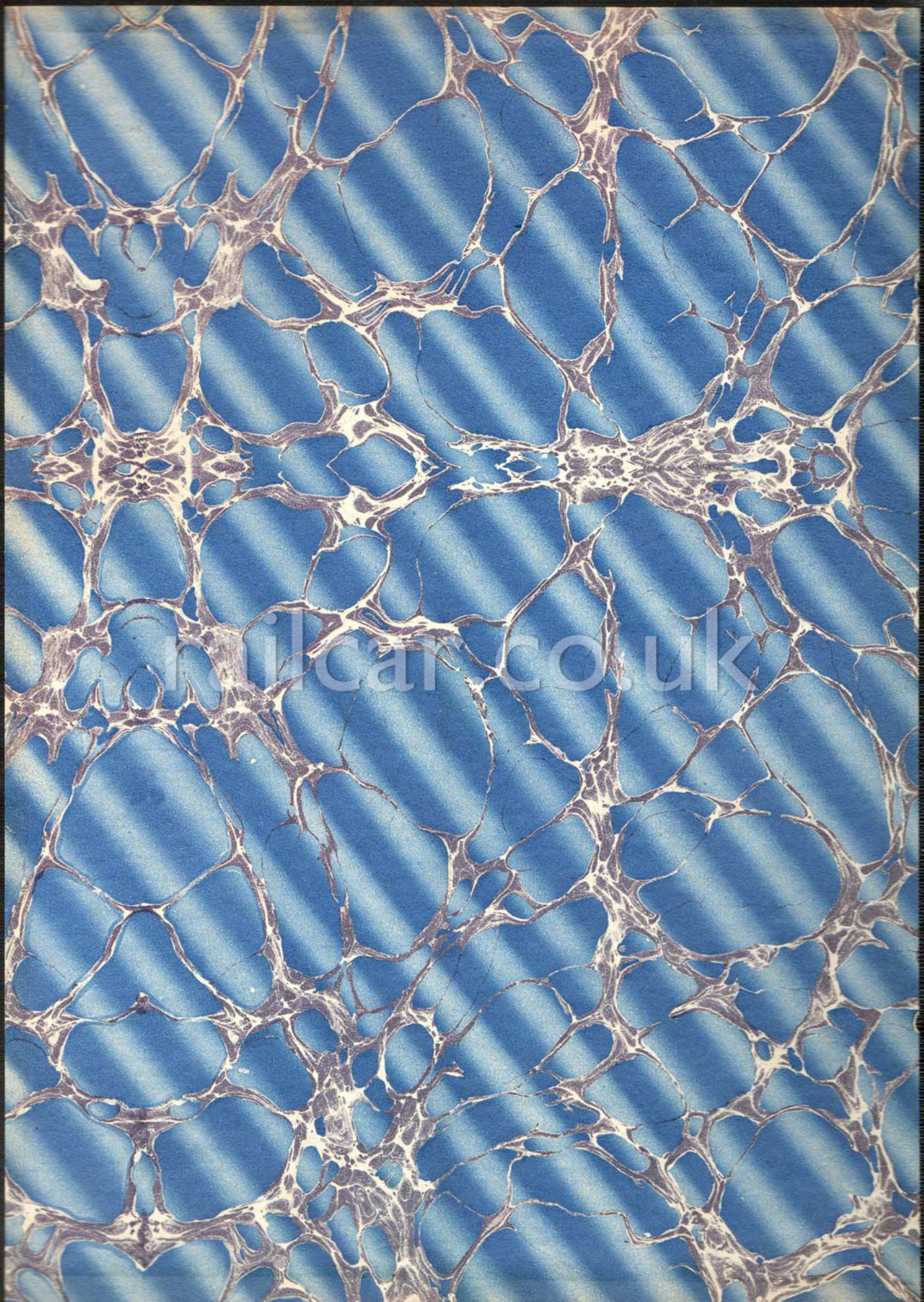
BRITISH RAILWAYS
DIESEL TRAIN
'A' TYPE UNITS
OVERHAUL MANUAL

BRITISH UNITED TRACTION LTD.



SERVICE MANUAL

(OVERHAUL)

B.U.T.

TRACTION EQUIPMENT

BRITISH RAILWAYS
LIGHTWEIGHT M.U. DIESEL CARS

(79000 Series. Excluding 79000-7 & 79500-7 & Two-Axle Cars)

BRITISH UNITED TRACTION LIMITED

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

ENGLAND.

Telephone : MAYfair 8561-2

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Book No. 372-217

T.P.22 600 H & C 3-56

Book 4.

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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.

1500 H & C 4-56

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 ".

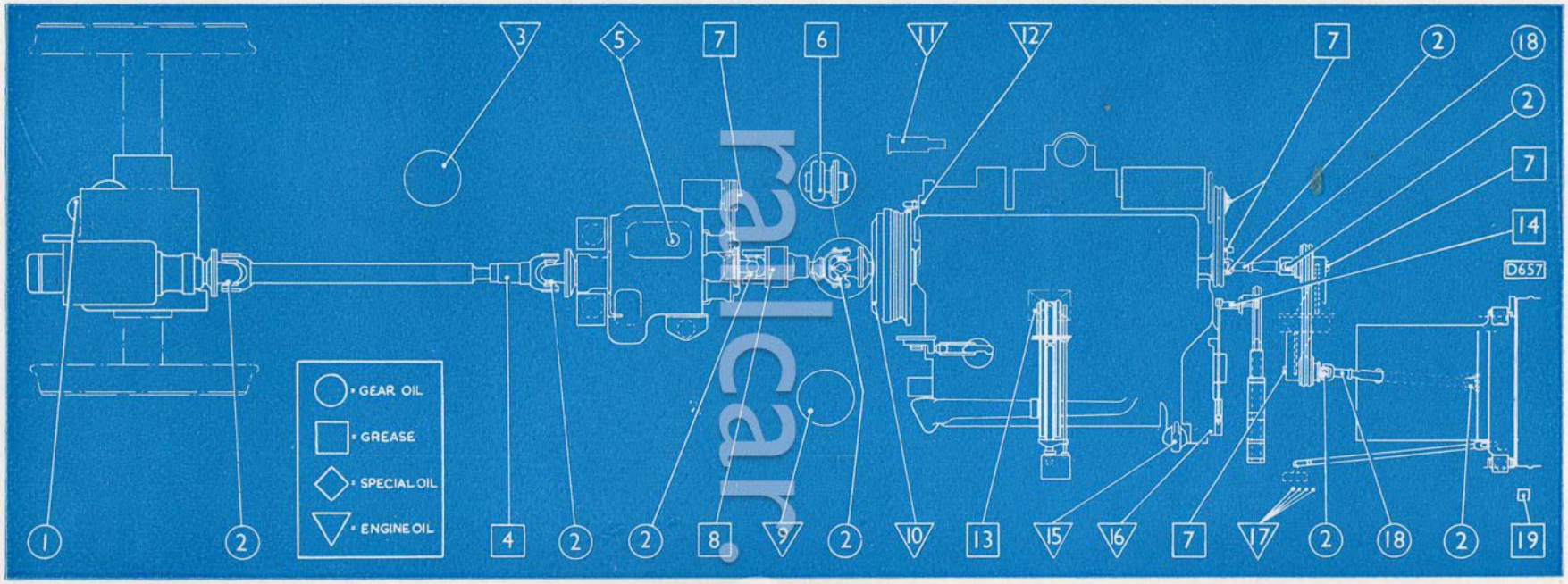
P.T.O.

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



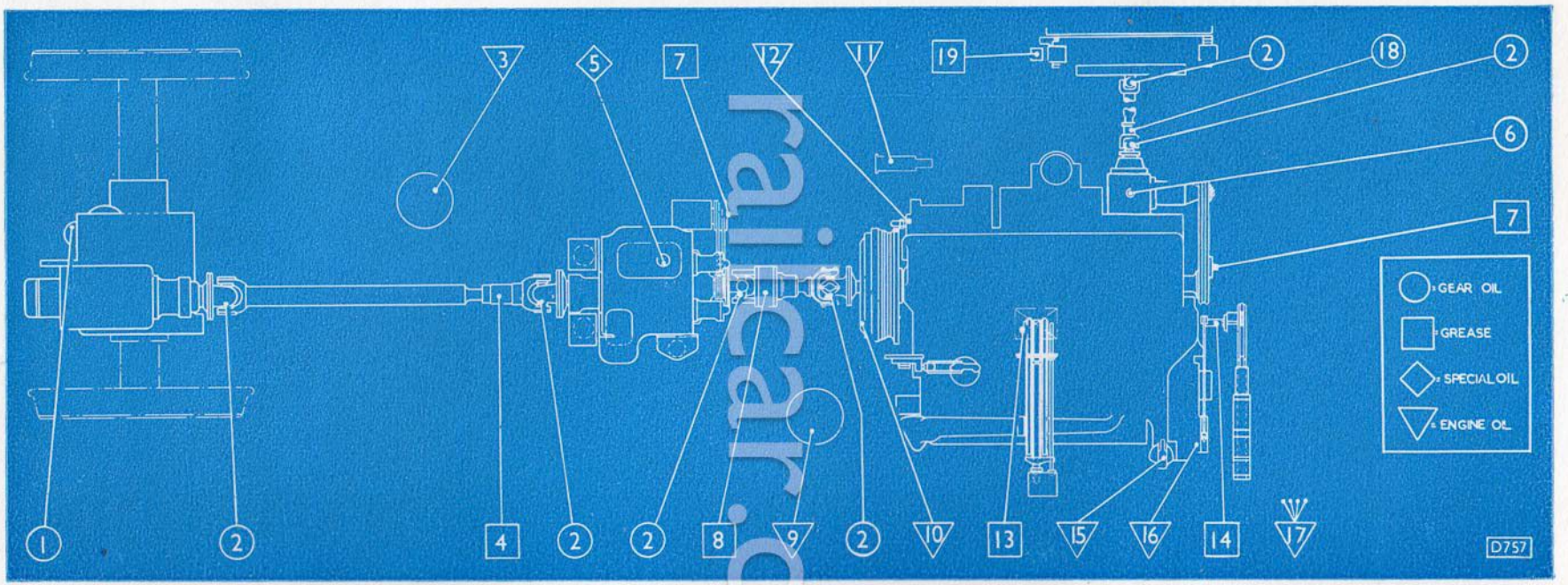
Location Number	Part	Class of lubricant	Number of lubrication points per car	Period
1	Driving axles	Gear oil	2	
	Drive shaft universal joints:—			
2	Needle roller bearing type	Gear oil	14 (early type) 16 (late type)	
6	Plain bearing type... ...	Grease	2 (early type only)	
3	Exhauster oil separator ...	Engine oil	1	
	Drive shaft splined ends:—			
18	Small diameter shafts (fan drive)	Gear oil	4	
4	Large diameter shafts ...	Grease	2	
5	Gearboxes	Special	2	
7	Pulley bearings	Grease	10	
8	Freewheels	Grease	2	
9	Engine air cleaners	Engine oil	2	
10	Fluid couplings	Engine oil	2	
11	Air pressure reducing valve...	Engine oil	1*	
12	Starter motors	Engine oil	2	
13	Engine lifting gears (if fitted)	Grease	2	
14	Throttle relay shafts... ...	Grease	2	
15	Engines	Engine oil	2	
16	Fuel-injection pump governor casings	Engine oil	2	
17	Throttle control motors ...	Engine oil	8*	
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 (*without right-angle fan drive*).

Plate S80 1,500 H & C 4-56



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.

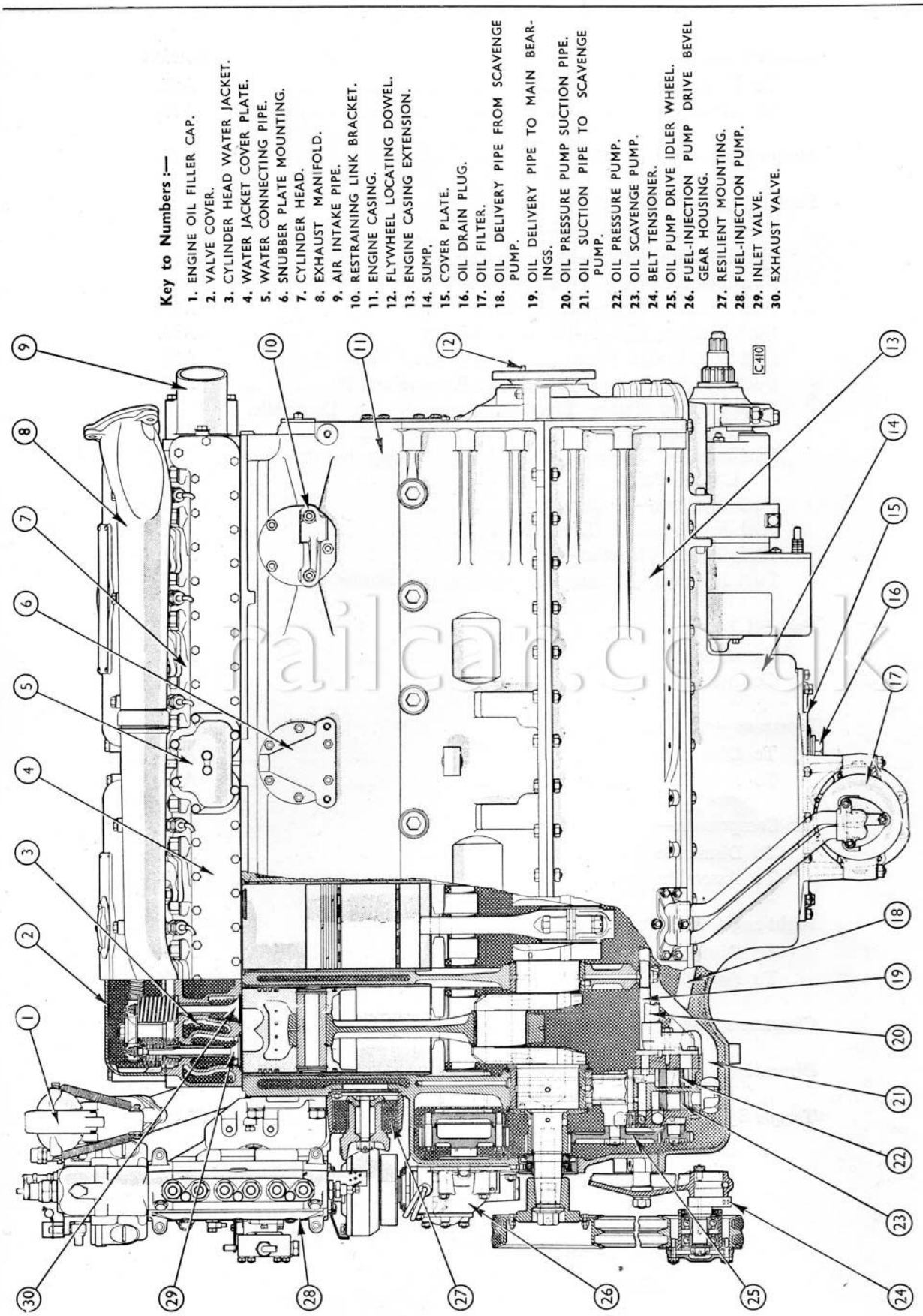


Fig. 1. Longitudinal cross-section of engine.

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.

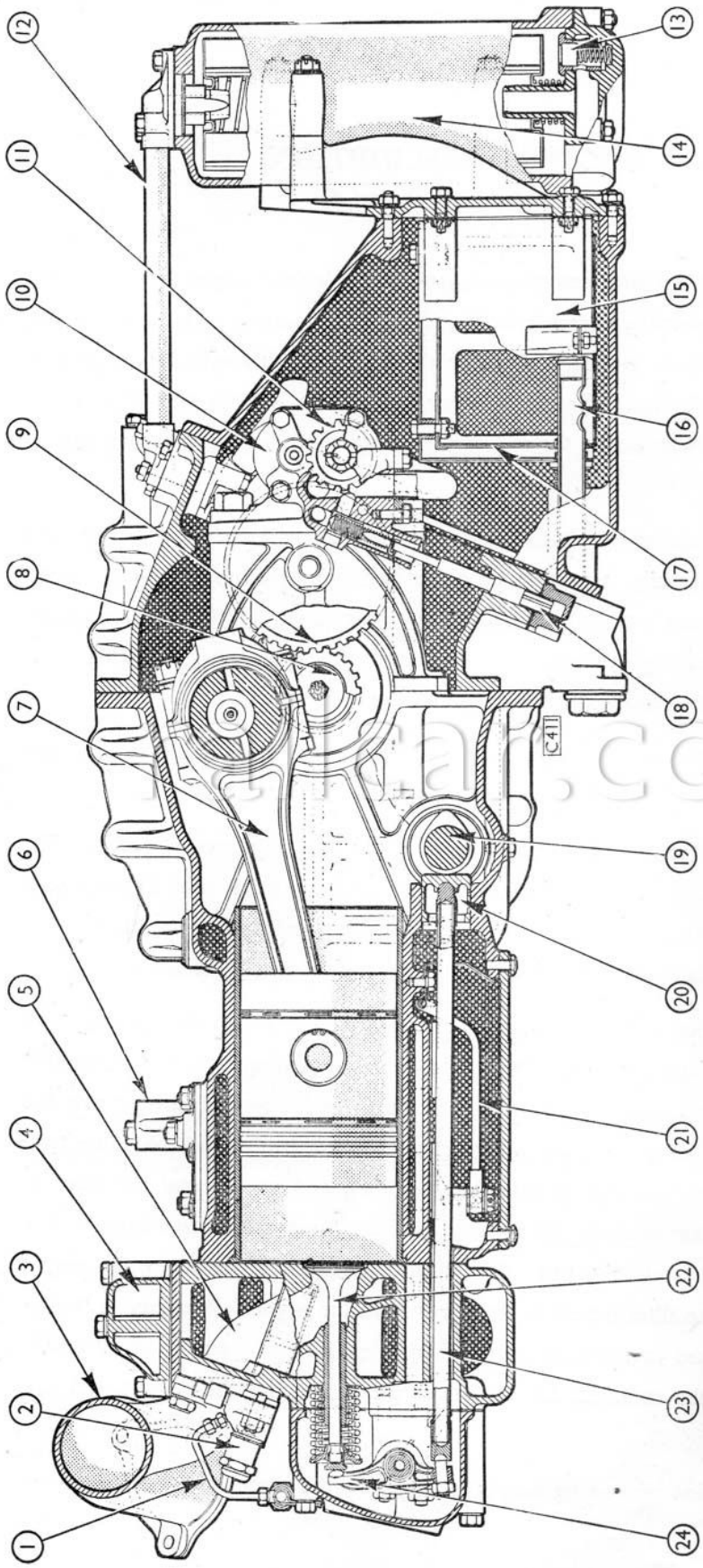
The engine casing is divided vertically at the crankshaft centre line, and comprises an integrally cast cylinder block and crankcase to which an engine casing extension and sump are bolted. The engine casing is fitted with renewable dry liners of centrifugally cast iron, and detachable covers are provided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

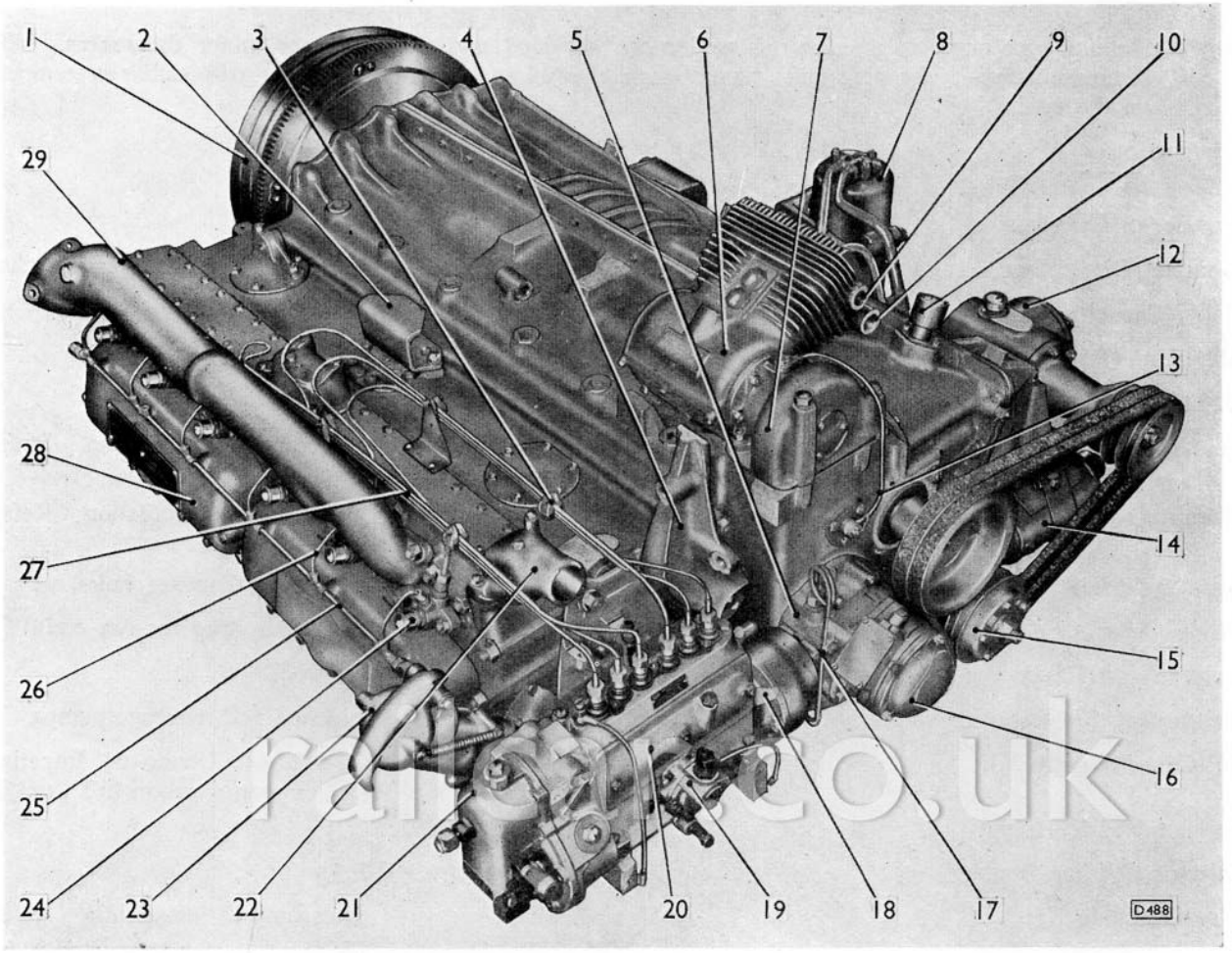
1. FUEL RETURN (OR DRIBBLE) PIPE.
2. FUEL INJECTOR.
3. STANDARD EXHAUST MANIFOLD (DIFFERENT FOR SUPER-CHARGED ENGINES).
4. WATER CONNECTING PIPE.
5. EXHAUST PORT.
6. RESTRAINING LINK BRACKET (NOT FITTED ON SUPER-CHARGED ENGINES).
7. CONNECTING ROD.
8. CRANKSHAFT GEAR.
9. IDLER WHEEL.
10. OIL PUMP.
11. 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.).

D A T A.

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).

D A T A.

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

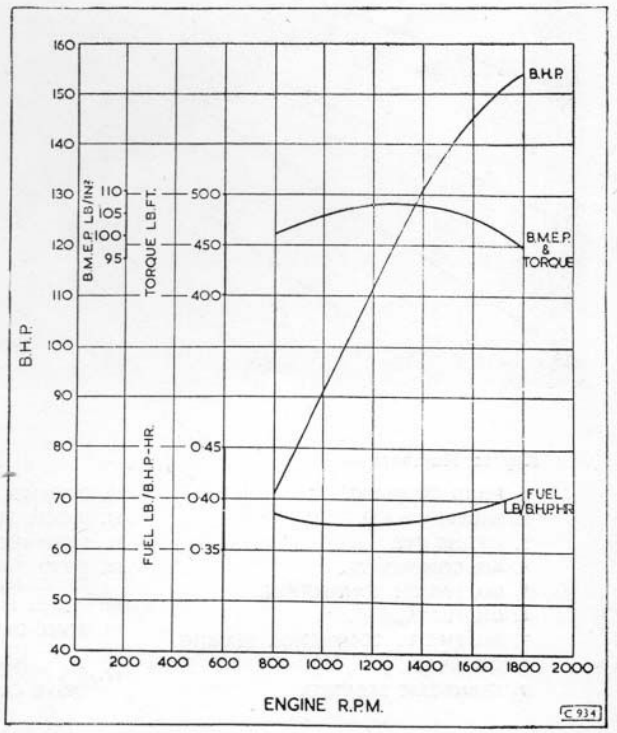


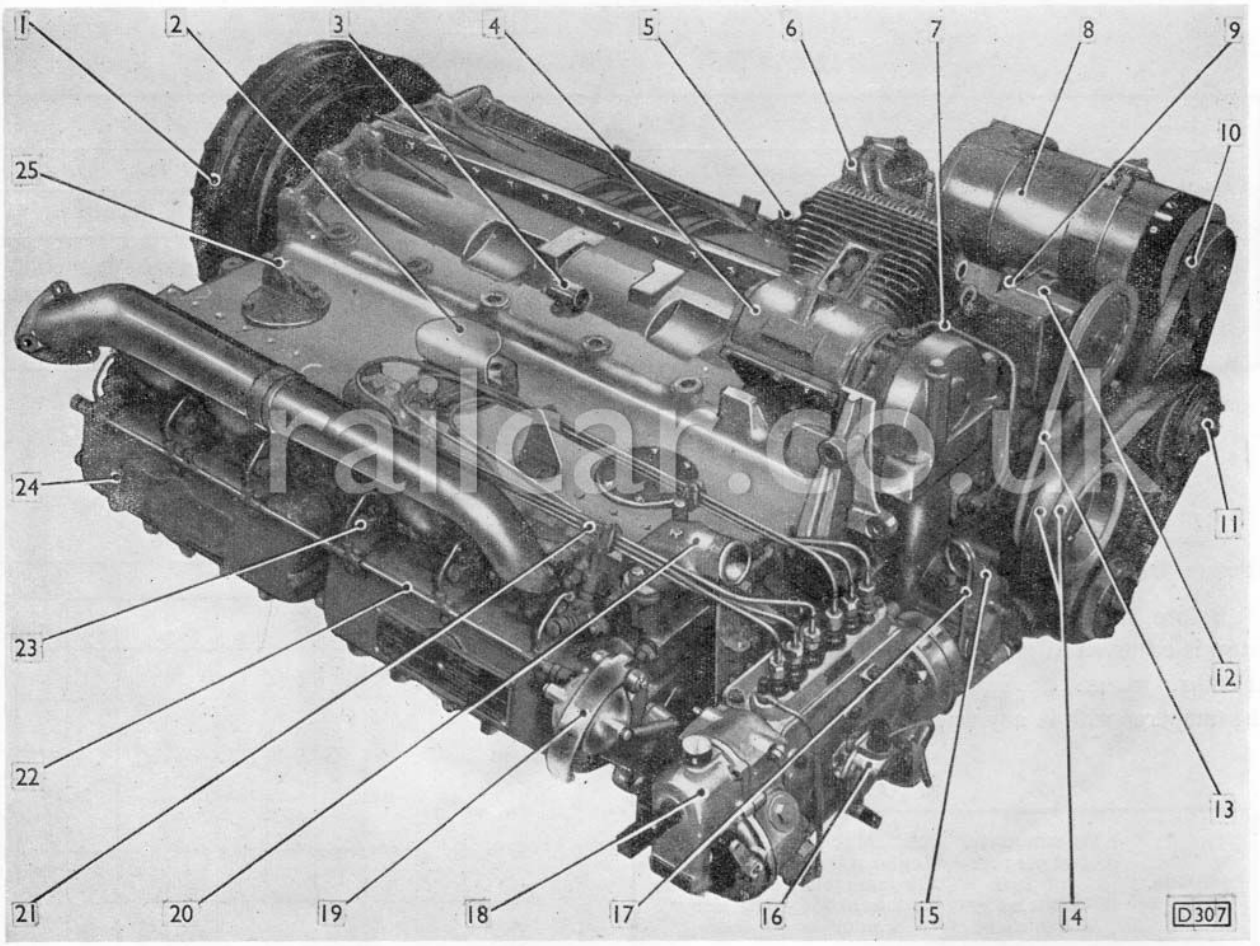
Fig. 4. Average performance curves of 11·3 litre horizontal engine.

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.

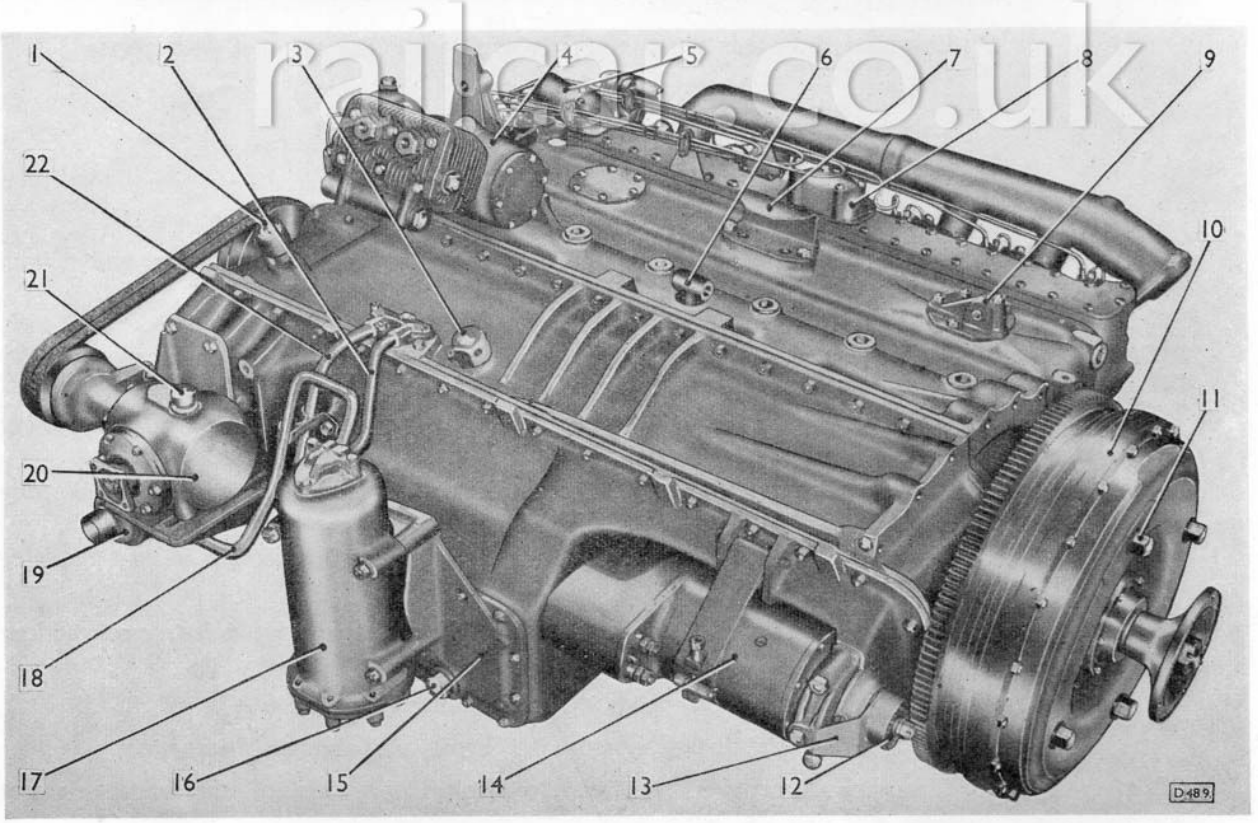
Fig. 5. Three-quarter front view of engine—not fitted with right-angle fan drive unit.

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.

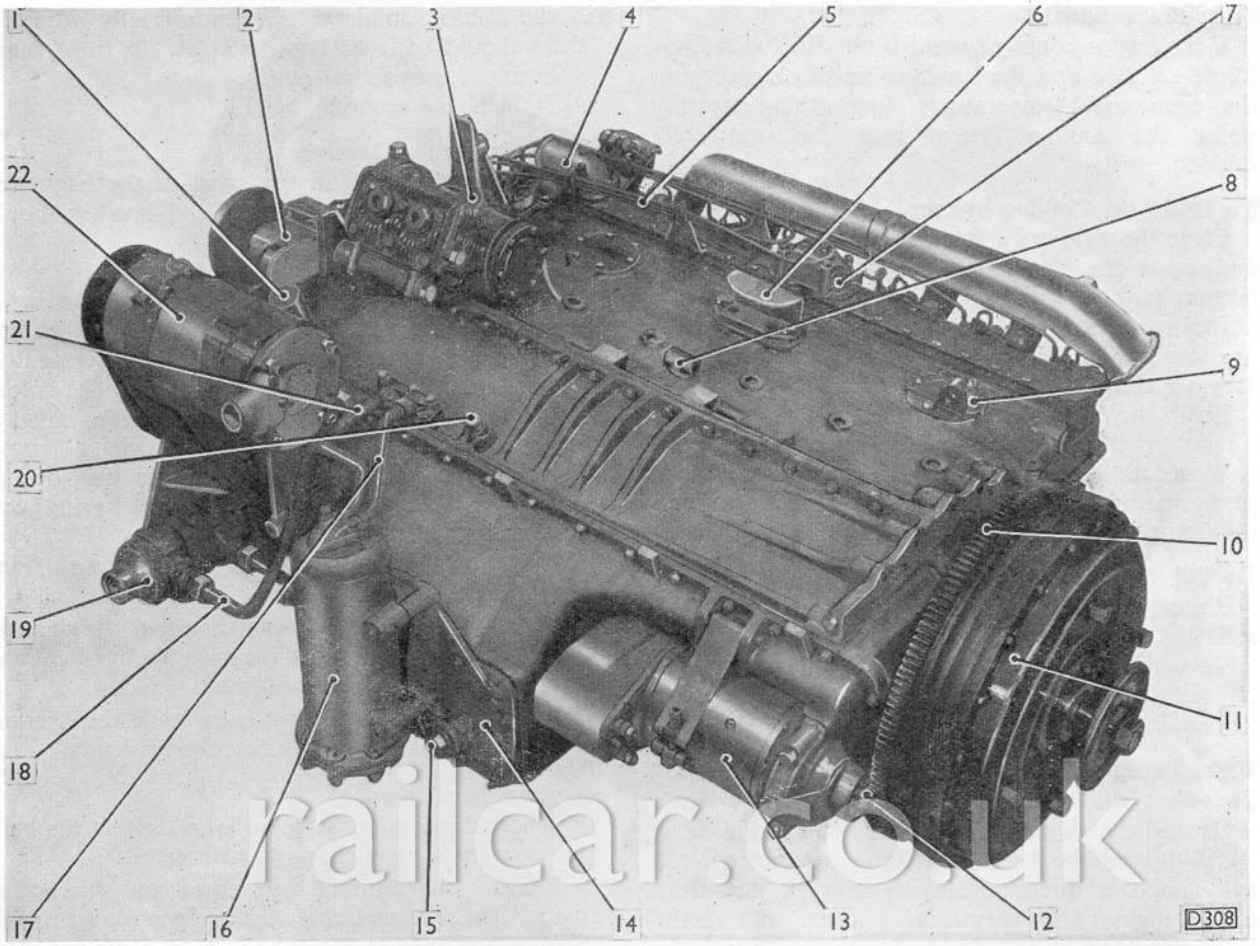
Note.—For split field dynamos with two (F) terminals a test should be made independently from each.

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.

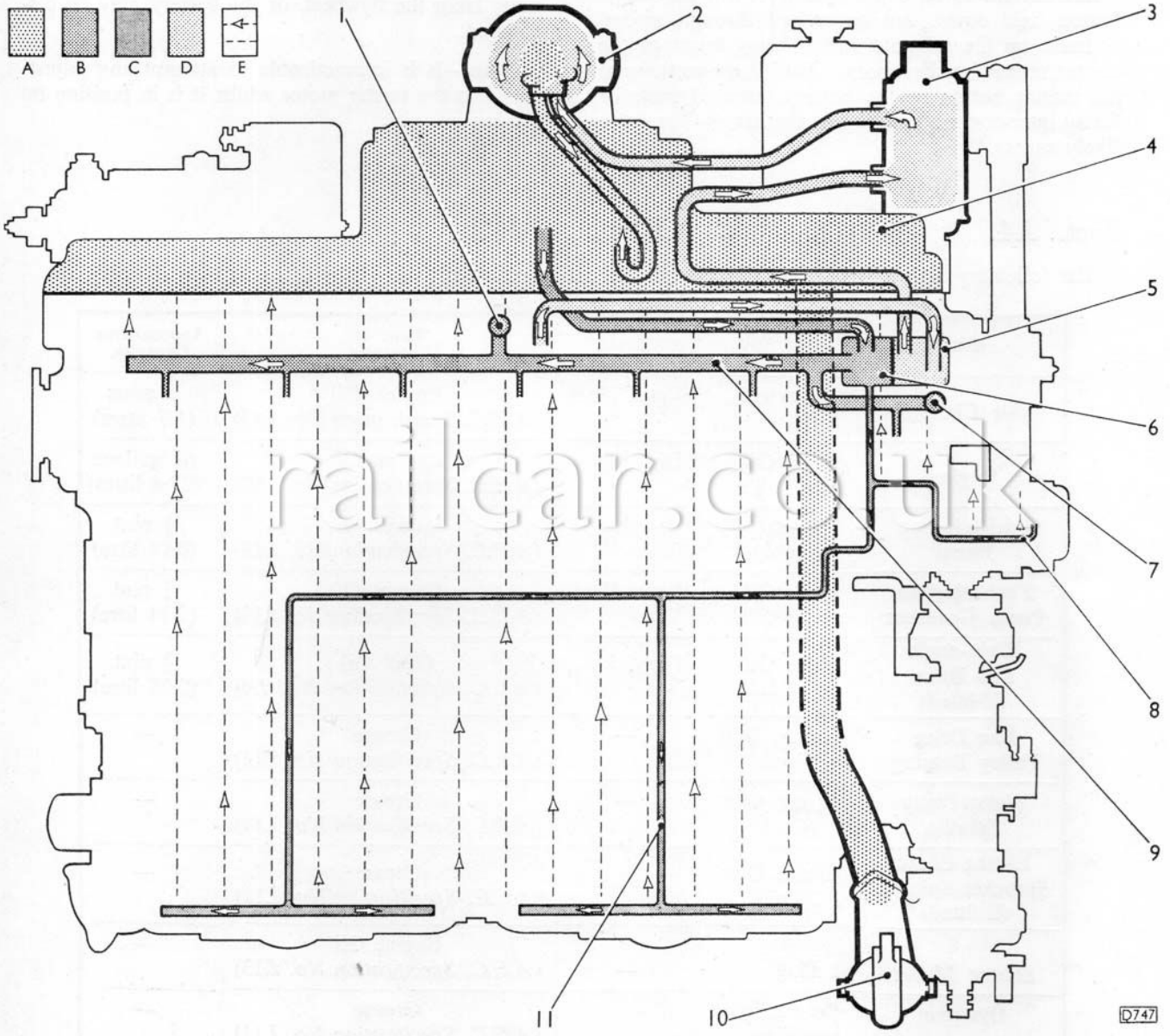
Whenever possible the unit should be drained immediately after the car has completed a run and the oil is warm.

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 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.

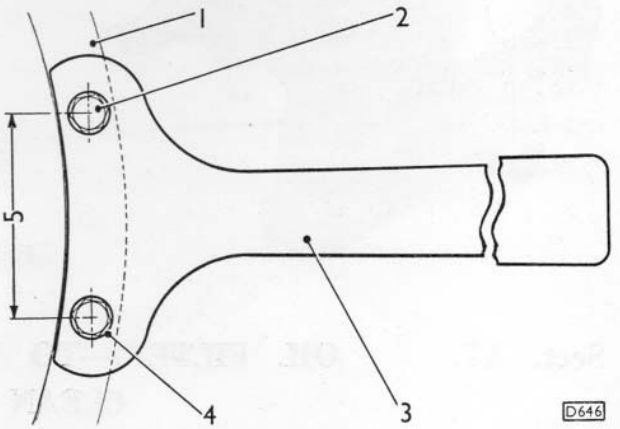
Turn the crankshaft, by using a suitable tool to turn the fluid coupling (*see Fig.* 9), until the valve is open fully, then turn through one complete revolution to bring the tappet on to the back of the cam.

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.

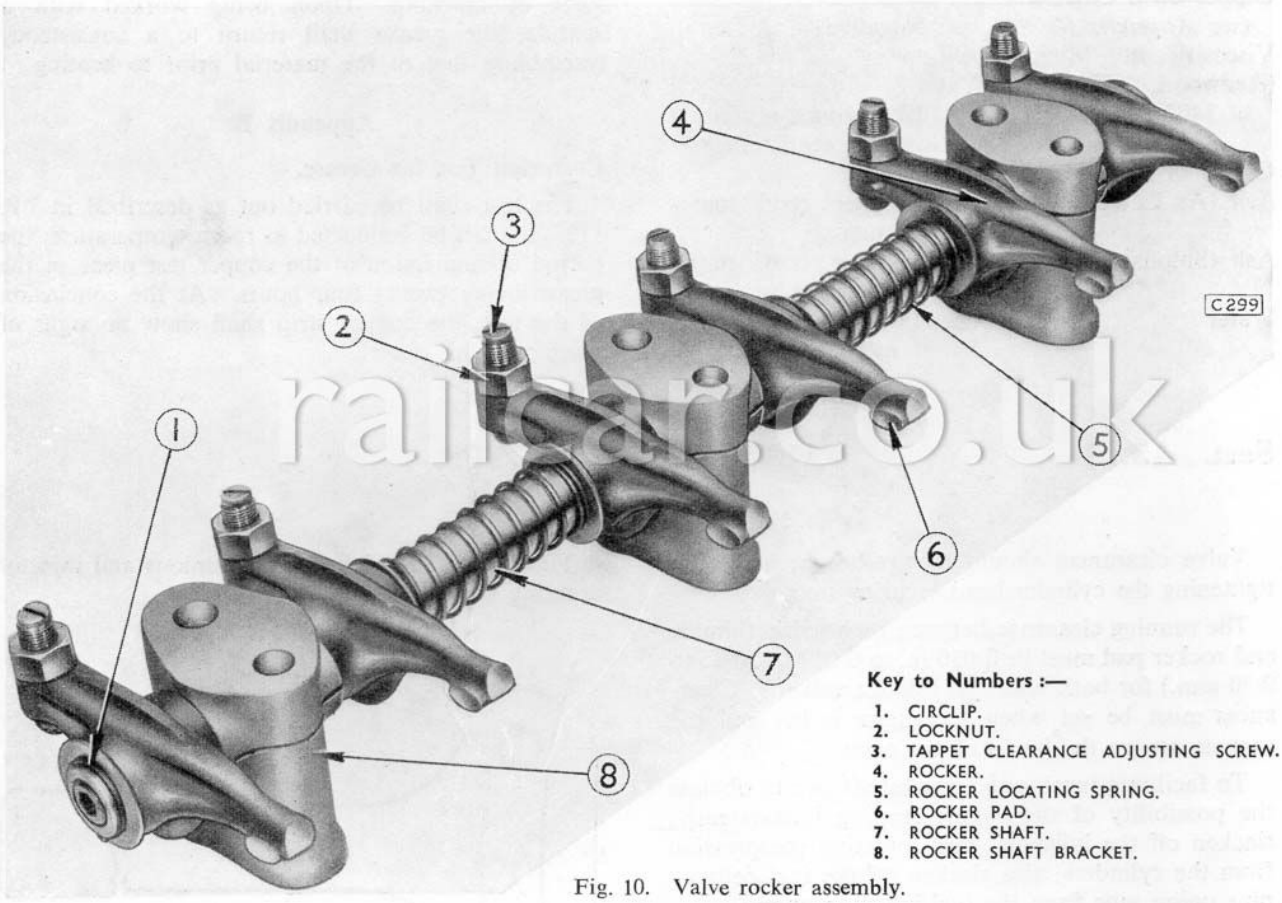
(*See Figs.* 2 *and* 8).

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.



Key to Numbers :—

1. CIRCLIP.
2. LOCKNUT.
3. TAPPET CLEARANCE ADJUSTING SCREW.
4. ROCKER.
5. ROCKER LOCATING SPRING.
6. ROCKER PAD.
7. ROCKER SHAFT.
8. ROCKER SHAFT BRACKET.

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).

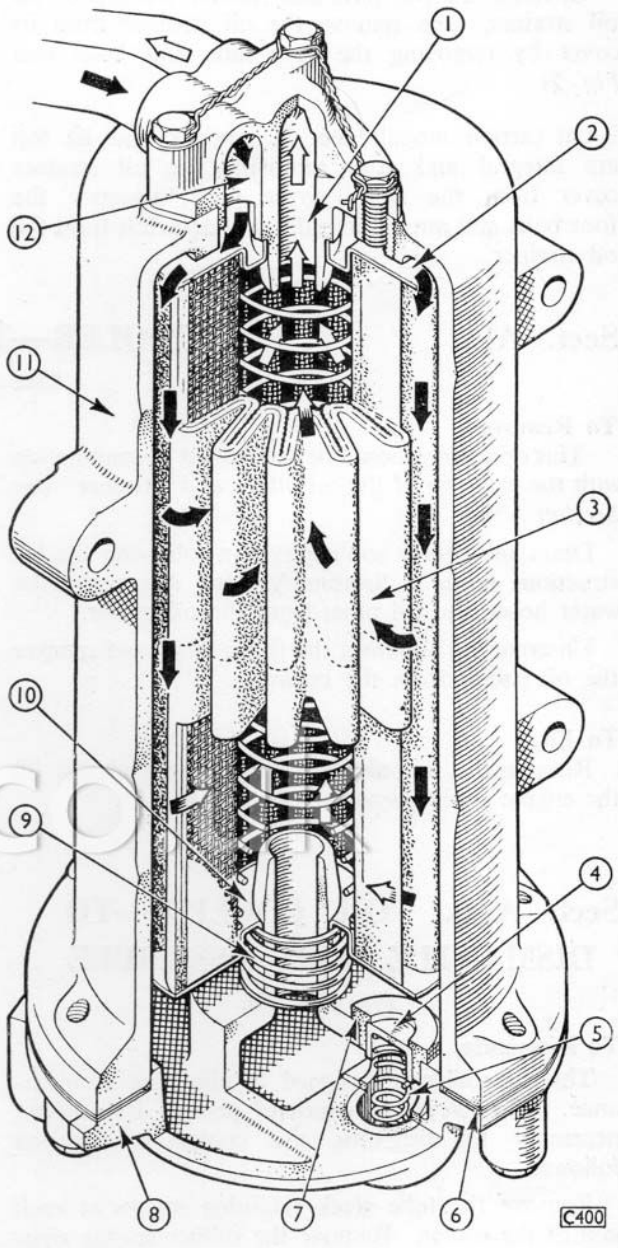


Fig. 11. Cut-away view of oil filter.

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.

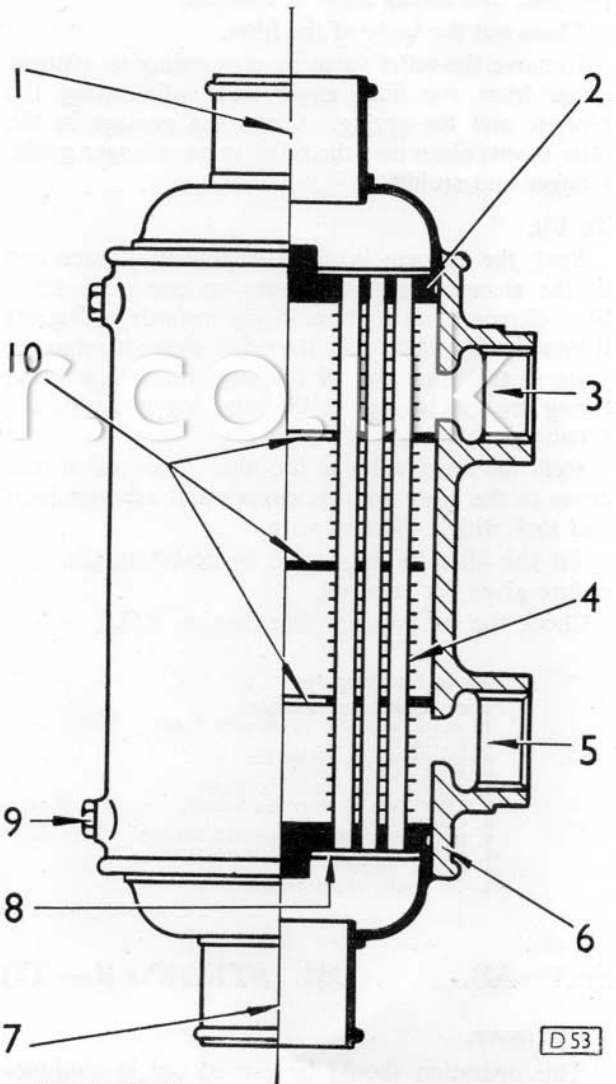
Each movement will expose a rubber sealing ring which must be removed before completely removing the tube stack.

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.

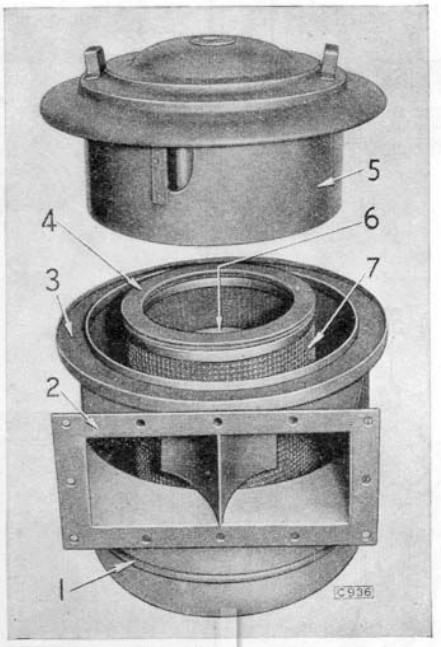
Remove the screens, wash thoroughly in clean paraffin and allow to drain.

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).

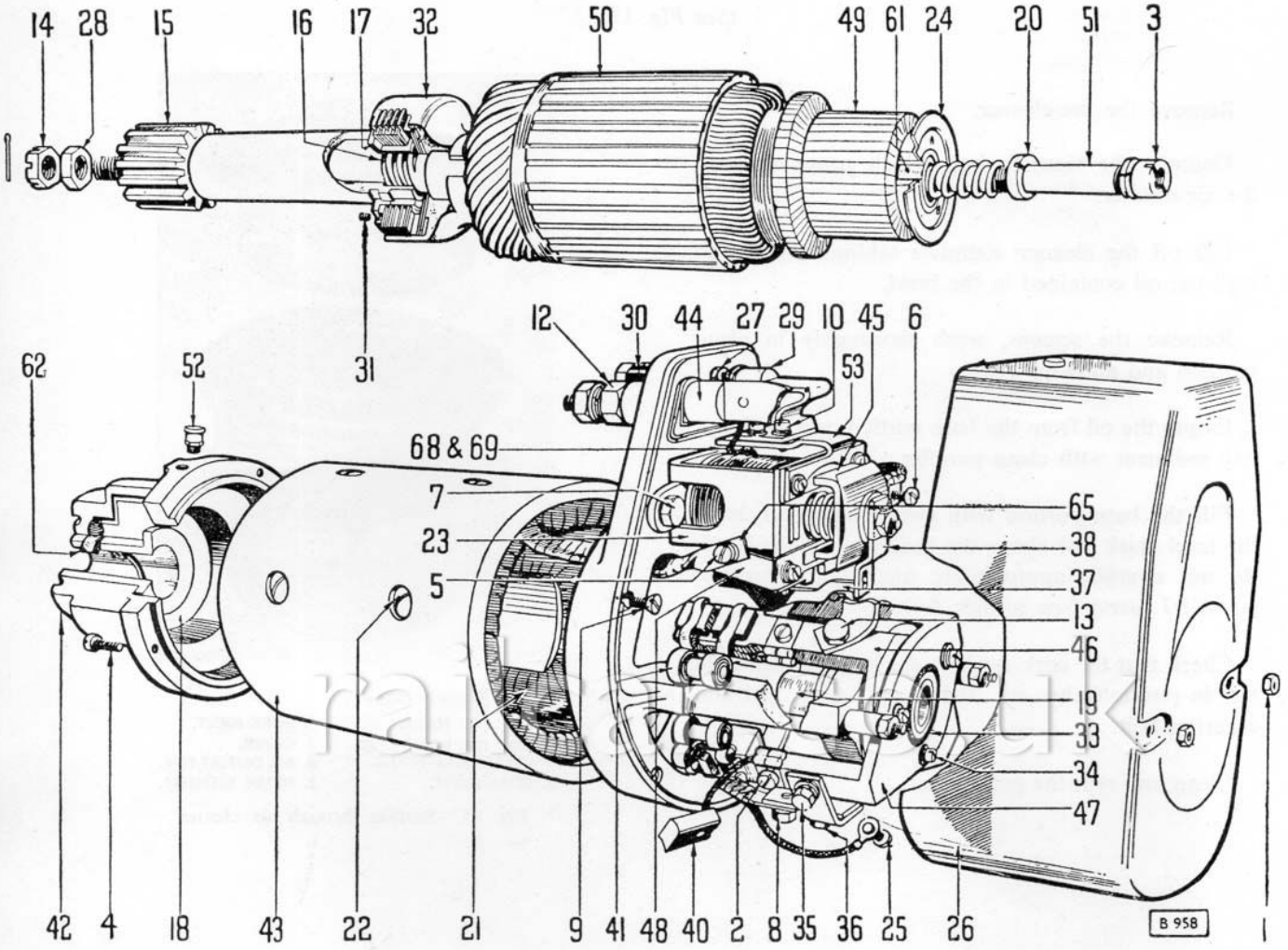
This 24-volt starter motor is of the axial type and provided with a built-in solenoid switch giving two-stage operation.

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.

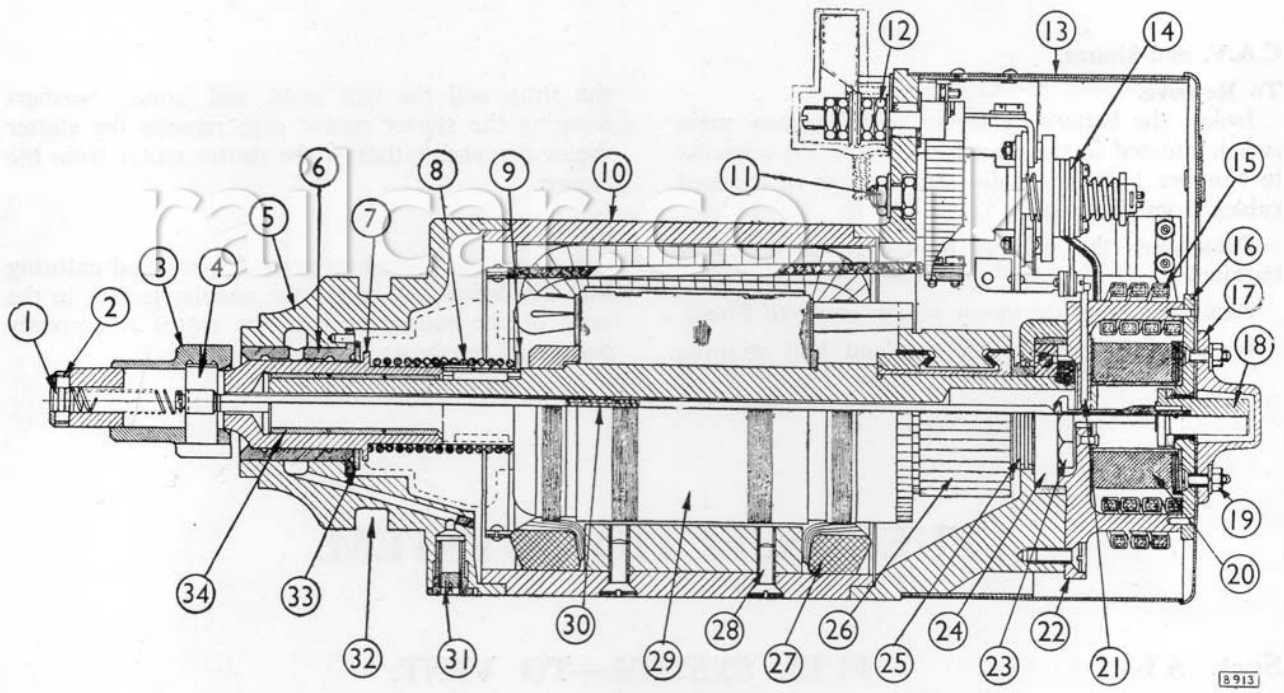
(SIMMS TYPE SG) (*see Fig.* 15).

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 energiving 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.

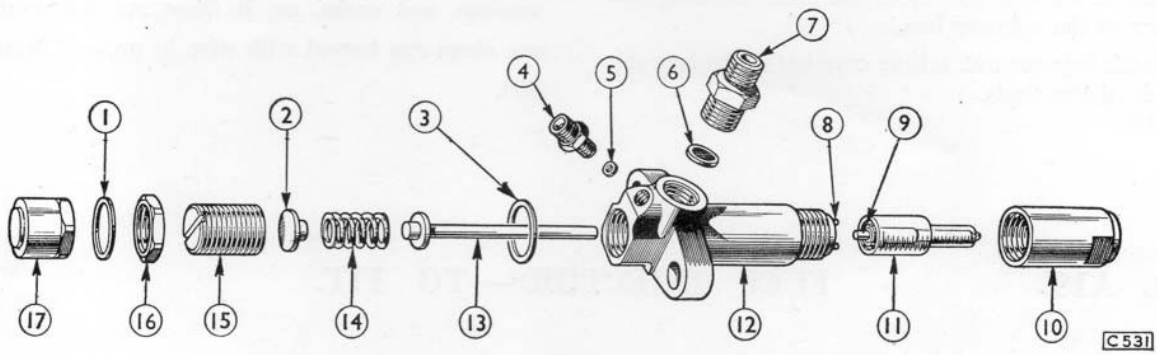
Sect. A15. FUEL INJECTORS—DESCRIPTION.

(*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.

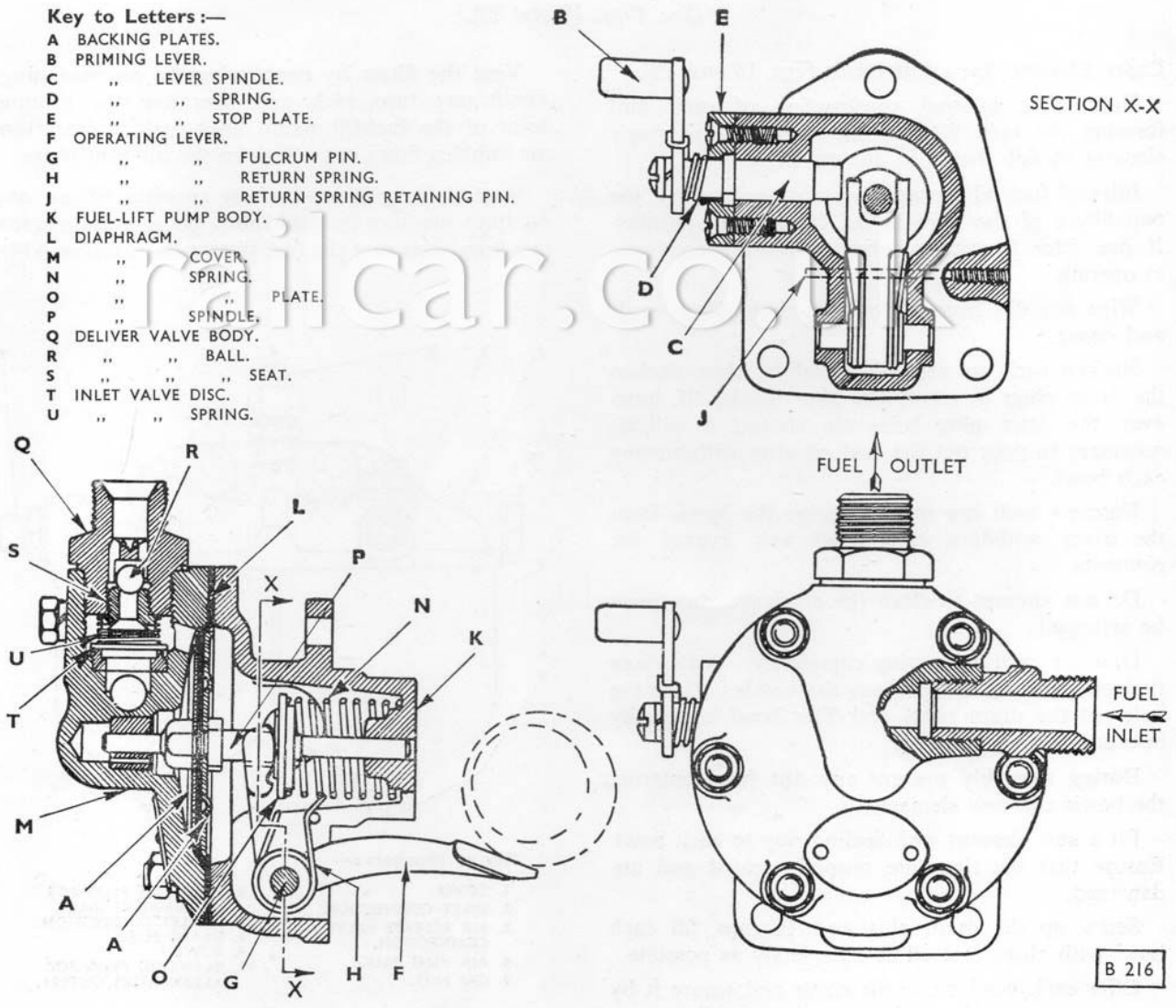


Fig. 17. Sections through C.A.V. fuel-lift pump.

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.

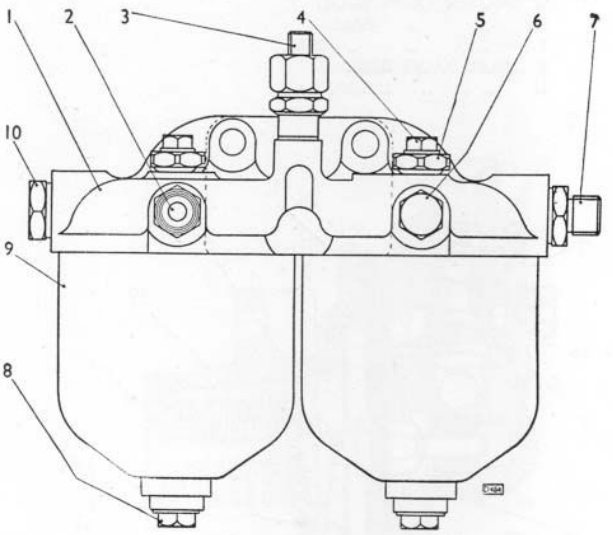
Fit a **new element** with sealing ring to each bowl. Ensure that the rings are properly seated and undamaged.

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).

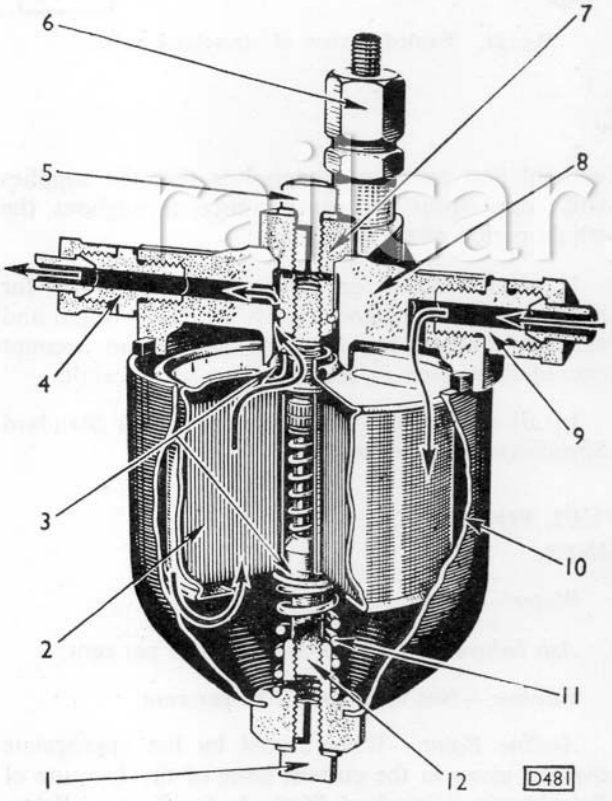
To Clean.

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.

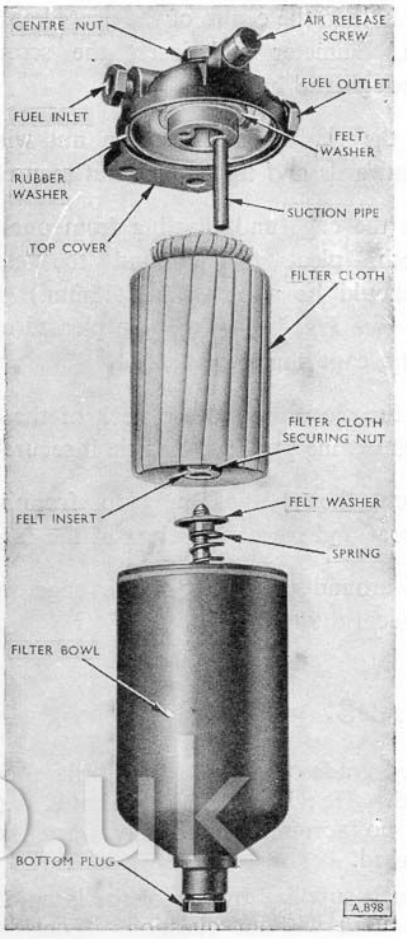


Fig. 20. Exploded view of main fuel filter (C.A.V.) —cloth element type.

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.

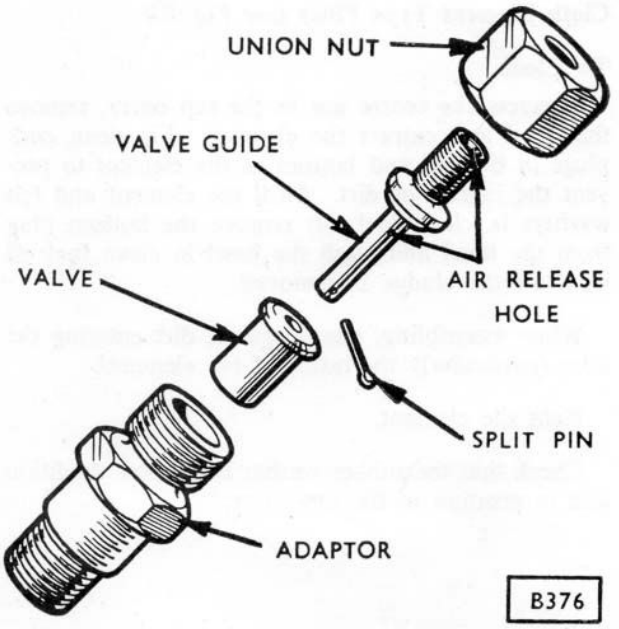


Fig. 21. Exploded view of air release valve.

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.

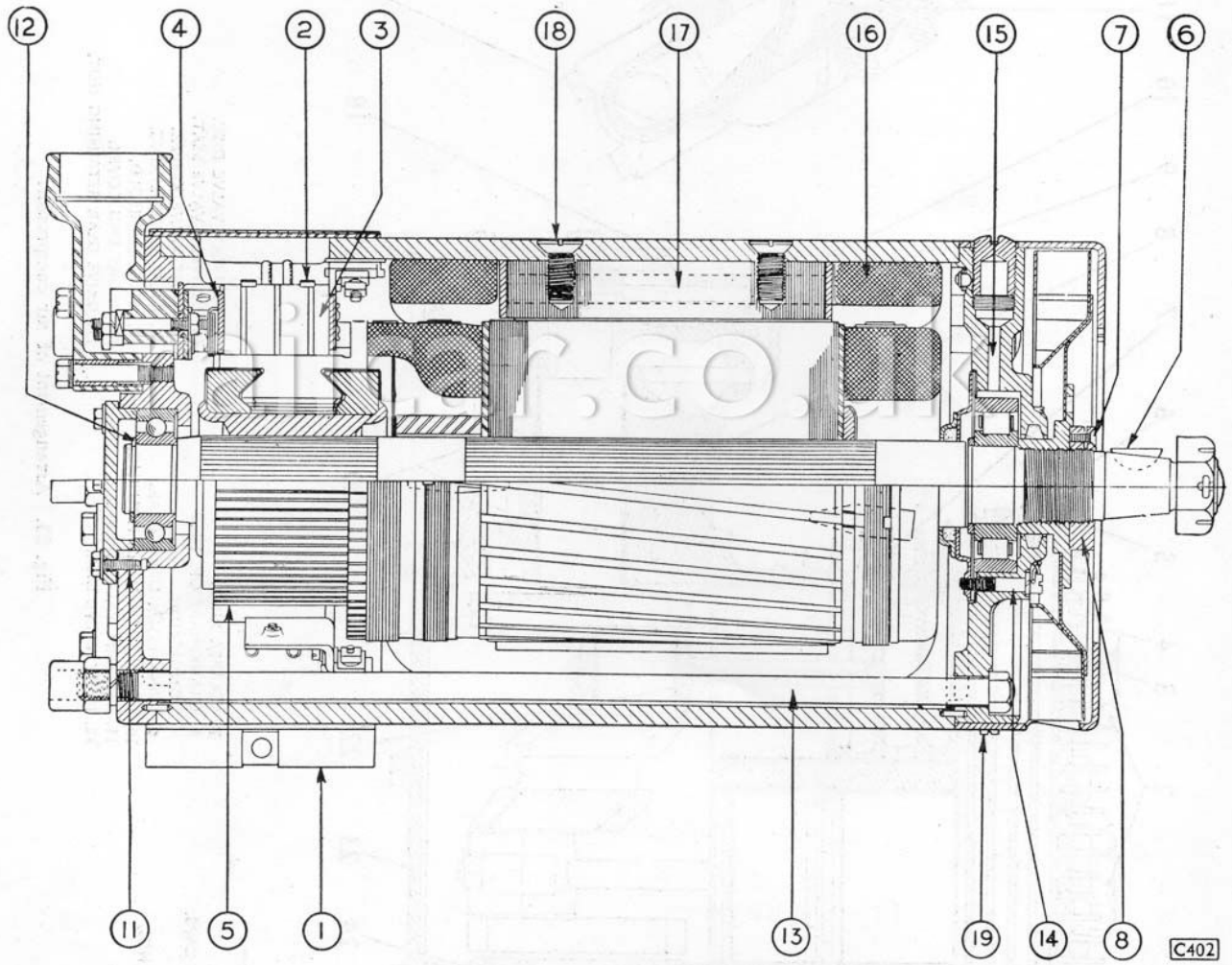
(*See Fig.* 22).

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.

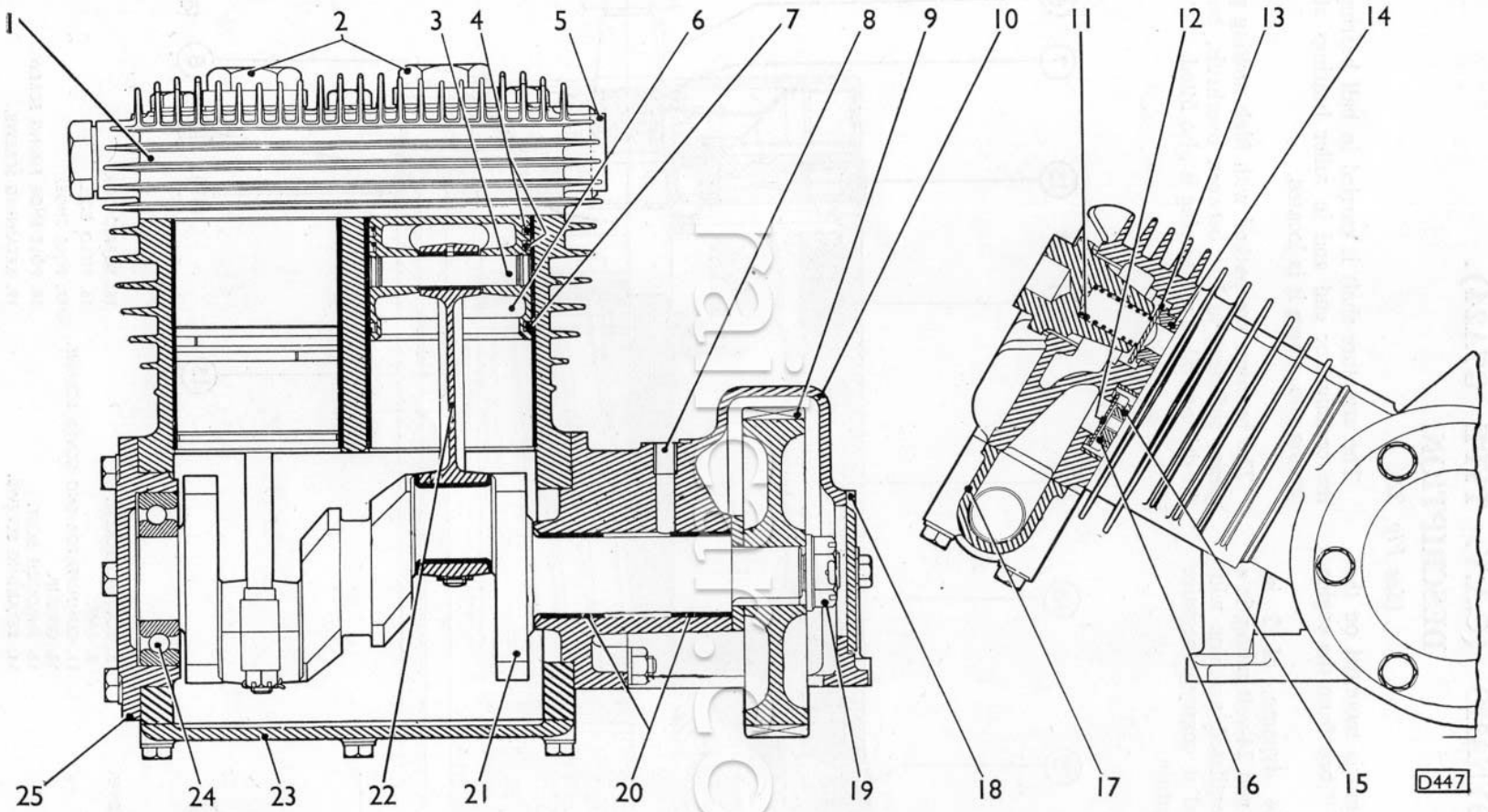
The bearings are packed with **high melting point grease** sufficient to last between overhauls, but, at the driving end, a grease plug is also fitted.



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.

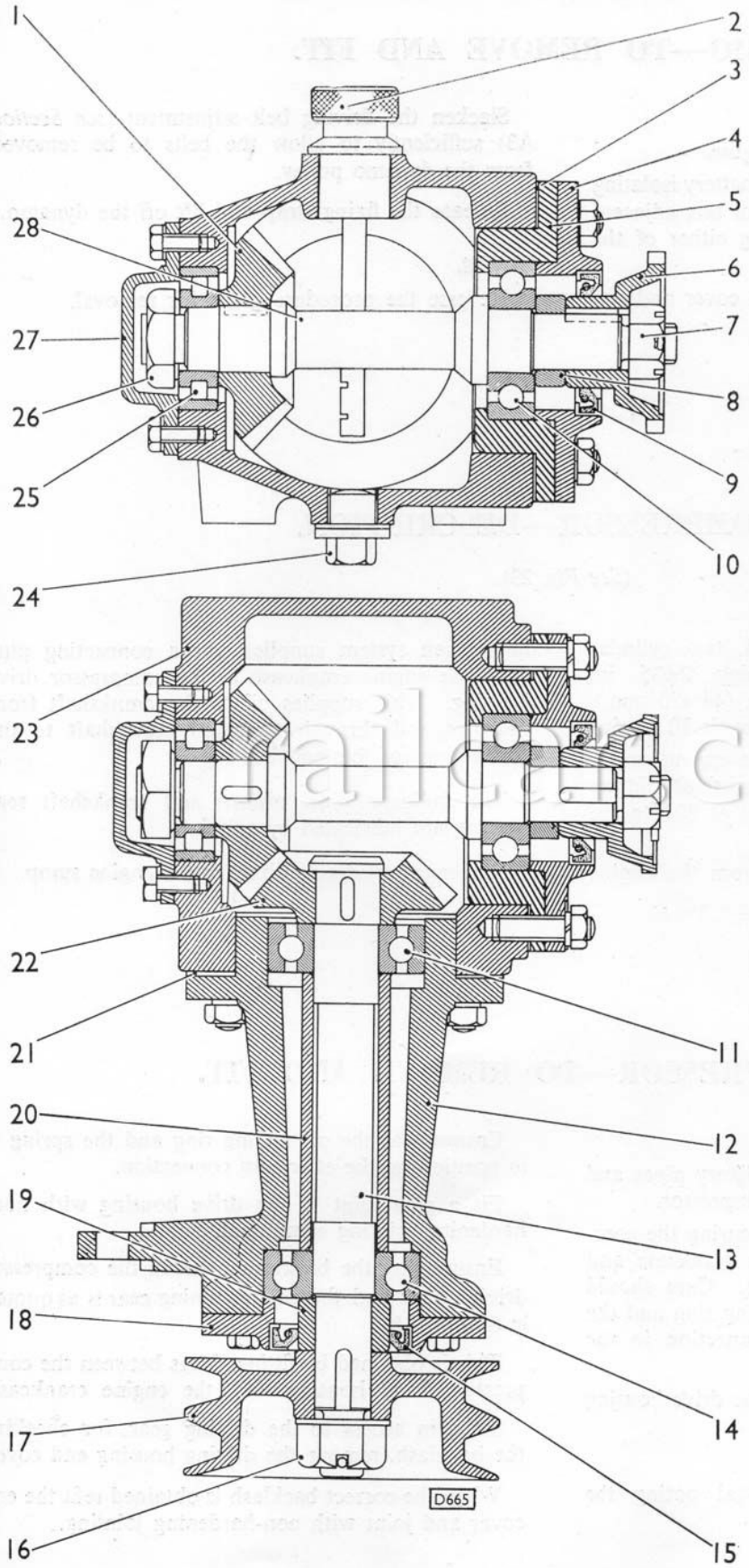
Fit a new joint to the drive housing with non-hardening jointing compound.

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.

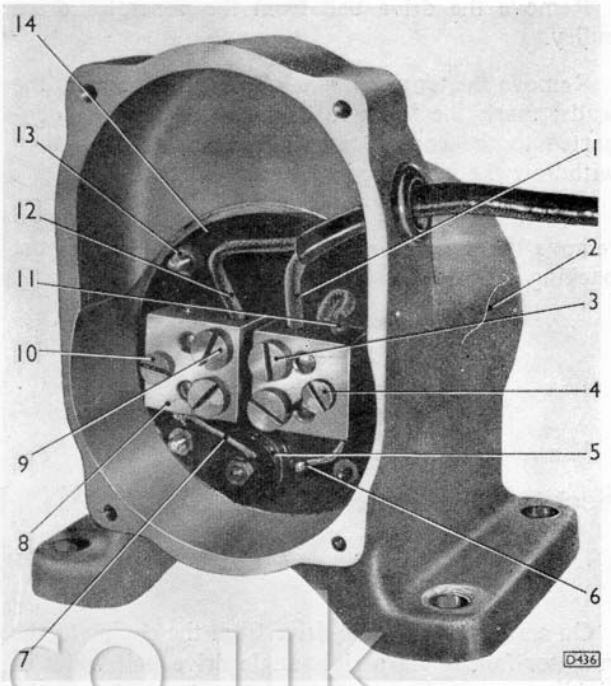


Fig. 25. Engine speed indicator generator (belt driven type).

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

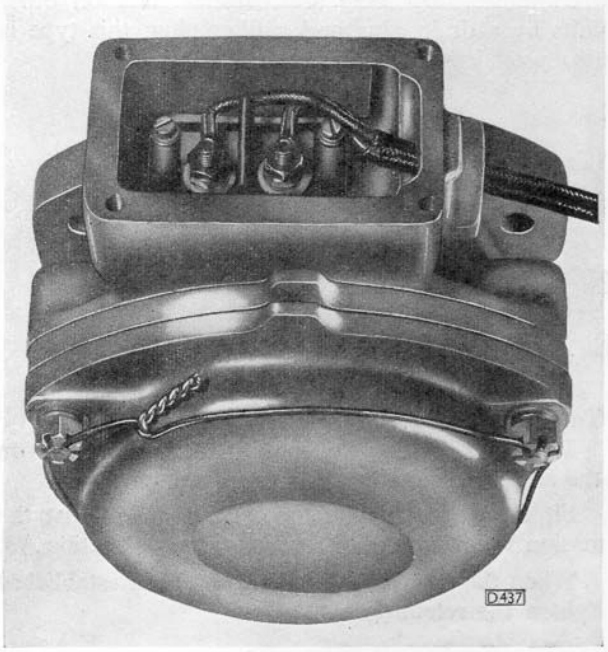


Fig. 26. Engine speed indicator generator—with cover removed (gear driven type).

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.

Sect. A32. ENGINE—TO REMOVE AND FIT.

(*See Figs.* 27, 28, 29, 30 and 31).

To Remove.

Disconnect the car batteries by means of the main switch situated in the electrical control box adjacent to number 1 engine.

Drain the oil from the engine (*see Section* A4).

Turn off the stop cock fitted to the low water tank and drain the water from the cooling system (*see Section* A3).

Disconnect the wiring from the oil pressure switch, the speed indicator transmitter, the dynamo and the starter motor.

Slacken the hose clips and disconnect the water hoses from the oil cooler and the cylinder head.

Disconnect, at the fuel-lift pump, the pipe between the fuel supply tank and the lift pump.

Disconnect, at the fuel filter, the pipe between the supply tank and the fuel filter.

Remove the fuel pipes between the fuel-injection pump and the filters and between the lift pump and the filters.

Disconnect the air pipes from the air compressor.

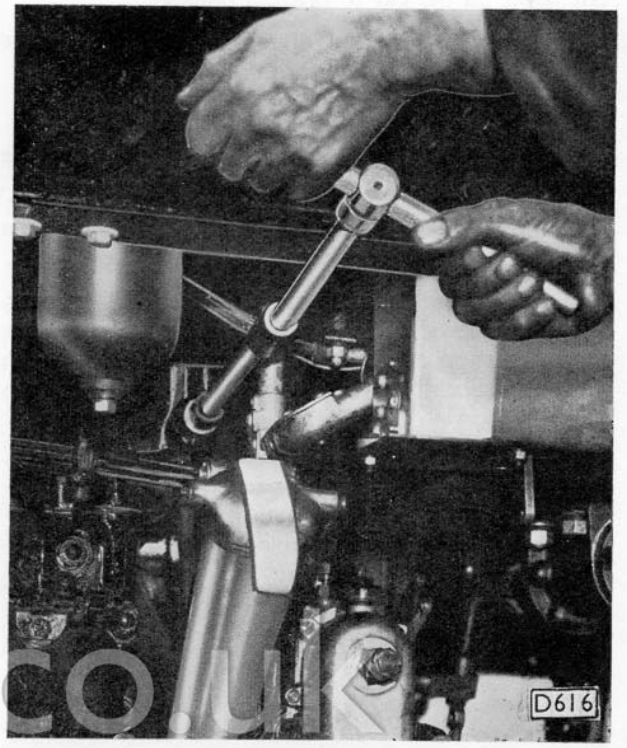
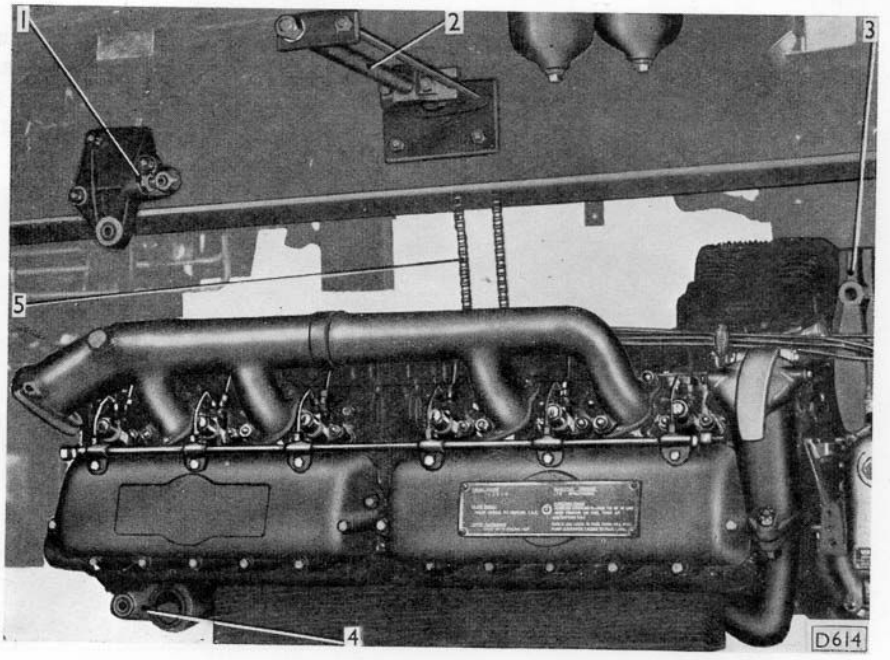


Fig. 27. Method of tightening or unscrewing the retaining bolts for engine front support bracket.



Key to Numbers :—

1. RESTRAINT LINK EYEBOLT.
2. ENGINE LIFTING GEAR.
3. FRONT SUPPORT BRACKET.
4. TORQUE TUBE.
5. ENGINE LIFTING CHAIN.

Fig. 28. Engine in position for fitting to car.

Disconnect from the engine, the fan drive shaft coupling flange and the freewheel shaft universal joint coupling flange; secure the shafts to a convenient point on the car to prevent damage.

Slacken the clip and disconnect the air cleaner hose from the cylinder head.

Disconnect the exhaust pipe from the manifold.

Remove the fork-end pin and disconnect the throttle control rod from the fuel-injection pump.

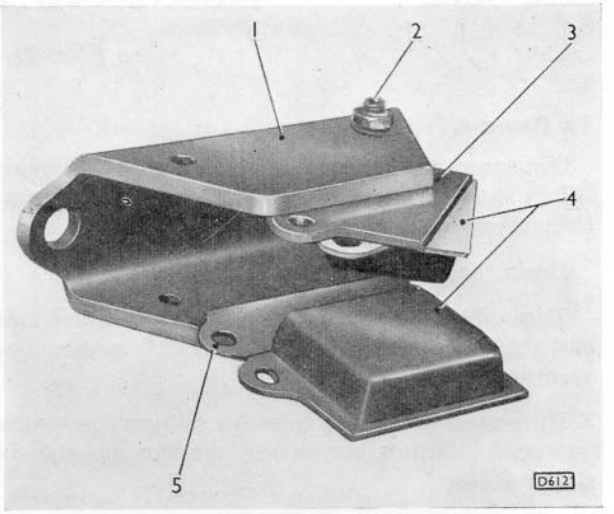
Remove the fork-end pin and disconnect the engine trip rod from the trip lever.

If the engine is not provided with lifting gear, suitable jacks should be placed in position at this stage to support the engine whilst removing the mounting bolts, and to lower the engine to the ground.

Remove the bolts securing the engine snubber assembly to the frame (*see Fig.* 29).

Remove the bolts securing the engine restraint links to the frame.

Disconnect the torque tube links from the bracket on the car frame by removing the retaining bolt and disconnect the other end of the torque tube from its eye on the car frame.



Key to Numbers :—

1. SNUBBER BRACKET.
2. BUFFER AND SHIM FIXING BOLT.
3. THICK SHIM.
4. RUBBER BUFFERS AND PLATES.
5. THIN SHIM.

Fig. 29. Engine snubber bracket assembly.

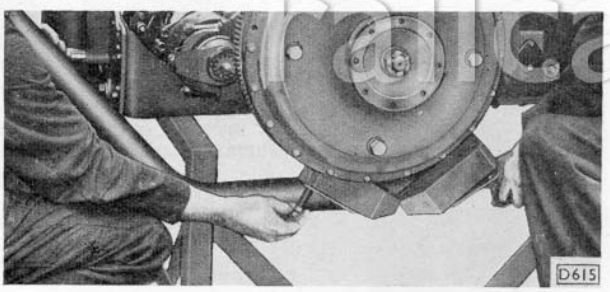
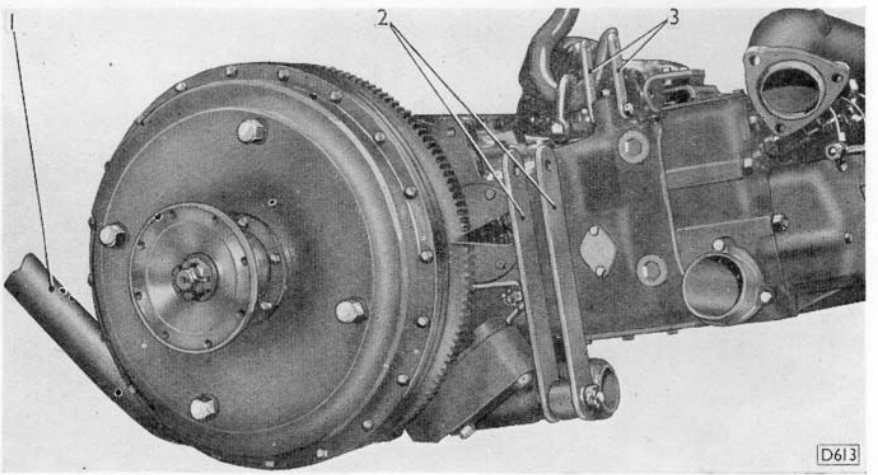


Fig. 30. Method of fitting engine torque tube.

Remove the bolts securing the engine front support bracket to the frame (*see Fig.* 27).

If no lifting gear is fitted to the engine, lower the engine by means of the jacks.

If the engine is provided with lifting gear, place a suitable trolley in position under the engine and lower the engine by means of the lifting gear; remove the bolt securing the lifting chain to the engine.



Key to Numbers :—

1. ENGINE TORQUE TUBE.
2. TORQUE TUBE LINKS.
3. RESTRAINT LINKS.

Fig. 31. Engine fitted with torque tube and linkage prior to fitting to car.

To Fit.

Fit the engine to the car, reversing the procedure given for removal, noting the following points:—

Before fitting the engine snubber assembly, all engine mounting bolts should be tightened securely.

When fitting the snubber assembly, ensure that the rubber buffers seat firmly on each side of the snubber bracket attached to the engine.

Adjustment is provided by means of shims fitted between the bracket and buffers (*see Fig.* 29), (*for dimensions of shims available see Section* A83).

If lifting gear is provided, ensure that the lifting chain is left slack after the engine has been fitted to the car.

Ensure that all water hoses and oil, fuel and air pipe connections are secure.

Fill the engine with oil (*see Section* A4).

Ensure that the drain cock on the radiator is turned off then turn on the stop cock fitted to the low water tank (*see Section A*3).

Switch on the car batteries.

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

Sect. A33. CYLINDER HEADS—TO REMOVE.

(*See Figs.* 2, 32 *and* 33).

Drain the engine cooling system (*see Section* A3) and remove the following parts:—

Valve covers and gaskets. (It is advisable to have a suitable container available before removal as a certain amount of oil will be trapped).

Exhaust manifold.

Fuel delivery and dribble pipes.

Fuel injectors.

Water connecting pipe between the two cylinder heads.

Rocker gear, valve thimbles and push rods.

Disconnect the air intake and water outlet pipes.

Slacken the hose clip around the air connection between the cylinder heads.

Remove all the securing nuts and washers, **except the jack nuts** (*see Fig.* 32).

The two jack nuts are fitted to facilitate removal and are so arranged that as they are unscrewed they will lift the heads clear of the cylinders.

These two nuts must not be unscrewed until the other nuts have been removed.

Unscrew the jack nuts evenly as far as they will go, then lift the heads clear of the studs.

Note.—On certain engines the cylinder head holding down studs are fitted with sleeves, and care should be taken when removing the heads to ensure that the sleeves are not lost.

If there is difficulty in removing the heads when they have been lifted to the full extent of the jack nuts, it may be overcome by using two special tee screws similar to those shown in Figure 33.

Screw these special tee screws into the jack nuts, then screw down each in turn whilst holding the jack nuts steady with a spanner, so that the cylinder head is lifted slightly. Repeat on alternate jack nuts, a little at a time, until the head is removed.

IF A HEAD IS DIFFICULT TO REMOVE, NEVER ATTEMPT TO LEVER IT OFF.

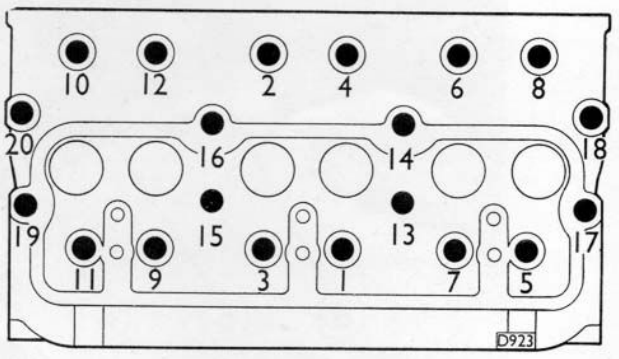


Fig. 32. Diagram showing sequence of tightening cylinder head nuts (Nos. 14 and 15 are jacknuts).

Sect. A34. CYLINDER HEADS—TO FIT.

(See Fig. 32).

Thoroughly clean the joint faces of the cylinder heads and the top face of the cylinders making certain that no foreign matter has entered the cylinder bores.

Renew the gaskets, making sure that they are placed in position correct side up as marked. Do **not** use jointing compound.

Place the cylinder head on the studs until it comes up to the jack nuts.

Keeping the head parallel with the top face of the cylinder block, bring the two together by giving each jack nut alternately a few turns with a spanner until tight, making sure that it fits on to the locating dowels.

Fit the sleeves to the cylinder head holding down studs, fit all the cylinder head securing nuts and washers, then tighten the head down evenly giving each nut a few turns at a time in the order shown in Figure 32. *(For torque spanner loadings, see Section* A84).

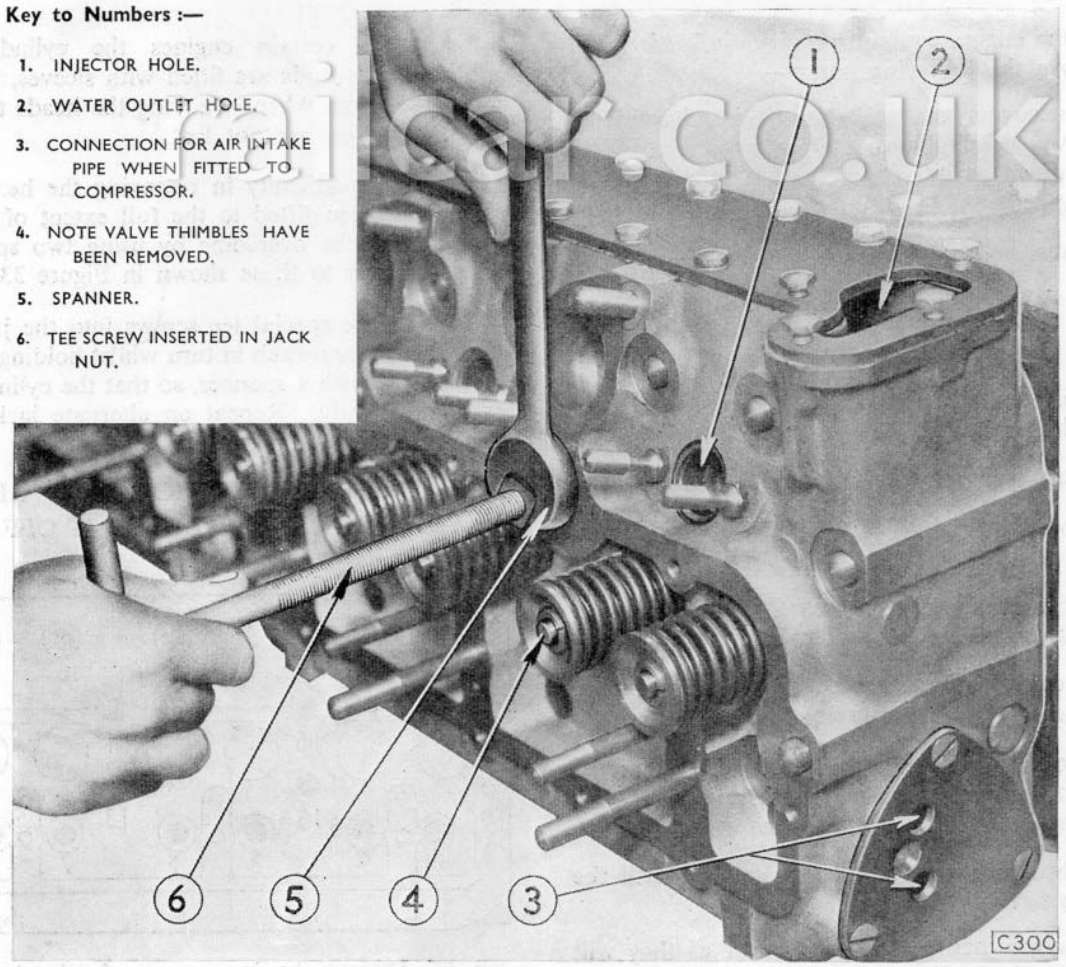


Fig. 33. Removal of cylinder head.

Fit the other cylinder head in a similar manner and tighten the hose clip round the resilient ring on the air connection between the heads.

Fit the remaining parts in the reverse order to their removal.

Always re-tighten the cylinder head securing nuts after initial running, and whilst the engine is still hot set the clearances between the valves and rockers (*see Section* A5).

Note.—Do not attempt to cure gasket leakage by excessive tightening of the nuts as this will only produce distortion of the head or engine casing. It is much better to slacken off the nuts and re-tighten to the correct tightness. (*For torque spanner loadings, see Section* A84).

Sect. A35. VALVE SPRINGS—TO REMOVE AND FIT.

(*See Figs.* 10, 34 *and* 35).

To Remove.

Slacken off the tappet adjustment completely and, in the case of the four centre rockers on each head, slide them along the rocker shaft clear of the valve after slightly depressing the valve and springs to allow the adjusting screw to clear the push rod cup. **Bring the piston under the valve concerned to its top dead centre,** then remove the thimble from the top of the valve, press down the collar with a tool similar to that shown in Figure 35, and remove the split cotter.

Lift off the collar and remove the springs.

The procedure is similar for the end valves, but the rocker should first be removed by detaching the circlips from the ends of the rocker shafts; the rockers can then be pulled off.

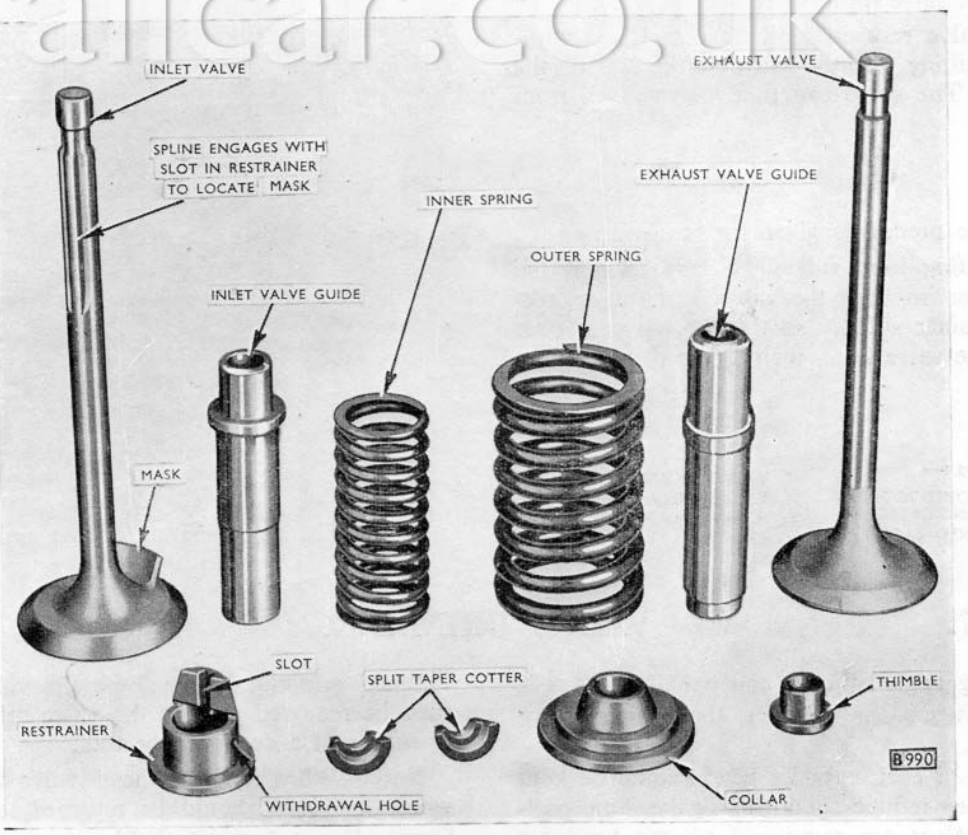


Fig. 34. Valve details.

To Fit.

Check the length and tension of the valve springs.

When new, the lengths are:—Inner, 80 mm. ($3\frac{5}{32}$ in.) free. Load to compress to 44 mm. ($1\frac{3}{4}$ in.), is 50 lb. (22·7 Kg.). Outer, 85 mm. ($3\frac{11}{32}$ in.) free. Load to compress to 47 mm. ($1\frac{27}{32}$ in.) is 83 lb. (37·5 Kg.).

If it becomes necessary to renew valve springs, they should be renewed in sets.

Refit the springs, collar, collett and thimble, slide the rocker back into position and adjust the tappet.

Check valve clearances when the engine is **hot** (*see Section* A5).

To ensure free movement of the rocker arms, washers of varying thicknesses are available for fitting between the arm and the circlip at each end of the rocker shaft (*for dimensions of the washers available see Section* A83).

Sect. A36. VALVES—TO REMOVE AND FIT.

(*See Fig.* 35).

To Remove.

Remove the cylinder heads in accordance with Section A33, then to assist removal of the valves, temporarily refit the rocker shaft.

Exhaust valves.

Remove the valve springs (*see Section* A35) and withdraw the valve.

Inlet valves.

Remove the valve springs (*see Section* A35).

Lift the valve restrainer off its dowel and withdraw it by tilting slightly when at the top of the valve stem. The valve can then be removed from its guide.

To Fit.

Reverse the procedure given for removal.

When refitting inlet valves, be sure to refit the restrainer after inserting the valve in its guide, tilting the restrainer slightly so that it will pass over the end of the valve stem, then locate the restrainer on its dowel.

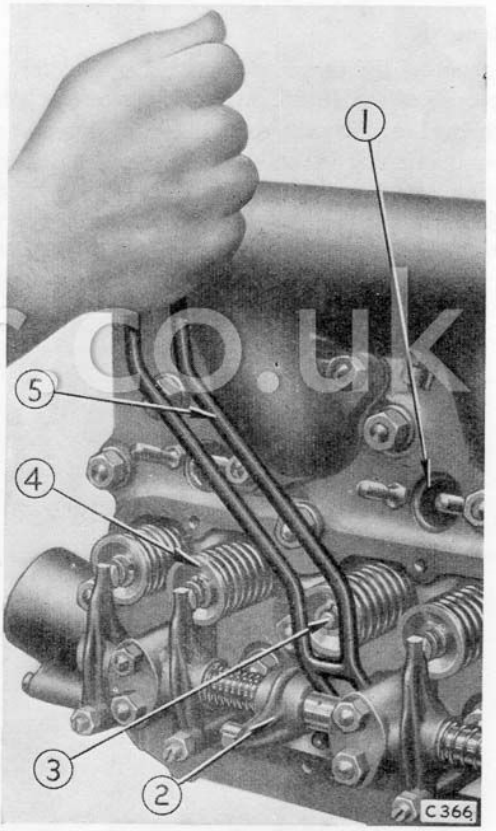


Fig. 35. Removal of valve springs.

Key to Numbers :—

1. INJECTOR REMOVED TO FACILITATE TURNING OF ENGINE.
2. ROCKER TURNED BACK.
3. VALVE THIMBLE REMOVED.
4. VALVE COLLAR.
5. TOOL FOR DEPRESSING VALVE SPRINGS.

Sect. A37. VALVE GRINDING.

The seating angle of inlet and exhaust valves is 30°, on certain engines however, the exhaust valve seating is 45°.

The valves of each cylinder head should be kept apart and when refitted should be in the same position. The valves are numbered on the head for guidance.

When grinding inlet valves, the valve restrainer must be removed so that the valve may be rotated by means of a suction type tool.

Note.—When cylinder head valve seats become worn the heads should be returned to any B.U.T. Service Depot for detachable type seatings to be fitted or renewed.

Sect. A38. CAMSHAFT TIMING—TO CHECK.

(*See Figs.* 36 *and* 37).

The firing order is 1, 5, 3, 6, 2, 4 (numbers taken from front of engine).

The flywheel rim is marked to show Top Dead Centre No. 1, thus " T.D.C.1 " for numbers 1 and 6 cylinders, and the part preceding this marking is graduated in inches and half inches.

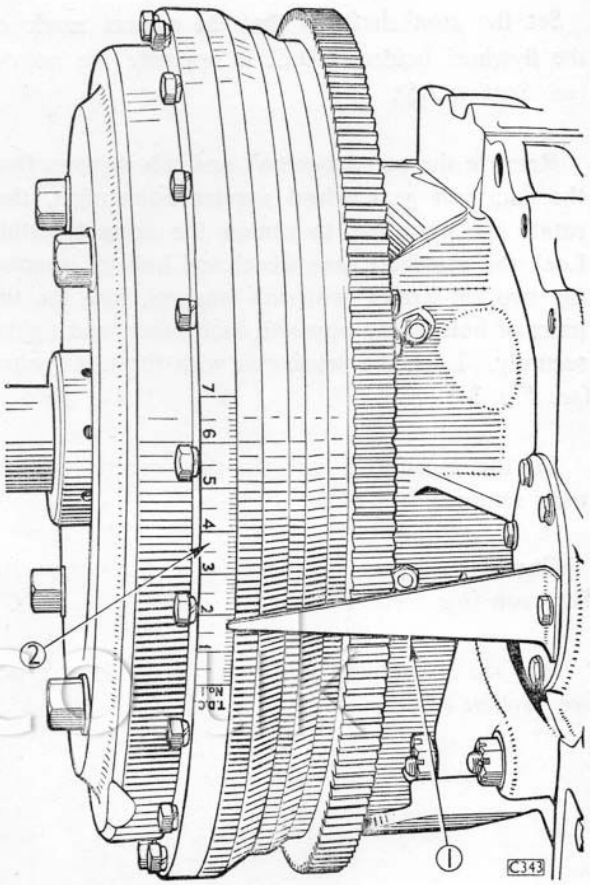
The timing pointer is fitted to the engine casing.

To obtain correct calculated valve timing, tappet clearance must be set to 0·012 in. (0·30 mm.) dead, with the engine **cold.**

Inlet valve opens at 10° before T.D.C. which then gives $1\frac{3}{4}$ in. $\pm$ $\frac{3}{8}$ in. before T.D.C..

The above dimensions measured on the flywheel rim are governed by the flywheel diameter which is 19·8 in. (503 mm.).

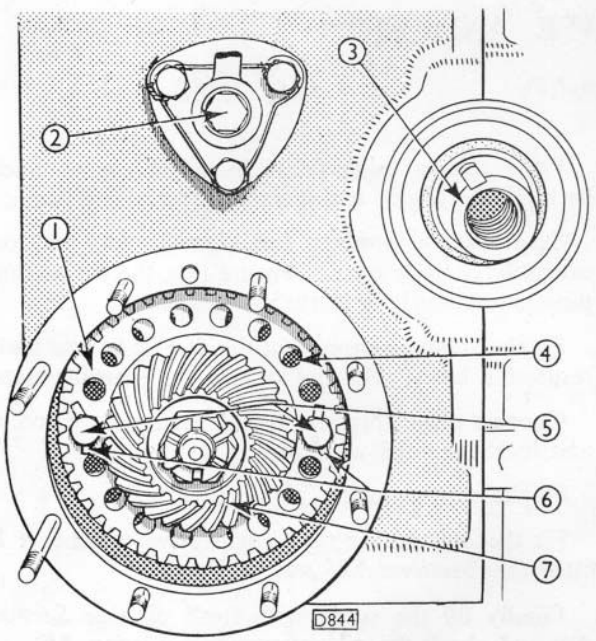
To alter the camshaft timing, first remove the bevel drive housing, and on certain engines also the speed indicator generator to expose the camshaft gear wheel with its vernier adjustment (*see Sections* A28 *and* A29).



Key to Numbers :—

1. TIMING POINTER.
2. TIMING MARKS ON FLYWHEEL.

Fig. 36. Position of the flywheel for inlet valve opening.



Key to Numbers :—

1. CAMSHAFT GEAR WHEEL.
2. CONNECTION FOR AIR COMPRESSOR OIL PIPE.
3. CRANKSHAFT.
4. VERNIER ADJUSTMENT HOLES FOR CAMSHAFT TIMING.
5. LOCKING SET-SCREWS.
6. LOCKING TABS.
7. FUEL-INJECTION PUMP DRIVE GEAR.

Fig. 37. Camshaft gear showing vernier adjustment.

Check that the tappet clearances are set to 0·012 in. (0·30 mm.) with the engine **cold** (*see Section* A5).

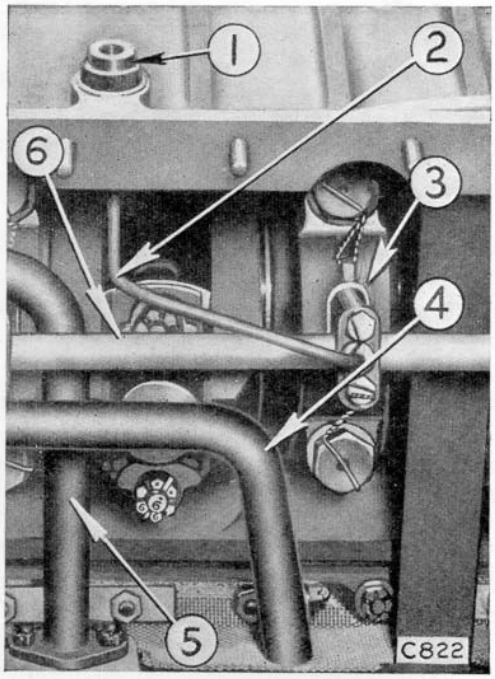
Set the crankshaft **so that the correct mark** on the flywheel before T.D.C. is opposite the pointer (*see Section* A5).

Remove the two set-screws and tab washers from the camshaft gear wheel vernier adjustment, then rotate the camshaft to obtain the correct setting. Lock the camshaft gear wheel and hub by inserting the two set-screws, with tab washers, into the two pairs of holes lying opposite each other, and tighten securely. Lock the set-screws with the tab washers (*see Fig.* 37).

Fit the remaining parts in the reverse order to their removal.

Check the tappet clearances after the engine has been run (*see Section* A5).

(*For the correct backlash between the bevel gears, see Section* A82).



Key to Numbers :—

1. OIL PRESSURE GAUGE ADAPTOR.
2. OIL PRESSURE GAUGE PIPE.
3. No. 4 MAIN BEARING CAP.
4. SCAVENGE PUMP SUCTION PIPE.
5. PRESSURE PUMP SUCTION PIPE.
6. MAIN BEARING OIL SUPPLY PIPE.

Fig. 38. Oil pressure gauge pipe (fitted on late engines)

Sect. A39. SUMP—TO REMOVE AND FIT.

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

To Remove.

Drain the oil from the engine (*see Section* A4).

Remove the dynamo or right-angle fan drive, whichever is fitted (*see Sections* A25 *and* A31 *also Figs.* 6 *and* 7).

Remove the starter motor (*see Section* A13).

Disconnect the oil pipes from the oil filter and oil cooler.

Remove the securing nuts and lift off the sump.

(*To remove, clean and fit the internal oil grids, see Section* A52).

To Fit.

Before the sump is refitted, see that the internal oil grids are clean.

Fit a sealing joint, 0·006 in. (0·15 mm.) thick between the engine casing extension and the sump.

Clean the oil strainer (*see Section* A8) and on assembly exercise care to ensure that the oil suction pipe enters the hole in the oil strainer.

Fit the sump ensuring that the dowels fit into their respective holes, refit and tighten the securing nuts.

Connect the oil pipes to the oil filter and oil cooler and lock the bolts with wire.

Fit the starter motor (*see Section* A13).

Fit the dynamo or right-angle drive, whichever is fitted (*see Sections* A25 *and* A31).

Finally fill the sump with fresh oil (*see Section* A4) and check the oil pressure (*see Section* A6).

Sect. A40. PISTONS AND CONNECTING RODS—TO REMOVE.

(*See Figs.* 39 *and* 42).

Drain the oil from the engine and remove the sump (*see Sections* A4 *and* A39).

Remove the cylinder heads and gaskets (*see Section* A33) and any carbon deposit from the top of the cylinder bores.

Remove the oil return pipe by disconnecting it from the scavenge pump and the top of the engine casing extension.

Remove the oil scavenge pipe by disconnecting it from the scavenge pump and the lower side of the engine casing extension.

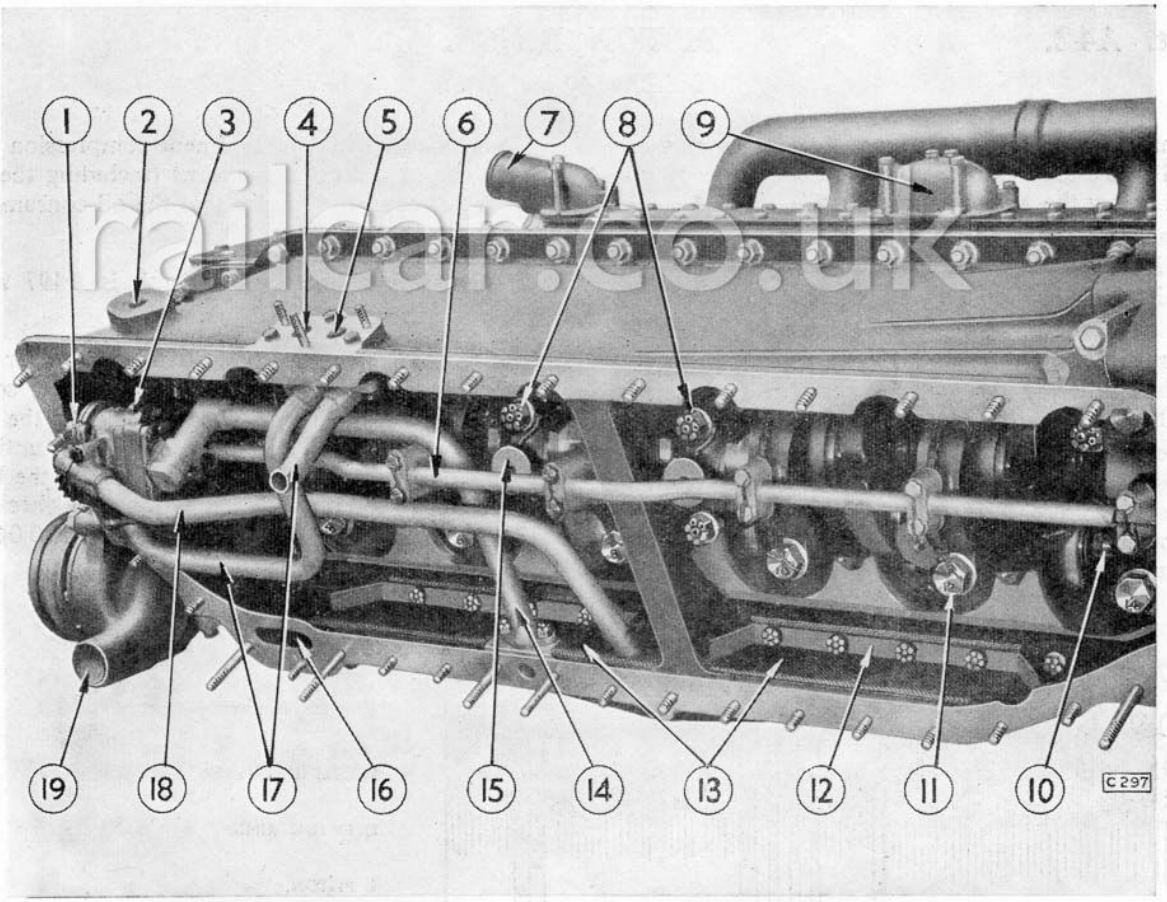
Remove the oil suction pipe by disconnecting it from the pressure pump and the lower side of the engine casing extension.

If the crankshaft is to be removed, remove the oil gallery pipe from the pressure pump and main bearing caps.

Disconnect the oil pressure gauge pipe (if fitted) (*see Fig.* 38).

Retain any shims fitted between the pipe connections and the oil pump body.

Before dismantling the big-end bearings, and to ensure correct assembly, carefully examine the parts and ascertain how everything is numbered, and in what position the big-end nuts are pinned (*see Figs.* 39 *and* 43).



Key to Numbers :—

1. SCAVENGE PUMP.
2. BREATHER.
3. PRESSURE PUMP.
4. OUTLET TO EXTERNAL OIL FILTER.
5. RETURN FROM EXTERNAL OIL FILTER.
6. OIL DELIVERY PIPE TO MAIN BEARINGS.
7. WATER OUTLET PIPE.
8. NOTE RELATIVE POSITIONS OF SPLIT PINS AND MARKINGS.
9. WATER CONNECTION BETWEEN THE TWO CYLINDER HEADS.
10. CAMSHAFT.
11. NOTE POSITION OF NUMBERS RELATIVE TO CORRESPONDING NUMBERS ON SIDES OF BEARING CAPS (CERTAIN ENGINES). NOTE LOCKING WIRE.
12. OIL GRID SUPPORT STRIP.
13. OIL GRIDS.
14. PRESSURE PUMP SUCTION PIPE.
15. CONNECTING ROD CAP.
16. CONNECTION BETWEEN OIL FILLER PIPE AND SUMP.
17. OIL RETURN PIPE FROM SCAVENGE PUMP.
18. OIL SCAVENGE PIPE.
19. WATER INLET PIPE.

Fig. 39. View of interior of engine casing.

Remove the big-end nuts with a box key, remove the caps and place them in sequence on a clean bench.

Push the connecting rods carefully into the cylinder bores until the pistons can be removed from the " top "; care must be taken to ensure that the connecting rods do not score the bore when being withdrawn.

Notes.—

(i) **The pistons cannot be removed through the crankcase.**

(ii) On no account should the connecting rods be marked either with a file or centre punch to denote the cylinder or unit number, as they are already marked and any further markings of any kind are prone to set up local stress concentrations which may result in the failure of the rods.

Sect. A41. GUDGEON PINS.

(*See Fig.* 42).

The gudgeon pins are fully-floating, i.e., free in both the piston and the small end of the connecting rod, and are located endways by circlips sprung into grooves in the pistons. These circlips can be removed with suitable round nosed pliers, and after heating the piston in hot water, the gudgeon pin can be pushed out or refitted by thumb pressure. **On no account must the piston be reamed out.**

Sect. A42. PISTON RINGS.

(*See Figs.* 40 *and* 42).

Three compression rings and one scraper ring are fitted at the top of the piston and one scraper ring is fitted below the gudgeon pin (*see Fig.* 42).

On certain engines all piston rings are of plain cast iron, **on other engines** the top compression ring is chromium plated and all other rings are of plain cast iron (*for gap clearances see Section* A82).

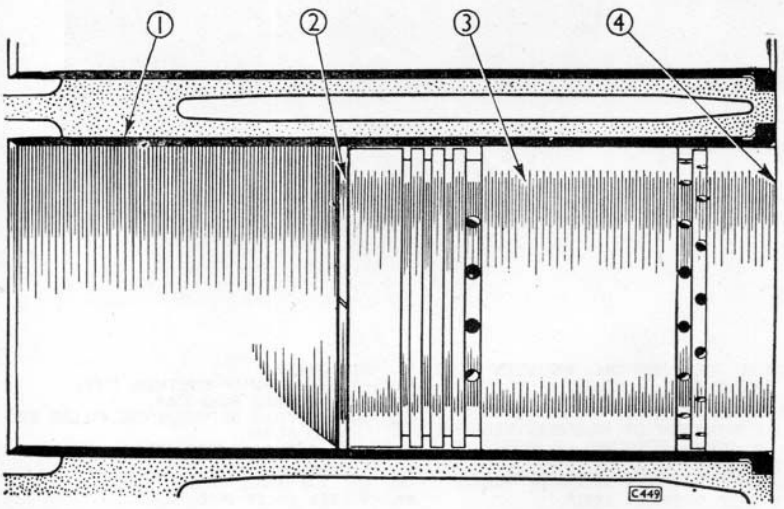
Piston rings which show blackened or discoloured patches either on the working surfaces or the sides, should be renewed.

Clean all carbon from the piston rings and their grooves, then check with feelers for excessive side clearance between each piston and its rings. If the clearance is in excess of 0·018 in. (0·457 mm.), fit new rings.

It is essential that replacement compression rings should be of correct dimensions (including the correct radial depth) to ensure that the oil consumption of the engine is not excessive.

Note.—The correct radial depth is 0·197 in. to 0·205 in. (4·93 mm. to 5·12 mm.).

Place the piston ring in its correct cylinder bore so that it is approximately half way down, square it up by means of a piston inserted into the bore crown first from the " top " of the block, until the piston skirt is flush with the " top " face of the block (*see Fig.* 40). Withdraw the piston and check the piston ring gap, and if this is in excess of 0·040 in. (1·0 mm.), renew the ring.



Key to Numbers :—

1. CYLINDER LINER
2. PISTON RING.
3. PISTON.
4. PISTON SKIRT FLUSH WITH FACE OF CYLINDER BLOCK.

Fig. 40. Method of measuring piston ring gap.

Sect. A43. PISTONS AND CONNECTING RODS—TO FIT.

(*See Figs.* 40, 41, 42 *and* 43).

Refit the parts in the reverse order to their removal (*see Section* A40).

Pistons, connecting rods, caps, bearing shells, big-end bolts, nuts, and the shims (if fitted) are numbered in sequence from the front end, **and must be fitted to the cylinders from which they were removed.**

Bearing shells are numbered 1 to 6 on one side only and **must** be fitted, number to number, on the connecting rods.

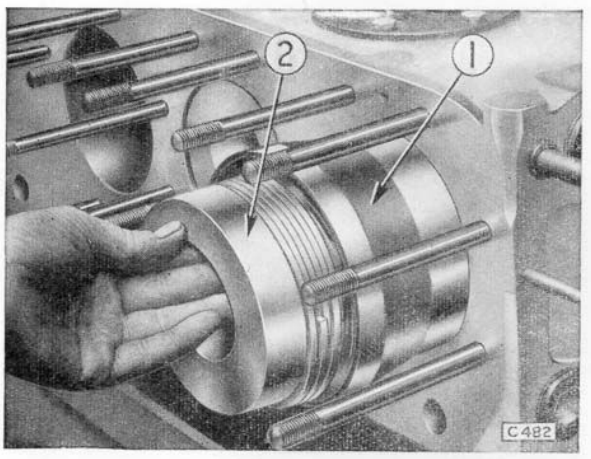
The reverse side of each rod, cap, and shim (if fitted) are marked with the letter " O " and on erection all the " O's " must be on the injector side of the engine. **Under no circumstances must the numbers** 1, 2, 3, etc., appear mated to the letter " O."

When new bearings are necessary, it is important that these should provide the clearance specified in the charts in Section A82. If shims are fitted do not attempt to use shims of a thickness other than those originally fitted to the engine.

When installing new bearings, the crank pins must be examined for signs of scoring, and measured with a micrometer, checking at the same time for the amount of ovality.

If necessary, the crank pins should be reground to fit undersize bearings. Replacement bearings are available in plan and undersizes, details of which appear in the charts in Section A82).

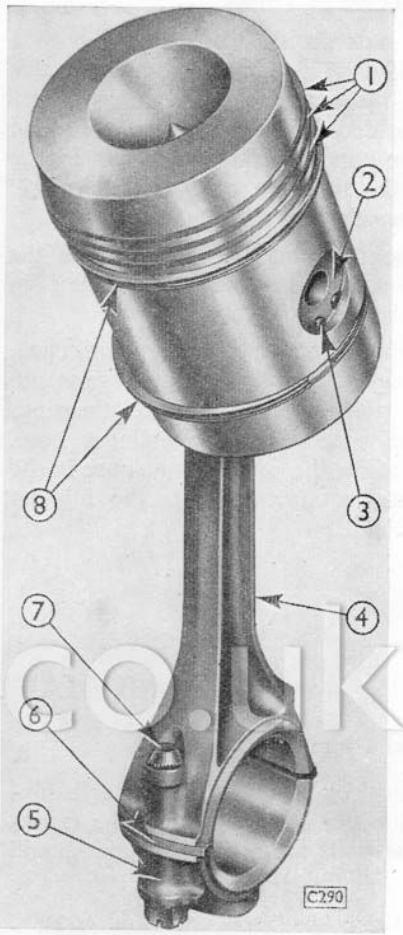
Remove and instal one set of bearings at a time. Crank pins should be free from scores and the clamping surfaces of caps and rods should not be damaged or filed.



Key to Numbers :—

1. PISTON FITTING TOOL. 2. PISTON.

Fig. 41. Method of fitting pistons.



Key to Numbers :—

1. PISTON RINGS.
2. GUDGEON PIN.
3. CIRCLIP.
4. CONNECTING ROD.
5. CONNECTING ROD CAP.
6. SHIM.
7. CONNECTING ROD BOLT.
8. SCRAPER RINGS.

Fig. 42. Piston and connecting rod.

At complete overhaul periods always fit new connecting rod bolts and nuts with their special design of split pin.

Cleanliness in handling bearings is vital to successful running.

Replacement rods complete with bearings should be obtained; alternately, new bearings should be fitted and bored in a diamond type precision boring machine to the limits shown in the charts in Section A82. **No attempt should be made to " let up " a cap by filing either the rod, cap or shim.**

Note.—Replacement rods are not marked to indicate their cylinder number. They should, therefore, be stamped with a punch in a similar manner to the rod to be displaced. **Do not mark or file the rods in any other way.**

Before fitting any connecting rod see that your hands are clean, then wipe the crank pin with clean muslin, and lightly smear with clean engine oil both the crank pin and the surface of the bearing shell; clean and instal one set at a time.

Connecting rod nuts should be tightened with a box key using a 10 in. (254 mm.) tommy bar; this length will secure the requisite degree of tightness of the nuts as provided for in the design. Tighten until the two centre punch marks on the nut appear on either side of the split pin hole. (*For torque spanner loadings, see Section* A84).

In order that the rings may be entered into the bore without difficulty, the guide tool shown in Figure 41 should be used.

The piston and rings should be smeared with clean engine oil, the rings spaced so that the gaps are staggered, and the guide tool fitted round the rings before pushing the piston into the cylinder bore. **When fitting the pistons, the combustion space in the piston crown must be offset towards the injector side of the engine.**

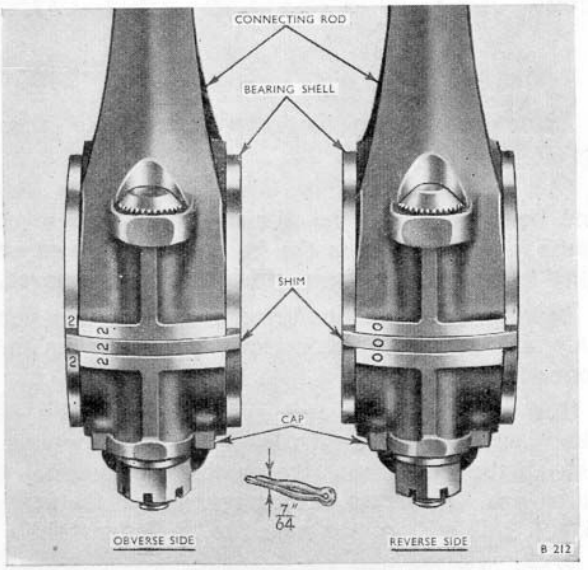


Fig. 43. Connecting rod big-end showing markings and special type split pin for bolts.

Sect. A44. CRANKSHAFT—TO REMOVE.

Remove the fluid coupling.

Detach the flywheel by removing the six split pins and nuts leaving the bolts and dowel in the crankshaft flange. These bolts are a drive fit and should not be removed (*see Fig.* 44).

Remove the cylinder heads (*see Section* A33).

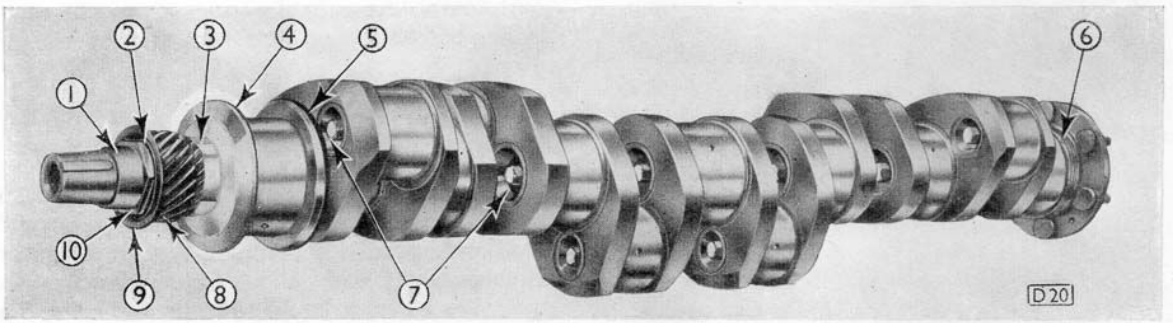
Slacken off the adjustment and remove the fan and water pump drive belts (*see Section* A3).

On certain engines remove also the speed indicator generator drive belt.

Slacken off the adjustment and remove the dynamo or right-angle fan drive belt(s) (*see Section* A3).

Remove the pulley from the end of the crankshaft (*see Section* A49).

Remove the belt tensioner and mounting bracket complete.



Key to Numbers :—

1. OIL SEAL FITS OVER HERE
2. TAB WASHER.
3. DISTANCE PIECE
4. THRUST WASHER.
5. DOWELLED THRUST RING.
6. GROOVES FORMING OIL SEAL.
7. END CAPS.
8. DRIVING GEAR.
9. OIL THROWER (IF FITTED).
10. LOCKNUT.

Fig. 44. Crankshaft assembly.

Remove the water pump (*see Section* A49).

Remove the sump (*see Section* A39).

Unscrew the oil pressure relief valve adjusting spindle until it clears the body of the oil pump (*see Section* A6).

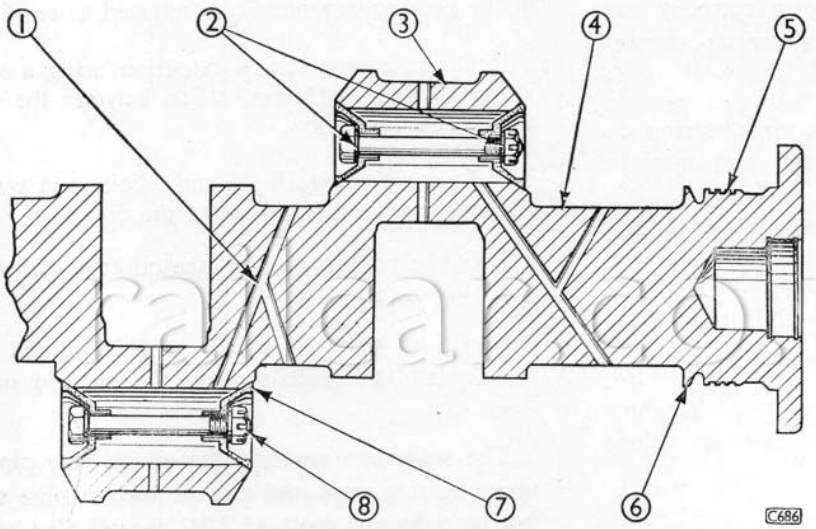
Remove the pistons and connecting rods (*see Section* A40).

Unscrew the securing bolts and remove the oil grid support strips, the oil grids and the copper washers (if fitted) and then the engine casing extension.

Before removing the main bearing caps note the position and numerical sequence of the caps and set-screws to ensure that these can be refitted in their original positions. Remove the oil pump (*see Section* A53), the front main bearing cap complete with the idler gear, and the remaining main bearing caps.

Lift out the crankshaft complete with driving gear and oil seal (*see Fig.* 44).

The crankshaft has hollow pins and drilled journals (*see Fig.* 45), which form oil passages under pressure from the oil pump. When the engine is overhauled the caps covering these passages must be removed and the sludge cleaned out. **This is very important.**



Key to Numbers:—

1. OIL PASSAGE.
2. COPPER WASHER.
3. CRANK PIN.
4. MAIN JOURNAL.
5. GROOVES FOR OIL SEAL.
6. OIL THROWER.
7. END CAP.
8. SPLIT PIN.

Fig. 45. Diagram of crankshaft oil passages.

Sect. A45. CRANKSHAFT—TO FIT.

(*See Figs.* 44 *and* 45).

If the crankshaft driving gear has been removed, assemble the front end of the crankshaft as follows (*see Fig.* 44): —

Push on the thrust ring and locate it on the dowel in the crankshaft.

Fit the key, press on the thrust washer, distance piece and driving gear.

Fit the oil thrower (if fitted), concave side first, followed by the tab washer and the locknut, sleeve outwards.

Tighten the locknut and secure with the tab washer.

Note (i).—On certain engines when no oil thrower is fitted, ensure that the lockwasher is located in the slots provided in the face of the driving gear.

Fit the oil seal to its housing and slide the seal into position over the sleeve of the locknut with its lip facing inwards.

Before fitting the crankshaft, ensure that the flange bolts are in position as they cannot be inserted after the crankshaft has been installed, then prime the hollow pins and journals with clean engine oil and see that the copper washers are fitted beneath the bolt heads and nuts securing the end caps. **These caps must be perfectly oil tight** (*see Fig.* 45).

Fit the crankshaft and its bearings. (*For table of clearances, see Section* A82). Fit the bearing caps making sure that they are fitted to the bearings from which they were removed (the bearings are numbered 1 to 7 from the front end).

Ensure that the set-screws are fitted in their correct positions and tightened down correctly and secured with locking wire. (*For torque spanner loadings, see Section* A84).

Note (ii).—On certain engines the main bearing set-screws are of high tensile material and may be identified either by notches cut in the hexagon or a ring machined on the top of the head (*see Fig.* 46).

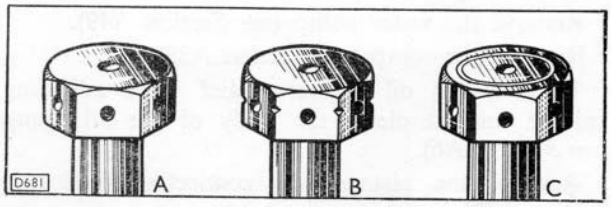
These set-screws should be tightened to a greater torque loading than the plain type shown in Figure 46. (*For torque spanner loadings, see Section* A84).

Main bearing set-screws all requiring the same torque loading should be fitted to any one engine (*see Fig.* 46).

Fit the connecting rods and pistons (*see Section* A43) and check the protrusion of the pistons above the engine casing at T.D.C. The heads of the pistons should be flush with the top face of the engine casing ± 0·005 in. (0·127 mm.), but if the engine casing has been "flashed" a shim of equal thickness to the amount removed by "flashing" must be fitted under each cylinder head gasket. (*For shims available see Section* A83).

Fit the oil pump (*see Section* A53) and check that the correct backlash is obtained between the driving and driven helical gears, and between the teeth of the idler gear and the crankshaft driving gear (*see Section* A82).

Note (iii).—The clearance between the hub of the oil pump drive idler gear and the crankshaft front bearing cap must not exceed 0·045 in. (1·125 mm.) and not less than 0·010 in. (0·25 mm.). If the minimum clearance cannot be maintained, the adjacent face of the bearing cap should be reduced as required.



Key to Letters :—

A. PLAIN SET-SCREW.
B. SET-SCREW WITH IDENTIFICATION NOTCH.
C. SET-SCREW WITH IDENTIFICATION RING.

Fig. 46. Main bearing set-screws showing alternative identification marks, see Note (ii) in Section A45.

Refit the engine casing extension using a sealing joint, 0·006 in. (0·15 mm.) thick, between the engine casing and extension.

Refit and tighten all the nuts, bolts and washers, except those used for securing the oil grids.

Refit the copper washers, the oil grids and the oil grid support strips (if fitted).

Note (iv).—Copper washers should be fitted under the heads of the bolts securing the oil grid support strips.

The set-screws securing the oil delivery pipe, the main bearing caps and the oil suction pipe should not be tightened until AFTER the oil pipe connections have been finally fitted to the oil pump body (*see Fig.* 39).

Shims should be fitted between the oil pump body and the oil pipe connections as necessary to ensure correct alignment of the latter.

When mounting the flywheel ensure that the dowel hole engages with the dowel in the crankshaft flange.

Refit the remaining parts in the reverse order to their removal.

Adjust the fan and water pump drive belts, then adjust the dynamo or right-angle fan drive belt(s) (*see Section* A3).

Time the camshaft in accordance with Section A38 and the fuel-injection pump in accordance with Section A65, and check the oil pressure (*see Section* A6).

Sect. A46. CAMSHAFT—TO REMOVE AND FIT.

(*See Fig.* 1).

To Remove.

Remove the fluid coupling, the flywheel, and the rear mounting bracket.

Remove the valve rocker assembly and push rods (*see Section* A33) and rotate the engine two revolutions to clear the tappets from the camshaft.

Remove the camshaft rear end cover plate.

Remove the bevel gear housing assembly and the speed indicator generator (if fitted) (*see Sections* A29 *and* A55).

Draw the camshaft out in a forward direction.

To Fit.

Reverse the procedure given for removal ensuring that the correct backlash is maintained between the bevel gears (*see Sections* A29 *and* A56).

The camshaft can be assisted into its final position by inserting a suitable tool into the centre hole, situated in the rear end of the camshaft, and slightly lifting while light end pressure is exerted.

Sect. A47. TIMING GEAR IDLER WHEEL —TO REMOVE AND FIT.

The timing gear idler wheel is either of the spring-loaded type or the solid type.

To Remove.

Remove the crankshaft (*see Section* A44).

Disconnect the oil pipe from the air compressor bearing at the idler wheel spindle.

Remove the three set-screws which secure the idler wheel spindle, from the front of the engine casing and withdraw the spindle; retain any shims fitted beneath the flange of the spindle so as to ensure the correct end clearance of the idler wheel when re-fitted (*see Section* A82).

Remove the fuel-injection pump (*see Section* A64).

Remove the bevel gear housing and on certain engines remove also the speed indicator generator (*see Sections* A29 *and* A55) and draw the camshaft forward to clear the idler gear.

Withdraw the idler gear through the engine casing.

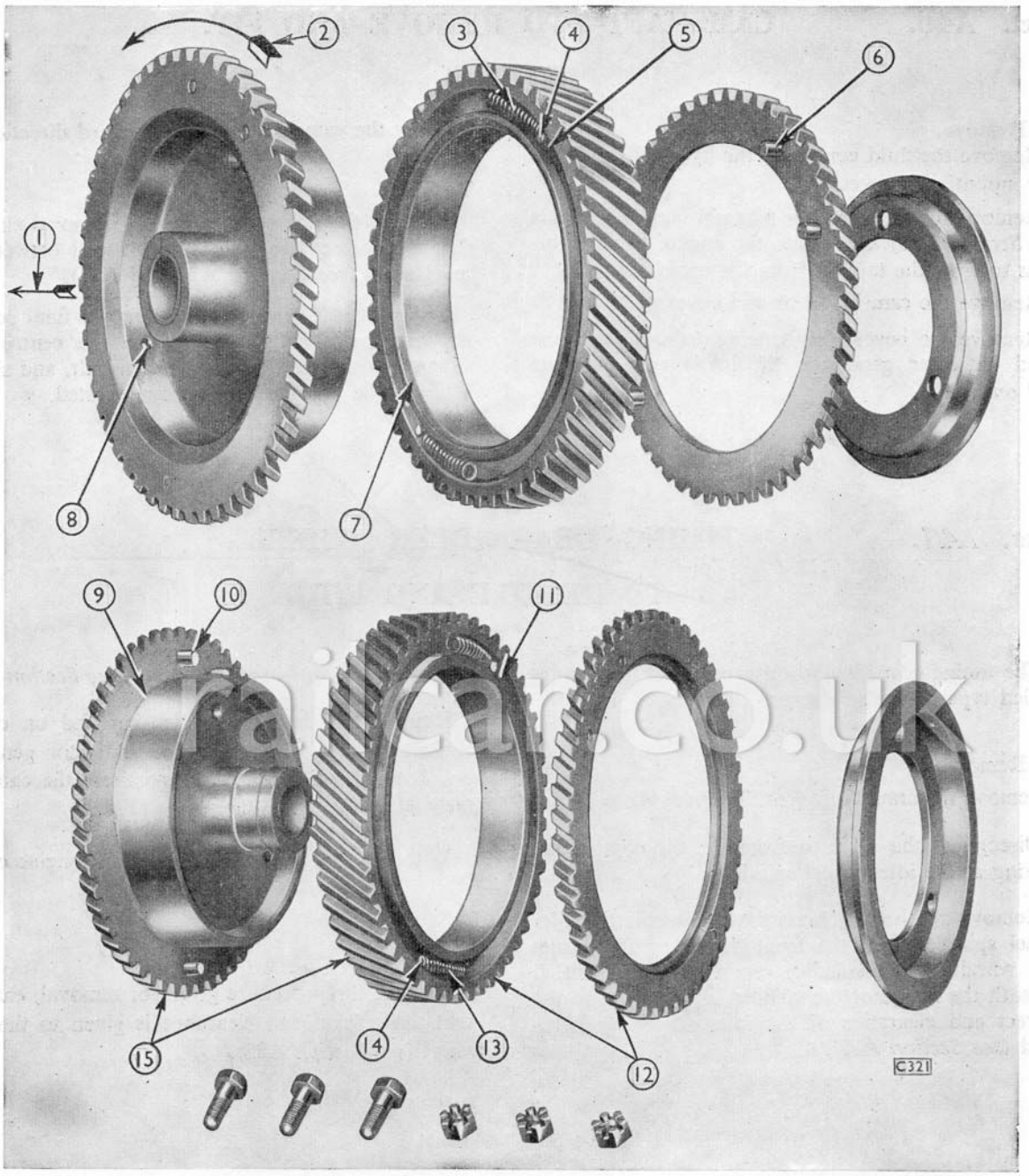
To Fit.

Reverse the procedure given for removal, ensuring that the correct end clearance is given to the idler wheel (*see Section* A82).

Sect. A48. TIMING GEAR IDLER WHEEL (SPRING LOADED TYPE) —TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 47).

Figure 47 clearly shows the construction of this unit; if the parts are assembled in the manner shown no difficulty will be experienced as provision has been made in the design to ensure that assembly cannot be carried out incorrectly.



Key to Numbers :—

1. TO FRONT OF ENGINE.
2. DIRECTION OF ROTATION.
3. SPRING.
4. DOWEL PEG.
5. FIT STOP PEG HERE.
6. STOP PEG.
7. CHAMFER.
8. OIL HOLE.
9. RADIUS.
10. STOP PEG.
11. FIT STOP PEG HERE.
12. MESH WITH CAMSHAFT DRIVEN GEAR.
13. SPRING.
14. DOWEL PEG.
15. MESH WITH CRANKSHAFT DRIVING GEAR.

Fig 47. Exploded views of spring loaded timing gear idler wheel.

Sect. A49. WATER PUMP—TO REMOVE AND FIT.

(*See Fig.* 48).

To Remove.

Drain the engine cooling system (*see Section* A3).

Slacken off the belt adjustment (*see Section* A3) and remove the fan and water pump drive belts.

With pumps secured by set-screws, remove the two bolts securing the locking plate to the crankshaft pulley and remove the locking plate. Unscrew and remove the set bolt in the centre of the pulley securing it to the crankshaft then draw the pulley off the crankshaft with a suitable withdrawal tool and remove the key.

Slacken the clips of the water inlet and outlet hoses, then disconnect the pipes.

Remove the nuts or set-screws and spring washers, then lift off the pump assembly.

To Fit.

Reverse the procedure given above.

Sect. A50. WATER PUMP—TO DISMANTLE.

(*See Figs.* 48 *and* 50).

Unscrew the lubricator and the lock nut and remove the tab washer from the end of the water pump spindle.

Remove the pulley hub, together with the pulley, from the water pump spindle.

Unscrew and remove the set-screws and copper washers and detach the bearing housing.

Unscrew the brass nut from the small end of the spindle and draw off the impeller and gland assembly, taking care not to damage the carbon gland or rubber seal, then remove the key.

Remove the large grease retainer from the bearing housing and then the ball bearing retaining circlip.

Remove the spindle, and the bearing, by tapping it with a lead hammer on its smaller end.

Remove the small grease retainer from the bearing housing if it requires renewing.

Dismantle the gland assembly by removing from the impeller the spring ring, the carbon seating, the rubber seal (with housing and distance ring) and the gland loading spring, in that order.

Key to Numbers :—

1. CARBON SEATING.
2. SPRING RING.
3. GREASE RETAINER.
4. WATER PUMP DRIVE PULLEY.
5. DISTANCE COLLAR.
6. RETAINING CIRCLIP.
7. GREASE RETAINER.
8. TAB WASHER.
9. LOCK NUT.
10. LUBRICATOR.
11. WATER PUMP SPINDLE.
12. BALL BEARINGS.
13. BEARING HOUSING.
14. IMPELLER.
15. RUBBER SEAL.
16. KEY.
17. DISTANCE RING (FITTED ON TO RUBBER SEAL).
18. GLAND LOADING SPRING.
19. HOUSING.

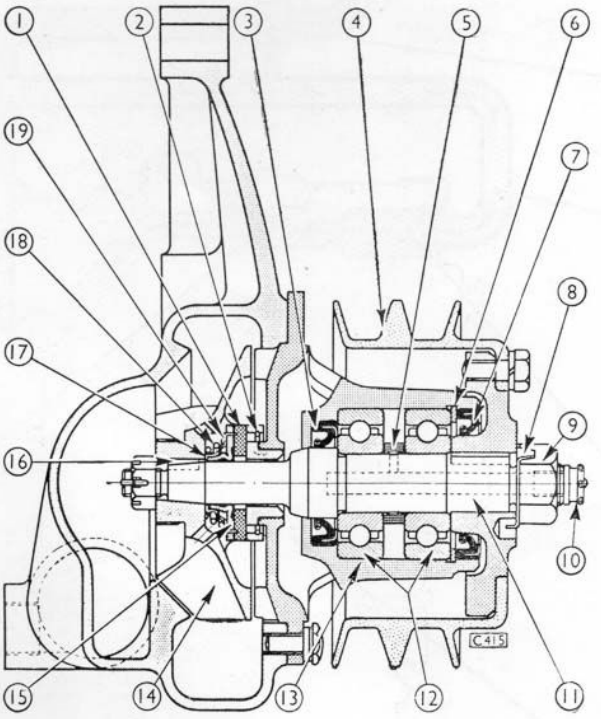


Fig. 48. Section through water pump.

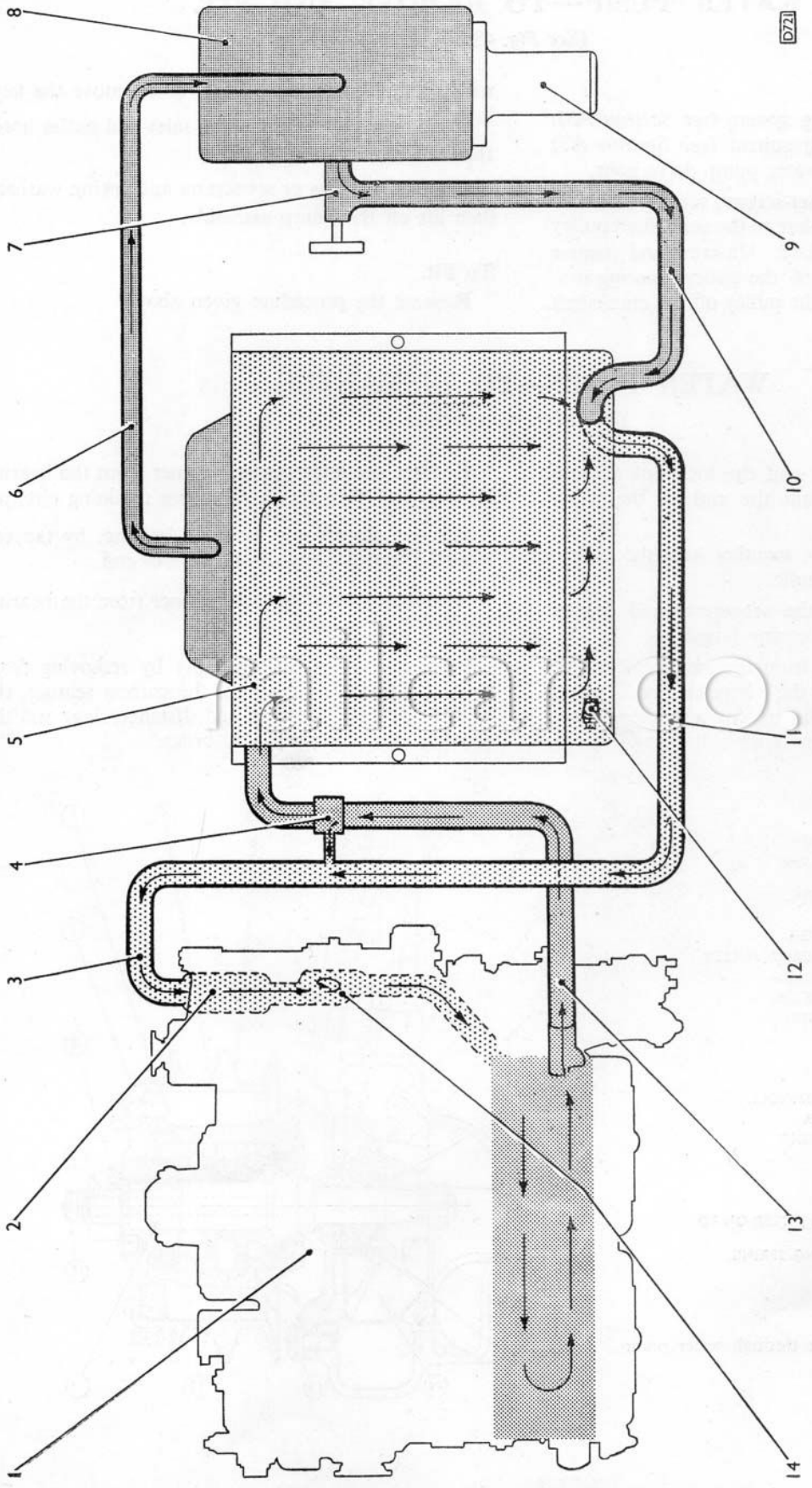


Fig. 49. Diagrammatic view of engine cooling system.

Sect. A51. WATER PUMP—TO ASSEMBLE.

(*See Figs.* 48 *and* 50).

Assemble the parts in the reverse order to their removal noting the following points: —

Pack the bearings with grease.

Check that the grease retainers are in good condition and in place; the small retainer must be fitted in the bearing housing with its lip facing **inwards** and the large retainer must also be fitted into the bearing housing with its lip facing **inwards,** i.e., with the lips of both retainers facing in the same direction.

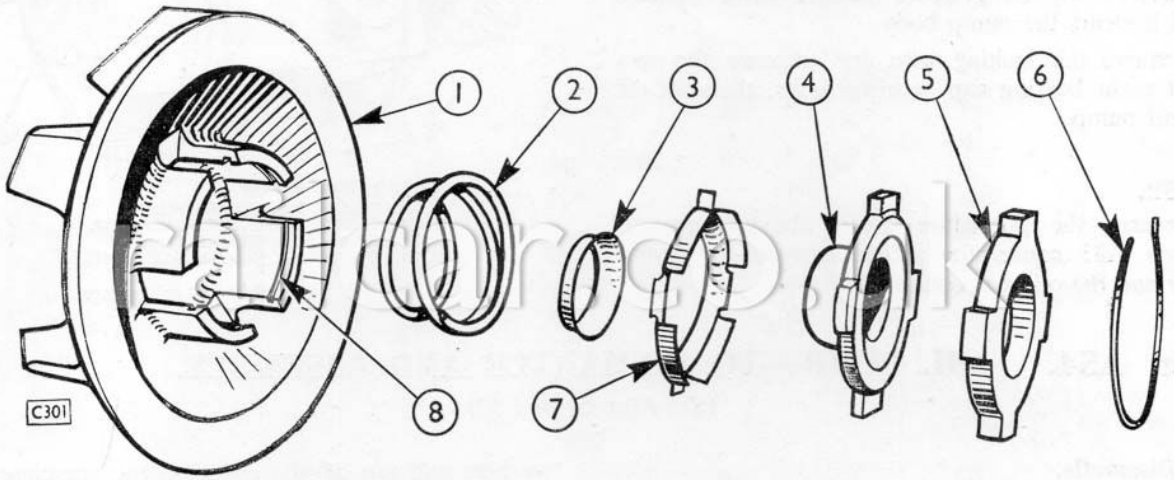
Place the gland loading spring into the impeller, **small end first,** followed by the rubber seal with its housing and distance ring so that the housing abuts the large end of the spring.

Place the carbon seating against the rubber seal, compress it against the gland loading spring and insert the spring ring into its groove.

Check that the face of both the carbon seating and the brass seat in the pump body are not grooved or pitted, then fit the bearing housing to the pump body.

See that the brass nut which secures the impeller on its taper is locked with a **brass** split pin and that the circlip retaining the ball bearings is in position in the body.

Note.—The spindle is a clearance fit in the brass seat in the pump body.



Key to Numbers :—

1. IMPELLER.
2. GLAND LOADING SPRING.
3. DISTANCE RING (FITS ON TO RUBBER SEAL).
4. RUBBER SEAL.
5. CARBON SEATING.
6. SPRING RING.
7. HOUSING.
8. GROOVE FOR SPRING RING.

Fig. 50. Exploded view of water pump gland.

Sect. A52. INTERNAL OIL GRIDS—TO REMOVE, CLEAN AND FIT.

(*See Fig.* 39).

To Remove.

Remove the sump (*see Section* A39).

Remove the oil return pipe by disconnecting it from the scavenge pump and the top of the engine casing extension.

Remove the scavenge pipe by disconnecting it from the scavenge pump and the lower side of the engine casing extension.

Retain all the copper washers.

Unscrew the retaining nuts, remove the bolts and lift off the support strips, the oil grids and the copper washers (if fitted).

To Clean and Fit.

Wash the oil grids thoroughly in clean paraffin and allow them to drain, then refit them by reversing the procedure given above (*see Section* A83 *concerning the fitting of the copper washers*).

Sect. A53. OIL PUMP—TO REMOVE AND FIT.

(*See Fig.* 51).

To Remove.

Remove the sump (*see Section* A39).

Remove the oil return pipe by disconnecting it from the scavenge pump and the top of the engine casing extension.

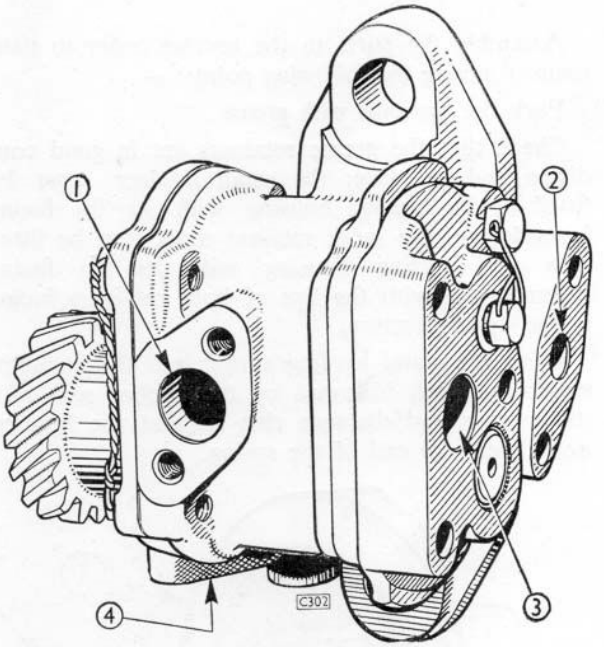
Remove the scavenge pipe by disconnecting it from the scavenge pump and the lower side of the engine casing extension.

Remove the oil suction pipe by disconnecting it from the pressure pump and the lower side of the engine casing extension.

Disconnect from the pressure pump the gallery pipe; retain any shims fitted between the pipe connections and the pump body.

Unscrew the oil pressure release valve spindle until it clears the pump body.

Remove the locking wire and unscrew the two front main bearing cap securing bolts, then lift off the oil pump.



Key to Numbers :—
1. OIL INLET TO SCAVENGE PUMP.
2. OIL OUTLET FROM PRESSURE PUMP.
3. OIL INLET TO PRESSURE PUMP.
4. OIL OUTLET FROM SCAVENGE PUMP.

Fig. 51. Assembly of oil pumps.

To Fit.

Reverse the procedure given above (*refer to Section* A83 *concerning shims between the pump body and the oil pipe connections*).

Sect. A54. OIL PUMP—TO DISMANTLE AND ASSEMBLE.

(*See Figs.* 51 *and* 52).

To Dismantle.

Note.—On certain engines, shims are fitted between the scavenge pump driving gear and the shoulder on the driving spindle, to maintain a clearance between both scavenge and pressure pump driving gears and the central wall of the pump body.

Should it be necessary to remove the scavenge pump driving gear from the spindle, ensure that the shims are retained for refitting when assembling (*for dimensions of shims available see Section* A83).

Remove the nut securing the helical gear to the spindle.

Remove the helical gear from its taper by means of a suitable withdrawal tool.

Remove the key. Remove the set-screws securing the pressure pump cover.

Tap the cover off its dowels.

Remove the driven gear and tap out the driving spindle, together with the driving gear, from the reverse side of the pump body.

Unscrew and remove the four set-screws and washers and tap off the cover on the scavenge side of the pump, together with the driven gear spindle.

Remove the scavenge driven and driving gears from the body.

If the driven gear spindle has to be renewed tap it out of the scavenge pump cover.

Note.—On certain engines all pump circulating gears are the same width. **On other engines** the scavenge pump gears are wider than the pressure pump gears.

To Assemble.

Wash all parts in clean paraffin before assembling and see that all oilways are clear, including the two small holes, for the low pressure oil supply, at the base of the teeth in the driven gears of the pressure pump.

Fit the driven gear spindle into the scavenge pump cover.

Fit the keys and the scavenge pump driving gear to the driving spindle and place it in the body.

Fit the scavenge pump driven gear, the cover and the washers, then tighten the four set-screws.

Tap the pressure pump driving gear on to the keyed spindle and fit the driven gear.

Fit the cover and the short set-screw and the two long set-screws and temporarily tighten down.

Note.—The two long set-screws are fitted temporarily to ensure that the pump runs freely when the cover is tightened down; when the pump is fitted to the engine the long set-screws should be removed one at a time.

Wire together the four set-screws securing the scavenge pump cover and wire the short set-screw to the blanking screw on the end of the oil pump idler gear spindle.

After assembly, the pumps should be capable of being turned smoothly and without effort.

Under no pretext must the peripheral and end clearances of the pump gears be increased (*see Section* A82).

Sect. A55. BEVEL GEAR HOUSING ASSEMBLY —TO REMOVE AND FIT.

(*See Figs.* 3, 5 *and* 53).

To Remove.

Drain the water from the cooling system and remove the water pipe connecting the water pump and the engine casing.

Remove the fuel-injection pump (*see Section* A64).

Remove the crankshaft pulley (*see Section* A49); this is only necessary if the two bevel gear housing set-screws nearest to the fuel-injection pump, are **not** fitted.

Remove the lubrication pipe from the bevel gear housing and the bottom of the engine casing.

On certain engines it will be necessary to remove the speed indicator generator from the bevel gear housing; retain any shims fitted (*see Section* A29).

A suitable container should be placed under the bevel gear housing to collect the oil when the housing is removed.

Unscrew the nuts or set-screws securing the bevel gear housing to the engine casing and remove the housing together with the shims and joints.

To Fit.

Reverse the procedure given above ensuring that the correct shims are fitted to give the required backlash.

(*For the correct backlash between the bevel gears* (*see Section* A82).

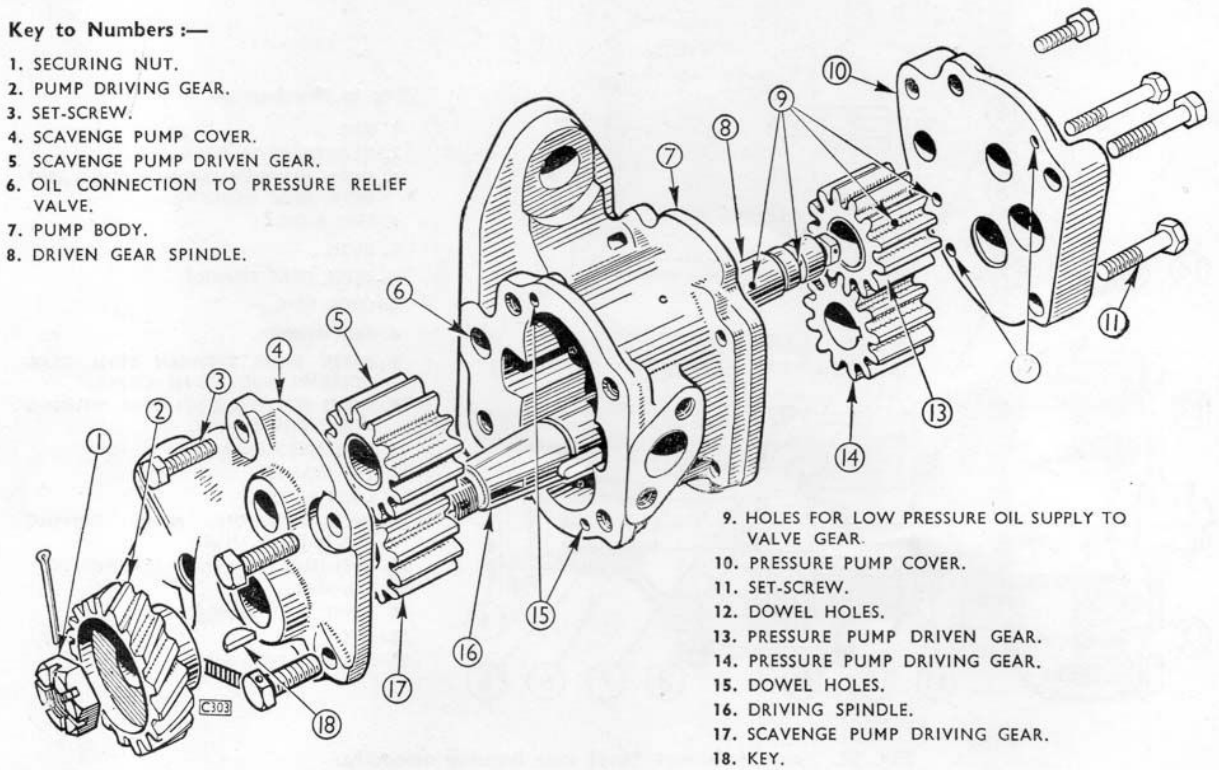


Fig. 52. Exploded view of pressure and scavenge oil pumps.

Sect. A56. BEVEL GEAR HOUSING ASSEMBLY —TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 53).

To Dismantle.

Remove the plug at the end of the main spindle.

Unscrew the nut securing the coupling flange to the bevel gear spindle and remove the tab washer, coupling flange and distance collar.

Unscrew the locknut securing the bevel wheel to the spindle and tap out the spindle through the spindle bush.

Remove the lock nut, tab washer and bevel gear from the inside of the bevel gear housing.

Unscrew and remove the four nuts and washers securing the spindle bush, then remove the bush, shims and joints.

Remove the oil seal from its housing if it needs renewing.

To Assemble.

If a new oil seal is to be fitted see that its lip faces **inwards.**

Refit the spindle bush into the bevel gear housing together with any shims which were removed.

Place the driven gear in the bevel gear housing, refit the spindle through the housing and driven gear (long end first) and lock the bevel gear to it with the tab washer and lock nut. Do not bend the tab washer over at this stage.

Fit the distance collar and coupling flange to the spindle and lock them to it by means of the tab washer and lock nut. Do not bend this tab washer over at this stage.

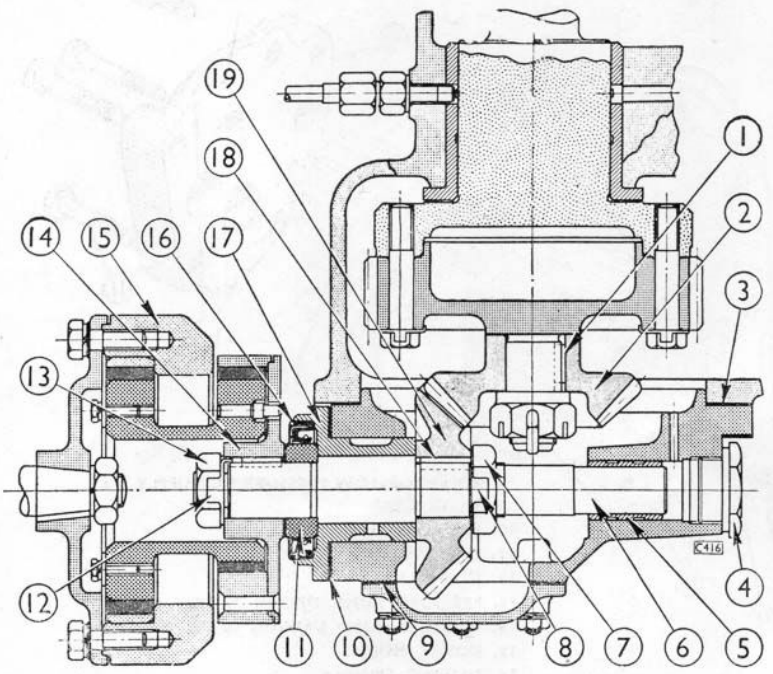
Lightly coat a few widely spaced teeth on the driving gear with marking blue.

Fit the housing to the engine casing, fitting any shims that were removed.

Rotate the coupling flange a number of times in both directions by turning the engine flywheel.

Check the gears for the correct mesh and correct amount of backlash.

If the mesh requires adjustment, then vary the thickness of the shims between the bevel gear housing and the spindle bush. (*For the thickness of shims available see Section* A83).



Key to Numbers :—

1. KEY.
2. DRIVING BEVEL GEAR.
3. SHIMS BETWEEN ENGINE CASING AND BEVEL GEAR HOUSING.
4. END PLUG.
5. BUSH.
6. BEVEL GEAR SPINDLE.
7. LOCK NUT.
8. TAB WASHER.
9. PAPER JOINT BETWEEN BEVEL GEAR HOUSING AND FRONT COVER.
10. SHIMS BETWEEN BEVEL GEAR HOUSING AND SPINDLE BUSH.
11. DISTANCE COLLAR.
12. TAB WASHER.
13. LOCK NUT.
14. FUEL - INJECTION PUMP DRIVING COUPLING FLANGE.
15. FUEL-INJECTION PUMP FLYWHEEL.
16. OIL SEAL.
17. BEVEL GEAR SPINDLE BUSH.
18. KEY.
19. DRIVEN BEVEL GEAR.

Fig. 53. Section through bevel gear housing assembly.

To obtain the correct amount of backlash between the gears, remove the front cover from the bevel gear housing and attach to the housing a suitable clock gauge with its plunger touching the face of one tooth on the driven gear.

Rotate the coupling flange by hand in alternate directions and observe the reading on the gauge ; the amount of backlash indicated should be from 0·002 in. (0·051 mm.) to 0·003 in. (0·076 mm.) (*see Section* A82).

If incorrect alter the thickness of shims between the engine casing and bevel gear housing. (*For the thickness of shims available see Section* A83).

Having obtained the correct fitting between the gears bend over the two tab washers and fit the end plug and front cover to the bevel gear housing.

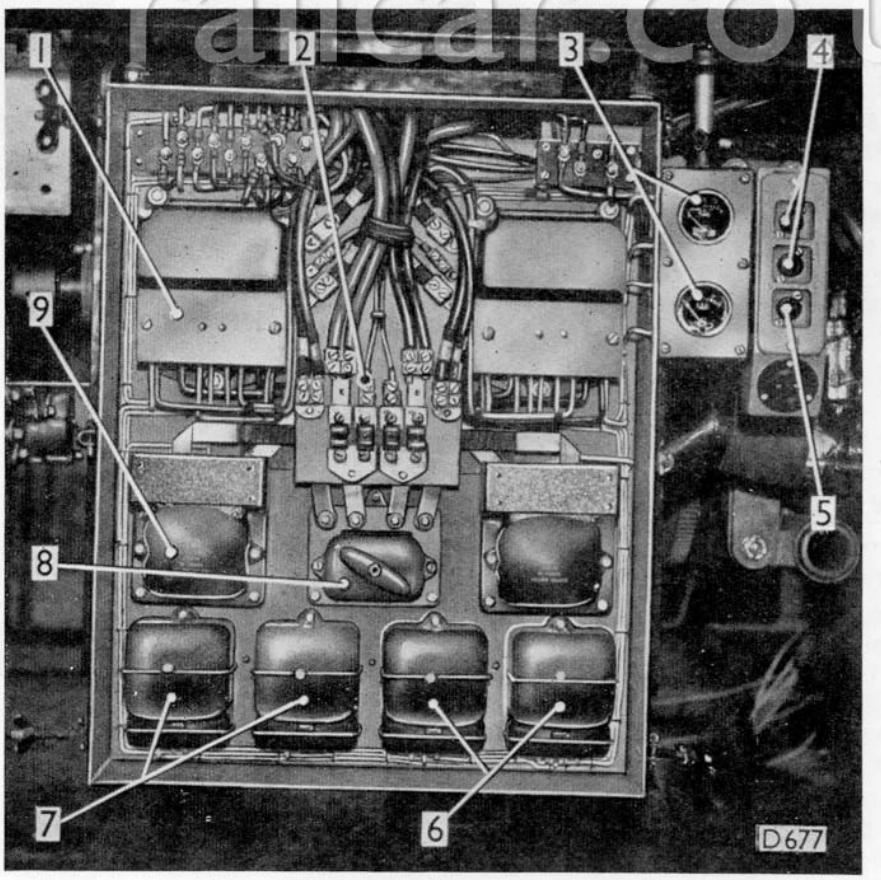
On engines fitted with a gear driven speed indicator generator, fit the generator to the bevel gear housing together with the shims (*see Section* A29).

Sect. A57. ENGINES—TO ADJUST FOR IDLING AND MAXIMUM SPEEDS.

(*See Figs.* 54, 55, 56, 57 *and* 58.)

When a new or overhauled engine is fitted to a car it is essential to adjust the idling and maximum speeds. No adjustment is provided at the throttle motor; all adjustments should therefore be carried out by means of the throttle control rod on the fuel-injection pump and/or the adjustable pillar at the swing lever bracket. To **increase** the travel of the throttle control rod, the adjustable pillar should be lowered and to **decrease** the travel it should be raised. By this means the travel of the throttle motor is arranged to match the travel of the pump control lever. Proceed as follows: —

Close the isolating switch in the electrical control box which is adjacent to Number 1 engine (*see Fig.* 54).



Key to Numbers :—

1. CONTROL UNIT (TWO).
2. BATTERY CHARGING AND SUPPLY FUSES.
3. DYNAMO AMMETERS.
4. ENGINE AUXILIARY STARTER BUTTONS.
5. ENGINE AUXILIARY STOP BUTTON.
6. STARTER RELAYS.
7. STARTER ISOLATING RELAYS.
8. BATTERY ISOLATING SWITCH.
9. STARTER ISOLATING SWITCH (TWO).

Fig. 54. Electrical control box.

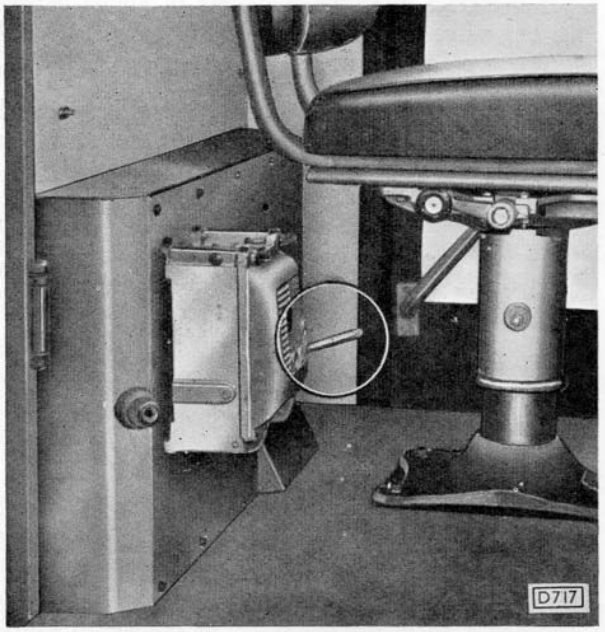


Fig. 55. Train switch—key removable when in the " OFF " position only.

Close the train switch situated in the driver's cab (*see Fig.* 55).

Working from the outside of the car, move the throttle control hand lever, on the appropriate engine, to full throttle and start the engine by means of the starter button adjacent to the engine (*see Fig.* 54).

Hold the throttle hand lever at approximately $\frac{1}{4}$ throttle **(do not race the engine)** until a pressure of 45 to 50 lb. per sq. in. (3·163 to 3·515 Kg. per sq. cm.) is recorded on the pressure gauge in the driver's cab, thus allowing the engine to idle under control of the throttle motor.

Stop the engine by means of the adjacent button (*see Fig.* 54).

Note.—The engine cannot be stopped by means of the stop button in the driver's cab until " Forward " or " Reverse " speed is engaged.

Select " Forward " or " Reverse " speed by means of the selector lever on the control table (*see Fig.* 58).

To ensure the final drive is engaged, " inch " the engine over by pressing the stop button on the control panel in the driver's cab (*see Fig.* 56) at the same time pressing the starter button for the appropriate engine; hold both buttons for two or three seconds, then release the starter button followed by the stop button.

Start the engine from inside the driver's cab and run it until fairly hot; ensure that the maximum pressure of 85 lb. per sq. in. (5·976 Kg. per sq. cm.) is recorded on the air pressure gauge, then adjust for idling speed as follows: —

Slacken the idling damper stop right back, then obtain idling speed by adjusting the length of the throttle control rod. Test as follows:—

See that the hand brake is firmly applied.

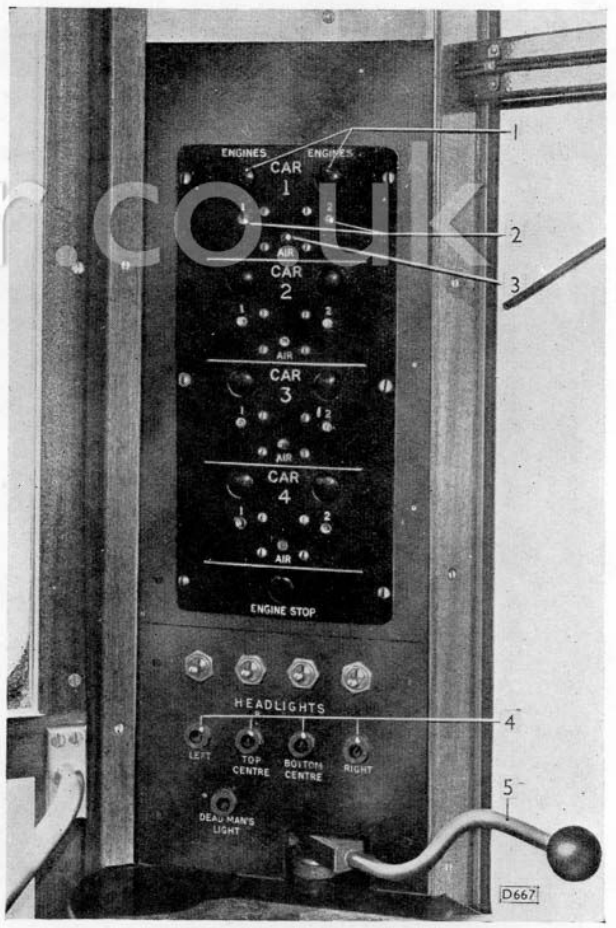
Select first gear by means of the selector lever, the engine should not " stall "; should it do so, select " neutral " and restart the engine.

Increase the idling speed by further adjustments to the control rod and repeat the above test.

Select " neutral " and check that the engine will stop; if necessary, adjustment should be made at the adjustable pillar.

Stop the engine.

With the engine stationary adjust for maximum speed as follows:—



Key to Numbers :—

1. ENGINE STARTING BUTTONS.
2. OIL PRESSURE INDICATOR LIGHTS.
3. AIR PRESSURE INDICATOR LIGHT.
4. HEADLIGHT INDICATOR LIGHTS.
5. COMBINED THROTTLE LEVER AND DEADMAN'S HANDLE.

Fig. 56. Driver's control panel.

With an assistant in the driver's cab holding the throttle control lever in the fully open position, check that the injection pump control rod lever is at full travel; in this position it should be **just** possible to pass a 0·004 in. to 0·005 in. (0·102 to 0·127 mm.) feeler gauge between the lever and the stop: if necessary, adjust the pillar until the desired result is obtained.

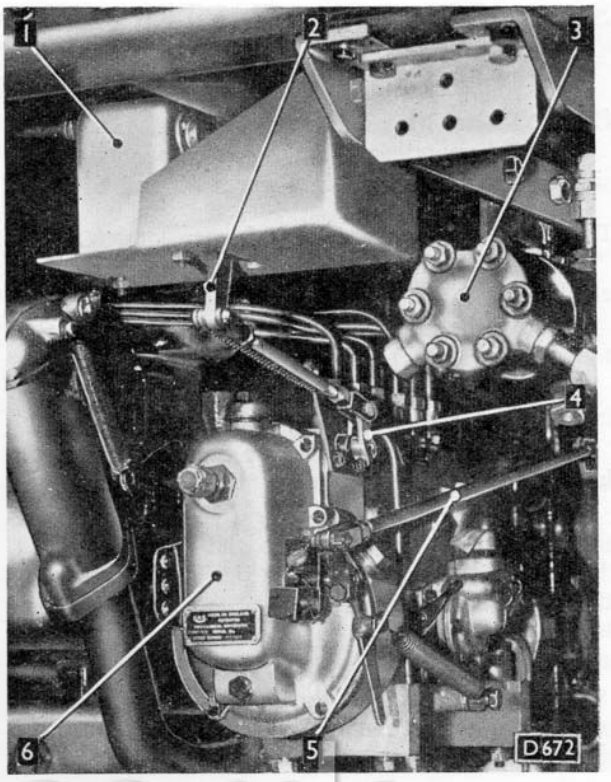
Release the throttle control lever in the driver's cab.

Start the engine and allow it to idle, then screw in the damper stop to slightly increase the speed. If this results in too fast an idling speed, slacken back the damper stop until the optimum idling speed is obtained.

Again hold the throttle control lever in the driver's cab, in the fully open position and check the engine speed indicator to see if the engine registers maximum r.p.m., after which it is advisable to again make a check at the injection pump.

Re-check if the engine will stop and if necessary adjust the adjustable pillar and at the same time check the idling and maximum speeds to ensure that the adjustment has not been altered.

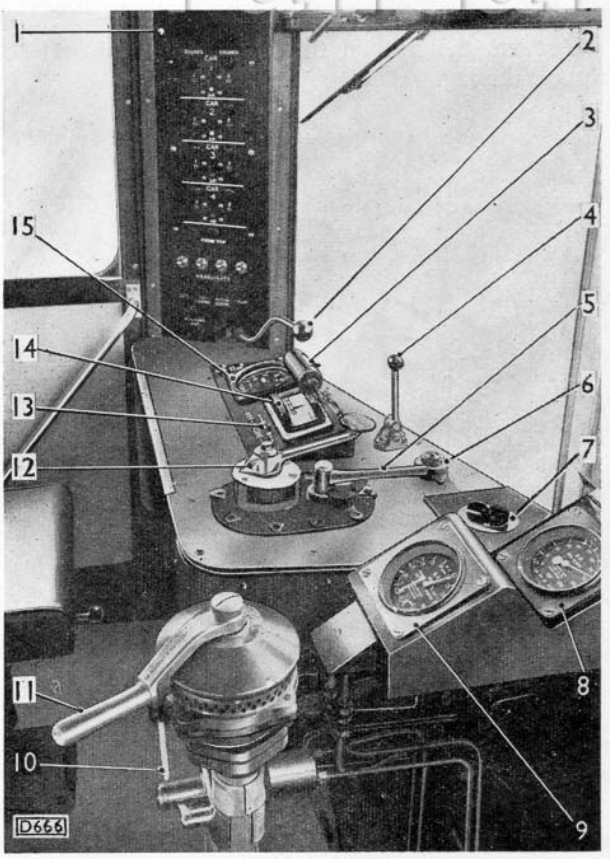
Note.—After effecting an adjustment of the pillar it will usually be found necessary to re-adjust the conrol rod.



Key to Numbers :—

1. ENGINE SHUT DOWN SOLENOID.
2. SOLENOID TRIP LEVER.
3. THROTTLE CONTROL MOTOR.
4. STOP LEVER.
5. THROTTLE CONTROL ROD.
6. FUEL-INJECTION PUMP.

Fig. 57. Fuel-injection pump controls.



Key to Numbers :—

1. CONTROL PANEL.
2. COMBINED THROTTLE LEVER AND DEADMAN'S HANDLE.
3. CONTROL TABLE LIGHT.
4. HORN SWITCH.
5. FORWARD AND REVERSE LEVER.
6. WINDSCREEN WIPER VALVE.
7. HEADLIGHT DIMMER SWITCH.
8. AIR PRESSURE GAUGE.
9. DUPLEX VACUUM GAUGE.
10. WINDSCREEN WASHER LEVER.
11. HANDBRAKE LEVER.
12. CHANGE-SPEED SELECTOR LEVER.
13. ENGINE SPEED INDICATOR SWITCH.
14. ENGINE SPEED INDICATOR.
15. SPEEDOMETER.

Fig. 58. Driver's control table.

Sect. A58. STARTER MOTOR—TO DISMANTLE.

(*See Figs.* 14, 15, 60, 61, 62, 63 *and* 64).

C.A.V. Starter Motor (*see Figs.* 14 *and* 62).

Before dismantling it is advisable to obtain tools similar to those shown in Figures 60 and 61.

To remove the commutator end frame complete.

Remove the nuts, and take off the commutator end cover.

Remove the nut on the armature plunger, using a tool similar to that shown in Figure 61.

Lift the brushes in their holders and retain them in the lifted position by the brush springs.

Note.—Brushes must not be removed from the holders except for renewal or " bedding " purposes.

Remove the screws securing the main and auxiliary field coil connections to the solenoid switch. These screws are numbered (5), (6), (8) and (25); the other screw is on the side of the solenoid switch lower fixed contact opposite to (5) and is not visible in Figure 14.

Remove the commutator end frame fixing screws and withdraw the commutator end frame and brush gear complete.

To remove the solenoid switch from the commutator end frame.

Dismantle in accordance with the instructions given " To remove the commutator end frame complete," paragraphs 1 and 4.

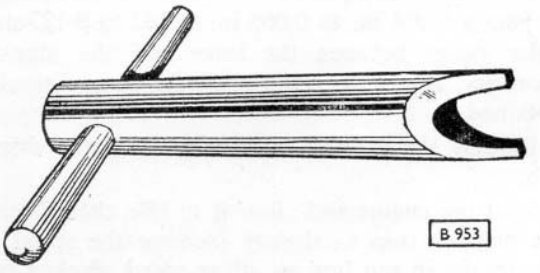


Fig. 60. Tool for starter motor armature spring nut.

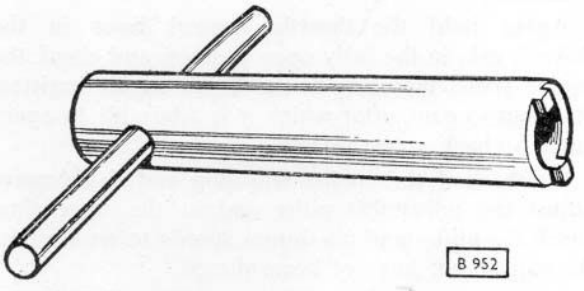


Fig. 61. Tool for starter armature plunger nut.

Remove the screws securing the (+) terminal connector.

Remove the nut on the (SOL) terminal and so release the tag.

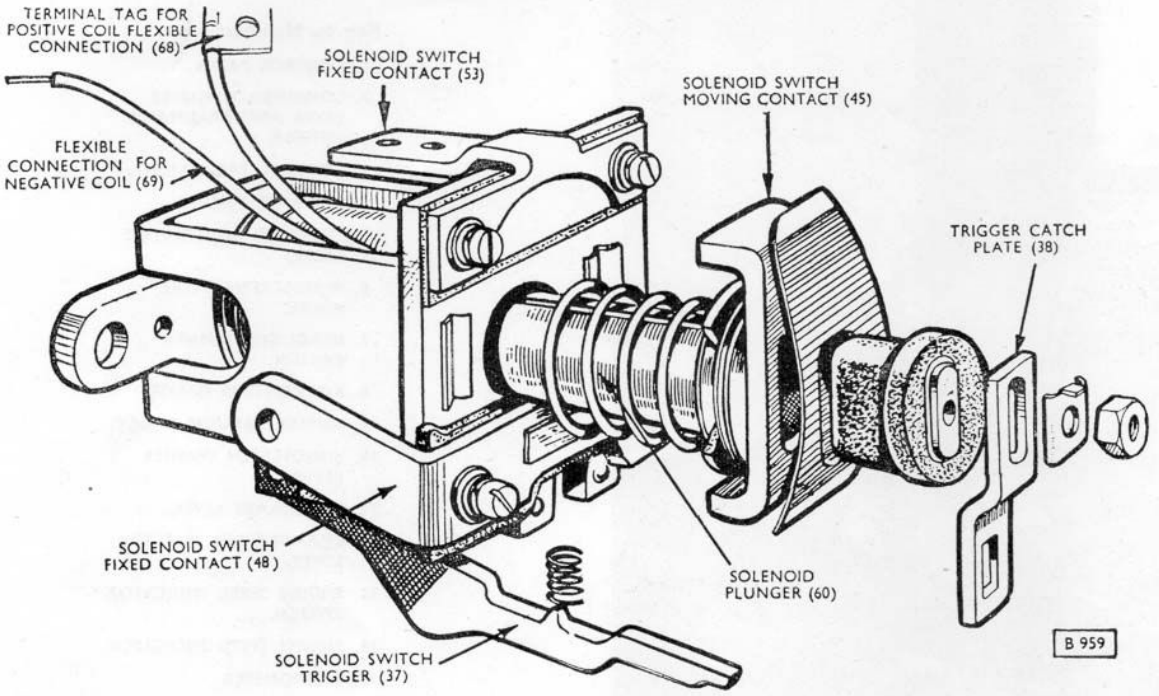


Fig. 62. Exploded view of starter motor solenoid switch (C.A.V.).

If the switch is to be removed for cleaning: —

Remove the main (–) terminal nuts and the screw securing the (–) connector to its brush holder.

Take off the solenoid fixing screws and remove the switch and (–) connector together, taking care not to break the flexible connection.

If the switch is to be completely renewed: —

Unsolder the flexible connection from the (–) connector.

Take off the switch fixing screws and remove the complete switch.

To remove the driving end frame and armature.

The driving end frame and the armature can be removed without taking off the commutator end frame, by first dismantling according to the instructions given " To remove the commutator end frame complete," paragraphs 1, 2 and 3.

Remove the driving end frame screws, tap the end frame away from the carcass with a hide or wooden mallet, and gently slide out the armature and end frame complete.

The bearing bush inside the armature plunger spring cavity, at the commutator end, should be renewed if this allows the entry of a plug gauge 0·849 in. (21·57 mm.) maximum diameter. As a special tool is required for fitting this bearing, the complete armature must be renewed if the bearing is worn.

To withdraw the armature spring and plunger unscrew the retaining nut using tools similar to those shown in Figures 60 and 61 and take out the plunger.

To change the pinion.

To change the pinion without dismantling the starter motor (*see Figs.* 14 *and* 63) **is only possible if these instructions are followed with the greatest care :—**

Remove the split pin and slotted nut from the shaft.

Stand the starter motor on end, pinion uppermost. Slacken the thin shaft nut, keep the pinion held down firmly against its spring pressure, and take off the nut and distance washers (not shown in Figure 14); remove the plug and spring.

Whilst still maintaining resistance against the spring, turn the pinion slowly in the **opposite direction** to the normal starter motor driving rotation, as indicated on the nameplate fixed to the driving end frame barrel, and gradually release the pressure while turning until the pinion is unscrewed from the clutch and is removable from the end frame. **It is essential that this operation is done slowly and carefully to avoid disturbing the clutch plates.**

See that the new pinion has the same part number as the old one; this will be found on the front face of the pinion.

Carefully insert the new pinion into the end frame until it meets with resistance, then turn it slowly in the normal driving direction of the starter motor rotation, until a forward movement is felt indicating that the pinion has engaged with the clutch plates.

Push the pinion into the end frame to its full extent against the spring pressure. Hold it in position and screw on the thin shaft nut with its shim and washer (bronze pinion) or hardened washer (steel pinion); tighten the nut securely. Screw on the slotted nut, tighten it and insert a split pin; then refit the spring and plug.

Simms Starter Motor (*see Figs.* 15 *and* 64).

To remove the pinion and driving end frame.

Push the plug inwards for about $\frac{1}{8}$ in. (3 mm.), push out the cross dumbell, then remove the plug, spring and cross key locking plug and drive out the cross key by means of a drift inserted through the hole in the pinion.

On certain starters the pinion was retained by various methods so proceed as follows: —

Fig. 63. Method of changing starter motor driving pinion without dismantling unit.

If a cap nut is fitted on the end of the armature shaft: —Remove the nut and withdraw the pinion return spring, move the pinion forward ½ in. (13 mm.) to ensure that the push rod no longer locates the cross key and drive out the key by means of a flat punch inserted at the back of the pinion through the slot in the splined shaft.

If the armature shaft centre is closed with a screwed plug the key may be driven out.

If a circlip is fitted at the end of the armature shaft: —Remove the circlip, plug, spring and tenon plug and then tap out the cross key.

Slide the pinion off the shaft.

Unscrew the two nuts on the tie rods and remove the nose.

If the nose bearing has seized to the pinion shaft when the end frame is removed, the shaft will come away with it and may be tapped out. Any high spots in the bearing should be eased until the shaft is a very easy " slide " fit. If the bearing is worn it should be renewed.

To remove the pinion shaft and spring release clutch.

Dismantle according to instructions given above.

Slide the pinion shaft and the clutch from the main armature shaft. This will expose the driving keys (*see Fig.* 15). Care should be taken to see that these keys are retained.

Tilt the entire machine with the commutator end downwards and the push rod parts will be freed.

Separate the driving sleeve and splined shaft from the clutch spring by twisting the parts in the direction of normal rotation.

Certain starters were fitted with a clutch drum which should be removed in a similar manner.

After dismantling the parts should be thoroughly cleaned, and the spring packed with **graphite grease.**

To remove the solenoid switch and auxiliary coils.

Unscrew the two retaining nuts and remove the plunger cover and the commutator end cover.

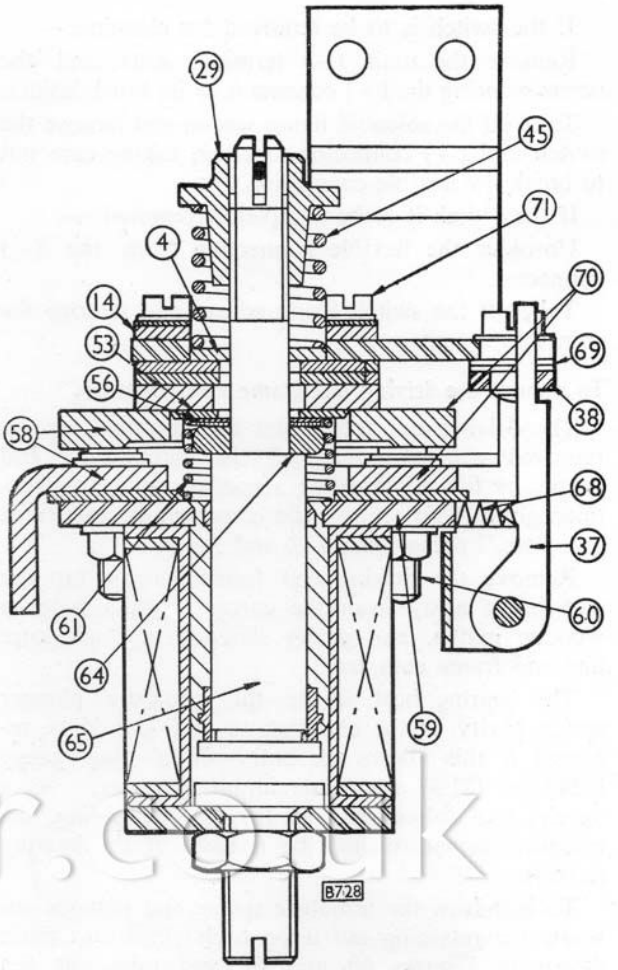
Release all connections to the switch, which are as follows: —

Two flexible switch coil leads; heavy strip connection on top contact; heavy strip connection to bottom contact; flexible connection to moving contact.

Remove the solenoid switch fixing nut and screw (if fitted).

Lift the trigger, see Figure 64, at the same time withdrawing the switch from the machine.

Remove the switch trigger operating rod.



Key to Numbers :—

4. WASHER.
14. FIBRE WASHER.
29. ADJUSTING NUT.
37. TRIGGER.
38. TRIGGER CATCH PLATE.
45. SPRING.
53. MOVING CONTACT ASSEMBLY.
56. WASHERS.
58. FIRST CONTACTS.
59. FIXED CONTACT FRAME.
60. FIXED CONTACT SECURING SCREWS
61. SPRING.
64. COLLAR.
65. PLUNGER.
68. TRIGGER SPRING.
69. CATCH PLATE WASHERS.
70. SECOND CONTACTS.
71. CATCH PLATE SECURING SCREWS.

Fig. 64. Starter motor solenoid switch (Simms).

Remove the solenoid end plate by unscrewing the retaining screws.

Remove the light solenoid coil and the heavy series coil.

If any of the contacts are dirty they should be cleaned with petrol or very fine carborundum paper

(not emery cloth); as little metal as possible should be removed and if the contacts are badly pitted, a replacement set should be fitted.

To remove the armature and commutator end frame.

Dismantle according to directions given above.

Remove the solenoid frame by unscrewing the three fixing screws.

Lift all the brushes off the commutator and retain them in their lifted positions by means of the brush springs.

Note.—Brushes should not be removed from their holders except for renewal or " bedding " purposes.

Slacken the grub screw in the commutator end shaft nut and remove the nut.

The armature can now be removed from the driving end, if necessary driving with a soft mallet, so making the commutator end bearing accessible for cleaning, lubrication or renewal.

The commutator end plate and brush gear assembly may be removed after unscrewing the four screws holding the field coil connections. Care should be taken not to bend or strain the field coil leads.

For instructions on further dismantling, apply to the manufacturers of the starter motors.

Sect. A59. STARTER MOTOR—TO ASSEMBLE.

(*See Figs.* 14, 15, 62 *and* 64).

C.A.V. Starter Motors (*see Fig.* 14).

Assembly is mainly a reversal of the instructions set out in Section A58.

The following points should, however, receive special consideration:—

Make sure the clutch has been assembled correctly.

Insert the armature into the carcass and locate it carefully on its bearing at the commutator end.

Tighten all screws holding both driving and commutator end frames.

Make sure that the flexible leads from the field coils are carried to their correct connection points.

Fill the lubricator on the driving end frame with engine oil.

Fill the interior of the pinion with grease.

Fill the plunger spring cavity inside the armature with grease.

Simms Starter Motor (*see Fig.* 15).

Assembly is mainly a reversal of the instructions set out in Section A58.

Before assembling see that the self lubricating bushes are soaked in engine oil.

Mount the commutator end frame assembly on to the carcass and refit the main field connections by means of their screws.

Ascertain that all the brushes are lifted and wedged in their respective holders by means of the brush springs. Then slide the armature into the carcass. Refit and tighten the commutator end shaft nut, and lock it by means of the grub screw. Then release the brushes.

Re-assemble the spring release clutch and three self lubricating bushes, then push the clutch assembly on to the armature. Take care to avoid damage to the keys when fitting the clutch.

Refit the driving end frame assembly, (if a felt washer is fitted lubricate it thoroughly with engine oil before re-fitting and ease it on to the splined shaft as the nose slides on), and bolt in position, (on certain starters take care to ensure that the turned up end of the clutch brake spring surrounding the outside of the clutch drum is located in the slot provided); then check the armature for end play by pulling and pushing on the splined shaft. **The end play must be between 0·004 and 0·008 in. (0·10 and 0·20 mm.).** Carry out any necessary adjustments by changing the steel thrust washer which is fitted inside the nose against the flange of the nose bearing.

If a tapped hole is provided, the starter motor should be pressure lubricated with grease, after assembly (*see Fig.* 15).

The push rod, shock spring, and push rod and thrust bearing must then be pushed into the hollow armature shaft from the commutator end, in the order mentioned. On some starters the shock spring has a short rod fitted inside it; **where this is so, the rod must be refitted.**

Refit the solenoid frame and insert the switch trigger operating rod.

Refit the two stage solenoid switch, making sure that the trigger, (*see Fig.* 64) is correctly engaged with the switch trigger operating rod; fit holding on and engagement windings, and the solenoid end plate with its screws.

Remake all connections to switch, terminals, coils and connectors exactly as removed.

Refit the pinion and return spring parts in the reverse order to their removal.

Note.—If the cross key has two slots, the wider slot should be to the front of the splined shaft.

C.A.V. and Simms Starter Motors.

Commutators.

To clean. The commutator surface should be clean and free from black discoloration; a dark chocolate colour is, however, quite normal. The surface may be cleaned with a rag dipped in petrol, or, if necessary, with very fine glass or carborundum paper, **not emery cloth.**

To skim. If the commutator surface is pitted, the armature should be set up in a lathe and the commutator skimmed. To ensure that the commutator surface remains concentric with the shaft during this operation it is advisable to support the armature in the lathe in ball bearings rather than between centres.

Only a light cut should be taken and, where possible, a diamond tool used to provide the necessary high quality finish. Alternatively, the tool must be sufficiently keen to leave a smooth surface, after which the commutator should be polished with a strip of very fine carborundum paper.

To undercut. After turning, the commutator must be undercut, i.e. the mica insulation between the commutator bars must be removed to a depth of $\frac{1}{32}$in. (1 mm.) below the surface of the copper, care being taken to ensure that the full width of mica is removed and that nothing is left to project above the copper. A suitable tool for this operation usually takes the form of a short saw blade with handle and a heavy reinforced back to the blade in order to assist steadiness in use. If this tool is not available an old hacksaw blade, ground to the width of the mica, will make a serviceable tool (*see Fig.* 65). After undercutting, any burrs must be removed by polishing the commutator with fine carborundum paper.

Brushes.

To check for freedom (*see Section* A3).

To bed. Brushes must be well "bedded," i.e., they must conform to the commutator periphery. When new brushes are fitted, or if existing ones need "bedding," wrap a strip of very fine glass or carborundum paper (**not emery cloth**), firmly around the commutator, abrasive surface towards the brushes. Then, with the brush in position, rotate the armature **by hand** in the normal working direction of rotation until the correct brush shape is obtained (*see Fig.* 82).

To check the brush spring pressure. Test the brush spring pressure by means of a spring balance hooked under the tip of the brush spring or trigger (*see Fig.* 81). The pressure should be as shown in Section A2. If the pressure is not within the given limits, the springs should be adjusted by moving them into different locations or, where no adjustment is provided, the springs should be renewed.

Sect. A60. STARTER RING—TO REPOSITION.

The starter ring can be assembled on to the engine flywheel either way round and is provided with three keyways; by these means it is possible for it to be fitted in six alternative positions. In the event of the ring showing signs of excessive wear at the point where the starter pinion engages, it should be removed from the engine flywheel and refitted in one of the alternative positions (*see "Note" at the end of this Section.*)

Remove the fluid coupling from the crankshaft.

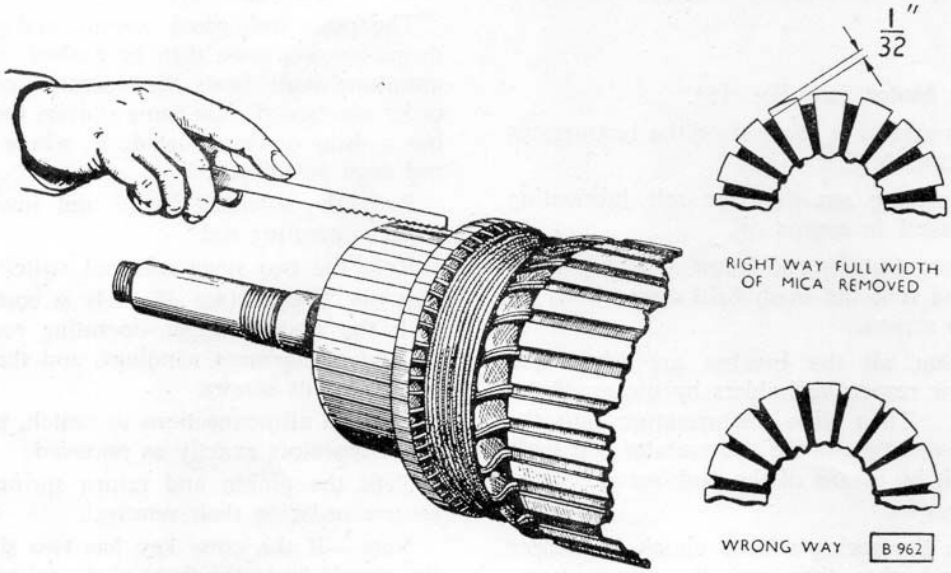


Fig. 65. Method of undercutting commutator mica.

Unfasten the locking wires and remove the set-screws and retaining plates (if fitted), which secure the starter ring to the flywheel. Tap the ring off its register with a lead hammer.

Select one of the alternative keyway positions and assemble by reversing the foregoing procedure.

Note.—

The alternative keyway positions are stamped 1, 3 and 5 on one side of the starter ring and 2, 4 and 6 on the reverse side of the ring.

Sect. A61. FUEL-INJECTION PUMP SETTING.

When calibrated correctly, the variation in delivery from all plungers at the set maximum output must be within ± 2½ per cent. at pump speeds of 500, 750 and 900 r.p.m.

The fuel flow for normal and altitude settings are given in Section A2.

Sect. A62. FUEL-INJECTION PUMP—MAINTENANCE.

(*See Fig.* 66).

"N" Type Fuel-injection Pump.

Apart from periodical lubrication (if required), the pump should require no attention other than re-calibration and renewal of the element in the built-in fuel filter at overhaul periods. It is set correctly and sealed and the fuel setting should not be altered.

Lubrication.

Cam chamber.

The C.A.V. "N" type fuel-injection pump should be initially filled with engine oil when fitted to the engine; it should not require any further maintenance as the level of the oil is maintained by the back leakage from the pump elements.

If it becomes necessary to top-up or fill the fuel-injection pump proceed as follows:—

Remove the filler or breather plug and pour in oil until the surplus runs out of the overflow pipe; refit and tighten the plug.

Governor casing.

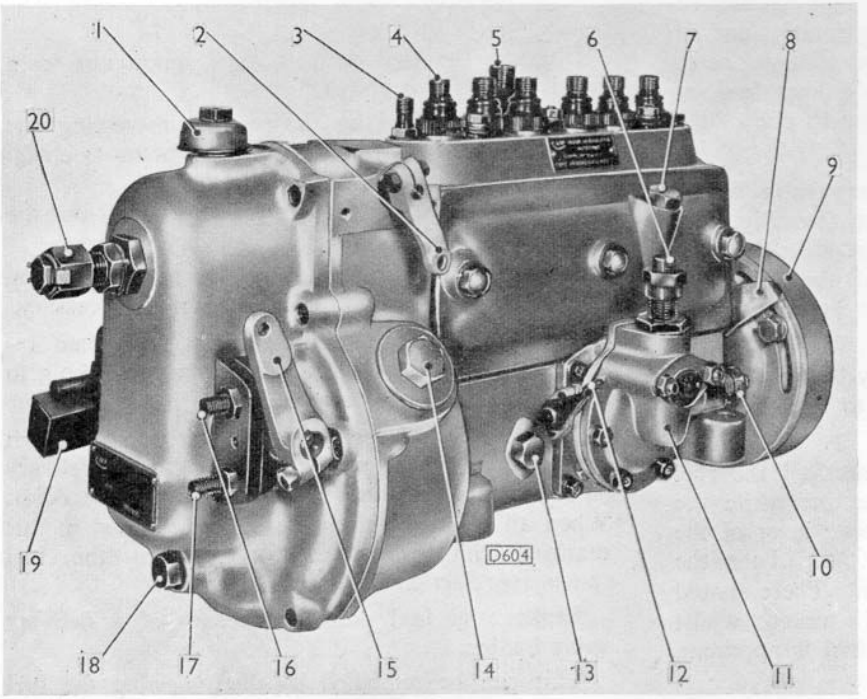
At periods quoted in Section A3 remove the governor oil level plug, then either allow the surplus oil to drain out or add oil through the governor oil filler plug (*see Fig.* 66).

Refit and tighten the plugs.

Adjustments.

Idling.

For instructions on adjusting for idling refer to Section A57.



Key to Numbers :—

1. BREATHER.
2. STOP LEVER.
3. AIR VENT PIPE CONNECTION.
4. DELIVERY VALVE HOLDER.
5. FUEL INLET CONNECTION.
6. FUEL OUTLET CONNECTION TO FILTER.
7. OIL FILLER PLUG.
8. TIMING POINTER.
9. FLYWHEEL.
10. FUEL INLET CONNECTION FROM SUPPLY TANK.
11. FUEL-LIFT PUMP.
12. PRIMING LEVER.
13. OVERFLOW PLUG.
14. GOVERNOR OIL FILLER PLUG AND ACCESS HOLE TO GOVERNOR SPRINGS.
15. CONTROL LEVER.
16. IDLING STOP.
17. SECONDARY MAXIMUM DELIVERY STOP.
18. GOVERNOR CASING OIL LEVEL PLUG.
19. SEALED COVER FOR MAXIMUM DELIVERY STOP.
20. IDLING DAMPER STOP.

Fig. 66. Fuel-injection pump.

Maximum delivery stop.

The maximum delivery stop screw is fitted on the governor casing. **This stop is set to the correct maximum delivery and then sealed. As it is impossible to set accurately except on a calibrating test bench, it should not be altered.**

Rack stop.

This is on the front end of the pump. **The stop is set and sealed in a definite relation to the maximum fuel delivery and this setting must not be altered except on a calibrating bench.**

Sect. A63. FUEL-INJECTION PUMP TROUBLES

(*See also Sections* A16 *and* A17).

To prevent dirt reaching the injectors, it is imperative that all the fuel filters should be cleaned regularly and thoroughly (*see Sections* A22 *and* A73).

When fuel pipes have been disconnected, make sure they are **cleaned thoroughly internally** with clean fuel oil before refitting them.

If either engine misfires on one or more cylinders or lacks power, the fuel-injection pump should be checked as follows:—

See that there is an adequate supply of fuel in the fuel supply tank.

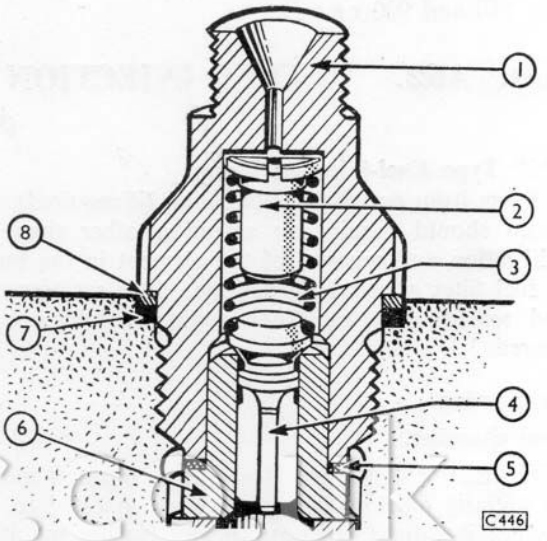
Air-lock existing in the pump chamber. This must be cleared by opening the air vent cock (*see Fig.* 66), with the engine stopped and operating the priming lever of the fuel-lift pump (*see Fig.* 66) until fuel, free from air bubbles, flows from the pipe on the air vent cock.

Check the discharge from each injection pump plunger by disconnecting each of the fuel delivery pipe unions, at the injector end, in turn, while the engine is idling and then **momentarily** pull the throttle control hand lever. The fuel should be delivered in well defined spurts, regularly, and in uniform quantity. Should this test reveal that one or more plungers are either failing to deliver fuel, or doing so irregularly, this may be due to one of the following causes: —

Persistent dribble from the delivery valve holder caused by a sticking delivery valve (*see Fig.* 67). This may be due to dirt admitted either by careless handling of the pump, or the fuel pipe between the main filter and pump during removal from the engine.

Alternatively, a filter element may be damaged or inefficient, allowing dirt to pass to the injection pump.

To determine the cause, disconnect all the fuel delivery pipe unions from the injectors while the engine is stopped, operate the priming lever of the fuel-lift pump (*see Figs.* 17 and 66). Turn the engine approximately one revolution. There should be no flow of fuel from any of the unions whilst the engine is stopped. If flow of fuel is apparent, remove the delivery valve as follows:—



Key to Numbers :—

1. DELIVERY VALVE HOLDER.
2. VALVE SPRING GUIDE.
3. SPRING.
4. DELIVERY VALVE.
5. SEALING WASHER.
6. SEATING.
7. RESILIENT SEALING RING.
8. STEEL WASHER.

Fig. 67. Section through "N" type pump delivery valve assembly.

Unscrew the fuel delivery pipe union nut from the delivery valve holder.

Remove the locking device by unscrewing the central nut and lifting off the locking plates (*see Fig.* 66).

Unscrew the delivery valve holder and lift out the valve spring guide, spring and delivery valve.

Inspect the sealing washer and the resilient sealing ring for scoring or splitting and renew if necessary.

Wash all the parts in clean fuel oil, then reassemble on to the fuel-injection pump, checking to see that the delivery valve is free in its guide.

Tighten the delivery valve holder and secure it with the locking device, then connect the fuel delivery pipe (*for torque spanner loading see Section* A84). When all delivery valves have been checked in this manner, with the engine stopped, vent the fuel system (*see Section* A14).

Leakage of fuel past the threads of a delivery valve holder.

This can be remedied by disconnecting the fuel

delivery pipe from the delivery valve holder, removing the delivery valve holder and fitting a new sealing ring.

Note.—All delivery valves are a plunger fit in their respective guides and must NOT be interchanged; each valve and seat must remain as a pair.

A delivery valve may be seized or a spring broken, in which case replacement parts should be fitted.

For fuller particulars concerning the C.A.V. "N" type pump see C.A.V. Publications Nos. 1021 and 2020/1.

Sect. A64. FUEL-INJECTION PUMP—TO REMOVE.

Note.—Dirt allowed into the injection pump or injectors will cause serious damage. Immediately pipes are disconnected from the injection pump, the ends of the pipes and the unions of the injection pump must be closed by suitable caps; if these are not available they may be covered with clean rag and bound with wire.

Close the fuel stop valve.

Disconnect from the injection pump, the fuel delivery pipes to the injectors, the fuel inlet pipe, the vent pipe, and the oil overflow pipe (if fitted).

Disconnect from the fuel-lift pump, the fuel inlet and outlet pipes and place corks or suitable stoppers in their ends to prevent the loss of any fuel.

Unhook the control rod return spring(s).

Remove the connecting fork-end pin from the end of the control lever.

Remove the set-screws securing the fuel-injection pump to the mounting bracket.

Move the pump away from the bevel gear housing to disengage its half-coupling, then lift it clear of its bracket.

Sect. A65. FUEL-INJECTION PUMP—TO FIT AND TIME.

(See Fig. 68 and also Section A69).

Reverse the procedure given in Section A64 noting the following points:—

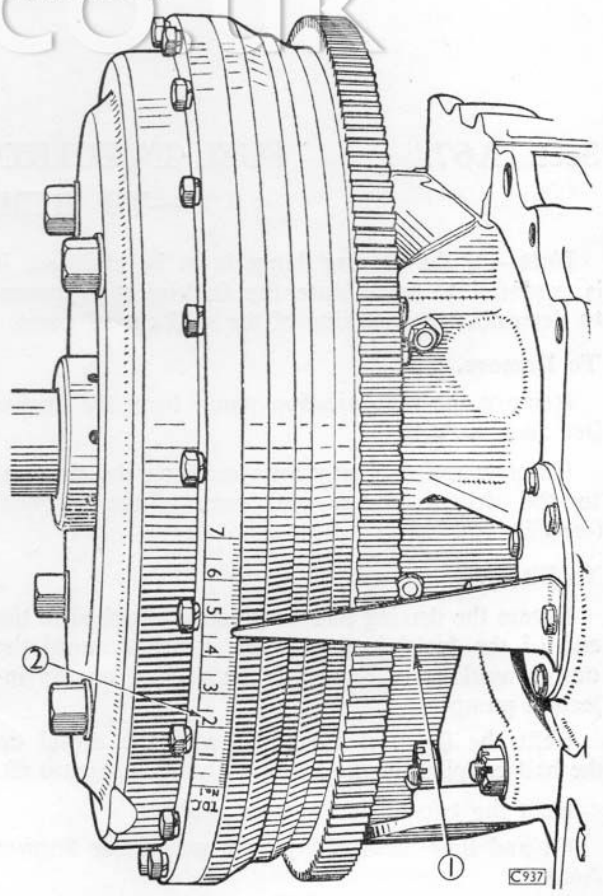
The original timing will be maintained as the dowel allows the engine-half of the coupling to engage in one position only.

Check the timing by rotating the flywheel in a clockwise direction (viewed from the flywheel end of the engine), until, with No. 1 piston on the compression stroke, No. 6 cylinder exhaust valve closing, the timing pointer, on the engine casing, is in line with the mark on the flywheel: —

$4\frac{5}{8}$ in. (27°) before T.D.C.

[Flywheel dia. 19·8 in. (503 mm.)].

The mark on the injection pump driving flange should then be in line with the pointer on the pump body. Any slight variation can be corrected by slackening the two set-screws on the injection pump flywheel, lining up the markings by rotating the injection pump driving flange, then tightening the set-screws (*see Fig.* 66).



Key to Numbers :—
1. TIMING POINTER.
2. TIMING MARKS ON FLYWHEEL.

Fig. 68. Position of engine flywheel for fuel-injection pump spill cut-off point.

Sect. A66. FUEL SPILL CUT-OFF POINT.

The term "fuel spill cut-off point" refers to the instant when the flow of fuel through the fuel spill port of the fuel-injection pump is cut off by the plunger on its upward stroke, as shown in Figure 70. For all practical purposes it corresponds to the commencement of fuel-injection.

The following procedure is for determining the point of fuel spill cut-off for a C.A.V. type injection pump.

Remove the fuel injectors (*see Section* A18).

Unscrew the fuel delivery pipe union nut from No. 1 delivery valve holder.

Remove the locking device from Nos. 1 and 2 delivery valve holders by loosening the central nut (*see Fig.* 66).

Unscrew No. 1 delivery valve holder and lift out the spring guide, spring and delivery valve (*see Fig.* 67).

Refit the delivery valve holder and put the spring guide, spring and delivery valve in a clean and safe place.

Connect the injection pump fuel inlet pipe to a supply of fuel under a **small head.**

Move the fuel-injection pump control lever to the full power position, then turn the **pump** slowly in a **clockwise** direction looking at the flywheel end of the pump, or if on the engine, turn the **engine** slowly in a **clockwise** direction looking at the flywheel end.

Fuel will flow freely from No. 1 delivery valve holder for a large part of a revolution of the **pump** and then drop to a barely perceptible amount as determined by wiping the fuel out of the depression in the top of the delivery valve holder and watching for it to creep slowly back again (*see Fig.* 70).

The instant when the flow of fuel ceases is the point of fuel spill cut-off.

Note.—The flow of fuel will be stopped at two points during one revolution of the **pump.** These points are fairly close together, one on the up-stroke of the plunger and the other on the down-stroke. It is the **first** stoppage after the **longer** period of flow that is the correct point. The cycle is shown diagrammatically in Figure 70.

Sect. A67. FUEL-INJECTION PUMP FLYWHEEL —TO REMOVE AND FIT.

Note.—If the driving flange is to be changed, it is essential to recalibrate the fuel-injection pump to determine the marking of the spill cut-off point.

To Remove.

Remove the fuel-injection pump from the engine (*see Section* A64).

Unscrew the two set-screws securing the flywheel to the driving flange and remove the flywheel (*see Fig.* 66).

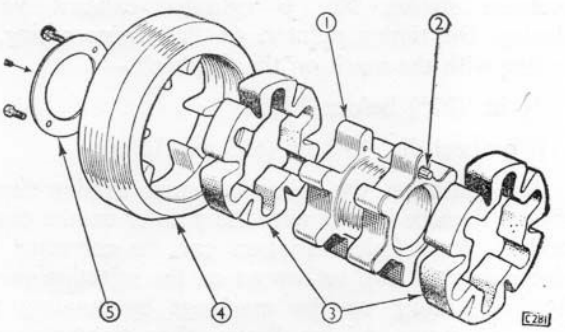
To Fit.

Rotate the driving flange, which is attached to the end of the fuel-injection pump camshaft, until the timing mark is in line with the pointer on the injection pump.

Refit the flywheel assembly, with the dowel on the half coupling in the position shown in Figure 69.

Refit the two set-screws and washers.

Fit and time the fuel-injection pump (*see Section* A65).



Key to Numbers :—

1. CENTRE DRIVING PIECE.
2. DOWEL.
3. RUBBER PORTIONS.
4. FUEL-INJECTION PUMP FLYWHEEL.
5. RETAINING RING.

Fig. 69. Exploded view of fuel-injection pump flywheel assembly.

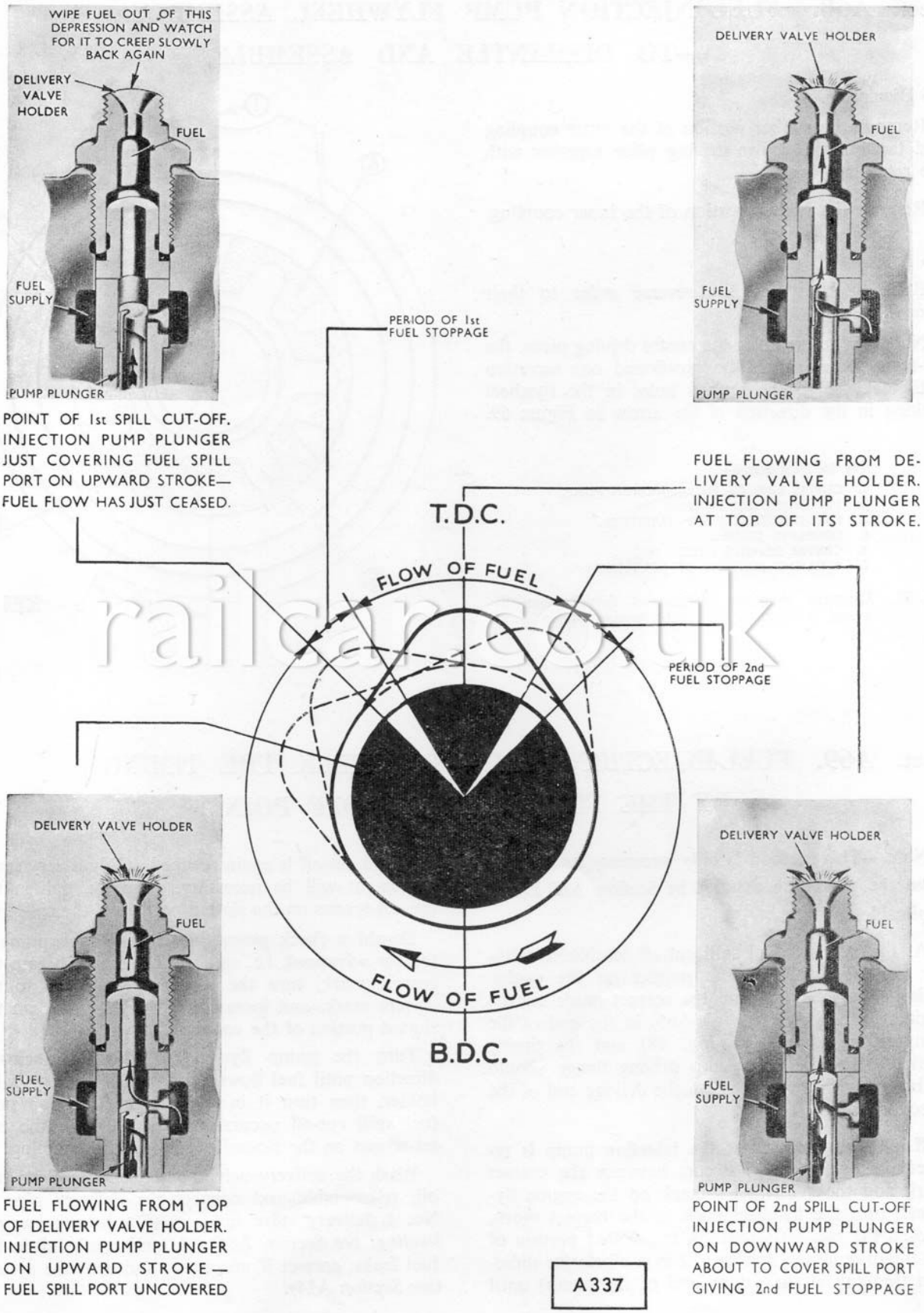


Fig. 70. Diagram showing C.A.V. fuel-injection pump cycle of operation. (Note delivery valve is removed).

Sect. A68. FUEL-INJECTION PUMP FLYWHEEL ASSEMBLY —TO DISMANTLE AND ASSEMBLE.

To Dismantle.

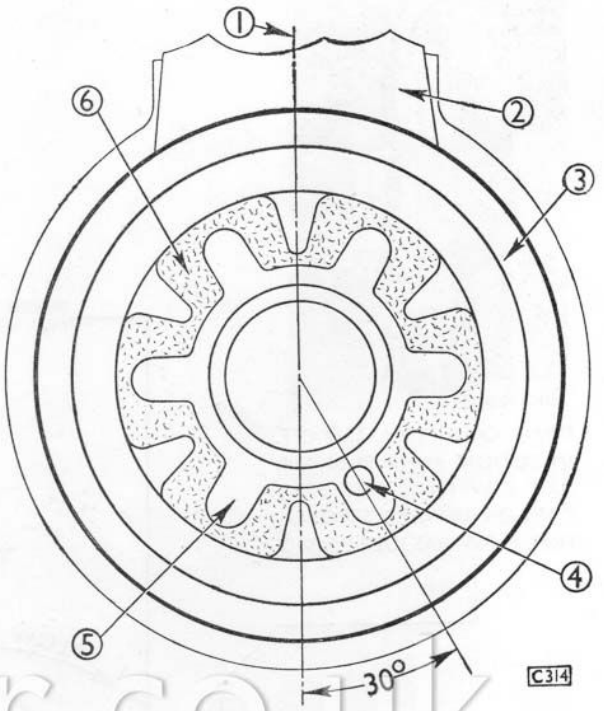
Remove the rubber portion of the outer coupling and tap out the centre driving piece together with the retaining ring.

Remove the rubber portion of the inner coupling.

To Assemble.

Refit the parts in the reverse order to their removal.

Note.—When refitting the centre driving piece, the set-screw holes should be positioned one serration anti-clockwise to the tapped holes in the flywheel looking in the direction of the arrow in Figure 69.



Key to Numbers :—

1. CENTRE LINE OF FUEL-INJECTION PUMP.
2. FUEL-INJECTION PUMP.
3. FUEL-INJECTION PUMP FLYWHEEL.
4. COUPLING DOWEL.
5. CENTRE DRIVING PIECE.
6. RESILIENT PORTION OF COUPLING.

Fig. 71. Diagram showing position of dowel when flywheel is fitted to the fuel-injection pump.

Sect. A69. FUEL-INJECTION PUMP—TO CHECK THE TIMING BY THE FUEL SPILL CUT-OFF POINT.

Note.—This method is only necessary as a check when the procedure detailed in Section A65 is not applicable.

At the point of fuel spill cut-off for No. 1 cylinder (*see Section* A66) **the pointer on the engine casing** should be opposite the correct mark on the engine flywheel (*see Section* A65) at the end of the compression stroke (*see Fig.* 68) and the timing mark on the injection pump driving flange should be in line with the pointer on the driving end of the injection pump.

If a check proves that the injection pump is retared, i.e., spill cut-off occurs between the correct mark and the " T.D.C.1 " mark on the engine flywheel, turn the flywheel **back** to the correct mark. Loosen the two set-screws on the slotted portion of the pump coupling and turn it in a **clockwise** direction (looking at the driven end of the pump) until fuel spill cut-off is again reached. Only a very small movement will be necessary. Finally, tighten the two set-screws on the slotted portion of the coupling.

Should a check prove that the injection pump is too far advanced, i.e. spill cut-off occurs before the correct mark, turn the engine flywheel **on** to the correct mark, and loosen the two set-screws on the slotted portion of the coupling.

Turn the pump flywheel in an **anti-clockwise** direction until fuel flows from No. 1 delivery valve holder, then turn it in a **clockwise** direction until fuel spill cut-off occurs. Finally, tighten the two set-screws on the slotted portion of the coupling.

Wash the delivery valve components in clean fuel oil, re-assemble and connect the delivery pipe to No. 1 delivery valve holder. (*For torque spanner loadings see Section* A84). Examine all unions for fuel leaks, correct if necessary, and vent the system (*see Section* A14).

Sect. A70. FUEL INJECTORS—TO SERVICE.

Injectors should be dismantled on a bench used specifically for the purpose and where scrupulous cleanliness is observed.

Faulty injection may be caused by any of the following defects:—

(i) External carbon on the nozzle.
(ii) Choked nozzle holes.
(iii) Dirt and carbon under the seat of the nozzle valve in the nozzle tip.
(iv) Nozzle valve sticking in the body.
(v) A cracked nozzle.
(vi) A broken spring.
(vii) Incorrect spring adjustment.
(viii) Air and water in any part of the fuel system due to defective filters.

After removing the suspected injector and **before opening it up,** proceed as follows:—

Clean any carbon from the exterior of the nozzle with the brass wire brush shown in Figure 74.

Reconnect it to its fuel delivery pipe, start the engine and note the sprays from the nozzle.

Alternatively, if available, use a hand-testing pump (*see Fig.* 72).

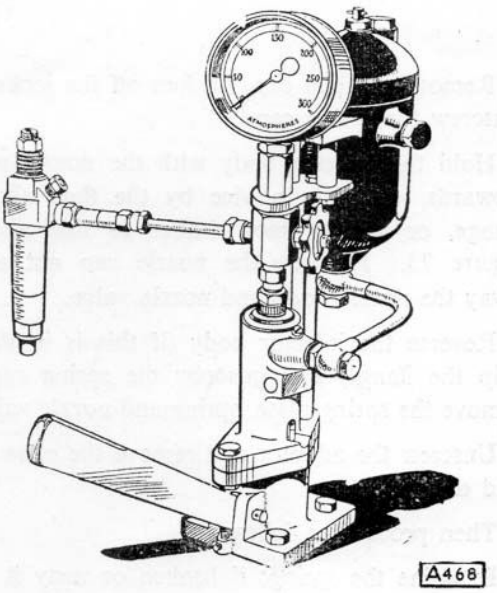


Fig. 72. C.A.V. hand-testing pump for injectors.

When the hand-testing pump is used for testing a nozzle for dribble, or for observing the nature of the sprays, the pressure gauge must be shut off by means of the stop valve.

When working correctly, the nozzle should give four sprays which should appear alike and of the same length free from streaks or jets of undivided fuel, and the nozzle tip should remain dry after fuel cut-off.

To test the injector :—

Fit the injector to the hand-testing pump.

Give about six strokes of the hand lever to expel all air from the nozzle.

Operate the hand lever at the rate of about 60 strokes per minute and observe the sprays as described above.

If all four sprays are satisfactory, but dribble occurs after cut-off it may be due either to defect number (iii) or (v), or occasionally number (iv).

Wipe the nozzle dry and repeat the test, watching carefully to see the point from which fuel leakage originates. If from the nozzle holes, number (iii) or (iv) is the cause; if from between the nozzle and the nozzle cap nut, or elsewhere, the nozzle cap nut may be loose or dirt may be trapped between the joint faces of the injector and nozzle bodies; a cracked nozzle may also be responsible.

Jets without spray indicate that the injector valve adjustment has slackened off, lowering the spring tension; that the nozzle valve is sticking; that there is a broken spring; or there is foreign matter under the valve seat.

If all the holes are clear, the sprays even, and the nozzle does not show signs of dribble, turn on the pressure gauge on the hand-testing pump and check that the spraying pressure reads **175 atmospheres.**

If the pressure is incorrect, unscrew the end cap on top of the injector, slacken the locknut on the adjusting screw or spring cap, and screw **in** the adjusting screw or spring cap to **increase** the pressure, or **out** to **decrease** the pressure. Tighten the locknut and check again (*see Fig.* 16).

When the opening pressure is correct, hold the pressure at 100 atmospheres for one minute. The nozzle tip should not become wet or tend to dribble during this period; if satisfactory refit the end cap.

The injector is then ready for fitting to the engine.

Note.—When testing nozzles, care must be taken to prevent the hand from contacting the spray as the working pressure is sufficient to cause fuel oil to penetrate the skin.

Sect. A71. FUEL INJECTORS—TO DISMANTLE.

(*See Figs.* 16 *and* 73).

Remove the end cap, slacken off the locknut and unscrew the spring cap.

Hold the injector body with the nozzle pointing upwards, either in a vice by the flats above the flange, or with a tool similar to that shown in Figure 73. Unscrew the nozzle cap nut and lift away the nozzle body and nozzle valve.

Reverse the injector body (if this is in the vice, grip the flange) and unscrew the spring cap, then remove the spring plate, spring and nozzle valve rod.

Unscrew the adaptor and remove the cone washer and disc filter.

Then proceed as follows:—

Examine the spring; if broken or rusty it should be renewed.

Examine the nozzle body and valve; these parts must be handled with care and every precaution taken to avoid damage.

It is important that the nozzle valve must always be mated to its original nozzle body. Accordingly, injectors should only be dismantled one at a time.

Withdraw the nozzle valve from the body. The valve must be a smooth sliding fit in the nozzle body and the bearing surface of the valve must be smooth and free from scores, scratches or discoloration. Clean in accordance with Section A73. If the bearing surface of the valve is scored or the tip shows a blue discoloration, **both nozzle body and valve should be renewed.**

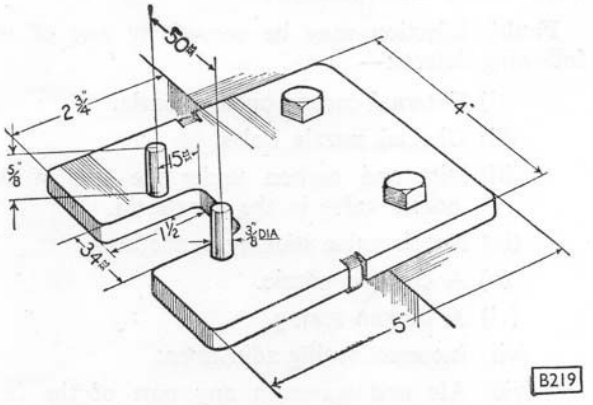


Fig. 73. Tool for holding injectors when dismantling.

Note.—Replacement bodies and valves must be fitted in pairs and not as single parts.

Sect. A72. FUEL INJECTOR NOZZLES—TO SERVICE.

CLEANLINESS IS ESSENTIAL AND AMPLE SUPPLIES OF **CLEAN** PARAFFIN OR FUEL OIL **MUST** BE AVAILABLE. Special tools are shown in Figures 74 to 80 to enable the servicing of a nozzle to be carried out quickly and safely. ON NO ACCOUNT MUST DISSIMILAR TOOLS BE USED OR SERIOUS DAMAGE TO NOZZLES WILL RESULT.

ABRASIVE OR METAL POLISH **MUST NOT** BE USED ON THE NOZZLE BODIES OR VALVES.

A special hand-testing pump (*see Fig.* 72) to facilitate the testing and setting of nozzles should be available, together with a cleaning outfit (*see Fig.* 74).

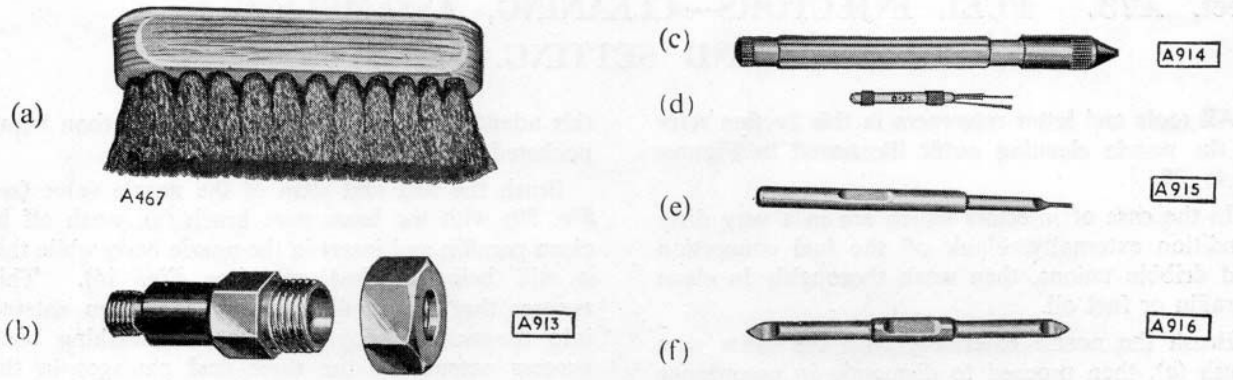


Fig. 74. Injector cleaning tools.

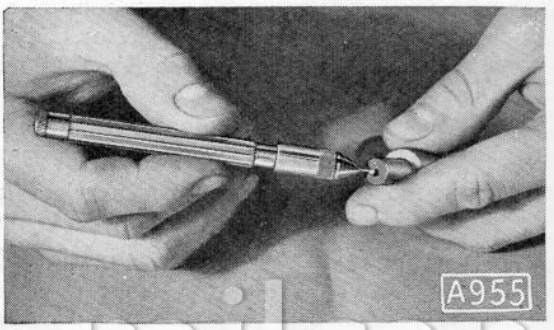


Fig. 75. Pricking out nozzle holes.

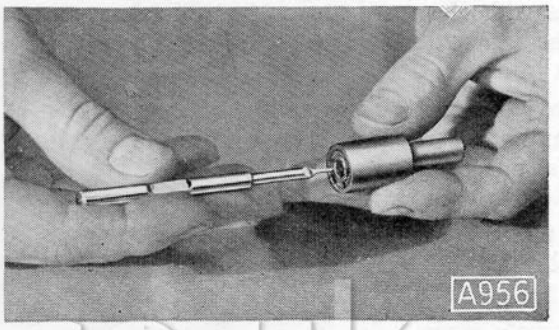


Fig. 76. Tool for cleaning nozzle tip.

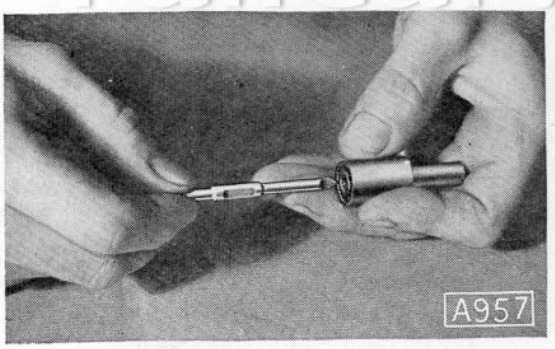


Fig. 77. Tool for cleaning nozzle seat.

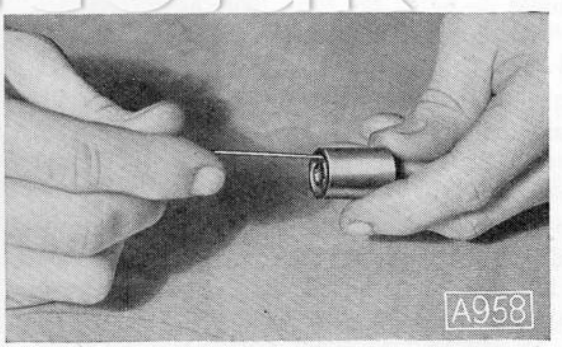


Fig. 78. Cleaning nozzle fuel passages.

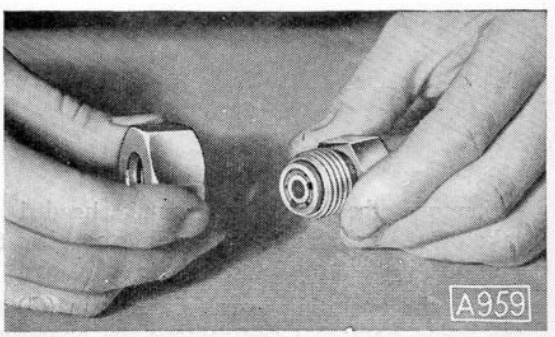


Fig. 79. Nozzle inserted in adaptor for washing.

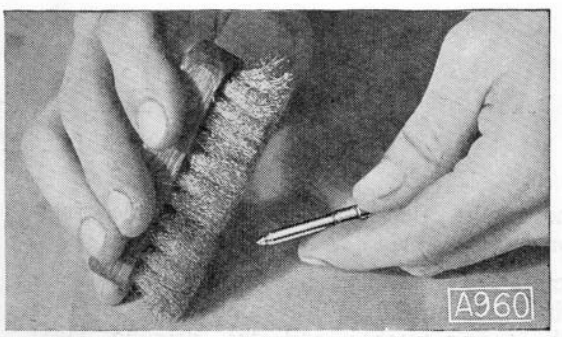


Fig. 80. Brass wire brush for cleaning nozzle valve.

Sect. A73. FUEL INJECTORS—CLEANING, ASSEMBLING AND SETTING.

All tools and letter references in this Section refer to the nozzle cleaning outfit illustrated in Figures 74 to 80.

In the case of injectors which are in a very dirty condition externally, blank off the fuel connection and dribble unions, then wash thoroughly in clean paraffin or fuel oil.

Brush the nozzle externally with the brass wire brush (a), then proceed to dismantle in accordance with Section A71.

Wash the injector body and wash out the fuel passages with clean paraffin or fuel oil; clean and wash the cap nut and place the injector body and cap nut to drain.

Remove the nozzle valve and complete the external cleaning of the **nozzle body** with the brass wire brush (a) then wash externally.

Prick out the nozzle holes (*see Fig.* 75) with one of the wire needles (d) holding it by means of the tool holder (c), and dislodge any dirt from the **nozzle tip** (*see Fig.* 76) with the brass tool (e).

All nozzle spray holes for 11·3 litre engines are 0·35 mm. diameter.

It should be noted therefore that the correct size of "D" needles must always be used when clearing choked holes to avoid damage to the nozzle.

Clean the nozzle valve seat (*see Fig.* 77) with the brass tool (f), then clean out the three fuel passages in the **nozzle body** with a piece of **brass** wire (*see Fig.* 78).

Place the **nozzle body** (*see Fig.* 79) in the adaptor and nut (b), and wash it out **backwards** with clean fuel oil under pressure from the hand-testing pump (*see Fig.* 72). The nozzle joint face should be arranged to point downwards when in this adaptor, in order to avoid dirt or carbon being pocketed in the nozzle recesses.

Brush the seat and stem of the nozzle valve (*see Fig.* 80) with the brass wire brush (a), wash off in clean paraffin and insert in the nozzle body while this is still being washed out (*see Fig.* 16). This ensures that the needle seat is clean when entered into the nozzle body and that the washing back process extends to the three fuel passages in the nozzle body.

Wash off the joint face of the **injector body,** remove the nozzle body and valve from the washing adaptor and mount it on the injector body, taking care to **engage the dowels** (*see Fig.* 16); screw on the cap nut and tighten. No unnecessary force should be used when tightening the cap nut; only an ordinary pull should be exerted on the spanner.

Wash thoroughly and refit the nozzle valve rod, spring, spring plate, spring cap and lock nut.

Wash thoroughly the disc filter in clean fuel oil and refit the inlet connection.

Reset the opening pressure to **175 atmospheres** and test the injector (*see Section* A70), operating the hand-testing pump at the rate of about 30 to 40 strokes per minute.

Hold the Pressure at 100 atmospheres for one minute. The nozzle tip should not become wet or tend to dribble during this period.

Fit the copper washer and end cap.

Finally, blank off the fuel connection with a clean nut and blanking disc, plug the dribble pipe union and place a dust cover over the nozzle.

If the injector is not to be fitted immediately to the engine, it should be wrapped in a clean rag to prevent damage and exclude dirt.

Sect. A74. FUEL-LIFT PUMP—TO DISMANTLE.

(*See Fig.* 17).

Remove the fuel-lift pump from the fuel-injection pump (*see Section* A21).

Unscrew the small cheese-headed screw and pull the priming lever (B) off its spindle (C) together with the spring washer and the priming lever spring (D).

Remove the two countersunk headed screws, take off the priming lever spindle stop plate (E) and pull out the priming lever spindle (C).

Tap the operating lever fulcrum pin (G) through the pump body (K) and remove the operating lever (F) together with its return spring (H).

Unscrew from the diaphragm cover (M) the delivery valve body (Q) and lift out the inlet valve spring (U) and disc (T); the delivery valve ball (R) can then be removed by unscrewing the ball seat (S) from the delivery valve body (Q).

Remove the six nuts and lift off the diaphragm cover (M).

Lift the diaphragm assembly (L), (O) and (P) off the studs taking care not to damage the fabric of the diaphragm (L), and take out the diaphragm spring (N).

The diaphragm and spindle assembly must be considered as a unit and should not be taken apart.

The operating lever return spring retaining pin (J) cannot be removed.

Sect. A75. FUEL-LIFT PUMP—TO ASSEMBLE.

Reverse the procedure given in Section A74 noting the following points:—

On early pumps the ends of the operating lever return spring (H) must be pushed into position over the retaining pin (J) by means of a screwdriver **before** the operating lever fulcrum pin (G) is tapped into position.

To enable the priming lever spindle (C) to be pushed right home the operating lever (F) should be depressed slightly.

When finally fitting the priming lever (B) see that one end of its spring (D) is hooked over the stop plate (E) and the other over the priming lever (B).

Sect. A76. DYNAMO—TO DISMANTLE.

(*See Fig.* 22).

Remove the split pin and slotted nut and withdraw the belt pulley by means of a suitable withdrawal tool; remove the pulley key from the shaft.

Remove the commutator band cover, pull back the brush springs, lift the brushes from the commutator surface and wedge in a raised position with the brush springs.

Take out the retaining screws attaching the fan shield to the carcass. Screw in the grease plug until its head clears the underside of the fan shield, thus allowing the latter to be removed.

Loosen the nuts and washers from the through bolts and withdraw the bolts. Unscrew the commutator end cover screws and remove the cover.

Sect. A77. DYNAMO—TO ASSEMBLE.

(*See Figs.* 22 *and* 65).

In general the instructions for dismantling given in the previous Section may be followed in the reverse order, but the following points should be noted:—

Carefully fit all leads in their original positions and secure them tightly.

Lubricate the felt seals in the driving end inner bearing cap and in the driving end frame with a little oil. Fill the recesses in the driving end inner bearing cap and commutator end cover with **high melting point grease.**

Note.—If new felt seals are needed they should be soaked in oil for 24 hours before use.

Bearings must be cleaned thoroughly in petrol, dried, and inspected for signs of wear.

If there is any play between outer and inner races, or flat spots on the balls or rollers, a bearing must be renewed.

Before assembly bearings should be packed to approximately two-thirds of their capacity with **high melting point grease** and screw in the grease plug until its top is flush with the end frame. Remove any excess grease that exudes into the bearing recess.

Both end frames must be located by their dowels.

After fitting the fan, tighten the clamping nut with the locking screw, which should then be caulked.

Commutators.

To clean. The commutator surface should be clean and free from black discolouration; a dark chocolate colour is, however, quite normal. The surface may be cleaned with a rag dipped in petrol or, if necessary, with very fine glass or carborundum paper, **not emery cloth**.

To skim. If the commutator surface is pitted, the armature should be set up in a lathe and the commutator skimmed. To ensure that the commutator surface remains concentric with the shaft during this operation it is advisable to support the armature in the lathe in ball bearings rather than between centres.

Only a light cut should be taken and, where possible, a diamond tool used to provide the necessary high quality finish. Alternatively, the tool must be sufficiently keen to leave a smooth surface, after which the commutator should be polished with a strip of very fine carborundum paper.

To undercut. After turning, the commutator must be undercut, i.e. the mica insulation between the commutator bars must be removed to a depth of $\frac{1}{32}$ in. (1 mm.) below the surface of the copper, care being taken to ensure that the full width of mica is removed and that nothing is left to project above the copper. A suitable tool for this operation usually takes the form of a short saw blade with handle and a heavy reinforced back to the blade in order to assist steadiness in use. If this tool is not available an old hacksaw blade, ground to the width of the mica, will make a serviceable tool (*see Fig.* 65). After undercutting, any burrs must be removed by polishing the commutator with fine carborundum paper.

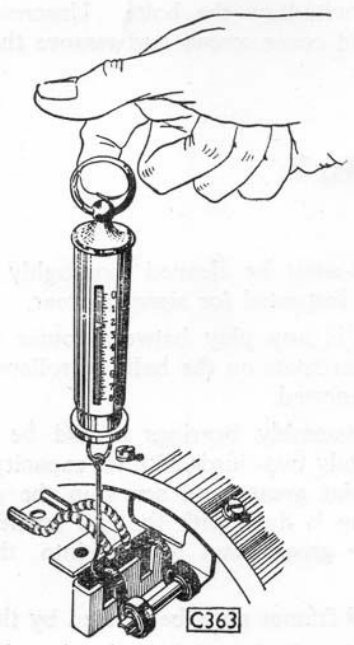


Fig. 81. Method of checking brush spring pressures.

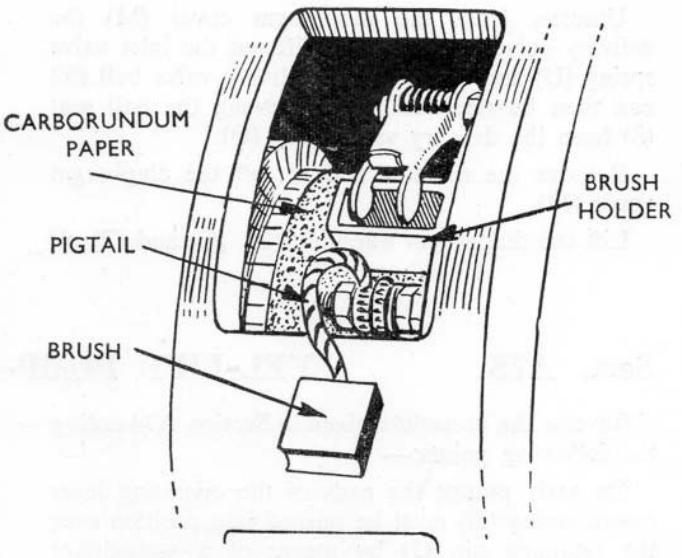


Fig. 82. Method of "bedding" dynamo and starter motor brushes.

Brushes.

To check for freedom (*see Section* A3).

To bed. Brushes must be well "bedded," i.e., they must conform to the commutator periphery. When new brushes are fitted, or if existing ones need "bedding," wrap a strip of very fine glass or carborundum paper (**not emery cloth**), firmly around the commutator, abrasive surface towards the brushes. Then, with the brush in postion, rotate the armature **by hand** in the normal working direction of rotation until the correct brush shape is obtained (*see Fig.* 82).

To check the brush spring pressure. Test the brush spring pressure by means of a spring balance hooked under the tip of the brush spring or trigger (*see Fig.* 81). The pressure should be as shown in Section A2. If the pressure is not within the given limits, the springs should be adjusted by moving them into different locations or, where no adjustment is provided, the springs should be renewed.

Sect. A78. AIR COMPRESSOR—TO DISMANTLE.

(*See Fig.* 23).

Unscrew the set-screws securing the bottom cover and remove the cover.

Remove the set-screws and lift off the cylinder head.

Remove the end cover from the drive housing.

Remove the split pin, nut and washer securing the driving gear.

Mark the connecting rods and their corresponding caps, remove the split pins, unscrew the nuts and remove the caps.

Withdraw the piston and connecting rod assemblies through the top of the cylinder bores.

Unscrew the set-screws and gently prise off the rear end cover.

Remove the nuts and washers securing the drive housing to the compressor crankcase, then withdraw the housing together with the crankshaft.

Withdraw the driving gear and housing from the crankshaft.

Should it be necessary to renew the crankshaft rear bearing, it should be withdrawn using a suitable withdrawal tool.

To dismantle the cylinder head.

Remove the inlet manifold.

Unscrew the delivery valve caps, withdraw the valve springs and discs.

Unscrew the delivery valve seats using a special tool obtainable from the manufacturers.

Withdraw the inlet valve spring keepers, using a special tool obtainable from the manufacturers, then remove the valve springs and discs.

Sect. A79. AIR COMPRESSOR—TO ASSEMBLE.

The dimensions of the cylinder bores when new are 2·625 in. to 2·626 in. (66·68 mm. to 66·70 mm.) diameter.

Wear on these diameters is permissible up to 0·005 in. (0·13 mm.) but new piston rings should be fitted at this stage.

When wear has reached between 0·005 in. and 0·010 in. (0·13 mm. and 0·25 mm.) on these diameters the cylinders should be bored out to 2·635 in. to 2·636 in. (66.93 mm. to 66·95 mm.) diameter and new +0·010 in. (0·25 mm.) oversize pistons and rings fitted.

Wear on these diameters is permissibble up to 0·005 in. (0·13 mm.) but new +0·010 in. (0·25 mm.) oversize piston rings should be fitted at this stage.

In the event of wear in excess of 0·015 in. (0·381 mm.), it is recommended that the cylinder block should be returned to the manufacturers for reconditioning.

The standard clearances for cast iron pistons are 0·001 in. to 0·0025 in. (0·025 mm. to 0·064 mm.).

Both compression and scraper ring gaps should be between 0·003 in. and 0·006 in. (0·76 mm. and 0·152 mm.) when fitted (butt jointed rings), and between 0·002 in. and 0·004 in. (0·50 mm. and 0·101 mm.) when fitted (scarf jointed rings).

Butt and scarf jointed rings may be used together on the same piston.

If the connecting rod big-end bearings are re-metalled, care must be taken to maintain the bearing centres at 4·123 in. to 4·127 in. (104·72 mm. to 104·83 mm.).

The rear main bearing should be washed out in paraffin and then checked for smooth running and absence of slackness. Renew if necessary.

Before assembling ensure that all working parts are lightly smeared with clean engine oil.

Insert the connecting rod and piston assemblies through the tops of the cylinder bores.

If the crankshaft rear bearing has been removed it should be fitted to the crankshaft.

Fit the crankshaft to the drive housing, fitting also the driving gear during the operation, and secure the gear with the nut, washer and split pin.

Fit the crankshaft into the crankcase and secure the drive housing to the crankcase with the nuts and Grover washers; ensure that a new joint is fitted between the faces.

Fit the crankshaft rear end cover and secure it with the set-screws and Grover washers.

Fit the connecting rod bearings to the crankshaft and fit the end caps ensuring that they are fitted as marked on dismantling (*see Section* A78) and secure them with the nuts and split pins.

Temporarily fit the drive housing end cover (*see Section* A27 *on shimming for backlash*).

Fit the bottom cover with a new joint and non-hardening jointing compound; ensure that a new oil sealing ring is fitted to the oil return connection.

If the valve discs are ridged or distorted they should be renewed and the valve seats relapped.

Check the free length of the delivery valve springs; these should be 1·109 in. (28·169 mm.) if less than 1·062 in. (26·975 mm.) they should be renewed.

Sect. A80. RIGHT-ANGLE FAN DRIVE UNIT —TO DISMANTLE.

(*See Fig.* 24).

Remove the unit from the engine following the instructions given in Section A31.

Remove the drain plug situated in the bottom of the casing and drain the oil into a suitable container. It is advisable to drain the oil when it is warm, i.e., after the car has completed a run.

Remove the oil level dipstick (if fitted).

Remove the split pin and retaining nut, and withdraw the drive pulley from the input shaft.

Remove the pulley key from the shaft and retain the distance piece and washer.

Remove the nuts and washers and withdraw the input shaft and housing assembly; retain the shims fitted between the housing and the casing.

If it is necessary to dismantle the input shaft assembly proceed as follows:—

Unscrew the set-screws and remove the oil seal cover from the housing; retain the cork joint.

Drive the input shaft from its housing using a hammer and brass drift; retain the bearing spacer.

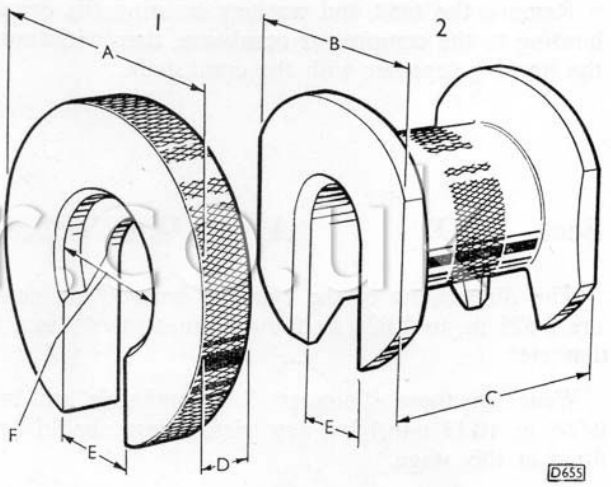
Press the bearing and the bevel gear off the shaft, and remove the remaining bearing from the housing.

To remove the output shaft assembly proceed as follows:—

Remove the end cover.

Remove the nuts and washers securing the oil seal housing.

Obtain withdrawal tools similar to those shown in Figure 83, and place tool (1) over the output shaft with its recessed face towards the bearing housing.



Key to Letters :—

A. 3·25 in. (82·5 mm.) DIA.
B. 2·375 in. (60·3 mm.) ACROSS FLATS.
C. 2·3125 in. (58·7 mm.).
D. 0·4688 in. (11·8 mm.).
E. 0·875 in. (22·2 mm.).
F. 1·4375 in. (36·5 mm.) DIA. X 0·3125 in. (4·8 mm.) DEEP.

Fig. 83. Tools for removing output shaft.

Place tool (2) over the output shaft between tool (1) and the bevel gear.

Using a hammer and brass drift, drive the output shaft assembly from the casing; the outer race of the roller bearing will remain in the casing and should be removed if necessary.

If it is necessary to dismantle the output shaft assembly, proceed as follows:—

Grip the roller bearing retaining nut in a vice, remove the coupling flange retaining nut and withdraw the flange.

Remove the oil seal housing and cork joint; retain the coupling flange distance piece.

Remove the shaft from the vice and draw the bearing and housing off the shaft; if necessary remove the bearing from the housing.

Remove the bearing retaining nut and press the bearing and bevel gear off the shaft.

Sect. A81. RIGHT-ANGLE FAN DRIVE UNIT —TO ASSEMBLE.

Wash all parts in clean paraffin and assemble the input and output shafts, reversing the procedure given for dismantling (*see Section* A80), and noting the following points:—

Certain units are fitted with gears of the spiral bevel type whilst other units are fitted with straight bevel gears.

It is therefore essential when renewing the gears, that both gears are of the same type.

Examine the oil seals and cork joints and renew if necessary.

Fit the outer race of the roller bearing to the casing then fit the output shaft assembly, together with the shims, and secure it with the nuts and washers.

Fit the input shaft assembly, together with the shims, and secure it with the nuts and washers.

Check that the backlash between the bevel gears is as quoted in Section A82.

Adjustment for the backlash is provided by means of shims between the input shaft housing and the casing, and between the output shaft bearing housing and the casing (*for dimensions of shims available see Section* A83).

When the correct backlash has been obtained and the input and output shafts secured, fit the drain plug and fill the casing with oil (*see Section* A4).

Sect. A82. CLEARANCES, STANDARDS, OVERSIZE AND UNDERSIZE PARTS, etc.

CLEARANCES (when new).

Unit.	Component.		Clearance. Inches. Maximum.	Inches. Minimum.	Millimetres. Maximum.	Millimetres. Minimum.
	DIAMETRICAL CLEARANCES.					
BEARINGS	Crankshaft and Main Bearings :— All Standards—All Copper-lead Lined		0·007	0·004	0·180	0·102
	Crankshaft and Connecting Rod Big-end Bearings:— All Standards		0·0047	0·0034	0·120	0·087
	Gudgeon Pin and Connecting Rod Small-end Bearings		0·00125	0·00025	0·0317	0·006
	Gudgeon Pin and Piston		0·0005	0·00025	0·0127	0·006
				Interference		Interference
CAMSHAFT	Camshaft and Bearings (Front and Rear)		0·0045	0·0032	0·116	0·082
PISTONS	Cylinder Liner and **Top** of Piston **Top** Land	Wellworthy	0·036	0·032	0·914	0·812
		Wellworthy‡	0·035	0·031	0·889	0·787
		Specialloid	0·0279	0·0249	0·708	0·633
		B.H.B.	0·035	0·030	0·889	0·762
	Cylinder Liner and Bottom of Piston Skirt	Wellworthy*	0·015	0·010	0·381	0·259
		Specialloid*	0·009	0·0072	0·228	0·183
		B.H.B.	0·012	0·007	0·305	0·178
VALVE GEAR	Valve and Valve Guide (Inlet and Exhaust)		0·0045	0·0022	0·115	0·055
	Valve Tappet and Crankcase		0·0042	0·002	0·107	0·051
	Rocker Shaft and Rocker Bearings		0·0035	0·0008	0·089	0·019
OIL PUMP	Oil Pump Body and Outside of Oil Pump Gears		0·007	0·0045	0·180	0·115
CRANKSHAFT	Rear Oil Seal		0·0218	0·0163	0·551	0·414
	SIDE AND END CLEARANCES.					
CRANKSHAFT AND BEARINGS	Crankshaft End Float (governed by No. 1 Main Bearing)		0·0083	0·0031	0·210	0·080
	Crankshaft and Connecting Rod Big-end Bearings:— All Standards		0·010	0·007	0·254	0·178
PISTON AND RINGS	Piston Rings and Grooves :— Top Compression Ring	Wellworthy	0·006	0·0045	0·152	0·115
		Specialloid	0·006	0·0045	0·152	0·115
		B.H.B.	0·006	0·0045	0·152	0·115
	2nd and 3rd Compression Rings	Wellworthy	0·0055	0·004	0·140	0·102
		Specialloid	0·0055	0·004	0·140	0·102
		B.H.B.	0·0055	0·004	0·140	0·102
	Scraper Rings	Wellworthy	0·0055	0·004	0·140	0·102
		Specialloid	0·0055	0·004	0·140	0·102
		B.H.B.	0·0055	0·004	0·140	0·102
	Piston Ring Gap (Other Rings)		0·022	0·015	0·559	0·381
	Top Compression Ring Gap (Chromium Plated)		0·027	0·020	0·686	0·508
OIL PUMP	Oil Pump Gears and Oil Pump Body Facing		0·004	0·000	0·102	0·000
CAMSHAFT	Timing Idler Gear		0·015	0·010	0·381	0·254
	BACKLASH OF GEARS.					
OIL PUMP	Crankshaft Driving Gear and Oil Pump Idler Gear†		0·005	0·003	0·127	0·076
	Oil Pump Idler Gear and Oil Pump Driving Gear†		0·009	0·007	0·229	0·178
CAMSHAFT	Camshaft Driving Bevel Gear and Fuel-injection Pump Driven Bevel Gear		0·003	0·002	0·076	0·051
AIR COMPRESSOR	Compressor Drive Gear and Engine Timing Gear		0·003	0·002	0·076	0·051
ENGINE SPEED INDICATOR GENERATOR	Fuel-injection Pump Drive Bevel Gear and Engine Speed Indicator Generator Bevel Gear		0·003	0·002	0·076	0·051
RIGHT-ANGLE FAN DRIVE	Input Shaft and Output Shaft Bevel Gears		0·006	0·004	0·152	0·102

* Oval piston on this dimension. Dimensions given are at right angles to gudgeon pin axis.
† Axial backlash on these gears.
‡ Bonded insert type.

STANDARDS.

CRANKSHAFT.

Standard.	Undersize.	Diameter.			
		Main Journals.		Crank Pins.	
		Maximum.	*Minimum.*	*Maximum.*	*Minimum.*
Plan	—	94·975 mm. 3·7392 in.	94·945 mm. 3·7380 in.	74·99 mm. 2·9524 in.	74·97 mm. 2·9516 in.
2nd	0·5 mm.	94·475 mm. 3·7195 in.	94·445 mm. 3·7183 in.	74·49 mm. 2·9327 in.	74·47 mm. 2·9319 in.
3rd	1·0 mm.	93·975 mm. 3·6998 in.	93·945 mm. 3·6986 in.	73·99 mm. 2·9130 in.	73·97 mm. 2·9122 in.
4th	1·5 mm.	93·475 mm. 3·6801 in.	93·445 mm. 3·6789 in.	73·49 mm. 2·8933 in.	73·47 mm. 2·8925 in.
5th	2·0 mm.	92·975 mm. 3·6604 in.	92·945 mm. 3·6592 in.	72·99 mm. 2·8736 in.	72·97 mm. 2·8728 in.
6th	2·5 mm.	92·475 mm. 3·6408 in.	92·445 mm. 3·6396 in.	72·49 mm. 2·8539 in.	72·47 mm. 2·8531 in.

Note.—All journal radii = 3 mm.
All crank pin radii = 5 mm.

CRANKSHAFT MAIN BEARINGS.

Standard.	Undersize.	Nominal Dimensions of Precision Bearings which only require fitting after the crankshaft has been ground to suit the required standard.
Plan	—	95·0 mm. = 3·7402 in.
2nd	0·5 mm.	94·5 mm. = 3·7205 in.
3rd	1·0 mm.	94·0 mm. = 3·7008 in.
4th	1·5 mm.	93·5 mm. = 3·6811 in.
5th	2·0 mm.	93·0 mm. = 3·6614 in.
6th	2·5 mm.	92·5 mm. = 3·6417 in.

CONNECTING ROD REPLACEMENT BEARINGS.

Standard.	Undersize.	Bore with Diamond Type Machine Tool to Nominal Diameter stated below with Clearance between Bearing and Shaft as given in the table at the beginning of this Section.
Plan	—	75·0 mm. = 2·9528 in.
2nd	0·5 mm.	74·5 mm. = 2·9331 in.
3rd	1·0 mm.	74·0 mm. = 2·9134 in.
4th	1·5 mm.	73·5 mm. = 2·8937 in.
5th	2·0 mm.	73·0 mm. = 2·8740 in.
6th	2·5 mm.	72·5 mm. = 2·8543 in.
		Big end and small end centres 290 ± 0·05 mm. = 11·417 in. ± 0·002 in.

Note.—3rd Standard bearings make Plan, 2nd and 3rd Standards.
6th Standard bearings make 4th, 5th and 6th Standards.

CYLINDER LINERS.

The cylinder bores are fitted with renewable dry liners. When the liners need renewing, the engine casing should be returned to a Service Depot of British United Traction in exchange for an engine casing fitted with new liners.

Cylinder Liner Bores—(Standard).

Dia. after Honing.	
Maximum.	*Minimum.*
130·038 mm. or 5·1196 in.	130·013 mm. or 5·1186 in.

PISTONS.

Make of Piston.	Skirt Diameter at bottom of Piston when new.			
	Parallel to Gudgeon Pin.		At Right Angles to Gudgeon Pin.	
	Maximum.	*Minimum.*	*Maximum.*	*Minimum.*
Wellworthy	129·66 mm. 5·1049 m.	129·63 mm. 5·1039 m.	129·75 mm. 5·1084 in.	129·73 mm. 5·1074 in.
Specialloid	129·72 mm. 5·1070 in.	129·70 mm. 5·1063 in.	129·83 mm. 5·1114 in.	129·80 mm. 5·1102 in.
B.H.B.	129·77 mm. 5·1091 in.	129·71 mm. 5·1068 in.	129·82 mm. 5·1111 in.	129·80 mm. 5·1102 in.

OVERSIZE AND UNDERSIZE PARTS.

Part.	Inside diameter.	Outside diameter.	Remarks.
Piston	—	130·5 mm. nominal	Cylinder liner must be bored and honed to give the clearance stated in the table above.
,,	—	131·0 mm. nominal	
Piston ring, compression	—	130·5 mm. nominal	Width 0·125 in., 0·145 in. or 0·165 in.
,,	—	131·0 mm. nominal	
Piston ring, scraper	—	130·5 mm. nominal	
,,	—	131·0 mm. nominal	
Crankcase rear oil seal	99·25 mm.	—	Machining allowance in bore for machining in line with main bearings.
Main bearings			
Plan	95·097 mm.	—	No machining is necessary when fitting these bearings.
2nd Standard	94·597 mm.	—	
3rd Standard	94·097 mm.	—	
4th Standard	93·597 mm.	—	
5th Standard	93·097 mm.	—	
6th Standard	92·597 mm.	—	
Connecting rod bearings	74·5 + 0·090 mm. + 0·077 mm.	—	Finished machined and fitted to connecting rod ready for assembly.
,,	74·0 + 0·090 mm. + 0·077 mm.	—	
,,	73·5 + 0·090 mm. + 0·077 mm.	—	
,,	73·0 + 0·090 mm. + 0·077 mm.	—	
,,	72·5 + 0·090 mm. + 0·077 mm.	—	

Over and Undersize Parts (continued).

Part.	Inside diameter.	Outside diameter.	Remarks.
Connecting rod bush	44·0 + 0·602 mm. + 0·500 mm.	52·0 + 0·082 mm + 0·070 mm.	Bore in position 45·0 + 0·027 mm. + 0·008 mm.
Connecting rod bolt	—	·5 in. +0·001 in. +0·000 in.	
Camshaft bearing	2·418 in. ±0·00075 in.	—	Camshaft bearing journal must be ground to give the clearance stated in the table at the beginning of this Section.
Valve seats (inlet and exhaust)	—	—	To be fitted to cylinder head after machining.

Sect. A83. DIMENSIONS OF SHIMS AND DISTANCE WASHERS AVAILABLE.

Part.	Thickness.	Remarks.
Shims:— Cylinder head/ Engine casing	0·005 in. (0·127 mm.) 0·010 in. (0·254 mm.) 0·020 in. (0·508 mm.)	For use after top face of cylinder block has been "flashed."
Oil scavenge pump suction pipe/ Oil pump body	0·005 in. (0·127 mm.) 0·010 in. (0·254 mm.) 0·020 in. (0·508 mm.)	
Front connection to oil pump cover	0·005 in. (0·127 mm.) 0·010 in. (0·254 mm.) 0·015 in. (0·381 mm.)	
Timing idler wheel spindle	0·018 in. (0·457 mm.) 0·036 in. (0·914 mm.)	
Oil delivery pipe connection/Oil pump body	0·005 in. (0·127 mm.) 0·010 in. (0·245 mm.) 0·032 in. (0·813 mm.)	
Bush and seal housing/Bevel gear housing	0·002 in. (0·051 mm.) 0·003 in. (0·076 mm.) 0·015 in. (0·381 mm.)	
Engine speed indicator generator to bevel drive housing	0·005 in. (0·127 mm.) 0·010 in. (0·254 mm.) 0·030 in. (0·762 mm.)	
Right-angle Fan drive input shaft housing and ball bearing housing	0·003 in. (0·076 mm.) 0·005 in. (0·127 mm.) 0·010 in. (0·254 mm.)	
Compressor housing to engine casing	0·002 in. (0·051 mm.) 0·003 in. (0·076 mm.) 0·006 in. (0·152 mm.)	
Oil pump driving spindle	0·010 in. (0·254 mm.) 0·003 in. (0·076 mm.) 0·002 in. (0·051 mm.)	
Engine snubber bracket buffer	0·128 in. (3·251 mm.) 0·028 in. (0·711 mm.)	
Distance washers:— Valve rocker arm	0·022 in. (0·559 mm.) 0·048 in. (1·218 mm.) 0·081 in. (2·032 mm.)	

Sect. A84. TORQUE SPANNER LOADINGS.

If torque spanners are available the more important nuts and bolts should be tightened to the loads given in the following table.

Part.	Torque	
	lb. ft.	*Kg. M.*
Main bearing bolts	120	16·6
Main bearing set-screws (with identification notch or ring)	160	22·1
Connecting rod bolt nuts	80	11·0
Cylinder head stud nuts	90	12·4
Flywheel bolt nuts	80	11·0
Fuel-injection pump delivery valve holders ("N" type pumps)	36	5·9

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.

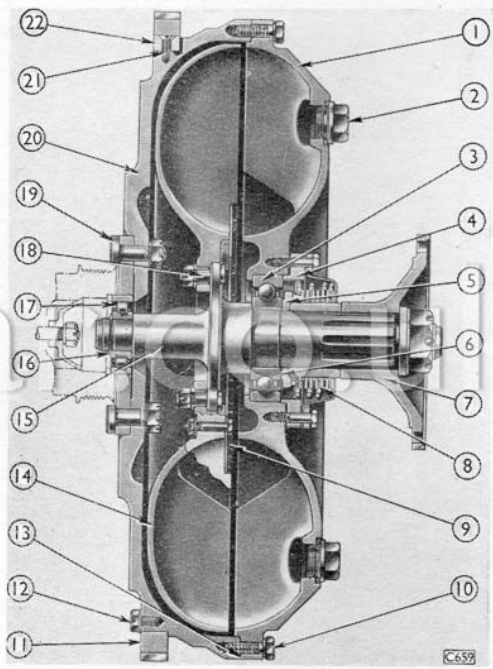


Fig. 1. Section through fluid coupling and bellows gland oil seal.

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

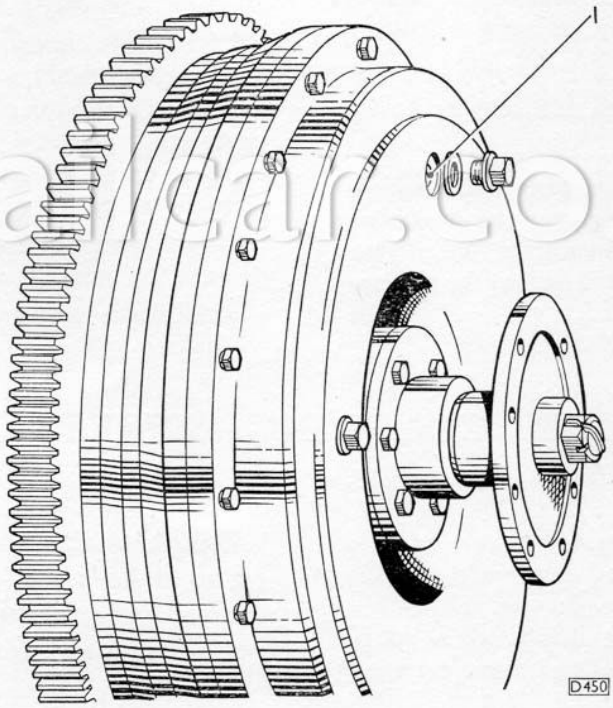


Fig. 2. Position of filler plug hole (1) when filling or topping-up the fluid coupling.

Sect. B5. FLUID COUPLING—TO REMOVE AND FIT.

(*See Fig.* 1).

To Remove.

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

Disconnect the propeller shaft from the fluid coupling.

Unscrew the set-screws around the outer edge of the flywheel rim and withdraw the runner shaft together with the driving and driven members; four tapped holes are provided for $\frac{3}{8}$ in. B.S.F. jack screws. The inner race and rollers of the bearing in the end of the crankshaft will be withdrawn on the runner shaft but the outer race of the bearing will remain in the crankshaft.

To remove the roller bearing, remove the circlip and withdraw the inner race and rollers from the end of the runner shaft using suitable pliers and extractor.

Withdraw the outer race from the engine crankshaft using a suitable withdrawal tool.

Remove the felt oil retainer from the crankshaft.

Remove the nuts from the fitted bolts securing the flywheel to the crankshaft flange and lift off the flywheel.

To Fit.

Reverse the procedure for removal noting the following points :—

Examine the felt oil retainer and renew if necessary.

Ensure that a paper joint and sufficient non-hardening jointing compound is used on the joint between the driving and driven members so that a perfectly oil tight seal is obtained.

After assembly turn the engine until the hole from which the filler plug was removed is at top dead centre, then by means of a funnel, fill the coupling with oil (*see Section* B4).

Refit and tighten the plug.

Sect. B6. FLUID COUPLING RUNNER SHAFT BEARING—TO RENEW.

(*See Fig.* 1).

To Remove.

If it becomes necessary to renew the runner shaft bearing, proceed as in Section B3, then continue as follows :—

Separate the runner shaft assembly from the driving member by using a lead hammer on the splined end of the shaft.

Remove the bearing from the driving member.

To Fit.

Fit a new bearing to the driving member and re-assemble the parts reversing the procedure for removal, then continue as in Section B3.

GEARBOX.

CHAPTER C.

CONTENTS.

NOTE.

The gearbox described and illustrated in Chapter "C" is fitted to the following diesel cars only:—

Nos. 79008—79082.
Nos. 79150—79154.
Nos. 79508—79512.

T.S.L. 592—H & C—1,500—10-56

Sect. C1. GEARBOX—DESCRIPTION.

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

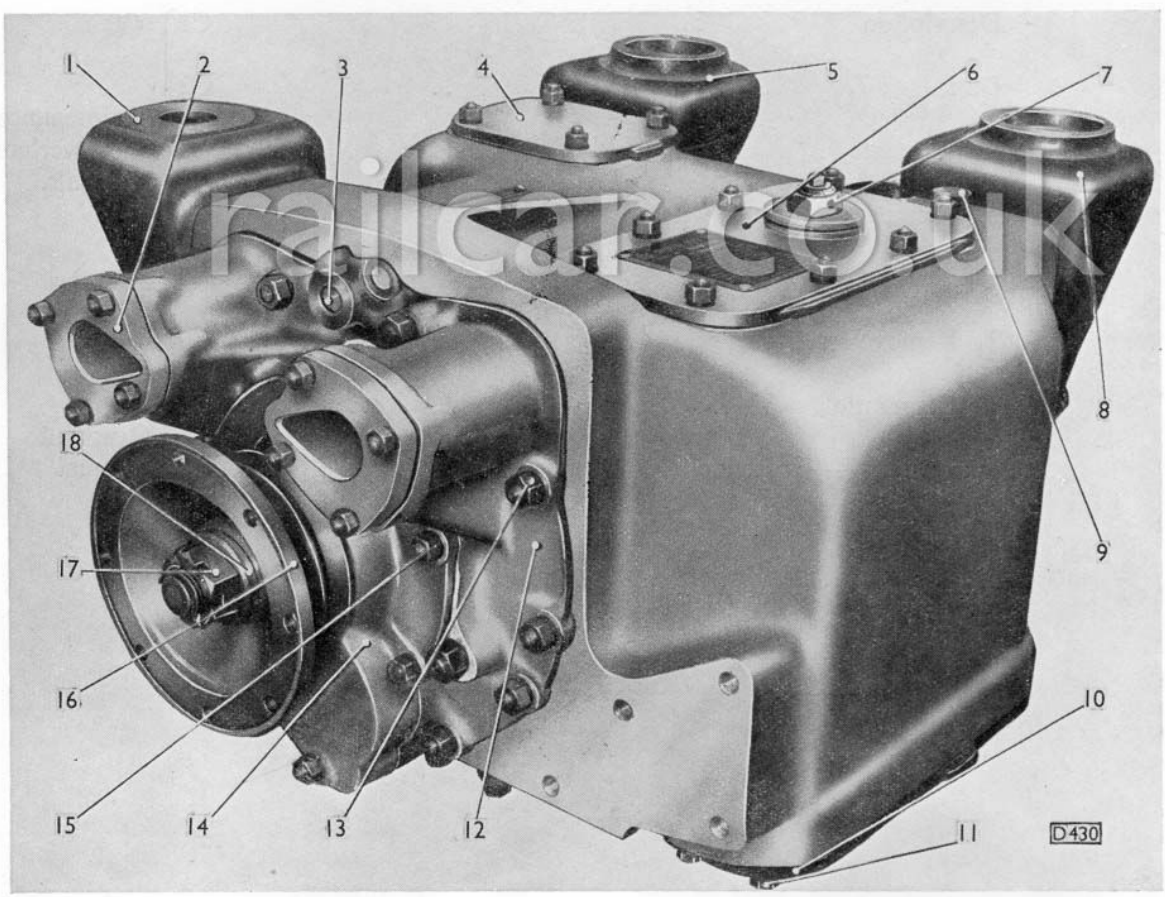
The four-speed direct acting type gearbox manufactured under Wilson Patents, has three forward speeds provided by epicyclic gear trains, and a direct drive top speed which is obtained by means of a multi-plate clutch.

Operation of the clutch couples together the gear trains which comprise the direct gears, thus preventing rotation of the gear trains relative to each other and providing a direct drive from input to output shaft.

All gears are air-operated, each indirect gear being provided with a single air cylinder mounted on the bottom cover plate, whilst the top gear clutch is actuated by two pistons operating in cylinders cast integral with the gearbox front cover.

Air for actuating the pistons is controlled by an electro-pneumatic (EP) valve situated on the frame and operated by a gear change lever in the driver's cab. Restrictor valves are incorporated in the adaptors fitted to the base plate covering the 1st, 2nd and 3rd speed cylinders. These valves restrict the air flow to and from the operating cylinders, so as to release one brake band while progressively applying the brake band of the gear to be engaged.

The gearbox is always disengaged when there is no air in the system, so that the driver cannot



Key to Numbers:—

1. MOUNTING BRACKET.
2. TOP SPEED AIR CYLINDER COVER.
3. AIR SUPPLY PIPE CONNECTION.
4. INSPECTION COVER
5. MOUNTING BRACKET.
6. INSPECTION COVER FOR FORWARD SPEED BRAKE BAND.
7. FILLER PLUG AND BREATHER.
8. MOUNTING BRACKET.
9. OIL DIPSTICK.
10. BOTTOM COVER.
11. BOTTOM COVER NUT.
12. FRONT COVER.
13. FRONT COVER NUT.
14. OIL PUMP COVER.
15. OIL PUMP COVER NUT.
16. INPUT SHAFT COUPLING FLANGE.
17. COUPLING FLANGE RETAINING NUT.
18. COUPLING FLANGE WASHER.

Fig. 1. Front view of gearbox.

move the car until the air pressure system is functioning and is fully charged to the pressure quoted in Section C2.

Gear selection and engagement is obtained by movement of the gear change lever, which actuates the electro-pneumatic valve, and allows air to enter the cylinder of the selected gear.

Each indirect gear has its own brake which consists of two concentric bands one within the other. They are of the self-wrapping type, so that friction of the brakes on the drums will increase their grip.

The actuating mechanism for the brake bands on all indirect gears is the same, with the exception of the dimensions of the air cylinders and pistons. First speed has the largest diameter cylinder owing to greater torque reaction occurring in this gear.

Automatic adjustment is provided for all brake bands on indirect gears by automatic adjuster nuts attached to the pull rods.

A drain plug, breather, filler plug and a dipstick are provided in the gearbox casing.

Lubrication for the gear trains and bearings is provided by an oscillating type oil pump mounted on the front of the gearbox. The pump plunger is actuated by an eccentric keyed to the input shaft.

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.

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

IMPORTANT: If a car is to be TOWED, for any reason, the driving axles must be isolated as follows:—

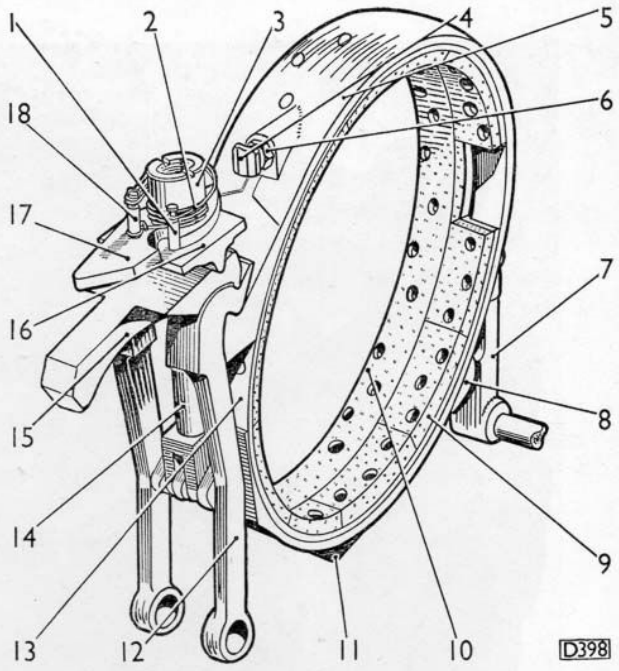
Stop the car. Remove the driver's control key; this will automatically de-energise the electro-pneumatic valve magnets which, in turn, will release the pressure in the striking fork air cylinders.

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



Key to Numbers:—

1. ADJUSTER PLATFORM SPRING PIN.
2. ADJUSTER SPRING.
3. ADJUSTER NUT.
4. ADJUSTING SCREW.
5. EXTERNAL BRAKE BAND.
6. ADJUSTING SCREW LOCKNUT.
7. INTERNAL BRAKE BAND LINK.
8. CENTRALISER LUG.
9. INTERNAL BRAKE BAND LINING.
10. EXTERNAL BRAKE BAND LINING.
11. CENTRALISER LUG.
12. BRAKE BAND HOOK.
13. INTERNAL BRAKE BAND
14. BRAKE BAND PULL ROD
15. THRUST PAD.
16. ADJUSTER PLATFORM.
17. ADJUSTER RING.
18. ADJUSTER RING SPRING PIN.

Fig. 2. Third speed brake band assembly.

necessary until the locking plunger engages the slot in the "neutral" lock plate.

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

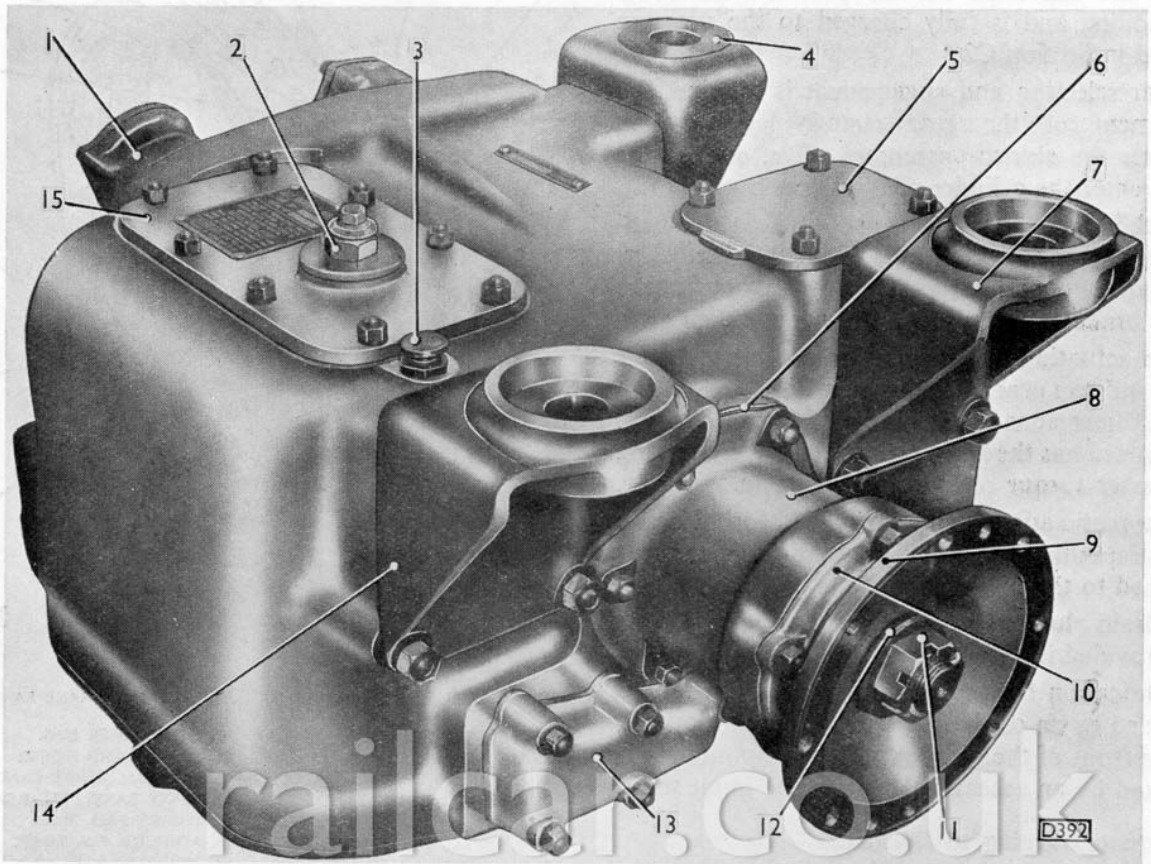
On late axles, ascertain by means of the indicator in the driver's cab or the pointer on the axle casing, whether the axle is engaged in forward or reverse speed.

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" lock plate.

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



Key to Numbers:—

1. TOP SPEED AIR CYLINDER.
2. FILLER PLUG AND BREATHER.
3. OIL DIPSTICK.
4. MOUNTING BRACKET.
5. INSPECTION COVER.
6. SHIMS FOR RUNNING GEAR END CLEARANCE.
7. MOUNTING BRACKET.
8. OUTPUT SHAFT BEARING HOUSING.
9. OUTPUT SHAFT COUPLING FLANGE.
10. BEARING HOUSING OIL SEAL COVER.
11. COUPLING FLANGE RETAINING NUT.
12. COUPLING FLANGE WASHER.
13. OIL TRANSFER BOX.
14. MOUNTING BRACKET.
15. INSPECTION COVER FOR BRAKE BAND ADJUSTER MECHANISM.

Fig. 3. Rear view of gearbox.

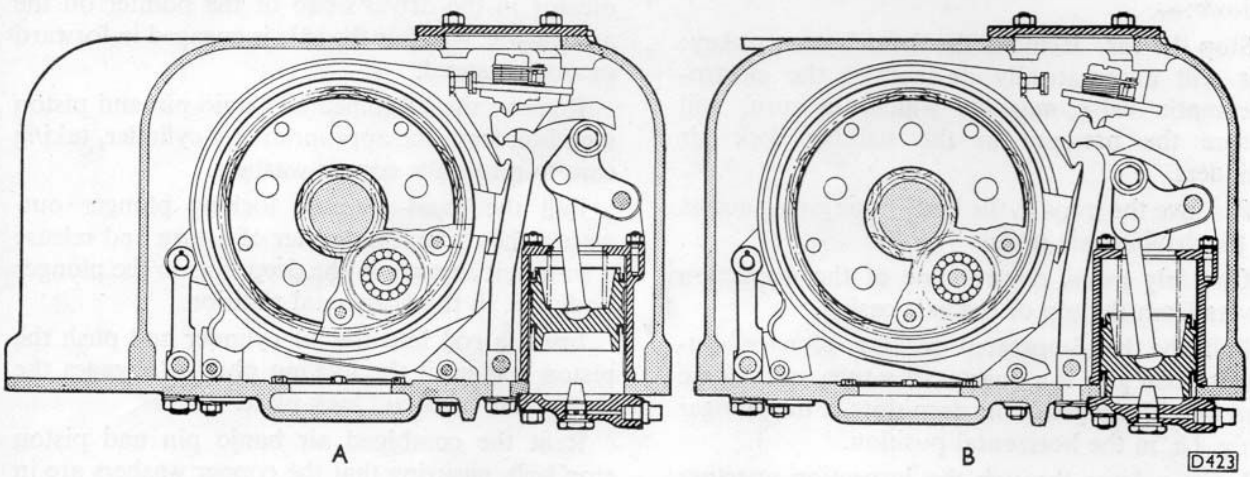


Fig. 4. Section through gearbox showing 1st speed actuation—"A" brake on. "B" brake off.

Sect. C2. GEARBOX—DATA.

Type .. .. Direct acting, 4 forward speeds.

Gear Ratios.

1st speed	..	4·28 to 1.
2nd speed	..	2·42 to 1.
3rd speed	..	1·59 to 1.
4th speed	..	1·00 to 1.

Piston Springs.

	Fitted length	*Load in lb.*
1st speed	3·50 in. (88·90 mm.)	14·36 lb. (6·51 Kg.)
2nd speed	3·50 in. (88·90 mm.)	15·6 lb. (7·07 Kg.)
3rd speed	3·50 in. (88·90 mm.)	13·36 lb. (6·06 Kg.)

Air Pressure for Operating Pistons.

Pressure in reservoir .. .. .. 84 to 85 lb. per sq. in. (5·90 to 5·97 Kg. per sq. cm.)

Pressure at reducing valve outlet .. .. 65 lb. per sq. in. (4·57 Kg. per sq. cm.)

Sect. C3. GEARBOX—ADJUSTMENTS.

(*See Fig.* 5).

When the brakes are being adjusted, it is essential that a constant air pressure, equal to the normal operating pressure, be maintained throughout the operation by adopting one of the following methods:—

(*a*) An independent air line taken through a reducing valve from a main supply.

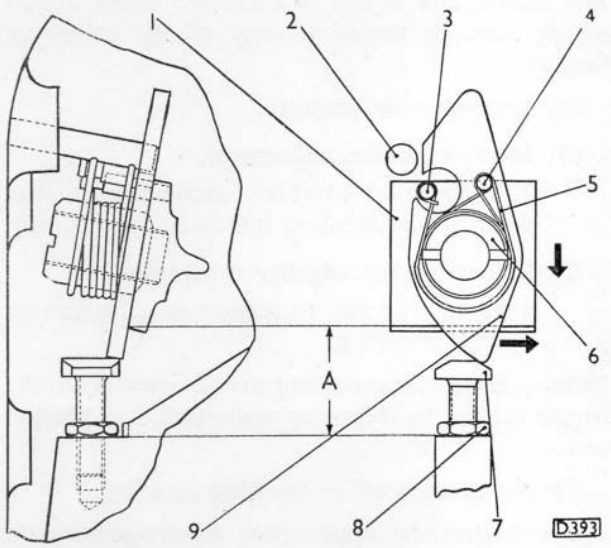
(*b*) A portable air compressor, set to give the correct pressure.

(*c*) If no independent supply is available, re-charge the reservoir on the car by running the engine with the gearbox in "neutral"; temporarily fit the inspection covers to prevent oil being thrown from the gearbox.

To obtain satisfactory results a strict watch should be kept on the pressure gauge reading.

Slipping Brakes.

"Slip" is failure of the brake bands to stop and hold the speed drums, due to insufficient toggle action.



Key to Numbers:—

1. ADJUSTER PLATFORM.
2. TAIL PIN.
3. ADJUSTER PLATFORM SPRING PIN.
4. ADJUSTER RING SPRING PIN.
5. ADJUSTER SPRING.
6. ADJUSTER NUT.
7. ADJUSTING SCREW.
8. ADJUSTING SCREW LOCKNUT.
9. ADJUSTER RING.

A. 1st SPEED = $1\frac{7}{16}$ in. (36·513 mm.)
2nd SPEED = $1\frac{3}{8}$ in. (34·925 mm.)
3rd SPEED = $1\frac{7}{16}$ in. (36·513 mm.)

Fig. 5. Method of setting brake bands.

When "slip" is detected the cause should be rectified immediately to prevent rapid wear of the brake linings.

"Slip" may be traced to one of the following faults:—

(*a*) **Low air pressure.**
The operating pressure should always be maintained at the figure quoted in Section C2.

(*b*) **Incorrect brake adjustment.**
It is essential to check each indirect gear when an adjustment has been carried out.

(*c*) **Worn brake band linings.**
When the gearbox has been in service for a considerable period, the brake band linings may become worn so that the rivets will rub on the drums preventing full contact with the linings. For instructions on renewing the linings see Section C8.

(*d*) **Faulty piston seal.**
Air leaking past a faulty piston seal can be detected by air escaping from the breather. For instructions on renewing the piston seal see Section C9.

"Fierce" Brakes.

Fierceness is when brake application is sudden and heavy, and is due to excessive toggle action which may be traced to any of the following faults:—

(*a*) **Excessive air pressure.**

(*b*) **Incorrect brake adjustment.**
It is essential to check each indirect gear when an adjustment has been carried out.

(*c*) **Failure of the adjuster mechanism.**
This may be due to seizure or a broken or displaced spring.

Note.— Before commencing any adjustments to the toggle action the following tests should be carried out:—

Check the oil level in the fluid coupling.

Check that the appropriate electro-pneumatic valve is functioning, by hand-operating the test plunger on the base of the valve.

Setting the Brakes (*see Fig.* 5).

No adjustment is provided for the top speed clutch; to compensate for wear on the clutch plates, the travel of the operating piston automatically increases.

Setting the brakes should be carried out when the gearbox is cold. It is also important, in order to allow full air pressure to reach the cylinder, that each time the brake is applied it should be left in the applied position for at least five seconds.

Release the adjuster spring by removing the two eyes from the pins; it is not necessary to remove the spring, then unscrew the adjuster nut several turns in an **anti-clockwise** direction and engage the gear concerned.

Slacken the locknut on the adjusting screw in the brake band, and screw in the adjusting screw as far as possible.

Check the setting by measuring with a rule or callipers between the edge of the adjuster table and the boss on the brake band (*see Fig.* 5).

If the gap is too small, release the brake and screw the adjuster nut **clockwise,** then again apply the brake and check the gap. If necessary repeat the operation until the correct setting is obtained.

When the gap is too large, screw the adjuster nut **anti-clockwise** to obtain the correct setting.

When the correct setting has been obtained, release the brake and attach the adjuster spring eyes to the pins, whilst holding the adjuster ring against the tail pin.

Alternately apply and release the brake, unscrewing the adjusting screw in the brake band at each release; repeat this operation until the adjuster ring just contacts the screw when the brake is in the applied position.

Lock the adjusting screw with its locknut, ensuring that the face which contacts the adjuster ring is vertical (*see Fig.* 5), then release the spring from its pins, screw the adjuster nut **anti-clockwise** half a turn and refit the spring eyes to the pins.

Check the setting as follows:—

(*a*) Alternately apply and release the brake several times noting if the adjuster nut turns.

To check this, place a straight-edge across the inspection aperture parallel to the slots in the adjusting nut, while the brake is in the released position, and check the position of the slots each time the brake is released.

If the adjuster nut has turned, continue to apply and release the brake until the nut appears to have stopped turning; approximately six more applications of the brake should be made to ensure that no further movement takes place.

(*b*) If the adjuster nut fails to turn, unscrew the adjusting screw half a turn at a time until the nut commences to turn, then alternately apply and release the brake until the nut ceases to turn; check the gap.

Final Adjustment.

If the gap is too small, release the brake, slacken the locknut and unscrew the adjusting screw half a turn, then tighten the locknut.

Alternately apply and release the brakes until the adjuster nut stops turning then again check the gap. If necessary, repeat these operations until the desired result is obtained.

If the gap is too large, release the brake, slacken the locknut and screw in the adjusting screw half a turn then tighten the locknut. Release the eyes of the adjuster spring and screw the adjuster nut half a turn in an **anti-clockwise** direction. Fit the adjuster spring eyes to their pins, then alternately apply and release the brake until the adjuster nut stops turning. Check the gap and, if necessary, repeat these operations until the desired result is obtained.

Sect. C4. GEARBOX—MAINTENANCE.

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

Period.	Attention required.
DAILY	Check the air pressure for the operating pistons (*see below*).
WEEKLY	Top-up the gearbox with oil (*see Section* C5).
AFTER FIRST 1,000 MILES (1,600 KM.) OF A NEW OR RECONDITIONED GEARBOX	Drain and refill the gearbox with oil (*see Section* C5).
HALF YEARLY OR EVERY 30,000 MILES (48,000 KM.)	Drain and refill the gearbox with oil (*see Section* C5). Remove, clean and refit the breather (*see Section* C5).

Air Pressure.

The correct pressure for operating the pistons is quoted in Section C2 and should not be allowed to vary from this pressure.

If the pressure is too low "slip" may occur, especially in the lower gears; should the pressure be too high, fierce engagement of the gears may result. In either case adjust the pressure at the reducing valve to the correct value and check the brake setting (*see Section* C3).

If "slip" should occur, when the correct pressure is available at the reservoir, examine the air pipe connections for leaks by applying a solution of soap and water to the joints in the piping and checking for bubbles.

When "slip" is detected the cause should be rectified immediately to prevent deterioration of the linings.

To Adjust the Air Pressure at the Reducer Valve (*see Fig.* 7).

Ensure that the air pressure gauge in the driver's cab shows a reading of 84 to 85 lb. per sq. in. (5·90 to 5·97 Kg. per sq. cm.).

Disconnect the outlet pipe from the reducer valve and connect in its place an accurate gauge capable of recording pressures up to 70 lb. per sq. in. (4·92 Kg. per sq. cm.).

Remove the locking piece securing the adjusting screw.

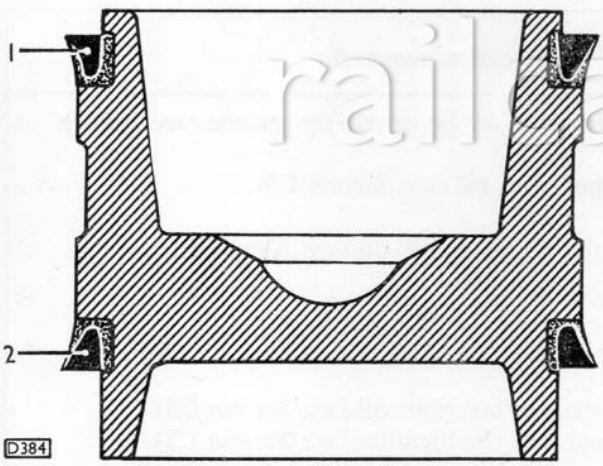
Adjust the pressure to that quoted in Section C2.

Turn the adjusting screw **in** to **increase** the air pressure or **out** to **decrease** the pressure.

When the correct pressure setting is obtained, lock the adjusting screw with the locking piece, remove the pressure gauge and refit the outlet pipe.

Gearbox Overheating.

Check the oil level and, if it is below the mark on the dipstick, "top-up" (*see Section* C5). When the gears are disengaged ascertain that the brake



Key to Numbers:—

1. OIL WIPER SEAL.
2. AIR DISTRIBUTOR SEAL.

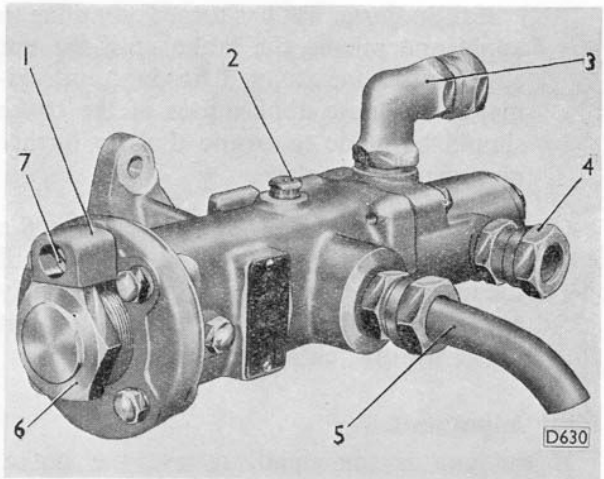
Fig. 6. Method of fitting piston seals.

bands are fully released from the drums, by inserting a screwdriver between the bands and checking that they are free to move.

Should overheating persist, the matter should be reported immediately.

Piston Seals.

Examine the piston seals for air leakage, this can be detected by air escaping from the breather



Key to Numbers:—

1. ADJUSTING NUT LOCKING PIECE.
2. LUBRICATOR.
3. AIR PIPE CONNECTION FOR PIPE TO E.P. VALVE UNIT
4. AIR PIPE CONNECTION FOR PIPE FROM AIR RESERVOIR.
5. EXHAUST PORT TO ATMOSPHERE.
6. ADJUSTING SCREW.

Fig. 7. Air reducer valve.

or by vapour inside the gearbox. If the seals are worn or damaged they should be renewed as follows:—

To Remove the Pistons.

Isolate the batteries by means of the switch situated in the electrical control box which is adjacent to Number 1 engine.

Drain the oil from the gearbox following the instructions given in Section C5.

Disconnect the air supply pipes from the gearbox and secure them to a convenient point on the car to prevent damage.

Remove the cylinder base plate from the 1st, 2nd and 3rd speed cylinders, and the covers from the top speed cylinders.

Withdraw the pistons from the cylinders, together with the piston return springs where fitted.

Remove the worn piston seals.

To Fit the Pistons.

Fit new seals to the pistons (*see Fig.* 6).

Smear the pistons and seals with oil then fit them into their cylinders.

Refit the parts reversing the procedure given for removal and noting the following points:—

Fit the drain plug to the gearbox bottom cover and fill the gearbox with oil (*see Section* C5).

Close the battery main switch.

Brake Adjustment.

The automatic brake band adjusters will normally maintain fully effective brakes and no maintenance should be required. If, however, their functioning is faulty, proceed as in Section C3.

Adjuster Nut Binding.

The accumulation of excessive sludge in the threads of an automatic adjuster nut may cause the nut to bind and cease to adjust automatically. To remedy this, remove the adjuster nut, and run a tap ($\frac{11}{16}$ in. B.S.F. right-hand thread) through the threads of the nut to remove all foreign matter. Refit the nut and re-adjust the brake band. (*For instructions on adjusting, see Section* C3.)

Distortion of Steel Clutch Plates (Top Speed).

If difficulty is experienced due to the top speed ceasing to operate, the steel clutch plates may be distorted and the matter should be reported immediately.

Sect. C5. GEARBOX—LUBRICATION.

(*See Fig.* 3).

To Drain and Refill.

Remove the drain plug from beneath the main casing, using a suitable key, also remove the combined filler plug and breather from the top of the casing (*see Fig.* 3).

Allow all oil to drain away into a suitable container.

Refit the drain plug, then pour oil through the filler plug hole until the level indicated by the mark on the dipstick is reached.

For a suitable grade of gearbox lubricant, operators are advised to apply direct to any reputable oil company for their recommendation.

The capacity of the gearbox is 3 Imperial gallons (13·6 litres).

To Clean and Refit the Breather.

Clean the breather by unscrewing the centre hexagon plug and removing the dished washer, also clean the holes in the inner tube and hexagon plug.

Refit the hexagon plug and dished washer to the inner tube, and the combined filler plug and breather to the gearbox casing.

NOTES

Sect. C6. GEARBOX—TO REMOVE AND FIT.

(*See Figs.* 1, 3 *and* 8).

To Remove.

Isolate the batteries by means of the switch situated in the electrical control box which is adjacent to Number 1 engine.

Remove the drain plug from the bottom cover and drain the oil from the gearbox into a suitable container.

Disconnect the air supply pipes from the gearbox and secure them to a convenient point on the car to prevent damage.

Disconnect the propeller shaft coupling flanges from the front and rear of the gearbox and secure the shafts to some convenient point on the car to prevent damage. Care must be taken when handling the freewheel shaft to ensure that the freewheel and joint assembly does not slide off the shaft.

Slacken the exhauster belt adjuster to enable the belts to be removed.

Remove the gearbox trap from the body floor and place a suitable tripod and lifting tackle in position.

Attach the lifting chain or sling to the gearbox coupling flanges and take up the slack in the chain or sling.

Remove the split pins and nuts securing the gearbox to its mounting brackets.

Lower the gearbox through the frame on to a suitable trolley when it can be withdrawn away from the car.

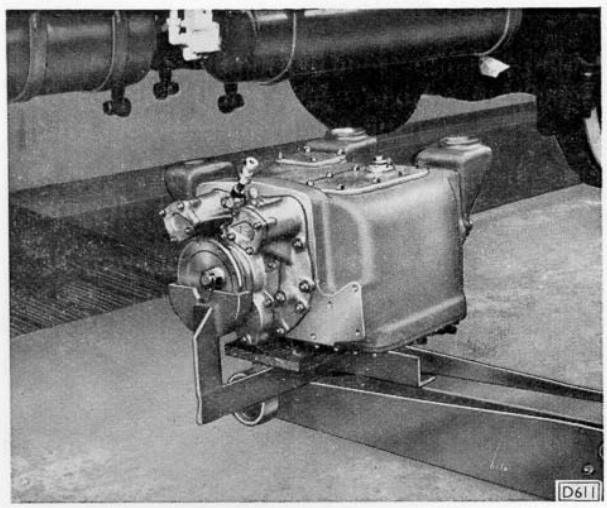


Fig. 8. Gearbox ready for moving into position for mounting.

To Fit.

Reverse the procedure for removal, noting the following points:—

Refit the drain plug to the gearbox bottom cover and fill the gearbox with oil (*see Section* C5).

Close the battery main switch.

Run the engines and charge the air pressure system (*see Section* C2).

Sect. C7. GEARBOX—TO DISMANTLE.

(*See Figs.* 9, 10, 11, 12 *and* 13).

Drain the oil from the gearbox, remove the gearbox from the car (*see Section* C6) and place it on a suitable stand or bench.

Remove the oil level dipstick and the two inspection covers from the top of the gearbox casing.

Remove the springs from the brake band adjuster nuts, unscrew the nuts and remove the adjuster rings, platforms and thrust pads.

Remove the split pin and nut securing the output shaft coupling flange and withdraw the flange; remove the oil sealing ring if fitted.

Remove the split-pin and slacken the nut securing the input shaft coupling flange.

Unscrew the nuts securing the front cover to the gearbox casing.

Separate the front cover from the gearbox

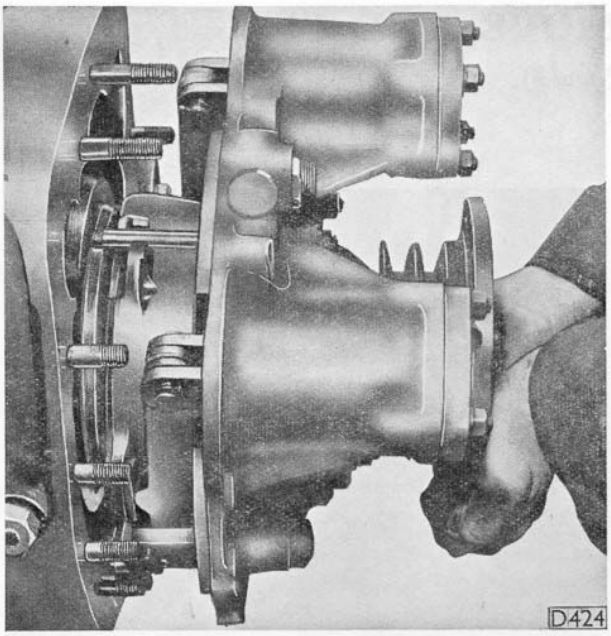


Fig. 9. Method of removing running gear—1st stage.

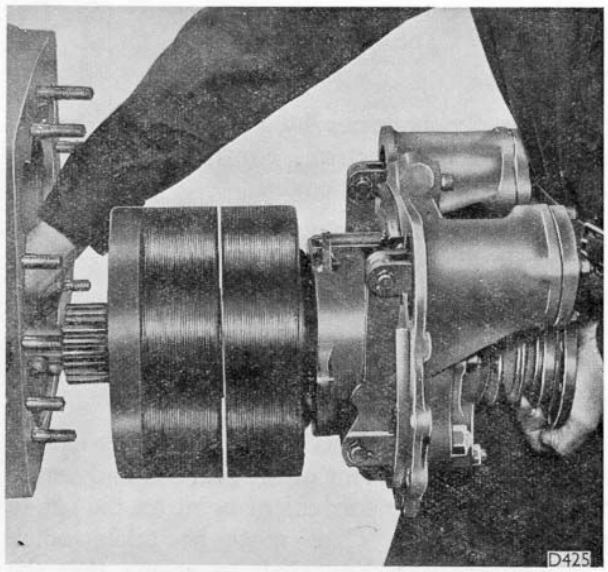
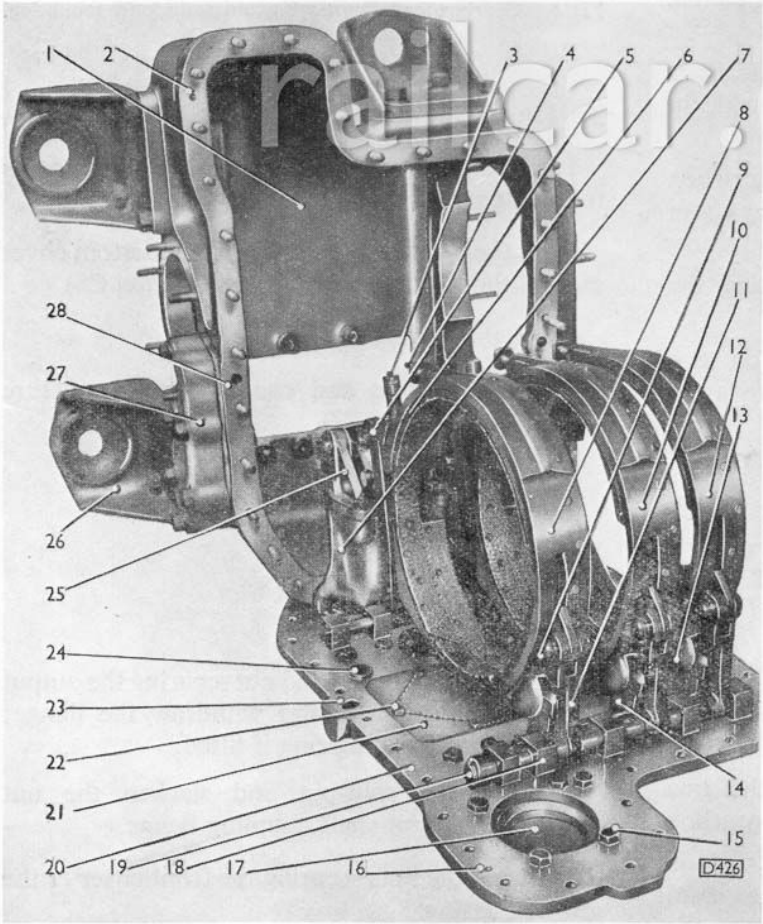


Fig. 10. Method of removing running gear—2nd stage.



Key to Numbers:—

1. GEARBOX CASING.
2. DOWEL.
3. BRAKE BAND PULL ROD.
4. BRAKE BAND ADJUSTING SCREW.
5. BRAKE BAND HOOK.
6. INTERNAL BRAKE BAND.
7. CYLINDER BLOCK.
8. FIRST SPEED EXTERNAL BRAKE BAND.
9. BRAKE BAND LINK PIN.
10. SECOND SPEED EXTERNAL BRAKE BAND.
11. BRAKE BAND LINK.
12. THIRD SPEED EXTERNAL BRAKE BAND.
13. CENTRALISER LUG.
14. CENTRALISER.
15. BLANKING PLATE RETAINING BOLT.
16. DOWEL HOLE.
17. BLANKING PLATE.
18. FULCRUM ROD EYE BOLT.
19. FULCRUM ROD.
20. BOTTOM COVER.
21. OIL SUMP COVER PLATE.
22. COVER PLATE SET-SCREW.
23. OIL HOLE TO SUMP.
24. DRAIN PLUG.
25. CYLINDER COVER.
26. GEARBOX MOUNTING BRACKET.
27. OIL TRANSFER BOX.
28. OIL HOLE TO SUMP.

Fig. 11. Gearbox casing removed from bottom cover.

casing by using a lead hammer on the inside of the coupling flange, then withdraw the running gear (*see Figs.* 9 *and* 10).

Retain the input shaft bushes.

Withdraw the first speed drum, second speed annulus and planet carrier together with the output shaft; the inner race of the small roller bearing will remain on the shaft.

Unscrew the retaining nuts and remove the output shaft bearing housing; retain the shims. If it is necessary to remove the bearings drive them out using a hammer and brass drift.

Stand the running gear assembly in a suitable adaptor or fixture and remove the coupling flange; remove the oil sealing ring if fitted.

Unscrew the nuts from the oil pump cover, remove the cover together with the oil thrower and pump assembly, withdraw the oil pump eccentric from the input shaft.

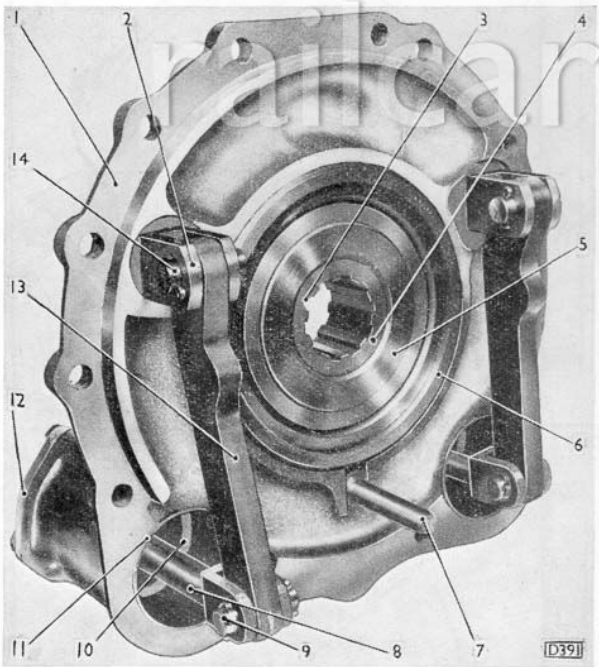
Remove the front cover assembly from the shaft.

To Dismantle the Front Cover.

Unscrew the nuts and remove the cylinder covers, push the pistons from their bores by means of the piston rods.

Remove the nuts and washers, securing the eyebolts, from the front of the cover and remove the piston rod, clutch operating lever and eyebolt as a unit; should it be necessary to remove the link pins, they should be pressed out with a hand press.

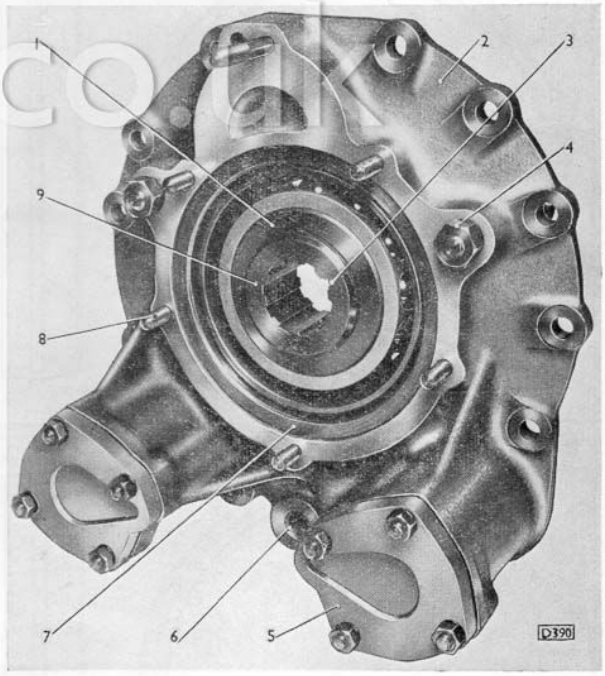
If necessary, press out the input shaft bearing from its housing and press the splined sleeve from the bearing. **Note the correct position of the bearing and sleeve for refitting as shown in Figures 12 and 13.**



Key to Numbers:—

1. FRONT COVER.
2. CLUTCH OPERATING LEVER EYE BOLT.
3. KEYWAY (LOCATES OIL PUMP ECCENTRIC KEY).
4. SPLINED SLEEVE.
5. INPUT SHAFT BEARING.
6. BEARING HOUSING.
7. LOCATING PEG (SEE FIGURES 19 AND 20).
8. PISTON ROD.
9. PISTON ROD LINK PIN.
10. PISTON.
11. CYLINDER LINER.
12. CYLINDER COVER.
13. CLUTCH OPERATING LEVER.
14. CLUTCH OPERATING LEVER LINK PIN.

Fig. 12. Rear view of front cover assembly.



Key to Numbers:—

1. INPUT SHAFT BEARING.
2. FRONT COVER.
3. KEYWAY (LOCATES OIL PUMP ECCENTRIC KEY).
4. NUT SECURING CLUTCH OPERATING LEVER EYE BOLT.
5. CYLINDER COVER.
6. AIR SUPPLY PIPE CONNECTION.
7. BEARING HOUSING.
8. OIL PUMP COVER STUDS.
9. SPLINED SLEEVE.

Fig. 13. Front view of front cover assembly.

To Dismantle the Running Gear.

Remove from the input shaft the key which retains the oil pump eccentric and the input shaft bearing bush.

Withdraw the distance piece and the top speed clutch sliding member taking care not to lose any of the clutch return springs.

Remove the return springs and withdraw the clutch driving member together with the clutch plates; retain the halves of the split retaining ring.

Withdraw the third speed brake drum and sun wheel, retain the bushes.

Withdraw the second speed brake drum with the third speed planet carrier and bush.

To Remove the Bottom Cover.

Turn the gearbox on to its side, remove the nuts and washers which secure the bottom cover to the gearbox casing, gently prise the cover free of the casing and lift off the casing (*see Fig.* 11).

To Dismantle the Brake Band Assembly.

Using a screwdriver release the hooks from the external brake bands.

At the other side of the brake band assembly, remove the split pins from the internal band link pins, then remove the link pins.

Unscrew the $\frac{5}{16}$ in. B.S.F. nuts from the eye bolts securing the centraliser rods to the bottom cover.

Remove the three brake band assemblies together with the centralisers, rods and eye bolts as a unit.

The brake bands can then be removed individually as necessary.

If it is necessary to remove the hooks and link assemblies, unscrew the $\frac{9}{16}$" in. B.S.F. nuts from the eye bolts and tap the eye bolts through the bottom cover.

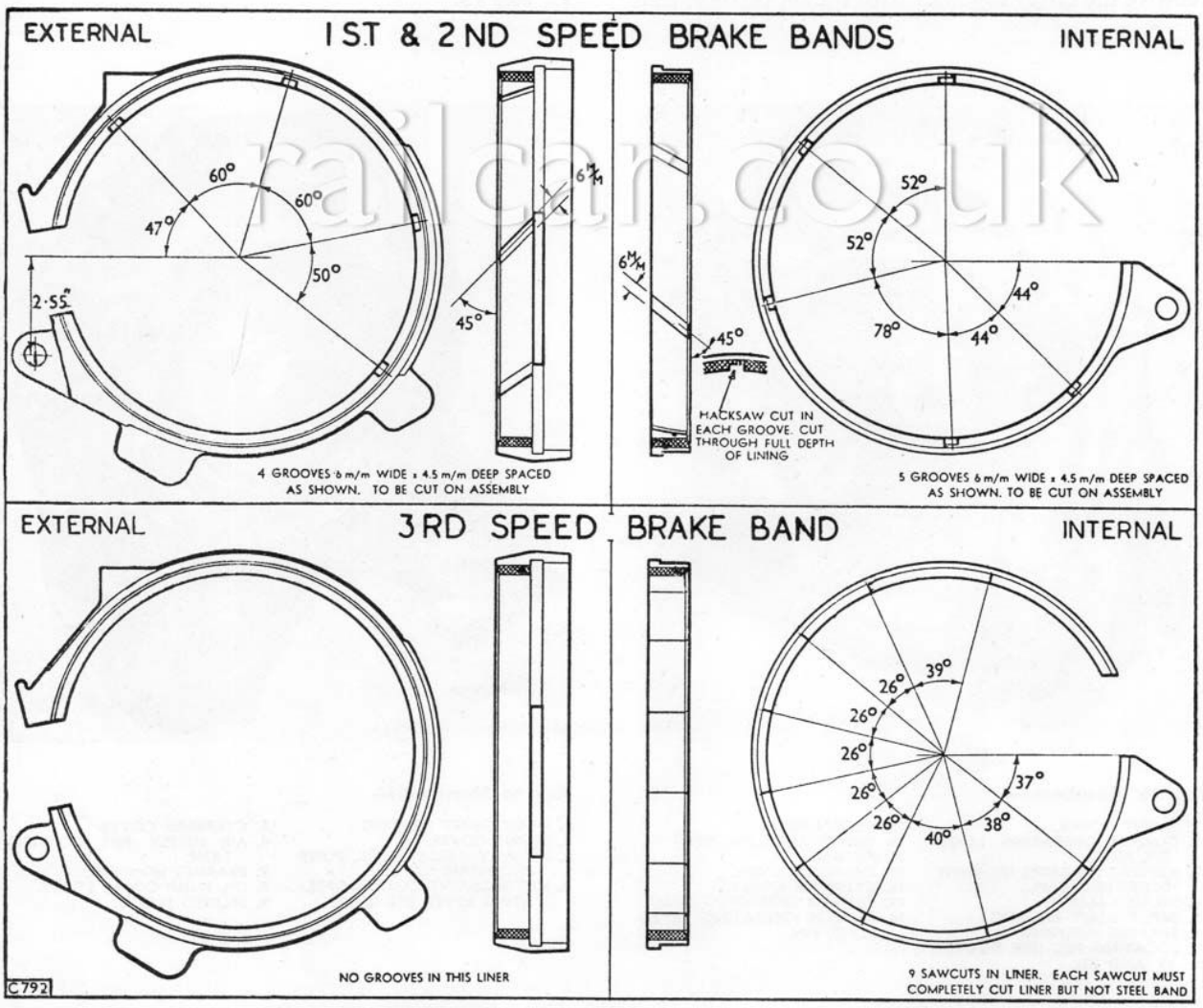


Fig. 14. Dimensions for cutting oil grooves in brake band linings.

Sect. C8. BRAKE BANDS—TO RELINE.

(*See Fig.* 14).

The brake bands will last for a considerable mileage, providing the gearbox is used with reasonable care.

It is recommended that brake bands which need relining should be removed and reconditioned ones fitted, these are obtainable through British United Traction Ltd. The old bands are returnable for credit less the cost of reconditioning.

If, however, operators undertake the work of relining the bands themselves, the following points should be noted:—

It is important that the same make and grade of lining be used on any one brake band assembly.

Use countersunk-headed aluminium rivets and make sure that all rivets are perfectly tight after the new linings have been fitted.

Cut the oil grooves in the 1st and 2nd gear linings as shown in Figure 14.

The third gear lining has a series of hacksaw cuts in the **inner** liner only (*see Fig.* 14).

Care must be taken when cutting the linings not to damage the steel bands.

Make certain that the rivet heads on the inner bands are filed down flush with the band.

Ensure that the inner band is in its correct position and that it works freely inside the outer band.

Note.— The purpose of the oil grooves is to allow the oil to escape quickly as a gear is engaged.

Sect. C9. GEARBOX—TO ASSEMBLE.

(*See Figs.* 12, 13, 15, 16, 21, 22 *and* 23).

Wash all parts in clean paraffin ensuring that all traces of jointing compound are removed from joint faces on the gearbox casing and covers, then allow them to thoroughly dry.

Examine all running gear thrust washers and bushes, also the top speed steel and friction plates.

Check the brake band linings for wear, if worn they should be renewed (*see Section* C8).

Examine the pistons and cylinder liners for scores and the piston seals for wear and renew if necessary.

Ensure that any other parts showing signs of wear are renewed.

To Assemble the Brake Bands (*see Fig.* 2).

If any of the brake bands have been dismantled, remove the appropriate centralisers and springs from the centraliser rods, taking careful note of the position of the centralisers.

With a spring in position in its centraliser, grip the ends of the spring in a vice so that more than half the spring is above the level of the vice jaws. Tighten the vice until it is possible to fit the lugs on the brake band over the ends of the spring protruding above the vice.

Slacken the vice and remove the centraliser and brake band (*see Fig.* 15). The centraliser can then be moved into any required position with the ends of its spring bearing on the inside faces of the lug.

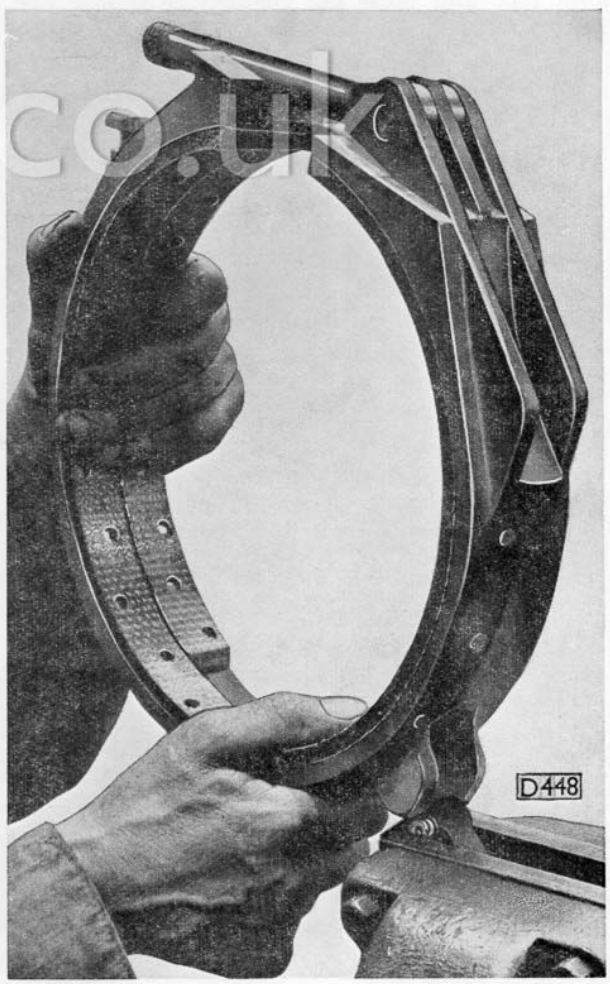


Fig. 15. Method of fitting centraliser spring.

Repeat until all centralisers and springs are in position on the brake bands which have been removed. Fit the centraliser rods and eye bolts, then split pin the ends. Place the brake band assembly in position on the bottom cover and screw up the $\frac{5}{16}$ in. B.S.F. nuts to secure.

On the other side of the brake band assembly, fit the three internal band link pins, and secure them with split pins.

Push downwards on the 1st, 2nd and 3rd speed brake bands and fit into position the six brake band hooks.

To Assemble the Bottom Cover.

If the bottom cover has been completely dismantled, proceed as follows:—

Carefully examine the cover to ensure that it is perfectly clean. Clean out any foreign matter which may have accumulated in the oil well in the base of the cover; if an air line is available apply the nozzle to one of the two oil holes drilled in the joint face and blow the channel clear (*see Fig.* 11).

With a wire brush remove all traces of jointing compound from all joint faces.

Apply non-hardening jointing compound to the oil sump cover plate and secure it to the bottom cover with the set-screws and locking wire.

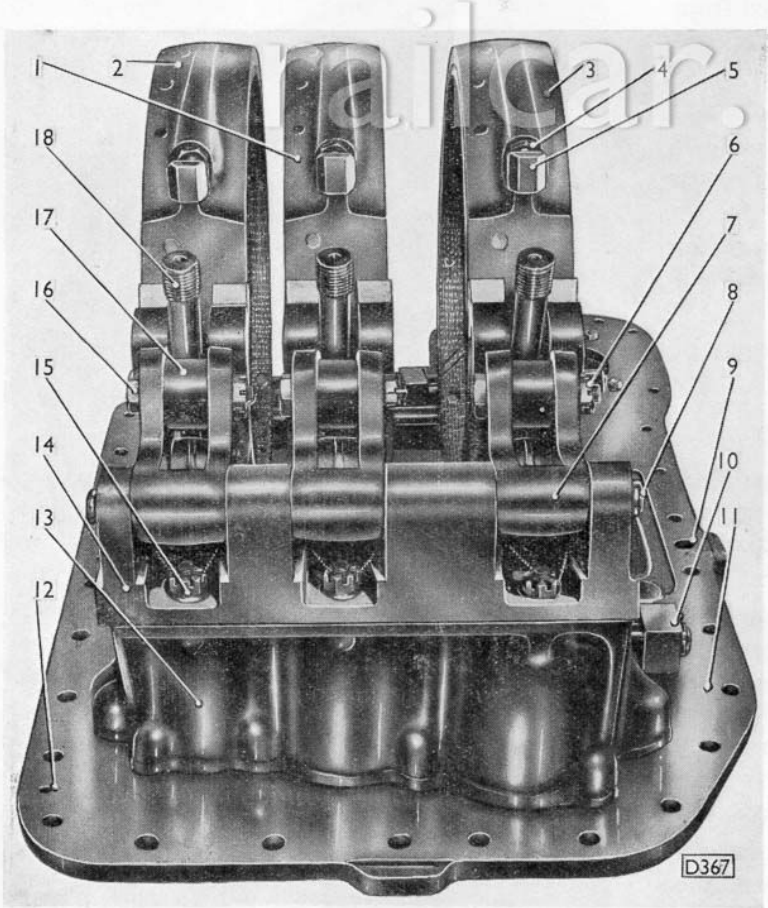
Fit the brake band hook and link assemblies to the bottom cover and secure the eye bolts with the $\frac{9}{16}$ in. B.S.F. nuts and Thackray washers.

If the small blanking plate has been removed from the bottom cover it should be fitted with a paper joint and non-hardening jointing compound; the securing bolt nuts should be on the underside of the bottom cover.

Ensure that the locating dowels (2 on each face) are fitted in the cylinder block and that the cylinder bores are in good condition.

Fit the cylinder block to the bottom cover with a new cork gasket and non-hardening jointing compound and secure with $\frac{3}{8}$ in. nuts and Thackray washers on the two short studs.

Fit the cylinder cover and secure it with $\frac{5}{16}$ in. B.S.F. slotted nuts, Thackray washers and locking wire; no joint or jointing compound is necessary.



Key to Number:—

1. SECOND SPEED EXTERNAL BRAKE BAND.
2. THIRD SPEED EXTERNAL BRAKE BAND.
3. FIRST SPEED EXTERNAL BRAKE BAND.
4. ADJUSTING SCREW LOCKNUT.
5. ADJUSTING SCREW.
6. CAM BEARING RETAINING NUT.
7. PISTON OPERATING LEVER.
8. PISTON OPERATING LEVER FULCRUM ROD.
9. OIL HOLE TO SUMP.
10. EYE BOLT FOR BRAKE BAND HOOK FULCRUM ROD.
11. BOTTOM COVER.
12. DOWEL HOLE FOR GEARBOX CASING DOWEL.
13. CYLINDER BLOCK.
14. CYLINDER BLOCK COVER.
15. CYLINDER BLOCK COVER RETAINING NUT.
16. CAM BEARING RETAINING BOLT.
17. PISTON OPERATING LEVER CAM.
18. BRAKE BAND PULL ROD.

Fig. 16. End view of bottom cover assembly showing cylinder block.

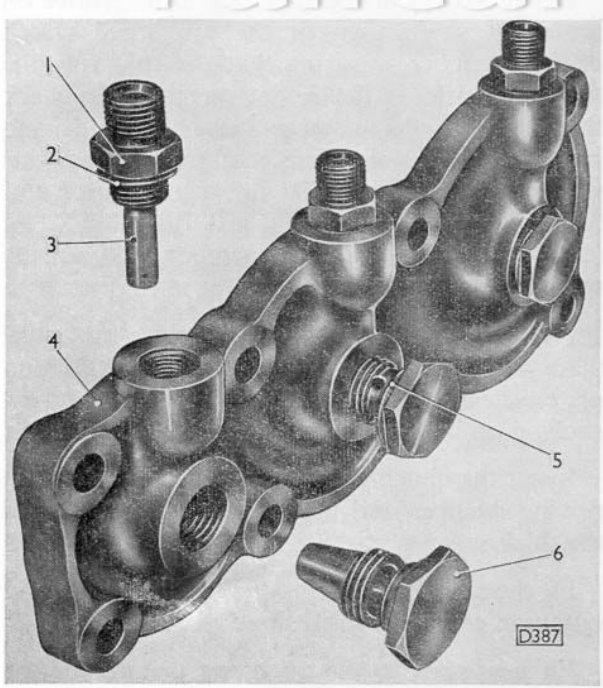
Insert the piston return springs into the 1st, 2nd and 3rd speed cylinders ensuring that they fit into the register in the cylinder cover

Fit new piston seals to the pistons, smear the pistons and cylinder bores with gear oil and fit the pistons, skirt end first, into their respective bores; the lip of the distributor seal should face toward the cylinder base plate and the lip of the oil wiper seal should face toward the cylinder cover; the two seals are interchangeable (*see Fig.* 6).

Smear the face of the cylinder base plate with oil and fit the paper joint; do not use jointing compound. Fit the base plate to the bottom cover and secure it with $\frac{3}{8}$ in. B.S.F. nuts and Grover washers.

Screw the special plugs into the cylinder base plate, one for each cylinder; care should be taken to ensure that the copper washers do not stick in the recess cut into the threads of the plug, as this will prevent the plugs from being fully tightened down, they should seat over the register provided on the plug head (*see Fig.* 17).

Ensure that the holes in the restrictor valves are clear, then fit the restrictor valves into their adaptors and screw the adaptors into the cylinder base plate (*see Figs.* 17 *and* 18).



Key to Numbers:—

1. RESTRICTOR VALVE ADAPTOR.
2. COPPER WASHER.
3. RESTRICTOR VALVE.
4. CYLINDER BASE PLATE.
5. COPPER WASHER.
6. PLUG.

Fig. 17. Cylinder base plate for 1st, 2nd and 3rd speed cylinders.

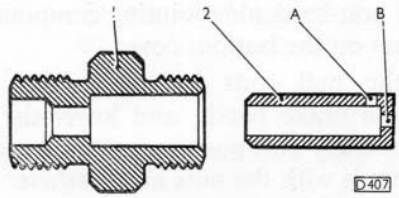


Fig. 18. Restrictor valve and adaptor.

Note.— The diameter of the restrictor holes in the 1st speed valve are larger than those in the 2nd and 3rd speed valves, and care must be taken to ensure that the valves are fitted to the correct cylinders. 1st speed valves have "1" "R" and 2nd and 3rd speed valves have "2" "3" respectively, etched on their ends.

If any of the piston rod and operating lever assemblies have been dismantled, they should be assembled as follows:—

Ensure that the dowel is in the piston rod link pin, fit one circlip to the pin on the same end as the dowel, then fit the piston rod to the operating lever and secure with the link pin; ensure that the dowel fits into its groove. Fit the remaining circlip.

Examine the needle rollers in the operating lever cam bearing and renew if necessary. Pack the needle rollers into the inner and outer races with grease.

Fit the bearing into the operating lever and secure it with the bearing bolt, slotted nut and split pin; the head of the bolt should be on the same side of the operating lever as the piston rod link pin dowel.

The bearing must be able to rotate freely.

Insert the piston rods into the pistons through the cylinder cover, fit the operating levers to the cylinder cover and insert the lever shaft, then secure the shaft with split pins.

To Fit the Gearbox Casing to the Bottom Cover.

Examine the gearbox casing to ensure that it is perfectly clean. If an air line is available apply the nozzle to the oil hole leading to the oil transfer box and blow the channel clear.

Ensure that all traces of jointing compound is removed from the joint faces.

Apply non-hardening jointing compound to the joint faces on the bottom cover.

Lift the pull rods into a vertical position against the brake bands, and lower the gearbox casing carefully into position on the bottom cover and secure it with the nuts and washers.

Fit the drain plug to the bottom cover and wire it to one of the cover fixing nuts.

Fit the thrust pads, platforms, adjuster rings, adjuster nuts and springs to the brake band pull rods; ensure that the adjuster nuts are an easy fit on the pull rod threads.

To Assemble the Running Gear.

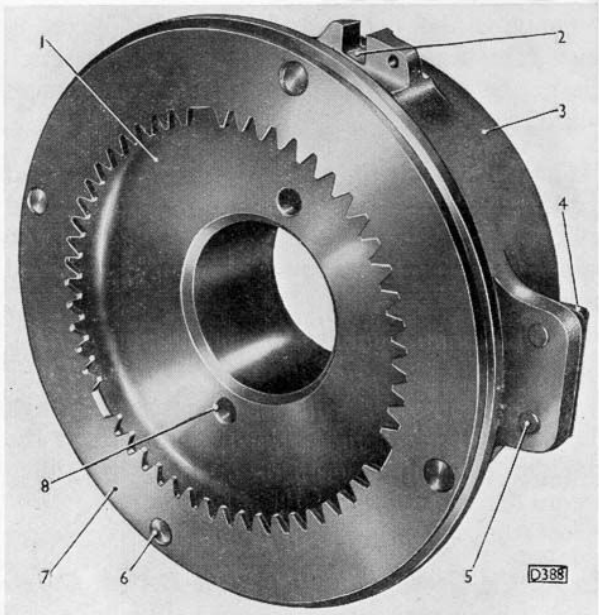
Ensure that all parts are perfectly clean, then place the input shaft into a suitable adaptor or fixture.

All parts should be lightly smeared with oil on their working surfaces before assembling.

Fit the 3rd speed sun wheel rear bush to the input shaft.

Fit the 2nd speed brake drum with the 3rd speed planet carrier and drum bush.

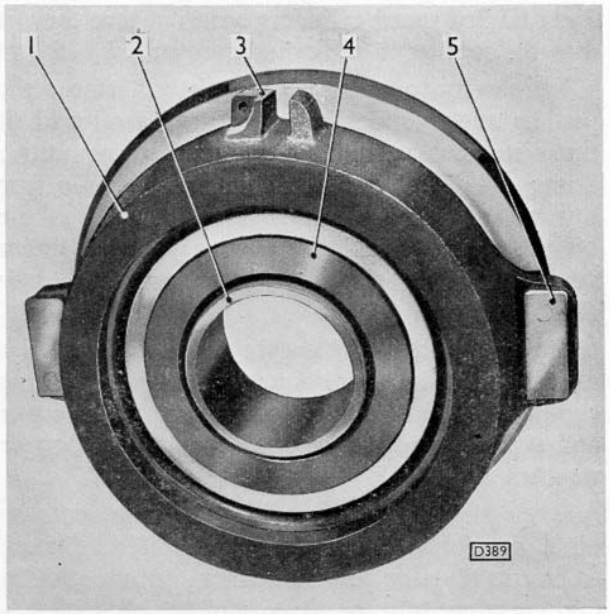
Fit the 3rd speed brake drum and the sun wheel front bush.



Key to Numbers:—

1. SLIDING MEMBER.
2. SLOT FOR LOCATING PEG IN FRONT COVER (AT BOTTOM WHEN FITTED, SEE No. 7 ON FIGURE 12).
3. THRUST RING AND BEARING HOUSING.
4. PRESSURE PAD.
5. PRESSURE PAD RIVET.
6. CLUTCH PLATE RIVET.
7. CLUTCH PLATE.
8. HOLE FOR INSERTING DRIFT WHEN REMOVING THRUST BEARING.

Fig. 19. Rear view of top speed clutch sliding member assembly.



Key to Numbers:—

1. THRUST RING AND BEARING HOUSING.
2. SLIDING MEMBER.
3. SLOT FOR LOCATING PEG IN FRONT COVER (AT BOTTOM WHEN FITTED, SEE No. 7 ON FIGURE 12).
4. THRUST BEARING.
5. PRESSURE PAD.

Fig. 20. Front view of top speed clutch sliding member assembly.

Fit the halves of the split ring to its groove on the input shaft, then fit the top speed clutch driving member, ensuring that the split ring fits into the register in the driving member. To check this, measure the distance between the driving member and the oil pump eccentric keyway, this should be between 0·500 in. (12·70 mm.) and 0·625 in. (15·87 mm.), if less than 0·500 in. (12·70 mm.) the driving member will not be seating on the split ring correctly.

Fit the clutch plates, friction plate and steel plate alternately, commencing with a friction plate, smearing each plate with oil to prevent sticking on initial operation.

Insert the clutch springs into their holes in the driving member and fit the sliding member and the thick spacing washer.

Fit the key, for retaining the bearing sleeve and oil pump eccentric, to the input shaft.

Fit new seals to the operating pistons for the top speed clutch, the lip of each distributor seal should face toward the cylinder cover and the lip of each oil wiper seal should face toward the piston rod; the two seals are interchangeable (*see Fig.* 6).

Assemble the front cover reversing the procedure for dismantling (*see Section* C7).

Ensure when fitting the cylinder covers that new joints are fitted.

Fit the front cover assembly to the input shaft, ensuring that the locating pin in the cover enters its slot in the top speed thrust ring.

Fit the oil pump eccentric to the input shaft.

Examine the oil seal in the oil pump cover and if worn or damaged it should be renewed.

Smear the parts with oil and assemble the oil pump into its cover. Apply non-hardening jointing compound to the joint face of the input cover, fit the assembly to the gearbox front cover and shaft and secure with the nuts and washers.

Fit a new oil sealing ring to the input shaft, then fit the input shaft coupling flange and washer and secure it with the nut and split pin.

Remove the running gear assembly from its adaptor or fixture and stand it on its coupling flange on a suitable fixture (*see Fig.* 22).

To Fit the Output Shaft.

Fit the large and small bushes to the input shaft.

Fit the output shaft together with the 1st speed brake drum, the 2nd speed annulus and planet carrier, to the input shaft (*see Fig.* 23).

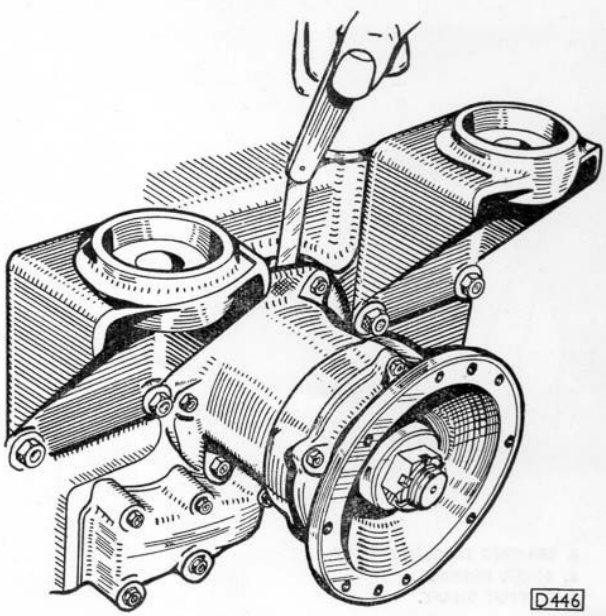
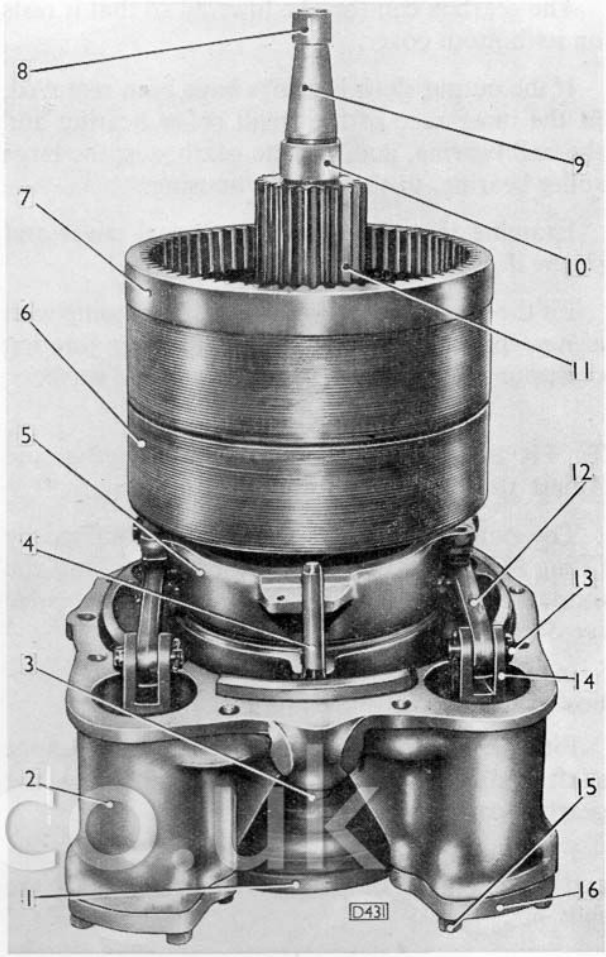


Fig. 21. Method of measuring gap for shimming running gear end clearance.



Key to Numbers:—

1. INPUT SHAFT COUPLING FLANGE.
2. FRONT COVER.
3. AIR PIPE CONNECTION.
4. SLIDING MEMBER LOCATING PEG.
5. TOP SPEED CLUTCH SLIDING MEMBER.
6. THIRD SPEED BRAKE DRUM.
7. SECOND SPEED BRAKE DRUM.
8. INPUT SHAFT INNER BUSH.
9. INPUT SHAFT.
10. INPUT SHAFT OUTER BUSH.
11. FIRST SPEED SUN WHEEL.
12. TOP SPEED CLUTCH OPERATING LEVER.
13. FULCRUM PIN.
14. PISTON ROD.
15. CYLINDER COVER NUT.
16. CYLINDER COVER.

Fig. 22. Running gear assembly.

To Fit the Running Gear and Output Shaft.

Apply non-hardening jointing compound to the joint face of the front cover.

With the running gear assembled in the position shown in Figure 22, lift the gearbox casing assembly, complete with brake bands in position, and lower it carefully over the running gear.

Line up the studs in the main casing with their mating holes in the front cover and carefully lower the casing into position and secure with the nuts and washers.

The gearbox can then be lowered so that it rests on its bottom cover.

If the output shaft bearings have been removed, fit the inner race of the small roller bearing and the ball bearing, and, on late gearboxes, the large roller bearing, to the bearing housing.

Examine the oil seal in the oil seal cover and renew if necessary.

Fit the oil seal cover to the bearing housing with a new paper joint and non-hardening jointing compound and secure it with the nuts and washers.

To Fit the Output Shaft Bearing Housing and Adjust the Running Gear End Clearance.

The running gear end clearance is obtained by fitting shims between the gearbox casing and the output shaft bearing housing (*for shims available see Section* C10).

Insufficient end clearance may result in the gearbox overheating (*see Section* C4).

Fit the bearing distance piece to the output shaft and the bearing housing assembly to the gearbox casing, **omitting the shims.**

Fit the coupling flange, tighten the retaining nut and locate the split pin hole; **do not yet fit the split pin.**

Fit the bearing housing retaining nuts and tighten them evenly in succession, meanwhile turning the output shaft by hand. Continue tightening the nuts until the bearings just nip and the output shaft cannot be turned by hand.

Insert a feeler gauge into the gap between the joint faces of the gearbox casing and the bearing housing and measure the gap (*see Fig.* 21).

Remove the coupling flange and bearing housing and insert shims to equal this measurement plus 0·020 in. (0·508 mm.), this will give the running gear an end clearance of 0·020 in. (0·508 mm.).

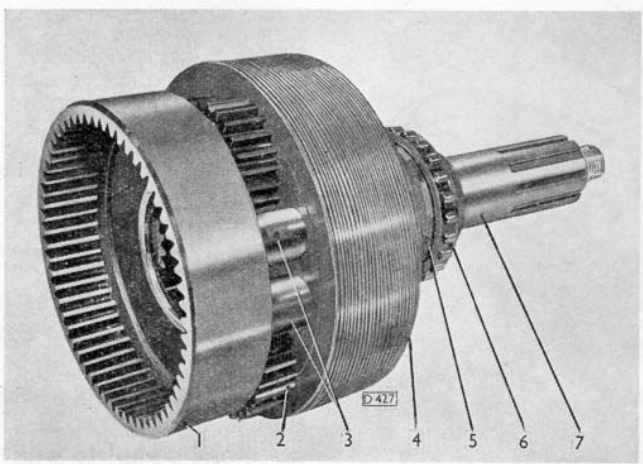
When the correct end clearance has been obtained, fit a new oil sealing ring to the output shaft, then refit the bearing housing and secure it with the nuts and washers.

Fit the coupling flange, tighten the retaining nut and fit the split-pin.

Adjust the brake bands following the instructions given in Section C3.

Fill the gearbox with oil to the level mark on the dipstick (*see Section* C4).

Apply non-hardening jointing compound to the inspection covers, and fit them to the top of the gearbox casing.



Key to Numbers:—

1. SECOND SPEED ANNULUS.
2. PLANET WHEEL.
3. DISTANCE PIECES.
4. FIRST SPEED DRUM.
5. BEARING DISTANCE PIECE.
6. INNER BEARING.
7. OUTPUT SHAFT.

Fig. 23. Output shaft assembly.

Sect. 10. DIMENSIONS OF SHIMS AVAILABLE.

Shim, Output Shaft Bearing Housing.		
Part No.	**Thickness.**	
Z2/46409	0·0004 in. (0·010 mm.)	Early gearboxes.
Z2/46410	0·0012 in. (0·030 mm.)	
Z2/46411	0·0004 in. (0·010 mm.)	Late gearboxes.
Z2/46412	0·0012 in. (0·030 mm.)	

GEARBOX

CHAPTER S

CONTENTS

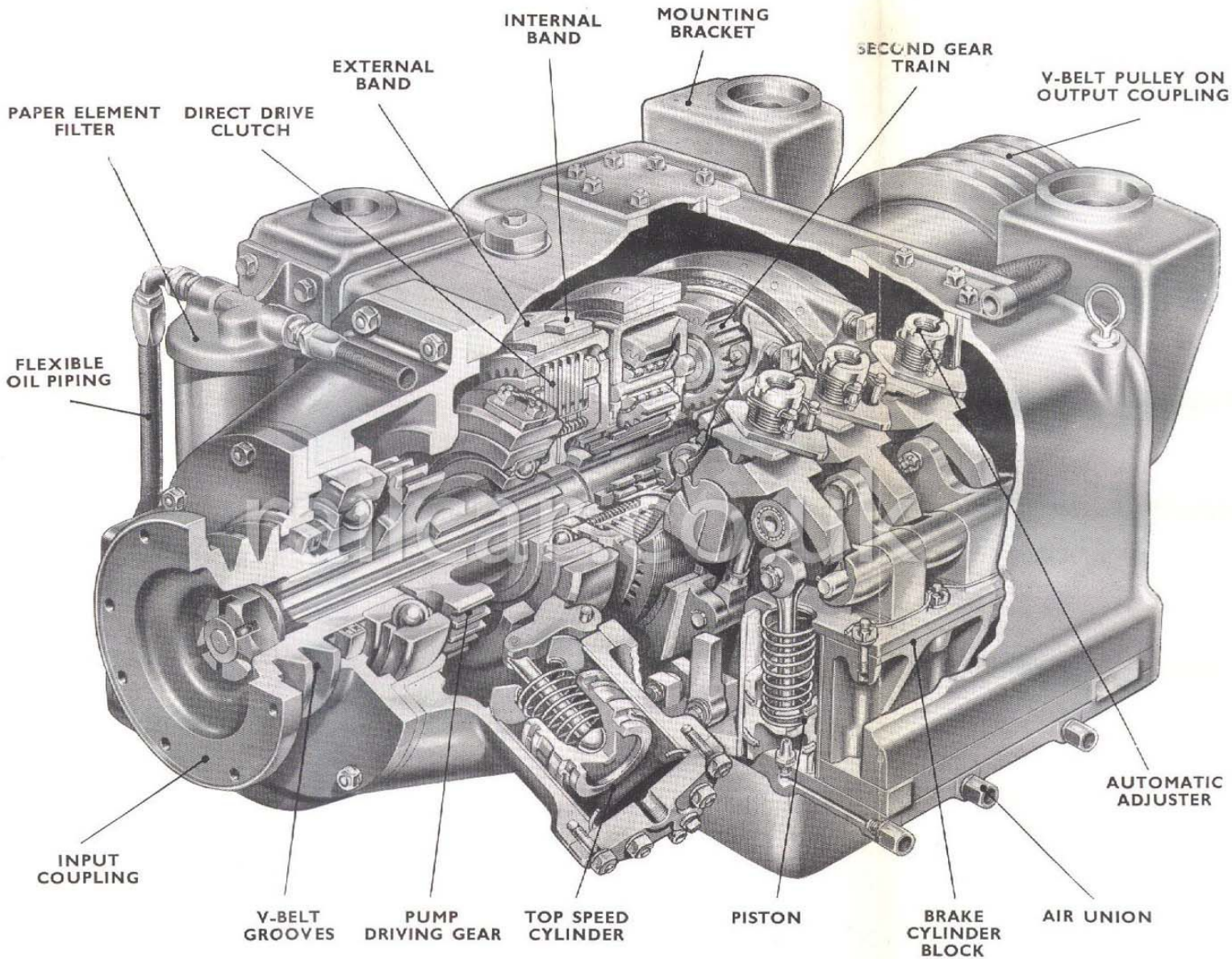


Fig. 1. The Gearbox.

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.

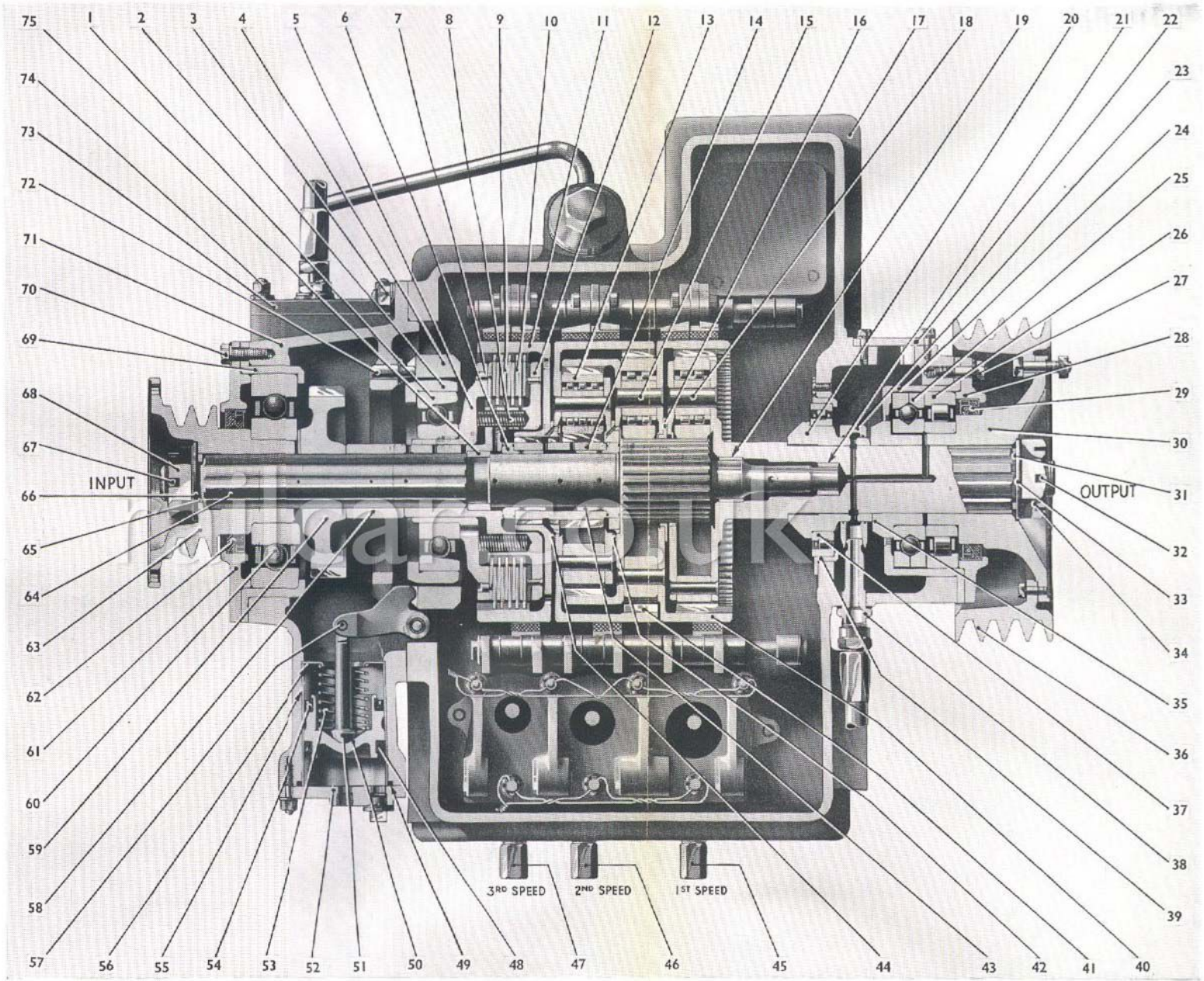


Fig. 2. Section through Gearbox.

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.

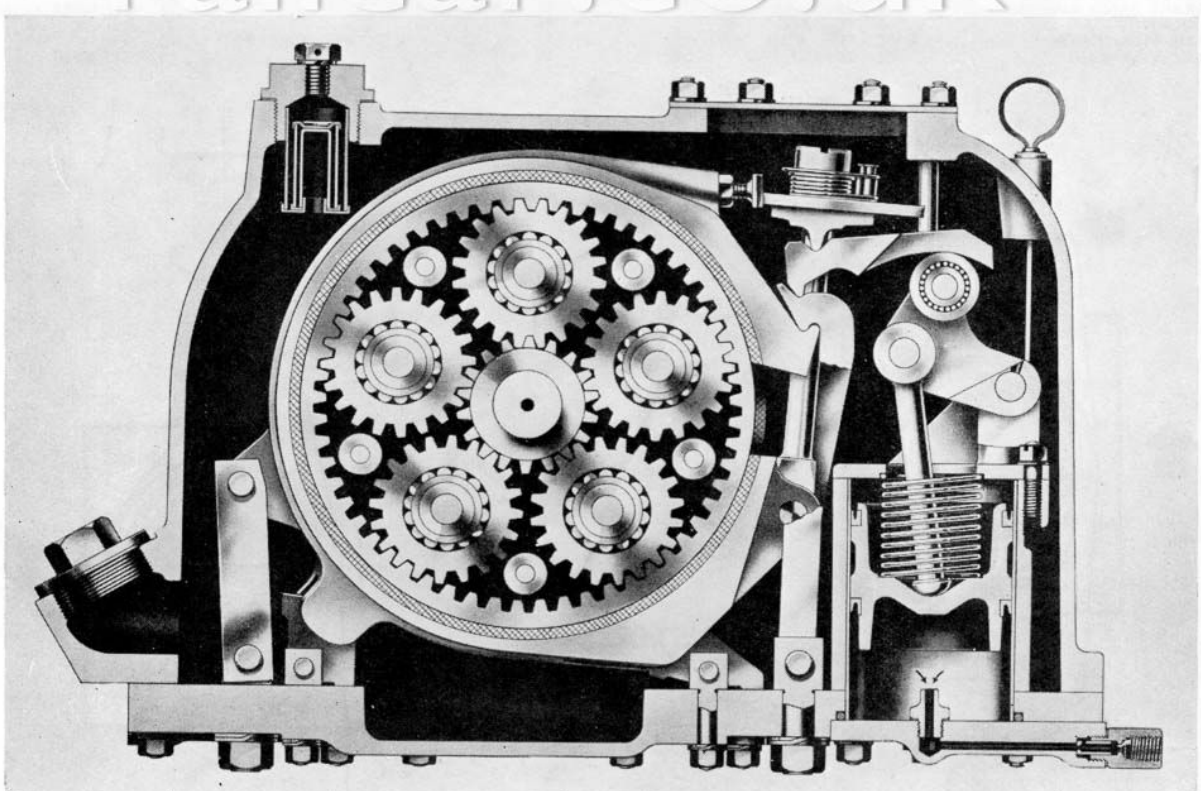


Fig. 3. Section through 1st Speed Band Brake. (Brake On)

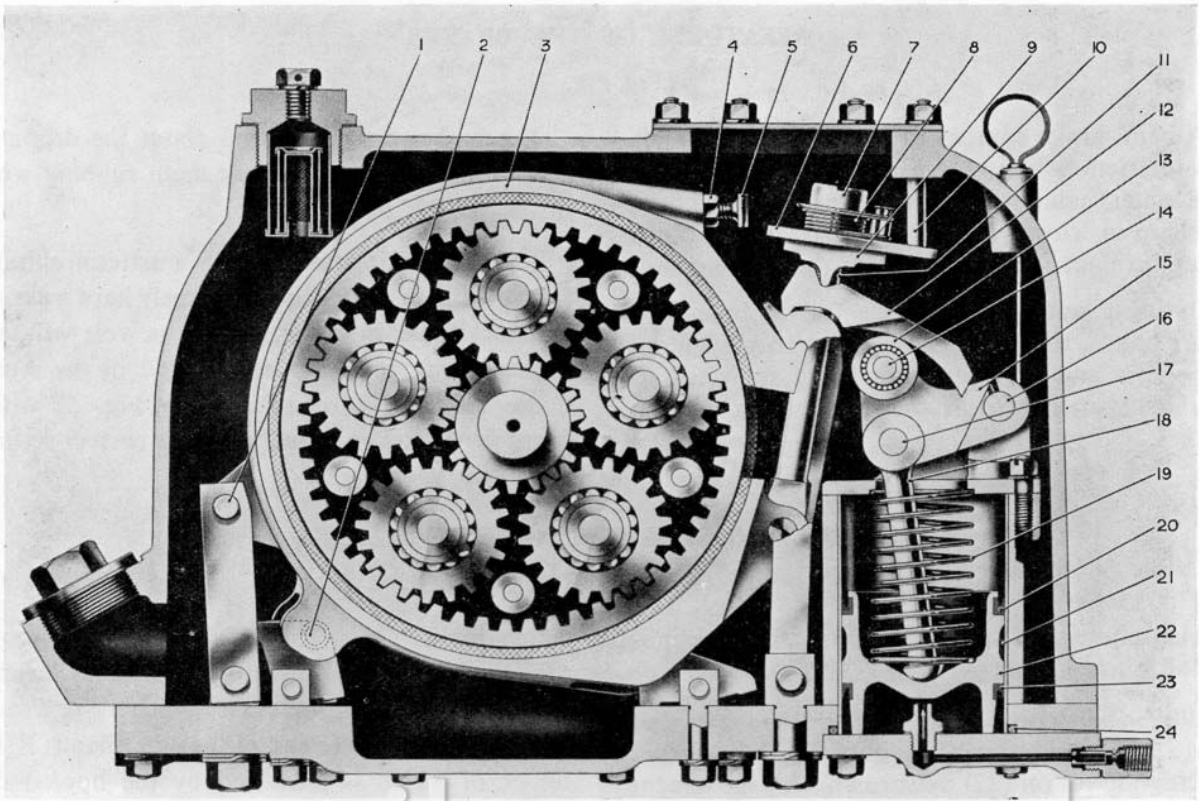


Fig. 4. Section through the 1st Speed Band Brake. (Brake Off)

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 (long)
17. BEARING PIN, DOWEL, CIRCLIP
18. PISTON ROD
19. PISTON SPRING
20. SEAL
21. CYLINDER LINER
22. PISTON
23. SEAL
24. "O" RING

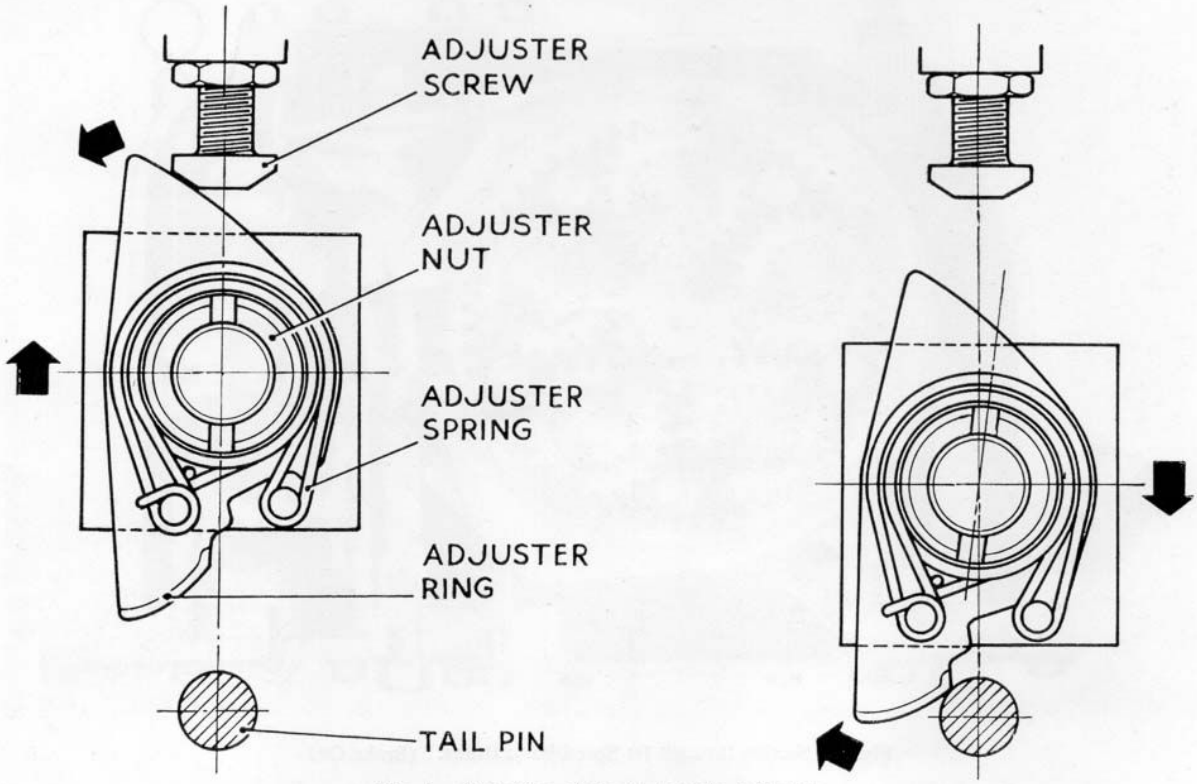


Fig. 5. Operation of the Automatic Adjuster.

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)

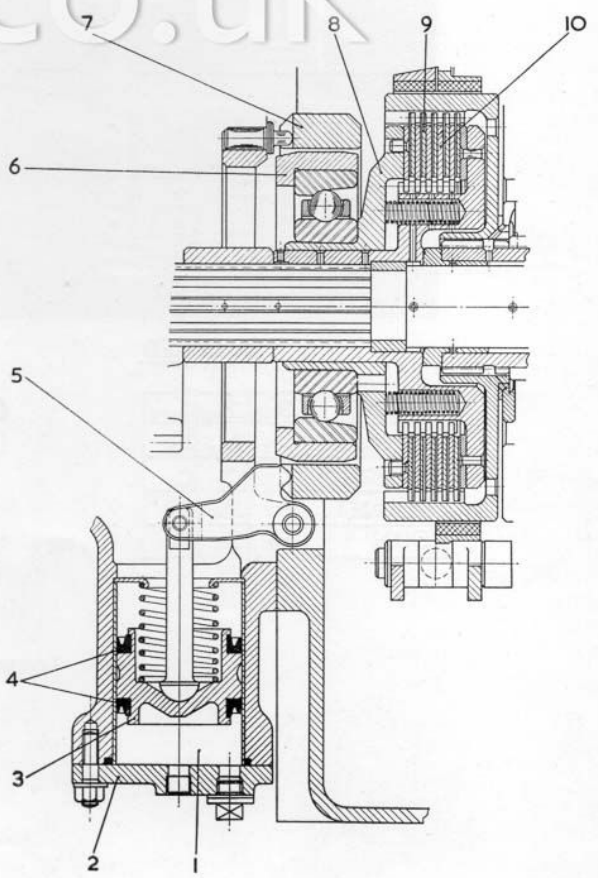
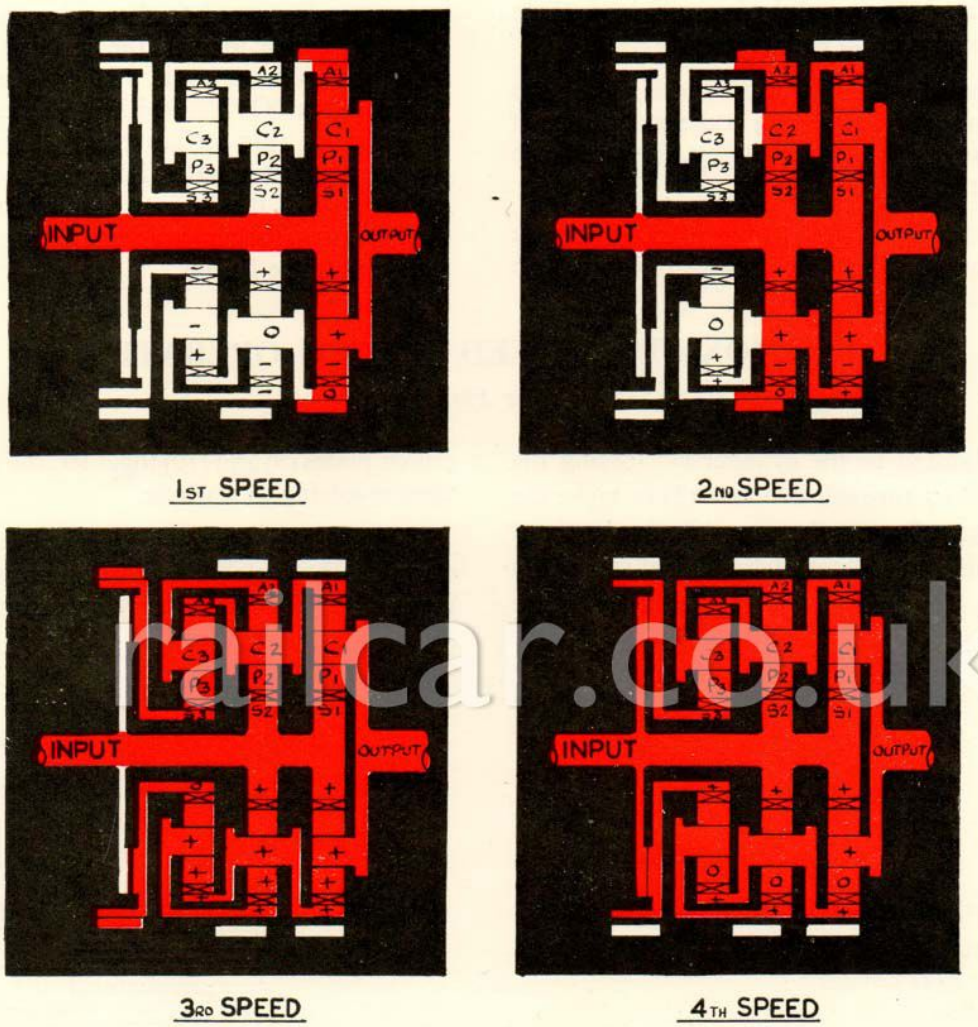


Fig. 6. Top Speed Clutch Actuation.



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)

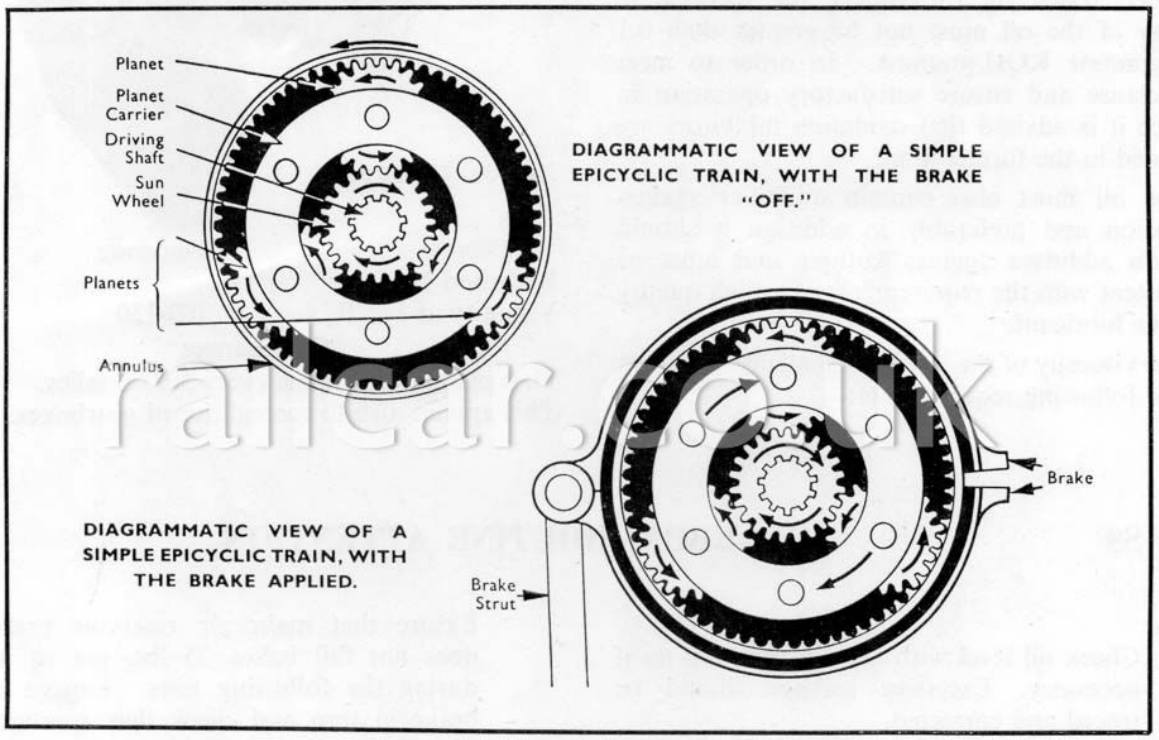


Fig. 8. Diagrammatic View of Epicyclic Gear Train.

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:—

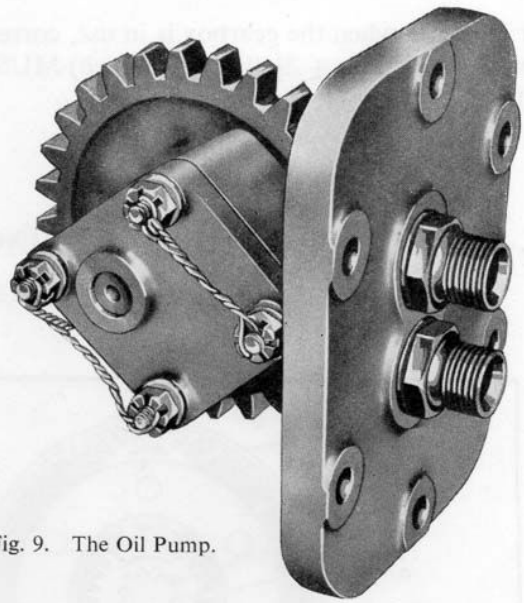


Fig. 9. The Oil Pump.

	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.

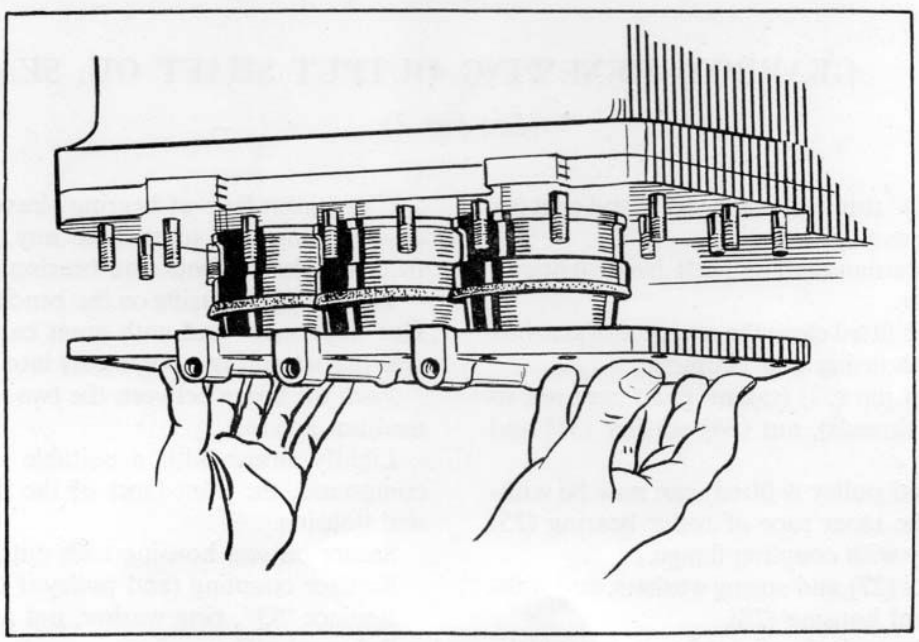


Fig. 10. Removing the Cover Plate (1st, 2nd & 3rd Speeds).

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.

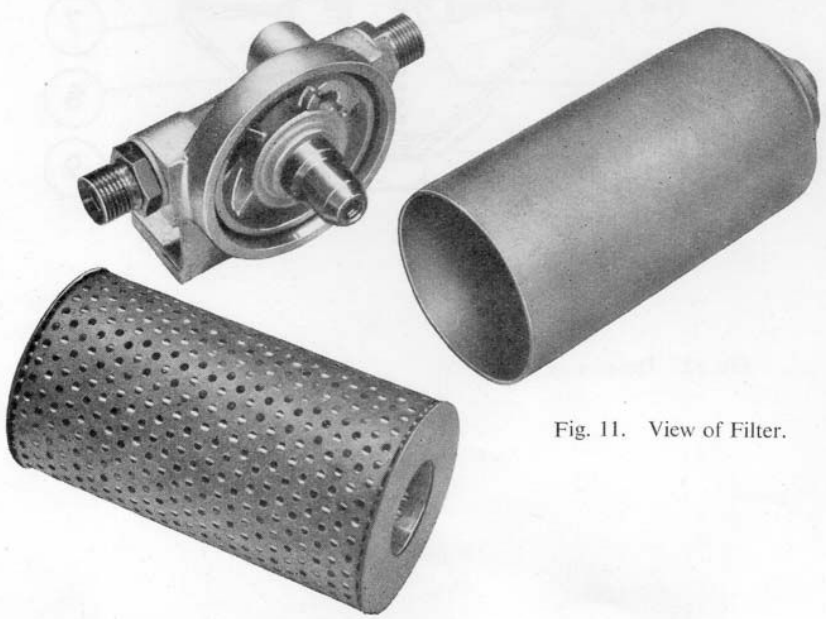


Fig. 11. View of Filter.

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).

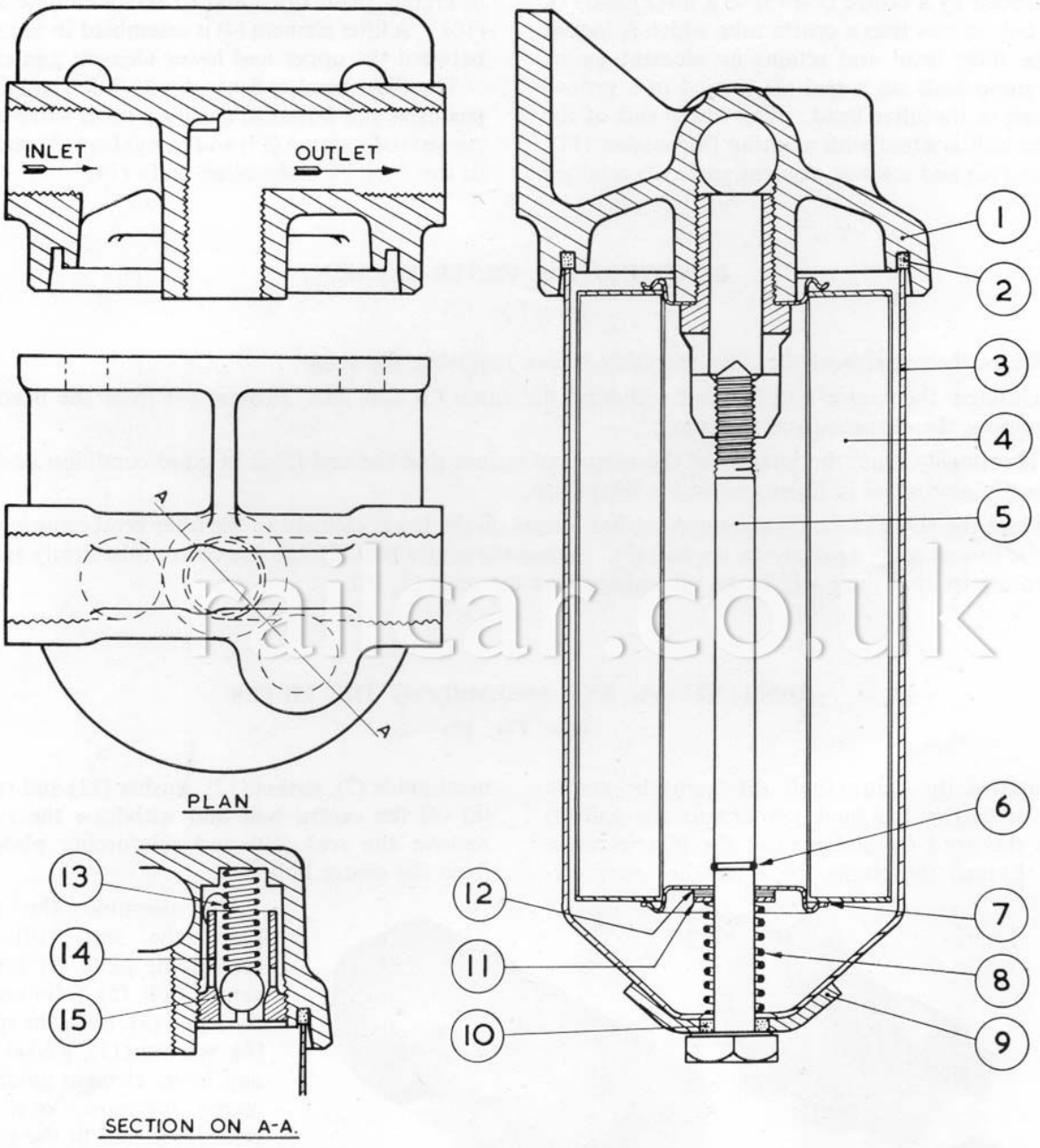


Fig. 12. Drawing of Filter.

Sec. S14 GEARBOX—SERVICING THE BRAKES

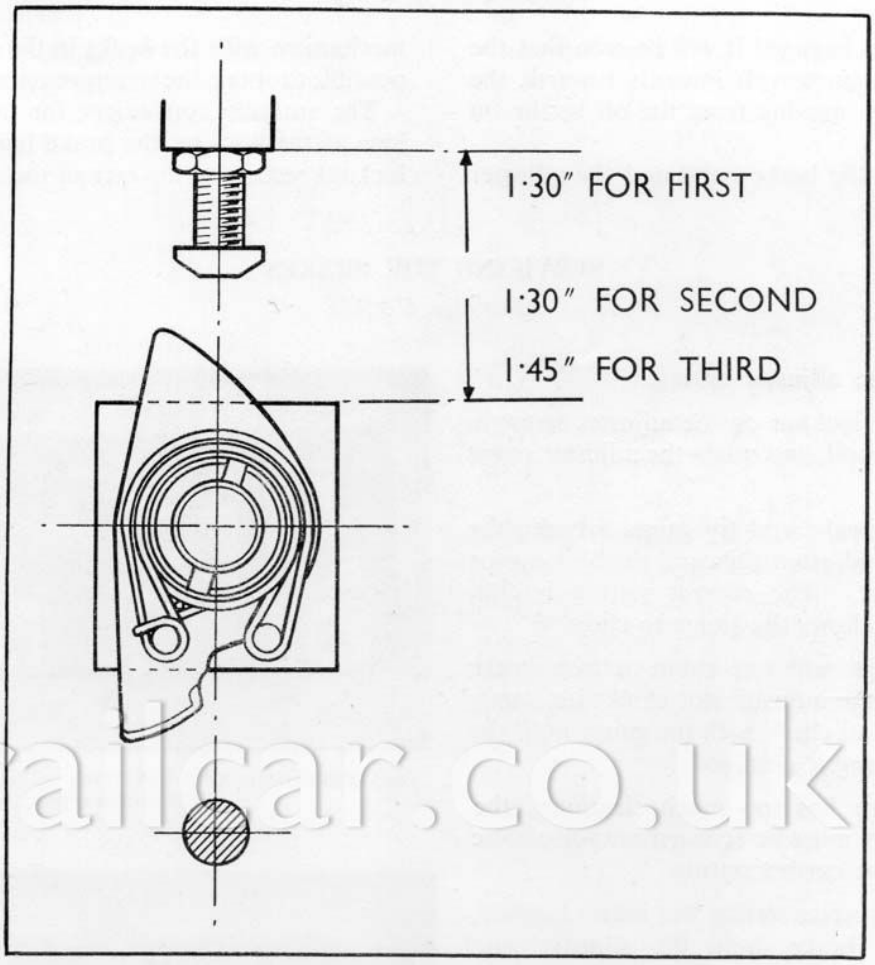


Fig. 13. Brake setting Dimensions

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.

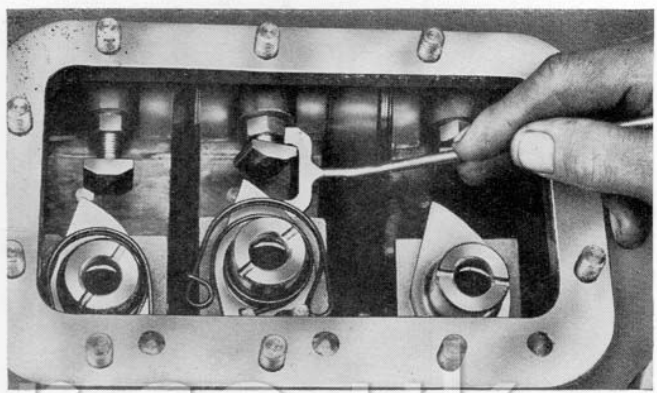


Fig. 14 GAUGE APPLICATION. This shows where the gauge should be applied.

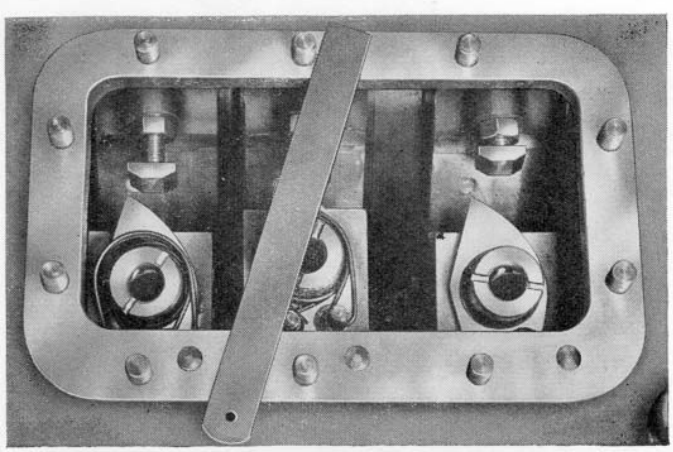


Fig. 15. Checking Movement of Adjuster Nut

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.

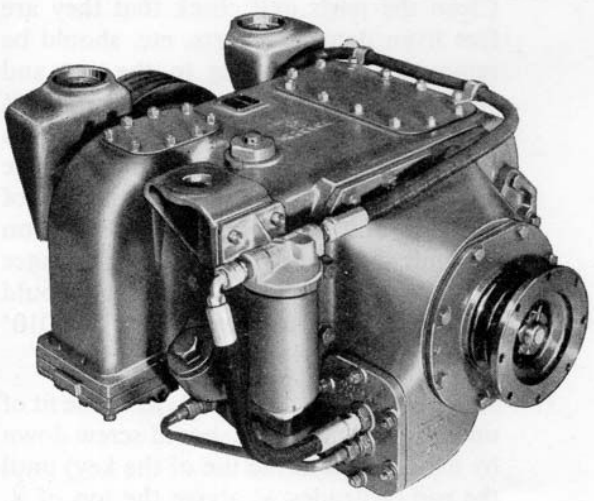


Fig. 16. View of Gearbox (a).

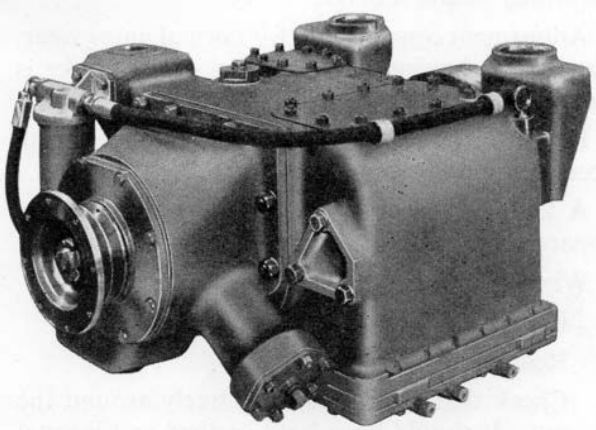


Fig. 17. View of Gearbox (b).

Sec. S16 GEARBOX—TO DISMANTLE

(*See Fig.* 4)

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

Support the gearbox on a suitable bench.

Check the necessity for relining the brakes by observing the position of the adjuster nut (7) on the pull rod (11). Brake life is exhausted when the top faces of the adjuster nut and pull rod coincide.

Preparatory to removing the running gear the three brake adjuster mechanisms must be slackened off. Access to the adjusters is obtained by removing the large inspection cover on top of the gearcase.

Remove the two eyes of each adjuster spring (8) from the ring pin (6) and the loop from the table pin (9) to release the adjuster nut (7) this should then be screwed three complete turns anti-clockwise.

REMOVE REAR END ASSEMBLY

(*See Fig.* 2)

Take off split pin (32) nut (34) and washer (33) followed by the "O" ring (31).

Next remove the output coupling (30) complete with pulley (36) (if fitted) and inner race of bearing (26).

Remove nuts (27) and spring washers from the studs, and take away the oil seal housing (28) with oil seal (29).

Using special extractor tools (Part No. 37428) withdraw the bearing sleeve (24) complete with outer race of bearing (26) bearing (25) and bearing collar (35).

There should be no necessity to disturb the cover plate (22). Next unscrew the oil union (38) out of the gearcase together with its copper washer; the oil muff (23) can then be removed from the bearing collar (20).

TO REMOVE FRONT COVER, etc.

(*See Fig.* 2)

Remove nuts (74) and the washers from studs, then remove oil pump assembly and gasket from the front cover (71).

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.

Take from the input shaft (64) the pump driving gear (59) and sleeve (58).

Remove nuts (3) and spring washers securing the front cover (71) to the gearcase (17) this includes those situate in the pump mounting aperture. The front cover can then be taken away complete with the top speed piston (50), etc.

Note. Do not disturb pivot pin (72).

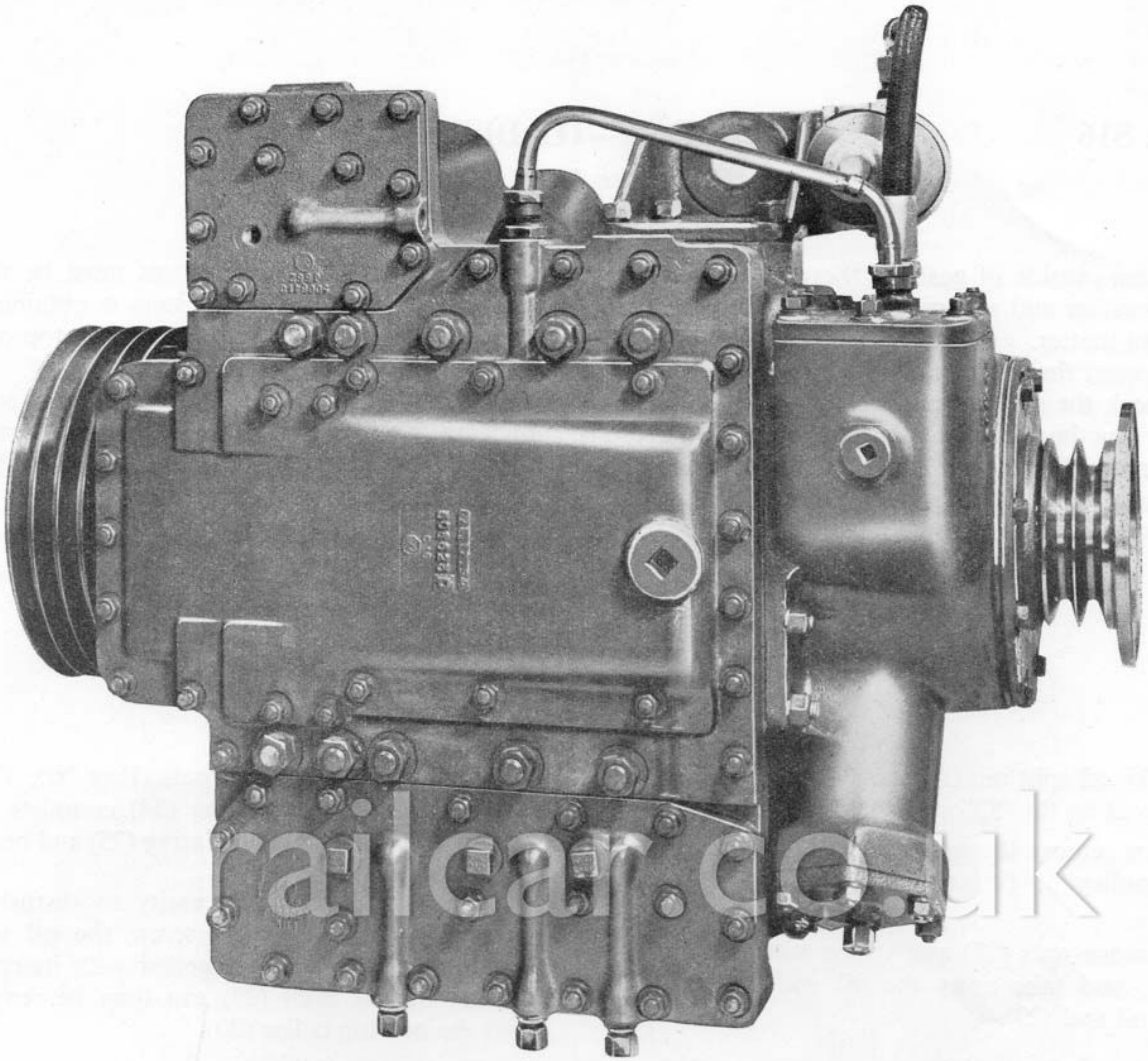


Fig. 18. View of the Bottom Cover, etc.

DISMANTLING THE RUNNING GEAR

(*See Fig.* 2)

Remove the bearing (1) bearing housing (2) trunnion ring (4) and the clutch sliding panel (5). The bearing housing and trunnion ring should be left assembled on the bearing unless a replacement is necessary.

Take out the clutch return springs (8), and spigot pins and remove the clutch inner member (12) complete with clutch plates (9-10). The split ring (75) can then be removed from the shaft (ensure removal of both halves).

The following components should next be removed, in the order given:—

Bush (6)

3rd speed brake drum (11), with Sunwheel (14) (Assembly)

Bush (44)

3rd Speed Planet assembly (13)

Bush (42)

Bush (43)

Input shaft (64)

2nd Speed Planet assembly (15)

Adjusting washer (16)

Bushes (19 and 21)

1st Speed Planet assembly (18) with output shaft assembly. Withdraw this centrally to avoid damage to surrounding parts.

The bearing collar (20) together with the inner race of bearing (37) can then be removed; the bearing outer race, together with the bearing housing (39) can be left in position unless replacement is necessary.

REMOVAL OF GEARCASE FROM BOTTOM COVER

(*See Fig.* 18)

From their studs unscrew all the nuts securing the bottom cover to the gearcase and lift the gearcase away, leaving the bottom cover, complete with brake bands, brake actuating mechanism and the air cylinders.

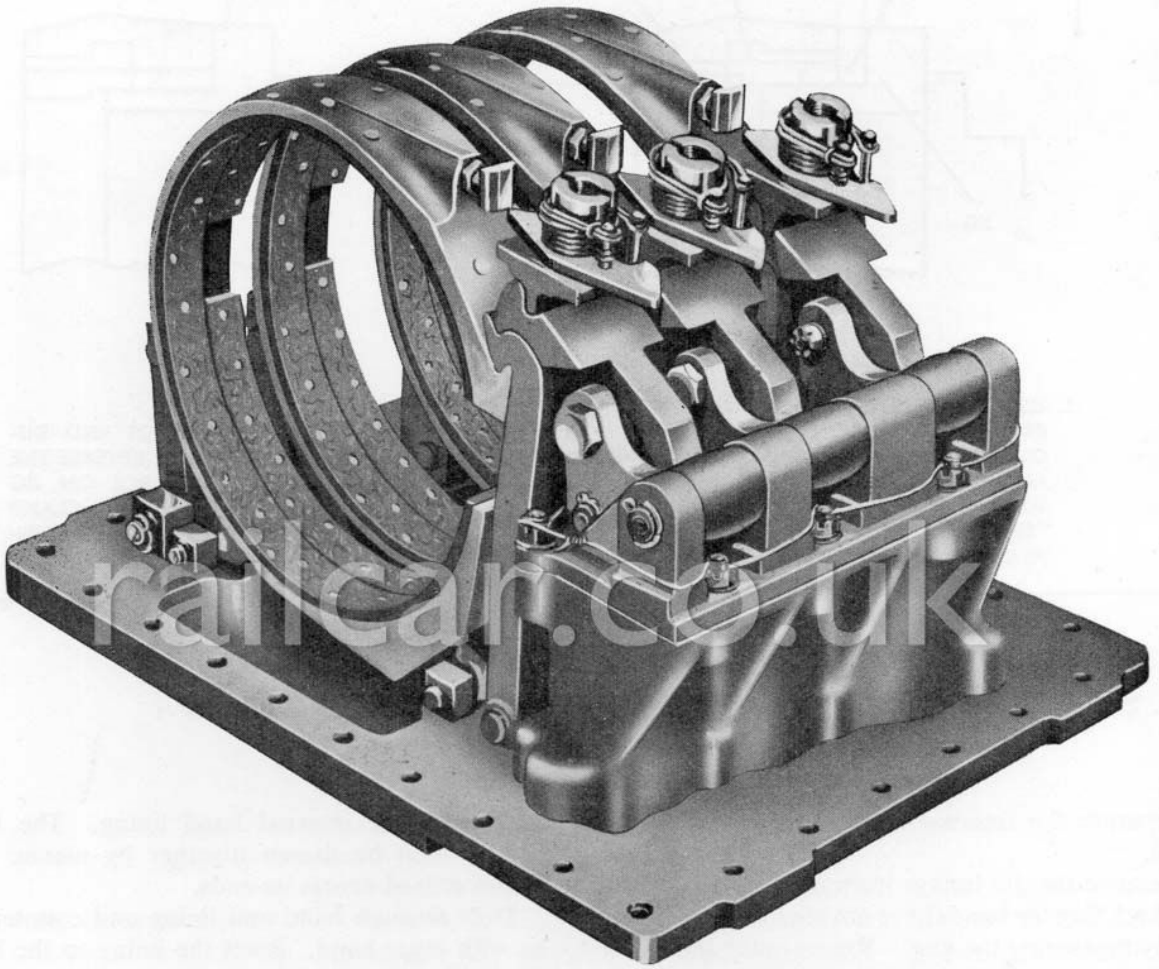


Fig. 19. The Bottom Cover and Brake Band Assembly

REMOVAL OF BRAKE BANDS

(*See Fig.* 4)

Remove the adjuster spring (8), nut (7), ring (6), table (9) and thrust pad (12) from each brake. It is advisable to keep these in sets for subsequent re-assembly to the same band.

Press down on top of each brake band (3) to release the hooks. Take out the split pins from the internal band link pins (1) and extract the pins.

Lift the bands away, first placing rag round the centralizers to prevent the springs (2) from flying out.

EXTRACTING THE PISTONS

Refer to Section S10 for removal of pistons.

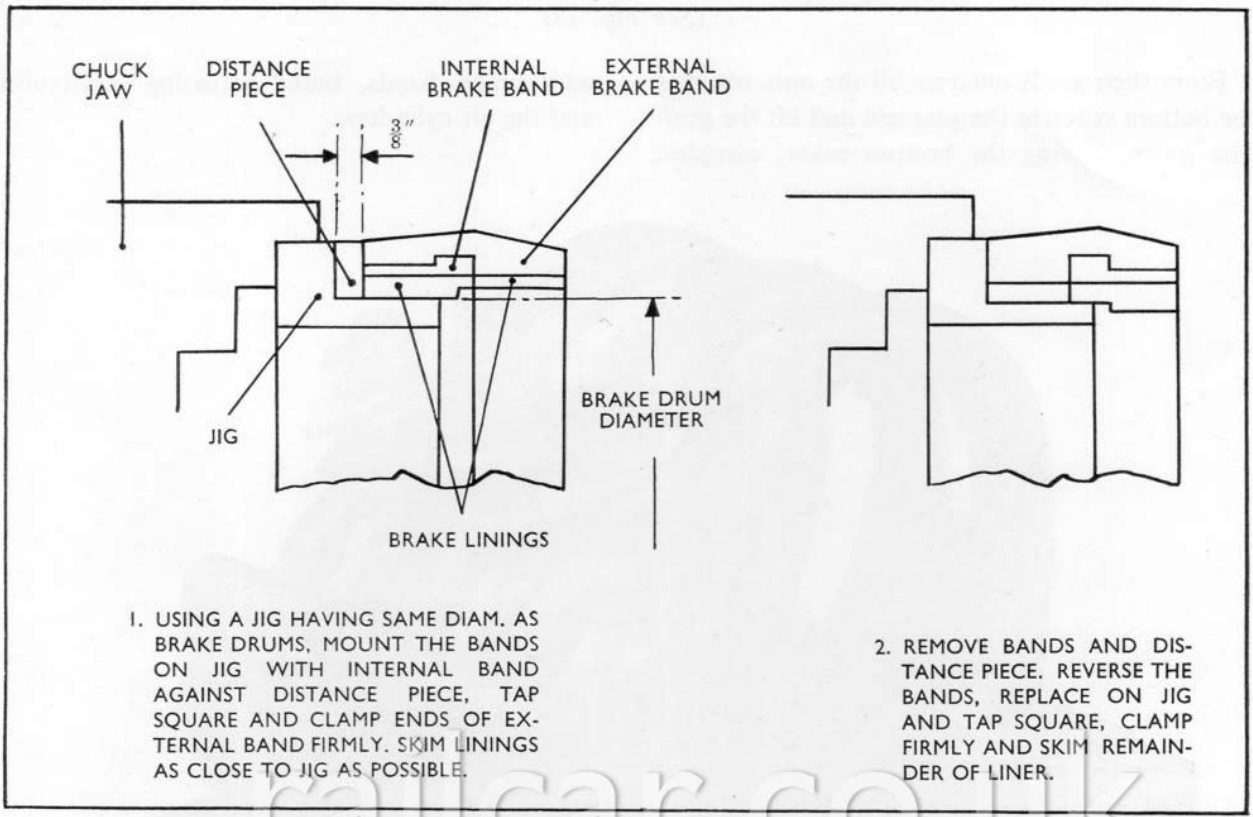


Fig. 20. Relining the Brake Bands.

Sec. S17 GEARBOX—RELINING THE BRAKE BANDS

(*See Fig.* 20)

Separate the internal band from the external band.

Remove the old linings from the bands.

Check that the bands have not taken a permanent set by measuring the gap. Renew outer and inner band if gap is less than 2.0".

To replace the internal lining, first cut through it and place it in the band securing with clamps. Next drill through the band and lining using an $\frac{11}{64}$" drill.

Countersink to $\frac{5}{32}$" depth the holes in lining using a $\frac{11}{32}$" tungsten carbide tipped drill (90° included angle). Rivet the lining to the internal band and file flush. (Important).

Trim lining at extreme ends level with brake band, ensure also that the lining is flush at the lug side.

Position the new lining in the external band, ensuring the lining is level at the edge that will mate with the internal band lining. The band should then be drawn together by means of a clamp affixed across its ends.

Drill through band and lining and countersink as with inner band. Rivet the lining to the band leaving out the two end rivets.

Cut the lining and release the clamp, rivet the ends of the lining. The lining should then be trimmed at the ends, level at the lug end and leaving a $\frac{1}{8}$" projection at the other end.

File the rivets level to the band on the machined surface.

After relining, the lug on the internal band is led through its slot in the external band and the free end again pushed toward the centre, when the band will slip easily into position.

The linings are then skimmed up as shown in Fig. 20, the bands can then be replaced as explained in Section S18.

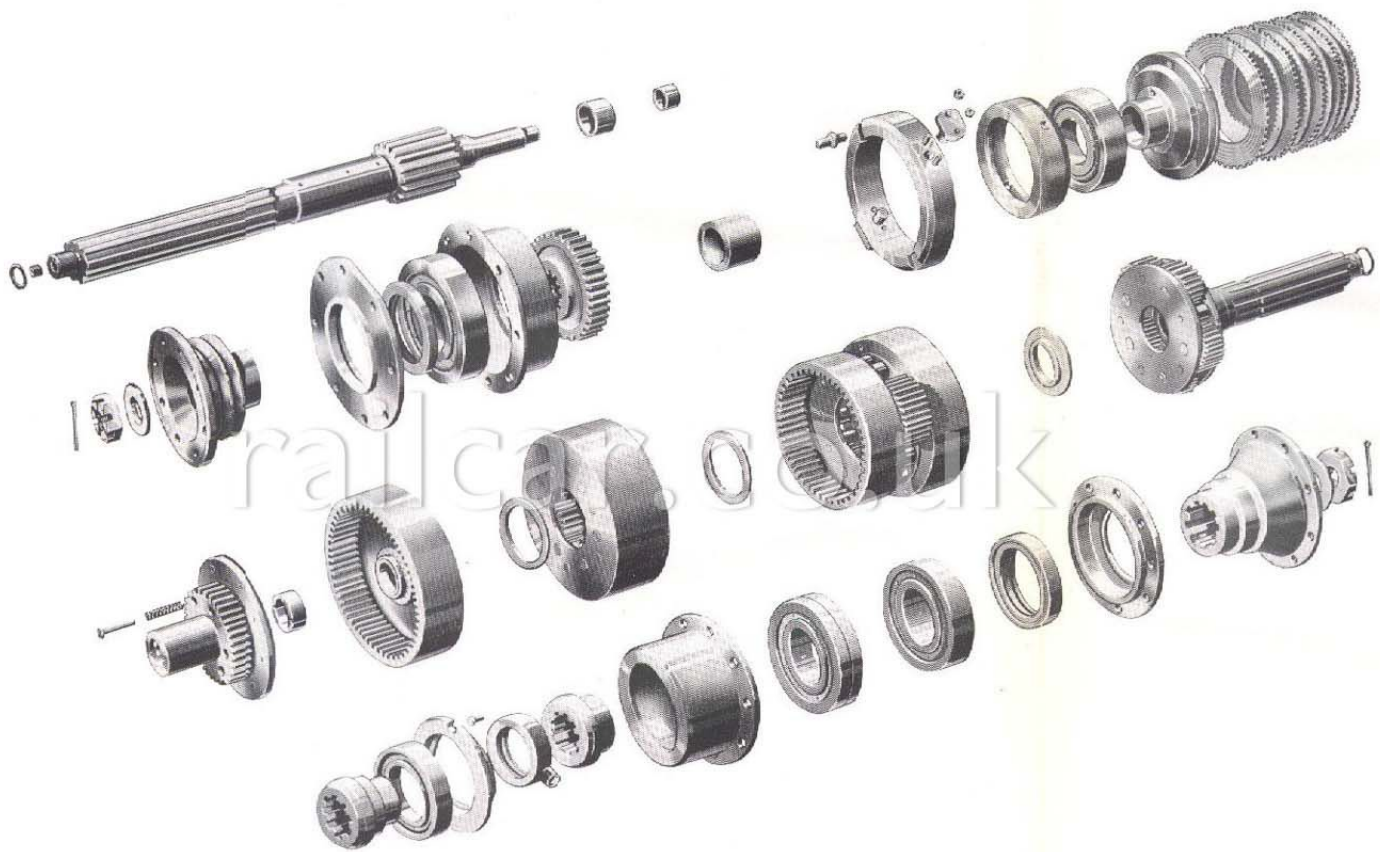
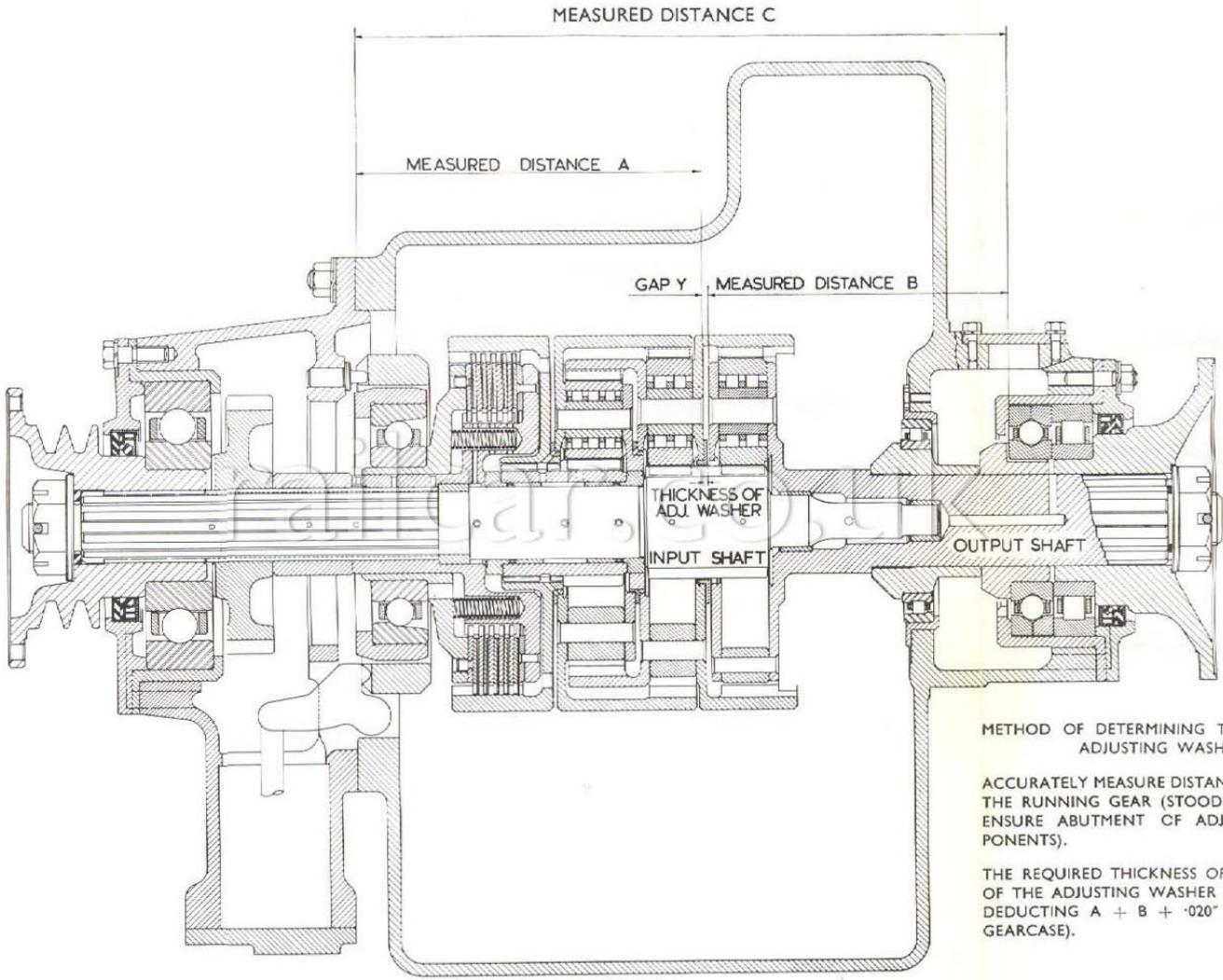


Fig. 21. Running Gear, etc. (Shown in Sequence).



METHOD OF DETERMINING THICKNESS OF ADJUSTING WASHER

ACCURATELY MEASURE DISTANCES A & B ON THE RUNNING GEAR (STOOD ON END TO ENSURE ABUTMENT OF ADJACENT COMPONENTS).

THE REQUIRED THICKNESS OF THE FLANGE OF THE ADJUSTING WASHER IS FOUND BY DEDUCTING A + B + ·020" FROM C (ON GEARCASE).

Fig 22. Method of Determining Thickness of Adjusting Washer.

Sec. S18 GEARBOX—TO ASSEMBLE

Note. ENSURE THAT ALL PARTS ARE THOROUGHLY CLEAN AND FIT FOR FURTHER SERVICE. (SEE SECTION S19).

CHECKING THE END FLOAT

(*See Fig.* 22)

From the Measured Distance C deduct the sum of A + B + thickness of flange of adjusting washer. If the remainder exceeds .050″ a new adjusting washer must be used, its flange thickness being determined as outlined in figure 22. When new flanged bushes are fitted ALL brakes should be re-lined.

REPLACE PISTONS

Refer to Section S10 for replacement of the pistons.

REPLACE BRAKE BANDS

(*See Fig.* 4)

Note. Before commencing ensure that the adjuster nuts are an easy fit on the pull rod (11) $\frac{11}{16}$″-16 UNS—2A thread. Tight nuts $\frac{11}{16}$″-16 UNS —2B thread may be eased by use of a tap. Ill fitting or damaged pull rods can be corrected by the use of a die nut.

It is essential that brakes which have not been re-lined are assembled in their original positions.

Considerable time in the adjustment of the brakes, can be saved by making a practice of re-assembling brakes, thrust pads and adjuster components in their original positions.

Insert the springs (8) into the centralizers and compress each spring in turn and pass the ears of the band (3) over them.

Fit the internal band link pins (1) and secure with split pins.

Compress the external bands (3) and engage the brake hooks.

Fit to the pull rods (11), thrust pads (12) adjuster tables (9) and the adjuster rings (6), secure these with the adjuster nuts (7), screw down far enough to keep them in position.

Replace the adjuster springs (8).

REPLACE THE GEARCASE TO BOTTOM COVER

(*See Fig.* 18)

After applying jointing compound lower the bottom cover with brake assemblies inverted onto the gearcase, secure with nuts and spring washers onto bottom cover.

REPLACE RUNNING GEAR

(*See Fig.* 2)

Note. Ensure that all the running gear is pushed fully into position when in mesh. Dip all bushes in oil when fitting.

The first component to be replaced in the gearcase, (since the bearing housing (39) and outer race of bearing (37) are normally left undisturbed) is the bearing collar (20) together with the inner race of the bearing (37).

Replace next the 1st speed planet and output shaft assembly bushes (19 and 21).

The adjusting washer (16) should be fitted to the face of the 2nd speed planet assembly with a smear of grease.

Fit the 2nd speed planet assembly (15) with the adjuster washer into position followed by the bush (42). The input shaft (64) can now be replaced into mesh with the 1st and 2nd speed planet trains (15 and 18).

Fit bush (43), and replace the 3rd speed planet assembly, fit bush (44).

Replace the 3rd speed sunwheel (14) and brake drum (11) assembly and bush (6).

The split ring (75) should then be greased and positioned onto the shaft, and the clutch inner member (12) passed over it.

Replace the clutch plates (9-10) in the order shown on Fig. 1 and insert the springs (8) and spigot pins.

Position onto the clutch inner member (12) the sliding panel complete with bearing (1) bearing housing (2) and trunnion ring (4) in position.

The sleeve (58) should then be replaced followed by the pump driving gear (59).

REPLACE THE FRONT COVER ASSEMBLY

(*See Fig.* 2)

Fit to the front cover (71) the 4th speed actuating assembly (50 and 51, etc.) if these parts have been removed. The bearing housing (69) complete with bearing (60) oil seal housing (61) with oil seal (62) should then be fitted to the gearcase (first applying jointing compound).

Note. The oil seal (62) should be packed with grease before replacement.

Position front cover assembly to gearcase, first applying jointing compound, replace spring washers and nuts (3) to the studs (including the nuts situate in the pump mounting aperture).

Replace the oil pump assembly (73) with gasket, fastening with nuts and washers.

Tap the input coupling (63) into position and replace sealing washer (65) washer (66) nut (68) and split pin (67).

REPLACE THE REAR END ASSEMBLY

(*See Fig.* 2)

Fit the oil muff (23) over the bearing collar (20) and screw the oil union (38) into position in the casing, together with its copper washer.

Replace the bearing collar (35) to the output shaft, followed by the bearing sleeve (24) and bearings (25 and 26).

Pack the oil seal (29) with grease.

The oil seal housing (28) can then be replaced complete with oil seal (29) (first applying jointing compound), secure by replacing nuts (27) with spring washers to the studs.

The output coupling (30) complete with pulley (36) (if fitted) should next be fitted, tapping into position.

Replace "O" ring (31) washer (33) nut (34) and split pin (32).

The gearbox is now completely assembled.

THE BRAKES MUST NOW BE ADJUSTED SEE SECTION S14.

Sec. S19 PERMISSIBLE CLEARANCE FOR RUNNING GEAR BUSHES

Part No.	Item No. Ref. Fig. 2	Description	Dimension Ref.	Minm Permissible Diametral Clearance (New)	Maxm Permissible Diametral Clearance (Worn)	Minm Permissible Flange Thickness (Worn)
500067	6	3rd Speed Sunwheel-Bush	Bore	.0005″	.015″	.387″
			°/Dia.	.002″	.015″	
500067	43	3rd Speed Sunwheel-Bush	Bore	.0005″	.015″	.387″
			°/Dia.	.002″	.015″	
			Flange °/Dia.	.004″	.020″	
500046	42	3rd Speed Annulus-Bush	Bore	.002″	.015″	.088″
			°/Dia.	.003″	.015″	
500046	44	2nd Speed Annulus-Bush	Bore	.002″	.015″	.088″
			°/Dia.	.003″	.015″	
500078	19	Input Shaft Bush—(Large)	Bore	.001″	.010″	—
			°/Dia.	.0015″	.010″	
500063	21	Input Shaft Bush—(Small)	Bore	.001″	.010″	—
			°/Dia.	.0015″	.010″	
518525	16	Adjusting Washer	°/Dia.	.003″	.020″	Renew when Total End Float Exceeds .050″

DRIVING AXLE.

CHAPTER E.

CONTENTS.

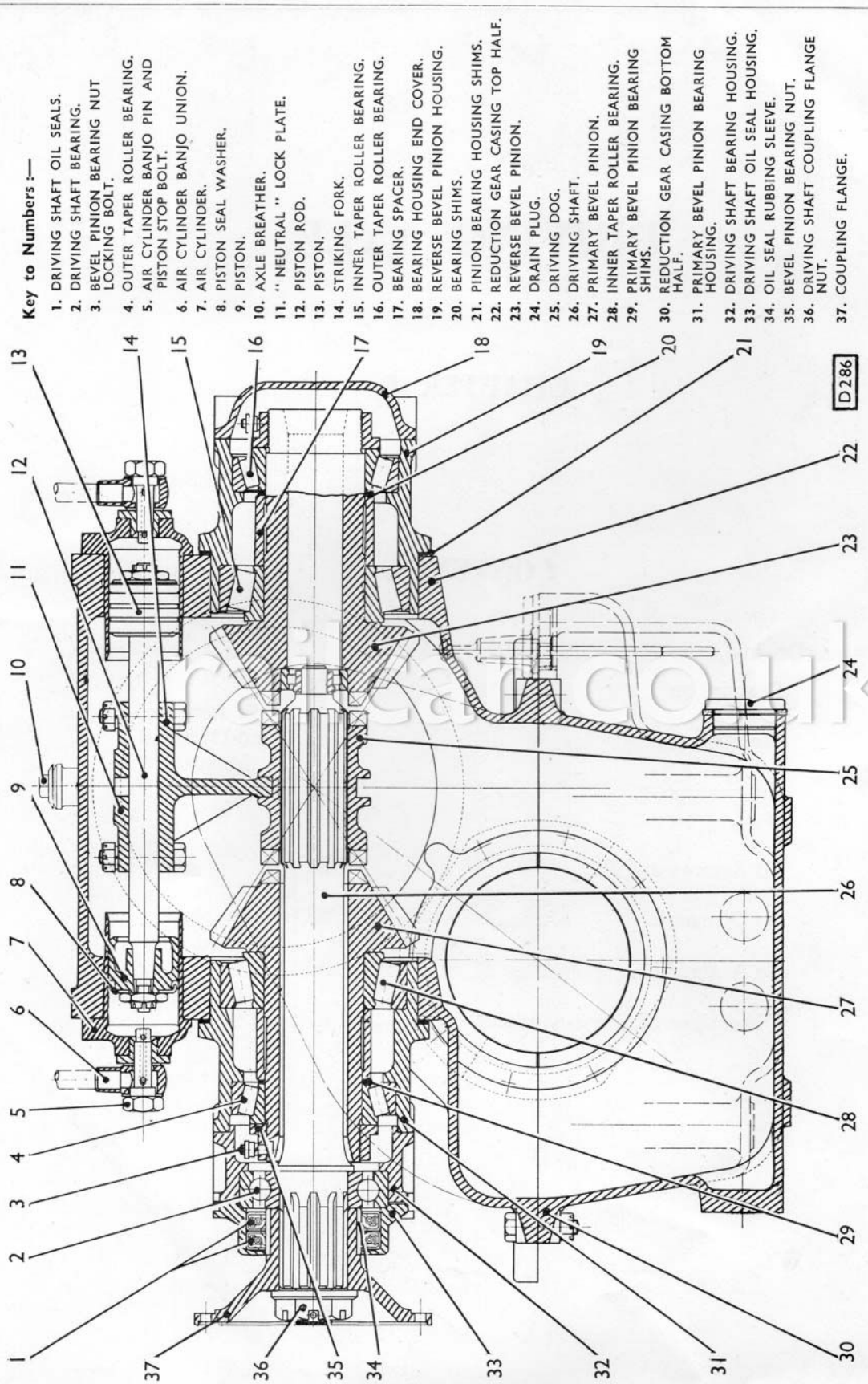


Fig. 1. Longitudinal section through bevel pinions.

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.

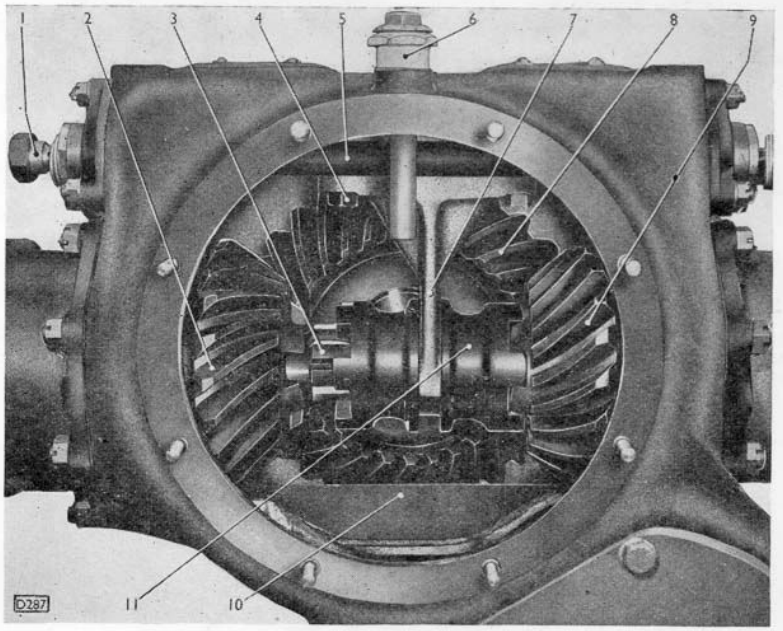
It is possible to isolate the axle drive by locking the striking fork in the " neutral " position with the hand operated plunger mounted on the axle casing.

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.

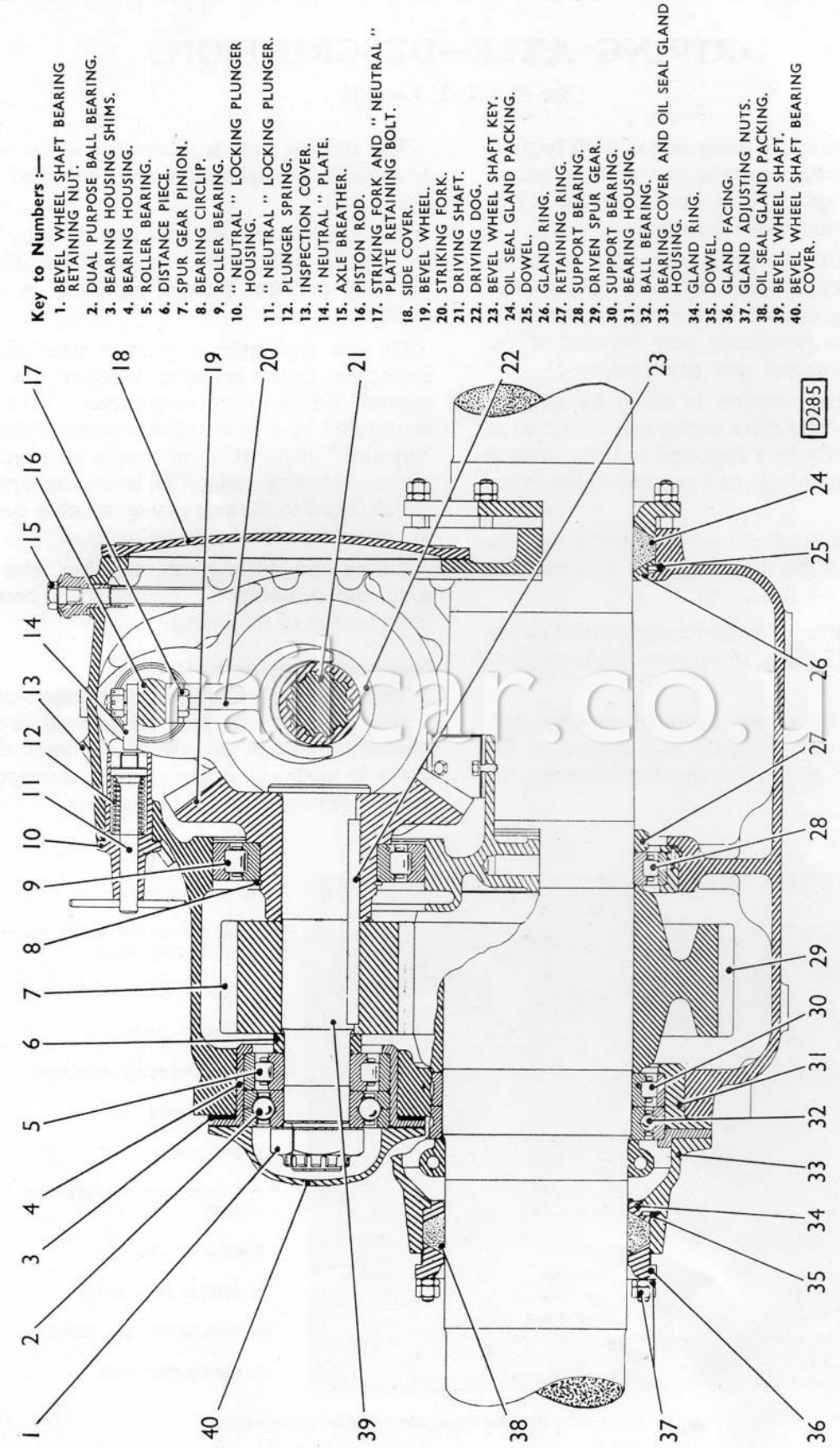


Fig. 3. Longitudinal section through bevel wheel and shaft.

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.

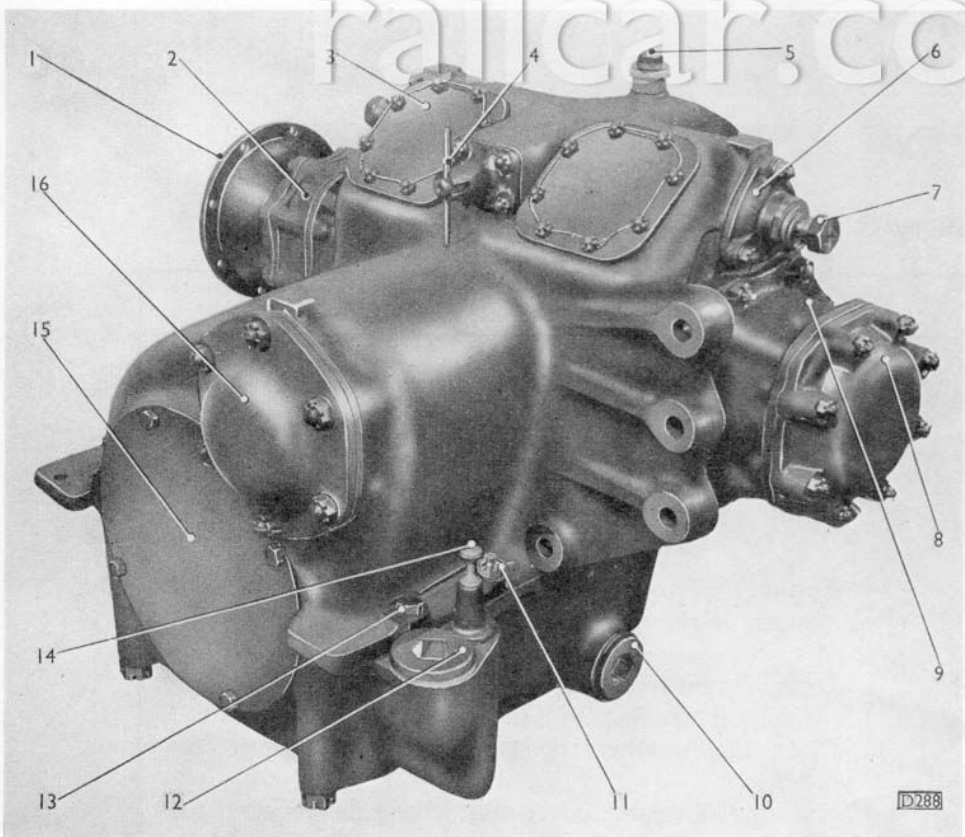
Unscrew the nuts securing one of the air cylinders and drive out the cylinder using a hammer and brass drift from inside the final drive casing.

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.

Sect. E4. DRIVING AXLE—TO REMOVE AND FIT.

(*See Figs.* 1, 4, 5 *and* 6).

To Remove.

Isolate the car batteries by means of the switch situated in the electrical control box which is adjacent to Number 1 engine.

Drain the oil from the final drive casing following the instructions given in Section E3.

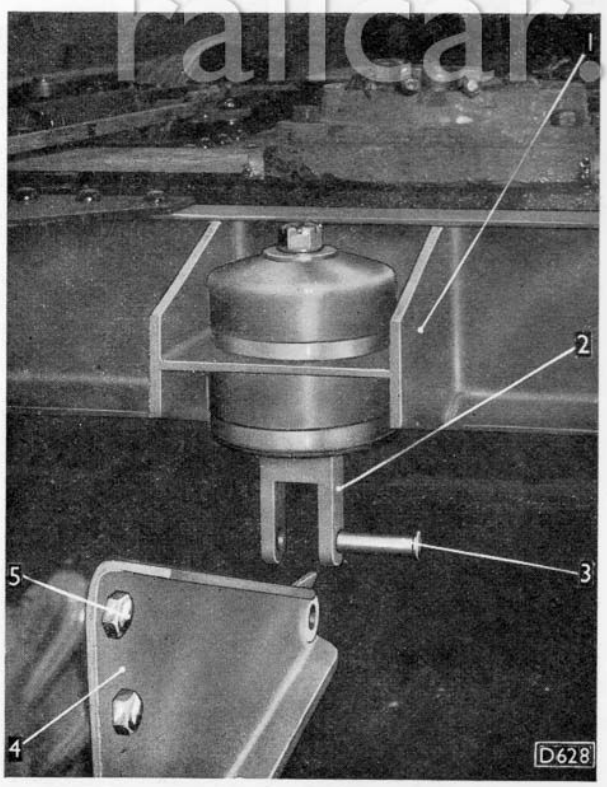
Disconnect the universal joint coupling flange from the driving shaft coupling flange.

Disconnect the supply pipes from the air cylinders; ensure that the banjo pins are marked so that they can be fitted to their original cylinders when refitting.

Remove the pivot pin and disconnect the torque arm from the torque reaction bracket (*see Fig.* 5).

Remove the axle from the car.

Place a lifting jack or wood blocks under the final drive unit to support the bottom half of the casing whilst lifting off the top half (*see Fig.* 6).



Key to Numbers :—

1. TORQUE REACTION BRACKET.
2. TORQUE ARM EYE BOLT.
3. PIVOT PIN.
4. TORQUE ARM.
5. RETAINING BOLT.

Fig. 5. Method of detaching torque arm from bogie.

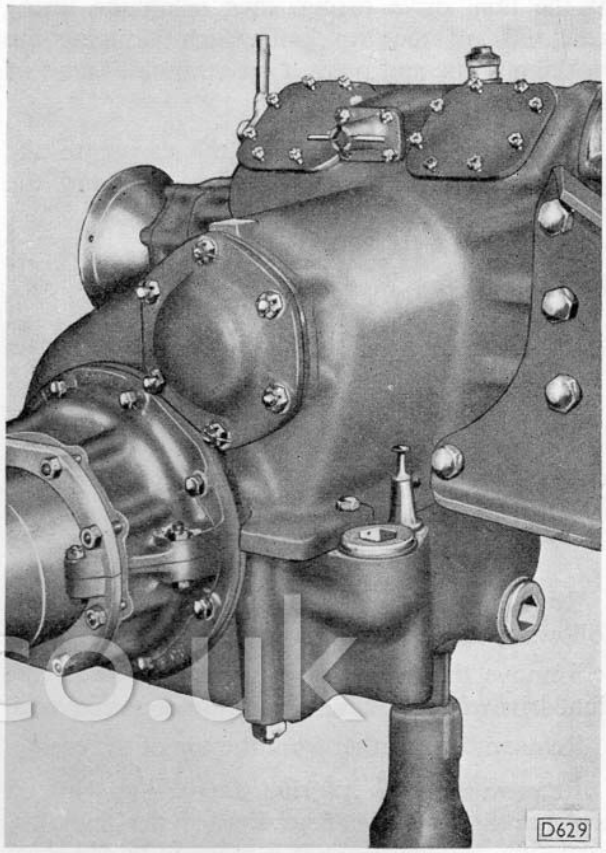


Fig. 6. Method of supporting bottom half of final drive casing whilst removing torque arm.

Remove the torque arm from the final drive casing.

Place a suitable lifting tripod in position and attach the lifting chain or sling around the coupling flange and the reverse bevel gear housing; take up the slack in the chain or sling.

Remove the gland facings from the axle; the gland facings, which are numbered, should be retained in pairs by refitting the clamp bolts (*see Fig.* 6).

Remove the oil seal gland packing.

Detach the bearing cover from the final drive casing, separate the halves of the cover by removing the clamp bolts, and remove from the axle shaft.

The halves of the bearing cover are numbered

and should be retained as a unit by refitting the clamp bolts.

Remove the nuts and bolts securing the halves of the final drive casing, then using the lifting gear, lift off the top half which contains the working parts, and place it on a suitable stand or bench for dismantling.

Lower the bottom half of the casing to the ground, leaving the driven spur gear and the support bearings on the axle shaft.

To Fit.

Reverse the procedure for removal, noting the following points:—

Wash all parts in clean paraffin.

Examine the support bearings on the axle shaft and renew if necessary.

Ensure that the oil seal bearing surfaces on the axle shaft are not scored or damaged.

Renew the oil seal gland packing.

Remove all traces of jointing compound from all joint faces.

Renew all joints and fit with non-hardening jointing compound.

Ensure that the air pipe connections are secure.

Refit the drain plug to the final drive casing and fill with oil following the instructions given in Section E3.

Close the battery main switch in the electrical control box.

Sect. E5. DRIVING AXLE—TO DISMANTLE.

(*See Figs.* 1, 2, 3 *and* 7).

Remove the final drive unit from the axle following the instructions given in Section E4.

Remove the large cover from the side of the final drive casing and remove the inspection covers.

Remove the breather from the top of the casing.

Remove the nuts securing the driving shaft oil seal housing and withdraw the driving shaft; remove the driving dog as it is released by the shaft (*see Fig.* 1).

Remove the nuts securing the primary bevel pinion bearing housing and withdraw the housing and bevel pinion assembly complete. Repeat this operation for the reverse bevel pinion assembly. Retain any shims fitted between the bearing housings and the casing.

Unscrew the nuts securing the striking fork to the piston rod and detach the fork and " neutral " plate. Remove the nuts securing one of the air cylinders and tap it out from inside the final drive casing using a hammer and brass drift. Withdraw the piston and piston rod. Mark the pistons and piston rod to ensure that they are refitted in their original positions.

Remove the bevel wheel shaft end cover and unscrew the large nut from the end of the shaft.

Insert two $\frac{1}{2}$ in. B.S.F. bolts in the withdrawal holes provided and remove the bearing housing, complete with bearings, by tightening each bolt a **little at a time.** Retain any shims fitted between the bearing housing and the casing.

Remove the bevel wheel oil trough (*see Fig.* 7).

Carefully drive out the bevel wheel shaft assembly towards the large aperture in the side of the final drive casing.

Each of these sub-assemblies may be further dismantled as follows:—

Driving shaft assembly.

Remove the coupling flange and oil seal housing and examine the seals for hardness, damage or wear.

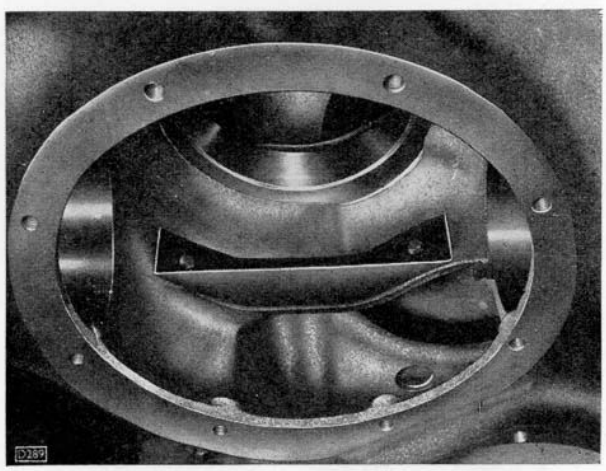


Fig. 7. Final drive casing showing oil trough.

Press the driving shaft bearing housing, complete with bearing, off the driving shaft. Drive the bearing out of the housing.

Primary bevel pinion assembly.

Remove the locking bolts and unscrew the large nut from the end of the bevel pinion shaft.

Drive out the bevel pinion and shaft through the taper roller bearings, taking care to retain the bearing spacer and any shims fitted between the bearings.

Remove the bearing cup from the bearing housing using a hammer and brass drift. Press the remaining inner roller assembly off the shaft.

Reverse bevel pinion assembly.

Remove the end cover and repeat the foregoing operation.

Bevel wheel and shaft assembly.

A 25 ton press is required for the removal of the wheel, race and spur gear pinion.

Press the spur gear pinion off the shaft.

Remove the circlip and press the bearing off the bevel wheel.

If considered necessary, press the bevel wheel off the shaft.

Sect. E6. DRIVING AXLE—TO ASSEMBLE.

(*See Figs.* 1, 2, 3, 7, 8, 9 *and* 10).

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

The thickness of shims between the distance piece and bearings of the bevel pinion shafts should be varied to obtain an end float of 0·005 in. to 0·007 in. (0·127 mm. to 0·178 mm.) when the bearing nut is **fully** tightened. (*For dimensions of shims available see Section* E7).

Correct meshing of the bevel gears is obtained by varying the thickness of shims between the reduction gear casing and the bevel pinion shaft bearing housings, also between the reduction gear casing and the bevel wheel shaft bearing housing. (*For dimensions of shims available see Section* E7).

The optimum backlash between the bevel pinions and bevel wheel is 0·12 in. to 0·015 in. (0·30 mm. to 0·38 mm.) (*see Fig.* 8) with a marking as shown in Figure 10.

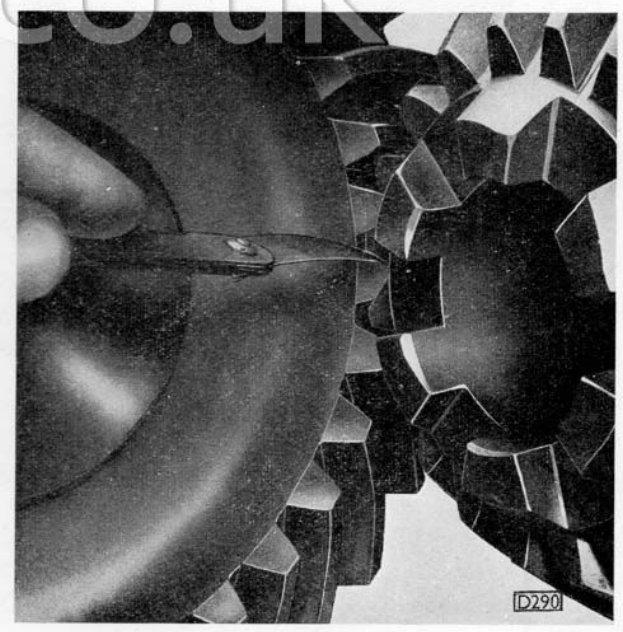


Fig. 8. Method of measuring bevel wheel and pinion backlash.

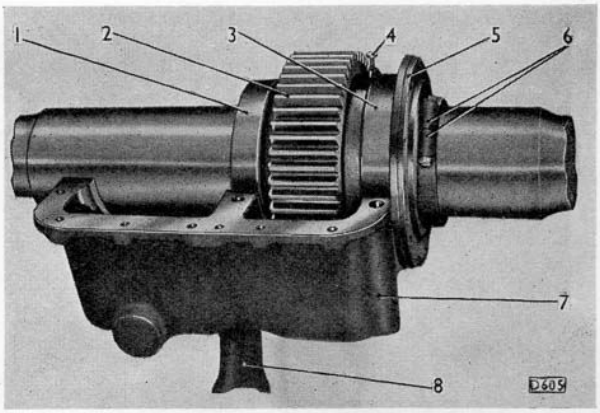
When assembling the striking gear, the parts **must** be fitted in their original positions. Should it be necessary to fit a new air pipe banjo pin, note that sufficient material is allowed at the small end for " fitting " purposes, as the end of the pin forms a " stop " to limit the travel of the piston rod, and thus controls the clearance between the striking fork and driving dog groove. Excess material should be filed away to provide a running clearance of 0·015 in. to 0·020 in. (0·38 mm. to 0·50 mm.).

When fitting split pins to the piston rod end nuts keep the tails of the pins clear of the rod ends.

When fitting the adjustable axle oil seals **do not over tighten** the adjusting nuts.

Clean and refit the axle breather (*see Section* E3).

Fill with fresh oil **through one of the top inspection cover apertures** (*see also Section* E3).



Key to Numbers :—
1. SUPPORT BEARING.
2. SPUR GEAR.
3. BEARING HOUSING.
4. OIL LEVEL DIPSTICK.
5. BEARING RETAINING RING.
6. SPLIT CLAMPING RING.
7. CASING BOTTOM HALF.
8. JACK OR WOOD BLOCK.

Fig. 9. Method of fitting bottom half of final drive casing to axle shaft.

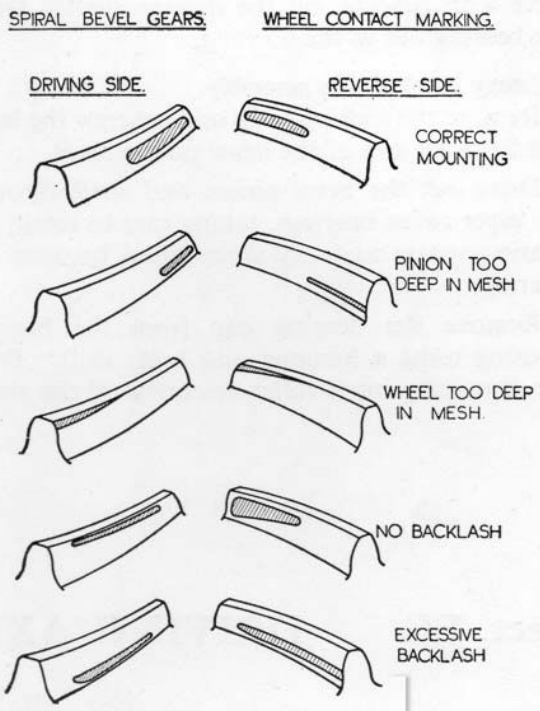


Fig. 10. Marking on teeth of spiral bevel wheel.

Sect. E7. DIMENSIONS OF SHIMS AVAILABLE.

Part.	Part No.	Width or Thickness.
Bevel Pinion Taper Roller Bearings. ..	Z2/46556A	19 I.W.G. (0·040 in., 1·02 mm.)
	Z2/46556B	20 I.W.G. (0·036 in., 0·91 mm.)
	Z2/46556C	27 I.W.G. (0·016 in., 0·42 mm.)
Bevel Wheel Bearing Housing/Reduction Gear Casing.	Z3/46551	18 I.W.G. (0·048 in., 1·22 mm.)
	Z3/46509	30 I.W.G. (0·012 in., 0·30 mm.)
	Z3/46508	39 I.W.G. (0·005 in., 0·12 mm.)
Bevel Pinion Bearing Housings/Reduction Gear Casing.	Z2/46557A	23 I.W.G. (0·024 in., 0·61 mm.)
	Z2/46557B	30 I.W.G. (0·012 in., 0·30 mm.)
	Z2/46557C	39 I.W.G. (0·005 in., 0·12 mm.)

PROPELLER SHAFTS.

CHAPTER D.

CONTENTS.

Sect. D1. PROPELLER SHAFTS—DESCRIPTION.

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

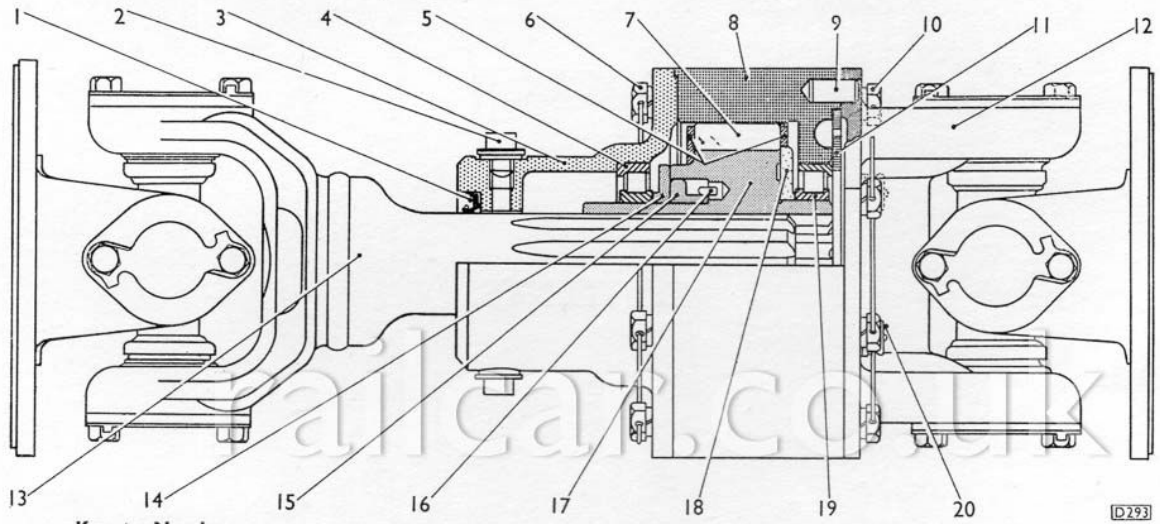
The drive from the engine and fluid coupling to the driving axle is transmitted by means of two propeller shafts as follows:—

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.

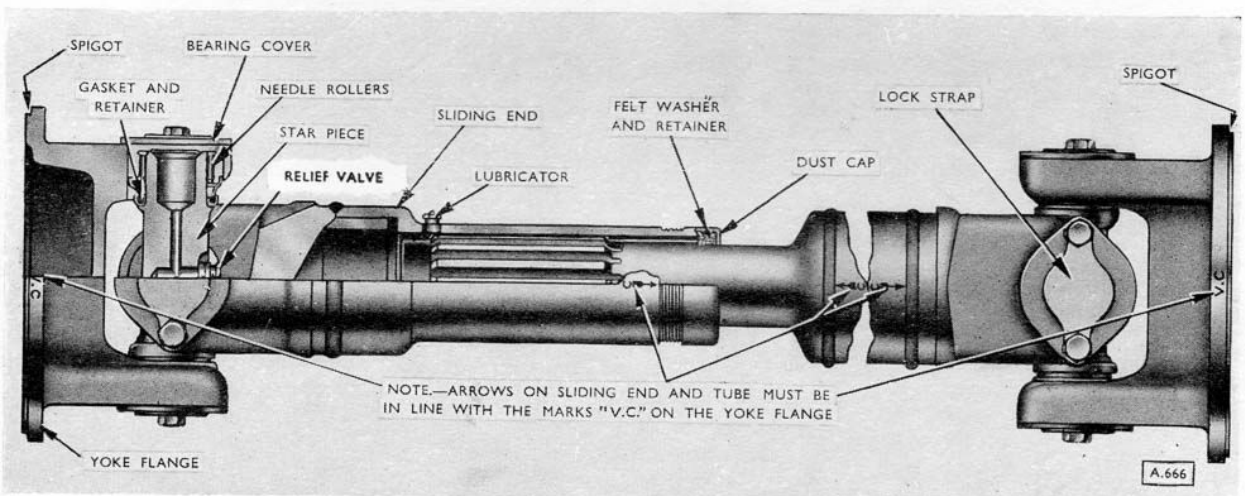


Fig. 2. Section through propeller shaft—needle roller bearing type joints.

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.

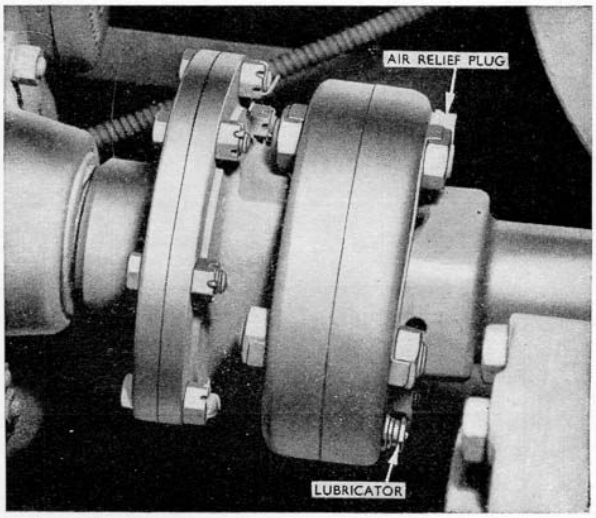


Fig. 3. Plain bearing type universal joint showing lubricating point.

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

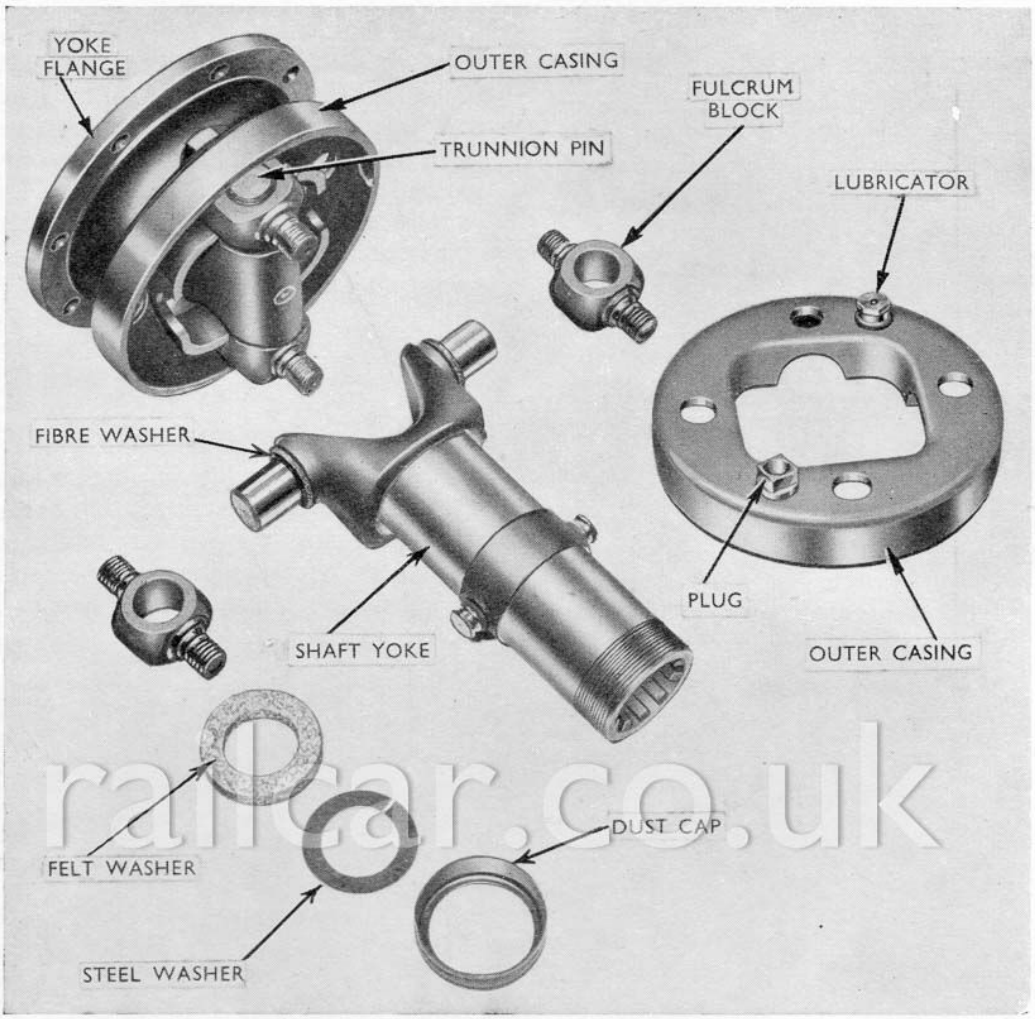


Fig. 4. Exploded view of plain bearing type universal joint fitted to early cars.

SPECIFICATION OF GREASE.

(*A.E.C. Specification No. 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 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. D4. PROPELLER SHAFTS TO REMOVE AND DISMANTLE.

(*See Figs.* 1, 2, 4 *and* 6).

To Remove.

All propeller shafts.

Disconnect both flanges, move the sliding end along its splines and remove the shaft.

To Dismantle.

Propeller shaft and freewheel (*see Figs.* 1 *and* 7).

Withdraw the sliding end universal joint assembly from the freewheel assembly.

Unscrew the set-screws securing the sleeve to the outer cage and remove the sleeve; the outer race of the roller bearing will remain in the sleeve, if necessary drive it out using a hammer and brass drift.

Taking care not to lose any of the freewheel rollers, withdraw from the outer cage, the splined sleeve complete with the roller assembly and the inner races of the roller bearings.

Lever the two inner races of the roller bearings off the sleeve using suitable pinch bars; ensure that the races are retained with their mating outer races.

Remove the bearing distance washers, followed by the spring retainer and spring and also the roller cage.

Unscrew the set-screws securing the universal joint assembly to the outer cage and remove it from the dowels. Remove the retaining plate and

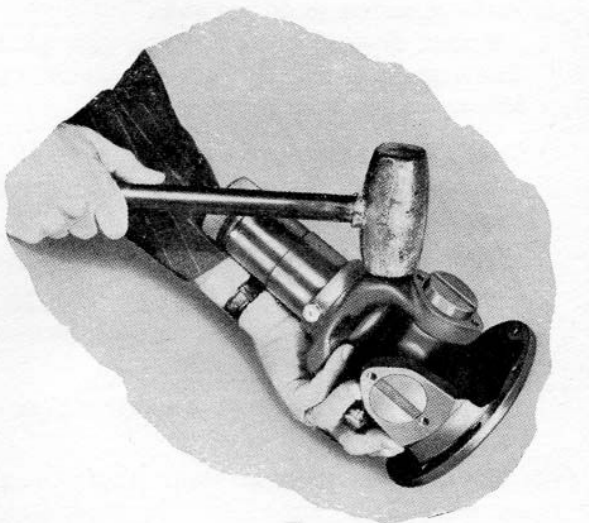


Fig. 5. Method of removing needle roller bearings from Hardy Spicer universal joint.

if necessary remove the outer race of the roller bearing from the outer cage.

Other shafts.

Unscrew the dust cap from the shaft yoke and pull the complete sliding end away from its shaft; remove the dust cap, split felt or cork washer and the steel washer, from the end of the shaft.

(*For further dismantling see Section* D5).

Sect. D5. UNIVERSAL JOINTS—TO DISMANTLE.

(*See Figs.* 4, 5 *and* 6).

Plain Bearing Type Universal Joints (*see Fig.* 4).

Remove the nuts from the fulcrum blocks on both sides of the universal joint and, with a lead hammer, tap the ends of the fulcrum block threads and the outside of the outer casing to break the joint between the two halves of the casing. **On no account should a screwdriver or chisel be inserted between the halves of the outer casing to break the joint,** as this will damage the faces and result in loss of lubricant after assembly.

The portion of the outer casing adjacent to the yoke flange can only be completely detached by removing the trunnion pin. This pin is a press fit in the yoke flange and is secured by a rivet through its centre. The trunnion pin should only be removed if it is desired to renew the pin or the portion of the outer casing.

To detach the fixed yoke from the sliding shaft, remove the split pin, plain washer and hexagon slotted nut.

A service hole in the fixed yoke is provided to facilitate access to the split pin.

Needle Roller Bearing Type Universal Joints (*see Figs.* 5 *and* 6).

Shaft—Gearbox to driving axle.

Knock down the tabs of the lock plates then remove the fixing screws, plates and bearing covers from the yoke ears.

Shaft—Engine to fan.

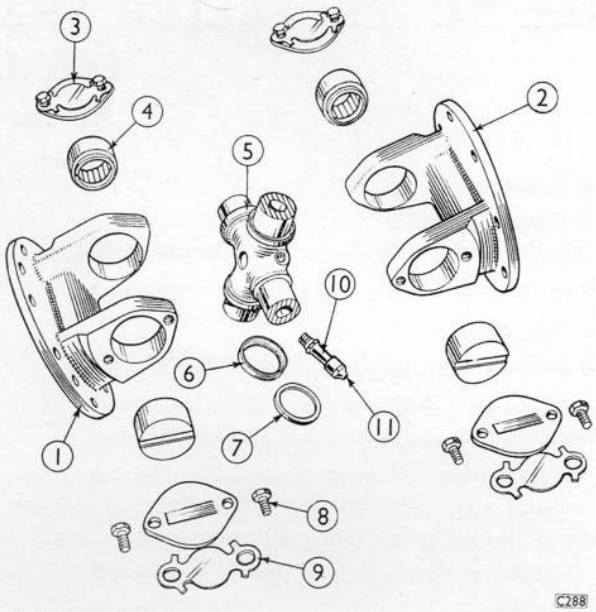
Remove the circlips securing the needle roller bearings in the yoke ears.

Then on both shafts proceed as follows:—

Tap the ears of the yoke downwards with a lead hammer so that the needle roller bearing is knocked out of the roller bore.

Repeat the operation for the opposite bearing.

Support the two exposed star piece journals on lead blocks (to protect the ground surfaces) and tap the ears of the yoke flange, to remove the needle roller bearing. Turn the assembly over and repeat the operation to remove the other needle roller bearing.



Key to Numbers :—

1. OUTPUT FLANGE.
2. INPUT FLANGE.
3. BEARING COVER.
4. NEEDLE ROLLER BEARING.
5. STAR PIECE.
6. GASKET RETAINER.
7. STAR PIECE GASKET.
8. SCREW FOR BEARING COVER.
9. LOCK PLATE FOR SCREWS.
10. LUBRICATOR EXTENSION.
11. LUBRICATOR.

Fig. 6. Exploded view of needle roller bearing type universal joint on first shaft.

Sect. D6. PROPELLER SHAFTS AND UNIVERSAL JOINTS—TO ASSEMBLE AND FIT.

(*See Figs.* 1, 2, 4, 5, 6 *and* 7).

To Assemble.

Assemble the parts in the reverse order to their removal, noting the following points:—

Plain bearing type universal joints on first shafts (*see Fig.* 4).

Renew any parts that are worn, smear the joint faces of each universal joint outer casing and the flange joint faces of the outer cage with non-hardening jointing compound and pack with grease. The freewheel mechanism should also be packed with grease.

Ensure that the oil seal in the sleeve has its sealing lip facing away from the freewheel.

When assembling a sliding end joint see that the mark " VC " on the yoke flange is in line with the arrow on the shaft yoke.

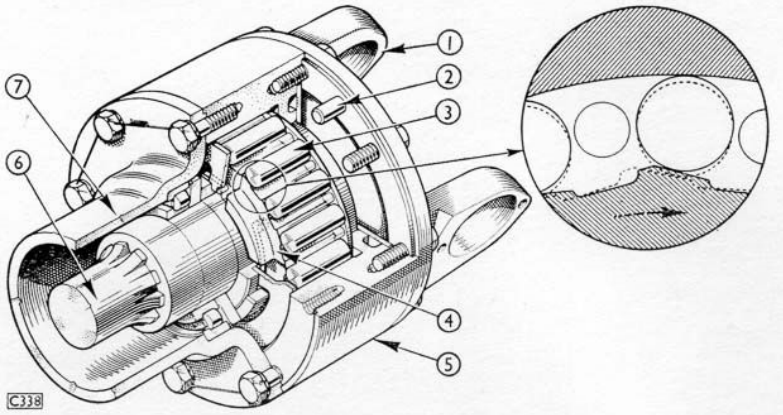
When assembling the sliding end joint on to the shaft splines, smear the splines liberally with grease and **see that the mark " VC " on the yoke flange and the arrow on the shaft are in line.**

Compression of the felt or cork washer sufficient to ensure a good oil seal should be possible by **hand tightening** of the dust cap.

Needle roller bearing type universal joints (*see Fig.* 6).

Assemble the parts in the reverse procedure to that given for removal, noting the following points:—

Renew any parts that are worn, and fill the joints with gear oil. It is advisable to fit new gaskets on the star piece, the shoulders of which should be coated with shellac prior to fitting, to



Key to Numbers :—

1. YOKE FLANGE.
2. DOWEL.
3. ROLLER.
4. SPLINED SLEEVE.
5. OUTER CAGE.
6. DRIVING SHAFT.
7. SLEEVE.

Fig. 7. View of freewheel showing method of operation.

ensure a good oil seal; make sure that the star piece oil channels are filled with lubricant and that the needle roller bearings are also about one-third full. If any difficulty be encountered when assembling the rollers into the housings, smear the wall of the housing with grease.

Insert the journal of the star piece in the yoke flange holes and, using a lead hammer, tap one of the needle roller bearings into position so that the slot in the end of the bearing is in line with the two tapped holes in the yoke flange ear.

Repeat this operation for the opposite bearing.

If the joints appear to bind when assembled, tap the lugs **lightly** with a lead hammer, to relieve any pressure on the end of the star piece bearings.

When assembling a sliding end joint see that the mark " VC " on the yoke flange is in line with the arrow on the shaft yoke.

When assembling the sliding end joint on to the shaft splines, smear the splines liberally with grease and **see that the marks " VC " on each yoke flange and the arrow on the shaft are in line.**

Compression of the felt or cork washer sufficient to ensure a good oil seal should be possible by **hand tightening** of the dust cap.

RADIATOR AND FAN.

CHAPTER F.

CONTENTS.

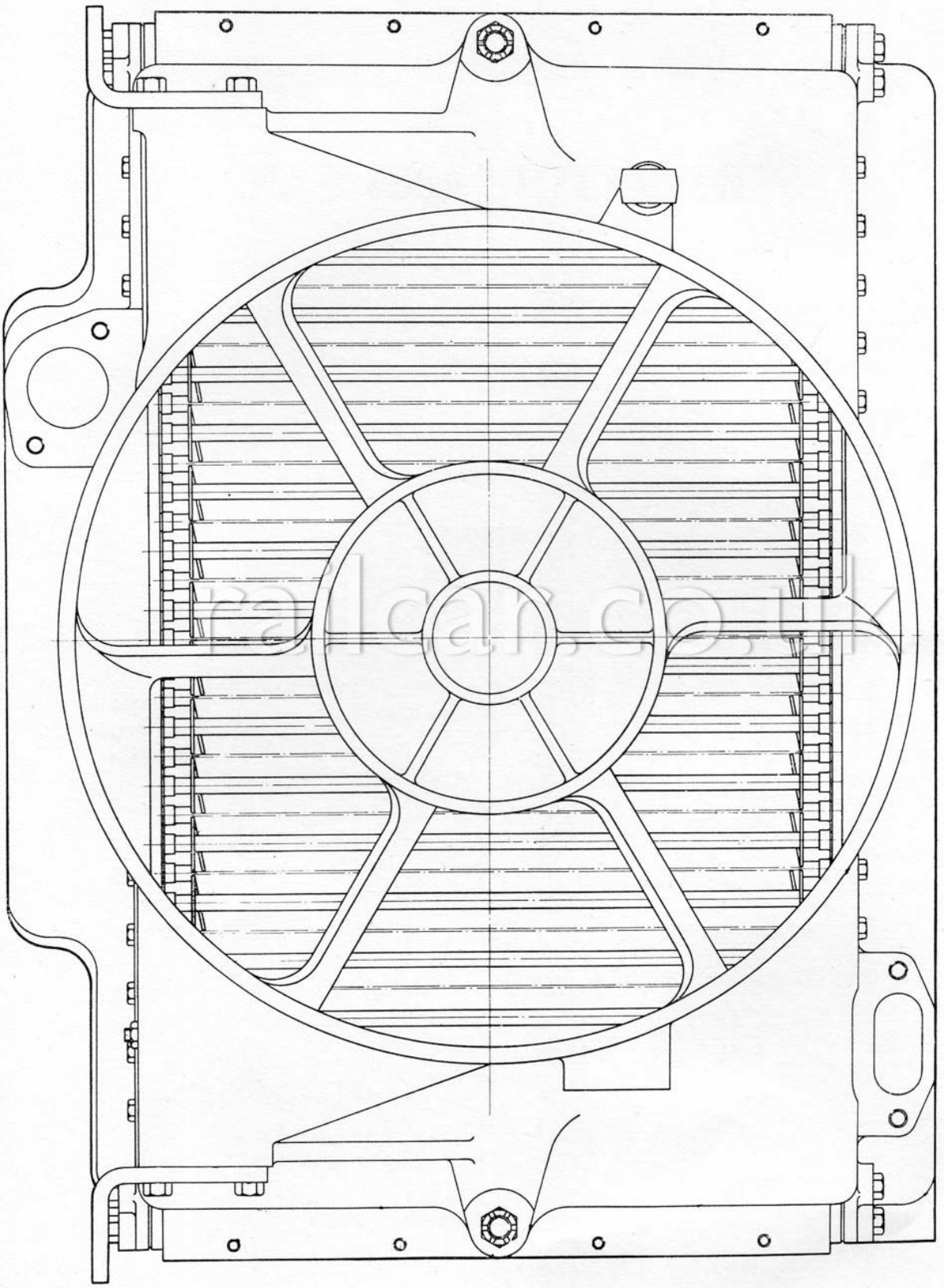


Fig. 1. Arrangement of radiator and fan cowl.

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.

Sect. F4. RADIATOR AND FAN—TO REMOVE AND FIT.

(*See Figs.* 2 *and* 3).

To Remove.

Close the stop cock fitted to the low water tank.

Open the drain cock situated on the radiator bottom tank and drain off the water.

Disconnect the lubrication pipe to the fan bearings by unscrewing the union nut behind the lubricator on the frame (*see Fig.* 2).

Remove the radiator guard and disconnect the water pipes from the radiator top and bottom tanks.

Disconnect the tie rod from the radiator.

Disconnect the universal joint from the fan hub and secure the propeller shaft to a convenient point on the car to prevent damage.

Place a jack or wood blocks under the radiator, remove the nuts securing the fan cowl to the mounting brackets; retain the rubber bushes and lower the assembly to the ground.

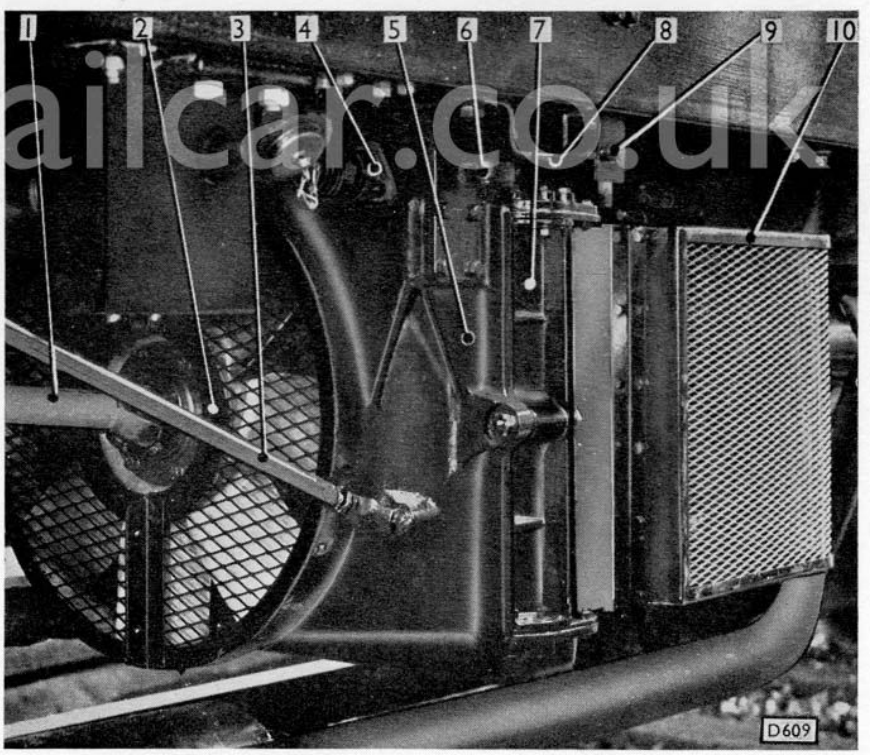
To Fit.

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

Examine the rubber mounting bushes and renew if necessary.

Ensure that all water connections are secure 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.



Key to Numbers :—

1. FAN DRIVE SHAFT.
2. FAN GUARD.
3. RADIATOR TIE ROD.
4. WATER CONNECTION FROM ENGINE.
5. FAN COWL.
6. RESILIENT MOUNTING.
7. RADIATOR BLOCK.
8. MOUNTING BRACKET.
9. LUBRICATOR FOR FAN BEARINGS.
10. RADIATOR GUARD.

Fig. 2. Radiator and fan assembly.

Sect. F5. RADIATOR—TO DISMANTLE AND ASSEMBLE.

(*See Figs.* 1 *and* 5).

To Dismantle.

Remove the radiator assembly from the car (*see Section* F4).

Remove the fan and fan cowl from the radiator block (*see Section* F7).

Unscrew and remove the three nuts and bolts at each end of the side standards and detach the side standards.

Unscrew and remove the nuts from the bolts and studs holding the top and bottom tanks to the tube block and separate these three components.

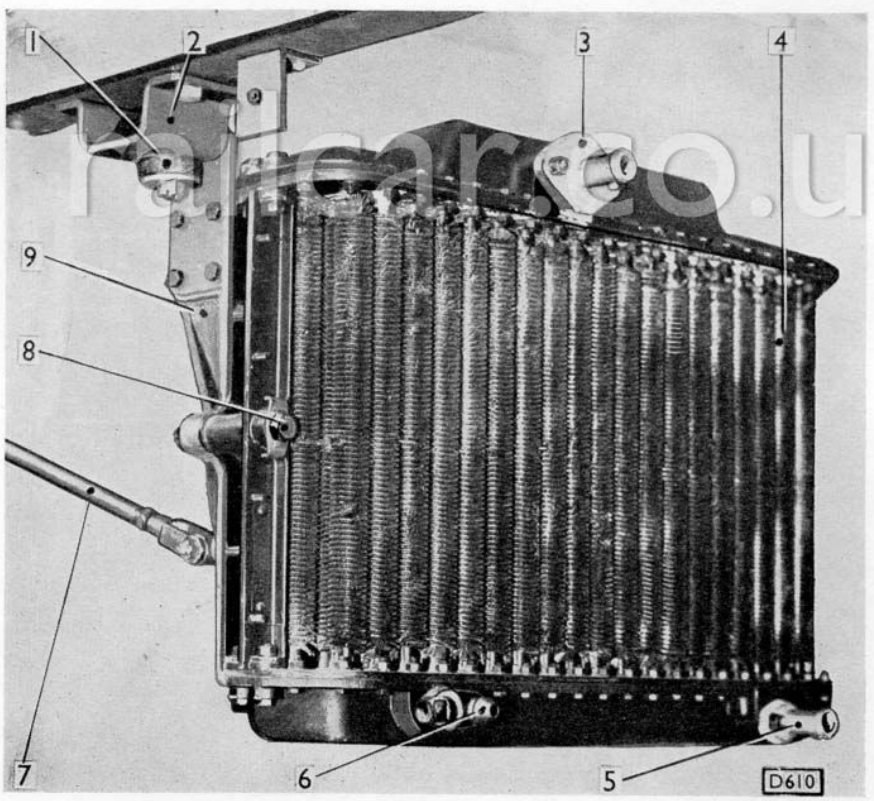
To Assemble.

It is recommended that at vehicle overhaul periods the exterior of the radiator be subjected to high pressure hosing to remove the accumulation of dust and dirt from the tubes, the presence of which reduces the effectiveness of the cooling.

Clean out the top and bottom tanks and push a suitable piece of wire through each tube to clear away any sediment.

Clean the joint faces of each component where gaskets are fitted. All gaskets should be renewed when assembling and should be lightly coated with non-hardening jointing compound before being placed in position.

Refit the parts in the reverse order to that given for dismantling.



Key to Numbers :—

1. RESILIENT MOUNTING.
2. MOUNTING BRACKET.
3. RADIATOR VENT PIPE CONNECTION.
4. RADIATOR BLOCK.
5. RADIATOR INLET PIPE CONNECTION FROM HEADER TANK.
6. RADIATOR DRAIN COCK.
7. RADIATOR TIE ROD.
8. BOLT SECURING RADIATOR BLOCK TO FAN COWL.
9. FAN COWL.

Fig. 3. Radiator and fan assembly less water pipes and radiator guard.

Sect. F6. THERMOSTAT—DESCRIPTION.

(*See Fig.* 4).

The thermostat assembly consists of a gas filled metal bellows secured at the bottom to a frame which fits into the thermostat body.

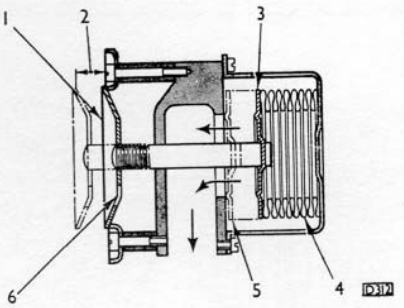
The thermostat valve incorporates a $\frac{1}{8}$ in. (3·175 mm.) hole which provides a release for excessive pressure or steam accumulating in the cylinder block or heads.

The thermostat valve should begin to open at between 175°F. and 185°F. (79·4°C. and 85°C.).

It should be fully open between 190°F. and 200°F. (87·7°C. and 93·3°C.).

The maximum lift of the valve is $\frac{3}{8}$ in. (9·52 mm.).

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



Key to Numbers :—

1. THERMOSTAT VALVE CLOSED.
2. THERMOSTAT VALVE LIFT = $\frac{1}{4}$" (0·375 mm.).
3. BY-PASS VALVE OPEN.
4. THERMOSTAT BELLOWS.
5. BY-PASS VALVE CLOSED.
6. PRESSURE RELEASE HOLE.

Fig. 4. Section through thermostat.

Sect. F7. FAN—TO REMOVE, DISMANTLE, ASSEMBLE AND FIT.

(*See Fig.* 5).

To Remove.

Remove the radiator block and fan assembly from the car following the instructions given in Section F4.

To Dismantle.

Detach the fan and cowl assembly from the radiator block.

Remove the fan guard from the fan cowl and the lubrication pipe from the fan cowl end cover.

Unscrew the nuts securing the end cover to the fan cowl and remove the cover.

Remove the retaining nut and washer from the fan shaft.

Using a hammer and brass drift, tap the fan shaft out through the bearing housing.

Unscrew the nuts securing the fan to the fan shaft hub and remove the fan.

Press out the fan shaft bearing housing with a small press but if this is not available use a hammer and brass drift and gently tap it out through the front of the fan cowl.

Remove from the bearing housing the oil seal, the distance ring behind the oil seal and the circlip securing the small ball bearing.

Withdraw the two ball bearings from the housing.

To Assemble.

Reverse the procedure for dismantling and note the following points:—

Remove any burrs that might prevent satisfactory fitting.

Renew the oil seal and ball bearings if necessary and grease the ball bearings before fitting them in the housing.

Fit the ball bearings, the circlip, the distance ring and the oil seal into the housing and fit the assembly into the fan cowl.

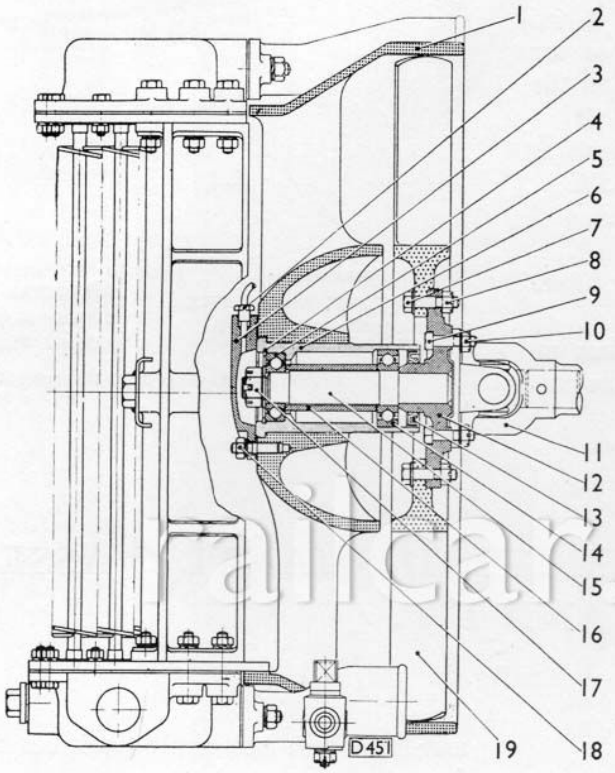
Bolt the fan to the fan shaft hub.

Fit the fan shaft into the bearing housing and secure it with the washer, nut and split pin; refit the end cover to the fan cowl.

There should be no vertical or horizontal movement of the fan shaft but at the same time the shaft should be easy to rotate in the bearings.

To Fit.

Fit the fan and cowl assembly to the radiator block, then fit the complete radiator assembly to the car following the instructions given in Section F4.



Key to Numbers :—

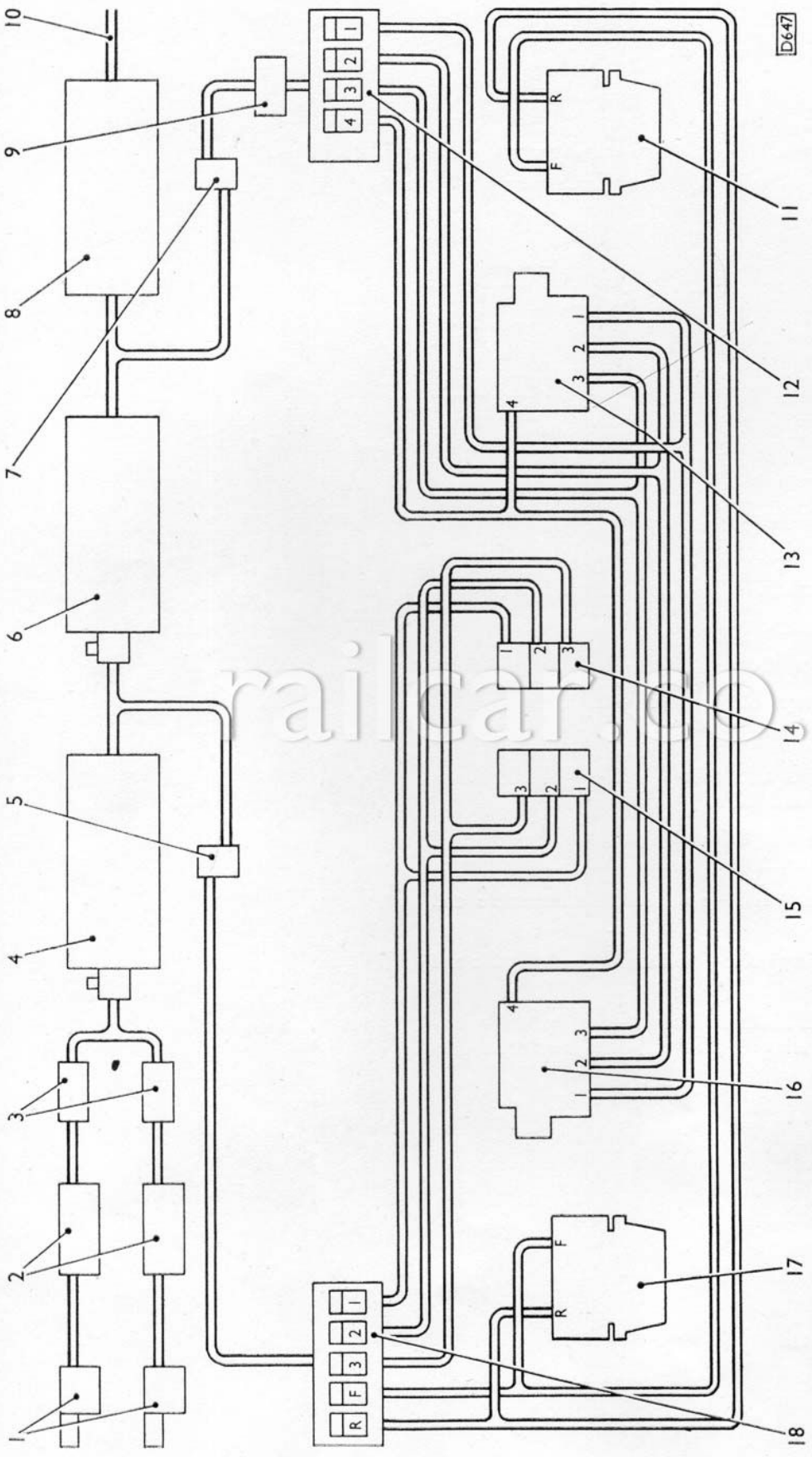
1. FAN COWL.
2. FAN BEARING LUBRICATION PIPE.
3. FAN COWL END COVER.
4. BEARING CIRCLIP.
5. BEARING.
6. FAN SHAFT EARING HOUSING.
7. FAN RETAINING BOLT.
8. RETAINING BOLT NUT.
9. PROPELLER SHAFT COUPLING FLANGE BOLT.
10. COUPLING FLANGE NUT.
11. UNIVERSAL JOINT.
12. FAN HUB.
13. OIL SEAL.
14. BEARING.
15. FAN SHAFT.
16. BEARING DISTANCE SLEEVE.
17. FAN SHAFT RETAINING NUT.
18. FAN COWL END COVER RETAINING NUT.
19. FAN.

Fig. 5. Section through radiator and fan drive.

CONTROLS.

CHAPTER G.

CONTENTS.



Key to Numbers :—

1. AIR FILTERS AND ANTI-FREEZERS.
2. COMPRESSORS.
3. NON-RETURN VALVES.
4. AIR RESERVOIR WITH UNLOADER AND SAFETY VALVES.
5. AIR FILTER.
6. AIR RESERVOIR WITH DIVERTER VALVE.
7. AIR FILTER.
8. AUXILIARY AIR RESERVOIR.
9. REDUCING VALVE.
10. AIR LINE, TO PRESSURE GAUGE, HORNS AND AIR PRESSURE SWITCH.
11. FINAL DRIVE UNIT.
12. ELECTRO-PNEUMATIC VALVES— GEARBOX OPERATION.
13. GEARBOX.
14. THROTTLE CONTROL MOTOR.
15. THROTTLE CONTROL MOTOR.
16. GEARBOX.
17. FINAL DRIVE UNIT.
18. ELECTRO-PNEUMATIC VALVES— THROTTLE CONTROL AND FINAL DRIVE OPERATION.

Fig. 1. Diagrammatic layout of air pressure system.

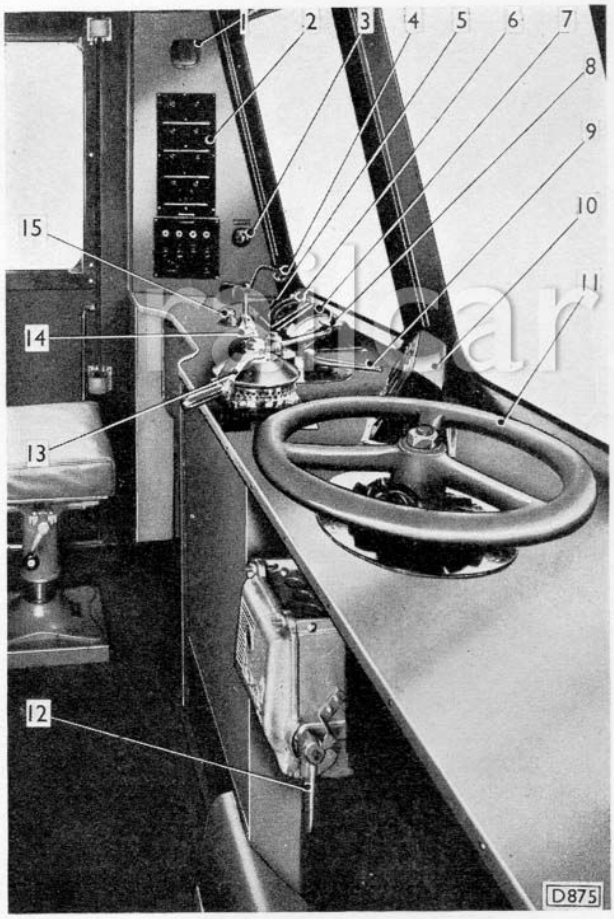
Sect. G1. CONTROLS—DESCRIPTION.

(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 mounted on the control table to the right of the driver a forward and reverse lever and a change speed selector lever.

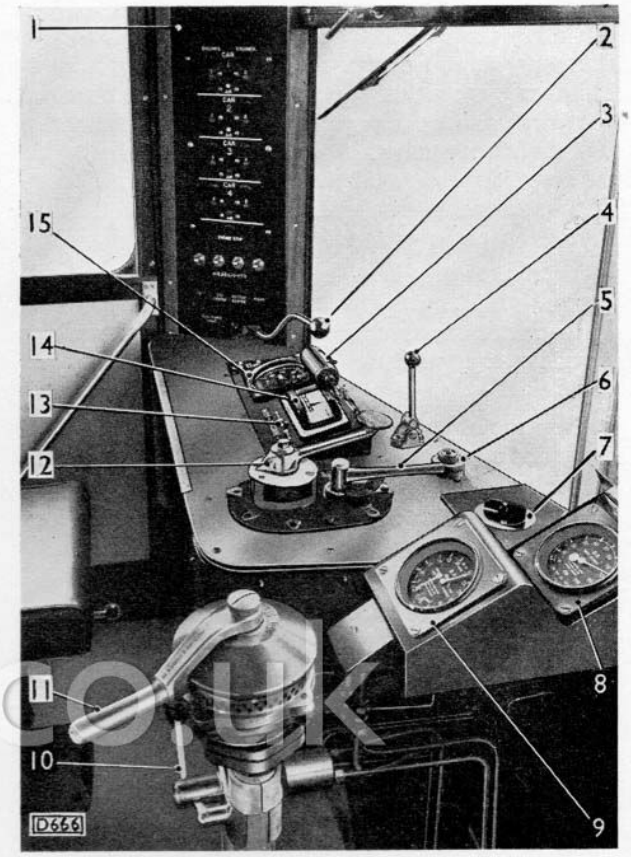
These levers, through the media of electro-pneumatic (E.P.) valves, operate the fuel-injection pumps, forward and reverse gears in the final drive units and the gearbox pistons.



Key to Numbers :—

1. GUARD'S SIGNAL BUZZER.
2. CONTROL PANEL.
3. DESTINATION INDICATOR LIGHT SWITCH.
4. COMBINED THROTTLE LEVER AND " DEAD-MAN'S " HANDLE.
5. ENGINE SPEED INDICATOR SWITCH.
6. SPEEDOMETER.
7. ENGINE SPEED INDICATOR.
8. CHANGE-SPEED SELECTOR LEVER.
9. FORWARD AND REVERSE LEVER.
10. AIR PRESSURE AND DUPLEX VACUUM GAUGES.
11. HANDBRAKE WHEEL.
12. TRAIN SWITCH.
13. VACUUM BRAKE LEVER.
14. HORN SWITCH.
15. WINDSCREEN WIPER VALVE.

Fig. 2. Driver's Controls (Metropolitan-Cammell).



Key to Numbers :—

1. CONTROL PANEL.
2. COMBINED THROTTLE LEVER AND DEADMAN'S HANDLE.
3. CONTROL TABLE LIGHT.
4. HORN SWITCH.
5. FORWARD AND REVERSE LEVER.
6. WINDSCREEN WIPER VALVE.
7. HEADLIGHT DIMMER SWITCH.
8. AIR PRESSURE GAUGE.
9. DUPLEX VACUUM GAUGE.
10. WINDSCREEN WASHER LEVER.
11. HANDBRAKE LEVER.
12. CHANGE-SPEED SELECTOR LEVER.
13. ENGINE SPEED INDICATOR SWITCH.
14. ENGINE SPEED INDICATOR.
15. SPEEDOMETER.

Fig. 3. Driver's controls (B. Rlys. Derby)

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

In addition to the hand controls, the following are mounted on the control table ; speedometer, engine speed indicator, horn, headlight dimmer and windscreen wiper switches.

To the right of the control table are air pressure and duplex vacuum gauges and to the left is a vertically mounted control panel.

The layout is shown in Figures 2 and 3.

AIR PRESSURE SYSTEM.

Compressed air for operating the throttle motors, gearbox pistons, forward and reverse pistons in the final drive units and the horns, is provided by two compressors mounted on the engines.

Air is drawn by the compressors through the air filters and anti-freezers 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 electro-pneumatic valves for the throttle motors and the final drive units to be operated.

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

The function of the unloader valve is to reduce the load on the compressors when the air system is fully charged, by allowing surplus air to escape to atmosphere.

Air from the main reservoirs passes via an air filter through a reducing valve to the electro-pneumatic 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 the horns on the power car and the trailer car.

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.

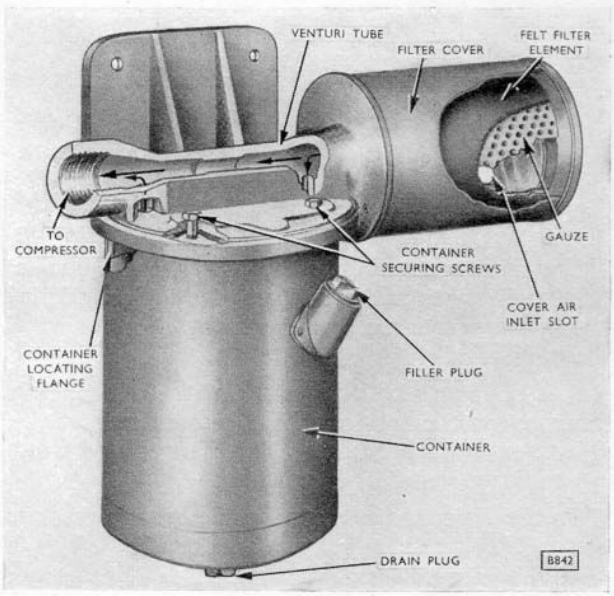
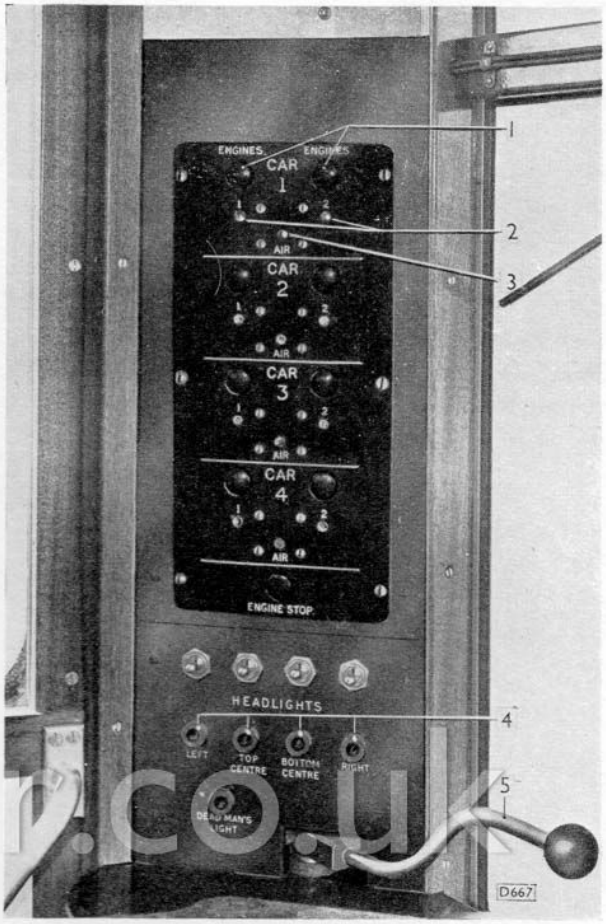


Fig. 4. Combined air filter and anti-freezer.



Key to Numbers :—

1. ENGINE STARTING BUTTONS.
2. OIL PRESSURE INDICATOR LIGHTS.
3. AIR PRESSURE INDICATOR LIGHT.
4. HEADLIGHT INDICATOR LIGHTS.
5. COMBINED THROTTLE LEVER AND DEADMAN'S HANDLE.

Fig. 5. Driver's control panel.

Air reservoirs.

The three air 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.

Drain cocks are provided on the underside of each reservoir.

Mounted on the end of the first reservoir are the unloader and safety valves whilst the diverter valve is mounted on the end of the second reservoir *(see Fig. 8)*.

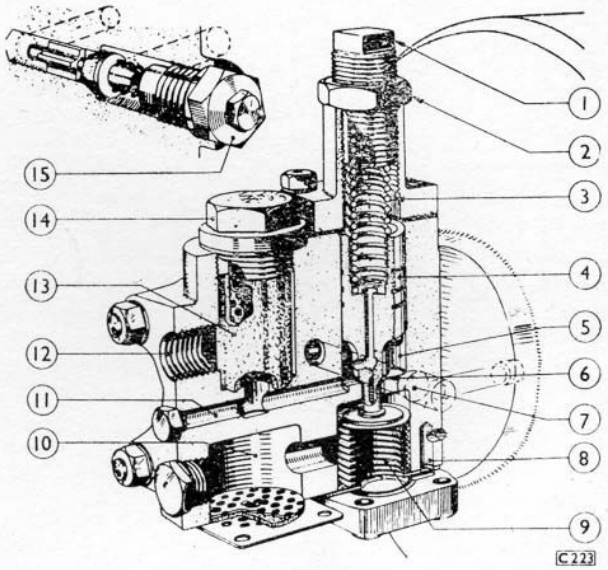
Unloader valve *(see Fig. 7)*.

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 the inlet port and passes through the felt strainer along the 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.

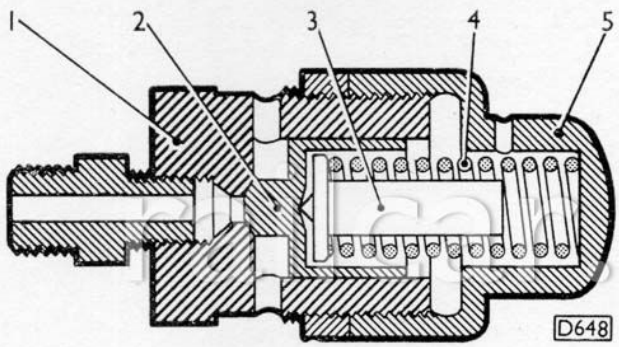
Reservoir pressure is communicated to the inside of a metal bellows, situated below the valve, and when



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. 7. Unloader valve.



Key to Numbers :—

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

Fig. 6. Safety valve.

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.

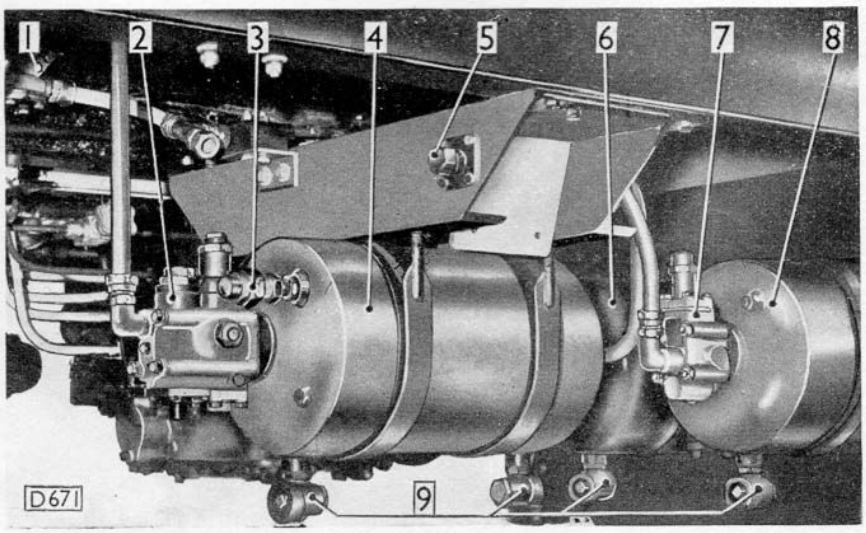
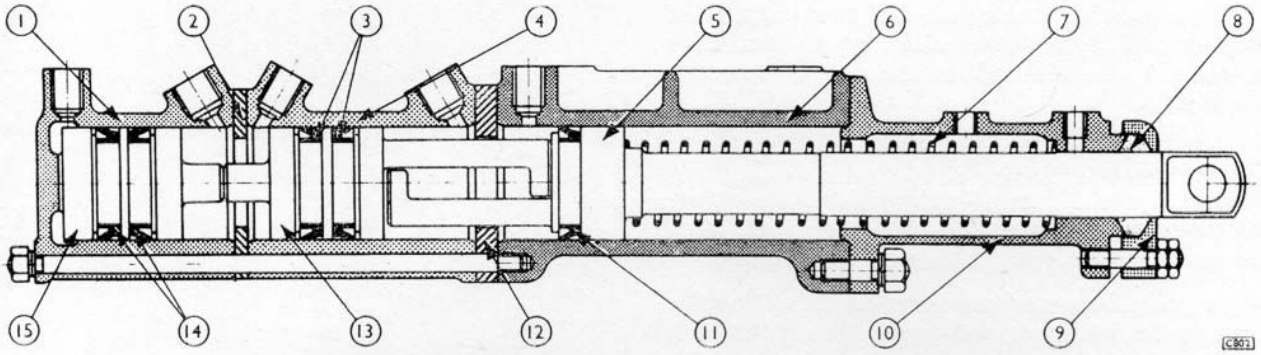


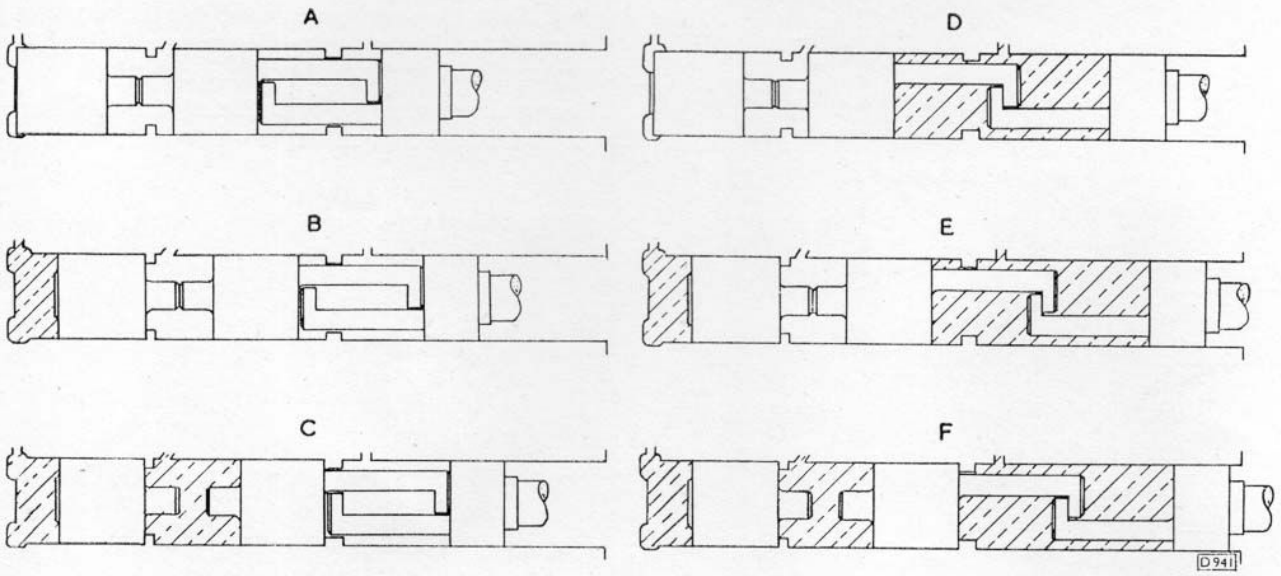
Fig. 8. Air reservoirs, unloader and diverter valves.



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 FISTON.

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

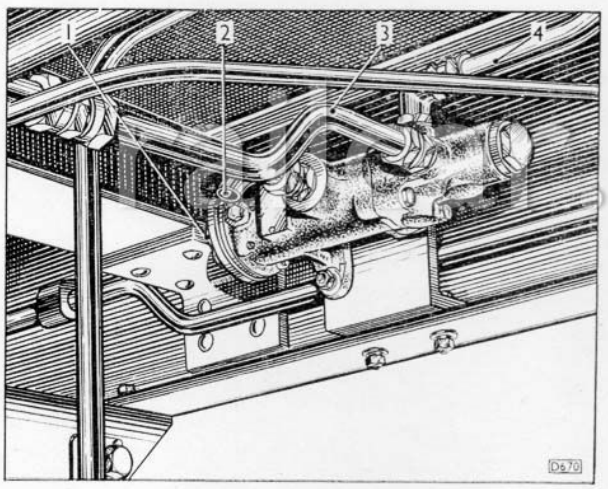
Air continuing to enter the unloader valve from the compressor is then diverted through the silencing chamber to atmosphere.

Safety valve *(see Fig. 6).*

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

Non-return valve *(see Fig. 12).*

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



Key to Numbers :—

1. AIR PRESSURE ADJUSTING SCREW.
2. EXHAUST PIPE.
3. REDUCING VALVE INLET PIPE.
4. OUTLET PIPE TO E.P. VALVES.

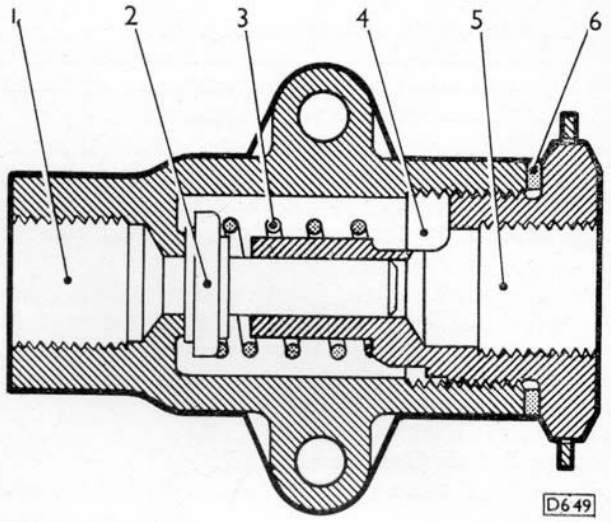
Fig. 11. Air reducing valve in position on the car.

It is designed to prevent air escaping from the reservoirs back to the compressors whilst the engines are idling or stopped, thereby maintaining the full pressure in the air system.

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.

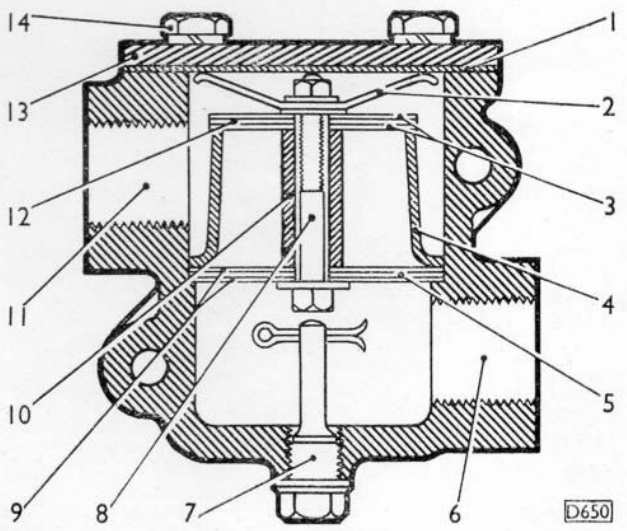
When the air flow ceases, the pressure in the reservoir, assisted by the action of the spring, forces the valve on to its seat, thus preventing air to escape back to the compressor.



Key to Numbers :—

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

Fig. 12. Non-return valve



Key to Numbers :—

1. TOP COVER JOINT.
2. CONICAL SPRING WASHER.
3. PERFORATED PLATES.
4. OUTER DISTANCE PIECE.
5. GAUZE.
6. INLET PORT.
7. DRAIN PLUG.
8. FILTER ASSEMBLY RETAINING BOLT.
9. PERFORATED PLATES.
10. INNER DISTANCE PIECE.
11. OUTLET PORT.
12. GAUZE.
13. TOP COVER.
14. TOP COVER RETAINING SET-SCREW.

Fig. 13. Pipe line air filter.

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 from the electro-pneumatic valves.

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

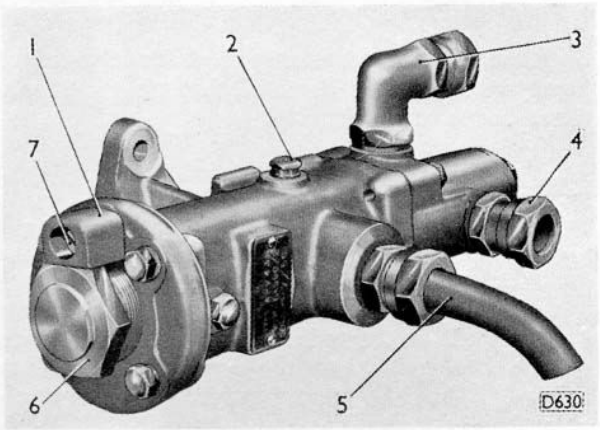
The pistons in the throttle control motors operate the control levers on the fuel-injection pumps in a series of steps which correspond to the steps felt when moving the driver's throttle control lever *(see Fig.* 10).

Pipe line air filters (*see Fig.* 13).

Air filters are mounted in the pipe line between the reservoirs and the reducing valve and between the reservoirs and the electro-pneumatic valve block for the throttle motors and final drives.

The purpose of the filters is to provide an additional safeguard against foreign matter entering the electro-pneumatic valves.

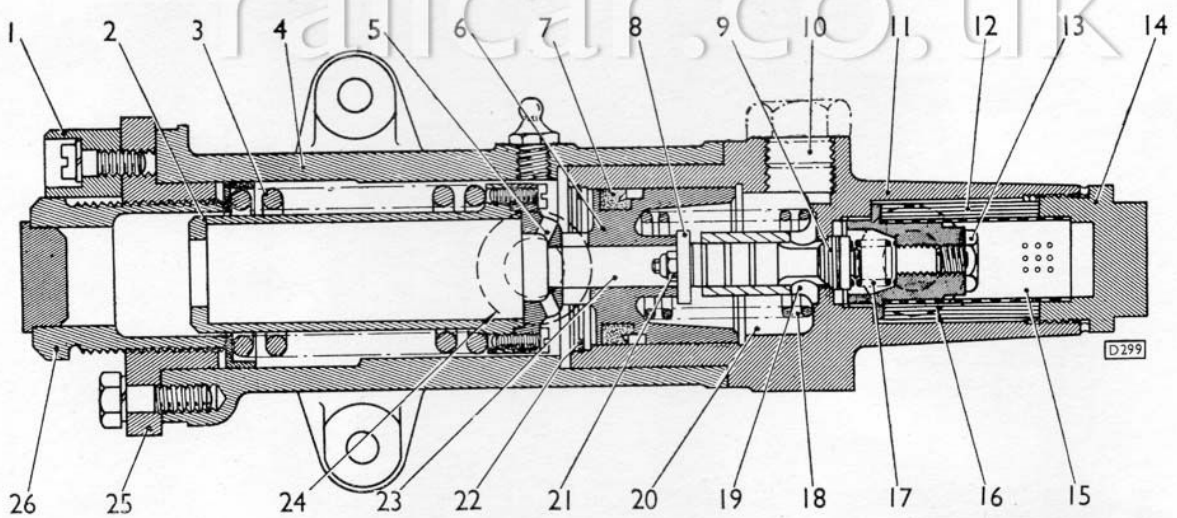
Each filter consists of two gauze elements retained between perforated plates and contained within a brass body (*see Fig.* 13).



Key to Numbers :—

1. ADJUSTING NUT LOCKING PIECE.
2. LUBRICATOR.
3. AIR PIPE CONNECTION FOR PIPE TO E.P. VALVE UNIT.
4. AIR PIPE CONNECTION FOR PIPE FROM AIR RESERVOIR.
5. EXHAUST PORT TO ATMOSPHERE.
6. ADJUSTING SCREW.
7. LOCKING SCREW.

Fig. 14. Air reducing valve.



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 CHAMBER.
16. INLET PORT.
17. SPRING FOR INLET VALVE.
18. SPRING FOR CONTROL PISTON.
19. AIR SPACE UNDER INLET VALVE.
20. AIR CHAMBER.
21. NUT FOR DISC VALVE.
22. CIRCLIP.
23. AIR PASSAGE.
24. EXHAUST PORT TO ATMOSPHERE.
25. ADJUSTING SCREW CARRIER.
26. ADJUSTING SCREW.

Fig. 15. Sectioned view of reducing valve.

Reducing valve *(see Figs.* 11, 14 *and* 15).

The function of the reducing valve is to maintain the pressure of the air supply to the electro-pneumatic valve block within the gearbox operating limit quoted in Section G2.

Mounted in the pipe line between an air filter and the gearbox electro-pneumatic valve block, the reducing valve maintains a supply of air at the necessary pressure to operate gear changes. As shown in Figure 15, the valve consists of a reaction head containing a filter, an inlet valve, release valve and reaction piston ; together with a main body housing the control spring which is fitted in a pre-loaded condition. The inlet port is connected to the compressed air system through an air filter and the outlet port is connected to the gearbox electro-pneumatic 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 gear change electro-pneumatic valve block.

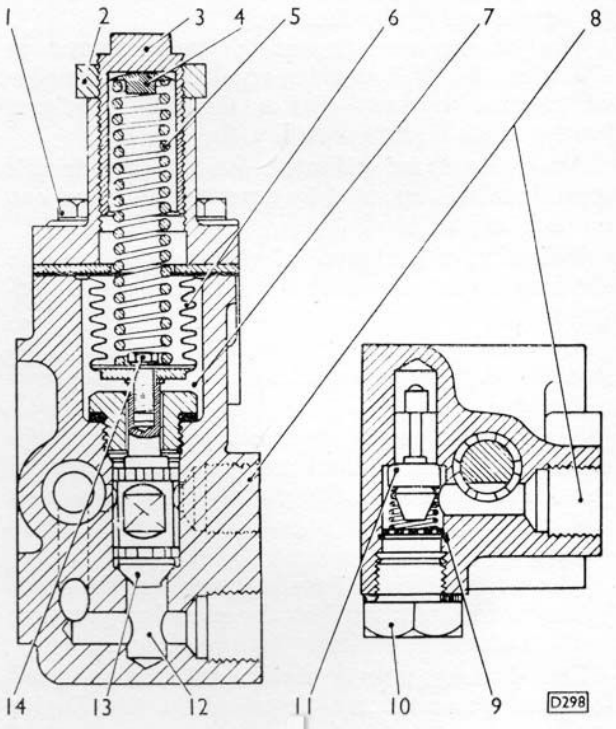
As pressure rises in the chamber (20) it causes the reaction piston to move against the control spring. When the correct pressure is attained, the movement of the reaction piston is sufficient to close the inlet valve, thereby cutting off the supply of compressed air from the reservoirs.

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 (EP) 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 pressure is again established.

Diverter valve *(see Fig.* 16).

The purpose of the diverter valve is to ensure that the main system is charged to at least the pressure quoted in Section G2 before pressure is allowed to build up in the auxiliary 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 auxiliary system.



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. 16. Sectioned view of diverter valve.

The valve is mounted on the second reservoir and connected to a branch pipe from the main compressed air supply. 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 Plates* O57 *and* O74 *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, fitted to the driver's control table, is operated by generators mounted one on each engine.

Indication of the speed of either engine may be obtained by movement of the indicator switch provided (*see Figs.* 2 *and* 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 headlight switches, indicator lights for oil and air pressures and " deadman's " indicator light (*see Fig.* 5).

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

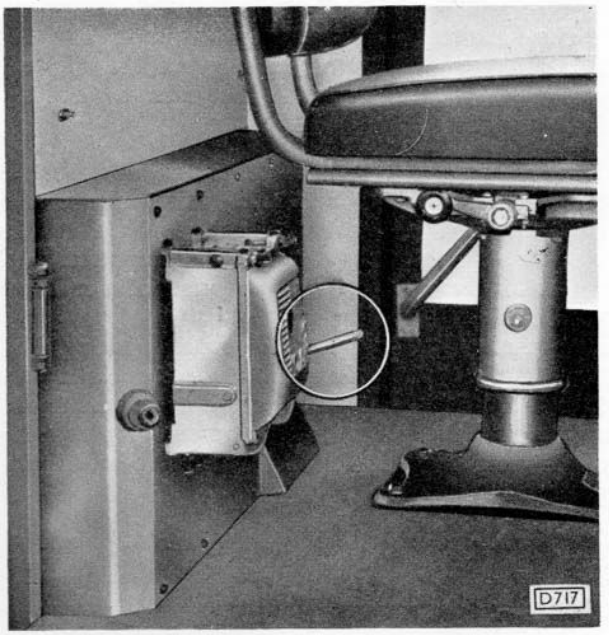
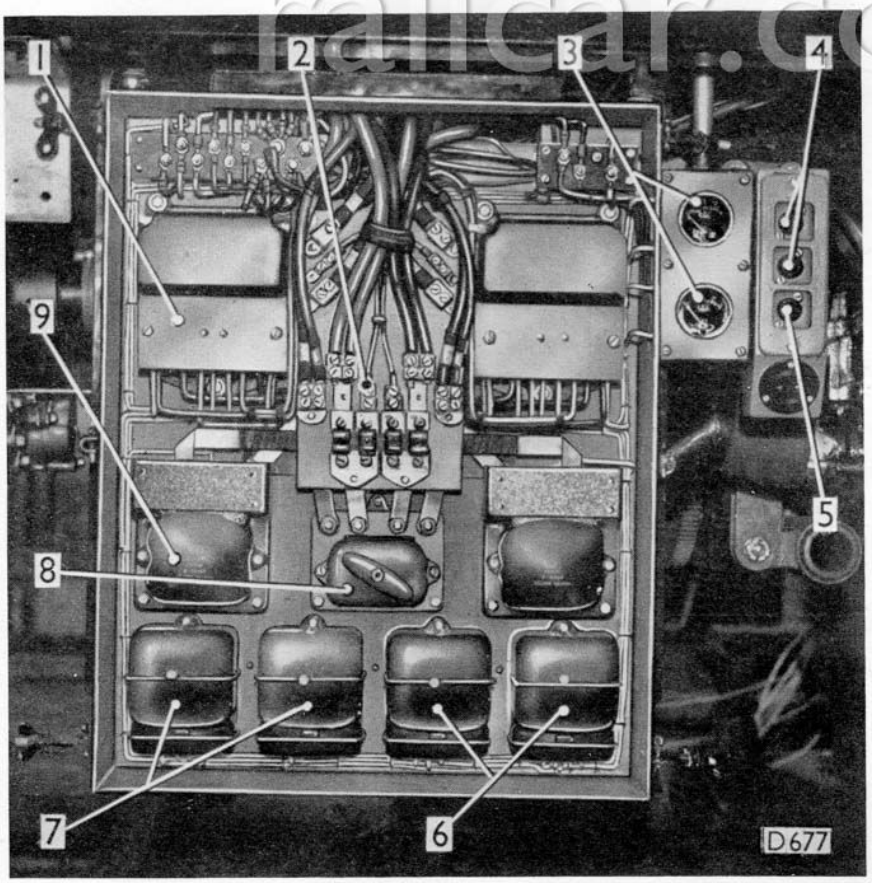


Fig. 17. Train Switch (B. Rlys. Derby)



Key to Numbers :—

1. CONTROL UNIT (TWO).
2. BATTERY CHARGING AND SUPPLY FUSES.
3. DYNAMO AMMETERS.
4. ENGINE AUXILIARY STARTER BUTTONS.
5. ENGINE AUXILIARY STOP BUTTON.
6. STARTER RELAYS.
7. STARTER ISOLATING RELAYS.
8. BATTERY ISOLATING SWITCH.
9. STARTER ISOLATING SWITCH (TWO).

Fig. 18. Electrical control box (engine mounted dynamo equipment).

Control unit *(see Figs.* 18 *and* 20).

A control unit is used in conjunction with each dynamo and is mounted in the electrical control box adjacent to Number 1 engine.

Each control unit houses a double-element regulator, cut-out, main fuse and terminals for battery, dynamo, load, ammeter and starter solenoid switch connections. The regulator operates on the **current voltage control system** whereby the battery, if partially discharged, is charged at a constant current until its voltage reaches a predetermined value, when the charging changes to constant voltage control. Normally only one of the regulator elements, therefore, is in operation at any one time.

Spare fuse strips are carried in a clip on the inside of the fuse and terminal cover plate, which is attached to the main cover by two captive screws.

The two ammeter terminals are shunted, to produce an instrument deflection current of 1·875 milliamperes for each ampere load current.

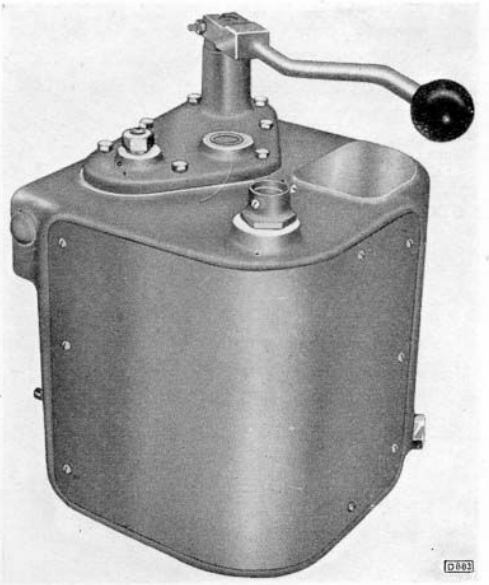
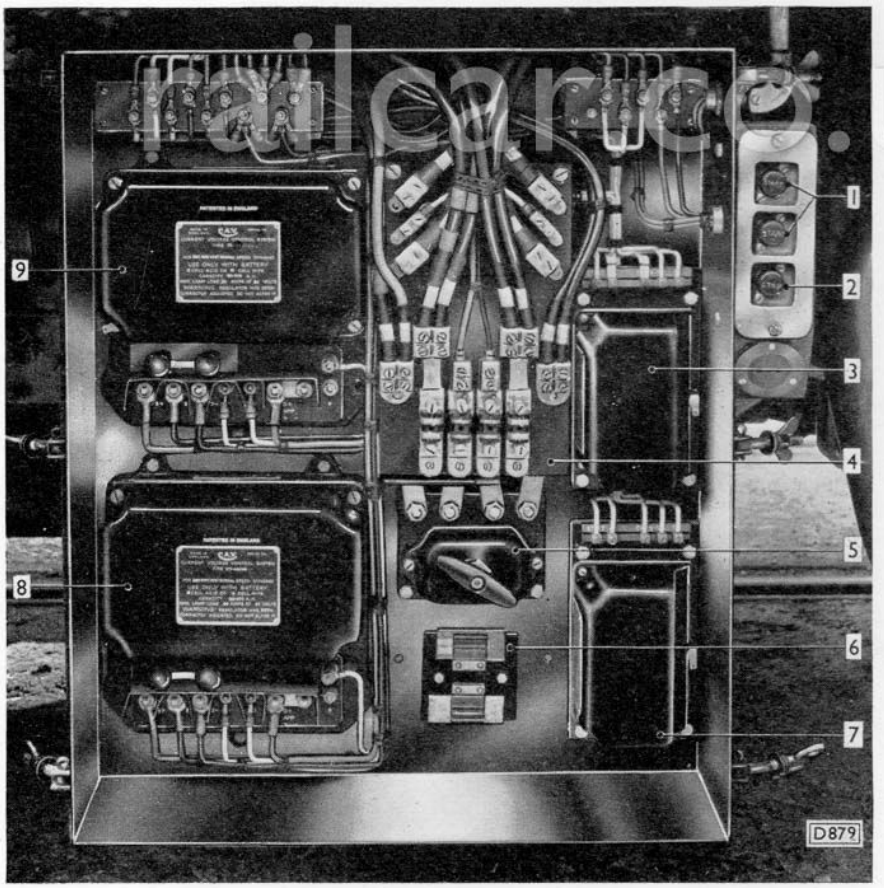


Fig. 19. Throttle controller.



Key to Numbers :—

1. ENGINE AUXILIARY STARTER BUTTONS.
2. ENGINE AUXILIARY STOP BUTTON.
3. STARTER ISOLATING RELAY — No. 1 ENGINE.
4. BATTERY CHARGING AND SUPPLY FUSES.
5. BATTERY ISOLATING SWITCH.
6. SPARE FUSES.
7. STARTER ISOLATING RELAY — No. 2 ENGINE.
8. CONTROL UNIT — No. 2.
9. CONTROL UNIT — No. 1.

Fig. 20. Electrical control box (frame mounted dynamo equipment).

Battery isolating switch (*see Figs.* 18 *and* 20).

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

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

Train switch (*see Figs.* 2 *and* 17).

The train switch, mounted in the driver's cab at the rear of the driver's seat or on the front panel of the control table, 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.

Combined throttle controller and "deadman's" control (*see Figs.* 2, 19 *and* 30).

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 electro-pneumatic valve, thus actuating the throttle control motors.

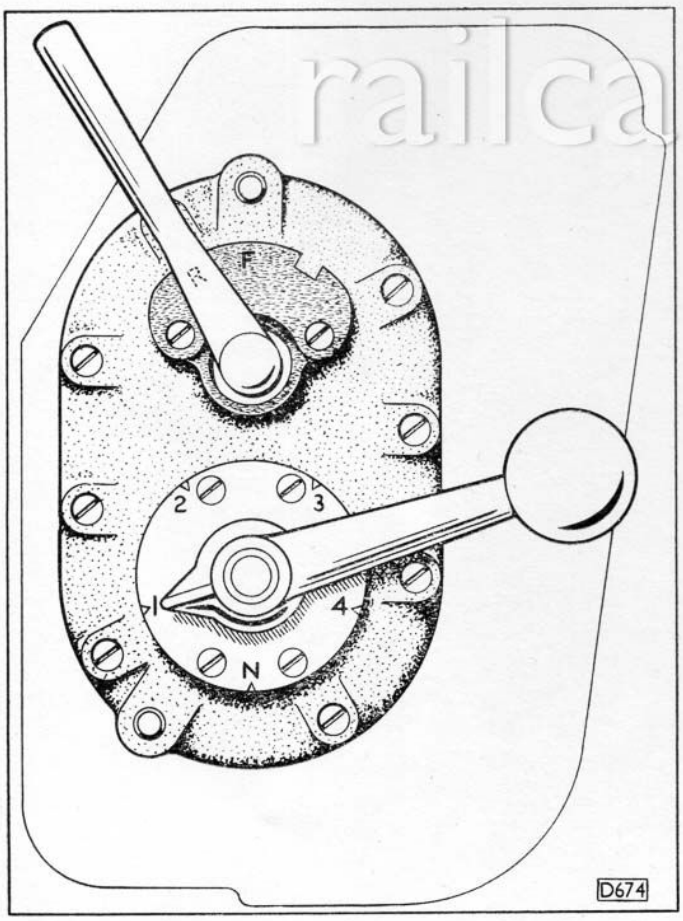


Fig. 22. Forward and reverse and gear selector levers.

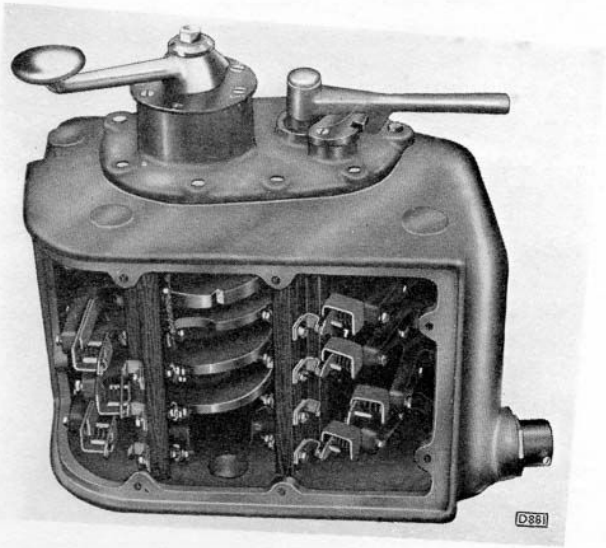


Fig. 21. Gearbox and final drive controllers showing 2nd speed and forward contacts closed.

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.

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

Gearbox controller (*see Figs.* 21 *and* 22).

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

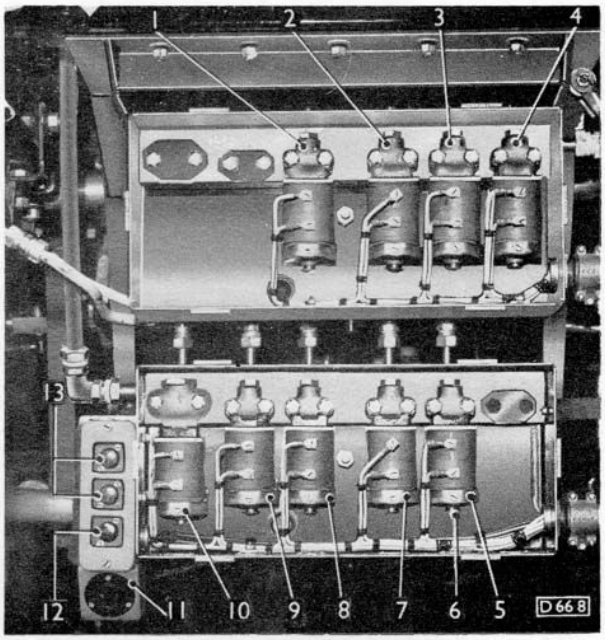
When the forward and reverse lever is in the neutral position, it can be removed from the controller, thus rendering the car immobile.

Electro-pneumatic valves *(see Fig.* 23).

Each car is provided with a number of electro-pneumatic 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 type designation should appear stamped on a raised portion on the underside of the valve ; also on the underside is a push button for operating the valve by hand for testing.

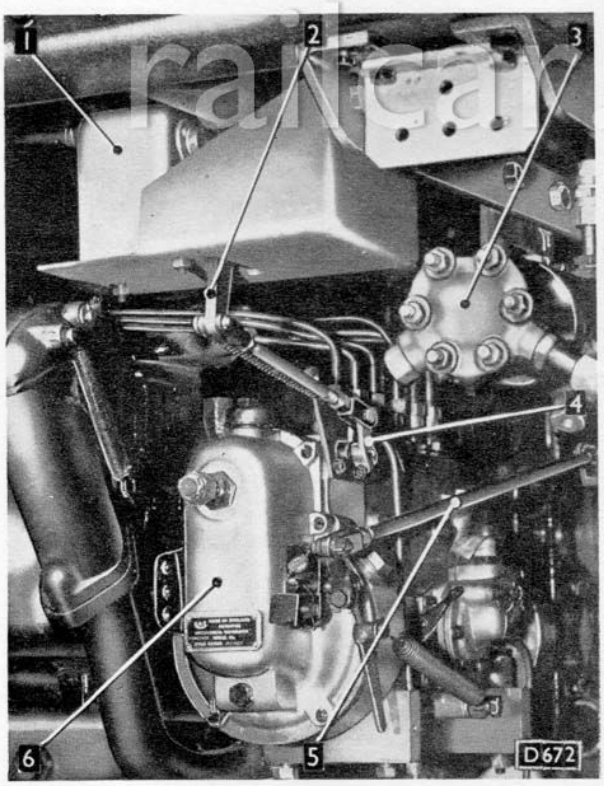
Each electro-pneumatic valve embodies a needle valve which either opens or closes—depending upon the type—a short passage connecting an air feed pipe to a delivery pipe which leads to the actuating mechanism concerned. The needle valve is operated by a loosely fitting plunger inside the core of a solenoid whenever the latter is energised, and works against the pressure in the air line in addition to that exerted by a small coil spring. The design of the connecting passage and the plunger top is such that any air leaking past the valve is discharged to atmosphere.



Key to Numbers :—

1. GEARBOX E.P. VALVE—1st SPEED.
2. GEARBOX E.P. VALVE—2nd SPEED.
3. GEARBOX E.P. VALVE—3rd SPEED.
4. GEARBOX E.P. VALVE—TOP SPEED.
5. FINAL DRIVE E.P. VALVE—REVERSE SPEED.
6. E.P. VALVE HAND TESTING BUTTON.
7. FINAL DRIVE E.P. VALVE—FORWARD SPEED.
8. THROTTLE MOTOR E.P. VALVE—No. 3.
9. THROTTLE MOTOR E.P. VALVE—No. 2.
10. THROTTLE MOTOR E.P. VALVE—No. 1.
11. INSPECTION LAMP SOCKET.
12. ENGINE STOP BUTTON.
13. ENGINE START BUTTONS.

Fig. 23. Electro-pneumatic valves.



Key to Numbers :—

1. ENGINE SHUT DOWN SOLENOID.
2. SOLENOID TRIP LEVER.
3. THROTTLE CONTROL MOTOR.
4. STOP LEVER.
5. THROTTLE CONTROL ROD.
6. FUEL-INJECTION PUMP.

Fig. 24. View showing position of engine shut-down solenoid and linkage.

Air pressure switch (if fitted).

The air pressure switch is totally enclosed, its function being to indicate electrically, the state of the air pressure in each power car.

Fluctuation of air pressure in the system, operates the switch, which actuates an indicator light on the control panel in the driver's cab.

These lights are " on " when the switch cuts in and " off " when the switch cuts out (*for air pressures see Section* G2).

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

Water level switch *(see Fig.* 25).

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

Engine shut down solenoid *(see Fig.* 24).

The engine shut down solenoid is connected by linkage to the fuel-injection pump stop lever.

When the water level switch is closed, it energises the solenoid which operates the trip lever and shuts off the supply of fuel to the injectors.

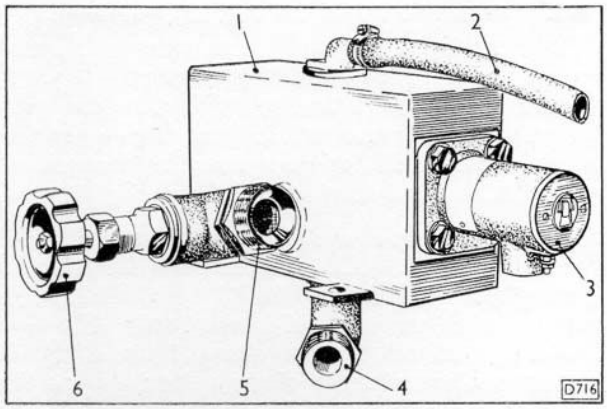
Oil pressure switch.

The oil pressure switch is mounted on the engine casing extension and operates the oil pressure indicator lights on the control panel situated in the driver's cab.

Starter switches *(see Figs.* 18 *and* 20).

The starter circuit contains three switches, mounted in the control box.

When the starter button is operated, a solenoid coil is energised in the **starter relay,** which closes the solenoid circuit of the **starter switch.** This solenoid draws in a plunger until a bridge piece, mounted on the end of the plunger, engages two fixed contacts, thus completing the circuit between the starter motor and the battery negative terminal.



Key to Numbers :—

1. LOW WATER TANK.
2. VENT PIPE FROM RADIATOR.
3. WATER LEVEL INDICATOR SWITCH.
4. INLET PIPE FROM SUPPLY TANK.
5. OUTLET PIPE TO RADIATOR.
6. STOP COCK.

Fig. 25. Low water tank and level switch.

The **starter isolating relay** protects the starter motor against inadvertent re-engagement while the engine is running.

It is operated by the output of the engine driven dynamo, which, when reaching a predetermined speed, energises a solenoid coil, this in turn operates contacts to interrupt the starter motor solenoid circuits.

Sect. G2. CONTROLS—DATA.

AIR PRESSURE SYSTEM

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.

Sect. G3. 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 below*). Check the level of " Methanol " in the anti-freezer container (*see below*).
WEEKLY.	Lubricate the throttle control motors (*see Section* G4). Lubricate the reducing valve (*see Section* G4). 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 below and " To check for air leaks "*). Top-up the exhauster oil reservoir (*see Section* G4).
MONTHLY.	Clean the felt element in the combined air filter and anti-freezer (*see below*). Clean the felt filter element in the reducing valve (*see below*). Clean the gauzes in the pipe line air filters (*see below*).
QUARTERLY.	Clean or if necessary renew the felt element in the combined air filter and anti-freezers (*see below*). Clean or if necessary renew the felt filter element in the reducing valve (*see below*). Drain the oil from the exhauster oil reservoir, clean the filters and fill with fresh oil (*see Section* G4).

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.

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. 7).*

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

The unloader cut-out pressure is adjusted to the figure given in Section G2 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 the thimble down just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. Retighten 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.

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.

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

Reducing valve.

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. Refit the plug temporarily to prevent entry of dirt.

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

Throttle control motors.

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 remaining in the " full throttle " position when in service.

Lubricate the pistons and piston operating rods *(see Section* G4).

Pipe line air filters

At intervals quoted in the chart at the beginning of this Section remove and clean the gauzes 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.

In order that each part can be washed separately, unscrew the retaining nut and dismantle the assembly.

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

If either the top or bottom gauze is damaged it should be renewed.

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

Screw in the drain plug.

"Deadman's" control valve.

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

Exhauster oil reservoir *(see Fig. 26).*

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.

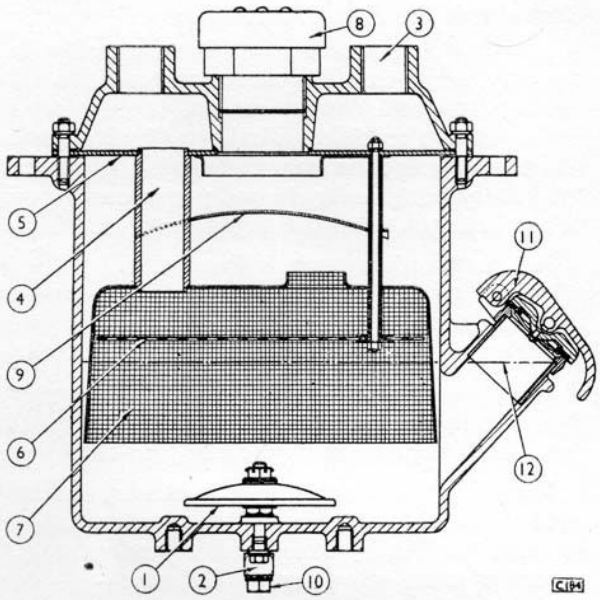
Oil from the exhauster is combined with air, drawn from the brake system ; a breather is provided to allow this air to escape, the oil being retained in the reservoir. Oil leakage through the breather is prevented by a baffle plate.

A drain plug is fitted to facilitate cleaning.

The reservoir requires no maintenance other than topping-up the oil level (*see section* G4).

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.



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. 26. 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.
QUARTERLY.	Inspect the control unit and if necessary, test and adjust *(see following paragraphs).*
	Inspect the electro-pneumatic valves *(see following paragraphs).*
	Inspect and if necessary adjust the air pressure switch *(see following paragraphs).*
	Check manually the engine shut down solenoid for correct operation *(see following paragraphs).*
HALF-YEARLY.	Clean the contacts in the throttle controller *(see following paragraphs).*
	Clean the contacts in the gearbox controller *(see following paragraphs).*
	Clean the contacts on the starter relay, starter isolating relay and starter switch, all in the electrical control box *(see following paragraphs).*
	Clean the contacts in the water level switch *(see following paragraphs).*
	Clean the contacts in the air pressure switch *(see following paragraphs).*

Control unit *(see Figs.* 17 *and* 19).

The control unit should not be tampered with in any way unless there is good reason to suspect that the regulator and cut-out are not functioning properly. Such a condition is indicated by bad starting and poor illumination from the interior lights, due to the battery being under-charged ; or frequent gassing of the battery, due to it being overcharged.

See that the dynamo main fuse is intact ; if it has " blown " it should be renewed after ascertaining and rectifying the cause of its failure. Both the dynamo and battery should be inspected for possible faults.

The replacement fuse must be of the same material, thickness and shape as the one it is replacing. The fuse size is stamped at one end of the strip.

Assuming that the main fuse is intact and that the dynamo is in good order, it will then be necessary to open the battery cut-off switch and remove the control unit for adjustment, as follows :—

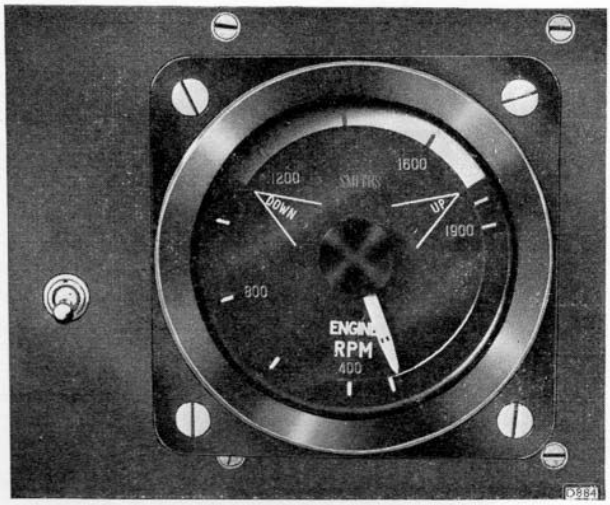


Fig. 27. Engine speed indicator and switch (gear driven generator type).

Regulator.

Mechanical setting.

This should be made with the regulator at an approximate temperature of 68° F. (20° C.).

Note that there are two regulator elements and the following operations should be carried out on each one in turn.

Slacken the screws attaching the flat armature hinge spring to the frame.

Slacken the adjustable contact screw and auxiliary and stop spring adjusting screws.

Press the armature down firmly on to the core so that the back of the armature is against the frame.

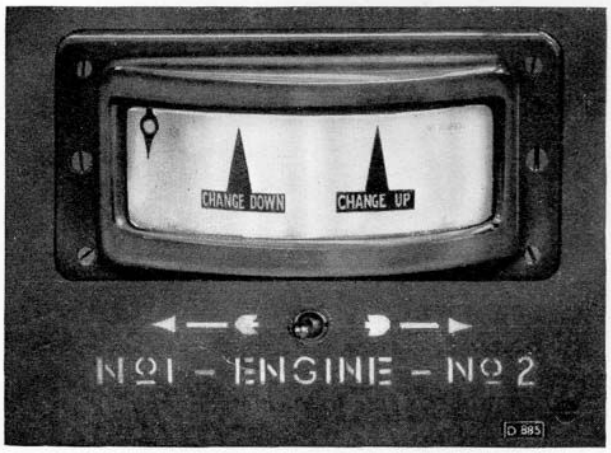


Fig. 28. Engine speed indicator and switch (belt driven generator type).

The gap (if any) that appears between the top of the frame and the underside of the armature hinge spring must be closed by shims, taking care not to insert more than are necessary and thus distort the spring.

Tighten the armature screws.

Note.—With the armature pressed down it should touch the core at front or rear, and a maximum gap of 0·005 in. (0·13 mm.) can be allowed between the parts not touching. A 0·002 in. (0·05 mm.) feeler gauge should not enter between the back of the armature and the frame.

Examine the contacts for signs of burning or pitting and, if necessary, clean them with fine glass paper and wipe them with a clean rag dipped in petrol.

Adjust the moving contact until the gap between the tip of the armature and core is between 0·045 and 0·050 in. (1·14 and 1·27 mm.) when the contacts are closed. Lock the contacts at this setting.

Screw in the stop screw until it just touches the bronze stop spring. Then unscrew it three-quarters of a turn and lock at this setting.

Electrical setting

Connect the control unit to a dynamo **(of the same type as that fitted to the car)** on a variable speed test stand and connect a voltmeter (range 0—35) across the terminals (D+) and (D−). See that the main fuse is intact.

Unscrew the stop screw until it is well clear of the stop spring.

Run the dynamo up to a speed of 2,000 r.p.m. and adjust the element by means of the lower adjusting screw until the voltmeter reading is 29·0—29·25 volts.

Stop and start the dynamo several times, making any further adjustment that may be necessary to keep the voltage within these limits. Lock the screw after each adjustment.

Screw in the stop screw very slowly, with the dynamo still running at 2,000 r.p.m., until the voltage begins to rise ; then unscrew it three-quarters of a turn and lock at this setting. Stop the dynamo.

Now set the current regulator element as follows:—

Connect a voltmeter (range 0·35) across the (D+) and (D−) terminals of the control unit.

Connect an ammeter, reading up to 60 amperes, in the cable between the dynamo (+) and the (D+) terminals on the control unit.

Alternatively, connect a centre zero ammeter (range 60-0-60) C.A.V. model A4134T or its equivalent across the control unit terminals marked (+) AMP (−).

Apply a load of approximately 60 amperes across the terminals (B+) and (B−) on the control unit.

Run the dynamo at 2,000 r.p.m.

Unscrew the stop screw until it is well clear of the stop spring. Adjust the current regulator by means of the adjusting screw to give a reading on the ammeter of 60·5 ± 0·5 amperes.

During this setting, the voltage across (D+) and (D−) terminals should be approximately 27 volts and in no case must it exceed 28 volts.

When setting the current regulator, it is important to slow down and speed up the dynamo several times to 2,000 r.p.m. to ensure stability of the setting.

With the dynamo speed at 2,000 r.p.m., screw in the screw very slowly, until the current value begins to increase ; then unscrew it three-quarters of a turn and lock it at this setting.

Cut-out.

Mechanical setting.

Slacken the armature spring screws attaching the flat armature hinge spring to the frame.

Unscrew and separate the main contacts and the auxiliary contacts behind them. Unscrew (auxiliary contact) adjusting screw.

Insert a 0·004 in. (0·10 mm.) feeler gauge between the back of the armature and frame.

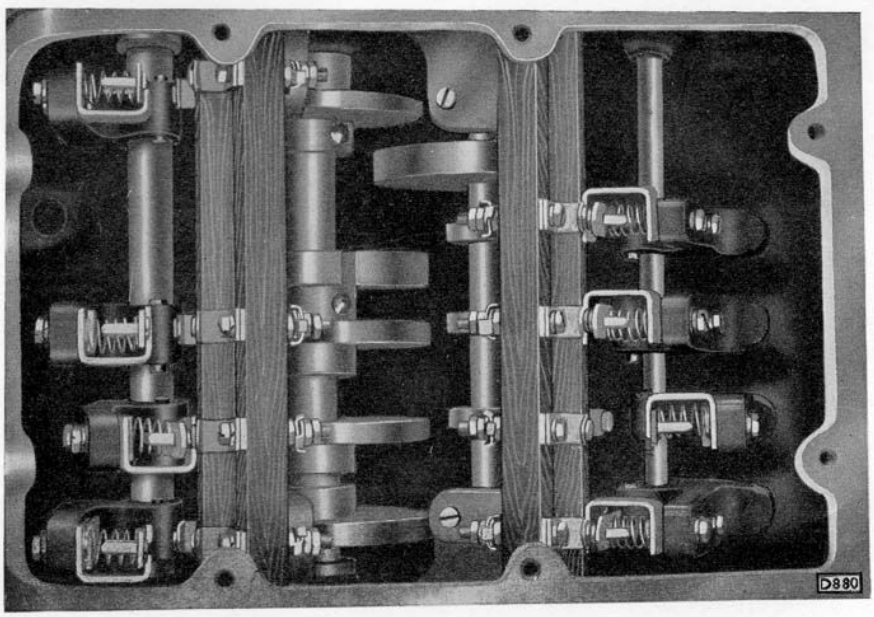


Fig. 29. Gearbox and final drive controllers showing electrical contacts.

Press the armature firmly down on to the core. The gap (if any) that appears between the top of the frame and the underside of the armature hinge spring must be closed by shims, taking care not to insert more than are necessary and thus distort the spring.

Tighten the armature screws.

Note.—With the armature pressed down it should touch the core at front or rear and a maximum gap of 0·005 in. (0·13 mm.) can be allowed between the parts not touching.

Examine the contacts for signs of burning or pitting and, if necessary, clean them with fine glass paper and wipe them with a clean rag dipped in spirit.

Screw down the main contacts until the gap between the tip of the armature and the core is 0·020 in. (0·51 mm.) with the armature held down.

With a 0·008 in. (0·20 mm.) feeler gauge between the main contacts, hold the armature down and adjust the auxiliary contacts behind them to touch. Lock both main and auxiliary contacts at these settings.

Insert a 0·004 in. (0·1 mm.) feeler gauge between the main contacts, hold down armature and adjust the extra auxiliary contacts so that they touch.

With the contacts open, the gap between the armature tip and the core should be 0·055 in. (1·4 mm.) obtained by bending the armature stop, if necessary.

Electrical setting.

Connect the control unit to the dynamo on a variable speed test stand and connect a voltmeter across the terminals (D+) and (D−), with a rheostat adjusted to 6 ohms across the terminals (B+) and (B−).

Gradually speed up the dynamo and note the cutting-in voltage when the contacts close. This should be 27·0—27·5 volts.

To adjust to this value, stop the dynamo and turn the adjusting screw as required and lock. When the setting is correct adjust the load to 60·5 ± 0·5 amperes by means of the rheostat. Then test the

Fig. 30. Throttle controller showing electrical contacts.

setting by stopping and starting the dynamo several times, thus cutting-in and cutting-out.

Stop the dynamo.

Battery isolating switch.

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

Electro-pneumatic valves.

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, " lap in " the existing valve and seat, or fit replacements.

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 dipped in 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 dipped in petrol ; fit the cover.

Engine shutdown solenoid *(see Fig.* 24).

Check the engine shutdown solenoid to ensure that the trip linkage is operating correctly.

To do this, press down the lever situated on the side of the solenoid unit and, if the " tripping " mechanism is operating correctly, the trip lever should move the stop lever on the fuel-injection pump to the stop position.

When the above check has been made, return the trip lever to the running position by moving it back until it can be felt to " click " into place.

If the connecting rod between the trip lever and the stop lever is too short, it will not be possible for the solenoid to " trip " or for the lever to return to the running position.

In this case, remove one of the connecting rod fork-end pins, slacken off the locknut and unscrew the fork-end to obtain the optimum length of the rod to enable the solenoid to " trip " correctly.

Tighten the locknut and fit the fork-end pin.

Gearbox and throttle controllers *(see Figs.* 19 *and* 21).

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

At overhaul periods lightly smear all working parts with lubricant.

Starter switches.

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

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

Sect. G4. CONTROLS—LUBRICATION.

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

At intervals quoted in the chart in Section G3.

Lubricate the pistons and piston operating rods with an oil gun, through the lubricators provided, using an oil to the following specification.

Reducing valve *(see Fig.* 15).

At intervals quoted in the chart in Section G4 lubricate the reducing valve piston with an oil gun, through the lubricator provided, using an oil to the following specification.

Exhauster oil reservoir *(see Fig.* 26).

At intervals quoted in the chart in Section G3, 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 up to the level of the filler cap hole with an oil to the following specification.

OIL SPECIFICATION.

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

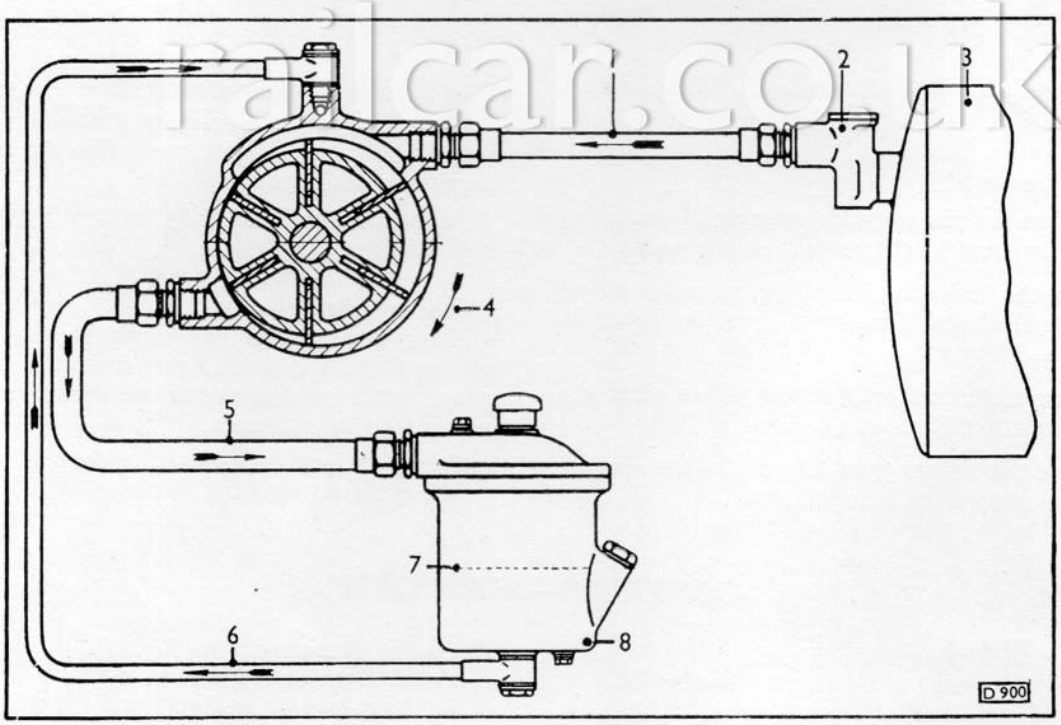
Description.—To be a pure hydrocarbon oil refined by the Solvent Extraction Process, thoroughly filtered to remove all solid matter, and to be entirely free from water, dirt, suspended matter or any other impurities. To be free from mineral acidity and objectionable odour.

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. 31. Diagrammatic illustration showing lubrication by separate oil reservoir.

Sect. G5. ELECTRICAL CONTROL GEAR—TO REMOVE AND FIT.

To Remove.

Control unit.

Isolate the battery by opening the battery isolating switch (*see Figs.* 18 *and* 20).

Remove the fuse and terminal cover plate by unscrewing the two captive screws.

Disconnect the cables from their terminals.

Remove three bolts securing the control unit to the frame and lift the unit away.

Battery isolating switch (*see Figs.* 18 *and* 20).

Ensure that this is open ; then disconnect the cables from the terminal posts on the battery and tape them clear.

Disconnect the cables from all terminals and remove the three bolts holding the unit to the chassis frame.

To Fit.

Reverse the procedure given for removal, ensuring that all connections are secured to their correct terminals and all screws and bolts are screwed up tightly.

Sect. G6. EXHAUSTER OIL RESERVOIR —TO REMOVE, DISMANTLE, ASSEMBLE AND FIT.

(*See Fig.* 26).

To Remove.

Drain the oil by removing the drain plug (*see Section* G4).

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

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

To Dismantle.

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

Unscrew the breather.

Remove the inner top plate and strainer complete.

Unwire and remove the bottom filters.

To Assemble.

Wash all parts thoroughly in clean paraffin.

Reverse the procedure given for dismantling.

To Fit.

Reverse the procedure for removal, fill with fresh oil (*see Section* G4).

NOTES.

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Sect. G7. UNLOADER AND SAFETY VALVES —TO OVERHAUL, TEST AND ADJUST.

(*See Fig.* 6).

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

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

To Overhaul.

Unloader valve.

The unloader valve is removed from the reservoir by unscrewing the nuts from the four securing studs and drawing it away.

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

Remove the cover below the bellows.

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

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

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

Examine the bellows carefully for deterioration or distortion.

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

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

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

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

Lightly oil all moving parts.

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

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

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

Safety valve.

Dismantle and clean all parts.

If necessary, lightly grind the valve on to its seating.

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

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

To Test.

Unloader valve.

Charge the reservoir by running the compressor or by admitting air from the shop air line. The unloader valve should be adjusted to unload when the reservoir pressure gauge indicates the figure given in Section G2. If a test gauge has been fitted in the air supply line, it should give a zero or very low reading **after** the unloader valve has unloaded.

Slowly lower the reservoir pressure by opening the drain cock or plug. The unloader valve should cut in again at the pressure indicated in Section G2.

Close the drain cock or plug and charge the reservoir to the unloader cut-out pressure, checking meanwhile that there is no escape of air through the exhaust silencer, nor should there be any leaks from any of the joints round the unloader valve.

Safety valve.

The safety valve must be removed from the reservoir, tested for correct operating pressure (*see Section* G2) and adjusted if necessary. It should close at approximately 10 lb. per sq. in. (0·7 Kg. per sq. cm.) below blow-off pressure and should be tested with soap and water at unloader cut-out pressure (*see Section* G2) when no leakage must occur.

To Adjust.

Unloader valve.

The unloader cut-out pressure is adjusted to the figure given in Section G2 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 the thimble down just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. Retighten the locknut and recheck the setting.

There is no adjustment for the cut-in pressure, and if this is low, the unloader valve must be dismantled again and checked. It is important that the reservoir pressure does not fall below the cut-in pressure given in Section G2 but it does not matter if the actual cut-in pressure is a little higher.

Safety valve.

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

Sect. G8. NON-RETURN VALVE—TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 12).

To Dismantle.

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

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

To Assemble.

Wash all parts thoroughly in clean paraffin.

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

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

Sect. G9. DIVERTER VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST.

(*See Fig.* 16).

To Dismantle.

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

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

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

Withdraw the control spring and button.

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

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

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

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

To Assemble.

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

All moving parts should be smeared with oil.

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

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

To Adjust.

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

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

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

Release the pressure from the system ; run the compressor and verify that the diverter valve opens at the correct pressure quoted in Section G2.

Sect. G10. REDUCING VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST.

(*See Fig.* 15).

To Dismantle.

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

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

Unscrew the end cap and remove the felt filter element.

Unscrew the adjusting screw carrier.

Extract the circlip with suitable pliers and withdraw the piston. Care must be taken to avoid damage to the sealing ring and also to the flat annular face of the release valve.

Unscrew the nut securing the release valve seat.

To Assemble.

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

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

Inspect the bore and piston for scoring.

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

To Adjust.

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

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

Connect to the outlet port an accurate gauge, capable of reading up to at least 65 lb. per sq. in. (4·57 Kg. per sq. cm.).

The setting of the control spring should then be adjusted by means of the adjusting screw so that there is constant pressure as quoted in Section G2.

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

Finally, lock the adjusting screw.

Sect. G11. THROTTLE CONTROL MOTORS—TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 9).

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

To Dismantle.

Remove the cylinder securing nuts and withdraw the end cylinder, piston and distance piece.

Withdraw the intermediate cylinder and " unhook " the intermediate piston. Remove the distance piece and withdraw the operating piston and rod.

Remove the nuts securing the end cover to the body and detach the cover. Remove the nuts and locknuts securing the gland and detach the gland and felt packing washer.

To Assemble.

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

Examine the piston rubbers for signs of damage, hardness or wear and renew if necessary.

Lubricate all cylinder bores with engine oil to facilitate entry of the pistons and rubbers.

The **thick** distance piece is fitted between the intermediate cylinder and the body.

It is advisable to fit the gland and felt washer last of all, taking care **not** to over tighten the adjusting nuts or the motor will remain in the full throttle position when in service.

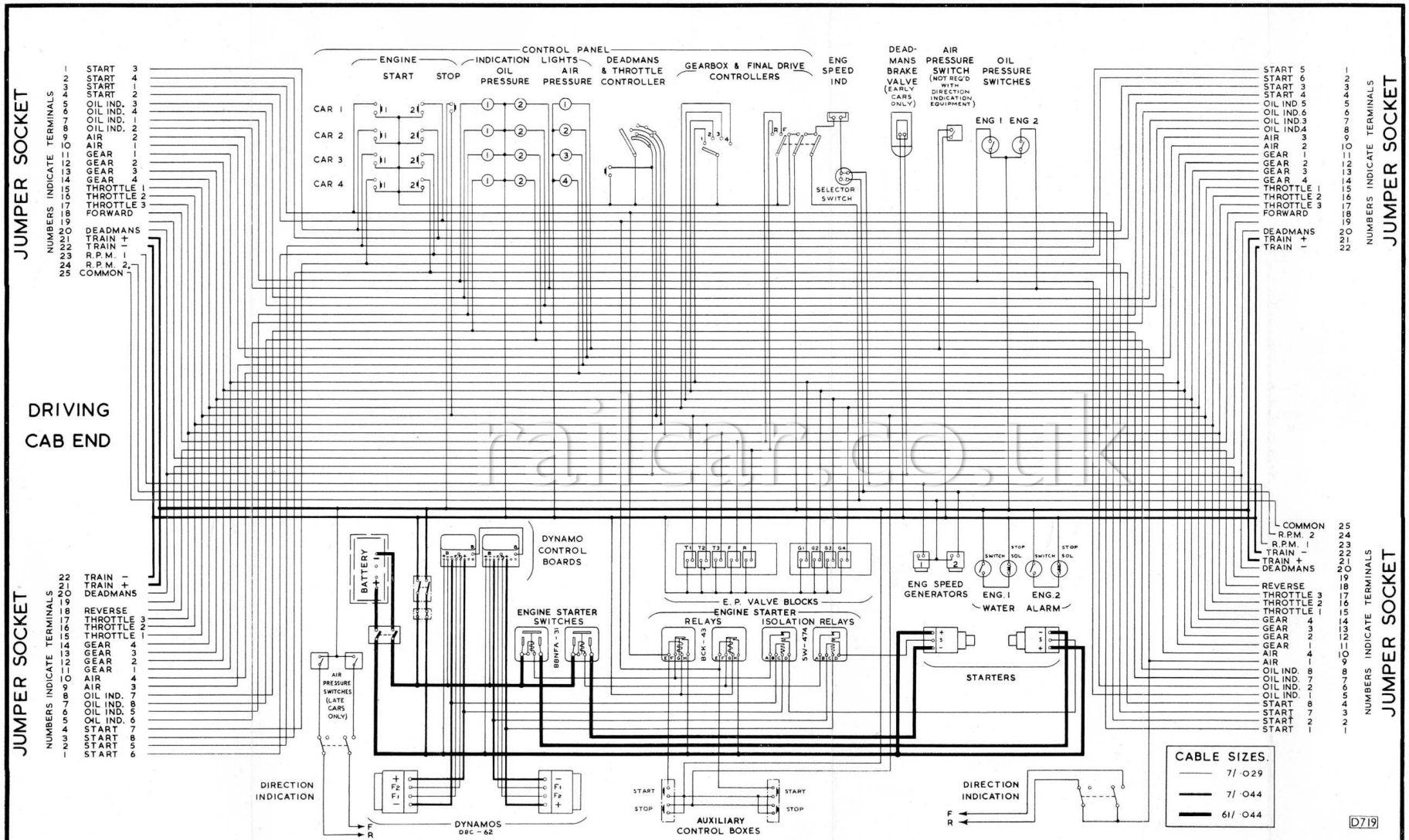


PLATE No. 057.

WIRING DIAGRAM for B.U.T. TRACTION EQUIPMENT (Power Cars).

British Railways Lightweight M.U. Diesel Cars 79,000 Series.

(Excluding 79,000 to 79,007; 79,047 to 79,082; 79,500 to 79,507; Inter-City & Two-axle Cars).

NOTE.—This diagram applies to units with 7 in. dia. engine mounted dynamos.

Where 8 in. dia. frame mounted dynamos are fitted, engine starter relays are modified as shown in Plate 074 and also engine starter switches are deleted.

1500 H & C 7-56

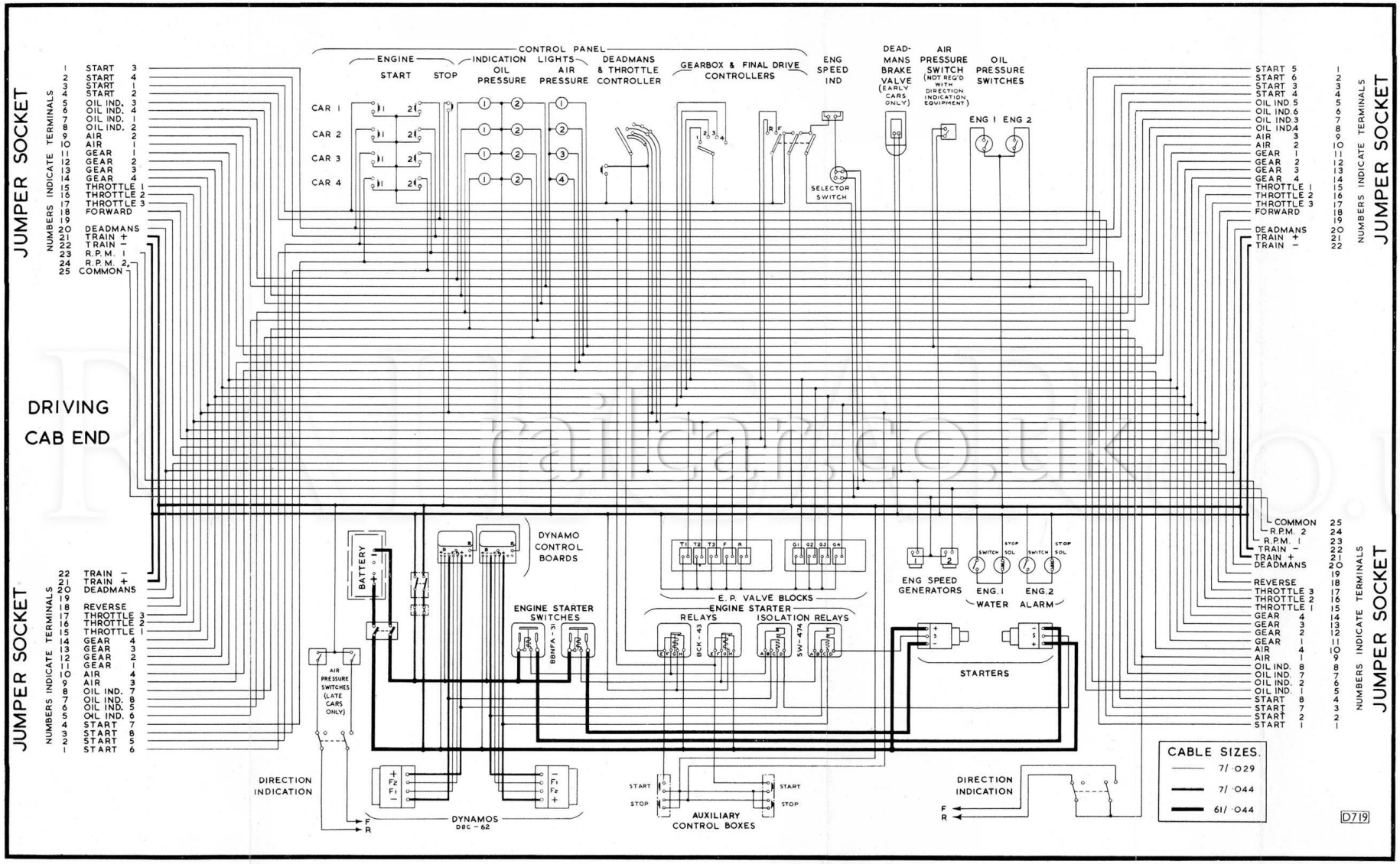
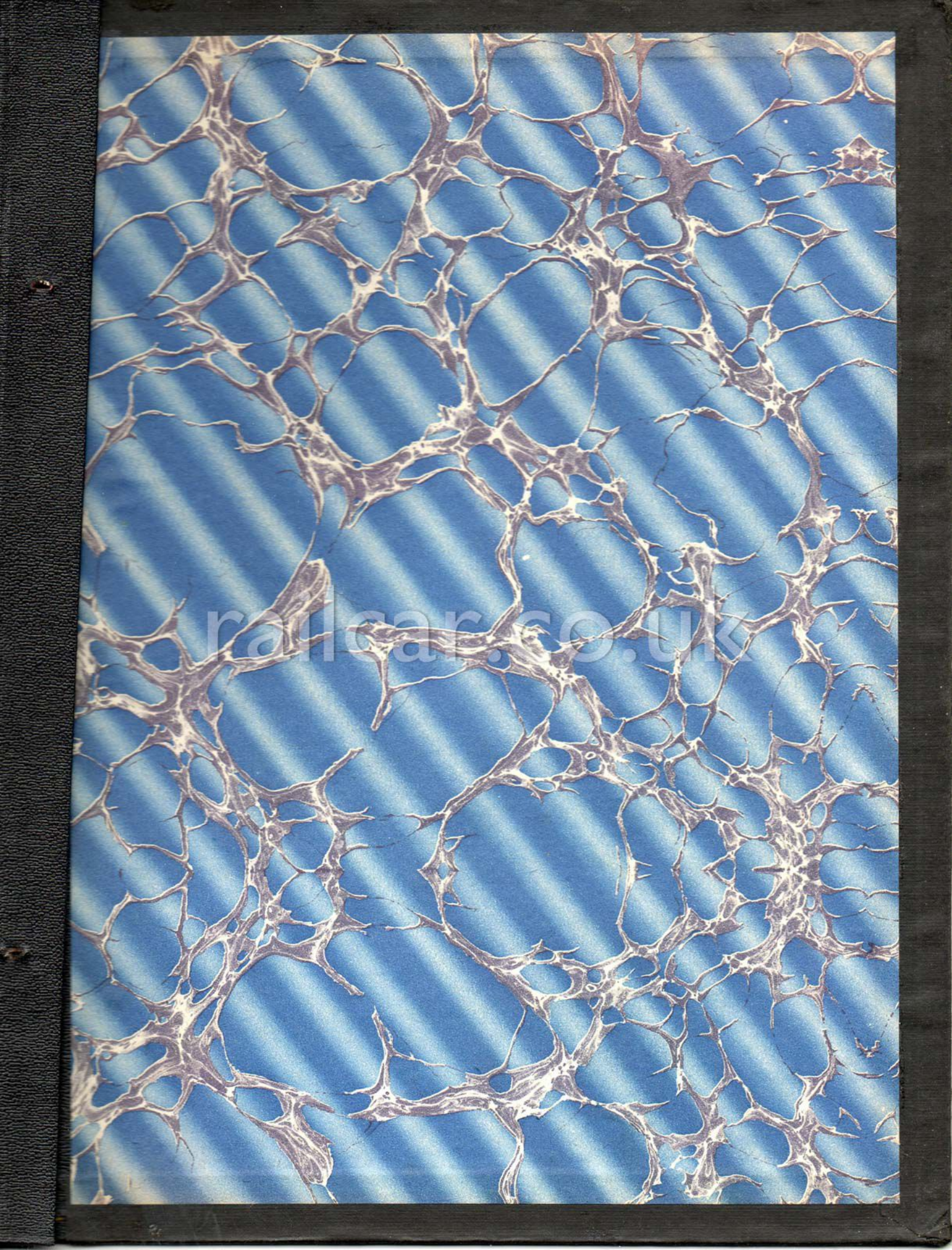


PLATE No. 074.

WIRING DIAGRAM for B.U.T. TRACTION EQUIPMENT (Power Cars).

British Railways
Lightweight M.U. Diesel Cars
79,000 Series.

(Cars 79,047 to 79,082 inclusive).



BRITISH RAILWAYS DIESEL TRAIN 'A' TYPE UNITS — OVERHAUL M

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