43. BUSH.
44. BUSH.
45. ADAPTOR FIRST SPEED.
46. ADAPTOR SECOND SPEED.
47. ADAPTOR THIRD SPEED.
48. SEAL.
49. O RING.
50. PISTON FOURTH SPEED.
51. PISTON ROD FOURTH SPEED.
52. CYLINDER COVER.
53. SPRING.
54. SEAL.
55. CYLINDER LINER.
56. PLATE.
57. PIN.
58. SLEEVE.
59. PUMP DRIVING GEAR
60. BALL BEARING.
61. OIL SEAL HOUSING.
62. OIL SEAL.
63. INPUT COUPLING.
64. INPUT SHAFT.
65. SEALING WASHER.
66. WASHER.
67. SPLIT PIN.
68. INPUT COUPLING NUT.
69. BEARING HOUSING.
70. SET BOLT.
71. FRONT COVER.
72. PIVOT PIN.
73. OIL PUMP.
74. NUT.
75. SPLIT RING.

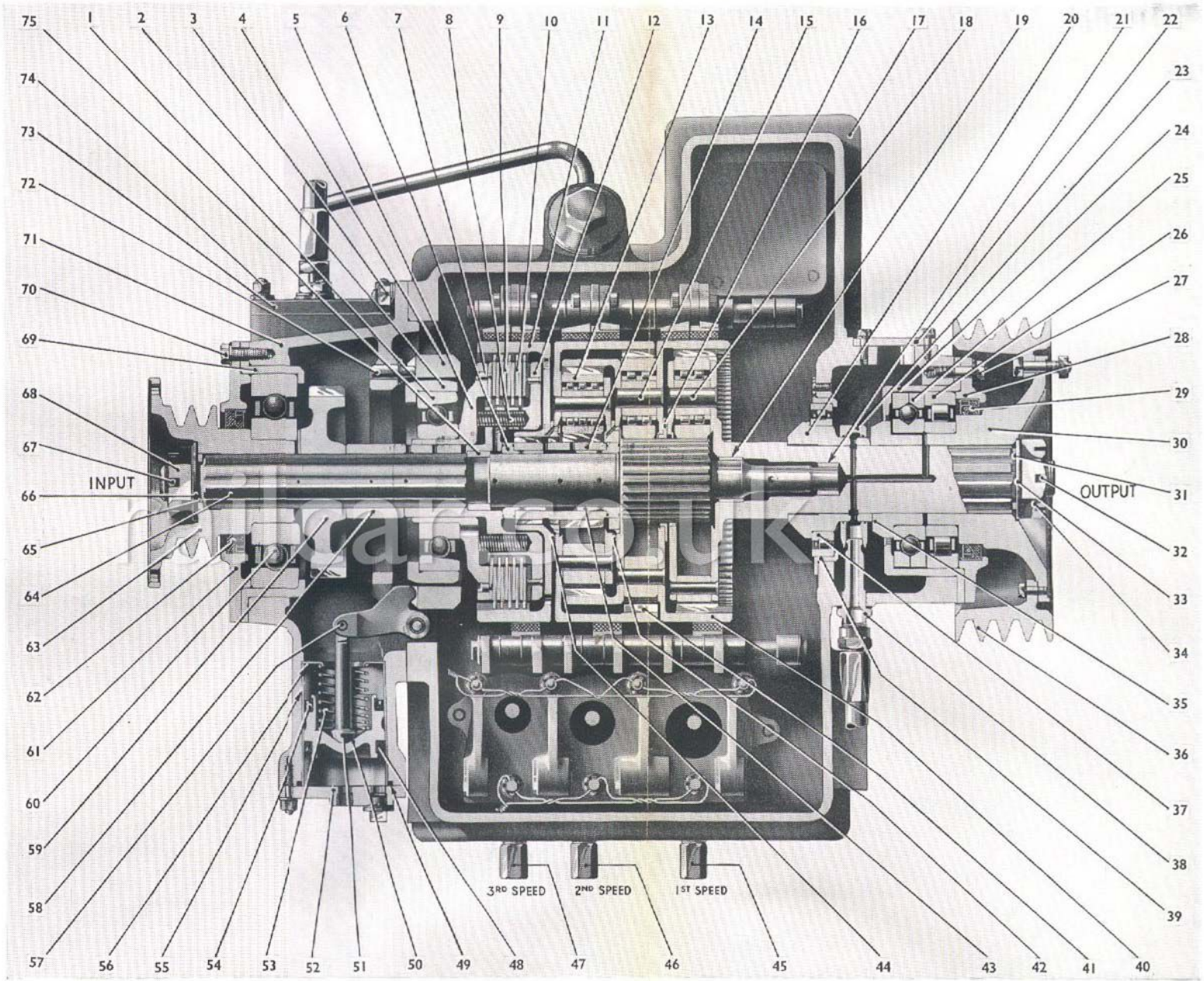


Fig. 2. Section through Gearbox.

FEATURES OF THE BRAKES

(*See Fig.* 4)

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

By using suitable anchorages for the inner and outer bands, the brake is balanced so preventing the shafts and bearings from being subjected to any load arising from the application of the brakes.

The brakes are centralised about the drums in such a manner as to prevent them rubbing when in the "OFF" position.

The brake linings are made of a material suitable for working in oil which is extremely hard wearing. It is inevitable, however, that some wear will take place in time, and this is corrected by the Automatic Adjuster Mechanism (See Fig. 5) which keeps the brakes constantly at their correct setting.

OPERATING SEQUENCE OF THE BRAKES

(*See Figs.* 3 & 4)

The sequence of operation during brake application is as follows:—

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

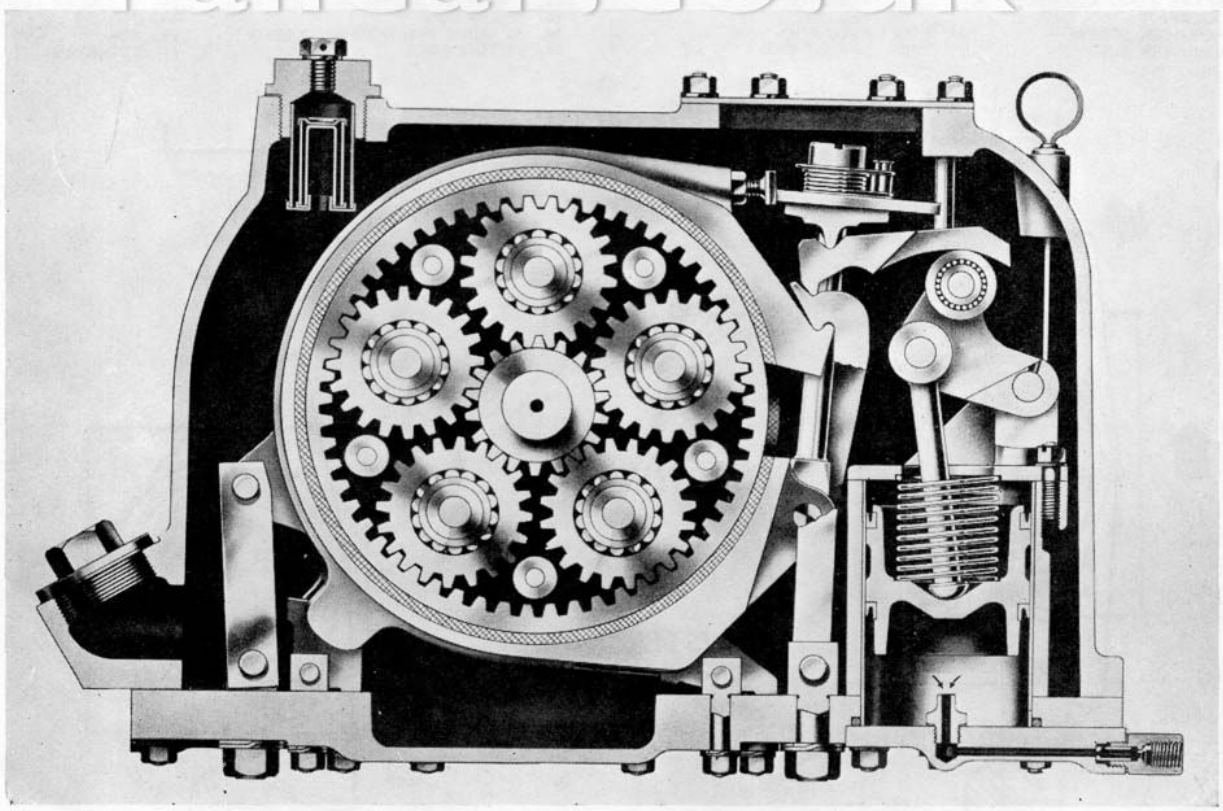


Fig. 3. Section through 1st Speed Band Brake. (Brake On)

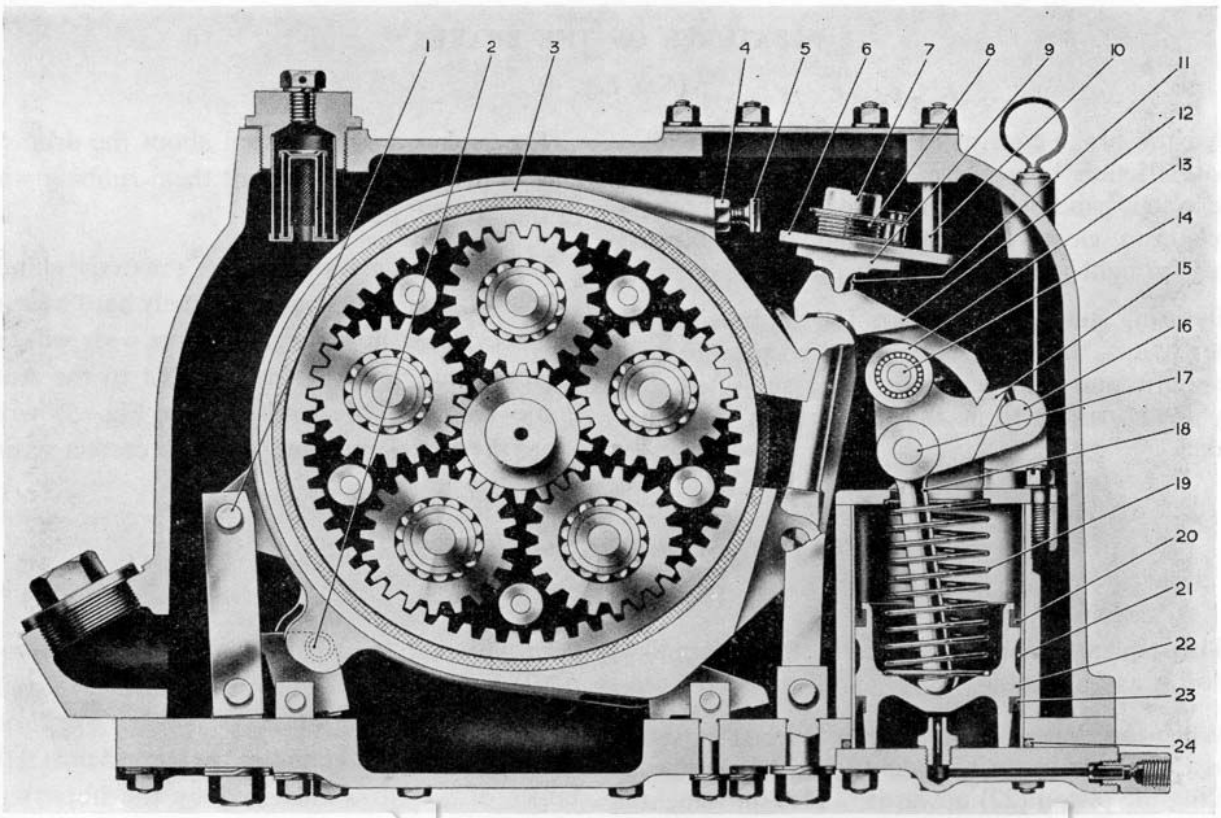


Fig. 4. Section through the 1st Speed Band Brake. (Brake Off)

1. LINK PIN
2. CENTRALISER SPRING
3. BRAKE BAND ASSEMBLY
4. LOCKNUT
5. ADJUSTER SCREW
6. ADJUSTER RING
7. AUTOMATIC ADJUSTER NUT
8. AUTOMATIC ADJUSTER SPRING
9. ADJUSTER TABLE
10. TAIL PIN
11. PULL ROD
12. THRUST PAD
13. CAM ROLLER RACE
14. CAM ROLLER PIN
15. OPERATING LEVER
16. SHAFT (iong)
17. BEARING PIN, DOWEL, CIRCLIP
18. PISTON ROD
19. PISTON SPRING
20. SEAL
21. CYLINDER LINER
22. PISTON
23. SEAL
24. "O" RING

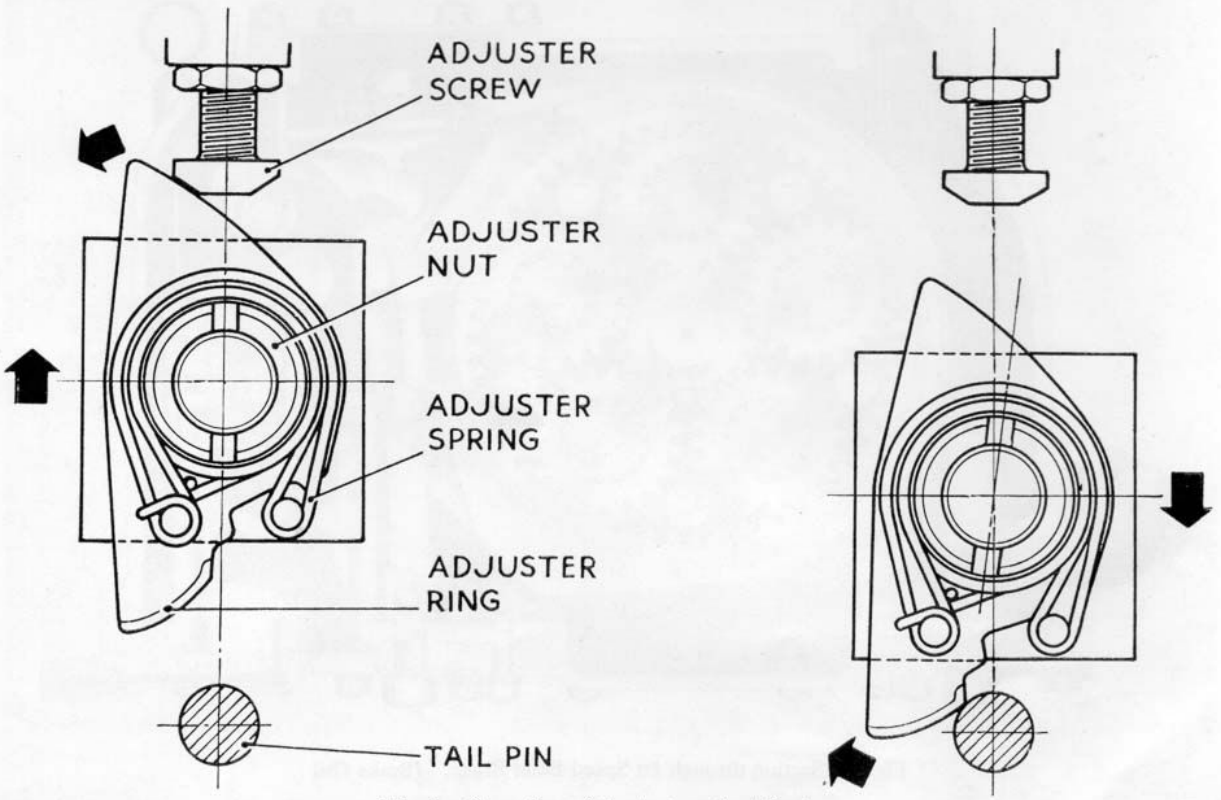


Fig. 5. Operation of the Automatic Adjuster.

Sec. S4 GEARBOX—AUTOMATIC ADJUSTER

(*See Fig.* 5)

This is a device for reducing the effective length of the pull rod and thus taking up the extra movement caused by the wear of the brake linings; there is one set per reduction gear train.

The height to which the thrust pad is allowed to swing determines the grip of the brake, and the travel of this thrust pad is governed by the automatic adjuster nut.

Wear on the brake linings will allow the thrust pad to move higher. When this happens the automatic adjuster ring striking the adjuster screw will be rotated **anti-clockwise.** The adjuster ring is pinned to the spring in such a way that this action loosens the spring from contact with the adjuster nut. When the brake approaches the "OFF" position the rear portion of the adjuster ring strikes the tail pin. The adjuster ring now rotates in a clockwise direction taking with it the adjuster nut which is thereby screwed down, taking up the movement caused by the wear of the linings.

Sec. S5 GEARBOX—TOP SPEED CLUTCH OPERATION

(*See Fig.* 6)

Air is admitted to the cylinder (1) forcing the piston (3) to act through the lever (5) to move the trunnion ring (7) with bearing housing (6) and bearing against the clutch sliding panel (8). This then moves forward under pressure to lock the clutch plates (9) and (10) together, the running gear then revolving as a whole.

The top speed clutch needs no adjustment since wear on the clutch plates is compensated by increased travel of the operating piston.

KEY TO NUMBERS:—

1. CYLINDER
2. CYLINDER COVER
3. PISTON
4. SEALS
5. OPERATING LEVER
6. BEARING HOUSING
7. TRUNNION RING
8. SLIDING PANEL
9. CLUTCH PLATE (OUTER)
10. CLUTCH PLATE (INNER)

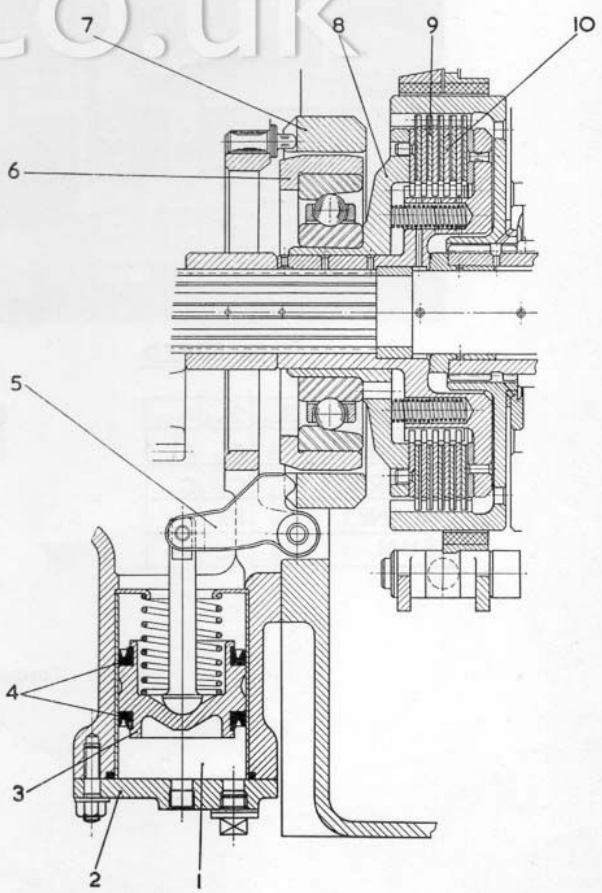
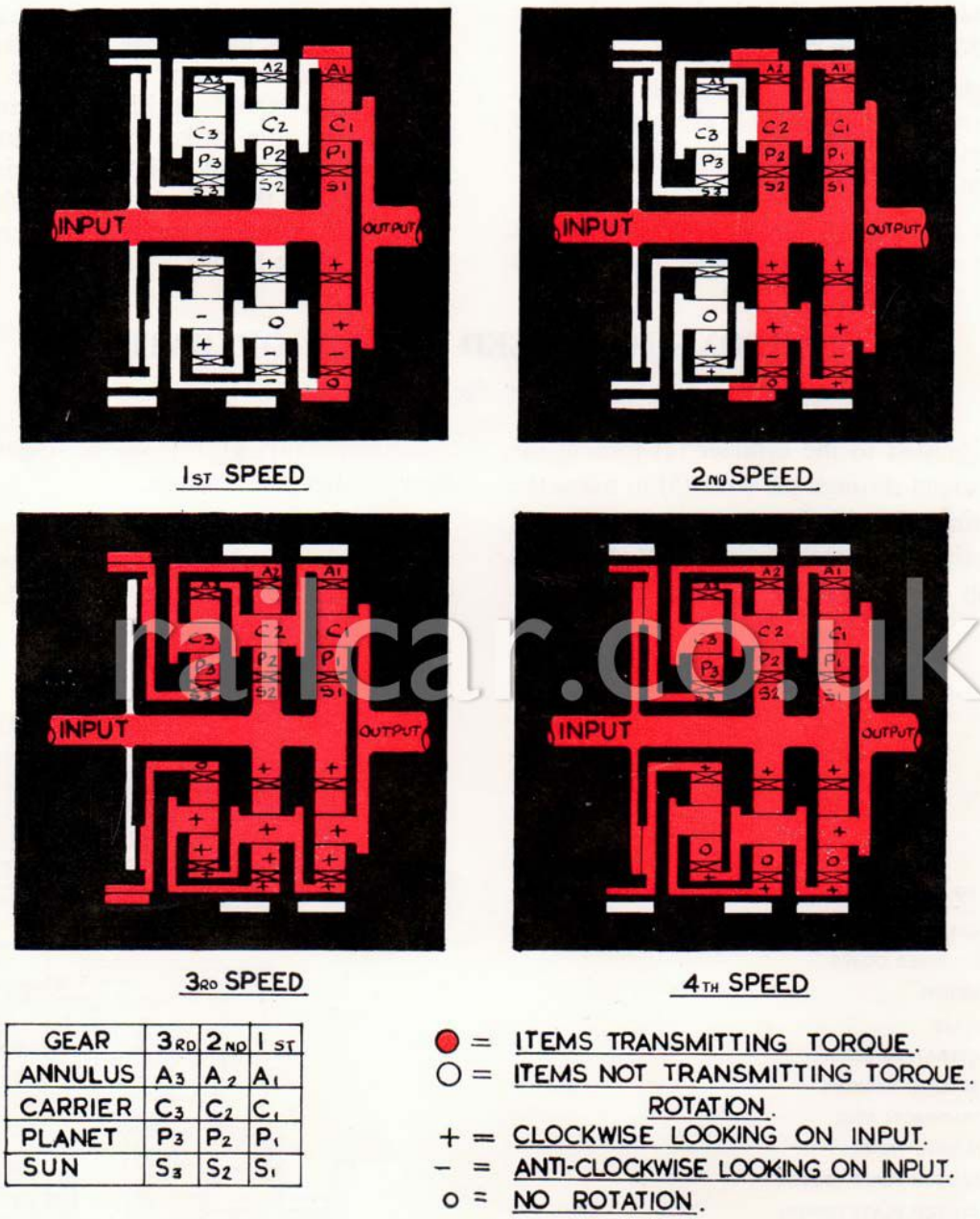


Fig. 6. Top Speed Clutch Actuation.



GEAR	3RD	2ND	1ST
ANNULUS	A_3	A_2	A_1
CARRIER	C_3	C_2	C_1
PLANET	P_3	P_2	P_1
SUN	S_3	S_2	S_1

● = ITEMS TRANSMITTING TORQUE.
○ = ITEMS NOT TRANSMITTING TORQUE.

ROTATION.

\+ = CLOCKWISE LOOKING ON INPUT.
− = ANTI-CLOCKWISE LOOKING ON INPUT.
o = NO ROTATION.

Fig. 7. Torque Transmission Diagram.

Sec. S6 GEARBOX—AIR PRESSURE

At all times when the gearbox is in use, correct air pressure (65 lbs. $\pm 2\frac{1}{2}$ lbs. per sq. inch) MUST be maintained.

This is essential because AIR PRESSURE ALONE holds the friction surfaces of brakes and clutch together and prevents them from slipping.

Sec. S7 GEARBOX—PRINCIPLE OF OPERATION

(*See Fig.* 7)

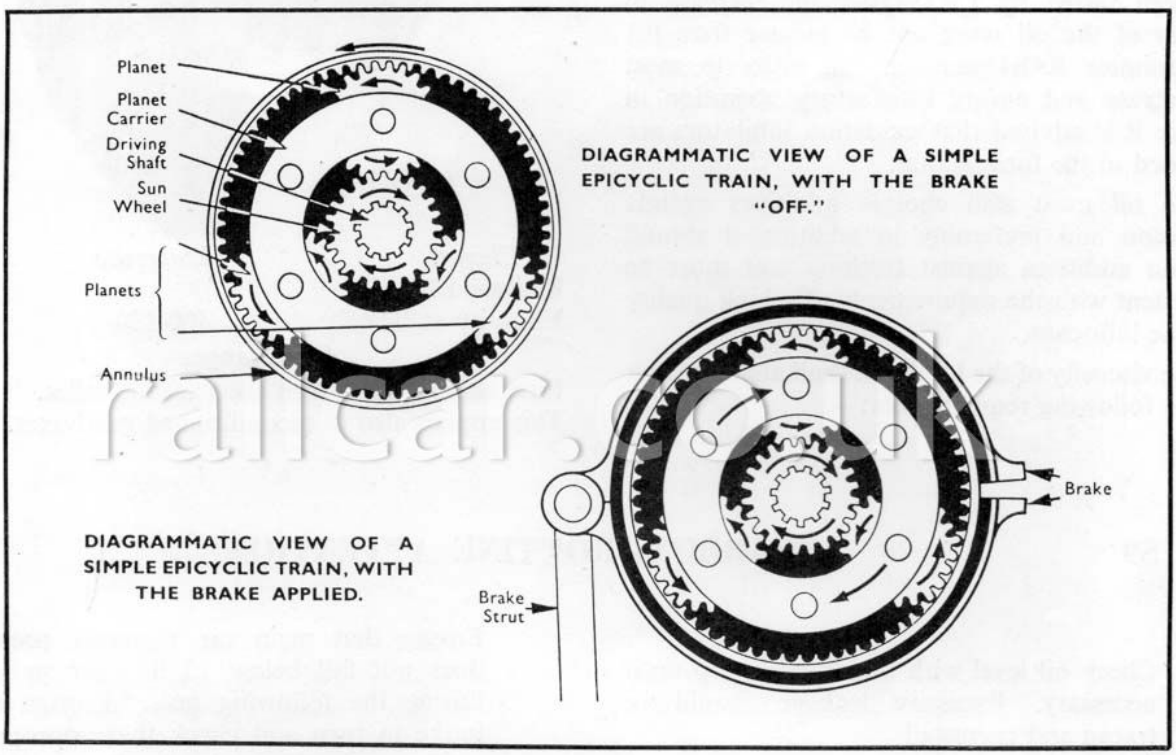


Fig. 8. Diagrammatic View of Epicyclic Gear Train.

There are in this gearbox three gear trains each composed of the parts shown on Fig. 8.

With 1st gear engaged the brake holds stationary the annulus A1, so that revolution of the sunwheel S1, which is connected to the driving shaft, causes the planets P1 to roll round the internal teeth of the annulus, taking with them the planet carrier C1 in the same direction as the driving shaft, but at a lower speed.

With the 2nd gear engaged, the annulus A2 of the second gear train is held stationary, thus speeding up the 1st gear annulus through its interconnection with the 2nd speed carrier.

A similar speeding up of the 1st and 2nd gear annuli is brought about by holding stationary the 3rd gear sunwheel, causing the 3rd speed planets to rotate round the sunwheel.

Top gear is obtained by means of a plate clutch which, when engaged, connects the 3rd speed sunwheel to the 1st and 2nd gear sunwheel, thereby locking the whole assembly, and giving a direct drive.

Sec. S8 GEARBOX—LUBRICATION

Lubrication is provided by a gear type pump mounted on the front casing, the flow of oil passes through an external pipe and filter, to an oil muff where it is delivered to the gear trains and bearings.

The gearbox requires approximately 2½ gallons of oil.

The base lubricant should be 100% mineral oil of high quality possessing a high resistance to oxidation and a natural viscosity index of not less than 90.

When tested by I.P.114/55T the increase in acidity of the oil must not be greater than 0.1 milligramme KOH/gramme. In order to meet this clause and ensure satisfactory operation in service it is advised that oxidation inhibitors are included in the formulation.

The oil must also contain additives against corrosion and preferably in addition it should contain additives against frothing and must be consistent with the requirements of a high quality turbine lubricant.

The viscosity of the lubricant shall also conform to the following requirements:—

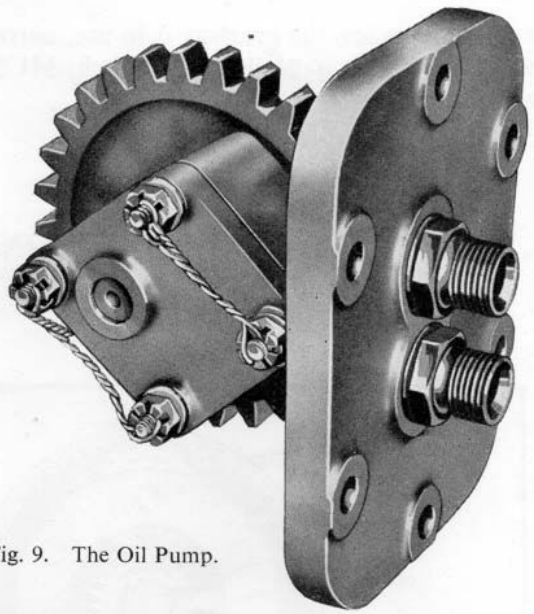


Fig. 9. The Oil Pump.

	Climate	*Temperate*
Redwood No. 1 Viscosity at 140°F.		100-130

Oil Changes

First change 1,000 then every 30,000 miles.
This applies also to reconditioned gearboxes.

Sec. S9 GEARBOX—ROUTINE ATTENTION

Daily.

1. Check oil level with the dipstick, top up if necessary. Excessive leakage should be traced and corrected.

Every 3000 miles.

1. Check upper piston seals for oil leakage by removing gearbox cylinder drain plugs (one gearbox at a time) and selecting each gear in turn. If oil is blown out replace leaking piston seal.
   The free flow of air indicates clear supply pipes. If the flow is unduly restricted clean air restrictors (if fitted) in gearbox air inlet unions and supply pipe if necessary.
2. Check lower piston seals for air leakage by engaging each gear in turn. Leaking air can be detected escaping from gearbox breather. Replace seals which leak.
3. Thoroughly clean top of gearbox and remove inspection cover.
   Ensure that main air reservoir pressure does not fall below 75 lbs. per sq. inch during the following tests. Engage each brake in turn and check that appropriate setting gauge (Figs. 13, 14) will enter. (Note, clearance up to $\frac{1}{16}$" is not abnormal, as the mechanism will not move so far when the brakes are engaged in this manner, as they will when under load.) If the gauge will not enter (see Section S14).
4. Check that brakes are still serviceable. (Relining is necessary when the top faces of the adjuster nut and pullrod coincide).

Every 6000 miles (in addition to the foregoing).

1. Check filter element and renew if choked or damaged. Clean filter, bypass valve.

Every 30,000 miles (in addition to the foregoing).

1. Drain gearbox and refill with new oil.

Every 150,000 miles.

1. Remove gearbox for complete overhaul.

Sec. S10 GEARBOX—SERVICING THE AIR PISTONS

TO REMOVE AND REPLACE 1st, 2nd & 3rd SPEED PISTONS

(*See Fig.* 10)

1. Remove the nuts which secure the cover plate to the bottom cover, and allow the cover plate to come away under the pressure of the piston return springs. Remove the gasket. As considerable oil will be released (from cylinders only) provision of an adequate tray is advisable.
2. Remove the pistons and springs.
3. Wash all components in paraffin, drain and immerse in clean oil.
4. Carefully examine both seals and renew if hardened, or having worn or cracked lips. Fit new seals by stretching them over the flanges on the pistons the grooves to be facing outwards when in position.
5. Inspect "O" ring seals (item 24 Fig. 4) at base of liners, and renew if hardened.
6. Insert each spring and piston, etc. into its cylinder (taking care not to damage the seal lips) until the top flange has entered, and tilt the piston to retain it until the other pistons are fitted.
7. Replace the cover plate and gasket, secure with nuts and washers.

TO REMOVE AND REPLACE 4th SPEED PISTON

1. Remove the cover and gasket, the piston will emerge under pressure of the piston return spring.
2. Inspect "O" ring seal at base of liner and renew if hardened.
3. Wash the components in paraffin, drain and immerse in clean oil.
4. Replace parts and secure with nuts and washers.

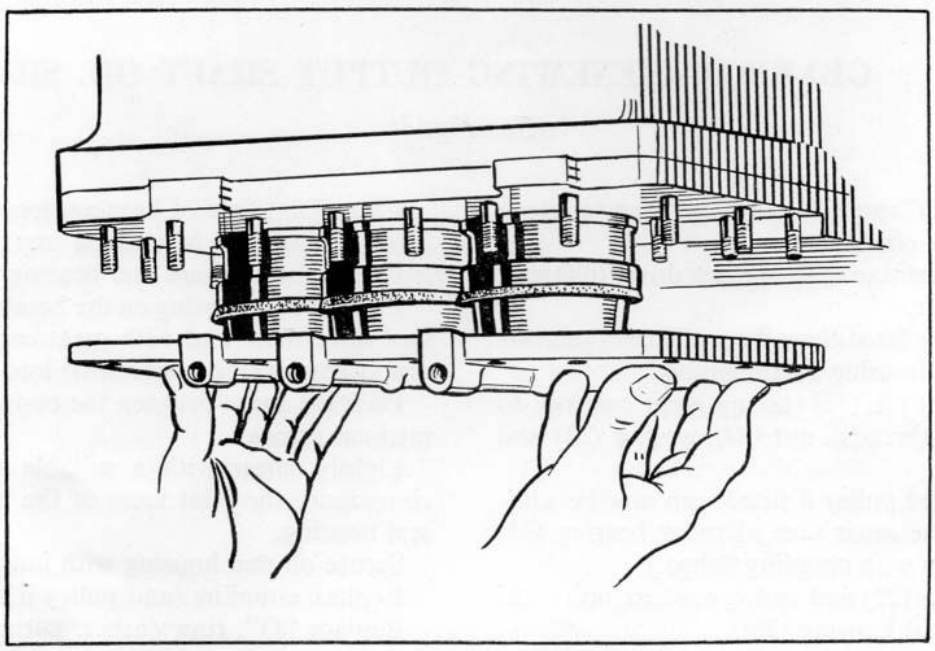


Fig. 10. Removing the Cover Plate (1st, 2nd & 3rd Speeds).

Sec. S11 GEARBOX—RENEWING INPUT SHAFT OIL SEAL

(See Fig. 2)

(Note—A new sealing washer (65), washer (66) and split pin (67), should be available.)

Remove the cardan shaft and freewheel complete, and all other drives taken from the gearbox input coupling.

Locally clean front face of gearbox including oil seal housing and coupling.

Engage third gear to lock input shaft.

Remove split pin (67) (taking great care not to damage screw threads of input shaft), nut (68), washer (66), and sealing washer (65).

Remove set screws (70) with spring washers, using special extractor tools—part number 37428. Remove coupling (63) complete with oil seal housings (61). As the withdrawal proceeds tap the end of the input shaft (64) back through the coupling.

With coupling flange downwards, adequately support oil seal housing (61) and press coupling (63) out of bearing.

Remove faulty seal from housing (61). Clean the seal housing joint face. Wash the seal housing and coupling in paraffin and drain. Clean the exposed parts of bearing housing (69), taking care to exclude any foreign matter from the bearing race.

Lay the seal housing on the bench with the joint face uppermost and with great care drive the oil seal (with the garter spring uppermost) into position.

Pack the space between the two sealing lips with medium grease.

Ease the oil seal in its housing on to the coupling. Press the bearing (and bearing housing) home on to the coupling.

Clean the gearcase face taking care to prevent foreign matter entering the gearbox.

Lightly smear with a suitable shellac jointing compound the joint faces of the gearcase and mating face on bearing housing.

Slide coupling onto shaft, lining holes (note these are unequally spaced) in gearcase and flanges. (The extractor tools may be screwed into gearcase to facilitate this assembly.)

With a thin blade apply a suitable shellac jointing compound to the faces of oil seal and bearing housings.

Secure with bolts and washers. Fit sealing washer (65) (new), washer (66) (new if rubber seal has hardened), nut (68) and split pin (67) (new).

Release 3rd gear.

Replace belt drives and cardan shaft.

Sec. S12 GEARBOX—RENEWING OUTPUT SHAFT OIL SEAL

(See Fig. 2)

(Note a new "O" ring (31), washer (33) and split pin (32) should be available.)

Remove the cardan shaft and belt drives (if fitted). Engage 1st gear.

If no pulley is fitted clean the rear face of gearbox including seal housing and coupling.

Remove split pin (32) (taking great care not to damage screw threads), nut (34), washer (33) and "O" ring (31).

Coupling (and pulley if fitted) can now be withdrawn (note the inner race of roller bearing (35) will come away with coupling flange.)

Remove nuts (27) and spring washers, and withdraw the oil seal housing (28).

Remove faulty seal, clean joint face and wash the seal housing in paraffin and drain.

Clean joint face of bearing sleeve (24) (in gearcase), taking care to exclude any foreign matter from the shaft splines and bearings.

Lay the seal housing on the bench with the joint face uppermost and with great care drive the oil seal (garter spring uppermost) into position.

Pack the space between the two sealing lips with medium grease.

Lightly smear with a suitable shellac jointing compound, the joint faces of the bearing and oil seal housing.

Secure oil seal housing with nuts and washers.

Replace coupling (and pulley if fitted).

Replace "O", ring washer, nut and split pin.

Release 1st Gear.

Replace belt drives (if fitted) and cardan shaft.

Sec. S13 GEARBOX—OIL FILTER

(*See Fig.* 12)

The filter assembly consists of a sump (3) positioned by a centre bolt (5) to a filter head (1). The bolt screws into a centre tube which is locked in the filter head and retains an element guide. The sump beds on a seal (2) carried in a groove formed in the filter head. The lower end of the centre bolt is fitted with a spring (8), washer (11), gasket (12) and a lower element guide (7) retained by a circlip (6). The base of the sump has a reinforcing plate (9) bored to accommodate a seal (10). A filter element (4) is assembled in the sump between the upper and lower element guides.

The filter head is formed with inlet and outlet passages and bored to receive a relief valve which consists of a spring (13) and ball valve (15) retained in the bore by a threaded body (14).

RENEWING THE FILTER ELEMENT

(*See Fig.* 12)

1. Clean the exterior of the filter assembly before removing the sump.
2. Unscrew the centre bolt (5) and withdraw the sump (3) and filter element (4) from the head (1); remove the element from the sump.
3. Thoroughly clean the interior of the sump and ensure that the seal (2) is in good condition and correctly assembled in its groove in the filter head.
4. Place the new element in the sump so that it rests on the lower element to the filter head ensuring that the former seats squarely on the seal (2). Screw the centre bolt (5) into the centre tube firmly enough to ensure that there will be no oil leakage past the seals (2, 10).

DISMANTLING AND ASSEMBLING THE FILTER

(*See Fig.* 12)

Unscrew the centre bolt (5) from the centre tube, withdraw the sump (3), extract the seal (2) from the head (1) and remove the filter element (4). Extract the circlip (6), slide the lower element guide (7), gasket (12), washer (11) and spring (8) off the centre bolt and withdraw the sump; remove the seal (10) and reinforcing plate (9) from the centre bolt.

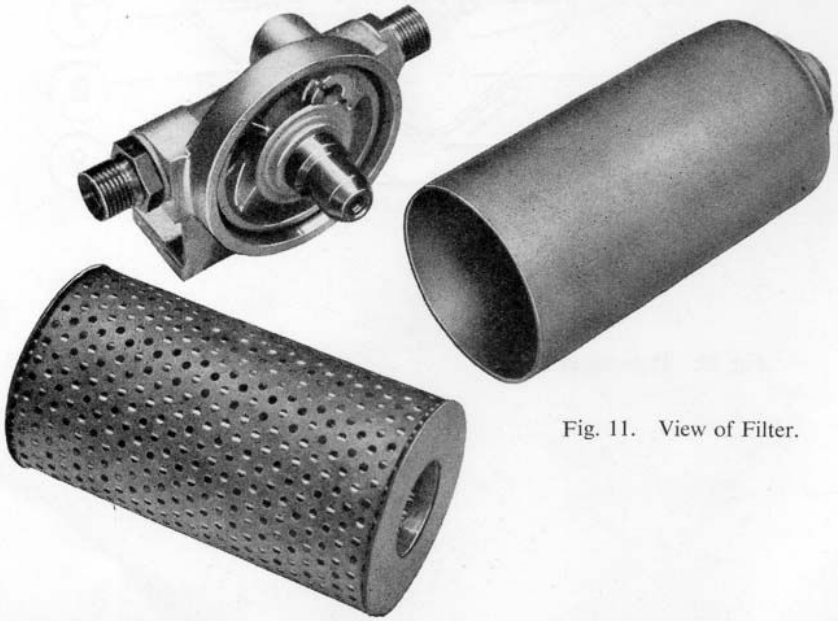


Fig. 11. View of Filter.

To assemble the filter place the seal (10) and reinforcing plate (9) on the centre bolt (5) followed by the sump (3). Slide the spring (8), washer (11), gasket (12) and lower element guide (7), recess foremost, over the centre bolt and fit the circlip (6). Place the filter element (4) in the sump so that it rests on the lower element guide, fit the seal (2) in its groove in the filter head. Screw the centre bolt into the centre tube firmly enough to ensure that there will be no oil leakage past the seals (2, 10).

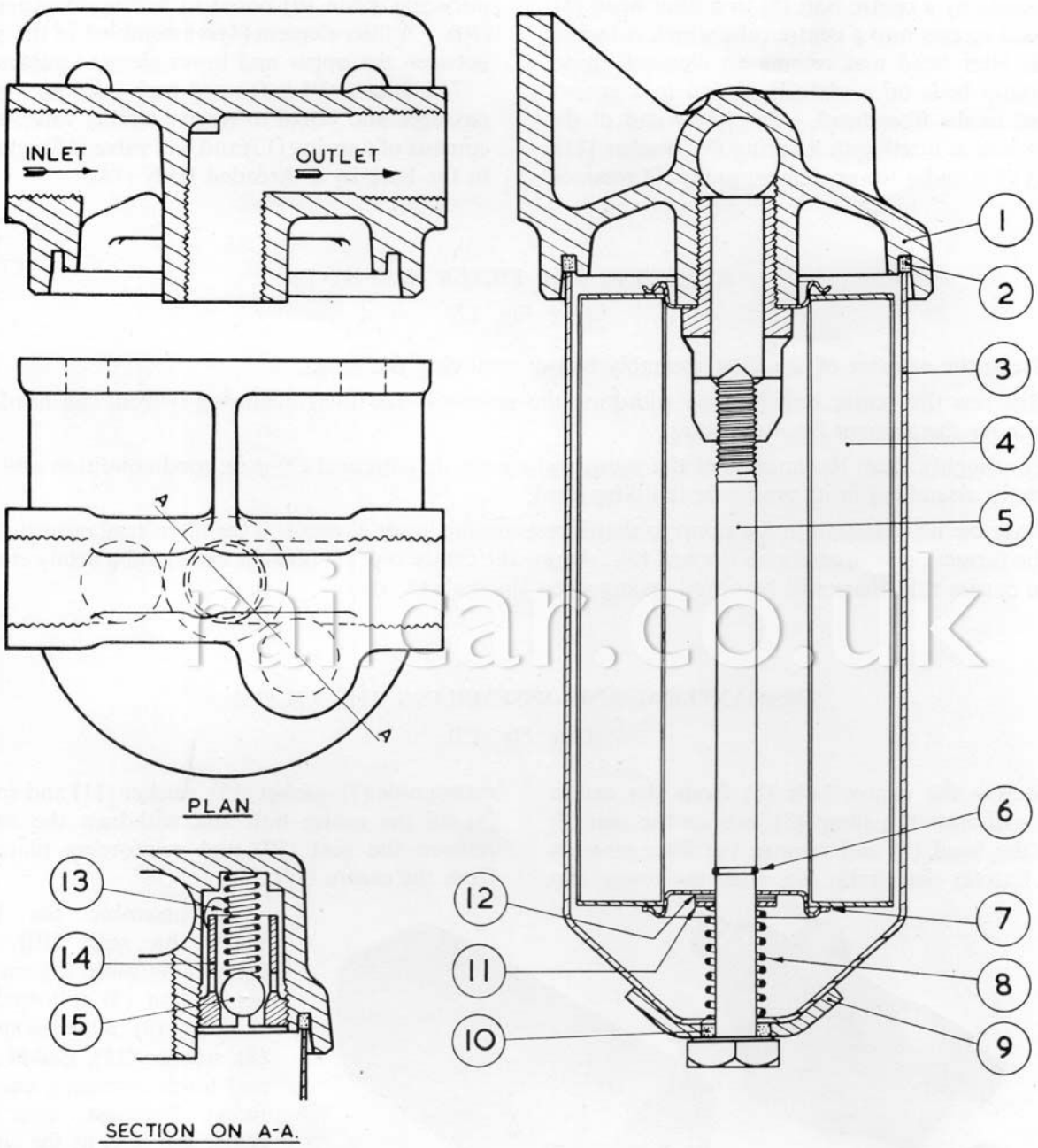


Fig. 12. Drawing of Filter.

Sec. S14 GEARBOX—SERVICING THE BRAKES

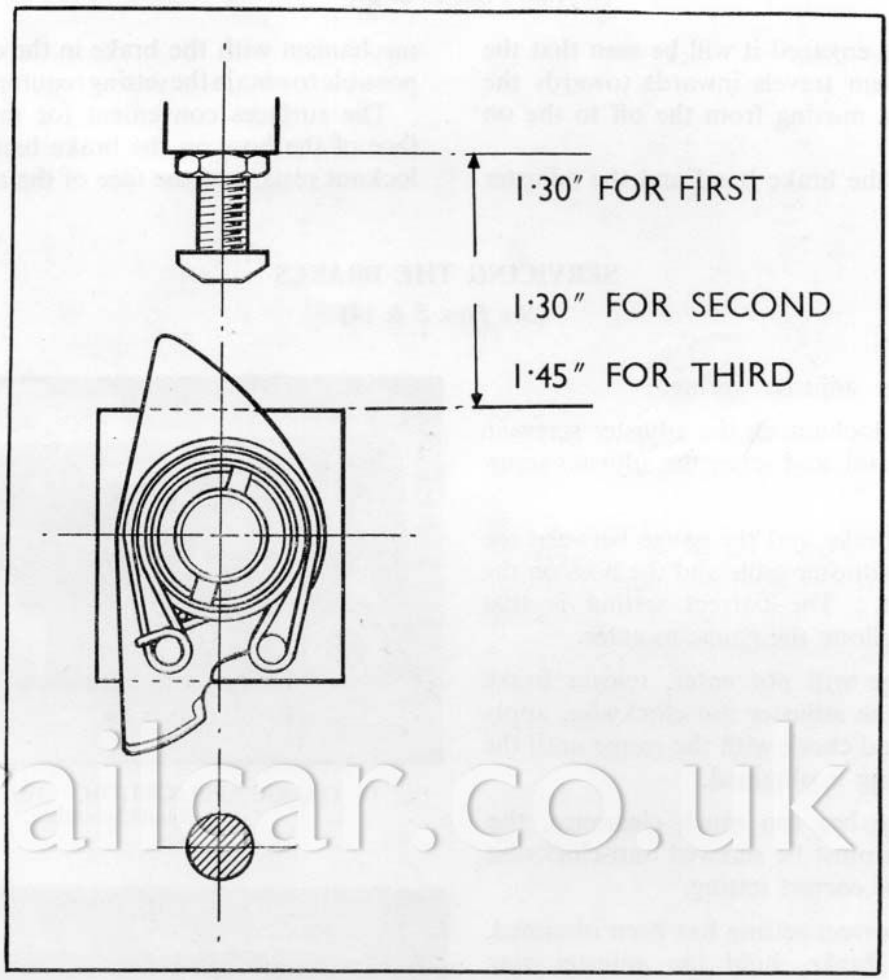


Fig. 13. Brake setting Dimensions

AIR SUPPLY FOR BRAKE ADJUSTMENT

It is essential that dry compressed air, maintained at the correct pressure is available and connected through a suitable two way valve to the brake receiving attention.

The air supply may be obtained from any compressor of suitable capacity, or from a "live" railcar in which an engine can be kept running.

If the gearbox is already installed in a railcar, in the absence of an independent supply, its own reservoir may be charged by running the engines with the gearbox in "Neutral" and the inspection cover in place. The engines must be stopped before the cover is removed. Brake setting can proceed until the main reservoir pressure drops to 5 p.s.i. higher than the gearbox operating pressure, when it is necessary to recharge by replacing the inspection cover and starting the engines again.

FITTING THE AUTOMATIC ADJUSTER SPRING

The spring is fitted over the adjuster nut with the wide coils lying uppermost. The two eyelets and the loop which lies between them are placed on the adjuster ring pin and the remaining loop over the table pin.

THE BRAKE SETTING DIMENSION

(*See Figs.* 13 & 14)

When a gear is engaged it will be seen that the adjuster mechanism travels inwards towards the brake band when moving from the off to the on position.

By measuring the brake band and the adjuster mechanism with the brake in the on position, it is possible to obtain the setting required for each brake.

The surfaces convenient for measuring are the face of the boss on the brake band on which the locknut rests, and the face of the adjuster table.

SERVICING THE BRAKES

(*See Figs.* 5 & 14)

1. Remove the adjuster spring.
2. Loosen the locknut on the adjuster screw in the brake band, and screw the adjuster screw right in.
3. Apply the brake and try gauge between the face of the adjuster table and the boss on the brake band. The correct setting is that which just allows the gauge to enter.
4. If the gauge will not enter, release brake and screw the adjuster nut clockwise, apply the brake and check with the gauge until the correct setting is obtained.
5. If the gauge has too much clearance, the adjuster nut must be screwed anti-clockwise to obtain the correct setting.
6. When the correct setting has been obtained, release the brake, hold the adjuster ring against the tail pin and replace the spring.
7. Apply and release the brake, moving the adjuster screw out at each release, until the adjuster ring just touches the screw in the on position.
8. Lock the adjuster screw, with the face which contacts the adjuster ring vertical.
9. Release the spring, then screw the adjuster nut anti-clockwise half a turn and replace the spring.
10. Apply and release the brakes several times and note if the adjuster nut has turned. (This may be seen by laying a straight edge across the inspection aperture parallel to the slots in the nut when the brake is in the off position, and then sighting the slots at each release.) If the adjuster nut has turned, apply and release the brake repeatedly until the nut stops turning. When the nut appears to have stopped turning, another six applications should be made to ensure that no further movement takes place.
11. If the adjuster nut has not turned, move the adjuster screw out half a turn at a time until the nut commences to turn, apply and release the brake until the nut has ceased to turn, and check the gap with the gauge.

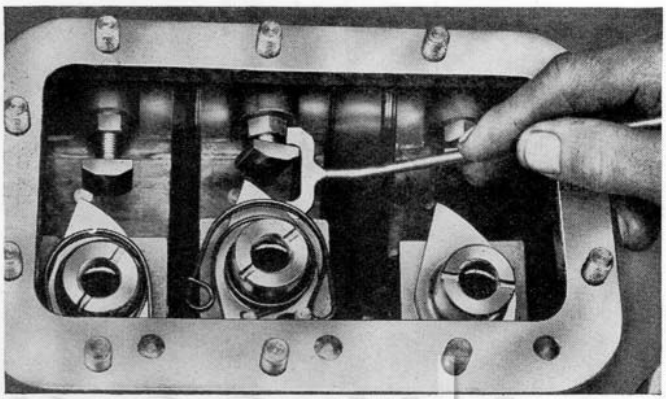


Fig. 14 GAUGE APPLICATION. This shows where the gauge should be applied.

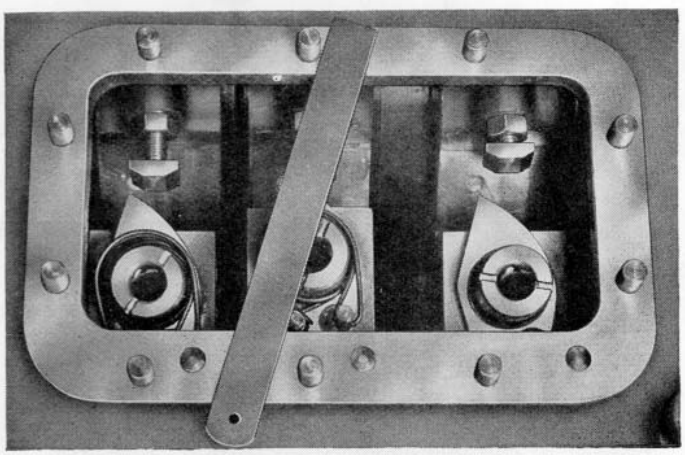


Fig. 15. Checking Movement of Adjuster Nut

FINAL ADJUSTMENT

Insufficient Gauge Clearance:—

1. If the gauge will not enter, release the brake and move the adjuster screw half a turn outwards and relock.
2. Apply and release the brake until the adjuster nut stops turning.
3. Check the gap.
   Repeat these operations 1 to 3 if required.

Excessive Gauge Clearance:—

1. If the gauge has too much clearance, move the adjuster screw half a turn inwards and relock.
2. Release the adjuster spring and screw the adjuster nut half a turn in the anti-clockwise direction.
3. Replace the adjuster spring, apply and release the brake until the adjuster nut stops turning.
4. Check the gap.
   Repeat these operations 1 to 4 if required.

NOTE—Should the mechanism fail to respond to this setting sequence (especially failure of adjuster nut to turn when the adjuster spring is considerably deflected) see Failure of Automatic Adjuster.

FAILURE OF AUTOMATIC ADJUSTER

This mechanism depends on the ratcheting effect of the automatic adjuster spring turning the adjuster nut. This lifts the pullrod and reduces the clearance between the brake band and the drum so reducing the amount of movement permitted to the linkage.

Adjustment compensates for normal lining wear, but the mechanism will not work if the brake is badly out of adjustment.

If failure is suspected, first adjust the brake according to 'Servicing the Brakes'.

A fault in the automatic adjuster will become apparent in the application of paragraph 11.

When failure is established.

1. Engage the brake.
2. Remove the spring.
3. Check that the ring swings freely around the nut. It should have both vertical and journal clearance.
4. Release the brake.
5. With the special key, turn the adjuster nut clockwise (to test for tightness), and back again. If tight refer to 6 (b).
6. If checks 3 or 5 reveal trouble, remove the adjuster nut, ring and table:—

   (a) Tightness of the ring may be occasioned by the intrusion of foreign matter or by wear.

   Clean the parts and check that they are free from damage—burrs, etc. should be removed. Fit the ring to the nut and check that in its working position it swings freely. With the ring in position press the nut into its seating on the table and test for clearance between the face of the ring and the abutment shoulder on the nut. If less than .005″ clearance exists, the underside of the plate should be filed down to give .005″ to .010″ clearance.

   (b) Remove the thrust pad and check the fit of nut on the pullrod. It should screw down by hand (without the use of the key) until the rod protrudes $\frac{1}{8}$″ above the top of it. Tightness in the nut may be corrected by the use of a tap ($\frac{11}{16}$″—16 UNS—2 B Thread).

   If the pullrod threads are damaged the gearbox must be sent for overhaul.

   (c) If (a) and (b) do not reveal the trouble, fit new automatic adjuster spring.

Sec. S15 GEARBOX—TO REMOVE AND FIT

Drain the oil from the gearbox by removing the two plugs fitted in the bottom cover and the front cover.

NOTE—The drain plug in the bottom cover is of the magnetic type and should be cleaned prior to replacement.

Disconnect the propeller shaft couplings from the front and rear of gearbox, also the pulley belts if fitted.

Release the four air connections at the gearbox.

Pack up the gearbox and remove the mounting bolts.

Remove the gearbox from the railcar and transfer to bench for dismantling.

Clean outside of gearbox thoroughly, masking the breather and air unions to prevent entrance of foreign matter.

To replace the gearbox, reverse the above procedure.

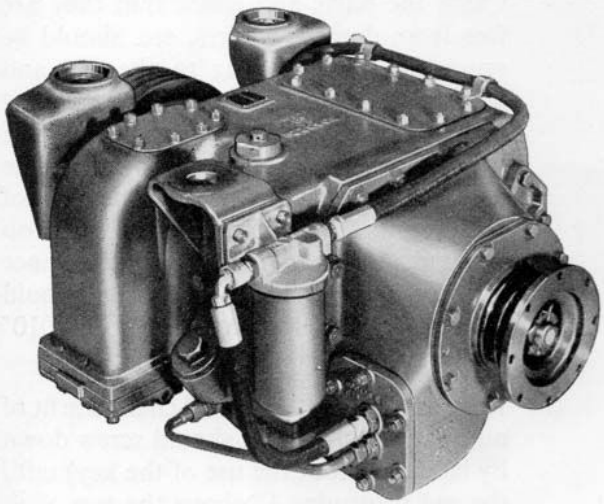


Fig. 16. View of Gearbox (a).

Fig. 17. View of Gearbox (b).

DRIVING AXLE.

CHAPTER E.

CONTENTS.

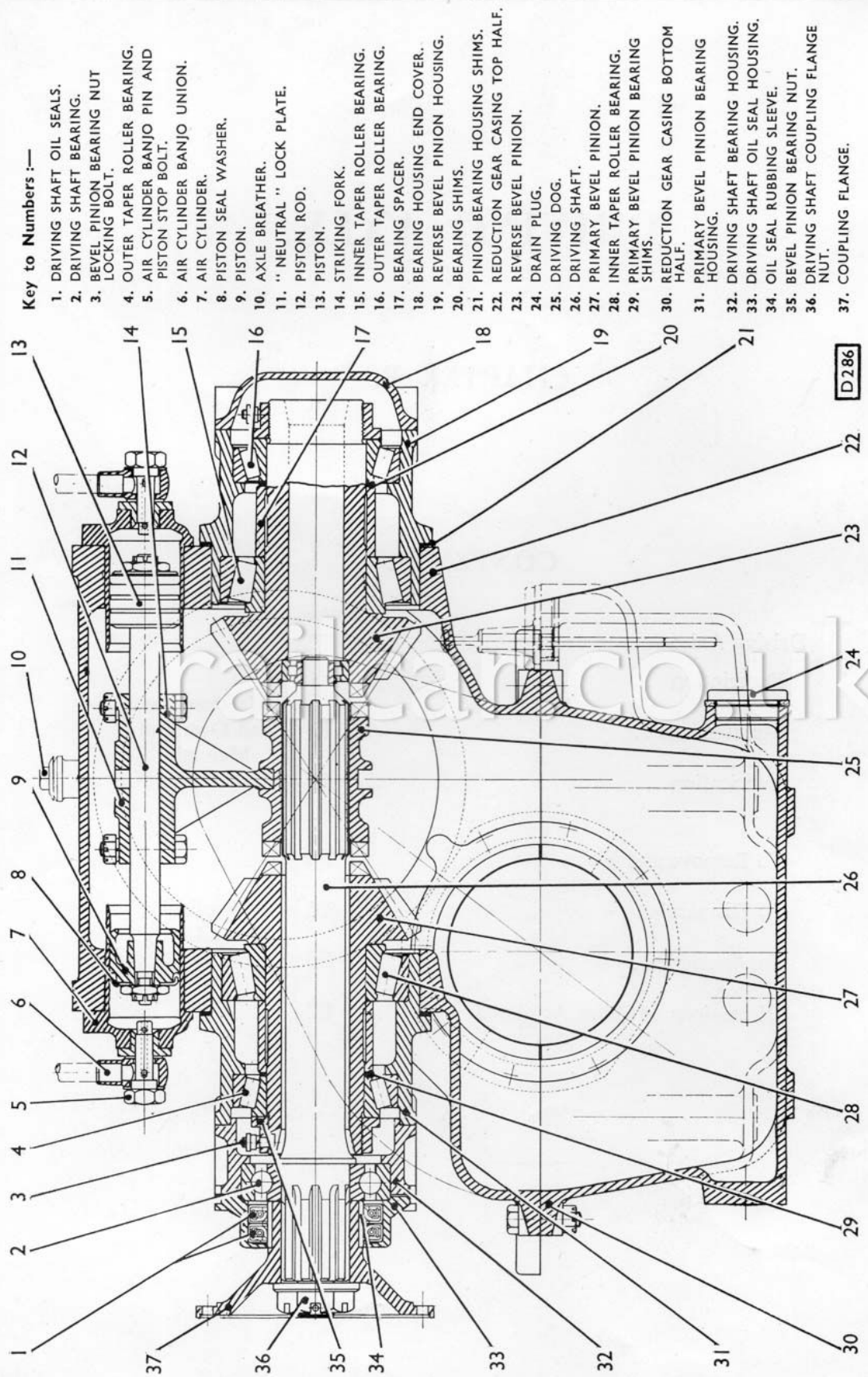


Fig. 1. Longitudinal section through bevel pinions.

Sect. E1. DRIVING AXLE—DESCRIPTION.

(*See Figs.* 1, 2, 3 *and* 4).

The final drive to the inner axle of each bogie is of the double reduction type, the primary reduction being by spiral bevel gears, the secondary reduction by straight spur gearing.

The final drive casing is mounted on roller bearings between the wheels of the driving axle; the casing being divided horizontally in the plane of the axle thus permitting easy removal of the primary reduction and spur gear pinion.

Driving torque reaction is taken by an arm attached to the final drive casing and restricted at its outer extremity by a fork-end and pin, carried in a resilient mounting, and secured to the bogie frame.

Two opposed bevel pinions mounted in the fore and aft plane of the bogie provide forward and reverse motion for the railcar.

The drive is transmitted by a shaft which passes through the hollow primary pinion and is spigoted in the reverse pinion.

Selection is by an air operated striking fork which engages with a sliding dog, carried on the splined portion of the driving shaft between the bevel pinions.

The striking fork is secured to a rod which is actuated by air operated pistons attached to each end.

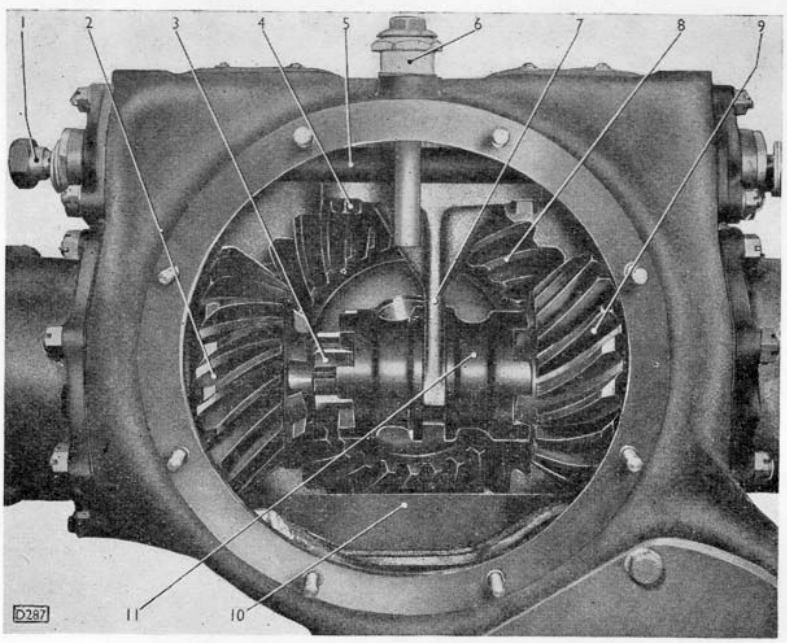
It is possible to isolate the axle drive by locking the striking fork in the " neutral " position with the hand operated plunger mounted on the axle casing.

On late type axles a pointer attached to the inspection cover indicates whether the axle is engaged in forward or reverse speed. The pointer is operated by a lever which engages a slot in the " neutral " plate which in turn is actuated by the piston operating rod. The lever also operates a switch, fitted to the axle casing, which is connected to an indicator in the driver's cab.

Filling and drain plugs, together with a dip-stick, are provided for lubricant; a breather is fitted on top of the casing.

Important Warning to Drivers.

The oil pump will not function unless the input shaft is turning, it is therefore imperative that **the gearboxes must be in gear at all times when the car is in motion** in order to avoid damage to the gearbox through lack of lubrication.



Key to Numbers :—

1. AIR SUPPLY PIPE BANJO PIN AND PISTON STOP BOLT.
2. PRIMARY BEVEL PINION.
3. DRIVING SHAFT.
4. STRIKING FORK SET-SCREW.
5. PISTON ROD.
6. BREATHER.
7. ENGAGEMENT DOG STRIKING FORK.
8. BEVEL WHEEL.
9. REVERSE BEVEL PINION.
10. BEVEL WHEEL OIL TROUGH.
11. ENGAGEMENT DOG.

Fig. 2. Final drive showing engagement dog in forward speed.

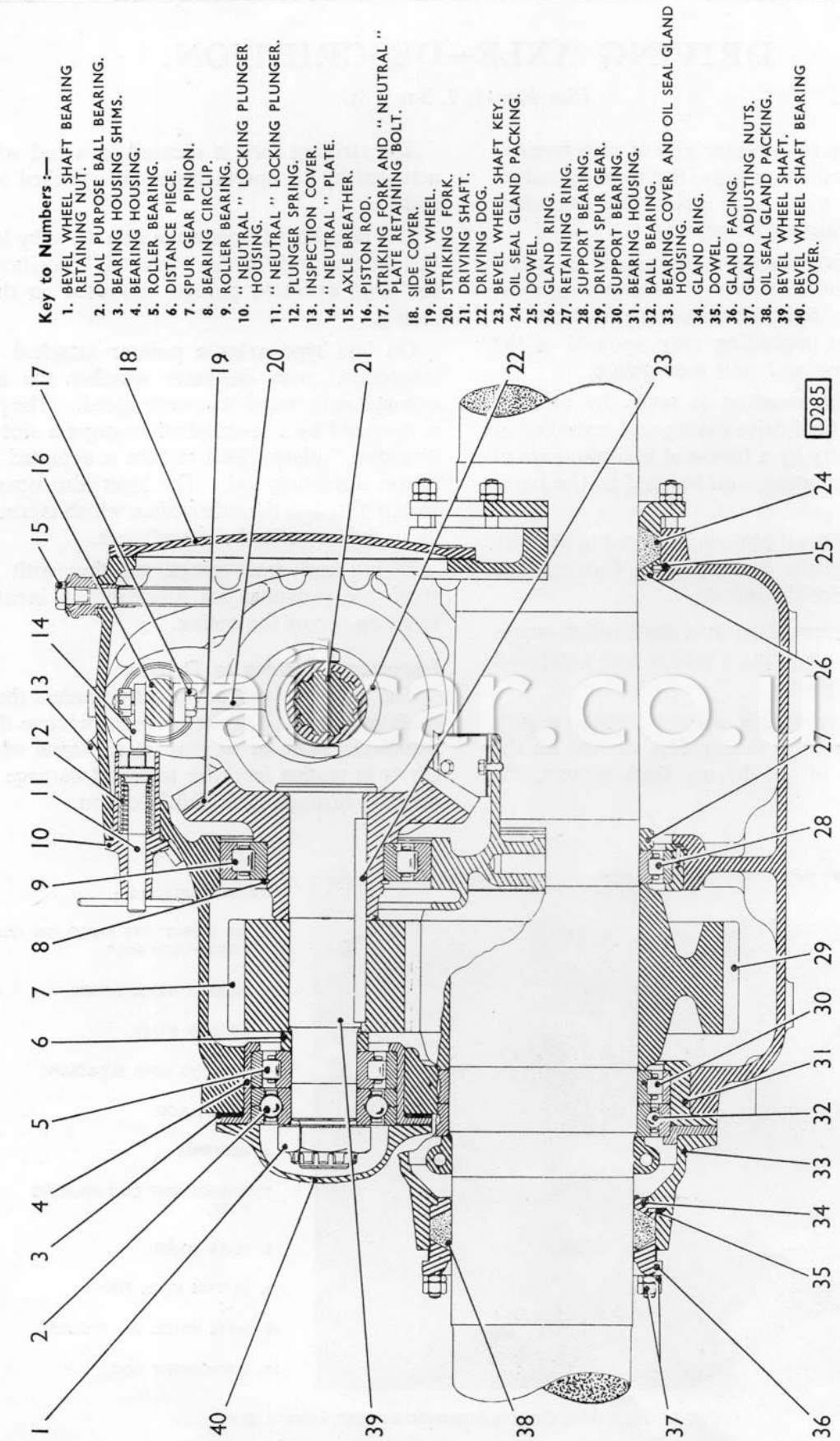


Fig. 3. Longitudinal section through bevel wheel and shaft.

For this reason "COASTING" must be avoided at all times.

IMPORTANT: If a car is to be TOWED, due to failure, the driving axles must be isolated as follows:—

Stop the car. Remove the driver's control key; this will automatically de-energise the electro-pneumatic valve magnets which, in turn, will release the pressure in the striking fork air cylinders.

Remove the traps in the body floor giving access to the driving axle units.

On early axles, remove one of the inspection covers from the top of the axle casing.

Pull the hand-operated locking plunger outwards, then give it a quarter of a turn and release it so that it engages in the deep slots in the plunger body, i.e. in the horizontal position.

Insert a lever through the inspection aperture and move the selector fork to either left or right as necessary until the locking plunger engages the slot in the "neutral" locking plate.

Refit the inspection cover and secure it with the nuts and locking wire.

On late axles, ascertain by means of the indicator in the driver's cab or the pointer on the axle casing, whether the axle is engaged in forward or reverse speed.

Remove the combined air banjo pin and piston stop bolt from the appropriate air cylinder, taking care to retain the copper washers.

Pull the hand-operated locking plunger outwards, then give it a quarter of a turn and release it so that it engages in the deep slots in the plunger body, i.e. in the horizontal position.

Insert a rod into the air cylinder and push the piston rod until the locking plunger engages the slot in the "neutral" locking plate.

Refit the combined air banjo pin and piston stop bolt, ensuring that the copper washers are in position.

Sect. E2. DRIVING AXLE—MAINTENANCE.

The following points require attention at the intervals quoted below.

Period.	Attention required.
AFTER FIRST 1,000 MILES (1,600 KM.) OF A NEW OR OVERHAULED CAR	Drain the oil from the final drive casings and refill with fresh oil (*see Section* E3). Check the oil seal packing glands on the axle shaft, for oil leaks, and if leaking report immediately.
DAILY	Check for air leaks (*see below*).
WEEKLY	Top-up the final drive casings with oil up to the " Full " mark on the dipstick (*see Section* E3).
BIMONTHLY OR EVERY 10,000 MILES (16,000 KM.).	Drain the oil from the final drive casings and fill with fresh oil (*see Section* E3). Clean the breathers on the final drive casings (*see below*). Examine all casing, cover and driving flange joints for leakage and rectify if necessary.

To Check for Air Leaks.

To check for leaks apply a solution of soap and water and watch for bubbles.

Check the air pipe connections on the air cylinders for leaks and tighten the banjo pins or renew the copper washers as necessary.

Check the joints between the air cylinders and the final drive casing and tighten the cylinder nuts if necessary.

If air leaking past the piston seals is suspected, remove the inspection cover from the top of the final drive casing, ensure that the axle is engaged, and if a leakage is occurring it can be detected by air escaping into the casing.

To Renew the Piston Seals (*see Figs.* 1 *and* 2).

When a leak is apparent the piston seals should be renewed as follows:—

Ensure that the "Forward" and "Reverse" lever in the driver's cab is removed to immobilise the car.

Unscrew the banjo pins from the air cylinders; this will release the air in the pipe line.

Remove the bevel wheel cover from the final drive casing.

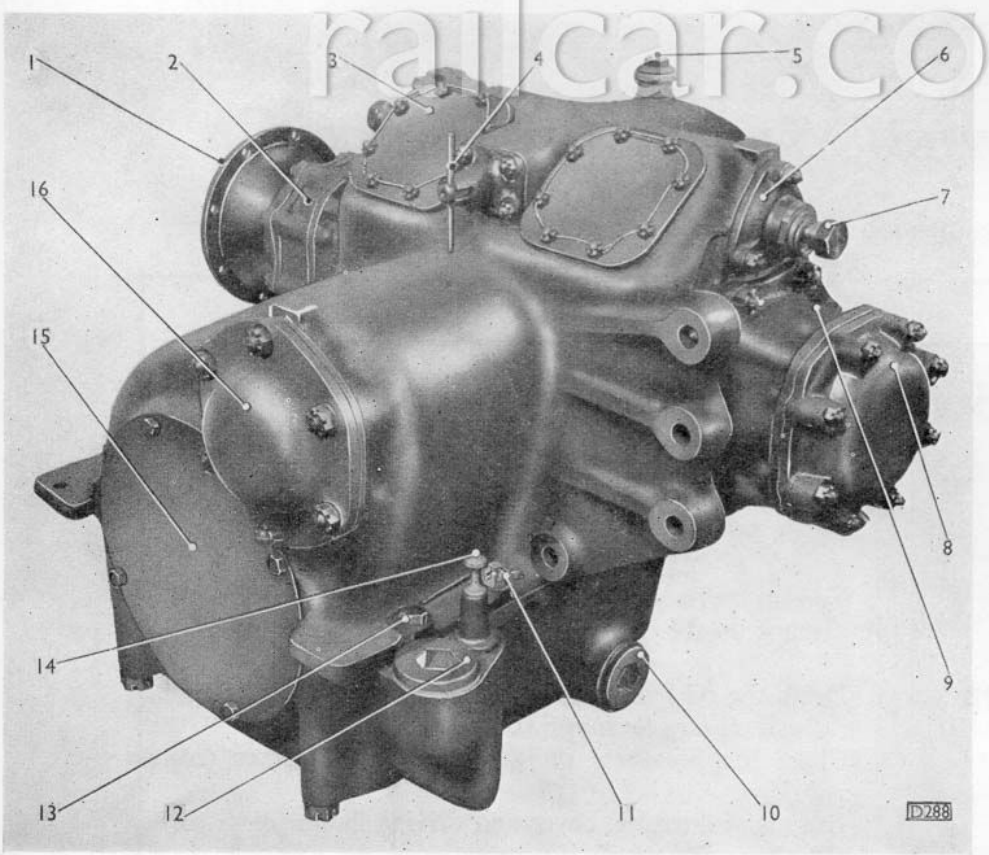
Unscrew the nuts securing one of the air cylinders and drive out the cylinder using a hammer and brass drift from inside the final drive casing.

Move the piston rod as far as possible towards the bore from which the cylinder has been removed, extract the split pin and remove the nut securing the piston to its rod.

Remove the piston seal retaining washer followed by the seal.

Fit a new seal with its lip facing towards the **outside** of the final drive casing, then secure it with the retaining washer, nut and split pin.

Lightly smear the air cylinder with oil, fit it to the casing, taking care not to damage the piston seal, and secure it with the nuts and split pins.



Key to Numbers :—

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

Fig. 4. Final drive unit.

Secure the air cylinder banjo union with the banjo pin, ensuring that the washers are in position and in good condition.

Repeat the procedure for the other piston; then refit the bevel wheel cover and inspection cover.

To Clean the Breather.

Clean the breathers on the final drive casings as follows (*see Figs.* 2 *and* 3):—

Unscrew the breather body, using a $\frac{7}{8}$ in. B.S.F. spanner, and remove the assembly.

Unscrew the set-screw and remove the dished washer.

Wash the parts in clean paraffin and, if an air line is available, apply the nozzle to the breather body and blow the holes clear.

Reassemble the parts reversing the procedure for dismantling, ensure that the leather washer is in good condition and refit the breather to the reduction gear casing.

Sect. E3. DRIVING AXLE—LUBRICATION.

(*See Figs.* 1 *and* 4).

To drain the oil from the axle, place a suitable container in position and remove the drain plug from the final drive casing (*see Fig*, 1).

Whenever possible drain the oil when warm, i.e., directly the car has completed a run.

When the axle has been completely drained, refit and tighten the drain plug.

To refill or " top-up " the axle, pour in oil through the filler plug hole until it reaches the " Full " mark on the dipstick (*see Fig.* 1).

The capacity of the axle is $3\frac{1}{2}$ Imp. gallons (15·91 litres) of gear oil to the following specification.

SPECIFICATION OF GEAR OIL

(*A.E.C. Specification No. L6*).

Description.—To be a pure hydrocarbon oil thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's " Standard Methods for Testing Petroleum and its Products, " the oil must conform with the following requirements :—

Specific Gravity ..	..0·950 maximum
Viscosity (Redwood No. 1) at 140° F. (60° C.)	.. 850—950 seconds (205—235 centistokes)
Viscosity (Redwood No. 1) at 200° F. (93·3° C.)	.. 165 seconds minimum (39·5 centistokes)
Pour Point.. ..	.. 30° F. (minus 1·1° C.) maximum
Closed Flash Point	..490° F. (254·4° C.) minimum
Acidity (organic)	.. 0·10 mgms. KOH per gm. maximum
Ash	.. 0·02 per cent. maximum
Asphaltenes ..	.. 0·10 per cent. maximum

NOTES.

PROPELLER SHAFTS.

CHAPTER D.

CONTENTS.

Sect. D1. PROPELLER SHAFTS—DESCRIPTION.

(*See Figs.* 1, 2 *and* 4).

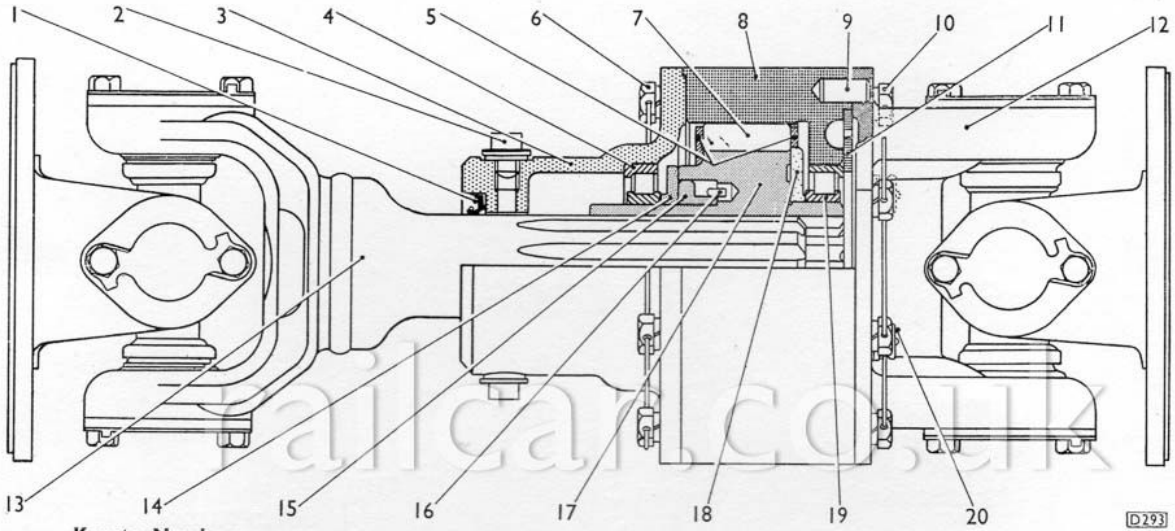
The drive from the engine and fluid coupling to the driving axle is transmitted by means of two propeller shafts as follows:—

First shaft from the fluid coupling to the gearbox.

Second shaft from the gearbox to the driving axle.

The first shaft incorporates the free wheel mechanism and, on early cars, is fitted with two types of universal joint, the one at the engine end being of the plain bearing type, the other being the needle roller bearing type.

On late cars, both universal joints are of the needle roller type.



Key to Numbers :—

1. OIL SEAL.
2. LUBRICATING PLUG.
3. SLEEVE.
4. BEARING.
5. ROLLER CAGE.
6. SLEEVE SET-SCREW.
7. ROLLER.
8. OUTER CAGE.
9. DOWEL.
10. UNIVERSAL JOINT SET-SCREW.
11. RETAINING PLATE.
12. UNIVERSAL JOINT ASSEMBLY (NEEDLE ROLLER BEARING TYPE).
13. SPLINED SHAFT AND UNIVERSAL JOINT ASSEMBLY (NEEDLE ROLLER BEARING TYPE).
14. DISTANCE WASHER.
15. SPRING RETAINER.
16. SPRING.
17. SPLINED SLEEVE.
18. RETAINING WASHER.
19. BEARING.
20. LUBRICATOR.

Fig. 1. Arrangement of first propeller shaft and freewheel—needle roller bearing type joints.

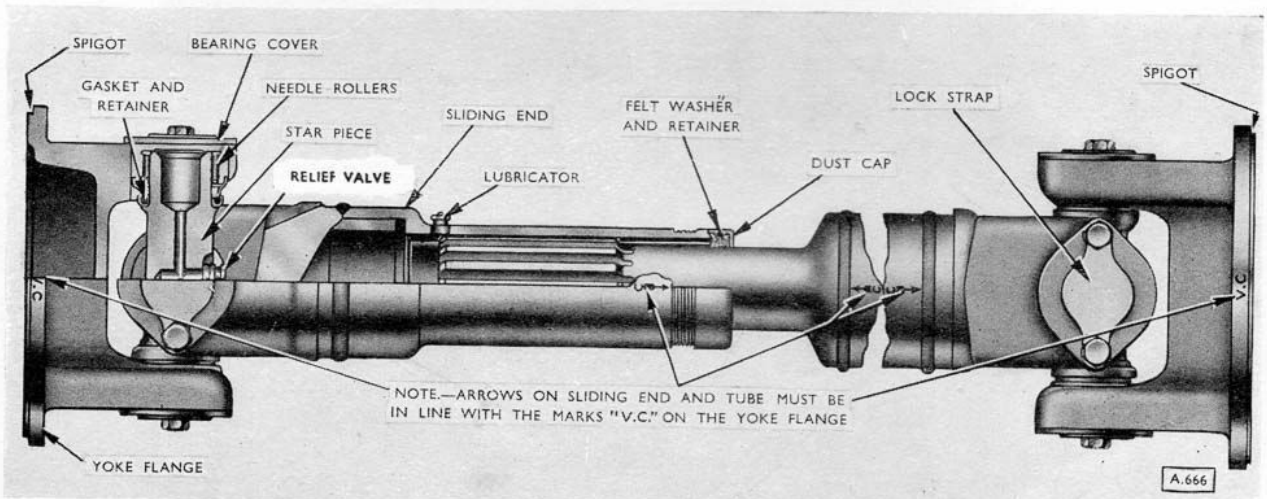


Fig. 2. Section through propeller shaft—needle roller bearing type joints.

The second shaft has a sliding universal joint at one end and both joints are of the needle roller bearing type.

On early cars the drive from the engine to the fan is via two shafts as follows:—

First shaft from the engine to the relay bracket.

Second shaft from the relay bracket to the fan.

On late cars only one shaft is fitted between the engine and the fan.

All shafts between the engine and the fan have a sliding universal joint at one end, the joints being of the needle roller bearing type.

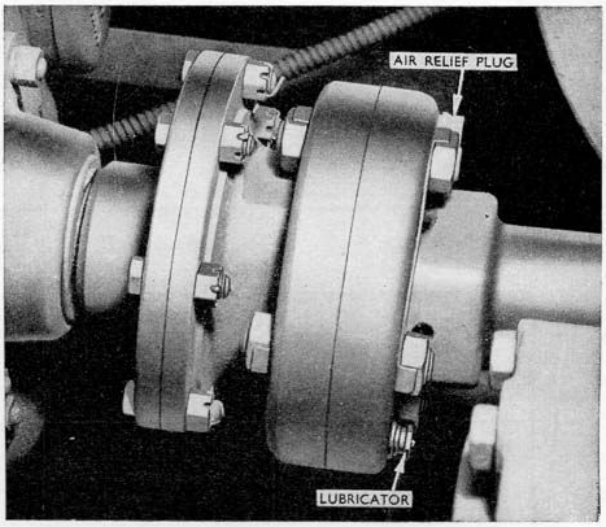


Fig. 3. Plain bearing type universal joint showing lubricating point.

Sect. D2. PROPELLER SHAFTS—MAINTENANCE.

The following instructions are principally intended as a guide, but it is hoped that they will be of use to operators in maintaining their propeller shafts.

Period.	Attention required.
WEEKLY.	Examine the universal joint bearings and check for "play." If "play" is detected it should be reported. Lubricate the free wheels with the **grease** gun. Lubricate the plain bearing type universal joints of the engine/gearbox propeller shafts with the **grease** gun. Lubricate the splined sliding ends with the **grease** gun. Lubricate the needle roller bearing type universal joints with the **oil** gun. Lubricate the universal joints of the gearbox/final drive propeller shafts with the **oil** gun. Lubricate the splined sliding ends with the **grease** gun. Lubricate the universal joints of the engine fan propeller shafts with the **oil** gun. Lubricate the splined sliding ends with the **grease** gun.
MONTHLY OR EVERY (5,000 MILES 8,000 KM.)	Examine for slackness, the bolts securing the universal joint coupling flanges and tighten if necessary.

Sect. D3. PROPELLER SHAFTS—LUBRICATION.

(*See Figs.* 1, 2, 3 *and* 4).

Plain bearing type and needle roller type universal joints and all sliding ends should be lubricated as follows:—

Item.	Number of Lubricating points.	Oil Level.	Type of Lubricant.
Needle Roller Type Universal Joints	14 Nipples	Relief Valve	Gear Oil (*A.E.C. Specification No.* L6)
Plain Bearing Type Universal Joints	2 Nipples	Level Plug (*see below*)	Grease (*A.E.C. Specification No.* L11)
Splined Sliding Ends	6 Nipples	—	Grease (*A.E.C. Specification No.*L 11)
Freewheels	4 Nipples	—	Grease (*A.E.C. Specification No.* L11)

When lubricating the freewheels, remove the plug in the top of each freewheel sleeve, to permit the escape of air; then inject grease through the lubricator until an excess appears at the plug hole. Then refit and tighten the plug (*see Fig.* 1).

When lubricating plain bearing type universal joints, remove the plug opposite the lubricator to permit the escape of air; then inject grease through the lubricator until an excess appears at the plug hole. Then screw in and tighten the plug (*see Figs.* 3 *and* 4).

With needle roller joints, inject lubricant via the oil nipple until it exudes through the relief valve situated in the centre of the star piece (*see Fig.* 2).

SPECIFICATION OF GEAR OIL.

(*A.E.C. Specification No. L6*).

Description.—To be a pure hydrocarbon oil thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

Specific Gravity	0·950 maximum
Viscosity (Redwood No. 1) at 140° F. (60° C.)	850—950 seconds (205—235 centistokes)
Viscosity (Redwood No. 1) at 200° F. (93·3° C.)	165 seconds minimum (39·5 centistokes)
Pour Point	30° F. (minus 1·1° C.) maximum
Closed Flash Point	490° F. (254·4° C.) minimum
Acidity (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·02 per cent. maximum
Asphaltenes	0·10 per cent. maximum

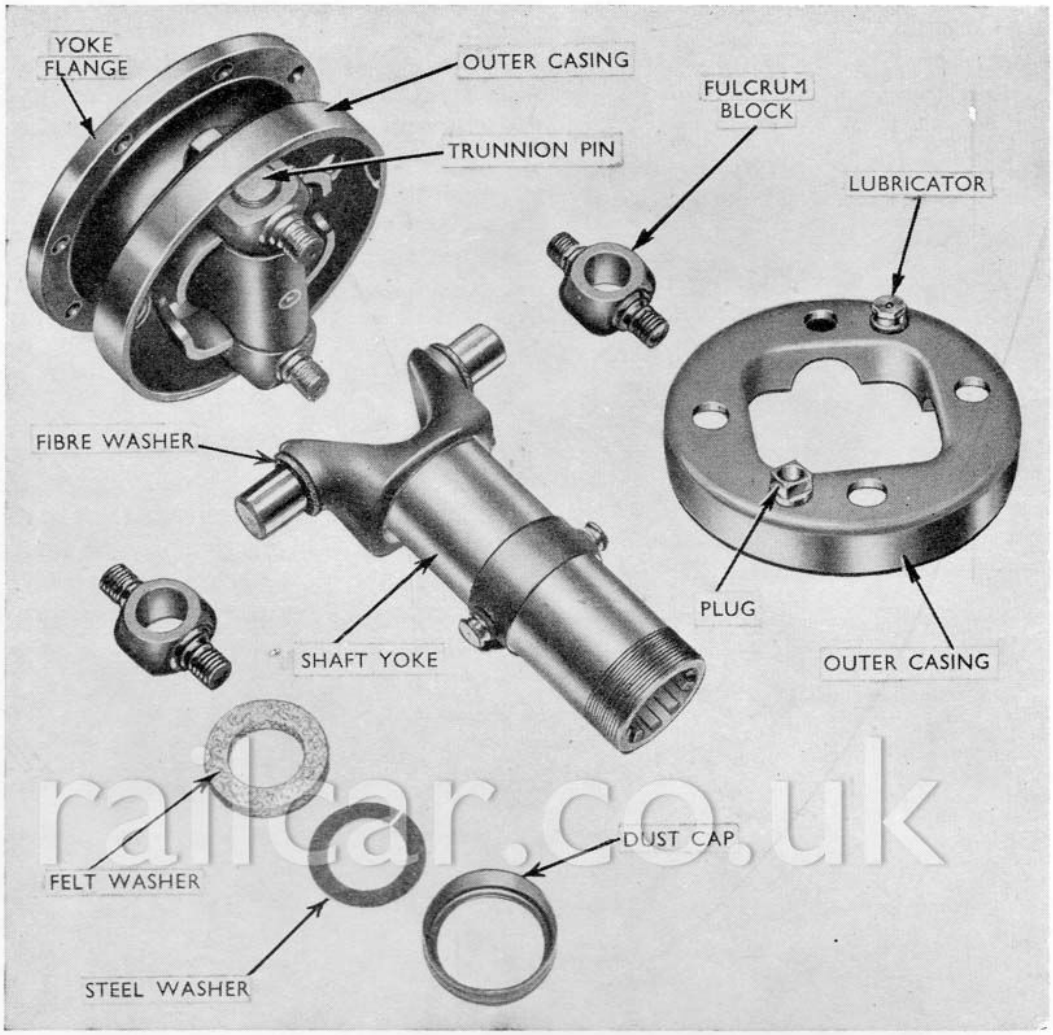


Fig. 4. Exploded view of plain bearing type universal joint fitted to early cars.

SPECIFICATION OF GREASE.

(A.E.C. Specification No. L11).

Description.—The grease to be a smooth, homogeneous preparation possessing no bad odour. To be suitable for lubrication of roller and ball bearings.

The grease to be prepared from refined and filtered mineral oil together with saponifiable materials of good quality, saponified with a good grade lime. Rosin or rosin oil must not be present. The grease also to be entirely free from mineral filling matter of any kind, or grit. To exhibit no tendency for oil to separate on storage or to emulsify with water.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's " Standard Methods for Testing Petroleum and its Products," the grease must conform with the following requirements:—

Soap Base	.. Lime
Drop Point ..	.. 203° F. (95° C.) minimum
Worked Penetration	.. 230—260 units.
Heat Resistance (*see Appendix* A)	.. No oil separation or hardening

Copper Strip Corrosion (*see Appendix* B)	Negative
Viscosity of Mineral Oil (Redwood No. 1) at 140° F. (60° C.)	130 seconds minimum (31·5 centistokes)
Colour of Mineral Oil	Pale
Ash (As CaO)	2·0 per cent. maximum
Ash (Sulphated)	4·9 per cent. maximum
Water	1·0 per cent. maximum
Free Alkali and/or Acid	2·0 mgms. KOH per gm. maximum

Appendix A.

Method of Determining Heat Resistance of Grease.

A portion of grease weighing 10—20 gms., contained in a clock glass of suitable dimensions, shall be maintained at 248° F. (120° C.) in an air oven for a period of one hour. The test sample shall then be left undisturbed for twenty-four hours at room temperature. At the conclusion of the test period, the sample shall be examined for oil separation, and signs of cracking. Upon being worked with a spatula, the grease shall return to a consistency resembling that of the material prior to heating.

Appendix B.

Corrosion Test for Grease.

The test shall be carried out as described in I.P. 112. It shall be conducted at room temperature, the period of immersion of the copper test piece in the grease being twenty-four hours. At the conclusion of the test, the copper strip shall show no signs of discoloration.

RADIATOR AND FAN.

CHAPTER F.

CONTENTS.

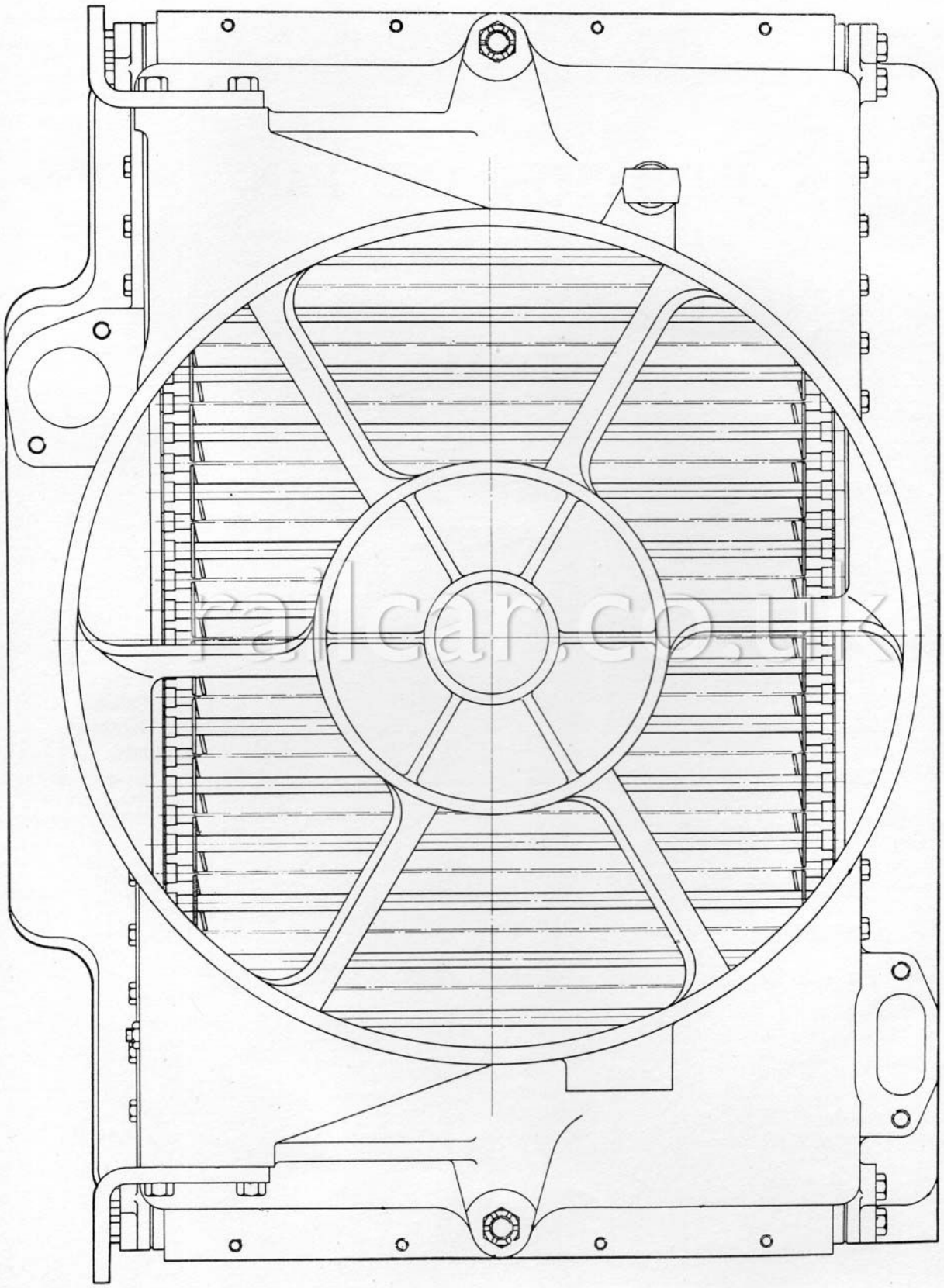


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Fig. 1. Arrangement of radiator and fan cowl.

Sect. F1. RADIATOR—DESCRIPTION.

(*See Fig.* 1).

The radiator consists of a tube block formed of vertical tubes and horizontal gill plates, detachable top and bottom tanks and side standards. A drain cock is provided in the bottom tank and the complete block is secured to the fan housing by two bolts.

The fan housing encloses an eight-bladed fan which is carried on a spindle mounted on two ball bearings.

On early cars the fan is driven from the engine crankshaft via two propeller shafts and "V" belts. Adjustment for the belts is provided by two eccentric pulley type tensioners.

On late cars the fan is driven from a right angle drive unit, mounted on the engine crankcase, via a single propeller shaft.

Clearance between the tips of the fan blades and the housing is kept to a minimum, the housing incorporating fixed vanes in front of the fan in order to prevent excessive air swirl and thus enables the fan to develop its maximum efficiency.

The thermostat, which is fitted in the return water pipe line between the engine and the radiator, is a two-way valve operated automatically by the temperature of the cooling water. On starting the engine the by-pass is open and the coolant, not being free to circulate through the radiator block, rapidly rises in temperature. As the temperature approaches a predetermined figure a gas-filled metal bellows within the thermostat expands and closes the by-pass, allowing the coolant to pass to the radiator block.

Sect. F2. MAINTENANCE.

The following points require attention at intervals quoted below :—

Period.	Attention Required.
DAILY.	Check the level of water in the radiator supply tank and top-up if necessary. Check that the thermostat valve is working satisfactorily (*see below*).
WEEKLY.	Lubricate the fan spindle bearings (*see Section* F3).
MONTHLY OR EVERY 5,000 MILES (8,000 KM.).	Check the radiator hose connections and if necessary tighten the clips. Check the retaining bolts on the fan universal joint flange and tighten if necessary.

Soft water, preferably clean rain water, should always be used in the cooling system, otherwise pipes and tubes will become "furred." Cold water should **never** be put into the radiator supply tank whilst the engine is hot.

Should the engine show any signs of overheating check that the thermostat valve is working satisfactorily.

If the thermostat valve assembly does not function correctly, do not attempt to repair it, fit a new one.

Sect. F3. LUBRICATION.

The fan spindle bearings should be lubricated (*see Lubrication Chart*) through the pipe from the appropriate nipple on the frame, with a grease to the following specification.

SPECIFICATION OF GREASE.

(*A.E.C. Specification No. L*11).

Description.—The grease to be a smooth, homogeneous preparation possessing no bad odour. To be suitable for lubrication of roller and ball bearings.

The grease to be prepared from refined and filtered mineral oil together with saponifiable materials of good quality, saponified with a good grade lime. Rosin or rosin oil must not be present. The grease also to be entirely free from mineral filling matter of any kind, or grit. To exhibit no tendency for oil to separate on storage or to emulsify with water.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the grease must conform with the following requirements:—

Soap Base	.. Lime
Drop Point ..	.. 203° F. (95° C.) minimum
Worked Penetration	.. 230—260 units
Heat Resistance (*see Appendix* A)	.. No oil separation or hardening
Copper Strip Corrosion (*see Appendix* B)	.. Negative
Viscosity of Mineral Oil (Redwood No. 1) at 140° F. (60° C.)	.. 130 seconds minimum (31·5 centistokes)
Colour of Mineral Oil ..	Pale
Ash (As CaO)	2·0 per cent. maximum
Ash (Sulphated)	4·9 per cent. maximum
Water	1·0 per cent. maximum
Free Alkali and/or Acid ..	2·0 mgms. KOH per gm. maximum

Appendix A.

Method of Determining Heat Resistance of Grease.

A portion of grease weighing 10—20 gms., contained in a clock glass of suitable dimensions, shall be maintained at 248° F. (120° C.) in an air oven for a period of one hour. The test sample shall then be left undisturbed for twenty-four hours at room temperature. At the conclusion of the test period, the sample shall be examined for oil separation, and signs of cracking. Upon being worked with a spatula, the grease shall return to a consistency resembling that of the material prior to heating.

Appendix B.

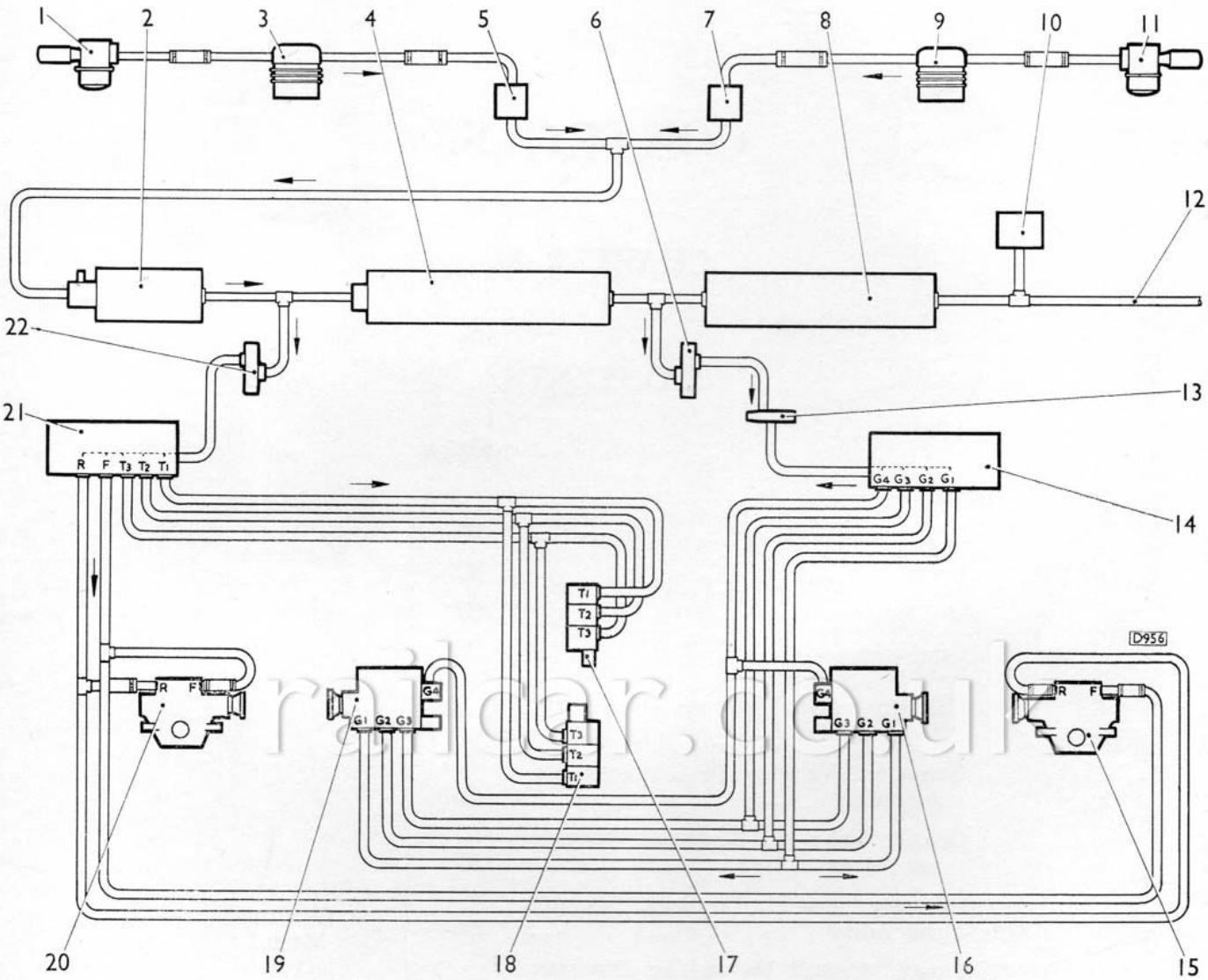
Corrosion Test for Greases.

The test shall be carried out as described in I.P. 112. It shall be conducted at room temperature, the period of immersion of the copper test piece in the grease being twenty-four hours. At the conclusion of the test, the copper strip shall show no signs of discoloration.

CONTROLS.

CHAPTER H.

CONTENTS.



Key to Numbers :—

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. THIRD AIR RESERVOIR.
9. AIR COMPRESSOR.
10. AIR PRESSURE SWITCH.
11. AIR FILTER AND ANTI-FREEZER.
12. PIPE LINE TO AIR PRESSURE GAUGE AND AUXILIARIES.
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.

Fig. 1. Diagrammatic layout of air pressure system

Sect. H1. 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 change speed 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 motors, forward and reverse gears in the final drive units and the gearbox pistons.

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

Key to Numbers :—

1. TRAIN SWITCH.
2. AIR PRESSURE GAUGE.
3. DUPLEX VACUUM GAUGE.
4. SPEEDOMETER.
5. ENGINE SPEED INDICATOR.
6. CHANGE-SPEED LEVER.
7. FORWARD AND REVERSE LEVER.
8. HORN SWITCH.

Fig. 2. Gauge panel and driver's controls.

Key to Numbers :—

1. ENGINE STARTER BUTTONS.
2. ENGINE STOP BUTTON.
3. COMBINED THROTTLE LEVER AND " DEAD-MAN'S " HANDLE.
4. WINDSCREEN WIPER VALVE.
5. HORN SWITCH.
6. CHANGE-SPEED LEVER.
7. VACUUM BRAKE LEVER.
8. AIR PRESSURE SWITCH.
9. " DEADMAN'S " INDICATOR LIGHT.
10. ENGINE SPEED INDICATOR CHANGE OVER SWITCH.
11. PANEL LIGHT SWITCH.
12. HANDBRAKE WHEEL.
13. OIL PRESSURE INDICATOR LIGHTS — L.H. ENGINES.
14. AIR PRESSURE AND FINAL DRIVE DIRECTION INDICATOR LIGHTS.
15. OIL PRESSURE INDICATOR LIGHTS — R.H. ENGINES.

Fig. 3. Driver's controls.

In addition to the hand controls, the following are mounted in the driver's cab, a train switch, speedometer, 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.

AIR PRESSURE SYSTEM.

Compressed air is provided by two engine mounted compressors for operating the throttle motors, epicyclic gear-box pistons and forward and reverse pistons in the final drive units.

Air is drawn 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 motor E.P. valves to be operated.

When pressure in this reservoir reaches a predetermined 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 gearbox pistons.

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

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 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.

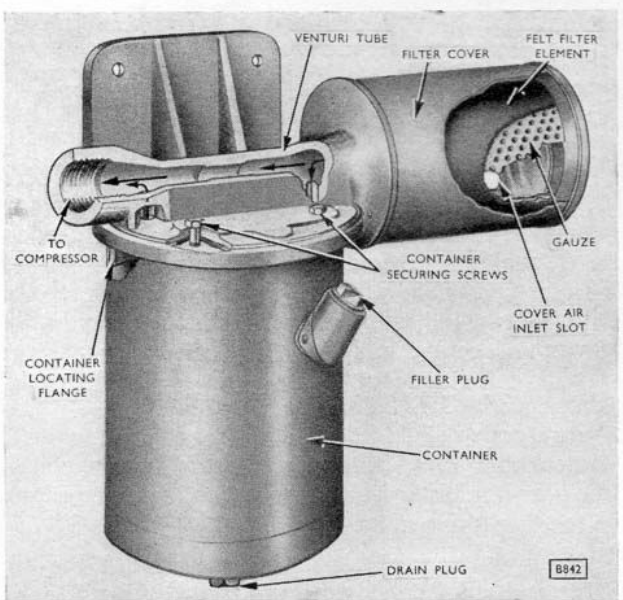
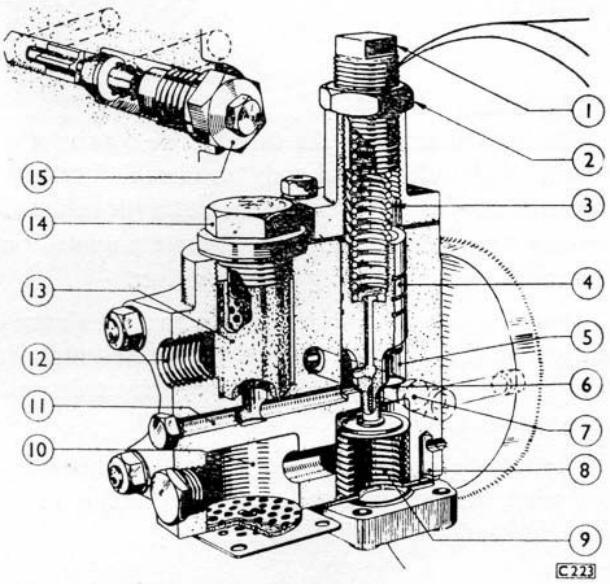


Fig. 4. Combined air filter and anti-freezer.



Key to Numbers :—

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.

Fig. 5. Unloader valve.

Air reservoirs.

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 cocks fitted to the underside of each reservoir.

Unloader valve *(see Fig. 5).*

The purpose of the unloader valve is to relieve the compressors of most 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.

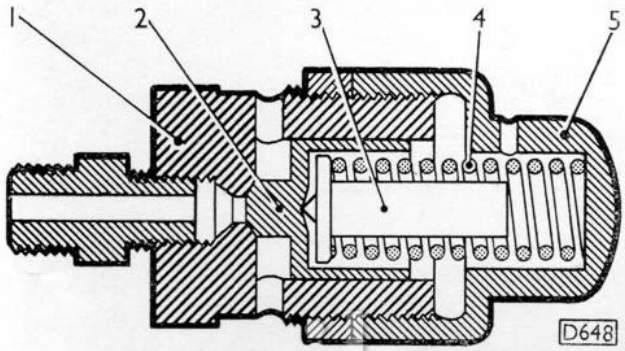
When the reservoir pressure exceeds that of the unloader, the bellows are forced up, thus overcoming

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.



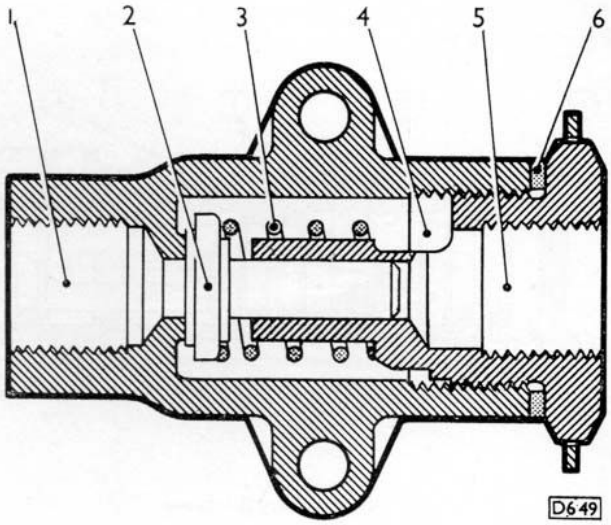
Key to Numbers :—

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

Fig. 6. Safety valve.

Non-return valve *(see Fig. 7).*

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



Key to Numbers :—

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

Fig. 7. Non-return valve.

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

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

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, the air 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

Key to Numbers :—

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

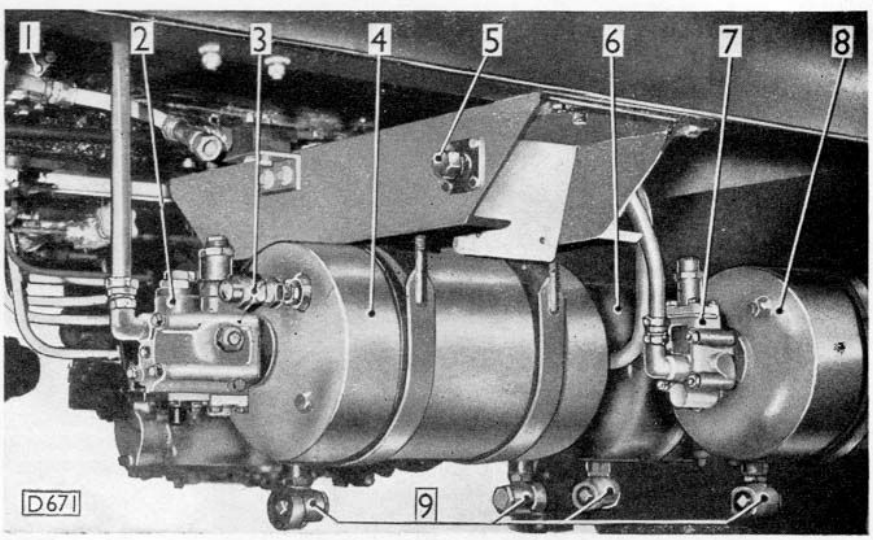
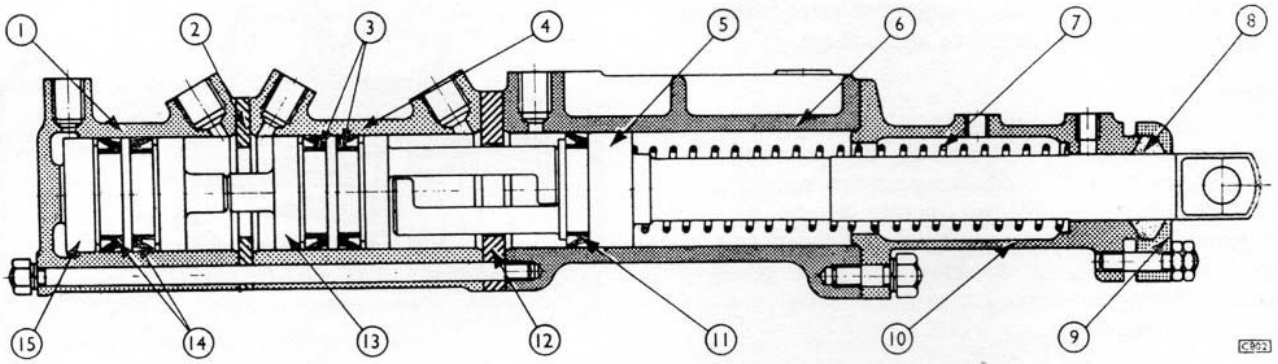


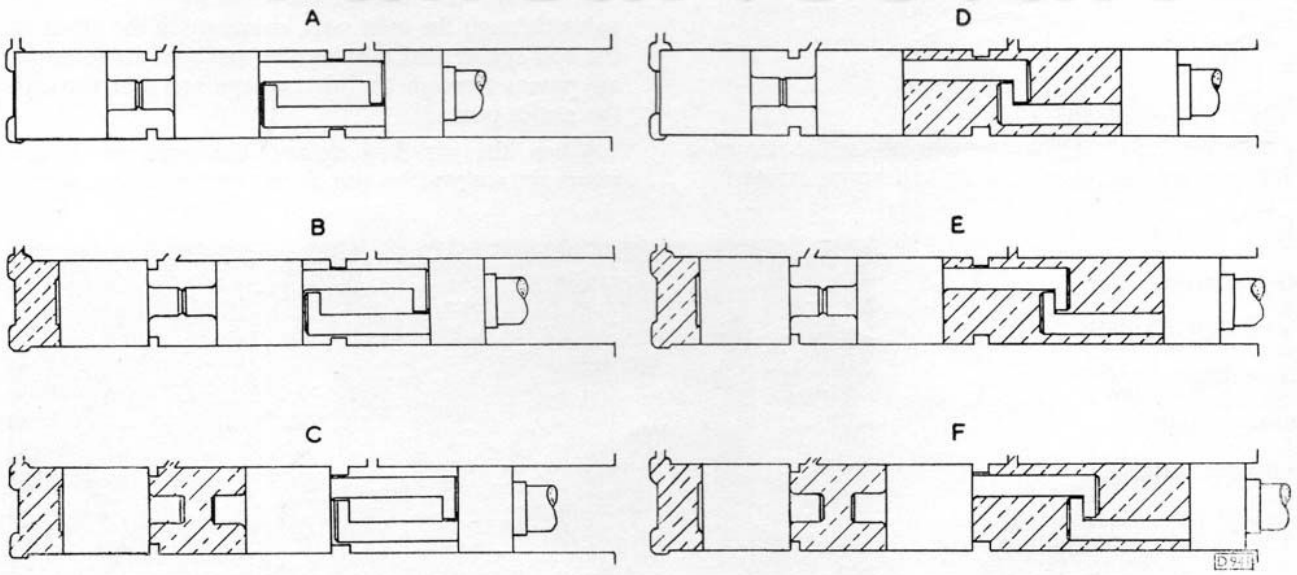
Fig. 8. Air reservoirs, unloader and diverter valves.



Key to Numbers :—

1. END CYLINDER.
2. DISTANCE PIECE.
3. INTERMEDIATE PISTON RUBBER SEALS.
4. INTERMEDIATE CYLINDER.
5. OPERATING PISTON.
6. BODY.
7. RETURN SPRING.
8. FELT PACKING WASHER.
9. GLAND.
10. END COVER.
11. OPERATING PISTON RUBBER SEAL.
12. DISTANCE PIECE (THICK).
13. INTERMEDIATE PISTON.
14. END PISTON RUBBER SEALS.
15. END PISTON.

Fig. 9. Arrangement of throttle control motor.



Key to Letters :—

A. ENGINE STOPPED.
B. ENGINE IDLING.
C. ENGINE ON QUARTER THROTTLE
D. ENGINE ON HALF THROTTLE.
E. ENGINE ON THREE-QUARTER THROTTLE
F. ENGINE ON FULL THROTTLE

Fig. 10 Diagrammatic operation of throttle control motor.

the valve on to its seat, thus preventing air escaping back to the compressor.

Throttle control motors *(see Fig. 9).*

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.

They are connected by linkage to an adjustable pillar and 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 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 *(see Fig. 10).*

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

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

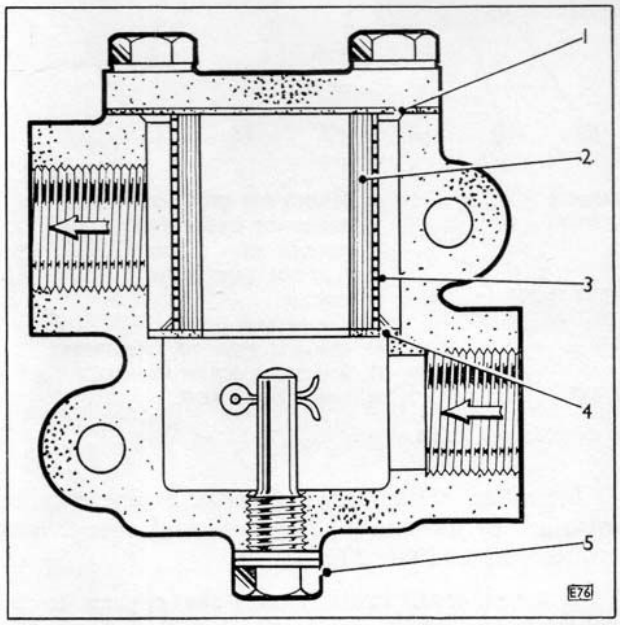
The purpose of the filters is to provide an additional safeguard against foreign matter entering the E.P. valves.

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

Reducing valve *(see Fig. 13).*

Mounted in the pipe line between an air filter and the gearbox E.P. valve block, the reducing valve maintains a supply of air at the necessary pressure to operate the epicyclic gearbox (*for air pressures see Section* H2). As shown in Figure 13, the valve consists of a reaction head containing a filter, an inlet valve, release valve and reaction piston ; together with a main body containing the control spring which is fitted in a pre-loaded condition. The inlet port is connected to the compressed air system via an air filter and the outlet port is connected to the epicyclic gearbox E.P. valve block.

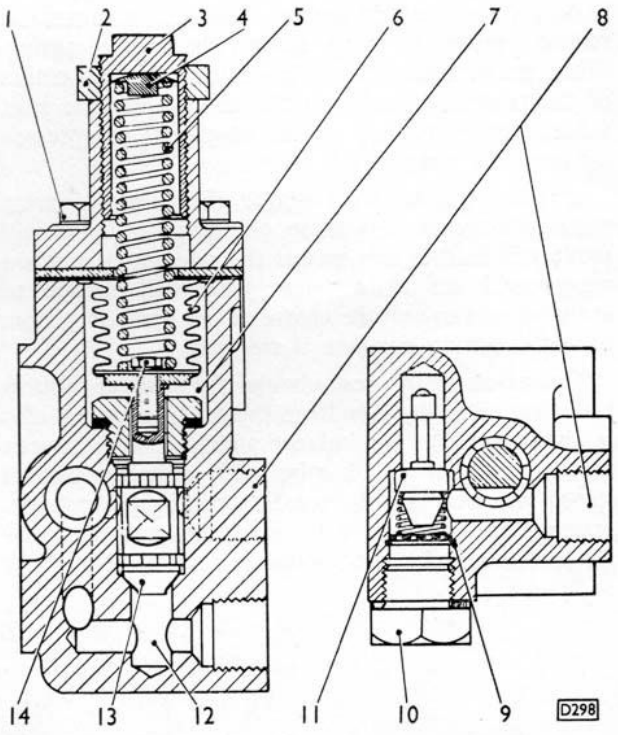
When there is no pressure in the system, the control spring causes the reaction piston to seat against the release valve thus holding the inlet valve open. As pressure is built up in the system, air entering the inlet port passes through the felt filter in the air chamber. The restrictor, fitted in front of the inlet valve, prevents a surge of pressure. The air then flows through the inlet valve, into the chamber (20) and out through the outlet port which is connected to the epicyclic gearbox E.P. valve block.



Key to Numbers :—

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

Fig. 11. Pipe line air filter.



Key to Numbers :—

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. SET-SCREW SECURING BELLOWS.

Fig.12. Sectioned view of diverter valve.

As pressure rises in the chamber (20) it causes the reaction piston to move against the control spring. When the correct pressure is attained, the movement of the reaction piston is sufficient to close the inlet valve, thereby cutting off the supply of compressed air from the reservoirs.

If the pressure rises above the control spring setting during this operation, the reaction piston will move still further and unseat the release valve when compressed air in chamber (20) will escape to atmosphere through the centre of the reaction piston, until the setting pressure is restored.

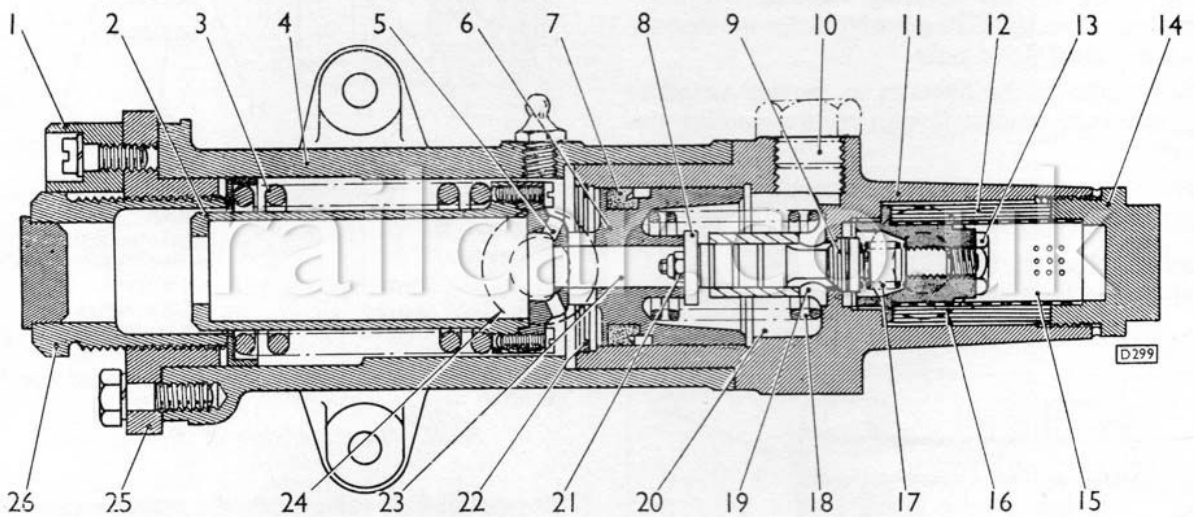
Operation of the gear-change E.P. valves reduces the pressure in the pipe from the outlet port and also in chamber (20). The balance which existed between the air pressure in chamber (20) and the control spring is upset, and the reaction piston moves back, opening the inlet valve to admit more compressed air, until the balance of pressure is again established

Air enters through the inlet port and passes through flutes in the valve stem to the air chamber. When the main pressure has been built up to the diverter valve setting, air compresses the bellows causing them to contract against the control spring and to lift the valve from its seat. Air then passes directly from the inlet port to the outlet pipe leading to the reducing valve. If the pressure in the main system falls below the setting of the reducing valve, the air overcomes the non-return valve and passes back to the main system.

ELECTRICAL SYSTEM (*see Plate* O77 *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.



Key to Numbers :—

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.

Fig. 13. Sectioned view of reducing valve.

Diverter valve (*see Fig.* 12).

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 H2 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.

Indication of the speed of either engine may be obtained by movement of the indicator change over switch provided (*see Fig.* 3).

A water level switch causes the engines to be stopped when the water in the supply 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 light (*see Fig.* 3).

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

Engine control relay panel.

The engine control relay box contains three Tonum type relays mounted on an 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 T3499) consists of one pair of normally closed and one pair of normally open contacts in addition to two pairs of normally open auxiliary contacts. The auxiliary contacts form a separate circuit from the former and are isolated from each other.

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

E.P. control relay panel.

The E.P. control relay box contains an insulated panel on which are mounted twelve 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 collect no dust.

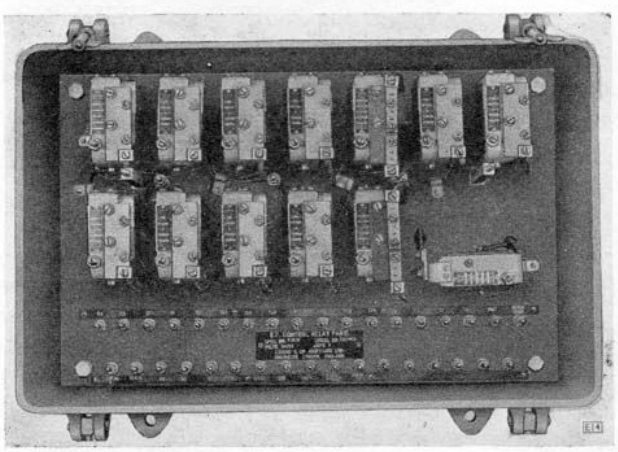


Fig. 14. E.P. control relay panel.

Two relays (specification T5301) 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.

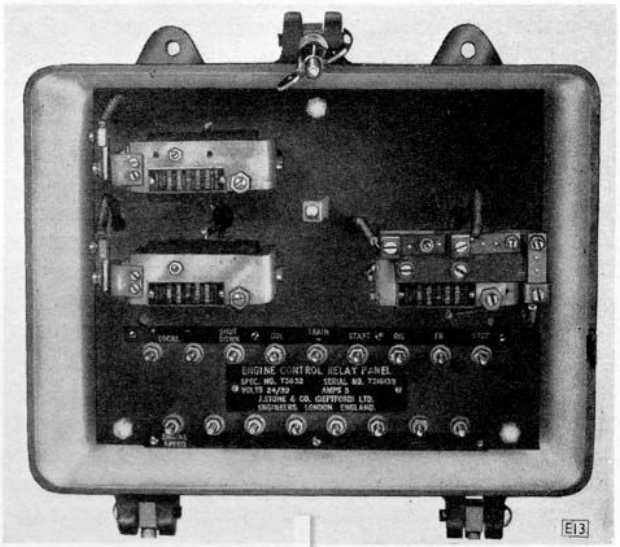


Fig. 15. Engine control relay panel.

The remaining nine relays (specification T3502) are similar to specification T5301, except that they have only one pair of normally open main contacts and one pair of normally open auxiliary contacts.

Battery isolating switch.

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

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

Engine isolating switch.

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.

Train switch (*see Fig.* 2).

The train switch, mounted in the driver's cab, is of the double pole type and is provided with a detachable key.

This key can only be removed when it is in the " OFF " position.

The function of the train switch is to connect a battery to the train wiring.

Direction switch.

The direction switch consists of a pair of switches contained in a casing, one being mounted on each final drive casing ; they are operated by actuation of the striking lever in the final drive unit.

Combined throttle controller and " deadman's " control *(see Fig.* 16*).*

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.

A notched locating plate on the end of the camshaft, which engages with a spring-loaded pin, retains the camshaft in any selected position, unless the driver releases the control lever, in which case, the camshaft will turn under the action of a return spring and select " idling " and " deadman's " position.

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 Fig.* 17*).*

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.

When the forward and reverse lever is in the OFF position, it can be removed from the controller, thus de-energising the driver's control table.

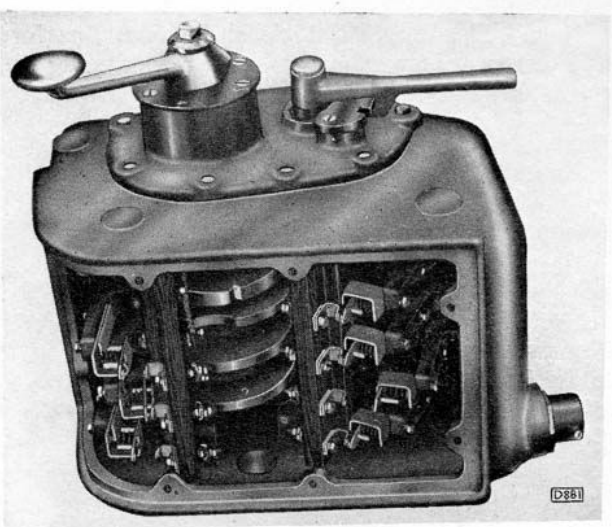


Fig. 17. Gearbox and final drive controllers showing contacts.

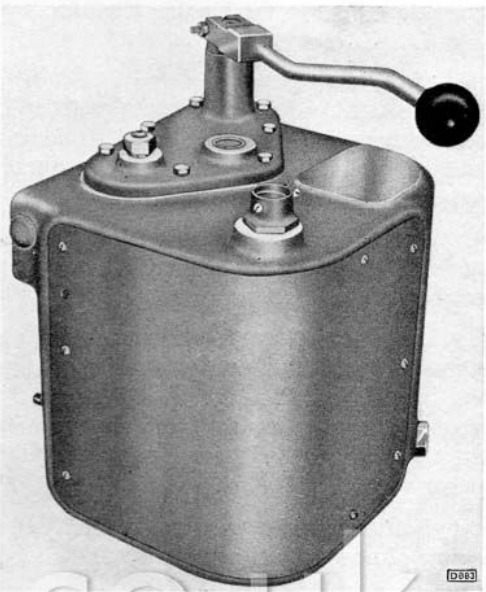


Fig. 16. Throttle controller.

Electro-pneumatic valves *(see Figs.* 18 *and* 19*).*

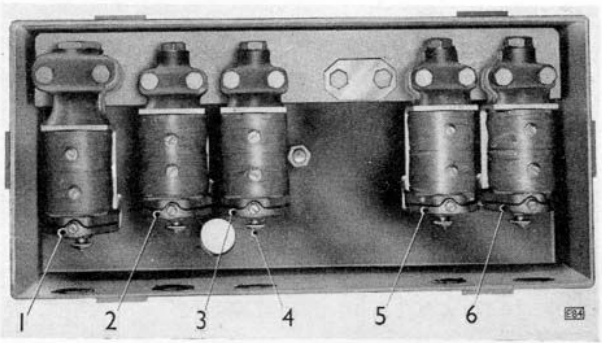
Each car is provided with a number of E.P. valves for controlling the supply of compressed air to the actuating mechanism for gear selection and engagement, for the engine throttle control motors and for engagement of forward or reverse in the final drive units.

These valves are of two types, " ON " and " OFF." The " ON " type WILL pass air when the solenoid is energised, whereas the " OFF " type WILL NOT pass air when the solenoid is energised.

The valves can easily be identified as the " OFF " type is a larger unit than the " ON " type, and the designation should appear stamped on a raised portion on the body of the valve.

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

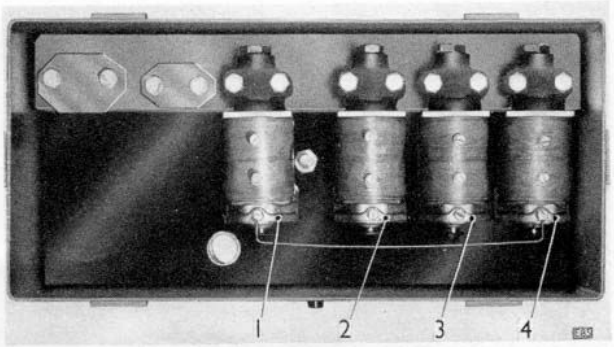
Each E.P. valve embodies a needle valve which either opens or closes—depending upon the type—a short passage connecting an air feed pipe to a delivery pipe which leads to the actuating mechanism concerned. The needle valve is operated by a loosely fitting plunger inside the core of a solenoid whenever the latter is energised, and works against the pressure in the air line in adddition to that exerted by a



Key to Numbers :—

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. E.P. VALVE HAND-TESTING BUTTON.
5. FINAL DRIVE E.P. VALVE — FORWARD SPEED.
6. FINAL DRIVE E.P. VALVE — REVERSE SPEED.

Fig. 18. Electro-pneumatic valves for engine and final drive.



Key to Numbers :—

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. 19. Electro-pneumatic valves for gearbox.

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 switch.

The air pressure switch indicates electrically, by means of a light on the driver's control panel, the state of the air pressure in the car.

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* H2).

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.

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 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.

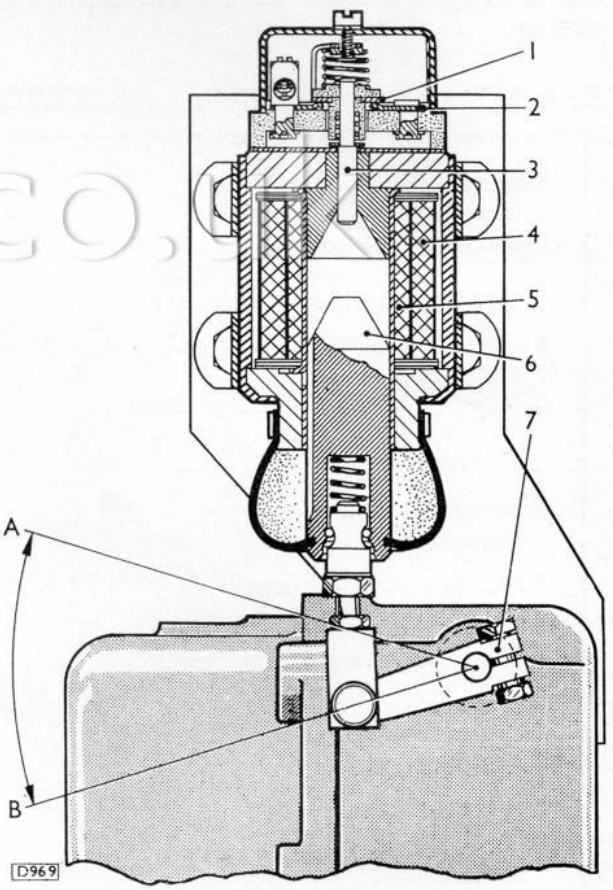
The adjacent poles of the two magnets repel one another, and by this method the switch contacts are

Engine shut-down solenoid (*see Fig.* 20).

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.

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 contacts. This action brings into circuit the



Key to Letters :—

A. STOP POSITION.
B. RUN POSITION.

Key to Numbers :—

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.

Fig. 20. Section through engine shut-down solenoid.

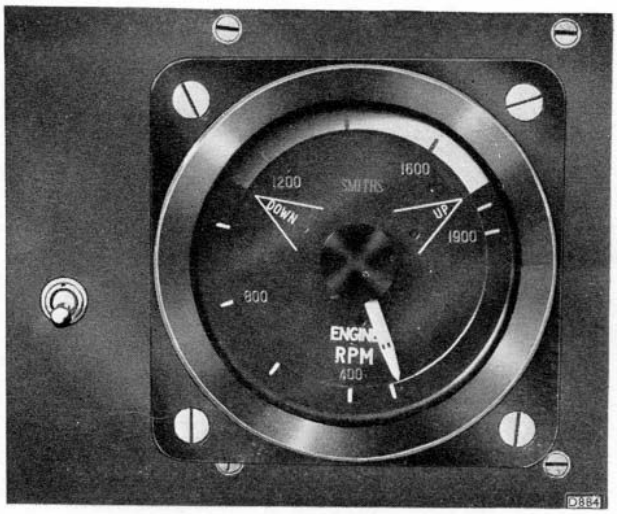


Fig. 21. Engine speed indicator and change-over switch.

" 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 stop solenoid.

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 stop solenoid (*for oil pressure see Section* H2).

Starter switches *(see Fig.* 3).

When the starter button is operated the starter switch becomes energised thus completing the battery negative circuit.

Sect. H2. CONTROLS—DATA.

Reservoir (first)		
Capacity.	1,414 cu. in.	23·2 litres.
Unloader valve—Cut-out pressure.	80 to 90 lb. per sq. in.	5·62 to 6·32 Kg. per sq. cm.
Cut-in pressure.	60 to 70 lb. per sq. in.	4·21 to 4·92 Kg. per sq. cm.
Safety valve—Blow off pressure.	90 to 95 lb. per sq. in.	6·3 to 6·7 Kg. per sq. cm.
Reservoir (second).		
Capacity.	3,600 cu. in.	59·0 litres.
Diverter valve—Cut-out pressure	80 to 90 lb. per sq. in.	5·62 to 6·32 Kg. per sq. cm.
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.
Reducing valve pressure.	62·5 to 67·5 lb. per sq. in.	4·4 to 4·7 Kg. per sq. cm.
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.	2·87 pints.	1·63 litres.
Exhauster oil reservoir capacity.	10·00 pints.	5·67 litres.
Engine control relay box.	Specification No. T3526	All relays to energise at 7·4 volts cold.
E.P. control relay box.	Specification No. T3525	Shunt coil resistance, 101·5 ohms, ±5%, at 20 deg. Centigrade, 24/30v.

Sect. H3. CONTROLS—MAINTENANCE

AIR PRESSURE SYSTEM.

The following points require attention at periods quoted below.

Period	Attention Required
DAILY.	Drain the moisture from the reservoirs (*see instructions in the following paragraphs*). Check the level of "Methanol" in the anti-freezer container (*see instructions in the following paragraphs*).
WEEKLY.	Check all air pipe unions for leakage and tighten if necessary (*see "To check for air leaks"*). 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"*). Lubricate the throttle control motors (*see Section* H4) Lubricate the reducing valve (*see Section* H4).
MONTHLY.	Clean the felt element in the combined air filter and anti-freezer (*see instructions in the following paragraphs*). Clean the felt filter element in the reducing valve (*see instructions in the following paragraphs*). Clean the felt filter element in the pipe line air filters (*see instructions in the following paragraphs*).
QUARTERLY.	Clean or if necessary renew the felt element in the combined air filter and anti-freezers (*see instructions in the following paragraphs*). Clean or if necessary renew the felt filter element in the reducing valve (*see instructions in the following paragraphs*).

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 Mineralised Methylated Spirit, Ethyl Alcohol or METHYL ALCOHOL ; best results will be obtained with the latter. Methyl Alcohol can be obtained from methylaters under the name of "Blending Methanol" or "I.M.S. Substitute," both 74 per cent. overproof.

Note.—These agents are, however, toxic in both the liquid and vapour state and have 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 alcohol.

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

Air reservoirs *(see Fig. 8).*

Empty and drain the air reservoirs as follows :—

Slowly open the drain 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 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.* 5).

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 H2 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.* 7).

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.* 12).

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

Reducing valve *(see Fig.* 13).

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.* 9 *and* 10).

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

At periods quoted in the chart at the beginning of this Section, check all joints for oil leakage and pipe unions for air leakage (*see " To check for air leakage " at the end of this Section*).

If there are signs of oil leakage around the piston operating rod, adjust the gland by means of the nuts and locknuts provided ; **do not over tighten the gland nuts** as this will result in the throttle motor sticking when in service.

Lubricate the pistons and piston operating rods (*see Section* H4).

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

At intervals quoted in the chart at the beginning of this Section 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 parts suspected of leakage, apply a solution of soap and water to the parts ; leakage may then be detected by the appearance of bubbles.

VACUUM SYSTEM.

The following points require attention at periods quoted below.

Period	Attention Required
DAILY.	Top-up the exhauster oil reservoir (*see Section* H4).
WEEKLY.	Check all pipe connections on the exhauster and the exhauster oil reservoir for leakage and tighten if necessary.
MONTHLY.	Check the tension of the exhauster drive belts and adjust if necessary (*see instructions in the following paragraphs*).
QUARTERLY.	Drain the oil from the exhauster oil reservoir, clean the filters and fill with fresh oil (*see Section* H4).

" Deadman's " control valve.

See Gresham and Craven's handbook " Instructions for Gresham's Quick Release Vacuum Brake Equipment on British Railways Railcars."

Exhausters *(see Fig. 23).*

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 the 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 being 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 oil out at the shaft end. For this reason a double seal is fitted, which runs on the hardened shaft collar.

Exhauster oil reservoir *(see Fig. 22).*

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* H4).

Exhausters—drive belts to adjust.

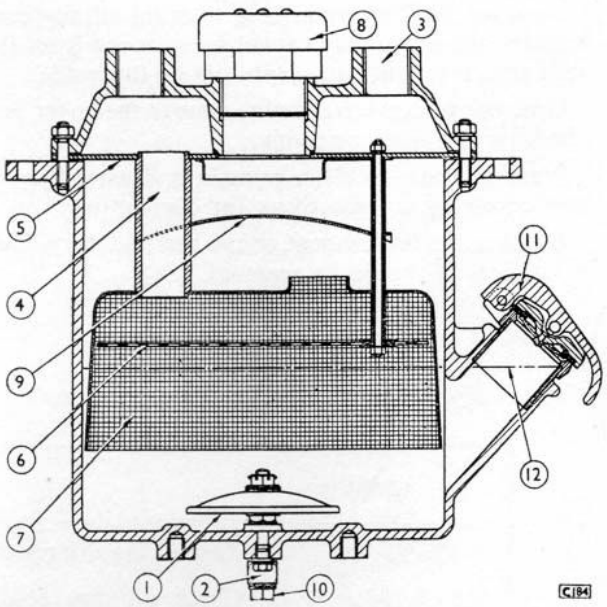
The exhausters are pivoted on brackets fitted to the underframe.

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. (43 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.



Key to Numbers :—

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.

Fig. 22. Section through exhauster oil reservoir.

ELECTRICAL SYSTEM.

The following points require attention at periods quoted below.

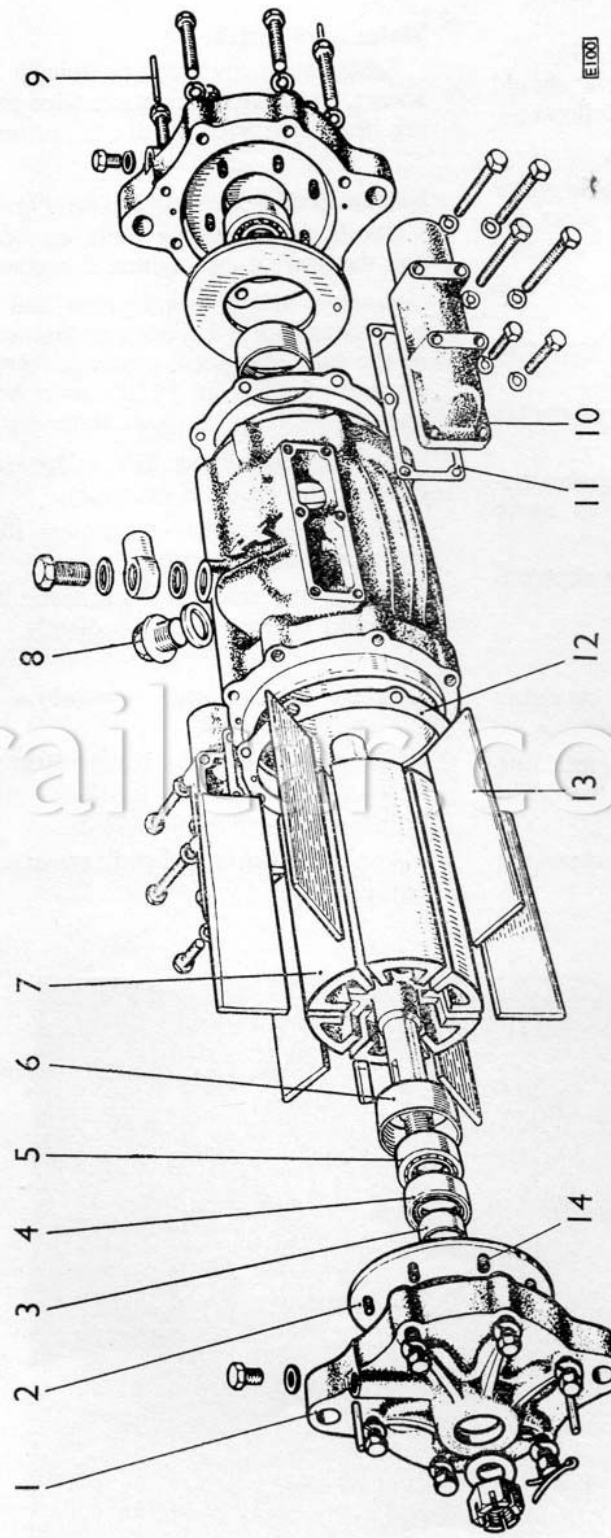
Period.	Attention Required.
MONTHLY.	Check all electrical connections for security. Check manually the engine shut down solenoid for correct operation (*see instructions in the following paragraphs*).
QUARTERLY.	Inspect the electro-pneumatic valves *(see instructions in the following paragraphs)*. Inspect and if necessary adjust the air pressure switch *(see instructions in the following paragraphs)*.
HALF-YEARLY.	Clean the contacts in the following:—throttle controller, gearbox and final drive controller, starter switch, water level switch, air pressure switch, engine shut down solenoid switch, 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.* 14 *and* 15*).*

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, the matter should be reported.



Key to Numbers :—

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 ½" B.S.F.
9. END COVER LOCATING PEG.
10. MANIFOLD.
11. MANIFOLD JOINT.
12. END COVER JOINT.
13. ROTOR BLADE.
14. SEALING PLATE SPRING.

Fig. 23. Exploded view of exhauster.

Battery isolating switch.

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

Electro-pneumatic valves *(see Figs.* 18 *and* 19*).*

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 these are 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.

Air pressure switch.

To adjust the air pressure, unscrew the retaining set-screw 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 cover by unscrewing its retaining set-screws. To clean the contacts wipe them with a clean rag moistened with petrol ; fit the cover.

Engine shutdown solenoid *(see Fig.* 20*).*

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

Remove the terminal cover and check that the connecting link is adjusted so that with the armature in the fully energised position, there is a minimum air gap of 0·063 in. (1·600 mm.) between the fixed and the moving contacts. 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.

Should the solenoid become faulty in operation, it should be reported immediately.

Gearbox and throttle controllers *(see Figs.* 16 *and* 17*).*

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

At overhaul periods lightly smear all working parts with lubricant.

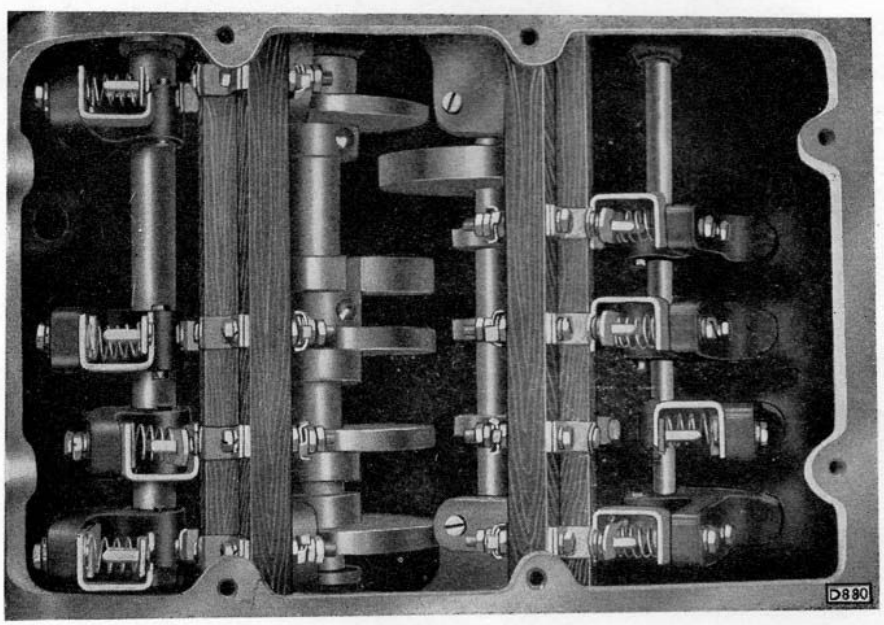


Fig. 24. Gearbox and final drive controllers showing electrical contacts.

Starter switches.

Clean the contacts by wiping them with a rag moistened with petrol. Apart from this the starter switch requires no maintenance.

Direction switch.

Check that the direction switches are operating correctly and, if necessary, adjustment should be made so that the switches operate when the final drive engagement dog is two-thirds engaged with either the forward or the reverse bevel pinion.

Note.—If any of these switches should prove faulty, the matter must be reported immediately.

Sect. H4. CONTROLS—LUBRICATION.

Throttle control motors *(see Fig. 9).*

At intervals quoted in the chart in Section H3, lubricate the pistons and piston operating rods with an oil gun, through the lubricators provided, using an oil to specification L13 (*see Lubrication Chart*).

Reducing valve *(see Fig. 13).*

At intervals quoted in the chart in Section H3 lubricate the reducing valve piston with an oil gun, through the lubricator provided using an oil to specification L13 (*see Lubrication Chart*).

Exhauster oil reservoir *(see Fig. 22).*

At intervals quoted in the chart in Section H3, 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 the drain plug and tighten securely.

Fill the reservoir to the level of the filler cap hole with an oil to specification L13.

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.

Fig. 25. Throttle controller showing electrical contacts.

OIL SPECIFICATION.

(*A.E.C. Specification No. L*13).

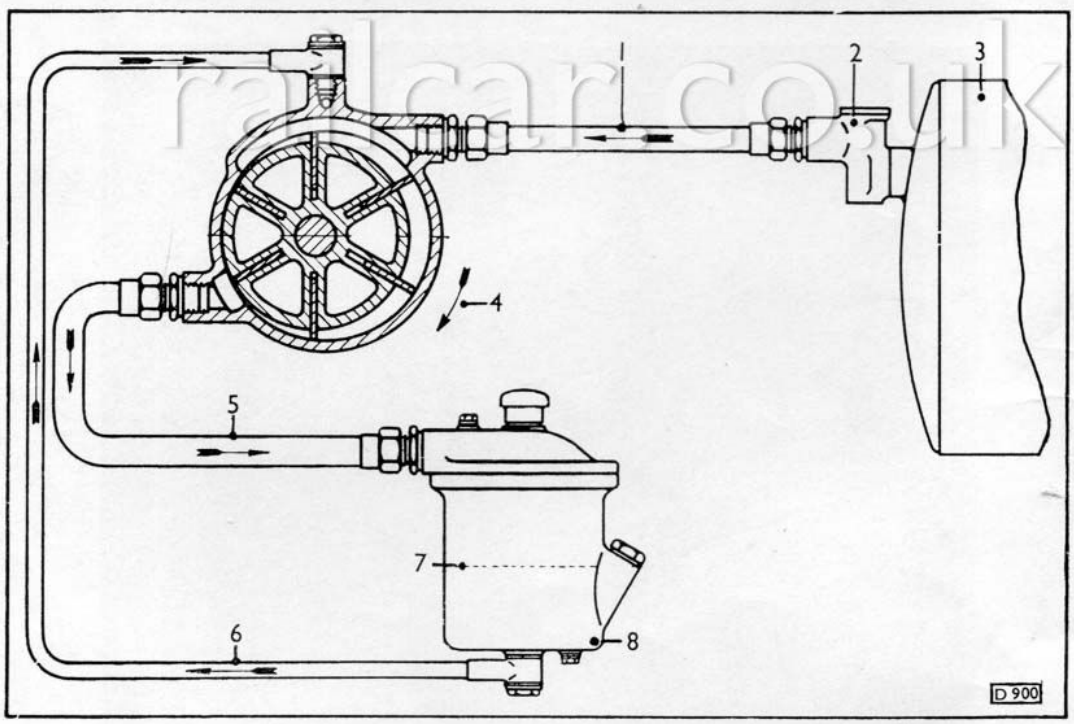
Description.—To be a pure hydrocarbon oil refined by the Solvent Extraction Process, thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity and objectionable odour.

Characteristics.—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements :—

Viscosity (Redwood No. 1) at 140° F. (60° C.) ...	160—175 seconds (39—42·5 centistokes)
Viscosity (Redwood No. 1) at 210° F. (99° C.) ...	55 seconds minimum (11·0 centistokes)
Viscosity Index	90 minimum
Closed Flash Point	400° F. (204·4° C.) minimum
Pour Point	15° F. (minus 9·4° C.) maximum
Acidity (organic)	0·10 mgms. KOH per gm. maximum
Ash	0·005 per cent. maximum
Carbon Residue (Ramsbottom)	0·5 per cent. maximum

Oxidation Characteristics.—

Viscosity Ratio at 140° F. (60° C.)	1·5 maximum
Increases in Carbon Residue	0·7 per cent. maximum
Asphaltenes in Oxidised Oil	0·05 per cent. maximum



Key to Numbers :—

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.

Fig. 26. Diagrammatic illustration showing lubrication by separate oil reservoir.

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(*A.E.C. Specification No. L*13).

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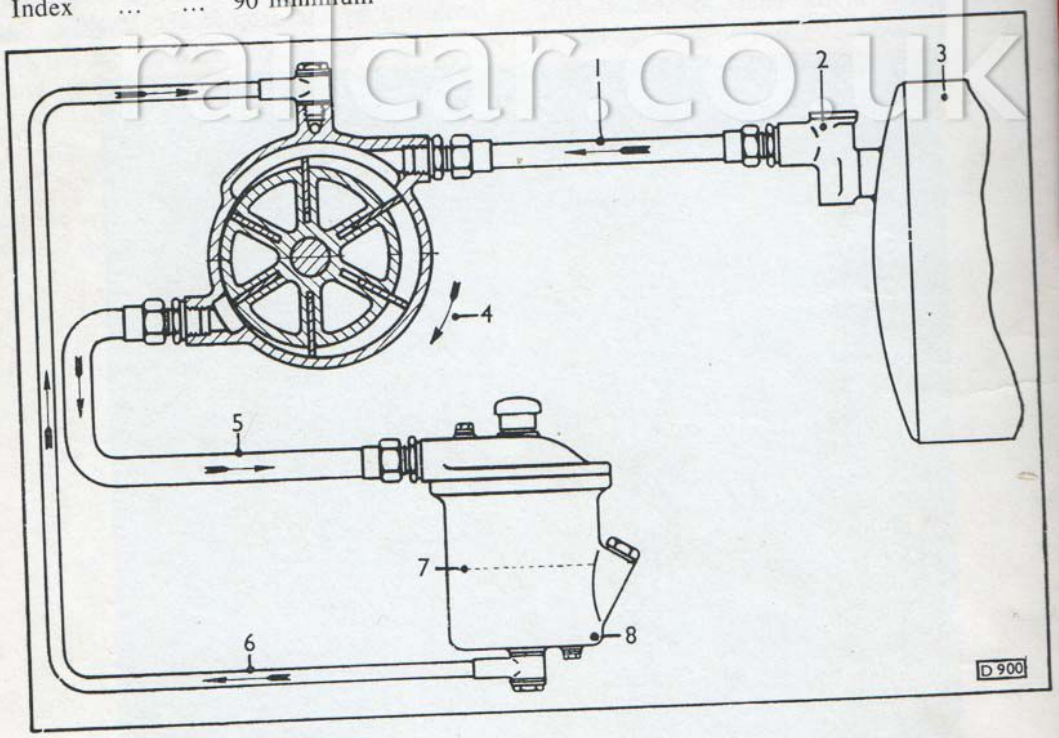

Key to Numbers :—

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Fig. 26. Diagrammatic illustration showing lubrication by separate oil reservoir.

BRITISH RAILWAYS DIESEL TRAIN 'A' TYPE UNITS — OVERHAUL

BRITISH RAILWAYS DIESEL TRAIN 'A' TYPE UNITS — MAINTENANCE MANUAL