SERVICE MANUAL

B.U.T. TRACTION EQUIPMENT

BRITISH RAILWAYS

DIESEL RAILBUS.

BRITISH UNITED TRACTION LTD.

SERVICE MANUAL

FOR

B.U.T.

TRACTION EQUIPMENT

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"RAILBUS"

BRITISH UNITED TRACTION LIMITED

FOREWORD.

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

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

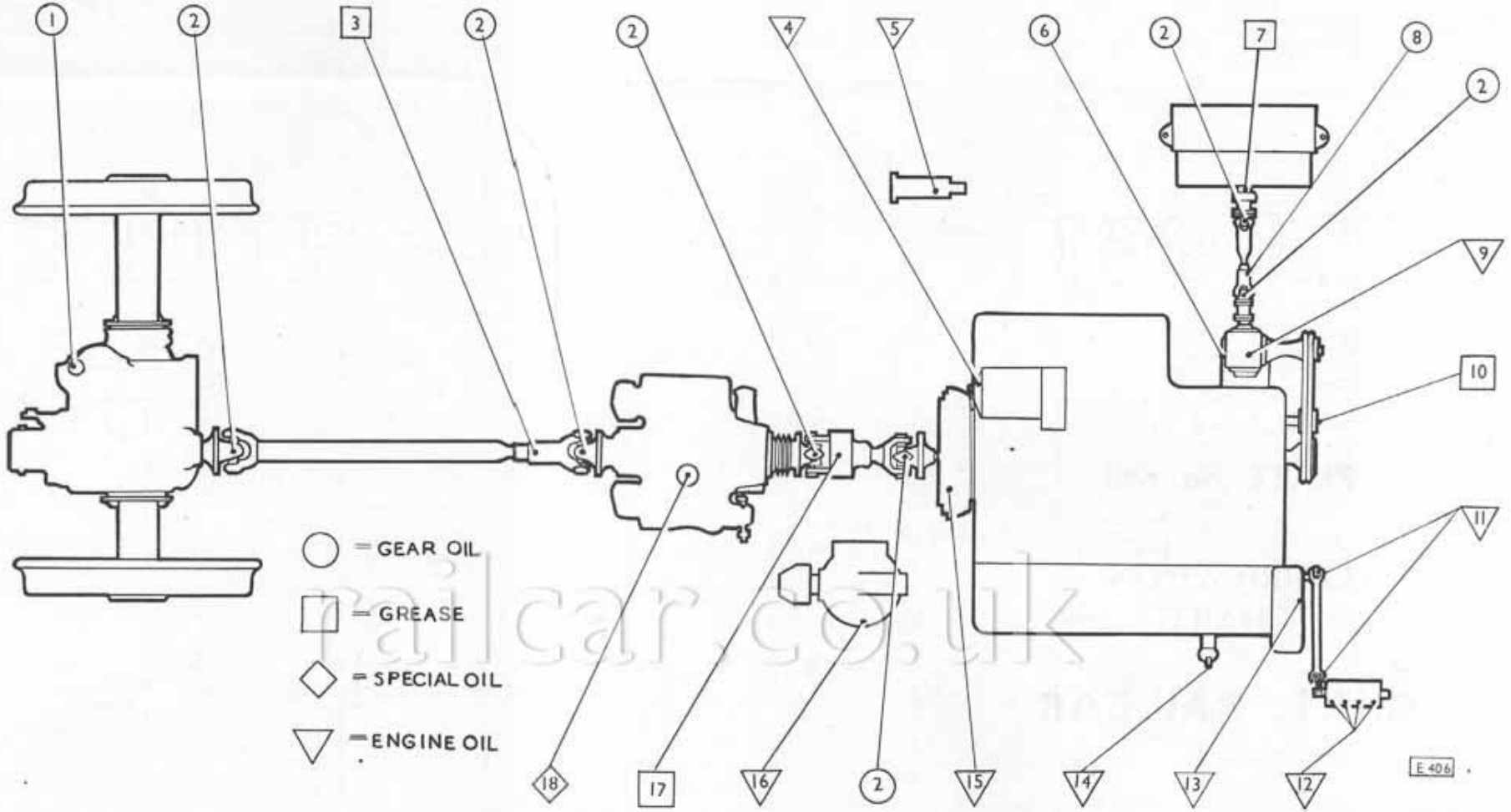
While every care has been taken in the design and manufacture of this equipment in an endeavour to obtain the maximum mileage coupled with the minimum amount of servicing between overhauls, apart from certain essential adjustments and periodic routine maintenance, equipment that is performing satisfactorily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

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

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

PLATE No. S88

LUBRICATION CHART
FOR
B.U.T. RAILCAR



Location Number	Part	Class of Lubricant	Number of points per car
1	Final drive	Gear oil	1
	Propeller shafts:-		
2	Universal joints	Gear oil	6
	Splined ends:-		
8	Small diameter shaft(fan drive)	Gear oil	1
3	Large diameter shaft	Grease	1
4	Starter motor	Engine oil	1
5 *	Air reducing valve - Gearbox	Engine oil	1
6	Right-angle fan drive	Gear oil	1
7	Fan bearings	Grease	1
9	Right-angle fan drive breather	Engine oil	1
10	Water pump spindle	Grease	1
11	Fuel-injection pump to throttle motor linkage	Engine oil	2
12 *	Throttle control motor	Engine oil	4
13	Fuel-injection pump governor casing	Engine oil	1
14	Engine	Engine oil	1
15	Fluid coupling	Engine oil	1
16	Engine air cleaner	Engine oil	1
17	Freewheel	Grease	1
18	Epicyclic gearbox	Special	1

* One stroke only of pressure gun.

This chart should be read in conjunction with the appropriate lubrication Sections.

ENGINE

(A - Type)

CHAPTER K

CONTENTS

As an air compressor is not fitted to the Railbus engine, Sections K71, K72, K73, K74 and all other references to the compressor should be ignored.

Part B35

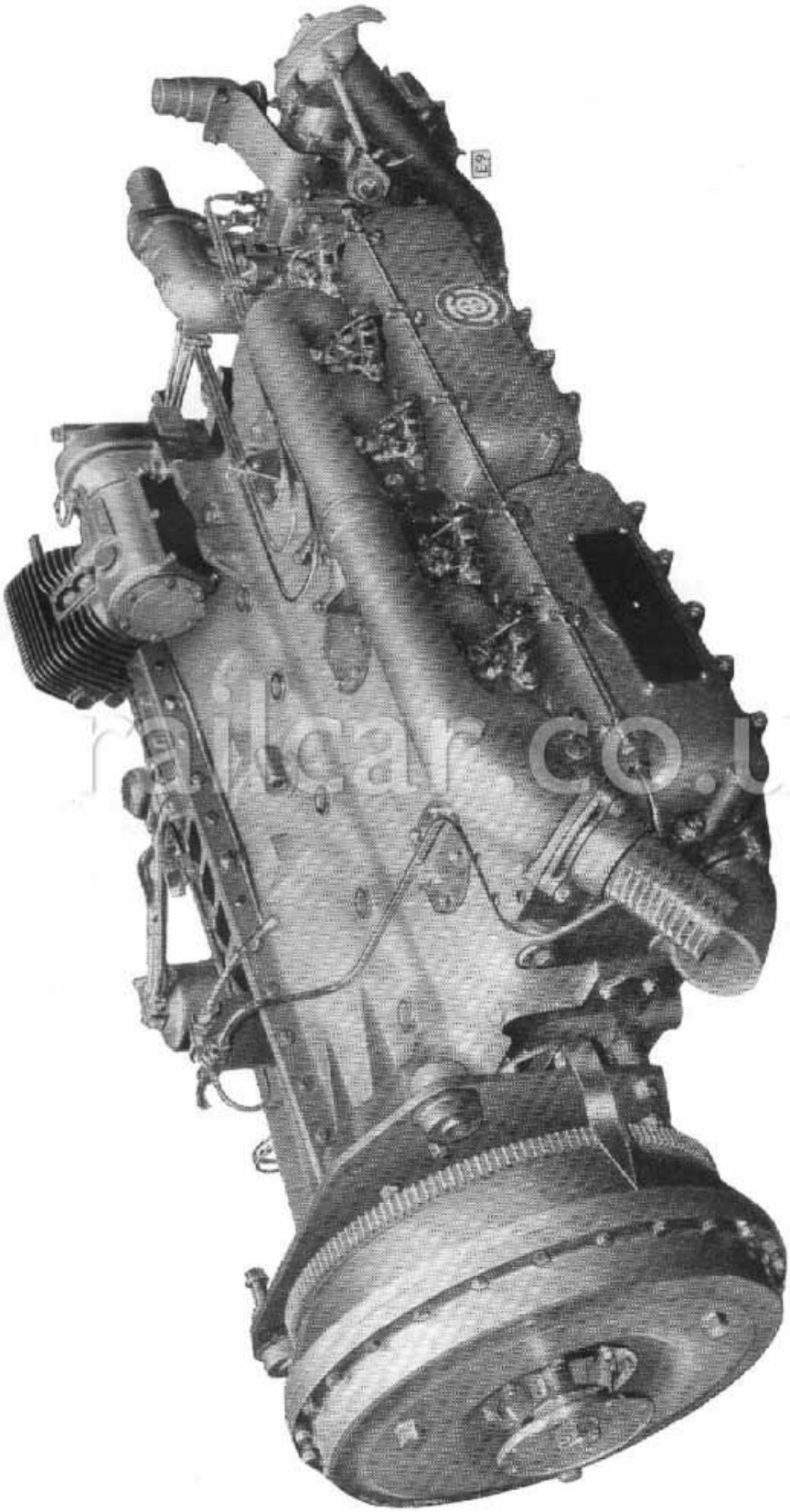


Fig. 1. General view of engine.

Sect. K1. ENGINE — DESCRIPTION.

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

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

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

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

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

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

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

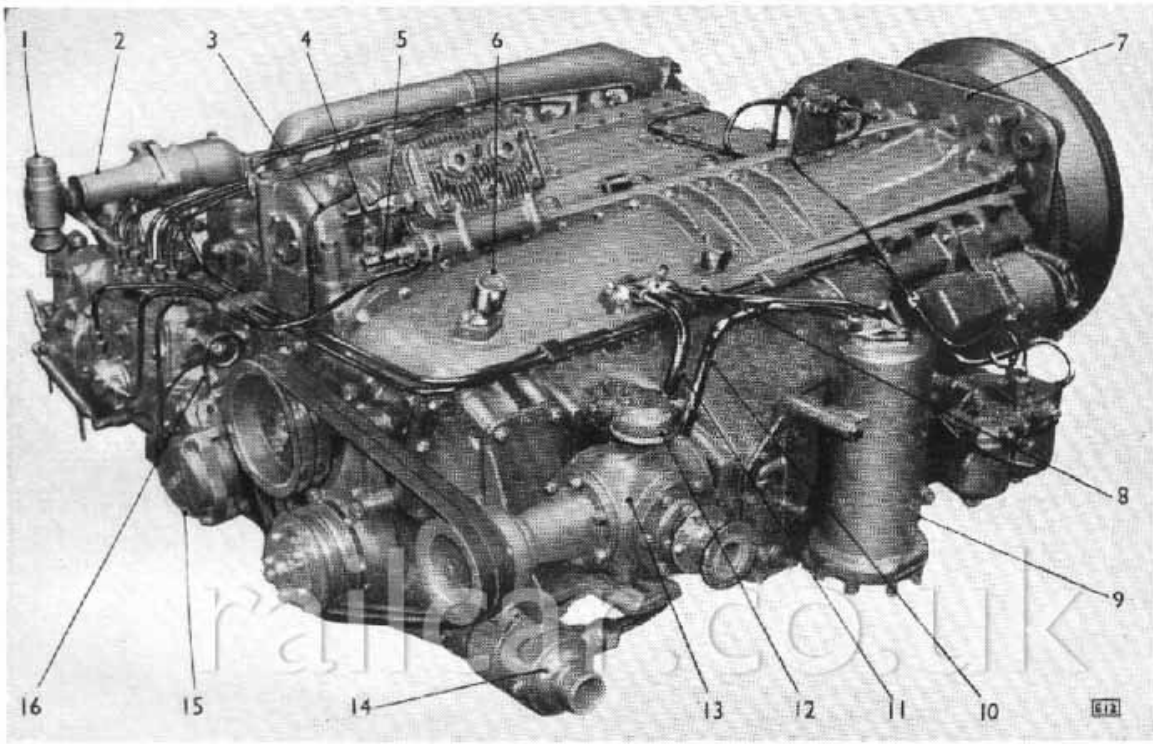


Fig. 2. Three-quarter front view of engine.

1. ENGINE STOP SOLENOID.
2. WATER OUTLET CONNECTION.
3. OIL PIPE TO COMPRESSOR BEARING.
4. COMPRESSOR OUTLET PORT.
5. COMPRESSOR INLET PORT.
6. CRANKCASE BREATHER.
7. ENGINE REAR MOUNTING BRACKET.
8. OIL PIPE — FILTER TO SUMP.
9. OIL FILTER.
10. OIL PIPE — OIL COOLER TO FILTER.
11. OIL PIPE — SUMP TO OIL COOLER.
12. BREATHER.
13. RIGHT-ANGLE FAN DRIVE UNIT.
14. OIL COOLER.
15. ENGINE SPEED INDICATOR GENERATOR.
16. OIL PIPE — CRANKCASE TO BEVEL DRIVE CASING.

Sect. K2. 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. Type	A220AC.
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)]
Oil Pressure	30 lb. per sq. in. (2·1 kg. per sq. cm.) minimum at the governed speed of 1,800 r.p.m. (with engine **hot**).
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).

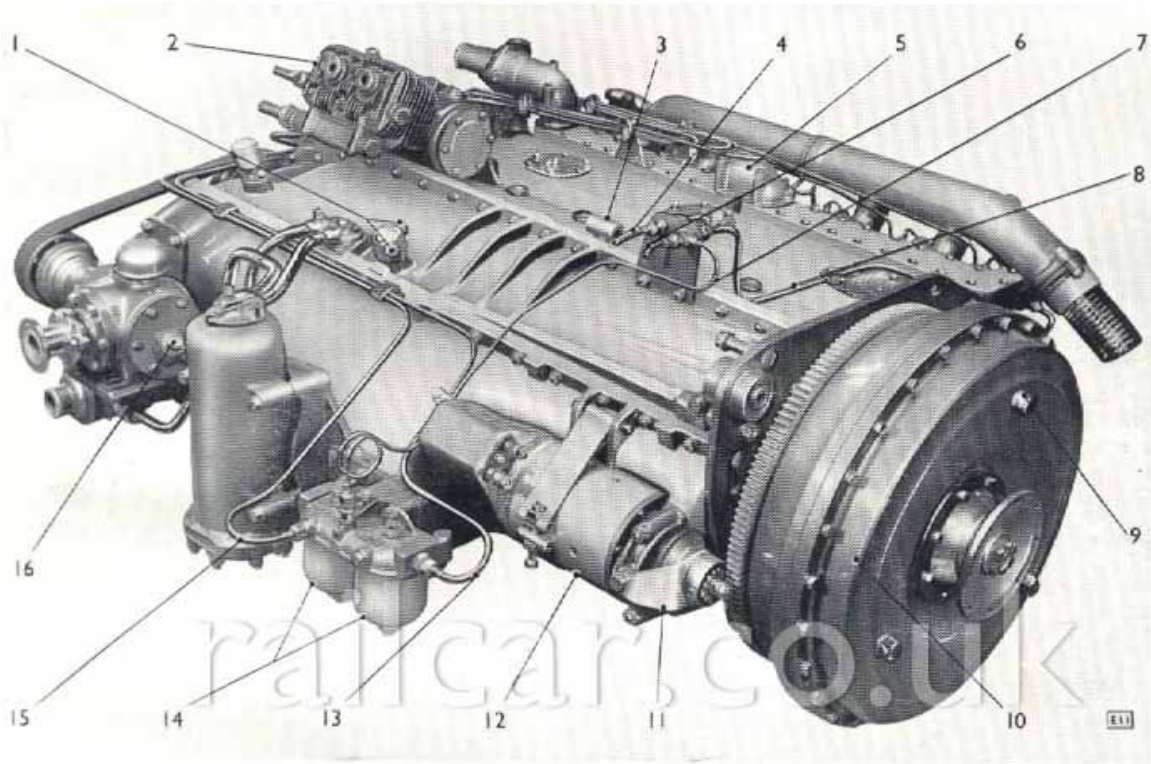


Fig. 3. Three-quarter rear view of engine.

1. CONNECTIONS FOR OIL PRESSURE SWITCHES.
2. AIR COMPRESSOR.
3. LIFTING EYE.
4. FUEL PIPE — SUPPLY TANK TO LIFT PUMP.
5. WATER CONNECTING PIPE.
6. FUEL PIPE — GALLERY PIPE TO ADAPTOR.
7. AIR VENT PIPE.
8. FUEL PIPE — ADAPTOR TO FILTER.
9. FLUID COUPLING FILLER PLUG.
10. FLUID COUPLING.
11. STARTER MOTOR PINION GUARD.
12. STARTER MOTOR.
13. FUEL PIPE — FILTER TO FUEL-INJECTION PUMP.
14. TWIN FUEL FILTERS.
15. FUEL PIPE — LIFT PUMP TO FILTER.
16. RIGHT-ANGLE FAN DRIVE UNIT FILLER PLUG.

Maximum Governed Speed (under load)	1,800 r.p.m.
Maximum Runaway Speed (no load)	2,000 r.p.m.
Starter Motor	C.A.V. Type varies according to installation. Refer to Type Plate on Starter Motor.
Air Compressor	Clayton Dewandre. Type varies according to installation. Refer to Type Plate on Compressor.
Engine Speed Indicator Generator	Smiths Gear Driven Type.
Approximate Weight (For lifting purposes)	15¾ cwts. (800 Kg.).

ENGINE PERFORMANCE CURVES (AT SEA LEVEL AND NORMAL TEMPERATURE) FOR BASIC ENGINES NOT FITTED WITH AUXILIARIES.

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.	Injection pump delivery from each element on a Hartridge type test rig per 200 pump revolutions at 600 r.p.m.	B.H.P. at 1,800 r.p.m.
Sea Level	22·2 ccs.	150
2,000 ft.	21·2 ccs.	140
4,000 ft.	20·3 ccs.	130
6,000 ft.	19·3 ccs.	120

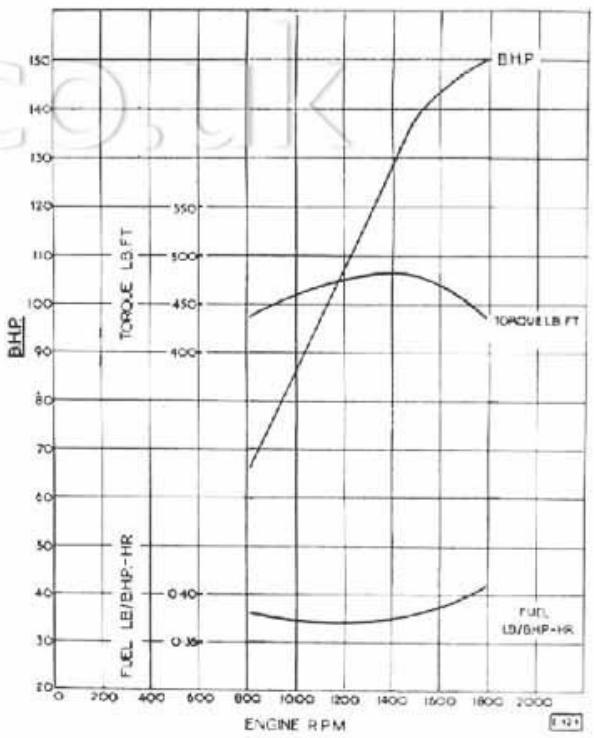


Fig. 4. Performance curves of 11·3 litre horizontal engine.

ENGINE NUMBER.

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.

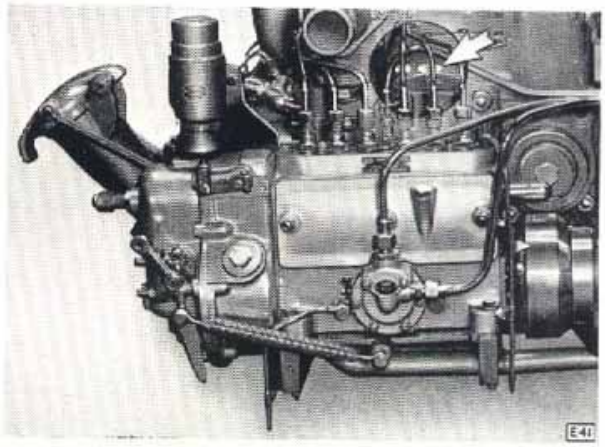


Fig. 5. Engine number stamped as indicated by arrow.

STARTER MOTOR (C.A.V.).

DATA.

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

Sect. K3. MAINTENANCE.

Important.—All new or overhauled engines should receive early attention as follows :—

Drain and refill the engine and fan drive unit and attend to items 2 and 3 in the table below.

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

1	Attend to items detailed in Section K4 and on the Lubrication Chart.
2	Tighten down engine cylinder heads (*see Section* K6).
3	Check the inlet and exhaust valve tappet clearances (*see Section* K7).
4	Remove the engine cylinder heads, pistons, etc., and carry out a general inspection.
5	Replenish the fuel tanks.
6	Check that the water header tank is full to ensure a constant supply to the radiator and engine cooling system.
7	Check the tension of the fan and water pump drive belts (*see instructions in this Section*).
8	Check for security and absence of leakage all pipes carrying oil, fuel, water, air and vacuum.
9	Remove the fuel injectors and fit a set of new or reconditioned ones (*see Sections* K24 *and* K25).
10	Examine the fuel-injection pump drive coupling rubber for deterioration and renew if necessary.
11	Check the fuel-injection pump timing (*see Section* K34).
12	Clean or renew the elements in the fuel filters and vent the fuel system (*see Sections* K20 *and* K43).
13	Check the oil pressure (*see Section* K49).
14	Examine the air compressor joints and pipe connections for leakage and tighten if necessary.
15	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 any carbon deposits from the valve discs and if necessary renew the valve springs and discs (*see Sections* K73 *and* K74).
16	Examine the starter motor commutators and brushes (*see instructions in this Section*).
17	Examine the teeth of the starter ring and if worn or damaged the ring should be repositioned or renewed (*see Section* K70).
18	Check that the thermostat valve is working satisfactorily (*see Section* K61).

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.

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 radiator drain cock is **shut** and fill the header tank.

Allow sufficient time for the radiator to fill, then top-up the header tank.

Do not run the engine until the radiator is full.

Right-angle Fan Drive Unit and Water Pump.

To adjust the drive belts.

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

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

Starter Motor.

Commutator and brushes.

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.

Sect. K4. LUBRICATION.

(See Engine Lubrication Diagram—Plate B6).

This Section should be read in conjunction with the Lubrication Chart.

Item	Attention Required.	Approximate Capacity
Air Cleaner	Remove, clean, refit and refill with oil (*see instructions in Section* K57).	7 Pints (4 litres)
Engine	Top-up or drain oil and refill (*see instructions in this Section*).	6¼ Imp. gallons (28·4 litres)
Fuel-injection Pump	Fill with oil on assembly only (*see instructions in Section* K31).	¼ Pint (0·14 litre)
Fuel-injection Pump Governor	Top-up or drain oil and refill (*see instructions in Section* K31).	¼ Pint (0·14 litre)
Right-angle Fan Drive	Top-up or drain oil and refill (*see instructions in this Section*).	½ Pint (0·28 litre)
Water Pump Spindle	Lubricate with grease gun (*see Lubrication Chart*).	—
Starter Motor	Remove plug and lubricate with oil can.	—
Engine Speed Indicator Generator	Pre-packed bearings (*packed on assembly*).	—
Fuel-injection Pump Control Rod Ball Joints	Lubricate with oil can.	—

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.

To Fill the Engine.

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

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

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.* 62).

To Fill the Right-angle Fan Drive unit.

Clean the breather and fill with fresh oil (*see Section* K62).

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.

Note.—In order to proceed with the following Sections it may be found necessary to remove the engine plug, socket and harness, if so refer to Chapter P for instructions.

Sect. K5. CYLINDER HEADS — TO REMOVE.

(See Figs. 6 and 7).

Drain the engine cooling system (*see Section* K3) 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 escape.

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.* 8).

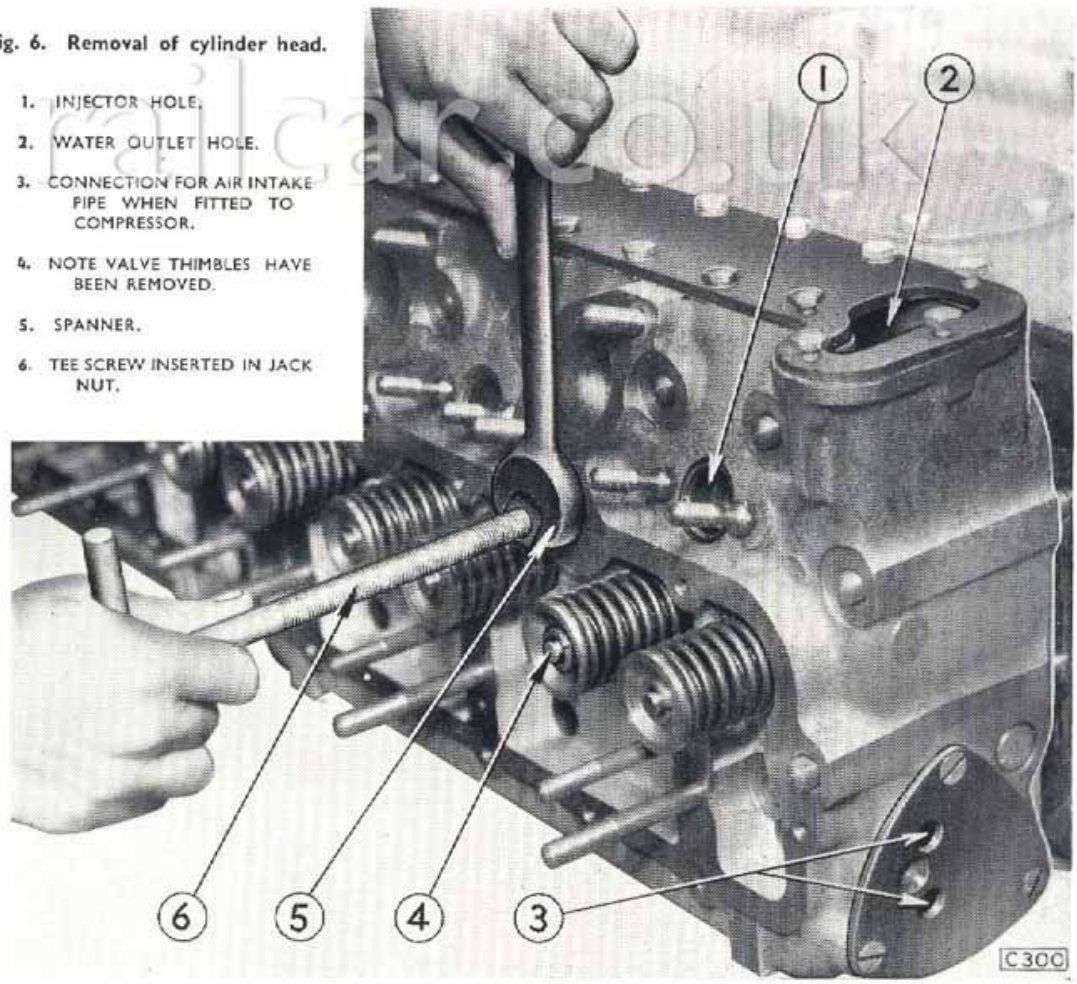
The two jack nuts are fitted to facilitate removal and are so arranged that as they are unscrewed they will lift the heads clear of the cylinders.

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.

Fig. 6. Removal of cylinder head.

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.



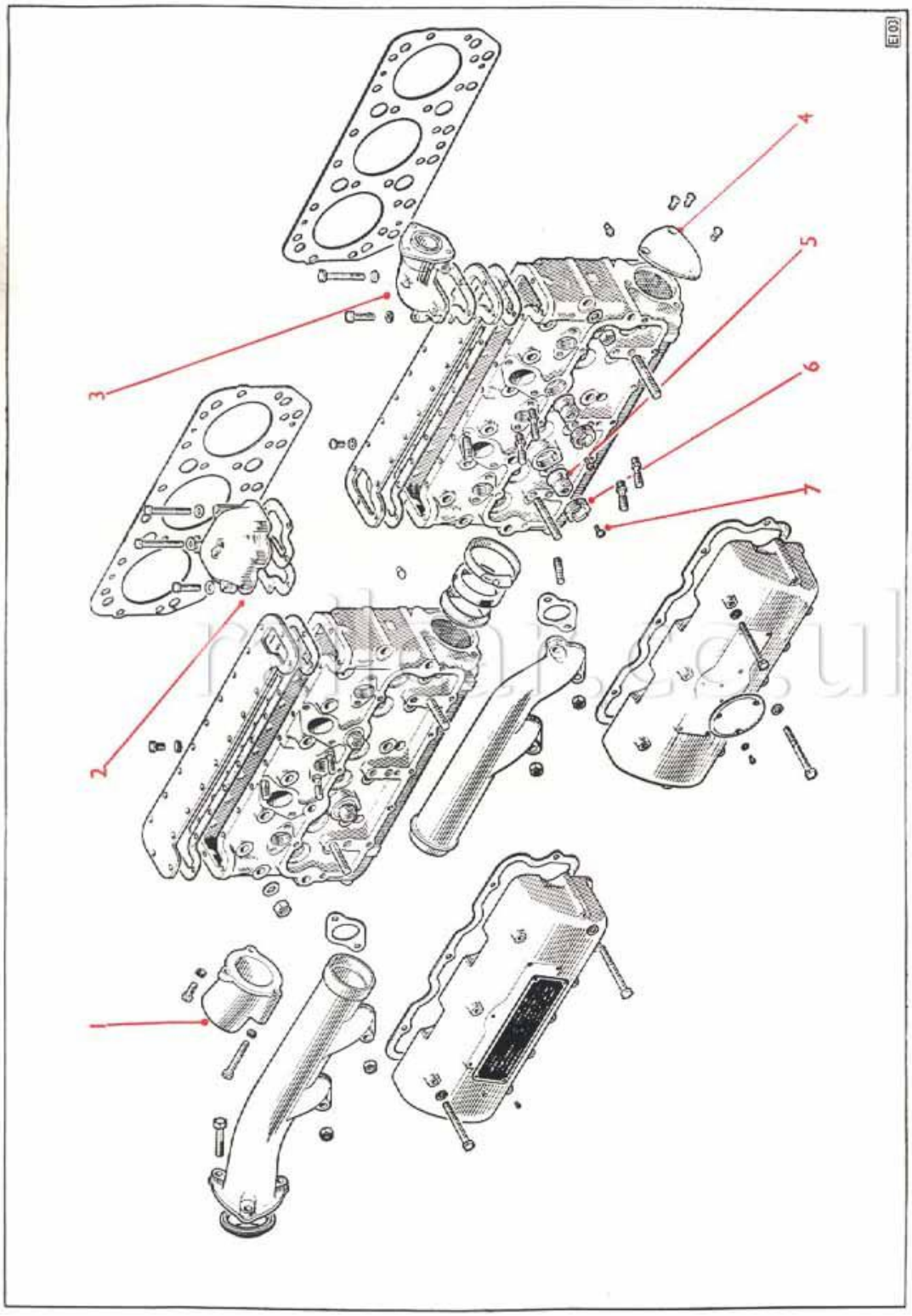


Fig. 7. Exploded view of cylinder heads.

1. AIR INTAKE ELBOW.
2. WATER CONNECTING PIPE.
3. WATER OUTLET PIPE.
4. AIR BLANKING PLATE.
5. JACKNUT.
6. JACKNUT COLLAR.
7. COLLAR RETAINING SCREW.

Note.—Certain of 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 (*see Fig.* 8).

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 6.

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.

Sect. K6. CYLINDER HEADS — TO FIT.

(*See Fig.* 8).

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.

Ensure that the sleeves are fitted beneath the jack nuts, then 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 remaining sleeves to the cylinder head holding down studs (see Note to Figure 8), 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 8 (*For torque spanner loadings, see Section* K79).

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

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

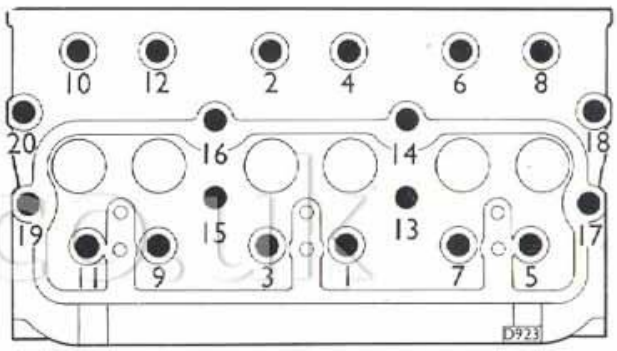


Fig. 8. Diagram showing sequence of tightening cylinder head nuts (Nos. 14 and 15 are jacknuts).

Note to Figure 8. Sleeves are fitted to the following cylinder head studs:—
Short sleeves, Nos. 1, 3, 5, 7, 9, 11, 18 and 20.
Medium sleeves, Nos. 14 and 15.
Long sleeves, Nos. 13, 16, 17 and 19.

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* K7).

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* K79).

Sect. K7. VALVE ADJUSTMENTS.

(*See Figs.* 9 *and* 11).

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.* 11) 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, slacken 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.* 9).

Tighten the fuel delivery pipe unions and injector securing nuts.

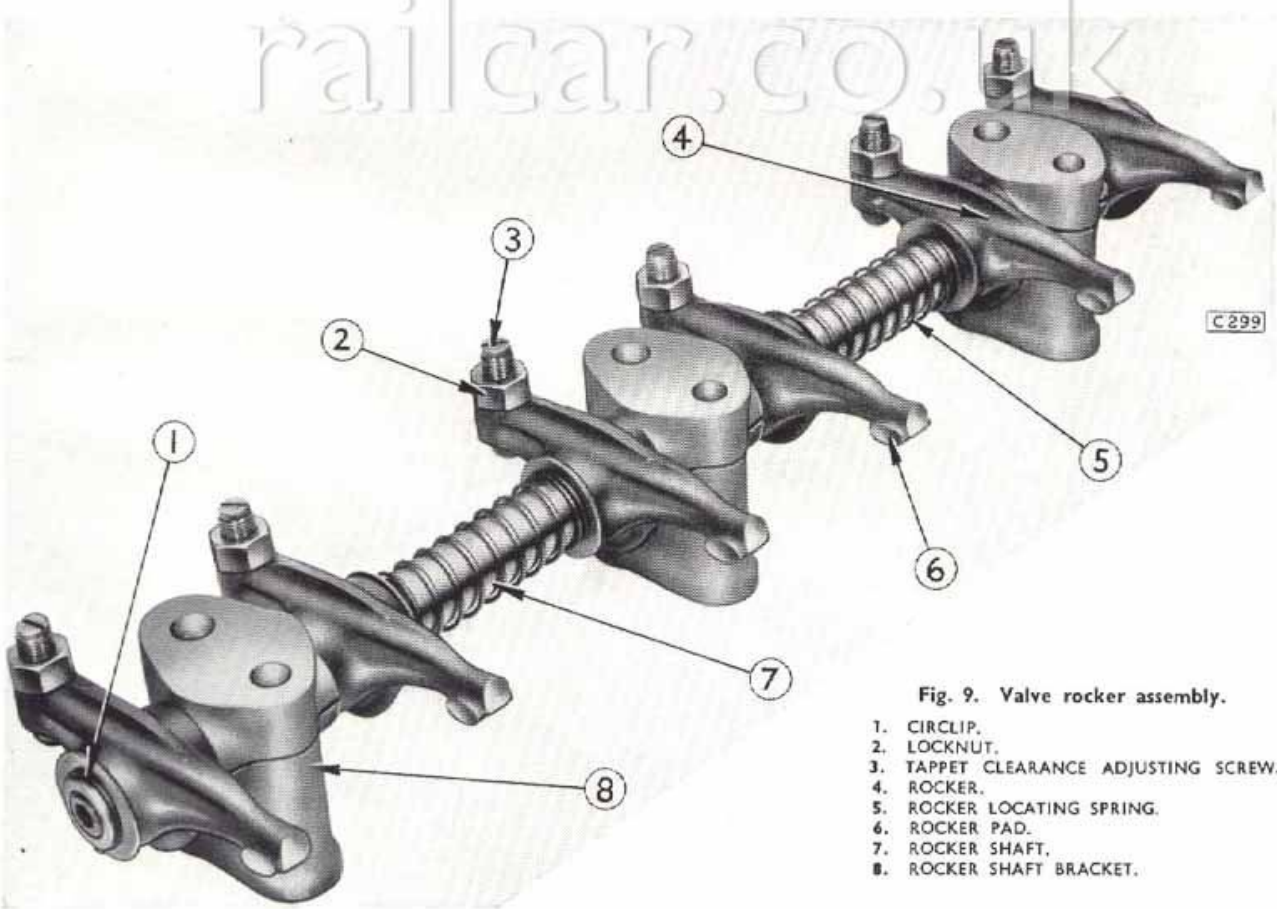


Fig. 9. Valve rocker assembly.

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

Sect. K8. VALVE SPRINGS—TO REMOVE AND FIT.

(See Figs. 6 and 10).

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 10, and remove the split collet.

When using this tool ensure that the tool adaptor is screwed down to the end of the thread on the injector securing stud.

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.

To Fit.

Check the length and tension of the valve springs.

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

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

Care should be taken when renewing valve collets and collars as these may have either a 10° or a 30° angle and must therefore be fitted in sets also ensuring that collets and collars are the same angle.

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

Check valve clearances when the engine is **HOT** (*see Section* K7).

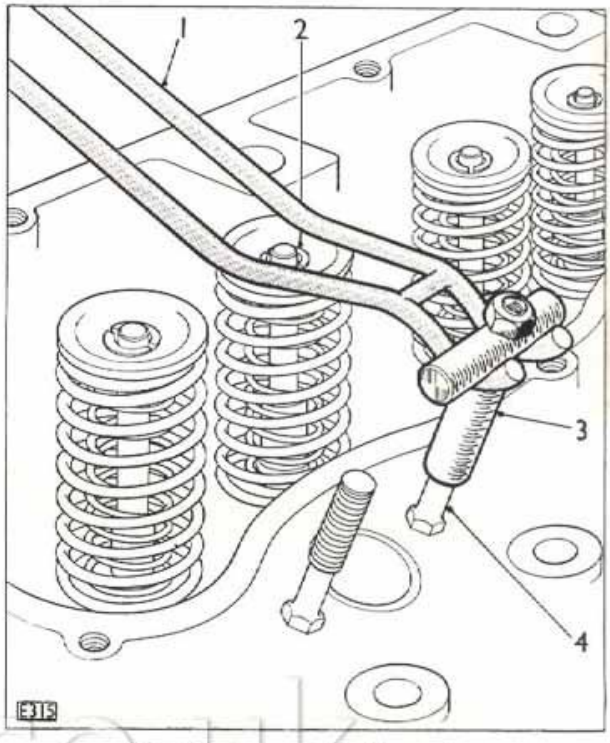


Fig. 10. Removal of valve springs.

1. TOOL FOR DEPRESSING VALVE SPRING.
2. VALVE COLLAR—NOTE VALVE THIMBLES REMOVED.
3. TOOL ADAPTOR.
4. INJECTOR SECURING STUD.

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* K78).

Sect. K9. VALVES—TO REMOVE AND FIT.

(See Fig. 10).

To Remove.

Remove the cylinder heads in accordance with Section K5.

Exhaust valves.

Remove the valve springs (*see Section* K8) and withdraw the valve.

Inlet valves.

Remove the valve springs (*see Section* K8).

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.

Sect. K10. VALVE GRINDING.

The seating angle of exhaust valves is 45° and inlet valves 30°.

Note.—On certain engines, however, the exhaust valve seating is also 30°, and it is advisable at overhaul periods to alter **all valves and seatings** to the 45° type.

The valves of each cylinder head should be kept apart and when refitted should be in the same position. The valve heads are numbered to ensure correct fitting.

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 (*see Note in "Oversize and Undersize Parts" in Section* K77).

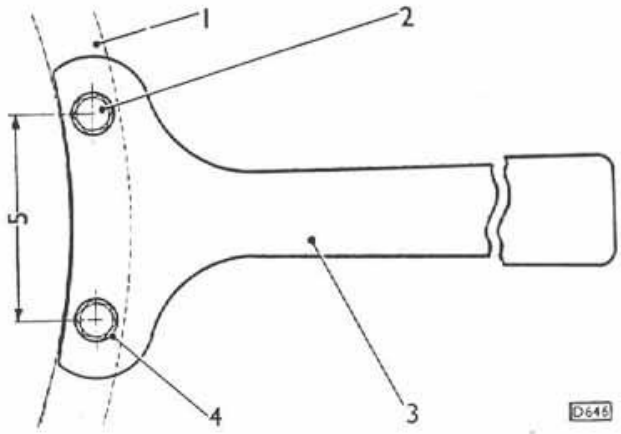


Fig. 11. Tool for turning engine crankshaft.

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

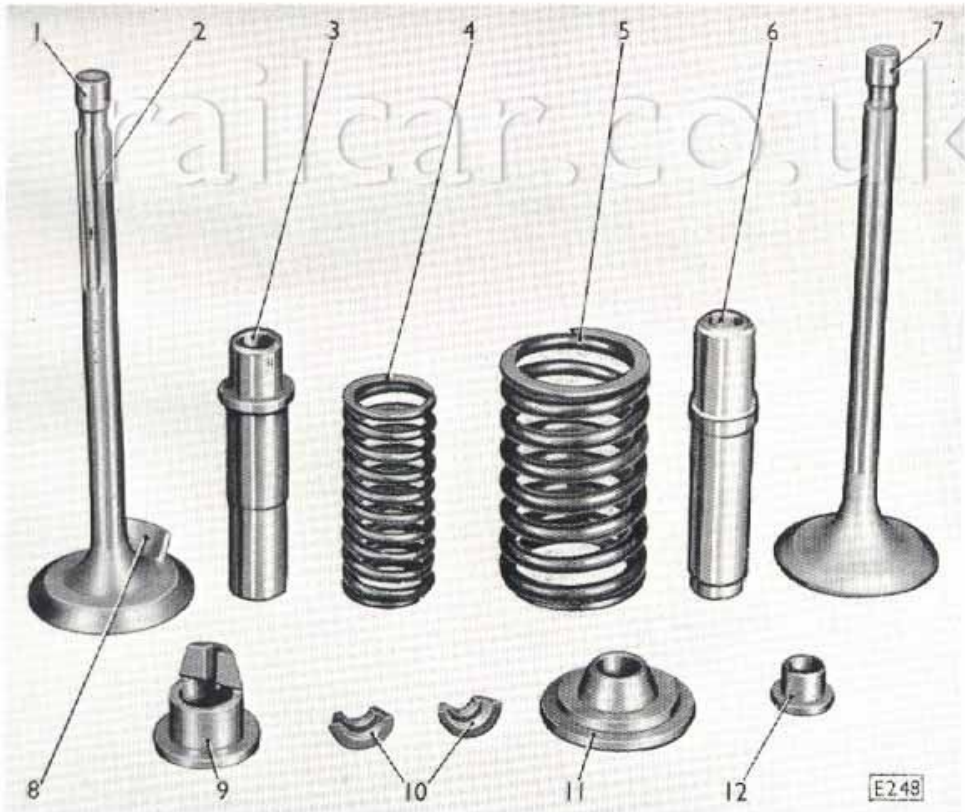


Fig. 12. Valve details.

1. INLET VALVE.
2. RESTRAINER SPLINE.
3. INLET VALVE GUIDE.
4. INNER VALVE SPRING.
5. OUTER VALVE SPRING.
6. EXHAUST VALVE GUIDE.
7. EXHAUST VALVE.
8. MASK.
9. RESTRAINER.
10. SPLIT TAPER COLLET.
11. COLLAR.
12. VALVE THIMBLE.

Sect. K11. CAMSHAFT TIMING — TO CHECK.

(*See Figs.* 13 *and* 14).

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

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

The timing pointer is fitted to the engine casing.

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

Inlet valve opens at 10° before T.D.C. which then gives 2·0 in. $\pm \frac{3}{4}$ in. before T.D.C.

The above dimensions measured on the flywheel rim are governed by the flywheel diameter which is 22·375 in. (568·315 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* K46 *and* K76).

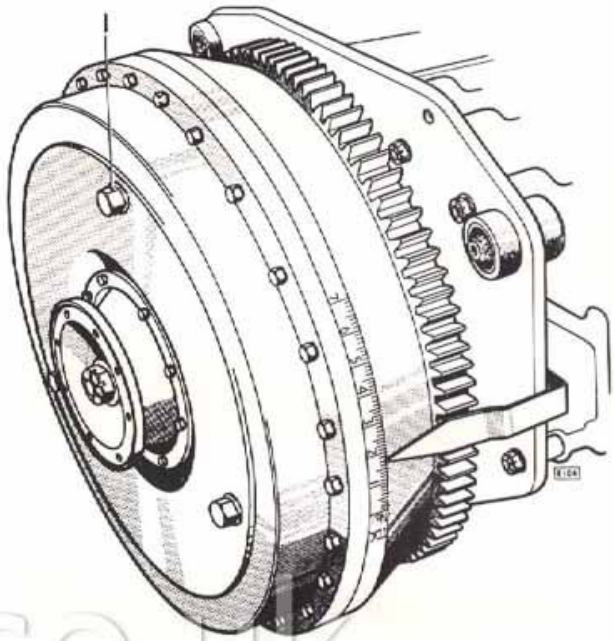


Fig. 13. Position of the flywheel for inlet valve opening.

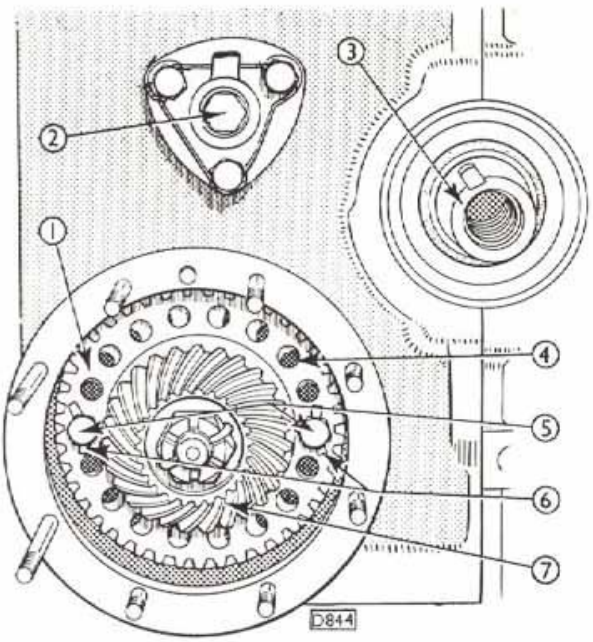


Fig. 14. Camshaft gear showing vernier adjustment.

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

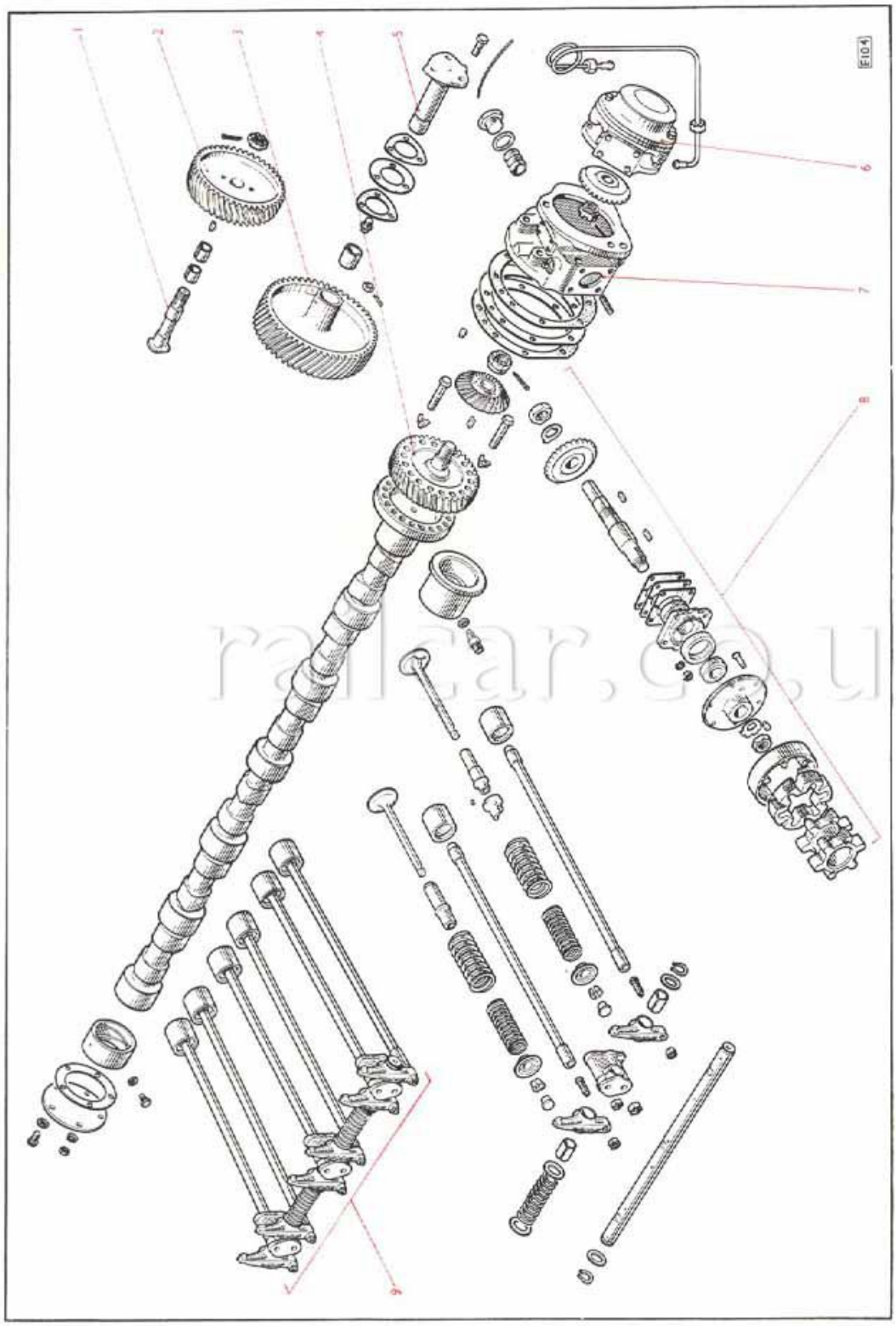


Fig. 15. Exploded view of camshaft and valve gear.

1. OIL PUMP IDLER GEAR SPINDLE.
2. OIL PUMP IDLER GEAR.
3. CAMSHAFT TIMING GEAR IDLER WHEEL.
4. CAMSHAFT GEAR.
5. TIMING GEAR IDLER WHEEL SPINDLE.
6. ENGINE SPEED INDICATOR GENERATOR.
7. BEVEL DRIVE CASING.
8. FUEL-INJECTION PUMP DRIVE.
9. VALVE ROCKER GEAR.

Check that the tappet clearances are set to 0·012 in. (0·30 mm.) with the engine **COLD** (*see Section* K7).

Set the crankshaft **so that the correct mark** on the flywheel before T.D.C. is opposite the pointer (*see Section* K7).

Remove the 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 set-screws, with tab washers, into the pairs of holes lying opposite each other, and tighten securely. Lock the set-screws with the tab washers (*see Fig.* 14).

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

Check the tappet clearances after the engine has been run (*see Section* K7).

(*For the correct backlash between the bevel gears see Section* K77).

Sect. K12. CAMSHAFT — TO REMOVE AND FIT.

(*See Fig.* 15).

To Remove.

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

Remove the valve rocker assembly and push rods (*see Section* K5) 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 (*see Sections* K46 *and* K76).

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* K46 *and* K76).

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. K13. TIMING GEAR IDLER WHEEL — TO REMOVE AND FIT.

To Remove.

Remove the crankshaft (*see Section* K14).

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 refitted (*see Section* K77).

Remove the fuel-injection pump (*see Section* K33).

Remove the speed indicator generator and the bevel gear housing (*see Sections* K46 *and* K76) 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* K77).

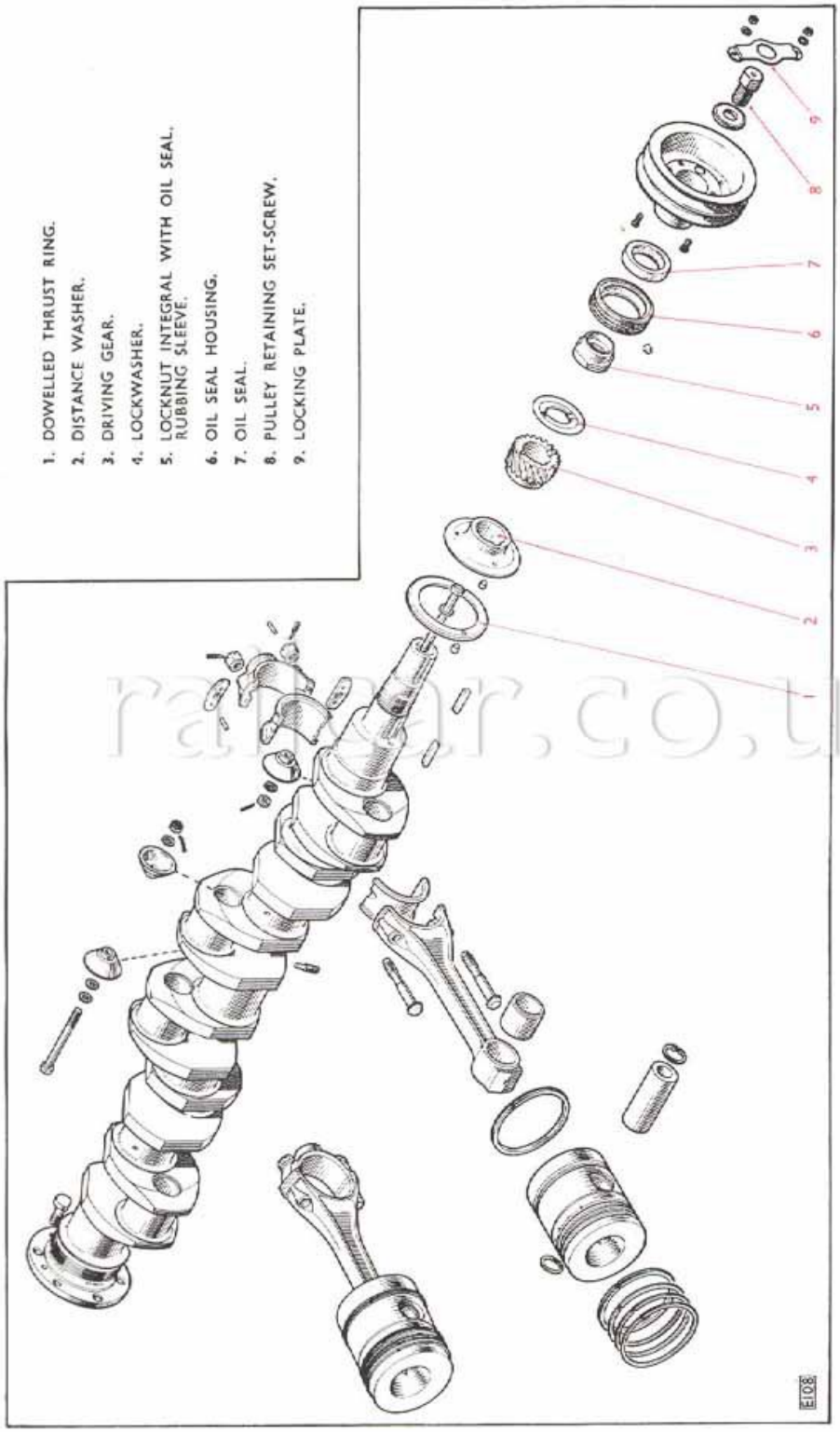


Fig. 16. Exploded view of crankshaft assembly and pistons.

Sect. K14. 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.* 18).

Remove the cylinder heads (*see Section* K5).

Slacken off the adjustment and remove the fan and water pump drive belts (*see Section* K3).

Slacken off the adjustment and remove the right-angle fan drive belt (*see Section* K3).

Remove the pulley from the end of the crankshaft (*see Section* K58).

Remove the belt tensioner and mounting bracket.

Remove the water pump (*see Section* K58).

Remove the sump (*see Section* K48).

Unscrew the oil pressure relief valve adjusting spindle until it clears the body of the oil pump (*see Section* K49).

Remove the pistons and connecting rods (*see Section* K16).

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* K55), 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.* 18).

The crankshaft has hollow pins and drilled journals forming passages through which oil passes under pressure from the oil pump. When the engine is overhauled the end caps must be removed and the sludge cleaned out. **This is very important** (*see Fig.* 17).

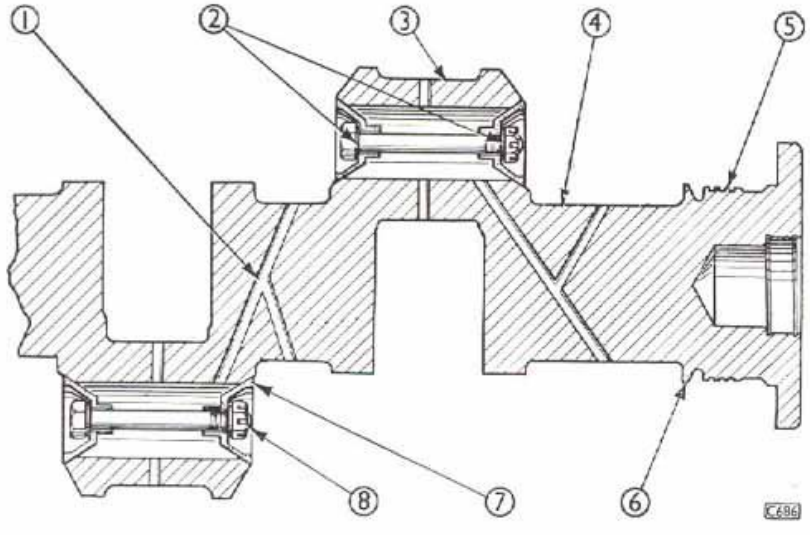


Fig. 17. Diagram of crankshaft oil passages.

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.

Sect. K15. CRANKSHAFT — TO FIT.

(See Figs. 17 and 18).

If the crankshaft driving gear has been removed, assemble the front end of the crankshaft as follows *(See Fig. 18)*:—

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 lockwasher, ensuring that it locates in the slots provided in the face of the driving gear, then fit the locknut, with the sleeve outwards, and tighten.

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 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. 17)*.

Fit the crankshaft and its bearings. *(For table of clearances, see Section* K77). 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* K79).

Fit the connecting rods and pistons *(see Section* K19) and check the protrusion of the pistons above the engine casing at T.D.C. The heads of the pistons should be flush with the top face of the engine casing ± 0·005 in. (0·127 mm.), but if the engine casing has been "flashed" a shim of equal thickness to the amount removed by "flashing" must be fitted under each cylinder head gasket. *(For shims available see Section* K78).

Fit the oil pump *(see Section* K55) 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* K77).

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

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

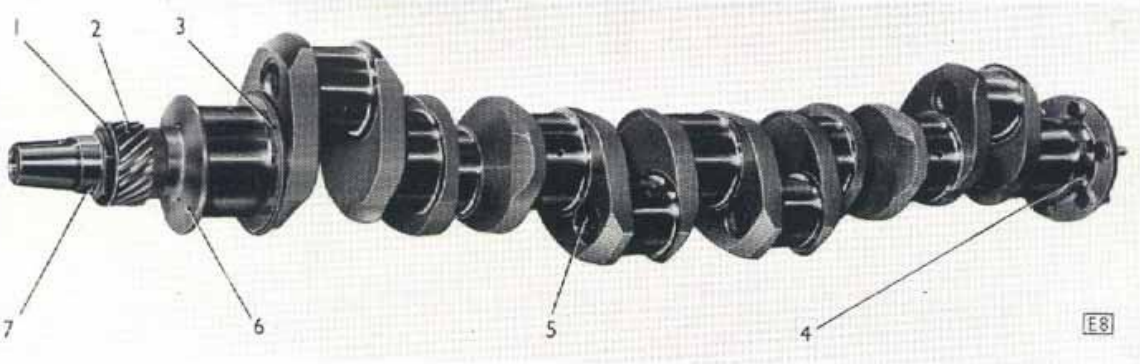


Fig. 18. Crankshaft assembly.

1. LOCKWASHER.
2. DRIVING GEAR.
3. DOWELLED THRUST RING.
4. GROOVES FORMING OIL SEAL.
5. OILWAY END CAPS.
6. THRUST WASHER.
7. LOCKNUT INTEGRAL WITH OIL SEAL RUBBING SLEEVE.

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 (ii).—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.* 54).

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 water pump and right-angle fan drive belts (*see Section* K3).

Time the camshaft in accordance with Section K11 and the fuel-injection pump in accordance with Section K34, and check the oil pressure (*see Section* K49).

Sect. K16. PISTONS AND CONNECTING RODS — TO REMOVE.

(*See Figs.* 21 *and* 55).

Drain the oil from the engine and remove the sump (*see Sections* K4 *and* K48).

Remove the cylinder heads and gaskets (*see Section* K5) 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 pipe to the oil pressure switch connection (*see Fig.* 55).

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.* 19 *and* 55).

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

To avoid damage to the crankpins, it is advisable to cover the connecting rod bolts with protective tubes.

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

Notes.—

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

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

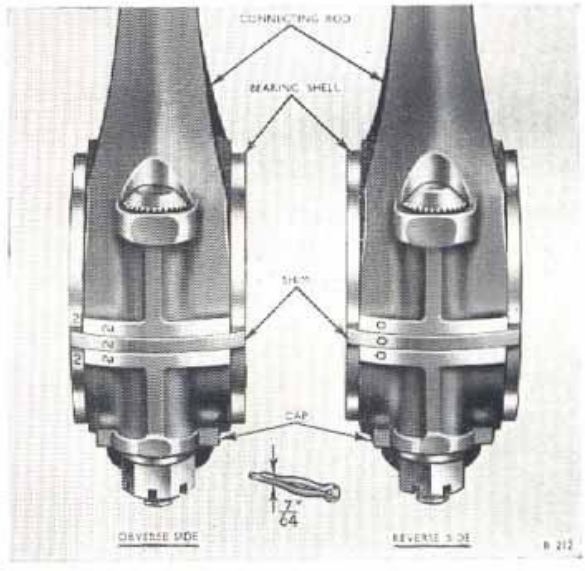


Fig. 19. Connecting rod big-end showing markings and special type split pin for bolts.

Sect. K17. GUDGEON PINS.

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

Sect. K18. PISTON RINGS.

(*See Figs.* 20 *and* 21).

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.* 21).

The top compression ring is chromium plated and all other rings are of plain cast iron. **On certain engines,** however, all piston rings are of plain cast iron (*for gap clearances see Section* K77).

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

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

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

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

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.* 20). 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.

Sect. K19. PISTON AND CONNECTING RODS — TO FIT.

(*See Figs.* 19, 20, 21 *and* 22).

Refit the parts in the reverse order to their removal (*see Section* K16).

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

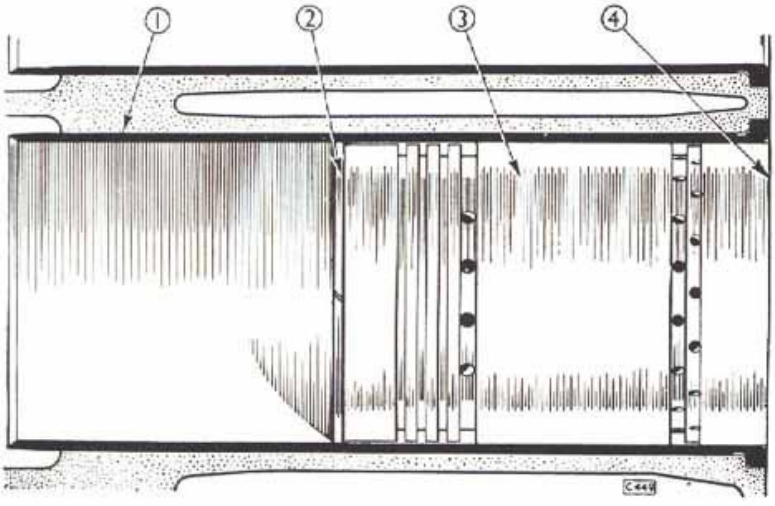


Fig. 20. Method of measuring piston ring gap.

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

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 K77. 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 K77.

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.

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 K77. **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.**

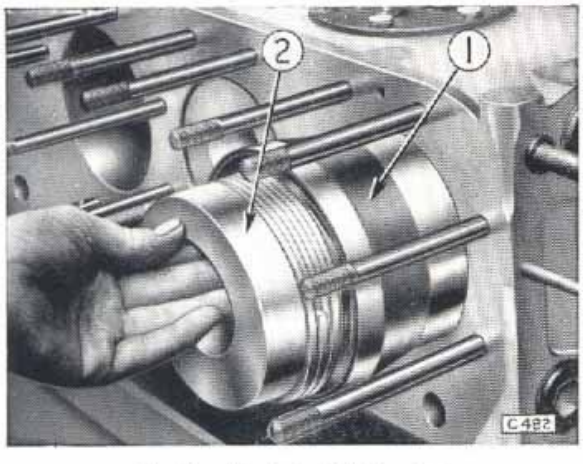


Fig. 22. Method of fitting pistons.

1. PISTON FITTING TOOL. 2. PISTON.

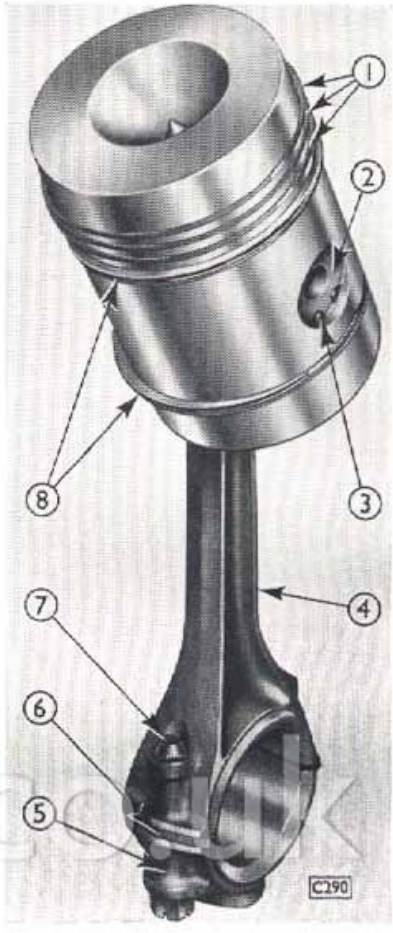


Fig. 21. Piston and connecting rod.

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

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* K79).

In order that the rings may be entered into the bore without difficulty, the guide tool shown in Figure 22 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.**

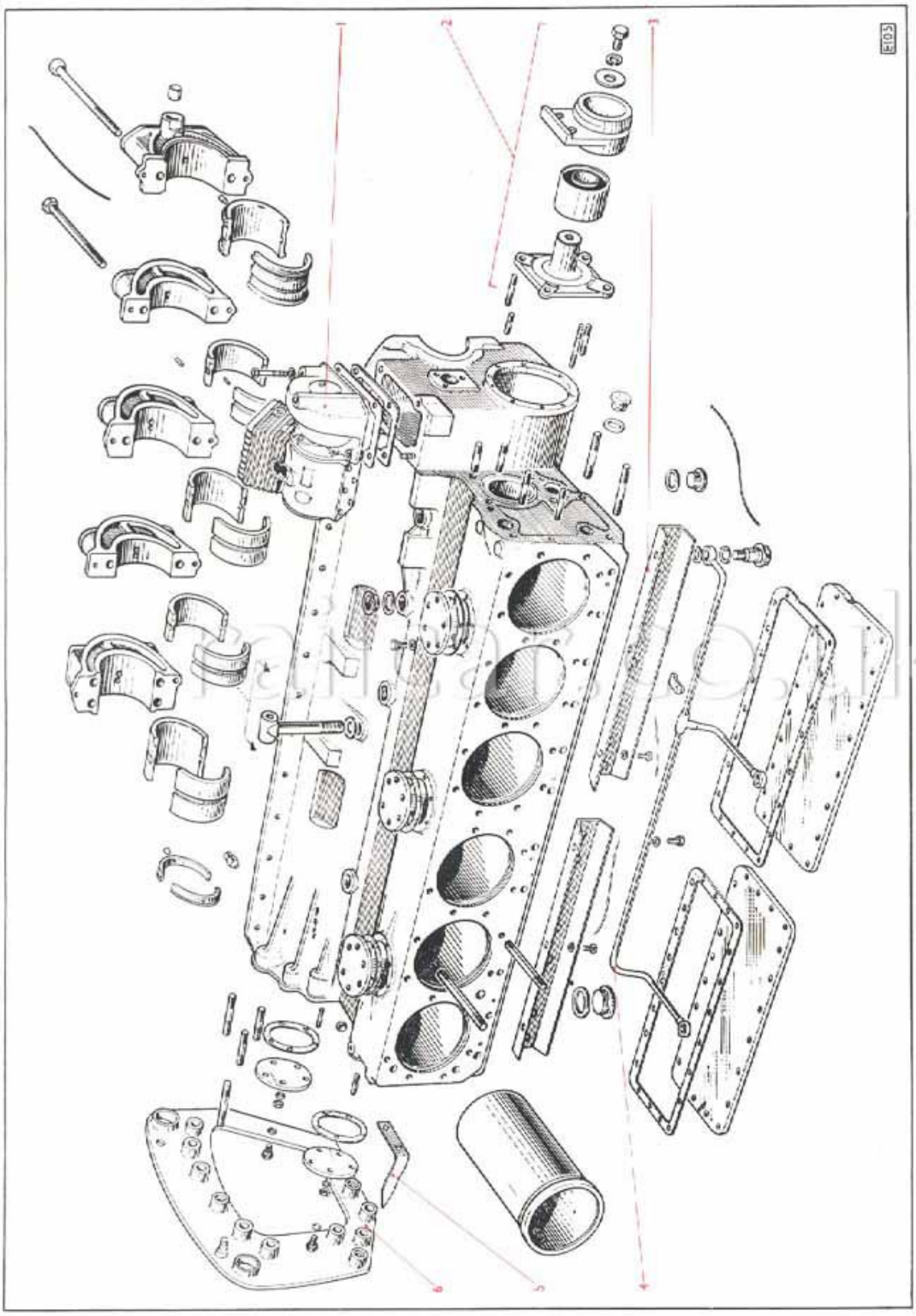


Fig. 23. Exploded view of mono-block and main bearings.

1. AIR COMPRESSOR DRIVE HOUSING.
2. ENGINE FRONT SUPPORT.
3. PUSH ROD GUIDES.
4. ROCKER GEAR OIL FEED PIPE.
5. TIMING POINTER.
6. ENGINE REAR SUPPORT BRACKET.

FUEL-INJECTION SYSTEM.

Sect. K20. 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.* 43 *and* 45) and operate the hand priming lever of the fuel-lift pump (*see Fig.* 42) 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. K21. FUEL INJECTORS — DESCRIPTION.

(*See Fig.* 24).

C.A.V. Type NLA 102.

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

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

A disc filter is contained in the fuel inlet connection.

Sect. K24. 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.

Note.—A rubber sealing washer, inserted in the top of the injector sleeve, has been introduced to obviate the possibility of corrosion ; remove and retain the washer when lifting out the injector.

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. K25. FUEL INJECTORS — TO FIT.

Insert the rubber sealing washer (if fitted) (*see note in Section* K24) and place the injector in the copper sleeve in the cylinder head. 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 K20.

Sect. K26. 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 dismantling,** proceed as follows :—

Clean any carbon from the exterior of the nozzle with the brass wire brush shown in Figure 26.

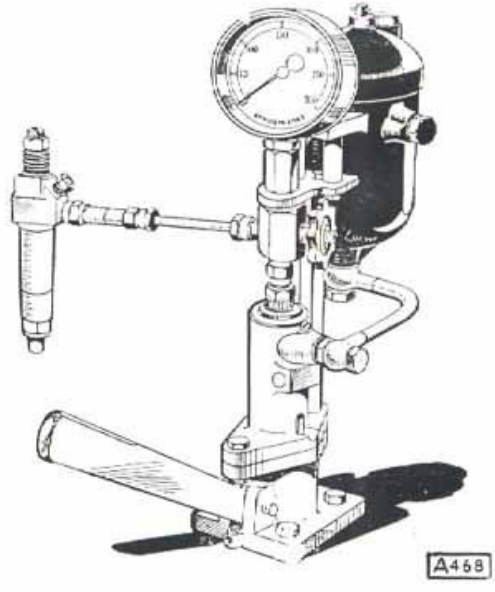


Fig. 25. C.A.V. hand-testing pump for injectors.

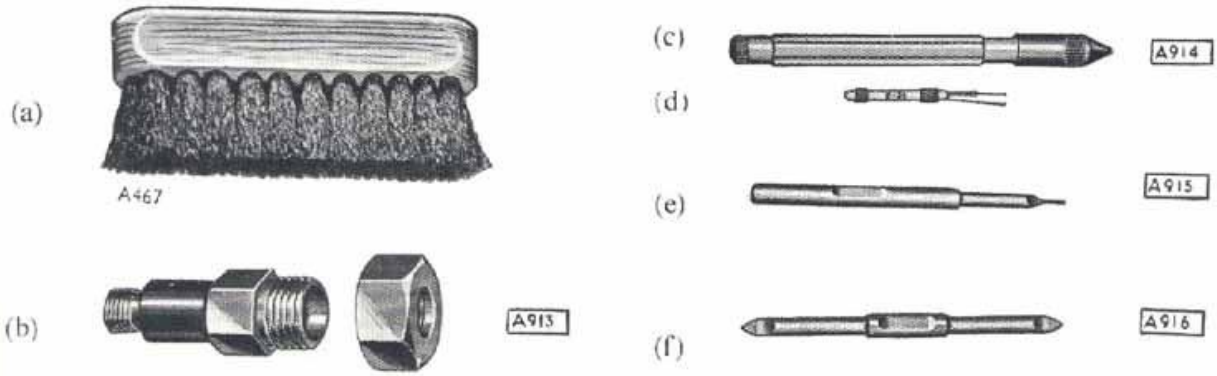


Fig. 26. Injector cleaning tools.

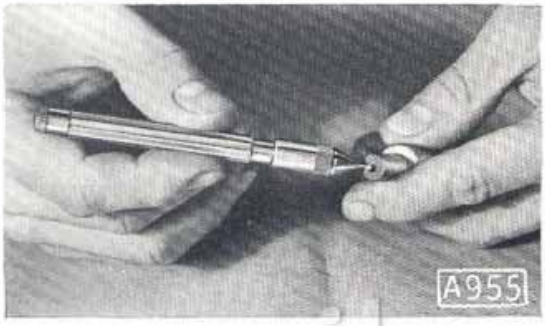


Fig. 27. Pricking out nozzle holes.

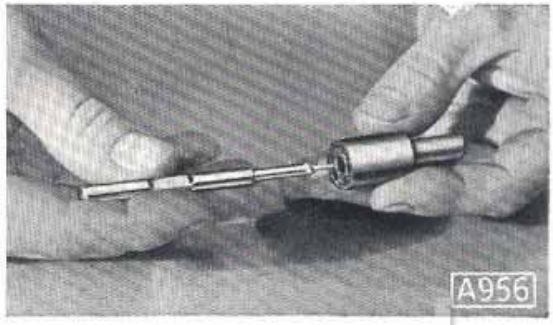


Fig. 28. Tool for cleaning nozzle tip.

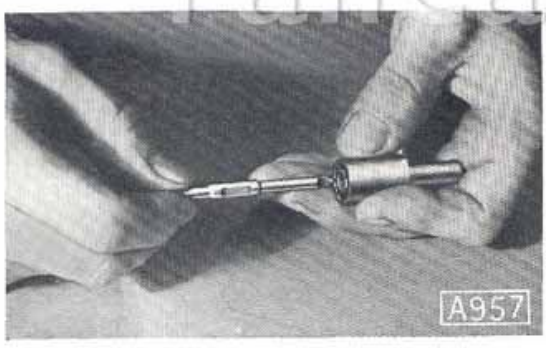


Fig. 29. Tool for cleaning nozzle seat.

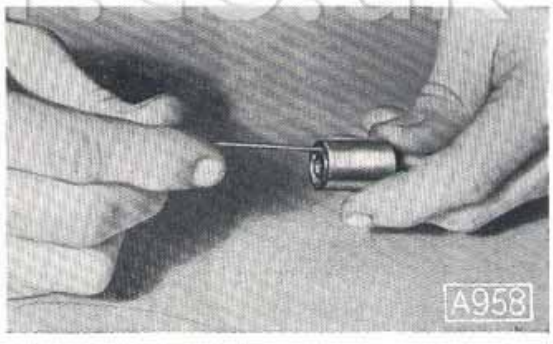


Fig. 30. Cleaning nozzle fuel passages.

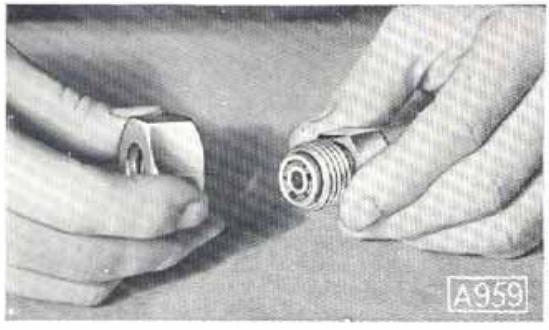


Fig. 31. Nozzle inserted in adaptor for washing.

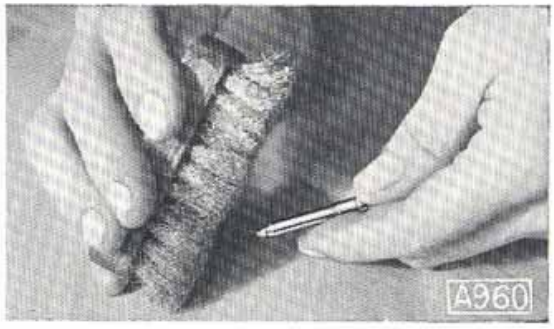


Fig. 32. Brass wire brush for cleaning nozzle valve.

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.* 25).

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

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

To test the injector :—

Fit the injector to the hand-testing pump.

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

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

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

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

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

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

If the pressure is incorrect, unscrew the end cap on top of the injector, slacken the locknut on the adjusting screw or spring cap, and screw **in** the adjusting screw or spring cap to **increase** the pressure, or **out** to **decrease** the pressure. Tighten the locknut and check again (*see Fig.* 24).

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. K27. FUEL INJECTORS — TO DISMANTLE.

(*See Figs.* 24 *and* 33).

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 33. 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.

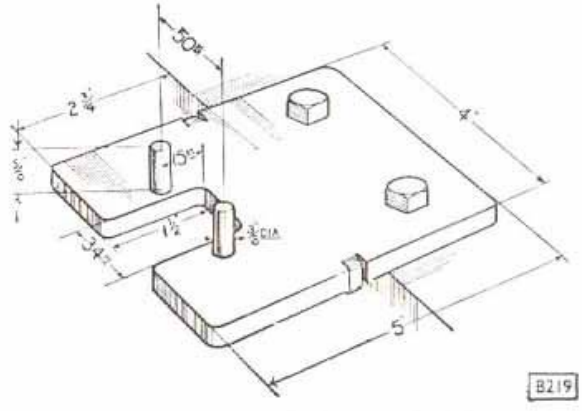


Fig. 33. Tool for holding injectors when dismantling.

Then proceed as follows:—

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

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

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

Withdraw the nozzle valve from the body. The valve must be a smooth sliding fit in the nozzle body and the bearing surface of the valve must be smooth and free from scores, scratches or discoloration. Clean in accordance with Section K29. 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. K28. 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 26 to 32 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.* 25) to facilitate the testing and setting of nozzles should be available, together with a cleaning outfit (*see Fig.* 26).

Sect. K29. FUEL INJECTORS — CLEANING, ASSEMBLING AND SETTING.

All tools and letter references in this Section refer to the nozzle cleaning outfit illustrated in Figures 26 to 32.

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 K27.

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.* 27) 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.* 28) 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.* 29) with the brass tool (f), then clean out the three fuel passages in the **nozzle body** with a piece of **brass** wire (*see Fig.* 30).

Place the **nozzle body** (*see Fig.* 31) in the adaptor and nut (b), and wash it out **backwards** with clean fuel oil under pressure from the hand-testing pump (*see Fig.* 25). 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.* 32) 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.* 24). 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.* 24); 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* K26), 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. K30. FUEL-INJECTION PUMP SETTING.

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

The fuel flow for normal and altitude settings are given in Section K2.

Sect. K31. FUEL-INJECTION PUMP — MAINTENANCE.

(*See Fig.* 36).

C.A.V. Type NL6F90/60.

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

Lubrication.

Cam chamber.

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

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

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

Governor casing.

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.* 36).

Refit and tighten the plugs.

Adjustments.

Idling.

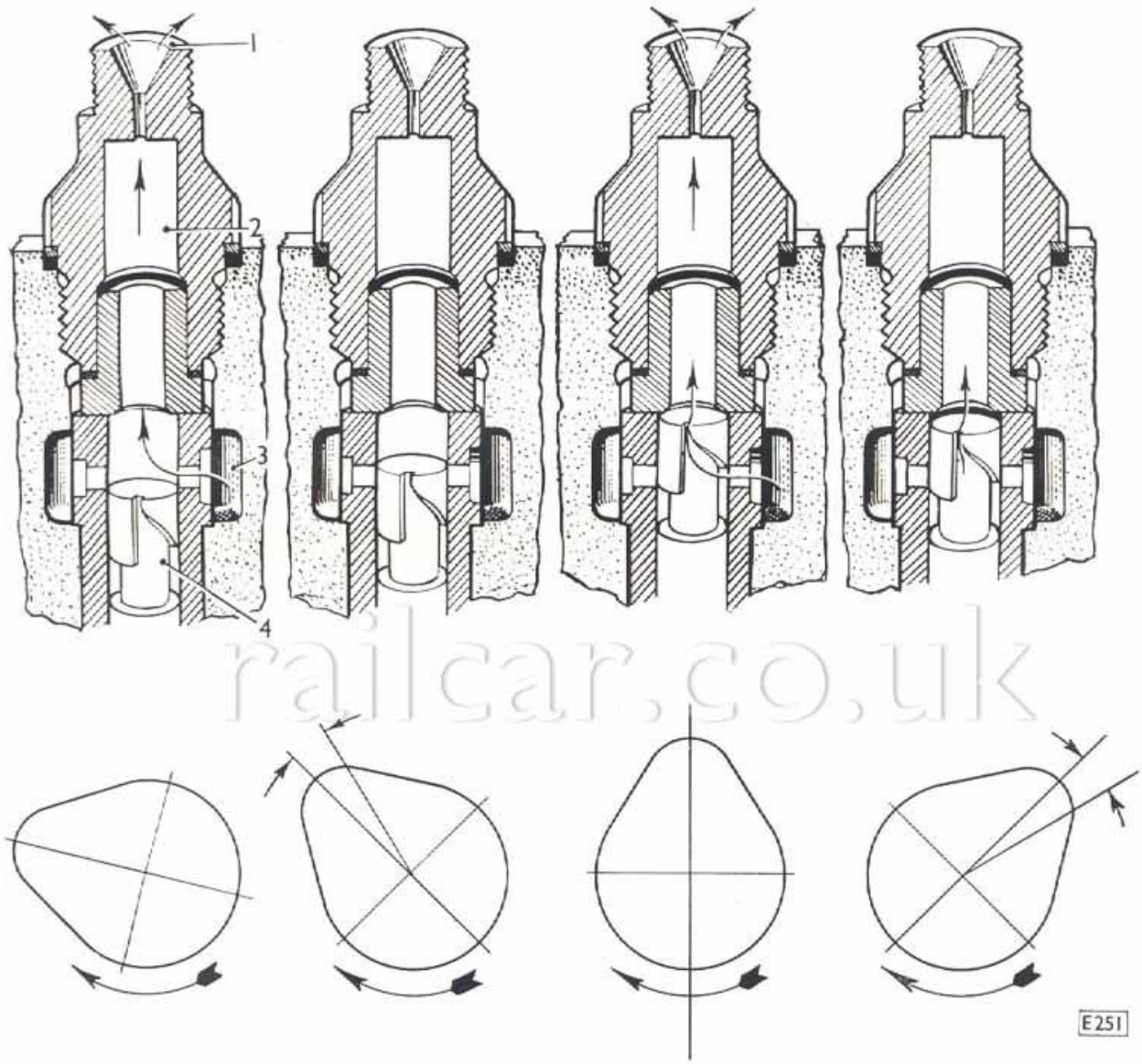
For instructions on adjusting for idling refer to Section K45.

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.**



FUEL FLOWING FROM TOP OF DELIVERY VALVE HOLDER. INJECTION PUMP PLUNGER ON UPWARD STROKE — FUEL SPILL PORT UNCOVERED.

POINT OF 1st SPILL CUT-OFF. INJECTION PUMP PLUNGER JUST COVERING FUEL SPILL PORT ON UPWARD STROKE— FUEL FLOW HAS JUST CEASED. (POINT AT WHICH PUMP IS TIMED).

FUEL FLOWING FROM DELIVERY VALVE HOLDER. INJECTION PUMP PLUNGER AT TOP OF ITS STROKE.

POINT OF 2nd SPILL CUT-OFF. INJECTION PUMP PLUNGER ON DOWNWARD STROKE ABOUT TO COVER SPILL PORT GIVING 2nd FUEL STOPPAGE.

Fig. 34. Diagram showing C.A.V. fuel-injection pump cycle of operation. (Note delivery valve is removed).

1. DELIVERY VALVE HOLDER.
2. FUEL.
3. FUEL SUPPLY.
4. PUMP PLUNGER.

Sect. K22. 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. K23. 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* K20). 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.

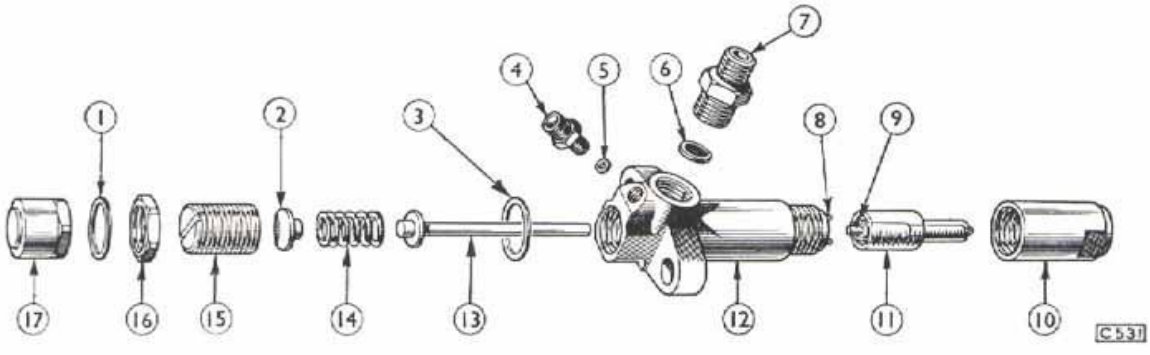


Fig. 24. Exploded view of injector.

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.

Sect. K32. FUEL-INJECTION PUMP TROUBLES.

(*See also Sections* K22 *and* K23).

To prevent dirt reaching the injectors, it is imperative that all the fuel filters should be cleaned regularly and thoroughly (*see Sections* K29 *and* K43).

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.* 36), with the engine stopped and operating the priming level of the fuel-lift pump (*see Fig.* 36) 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.* 35). 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.* 36 *and* 41). 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:—

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

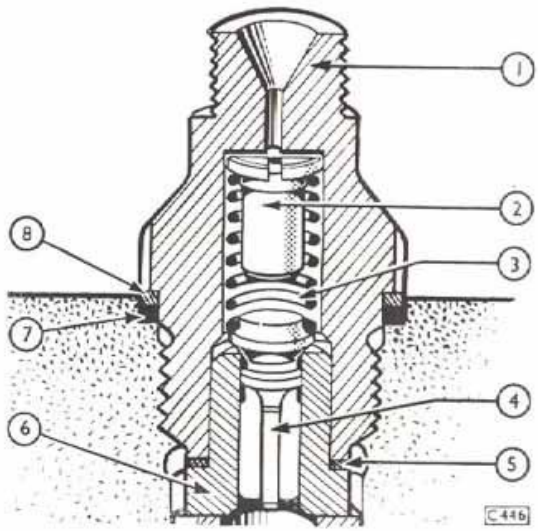


Fig. 35. Section through "N" type pump delivery valve assembly.

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

Remove the locking device by unscrewing the central nut and lifting off the locking plates (*see Fig.* 36).

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

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

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

Tighten the delivery valve holder and secure it with the locking device, then connect the fuel delivery pipe (*for torque spanner loading see Section* K79). When all delivery valves have been checked in this manner, with the engine stopped, vent the fuel system (*see Section* K20).

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. 2019/1 and 2044/1.

Sect. K33. 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).

Disconnect the control rod from the control lever.

Disconnect the cables from the engine stop solenoid.

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.

Note.—If the fuel-injection pump is to be returned to B.U.T. for overhaul, remove the engine stop solenoid and bracket.

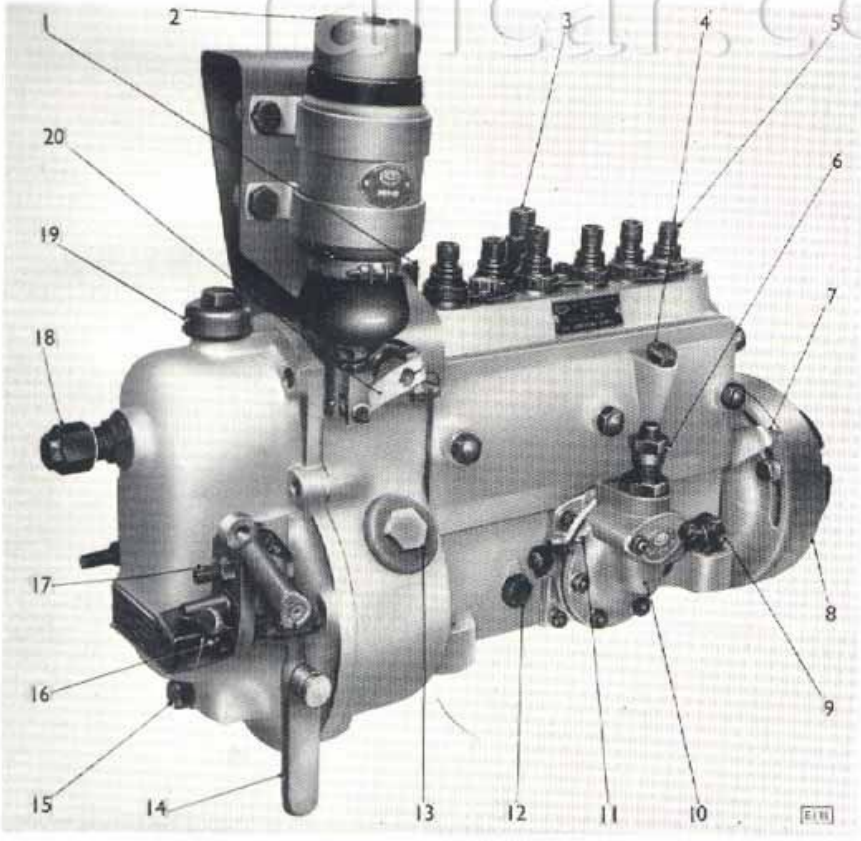


Fig. 36. Fuel-injection pump.

1. AIR VENT.
2. ENGINE STOP SOLENOID.
3. FUEL INLET.
4. OIL FILLER PLUG.
5. DELIVERY VALVE HOLDER.
6. FUEL OUTLET (FUEL-LIFT PUMP).
7. TIMING POINTER.
8. FLYWHEEL.
9. FUEL INLET (FUEL-LIFT PUMP).
10. FUEL-LIFT PUMP.
11. PRIMING LEVER.
12. OIL LEVEL PLUG.
13. GOVERNOR OIL FILLER PLUG AND ACCESS TO GOVERNOR SPRINGS.
14. THROTTLE CONTROL LEVER.
15. GOVERNOR OIL LEVEL PLUG.
16. MAXIMUM DELIVERY ADJUSTING SCREW AND STOP (SEALED).
17. IDLING SPEED ADJUSTING SCREW AND STOP.
18. IDLING DAMPER STOP.
19. BREATHER.
20. STOP LEVER.

Sect. K34. FUEL-INJECTION PUMP—TO FIT AND TIME.

(*See Fig.* 37 *and also Section* K36).

Reverse the procedure given in Section K33 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 free 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: —

5¼ in. (27°) before T.D.C.

[Flywheel dia. 22·375 in. (568·315 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.* 36).

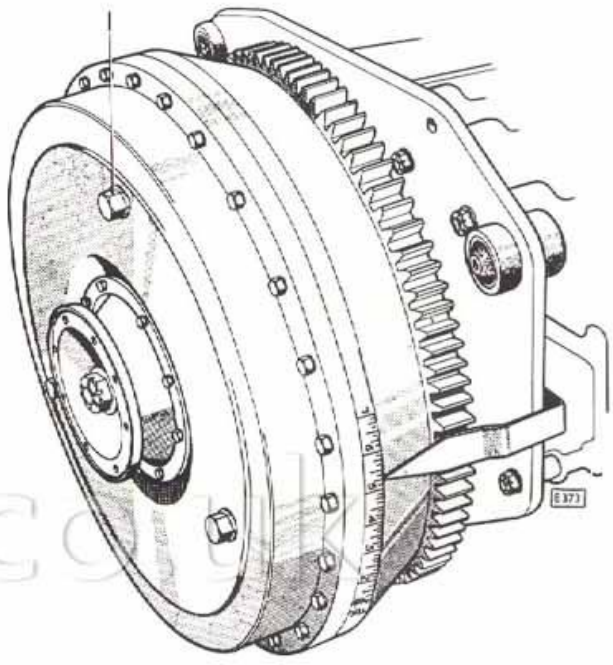


Fig. 37. Position of engine flywheel for fuel-injection pump spill cut-off point and (1) for filling or topping-up.

Sect. K35. 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 34. 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* K24).

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 slackening the central nut (*see Fig.* 36).

Unscrew No. 1 delivery valve holder and lift out the spring guide, spring and delivery valve (*see Fig.* 35).

Refit the delivery valve holder and put the spring

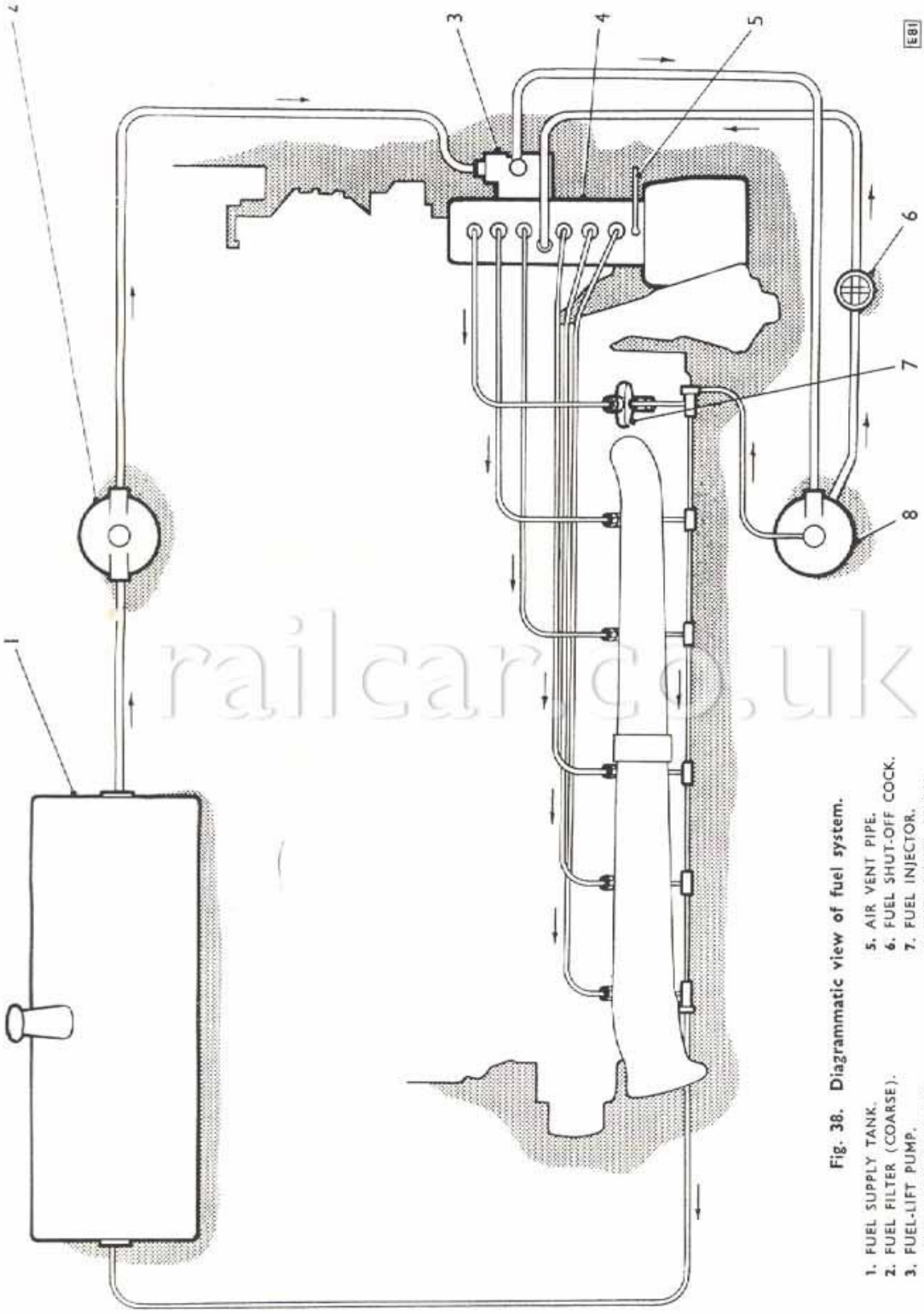


Fig. 38. Diagrammatic view of fuel system.

1. FUEL SUPPLY TANK.
2. FUEL FILTER (COARSE).
3. FUEL-LIFT PUMP.
4. FUEL-INJECTION PUMP.
5. AIR VENT PIPE.
6. FUEL SHUT-OFF COCK.
7. FUEL INJECTOR.
8. FUEL FILTER (FINE).

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 an **anti-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.* 34).

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 34.

Sect. K36. 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 K34 is not applicable.

At the point of fuel spill cut-off for No. 1 cylinder (*see Section* K35) **the pointer on the engine casing** should be opposite the correct mark on the engine flywheel (*see Section* K34) at the end of the compression stroke (*see Fig.* 37) 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. Slacken the two set-screws on the slotted portion of the pump coupling and turn it in an **anti-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 slacken the two set-screws on the slotted portion of the coupling.

Turn the pump flywheel in a **clockwise** direction until fuel flows from No. 1 delivery valve holder, then turn it in an **anti-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* K79). Examine all unions for fuel leaks, correct if necessary, and vent the system (*see Section* K20).

Sect. K37. 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* K33).

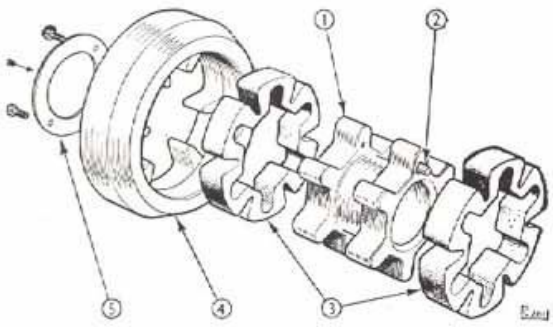


Fig. 39. Exploded view of fuel-injection pump flywheel assembly.

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

Unscrew the two set-screws securing the flywheel to the driving flange and remove the flywheel (*see Fig.* 36).

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 39.

Refit the two set-screws and washers.

Fit and time the fuel-injection pump (*see Section* K34).

Sect. K38. FUEL-INJECTION PUMP FLYWHEEL ASSEMBLY —TO DISMANTLE AND ASSEMBLE.

To Dismantle.

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

Remove the resilient 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 Fig. 39.

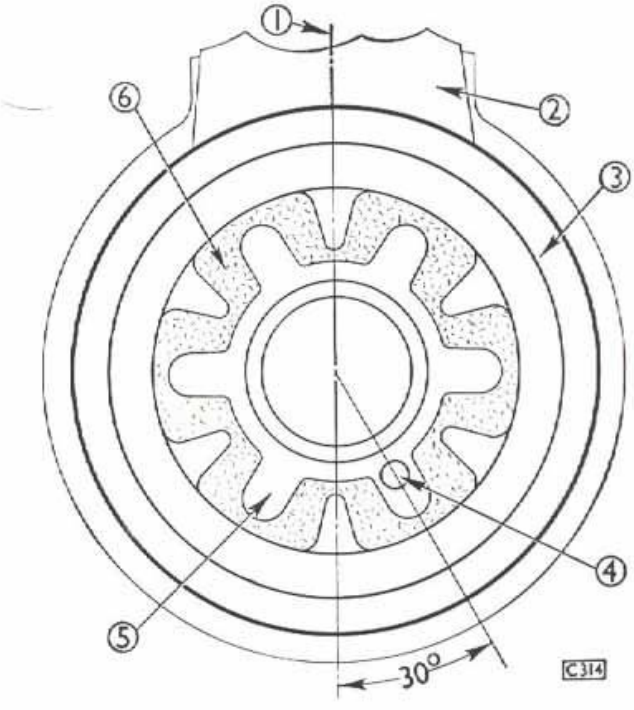


Fig. 40. Diagram showing position of dowel when flywheel is fitted to the fuel-injection pump.

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.

Sect. K39. FUEL-LIFT PUMP — DESCRIPTION.

(*See Figs.* 41 *and* 42).

C.A.V. Type DFP3/2S.

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

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

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

An air bell is fitted to the fuel-lift pump, when the fuel pipe run from the fuel filter to the lift-pump exceeds 3 ft., to ensure that the fuel flows smoothly at each pumping stroke (*see Fig.* 41).

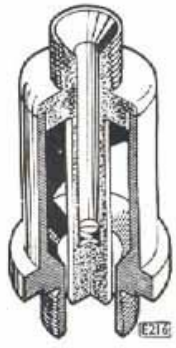


Fig. 41. Fuel-lift pump air bell.

Sect. K40. FUEL-LIFT PUMP — TO REMOVE AND FIT.

(*See Figs.* 41 *and* 42).

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 the inlet and outlet fuel pipes.

Vent the fuel system (*see Section* K20).

Sect. K41. FUEL-LIFT PUMP — TO DISMANTLE.

(*See Figs.* 41 *and* 42).

Remove the fuel-lift pump from the fuel-injection pump (*see Section* K40).

Unscrew the small cheese-headed screw and pull the priming lever off its spindle.

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

Remove the lockwire, unscrew the operating lever fulcrum screw and remove the operating lever together with its return spring.

Unscrew from the diaphragm cover the delivery valve body and lift out the delivery valve ball. Unscrew the ball seating and remove the inlet valve spring and disc.

Remove the six nuts and lift off the diaphragm cover.

Lift the diaphragm assembly off the studs, taking care not to damage the fabric of the diaphragm, and take out the diaphragm spring.

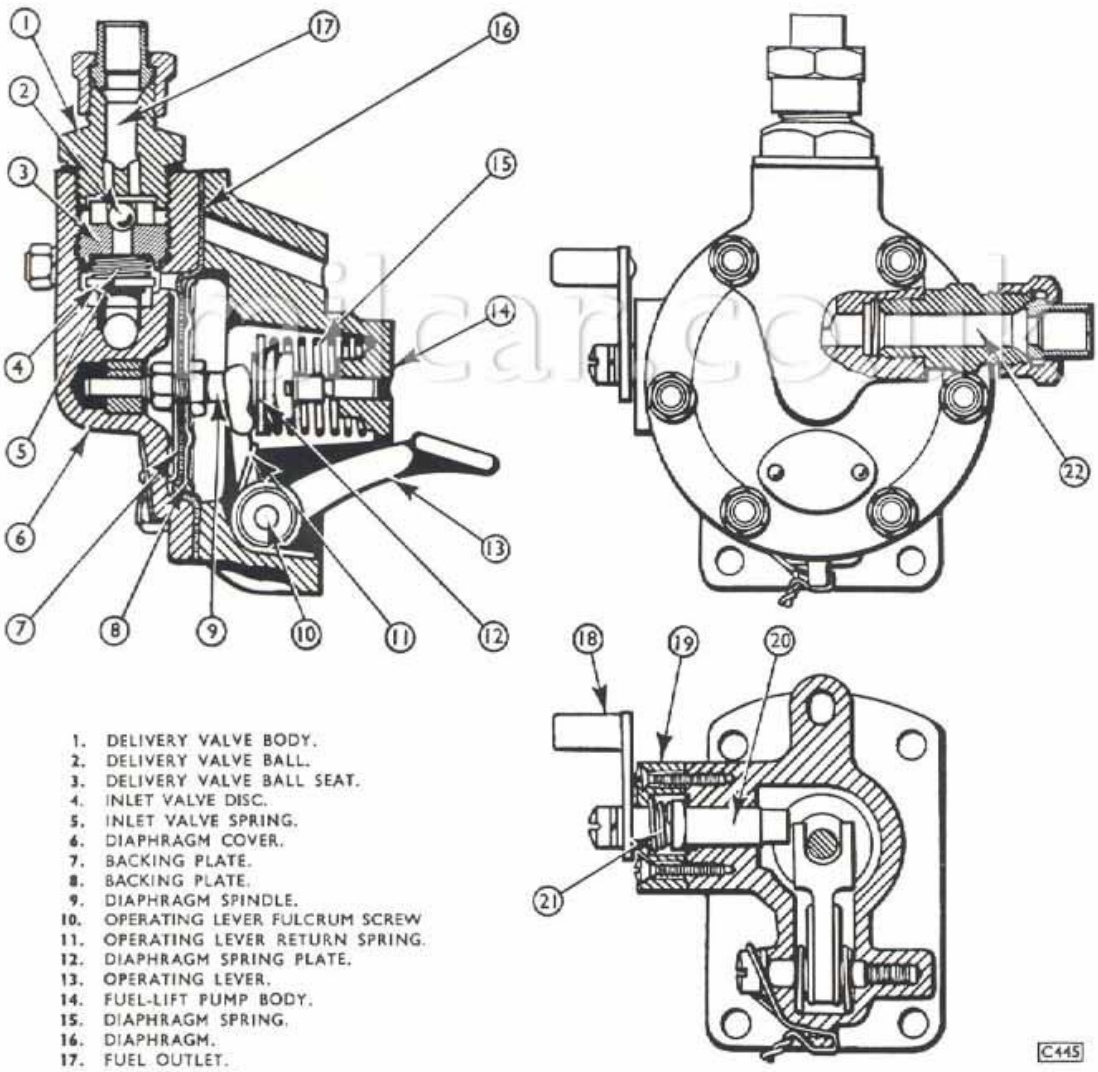
The diaphragm and spindle assembly must be considered as a unit and should not be taken apart.

Sect. K42. FUEL-LIFT PUMP—TO ASSEMBLE.

Reverse the procedure given in Section K41 noting the following points:—

To enable the priming lever spindle to be pushed right home, the operating lever should be depressed slightly.

When refitting the priming lever spindle stop plate, ensure that the priming lever spring is correctly located, with one end in the slot on the spindle stop plate and the other in the hole in the spindle shoulder.



1. DELIVERY VALVE BODY.
2. DELIVERY VALVE BALL.
3. DELIVERY VALVE BALL SEAT.
4. INLET VALVE DISC.
5. INLET VALVE SPRING.
6. DIAPHRAGM COVER.
7. BACKING PLATE.
8. BACKING PLATE.
9. DIAPHRAGM SPINDLE.
10. OPERATING LEVER FULCRUM SCREW
11. OPERATING LEVER RETURN SPRING.
12. DIAPHRAGM SPRING PLATE.
13. OPERATING LEVER.
14. FUEL-LIFT PUMP BODY.
15. DIAPHRAGM SPRING.
16. DIAPHRAGM.
17. FUEL OUTLET.
18. PRIMING LEVER.
19. PRIMING LEVER STOP PLATE.
20. PRIMING LEVER SPINDLE.
21. PRIMING LEVER SPRING.
22. FUEL INLET.

Fig. 42. Sections through C.A.V. fuel-lift pump.

Sect. K43. MAIN FUEL FILTERS — MAINTENANCE.

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

Paper Element Type Filter (*see Figs.* 43 *and* 44).

Note.—The internal construction of each unit forming the twin filter is the same as the single element model shown in Figure 43.

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.

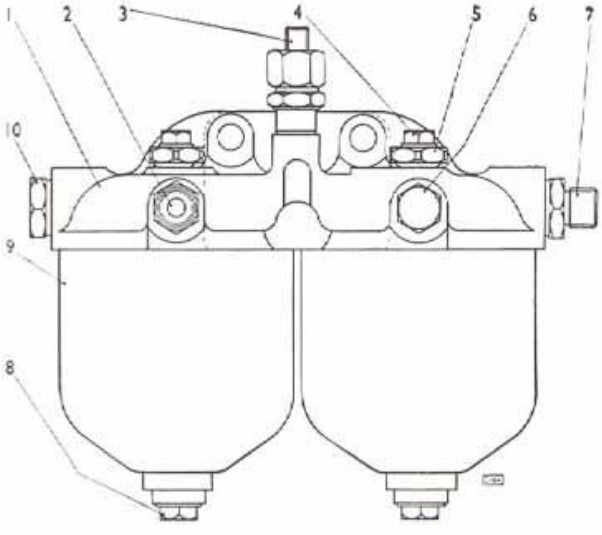


Fig. 43. Arrangement of fuel filter (C.A.V.)—twin paper element type.

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

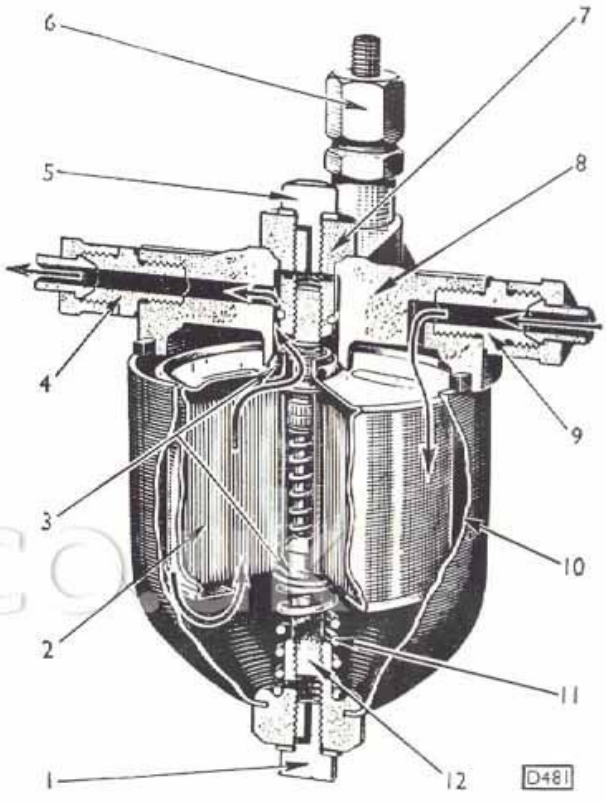


Fig. 44. Section of fuel filter (C.A.V.)—paper element type.

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

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 in 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* K20).

Cloth Element Type Filter (*see Fig.* 45).

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.

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* K20).

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.* 45).

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.

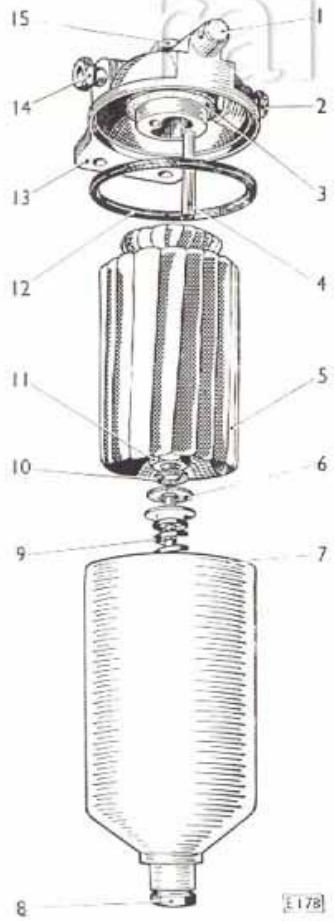


Fig. 45. Exploded view of main fuel filter (C.A.V. cloth element type).

1. AIR RELEASE SCREW
2. FUEL OUTLET.
3. FELT WASHER.
4. SUCTION PIPE.
5. FILTER CLOTH.
6. FELT WASHER.
7. FILTER BOWL.
8. BOTTOM PLUG.
9. SPRING.
10. FELT INSERT.
11. FILTER CLOTH SECURING NUT.
12. RUBBER WASHER.
13. TOP COVER.
14. FUEL INLET.
15. CENTRE NUT.

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

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

Invert the cage and, starting from one corner of the cloth, pleat this around the cage. The pleats should be about ½ in. (13mm.) wide and uniform (*see Fig.* 45). 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.

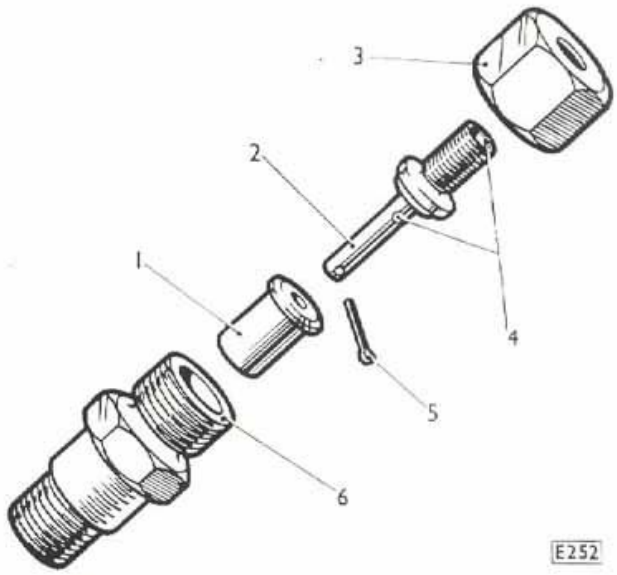


Fig. 46. Exploded view of air release valve.

1. VALVE.
2. VALVE GUIDE.
3. UNION NUT.
4. AIR RELEASE HOLE.
5. SPLIT PIN.
6. ADAPTOR.

Sect. K44. 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.

In all cases fuels should be to British Standard Specification.

Sect. K45. ENGINES — TO ADJUST FOR IDLING AND MAXIMUM SPEEDS.

(*See Figs.* 47 *and* 48).

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 on the fuel pump, which should then be locked by tightening the locknut. This operation limits the total angle through which the fuel pump lever can travel, the maximum speed stop having been set and sealed when the engine was tested.

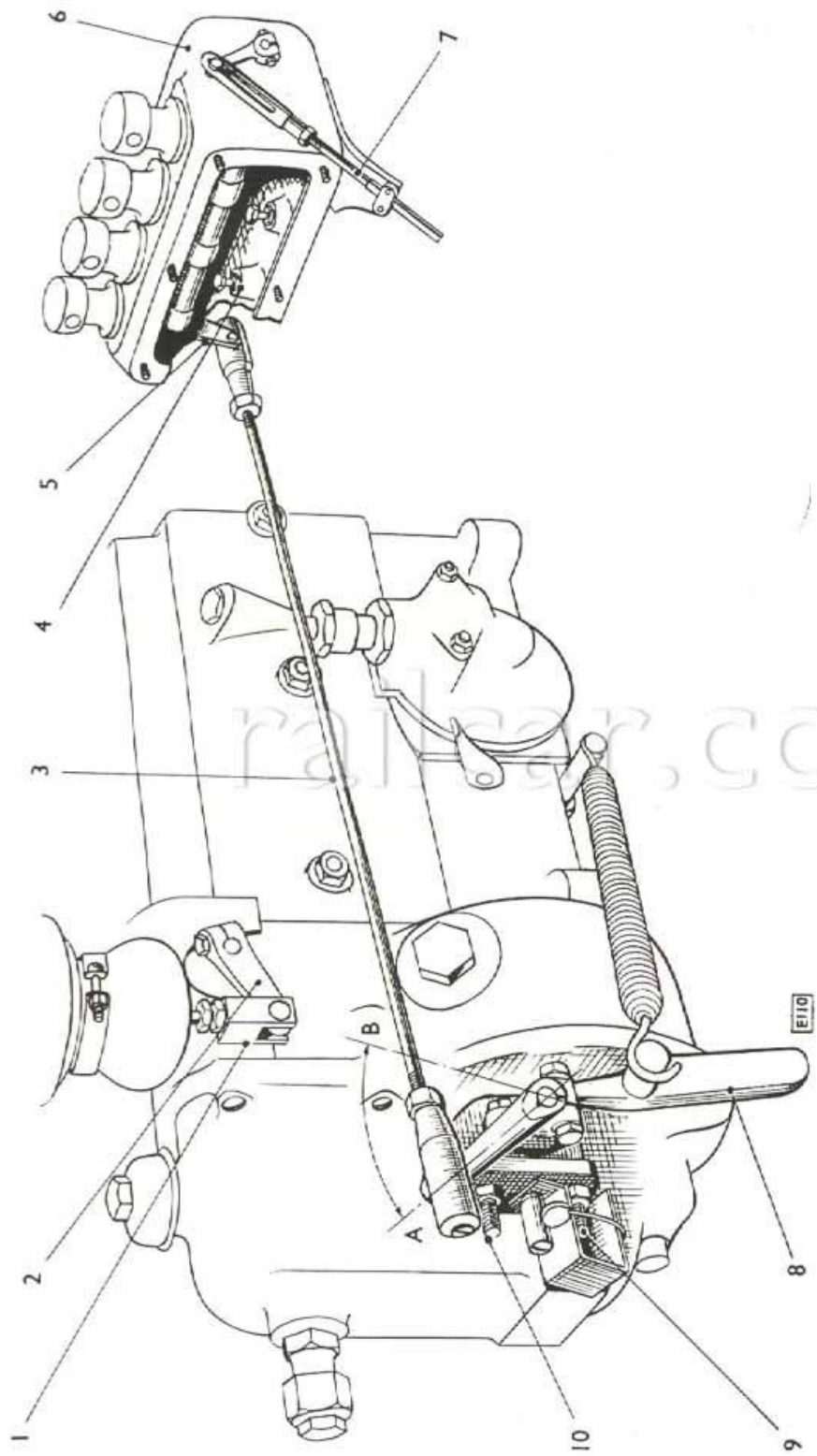


Fig. 47. Throttle motor linkage.

A. IDLING SPEED POSITION.
B. MAXIMUM SPEED POSITION.
1. ENGINE SHUT-DOWN SOLENOID LINKAGE.
2. STOP LEVER.
3. THROTTLE CONTROL ROD.
4. THROTTLE MOTOR ADJUSTING SCREW.
5. THROTTLE MOTOR CONTROL LEVER.
6. THROTTLE MOTOR.
7. HAND CONTROL.
8. FUEL PUMP CONTROL LEVER.
9. MAXIMUM SPEED ADJUSTING SCREW AND STOP (SEALED).
10. IDLING SPEED ADJUSTING SCREW AND STOP.

Ensure that the shut-down solenoid linkage is connected to the stop lever on the fuel pump and check that when operated the solenoid will stop the engine.

Ensure also that the switch contacts in the solenoid break the main operating current after operation. If necessary, make corrections by means of the adjustable fork-end.

Attach the throttle control rod to the fuel pump lever and to the control lever on the throttle motor.

With the throttle motor in the idling position, adjust the control rod to obtain idling position on the fuel pump and check that the engine does not stall when engaging gear.

Note.—The fuel pump idling stop and **not** the throttle motor, should determine the idling position.

With air applied and the throttle motor in the quarter throttle position, adjust the quarter throttle adjusting screw until the engine speed just starts to increase.

Note.—This adjustment, i.e., quarter throttle, will at first slightly increase the engine speed to approximately 550–600 r.p.m. at which speed it will remain during further adjustment until it suddenly accelerates to full speed.

The optimum setting is a **steady** speed just below the runaway position.

With the throttle motor in the full throttle position, adjust the full throttle adjusting screw in the motor so that the fuel pump lever is at full throttle.

In order to avoid possible damage to the stop on the fuel pump, the control 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.

Set the two remaining adjusting screws in the throttle motor to divide equally the angle of travel of the fuel pump lever between idling and full throttle positions. Having set all adjusting screws, they should be securely locked by means of the locknuts.

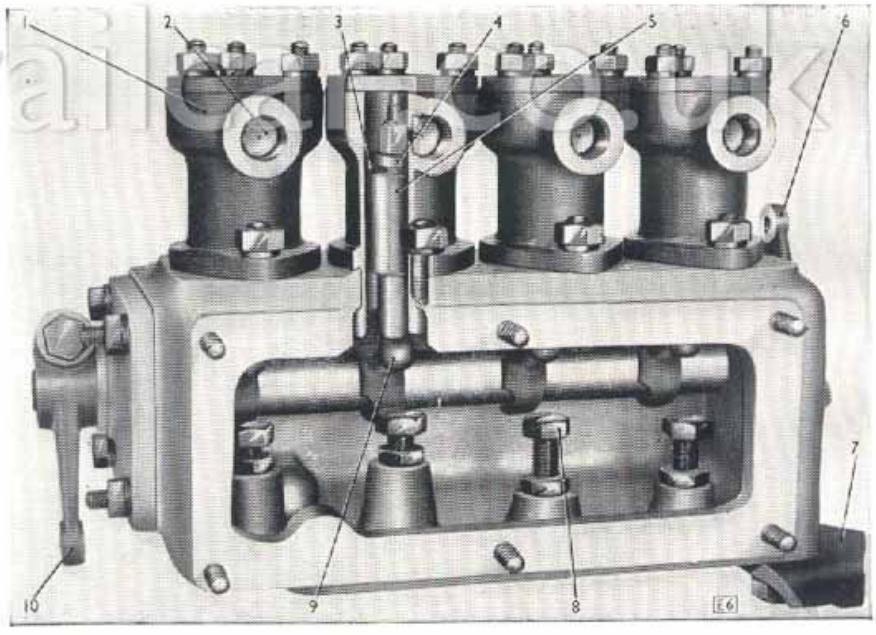


Fig. 48. Throttle motor showing cut-away view of operating piston.

1. AIR CYLINDER.
2. AIR INLET PORT.
3. PISTON SEAL.
4. PISTON SEAL RETAINING WASHER.
5. PISTON.
6. HAND CONTROL LEVER
7. CONTROL CABLE ANCHOR BRACKET
8. ACTUATING LEVER ADJUSTING SCREW.
9. ACTUATING LEVER.
10. CONTROL LEVER.

Sect. K46. BEVEL GEAR HOUSING ASSEMBLY —TO REMOVE AND FIT.

(*See Figs.* 2 *and* 49).

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* K33).

Remove the crankshaft pulley (*see Section* K58); 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.

Disconnect the engine plug and socket cable and conduit from the speed indicator generator (*see Chapter* P. *Page* P35).

Remove the speed indicator generator from the bevel gear housing; retain any shims fitted (*see Section* K76).

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* K77).

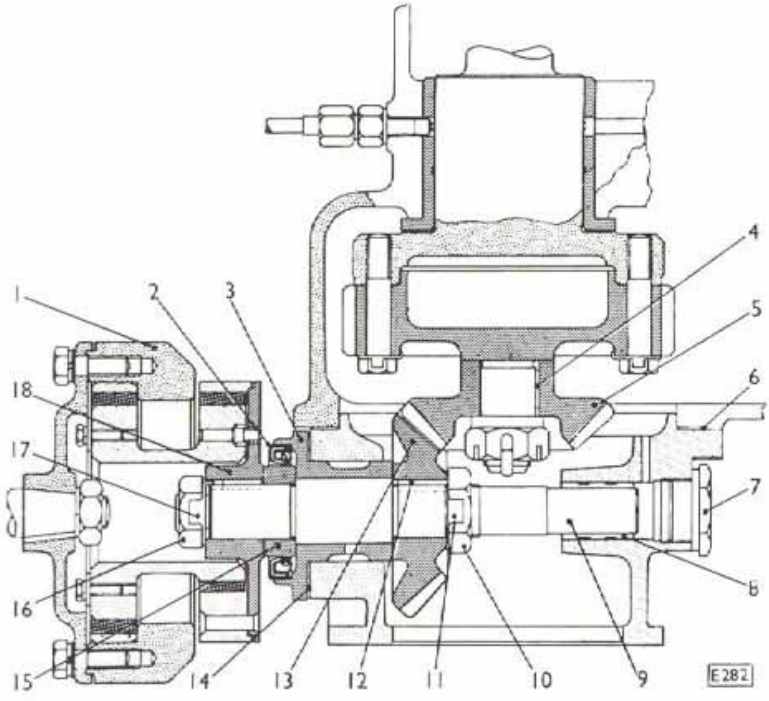


Fig. 49. Section through bevel gear housing assembly.

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

Sect. K47. BEVEL GEAR HOUSING ASSEMBLY —TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 49).

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* K78).

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* K77).

If incorrect alter the thickness of shims between the engine casing and bevel gear housing. (*For the thickness of shims available see Section* K78).

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.

Fit the engine speed indicator generator to the bevel gear housing together with the shims (*see Section* K76).

Notes.

Sect. K48. SUMP — TO REMOVE AND FIT.

(*See Figs.* 2 *and* 54).

To Remove.

Drain the oil from the engine (*see Section* K4).

Remove the right-angle fan drive (*see Section* K63, *also Fig.* 62).

Remove the starter motor (*see Section* K67).

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

On certain engines it may be necessary to disconnect the engine rear support bracket to facilitate the removal of the sump.

Remove the securing nuts and lift off the sump.

(*To remove, clean and fit the internal oil grids, see Section* K54).

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* K51) 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* K67).

Fit the right-angle fan drive (*see Section* K63).

Finally fill the sump with fresh oil (*see Section* K4) and check the oil pressure (*see Section* K6).

Sect. K49. OIL PRESSURE RELIEF VALVE.

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** is quoted in Section K2.

Provision is made to fit an oil pressure switch on the engine casing extension.

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.

Sect. K50. OIL FILTER — TO REMOVE, DISMANTLE, CLEAN AND FIT.

(*See Fig.* 41).

To Remove.

This operation should be carried out in conjunction with the cleaning of the oil strainer (*see Section* K51).

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* K49).

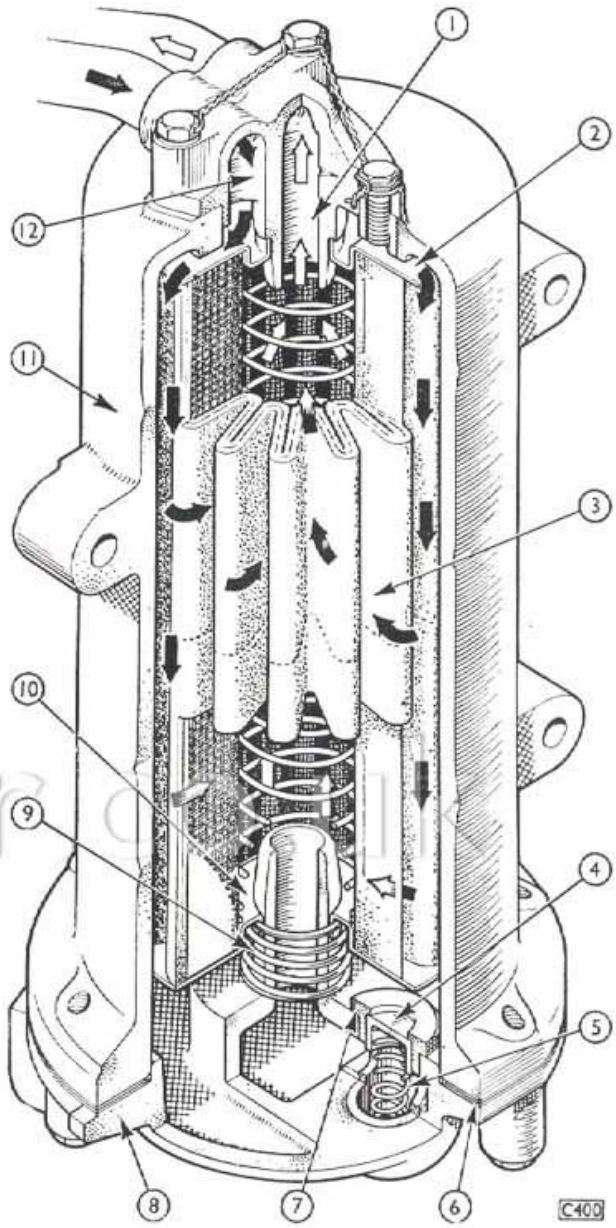


Fig. 50. Cut-away view of oil filter.

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

Sect. K51. OIL STRAINER—TO REMOVE, CLEAN AND FIT.

To Remove.

This operation should be carried out in conjunction with the cleaning of the oil filter (*see Section* K50).

Drain the oil from the sump by removing the drain plug from the cover plate.

Remove the oil filter (*see Section* K50).

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.

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

To Clean.

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

To Fit.

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

Fill the engine with fresh oil (*see Section* K4) and check the oil pressure (*see Section* K49).

Sect. K52. OIL COOLER — TO REMOVE AND FIT.

(*See Fig.* 51).

To Remove.

Drain the engine cooling system following the instructions given in Section K3, 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* K3).

Sect. K53. OIL COOLER — TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 51).

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.

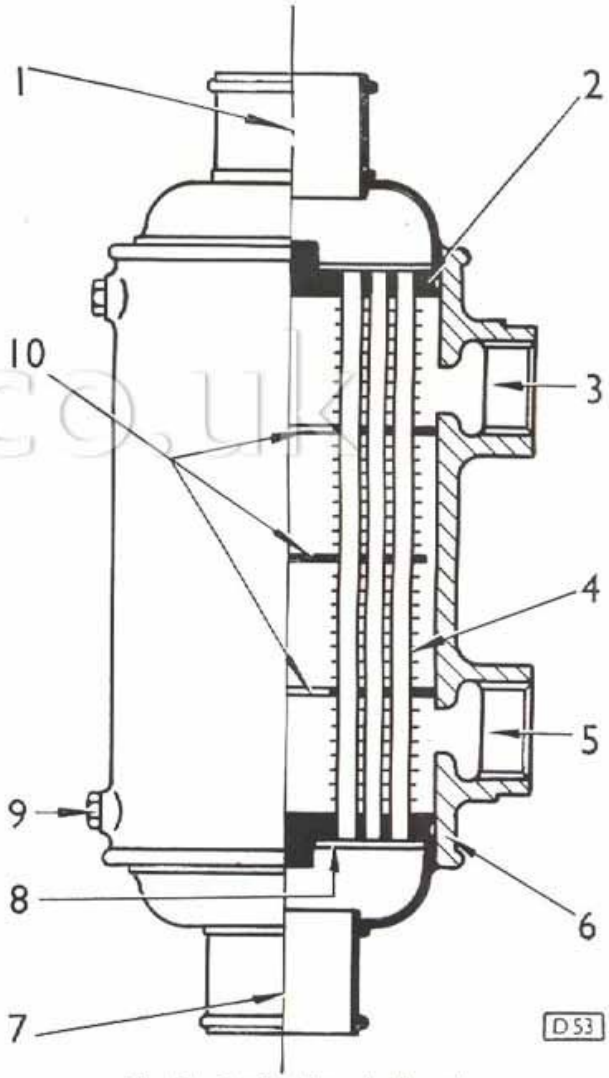


Fig. 51. Section through oil cooler.

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

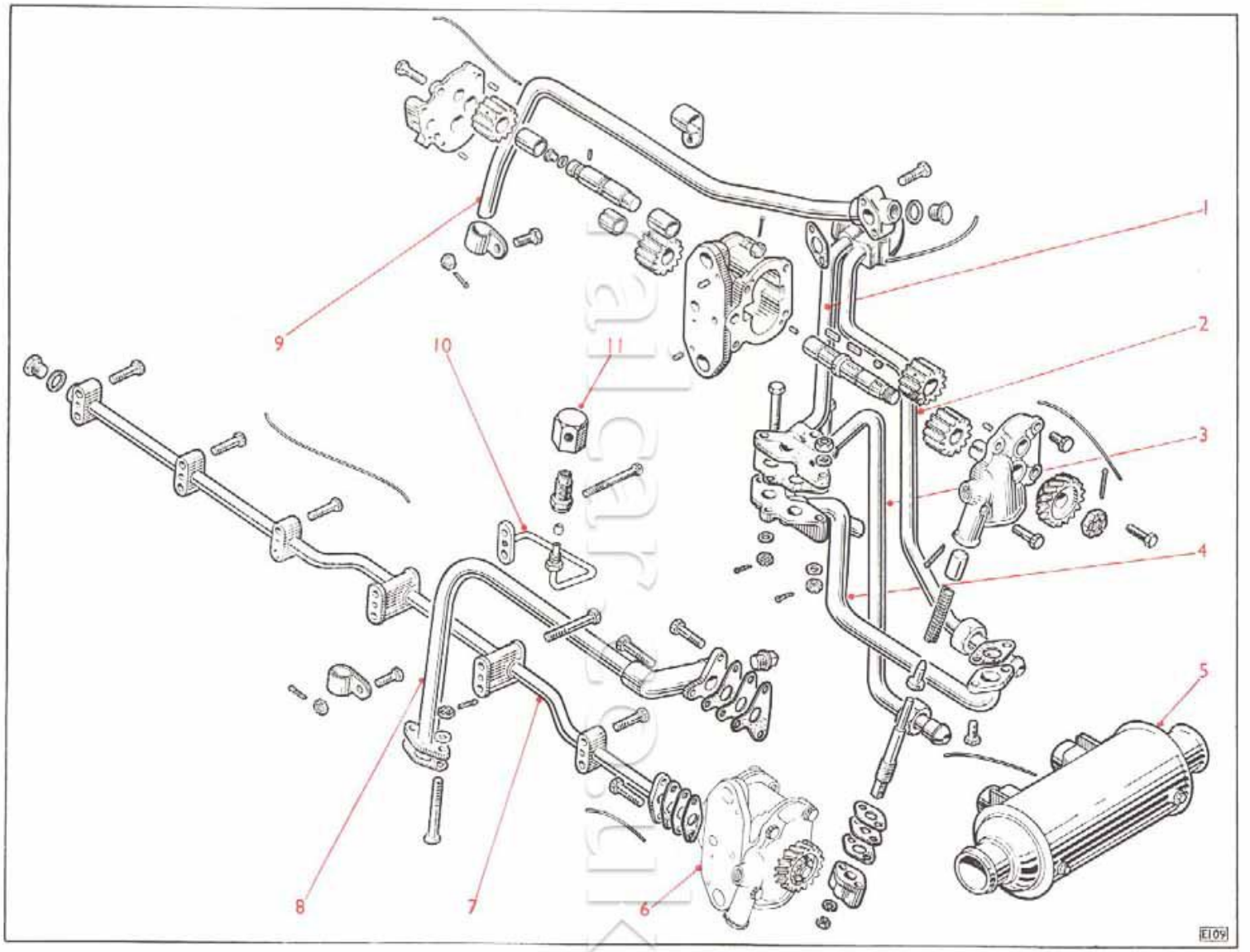


Fig. 52. Exploded view of oil pumps and lubrication pipes.

1. OIL PIPE—EXTENSION CASING TO FILTER.
2. OIL PIPE—FILTER TO COOLER.
3. OIL PIPE—COOLER TO EXTENSION CASING.
4. OIL DELIVERY PIPE—SCAVENGE.
5. OIL COOLER.
6. OIL PUMPS.
7. OIL DELIVERY PIPE—PRESSURE.
8. OIL SUCTION PIPE—PRESSURE.
9. OIL SUCTION PIPE—SCAVENGE.
10. OIL PIPE TO RELIEF VALVE.
11. OIL PRESSURE SWITCH ADAPTOR.

Sect. K54. INTERNAL OIL GRIDS—TO REMOVE, CLEAN AND FIT.

(*See Fig.* 55).

To Remove.

Remove the sump (*see Section* K48).

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* K78 *concerning the fitting of the copper washers*).

Sect. K55. OIL PUMP—TO REMOVE AND FIT.

(*See Fig.* 53).

To Remove.

Remove the sump (*see Section* K48).

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* K78 *concerning shims between the pump body and the oil pipe connections*).

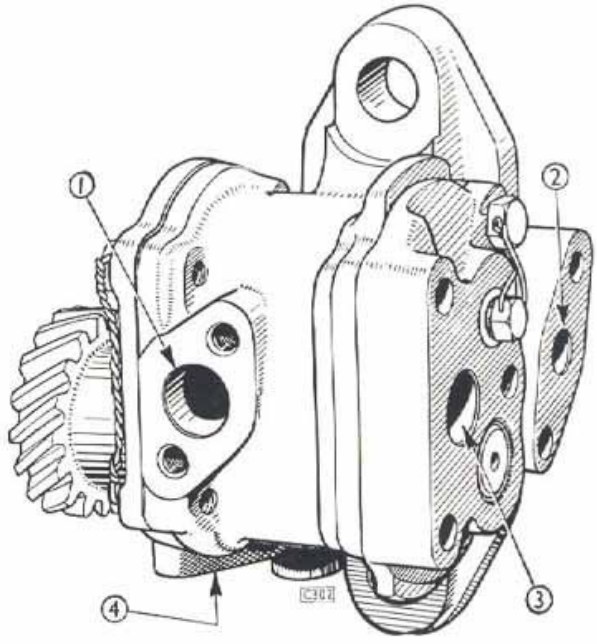


Fig. 53. Assembly of oil pumps.

1. OIL INLET TO SCAVENGE PUMP.
2. OIL OUTLET FROM PRESSURE PUMP.
3. OIL INLET TO PRESSURE PUMP.
4. OIL OUTLET FROM SCAVENGE PUMP.

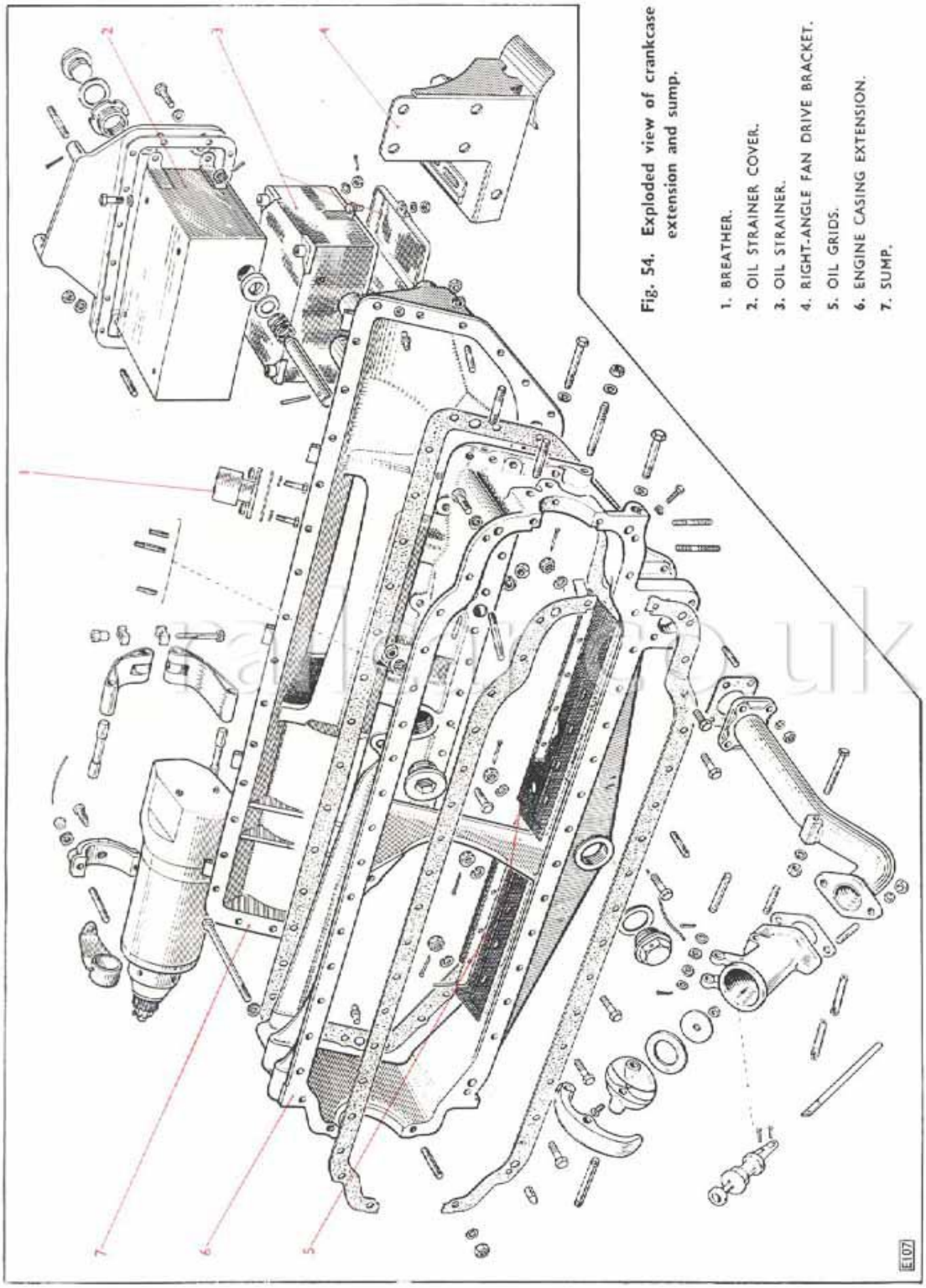


Fig. 54. Exploded view of crankcase extension and sump.

1. BREATHER.
2. OIL STRAINER COVER.
3. OIL STRAINER.
4. RIGHT-ANGLE FAN DRIVE BRACKET.
5. OIL GRIDS.
6. ENGINE CASING EXTENSION.
7. SUMP.

Sect. K56. OIL PUMP—TO DISMANTLE AND ASSEMBLE.

(*See Figs.* 53 *and* 56).

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* K78).

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.

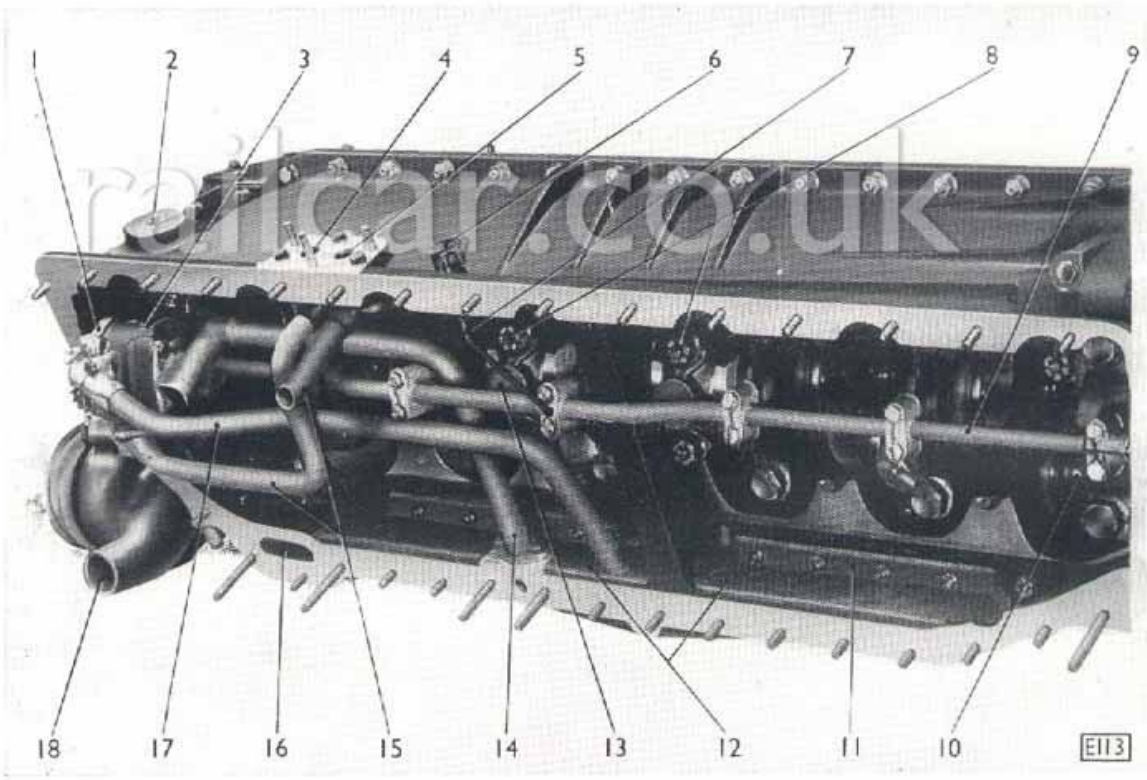


Fig. 55. View of interior of engine casing.

1. SCAVENGE PUMP.
2. BREATHER CONNECTION.
3. PRESSURE PUMP.
4. OUTLET TO EXTERNAL OIL FILTER.
5. RETURN FROM EXTERNAL OIL FILTER.
6. OIL PRESSURE SWITCH CONNECTION.
7. PIPE TO OIL PRESSURE SWITCH CONNECTION.
8. NOTE RELATIVE POSITIONS OF SPLIT PINS AND MARKINGS.
9. OIL DELIVERY PIPE TO MAIN BEARINGS.
10. CAMSHAFT.
11. OIL GRID SUPPORT STRIP.
12. OIL GRIDS.
13. CONNECTING ROD CAP.
14. PRESSURE PUMP SUCTION PIPE.
15. OIL RETURN PIPE FROM SCAVENGE PUMP.
16. CONNECTION BETWEEN OIL FILLER PIPE AND SUMP.
17. OIL SCAVENGE PIPE.
18. WATER INLET PIPE.

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.

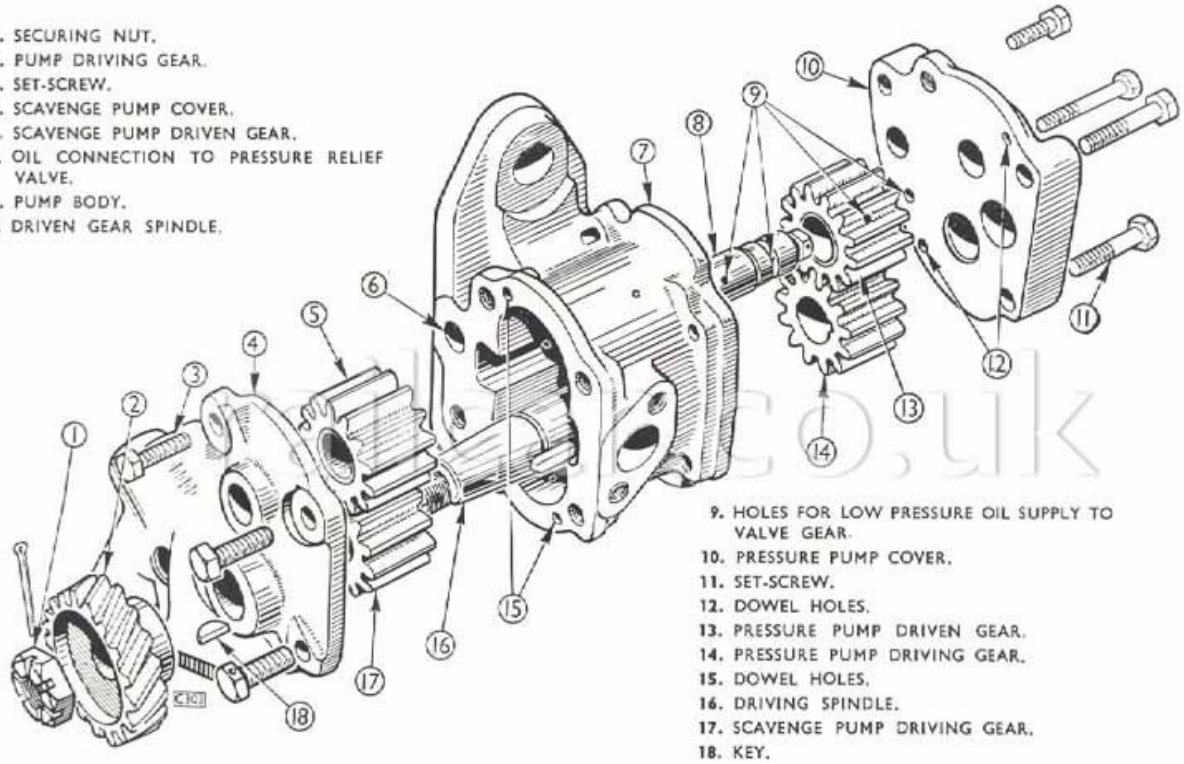
The scavenge pump gears are wider than the pressure pump gears.

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

Fig. 56. Exploded view of pressure and scavenge oil pumps.



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.

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* K77).

Sect. K57. AIR CLEANER — MAINTENANCE.

(*See Fig.* 57).

Unscrew the three wing nuts and detach the cleaner assembly from the mounting ring, taking care not to spill the oil contained in the bowl.

Remove the elements from the bowl, wash them in clean paraffin and allow to drain.

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

Examine the felt rings in the elements and the mounting ring ; if worn or damaged, they should be renewed.

Fill the bowl with fresh engine oil up to the arrow marked on the inside of the bowl (*for capacity of air cleaner see Section* K4).

Fit the elements into the bowl, attach the assembly to the mounting ring and tighten the wing nuts evenly.

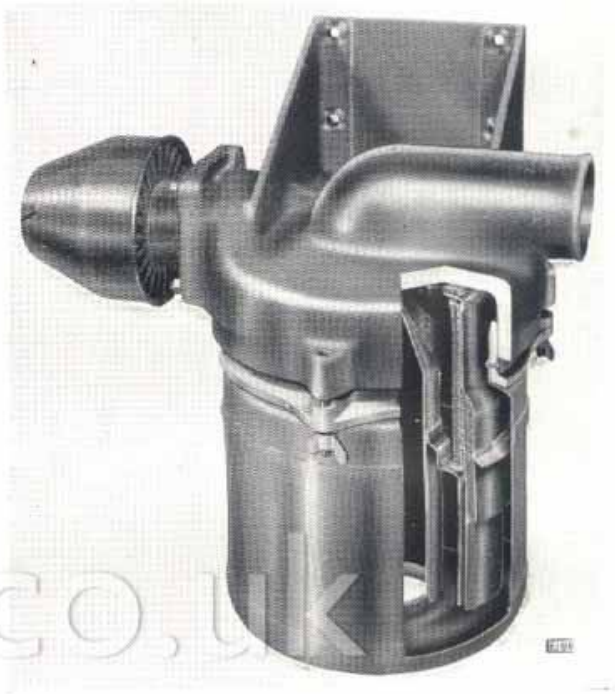


Fig. 57. Air cleaner.

Sect. K58. WATER PUMP — TO REMOVE AND FIT.

(*See Fig.* 59).

To Remove.

Drain the engine cooling system (*see Section* K3).

Slacken off the belt adjustment (*see Section* K3). and remove the fan and water pump drive belts.

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

To Fit.

Reverse the procedure given above.

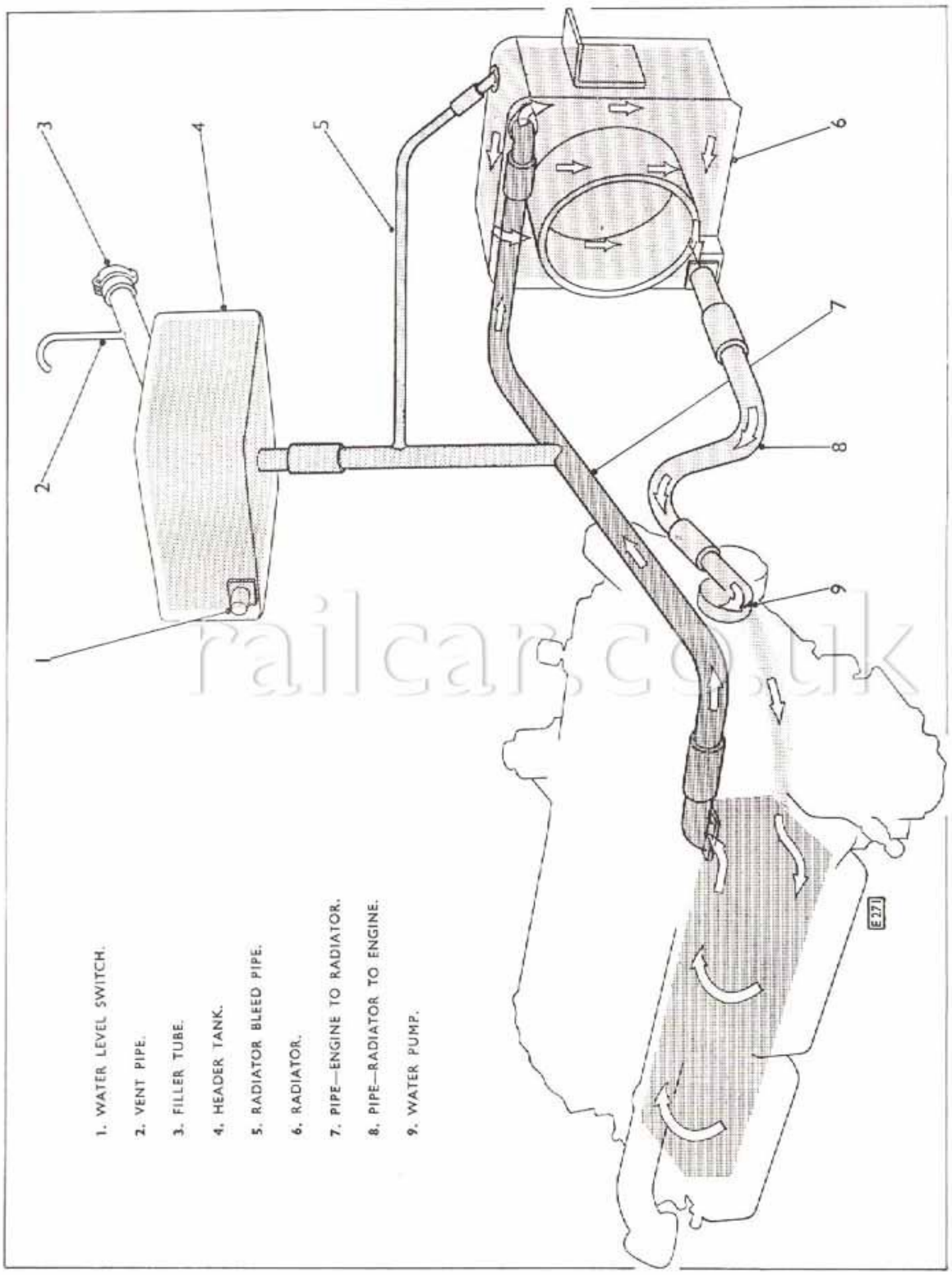


Fig. 58. Diagrammatic layout of engine cooling system.

Sect. K59. WATER PUMP — TO DISMANTLE.

(See Figs. 59 and 60).

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.

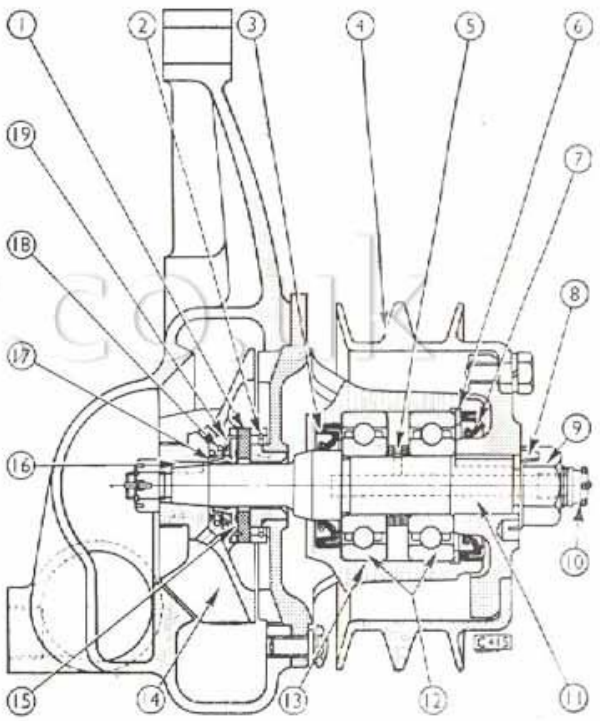
Remove the spindle, and the bearing, by tapping it with a lead hammer on its smaller end.

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.

Fig. 59. Section through water pump.

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.



Sect. K60. WATER PUMP — TO ASSEMBLE.

(See Figs. 59 and 60).

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

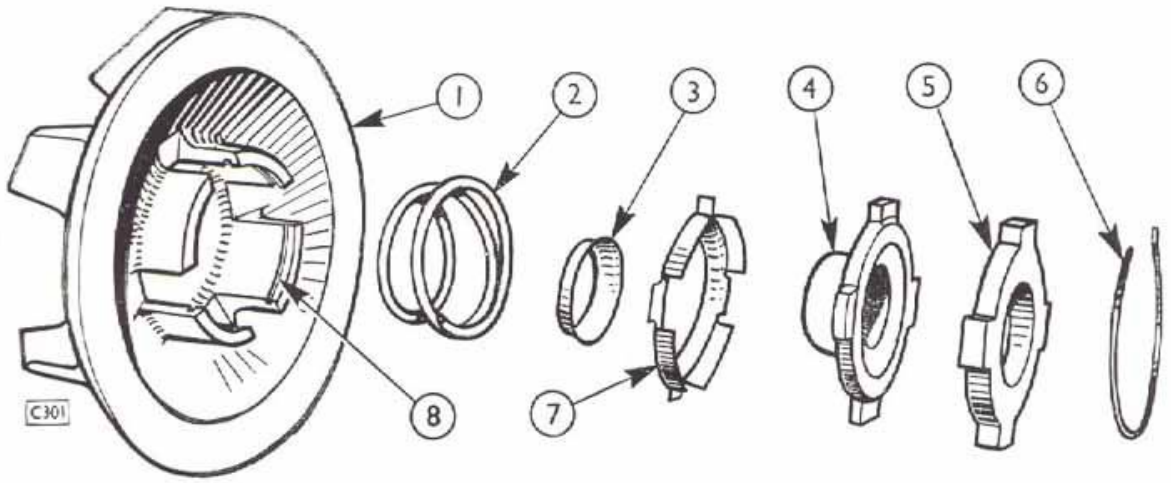


Fig. 60. Exploded view of water pump gland.

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.

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.

Sect. K61. THERMOSTAT—DESCRIPTION.

(*See Fig.* 61).

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 an $\frac{1}{8}$ 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.

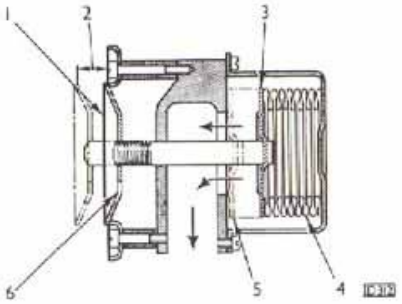


Fig. 61. Section through thermostat.

1. THERMOSTAT VALVE CLOSED.
2. THERMOSTAT VALVE LIFT = $\frac{3}{8}$" (0·375 mm.).
3. BY-PASS VALVE OPEN.
4. THERMOSTAT BELLOWS.
5. BY-PASS VALVE CLOSED.
6. PRESSURE RELEASE HOLE.

Sect. K62. RIGHT-ANGLE FAN DRIVE UNIT —DESCRIPTION.

(*See Fig.* 62).

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.

To provide facilities for draining and filling the casing with oil, the unit is fitted with a drain plug, a filler plug and a gauze type breather.

Certain units are fitted with a drain plug and a combined filler plug and dipstick, which is drilled to form a breather.

Sect. K63. 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.

Connect the propeller shaft to the output shaft.

Fit the drive belts to the pulleys and adjust the tension following the instructions given in Section K3.

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

Sect. K64. RIGHT-ANGLE FAN DRIVE UNIT —TO DISMANTLE.

(*See Fig.* 62).

Remove the unit from the engine following the instructions given in Section K63.

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.

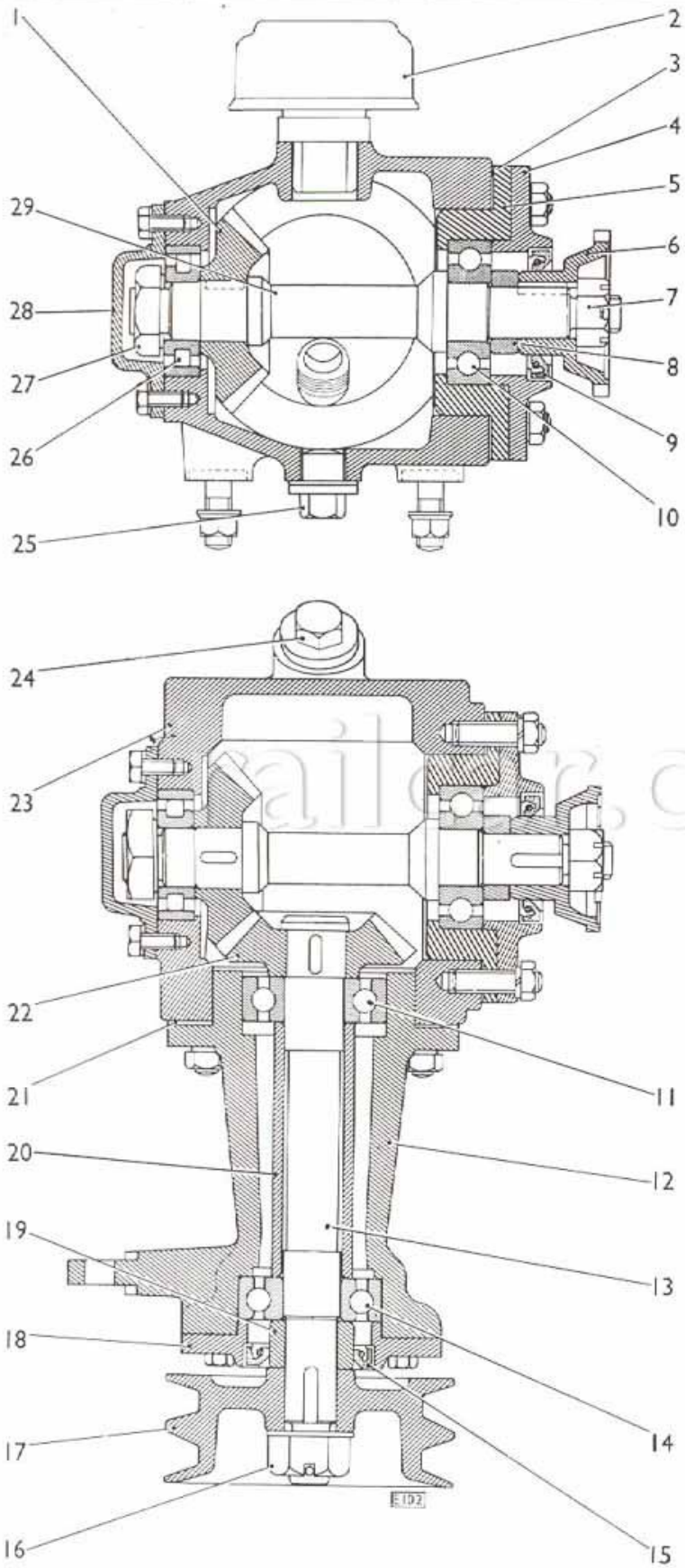


Fig. 62. Arrangement of right-angle fan drive unit.

1. OUTPUT SHAFT BEVEL GEAR.
2. BREATHER.
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. FILLER AND LEVEL PLUG.
25. DRAIN PLUG.
26. ROLLER BEARING.
27. BEARING RETAINING NUT.
28. END COVER.
29. OUTPUT SHAFT.

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

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 securing the oil seal housing.

Screw two $\frac{3}{8}$ in. B.S.F. set-screws into the tapped withdrawal holes provided in the bearing housing, and screw in each set-screw evenly and in succession until the bearing housing is withdrawn from the casing.

Withdraw the shaft assembly from the casing and retain the shims fitted between the bearing housing and the casing.

If necessary remove the roller bearing from the casing.

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

Sect. K65. 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* K64), 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 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.

NOTE.—Before securing the oil seal housing ensure that the withdrawal holes in the bearing housing are in line with those in the oil seal housing.

Check that the backlash between the bevel gears is as quoted in Section K77.

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* K78).

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* K4).

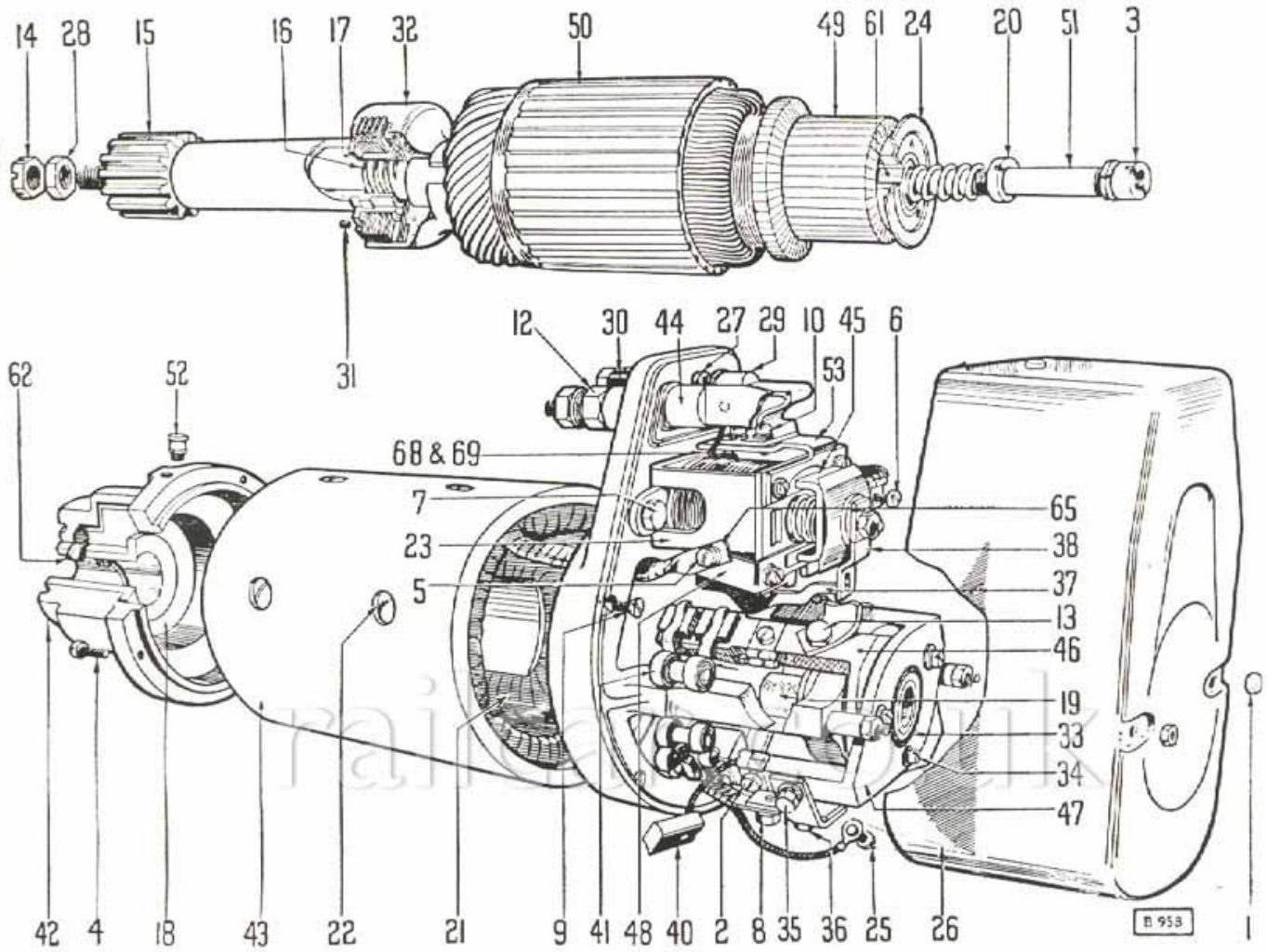


Fig. 63. Exploded view of C.A.V. starter motor.

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

Sect. K66. STARTER MOTOR — DESCRIPTION.

(*See Fig.* 63).

C.A.V. Type U624.

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 two main series field coils, two auxiliary coils, each made up of an auxiliary shunt coil, and 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.

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. K67. STARTER MOTOR — TO REMOVE AND FIT.

(*See Figs.* 2 *and* 3).

To Remove.

Isolate the battery by means of the battery isolating switch 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 2 and 3.

Sect. K68. STARTER MOTOR — TO DISMANTLE.

(*See Figs.* 63, 64, 65 *and* 66).

Before dismantling it is advisable to obtain tools similar to those shown in Figures 64 and 65.

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 64.

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 63.

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

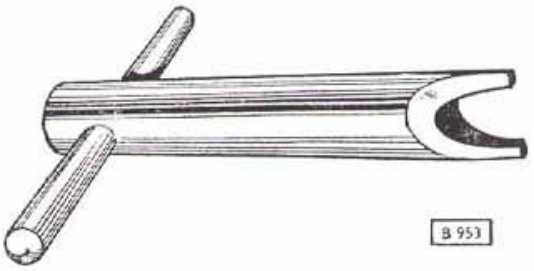


Fig. 64. Tool for starter motor armature spring nut.

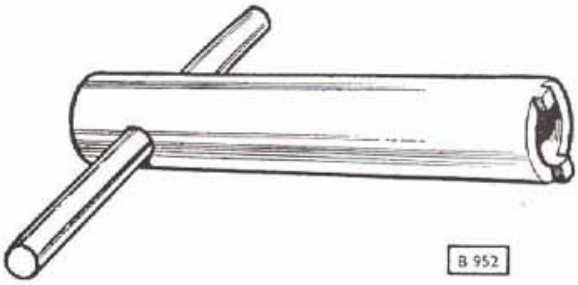


Fig. 65. Tool for starter armature plunger nut.

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.

Remove the screws securing the (+) terminal connector.

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

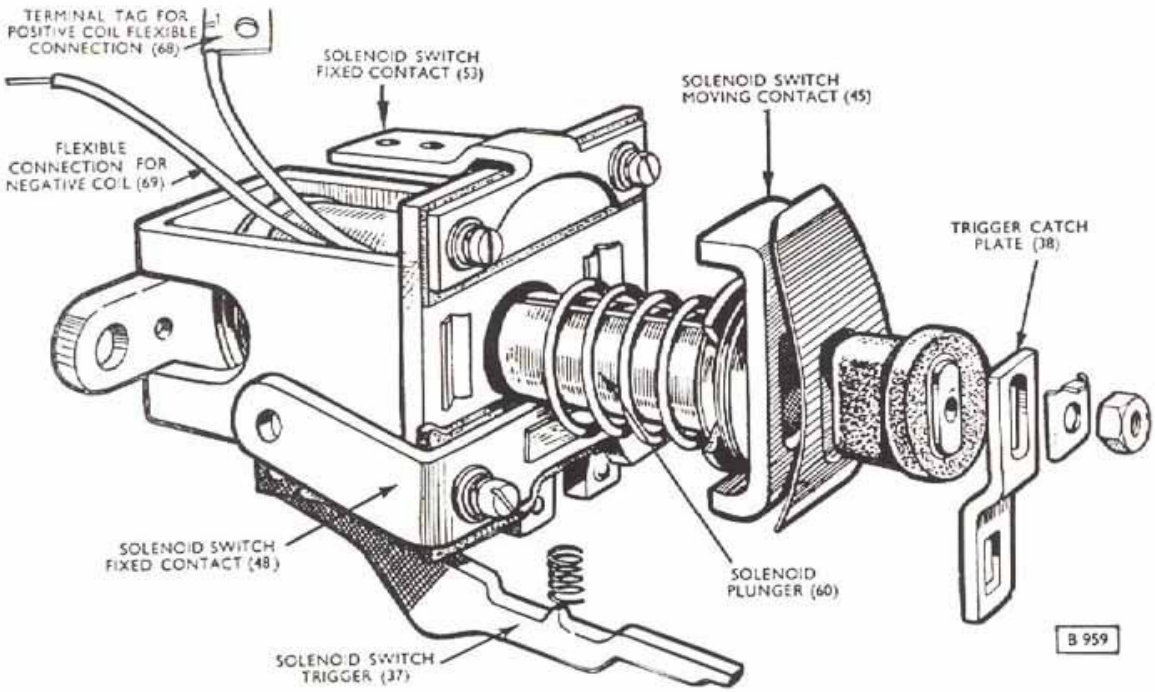


Fig. 66. Exploded view of starter motor solenoid switch (C.A.V.)

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, the complete starter motor should be returned to B.U.T. for overhaul.

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 64 and 65 and take out the plunger.

To change the pinion.

To change the pinion without dismantling the starter motor (*see Figs.* 63 *and* 67) **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 63); 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 hardened washer; tighten the nut securely. Screw on the slotted nut, tighten it and insert a split pin; then refit the spring and plug.

Fig. 67. Method of changing starter motor driving pinion without dismantling unit.

Sect. K69. STARTER MOTOR — TO ASSEMBLE.

(*See Figs.* 63, 66, 67 *and* 69).

Assembly is mainly a reversal of the instructions set out in Section K68.

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

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 wit engine oil.

Fill the interior of the pinion with grease.

Fill the plunger spring cavity inside the armature with grease.

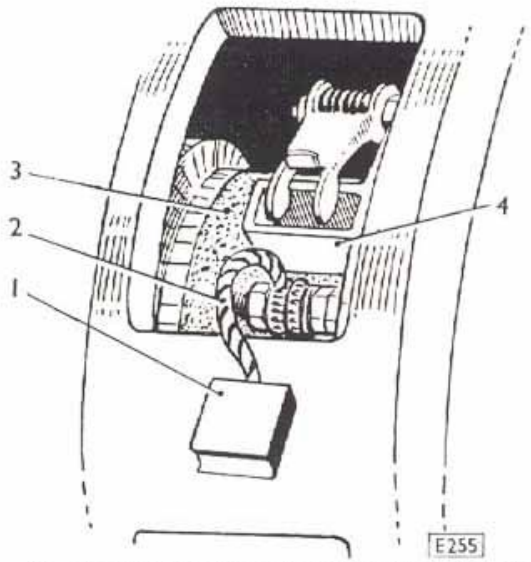


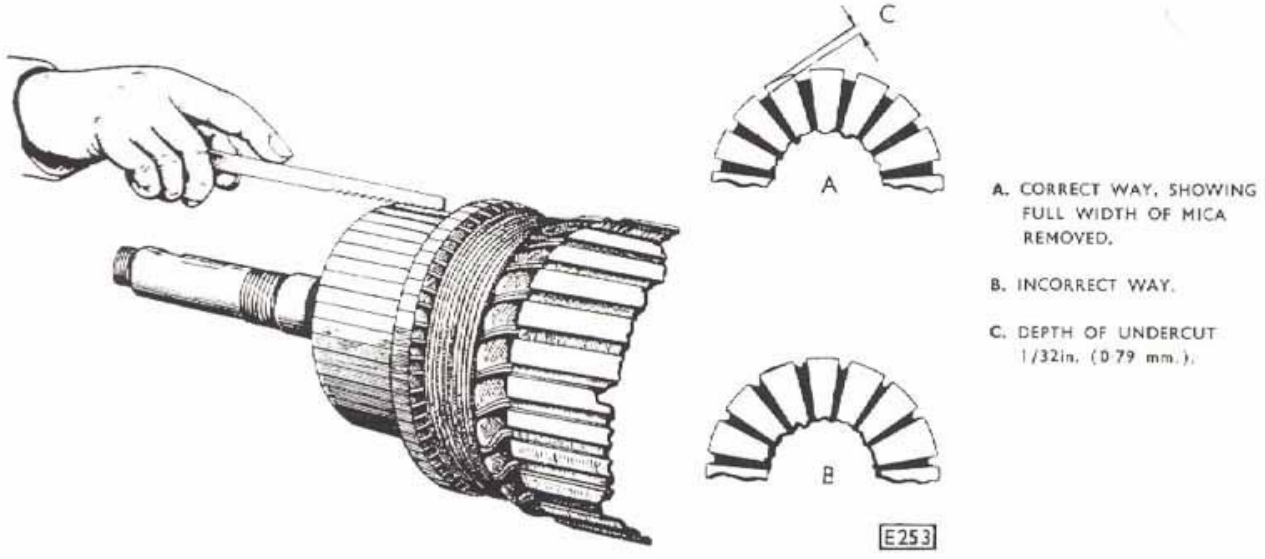
Fig. 68. Method of "bedding" starter motor brushes.

1. BRUSH.
2. PIGTAIL.
3. CARBORUNDUM PAPER.
4. BRUSH HOLDER.

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 moistened with 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.



A. CORRECT WAY, SHOWING FULL WIDTH OF MICA REMOVED.

B. INCORRECT WAY.

C. DEPTH OF UNDERCUT 1/32in. (0·79 mm.).

Fig. 69. Method of undercutting commutator mica.

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.* 69). After undercutting, any burrs must be removed by polishing the commutator with fine carborundum paper.

Brushes.

To check for freedom (*see Section* K3).

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.* 68).

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.* 70). The pressure should be as shown in Section K2. 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.

Testing starter motor in position on the car.

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

Fig. 70. Method of checking brush spring pressures.

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.

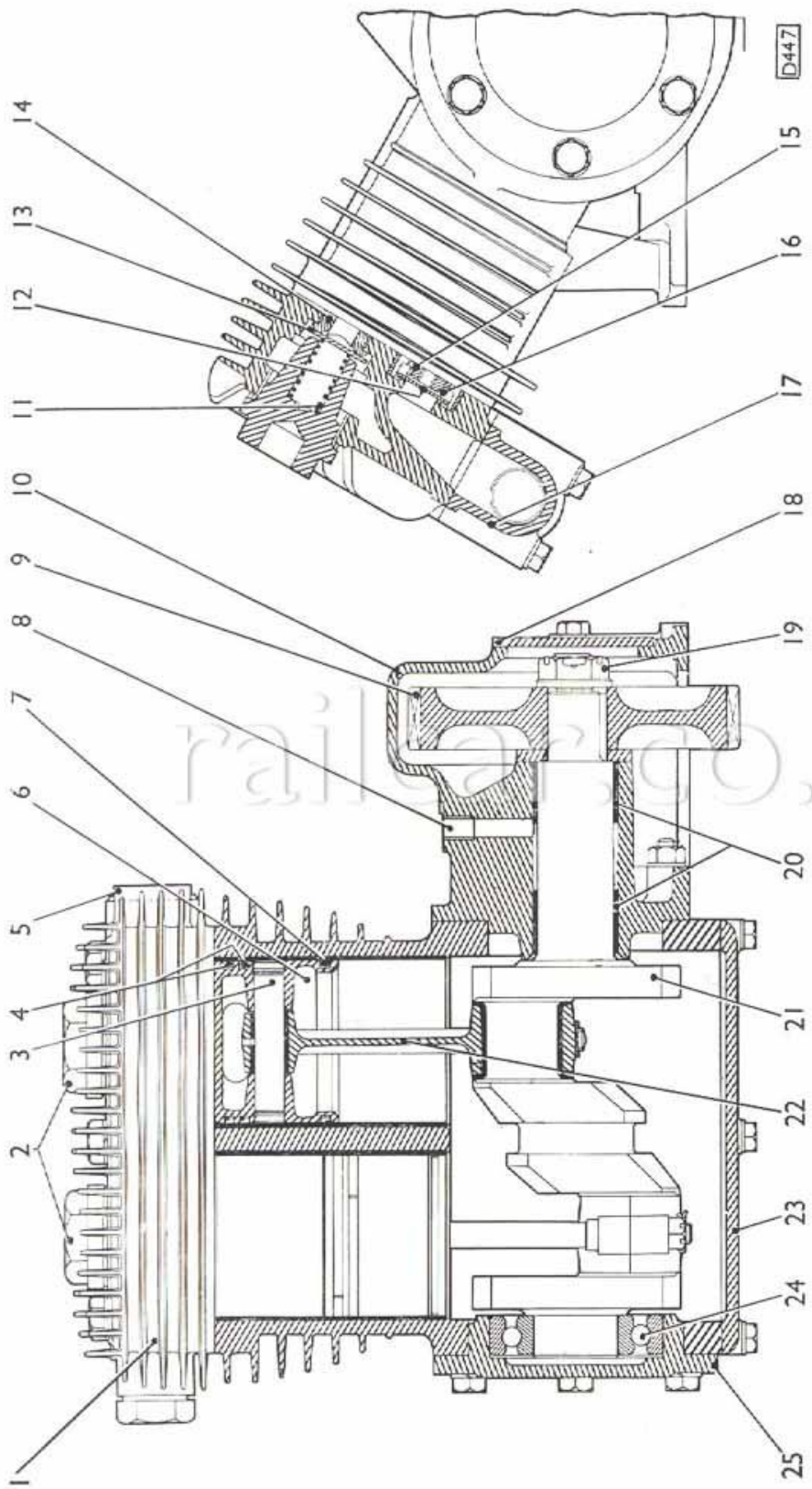


Fig. 71. Arrangement of air compressor.

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.

Sect. K70. 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.

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. K71. AIR COMPRESSOR — DESCRIPTION.

(*See Fig.* 71).

Clayton Dewandre Type P.C.G.A. 189.

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. K72. 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 K77.

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 compound.

Sect. K73. AIR COMPRESSOR — TO DISMANTLE.

(*See Fig.* 71).

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. K74. AIR COMPRESSOR — TO ASSEMBLE.

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

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

When wear has reached between 0·005 in. and 0·010 in. (0·13 mm. and 0·25 mm.) on these diameters the cylinders should be bored out to 2·635 in. to 2·636 in (66·93 mm. to 66·95 mm.) diameter and new +0·010 in. (0·25 mm.) oversize pistons and rings fitted.

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

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

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

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

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

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

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

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

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

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

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

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

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

Fit the connecting rod bearings to the crankshaft and fit the end caps ensuring that they are fitted as marked on dismantling (*see Section* K73) and secure them with the nuts and split pins.

Temporarily fit the drive housing end cover (*see Section* K72 *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. K75. ENGINE SPEED INDICATOR GENERATOR —DESCRIPTION.

(*See Fig.* 72).

Smith's Type MDG.

The generator is mounted on the engine bevel gear housing and is gear driven by the fuel-injection pump bevel gear.

Its purpose is to record electrically the engine speed by means of an indicator mounted on the driver's control table.

For specification of the generator see Section K2.

Should failure occur in the generator it is recommended that the unit be returned to B.U.T. for overhaul.

Sect. K76. ENGINE SPEED INDICATOR GENERATOR —TO REMOVE AND FIT.

(*See Fig.* 72).

To Remove.

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.

To Fit.

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* K77).

Fig. 72. Engine speed indicator generator—with cover removed.

Sect. K77. CLEARANCES, STANDARDS, OVERSIZE AND UNDERSIZE PARTS, ETC.

CLEARANCES (when new).

Unit.	Component.	Clearance.			
		Inches.		*Millimetres.*	
		Maximum.	*Minimum.*	*Maximum.*	*Minimum.*
	DIAMETRICAL CLEARANCES.				
BEARINGS	Crankshaft and Main Bearings :— All Standards—All Copper-lead Lined	0·007	0·004	0·180	0·102
	Crankshaft and Connecting Rod Big-end Bearings:— All Standards	0·0047	0·0034	0·120	0·087
	Gudgeon Pin and Connecting Rod Small-end Bearings	0·0020	0·0010	0·051	0·026
	Gudgeon Pin and Piston	0·0005	0·00025 Interference	0·0127	0·006 Interference
CAMSHAFT	Camshaft and Bearings (Front and Rear)	0·0045	0·0032	0·116	0·082
PISTONS	Cylinder Liner and extreme Top of Piston Wellworthy	0·042	0·038	1·080	0·979
	Cylinder Liner and Bottom of Piston Skirt Wellworthy*	0·012	0·010	0·310	0·260
VALVE GEAR	Valve and Valve Guide (Inlet and Exhaust)	0·0045	0·0022	0·115	0·055
	Valve Tappet and Crankcase	0·0042	0·002	0·107	0·051
	Rocker Shaft and Rocker Bearings	0·0035	0·0008	0·089	0·019
OIL PUMP	Oil Pump Body and Outside of Oil Pump Gears	0·007	0·0045	0·180	0·115
CRANKSHAFT	Rear Oil Seal	0·0218	0·0163	0·551	0·414
	SIDE AND END CLEARANCES.				
CRANKSHAFT AND BEARINGS	Crankshaft End Float (governed by No. 1 Main Bearing)	0·0083	0·0031	0·210	0·080
	Crankshaft and Connecting Rod Big-end Bearings:— All Standards	0·010	0·007	0·254	0·178
PISTON AND RINGS	Piston Rings and Grooves :— Top Compression Ring Wellworthy	0·006	0·0045	0·152	0·115
	2nd and 3rd Compression Rings Wellworthy	0·0055	0·004	0·140	0·102
	Scraper Rings Wellworthy	0·0055	0·004	0·140	0·102
	Piston Ring Gap (Other Rings)	0·022	0·015	0·559	0·381
	Top Compression Ring Gap (Chromium Plated)	0·027	0·020	0·686	0·508
OIL PUMP	Oil Pump Gears and Oil Pump Body Facing	0·004	0·000	0·102	0·000
CAMSHAFT	Timing Idler Gear	0·015	0·010	0·381	0·254
	BACKLASH OF GEARS.				
OIL PUMP	Crankshaft Driving Gear and Oil Pump Idler Gear†	0·005	0·003	0·127	0·076
	Oil Pump Idler Gear and Oil Pump Driving Gear†	0·009	0·007	0·229	0·178
CAMSHAFT	Camshaft Driving Bevel Gear and Fuel-injection Pump Driven Bevel Gear	0·003	0·002	0·076	0·051
AIR COMPRESSOR	Compressor Drive Gear and Engine Timing Gear	0·003	0·002	0·076	0·051
ENGINE SPEED INDICATOR GENERATOR	Fuel-injection Pump Drive Bevel Gear and Engine Speed Indicator Generator Bevel Gear	0·003	0·002	0·076	0·051
RIGHT-ANGLE FAN DRIVE	Input Shaft and Output Shaft Bevel Gears	0·006	0·004	0·152	0·102

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

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STANDARDS.

CRANKSHAFT.

Standard.	Undersize.	Diameter. Main Journals. Maximum.	Main Journals. Minimum.	Crank Pins. Maximum.	Crank Pins. 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. Maximum.	Minimum.
Plan	—	95·123 mm. = 3·7450 in.	95·072 mm. = 3·7429 in.
2nd	0·5 mm.	94·623 mm. = 3·7253 in.	94·572 mm. = 3·7233 in.
3rd	1·0 mm.	94·123 mm. = 3·7056 in.	94·072 mm. = 3·7036 in.
4th	1·5 mm.	93·623 mm. = 3·6859 in.	93·572 mm. = 3·6839 in.
5th	2·0 mm.	93·123 mm. = 3·6662 in.	93·072 mm. = 3·6642 in.
6th	2·5 mm.	92·623 mm. = 3·6465 in.	92·572 mm. = 3·6445 in.

CONNECTING ROD REPLACEMENT BEARINGS.

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

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

CYLINDER LINERS.

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

Cylinder Liner Bores—(Standard).

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

PISTONS.

Make of Piston.	Skirt Diameter at bottom of Piston when new.			
	Parallel to Gudgeon Pin.		At Right Angles to Gudgeon Pin.	
	Maximum.	*Minimum.*	*Maximum.*	*Minimum.*
Wellworthy	129·66 mm. 5·1049 m.	129·63 mm. 5·1039 m.	129·75 mm. 5·1084 in.	129·73 mm. 5·1074 in.

OVERSIZE AND UNDERSIZE PARTS.

Part.	Inside diameter.	Outside diameter.	Remarks.
Piston	—	130·5 mm. nominal	Cylinder liner must be bored and honed to give the clearance stated in the table above.
,,	—	131·0 mm. nominal	
Piston ring, compression	—	130·5 mm. nominal	Width 0·125 in., 0·145 in. or 0·165 in.
,,	—	131·0 mm. nominal	
Piston ring, scraper	—	130·5 mm. nominal	
,,	—	131·0 mm. nominal	
Crankcase rear oil seal	99·25 mm.	—	Machining allowance in bore for machining in line with main bearings.
Main bearings			No machining is necessary when fitting these bearings.
Plan	95·097 mm.	—	
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.	—	
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.

Over and Undersize Parts (continued).

Part.	Inside diameter.	Outside diameter.	Remarks.
Connecting rod bolt	—	0·5 +0·001 in. +0·000 in.	
Camshaft bearing	2·418 ± 0·00075 in.	—	Camshaft bearing journal must be ground to give the clearance stated in the table at the beginning of this Section.
Valve guide (inlet and exhaust)	—	18 +0·280 mm. +0·273 mm.	
Valve seats (inlet and exhaust)	—	—	To be fitted to cylinder head after machining (see note below).

Note.—For further details see B.U.T. Service Bulletin Number 8.

Sect. K78. DIMENSIONS OF SHIMS AND DISTANCE WASHERS AVAILABLE.

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

Sect. K79. TORQUE SPANNER LOADINGS.

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

Part.	Torque	
	lb. ft.	*Kg. M.*
Main bearing set-screws	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

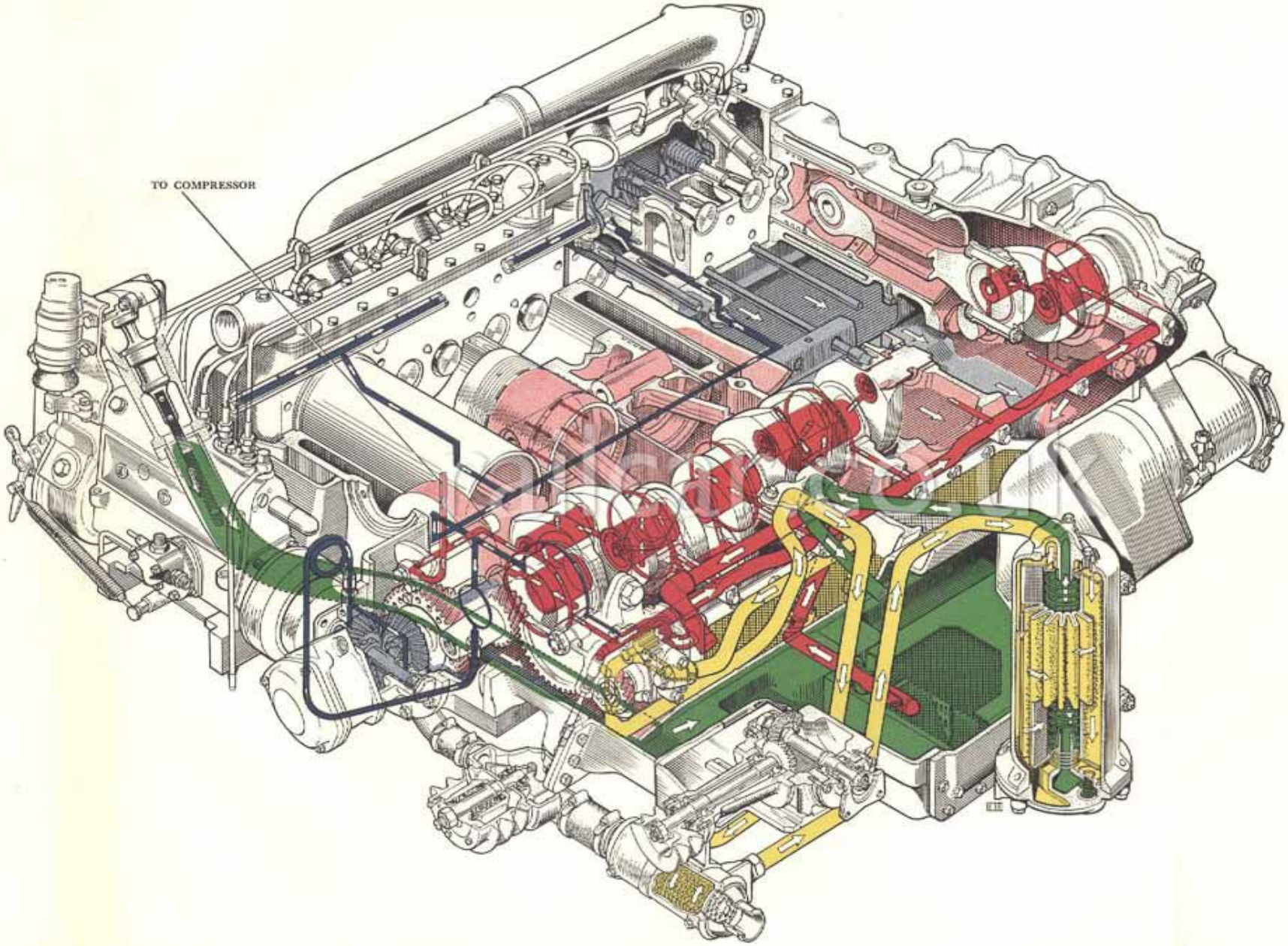
*Note.—Should the split pin hole not align after tightening these nuts to the specified torque given above, the nut may be **tightened** to the next slot for insertion of the split pin.

PLATE No. **B 6**

B.U.T. 11·3 LITRE DIRECT INJECTION HORIZONTAL OIL ENGINE

("A" Type Units)

LUBRICATION SYSTEM



Key to Colours :—

- OIL IN SUMP.
- HIGH PRESSURE SYSTEM
- LOW PRESSURE SYSTEM
- SCAVENGE SYSTEM
- SPLASH
- RETURN TO SUMP

300 H & C 11-58

FLUID COUPLING

(A- and L-Type Units)

CHAPTER M

CONTENTS

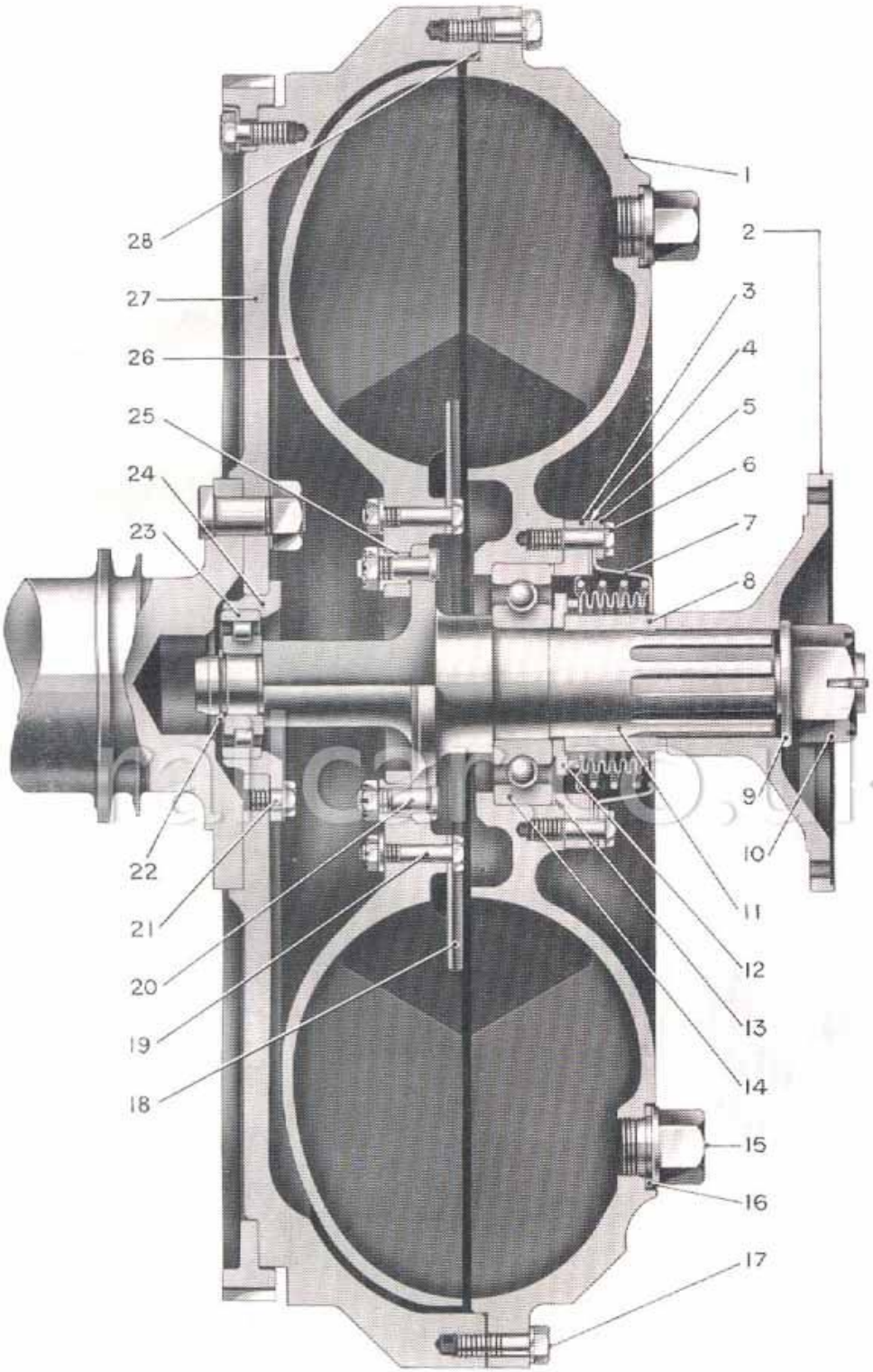


Fig. 1. Section through fluid coupling (L-type).

1. REAR CASING.
2. FLANGE.
3. SPACER RING.
4. JOINT.
5. STIFFENER RING.
6. SETSCREW.
7. OIL SEAL.
8. DISTANCE PIECE.
9. WASHER.
10. NUT.
11. RUNNER SHAFT.
12. RUBBING WASHER.
13. JOINT.
14. BEARING.
15. PLUG.
16. WASHER.
17. SETSCREW.
18. BAFFLE PLATE.
19. BOLT.
20. BOLT.
21. SETSCREW.
22. CIRCLIP.
23. BEARING.
24. HOUSING.
25. FERRULE.
26. RUNNER.
27. ENGINE FLYWHEEL
28. JOINT.

L/0358

Sect. M1 FLUID COUPLING—DESCRIPTION

(See Figs. 1 and 2)

The fluid coupling fitted to both A- and L-type engines consists in each instance of two main parts: the rear casing which is secured to the engine flywheel (which in turn is secured to the crankshaft); and the runner, which is free to rotate within the outer casing (formed by the flywheel and the rear casing) and is coupled to the joint flange of the freewheel unit.

The rear casing and the runner are each provided with a series of pockets separated by radial-webs formed on their inner surfaces.

The runner shaft which is bolted to the runner is located in two bearings, one of which is fitted in the flywheel and the other in the rear casing. The flywheel or spigot bearing is located direct into the flywheel bore on the A-type engine, whereas on the L-type engine this bearing is carried in its own housing which in turn is setscrewed to the flywheel.

A self-adjusting bellows-type packless gland oil seal is fitted to the outer side of the rear casing.

Sect. M2 FLUID COUPLING—MAINTENANCE

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

1	Check the oil level in the fluid coupling and top-up if required (*see Section M4*).
2	Check the runner shaft bellows gland for oil leaks (*see Section M3*).

Sect. M3 FLUID COUPLING BELLOWS GLAND—TO RENEW

To Remove

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

1. Drain the coupling (*see Section M4*).
2. Disconnect the freewheel unit from the coupling flange on the runner shaft.
3. Remove split-pin, nut and washer, and draw the coupling flange off the runner shaft with a suitable withdrawal tool.
4. Break locking wire and remove setscrews securing the oil seal to the rear casing.
5. Remove the stiffener ring, joint, bellows gland, adapter ring together with joint, and the rubbing ring. On the L-type engine a distance-piece has to be removed first before the rubbing ring can be taken off the shaft.

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

Reverse the procedure given for removal, noting the following points:—

1. Smear with non-hardening jointing compound the abutting faces of the adapter ring and bearing, rubbing ring and coupling flange and the abutting faces of the rubbing ring, spacer and coupling flange in the case of the L-type engine. Also smear the splined end of the runner shaft and the abutting faces of the coupling retaining washer and nut.
2. Smear the polished joint face of the seal with clean engine oil.
3. Fit a new paper joint between the adapter ring and the flange of the oil seal and between the abutting faces of the adapter ring and bearing.

Note.—It is important that the rubbing ring be assembled with the polished face 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.

4. Fit the coupling flange to the runner shaft and connect the freewheel.
5. Fill the fluid coupling with oil as described in Section M4.

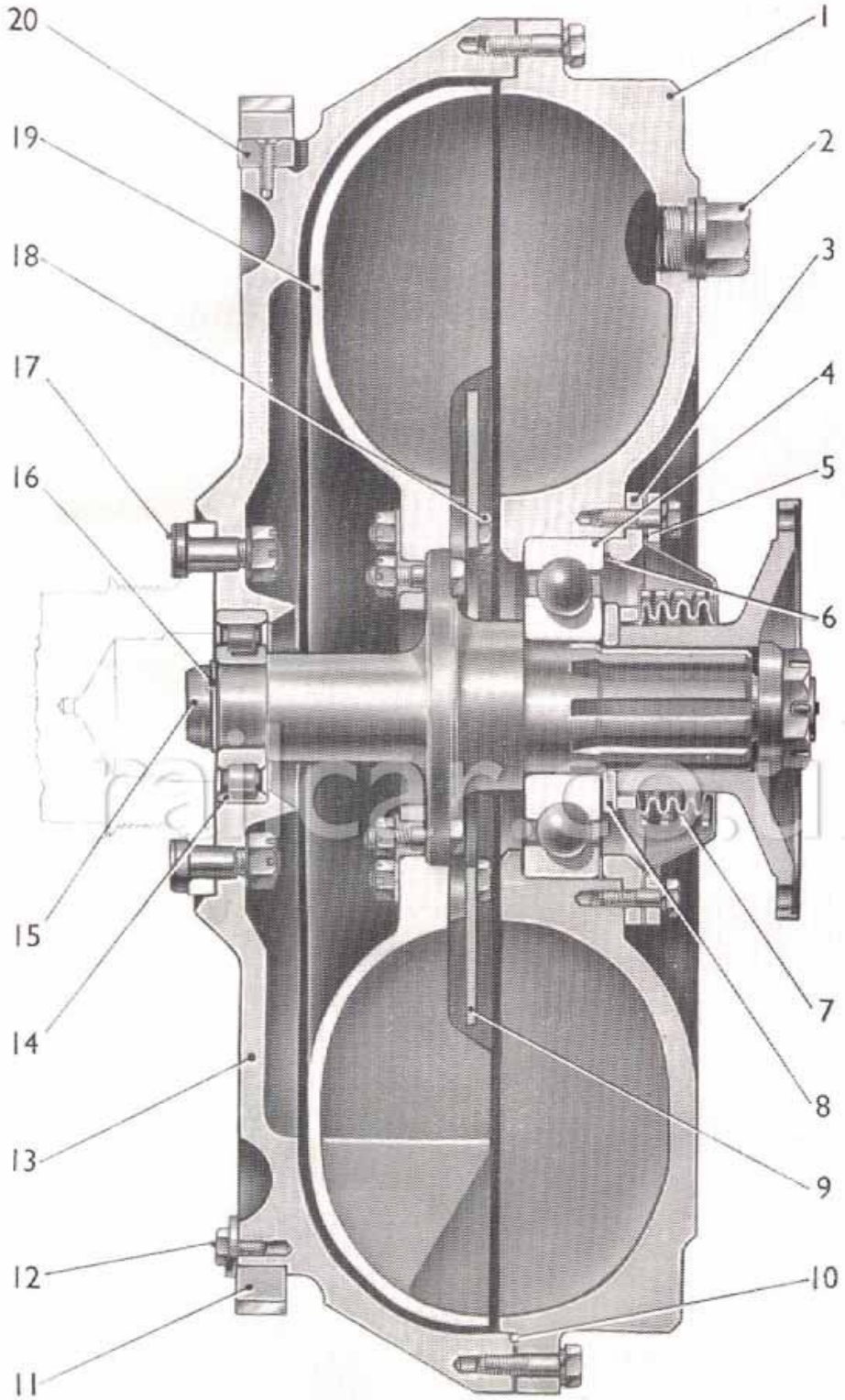


Fig. 2. Section through fluid coupling (A - type).

1. DRIVING MEMBER.
2. FILLER AND DRAIN PLUG.
3. ADAPTER RING.
4. RUNNER SHAFT BEARING.
5. PAPER JOINT.
6. PAPER JOINT.
7. BELLOWS GLAND.
8. RUBBING RING.
9. OIL DEFLECTOR PLATE.
10. PAPER JOINT.
11. STARTER RING.
12. STARTER RING RETAINING SETSCREW.
13. FLYWHEEL.
14. RUNNER SHAFT SPIGOT BEARING.
15. RUNNER SHAFT.
16. RUNNER SHAFT SPIGOT BEARING CIRCLIP.
17. CRANKSHAFT FLANGE BOLT.
18. OIL DEFLECTOR PLATE RETAINING BOLT.
19. DRIVEN MEMBER.
20. STARTER RING KEY.

L/0355

Sect. M4 FLUID COUPLING—LUBRICATION

To Drain the Fluid Coupling

To drain the fluid coupling turn the engine with a suitable lever until one of the plugs (there are four on the L-type engine and three on the A-type engine) in the rear face of the coupling is at the bottom. Remove the plug and allow the oil to drain into a suitable receptacle. To allow the oil to drain away quickly on the L-type engine the top plug may be removed. Replace this plug when draining has been completed.

To Fill or Top-up the Fluid Coupling

Turn the engine as previously described until the filler plug hole is at the top.

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 capacities of the two types of fluid couplings are as follows:

A-type engine ..	Total capacity, 4½ gallons (20.5 litres).
L-type engine ..	Total capacity, 4¼ gallons (19.3 litres).

Use engine oil only.

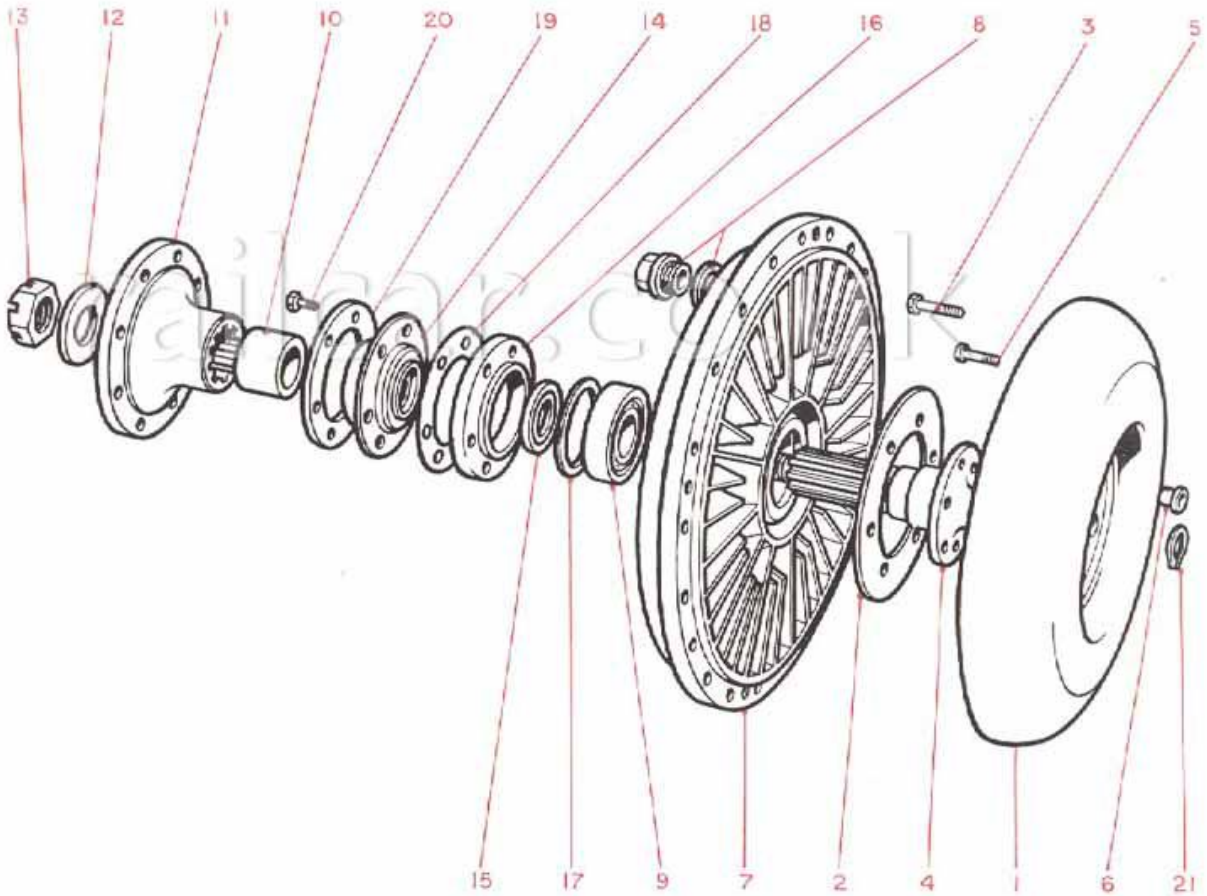


Fig. 3. Exploded view of fluid coupling (L - type).

1. RUNNER.
2. BAFFLE PLATE.
3. BOLT.
4. RUNNER SHAFT.
5. BOLT.
6. FERRULE.
7. REAR CASING.
8. PLUG.
9. BEARING.
10. DISTANCE PIECE.
11. COUPLING FLANGE.
12. WASHER.
13. NUT.
14. OILSEAL.
15. RUBBING WASHER.
16. SPACER RING.
17. JOINT.
18. JOINT.
19. STIFFENING RING.
20. SETSCREW.
21. CIRCLIP.

Sect. M5 FLUID COUPLING—TO REMOVE AND FIT

(See Figs. 1 and 2)

To Remove

1. Drain the fluid coupling (*see Section M4*).
2. Disconnect the freewheel unit at the joint flange at the rear of the fluid coupling.
3. Remove setscrews from around the outer edge of the flywheel rim.
4. Withdraw the runner shaft together with the rear casing and runner. Holes, tapped $\frac{5}{8}$in. B.S.F. are provided for jacking screws. The inner race and rollers of the spigot bearing will be withdrawn with the runner shaft and the bearing outer race will remain within the flywheel bore.

   It is advisable to place a suitable receptacle beneath the fluid coupling before carrying out the above instruction, as a quantity of oil still remains in the coupling after draining.
5. Remove the circlip from the end of the runner shaft and withdraw the inner race and rollers of the spigot bearing using suitable pliers and extractor.
6. Remove the nuts from the bolts securing the flywheel to the crankshaft flange and lift off the flywheel.
7. Remove the outer race of the spigot bearing from the flywheel bore. On the L-type engine, however, this outer race is located within its own housing, which in turn is setscrewed to the flywheel.

To Fit

Reverse the procedure for removal, noting the following points:

1. Ensure that a paper joint and sufficient non-hardening compound is used on the joint between the rear casing and the flywheel so that a perfectly oil-tight seal is obtained.
2. Refill the fluid coupling with oil as described in Section M4.

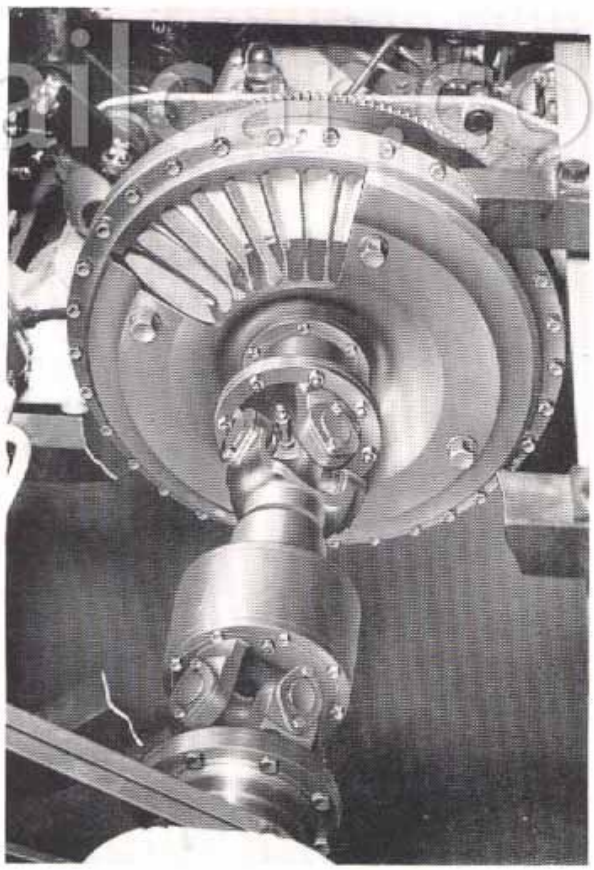


Fig. 4. Fluid coupling in position, shown part cut away.

Sect. M6 FLUID COUPLING—TO DISMANTLE AND ASSEMBLE

(See Figs. 1 and 2)

To Dismantle

1. Remove the fluid coupling as described in Section M5.
2. Remove the bellows gland as described in Section M3.
3. To remove the rear casing from the runner shaft use a lead hammer on the splined end of the shaft. The bearing can then be removed if required.
4. Remove the bolts securing the baffle plate to the runner and remove the baffle plate.
5. Remove the bolts securing the runner shaft to the runner and separate the parts.

To Assemble

Reverse the procedure for dismantling, making special note of the instructions given in Sections M3 and M5.

GEARBOX

CHAPTER S

CONTENTS

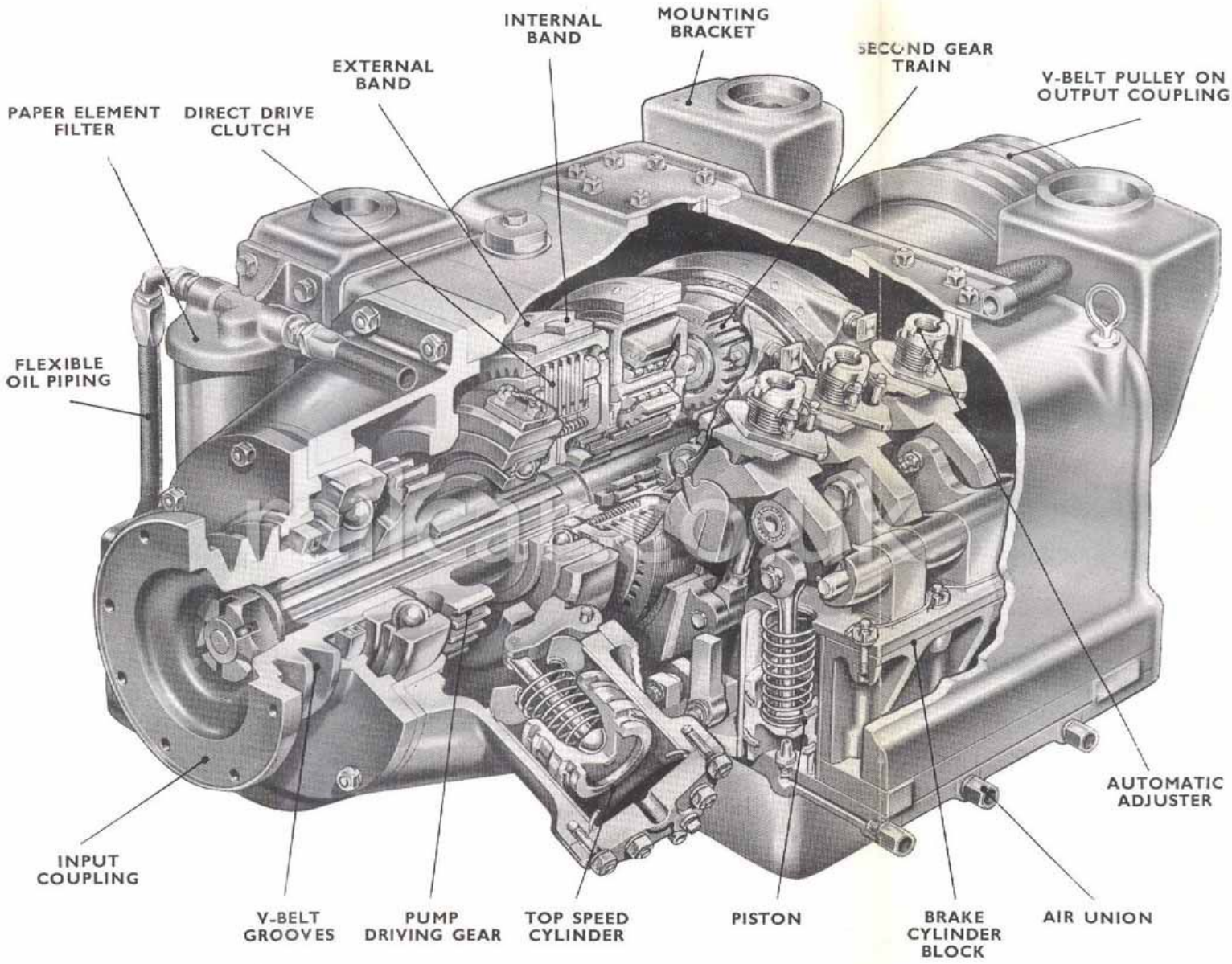


Fig. 1. The Gearbox.

Sec. S1 GEARBOX—DATA

(TYPE R.14)

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

Gear Ratios

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

Rotation: Clockwise looking on input end
Mounting: Independent mounting using bearer brackets
Operation: By air pressure at 65 lbs./sq. in. $\pm$ 2½lbs.
Oil Pump: Gear pump driven from input shaft

Brake Setting Gauge Dimensions

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

Sec. S2 GEARBOX—DESCRIPTION

(*See Figs.* 2 & 4)

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

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

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

Sec. S3 GEARBOX—BRAKE OPERATION

(*See Figs.* 3 & 4)

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

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

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

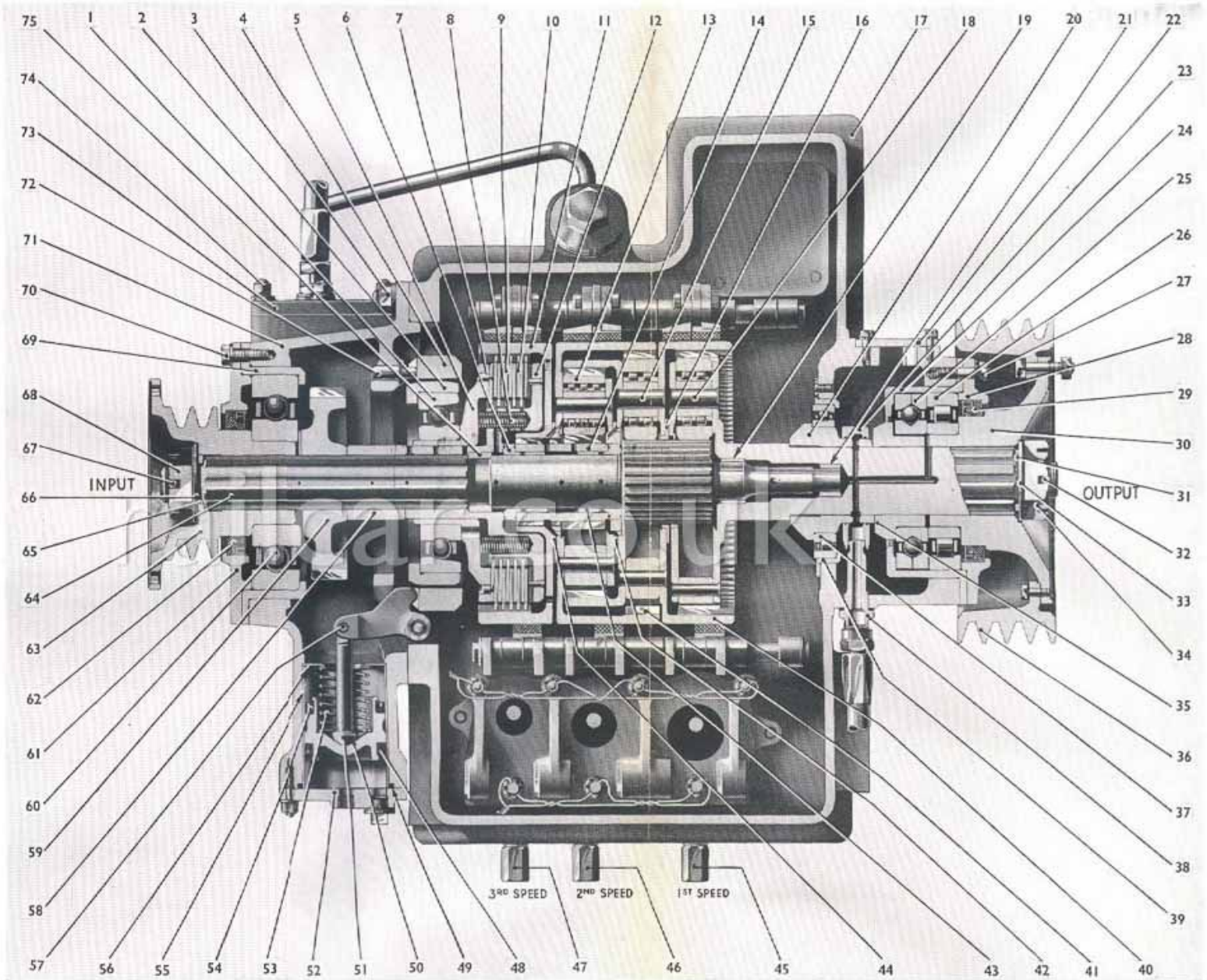


Fig. 2. Section through Gearbox.

FEATURES OF THE BRAKES

(*See Fig.* 4)

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

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

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

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

OPERATING SEQUENCE OF THE BRAKES

(*See Figs.* 3 & 4)

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

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

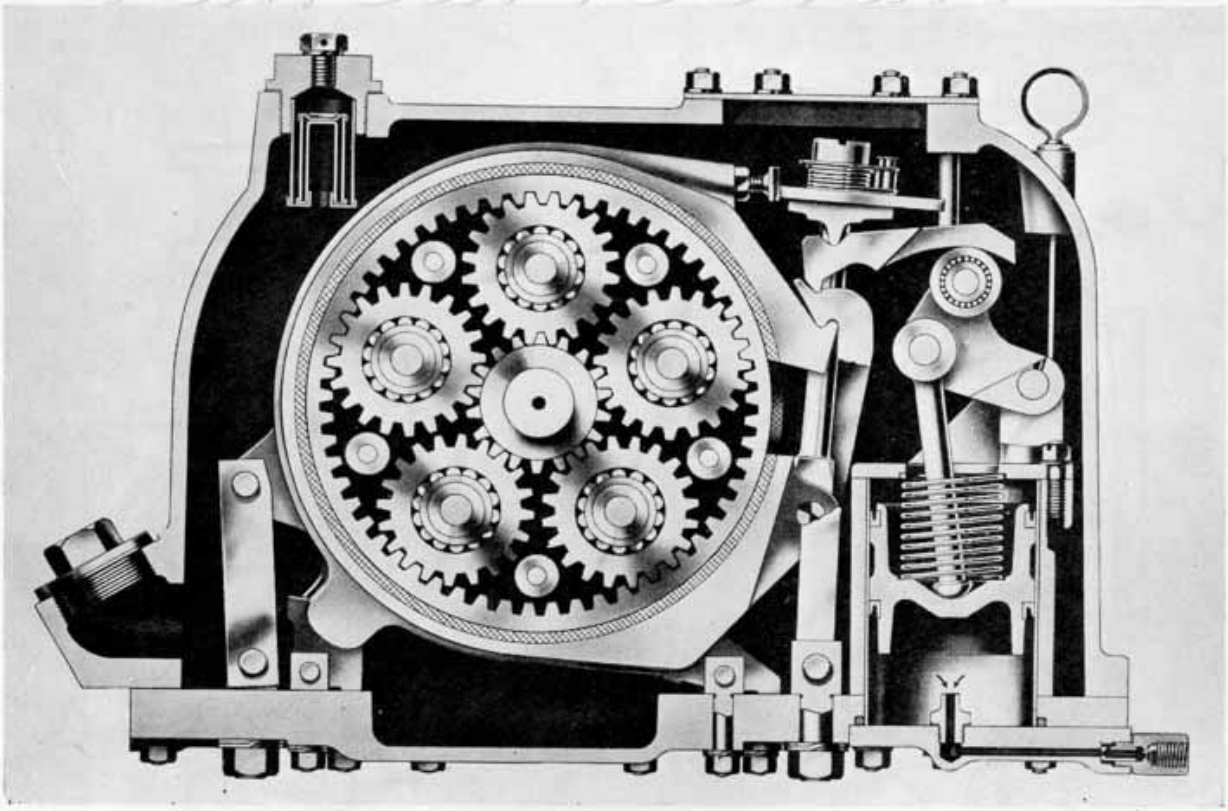


Fig. 3. Section through 1st Speed Band Brake. (Brake On)

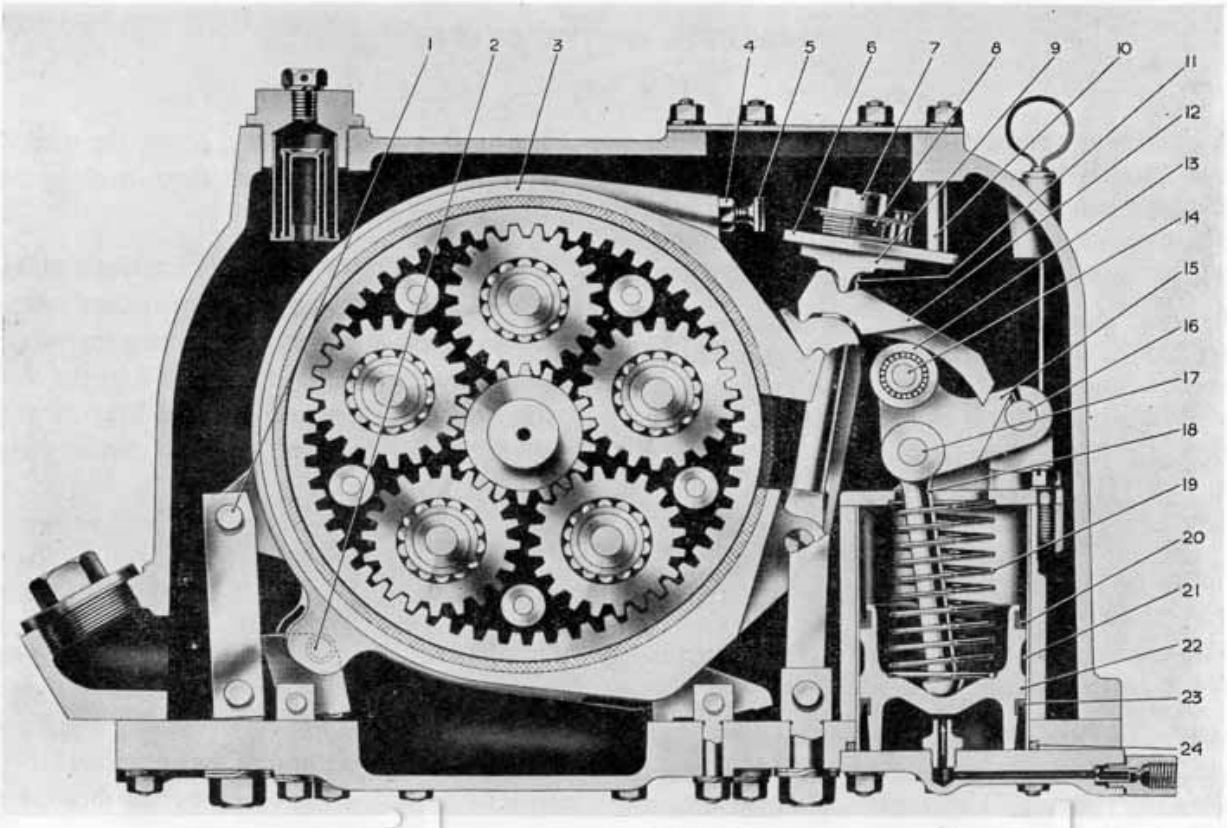


Fig. 4. Section through the 1st Speed Band Brake. (Brake Off)

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

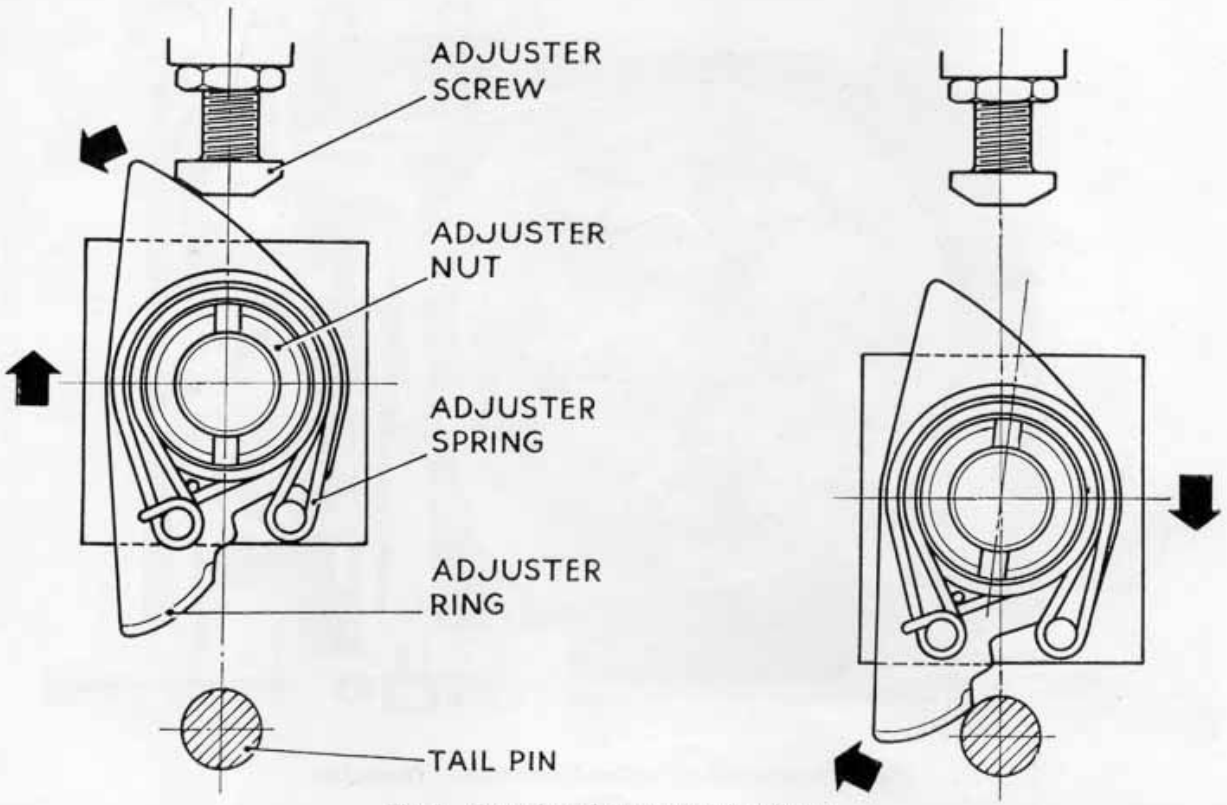


Fig. 5. Operation of the Automatic Adjuster.

Sec. S4 GEARBOX—AUTOMATIC ADJUSTER

(*See Fig.* 5)

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

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

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

Sec. S5 GEARBOX—TOP SPEED CLUTCH OPERATION

(*See Fig.* 6)

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

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

KEY TO NUMBERS:—

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

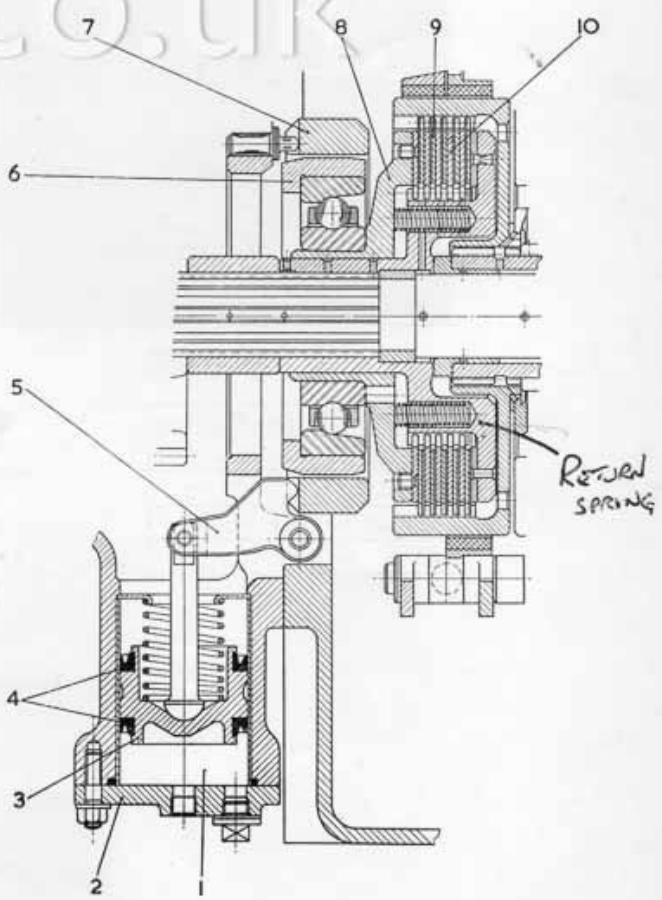
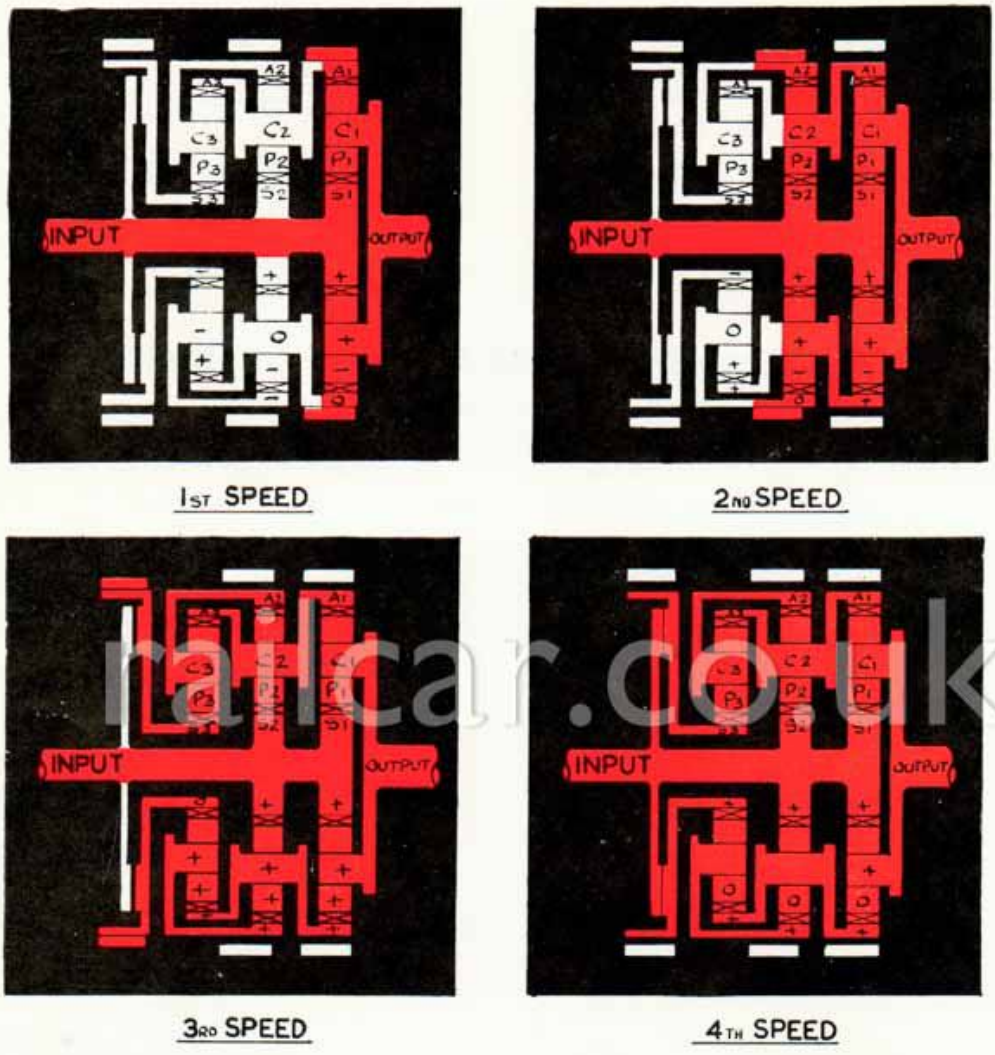


Fig. 6. Top Speed Clutch Actuation.



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

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

ROTATION.

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

Fig. 7. Torque Transmission Diagram.

Sec. S6 GEARBOX—AIR PRESSURE

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

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

Sec. S7 GEARBOX—PRINCIPLE OF OPERATION

(*See Fig.* 7)

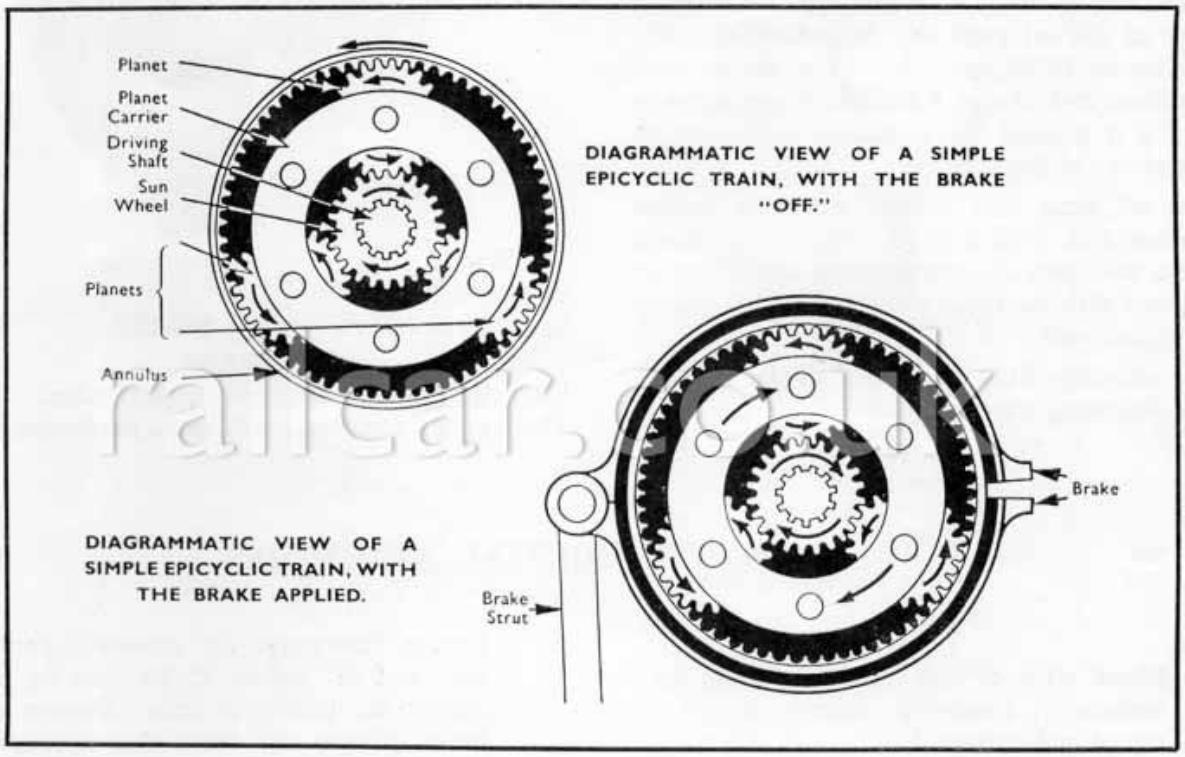


Fig. 8. Diagrammatic View of Epicyclic Gear Train.

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

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

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

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

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

Sec. S8 GEARBOX—LUBRICATION

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

The gearbox requires approximately 2½ gallons of oil.

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

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

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

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

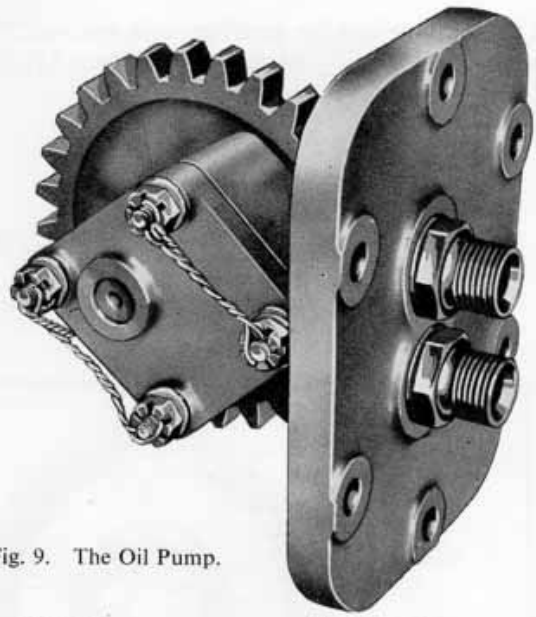


Fig. 9. The Oil Pump.

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

Oil Changes

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

Sec. S9 GEARBOX—ROUTINE ATTENTION

Daily.

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

Every 3000 miles.

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

Every 6000 miles (in addition to the foregoing).

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

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

1. Drain gearbox and refill with new oil.

Every 150,000 miles.

1. Remove gearbox for complete overhaul.

Sec. S10 GEARBOX—SERVICING THE AIR PISTONS

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

(*See Fig.* 10)

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

TO REMOVE AND REPLACE 4th SPEED PISTON

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

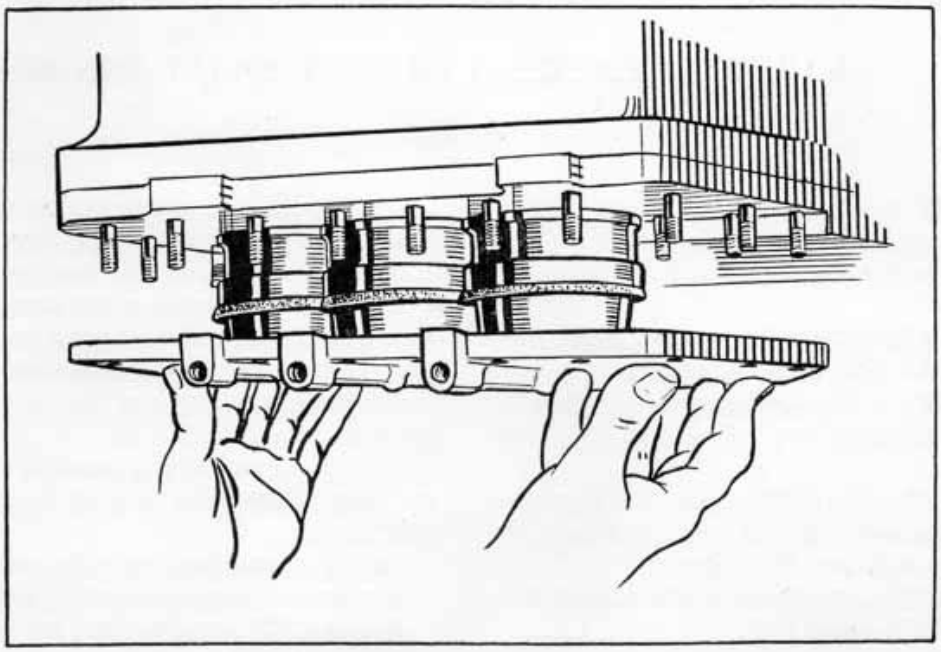


Fig. 10. Removing the Cover Plate (1st, 2nd & 3rd Speeds).

Sec. S11 GEARBOX—RENEWING INPUT SHAFT OIL SEAL

(See Fig. 2)

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

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

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

Engage third gear to lock input shaft.

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

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

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

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

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

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

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

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

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

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

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

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

Release 3rd gear.

Replace belt drives and cardan shaft.

Sec. S12 GEARBOX—RENEWING OUTPUT SHAFT OIL SEAL

(See Fig. 2)

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

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

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

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

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

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

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

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

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

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

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

Secure oil seal housing with nuts and washers.

Replace coupling (and pulley if fitted).

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

Release 1st Gear.

Replace belt drives (if fitted) and cardan shaft.

Sec. S13 GEARBOX—OIL FILTER

(*See Fig.* 12)

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

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

RENEWING THE FILTER ELEMENT

(*See Fig.* 12)

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

DISMANTLING AND ASSEMBLING THE FILTER

(*See Fig.* 12)

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

Fig. 11. View of Filter.

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

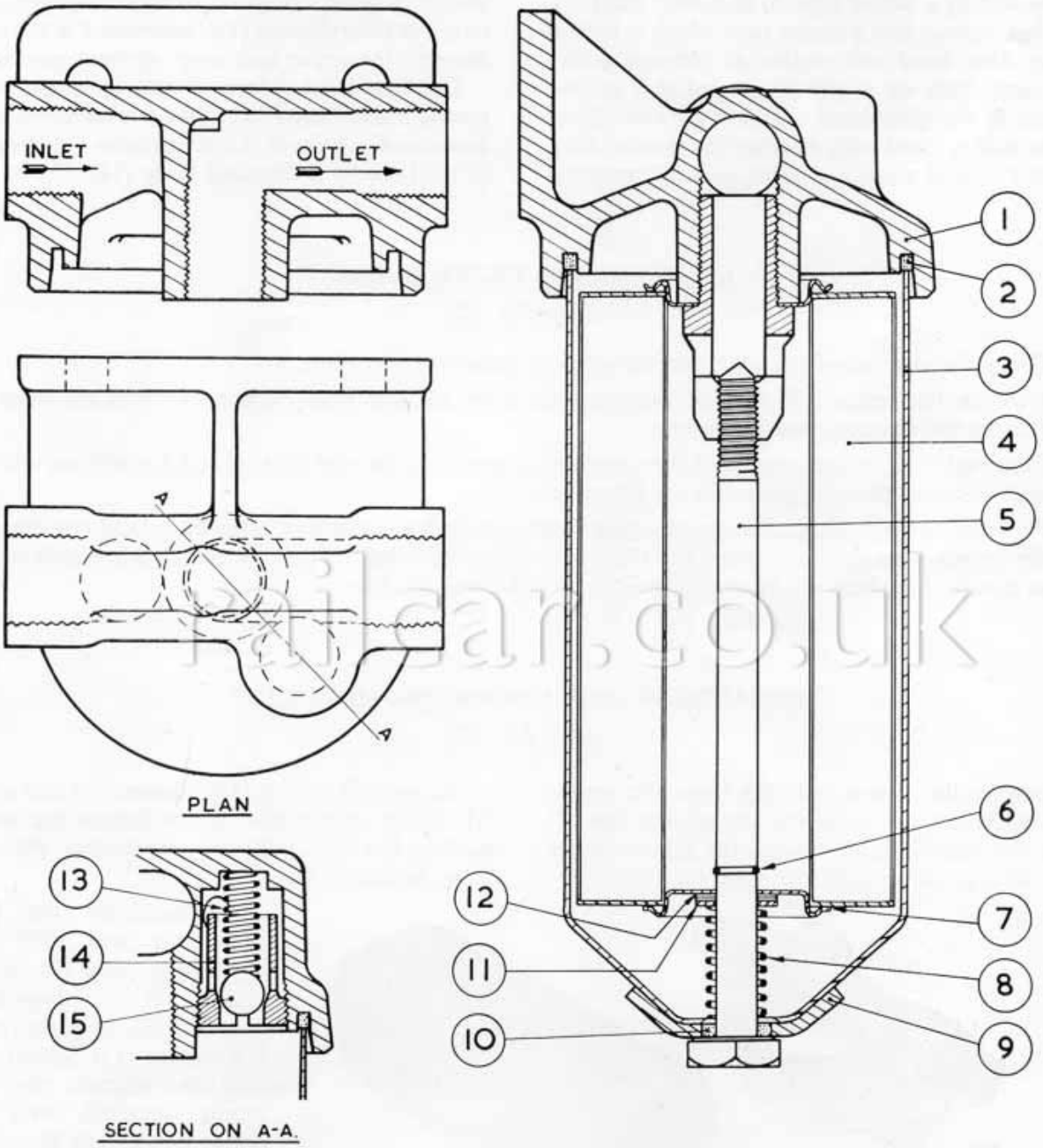


Fig. 12. Drawing of Filter.

Sec. S14 GEARBOX—SERVICING THE BRAKES

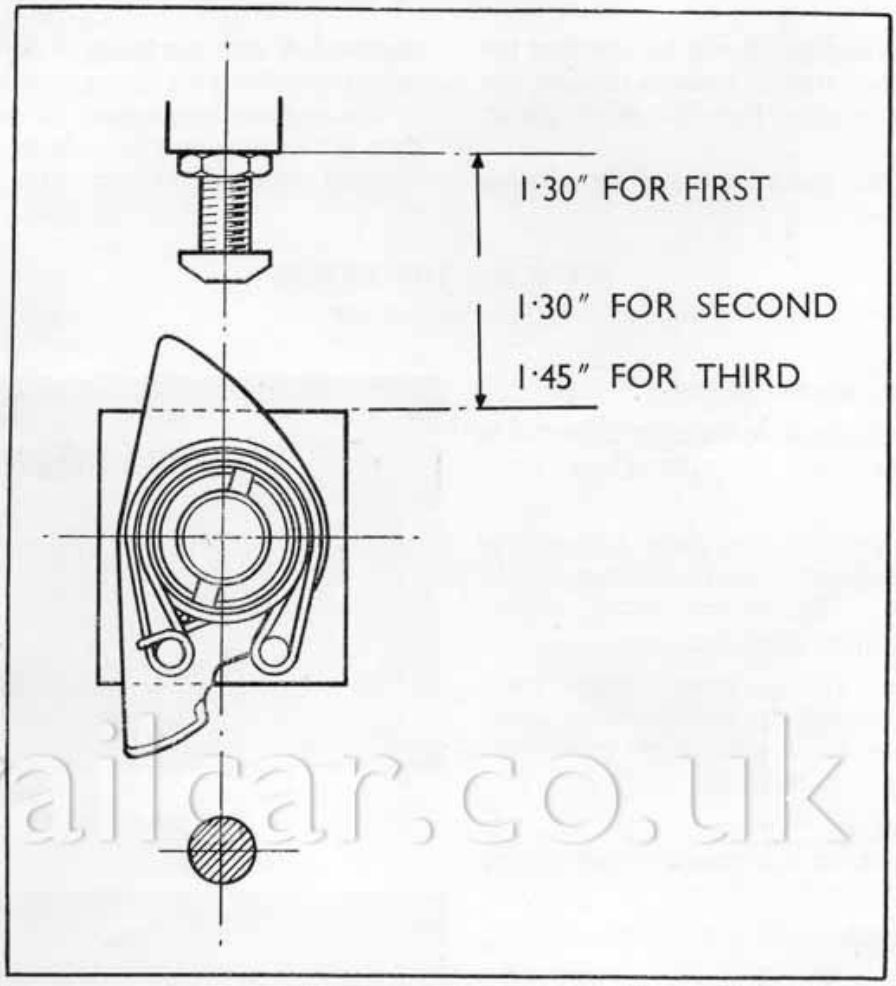


Fig. 13. Brake setting Dimensions

AIR SUPPLY FOR BRAKE ADJUSTMENT

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

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

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

FITTING THE AUTOMATIC ADJUSTER SPRING

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

THE BRAKE SETTING DIMENSION

(*See Figs.* 13 & 14)

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

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

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

SERVICING THE BRAKES

(*See Figs.* 5 & 14)

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

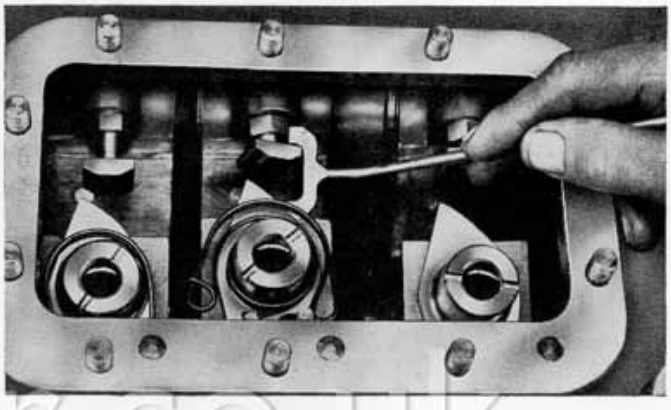


Fig. 14 GAUGE APPLICATION. This shows where the gauge should be applied.

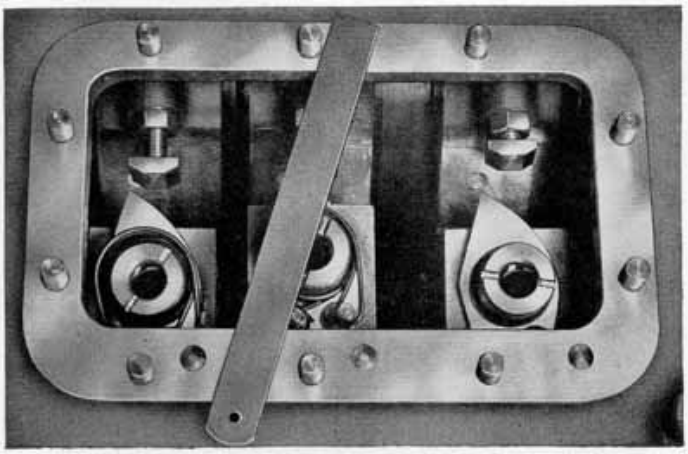


Fig. 15. Checking Movement of Adjuster Nut

FINAL ADJUSTMENT

Insufficient Gauge Clearance:—

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

Excessive Gauge Clearance:—

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

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

FAILURE OF AUTOMATIC ADJUSTER

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

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

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

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

When failure is established.

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

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

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

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

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

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

Sec. S15 GEARBOX—TO REMOVE AND FIT

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

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

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

Release the four air connections at the gearbox.

Pack up the gearbox and remove the mounting bolts.

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

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

To replace the gearbox, reverse the above procedure.

Fig. 16. View of Gearbox (a).

Fig. 17. View of Gearbox (b).

Sec. S16 GEARBOX—TO DISMANTLE

(*See Fig.* 4)

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

Support the gearbox on a suitable bench.

Check the necessity for relining the brakes by observing the position of the adjuster nut (7) on the pull rod (11). Brake life is exhausted when the top faces of the adjuster nut and pull rod coincide.

Preparatory to removing the running gear the three brake adjuster mechanisms must be slackened off. Access to the adjusters is obtained by removing the large inspection cover on top of the gearcase.

Remove the two eyes of each adjuster spring (8) from the ring pin (6) and the loop from the table pin (9) to release the adjuster nut (7) this should then be screwed three complete turns anti-clockwise.

REMOVE REAR END ASSEMBLY

(*See Fig.* 2)

Take off split pin (32) nut (34) and washer (33) followed by the "O" ring (31).

Next remove the output coupling (30) complete with pulley (36) (if fitted) and inner race of bearing (26).

Remove nuts (27) and spring washers from the studs, and take away the oil seal housing (28) with oil seal (29).

Using special extractor tools (Part No. 37428) withdraw the bearing sleeve (24) complete with outer race of bearing (26) bearing (25) and bearing collar (35).

There should be no necessity to disturb the cover plate (22). Next unscrew the oil union (38) out of the gearcase together with its copper washer; the oil muff (23) can then be removed from the bearing collar (20).

TO REMOVE FRONT COVER, etc.

(*See Fig.* 2)

Remove nuts (74) and the washers from studs, then remove oil pump assembly and gasket from the front cover (71).

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

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

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

Take from the input shaft (64) the pump driving gear (59) and sleeve (58).

Remove nuts (3) and spring washers securing the front cover (71) to the gearcase (17) this includes those situate in the pump mounting aperture. The front cover can then be taken away complete with the top speed piston (50), etc.

Note. Do not disturb pivot pin (72).

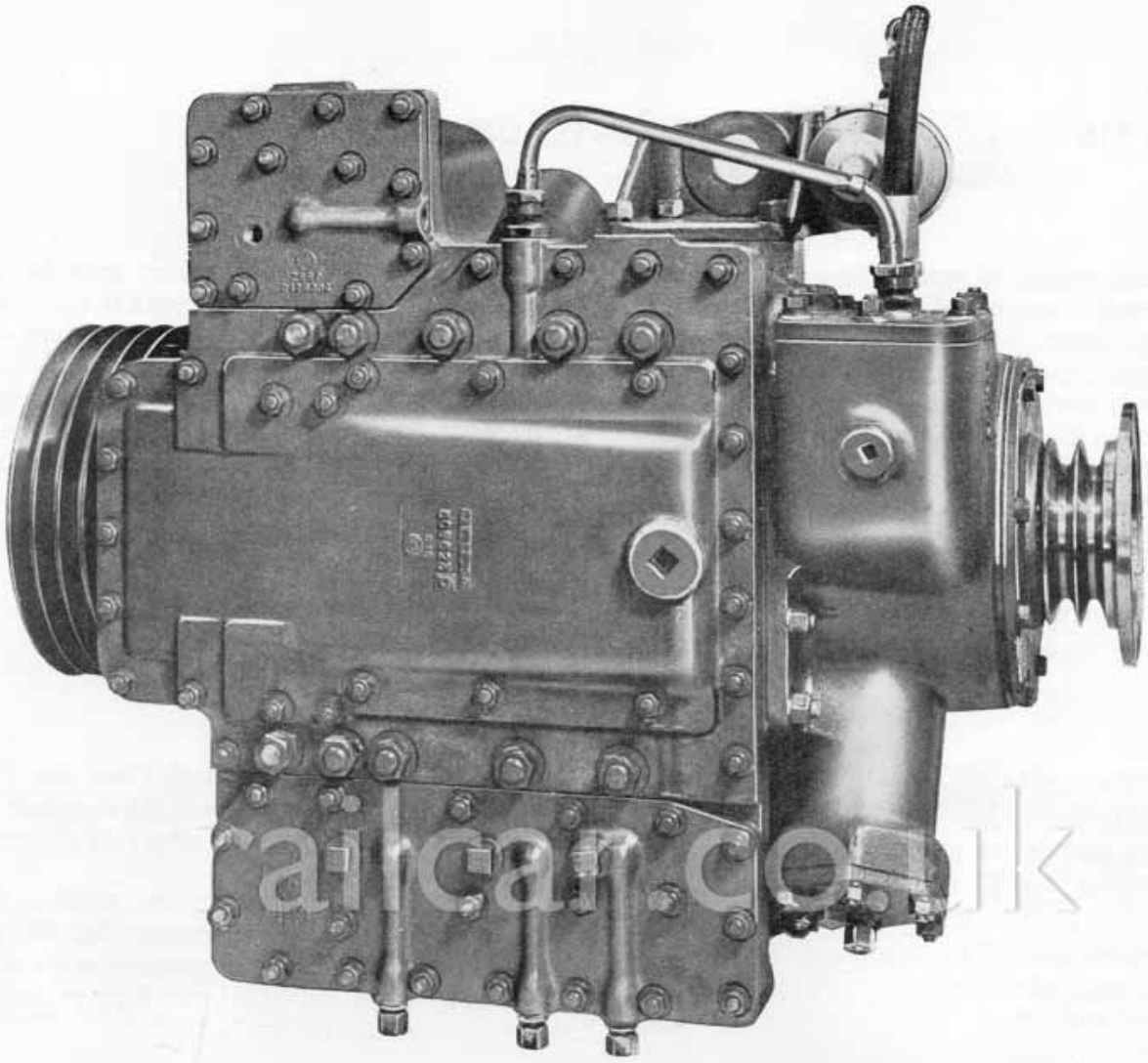


Fig. 18. View of the Bottom Cover, etc.

DISMANTLING THE RUNNING GEAR

(*See Fig.* 2)

Remove the bearing (1) bearing housing (2) trunnion ring (4) and the clutch sliding panel (5). The bearing housing and trunnion ring should be left assembled on the bearing unless a replacement is necessary.

Take out the clutch return springs (8), and spigot pins and remove the clutch inner member (12) complete with clutch plates (9-10). The split ring (75) can then be removed from the shaft (ensure removal of both halves).

The following components should next be removed, in the order given:—

Bush (6)
3rd speed brake drum (11), with Sunwheel (14) (Assembly)
Bush (44)
3rd Speed Planet assembly (13)
Bush (42)
Bush (43)
Input shaft (64)
2nd Speed Planet assembly (15)
Adjusting washer (16)
Bushes (19 and 21)
1st Speed Planet assembly (18) with output shaft assembly. Withdraw this centrally to avoid damage to surrounding parts.

The bearing collar (20) together with the inner race of bearing (37) can then be removed; the bearing outer race, together with the bearing housing (39) can be left in position unless replacement is necessary.

REMOVAL OF GEARCASE FROM BOTTOM COVER

(*See Fig.* 18)

From their studs unscrew all the nuts securing the bottom cover to the gearcase and lift the gearcase away, leaving the bottom cover, complete with brake bands, brake actuating mechanism and the air cylinders.

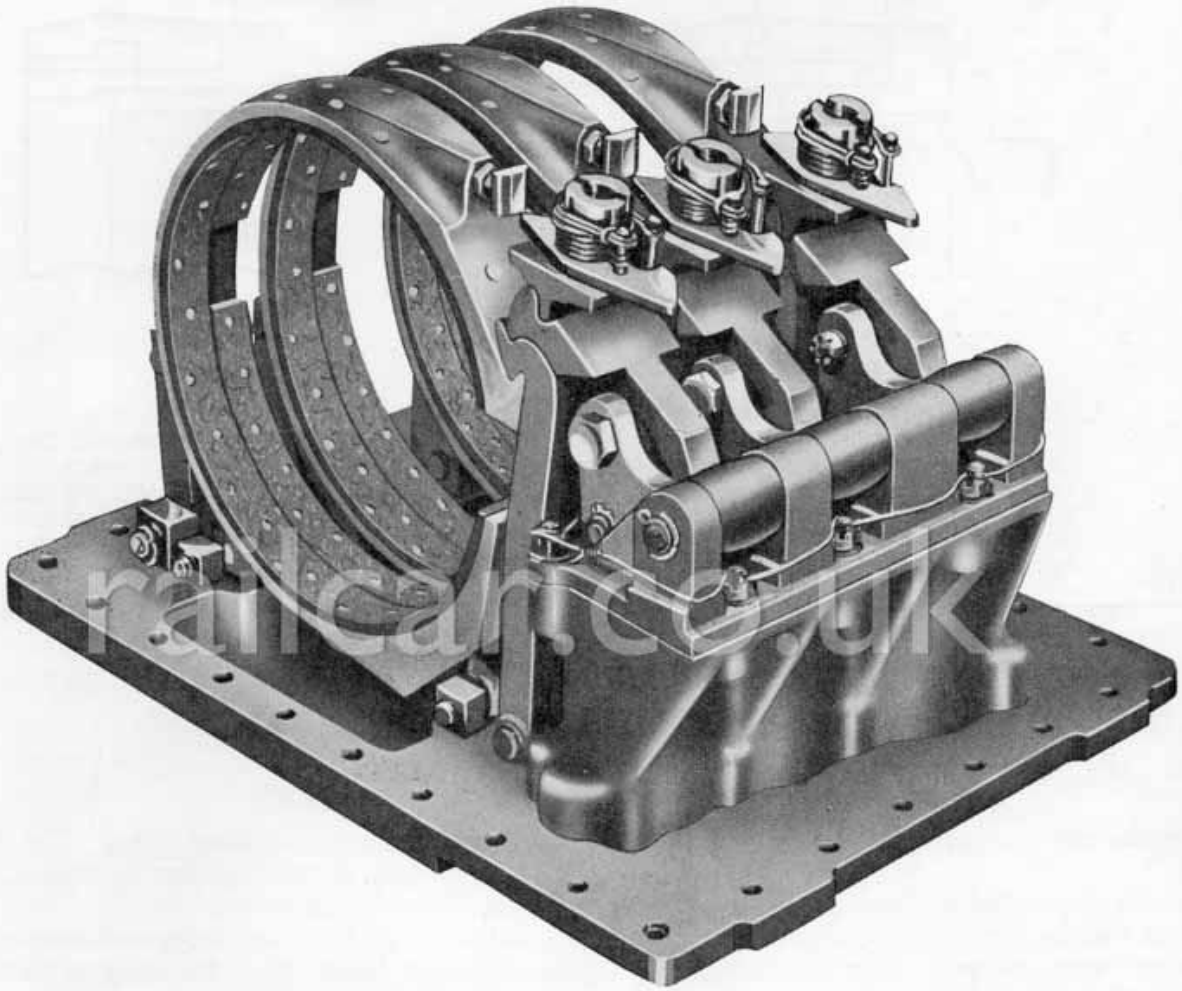


Fig. 19. The Bottom Cover and Brake Band Assembly

REMOVAL OF BRAKE BANDS

(*See Fig.* 4)

Remove the adjuster spring (8), nut (7), ring (6), table (9) and thrust pad (12) from each brake. It is advisable to keep these in sets for subsequent re-assembly to the same band.

Press down on top of each brake band (3) to release the hooks. Take out the split pins from the internal band link pins (1) and extract the pins.

Lift the bands away, first placing rag round the centralizers to prevent the springs (2) from flying out.

EXTRACTING THE PISTONS

Refer to Section S10 for removal of pistons.

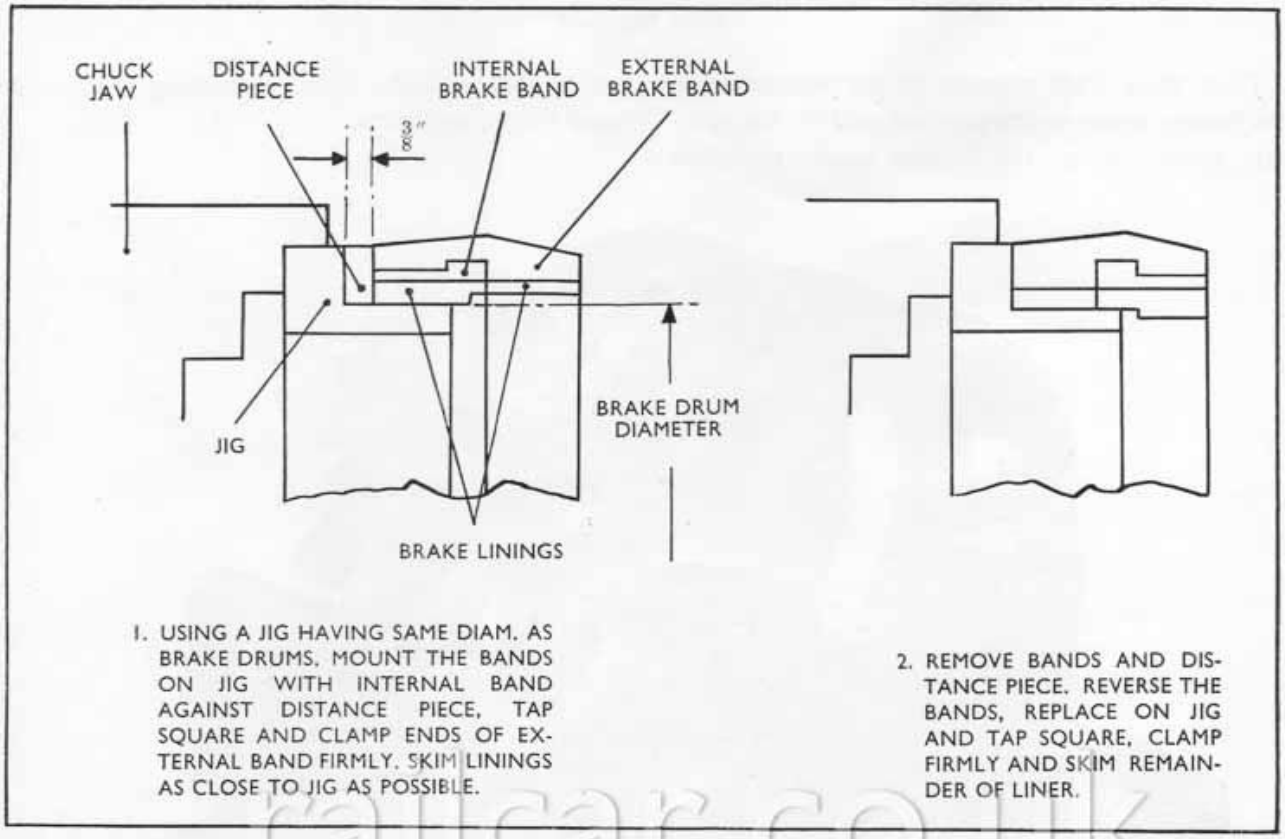


Fig. 20. Relining the Brake Bands.

Sec. S17 GEARBOX—RELINING THE BRAKE BANDS

(*See Fig.* 20)

Separate the internal band from the external band.

Remove the old linings from the bands.

Check that the bands have not taken a permanent set by measuring the gap. Renew outer and inner band if gap is less than 2.0".

To replace the internal lining, first cut through it and place it in the band securing with clamps. Next drill through the band and lining using an $\frac{11}{64}$" drill.

Countersink to $\frac{5}{32}$" depth the holes in lining using a $\frac{11}{32}$" tungsten carbide tipped drill (90° included angle). Rivet the lining to the internal band and file flush. (Important).

Trim lining at extreme ends level with brake band, ensure also that the lining is flush at the lug side.

Position the new lining in the external band, ensuring the lining is level at the edge that will mate with the internal band lining. The band should then be drawn together by means of a clamp affixed across its ends.

Drill through band and lining and countersink as with inner band. Rivet the lining to the band leaving out the two end rivets.

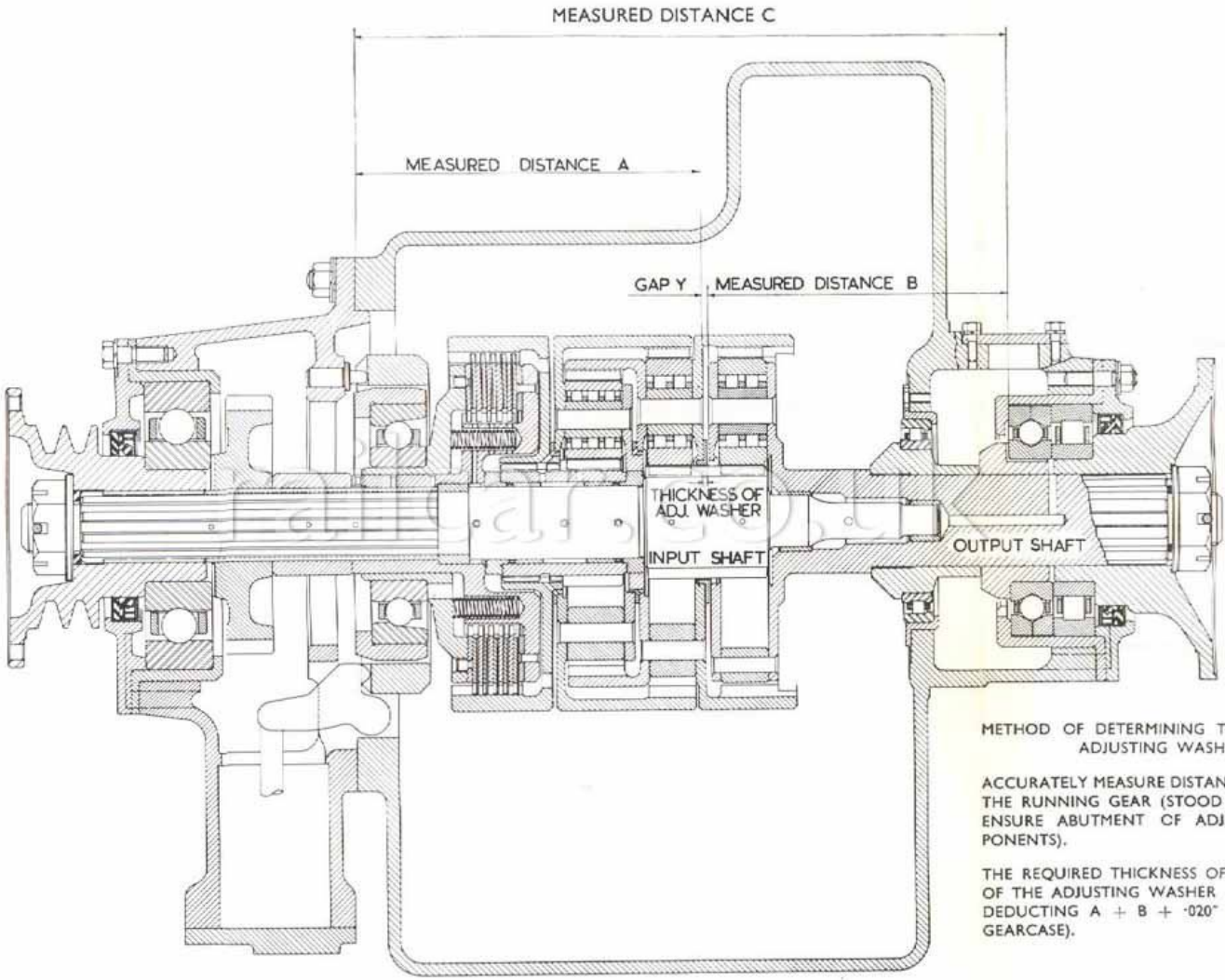
Cut the lining and release the clamp, rivet the ends of the lining. The lining should then be trimmed at the ends, level at the lug end and leaving a $\frac{1}{8}$" projection at the other end.

File the rivets level to the band on the machined surface.

After relining, the lug on the internal band is led through its slot in the external band and the free end again pushed toward the centre, when the band will slip easily into position.

The linings are then skimmed up as shown in Fig. 20, the bands can then be replaced as explained in Section S18.

Fig. 21. Running Gear, etc. (Shown in Sequence).



METHOD OF DETERMINING THICKNESS OF ADJUSTING WASHER

ACCURATELY MEASURE DISTANCES A & B ON THE RUNNING GEAR (STOOD ON END TO ENSURE ABUTMENT OF ADJACENT COMPONENTS).

THE REQUIRED THICKNESS OF THE FLANGE OF THE ADJUSTING WASHER IS FOUND BY DEDUCTING A + B + ·020" FROM C (ON GEARCASE).

Fig 22. Method of Determining Thickness of Adjusting Washer.

Sec. S18 GEARBOX—TO ASSEMBLE

Note. ENSURE THAT ALL PARTS ARE THOROUGHLY CLEAN AND FIT FOR FURTHER SERVICE. (SEE SECTION S19).

CHECKING THE END FLOAT

(*See Fig.* 22)

From the Measured Distance C deduct the sum of A + B + thickness of flange of adjusting washer. If the remainder exceeds .050″ a new adjusting washer must be used, its flange thickness being determined as outlined in figure 22. When new flanged bushes are fitted ALL brakes should be re-lined.

REPLACE PISTONS

Refer to Section S10 for replacement of the pistons.

REPLACE BRAKE BANDS

(*See Fig.* 4)

Note. Before commencing ensure that the adjuster nuts are an easy fit on the pull rod (11) $\frac{11}{16}$″-16 UNS—2A thread. Tight nuts $\frac{11}{16}$″-16 UNS —2B thread may be eased by use of a tap. Ill fitting or damaged pull rods can be corrected by the use of a die nut.

It is essential that brakes which have not been re-lined are assembled in their original positions.

Considerable time in the adjustment of the brakes, can be saved by making a practice of re-assembling brakes, thrust pads and adjuster components in their original positions.

Insert the springs (8) into the centralizers and compress each spring in turn and pass the ears of the band (3) over them.

Fit the internal band link pins (1) and secure with split pins.

Compress the external bands (3) and engage the brake hooks.

Fit to the pull rods (11), thrust pads (12) adjuster tables (9) and the adjuster rings (6), secure these with the adjuster nuts (7), screw down far enough to keep them in position.

Replace the adjuster springs (8).

REPLACE THE GEARCASE TO BOTTOM COVER

(*See Fig.* 18)

After applying jointing compound lower the bottom cover with brake assemblies inverted onto the gearcase, secure with nuts and spring washers onto bottom cover.

REPLACE RUNNING GEAR

(*See Fig.* 2)

Note. Ensure that all the running gear is pushed fully into position when in mesh. Dip all bushes in oil when fitting.

The first component to be replaced in the gearcase, (since the bearing housing (39) and outer race of bearing (37) are normally left undisturbed) is the bearing collar (20) together with the inner race of the bearing (37).

Replace next the 1st speed planet and output shaft assembly bushes (19 and 21).

The adjusting washer (16) should be fitted to the face of the 2nd speed planet assembly with a smear of grease.

Fit the 2nd speed planet assembly (15) with the adjuster washer into position followed by the bush (42). The input shaft (64) can now be replaced into mesh with the 1st and 2nd speed planet trains (15 and 18).

Fit bush (43), and replace the 3rd speed planet assembly, fit bush (44).

Replace the 3rd speed sunwheel (14) and brake drum (11) assembly and bush (6).

The split ring (75) should then be greased and positioned onto the shaft, and the clutch inner member (12) passed over it.

Replace the clutch plates (9-10) in the order shown on Fig. 1 and insert the springs (8) and spigot pins.

Position onto the clutch inner member (12) the sliding panel complete with bearing (1) bearing housing (2) and trunnion ring (4) in position.

The sleeve (58) should then be replaced followed by the pump driving gear (59).

REPLACE THE FRONT COVER ASSEMBLY

(*See Fig.* 2)

Fit to the front cover (71) the 4th speed actuating assembly (50 and 51, etc.) if these parts have been removed. The bearing housing (69) complete with bearing (60) oil seal housing (61) with oil seal (62) should then be fitted to the gearcase (first applying jointing compound).

Note. The oil seal (62) should be packed with grease before replacement.

Position front cover assembly to gearcase, first applying jointing compound, replace spring washers and nuts (3) to the studs (including the nuts situate in the pump mounting aperture).

Replace the oil pump assembly (73) with gasket, fastening with nuts and washers.

Tap the input coupling (63) into position and replace sealing washer (65) washer (66) nut (68) and split pin (67).

REPLACE THE REAR END ASSEMBLY

(*See Fig.* 2)

Fit the oil muff (23) over the bearing collar (20) and screw the oil union (38) into position in the casing, together with its copper washer.

Replace the bearing collar (35) to the output shaft, followed by the bearing sleeve (24) and bearings (25 and 26).

Pack the oil seal (29) with grease.

The oil seal housing (28) can then be replaced complete with oil seal (29) (first applying jointing compound), secure by replacing nuts (27) with spring washers to the studs.

The output coupling (30) complete with pulley (36) (if fitted) should next be fitted, tapping into position.

Replace "O" ring (31) washer (33) nut (34) and split pin (32).

The gearbox is now completely assembled.

THE BRAKES MUST NOW BE ADJUSTED SEE SECTION S14.

Sec. S19 PERMISSIBLE CLEARANCE FOR RUNNING GEAR BUSHES

Part No.	Item No. Ref. Fig. 2	Description	Dimension Ref.	Min^{m} Permissible Diametral Clearance (New)	Max^{m} Permissible Diametral Clearance (Worn)	Min^{m} 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"

FINAL DRIVE

CHAPTER T

CONTENTS

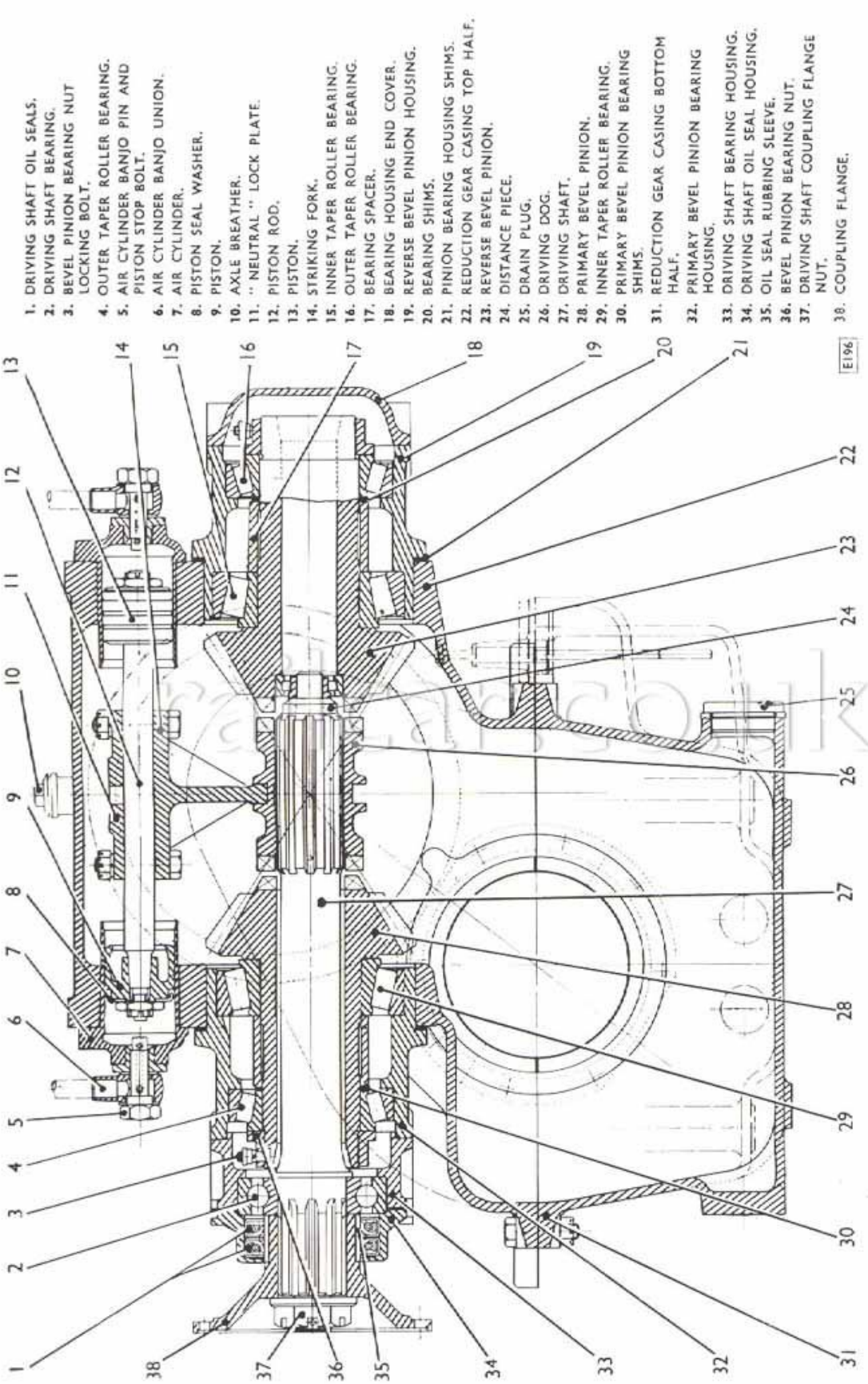


Fig. 1. Longitudinal section through bevel pinions.

Sect. T1. FINAL DRIVE — DESCRIPTION.

(See Figs. 1, 2 and 3).

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. A pointer attached to one of the inspection covers indicates the position of the sliding dog. This pointer is operated by a lever which engages a slot in the " neutral " plate which in turn is actuated by the piston operating rod. The lever also operates a switch, fitted to the axle casing, which is connected to an indicator in the driver's cab.

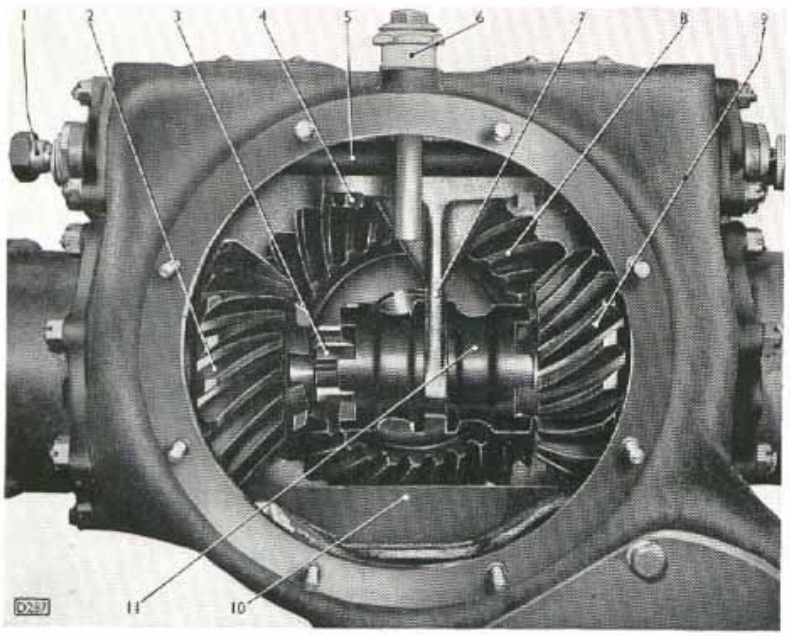
Filling and drain plugs, together with a dip-stick, are provided for lubricant ; a breather is fitted on top of the casing.

IMPORTANT : If a car is to be TOWED, due to failure, the final drive must be isolated.

Alternative methods of isolating the final drive.

Stop the car and ensure that the handbrake is firmly applied. If sufficient air pressure is available proceed as follows : —

Pull the hand operated plunger outwards, then



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

Fig. 2. Final drive showing engagement dog in forward speed. (The indicator switch is not shown in this illustration).

1. DUAL PURPOSE BALL BEARING.
2. DISTANCE PIECE.
3. BEARING HOUSING.
4. SPUR GEAR PINION.
5. BEARING CIRCLIP.
6. BEVEL WHEEL.
7. DIRECTION INDICATOR.
8. DIRECTION SWITCH.
9. " NEUTRAL " LOCKING PLUNGER.
10. DIRECTION INDICATOR OPERATING LEVER.
11. BREATHER.
12. " NEUTRAL " PLATE.
13. PISTON ROD.
14. STRIKING FORK.
15. DRIVING SHAFT.
16. DRIVING DOG.
17. BEVEL WHEEL SHAFT KEY.
18. OIL SEAL COVER.
19. OIL SEALS.
20. RETAINING RING.
21. DRIVEN SPUR GEAR.
22. BEARING HOUSING.
23. OIL SEAL HOUSING.
24. OIL SEALS.
25. OIL SEAL COVER SET-SCREW.
26. OIL SEAL COVER.
27. BEARING HOUSING SHIMS.

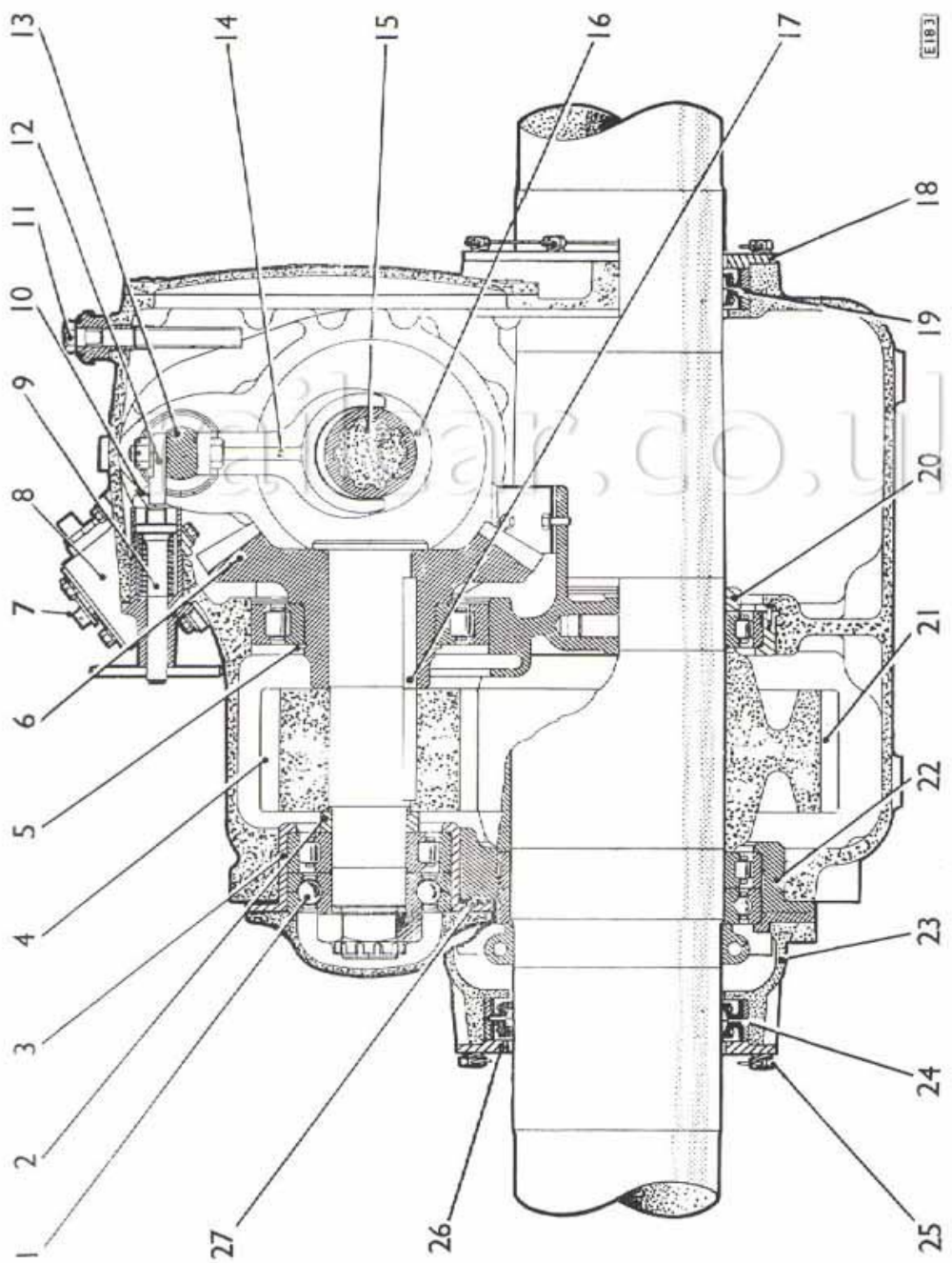


Fig. 3. Longitudinal section through bevel wheel and shaft.

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.

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, the following method should be applied:—

Stop the car and ensure that the handbrake is firmly applied. 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 trap in the body floor giving access to the final drive unit and remove the inspection cover from the top of the final drive 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 and secure the inspection cover.

Sect. T2. FINAL DRIVE — MAINTENANCE.

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

1	Top-up or drain and refill the final drive casings with fresh oil (*see Section* T3).
2	Check for leaks the oil seals or packing glands on the axle shaft, and if leaking report immediately.
3	Check for air leaks (*see instructions in this Section*).
4	Clean the breathers on the final drive casings (*see instructions in this Section*).
5	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 to the suspected joints 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.

Disconnect the supply pipes from the air cylinders; ensure that the air cylinders and banjo pins are marked and retained with their washers, so that they can be fitted to their original cylinders when refitting.

Remove the side cover from the final drive casing (*see Fig.* 2).

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.

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

Repeat the procedure for the other piston ; then refit the side 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 final drive casing.

Sect. T3. FINAL DRIVE — LUBRICATION.

(*See Fig.* 4).

To drain the oil from the final drive unit, place a suitable container in position and remove the drain plug from the casing (*see Fig.* 4).

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

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

To refill or "top-up", pour in oil through the filler plug hole until it reaches the "Full" mark on the dipstick.

The oil capacity of the final drive is 3½ Imp. gallons (15·91 litres).

Sect. T4. FINAL DRIVE — TO REMOVE AND DISMANTLE.

(*See Figs.* 1, 5 *and* 6).

To Remove.

Isolate the car batteries by means of the isolating switch.

Drain the oil from the final drive casing following the instructions given in Section T3.

To disconnect the leads from the direction indicator switch, remove the locking split pin and unscrew the plug from the socket.

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

Disconnect the supply pipes from the air cylinders; ensure that the air cylinders and banjo pins are marked and retained with their washers, 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.

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.* 5).

If necessary, 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.

If oil seals are fitted to the axle shaft, remove the oil seal covers, the halves of which are numbered and should be retained in pairs.

Withdraw the oil seals from their housings and remove them from the axle shaft.

Note.—To facilitate fitting and removal, the oil seals are split and the toroidal spring is joined by means of a dowel screwed into the coil.

To remove the oil seal spring from the axle shaft, locate the join and unscrew as for left-hand thread.

Where oil seal gland packing is fitted, remove the gland facings from the axle; the gland facings, which are numbered, should be retained in pairs by refitting the clamp bolts.

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 them 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.

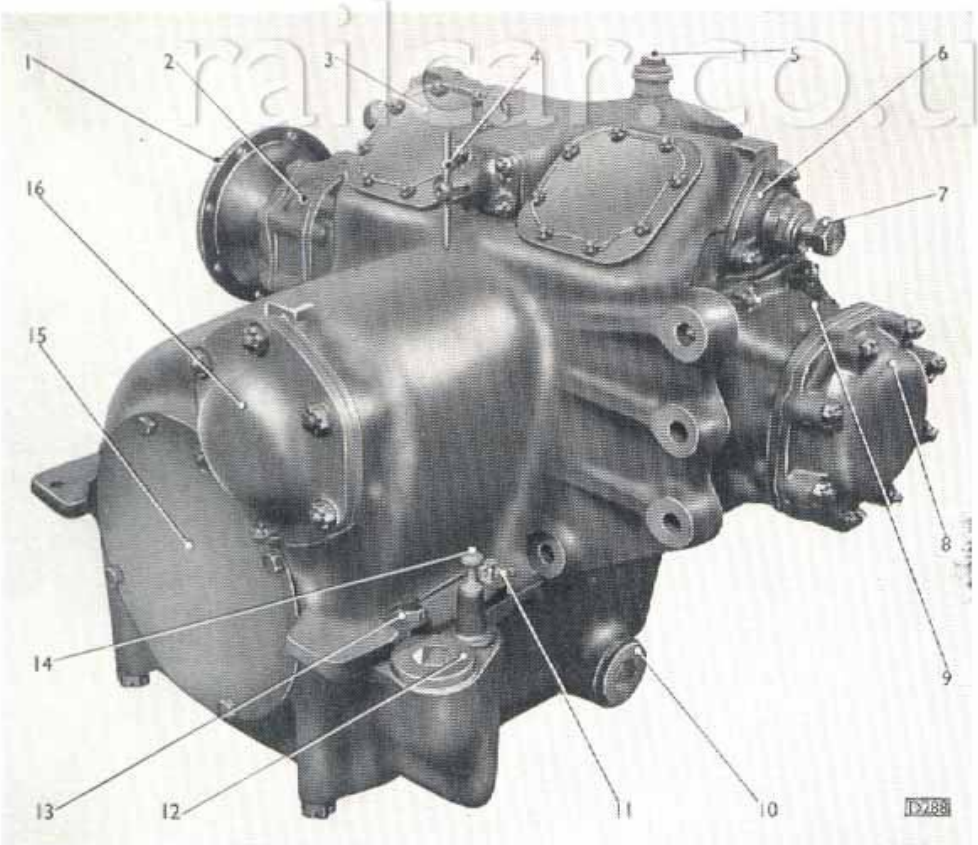
To Dismantle.

Remove the side cover from the final drive casing also the inspection covers and direction indicator switch.

Unscrew 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



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. (The indicator switch is not shown in this illustration).

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.* 6).

Carefully drive out the bevel wheel shaft assembly towards the large aperture in the side of the final drive casing.

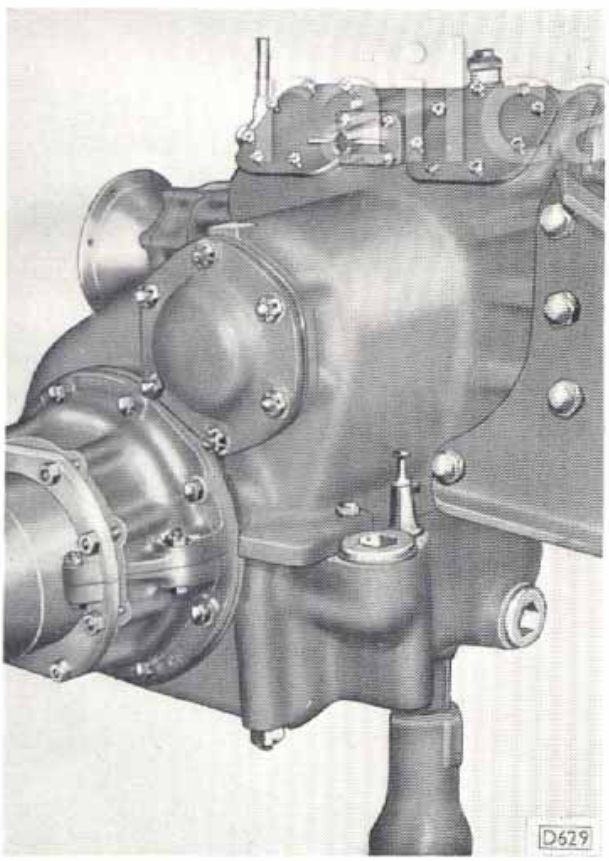


Fig. 5. Method of supporting bottom half of final drive casing whilst removing torque arm.

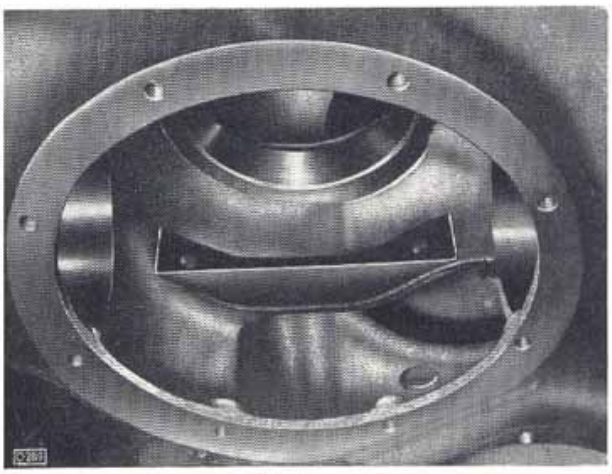


Fig. 6. Final drive casing showing oil trough.

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.

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. T5. FINAL DRIVE—TO ASSEMBLE AND FIT.

(*See Figs.* 1, 7, 8 *and* 9).

To Assemble.

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* T6).

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* T6).

The optimum backlash between the bevel pinions and bevel wheel is 0·012 in. to 0·015 in. (0·30 mm. to 0·38 mm.) (*see Fig.* 7) with a marking as shown in Figure 8.

When fitting the driving dog it is essential that it is fitted the correct way round.

On certain final drive units the driving dog has an identification groove machine on its periphery adjacent to the forward speed dogs and must be fitted with this groove nearest to the propellor shaft coupling flange.

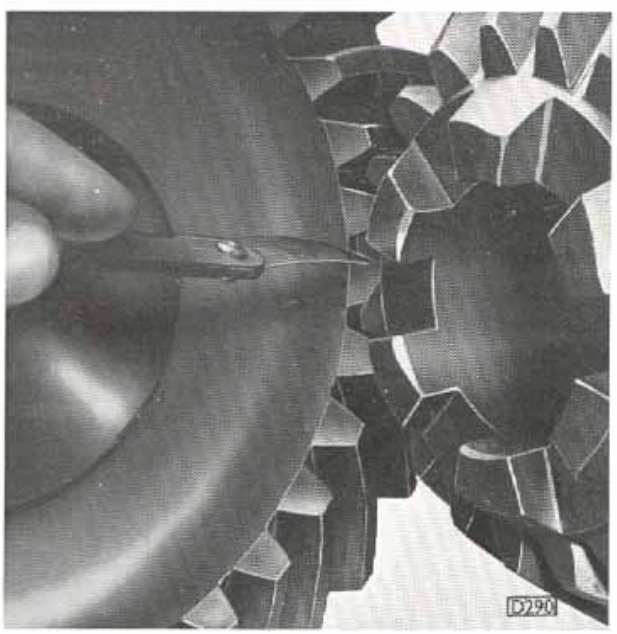


Fig. 7. Method of measuring bevel wheel and pinion backlash.

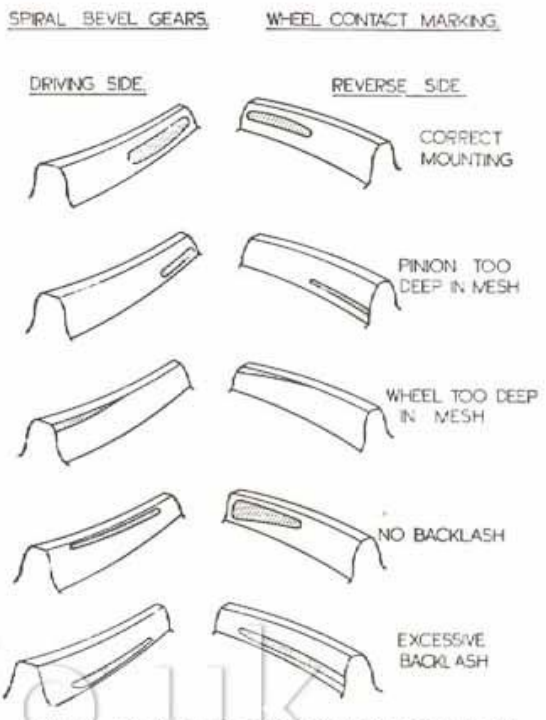


Fig. 8. Marking on teeth of spiral bevel wheel.

When assembling the striking gear, the parts **must** be fitted in their original positions. Should it be necessary to fit a new air pipe banjo pin, note that sufficient material is allowed at the **small** end for "fitting" purposes, as the end of the pin forms a "stop" to limit the travel of the piston rod, and thus controls the clearance between the striking fork and driving dog groove. Excess material should be filed away to provide a running clearance of 0·015 in. to 0·020 in. (0·388 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 oil seals of the gland packing type **do not overtighten** the adjusting nuts.

Clean and refit the axle breather (*see Section* T3).

Fill with fresh oil **through one of the top inspection cover apertures** (*see also Section* T3).

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 seals or gland packing, whichever is fitted.

Oil seals should be fitted as follows:—

Remove the spring and pass the split seal around the axle shaft with the lip towards the housing.

Locate the join in the spring and unscrew as for left-hand thread. Pass the spring around the axle shaft holding one end in each hand, twist one end three to four complete right-hand turns, place the two ends together and allow them to screw up left-hand, as the spring relaxes.

Test the join by slightly stretching the spring, then insert the spring into the groove in the oil seal.

Enter the seal into its housing with the join at 60° before T.D.C.

Repeat the procedure for the second seal ensuring that the lip of the seal is facing away from the housing and that the join is at 60° after T.D.C.

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, 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.

Refit the drain plug to the final drive casing and fill with gear oil following the instructions given in Section T3.

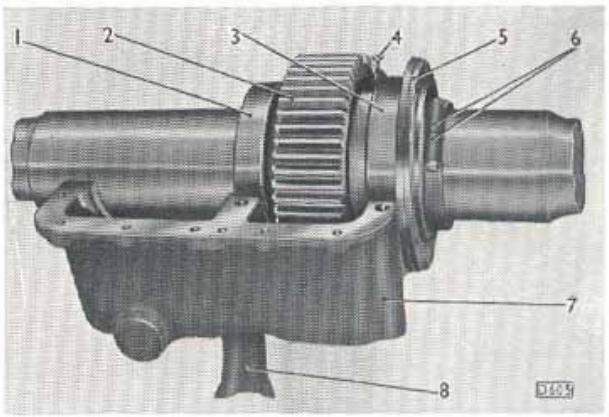


Fig. 9. Method of fitting bottom half of final drive casing.

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.

When fitting the direction indicator switch to the final drive casing refer to Chapter P.

Connect the leads to the direction indicator switch, and lock the plug in position with the split pin.

Note.—The plug and socket can only be fitted one way, as they are provided with a locating register.

Close the battery isolating switch.

Sect. T6. DIMENSIONS OF SHIMS AND DISTANCE PIECES AVAILABLE.

Part	Part No.	Width or Thickness
Shims		
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.)
	Z2/46556D	40 I.W.G. (0·0048 in., 0·12 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., 0·13 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., 0·13 mm.)
Distance piece.	Z9/44813	0·5625 in. (14·29 mm.)
Driving Shaft Spigot Bearing.	Z9/44815	0·5425 in. (13·78 mm.)
	Z9/44816	0·5225 in. (13·27 mm.)

PROPELLER SHAFTS

CHAPTER U

CONTENTS

Sect. U1. PROPELLER SHAFTS — DESCRIPTION.

(See Figs. 1, 2 and 3).

Transmission.

The drive from the engine and fluid coupling to the driving axle is transmitted by means of two propeller shafts.

The first shaft, from the fluid coupling to the epicyclic gearbox, incorporates the freewheel mechanism *(see Figs. 1 and 3).*

The second shaft, from the epicyclic gearbox to the final drive, has a sliding universal joint at the gearbox end *(see Fig. 2).*

All universal joints are of the needle roller type.

Fan drive.

The drive from the engine to the fan is via a shaft which has a sliding universal joint at one end, the joints being of the needle roller bearing type.

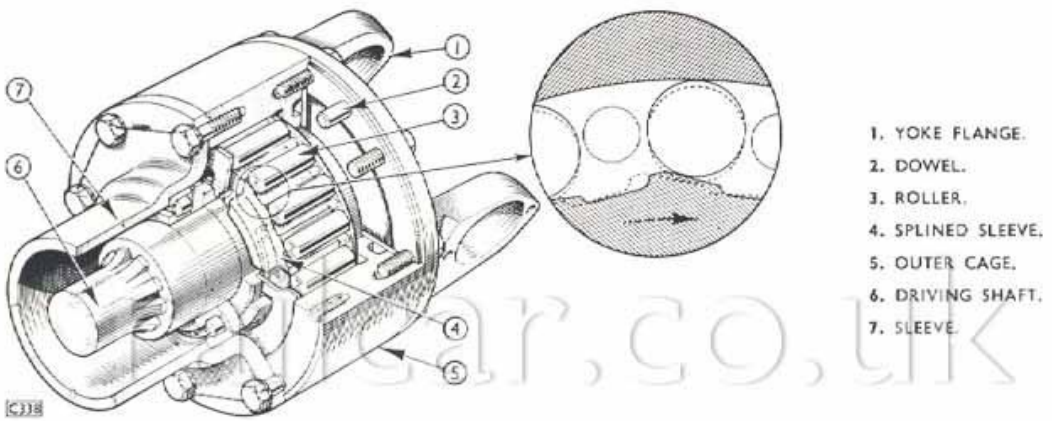


Fig. 1. View of freewheel showing method of operation.

Sect. U2. PROPELLER SHAFTS — MAINTENANCE.

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

1	Examine the universal joint bearings and check for "play." If "play" is detected it should be reported.
2	Lubricate the free wheels with **grease.**
3	Lubricate the splined sliding ends with **grease.**
4	Lubricate the needle roller bearing type universal joints with **oil.**
5	Lubricate the universal joints of the gearbox/final drive propeller shafts with **oil.**
6	Lubricate the universal joints of the engine/fan propeller shafts with **oil.**
7	Examine for slackness, the bolts securing the universal joint coupling flanges and tighten if necessary.

Sect. U3. PROPELLER SHAFTS — LUBRICATION.

(See Figs. 2 and 3).

This Section should be read in conjunction with the Lubrication Chart.

Item	Attention required
Needle Roller Type Universal Joints	Lubricate through the nipples provided (*see below*).
Splined Sliding Ends	Lubricate through the nipples provided (*see below*).
Freewheels	Lubricate through the nipples provided (*see below*).

When lubricating the freewheels, inject grease through the lubricator until an excess exudes from the oil seal (*see Fig.* 3).

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).

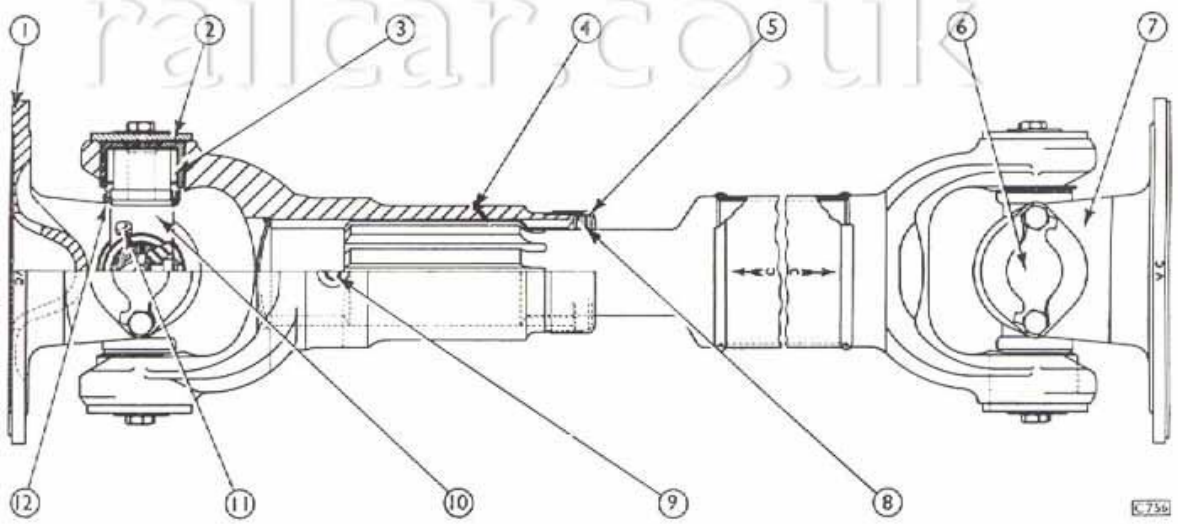


Fig. 2. Universal joint with tubular shaft.

1. SPIGOT.
2. BEARING COVER.
3. NEEDLE ROLLERS.
4. SLIDING END.
5. DUST COVER.
6. LOCK STRAP.
7. YOKE FLANGE.
8. FELT WASHER.
9. SLIDING END LUBRICATOR
10. STAR PIECE.
11. RELIEF VALVE.
12. GASKET AND RETAINER.

Sect. U4. PROPELLER SHAFTS —TO REMOVE AND DISMANTLE.

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

To Remove.

All propeller shafts.

Disconnect both coupling flanges, move the sliding end along its splines and remove the shaft.

To Dismantle.

Propeller shaft and free wheel (*see Figs.* 1 *and* 3).

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 inner 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 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* U5.)

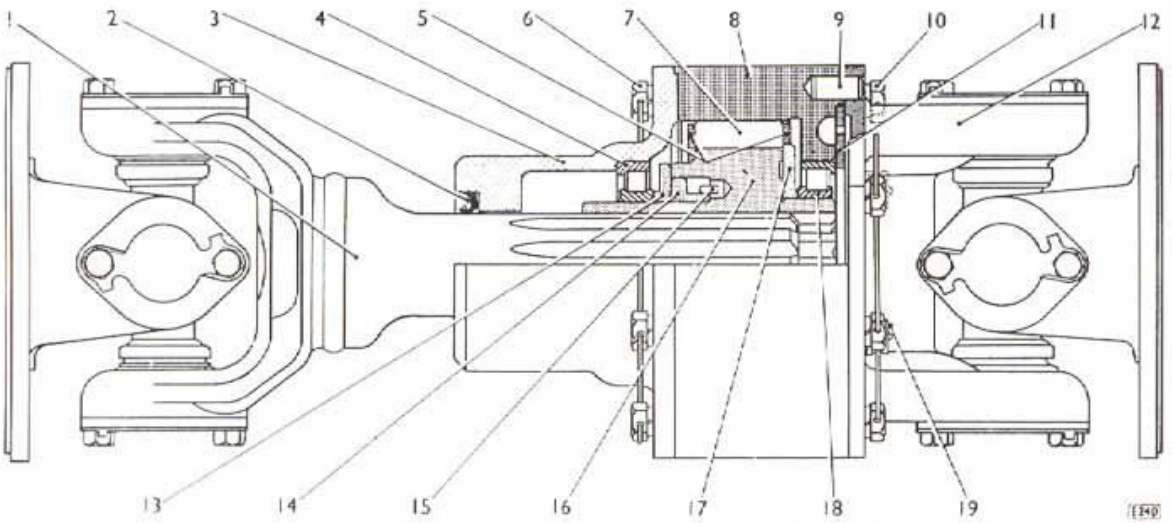


Fig. 3. Arrangement of first propeller shaft and freewheel.

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

Sect. U5. UNIVERSAL JOINTS — TO DISMANTLE.

(See Figs. 3, 4 and 5).

Shaft—Gearbox to final drive.

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.

Fig. 4. Method of removing needle roller bearings from universal joint.

Sect. U6. PROPELLER SHAFTS AND UNIVERSAL JOINTS — TO ASSEMBLE AND FIT.

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

To Assemble.

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

Renew any parts that are worn, and fill the joints with lubricant. It is advisable to fit new gaskets on the star piece, the shoulders of which should be coated with shellac prior to fitting, to 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.**

Compress the felt or cork washer sufficiently to ensure a good oil seal, this should be possible by **hand tightening** the dust cap.

Fig. 5. Exploded view of needle roller bearing type universal joint.

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

RADIATOR AND FAN

CHAPTER Z

CONTENTS

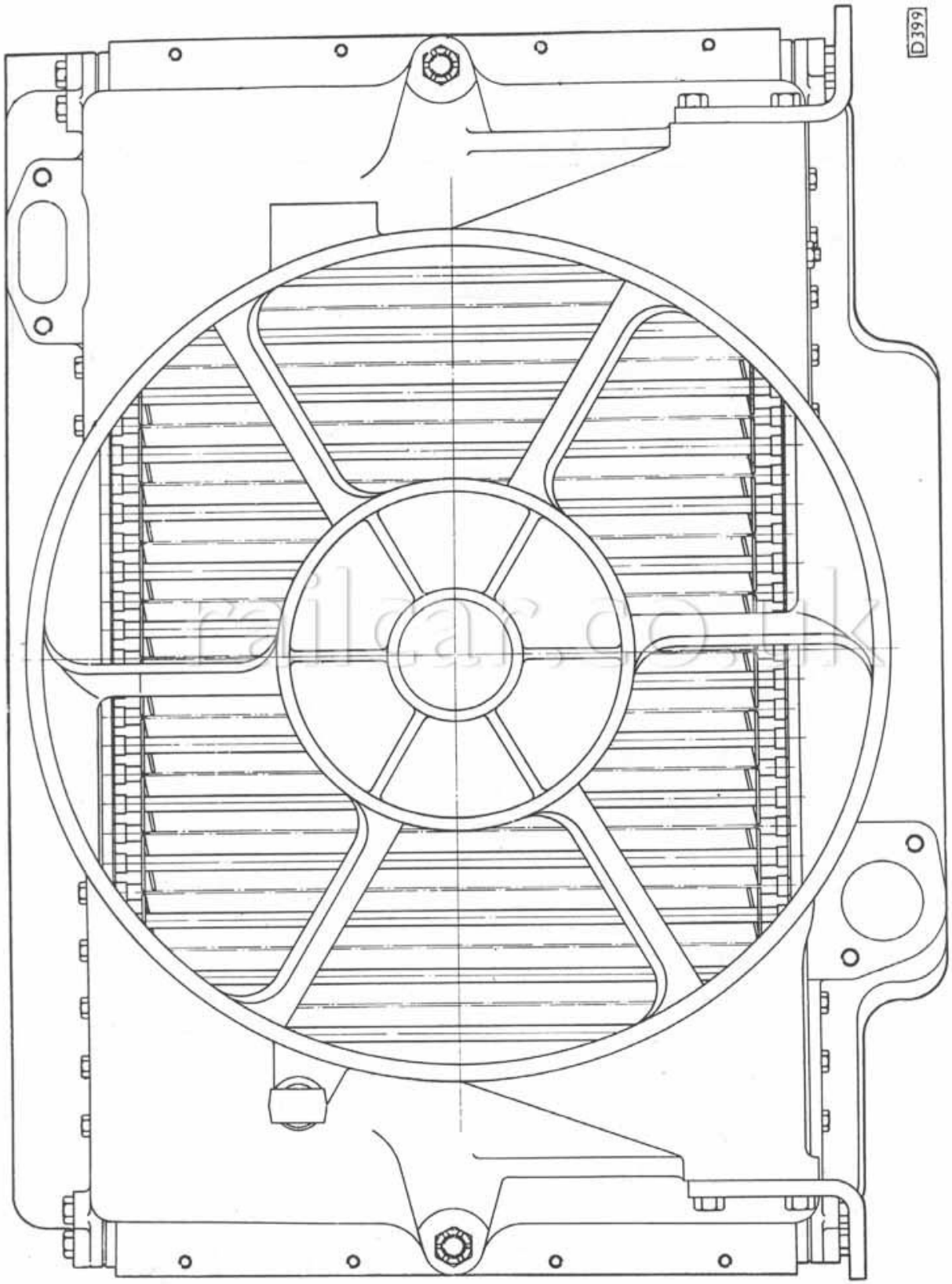


Fig.1. Arrangement of radiator and fan cowl.

Sect.Z1. 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.

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.

Sect.Z2. MAINTENANCE.

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

1	Check the level of water in the radiator supply tank and top-up if necessary.
2	Lubricate the fan spindle bearings (see Section Z3).
3	Check the radiator hose connections and if necessary tighten the clips.
4	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 (see Engine Chapter).

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

Sect.Z3. LUBRICATION.

The fan spindle bearings should be lubricated through the pipe from the appropriate nipple on the frame (see Lubrication Chart).

Sect.Z4. RADIATOR - TO DISMANTLE AND ASSEMBLE.

(See Figs.1 and 2).

To Dismantle.

Remove the radiator assembly from the car.

Remove the radiator stone guard.

Remove the fan and fan cowl from the radiator block.

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.

Sect.Z5. FAN - TO REMOVE, DISMANTLE, ASSEMBLE AND FIT.

(See Fig.2).

To Remove.

Remove the radiator block and fan assembly from the car.

To Dismantle.

Detach the fan and cowl assembly from the radiator block.

Disconnect 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.

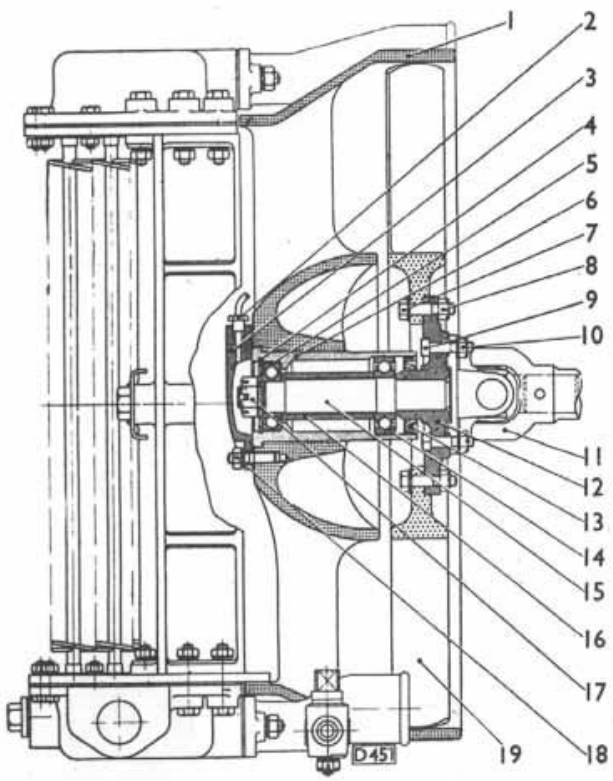


Fig.2. Section through radiator and fan drive.

1.Fan cowl.
2.Fan bearing lubrication pipe.
3.Fan cowl end cover.
4.Bearing circlip.
5.Bearing.
6.Fan shaft bearing 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.

C O N T R O L S

CHAPTER Y

CONTENTS

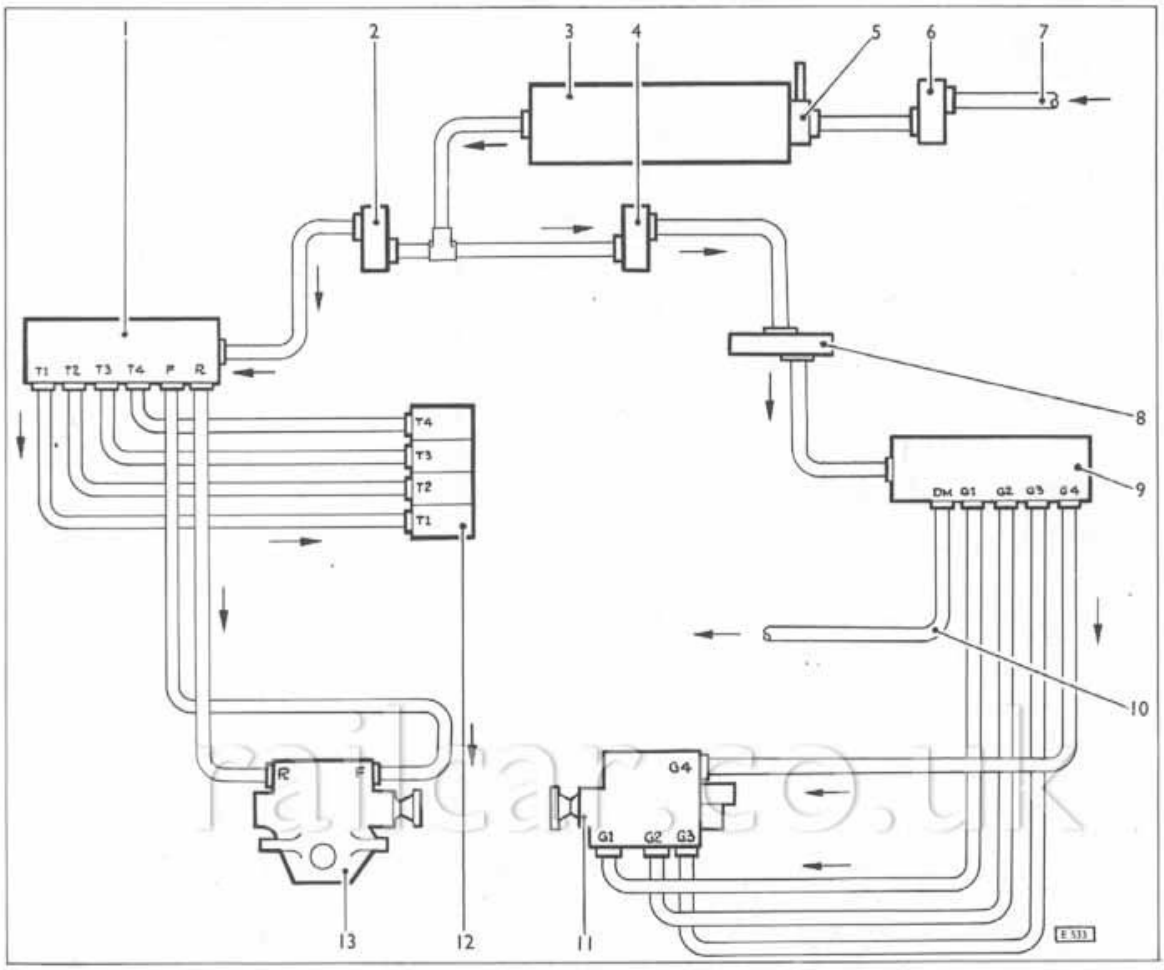


Fig.1. Diagrammatic layout of air pressure system for driver's controls.

1. Electro-pneumatic valves - Throttle control and final drive operation.
2. Pipe line air filter.
3. Air reservoir.
4. Pipe line air filter.
5. Diverter valve.
6. Pipe line air filter.
7. Air supply for driver's controls from Car main supply.
8. Air reducing valve (Gearbox).
9. Electro-pneumatic valves - Gearbox and "deadmans" brake valve operation.
10. Air supply to "deadmans" brake valve.
11. Epicyclic gearbox.
12. Throttle control motor.
13. Final drive unit.

Sect.Y1. CONTROLS - DESCRIPTION.

GENERAL.

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

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 epicyclic gearbox pistons.

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

In addition to the hand controls, the following are provided in the driver's cab; an engine speed indicator, push button switches for starting and stopping the engine and indicator lights.

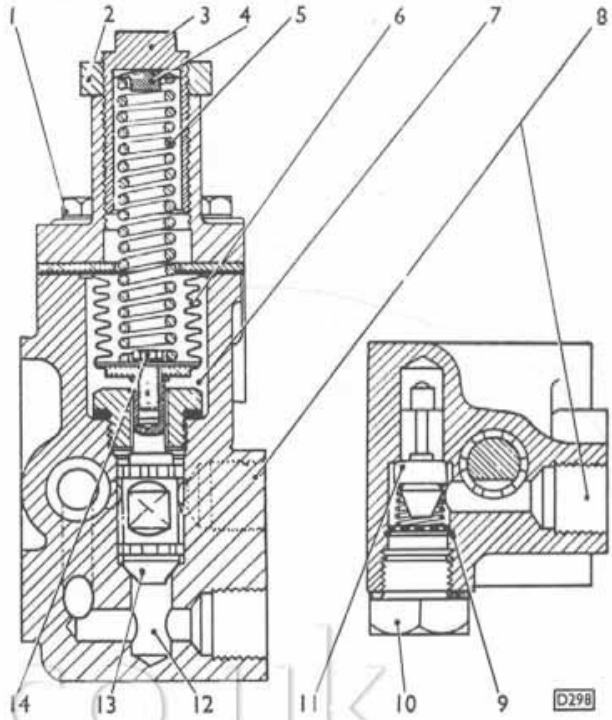


Fig.2. Sectioned view of diverter valve.

1. Set-screw securing top cover.
2. Locknut.
3. Adjuster.
4. Control spring button.
5. Control spring.
6. Bellows.
7. Air chamber.
8. Inlet port.
9. Circlip securing perforated plate and spring.
10. Hexagon plug for non-return valve.
11. Non-return valve.
12. Cored passage to reservoir.
13. Valve.
14. Set-screw securing bellows.

AIR PRESSURE SYSTEM.

Compressed air for operating the driver's controls is supplied from the car main supply system.

The air passes from the main supply to a reservoir via an air filter and a diverter valve.

When pressure in this reservoir reaches a predetermined figure and the appropriate controller is operated, air passes through an air filter and E.P. valves to either the throttle control motor or the final drive unit, or through another air filter, a reducing valve and another set of E.P. valves to either the epicyclic gearbox or the "deadman's" brake valve.

Air Reservoir.

The reservoir is provided for storing compressed air, supplied from the main supply system, at a convenient pressure for operating the controls air equipment.

The reservoir is of welded steel construction and is 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 the reservoir.

Throttle control motor (see Fig.4).

The throttle control motor is mounted on the car adjacent to the fuel-injection pump and is operated by air via the E.P. valves.

It is connected by linkage to the fuel-injection pump control lever, 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 motor operate the actuating levers, which in turn operate the control lever on the fuel-injection pump, in a series of steps which correspond to the steps felt when moving the driver's throttle control lever.

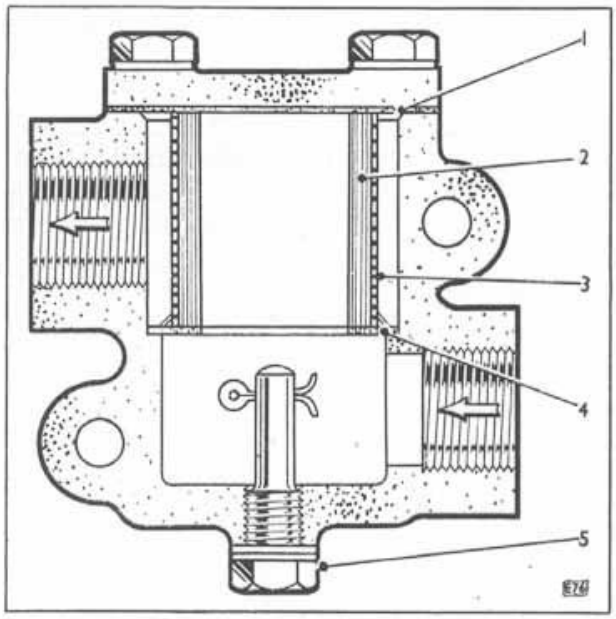


Fig.3. Pipe line air filter.

1. Cover joint.
2. Felt element.
3. Perforated cylinder.
4. Washer.
5. Drain plug.

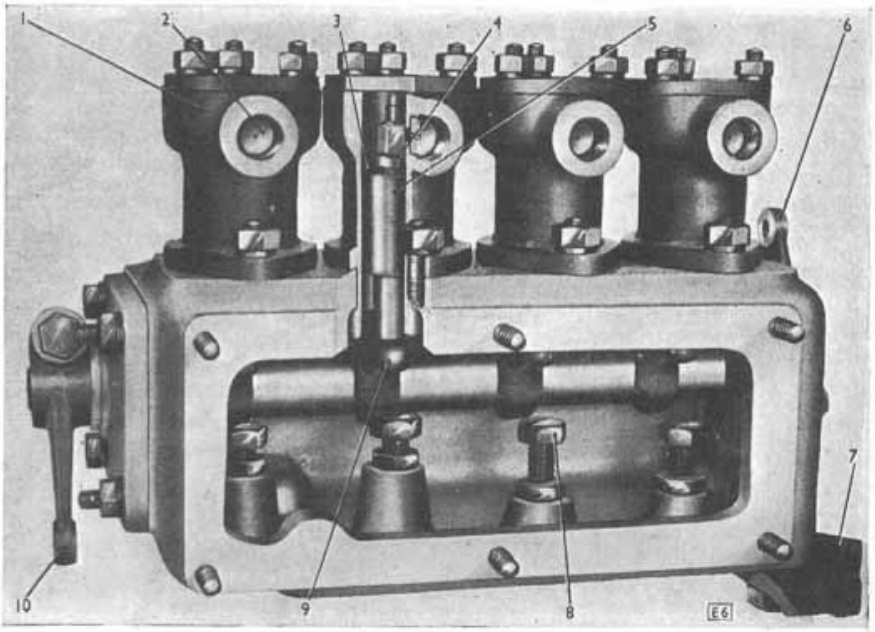


Fig.4. Throttle motor showing adjusting screws.

1. Air cylinder.
2. Air inlet port.
3. Piston seal.
4. Piston seal retaining washer.
5. Piston.
6. Hand control lever.
7. Control cable anchor bracket.
8. Actuating lever adjusting screw.
9. Actuating lever.
10. Control lever.

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

Pipe line air filters (see Fig.3).

Air filters are mounted in the pipe line between the main supply and the diverter valve, between the reservoir and the reducing valve and between the reservoir and the E.P. valve block for the throttle motor and final drive unit.

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

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

Diverter valve (see Fig.2).

The diverter valve is connected to the main compressed air supply. Its purpose is to divert air from the main supply to ensure that the air pressure system for the driver's controls, is charged to at least the pressure quoted in Section Y2.

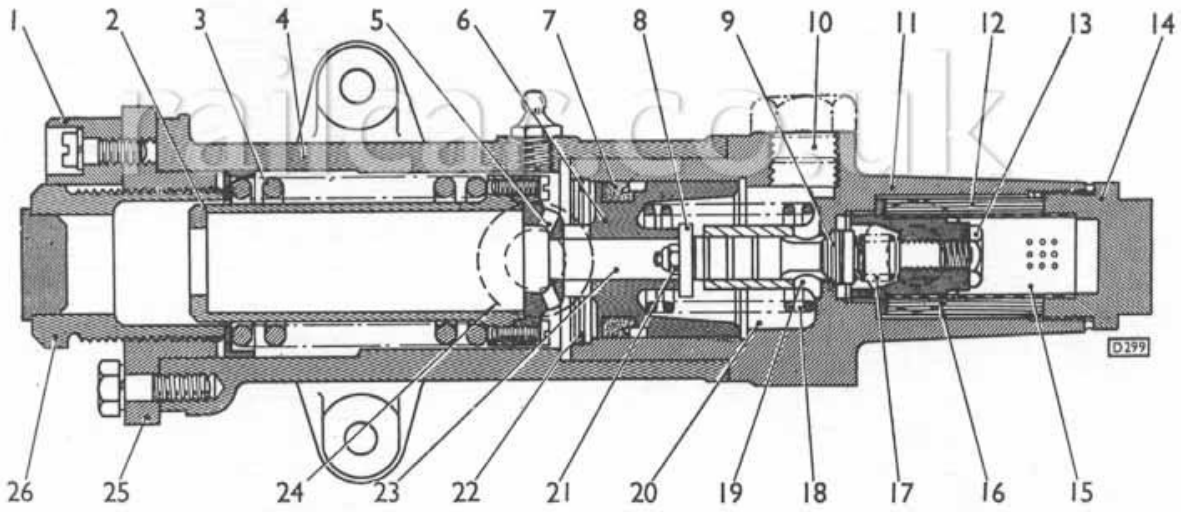


Fig.5. Sectioned view of air reducing valve.

1. Locking Piece.
2. Control spring guide.
3. Control spring.
4. Valve body.
5. Air hole.
6. Reaction piston.
7. Sealing ring.
8. Disc type release valve.
9. Conical inlet valve.
10. Outlet port to gearbox electro-pneumatic valves.
11. Valve head.
12. Felt filter.
13. Restrictor to prevent surge.
14. End cap.
15. Air inlet chamber.
16. Inlet port.
17. Spring for inlet valve.
18. Spring for control piston.
19. Air space under inlet valve.
20. Air reaction chamber.
21. Nut for disc valve.
22. Circlip.
23. Air passage.
24. Exhaust port to atmosphere.
25. Adjusting screw carrier.
26. Adjusting screw.

Air reducing valve - Gearbox. (see Fig.5).

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

An adjusting screw is provided for setting the valve to obtain the desired air pressure (for air pressure see Section Y2).

ELECTRICAL SYSTEM (see Plate 085 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 a generator mounted on the engine.

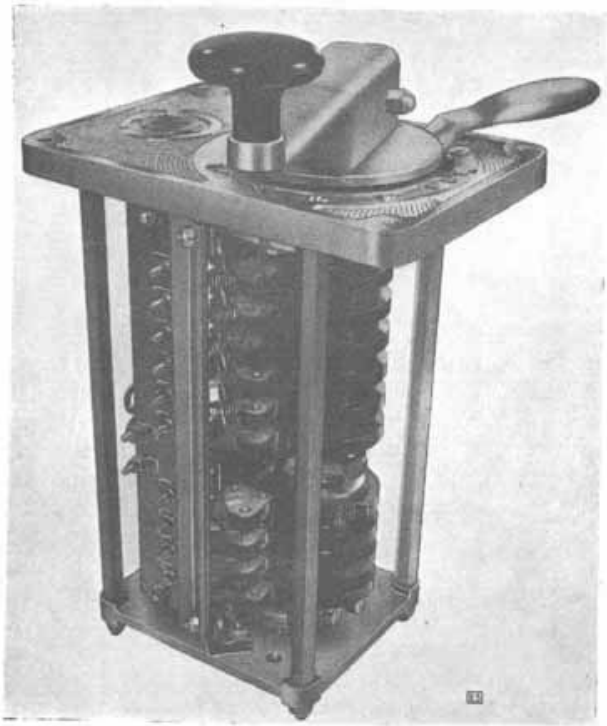


Fig.6.Gearbox and final drive controller.

Fig.7. Throttle controller.

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

Facilities for starting or stopping the engine 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 the engine and on the opposite side of the car.

Also mounted on the control panel are the indicator lights for oil and air pressures and "deadman's" indicator.

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

Engine control relay panel.

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

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

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

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

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

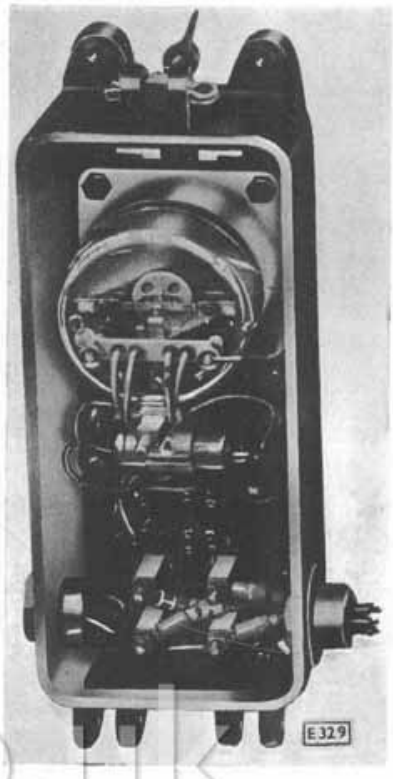


Fig.9. Starter motor isolating relay.

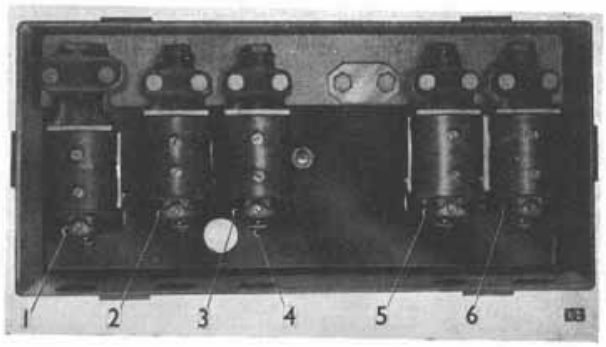


Fig.8. Electro-pneumatic valves for gearbox and "deadman's" brake valve.

1. "Deadman's" E.P. valve "OFF" type.
2. First speed gearbox E.P.valve("ON" type).
3. Second speed gearbox E.P.valve("ON" type).
4. Hand-testing button.
5. Third speed gearbox E.P.valve("ON" type).
6. Fourth speed gearbox E.P.valve("ON" type).

Combined throttle controller and "deadman's" control (see Fig.7).

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 motor.

Gearbox and final drive controller (see Fig.6).

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 gearbox and one to actuate the forward and reverse gears in the final drive. Each cam closes an electrical contact, thereby operating the appropriate E.P. valve, which in turn engages the selected gear.

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

Starter motor isolation relay (see Fig.9).

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

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

To avoid possible errors in the tripping speed, the relay is mounted on the car in a vertical position selected so as to avoid excessive heat, (50 deg.C. - 122 deg.F. maximum).

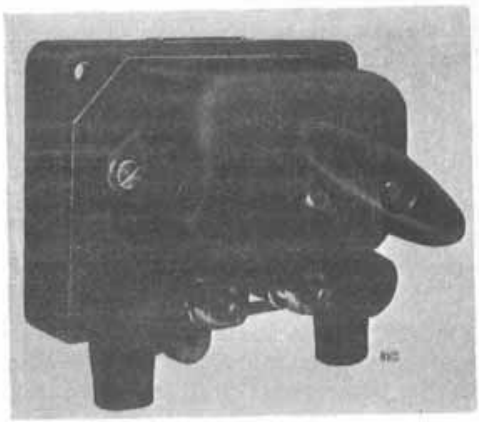


Fig.10. Battery isolating switch.

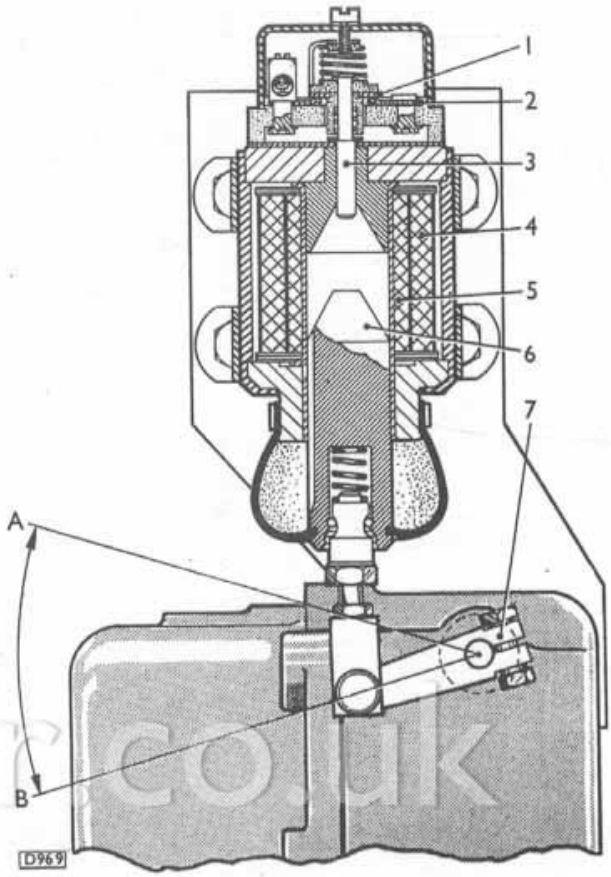


Fig.11. Section through engine shut-down solenoid.

A.Stop position.
B.Run position.

1.Moving contacts.
2.Fixed contacts.
3.Actuating plunger.
4.Pull-in coil.
5.Hold-in coil.
6.Solenoid core.
7.Fuel-injection pump stop lever.

Electro-pneumatic valves (see Fig.8).

Each car is provided with a number of E.P. valves; these control the supply of compressed air to the actuating mechanism for gear selection and engagement, the engine throttle control motor, the engagement of forward or reverse gears in the final drive unit, and the "deadman's" brake valve.

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.

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

Each E.P. valve embodies a needle valve which opens a short passage connecting an air feed pipe to a delivery pipe which leads to the actuating mechanism concerned. The needle valve is operated by a loosely fitting plunger inside the core of a solenoid whenever the latter is energised, and works against the pressure in the air line in addition to that exerted by a small coil spring. The design of the connecting passage and the plunger top is such that any air leaking past the valve is discharged to atmosphere.

Water level switch.

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

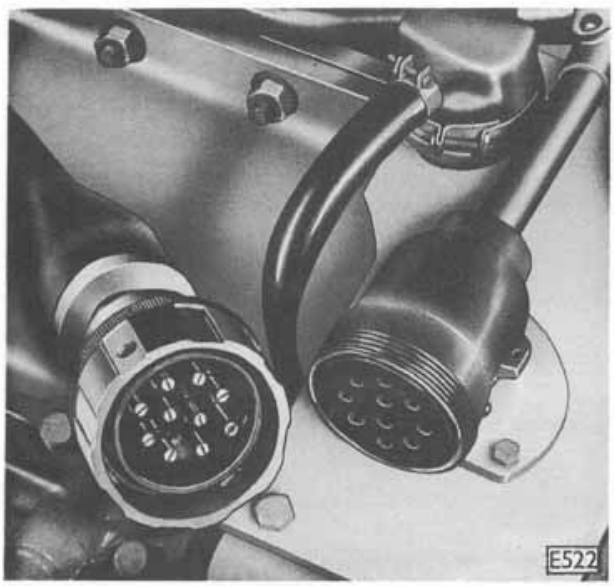


Fig.12. Engine plug and socket.

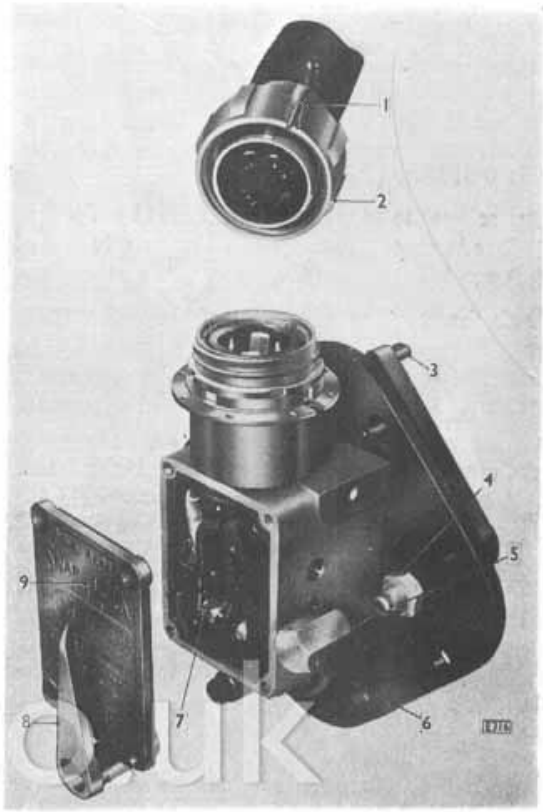


Fig.13. Direction indicator switch.

1. Locking split pin.
2. Plug.
3. Actuating pin.
4. Locknut.
5. Adjusting screw.
6. Cap for adjusting screw.
7. Contacts.
8. Pointer.
9. Indicator and cover plate.

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 thus the switch contacts are made to change over with a snap action.

Engine shut-down solenoid (see Fig.11).

The shut-down solenoid is mounted on a bracket attached to the fuel-

Sect.Y2. CONTROLS - DATA.

Reservoir.		
Capacity.	1·540 cu.in.	25·2 litres.
Diverter valve - Cut-in pressure.	47·5 to 52·5 lb. per sq.in.	3·33 to 4·03 Kg.per sq.cm.
Air reducing valve - Gearbox. pressure.	62·5 to 67·5 lb. per sq.in.	4·4 to 4·7 Kg.per sq.cm.
Engine control relay panel.	Specification No. T3632.	All relays to energise at 7 4 volts cold. Shunt coil resistance, 101·5 ohms. ± 5%, at 20 deg. Centigrade, 24/30v.

Sect.Y3. CONTROLS - MAINTENANCE.

AIR PRESSURE SYSTEM.

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

1	Drain the moisture from the reservoir (see instructions in the following paragraphs).
2	Check all air pipe unions for leakage and tighten if necessary (see "To check for air leaks").
3	Check the diverter valve and throttle control motor for air leakage (see instructions in the following paragraphs and "To check for air leaks").
4	Lubricate the throttle motor air cylinders and the air reducing valve (see Section Y4).
5	Clean or if necessary renew the felt filter element in the air reducing valve (see instructions in the following paragraphs).
6	Clean the felt filter element in the pipe line air filters (see instructions in the following paragraphs).

To check for air leakage.

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

ELECTRICAL SYSTEM.

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

1	Check all electrical connections for security.
2	Check manually the engine shut-down solenoid for correct operation (see instructions in the following paragraphs).
3	Inspect the electro-pneumatic valves (see instructions in the following paragraphs).
4	Clean the contacts in the following:- throttle controller, gearbox and final drive controller, water level switch and engine shut-down solenoid switch (see instructions in the following paragraphs).

Starter motor isolation relay (see Fig.9).

Apart from the following tests no maintenance is required.

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

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

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

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

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

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

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

Electro-pneumatic valves (see Fig.8).

When it becomes necessary, each valve should be removed from the car and

Sect.Y4. CONTROLS - LUBRICATION.

This Section should be read in conjunction with the Lubrication Chart.

Item	Attention required.
Air Reducing Valve (Gearbox)	Lubricate through the nipple provided (see below)
Throttle Control Motor	Lubricate through the nipples provided(see below)

Air reducing valve - Gearbox. (see Fig.5).

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

Throttle control motor (see Fig.14).

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

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

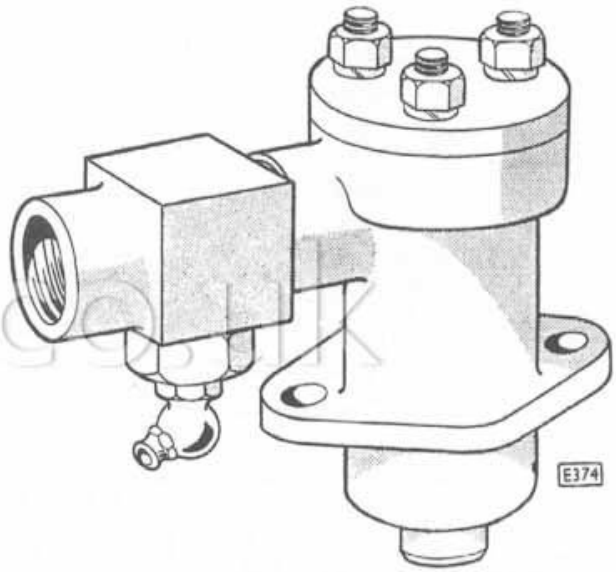


Fig.14. Throttle control motor piston and cylinder assembly showing lubricator.

Sect.Y5. DIVERTER VALVE - TO DISMANTLE, ASSEMBLE AND ADJUST.

(See Fig.2).

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.

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 90 lb. per sq.in. (6.33 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 Y2.

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

Finally lock the adjusting screw.

Sect.Y7.

THROTTLE CONTROL MOTOR - TO DISMANTLE AND ASSEMBLE.

(See Figs.4 and 15).

To Dismantle.

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

Remove the side cover.

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

Unscrew the nuts, remove the

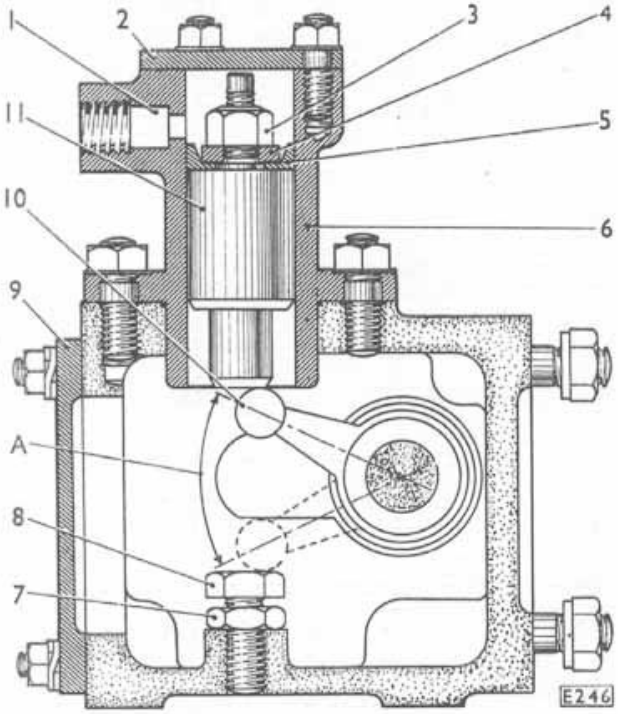


Fig.15. Section through throttle control motor showing travel of actuating lever at full throttle.

A. Maximum travel 47° - Full throttle.
1. Air inlet port.
2. Cylinder cover.
3. Piston seal retaining nut.
4. Retaining washer.
5. Piston seal.
6. Air cylinder.
7. Locknut.
8. Actuating lever adjusting screw.
9. Cover plate.
10. Actuating lever.
11. Piston.

injection pump, and when energised cuts off the supply of fuel to the engine.

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

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

Battery isolating switch (see Fig.10).

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

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

Oil pressure switch.

This switch is mounted on the engine casing extension and operates the oil pressure warning light on the driver's control panel; in the event of low oil pressure, it operates the engine shut-down solenoid.

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

Oil pressure on the diaphragm causes the contacts to close, thus completing the electrical circuit to the indicator light and the engine shut-down solenoid relay.

Direction indicator switch (see Fig.13).

A direction indicator switch is mounted on the final drive casing.

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

It indicates electrically, by means of a light on the driver's control panel, whether the final drive is properly engaged.

Engine plug and socket (see Fig.12).

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

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

Engine local control boxes.

These units are provided to facilitate starting or stopping the engine from the sides of the car. They are provided with push button switches for starting and stopping the engine.

One control box is mounted on each side of the car.

Air reservoir.

Empty and drain the air reservoir as follows:-

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

The drain cocks should only be opened sufficiently to allow air to exhaust.

On no account should a drain cock be fully opened unless the reservoir has been exhausted of air.

Routine draining of the reservoir during frosty weather is most important; to neglect this precaution may result in the collected condensate freezing and prevent correct operation of the valves.

Diverter valve (see Fig.2).

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

Air reducing valve - Gearbox. (see Fig.5).

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 motor (see Figs.4 and 15).

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

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

Lubricate the air cylinders (see Section Y4).

Pipe line air filters (see Fig.3).

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.

serviced as follows:-

Dismantle and wash all working parts in paraffin.

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

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

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

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

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

Engine shut-down solenoid (see Fig.11).

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

The solenoid should stop the engine from full speed running; check this, and when the engine has stopped, remove the terminal cover from the solenoid and ensure that there is a minimum air gap of 0.063 in. (1,600 mm.) between the fixed and moving contacts.

If necessary adjust the fork-end to obtain this gap and ensure that the fork-end does not deviate more than 5 deg. from the longitudinal axis of the solenoid.

Refit the terminal cover.

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

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

Gearbox and throttle controllers (see Figs.6 and 7).

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.

Battery isolating switch (see Fig. 10).

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

Water level switch.

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

Direction indicator switch. (see Fig.13).

Check that the direction switch is operating correctly and if necessary, adjustment should be made following the instructions given in Section Y9.

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

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.

Ensure that the gearbox is in the neutral position; 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 Y2.

Sect.Y6. AIR REDUCING VALVE (GEARBOX) - TO DISMANTLE, ASSEMBLE AND ADJUST.

(See Fig.5).

To Dismantle.

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

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

Unscrew the end cap and remove the felt filter element.

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

Unscrew the nut securing the release valve seat.

To Assemble.

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

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

Inspect the bore and piston for scoring.

Lightly coat all inner surfaces

cylinder cover and withdraw the piston assembly from each cylinder.

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

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

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

To Assemble (see Fig.15).

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

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

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

Examine the shaft bushes for wear, renew if necessary.

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

Ensure that the shims are fitted between the bush in the cover and the distance piece (for thickness of shims available see Section Y11).

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

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

To achieve this result it may be necessary to fit a shim between the seal and the piston (for thickness of shims available see Section Y11).

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

Sect.Y8.

ENGINE CONTROL RELAY PANEL - TO ADJUST CONTACTS AND CALIBRATE RELAYS

(See Fig.16).

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

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

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

To adjust the armature hinge gap.

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

then tighten the screw securing the spring to the armature.

With the armature core gap at 0.010 in. (0.254 mm.) adjust the armature hinge gap to 0.040 in. (1.016 mm.); the hinge gap must be parallel in the direction across the yoke, making sure that the clamping plate is the correct way round.

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

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

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

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

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

To adjust the normally open main contacts (as in specification T3633).

Adjust these contacts, by means of the adjusting screw, until the faces just meet and the armature core gap is 0.010 in. (0.254 mm.).

Adjust the armature core gap to 0.050 in. (1.270 mm.) with the main contacts open.

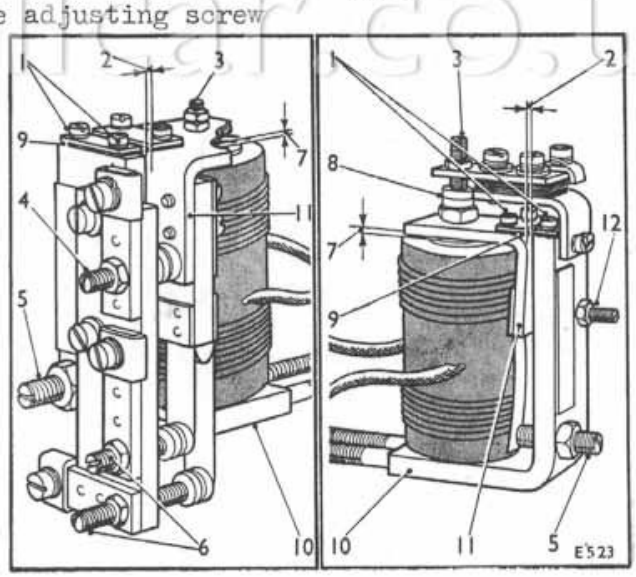


Fig.16. Diagrams for setting control relays.

A.Tonum type relay specification T3633.
B.Tonum type relay specification T3500.
1.Armature hinge fixing screws.
2.Armature hinge gap 0.040 in.
3.Normally closed main contacts setting screw.
4.Normally open main contacts and armature setting screw.
5.Control spring adjusting screw.
6.Normally open auxiliary contacts setting screw.
7.Armature core gap 0.010i
8.Normally closed main contacts.
9.Hinge spring.
10.Yoke.
11.Armature.
12.Armature setting screw.

Lock the contacts by means of the locknuts.

To adjust the normally open auxiliary contacts (as in specification T3633).

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

Lock the contacts by means of the locknuts.

To Calibrate the Relays.

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

The energising voltage is given in Section Y2, 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.

Sect.Y9.

DIRECTION INDICATOR SWITCH - TO FIT AND ADJUST.

(See Fig.13).

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

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

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

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

Return the hand operated locking plunger to its original position.

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

Connect the leads to the switch.

Sect.Y10.

ENGINE PLUG AND SOCKET - TO REMOVE AND FIT.

(See Fig.17).

To Remove.

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

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

Disconnect the leads from the engine speed indicator generator.

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

Remove the bolts securing the socket to its bracket.

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

To Fit.

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

Fig.17. Engine plug and socket, harness and conduit

1.Engine shut-down solenoid.
2.Oil pressure switch.
3.Engine plug and socket.
4.Engine speed indicator generator.

Sect.Y11.

SIZES OF SHIMS AVAILABLE.

Part.	Part No.	Thickness.
Throttle control motor shaft.	Z4/46517	0.005 in. (0.127 mm.)
	Z4/46518	0.010 in. (0.254 mm.)
	Z4/46519	0.015 in. (0.381 mm.)
Throttle motor piston seal.	Z4/46549	0.003 in. (0.076 mm.)

PLATE No. 085

WIRING DIAGRAM

FOR

B. U. T.
RAILCAR