BRITISH RAILWAYS
DIESEL TRAIN
'A' & 'L' TYPE UNITS
(50,000 SERIES)
OVERHAUL MANUAL

BRITISH UNITED TRACTION LTD.

MR M°PHERSON 9-8-61

SERVICE MANUAL

SERVICE MANUAL

FOR

B.U.T

TRACTION EQUIPMENT

A-Type and L-Type Units

BRITISH RAILWAYS

MULTIPLE-UNIT

DIESEL CARS

(50,000 Series)

Price Three Guineas

BRITISH UNITED TRACTION LIMITED

96 PICCADILLY LONDON W1 ENGLAND

Telephone: GROsvenor 7121 Telegrams and Cables: BRITROL LONDON

L10159

FOREWORD

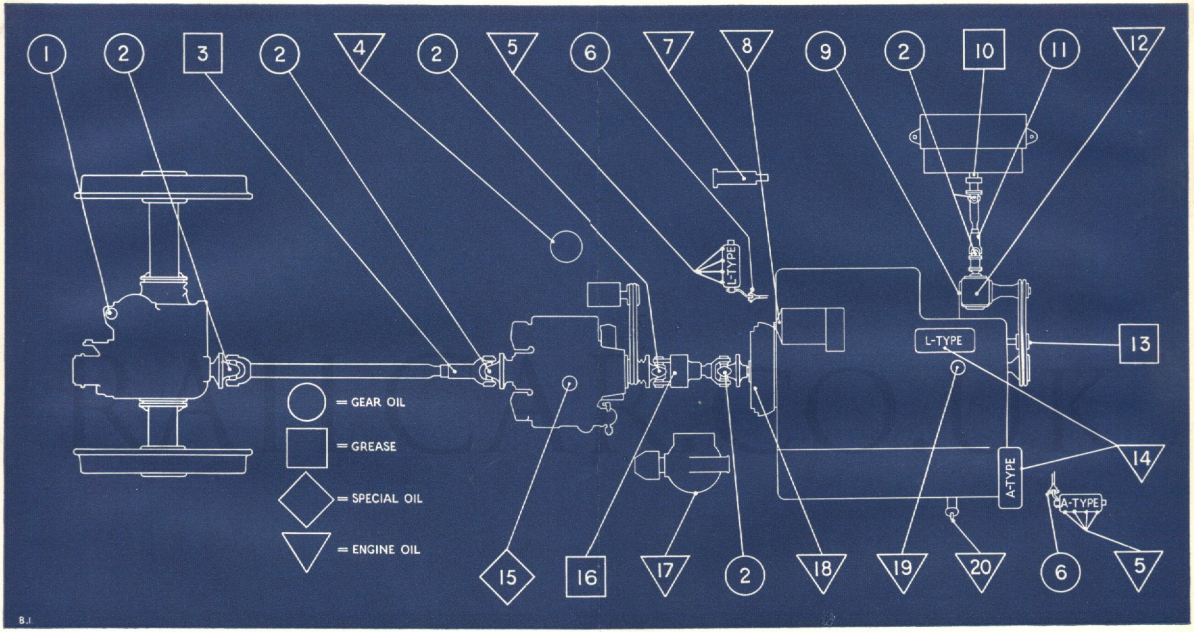
This Service Manual has been compiled to assist those responsible for the maintenance and reconditioning of **B.U.T. Diesel Railway Traction Equipment.**

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.



Ref. No.	Component	Remarks	No. of points per car	Class of Lubricant
1	Final drive	Dipstick and filler plug	2	Gear oil
2	Drive shaft universal joints	Oil gun	12	Gear oil
	Drive shaft splined ends:			
3	Large diameter shafts	Grease gun	2	Grease
11	Small diameter shafts	Oil gun	2	Gear oil
4	Exhauster oil reservoir	Combined oil level and filler cap ...	1	Engine oil
5	Throttle motor cylinders	Oil gun (one stroke only)	8	Engine oil
6	Throttle motor and solenoid control rod ball joints and linkage	Oil can	—	Gear oil
7	Air pressure reducing valve	Oil gun (one stroke only)	1	Engine oil
8	Starter motor	Oil can (plug if fitted)	2	Engine oil

Ref. No.	Component	Remarks	No. of points per car	Class of Lubricant
9	Right-angle fan drive unit	Combined oil level and filler plug ...	2	Gear oil
10	Fan bearings	Grease gun	2	Grease
12	Right-angle fan drive breather	Oil wire wool element	2	Engine oil
13	Water pump shafts (A-type engine only) ...	Grease gun	2	Grease
14	Fuel injection pump governor	Filler plug	2	Engine oil
15	Gearboxes	Dipstick and filler plug	2	Special
16	Freewheels	Grease gun	2	Grease
17	Engine air cleaners	Oil level mark inside bowl	2	Engine oil
18	Fluid couplings	Combined oil level and filler plug ...	2	Engine oil
19	Engine crankcase breather	Oil level mark inside bowl	2	Engine oil
20	Engines	Dipstick and filler cap	2	Engine oil

LUBRICATION CHART for B.U.T. A-TYPE and L-TYPE TRACTION UNITS

ENGINE

(A - Type)

CHAPTER K

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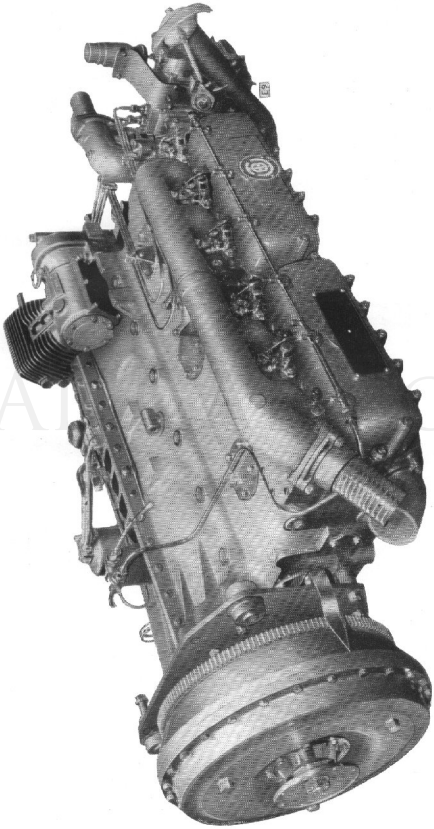


Fig. 1. General view of engine.

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.

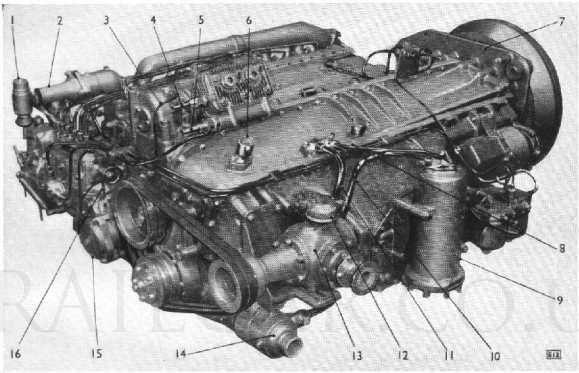


Fig. 2. Three-quarter front view of engine.

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).

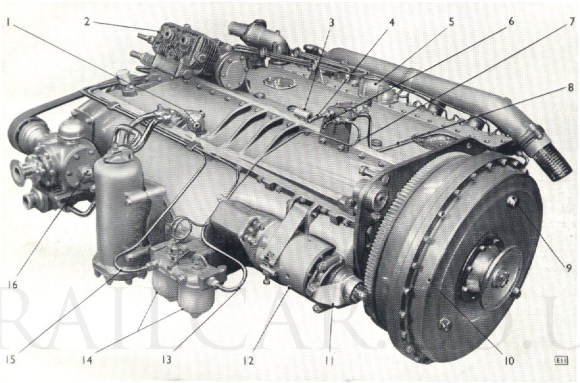


Fig. 3. Three-quarter rear view of engine.

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

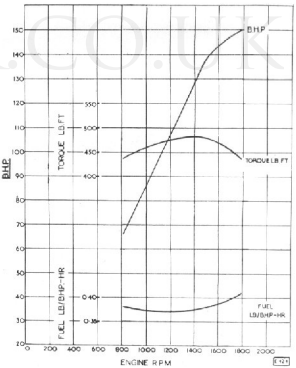


Fig. 4. Performance curves of 11·3 litre horizontal engine.

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.

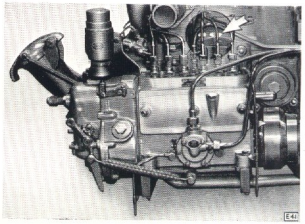


Fig. 5. Engine number stamped as indicated by arrow.

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).

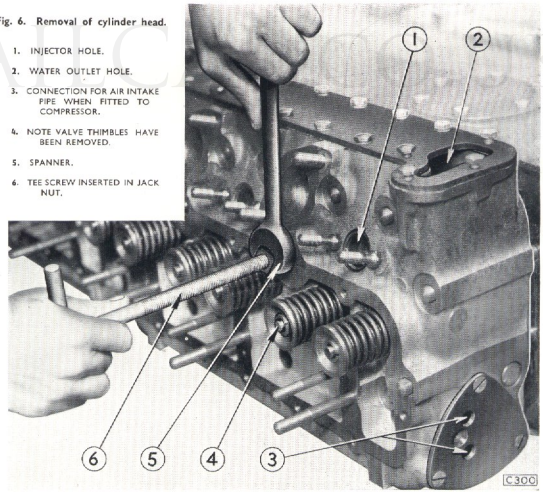
The two jack nuts are fitted to facilitate removal and are so arranged that as they are unscrewed they will lift the heads clear of the cylinders.

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.



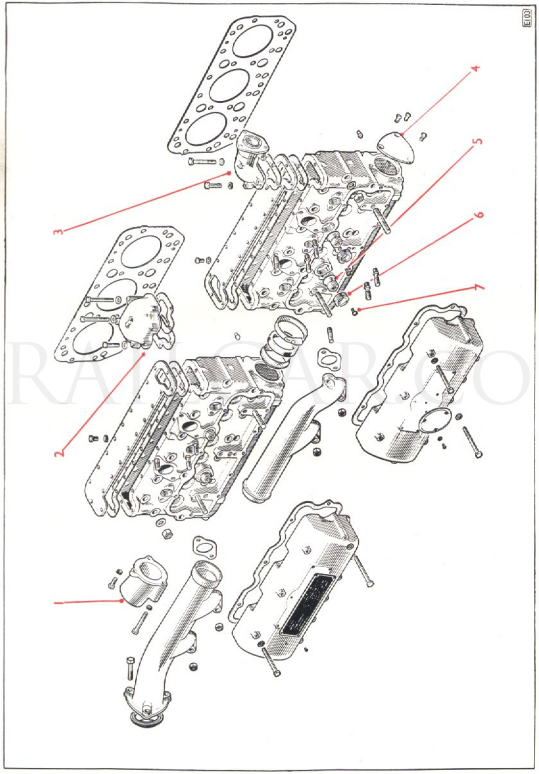


Fig. 7. Exploded view of cylinder heads.

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.

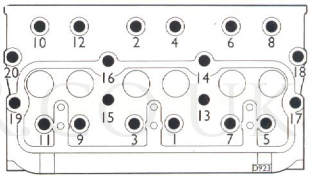


Fig. 8. Diagram showing sequence of tightening cylinder head nuts (Nos. 14 and 15 are jacknuts).

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.

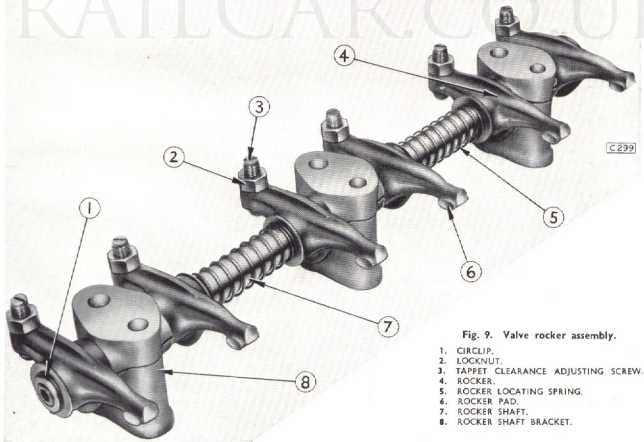


Fig. 9. Valve rocker assembly.

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).

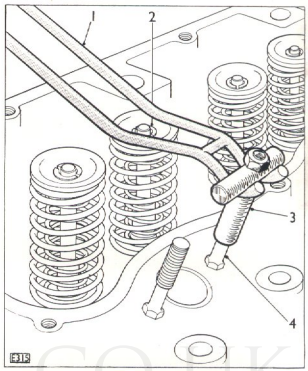


Fig. 10. Removal of valve springs.

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).

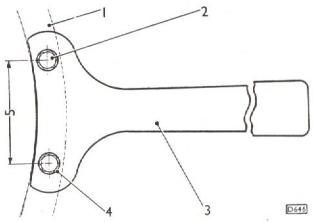


Fig. 11. Tool for turning engine crankshaft.

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.).

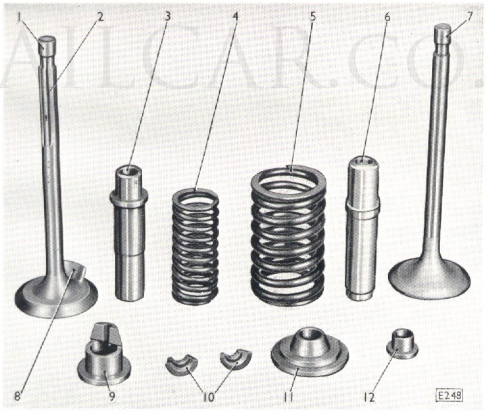


Fig. 12. Valve details.

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).

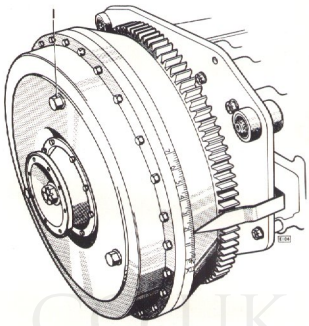


Fig. 13. Position of the flywheel for inlet valve opening.

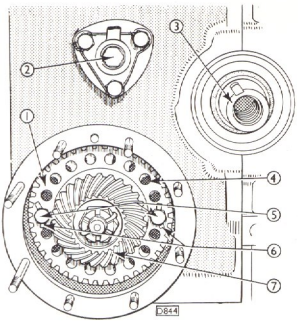


Fig. 14. Camshaft gear showing vernier adjustment.

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.

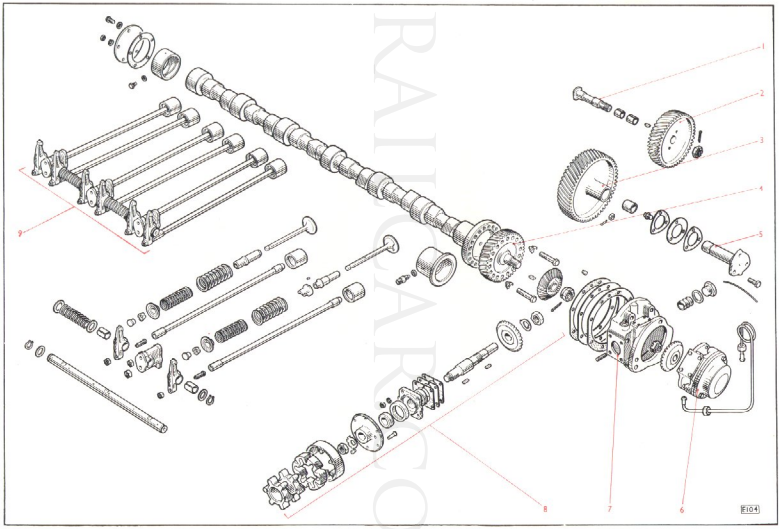


Fig. 15. Exploded view of camshaft and valve gear.

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).

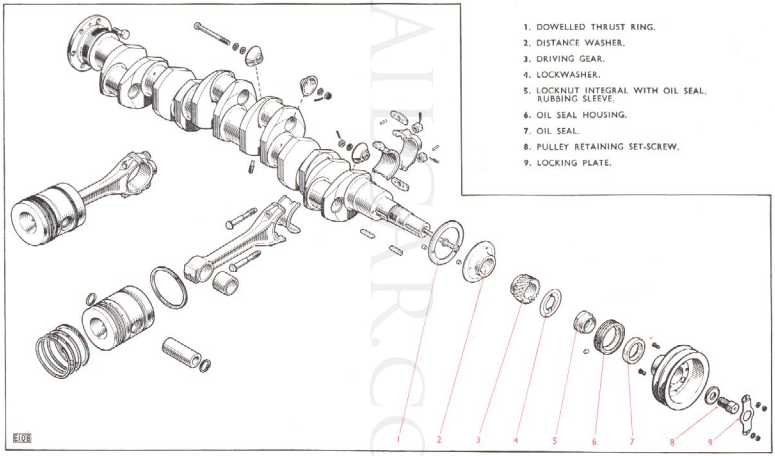


Fig. 16. Exploded view of crankshaft assembly and pistons.

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).

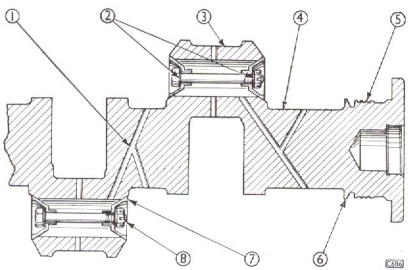


Fig. 17. Diagram of crankshaft oil passages.

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.

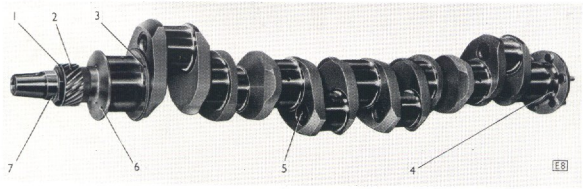


Fig. 18. Crankshaft assembly.

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.

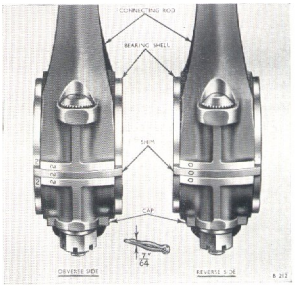


Fig. 19. Connecting rod big-end showing markings and special type split pin for bolts.

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

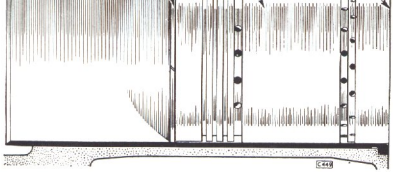


Fig. 20. Method of measuring piston ring gap.

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.**

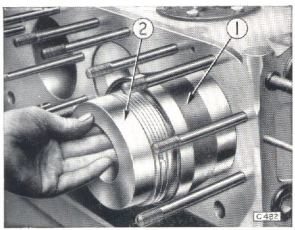


Fig. 22. Method of fitting pistons.
1. PISTON FITTING TOOL. 2. PISTON.

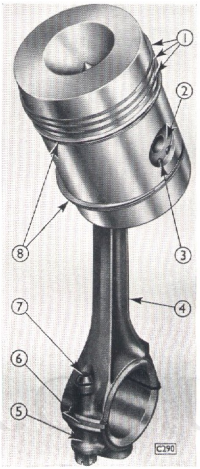


Fig. 21. Piston and connecting rod.

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.**

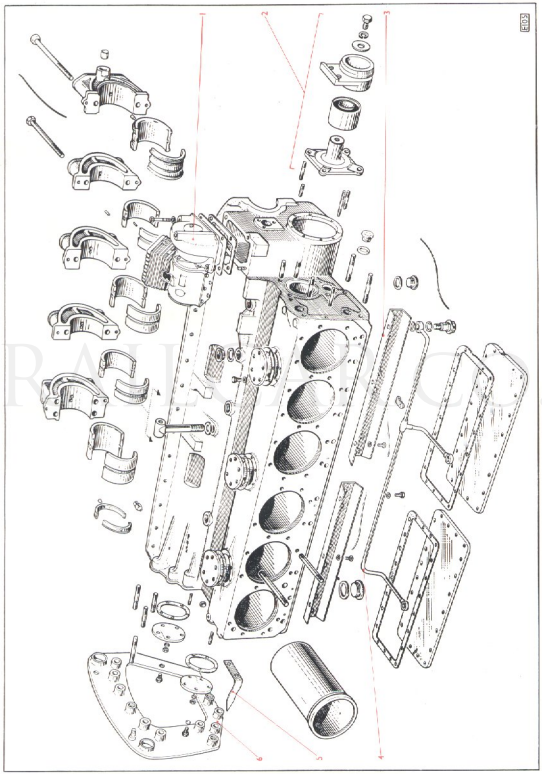


Fig. 23. Exploded view of mono-block and main bearings.

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. 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.

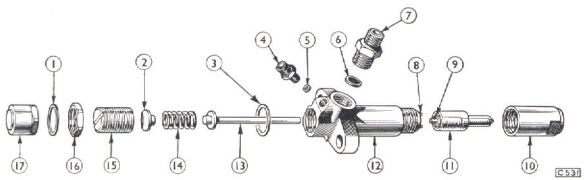


Fig. 24. Exploded view of injector.

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. 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.

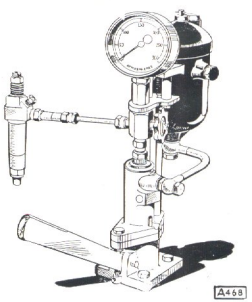


Fig. 25. C.A.V. hand-testing pump for injectors.

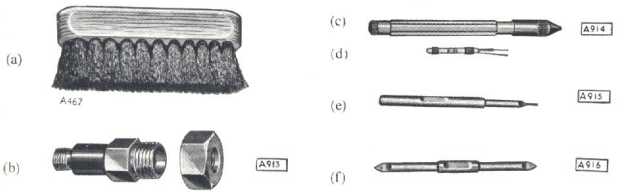


Fig. 26. Injector cleaning tools.

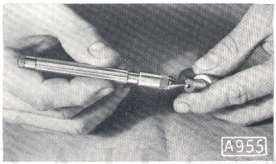


Fig. 27. Pricking out nozzle holes.

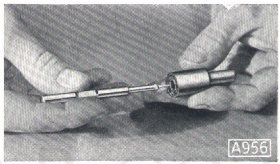


Fig. 28. Tool for cleaning nozzle tip.

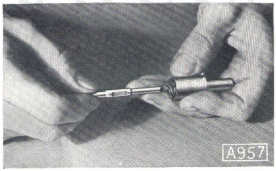


Fig. 29. Tool for cleaning nozzle seat.

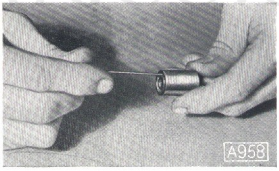


Fig. 30. Cleaning nozzle fuel passages.

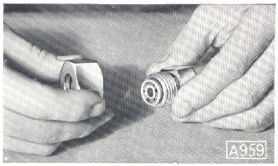


Fig. 31. Nozzle inserted in adaptor for washing.

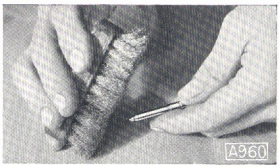


Fig. 32. Brass wire brush for cleaning nozzle valve.

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.

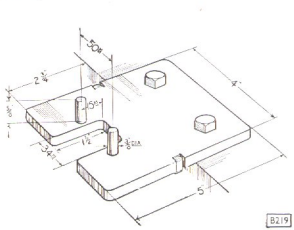


Fig. 33. Tool for holding injectors when dismantling.

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 recalibration and renewal of the element in the built-in fuel filter at overhaul periods. It is set correctly and sealed and the fuel setting should not be altered.

Lubrication.

Cam chamber.

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

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

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

Governor casing.

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.

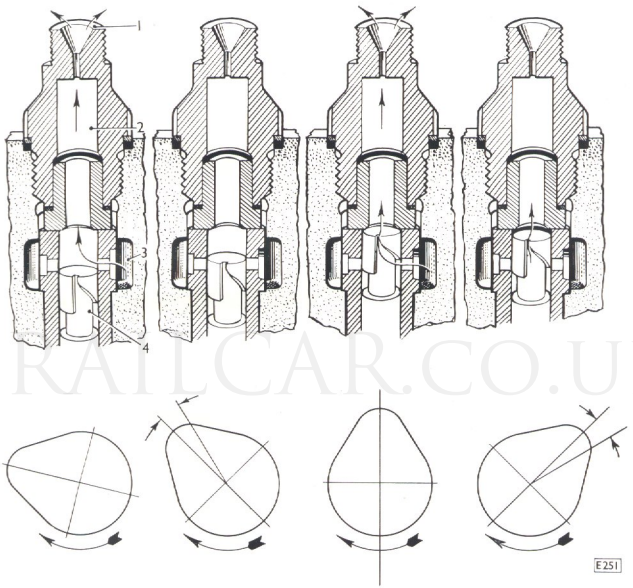
For instructions on adjusting for idling refer to Section K45.

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 toset accurately except on a calibratingtest 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. 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.

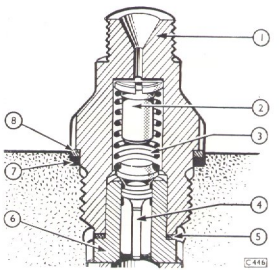


Fig. 35. Section through "N" type pump delivery valve assembly.

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 re-assemble on to the fuel-injection pump, checking to see that the delivery valve is free in its guide.

Tighten the delivery valve holder and secure it with the locking device, then connect the fuel delivery pipe (*for torque spanner loading see Section* 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.

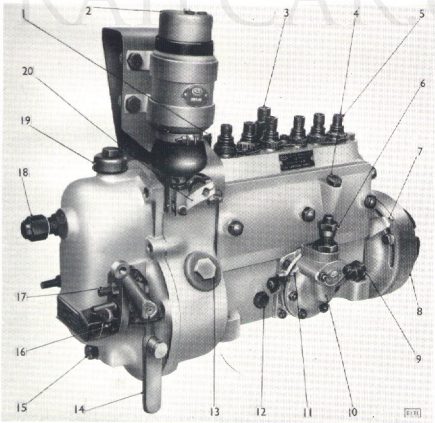


Fig. 36. Fuel-injection pump.

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).

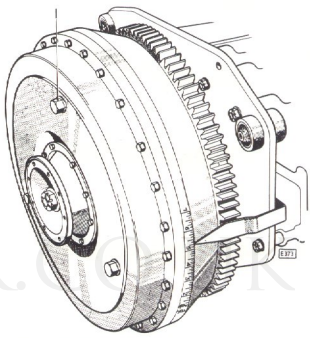


Fig. 37. Position of engine flywheel for fuel-injection pump spill cut-off point and (1) for filling or topping-up.

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

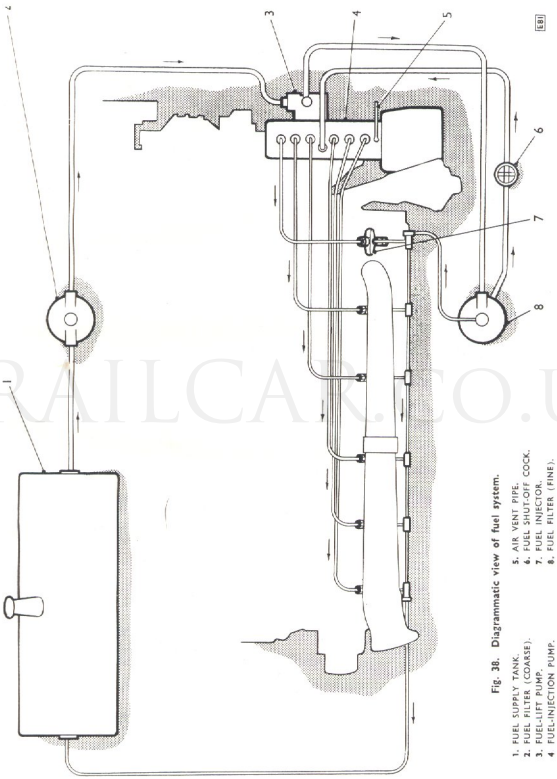


Fig. 38. Diagrammatic view of fuel system.

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).

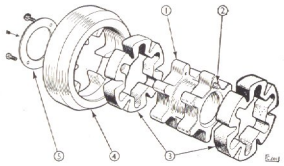


Fig. 39. Exploded view of fuel-injection pump flywheel assembly.

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.

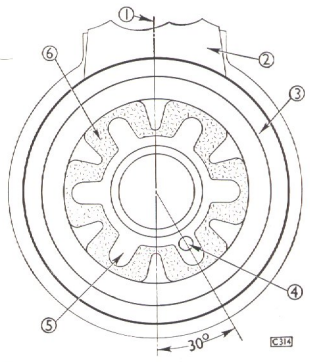


Fig. 40. Diagram showing position of dowel when flywheel is fitted to the fuel-injection pump.

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).

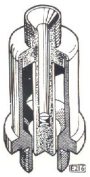


Fig. 41. Fuel-lift pump air bell.

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.

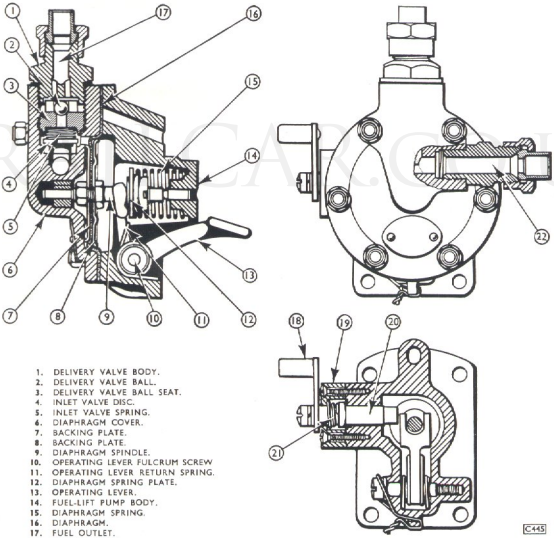
The diaphragm and spindle assembly must be considered as a unit and should not be taken apart.

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.

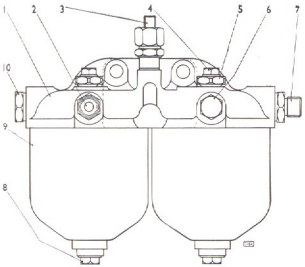


Fig. 43. Arrangement of fuel filter (C.A.V.)—twin paper element type.

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.

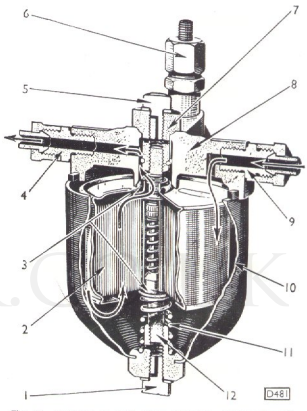


Fig. 44. Section of fuel filter (C.A.V.)—paper element type.

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.

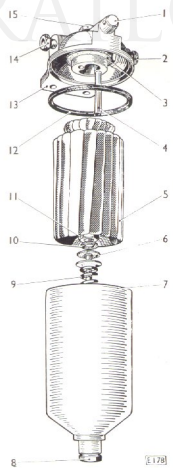


Fig. 45. Exploded view of main fuel filter (C.A.V. cloth element type).

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 ¼ 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.

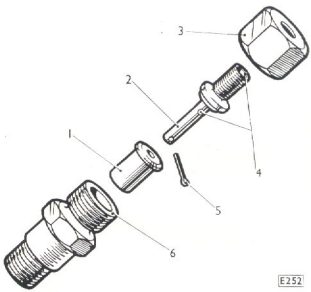


Fig. 46. Exploded view of air release valve.

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.

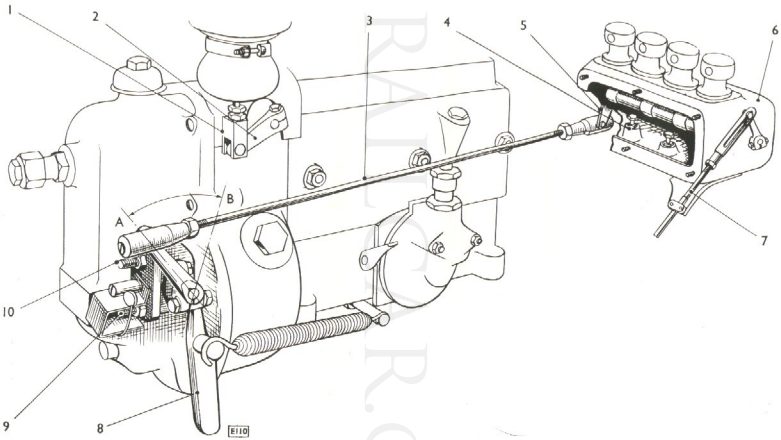


Fig. 47. Throttle motor linkage.

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.

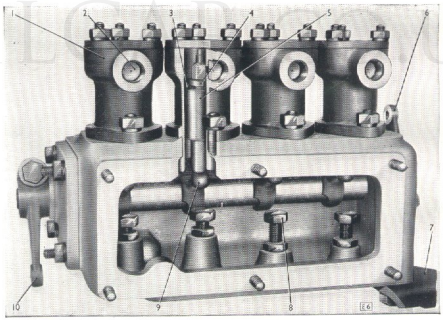


Fig. 48. Throttle motor showing cut-away view of operating piston.

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).

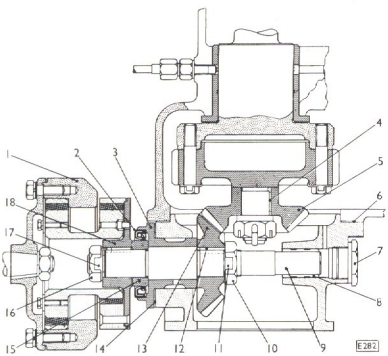


Fig. 49. Section through bevel gear housing assembly.

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).

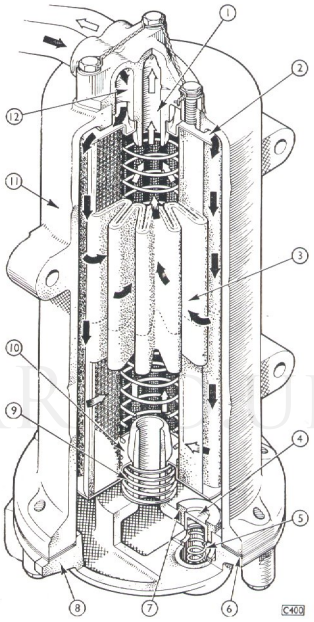


Fig. 50. Cut-away view of oil filter.

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.

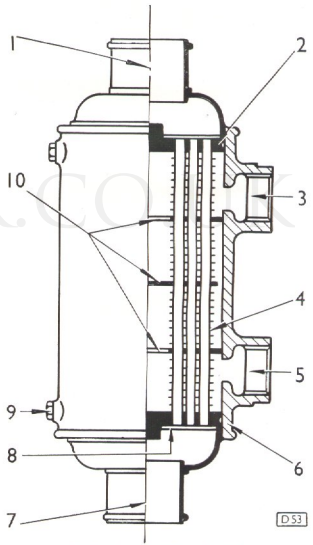


Fig. 51. Section through oil cooler.

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.

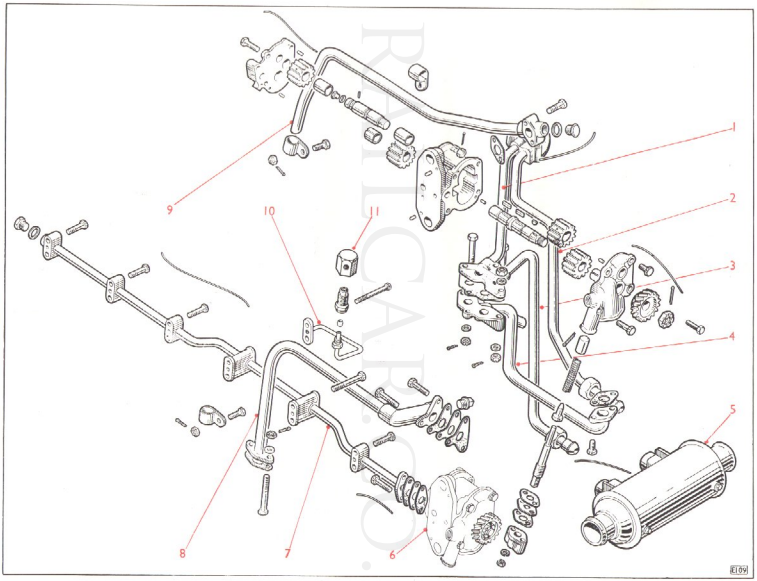


Fig. 52. Exploded view of oil pumps and lubrication pipes.

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*).

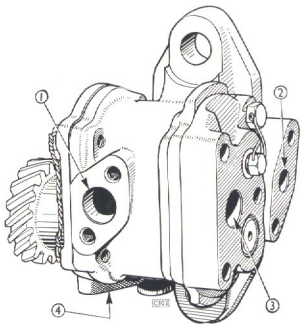


Fig. 53. Assembly of oil pumps.

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

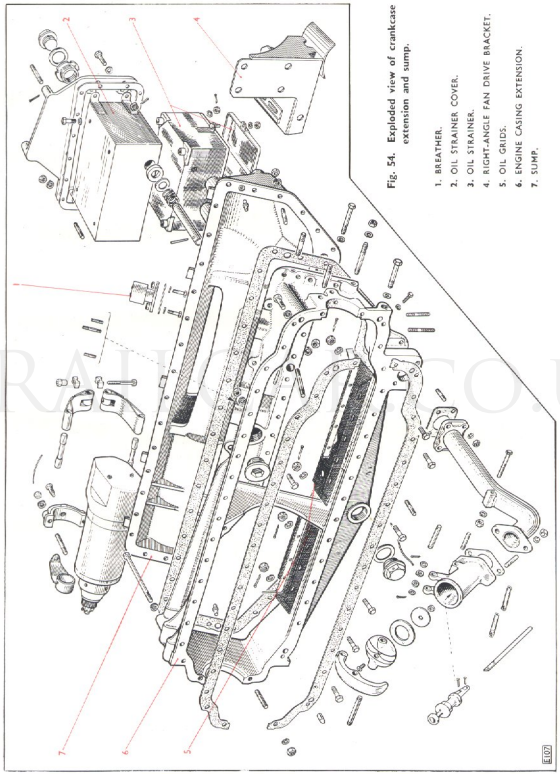


Fig. 54. Exploded view of crankcase extension and sump.

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.

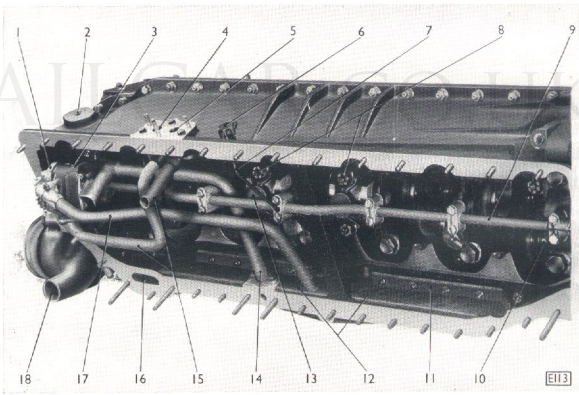


Fig. 55. View of interior of engine casing.

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.

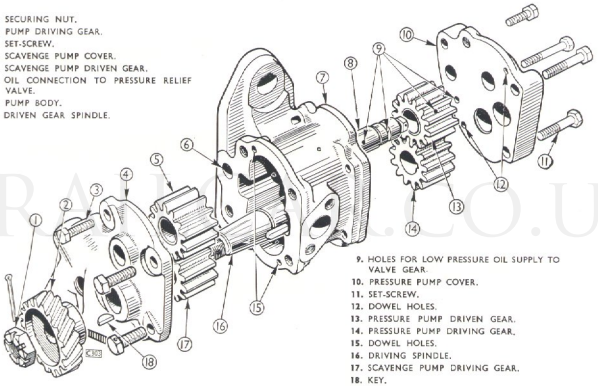
The scavenge pump gears are wider than the pressure pump gears.

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 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.

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.

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.

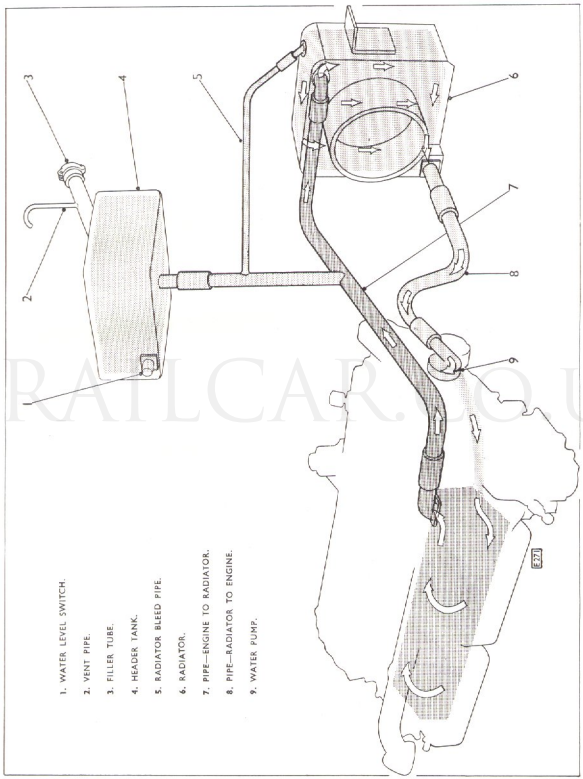


Fig. 58. Diagrammatic layout of engine cooling system.

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.

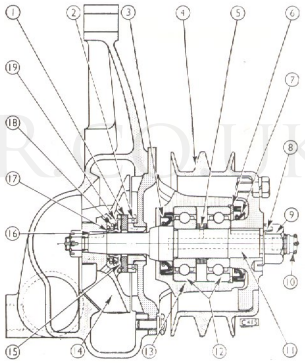


Fig. 59. Section through water pump.

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

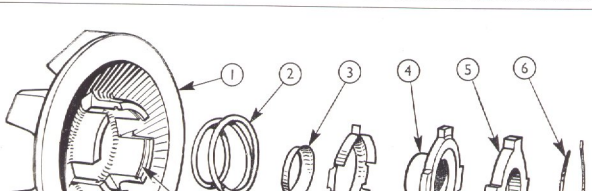


Fig. 60. Exploded view of water pump gland.

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.

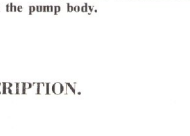


Fig. 61. Section through thermostat.

1. THERMOSTAT VALVE CLOSED.
2. THERMOSTAT VALVE LIFT $\frac{3}{8}$" (9·375 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.

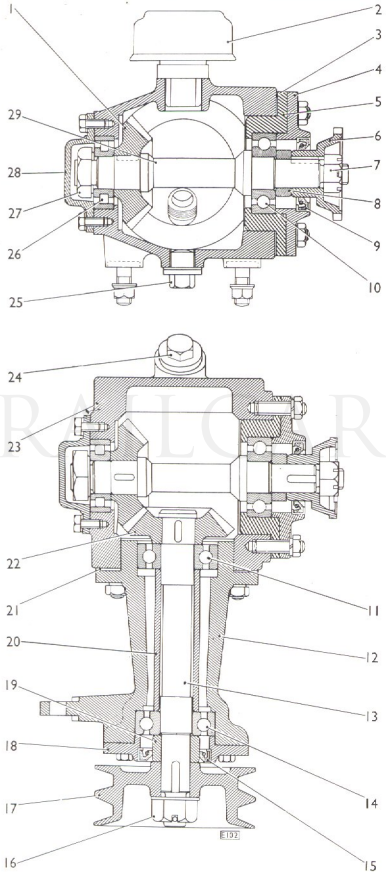


Fig. 62. Arrangement of right-angle fan drive unit.

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).

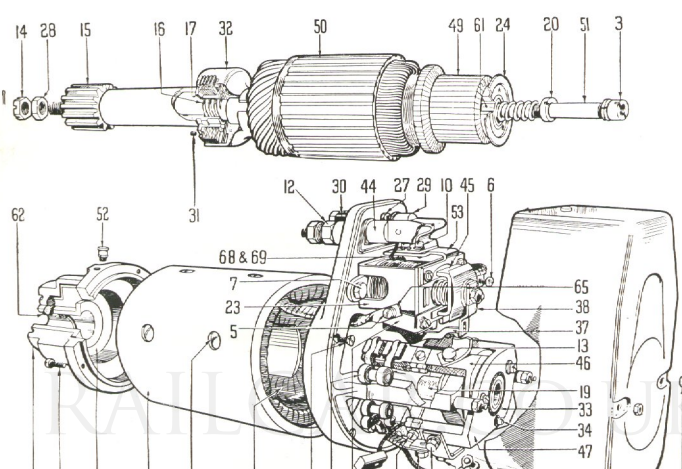


Fig. 63. Exploded view of C.A.V. starter motor.

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.

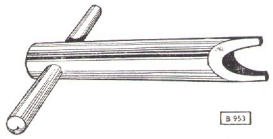


Fig. 64. Tool for starter motor armature spring nut.

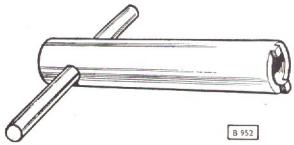


Fig. 65. Tool for starter armature plunger nut.

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.

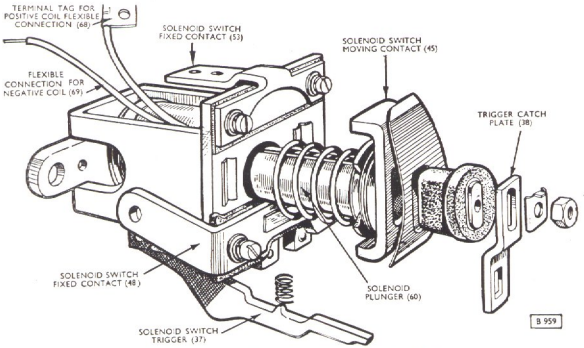


Fig. 66. Exploded view of starter motor solenoid switch (C.A.V.)

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.

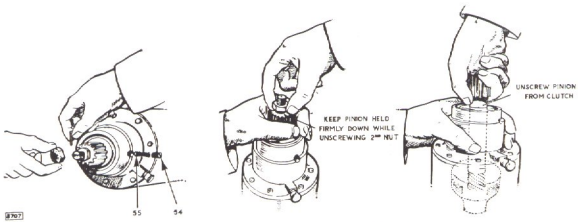


Fig. 67. Method of changing starter motor driving pinion without dismantling unit.

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.

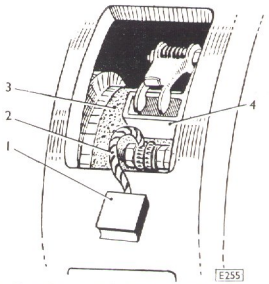


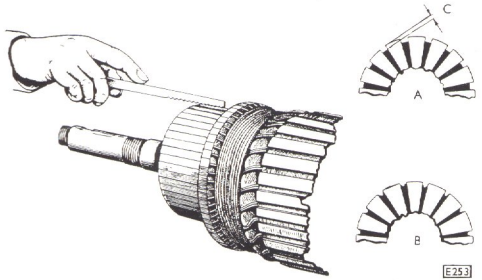
Fig. 68. Method of "bedding" starter motor brushes.

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.

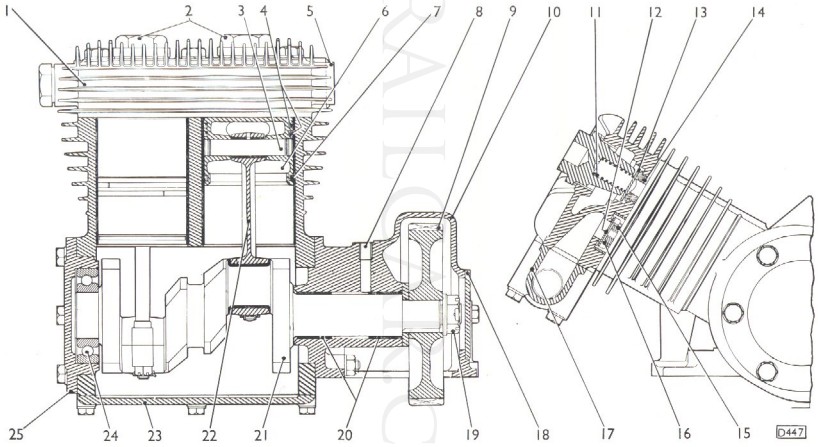


Fig. 71. Arrangement of air compressor.

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 1·409 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).

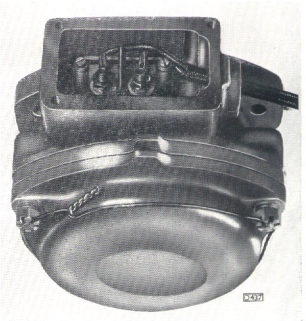


Fig. 72. Engine speed indicator generator—with cover removed.

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

CLEARANCES (when new).

Unit.	Component.	Clearance. Inches. Maximum.	Inches. Minimum.	Millimetres. Maximum.	Millimetres. Minimum.
	DIAMETRICAL CLEARANCES.				
BEARINGS	Crankshaft and Main Bearings :— All Standards—All Copper-lead Lined	0·007	0·004	0·180	0·102
	Crankshaft and Connecting Rod Big-end Bearings:— All Standards	0·0047	0·0034	0·120	0·087
	Gudgeon Pin and Connecting Rod Small-end Bearings	0·0020	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.

4th 5th + 6th Deleted Service Bulletin 87

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	Width 0·125 in., 0·145 in. or 0·165 in.
,,	—	131·0	
Piston ring, scraper	—	130·5 mm. nomin	
,,	—	131·0	
Crankcase rear oil seal	99·25 mm.	—	Machining allowance in bore for machining in line with main bearings.
Main bearings			
Plan	95·097 mm.	—	No machining is necessary when fitting these bearings.
2nd Standard	94·597 mm.	—	
3rd Standard	94·097 mm.	—	
4th Standard	93·597 mm.	—	
5th Standard	93·097 mm.	—	
6th Standard	92·597 mm.	—	
Connecting rod bearings	74·5 + 0·090 mm. + 0·077 mm.	—	Finished machined and fitted to connecting rod ready for assembly.
,,	74·0 + 0·090 mm. + 0·077 mm.	—	
,,	73·5 + 0·090 mm. + 0·077 mm.	—	
,,	73·0 + 0·090 mm. + 0·077 mm.	—	
,,	72·5 + 0·090 mm. + 0·077 mm.	—	
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

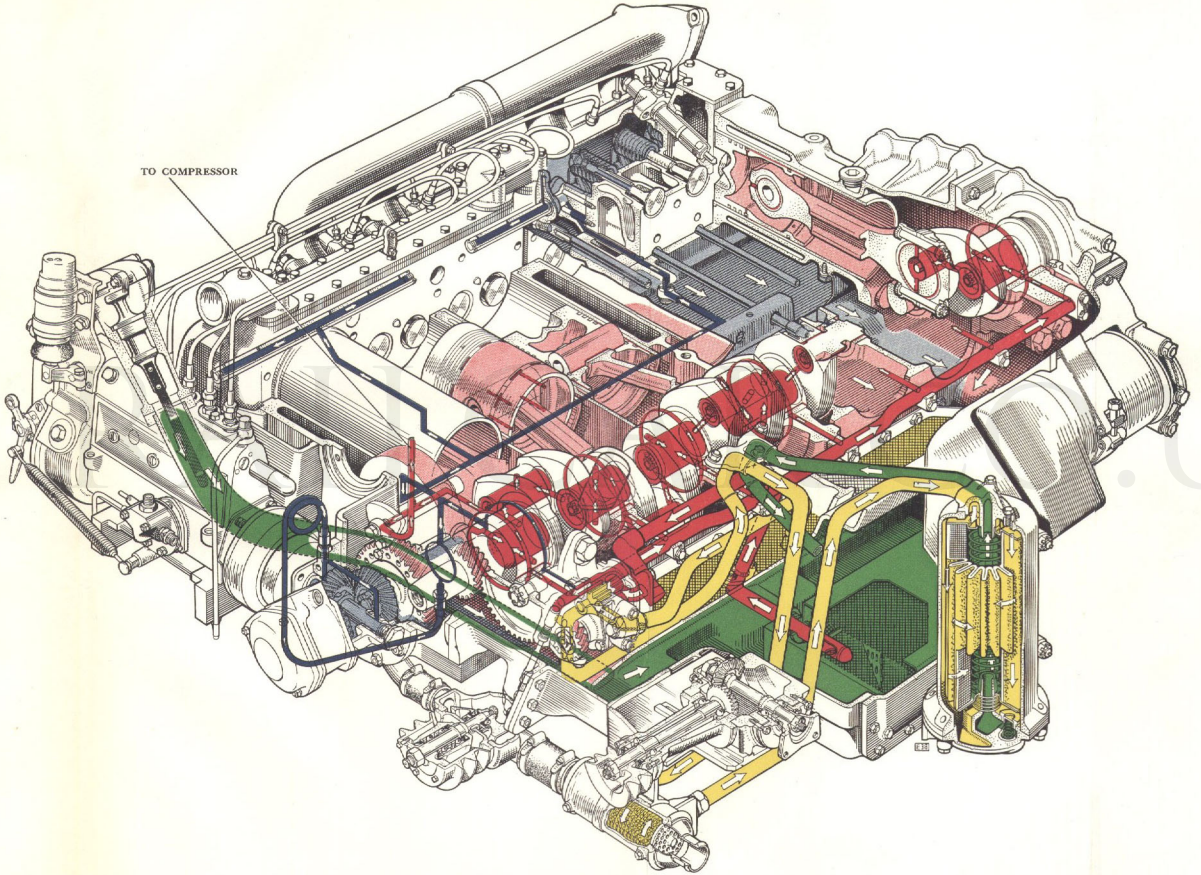
*Note.—Should the split pin hole not align after tightening these nuts to the specified torque given above, the nut may be **tightened** to the next slot for insertion of the split pin.

PLATE No. **B6**

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

ENGINE
(L - Type)

CHAPTER L

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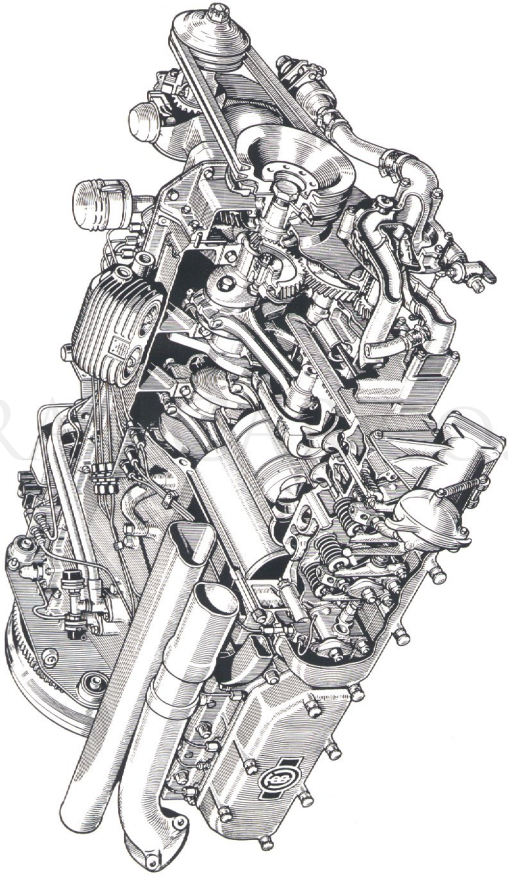


Fig. 1. Cut-away view of the (L - type) engine.

Sect. L1 ENGINE—DESCRIPTION

THE B.U.T. L-type 11.1 litre Diesel engine is a horizontal six-cylinder, direct-injection, overhead-valve, four-stroke unit with a pump-driven water circulation system. Valves, rocker gear and injectors are carried in the two detachable cylinder heads, each head covering three cylinders. The valves are push-rod operated from the tappets and camshaft through rocker levers.

The crankcase and cylinder block form a monobloc casting, the cylinder bores being fitted with renewable liners. The gear-driven camshaft is also housed within the crankcase.

The crankshaft is carried in seven thin-shell indium-coated copper-lead bearings and carries a vibration damper at the front end.

The pistons are fitted with three compression rings, the top ring being chromium plated, and two scraper rings. The combustion chamber in the piston crown is of toroidal form. The fully-floating gudgeon pins are retained by circlips.

The timing gears consist of a train of helical gears which drive the camshaft, fuel injection pump, water pump, compressor and engine tachometer generator through two idler gears driven by the camshaft gear.

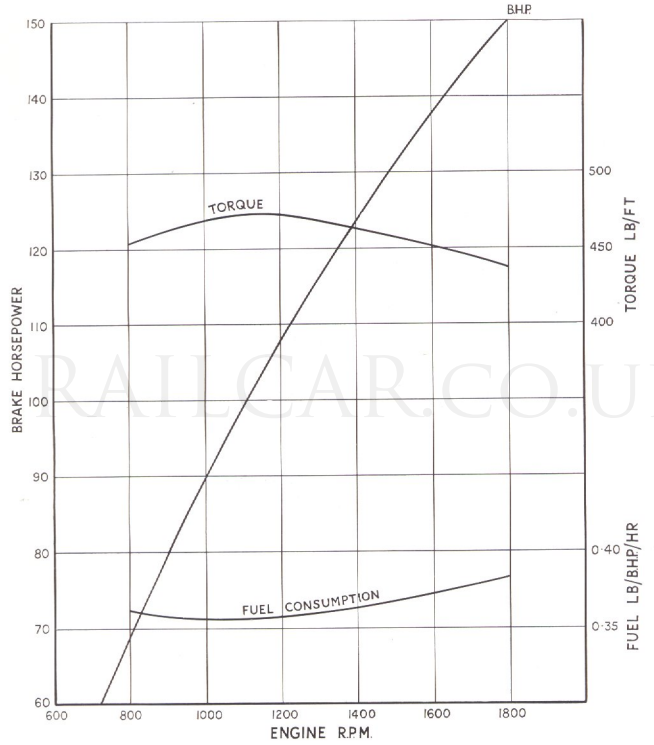
Lubricating oil is pressure fed by a gear-type pump to the bearings etc., through drilled oilways. A by-pass centrifugal oil filter is incorporated in the system.

The fuel injection pump is mounted on the inner sump face and incorporates an idling and maximum speed governor and a diaphragm type lift pump. Multi-hole fuel injectors are fitted.

On later engines all electrical leads are carried in conduit and connected to a Niphan plug-and-socket, enabling the engine to be removed and replaced without disconnecting the terminal connections from the various components.

An oil-bath type air cleaner is mounted on the car underframe and is connected by hose to the inlet manifold.

A water-cooled oil cooler is mounted on the engine.



Performance curves for L-Type engine.

Sect. L2

UNIT	DATA	
GENERAL	Type	B.U.T. L-type, R/E.680, horizontal Diesel engine (11.1 litres).
	Main features	Six-cylinder, compression-ignition, direct-injection, overhead-valve, horizontal, water-cooled.
	Bore	5.00 in. (127 mm.).
	Stroke	5.75 in. (146.05 mm.).
	Cubic capacity	677 cubic inches (11,093 c.c.).
	Maximum torque	450 lb./ft. at 1,100 r.p.m. (62.1 kg./m.).
	Maximum b.h.p.	150 at 1,800 r.p.m.
	Compression ratio	15.75 to 1.
	Firing order	1, 5, 3, 6, 2, 4.
LUBRICATION	Type	Wet sump, gear-type pump.
	Sump capacity	44 pints (18 litres) approx. with wet engine.
	Oil pressure	60 p.s.i. (4.2 kg./s. cm.) at 1,000 r.p.m. or higher speeds, with warm engine. Not below 5 p.s.i. (.35 kg./s. cm.) with engine idling.
	Pump delivery	48 pints (27 litres) approx. per minute at 1,000 r.p.m. crankshaft speed.
	Filter	Centrifugal.
	Oil cooler	Serck guided flow.
CYLINDER HEADS	Type	Detachable, 2 per engine, each covering 3 cylinders.
	Material	Cast iron.
	Valve guide interference in head	.001 to .002 in. (.0254 to .0508 mm.).
ENGINE BLOCK	Type	Cylinders and crankcase in one-piece casting.
	Material	Cast iron.
	Liners	Pre-finished, dry, cast iron, press fit, shoulder located.
	Initial bore of liner before fitting to engine block	5.0017 ~ 5.0025" 5.0010 to 5.0018 in. (~~127.025~~ to ~~127.046~~ mm.).
	Reline when wear of liner bore exceeds	.020 in. (.508 mm.).
PISTON AND RINGS	Piston type	Toroidal cavity.
	Piston material	Aluminium alloy.
	Compression Rings	
	Number of rings	Three (1st, 2nd and 3rd grooves). The top compression ring is chromium plated.
	Type of ring	.125 in. (3.175 mm.) wide, 3° tapered sides, hardened and tempered, 90° gap.
	Initial gap	.020 to .024 in. (.508 to .6096 mm.).
	Renew rings when gap exceeds	.100 in. (2.540 mm.).
	Scraper Rings	
	Number of rings	Two (4th and 5th groves).
	Type of ring	.250 in. (6.350 mm.) wide, straight sides, slotted, 90° gap.
	Initial gap	.020 to .024 in. (.508 to .6096 mm.).
	Renew rings when gap exceeds	.100 in. (2.540 mm.).

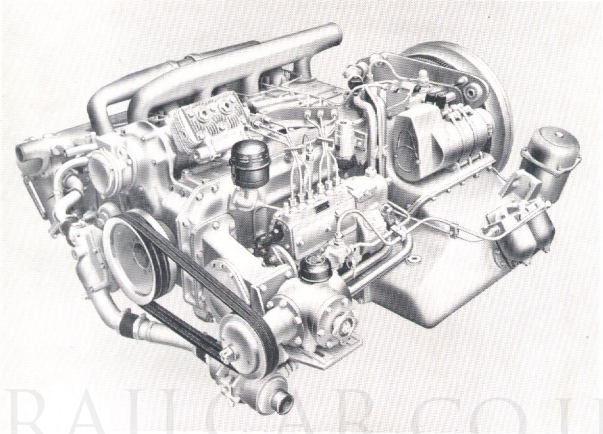


Fig. 2. Front left-hand view of the R.E.680 engine.

UNIT	DATA	
CONNECTING RODS AND GUDGEON PINS	Gudgeon pin	1.625 in. (41.275 mm.) dia. hollow, fully floating.
	Pin retained by	Two circlips in piston.
	Connecting rod type	I-section.
	Small-end bearing	Phosphor-bronze bush.
	Initial diametral clearance of pin in small-end bush (cold)	.00045 to .001 in. (.01143 to .0254 mm.).
	Renew small-end bush when diametral clearance exceeds	.0025 in. (.0635 mm.).
	Interference of small-end bush in connecting rod	.00225 to .00425 in. (.05715 to .10795 mm.).
	Big-end bearing type	Pre-finished, lead-bronze, steel shell, bearing surface indium-coated.
	Big-end initial diametral clearance	.0018 to .0037 in. (.04572 to .09398 mm.).
	Renew when diametral clearance exceeds	.008 in. (.2032 mm.).
	Undersize big-end bearings available	Pre-finished in five steps of .010 in. (.254 mm.) each.
	Do not grind sides of crankpins	

TABLE OF CRANKSHAFT DIMENSIONS

Type	Part Number	Crankpin Diameter		Crankpin Width		Journal Diameter		Journal Width							
								Front		Centre		Rear		Others	
		in.	mm.	in.	mm.	in.	mm.	in	mm.	in.	mm.	in.	mm.	in.	mm.
Standard Service	Part Number as stamped on front web	3.0005 2.9998	76.213 76.195	2.203 2.200	55.956 55.880	3.5005 3.4998	88.913 88.895	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
1st Service	Part Number /S.1	2.9905 2.9898	75.959 75.941	2.203 2.200	55.956 55.880	3.4905 3.4898	88.659 88.641	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
2nd Service	,, /S.2	2.9805 2.9798	75.705 75.687	2.203 2.200	55.956 55.880	3.4805 3.4798	88.404 88.387	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
3rd Service	,, /S.3	2.9705 2.9698	75.451 75.433	2.203 2.200	55.956 55.880	3.4705 3.4698	88.151 88.133	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
4th Service	,, /S.4	2.9605 2.9598	75.197 75.179	2.203 2.200	55.956 55.880	3.4605 3.4598	87.897 87.879	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
5th Service	,, /S.5	2.9505 2.9498	74.943 74.925	2.203 2.200	55.956 55.880	3.4505 3.4498	87.643 87.625	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180

Note 1.—When re-grinding crankpin and journals the sides must not be ground unless they have been damaged. If the location faces of the centre main bearing have been damaged, the width should be increased to 2.710 in./2.712 in. (68.834 mm./68.885 mm.); otherwise the dimension should remain unchanged.

Note 2.—The crankshaft should be re-nitrided at service sizes S.2 and S.4.

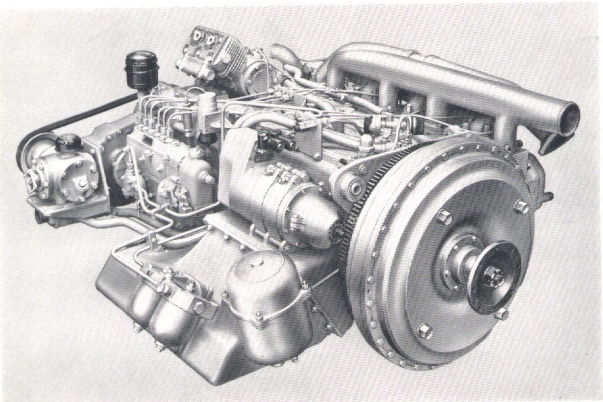


Fig. 3. Rear left-hand view of the R.E.680 engine.

UNIT		DATA
CRANKSHAFT AND MAIN BEARINGS	Number of main bearings ..	Seven.
	Main bearing type	Pre-finished strip bearings.
	Type of bearing	Lead-bronze, steel shell, bearing surface indium coated.
	Crankshaft type	Forging, incorporating balance weights.
	Crankshaft material	Alloy-steel, nitrided.
	Thrust taken on	Thrust washers at centre journal.
	Centre journal initial end clearance	.004 to .010 in. (.1016 to .254 mm.).
	Renew thrust washers when end clearance exceeds	.014 in. (.3556 mm.).
	Oversize thrust washers available	One set .010 in. (.254 mm.) thick (.005 in. (.1270 mm.) each washer).
	Regrind journals and crankpins ..	When .003 in. (.0762 mm.) oval.
	Undersize main bearings available	Five, in steps of .010 in. (.254 mm.) each.
	Main bearing initial diametral clearance	.0020 to .0042 in. (.0508 to .1067 mm.).
	Renew when diametral clearance exceeds	.009 in. (.2286 mm.).
	Maximum run-out on shaft ..	.003 in. (.0762 mm.) total clock reading .006 in. (.1524 mm.).
	Maximum run-out between two adjacent bearings	.003 in. (.0762 mm.) total clock reading.

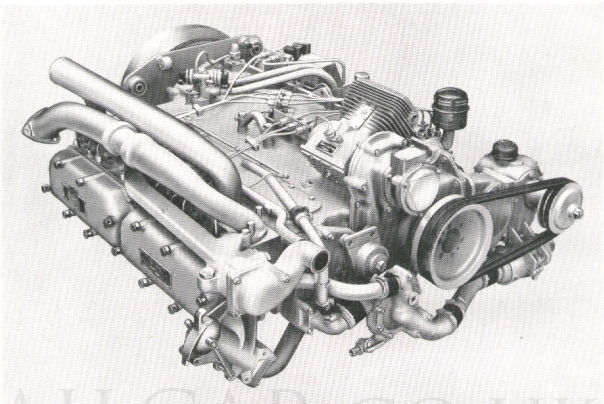


Fig. 4. Front right-hand view of the R.E.680 engine.

UNIT	DATA	
	Crankshaft damper	Rubber-bonded vibration damper at front of crankshaft.
CAMSHAFT	Number	One.
	Camshaft type	Forged with integral cams.
	Camshaft material	Steel.
	Type of drive	Single-helical gear.
	Number of bearings	Seven.
	Material	Front and rear—leaded gunmetal; intermediate—carobronze.
	Thrust taken on	Front bearing only.
	Interference fit of all bearings in engine block	.0005 to.0025 in. (.01270 to .06350 mm.).
	Journal diameters	2.396 to 2.397 in. (60.858 to 60.883 mm.).
	Initial diametral clearance in all bearings	.004 to .0055 in. (.1016 to .1397 mm.).
	Renew bearings when clearance exceeds	.010 in. (.254 mm.).
	Initial dimension from nose to back of cam	1.995 to 2.005 in. (50.673 to 50.927 mm.).

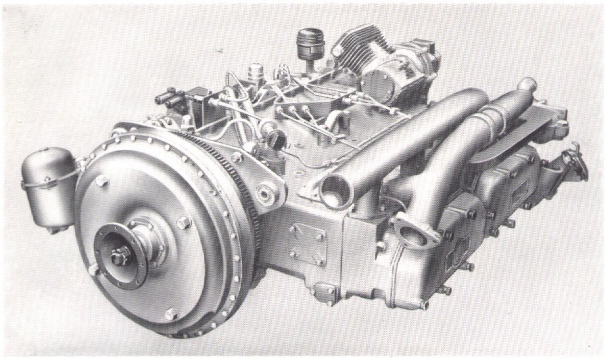


Fig. 5. Rear right-hand view of the R.E.680 engine.

UNIT		DATA
Camshaft (contd.)	Renew camshaft when this dimension is	1.983 in. (50.368 mm.).
TIMING GEARS	Type	Single-helical gears.
	Gear material	Hardened and ground steel.
	Permissible backlash between each pair of gears	.002 to .004 in. (.0508 to .1016 mm.).
	Idler gears, initial diametral clearance between bush and gear ..	.001 to .00325 in. (.0254 to .0826 mm.).
	Diametral clearance between bush and idler spindle	.001 to .00325 in. (.0254 to .082550 mm.).
	End float between thrust washers and idler gear	.004 to .0095 in. (.1016 to .2413 mm.).
	Renew thrust washers when end clearance exceeds	.012 in. (.3048 mm.).
	Interference fit of timing gear on crankshaft	.00075 to .00225 in. (.019050 to .057150 mm.).
VALVES	Type	Overhead poppet.
	Valve material	Stellite-faced, hard chrome-plated stems.
	Number per cylinder	One inlet, one exhaust.
	Stem diameter:	
	Inlet	.43475 to .43425 in. (11.0425 to 11.0300 mm.).
	Exhaust	.43325 to .43275 in. (11.0046 to 10.9918 mm.).
	Stem clearance in guide:	
	Inlet	.0025 to .00375 in. (.06350 to .09525 mm.).
	Exhaust	.004 to .00525 in. (.1016 to .13335 mm.).

UNIT	DATA	
	Valve head diameter:	
	Inlet	2.20 in. (55.88 mm.).
	Exhaust	1.90 in. (48.26 mm.).
	Angle of valve seat	30°.
	Angle of valve face	29½°.
	Valve lift	0.5 in. (12.70 mm.).
	Number of valve springs	Two per valve, concentric.
	Maximum spring pressure (valve open)	134 lb. (60.782 kg.).
	Free length of spring:	
	Inner	2.130 in. (54.102 mm.).
	Outer	2.50 in. (63.50 mm.).
	Renew springs when	Inner spring will compress to 1.25 in. (31.750 mm.) under a load less than 35 lb. (15.87 kg.). Outer spring will compress to 1.50 in. (38.100 mm.) under a load less than 74 lb. (33.56 kg.).
	Initial diametral clearance of rocker shaft in rocker	.0005 to .00175 in. (.01270 to .04445 mm.).
	Renew rocker shaft bushes when diametral clearance exceeds ..	.003 in. (.0762 mm.).

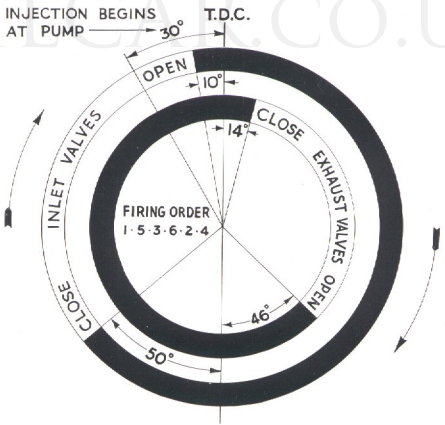


Fig. 6. Valve timing diagram.

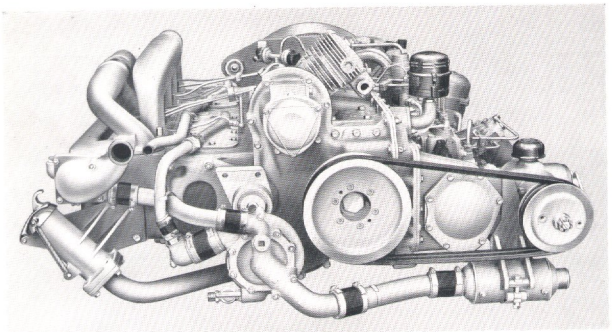


Fig. 7. Front-end view of the R.E.680 engine.

UNIT	DATA	
Valves (contd.)	Initial diametral clearance of tappet in engine block	.00175 to .00375 in. (.04445 to .09525 mm.).
	Renew tappet when diametral clearance in engine block exceeds	.004 in. (.1016 mm.).
	Tappet clearance:	
	Inlet	.020 in. (.508 mm.), engine cold.
	Exhaust	.020 in. (.508 mm.), engine cold.
VALVE TIMING	Inlet opens	10° before T.D.C.=1.76 in. (44.704 mm.) on flywheel rim.
	Inlet closes	50° after B.D.C.=8.82 in. (224.028 mm.) on flywheel rim.
	Exhaust opens	46° before B.D.C.=8.11 in. (205.994 mm.) on flywheel rim.
	Exhaust closes	14° after T.D.C.=2.47 in. (62.738 mm.) on flywheel rim.
FUEL SYSTEM	Primary fuel filter	C.A.V. type B.F.A. (cloth element).
	Secondary fuel filter	C.A.V. type 2F3/13L (twin-bowl, paper element).
INJECTION PUMP	Make	C.A.V.
	Type	NL 6F 80.
	Number of deliveries	6.
	Plunger diameter	8.0 mm.
	Plunger stroke	9.0 mm.
	Helix	Right-hand.
	Drive	Flexible, adjustable coupling, clockwise rotation, half engine speed.

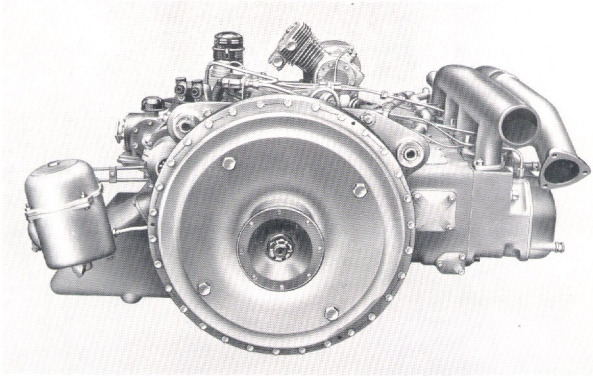


Fig. 8. Rear-end view of the R.E.680 engine.

UNIT	DATA	
	Timing	Timing begins at the injection pump, 30° before T.D.C.
GOVERNOR	Make	C.A.V.
	Type	GRWB21.
	Governed speed	1,800 r.p.m.
	Runaway speed	2,000 r.p.m.
	Idling speed	375/400 r.p.m.
FUEL FEED PUMP	Make	C.A.V.
	Type	DFP 3/2S.
	Pressure maintained	4 to 5 lb. per sq. in. (.28 to .35 kg./sq. cm.).
	Operation	Operated by arm in contact with eccentric on injection pump camshaft.
INJECTORS	Make	Leyland.
	Type	R/N.1.
	Discharge pressure	140 to 145 atmospheres, 2,057 to 2,130 p.s.i. (144.6 to 149.7 kg./s. cm.).
	Adjusting washer	Available in ten steps of .010 in. (.254 mm.) each from .103 in. (2.6162 mm.) to 193 in. (4.9022 mm.).
	Needle lift	.016 to .018 in. (.4064 to .4572 mm.).

UNIT	DATA	
Injectors (contd.)	Needle valve adjusting washer ..	Available in the following thicknesses:
		.0925 in., 2.3495 mm.
		.0945 in., 2.4003 mm.
		.0965 in., 2.4511 mm.
		.0975 in., 2.4765 mm.
		.0985 in., 2.5019 mm.
		.0995 in., 2.5273 mm.
		.1005 in., 2.5527 mm.
		.1020 in., 2.5908 mm.
		.1040 in., 2.6416 mm.
		.1060 in., 2.6924 mm.
		.1080 in., 2.7432 mm.
		.1100 in., 2.7940 mm.
		.1120 in., 2.8448 mm.
		.1140 in., 2.8956 mm.
	Angle of sprays	140°.
	Valve spring free length	1.5625 in. (39.687 mm.).
	Valve spring length under a load of 48 to 54 lb. (21.773 to 24.494 kg.)	1.355 in. (34.417 mm.).
COMPRESSOR	Make	Clayton, Dewandre.
	Type	PCGA 246.
	Bore	2.625 in. (66.675 mm.).
	Drive	Gear type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.
RIGHT ANGLE FAN DRIVE	Drive gear	No. of teeth, 27.
	Driven gears	No. of teeth, 27.
	Type	Straight bevel.
	Backlash when in mesh with mating gear	.004 to .008 in. (.1016 to .2032 mm.).
	Interference fit of driven gears on shafts	.00175 in. (.0446 mm.).
	Interference fit of pulley on shaft	.00125 in. (.0318 mm.).
	Interference fit of coupling flange on shafts	.0015 in. (.0381 mm.).
	Oil seals	Gaco No. MIS.17.
	Oil capacity	1 pint (.6 litre).
COOLING SYSTEM	Controlled by thermostat ..	Thermostat opens at 183 to 190°F. (83.8 to 87.7°C.).
	Water pump	Gear-driven from camshaft gear.
AIR CLEANER	Make and type	Air-Maze, heavy duty, two-stage oil-bath, capacity 5 pints approx. (2.8 litres).
TACHOMETER GENERATOR	Make	Smiths.
	Type	'M'.
STARTER MOTOR	Make	C.A.V.
	Type	U 624.

Sect. L3 MAINTENANCE

1. **Important.**—At a period laid down in **Railway Standing Instructions** all new or overhauled engines should be checked over generally, attaching particular importance to the following:

Drain and refill the engine and right-angle-drive unit with oil and attend to items 2 and 3 in the table below.

2. **Periodical Attention**

1	Attend to items detailed in Section L4 and on the lubrication chart.
2	Tighten down engine cylinder head nuts in the correct order (*see Section L17*).
3	Check the inlet and exhaust valve tappet clearances (*see Section L22*).
4	Liveliness of engine—smoothness—exhaust.
5	Remove cylinder heads, valve gear, etc., and decarbonize (*see Section L19*).
6	Replenish the fuel tanks.
7	Check that the water header tank is full, to ensure a constant supply of water to the cooling system.
8	Check the tension of the fan drive belts (*see Section L35*).
9	Check all pipes carrying oil, fuel, water, air and vacuum, for loose nuts and leakages.
10	Remove the fuel injectors and fit a set of new or reconditioned ones (*see Section L42*).
11	Check fuel injection pump timing (*see Section L47*).
12	Renew the elements in the fuel filters and clean the bowls. Vent the fuel system (*see Sections L57 and L59*).
13	Check engine oil pressure.
14	Remove the air compressor cylinder head for examination, 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 springs and discs (*see Section L68*).
15	Examine the starter motor brushes and commutator (*see Section L63*).
16	Examine the teeth of the starter ring. If worn or damaged, the ring should be repositioned or renewed (*see Section L29*).
17	Inspect the engine and radiator suspension for loose nuts, etc.
18	Clean the centrifugal oil filter and the sump filter at engine oil change (*see Sections L10 and 11*).

3. Frost Precautions

If anti-freeze solution is not in use and the car is to remain standing in the open with temperatures approaching freezing point, the cooling system must be completely drained by opening the drain tap which is located in the radiator water outlet pipe.

Drain when the engine is hot, and do not leave the vehicle until the water is completely drained.

Drain taps should be tested at frequent intervals by inserting a length of wire to ensure that they are clear. This should be done immediately they are opened so that any obstruction freed by the wire may be flushed out by the water.

After draining place a notice in a conspicuous place to the effect that the cooling system is empty and the drain taps are open.

Cars with anti-freeze mixture in the engine cooling system should be marked accordingly, and if the car is so marked do not drain the cooling system.

Sect. L4 ENGINE LUBRICATION

(See Engine Lubrication Diagram)

This Section should be read in conjunction with the Lubrication Chart

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

Item	Method	Approximate Capacity
Air Cleaner	Remove the bowl, clean, refit and refill with oil (*see instructions in Section L70*)	5 pints (2.8 litres.)
Engine	Top-up with oil or drain and refill (*see instructions in this section*)	44 pints (25 litres)
Fuel-injection Pump	Fill with oil on assembly only, subsequent lubrication by back leakage of fuel oil (*see Section L47*)	¼ pint (0.14 litre)
Fuel-injection Pump Governor	Top-up with oil or drain and refill (*see Fig. 79 showing oil level and filler plugs*)	¼ pint (0.14 litre)
Right-angle Fan Drive	Top-up with oil or drain and refill (*see instructions in this section*)	½ pint (0.28 litre)
Starter Motor	Remove plug and lubricate with engine oil. Use oil can	—
Engine Speed Indicator Generator	Bearings pre-packed on assembly	—
Fuel-injection Pump Control Rod Ball Joints	Lubricate with oil can	—

To Drain the Engine

This operation should be carried out with the car standing on level ground and while the engine oil is still warm after the engine has been running.

Place a suitable container beneath the plug in the sump and remove the plug. Replace the plug after draining.

To Fill the Engine

Fill the engine with oil, through the oil filler, until the level is at the full mark on the dipstick. Start the engine and run it for a few minutes at idling speed. Stop the engine and check the oil level. If necessary top-up to the full mark on the dipstick.

When checking the oil level remove the dipstick, wipe it clean, re-insert it, remove it and check the level of the oil.

To Drain the Right-angle Fan Drive Unit

This unit, like the engine, should be drained with the car standing on level ground and while the oil is still warm after the engine has been running.

Place a suitable container beneath the unit and remove the drain plug. Replace the plug after draining.

To Fill the Right-angle Fan Drive Unit

Remove the filler plug and fill the unit with gear oil to the level of the plug hole.

Replace the filler plug and clean the breather.

Sect. L5 ENGINE LUBRICATION—DESCRIPTION

Engine lubrication is on the wet sump system, the oil being circulated by a gear-type oil pump.

Oil is drawn from the outer sump well through a suction filter, and pressure fed by the pump into the main lubrication system via an oil cooler situated at the front of the crankcase. A by-pass centrifugal oil filter is incorporated in the system.

The crankshaft main bearings, big-end bearings, idler-gear for camshaft drive, and camshaft bearings, are supplied with oil through oilways drilled in the engine block.

A supply is tapped off the front main bearing to lubricate the idler-gear transmitting drive to exhauster and injection pump drive gear. The cylinder walls and gudgeon-pin bushes are lubricated by splash and intermittent spray from oilways drilled in the crank-pins and connecting-rod big ends.

The rocker gear is also lubricated, Fig. 9, by an intermittent feed from the second and fifth camshaft bearings via horizontal oilways drilled in the engine-block and heads, through the centre rocker shaft support bracket on each head, along the tubular rocker shafts to the rocker levers. A hole drilled in each rocker lever carries a supply of oil to the top of the rocker in order to lubricate the contact surfaces between the valve cap and rocker lever. Oil is returned from the valve operating gear via two external pipes, running from the tappet gallery bottom covers to the inner sump.

Oil pressure, which is taken from the crankcase end of the oil cooler to crankcase oil return pipe is indicated by an oil pressure switch and connected to an indicator light on the panel.

The system is provided with a relief valve mounted on top of the engine block at the rear left-hand side; it consists simply of a spring-loaded valve provided with an adjusting screw. Oil by-passed by this valve spills back into the main sump well.

Crankcase breathing is effected through holes drilled in the top four valve cover holding-down bosses, and an oil-washed air breather fitted to the inner sump.

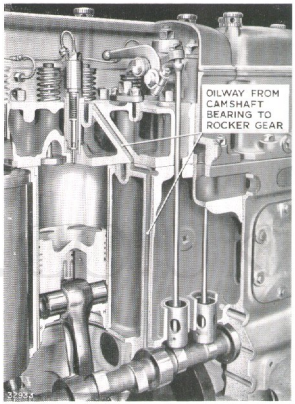


Fig. 9. Rocker gear lubrication (engine in stand).

Sect. L6 SUMP—TO REMOVE AND FIT

Outer Sump—To Remove

1. Drain the engine of oil.
2. Uncouple pipe connections from oil filter and fuel filter.
3. Disconnect the filler and oil return pipes from the rear of the sump.
4. Unscrew nuts securing the outer sump to the inner sump and remove outer sump.

Outer Sump—To Fit

Reverse the removal procedure using new joints.

Inner Sump—To Remove

1. Withdraw niphan plug.
2. Remove outer sump, as described previously, but drain off the water in addition to the oil.
3. Remove starter motor (*see Section L62*).
4. Remove fuel pump (*see Section L47*).
5. Remove right-angle fan drive gearbox (*see Section L35*).
6. Remove oil cooler (*see Secion L13*).
7. Remove the fan drive gearbox support bracket.

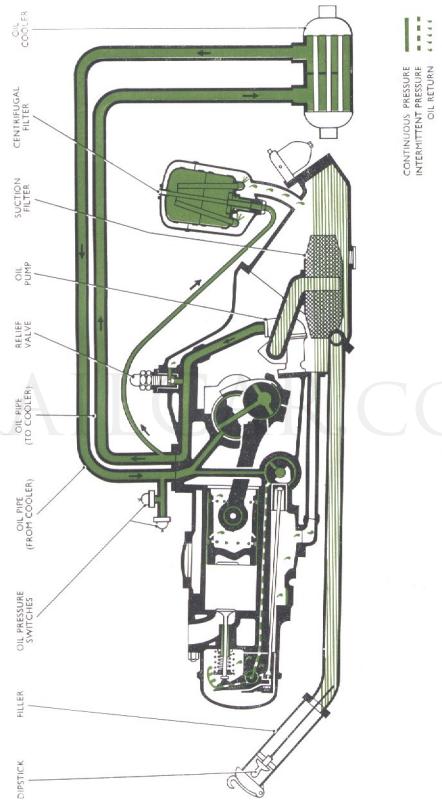


Fig. 10. Engine oil circulation diagram.

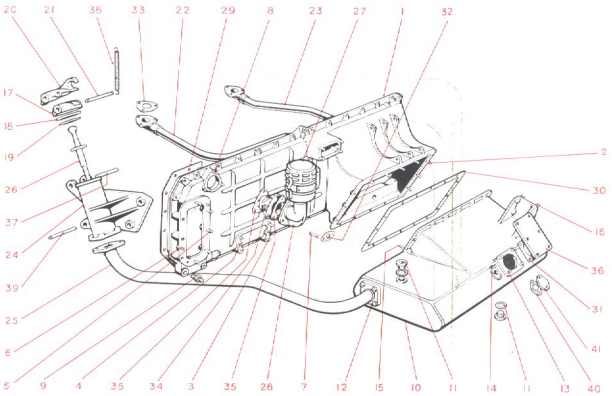


Fig. 11. Exploded view of the engine sump.

1. SUMP, INNER.
2. STUD, NUT, WASHER.
3. STUD, NUT, WASHER.
4. DOWEL.
5. STUD, NUT, WASHER.
6. DOWEL.
7. SETSCREW, WASHER.
8. STUD, NUT, WASHER.
9. UNION, WASHER.
10. SUMP, OUTER.
11. PLUG, WASHER.
12. STUD, NUT, WASHER.
13. STUD, NUT, WASHER.
14. STUD, NUT, WASHER.
15. STUD, NUT, WASHER.
16. STUD, NUT, WASHER.
17. FILLER, CAP.
18. WASHER.
19. RETAINER, WASHER.
20. LIFTING HANDLE.
21. ANCHOR PIN.
22. OIL RETURN PIPE, FRONT.
23. OIL RETURN PIPE, REAR.
24. OIL FILLER.
25. OIL FILLER PIPE.
26. DIPSTICK.
27. BREATHER.
28. BREATHER ELBOW.
29. JOINT.
30. JOINT.
31. JOINT.
32. JOINT.
33. JOINT.
34. AIR AND OIL SEPARATOR.
35. JOINT.
36. FUEL FILTER BRACKET.
37. GROOVED PIN.
38. SPRING, OIL FILLER CAP.
39. ANCHOR PIN.
40. JOINT.
41. COVER.

8. Remove fuel feed pipe, leak-off pipe and air vent pipe from their support bracket.

9. Disconnect the oil filter feed pipe from the oil cooler feed pipe elbow.

10. Disconnect the oil pressure switches oil feed pipe from the oil cooler return pipe elbow.

11. Disconnect the electrical connections to the oil pressure switches and stop solenoid.

12. Remove niphan socket from its support bracket and remove nuts securing the conduit support brackets to the sump.

13. Remove solenoid from its support bracket.

14. Remove combined oil pipe clamp and oil pressure switch bracket.

15. Remove the oil cooler feed and return pipes.

16. Remove crankcase breather.

17. Remove nuts securing the inner sump to the engine block and remove sump.

Inner Sump—To Fit

Reverse the removal procedure using new joints.

Sect. L7 OIL PUMP—DESCRIPTION

The oil pump is housed at the rear end of the engine-block and consists of spur gears, shaft driven from the camshaft by spiral gears. At the outer end of the camshaft driven-gear, a tongue transmits the drive to the pump spindle, on which is pressed a spur gear, the woodruff key being used only to position the oil hole supplying lubrication to the spiral gears and thrust face.

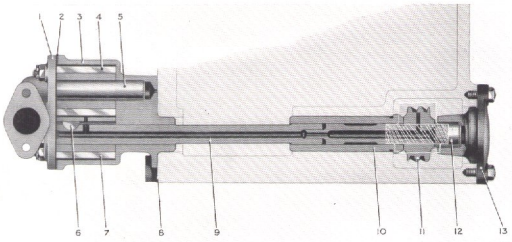


Fig. 12. Plan view of oil pump and drive.

1. END COVER.
2. JOINT.
3. PUMP CASING.
4. IDLER GEAR.
5. IDLER SPINDLE.
6. KEY.
7. PUMP GEAR.
8. JOINT.
9. DRIVING SPINDLE.
10. BUSH.
11. DRIVE GEAR AND SHAFT.
12. THRUST ROLLER.
13. THRUST HOUSING.

Sect. L8 OIL PUMP—TO REMOVE, DISMANTLE, ASSEMBLE AND FIT

To Remove

1. Remove the injection pump (*see Section L47*), compressor (*see Section L67*), and starter motor (*see Section L62*).
2. Remove the outer sump (*see Section L6*), suction filter (*see Section L11*), and inner sump (*see Section L6*). Disconnect the oil feed pipe from the crankcase face.
3. Remove the three nuts securing the pump body to the crankcase and withdraw the oil pump.

To Dismantle

1. Remove the oil pump end cover and withdraw the gear and spindle.

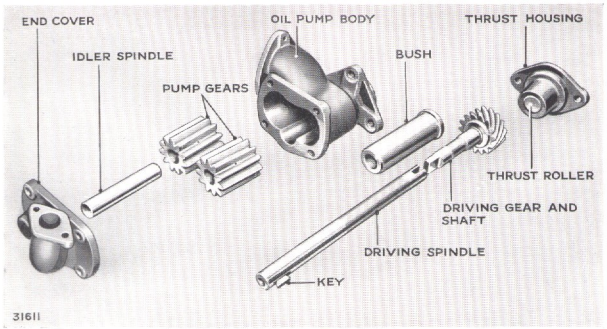


Fig. 13. Oil pump and drive dismantled.

2. All parts should be examined for wear and checked against the limits as laid down in **Section L2.**

3. To inspect the oil pump driving gear. Remove the thrust housing at the rear under side of the engine block and withdraw the gear (Fig. 14). Backlash between the two gears should be .004 in. to .008 in. (.1016 mm. to .2032 mm.).

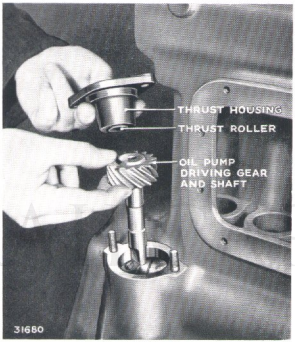


Fig. 14. Fitting oil pump drive gear and thrust housing (engine in stand).

To Assemble and Fit

Reverse the operation for removing and dismantling oil pump. Ensure that an oil-tight joint is made between the pump end cover and casing.

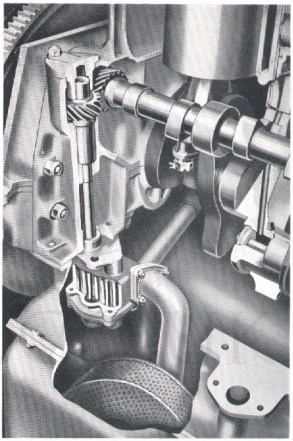


Fig. 15. Oil pump drive from camshaft (engine in stand).

Sect. L9 CENTRIFUGAL OIL FILTER—DESCRIPTION

The centrifugal oil filter, Fig. 17, comprises of an outer bowl, and an inner rotor mounted on a spindle rotating on bearings fitted in the top and bottom of the outer bowl. The filter in position is shown in Fig. 3.

Oil is fed into the filter, Fig. 17, from a tapping on the pressure side of the lubricating system and passes through channels in the outer body to the bottom end of the lower bearing.

The oil is then fed up through the hollow spindle into the rotor bowl, and passes down the two stack pipes which terminate in two tangential nozzles.

The reaction from the jets issuing from the nozzles causes the rotor to rotate at high speed and the dirt in the oil in the rotor is centrifuged out to the periphery where it builds up in the form of a black rubber-like layer with sufficient adhesion to resist being washed off.

Since the jets provide the main oil outlet from the rotor it will be seen that the oil leaving the jets has been subjected to the centrifugal action and therefore been filtered.

The oil issuing from the filter is returned to the sump.

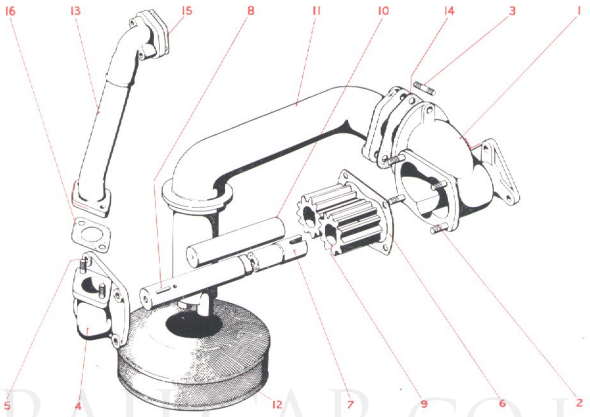


Fig. 16. Exploded view of the oil pump.

1. OIL PUMP BODY.
2. STUD AND NUT.
3. STUD AND NUT.
4. OIL PUMP COVER.
5. STUD AND NUT.
6. JOINT.
7. DRIVING SHAFT.
8. KEY.
9. OIL PUMP GEAR.
10. SPINDLE FOR IDLER GEAR.
11. SUCTION PIPE.
12. SUCTION FILTER.
13. DELIVERY PIPE.
14. JOINT.
15. JOINT.
16. JOINT.

Sect. L10 CENTRIFUGAL OIL FILTER—TO CLEAN

The cleaning period should be fixed as the time taken for a deposit of .75 in. (19.05 mm.) to build up on the rotor wall.

Cleaning the Filter

1. Remove the body cover and gasket by unscrewing the four nuts.
2. Remove the rotor from the bottom bearing.
3. Unscrew the top nut and washer. The rotor may be taken apart. If necessary, a screw-driver may be inserted at the joint.
4. Run a knife round the periphery of the bowl and tip out the compacted sludge. To prevent particles of hard-packed grit dropping into the stand pipes and so choking the nozzles, do not remove the gauzes on the stand pipes until the bowl has been cleaned.
5. Clean the bowl and cap thoroughly.
6. Remove the gauzes and clean with a stiff brush.
7. Clean out stand pipes and nozzles with high pressure air hose if possible.
8. Replace the gauzes.
9. Reassemble the bowl unit, carefully tightening the nut until the cap comes down on the stop.
10. Replace the rotor assembly, taking care not to damage the bearings.
11. Reassemble the body ensuring that the gasket is not damaged.

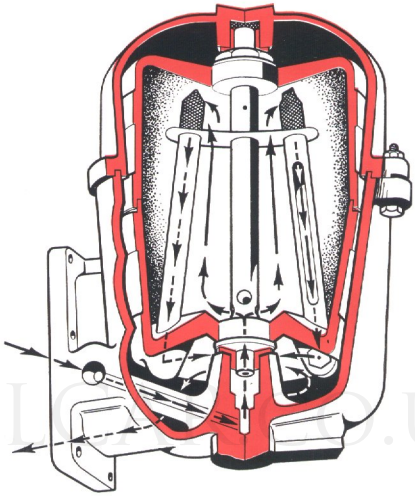


Fig. 17. Section through the centrifugal oil filter.

Sect. L11 SUCTION FILTER—TO REMOVE, CLEAN AND FIT

To Remove

1. Remove the outer sump as described in *Section L6.*
2. Remove the two setscrews securing the basket to the suction pipe.

To Clean

Thoroughly wash the suction filter in paraffin.

To Fit

Reverse the removal procedure.

Sect. L12 OIL COOLER—DESCRIPTION

The oil cooler (Fig. 18) comprises a non-ferrous tube stack housed in a cast-aluminium cylinder. Straight-through hose connections for the cooling water are attached permanently at either end of the tube stack. The oil pipe connections are taken from tapped bosses on the side of the cylinder.

A groove is machined on the outside edge of the tube stack end-plates to take a circular section rubber sealing ring. The tube stack is located in the cylinder by two retaining screws in the cylinder wall.

The cooler should be removed and cleaned at engine sump oil change.

Sect. L13 OIL COOLER—TO REMOVE, DISMANTLE, CLEAN, ASSEMBLE AND FIT

To Remove

1. Drain all water and oil from the engine.
2. Disconnect the oil and water pipe connections.
3. Uncouple the securing strap and remove the cooler.

To Dismantle and Clean

1. Remove the two retaining screws and withdraw the tube stack from the cylinder.
2. Remove the two rubber sealing rings from the tube stack and wash the stacks and rings in paraffin.

On no account use stiff metal brushes or probes to clean the tube stack as the tubes and flow guide plates may be damaged.

To Assemble

1. Ensure that all parts are quite clean and dry. Then lightly smear the sealing rings and the interior of the cylinder with fresh oil.

If the rubber sealing rings are damaged or have hardened, replacements should be fitted.

Fig. 18. Oil cooler showing tube stack.

2. Fit one of the rings into its groove at one end of the tube stack.
3. Insert the other end of the stack into the cylinder and push it right through until it protrudes from the other end of the cylinder. Then fit the second rubber ring at that end.
4. At the same end screw the retaining screw into the cylinder and push back the stack until it stops against the screw. Finally, screw home the other retaining screw.

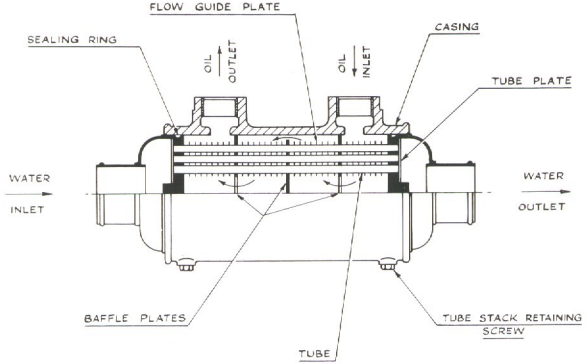


Fig. 19. Sectioned view of oil cooler.

To Fit

1. Fit the cooler to the bracket, place the strap in position and bolt up, ensuring that the two saddle washers are in position.
2. Couple up the water and oil pipe connections and refill the engine with water and oil.

Sect. L14 OIL PRESSURE RELIEF VALVE—TO ADJUST

To adjust the relief valve, remove the cover, slacken the locknut and turn the adjusting screw. Screw **in to increase** and **out to decrease** the pressure. Lock the screw and replace the cover after adjustment.

The valve should be adjusted to give a maximum pressure of 60 p.s.i. (4.2 kg./s. cm.) with a warm engine running at 1,000 r.p.m. or higher speeds.

When setting the oil pressure, an oil-pressure gauge must be included in the oil-circulation circuit; this can be done by removing the oil-pressure switch and inserting an oil-pressure gauge in the adapter.

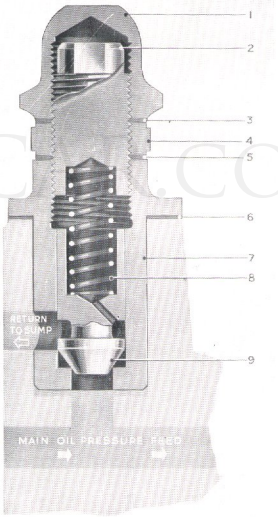


Fig. 20. Oil pressure relief valve.

1. DOMED NUT.
2. ADJUSTING SCREW.
3. COPPER WASHER.
4. LOCKNUT.
5. COPPER WASHER.
6. JOINT.
7. RELIEF VALVE-BODY.
8. SPRING.
9. OIL RELIEF VALVE.

Sect. L15 CRANKCASE BREATHER—TO CLEAN

The cleaning period should be fixed as the time taken for the dirt in the bottom of the bowl to reach a depth of $\frac{1}{4}$ in.

Do not remove breather or breather cap whilst the engine is running.

1. Remove breather from inner sump.
2. Release clips holding the cap down on the bowl.
3. Remove cap. The wire mesh element is attached to the inside of the cap.
4. Empty out used oil and sludge and thoroughly scrape out dirt from bowl.
5. When cleaned, refill the bowl with clean engine oil to oil-level mark.
6. Secure cap and element on bowl and replace breather on engine.

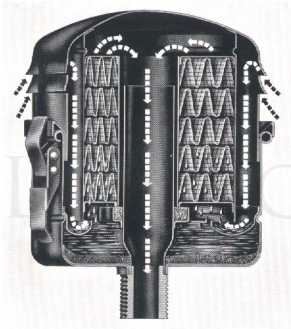


Fig. 21. Engine crankcase breather.

Sect. L16 CYLINDER HEADS AND VALVE GEAR— DESCRIPTION

The two cylinder heads are interchangeable, each head covering three cylinders. Valmet exhaust valve seats are shrunk into the heads.

The rocker levers (Fig. 22) are bushed and carried on hollow shafts. Each shaft is held in position by three support brackets which also carry the decompressor shaft. The number one bracket on each head carries a spring-loaded plunger which comes into contact with a flat, milled on the decompressor shaft, and holds it in the off position.

Lubrication is effected by an intermittent feed from the second and fifth camshaft bearings, via oilways drilled in the engine block and heads, and through the centre rocker-shaft support brackets, thus along the rocker-shafts to the rocker levers, a drilled passage in each rocker carries a supply of oil to the top of rocker lever.

The correct tappet clearance is .020 in. (.508 mm.) (cold) for both inlet and exhaust valves. When checking the clearances make sure the tappets are on the backs of the cams. Turn the engine until the valve is fully open, then turn through one complete revolution to bring the tappet on the back of the cam.

Both valves are stellite-faced and have hard-chrome-plated stems. The valves can be distinguished by the difference in size across their heads (Fig. 28).

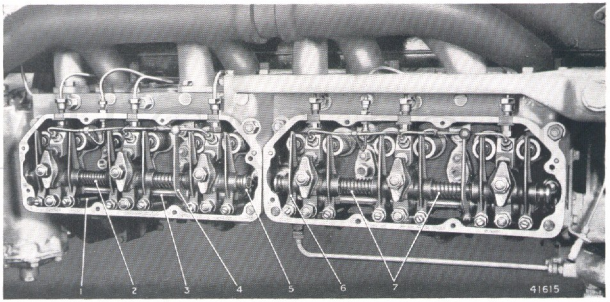


Fig. 22. Cylinder heads in position showing valve gear.

1. PUSH ROD.
2. ROCKER SHAFT.
3. DECOMPRESSOR SHAFT.
4. DECOMPRESSOR LEVER.
5. RETAINER AND CIRCLIP.
6. ROCKER LEVER.
7. ROCKER SHAFT SPRING.

Sect. L17 CYLINDER HEADS AND VALVE GEAR— TO REMOVE AND FIT

To Remove

1. Disconnect the inlet, exhaust and water manifolds and remove them from the heads.

2. Remove oil filler.

3. Remove valve covers and uncouple and remove the fuel pipes between the support bracket and the injectors.

4. Take off the nuts securing the rocker shaft brackets. Lift off the rocker assembly and withdraw the push-rods.

5. Remove all cylinder head nuts and raise the heads by unscrewing the special lifting nuts (*see Fig.* 27). Two lifting nuts are provided for each of the heads, to prevent damage to the gaskets when lifting. Both nuts should be screwed evenly as far as they will go, then lift the

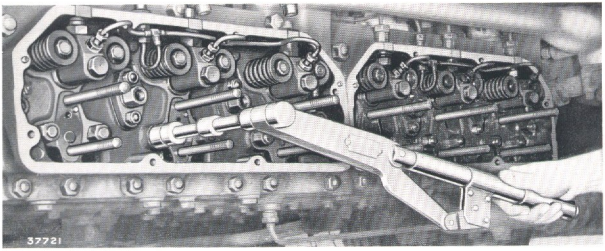


Fig. 23. Tightening head nuts with torison spanner.

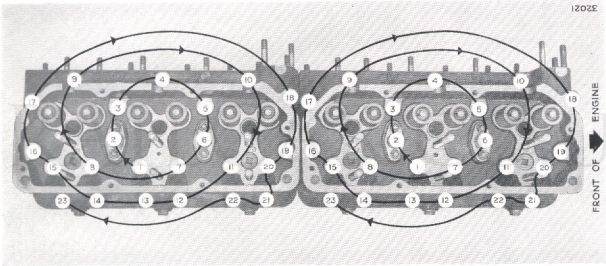


Fig. 24. Correct sequence of tightening head nuts.

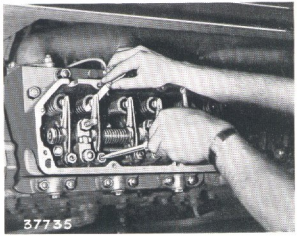


Fig. 25. Adjusting the tappets.

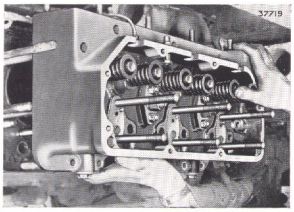


Fig. 26. Removing the cylinder heads.

heads off the studs. If the heads are tight on the studs, a further lift can be obtained by screwing long $\frac{1}{2}$ in. B.S.F. bolts into the lifting nuts.

To Fit

Fitting the cylinder heads and valve gear is the reverse of the removal procedure, but the following points should be noted:

1. Before replacing the cylinder heads, wash out all water spaces. Clean all rust and carbon from the studs and engine block face. If this left on, the heads may scrape some down and prevent a good bed being obtained when the nuts are tightened.

2. New gaskets should be fitted if the old ones are not in good condition. Gaskets must always be fitted so that the turnover reinforcement surrounding the cylinder bores is facing outwards. **Do not use jointing compound on the gaskets.**

3. Place each head on to the lifting-nut studs and screw down the nuts evenly a little at a time, keeping the heads parallel with the engine block.

4. To ensure freedom from distortion and gasket leaks, the cylinder head nuts must be tightened down evenly in a definite order, starting at the centre and working outwards, as shown in Fig. 24. First tighten down with a short spanner, then with a torsion spanner set at 150 to 160 lb./ft. (20.5 kg./m. to 22 kg./m.) (*see Fig. 23*). A torsion spanner set at 80 to 85 lb./ft. (11 to 11.7 kg./m.) should also be used for the $\frac{7}{8}$ in. dia. B.S.F. nuts along the right-hand of the cylinder heads.

5. Replace push-rods and fit rocker gear. Set inlet and exhaust valve clearances to .020 in. (.508 mm.) cold. Replace fuel pipes and manifolds. Ensure that the inlet manifold gaskets are fitted with the metal face next to the cylinder head.

6. Do not **over-tighten** the exhaust manifold nuts or the flanges may be fractured.

7. Check tappet clearances after the engine has had a short run.

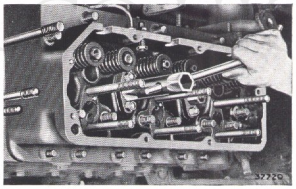


Fig. 27. Tightening lifting nuts.

Sect. L18 VALVES—TO REMOVE AND FIT

When removing the valves and springs for inspection and refacing, it is important that subsequently they are replaced in their original position. The valves and cylinder heads are numbered as shown in Fig. 31 to facilitate reassembly.

To Remove

1. Remove the cylinder head (*see Section L17*) and place it face downwards on the bench.

2. Extract the split cone (Fig. 32) and remove the valve collar together with the rubber sealing ring and valve springs (Fig. 29).

3. The rubber sealing rings should be inspected and renewed if perished.

4. Check valve springs for length (*see* **Data**).

To Fit

Fitting of the valves and springs is the reversal of the removal procedure.

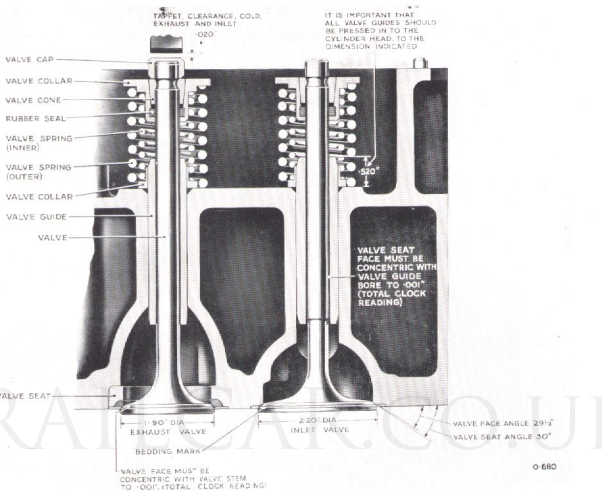


Fig. 28. Valves and springs in position.

Sect. L19 CYLINDER HEADS AND PISTONS—DECARBONISING

Remove the heads and valves as previously described. Carefully scrape off the carbon deposit on the heads and pistons, but on no account must any form of abrasive be used. Do not disturb the ring of carbon at the top of the bore, as it will help to restrict the passage of oil into the combustion chamber if the bores are worn.

Sect. L20 VALVE GUIDES—TO RENEW

1. Check the valve guides for stem clearances. If this is excessive, .010 in. (.254 mm.) or over, renew the guide. If the stem is worn, renew the valve. Always check the fit of a valve in the new guides. They must have .0025 in. to .00375 in. (.06350 mm. to .09525 mm.) clearance for the inlet valves and .004 in. to .00525 in. (.1016 mm. to .13335 mm.) clearance for the exhaust.
2. The valve guides are an interference-fit in the heads and must be pressed in and out when replacements are necessary. See Fig. 28 for position of valve guide in head.
3. After fitting a new valve guide, always regrind the valve seat so that it is concentric with the guide.

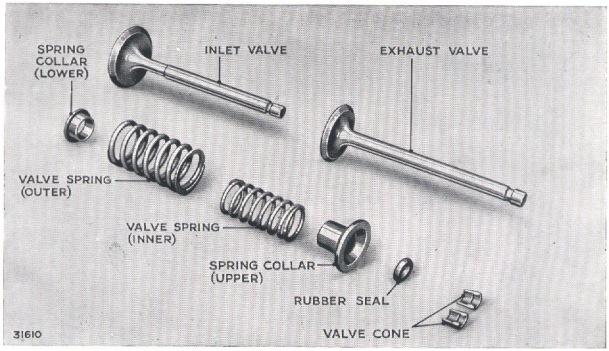


Fig. 29. Valves and springs.

Sect. L21 VALVES—TO REGRIND AND LAP IN

1. Examine the valve facings and seats. If the valve seats are at all pitted and require grinding, a special carborundum tool must be used. This must have a working face of 30° (the accuracy of this angle is important), and must be accurately positioned by a spindle located in the valve guide. The stone must be rotated at high speed. **The face of the seat should be concentric with the valve guide bore to within .001 in. (.0254 mm.) (total clock reading).**

2. If the valves require refacing, this should be done in a valve-facing machine with the stone set at an angle of 29½°. **The valve facing must be concentric with the valve stem to within .001 in. (.0245 mm.) (total clock reading).**

3. On no account must badly pitted valves and seats be lapped together, as this will cause excessively wide seats.

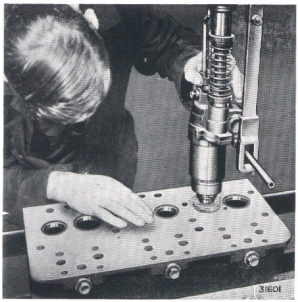


Fig. 30. Grinding valve seats.

Fig. 31. Test gas-tightness of valve on its seat.

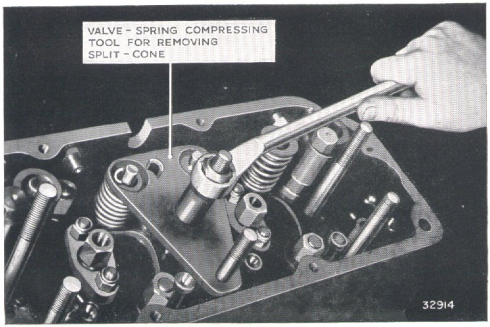


Fig. 32. Valve spring compressing tool.

Key to Fig. 33 on opposite page.

1. CYLINDER HEAD.
2. PLUG, WASHER.
3. VALVE GUIDE.
4. VALVE SEAT, EXHAUST.
5. SLEEVE, NOZZLE HOLDER.
6. STUD.
7. STUD.
8. STUD.
9. STUD.
10. SIMMONDS NUT.
11. STUD.
12. DOWEL.
13. DOWEL.
14. LINER, OIL AND STUD HOLES.
15. LIFTING NUT.
16. LIFTING PLATE.
17. VALVE INLET.
18. VALVE EXHAUST.
19. VALVE SPRING, INNER.
20. VALVE SPRING, OUTER.
21. VALVE SPRING COLLAR.
22. VALVE CONE, 2 HALVES.
23. VALVE SEAL.
24. VALVE SPRING COLLAR.
25. ROCKER LEVER.
26. BUSH.
27. BALL END.
28. PLUNGER, DECOMPRESSOR SHAFT.
29. SPRING, PLUNGER.
30. ROCKER SHAFT.
31. ROCKER BRACKET.
32. SPRING, LONG.
33. SPRING, SHORT.
34. WASHER, SPRING.
35. CIRCLIP, SHAFT.
36. WASHER, CIRCLIP.
37. WELCH WASHER.
38. DECOMPRESSOR SHAFT.
39. DECOMPRESSOR LEVER.
40. WATER OUTLET PIPE.
41. STUD.
42. STUD.
43. THERMOSTAT.
44. SETSCREW.
45. WATER OUTLET ELBOW.
46. JOINT.
47. CYLINDER HEAD COVER.
48. MONOGRAM PLATE.
49. INLET MANIFOLD.
50. JOINT, CYLINDER HEAD COVER.
51. GASKET, CYLINDER HEAD.
52. ADAPTOR.
53. VALVE CAP.
54. JOINT, ROCKER BRACKET.
55. JOINT, INLET MANIFOLD, 1-2-4-5 CYLINDERS.
56. JOINT, INLET MANIFOLD, 3-6 CYLINDERS.
57. CLAMP, NOZZLES.
58. EXHAUST MANIFOLD, FRONT.
59. EXHAUST MANIFOLD, REAR.
60. GASKET, EXHAUST MANIFOLD.
61. SETSCREW, CYLINDER HEAD COVER.
62. JOINT, WATER OUTLET PIPE.
63. CONNECTING TUBE.
64. SEALING RING.

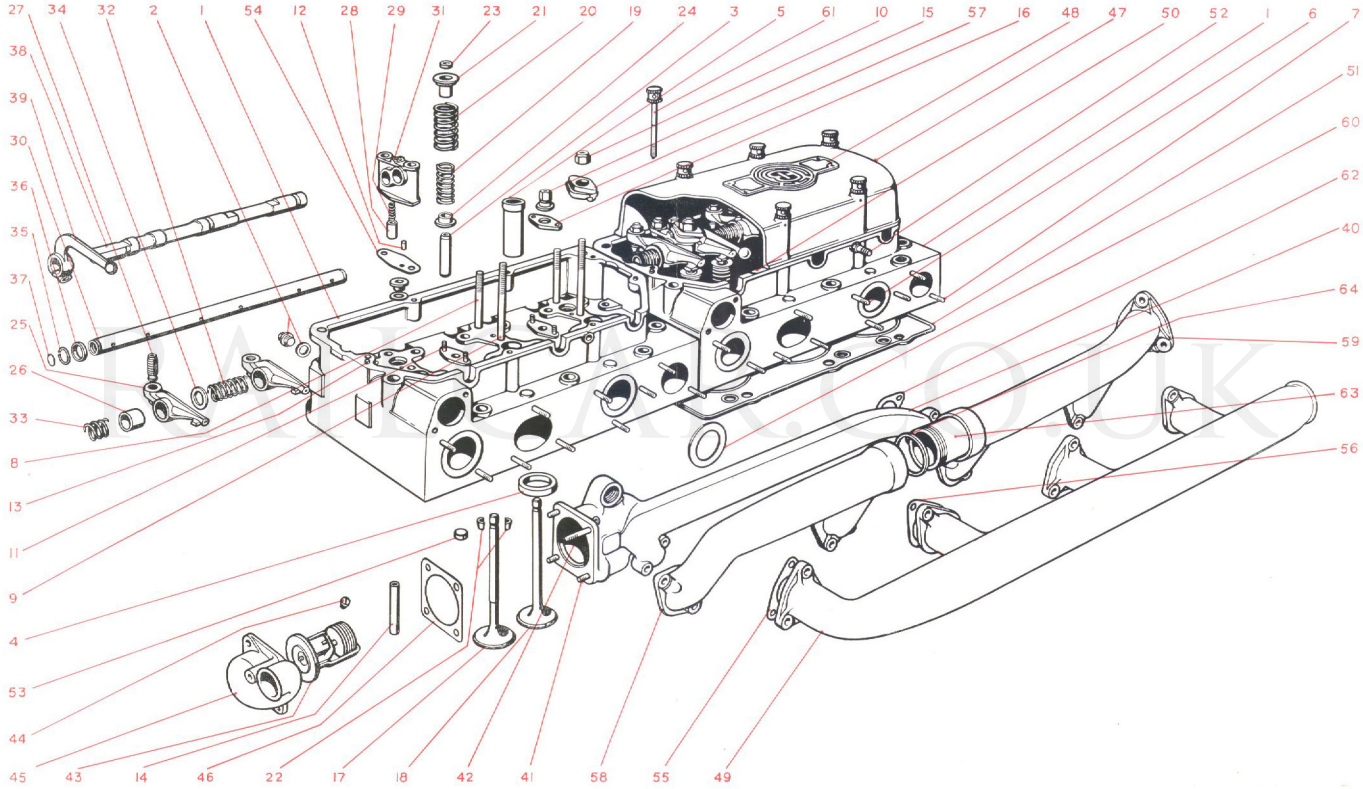


Fig. 33. Exploded view of cylinder head.

4. When the valves and seats have been re-cut, or when the valves and seats are in good condition, they should be lightly lapped together to give a perfect seating. The seating mark should be a thin line towards the top of the seat (Fig. 28).

5. To lap in the valves, smear a thin layer of fine grade carborundum paste on the valve seat and rotate the valve to and fro on the seat, occasionally lifting the valve off the seat. Do not rotate the valve through a complete revolution before lifting as this will groove the seat. All traces of grinding compound must be removed before assembly.

Sect. L22 VALVES—TO CHECK TIMING

The valve timing is shown in Fig. 34 and also in Fig. 6, under **Section L2.**

1. To check the valve timing, set the tappet clearances of all cylinders to .020 in. (.508 mm.) (cold).

2. Turn the engine until No. 1 piston is on T.D.C. of the firing stroke, i.e., the fuel pump has just delivered. At this point the inlet and exhaust valves are closed.

3. Now turn the engine until the inlet valve of No. 6 cylinder just opens. To check when the inlet valve is just opening, hold the valve collar between thumb and forefinger and attempt to turn. When the valve lifts off its seat, the collar will turn. If the timing is correct, the valve should open 1.76 in. (44.704 mm.) before T.D.C. measured on the flywheel rim.

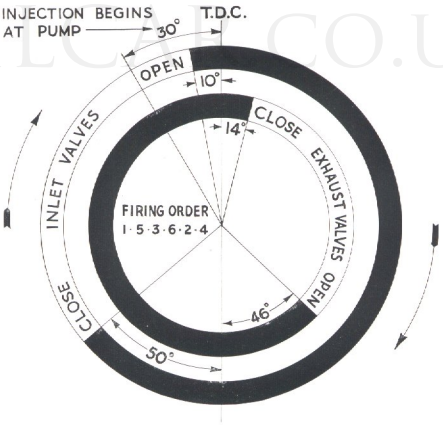


Fig. 34. Valve timing diagram.

Sect. L23 ENGINE BLOCK AND CAMSHAFT—DESCRIPTION

The engine block is a one-piece casting; the cylinders being fitted with dry cast-iron liners, shoulder located.

The camshaft is carried in seven pressure lubricated bearings which are setscrew located on the underside of the engine block, the thrust being taken on the front bearing only. The drive is transmitted from the front of the crankshaft through helical gearing.

Sect. L24 CAMSHAFT—TO REMOVE AND FIT

To Remove

1. Drain off all water and oil from the engine.
2. Remove engine from the car.
3. Remove cylinder heads and rocker gear (*see Section L17*) and remove the push-rods.
4. Remove oil return pipes from the tappet gallery bottom covers and remove covers. Extract the tappets.
5. Remove driving belts from crankshaft pulley.
6. Unscrew Allen screws securing pulley and damper to the driving flange and remove.
7. Remove 1 in. UNF bolt and withdraw driving flange from crankshaft complete with oil flinger.
8. Remove water pump (*see Section L40*).
9. Remove engine mounting bracket.

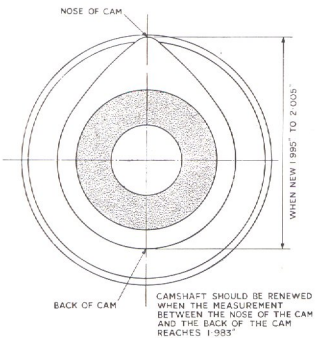


Fig. 35. Cam wear diagram.

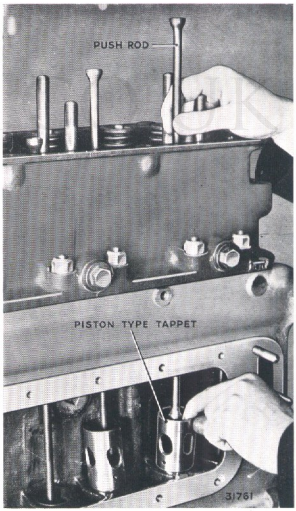


Fig. 36. Removing push rod and tappet (engine in stand).

10. Remove compressor (*see Section L37*).

11. Disconnect electrical connections from the generator mounted on the timing case.

12. Now remove the timing case, taking care not to damage the oil seal housed in the bore surrounding the crankshaft end.

13. Remove the four setscrews and locking plates securing the driving gear to the camshaft and withdraw the gear, taking care to note the position of the timing mark on the gear in relation to the mark on the timing backplate when No. 1 piston is on T.D.C. of firing stroke.

14. Remove the four setscrews securing the camshaft thrust washer and withdraw the camshaft.

15. Withdraw the front camshaft bearing, retaining the locating dowel.

16. To remove the intermediate bearings it is necessary to remove the sump and the bearing retaining screws. They can then be driven out of their housings. The intermediate bearings are interchangeable.

17. To remove the rear bearing, remove the fluid flywheel and drive out the bearing.

18. Check all bearings for wear and renew when diametral clearance exceeds .010 in. Normal end play of the camshaft with the retaining plate tight up and adjusting shim in position is .004 in. If the end-play is .008 in. to .010 in., the shim should be removed.

To Fit

Refitting the camshaft is the reversal of the removal procedure.

Take care that the bearings are not burred when replacing them.

Key to Fig. 37 on opposite page.

1. CRANKCASE.
2. BEARING CAP, FRONT.
3. BEARING CAP, INTERMEDIATE.
4. BEARING CAP, CENTRE.
5. BEARING CAP, REAR.
6. DOWEL.
7. STUD.
8. STUD.
9. CAMSHAFT BEARING, FRONT.
10. CAMSHAFT BEARING, REAR.
11. CAMSHAFT BEARING, INTERMEDIATE.
12. DOWEL.
13. BUSH.
14. STUD.
15. STUD.
16. STUD.
17. STUD.
18. STUD.
19. STUD.
20. STUD.
21. STUD.
22. UNION.
23. GEAR CARRIER.
24. CYLINDER LINER.
25. COVER.
26. RETAINER BAR.
27. STUD.
28. FERRULE.
29. COVER.
30. JOINT.
31. COVER.
32. JOINT.
33. JOINT.
34. TOP COVER.
35. REAR COVER.
36. JOINT.
37. CAMSHAFT.
38. PLUG.
39. BODY, OIL RELIEF VALVE.
40. OIL RELIEF VALVE.
41. SPRING.
42. ADJUSTING SCREW.
43. DOMED NUT.
44. LOCKNUT.
45. THRUST HOUSING.
46. THRUST BUTTON.
47. DRAIN PIPE.
48. CRANKSHAFT SEAL HOUSING, R.H.
49. CRANKSHAFT SEAL HOUSL.H.
49A. SEALING RING.
50. SUPPORT HOUSING.
51. BUSH.
52. REAR MOUNTING PLATE.
53. EYE BOLT.
54. MAIN BEARING, FRONT.
55. MAIN BEARING, INTERMEDIATE.
56. MAIN BEARING, CENTRE AND REAR.
57. THRUST WASHER.
58. DRIVING GEAR, CAMSHAFT.
59. TAB WASHER.
60. THRUST WASHER.
61. SHIM.
62. PUSH ROD.
63. TAPPET.
64. INTERMEDIATE GEAR.
65. BUSH.
66. SPINDLE.
67. BOLT.
68. NUT.
69. WASHER.
70. THRUST WASHER.
71. TIMING BACKPLATE.
72. JOINT, TIMING BACKPLATE.
73. DRIVING SHAFT, OIL PUMP.
74. JOINT.
75. JOINT.
76. JOINT.
77. TIMING POINTER.
79. JOINT.
80. JOINT.
81. LIFTING HANDLE.
82. WATER JACKET INLET PIPE.
83. WATER JACKET OUTLET PIPE.

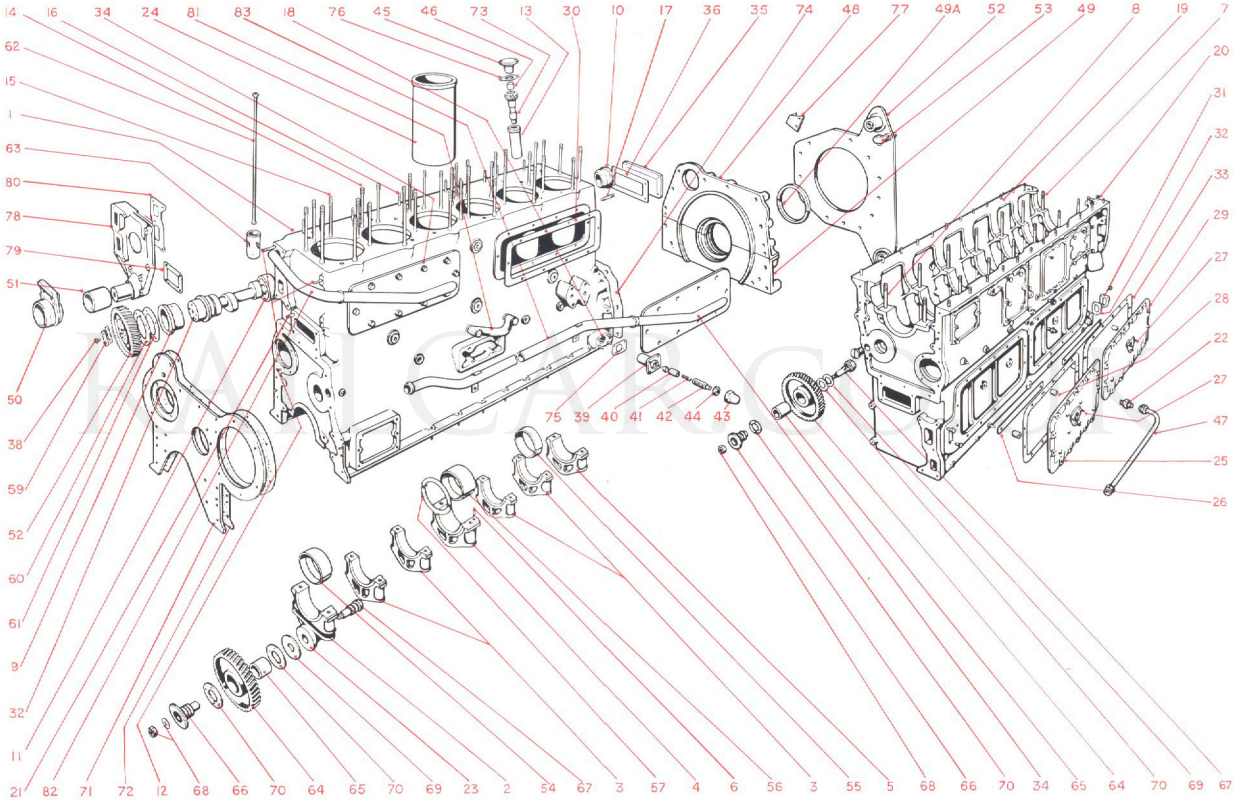


Fig. 37. Exploded view of the engine block.

Sect. L25 CAMSHAFT—TO TIME

1. Turn the engine until No. 1 piston is on T.D.C. of the firing stroke.

2. Fit the camshaft gear so that when the dowel hole in the gear locates on the dowel in the camshaft end, the arrows on the gear face and timing back plate are in line (Fig. 38), that is, 90° to the outer face of the engine block.

3. Refit the locking plates and tighten the setscrews securely. Make sure that the locking plate tabs are turned over after the setscrews have been tightened.

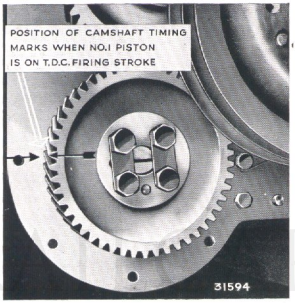


Fig. 38. Camshaft timing marks.

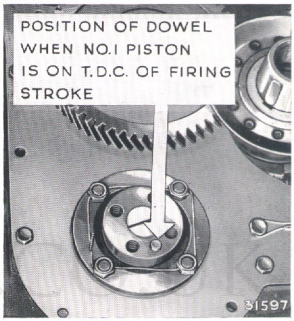


Fig. 39. Gear location in camshaft end.

Sect. L26 CYLINDER LINERS—TO REMOVE AND FIT

At overhaul the liner bores should be measured and if the maximum diameter exceeds 5.00 in. + .020 in. (127 mm. + 508 mm.) at the top, new liners must be fitted.

To Remove and Fit

1. The cylinder liners are pre-finished ready for inserting in the engine block. A special tool has been designed both to extract the old liner and to insert the new one in the block.

2. The projection of cylinder liners above the top face of the engine block must be within the limits of .000 in. to .002 in.

3. Before fitting new liners thoroughly clean out the cylinder bores and invert the liners placing the liner flange in the recess of the cylinder, and using a straight-edge and feelers check that the projection figures are within the limits stated.

   If necessary, shims are available to ensure that the liners are correctly positioned within these limits.

4. When installing the liners lightly smear the bores of the block with thin oil. This will facilitate subsequent removal.

Sect. L27 CONNECTING RODS AND PISTONS—DESCRIPTION

The connecting rods are alloy steel stampings of exceptionally rigid design, drilled to provide intermittent oil spray for cylinder wall lubrication. The big ends have steel-shell type, lead-bronze bearings with the bearing surface indium-coated. The small ends are bushed.

The pistons are of special aluminium alloy, fitted with three compression and two scraper rings, the top compression rings are chromium plated. A toroidal cavity in the piston crown forms the combustion chamber. The hollow gudgeon pins are located in the pistons by circlips.

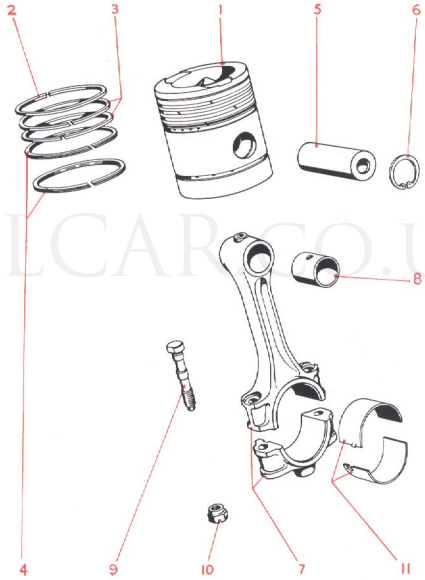


Fig. 40. Exploded view of the connecting rod and piston.

1. PISTON.
2. PISTON RING, TAPER, TOP.
3. PISTON RING, TAPER, SECOND AND THIRD.
4. PISTON RING, SCRAPER.
5. GUDGEON PIN.
6. CIRCLIP.
7. CONNECTING ROD AND CAP.
8. SMALL END BUSH.
9. BOLT.
10. NUT AND SPLIT PIN.
11. BIG-END BEARING (HALF-BEARING).

Sect. L28 CONNECTING RODS AND PISTONS—TO REMOVE, DISMANTLE, ASSEMBLE AND FIT

To Remove

The dimensions of the crankshaft are such that the pistons cannot be withdrawn through the crankcase; they can, however, be withdrawn through the cylinder bores. This, of course, necessitates the removal of the cylinder heads and sump, after which the connecting rod and caps should be removed.

Care should be taken not to scratch the bores when removing or replacing the connecting rod assemblies.

To Dismantle

1. Remove the gudgeon pin circlips.

2. Heat the pistons in boiling water and tap or push the pin out while the piston is hot.

Note.—The gudgeon pins must not be forced in or out of the pistons when cold. The pins are an interference-fit in the piston bosses when cold and an easy push-fit in the small-end bushes.

To Assemble

1. Heat the pistons in boiling water or in an oven before the gudgeon pins are inserted. The oven temperature must not exceed 150° C. (302° F.).

2. Fit pistons to connecting rods with the offset combustion chamber in the piston heads on the same side as the oil spray hole in the connecting rod big-end (Fig. 43).

1st, 2nd, 3rd grooves — Fit compression rings; these are plain, tapered rings, with a gap cut at 90°. The top compression ring is chromium plated.

4th and 5th grooves — Scraper rings, slotted, ring gap cut at 90°.

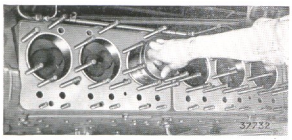


Fig. 41. Fitting the piston.

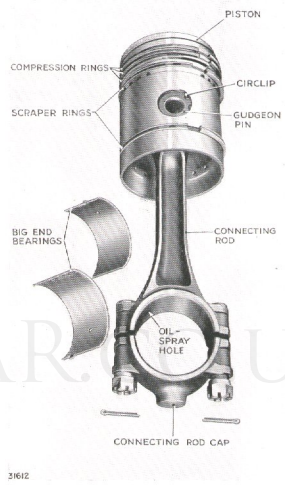


Fig. 42. Piston and connecting rod assembly.

The initial piston ring gap is .020 in. to .024 in. (.508 mm. to .6096 mm.). Renew rings when gap exceeds .100 in. (2.540 mm.).

To Fit

1. Wipe the crankpin and bearing surfaces with a clean rag and lightly smear with clean engine oil both crankpin and lead-bronze surface of bearing shells.

2. Fit the connecting rod assemblies with the offset combustion chamber in the piston heads and the oil spray hole in the big ends on the same side as the camshaft.

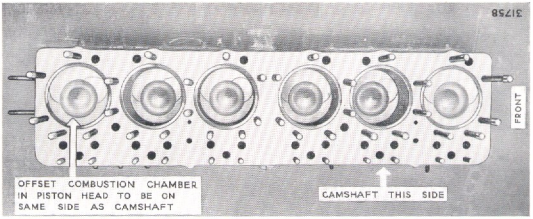


Fig. 43. Position of offset combustion chambers in piston heads in relation to the camshaft.

3. Fit connecting rod caps and ensure that the number stamped on the connecting rod big end corresponds with the number stamped on the cap (*see Fig. 44*).
4. The connecting rod bolts must be tightened to a total elongation of .006/.008 in. (.1524 mm. to .2032 mm.). This dimension should be measured by micrometer.
5. On no account must the nuts be slacked off to bring the pin holes into line. If the pin holes will not line up with the correct bolt elongation, the nut must be filed to bring the pin holes into line, care being taken to keep the faces true. Fit the split-pins and slack off nuts just sufficiently to "nip" the split-pins.

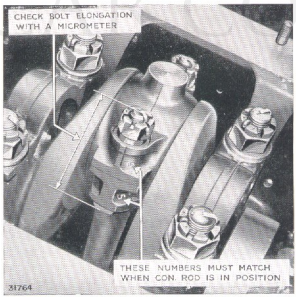


Fig. 44. Connecting rod in position.

Sect. L29 CRANKSHAFT AND MAIN BEARINGS—DESCRIPTION

The crankshaft is supported in seven lead-bronze, steel-shell, indium-coated, main bearings. The oil holes in the crankpins are drilled eccentrically to reduce centrifugal loading and also to act as sludge traps to protect the big-end bearings.

A labyrinth oil seal at the rear end of the crankshaft prevents loss of oil from the lower half of the engine-block and a felt sealing ring fitted in the upper and lower halves of the crankshaft seal housing prevents engine breathing. A large diameter flywheel is bolted to the crankshaft rear end flange. The bolt holes in the flange and flywheel are drilled out of pitch, so that the flywheel can only be mounted in correct relation to the throws of the crankshaft, for timing purposes.

A rubber-bonded vibration damper is bolted to the pulley at the front end of the crankshaft.

The starter gear ring is spigoted and bolted to the flywheel so that its position can be changed as local wear takes place. It is reversible and can be turned completely over to obtain further service.

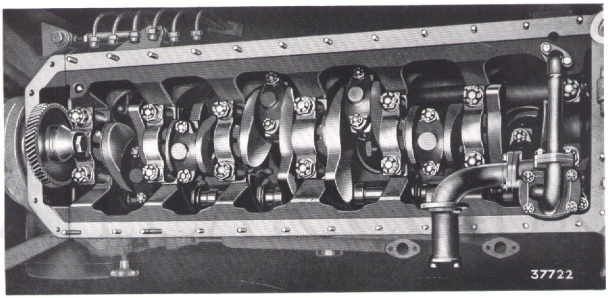


Fig. 45. Crankshaft in position.

Sect. L30 CRANKSHAFT AND MAIN BEARINGS—TO FIT NEW BEARINGS AND THRUST WASHERS

Normally by the time the main bearings require replacing, the crankshaft will need to be removed for regrinding, the instructions for these two latter operations being detailed in the sections headed **Crankshaft—To Regrind.**

However, if at any time one or more bearings should have to be renewed or removed for inspection, this can be done satisfactorily as follows:

1. Drain off all water and oil from the engine.

2. Remove sump (*see Section L6*), suction oil filter (*see Section L11*), and oil pump (*see Section L8*).

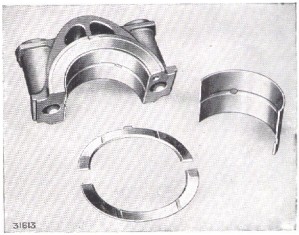


Fig. 46. Centre main bearing and thrust washers.

3. To renew or inspect an individual bearing only, take off the cap of the bearing in question.

4. Slacken all the remaining bearing cap nuts one or two turns to facilitate removal of the top halves of the bearings.

5. Remove the lower half of the bearing from the cap, push out the top half of the bearing by rotating it on the crankshaft, using L-type tool No. 245872, which should be placed in the oil hole in the journal, for the centre main bearing use L-type tool No. 245869, this is placed on the bearing cap stud.

6. Inspect the old bearing shells and if they require renewing insert a new half-bearing in the top and also fit a new half-bearing in the cap. If the old bearings are under size, replace by a new bearing of the same size.

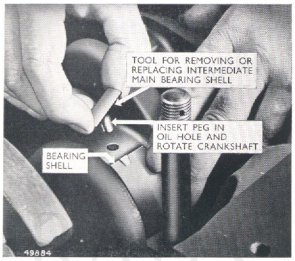


Fig. 47. Removal of intermediate bearing shell.

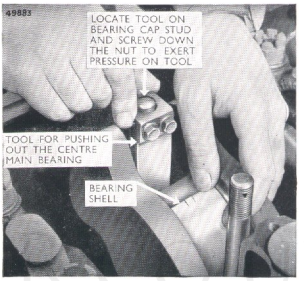


Fig. 48. Removal of main bearing shell.

Sect. L31 CRANKSHAFT—TO REMOVE AND FIT

To Remove

1. Drain off all water and oil from the engine.

2. Remove engine from car and place on a suitable stand.

3. Remove sump (*see Section L6*).

4. Remove suction oil filter (*see Section L11*), oil pump (*see Section L8*) and fluid flywheel as described in Chapter M.

5. Remove rear support plate and sump half of crankshaft seal housing.

6. From front end of crankshaft remove pulley and damper, 1 in. UNF bolt and withdraw driving flange complete with oil flinger.

7. Remove water pump (*see Section L40*) and engine support bracket.

8. Remove compressor and disconnect electrical connections to the generator and remove, then remove timing case taking care not to damage the oil seal housed in the bore surrounding the crankshaft.

9. Remove connecting rod caps and push the rods clear of the crankshaft.

10. Remove main bearing caps, taking out front main bearing cap and idler gear as a complete unit.

11. Lift out the crankshaft.

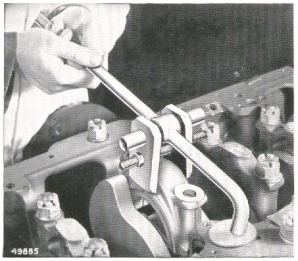


Fig. 49. Removal of bearing caps.

To Fit

Main bearing caps, bearings and nuts must be refitted in their original positions and, for this purpose, the caps and engine-block nuts are stamped with index marks A, B, C, etc., starting from the front of the engine. When correctly assembled all marks must correspond.

1. Fit the top halves of the main bearings in their correct seatings; check that the shells bed down correctly.

2. Remove the oil seal plugs (Fig. 50) and flush out the oil passages and oil holes. Replace the seal plugs and bolts. **Do not** use sealing compound on these plugs. Ensure that the nuts are split-pinned and smear the main bearing journals with clean engine oil.

3. Lower the crankshaft carefully into position, replace the main bearing caps in their correct positions, and tighten down, fitting the nuts to their original studs when possible. A torsion spanner set at 215 to 228 lb./ft. (35.9 to 37.3 kg./m.) should be used to tighten the bearing cap nuts.

4. Ensure that the timing gear mounted at the front main bearing is correctly meshed with the gear on the crankshaft.

5. Check the crankshaft end-play. This should not exceed .014 in. (.3556 mm.) (Fig. 52).

6. Fill the crankshaft oilways with clean engine oil.

7. Refit the connecting rods. The initial big-end clearance should be .0018 in. to .0037 in. (.0457 mm. to .0939 mm.) and should be renewed if it exceeds .008 in. (.2032 mm.).

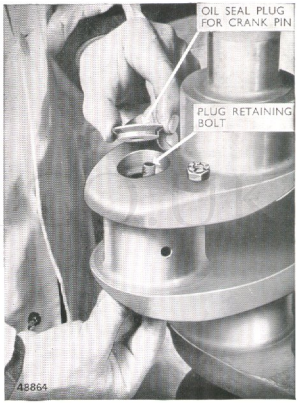


Fig. 50. Removal of oil seal plug.

Sect. L32 CRANKSHAFT—TO REGRIND

When regrinding journals and crankpins, the end faces must not be ground. If the location faces of the centre bearing have been damaged, the width should be increased to 2.710 in. to 2.712 in. (68.834 mm. to 68.885 mm.), otherwise the dimensions should remain at 2.700 in. to 2.702 in. (68.580 mm. to 68.631 mm.).

After grinding, support the crankshaft at the front and rear journals. Check the relative eccentricity of the centre main journal; this must not exceed .003 in. (.0762 mm.) in radius—total run-out of .006 in. (.1524 mm.). The permissible error between one bearing and its neighbour must not exceed .003 in. (.0762 mm.) (total clock reading).

It is not permissible to straighten a crankshaft in a press.

The crankshaft should be re-nitrided at the second and fourth regrinds.

Fig. 51. Sections of journal-to-web fillets.

Important

It cannot be emphasised too strongly that, in cases where the operator regrinds a crankshaft without re-nitriding, extreme care should be taken to ensure that an excessive amount of case is not removed from the fillets by using a grinding wheel having a corner radius considerably less than the designed radius between the journal and web of the crank (Fig. 51.)

A grinding wheel having a radius of 0.15 in. to 0.17 in. (3.810 mm. to 4.318 mm.) should be used.

If the operator has any doubt on this point, crankshafts should be re-nitrided after regrinding irrespective of the amount of case which has been removed from the pin or journal diameter.

Check the main bearing diametral clearance. This should be within the limits .0020 in. to .0042 in. (.0508 mm. to .1067 mm.) when new bearing shells are fitted. Bearings should be renewed when diametral clearance exceeds .009 in. (.2286 mm.).

When refitting the flywheel to the crankshaft, check that the flywheel runs true with the crankshaft to within .004 in. (.1016 mm.) as shown in Fig. 53.

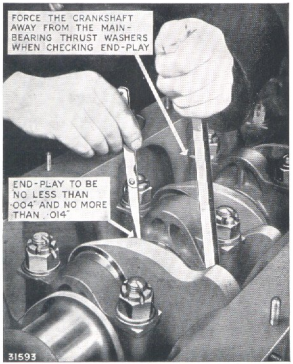


Fig. 52. Checking crankshaft end-play.

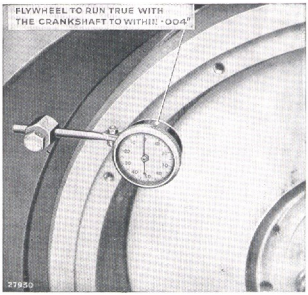


Fig. 53. Checking flywheel for running true.

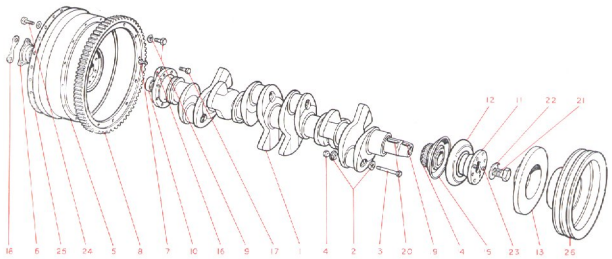


Fig. 54. Exploded view of crankshaft.

1. CRANKSHAFT.
2. PLUG.
3. BOLT.
4. NUT.
5. FLYWHEEL CASING.
6. SPIGOT BEARING HOUSING.
7. SETSCREW.
8. STARTER RING.
9. BOLT, LOCKING PLATE.
10. ROLLER BEARING.
11. DRIVING FLANGE.
12. FLINGER.
13. DAMPER.
14. TIMING GEAR.
15. OIL THROWER.
16. JOINT.
17. BOLT.
18. LOCKING PLATE.
19. KEY.
20. KEY.
21. BOLT.
22. LOCKING WASHER.
23. DOWEL.
24. BOLT.
25. JOINT.
26. PULLEY.

Sect. L33 TIMING GEARS—DESCRIPTION

The hardened and ground timing gears have single-helical teeth. The drive to the camshaft, compressor and tachometer generator on one side of the crankshaft and to the injection-pump on the other, is distributed through two identical idler gears, the one for the camshaft, compressor and tachometer generator being mounted on the engine-block, and that for the injection-pump on a lug cast on the front main bearing cap. Each idler gear is carried on a spindle and bolt, and runs on a floating bush, thrust being taken by two special washers.

The idler gear, mounted on the engine-block, drives the camshaft, compressor and tachometer generator gear direct.

The injection-pump drive gear is driven from the idler gear mounted on the front main bearing cap.

This gear is carried in ball and roller bearings, mounted in a housing and bolted in the injection-pump drive gear casing, and the drive to the injection-pump is transmitted by a short shaft formed with the gear. The shaft runs through an oil seal fitted in the rear of the gear casing and is connected to the injection-pump by a flexible coupling.

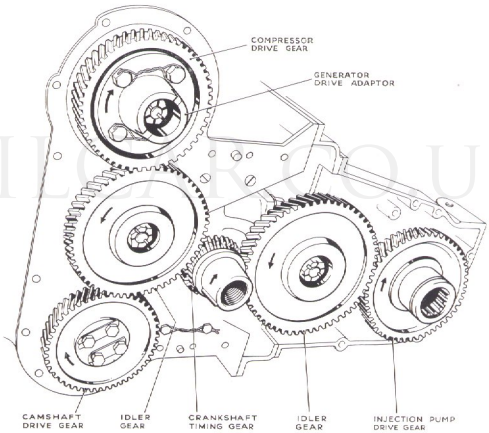


Fig. 55. The timing gears.

Sect. L34 RIGHT-ANGLE FAN DRIVE—DESCRIPTION

The right-angle fan drive gearbox (Fig. 56) is mounted at the front L.H. side of the engine. It consists of a cast-iron casing in which two shafts are housed, set at right angles to each other, and mounted on ball and roller bearings. Within the casing, a bevel gear is keyed to the end of each shaft.

A pulley having two 'V' grooves is secured to the input shaft and a coupling flange is secured to the outer end of the output shaft.

The drive is taken from the crankshaft pulley and is transmitted to the fan via the bevel gears and a short propeller shaft which is bolted to the coupling flange.

A wire-mesh-element type breather is fitted in the top of the casing and a combined oil filler and level plug is incorporated in the side cover, whilst a drain plug is provided in the bottom of the casing.

Slots in the support bracket platform enable the tension of the driving belts to be adjusted by sliding the unit along the bracket.

Lubrication of the bearings is effected by splash from the bevel gears, leakage of lubricant being prevented by oil seals.

Sect. L35 RIGHT-ANGLE FAN DRIVE—TO REMOVE AND FIT

To Remove

1. Uncouple the fan propeller shaft.
2. Remove the four nuts securing the unit to the bracket.
3. Remove the driving belts and lift the unit from the bracket.

To Fit

1. Place the unit on the support bracket and screw in the four nuts but do not tighten.
2. Fit the driving belts on the pulley and adjust the tension by sliding the unit away from the engine. There should be a movement of approximately $\frac{1}{4}$ in. in the centre of each belt when adjusted.
3. Tighten the nuts and couple-up the fan propeller shaft.

Sect. L36 RIGHT-ANGLE FAN DRIVE—TO DISMANTLE AND ASSEMBLE

To Dismantle

1. Remove the drain plug and drain the oil from the unit.
2. Remove the nut and split-pin from the end of the input shaft and withdraw pulley, retaining the spacer. Two $\frac{3}{8}$ in. B.S.F. tapped holes are provided in the pulley for this purpose.
3. Remove breather from unit.
4. Remove nuts securing the input shaft housing to the casing and remove the housing, retaining the shims.

To dismantle the input shaft assembly proceed as follows:

1. Remove the oil seal housing and sealing ring.
2. Using a hammer and brass drift, drive the shaft from the housing, retaining the shims.
3. Remove the bearing, bevel gear and the shaft and remove the remaining bearing from the housing.

To remove the output shaft assembly from the casing proceed as follows:

1. Remove the setscrews from the end cover and remove cover.
2. Remove the nuts securing the oil seal housing and bearing housing to the casing.
3. Using a hammer and brass drift, drive the shaft from the casing at the bevel gear end. The outer race of the roller bearing will remain in the casing and can be removed if necessary.

To dismantle the output shaft assembly:

1. Remove split-pin and nut securing coupling flange to the shaft and remove flange.

2. Remove oil seal and bearing housing together with sealing ring, from the shaft. Remove bearing from its housing if necessary.

3. Remove split-pin and nut from opposite end of the shaft and remove inner race of roller bearing and bevel gear.

To Assemble

Assembly is the reversal of the dismantling procedure but care should be taken that shims of the correct thickness are fitted to give a backlash of .004 to .008 in. (.1016 mm. to .2032 mm.) when the gears are in mesh. Replace the drain plug, and fill the unit with oil. Ensure that all joints are tight and that the oil seals are in good condition. If not, renew where necessary.

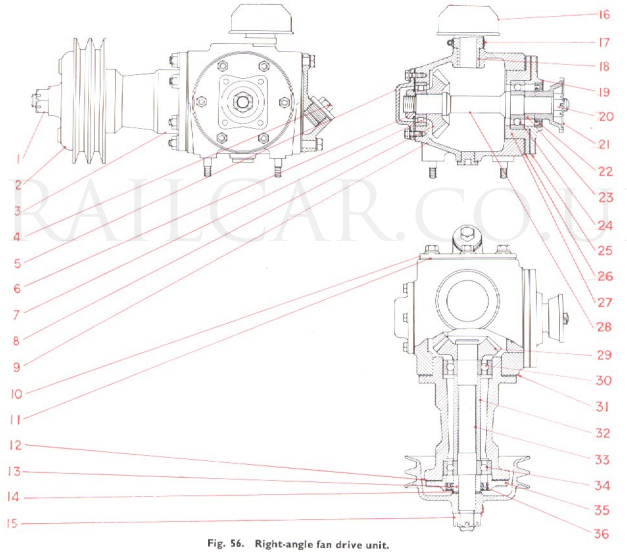


Fig. 56. Right-angle fan drive unit.

1. NUT.
2. PULLEY.
3. INPUT SHAFT HOUSING.
4. OIL LEVEL AND FILLER PLUG.
5. END CAP.
6. LOCKNUT.
7. ROLLER BEARING.
8. BEVEL GEAR.
9. CASING.
10. COVER.
11. JOINT.
12. JOINT.
13. SEAL RING.
14. SPACER.
15. NUT.
16. BREATHER.
17. JUBILEE CLIP.
18. BREATHER TUBE.
19. OIL SEAL HOUSING.
20. NUT.
21. COUPLING FLANGE.
22. OIL SEAL.
23. SEAL RING.
24. BALL BEARING.
25. JOINT.
26. SHIM.
27. BEARING HOUSING.
28. OUTPUT SHAFT.
29. BEVEL GEAR.
30. BALL BEARING.
31. SHIM.
32. SPACER.
33. INPUT SHAFT.
34. BALL BEARING.
35. OIL SEAL HOUSING.
36. OIL SEAL.

Sect. L37 COOLING SYSTEM—DESCRIPTION

Water is driven by the pump through the oil cooler and passes direct into the engine block for circulation through the cylinder water jackets. After leaving the block the water enters a cored passage in the top of the casing and is then directed through drilled holes into the cylinder heads.

A thermostat fitted in the water outlet pipe, allows hot water to flow through the thermostat to the radiator, or cool water to return to the suction side of the pump through a by-pass.

An additional return pipe fitted on the top of the crankcase allows the water round the cylinders to pass to the water outlet pipe. A separate header tank is incorporated in the system.

Water cooling is effected by an eight-bladed fan enclosed in a cowl which is bolted to the radiator. The drive to the fan is taken from a small right-angle drive gearbox, belt-driven from a pulley at the front end of the crankshaft.

Sect. L38 THERMOSTAT—DESCRIPTION

The thermostat consists basically of a gas-filled metal bellows which expands and contracts at predetermined temperatures, thereby operating a valve which is housed with the bellows in a metal frame.

The thermostat valve should begin to open at 160° F. to 170° F. (71.1°C. to 76.6° C.), and normally should be fully open at 200° F. (93.3° C.).

The minimum lift of the valve is $\frac{1}{2}$ in. (12.7 mm.).

If the thermostat does not function correctly, do not attempt to repair or adjust it, but fit a new one.

Sect. L39 WATER PUMP—DESCRIPTION

The impeller-type water-pump, mounted on the timing gear case at the front end of the engine-block, is gear-driven from the camshaft gear. A spring-loaded, self-adjusting, carbon seal unit (20), Fig. 59, carried on the driving shaft, completely isolates the impeller chamber from the ball and roller bearings. The bearings are lubricated by splash from the camshaft gear. An oil seal prevents oil from penetrating to the impeller chamber.

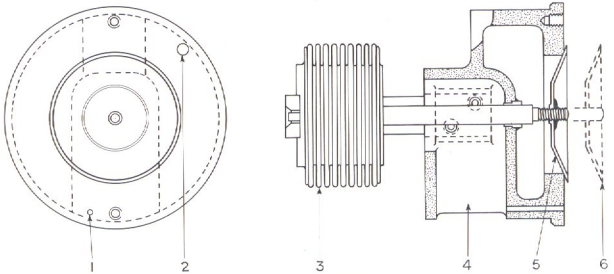


Fig. 57. Thermostat.

1. WATER DRAIN HOLE.
2. PRESSURE RELEASE HOLE.
3. BELLOWS GLAND.
4. BYE-PASS OUTLET.
5. VALVE CLOSED.
6. VALVE OPEN.

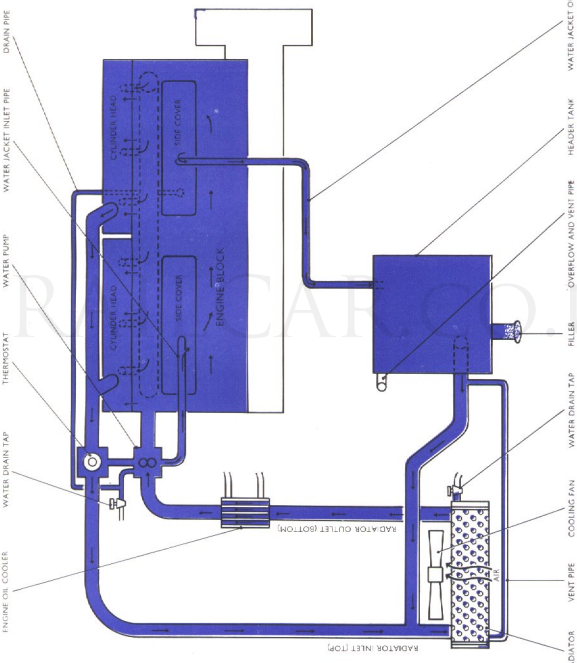


Fig. 58. Water circulation diagram.

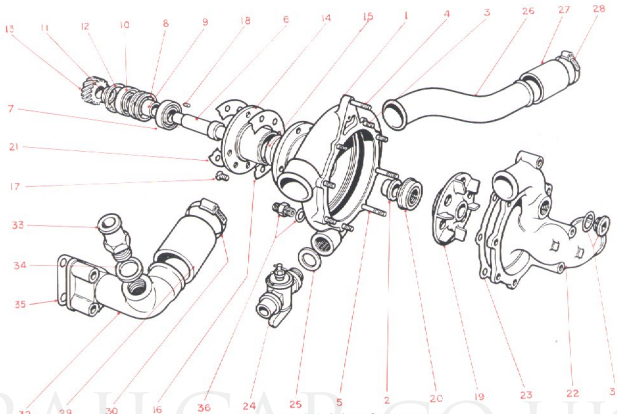


Fig. 59. Exploded view of water pump.

1. PUMP CASING.
2. BUSH.
3. STUD.
4. STUD.
5. STUD.
6. DRIVING SHAFT.
7. BALL BEARING.
8. DISTANCE PIECE, OUTER.
9. DISTANCE PIECE, INNER.
10. ROLLER BEARING.
11. DISTANCE PIECE.
12. CIRCLIP.
13. DRIVING GEAR.
14. BEARING HOUSING.
15. OIL SEAL.
16. JOINT
17. SETSCREW.
18. PIN.
19. IMPELLER.
20. SEAL.
21. JOINT.
22. END COVER.
23. JOINT.
24. DRAIN TAP
25. WASHER.
26. BY-PASS TUBE.
27. HOSE.
28. JUBILEE CLIP.
29. HOSE.
30. JUBILEE CLIP.
31. PLUG, WASHER.
32. ELBOW, WATER INLET.
33. ADAPTER.
34. WASHER.
35. JOINT.
36. UNION, WASHER.

Sect. L40 WATER PUMP—TO REMOVE, DISMANTLE, ASSEMBLE AND FIT

To Remove

1. Drain the cooling system by opening the tap fitted in the water pipe at the bottom of the radiator.

2. Disconnect the water pipe connections and remove the nuts securing the pump to the timing case. The complete unit can now be removed for dismantling.

To Dismantle

1. Remove the nuts securing the front cover and withdraw the cover.

2. Draw the impeller off the driving shaft, using the screwed end of the impeller to fix the withdrawal tool. Special tool available.

3. Remove the carbon seal unit from the impeller.

4. Remove the two countersunk-head setscrews securing the ball and roller race assembly to the pump housing. The assembly is now free to be separated from the pump housing.

To dismantle the shaft and bearings for examination, take out the circlip locating the bearings and press the shaft and bearings out of the housing, pressing at the seal end of the shaft.

The carbon seal unit should not require attention for long periods, but if at overhaul the rubber is damaged, or the carbon excessively worn, a new seal unit can be obtained from B.U.T. Service.

To Reassemble

To reassemble the water pump, reverse the procedure for dismantling.

Note.—It is important that the driving shaft end and the impeller end face should be flush when in position, as this determines the correct spring pressure on the sealing face of the carbon gland.

To Fit

Fit the pump to the engine and tighten down the nuts.

Connect water pipe connections.

Sect. L41 THE FUEL INJECTORS—DESCRIPTION

The fuel is delivered at high pressure to injectors (Fig. 60) which break up the fuel into a fine mist and distribute it in the combustion chamber. They also ensure a snap-start and finish to injection and prevent air from entering the pipe lines during the compression stroke.

The inlet adapter is provided with an "edgewise" type filter. From the filter, fuel is fed through a drilled passage to the nozzle. When the required pressure is reached, the nozzle valve snaps open and allows fuel to be sprayed into the combustion chamber through four small, equally spaced holes in the nozzle tip. Although the needle valve is a very fine fit in its bearing in the injector body, a small quantity of fuel leaks past the valve stem and this is led away through a drilled passage in the injector body to a branch pipe and thence to the main leak-off gallery pipe (Fig. 62).

The injectors will give long periods of efficient service. Special equipment is required for reconditioning the injectors and special lapping tools are obtainable. If, however, no equipment is at hand, injectors should be returned to B.U.T. Service and a replacement set fitted.

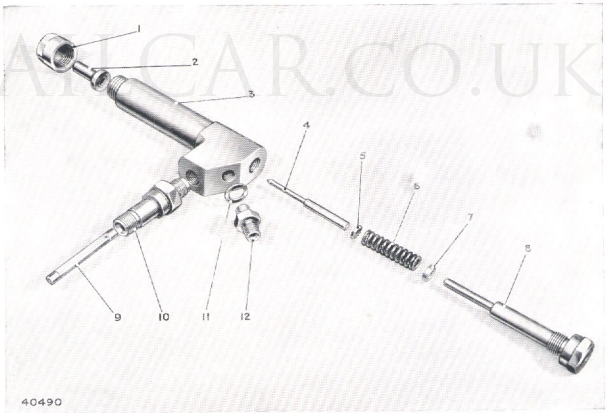


Fig. 60. Exploded view of the injector unit.

1. LOCKNUT.
2. NOZZLE.
3. INJECTOR BODY.
4. NEEDLE VALVE.
5. NEEDLE VALVE LIFT DISTANCE WASHER.
6. VALVE SPRING.
7. DISCHARGE PRESSURE ADJUSTING WASHER.
8. END PLUG.
9. EDGEWISE FILTER.
10. INLET ADAPTER.
11. COPPER WASHER.
12. LEAK-OFF ADAPTER.

Fig. 61. An injector unit sectioned.

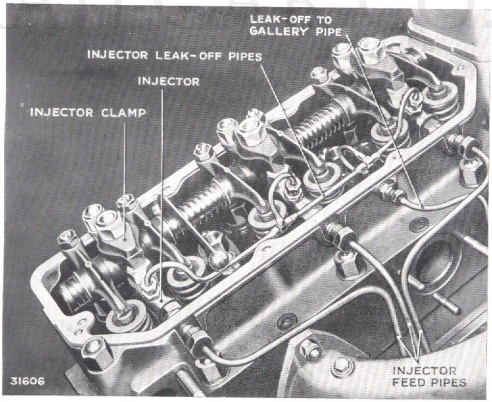


Fig. 62. Injectors and leak-off pipes in position in cylinder head.

Sect. L42 THE FUEL INJECTORS—TO REMOVE AND FIT

To Remove

1. Remove cylinder head cover.
2. Remove leak-off pipe assembly and disconnect feed pipes from the injectors.
3. Remove injector clamp and withdraw injector. Retain rubber seal.

To Fit

1. Press in injector and secure with the clamp. Ensure that the rubber seal is in position.
2. Connect up the leak-off pipe assembly and feed pipes.
3. Replace cylinder head cover.

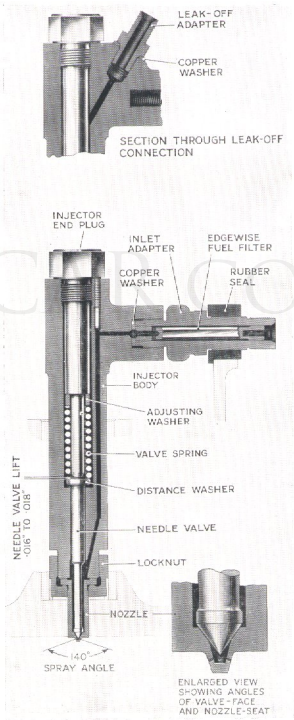


Fig. 63. The injector unit.

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Sect. L43 THE FUEL INJECTORS—DIAGNOSIS OF TROUBLE AND TESTING

Diagnosis of Injector Trouble

Provided the fuel filters receive regular attention, thereby ensuring that only clean fuel is fed to the injectors, no attention is likely to be required for long periods. Any inefficiency can usually be detected by one of the following symptoms:—

1. Pronounced knocking on one (or more) cylinders.
2. Complete or intermittent misfiring.
3. Smoky exhaust (black), injector discharging unvaporised fuel; (blue), denotes a choked injector.
4. Increased fuel consumption.
5. Engine overheating.

To locate a faulty injector, slacken off the injector pipe union nut two or three turns and allow the fuel to leak past the threads while the engine is running slowly. This cuts out the injector and if no change in engine performance can be detected, it is reasonable to assume that the injector is faulty and should be removed (*see Section L42*) for examination.

Faulty injection may be due to any of the following:—

1. External carbon on nozzles.
2. Choked nozzle spray holes.
3. Loose nozzle lock-nut.
4. Dirt on the joint face between nozzle and body.
5. Dirt or carbon on needle valve seat.
6. Needle valve sticking in body.
7. Faulty valve spring adjustment.
8. Broken needle valve spring.
9. Cracked injector body.

To Test Injectors

Connect the injector to an injector test pump, give the handle about ten strokes to expel all air, and

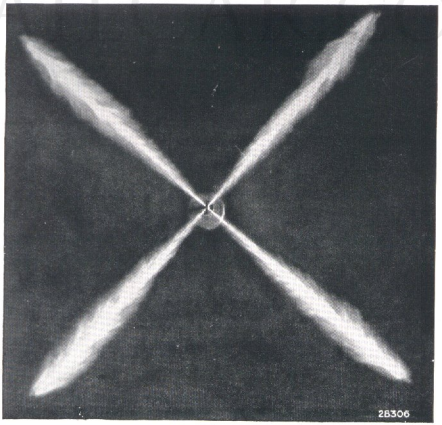

Fig. 64. Injector spray as seen by the high-speed camera.

observe the nature of the spray when pumping at about 2 strokes per second. If no test pump is available, connect the injector to the injection pump, so that the spray can be observed. Slacken the unions on the remaining injectors to prevent unburnt fuel being sprayed into the cylinders. **Decompress** the engine. Turn the engine, and observe the spray.

When the injector is operating correctly, the spray from the nozzle spray holes should appear alike, and of equal length and free from streaks or jets of undivided fuel (Fig. 64).

A sharp, high-pitched, metallic squeak should be heard whilst the injector is spraying.

The nozzle tip must remain dry after fuel cut-off.

Sect. L44 THE FUEL INJECTORS—TO DISMANTLE AND CLEAN, RE-LAP NOZZLE AND VALVE SEATS, ASSEMBLE AND TEST

To Dismantle and Clean

When dismantling injectors absolute cleanliness is essential. **Needle valves are not interchangeable,** care must be taken when dismantling to keep all parts with their original injectors.

1. Remove the injector end plug and withdraw the valve spring, discharge pressure adjusting washer, needle valve lift distance washer and needle valve. If the needle valve is tight, screw a piece of 3 BA screwed rod into the tapped bore of the needle valve and draw it out.

2. Remove the nozzle lock-nut and nozzle.

3. Wash the needle valve, nozzle and injector body in clean fuel oil. Both faces of the nozzle flange, the inner face of the lock-nut and face of the body should be bright and without trace of damage. They must bed perfectly to ensure a pressure-tight joint.

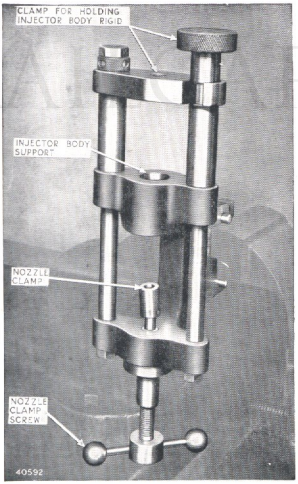

Fig. 65. Nozzle and needle aligning jig.

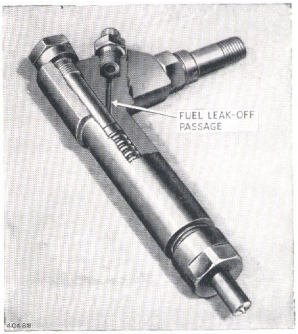

Fig. 66. Part sectioned view of injector unit.

4. The stem of the needle valve must be free from high spots or scratches. If dirty or coked, clean with a fine brass wire brush.

5. Clean the nozzle seat thoroughly and clear the spray holes with a pricker. Brush through injector body bores and inlet adapter. Flush out the inlet port drilling and nozzle with fuel oil. Finally, rinse in clean white spirit before assembly.

To Re-lap Nozzle and Valve Seats

Use only the special fine grade lapping compound known as "2A.700.O.F.", supplied by the Carborundum Co., Ltd., Trafford Park, Manchester, 17.

When lapping, only use **very** light pressure.

Never give the needle or nozzle lapping jigs more than a **few** twists at a time between each test.

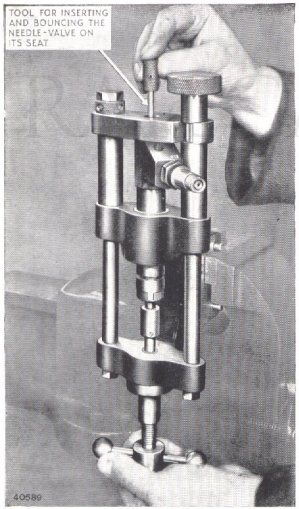

Fig. 67. Clamping the nozzle after centralizing the needle valve.

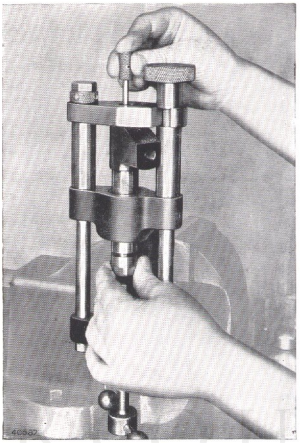

Fig. 68. Bouncing the needle valve on its seat.

Wash away every trace of lapping compound, assemble the injector and test for a dry seat with a sustained pressure of 125 atmospheres (1,827 p.s.i., 129 kg./s. cm.). If the seat does not remain dry, repeat the lapping operations until such a condition is obtained.

Assembly and Test of Injectors

The most important point to check when assembling an injector unit is the correct alignment of the nozzle in relation to the bore in the injector body. If the alignment is not correct the unit will not function properly and failure will occur at very low mileages. The components should be thoroughly washed in white spirit or fuel oil and kept free from grit or dirt throughout the entire operation.

Fluffy material should not be used to wipe the components.

1. Check that all parts are perfectly clean and dry.

2. Fit the injector body in the jig. (Fig. 65).

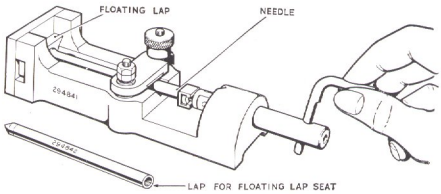

Fig. 69. Injector needle lapping jig.

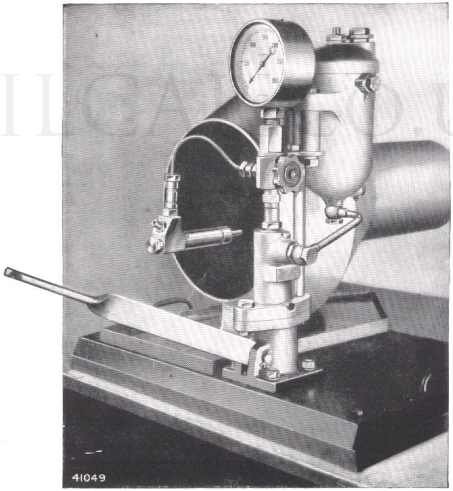

Fig. 70. Injector unit test rig.

3. Fit the nozzle and lock-nut and screw up the lock-nut so that the nozzle can just be rotated with the fingers.

4. Screw the 3BA rod into the needle valve bore and insert the valve into the injector body.

5. Tighten the lock-nut slowly and carefully with the fingers, at the same time using the 3BA rod to bounce the needle valve rapidly on the nozzle seat (Fig. 68).

This ensures perfect centralisation of the nozzle and needle, without which the injector will not operate correctly. When the needle valve bounces freely on its seat, tighten the jig clamp screw to hold the nozzle in position (Fig. 67), and finally tighten the lock-nut with the ring spanner (Fig. 71), taking great care not to knock the nozzle when fitting the spanner. When the lock-nut has been fully tightened a further and

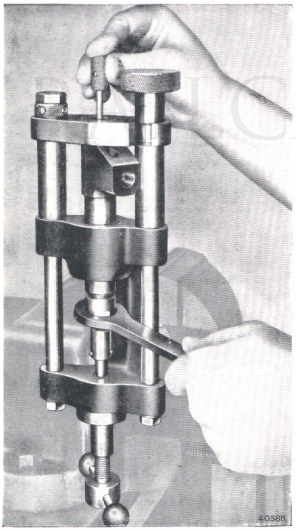

Fig. 71. Tightening the nozzle clamp nut.

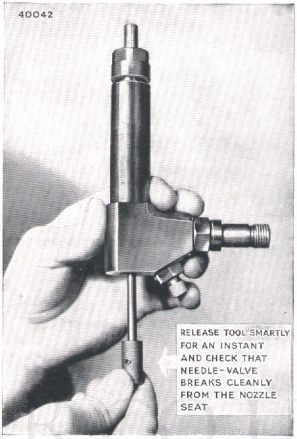

Fig. 72. The inverted test.

most important check that the needle valve operates freely, is the "Inverted Test" carried out as follows:

1. Remove the injector from the jig.

2. Hold the injector vertically in an inverted position (Fig. 72).

3. With the needle valve attached to the screwed rod, insert the needle valve into the injector body and push it firmly on to the nozzle's seating.

4. Release the rod smartly for an instant, and check that the needle valve breaks cleanly from the nozzle seat without sticking or binding.

Make this test with the needle valve in at least four different positions on the nozzle seat. If the needle valve sticks in any one position, then:

(*a*) Check the needle valve slides freely in the injector body.

(*b*) Check that the end face of the injector body and the end face of the nozzle are clean and fit flush.

(*c*) After these checks, re-align the injector body and nozzle in the jig, and again carry out the "Inverted Test" until the condition described in paragraph 4 is obtained.

5. Now assemble the needle valve lift distance washer, valve spring and discharge pressure adjusting washer in the injector body and replace the injector end plug.

Sect. L45 THE FUEL INJECTORS—TO CHECK AND ADJUST

To Check and Adjust

This can only be done successfully with a specially designed injector test pump (Fig. 70).

1. Connect the injector to the test pump; expel all air from the pump by pumping the handle for about ten strokes.

2. Carefully note pressure at which spray breaks when the pump handle is operated. The correct pressure is between 140 and 145 atmospheres (2,057 to 2,130 p.s.i., 144.6 to 149.7 kg./s. cm.).

3. The seat must remain dry with a sustained pressure of 125 atmospheres (1,837 p.s.i., 129 kg./s. cm.).

4. If the discharge pressure is not correct, check that the needle is free in the body; if this is in order, adjust the spring pressure by inserting a discharge pressure adjusting washer of a different thickness (*see* **Data** under heading **Injectors**). Re-check the discharge pressure.

5. Check that the needle lift is between .016 in. and .018 in. (.4064 mm. to .4572 mm.). To do this remove the injector end plug and valve spring. Insert a .025 in. (.6350 mm.) thick shim on top of the needle valve lift distance washer and replace the end plug. Screw down the plug by hand and measure the gap between the end plug and injector body, using a set of feeler gauges (Fig. 74).

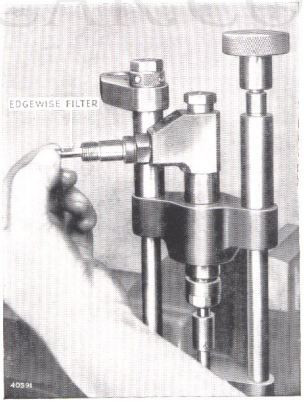

Fig. 73. Fitting the edgewise fuel filter.

If this gap is between .007 in. and .009 in. (.1778 mm. and .2286 mm.) the needle lift is correct. If the gap is not correct, fit a different thickness of distance washer and re-check (*see* **Data** under heading **Injectors**), when a needle valve lift distance washer of the correct thickness has been obtained, remove the .025 in. (.6350 mm.) thick shim and assemble the injector for test.

6. Check the time for the pressure to fall from 90 to 50 atmospheres (1,323 to 588 p.s.i., 93 to 41.4 kg./s. cm.). The limits for rejection are as follows (at room temperature 40°F. to 70°F.) (5°C. to 21°C.):—
Using fuel oil .. .. .. 4½ to 14 secs.

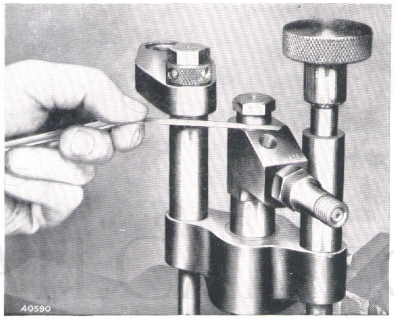

Fig. 74. Checking the needle valve lift.

Sect. L46 FUEL INJECTION PUMP—DESCRIPTION

The fuel injection pump is of the constant-stroke, cam-actuated, lapped-plunger type and incorporates an idling and maximum speed mechanical governor and an excess fuel device for easy starting. The pump consists of a body with a camshaft compartment at the bottom and with six individual pumping elements occupying the middle and upper portions.

In the middle and upper portions of the pump housing are located the plunger and barrel assemblies, metering control sleeves with regulating toothed quadrants, plunger springs and control rod. The upper portion of the housing contains the fuel chamber, delivery valve assemblies and delivery valve holders for connection to the injection feed pipes. Built into the rear of the housing is a secondary fuel filter composed of felt pads intended to supplement the main fuel filter.

Each pumping element comprises of a barrel (G) and plunger (H), *see* Fig. 75, and are of highly ground and hardened steel, finished to a high degree of accuracy to permit operation at high speeds and pressures. Thus, each pair must be regarded as inseparable and not interchangeable.

Fuel oil is fed to each element from a common gallery; the stroke of the plunger is constant, but the effective pumping stroke, i.e., that portion of the stroke during which oil is actually forced into the combustion chamber, is variable by means of a control helix on the plunger which operates in conjunction with ports in the barrel.

Referring to Fig. 77, the form of the helix and its relation to the ports and oil passages of the element are clearly shown. It will be seen that when the plunger is at bottom dead centre (B.D.C.) oil can enter the barrel through the inlet port. As the plunger is raised by the cam, the top edge of the plunger covers the ports, sealing off escape for the oil, which is then forced out through the delivery valve and high-pressure piping to the injector, as in Fig. 77(b). As the plunger rises higher, pumping continues until the edge of the control helix reaches the lower edge of the ports. This allows oil to escape via the spill port, as in Fig. 77(c), releasing the pressure in the element and piping, and thus terminating the pumping stroke. The plunger can now complete its stroke without any further pumping, and is then returned by the plunger spring to bottom dead centre ready for the next cycle.

The quantity of fuel oil pumped is dependent on the length of pumping stroke between the points shown in Fig. 77 (b and c). This effective stroke is varied by rotating the plunger to bring a higher, or lower, portion of the control helix into line with the spill port. Compare Figs. 77(c), 77(d) and 77(e), which shows approximately the positions for full-load, half-load and idling respectively.

At its upper end the control helix emerges into an axial groove running up to the top face of the plunger. If this axial groove is in line with the spill port, then

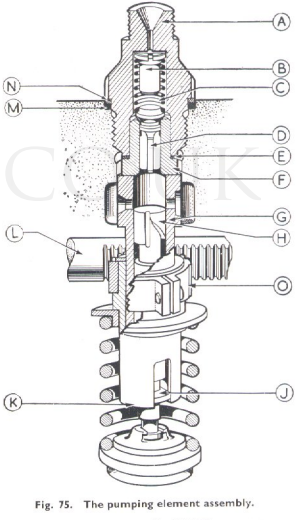

Fig. 75. The pumping element assembly.

A. DELIVERY VALVE HOLDER.
B. SPRING PEG.
C. DELIVERY VALVE SPRING.
D. DELIVERY VALVE.
E. WASHER.
F. DELIVERY VALVE SEAT.
G. PLUNGER BARREL.
H. PLUNGER.
J. PLUNGER LOCATING LUG.
K. CONTROL SLEEVE.
L. CONTROL ROD.
M. RUBBER SEAL.
N. WASHER.
O. CONTROL QUADRANT.

the oil in the barrel has a continuous line of escape to the spill port, and obviously no pumping stroke is possible. This represents the "Stop" position in pump operation, when no oil is delivered at all, as in Fig. 77(f).

Rotation of the plunger, to give any required delivery position between "Full Load" and "Stop", is effected in the following way:

The lower end of the plunger (H), Fig. 75, carries a lug, or toe (J). This engages in a slot in the skirt of the control quadrant (K). Around its upper flange, the quadrant is machined to form gear teeth, and these engage with similar teeth on the control rack (L), the latter running the length of the pump and engaging the quadrant of each pumping element. Thus, movement of the rack causes all the plungers to rotate in unison and selects the position of the helices corresponding to the fuel delivery required.

The control rack is normally coupled to and operated by the governor unit, or other control linkage.

In order to ensure complete and instantaneous relief of pressure in the fuel line after the pump plunger has completed its injection stroke, a delivery valve with the well-known "unloading collar" used in previous types of C.A.V. pump, is fitted immediately above the element, as shown in Fig. 76.

The delivery valve seating is held against the top of the element barrel (G), Fig. 75, both faces of this joint being lapped flat. The seating is held down by the delivery valve holder (A), which is screwed in to the pump body, a washer (E) being inserted between the valve seating (F) and the holder (A), to prevent leakage of high-pressure oil down the inside of the holder. Leakage of oil at low pressure up the threads in the pump body is prevented by a synthetic rubber seal ring (M), with a steel slip washer (N), which is trapped in a counterbore in the pump body by the delivery valve holder.

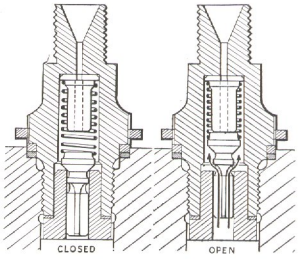

Fig. 76. Injection pump delivery valve.

A steel peg (B) is used to centralise the upper end of the valve spring (C) and also to help reduce the fuel capacity of the holder. This fuel capacity has been kept to a minimum, as it is known that reduction of capacity between pump plunger and injector seat gives improved injection control under many conditions.

In operation, when the pump element barrel ports are closed and delivery occurs, the delivery valve is lifted from its seat so that the unloading collar is clear of the seat bore and the oil passes through. (*See* Fig. 76.) When delivery is ended by the opening of the spill port, the sudden collapse of pressure in the pump element causes the valve to "snap" on to its seating sharply. As the lower edge of the unloading collar enters the seat bore, it stops any flow of oil past the collar so that the capacity above the valve is sealed off. Further movement of the valve on to its seat now causes an increase of the capacity above the valve. The resultant sharp drop in pressure speeds up the closing of the injector, giving very positive shut-off and preventing dribble with its attendant troubles of carbon-formation and nozzle deterioration.

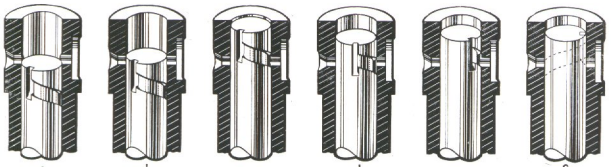

Fig. 77. The principle of fuel metering.

Sect. L47 FUEL INJECTION PUMP—TO REMOVE AND FIT

To Remove

Immediately pipes are disconnected from the fuel pump, the ends of the pipes, together with the unions on the pump, must be covered with clean rag or caps. **On no account must dust be allowed to fall into the injection pump.**

1. Disconnect the control rod.
2. Disconnect the stop control.
3. Uncouple the pipe from the main filter to the pump and the suction and delivery pipes to the diaphragm fuel feed pump.
4. Disconnect the delivery pipes to the injectors.
5. Disconnect the vent pipe.
6. Remove the two setscrews connecting the coupling to the pump flywheel.
7. Remove the four bolts fixing pump to bracket and remove the pump.

To Fit

1. Set the engine to the "**No. 1 INJ**" mark on the flywheel, so that **No. 1** piston is on the **compression** stroke (that is, both valves closed).
2. Turn the pump camshaft until the mark on its flywheel is in line with the pointer on the pump body.
3. Place the pump on its bracket and connect up to the drive coupling.
4. Check that all timing marks are in line.
5. Bolt the pump to its bracket.
6. Couple up all pipe connections, stop control and control rod.

On fitting the pump to the engine, the cambox should be filled up to the level of the drain connection with engine oil, through the filler plug. This oil level will be maintained by the back leakage from the pumping elements as this leakage is all led back to the

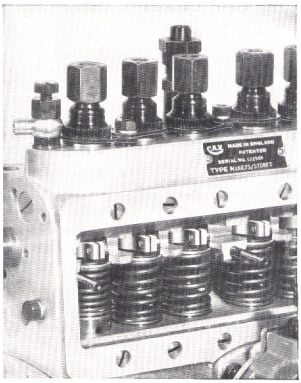

Fig. 78. The pump control quadrants.

pump sump, any surplus being taken away by the drain on the side of the pump.

Although the original lubricating oil will be thinned out by the back leakage fuel oil, experience has proved that the pump will run in perfect safety with fuel oil as a lubricant.

If a replacement pump is being fitted and its flywheel has no timing mark, proceed as follows:

1. Set the engine to the **"No. 1 INJ"** mark on the flywheel, so that **No. 1** piston is on the **compression** stroke.

2. Fit the pump to the engine and couple up the main feed pipes, but only No. 1 cylinder delivery pipe and injector.

3. Prime the injection pump through to No. 1 injector.

4. Turn the pump flywheel **clockwise** until resistance becomes solid.

   At this point No. 1 injector starts injecting fuel; fit the coupling locking setscrews and tighten up.

5. When the pump is correctly timed, mark the pump flywheel opposite the timing pointer on the pump body, so that the pump can easily be fitted if subsequent removal is necessary.

6. Fit and tighten all fuel delivery pipes to injectors.

Sect. L48 SOLENOID—DESCRIPTION

The engine stop control solenoid is mounted above and to one side of the governor, on a bracket secured to the face of the inner sump.

The solenoid consists of an electrical coil and sliding plunger, the plunger being connected to the stop control lever on the governor.

When the coil is energised the plunger is drawn to the end of its stroke and in turn, through the lever, the control rod is drawn to the fuel cut-off position, thereby stopping the engine.

When the electrical circuit is broken, the solenoid plunger and fuel pump control rod return to their normal positions.

Sect. L49 SOLENOID—TO REMOVE AND FIT

To Remove

1. Isolate the batteries.
2. Remove the terminal cover.
3. Disconnect the electrical connections.
4. Disconnect the plunger from the stop-control lever on the governor.
5. Remove four nuts and bolts securing the solenoid to the bracket and remove solenoid.

To Fit

Fitting of the solenoid is a reversal of the removal procedure.

Sect. L50 GOVERNOR—DESCRIPTION

The governor (Fig. 79), which is secured to the end of the injection pump, is driven by the pump camshaft. Contained in the governor housing and attached to the camshaft are flyweights which are thrown outwards by centrifugal force (Fig. 80). These are connected by bell crank levers to a crosshead which moves inward as the weights extend. A forked lever, on the crosshead, is linked to the pump control rod.

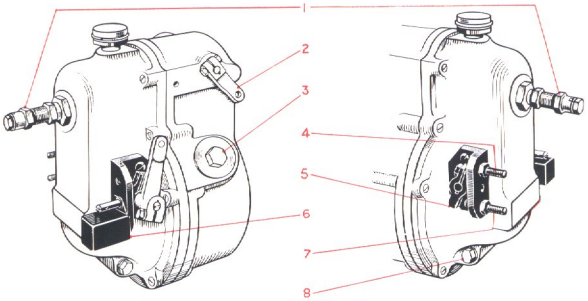

Fig. 79. The governor.

1. AUXILIARY IDLING DAMPER.
2. STOPPING LEVER.
3. OIL FILLER PLUG.
4. IDLING SPEED STOP.
5. BEARING PAWL.
6. MAXIMUM FUEL STOP COVER.
7. SECONDARY MAXIMUM FUEL STOP.
8. OIL LEVEL PLUG.

to which movement is imparted, and so controls the quantity of fuel delivered by the pump to the engine according to the speed.

The movement of the flyweights is restricted by two sets of compression springs. One spring in each set is so rated that it restrains the weight until idling speed is reached. If the idling speed tends to rise above normal, the weights, overcoming the springs, move outwards, and through the linkage previously described the pump control rod is moved towards the stop position. Similarly, if the idling speed falls below that required, the reverse action takes place.

Between idling and maximum speed the engine is under direct control of the throttle-control lever, as this works independently on the control rod by an eccentric shaft through the fulcrum point of the forked lever. The governor weights during this period are restricted in their outward travel by the outer springs in the set and it is not until these are compressed that the governor again takes control. At this point the predetermined maximum is reached and once the tension of the springs is overcome the weights travel outwards withdrawing the control rod and holding the maximum engine speed.

The engine can be stopped by the operation of an electric solenoid which is connected to the stop lever on the side of the governor housing and when operated moves the pump control rod to the fuel cut-off position, thereby stopping the engine.

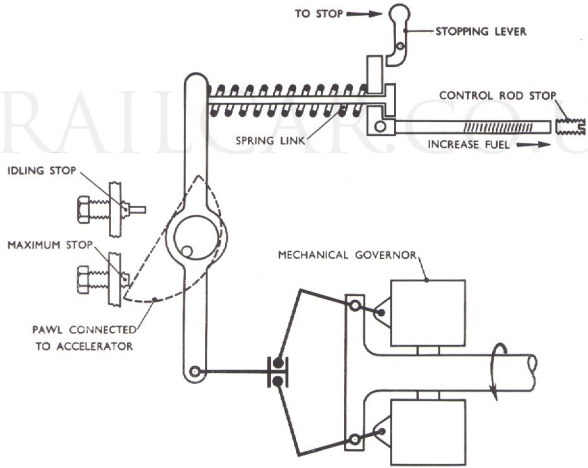

Fig. 80. Principle of the mechanical governor.

Sect. L51 ENGINES—SPEED ADJUSTMENT

Idling Stop

Run the engine until it is warm and then adjust the governor control lever to give an idling speed of 375 to 400 r.p.m. Screw in the idling stop until it just makes contact with the pawl, and tighten the lock-nut. Check that the fuel can be cut off by pulling the stop control lever.

Note.—The auxiliary idling damper must be fully retracted whilst the above adjustment is being made.

Maximum Speed Stop

The maximum speed stop is adjusted and sealed whilst the engine is undergoing test at the factory and should not be tampered with.

Auxiliary Idling Damper

The auxiliary idling damper fitted in the end of the governor casing consists of a spring-loaded plunger which contacts the forked lever within the governor. This damps out oscillations and stabilises the pump control rod at idling speed.

If it has been wrongly adjusted and the engine tends to hunt at idling speed, release the lock-nut and screw in the body until a pronounced increase in speed occurs, then screw out the body until normal idling is restored. Unscrew the body a further half-turn and tighten the lock-nut.

Check the setting by accelerating the engine and then allow it to drop back to idling speed which should remain steady.

To Adjust the Throttle Motor

Attach the throttle motor control rod to the fuel pump lever and to the throttle 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 the throttle motor in the full-throttle position, adjust the maximum fuel 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 .005 in. feeler gauge will just pass between the stop on the fuel pump control lever and the stop on the pump.

Set the three 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 lock-nuts.

Sect. L52 FUEL FEED PUMP—DESCRIPTION

The feed pump (Fig. 81), is of the variable-stroke-diaphragm type, driven directly by an eccentric on the injection pump camshaft. The pump is of ample capacity to ensure an adequate supply of fuel at all speeds.

As the injection pump camshaft revolves, the eccentric pushes the rocker arm down; this pulls the diaphragm held between metal discs, inward against spring pressure, thus creating a vacuum in the pump chamber.

Fuel enters the pump through the suction valve into the pump chamber. On the return stroke the return-spring pressure pushes the diaphragm outward, forcing fuel from the chamber through the pressure valve into the main fuel filter and so to the injection pump.

When the injection pump fuel gallery is full, a pressure is created in the pump chamber. This pressure will hold the diaphragm inward against the return-spring pressure, where it will remain inoperative until the pressure in the injection pump drops.

The hand priming device, which operates the diaphragm by a cam formed on the end of a spindle, is kept out of engagement during normal running by a torsion spring. The small spring on the rocker arm is merely to keep the arm in constant contact with the eccentric to eliminate noise.

Sect. L53 FUEL FEED PUMP—TO REMOVE AND FIT

If trouble occurs in the fuel supply to the injection pump, the following checks should be made before attempting to remove and repair the pump:

1. Make sure the fuel pipes are not blocked.
2. Check that all fuel filters are clean.
3. Examine for leaks on the suction side of the pump.
4. Examine the valves and, if defective, renew.

If the pump still fails to operate satisfactorily, dismantle (*see Section L54*) and check for the following:

1. Broken diaphragm return spring.
2. Diaphragm retaining-nut loose.
3. Punctured or worn-out diaphragm.
4. Leakage at diaphragm flange.
5. Broken rocker arm.

To Remove

1. Disconnect the inlet and outlet fuel pipe connections.
2. Remove the nuts securing the feed pump to the injection pump.

To Fit

1. Reverse the removal procedure using a new joint.

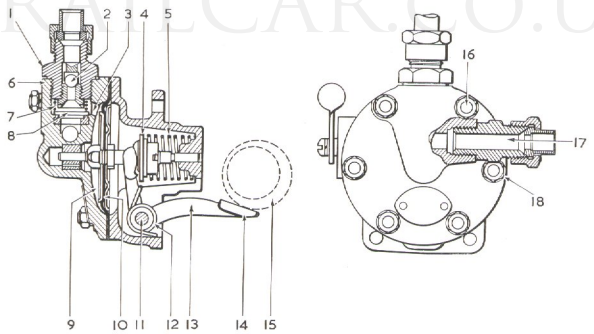

Fig. 81. Fuel feed pump.

1. DELIVERY VALVE BODY.
2. DELIVERY VALVE BALL.
3. PORT.
4. SPRING PLATE.
5. DIAPHRAGM SPRING.
6. PUMP CASING.
7. SPRING FOR PLATE VALVE.
8. PLATE VALVE.
9. PUMP CHAMBER.
10. DIAPHRAGM.
11. ROCKER ARM SPINDLE.
12. ROCKER ARM RETURN SPRING.
13. ROCKER ARM.
14. CONTACT PAD.
15. INJECTION PUMP CAMSHAFT.
16. STUD.
17. SUCTION PASSAGE FROM FUEL SUPPLY.
18. NUT.

Sect. L54 FUEL FEED PUMP—TO DISMANTLE AND ASSEMBLE

To Dismantle

1. Remove unit from injection pump (*see Section L53*).
2. Remove hand priming lever.
3. Remove the two countersunk screws and remove stop plate. The hand priming lever and spindle with return spring can now be withdrawn.
4. Remove the union (1) and detach disc valve (8) and spring (7). If necessary, the ball valve (2) can be removed by unscrewing valve seat from union (1).
5. Unscrew six nuts (18) from studs (16) and remove casting (6).
6. Ease edges of diaphragm leaves (10) from housing to allow the insertion of a thin spanner to engage flats of nut behind diaphragm.
7. Unscrew lock-nut and remove diaphragm pack and support plates as a unit.
8. Carefully tap the bell-crank lever spindle out of the housing and remove lever and springs.
9. The diaphragm spindle and return spring can now be removed.

To Assemble

Assembly is the reversal of the dismantling procedure, noting the following points:—

1. Ensure that all return springs are in their correct positions.
2. When fitting the diaphragm ensure that the large support plate is towards the operating lever.
3. Lock all parts together, ensuring that diaphragm does not get twisted or distorted.
4. When fitting the priming lever spindle depress the operating lever slightly to enable the spindle to be pushed home to its fullest extent.

Sect. L55 FUEL SYSTEM—DESCRIPTION

The fuel is drawn from the tank through a cloth element fuel filter (Fig.82) by a small diaphragm-type lift pump which is secured to the side of the injection pump and driven by an eccentric formed on the injection pump camshaft.

Fuel is delivered to the injection pump via a twin paper element fuel filter (Fig. 83) and the fuel is then delivered under high pressure through separate pipes to the injectors.

A leak-off pipe fitted to each injector is connected to a gallery pipe which discharges back into the fuel tank.

The fuel before entering the injection pump passes through a gravity vent valve which acts as a constant air-bleed, allowing aerated fuel to be expelled automatically and so preventing the possibility of air locks forming in the system.

Sect. L56 FUEL FILTER (CLOTH ELEMENT)—DESCRIPTION

The fuel filter (Fig. 82) is of the cross-flow type and consists of a bowl, housing a close-weave fabric element pleated to a cylindrical form over a wire cage and secured by cotton twine.

A cover and a cork sealing washer are secured to the top of the bowl by a central fixing bolt and nut. At the sides of the cover are the inlet and outlet connections and at the front an air release screw is fitted.

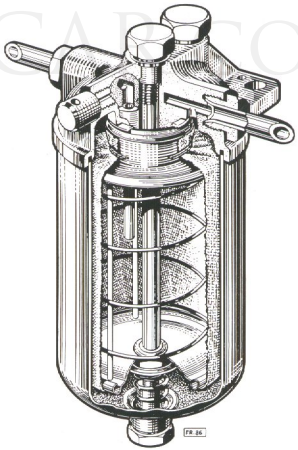

Fig. 82. Fuel filter (cloth element)

Sect. L57 FUEL FILTER (CLOTH ELEMENT)—TO REPLACE ELEMENT

1. Thoroughly clean the outside of filter bowl and cover.
2. Unscrew the centre cap nut with the hand under the bowl and lower the bowl. Take precautions against dirt entering the suction tube in the cover.
3. Extract the element, remove the sludge plug at the bottom and thoroughly clean the bowl. Refit the sludge plug when cleaned.
4. Obtain a replacement element complete with cage and insert in the bowl.
5. Reassemble filter, making sure that the sealing washers are in good condition and seating properly. Tighten cap nut.
6. Add clean fuel oil to the filter through the closing plug and prime the system.

Separate fabric cloths are available for refitting to the cage but these must be carefully fitted and sealed.

Note.—Never attempt to clean the element fabric as dirt will inevitably be deposited on the clean side.

Sect. L58 FUEL FILTER (PAPER ELEMENT)—DESCRIPTION

Fig. 83 shows the general view of the filter and also direction of flow of fuel.

The filter is of the cross-flow type, the inlet and outlet connections being carried in the cover. Also incorporated in the cover is an air vent plug and a bracket for support. The bowl is of pressed steel, and forms an oil-tight container for the element. A drain plug is provided at the bottom of the bowl.

The paper element, which is contained in a thin metal canister, is wound round a circular core in such a manner as to provide a large filter area. A small rubber sealing ring is fitted to the top of the element, and a large one fitted on the centre spindle in the bowl, seals the bottom of the element. No attempt should be made to clean a dirty element.

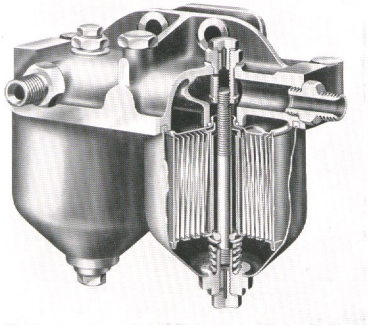

Fig. 83. Fuel filter (paper element).

Sect. L59 FUEL FILTER (PAPER ELEMENT)—TO REPLACE ELEMENT

1. Thoroughly clean the outside of filter bowl and cover.

2. Slacken off the vent plug at top of cap nut and unscrew drain plug until fuel drains from the hole in the plug.

   If sludge hole is blocked retighten the plug.

3. Unscrew central top cap nut and withdraw bowl and element from cover.

If draining through the bottom plug was impossible, push the element down against the spring until the top is level with the edge of the bowl. Swill round the contents and pour out to waste. Clean out the drain holes in the drain plug and filter body boss.

4. Remove dirty filter element. Any deposit of solid matter in the bowl should be scooped out, taking care not to allow any to foul the "clean" portion of the centre spindle above the bottom sealing ring.

5. Fit new paper element in bowl. Make sure that the sealing ring is in good condition.

6. Fit the filter bowl containing new element to the cover. Engage the cap nut with the centre spindle and screw up tightly. Undue force should not be applied in an attempt to stop leakage.

7. Tighten up oil drain plug and vent the fuel system.

Sect. L60 STARTER MOTOR—DESCRIPTION

The axial-type starter motor is mounted on the left-hand side of the engine. Incorporated in it is the solenoid switch and overload clutch.

The field winding is divided into two main field coils and two auxiliary coils, each of the latter being made up of an auxiliary shunt coil and an auxiliary series coil. When the starter switch is operated, a small current passes through the auxiliary coils, causing the armature to rotate slowly. Simultaneously the magnetic field set up pulls the armature forward and brings the pinion gently into mesh with the starter ring.

This movement of the armature causes a tripping disc to operate the switch trigger, which releases the contacts of the solenoid switch and so completes the main circuit. The full current passes to the starter which exerts its full torque on the engine.

The overload device is a simple screw and spring-loaded clutch arrangement, which has a slipping torque above the lock torque of the starter but below the shearing strength of the pinion teeth.

A large oil reservoir is incorporated into the drive-end shield.

Sect. L61 STARTER MOTOR—OPERATION TESTS

If the starter does not operate satisfactorily, certain tests can be carried out whilst it is on the engine. If any component of the starter is found to be faulty, fit a replacement starter.

1. Check battery isolating switch is in the ON position.
2. Check that battery is fully charged.
3. See that cable connections are securely made.
4. Push starter button; if starter does not operate, connect voltmeter between **SOL** terminal on starter and—terminal. Push starter button again. If no reading on the voltmeter, the fault is between the button and starter.
5. Push starter button, if solenoid clicks it indicates that the switch is working on first contacts only and full load current is not being applied to starter. Faulty armature adjustment or worn switch trigger can cause this.
6. If starter crashes into engagement, the switch trigger and plate may be worn on the step and slotted portions.
7. Intermittent starter operation with the starter button held down can be caused by second contacts (Fig. 85) on solenoid switch being burnt or starter brushes worn. Faulty connections on starter button or battery terminal posts can also cause this.
8. Worn bearing at driving end of starter will cause slow engagement and loss of power by the armature fouling the pole pieces.
9. If the starter operates but does not turn the engine, clutch may be slipping or teeth may be worn.

Sect. L62 STARTER MOTOR—TO REMOVE AND FIT

To Remove

1. Disconnect the three cables from the terminals.
2. Remove straps securing it in the cradle and remove starter.

To Fit

1. Place the starter in the cradle and position it so that there is a dimension of .125/156 in. between the pinion and starter ring face when starter is disengaged.
2. Secure starter to the cradle with the straps, ensuring that the saddle washers are in position.
3. Connect the three cables to the starter terminals.

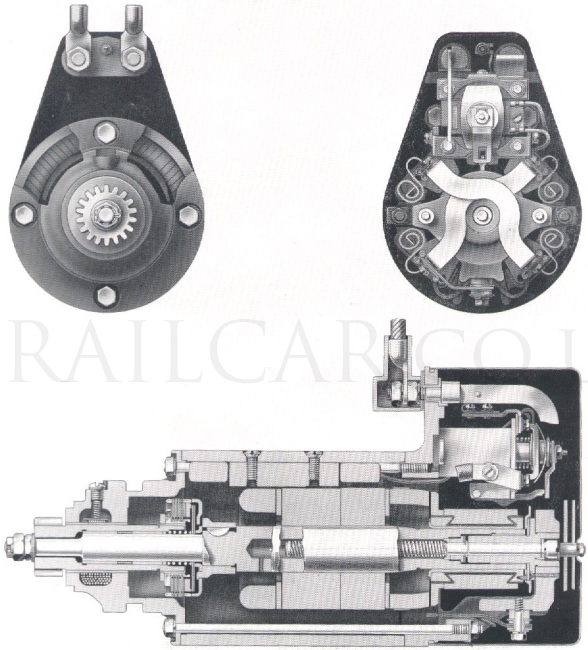

Fig. 84. The starter motor.

Sect. L63 STARTER MOTOR—TO DISMANTLE

Armature, Clutch and Pinion

1. Remove nuts and take off commutator end cover.
2. Remove nut on plunger with tool C.A.V. 842X.
3. Remove screws securing brush tags and lift brushes in their boxes and secure by wedging with brush springs.
4. Remove driving end shield screws, free end shield from yoke and gently withdraw armature assembly.
5. Hold armature securely, remove nuts in front of pinion, and withdraw pinion and end shield together.
6. Take out pinion spring.
7. Withdraw clutch and pressure plates from housing.
8. To remove armature spring and plunger, unscrew nut with spanner C.A.V. 5H.L.

Solenoid Switch

1. Remove screws securing positive terminal connector, main and auxiliary field connections to switch.
2. Remove nut on SOL terminal and take off switch connection, also the screw and flex connected to negative cable.
3. Remove fixing nut and take off switch without connections.

Commutator End Shield and Brush Gear

1. Remove the screw holding connector to brush holder.
2. Remove three screws securing brush holders, taking care not to break or lose the mica washers and three small bushes.
3. Remove the two brush holders.
4. Remove large insulating bush and two large washers, noting the position of the shaped washer.
5. Remove main positive and solenoid terminals.

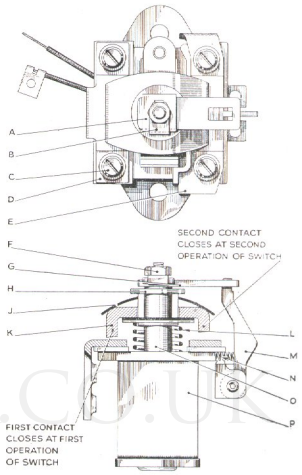

Fig. 85. Solenoid switch.

Sect. L64 STARTER MOTOR—OVERHAUL OF INDIVIDUAL PARTS

Armature Bearings

The bushes in the commutator end shield and driving-end shield are machined in position. For replacement it is desirable that end shields complete with bushes are used as supplied for spares.

A special tool is required for removing and replacing internal bush in commutator end of armature.

Commutator

The commutator surface must be clean and free

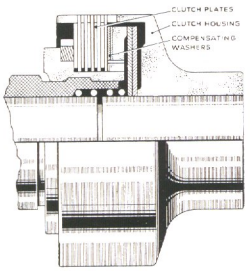

Fig. 86. Starter motor clutch.

from uneven discoloration. There must be no deposit bridging between the bars.

Clean with fine grade glass paper, not emery. If in a badly pitted condition, skim up in a lathe. Take a very light cut and use preferably a diamond tool to obtain high finish.

After turning, or if mica is high, undercut mica to a depth of $\frac{1}{32}$ in.; start with a three-cornered file and finish with a hacksaw blade ground to width of mica.

Clutch and Pinion

Renew clutch plates and pinion if worn.

Test the clutch for slip torque by rigging up as shown in Fig. 87.

Insert the clutch plates, alternately bronze and steel, five of each, starting with a bronze plate so that the last one will be steel to take the pressure of the small springs. Smear the parts lightly wtih grease.

Check that a new pinion has the same number of teeth as the old one, and test thread in the inner race of clutch for smooth action. See that the pinion spring has not lost compression.

Fit the small initial pressure springs with the large diameter end in the clutch race holes. Fill the pinion with grease.

Feed the pinion through the end shield, lifting the felt lubricating pad to prevent damage.

Replace pinion spring and engage pinion with inner race of clutch.

Push the pinion home against spring pressure and replace the nut and locking nut on the shaft. Check that the nuts are up against the shoulder on the shaft before inserting split-pin.

To Test Clutch for Slip Torque

After assembly the clutch must be tested for slip torque.

Rig up the clutch as shown in Fig. 87, with an arm one foot long and apply weight to the end.

When newly assembled the clutch must be adjusted to slip at 100 to 115 lb./ft. (13.8 to 15.8 kg. m.) and tested ten times. Then adjust to slip at 80 to 100 lb./ft. (11.0 to 13.8 kg. m.).

If the clutch slips at less than 80 lb./ft. (11.0 kg. m.) torque, a compensating washer (Fig. 86), must be fitted between clutch plates and back ring. Washers are available .004 in. and .006 in. (.1016 mm. and .1524 mm.) thick, and one or more must be inserted as required.

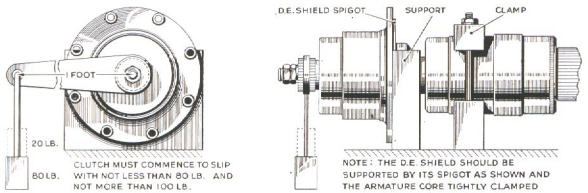

Fig. 87. Testing clutch slip torque.

To Renew Pinion without dismantling Starter

If pinion teeth are badly worn, a new pinion can be fitted without dismantling starter if considerable care is used.

1. Remove split-pin and castellated nut (Fig. 89), from shaft.

2. Stand starter on end, pinion uppermost. Loosen thin shaft nut, keep pinion held down firmly against spring pressure and take off nut.

3. Remove lubrication screw (Fig. 84) and spring.

4. Whilst still maintaining resistance against spring, turn pinion slowly in opposite direction to rotation when driving, anti-clockwise from pinion end. Gradually release pressure whilst turning until pinion is unscrewed from clutch and free to remove from end shield.

   It is essential to do the operation slowly and carefully to avoid disturbing the clutch plate.

5. Check that pinion has same number of teeth as the old one.

6. Carefully insert pinion into end shield until it meets resistance, then turn slowly in direction of starter rotation, clockwise until forward movement is felt. This indicates that the pinion has engaged with clutch plates.

7. Push pinion into end shield to full extent against spring pressure. Hold in position and screw on thin shaft nut. Screw on castellated nut, tighten and insert split-pin.

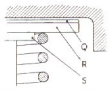

Fig. 88. Arrangement of packing washers of bridge piece.

8. Replace small spring and lubricator.

Brush Gear

Check that the brushes are free in their guides and flex leads are free for movement.

Positive and negative brush holders must be insulated from one another and from rest of starter.

Test insulation with test lamp.

Check brush spring pressures by hooking spring balance under springs. The correct tension is 18 to 24 oz. (510 to 680 grm.).

Replace brushes if worn so that the flexibles nearly touch the bottom of the slot in the brush holders.

Bed brushes to commutator with fine glass or carborundum paper. Don't reverse brushes after bedding.

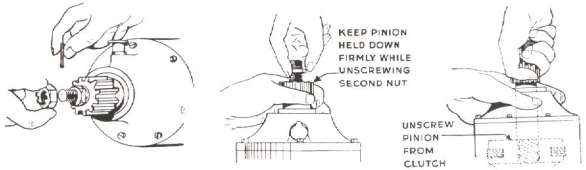

Fig. 89. Renewing starter motor pinion.

Sect. L65 STARTER MOTOR—TO ASSEMBLE AND CHECK PERFORMANCE

To reassemble, reverse the dismantling operations.

Assemble brush gear on commutator end shield and fit assembly to yoke. See that securing screws are tight.

Fix the solenoid switch in position and join up the field connections.

Feed the armature and clutch assembly into the casing. The brushes must be raised in their boxes to allow commutator to pass.

Check that all connections, both internal and external, are clean and tight.

To Check Performance

Before fitting starter to engine a rough test may be made.

Connect a 24-volt battery to the main starter terminals, battery positive to starter positive. Connect a lead from battery positive to SOL terminal through a push-button switch. Insert a piece of paper between the second contacts (Fig. 85), of the solenoid switch.

Operate the push-switch and starter should revolve in a clockwise direction, viewed from pinion end, and the pinion move approximately one inch forward, where it will remain revolving slowly so long as the push-switch is closed. Don't prolong the test.

Release the switch and remove the paper from the solenoid contacts. Operate the push-switch again momentarily and the starter should work as before but at a higher speed.

Sect. L66 AIR COMPRESSOR—DESCRIPTION

The air compressor (Fig. 91), which is mounted at the top front of the crankcase, is an air-cooled reciprocating piston type.

The crankshaft runs in ball-races, one located in the rear end cover and two in the drive cover. The connecting rods are white metalled at the big ends and bronze bushed for the gudgeon pins at the small ends. The pistons, which are fitted with two compression rings and a scraper ring at the piston skirt, are secured to the connecting rods by fully floating gudgeon pins secured at either end by circlips.

The cast-iron cylinder head embodies the inlet and delivery valves.

Oil is supplied to the compressor through a pipe connected to the engine main oil gallery and pressure fed to a lubricator strap which is fitted to the crankshaft centre bearing. Oil reaches the big-end bearings through drilled passages in the crankshaft. The gudgeon pins, cylinder walls and crankshaft ball bearings are lubricated by oil thrown out by big-end bearings. Surplus oil drains back into the sump, via the timing case, through an aperture in the compressor end flange.

Sect. L67 AIR COMPRESSOR—TO REMOVE AND FIT

To Remove

1. Uncouple air pipe and oil pipe connections.
2. Remove nuts securing compressor to the timing case and remove compressor complete with driving gear from the engine.

To Fit

Replacement of the compressor on the engine is the reversal of removal.

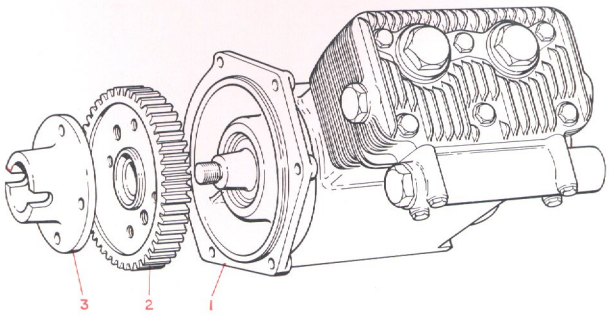

Fig. 90. The air compressor.

Sect. L68 AIR COMPRESSOR—TO DISMANTLE AND ASSEMBLE

To Dismantle

1. Remove crankcase breather assembly and base cover.
2. Remove the cylinder head, discarding the gasket.
3. Remove the oil inlet supply flange and unbolt the lubricator strap from the centre journal of the crankshaft.
4. Mark the connecting rods, and their corresponding caps. Remove the caps and withdraw the piston and connecting rod assemblies through the top of the cylinder bores.
5. Remove setscrews securing the rear end cover and ease off the cover.
6. Remove four setscrews securing drive adaptor to the driving gear and remove adapter.
7. Remove split-pin and nut from end of crankshaft and remove driving gear.
8. Remove setscrews securing the drive housing and withdraw housing with the crankshaft.
9. Withdraw the crankshaft from the drive housing.

To Dismantle the Cylinder Head

1. Remove the inlet manifold.
2. Unscrew the delivery valve caps and withdraw the valve springs and discs.
3. With a special tool unscrew the delivery valve seats.
4. Using a special tool withdraw the inlet valve spring keepers. Remove the springs and discs.

Pistons and Rings

The original bore diameter is to the limits of 2.625 in./2.626 in. and the standard clearance for cast-iron pistons is .001 in./.0025 in.

Fit new standard rings if wear in bore is +.005 in. If wear in bore is +.005 in. to .010 in., bore out to +.010 in. and fit new .010 in. oversize pistons and rings, and fit new oversize rings if wear is —.010 in. to .015 in.

Wear above +.015 in. should not normally occur.

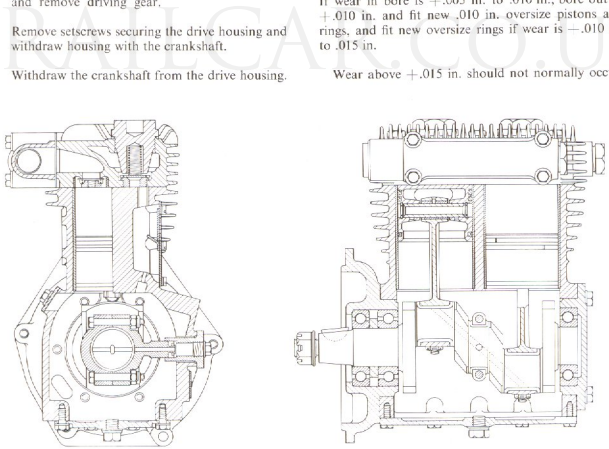

Fig. 91. Sectioned view of air compressor.

Piston and scraper ring gap should not exceed .012 in. Gaps on new rings should be between .003 in. to .006 in. on butt-jointed types and .002 in. on scarf-jointed rings.

Bearings

Bearings should be fitted with particular attention to the clearance at the sides of the crankpins. It should not be possible to insert thicker than .003 in. feeler between crankpins and journal shoulders.

Check that ball-races are in good condition and rotate freely.

Connecting Rods

In the event of the connecting rod big-ends being remetalled it is important to maintain the correct connecting rod length of 4.127 in./4.123 in., between centres.

Valves

The free length of delivery valve springs should be 1.7/64 in. but if found to be 1.1/16 in. or less, they should be renewed.

If the valve discs are ridged or distorted they should be renewed, relapping the valve seats if necessary.

To Assemble

1. Insert connecting rods and piston assemblies from the top of the cylinder bores.
2. Reassemble the crankshaft in the drive housing.
3. Insert the crankshaft in the cylinder block and secure the drive housing using a new joint between the faces.
4. Refit the rear end cover using a new joint.
5. Locate the connecting rods on the crankshaft bearings and place the correct cap (marked on dismantling) on its connecting rod, and secure the rods to the crankshaft.
6. Fit the lubricator strap to the centre bearing of the crankshaft. Replace the oil inlet supply flange. Care should be taken during this operation so as not to damage the seal when inserting the lubricator strap into the seal housing.
7. Refit the base plate, using a new joint.
8. Assemble breather to crankcase.

To Assemble the Cylinder Head

1. The new inlet valve disc and springs should be located in their respective places and the inlet valve spring keepers pressed into position.
2. Refit the delivery valve seats, and place the delivery valve discs in position. Spread coil of spring and fit into delivery valve cap. Assemble cap with copper washer.
3. Refit the inlet manifold using a new joint.
4. Using a new gasket, refit the cylinder head.

Sect. L69 THE AIR CLEANER—DESCRIPTION

Air drawn from the atmosphere first passes through the pre-cleaner, and then enters the main oil-bath filter.

The oil-bath-type air cleaner filters the air in two stages. Firstly, by reversal of the air flow and the impingement of the air on the surface of the oil. Secondly, by passing the oil-laden air through the filtering element and depositing the grit and dust on the oil-wetted wire wool element, allowing the cleaned air to pass into the engine.

The action of the air cleaner through the speed range is shown in Fig. 93.

No Air Flow

The oil levels shown are maintained only when no air is passing through the cleaner.

Engine Speed—Low

The oil level in the outer chamber is lowered with a consequent rise behind the baffle. The air strikes the free surface of the oil, and is deflected upwards, leaving a certain amount of the impurities in the oil. But some impurities are carried upwards, mixed with the air, and oil mist; these are removed when the air passes through the element. All oil and sludge drains from the filter element back into the oil bath.

Engine Speed—High

The action of the air filter at high speeds is the same as at low speeds, except the level in the outer chamber is still further lowered, and the level behind the baffle consequently rises and spills over the baffle, giving additional oil to the upward air flow.

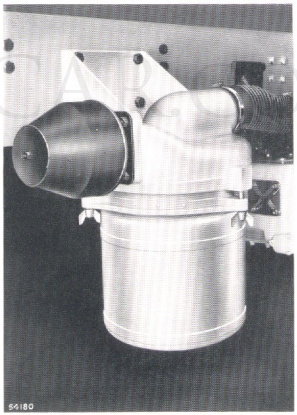

Fig. 92. The engine air cleaner.

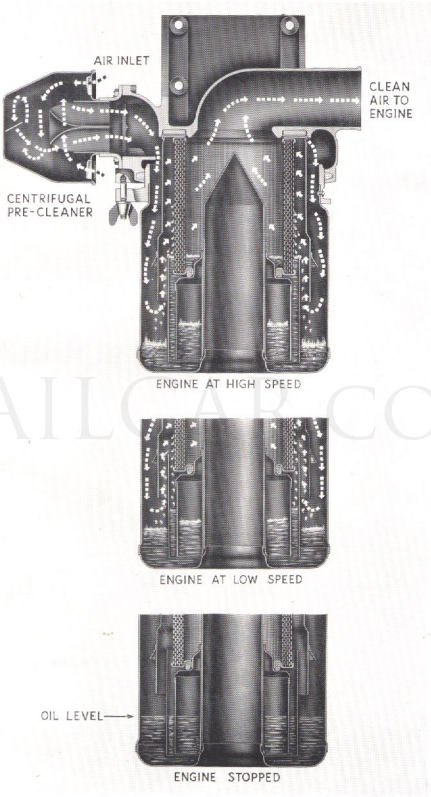

Fig. 93. Operation of the oil-bath air cleaner.

Sect. L70 AIR CLEANER—MAINTENANCE

Filter maintenance consists of keeping the element clean and the oil to the level indicated in Fig. 93.

Remove the filter unit and pre-cleaner from the top cover and remove to a suitable place for cleaning.

Remove the element and wash it thoroughly in petrol or paraffin. Clean thoroughly in petrol, paraffin or fuel oil, the baffle assembly, element support, bowl, and pre-cleaner. Examine the element carefully for punctures or any damage. Assemble the filter unit and fill with oil to arrow point on the oil level indicator inside the bowl. Refit the filter unit to the top cover.

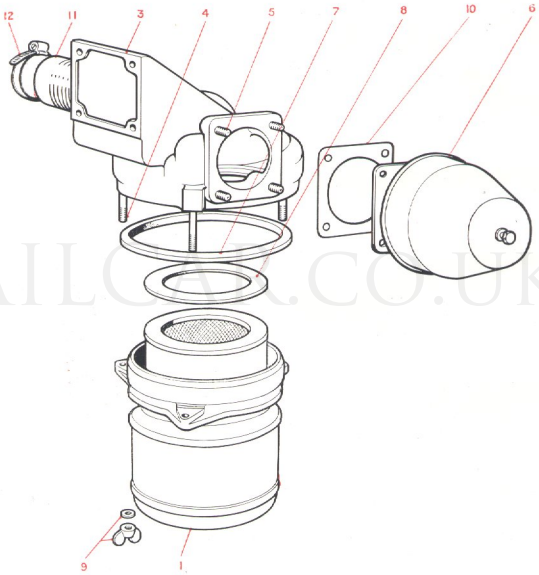

Fig. 94. Exploded view of air cleaner.

1. AIR FILTER.
2. SEALING RING, RIVET.
3. AIR FILTER COVER BRACKET.
4. STUD.
5. STUD.
6. PRE-CLEANER.
7. FELT SEAL, OUTER.
8. FELT SEAL, INNER.
9. WING NUT, WASHER.
10. JOINT.
11. HOSE CONNECTION.
12. JUBILEE CLIP.

Sect. L71 TACHOMETER GENERATOR—DESCRIPTION

The engine tachometer generator (Fig. 95) is mounted at the front of the engine on the timing case cover and is driven in tandem with the compressor from the timing gears.

If a fault should occur in the generator it is recommended that it be returned to B.U.T.

Sect. L72 TACHOMETER GENERATOR—TO REMOVE AND FIT

To Remove

1. Isolate the batteries.
2. Remove terminal box cover and disconnect electrical connections. Should electric conduit piping be connected to the generator, this should be removed also.
3. Unscrew the three nuts securing the generator to the timing case and lift the generator off the studs.

To Fit

Fitting is the reverse of the removal procedure, ensuring that the tongue on the drive adapter engages in the slot cut in the adapter mounted on the compressor drive gear.

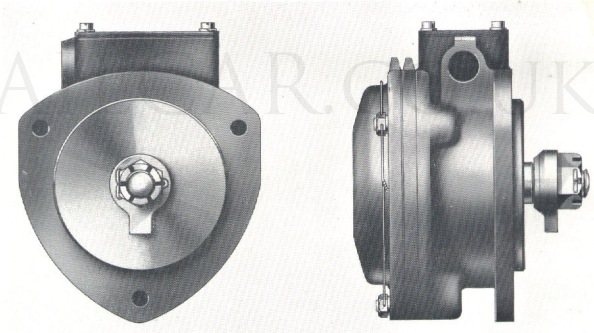

Fig. 95. The engine tachometer generator.

FLUID COUPLING

(A- and L-Type Units)

CHAPTER M

CONTENTS

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Fluid Coupling:	
Description	M3
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To Remove and Fit	M6
To Dismantle and Assemble	M7

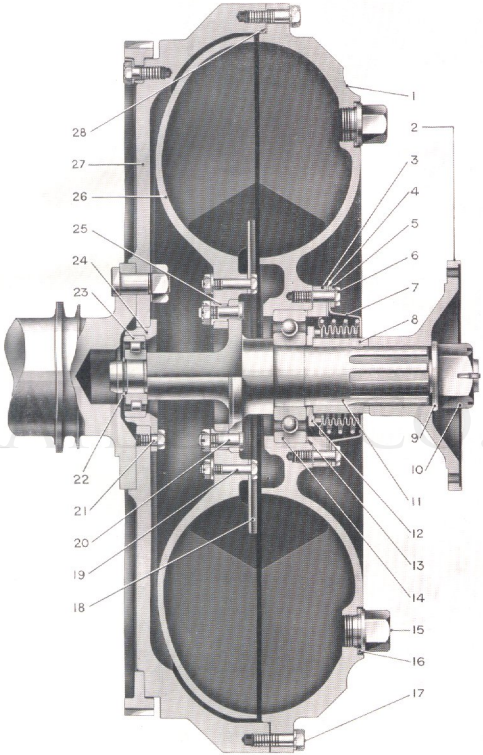

Fig. 1. Section through fluid coupling (L-type).

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.

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.

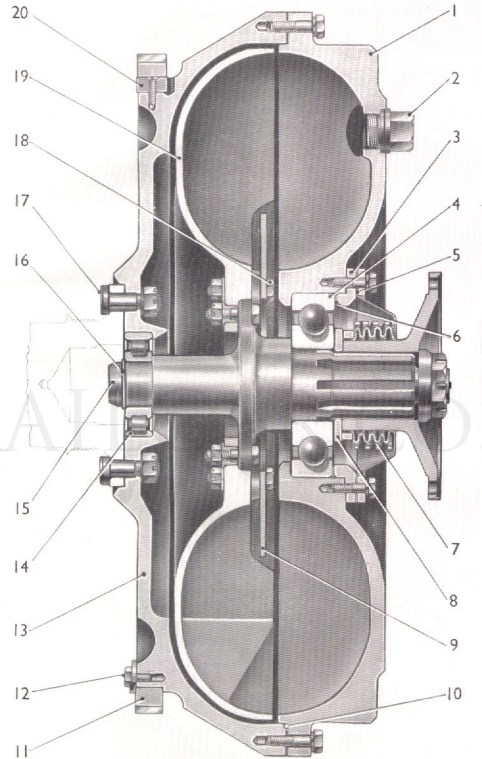

Fig. 2. Section through fluid coupling (A - type).

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/0338

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.

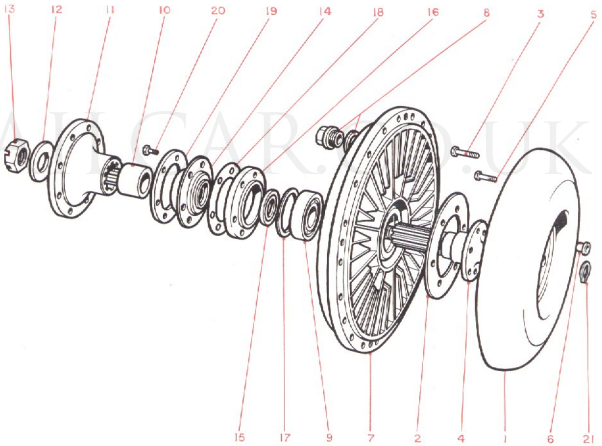

Fig. 3. Exploded view of fluid coupling (L - type).

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.

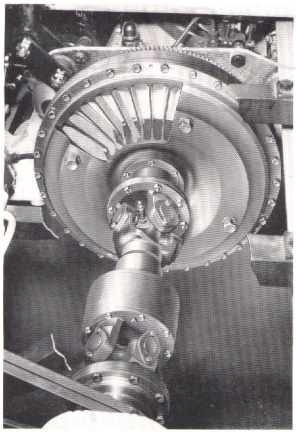

Fig. 4. Fluid coupling in position, shown part cut away.

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

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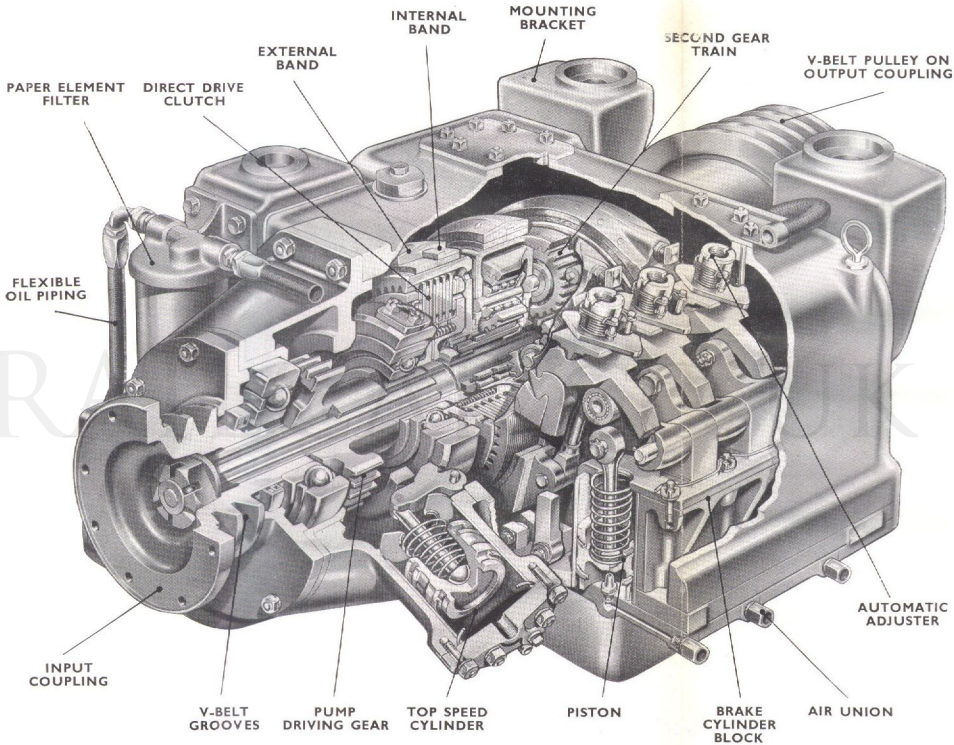


Fig. 1. The Gearbox.

Sect. S1. GEARBOX—DATA

(TYPE R.14).

Type	Epicyclic gearbox, 4 forward speeds			
Gear Ratios	1st speed	4.28:1	3rd speed	1.59:1
	2nd speed	2.43:1	4th speed	1.1
Rotation:	Clockwise looking on input end			
Mounting:	Independent mounting using bearer brackets			
Operation:	By air pressure at 65 lbs./sq. in. $\pm 2\frac{1}{2}$ lbs.			
Oil Pump:	Gear pump driven from input shaft			
Oil Capacity:	$2\frac{1}{2}$ gallons (approx.)			

Brake Setting Gauge Dimensions

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

Sect. S2. GEARBOX—DESCRIPTION

(*See Figs.* 2 *and* 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 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.

Sect. S3. GEARBOX—BRAKE OPERATION

(*See Figs.* 3 *and* 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.

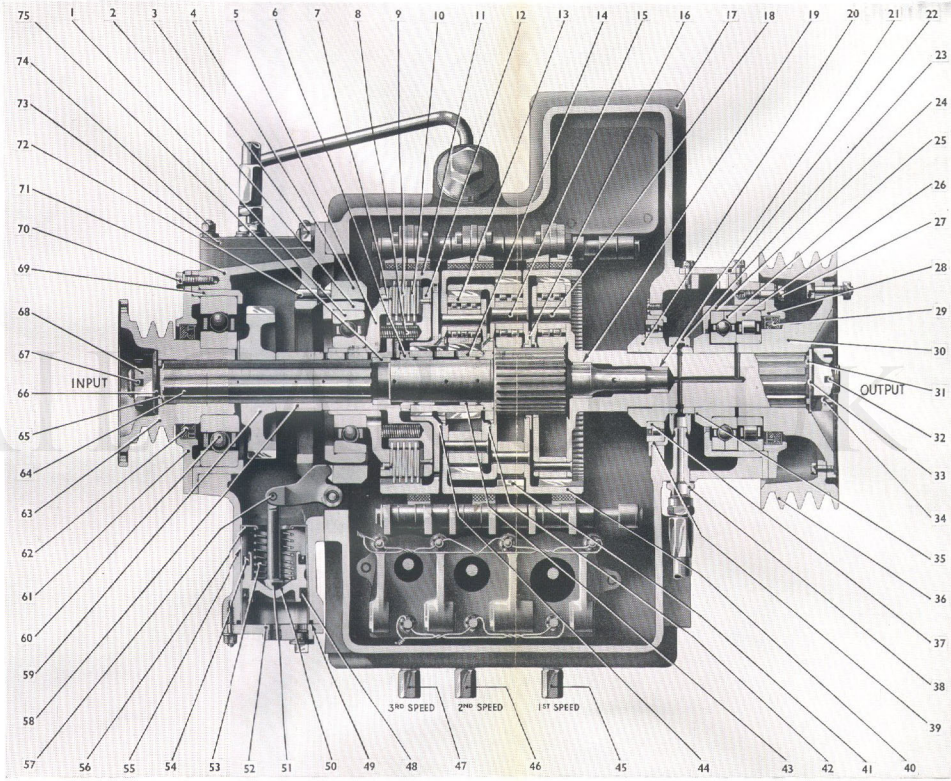


Fig. 2. Section through Gearbox.

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 Figure* 5) which keeps the brakes constantly at their correct setting.

Operating Sequence of the Brakes (*see Figs.* 3 *and* 4).

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

When the change speed lever is moved into a gear position, air is admitted to the cylinder, forcing the piston (22) upwards. This movements 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.

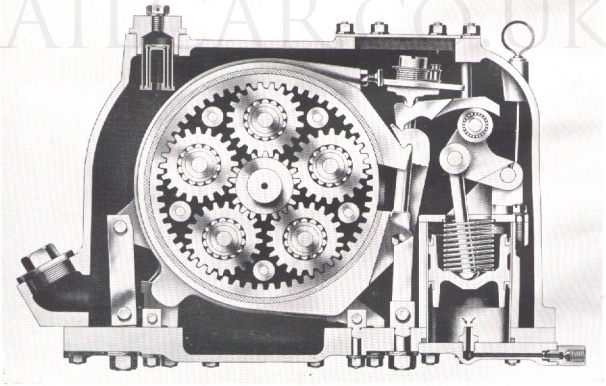


Fig. 3. Section through 1st Speed Band Brake. (Brake On)

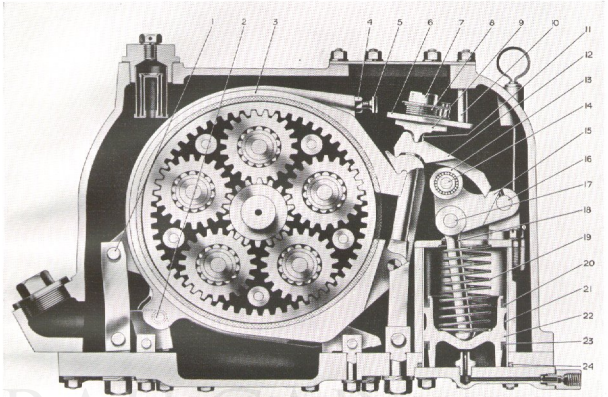


Fig. 4. Section through the 1st Speed Band Brake. (Brake Off)

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

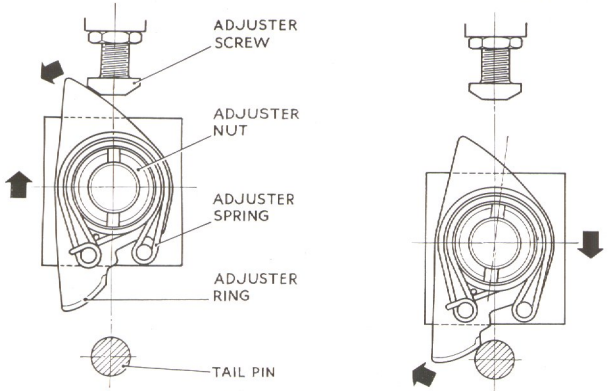


Fig. 5. Operation of the Automatic Adjuster.

Sect. 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.

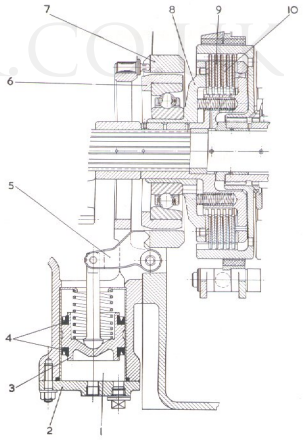
Wear on the brake linings will allow the thrust pad to move higher. When this happens the automatic adjuster ring striking the adjuster screw will be rotated **anti-clockwise.** The adjuster ring is pinned to the spring in such a way that this action loosens the spring from contact with the adjuster 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.

Sect. S5. GEARBOX—TOP SPEED CLUTCH OPERATION

(See Fig. 6).

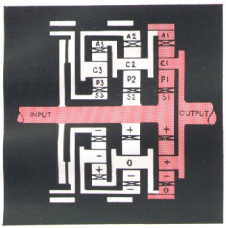
Air is admitted to the cylinder (1) forcing the piston (3) to act through the lever (5) to move the trunnion ring (7) with bearing housing (6) and bearing against the clutch sliding panel (8). This then moves forward under pressure to lock the clutch plates (9) and (10) together, the running gear then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

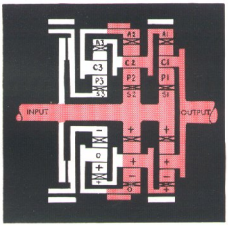


1. CYLINDER
2. CYLINDER COVER
3. PISTON
4. SEALS
5. OPERATING LEVER
6. BEARING HOUSING
7. TRUNNION RING
8. SLIDING PANEL
9. CLUTCH PLATE (OUTER)
10. CLUTCH PLATE (INNER)

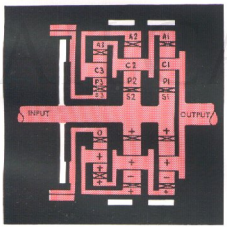
Fig. 6. Top Speed Clutch Actuation.



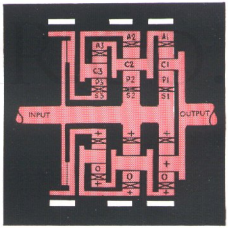
1ST. SPEED



2ND. SPEED



3RD. SPEED



4TH. SPEED

GEAR	3rd	2nd	1st
ANNULUS	A3	A2	A1
CARRIER	C3	C2	C1
PLANET	P3	P2	P1
SUN	S3	S2	S1

■ = 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.

Sect. 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.

Sect. S7. GEARBOX—PRINCIPLE OF OPERATION

(*See Fig.* 7).

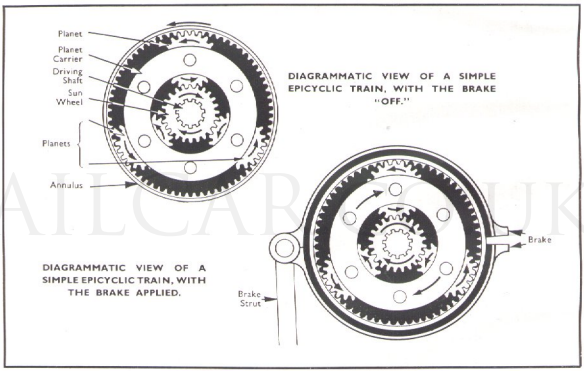


Fig. 8. Diagrammatic View of Epicyclic Gear Train.

There are in this gearbox three trains each composed of the parts shown on Figure 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.

Sect. 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 oil specification relating to the gearbox is quoted in Railway Standing Instructions.

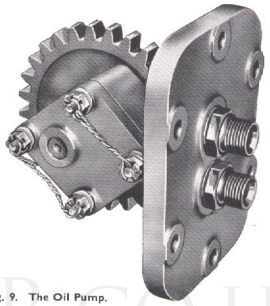


Fig. 9. The Oil Pump.

Sect. S9. GEARBOX—MAINTENANCE

The following maintenance procedure should be carried out at the intervals quoted in Railway Standing Instructions.

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

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.

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.

Thoroughly clean top of gearbox and remove inspecting 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 (*see Figures* 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).

Check that brakes are still serviceable. (Relining is necessary when the top faces of the adjuster nut and pullrod coincide).

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

Drain gearbox and refill with new oil.

Remove gearbox for complete overhaul.

Sect. S10. GEARBOX—SERVICING THE AIR PISTONS

To Remove and Fit 1st, 2nd and 3rd Speed Pistons (*see Fig.* 10)

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.

Remove the pistons and springs.

Wash all components in paraffin, drain and immerse in clean oil.

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.

Inspect "O" ring seals (*item* 24 *Figure* 4) at base of liners, and renew if hardened.

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.

Fit the cover plate and gasket, secure with nuts and washers.

When new seals are being fitted or the pistons are removed for examination, cylinder liners, seals and pistons should be oiled before being replaced, preferably with "OILDAG" Colloidal Graphite. If the gearbox has been standing without use for some months, the pistons should be withdrawn and the parts oiled as described above.

To Remove and Fit 4th Speed Piston

Remove the cover and gasket, the piston will emerge under pressure of the piston return spring.

Inspect "O" ring seal at base of liner and renew if hardened.

Wash the components in paraffin, drain and immerse in clean oil.

Assemble parts and secure with nuts and washers.

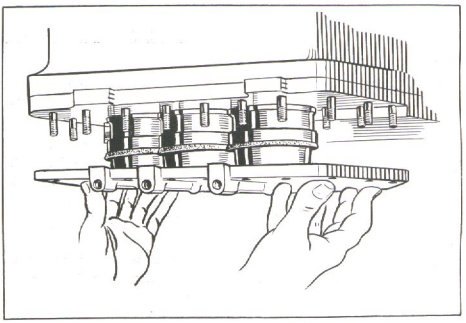


Fig. 10. Removing the Cover Plate (1st, 2nd and 3rd Speeds).

Sect. 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 non-hardening 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 non-hardening jointing compound to the face 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.

Fit belt drives and cardan shaft.

Sect. 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.

Fit coupling (and pulley if fitted).

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

Release 1st Gear.

Fit belt drives (if fitted) and cardan shaft.

Sect. 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).

Clean the exterior of the filter assembly before removing the sump.

Unscrew the centre bolt (5) and withdraw the sump (3) and filter element (4) from the head (1); remove the element from the sump.

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.

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.

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).

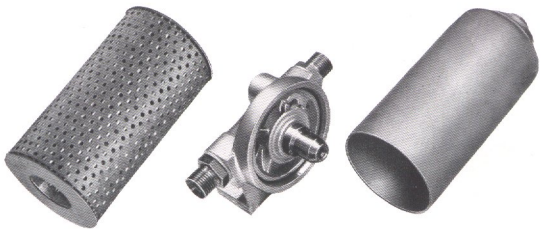


Fig. 11. View of Filter.

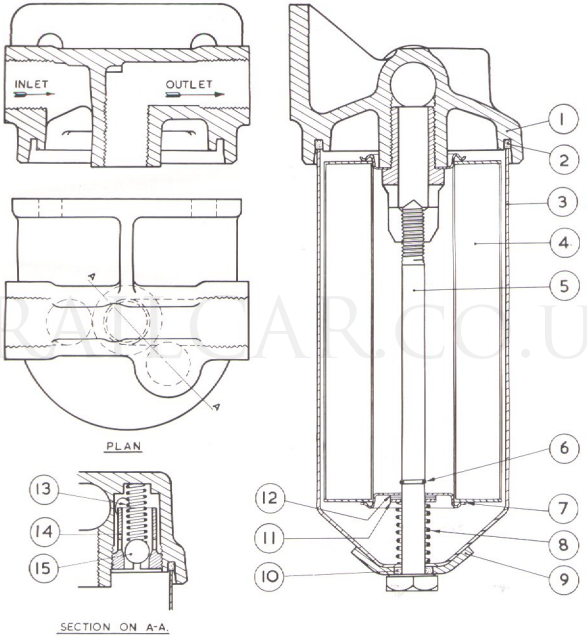


Fig. 12. Drawing of Filter.

Sect. S14. GEARBOX—SERVICING THE BRAKES

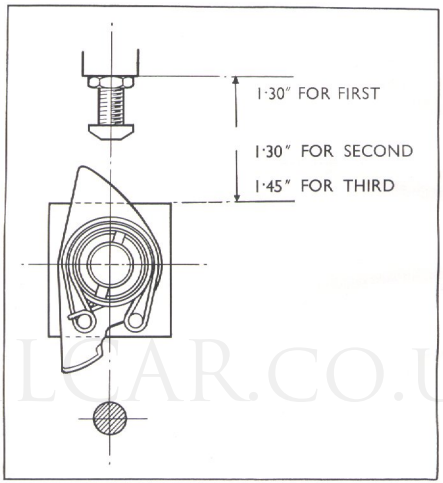


Fig. 13. Brake Setting Dimensions.

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.

GEARBOX—THE BRAKE SETTING DIMENSION

(*See Figs.* 13 *and* 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 between 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.

GEARBOX—BRAKE ADJUSTMENT

(*See Figs.* 5 *and* 14)

Remove the adjuster spring.

Loosen the locknut on the adjuster screw in the brake band, and screw the adjuster screw right in.

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.

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.

If the gauge has too much clearance, the adjuster nut must be screwed anti-clockwise to obtain the correct setting.

When the correct setting has been obtained, release the brake, hold the adjuster ring against the tail pin and replace the spring.

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.

Lock the adjuster screw, with the face which contacts the adjuster ring vertical.

Release the spring, then screw the adjuster nut anti-clockwise half a turn and replace the spring.

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.

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.

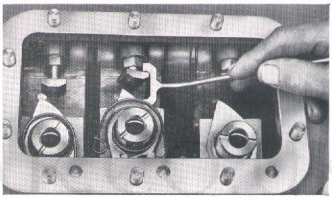


Fig. 14. Gauge Application.

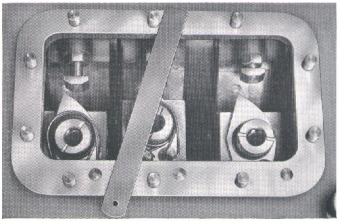


Fig. 15. Checking Movement of Adjuster Nut.

Final Adjustment

Insufficient Gauge Clearance:—

If the gauge will not enter, release the brake and move the adjuster screw half a turn outwards and relock.

Apply and release the brake until the adjuster nut stops turning.

Check the gap.

Repeat these operations if required.

Excessive Gauge Clearance:—

If the gauge has too much clearance, move the adjuster screw half a turn inwards and relock.

Release the adjuster spring and screw the adjuster nut half a turn in the anti-clockwise direction.

Replace the adjuster spring, apply and release the brake until the adjuster nut stops turning.

Check the gap.

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.

GEARBOX—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'.

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 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.

Sect. 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.

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.

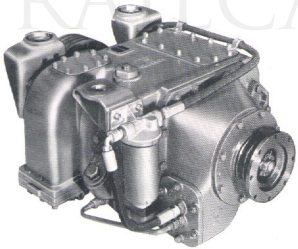


Fig. 16. View of Gearbox (a).

Fig. 17. View of Gearbox (b).

Sect. 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 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.

Do not disturb pivot pin (72).

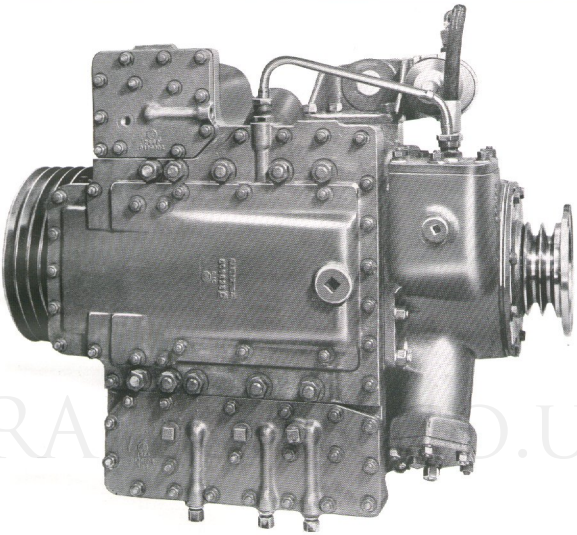


Fig. 18. View of the Bottom Cover, etc.

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.

To 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.

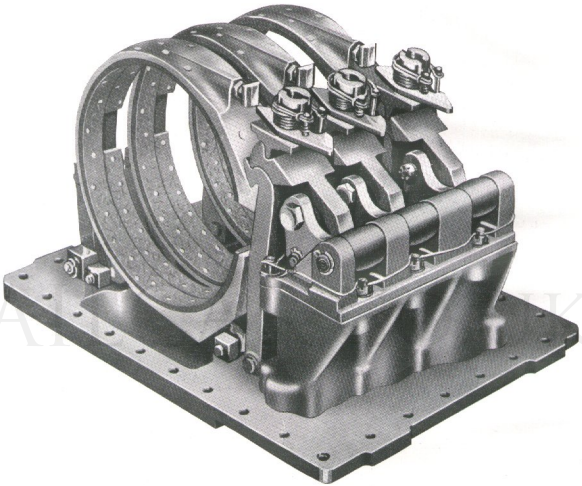


Fig. 19. The Bottom Cover and Brake Band Assembly.

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 around the centralizers to prevent the springs (2) from flying out.

Extracting the Pistons

Refer to Section S10 for removal of pistons.

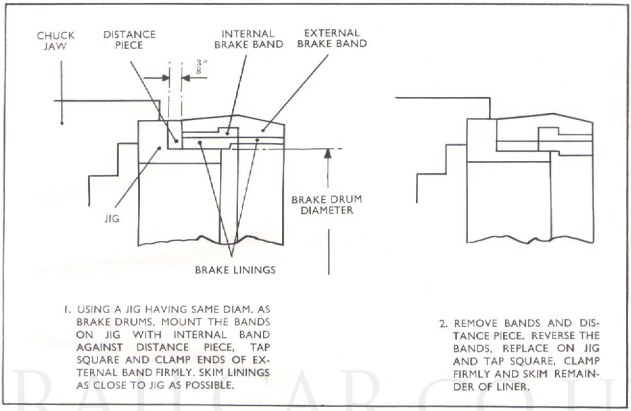


Fig. 20. Relining the Brake Bands.

Sect. 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 fit 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.**

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 *Figure* 20, the bands can then be replaced as explained in Section S18.

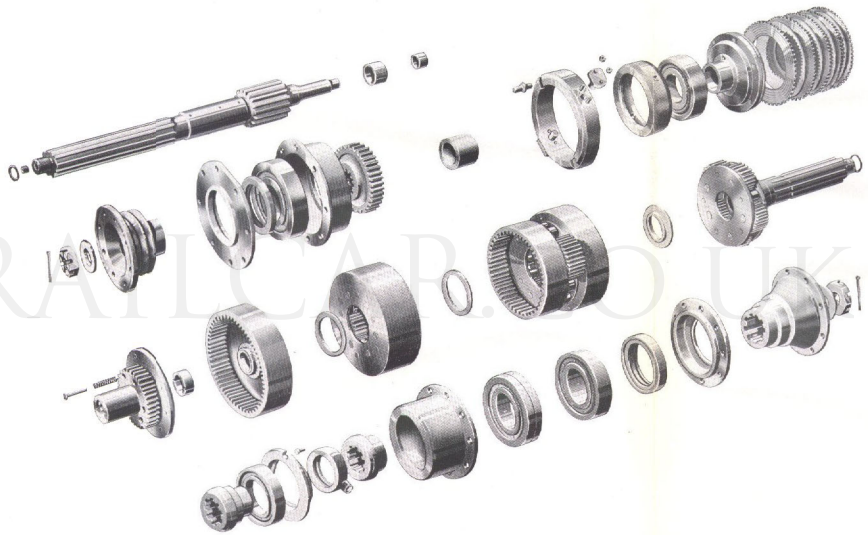
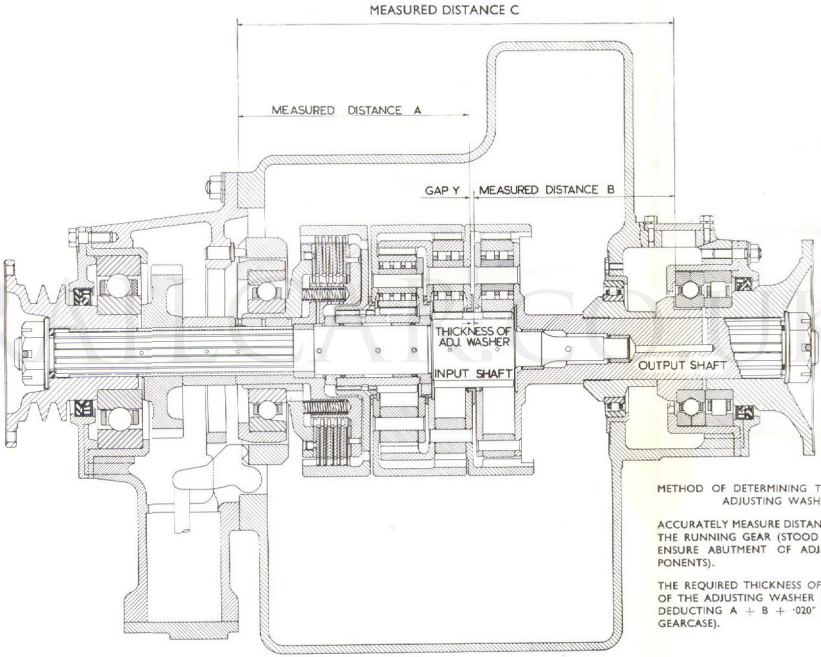


Fig. 21. Running Gear, etc. (Shown in Sequence).



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.

Sect. 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 Fig. 22. When new flanged bushes are fitted **ALL** brakes should be re-lined.

Pistons—To Assemble and Fit

Refer to Section S10 for replacement of the pistons.

Brake Bands—To Assemble and Fit (*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.

Fit the adjuster springs (8).

Fit 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.

Running Gear—To Assemble and Fit (*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 fitted in the gearcase, (since 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).

Fit 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).

Assemble 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.

Fit 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 fitted followed by the pump driving gear (59).

The Front Cover Assembly—To Fit (*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).

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).

The Rear End Assembly—To Fit (*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.

Fit 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 fitted complete with oil seal (29) (first applying non-hardening jointing compound), secure by fitting 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.

Fit "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.

Sect. 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

Final Drive:—	*Page*
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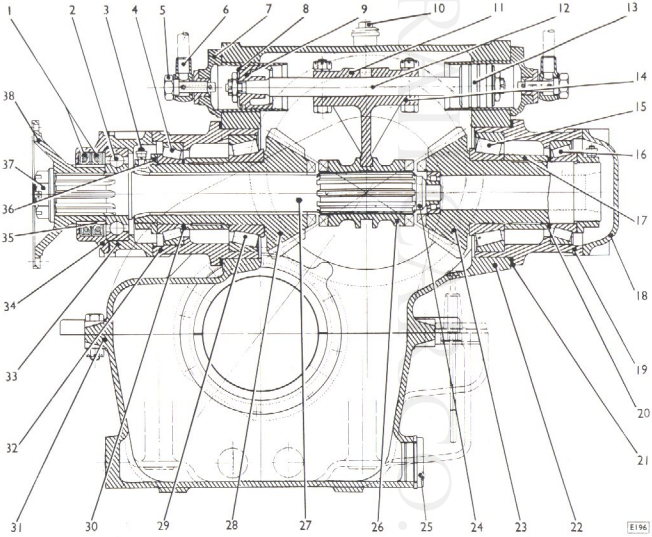


1. DRIVING SHAFT OIL SEALS.
2. DRIVING SHAFT BEARING.
3. BEVEL PINION BEARING NUT LOCKING BOLT.
4. OUTER TAPER ROLLER BEARING.
5. AIR CYLINDER BANJO PIN AND PISTON STOP BOLT.
6. AIR CYLINDER BANJO UNION.
7. AIR CYLINDER.
8. PISTON SEAL WASHER.
9. PISTON.
10. AXLE BREATHER.
11. "NEUTRAL" LOCK PLATE.
12.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

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.

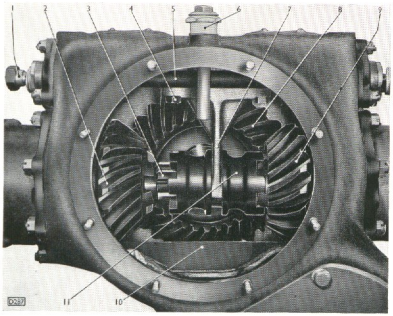
Filling and drain plugs, together with a dip-stick, are provided for lubricant ; a breather is fitted on top of the casing.

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

Alternative methods of isolating the final drive.

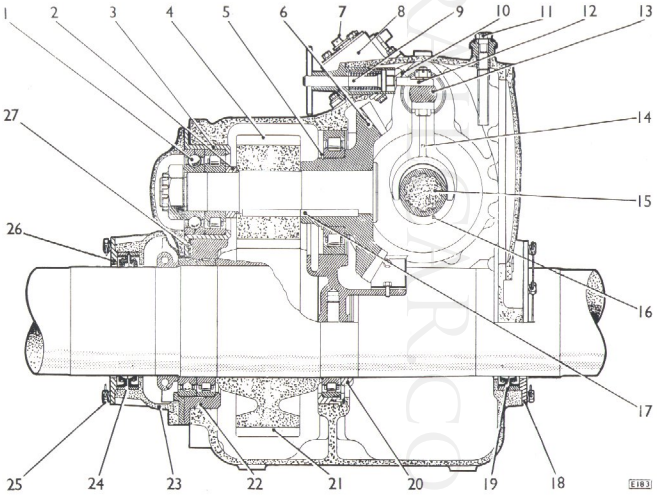
Stop the car and ensure that the handbrake is firmly applied. If sufficient air pressure is available proceed as follows : —

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.

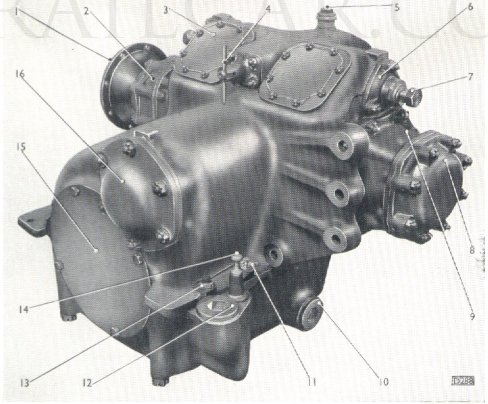
To Dismantle.

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 ½ 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.

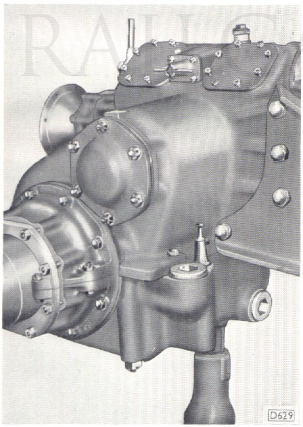


Fig. 5. Method of supporting bottom half of final drive casing whilst removing torque arm.

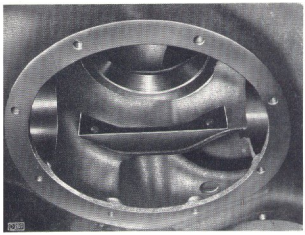


Fig. 6. Final drive casing showing oil trough.

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.

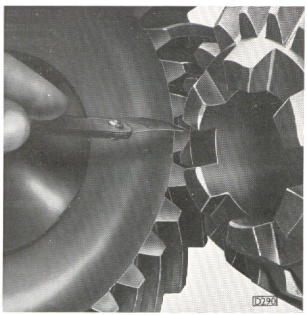


Fig. 7. Method of measuring bevel wheel and pinion backlash.

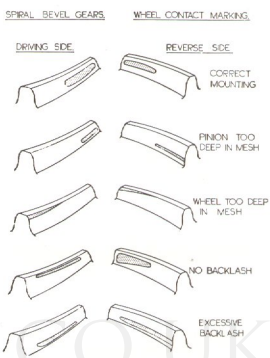


Fig. 8. Marking on teeth of spiral bevel wheel.

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.

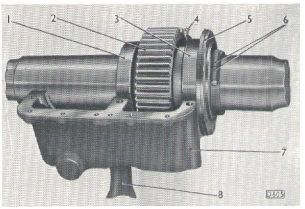


Fig. 9. Method of fitting bottom half of final drive casing.

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. Driving Shaft Spigot Bearing.	Z9/44813	0·5625 in. (14·29 mm.)
	Z9/44815	0·5425 in. (13·78 mm.)
	Z9/44816	0·5225 in. (13·27 mm.)

PROPELLER SHAFTS

CHAPTER U

CONTENTS

Propeller Shafts :—	*Page*
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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.

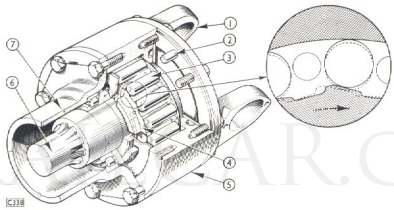
The first shaft, from the fluid coupling to the epicyclic gearbox, incorporates the freewheel mechanism (*see Figs.* 1 *and* 3).

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.



1. YOKE FLANGE.
2. DOWEL.
3. ROLLER.
4. SPLINED SLEEVE.
5. OUTER CAGE.
6. DRIVING SHAFT.
7. SLEEVE.

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).

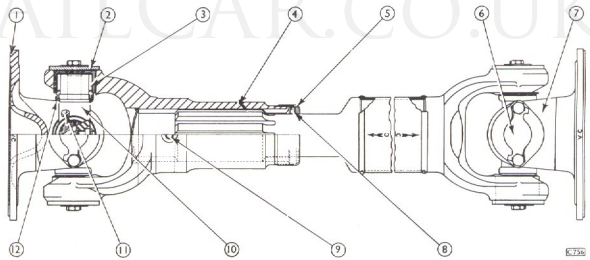


Fig. 2. Universal joint with tubular shaft.

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.)

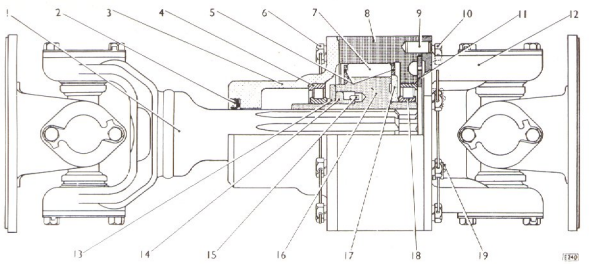


Fig. 3. Arrangement of first propeller shaft and freewheel.

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.

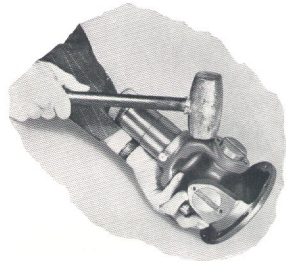


Fig. 4. Method of removing needle roller bearings from universal joint.

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.

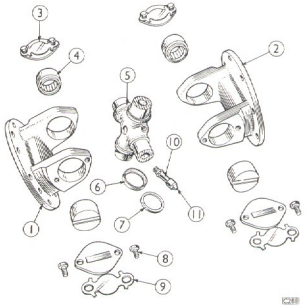


Fig. 5. Exploded view of needle roller bearing type universal joint.

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

(A- and L-Type Units)

CHAPTER R

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Fan—To Dismantle and Assemble	R4

Sect. R1 RADIATOR—DESCRIPTION

(Fig. 1)

The radiator is flexibly mounted in two brackets on the car frame and positioned by a tie-rod. The main components are a flat tube cooling stack with aluminium top and bottom water tanks and two side standards.

Attached to the radiator is the fan cowl which encloses an eight-bladed fan, the driving shaft running in ball and roller bearings housed in the cowl. Six fixed diffuser blades in the cowl ensures maximum cooling efficiency.

A right-angle-drive gearbox mounted on the engine drives the fan through a propeller shaft. (*See* ENGINE and PROPELLER SHAFTS chapters.)

The radiator is filled from the side of the car through a filler pipe connected to the header tank. (*See* ENGINE chapter for water system layout.)

The water can be drained from the system by opening the drain tap located in the radiator water outlet pipe. (*See Fig. 1.*)

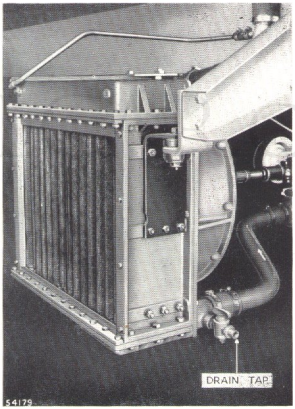

Fig. 1. Radiator showing position of drain tap.

Sect. R2 LUBRICATION

The fan shaft bearings should be lubricated through the grease nipple located at the bottom of the fan cowl. (*See* LUBRICATION CHART.)

For frequency of lubrication, see **Railway Standing Instructions.**

Sect. R3 RADIATOR—TO DISMANTLE AND ASSEMBLE

To Dismantle

1. Remove radiator complete with fan and cowl.
2. Remove fan cowl complete with fan from the radiator.
3. Remove nuts and bolts securing the side standards to the top and bottom tanks and remove side standards.
4. Unscrew nuts securing the top and bottom water tanks to the tube blocks and separate.
5. An individual tube can be removed from the block by inserting a lever under the locating washer at the bottom of the tube and exerting pressure to push the tube upwards until it is free of the rubber ferrule.

To Assemble

Assembly is the reversal of the dismantling procedure, but before assembling examine the rubber ferrules at the top and bottom of each tube for signs of perishing. If one or two have perished it is advisable to replace the whole set as follows and as illustrated in Fig. 2.

1. Lightly smear the tube holes in the tube plates (Fig. 2, A) with petroleum jelly and treat the outside diameter of the rubber ferrule (B) in a similar manner.
2. Press the ferrule into the tube holes (C) and lightly strike the ferrules with a hammer (D) to ensure that the flange on the ferrules fits flush on the tube plate.

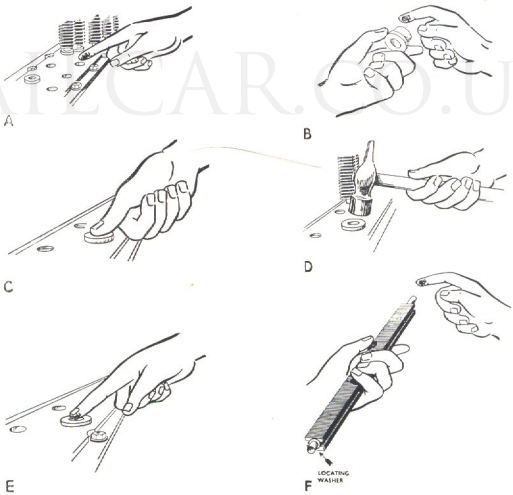

Fig. 2. Method of fitting rubber ferrules in radiator.

To replace the radiator tubes proceed as follows:

1. Smear the inside of the rubber ferrule with petroleum jelly (Fig. 2, E) and treat each end of the radiator tube in a similar manner.
2. The top and bottom ends of the tubes are distinguished by the top end having a long length of tube bare of gilling and the bottom end being fitted with a locating washer (F).
3. Enter the top end of the tube into the rubber ferrule in the top tank and press upwards until the short end of the tube is clear of the flange of the ferrule in the bottom tank. Carefully enter the bottom of the tube into the rubber ferrule taking care not to damage the ferrule by scoring and press down firmly until the locating washer rests on the flange of the rubber ferrule joint.

It is recommended that whilst the radiator is stripped it should be cleaned thoroughly both externally and internally. Any deposit in the tubes can be loosened by passing a rod down each tube.

When refitting the tanks use new joints, and paint with red lead before fitting.

Sect. R4 FAN—TO DISMANTLE AND ASSEMBLE

To Dismantle (A-type Engine)

1. Disconnect the lubricating pipe from the end cover.
2. Remove the nuts and washers securing the end cover.
3. Remove split-pin, nut and washer from the fan spindle.
4. Remove bearing circlip.
5. Drive the fan spindle from the bearing housing.
6. Remove the split-pins, nuts and washers securing the fan to the spindle and remove fan.
7. Remove oil seal, large bearing and distance tube from the housing.
8. Drive the bearing housing from the fan cowl and withdraw the small bearing.

To Dismantle (L-type Engine)

1. Remove split-pin, nut and washer from the end of the spindle.
2. Remove oil seal housing.
3. Drive spindle from the fan cowl retaining the small distance-piece on the end of the spindle.
4. Remove fan from spindle.
5. Remove second oil seal housing.
6. Remove bearings and distance tubes from their housing.

To Assemble

Assembly on both engine types is a reversal of their respective dismantling procedures. Examine bearings and seals and renew if defective.

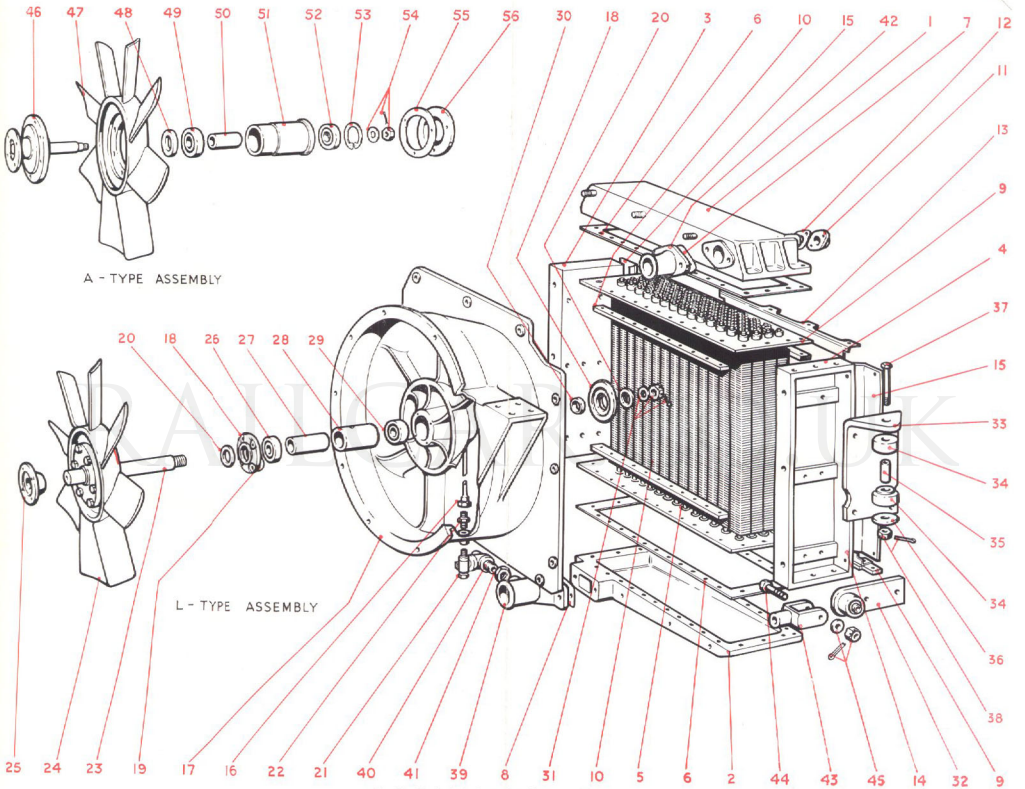

Fig. 3. Exploded view of radiator and fan.

1. TOP TANK.
2. BOTTOM TANK.
3. SIDE STANDARD L.H.
4. SIDE STANDARD R.H.
5. TUBE BLOCK.
6. JOINT.
7. JOINT.
8. JOINT.
9. STIFFENING STRIP. FRONT.
10. STIFFENING STRIP. REAR.
11. OVERFLOW PIPE ELBOW.
12. JOINT.
13. FRONT TOP AIR BAFFLE.
14. FRONT BOTTOM AIR BAFFLE.
15. SIDE AIR BAFFLE.
16. PIPE.
17. FAN COWL.
18. BEARING COVER.
19. JOINT.
20. FELT WASHER.
21. GREASE PLUG.
22. UNION.
23. DRIVING SHAFT.
24. FAN.
25. COMPANION FLANGE.
26. BALL BEARING.
27. DISTANCE PIECE, INNER.
28. DISTANCE PIECE, OUTER.
29. ROLLER BEARING.
30. DISTANCE PIECE.
31. NUT, WASHER, SPLIT PIN.
32. SUPPORT PLATE.
33. RADIATOR MOUNTING BRACKET.
34. PAD.
35. DISTANCE TUBE.
36. WASHER.
37. BOLT.
38. NUT, WASHER, SPLIT PIN.
39. RADIATOR OUTLET PIPE.
40. DRAIN COCK.
41. LOCKNUT.
42. RADIATOR INLET ADAPTOR.
43. JAW END.
44. BOLT.
45. NUT, WASHER, SPLIT PIN.
46. FAN SPINDLE.
47. FAN.
48. OIL SEAL.
49. ROLLER BEARING.
50. DISTANCE PIECE.
51. SLEEVE.
52. ROLLER BEARING.
53. CIRCLIP.
54. NUT, WASHER, SPLIT PIN.
55. JOINT.
56. COVER.

CONTROLS

CHAPTER P

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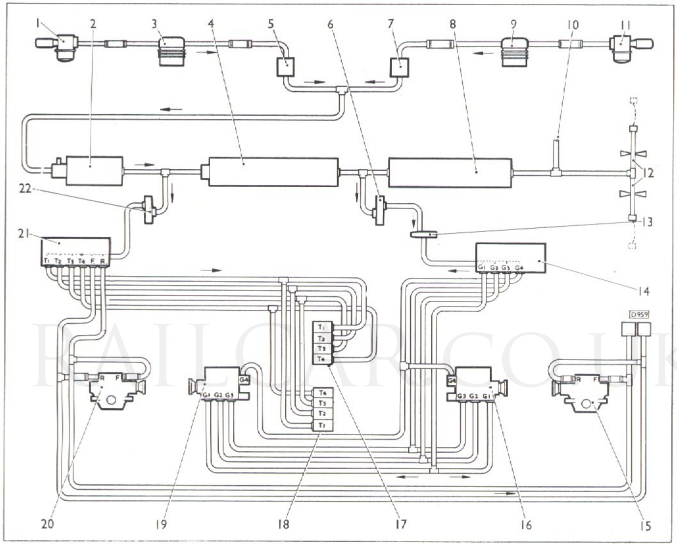


Fig. 1. Diagrammatic layout of air pressure system.

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

Sect. P1. CONTROLS—DESCRIPTION.

(See Figs. 2 and 3).

GENERAL.

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

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

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

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

Fig. 2. Driver's controls (Metropolitan Cammell).

1. WINDSCREEN WIPER VALVE.
2. ENGINE SPEED INDICATOR.
3. SPEEDOMETER.
4. EMERGENCY LIGHT SWITCH AND SOCKET.
5. VACUUM GAUGE.
6. AIR PRESSURE GAUGE.
7. GUARD'S BRAKE CONTROL VALVE
8. DEADMAN'S SWITCH.
9. THROTTLE CONTROLLER.
10. ENGINE SPEED INDICATOR CHANGE OVER SWITCH (RIGHT). PANEL LIGHT SWITCH (LEFT).
11. HORN SWITCH.
12. BUZZER BUTTON.
13. GEAR CHANGE LEVER.
14. FORWARD AND REVERSE LEVER.
15. VACUUM BRAKE LEVER.
16. HANDBRAKE WHEEL.

AIR PRESSURE SYSTEM.

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

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

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

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

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

The air compressors are described in the Engine Chapter.

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

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

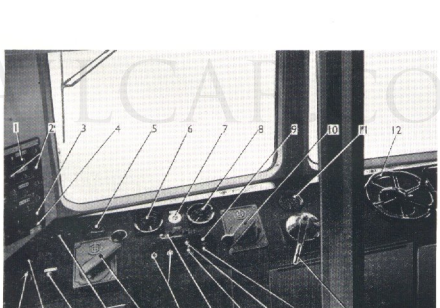


Fig. 3. Driver's controls (Cravens).

1. AIR INDICATOR LIGHTS.
2. OIL INDICATOR LIGHTS.
3. STARTER BUTTON.
4. STOP BUTTON.
5. AIR PRESSURE GAUGE.
6. ENGINE SPEED INDICATOR.
7. BELL.
8. SPEEDOMETER.
9. ENGINE SPEED INDICATOR CHANGE OVER SWITCH.
10. GEARBOX CONTROLLER.
11. VACUUM GAUGE.
12. HANDBRAKE WHEEL.
13. PANEL LIGHTS DIMMER.
14. LAMP TEST BUTTON.
15. TRAIN OPERATING KEY SWITCH.
16. WINDSCREEN WIPER VALVE.
17. THROTTLE CONTROLLER.
18. TAIL LIGHT SWITCH.
19. HORN SWITCH.
20. DESTINATION LIGHT SWITCH.
21. FAN SWTCH.
22. PANEL LIGHTS SWITCH.
23. VACUUM BRAKE LEVER.

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

Air reservoirs (*see Fig. 5*).

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

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

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

Unloader valve (*see Fig. 7*).

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

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

When the pressure in the reservoir is below that of the unloader, the spring-loaded valve remains closed

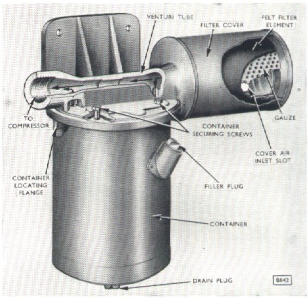


Fig. 4. Combined air filter and anti-freezer.

and air flows via a non-return valve into the reservoir. The non-return valve retains the pressure built up in the reservoir when the compressor is not operating.

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

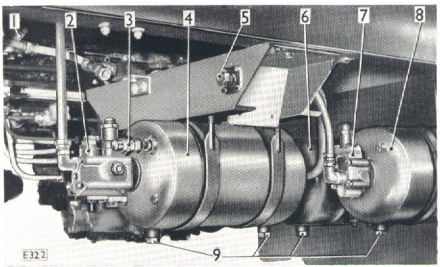


Fig. 5. Air reservoirs, unloader and diverter valves.

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

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

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

Safety valve *(see Fig. 6).*

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

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

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

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

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

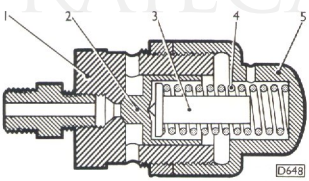


Fig. 6. Safety valve.

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

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

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

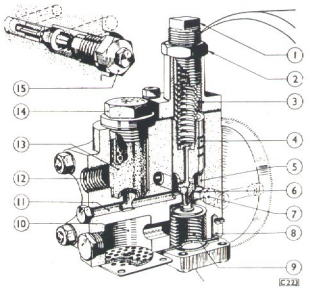


Fig. 7. Unloader valve.

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

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

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

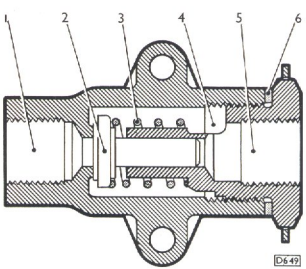


Fig. 8. Non-return valve.

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

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

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

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

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

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

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

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

Diverter valve (*see Fig.* 9).

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

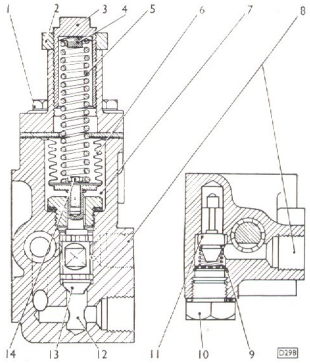


Fig. 9. Sectioned view of diverter valve.

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

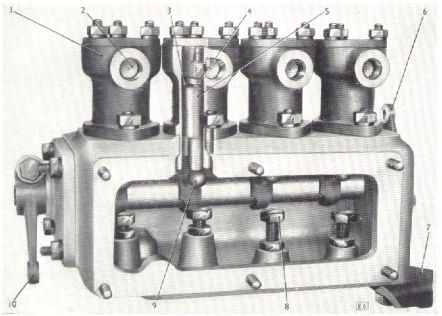


Fig. 10. Throttle motor showing adjusting screws.

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

Reducing valve (*see Fig.* 12).

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

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

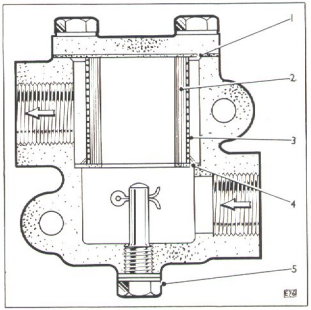


Fig. 11. Pipe line air filter.

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

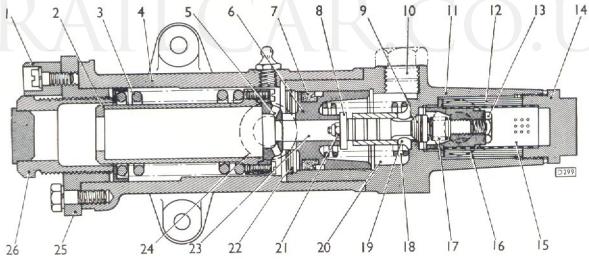


Fig. 12. Sectioned view of air reducing valve.

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

ELECTRICAL SYSTEM (*see Plate* O 63 *at the end of this Section*).

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

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

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

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

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

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

Fig. 14. Throttle controller.

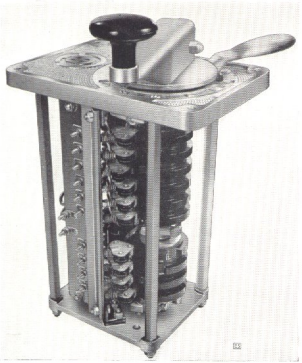


Fig. 13. Gearbox and final drive controller.

Engine control relay panel.

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

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

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

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

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

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

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

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

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

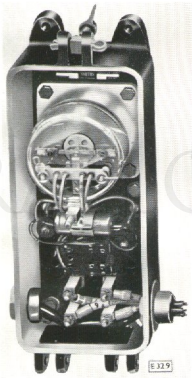


Fig. 15. Starter motor isolating relay.

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

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

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

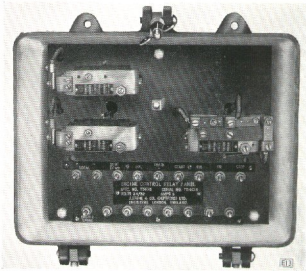


Fig. 16. Engine control relay panel.

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

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

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

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

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

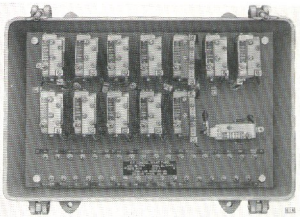


Fig. 17. E.P. control relay panel.

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

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

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

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

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

The gearbox controller is similar in construction to the throttle controller. There are two camshafts,

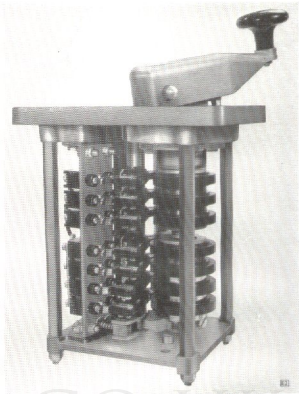


Fig. 19. Throttle controller showing contacts.

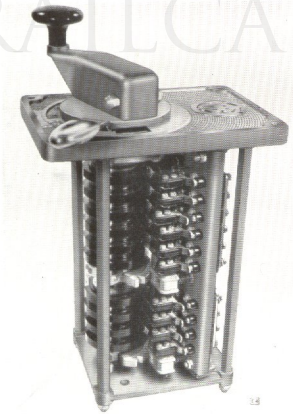


Fig. 18. Gearbox and final drive controllers showing contacts.

one for the operation of the gears in the epicyclic gearboxes and one to actuate the forward and reverse gears in the final drives. Each cam closes an electrical contact, thereby operating the appropriate E.P. valve, which in turn engages the selected gear.

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

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

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

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

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

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

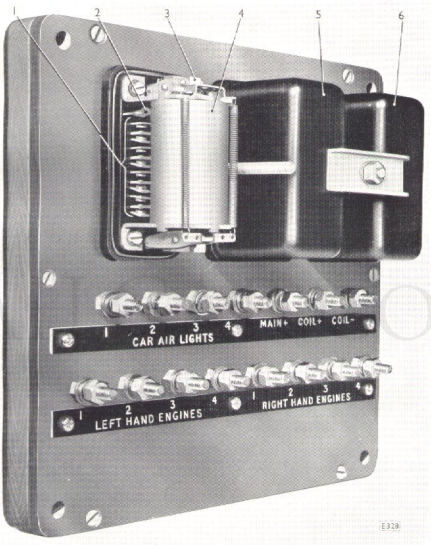


Fig. 20. Relay-operated switch panel (12 way).

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

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

Air pressure switches (*see Fig.* 22).

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

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

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

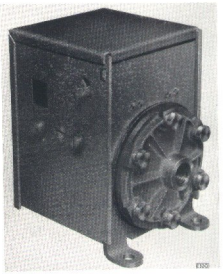


Fig. 22. Air pressure switch.

Water level switch.

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

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

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

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

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

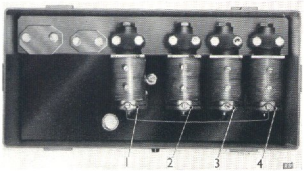


Fig. 21. Electro-pneumatic valves for gearbox.

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

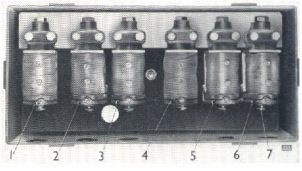


Fig. 23. Electro-pneumatic valves for engine and final drive.

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

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

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

Oil pressure switch.

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

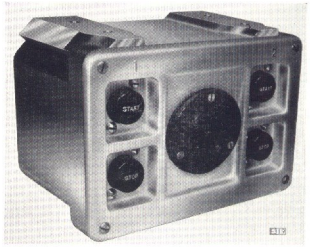


Fig. 25. Engine local control box.

Fig. 24. Battery isolating switch.

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

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

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

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.

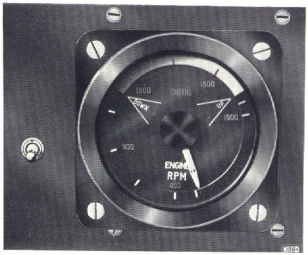


Fig. 26. Engine speed indicator and switch.

Engine isolating switch (*see Fig.* 28).

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

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

Direction switch (*see Fig.* 38).

A direction switch is mounted on each final drive casing.

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

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

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

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

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

One control box is mounted adjacent to each engine.

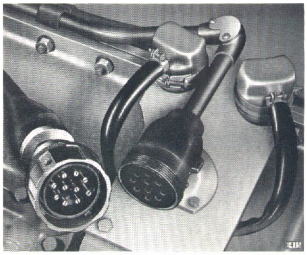


Fig. 27. Engine plug and socket.

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

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

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

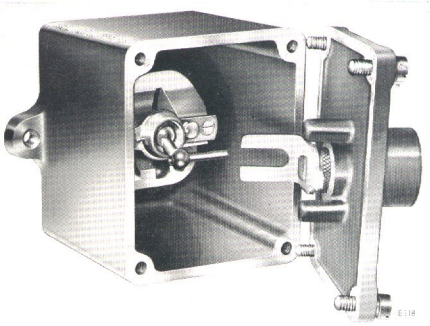


Fig. 28. Engine isolating switch.

VACUUM SYSTEM.

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

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

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

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

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

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

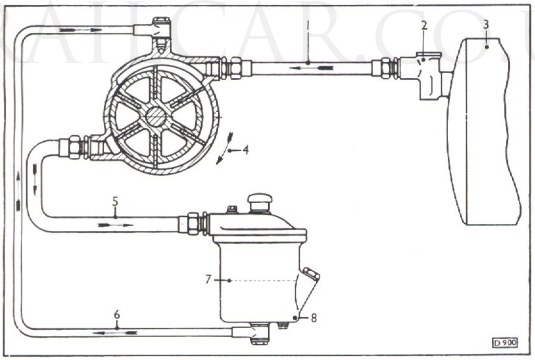


Fig. 29. Diagrammatic illustration showing lubrication by separate oil reservoir.

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

Exhauster oil reservoir (*see Fig.* 36).

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

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

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

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

A drain plug is fitted to facilitate cleaning.

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

Sect. P2. CONTROLS—DATA.

Reservoir (first).		
Capacity.	1,414 cu. in.	23·2 litres.
Unloader valve—Cut-out pressure.	95 lb. per sq. in. (approximately)	6·679 Kg. per sq. cm.
Cut-in pressure.	75 to 80 lb. per sq. in.	5·272 to 5·625 Kg. per sq. cm.
Safety valve—Blow off pressure.	Set to blow-off between 98 to 100 lbs. per sq. in.	
Reservoir (second).		
Capacity.	3,600 cu. in.	59·0 litres.
Diverter valve—Cut-in pressure.	47·5 to 52·5 lb. per sq. in.	3·33 to 4·03 Kg. per sq. cm.
Reservoir (third).		
Capacity.	3,600 cu. in.	59·0 litres.
Air reducing valve pressure.	62·5 to 67·5 lb. per sq. in.	4·4 to 4·7 Kg. per sq. cm.
Air pressure gauge maximum pressure.	85 lb. per sq. in.	6·0 Kg. per sq. cm.
Air pressure switch—Cut-out pressure.	60 lb. per sq. in.	4·9 Kg. per sq. cm.
Cut-in pressure.	75 lb. per sq. in.	5·3 Kg. per sq. cm.
Anti-freezer capacity.	2·87 pints.	1·63 litres.
Exhauster oil reservoir capacity.	10·00 pints.	5·67 litres.
Engine control relay panel.	Specification No. T3632.	All relays to energise at 7·4 volts cold.
E.P. control relay panel.	Specification No. T3631.	Shunt coil resistance, 101·5 ohms, ±5%, at 20 deg. Centigrade, 24/30v.

NOTES.

Sect. P3. CONTROLS—MAINTENANCE.

AIR PRESSURE SYSTEM.

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

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

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

Air filter.

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

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

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

Anti-freezer.

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

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

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

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

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

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

Air reservoirs (*see Fig.* 5).

Empty and drain the air reservoirs as follows: —

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

On on account unscrew a drain plug or cock more than two or three turns unless the reservoir has been exhausted of air.

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

Unloader valve (*see Fig.* 7).

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

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

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

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

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

Safety valve (*see Fig.* 6).

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

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

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

Diverter valve (*see Fig.* 9).

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

Air reducing valve (*see Fig.* 12).

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

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

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

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

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

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

Lubricate the air cylinders (*see Section* P4).

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

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

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

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

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

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

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

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

Screw in the drain plug.

To check for air leakage.

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

ELECTRICAL SYSTEM.

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

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

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

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

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

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

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

Apart from the following tests no maintenance is required.

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

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

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

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

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

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

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

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

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

Dismantle and wash all parts in paraffin.

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

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

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

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

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

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

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

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

remove the terminal cover from the solenoid and ensure that there is a minimum air gap of 0·063 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.* 13 *and* 14).

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

At overhaul periods lightly smear all working parts with lubricant.

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

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

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

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

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

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

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

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

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

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

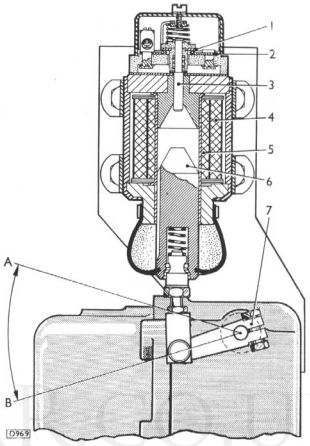


Fig. 30. Section through engine shut-down solenoid.

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.

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

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

Air pressure switches (*see Fig.* 22).

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

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

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

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

Water level switch.

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

Direction switch (*see Fig.* 38).

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

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

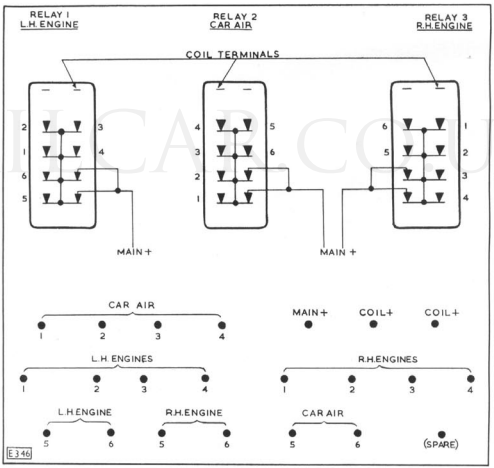


Fig. 31. Diagram of 18 way relay operated switch panel.

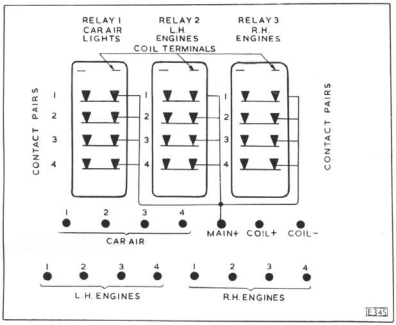


Fig. 32. Diagram of 12 way relay operated switch panel.

VACUUM SYSTEM.

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

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

Exhausters—drive belts to adjust.

The exhausters are pivoted on brackets fitted to the underframe.

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

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

When correctly adjusted, there should be from 1¼in. to 2in. (38 mm. to 51 mm.) vertical movement at the centre of the belts.

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

Sect. P4. CONTROLS—LUBRICATION.

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

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

Air reducing valve (*see Fig.* 12).

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

Exhauster oil reservoir (*see Fig.* 36).

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

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

Refit and tighten the drain plug.

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

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

Throttle control motors (*See Fig.* 33).

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

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

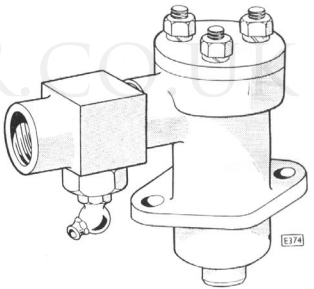


Fig. 33. Throttle control motor piston and cylinder assembly showing lubricator.

Sect. P5. UNLOADER AND SAFETY VALVES —TO OVERHAUL, TEST AND ADJUST.

(See Figs. 6 and 7).

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

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

To Overhaul.

Unloader valve.

Remove the unloader valve from the reservoir.

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

Remove the cover below the bellows.

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

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

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

Carefully examine the bellows for deterioration or distortion.

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

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

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

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

Lightly oil all moving parts.

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

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

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

Safety valve.

Dismantle and clean all parts.

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

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

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

To Test.

Unloader valve.

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

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

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

Safety valve.

The safety valve should be removed from the reservoir, tested for correct operating pressures (*see Section* P2) and adjusted if necessary. It should close between 80 and 90 lb. per sq. in. (5·62 and 6·32 Kg. per sq. cm.) and should be tested with soap and water at maximum unloader valve cut-out pressure (*see Section* P2) when no leakage must occur.

To Adjust.

Unloader valve.

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

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

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

Safety valve.

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

Sect. P6. NON-RETURN VALVE—TO DISMANTLE AND ASSEMBLE.

(*See Fig.* 8)

To Dismantle.

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

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

To Assemble.

Wash all parts in clean paraffin.

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

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

Sect. P7. DIVERTER VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST.

(*See Fig.* 9).

To Dismantle.

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

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

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

Withdraw the control spring and button.

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

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

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

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

To Assemble.

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

All moving parts should be smeared with oil.

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

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

To Adjust.

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

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

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

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

Sect. P8. AIR REDUCING VALVE—TO DISMANTLE, ASSEMBLE AND ADJUST.

(*See Fig.* 12).

To Dismantle.

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

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

Unscrew the end cap and remove the felt filter element.

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

Unscrew the nut securing the release valve seat.

To Assemble.

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

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

Inspect the bore and piston for scoring.

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

To Adjust.

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

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

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

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

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

Finally, lock the adjusting screw.

Sect. P9. THROTTLE CONTROL MOTORS—TO DISMANTLE AND ASSEMBLE.

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

To Dismantle.

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

Remove the side cover.

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

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

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

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

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

To Assemble (*see Fig.* 34).

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

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

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

Examine the shaft bushes for wear, renew if necessary.

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

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

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

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

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

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

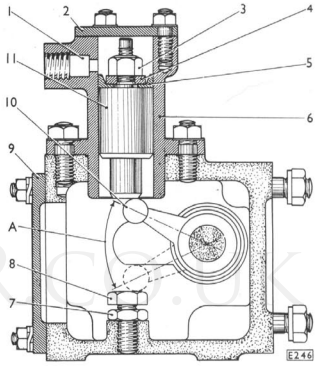


Fig. 34. Section through throttle control motor showing travel of actuating lever at full throttle.

A. MAXIMUM TRAVEL 47° — FULL THROTTLE.
1. AIR INLET PORT.
2. CYLINDER COVER.
3. 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.

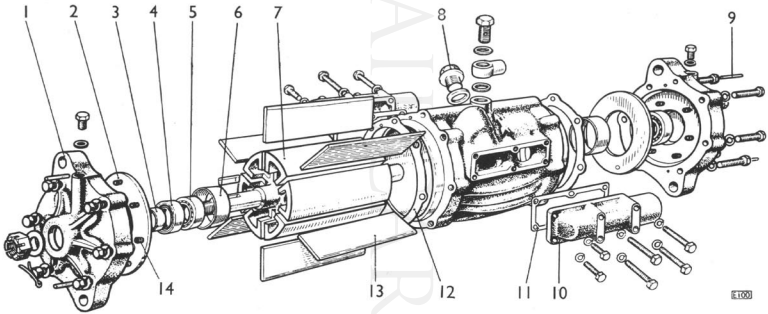


Fig. 35. Exploded view of exhauster.

1. DRIVE END COVER.
2. SEALING PLATE WITH PEG.
3. SHAFT COLLAR.
4. METAL INSERT SEAL.
5. ROLLER RACE.
6. FLOATING CAM RING.
7. ROTOR AND SHAFT.
8. PLUG ¼" B.S.F.
9. END COVER LOCATING PEG.
10. MANIFOLD.
11. MANIFOLD JOINT.
12. END COVER JOINT.
13. ROTOR BLADE.
14. SEALING PLATE SPRING.

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

(*See Fig.* 36).

To Remove.

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

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

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

To Dismantle.

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

Unscrew the breather.

Remove the inner top plate and strainer complete.

Unwire and remove the bottom filters.

To Assemble.

Wash all parts thoroughly in clean paraffin.

Reverse the procedure given for dismantling.

To Fit.

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

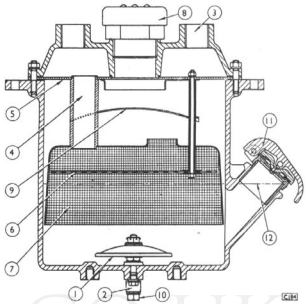


Fig. 36. Section through exhauster oil reservoir.

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

Sect. P11. EXHAUSTERS—TO DISMANTLE AND ASSEMBLE

(*See Fig.* 35).

To Dismantle.

Remove the exhauster from the car.

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

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

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

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

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

To Assemble.

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

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

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

Examine the bearings and renew if worn.

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

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

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

Ensure that the bearings run freely, when fitted.

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

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

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

Smear the end covers with grease before fitting new joints.

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

To Test.

See Railway instructions for testing the vacuum system.

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

(See Fig. 37).

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

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

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

To adjust the armature hinge gap.

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

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

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

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

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

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

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

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

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

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

Lock the contacts by means of the locknuts.

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

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

Lock the contacts by means of the locknuts.

To Calibrate The Relays.

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

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

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

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

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

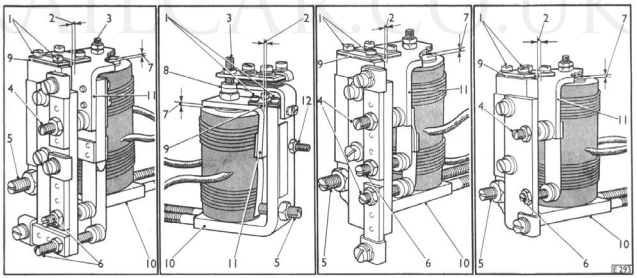


Fig. 37. Diagrams for setting control relays.

A. TONUM TYPE RELAY SPECIFICATION T3633.
B. TONUM TYPE RELAY SPECIFICATION T3500.
C. TONUM TYPE RELAY SPECIFICATION T3501.
D. TONUM TYPE RELAY SPECIFICATION T3502.

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

Sect. P13. DIRECTION INDICATOR SWITCH —TO FIT AND ADJUST

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

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

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

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

Return the hand operated locking plunger to its original position.

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

Connect the leads to the switch.

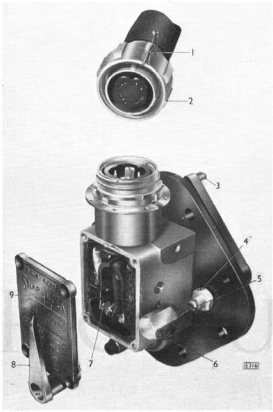


Fig. 38. Direction indicator switch.

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

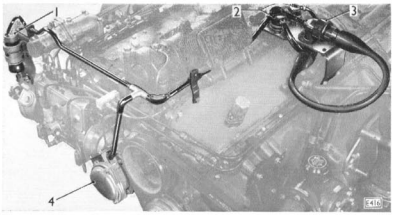


Fig. 39. Engine plug and socket, harness and conduit.

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

Sect. P14. ENGINE PLUG AND SOCKET —TO REMOVE AND FIT.

(See Fig. 39).

To Remove.

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

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

Disconnect the leads from the engine speed indicator generator.

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

Remove the bolts securing the socket to its bracket.

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

To Fit.

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

Sect. P15. SIZES OF SHIMS AVAILABLE.

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

PLATE No. 063

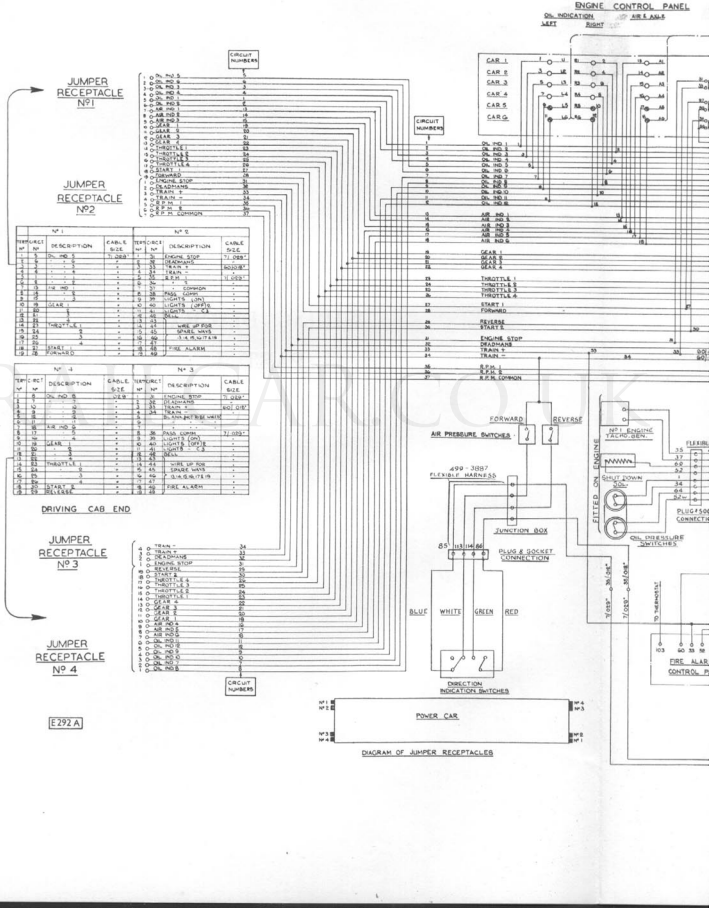
WIRING DIAGRAM

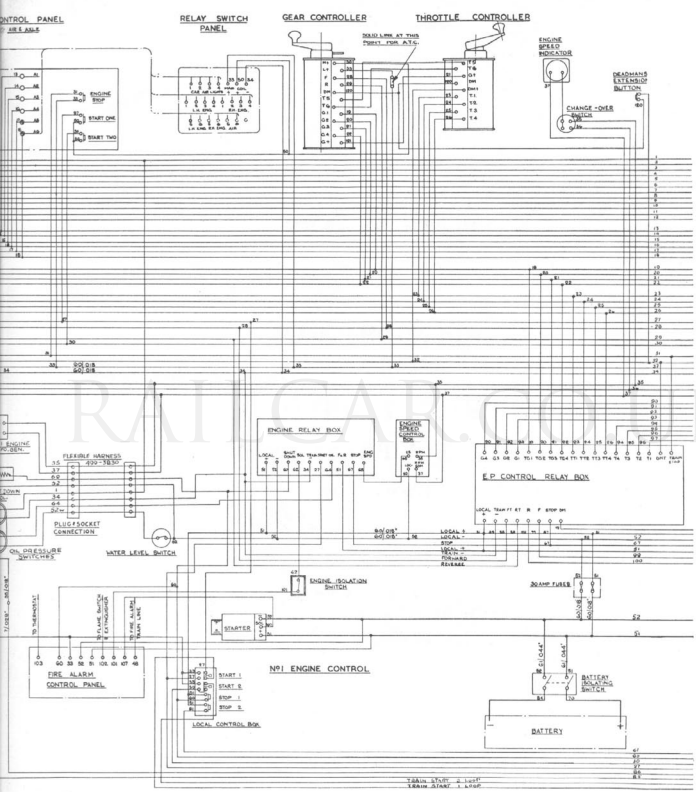
for

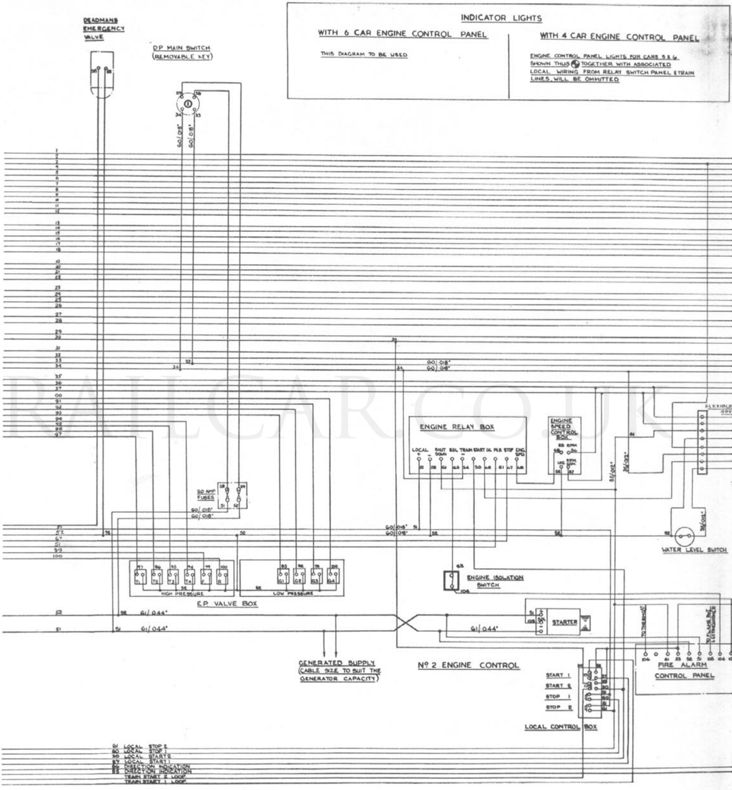
B.U.T. TRACTION EQUIPMENT

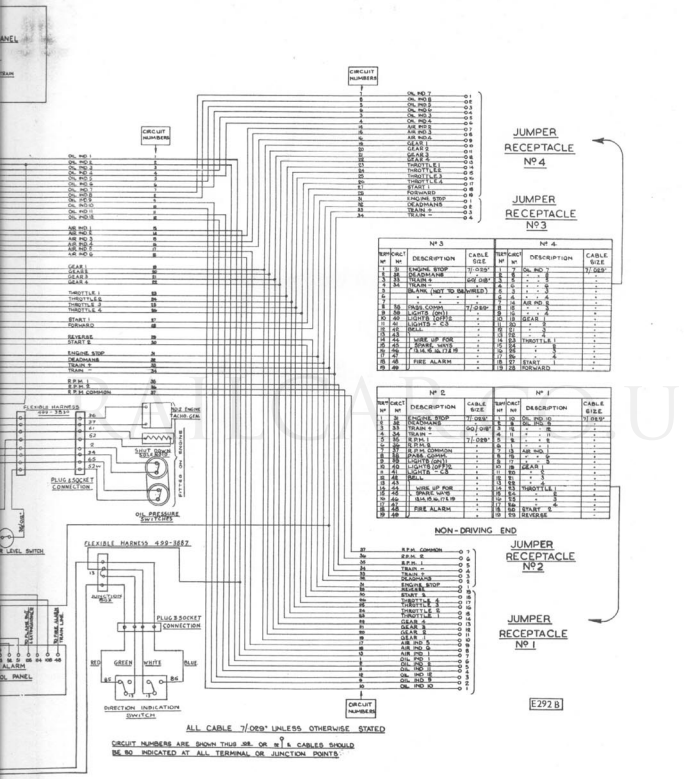
(Power Cars).

British Railways
Multiple-Unit Diesel Cars
(50,000 Series)


ENGINE CONTROL PANEL
JUMPER RECEPTACLE Nº1
JUMPER RECEPTACLE Nº2
JUMPER RECEPTACLE Nº3
JUMPER RECEPTACLE Nº4
DRIVING CAB END
DIAGRAM OF JUMPER RECEPTACLES
POWER CAR
FORWARD
REVERSE
AIR PRESSURE SWITCHES
JUNCTION BOX
PLUG & SOCKET CONNECTION
DIRECTION INDICATION SWITCHES
BLUE
WHITE
GREEN
RED
E292A


CONTROL PANEL
RELAY SWITCH PANEL
GEAR CONTROLLER
THROTTLE CONTROLLER
ENGINE SPEED INDICATOR
DEADMANS EXTENSION BUTTON
CHANGE-OVER SWITCH
ENGINE STOP
START ONE
START TWO
ENGINE RELAY BOX
ENGINE SPEED CONTROL BOX
E.P CONTROL RELAY BOX
FLEXIBLE HARDNESS
PLUG & SOCKET CONNECTION
WATER LEVEL SWITCH
OIL PRESSURE SWITCHES
ENGINE ISOLATION SWITCH
STARTER
30 AMP FUSES
BATTERY ISOLATING SWITCH
BATTERY
FIRE ALARM CONTROL PANEL
LOCAL CONTROL BOX
No1 ENGINE CONTROL




CIRCUIT NUMBERS
JUMPER RECEPTACLE Nº4
JUMPER RECEPTACLE Nº3
JUMPER RECEPTACLE Nº2
JUMPER RECEPTACLE Nº1
Nº 3
Nº 4
Nº 2
Nº 1
DESCRIPTION
CABLE SIZE
ENGINE STOP
DEADMANS
TRAIN +
TRAIN -
(NOT TO BE WIRED)
TRAIN CONN
LIGHTS (RH)
LIGHTS (LH)
SPARE WIRE
FIRE ALARM
WIRE UP FOR
R.P.M. COMMON
R.P.M. B
R.P.M. A
THROTTLE 1
THROTTLE 2
THROTTLE 3
THROTTLE 4
START
REVERSE
GEAR 1
GEAR 2
GEAR 3
GEAR 4
ENGINE STOP
DEADMANS
TRAIN +
TRAIN -
FLEXIBLE HARNESS 499-1841
FLEXIBLE HARNESS 499-3887
SHUT DOWN SOLENOID
OIL PRESSURE SWITCHES
PLUG & SOCKET CONNECTION
OIL LEVEL SWITCH
ALARM
OIL PANEL
DIRECTION INDICATION SWITCH
RED
GREEN
WHITE
BLUE
ALL CABLE 7/.029" UNLESS OTHERWISE STATED
CIRCUIT NUMBERS ARE SHOWN THUS .08. OR ⊓ & CABLED SHOULD BE SO INDICATED AT ALL TERMINAL OR JUNCTION POINTS.
E292B