ENGINE
(900 Series)

CHAPTER V

CONTENTS

GENERAL NOTES ON OVERHAULING

CLEANING

All assemblies dismantled for overhaul should be thoroughly degreased and cleaned before any inspection for wear or damage is carried out. Small but dangerous cracks may pass undetected unless cleaning is carried out.

When rebuilding assemblies after overhaul, observe scrupulous cleanliness throughout the operation. Dirt or swarf left between fitting faces causes oil leaks.

All oilways, pipes, etc., should be thoroughly flushed clear of sludge and old oil.

BEARINGS

Examine for excessive play between the balls or rollers and the races.

Examine for broken cages and cracked balls or rollers.

Examine for any signs of blueing due to overheating.

Use a press whenever possible for inserting bearings which are an interference-fit in housings. If no press is available, hammer in with a block of wood laid across the bearing. Always make certain that the bearing enters the housing squarely.

TAPER-ROLLER BEARINGS

The bearing assembly consists of two parts: the outer race or cup and the roller assembly, i.e., rollers secured in a cage on the cone or inner race.

1. Outer Races

i. The cups must be an interference-fit in their housings. If not, the housings should be replaced.

Do not resort to knurling, application of solder, or the use of liners, other than press-in-steel.

ii. The cups must not be tilted when being pushed in.

iii. The cups must be pressed right home against the abutment shoulder, preferably under a press, or by a bolt and nut arrangement. It should not be possible to enter a 0.002 in. (0.0508 mm.) thickness gauge between the cup and the abutment shoulder.

iv. Grease the seating for the cup, which should be assembled clean and smeared with lubricant after installation.

2. Roller Assemblies

i. Cones on stationary shafts must be a "creep" fit on the shaft, the ideal being 0.0005 in. (0.0127 mm.) loose. The seatings for the inner races must always be smeared with grease before the bearings are fitted. Bearings should be adjusted by screwing up the adjoining nut fairly tightly, revolving the rollers, then slacken back the nut to give the correct end-play. Always make a check after the assembly has been locked up.

ii. Cones on revolving shafts should be a press-fit, but in some cases where bearing adjustment is made by moving one of the cones, it is not practicable to be more than a light push-fit. If the cones are loose enough to turn on the rotating shaft, overheating and rapid wear of the seating will occur.

OIL SEALS

1. Use Of Part-worn Oil Seals

As a general rule, once a part-worn oil seal has been removed from its location, it is advisable to renew it.

Warning: Never allow a seal to pass through a degreasing plant (trichlorethylene). Do **not** clean with petrol or paraffin. Use light lubricating oil.

2. Examination of Seals Before Refitting

In determining whether a seal is suitable for further use:

i. Discard the seal if charred, cut, hard, or the wiping edge has become folded back.

ii. Discard the seal if loose in the shell.

iii. Discard any seal with a broken or damaged spring.

iv. Discard seals in which the shell or metal components are distorted or damaged.

v. Finally, on shafts or sleeves which are scored sufficiently to necessitate a reduction in diameter of 0.03125 in. (0.7937 mm.) to clean up, fit a new part and seal.

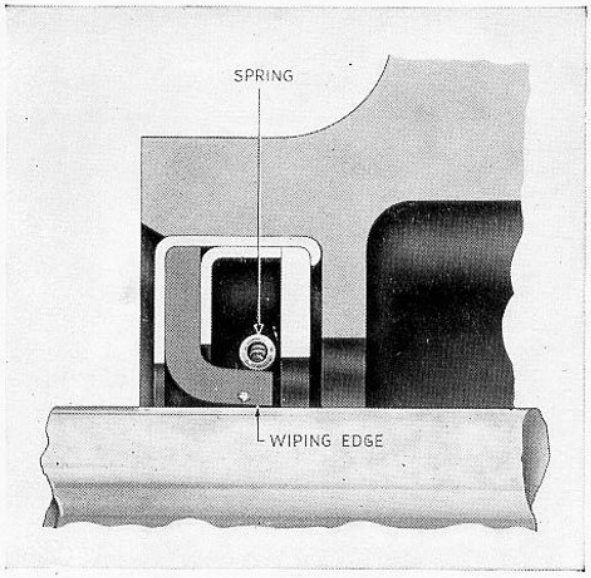


FIG. 1. SECTION THROUGH OIL SEAL IN POSITION

3. To Fit A Seal

i. Assemble the wiping edge or lip of the sealing member towards the bearing in which the lubricant is to be retained, as shown in Fig. 1.

ii. Fit the seal into the housing with a tool or ram, approximately 0.015 in. (0.0381 mm.) less in diameter than the outer diameter of the seal, by exerting a firm and uniform pressure squarely on it. Avoid entry of the seal into the recess in a tilted position and under no circumstances fit with a drift and hammer, as the irregular impact will loosen the rolled edge and release the pressure of the inner member on the sealing element and cause seepage round the sealing lip.

GEARS

Gear teeth should be examined for signs of cracks or pitting. A burnished finish indicating wear is not in any way detrimental. Discard any gear which is chipped right through the case-hardening.

Examine the bores of gears which rotate on shafts for wear or scoring. Check for excessive diametral clearance in excess of that permitted for that particular gear.

Examine the teeth of all the gear-type engagement dogs for tapered wear. This can be one of the causes of gears slipping out of engagement.

It is not sufficient to replace worn or damaged gears without first ascertaining the cause. Gears do not fail or wear badly at low mileages on their own account; badly adjusted or worn bearings, lack of or unsuitable lubricant and bad fitting are usually the cause.

COVERS AND HOUSINGS

Whenever tapped holes are provided for jacking screws, use them.

When fitting spigoted housings or covers, check that the spigot is not burred or damaged in any way. Check that there is a good chamfer on the main component for entering the spigot.

Always enter a spigoted component evenly. Damage will be caused if it is entered in a tilted position.

Always see that the fitting faces are wiped perfectly clean.

GASKETS AND JOINTS

Fit new gaskets and joints throughout when rebuilding, unless existing gaskets and joints are obviously in good condition.

Where an oil-tight joint is required, paint the joint and fitting face with jointing compound.

SHIMS

When stripping, note the number and position of shims removed and place in a clean place for subsequent use.

Discard any torn or crumpled shims and substitute new ones of the same thickness.

Wipe all shims clean before reassembly and smear lightly with oil.

Where an oil-tight joint is required at a shimmed face, smear the shims lightly with jointing compound before final assembly.

BUSHES

Never re-insert extracted bushes.

Always ream out new bushes after pressing in.

New bushes should be inserted by a press where possible.

Failing that, use a block of wood or a hide hammer.

Make certain that the bush does not enter its housing in a tilted position.

FITTING FLANGES ON TAPER SHAFTS

The essential features are:

1. They must be lapped.
2. They must be clean.
3. They must be tight.

In the case of propeller shaft flanges, the following procedure should be adopted:

1. Lap lightly with Carborundum Compound, Grade F.
2. Wash thoroughly with white spirits and brush clean.
3. Immerse the flange in boiling water for 15 minutes.
4. Fit the flange on the taper immediately and tap it home with tube and hammer. Fit the nut quickly and tighten with the special spanner. The spanner must have a head deep enough to clear the end of the shaft and it must have a shank or tommy bar 3 ft. 6 in. (1 metre) long. Tension must be maintained on the spanner by one man whilst another strikes the head of the spanner with a 7 lb. hammer.

Special Note: We do not advise the reclamation of propeller shaft flanges by any means whatever. If you have any cause to doubt the taper bore of a propeller shaft flange after it has been removed from its shaft, we strongly recommend fitting a new one—there is no other way of getting a satisfactory fit.

In the case of smaller flanges fitted on taper shafts and used on various units of the vehicle, we recommend that they should be lapped with Carborundum Compound, Grade F, they should be cleaned thoroughly with white spirits and a brush, and they should be pulled up dead tight on their taper—but we do not recommend immersing them in boiling water.

KEYWAYS

When fitting a key, check that it bottoms in the keyway.

Check that the top of the key is not bedding in the bottom of the keyway of the component fitted to the shaft, as shown in Fig. 2.

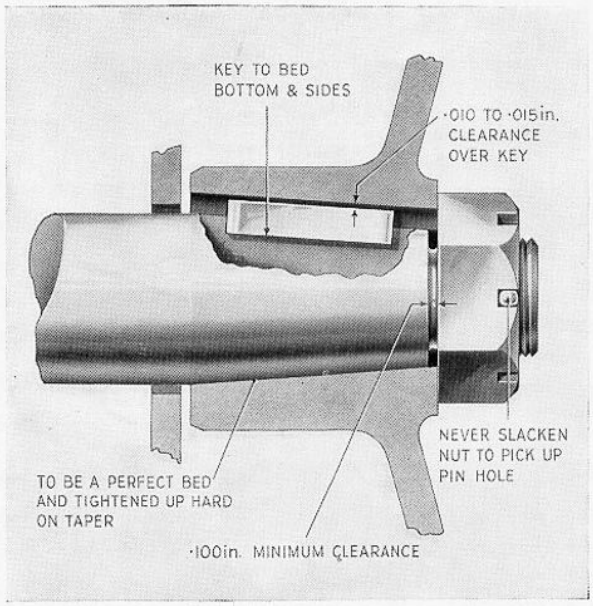


FIG. 2. TAPERS, KEYWAYS AND NUTS

SCREW THREADS, NUTS AND SPLIT-PINS

Screw Threads

Threads in exposed positions should be protected against burring.

Threads on large-diameter shafts, etc., should be wrapped with a rag or tape for protection against damage or dirt. A small amount of dirt will bind or jam the nut, especially where Simmonds nuts are used.

Clean all split-pin holes and threads before final assembly on any unit.

Discard any bolts or studs on which the condition of the thread is bad (e.g., threads stripped or deformed).

Nuts

When tightening up a slotted or castellated nut, **never slacken it back** to insert the split-pin or locking wire. File the base of the nut until the pin or wire can be inserted.

Simmonds nuts can be removed and replaced as many

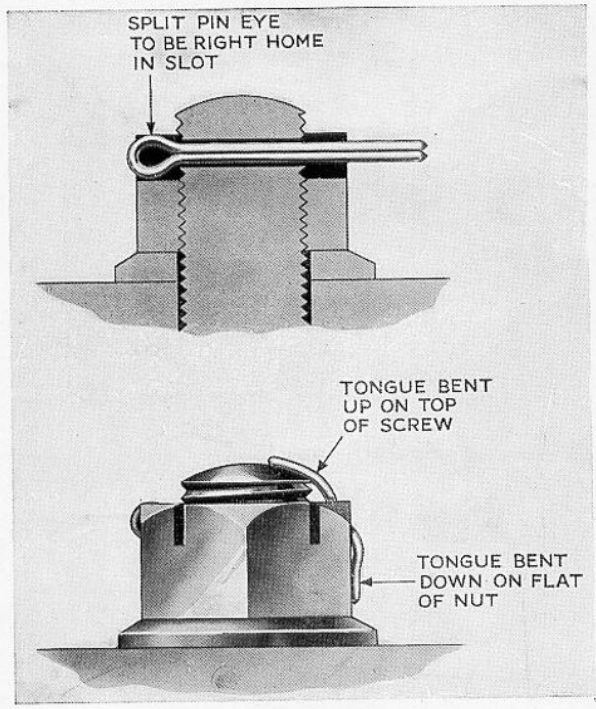


FIG. 3. FITTING SPLIT-PINS

times as desired. This type of nut is renewed only when it is obvious that the fibre insert is no longer locking the nut.

Split-Pins

Never refit an old split-pin after removal, always fit a new one.

Always fit split-pins where split-pins were originally used. Do not substitute spring washer—there is always a good reason for the use of a split-pin.

All split-pins should be fitted as shown in Fig. 3, unless otherwise stated.

UNIFIED THREADS (UNF)

The unified thread is in accordance with British Standards 1768-1951, and 1580-1949, issued under the authority of the Mechanical Engineering Industry Standards Committee. Components are identical with American standards for all practical purposes, so that nuts and bolts can be freely interchanged.

For identification purposes the following markings, see Fig. 4, are used on unified parts.

Bolts

A circular recess is stamped in the upper surface of the bolt head.

Nuts

A continuous line of circles is indented on one of the flats of the hexagon, parallel to the axis of the nut.

Studs, Brake Rods, etc.

The component is reduced to the core diameter for a short length at its extremity.

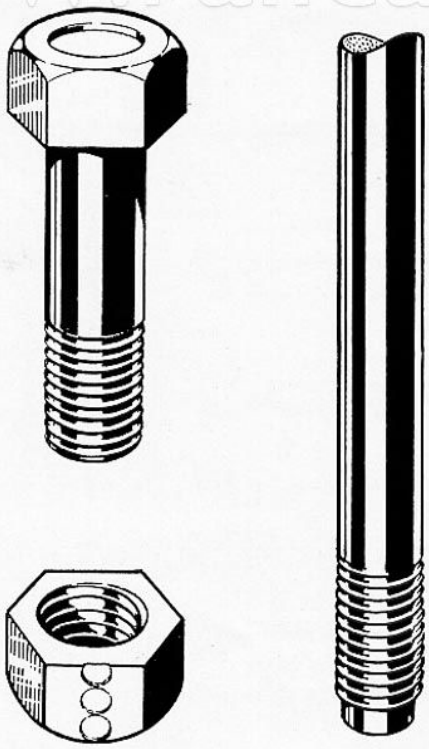


FIG. 4. IDENTIFICATION MARKINGS OF UNIFIED THREADS

PIPES, NIPPLES AND UNIONS

Examine all pipes carefully for cracking, chafing or fatiguing, especially at bends or clips.

In addition to being examined as above, pipes should be examined for cracked union nuts, dirt under the cones and seatings of the nipples.

Before connecting up a pipe, whether old or new, it is advisable to blow it through with compressed air.

Never strain or pull a pipe when connecting it up, find out why it will not meet the other component.

HOSE CONNECTIONS

Examine all hose connections for:

1. Hardening due to heat.
2. Softening due to oil.
3. General deterioration.

Replace any connections which appear to be in a doubtful condition.

SPECIAL TOOLS

Special tools are available for some of the operations described in this manual, apart from those supplied as standard equipment.

These special tools are described and illustrated in a separate catalogue and are obtainable from the Company's service depots and agents.

ENGINE DESCRIPTION

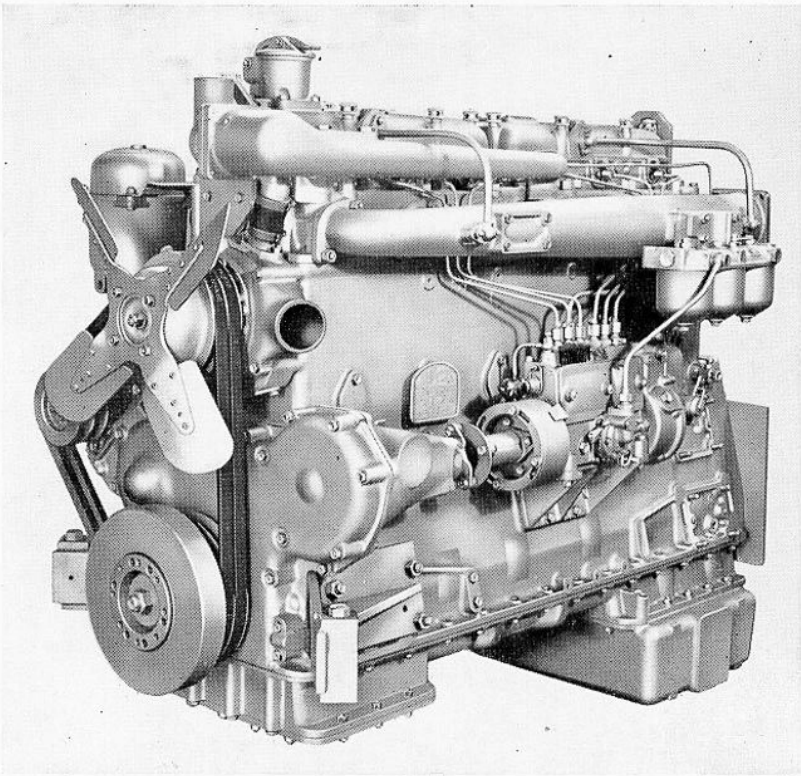


FIG. 1. L.H. FRONT VIEW OF VERTICAL ENGINE—NATURALLY ASPIRATED

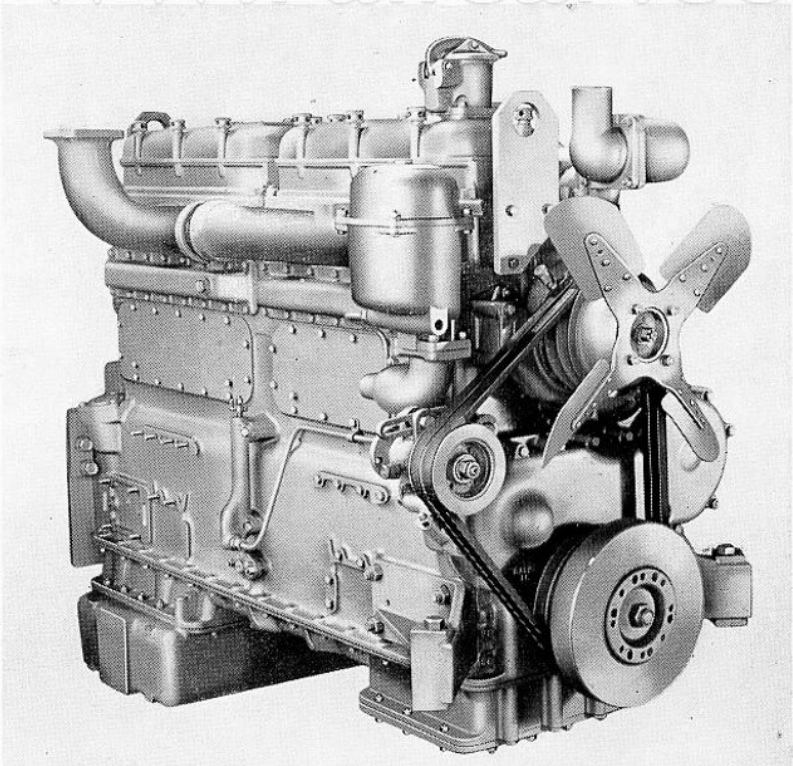


FIG. 2. R.H. FRONT VIEW OF VERTICAL ENGINE—NATURALLY ASPIRATED

DESCRIPTION

The 900 series six-cylinder vertical and horizontal 15.177 litre, compression-ignition oil engines are of the four-stroke direct-injection type.

The two detachable cast-iron cylinder heads, each covering three cylinders, are of identical design. Both inlet and exhaust valves seat on renewable hardened inserts, renewable cast-iron valve guides are also fitted. 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. A decompressor shaft operates on the exhaust valves.

The crankcase and cylinder block form a monobloc iron casting. Prefinished wet-type cylinder liners of cast-iron are fitted and are shoulder-located; these can be easily removed and replaced. As the engine is designed to breathe through the cylinder head covers, the crankcase pressure on naturally-aspirated vertical engines is usually relieved by connecting the two detachable cylinder head covers by pipes to the inlet manifold; and on all types of horizontal engines and turbocharged vertical engines it is relieved through oil-wetted wire mesh breathers situated on each of the detachable cylinder head covers. In certain cases breathers are fitted to naturally-aspirated vertical engines.

The bottom cover or sump on a horizontal engine is built up in two portions, and in addition to being an oil container, supports various units as described elsewhere.

The crankshaft is carried in seven steel-backed indium-coated copper-lead bearings. At the front there is a pinion for the timing gear drive and a torsional vibration damper. The flywheel is bolted to the rear end, and is fitted with a renewable starter gear ring.

The cast-iron camshaft with chilled cams, which is situated in the crankcase, is carried in seven bearings, and operates the valves through push-rods and rocker gear. The front and rear bearings are phosphor-bronze. The camshaft is gear driven through an intermediate gear with helical teeth from the front end of the crankshaft.

The pistons are fitted with three compression rings and two scraper rings. The combustion chamber in the piston crown is either of toroidal or hemispherical 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, compressor, tachometer generator and the water pump in the case of horizontal engines through two intermediate gears driven by the crankshaft pinion.

The lubrication system is of the wet-sump type, the oil being circulated under pressure by a gear-type oil pump driven from a skew gear at the front or rear of the camshaft, depending on the type of sump fitted. A scavenge pump driven from a skew gear at the opposite end of the camshaft from the main oil pump, transfers oil accumulating in the scavenge sump to the main sump. A gauze-type of filter is fitted at the main suction pipe. Full pressure is maintained to the main, big-end and camshaft bearings and to the intermediate timing gears. The valve gear receives an intermittent feed from the second and fifth camshaft bearings, this arrangement ensuring that, whilst sufficient oil reaches the rockers, there is no danger of any excess flooding at the valve stems. A centrifugal oil filter of the by-pass type takes oil from the main oil gallery and returns it filtered to the sump for recirculation, and additionally, when fitted, oil is filtered through a twin-bowl full-flow filter of the paper-element type. The timing gears are lubricated through the intermediate gear spindles. A spring-loaded relief valve limits the oil pressure. When required an oil cooler can be mounted on the cylinder block.

The fuel injection pump is mounted on the engine block on vertical engines and on the sump on horizontal engines, a governor being included in the assembly. An adjustable coupling between the pump and its driving shaft permits accurate timing of injection.

The engine is water-cooled, circulation being maintained by a centrifugal type pump. A drain cock is provided to enable the water to be drained completely when required.

In the case of some horizontal engines a tachometer generator and a compressor are mounted at the front and driven from the timing gears. Either one or two electric starter motors are fitted, working on 24 volts. The engine stop-control in the case of horizontal engines is solenoid-operated, and warning devices are incorporated in the lubrication and cooling systems.

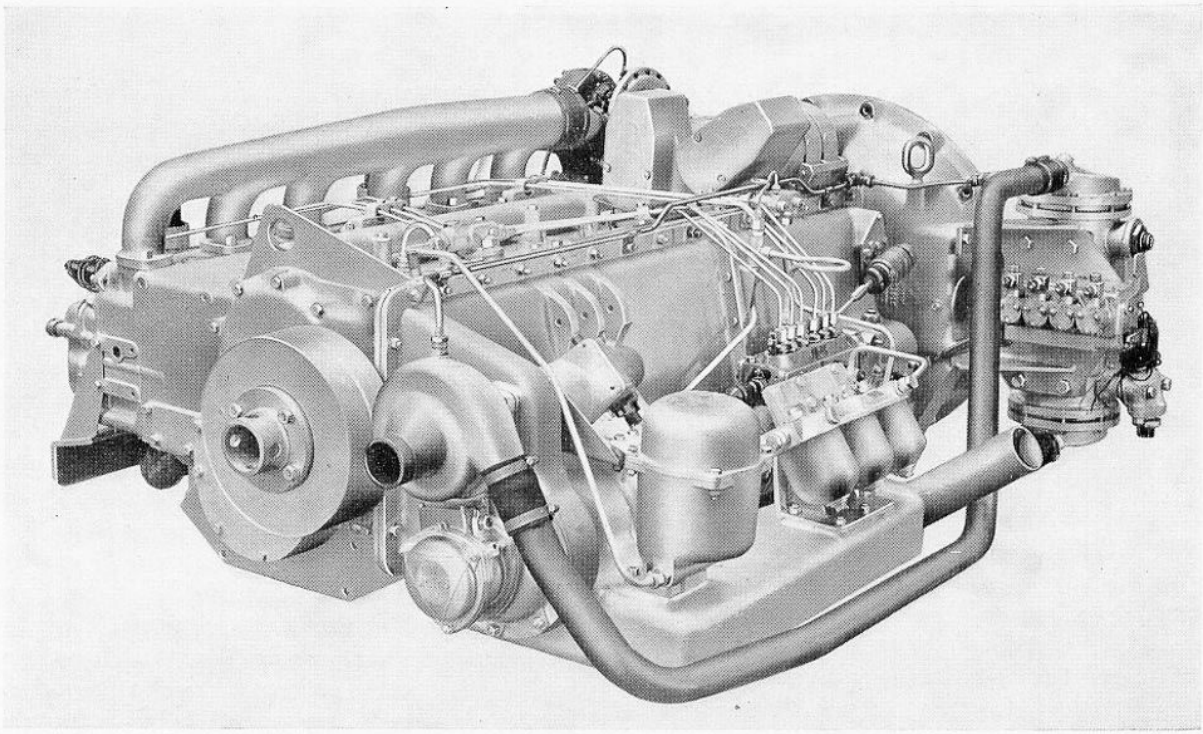


FIG. 3. L.H. FRONT VIEW OF HORIZONTAL ENGINE—TURBOCHARGED

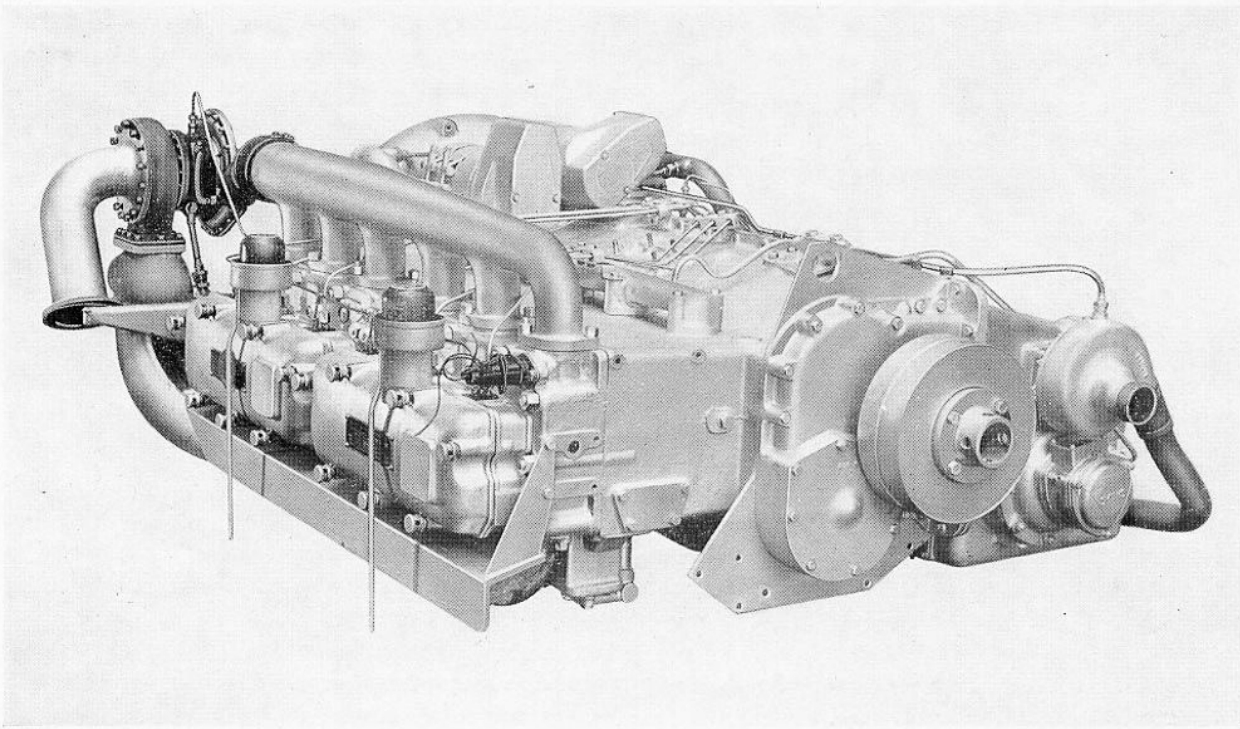


FIG. 4. R.H. FRONT VIEW OF HORIZONTAL ENGINE—TURBOCHARGED

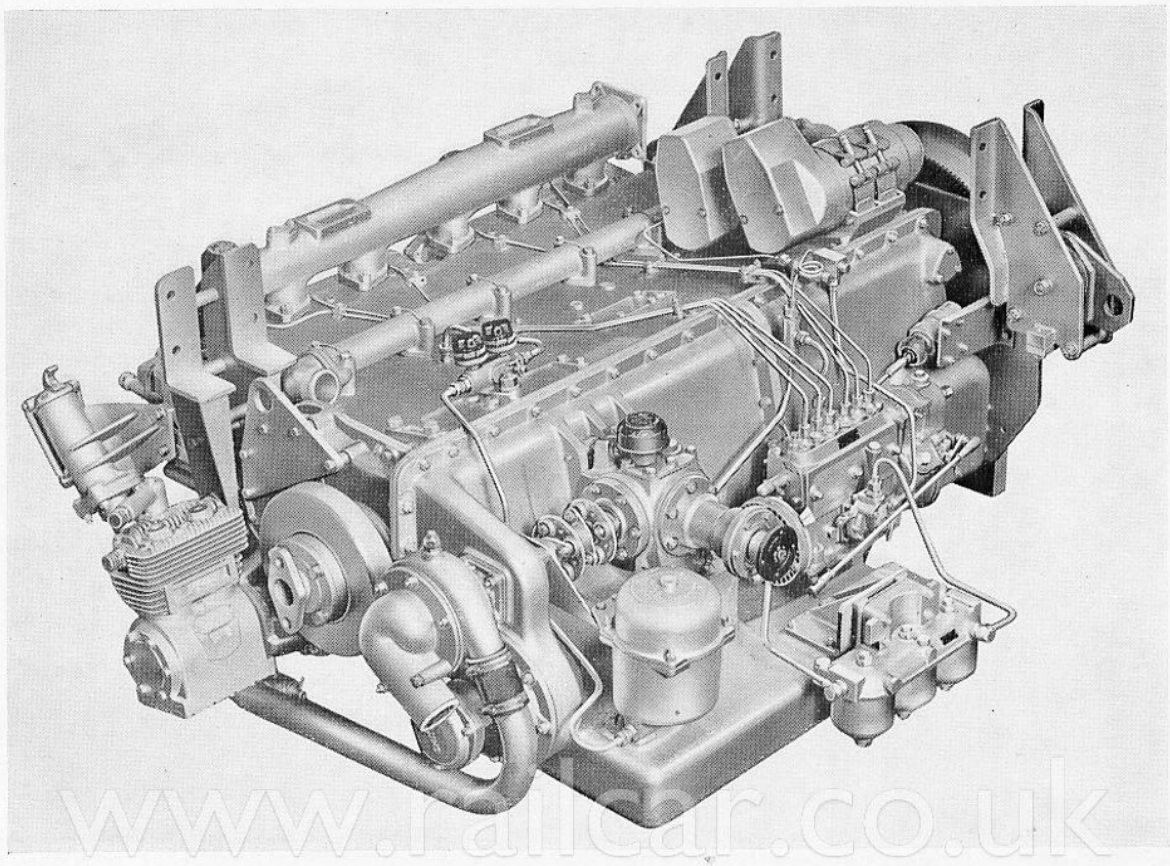


FIG. 5. L.H. FRONT VIEW OF HORIZONTAL ENGINE—NATURALLY ASPIRATED

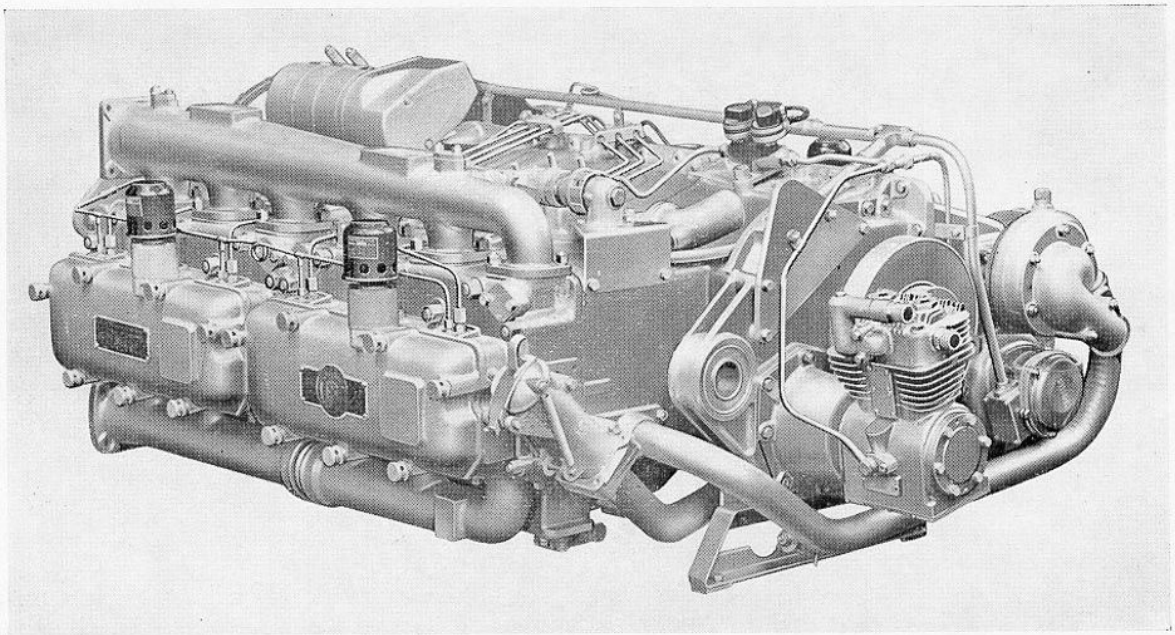


FIG 6. R.H. FRONT VIEW OF HORIZONTAL ENGINE—NATURALLY ASPIRATED

ENGINE DATA

DATA

Note: The unit type numbers given under **Data** in the sections are abridged and do not cover minor differences. All communications concerning units should quote the full and exact type and serial numbers, with suffixes, as stamped on the unit.

Type ... ... 900 series (15.177 litres), vertical and horizontal Diesel engines.

Main features ... Six-cylinder, compression-ignition, direct-injection, overhead-valve, four-stroke, water-cooled.

Bore ... ... 5.5 in. (139.7 mm.).

Stroke ... ... 6.5 in. (165.1 mm.).

Cubic capacity ... 926.6 cu. in. (15.177 litres).

Firing order ... 1, 5, 3, 6, 2, 4 (the front cylinder being No. 1).

Direction of rotation Clockwise looking at front of engine.

Idling speed ... 400 r.p.m.

Engine Type	Type of Compression Chamber	Compression Ratio	Brake Horse-power	Maximum Torque
900V	Toroidal	15.1 : 1	200 at 1,800 r.p.m.	658 lb./ft. (92.011 kg.m.) at 1,000 r.p.m.
900H	,,	,,	,,	,,
901V	Hemispherical	14.0 : 1	230 at 1,900 r.p.m.	708 lb./ft. (97.916 kg.m.) at 1,150 r.p.m.
901H	,,	,,	,,	,,
901V	,,	15.5 : 1	,,	,,
901H	,,	,,	,,	,,
901V (Turbocharged)	Toroidal	15.0 : 1	275 at 1,800 r.p.m.	840 lb./ft. (116.172 kg.m.) at 1,200 r.p.m.
901H (Turbocharged)	,,	,,	,,	,,
901H	Hemispherical	14.0 : 1	200 at 1,750 r.p.m.	635 lb./ft. (87.82 kg.m.) at 1,150 r.p.m.

ENGINE TYPE NUMBERS

The engine type and serial numbers are stamped on identification plates fixed to the cylinder head valve covers.

When writing for spares, guarantee claims, or in any connection whatsoever relating to the engine, it is important that the full and exact type and serial numbers with suffix is given, due to these engines being manufactured in various forms.

UNIT TYPE NUMBERS

The type and serial numbers of units connected with the engine and engine installation are stamped on identification plates fixed to that particular unit and should be quoted in all communications.

RUNNING INSTRUCTIONS

STARTING

Before starting the engine see that:

1. Engine cooling system is full.
2. Engine oil level is correct (dipstick).
3. Fuel tank is full (gauge on side of tank) and fuel is turned on.
4. Fuel pump and filters are primed.
5. Gear lever is in neutral.
6. Handbrake is on.
7. Torque convertor tank is full (gauge on side of tank) when fitted.

To start the engine

1. Close the battery cut-off switch (when fitted).
2. Move the starting switch to the **on** position.
3. Press the starter button firmly.
4. Release the starter motor button as soon as the engine starts. Do not keep the starters running unduly long if the engine does not fire, but find the cause of the failure to start. It will sometimes be found necessary, especially during cold weather, to open the throttle for a few moments after the engine starts, but as soon as it has warmed up slightly, this will not be necessary.

Warning: After starting up, allow the engine to warm up for a few minutes. Do not abuse the ability of loading the engine while it is cold, but allow the lubricating oil to circulate. The ideal running temperature of the engine is 165°F. (75°C.).

To stop the engine

Press the stop control button.

Important: When the engine starts, check that the oil gauge registers at least 25 p.s.i. (1.76 kg./s.cm.) when idling. If not, stop immediately and trace the cause.

FAULTY STARTING

If the engine fails to start, it may be due to the following:

1. Bad starting is usually due to the battery not being sufficiently charged so that the engine turns over compression in jerks.
2. No starting troubles should occur if the battery is kept in good condition, terminals clean, the plates covered with electrolyte and the dynamo charging properly.
3. If the engine has been standing in the open, particularly in cold weather, it is an advantage to fill the cooling system with hot water to free the pistons.
4. Failure to start after overhaul may be caused by incorrect fuel pump timing. Check that the pump timing is correct. The pump may have been replaced 180° out, so that the injection takes place at the end of the exhaust stroke.
5. Make sure, by means of the vent cock, that fuel is being delivered to the pump, and loosen several of the delivery pipe nuts at the injectors. Turn the engine by hand and check that fuel is reaching the nozzles.
6. Weak compression, resulting from badly seating or sticking valves, broken valve springs, faulty cylinder head gasket, cracked piston, worn or stuck piston rings, worn or scored cylinder bores, or cracked cylinder head.

RUNNING FAULTS

Erratic Running

If the engine runs unevenly it may be due to an air lock in the fuel system.

Remedy

1. Check that there is fuel in the fuel tank.
2. Vent the fuel system.
3. If unsuccessful, check that:
   i. No pipes are leaking, especially those on the suction side of the feed pump, where a small air leak may pass undetected.

ii. The vent pipe is not blocked.

iii. The filters are clean.

Faulty Injection

A faulty injector will probably be accompanied by one or more of the following:

1. Heavy blue-white smoke in the exhaust when the engine is hot and pulling on load.

2. Misfiring.

3. Pronounced knocking in the cylinder affected.

4. Loss of power.

To locate the cylinder that is misfiring, loosen the delivery pipe nut at the injector for each cylinder in turn and so stop delivery of fuel to that cylinder. If the cylinder has been firing, the unevenness will be accentuated; if not firing, there will be no difference in the running.

5. Check that the compression of each cylinder is good by turning by hand and listening for blow-by. Weak compression may be caused by badly seating or sticking valves, broken valve springs, faulty cylinder head gasket, cracked piston, worn or stuck piston rings, worn or scored cylinder bores, or cracked cylinder head. If the compression is good, misfiring and smoky exhaust is almost certainly due to a faulty injector.

Do not run with fuel being delivered to a faulty cylinder, as the unburnt fuel will dilute the lubricating oil. Always disconnect the delivery pipe so that the fuel runs on the outside of the engine and so that it cannot come in contact with the exhaust manifold or pipe, or the turbocharger when fitted.

MAINTENANCE

(ENGINE AND AUXILIARIES)

It is appreciated that many engine owners have their own methods of inspection and maintenance, but we offer the following inspection procedure as a guide to those in charge of individual engine installations and to service engineers not too familiar with the unit and installation.

As far as possible, engines should be kept clean to facilitate maintenance work, and also to prevent dirt getting into the engine generally, and into the fuel injection system in particular.

Important: The first 5,000 miles (8,000 kilometres) or 100 hours' service of a new engine can be regarded as a running-in period during which everything on the engine beds down. At the end of this period all new and overhauled engines should be checked over generally, attaching particular attention to the following items:

1. Drain the sump, detach the sump filter, clean and refit.
2. Fill the sump with new lubricating oil up to the **full** mark on the dipstick.
3. Detach the lubricating oil filters, fit new elements and clean out the centrifugal filter.
4. Tighten all setscrews, nuts and bolts in general.
5. Tighten down cylinder heads. A torsion spanner set at 200 lb. ft. (27.5 kg.m.) for $\frac{5}{8}$ in UNF. nuts and 100 lb. ft. (13.8 kg.m.) for $\frac{1}{2}$ in. UNF. nuts.
6. Check the inlet and exhaust valve tappet clearances, set to 0.020 in. (0.50 mm.) cold.

Periodical Inspection

The following items require attention at intervals quoted by respective owners' instructions:

1. Attend to items detailed in the **Lubrication** section.
2. Tighten down engine cylinder head nuts in the correct order, see **Cylinder Heads and Valve Gear** section.
3. Check the inlet and exhaust valve tappet clearances, see **Cylinder Head and Valve Gear** section.
4. Liveliness of engine, smoothness and exhaust.
5. Replenish the fuel tank.
6. Inspect the engine suspension for loose nuts, etc., see **To Remove and Replace Engine** section.
7. In the case of vertical engines, check the tension of the fan and water pump drive belts, see **Belt Tensioner** section.
8. Check all oil, fuel, water, air and vacuum pipes for loose nuts and leakages.
9. When fitted, check the air compressor joints and pipe connections for leakages, see **Air Compressor** section.
10. When fitted, 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 **Air Compressor** section.
11. Remove the fuel injectors and fit a set of new or reconditioned ones, see **Fuel Injectors** section.
12. Examine the fuel injection pump drive coupling discs for deterioration and renew if necessary, see **Timing Gears and Auxiliary Drives** section.
13. Check the fuel injection pump timing.
14. Renew the elements in the fuel filters and clean the bowls. Vent the fuel system, see **Fuel System** section.
15. Check engine oil pressure, see **Lubrication** section.
16. Examine the starter motor brushes, relays, commutator and pinion, see **Starter Motor** section.
17. Examine the teeth of the starter ring. If worn or damaged, the ring should be repositioned or renewed, see **Crankshaft and Main Bearings** section.
18. Clean the sump filter, oil filters and centrifugal filter at engine oil change, see **Lubrication** section.

19. Drain engine oil and refill, see **Lubrication** section.

20. When fitted, check turbocharger shaft for stiffness, see **Turbocharger** section.

21. Check that the dynamo is charging and warning light is working, see **Dynamo** section.

22. Check that the thermostat is working correctly, see **Engine Cooling Water Circulating** section.

23. When fitted, turbocharger—Holset type. Remove oil gauze filter and clean.

24. Throttle motor—remove and inspect; renew parts if necessary, see **Throttle Motor** section.

25. Remove the engine cylinder heads, valve gear and pistons, etc., decarbonise and carry out a general inspection, see **Cylinder Heads and Valve Gear** and **Pistons and Connecting Rods** sections.

A guide to these inspection periods, assuming a mileage of approximately 120,000 miles (196,000 kilometres), before major overhaul, is given below:

Daily Inspection:

1. Water level in cooling system, top up if necessary.
2. Oil level in sump with dipstick, top up to **full** mark if necessary.
3. Fuel level in tank, fill up if necessary.
4. Engine oil pressure.
5. Check for the air reservoir supply to build up to the correct operating pressure.
6. Check dynamo is charging and warning light is working.

Weekly Inspection:

1. Fuel injection pump, check oil level, top up as required.
2. Fuel injection pump governor, check oil level, top up as required.
3. Belt tensioner. Check tension of belt drives. Screw down greaser one turn—refill when empty.
4. Fuel injection pump control rod ball joints and stop solenoid for freedom of action.
5. Starter motors. Check brushes, relays, connections, starter pinion and starter ring.
6. Engine oil pressure, 45-55 p.s.i. (3.16-3.87 kg. s.cm.) at maximum governed speed with warm engine. Not below 10-25 p.s.i. (0.70-1.76 kg.s.cm.) with engine idling.
7. Liveliness of engine, smoothness and exhaust.
8. All switches.
9. When fitted, turbocharger, check pipes and flanges for leaks, check hose connections.
10. Check for oil, fuel, water, air and vacuum leaks.
11. Examine equipment generally for loose, missing or defective parts.

10,000 Mile Inspection: (16,000 kilometres)

1. Drain engine of oil, refill to **full** mark on dipstick.
2. Renew lubricating oil filter elements.
3. Clean out centrifugal filter.
4. Clean and wash sump filter.
5. Fuel injection pump. Drain oil and refill.
6. Examine fuel injection pump drive.
7. Check fuel injection pump timing.
8. Compression.
9. Tappet clearances.
10. Renew fuel filter elements.
11. Starter motors, lubricate bearings with oil.
12. Engine suspension.

13. Water pump (vertical engine) lubricate bearings with grease.

14. Belt tensioner, limited supply greaser—lubricate bearings with grease.

15. Thermostat, check if working correctly.

16. Air compressor, remove and inspect.

17. Tachometer generator, lubricate bearings with grease.

18. When fitted, turbocharger—Holset. Remove exhaust pipe and check for free rotation of the rotor assembly.

19. When fitted, turbocharger—Holset. Remove oil gauze filter and clean.

20. Throttle motor. Lubricate with engine oil (one shot only).

20,000 Mile Inspection: (32,000 kilometres)

1. Fuel injectors.

30,000 Mile Inspection: (48,000 kilometres)

1. Cylinder head nuts. Check for tightness.

60,000 Mile Inspection: (96,000 kilometres)

1. When fitted, turbocharger—Simms. Remove exhaust pipe and check for free rotation of the rotor assembly.

2. Throttle motor—remove and carry out a general inspection, renew parts if necessary.

120,000 Mile Inspection: (192,000 kilometres)

1. Remove engine cylinder heads, valve gear and pistons, etc.; decarbonise and carry out a general inspection; renew parts if necessary.

2. When fitted, turbocharger—return to makers for inspection.

3. Belt tensioners, remove and inspect.

ENGINE LUBRICATION

DATA

Type	Wet sump-gear type pump. Scavenge pumps fitted as required.

PUMP DATA

Interference of pump gear on driving shaft	.0007 in. to .0017 in. (.018 mm. to .043 mm.)
Diametral clearance between idler gear and spindle ...	.0022 in. to .0037 in. (.056 mm. to .094 mm.)
Backlash between gears	.022 in. to .026 in. (.56 mm. to .66 mm.)
Diametral clearance of gears in pump body	.003 in. to .007 in. (.08 mm. to .18 mm.)
End clearance of gears in pump body	.003 in to .008 in. (.08 mm. to .20 mm.)
Clearance of driving spindle in pump body	.001 in. to .0022 in. (.025 mm. to .056 mm.)
Initial backlash between skew gears on spindle and camshaft	.008 in. to .012 in. (.20 mm. to .30 mm.)
Clearance between spindle and bush	.001 in. to .002 in. (.03 mm. to .06 mm.)
Sump capacity—with filters:	
900 series vertical	6½ galls (30 litres) approx.
900 series horizontal	8 galls (36 litres) approx.
Oil pressure relief valve	Non-adjustable. Valve spring should compress to 1.6 in. (40.6 mm.) under a load of 21-27 lb. (9.5-12.2 kg.)
Oil pressure	45-55 p.s.i. (3.16-3.87 kg. s.cm.) at maximum governed speed with warm engine. 10-25 p.s.i. (0.70-1.76 kg. s.cm.) with engine idling.
Pump delivery	17.5 galls/min. (80 litres/min.) approx. at 1,900 r.p.m. crankshaft speed.
Filters	Gauze strainer in sump. Centrifugal by-pass type Glacier GF2/7. Purolator, full-flow, twin-bowl, paper elements—when fitted.
Oil cooler	Integral with engine cylinder block.

LUBRICATION PERIODS

DAILY

1. **Engine.** Check oil level in sump with dipstick. Top up as required.

WEEKLY

1. **Fuel Injection Pump.** Check oil level with dipstick. Top up as required.
2. **Fuel Injection Pump.** Control rod ball joints. Oil can.
3. **Fuel Injection Pump Governor.** Check oil level with dipstick. Top as required.
4. **Belt Tensioner (Link Type).** One turn of greaser. Refill when empty.

10,000 MILES

1. **Engine.** Drain and refill to "full" mark on dipstick.
2. **Fuel Inspection Pump.** Drain and refill to "full" mark on dipstick.
3. **Water Pump Drive (Vertical Engine).** Grease gun.
4. **Belt Tensioner (handle and screw type).** Grease gun.
5. **Starter Motor Bearing.** Oil can. Few drops only.

120,000 MILES (UNIT OVERHAUL)

1. **Dynamo.** Clean and repack bearings.
2. **Starter Motor.** Clean and repack pinion and clutch.

Renewal of Lubricating Oil Filter Elements

The lubricating oil filter elements should be renewed at regular intervals approximately 10,000 miles (10,000 kilometres) or monthly, dependent upon operating conditions. See Section 6—Maintenance.

Centrifugal Oil Filter. Clean out when changing oil filter elements.

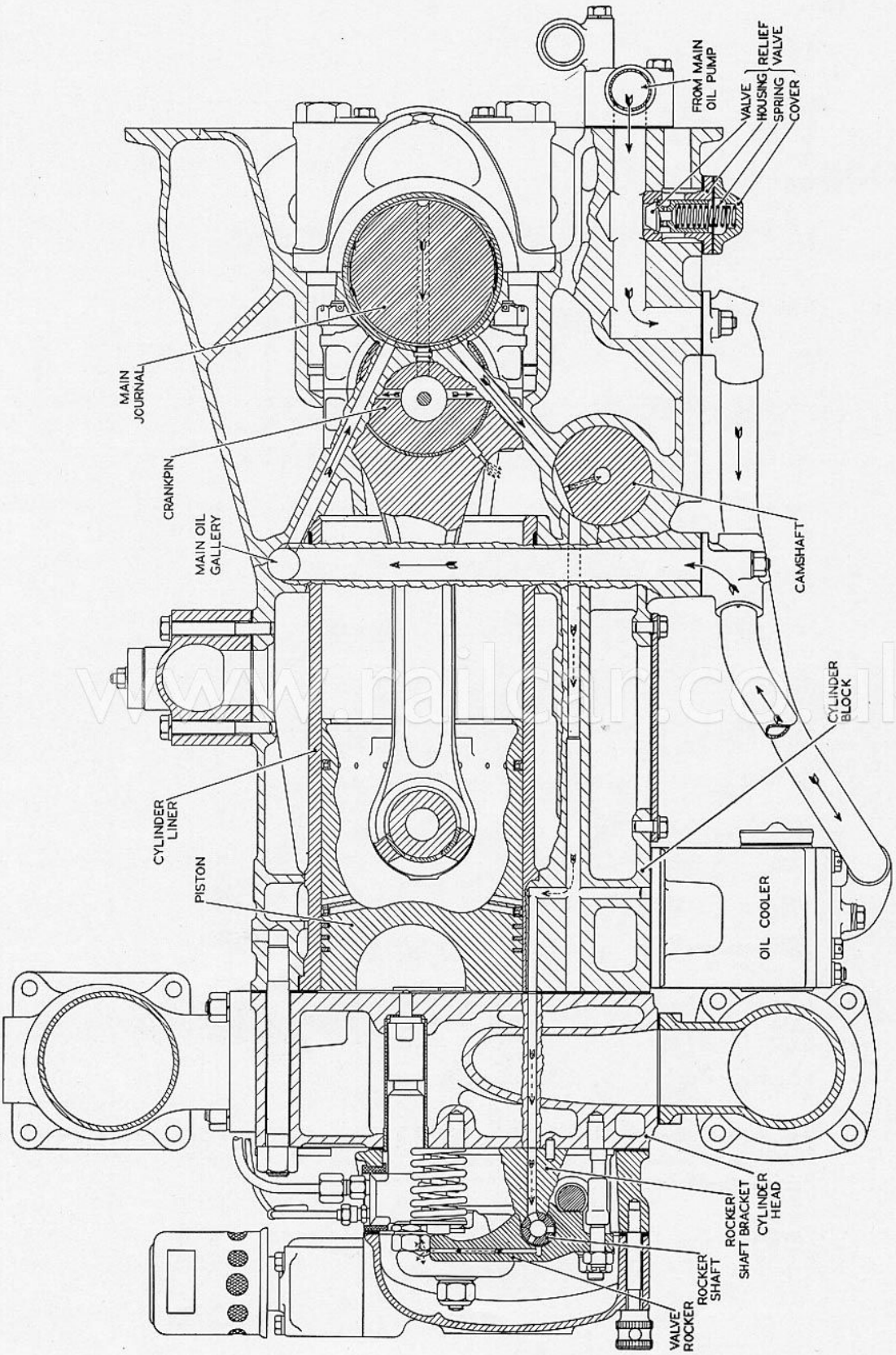


FIG. 1. TYPICAL CROSS SECTION OF ENGINE SHOWING OIL CIRCULATION

DESCRIPTION

The engine is lubricated on the wet sump system and oil is circulated under pressure to all main bearings by a straight toothed gear type pump driven from a skew gear on the camshaft.

The main oil pump (Fig. 2) draws its supply through a gauze strainer in the sump. On some engines a scavenge pump (Fig. 6) of similar design to the main pump is fitted at the other end of the sump to prevent oil starvation of the bearings when the unit is operating on steep gradients, this pump returns to the main sump any oil collecting in a scavenge sump provided for this purpose (Fig. 1), thereby keeping the gauze strainer covered at all times.

Oil pressure is regulated by a spring loaded relief valve in the pump outlet passage.

Filtration is by means of a centrifugal oil filter which is fitted and operates on the by-pass principle, and has a flow rate sufficiently high to ensure that the entire oil supply is filtered every few minutes. On some engines in addition to the centrifugal filter, a twin-bowl, full flow filter of the paper element type is also fitted. Piping has been almost completely eliminated, drilled passages in the castings forming the majority of the oilways.

From the main pump, oil is delivered under pressure through a passage in the crankcase, past the relief valve to a transverse passage up through the engine block into the main oil gallery running the length of the engine (Fig. 1). On some engines an integral water-jacketed oil cooler is fitted on the side of the engine block, and oil after passing the oil relief valve, passes through this oil cooler and is then piped back to the transverse passage in the engine block.

From the main gallery oil is fed through drillings in the engine block webs to the individual bearings, and then through oilways in the crankshaft webs to the hollow crankpins, which are sealed to form oil reservoirs. Transverse drillings in the crankpins admit this oil to the big end bearings, whilst a small hole in each connecting rod big end is so arranged, that, as it registers with each of the crankpin drillings, oil is sprayed over

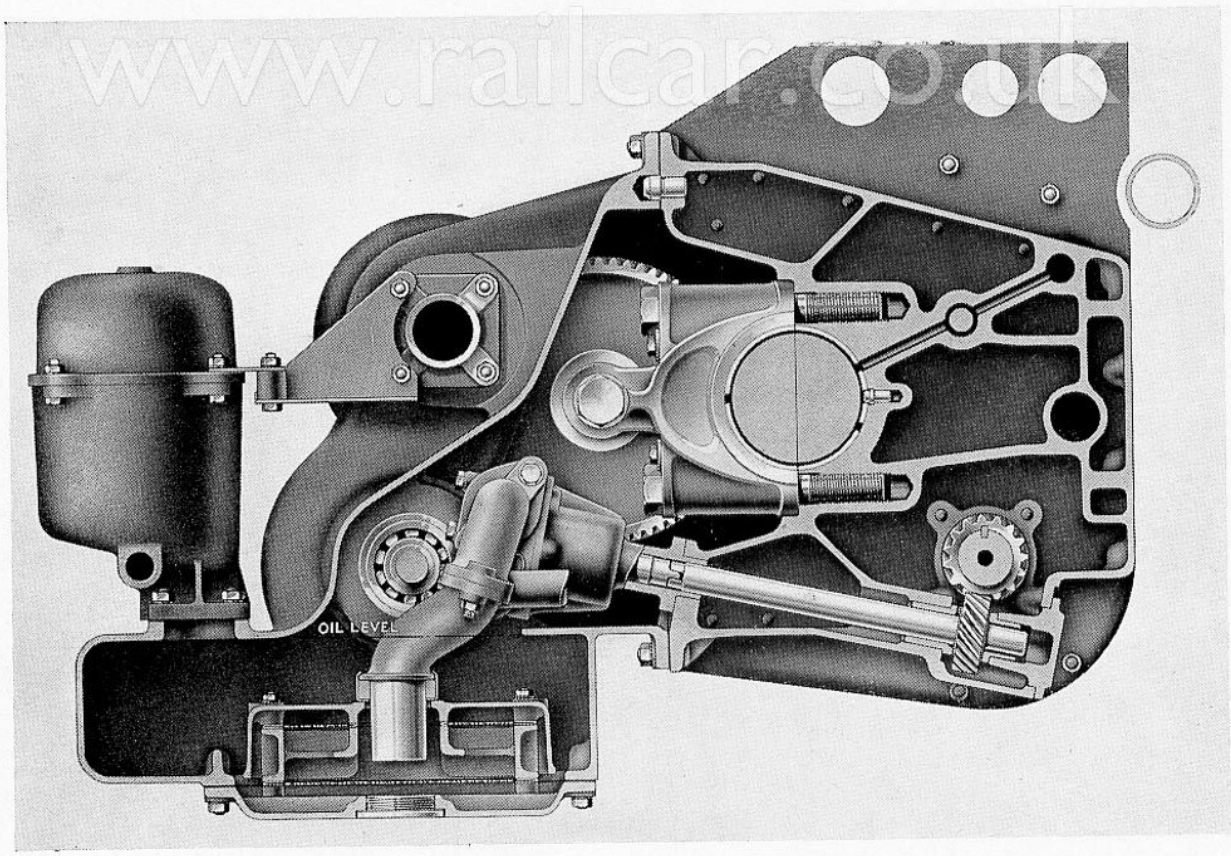


FIG. 2. VIEW THROUGH HORIZONTAL ENGINE SHOWING SUMP FILTER, SUCTION PIPE AND MAIN OIL PUMP DRIVE

the cams of the camshaft and over the thrust face of the cylinder wall. The gudgeon pin bushes are splash lubricated.

The intermediate gear bush and thrust washers are lubricated from the oilway to the front main bearing, the hole for the intermediate gear spindle breaking into the oilway to the front main bearing. On horizontal engines a second intermediate gear bush and thrust washer is fitted to drive the water pump and fuel injection pump, etc., and this is similarly fed from a drilling in the front main bearing cap. Oil escaping past the intermediate gear thrust washers is trapped in a groove round the gear rims, whence radial drillings direct it on to the remaining timing gears and auxiliary drives.

Second drillings from the centre and intermediate main bearings feed the corresponding camshaft bearings, and also the front and rear camshaft bearings through central oilways in the shaft. Tappings from No. 2 and 5 camshaft bearings provide intermittent feed via oil ways drilled in the cylinder block and heads into the centre rocker shaft support brackets, and thence through the hollow rocker shafts to holes at the individual rockers (Fig. 1). Holes drilled in the rocker shafts and in each rocker lever carries a supply of oil to lubricate the contact surfaces between the valve cap and the rocker lever. The used oil lubricates the push rods in returning to the sump for re-circulation.

TO DRAIN AND FILL ENGINE

To Drain

This operation should be carried out with the engine in a level position and while the oil is still warm, i.e. immediately after the engine 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. Replace the plugs after draining.

To Fill

Fill the engine with oil through the oil filler provided, until the oil level is at the full mark on the dipstick, ensuring first that the engine is standing level. Start the engine and run it for a few moments 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.

A further check, with engine level, 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.

OVERHAUL

SUMP

VERTICAL ENGINE

To Remove

1. Drain the engine of oil.
2. Remove the starter motors.
3. Remove nuts securing the sump to the crankcase and remove the sump.

To Fit

Reverse the removal procedure using new joint.

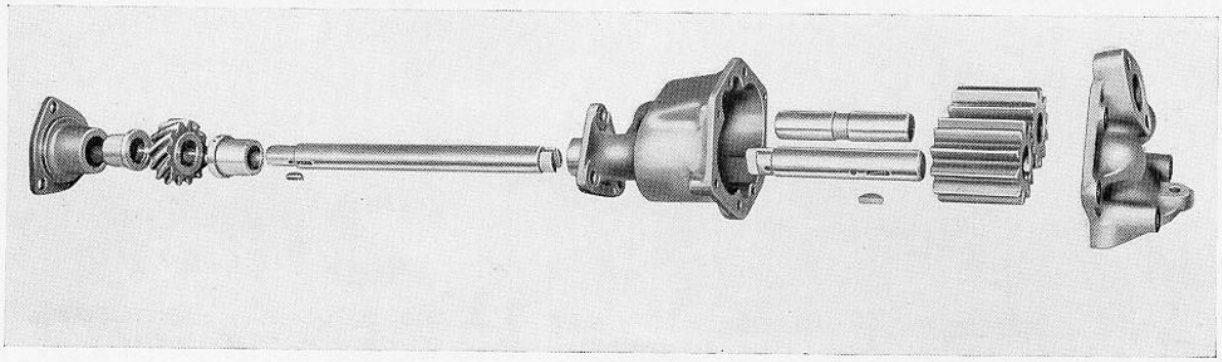


FIG. 3. OIL PUMP AND DRIVE DISMANTLED

HORIZONTAL ENGINE

To Remove

1. Drain the engine of oil.
2. Drain the cooling system.
3. Remove the oil filler pipe.
4. Remove the water pipes to the water pump.
5. Remove the oil pipe to the centrifugal filter.
6. Disconnect the fuel feed pipes at the monitor block. Plug or tape over all open pipes and unions to prevent entry of dirt.
7. Disconnect the leak-off pipes. Plug or tape over all open pipes and unions to prevent entry of dirt.
8. Disconnect the injector pipes at the fuel injection pump end and at the junction bracket on top of the engine block, then remove the injector pipes. On some engines disconnect the injector pipes at the fuel injection pump end and at the injectors, then remove the injector pipes. Plug or tape over all open pipes and unions to prevent entry of dirt.
9. Disconnect the electrical connections at the stop solenoid.
10. Remove the sump base plate, take out two setscrews retaining the bottom portion of the oil suction pipe to the main oil pump, and remove pipe.
11. Remove all nuts securing the sump to the engine block, withdraw the sump from its locating dowels, lower it slightly and, tilting the bottom inwards to clear the scavenge oil pump, manoeuvre it down and outwards away from the engine.

On some types of engines the following parts will have to be removed:

12. Wiring to the engine tachometer generator.
13. Oil pipes to the Plessey pump.
14. Throttle motor.
15. Remove nuts securing the conduit support bracket and clip to the crankcase cover.
16. Remove drive shaft to the right-angle drive.

To Refit

Reverse the removal procedure using new joints.

OIL PUMPS

MAIN AND SCAVENGE

DESCRIPTION

Apart from inlet and outlet connections, which are shown in Fig. 5, the main and scavenge oil pumps, housed in the crankcase, Fig. 4, are of identical construction.

Referring to Fig. 6 the pump body (3) houses two meshing spur gears, one running freely on the idler spindle (6) and the other keyed to the oil pump spindle

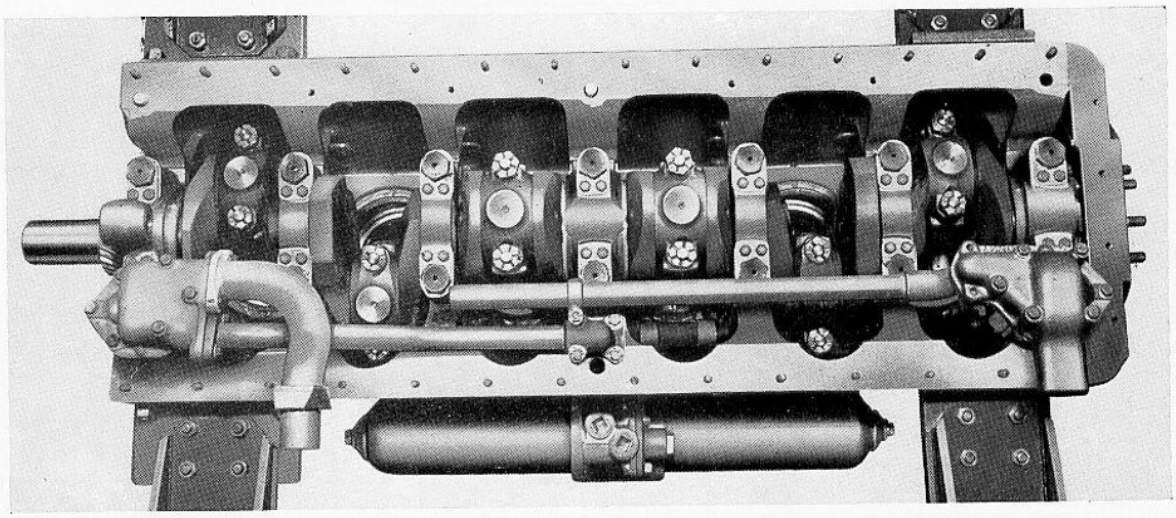


FIG. 4. OIL PUMPS IN POSITION

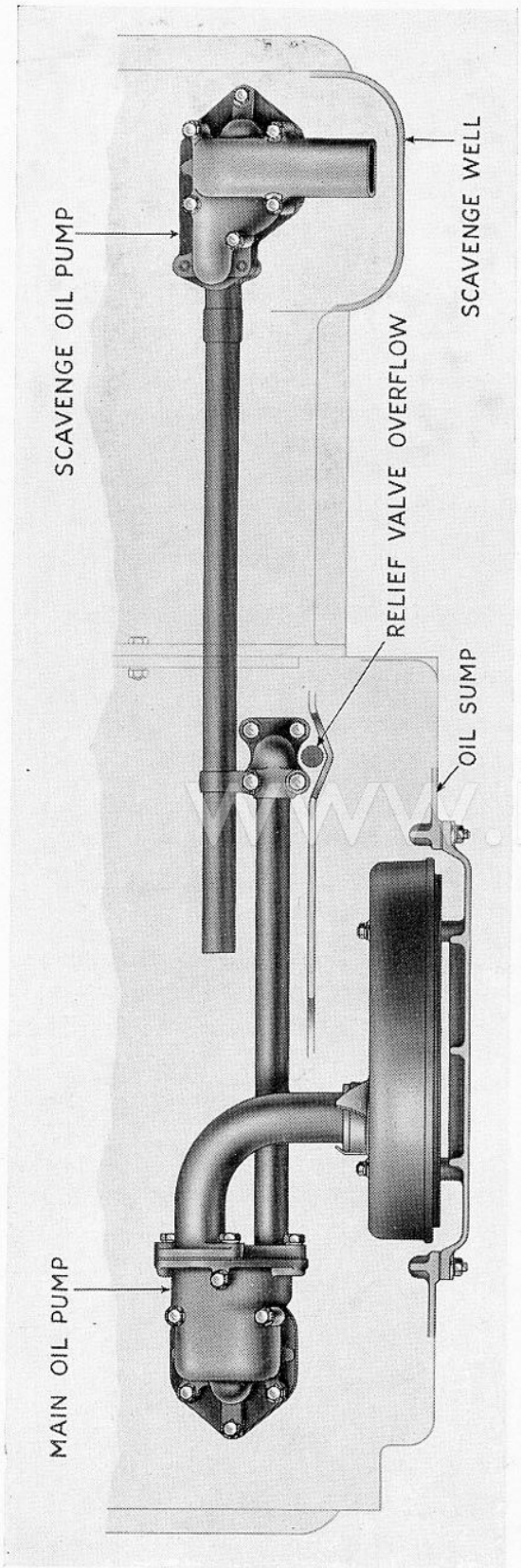


FIG. 5. OIL PUMP CONNECTIONS

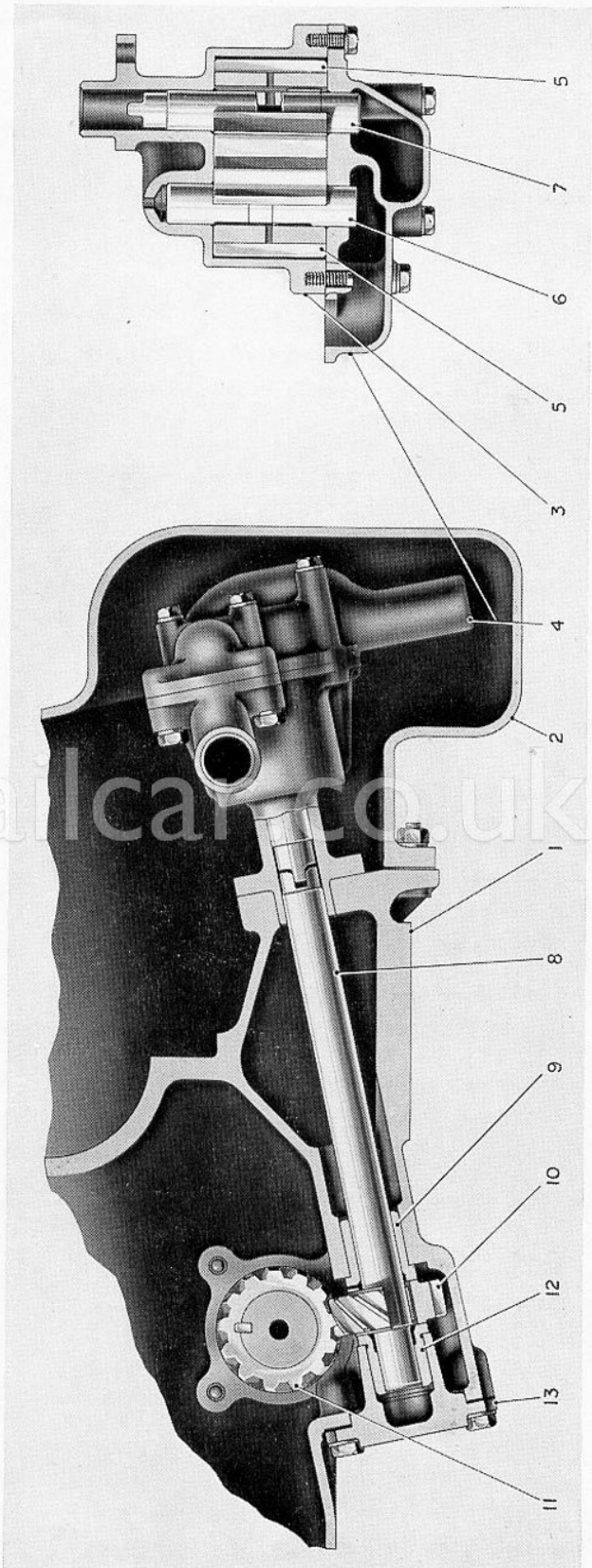


FIG. 6. SCAVENGE OIL PUMP AND DRIVE

(7) which is tongued to the driving spindle (8), driven off the camshaft through the skew gears (10) and (11). Driving end thrust is taken by a flanged collar (12) pressed into the cover (13) on the outside of the crankcase, and lubrication of the drive is effected by a pressure oil feed through the central oilway in the driving spindle to the thrust collar, and then through a groove in the bore of the skew gear to the annular recess in the extension spindle bush (9), whence a small orifice directs a jet of oil on to the camshaft gear.

To Remove

Access to both main and scavenge oil pumps is obtained on removing the sump as described. It is then only necessary to remove the oil delivery pipes and three screws securing each pump to the crankcase, and then the pumps can be withdrawn complete.

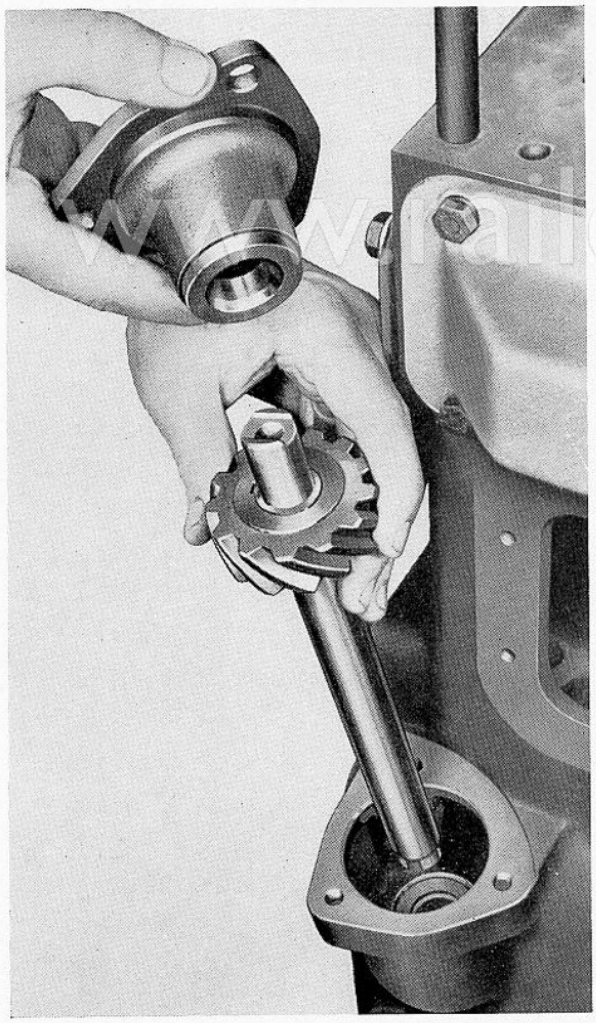


FIG. 7. FITTING OIL PUMP GEAR AND THRUST HOUSING

To Fit

When refitting, first line up the slot in the driving spindle with the tongue of the oil pump spindle, then follow removal procedure in reverse.

To Dismantle and Overhaul

The pump gears and driving spindle can be slipped out after removing the end cover, and the idler spindle can be driven out if necessary with a rod passed through the hole provided in the pump body for this purpose, Fig. 3.

All parts should be checked for wear by comparison with the manufacturing limits listed under **Data.**

To Assemble

When reassembling check that the pump rotates freely both before and after tightening the cover fixing screws.

OIL PUMP DRIVES

Description

Access to the oil pump drives (Figs. 2 and 5) is obtained by removing the thrust covers on the side of the crankcase. The driving spindles can then be withdrawn with the fingers (Fig. 7). It is important to note, that, if the bush in the crankcase is being renewed, the oil jet hole must point towards the camshaft gear. The slot in the end of the driving spindle must engage freely with the tongue of the oil pump spindle.

CENTRIFUGAL OIL FILTER

Description

The centrifugal oil filter is flange mounted on top of the sump in the case of horizontal engines, and on the front right-hand side cover in the case of vertical engines. The 'Glacier' centrifugal oil filter operates on the by-pass principle, taking oil from the main oil gallery and returning it filtered to the sump for recirculation. It has a flow rate of approximately 1½ pts. min. (6.53 litres/min.).

Referring to Fig. 9, oil under pressure from the pump is tapped off the main oil gallery and piped to the inlet union in the bore of the filter casing (A), passing then up the hollow centre spindle (B) and out through ports (C) into the rotor bowl (F). When the bowl is full, the overflow escapes downwards through the stand pipes (H) and, due to the restriction of the nozzles (J), is expelled at high velocity into the filter casing. As

the nozzles are arranged tangentially and the rotor is freely mounted on the centre spindle, reaction of the oil jets at the nozzles sets the rotor spinning at high speed, with the result that all solid matter suspended in the oil is thrown out by centrifugal force against the inside of the bowl. It collects there as a tightly compacted mass with sufficient adherence to resist being washed off, whilst cleaned oil drains off through the base of the casing back to the sump for recirculation.

Advantages of the centrifugal filter are that it removes suspended carbon, metallic particles, dust, etc., with great efficiency, and maintains this efficiency uniformly irrespective of the amount of dirt accumulated and cannot become clogged.

To Clean

This operation is very simply performed and 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.

1. Remove the four retaining bolts and detach the filter cover (D).

2. Remove the rotor from the bottom bearing.

3. Unscrew the retaining nut and washer, the rotor (F and G) may be taken apart. If necessary, a screw driver may be inserted at the joint.

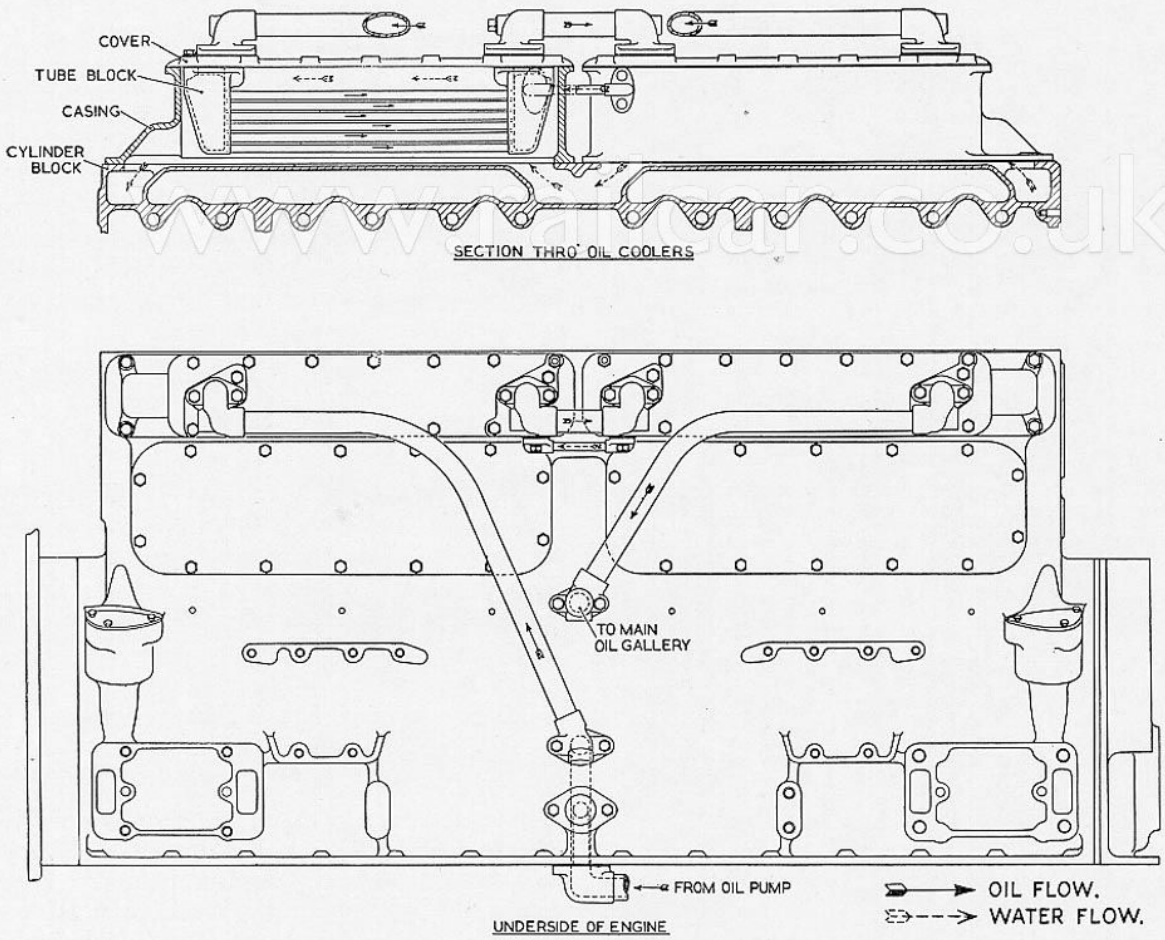


FIG. 8. ARRANGEMENT OF OIL COOLERS

4. Run a knife round the periphery of the two halves of the rotor and tip out the compacted sludge. To prevent particles of the sludge dropping into the stand pipes and so choking the nozzles, do not remove the gauzes on the stand pipes until that part of the rotor has been cleaned.

5. Clean the two halves of the rotor thoroughly.

6. Remove the gauzes and clean with a stiff brush.

7. Clean out stand pipes and nozzles (J) with compressed air if possible.

8. Replace the gauzes.

9. Reassemble the rotor unit.

10. Replace the rotor assembly, taking care not to damage the bearings.

11. Reassemble the body ensuring that the gasket (E) is not damaged.

Note: On new and reconditioned engines, the centrifugal filter should be given a preliminary cleaning when the initial oil change is made on completion of the first 500 miles (800 km.).

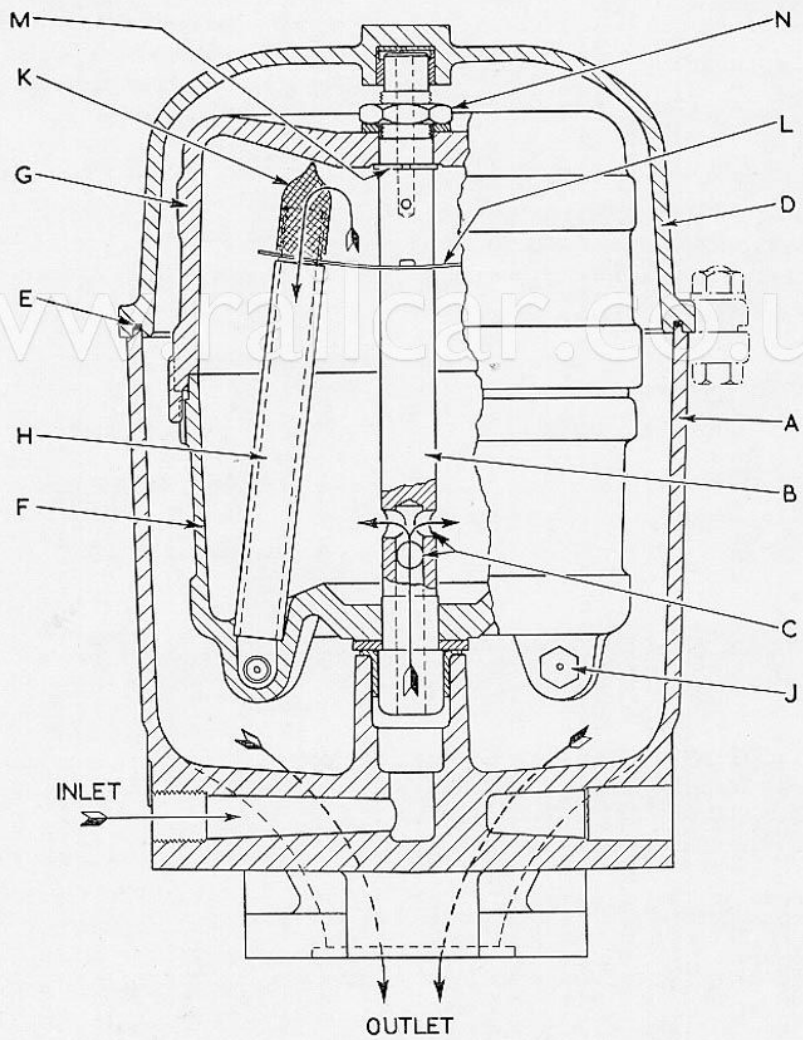


FIG. 9. CENTRIFUGAL OIL FILTER

A. Filter casing.
B. Centre spindle.
C. Ports.
D. Filter cover.
E. Cover gasket.
F. Rotor bowl.
G. Rotor cover.
H. Stand pipes.
J. Nozzles.
K. Gauze strainers.
L. Retaining spring.
M. Circlip.
N. Retaining nut.

SUCTION FILTER

To Remove—Vertical Engines

1. Drain the engine of oil.
2. Remove sump from crankcase cover.
3. Remove cover and gauze strainer from sump.

To Remove—Horizontal Engines

1. Drain the engine of oil.
2. Remove the sump base plate.
3. Remove cover and gauze strainer from base plate.

To Clean

Thoroughly wash the gauze strainer in paraffin.

To Fit

Reverse the removal procedure. On assembly, make sure that the felt seal and its retainer are in good condition and in place on the end of the oil suction pipe and ensure that the oil suction pipe enters the hole in the gauze strainer.

PUROLATOR OIL FILTER

Description

A Purolator Micronic full-flow filter of the twin-bowl type (Figs. 10 and 11) when fitted is mounted on the camshaft side of the cylinder block.

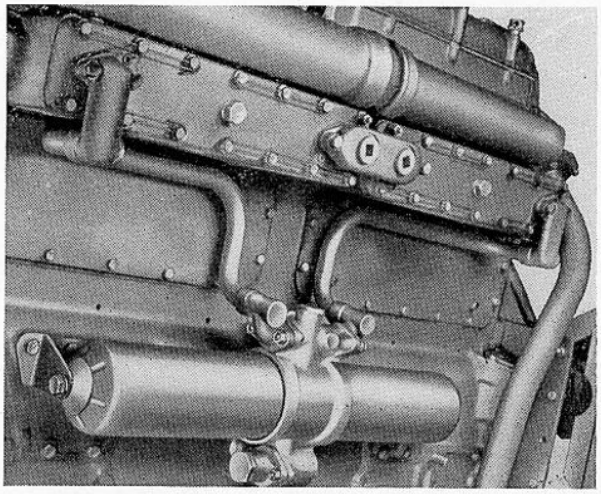


FIG. 10. PUROLATOR OIL FILTER SHOWING CONNECTIONS TO OIL COOLER

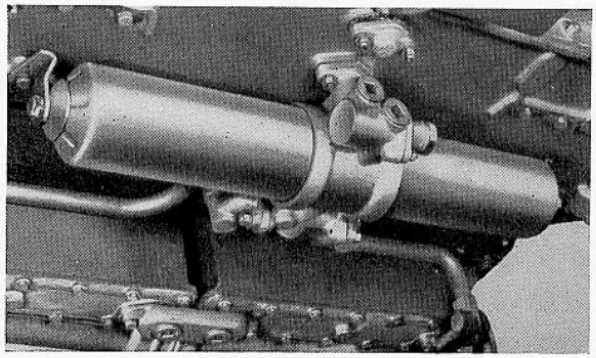


FIG. 11. PUROLATOR OIL FILTER SHOWING CONNECTION TO MAIN OIL GALLERY

The design incorporates two paper elements connected together in parallel by a common head. A relief valve is provided to ensure continuous oil flow, should the filter be allowed to get choked. When renewal becomes necessary, the elements may readily be replaced.

To Remove

1. Remove casing and element together by undoing centre bolts.

To Clean

Thoroughly wash the interior of the casing.

To Fit

1. Insert new element in casing.
2. Tighten the centre bolt.

OIL COOLER

Description

To prevent excessive engine oil temperature being attained, and to assist warming up the oil from cold, the output of the main oil pump, before delivery to the engine bearings, is fed through two identical water-jacketed oil coolers connected in series and bolted to the cylinder block (see Figs. 8 and 10). Each cooler comprises a casing open to the cylinder water jacket, and a cover inside which is bolted to a tube block assembly, built up of 21 tubes brazed into a small header tank at each end. Oil flows through the two tube blocks from rear to front and any excessive heat is dissipated in the surrounding water, which normally circulates through the casings in the opposite direction.

During the major overhauls the oil cooler covers should be removed so that rust and scale can be cleaned out from between the cooler tubes, no other attention is required. These oil coolers are only fitted when required.

To Remove

1. Drain water from the engine.
2. Disconnect all oil and water pipe connections.
3. Remove oil cooler cover.

To Clean

Remove the rust and scale from between the cooler tubes and clean with compressed air.

To Fit

Reverse the removal procedure.

OIL PRESSURE RELIEF VALVE

Description

The oil pressure relief valve is situated in the side of the crankcase, and is of the spring loaded plunger type and is shown sectioned in Fig. 1. Operated by pressure in the oil delivery line from the main oil pump, it is designed to open and by-pass oil back to the sump when the pressure exceeds 55 p.s.i. (3.87 kg. sq.cm.). It is non-adjustable.

Access to the relief valve is readily obtained on removing the cover. The valve plunger should be perfectly free in its housing and the seating must be clean and unmarked.

TO REMOVE AND REPLACE ENGINE

VERTICAL ENGINE

To Remove

1. Remove any detachable panels round the engine unit.
2. Isolate from batteries by the battery cut-off switch if fitted, or by disconnecting at the terminals.
3. Drain the cooling system.
4. Disconnect the inlet and outlet water pipes from the engine to the cooling system.
5. Disconnect the fuel feed pipe and leak-off pipe.
6. Remove the connection between the engine air filter and the inlet manifold.
7. Disconnect the exhaust pipe at the exhaust manifold or turbocharger when fitted.
8. Detach the cables from the starter motors.
9. Uncouple the drive shaft from rear of engine.
10. Detach the throttle control rod and spring.
11. Detach the engine stop control cable from the stop control lever on the fuel injection pump.
12. Uncouple the oil gauge pipe.
13. All the interconnecting parts have now been removed.
14. In some cases where the engine is driving through a gearbox, torque converter, fluid drive or directly driving a unit such as a compressor, the whole unit can be removed together.
15. Take the weight of the engine, etc., on a suitable crane.
16. Raise the engine slightly to relieve the load on the front and rear mountings.
17. Remove the bolts from the engine mounting brackets and withdraw the engine from its cradle or mounting frame.

On some types of engines the following parts will have to be removed:

18. Disconnect the top and bottom water pipes on the radiator and remove.
19. Disconnect the top radiator stay, remove the bolts from the radiator mounting brackets, and remove the radiator.
20. Detach the cables from the dynamo.
21. Uncouple the speedometer drive cable.
22. Detach the wiring from the tachometer generator transmitter.
23. Disconnect the pipes to the compressor.
24. Disconnect the pipes to the Plessey pump.
25. Uncouple the drive shaft from front of engine.
26. Disconnect the fluid pipes to the torque convertor.
27. Uncouple the clutch operating rod.

To Replace

Replacement of engine, etc., is the reverse of the removal procedure.

HORIZONTAL ENGINE

To Remove

1. Remove any detachable panels round the engine unit.
2. Isolate from batteries by the battery cut-off if fitted, or by disconnecting at the terminals.
3. Drain the cooling system.
4. Drain the engine sump.
5. Disconnect the inlet and outlet water pipes from the engine to the cooling system and remove.
6. Disconnect the fuel feed pipe and leak-off pipe.
7. Remove the connection between the engine air filter and the inlet manifold.
8. Disconnect the exhaust pipe at the exhaust manifold or turbocharger when fitted.

9. Detach the cables from the starter motor.

10. Uncouple the drive shaft from rear of engine.

11. Disconnect the reaction bracket from the frame.

12. All the interconnecting parts have now been removed.

13. In some cases where the engine is driving through a gearbox, torque converter, fluid flywheel or directly driving a unit such as a compressor, the whole unit can be removed together.

14. Take the weight of the engine, etc., on a suitable lifting gear, interposing wooden blocks as required to give a steady vertical lift and prevent damage to the engine casing.

15. Raise the engine slightly to relieve the load on the front and rear mountings.

16. Remove the bolts from the engine mounting brackets and carefully manoeuvre the engine, etc., out from below the chassis or frame. On some installations the engine is mounted in a sub-frame, the engine and sub-frame then being removed together.

On some types of engines the following parts will have to be removed:

17. Disconnect the water bleed pipes from engine.

18. Detach the cables from the dynamo.

19. Detach the pipes to the compressor.

20. Detach the air pipes to the throttle motor.

21. Detach the oil pipes to the Plessey pump.

22. Remove the outer oil filter tube and dipstick when mounted separate from engine.

23. Uncouple the drive shaft from front of engine.

24. Uncouple the drive shaft from the right-angle drive.

25. Withdraw the thermometer bulb from the water manifold or cylinder head.

26. Disconnect the wiring at the water temperature switch.

27. Disconnect the wiring to the stop solenoid.

28. Disconnect the wiring to the tachometer generator or transmitter.

29. Uncouple the speedometer drive cable.

30. Uncouple the oil gauge pipe.

31. Disconnect the wiring to the oil pressure switch.

32. Uncouple the clutch operating rod.

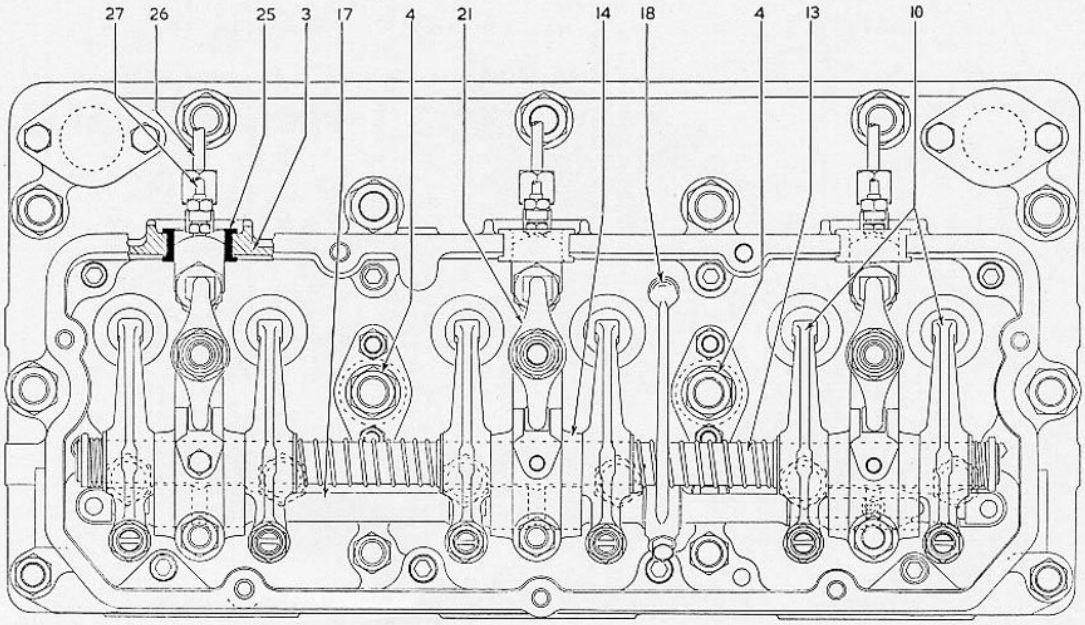
33. Uncouple the gear change coupling rod at gearbox.

34. Disconnect the fluid pipes to the torque converter.

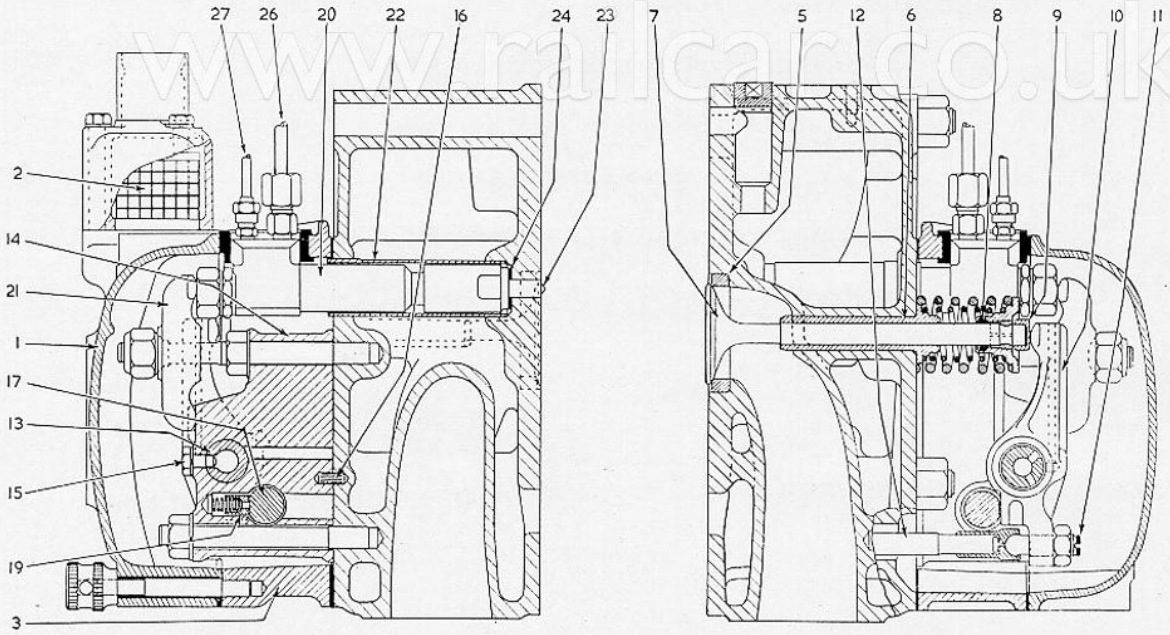
To Replace

Replacement of engine, etc., is the reverse of the removal procedure.

CYLINDER HEADS AND VALVE GEAR



PLAN VIEW.



SECTION AT INJECTOR.

SECTION AT VALVE.

FIG. 1. ARRANGEMENT OF CYLINDER HEAD AND VALVE GEAR

1. Valve cover.
2. Strainer.
3. Valve gear casing.
4. Cylinder head jack nuts.
5. Valve inserts.
6. Valve guide.
7. Valve.
8. Sealing ring.
9. Valve stem cap.
10. Valve rockers.
11. Tappet adjusting screw.
12. Push rod.
13. Rocker shaft.
14. Rocker shaft bracket.
15. Locating screw.
16. Dowel.
17. Decompressor shaft.
18. Decompressor lever.
19. Locking plunger.
20. Fuel injector.
21. Injector clamp.
22. Injector tube.
23. Injector nozzle.
24. Nozzle washer.
25. Injector seal.
26. Injection pipe.
27. Spill pipe.

DATA

CYLINDER HEAD

Type	Detachable, 2 per engine, each covering three cylinders.
Material	Cast iron.
Valve guide interference in head	.0025/.002 in. (.0635/.0508 mm.).
Valve insert interference in head:	
Inlet	.0035/.006 in. (.09/.15 mm.).
Exhaust	.003/.0055 in. (.08/14. mm.).
Renew valve inserts if valve heads, after regrinding, do not stand proud of head:	
Inlet	.070/.089 in. (1.78/2.26 mm.).
Exhaust	.032/.051 in. (.81/1.29 mm.).

VALVE GUIDES

Material	Cast iron.
Initial bore	.437/.439 in. (11.10/11.15 mm.).

VALVES

Type	Overhead poppet.
Material:	
Inlet	Silicon chrome, stellite faced.
Exhaust	Silicon chrome, stellite faced, hard chrome plated stem.
Number per cylinder	One inlet, one exhaust.
Stem diameter:	
Inlet	.43475/.43425 in. (11.0425/11.030 mm.).
Exhaust	.43325/.43275 in. (11.0046/10.9918 mm.).
Stem clearance in guide	
Inlet	.00225/.00475 in. (.05715/.12065 mm.).
Exhaust	.00375/.00625 in. (.09525/.15875 mm.).
Renew valve guides when valve stem clearance exceeds	.010 in. (.25 mm.).
Valve head diameter:	
Inlet	2.50 in. (63.50 mm.).
Exhaust	2.10 in. (53.34 mm.).

Angle of valve seat	30°.
Angle of valve face	29½°.
Valve lift	.59 in. (14.986 mm.).
Number of valve springs	Two per valve, concentric.
Free length of spring:	
Inner	2.04 in. (51.816 mm.) left hand coil.
Outer	2.35 in. (59.69 mm.) right hand coil.
Renew springs when	Inner spring will compress to 1.13 in. (28.7 mm.) under a load of less than 52/58 lb. (23.6/26.3 kg.). Outer spring will compress to 1.385 in. (35.1 mm.) under a load of less than 97/103 lb. (44.0/46.7 kg.).
Initial diametral clearance of rocker shaft in rocker ...	.0005/.00225 in. (.0127/.05715 mm.).
Renew rocker shaft bushes when diametral clearance clearance exceeds	.003 in. (.08 mm.).

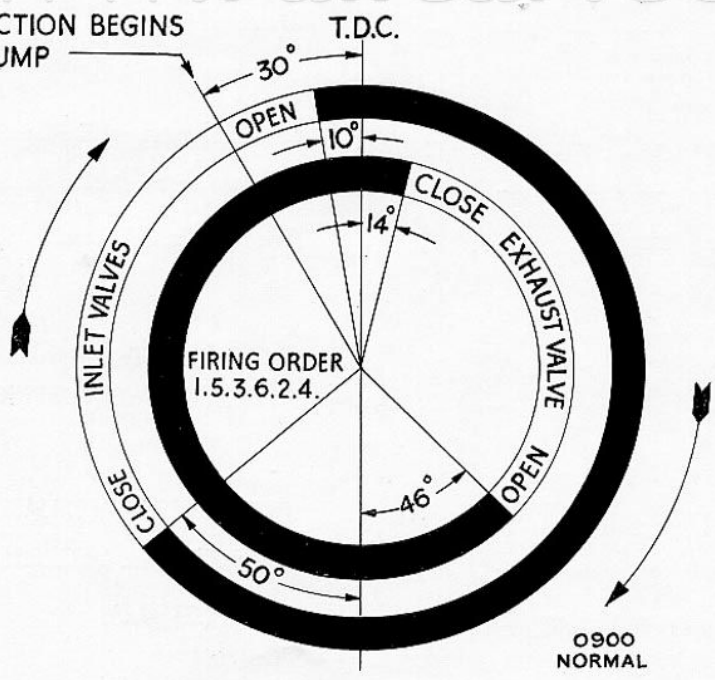


FIG. 2. VALVE TIMING DIAGRAM
(Naturally aspirated vertical and horizontal engines)

Tappet clearance:

Inlet	.020 in. (.508 mm.) engine cold.
Exhaust	.020 in. (.508 mm.) engine cold.

Valve timing:

Naturally aspirated engine (measured on 21.25 dia. of flywheel)—

Inlet opens	10° before T.D.C.
Inlet closes	50° after B.D.C.
Exhaust opens	46° before B.D.C.
Exhaust closes	14° after T.D.C.

Turbocharged engine (measured on 22.75 dia. of flywheel-rim)—

Inlet opens	30° before T.D.C.
Inlet closes	46° after B.D.C.
Exhaust opens	50° before B.D.C.
Exhaust closes	26° after T.D.C.

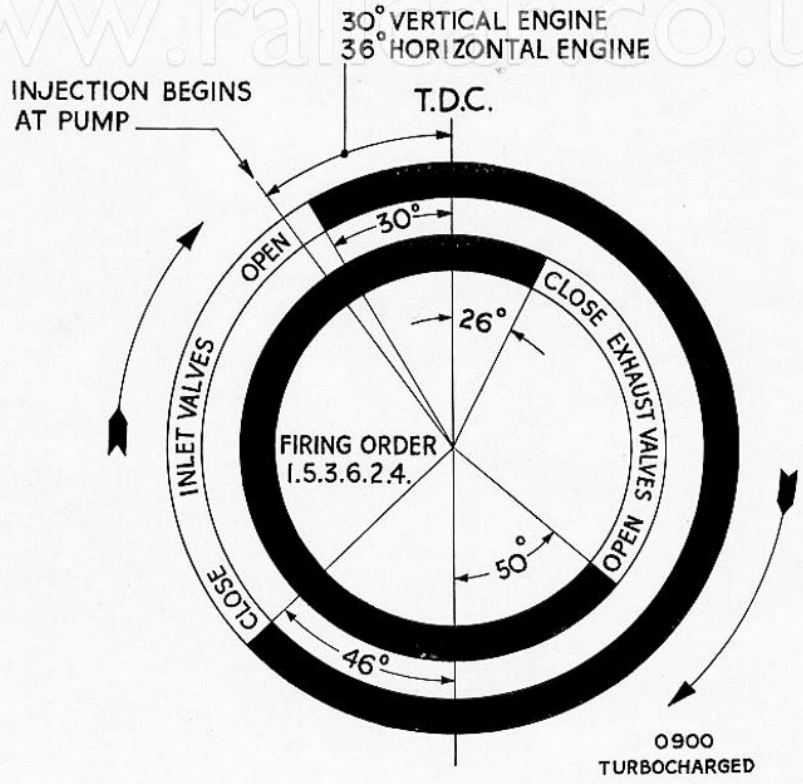


FIG. 3. VALVE TIMING DIAGRAM
(Turbocharged engine)

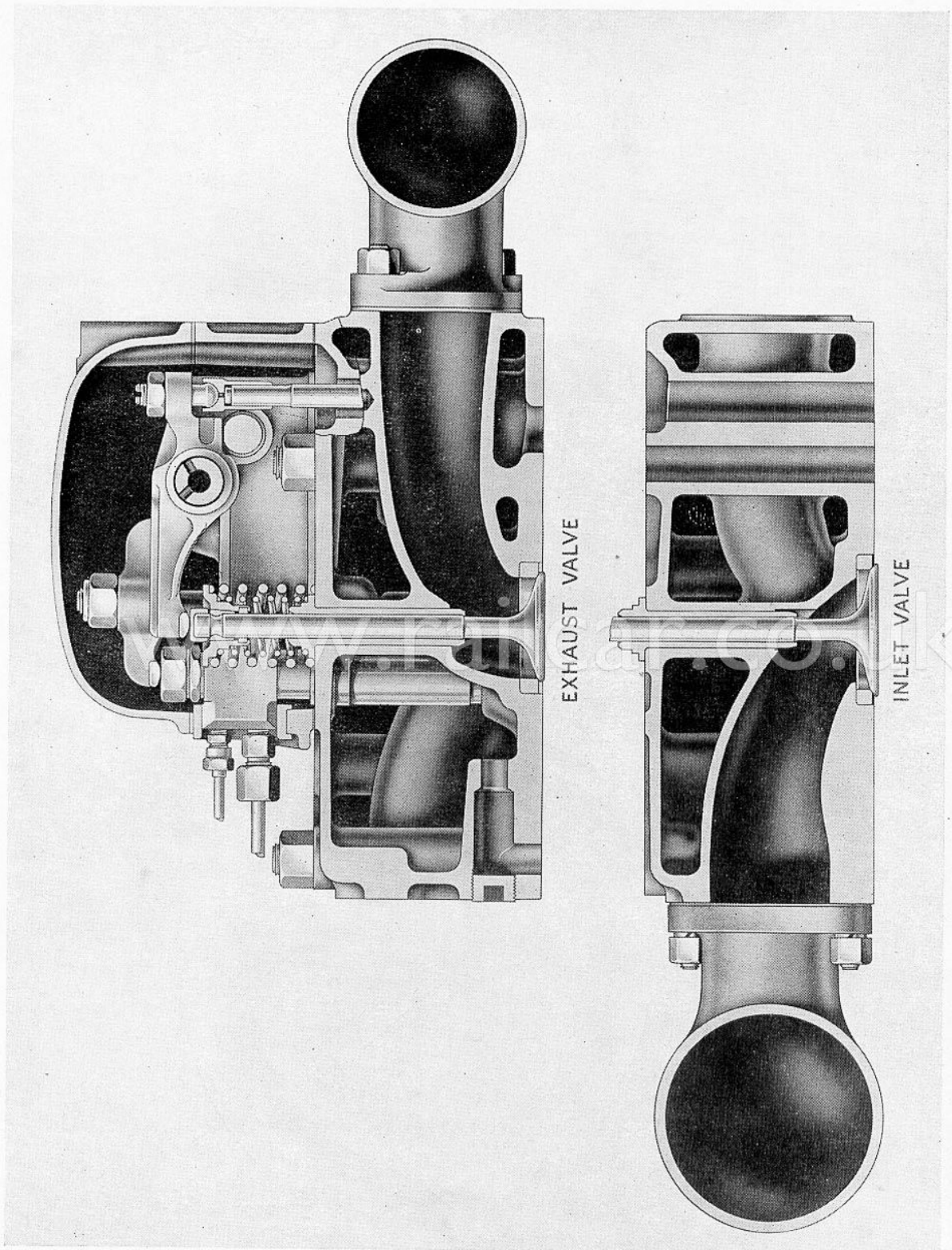


FIG. 4. SECTIONS THROUGH CYLINDER HEAD AT VALVES

DESCRIPTION

The two cylinder heads are interchangeable, each head covering three cylinders. Renewable press-in valve guides, Valmet inlet and exhaust valve seat inserts, and expanded copper tubes to house the fuel injectors are fitted. Arrangement of cylinder head and valve gear is shown in Fig. 1.

Valves are all fitted with two concentric springs and are located in conventional manner by the spring caps and split collars (Fig. 10).

Mounted on each head are the valve rocker assemblies (Fig. 1). Each rocker shaft is supported in three brackets, which also carry a decompressor shaft for manual opening of the exhaust valves. The front bracket on each head houses a spring loaded plunger which contacts a flat on the decompressor shaft and holds it in the **off** position.

Valve gear and fuel injectors are all enclosed by the distance pieces and covers, the latter being readily detachable for inspection and tappet adjustments.

The correct tappet clearance is .020 in. (.508 mm.) cold, for both inlet and exhaust valves. When checking the clearances, make sure that 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, the exhaust valve having a hard chrome plated stem. The valves can be distinguished by the difference in size across their heads, the exhaust being 2.10 in. (53.34 mm.) diameter, and the inlet 2.50 in. (63.50 mm.) diameter, Fig. 10. (See also **Data**).

When removing the valves and springs for inspection and refacing, it is important that subsequently they are replaced in their original position. The heads of all valves, as fitted initially, are stamped with one of the numbers 1 to 12 to correspond with their position in the heads (Fig. 12). New valves should be similarly marked for future guidance.

When renewing valve seats use the special drivers with centralizing guides (Albion Nos. EQP/300/13 inlet, and EQP/300/14 exhaust).

As the horizontal engines are designed to breathe through the valve covers a crankcase breather filter is situated on each cover.

CYLINDER HEADS

To Remove

1. Drain the cooling system.
2. Remove the valve covers and uncouple and remove fuel injector pipes, fuel pipes and leak-off pipes, and take precaution to prevent dirt getting into any of them.
3. On certain horizontal engines detach the oil filler from the cylinder head.
4. If a turbocharger is fitted, uncouple lubricating oil feed pipe and drain pipe, and then remove the turbocharger. Seal connections to manifolds and air cleaner, and oil connections to prevent ingress of dirt.
5. Remove the inlet and exhaust manifolds and water pipes.
6. Remove the fuel injectors, plug or tape over the open unions and store injector pipes and leak-off pipes with the injectors in a dry clean place until required.
7. Take off the nuts securing the rocker shaft support brackets. Lift off the rocker assemblies and withdraw the push rods.
8. Remove all cylinder head nuts except Nos. 2 and 6

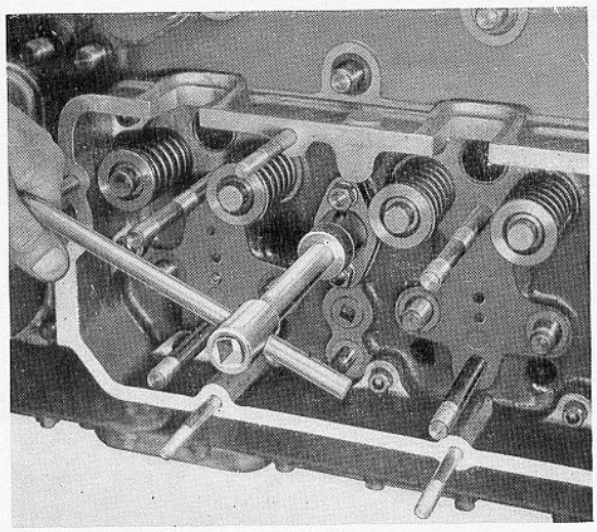


FIG. 5. TIGHTENING LIFTING NUTS

(Fig. 5 and 7) on each head. These four nuts are lifting nuts and should finally be slackened off a little at a time as far as they will go, to raise the heads evenly until they can be lifted off the studs (Fig. 8). If the heads are found to be tight on the studs, additional lift can be obtained by screwing long $\frac{5}{8}$ in. UNF bolts into the jack nuts.

9. Remove the cylinder head gaskets.

To Refit

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 cylinder head studs and from the faces of the cylinder heads and cylinder block, and from the valve ports. If this is not removed it may be displaced during refitting and prevent the heads bedding down satisfactorily. Clean out the injector seatings and valve gear lubricating oilways.

2. New gaskets should be fitted if the old ones are not in good condition. Do not use jointing compound on the gaskets.

3. Place each head on to the lifting-nut studs, and tighten down evenly a little at a time, keeping the faces of the heads parallel with the cylinder block.

4. Refit all remaining cylinder head nuts and tighten down with a short spanner.

5. To ensure freedom from distortion and gasket leaks, the cylinder head nuts must be tightened down evenly in a definite sequence, starting at the centre and working outwards, as shown in Fig. 7. Tighten down with a torsion spanner set at 200 lb. ft. (27.5 kg. m.) for all $\frac{5}{8}$ in. UNF nuts and 100 lb. ft. (13.8 kg. m.) for $\frac{1}{2}$ in. UNF nuts (Nos. 21, 12, 13 and 16). At a convenient time, provided that the engine has been running for over 45 minutes, see Fig. 6. All the nuts must be retightened immediately after stopping the engine, using the torsion spanner.

6. Replace push rods and fit the rocker gear (Fig. 9). Set inlet and exhaust valve clearances to .020 in. (.508 mm.) cold (Fig. 14).

7. Replace the injectors, making sure that the nozzle sealing washers are in position. When tightening down injector clamps, see that the injectors are seated squarely.

8. Replace the inlet and exhaust manifolds and water pipes using new gaskets, do not overtighten the exhaust manifold nuts.

9. Replace injector pipes, fuel pipes and leak-off pipes.

10. Replace the valve covers.

11. Replace the turbocharger when fitted.

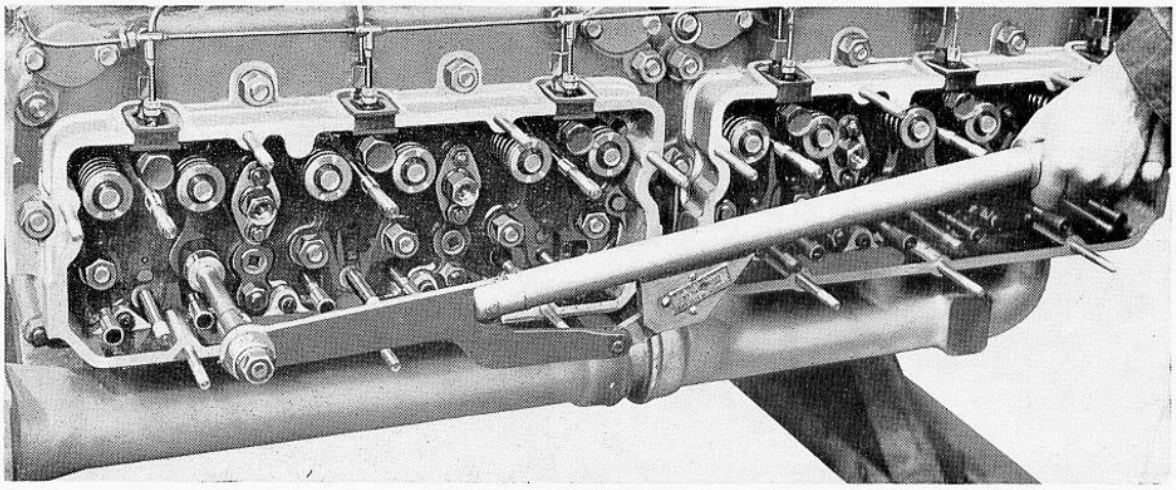


FIG. 6. TIGHTENING CYLINDER HEAD NUTS WITH A TORSION SPANNER

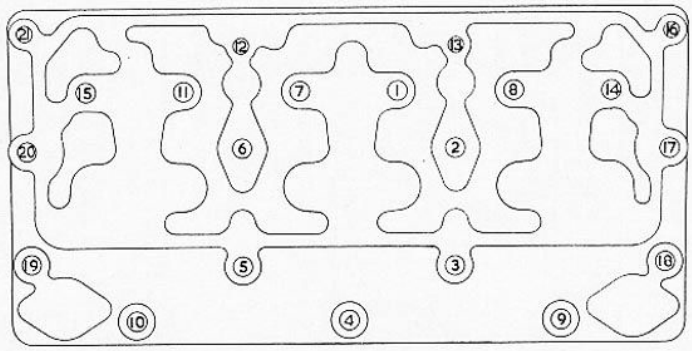


FIG. 7. CORRECT SEQUENCE OF TIGHTENING CYLINDER HEAD NUTS

12. Refill the cooling system.

13. Check tappet clearances after the engine has had a short run (Fig. 14).

VALVE ROCKER GEAR

To Remove

The valve rocker gear can be lifted off each head as a complete assembly after removing the injector clamps and the nuts securing the three rocker shaft brackets (Fig. 9).

To Dismantle

1. Remove the set pin in the rear bracket, which locates the rocker shaft.

2. Push back the cup washers at each end of the shaft and remove the circlips, when all parts will be freed.

Wash all parts in paraffin and make sure that the oilways in the rockers, brackets and shaft are clear. If the oilway up the centre of the rocker shaft is choked, drill out the Welch washers in the ends and fit new ones when reassembling. Inspect the rockers and shaft for wear and renew the rocker bushes if diametral clearance on the shaft exceeds .003 in. (.08 mm.).

When reassembling, note that the front end of each rocker shaft is marked.

To Assemble

1. Fit rear bracket to rocker shaft and insert set pin to locate the shaft.

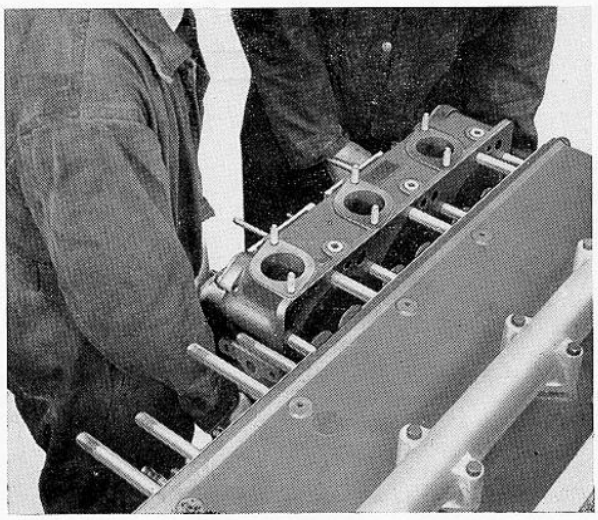


FIG. 8. REMOVING CYLINDER HEAD

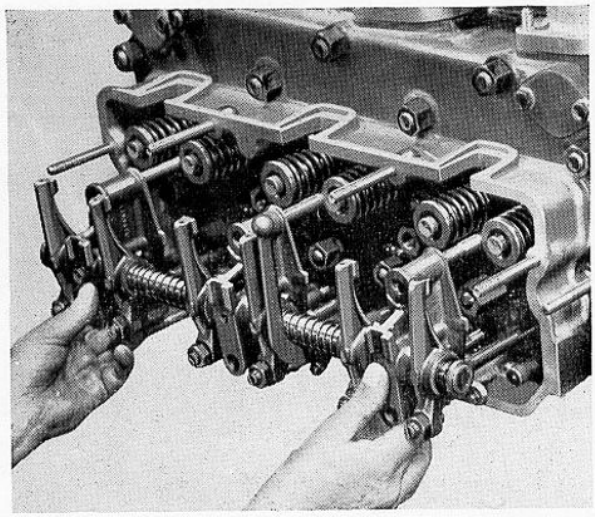


FIG. 9. REMOVING VALVE ROCKER GEAR

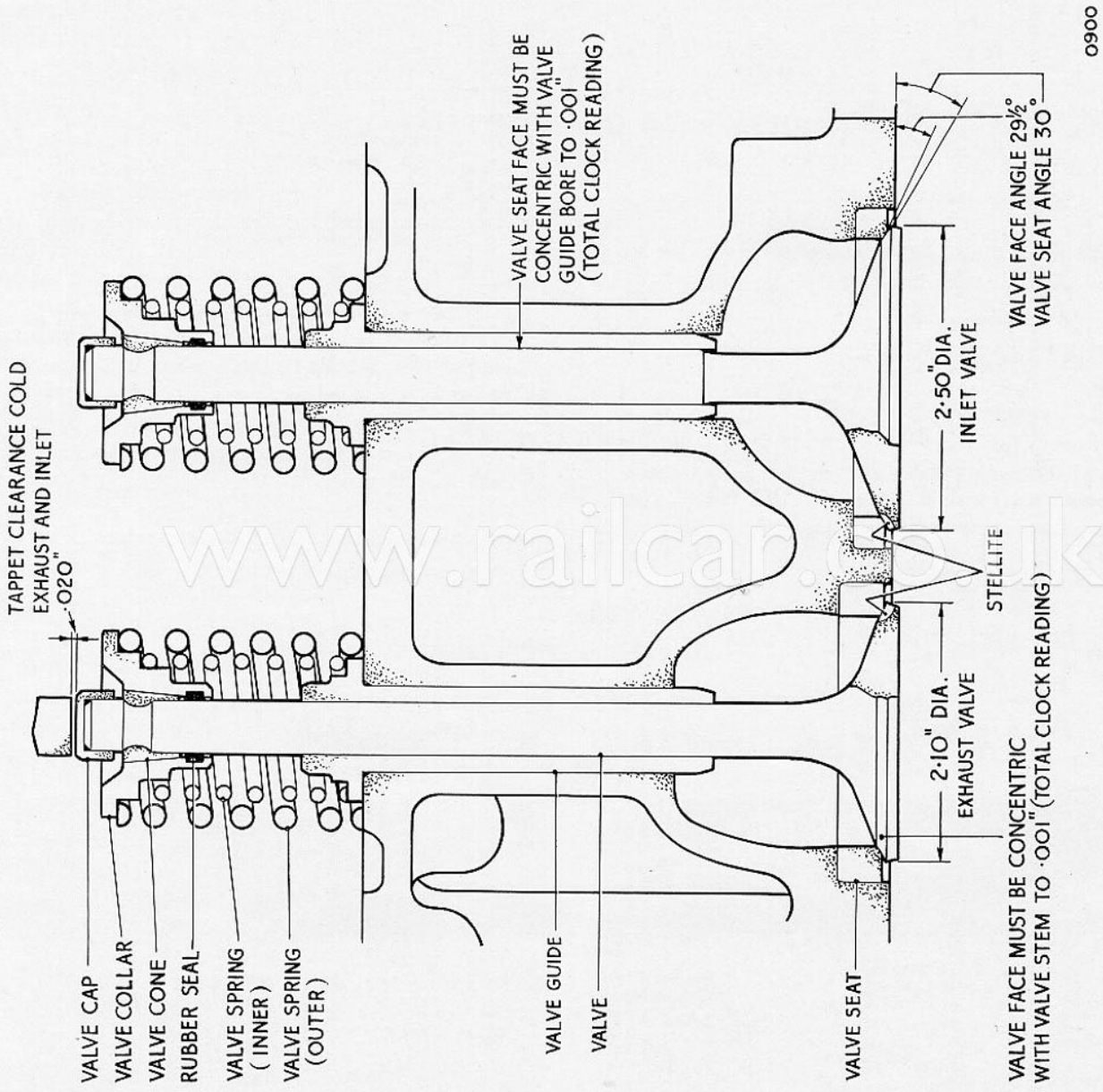


FIG. 10. VALVES, SPRINGS AND VALVE SEATS IN POSITION

2. Fit rearmost rocker and locate with spring, cup washer and circlip.

3. Fit remaining rockers, brackets and decompressor shaft, not forgetting to insert the spring-loaded decompressor shaft locking plunger in the front bracket, before finally replacing the front cup washer and circlip.

To Refit

Reverse the removal procedure.

VALVES

To Remove

1. Remove the cylinder head as previously described and place it face downwards on the bench.

2. Remove the caps from the valve stems.

3. Using the valve spring compressor, compress the valve springs and extract the split cone (Fig. 11). Remove the valve collar with the rubber sealing ring, thus releasing the valves and springs, allowing them to be withdrawn.

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

5. Check valve springs for length, see **Data**.

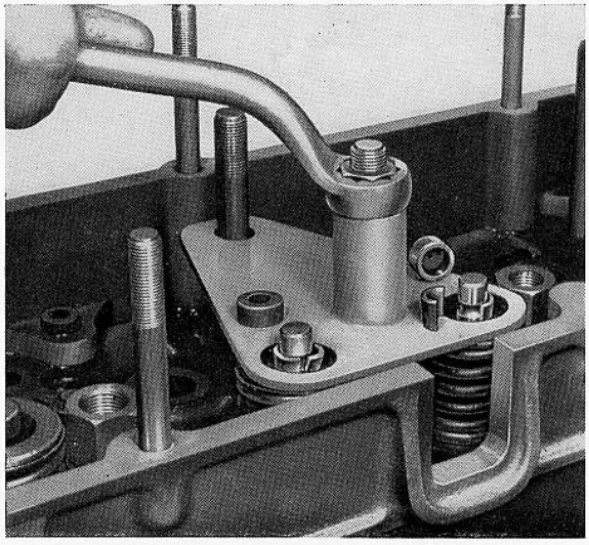


FIG. 11. VALVE SPRING COMPRESSING TOOL

Note: 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. 12, to facilitate reassembly.

To Refit

Reverse the removal procedure.

THE CYLINDER HEADS

Decarbonising

Having removed the cylinder heads, remove the valves as previously described, then wash out all water passages and scrape off all rust and carbon on the faces of both heads and cylinder block and in the valve ports. Particular care should be taken to remove any deposit round cylinder head studs, as any left there may be displaced during refitting and will prevent the heads bedding down satisfactorily. Clean out the injector seatings and valve gear lubrication oilways.

Finally bring each piston to the top of its stroke and scrape carbon off the piston crowns. Leave a ring of carbon about $\frac{1}{4}$ in. (16 mm.) wide round the rims as this acts as a compression seal and prevents leakage of oil into the combustion chambers, when the cylinder bores are worn. For the same reason, do not disturb the ring of carbon at the top of the bores.

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 guide. They must have .00225/.00475 in. (.05715/.12065 mm.) clearance for the inlet valves and .00375/.00625 in. (.09525/.15875 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. The valve guide is shoulder located.

3. After fitting a new valve guide, always regrind the valve seat so that it is concentric with the guide.

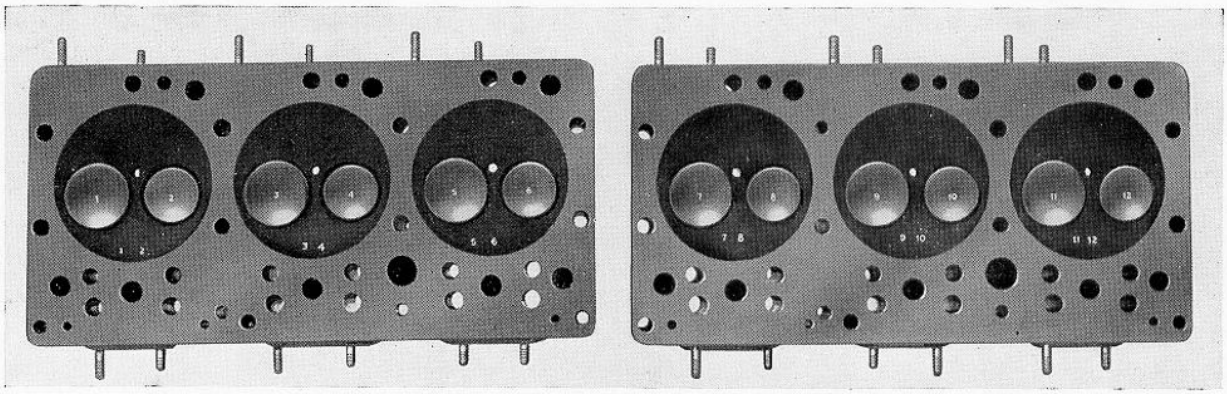


FIG. 12. POSITION OF VALVES IN CYLINDER HEADS

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 (Fig. 13). The stone must be rotated at high speed. The face of the seat should be concentric with the valve guide bore to within .0005 in. (.013 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 .0005 in. (.013 mm.) total clock reading.

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

4. When the valve 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. 10).

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 revolve the valve through a complete revolution before lifting as this will groove the seat. All traces of grinding compound must be removed before assembly.

VALVE TIMING

The valve timing for a naturally aspirated engine is shown in Fig. 2, and for a turbocharged engine in Fig. 3, also see **Data.**

The timing is determined by the mesh of the camshaft timing gear through the intermediate gear with the crankshaft timing pinion and cannot therefore, alter in service. Any inaccuracy can only arise from faulty assembly.

To Check Valve Timing

1. Remove the valve covers and adjust the tappet clearances to .020 in. (.508 mm.) cold.

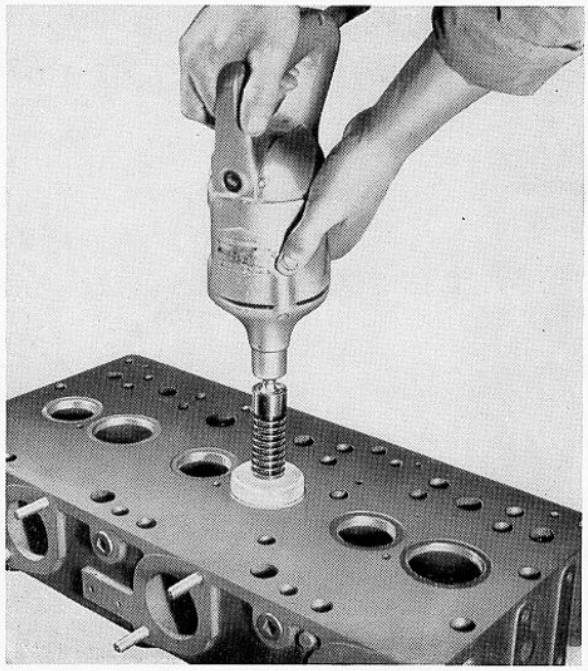


FIG. 13. GRINDING VALVE SEATS

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. If not already marked, mark the flywheel for the inlet valve opening the appropriate distance before T.D.C. on the flywheel.

4. Now turn the engine one complete turn to bring No. 6 cylinder on to its firing stroke, when No. 1 cylinder will be at T.D.C. on its exhaust stroke ready for checking the valve timing.

5. Now turn the engine until the inlet valve of No. 1 cylinder just opens. To check when the inlet valve is just opening, hold the valve cap between thumb and forefinger, and attempt to turn. When the valve lifts off its seat, the cap will not turn. If the timing is correct the I.V.O. mark on the flywheel should register with the timing pointer.

CRANKCASE BREATHER

Engine crankcase breather filters are fitted to horizontal type engines and to turbocharged vertical engines.

The two crankcase breather filters are situated on the two detachable cylinder head covers, in conjunction with the wire mesh strainers behind each. They serve as filters for the engine breather system.

To Remove

1. Pull the breather filter off their adaptors.
2. Remove adaptors to extract wire mesh strainer.

To Clean

Thoroughly wash the breather filter in paraffin and allow to dry. Thoroughly wash the wire mesh strainer in paraffin.

To Refit

Reverse the removal procedure, but before refitting the breather filters, re-oil them by holding them inverted, pouring clean engine oil over the wire mesh elements, turning right way up and allowing excess oil to drain off.

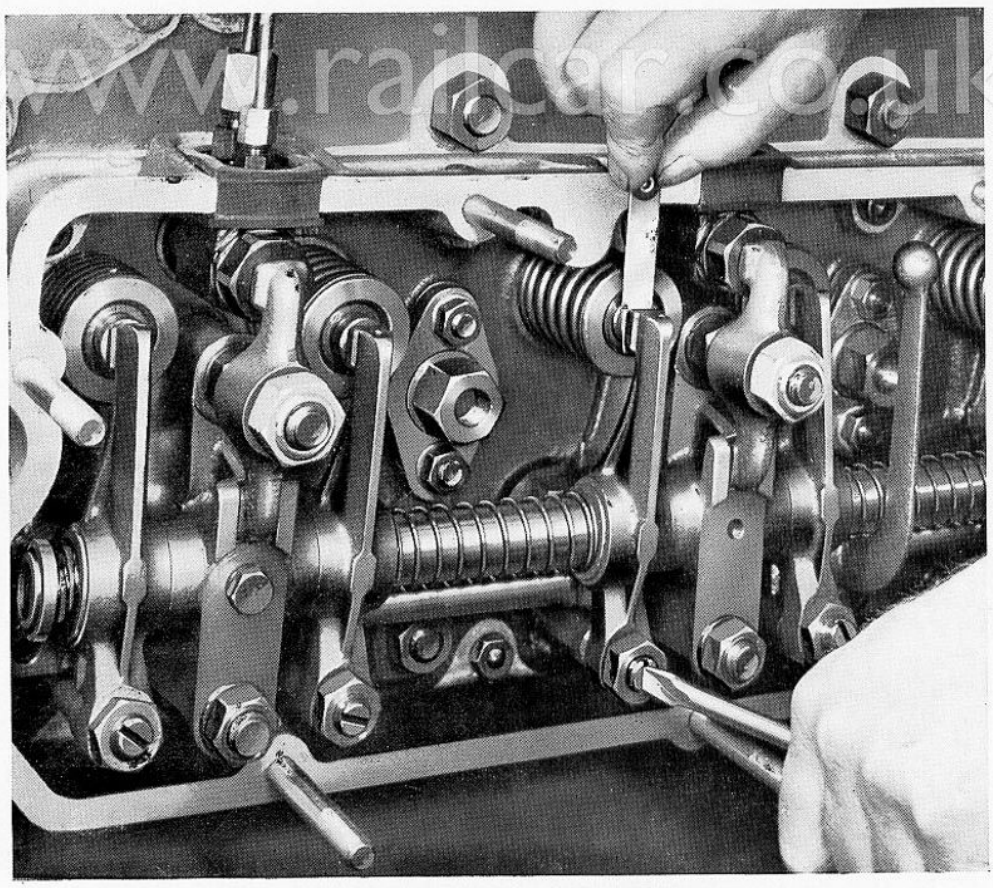


FIG. 14. ADJUSTING THE TAPPETS

ENGINE BLOCK, LINERS AND CAMSHAFT

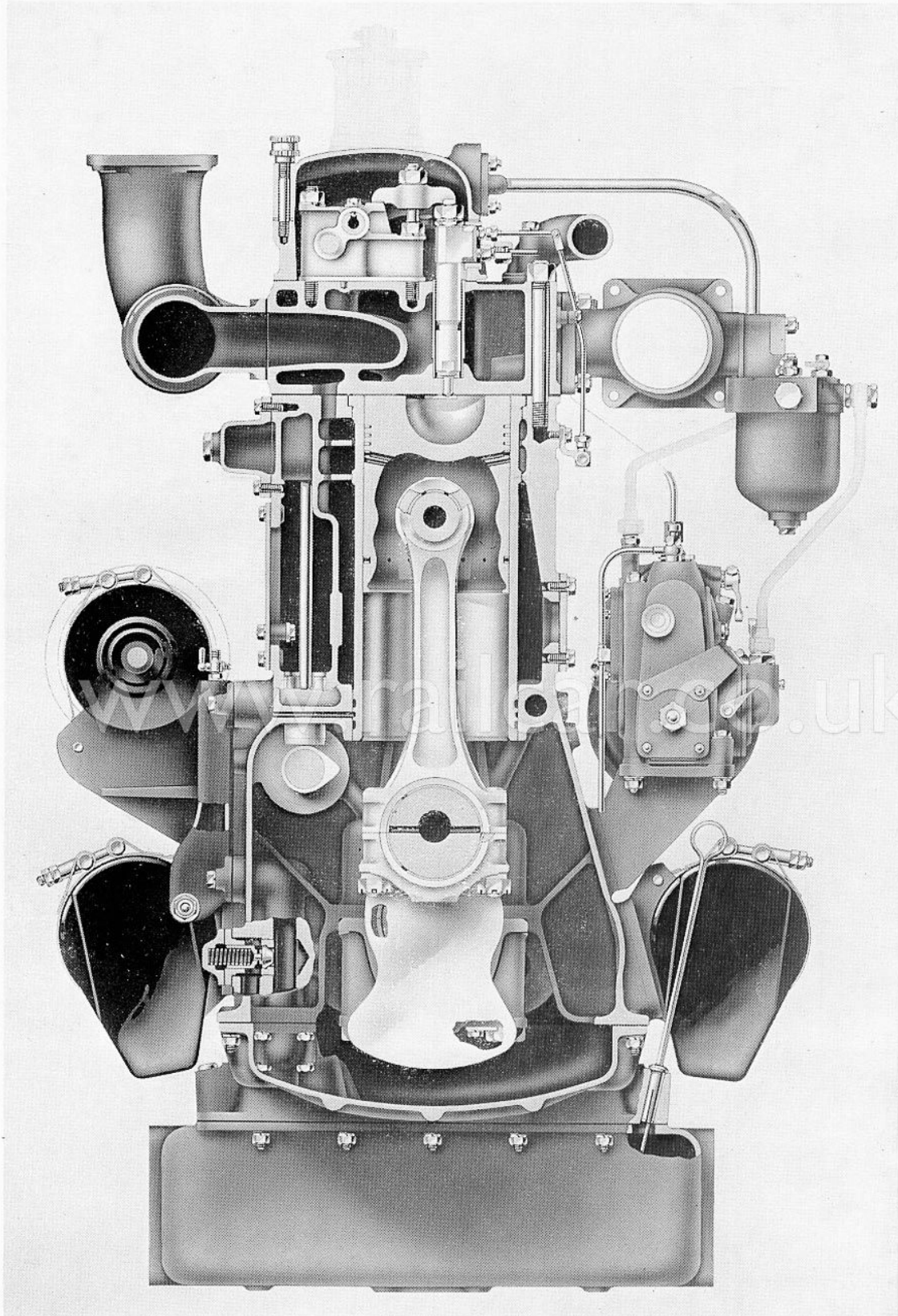


FIG. 1. CROSS SECTION THROUGH VERTICAL ENGINE

DATA

ENGINE BLOCK

Type	Cylinders and crankcase in one-piece casting.
Material	Cast iron.
Initial diametral clearance of cam followers in engine block	.00175/.00375 in. (.04445/.09525 mm.).
Renew cam follower when diametral clearance in engine block exceeds	.004 in. (.1016 mm.).

LINERS

Type	Prefinished, wet, press-fit shoulder-located.
Material	Cast iron.
Initial bore of liner before fitting to engine block ...	5.501/5.50175 in. (139.73/139.74 mm.).
Reline when wear of liner bore exceeds	.016 in. (.41 mm.).
Maximum projection of liner from face of engine block	.003 in. (.076 mm.).

CAMSHAFT

Number	One.
Type	Casting with integral cams.
Material	Cast iron, chilled on cams.
Type of drive	Single helical gear.
Number of bearings	Seven.
Bearing material	Front and rear—phosphor bronze. Intermediates—direct in engine block.
Thrust taken on	Front bearing only.
Interference fit of rear bearing in engine block... ...	.0025/.00325 in. (.00635/.08655 mm.).
Journal diameters:	
Front and rear	1.625/1.6225 in. (41.1861/41.2115 mm.).
Intermediate	2.6965/2.6975 in. (68.4911/68.5165 mm.).

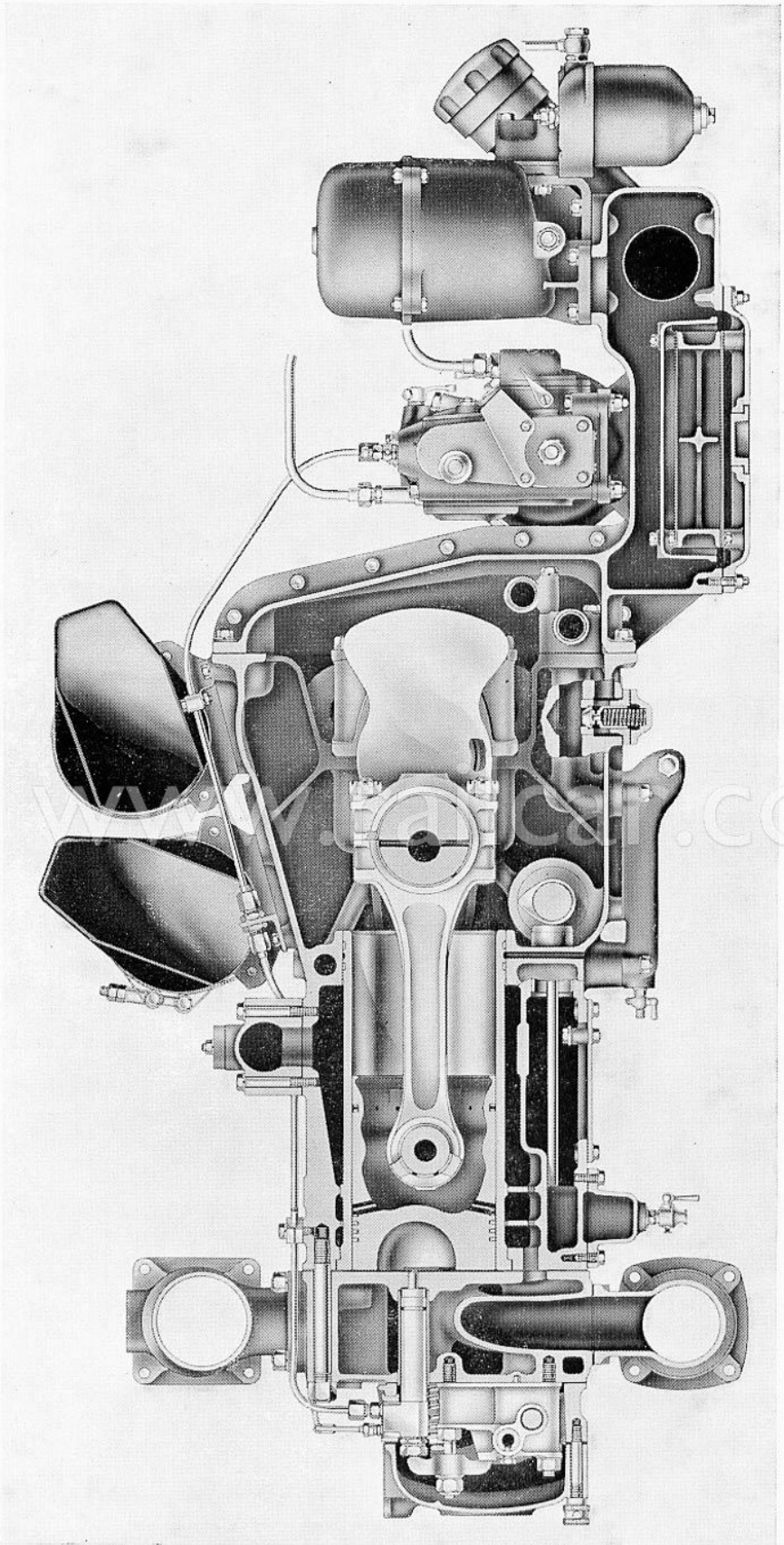


FIG. 2. CROSS SECTION THROUGH HORIZONTAL ENGINE

Initial diametral clearance in bearings:	
Front	.00225/.00425 in. (.05715/.10795 mm.).
Intermediates	.00175/.00475 in. (.04445/.12065 mm.).
Rear	.0035/.006 in. (.0889/.1524 mm.).
Renew front and rear bearings when clearance exceeds ...	.010 in. (.25 mm.).
Initial dimensions from nose to back of cam:	
Naturally aspirated	2.19475/2.20475 in. (55.74665/56.00065 mm.).
Turbocharged	2.1384/2.1484 in. (54.31536/54.56936 mm.).
Renew camshaft when this dimension (Fig.3) is less than:	
Naturally aspirated	2.18275 in. (53.41 mm.).
Turbocharged	2.1264 in. (54.01 mm.).
End float	.002/.009 in. (.0508/.2286 mm.).

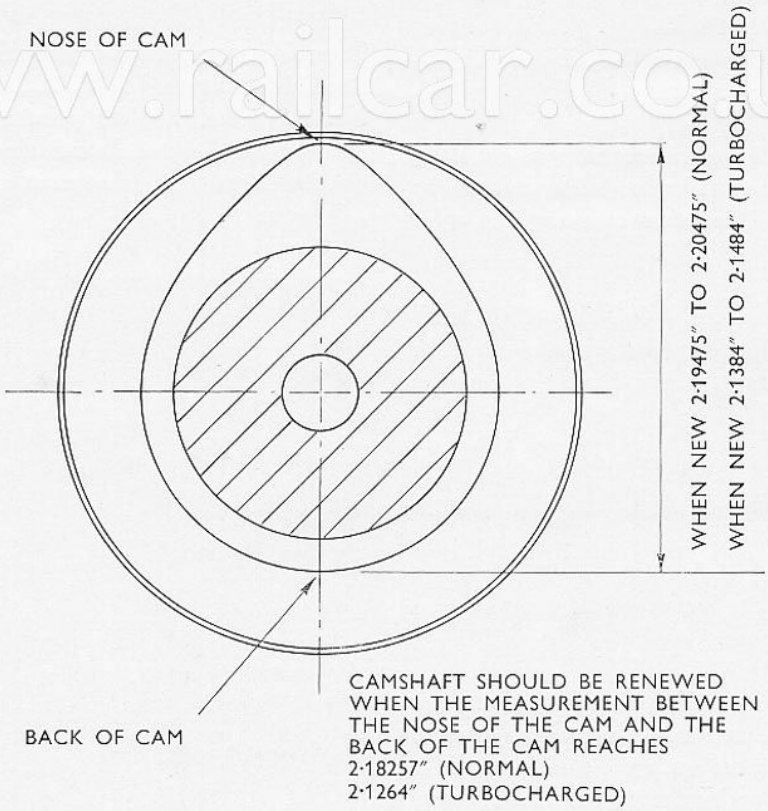


FIG. 3. CAM WEAR DIAGRAM

DESCRIPTION

The combined cylinder block and crankcase is of cast iron. The cylinders being fitted with renewable hard cast iron, wet, cylinder liners.

Referring to Figs. 1 and 2 it will be seen that the liners are shoulder located at the top and held in position by the cylinder head gaskets, which also form the water seal at this point. At the bottom, the liners are located and sealed by two rubber rings fitted in grooves around the circumference. The third groove between the rings registers with a drilling through to the side of the engine block at each cylinder, so that any slight amount of water or oil which leaks past the rubber rings will drain off automatically.

The camshaft is located in the side of the engine block and operates the valve rocker gear through cam follower plungers and push rods. It is driven through an intermediate gear from the crankshaft timing pinion (Fig. 5) through helical gearing, and is carried in seven pressure lubricated bearings. Front and rear bearings are fitted with renewable bushes, the intermediate journals bear direct in the engine block. The end thrust is taken by a thrust washer at the front bush (Fig. 5). Helical gears at the front and rear of the camshaft drive either the main or scavenge oil pumps.

The cam follower plungers are accessible on detaching the two side covers on the engine block, and can be slipped out for inspection after removing the valve rocker gear assemblies (Fig. 6).

Note: The six drain holes should be kept clear and if excessive leakage becomes evident, liners should be withdrawn so that new rubber sealing rings can be fitted.

CYLINDER LINERS

To Remove

1. Remove the cylinder heads, gaskets, sump, pistons and connecting rods.

2. Withdraw the liners with the special extractor designed for this purpose. Care must be taken to keep the liners square and avoid fouling the baffle webs near the top of the engine block. Every precaution should also be taken to prevent rust, scale, etc., on the outside of the liners from getting into the interior of the engine.

3. Check for wear, and if excessive, renewal of the liners is advisable, see **Data**.

To Fit

Before fitting new or used cylinder liners, carefully scrape away any carbon deposit etc., from the flange recesses in the cylinder block. Liners are prefinished.

1. Thoroughly clean out the cylinder bores and lightly smear them with thin oil.

2. Fit new rubber sealing rings on liners, and smear with soft soap to act as a lubricant.

3. Enter the liners into the engine block by hand, drive squarely home with a hide hammer. When in position check the projection of the liners from the face of the engine block see **Data**, on no account must they be below the engine block face.

CAMSHAFT

OVERHAUL

To Remove The Camshaft (See Fig. 3).

To avoid unnecessarily upsetting the timing, the engine should first be turned to T.D.C., of the firing stroke on No. 6 cylinder, at which point both valves of No. 6 cylinder will be closed, and should be kept in this position throughout subsequent operations, which are as follows:

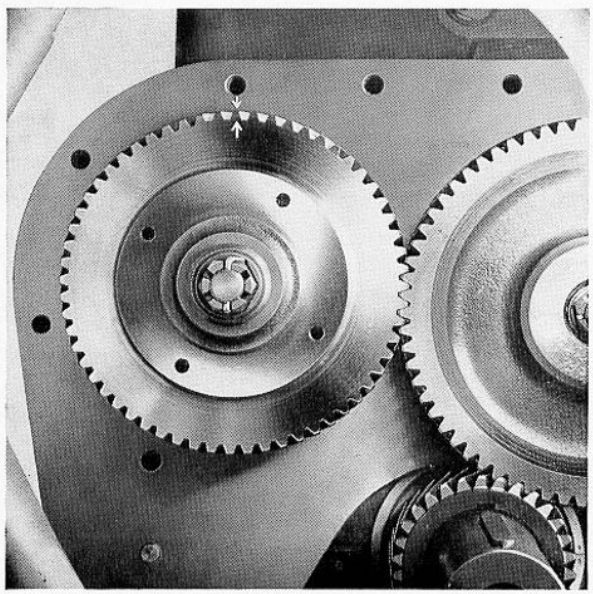


FIG. 4. CAMSHAFT TIMING MARKS

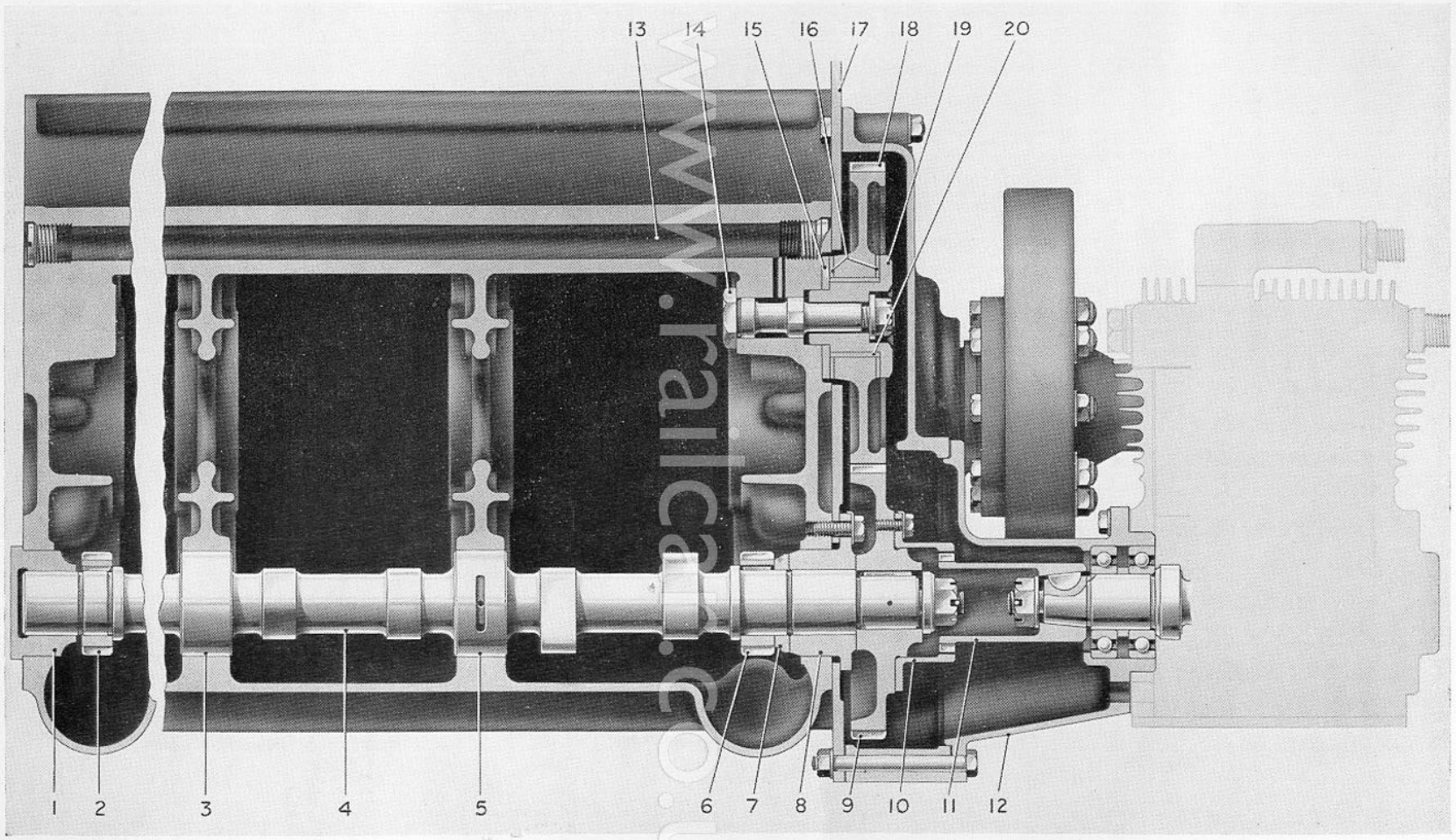


FIG. 5. ARRANGEMENT OF CAMSHAFT AND IDLER GEAR

1. Rear (No. 7) bearing bush.
2. Scavenge oil pump drive gear.
3. No. 3 camshaft bearing (No. 4 similar).
4. Camshaft.
5. No. 2 camshaft bearing (Nos. 5 and 6 similar).
6. Main oil pump driving gear.
7. Thrust washer.
8. Front (No. 1) bearing bush.
9. Camshaft gear.
10. Compressor coupling gear.
11. Compressor coupling.
12. Compressor drive housing.
13. Main oil gallery.
14. Idler gear centre bolt.
15. Wearing washer.
16. Thrust washers.
17. Timing backplate.
18. Idler gear.
19. Idler spindle.
20. Floating bush.

1. Remove the engine from unit.

2. Remove the cylinder head covers and uncouple and remove fuel injector pipes and leak-off pipes, and take precaution to prevent dirt getting into any of them.

3. Remove the fuel injectors, valve rocker gear and extract the push rods.

4. Remove the two cover plates on the side of the engine block and withdraw all the cam plunger followers (Fig. 6).

5. Remove the thrust housings and hour recorder, when fitted, for the oil pumps, main and scavenge when fitted, and withdraw the oil pump driving spindles.

6. On vertical type engines, remove the cooling fan and belts.

7. Remove the driving shaft from front of crankshaft and shaft coupling flange when fitted or cold starting equipment if fitted.

8. On vertical type engines and horizontal type engines having no auxiliary equipment attached to the timing case, remove the centre nut and washer securing the vibration damper hub, then attaching a suitable extractor to the damper outer distance piece and using $\frac{1}{2}$ in. UNF bolts, withdraw the crankshaft vibration damper and hub. The belt pulley is removed with the hub on vertical type engines.

9. On horizontal type engines having any auxiliary equipment attached to the timing case, and driven from the camshaft gear, remove the centre nut and washer screwing the vibration damper hub, and nuts and setscrews securing the auxiliary equipment to the timing case. Partially withdraw from the timing case the auxiliary equipment then attaching a suitable extractor to the damper outer distance piece and using $\frac{1}{2}$ in. UNF bolts, withdraw the crankshaft vibration damper and hub, and remove the auxiliary equipment at the same time.

10. On vertical type engines, disconnect the drive to the Plessey pump and or dynamo when fitted.

11. On vertical type engines, remove the retaining screws and detach the timing case, taking care not to damage the oil seal housed in the bore surrounding the crankshaft.

12. On horizontal type engines when no auxiliary equipment is fitted to the timing case, remove the retaining nuts and setscrews securing the cover to the timing case at the camshaft drive.

13. At this stage, check the camshaft end float with a clock gauge, see **Data**. If excessive, the thrust washer (7) requires renewal.

14. Remove the auxiliary equipment coupling gear (3) from the camshaft timing gear when fitted, and the nut and washer securing the timing gear to the camshaft.

15. Withdraw the timing gear with a suitable extractor (Albion Pt. No. EQP/320/53) taking care to note the position of the timing mark on the gear in relation to the mark on the timing back plate when No. 6 piston is on T.D.C. of the firing stroke (Fig. 4).

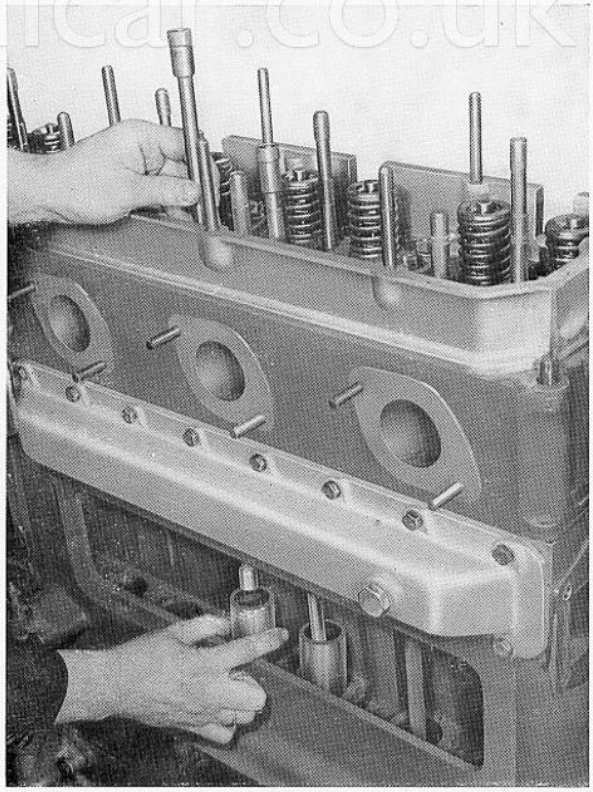


FIG. 6. REMOVING PUSH RODS AND CAM FOLLOWERS

16. Remove the setscrews securing the camshaft front bush (6) and remove.

17. Refit the timing gear and use it to withdraw the camshaft from the engine block, care must be taken in this operation, and the camshaft should be turned as required to avoid damaging the cams in its passage through the bearings.

Inspect bushes and individual cam profiles for wear and renew if necessary, see **Data**.

To Refit the Camshaft

Fitting the camshaft is the reverse of the removal procedure, but the following points should be noted:

1. Clean out all oilways.

2. Carefully enter the camshaft into position, fit the thrust washer and front bush and, using new lock plates, tighten the retaining screws, make sure that the locking plate tabs are turned over after the retaining screws have been tightened.

3. Enter the timing gear (2) on to the camshaft, and turn the camshaft so that, on tapping the gear into full engagement with the intermediate gear (17), the arrows on the rim of the timing gear and on the timing backplate are in line (Fig. 4), corresponding with T.D.C. of the firing stroke of No. 6 cylinder, in which position the engine was set before removal of the crankshaft. Refit the centre retaining nut, washer and split pin.

4. Refit the remaining parts following the removal procedure in reverse order, and finally adjust the tappet clearances and check the timing.

To Time the Camshaft

Refer to **Valve Timing** in Section 10—**Cylinder Heads and Valve Gear.**

PISTONS AND CONNECTING RODS

DATA

PISTON

Type:	
EN. 900V and EN. 900H engines	Toroidal cavity.
EN. 901V and EN. 901H engines	Hemispherical cavity.
Turbocharged engines	Toroidal cavity.
Make	Wellworthy.
Material	Aluminium alloy.

PISTON RINGS

Compression rings:	
Number	Three (1st, 2nd, and 3rd grooves).
Type	.1405/.1415 in. (3.5687/3.5941 mm.) wide. 3° tapered sides, hardened and tempered, 90° gap.
Initial up and down clearance	.004/.006 in. (.1016/.1524 mm.). Special rig required.
Initial gap	.002/.029 in. (.56/.74 mm.).
Renew rings when gap exceeds	.040 in. (1.02 mm.).

Scraper Rings

Number	Two (4th and 5th grooves).
Type	.2475/.2485 in. (6.2865/6.3119 mm.) wide. Straight sides, slotted, 90° gap.
Initial up and down clearance	.004/.006 in. (.1016/.1524 mm.).
Initial gap	.022/.029 in. (.56/74 mm.).
Renew rings when gap exceeds	.040 in. (.102 mm.).

Connecting Rods

Type	I-section.
Material	Steel alloy stamping.
Small-end bearing	Phosphor bronze, pressed in bush.

Interference of small-end bush in connecting rod ...	.001/.0035 in. (.0254/.0889 mm.).
Big-end bearing type	Prefinished, copper lead, steel shell, bearing surface tin flashed.
Big-end initial diametral clearance	.00275/.005 in. (.070/.127 mm.).
Renew when diametral clearance exceeds	.010 in. (.254 mm.).
Undersize big-end bearings available	Prefinished in five steps of .010 in. (.254 mm.) each.

Do not grind sides of crankpins.

PISTON PIN

Type	Fully-floating, hollow.
Initial diameter	1.875/1.87525 in. (47.625/47.6314 mm.).
Retained by	Two circlips in piston.
Initial diametral clearance of pin in small-end bush (cold)	.00075/.0015 in. (.019/.038 mm.).
Renew small-end bush when diametral clearance exceeds	.003 in. (.0762 mm.).

DESCRIPTION

The pistons are of aluminium alloy, fitted with three compression and two scraper rings. (Fig. 1). A hemispherical or toroidal cavity in the piston head forms the combustion chamber.

The connecting rods are I-section alloy stampings, drilled at the big-ends to provide intermittent oil spray lubrication for cylinder walls and camshaft. Big-ends are fitted with renewable steel shell type, copper lead bearings with the bearing surface tin-flashed, which are precision manufactured to give correct running clearance without any scraping or adjustment. The small-ends are fitted with pressed-in phosphor-bronze bushes. The big-end bearing caps are secured by two bolts with slotted nuts and split-pins.

Note: On later engines the connecting rods have no oil spray hole in the big ends and no balancing boss on the big end caps.

The hollow type piston pins are fully floating and are located endwise in the pistons by circlips.

OVERHAUL

To Remove Pistons and Connecting Rods

The dimensions of the crankshaft are such that the piston and connecting-rod assemblies cannot be withdrawn through the crankshaft side of the engine block, they can, however, be withdrawn through the cylinder bores.

Care must be taken not to scratch the bores when removing the piston and connecting-rod assemblies.

1. Remove first the cylinder heads, gaskets and crankcase cover as explained in their particular sections.

2. Carefully scrape the ring of carbon deposit off the tops of all the cylinder bores.

3. Taking each connecting rod in turn, remove the big-end cap and withdraw the piston and connecting-rod assembly through the cylinder bore. Big-end caps are not interchangeable and should, therefore, be kept with their respective connecting rods.

To Separate Piston from Connecting Rod

1. Remove the piston pin circlips.

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

Note: The piston pin is an interference fit in the piston bosses when cold and no attempt must be made to force it out without heating.

3. Check piston clearances in the small-end bushes, see **Data**, renew bushes if clearance is excessive. The piston is an easy push fit in the small-end bushes.

   Check ring gaps when rings are inserted in the smallest part of the cylinder bore (usually towards the bottom. It is advisable first to check for bore wear in case cylinder liners require renewal. Renew rings if gap is excessive, see **Data.**

4. The big-end bearings should be inspected when the pistons are removed. Bearings should be renewed if clearance exceeds .010 in. (.254 mm.) or if any scoring or damage is present.

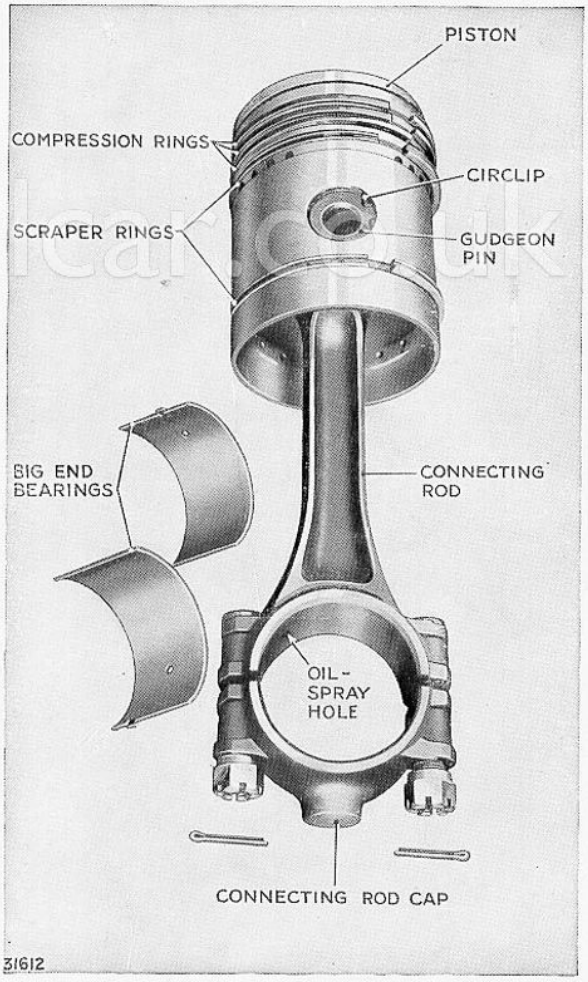


FIG. 1. TYPICAL ILLUSTRATION OF PISTON AND CONNECTING ROD
(Later engines have no oil spray hole in the big end or balancing boss on the big end cap).

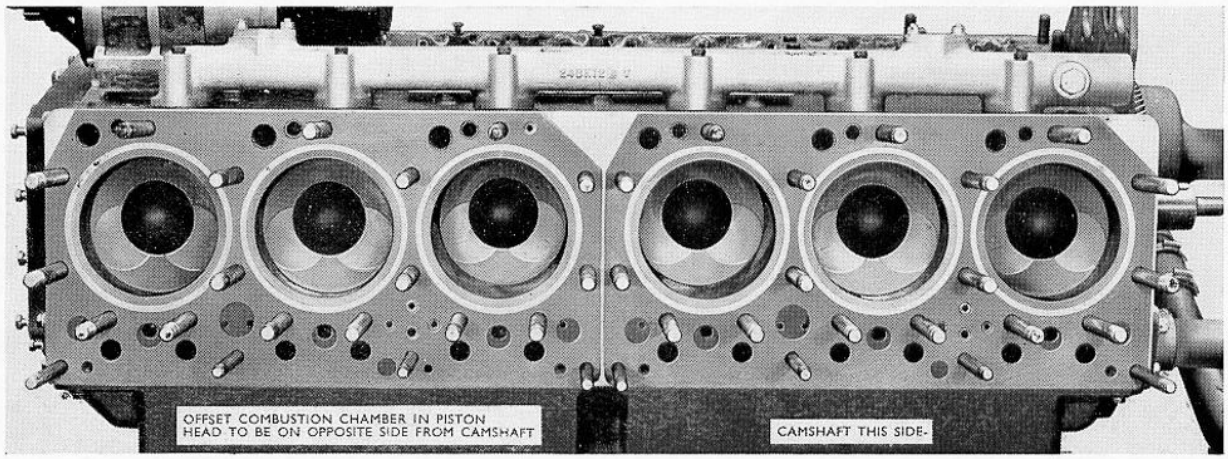


FIG. 2. POSITION OF OFFSET COMBUSTION CHAMBERS IN PISTON HEADS, IN RELATION TO THE CAMSHAFT

To Assemble

1. Heat the piston in boiling water or in an oven before the piston pin is inserted. The oven temperature must not exceed 302° F. (150° C.).

2. Fit piston to connecting rod with the valve recesses to the same side as the oil spray holes in the connecting-rod big-ends (if fitted with this type of connecting rod), insert the piston pin and locate with the circlips.

3. Fit the rings on the pistons with the gaps in successive rings at 180° to each other.

To Refit

1. Before fitting, thoroughly clean the bearing shells, their seatings in both the rod and cap, wipe the crankpin, to ensure that the shells bed down correctly, lightly smear with clean engine oil both crankpin and bearing shells.

2. Tap the big-end bolts into position in the connecting rods if they have been removed, place the rod half bearing shell in position, and insert the piston and connecting-rod assemblies through the cylinder bores (Fig. 3) with the offset combustion chambers in the piston head on the same side as the camshaft (Fig. 2). On engines fitted with connecting rods having oil spray holes in the big ends locate the big-ends on the crankpins with the oil spray holes in the big-ends to the same side as the camshaft.

   Care must be taken not to scratch the bores when replacing the piston and connecting-rod assemblies.

3. Taking care to pair the individual big-end caps with their original connecting rods according to the assembly numbers stamped on the corresponding bolt bosses, place the big-end half bearing shell in position, and tap the big-end caps into position.

   Note: If bearings require renewing, always renew both halves of the bearing shells together, and, if the crankshaft has been reground, see that the appropriate undersize replacement bearings are used. Note that all replacement bearings are supplied ready for fitting and no scraping is permissible.

4. Refit the big-end nuts and tighten securely with a torque spanner, set at 150 lb. ft. (20.5 kg.m.).

5. On no account must the nuts be slackened off to bring the pin holes into line. If the pin holes will not line up with the correct tension, the nuts must be filed to bring the pin holes into line, care being taken to keep the faces absolutely square. Fit the split pins and slack off nuts just sufficiently to 'nip' the split pins.

6. Refit the remaining parts following the removal procedure in reverse order, and finally adjust the tappet clearances.

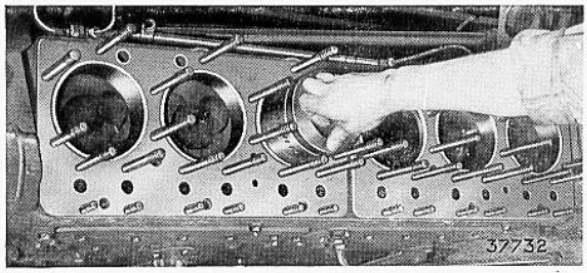


FIG. 3. FITTING THE PISTON

CRANKSHAFT, MAIN BEARINGS AND DAMPER

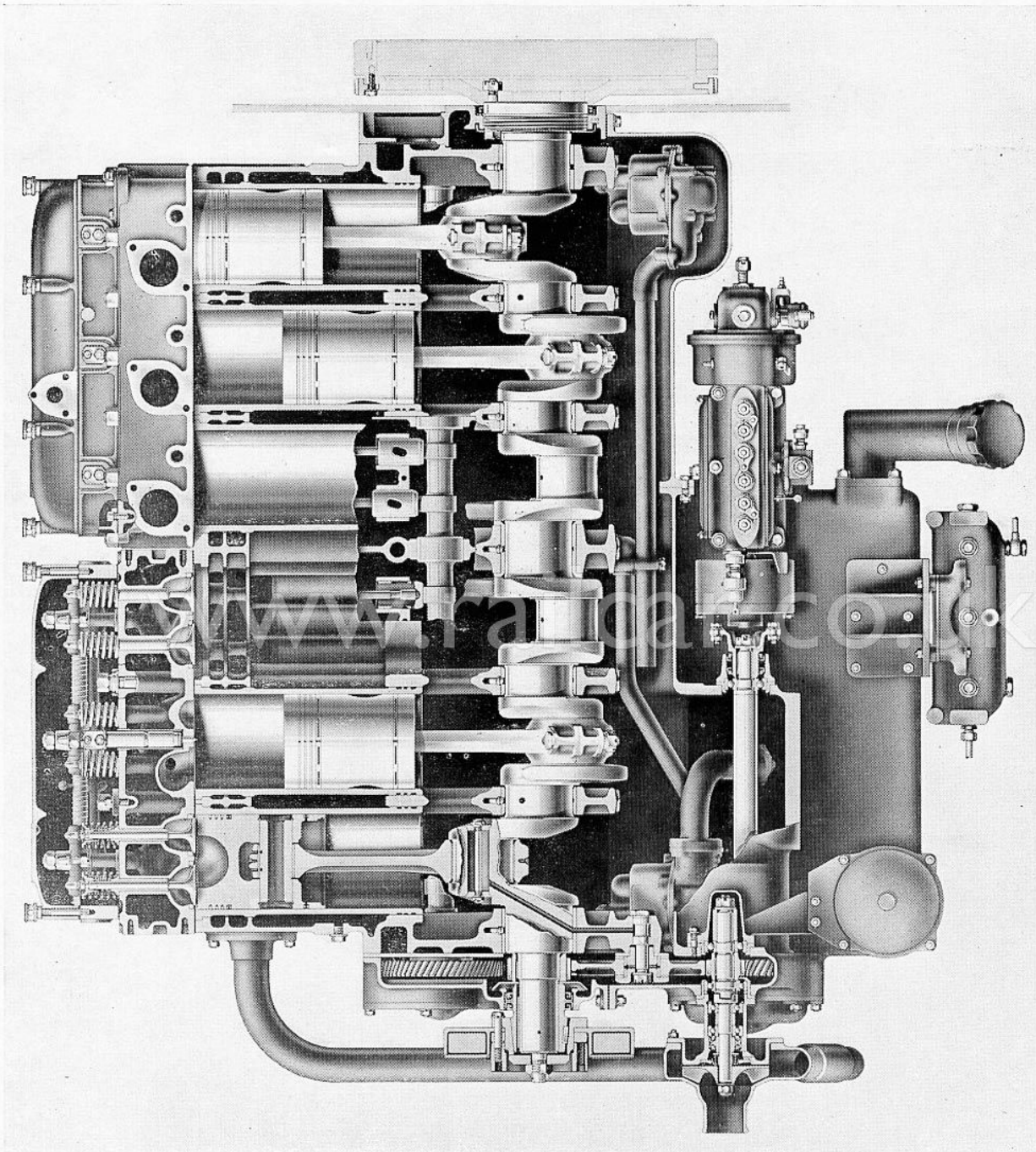


FIG. 1. SECTION THROUGH HORIZONTAL ENGINE

DATA

CRANKSHAFT

Type	Forging, incorporating balance weights.
Material	Alloy steel, nitrided.
Thrust taken on	Centre bearing.
Initial diameter of journals	3.9005/3.901 in. (99.073/99.085 mm.).
Initial diameter of crankpins	3.4983/3.499 in. (88.857/88.875 mm.).
Regrind journals and crankpins when	.003 in. (.0762 mm.) oval.
Maximum run-out	.006 in. (.152 mm.) total clock reading.
Maximum run-out between two adjacent bearings ...	.003 in. (.0762 mm.) total clock reading.
Radius at corners of journals and crankpins	0.15/0.17 (3.810/4.318 mm.).

MAIN BEARINGS

Number	Seven.
Type	Prefinished, copper-lead, steel shell, bearing surface indium-coated.
Centre journals initial end clearance	.002/.010 in. (.0508/.254 mm.).
Re-new centre main bearings when end clearance exceeds	.012 in. (.31 mm.).
Undersize main bearings available	Five, in steps of .010 in. (.254 mm.) each.
Mainbearing initial diametral clearance	.0035/.0065 in. (.089/.165 mm.).
Renew when diametral clearance exceeds	.007 in. (.178 mm.).

DAMPER

Type	Holmes 'Holset' torsional vibration damper at front of crankshaft.

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	3.4990 3.4983	88.875 88.857	2.503 2.500	63.576 63.500	3.9010 3.9005	99.085 99.073	2.850	72.390	3.301 3.299	83.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260
1st Service	Part Number /	3.4890 3.4883	88.621 88.603	2.503 2.500	63.576 63.500	3.8910 3.8905	98.831 98.819	2.850	72.390	3.301 3.299	83.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260
2nd Service	,, /	3.4790 3.4783	88.367 88.349	2.503 2.500	63.576 63.500	3.8810 3.8805	98.577 98.565	2.850	72.390	3.301 3.299	83.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260
3rd Service	,, /	3.4690 3.4683	88.113 88.095	2.503 2.500	63.576 63.500	3.8710 3.8705	98.323 98.311	2.850	72.390	3.301 3.299	83.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260
4th Service	,, /	3.4590 3.4583	37.859 87.841	2.503 2.500	63.576 63.500	3.8610 3.8605	98.069 98.057	2.850	72.390	3.301 3.299	83.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260
5th Service	,, /	3.4490 3.4483	87.605 87.587	2.503 2.500	63.576 63.500	3.8510 3.8505	97.815 97.803	2.850	72.390	3.301 3.299	33.845 83.795	3.100	78.740	1.910 1.900	48.514 48.260

Note 1. When regrinding crankpin and journals the sides must not be ground.

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

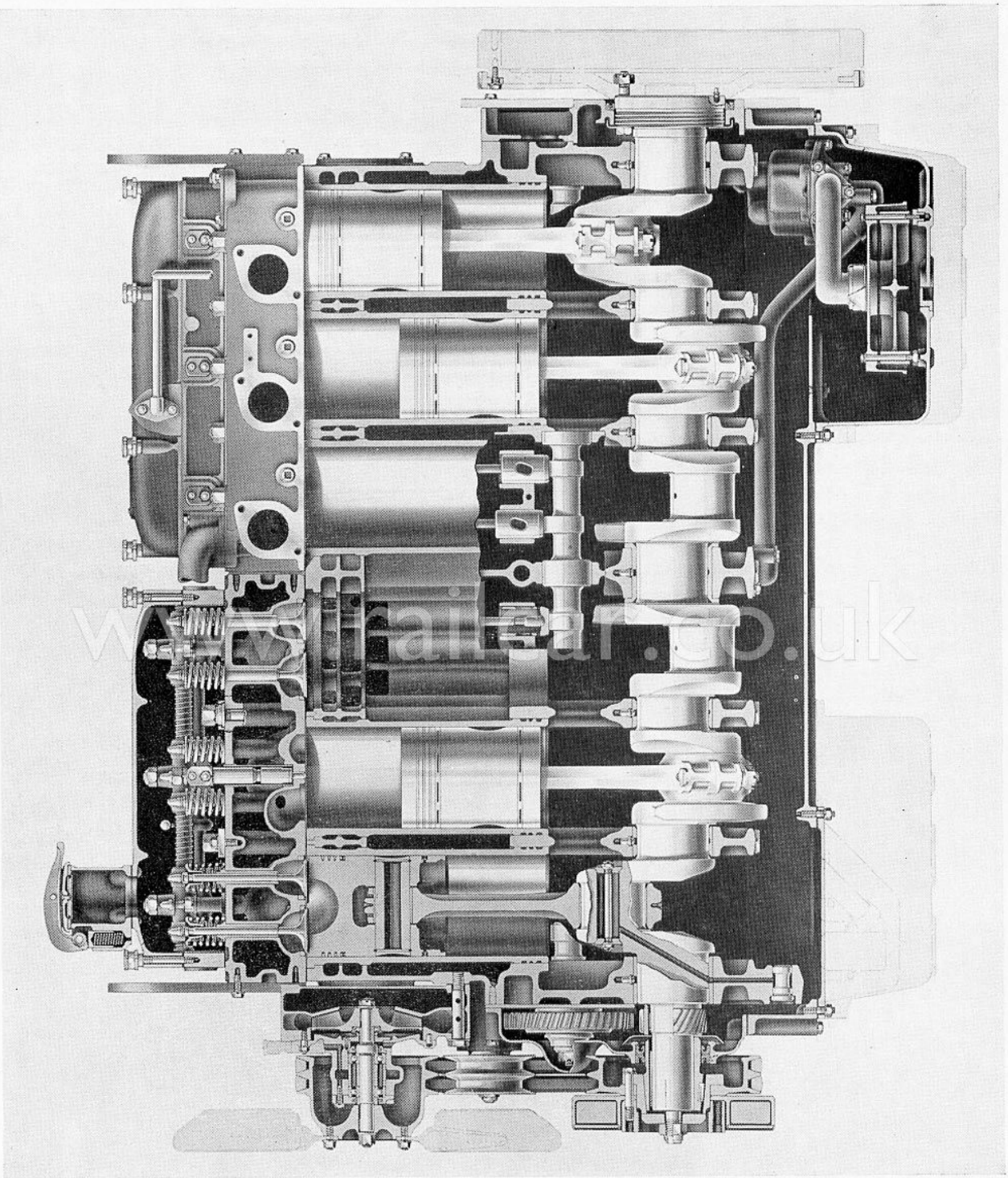


FIG. 2. SECTION THROUGH VERTICAL ENGINE

DESCRIPTION

The nitrided fully-balanced crankshaft is machined from a single alloy steel forging, and is supported in seven bearings (Figs. 1 and 2). The journals are lubricated from the main engine oil gallery and oilways through the crankwebs feed the connecting-rod big-end bearings through axial wells in the crankpins. These wells are drilled eccentrically to reduce centrifugal loading and also to act as sludge traps.

On the front end of the crankshaft are keyed the timing pinion for the timing gear drive, and the hub for the inertia type, torsional vibration damper, and pulley if a vertical type engine. Two spring loaded synthetic rubber seals fitted back to back to prevent the engine from breathing are fitted to the crankshaft at the front.

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 spring loaded synthetic rubber seal fitted in the flywheel housing or back-plate prevents the engine from breathing. An oil thrower is also fitted to the front and rear of the crankshaft.

The flywheel is dowelled in correct position and secured by eight bolts to the crankshaft rear flange. Bolted to the flywheel is a renewable starter ring, which is reversible, and can be fitted either way round. Provision is made for fitting attachments to the flywheel for different types of drives.

All main bearings are fitted with renewable steel shell type copper-lead indium coated bearings, which are precision manufactured to give correct running clearance without any scraping or adjustment. They are in two halves and are located together by pegs (Fig. 7). The centre one being flanged to take the crankshaft end thrust. The halves in the engine block are all dowelled to their seatings to prevent turning.

Note: On later engines strip bearings are fitted and to facilitate easy removal they are not located together by pegs or dowels. The top halves can be removed for inspection or replacement without removing the crankshaft.

Main bearing caps are bored in position in the engine block and, to ensure that they are always fitted correctly, both caps and seatings are stamped adjacent to the mating joints with one of the numbers 1 to 7, corresponding to their position in the engine. Bearing shells are marked in the same way.

OVERHAUL

To Remove Crankshaft

1. Remove the engine from unit, and mount it on the special supports designed for this purpose.
2. Remove the clutch, torque converter, gearbox or driving shaft as fitted.
3. Remove the cylinder heads and gaskets.
4. Remove the sump.
5. Remove the main and scavenge oil pumps.

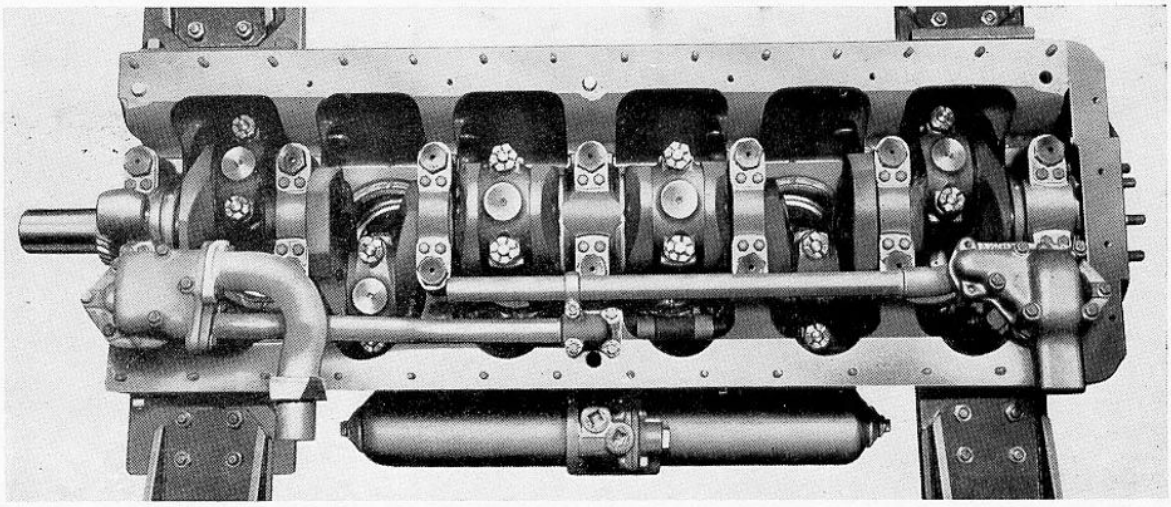


FIG. 3. CRANKSHAFT IN POSITION

6. Disconnect the connecting rods and withdraw the pistons and connecting rods.

7. Remove damper and pulley as fitted and timing gear cover.

8. Remove the flywheel; two ½ in. UNF tapped holes are provided for the insertion of extracting screws should this be necessary.

9. Remove the bolts securing the crankcase rear cover, rear support plate and flywheel housing to the engine block as fitted, and lift off.

10. Remove the locking plates for main bearing bolts.

11. Remove the main bearing caps (Fig. 4). On a horizontal type engine remove the front main bearing cap and intermediate gear as a complete unit.

12. Lift out the crankshaft.

Crankshaft Inspection and Regrinding

Having removed the crankshaft, dismantle and clean out the crankpin sludge traps and oilways. Inspect carefully for cracks and check crankpins and journals for wear, see **Data**.

FIG. 4. REMOVING BEARING CAPS

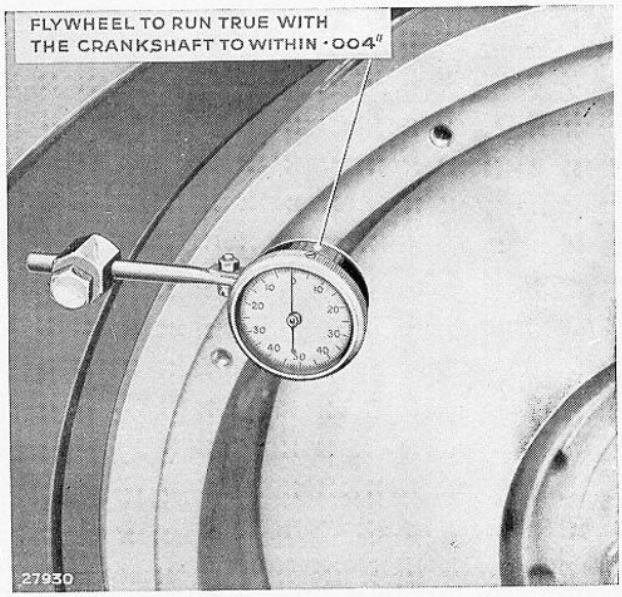


FIG. 5. CHECKING FLYWHEEL FOR RUNNING TRUE

When either the crankpins or journals become .003 in. (.0762 mm.) oval they should be reground .010 in. (.254 mm.) undersize. Do not grind end faces of crankpins and journals, but maintain the 0.15 in./0.17 in. (3.81 mm./4.318 mm.) radius at the corners in every case.

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

It cannot be emphasized 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 journals and web of the crank (Fig. 6).

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 doubts 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 diameters.

After re-grinding, and also after re-nitriding following re-grinding, support the crankshaft at the front and

rear journals and check the relative eccentricity of the centre main journal, this must not exceed .003 in. (.0762 mm.) in radius or total run-out of .006 in. (.1524 mm.). The permissible error between any two adjacent bearings must not exceed .003 in. (.0762 mm.) total clock reading.

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

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. 5.

Main Bearing Inspection and Replacement

The main bearings should not, if possible, be detached unless there is a reason to believe they are in need of attention. A fair idea of their condition can, if necessary, be obtained by removing the crankcase cover and detaching the bearing caps one by one. Only the cap half shells can be inspected in this way, when the earlier type bearings are fitted, but it can generally be assumed that, if they are in good condition and the journals show no evidence of scoring, no further action is necessary and caps should, therefore, be refitted exactly as removed. Tighten the retaining bolts with a torque wrench set at 200 lb. ft. (27.65 kg.m.) then refit the locking plates.

Before refitting the crankcase cover, check crankshaft end float by levering the shaft backwards and forwards and checking the clearance alternately in front and behind the centre bearing flanges (Fig. 8). Initial clearance is .002 to .010 in. (.05 to .25 mm.) and the bearing shells should be removed if it exceeds .012 in. (.31 mm.).

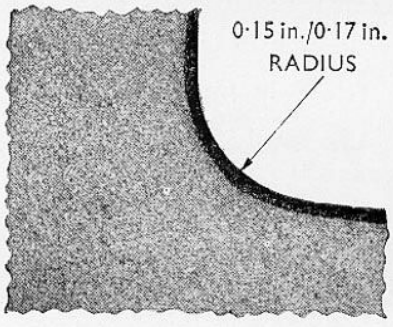
The foregoing procedure does not permit checking of the actual bearing clearances, and if this is desirable, or shells are seen to have flaws necessitating their replacement, or journals are scored, the crankshaft must be removed. Assuming that the shaft does not require regrinding, bearing clearances can then be checked by reassembling the caps and shells on the crankcase, measuring the bores and journals and noting the difference. Initial running clearance is .0035 to .0065 in. (.089 to .165 mm.) and shells should be renewed if clearance exceeds .0070 in. (.178 mm.). Where the shaft is reground, correct running clearance will be obtained automatically on selecting the appropriate undersize bearing sheels, which are available in five steps of .010 in. (.254 mm.) each.

Note: It is not necessary to remove the crankshaft to inspect or renew the new type bearings as the top half can be pushed out after first slackening off the remaining bearing cap screws.

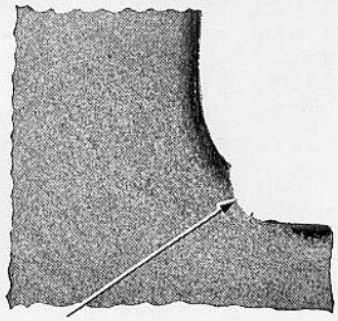
To Refit the Crankshaft

Main bearing caps, bearing and nuts must be refitted in their original positions, and, for this purpose, the caps and seatings are marked. When correctly assembled all marks must correspond.

1. Thoroughly clean the backs of the bearing shells and their seatings in the crankcase and main bearing caps to ensure that the shells will bed down correctly. See that the locating dowels in the crankcase seatings and the pegs in the shell ends are securely in position, (Fig. 7), if applicable, then fit the shells in the caps and seatings so that all markings correspond. New bearing shells should be marked like the originals to avoid future confusion. Smear all shells with clean engine oil.



USE GRINDING WHEEL WITH
0·15 in./0·17 in. (3·810 mm. /4·318 mm.)
RADIUS



NITRIDED CASE REMOVED
OWING TO INCORRECT RADIUS
OF GRINDING WHEEL

FIG. 6. SECTIONS OF JOURNAL TO-WEB FILLETS

2. Turn the camshaft timing wheel until the arrow on the rim coincides with the arrow on the timing back plate.

3. Drive the timing pinion on to the front of the crankshaft if it has been removed for any reason.

4. Smear the main bearing journals with clean engine oil, then, taking care not to disturb the camshaft setting, lift the crankshaft into position in the crankcase and engage the timing pinion with the timing intermediate gear so that Nos. 1 and 6 crankpins are at top dead centre (the flywheel fixing bolt in line with No. 6 crankpin should be on the engine centre line). Refit the main bearing caps and tighten the retaining bolts with a torque wrench set at 200 lb. ft. (27.65 kg.m.), then refit the locking plates.

5. Refit the pistons and connecting rods.

6. Refit the main and scavenge oil pumps.

7. Refit the crankcase rear cover, rear support plate and flywheel housing as fitted.

8. Refit the flywheel and check that, when the T.D.C. mark on the flywheel is in line with the timing pointer in the flywheel housing, the arrows on the camshaft timing wheel and timing back plate are also in line. When no flywheel housing is fitted the T.D.C. mark on the flywheel should line up with the pointer on the rear support plate.

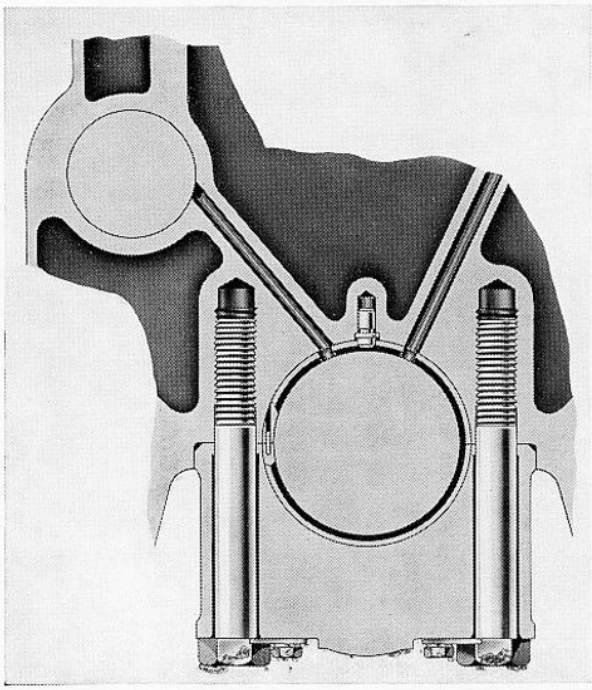


FIG. 7. SECTION THROUGH MAIN BEARING

FIG. 8. CHECKING CRANKSHAFT END PLAY

9. Place the oil thrower on front of the crankshaft, and, fitting two new oil seals back to back in the timing casing, refit the timing case.

10. Refit the cylinder heads and adjust the tappets.

11. Refit the sump.

12. Re-time the injection pump.

13. Refit the crankshaft damper and pulley as fitted.

14. Refit the clutch, torque convertor, gearbox or driving shaft as fitted.

15. Re-install the engine in the unit.

The Crankshaft Damper

The Holmes 'Holset' torsional vibration damper (Fig. 9) or dampers is situated at the front end of the crankshaft and consists of a flywheel totally enclosed in a light casing. A small clearance between the casing and the flywheel is filled with a high viscous fluid. The casing is fastened to the crankshaft and the

only connection between the crankshaft and the damper flywheel is through the fluid. Under conditions of no vibration, the casing and flywheel revolve together, but as the torsional vibration amplitudes increase, the casing follows the movement of the crankshaft but the flywheel tends to rotate uniformly by virtue of its inertia, and relative motion occurs between the flywheel and the casing. The viscous fluid film, therefore, undergoes a shearing action and vibration energy is absorbed and appears as heat.

Referring to Figs 2 and 3 the damper and inner distance piece are held between the damper hub flange and outer distance piece by eight setscrews entered from behind. The damper hub is in two portions, the inner being partially split endwise so that the taper bore of the outer portion compresses it tightly on the end of the crankshaft. The complete assembly is held in position by the centre nut and washer.

In the event of leakage at the crankshaft front oil seals, the damper or dampers must be removed as follows to allow renewal of the oil seals:

1. On vertical engines remove the cooling fan.
2. Remove the driving shaft from the front of the crankshaft and shaft coupling flange when fitted.
3. Remove the centre nut and washer securing the vibration damper hub, and nuts and setscrews securing any auxiliary equipment driven by the engine to the timing case.
4. Partially withdraw from the timing case any auxiliary equipment, then attach a suitable extractor by means of $\frac{1}{2}$ in. UNF bolts to the damper outer distance piece, withdraw the damper assembly, and remove the auxiliary equipment at the same time. When a belt pulley is fitted this is removed with the damper hub.
5. The inner portion of the damper hub will be left in place at this stage and must now be withdrawn separately with a claw type extractor, after which the timing casing can be detached and the oil seals driven out for renewal. The inner portion of the damper hub should also be renewed, if the oil seal bearing surface is worn.

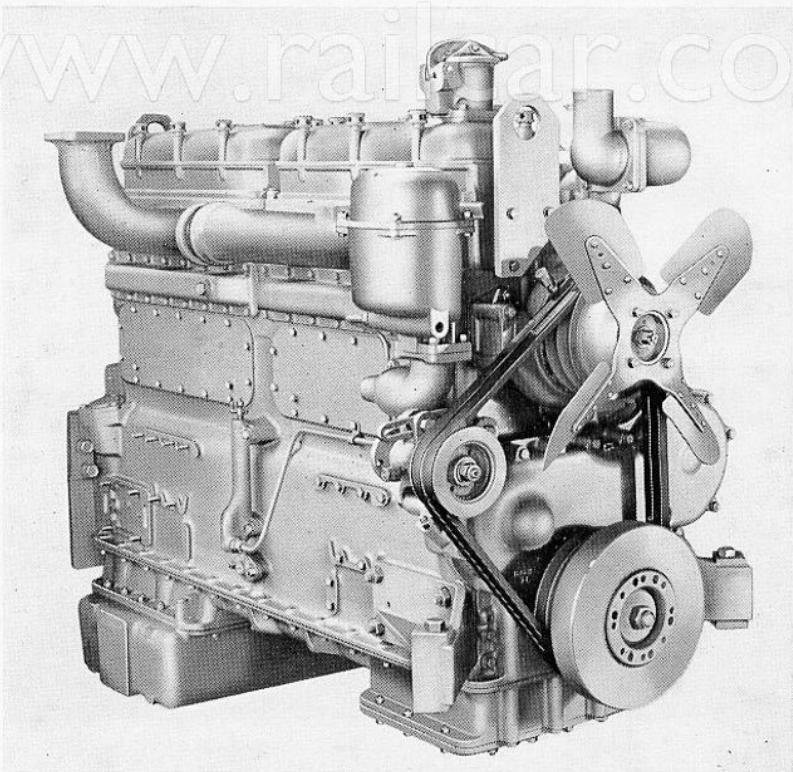


FIG. 9. VIEW OF ENGINE SHOWING CRANKSHAFT DAMPER IN POSITION

TIMING GEARS AND AUXILIARY DRIVES

DATA

Type	Single helical.
Gear material	Case hardened and ground steel.
Intermediate gears, initial diametral clearance between bush and gears	.001/.0035 in. (.025/.089 mm.).
Diametral clearance between bush and intermediate gear spindle	.001/.0035 in. (.025/.089 mm.).
End float between thrust washers and intermediate gears	.0025/.0095 (.063/.241 mm.).
Renew thrust washers when end clearance exceeds ...	.012 in. (.305 mm.).
Interference fit of timing gear on crankshaft	.00125/.00225 in. (.03175/.05715 mm.).

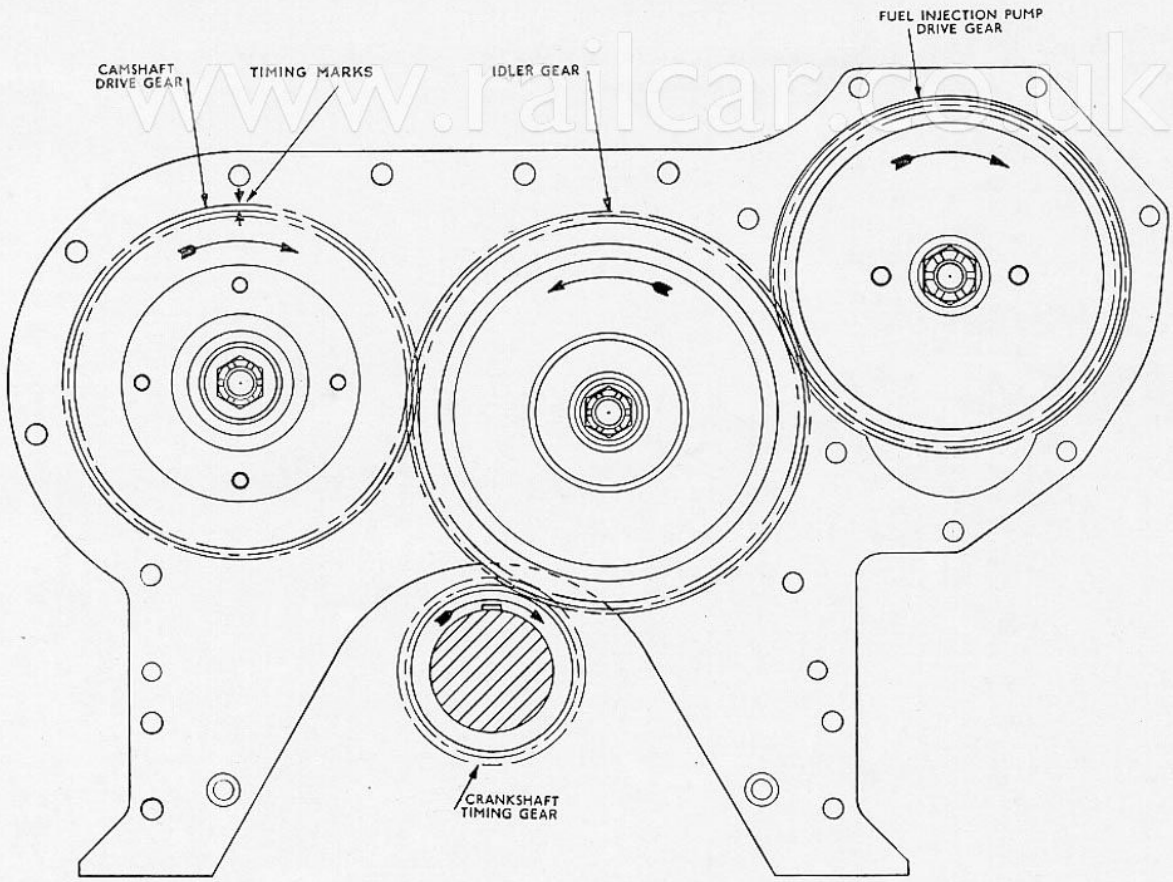


FIG. 1. ARRANGEMENT OF TIMING GEARS (VERTICAL ENGINE)

1060

DESCRIPTION

The arrangement of the hardened and ground single-helical timing gear train for a vertical engine is shown in Fig. 1 and that of a horizontal engine in Fig. 2.

Vertical Engines

The drive to the camshaft, and exhauster or compressor and fuel injection pump, is transmitted from the crankshaft timing pinion through an intermediate gear (Fig. 1). The intermediate gear, mounted on a spindle bolted to the engine block, runs on a floating bush, the thrust being taken by two special washers (Fig. 6).

When an exhauster or compressor is fitted the drive gear is mounted on the exhauster or compressor rotor shaft, and can be removed by using the two tapped holes in the gear face to attach a withdrawal tool. The end flange of the exhauster or compressor casing is bolted to the timing back plate and the drive from the exhauster or compressor is connected to the fuel injector pump by a flexible coupling.

The alternative drive when an exhauster or compressor is not required, is by gear and shaft carried in ball bearings mounted in a housing which is bolted to the timing back plate. The shaft runs through oil seals fitted in a cover attached to the housing and is connected to the fuel injection pump by a flexible coupling.

Horizontal Engines

The drive to the camshaft is on one side of the crankshaft and to the fuel injection pump and water pump on the other, and is transmitted from the crankshaft timing pinion through two intermediate gears. The intermediate gear mounted on the engine block drives the camshaft gear, whilst the intermediate gear mounted on the front main bearing cap (Fig. 5) drives the fuel injection pump and water pump. The intermediate gears are carried on spindles bolted to the engine block and front main-bearing cap and run on a floating bush, the thrust being taken by two special washers.

Any equipment such as a compressor when fitted is mounted on the front of the timing case and is driven

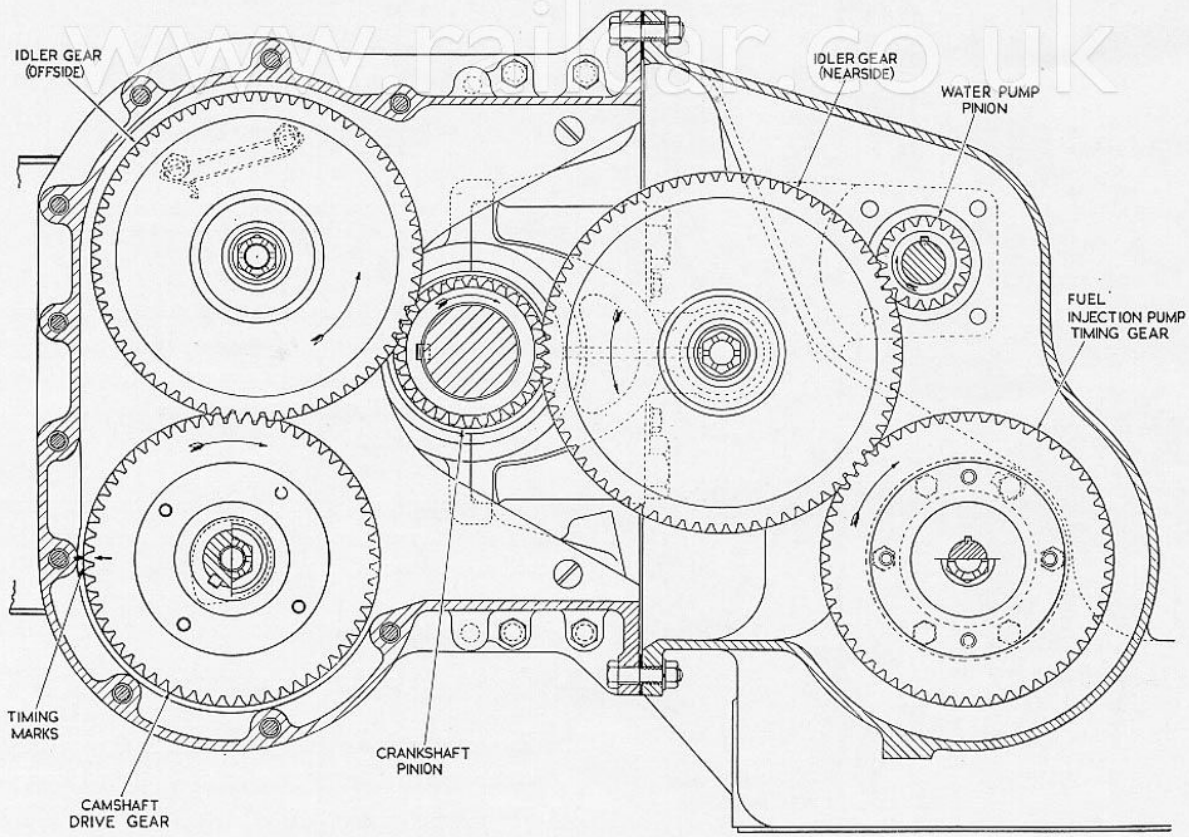


FIG. 2. ARRANGEMENT OF TIMING GEARS (HORIZONTAL ENGINE)

by an extension coupling gear fastened to the camshaft drive gear. When a tachometer generator or transmitter is fitted this is also mounted on the front of the timing case and driven by a dog extension bolted to the fuel injection pump driving gear. Further auxiliary equipment can be mounted on the rear of the timing case at the front of the crankcase cover which can be driven from the water pump drive pinion and spindle.

The main and or scavenge oil pumps when fitted are skew gear driven off small helical pinions at the front and or rear of the camshaft.

The pinion on the crankshaft is an interference fit, the key being used only to locate the pinion for timing purposes.

INTERMEDIATE TIMING GEARS

The arrangement of the intermediate timing gear transmitting the drive to the camshaft timing gear on a vertical engine is shown in Fig. 1, and on a horizontal engine in Fig. 2. The intermediate gear for the camshaft drive for both types of engines is the same, but apart from its larger diameter the second intermediate gear on a horizontal engine, mounted on the front main bearing cap, is identical.

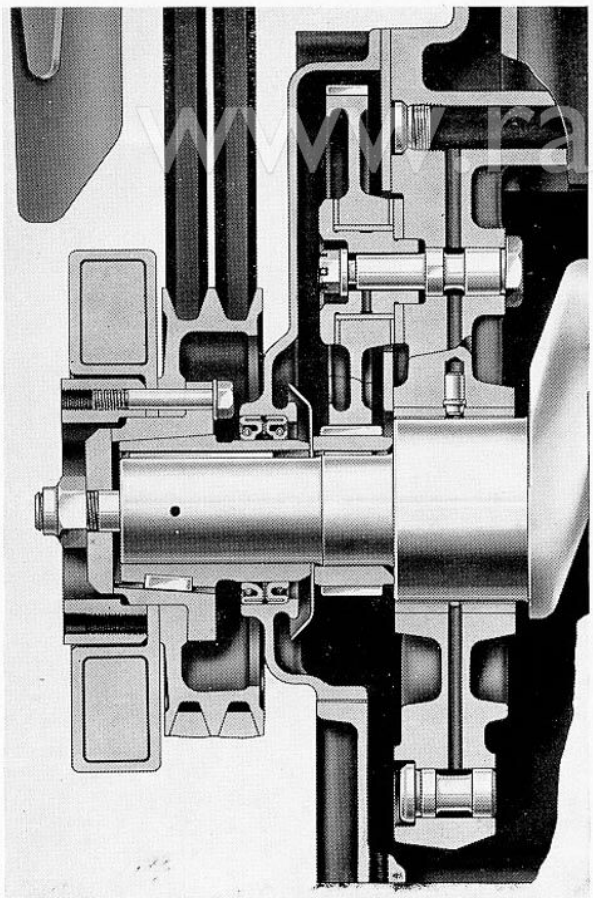


FIG. 3. SECTION THROUGH FRONT OF VERTICAL ENGINE SHOWING CRANKSHAFT AND IDLER GEAR

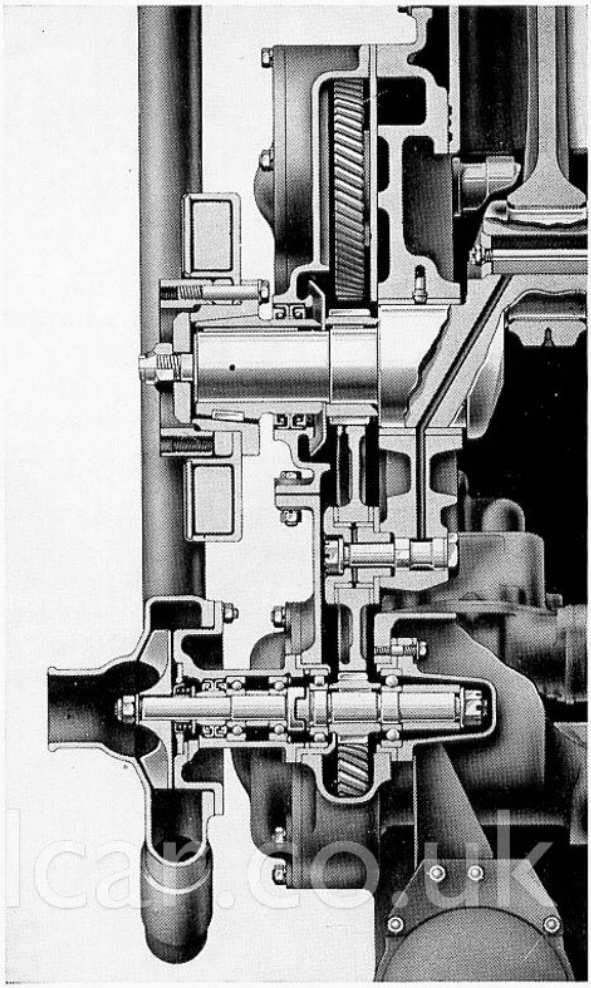


FIG. 4. SECTION THROUGH FRONT OF HORIZONTAL ENGINE SHOWING TIMING GEARS

To gain access to the intermediate gears on some installations, the engine will have to be removed, now proceed as follows:

Vertical Engine

1. Remove the cooling fan and belts.

2. Remove the driving shaft from front of crankshaft and shaft coupling flange or cold starting equipment when fitted.

3. Remove the centre nut and washer securing the

vibration damper hub, then attaching a suitable extractor by means of ½ in. UNF bolts to the damper outer distance piece withdraw the crankshaft vibration damper and hub. When a belt pulley is fitted this is removed with the damper hub.

4. Disconnect the drive to the Plessey pump and or dynamo when fitted.

5. Remove the retaining screws and detach the auxiliary drive casing, taking care not to damage the oil seal housed in the bore surrounding the crankshaft.

6. Remove the split pin and nut from end of fixing bolt and withdraw gear and spindle.

Horizontal Engine

1. Remove the driving shaft from front of crankshaft and shaft coupling flange or cold starting equipment when fitted.

2. Remove the centre nut and washer securing the vibration damper hub, and nuts and setscrews securing any auxiliary equipment attached to the timing case and driven by the engine at the camshaft centre. Partially withdrawn from the timing case this auxiliary equipment, then attaching a suitable extractor by means of ½ in. UNF bolts to the damper outer distance piece, withdraw the crankshaft vibration damper and hub, and remove the auxiliary equipment at the same time.

3. Remove the retaining screws and detach the auxiliary drive casing, taking care not to damage the oil seal housed in the bore surrounding the crankshaft.

4. To gain access to the intermediate gear which drives the fuel injection pump and water pump, remove the sump.

5. Remove split pins and nuts from the ends of the fixing bolts and withdraw gears and spindles.

Note: After fitting new gears always check that slight backlash is present in the gear train.

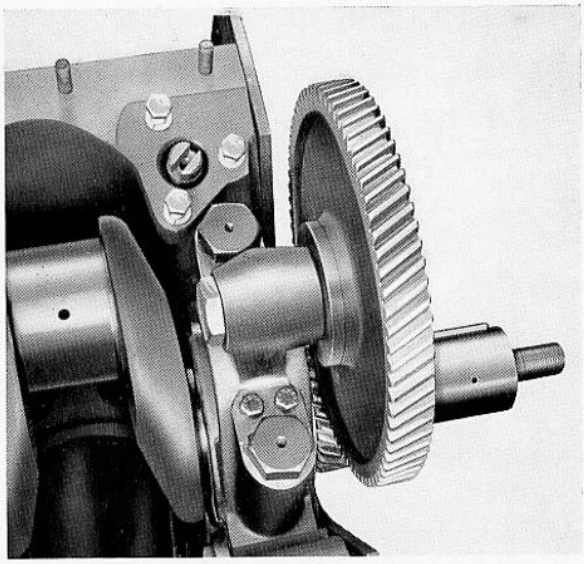


FIG. 5. IDLER GEAR IN POSITION—HORIZONTAL ENGINE

WATER PUMP DRIVE

Horizontal Engine

The drive spindle and pinion for the water pump drive is supported in ball and roller bearings (Fig. 4), and is situated in the crankcase cover, the water pump being driven by a dog at the front. A right-angle-drive, dynamo, or some form of auxiliary equipment can be driven by the drive spindle at the rear of the water pump drive which can be attached to the crankcase cover. If no auxiliary equipment is mounted at this point a blind cover is fitted.

To remove the drive, proceed as follows:

1. Drain the cooling system and remove the water pump.

2. Remove any auxiliary equipment fitted at the water pump drive. If no auxiliary equipment is fitted, remove blind cover.

3. Remove the coupling on rear of the auxiliary equipment drive spindle as fitted, remove the spindle rear bearing cover and withdraw the rear bearing housing complete with bearing.

4. Tap the spindle assembly out through the front of the crankcase cover.

To Refit

Reverse the above procedure.

FUEL INJECTION PUMP DRIVE

Horizontal Engine

The fuel injection pump drive shaft is supported in ball bearings in the side of the crankcase cover.

To remove the fuel injection pump drive proceed as follows:

1. Remove the fuel injection pump.
2. Withdraw the coupling on the rear of the drive shaft, remove the rear bearing cover and withdraw the rear bearing housing complete with bearing.
3. Remove the tachometer generator or transmitter when fitted.
4. Remove cover over the fuel injection pump timing wheel.
5. With a hide hammer, tap the shaft complete with timing wheel out through the front of the crankcase cover.

To Refit

Reverse the above procedure, and finally retime the fuel injection pump.

TACHOMETER GENERATOR OR TRANSMITTER DRIVE

Horizontal Engine

A dog extension bolted to the fuel injection pump drive gear provides the drive for the tachometer generator, or transmitter, which is flange mounted on the front of the crankcase cover when fitted.

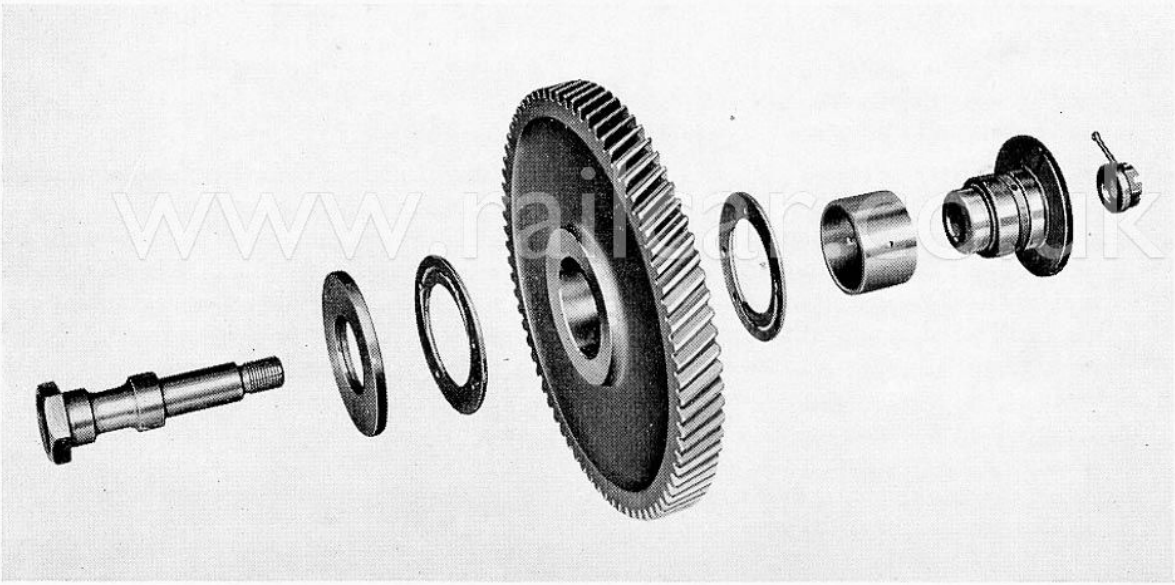


FIG. 6. IDLER GEAR DISMANTLED

ENGINE COOLING
WATER CIRCULATION

DATA

VERTICAL ENGINE

Controlled by	Thermostat in water cooling installation.
Water pump and fan drive	Belt driven from pulley on crankshaft.

HORIZONTAL ENGINE

Controlled by	Thermostat in water cooling installation.
Water pump	Gear driven, at 1.666 times engine speed.

DESCRIPTION

Vertical Engine

The water passes through the impeller-type pump, situated at the front of the engine, direct into the engine block for circulation through the cylinder water jackets. A large quantity of the water is directed into the water gallery running along the top of the engine block and thence through holes into the engine block. On some engines integral water jacketed oil coolers are fitted on the side of the engine block in place of the water gallery covers. After leaving the engine block the water flows through drilled holes into the cylinder heads and is directed on to the nozzle and exhaust valve housings. The water leaves each cylinder head at one point and flows into a common water outlet manifold, and then to the thermostat housing.

The thermostat, fitted in the front end of the water outlet manifold, enables the engine to reach the correct running temperature in the shortest possible time. The thermostat valve seals the outlet to the water cooling arrangement while the water is cold, but allows it to circulate through the engine block and cylinder head until the water temperature rises to 185° F. (85° C.), when the valve is fully open and brings the water cooling arrangement into full operation.

A drain cock is provided to enable the water to be drained completely when required.

Horizontal Engine

The water passes through the impeller type pump, situated at the front of the engine, via a pipe to the front of the engine block, for circulation through the cylinder water jackets. A large quantity of the water is directed into the water gallery running along the underside of the engine block and thence through holes into the engine block. On some engines, integral water-jacketed oil coolers are fitted on the underside of the engine block in place of the water gallery covers. After leaving the engine block some of the water flows through drilled holes into the cylinder heads, and is directed on to the nozzle and exhaust valve housings, this water returns to the engine block. All the water leaves the engine block in a common water manifold, situated on the top of the engine block, with the outlet at the front or rear and then to the water cooling arrangement. On some engines a water temperature switch (Fig. 5), is fitted in the water outlet manifold or cylinder head.

On some engines the water, after passing through the pump, is piped to a heat exchanger, and then into the rear of the engine block. The water passes through the engine as previously described. Again all the water leaves the engine block in a common water manifold, situated on the top of the engine block, with the outlet at the rear and thence to the water cooling arrangement.

A drain cock is provided on the engine to enable the water to be completely drained when required.

DRAINING THE COOLING SYSTEM

This operation should be carried out with the engine in a level position. Do not leave until the water is completely drained.

Notes

If the cooling system is pressurised, do not remove the radiator or filler cap until the engine has cooled down and relieved the pressure.

After draining display a notice in a prominent position to the effect that the cooling system is empty and the drain cocks are open.

Engines with anti-freeze solution in the cooling system

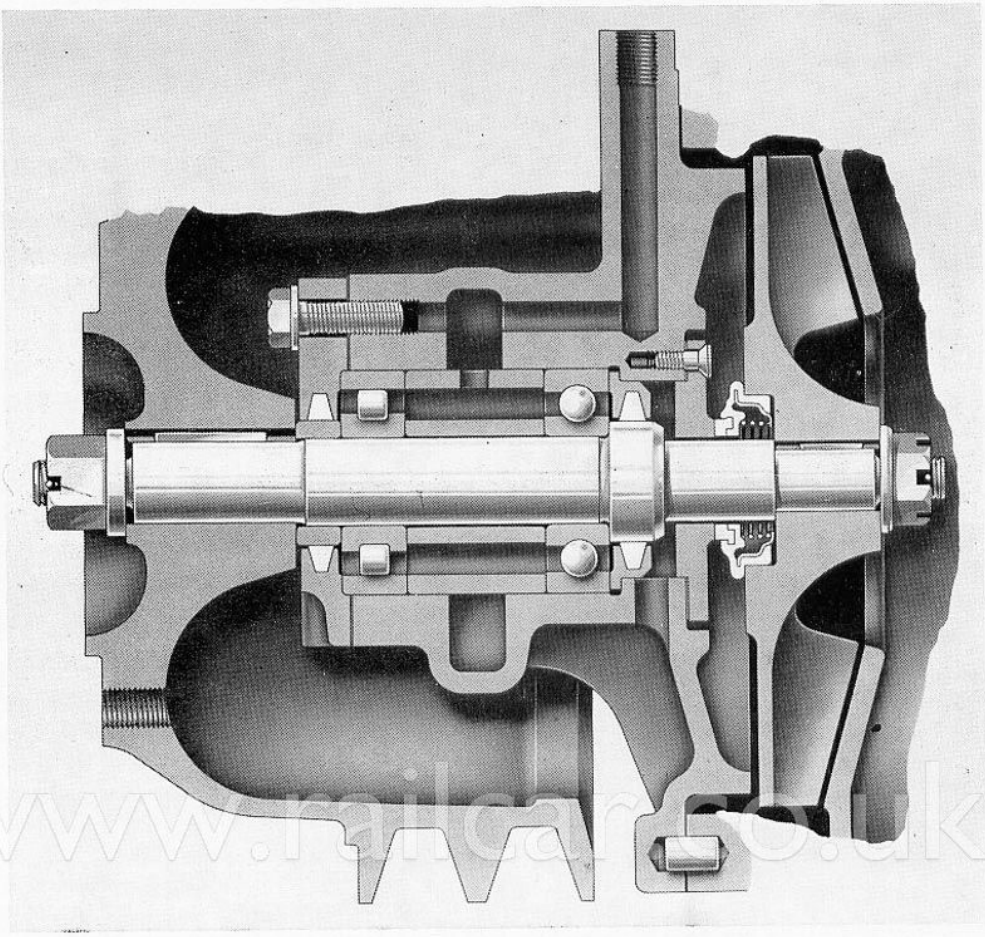


FIG. 1. SECTION THROUGH WATER PUMP (VERTICAL ENGINE)

should be marked accordingly, and if the engine is so marked do not drain the cooling system.

Drain cocks 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 obstructions freed by the wire may be flushed out by the water.

Vertical Engine

To drain the cooling system open the drain cock provided, which is situated at the rear of the engine block on the fuel injection pump side.

Horizontal Engine

To drain the cooling system open the drain cock which is provided on the engine.

Frost Precautions

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

WATER PUMP

Vertical Engine

Description

The impeller-type water pump (Fig. 1), mounted at the upper front end of the engine block, is driven from the crankshaft by pulley and twin driving belts. A spring loaded, self-adjusting, carbon seal unit carried in the pump impeller or attached to the pump housing

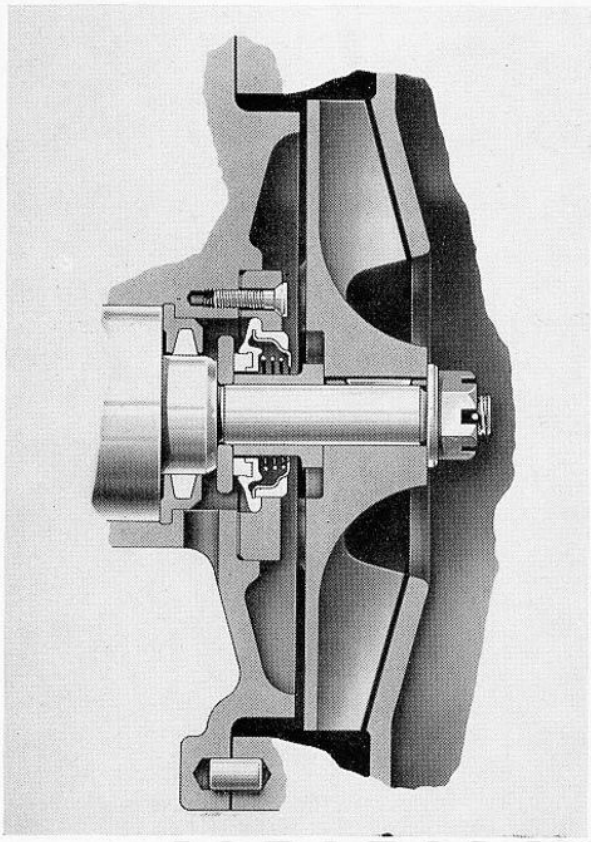


FIG. 2. SECTION THROUGH WATER PUMP (PRESSURISED SYSTEM)

and bearing on the thrust plate or rubbing washer, completely isolates the impeller chamber from the ball and roller bearings. A drain hole is also provided in the pump housing behind the seal to prevent water reaching the bearings. The bearings are lubricated through a limited supply grease nipple on the pump housing, loss of grease being prevented by felt washers.

The water pump is unlikely to require any attention for long periods, but should excessive leakage develop the pump should be dismantled for examination of the carbon seal unit.

To Overhaul

If leakage of the carbon seal unit is experienced, the carbon seal unit should be renewed as follows:

To Dismantle

1. Drain the cooling water.
2. Remove the cooling fan and pulley.
3. Remove the nuts securing the bearing housing assembly to the pump casing, and detach the housing complete with impeller and spindle, using the two $\frac{5}{16}$ in. UNF tapped holes in the housing flange for this purpose.
4. Remove the split pin and retaining nut and withdraw the impeller and extract the impeller key.
5. Remove the carbon seal unit. On some engines, remove the four retaining screws, detach the thrust plate, and withdraw the carbon seal unit and distance piece.
6. Inspect the thrust plate or rubbing washer, and renew it if the rubbing face is scored or marked in any way.
7. Smear the thrust plate or rubbing washer with marking paste, fit the new carbon seal unit and refit the impeller. On some engines refit the new carbon seal unit, thrust plate, distance piece and impeller.
8. Rotate the pump spindle a few times, then dismantle the carbon seal unit and inspect the marking so obtained on the thrust plate or rubbing washer. It should show an unbroken circle of contact, and if so the pump can be assembled and refitted on the engine.

   If the pump bearings and seals are to be inspected, proceed as above up to stage 5, and then proceed as follows:
9. Remove the four retaining screws and detach the thrust plate, on some engines remove the rubbing washer.
10. Press the pump spindle out of the bearing housing, pressing from the pulley end of the spindle.
11. Remove the end cover and using the felt washer retaining ring, press out the bearings and distance pieces, pressing from the impeller end.
12. Remove the felt washers.

To Reassemble

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

When reassembling the bearings must be driven fully home.

New felt washers must be used.

Pack the bearings with the prescribed grease.

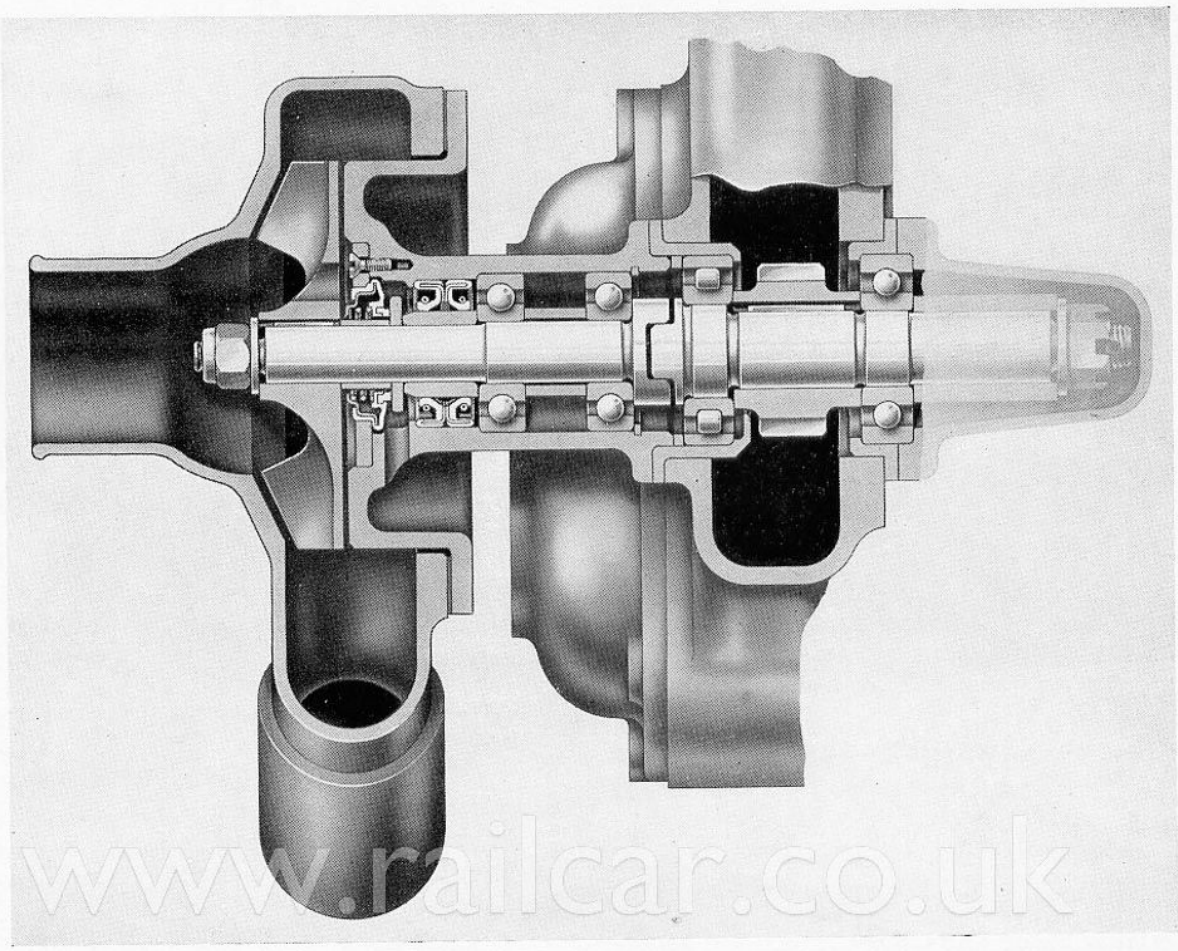


FIG. 3. SECTION THROUGH WATER PUMP (HORIZONTAL ENGINE)

WATER PUMP

Horizontal Engine

Description

The impeller-type water pump (Fig. 3), mounted on the front of the crankcase cover, is dog driven from the timing gears. A spring loaded, self-adjusting carbon seal unit carried on the spindle distance piece, and bearing on the rubbing washer, completely isolates the impeller chamber from the ball and roller bearings. A drain hole is provided in the pump housing behind the seal, and this, in conjunction with the double seal, prevents water reaching the bearings. The double seal also prevents leakage of oil which is fed automatically to the bearings from the timing gears.

The water pump is unlikely to require any attention for long periods, but should excessive leakage develop the complete water pump should be removed and dismantled for examination of the carbon seal unit.

To Overhaul

If leakage of the carbon seal unit is experienced, the carbon seal unit should be renewed as follows:

To Remove

1. Drain the cooling system.

2. Uncouple the inlet and outlet water pipe connections at the pump, and uncouple bleed pipe to pump casing if fitted.

3. Remove the four nuts securing the pump end cover to the crankcase cover, and detach the water pump complete.

To Dismantle

1. Remove the nuts securing the pump casing to the pump end cover and detach the casing.

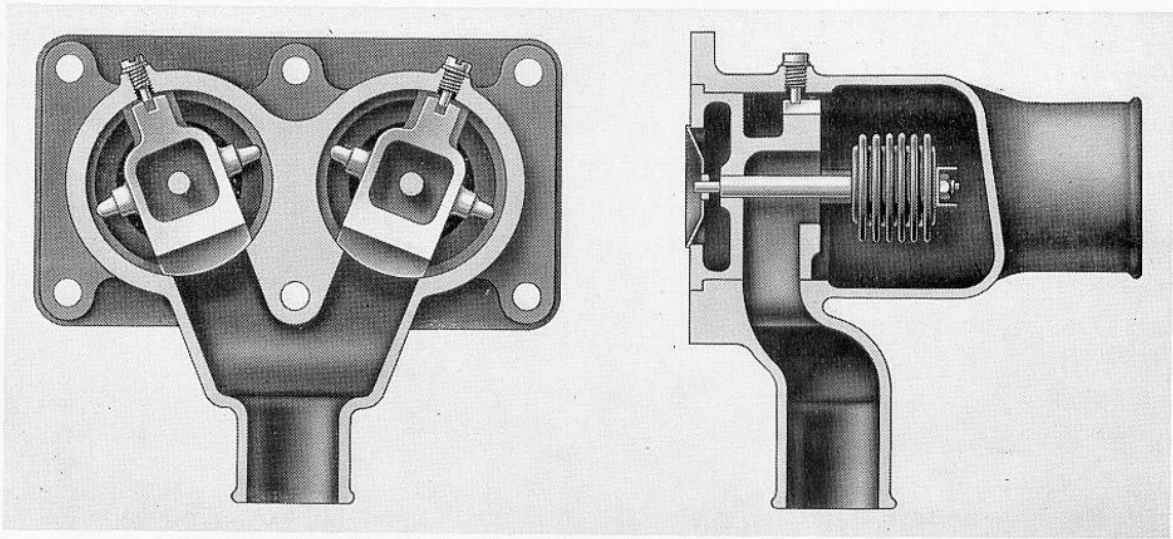


FIG. 4. THERMOSTAT IN POSITION (TWIN TYPE)

2. Remove the retaining nut and withdraw the impeller and extract the impeller key.

3. Remove the four retaining screws, detach the thrust plate, and withdraw the carbon seal unit.

4. Inspect the rubbing washer, and renew it if the face is scored or marked in any way.

5. Smear the rubbing washer with marking paste, fit the new carbon seal unit and refit the thrust plate and impeller.

6. Rotate the pump spindle a few times, then dismantle the carbon seal unit and inspect the marking so obtained on the rubbing washer. It should show an unbroken circle of contact, and if so the pump can be assembled and refitted on the engine.

   If the pump bearings and oil seals are to be inspected, proceed as above up to stage 3, and then proceed as follows:

7. Remove the rubbing washer and distance piece.

8. Remove the circlip, and placing a suitable sized tube on the pump spindle and butting up against the distance piece carrying the back to back oil seal, press the tube, thus removing the pump spindle complete with bearings and distance piece out of the end cover.

9. Remove the back to back oil seal.

To Reassemble

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

When reassembling, note that the oil seals must be fitted back to back as illustrated, and must be driven fully home, as also must the bearings. New oil seals must be used.

Pack the bearings with the prescribed grease.

THERMOSTAT

Description

The thermostat assembly consists of gas filled metal bellows which expand and contract at predetermined temperatures, thereby operating the valve which is housed with the bellows in a metal frame.

The thermostat is either on the engine itself or mounted on the radiator.

When the water is cold, the valve is down on its seat, thus closing the intake from the engine to the radiator. The water then flows solely through the by-pass after passing through the engine water jackets. At about 160° F. (71° C.) the expansion of the bellows gradually opens the valve and allows circulation to an increasing degree through to the radiator until at 183°-190° F. (84°-88° C.) the valve is fully open allowing maximum flow through the radiator.

The thermostat incorporates a bleed hole which provides a release for excessive pressure or steam accumulating in the engine block or cylinder heads.

The maximum lift of the valve is $\frac{5}{8}$ in. (15.875 mm.).

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

TEMPERATURE SWITCH

A water temperature switch (Fig. 5) is usually fitted to horizontal type engines and is situated in the water outlet manifold or cylinder head and wired to a temperature gauge in the instrument panel or to the engine cut-out switch, denoting the temperature of the engine cooling water.

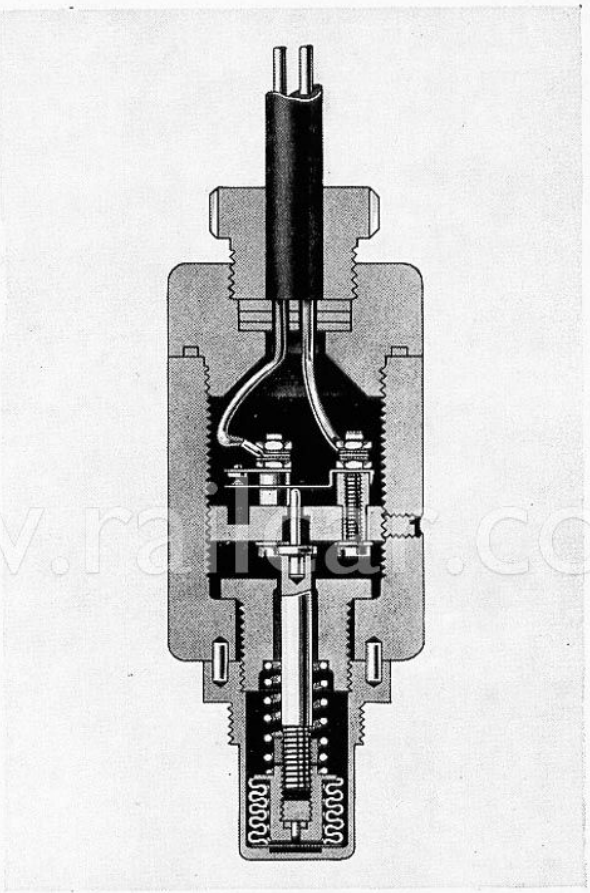


FIG. 5. WATER TEMPERATURE SWITCH

ENGINE

FUEL INJECTORS

DATA

Make (for engines type EN. 901V and H)	C.A.V.
Nozzle and holder assembly (use with loose olive) ...	9231Z15A.
Nozzle	9232 Z 4A (BDLL 140 S6254).
Holder assembly	9232 Z16A (BKBL 109 S5022). Incorporating adaptor 7008/185B.
Nozzle and holder assembly (use with swaged pipe end)	9231 Z18.
Nozzle	9232 Z 4A (BDLL 140 S6254).
Holder assembly	9232 Z 19 (BKBL 109 S5063). Incorporating high pressure adaptor 7008/185E and leak off adaptor 70008/115A.
Injector pressures:	
Pressure initially set at	185 atmospheres, 2,720 p.s.i. (190.1 kg. sq.cm.).
Working pressure	175 atmospheres, 2,570 p.s.i. (180.83 kg. sq.cm.).
Angle of spray	140°.
Diameter of spray holes	.014 in. (0.35 mm.).
Diameter of spray holes	.016 in. (0.40 mm.).
Nozzle	BDLL 14SX3767.

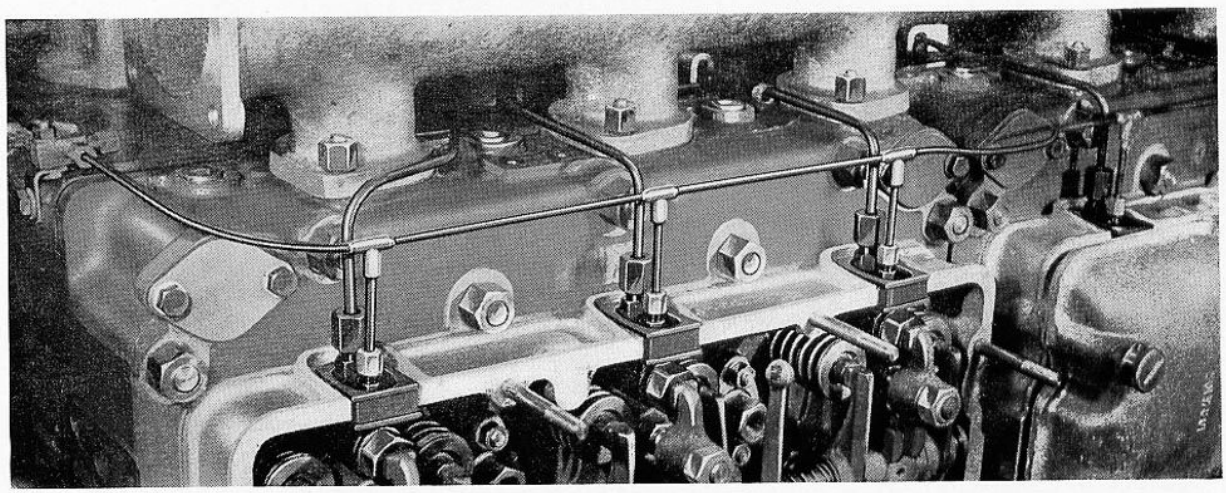


FIG. 1. INJECTORS AND LEAK-OFF PIPE IN POSITION

DESCRIPTION

The fuel injectors are of the 'long stem' four hole type, and are located inside the valve covers.

Housed in copper tubes in the cylinder heads, which seal them from the water jacket, the injectors are clamped in position so that they spray straight into the combustion chambers in the piston crowns. A sealing washer between the injector and the cylinder head provides the compression seal.

The 'long stem' nozzle has an extended body, in the tip of which is provided the valve seating and dome for the injector holes. The valve stem is also elongated, it is a clearance fit in the body, the lapped portion of the barrel being confined to the section located above the fuel gallery.

The fuel is delivered by the fuel injection pump to the injectors, and is then fed through a drilled passage to the fuel gallery. When the required pressure is reached the nozzle valve snaps open and allows fuel to be sprayed into the combustion chamber through the holes in the nozzle tip as a fine mist. The nozzle valve is adjusted to open automatically as soon as the fuel oil reaches a predetermined pressure, the quantity of fuel oil delivered to the engine being controlled by the fuel injection pump. The injector also provides a snap finish to the injection and prevents air from entering the pipe line during the compression stroke.

The slight leakage of fuel oil past the valve stem and body serves as a lubricant, and is then led away through a drilled passage in the injector body to a gallery pipe which is connected up to the fuel supply tank (Fig. 1).

The injectors will give long periods of efficient service. Special equipment is required for reconditioning the injectors and special cleaning tools are obtainable. If, however, no equipment is at hand, injectors should be returned to Leyland, Albion Service Departments, or C.A.V. Service Department, and a replacement set fitted.

On no account must the injectors be interchanged with those used on any other make of engine.

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 unvapourised fuel: (blue), denotes a choked injector.
4. Increased fuel consumption.
5. Engine overheating.
6. Loss of power.

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 reasonably assumed that the injector is faulty.

Fit a spare injector and vent the fuel system. (Blank off the injector pipe and leak-off pipe unions of the faulty injector, fit a dust cap to the nozzle and return it for servicing.)

Note: It is important that the leak-off pipe is not bent when removing an injector.

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

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 nozzle valve spring.
9. Cracked injector body.
10. Cracked nozzle.

To Remove

1. Remove the valve covers and joints.
2. Disconnect the fuel injection and leak-off pipes from the injectors, and take precaution to prevent dirt getting into any of them.
3. Remove the nuts securing the injector clamps, and remove clamps.
4. Withdraw the injectors from the cylinder heads, taking care not to damage the nozzle. If the nozzle sealing washers do not come away at the same time, remove them immediately.

Note: If the injectors are not being refitted immediately, plug or tape over the open unions.

To Test

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 (Fig. 3).

Connect the injector to an injector hand-testing pump (Fig. 2), give the handle about ten strokes to expel all air from the pipe and injector, and observe the nature of the spray when pumping at about two strokes per second. When a hand-test pump is used for testing a nozzle for dribble or for observing the nature of the spray, the pressure gauge should be shut-off by means of the stop valve.

If no hand-test pump is available, connect the injector to the fuel 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 and turn the engine, with the fuel injection pump rack in the "full load" position, and observe the spray.

Alternatively, when no hand-test pump is available, test the injectors by reconnecting it to its fuel injection pipe, start the engine and observe the spray.

When the injector is operating correctly, the spray in finely atomized form should issue from all the four nozzle holes and appear alike, of equal length and free from streaks or jets of undivided fuel. The injectors should "buzz" distinctly whilst the injector is spraying. The nozzle tip should remain dry after fuel cut-off.

If the spray is uneven or streaky, or if drops of fuel oil form on the tip of the nozzle, a complete new or reconditioned injector must be substituted.

If all four sprays are satisfactory, but dribble occurs after cut-off it may be due either to dirt or carbon on the needle valve seat, cracked nozzle or needle valve sticking in body.

Wipe the nozzle dry and repeat the test, watching carefully to see the point from which fuel leakage originates. If from the nozzle holes, dirt or carbon on the needle valve seat or needle valve sticking in body, 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 body and nozzle body; 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 holes are clear, the sprays even, and the nozzle does not show signs of dribble, turn on the pressure gauge on the hand-test pump and check that the working pressure is 175 atmospheres, 2,570 p.s.i. in (180:83 kg. sq.cm.).

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.

When the opening pressure is correct, hold the pressure at 100 atmospheres, 1,790 p.s.i. (103.3 kg. sq.cm.) 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.

OVERHAUL

To Dismantle and Clean

Injectors should be dismantled on a bench used specifically for the purpose and where scrupulous cleanliness is observed. All tools and letter references in this section refer to the nozzle cleaning outfit illustrated in Fig. 11.

In the case of injectors which are in a very dirty condition externally, blank off the fuel connection and

leak-off unions, then wash thoroughly in clean paraffin or fuel oil.

Brush the nozzle externally with the brass wire brush (Fig. 3) then proceed to dismantle as follows:

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

2. Hold the injector body in a vice by the flats provided on the injector body with the nozzle pointing upwards. Unscrew the nozzle cap nut and lift away the nozzle body and valve.

3. Reverse the injector body in the vice and unscrew the spring cap, then remove the spring plate, spring and nozzle valve rod.

   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 be fitted 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, scratched or discoloration. 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.

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.

Withdraw the nozzle valve from the body and complete the external cleaning of the nozzle body with the brass wire brush then wash externally.

Prick out the holes (see Fig. 5) with one of the wire needles, holding it by means of the tool holder, and dislodge any dirt from the nozzle tip (see Fig. 6) with the brass tool.

It should be noted, that the correct size of 'D' needles must always be used when cleaning choked holes to avoid damage to the nozzle.

Clean the nozzle valve seat (see Fig. 7) with the brass tool, the clean out the fuel gallery and passages in the nozzle body with a piece of brass wire (see Figs. 8 and 9).

Place the nozzle body (see Fig. 10) in the flushing tool 7044/137 and wash it out backwards with clean fuel oil under pressure from the hand-test pump (see Fig. 2). 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. 11) with the brass wire brush wash off in clean paraffin and insert in the nozzle body while this is still being washed out. This ensures that the needle seat is clean when entered into the nozzle body and that the washing back process extends to the fuel passages in the nozzle body.

Finally, rinse in clean white spirit before assembly.

To Reassemble and Test

The components should be thoroughly washed in paraffin 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. 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: 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.

2. Wash thoroughly and refit the nozzle rod, spring, spring plate, spring cap and locknut.

3. Wash and refit the inlet adaptor.

4. Connect the injector to the hand-test pump (Fig. 2); give the handle about ten strokes to expel all air from the pipe and injector.

5. Carefully note pressure at which spray breaks when the pump handle is operated. The correct working pressure is 175 atmospheres, 2,570 p.s.i. (180.83 kg. sq.cm.).

6. The nozzle tip must remain dry with a sustained pressure of 100 atmospheres, 1,470 p.s.i. (103.3 kg. sq. cm.) for one minute.

7. Fit the copper washer and end cap.

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

To Fit

Before refitting the injectors, scrape all carbon deposit carefully off the seatings and nozzle holes in the cylinder heads, a decarbonising reamer can be supplied for this purpose. Clean also the outside of the nozzles with a wire brush. Renew the nozzle sealing washers and the rubber blocks which seal the injectors in the valve cover distance pieces, unless these are in perfect condition, then refit injectors one by one as follows:

1. Slipping a sealing washer over the nose of the injector, held in position by grease, and the rubber block in position on the inlet adaptor, insert the injector in the cylinder head.

2. Carefully centralise the injector in its tube, replace the clamp, and tighten the nut securing the injector to the cylinder head, with a torque spanner set at 30/35 lb./ft.

3. Connect the fuel injector pipes from the pump to the injectors.

4. Connect the leak-off pipe to the injectors.

5. Examine all pipe connections for leaks, correct as necessary, and vent the fuel system.

6. Start up the engine and check that there is no compression leakage past the nozzle sealing washers. If necessary, recentralize the injectors.

7. Fit the valve covers and joints.

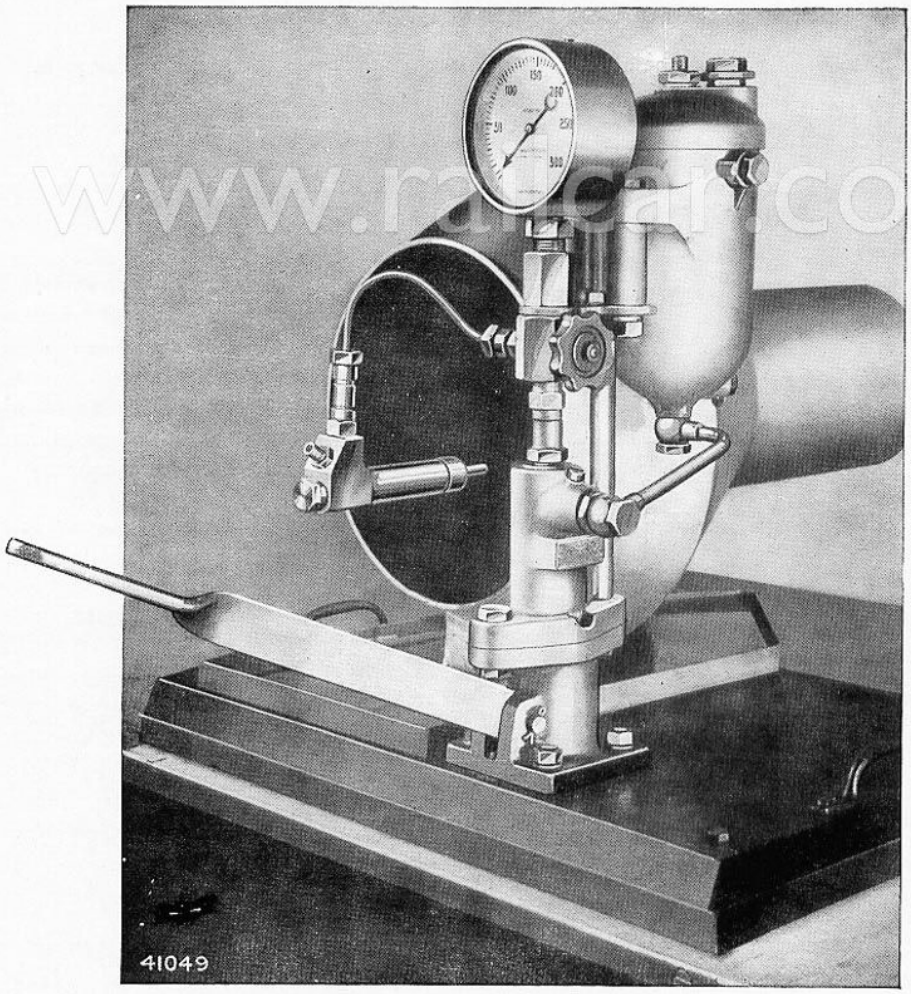


FIG. 2. INJECTOR UNIT TEST RIG

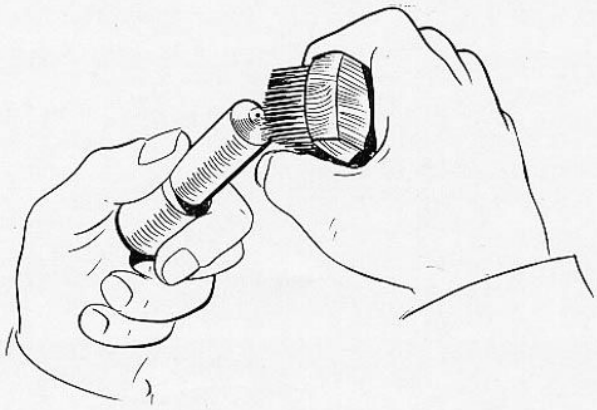


FIG. 3. CLEANING NOZZLE TIP

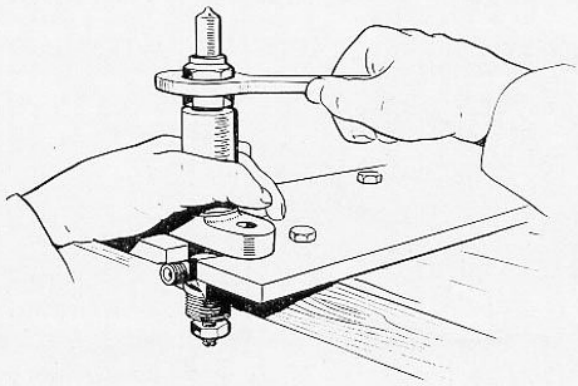


FIG. 4. REMOVING NOZZLE CAP NUT

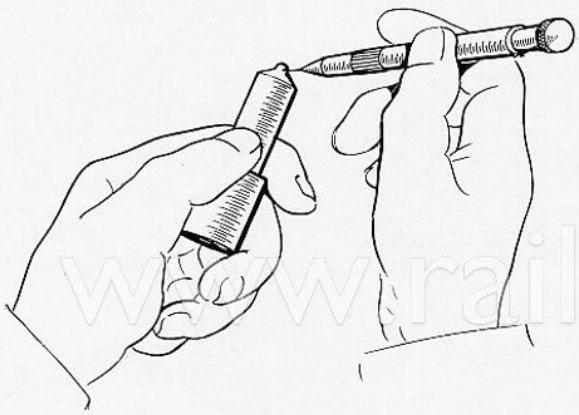


FIG. 5. CLEANING NOZZLE SPRAY HOLES

FIG. 6. CLEANING DOME CAVITY

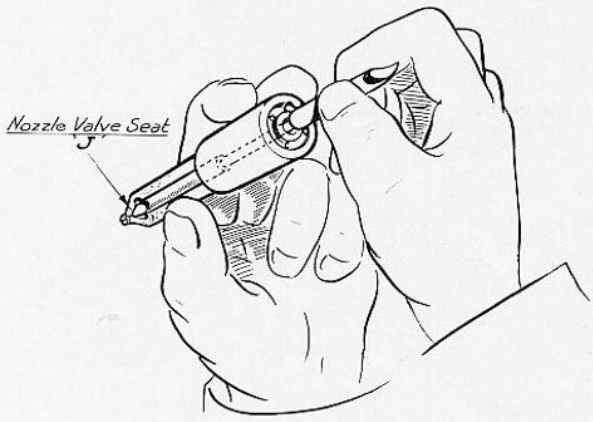


FIG. 7. CLEANING NOZZLE VALVE SEAT

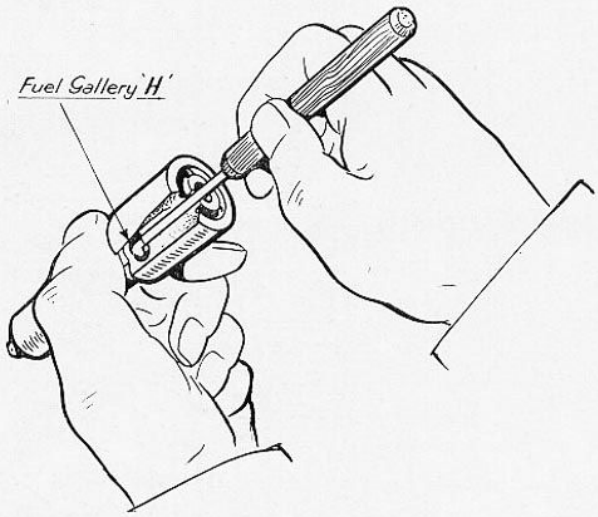


FIG. 8. CLEANING FUEL GALLERY

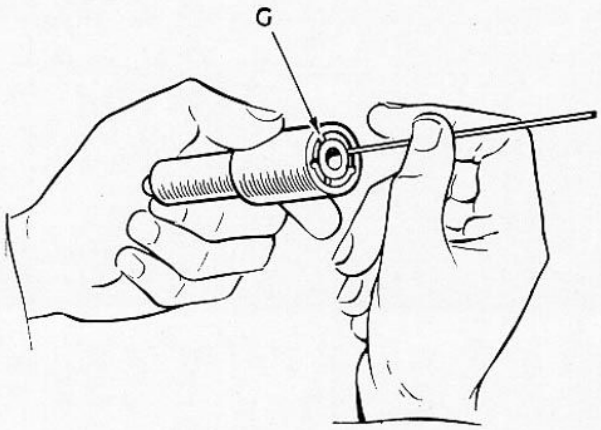


FIG. 9. CLEANING FEED CHANNEL BORES

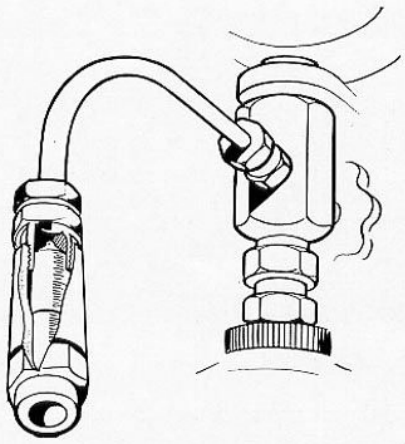


FIG. 10. FLUSHING NOZZLE

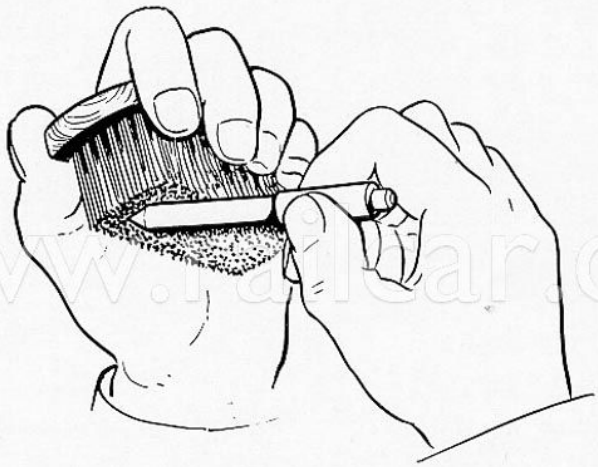


FIG. 11. CLEANING NEEDLE VALVE

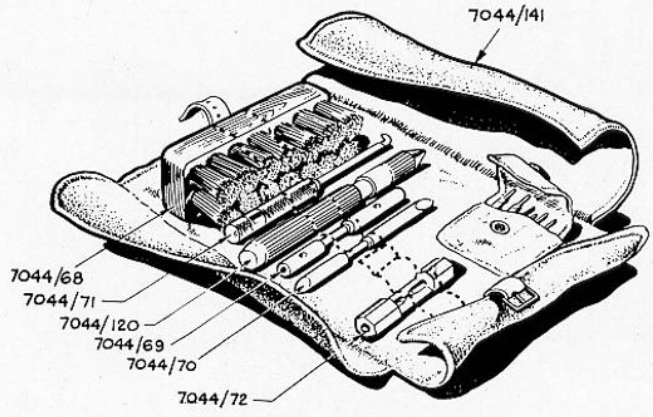


FIG. 12. NOZZLE CLEANING KIT

FUEL INJECTION PUMP

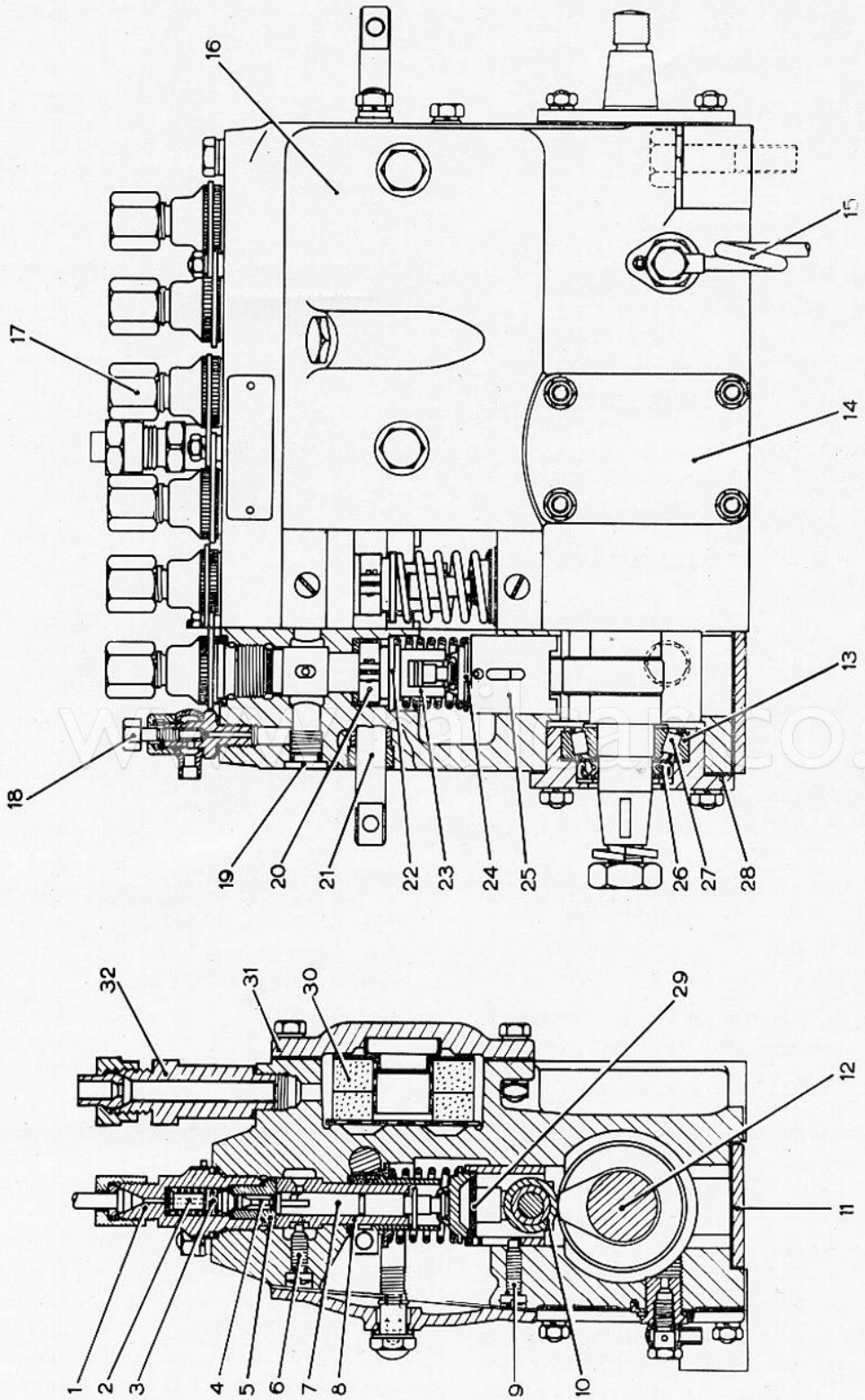


FIG. 1. SECTIONED VIEWS OF TYPICAL 'NN' TYPE PUMP

'NN' TYPE FUEL INJECTION PUMPS

INTRODUCTION

C.A.V. 'NN' fuel injection pumps are cam-operated, spring-return, plunger pumps, with separate pumping elements for each engine cylinder, and are available for multi-cylinder engines. The elements are arranged in-line and operated by the camshaft and tappet arrangement within the pump housing. A pneumatic, mechanical, or hydraulic governor can be fitted, also an excess fuel device.

The type number is shown on the plate on the pump housing and indicates the following features:

NN	Basic Type Pump
L	Camshaft assembly
6	Number of pumping elements
A	Design change letter
75	Plunger diameter in tenths of mm. (75=7.5 mm.)
/	Dividing stroke
56	Individual features number
E	Standard excess fuel device fitted
EL	Non-standard excess fuel device fitted (The letter 'A' instead of 'L' indicates automatic excess fuel device fitted.) Camshaft assembly letter 'L' or 'R' indicates notched end of camshaft at left or right hand end looking on the inspection cover side of pump. Element plungers with L.H. or R.H. helix, are available in the following diameters: 6.0 mm.:6.5 mm.:7.0 mm.:7.5 mm.:8.0 mm. 9.0 mm.: and 10 mm.

Lubrication of the pump is carried out initially by removing the inspection plate filler and filling the camshaft chamber to the prescribed level with best quality lubricating oil (same oil as is used in the engine). During operation of the pump, a slight back-leakage of diesel fuel past the plunger takes place and drains into the camshaft chamber to maintain the lubricating oil level. As dilution of the lubricating oil takes place it is essential to drain the camshaft chamber periodically and refill with fresh lubricating oil. The frequency of this operation will depend upon the application, conditions under which the pump is operating, type of diesel fuel employed etc. and will vary in different parts of the world. Because of the variation in operating conditions it is impossible to lay down any specific draining period and experience alone is the deciding factor.

Some later type pumps are fitted with a drain plug and oil filler/breather cap to facilitate draining and refilling.

Any queries in connection with the lubrication of the fuel pump, or concerning the fuel injection equipment, should be referred to the C.A.V. agent or service depot who will gladly advise on any fuel injection problem.

The pump is of high precision manufacture and must be handled with great care and scrupulous cleanliness at all times. Good quality fuel correctly stored and filtered, should always be used, for even small amounts of foreign matter will be detrimental to the efficient performance of the pump, and will shorten its working life.

MECHANICAL DETAILS

Except where otherwise stated, all reference numbers quoted in this section refer to Fig. 1, which is an annotated sectional view of the 'NN' type fuel pump.

The Pumping Element

Each element is comprised of a plunger and a plunger barrel lapped together to form a mated assembly. The parts are not interchangeable and damage to either will necessitate the renewal of the complete element. The upper portion of the plunger element (8) Fig. 1 is in the form of a shoulder which seats against a corresponding shoulder in the pump housing. It is prevented from turning by the locking screw (6) which passes through the pump housing and engages in the groove machined on the barrel surface. The upper portion of the barrel, located within the common fuel chamber, is provided with two oppositely drilled holes, permitting the fuel to flow from the fuel chamber into the element. The countersunk hole is known as the inlet port and the other the spill port. The upper surface of the barrel has been ground flat and square to the axis to produce an oil-tight jointing face against the base of the delivery valve seating (5).

Inside the barrel is the plunger (7) which is actuated by the cam and tappet and has a constant stroke of 10 mm. for 'NN' type, but to enable the pump to vary the quantity of fuel delivered to the engine per stroke, each plunger is provided with a vertical channel extending from its top edge to an annular groove cut in the form of a helix. The function of this groove is described later.

External means whereby the plungers can be rotated in their barrels are provided by control rod (21) acting in conjunction with control quadrant (20) mounted on the control sleeve (23).

A return spring, located between the upper plate (22) and the lower plate (24) fitted to the plunger bottom, gives a positive plunger return.

A part section of the complete pumping element and delivery valve is shown at Fig. 4.

The Tappet Arrangement

Each tappet assembly slides in a bore machined in the pump housing and is located by the locating screw (9) which passes through the housing and engages a groove milled in the tappet assembly wall. It is provided with a hardened steel roller (10) which is held in contact with the operating cam by the action of the plunger return spring.

The lower spring plate (24) which fits over the bottom end of the plunger, seats against a shoulder in the hollow upper end of the tappet block and is retained by a spring clip which engages a hole drilled in the tappet wall. A phasing washer (29) is fitted between the lower spring plate and the shoulder in the tappet block to provide a means of phasing adjustment.

The Camshaft

The camshaft is carried in the lower portion of the pump housing and each end is supported by a tapered roller bearing. On the 'NN' type pump the bearings are located in steel sleeves pressed into the housing. End float adjustment is controlled by shims fitted between the race and end plate.

Individual cams with hardened surfaces are provided for each pumping element and the eccentric drive for operating the fuel lift pump, if fitted.

The camshaft ends are tapered and keyed and a threaded portion provided to enable the governor or the drive coupling to be mounted at either end of the shaft.

A notch or small saw cut will be found at one end of the camshaft, and care must be taken to ensure that the camshaft is reassembled after overhaul with this notched end at the specified end of the pump housing.

The Delivery Valve

This assembly consists of a delivery valve (4), delivery valve seating (5) complete with high pressure seal, spring (3), spring peg (2), delivery valve holder (1) and a low pressure seal fitted between a washer and the pump housing beneath the delivery valve holder.

The delivery valve and seating are of highly ground steel, finished to the finest limits and lapped together to ensure efficient operation at high speed and pressure. As with the pumping elements they must be regarded as a mated pair and never interchanged with similar components. The operation and function of the delivery valve is explained under the heading **Operation.**

The Control System

Movement of the control rod (21), which is controlled by the pump governor, is transmitted to the plungers (7) through the quadrants (20) and control sleeves (23) in the following manner.

Mounted on each control sleeve and secured by a clamping screw is a toothed quadrant which is in constant engagement with the rack on the control rod. The lower portion of the control sleeve has a slot into which the lug on the plunger fits.

As the control sleeve is a sliding fit over the plunger barrel, movement of the control rod rotates the control sleeve and alters the position of the plunger helix in relation to the fuel ports in the plunger barrel.

Vertical location of the control sleeve is provided by the plunger spring, which acts between the upper plate bearing against the underside of a shoulder on the control sleeve, and the lower plate which seats over the bottom end of the plunger, and is locked to the tappet assembly by means of a retaining spring.

The control rod slides in press-fitted bushes retained in position by the screwed-in locking rings. These bushes are line-reamed in position to ensure accuracy of alignment.

A locating plate, secured externally to the end of the pump housing, registers with a flat machine face on the control rod, thus preventing rotational movement which could cause seizure between the control rod and quadrants.

The Pump Housing

The pump housing is an aluminium casting, machined to accommodate the pump components. The upper portion carries the delivery valve holders, and is shaped to form a common fuel chamber for the pump elements. A cover plate (16) fitted to the front of the housing gives access to the control quadrants and the upper end of the tappet gear, so that adjustment can be made during calibration and phasing of the pump. The filter cover (31) mounted on the rear of the housing, encloses a felt pad final filter (30). A blanking plate (14) fitted on the front of the housing is removed when it is required to fit a feed pump operated by the pump camshaft. Oil seals (26) are fitted in each of the detachable end plates to prevent leakage of oil. The base is closed by a plate (11) which can readily be removed by unscrewing the retaining screws.

OPERATION

Fuel can be supplied to the pump by a gravity system incorporating a fuel filter in the feed line to the pump; but the forced feed system employing a low pressure fuel feed pump, driven from the camshaft eccentric drive, is the system more generally employed. Fuel from the gravity or forced feed system enters the injection pump common fuel chamber and is then drawn into each pump element through the ports provided in the element barrel.

Pumping (Fig. 2)

In a primed system, the barrel and pipe lines from the pump to the injector nozzles are full of fuel, and with the plunger head below the level of the two ports in the plunger barrel, fuel is fed in from the common chamber as shown in **a** Fig. 2. As the plunger rises, a certain amount of fuel is pushed back through the two ports until the plunger reaches position **b**, Fig. 2 when the top land closes the two ports. This is known as the 'spill cut-off' point.

The fuel on top of the plunger is now trapped and its only outlet is via the delivery valve mounted on top of the barrel. The pressure of this fuel increases as the plunger continues to rise under the influence of its cam until it causes the delivery valve to lift from its seating, allowing the fuel to pass into the pipe line leading to the injector nozzle. As this pipe line is full of fuel, the extra charge delivered by the pump plunger causes a further pressure rise, sufficient to lift the injector nozzle needle from its seat. This permits the fuel to be sprayed into the engine cylinder combustion chamber in a form most ready to ignite.

As soon as the lower edge of the control helix uncovers the port, as in **c**, Fig. 2, the fuel on top of the plunger, being at a much higher pressure than that in the common feed chamber, immediately returns via the vertical channel and annular groove.

This results in a reduced fuel pressure under the delivery valve which returns to its seating by spring pressure. Similarly, as the injector pipe line pressure collapses the injector needle returns to its seat by spring action. Thus fuel injection into the combustion chamber is terminated.

When the plunger passes top dead centre it commences its downward stroke under the action of the return spring.

It will be appreciated that the actual pumping part of the plunger stroke is the distance travelled by the plunger from the moment its top edge closes the ports (and compresses the fuel above) until the bottom edge of the control helix uncovers the port and reduces the fuel pressure via the vertical channel.

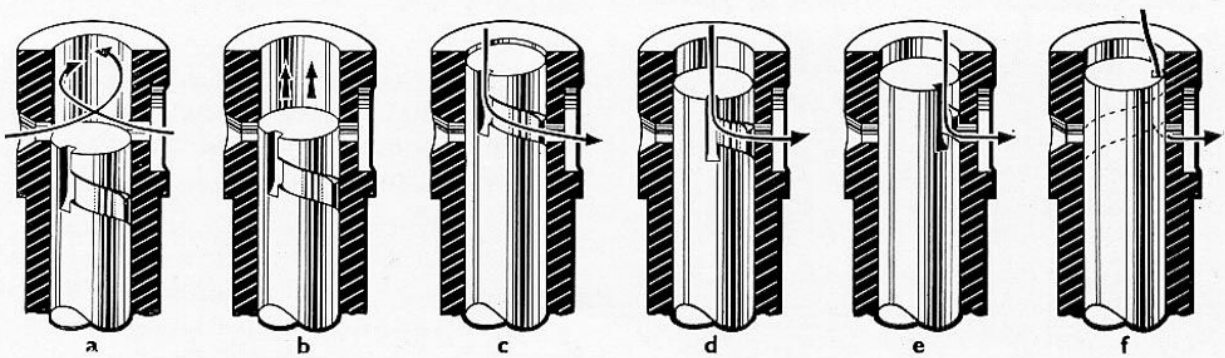


FIG. 2. PRINCIPLE OF FUEL METERING

The plunger stroke is always constant, but that part of it which is pumping can be varied by rotation of the plunger helical edge within the barrel in order to make the cut-off point occur earlier or later in the stroke and thereby permit a larger or smaller quantity of fuel to be delivered.

Fig. 2 diagrams **c**, **d**, and **e** show the approximate position of the helical edge for full load, half load and idling conditions.

The plunger is rotated by means of the toothed quadrant clamped to the control sleeve, slotted to engage the plunger toe. The quadrant meshes with a rack on the control rod which operates simultaneously all the pumping element quadrants in the pump assembly. Any movement therefore of the control rod causes all the plungers to rotate simultaneously and ensure an equal fuel delivery to each engine cylinder.

Diagram **f**, Fig. 2, shows the vertical channel opposite the right hand port and in this position the fuel is by-passed to the common fuel chamber during the plunger stroke. This is the engine **Stop** position.

Function of the Delivery Valve (Fig. 3)

When the pump is on its delivery stroke, the plunger pressure of the fuel rises until the delivery valve is lifted from its seat allowing the fuel to pass through the delivery valve seat and into the injector pipe line.

As soon as the pump plunger releases the pressure on its return stroke, the delivery valve resumes its seat and the injector in the engine cylinder head closes and shuts off the cylinder fuel supply.

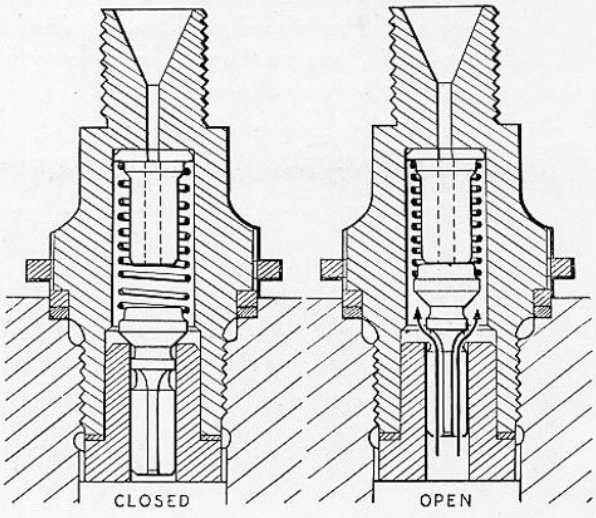


FIG. 3. SECTIONED VIEWS OF DELIVERY VALVE

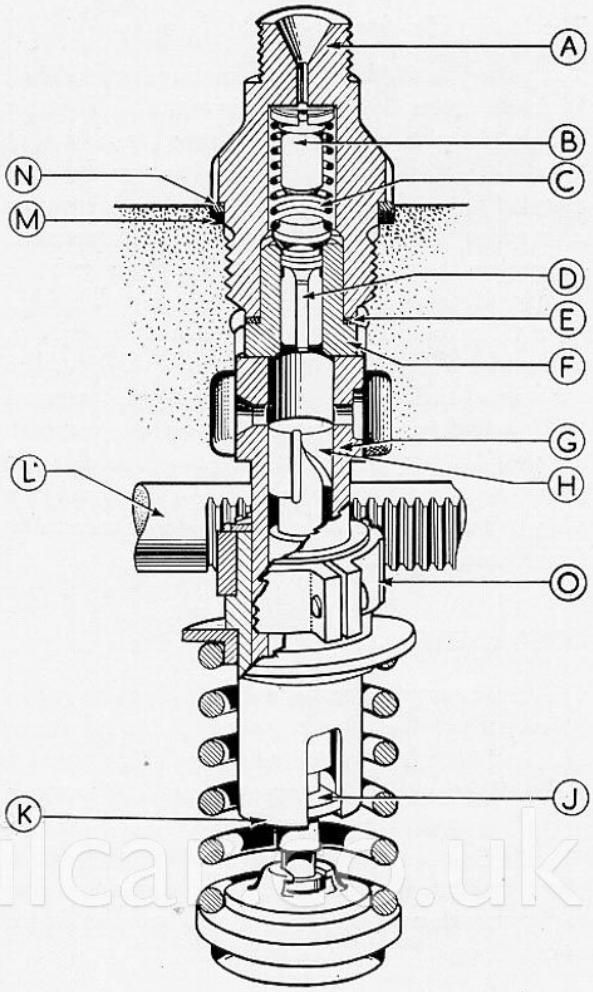


FIG. 4. SECTIONED VIEW OF PUMPING ELEMENT AND DELIVERY VALVE

A. Delivery valve holder.
B. Peg.
C. Spring.
D. Delivery valve.
E. High pressure seal.
F. Delivery valve seating.
G. Plunger barrel.
H. Plunger.
O. Quadrant.
J. Plunger foot.
K. Control sleeve.
L. Control rod.
M. Low pressure seal.
N. Steel washer.

OVERHAUL AND REPAIR

To facilitate dismantling and reassembly of fuel injection pumps it is essential that the correct tools are used. A complete list is given in the C.A.V. Publication No. 1067—Service Tools for Fuel Injection Equipment.

Overhaul of fuel injection pumps can only be undertaken by skilled personnel equipped with the special tools and test apparatus referred to in this chapter. If these conditions cannot be met the pump should be sent to the nearest C.A.V. agent who will have workshops fully equipped for this highly specialised work.

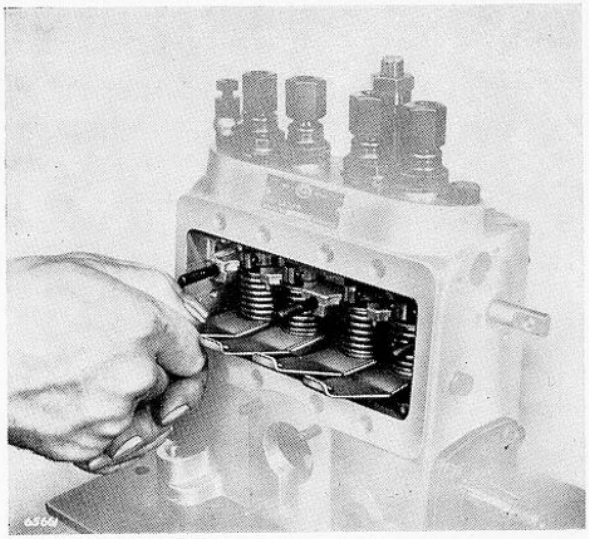


FIG. 5. INSERTING TAPPET HOLDERS—TYPICAL ILLUSTRATION

Scrupulous cleanliness must be maintained at all times in workshops where pump overhaul is carried out, since the presence in a pump of even minute particles of dirt or grit can result in damage and wear and will considerably shorten the pump working life.

The surface of the work bench must be thoroughly clean and covered with grease-proof paper. If the bench is specially reserved for fuel injection work, it should be covered with zinc sheeting or similar easily cleaned material.

Receptacles must be provided for the storage of dismantled components so that the parts can be arranged systematically and protected from damage or corrosion.

Great care must be taken not to mix the dismantled components. All components must be reassembled to their original position in the pump plunger—plungers and barrels, delivery valves and seats are mated components and are not interchangeable. Damage to either part of these components will necessitate replacement of the complete assembly.

Plungers and barrels, delivery valves and delivery valve seatings are **not** supplied as separate items, i.e. a delivery valve is **not** supplied without a seat, and no attempt must be made to lap or grind these parts, since such treatment will only result in damage.

The pump is correctly phased and calibrated before leaving the works and the original setting is indicated by the scribed lines on the quadrants and sleeves. The quadrants should be left locked to the sleeves during removal but if for any reason a quadrant screw is loosened, the setting lines on quadrant and sleeve must be aligned before the screw is tightened.

Before removing the pump half coupling note the camshaft position relative to the pump. A small notch will be found at either the L.H. or R.H. end of the threaded portion of the camshaft and the camshaft must be reassembled with this notch in the same position otherwise the firing order will be altered.

Dismantling Sequence

(Annotations refer to Fig. 1.)

1. Remove the base plate (11) and gasket and drain the fuel oil from the lower portion of the pump housing.

2. Remove the filter cover (31) and sealing gasket from the rear of the pump housing and drain the fuel oil from the filter chamber. Discard the felt filter pads, and lift out the filter support plate and gasket.

3. Remove the cover plate (16) from the front of the housing.

4. Remove the feed pump, or blanking plate (14) and the excess fuel device if fitted.

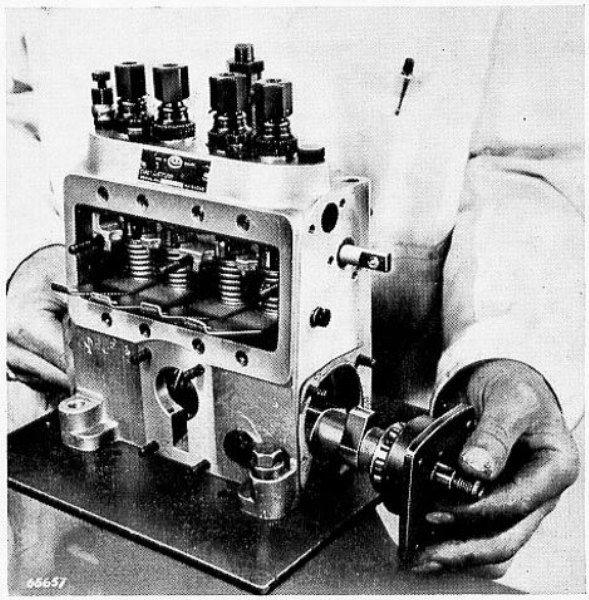


FIG. 6. REMOVING CAMSHAFT—TYPICAL ILLUSTRATION

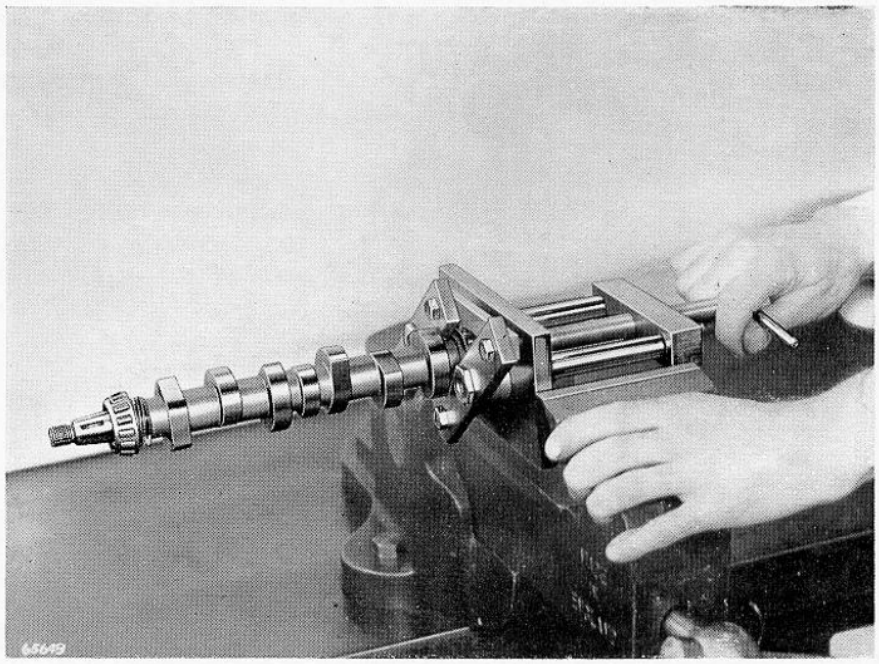


FIG. 7. WITHDRAWING ROLLER RACE FROM CAMSHAFT USING TOOL 7144/436A

5. Mount the pump on the base plate (C.A.V. Part No. 7044/650) and secure in a bench vice with the pump vertical.

6. Turn the camshaft (12) and as each tappet is lifted insert a tappet holder (C.A.V. Part No. 7144/480) between the lower spring plate and the upper surface of the tappet block (Fig. 5).

7. Remove the nuts which secure both camshaft bearing end plates. Tap one end of the camshaft lightly with a hide-faced hammer and dislodge one bearing end plate (28).

8. Withdraw the dislodged end plate from the securing studs, and tap the free end of the camshaft to dislodge the remaining end plate.

9. Withdraw the camshaft complete with races (27) and end plate from the pump housing (Fig. 6).

10. Remove the races and inner tracks of the bearings from the camshaft, using tool C.A.V. Part No. 7144/436A, as illustrated in Fig. 7.

11. Remove the tappet assembly locating screws (9).

12. Turn the pump to the horizontal position.

13. Holding the tappet assembly with the forceps, C.A.V. Part No. 7044/859, exert upward pressure and remove the tappet holder.

14. Withdraw the tappet assembly (25), together with the phasing washer (29), lower spring plate (24) and plunger (7) through the aperture in the base of the pump housing.

15. Separate the plunger from the lower spring plate and remove the spring plate, retaining spring, and phasing washer from the tappet block. Immerse the plunger in a bath of clean fuel oil to protect the lapped surface from damage.

16. Withdraw the plunger spring, and after disengaging the control quadrant (20) from the control rod (21), slide the control sleeve (23) from the plunger barrel.

17. Repeat items 14-17 for each element, keeping the components of each element assembly together, so that they can be reassembled in the same position from which they were taken.

18. Turn the pump to the vertical position.

19. Remove the locking plates securing the delivery valve holders and using the serrated box spanner

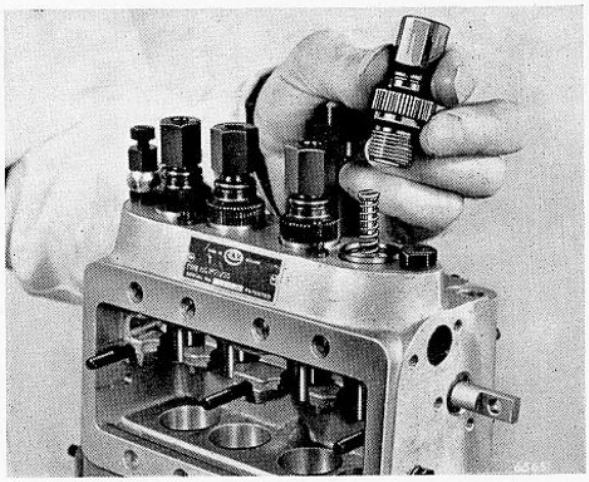


FIG. 8. REMOVING THE DELIVERY VALVE HOLDERS —TYPICAL ILLUSTRATION

C.A.V. Part No. 6044/661 unscrew and carefully remove the delivery valve holders from the pump housing. The delivery valve spring and spring peg are released as the valve holder is removed and will be dislodged if the holder is not removed with care (Fig. 8).

20. Remove each delivery valve spring (3) and peg (2), also the steel washers and low pressure seals.

21. Remove the delivery valve (4) and seating (5) complete with the high pressure seal.

22. Remove the barrel locking screws (6) and pushing the barrels upwards, withdraw them from the pump housing (Figs. 9 and 10).

23. Reassemble each plunger to its mated barrel and immerse in clean test oil to prevent any possibility of damage to the lapped surfaces.

24. Remove the control rod locating plate, and slide the control rod from the pump housing (Fig. 11).

INSPECTION AND REPAIR

When a pump is completely dismantled all components must be thoroughly cleaned in clean test oil. Abrasive or fluffy cleaning materials must not be used.

The pump components should be inspected for signs of scoring, pitting, corrosion, or excessive wear, and any defective part discarded.

All oil seals, jointing gaskets and sealing washers, must be renewed at each overhaul.

The faces in the pump housing against which the plunger barrels seat, must be inspected for pitting or other signs of damage, and if found to be unsatisfactory the surface should be lightly skimmed with the special cutter C.A.V. Part No. 7044/718. A minimum of material should be removed during this operation.

The cutter also skims an equal amount of material from the low pressure delivery valve holder seating face so that the vertical dimension between the two seating faces is maintained.

Control rod bushes must be checked for wear and ovality, by fitting a new control rod. Comparing the fit of the new rod against the fit of the one removed will give a good indication of the state of the bushes.

If necessary, worn bushes can be extracted after removing the locking rings with tool C.A.V. Part No. 7044/658 and by using the special extractor tool C.A.V. Part No. 7144/312. New bushes can now be pressed in and reamed out in position as detailed below.

A special long-shanked reamer C.A.V. Part No. 7044/563 is used in conjunction with two reamer guides C.A.V. Part No. 7044/562 and 7044/562A. These guides differ only in external diameter, 7044/562A being a snug fit in the new bush before reaming and 7044/562 a snug fit after reaming.

Guide 7044/562A is fitted to one control rod bush and the shank of the reamer is then passed through the remaining bush and into the core of the guide. After

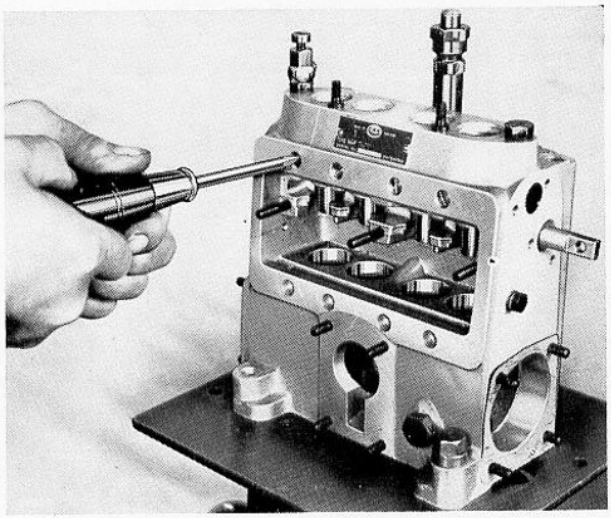


FIG. 9. UNSCREWING THE BARREL LOCKING SCREWS —TYPICAL ILLUSTRATION

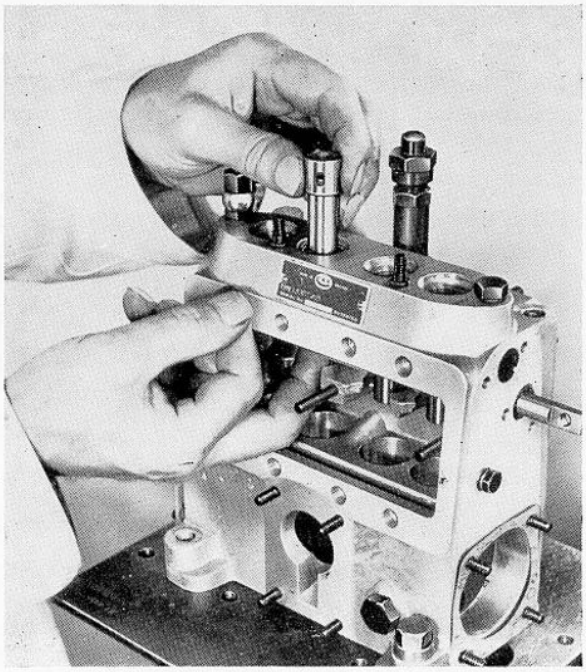


FIG. 10. LIFTING OUT THE ELEMENT BARRELS—TYPICAL ILLUSTRATION

securing a wrench to the reamer shank, the reamer is then drawn through the bush. This operation is repeated on the remaining bush, using the larger reamer guide 7044/562 fitted in the newly reamed out bush (Fig. 12). Take care to remove all swarf from the pump housing (especially in the corners) when reaming of the bushes has been completed.

Great care must be exercised when reaming control bushes as complete freedom of the control rod is dependent on the perfect alignment of the bushes. The final fit must permit the control rod to slide easily in the bushes without being 'loose'.

ASSEMBLY SEQUENCE

1. Mount the pump on the base plate, C.A.V. Part No. 7044/650, and secure in a bench vice with the pump in the horizontal position and the filter chamber upwards.
2. Fit the filter support plate gasket and then the filter support plate in position in the filter chamber.
3. Fit a new sealing gasket on the filter cover jointing face.
4. Fit new filter pads on the support tubes, push the cover on to the securing studs and secure with nuts and spring washers.
   Tighten down all nuts evenly and securely.
5. Turn the pump to the vertical position.
6. Slide the control rod into the control rod bushes, and fit the locating plate. There must be 0.002 in. (0.07 mm.) clearance between the locating plate and the flat on the control rod on pumps fitted with a hydraulic governor, or 0.005 in. (0.13 mm.) if a pneumatic or mechanical governor is fitted. Clearance must be checked over the full travel of the control rod.
7. Fit each plunger barrel in the pump housing, ensuring that the vertical groove is in alignment with the barrel locating screw hole.
8. Fit the barrel locating screws, ensuring that they engage the grooves in the plunger barrels before tightening. When tightened it should still be possible to move the barrel vertically until the locating screw contacts the end of the groove.
9. Fit each delivery valve to its mated seating and place a new delivery valve washer against the flange on the seat.
   Place each assembly in position against the upper face of the plunger barrel.

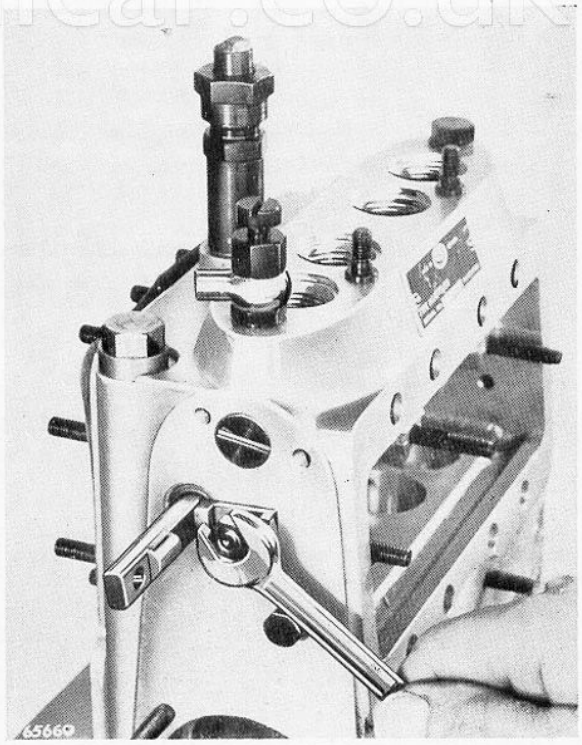


FIG. 11. REMOVING THE CONTROL ROD LOCATING PLATE—TYPICAL ILLUSTRATION

10. Dealing with each delivery valve in turn, fit the spring and spring peg.

11. Fit the delivery valve holder washers and seals and screw down each delivery valve holder by hand.

12. Using a torque spanner, tighten all delivery valve holders to a torque of 40 lb. ft. (5.5 kg.m.). Turn the pump to the horizontal position, front uppermost.

13. Using forceps C.A.V. Part No. 7044/J69B insert each plunger into its barrel and gently rotate several times. Dip each plunger in clean fuel before inserting into the barrel.

Each plunger must rotate freely without any 'binding'.

Place a piece of plastic or other suitable material over the tappet bores to prevent the plungers falling out.

At this stage the pressure test for element barrel seat leakage can be carried out.

Testing Barrel Seat Leakage and Pump Housing Porosity

To check the pump for barrel seat leakage and housing porosity an air line is connected to the pump at this stage of the assembly.

(a) Connect the fuel inlet connection to the air line.

(b) Blank off any openings in the common fuel gallery which would allow air to escape to atmosphere.

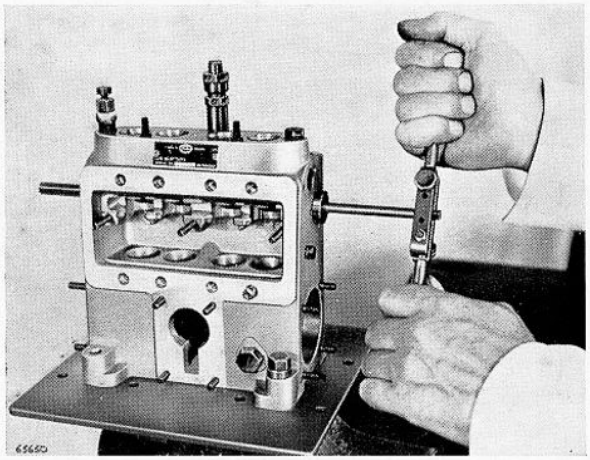


FIG. 12. REAMING THE CONTROL ROD BUSHES—TYPICAL ILLUSTRATION

(c) Turn on the air and make sure the pressure does not exceed 45 p.s.i. (3.1 kg. s.cm.).

(d) Immerse the pump in a clean bath of testing oil and examine the pump for leakage.

Air bubbles forming will indicate where the leakage is occurring and any leaks should be stopped before proceeding further. A slight leak past the plunger can be ignored.

Should an air supply not be available the C.A.V. nozzle testing outfit can be used as an alternative method of testing.

(a) Wipe off oil from the housing.

(b) Change the testing outfit standard gauge for a 0-200 p.s.i. (14.6 kg. s.cm.) gauge.

(c) Connect up the housing to the nozzle testing outfit by means of a suitable adaptor fitted to the housing fuel gallery. The other end of the gallery should be blanked off.

(d) Pump up the outfit until a pressure of 30 p.s.i. (2.1 kg. s.cm.) is indicated on the gauge.

(e) Examine the housing for signs of leakage and repair as necessary.

Note: The barrel seats can be recut with the aid of C.A.V. tool 7044/718. Do not over-cut. Take only a light skimming sufficient to cure the leak.

On completion of this test remove the piece of plastic and withdraw all plungers.

14. Mount pump horizontally in the vice with the front of the pump uppermost.

15. Centralise the control rod by aligning the centre punch mark at both ends of the rod with the ends of the pump housing.

16. If the control quadrants have been removed from the control sleeves they should be reassembled, taking care that the scribed line on the sleeve is aligned with that on the quadrant before the clamping screw is tightened.

Note: New quadrants will not have scribe marks and the clamping screws should be positioned accordingly to suit R.H. or L.H. governor fitting and governor type.

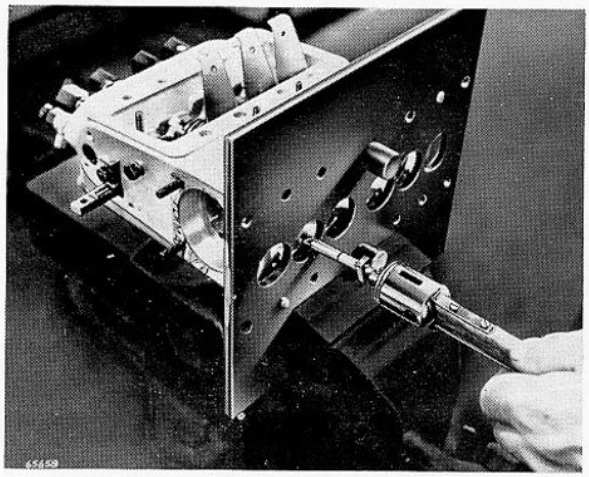


FIG. 13. INSERTING PLUNGER AND TAPPET BLOCK USING FORCEPS 7044/859—TYPICAL ILLUSTRATION

17. Slide the control sleeves on the plunger barrels, engaging the teeth on the control rod so that the quadrant is in the mid-travel position. Check that the control rod has complete freedom of movement after fitting each control sleeve.

18. Slide the upper spring plates on the control sleeves and seat them against the shoulders in the pump housing and place each plunger spring in position against each upper spring plate.

19. Fit the phasing washer to the upper end of each tappet assembly and place the lower spring plate complete with retaining spring in position above the phasing washer, engaging the retaining spring with the hole drilled in the wall of the tappet assembly.

20. Dip the plunger in clean test oil and engage it with the lower spring plate.

21. Using forceps C.A.V. Part No. 7044/859 hold the tappet assembly in the horizontal position, with the spring locating hole and the lug on the plunger marked with the Part No. uppermost. (See Fig. 13.)

Note: If correctly fitted, the plunger helix should be at the front.

Slide the plunger into the barrel and engage the lug on the plunger with the slot in the control sleeve. Force the tappet assembly upwards against the plunger spring until it is possible to insert a tappet holder between the lower spring plate and the pump housing, and then withdraw the forceps.

22. Fit the tappet assembly locating screw.

Note: Operations 16-22 are repeated for each element, care being taken that the plungers are assembled to their mated barrels.

23. Fit the races to the camshaft, making certain that end float adjustment shims of equal thickness are placed at each end of the camshaft.

Note: On 'NN' type pumps shims are fitted externally, that is, between the race and end plate.

24. Fit the bearing end plate to one end of the pump housing and secure with the spring washers and nuts.

25. Fit the protection cap C.A.V. Part No. 7044/884 to the appropriate end of the camshaft to protect the oil seal when the camshaft is pushed through the end plate.

Make certain that the end of the camshaft marked with the small notch on the threaded portion is at the specified end of the pump housing.

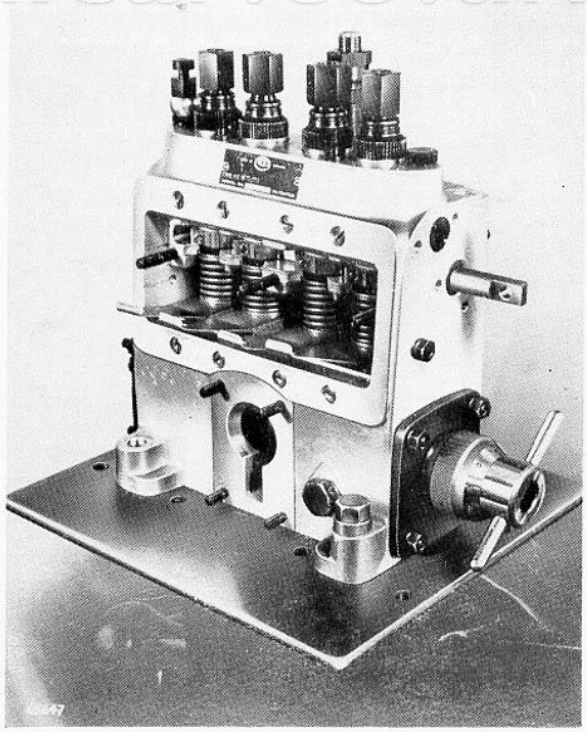


FIG. 14. CHECKING CAMSHAFT END FLOAT USING GAUGE 7044/634—TYPICAL ILLUSTRATION

26. Pass the camshaft through the pump housing and guide it through the oil seal in the end plate.

27. Remove the protection cap and fit to the other end of the camshaft.

28. Fit the remaining end plate over the camshaft and secure with spring washers and nuts.

Remove the protective cap from camshaft.

29. Check the camshaft end float using gauge C.A.V. Part No. 7044/634 (Fig. 14). End float must be 0.05 to 0.1 mm. with either ball or tapered roller bearings and 0.1 to 0.2 mm. when parallel roller bearings are fitted. The amount of end float is controlled by the thickness of the shims. Turn camshaft by hand several times to ensure that it is free.

Note 1: If shimming is required it must be carried out equally to each end of the shaft.

Note 2: Take care to settle the shaft after each adjustment to an 'NN' pump otherwise false readings will occur because the outer bearing is a tight fit in the housing.

30. Withdraw the tappet holders.

31. Turn the camshaft by hand, at the same time move the control rod over its full travel distance. There must be no sign of tightness or binding with the control rod or camshaft in any position.

32. Remove the pump from the assembly plate and fit the base plate complete with new gasket.

33. Fit feed pump or blanking plate, also the excess fuel device as required.

34. Fit front cover plate using new gasket if necessary. If a new gasket is fitted, a good adhesive of the fish glue type should be used to position the gasket to the cover prior to assembly.

PUMP TESTING

The injection pump must accurately measure minute quantities of fuel under all conditions of engine load and speed, and it must deliver this minute quantity of fuel into each cylinder at the exact point at which the engine requires it.

To ensure that these functions are carried out efficiently, each C.A.V. fuel injection pump is accurately tested and adjusted before it leaves the works. The final setting is indicated by the scribed line across each quadrant and control sleeve as shown in Fig. 16.

Resetting should only be necessary to compensate for wear after several hundred hours running, or if quadrants and sleeves have been replaced.

After a pump has been overhauled, it should be tested, and readjusted before it is refitted to the engine making reference to the appropriate Test Plan which can be obtained from C.A.V. Depots or Agents.

Special equipment is required if the tests are to be carried out correctly and it is recommended that such testing is carried out by an authorised C.A.V. agent.

Pump testing is divided into two parts: 'Phasing' and 'Calibration'.

It is essential that the pumping elements commence to inject at the correct interval in camshaft degrees. The interval on in-line pumps is 360° camshaft angle divided by the number of elements in the pump. The only exceptions to this rule are certain twin-cylinder engines or two pumps coupled together in line, when the firing order and the total elements of the tandem unit will have to be considered. This adjustment for correct timing interval is known as phasing or adjusting the phase angle of the pump and is carried out as described in the paragraph **Phasing.**

It is also necessary to determine the point at which the adjustment has to be made. This is generally referred to as the 'port closed position' which occurs when the rising plunger closes the ports through which the fuel has entered the element barrel.

The commencement of injection into the engine cylinder occurs after the port closes, the interval depending mainly upon the plunger diameter, cam profile, pipe length and the setting of the injector spring. Finally, adjustment is made for the balance of fuel output. This is known as calibrating the pump.

When the pump is working, the output of an element depends upon the position of the helical edge of the plunger in relation to the spill port of the barrel and this position can be varied by turning the plunger in the barrel.

During running the governor moves the control rod, thereby turning the quadrants, control sleeves and plungers together. For calibration adjustments, however, it is necessary to calibrate each element separately.

PHASING THE INJECTION PUMP

Adjustment of the phase angle of 'NN' type pumps is effected by increasing or decreasing the head clearance of the plunger in its barrel by means of the shims fitted between the lower spring plate and the tappet assembly. Care must be taken during phase adjustment to prevent the plunger striking the underside of the delivery valve seating as the plunger reaches the top of its stroke, otherwise considerable damage will result to the pump.

The adjustment is correctly set when the plunger at top dead centre has a head clearance of 0.5 mm. To achieve correct clearance a range of shims from 0.3 mm. to 1.4 mm. in thickness, in steps of 0.1 mm., are available to increase or decrease the clearance.

Special hook C.A.V. tool Part No. 7044/654 is used for removing the shims and gauge Part No. 7044/714 for checking the shim dimensions.

To Remove or Replace Shims

To alter the plunger head clearance proceed as follows:

Raise the cam to top dead centre and insert tappet holder between the lower spring plate and tappet assembly.

Turn the cam back to bottom dead centre and insert a pin drift in the hole in the tappet assembly wall. Push back the retaining spring and press the tappet assembly downwards to separate it from the lower spring plate. The shims can now be altered as required.

With the correct shims fitted, push back the retaining spring in the lower spring plate. Raise the cam to top dead centre.

The lower spring plate should now sit inside the tappet assembly. Remove the tappet holder and make certain that the retaining spring is now located in the hole drilled in the tappet assembly wall.

Phasing the Injection Pump

1. Turn the pump camshaft until the camshaft taper line is in line with the vertical line on the pump end plate. No. 1 plunger will now be at top dead centre.

2. Remove the front cover of the pump.

3. Using C.A.V. gauge 7144/166 check the plunger head clearance of No. 1 element and if necessary adjust this by varying the thickness of the shims (Fig. 15).

The point of injection must now be found and the complete phasing operation carried out in the following manner:

1. Remove the delivery valve holder and lift out the spring, spring peg, and delivery valve. (Not the seating.)

2. Replace the delivery valve holder. A short length of piping, bent into the form of a swan neck, should now be connected to the delivery valve holder.

   The extremity of this pipe should be chamfered to enable better observation of the fuel cut-off point.

3. Secure the pump to a suitable test bench and fit a graduated degree disc to the pump camshaft. Mount a pointer in a convenient fixed position in relation to this disc.

4. Ensure No. 1 cam is at top dead centre, then confirm plunger head clearance by inserting a screwdriver in the slot in the tappet assembly and gently raise the assembly until the crown of the plunger touches the underside of the delivery valve seating.

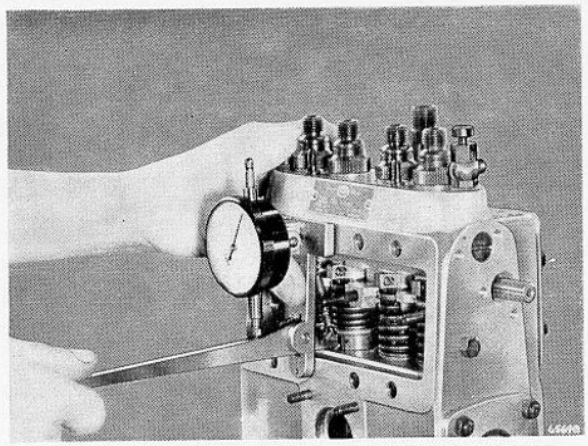


FIG. 15. CHECKING HEAD CLEARANCE USING GAUGE 7144/166—TYPICAL ILLUSTRATION

5. Connect the pump inlet to the fuel supply of the test bench and air vent the pump by loosening one of the air vent plugs situated on the fuel chamber.

Turn on the fuel and allow it to flow past this plug until there are no more air bubbles.

Tighten air vent plug and turn off fuel.

6. Place control rod in mid-position.

7. Rotate camshaft until No. 1 plunger is at bottom dead centre and turn on the fuel. Fuel will now flow from the fuel chamber into No. 1 element and out through the swan neck pipe. No fuel can pass through the remaining elements as their delivery valves are in position.

8. Turn the camshaft in the direction of rotation until No. 1 plunger starts to lift.

As the plunger closes the barrel ports, the flow of fuel from the swan neck pipe will gradually diminish. Continue to rotate the camshaft gently, until the flow of fuel ceases completely. This is the port closed position. This is also the injection point for No. 1 cylinder.

Take care that the plunger is rising at this point and not descending, otherwise a false reading will be obtained.

9. Align the zero on the graduated disc with the pointer, taking care not to disturb the camshaft. Check that the camshaft has not turned by repeating the operation detailed in paragraph 8.

10. Remove the swan neck pipe, wash No. 1 valve, spring and spring peg in clean fuel and replace.

Tighten delivery valve holder to 40 lb. ft. (5.5 kg.m.) torque with torque spanner.

The camshaft is now set at the point on No. 1 element to which all adjustments are co-related and the remaining elements must now be set to inject at their correct intervals.

On a six cylinder type pump with an injection sequence of 1, 5, 3, 6, 2, 4 proceed as follows:

11. Remove valve holder, spring peg, spring and valve (not the seating) from No. 5 element. Replace the valve holder and fit the swan neck pipe, turn on the fuel which will now flow from the pipe end.

12. Turn camshaft through 60° and check point of port closure on this element. This should be within a few minutes of 60°, but if in excess of 0.5° (1° on two stroke units) adjustments must be made by altering the shim as previously described. Check port closed position. If the point of port closure is early, reduce the thickness of the shims; if late, the thickness must be increased.

When standard cams are fitted, a 0.1 mm. change in shim thickness will alter the 'point of cut-off' by a little less than 0.5°.

13. Remove swan neck pipe and holder.

Replace delivery valve, spring and spring peg, also the holder. Tighten this down to 40 lb. ft. torque (5.5 kg.m.).

14. Check the head clearance (0.5 mm.±0.15 mm.).

Note: On No. 1 element, the head clearance is first determined and then the point of port closure found, but on the other elements, the correct phasing point is set and the head clearance checked afterwards.

Should the head clearance of any element not be within the required limits after phasing, it will be necessary to increase, or decrease, the clearance on No. 1 element within the tolerance of ±0.15 mm. and then completely rephase the pump.

15. Phase and check the head clearance on the other elements as detailed for No. 5 element in paragraph 11.

16. Finally, recheck the setting of No. 1 element in relation to the disc marking. Any discrepancy here will indicate that the pointer or disc has moved during the phasing operations, and the phasing will have to be completely rechecked again.

CALIBRATION OF THE PUMP

Pump calibration is carried out by slackening the screw which clamps the quadrant to the sleeve, and moving

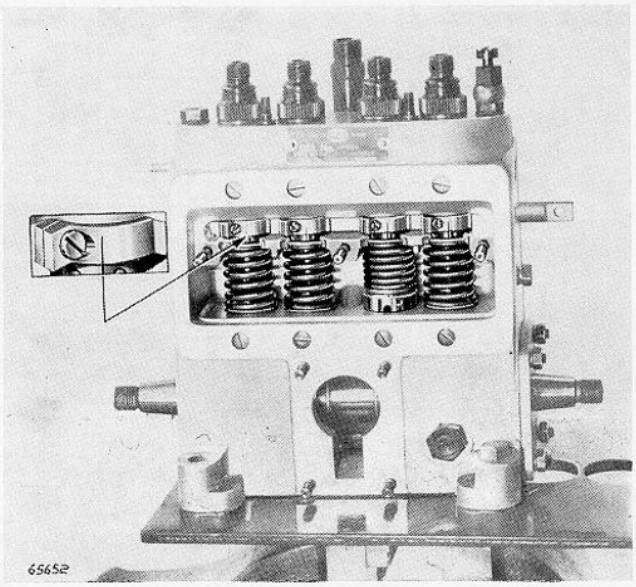


FIG. 16. SETTING LINES ON QUADRANT AND SLEEVES —TYPICAL ILLUSTRATION

the sleeve with the plunger into the required position. This adjustment is accurately carried out at the factory before the pump is despatched and the final setting is indicated by the line scribed across each quadrant and sleeve as shown in Fig. 16. After several hundred hours running, wear on the elements may necessitate some slight alteration to this setting but the setting should not deviate very much from the original.

The actual quantities of fuel delivered by each element and the points at which these are balanced and checked will depend upon the pump specification for the particular installation. As accurate measurement and adjustment of the output of each pump element can only be effected by highly skilled and trained personnel using a suitable power driven calibrating machine, it is strongly recommended that this work be undertaken by the nearest C.A.V. agent.

The test machine must be capable of driving the pump at the speeds given in the test specification and should be able to maintain any selected speed within very close limits. It must also supply filtered fuel or test oil to the injection pump either by gravity or pressure feed, and a filter must be incorporated which will provide the necessary standard of fuel filtration to give complete protection to the pump.

C.A.V. test nozzle type BDN12SD12, set at 175 atmospheres, should be mounted above the measuring glasses which are graduated in cubic millilitres. These test nozzles are connected to the high pressure connections on the pump by pipes 6 mm. outside diameter by 2 mm. internal diameter and 500 mm. long.

When calibrating, the output from each pumping element is measured during 100 pumping strokes. To enable this to be done with accuracy, the test machine is fitted with an automatic trip mechanism which diverts the fuel away from the measuring glasses on completion of 100 strokes.

Before setting the control rod to any given position, it must be first be placed in the fully closed position and then moved the required amount. Before calibrating, the pump, injectors and injector pipes must be thoroughly vented, an operation normally carried out with the pump turning at 200 r.p.m.

After venting, set the control rod and clamp the rod in position.

The pump is now driven at the prescribed r.p.m. and the individual element outputs checked over 100 strokes. Minor adjustments to individual elements must be followed by a complete check at the same control rod opening r.p.m. and over 100 strokes.

Calibration is now carried out and adjustments are made as necessary. Individual element output is adjusted by slackening the quadrant screw and moving the control sleeve, so that it alters the position of the plunger control helix in relation to the fuel port.

The quadrant clamping screw must be retightened after adjustment has been made, and a line scribed on the control sleeve and quadrant to indicate the relative position of these two parts. Before scribing, existing marks must be erased.

Maximum fuel output must now be set in accordance with the calibration figures given on the fuel injection pump instruction plate.

Finally, fit the front inspection cover plate securely.

REMOVAL AND REPLACEMENT OF FUEL PUMP

To Remove the Injection Pump

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 stop control.

2. Uncouple the pipe from the filter to the pump and the suction and delivery pipes to the diaphragm fuel feed pump.

3. Disconnect the delivery pipes to the injectors.

4. Remove the setscrews connecting the coupling to the pump flywheel.

5. Remove the four bolts fixing pump to bracket and remove the pump.

To Replace Injection Pump

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.

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 (30° B.T.D.C. on vertical engines, 36° B.T.D.C. on horizontal engines) 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.

GOVERNOR

TYPE RWB

DESCRIPTION

This governor is designed to regulate automatically the maximum and minimum speed of the engine to predetermined limits, while permitting the engine speed to be controlled by the accelerator pedal between these extremes of speed.

The governor is of conventional, centrifugally-actuated, fly-weight design, the motion of the weights being transmitted to the fuel injection pump control rod through suitable linkage. See Fig. 1.

The two spring-loaded fly-weights (15) are carried on a sleeve fitted to the injection pump camshaft (14) and move outwards under centrifugal force as the camshaft rotates. Bell crank levers (17) transmit the centrifugal action of the weights to the link pin and crosshead assembly (19), as a longitudinal movement. The crosshead turns the floating lever (22) about the eccentric (21), and the movement of the upper end of the lever is conveyed to the injection pump control rod (11) by the link screw (4) through the link block (8). The position of the control rod is thus adjusted to increase or decrease the quantity of fuel delivered by the injection pump elements.

The accelerator pedal is connected to the control lever (23), which is clamped to the shaft (20). When the shaft is turned by movement of the accelerator pedal, the eccentric—an integral part of the shaft—moves the floating lever and the control rod independently of the weight mechanism.

Idling Speed Control

Operation of the governor is shown diagrammatically in Fig. 2. While the mechanism is at rest, the flyweights (15) lie close to the camshaft sleeve and the injection pump control rod (11) is held towards the maximum fuel position.

Before the starter motor is engaged with the engine flywheel ring, the accelerator pedal should be fully depressed. After the engine fires and runs up to speed, the accelerator pedal should be steadily released and

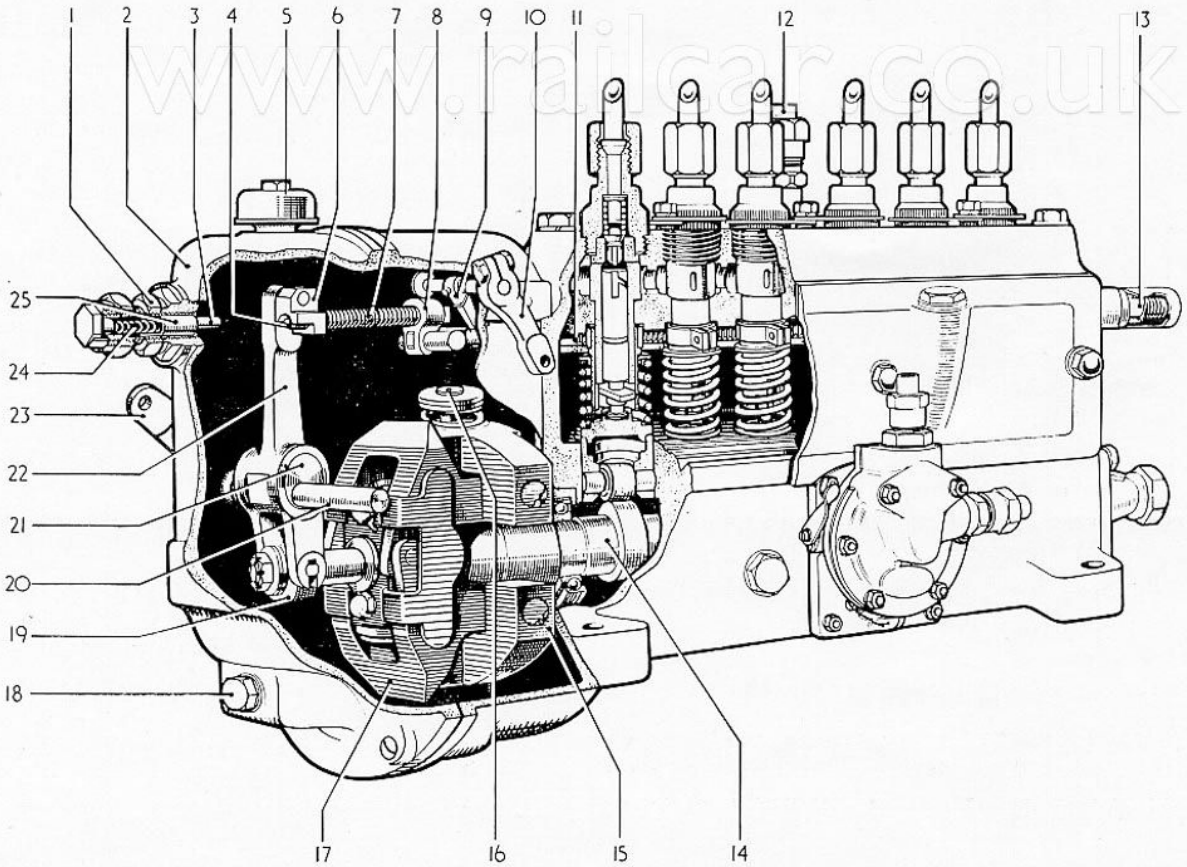


FIG. 1. CUT-AWAY VIEW OF GOVERNOR

the governor will then come into operation to control the engine at the predetermined idling speed (Fig. 2A).

Movement of the fly-weights is governed by two sets of springs (see Fig. 3). At idling speed (illustration A), the weights move outwards a comparatively short distance and compress only the outer springs (29). Should the engine speed tend to increase, the greater centrifugal force exerted on the fly-weights will move them further outwards. This action of the weights will pull the crosshead assembly inwards, towards the camshaft sleeve, and the control rod will be moved to reduce the injection pump fuel delivery until the engine idling speed is brought back to its original setting.

Similarly, if the idling speed falls below that required, the centrifugal force on the weights will be diminished and spring pressure will force the weights inwards. The control rod will now be moved to increase the quantities of fuel delivered by the injection pump and restore the engine idling speed to normal.

Movement of the fly-weights is extremely small and the idling speed is therefore maintained at a reasonably constant level.

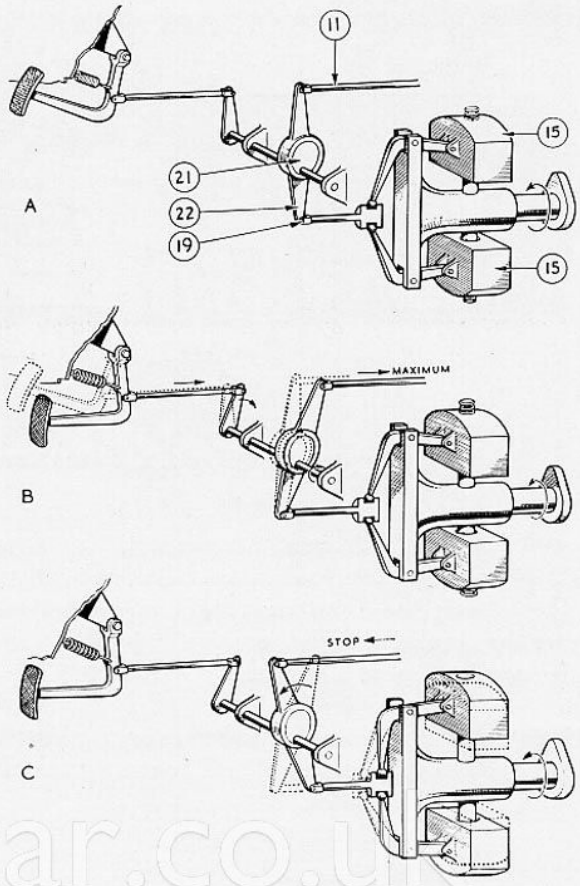


FIG. 2. OPERATION OF GOVERNOR

Intermediate Speed Control

Engine speeds between the predetermined idling and maximum limits are controlled by movement of the accelerator pedal (see Fig. 2B). This ungoverned condition is achieved by providing the floating lever (22) with two pivot points. Under governor control, the floating lever is moved around the eccentric (21), while movement of the accelerator pedal turns the shaft and the eccentric as a whole, thus pivoting the floating lever about the crosshead arms (19).

When the accelerator pedal is depressed to increase engine speed, the shaft and the eccentric will turn the floating lever and move the control rod towards the maximum fuel position, irrespective of the position of the governor weights.

Maximum Speed Control

Throughout the intermediate speed range of the engine, the governor fly-weights compress the outer idling springs (29), (Fig. 3) but are prevented from further outward movement by the heavier inner springs (27 and 28). The weights therefore remain in the position shown (B), (Fig. 3), until maximum speed is reached. Should the accelerator pedal be depressed so that the injection pump delivers more fuel than the engine requires for the load, the engine speed will tend to exceed the predetermined limit and the centrifugal force imposed on the weights will increase sufficiently to overcome the inner spring loading. The weights will now move further outwards (C), (Figs. 2 and 3), and turn the floating lever around the eccentric. The control rod is thereby drawn back to a position of reduced fuel delivery, despite the over-depressed position of the accelerator pedal.

Manual Stopping Control

The governor is provided with a manually operated stopping control of the type illustrated in Fig. 1. The parts shown comprise, a control lever (10) and spring-loaded pawl (9) attached firmly to a cross shaft. One end of the link screw (4) is threaded into the floating lever link (6), while its other end is free to slide in the control rod link block (8).

When the control lever (10) is moved to the "stop" position link block (8), under pressure exerted by the

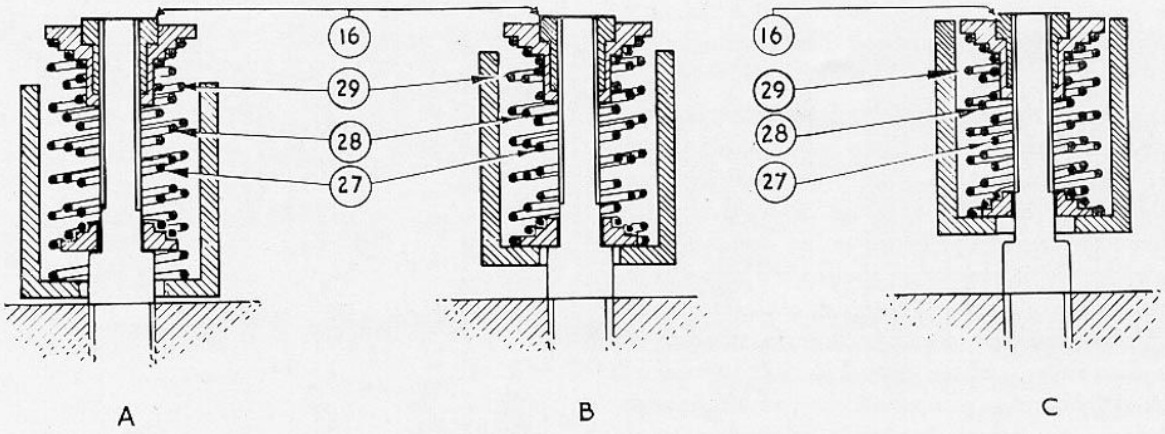


FIG. 3. OPERATION OF GOVERNOR SPRING

pawl, slides along link screw (4) to compress the springs (7) and move the control rod to the fuel cut-off position. The fuel supply to the engine is thus terminated, whatever the disposition of the governor fly-weights when the stopping control is operated.

After the engine has stopped and the stopping control lever is released, the springs (7) will return the control rod to its normal position.

ADJUSTMENTS

The length of the spring link is correctly adjusted when the governor is assembled to the injection pump and this setting should never be altered.

A rigid accelerator pedal stop must be provided, and this should be adjusted to prevent overloading of the control lever maximum fuel stops (6 and 7), (Fig. 4), when the pedal is depressed.

Adjustable stops are provided on the covers of C.A.V. idling and maximum speed governors and on the injection pump housing. These stops enable the idling and maximum fuel output of the injection pump to be regulated, by directly or indirectly limiting the travel of the control rod.

The correct adjustment of these stops is very important and the procedure recommended in the following pages should be closely followed. Incorrect adjustment of stops may result in damage to the governor mechanism.

Idling Speed Stops

The idling speed position of the governor control lever is set by the stop (8), Fig. 4. This stop is screwed into a flange (5) attached to the governor cover. A pawl (4) is clamped to the control lever shaft and the stop is adjusted to limit the movement of the pawl in one direction.

To adjust the idling stop, slacken the locknut (3) and position the control lever to give the required engine idling speed. Auxiliary idling stop (9) must be fully retracted before adjustment is made. Adjust the stop (8) so that it locates the pawl (4) at the desired engine idling speed position, then tighten locknut (3). Recheck idling speed and then operate the stopping control lever (1) to ensure that the fuel supply can be terminated.

Auxiliary Idling Stop

An adjustable, spring-loaded, damper valve, shown in Fig. 1, is fitted in the housing cover of the governor to assist in stabilizing the engine speed at the idling position of the injection pump control rod. This stop can only be satisfactorily set with the engine running.

When adjusting this stop, the engine must be hot and the governor control lever should be held in its idling position. The locknut (1) should then be slackened and the adjusting screw (25), which houses the plunger (3) and spring (24), should be screwed further into the cover until a pronounced increase in engine idling speed occurs. The sleeve should now be retracted until normal idling speed is restored. Before tightening the locknut, retract the sleeve a further half turn of the thread. Check the setting of this stop by accelerating the engine and then allowing the speed to return to idling. If the speed fall-off is sluggish, the auxiliary idling stop sleeve must be retracted further until the fall-off in speed is normal

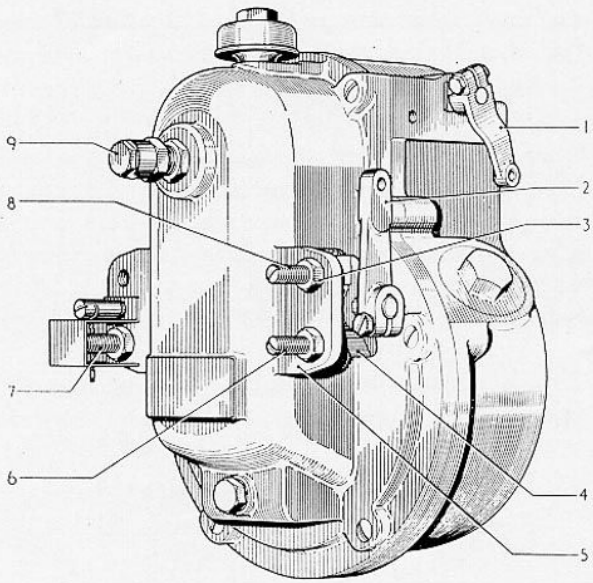


FIG. 4. GOVERNOR STOPS

Maximum Fuel Stops

The governor is provided with a control lever stop (7), Fig. 4, which contacts a pawl (not shown) when the control lever is in the maximum fuel position. This stop is sealed following the engine manufacturer's test bed trials. In addition to the sealed stop, a maximum fuel stop (6) is screwed into the flange (5) and limits the movement of pawl (4) in the opposite direction to that for idling. The second stop enables the operator to reduce maximum fuel delivery, and thus maximum power, below the setting of the sealed stop when this is desirable. A further stop (see Figs. 1 and 5) is provided at the opposite end of the pump to the governor to limit control rod movement.

When adjusting the sealed stop during engine tests, the following procedure should be carried out:

Slacken control rod stop (Fig. 5). Set control lever (2) Fig. 4 in its maximum fuel position, with engine developing the desired power and speed and with a clean exhaust. Adjust the stop (7), until it just contacts the control lever pawl, then tighten the locknut.

Recheck setting of stops, replace cover and seal.

Control Rod Stop—Excess Fuel Adjustment

During normal engine running, the control rod is restrained from movement beyond the maximum fuel position by the setting of the fly-weight springs and by the control lever stops. The control rod stop (Fig. 5) must, therefore, never be set to a position where control rod travel is restricted to less than that allowed by the maximum fuel stops (6 and 7), Fig. 4. Failure to observe this condition will impose unnecessary strain on the governor linkage.

Note: The control rod stop must be set on the engine test bed, not on the vehicle, Before setting is attempted, the maximum fuel stops (6 and 7), Fig. 4 must be correctly adjusted.

The recommended method for setting the control rod stop to obtain excess fuel is as follows:

Remove cap (4), Fig. 5, from control rod sleeve (1) and slacken locknut (3). With engine running at any speed between idling and maximum and developing full power, screw in adjusting stud (2) until engine power begins to fall. Retract stud until full power is restored, then retract stud a further 1 to 1½ turns. Tighten locknut and replace cap.

The exact excess fuel position of the control rod stop is determined by the cold starting characteristics of the engine and the operating conditions. For these reasons, the engine manufacturer's recommendations should always be followed, if different from those given above.

Adjustment of Governor Springs

The idling and maximum speeds permitted by the governor are determined by springs, selected and adjusted to the engine manufacturer's specification at our factory. The access plugs are sealed to prevent interference and we cannot accept responsibility for the performance of any governor on which the seals have been broken without our permission.

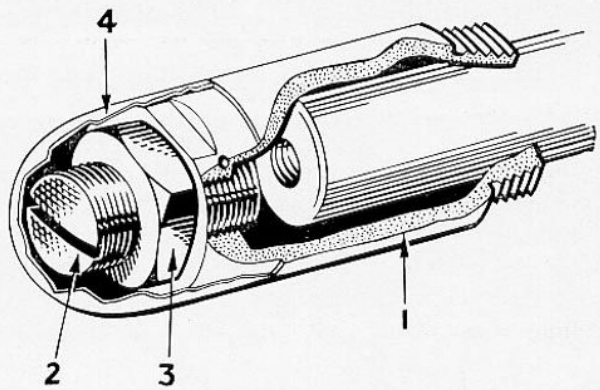


FIG. 5. CONTROL ROD STOP

Springs should not require adjustment, except after long periods of use. It is then recommended that the governor should be overhauled at the nearest C.A.V. Service Depot or by an authorised agent. If this is not possible, the speed range of the governor may be adjusted within narrow limits as follows:

1. Remove access plug on governor housing.

2. Turn the injection pump camshaft until the spring adjusting nut (16), Figs. 1 and 3, is accessible through the plug opening.

3. Using Key, Part No. 7044-65, turn the adjusting nut to right or left, depending on whether it is required to increase or decrease spring tension.

IMPORTANT NOTES:

The adjusting nut for each spring should not be given more than half a turn at a time, to ensure that it engages with its locking device.

The total range of adjustment is approximately 3 mm. for each nut. When decreasing the spring tension, the top face of the nut must not be moved more than 0.5 mm. (half a turn) beyond the outer end of the pillar on which the fly-weight and spring are retained.

When the nut (16) is adjusted, the tension of both idling and maximum springs is altered. The idling springs are, however, the least affected and a limited adjustment of the maximum speed springs can be made without materially altering the tension of the idling springs.

If it is necessary to remove the governor from the injection pump, the following special tools are required:

Extractor for governor mechanism, Part No. 7044-8.
Key for camshaft fixing nut, Part No. 7044-112.

LUBRICATION

Prior to running the governor for the first time, the breather should be removed and a quarter of a pint of good engine oil poured into the cover. Subsequently, oil should be added at regular intervals to maintain the level up to the drain plug (18), Fig. 1.

DIAPHRAGM FEED PUMP

TYPES

DFP3/2S **DFP3/7**
DFP3/12S **DFP3/21S**

GENERAL

These feed pumps are mounted on the side of the injection pump and provide an uninterrupted supply of oil at the injection pump inlet, under constant pressure.

Type DFP3/2S consists basically of a diaphragm contained in a suitable housing and actuated, through a bellcrank lever, by an eccentric on the fuel injection pump camshaft. A mechanism for hand priming is incorporated in the pump and is operated by a special hand lever.

Type DFP3/7 is similar to DFP3/2S except that a plunger is fitted on the end of the diaphragm spindle. This plunger acts as the pumping element, while the diaphragm merely prevents back leakage, any fuel trapped between it and the plunger escaping via an outlet duct.

Type DFP3/12S is similar to DFP3/2S except that it incorporates a scavenge pump which removes the excess fuel from the injection pump cambox.

Type DFP3/21S is similar to DFP3/7 except that it also incorporates a scavenge pump which removes the excess fuel from the injection pump cambox.

OPERATION (See Fig. 1)

An eccentric (15) on the injection pump camshaft operates diaphragm (10) through a bellcrank lever (13). As the camshaft revolves, a thrust is imposed on the lever which, by the action of the fork at its opposite end, displaces the diaphragm inwards against the spring (5). To minimise wear, the lever is provided with hardened and polished surfaces where it engages the eccentric at one end and the spring plate (4) at the other. Displacement of the diaphragm causes a depression above inlet disc valve (8), which lifts against its spring (7), and allows fuel to enter cavity (9) through two passages. The return stroke is controlled by spring (5) which replaces the diaphragm in its original position and allows fuel to be pumped from the cavity, through the passages and ball valve (2), to the fuel filter and on to the fuel gallery of the injection pump.

Once the operating pressure—controlled by the relief or orifice valve in the fuel system—has been reached, the spring (5) cannot fully return the diaphragm. The resulting limited movement of the diaphragm decreases the flow of the fuel oil until the pressure falls below the relief valve setting. Movement of the diaphragm therefore varies according to the pressure in the fuel system which is related to engine speed and load. When the

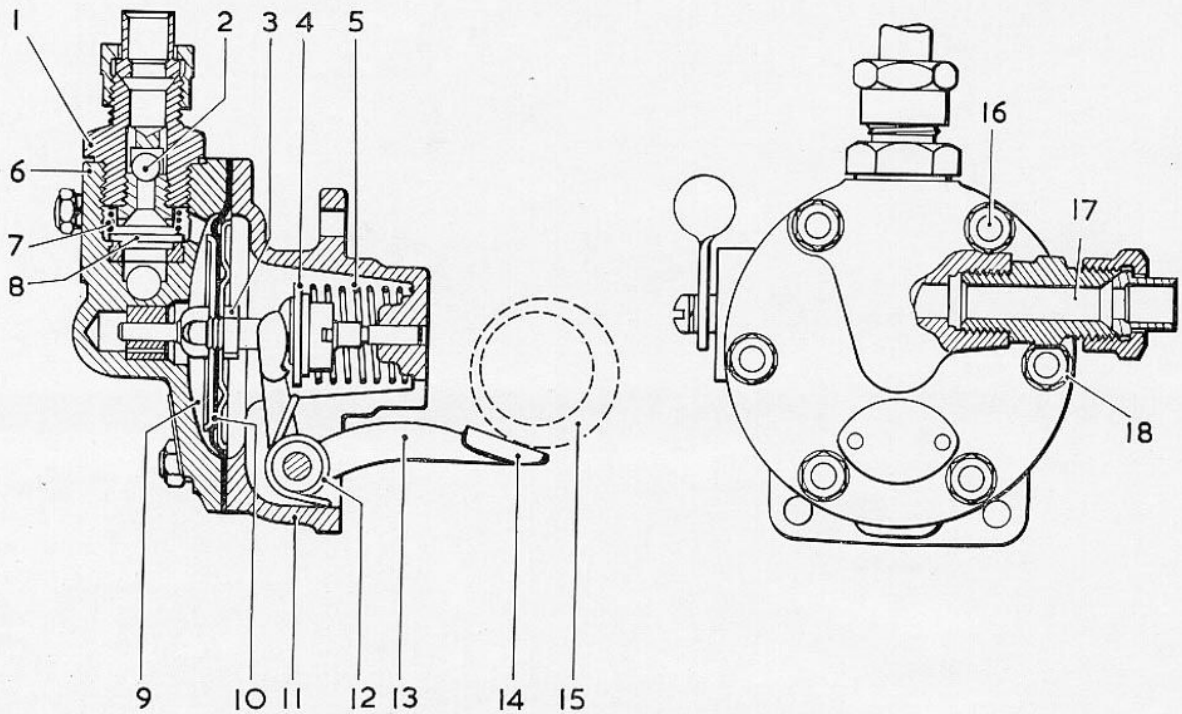


FIG. 1. TYPE DFP3/2S DIAPHRAGM FEED PUMP

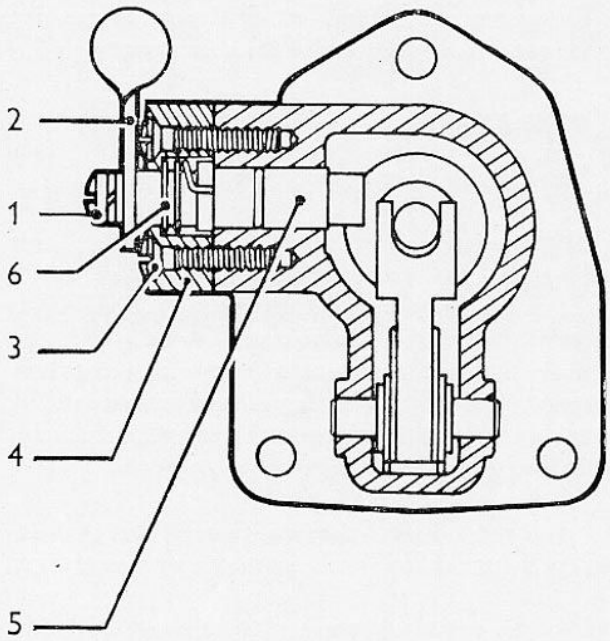


FIG. 2. SECTION THROUGH HAND PRIMING LEVER

diaphragm is not making its full stroke, spring (12) maintains the bellcrank lever in close contact with the eccentric, thereby eliminating excessive wear due to hammering.

Removing and Replacing Valves

Unscrew union (1) (Fig. 1) to detach disc valve (8) and spring (7). Ball valve (2) can then be dismantled by unscrewing valve seat from union (1).

Replace valves in the opposite order to that given above.

To Remove Diaphragm

(a) DFP3/2S

Detach screw (1) (Fig. 2) and lock washer to release priming handle (2). Unscrew two screws (3) and remove stop plate (4). Priming spindle (5) and its spring may then be withdrawn.

Unscrew six nuts (18) (Fig. 1) and lift casting (6) clear of studs (16). Do not attempt to detach the diaphragm complete with spindle but carry out the following operations:—

Ease edges of diaphragm leaves (10) from housing (11) to allow the insertion of a thin spanner to engage flats (3).

Unscrew lock-nut and remove diaphragm pack and support plates as a unit.

(b) DFP3/12S (See Fig. 3)

Dismantle priming mechanism as described previously.

Unscrew six nuts (4), then remove cover (1), gasket, filter ring (2) and feed pump housing (3).

Do not attempt to remove diaphragm complete with spindle but carry out the following operations:

Ease edges of diaphragm leaves from sandwich plate (31). Press diaphragm towards the pump body to expose flats on the back end of spindle (13). Then using these to prevent spindle from turning, remove nut (7).

Remove diaphragm and support plates as a unit.

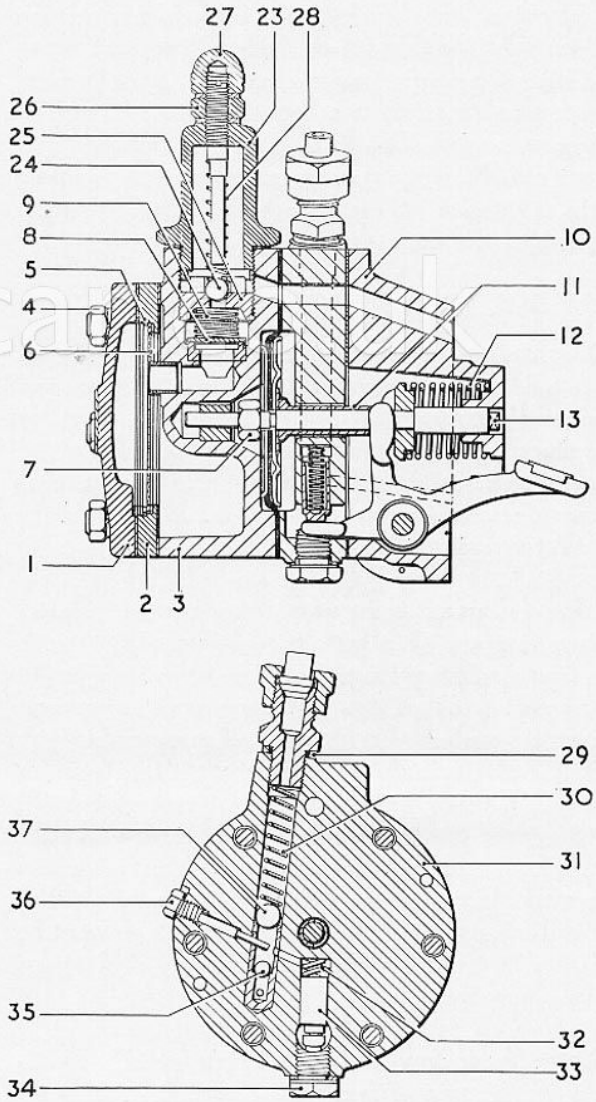


FIG. 3. TYPE DFP3/12S DIAPHRAGM FEED PUMP

To Replace Diaphragm

(a) DFP3/2S (See Fig. 1)

Separate support plates from diaphragm leaves and clean all old sealing compound from spindle and plates. Apply gold size, "Hermatite" or a similar sealing compound sparingly to the spindle thread and to the inner faces of the support plates on a diameter of approximately 1 in. Assemble in the following order:

Large support plate with its turned-over edge away from diaphragm, diaphragm leaves (ensuring, when these are of the corrugated type, that the outer corrugations register over the large support plate), small support plate with its flat side towards diaphragm pack. Finally lock all parts together with lock-nut taking care that diaphragm pack is not twisted or distorted during final tightening; when flat diaphragms are fitted the operating lever must be pushed to the full stroke position before all the parts are clamped together. Care must be taken to ensure that there is no possible chance of fuel oil leaking between diaphragm and spindle and finding its way into the injection pump cam box, thereby giving the impression of excessive back leakage from the pumping elements.

(b) DFP3/12S (See Fig. 3)

Separate support plates from diaphragm leaves and clean all old sealing compound from spindle, plates and sleeve (11). Apply sparingly gold size, "Hermatite" or a similar compound to the spindle thread, the large end of the sleeve and to the inner faces of the support plates on a diameter of approximately 1 in. Assemble in the following order:

Sleeve with small end towards operating lever, washer, large support plate with turned-over edge towards sleeve, diaphragm leaves (ensuring, when these are of the corrugated type, that the outer corrugations register over the large support plate), small support plate with its flat side towards diaphragm pack, then remaining washer. Finally lock together by means of nut (7), taking care that the diaphragm pack is not twisted or distorted in the final tightening. Ensure that no leakage can take place between diaphragm and spindle; when flat diaphragms are fitted the operating lever must be pushed to the full stroke position before all the parts are clamped together.

Note: Flat or corrugated diaphragms are fitted, depending on the type of feed pump installed. During reassembly, it is essential to ensure that the correct set of diaphragms is fitted and that diaphragms of one type are not mixed with those of the alternative type.

OPERATION

Fig. 4 clearly illustrates this type of pump.

Revolution of the camshaft eccentric displaces plunger (4) against the pressure of spring (9). This creates a depression above the inlet disc valve (12) which lifts against its spring (13), allowing fuel to enter cavity (6). When the eccentric rotates to relieve the pressure on spring (9) the plunger is returned to its original position, forcing fuel in the cavity past the ball valve and on to the fuel gallery of the injection pump.

Diaphragm (2) itself does no pumping but prevents back leakage of fuel which has seeped past the plunger.

Once the normal operating pressure, controlled by the relief valve in the fuel system, has been reached, the spring cannot fully return the diaphragm, and the limited action of the plunger decreases the flow of fuel oil until the pressure falls below the predetermined value. The pumping stroke of the plunger therefore varies according to the pressure of fuel in the system. When the plunger is not making its full stroke the bell-crank lever is kept in close contact with the eccentric by a spring which prevents excessive wear due to hammering.

Removing and Replacing Valves (See Fig. 4)

Unscrew union (17) and remove ball (14). Then unscrew inlet valve body (15) and remove disc valve (12) and spring (13).

Reverse the above order for reassembly, changing oil seal (16) if necessary.

To Remove Diaphragm and Plunger

(a) DFP3/7

Detach screw (1) (Fig. 2) and lock washer, to release priming handle (2). Remove two screws (3), stop plate (4) and spring (6). Pull out priming spindle (5).

Then unscrew six cover retaining nuts and lift cover (10) (Fig. 4) clear of studs. Ease edges of diaphragm leaves from housing (1) to allow insertion of a thin spanner to engage flats (7).

Unscrew locknut (11), remove washer (5) and plunger

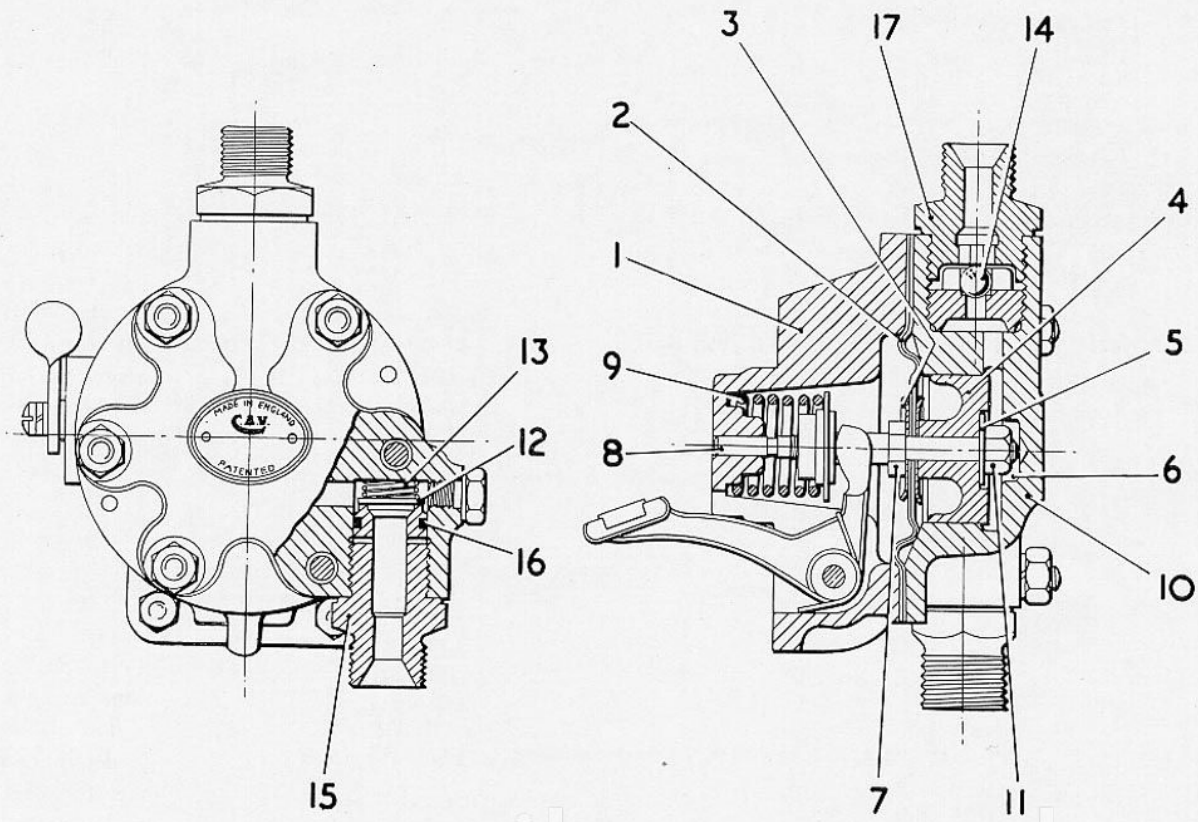


FIG. 4. TYPE DFP3/7 DIAPHRAGM PLUNGER FEED PUMP

(4), and finally extract diaphragm pack and support plates (3) as a unit.

(b) DFP3/21S (See Fig. 5)

Dismantle priming mechanism as described previously.

Unscrew six nuts (14) and lift cover clear of studs. Do not attempt to remove diaphragm (4) and plunger (7) complete with spindle (5), but carry out the following operations:

Ease edges of diaphragm leaves from sandwich plate (8).

Press diaphragm towards the pump body to expose flats in the back end of spindle (5). Then using flats to prevent spindle from turning, remove nut (2).

Extract washer (1) and plunger (7) and withdraw diaphragm and support plates as a unit.

To Replace Diaphragm and Plunger

(a) DFP3/7 (See Fig. 4)

Separate support plates from diaphragm leaves and clean all old sealing compound from spindle and plates. Apply sparingly gold size, "Hermatite" or a similar sealing compound to the thread of spindle (8) and the inner faces of the support plates on a diameter of approximately 1 in.

Assemble in the following order:

Inner support plate with turned-over edge away from diaphragm, diaphragm leaves, outer support plate, plunger (4) and washer (5). Finally lock together by means of nut (11), taking care that the diaphragm pack is not twisted or distorted in the final tightening; when flat diaphragms are fitted the operating lever must be pushed to the full stroke position before all the parts are clamped together. Ensure that no leakage can take place between diaphragm and spindle.

Note: Flat or corrugated diaphragms are fitted, depending on the type of feed pump installed. During reassembly, it is essential to ensure that the correct set of diaphragms is fitted and that diaphragms of one type are not mixed with those of the alternative type.

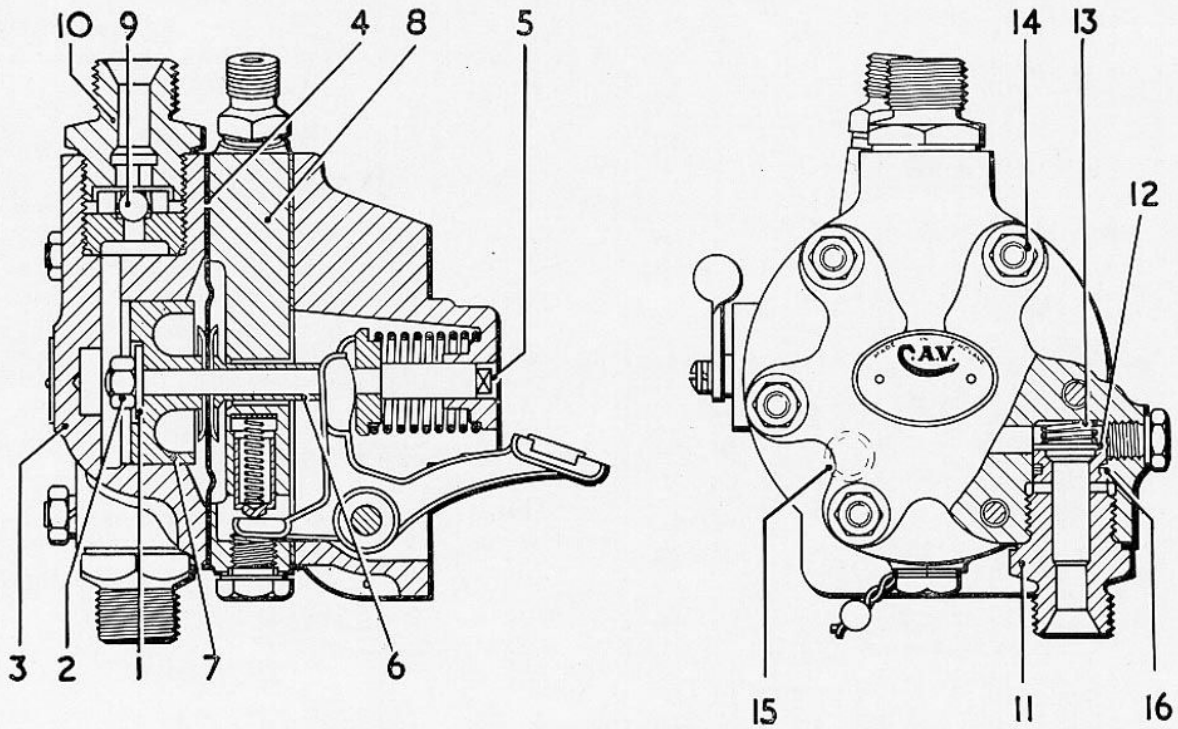


FIG. 5. TYPE DFP3/21S DIAPHRAGM-PLUNGER FEED PUMP

(b) DFP3/21S (See Fig. 5)

Separate support plates from diaphragm leaves and clean all old sealing compound from spindle, plates and sleeve (6). Apply sparingly gold size, "Hermatite" or a similar sealing compound to the thread of spindle (5), the large end of the sleeve and the inner faces of the support plates, on a diameter of approximately 1 in.

Assemble in the following order:

Sleeve with small end towards operating lever, support plate with bent edge towards sleeve, diaphragm leaves, remaining support plate with bent edge turned away from diaphragm, plunger and washer. Finally lock together by means of nut (2), taking care that the diaphragm pack is not twisted or distorted in the final tightening; when flat diaphragms are fitted the operating lever must be pushed to the full stroke position before all parts are clamped together. Ensure that no leakage can take place between diaphragm and spindle.

HAND PRIMING (See Fig. 2)

Depression of the small lever, on the left-hand side of the fuel feed pump, displaces the diaphragm a full stroke as in normal running. The small lever is spring-loaded to keep the priming mechanism out of engagement during normal operating of the feed pump. The priming mechanism is inoperative when the foot of the bellcrank lever is on the lobe of the cam, and when this occurs, 4-cycle engines must be turned through a complete revolution to obtain the full diaphragm stroke.

SCAVENGE PUMP

TYPES DFP3/12S AND DFP3/21S ONLY

Operation (See Fig. 3)

The scavenge pump consists of a plunger (33) and ball valves (35, 37) housed in a sandwich plate (31) which is fitted between the feed pump housing (3) and the feed pump body (10). The pump plunger is operated by the lower arm of a compound bellcrank lever.

When the oil in the injection pump sump rises above its normal level, it flows through a passage to the underside of ball valve (35). During the downward stroke of the spring-loaded plunger the oil is transferred to the top side of the ball valve. Then on the upward stroke of the plunger the oil is forced past spring-loaded ball valve (37) and thence through piping to the main fuel tank.

Dismantling (See Fig. 3)

Unscrew adapter (29) and remove spring (30) and ball (37).

Unscrew plug (36) and remove small ball (35).

To remove plunger (33), separate scavenge pump sandwich plate from feed pump body, unscrew plug (34) and withdraw plunger and spring (32).

Wash parts in clean petrol or paraffin and inspect for damage or wear. Do not wipe the parts with cloth as small particles of rag may stick to them.

Reassemble by reversing the dismantling procedure.

Note: Small ball (35) must be inserted before large ball (37). Plug (36) restricts the movement of the small ball.

Testing (See Fig. 3)

Remove plug (34), plunger (33) and spring (32). Test large ball (37) by applying air pressure of 10 lb./in.^{2} to union (29) and immersing sandwich plate in oil. Then withdraw large ball (37) and spring (30), insert a synthetic rubber plug in the plunger bore and repeat above mentioned procedure to test the small ball. Any wear or deterioration of the valves will be indicated by air bubbles appearing at the plunger bore or from the drilling beneath the smaller ball.

Note: Check scavenge pump operation if there appears to be excessive back leakage in the injection pump cam box.

RUNNING FAULTS

These pumps are so simple in design and operation that there is very little which is likely to cause trouble providing the installation has been carried out correctly. If, however, the pump delivers fuel spasmodically, or fails completely, the following points should be checked:

Examine feed pump valves for dirt.

Wash in clean petrol or paraffin if necessary.

Check pipe connections for leakage. See that there are no air leaks at the two faces which sandwich the diaphragm leaves.

Examine diaphragm and renew if necessary.

In the case of the diaphragm and plunger feed pumps, the plunger should also be examined for wear and renewed if necessary.

If there appears to be excessive back leakage in the injection pump cam box examine diaphragm and scavenge pump before suspecting the injection pump elements.

ENGINE

FUEL SYSTEM

DATA

Fuel filter (triple)	... ...	C.A.V. type No. 3F3/13.
Paper Element	... ...	C.A.V. No. 7111-44.

DESCRIPTION

The fuel is drawn from the fuel supply tank by a diaphragm or plunger type feed pump, secured to the side of the fuel injection pump.

The fuel is delivered under slight pressure to the injection pump after passing through a triple paper element filter (Figs. 1 and 3), and is then delivered under high pressure through separate pipes to each injector. On some horizontal engines each pipe line consists of two pipes joined at the support brackets on the engine block.

The filter is fitted with a permanent air bleed on the inlet passage which allows aerated fuel, without loss of fuel line pressure, to be expelled automatically and so prevent the possibility of air locks forming in the fuel system. On some horizontal engines no permanent air bleed is fitted in the filter, the fuel after passing through the filter and before entering the injection pump passes through a separate permanent air bleed (Fig. 3).

A leak-off pipe connected to each injector feeds excess fuel from the injectors, along with aerated fuel escaping from the permanent air bleed in the fuel system, back to the fuel supply tank for recirculation.

GENERAL MAINTENANCE

Great care should be taken to prevent dirt getting into the fuel supply tank.

When the engine is running the fuel in the pipe line between the fuel supply tank and the fuel feed pump is under suction and, instead of fuel leaking out at a faulty union, air and dirt can be drawn in. It is, therefore, important to keep all unions perfectly tight and pipes clean externally.

Note: Scrupulous cleanliness throughout the fuel system is of the utmost importance, and every precaution must be taken to prevent dirt or moisture getting into the pipes, and into the fuel injection pump or injectors when the pipes are removed.

Renewal of Paper Elements

The fuel filter paper elements should be renewed at regular intervals, approximately monthly or 10,000 miles (16,000 kilometres) dependent upon operating conditions.

OVERHAUL

Particular care must be taken during overhaul to prevent the ingress of dirt and moisture. Pipes should be plugged at their ends and all parts stored in a clean dry place. Workshop equipment also should be scrupulously clean.

If trouble occurs in the fuel supply to the fuel injection pump, the following checks should be made before attempting any repairs to the fuel feed pump.

1. Make sure the fuel pipes are not blocked.
2. Examine for leaks on the suction side of the fuel injection pump.
3. Examine the valves in the fuel feed pump and, if defective, renew.

If the fuel feed pump still fails to operate satisfactorily, dismantle 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 VENT OR PRIME

After removal of the fuel tank or any part of the fuel system such as injectors, pipes, filters, fuel injection pump, etc., the system must be subsequently vented or reprimed to expel all air.

Air, which inevitably enters the fuel system whenever any component is disconnected, will cause difficult starting and irregular running of the engine.

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

To Vent proceed as follows:

1. Check that there is a supply of fuel in the fuel supply tank.

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

3. Check that the fuel feed pump is operating, i.e. the operating cam is not on its maximum lift.

Vertical Engines

Slacken off the air vent screw at top-front of the fuel injection pump and operate the fuel feed pump priming handle until fuel, free from air bubbles, flows from the vent pipe, and then retighten the vent screw.

Horizontal Engines

a. If permanent air bleed is fitted to filter:

Slacken off the air vent screw at top-front of the fuel injection pump and operate the fuel feed pump priming handle until fuel, free from air bubbles, flows from the vent pipe, and then retighten the vent screw.

b. If permanent air bleed is fitted separate to filter:

1. Slacken off the centre air vent screw on the filter cover and operate the fuel feed pump priming handle until fuel, free from air bubbles, flows from the vent screw, and then retighten the vent screw.

2. Slacken off the air vent screw at top-front of the fuel injection pump and operate the fuel feed pump priming handle until fuel, free from air bubbles, flows from the vent pipe, and then retighten the vent screw.

Start the engine up and allow it to run at idling speed, if the fuel 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 injector pipe union nut at the fuel 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 fuel free from air bubbles appears, then retighten.

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, thus making sure that the system is kept free of air at all times.

FUEL FILTER

DESCRIPTION

The fuel filter is of the triple bowl C.A.V. type 3F3/13 and consists of three identical paper elements connected in parallel through a common cover so that in the event of blockage in one or more of the elements fuel flow continues uninterrupted through the remaining one. The internal construction of each unit forming the triple filter is the same as the double element model shown in Fig. 4. The filter is mounted on the induction manifold (Fig. 1) in the case of the vertical engine, and on the crankcase cover (Fig. 3) in the case of the horizontal engine.

The filter is of the cross-flow type, the inlet and outlet connections being carried in the cover, incorporated in the cover are also the air vent plugs. On some filters the centre air vent plug is substituted for a permanent air bleed.

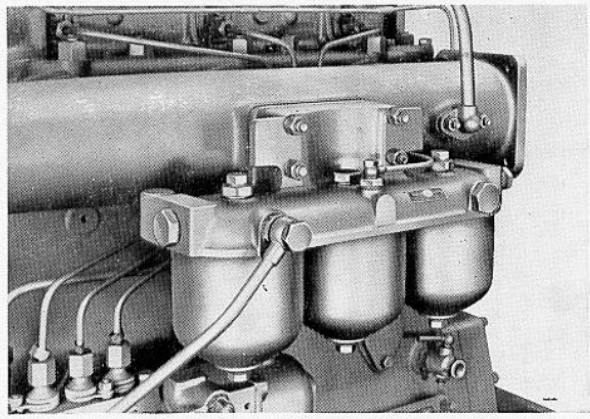


FIG. 1. MAIN FUEL FILTER—VERTICAL ENGINE

The bowls are of pressed steel, and form an oil-tight container for the element. A drain plug is provided at the bottom of each bowl.

The paper elements (C.A.V. No. 7111-44) are made up from special impregnated paper wound round a cylindrical core in the form of a spiral and contained in a thin metal canister. The winding is done in such a way as to provide a very large filter area within minimum filter bowl dimensions, as will be apparent from Fig. 2.

Fuel enters the filter at the union situated in the front of the filter cover, and is led into a common gallery communicating with all three filter bowls. Flowing into the bowls, the fuel passes down the outside of each canister, then up through the elements and out from the top of the canisters into a second common gallery leading to the outlet union, which is situated at the end of the filter cover. Dirty fuel is isolated from the clean upper sides of the elements by the oil seals at top and bottom of the central cores, oil tightness of the seals being maintained by the pressure of the springs.

The filter is fitted with a permanent air bleed on the inlet passage when required, which allows fuel, without loss of fuel line pressure, to be expelled automatically and so prevent the possibility of air locks forming in the fuel system. On some horizontal engines the permanent air bleed is separate to the filter. The permanent air bleed is connected to the leak-off pipe from the injectors, which leads excess fuel back to the fuel supply tank for recirculation.

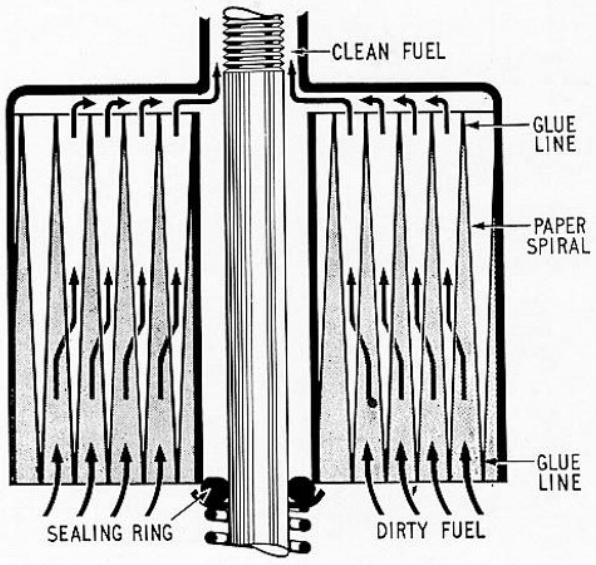


FIG. 2. THE DIRECTION OF FLOW

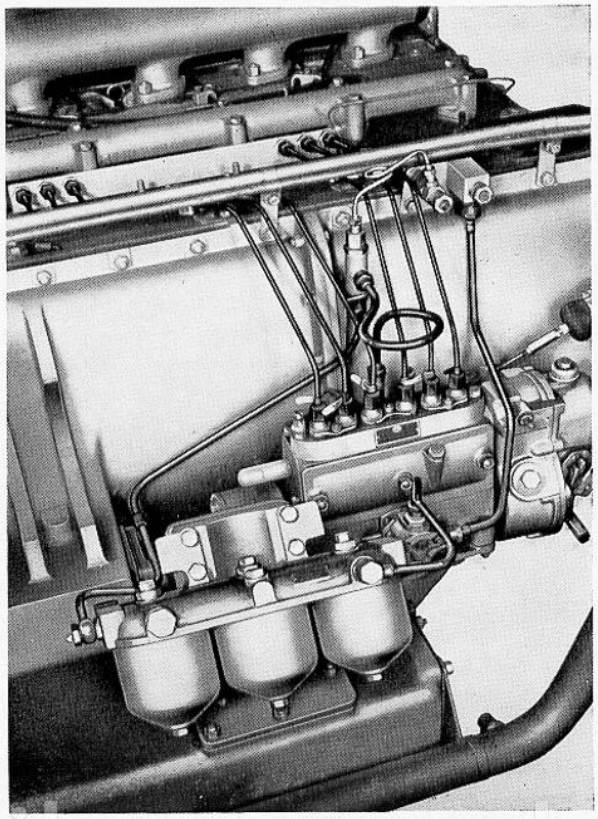


FIG. 3. MAIN FUEL FILTER—HORIZONTAL ENGINE

To Replace Elements

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

2. Slacken off each air vent plug and or permanent air bleed slightly at top of cap nut; and unscrew drain plugs until fuel drains from the hole in the plugs. If, however, the drain plug holes are blocked, retighten the plug.

3. Unscrew the central top cap nut to release each bowl from the filter cover; withdraw each bowl and element from the filter cover.

   If draining through the drain plugs is impossible, push the elements 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 bowl bosses.

4. Extract the element from the bowl. 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 stud above the bottom sealing ring.

Do not attempt to clean the elements. Used elements must always be discarded and replaced by new ones.

5. Fit new paper element in bowl. Ensure that the sealing rings (5) are properly seated and in good condition.

6. Offer each filter bowl containing new element to the cover and secure it by engaging the centre stud and cap nut. Screw up the cap nut tightly. Undue force should not be applied in an attempt to stop leakage.

7. Tighten up the drain plugs and vent the fuel system.

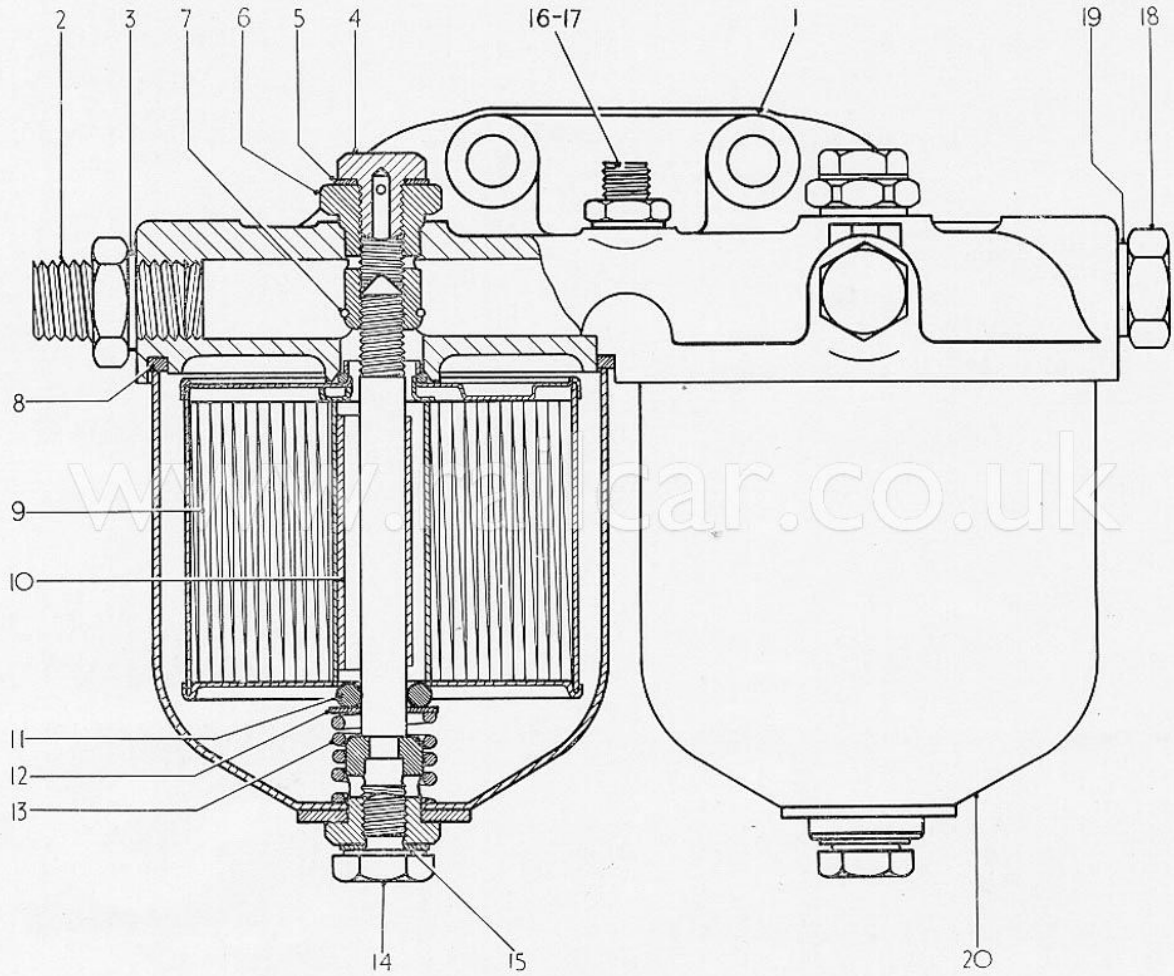


FIG. 4. SECTION THROUGH THE FUEL OIL FILTER

1. Housing cover.
2. Outlet union.
3. Washer.
4. Plug.
5. Washer.
6. Cap nut.
7. Circlip.
8. Joint.
9. Filter element.
10. Locating sleeve.
11. Seal ring, lower.
12. Washer.
13. Spring.
14. Plug sludge.
15. Washer.
16. Inlet union.
17. Washer.
18. Closing plug.
18. Washer.
20. Housing.

STOP SOLENOID

DESCRIPTION

The C.A.V. type 263-10 engine stop solenoid is mounted on the engine near to the fuel injection pump governor (Fig. 1.)

The solenoid consists of two electric coils and a sliding plunger, the plunger being connected to the stop control lever on the fuel injection pump governor.

The solenoid is continuously rated, one of the coils being for the "pull-in", and the other for the "hold-in", in which the plunger is free to move.

On energising the "pull-in" coil the sliding plunger is drawn to the end of its stroke against an 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 plunger in the stop position, thereby stopping the engine.

When the electrical circuit is broken, the stop solenoid plunger and stop control lever return to their normal positions.

To Remove

1. Isolate from the batteries by the battery cut-off switch if fitted, or by disconnecting at the terminals.
2. Remove the terminal cover.
3. Disconnect the electrical connections, then withdraw the connections from the cover.
4. Refit the terminal cover.
5. Disconnect the plunger from the stop control lever on the fuel injection pump governor.
6. Remove the four nuts and bolts securing the stop solenoid to the bracket and remove stop solenoid.

To Fit

Fitting of the stop solenoid is the reversal of the removal procedure, noting the following points:

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

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

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

Adjustment

After fitting the stop solenoid the following adjustments should be checked:

1. Check that the stop solenoid stops the engine from full speed running.
2. With the engine stopped remove the terminal cover from the stop solenoid and check that there is a minimum clearance of 0.063 in. (1.60 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 stop solenoid.

Refit the terminal cover.

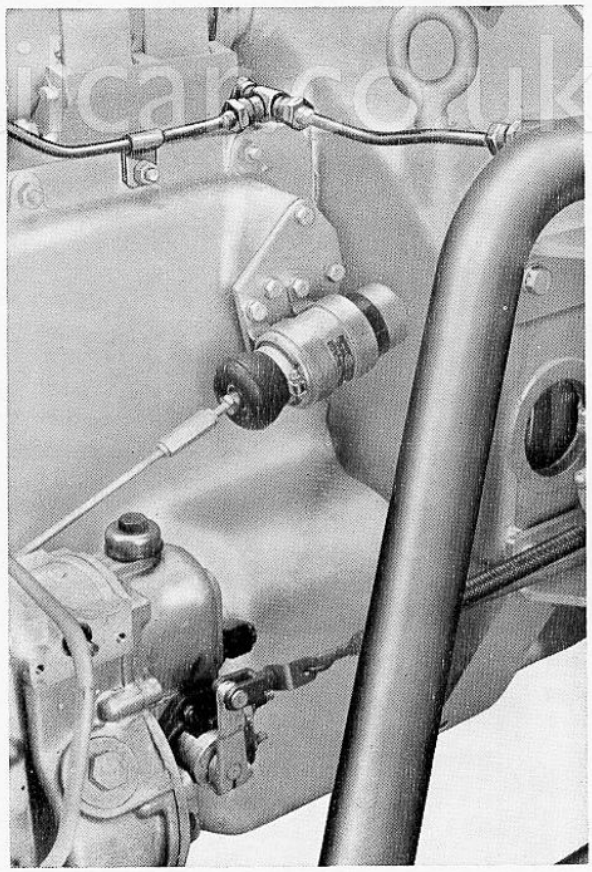


FIG. 1. STOP SOLENOID IN POSITION

STARTER MOTORS

C.A.V. TYPES

SP624-1

BS524P-81M

U624-5

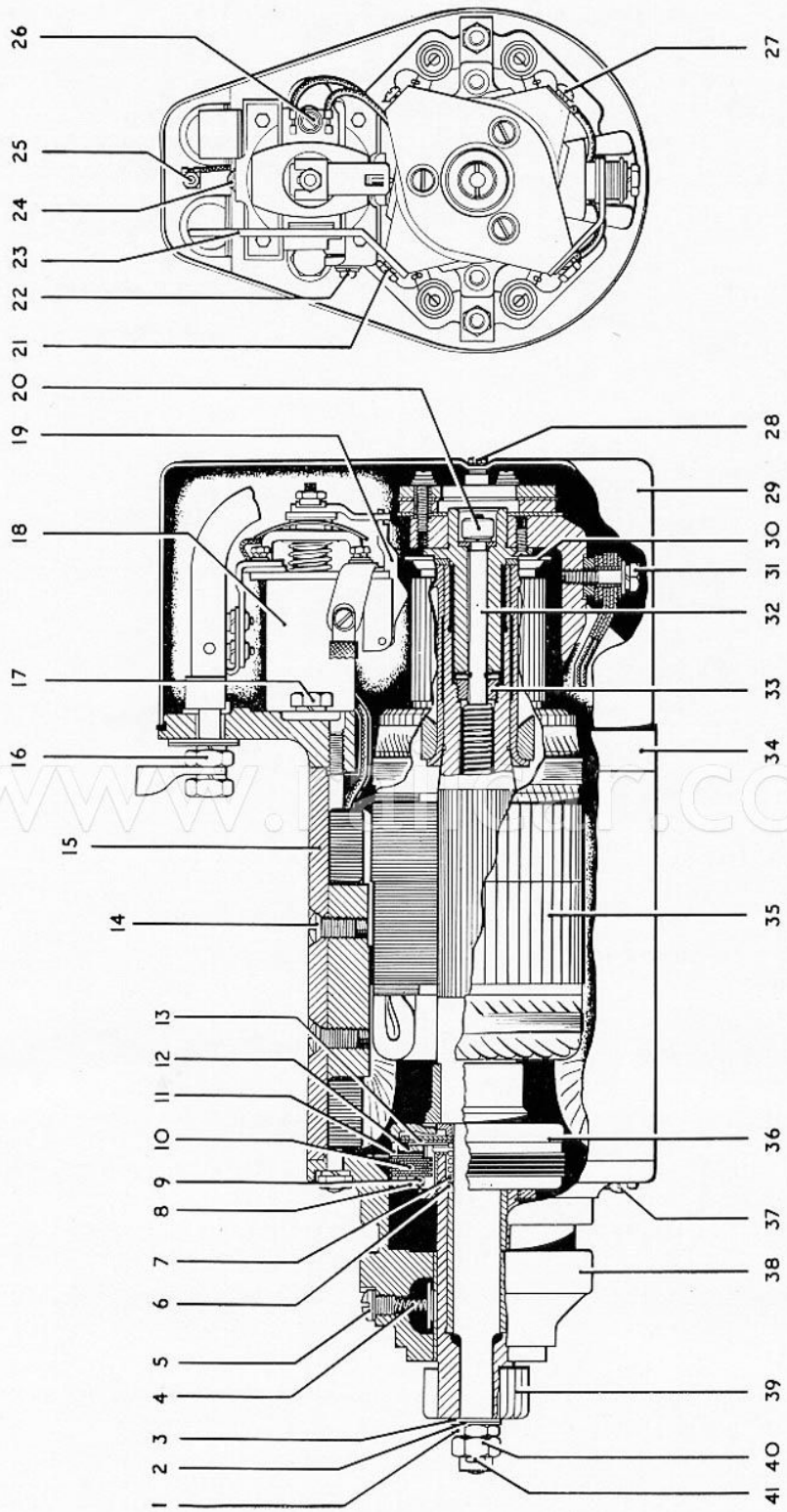


FIG. 1. TYPICAL STARTER MOTOR

GENERAL DESCRIPTION

"Axial" starters are designed for use on the larger type of engine where, because of the high inertia of flywheel and crankshaft, it is necessary for the starter pinion to engage with the engine flywheel before the starter develops full torque, thus avoiding heavy engagement shock and excessive wear on the gear teeth. Engagement between starter and engine is effected by an axial movement of the complete armature assembly, and it is from this movement that the term "Axial" starter is derived.

The field windings of the machine consist of a main series winding, an auxiliary series winding and an auxiliary shunt winding. A solenoid operated two stage switch forms an integral part of the starter and is used to control the starting cycle, so that only a small switch to handle the solenoid current is required externally.

When the starter switch is operated, the first stage contacts on the solenoid switch (18) (Fig. 1) close, and a small current passes through the auxiliary field windings, causing the armature to rotate slowly. Simultaneously, the complete armature assembly (35) is drawn towards the driving end of the machine by the magnetic field set up in the windings, and pinion (39) is brought into mesh with the engine flywheel gear. As the armature nears the end of its axial travel, tripping disc (30) operates trigger (19) on the solenoid switch, causing the second stage contacts to close and complete the circuit to the main series winding. The starter then exerts its full torque on the engine. When the starter button is released, the armature is returned to its disengaged position by the coiled spring on armature plunger (32).

The starters are fitted with an overload clutch (36) which is interposed in the drive between armature and pinion. The clutch has a slipping torque of about twice the lock torque of the starter but below the shearing strength of the pinion teeth, and is thus an effective safeguard against the teeth of the pinion being sheared due to excessive load.

SP624-1

A high-powered, cradle-mounted machine, this model has a 6-inch yoke with insulated return wiring and a 13 tooth, 8-10 pitch pinion (bronze). Designed for clockwise rotation, the SP624-1 operates on a nominal voltage of 24 at a running speed of 1,600 r.p.m.

The driving-end shield on this starter is of a long nose design.

BS524P-81M

Also designed for 24 volt, clockwise rotational operation, this type, which is of a marine finish, accommodates a 5 inch dia. yoke fitted with a dowel pin. The starter is designed for insulated return wiring and employs an 11 tooth, 8-10 pitch stub type pinion (steel). The BS524P-81M type is assembled on a No. 2 SAE medium/heavy flange mounting, and is provided with a special commutator end cover.

U624-5

This model is fitted with special connection for dual-starter arrangement. Universally mounted, i.e. suitable for either cradle or barrel fitting, the U624-5 incorporates a 13 tooth, 8-10 pitch steel stub pinion, clockwise rotating within a 6 inch yoke. It is return wiring insulated, this starter is for 24 volt usage, and operates in conjunction with a dual starter switch.

USING THE STARTER

The following points should be rigidly observed when starting the engine.

1. Make sure that all engine controls are correctly adjusted.

2. Press the starter button firmly and release it immediately the engine fires.

3. If the engine does not fire at once, allow it to come to rest before pressing the starter button again.

4. Do not run the battery down by keeping the starter button pressed when the engine refuses to start. Ascertain the cause of failure.

5. With some engines it is often helpful to depress the clutch when starting from cold.

6. On no account should the starter be operated when the engine is running, otherwise serious damage is likely to occur to both starter and flywheel teeth.

The starter should be examined at regular intervals during service to ensure that its mounting bolts or cradle straps are securely fastened and that all electrical

connection are clean and tight. The cables should be examined for fractures, particularly at the point where the cables enter the terminal lug. The cable insulation must be free from signs of chafing and deterioration due to oil, etc.

MAINTENANCE

Very little attention during service should be necessary with these starters, but in order to ensure maximum life and trouble-free starting, we suggest that the following maintenance procedures are undertaken at regular intervals, the length of which are dependent on service conditions.

Brushgear

Check that the brush leads are clear of any obstruction likely to impede movement, and see that the brushes are free in their holders by pulling gently on the brush leads. If a brush is inclined to stick, remove it from its holder and clean the inside of the holder with a clean cloth moistened in petrol. Be sure to replace the brush in its original position so that the curvature of its contact surface accurately conforms with the commutator periphery.

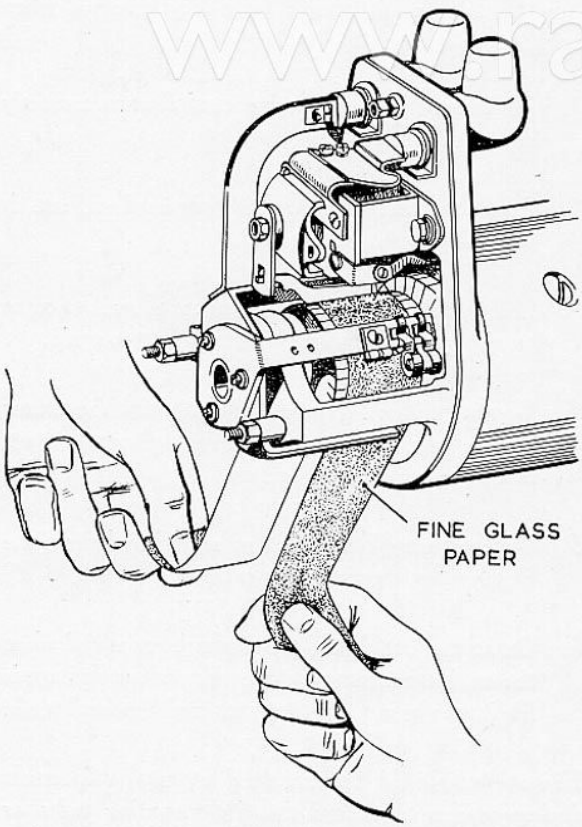


FIG. 2. BEDDING STARTER MOTOR BRUSHES

Where spiral fibre insulation is provided on the brush leads, see that it has not become burnt or charred, thus creating the danger of short circuits.

The brushes should be well "bedded", i.e. worn to the commutator periphery over at least 60 per cent of their contact area. If not, lift each brush from the commutator and wedge in position with its spring. Wrap a strip of very fine glass paper (do not use emery cloth or carborundum paper) around the commutator with the abrasive side outwards as shown in Fig. 2. Lower the brush (or brushes) in one brushgear arm on to the glass paper, and bed to the correct shape by drawing the glass paper backwards and forwards over the commutator. Raise the finished brushes and repeat the bedding procedure for the brushes on the other brushgear arms in turn. After bedding, each brush must be removed from its holder and all traces of dust and abrasive cleaned away, preferably using compressed air or some form of hand bellows. Examine the brushes to ensure that no particles of abrasive are embedded in their contact surfaces.

Check the pressure of the brush springs using a spring balance hooked under the spring or trigger lip as shown in Fig. 3. The pressure of each spring when taken at the point of contact with the brush should be within the following limits:

Starter Type

BS5	24 volt	42-53 oz	(1,191—1,503g)
SP6	24 volt	18-24 oz	(510— 680g)
U6	24 volt	18-24 oz	(510— 680g)

If the brushes are worn so that the springs no longer provide effective pressure they must be renewed. It is essential that replacement brushes are fitted in complete sets, and under no circumstances should brushes of different grades be used together. To be sure of obtaining the correct grade of brush, always specify C.A.V. spares.

It is not practicable to supply replacement brushes already bedded, as the periphery of the commutator will vary according to the number of skimming operations performed on the armature. Replacement brushes must therefore be bedded to the commutator as described above.

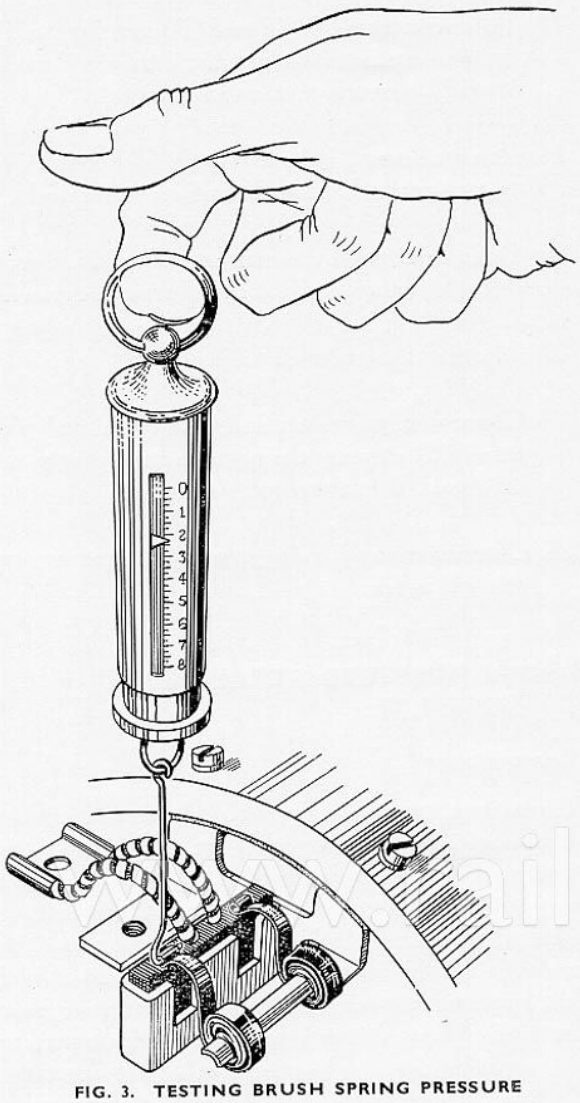


FIG. 3. TESTING BRUSH SPRING PRESSURE

Commutator

The commutator surface should be clean and entirely free of oil, any trace of which should be removed by pressing a dry, clean fluffless cloth against the commutator while the armature is hand rotated.

If the commutator is dirty or badly discoloured, lift the brushes and wedge in position with their springs. Wrap a strip of very fine glass paper (do not use emery cloth or carborundum paper) around the commutator with the abrasive side inwards, and draw the glass paper backwards and forwards over the commutator, whilst slowly rotating the armature, until the surface is clean. Remove all traces of dust and abrasive using compressed air or hand bellows. Finally, lower the brushes on to the commutator and carefully replace the commutator cover.

Lubrication

The driving end bearing on earlier type starters is supplied with oil from a lubricator fitted to the driving endshield. This lubricator should be filled with oil at regular intervals during service. See list of recommended lubricants at end of section.

The driving end bearing of all later type starters is lubricated by oil from a large reservoir contained in the driving endshield, the capacity of which is sufficient for approximately three years normal running time. Refilling can most conveniently be done when the starter is dismantled at overhaul periods, the procedure described in **Assembly** being adopted.

An oil-less bearing is fitted at the commutator end and requires no attention during service.

Fault Finding with the Starter on the Engine

If the starter does not function, or is sluggish or intermittent in operation, check that the state of the charge of the battery is satisfactory and that all cable connections are clean and tight. A defective starter push switch or badly worn starter brushes are other possible causes of failure.

Difficulty in smooth engagement between starter and engine may be due to incorrect flywheel to pinion clearance. This should be 0.125 in.±0.031 in. (3.18± 0.79 mm.), between the face of the flywheel and the engaging face of the pinion when the pinion is at rest.

Removing the Starter from the Engine

As individual mounting arrangements vary, reference should be made to the engine makers manual for the correct method of removing the starter. It is recommended, however, that the battery be disconnected before any attempt is made to take off the machine.

SPECIAL TOOLS

Before overhauling the starter, it is advisable to obtain the special tools listed at the end of this section. These tools are not essential, but will reduce the time spent on overhauling the starter, and will enable a closer approach to factory standards to be obtained.

DISMANTLING

1. Unscrew nuts (28) and take off commutator cover (29).

2. Unscrew brush lead screws (27), lift brush springs and remove brushes from their holders. It will be seen that removal of the brush lead screws also frees the auxiliary field connections to the brushgear.

   Note: At this stage, the leads to the brushgear and solenoid switch should be marked so that they can be easily identified when the starter is assembled.

3. Remove nut (20) from the armature plunger by means of tool No. 5693/45 (SP6 and U6), or box spanner (BS5).

4. Remove main fixing bolts or screws (37). Tap driving endshield (38) gently away from yoke (15) with a hide or wooden mallet, and withdraw endshield complete with armature (35).

5. Hold the armature in an armature clamping device, or in a vice fitted with soft metal or wood jaw clamps.

6. Remove lubricating plug (5) and spring (4) from the driving endshield.

7. Remove split pin (41), nuts (40) and (1), and washers (2) and (3) from front end of pinion (39), and slide pinion and driving endshield off the armature shaft.

8. Remove pinion spring (7).

9. Collect clutch inner race (8), clutch plates (10), shim washers (11), back plate (12) and pressure plates (13) from clutch assembly.

   Note: The clutch plates should be tied together in the order of removal so that they can be replaced in their original positions in the clutch when the starter is assembled.

10. Withdraw shim (6) from bore of pinion.

11. Undo armature plunger retaining nut (33) by means of Tool No. 5693/103 (SP6 and U6) or Tool No. 5693/106 (BS5). Earlier starters were fitted with retaining nuts having a narrow slot, and in these cases tools 5693/100 or 5693/190 should be used respectively.

12. Withdraw armature plunger (32) from bore of armature.

13. Remove screws (24), (22) and (26) securing positive terminal connector, main field coil ends, and auxiliary field connections to solenoid switch.

14. Remove screw (31) holding main field connections to connector at bottom of commutator endshield.

15. Carefully separate the commutator endshield from the yoke by tapping with a hide or wooden mallet.

16. Disconnect the solenoid coil leads.

17. Unscrew negative terminal nuts (16), and also screw (21) securing the negative connector to the brushgear. Remove negative connector.

18. Unscrew solenoid fixing screws (17), and remove solenoid switch.

INSPECTION AND REPAIR OF COMPONENTS

Commutator

The commutator surface should be clean and free from grooves, pits or uneven discoloration. The surface can be cleaned with a very fine grade of glass paper (do not use emery cloth or carborundum paper), except in cases where it is in a very bad condition when it should be set up in a lathe and skimmed. A rough cut should first be taken, removing just sufficient copper to clear traces of pitting or distortion. Then, if mica is used as the insulating material between commutator segments, the commutator should be undercut, i.e. the mica removed to a depth not exceeding the width of insulation. A special tool is available for this purpose, but an old hacksaw blade, ground to the width of the insulation, will make a serviceable tool in case of emergency. See Fig. 4.

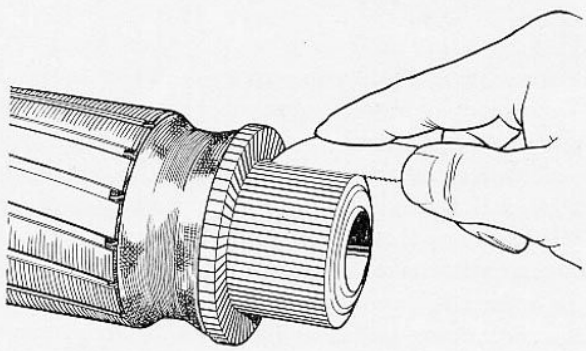


FIG. 4. UNDERCUTTING THE MICA

If melamine is used as the insulating material between segments, the commutator need not be undercut. The type of insulating material can best be determined by examining that part of the commutator surface untouched by the brushes, that is, where it has not been subjected to wear. If the insulators show no signs of being undercut, then it can be reasonably assumed that they are melamine. If there is any doubt, however, we advise undercutting.

Finally, a light cut should be made on the lathe, using a diamond tool to obtain the desired high quality finish. The commutator and armature must be thoroughly cleaned after machining, preferably using compressed air or some form of hand bellows.

Armature Winding

These can be tested for continuity and short circuits by means of a "growler" armature tester. If a "growler" is not available, the armature should be tested by substitution. In the event of the armature being found to be faulty, clutch outer race (36) should be pressed off the shaft with the aid of Tool No. 5693/61, and the armature returned direct to us or to the nearest C.A.V. Agent. When the clutch outer race is pressed on to the shaft of the new or replacement armature, Tool No. 5693/94 (SP6 and U6) or Tool No. 5693/95 (BS5) should be inserted into the armature bore as shown in Fig. 6 so that the press bears upon the tool and not upon the end of the commutator. If this is not done, the force exerted by the press may distort the commutator segments.

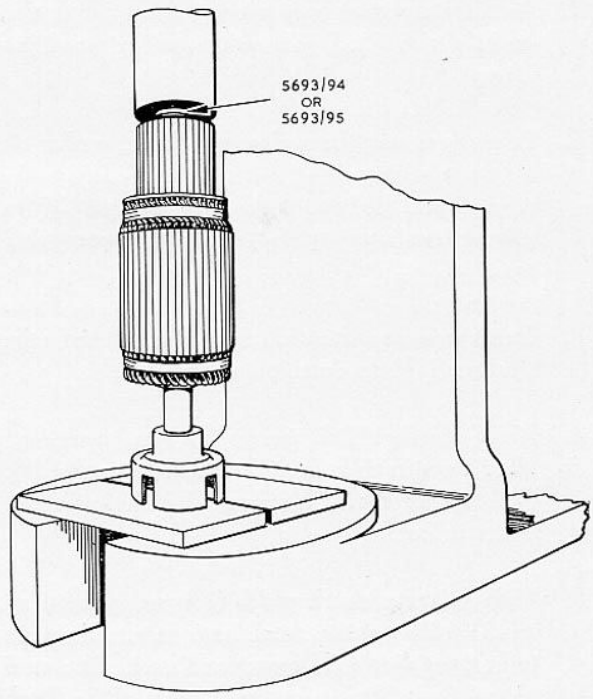


FIG. 5. PRESSING CLUTCH OUTER RACE ON ARMATURE SHAFT

Field Windings

The field windings can be tested for short circuits to the yoke and poles by means of test prods connected to a mains supply and in series with a lamp of suitable voltage positioned on the live side of the system. Apply one prod to the yoke at a position where it is free from enamel and insulation, and apply the other to the ends of each of the windings in turn. If the lamp does not light then the insulation is intact.

Open circuits can easily be detected by means of an ohmmeter. The instrument should be connected across each of the windings in turn. If no reading is obtained then an open circuit is indicated in the winding being tested. Internal shorts in the coils can best be detected by means of a low reading ohmmeter. Where no such instrument is available and the existing windings are suspect, they should be checked by substitution. Unserviceable coils should be renewed as follows:

1. Unscrew pole fixing screws (14) and withdraw poles and windings, noting position of windings in order to facilitate reassembly. It will be seen that each pole has a small step machined on its surface, and is marked with a number which corresponds with a number stamped on the end of the yoke. When replacing the poles, care must be taken that the steps are all towards the commutator end of the yoke and that the numbers correspond.

2. Fit the new windings to the poles as dismantled, so that they bed down as far as possible on the poleshoe wings.

3. Assemble poles and windings into yoke and insert pole fixing screws.

4. Tighten the screws using a commercial pole screwdriver. Care must be taken that the screws are tightened down firmly so that no space exists between the mating surfaces of the poles and yoke. This can be checked by means of a thin feeler gauge.

Note: The windings will bed down more easily if the yoke, windings and poles are heated gently in an oven before the pole fixing screws are tightened.

Bearings

Insert the pinion into its bearing in the driving endshield and slide the commutator end of the armature on to the bearing pin in the commutator endshield and check both bearings for excessive side-play.

If the bearing pin is worn, it is recommended that the complete commutator endshield and bearing pin assembly is replaced as the endshield spigot is machined concentric with the bearing pin after the pin has been assembled.

The driving end bearing may be removed from its endshield and renewed, provided facilities exist for accurate machining. Where no such facilities are available, the complete driving endshield and bearing assembly should be returned to C.A.V. for replacement. If the bearing is to be renewed the following procedure should be adopted:

1. Push the lubricating wick well away from the bore so that it does not get trapped during the pressing operations.

2. Press the old bearing out of the endshield.

3. Press in the new bearing from inside the endshield, using a split dolly to prevent the lubricating wick from being trapped between the end of the bearing and the edge of the oil reservoir.

4. Set up the endshield in a lathe in such a manner that when machining of the bearing bore is complete, the bore is perfectly concentric with the endshield spigot where it registers with the yoke. This can best be done by means of faceplate 5693/93, which is designed to be located in a recess machined in the faceplate of the lathe, and is itself provided with accurately machined recesses for locating the endshield spigots of the various sizes of starter.

5. Turn the bearing bore to 35.050—35.095 mm. diameter, and ensure that the surface finish is of the highest quality.

6. Turn both ends of the bearing flush with the faces of the casting.

Brushgear

Check the brushgear insulation as detailed below, using a main supply, test prods and lamp as described in the section headed **Field Windings.** If the lamp lights during any of these tests the insulation is faulty.

1. Between positive and negative brush holders.

2. Between positive brush holder and frame.

3. Between negative brush holder and frame.

Clutch

If clutch plates (10) are badly worn or discoloured they must be renewed. Individual new parts should not be put in unless facilities exist for testing the slipping torque. Where no such facilities exist and parts of the clutch need renewing, a complete new interior should be fitted, or alternatively, the clutch together with armature, pinion and driving endshield should be returned to C.A.V. Ltd. for attention.

Pinion

If the teeth of pinion (39) are badly worn or damaged the pinion should be changed. See that the new pinion has the same number of teeth and is made of the same material as the old component.

ASSEMBLY

1. Hold the armature in an armature clamping device, or in a vice fitted with soft metal or wood jaw clamps.

2. Liberally smear the spring and thrust washer on armature plunger (32) with grease. Insert the plunger into the bore of the armature, and tighten plunger retaining nut (33) using the appropriate tool.

3. Insert pressure plates (13), back ring (12) and shim washers (11) into clutch outer race (36).

4. Lightly smear clutch springs (9) with grease, and place them in their holes in clutch inner race (8). Each spring should be inserted with its largest diameter first.

5. Lightly grease clutch plates (10) and place them on the splines of the clutch inner race, taking care to fit them alternately bronze and steel. Fit a steel plate first so that it takes the pressure of the clutch springs.

6. Assemble clutch inner race, together with clutch plates and springs, into the clutch outer race.

7. Grease pinion spring (7), and slide it on to the armature shaft.

8. Grease bore of pinion (39) and insert shim (6).

9. Insert pinion into driving endshield (38). In order not to damage the felt lubricating pad, the pinion should be twisted in the direction of the spiral of the pinion thread whilst the lubricating pad is lifted by one finger from inside the casting.

10. Slide pinion and driving endshield on to the armature shaft. Push the pinion forward and rotate it until its thread engages in the internal thread in the clutch inner race. Hold in this position, and replace shim (3), washer (2) and nut (1). Make sure that the shim locates over the shoulder of the shaft and tighten the nut securely. After the nut has been tightened, the pinion must be capable of a small endways movement on the armature shaft.

11. Where facilities exist, the slipping torque of the clutch should now be adjusted as follows:

    (a) Clamp the armature to the bench using clamp bracket 5693/62, and fit torque bar 5693/147 to the pinion as shown in Fig. 6. The torque bar should be fitted so that torque is applied in the opposite direction to the normal starter rotation:

    (b) Adjust the clutch to slip at 100 to 115 lb. ft. (13.826 to 15.899 kg.m.). This should be done by removing or adding shims (11) (Fig. 1) between clutch plates (10) and back plate (12) until the clutch will support a weight of not less than 30.5 lb. (13.826 kg.) and not more than 35 lb. (15.899 kg.) on the end of the torque bar. The shims are made in two thicknesses, 0.1 and 0.15 mm. Adding shims will increase the slipping torque and vice versa.

    (c) Slip the clutch about ten times, and then adjust the clutch to slip at between 80 to 100 lb. ft. (11.060 to 13.826 kg.m.) which is equal to 24.5 to 30.5 lb. (11.060 to 13.826 kg.) on the end of the torque bar.

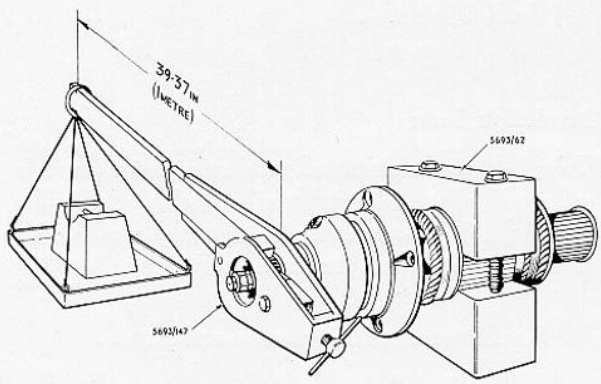


FIG. 6. TESTING THE CLUTCH

12. Replace castellated nut (40), tighten securely and then insert split pin (41).

13. Pour approximately 12 c.c. of oil into the oil filler hole in the driving endshield. Allow sufficient time for the lubricating pad to absorb the oil, and then replace spring (4) and lubricating plug (5). Wipe off any surplus oil which may have run into the inside of the driving endshield.

14. Fit solenoid switch (18) to commutator endshield (34) and secure in position with fixing screws (17).

15. Assemble negative connector (23) to the commutator endshield, and replace nuts (16) and screw (21).

16. Reconnect the solenoid winding leads to their respective terminals.

17. Fit commutator endshield to yoke (15) ensuring that the dowel in the yoke is correctly located.

18. Replace screws (22), (24) and (26) securing main field coil ends, positive terminal connector, and auxiliary field connections to the solenoid switch.

19. Replace screws and insulating pieces (31) holding main field connections to connector at bottom of commutator endshield.

20. Carefully assemble armature and driving endshield to yoke.

21. Replace main fixing bolts or screws (37) and tighten.

22. Spin the armature to see that it is not binding and is free to rotate.

23. Fit washers and nut (20) to armature plunger, and tighten.

24. Replace brushes, taking care that each brush is replaced in its original position. If new brushes are to be fitted, they must be bedded to the commutator as described in the section headed **Maintenance.**

25. Connect brush leads and auxiliary fields leads to the brushgear.

26. Check that the relationship between trigger (19) and tripping disc (30) is correct, by pulling the armature forward until the trigger is raised to its highest extent by the tripping disc. When the trigger is raised there should be an ample gap between the shoulder on the trigger and the bottom of the slot in the catch plate (see "A", Fig. 7).

TESTING

Engagement Mechanism

1. Connect the starter to a battery of suitable voltage.

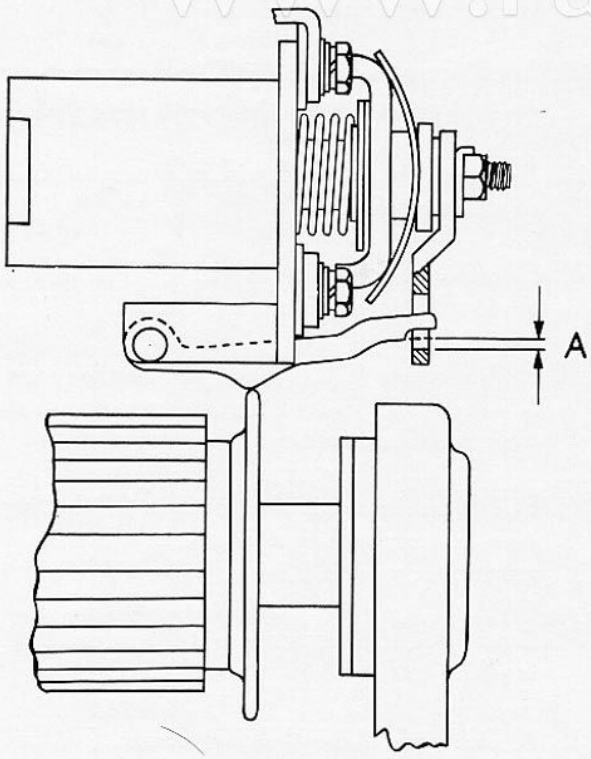


FIG. 7. SOLENOID SWITCH

2. Insert a strip of insulating material between the moving contact and the second stage contact of solenoid switch (18) to prevent the second stage contacts closing.

3. Operate the starter push switch. The first stage contacts of the solenoid switch should close, and the pinion revolve in its normal direction of rotation. At the same time, the pinion should move forward for a distance of approximately 1 in. (25.4 mm.).

   Caution: Do not keep the starter button depressed longer than is necessary to check that the starter is functioning satisfactorily, otherwise the auxiliary windings may be damaged by overheating.

4. Remove insulating strip from the second stage contacts.

Performance Tests

For the purposes of these tests, the brushes must be bedded over at least 60 per cent of their contact area.

1. Fit the starter to a starter test rig and connect the power supply. The gap between starter pinion and test rig flywheel must be set at 0.125 in. (3.175 mm.).

2. Check the lock torque, the running torque, and the light running torque of the starter.

3. When these tests have been successfully completed, the commutator end cover should be carefully fitted and the machine subjected to the insulation tests detailed below.

Insulation Tests

Using test prods connected to a mains supply and in series with a lamp of suitable voltage, check the insulation of the machine as detailed below. If the lamp lights during any of the tests the insulation is faulty.

(a) Between positive terminal and frame.

(b) Between negative terminal and frame.

RECOMMENDED LUBRICANTS

The following lubricants are recommended for all "Axial" type starters, and no departure from these should be made without reference to C.A.V. Ltd. Alternative greases must not be mixed.

Where Used	Recommended Lubricant	Alternatives
Drive end bearing (temperate climates)	Oil to SAE 10W/30W	—
Drive end bearing (sub-zero climates)	Oil to SAE 5W/20W	—
Clutch plates, springs, etc.	Shell Nerita Grease	B.P. Energrease N.3 Shell Retinax H

TEST DATA

Type	Nominal Voltage	Type of Test	Battery Capacity	Current (Amps.)	Torque (lb.ft)	Speed (r.p.m.)
SP6-24-1	24	Locked Torque	194 A-H	1,720-1,800	78	0
		Running Torque		840-880	33	1,600
		Light Running Torque		100-120	0	4,500

Type	Nominal Voltage	Type of Test	Battery Capacity	Current (Amps.)	Torque (lb.ft)	Terminal Voltage	Speed (r.p.m.)
BS524P-81M	24	Locked Torque	135-A-H	750-780	33-34	9	0
		Running Torque		360-380	15-20	16	1,450-1,650
		Light Running Torque		50-55	0	24	3,800-4,200

Type	Nominal Voltage	Type of Test	Battery Capacity	Current (Amps.)	Torque (lb.ft)	Terminal Voltage	Speed (r.p.m.)
U624-5	24	Locked Torque	154 A-H	1,150	70	11	0
		Running Torque		550	33	18	1,200
		Light Running Torque		50	0	24	3,000

TOOLS

Starter Types	Description	Tool No.
BS5, SP6 and U6	Torque bar for adjusting clutch	5693/147
	Clamp bracket and shims for adjusting clutch	5693/62
	Extractor for clutch outer race	5693/61
	Faceplate for rebushing drive end shield	5693/93

SP6 and U6 only	Key for plunger nut	5693/45
	Key for plunger stop	5693/100
	Key for plunger stop (with modified slot)	5693/103
	Dolly for pressing on clutch housing	5693/94
BS5 only	Key for plunger stop	5693/190
	Key for plunger stop (with modified slot)	5693/106
	Dolly for pressing on clutch housing	5693/95

TURBOCHARGERS

SIMMS-EBERSPACHER TURBOCHARGER

DATA

Make	Simms.
Type	23350.
Weight:	
Air cooled	37.5 lb. (17 kg.)
Water cooled	55 lb. (25 kg.)
Maximum speed	38,500 r.p.m.
Installation	Mounted direct on exhaust manifold.
Nozzle	10.2/9.5/11.7/2.

DESCRIPTION

The Simms-Eberspacher turbocharger (Fig. 1) is essentially a high-speed supercharging blower, consisting of the turbine rotor, bearing housing and compressor rotor. These main parts are built up as a small compact unit and mounted on the engine exhaust manifold, see Fig. 3.

The turbine rotor is located at one end of the bearing housing, and the compressor rotor at the other. The turbine rotor and compressor rotor are coupled by a single shaft to form the rotor assembly, which is carried in two bearings, resiliently mounted in the bearing housing. The bearing housing may be air or water cooled.

The turbine rotor is welded to the shaft, whilst the compressor rotor is readily detachable, being retained by a key and a domed nut which screws on to the shaft. Due to high rotational speed involved the rotor assembly is very finely balanced in order to protect bearing life. The rotating parts are dynamically balanced to an amount not greater than 1 mm. gm. and are checked as a separate rotor assembly and again when actually installed in the complete turbocharger unit.

The turbine housing incorporates the mounting flange for the turbocharger to the exhaust manifold distance piece. The housing is of the two port type, the exhaust gas entering the turbine housing through the flanged connection and is led to the nozzle ring through two separate passages cast in the housing. The nozzle ring is located by two dowel studs and is retained by the turbine housing cover, which also provides the turbine exhaust outlet. These nozzles direct the gasses radially inwards and convert the gas pressure into kinetic energy, giving the gas a high whirl velocity before it enters, and drives, the turbine rotor.

The exhaust cone provides a connection to which the exhaust pipe may be attached.

The turbine rotor in turn drives the compressor rotor. The air enters at the centre of the compressor rotor, flows radially outwards through the compressor volute to the tangential outlet, and thence to the engine inlet. manifold. The compressor volute is made up in two halves.

A connection is taken off the inner half of the compressor volute which conveys charged air through a passage in the bearing housing to a chamber at the rear of the turbine rotor. The air then passes through a labyrinth seal machined in the rear face of the turbine wheel and emerges at the wheel periphery. This air bleed provides a degree of cooling for the bearing housing and turbine wheel, and also prevents the ingress of exhaust gas into the bearing housing.

The lubricating oil is pressure fed from the engine to the oil inlet connection which incorporates a metering orifice, direct into the bearings via a distributor pipe. The oil then drains to a sump in the bearing housing and is returned under gravity to the engine sump. A system of oil throwers, radial and axial seals placed outboard of the bearings prevents the escape of oil and the ingress of air and dirt.

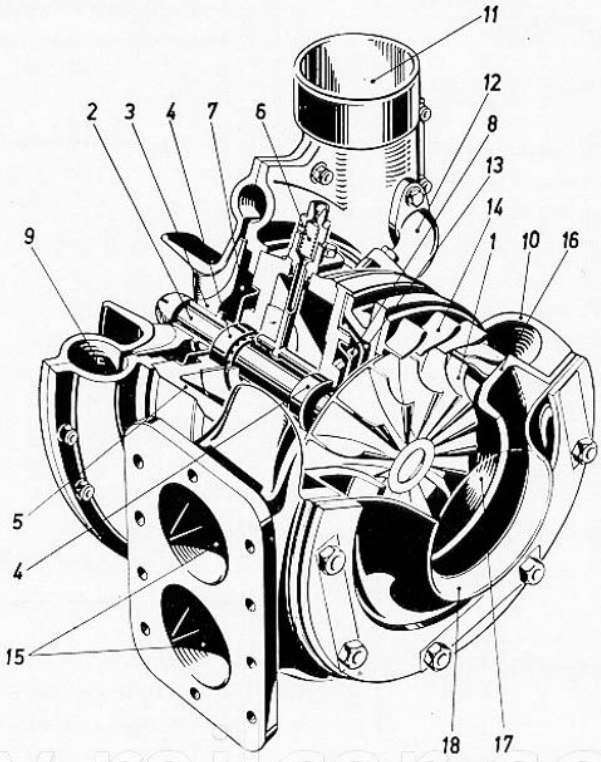


FIG. 1. CUT-AWAY VIEW OF SIMMS-EBERSPACHER TURBOCHARGER

1. Turbine wheel.
2. Shaft.
3. Compressor impeller.
4. Ball bearing.
6. Oil inlet connection (with metering orifice).
7. Isolation chamber.
8. Isolation chamber.
9. Compressor volute.
10. Turbine housing.
12. Air bleed pipe.
13. Cooling air chamber.
14. Nozzle ring.
15. Turbine inlet ports.
16. Turbine housing cover.
17. Turbine exhaust outlet.
18. Exhaust cone.

INSPECTION, MAINTENANCE AND CLEANING

Inspection Before Removing Turbocharger from Engine

Before deciding that the turbocharger is the cause of faulty operation, the following inspection should be made before removing the turbocharger from the engine:

1. Inspect oil drain and if there is a restriction in the drain pipe the oil will develop a back pressure, and the oil may then be forced through the seals.

   Note: The drain pipe line back to the engine must slope downwards for its entire length.

2. Check for restrictions in the air intake system, caused either by choked air cleaners or collapsed pipe.

3. Make sure that the crankcase breather filters are not blocked, thereby, pressurising the crankcase, since this may also force lubricating oil through the seals via the oil drain.

   If the above steps are followed and the turbocharger still shows evidence of faulty operation, check as follows:

   Remove the exhaust pipe and check for free rotation of the rotor assembly. If there is drag on the rotor assembly, or if it feels to be striking another member, it will be necessary to remove the turbocharger from the engine and return it to the makers.

MAINTENANCE

At every engine oil change it is recommended that the following instructions are carried out:

1. Check by ear the run down of the rotor assembly

2. Check all air pipes and their connections, for tightness, leakage, damage etc. (loss of air will reduce the power of the engine and may cause overheating of the turbine and engine).

3. Examine the exhaust manifold and check the tightness of the joint between the manifold and the turbine flange. Inspect for carbon deposits between the two flanges and ensure that there are no blown gaskets or distorted faces. Always use new gaskets for replacement.

4. Examine the exhaust pipe and silencer and ensure that there are no restrictions due to heavy carbon deposits or dents.

5. Inspect the oil supply and return pipes for tightness, leakage and damage.

   After every 25,000 miles (40,000 kilometres) or 600 hours of service it is recommended that the above instructions are carried out and in addition:

6. Remove induction pipe and examine compressor intake for damage. If appreciable damage such as deep scores or torn and bent impeller blades is observed, the turbocharger should be exchanged for a replacement unit in order to avoid further damage.

7. It is also recommended that the oil return pipe is disconnected and the oil flow checked.

   After every 60,000 miles (96,000 kilometres) 1,500 hours of service, it is recommended that the above instructions are carried out and in addition:

8. The compressor volute and impeller and the air delivery pipe should be cleaned, and the air bleed pipe checked for blockage.

9. The oil inlet connection and the distributor pipe assembly (item 6 Fig. 1) should be cleaned.

10. The turbine rotor and nozzle ring should be examined for possible damage. This is accomplished by disconnecting the exhaust pipe and removing the turbine housing cover. If it is found that the turbine rotor blades and or the nozzle ring blades are bent or torn, then the turbocharger must be exchanged.

11. Remove the brass nuts and the gaskets at the turbine flange and turbine housing cover.

    After every 120,000 miles (192,000 kilometres) or 3,000 hours of service or on reaching the agreed overhaul period the turbocharger should be replaced by an exchange unit, and the unit returned to the makers for overhaul.

CLEANING

The turbocharger need not necessarily be removed from the engine.

Cleaning the Compressor

After removal of the induction pipe and of the ring of bolts the outer half of the volute can be loosened by slight taps with a mallet. (Liquid jointing is used for sealing.) The two halves of the volute are centred by means of two dowel bolts.

Remove all dirt from the volute halves and the impeller by means of a soft brush and paraffin or diesel oil.

Under no circumstances, must the air bleed pipe or the impeller nut be removed, nor must wire brushes or scrapers be used for cleaning the impeller. The rotor assembly is carefully and finely balanced and must not be disturbed or damaged in any way.

If the entry of the air bleed pipe is found to be partially or completely blocked it is recommended that the unit be exchanged, as lack of cooling/sealing air would lead to overheating of the turbine and bearings. Unblocking of this pipe does not ensure that the cooling air stream will be restored and the blowing of compressed air through the pipe is also unsatisfactory and should not be undertaken.

The mating surfaces of the volute halves should be coated with a liquid jointing compound and the volute assembled by fitting and tightening the two dowel bolts in their respective holes. The remaining bolts can then be fitted and tightened.

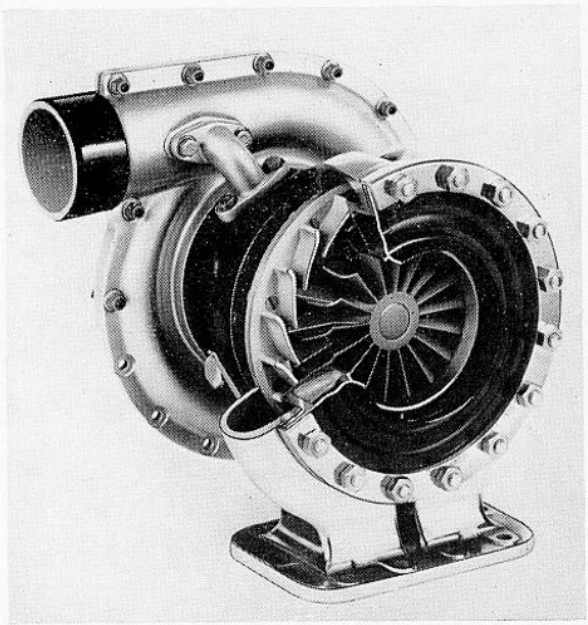


FIG. 2. PART SECTIONED VIEW OF TURBOCHARGER

If necessary, renew the rubber hose connections and fastenings on the air delivery pipe.

Cleaning the Oil Inlet Assembly

This comprises of two main parts:

The oil inlet connection which can be unscrewed from the distributor pipe assembly.

(a) The oil inlet connection (banjo screw or union) contains the metering orifice or restrictor and can only be cleaned satisfactorily if the latter is removed. The centre punch indentations retaining the restrictor should be removed by means of a pointed scraper and the withdrawal of the restrictor is made easier by gently heating the banjo screw. Cleaning is effected by washing in fuel oil or paraffin.

When re-inserting the restrictor ensure that the helix is not damaged; the use of a hammer or mallet for driving should be avoided. If necessary heat the inlet connection. The restrictor should be secured by small centre punch marks.

(b) The distributor pipe assembly is situated inside the bearing housing and may be removed by unscrewing the two holding down screws. (Ensure that no dirt is allowed to fall into the bearing housing.) Wash thoroughly in fuel oil or paraffin and blow through with compressed air. If necessary use new lock washers and a new gasket when replacing the distributor pipe assembly.

Turbocharger Units Equipped with Circulation Lubrication and Watercooled Turbine Housing

In addition to the foregoing, the following instructions must also be observed.

1. When the turbocharger is first installed ensure that the water supply is properly connected and does function.

2. The turbocharger must never be operated with the water supply disconnected as the differential thermal stresses set-up may fracture the turbine housing.

3. Periodically inspect the water pipes and their connections for leakage, blockage and corrosion.

4. If the engine is inoperative for a prolonged period the water should be drained from the turbine housing.

TROUBLES AND FAULTS

The following information is offered as a general guide to the location and remedy of any trouble which may be experienced with the turbocharger.

Breakdown of the Turbocharger

In order to avoid further damage the unit should be replaced immediately. If it is imperative to drive a short distance, then this must be done with reduced power to avoid smoke formation and thermal overload to the engine. In this case the rotor should be prevented from turning by means of the stop screw on the compressor volute. To accomplish this, remove the screw, ensure that there is no vane situated in front of the screw (turn the rotor if necessary) and then replace the screw without the spacer ring.

Rapid and Uneven Run-down of the Rotor

Remove the induction pipe and check the rotor for tightness. If the rotor can only be turned with difficulty the unit should be exchanged immediately. Meanwhile, secure the rotor as previously described.

Rough running and fierce vibrations

Exchange the unit immediately. Meanwhile, secure the rotor as previously described.

Smoky exhaust, loss of power

(a) Trouble with engine or injection system.

(b) Shortage of air:
Leaking air pipes or gas ducts between engine and turbocharger.

High depression in suction pipe due to blocked air filter or foreign matter in suction pipe.

Too high a temperature of induction air due to unfavourable position of air intake.

Resistance in exhaust pipe due to damage or heavy carbon deposits in pipe line or silencer.

Compressor volute and air delivery pipe heavily fouled (refer to **Cleaning Instruction**).

Oil in compressor volute and delivery pipe

Inadequate oil bath filter causing oil carry over. Engine breather connected to suction pipe without an oil separator.

If these points do not apply, then check the installation of the oil return pipe and ensure that it conforms to specification and has a minimum of $\frac{1}{2}$ in. bore size. Ensure that the pipe is not damaged or restricted (i.e. by dents or swollen rubber hose connections).

Ensure that the fall of the oil return pipe is not reduced below the minimum of 2 in. by operation in hilly country. If none of these causes apply then check the quantity of warm oil which flows through the units at maximum oil pressure and engine speed. This should be a maximum of 1.7 pints/min. (1 litre/min.).

If the flow is correct, then the seals in the turbocharger may be damaged and the unit must be exchanged.

Whistling noises

Leaks in compressor delivery pipe or in exhaust pipe.

SIMMS GENERAL NOTES

1. The turbocharger should never be operated under any circumstances with the compressor outlet open to atmosphere, as loss of oil would occur through lack of sealing air pressure.

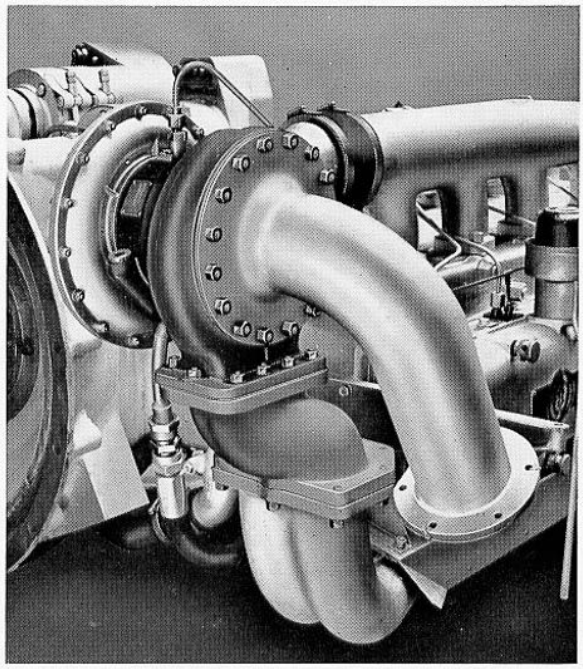


FIG. 3. SIMMS-EBERSPACHER TURBOCHARGER IN POSITION

2. To comply with conditions of Guarantee the following instructions must be observed:

(a) The fuel injection pump must not be adjusted to a higher delivery than that specified by the engine manufacturer.

(b) The turbocharger should not be operated beyond the specified overhaul period.

(c) the turbocharger must not be dismantled beyond those stages which are outlined in the following instructions.

(d) Claims under Guarantee must be submitted on Claim Form No. G.C.4/54 obtainable from Simms Motor Units Limited, Finchley, London.

HOLSET TURBOCHARGER

DATA

Make	Holset.
Type	4-650.
Maximum speed	51,000 r.p.m.
Installation	Mounted direct on exhaust manifold.
Nozzle	.345.
Lubricating oil pressure	30 p.s.i. (2.1 kg.s.cm.) minimum.

DESCRIPTION

The Holset turbocharger (Fig. 4) is essentially a high-speed supercharging blower, consisting of the turbine rotor, bearing housing and compressor rotor. These main parts are built up as a small compact unit and mounted on the engine exhaust manifold.

The turbine rotor is located at one end of the bearing housing, and the compressor rotor at the other. The turbine rotor and compressor rotor are coupled by a single shaft to form the rotor assembly, which runs in journal bearings held in the bearing housing. The whole forms a complete unit, which facilitates service to the turbochargers.

The turbine housing incorporates the mounting flange for the turbocharger to the exhaust manifold distance piece. The housing is of the two port type, the exhaust gas entering the turbine housing through the flanged connection and flows around the housing and radially inwards through a set of nozzles. These nozzles convert the gas pressure into kinetic energy, giving the gas a high whirl velocity before it enters, and drives, the turbine rotor.

The turbine rotor in turn drives the compressor rotor. The air enters at the centre of the compressor rotor, flows radially outwards through a diffuser section into the compressor housing, and leaves through a tangential outlet on the outside of the housing on its way to the engine inlet manifold.

A lubricating oil supply line is taken from the pressure side of the engine lubricating oil system to the bearing housing. Part of the oil flow lubricates the sleeve type bearings, while the other part circulates around and cools the bearing housing, which acts as a heat barrier between the compressor and the turbine. The oil is then drained back to the engine sump. Piston ring type oil seals are used at each end of the rotor shaft with air pressure from the compressor directed behind them to effectively seal off the oil. The lubricating oil connections are of the flange type, the small connection being the inlet which incorporates a gauze filter.

SERVICE INSTRUCTIONS

INTRODUCTION

In order to simplify and facilitate service on the turbocharger a complete unit which incorporates the turbine rotor, compressor rotor, shaft, bearing and bearing housing is used to replace the corresponding parts in the turbocharger.

The following procedure is based on using this complete pre-assembled unit when servicing the turbocharger.

Inspection Before Removing Turbocharger from Engine

Before deciding that the turbocharger is the cause of faulty operation, the following inspection should be made before removing the turbocharger from the engine:

1. Inspect oil drain and if there is a restriction in the drain pipe the oil will develop a back pressure, and the lubricating oil may be forced through the seals.

   Note: The drain pipe line back to the engine must slope downwards for its entire length.

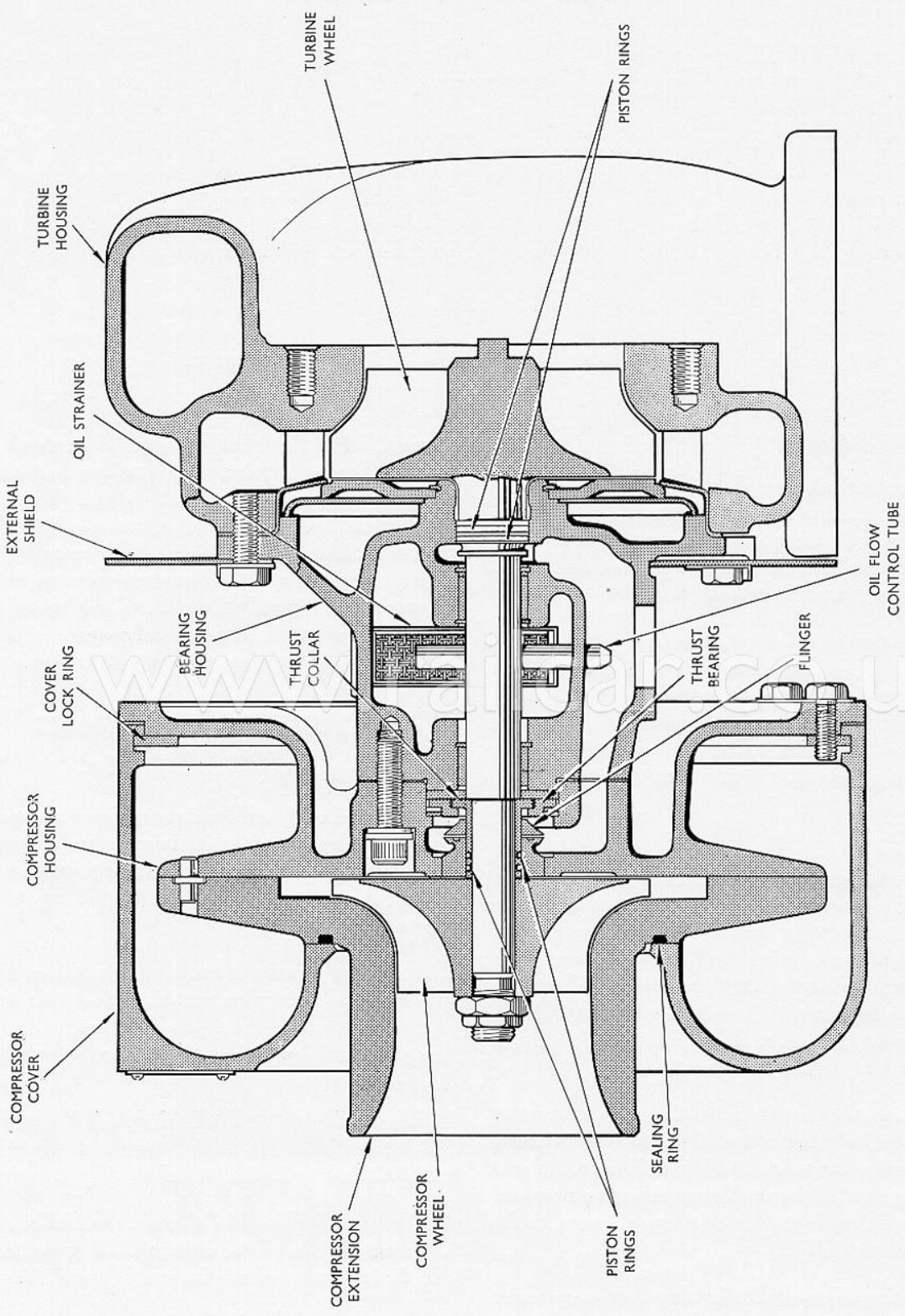


FIG. 4. SECTION THROUGH HOLSET TURBOCHARGER

2. Check for restrictions in the air intake system, caused either by choked air cleaners or collapsed pipe.

3. Make sure that the crankcase breather filters are not blocked, thereby pressurising the crankcase, since this may also force lubricating oil through the seals via the oil drain.

If the above steps are followed and the turbocharger still shows evidence of faulty operation, check as follows:

Remove the exhaust pipe and check for free rotation of the rotor assembly. If there is drag on the rotor assembly, or if it feels to be striking another member, it will be necessary to remove the turbocharger from the engine for inspection.

DISMANTLING

1. With the intake and discharge parts covered, wash the exterior of the turbocharger thoroughly before dismantling.

Caution: Do not use solution that will damage the finished surfaces.

Important: Before dismantling note the relative position of the pre-assembled unit, turbine housing, compressor cover, and external heat shield. This information is very important for rebuilding the unit.

2. With the compressor end up clamp the turbine housing flange in a vice.

3. Release lock plates and remove the compressor cover cap screws.

4. Raise compressor cover from the housing spigot and after removing the lock ring with suitable pronged pliers lift the cover off the unit (Fig. 11).

5. Remove the compressor cover gasket and the "O" ring.

6. Remove the compressor extension with the dowels.

7. Release lock plates and remove the cap screws which hold the turbine housing to the pre-assembled unit.

8. Remove the pre-assembled unit from the turbine housing. The heat may have distorted the spigot fit between the two castings so that it may be necessary to remove the turbine housing from the vice and drive these two members apart. Use only rubber or plastic mallet for this purpose. Be extremely careful to avoid cracking or otherwise damaging the unit during this operation. Care should also be taken to prevent dropping the nozzle ring which fits loose in the turbine housing and may fall out when the turbine housing is removed.

Important: Before removing the external shield note its position. It should be re-assembled in the same position.

9. Spread the external shield and remove it from the pre-assembled unit.

Note: To preserve the inner parts for future salvage value, do not dismantle any further. If the inspection reveals the necessity of replacing any inner parts, use the replaceable pre-assembled unit mentioned in the **Introduction**.

Caution: To prevent damaging the rotors, the pre-assembled unit should be placed in the cardboard protector which holds the new unit.

INSPECTION

1. Examine both rotors for damage or distorted vanes and for possible contact with housings or compressor extension. The spacing and contour of the vanes must be uniform.

2. The rotor should be checked for excessive radial movement which should not exceed .020 in. (.508 mm.) on model 3 units and 0.23 in. (.584 mm.) on model 4 units, measure at the ends of the rotor assembly.

Caution: It is not recommended cleaning the rotors because of the possibility of disturbing the delicate rotor balance or getting foreign matter inside the assembly.

3. Inspect the pre-assembled unit for any obvious damage.

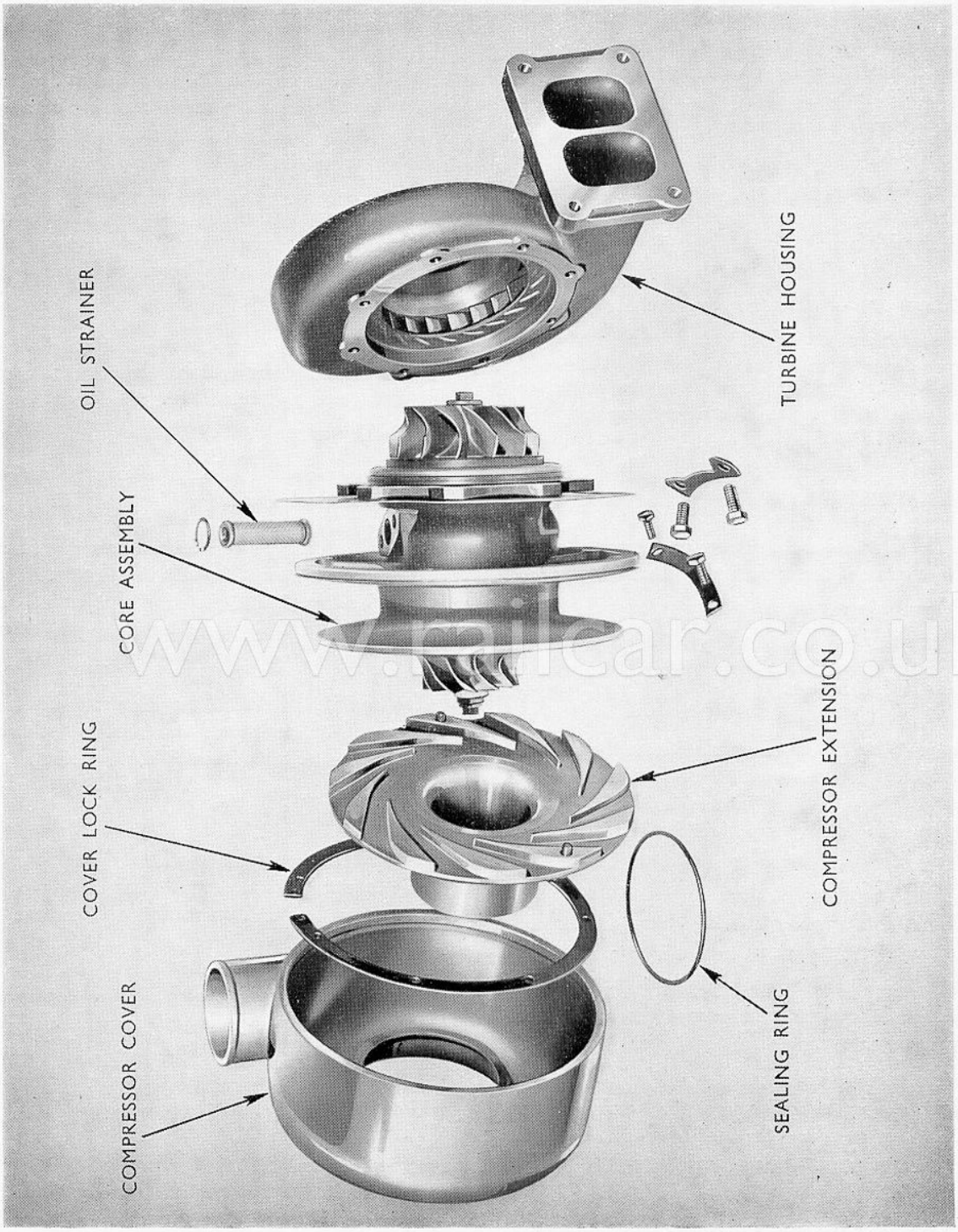


FIG. 5. EXPLODED VIEW OF HOLSET TURBOCHARGER

Note: Any of the above conditions may be symptoms of malfunctioning of the inner parts and the pre-assembled unit must be replaced.

4. The nozzle ring should be reusable unless the nozzle vanes are bent or broken, or the spacing is not uniform.

5. The turbine housing should be inspected for cracks or excessive scoring in the outlet contour.

6. The compressor extension should be replaced if badly scored or worn from rotor contact.

7. The compressor cover should be replaced if damaged.

ASSEMBLY

Make certain that all parts are clean before assembly. Clean conditions must be observed during the assembly operations. Special care should be taken not to damage either rotor during the assembly. Even a slight bend in one vane can upset the balance or cause high stresses, leading to early failure. If vanes are bent accidentally, do not try to straighten.

1. Place turbine housing, bearing housing end up, in a vice, clamping on the mounting flange. Install nozzle ring in the turbine housing if it has been removed (Fig. 6).

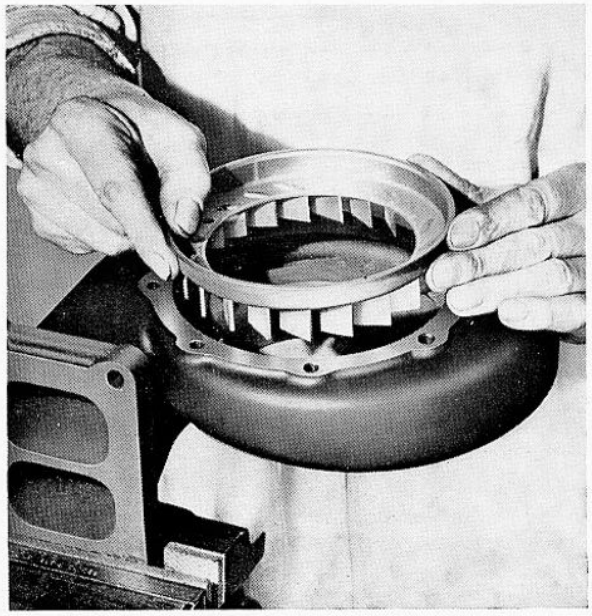


FIG. 6. INSTALLING NOZZLE RING

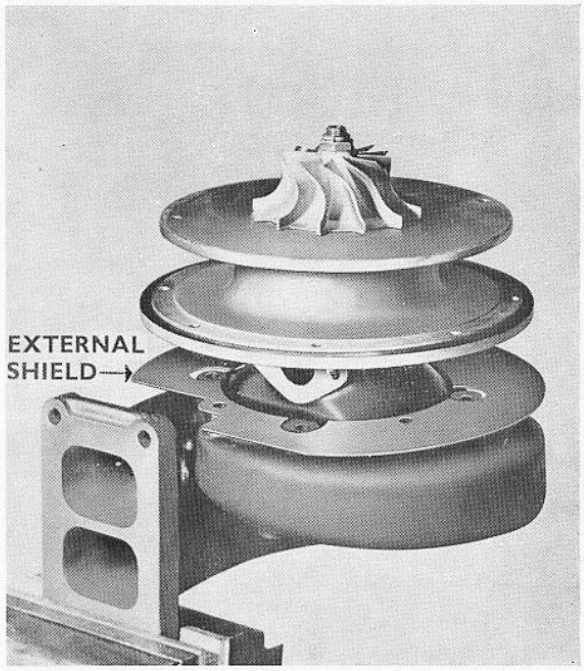


FIG. 7. POSITION OF EXTERNAL SHIELD

2. Spread external shield and replace it on the bearing housing end of the pre-assembled unit in the same position as before dismantling (Fig. 7).

3. Assemble pre-assembled unit to the turbine housing with lock plates and cap screws clamping the external shield (Fig. 8).

4. Tighten cap screws to 12 lb. ft. (1.65 kg.m.) torque and lock them with the lock plates.

5. Install a new compressor cover gasket.

6. Put the cover lock ring in place on compressor housing (Fig. 9).

7. Install compressor extension with dowels (Fig. 10).

8. Install a new "O" ring on the compressor extension (Fig. 10).

9. Place the compressor cover over the housing and with pronged pliers spring the lock ring in the compressor cover groove. (Fig. 11).

10. Install lock plates and cap screws. Rotate the cover to the required position and tighten cap screws to 5-6 ft. (.82 kg.m.) torque. Lock the screws by bending up the corners of the lock plates.

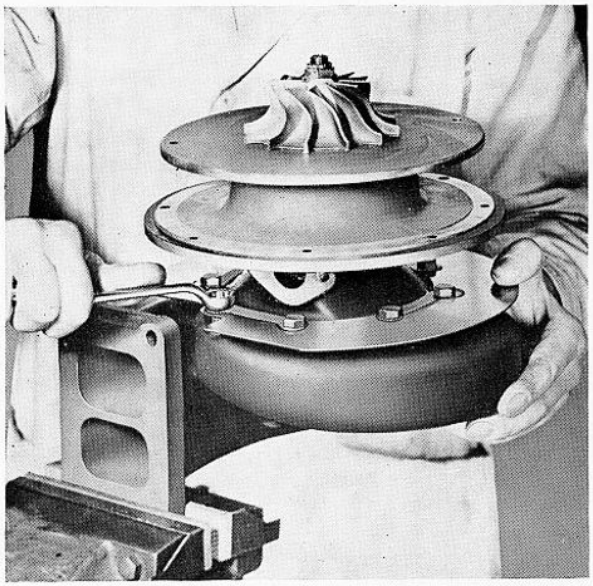


FIG. 8. ASSEMBLING CORE ASSEMBLY TO TURBINE HOUSING

11. Spin rotor assembly by hand and make sure that it rotates freely.

To Remove Turbochargers

1. Disconnect the air intake pipe, exhaust pipe and pipe to engine inlet manifold.

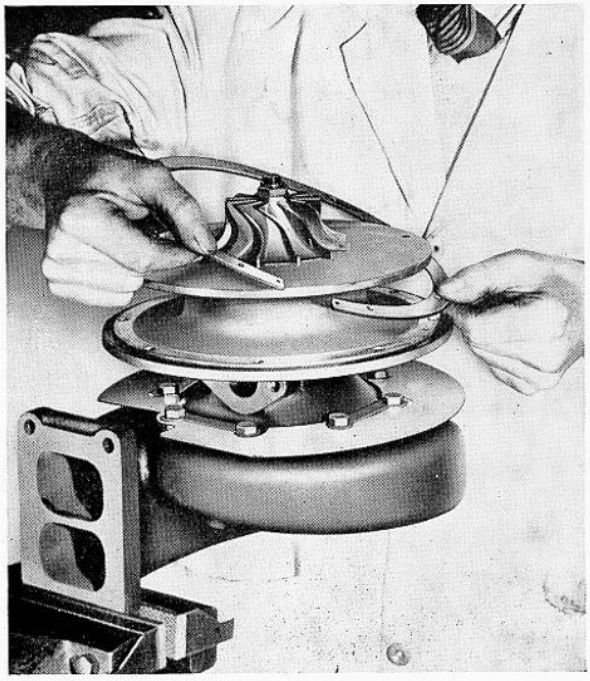


FIG. 9. PLACING LOCK RING OVER COMPRESSOR HOUSING

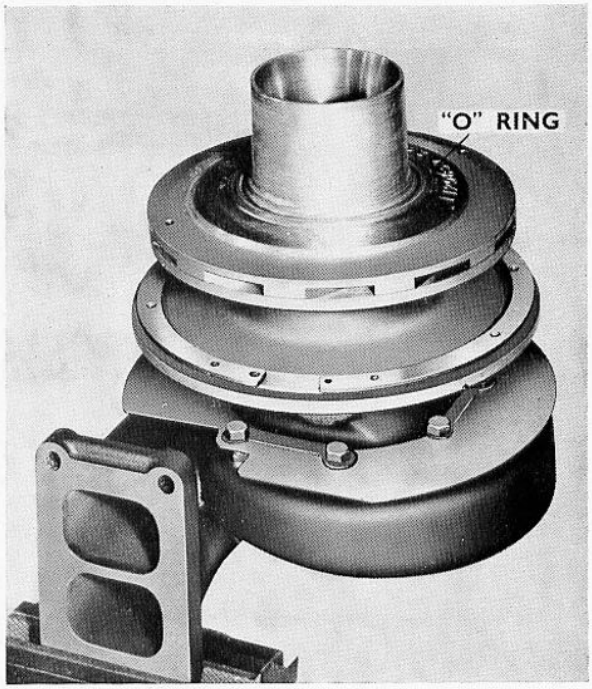


FIG. 10. COMPRESSOR EXTENSION AND 'O' RING IN POSITION

2. Disconnect the lubricating oil feed pipe and drain pipe connections.

3. Remove the nuts securing turbocharger to the exhaust manifold, and lift the turbocharger from the engine.

Note: Take precautions to prevent dirt getting into the lubricating oil pipes, air intake and discharge connections. If the turbocharger is not being refitted immediately, plug or tape over the open unions and connections.

To Fit Turbochargers

Replacement of the turbocharger on the engine is the reverse of the removal procedure, noting the following points:

Special care should be exercised when fitting joints so that there is no possibility of joints overhanging the metal facings and breaking off and going through the turbocharger.

On the turbine inlet joint, omit the centre web that divides the two flow passages.

"Thred-Gard" supplied by the Crane Packing Limited, Slough, Bucks, should be applied to all studs, bolts and

nuts used for fastening the exhaust pipe to the turbocharger and also for the distance piece which is fitted between the exhaust manifold and the turbocharger.

Before fitting the exhaust pipe spin the rotor assembly by hand to make sure that it rotates freely.

Performance of the engine can be seriously affected by intake and exhaust system leaks.

FIG. 11. REMOVING OR INSTALLING LOCK RING IN COMPRESSOR COVER

AIR COMPRESSOR

DATA

Make	Clayton Dewandre.
Type	P.C.G.A. 239.
Bore	2.625/2.626 in. (66.675/66.70 mm.).
Stroke	1.75 in. (44.45 mm.).
Delivery	10 cu.ft. (0.283 cu.m.) per minute, at 1,000 r.p.m.
Initial clearance of piston in bore	.001/.0025 in. (.0254/.0635 mm.).
Drive	Gear type coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.

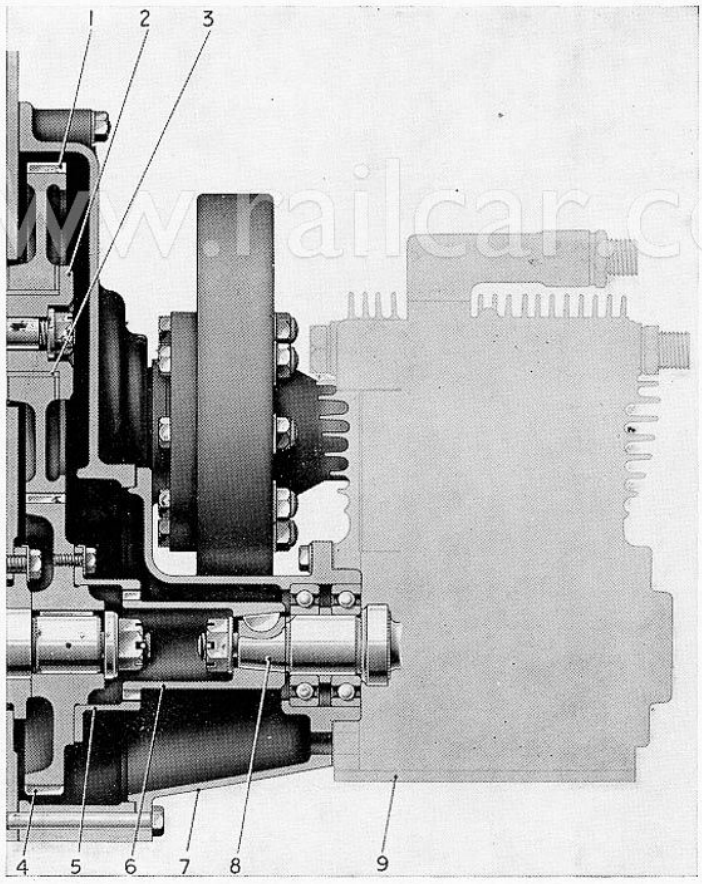


FIG. 1. COMPRESSOR DRIVE

1. Idler gear.
2. Idler spindle.
3. Floating bush.
4. Camshaft gear.
5. Compressor coupling gear.
6. Compressor coupling.
7. Compressor drive housing.
8. Compressor driving shaft.
9. Compressor.

DESCRIPTION

The compressor is flange-mounted at the front of the engine on the auxiliary drive casing and driven directly from the timing gear train through an extension coupling gear fastened to the camshaft drive gear (Fig. 1).

The crankshaft runs in ball-races, one located in the end cover and two in the drive housing. The connecting rods are white metalled at the big ends and bronzed 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 separate inlet and delivery valves for each cylinder. The valves are discs held in cavities and are spring loaded. The delivery valves are removable through plugs in the head for inspection and removal of carbon. The inlet valves cannot be inspected without head removal.

The rotation of the compressor crankshaft moves the piston down the cylinder, drawing air in through the inlet valve, and on the return stroke the air is compressed and discharged through the delivery valve.

On some installations an air compressor is separately driven from an auxiliary drive in the transmission.

LUBRICATION

Lubricating oil is supplied under pressure to the compressor through an external pipe connected to the engine main oil gallery. The oil is fed through a communicating member which is fitted to the crankshaft centre journal. Oil reaches the big end bearings through drilled passages in the crankshaft. The gudgeon pins, cylinder walls, pistons and crankshaft ball bearings are lubricated by oil thrown out by the big end bearings. Surplus oil drains back to the sump, via the auxiliary drive casing, through an aperture in the compressor casing. No daily inspection is necessary. Drain completely when engine oil is changed.

MAINTENANCE

The only maintenance required is at engine oil change. If the compressor is slow in building up pressure in the reservoir or fails to do so, and provided there are no leakages in other parts of the system the valves and springs should be removed and any carbon deposit removed. If the valves become ridged or distorted they should be renewed, relapping the valve seats if necessary.

Inspect the whole air-pressure system periodically for leaks in pipes, valves and cylinders. Leaks result in the compressor overheating.

The air inlet filter should be periodically dismantled, washed in petrol and dried.

The frequency of cleaning is solely dependent on the operating conditions.

To Remove

1. Disconnect the air and oil pipe connections.
2. Remove the nuts and setscrews securing the compressor drive housing and compressor to the auxiliary drive casing, and withdraw housing and compressor complete with coupling gear from the engine.

To Fit

Reverse the removal procedure, taking care to ensure that the teeth on the coupling gear members mesh with each other. A new joint may be required.

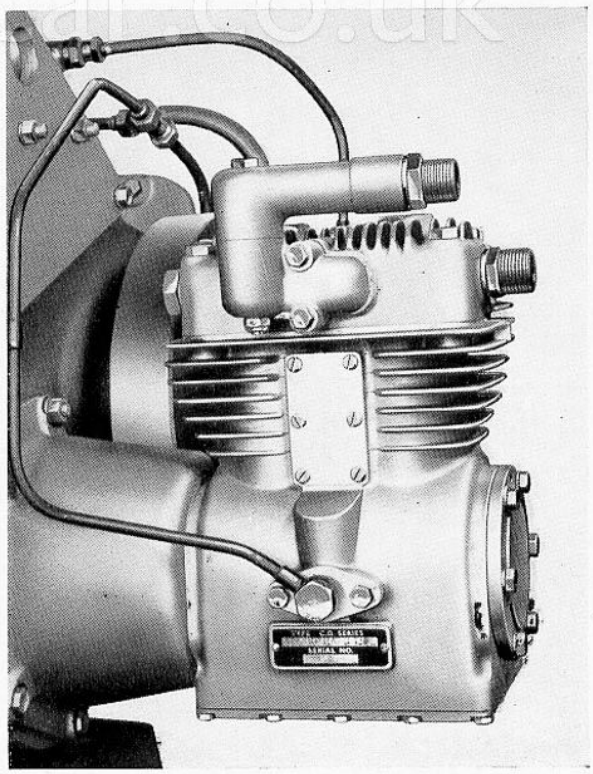


FIG. 2. COMPRESSOR IN POSITION (horizontal engine)

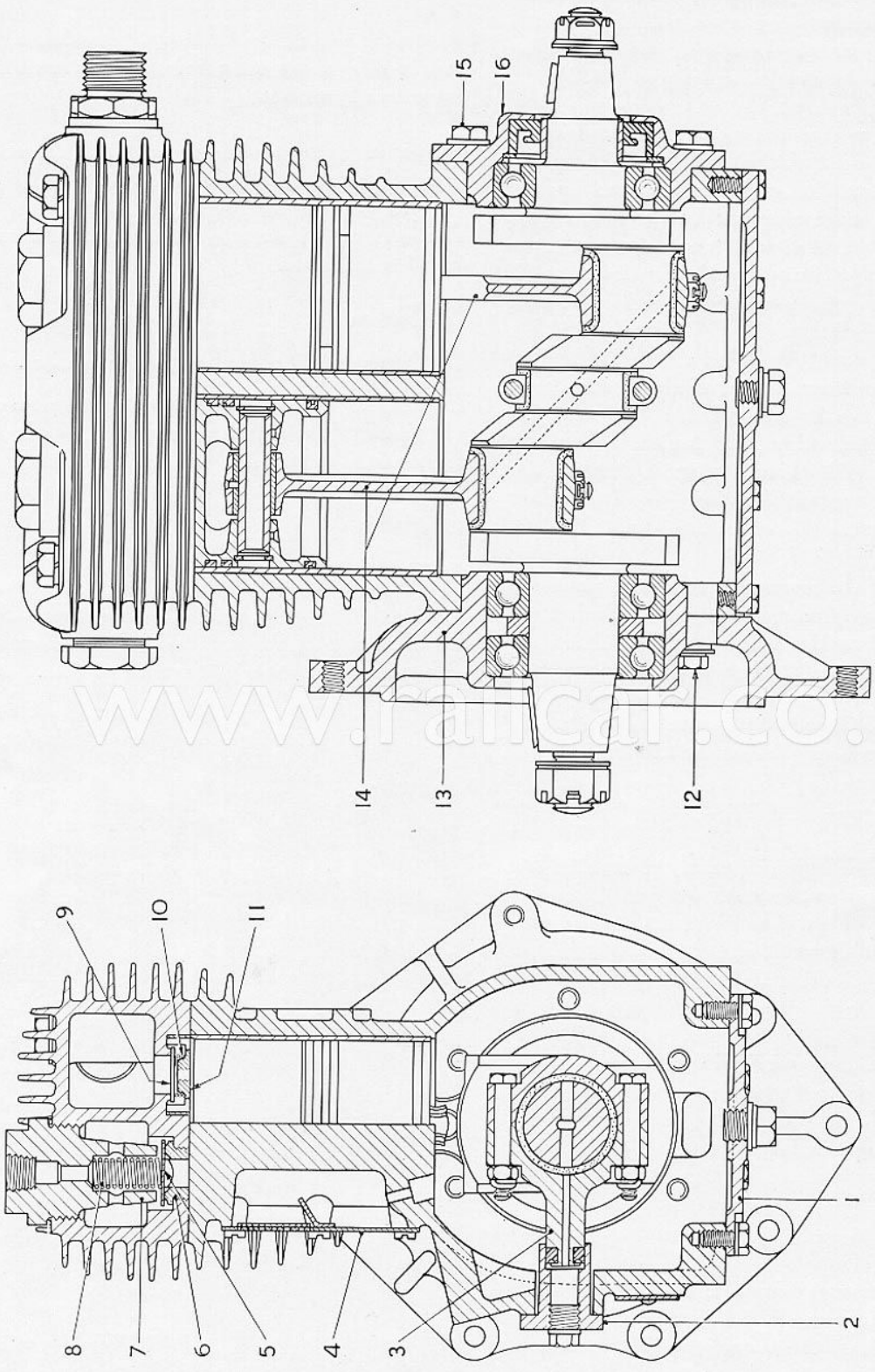


FIG. 3. TYPICAL SECTIONS THROUGH THE COMPRESSOR

1. Base cover.
2. Oil inlet supply flange.
3. Lubricator strap.
4. Breather assembly.
5. Delivery valve disc.
6. Delivery valve seat.
7. Delivery valve cap.
8. Delivery valve spring.
9. Inlet valve.
10. Inlet valve spring.
11. Inlet valve keepers.
12. Setscrew.
13. Drive housing.
14. Connecting rod.
15. Setscrew.
16. Rear end cover.

To Dismantle

1. Remove the crankcase breather assembly.

2. Remove the setscrews securing the bottom cover to the crankcase and remove the cover.

3. Remove the setscrews and lift off the cylinder head.

4. Remove the lubricating oil inlet supply flange and unbolt the communicating member from the centre journal of the crankshaft.

5. Mark the connecting rods and their corresponding caps. Remove the caps and withdraw the connecting rods and piston assemblies through the top of the cylinder bores.

6. Remove the setscrews securing the flat end cover and ease off the cover, two $\frac{5}{16}$ in. B.S.F. tapped holes are provided in the cover for this purpose.

7. Remove the split pin and nut from the end of the crankshaft and remove the coupling gear.

8. Remove setscrews securing the drive housing to the crankcase, then withdraw the housing together with the complete crankshaft assembly.

9. Withdraw the crankshaft from the drive housing.

To Dismantle 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, then remove the valve springs and discs.

Piston and Rings

The original bore diameter is 2.625/2.626 in. (66.75/66.70 mm.) and the standard clearance for cast-iron pistons is .001/.0025 in. (.0254/.0635 mm).

Fit new standard rings if wear in bore is +.005 in. (.127 mm.). If wear in bore is ±.005/.010 in. (.127/.254 mm.) bore out to ±.010 in. (.254 mm.) and fit new .010 in. (.254 mm.) oversize pistons and rings, and fit new oversize rings if wear is ±.010/.015 in. (.254/.381 mm.).

Wear above +.015 in. (.381 mm.) should not normally occur.

Piston and scraper ring gap should not exceed .012 in. (.310 mm.). Gaps on new rings should be between .003/.006 in. (.076/.152 mm.) on butt-jointed types and .002/.004 in. (.051/.102 mm.) 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. (.076 mm.) 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 4.123/4.127 in. (104.7242/104.8258 mm.) between centres.

Valves

The free length of delivery valve springs should be 1.7/64 in. (28.1788 mm.) but if found to be 1.1/16 in. (26.9875 mm.) or less, they should be renewed.

To Assemble

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

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

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

3. Fit the crankshaft to the drive housing, fitting also the coupling gear to the crankshaft and secure with nut, washer and split pin.

4. Insert the crankshaft into the crankcase and secure the drive housing to the crankcase using a new joint between the faces.

5. Fit the flat end cover using a new joint

6. 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.

7. Fit the communicating member for the lubricating oil to the centre journal of the crankshaft. Fit the oil inlet supply flange. Care should be taken during this operation so as not to damage the seal when inserting the communicating member into the seal housing.

8. Fit the bottom cover using a new joint.

9. Fit the crankcase breather assembly.

To Assemble 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. Fit 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. Fit the inlet manifold using a new joint.

4. Fit the cylinder head using a new gasket.

TACHOMETER GENERATORS

DATA

Make	Smiths Motor Accessories Ltd.
Type	'M'—Gear Driven—Fig. 1.
Code No.	M.D.G.23/4.

Make	Smiths Motor Accessories Ltd.
Type	S.T. 1101/01—Gear Driven—Fig. 2.
Voltage	24.
Code No.	Y.80822.
Shroud with Clips—Code No.	41-151-144-00.

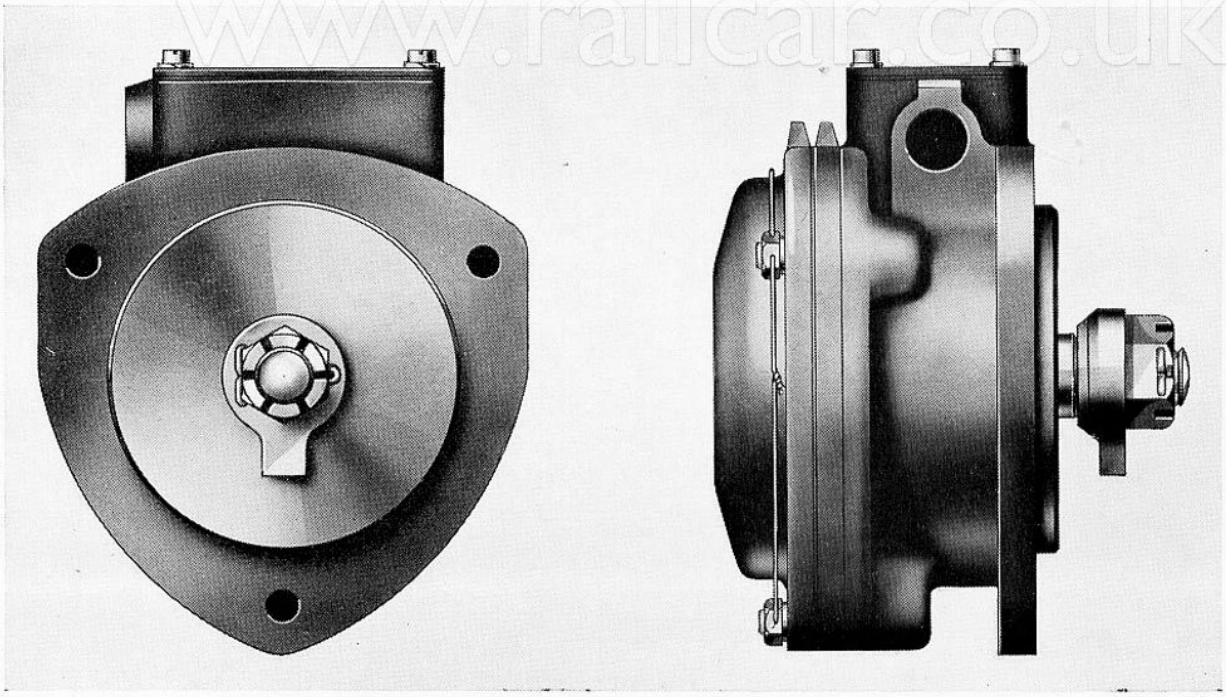


FIG. 1. 'M' TYPE TACHOMETER GENERATOR

DESCRIPTION

The purpose of the tachometer transmitter is to record electrically the engine speed by means of an indicator mounted on the driver's control panel.

The tachometer generator is flange-mounted as follows:

Vertical Engine

At the oil pump drive thrust housing at the rear of the engine block, and the drive is provided by a dog extension on the oil pump drive spindle.

Horizontal Engine

On the front of the crankcase cover, and the drive is provided by a dog extension bolted to the fuel injection pump drive gear.

Should failure occur in the transmitter it is recommended that the unit be returned for overhaul.

To Remove (Type ST1101/01) Fig. 2.

1. Isolate from batteries by the battery cut-off switch if fitted, or by disconnecting at the terminals.

2. Remove the shroud from the transmitter and disconnect the electrical connections.

   Mark the connections to ensure that they are connected to the correct terminals when refitting.

3. Remove the shroud from the electrical conduit, then withdraw the connections from the shroud.

4. Unscrew the three nuts securing the transmitter and lift the transmitter off the studs.

To Remove ('M' Type) Fig. 1.

1. Isotate from batteries by the battery cut-off switch if fitted, or by disconnecting at the terminals.

2. Remove the terminal box cover on the generator and disconnect the electrical connections.

   Should electrical conduit piping be connected to the generator, this should be removed.

   Mark the connections to ensure that they are connected to the correct terminals when refitting, then withdraw the connections from the terminal box.

3. Refit the terminal box cover.

4. Unscrew the three nuts securing the generator to the crankcase cover and lift the generator off the studs.

To Fit

Fitting is the reversal of the removal procedure, ensuring that the dog on the driven shaft engages in the slot provided in the driving member.

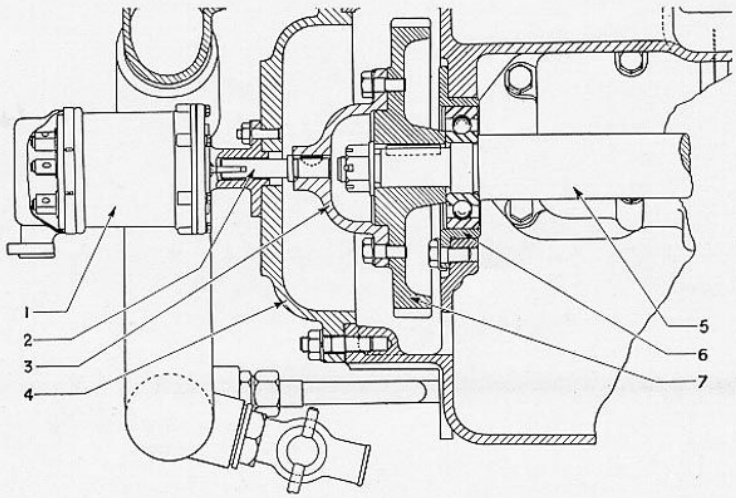


FIG. 2. TACHOMETER GENERATOR TYPE ST1101/01

1. Tachometer generator.
2. Dog extension.
3. Adaptor flange.
4. Injection pump drive cover.
5. Injection pump drive shaft.
6. Bearing housing.
7. Injection pump timing wheel.

THROTTLE MOTOR

DATA

Throttle motor shaft shims	Available in the following thicknesses:
	0.005 in. (0.127 mm.) Part No. Z4/46517
	0.010 in. (0.254 mm.) „ „ Z4/46518
	0.015 in. (0.381 mm.) „ „ Z4/46519
Throttle motor piston seal shim	0.003 in. (0.076 mm.) Part No. Z4/46549.

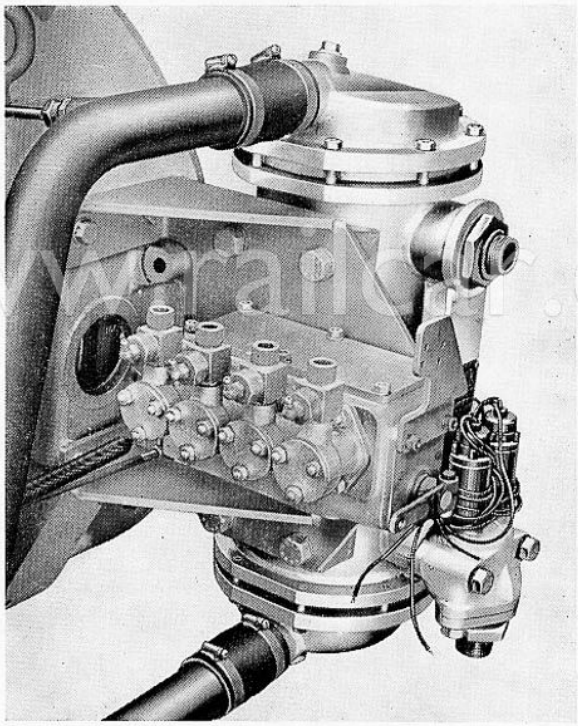


FIG. I. THROTTLE MOTOR IN POSITION

DESCRIPTION

The throttle motor is usually mounted on the engine back plate or mounting bracket adjacent to the fuel injection pump (Fig. 1).

The throttle motor is operated by air, through the media of electro-pneumatic (EP) valves, from the throttle controller at the driver's position. The air compressor mounted on the engine or independently provides air for operating the throttle motor.

The pistons in the air cylinders on the throttle motor operate the actuating levers, which in turn operate the lever which is linked to the accelerator lever on the fuel injection pump, in a series of speed positions. Adjustment of the actuating levers is provided by screws and locknuts.

A second lever may be fitted to the other end of the throttle motor which is operated by a manual controller, enabling the engine speed to be increased to a predetermined amount, usually about 800 r.p.m. It will sometimes be found necessary, especially during cold weather to use this manual controller, to increase the speed of the engine for a few moments after the engine starts. As soon as the engine has warmed up slightly, the manual controller should be returned to the "closed" position.

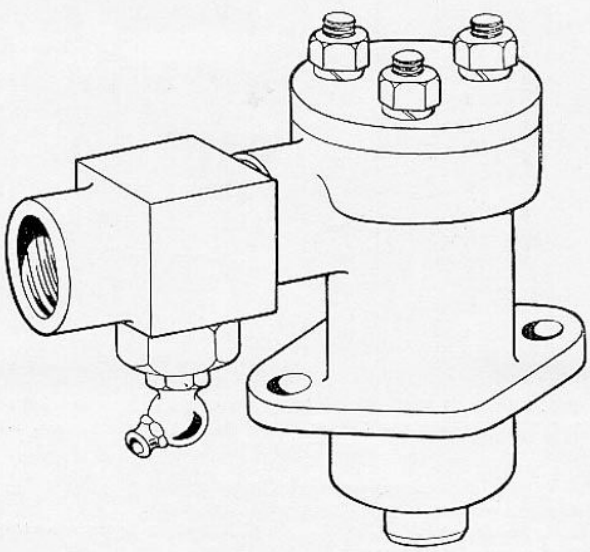


FIG. 2. THROTTLE CONTROL MOTOR PISTON AND CYLINDER ASSEMBLY, SHOWING LUBRICATOR

MAINTENANCE

The construction of the throttle motor is such that very little maintenance is required. Check all joints for oil leakage and pipe unions for compressed air leakage.

Lubricate the air cylinders and pistons with an oil gun, through the lubricators provided (Fig. 2).

Note: It is important that the throttle motor is not over lubricated.

To Check for Air Leaks

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

To Remove

1. Disconnect the compressed air pipes to the air cylinders on the throttle motor.
2. Disconnect the linkage between fuel injection pump and throttle motor lever.
3. Disconnect the linkage to the manual controller when fitted.
4. Unscrew the four nuts securing the throttle motor to the engine back plate or mounting bracket and remove throttle motor.

To Dismantle

1. Remove the loose air pressure reducing valves from the air inlet ports when fitted.
2. Unscrew the two nuts securing each air cylinder to the casing and detach the cylinders by gently prising with a screwdriver.
3. On the air cylinders, unscrew the three nuts, remove the cylinder cover and withdraw the piston assembly from each cylinder.
4. On the piston assemblies, unscrew the nut and remove the retaining washer, seal and shims when fitted.
5. Remove the side cover.
6. Remove the control levers and keys from the shaft.

On some throttle motors the lever, which is linked to the fuel injection pump, is pinned to the shaft.

7. Unscrew the nuts and detach the end cover and bush, then withdraw the actuating shaft assembly from the casing.

8. Retain the shims fitted to the shaft between the bush and distance piece at the cover end.

To Assemble

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

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.

Ensure that the shims are fitted between the bush in the cover and the distance piece—see **Data** for thickness of shims available.

Examine the air cylinder bores, if excessively scored or worn, a new or reconditioned air cylinder assembly should be fitted.

Examine the piston seals for wear or deterioration and renew if necessary.

When renewing the 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 piston seal and the piston—see **Data** for thickness of shim available.

In order to centralise 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.

Renew all paper joints and lightly smear all working parts with engine oil.

To Fit

Fitting is the reversal of the removal procedure.

Note: Before fitting the compressed air pipes, check that the loose air pressure reducing valves, if fitted, are in position in the inlet ports.

Adjustment

Before connecting the fuel injection pump to the throttle motor the following adjustments should be made to the fuel injection pump if required:

Idling Speed

Run the engine until warm, then ensure that the 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 injection pump, which should then be securely locked by tightening the lock nut.

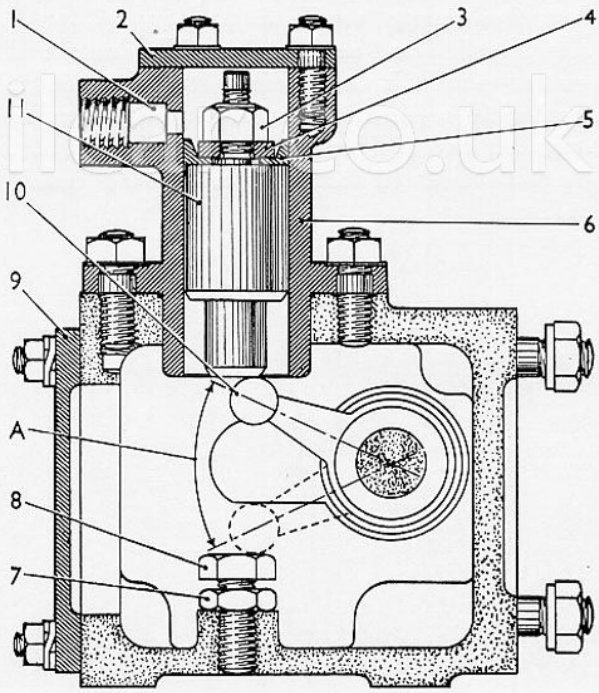


FIG. 3. SECTION THROUGH THROTTLE CONTROL MOTOR SHOWING TRAVEL OF ACTUATING LEVER AT FULL THROTTLE

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.

Maximum Speed

The maximum-speed stop is set and securely locked when the engine was tested.

The settings of the idling and maximum speeds, limit the movement through which the fuel injection pump lever can travel.

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

With the fuel injection pump lever in the idling position, adjust the control rod to the throttle motor so that the throttle motor does not interfere with the idling speed.

Note: The fuel injection pump idling stop and not the throttle motor should determine the idling position.

With compressed air applied, adjust the actuating levers in the throttle motor by the adjusting screws to give the engine speeds required.

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

Having set all the adjusting screws, they should be securely locked by means of the locknuts.

In order to avoid possible damage to the maximum speed stop on the fuel injection pump, the control rod should be set so that a 0.005 in. (0.127 mm.) feeler gauge will just pass between the stop on the fuel injection pump lever and the stop on the fuel injection pump.

AIR CLEANERS

DESCRIPTION—Coopers type 4PD.2117/3

Air drawn from the atmosphere passes direct into the oil bath filter where it is filtered in two stages. The filter element is shown in Fig. 4.

Firstly, by the reversal of the air flow, and impingement upon the surface of the oil which is contained in the well at the bottom of the filter, and secondly by passing the resultant oil laden air through a scrubber unit. Dust laden oil then gravitates through the scrubber to the bottom of the filter where it settles, whilst the cleaned air passes through the outlet of the cleaner to the engine.

The filter scrubber can be removed from the filter bowl after detaching the bowl from the air filter head.

MAINTENANCE

Air cleaner maintenance consists of keeping the bottom oil well and the filter scrubber unit clean, and also the oil to the level as indicated in Fig. 4.

For complete maintenance, proceed as follows:

1. Remove the air filter bowl from the air filter head, by unfastening the wing nuts, lowering the bowl on to the hooks, swinging the eye bolts clear, and then lifting and turning the bowl. Remove to a suitable place for cleaning.
2. Lift the filter scrubber unit out of the bowl and wash thoroughly in paraffin.
3. Pour the oil out of the bowl and clean out any sludge, and wash in paraffin.
4. Refill the inner bowl with clean oil to the rim indicated by the words "Oil Level".
5. Reassemble the cleaner completely.

The periods at which maintenance should be carried out depend on circumstances and experience, but a rough guide is provided by the depth of sludge accumulating at the bottom of the filter bowl. The same oil as is used in the engine sump should be used for the air cleaner.

Weekly Inspection: Check oil level, top up if necessary.

10,000 Mile (16,000 kilometres) Inspection: Clean and refill.

Warning: Never underfill with oil—this reduces cleaning efficiency, or overfill—this reduces engine performance.

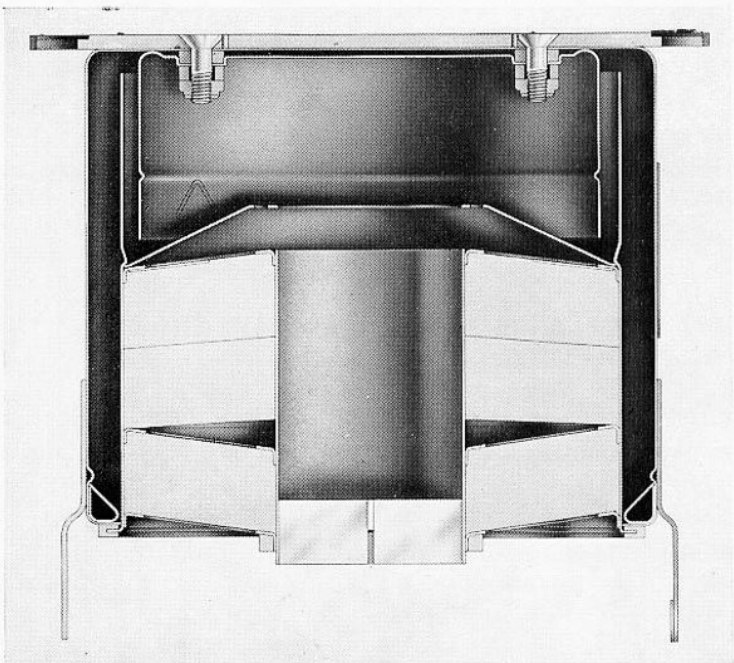


FIG. 4. AIR CLEANER—COOPERS TYPE 4PD.2117/3

BURGESS—OIL WASHED AIR CLEANER WITH CENTRIFUGAL OIL BATH PRE-CLEANER

DATA

Make	Burgess.
Type	Heavy duty oil washed air cleaner with centrifugal oil bath pre-cleaner.
Reference Nos.:	
Pre-cleaner	OBC-120/2.
Screen type final filter (Base)	OBA-120/7.
Oil Capacity (approx.):	
Pre-cleaner	1 pint (.57 litres) approx.
Final filter	6 pints (3.4 litres) approx.

BURGESS—OIL WASHED AIR CLEANER

DATA

Make	Burgess.
Type	Heavy duty oil washed air cleaner.
Reference No.	OBBR-120/2.
Oil Capacity	6 pints (3.4 litres) approx.

COOPERS—OIL WASHED AIR CLEANER

DATA

Make	Coopers.
Type	Heavy duty oil washed air cleaner.
Reference No.	4PD.2117/3.
Oil Capacity	9 pints (5.1 litres) approx.

DESCRIPTION—Burgess type OBA-120/7 and OBC-120/2.

It will be seen from Fig. 1 that the Burgess type OBA-120/7 air cleaner and type OBC-120/2 pre-cleaner are attached to each other by means of a clip. The upper component is a centrifugal type pre-cleaner, and the lower an oil-washed screen type final filter. The filter is provided with mounting brackets enabling attachment to any main frame structure.

Air drawn from the atmosphere, first passes through the centrifugal pre-cleaner, the velocity of which is increased as the air reaches the top of the annular conical duct. On entering the pre-cleaner, the air is given a rotary motion by the louvres at the bottom of the pre-cleaner, particles of grit or dust in the air are hurled, by centrifugal force, to the outside of the dome, from where they fall into the oil contained in the annular outer cup.

The pre-cleaner removes the major part of the grit and dust, and the air flow is then reversed and passes down through the central duct for final cleaning which is done in two stages.

Firstly, by reversal of the air flow, and impingement upon the surface of the oil which is contained in the well at the bottom of the screen filter, and secondly by passing the resultant oil laden air upwards through the working screens. The dust laden oil then gravitates through the screens to the annular outer part of the cup, where it settles at the bottom, whilst the cleaned air passes through the outlet of the cleaner to the engine. There are communicating oil holes between the outer and inner parts of the well and the screen is made in two parts, the upper fixed and the lower detachable.

MAINTENANCE

Air cleaner maintenance consists of keeping the pre-cleaner, bottom oil cup and the detachable portion of the screen filter clean, and also the oil to the levels as indicated in Fig. 2.

For complete maintenance, proceed as follows:

1. Remove the dome on the pre-cleaner by unfastening the toggle clips which secure it, and remove to a suitable place for cleaning.

2. Remove the annular outer cup by unfastening the clip.

3. Pour the oil out of the annular outer cup and clean out any sludge.

4. Refill the annular outer cup with fresh oil to the rim indicated by the words "Oil Level".

5. Remove the oil cup at the bottom of the screen filter, by unfastening the toggle clips which secure it, and remove to a suitable place for cleaning.

6. Pour the oil out of the oil cup and clean out any sludge.

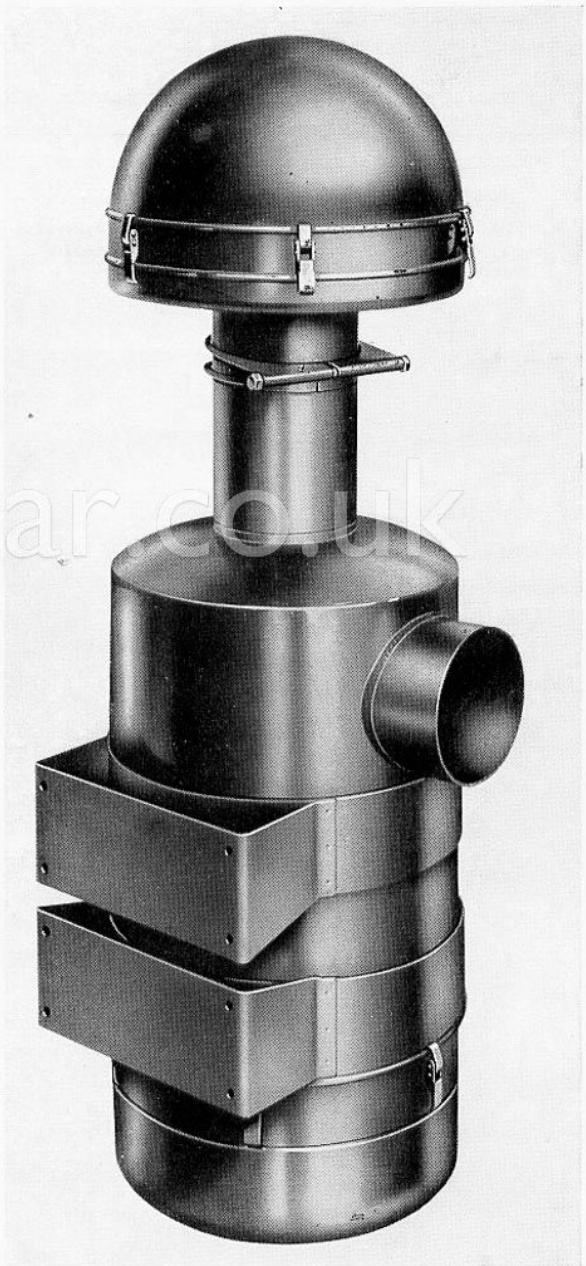


FIG. 1. BURGESS TYPE OBA-120/7 AIR CLEANER AND OBC-120/2 PRE-CLEANER

7. With the bottom oil cup removed, the detachable portion of the screen can be removed. This should be cleaned thoroughly in paraffin. The fixed portion, remaining in the main casing, does not need to be cleaned.

8. Refill the bottom oil cup with fresh oil, including the inner cup, to the rim indicated by the words "Oil Level".

9. Reassemble the cleaner completely.

The periods at which maintenance should be carried out depend on circumstances and experience, but a rough guide is provided by the depth of sludge accumulating at the bottom of the oil cup in the screen filter. This depth should not exceed $\frac{1}{2}$ in. The same oil as is used in the engine sump should be used for the cleaner.

Weekly Inspection: Check oil levels, top up if necessary.

10,000 Mile (16,000 kilometres) Inspection: Clean and refill.

Warning: Never underfill with oil—this reduces cleaning efficiency, or overfill—this reduces engine performance.

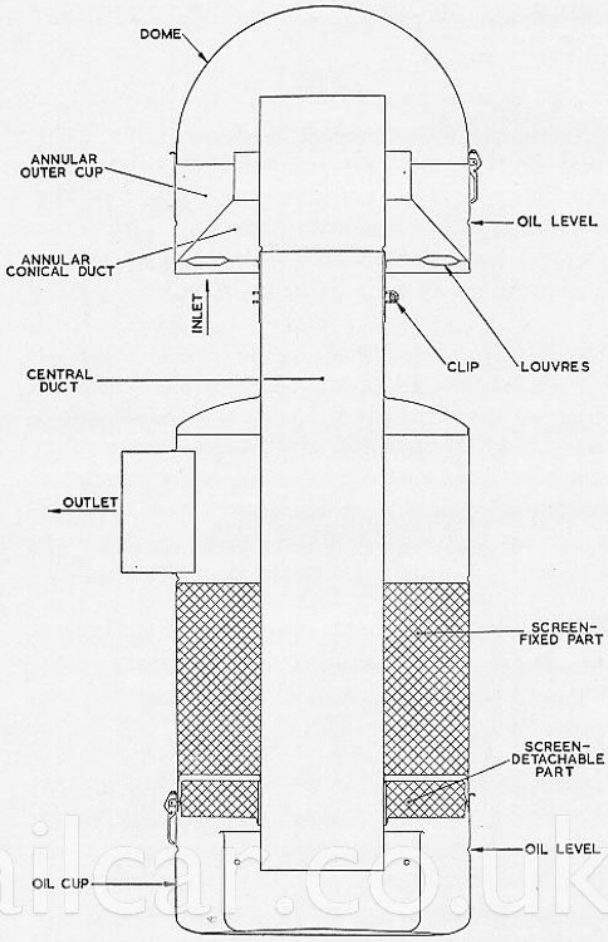


FIG. 2. SECTION THROUGH AIR CLEANER—BURGESS OBA-120/7 AND OBC-120/2

DESCRIPTION—Burgess type OBBR-120/2

Air drawn from the atmosphere passes through the louvres at the head of the Burgess type OBBR-120/2 air filter, and then passes down through the central duct where it is filtered in two stages, Fig. 3.

Firstly, by the reversal of the air flow, and impingement upon the surface of the oil which is contained in the well at the bottom of the screen filter, and secondly by passing the resultant oil laden air upwards, through the working screens. The dust laden oil then gravitates through the screens to the annular outer part of the cup, where it settles at the bottom, whilst the cleaned air passes through the outlet of the cleaner to the engine. There are communicating oil holes between the outer and inner parts of the well and the screeen is made in two parts, the upper fixed and the lower detachable.

MAINTENANCE

Air cleaner maintenance consists of keeping the bottom oil cup and the detachable portion of the screen filter clean, and also the oil to the level as indicated in the bottom oil cup.

For complete maintenance, proceed as follows:

1. Remove the oil cup at the bottom of the screen filter, by unfastening the toggle clips which secure it, and remove to a suitable place for cleaning.

2. Pour the oil out of the oil cup and clean out any sludge.

3. With the bottom oil cup removed, the detachable portion of the screen can be removed. This should be cleaned thoroughly in paraffin. The fixed portion, remaining in the main casing, does not need to be cleaned.

4. Refill the bottom oil cup with fresh oil, including the inner cup, to the rim indicated by the words "Oil Level".

5. Reassemble the cleaner completely.

The periods at which maintenance should be carried out depend on circumstances and experience, but a rough guide is provided by the depth of sludge accumulating at the bottom of the oil cup in the screen filter. This depth should not exeed $\frac{1}{2}$ in.

The same oil as is used in the engine sump should be used for the air cleaner.

Weekly Inspection: Check oil level, top up if necessary.

10,000 Mile (16,000 kilometres) Inspection: Clean and refill.

Warning: Never underfill with oil—this reduces cleaning efficiency, or overfill—this reduces engine performance.

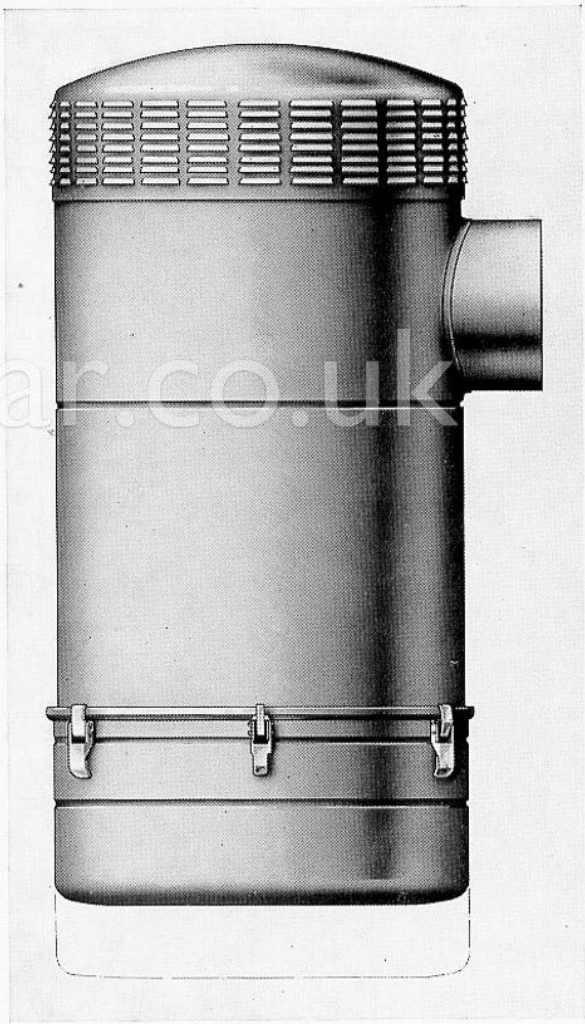


FIG. 3. AIR CLEANER—BURGESS OBBR-120/2

RIGHT-ANGLE DRIVE UNIT AND DRIVE

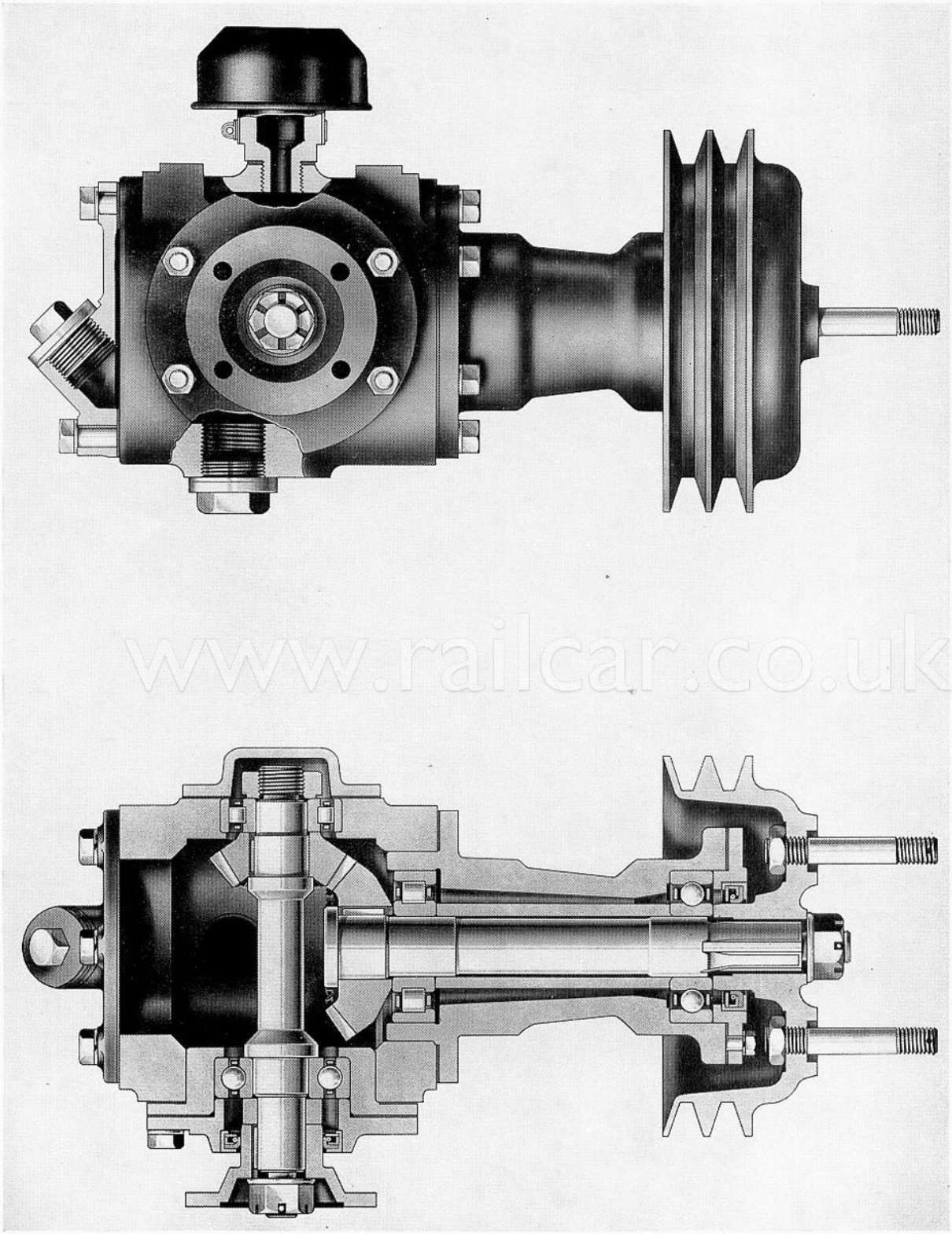


FIG. 1. THE RIGHT-ANGLE DRIVE UNIT

RIGHT-ANGLE DRIVE

DATA

Input Gear	Number of teeth 27.
Output Gear	Number of teeth 20.
Type	Straight bevel.
Gear Material	Nickel-Chromium, forged.
Backlash when in mesh with Mating Gear	.004 to .008 in. (.1016 to .2032 mm.).
Oil Seals:	
Casing	Gaco No. M.I.S.17.
Housing	Super No. 237120.
Oil Capacity	1 pint (.6 litre) approx.

PROPELLER SHAFT

DATA

Part No.	541181.
Position	When right-angle drive is mounted independently of the engine and driven from front of engine crankshaft.
Make	Layrub.
Type	$65 \times 1\frac{3}{8}$ in., 2-4 Series, No. 2408.
Part No.:	
Layrub Coupling	1699 Z 16.
Coupling Shaft	546418.
Position	When right-angle drive is mounted direct on engine crankcase cover.
Make	Layrub.
Type	No. 2402.

DESCRIPTION

The right-angle-drive unit, Fig. 1, used for a fan drive can be fitted to give an increase or decrease in speed of ratios of 1.35/1 and .741/1 of input speed. The unit can be mounted as follows:

1. On the crankcase cover, Fig. 2. The unit is then gear driven from the drive spindle which also drives the water pump spindle. The unit is driven through a short Layrub propeller shaft.

2. When the unit is mounted away from the engine it is then driven through a Layrub propeller shaft, direct from the front of the engine crankshaft.

The unit consists of a cast-iron casing in which two shafts, input and output, are housed at right-angles to each other. The shafts are carried in ball and roller bearings and connected together by bevel gears, the gears being keyed to each shaft.

A wire-mesh-element type breather is fitted in the top of the unit. The unit is also fitted with a filling plug, overflow plug and a drain plug. On some units a combined oil filler and level plug is incorporated in the cover.

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

MAINTENANCE

Particular attention should be paid to the right-angle-drive when the engine is checked over generally after the first 5,000 miles (8,000 kilometres) or 100 hours' service.

The unit should be drained and refilled with new lubricating oil: SAE 30 (Engine Lubricating Oil).

WEEKLY INSPECTION

(1) Check oil level, top up if necessary.

(2) Check the tension of the belts driven from the unit.

30,000 MILE INSPECTION (48000 KILOMETRES)

Remove unit and inspect, renew parts if necessary.

To Remove

1. Uncouple the drive to the engine and fan.

2. Remove the four nuts securing the unit to its mounting.

3. Remove the driving belts if pulley is fitted to input shaft, and lift the unit from its mounting.

To Dismantle

1. Remove the unit from its mounting.

2. Remove the drain plug and drain the oil from the unit.

3. Remove the breather from unit.

4. Remove the nuts securing the housing to the casing and remove the housing, retaining the shims fitted between the housing and the casing.

To dismantle the housing assembly proceed as follows:

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

2. Remove the setscrews securing the oil seal housing to the housing and remove oil seal housing together with the oil seal.

3. Using a hammer and brass drift, remove the shaft, gear, inner race of roller bearing and distance piece from the housing. The outer race of the roller

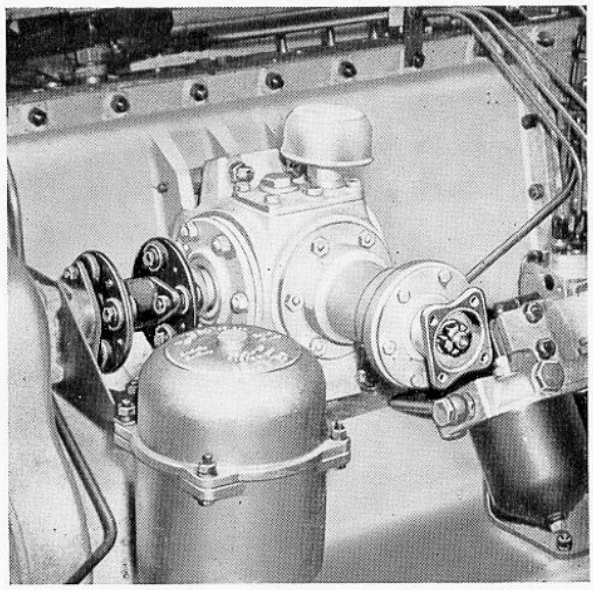


FIG. 2. RIGHT-ANGLE-DRIVE IN POSITION

bearing will remain in the housing and can be removed if necessary.

4. Remove the inner race of roller bearing and gear from the shaft.

5. Remove the remaining bearing from the housing.

To remove shaft assembly from the casing proceed as follows:

1. Remove the setscrews from the end cap and remove the cap.

2. Remove the nuts securing the oil seal housing and bearing housing to the casing.

3. Using a hammer and brass drift, remove the shaft assembly from the casing at the coupling flange end. The outer race of the roller bearing will remain in the casing and can be removed if necessary.

To dismantle the shaft assembly proceed as follows:

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

2. Remove oil seal and bearing housing together with the sealing ring from the shaft. Remove the bearing from its housing if necessary. Retain the shims fitted between the bearing housing and the casing.

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

To Assemble

Wash all parts in clean paraffin and assemble, reversing the dismantling procedure, and noting the following points:

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

2. Fit correct thickness of shims to give required backlash, see Data.

3. Examine that all joints are tight.

4. Replace the drain plug and fill the unit with oil.

To Fit

Reverse the removal procedure.

To Drain and Fill with Lubricating Oil

To Drain: Whenever possible the unit should be drained immediately after the engine has completed a run and the oil is still warm.

Place a suitable container in position and drain the oil from the unit by removing the drain plug. Replace the plug after draining.

To Fill: Remove the filler plug and fill the unit with lubricating oil to the required level. Replace the filler plug and clean the breather.

MAINTENANCE

The bolts on the propeller shaft must be kept dead tight; it is advisable to check these once a month.

OVERHAUL

The rubber inserts on the coupling require replacing when disintegration of the trunnion block and wire gauge screen becomes obvious.

1. Remove the propeller shaft.

2. Remove the coupling from the shaft.

3. Separate the two halves of the pressed-steel housing, by removing the four clamping bolts.

4. Remove the rubber blocks from the pressed-steel housings.

5. Press the spigoted trunnion sleeves from the rubbers. If the spigot is worn, the sleeve should be discarded, and the bolt holes in the shaft flange examined for ovality.

6. Press the steel trunnion sleeve into the new rubber block, using a round-nose pilot, the shank of which is turned down to fit the bore of the trunnion sleeve. The use of petroleum jelly as a lubricant facilitates assembly.

7. Press the sub-assemblies of rubber blocks and trunnion sleeves into the steel housing. This operation is eased by the application of soapy water.

8. Bolt the two pressed-steel housings together.

9. Refit the coupling to the propeller shaft, the radiused washers must be placed under the heads of the bolts with the radiused edges towards the rubber, and the bolts must be pulled up dead tight.

10. Check that the four clamping bolts are tight.

PLESSEY PUMP

DATA

Make	The Plessey Co., Ltd.
Type	2H 33 Group 2.
Model X	Shaft extension, flange end of pump.
Model Y	Shaft extension, both ends of pump.

Note: Complete overhaul of Plessey pumps involves the use of special tools and test apparatus and should not, except in emergency when the risk is justified and accepted, be undertaken by anyone not so equipped, otherwise serious damage will almost certainly result. The pump should be returned to the makers, or approved agents, for expert attention.

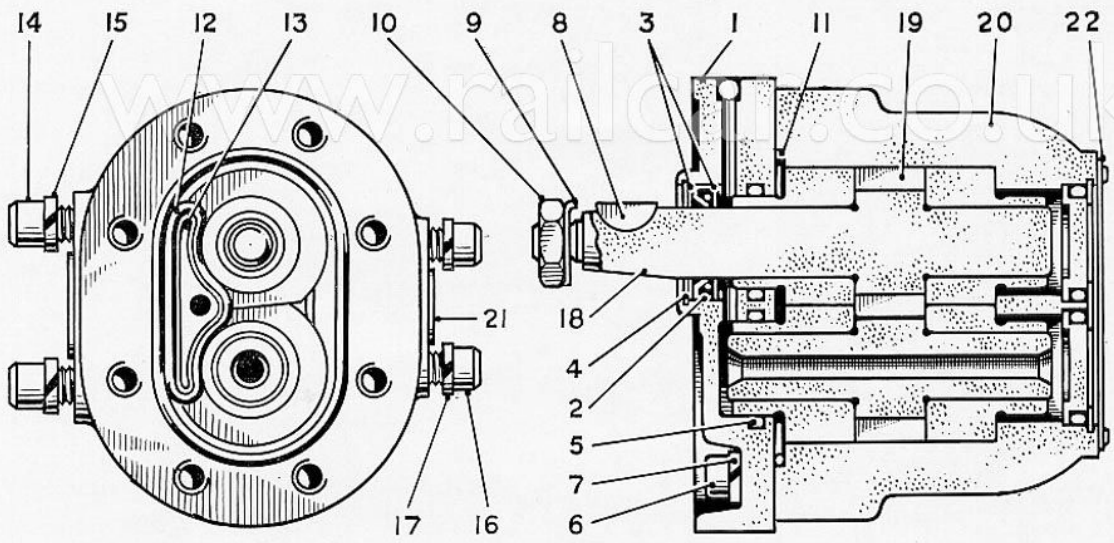


FIG. 1. SECTION THROUGH PLESSEY PUMP

1. Cover.
2. Shaft oil seal.
3. Backing washer.
4. Circlip.
5. 'O' ring (bearing shank).
6. Cover screw.
7. Spring washer.
8. Woodruff key.
9. Tab washer.
10. Drive shaft locknut.
11. 'O' ring (body).
12. 'O' ring (pressure relief plate)
13. Pressure relief plate.
14. Socket head screw (inlet port)
15. Spring washer (inlet port)
16. Socket head screw (outlet port)
17. Spring washer (outlet port)
18. Drive gear.
19. Driven gear.
20. Pump body.
21. Port dust cover.
22. Name plate.

DESCRIPTION

The Plessey spur gear type pump (Fig. 1) is of simple and robust construction. It is flange mounted on the rear of the timing case, at the front of the engine block cover (Fig. 3), the drive being taken from the water pump drive pinion and spindle. A flexible coupling is inserted between the engine driving dog and the pump to absorb any possible torsional vibration which could be transferred into the hydraulic circuit and so cause leakage.

The pump is sealed internally by means of synthetic rubber "O" rings, and the drive shaft by a standard flexible-lip type seal. The cover is secured to the body by eight screws and spring washers.

The pump incorporates pressure-loaded bearings which compensate for wear and maintain minimum possible clearance between the faces of the gears and bearings. The cover-end bearings being able, under the influence of fluid pressure, to move longitudinally in the body for this purpose.

A duct is formed between the body and the bearings at the outlet or pressure side of the pump, so that fluid under working pressure is forced through the duct and fills the space between the outer faces of the bearings and the inner face of the pump cover thus creating an inward pressure which forces the bearings towards the gears.

The pressure loaded space is restricted in size by a relief plate fitted at the inlet side to maintain the correct balance of hydraulic forces operating on the bearings.

The relief plate is surrounded by an "O" ring and provided with a hole for the release of any fluid that may seep past the seal. This hole connects with another duct formed between the body and the bearings.

Faults

Should the hydraulic system fail to operate satisfactorily, the following items should be checked before suspecting the pump:

1. Driving member properly connected.
2. Pump speed correct.
3. Sufficient fluid, and clean.
4. Leakage in the suction line.
5. Leakage in the delivery line.
6. Control valve functioning correctly.
7. Piping dented, cracked or blocked.
8. Relief valve working correctly.
9. Filter choked.
10. Shutter control and gland seals effective.

If the failure cannot be attributed to any of the foregoing causes then the pump should be inspected for possible damage to the shaft and cover seals.

To Remove

1. Disconnect the fluid piping to the pump.
2. Remove the nuts securing the pump to the housing, and remove pump from engine.

Note: Take precautions to prevent dirt getting into the fluid pipes. If the pump is not being refitted immediately, plug or tape over the open unions and connections.

To Dismantle

Important: Do not attempt any work except at a clean workbench under conditions of maximum cleanliness generally.

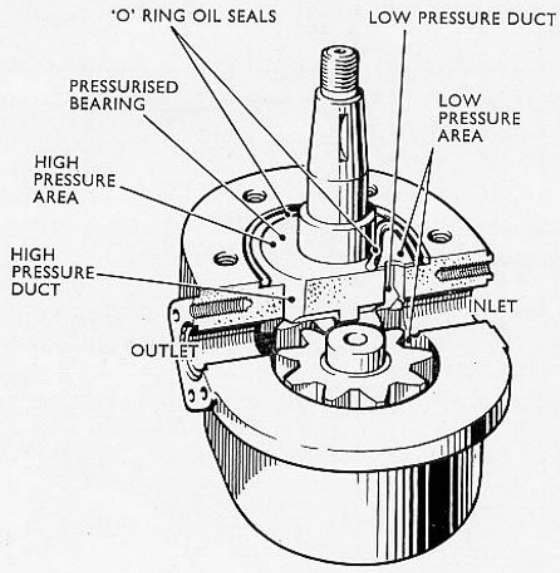


FIG. 2. CUT-AWAY VIEW OF PLESSEY PUMP

1060

The cover (Fig. 1) shaft and port adapters are pressure sealed with synthetic rubber seals which are easily renewed when necessary.

To inspect shaft seal and "O" rings proceed as follows:

First, note the position and direction of rotation of drive shaft to ensure correct reassembly, then remove the drive coupling in the following manner:

1. Hold the drive coupling in a vice, release the tab of the lockwasher and remove drive shaft locknut with a suitable spanner.

2. Remove the drive coupling from the vice and draw from shaft using an extractor; or support the drive coupling and, using a soft metal piece to protect the shaft threads, strike sharply with a hammer.

   Note: Levering against the pump casing causes damage to the bearings.

3. Remove the woodruff key.

To remove the pump cover:

1. Hold the pump body lightly in a vice (using smooth "soft" jaws across port orifices).

2. Remove eight fixing screws and lockwashers.

3. Wrap "bandage" of adhesive tape over keyway.

4. Lift cover from pump body.

The seals may now be inspected for surface imperfections but do not remove the seals unless it is necessary to replace with new.

The driving shaft seal can be taken from its housing in the cover by removing the circlip (if fitted) and pressing out seal and backing washer from inside.

To Reassemble

Important: First ensure that all parts are truly clean and that seal grooves are free from burrs and bruises, or other imperfections. When reassembling, ensure that the pressure plate is fitted towards the inlet, or low pressure side of the pump (witness marks on the top faces of the bearings usually give indication).

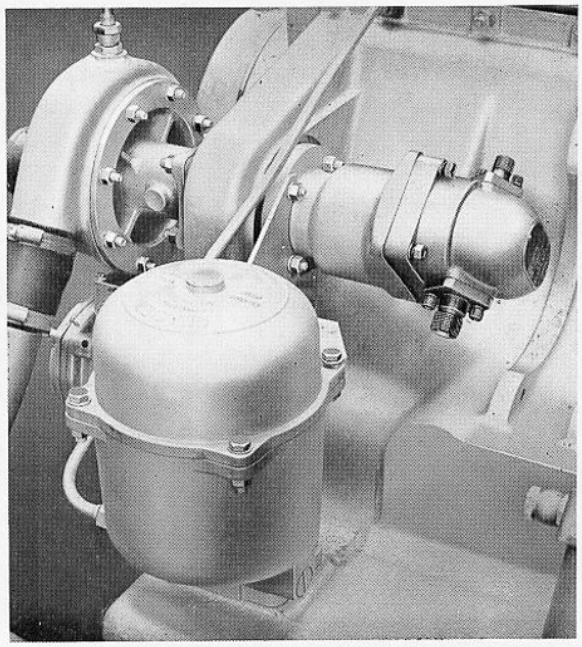


FIG. 3. PLESSEY PUMP IN POSITION

When replacing the cover after fitting a new shaft seal, care must be taken to avoid damage to the seal lip as it passes over the keyway; use a "bandage" of adhesive tape over the keyway.

"O" rings must be flexible and free from surface imperfections, and care must be exercised to ensure that they are not "trapped" when fitting the cover. Tighten the cover fixing screws evenly and securely.

Should the foregoing operations still not rectify the fault, then the need for a major overhaul is indicated and the pump should be returned to the makers, or approved agents, for expert attention.

To Fit

Replacement of the pump on the engine is the reverse of the removal procedure.

PROPELLER SHAFTS

DATA

Part No.	**350089A.**
Position	Aux. drive to bi-directional gearbox.
Make	Hardy Spicer Ltd.
Type	1700 series.
Universal joint (fixed)	KL.1708 GB.16.
Universal joint (slip)	KL.1701 GB.23
Fitting length	43 in.
Tube diameter	3.5 in.
Extension	1.25 in.
Compression	1.6875 in.
Angular movement of joint	33°/35°.

Part No.	**350604.**
Position	Between gearboxes.
Make	Hardy Spicer.
Type	1900 series.
Universal joint (fixed)	1908 GB.7.
Universal joint (slip)	1901 GB.3.
Fitting length	24.5 in.
Angular movement of joint	20°/22°.

Part No.	**545537.**
Position	Gearbox to final drive.
Make	Hardy Spicer Ltd.
Type	1900 series.
Universal joint (fixed)	1908.
Universal joint (slip)	1901.
Fitting length	62 in.
Tube diameter	4.5 in.
Angular movement of joint	20°/22°.

Part No.	**350741.**
Position	Gearbox to final drive.
Make	Hardy Spicer Ltd.
Type	1900 series.
Universal joint (fixed)	1908.
Universal joint (slip)	1901.
Fitting length	80 in.
Tube diameter	4.5 in.
Angular movement of joint	20°/22°.

Part No.	**541182.**
Position	Fan Drive.
Make	Hardy Spicer Ltd.
Type	1110 series.
Fitting length	22.087 in.
Tube diameter	2 in.
Extension	1.25 in.
Compression	1 in.

Part No.	**350213.**
Position	Fan Drive.
Make	Hardy Spicer Ltd.

DESCRIPTION

The tubular propeller shaft (Figs. 1 and 2) has universal joints of the trunnion journal and needle roller type, one end being fixed, and the other having a sliding coupling to allow for longitudinal float when running.

Each universal joint consists of a journal (3), four needle-roller bearing assemblies (2) and two yokes (1 and 10). Each needle-roller bearing assembly is retained in the yoke eye by a bearing cap (4) or circlip, and is sealed at its inner end by a seal (6) and retainer (7) assembled to the journal. A lubricator (8) and oilways drilled through each journal are provided for lubricating the bearings, a pressure relief valve is incorporated on some shafts to prevent damaging the seals when filling with a high pressure gun. The sliding coupling has an integral universal joint yoke, and the sleeve of the coupling is internally splined to engage the splined end of the propeller shaft.

The coupling is sealed at the journal end by a closing washer (9) and at the shaft end by a felt or cork seal (14) and washer (15) retained by a dust cap (13). A lubricator (11) is fitted to the sleeve yoke for lubrication purposes.

LUBRICATION

Regular lubrication with the correct lubricant is most important.

WEEKLY

Propeller shaft splines—grease.

Lubricate through the lubricators provided, with grease gun.

MONTHLY

Propeller shaft universal joints—grease.

Lubricate through the lubricators provided, with oil gun.

Inject lubricant via the lubricator provided, until it exudes through the pressure relief valve situated in the centre of the journal.

MAINTENANCE

Check the universal joints periodically for worn needle-roller bearings. This can be done by testing the lift in the joints.

Examine for slackness, the bolts securing the universal joint coupling flanges, and tighten if necessary.

If a considerable amount of oil or grease is being thrown out of the joints, check for faulty seals or lost lubricators.

To Remove

Remove the nuts and bolts from the flanges at the ends of the propeller shaft, move the sliding end along its splines, and remove the propeller shaft.

OVERHAUL

To Dismantle

1. Unscrew the dust cap (13) Figs. 2 and 3, from the sleeve yoke, and pull the complete sliding joint off the shaft.
2. Remove the dust cap, felt or cork washer, and steel washer, from the end of the shaft.
3. Bend down tabs of the locking plates, then take

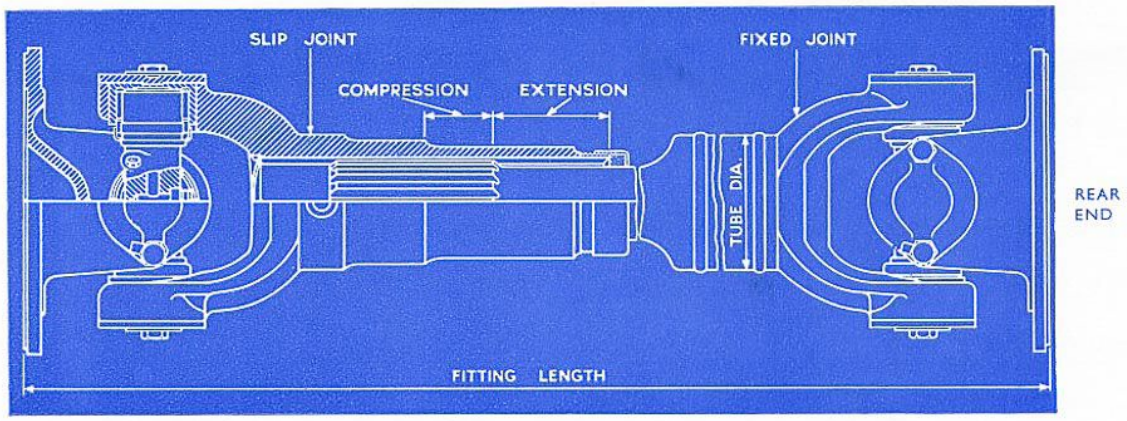


FIG. 1 THE PROPELLER SHAFT

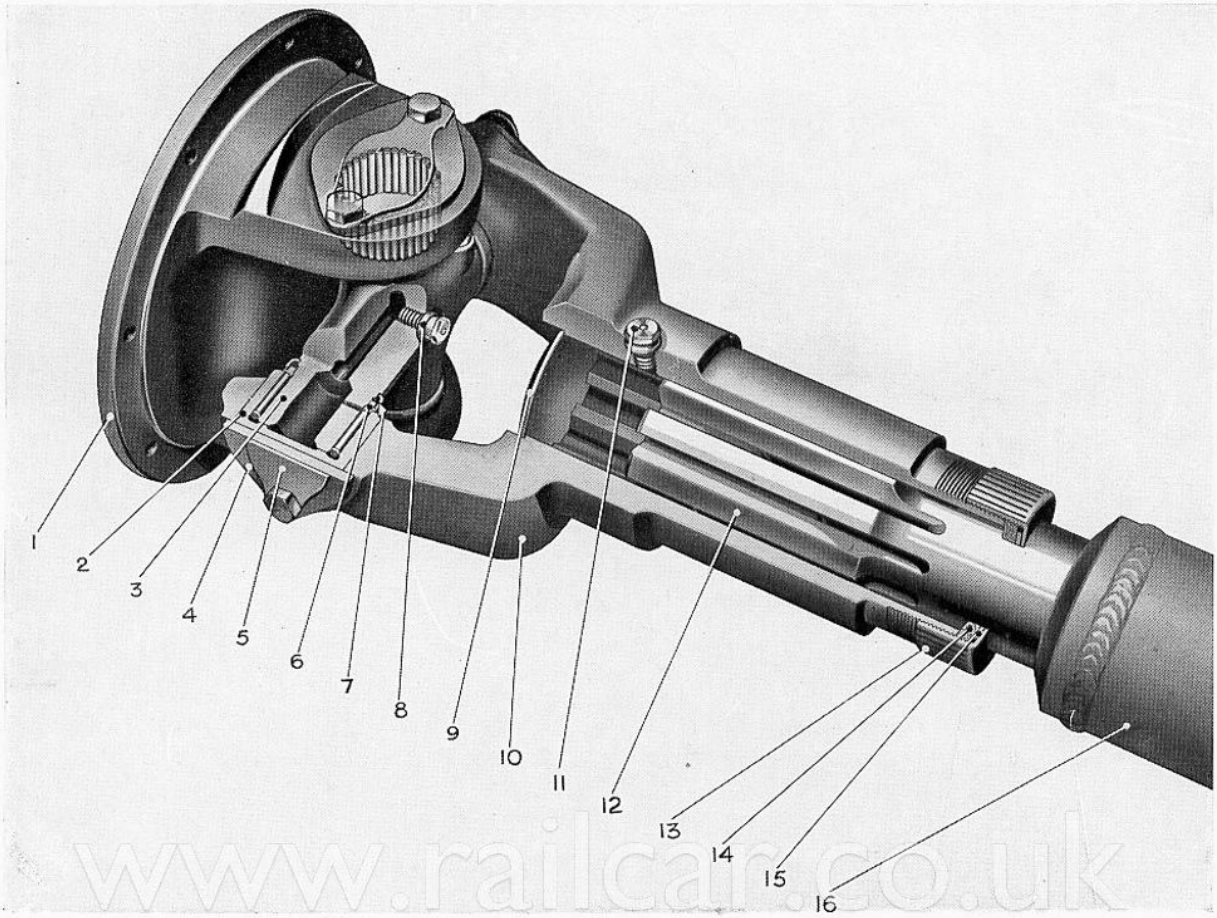


FIG. 2. SECTION THROUGH SPICER UNIVERSAL JOINT

1. Flange yoke.
2. Bearing assembly.
3. Journal.
4. Bearing cap.
5. Locking plate.
6. Bearing seal.
7. Journal retainer.
8. Lubricator.
9. Closing washer.
10. Sleeve yoke.
11. Lubricator.
12. Slip stub shaft.
13. Dust cap.
14. Felt washer.
15. Steel washer.
16. Tube.

out the retaining setscrews from the bearing caps of the yoke ears.

4. Remove locking plates (5) and bearing caps (4).

5. On some shafts, remove the circlips securing the needle-roller bearings in the yoke ears.

6. Support the flange yoke (1) and the sleeve yoke (10) on two wooden blocks.

7. Using a soft-nosed drift, slightly smaller than the outside diameter of the bearing housing, drive out from the top, the underneath bearing housing.

8. Repeat this operation for the opposite bearing, using the soft-nosed drift on the end of the exposed journal. The sleeve yoke (10) can then be removed.

9. Support the flange yoke on wood and tap out the bearings in a similar manner.

Checking Parts for Wear

1. Should the bearing race assemblies and journals be a loose fit, load markings or distortions be observed, they must be renewed complete. It is essential that the bearings are a light drive-fit in the flange and sleeve yoke eyes.

2. There should be no more than .010 in. (0.25 mm.)

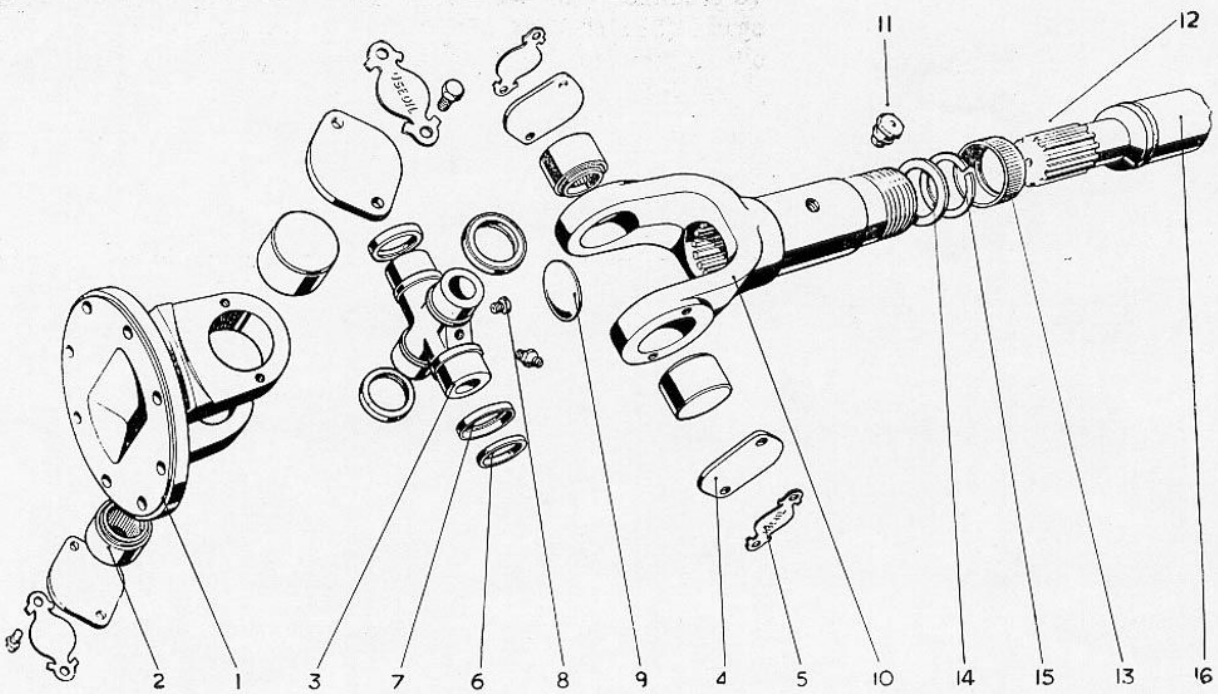


FIG. 3. EXPLODED VIEW OF UNIVERSAL JOINT (See Fig. 2 for Key to numbers)

circumferential movement between the slip stub shaft (12) and the sleeve yoke.

To Assemble

Assembly of the propeller shaft is the reverse of the dismantling procedure, noting the following points:

1. It is advisable to renew the oil seals and retainers.
2. See that all drilled holes in the journal are cleaned out and filled with oil.
3. Assemble the needle rollers in the bearing housings, if any difficulty is encountered smear the wall of the housing with oil.
4. Insert the journal (3) in the flange yoke (1).
5. Fit new oil seals, and using a drift, tap one bearing into position. It is essential that the bearing races are a light drive-fit, and are fitted with the slot on top in line with the bearing cap screw holes, so that they are prevented from rotating by the key in the bearing cap.
6. Repeat this operation for the other three bearings.
7. If the universal joints appear to bind when assembled, tap the ears lightly with the drift, to relieve any pressure on the end of the journal bearings.
8. Replace the bearing caps, locking plates and cap screws, bend up the locking tabs.
9. When assembling the sleeve yoke on to the splined shaft, smear the splines with oil.

To Fit

Replacement of the propeller shaft is the reverse of the removal procedure, noting the following points:

1. The universal flange nuts and bolts should be tightened evenly.
2. When the propeller shaft is in position, compress the felt or cork washer (14) sufficiently to ensure a good seal, this should be possible by hand tightening the dust cap (13).

AUXILIARY DRIVE UNIT

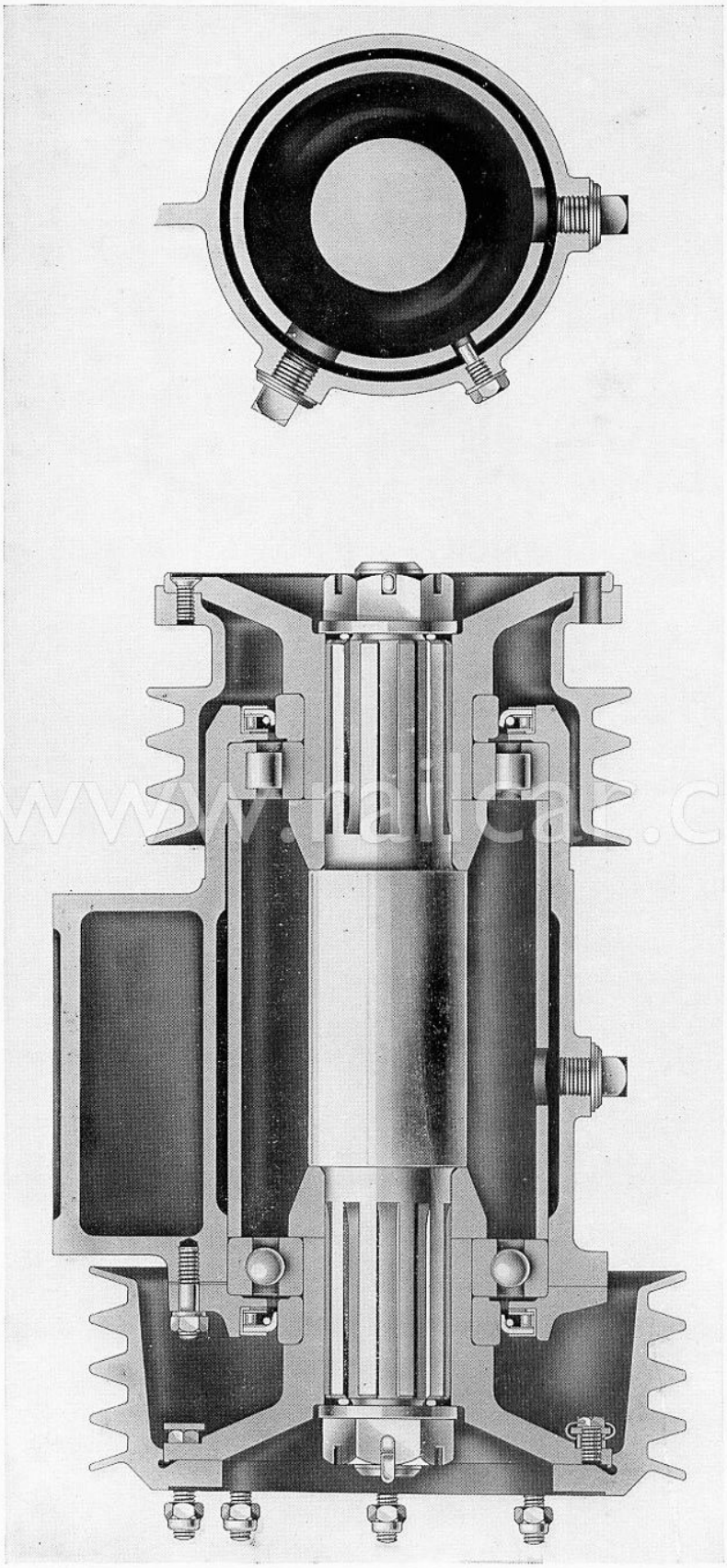


FIG. 1. SECTION THROUGH AUXILIARY DRIVE

DATA

Oil Capacity	1 pint (.6 litre) approx.
Oil Seals	Super, ref: 5254. Rubber insert.

DESCRIPTION

The auxiliary drive unit, which in this case forms part of the transmission, is used for driving two dynamos and an air compressor. The pulleys for driving the auxiliaries are attached to the coupling flanges at each end of the unit.

The unit (Fig. 1) consists of a cast-iron bearing housing bracket in which the shaft is carried in a ball and roller bearing. The coupling flanges are splined to the shaft.

Lubrication of the bearings is affected by splash, leakage of lubrication is prevented by oil seals.

The unit is fitted with a filling plug, oil level plug and a drain plug.

MAINTENANCE

Particular attention should be paid to the auxiliary drive unit when the engine is checked over generally after the first 5,000 miles or 100 hours service.

The unit should be drained and refilled with new lubricating oil: S.A.E. 30 (Engine Lubricating Oil).

WEEKLY INSPECTION

(1) Check oil level, top up if necessary.

(2) Check the tension of the belts driven from the unit.

120,000 MILE INSPECTION (192000 KILOMETRES)

Remove unit and inspect, renew parts if necessary.

To Remove

1. Remove the nuts and bolts from the front coupling flange, and then support the freewheel propeller shaft.

2. Remove Simmonds nuts from the rear coupling flange, and then move the propeller shaft to clear the protruding bolts attached to the auxiliary drive unit.

3. Remove the driving belts to the auxiliaries which the unit is driving.

4. Remove the four nuts and bolts securing the unit to its mounting, and remove the unit.

To Dismantle

1. Remove the unit from its mounting.

2. Remove the drain plug (13) and drain the oil from the unit.

3. Remove the rear pulley (1).

4. Remove split pin and nut securing the rear coupling flange (2) to the shaft (12) and remove coupling flange.

5. Remove split pin and nut securing the front coupling flange (9) and pulley (17) to the shaft (12) and remove coupling flange and pulley.

   Note: The two oil seal bearings (3 and 8) and the inner race of the roller bearing (7) should come away with the coupling flanges.

6. Remove the rubber sealing rings (10 and 15) from each end of the shaft.

7. Remove the nuts securing the oil seal housing and bearing housing (4) to the bearing housing bracket (5), and remove the oil seal housing together with the oil seal.

8. Using a hammer and brass drift, tap on the front end of the splined shaft to remove shaft, inner distance pieces (11 and 14) and ball bearing (18) from the rear end.

9. Remove oil level plug (16), followed by the removal of the outer distance piece (6).

10. Remove the two inner distance pieces from the shaft if required.

11. Remove the outer race of the roller bearing from the bearing housing bracket if necessary.

To Assemble

Wash all parts in clean paraffin and assemble reversing the dismantling procedure, and noting the following points:

1. When replacing the outer distance piece (6), make sure that the small positioning hole in the outer distance piece is opposite the oil level plug.

2. Examine the oil seals, sealing rings and joints and renew if necessary.

3. Examine that the joints are tight.

4. Replace the drain plug if not already fitted, and fill the unit with oil up to the oil level plug hole. Replace filler and oil level plugs.

To Fit

Reverse the removal procedure.

HEAT EXCHANGER

DESCRIPTION

The heat exchanger consists of a cylinder, tube stack, water boxes, and on some heat exchangers a safety expansion joint.

Cylinder

The cylinder, cast or fabricated, is machined and bored to receive the removable tube stack.

Tube Stack

The tubes are threaded through alternative disc and ring baffles spaced along their length, and at each end are expanded and solder bonded into tube plates. This obviates packings or ferrules and affords a double insurance against tube plate leakages. Baffles, besides directing the fluid over the tubes, give support along their length while the tube ends are trimmed to reduce inlet turbulence. Tube stacks are interchangeable.

Water Boxes

These are proportioned to reduce turbulence and pressure loss.

Expansion Joints

On some heat exchangers one tube plate is fixed between the cylinder and the water box; the other is free to move, permitting expansion of the stack as a whole, while the safety expansion ring with double synthetic rubber joints prevents interleakage of the fluid media.

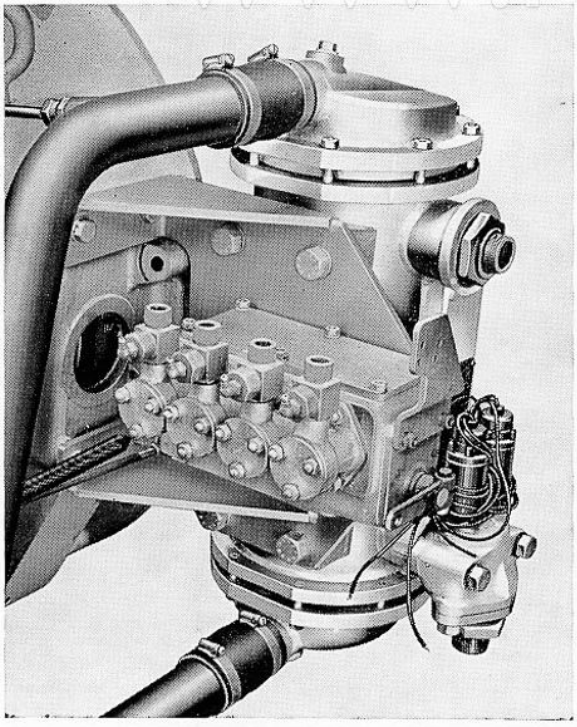


FIG. 1. HEAT EXCHANGER IN POSITION

The unit is so designed that the primary medium, usually oil or engine cooling water, flows over and around the tubes as directed by a series of baffles, while the secondary medium, such as engine cooling water or sea water flows through the tubes.

The unit should operate without attention for considerable periods, if however, a unit is allowed to become dirty or badly choked, loss of performance will result, which will eventually necessitate complete overhaul, to restore the surfaces to this original condition.

Deterioration of performance is characterised by rising temperatures in the priming medium, with or without a corresponding increase in pressure loss. This indicates the need for inspection of the surfaces with a view to cleaning.

To Remove

1. Drain the exchanger of oil and water.
2. Disconnect the oil and water pipe connections.
3. Remove the two temperature switches, if fitted, from the thermostat housing.
4. Unscrew the setscrews securing the heat exchanger to the support bracket and remove heat exchanger.

To Dismantle

1. File register marks across the edges of the cylinder tube stack plate and water box flanges to ensure correct alignment when reassembling.
2. Remove the metallic connector strip if fitted.
3. Unscrew the nuts fixing the end water boxes and joint ring to the cylinder and remove.
4. Remove the expansion end box together with the machined leakage ring and the two joint rings.
5. Owing to the close manufacturing tolerances maintained, it may be difficult to remove the tube stack from the cylinder that has been untouched for a number of years.

On no account use levers under the fixed end tube plate to prise the stack loose. This may damage the plate and cause leakage when the unit is re-assembled. An effective method of starting the stack is to place a suitable bar diametrically across the expansion end tube plate, then pull the box up to the cylinder by the progressive tightening of bolts which pass through the extremities of the bar and aligned holes in the cylinder flange.

Support the stack, if horizontal, with a webbing or leather sling of suitable strength, or with an eye-bolt for vertical hoisting. A tapped hole is provided at the centre of each tube plate for the insertion of an eye-bolt. Great care must be exercised to avoid damage to the stack during handling.

Tube Replacement

Adverse operating conditions or careless maintenance may be the cause of tube failure. As a temporary measure a defective tube should be isolated by using the wooden plugs supplied with each kit of cleaning and re-tubing tools (Fig. 3). A plug should be driven securely into both ends of the tube. When convenient, and particularly when a number of tubes have been plugged, take steps to fit new tubes, using the correct tools for the job and working to the following instructions:

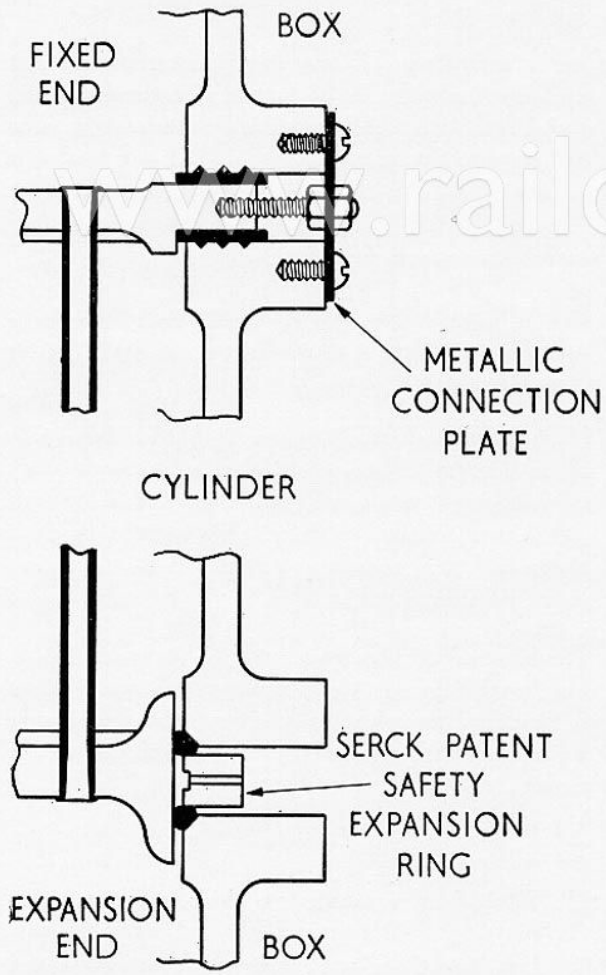


FIG. 2. FIXED AND EXPANSION END JOINTS

To Remove Tube

1. Fit drill in wrench, fill flutes with grease to retain cuttings and drill out tube in expansion end tube plate until tube is freed (Fig. 4A). Clean burrs from end of tube.

2. Remove drill and insert centralising pin (Fig. 4B).

3. Drill out tube in fixed end tube plate (Fig. 4C). Extract drill to permit removal of burrs from tube end. Replace drill to locate the tube.

4. Drive the centralising pin as far as it will go into the expansion end tube plate (Fig. 4D).

5. Lock the wrench over the tube and drill projecting from the fixed end tube plate (Fig. 4E). (The grub screw on the wrench should be transferred to the circular socket.)

6. Work the tube carefully out of the stack from the fixed end. Remove the centralising pin which is held by the expansion end tube plate (Fig. 4F).

To Fit New Tube

1. Tap the hole in each tube plate with the special tap provided, having greased the flutes to retain cuttings (Fig. 5A). Insert the new tube, the ends of which must be annealed and cleaned.

2. Secure in position by using the taper drift at each end (Fig. 5B).

3. Insert the expander into the tube and rotate in a clockwise direction using light finger pressure (Fig. 5C). Allow the expander to feed itself into its full extent, do not force the feed.

   Repeat for the other end of the tube.

Cleaning Instructions

Before commencing cleaning operations make sure that a new set of joints is available together with the necessary

tools and brushes (Fig. 3). The tool kit available for repairs to heat exchangers contains a spiral brush with handle and extension rods for brushing soft deposits out of the tubes. When reassembling examine the corrosion protector rods, if fitter, and replace if they are badly worn. Where metallic connector strips are fitted, be sure that they are correctly replaced, the surfaces being scraped to ensure a metal to metal contact.

H.D. degreasant powder is non-toxic and free from fire risk, so that it can be safely handled by the operating personnel without need for protective clothing. It is manufactured by Houseman and Thompson Ltd., of D.M. House, Newcastle upon Tyne.

Before immersion try to remove a proportion of the deposits on the tube stack by brushing or scraping.

The tank should be deep enough to immerse the tube stack completely. Fill the tank to the required level with fresh water and heat to boiling. For every gallon of water used, add 1 lb. of degreasant powder to the tank, giving a 10 per cent solution.

The degreasant should be added to the boiling water, and never vice versa.

With the larger type of heat exchanger, screw an eye-bolt into the centre of each tube plate and suspend by means of wire slings. For the smaller heat exchanger, metal clamps fastened around the stack with provision for shackle and wire sling will suffice.

Cleaning will be hastened if the stack is repeatedly raised and lowered to achieve a sluicing action. Sludge and deposits will be carried in suspension while the oily scum floats to the surface of the solution, to be removed by skimming or draining. If the stack is held partially submerged in the tank, a hosing of the solution will effectively remove most of the deposits. Finally skim the tank before removing the stack. Wash thoroughly with hot fresh water and dry by means of compressed air.

To Assemble

1. Ensure that all internal surfaces are quite clean.

2. Pass one flat joint ring over the stack, to rest against the inner side of the fixed end tube plate. Insert the stack into the cylinder, being careful to prevent damage, and align the register marks on the cylinder flange and the fixed end tube plate.

3. Place a flat joint ring in position and mount the fixed end water box so that the filed register marks are in alignment. Secure by tightening the nuts on to the studs or bolts, as applicable.

4. Affix the metallic conductor strip across the flanges, having first scraped clean the contacting surfaces to ensure a metal-to-metal contact. Do not forget to insert the central screw into the fixed end tube plate, as shown in Fig. 6.

5. Place the expansion end inner joint ring, safety leakage ring and outer joint ring over the expansion end tube plate. Mount the expansion end water box in position on the studs and secure by tightening all the nuts progressively and evenly, to avoid local overstressing.

6. Replace the water box covers, inspection doors and drain plugs, etc., as necessary.

Testing

Apply the correct oil or water pressure to the heat exchanger on both sides of the tubes independently and examine the tubes, plates and joints for leakage. The test pressure for units with $\frac{7}{16}$ in. (11.1 mm.) tubes is usually 60 p.s.i. (4.22 kg s.cm.), and for units with $\frac{9}{16}$ in. (14.3 mm.) tubes, 100 p.s.i. (7.03 kg s.cm.). If in doubt, however, inquire.

Should a newly fitted tube show signs of leakage at the tube plate joint, it is generally only necessary to re-expand lightly with the roller expander.

When the full hydraulic pressure is applied to the outside of the tubes on C types, when the water box is not fitted, it is necessary to use some form of clamp to hold the fixed end joint against the cylinder. A suggested clamp is shown in Fig. 7, use as many clamps as there are bolts in the main flange.

The loose packing piece of metal or hardwood, should be of such thickness that the clamp is at right angles to the axis of the bolt when fully tightened. The clamps are standard, being designed to fit practically all sizes of cooler.

To Fit

1. Fit the heat exchanger in position.

2. Couple up the oil and or water pipe connections and refill oil and or water systems.

MAINTENANCE

In extremely cold weather take action to prevent cracking through the water freezing.

When units are taken out of commission for some time, remove sludge or soft deposits from tubes and water boxes, then flush with hot water and dry out.

Periodic examination and cleaning is recommended.

Note: Up to 10 per cent of the total number of tubes in a heat exchanger may be plugged without affecting normal performance, but it is important that an early opportunity be taken to fit new tubes.

Corrosion is dangerous so keep air out of the system by the regular use of the air cocks.

Metallic Connection Plate

Reduces harmful electro-chemical activity between cylinder, tube stack and water boxes. This item must be replaced after maintenance involving its removal. Contacting surfaces should be kept clean by scraping if necessary to ensure a good metal-to-metal contact.

Deposit Attack

Occurs beneath porous deposits of foreign matter. The metal under the deposit becomes anodic to the adjacent metal so that electrolytic corrosion takes place. The best remedy is to remove any deposits particularly before lying up for long periods. Serck special cleaning brushes are best for the job.

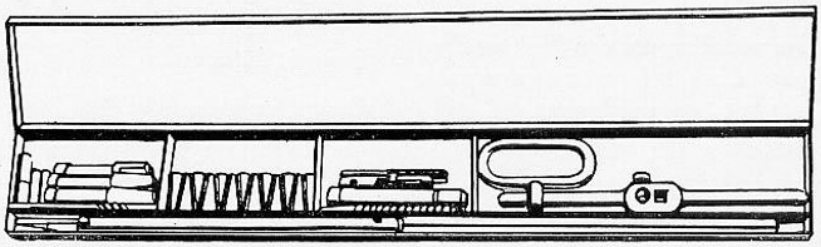
Serck Technical Advisory Service

For assistance with any problem in connection with a Serck heat exchanger contact the Serck Technical Advisory Service, quoting the serial number on the nameplate. There is an extensive Service Dept. at Warwick Road, Birmingham, equipped to carry out repairs, cleaning or complete renovation of Serck equipment.

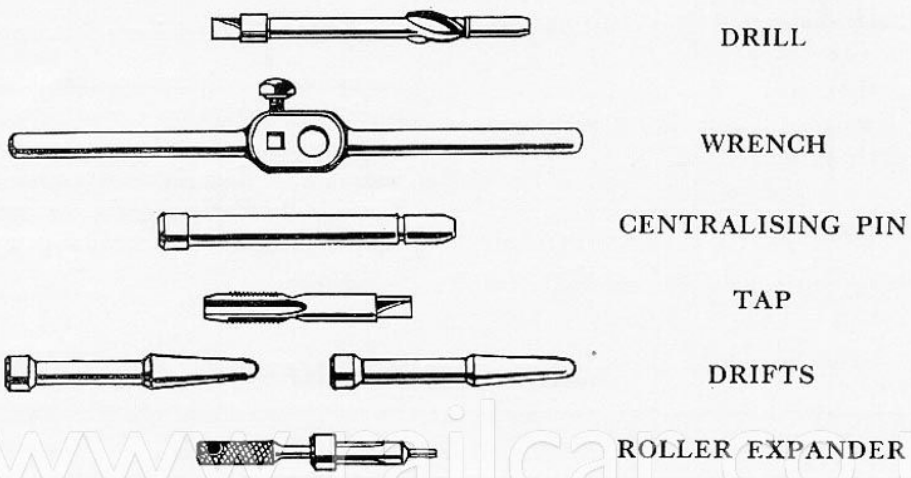
FAULT FINDING CHART

Fault	Cause	Remedy
Increasing temperature or pressure loss on oil or engine cooling water side.	Sludge scale or insulative film on outside of tubes.	Clean stack and cylinder using recommended solvent.
Normal pressure loss across outside of tubes, but rising oil or engine cooling water temperatures.	Mud or scale inside tubes and water boxes.	Brush through tubes to remove soft deposits. Remove hard deposits by means of solvents.
Loss of oil or engine cooling water into other side.	Tube(s) perforated.	(a) Seal tube temporarily with hard wood plug at each end. (b) Plug permanently with screwed brass plugs. Replace tube at the earliest opportunity.
Diminution of oil or water.	Lack of oil or water in system.	Correct the levels as necessary.
	Dirty oil or water pumps fitted or pipeline blockage.	Examine each in turn and clean.
	Air in system.	Trace and stop leakage at glands and joints. Keep pump suction immersed. Bleed off air, using air cocks.

TOOLS IN CASE



RE-TUBING TOOLS



DRILL

WRENCH

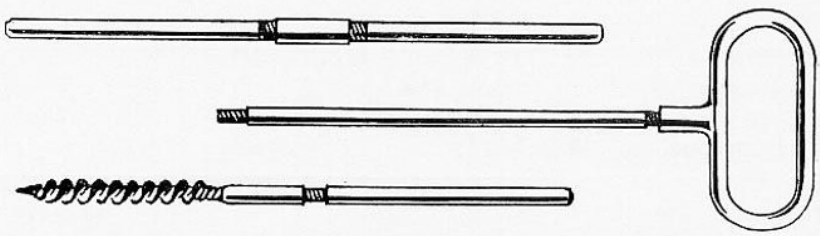
CENTRALISING PIN

TAP

DRIFTS

ROLLER EXPANDER

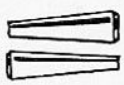
CLEANING TOOLS



BRUSH HANDLE, EXTENSION ROD AND BRUSH

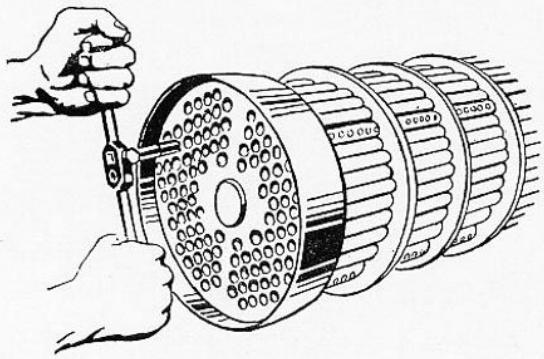
Rotate in clockwise direction to avoid unscrewing the component parts.

PLUGS

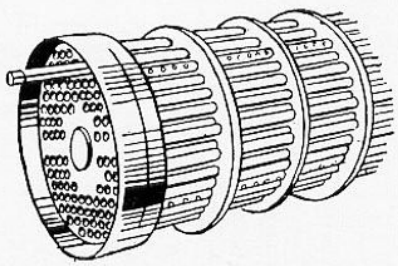


If a tube leaks, plug each end with the special hardwood plugs as a temporary measure. Fit a new tube at the earliest opportunity.

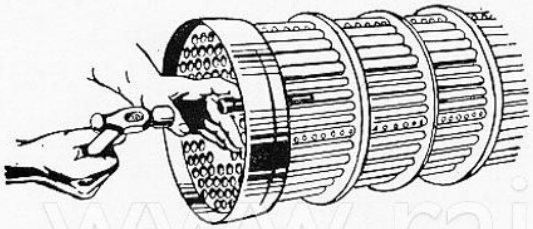
FIG. 3. CLEANING AND RE-TUBING TOOLS



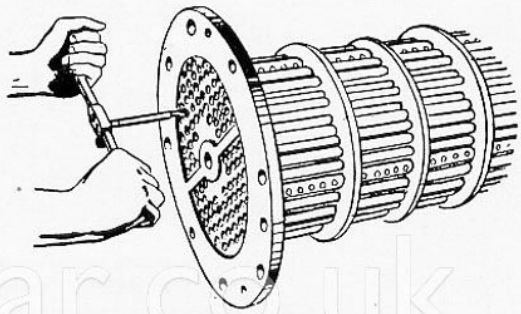
(a) Fit drill in wrench, fill flutes with grease to retain cuttings and drill out tube in expansion end tube plate until tube is freed. Clean burrs from end of tube.



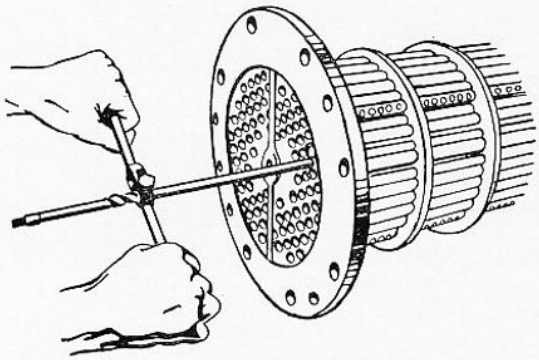
(b) Remove drill and insert centralising pin.



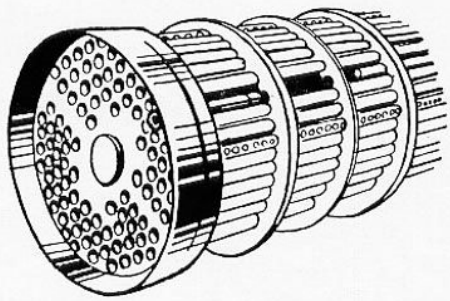
(c) Drill out tube end in fixed end tube plate. Extract drill to permit removal of burrs from tube end. Replace drill to locate the tube.



(d) Drive the centralising pin as far as it will go into the expansion end tube plate.

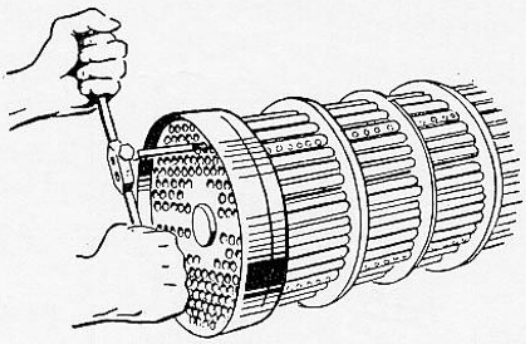


(e) Lock the wrench over the tube and drill projecting from the fixed end tube plate. (The grub screw on the wrench should be transferred to the circular socket).

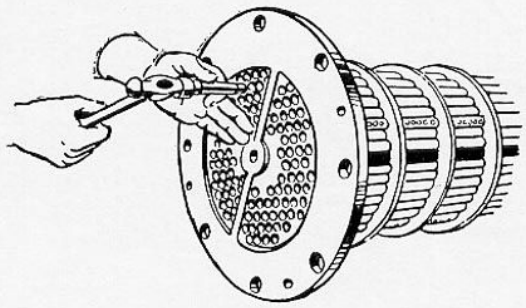


(f) Work the tube carefully out of the stack from the fixed end. Remove the centralising pin which, as shown, is held by the expansion end tube plate.

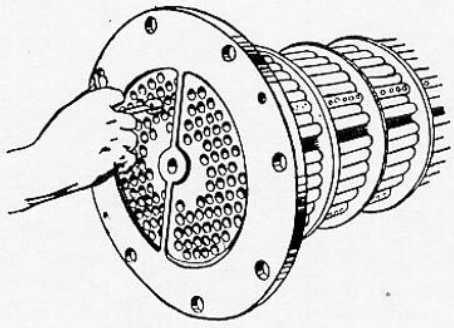
FIG. 4. REMOVING A DEFECTIVE TUBE



(a) Tap the hole in each tube plate with the special tap provided, having greased the flutes to retain cuttings. Insert the new tube, the ends of which must be annealed and cleaned.



(b) Secure in position by using the taper drift at each end.



(c) Insert the roller expander into the tube and rotate in a clockwise direction using light finger pressure.

Allow the expander to feed itself in to its full extent—do not force the feed.

Repeat for the other end of the tube.

FIG. 5. FITTING A NEW TUBE

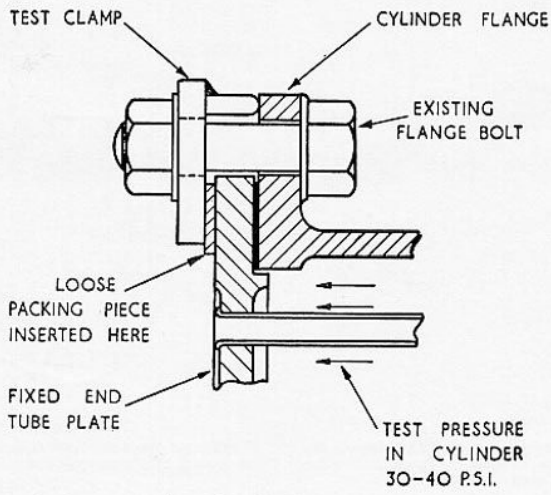


FIG. 6. A SUGGESTED TEST CLAMP