

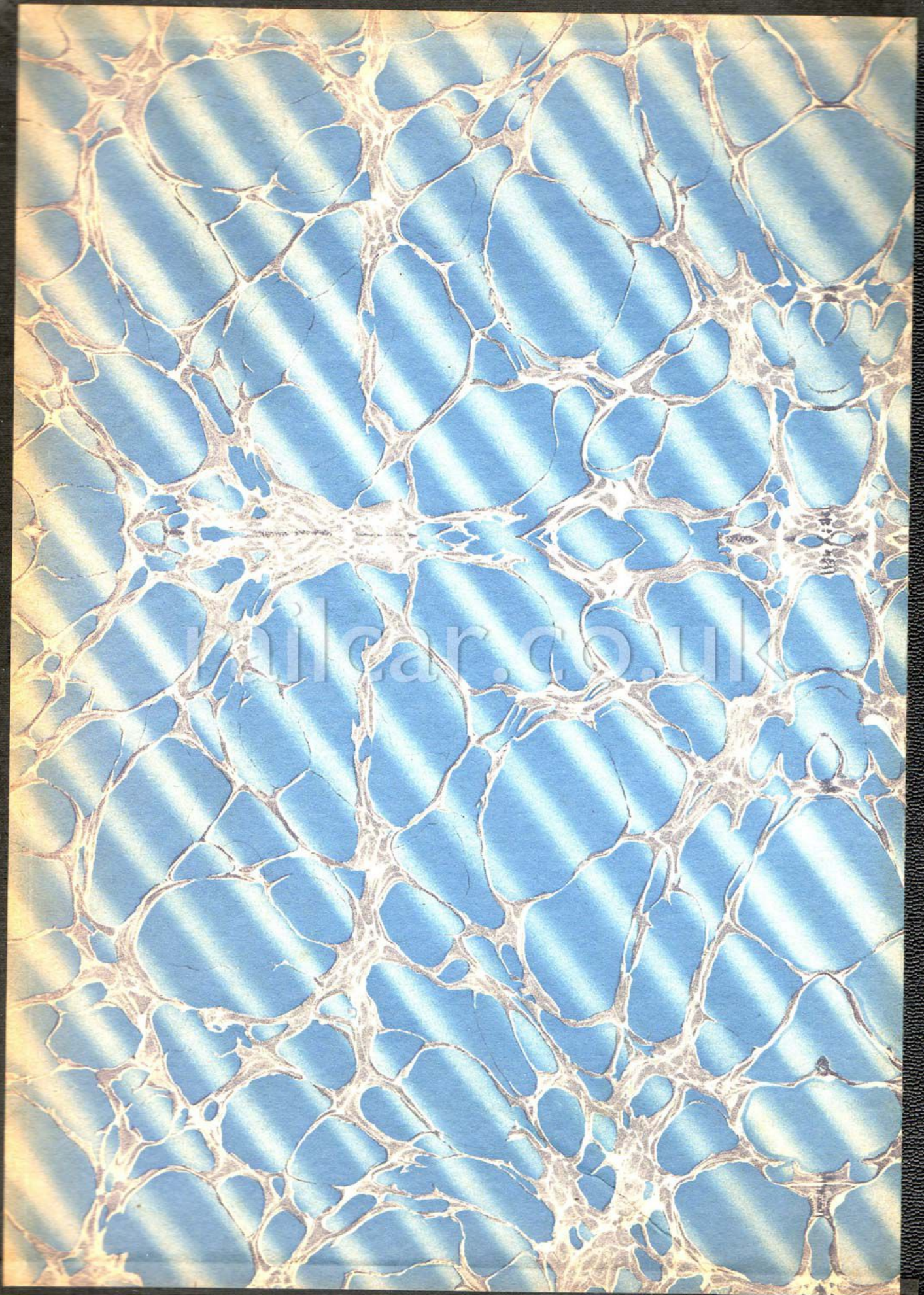


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BRITISH RAILWAYS  
DIESEL TRAIN  
'A' TYPE UNITS  
OVERHAUL MANUAL

BRITISH UNITED TRACTION LTD.







C + W. DIESEL OFFICE

J.M.B.  
23/2/61



**SERVICE MANUAL  
(OVERHAUL)**

FOR

**B.U.T.**

**TRACTION EQUIPMENT**

railcar.co.uk

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

**BRITISH UNITED TRACTION LIMITED**  
HANOVER HOUSE, 14, HANOVER SQUARE, LONDON, W.1,  
ENGLAND.

Telegrams & Cables : BRITROL, LONDON



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## FOREWORD.

**T**HIS 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.



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BRITISH UNITED TRACTION SERVICE MANUAL

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GENERAL INSTRUCTIONS

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# 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 ”.



**Page E 9.** *Column 1. Para. 4.*

*Reference :—*

*Insert :—*

After " marked "  
" and retained with their washers,"

**Page E 10.** *Column 2. Para. 6.*

*Reference :—*

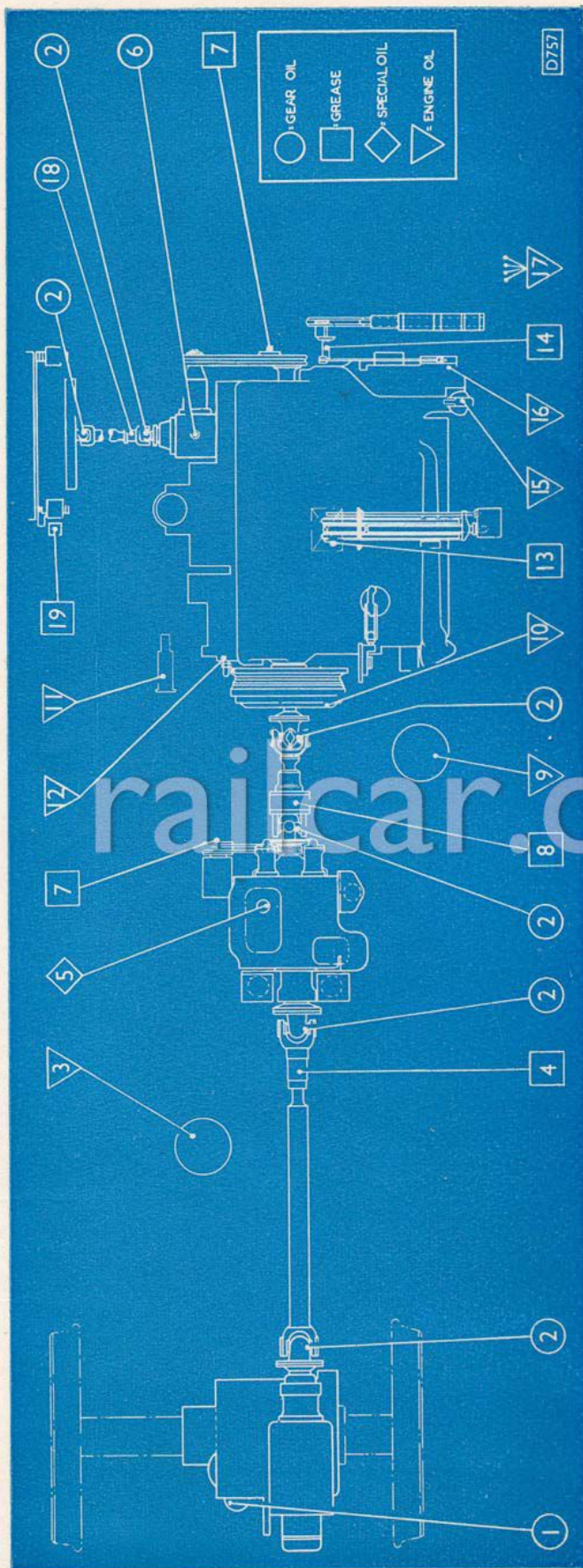
*Insert :—*

After " secure "  
" 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.

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



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# ENGINE.

## CHAPTER A.

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**Key to Numbers :—**

1. ENGINE OIL FILLER CAP.
2. VALVE COVER.
3. CYLINDER HEAD WATER JACKET.
4. WATER JACKET COVER PLATE.
5. WATER CONNECTING PIPE.
6. SNUBBER PLATE MOUNTING.
7. CYLINDER HEAD.
8. EXHAUST MANIFOLD.
9. AIR INTAKE PIPE.
10. RESTRAINING LINK BRACKET.
11. ENGINE CASING.
12. FLYWHEEL LOCATING DOWEL.
13. ENGINE CASING EXTENSION.
14. SUMP.
15. COVER PLATE.
16. OIL DRAIN PLUG.
17. OIL FILTER.
18. OIL DELIVERY PIPE FROM SCAVENGE PUMP.
19. OIL DELIVERY PIPE TO MAIN BEARINGS.
20. OIL PRESSURE PUMP SUCTION PIPE.
21. OIL SUCTION PIPE TO SCAVENGE PUMP.
22. OIL PRESSURE PUMP.
23. OIL SCAVENGE PUMP.
24. BELT TENSIONER.
25. OIL PUMP DRIVE IDLER WHEEL.
26. FUEL-INJECTION PUMP DRIVE BEVEL GEAR HOUSING.
27. RESILIENT MOUNTING.
28. FUEL-INJECTION PUMP.
29. INLET VALVE.
30. EXHAUST VALVE.

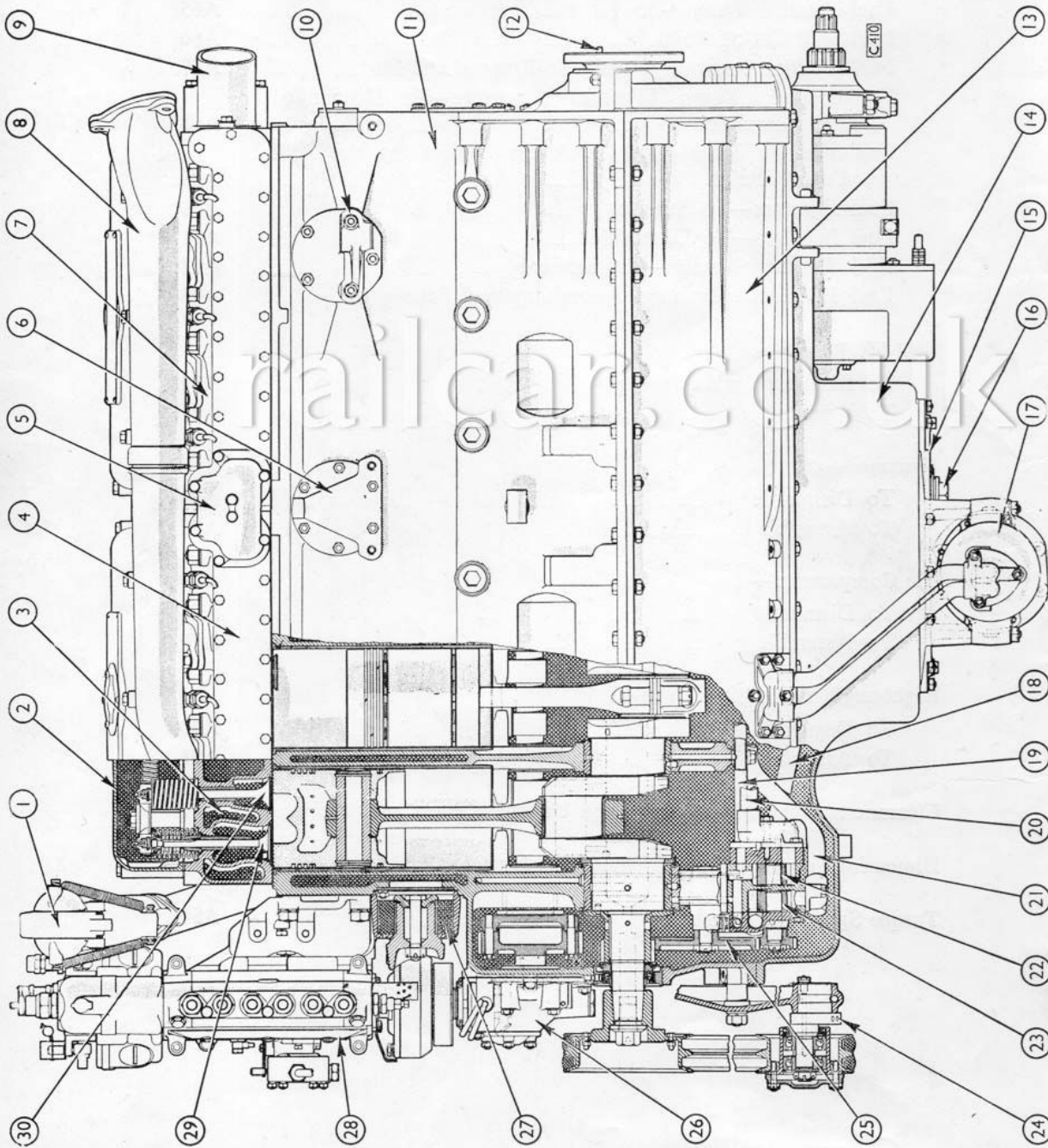


Fig. 1. Longitudinal cross-section of engine.



**Sect. A1. ENGINE—DESCRIPTION.**

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

**T**HE 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.

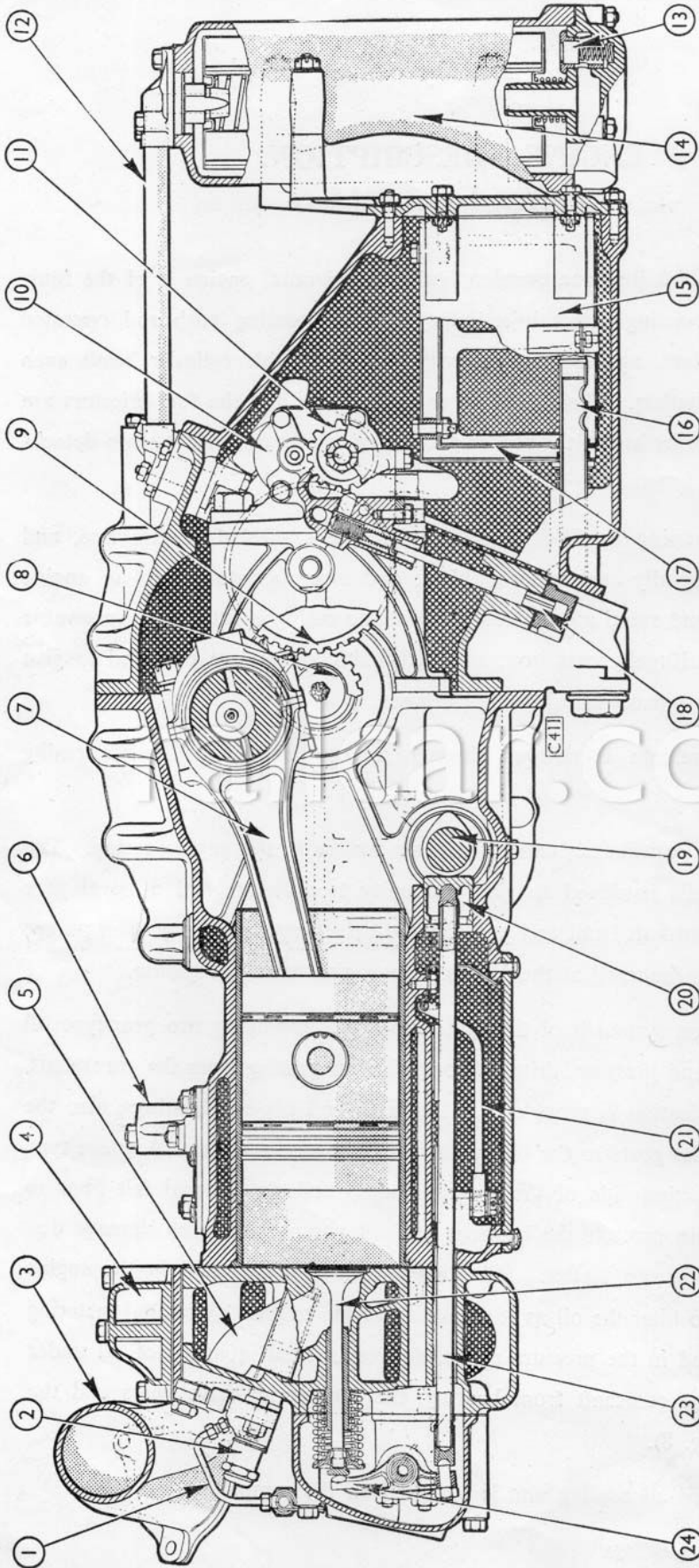
Crankcase pressure is relieved through a breather on the engine casing extension.

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 :—**

- |  |   |  |   |
|--|---|--|---|
| <ul style="list-style-type: none"> <li>1. FUEL RETURN (OR DRIBBLE) PIPE.</li> <li>2. FUEL INJECTOR.</li> <li>3. STANDARD EXHAUST MANIFOLD (DIFFERENT FOR SUPER-CHARGED ENGINES).</li> <li>4. WATER CONNECTING PIPE.</li> <li>5. EXHAUST PORT.</li> </ul> | <ul style="list-style-type: none"> <li>6. RESTRAINING LINK BRACKET (NOT FITTED ON SUPER-CHARGED ENGINES).</li> <li>7. CONNECTING ROD.</li> <li>8. CRANKSHAFT GEAR.</li> <li>9. IDLER WHEEL.</li> <li>10. OIL PUMP.</li> <li>11. OIL PUMP GEAR.</li> </ul> | <ul style="list-style-type: none"> <li>12. OIL INLET PIPE TO FILTER.</li> <li>13. OIL FILTER PRESSURE RELIEF VALVE.</li> <li>14. OIL FILTER.</li> <li>15. OIL STRAINER COVER.</li> <li>16. OIL SUCTION PIPE TO OIL PUMP.</li> <li>17. OIL STRAINER.</li> <li>18. OIL PRESSURE RELIEF VALVE.</li> </ul> | <ul style="list-style-type: none"> <li>19. CAMSHAFT.</li> <li>20. TAPPET.</li> <li>21. OIL FEED PIPE TO ROCKERS.</li> <li>22. EXHAUST VALVE.</li> <li>23. PUSH ROD.</li> <li>24. ROCKER.</li> </ul> |
|--|---|--|---|

Fig. 2. Cross-section through engine.



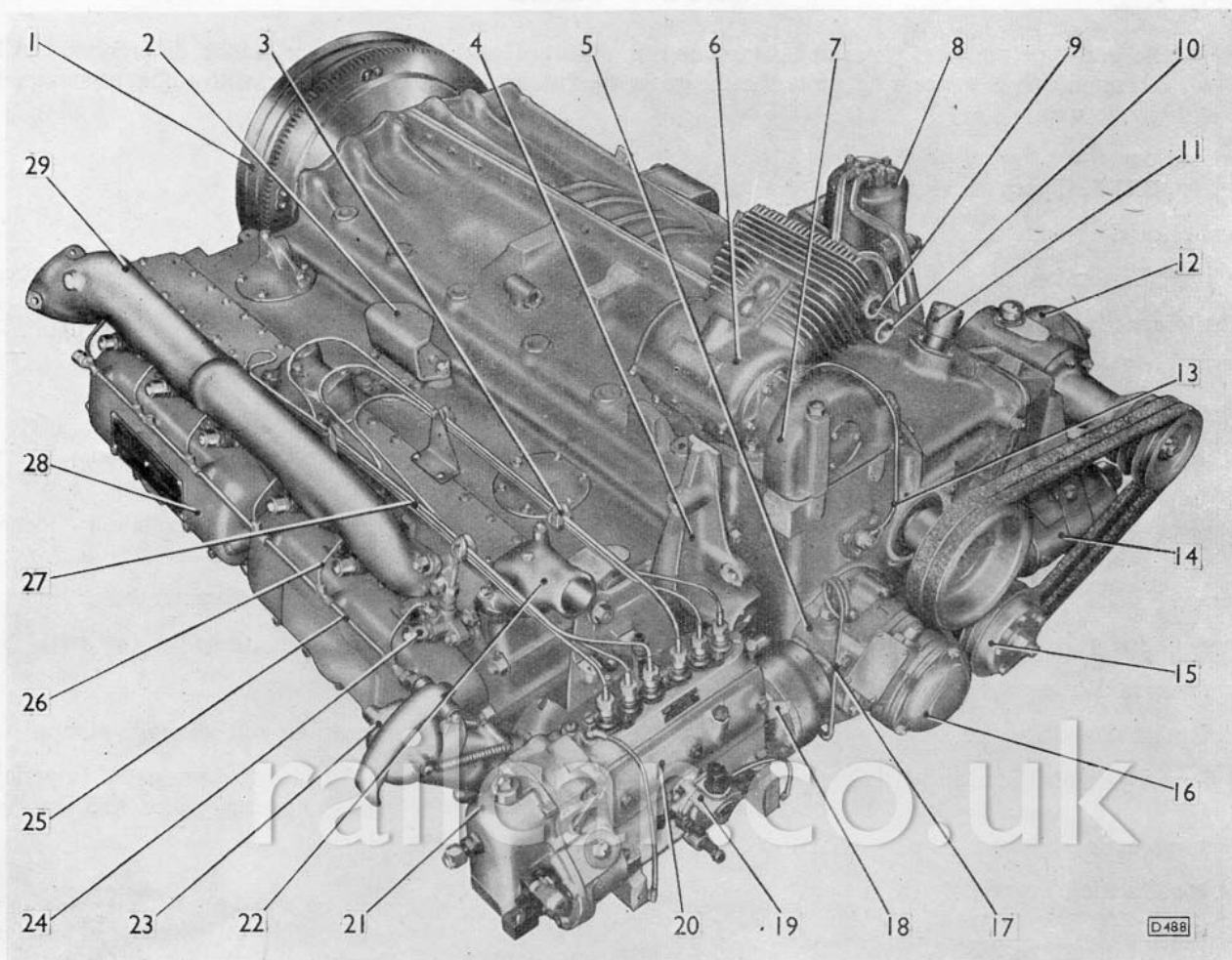
## Sect. A2.

## 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)	.....	.....	.....	.....	6½ 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. } (Type varies according to installation. Refer to Type Plate on Starter Motor). Simms }
Air Compressor	.....	.....	.....	.....	Clayton Dewandre. (Type varies according to installation. Refer to Type Plate on Compressor).
Engine Speed Indicator Generator	.....	.....	.....	.....	Everett and Edgcombe B35. Smiths MDG.
Approximate Weight (For lifting purposes)	.....	.....	.....	.....	15¾ cwts. (800 Kg.).





## Key to Numbers :—

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

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

## DYNAMO. (C.A.V.).

## D A T A.

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 de- scribed)	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 de- scribed)	65-70	8.9-9.6	1,000	18-24	510	0.001-0.003	Main field
				-		-	1.2	Aux. shunt field
				1,100		680	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 de- scribed)	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

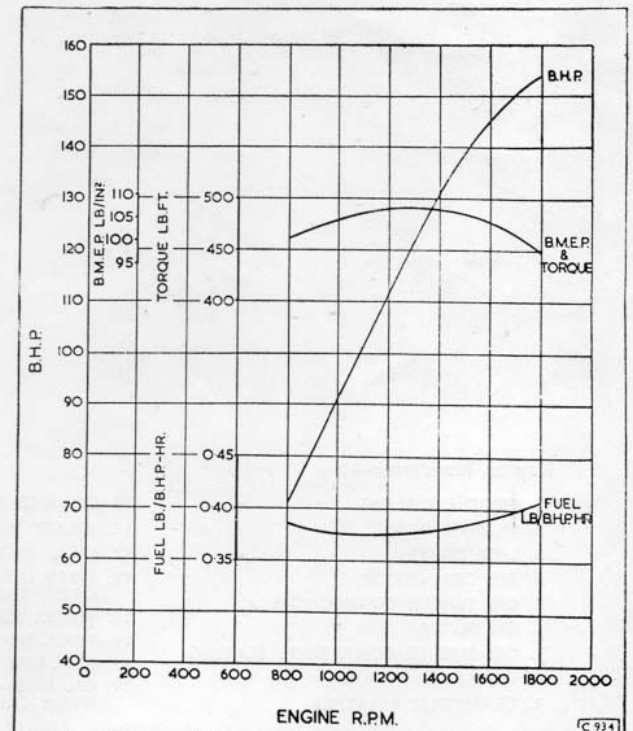


Fig. 4. Average performance curves of 11.3 litre horizontal engine.

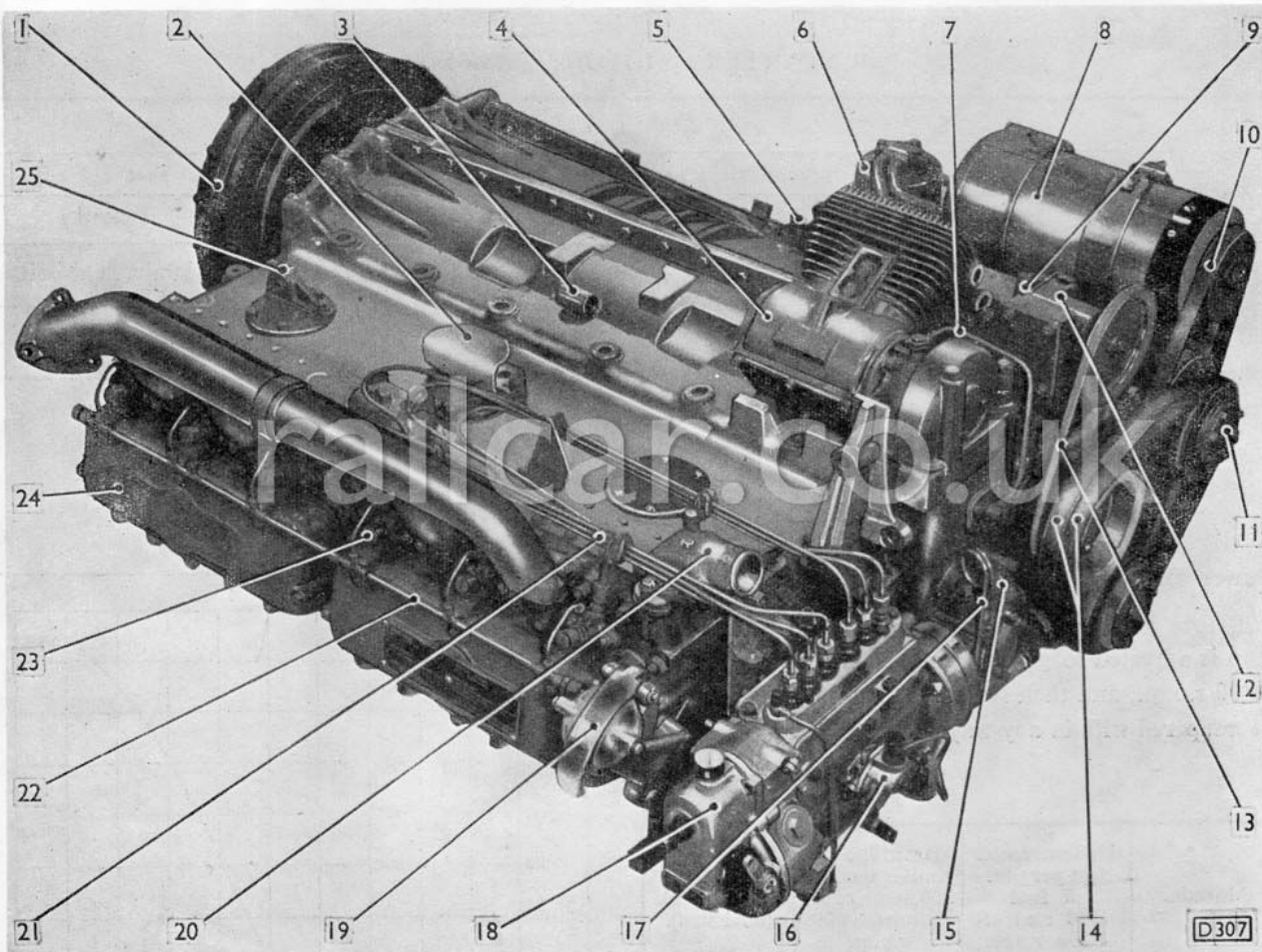


## ENGINE NUMBER.

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

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

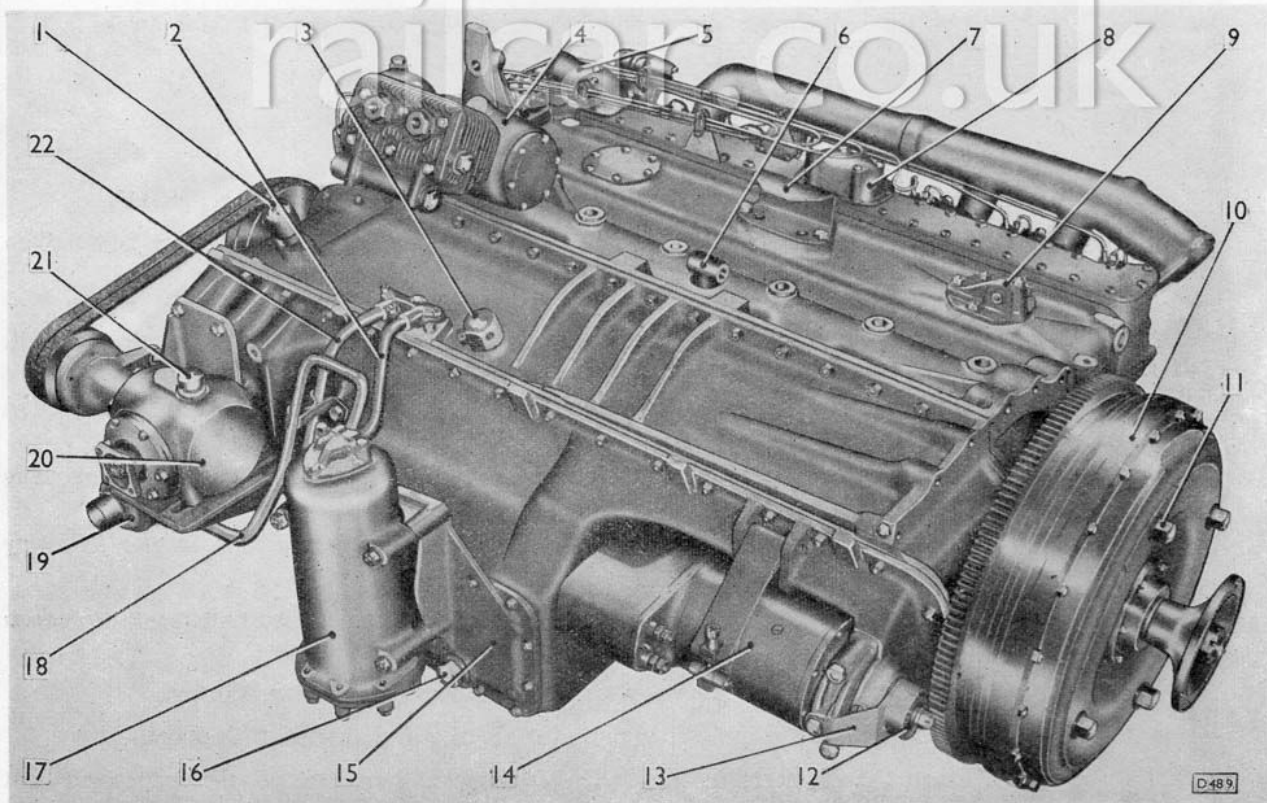
**Sect. A3.****MAINTENANCE.**

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



Period.	Attention Required.
<b>EVERY 10,000 MILES (16,000 KM.)</b>	Remove fuel injectors and fit a set of reconditioned ones. Return the old set for servicing ( <i>see Sections 18 and 19</i> ). 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.
<b>QUARTERLY OR EVERY 15,000 MILES (25,000 KM.)</b>	Check the fuel-injection pump drive coupling rubber for deterioration. Check the fuel-injection pump timing. Check the oil pressure ( <i>see Section A6</i> ). Examine the dynamo and starter motor commutators and brushes ( <i>see following paragraphs</i> ). Renew the elements in the fuel filters and vent the fuel system ( <i>see Sections A14 and A22</i> ). Remove the air compressor cylinder head and repeat as for 10,000 Miles but renew the valve discs and springs.
<b>HALF-YEARLY OR EVERY 30,000 MILES (50,000 KM.)</b>	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 ( <i>see Section A27</i> ). Lubricate the engine lifting gear (if fitted).



**Key to Numbers :—**

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

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 1½ 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 ½ in. to ¾ 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 1½ 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 ¾ 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.

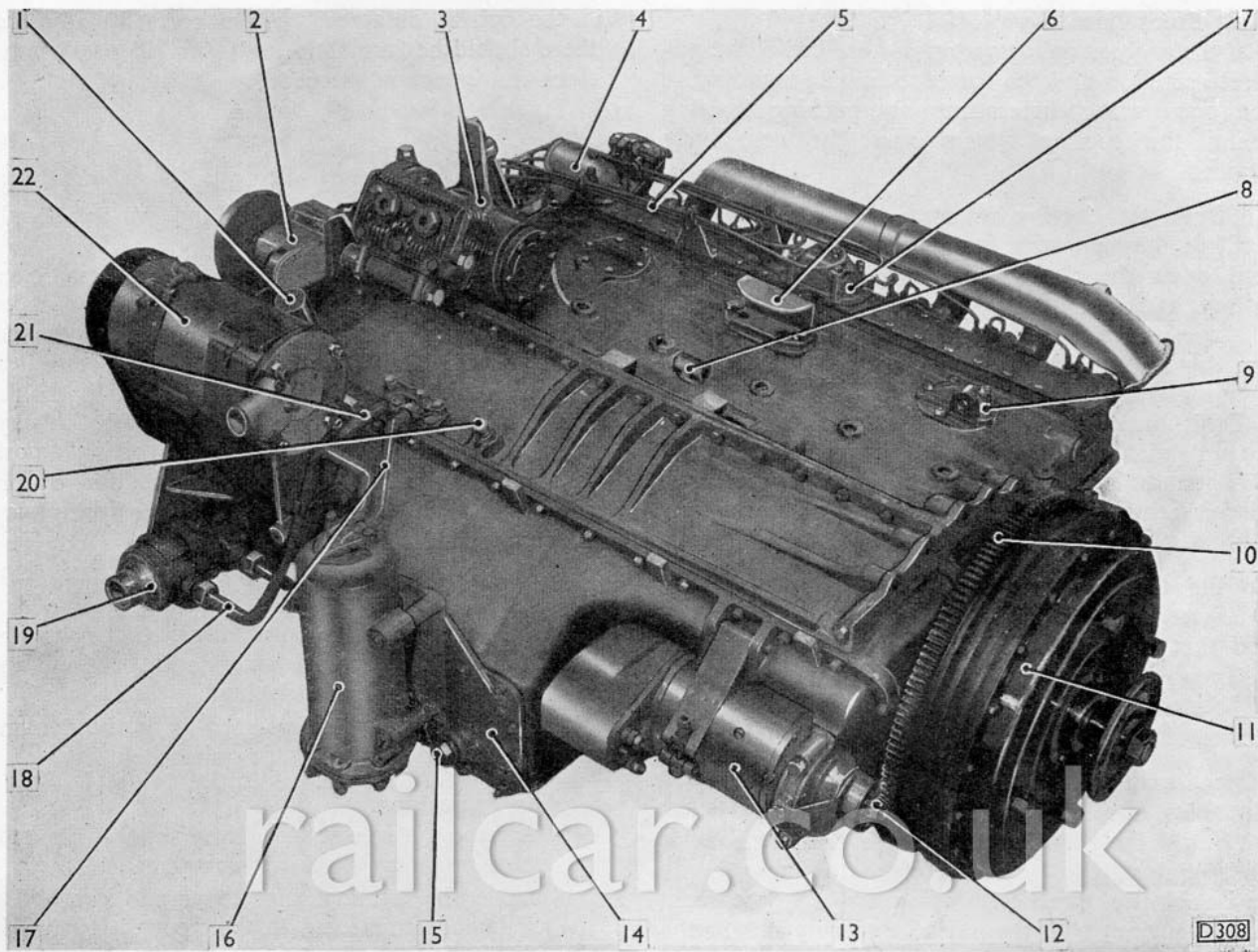
Connect a voltmeter (range 0-30) across the (+) and (-) terminals of the dynamo.

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

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)	6½ 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.**

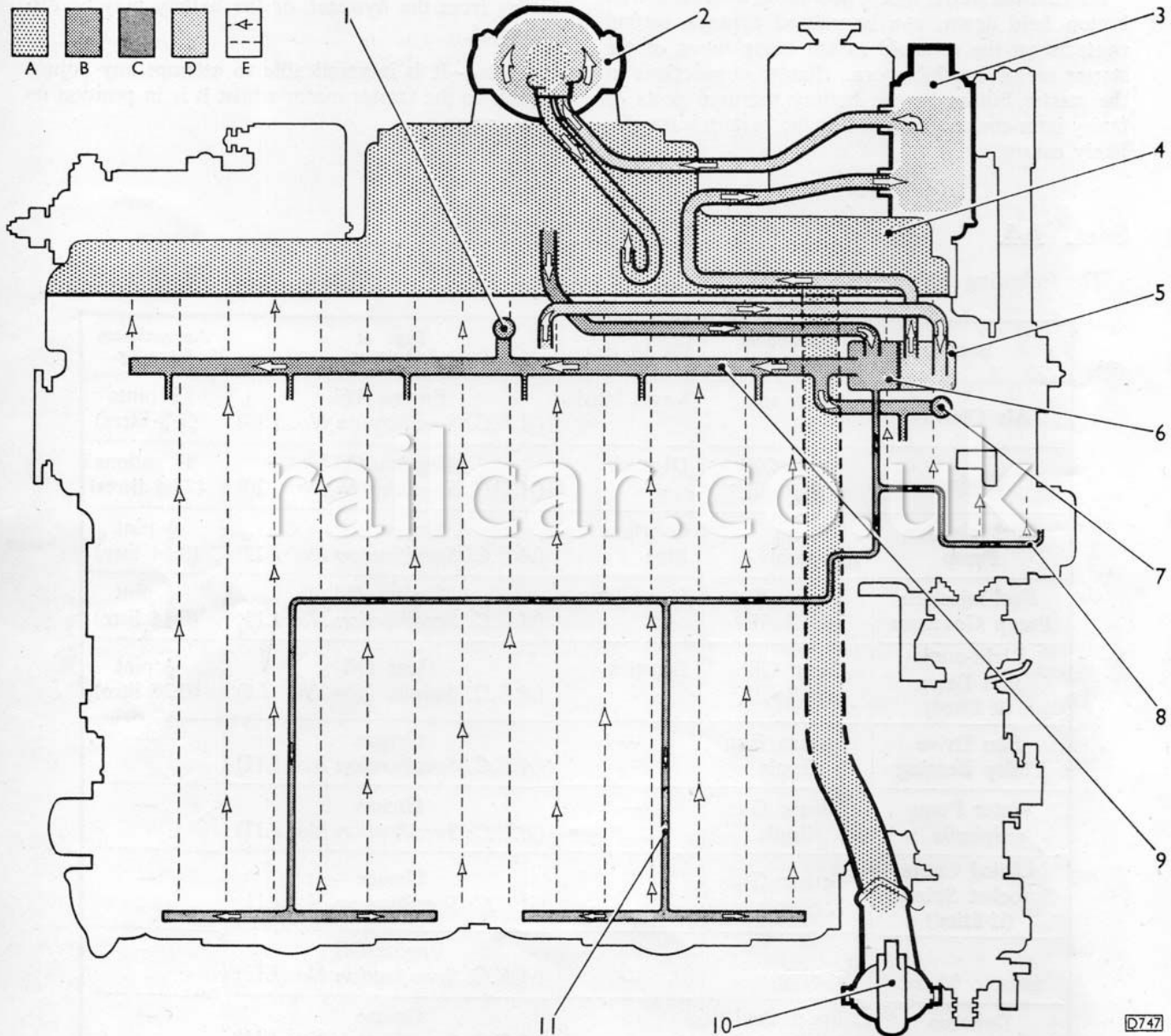
Whenever possible the unit should be drained immediately after the car has completed a run and the oil is warm.

Place a suitable container in position and drain the oil from the unit by removing the drain plug. (see Fig. 23).<sup>24</sup>

**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  $\frac{3}{4}$  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. L20).

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 Coordinating 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. L18.).

*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 centi- stokes)
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. maxi- mum
Carbon Residue (Rams- bottom)	.....	0·3 per cent. maxi- mum

*Oxidation Characteristics.*—

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



**SPECIFICATION OF ENGINE OIL.****For use with units other than the engine.***(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
Acidity (organic)	.....	0.10 mgms. KOH per gm. maximum
Ash	.....	0.005 per cent. maxi- mum
Carbon Residue (Rams- bottom)	.....	0.5 per cent. maxi- mum

*Oxidation Characteristics.*—

Viscosity Ratio at 140° F. (60° C.)	.....	1.5 maximum
Increase in Carbon Residue	.....	0.7 per cent. maxi- mum
Asphaltenes in Oxidised Oil	.....	0.05 per cent. maxi- mum

**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. maxi- mum
Asphaltenes	.....	0.10 per cent. maxi- mum

**SPECIFICATION OF GREASE.***(A.E.C. Specification No. L11).*

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

The grease to be prepared from refined and filtered mineral oil together with saponifiable

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

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

Soap Base .....	.....	.....	Lime
Drop Point .....	.....	.....	203° F. (95° C.) minimum
Worked Penetration .....	.....	.....	230—260 units
Heat Resistance (see Appendix A) .....	.....	.....	No oil separation or hardening
Copper Strip Corrosion (see Appendix B) .....	.....	.....	Negative
Viscosity of Mineral Oil (Redwood No. 1) at 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.

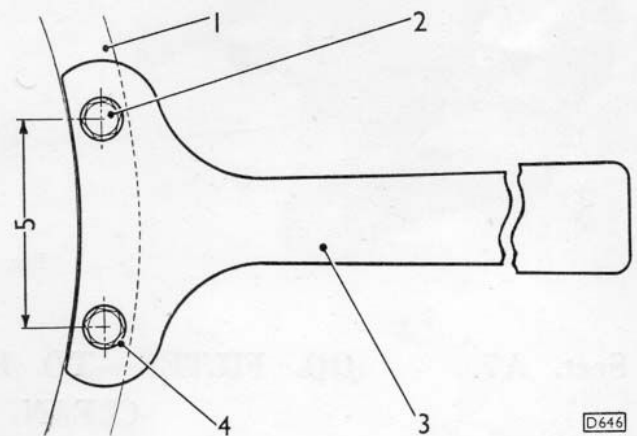
Turn the crankshaft, by using a suitable tool to turn the fluid coupling (see Fig. 9), until the valve is open fully, then turn through one complete revolution to bring the tappet on to the back of the cam.

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.                  | 4. SET-SCREW LOCATING HOLES, 0.75 in. (19 mm.) DIA. |
| 2. DRIVING MEMBER RETAINING SET-SCREWS. | 5. 2.98 in. (75.7 mm.).                             |
| 3. LEVER FOR TURNING ENGINE.            |   |

Fig. 9. Tool for turning engine crankshaft.



## Sect. A6. OIL PRESSURE RELIEF VALVE.

(See Figs. 2 and 8).

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

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

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

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

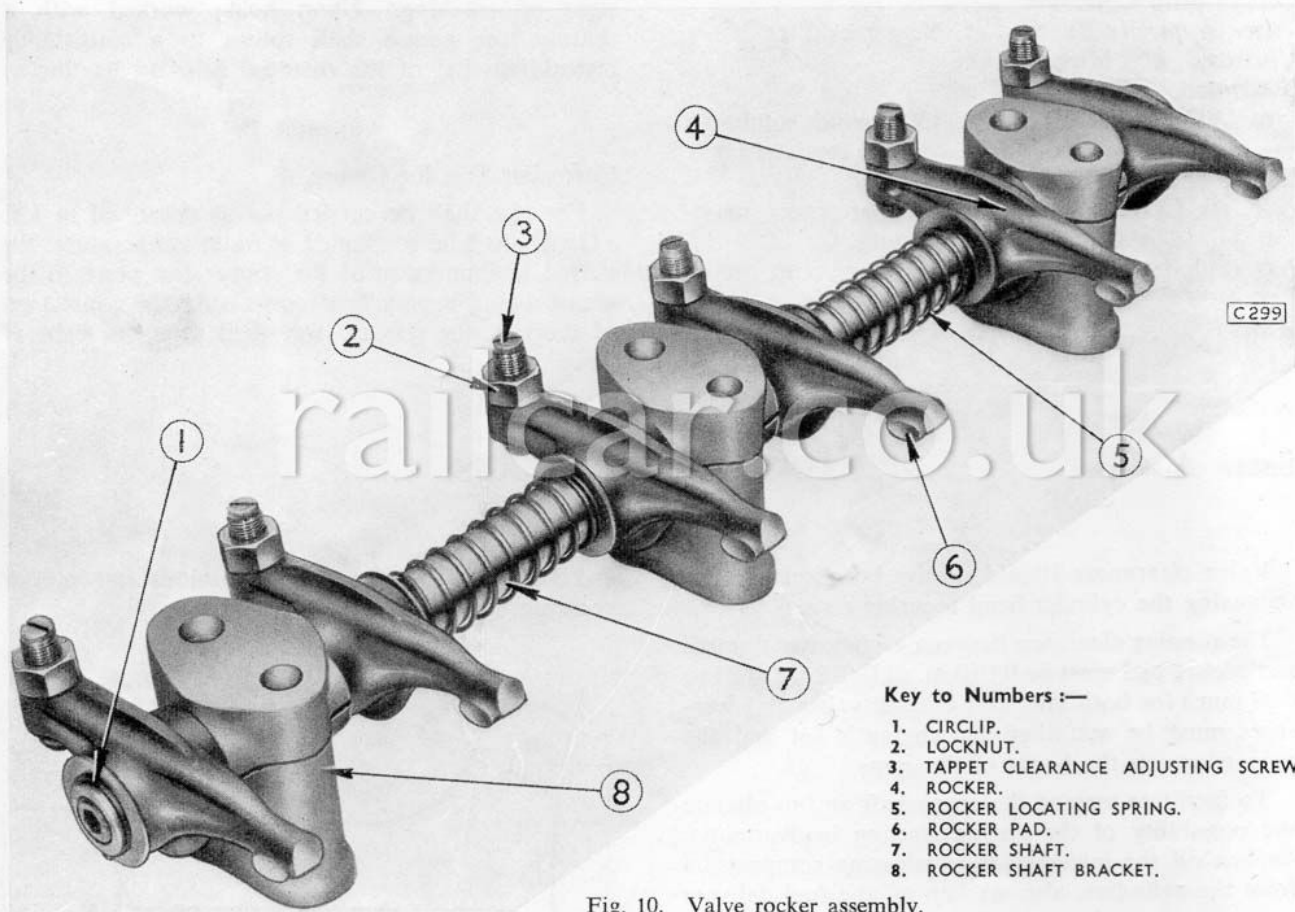


Fig. 10. Valve rocker assembly.

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

(See Fig. 11).

### To Remove.

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

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

Unscrew the oil filter securing nuts and remove the filter.

Drain out the oil [there will be approximately  $\frac{3}{4}$  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*).

#### 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.

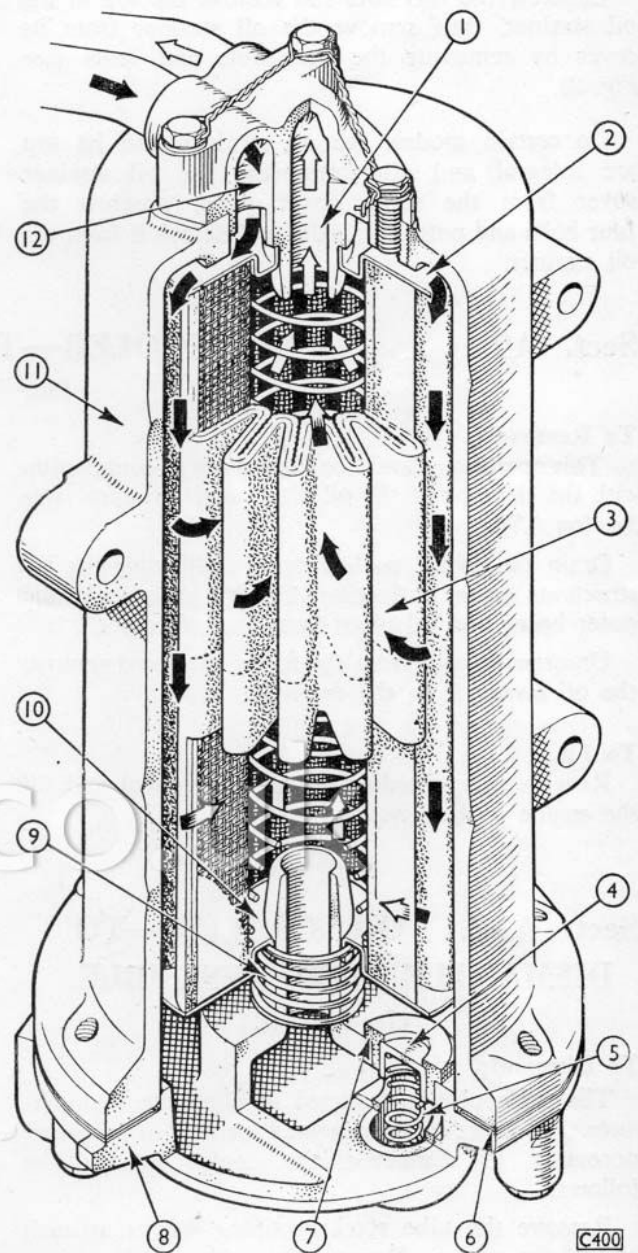


Fig. 11. Cut-away view of oil filter.

## 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.

## 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.

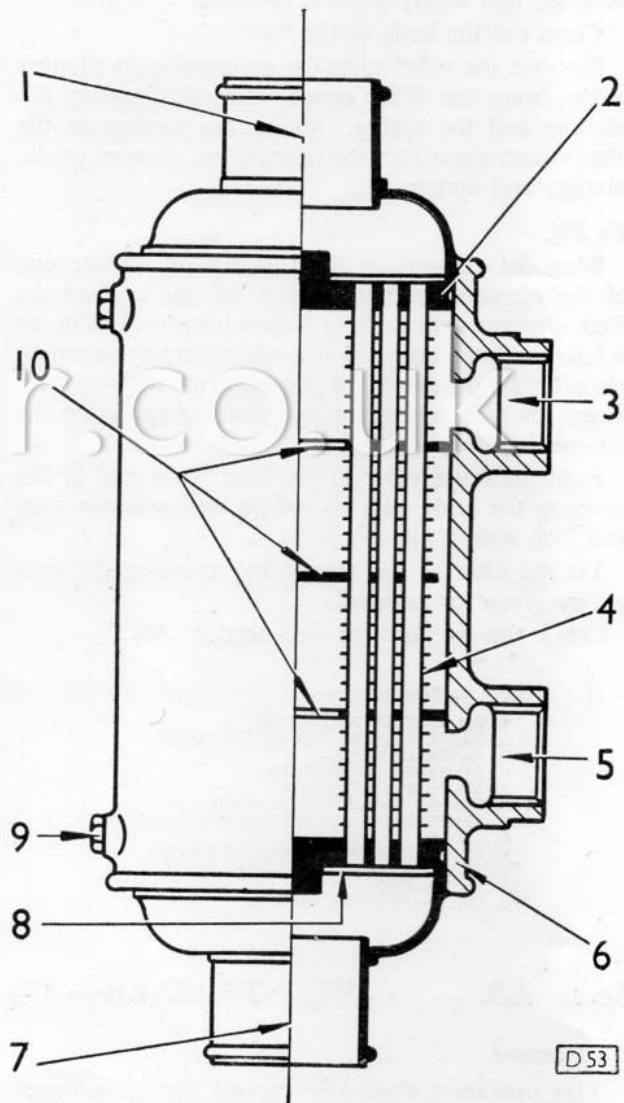
### To Clean.

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).



### Key to Numbers :—

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

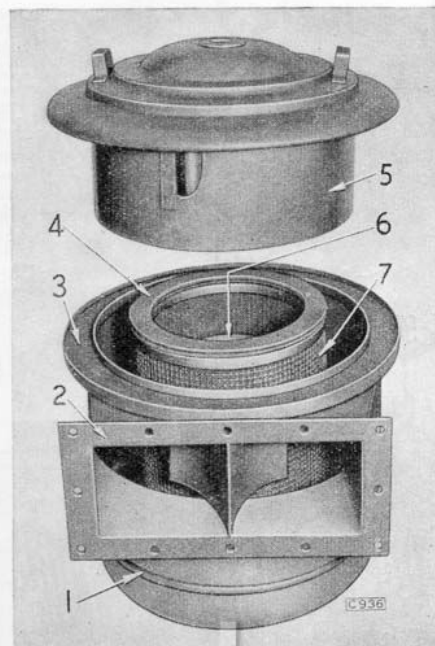
Remove the screens, wash thoroughly in clean paraffin and allow to drain.

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.                      | 4. CORK JOINT.      |
| 2. AIR INTAKE WITH PRE-CLEANER REMOVED. | 5. COVER.           |
| 3. CORK JOINT.                          | 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.

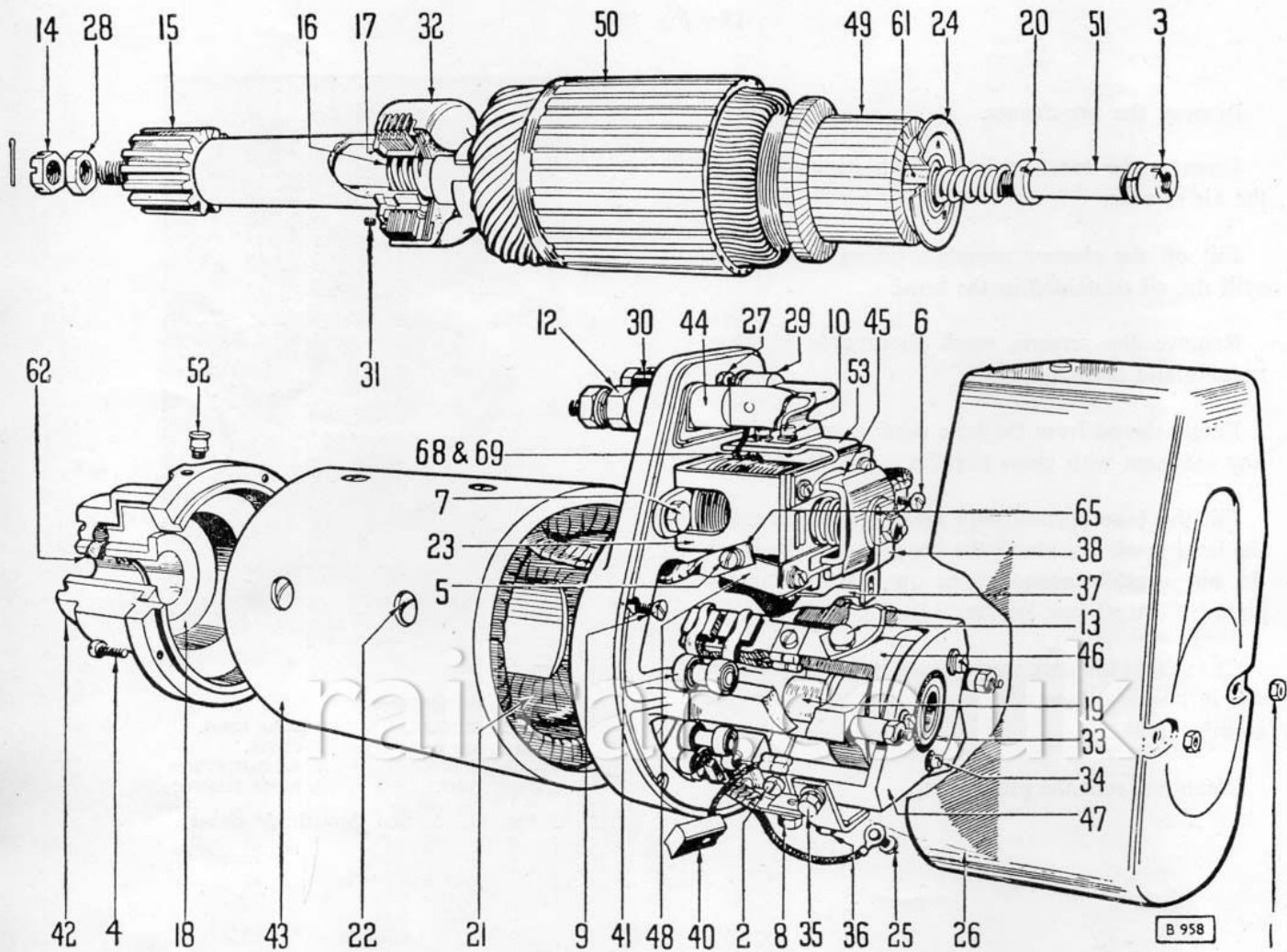
The field winding is divided into (a) two main series field coils, (b) two auxiliary coils, each made up of an auxiliary shunt coil, and (c) an auxiliary series coil. When the starter button is operated, the magnetic field set up in the switch windings draws in the plunger until the trigger catch plate 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.                   | 20. ARMATURE PLUNGER NUT.                     | 40. BRUSHES.                           |
| 2. BRUSH FLEXIBLE CONNECTION SCREW.         | 21. FIELD COILS.                              | 41. BRUSH SPRINGS.                     |
| 3. PLUNGER NUT (OUTER).                     | 22. POLE SHOE FIXING SCREWS.                  | 42. DRIVING END FRAME.                 |
| 4. DRIVING END FRAME SCREWS.                | 23. SOLENOID SWITCH.                          | 43. CARCASE (OR YOKE).                 |
| 5. MAIN FIELD TERMINAL SCREW.               | 24. SOLENOID SWITCH TRIPPING PLATE.           | 44. NEGATIVE TERMINAL CONNECTION.      |
| 6. AUXILIARY FIELD TERMINAL SCREW.          | 25. AUXILIARY FIELD NEGATIVE TERMINAL SCREWS. | 45. SOLENOID SWITCH MOVING CONTACT     |
| 7. SOLENOID SWITCH FIXING SCREW.            | 26. COMMUTATOR END COVER.                     | 46. BRUSH GEAR NEGATIVE ARM.           |
| 8. MAIN AND AUXILIARY FIELD TERMINAL SCREW. | 27. SOLENOID TERMINAL NUT.                    | 47. BRUSH GEAR POSITIVE ARM.           |
| 9. COMMUTATOR END FRAME FIXING SCREW.       | 28. DRIVING PINION PLAIN NUT.                 | 48. SOLENOID SWITCH FIXED CONTACT.     |
| 10. POSITIVE TERMINAL CONNECTOR SCREWS.     | 29. POSITIVE TERMINAL CONNECTION.             | 49. COMMUTATOR.                        |
| 12. NEGATIVE TERMINAL NUT.                  | 30. "SOL." TERMINAL.                          | 50. ARMATURE.                          |
| 13. NEGATIVE CONNECTOR TERMINAL SCREW.      | 31. CLUTCH PRESSURE SPRING.                   | 51. ARMATURE SPRING PLUNGER.           |
| 14. DRIVING PINION SLOTTED NUT.             | 32. CLUTCH HOUSING.                           | 52. LUBRICATOR.                        |
| 15. DRIVING PINION AND SLEEVE.              | 33. INSULATING BUSH.                          | 53. SOLENOID SWITCH FIXED CONTACT.     |
| 16. PINION SPRING.                          | 34. BRUSH-HOLDER FIXING SCREW.                | 61. COMMUTATOR END BEARING BUSH.       |
| 17. CLUTCH SLEEVE.                          | 35. NEGATIVE CONNECTOR FIXING SCREW.          | 62. FELT LUBRICATING PAD.              |
| 18. DRIVING END BEARING.                    | 36. NEGATIVE CONNECTOR FIXING SCREWS.         | 65. MAIN FIELD COIL NEGATIVE TERMINAL. |
| 19. COMMUTATOR END BEARING                  | 37. SOLENOID SWITCH TRIGGER.                  | 68. POSITIVE COIL FLEXIBLE CONNECTION. |
|   | 38. TRIGGER CATCH PLATE.                      | 69. NEGATIVE COIL FLEXIBLE CONNECTION. |

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

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

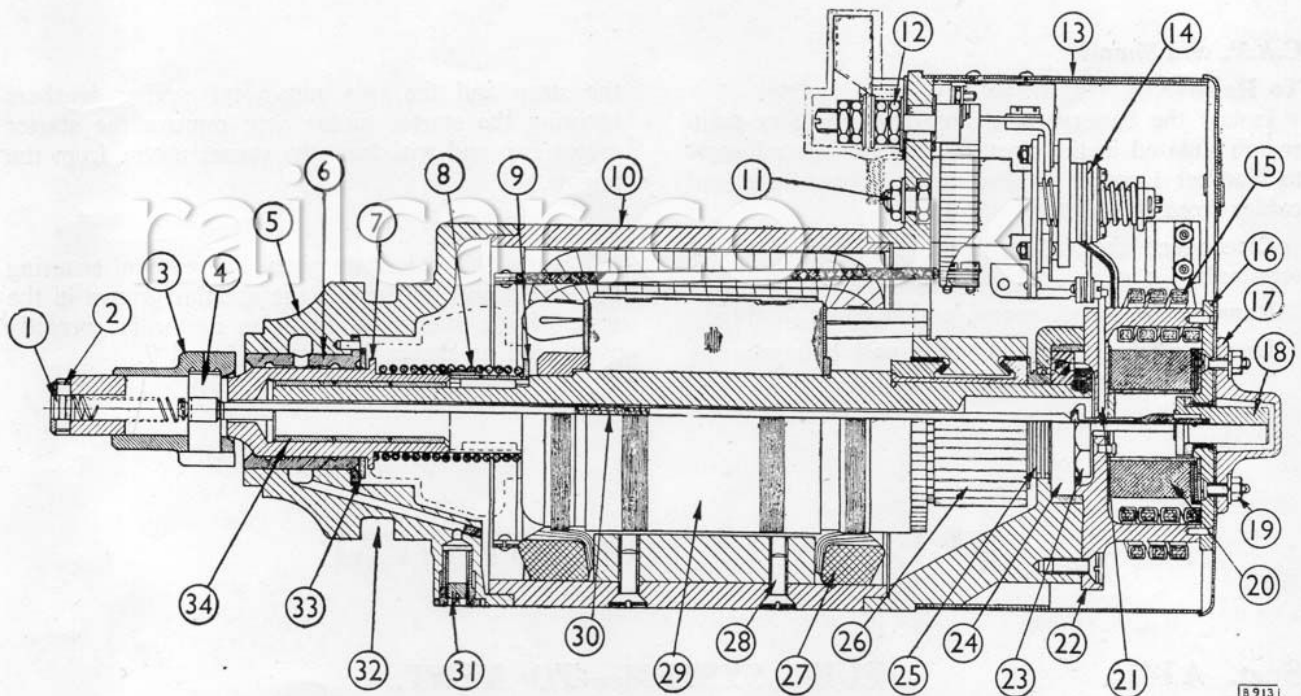
This 24-volt starter motor is of the axial type and is provided with a built-in solenoid switch giving two-stage operation. The field winding, which is in series with the armature, consists of four coils in parallel connected in pairs to each negative brush.

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

The pinion shaft is splined and carries the internally-splined pinion which is brought forward into the engagement position by two push rods passing through the hollow pinion and armature shafts from the solenoid-actuated plunger at the commutator end. The solenoid is wound with the engagement

winding and holding-on winding, whilst above the commutator is the two-stage solenoid switch. Between the two push rods is the shock spring, and the hollow nose of the pinion shaft is fitted with a coil spring to hold the pinion in—or return it to—its rest position.

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

**Key to Numbers :—**

1. PLUG.
2. CROSS DUMBELL.
3. INTERNALLY SPLINED PINION.
4. CROSS KEY.
5. NOSE.
6. NOSE BEARING.
7. PINION SHAFT.
8. SPRING RELEASE CLUTCH.
9. DRIVING SLEEVE.
10. CARCASS.
11. SOLENOID SWITCH FIXING NUT.

12. SOLENOID TERMINAL.
13. COMMUTATOR END COVER.
14. TWO-STAGE SOLENOID SWITCH.
15. HOLDING-ON WINDING.
16. SOLENOID END PLATE.
17. PLUNGER COVER.
18. SOLENOID ACTUATED PLUNGER.
19. PLUNGER AND COMMUTATOR END COVER FIXING NUT.
20. ENGAGEMENT WINDING.
21. SWITCH TRIGGER OPERATING ROD.
22. SOLENOID FRAME.

23. COMMUTATOR END SHAFT NUT.
24. COMMUTATOR END BEARING.
25. OIL GROOVES.
26. COMMUTATOR.
27. FIELD COIL.
28. POLE SHOE FIXING SCREW.
29. ARMATURE.
30. SHOCK SPRING.
31. TAPPED LUBRICATION HOLE.
32. DOWEL BOLT GROOVE.
33. STEEL THRUST WASHER.
34. SELF LUBRICATING BUSH.

Fig. 15. Section through Simms starter motor.



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

When the engine fires, the armature current, and hence the holding-on coil current, is reduced to a minimum. The return spring thereupon overcomes the pull of the "holding-on" coil and returns the

pinion smartly to its rest position, where it rotates freely until the push button is released.

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

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

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

(See Figs. 6 and 7).

#### C.A.V. and Simms.

##### To Remove.

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

Disconnect the cables from the starter motor terminals.

Remove the starter motor pinion cover (if fitted).

Unscrew and remove the nut and bolt securing

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

##### To Fit.

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

## FUEL-INJECTION SYSTEM.

### Sect. A14. FUEL SYSTEM—TO VENT.

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

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

Proceed as follows:—

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

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

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

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

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

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

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

manner and finally open the air vent cock for a few moments.

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

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

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

## Sect. A15. FUEL INJECTORS—DESCRIPTION.

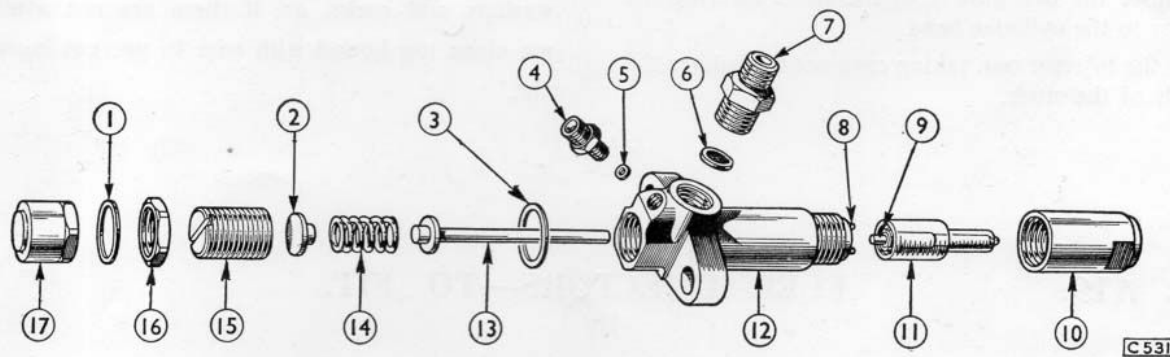
(See Fig. 16).

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

The injector is, in effect, a simple spring-loaded valve adjusted to open automatically as soon as the fuel oil reaches a predetermined pressure, the quan-

tity 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.

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### 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 pre-determined 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.

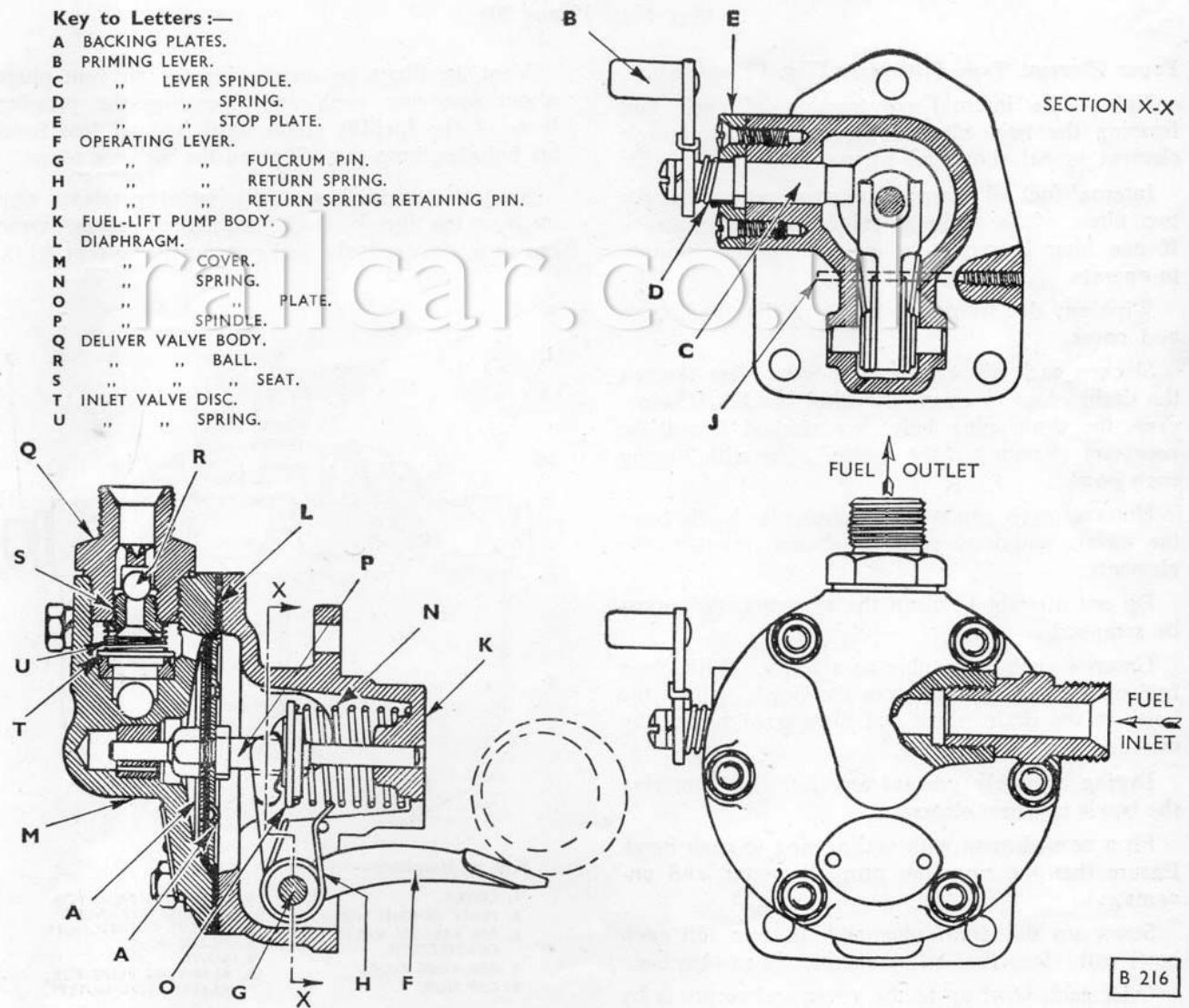


Fig. 17. Sections through C.A.V. fuel-lift pump.



## 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.

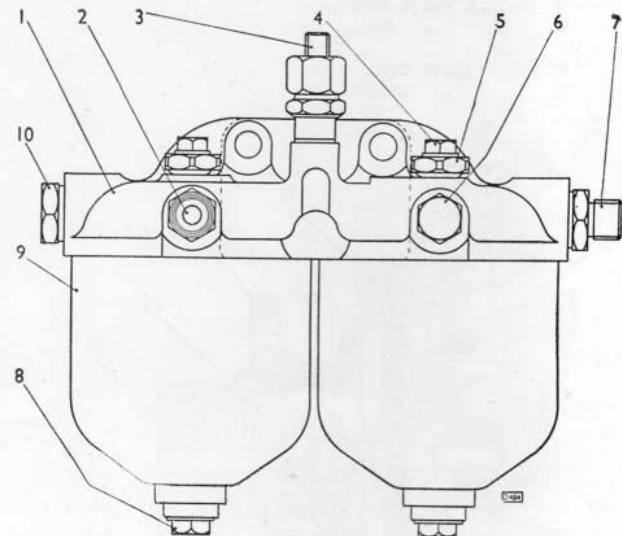
Fit a **new element** with sealing ring to each bowl. Ensure that the rings are properly seated and undamaged.

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

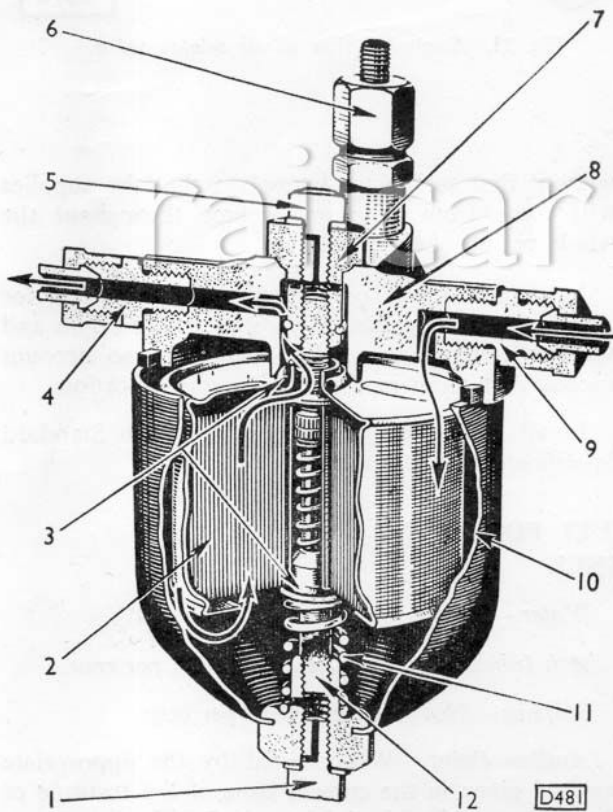
**To Clean.**

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

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

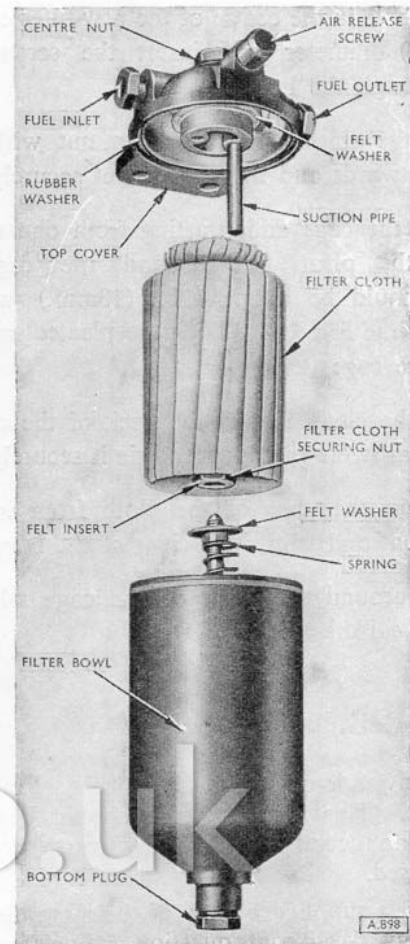


Fig. 20. Exploded view of main fuel filter (C.A.V.)—cloth element type.

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  $\frac{1}{2}$  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  $\frac{1}{2}$  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.

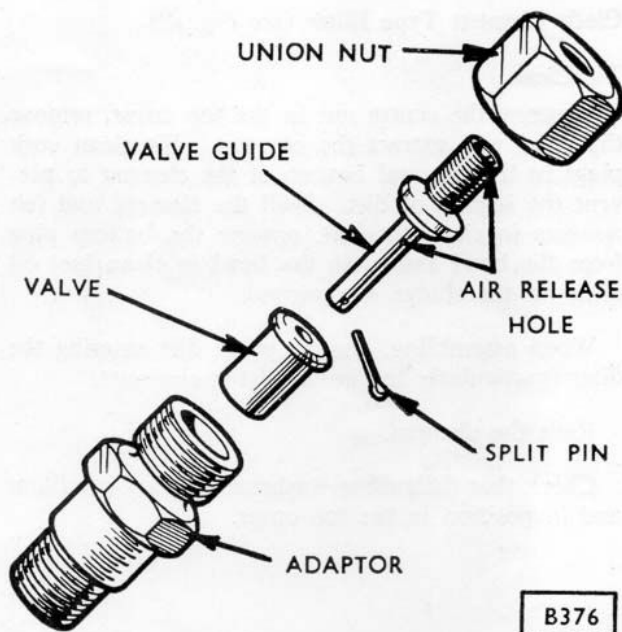


Fig. 21. Exploded view of air release valve.

## 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.

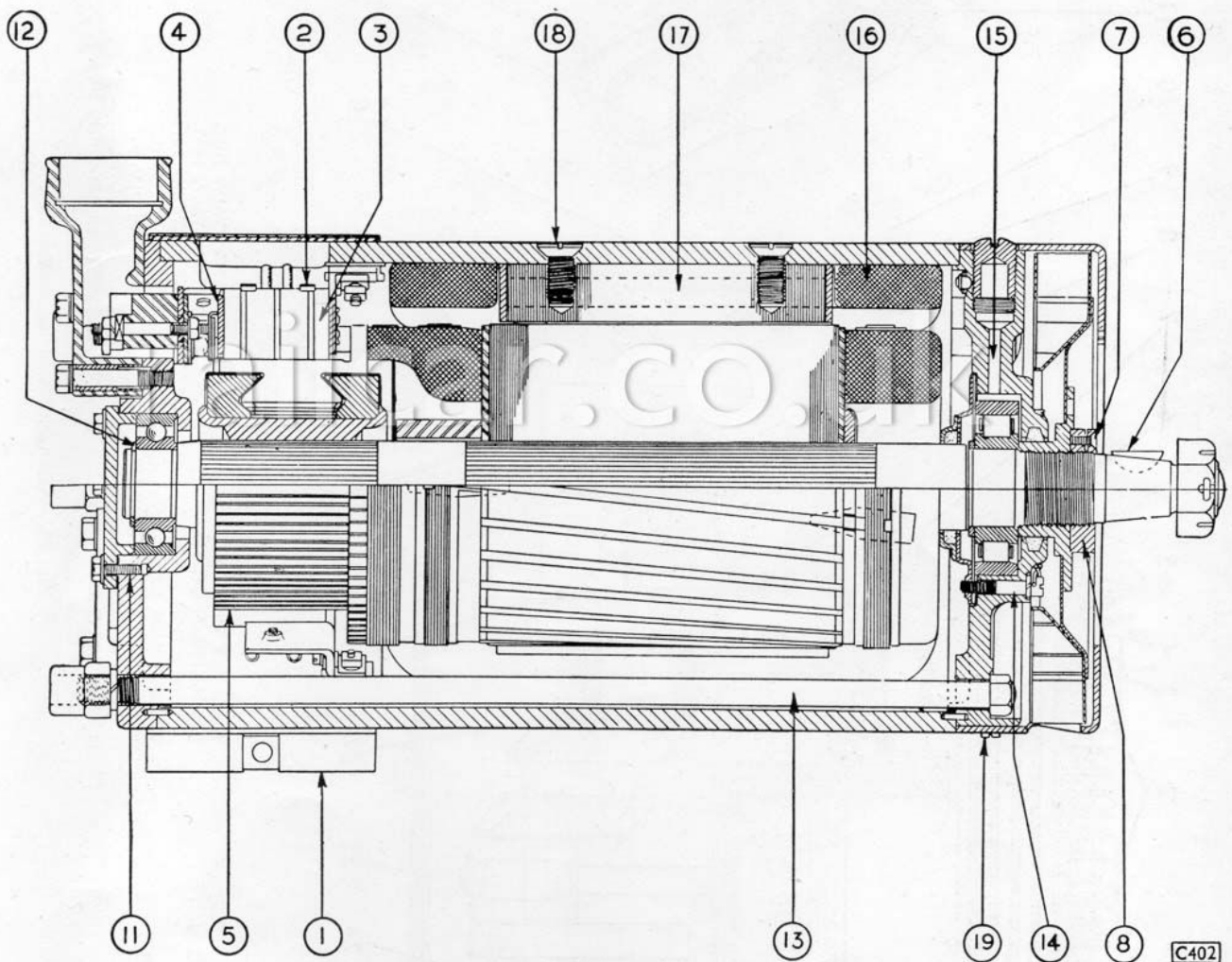
(See Fig. 22).

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 :—

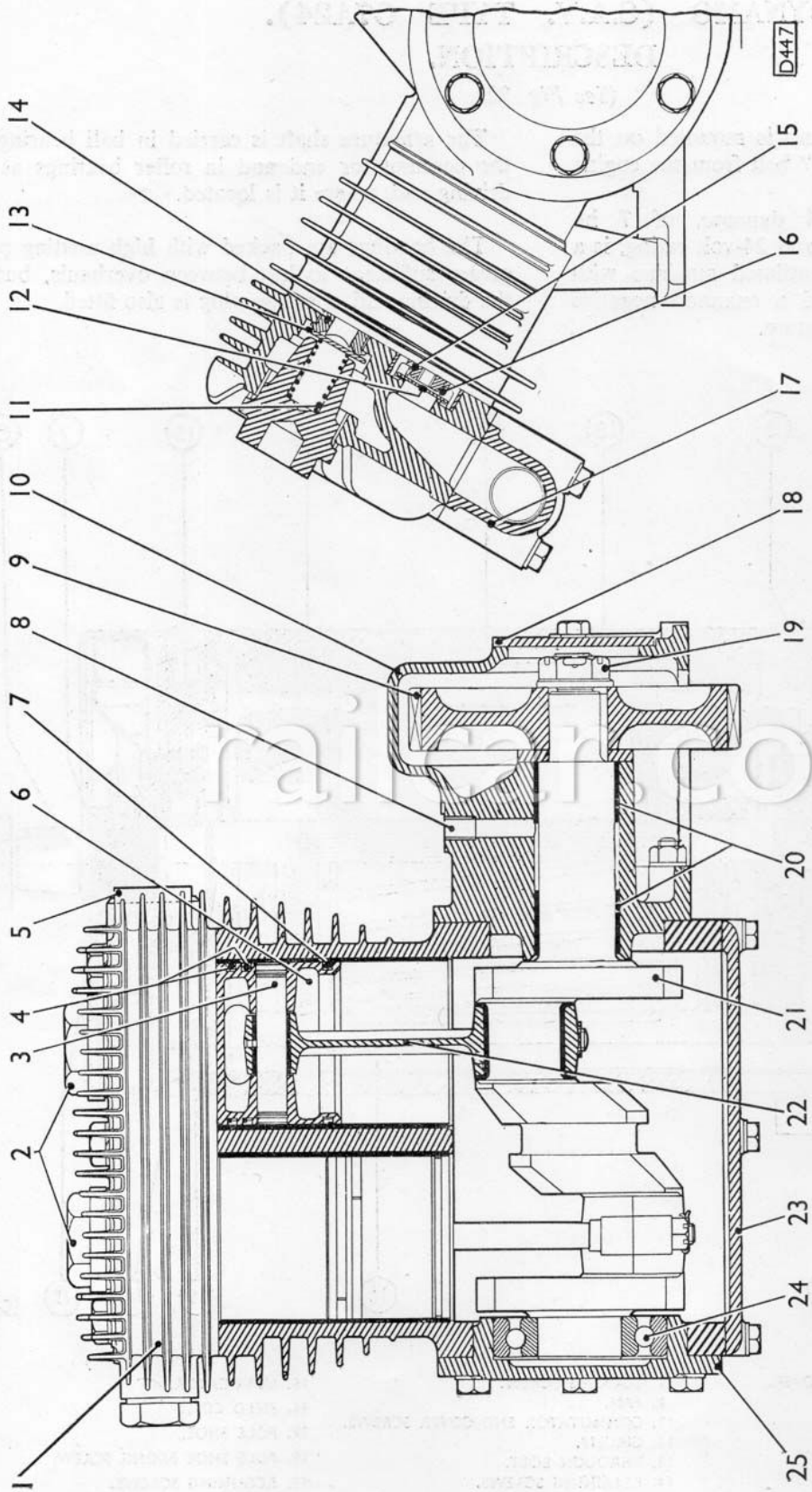
1. COMMUTATOR BAND COVER.
2. BRUSH SPRINGS.
3. BRUSHES.
4. BRUSH HOLDER.
5. COMMUTATOR.
6. SHAFT KEY.

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.

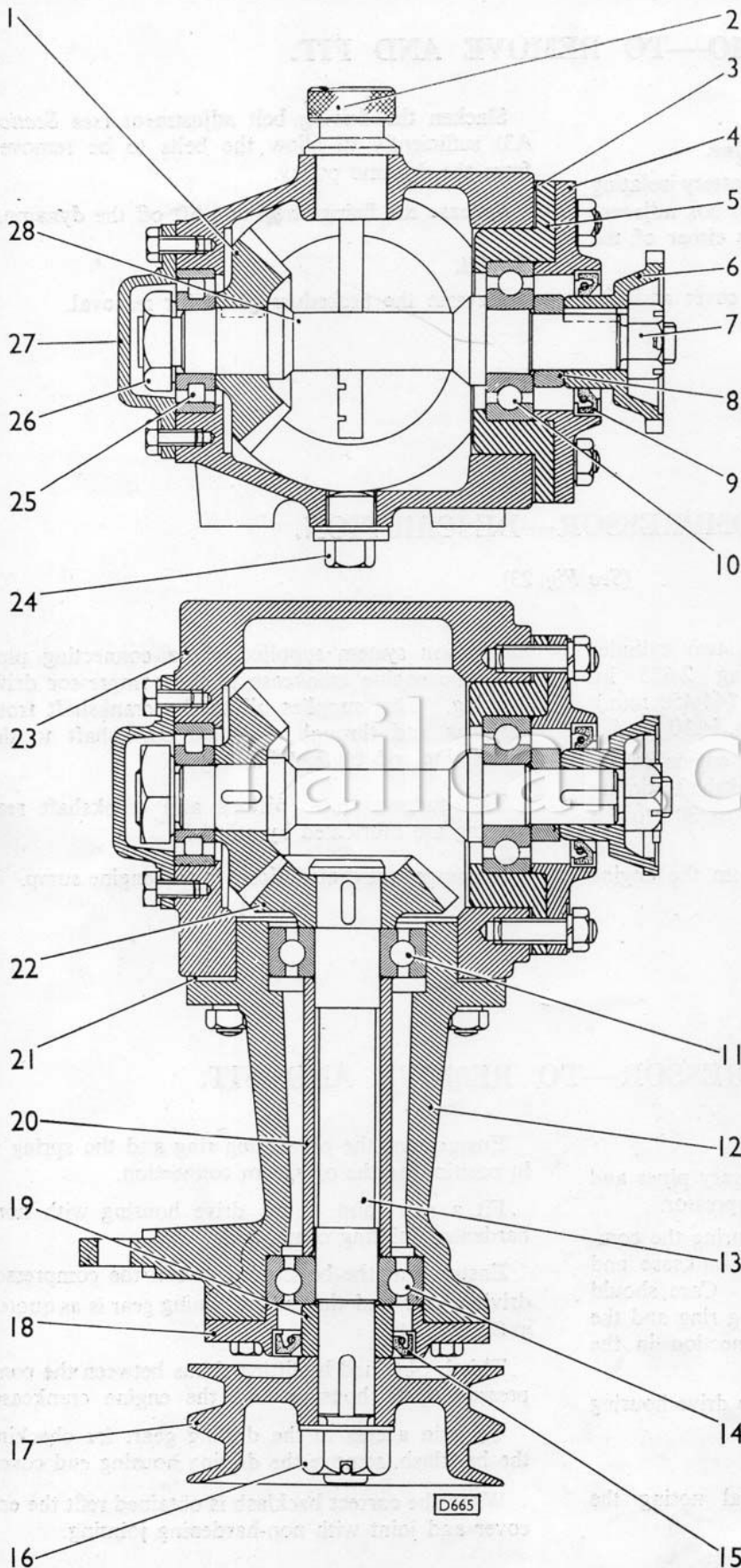
Ensure that the backlash between the compressor driving gear and the engine timing gear is as quoted in Section A82.

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 (1).
4. TERMINAL SCREW FOR (11).
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.

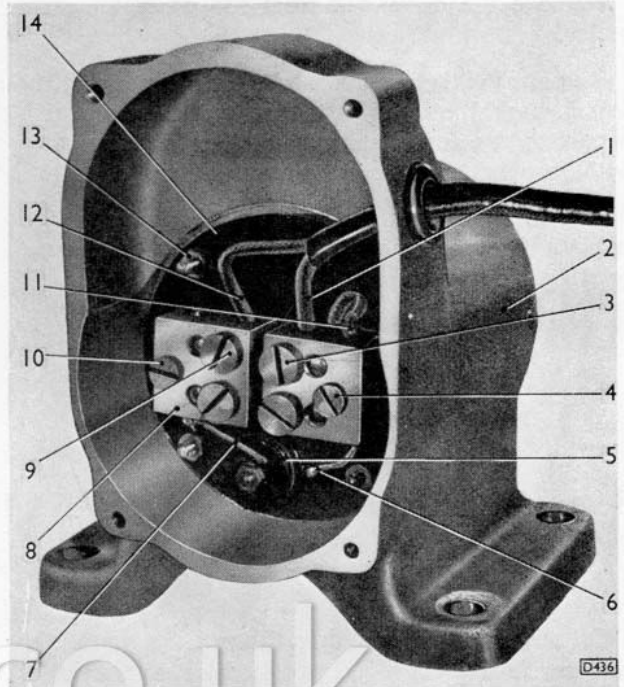


Fig. 25. Engine speed indicator generator (belt driven type).

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

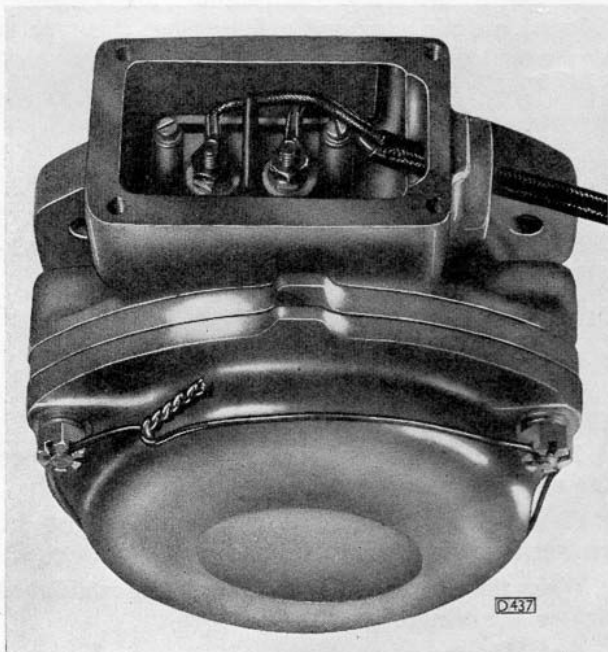


Fig. 26. Engine speed indicator generator—with cover removed (gear driven type).

### 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.

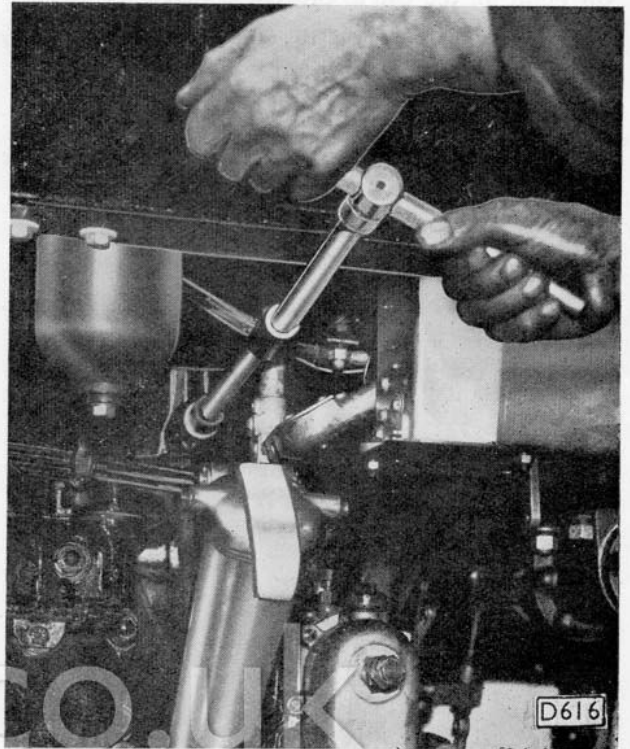


Fig. 27. Method of tightening or unscrewing the retaining bolts for engine front support bracket.

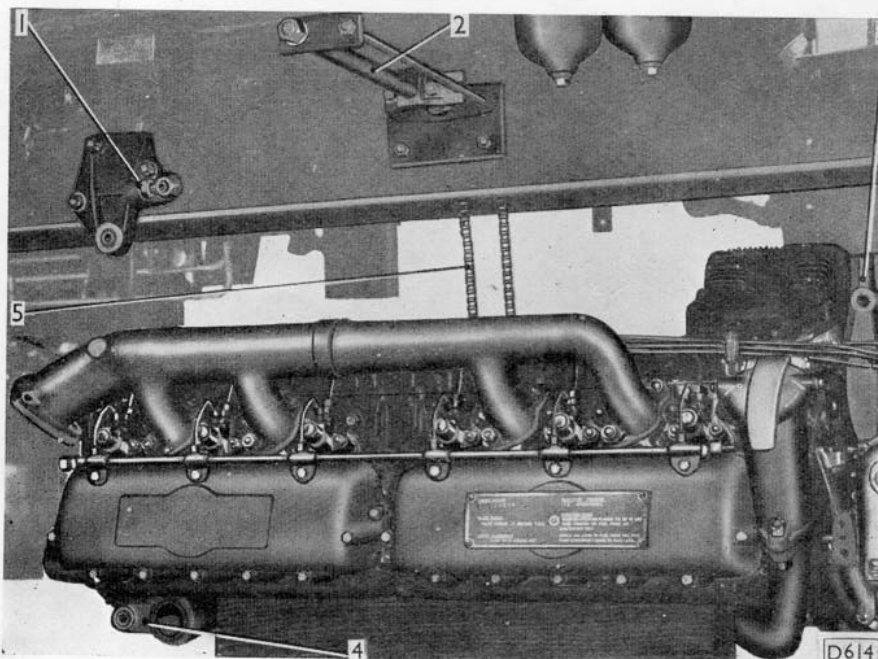


Fig. 28. Engine in position for fitting to car.

**Key to Numbers :—**

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

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

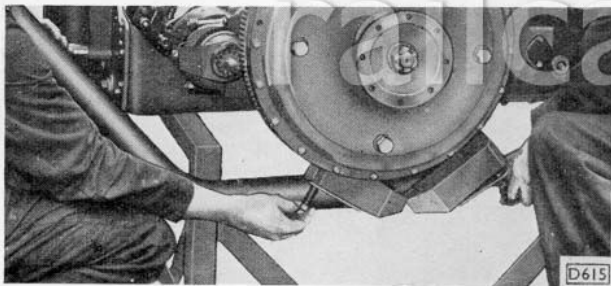


Fig. 30. Method of fitting engine torque tube.

**Key to Numbers :—**

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

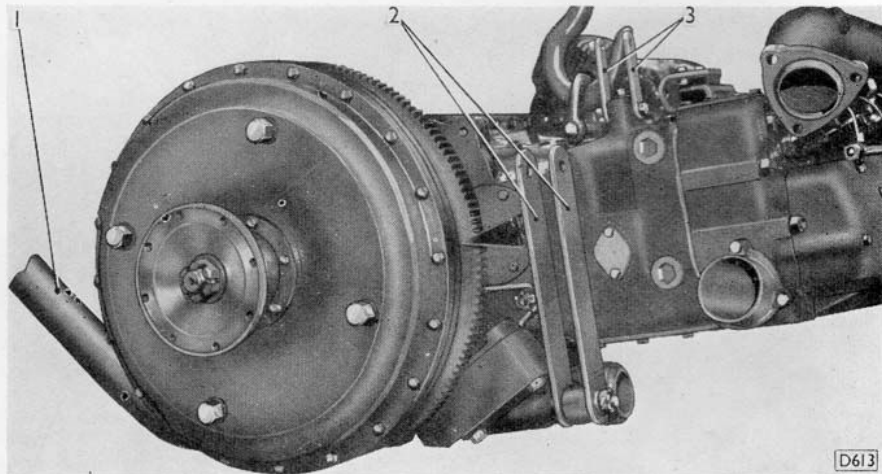
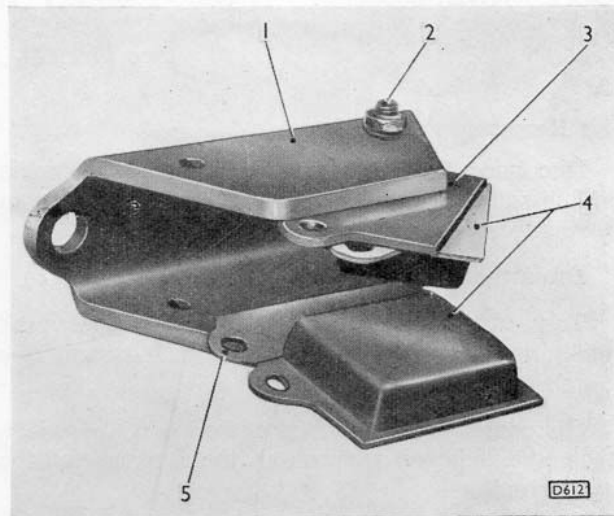


Fig. 31. Engine fitted with torque tube and linkage prior to fitting to car.



**Key to Numbers :—**

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

Fig. 29. Engine snubber bracket assembly.

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.

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.

**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 A3*).

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.**

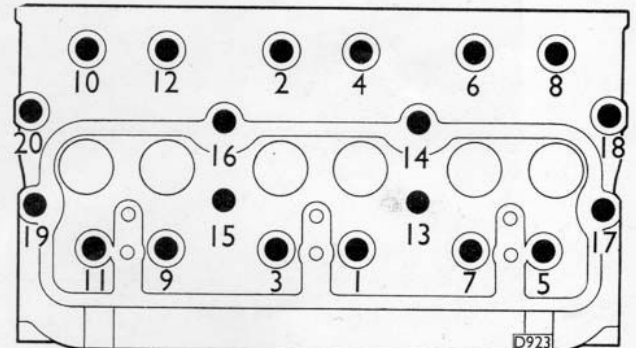


Fig. 32. Diagram showing sequence of tightening cylinder head nuts (Nos. 14 and 15 are jacknuts).



## 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).

### Key to Numbers :—

1. INJECTOR HOLE.
2. WATER OUTLET HOLE.
3. CONNECTION FOR AIR INTAKE PIPE WHEN FITTED TO COMPRESSOR.
4. NOTE VALVE THIMBLES HAVE BEEN REMOVED.
5. SPANNER.
6. TEE SCREW INSERTED IN JACK NUT.

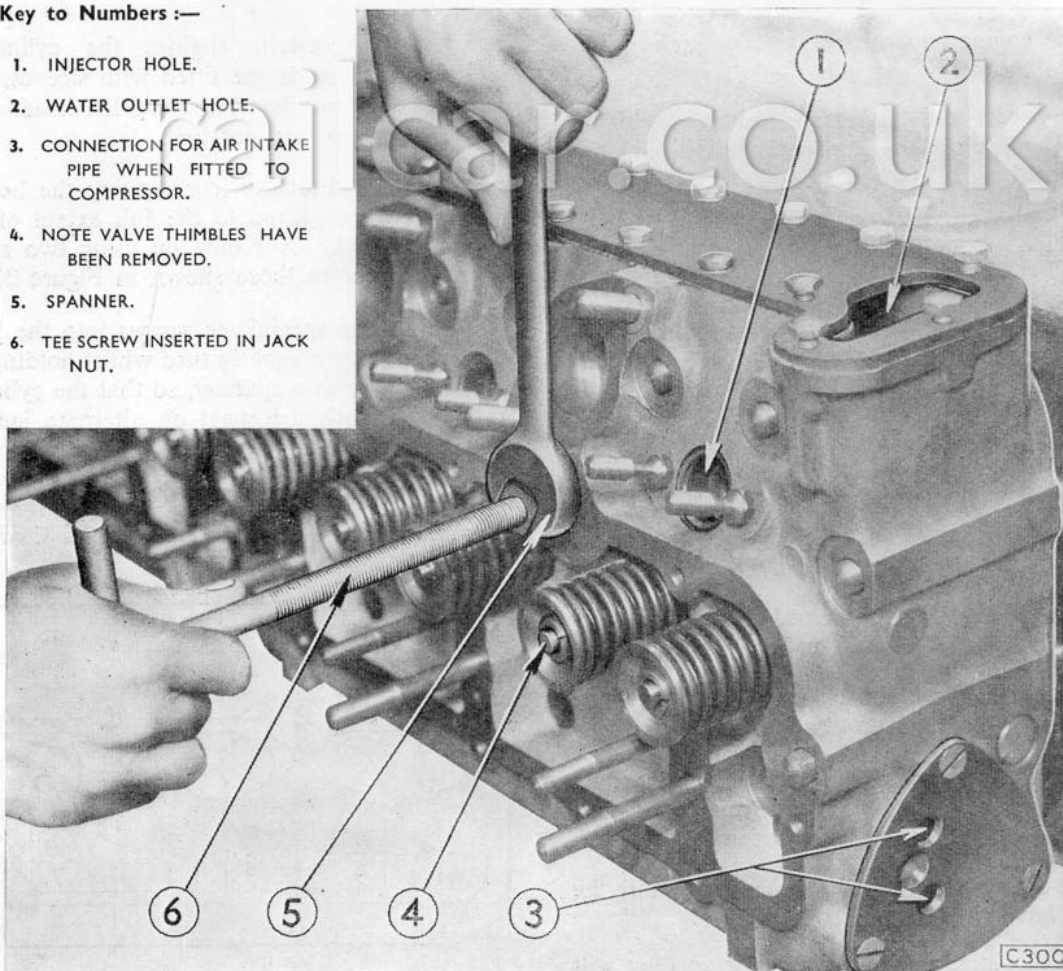


Fig. 33. Removal of cylinder head.

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.

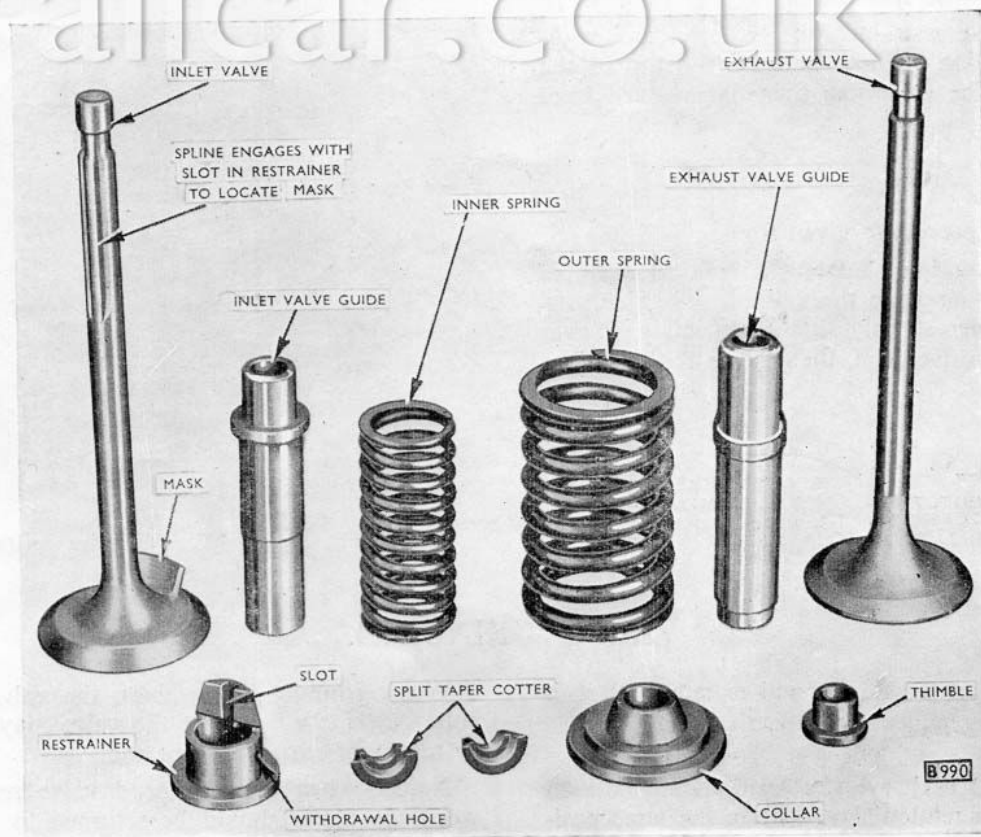


Fig. 34. Valve details.

**To Fit.**

Check the length and tension of the valve springs.

When new, the lengths are:—Inner, 80 mm. ( $3\frac{5}{16}$  in.) free. Load to compress to 44 mm. ( $1\frac{3}{4}$  in.), is 50 lb. (22.7 Kg.). Outer, 85 mm. ( $3\frac{11}{16}$  in.) free. Load to compress to 47 mm. ( $1\frac{37}{64}$  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.

**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.

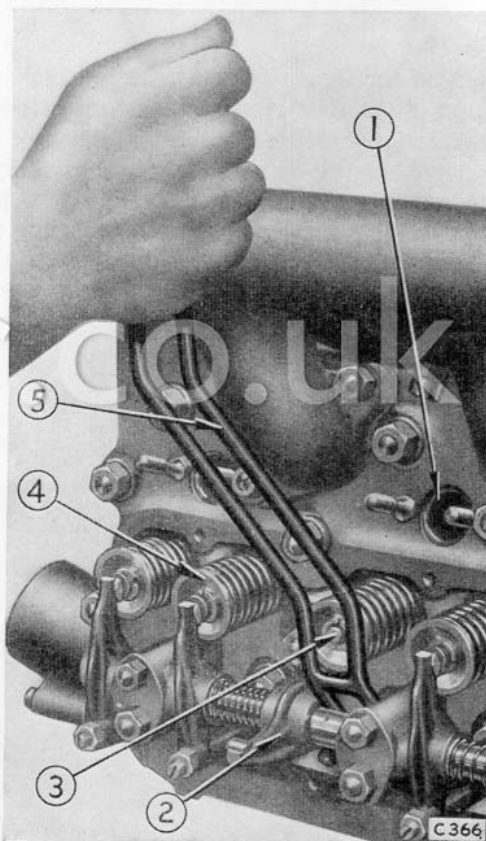


Fig. 35. Removal of valve springs.

**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.

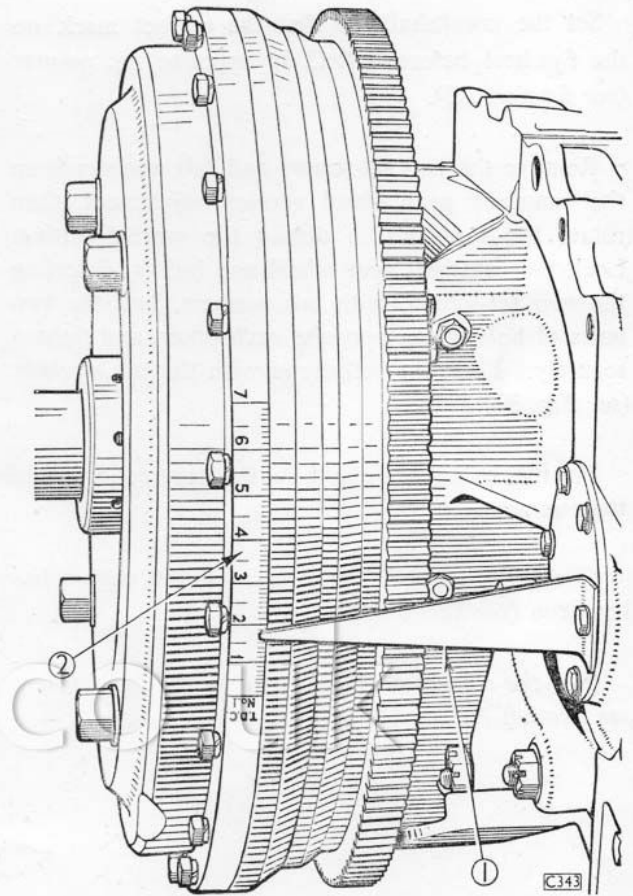
The timing pointer is fitted to the engine casing.

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  $10^\circ$  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.).

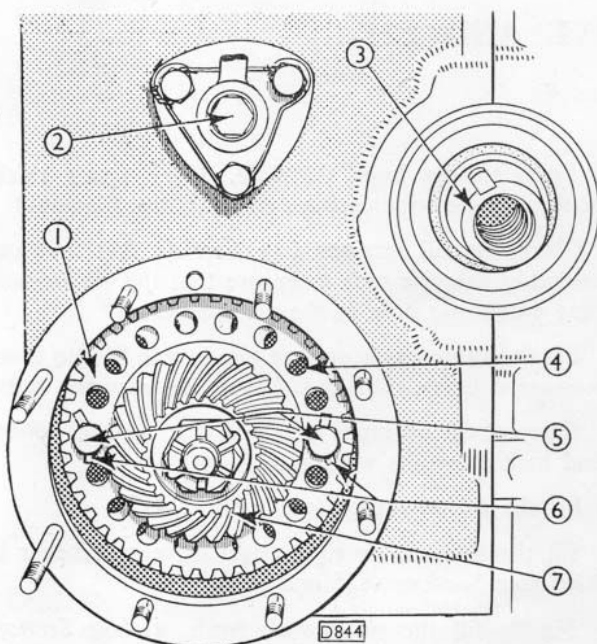
To alter the camshaft timing, first remove the bevel drive housing, and on certain engines also the speed indicator generator to expose the camshaft gear wheel with its vernier adjustment (see Sections A28 and A29).



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).

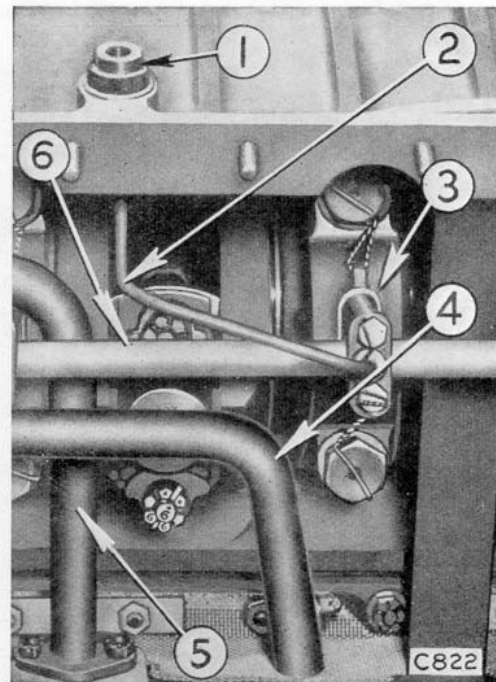
Set the crankshaft so that the correct mark on the flywheel before T.D.C. is opposite the pointer (see Section A5).

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. | 4. SCAVENGE PUMP SUCTION PIPE.   |
| 2. OIL PRESSURE GAUGE PIPE.    | 5. PRESSURE PUMP SUCTION PIPE.   |
| 3. No. 4 MAIN BEARING CAP.     | 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.

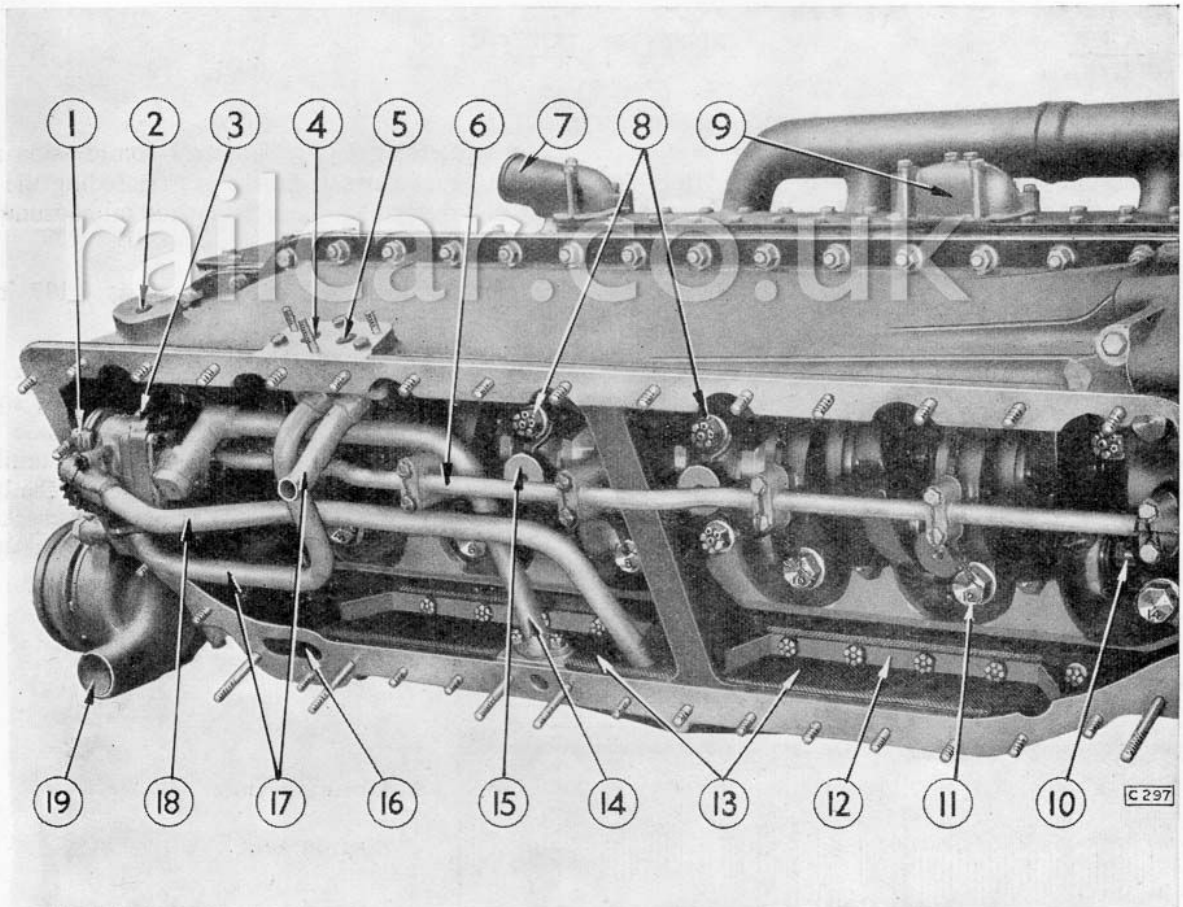
Remove the oil suction pipe by disconnecting it from the pressure pump and the lower side of the engine casing extension.

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

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.

## 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 re-

#### 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. 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.

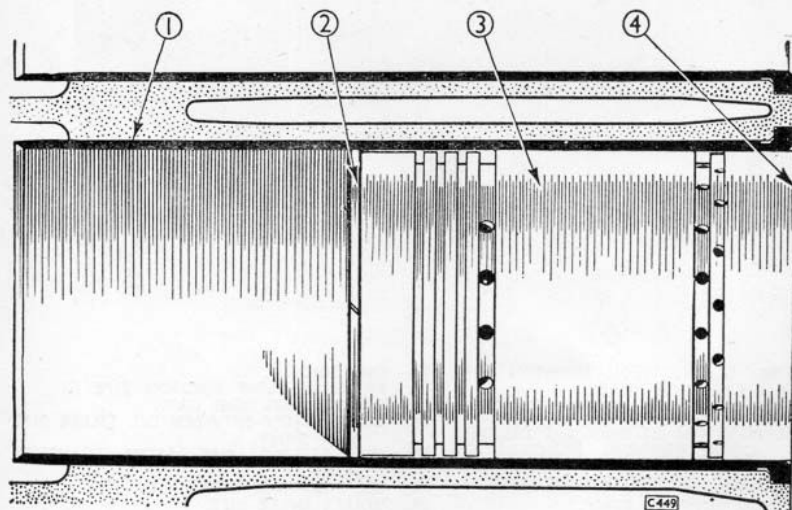
Clean all carbon from the piston rings and their grooves, then check with feelers for excessive side clearance between each piston and its rings. If the clearance is in excess of 0.018 in. (0.457 mm.), fit new rings.

moved 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.**

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.

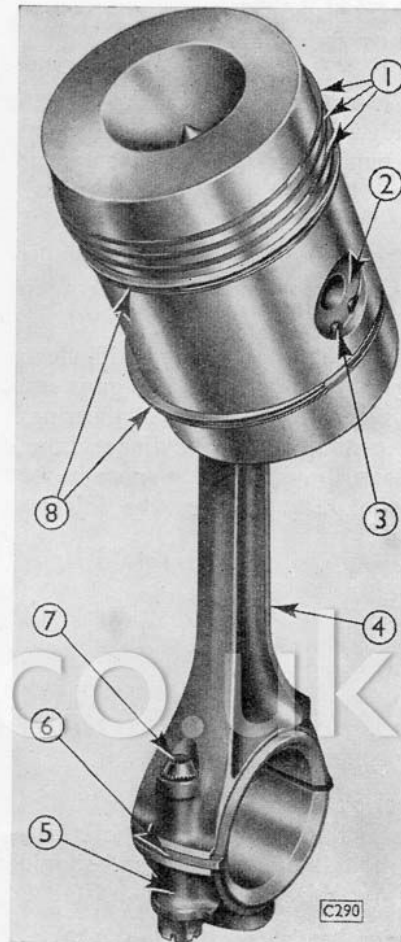
The reverse side of each rod, cap, and shim (if fitted) are marked with the letter "O" and on erection all the "O's" must be on the injector side of the engine. **Under no circumstances must the numbers 1, 2, 3, etc., appear mated to the letter "O."**

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.

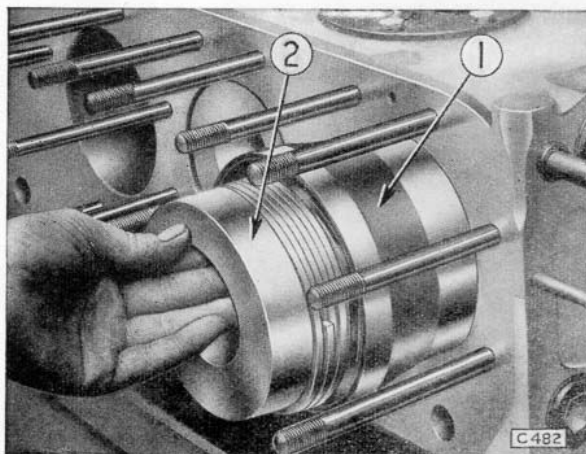
If necessary, the crank pins should be reground to fit undersize bearings. Replacement bearings are available in plan and undersizes, details of which appear in the charts in Section A82).

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 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.



Key to Numbers :—

1. PISTON FITTING TOOL.
2. PISTON.

Fig. 41. Method of fitting pistons.

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.**

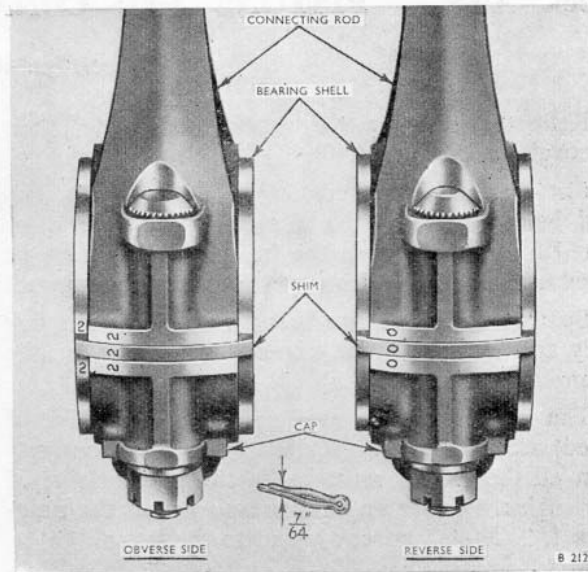


Fig. 43. Connecting rod big-end showing markings and special type split pin for bolts.

#### 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).

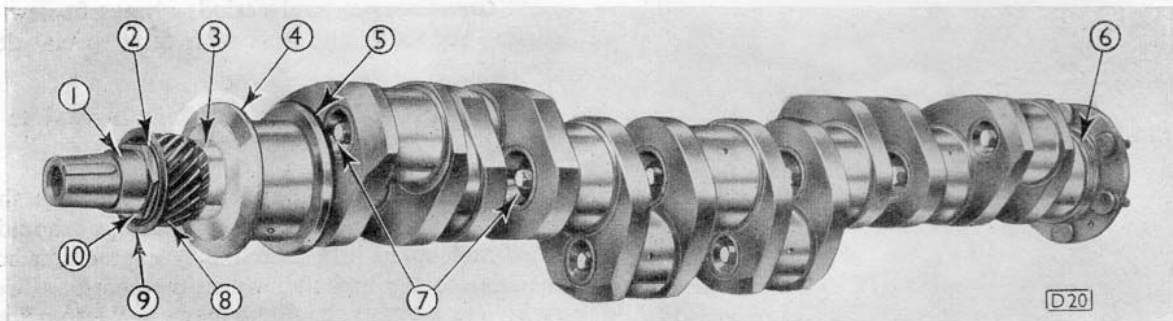
Slacken off the adjustment and remove the fan and water pump drive belts (see Section A3).

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*).

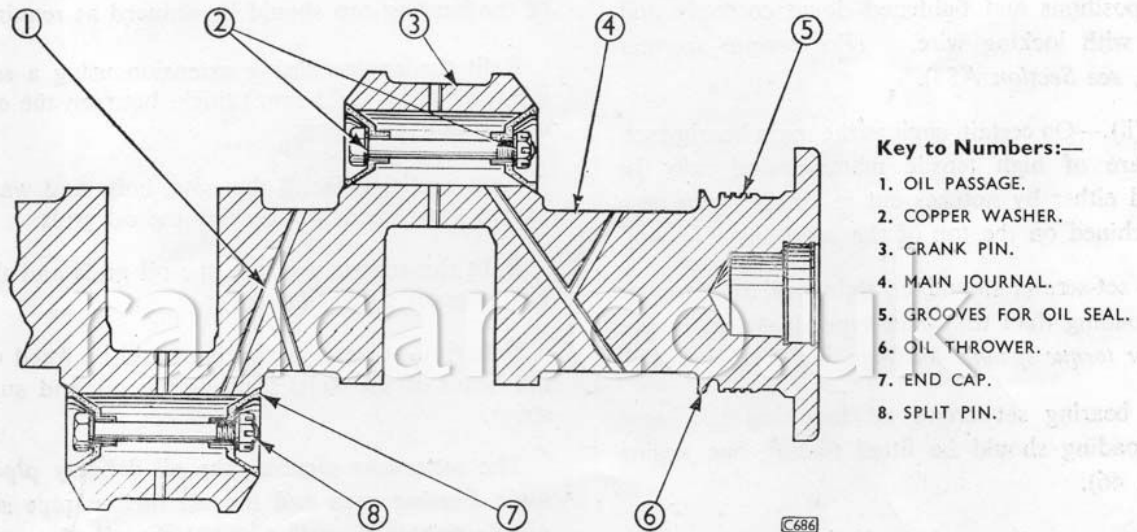
Unscrew the securing bolts and remove the oil grid support strips, the oil grids and the copper washers (if fitted) and then the engine casing extension.

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).

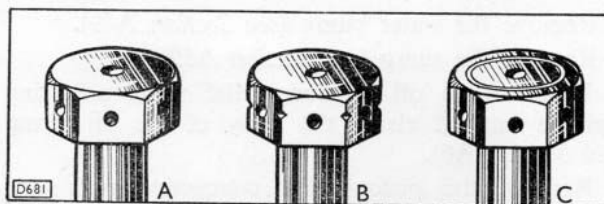
These set-screws should be tightened to a greater torque loading than the plain type shown in Figure 46. (For torque spanner loadings, see Section A84).

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  $\pm 0.005$  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



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.

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.

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).

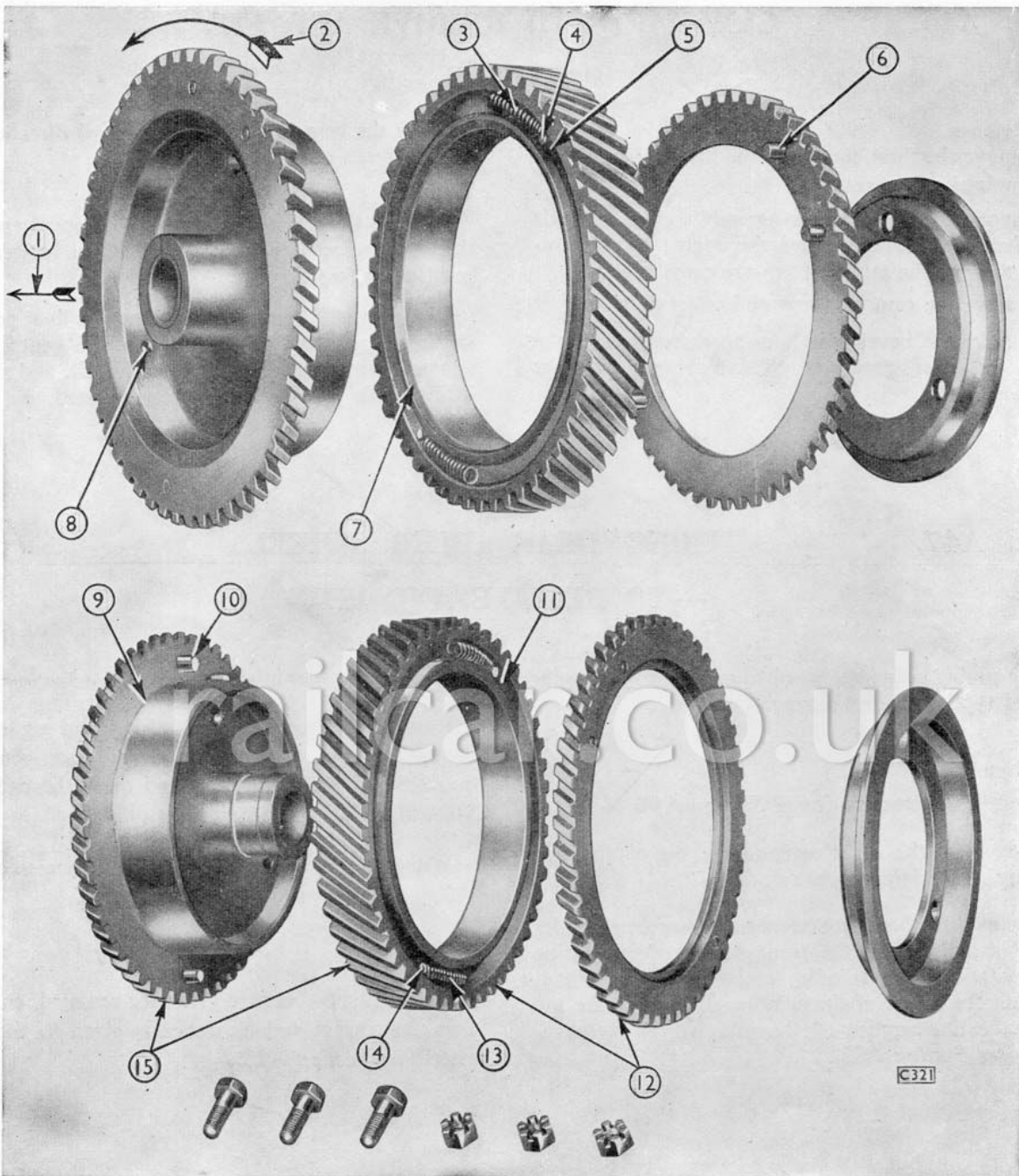
**Sect. A48. TIMING GEAR IDLER WHEEL (SPRING LOADED TYPE)  
—TO DISMANTLE AND ASSEMBLE.**

(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.

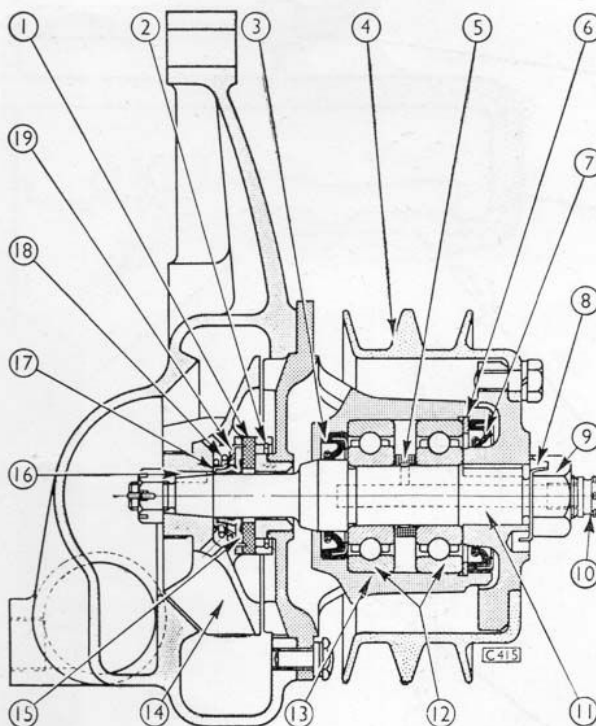
Remove the small grease retainer from the bearing housing if it requires renewing.

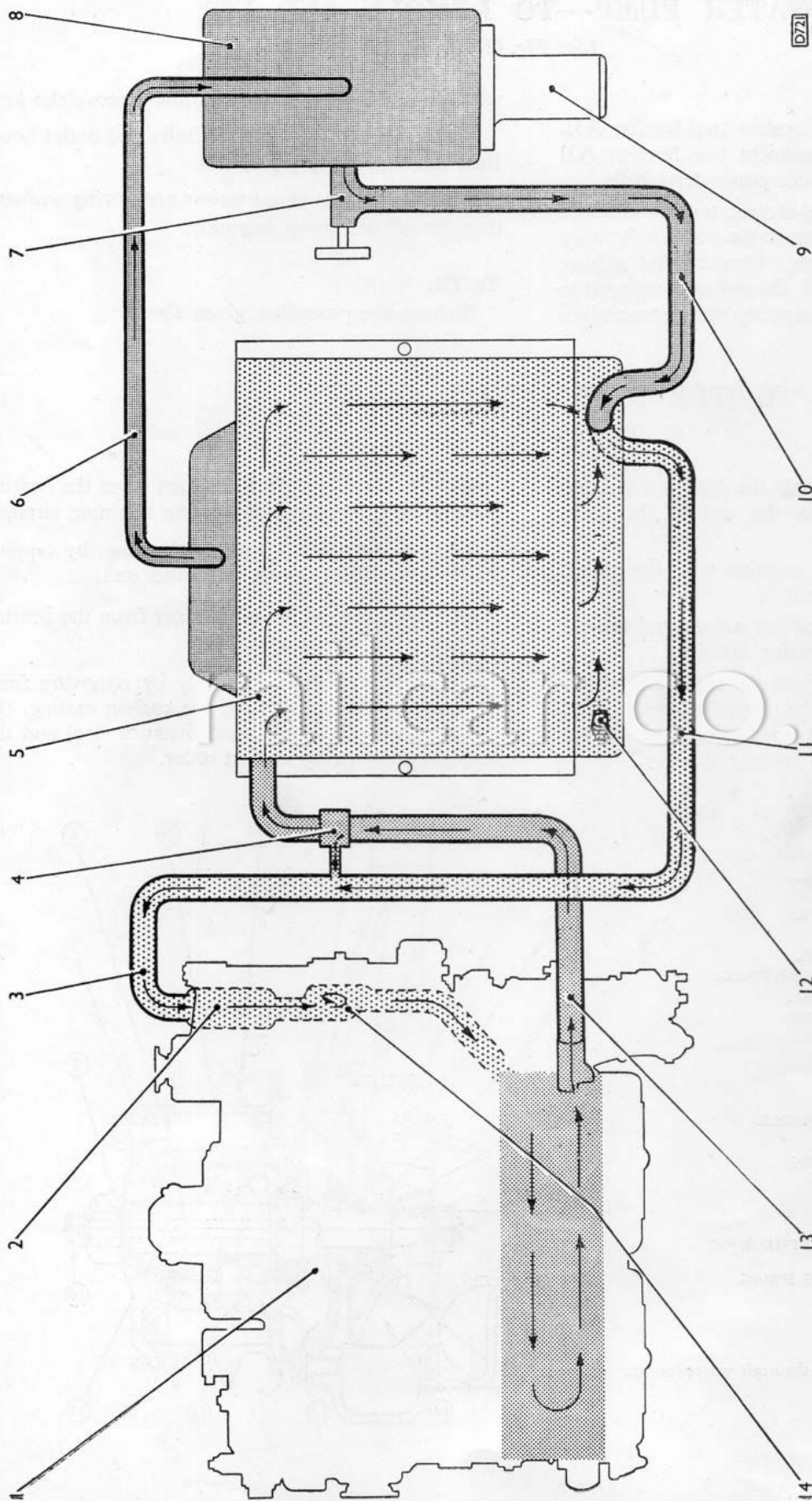
Dismantle the gland assembly by removing from the impeller the spring ring, the carbon seating, the rubber seal (with housing and distance ring) and the gland loading spring, in that order.

**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.





**Key to Numbers :—**  
 1. ENGINE.  
 2. OIL COOLER.  
 3. PIPE—ENGINE INLET.  
 4. THERMOSTAT.

5. RADIATOR.  
 6. PIPE—RADIATOR VENT.  
 7. STOP COCK.  
 8. LOW LEVEL WATER TANK.  
 9. LOW WATER LEVEL SWITCH.

10. PIPE—RADIATOR INLET.  
 11. PIPE—RADIATOR TO ENGINE.  
 12. RADIATOR DRAIN COCK.  
 13. PIPE—ENGINE INLET.  
 14. 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.

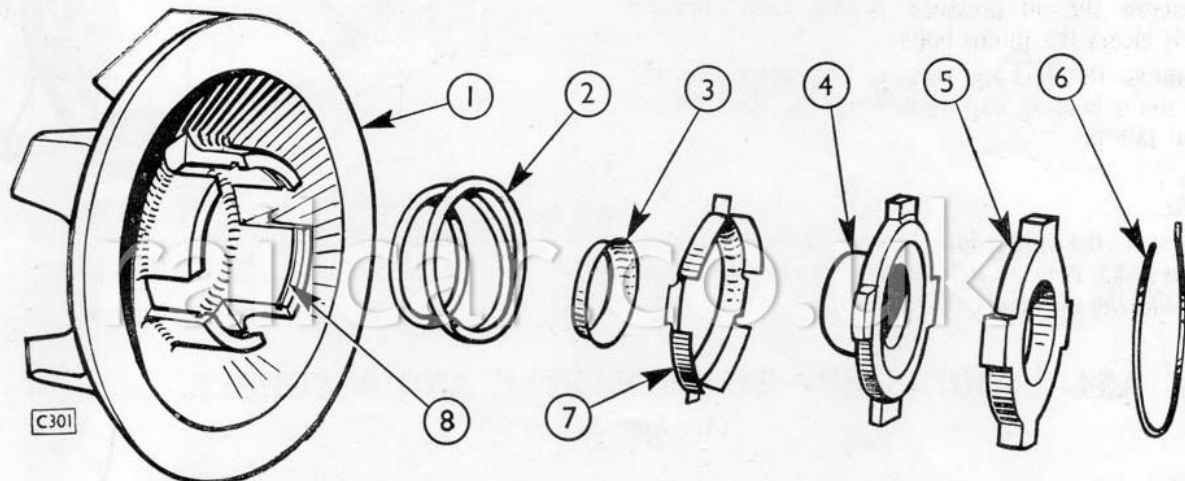
Place the gland loading spring into the impeller, **small end first**, followed by the rubber seal with its housing and distance ring so that the housing abuts the large end of the spring.

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.

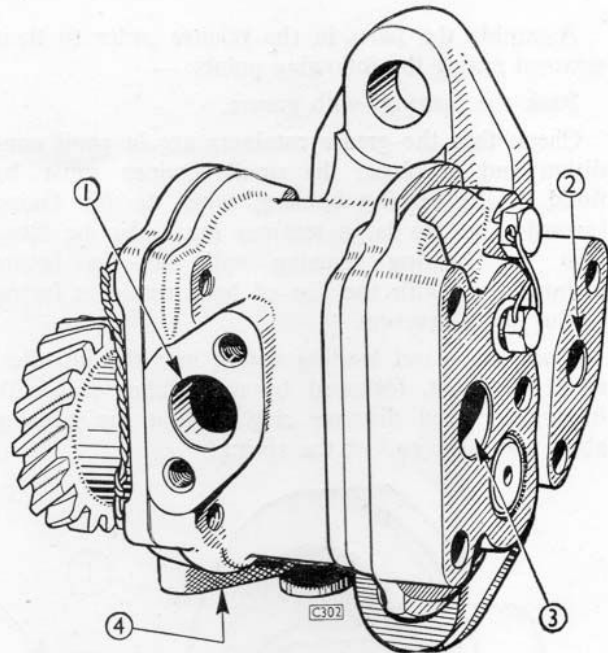
Disconnect from the pressure pump the gallery pipe; retain any shims fitted between the pipe connections and the pump body.

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.

**To Fit.**

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

**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.

**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).

### Key to Numbers :—

1. SECURING NUT.
2. PUMP DRIVING GEAR.
3. SET-SCREW.
4. SCAVENGE PUMP COVER.
5. SCAVENGE PUMP DRIVEN GEAR.
6. OIL CONNECTION TO PRESSURE RELIEF VALVE.
7. PUMP BODY.
8. DRIVEN GEAR SPINDLE.

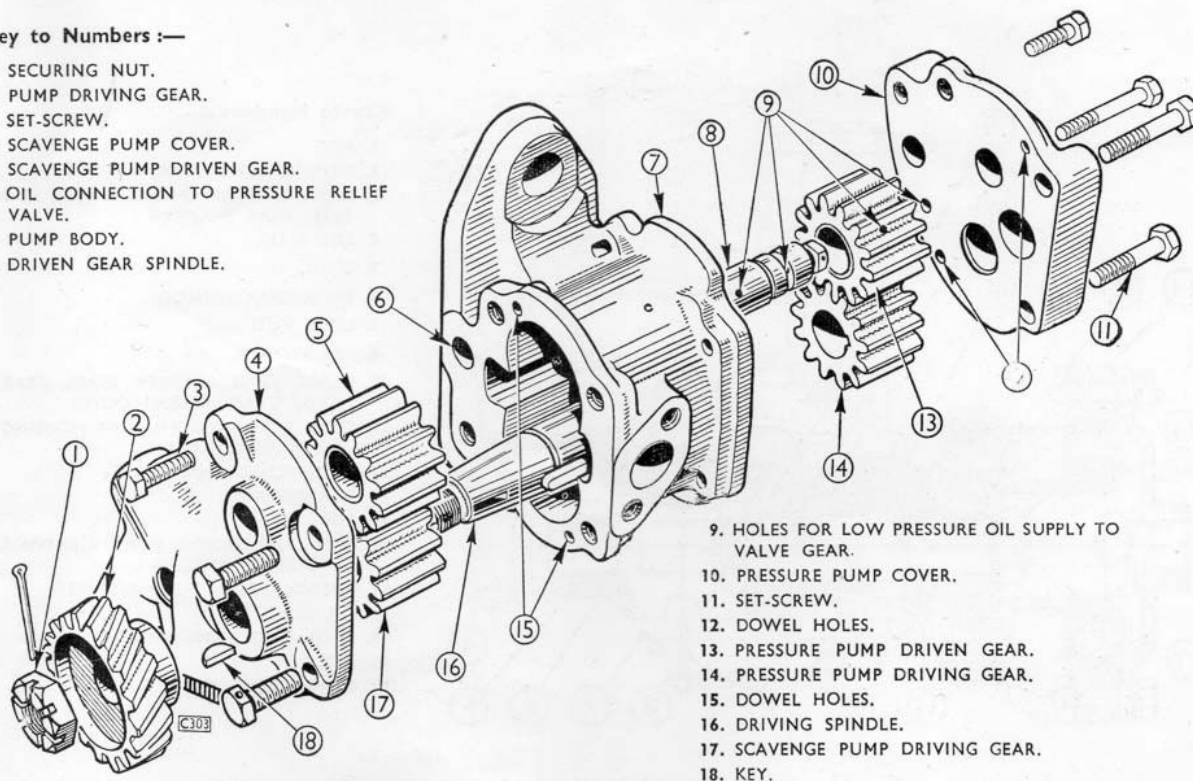


Fig. 52. Exploded view of pressure and scavenge oil pumps.



## 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.

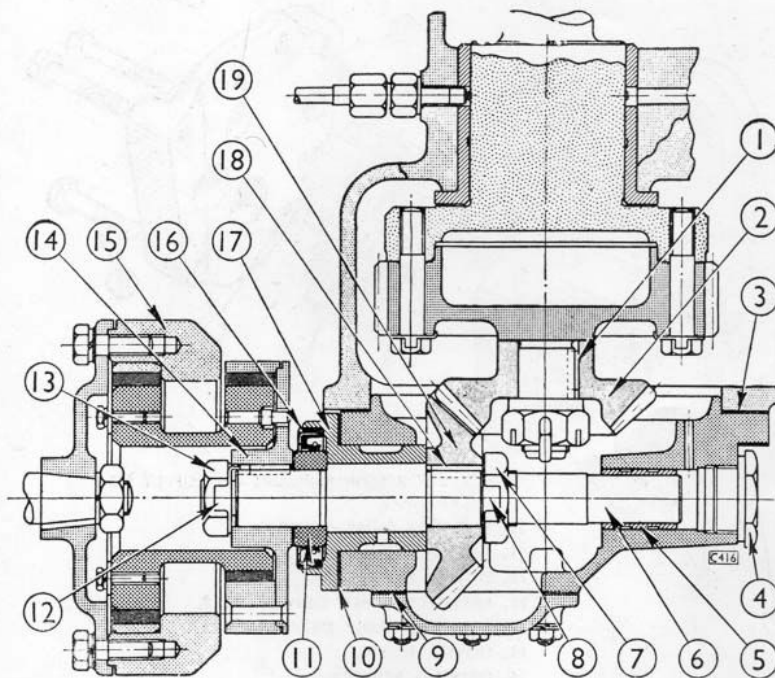
Lightly coat a few widely spaced teeth on the driving gear with marking blue.

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.

## SUPPLEMENT TO CHAPTER A.

For use with Swindon Built Inter-city Cars 79083-111  
and 79155-168 only.

For Section A57 in Chapter A substitute the following:—

### Sect. A57A ENGINE—TO ADJUST FOR IDLING AND MAXIMUM SPEEDS.

(See Fig. 1S).

Run the engine until warm, then ensure that idling speed is correctly set on the fuel-injection pump before any linkage is connected.

Obtain the optimum idling speed by means of the adjusting screw, which should then be securely locked by tightening the locknut. This operation limits the total angle through which the fuel pump control lever can travel, the maximum speed stop having been set and sealed when the engine was tested.

Check that the shut-down solenoid will stop the engine; correct if necessary by means of the adjustable fork-end.

Ensure also that the switch contacts in the solenoid are working correctly to break the main operating current after operation.

Extend the throttle motor to its maximum, i.e. full throttle position, and whilst in this position connect the links to the adjustable pillar; then set

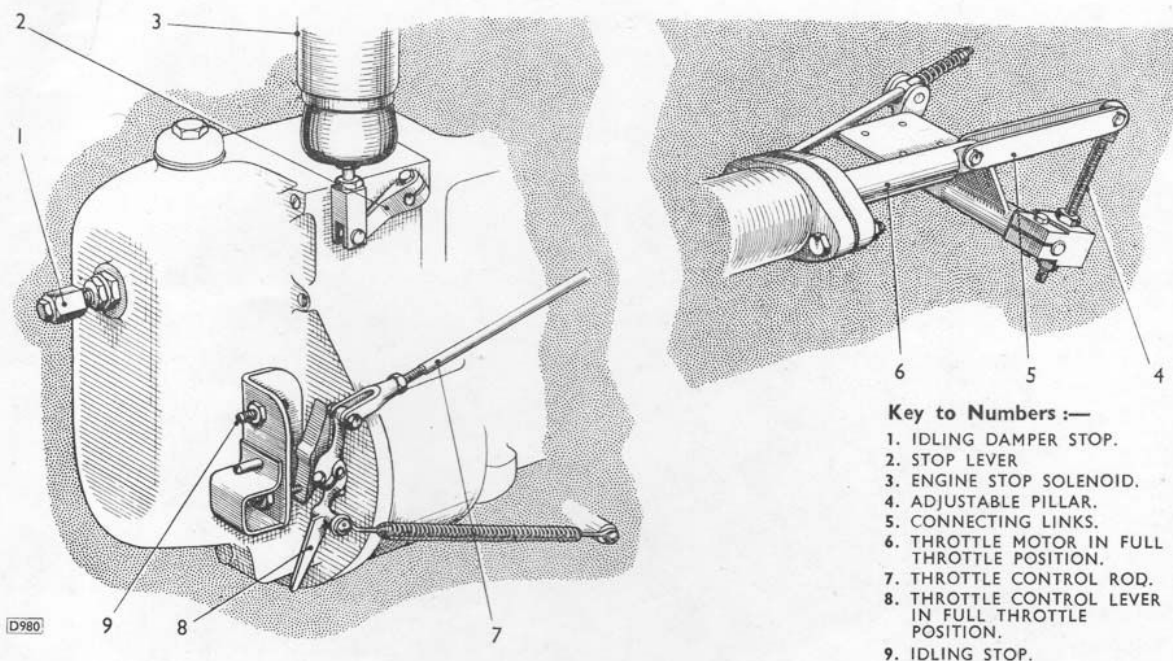


Fig. 1S. Throttle motor Linkage.

the pillar so that the links between the motor and the pillar are horizontal.

With the throttle motor still in the extended position adjust the fuel pump control rod so as to obtain full throttle on the pump; then connect the rod to the lever on the pump.

In order to avoid possible damage to the stop, the rod should be set so that a 0.005 in. feeler gauge will just pass between the stop on the fuel pump control lever and the stop on the pump.

Return the throttle motor to the idling position and check whether the fuel pump control lever is against the idling stop. If it does not reach, or if it is too hard against the stop, the pillar should be adjusted to alter the angle of movement. **Lowering** the pillar **increases**, and **raising** the pillar **decreases** the total angular movement of the pump control lever.

**Note.**—Movement of the adjustable pillar affects only the **angle** of travel, which is increased or decreased an equal amount at **both** ends of the fuel pump control lever travel, therefore any adjustment to the fuel pump control rod, for example, an increase of 10 deg. total, is in fact an increase of 5 deg. travel at either end of the total movement.

Thus to bring the fuel pump lever back to the original setting point, for example, full throttle, the control rod should be lengthened so as to take off the 5 deg. angle at the full throttle end of the travel, making a total of 10 deg. increase at the idling end.

Adjustment should be made so that the fuel pump stop, and **not the throttle motor**, controls idling speed, i.e. the throttle motor linkage should over travel approximately  $\frac{1}{16}$  in.

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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.

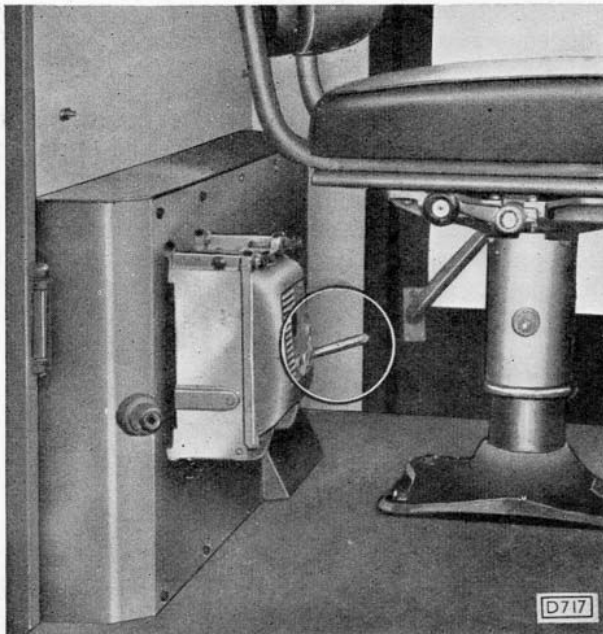


Fig. 55. Train switch—key removable when in the "OFF" position only.

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.**

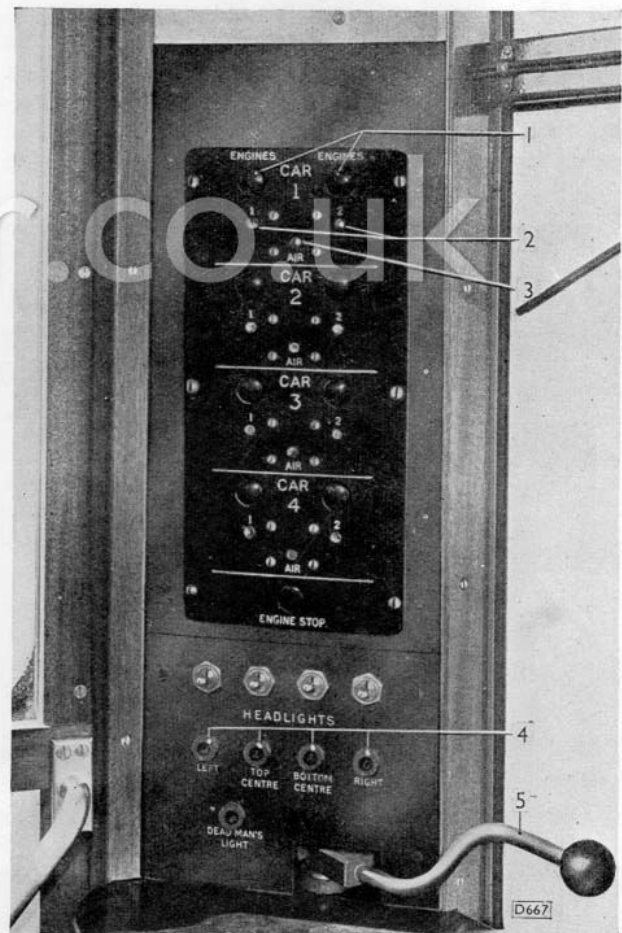
Select first gear by means of the selector lever, the engine should not "stall"; should it do so, select "neutral" and restart the engine.

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

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.

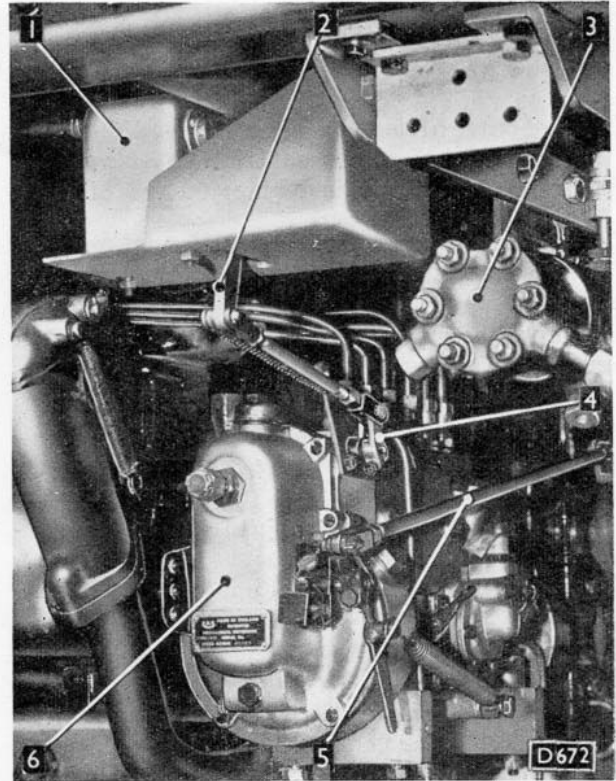
Release the throttle control lever in the driver's cab.

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.

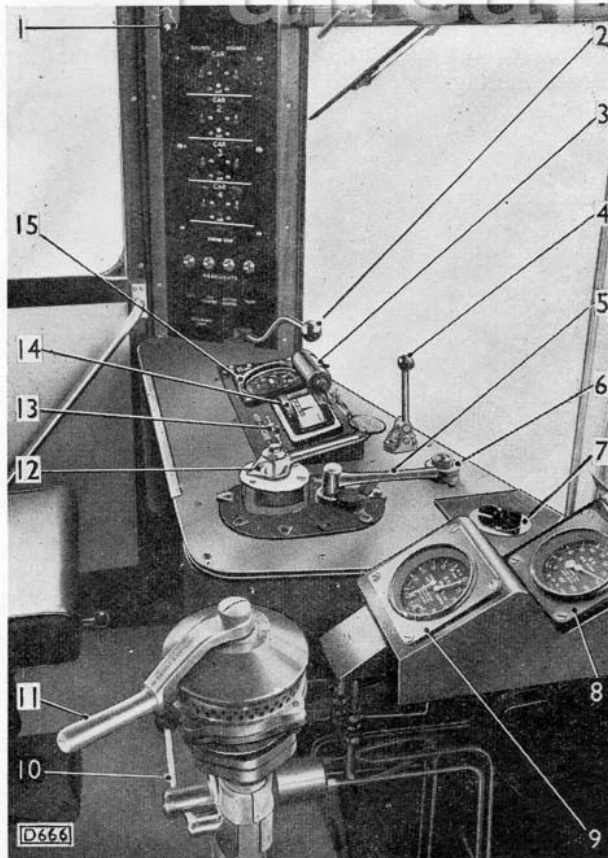
Re-check if the engine will stop and if necessary adjust the adjustable pillar and at the same time check the idling and maximum speeds to ensure that the adjustment has not been altered.

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

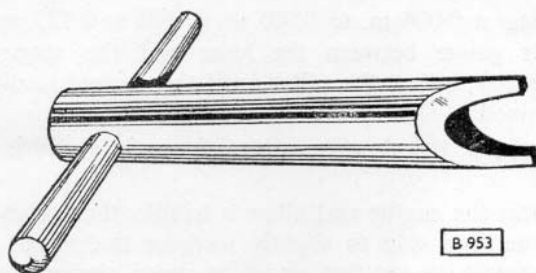


Fig. 60. Tool for starter motor armature spring nut.

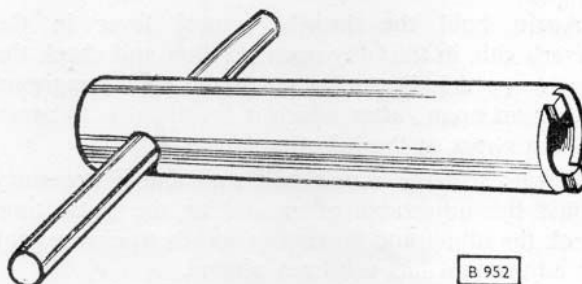


Fig. 61. Tool for starter armature plunger nut.

Remove the screws securing the (+) terminal connector.

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

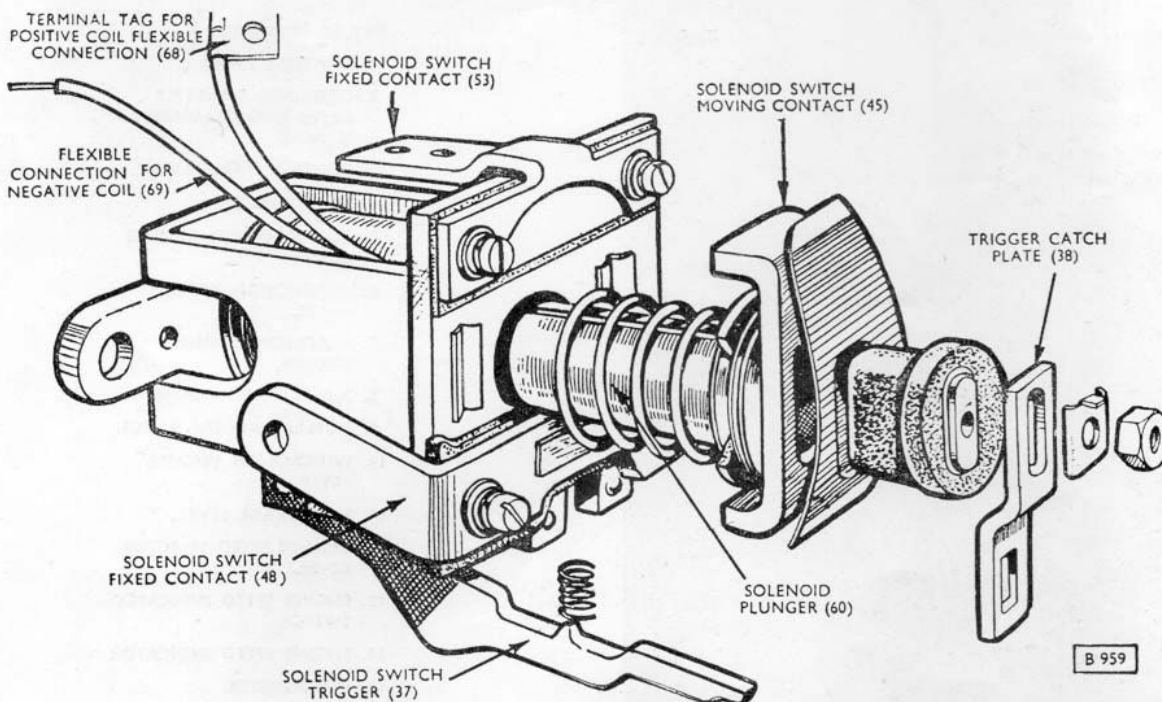


Fig. 62. Exploded view of starter motor solenoid switch (C.A.V.).

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 dumbbell, 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:—

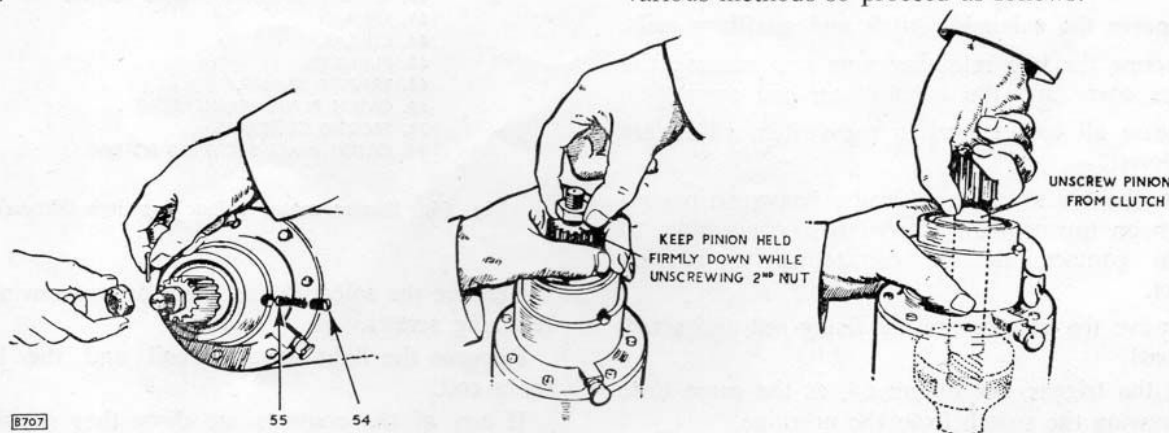


Fig. 63. Method of changing starter motor driving pinion without dismantling unit.

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  $\frac{1}{2}$  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.

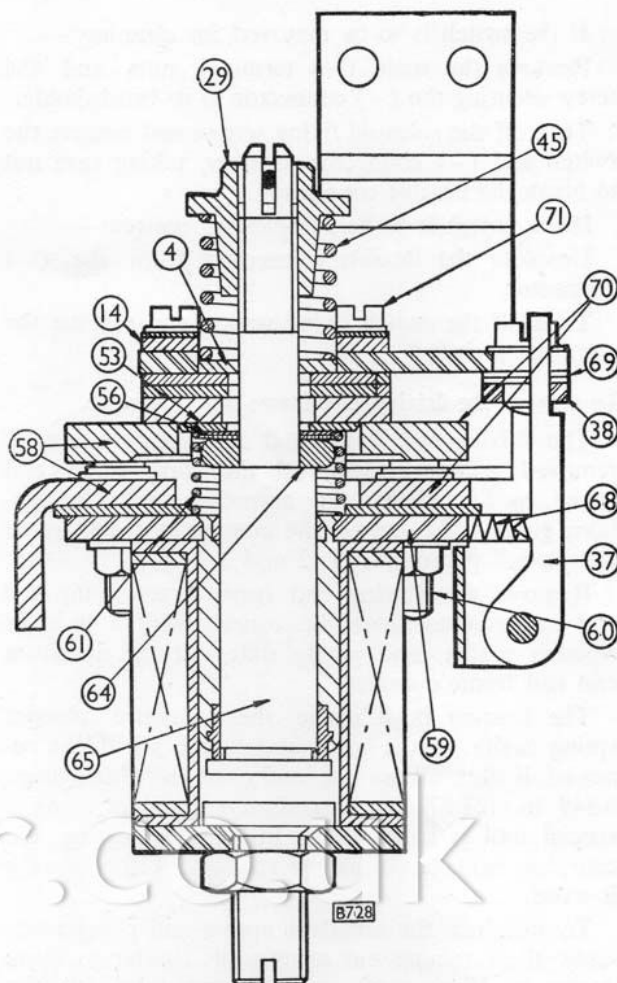
Release all connections to the switch, which are as follows:—

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 assem-

bly 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.

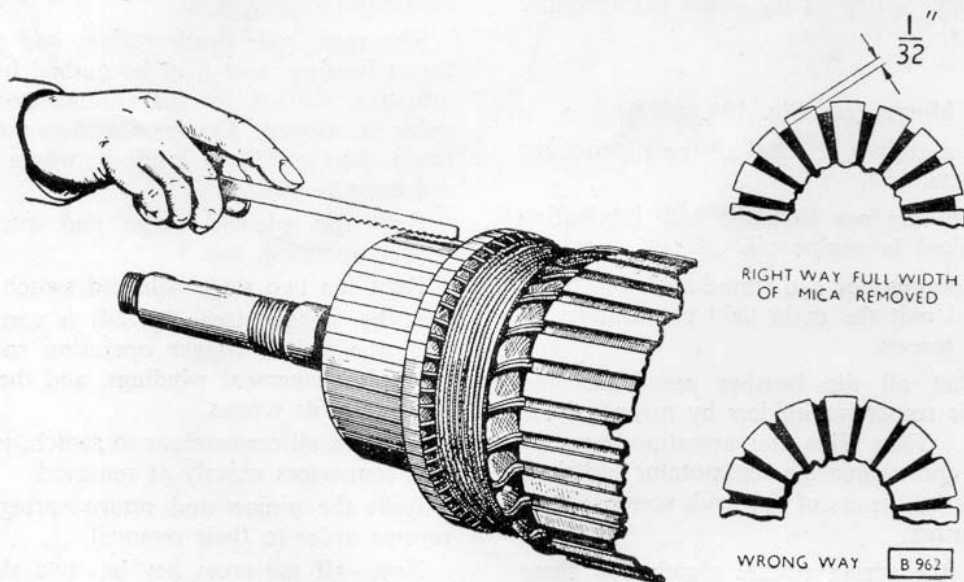


Fig. 65. Method of undercutting commutator mica.

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  $\pm 2\frac{1}{2}$  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 recalibration 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.

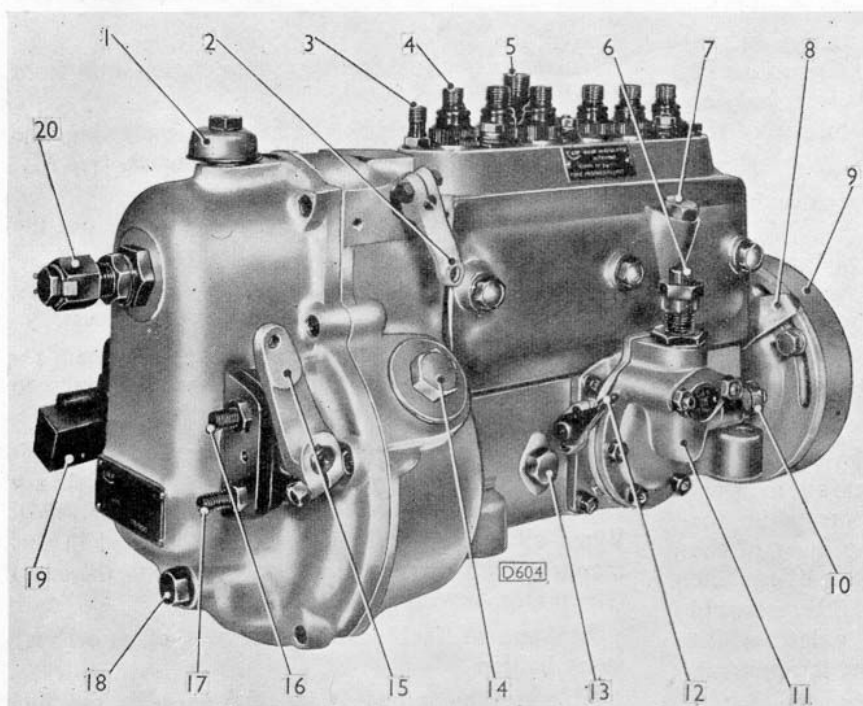
At periods quoted in Section A3 remove the governor oil level plug, then either allow the surplus oil to drain out or add oil through the governor oil filler plug (see Fig. 66).

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.

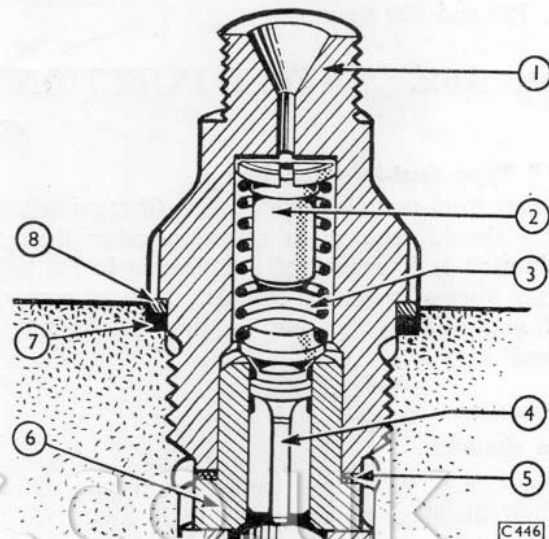
**Air-lock existing in the pump chamber.** This must be cleared by opening the air vent cock (see Fig. 66), with the engine stopped and operating the priming lever of the fuel-lift pump (see Fig. 66) until fuel, free from air bubbles, flows from the pipe on the air vent cock.

**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. | 5. SEALING WASHER.         |
| 2. VALVE SPRING GUIDE.    | 6. SEATING.                |
| 3. SPRING.                | 7. RESILIENT SEALING RING. |
| 4. DELIVERY VALVE.        | 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 re-assemble 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:—

$4\frac{3}{8}$  in. ( $27^\circ$ ) before T.D.C.

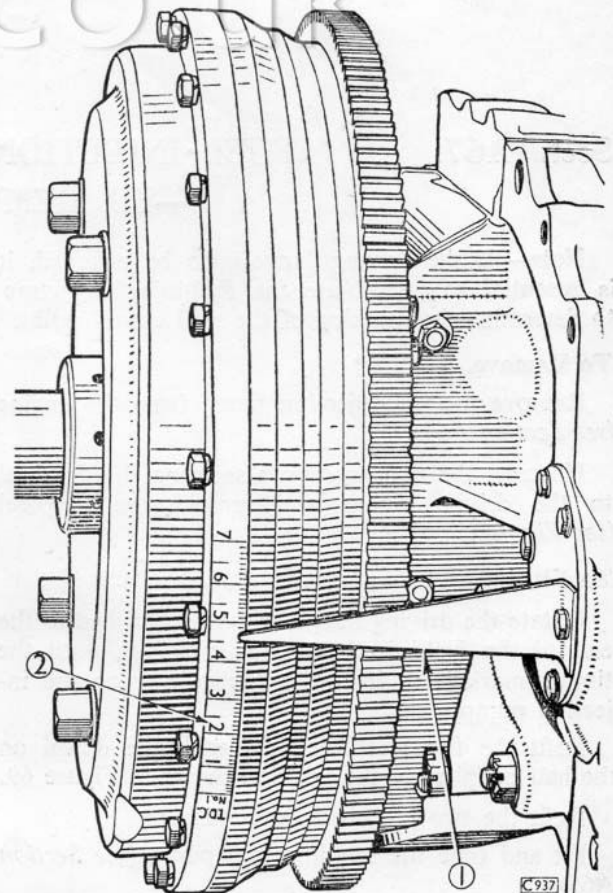
[Flywheel dia. 19.8 in. (503 mm.)].

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*).

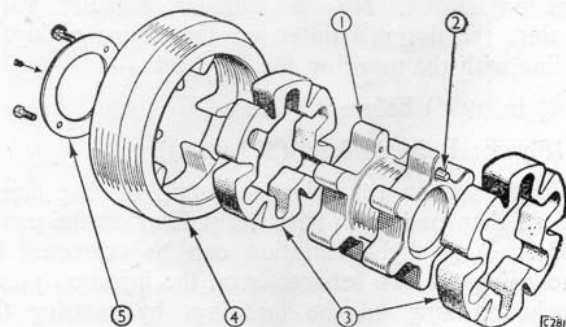
### To Fit.

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.



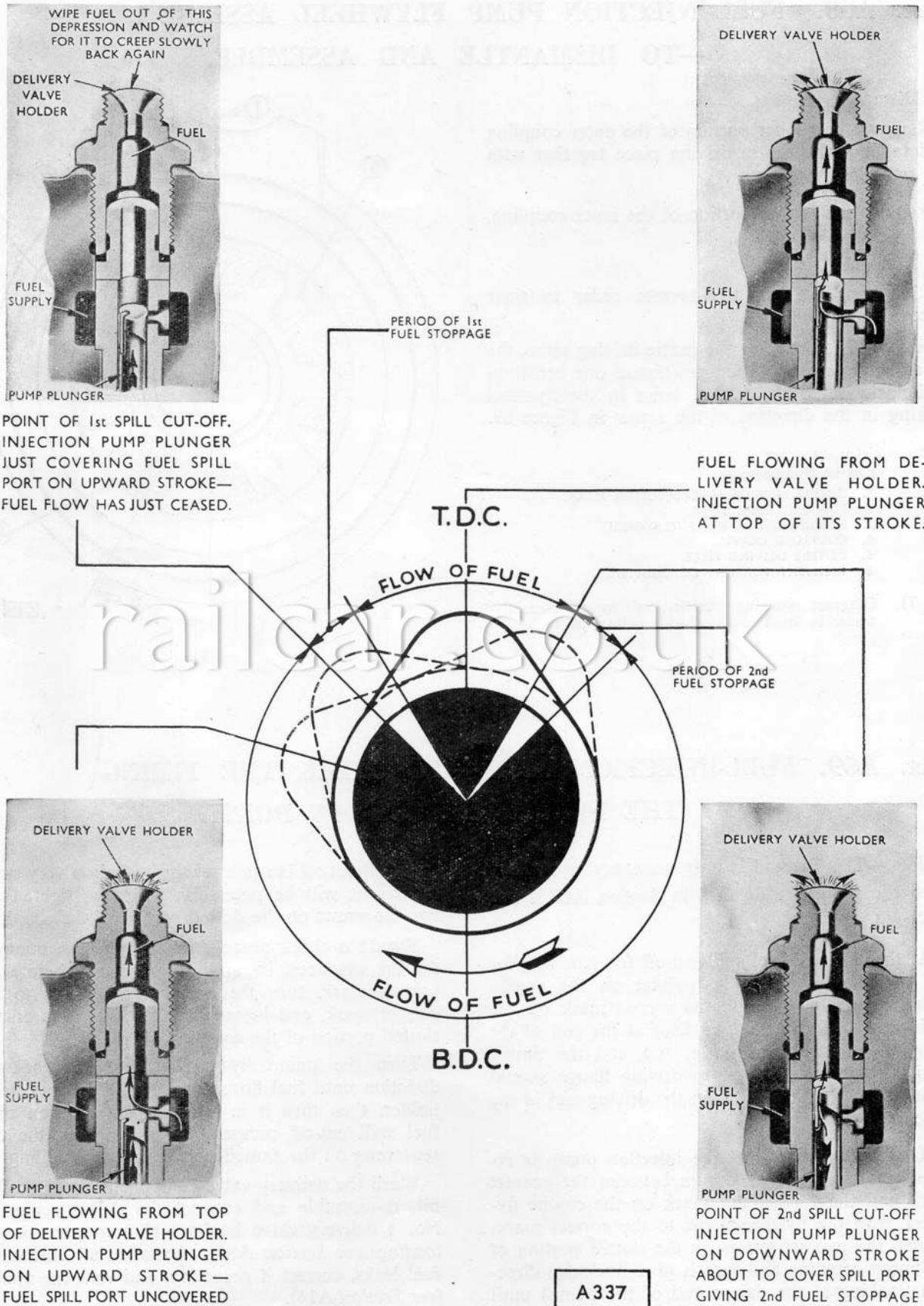


Fig. 70. Diagram showing C.A.V. fuel-injection pump cycle of operation. (Note delivery valve is removed).

## 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.

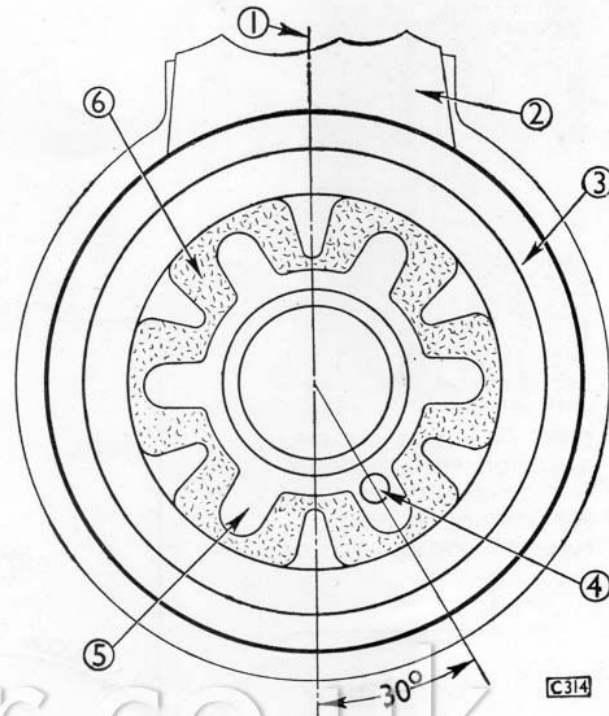
Refit the parts in the reverse order to their removal.

**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 retarded, 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).

**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

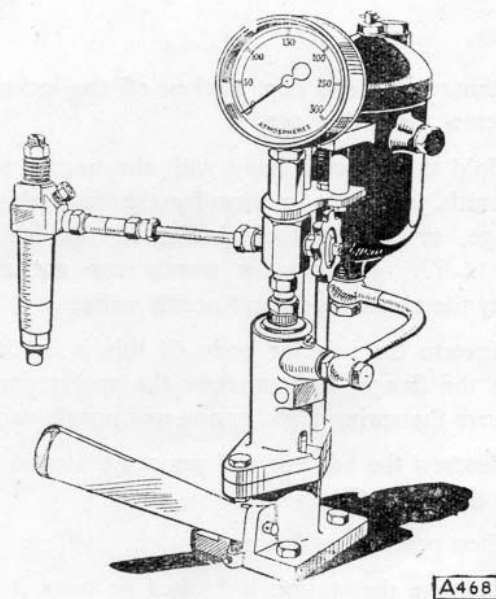


Fig. 72. C.A.V. hand-testing pump for injectors.

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

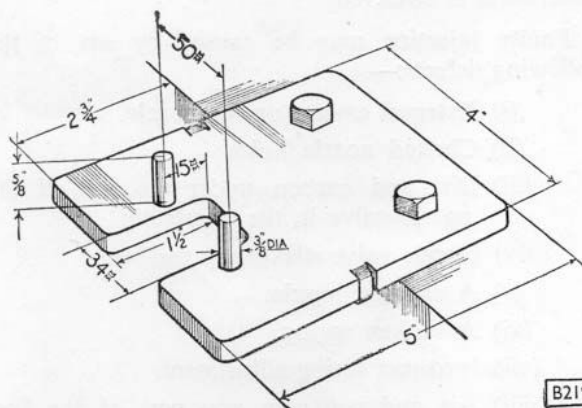


Fig. 73. Tool for holding injectors when dismantling.

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.**

**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).

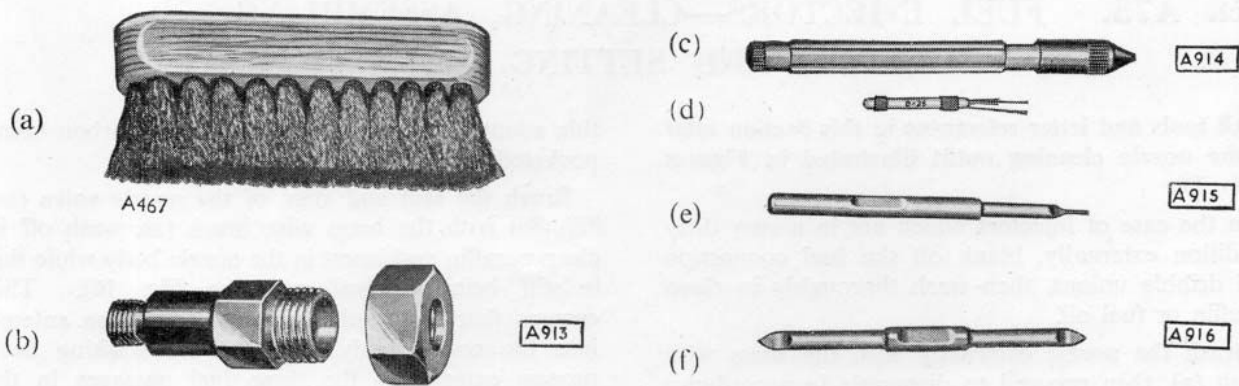


Fig. 74. Injector cleaning tools.

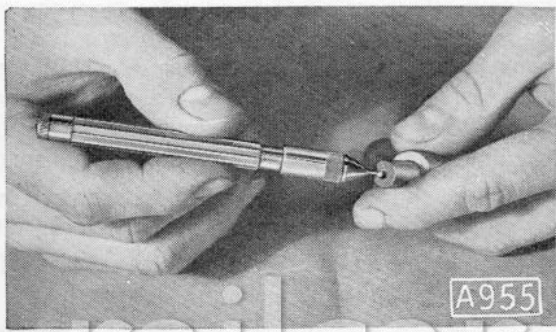


Fig. 75. Pricking out nozzle holes.

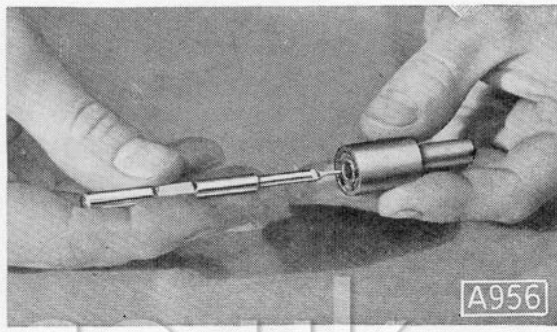


Fig. 76. Tool for cleaning nozzle tip.

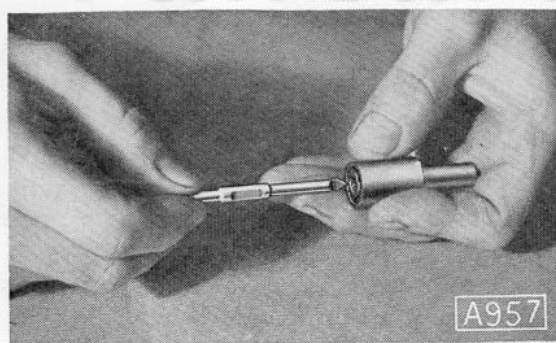


Fig. 77. Tool for cleaning nozzle seat.

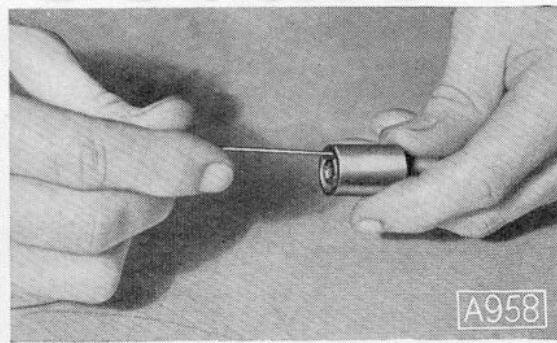


Fig. 78. Cleaning nozzle fuel passages.

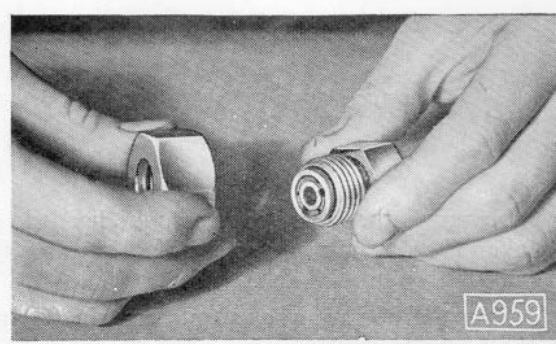


Fig. 79. Nozzle inserted in adaptor for washing.

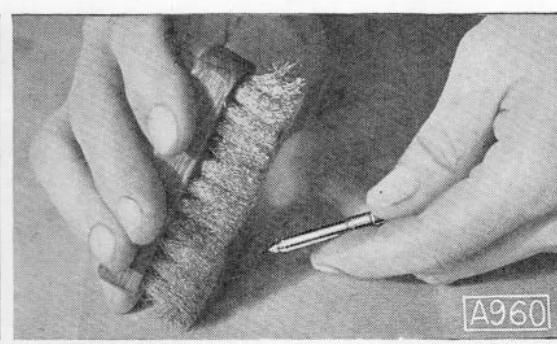


Fig. 80. Brass wire brush for cleaning nozzle valve.

### 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 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

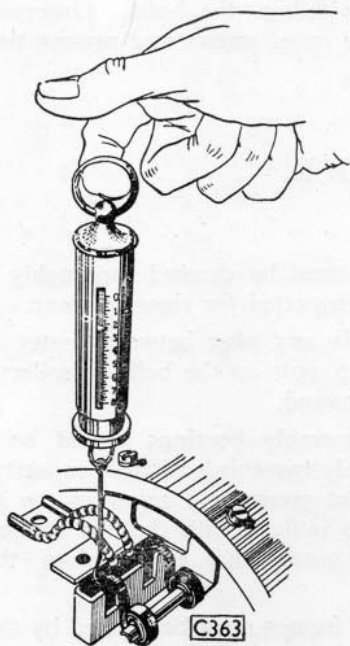


Fig. 81. Method of checking brush spring pressures.

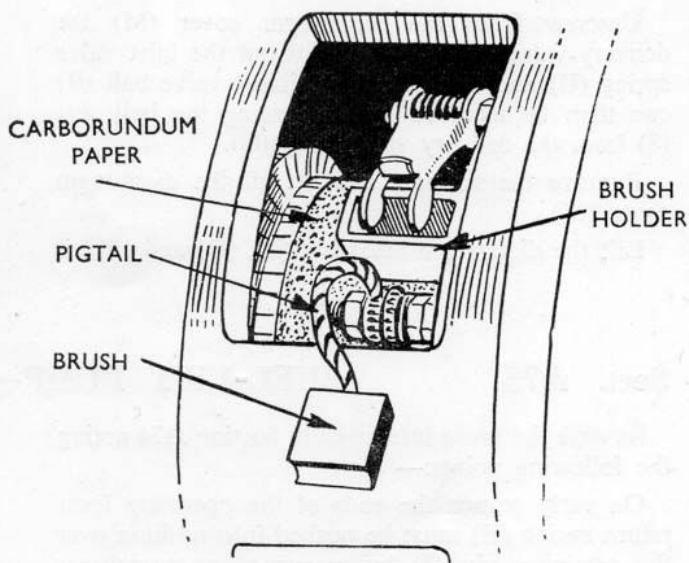


Fig. 82. Method of "bedding" dynamo and starter motor brushes.

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. 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 permissible 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.

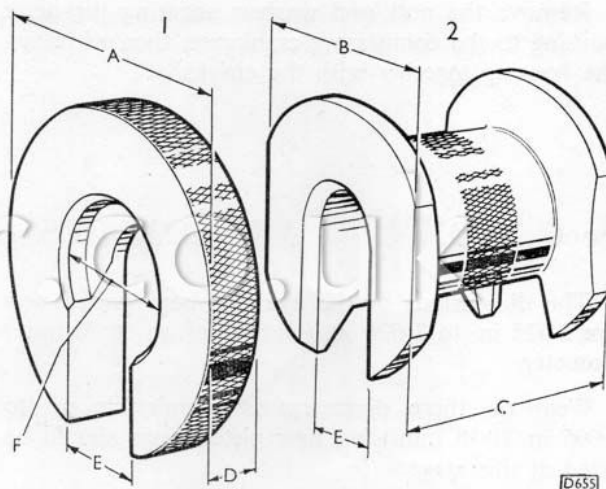
Press the bearing and the bevel gear off the shaft, and remove the remaining bearing from the housing.

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



### 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.

shaft with its recessed face towards the bearing housing.

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 A41*).

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

CLEARANCES (when new).

Unit.	Component.	Clearance.				
		Inches.		Millimetres.		
		Maximum.	Minimum.	Maximum.	Minimum.	
<b>DIAMETRICAL CLEARANCES.</b>						
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	
CAMSHAFT	Camshaft and Bearings (Front and Rear) .. .. .	0-0045	Interference 0-0032	0-116	Interference 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
		Specialaloid	0-0279	0-0249	0-708	0-633
	Cylinder Liner and Bottom of Piston Skirt .. .. .	B.H.B.	0-035	0-030	0-889	0-762
		Wellworthy*	0-015	0-010	0-381	0-259
		Specialaloid*	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	
<b>SIDE AND END CLEARANCES.</b>						
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
		Specialaloid	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
		Specialaloid	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
		Specialaloid	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	
<b>BACKLASH OF GEARS.</b>						
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.

## Cylinder Liner Bores—(Standard).

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.

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 in.	129.63 mm. 5.1039 in.	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	} Width 0.125 in., 0.145 in. or 0.165 in.
"	—	131.0	
Piston ring, scraper	—	130.5	
"	—	131.0	
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. To be fitted to cylinder head after machining.
Valve seats (inlet and exhaust)	—	—	

## Sect. A83.

DIMENSIONS OF SHIMS AND  
DISTANCE WASHERS AVAILABLE.

Part.	Thickness.	Remarks.
Shims:—	{ 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."
Cylinder head/Engine casing	{ 0.005 in. (0.127 mm.) 0.010 in. (0.254 mm.) 0.020 in. (0.508 mm.)	
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:—	{ 0.022 in. (0.559 mm.) 0.048 in. (1.218 mm.) 0.081 in. (2.032 mm.)	
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	
	<i>lb. ft.</i>	<i>Kg. M.</i>
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

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# FLUID COUPLING.

## CHAPTER B.

### CONTENTS.

Fluid Coupling :—	Section.	
Description .. .. .	B1	} Maintenance and Overhaul Manuals.
Maintenance .. .. .	B2	
Bellows Gland—To Renew .. .. .	B3	
Lubrication .. .. .	B4	
To Remove and Fit .. .. .	B5	} Overhaul Manual only.
Runner Shaft Bearing—To Renew .. .. .	B6	



## 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 pro-

vided 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.

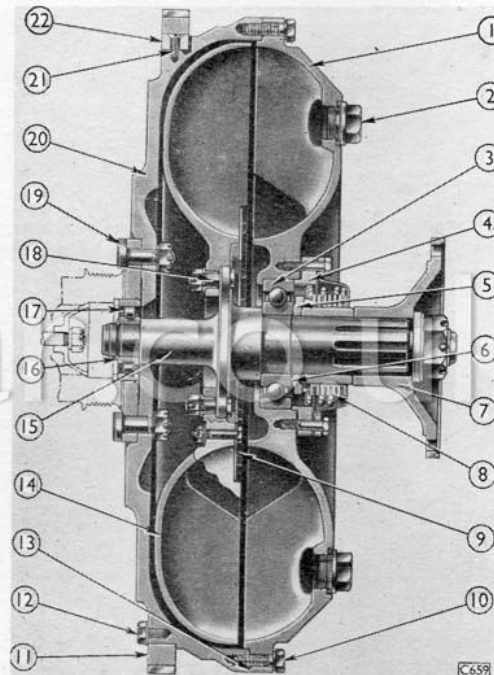


Fig. 1. Section through fluid coupling and bellows gland oil seal.

## Sect. B2. FLUID COUPLING—MAINTENANCE.

The following points require attention at intervals quoted below.

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

## 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  $3\frac{1}{4}$  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

Acidity (organic) .. .. 0.10 mgms. KOH per  
gm. maximum

Ash .. .. 0.005 per cent. maxi-  
mum

Carbon Residue (Rams-  
bottom) .. .. 0.5 per cent. maxi-  
mum

*Oxidation Characteristics.*—

Viscosity Ratio at 140° F.  
(60° C.) .. .. 1.5 maximum

Increase in Carbon Residue 0.7 per cent. maxi-  
mum

Asphaltenes in Oxidised Oil 0.05 per cent. maxi-  
mum

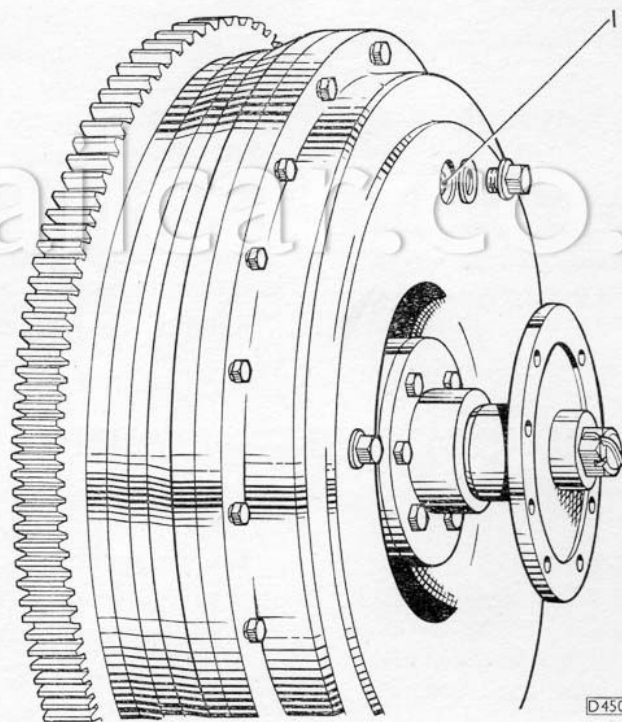


Fig. 2. Position of filler plug hole (1) when filling or topping-up the fluid coupling.



## 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.

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# GEARBOX

## CHAPTER S

### CONTENTS

Gearbox:—	<i>Section</i>	
Data .. .. .	S1	}
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Maintenance  
and Overhaul  
Manuals.

Overhaul  
Manual  
only.



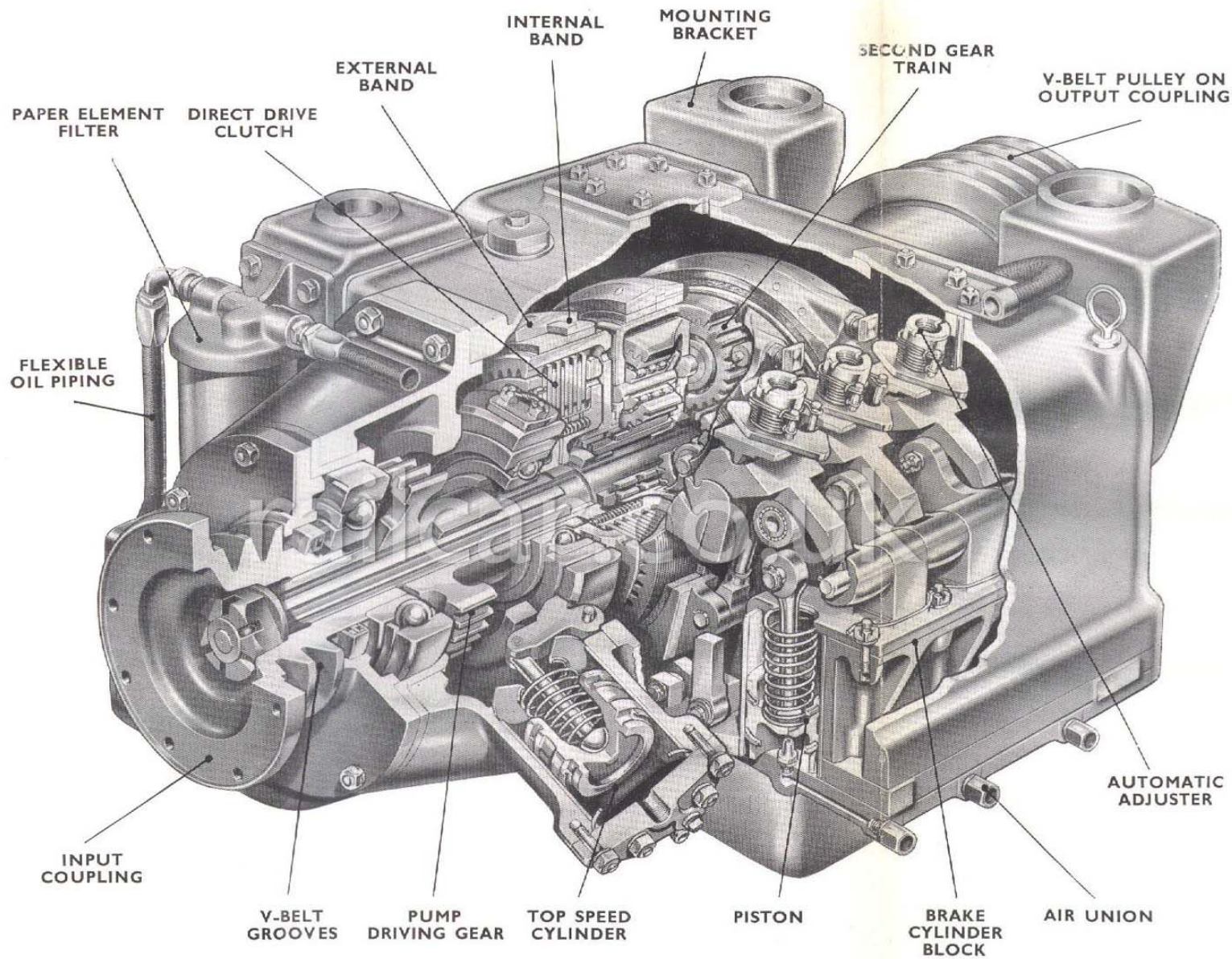


Fig. 1. The Gearbox.

## 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.  $\pm$  2½ 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 &amp; 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 &amp; 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.

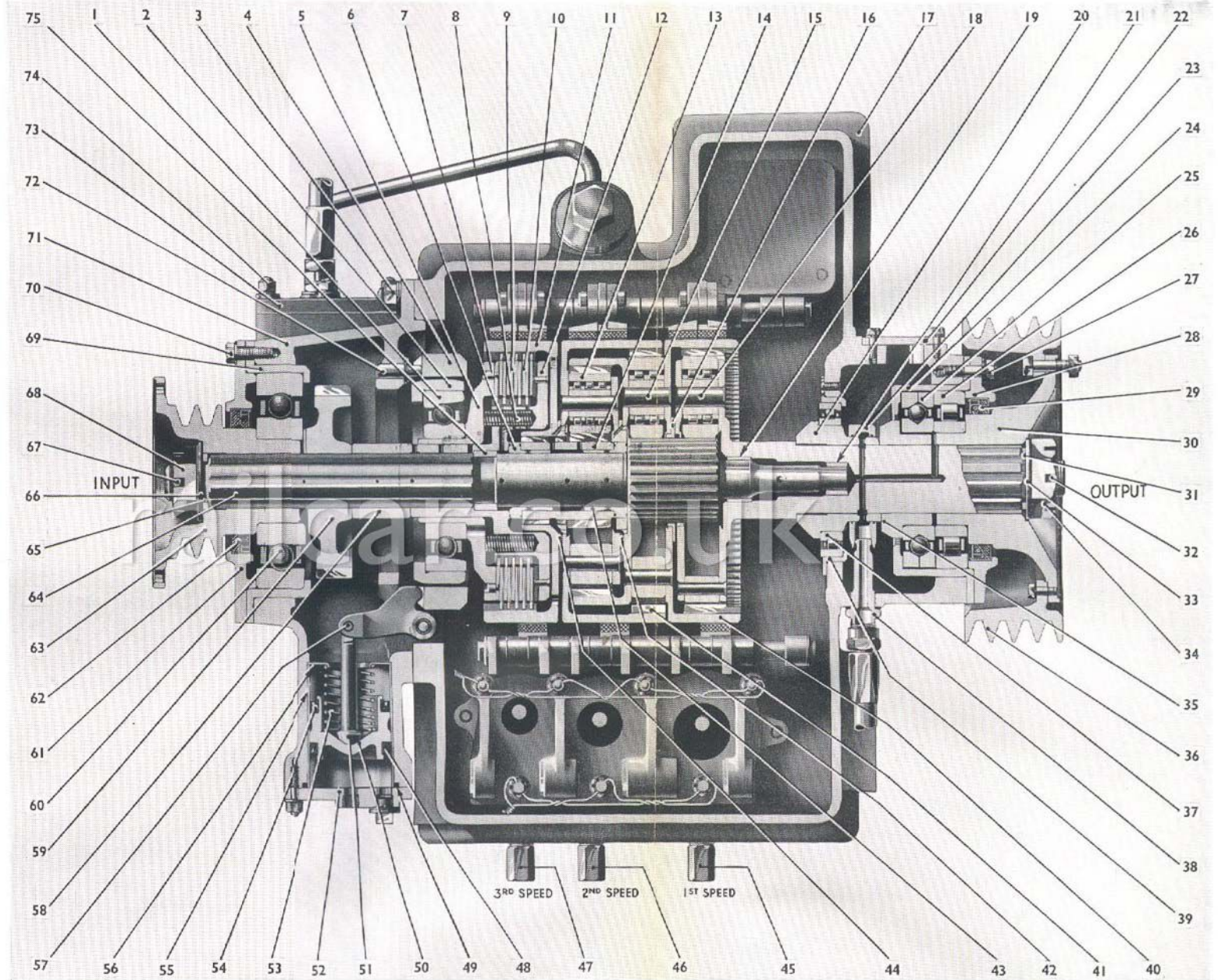


Fig. 2. Section through Gearbox.



### 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.

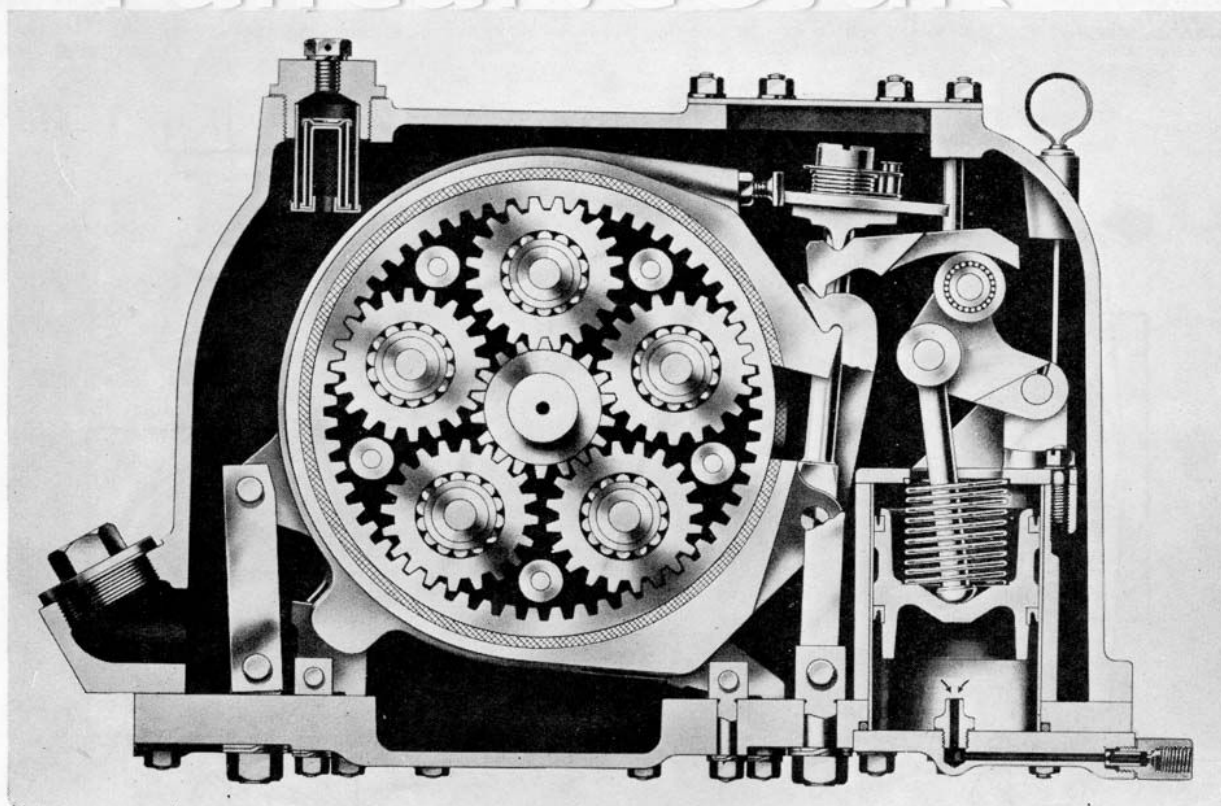


Fig. 3. Section through 1st Speed Band Brake. (Brake On)

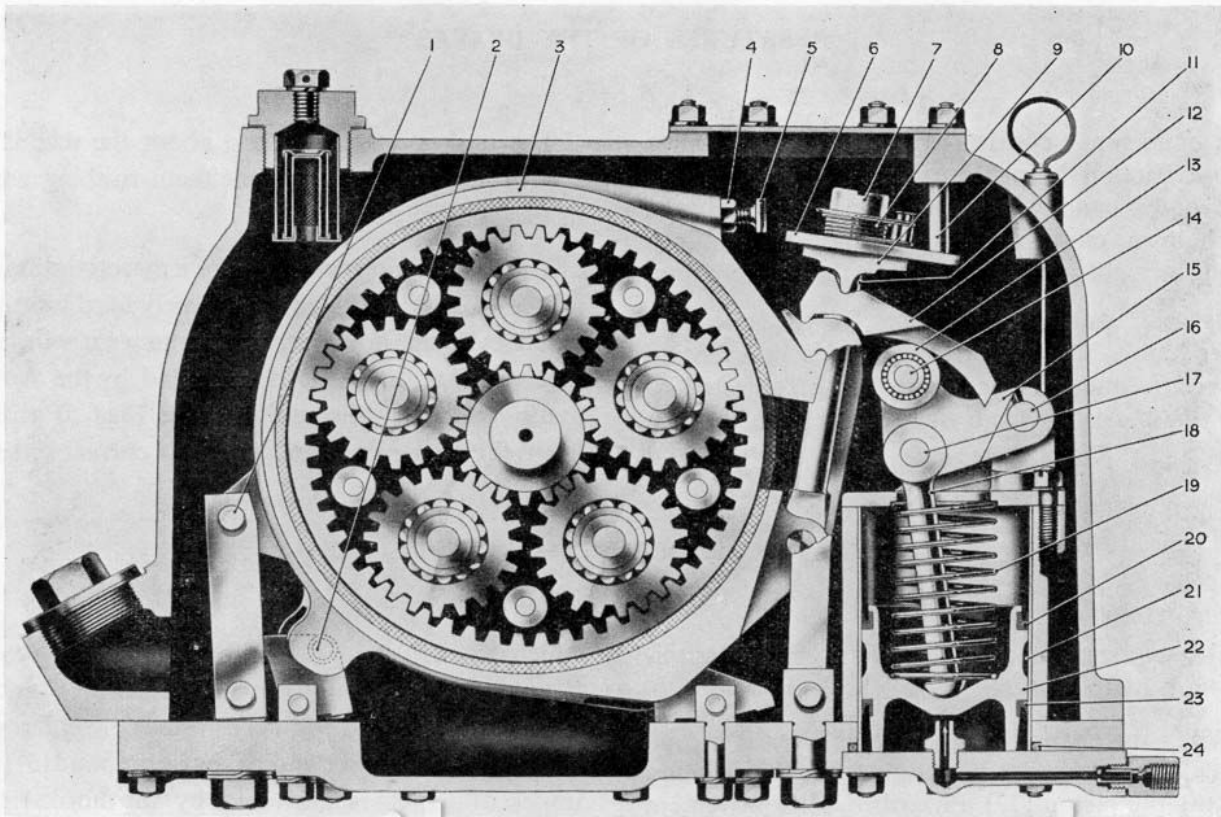


Fig. 4. Section through the 1st Speed Band Brake. (Brake Off)

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

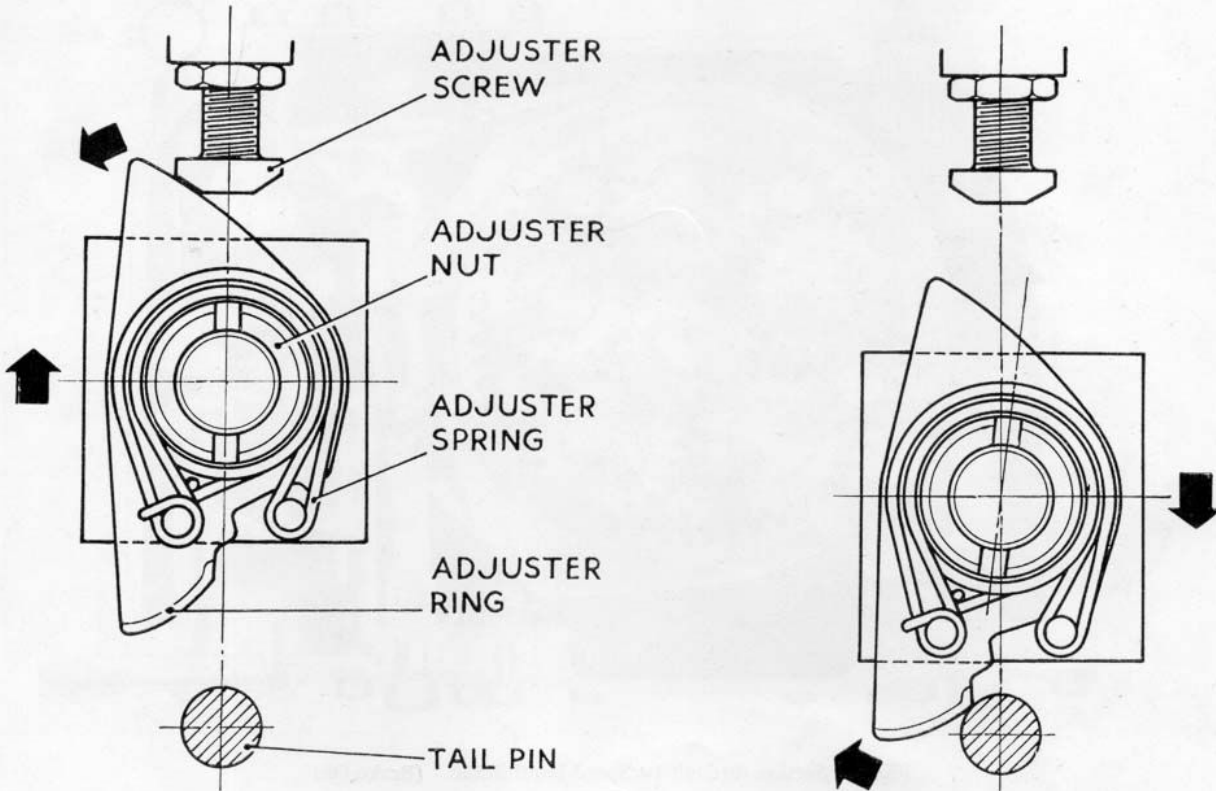


Fig. 5. Operation of the Automatic Adjuster.

## 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)

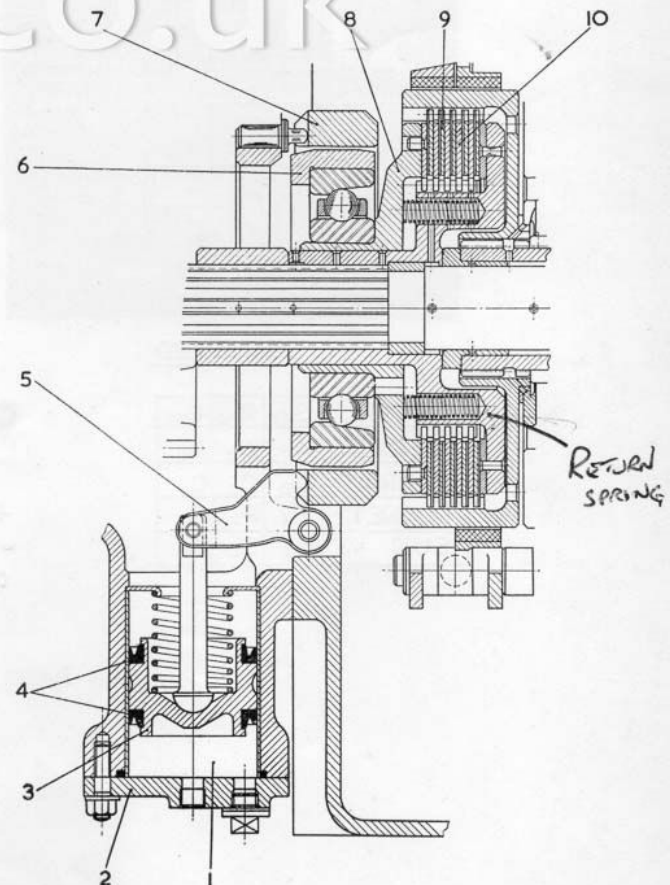
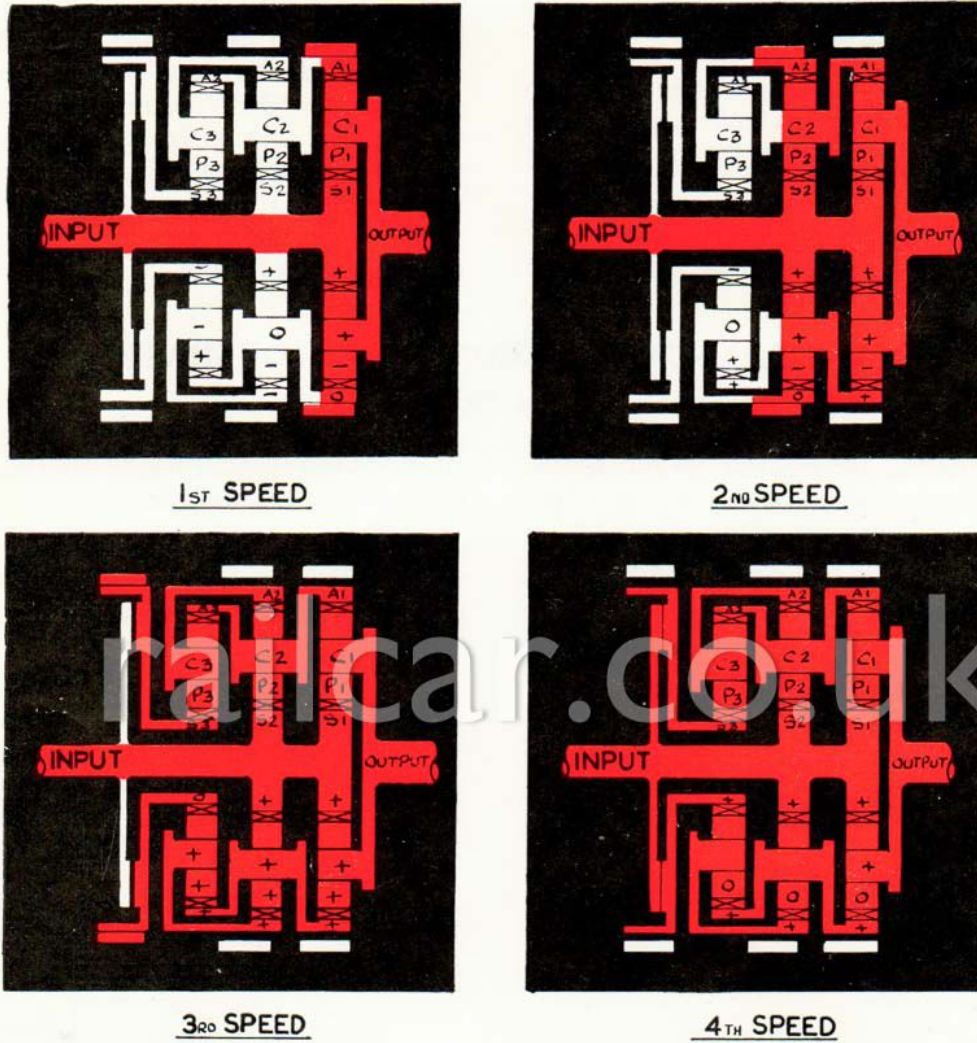


Fig. 6. Top Speed Clutch Actuation.





GEAR	3 <sup>RD</sup>	2 <sup>ND</sup>	1 <sup>ST</sup>
ANNULUS	A <sub>3</sub>	A <sub>2</sub>	A <sub>1</sub>
CARRIER	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>
PLANET	P <sub>3</sub>	P <sub>2</sub>	P <sub>1</sub>
SUN	S <sub>3</sub>	S <sub>2</sub>	S <sub>1</sub>

- = 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.  $\pm$  2½ 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)

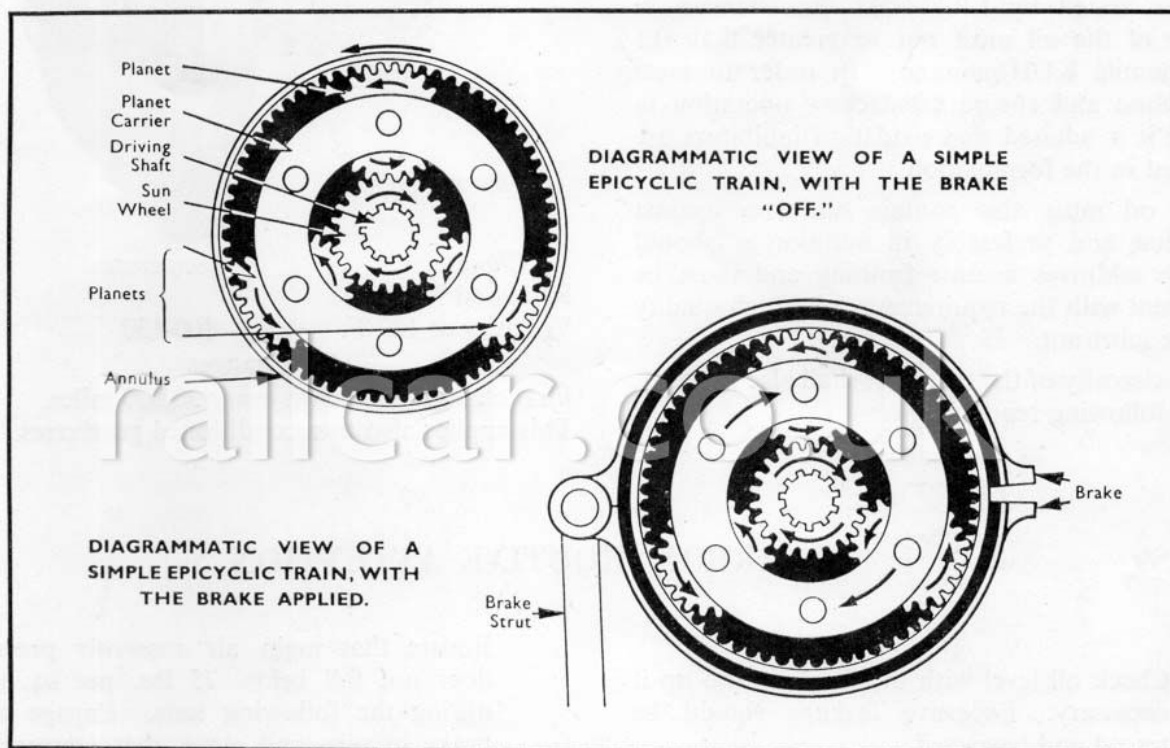


Fig. 8. Diagrammatic View of Epicyclic Gear Train.

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 speed-

ing 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:—

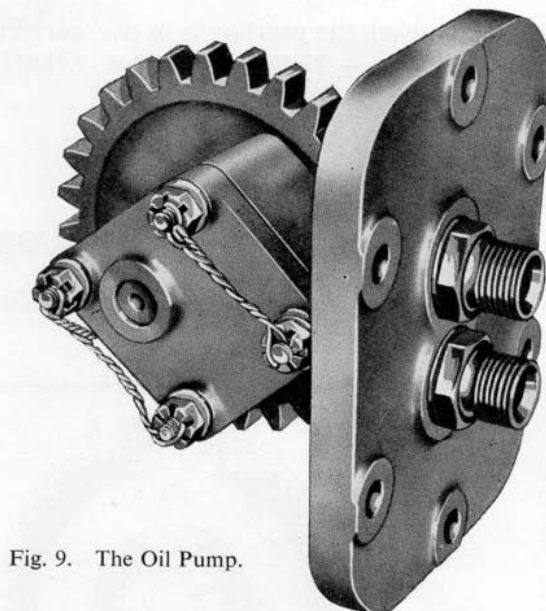


Fig. 9. The Oil Pump.

<i>Climate</i>	<i>Temperate</i>
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 &amp; 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.

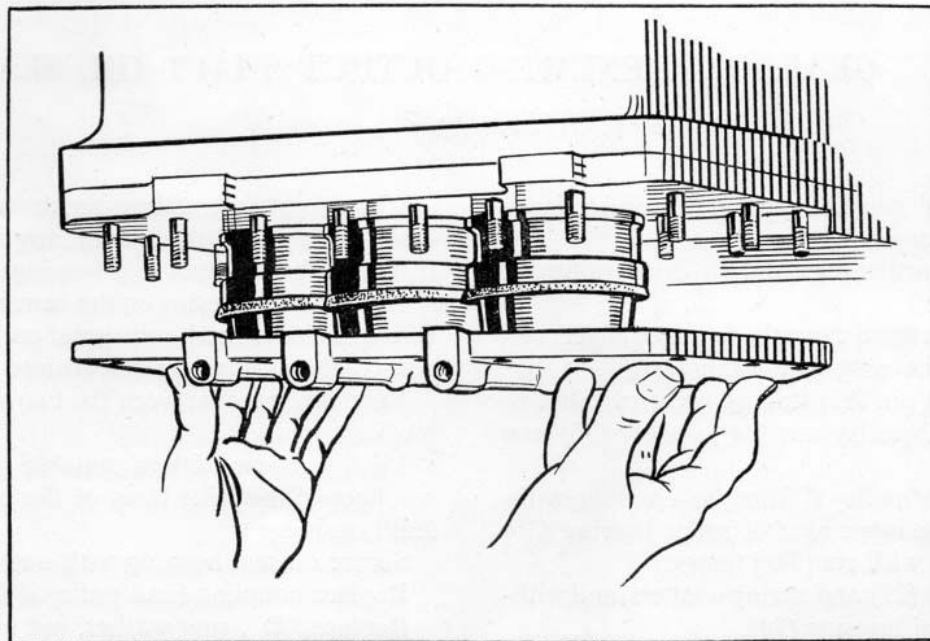


Fig. 10. Removing the Cover Plate (1st, 2nd &amp; 3rd Speeds).

**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.

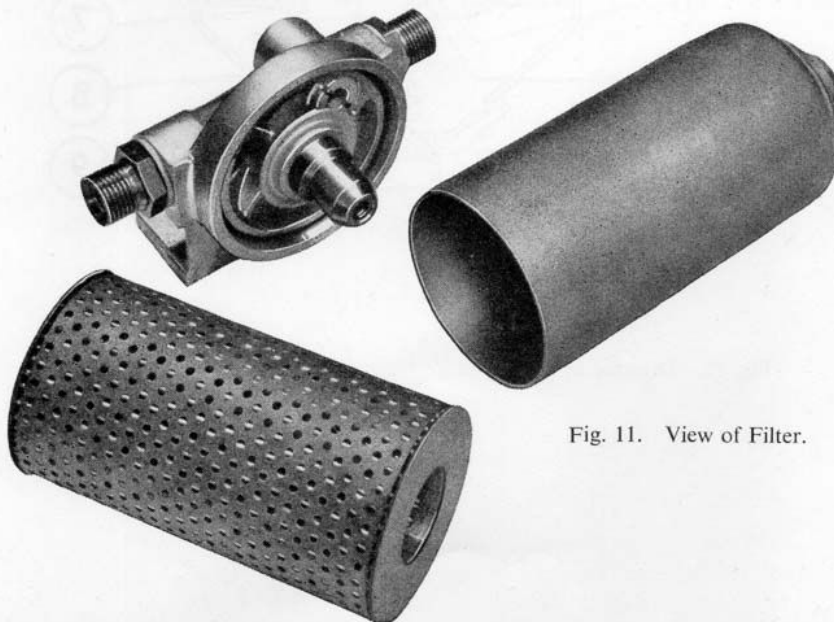


Fig. 11. View of Filter.

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).



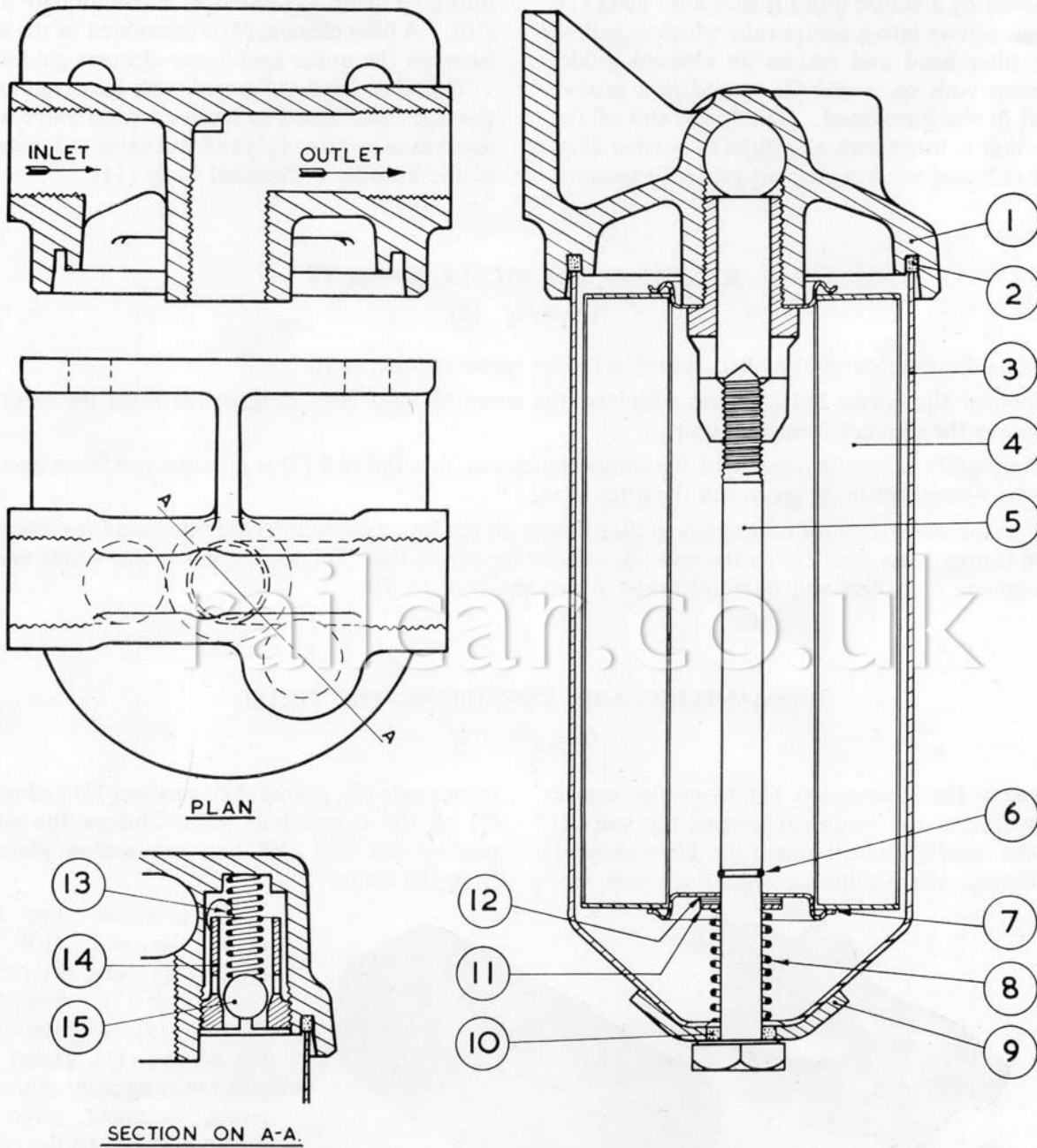


Fig. 12. Drawing of Filter.

## Sec. S14

## GEARBOX—SERVICING THE BRAKES

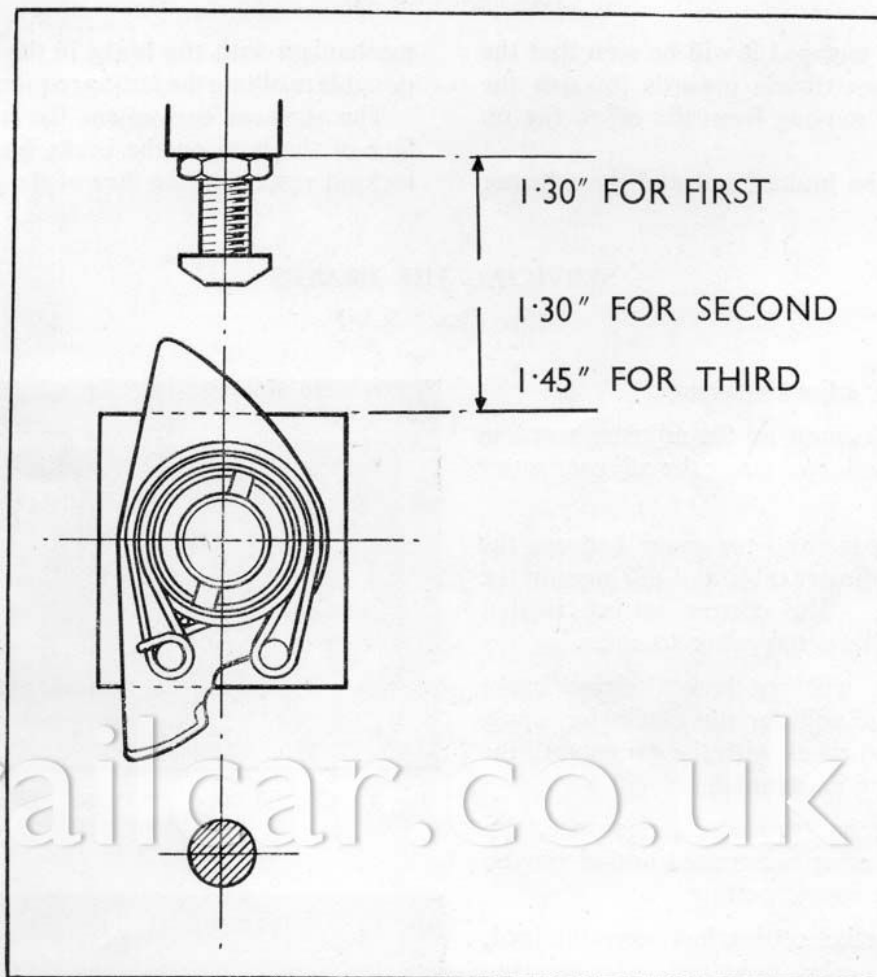


Fig. 13. Brake setting Dimensions

## 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 applica-

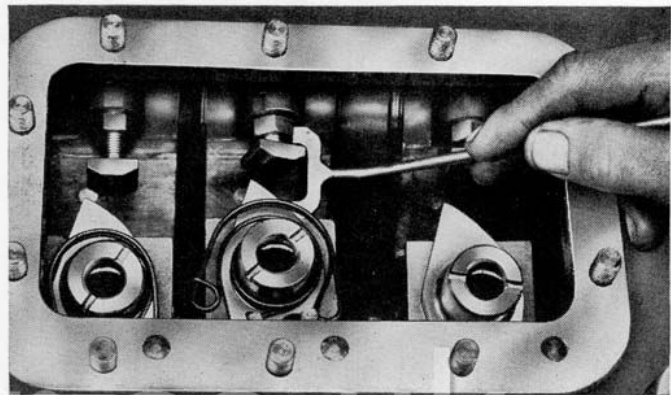


Fig. 14 GAUGE APPLICATION. This shows where the gauge should be applied.

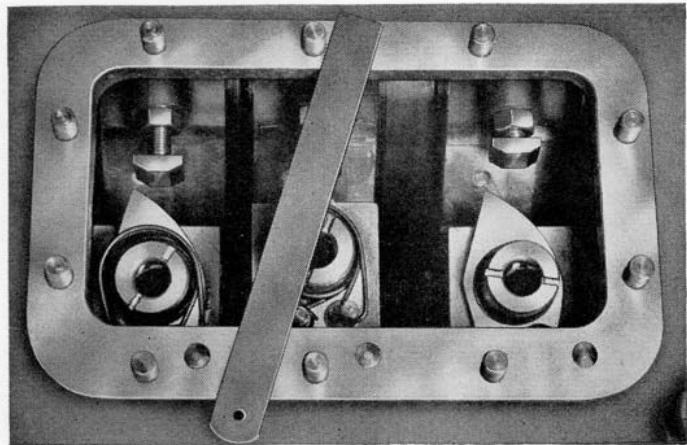


Fig. 15. Checking Movement of Adjuster Nut

tions 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.



## 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.

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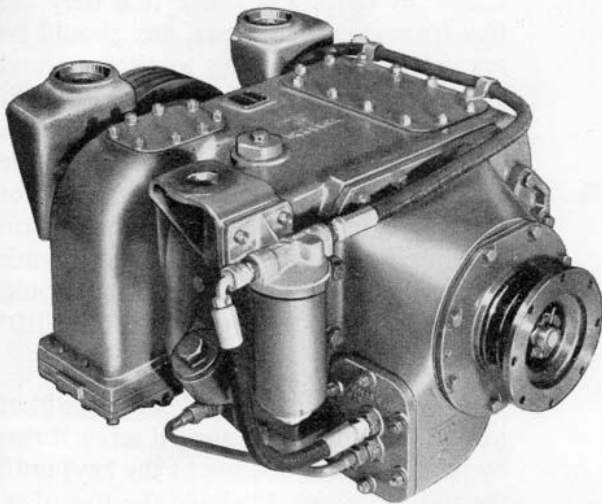


Fig. 16. View of Gearbox (a).

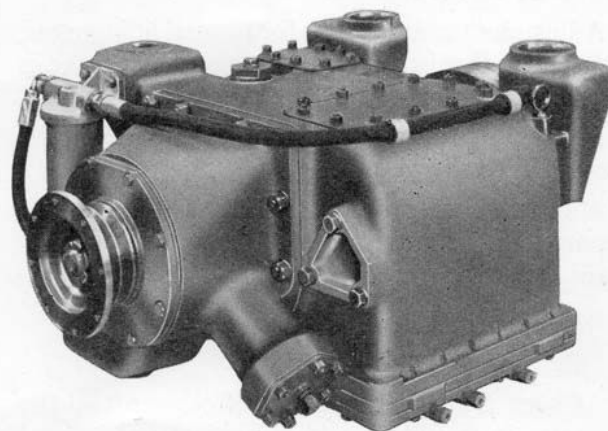


Fig. 17. View of Gearbox (b).

**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).



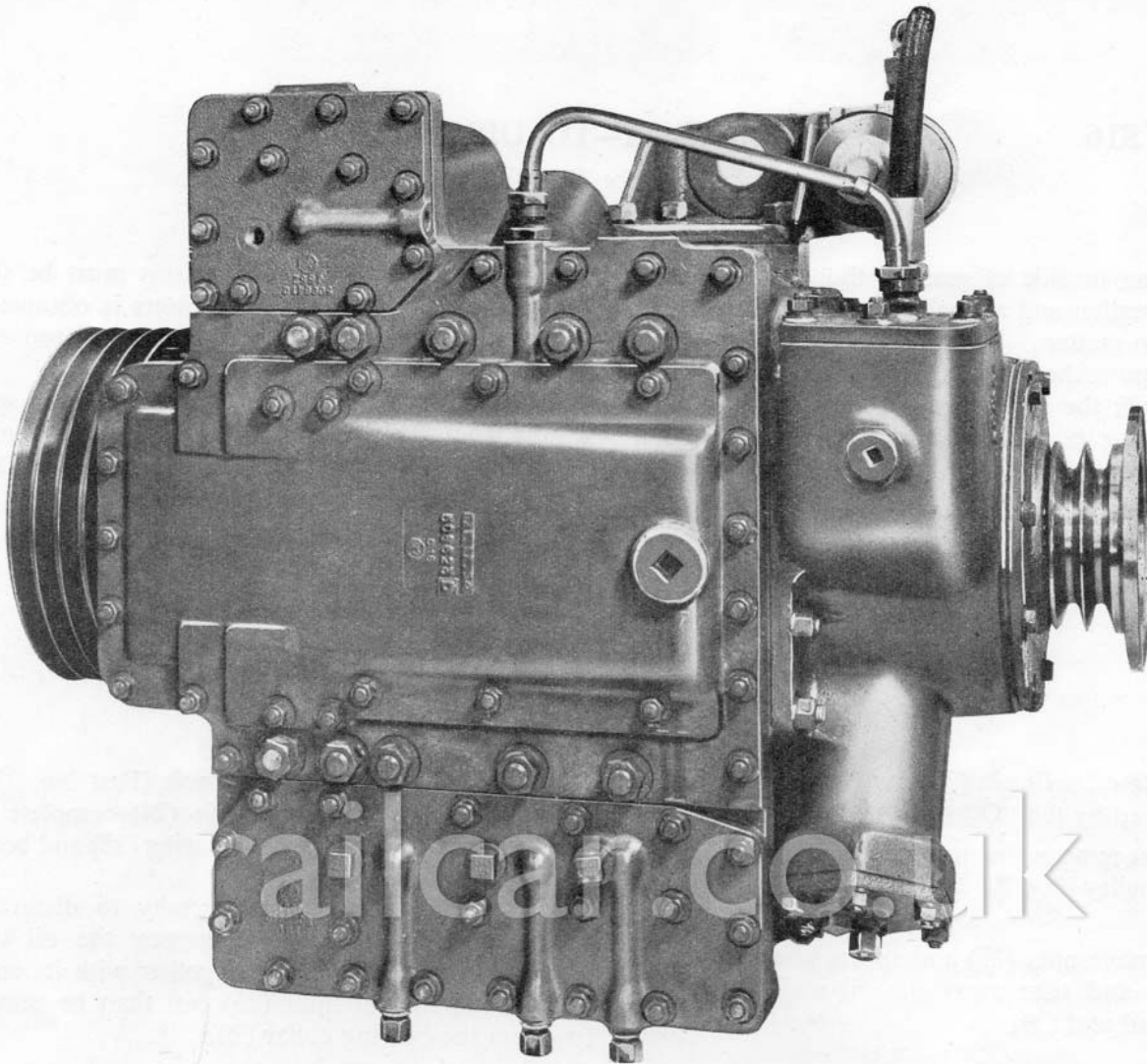


Fig. 18. View of the Bottom Cover, etc.

### 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.

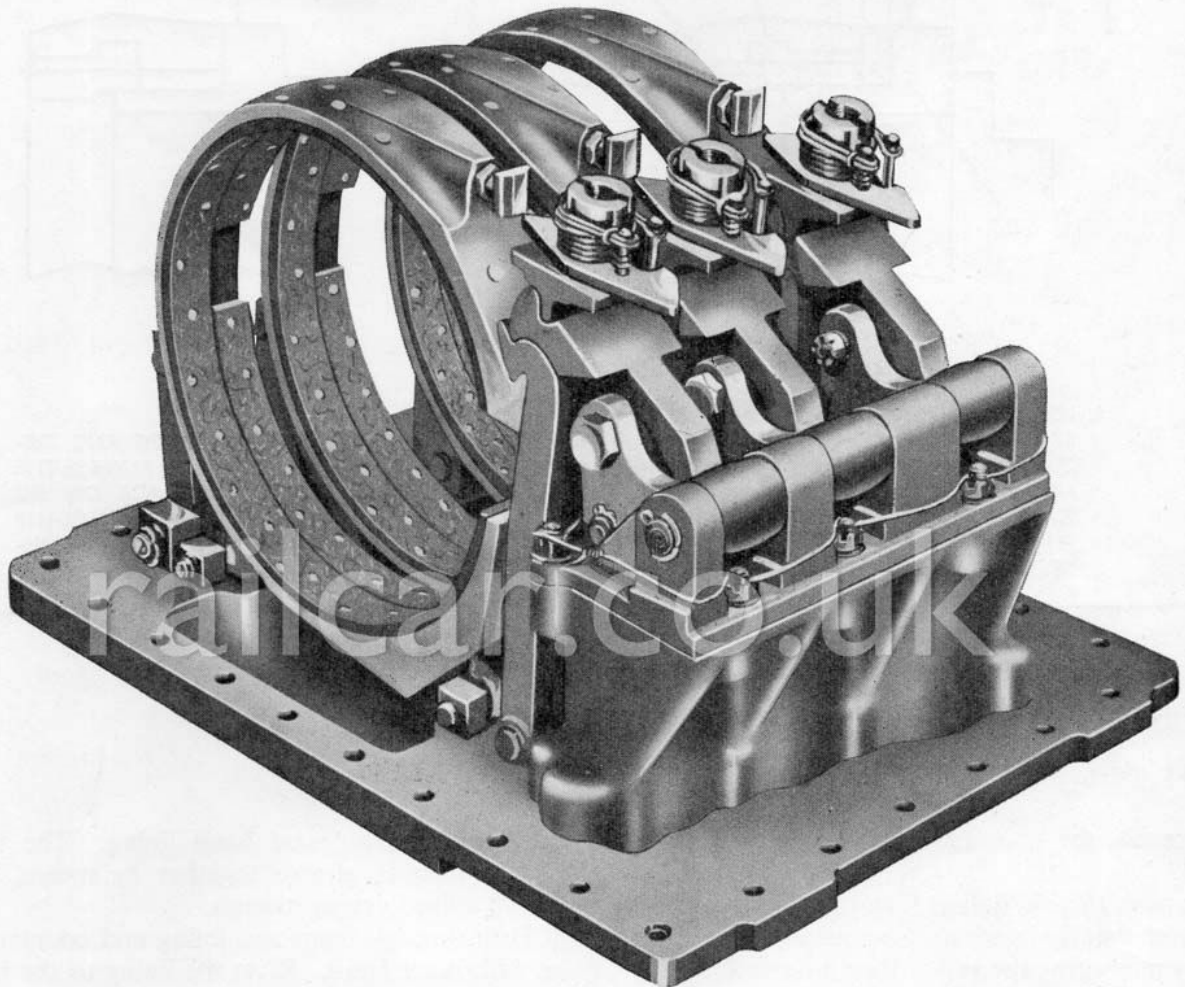


Fig. 19. The Bottom Cover and Brake Band Assembly

## 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.

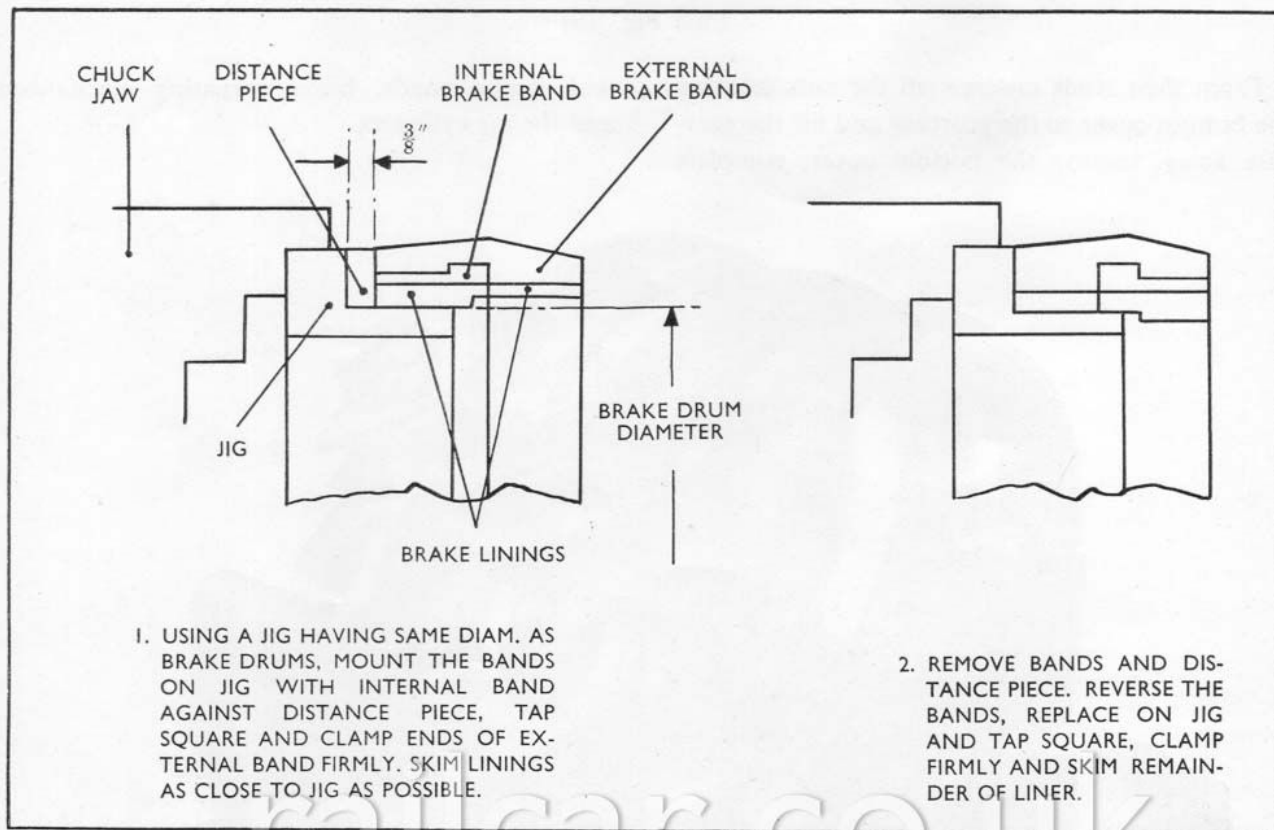


Fig. 20. Relining the Brake Bands.

**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  $\frac{1}{4}$ " drill.

Countersink to  $\frac{5}{32}$ " depth the holes in lining using a  $\frac{1}{32}$ " 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).

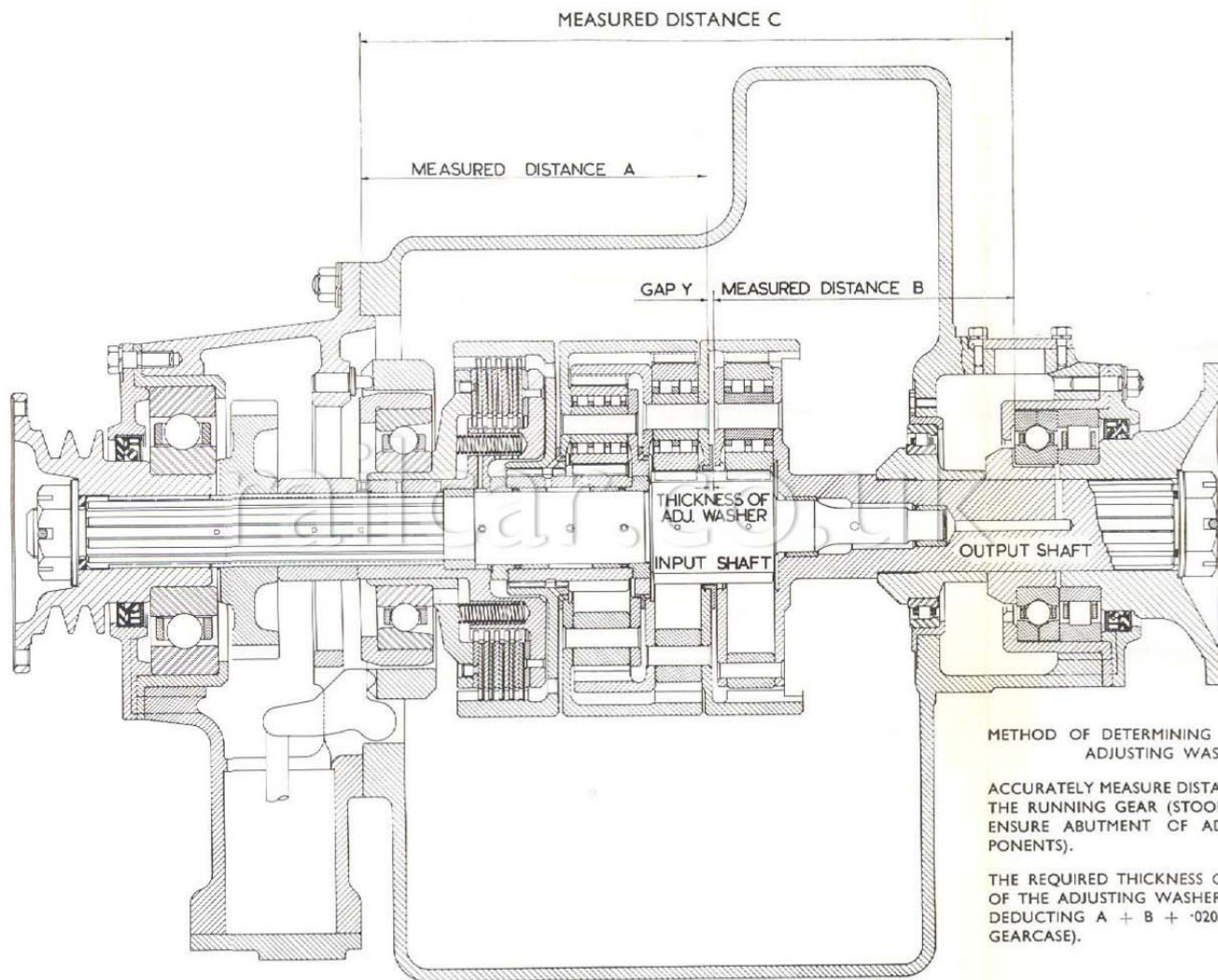


Fig 22. Method of Determining Thickness of Adjusting Washer.

**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.	Min <sup>m</sup> Permissible Diametral Clearance (New)	Max <sup>m</sup> Permissible Diametral Clearance (Worn)	Min <sup>m</sup> 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"

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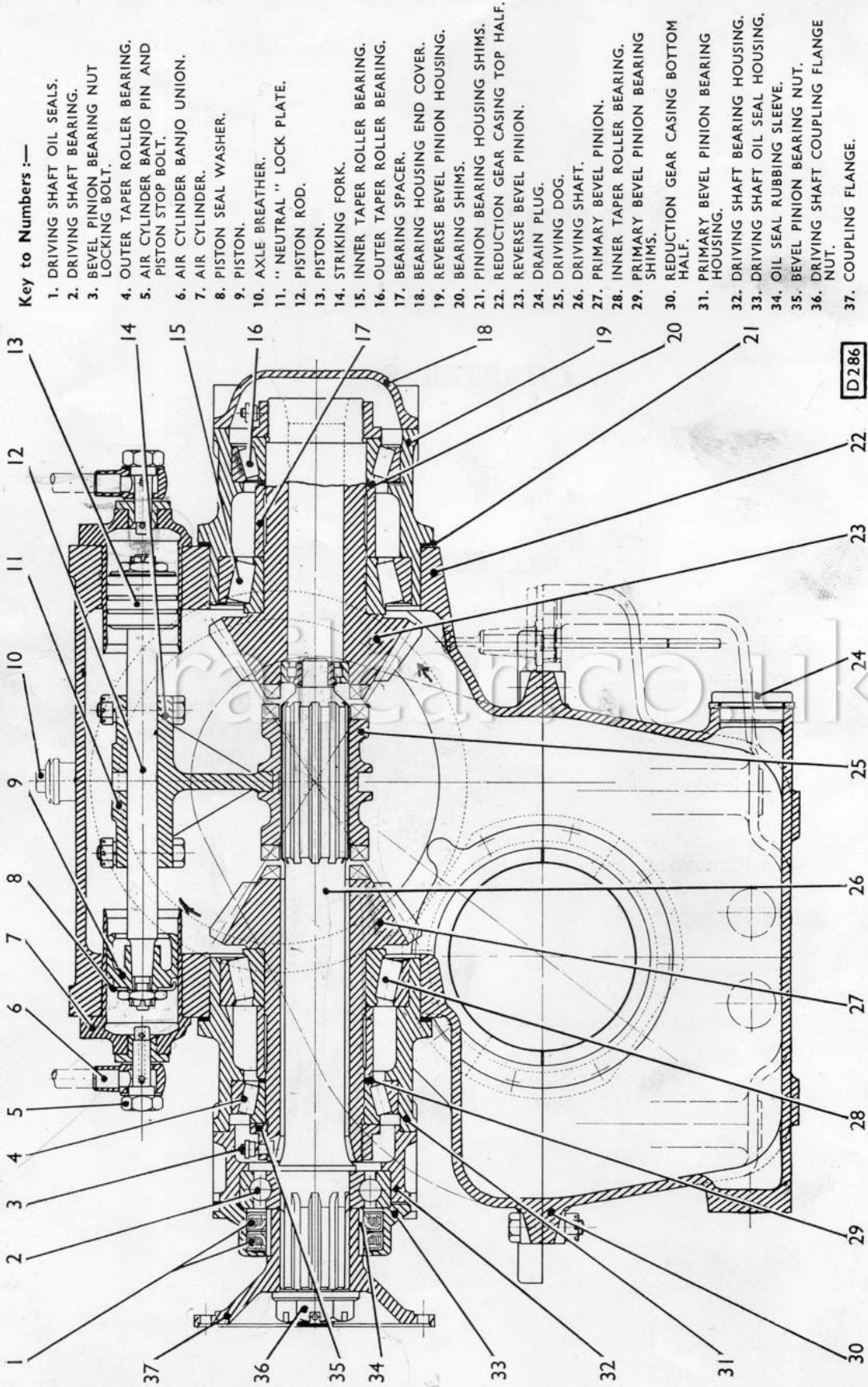
# DRIVING AXLE.

## CHAPTER E.

### CONTENTS.

	<i>Section.</i>	
Driving Axle:—		
Description .. .. .	E1	} Maintenance and Overhaul Manuals.
Maintenance .. .. .	E2	
Lubrication .. .. .	E3	
To Remove and Fit .. .. .	E4	} Overhaul Manual only.
To Dismantle .. .. .	E5	
To Assemble .. .. .	E6	
Dimensions of Shims Available .. .. .	E7	





Key to Numbers :—

1. DRIVING SHAFT OIL SEALS.
2. DRIVING SHAFT BEARING.
3. BEVEL PINION BEARING NUT LOCKING BOLT.
4. OUTER TAPER ROLLER BEARING.
5. AIR CYLINDER BANJO PIN AND PISTON STOP BOLT.
6. AIR CYLINDER BANJO UNION.
7. AIR CYLINDER.
8. PISTON SEAL WASHER.
9. PISTON.
10. AXLE BREATHER.
11. "NEUTRAL" LOCK PLATE.
12. PISTON ROD.
13. PISTON.
14. STRIKING FORK.
15. INNER TAPER ROLLER BEARING.
16. OUTER TAPER ROLLER BEARING.
17. BEARING SPACER.
18. BEARING HOUSING END COVER.
19. REVERSE BEVEL PINION HOUSING.
20. BEARING SHIMS.
21. PINION BEARING HOUSING SHIMS.
22. REDUCTION GEAR CASING TOP HALF.
23. REVERSE BEVEL PINION.
24. DRAIN PLUG.
25. DRIVING DOG.
26. DRIVING SHAFT.
27. PRIMARY BEVEL PINION.
28. INNER TAPER ROLLER BEARING.
29. PRIMARY BEVEL PINION BEARING SHIMS.
30. REDUCTION GEAR CASING BOTTOM HALF.
31. PRIMARY BEVEL PINION BEARING HOUSING.
32. DRIVING SHAFT BEARING HOUSING.
33. DRIVING SHAFT OIL SEAL HOUSING.
34. OIL SEAL RUBBING SLEEVE.
35. BEVEL PINION BEARING NUT.
36. DRIVING SHAFT COUPLING FLANGE NUT.
37. COUPLING FLANGE.

Fig. 1. Longitudinal section through bevel pinions.

PRIM. BEV. ENGL. ←  
 DIR. OF T. →  
 KEY, BEV. ENGL.

DIR. OF ROTATION Looking AT THIS END CLOCKWISE

## 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.

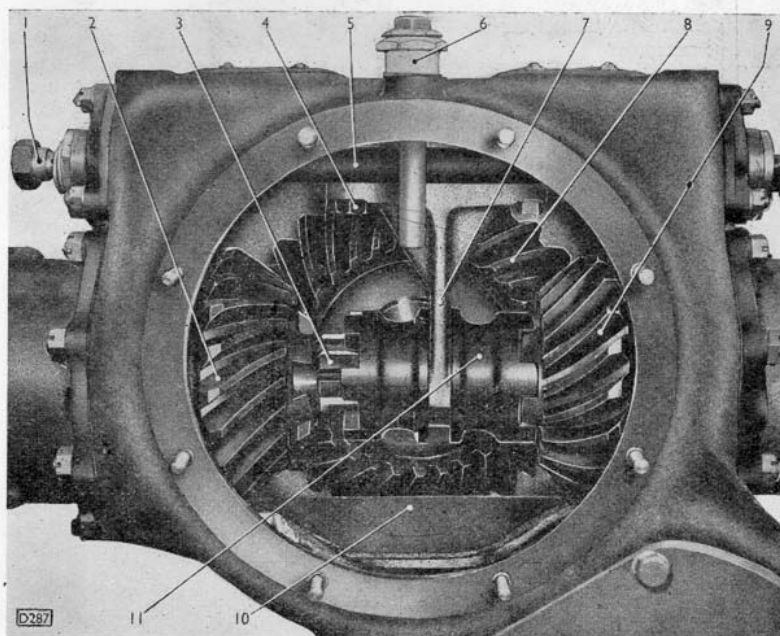
It is possible to isolate the axle drive by locking the striking fork in the "neutral" position with the hand operated plunger mounted on the axle casing.

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 dipstick, 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.

- Key to Numbers :-**
1. BEVEL WHEEL SHAFT BEARING RETAINING NUT.
  2. DUAL PURPOSE BALL BEARING.
  3. BEARING HOUSING SHIMS.
  4. BEARING HOUSING.
  5. ROLLER BEARING.
  6. DISTANCE PIECE.
  7. SPUR GEAR PINION.
  8. BEARING CIRCLIP.
  9. ROLLER BEARING.
  10. "NEUTRAL" LOCKING PLUNGER HOUSING.
  11. "NEUTRAL" LOCKING PLUNGER.
  12. PLUNGER SPRING.
  13. INSPECTION COVER.
  14. "NEUTRAL" PLATE.
  15. AXLE BREATHER.
  16. PISTON ROD.
  17. STRIKING FORK AND "NEUTRAL" PLATE RETAINING BOLT.
  18. SIDE COVER.
  19. BEVEL WHEEL.
  20. STRIKING FORK.
  21. DRIVING SHAFT.
  22. DRIVING DOG.
  23. BEVEL WHEEL SHAFT KEY.
  24. OIL SEAL GLAND PACKING.
  25. DOWEL.
  26. GLAND RING.
  27. RETAINING RING.
  28. SUPPORT BEARING.
  29. DRIVEN SPUR GEAR.
  30. SUPPORT BEARING.
  31. BEARING HOUSING.
  32. BALL BEARING.
  33. BEARING COVER AND OIL SEAL GLAND HOUSING.
  34. GLAND RING.
  35. DOWEL.
  36. GLAND FACING.
  37. GLAND ADJUSTING NUTS.
  38. OIL SEAL GLAND PACKING.
  39. BEVEL WHEEL SHAFT.
  40. COVER.

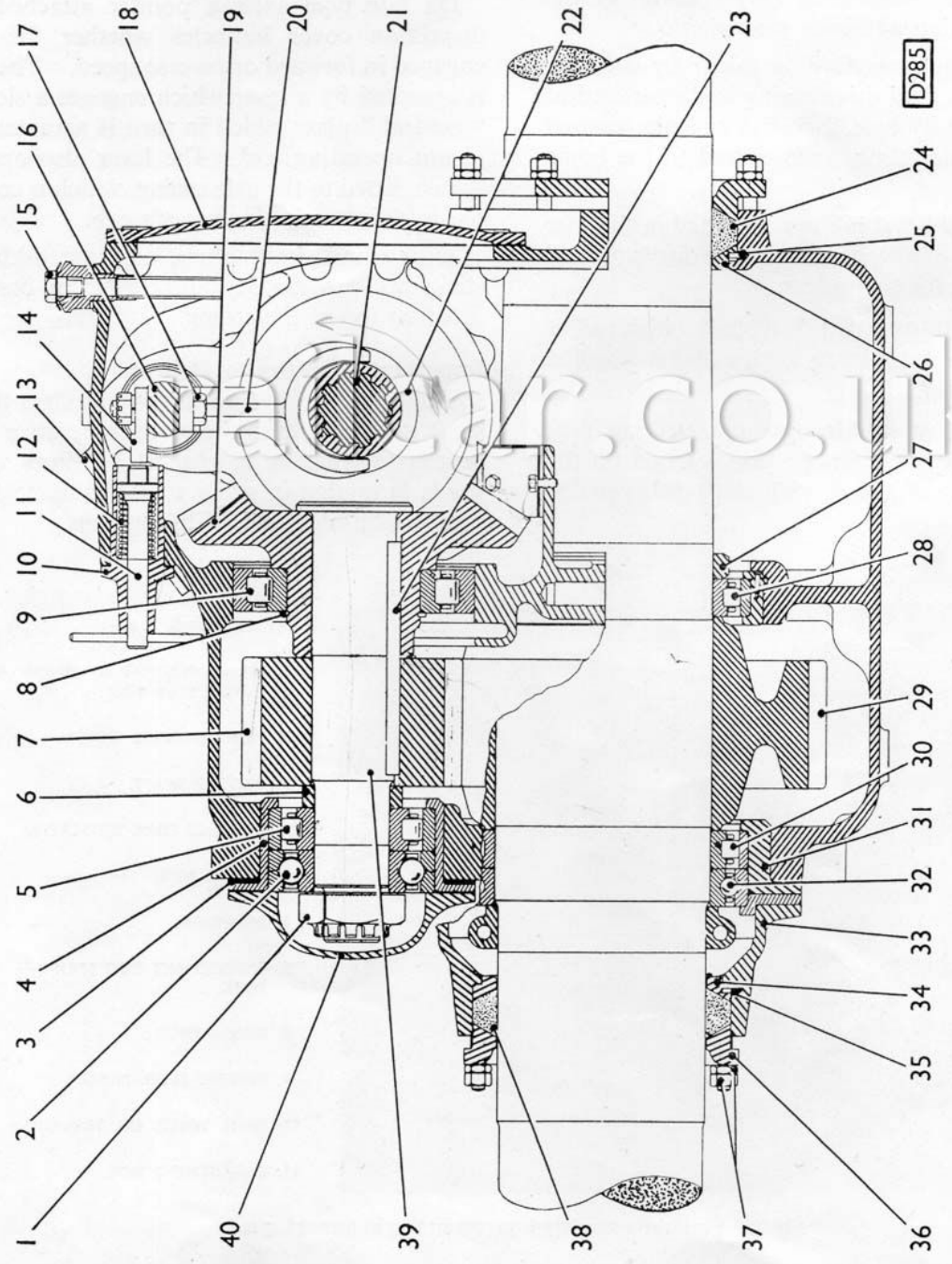


Fig. 3. Longitudinal section through bevel wheel and shaft.



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.

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## Sect. E2. DRIVING AXLE—MAINTENANCE.

The following points require attention at the intervals quoted below.

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

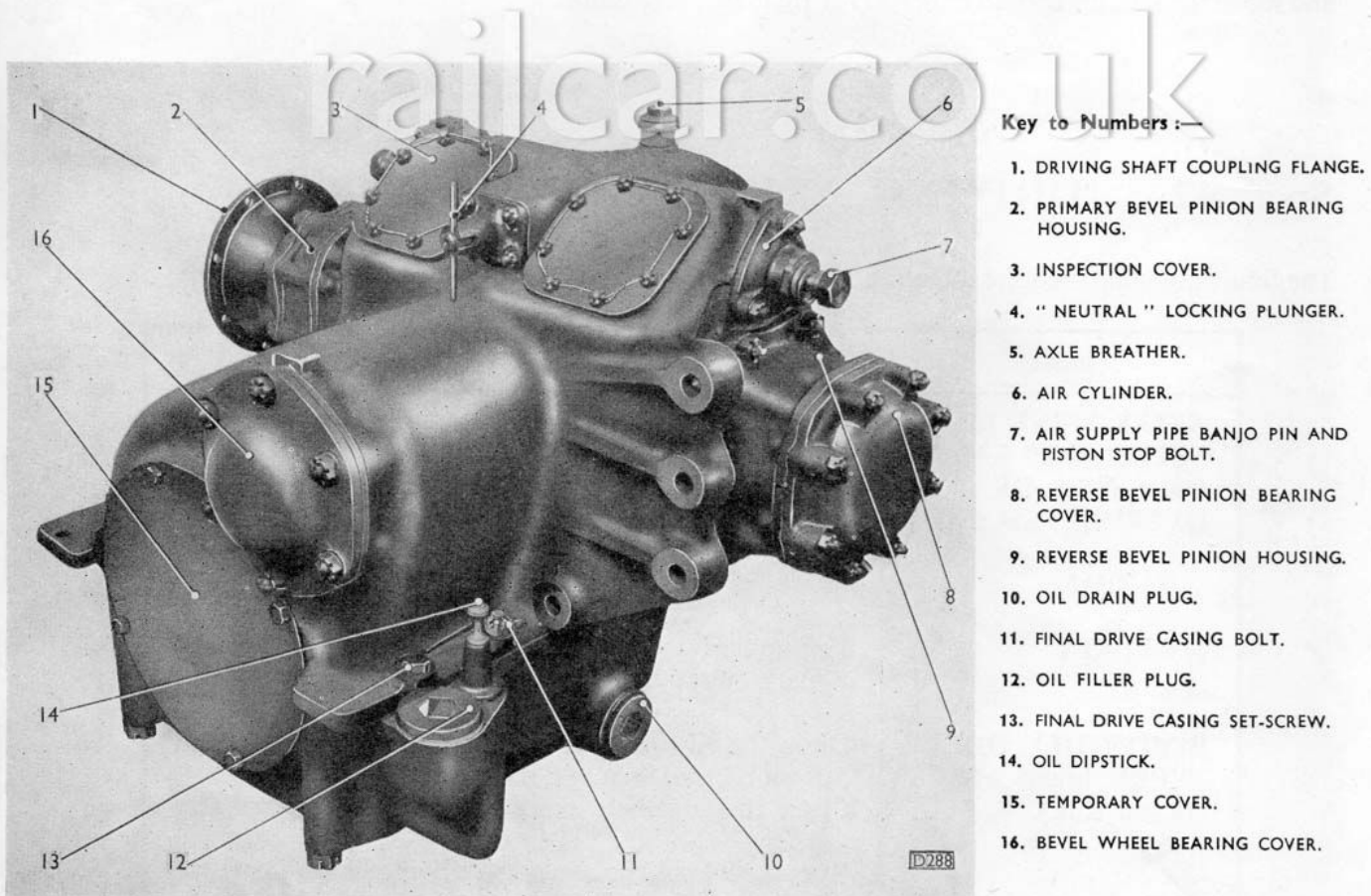
Unscrew the nuts securing one of the air cylinders and drive out the cylinder using a hammer and brass drift from inside the final drive casing.

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. maxi-  
 mum  
 Asphaltenes .. .. 0.10 per cent. maxi-  
 mum



NOTES.

Remove the oil cylinder caps with a screwdriver and remove the oil. Drain the oil into a clean container. Wash the parts in clean petrol and if soiled with a suitable soap, wash in the bath. Rinse the parts in clean petrol. Reassemble the parts retaining the procedure for adjustment, ensure that the leather washer is in good condition, and note the location of the adjustment pins.

Repeat the procedure for the other piston. Repeat the procedure for the other piston. Clean the bushings on the ball drive shafts. Lubricate the bushings with a thin B.S.F. grease and remove the assembly.

Sec. E3. DRIVING AXLE-LUBRICATION.

To drain the oil from the axle, place a suitable container in position and remove the drain plug from the axle housing. Turn the axle to the full "down" position. The capacity of the axle is 31 imp. gallons.

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Oil Grade	Capacity (Imp. Gallons)	Notes
SAE 100 (L.T.C.)	31.0	Minimum
SAE 150 (L.T.C.)	31.0	Maximum
SAE 200 (L.T.C.)	31.0	Maximum
SAE 300 (L.T.C.)	31.0	Maximum
SAE 400 (L.T.C.)	31.0	Maximum

## 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.

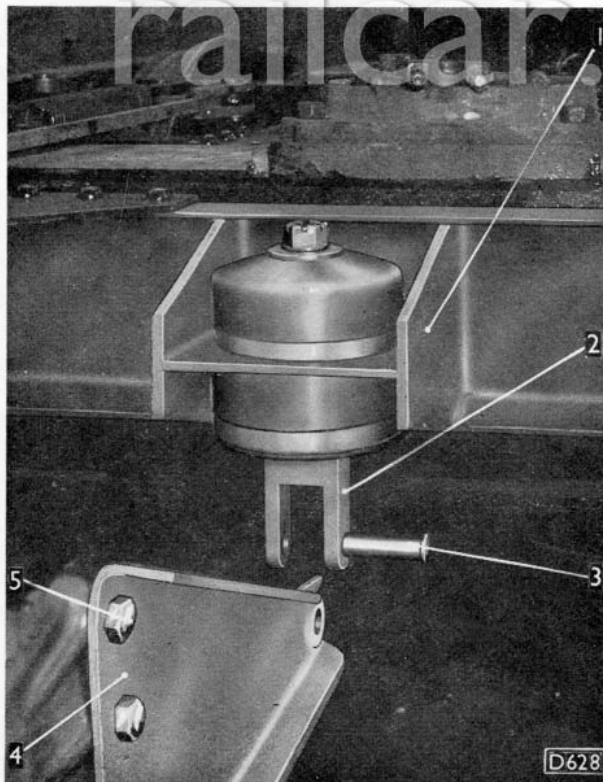
Disconnect the universal joint coupling flange from the driving shaft coupling flange.

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. | 3. PIVOT PIN.  |
| 2. TORQUE ARM EYE BOLT.     | 4. TORQUE ARM. |
| 5. RETAINING BOLT.          |                |

Fig. 5. Method of detaching torque arm from bogie.

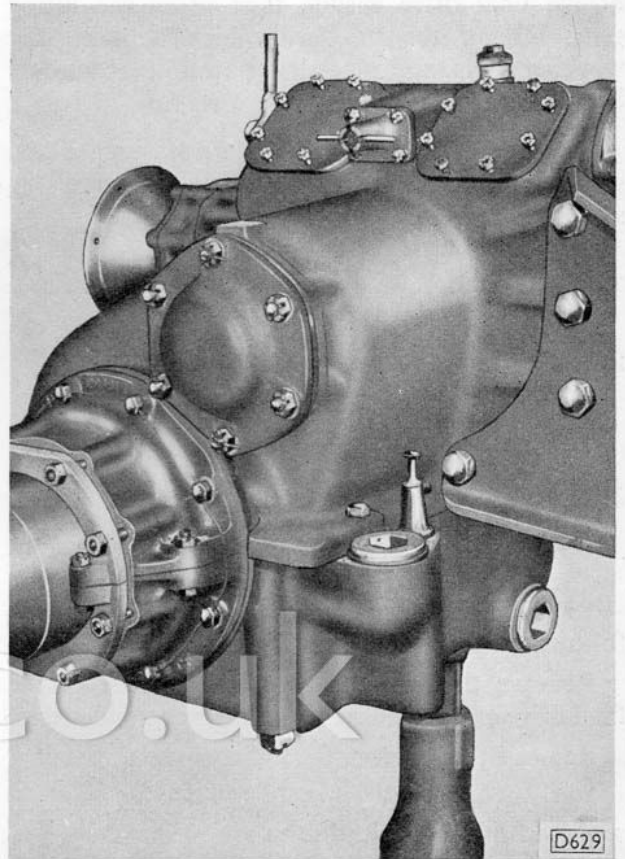


Fig. 6. Method of supporting bottom half of final drive casing whilst removing torque arm.

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.

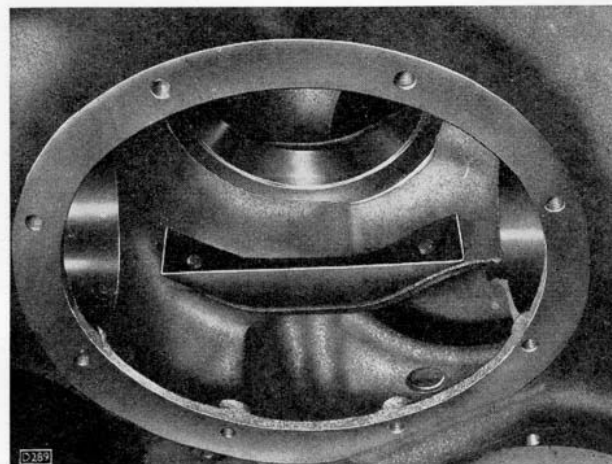


Fig. 7. Final drive casing showing oil trough.



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 0.15 in. (0.30 mm. to 0.38 mm.) (see Fig. 8) with a marking as shown in Figure 10.

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

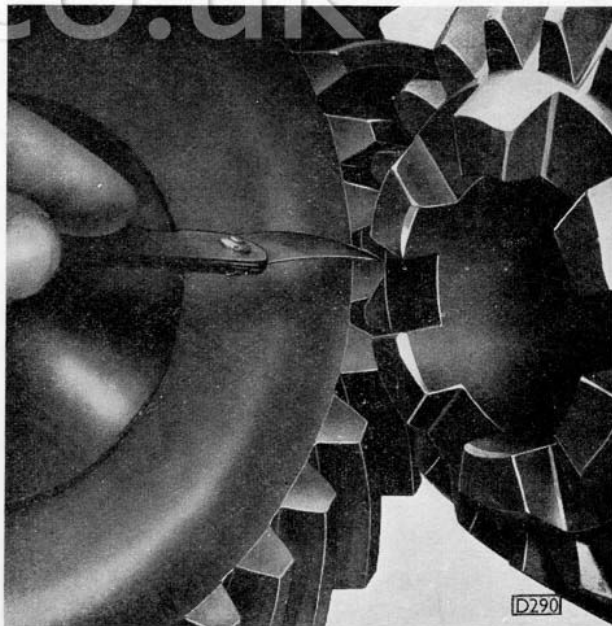


Fig. 8. Method of measuring bevel wheel and pinion backlash.

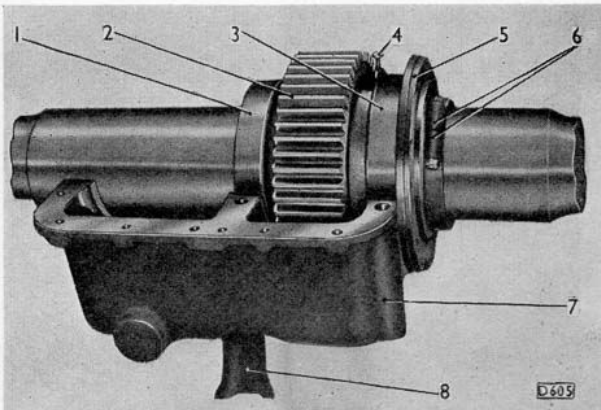
rod, and thus controls the clearance between the striking fork and driving dog groove. Excess material should be filed away to provide a running clearance of 0.015 in. to 0.020 in. (0.38 mm. to 0.50 mm.).

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.

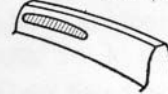
Fig. 9. Method of fitting bottom half of final drive casing to axle shaft.

SPIRAL BEVEL GEARS.

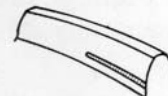
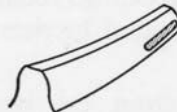
WHEEL CONTACT MARKING.

DRIVING SIDE.

REVERSE SIDE.



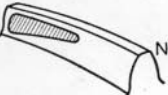
CORRECT MOUNTING



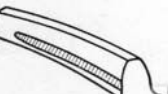
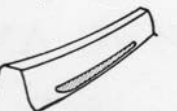
PINION TOO DEEP IN MESH



WHEEL TOO DEEP IN MESH.



NO BACKLASH



EXCESSIVE BACKLASH

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.)



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# PROPELLER SHAFTS.

## CHAPTER D.

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## Sect. D1. PROPELLER SHAFTS—DESCRIPTION.

(See Figs. 1, 2 and 4).

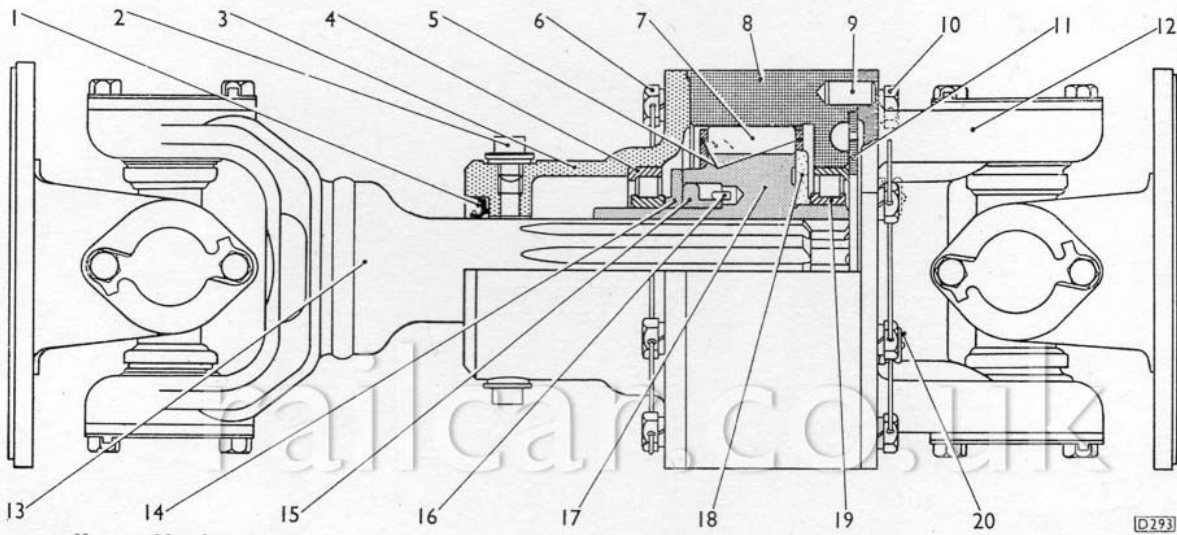
The drive from the engine and fluid coupling to the driving axle is transmitted by means of two propeller shafts as follows:—

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.

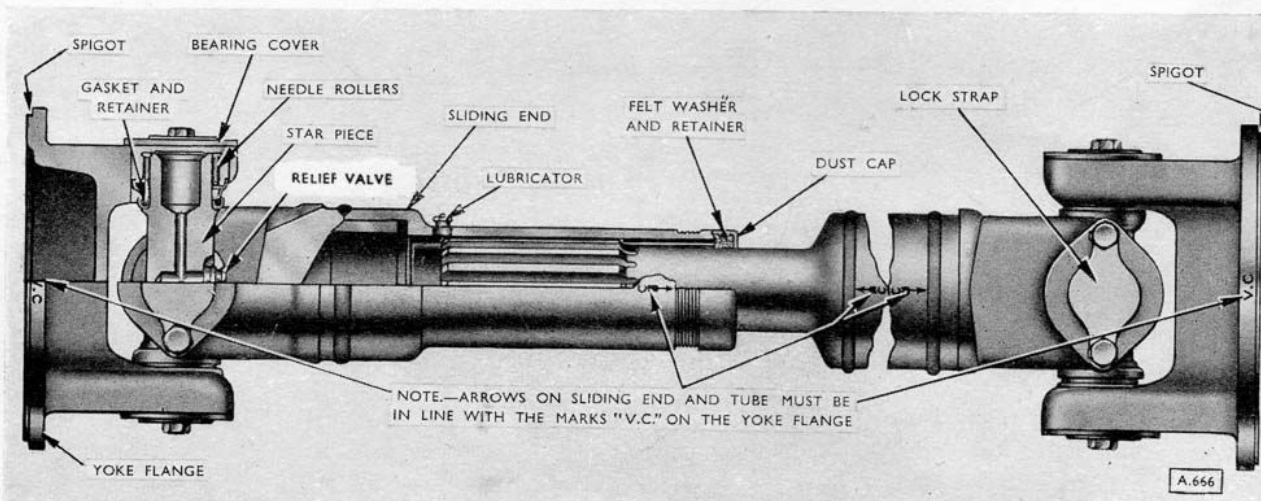
On late cars, both universal joints are of the needle roller type.



Key to Numbers:—

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

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



NOTE.—ARROWS ON SLIDING END AND TUBE MUST BE IN LINE WITH THE MARKS "V.C." ON THE YOKE FLANGE

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.

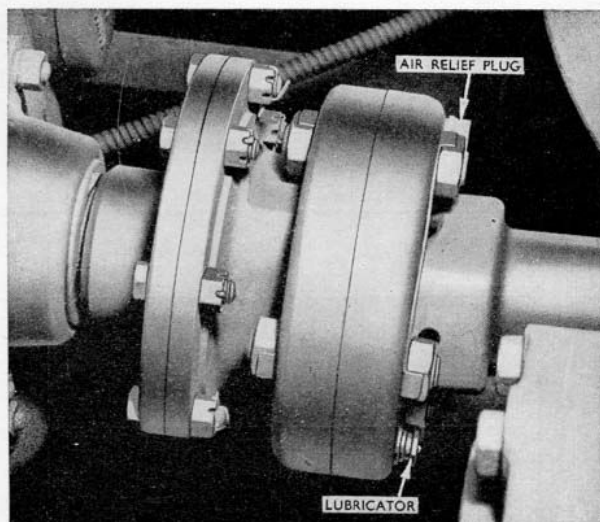


Fig. 3. Plain bearing type universal joint showing lubricating point.

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



## 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.
<b>Needle Roller Type Universal Joints</b>	14 Nipples	Relief Valve	Gear Oil (A.E.C. Specification No. L6)
<b>Plain Bearing Type Universal Joints</b>	2 Nipples	Level Plug (see below)	Grease (A.E.C. Specification No. L11)
<b>Splined Sliding Ends</b>	6 Nipples	—	Grease (A.E.C. Specification No. L11)
<b>Freewheels</b>	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. maxi-  
 mum  
 Asphaltenes .. .. 0.10 per cent. maxi-  
 mum



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

### SPECIFICATION OF GREASE.

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

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

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

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

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

Copper Strip Corrosion (see Appendix B)	.. Negative
Viscosity of Mineral Oil (Redwood No. 1) at 140° F. (60° C.)..	.. 130 seconds minimum (31.5 centistokes)
Colour of Mineral Oil	.. Pale
Ash (As CaO)	.. 2.0 per cent. maximum
Ash (Sulphated)	.. 4.9 per cent. maximum
Water	.. 1.0 per cent. maximum
Free Alkali and/or Acid..	2.0 mgms. KOH per gm. maximum

#### Appendix A.

##### Method of Determining Heat Resistance of Grease.

A portion of grease weighing 10—20 gms., contained in a clock glass of suitable dimensions,

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

#### Appendix B.

##### Corrosion Test for Grease.

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

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## 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

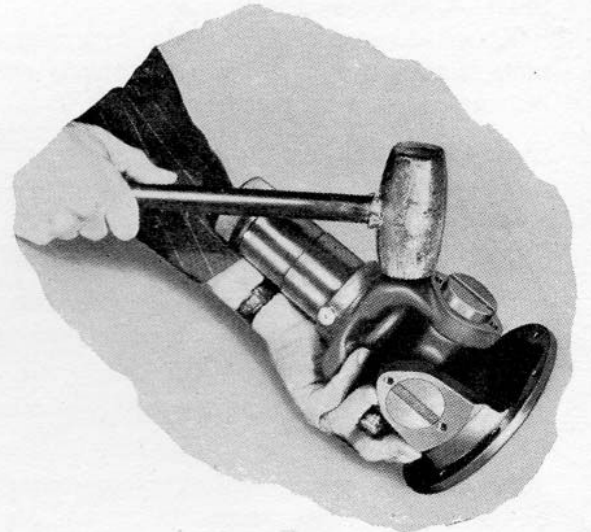


Fig. 5. Method of removing needle roller bearings from Hardy Spicer universal joint.

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.**

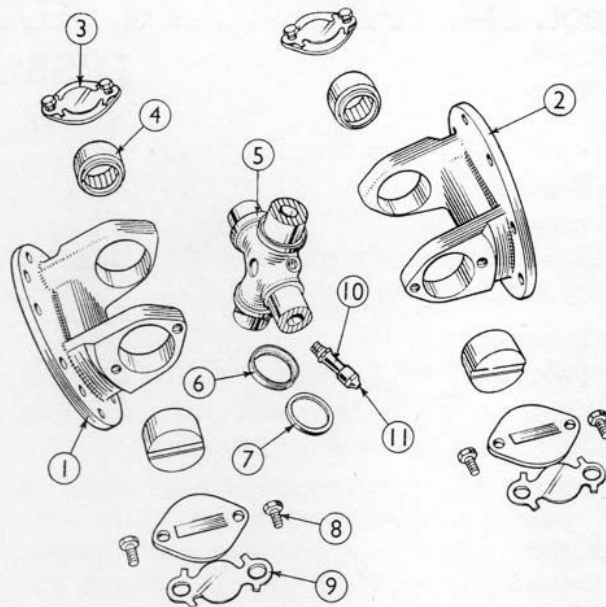
Remove the circlips securing the needle roller bearings in the yoke ears.

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.         | 7. STAR PIECE GASKET.       |
| 2. INPUT FLANGE.          | 8. SCREW FOR BEARING COVER. |
| 3. BEARING COVER.         | 9. LOCK PLATE FOR SCREWS.   |
| 4. NEEDLE ROLLER BEARING. | 10. LUBRICATOR EXTENSION.   |
| 5. STAR PIECE.            | 11. LUBRICATOR.             |
| 6. GASKET RETAINER.       |                             |

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

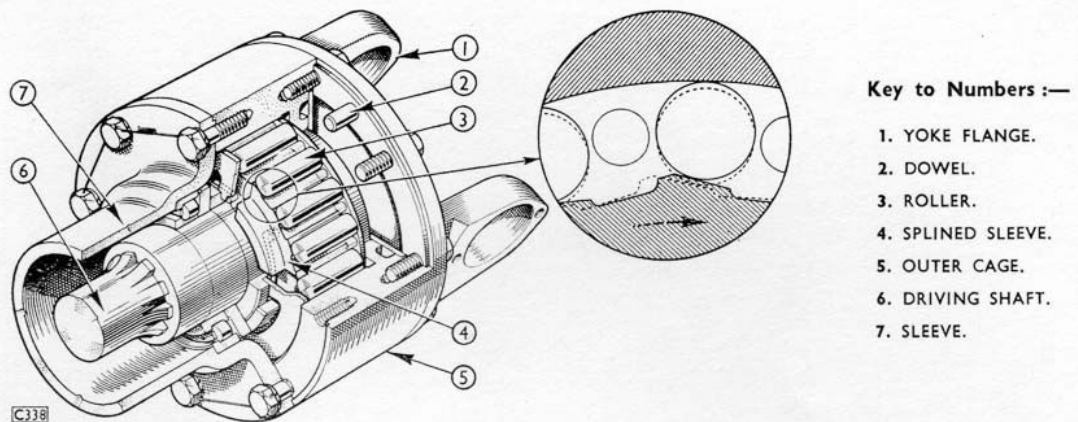


Fig. 7. View of freewheel showing method of operation.

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.



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# RADIATOR AND FAN.

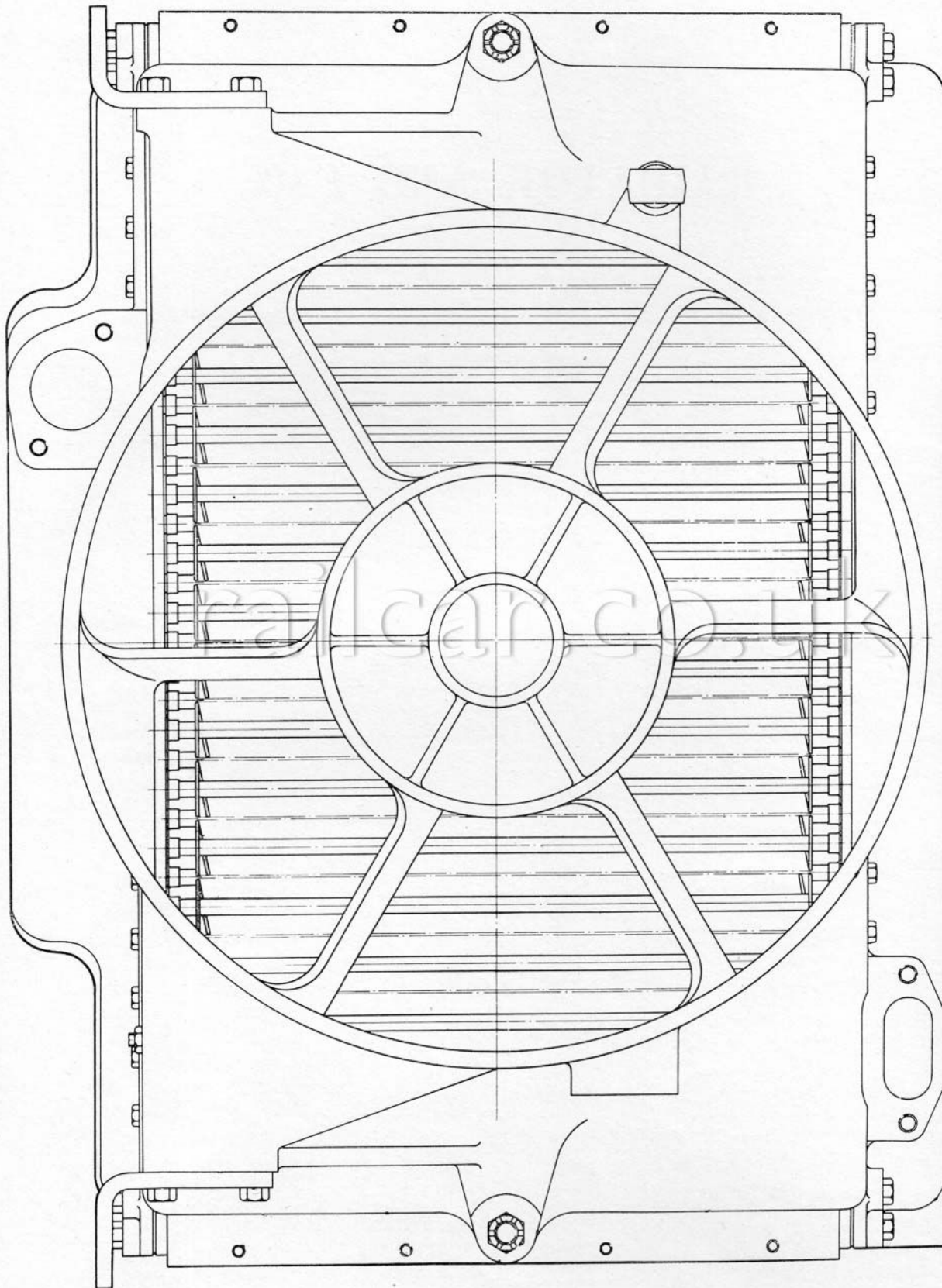
## CHAPTER F.

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Maintenance and Overhaul Manuals. }  
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Fig. 1. Arrangement of radiator and fan cowl.



## Sect. F1. RADIATOR—DESCRIPTION.

(See Fig. 1).

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

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

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

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

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

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

## Sect. F2. MAINTENANCE.

The following points require attention at intervals quoted below :—

Period.	Attention Required.
<b>DAILY.</b>	Check the level of water in the radiator supply tank and top-up if necessary. Check that the thermostat valve is working satisfactorily ( <i>see below</i> ).
<b>WEEKLY.</b>	Lubricate the fan spindle bearings ( <i>see Section F3</i> ).
<b>MONTHLY OR EVERY 5,000 MILES (8,000 KM.).</b>	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. L11).

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

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

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

Soap Base .. .. .	.. .. .	Lime
Drop Point .. .. .	.. .. .	203° F. (95° C.) minimum
Worked Penetration .. .. .	.. .. .	230—260 units
Heat Resistance (see <i>Appendix A</i> ) .. .. .	.. .. .	No oil separation or hardening
Copper Strip Corrosion (see <i>Appendix B</i> ) .. .. .	.. .. .	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.

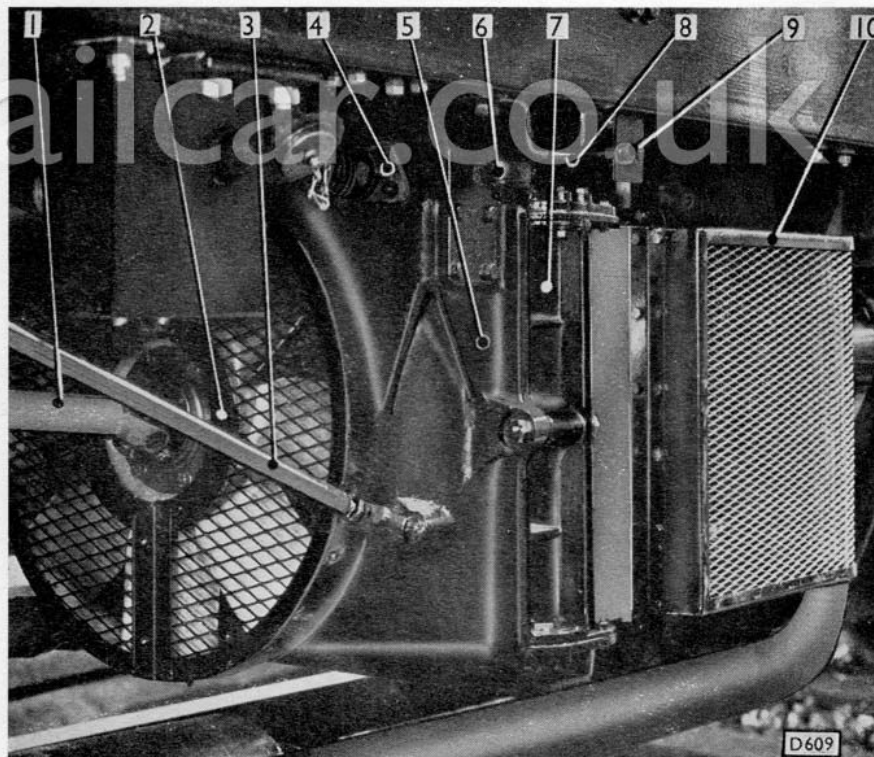
**To Fit.**

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.              | 6. RESILIENT MOUNTING.          |
| 2. FAN GUARD.                    | 7. RADIATOR BLOCK.              |
| 3. RADIATOR TIE ROD.             | 8. MOUNTING BRACKET.            |
| 4. WATER CONNECTION FROM ENGINE. | 9. LUBRICATOR FOR FAN BEARINGS. |
| 5. FAN COWL.                     | 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.

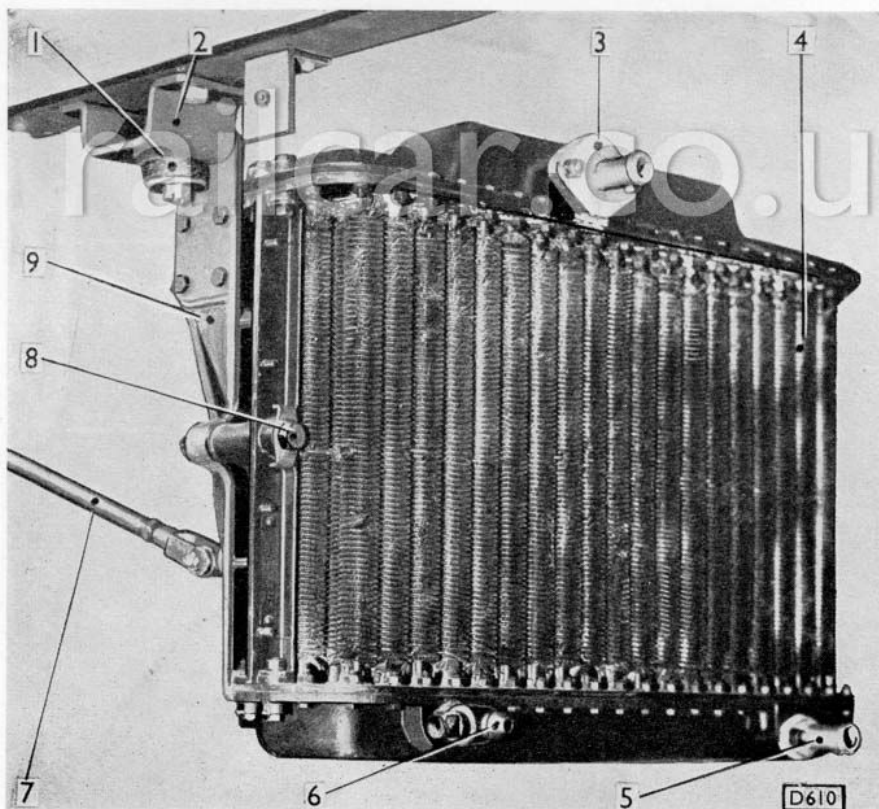
It is recommended that at vehicle overhaul

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.                              | 6. RADIATOR DRAIN COCK.                      |
| 2. MOUNTING BRACKET.                                | 7. RADIATOR TIE ROD.                         |
| 3. RADIATOR VENT PIPE CONNECTION.                   | 8. BOLT SECURING RADIATOR BLOCK TO FAN COWL. |
| 4. RADIATOR BLOCK.                                  | 9. FAN COWL.                                 |
| 5. RADIATOR INLET PIPE CONNECTION FROM HEADER TANK. |  |

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.

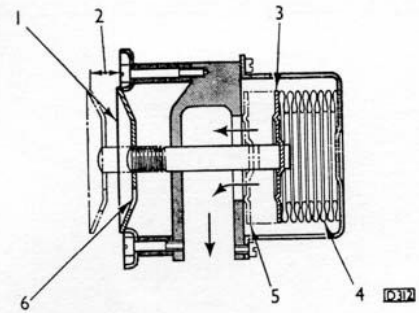
The thermostat valve incorporates a  $\frac{1}{8}$  in. (3.175 mm.) hole which provides a release for excessive pressure or steam accumulating in the cylinder block or heads.

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.	3. BY-PASS VALVE OPEN.
2. THERMOSTAT VALVE LIFT = $\frac{3}{8}$ " (9.52 mm.).	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.

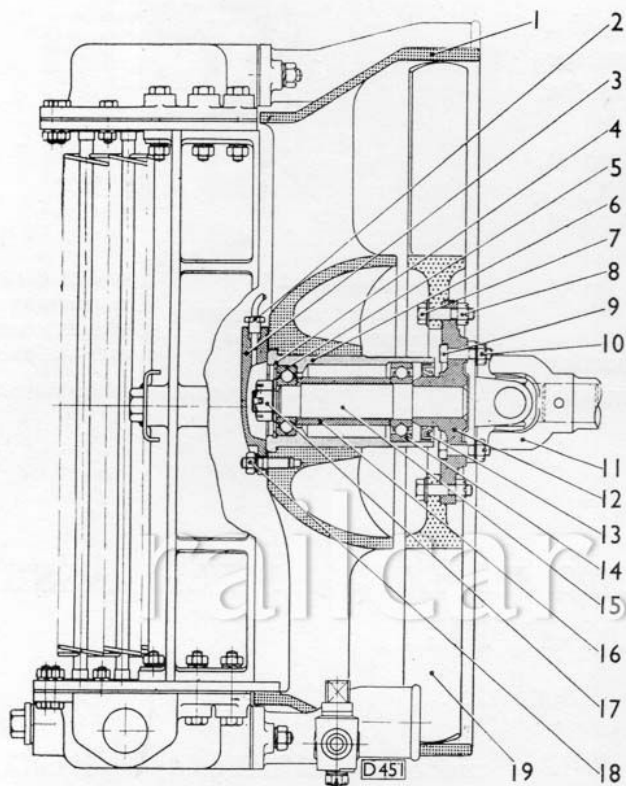
Bolt the fan to the fan shaft hub.

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.



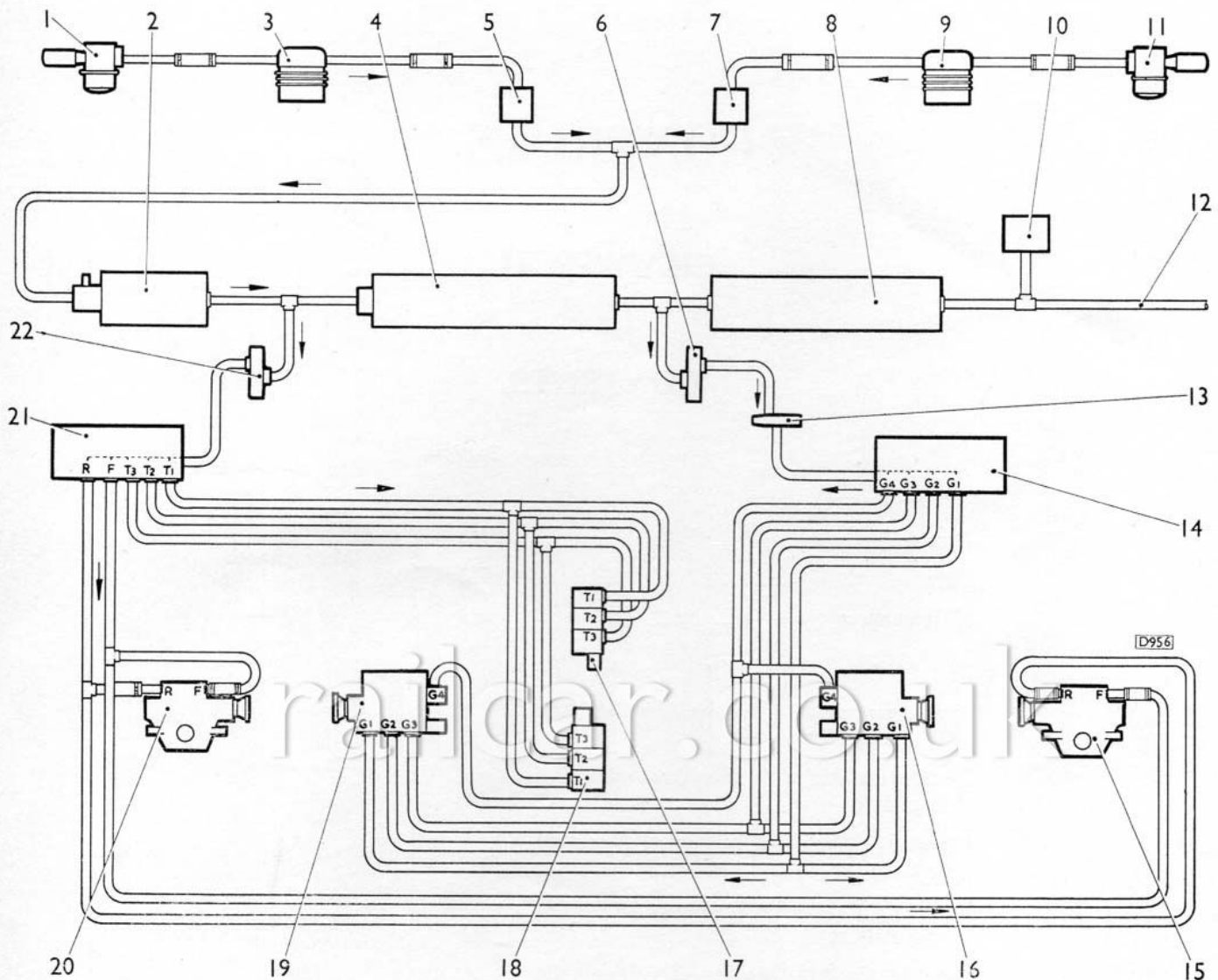
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# CONTROLS.

## CHAPTER H.

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## Key to Numbers :—

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

Fig. 1. Diagrammatic layout of air pressure system



## Sect. H1.

## CONTROLS—DESCRIPTION.

(See Figs. 2 and 3).

## GENERAL.

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

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

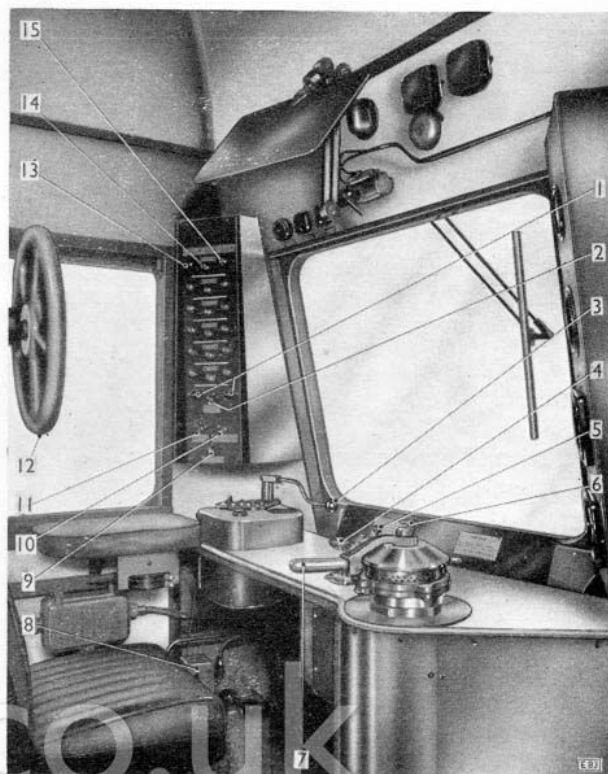
The throttle lever is also the "deadman's" handle; and when released, returns the engine to idling speed, and automatically applies the brakes.



## Key to Numbers :—

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

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



## Key to Numbers :—

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

Fig. 3. Driver's controls.

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

## AIR PRESSURE SYSTEM.

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

Air is drawn by the compressors through the air filter, and anti-freezer units and passed through non-return valves; at this point the combined output from both compressors, passes, via an unloader valve,

to a small capacity reservoir. This permits a rapid build-up of pressure, thus enabling the throttle motor E.P. valves to be operated.

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

Air from the main reservoirs passes, via an air filter, through a reducing valve to the E.P. valves which operate the gearbox pistons.

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

**The air compressors are described in the Engine Chapter.**

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

The air filter, which is an integral unit with the anti-freezer, consists of a cylindrical gauze on which is mounted a felt filter; the felt is surrounded by a slotted cover, cylindrical in shape and closed at one end. The cover is secured by one nut at its closed end. The anti-freezer consists of a reservoir above which a venturi tube is mounted; the reservoir communicates with the extremes of the venturi tube by means of two drillings. A proportion of the air, drawn through the venturi tube by the compressor, by-passes (down the first drilling) into the reservoir; there mixing with the alcohol vapour present. The mixture then passes up the second drilling to mix with the main air stream.

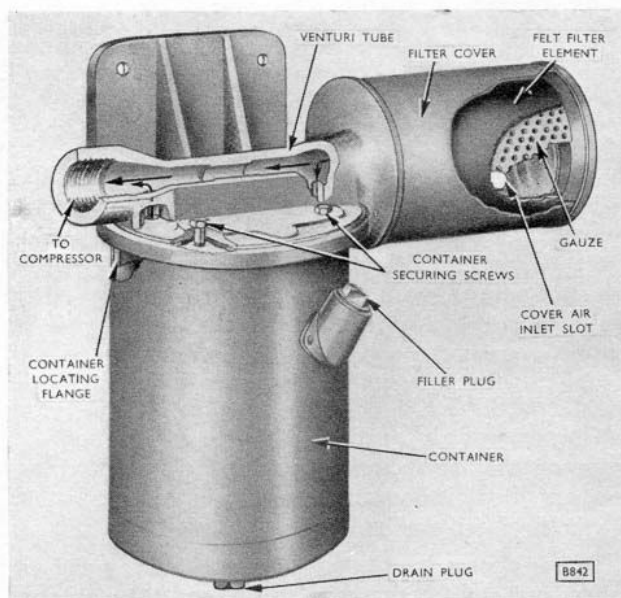
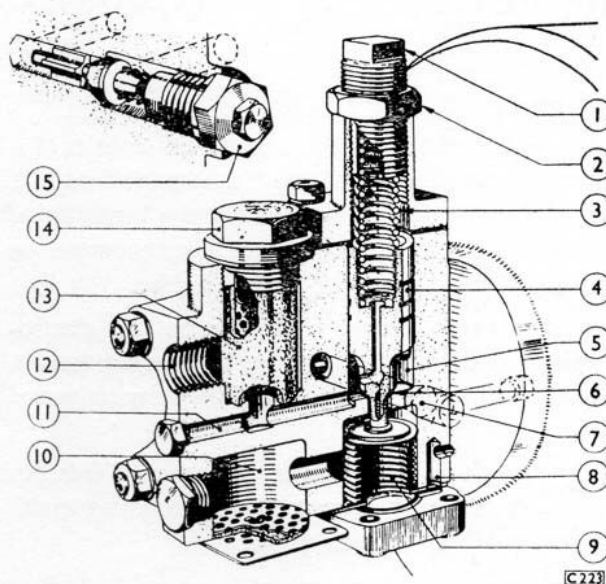


Fig. 4. Combined air filter and anti-freezer.



**Key to Numbers :—**

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

Fig. 5. Unloader valve.

**Air reservoirs.**

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

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

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

**Unloader valve (see Fig. 5).**

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

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

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

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

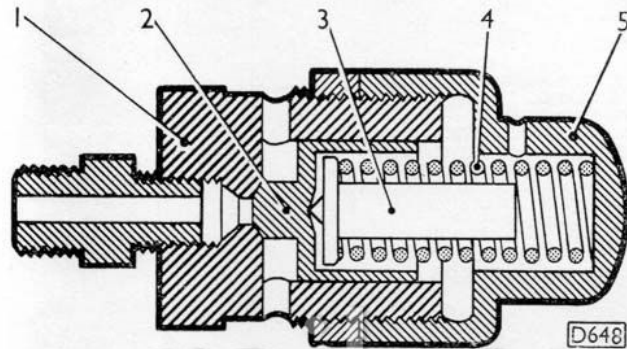
When the reservoir pressure exceeds that of the unloader, the bellows are forced up, thus overcoming

the resistance of the spring and lifts the valve off its seat.

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

**Safety valve** (see Fig. 6).

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

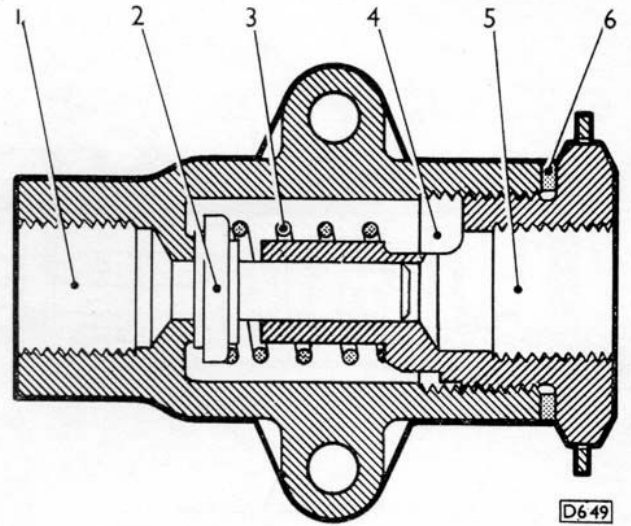


- Key to Numbers :—**
- 1. SAFETY VALVE BODY.
  - 2. VALVE.
  - 3. PLUNGER.
  - 4. SPRING.
  - 5. ADJUSTING END CAP.

Fig. 6. Safety valve.

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

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



- Key to Numbers :—**
- 1. INLET PORT.
  - 2. VALVE.
  - 3. SPRING.
  - 4. AIR PASSAGE.
  - 5. OUTLET PORT.
  - 6. COPPER WASHER.

Fig. 7. Non-return valve.

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

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

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

When the air flow ceases, the pressure in the reservoir, assisted by the action of the spring, forces

**Key to Numbers :—**

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

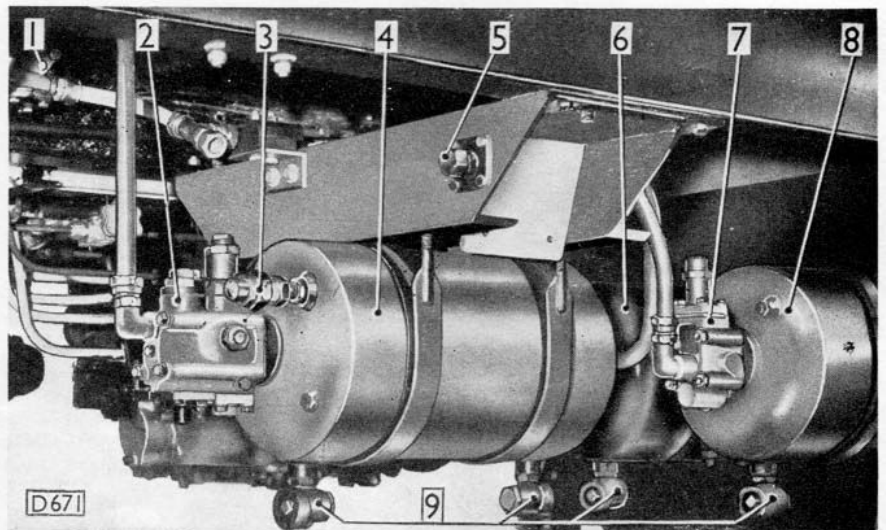
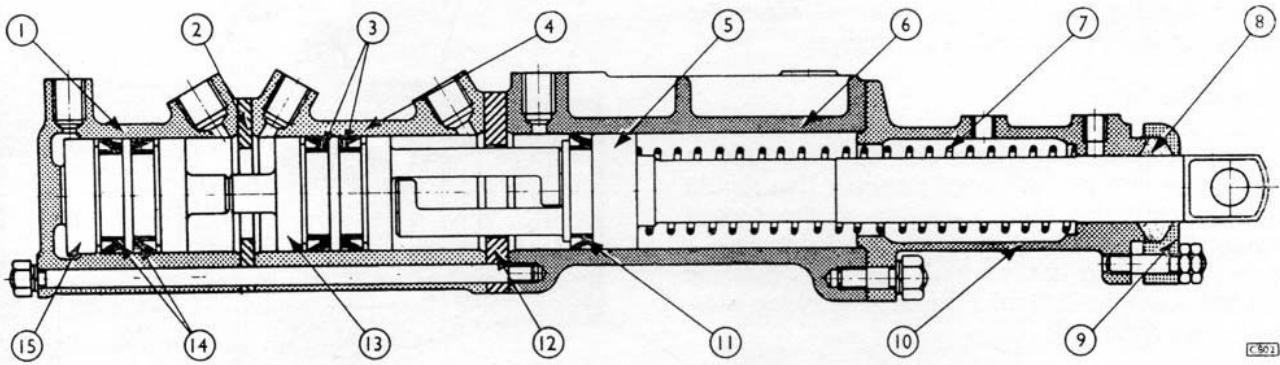


Fig. 8. Air reservoirs, unloader and diverter valves.



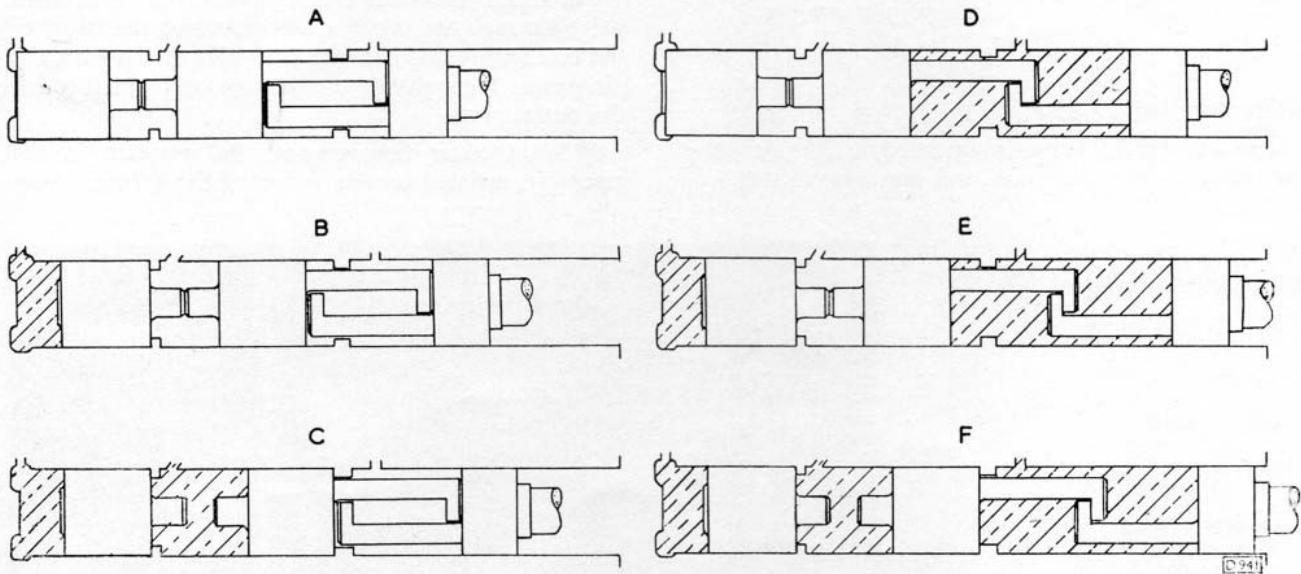


**Key to Numbers :—**

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

Fig. 9. Arrangement of throttle control motor.

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**Key to Letters :—**

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

Fig. 10 Diagrammatic operation of throttle control motor.

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

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

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

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

The pistons in the throttle control motors operate the control levers on the fuel-injection pumps in a series of steps which correspond to the steps felt when moving the driver's throttle control lever (see Fig. 10).

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

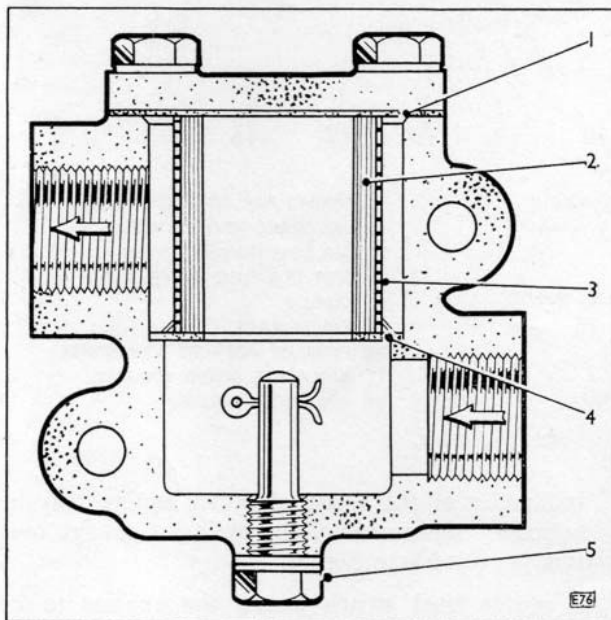
Air filters are mounted in the pipe line between the reservoirs and the reducing valve also between the reservoirs and the E.P. valve block for the throttle motors and final drive units.

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

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

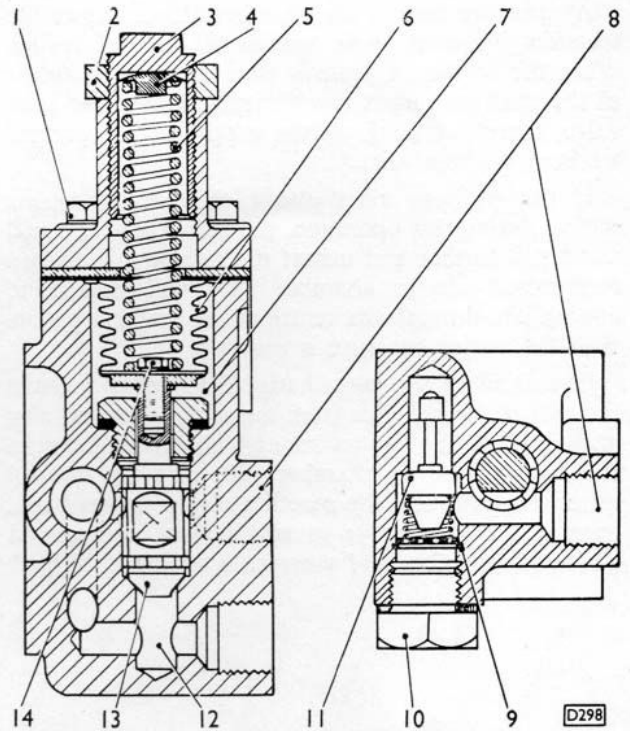
**Reducing valve** (see Fig. 13).

Mounted in the pipe line between an air filter and



- Key to Numbers :—**
- |                  |                         |
|------------------|-------------------------|
| 1. COVER JOINT.  | 3. PERFORATED CYLINDER. |
| 2. FELT ELEMENT. | 4. WASHER.              |
|                  | 5. DRAIN PLUG.          |

Fig. 11. Pipe line air filter.



**Key to Numbers :—**

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

Fig.12. Sectioned view of diverter valve.

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

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

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

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

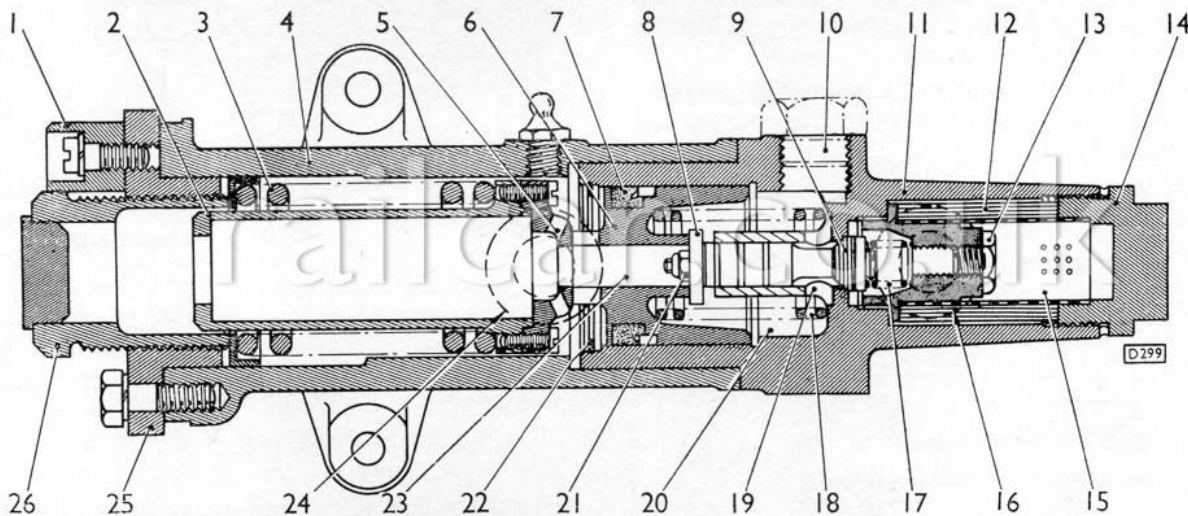
Operation of the gear-change E.P. valves reduces the pressure in the pipe from the outlet port and also in chamber (20). The balance which existed between the air pressure in chamber (20) and the control spring is upset, and the reaction piston moves back, opening the inlet valve to admit more compressed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

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

**ELECTRICAL SYSTEM** (see Plate O77 at the end of this Section).

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

An engine speed indicator is operated by generators mounted one on each engine.



**Key to Numbers:—**

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

Fig. 13. Sectioned view of reducing valve.

**Diverter valve** (see Fig. 12).

The diverter valve is connected to the main compressed air supply. Its purpose is to ensure that the primary system is charged to at least the pressure quoted in Section H2 before pressure is allowed to build up in the system beyond the valve. This valve will, however, permit the reverse flow of air if, for any reason, the pressure in the main system should fall below that in the secondary reservoir.

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

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

Facilities for starting or stopping the engines are provided by push buttons mounted on the control



panel situated in the driver's cab; auxiliary start and stop buttons are provided adjacent to each engine.

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

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

#### Engine control relay panel.

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

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

One relay (specification T3499) consists of one pair of normally closed and one pair of normally open contacts in addition to two pairs of normally open auxiliary contacts. The auxiliary contacts form a separate circuit from the former and are isolated from each other.

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

#### E.P. control relay panel.

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

One relay (specification T3500) consists of one pair of normally closed main contacts. This unit is mounted horizontally so that the contact faces are in a vertical plane, thereby ensuring that they collect no dust.

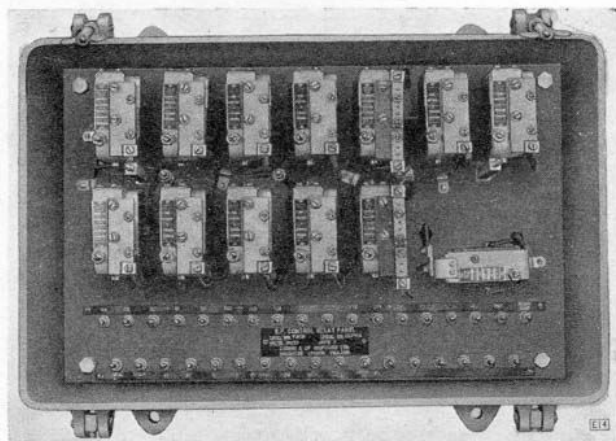


Fig. 14. E.P. control relay panel.

Two relays (specification T5301) each consist of two pairs of normally open main contacts, in the centre of which is located one pair of normally open auxiliary arcing contacts. These are often referred to as the "sparking tips" and are accordingly arranged to "make" a fraction **before**, and "break" a fraction **after** the main contacts.

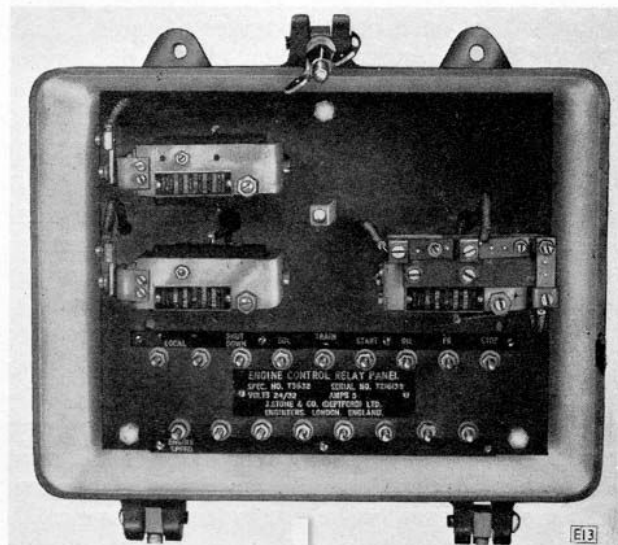


Fig. 15. Engine control relay panel.

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

#### Battery isolating switch.

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

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

#### Engine isolating switch.

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

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

#### Train switch (see Fig. 2).

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

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

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

**Direction switch.**

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

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

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

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

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

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

**Gearbox and final drive controller (see Fig. 17).**

The gearbox controller is similar in construction to the throttle controller. There are two camshafts, one for the operation of the gears in the epicyclic gearboxes and one to actuate the forward and reverse

gears in the final drives. Each cam closes an electrical contact, thereby operating the appropriate E.P. valve, which in turn engages the selected gear.

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

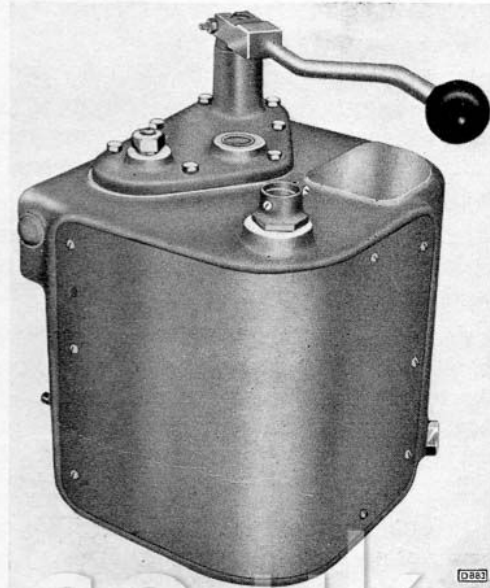


Fig. 16. Throttle controller.

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

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

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

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

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

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

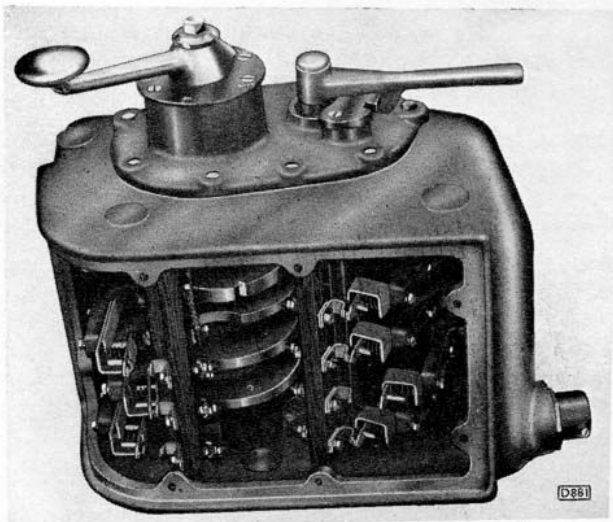
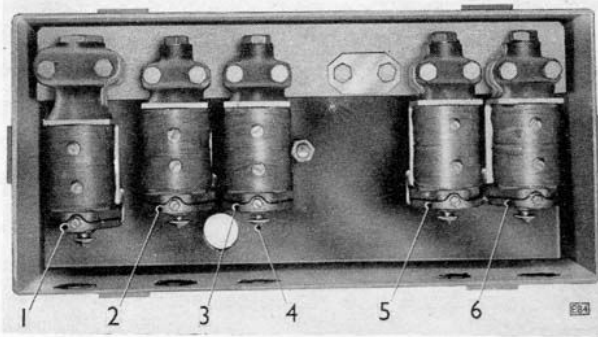


Fig. 17. Gearbox and final drive controllers showing contacts.



- Key to Numbers :—**
- |                                       |  |
|---------------------------------------|--|
| 1. THROTTLE MOTOR E.P. VALVE — NO. 1. | 4. E.P. VALVE HAND-TESTING BUTTON.         |
| 2. THROTTLE MOTOR E.P. VALVE — NO. 2. | 5. FINAL DRIVE E.P. VALVE — FORWARD SPEED. |
| 3. THROTTLE MOTOR E.P. VALVE — NO. 3. | 6. FINAL DRIVE E.P. VALVE — REVERSE SPEED. |

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

small coil spring. The design of the connecting passage and the plunger top is such that any air leaking past the valve is discharged to atmosphere.

**Air pressure switch.**

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

The indicator light will not be switched on until the final drive is properly engaged and the correct air pressure is obtained (for air pressures see Section H2).

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

**Water level switch.**

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

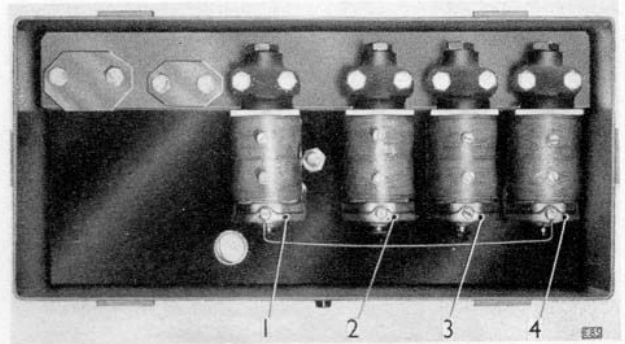
Incorporated in the float assembly is a permanent magnet which is opposed by a similar magnet in the switch assembly.

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

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

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

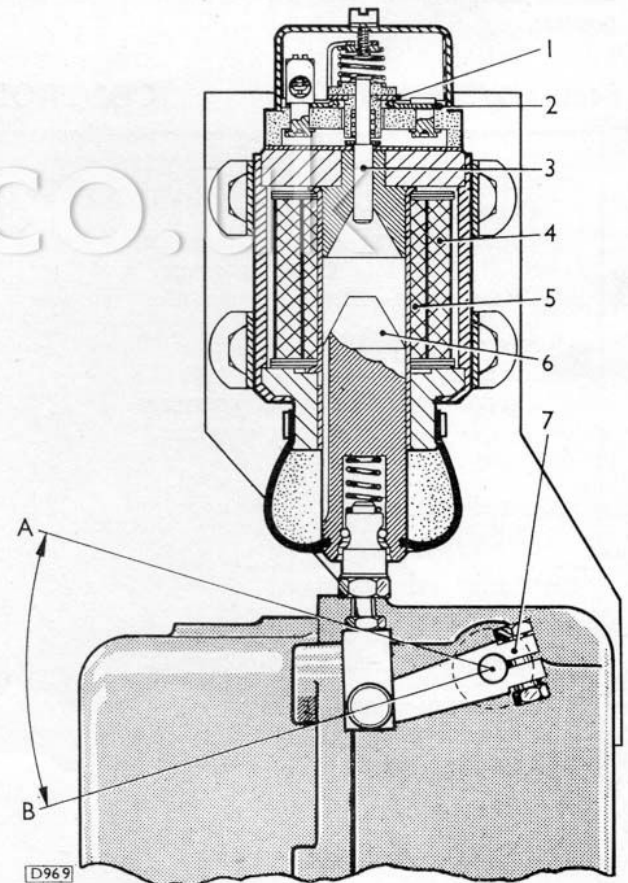
This unit is continuously rated and consists of a "pull-in" coil and a "hold-in" coil in which a solenoid core is free to move.



- Key to Numbers :—**
- |                                     |                                     |
|-------------------------------------|-------------------------------------|
| 1. FIRST SPEED GEARBOX E.P. VALVE.  | 3. THIRD SPEED GEARBOX E.P. VALVE.  |
| 2. SECOND SPEED GEARBOX E.P. VALVE. | 4. FOURTH SPEED GEARBOX E.P. VALVE. |

Fig. 19. Electro-pneumatic valves for gearbox.

On energising the "pull-in" coil the solenoid core rises against the actuating plunger and breaks the moving contacts. This action brings into circuit the



- Key to Letters :—**
- |                   |                       |
|-------------------|-----------------------|
| A. STOP POSITION. | 2. FIXED CONTACTS.    |
| B. RUN POSITION.  | 3. ACTUATING PLUNGER. |
- Key to Numbers :—**
- |                     |                                    |
|---------------------|------------------------------------|
| 1. MOVING CONTACTS. | 4. PULL-IN COIL.                   |
|                     | 5. HOLD-IN COIL.                   |
|                     | 6. SOLENOID CORE.                  |
|                     | 7. FUEL-INJECTION PUMP STOP LEVER. |

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





## Sect. H3.

## CONTROLS—MAINTENANCE

## AIR PRESSURE SYSTEM.

The following points require attention at periods quoted below.

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

**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 methylators under the name of "Blending Methanol" or "I.M.S. Substitute," both 74 per cent. overproof.

**Note.**—These agents are, however, toxic in both the liquid and vapour state and have a very low flash point. The following precautions should, therefore, be observed:—

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

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

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

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

**Air reservoirs** (see Fig. 8).

Empty and drain the air reservoirs as follows :—

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

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

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

**Unloader valve** (see Fig. 5).

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

The unloader cut-out pressure is adjusted to the figure given in Section H2 by slackening the locknut and turning the adjusting thimble **clockwise** to **increase** and **anti-clockwise** to **decrease** the pressure. When increasing the pressure it is desirable to screw down the thimble just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. Tighten the locknut and recheck the setting.

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

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

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

**Safety valve** (see Fig. 6).

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

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

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

**Diverter valve** (see Fig. 12).

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

**Reducing valve** (see Fig. 13).

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

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

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

**Throttle control motors** (see Figs. 9 and 10).

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

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

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

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

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

At intervals quoted in the chart at the beginning of this Section remove and clean the felt element and the perforated cylinder in the pipe line filters as follows :—

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



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

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

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

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

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

Screw in the drain plug.

#### To check for air leakage.

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

### VACUUM SYSTEM.

The following points require attention at periods quoted below.

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

#### “Deadman’s” control valve.

See Gresham and Craven’s handbook “Instructions for Gresham’s Quick Release Vacuum Brake Equipment on British Railways Railcars.”

#### Exhausters (*see Fig. 23*).

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

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

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

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

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

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

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

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

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

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

A drain plug is fitted to facilitate cleaning.

The reservoir requires no maintenance other than topping-up the oil level (*see Section H4*).

#### Exhausters—drive belts to adjust.

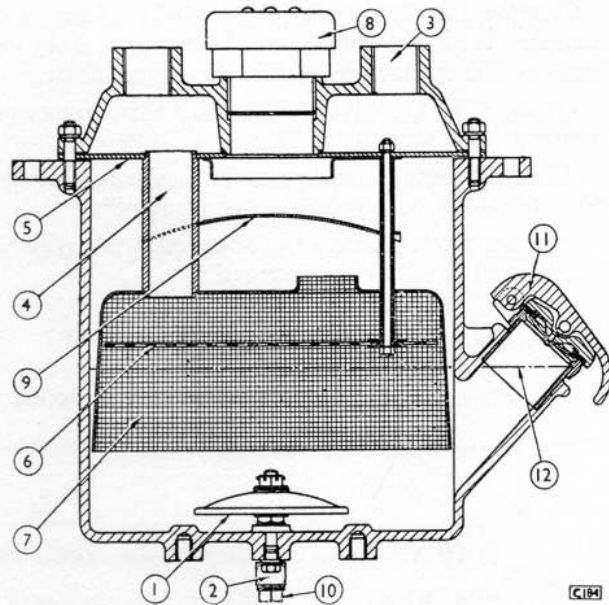
The exhausters are pivoted on brackets fitted to the underframe.

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

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

When correctly adjusted, there should be from  $1\frac{1}{2}$  in. to 2 in. (43 mm. to 51 mm.) vertical movement at the centre of the belts.

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



#### Key to Numbers :—

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

Fig. 22. Section through exhauster oil reservoir.

#### ELECTRICAL SYSTEM.

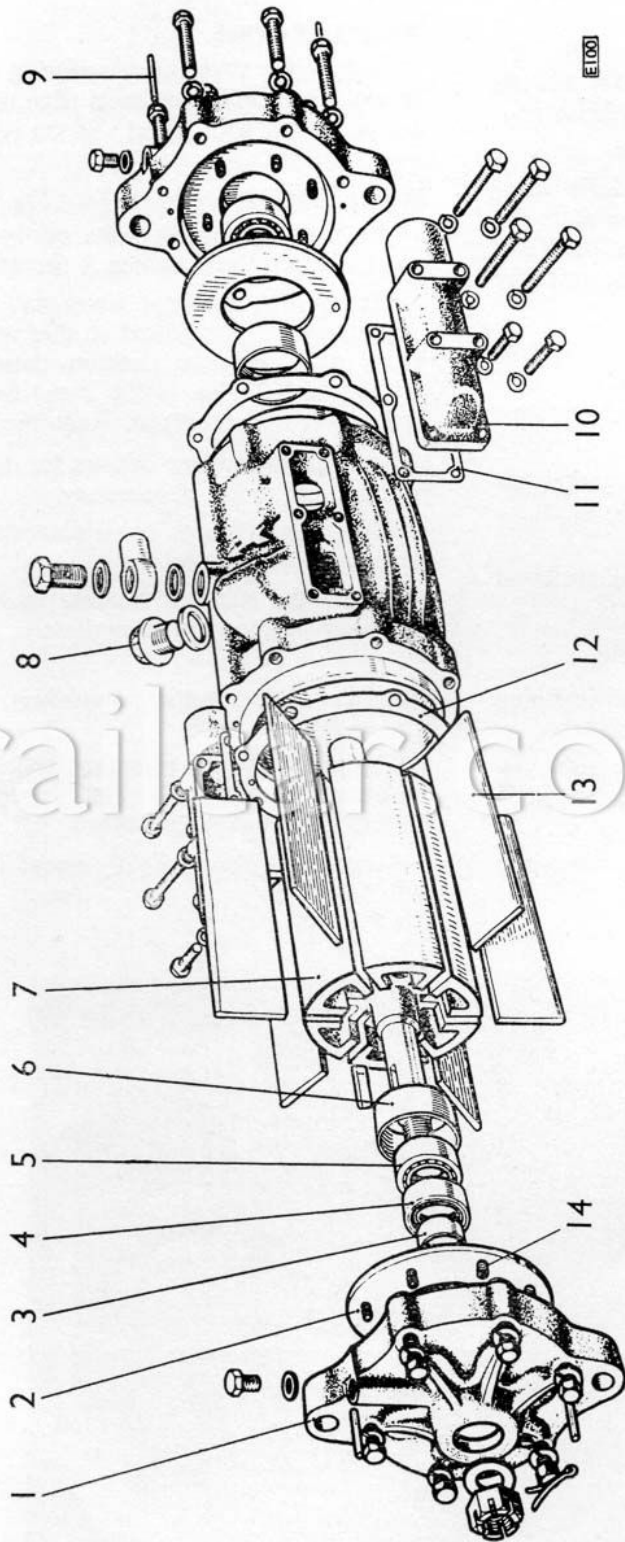
The following points require attention at periods quoted below.

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

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

**Engine and E.P. control relays** (*see Figs. 14 and 15*).  
Carefully clean the relay contacts with a clean rag moistened with petrol.

Apart from this, no further maintenance is required. If, however, the contacts are found to be burnt or pitted, the matter should be reported.



Key to Numbers :—

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

Fig. 23. Exploded view of exhauster.



**Battery isolating switch.**

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

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

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

Dismantle and wash all parts in paraffin.

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

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

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

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

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

**Air pressure switch.**

To adjust the air pressure, unscrew the retaining set-screw and remove the cover from the switch.

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

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

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

**Water level switch.**

Remove the cover by unscrewing its retaining set-screws. To clean the contacts wipe them with a clean rag moistened with petrol; fit the cover.

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

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

Remove the terminal cover and check that the connecting link is adjusted so that with the armature in the fully energised position, there is a minimum air gap of 0.063 in. (1.600 mm.) between the fixed and the moving contacts. Refit the terminal cover.

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

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

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

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

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

At overhaul periods lightly smear all working parts with lubricant.

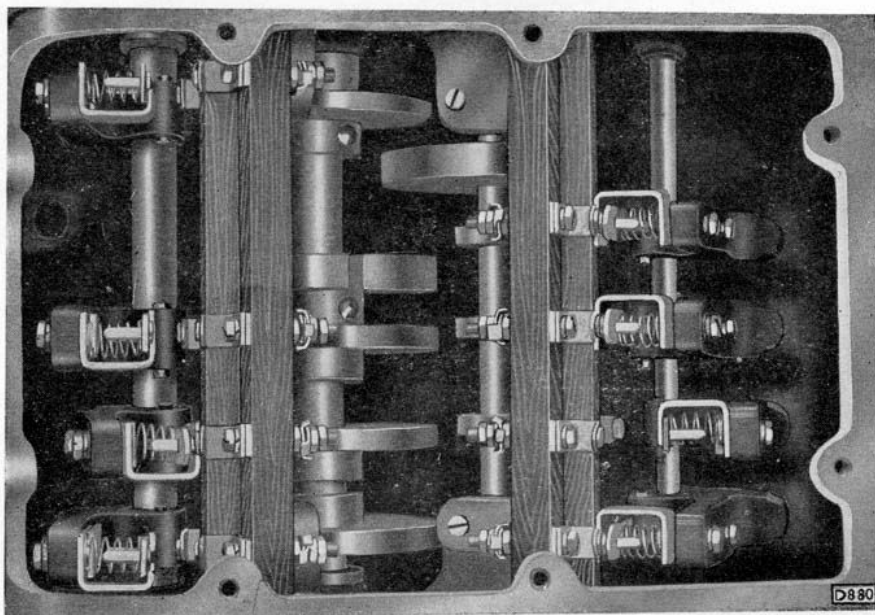


Fig. 24. Gearbox and final drive controllers showing electrical contacts.

**Starter switches.**

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

**Direction switch.**

Check that the direction switches are operating

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

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

**Sect. H4.****CONTROLS—LUBRICATION.****Throttle control motors** (see Fig. 9).

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

**Reducing valve** (see Fig. 13).

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

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

At intervals quoted in the chart in Section H3,

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

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

Refit the drain plug and tighten securely.

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

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



Fig. 25. Throttle controller showing electrical contacts.

## OIL SPECIFICATION.

(A.E.C. Specification No. 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.

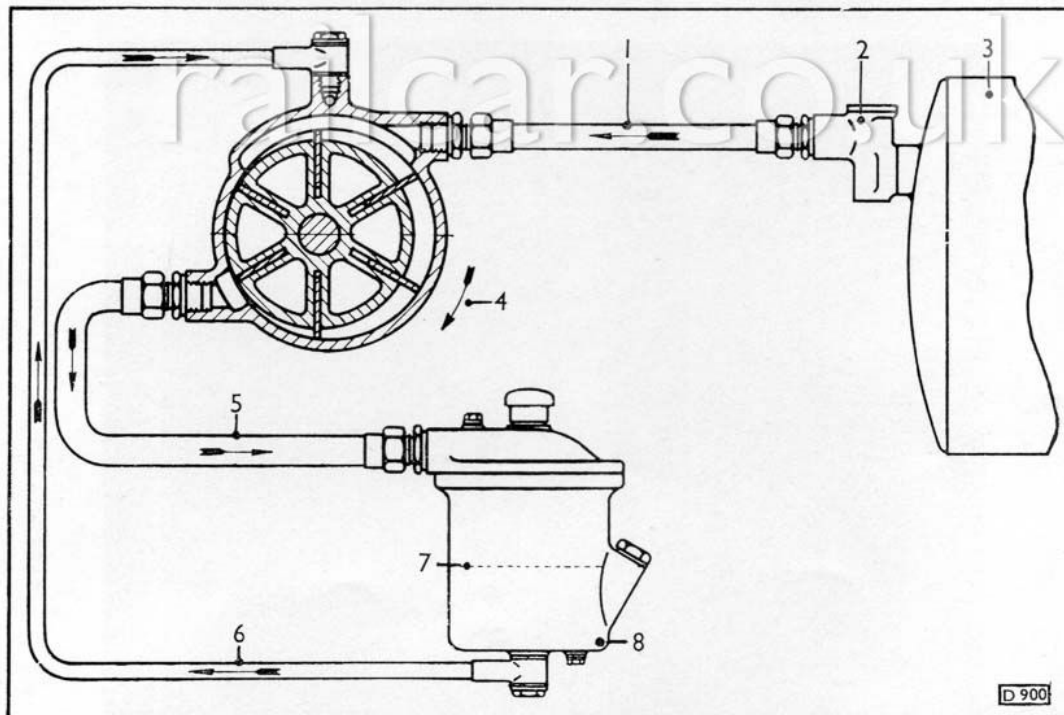
*Characteristics.*—When tested by the appropriate methods given in the current issue of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products," the oil must conform with the following requirements:—

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
Acidity (organic)	... 0·10 mgms. KOH per gm. maximum
Ash	... 0·005 per cent. maxi- mum
Carbon Residue (Rams- bottom)	... 0·5 per cent. maxi- mum

*Oxidation Characteristics.*—

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

**Key to Numbers:—**

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

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



## Sect. H5.

**UNLOADER AND SAFETY VALVES  
—TO OVERHAUL, TEST AND ADJUST.**

(See Figs. 5 and 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 undue wear and unreliable operation due to the entry of dirt.**

**To Overhaul.****Unloader valve.**

Remove the unloader valve from the reservoir.

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

Remove the cover below the bellows.

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

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

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

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 procedure for dismantling, noting the following points:—

Lightly oil all moving parts.

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

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

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

**Safety valve.**

Dismantle and clean all parts.

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

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

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

**To Test.****Unloader valve.**

Charge the reservoir by running the compressor or by admitting air from the shop air line. The unloader valve should be adjusted to unload when the reservoir pressure gauge indicates the figure given in Section H2. 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 H2.

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 H2) 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 H2) when no leakage must occur.

**To Adjust.****Unloader valve.**

The unloader cut-out pressure is adjusted to the figure given in Section H2 by slackening the locknut and turning the adjusting thimble **clockwise** to **increase** and **anti-clockwise** to **decrease** the pressure. When increasing the pressure it is desirable to screw down the thimble just beyond the desired point and then turn it back, so avoiding any twisting of the spring that will affect the setting. 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 H2 but it does not matter if the actual cut-in pressure is a little higher.

**Safety valve.**

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

**Sect. H6. NON-RETURN VALVE—TO DISMANTLE AND ASSEMBLE.**

(See Fig. 7)

**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. H7. DIVERTER VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST.**

(See Fig. 12).

**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 H2.

## Sect. H8.

**REDUCING VALVE—TO DISMANTLE,  
ASSEMBLE AND ADJUST.**

(See Fig. 13).

**To Dismantle.**

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

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

Unscrew the end cap and remove the felt filter element.

Unscrew the adjusting screw carrier and 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 engine oil before assembly. **Fuel oil must NOT be allowed to come into contact with any valve or piston seal.**

**To Adjust.**

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

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

Connect to the outlet port an accurate gauge, capable of reading up to at least 70 lb. per sq. in. (4.92 Kg. per sq. cm.).

The setting of the control spring should then be adjusted by means of the adjusting screw so that there is constant pressure as quoted in Section H2.

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

Finally, lock the adjusting screw.

## Sect. H9.

**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 otherwise the throttle motor may stick when in service.

Before fitting the throttle motor to the car, check for air leakage (see Section H3).



## Sect. H10. EXHAUSTER OIL RESERVOIR —TO REMOVE, DISMANTLE, ASSEMBLE AND FIT.

(See Fig. 22).

### To Remove.

Drain the oil by removing the drain plug (*see Section H4*).

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, then fill with fresh oil (*see Section H4*).

## Sect. H11. EXHAUSTERS—TO DISMANTLE, ASSEMBLE AND TEST.

(See Fig. 25).

### To Dismantle.

Remove the exhauster from the car.

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

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

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

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

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

### To Assemble.

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

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

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

markings are pronounced, the body should be renewed.

Examine the bearings and renew if worn.

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

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

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

Ensure that the bearings, when fitted, run freely.

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

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

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

Smear the end covers with grease before fitting new joints.

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

### To Test

See Railway instructions for testing the vacuum system.

## Sect. H12. ENGINE CONTROL, RELAY BOX AND E.P. CONTROL RELAY BOX— TO ADJUST CONTACTS AND CALIBRATE RELAYS.

(See Fig. 27).

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

If fitted correctly, the contact faces will meet squarely, when the armature is fully home, and should be aligned so that when they are closed it should not be possible to insert a 0.005 in. feeler gauge.

The distance between the faces of any pair of contacts must not exceed 0.031 in. (0.8 mm.).

### To adjust the armature hinge gap.

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

With the armature core gap at 0.010 in. (0.254 mm.) adjust the armature hinge gap to 0.040 in. (1.016 mm.); the hinge gap must be parallel in the direction across the yoke. Tighten the screw to secure

the hinge spring to the yoke, making sure that the clamping plate is the correct way round.

In the case of relays with normally closed contacts, as in specifications T3499 and T3500, fit the hinge spring so that the slots are to the rear, to avoid fouling the fixed contacts support.

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

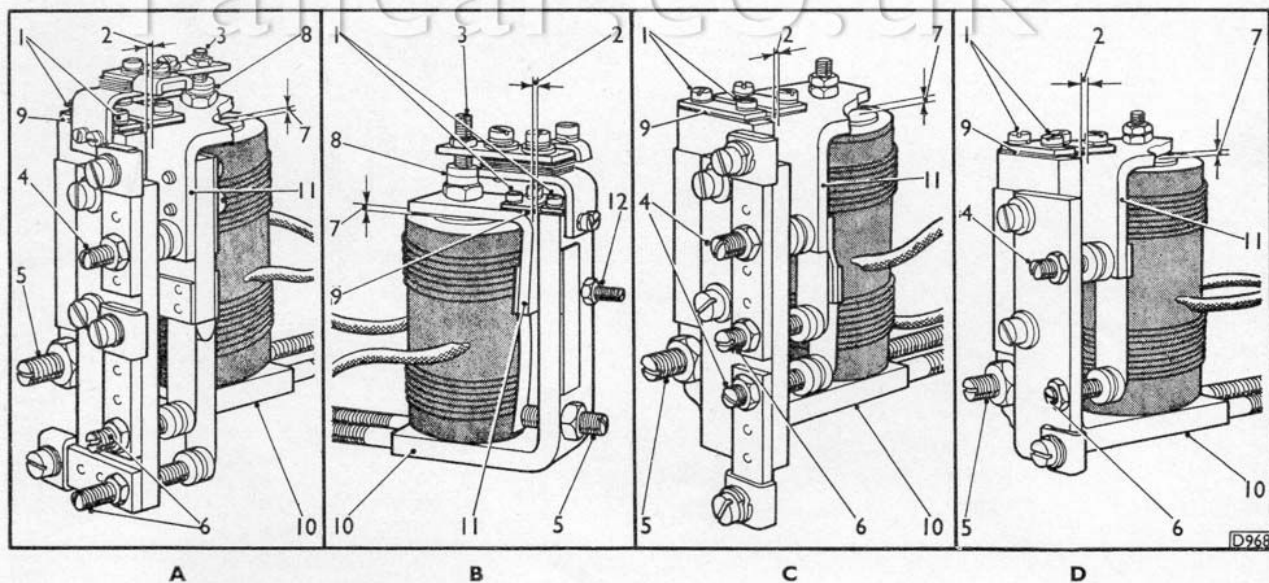
If an armature adjusting screw is fitted, as in specification T3500, this should be locked by means of the locknut.

### To adjust the normally closed contacts (as in specifications T3499 and T3500).

Adjust these contacts by means of the adjusting screw so that when they are closed, the armature core gap is 0.050 in. (1.270 mm.), then lock securely by means of the locknut.

### To adjust the normally open main contacts (as in specifications T3499, T3501 and T3502).

Adjust these contacts, by means of the adjusting



#### Key to Letters :—

- A. TONUM TYPE RELAY SPECIFICATION T3499.
- B. TONUM TYPE RELAY SPECIFICATION T3500.
- C. TONUM TYPE RELAY SPECIFICATION T3501.
- D. TONUM TYPE RELAY SPECIFICATION T3502.

#### Key to Numbers :—

- 1. ARMATURE HINGE FIXING SCREWS.
- 2. ARMATURE HINGE GAP 0.040in.
- 3. NORMALLY CLOSED MAIN CONTACTS SETTING SCREW.
- 4. NORMALLY OPEN MAIN CONTACTS AND ARMATURE SETTING SCREW.
- 5. CONTROL SPRING ADJUSTING SCREW.
- 6. NORMALLY OPEN AUXILIARY CONTACTS SETTING SCREW.
- 7. ARMATURE CORE GAP 0.010in.
- 8. NORMALLY CLOSED MAIN CONTACTS.
- 9. HINGE SPRING.
- 10. YOKE.
- 11. ARMATURE.
- 12. ARMATURE SETTING SCREW.

Fig. 27. Diagrams for setting control relays.

screw, until the faces just meet and the armature core gap is 0.010 in (0.254 mm.).

On relays to specifications T3501 and T3502, adjust the armature core gap is 0.050 in. (1.270 mm.), with the main contacts open.

Lock the contacts by means of the locknuts.

**To adjust the normally open auxiliary contacts** (as in specifications T3499, T3501 and T3502).

Adjust these contacts by means of the adjusting screw, until the faces just meet and the armature core gap is 0.030 in. (0.762 mm.); this setting ensures that compared with the main contacts, the auxiliary contacts will "make" first and "break" last.

Lock the contacts by means of the locknuts.

**Relays—To Calibrate.**

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

The energising voltage is given in Section H2, and the control spring adjusting screw should be set so that the relay "cuts-in" at this voltage. Always ensure that the locknut on the adjusting screw is tightened after making an adjustment.

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

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

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

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JUMPER RECEPTACLES  
NUMBERS INDICATE TERMINALS

JUMPER RECEPTACLE  
NUMBERS INDICATE TERMINALS

PLATE No. 077.

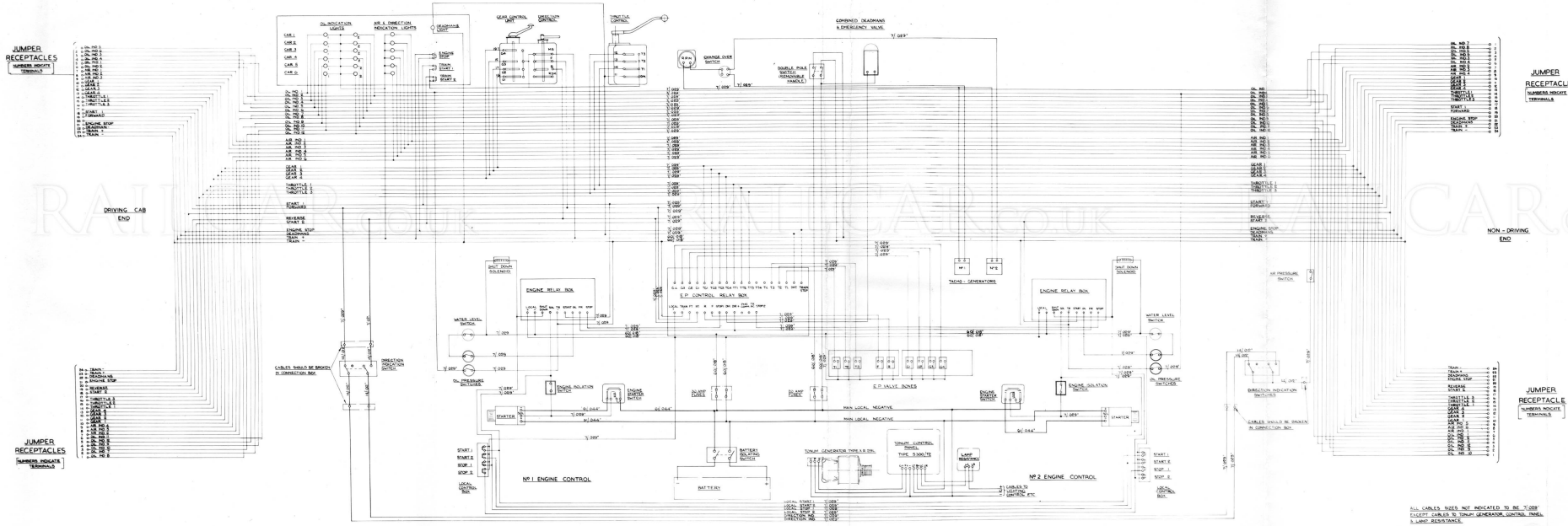
WIRING DIAGRAM  
for  
B.U.T.  
TRACTION EQUIPMENT  
(Power Cars).

British Railways  
Multiple-unit Diesel Cars  
(Swindon Built Inter-City Cars  
79,083-111 and 79,155-168)

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ALL CABLES SIZES NOT INDICATED TO BE 7/0.08"  
EXCEPT CABLES TO TOLNAY GENERATOR, CONTROL, SIGNAL  
& LIGHTS, RESISTANCE.







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**BRITISH RAILWAYS DIESEL TRAIN 'A' TYPE UNITS — OVERHAUL**

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