WORKSHOP MANUAL

Perkins

DIESEL ENGINES

PERKINS ENGINES LIMITED
PETERBOROUGH
ENGLAND

WORKSHOP MANUAL

And Instruction Book for

Perkins

DIESEL ENGINES

FOUR 192 & FOUR 203

RE-ISSUED AUGUST, 1961

PERKINS ENGINES LIMITED

SERVICE DIVISION

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CONTENTS

Unified Threads and Engine No. Location

All threads used on the Four 192 and Four 203 Engines, except on proprietary equipment are Unified Series, and American Pipe Series.

Unified threads are not interchangeable with B.S.F. and although B.S.W. have the same number of threads per inch as Unified Coarse Series, interchanging is not recommended, due to a difference in thread form.

The engine number consists of seven digits. In the case of Four 192 engines, it commences with the figures 25 and for Four 203 engines, it commences with the figures 26.

The engine number is stamped on two machined facings on the cylinder block, one on the camshaft tunnel adjacent to the fuel lift pump and the other on the opposite side near the fuel filter. See Figs. B.1. and B.2.

Always quote this number when requesting information or ordering Parts.

APPROVED SERVICE TOOLS

The tools referred to in this Manual are manufactured and supplied by V. L. Churchill and Co. Ltd. For further details see appendix.

FOREWORD

The Diesel Engine closely resembles its petrol counterpart inasmuch as the mechanism is essentially the same. Its cylinders are arranged above its closed crankcase, its crankshaft is one of the same general type as that of a petrol engine and it has the same sort of valves, camshaft, pistons, connecting rods and lubrication system.

It follows, therefore, that to a great extent, it requires the same treatment as that which any intelligent and careful operator would accord to a petrol engine and that gross negligence such as running the engine short of oil, with sludged oil, or with the water boiling will have the same expensive consequences.

Where the Diesel Engine does differ from the petrol engine, however, is in the method of handling and firing its fuel. Carburettor and ignition systems are done away with and in their place is a single component—the Fuel Pump—which performs the functions of both. This confers upon the Diesel a quite exceptional reliability, since the chances of breakdown are halved. In fact it may be axiomatically stated that a Diesel Engine never has an involuntary stop (other than one caused through mechanical damage due to abuse), unless there is a shortage of fuel.

The fuel pump though very simple in principle, must necessarily be a piece of precision engineering. Many years of experience and many hundreds of thousands of miles of running ensure that the fuel pump fitted to Perkins engines will, given only ordinarily decent treatment, continue to function faultlessly. It must not however be interfered with and its repair, should it need attention should be effected by specially trained personnel. It is built as a unit, so that in the rare event of failure it can be replaced en bloc.

Unremitting care and attention at the Perkins factory have resulted in an engine capable of hundreds of hours profitable service. WHAT THE MANUFACTURER CANNOT HOWEVER CONTROL IS THE TREATMENT THAT HIS PRODUCT WILL RECEIVE IN SERVICE. That part rests with you.

This manual is designed to be a guide to the Distributors of, and Dealers in applications equipped with the Perkins Diesel engine ; also to others who are concerned with the sale and subsequent maintenance of such engines.

Perkins Engines Ltd. are at one with all these Distributors and Dealers in the desire to ensure that Perkins Diesel engines in the hands of users shall give complete satisfaction.

An essential factor in the attainment of that object is efficient servicing. The company provides a number of facilities with that end in view ; one of them is this manual. In presenting it to responsible Distributors and Dealers the Company are in effect inviting their co-operation and at the same time providing an effective aid to that co-operation.

Immediate action to be taken on receipt of this manual : hand it over to the foreman who will be responsible for carrying out the maintenance operations which are described therein. Do not. please, file it in the office.

The issue of this manual has been described above as being one of the many aids which Perkins Engines Ltd. provide in order to ensure efficient service for the engines they market. Two of the others may appropriately be mentioned here.

A Service School is maintained at Peterborough where the mechanics employed by Distributors, Dealers and users are given instruction on the special characteristics of the engine.

Then there is the Perkins Perpetuity Plan which is, in fact, an engine exchange scheme of peculiar description having numerous special advantages. A booklet describing this can be obtained on request.

In conclusion we recommend Dealers, Distributors and users to communicate with the Service Division of Perkins Engines Ltd., Peterborough, in case of need.

ENGINE DESCRIPTION (A)

The Perkins Four 192 and Four 203 Engines are vertical four-stroke Power Units, entirely of British design and manufacture embodying the results of experience gained in the production of Diesel engines over a period of many years.

The materials and workmanship throughout are of the highest-class. All parts pass through a system of thorough inspection where they are checked to the closest-limits. Each engine is subject to stringent tests before leaving the works.

General.

The Four 192 has a bore of 3.5 in. and a stroke of 5 in. The Four 203 has a bore of 3.6 in. and a stroke of 5 in.

Cylinder Block.

The cylinder block and crankcase comprise a one piece high duty cast iron alloy casting, scientifically designed to give maximum strength and rigidity. The camshaft-chamber is situated high up in this casting. The water jackets are carried down the length of the cylinders which are fitted with renewable high duty cast iron alloy dry liners in the case of the Four 192, and renewable chromium plated liners in the Four 203.

Cylinder Head.

The cylinder head is a one piece cast iron alloy casting secured to the cylinder block by 19 high tensile steel studs. Valves and tappets are carried directly in the head on top of which the rocker shaft is mounted, the latter being enclosed in the rocker cover. It is important to note that removal of the cylinder head does not disturb the engine timing. All valves are of special alloy steel, the inlet being larger to ensure maximum volumetric efficiency. The spherical combustion chamber is formed half in the cylinder head and half by a detachable steel cap.

Camshaft.

The camshaft which is situated high on the offside of the cylinder block is provided with journals of generous bearing area. This construction eliminates push rods.

The cams and bearings are lubricated by means of an oil bath formed by a chamber cast in the cylinder block and fed by oil draining from the rocker shaft. The level of oil in the chamber is controlled by a weir.

Crankshaft.

The crankshaft which is machined from a chrome molybdenum steel forging is extremely rigid, being supported by five main bearings, the main journals being induction hardened. A flange is formed at the rear end on which the flywheel is mounted.

The rear end of the shaft is machined to provide an oil thrower and oil return scroll.

Oil seals are provided at the front and rear ends of the crankshaft. The front oil seal is of the spring loaded lip type fitted into the timing case cover and the rear seal is of the rubber bonded asbestos type retained in a split housing.

Crankshaft end float is limited by steel backed copper lead thrust washers fitted at each side of the rear main bearing.

Main Bearings and Bearing Caps.

The crankshaft is supported by five main bearings of generous area. The bearings which are pre-finished consist of thin wall shells lined with plated copper lead, or aluminium tin metal. They are located by tabs which fit into notches machined into the crankcase and bearing caps.

The main bearing caps are located in position by two large diameter dowels and are securely fastened to the crankcase by high tensile steel set bolts, suitably locked by tab washers.

Connecting Rods.

Light "H" Section high tensile steel forgings are used and kept as light as possible to reduce inertia stresses consistent with ample strength. The big end is split at right angles to the axis of the rod, the cap being secured by two fitted bolts, locked by self-locking nuts. Thin wall prefinished steel backed plated copper lead, or aluminium tin big-end bearings are fitted. The small end bushes are steel backed, and lead bronzed lined.

Pistons.

The pistons are flat topped. They are of special light aluminium alloy, with ample metal in the crown to carry off the heat of combustion. They are suitably ribbed to take the load directly to the gudgeon pin bosses.

The gudgeon pins are fully floating and are retained in the piston by two circlips.

For piston ring layouts see section J.

Timing Gears.

The camshaft and fuel pump are driven by a hardened steel gear on the crankshaft through two idler gears mounted on hubs bolted to the front of the cylinder block. The fuel pump, camshaft, and upper idler gears are machined from high duty cast iron. The lower idler gear is machined from steel. There is provision for an exhauster drive from this gear if required.

Lubrication.

The lubrication is high pressure force fed throughout the engine. The rotor type oil pump is gear driven from the front of the crankshaft. It is capable of maintaining an adequate pressure at all running speeds. There is a gauze strainer in the engine sump well and a full flow type filter in the pressure system mounted in an accessible position on the engine.

Fuel Pump and Atomisers.

A Distributor type fuel injection pump is fitted. This may have either a Mechanical or Hydraulic Governor depending on the application to which the engine is fitted.

A diaphragm type of lift pump is fitted and is driven by a special cam near the rear of the camshaft.

The atomisers are located in a very accessible position on top of the cylinder head on the near side, and have two sprays, one directed into the combustion chamber and the other into the cylinder itself, giving the engine the easy starting qualities associated with a direct injection engine.

Cooling.

The cooling water is pump circulated. The pump, of the centrifugal type, is located either on the front of the timing case or on the front of the cylinder head and is belt driven from the crankshaft pulley. Provision is made for a fan on the front of the pump pulley.

Cooling water from the pump is delivered to a cored passage in the cylinder block. The internal water passages in the cylinder block and head are of ample area, and are arranged to give a brisk circulation of water around the combustion chambers and atomiser seatings.

Air Intake.

A large air cleaner is fitted in the induction system through which must pass all air taken into the engine. Harmful dust is thus excluded and the life of the cylinders correspondingly prolonged, if the air cleaner is properly maintained.

Cold Starting Equipment.

A cold starting device is fitted, and has been designed for easy operation. It is fitted in the induction manifold and is controlled by a " heat-start " switch. For operation refer to Section " C."

Electric Starting Equipment.

Electric starting equipment incorporates a 12-volt Electric Starter. This is mounted on the off side of the cylinder block beneath the camshaft chamber, and does not, in this position materially increase the width of the engine.

Dynamo.

12 volt (earth return type). A facing is provided on the off side of the timing case for mounting the dynamo, the drive being by Vee Belt from the crankshaft pulley.

Manufacturer's Seals.

There are three seals on the mechanically governed fuel pump and two on the hydraulic type. On the former they are positioned :—

1. On the inspection cover retaining setscrews.
2. Connecting the governor housing retaining nuts.
3. On the maximum speed adjusting screw.

On the latter they are positioned :—

1. On the inspection cover which incorporates the fuel return pipe union.
2. On top of the governor housing.

These seals ensure that the Manufacturer's settings are not disturbed, and interference with them may result in forfeiture of the engine guarantee.

ENGINE PHOTOGRAPHS

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3. Exhaust Manifold.
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7. Pipe, Lift pump to Fuel Filter.
8. Pipe, Fuel inlet from filter to pump.
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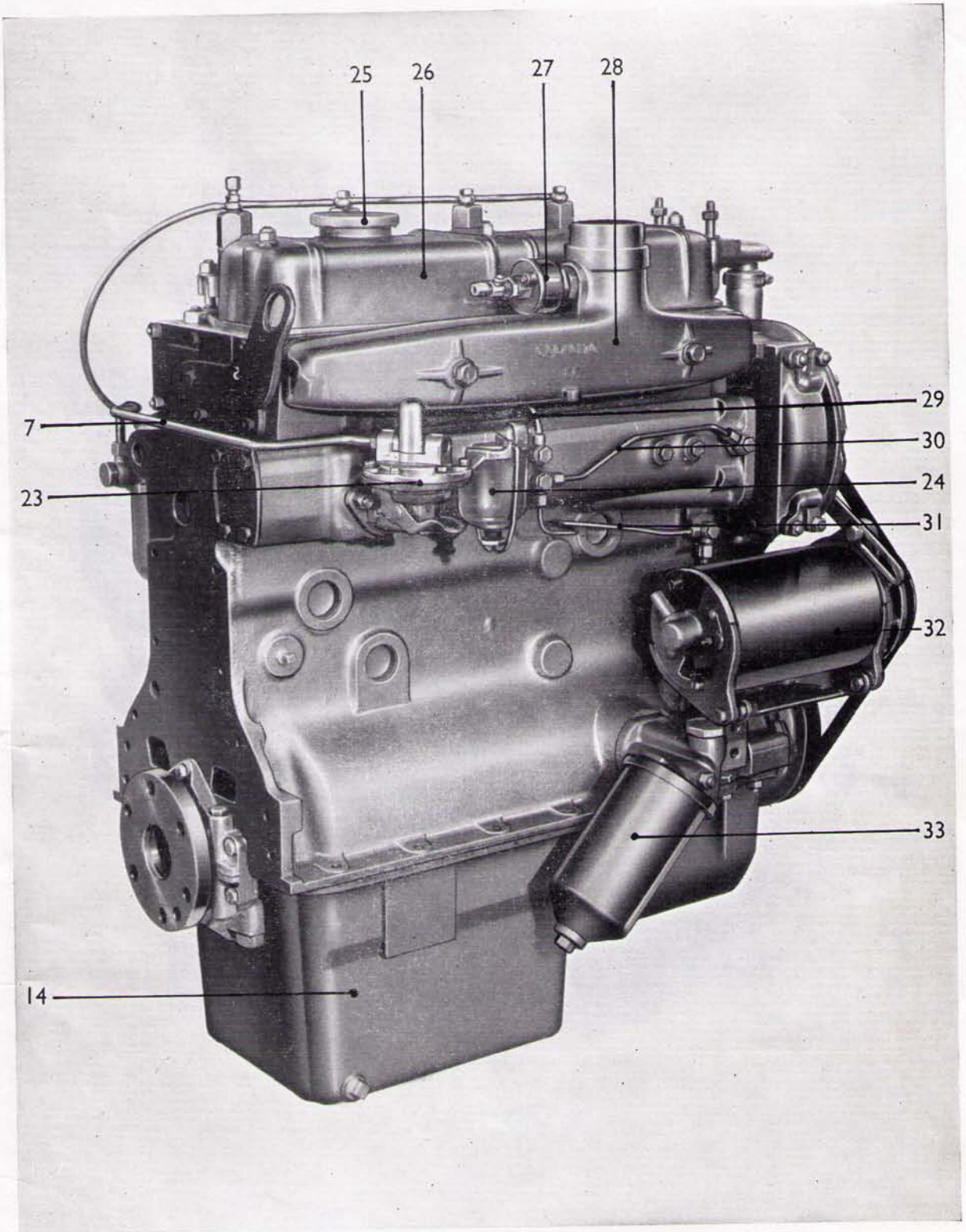
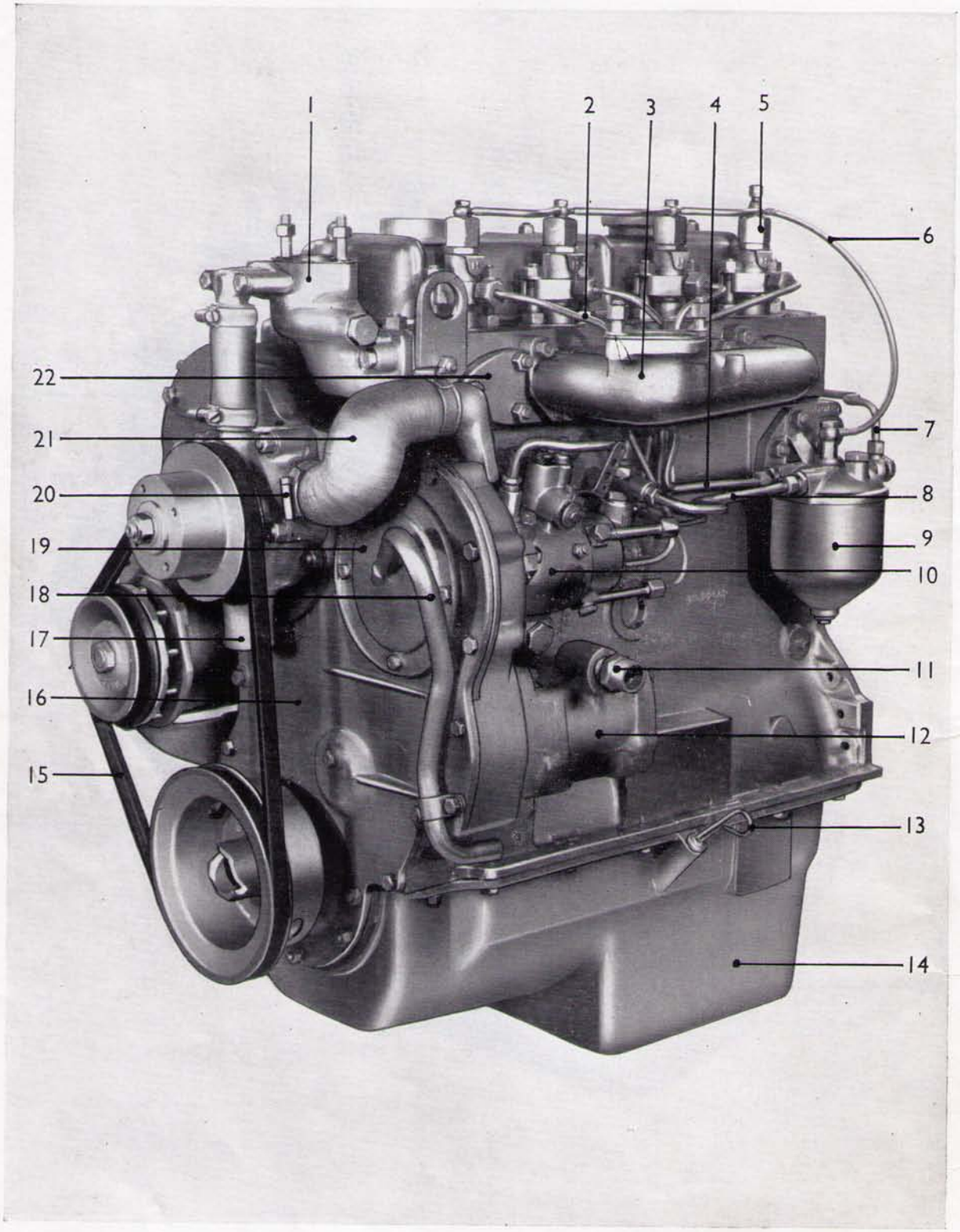


View of Camshaft Side of Engine.



View of Fuel Pump Side of Engine.

SETTINGS AND DATA (B)

Bore : Four 192	3.5 in. (88,9 mm)
Bore : Four 203	3.6 in. (91,44 mm)
Stroke : Four 192 & Four 203	5 in. (127 mm)
Compression Ratio : Four 192	16.5 : 1
Compression Ratio : Four 203	17.4 : 1
Inlet Valve Opens	13° B.T.D.C.
Exhaust Valve Closes ...	10° A.T.D.C.
Valve Lift	.36 in.
Fuel Injection Timing ...	20° B.T.D.C.
Fuel Pump Timing Letter ...	"C" * "A" †
Oil Pressure	40 lbs. per sq. in.
Tappet Clearance	.010 in. (hot)
Valve Seat and Face Angle ..	45°

*Mechanically governed pumps.
†Hydraulically governed pumps.

Engine Ratings.
Four 192

Vehicle Engine ...	60 b.h.p. at 2,600 r.p.m.
Maximum Torque ...	143 lb.ft. at 1,350 r.p.m.
Agricultural Engine...	54 b.h.p. at 2,250 r.p.m
Maximum Torque ...	143 lb.ft. at 1,350 r.p.m.
*Industrial Engine (Mech. Governor)...	50 b.h.p. at 2,000 r.p.m.
Maximum Torque ...	143 lb.ft. at 1,350 r.p.m.
*Industrial Engine (Hyd. Governor) ...	58 b.h.p. at 2,400 r.p.m.
Maximum Torque ...	143 lb.ft. at 1,350 r.p.m.

*Maximum intermittent rating varies according to application.

Four 203

Vehicle Engine ...	63 b.h.p. at 2,600 r.p.m.
Maximum Torque ...	147 lb.ft. at 1,350 r.p.m.
Agricultural Engine...	57 b.h.p. at 2,250 r.p.m.
Maximum Torque ..	151 lb.ft. at 1,350 r.p.m.
*Industrial Engine (Hyd. Governor) ...	60 b.h.p. at 2,400 r.p.m.
Maximum Torque ...	141 lb.ft. at 1,350 r.p.m.
*Industrial Engine (Mech. Governor)...	53 b.h.p. at 2,000 r.p.m.
Maximum Torque ..	151 lb.ft at 1,350 r.p.m.

*Maximum intermittent rating varies according to application.

Atomiser Data

Engine Type	Nozzle Holder	Nozzle	Pressure Settings (ats.)	Code Letter	Application
Four 192					
	BKB32SD5060	BDL110S6133	120	J	Agricultural & Industrial (Mech. Governor)
	BKB32S5060	BDL110S6267	120	H	Industrial (Hydraulic Governor)
	BKB32S5060	BDL110S6267	120	H	Vehicle
Four 203	BKB32S5060	BDL110S6267	120	H	Vehicle & Industrial (Hydraulic Governor)
	BKB32SD5060	BDL110S6133	120	J	Agricultural & Industrial (Mech. Governor)

Recommended Torque Tensions.

Cylinder Head Nuts ...	...	55— 60 lbs.ft.
Connecting Rod Nuts	...	65— 70 lbs.ft.
Main Bearing Setscrews	...	110—115 lbs.ft.
Flywheel Setscrews ...	...	75 lbs.ft.

N.B.—The connecting rod nuts are the self locking type and if removed for any reason, should be renewed.

De-Rating for Altitude.

When engines are called upon to operate in rarefied atmospheres occasioned by altitude, each engine should be de-rated. For details regarding procedure apply to Service Division, Perkins Engines Ltd., Peterborough, or to those overseas companies listed on Page 2.

Sump Capacities.

The lubricating oil level should be maintained in accordance with the marks on the dipstick. Only approved oils as listed in the appendix should be used.

Actual sump capacities vary according to the application and for further details apply to Service Division, Perkins Engines Ltd., Peterborough.

Fuel Oil Specification.

British Standard No. BS.2869 (1957) Class A.

ENGINE NUMBERS

ALWAYS QUOTE THE ENGINE NUMBER when requesting information or ordering parts. It is stamped in two prominent places on the cylinder block.

1. On a facing high at the rear of the fuel pump side of the block. See Fig. B.1.
2. On a facing midway along the camshaft tunnel, adjacent to the fuel lift pump. See Fig. B.2.

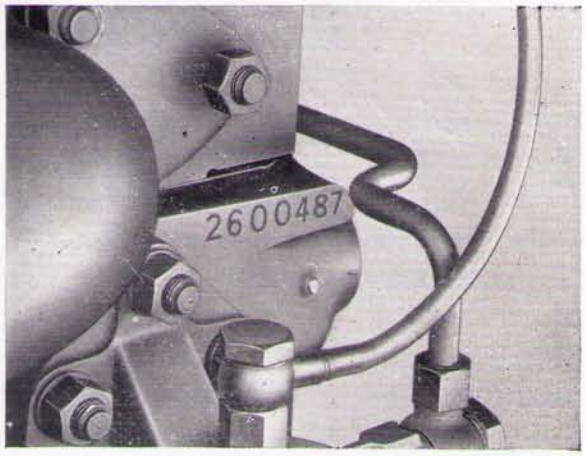


Fig. B.1.
Engine No. Location on Fuel Pump Side.

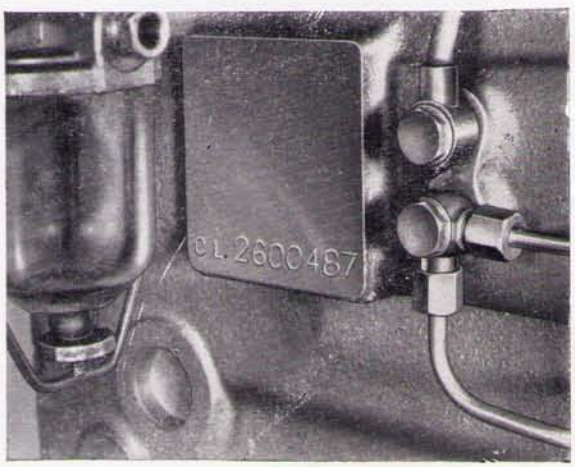


Fig. B.2.
Engine No. Location on Camshaft Tunnel.

STARTING THE ENGINE (C)

Preparation for Starting.

Check the radiator water level.

Check the engine sump oil level.

See that there is fuel oil in the tank.

Ensure that the starter battery is fully charged and that all electrical connections are properly made and all circuits are in order.

Lubricating Oil.

During the normal winter period, a lubricating oil of S.A.E. 20W viscosity of high detergency conforming to MIL/L/2104A or DEF/2101B specification should be used. For approved oils, see appendix.

Priming the Fuel System.

In the case of a new engine or an engine which has been standing idle for any length of time, it is important that the fuel system be "bled." A typical fuel system is shown in Fig. C.1.

To bleed the system, proceed as follows :—

Slacken the air vent screw (A) on the front side of the governor control cover (Mechanical governor) or the top of the control gear housing (Hydraulic governor).

Slacken one of the two hydraulic head locking screws (B) on the side of the pump body.

Unscrew, by two or three turns, the vent plug (C) on the top of the filter cover (not the return pipe to the tank).

Operate the priming lever on the fuel lift pump, and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order :—

1. Filter cover vent screw (C).
2. Head locking screw (B).
3. Governor vent screw (A).

Slacken the pipe union nut (D) at the pump inlet, operate the priming device and retighten when oil, free from air bubbles, issues from around the threads.

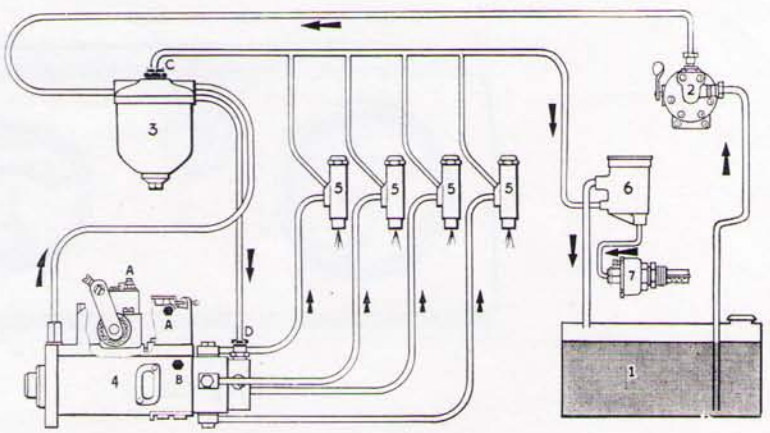
Slacken the unions at the atomiser ends of two of the high pressure pipes.

Set the engine speed control at the fully open position and ensure that the "stop" control is in the "run" position.

Turn the engine until fuel oil, free from air bubbles, issues from both fuel pipes.

Tighten the unions on the fuel pipes, and the engine is ready for starting.

It should be noted that if the cam on the camshaft driving the fuel lift pump is on maximum lift, then it will not be possible to operate the hand primer. If such a condition arises, then the engine should be turned until the hand primer can be operated.



A Typical Fuel System.

Fig. C.1.

1. Fuel Tank.
2. Fuel Lift Pump.
3. Filter.
4. Fuel Injection Pump.
5. Atomiser.
6. Cold Start Fuel Reservoir.
7. Cold Start Aid.

Starting the Engine.

If the engine is warm and has only been stopped for a little while, place the engine speed control in the fully open position and engage the starter motor by turning the starter switch in a clockwise direction. (See Fig. C.2).

If the battery is well up, enough to turn the starter motor quickly, the engine should start.

Idling Adjustment.

Should the engine "hunt" or surge, a steady idling may be obtained by juidical adjustment of the idling speed adjusting screw.

Cold Starting Aids.

Two different type starting aids have been fitted to the Four 192 and Four 203 engines, the Mk. I to the early engines and the Mk. III to the later types.

Description — Mk. I.

Referring to Figs. C.3 and C.4 the unit consists of a core (3), a solenoid (6) a spring loaded plunger (4) fitted with a special rubber insert (5) which abuts on a valve seat (7). The coil carrier (8) bears two heater coils (9, 10) and a circular shield surrounding the coils has large perforations (11) on one side, small perforations (13) on the other and a small flange (12) running along its outer surface.

Gravity fed fuel oil fills the adaptor (1), filter (2) hollow plunger (4) and the groove in the surface of the plunger. When the switch on the application control panel is operated, the solenoid (6) and coils (9, 10) are energised. Magnetism induced in the plunger (4) and adaptor (1) by the solenoid draws the plunger and rubber insert off the valve seat (7). Fuel oil then flows at a controlled rate along and around the coil (9) which causes the liquid to be vapourised. Coil (10) reaches the ignition temperature of the fuel vapour.

As soon as the engine is turned over by means of the starter motor, fresh air drawn into the inlet manifold enters the circular shield through the small perforations (13) and mixes with the vapourised fuel within. The resultant mixture is ignited by the coil (10) and so heats the air to facilitate combustion by promoting easier ignition of the fuel injected into the engine cylinders.

The flange (12) running along the outer surface of the shield provides a sheltered zone around the outlet holes (11) and protects the flame from the incoming air stream.

Maintenance.

Very little attention is required by the unit, but no reconditioning is possible. When in service the unit should be occasionally checked to ensure that it is firmly screwed and located in the manifold, with the arrow on the casing pointing in the direction of the airflow. It should also be ensured that the electrical lead wire is tightly fixed to the terminal, that the fuel banjo is tight and that there is no leakage.

To clean the unit, remove connections and withdraw from the inlet manifold. Wash components in petrol, paraffin or spirit and brush off any carbon which may have accumulated on the circular sheath, ensuring that all holes are clear. While no mechanical attempt should be made to

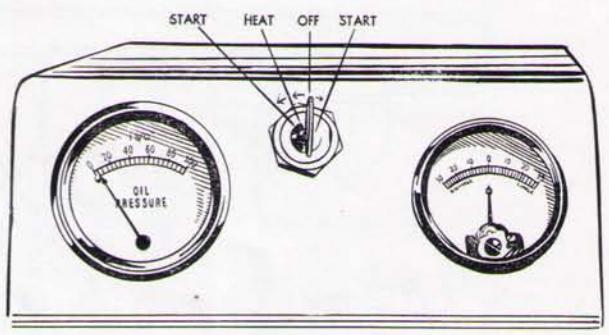


Fig. C.2.

remove or clean the internal filter (2), compressed air may be used to remove any foreign matter which may have been extracted from the fuel oil.

Dry the dismantled components and before re-assembling, examine the plunger (4) and rubber insert (5). Should there be any apparent damage, particularly in the case of the rubber insert, the whole assembly must be rejected and replaced by a new unit.

Description — Mk. III.

Referring to Fig. C.5, the cold start unit comprises a tubular valve body carried in a holder which screws into the inlet manifold and surrounded by a heater coil, an extension of which forms an igniter coil. The valve body houses a needle, the stem of which holds a ball valve in position against its seating. The whole is surrounded by an open perforated shield. Fuel oil from the container enters through an adaptor.

When the unit is cold, the ball valve is held closed. On switching on the coil, the valve body is heated and expands, opening the ball valve and permitting the entry of fuel. The fuel is vaporised by the heat of the valve body and when the engine is cranked and air is drawn into the manifold, the vapour is ignited by the coil extension and continues to burn, thus heating the inlet air.

When the coil is switched off, the flow of air in the manifold cools the valve body rapidly and the valve closes.

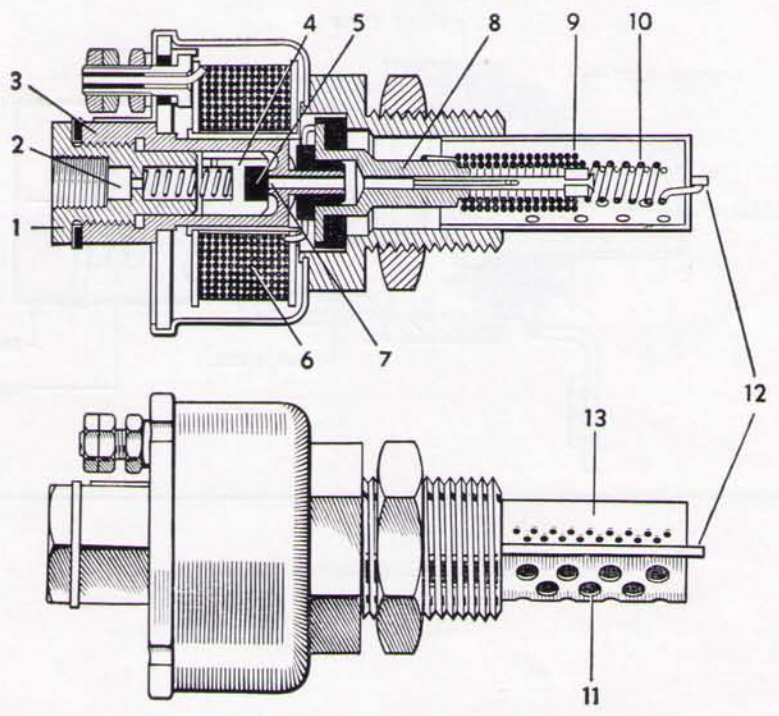
The cold start aid is a sealed unit and cannot be dismantled. If the unit ceases to function, it must be renewed.

Using the Equipment.

Switch on, ensuring the engine stop control is in the " run " position.

Turn cold start switch in an anti-clockwise direction to " heat " position for ten seconds (fifteen to twenty seconds in very cold weather). See Fig. C.2.

With the engine speed control in the fully open position, turn the switch a further anti-clockwise movement, thereby engaging the starter motor.



Figs. C.3 and C.4.
Mk. I Cold Starting Aid.

If the engine does not start after ten to fifteen seconds, return switch to " heat " position for five seconds and then re-engage starter motor.

As soon as the engine starts, the switch should be returned to the off position.

NOTE : The above procedure is not necessary when the engine is hot. To re-start, turn the switch in a clockwise direction which will engage the starter motor.

Things to Note.

Always be sure that the starter pinion has stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.

Ensure that the electrical connection to the cold starting aid is correctly made.

Always ensure that the reservoir feeding fuel to the cold starting aid is fully primed and not leaking.

Extended use of the cold starting equipment above the time periods already stated should be avoided, otherwise the cold start aid in the induction manifold may be damaged.

In the event of difficult starting, ensure that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel union. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the while the equipment is used. When the starting air cleaner and watching the cold starting aid switch is turned to the heat position, the element should become red hot and on engagement of the starter motor, it should burst into flame.

The Four 192 and 203 engines are fitted with efficient cold starting equipment and no responsibility can be accepted for any damage arising from the use of unauthorised starting aids.

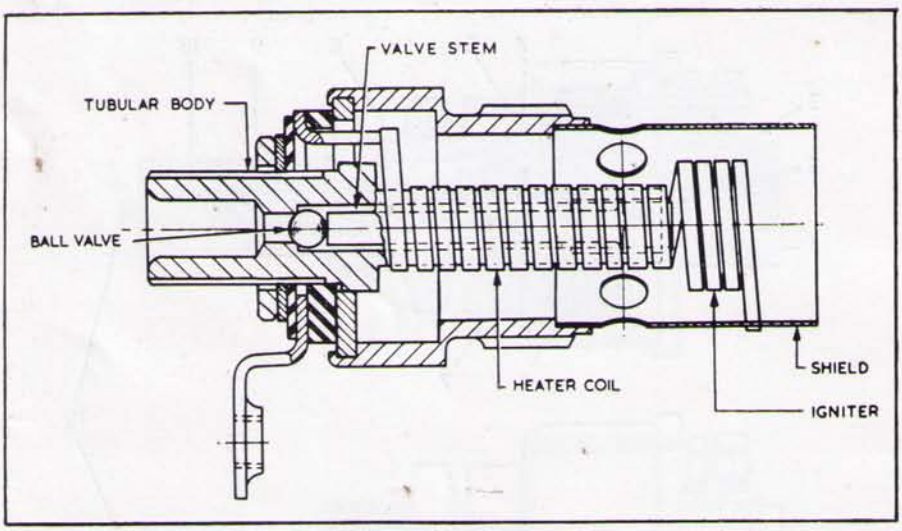


Fig. C.5.
Mk. III. Cold Starting Aid.

FAULT FINDING (D)

DIFFICULT STARTING.

No Fuel at Atomisers :—

(a) No fuel in tank.

(b) Fuel lift pump not working.

(c) Loose connections in the fuel system.

(d) Air in the fuel system (Trace from suction side).

Go over the whole of the above and make sure that the atomisers are fully primed and that the "pinging" or "squeaking" noise is heard from each atomiser when the engine is turned over by hand.

Engine not being turned over quickly enough.

(Particularly in cold weather).

(a) Incorrect grade of lubricating oil (See Appendix).

(b) Battery not fully charged. Fit fully charged battery.

(c) Engine "gummy" due to standing in the cold.

Use the cold starting equipment. (See page C.1).

Low Compression.

This may be due to dry cylinders and piston rings, worn piston rings, worn cylinders, or leaky valves. For any other than the dry cylinders, the proper course is to have the engine overhauled.

Atomisers Faulty.

Test Atomisers for "ping" or "squeak" as already mentioned. If any atomiser fails to give this "pinging" or "squeaking" noise when that cylinder is pulled smartly over compression and it has been made certain that the atomiser is fully primed, then the atomiser should be tested by removing it from the cylinder head. (See page R.4).

Disconnect pipes on other atomisers while making this test.

Sticking Valves.

Trouble with sticking valves may be due to overheating, the result of choked atomisers, or the use of unsuitable lubricating oil.

Test the atomisers as recommended on page R.4 and clean them is necessary.

The lubricating oil used should be of an approved type (See Appendix).

Sticking Rockers.

If the rockers stick, the cause may be : the use of unsuitable oil, shortage of oil, or sludging. Use only oil of an approved type. (See Appendix). If there is a shortage of lubricant the passages and pipes to and from the camshaft reducer should be cleaned.

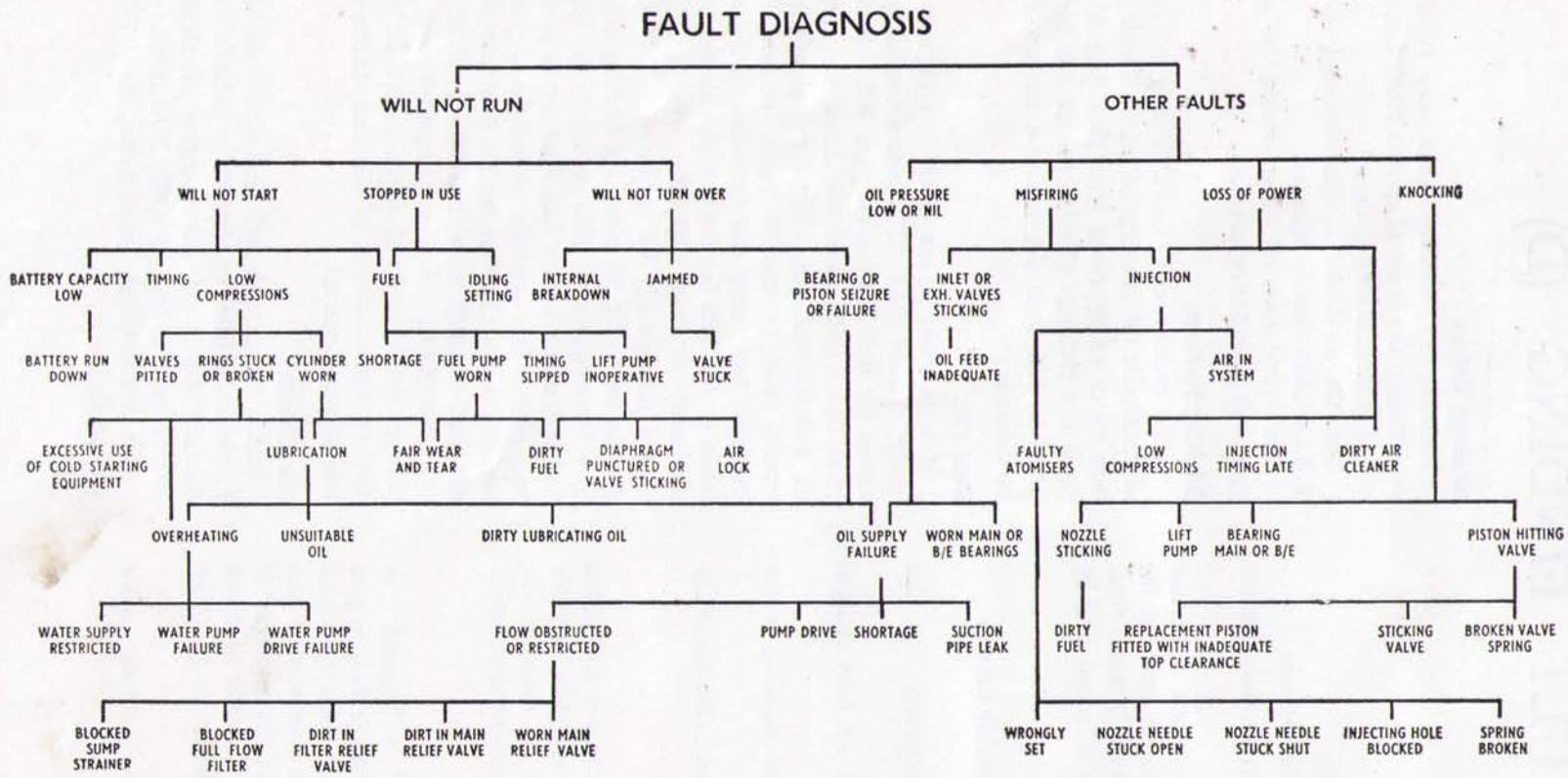
Fuel Oil.

It is essential to use clean fuel oil free from water, dirt or sand. The recommended specification for fuel is given on page B.2. Providing clean fuel is used, no trouble should be experienced with the fuel system but dirty oil will lead to trouble due to choked pipes, choked filters, damaged fuel pump and atomisers. If the engine tends to run well for a short period and then to die away or stop altogether, the fuel system should immediately be suspected. The trouble may be due to the lift pump not working properly, to a loose pipe joint allowing air to get into the fuel system, to a dirty fuel filter, or to a choked fuel pipe. The pre-filter should be cleaned by washing in clean fuel oil, but the final filter should not need attention more than once in 20,000 miles or 1,000 hours, when a completely new filter element should be fitted. If the conditions lead to dust or contamination of the fuel, decrease the maintenance interval.

Air Cleaner.

In accordance with periodical attentions, Section F, clean the filtering element in paraffin or fuel oil, and dip in oil. Fresh engine oil should be poured into the base up to the level mark.

For maintenance instructions see "Filters," Section G.



There is no machine made that is not liable to suffer occasional stoppage and/or failure. Sometimes the machine is at fault, but more often it is due to some human omission or neglect. Every effort is made to ensure that the Perkins engine is as near as possible fault proof, but for the benefit of those whose object it is to look after engines in service, the accompanying chart has been produced.

The main value of this chart is to help maintenance staff to consider any engine fault with which they are confronted, in a logical and organised manner. Prevention is better than cure, but if the fault has not been prevented, find it on this chart and follow it back to its cause.

DO AND DO NOT (E)

DO KEEP THE ENGINE CLEAN.
DO keep this book where it is conveniently accessible.
DO pay particular attention to lubrication.
DO use only approved grades of lubricating oil.
DO use only GENUINE PERKINS PARTS.
DO keep all bolts and nuts tight.
DO eliminate all air from the fuel system and keep all fuel oil unions AIR-TIGHT.
DO examine engine oil level in sump daily and replenish if necessary.
DO completely change engine oil in accordance with periodical attentions, Section F.
DO renew element in lubricating oil filter in accordance with periodical attentions.
DO check oil flow to rocker arms and examine the valve springs in accordance with periodical attentions.
DO use only filtered fuel oil. Never tip into the tank a half-empty barrel of fuel oil, the bung of which may have been out for weeks.
DO keep a check on the temperature of the cooling water. It should not be allowed to boil. The best temperature is 170°F., but where a pressurised cooling system is employed, the coolant temperature will be slightly higher.
DO attend immediately to fuel and lubricating oil leaks.
DO grind in valves when necessary.
DO check tappet clearance from time to time (.010 in.) with warm engine.
DO tighten cylinder head nuts in correct order.
DO quote engine number when ordering parts.
DO keep essential parts in store.
DO drain radiator if engine is being left idle in frosty weather.
DO drain cylinder block if engine is being left idle in frosty weather (drain tap on side of block).
DO ensure that the pressurised radiator filler cap is removed when draining the cooling system.
DO close these drain cocks and refill with water before attempting to re-start next morning.
DO when in doubt, read this Manual.
DO if the engine is to be laid up for a period of some months, carry out the procedure recommended on page F.1.

DO NOT neglect the routine attentions specified in Section F.
DO NOT race the engine in neutral.
DO NOT run the engine unless the gauge SHOWS OIL PRESSURE.
DO NOT unnecessarily interfere with any adjustments.
DO NOT break the fuel pump seals—remember if broken your Guarantee may be void.
DO NOT continue to run the engine if the cooling water boils.
DO NOT pour cold water into the cooling system of an engine which has become overheated.
DO NOT forget to keep the fan belt adjusted.
DO NOT continue to run the engine if black smoke is coming from the exhaust.
DO NOT if the engine stops without apparent reason, fail to make sure first of all that fuel is reaching the fuel pump.
DO NOT omit to wipe the engine over occasionally with a clean rag.
DO NOT take the fuel pump to pieces
DO NOT use cotton waste or any fluffy cloth when cleaning.
DO NOT use any but approved brands of lubricating oil.
DO NOT store fuel oil in a galvanised container
DO NOT subject any engine or vehicle to continuous overloading.
DO NOT load a vehicle to which this engine may be fitted beyond the manufacturer's stipulated payload : it does not pay.
DO NOT coast when travelling down hill.
DO NOT guess. For additional information contact suppliers of the vehicle, Industrial Plant Tractor, or Engine.

PERIODICAL ATTENTIONS (F)

POST-DELIVERY CHECKOVER.

After a customer has taken delivery of his Perkins Diesel engine, it is advisable, in his own interest, that a general checkover of the engine be carried out after the first 500 miles or 25 hours in service.

It is also recommended that the following procedure be adopted where an engine has been laid up for a considerable period before it is again put into service.

The checkover should comprise the following points :—

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with new clean oil (Do not overfill). When the sump is drained and it is possible to gain access to the sump strainer, it should be removed and cleaned.
2. Check and if necessary adjust slow running speed.
3. Check external nuts for tightness.
4. Check and adjust tappet clearances, (.010 in. hot).
5. Check fuel pipes from tank to fuel injection pump for leaks.
6. Examine engine for lubricating oil leaks, and rectify if necessary.
7. Check cooling system for leaks and inspect radiator water level.
8. Check fan belt for tension.
9. Check engine mounting bolts for tightness.
10. Carry out test to check general performance. of engine.

In addition to the above, it is recommended that the cylinder head nuts be checked to ascertain that they are tightened to the correct torque (see page B.2).

It is assumed that electrical equipment will have already been checked for such points as dynamo rate of charge, effectiveness of connections and circuits, etc.

Thereafter maintenance periods should be in accordance with the instructions given on the following pages.

PRESERVATION OF LAID-UP ENGINES.

Where an application which is powered by a Perkins engine is to be laid-up for several months it is advisable that some measure of protection be afforded the engine to ensure that it suffers no ill effect during the intervening period before operations are recommenced.

It is recommended, therefore, that the following procedure be adopted and applied immediately the unit is withdrawn from service.

1. Thoroughly clean all external parts of the engine.
2. Run the engine until warmed through. Stop the engine and drain lubricating oil sump.
3. Drain water from radiator and engine cylinder block.
4. Remove and clean gauze strainer in sump and renew lubricating oil filter element.
5. Clean out engine breather.
6. After replacing filters fill sump to correct level with clean, new lubricating oil or with a suitable preservative fluid.
7. Remove atomisers and spray into cylinder bores a $\frac{1}{4}$-pint of lubricating oil divided between the cylinders.
8. Replace atomisers and turn engine slowly over compressions.
9. Remove air cleaner and any intake pipe which may be fitted between the air cleaner and air intake. Carefully seal air intake orifice with waterproof adhesive tape or some other suitable medium.
10. Remove exhaust pipe and seal opening in manifold as in '9.'
11. Disconnect battery and store in fully charged condition. Before storing the battery, terminals should be treated to prevent corrosion.

The fuel system may either be drained and charged with a suitable preservative or alternatively, it may be left primed with normal fuel oil.

Where the latter course is taken it should be noted that deterioration of the fuel oil may be occasioned during the months the application is idle.

If this occurs, the fuel oil may become contaminated with a wax-like substance which will quickly clog the fuel filtering arrangement once the engine is returned to service.

Therefore, before commencing operations in respect of a unit primed with normal fuel oil which has lain idle for several months it is recommended that the fuel tank be drained and the interior of the tank thoroughly cleaned. The fuel oil drained off should be discarded as unfit for further use.

Fuel oil contained in the remainder of the fuel system should also be dispelled and the paper element in the final fuel filter renewed, following which the system may then be recharged with fresh clean fuel oil.

Preparations for starting the engine should then be in accordance with instructions contained on page C.1.

Where a preservative is used in the lubricating oil sump, this should be drained off and replaced by normal lubricant prior to re-starting the engine at the end of the storage period. In the case of a preservative being utilised to charge the fuel system, this need not necessarily be drained off before returning the engine to service. Therefore, where a preservative is used in this respect, the relevant manufacturers of the fluid should be contacted seeking their guidance as to whether their product should be drained away prior to re-starting the engine.

FROST PRECAUTIONS.

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the water system or where this is not convenient, an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Anti-Freeze should conform to British Standard 3151.

Should it be the policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in Perkins engines and also to ensure that their products will have no harmful effect on the cooling system generally.

When draining the water circulating system it is not enough merely to open the radiator drain tap. The one on the cylinder block must also be opened. This tap is on the near side of the cylinder block, near the flywheel housing.

Where a pressurised radiator filler cap is fitted, this should be removed slowly, before draining the cooling system.

When the engine is drained, in the majority of applications the water pump is also drained, but rotation of the pump may be prevented by :

(a) Locking of the impellor by ice due to the pump drain hole being blocked by sediment.

(b) The locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point.

1. Before starting the engine, turn the fan and water pump by hand ; this will indicate if freezing has taken place. If so, this should free any ice formation.

2. If it is impossible to turn the pump by hand, the radiator and engine should be filled with warm water.

3. To avoid this trouble it is advisable when all water has been drained, to run the engine for a few seconds at idling speed, thus dispersing any moisture remaining in the pump.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturer's instructions before refilling with normal coolant.

If the foregoing action is taken, no harmful effects should be experienced, but Perkins Engines Ltd. cannot be held responsible for any frost damage or corrosion which may be incurred.

PERIODICAL ATTENTIONS

VEHICLE

Keep Engine Clean.

DAILY

Check water in radiator.
Check oil level in sump.

EVERY 1,000 MILES. (1,600 Km.)

Attend to exhauster (See Section U).
Check adjustment of fan belt (See Section Q)
Top up batteries with distilled water.

EVERY 2,000 MILES. (3,200 Km.)

Drain oil from sump and renew.
Clean pre-filter to fuel lift pump (if fitted).
Examine air cleaner (See Note).

EVERY 4,000 MILES. (6,400 Km.)

Attend to exhauster (See Section U).
Renew element in lubricating oil filter.
Clean and treat battery terminals.
Lubricate dynamo rear bush.

EVERY 10,000 MILES. (16,000 Km.)

Examine valve springs and check tappet clearances.

Remove, clean and attend to air cleaner (See Note).

Clean gauze trap in fuel oil filler (if fitted).

Clean gauze strainer in lubricating oil filler (if fitted).

EVERY 20,000 MILES. (32,000 Km.)

Inspect commutator and brushes of dynamo.
Renew element in final fuel filter.
Check oil flow to valve rocker shaft assembly.
Clean and check atomisers.

NOTE :—

The time for cleaning the air cleaner depends on operating conditions. Therefore under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.

The correct maintenance of the air cleaner will greatly assist in extending the life of the engine.

PERIODICAL ATTENTIONS

TRACTOR

Keep Engine Clean.

DAILY

Check water in radiator.

Check oil level in sump (Make sure the tractor is on level ground).

EVERY 50 HOURS

Check fan belt adjustment (See Section Q).

Clean air cleaner and renew oil (See Note).

Top up batteries with distilled water.

Ensure that cylinder head cover nuts are tight.

EVERY 250 HOURS

Renew element in lubricating oil filter.

Drain oil from sump and renew.

Flush radiator with clean water.

Clean and treat battery terminals.

Clean gauze element in water trap type filter (if fitted).

Lubricate dynamo rear bush.

EVERY 500 HOURS

Clean and check atomisers.

Examine valve springs and check tappet clearances.

Clean gauze trap in fuel oil filler (if fitted).

Clean gauze strainer in lubricating oil filler (if fitted).

EVERY 1,000 HOURS

Drain fuel tank, remove and clean.

Inspect commutator and brushes of dynamo.

Inspect valve rocker shaft assembly for lubrication.

Renew element in final fuel filter.

NOTE :—

The time for cleaning the air cleaner depends on operating conditions. Therefore under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.

The correct maintenance of the air cleaner will greatly assist in extending the life of the engine.

PERIODICAL ATTENTIONS

INDUSTRIAL

Keep Engine Clean.

DAILY

Check water in radiator.
Check oil level in sump.

EVERY 50 HOURS

Check fan belt adjustment (See Section Q).
Top up batteries with distilled water.

EVERY 100 HOURS

Clean pre-filter to fuel lift pump (if fitted).
Clean intermediate fuel filter (if fitted).
Examine air cleaner and replenish oil (See Note).

EVERY 250 HOURS

Drain oil from sump and refill.
Renew lubricating oil filter element.
Clean and treat battery terminals.
Refill lubricator on dynamo (if fitted).

EVERY 500 HOURS

Remove, clean and attend to air cleaner, (See Note).
Clean and check atomisers.
Clean gauze trap in fuel oil filler (if fitted).
Clean gauze strainer in lubricating oil filler (if fitted).

EVERY 1,000 HOURS

Clean fuel tank in portable installation.
Renew final fuel filter element.
Inspect commutator and brushes in dynamo.
Remove cylinder head cover.
Check oil flow to valve rocker shaft assembly.
Examine valve springs and tappet clearances.
Renew element in intermediate fuel filter (if fitted).

NOTE :—

The time period for cleaning the air cleaner depends on operating conditions, therefore, under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.

The correct maintenance of the air cleaner will greatly assist in reducing bore wear, thereby extending the life of the engine.

FILTER MAINTENANCE (G)

Cleanliness is a prime consideration in the operation of Diesel engines and to ensure that such a condition is maintained, particular attention has been paid to the provision of adequate filtering apparatus for air, fuel oil and lubricating oil.

Filters are provided and all that the operator needs to do is to ensure that those filters are kept in such a state that they will most effectively perform their functions.

AIR FILTERS

The time period for cleaning the air filter depends on operating conditions. Therefore, under extremely dusty conditions, the time limit recommended hereafter for cleaning should be decreased.

The correct maintenance of the filter will greatly assist in extending the life of the engine.

Oil Bath Filter.

In the oil bath filter, the incoming air impinges upon the surface of the oil carried in a reservoir in the lower part of the filter casing.

As a result of this, particles of foreign matter are carried into the oil by their own momentum and there trapped.

The air next passes through a steel wire element before reaching the induction manifold and in that element are deposited any other particles of foreign matter which still remain in the air after its contact with the oil.

Maintenance.

Examine, replenish oil, and clean in accordance with periodical attentions Section F.

At the stipulated intervals, remove the top cover and lift out element, wash in paraffin or fuel oil and allow to drain. Empty oil out of outer case and scrape out accumulated sludge. Wash outer case with paraffin or fuel oil and refill with engine oil to level indicated (Do not overfill). Replace element and top cover, care being taken to see that the joint ring is in good condition, and is sealing.

FUEL OIL FILTERS

Great care has been taken in the design of the engine to ensure that only clean fuel oil reaches the fuel pump.

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

It should be taken out every 10,000 miles or 500 hours, cleaned, washed in fuel oil and immediately replaced.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

The second filter is usually a water trap or prefilter fitted with a comparatively coarse element.

This filter and element should be cleaned in accordance with periodical attentions unless the condition of the fuel oil warrants more regular attention.

Fig. G.1.

When re-assembling after cleaning, ensure that a good joint is made between the top of the bowl and the filter body as any leakage of air here may cause air locks in the fuel system.

The third and final filter is a paper element type filter. It is not possible to clean the paper element. It should be renewed every 20,000 miles or 1,000 hours.

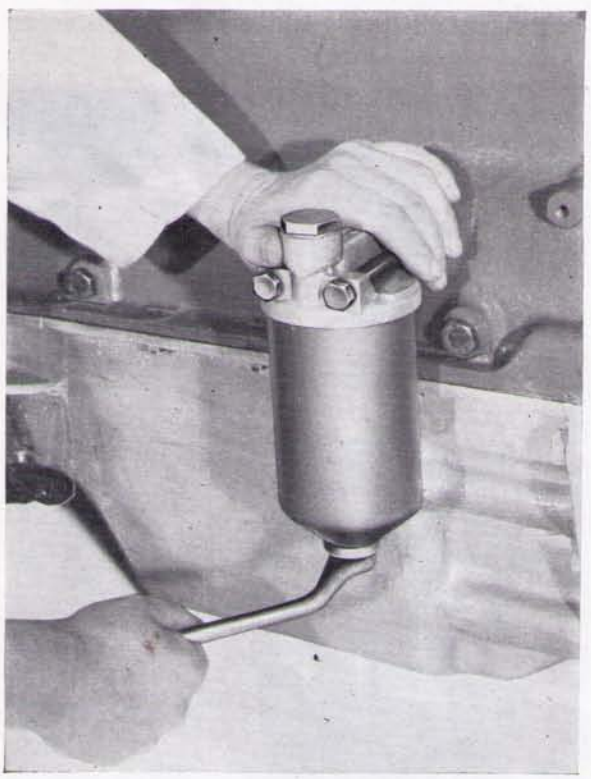
On certain industrial engines, an intermediate fuel filter is fitted, this should be cleaned and renewed as stipulated on page F.5.

To renew the element :—

1. Unscrew the bolt at the bottom of the bowl.
2. Drop filter bowl clear.
3. Remove element and discard. (See Fig. G.1).
4. Before putting new element in position, clean the filter bowl.
5. Ensure that the rubber joints are in good condition. If not replace by new ones.

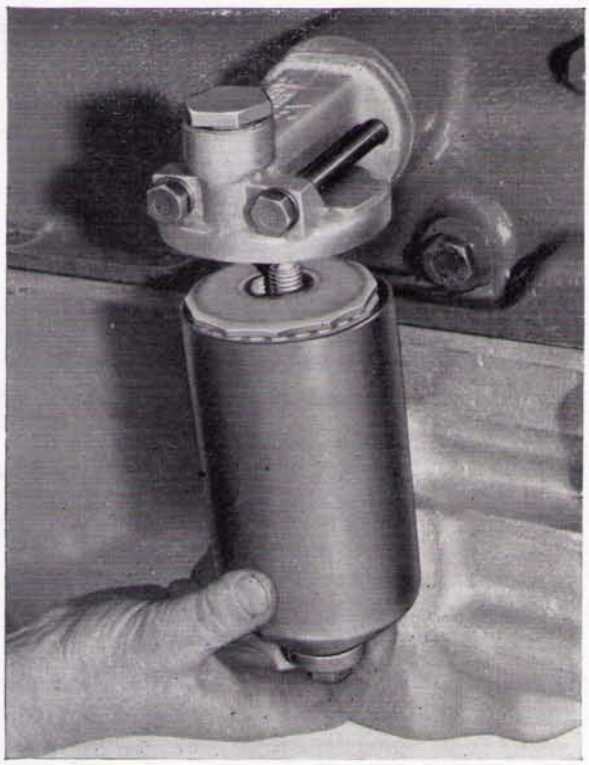
LUBRICATING OIL FILTERS

The importance of using clean lubricating oil in the first place, and providing means to ensure that it is always clean in use, is hardly second to the importance of cleanliness in respect of the fuel.



Unscrewing Bolt from Lubricating Oil Filter Bowl.

Fig. G.2.



Lowering Filter Bowl.

Fig. G.3.

It is imperative, therefore, that lubricating oil filters be not neglected. Moreover, if the periodical attentions herein recommended are carried out and the correct grade of clean oil used, a very long life can be obtained from the Perkins engine.

To ensure cleanliness, three filters are incorporated.

1. Oil Filler Strainer.
2. Sump Strainer.
3. Main (full flow) Filter.

The purpose of the oil filler strainer is to prevent large objects entering the sump when the engine is being filled with lubricating oil.

The sump strainer consists of a wire gauze container which fits over the suction pipe to the oil pump. This strainer requires no special attention but should be cleaned whenever the sump is removed.

Main (full flow) Filter.

This filter contains a paper element which should not be cleaned but renewed in accordance with periodical attentions, Section F.

To renew the element :—

1. Unscrew the centre bolt at bottom of cover (See Fig. G.2).
2. Drop filter bowl clear (See Fig. G.3).
3. Remove element and discard.
4. Before replacing new element, clean inside of filter bowl with paraffin or fuel oil.
5. Ensure that the felt washer and rubber joints are in good condition. If not, replace by new ones.

CYLINDER HEAD (H)

The Diesel engine rarely requires the removal of the cylinder head since, unlike its petrol counterpart, carbon deposits beyond a superficial coating do not accumulate in the combustion chambers. After a period, depending on the conditions under which the engine is operated, the valves and valve seats may need attention, this being indicated by a loss of power. A top overhaul is then necessary.

To Remove the Cylinder Head from the Engine.

Ensure that the cooling system is completely drained. Taps for this purpose are provided, one on the left hand side of the cylinder block and one usually at the base of the radiator.

Disconnect the water outlet hose from the thermostat housing.

Disconnect the exhaust pipe flange from the exhaust manifold.

Remove the lub. oil pipe between the camshaft chamber and the cylinder head.

Remove the air cleaner connection from the air intake and disconnect the fuel oil supply pipe and the electrical connection from the cold starting aid.

Remove the fuel injection pipes taking care to cover the fuel injection pump outlets with suitable caps or clean non fluffy cloth.

Disconnect the atomiser leak-off pipes and remove the atomisers.

Remove the rocker cover and rocker assembly together with its lub. oil supply pipe.

Remove the cylinder head securing nuts, slackening off in the reverse order to that shown in Fig. H.2.

When removing the cylinder head, it is advisable not to force steel wedges (i.e. screwdrivers etc.) between the cylinder head and the cylinder

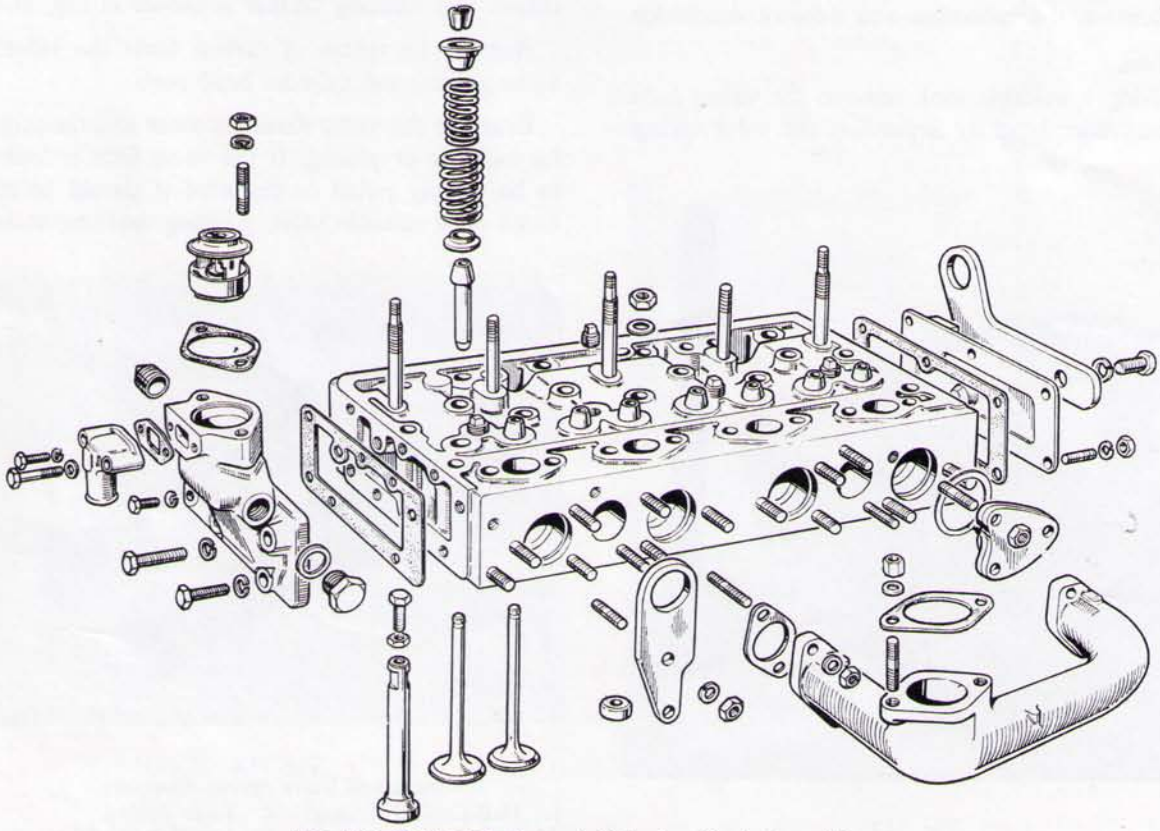


Fig. H.1. Exploded view of Cylinder Head Assembly.

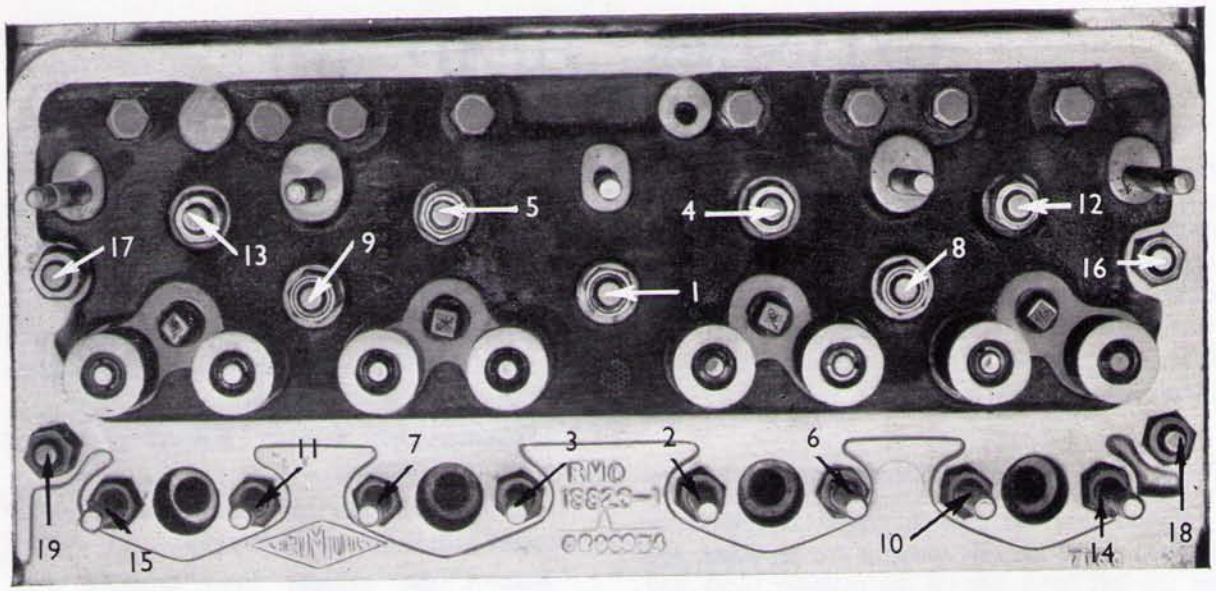


Fig. H.2.
Diagram showing Cylinder Head Nut tightening sequence.

block, otherwise damage may be caused to the machined faces.

To Overhaul the Cylinder Head.

Remove the induction and exhaust manifolds.

Valves.

Using a suitable tool, remove the valves from the cylinder head by depressing the valve springs and retaining caps and removing the split collets (Fig. H.3).

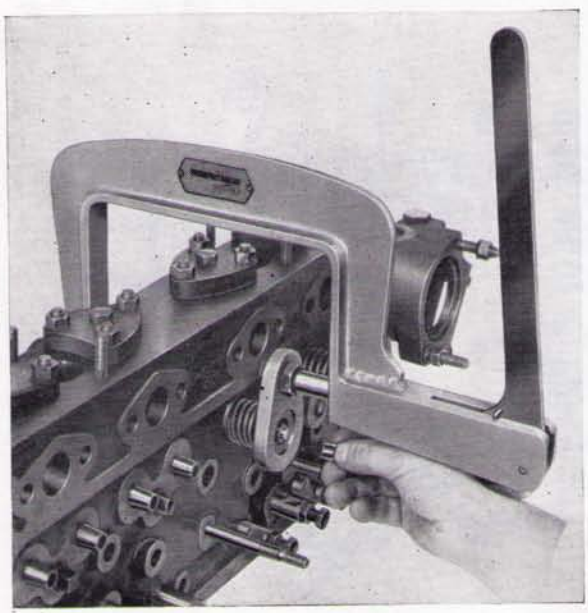


Fig. H.3.
Removing Valve from Cylinder Head.

Layout of the valve springs, spring retainer, collets and locating washer is shown in Fig. H.4.

Remove all traces of carbon from the valves, valve guides, and cylinder head ports.

Examine the valve stems for wear and the faces for burning or pitting. If the valve face is found to be unduly pitted or distorted it should be re-faced on a suitable valve grinding machine to an

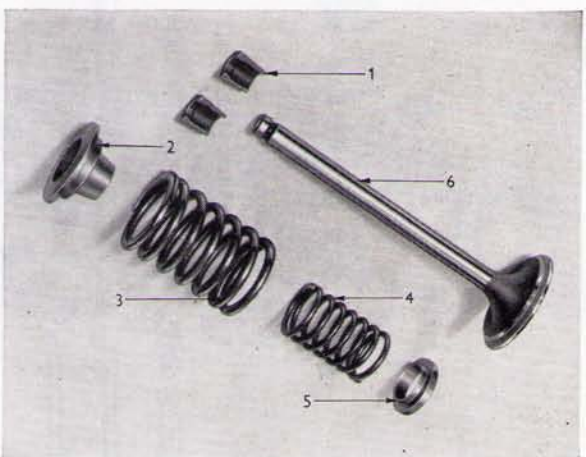


Fig. H.4.
Valve and Valve Spring Assembly.

1. Half-Conical Collets.
2. Spring Cap.
3. Outer Spring.
4. Inner Spring.
5. Locating Washer.
6. Valve.

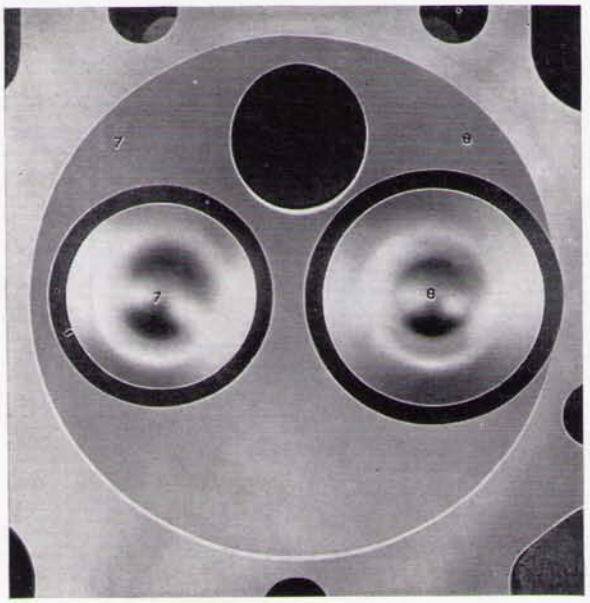


Fig. H.5.
Close up of Valves showing Identification numbers.

angle of 45 degrees. This operation should continue only until the face is clean and true, as the removal of an excessive amount of metal may reduce the thickness of the edge of the valve head to such an extent that it will burn or distort under operating conditions, the valve may be unduly lowered in its seating in the cylinder head and " pocketing " will result. If a valve is deemed to be beyond reclaiming it should be replaced and the corresponding number stamped on the head of the new valve. See Fig. H.5.

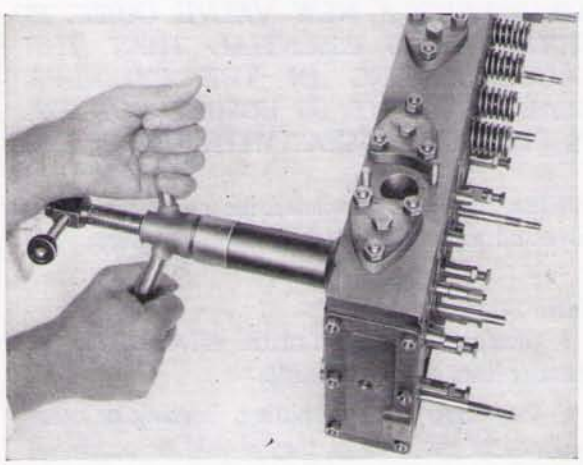


Fig. H.6.
Fitting Valve Guides

Valve Springs.

Two valve springs are fitted to each valve and they are similar for both inlet and exhaust valves.

Before being refitted they should be carefully examined paying particular regard to the squareness of the ends. They should always be renewed during major overhaul.

Valve Guides.

The valve guides are a press fit in the cylinder head. The vertical location of the guide is determined by a machined collar on its outer diameter.

All the guides should be examined for damage or wear on the internal bore.

Removal of a valve guide is accomplished by use of a special tool. Pass the rod of the tool through the valve guide from the top face of the cylinder head until the step on the rod abuts against the top of the valve guide. Fit the spacer to the lower end of the rod and screw on the knurled retainer. Turn the winged nut on the main tool and the guide will be drawn from the cylinder head.

Fig. H.7.
Cutting a Valve Seat.

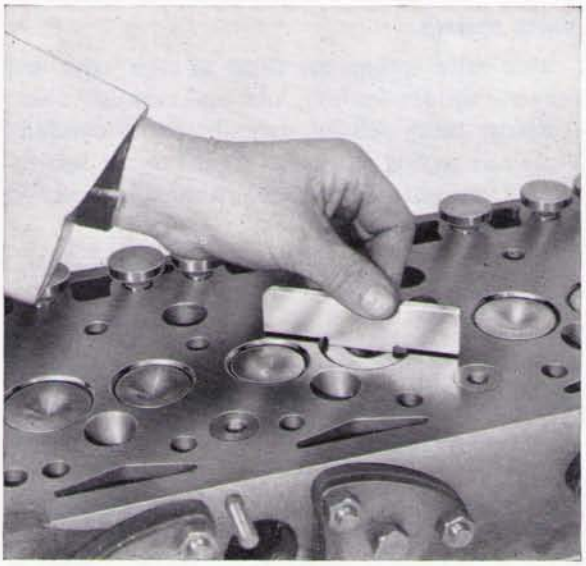


Fig. H.8.

Replacement of a valve guide is accomplished by use of the same tool but using the angled adaptor. (See Fig. H.6). Pass the rod of the tool through the valve guide bore from the cylinder head bottom face so that the angled adaptor fitted into the main tool body abuts against the valve seat in the cylinder head. Locate the valve guide on the rod and retain in position with the knurled nut. Turn the winged nut and the valve guide will be drawn into its bore in the cylinder head. Ensure that the machined collar is drawn firmly against the cylinder head. A light application of engine oil to the valve guide will facilitate its entry into the parent bore.

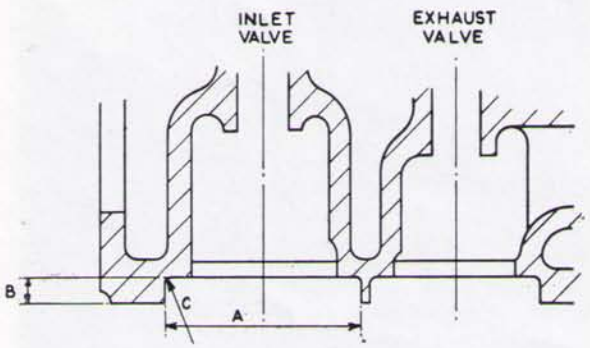


Fig. H.9.

Valve Seat Cutting Dimensions.

Inlet.	**Exhaust.**
A.—1.874″ to 1.875″.	A.—1.624″ to 1.625″.
B.—.248″ to .250″.	B.—.248″ to .250″.
C.—.040″ to .050″ Radius.	C.—.040″ to .050″ Radius.

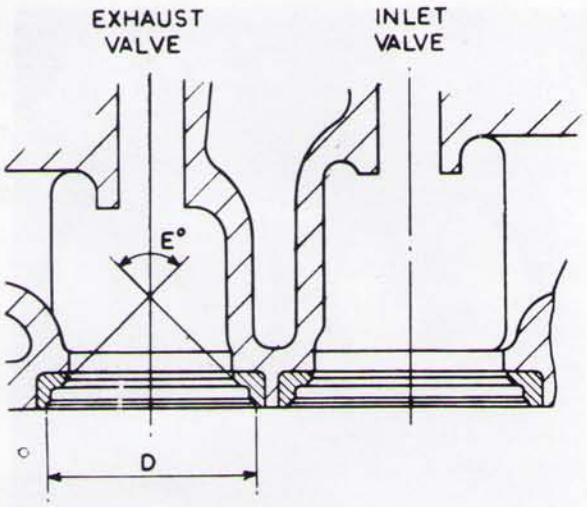


Fig. H.10.

Checking Valve Depths.

Valve Insert Finished Dimensions.

Inlet.	**Exhaust.**
D.—1.704″ to 1.714″.	D.—1.485″ to 1.495″.
E.—90°.	E.—90°.

On later engines, shoulderless valve guides are fitted. With these, both ends are chamfered, one at 45°, the other at 20°. The end which is chamfered at 20° is also recessed in the bore. This end should be inserted into the cylinder head top face and pulled into its parent bore until the opposite end (chamfered at 45°) protrudes .584/.594 in. above the top face.

When fitting later type valve guides, ensure that the correct valve spring washer is fitted as these washers are not interchangeable between shoulder and shoulderless guides.

N.B.—WHERE A NEW VALVE GUIDE IS FITTED, IT IS ESSENTIAL THAT THE VALVE SEATING IN THE CYLINDER HEAD BE RECUT TO ENSURE CONCENTRICITY OF THE SEAT WITH THE GUIDE.

When fitting is completed the guide should be inspected to ensure that it is free from burrs.

Valve Seats.

A careful examination of the valve seats in the cylinder head should be made.

If they show signs of pitting, burning or other evidence of gas leakage they should be machined or hand ground according to condition. Hand grinding is only a finishing process and on no

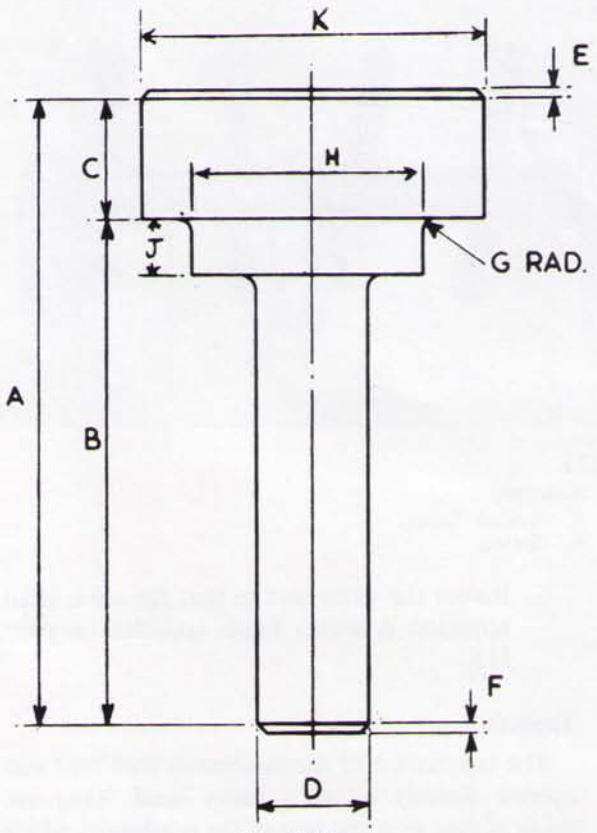


Fig. H.11.

Press Tool for Valve Seat Inserts.

Inlet Dimensions.	**Exhaust Dimensions.**
A.—2¾″.	A.—2¾″.
B.—2″.	B.—2″.
C.—¾″.	C.—¾″.
D.—.309″ to .310″.	D.—.309″ to .310″.
E.—1/16″ @ 45°.	E.—1/16″ @ 45°.
F.—1/16″ @ 45°.	F.—1/16″ @ 45°.
G.—1/32″ Radius.	G.—1/32″ Radius.
H.—1.401″ to 1.402″.	H.—1.182″ to 1.183″.
J.—.212″ to .215″.	J.—.212″ to .215″.
K.—1.855″ to 1.865″.	K.—1.605″ to 1.615″.

Material EN32A Case Hardened and Ground.

account should prolonged grinding be attempted otherwise seat angles may be altered and seat widths increased excessively.

Should it be deemed necessary to recut a valve seat, a special tool is available (Fig. H.7). This comprises an exhaust valve seat cutter, inlet valve seat cutter, valve seat cutter pilot and valve seat cutter handle. The tool is specially designed so that it not only recuts the seat, but also cuts the shoulder and prevents the seat becoming too wide. When the orthodox portable valve seat grinding machine is used, the stones should be set at an angle of 45°. If after grinding, the width of the seat exceeds 3/32 in. the shoulder should be cut down, otherwise the valve will become "pocketed."

N.B.—WHEN RECUTTING VALVE SEATS IT IS ESSENTIAL THAT THE MINIMUM AMOUNT OF METAL BE REMOVED, OTHERWISE THE MAXIMUM VALVE RECESSION TOLERANCE MAY BE EXCEEDED.

On completion of this work, a check should be made to ensure that the depth of the valve head below the level of the cylinder head face is not less than .066 in. (1,676 mm.) and not more than .140 ins. (3,556 mm.). (Fig. H.8).

Grinding in Valves.

This operation is to ensure that a perfect mating between the valve face and the seat is obtained. This is extremely important if good compressions are to be obtained. It will be noted that valves and seats are numbered and each valve must be ground on its corresponding seat .(See Fig. H.5). If the previous reconditioning processes to valves and seats have been carefully executed, very little grinding will be necessary to produce an even, clean, seat of matt grey finish, the width of which should be between 1/16 in. (1.58 mm). and 3/32 in. (2.38 mm.)

Medium or fine grinding paste should be used, and with the aid of a suction grinding tool, the valve should be rotated backwards and forwards frequently lifting it from its seat and turning it to a new position.

On completion of this operation, all traces of grinding paste must be removed from the valves, seats, and cylinder head.

Valve Seat Inserts.

It is permissible to fit valve seat inserts where the original seating has become unserviceable due to damage or to the maximum valve recession tolerance having been exceeded. This should prove successful providing that the listed tolerances are strictly adhered to and that Genuine Perkins Parts are used.

This operation must never be attempted with a worn valve guide in position. All machining must be completed from the bore of a new valve guide.

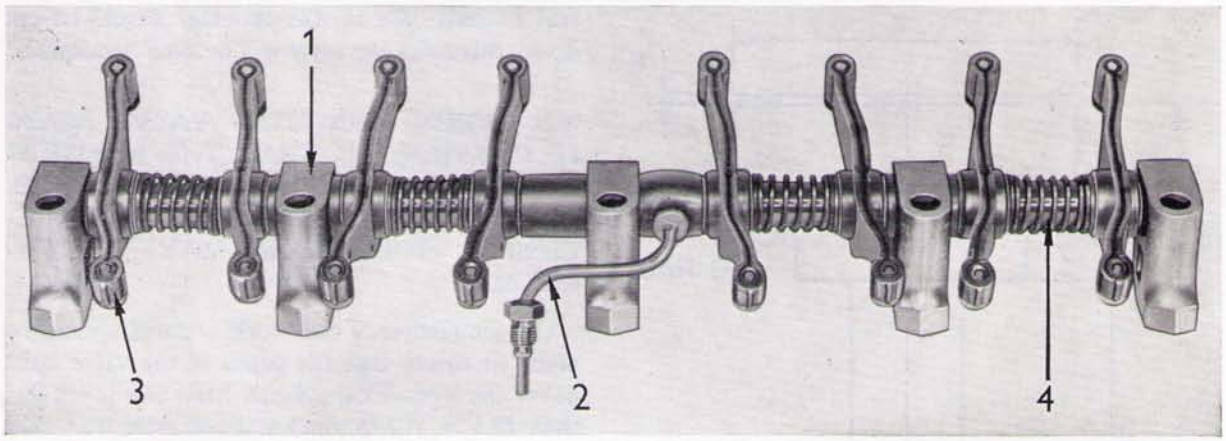


Fig. H.12.
Rocker Shaft Assembly.
1. Rocker Shaft Support Bracket.
2. Oil Feed Pipe.
3. Rocker Lever.
4. Spring.

Operation.

1. Press out the old valve guide and clean the parent bore.
2. Press in new valve guide to act as a pilot for subsequent operations.
3. Using a suitable cutting tool, the old seats should be cut away to the dimensions shown in Fig. H.9. Care should be taken that the cutting is clean, and that all the swarf is removed.
4. Using a dolly machined to the dimensions Fig. H.11), again using the valve guide bore as a pilot, press home the insert using steady pressure from a hand or hydraulic press. Under no circumstances should the insert be hammered in or lubricated.
5. Visually inspect to ensure that the insert is pressed in squarely and is flush with the bottom of the recess. See Fig. H.10.
6. Re-cut the valve seat so that the valve head recession is within limits specified on page H.5.

Tappets.

The tappets are of the mushroom foot type and operate directly in the cylinder head. They are made of cast iron, the face of the mushroom which runs on the camshaft being chill hardened. Hardened setscrews with locknuts are provided to effect the setting of valve clearances.

These should be examined for wear and to ensure that they can operate freely.

Rocker Assembly.

Before attempting to dismantle the rocker assembly (Fig. H.12) it should be noted that the slot in the end of the rocker shaft is in line with a punch mark on the support bracket. When this slot is positioned vertically in relation to the

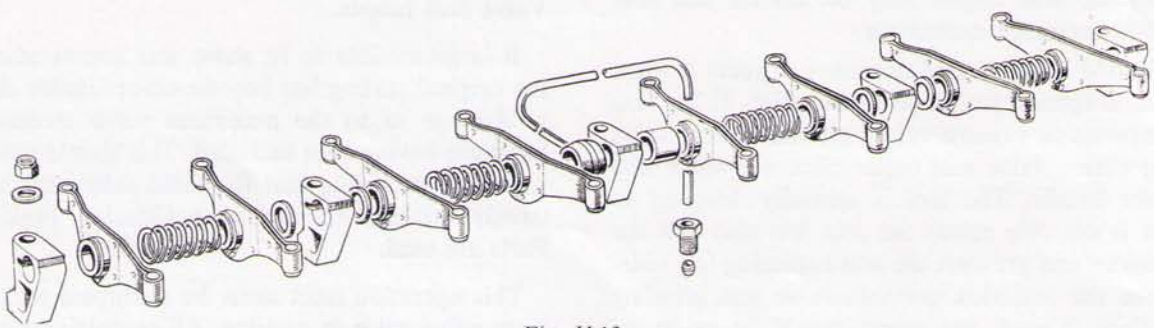


Fig. H.13.
Exploded view of Rocker Shaft Assembly.

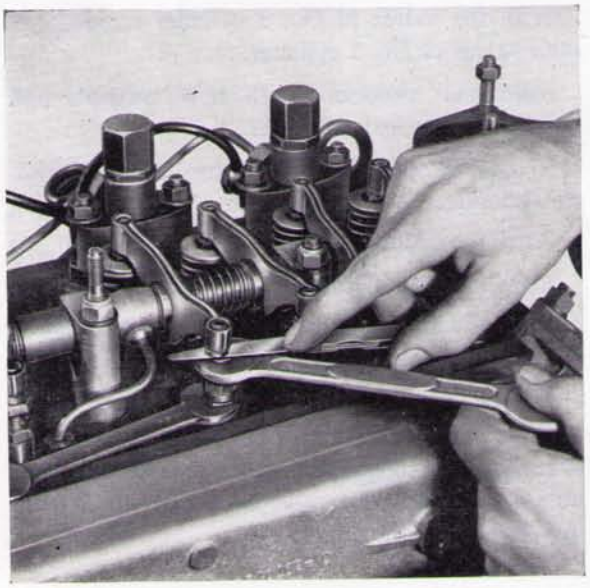


Fig. H.14.
Adjusting the Tappets.

support bracket then the maximum oil flow to the rocker assembly is obtained. In production the slot is set at 30 degrees before the vertical and this position is indicated by the punch mark on the rear support bracket.

To dismantle the rocker gear assembly, remove the circlips from the ends of the rocker shaft and slide off the components noting the positions of support brackets, rocker arms, springs, spacers and lub. oil supply pipe.

If on inspection it is found that rocker arms are worn or damaged, or the bushes are worn, then replacement arms must be fitted since the bushes are not replaceable. When ordering it is essential to note whether left handed or right handed rocker arms are required.

When re-assembling ensure that all components are fitted to the rocker shaft in the correct order (Fig. H.12) and that new circlips are fitted to the ends of the shaft.

Combustion Caps.

These are bolted to the left hand side of the cylinder head, part of the combustion chamber being formed in the cylinder head and part in the cap. Removal of these caps will facilitate cleaning of the combustion chambers should this be necessary. When refitting it is essential to use new copper washers and to tighten down the three securing nuts evenly.

To Re-assemble the Cylinder Head.

Lubricate the valve stems and valve guides with engine oil and place the valves in their respective guides. Replace in the following order. Locating washer, internal valve spring, external valve spring, and spring retaining cap. Compress the spring and fit the split collets.

Refit induction and exhaust manifolds using new joints.

To Refit the Cylinder Head to the Engine.

Remove all traces of old jointing compound, carbon, etc., from the face of the cylinder block.

Remove all carbon from the tops of the pistons leaving them clean and bright. During this operation it is advisable to lower the piston in its bore, smear some grease around the top of the bore and then bring the piston to T.D.C.

The grease will then form an effective seal and prevent carbon from reaching the piston rings.

Thoroughly clean, paying particular attention to the areas around the bases of the cylinder head studs, removing them from the block if considered necessary.

Examine the cylinder head studs for damage to the threads or looseness in the cylinder block, and check all nuts.

Smear a new cylinder head gasket with a suitable jointing compound and place on the cylinder block.

After ensuring that the face of the cylinder head is perfectly clean, position it on the studs and lower gently on to the gasket.

Fit the cylinder head nuts and using a torque wrench tighten down evenly in the sequence shown in Fig. H.2 to the recommended torque (see page B.2).

N.B.—Since the Four 192 and the Four 203 engines have different bore sizes, different cylinder head gaskets are required. To ensure that these are readily recognisable, a thick cylinder head stud has been positioned in the centre of the cylinder block face of the Four 203 engine. The corresponding hole in the gasket has been enlarged.

Refit the lub. oil pipe between the camshaft chamber and the cylinder head.

Refit air cleaner connection to the air intake and the fuel oil supply pipe and the electrical connections to the cold starting aid.

Replace the rocker asembly, tighten down evenly and reconnect the lub. oil supply pipe.

Reset the valve clearances (Fig. H.14). These can be done in the following sequence. With the valves of No. 4 cylinder rocking, set both valves of No. 1 cylinder to .012 in. (.30 mm).

With the valves of No. 2 cylinder rocking, set both valves of No. 3 cylinder.

With the valves of No. 1 cylinder rocking, set both valves of No. 4 cylinder.

With the valves of No. 3 cylinder rocking, set both valves of No. 2 cylinder.

Refit the atomisers with new washers and connect up the leak-off pipes.

Reconnect the water outlet hose to the thermostat housing.

Refill the cooling system.

Bleed out all air from the fuel system.

Start the engine and ensure that lub. oil is reaching the rocker shaft.

Replace the rocker cover using a new joint.

After a short settling in period, it is advisable to recheck the torque settings on the cylinder head nuts and to reset the valve clearances to .010 in (.25 mm.) with the engine hot.

PISTONS AND CONNECTING RODS (J)

The pistons are of high silicon aluminium and are not graded to bore size. They are not interchangeable between the Four 192 and the Four 203 engine due to difference in bore size. Grooves are provided to take three compression rings and one oil control ring above the gudgeon pin and one one oil control ring below the gudgeon pin. (See Fig. J.1).

Pistons for the Four 192 engine can be obtained in two sizes, standard and plus .030 in., it being possible to rebore the cast iron cylinder liners.

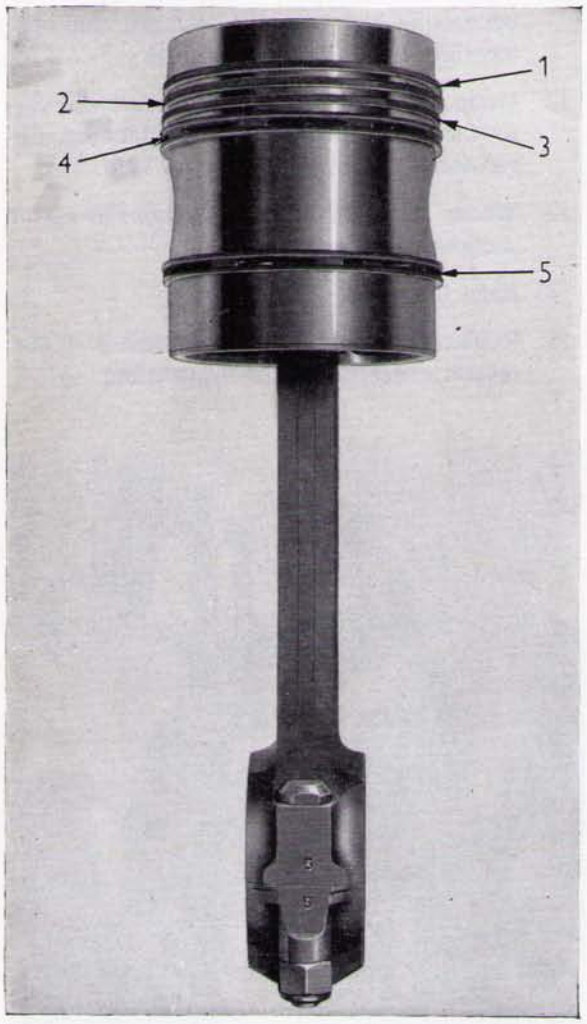


Fig. J.1.
Connecting Rod Assembly.

1. Top Compression Ring.
2. 2nd Compression Ring.
3. 3rd Compression Ring.
4. Upper Oil Control Ring.
5. Lower Oil Control Ring.

Pistons for the Four 203 can only be obtained in one size—standard—no reboring of the chrome liners being possible.

The connecting rods are of high tensile steel 'H' section forgings. The big end is split at right angles to the axis of the rod, the cap being secured by two fitted bolts, secured by self-locking nuts. Thin wall pre-finished, steel backed plated, copper lead lined or aluminium tin lined big end bearings and lead bronze lined, steel backed wrapped small end bushes are fitted.

The connecting rods are numbered on cap and rod, (See Fig. J.1 and J.4) when fitted to the engine in production and the assembly is fitted to the crankshaft so that these numbers are on the fuel pump side of the engine. Always fit the cap to the connecting rod so that the numbers are both on the same side. Never re-assemble the cap to the connecting rod incorrectly.

It is advisable when removing a piston assembly from the engine to check whether or not the connecting rod and cap has been suitably marked, as they may have been replaced at some time after the engine left the factory, in which case the numbering may not have been carried out. Such connecting rods and caps should be suitably marked.

To Remove a Connecting Rod and Piston Assembly.

1. Remove the cylinder head assembly.
2. Remove the sump.
3. Turn the crankshaft until the piston to be removed is at the bottom of its stroke.
4. If necessary, remove the oil pump suction and delivery pipes.
5. Carefully remove any carbon that may have formed at the top of the cylinder bore.
6. Release and remove the self locking nuts from the connecting rod bolts and remove the cap, bottom half of the big end bearing and the connecting rod bolts.
7. Turn the crankshaft until the piston is at the top of its stroke, push the piston and its connecting rod up the bore sufficiently to enable removal of the top half of the big end

Fig. J.2.
Withdrawing a Piston and Connecting Rod.

bearing. Continue to push the piston and connecting rod up and out of its bore. (See Fig. J.2).

8. Reassemble the bearings and cap to the connecting rod.

To Replace a Piston and Connecting Rod.

1. Clean out the cylinder bore with a clean dry non-fluffy rag and apply a liberal coating of lubricating oil to the cylinder bore.
2. Ensure the piston is thoroughly clean and free from scoring, and liberally oil.
3. Fit the piston rings to the piston in the correct order as given on Page J.4.
4. Position the ring gaps around the piston so that they are equally spaced.
5. Fit the piston assembly ring on the piston, entering it over the connecting rod end with the chamfer up towards the piston.
6. Ensure that the connecting rod number is on the fuel pump side of the engine and insert the connecting rod and piston into its bore.
7. Push the piston down into its bore through the assembly ring. (See Fig. J.3).
8. Turn the crankshaft until the relevant big end journal is at the bottom centre.
9. Liberally oil and fit the top half bearing in the connecting rod, ensuring that the tongue on the bearing engages in the machined recess in the big end bore.
10. Pull the connecting rod to the crankshaft and refit the big end bolts ensuring that they are fully located. The bolt head is machined so that the bolt locates in the connecting rod in one position only.
11. Liberally oil and locate the lower half bearing in the cap with the tongue registering in the machined recess and fit the cap to the connecting rod with the stamped numbers together. (See Figs. J.1 and J.4).
12. Using new self locking nuts, secure the cap to the connecting rod and tighten to the recommended torque (see page B.2).
13. Where necessary replace the lubricating oil suction and delivery pipes.
14. Refit the sump.
15. Replace the cylinder head assembly in the reverse order to that of dismantling.

Fitting a Piston.
Fig. J.3.

Piston Gudgeon Pin.

The piston gudgeon pins are fully floating and are located in the pistons by circlips, one each end.

To Remove a Piston from a Connecting Rod.

In production, the crown of each piston is stamped with a number denoting its position in the engine, No. 1 piston being at the front. The number on the piston crown is the same as that on the corresponding connecting rod and cap.

1. Remove the piston and connecting rod as previously described.
2. Ensure that the piston is numbered, as it may have been installed at some time after the engine left the factory without being marked, and if the piston removed is to be used again ensure that it is marked relative to the connecting rod so that it can be replaced in the same position on the rod.
3. Remove the two circlips retaining the gudgeon pin in the piston.
4. Warm the piston in hot water or oil and push out the gudgeon pin.

To Replace a Piston on a Connecting Rod.

1. With the piston thoroughly clean, fit one new circlip in position in the piston to serve as a location for the gudgeon pin on replacement.

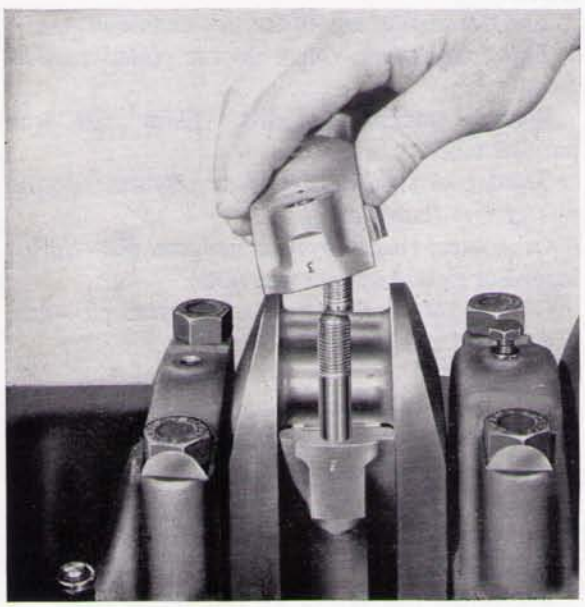


Fig. J.4.
Fitting a Connecting Rod Bearing Cap.

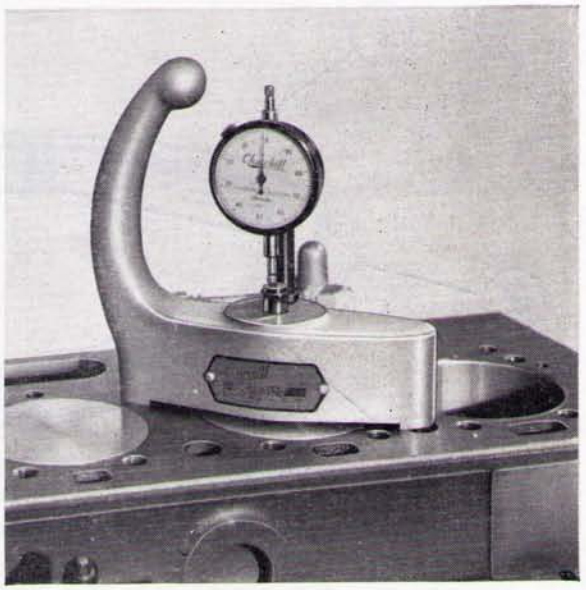


Fig. J.5.
Checking Piston Height.

2. Heat the piston in hot water or oil to allow easy replacement of the pin.
3. Insert the connecting rod between the piston bosses so that the marks made at the time of dismantling are in line. If a new piston is being used it may be fitted to the connecting rod, either way round.
4. Insert the gudgeon pin and fit the second circlip into the piston.
5. Ensure both circlips are fully located in their grooves.
6. Oil the component parts and reassemble to the engine as described in the appropriate Section.

When a new piston is fitted, it is necessary to machine the piston crown to provide the correct clearance of 0.000/0.005 in. below the top face of the cylinder block with the piston at T.D.C. This operation should be carried out as follows:

1. The piston and connecting rod must be reassembled and refitted as detailed.
2. Turn the crankshaft until the piston is at top dead centre and measure the distance between the top face of the cylinder block and the piston crown using the Piston Height Gauge. (See Fig. J.5).

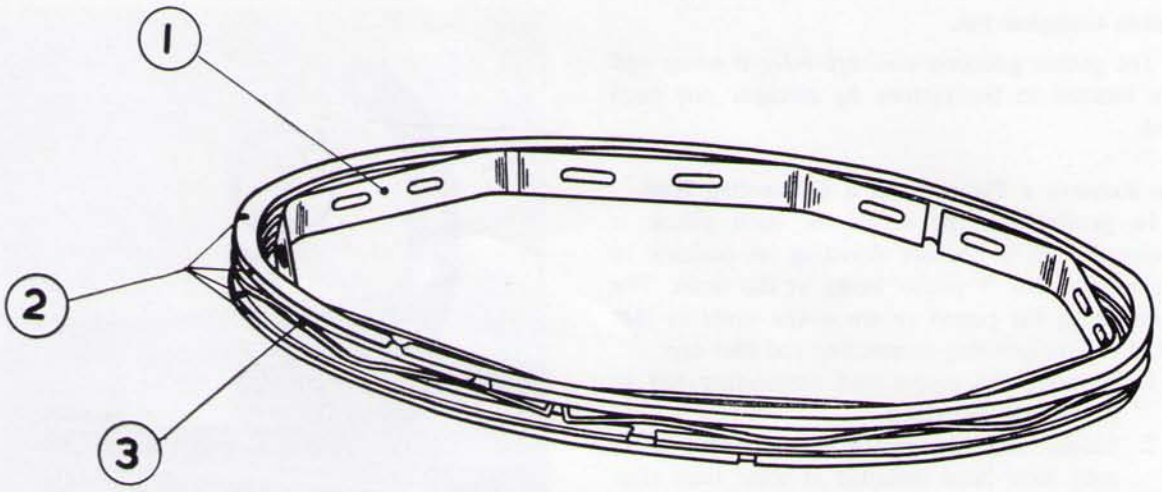


Fig. J.6.
Spring Loaded Scraper Ring (Four 192)

3. The piston and connecting rod assembly should then be withdrawn and dismantled to enable the piston crown to be skimmed until the clearance of 0.000/0.005 in. is obtained between the cylinder block top face and the piston crown.
4. Re-assemble and refit the piston and connecting rod and check that the correct clearance is obtained with the piston at top dead centre.
5. Carry out these instructions with every new piston that is fitted.

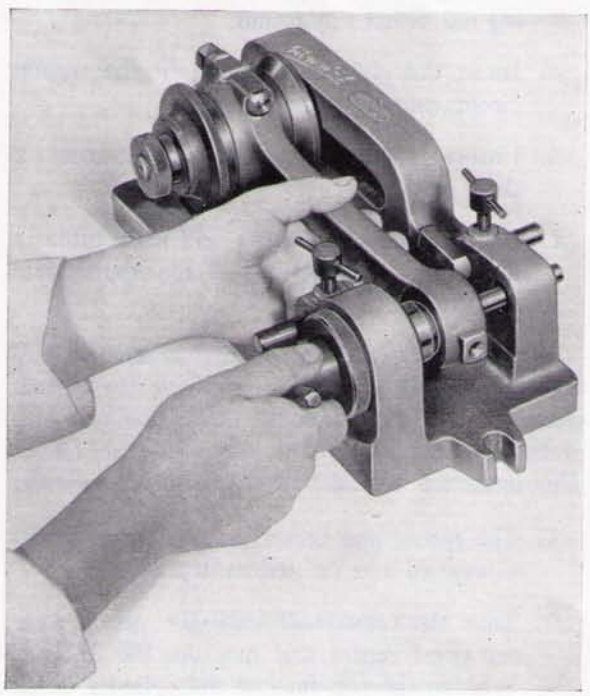


Fig. J.7.
Centralising the Small End Bush prior to Reaming.

Piston Rings.

Due to the different material surface of the cylinder liners incorporated in the Four 192 and Four 203 engines, different piston ring layouts are used.

Four 192 Engine. Bore 3.5 in. Cast Iron Cylinder Liners.

The piston ring layout for this engine is :—

Top compression ring—chrome plated parallel faced.

Second compression ring — plain cast iron parallel faced.

Third compression ring—four segment rings in one groove (laminated).

Oil control ring above the gudgeon pin—Spring loaded or slotted scraper (see note).

Oil control ring below the gudgeon pin—cast iron slotted scraper.

NOTE—The oil control ring above the gudgeon pin is either a spring loaded or slotted scraper ring depending on engine rating.

Four 203 Engine. Bore 3.6 in. Chromed thin wall Cylinder Liners.

The piston ring layout for this engine is :—

Top compression ring — cast iron parallel

Second compression ring—cast iron taper faced.

Third compression ring—cast iron taper faced.

On later type engines, a laminated compression ring is fitted in the third ring groove.

Oil control ring above the gudgeon pin—cast iron slotted scraper.

Oil control ring below the gudgeon pin—cast iron slotted scraper.

Taper faced rings are marked top and the side thus marked must be fitted uppermost.

N.B.—Under no circumstances should laminated piston rings with an expander be fitted to a chrome plated cylinder bore.

To Remove the Piston Rings.

Remove the connecting rod and piston assembly from the engine as previously detailed.

Carefully remove the rings using either guide strips or piston ring expanders, removing the top ring first. Where taper faced rings are fitted and it is intended to use them again, a check should be made before removal to ensure that the 'Top' marking is still legible, otherwise difficulty may be experienced in re-assembling them on the piston correctly.

Remove all carbon from the piston crown and grooves, taking care not to damage the piston.

Checking Piston Ring Gaps.

Insert the piston ring in a 3.5 or 3.6 in. piston ring gauge depending on the engine type or alternatively in the bottom of a cylinder bore.

Place the gauge on a flat metal surface, centralising the ring by means of a piston until it is at the bottom.

The gap may then be checked with a set of feeler gauges to ensure that it is within the specified limits. See Schedule of Fits and Tolerances.

Fitting Piston Rings to Pistons.

Ensure that all piston rings and piston ring grooves are perfectly clean, that the grooves are not damaged, or the pistons scored.

Parallel faced piston rings should be fitted to their respective grooves and checked to ensure that they are quite free.

Taper faced rings should be similarly fitted ensuring that the face marked 'T' is uppermost.

To Fit the Laminated Compression Ring. (Four 203 Engines).

Fit the first segment to the piston so that when held horizontally in the palm of the hand and radially compressed, the ring ends point downwards. Position this ring at the bottom of the groove with the gap over the gudgeon pin bore.

Fit the second segment on top of the first so that when held compressed as described above, the ring ends point upwards. Position the gap at 180° to the first segment gap.

The third segment should be fitted on top of the second so that when held and compressed as described, the ring ends point upwards. Position the gap immediately above that of the first segment.

To fit the Laminated Compression Ring (Four 192 Engines).

Fit the first segment to the piston so that when held horizontally in the palm of the hand and radially compressed the ring ends point downwards. Position this ring at the bottom of the groove with the gap over the gudgeon pin bore.

Fit the second segment on the top of the first, so that when held compressed as described above, the ring ends point upwards. Position the gap at 180° to the first segment gap.

The third segment should be fitted on the top of the second so that when compressed as described, the ring ends point downwards. Position the gap immediately above that of the first segment.

Fit the fourth segment on top of the third so that when held and compressed the ring ends point upwards. Position the gap above that of the second segment.

To Fit Spring Loaded Scraper Ring. Four 192 Engines.

The spring loaded scraper ring comprises one internal expander ring (1), two rail rings (2) each side of the spiral ring (3). See Fig. J.6.

1. Fit internal expander ring.
2. Fit lower two rail rings.
3. Fit spiral ring.
4. Fit upper two rail rings.

When fitting the lower and upper rail rings, the ring gaps should be staggered around the piston ring groove.

Renewing Connecting Rod Bearings.

Connecting Rod Big End Bearings may be renewed without removing the piston and connecting rod from the engine. The bearings are available in standard sizes and in undersizes of 0.010 in., 0.020 in. and 0.030 in.

1. Remove the sump.
2. Turn the crankshaft to bring the required big end to bottom centre and if necesary remove the oil pump suction and delivery pipes.
3. Remove the self locking nuts and detach the cap.
4. Push up the connecting rod sufficiently to clear the crankpin and move the big end to one side. The upper half of the bearing may now be removed from the connecting rod and the new one inserted with the tongue of the bearing locating in the machined recess in the big end bore.
5. The lower half of the bearing may now be extracted from the cap and a new one inserted engaging the tongue of the bearing in the machined recess of the cap.
6. Liberally lubricate the top half bearing in the connecting rod and fit the connecting rod to the crankpin taking care not to dislodge the bearing.
7. Liberally lubricate the bottom half bearing and replace the big end cap with the stamped numbers together. Ensure the cap bolts are fully located with the bolt heads against the sides of the rod.
8. Fit new self locking nuts and tighten to the recommended torque—see page B.2.
9. Where necessary replace the oil pump suction and delivery pipes.
10. Refit the sump.

Removing and Replacing Gudgeon Pin Bush.

In addition to examining visually the connecting rod for damage, the small end bush should be checked for condition and fit of its gudgeon pin. Should renewal of the bush be necessary, proceed as follows :—

Using a suitable tool remove the old bush by pressing in the replacement bush. The oil hole in the new bush must first be carefully aligned with the drilling feed in the top of the connecting rod.

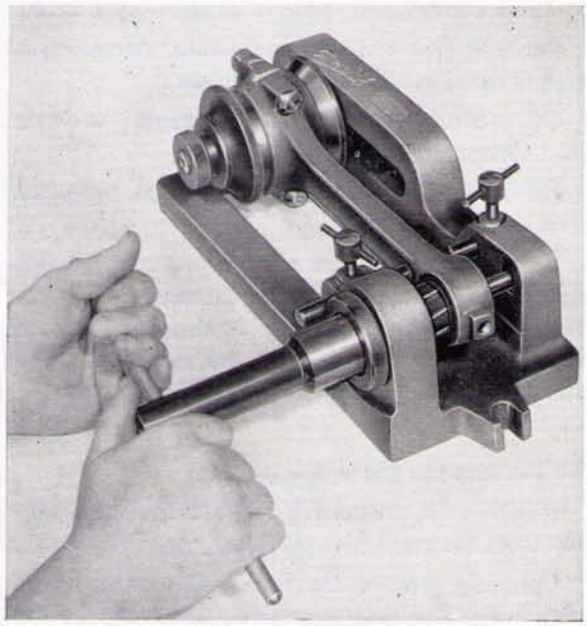


Fig. J.8.
Reaming a Small End Bush.

The remaining rods should be similarly treated making sure that each time the bush previously withdrawn has been extracted from the remover.

Before reaming a new gudgeon pin bush it is essential to check the connecting rod for misalignment.

Using a special tool, check the connecting rod alignment as follows :—

Remove the big end bearings, wash the connecting rod in kerosene and mount vertically on the arbor.

Fit the cone ended halves of the dummy gudgeon pin into each side of the small end bush and secure on the threaded shaft by the thumb screws

Place the indicator horizontally across the dummy gudgeon pin and any misalignment in the vertical plane will be apparent between the surface plate of the jig and the indicator studs. By reversing the indicator any misalignment in the lateral plane will then be shown. Should misalignment exceed the permissible allowance stated in the Fits and Tolerances Section, a new connecting rod in the same weight grade as those already fitted to the engine should be fitted.

Reaming Gudgeon Pin Bush.

1. Assemble the connecting rod in the fixture and secure the nut adjoining the angular collar, leaving the nuts at the back of the fixture finger tight.
2. Remove the slip bush and pass the centraliser with bearing surfaces oiled, through the bushes of the fixture and small end bush of the connecting rod until there is a small even clearance between the small end and centraliser. (See Fig. J.7).
3. Bring the support into contact with small end boss of the connecting rod (not the bush) and clamp.
4. Twist the centraliser at the same time applying as much forward pressure as possible
5. Secure the nut at the rear of the fixture.
6. Bring the support into contact with the connecting rod and tighten the clamp.
7. Remove the centraliser.
8. Obtain the reamer marked 'rough' and applying thin oil to the pilots insert the reamer into the bushes in the fixture. (See Fig. J.8). Apply kerosene to the cutting teeth and into the small end bush.
9. Proceed cutting, applying slight forward pressure, until the cutting edge is protruding as far as possible through the small end bush. Care should be taken not to foul the small bush in the fixture with the cutting teeth of the reamer. Remove any swarf from the teeth and withdraw by continuing to turn the reamer in a clockwise direction, at the same time applying backward pressure. Care should be taken not to damage the teeth against the hardened steel bushes.
10. Repeat Nos. 8 and 9 using a reamer marked 'Low.'
11. Loosen the nut adjoining the angular collar and its supports, swing up the connecting rod and attempt to fit a gudgeon pin.
12. It may be necessary to repeat Nos. 8 and 9 a second time using reamer marked 'Low' to obtain the accurate fit required by the gudgeon pin. In some cases it may be found necessary to repeat 8 and 9 using the 'High' reamer. Once satisfied with the fit of the gudgeon pin remove the connecting rod.

Great care has been given to the sizes and design of these reamers and it is most important that the same care is accorded to the reaming operation. A good fit can best be confirmed if, with the gudgeon pin oiled and held in a soft jawed vice, the connecting rod, after being worked a few times, will barely fall under its own weight.

Connecting Rod Weights.

In production the connecting rods are graded for weight and have etched numbers as follows :—

Code No.	Min. Weight		Max. Weight
9	3 lbs.	to	3 lbs. 2 ozs.
10	3 lbs. 2 ozs.	to	3 lbs. 4 ozs.
11	3 lbs. 4 ozs.	to	3 lbs. 6 ozs.
12	3 lbs. 6 ozs.	to	3 lbs. 8 ozs.
13	3 lbs. 8 ozs.	to	3 lbs. 10 ozs.
14	3 lbs. 10 ozs.	to	3 lbs. 12 ozs.
15	3 lbs. 12 ozs.	to	3 lbs. 14 ozs.

These weights include cap, small end bush, nuts and bolts.

When ordering parts, it is imperative that both the connecting rod code number, and the engine number be quoted.

This code number can be found etched on the machined portion of every rod adjacent to the bolt hole.

CYLINDER BLOCK AND LINERS (K)

The cylinder block is cast integral with the crankcase in high duty cast iron alloy, the crankcase joint face being co-planer with the crankshaft centre-line.

An exploded view of the cylinder block assembly is shown in fig. K.1.

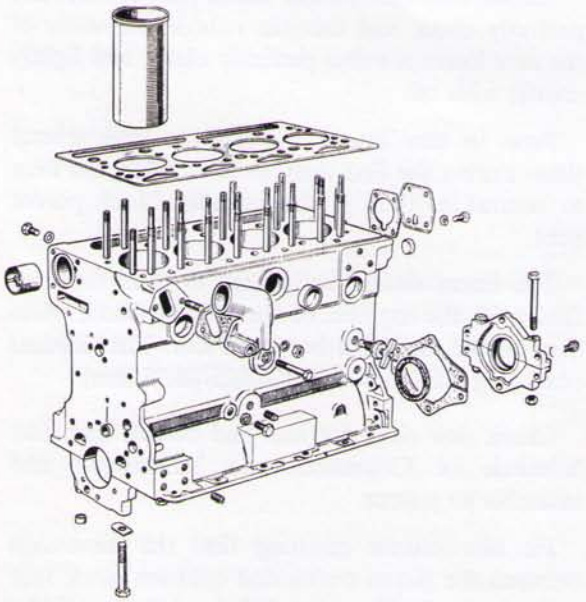


Fig. K.1.
Exploded view of Cylinder Block Assembly.

Removing and replacing the chrome plated cylinder liners fitted to Four 203 engines.

(a) To Remove Liners.

1. Remove cylinder head as detailed in Section H.

2. Remove the piston and connecting rod assemblies, crankshaft and all component parts of the cylinder block as detailed in the appropriate sections of this manual.

3. Remove cylinder head studs from the cylinder block.

4. Press the liners out through the top of the cylinder block, ensuring that no damage is done to the parent bore.

(b) Preparation for Fitting New Liners.

Great care must be taken in handling, transit and storage of new chrome plated liners, as the slightest burr or damage to this thin wall liner is sufficient to cause considerable local distortion of the liner bore when fitted.

After removal of the old liners, the parent bore must be thoroughly cleaned both in the top recess for the liner flange and in the parent bore itself. A check must be made to ensure that the whole areas of contact with the liners in the cylinder block are free from burrs, corrosion or damage. Remove any burrs present.

Ensure that the new liner is thoroughly clean before fitting. If kerosene is used to wash the liner, it is important that the liner be thoroughly dried and well oiled before fitting.

Throughout the whole operation, extreme cleanliness is essential as the entry of the smallest particle of grit or other foreign matter is sufficient to cause local distortion of the liner bore.

(c) To Fit New Liners.

1. Lubricate the outside diameter of the liners with clean oil which should be applied by means of a pressure can. The use of a brush is not recommended.

2. Press in the new liners using a suitable shouldered metal disc ensuring that the flanges at the top of the liners do not foul the counter-bore at the top of the parent bore thus causing distortion at the top of the internal diameter of the liner.
When fully home, the top face of the liner flange should be between 0.001 in. and 0.009 in. below the top face of the cylinder block. The fit of the new liners in the parent bore is a transition fit, that is the limits extend from minus 0.001 in. to plus 0.001 in.

3. It is advisable to allow a settling period to elapse before checking the fitted internal bore diameter of the liner. The acceptable limit is 3.6005/3.603 in. Each new liner should be checked in three positions—top,

centre and bottom ; the readings being taken transversely and parallel to the centre line of the cylinder block at each position.

4. Having fitted the new liners, the remainder of the re-assembly operations are a reversal of the removal procedure.

NOTE :—The removal and refitting of cylinder liners can be carried out under special circumstances with the crankshaft in position by using a special tool. Care must be taken not to damage the crankshaft during this operation.

The above procedures does not apply to Four 192 engines which are fitted with renewable high duty cast iron dry liners. These can either be re-bored to plus .030 in. or renewed as desired.

When reboring is carried out, begin by assembling a set of .030 in. oversized pistons and rings.

During reboring, it is most important to take care that the true alignment of the bores relative to the crankshaft axis be maintained.

The correct finished bore size should be 3.531/3.532 in. (89,687/89,712 mm). when 0.030 in. oversize pistons are used.

NOTE—When fitting 0.030 in. oversized pistons the dimension between the piston crown and the cylinder block face must be maintained at Zero to .005 in. below the block face.

To Renew Cylinder Liners.

Obtain a new set of liners and a set of standard pistons and rings.

Remove all component parts from cylinder block (See appropriate sections for removal of these).

Remove cylinder head studs from cylinder block.

Press out old liners.

Ensure that the cylinder block parent bores are perfectly clean, and that the outside diameters of the new liners are also perfectly clean, and lightly coated with oil.

Press in new liners releasing the load several times during the first inch, so as to allow the liner to centralise itself in the cylinder block parent bore.

The liners should be pressed in until they are flush with the top face of the cylinder block when they should be finish bored en situ. The finished size being 3.501/3.502 in. (88,925/88,95 mm).

Check new rings for size and correct gap, (see Schedule of Clearances and Tolerances) and assemble to pistons.

Fit new pistons ensuring that the dimension between the piston crown and cylinder block face is maintained. (Zero to .005 in. below cylinder block face).

Re-assemble engine as required to instructions given for various components.

CRANKSHAFT & MAIN BEARINGS (L)

The Crankshaft.

This is a one piece forging of chrome-molybdenum steel, the main and big end journals of which are induction hardened. Details of grinding limits and surface finish are listed in this section.

The rear end of the shaft is machined to provide an oil thrower, an oil return groove which works in conjunction with a rope type oil seal.

The front end of the shaft is machined to accept a key-located flanged pulley, and is provided with a threaded counterbore into which is screwed the pulley retaining dog-nut.

End float of the crankshaft is provided by four thrust washers which fit on both sides of the rear main bearing housing. 0.0075 in. oversize thrust washers are available which may be combined with standard thrust washers to give an adjustment of 0.0075 in. or when used on both sides of the bearing housing give an adjustment of 0.015 in.

Main Bearing Caps.

The main bearing caps are of high duty cast iron, and are located on ring dowels in the cylinder block. Two high tensile setscrews are fitted per cap and are locked by tab-washers. The tab-washers must only be used once.

In production the main bearing parent bores are machined with the caps in position. If, therefore, for any reason a main bearing cap becomes damaged and replacement is desired, it will be necessary to replace the cylinder block complete with main bearing caps.

The caps must always be replaced in their correct position on the cylinder block and the correct way round. Each cap is numbered with its appropriate position to the block with No. 1 at the front of the engine. On each cap also is stamped, a serial number. This number will be seen stamped on one side of the bottom face of the cylinder block, and the serial number on the cap must be on the same side as this. See Fig. L.2.

Main Bearings.

The main bearings are steel backed plated copper lead lined, or aluminium tin lined detachable shells, held in position by tongues which register with suitably machined locations in the cylinder block and cap, to prevent them from turning or moving out of position.

Replacement bearings are supplied 0.010 in., 0.020 in. and 0.030 in. undersize.

To Replace Bearings with Crankshaft in position.

1. Remove the cap of the bearing to be removed. No more than one bearing cap may be removed at one time.
2. Slacken the remaining bearing cap setscrews.
3. Remove the top half of the bearing by rotating it on the crankshaft applying a suitable soft tool, (e.g. wood), to the side opposite the locating tongue. See Fig. L.2. The main bearing locating recesses are machined in the cylinder block on the camshaft side.

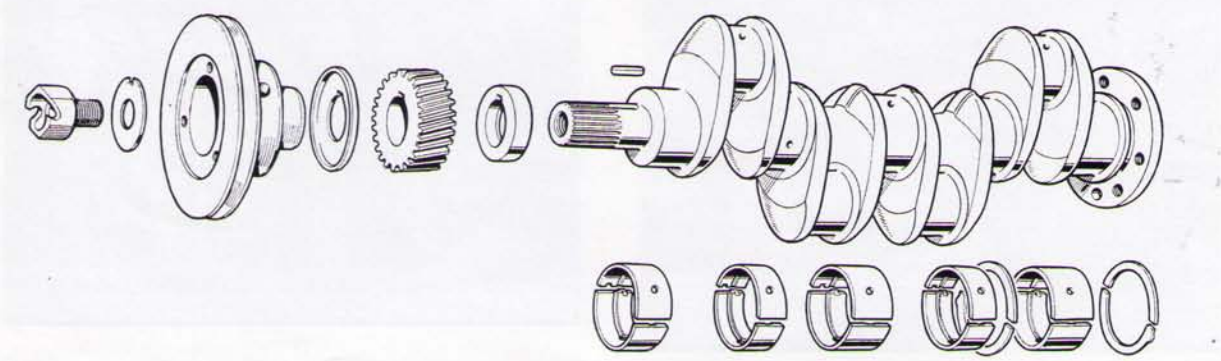


Fig. L.1.
Exploded view of Crankshaft and Main Bearing Assembly.

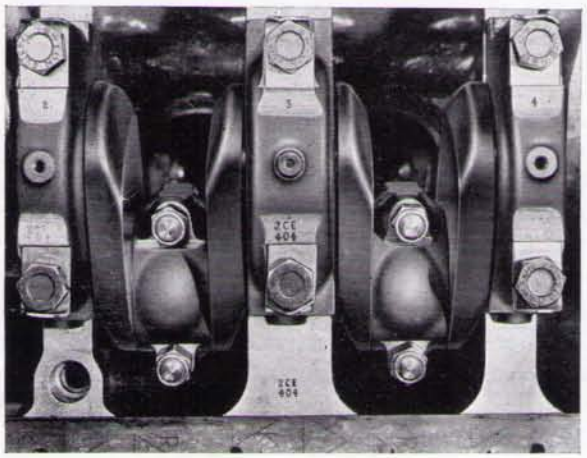


Fig. L.2.
View of Crankcase showing serial numbers and identification numbers.

4. Remove the lower half bearing from the cap.
5. Liberally oil the bearing shells to be refitted.
6. Fit the new top half-bearing by rotating it on the crankshaft, inserting the plain end first, and pushing it into position with the soft tool.
7. Fit the bottom half bearing to the cap.
8. Replace the cap, using new locking tab-washers and tighten the set-screws lightly before proceeding to the next bearing. See Fig. L.4.
9. Having completed the bearing replacement operation, tighten the setscrews to the recommended torque (see page B.2).

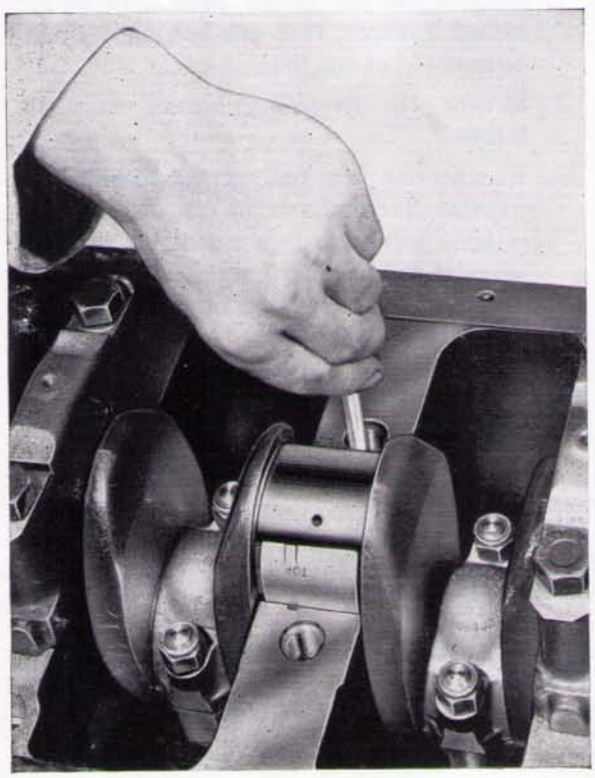


Fig. L.3.
Removing the top half of a Main Bearing (Engine Inverted).

Crankshaft End Float.

The crankshaft end float is controlled by detachable thrust washers fitted each side of the rear main bearing cap and the cylinder block half housing. The lower halves of these thrust washers fitted in the rear main bearing cap have suitable locating lugs to prevent them from turning out of position. Fit the crankshaft thrust washers to each side of the bearing housing with the vertical oil grooves facing outwards. See Figs. L.5 and L.6.

To check the crankshaft end float, push the crankshaft forward as far as it will go and using feeler gauges check the gap between the machined

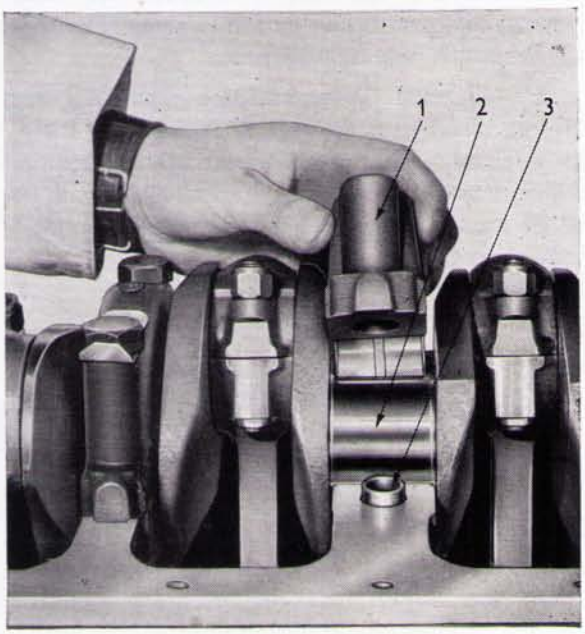


Fig. L.4.
Fitting Main Bearing Cap.
1. Main Bearing Cap. 2. Main Bearing Journal.
3. Dowel.

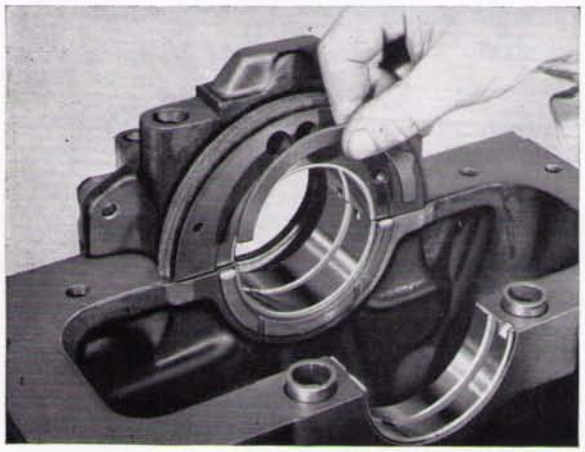


Fig. L.5.
Showing correct location of Crankshaft Thrust Washers (Crankshaft Removed).

shoulder on the crankshaft web and the crankshaft thrust washer. See Fig. L.7.

Check the gap on the other side of the rear main bearing with the bottom half housing of the oil seal removed and the crankshaft pushed back as far as it will go.

The clearances both sides of the bearing should be identical. The manufacturers production limits for the crankshaft end float are given in the Schedule of Clearances and Tolerances.

To Replace Thrust Washers.

1. Remove the rear main bearing cap and remove the lower half thrust washers from the cap. See Fig. L.8.
2. Push out the upper half thrust washers from the cylinder block housing.
3. Lubricate the upper halves of the new thrust washer and slide into the recesses provided on either side of the rear main bearing housing, ensuring the vertical oil grooves are facing outwards.
4. Fit the lower halves of the thrust washers on either side of the bearing cap. Light grease will assist in retaining the washers to the cap whilst the cap is positioned over the crankshaft.
5. Replace and secure the rear main bearing cap. See Fig. L.8.

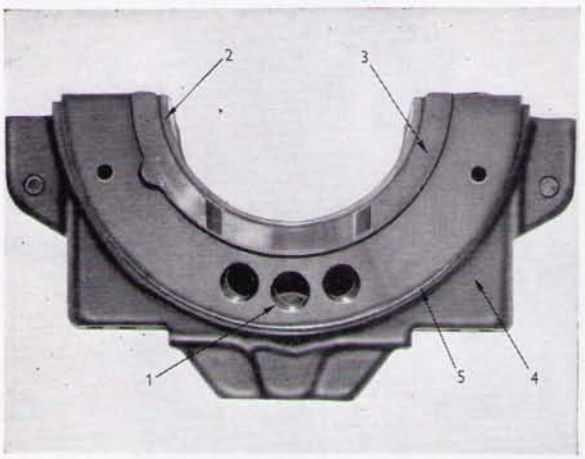


Fig. L.6.
Rear Main Bearing Cap.
1. Oil Drain Holes.
2. Bearing Shell.
3. Thrust Washer.
4. Bearing Cap.
5. Cork Seal.

To Remove Crankshaft.

1. Remove the engine from its application.
2. Remove the clutch assembly, flywheel, starter motor and transmission housing adaptor plate.
3. Remove the water pump, crankshaft pulley. dynamo and front timing case cover.
4. Remove the lubricating oil sump and oil pump suction and delivery pipes.
5. Remove the bolts and self-locking nuts securing the two halves of the rear main oil seal housings.
6. Remove the connecting rod caps and big end bearings.

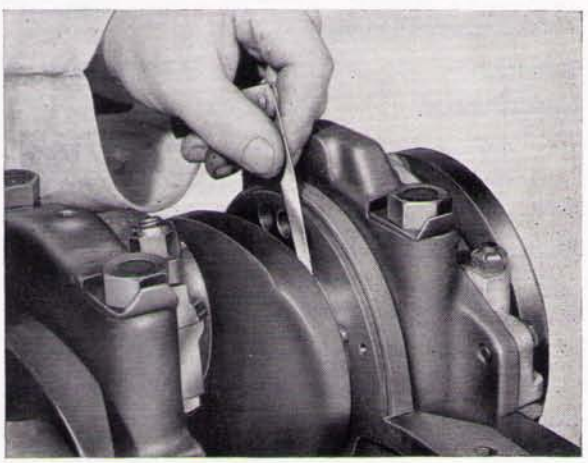


Fig. L.7.
Checking Crankshaft End Float.

7. Knock back the tab washers of the main bearing setscrews and remove the setscrews.
8. Detach the main bearing caps taking care not to drop either the bearing shells or thrust washers. The lubricating oil pump may remain affixed to No. 1 main bearing cap.
9. Lift the crankshaft from the cylinder block.
10. Ensure all the main bearings are identified with their relevant cap or cylinder block housing.
11. Remove the main oil filter and clean all the oilways in the cylinder block.
12. The crankshaft oilways and bearing surfaces must be cleaned.
13. Examine the main bearing setscrews for stretch and thread damage.
14 Remove the half housings of the rear main oil seal from the cylinder block and rear main bearing cap.

To Regrind Crankshaft.

1. Check the crankshaft main bearing and crankpin journals for wear to determine to which size the crankshaft must be reground.
2. Crack detect the crankshaft.
3. Demagnetise before proceeding with the regrinding.
4. The data and machining information is given in the following table :—

Main Journal Diameter.

Standard	... 2.7485/2.7490 in.
Undersizes	
0.010 in.	... 2.7385/2.7390 in.
0.020 in.	... 2.7285/2.7290 in.
0.030 in.	... 2.7185/2.7190 in.
Width of Rear Main Journal ...	1.87425/1.87625 in.
Max. Permissible Width of Journal after regrinding	... 1.89125 in.
Radius on Rear Main Journal	... 0.125/0.135 in.
Radii on Remaining Journals	... 0.0938/0.1094 in.

Crankpin Diameter.

Standard	... 2.2485/2.2490 in.
Undersizes	
0.010 in.	... 2.2385/2.2390 in.
0.020 in.	... 2.2285/2.2290 in.
0.030 in.	... 2.2185/2.2190 in.
Width of Crankpin ...	... 1.5620/1.5635 in.
Max. permissible width of Crankpin after regrinding	... 1.5785 in.
Radii on each Crankpin	... 0.1563/0.1719 in.

The surface finish on all diameters must not exceed 16 micro-inches as measured by a profilometer.

It is most important that the radii on the main journals and crankpins are maintained to the figures quoted.

The rear main journal radii must be burnished rolled with a load of 400 lb. on the shoe for 45 seconds at 150 r.p.m. after polishing.

After regrinding, the sharp corners on the oil holes must be removed and the crankshaft crack-detected and demagnetised.

To Replace Crankshaft.

1. Locate the upper halves of the main bearings in their block positions. Ensure that all oilways and passages are clear, and lubricate the bearings.

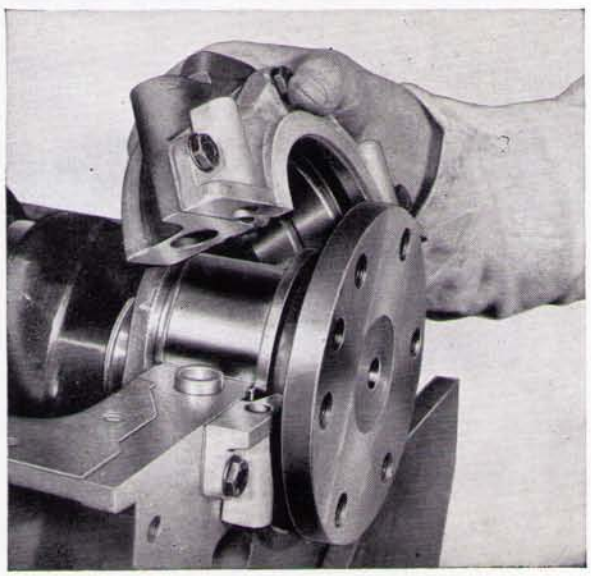


Fig. L.8.
Removing the Rear Main Bearing Cap.

If new main bearings are to be fitted it must be noted that the interchangeability of the new bearings before fitting is considerably limited.

The following table shows the interchangeability :—

Bearing Shell	Number off
Centre and Rear, Top and Bottom	4
Front, Top	1
Front, Bottom	1
Intermediate, Top and Bottom ...	4

2. Locate the upper halves of the crankshaft thrust washers on either side of the rear wall of the cylinder block housing with the oil grooves outwards. The upper halves of the thrust washers do not have locating tabs.
3. See that the ends of the thrust washers are level with the cylinder block face, otherwise there may be distortion when fitting the bearing cap. A light coating of grease will assist in holding the thrust washers in place until the crankshaft is fitted.
4. Ensure that the bearings are seating correctly in their caps with the tongues engaging in the machined recesses and that the thrust washers are located either side of the rear main bearing and cap, with the vertical oil grooves facing outwards.
5. Carefully lower the crankshaft on to the top half main bearings.
6. Refit the main bearing caps in their correct positions ensuring the serial number is to the same side as the corresponding number on the cylinder block bottom face. See Fig. L.2.
7. Check the crankshaft end float (See Schedule of Clearances and Tolerances). If the end float is incorrect fit new thrust washers Oversize thrust washers are available.
8. If the crankshaft has been reground, remove the cylinder head, refit the connecting rods to the crankshaft and check the distance between the cylinder block top face and the piston crowns with the pistons at T.D.C. If this distance is greater than 0.005 ins. then new pistons must be fitted and skimmed to obtain maximum performance of the engine.
9. Refit the rear main bearing oil seal housings and new rubber asbestos strips as described below.

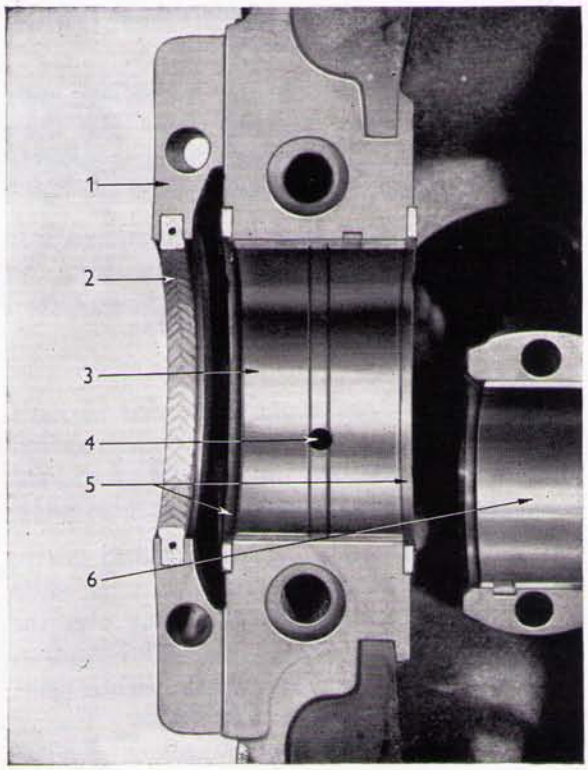


Fig. L.9.
Rear Main Bearing and Crankshaft Seal.

1. Seal Housing.
2. Rope Seal.
3. Rear Main Bearing Shell.
4. Oil Feed Hole.
5. Thrust Washers.
6. Big End Bearing Shell.

10. The main bearing cap setscrews should be tightened to the recommended torque (see page B.2), and locked with the tab washers.
11. Re-assemble the engine in accordance with the instructions supplied in the various sections of this manual.

Crankshaft Rear Oil Seal.

The crankshaft rear oil seal, Fig. L.9, is of the rubber cored asbestos rope type. It consists of two die cast half housings, suitably grooved to accept the two rope inserts, and clamped together by two long bolts fitted with self locking nuts. When fitted to the engine, the rope inserts directly contact that part of the crankshaft on which the oil return thread is machined.

To Remove.

1. Separate engine from transmission housing.
2. Remove clutch assembly and flywheel

3 Remove the adaptor plate from the cylinder block and engine sump.

4. Release and remove the self-locking nuts from the two clamping bolts that pass through the half housings of the crankshaft rear oil seal retainers and remove the bolts.

5. Unscrew the three setscrews from each half housing and remove the housings from the cylinder block and rear main bearing cap.

To Replace.

The new oil seals should be pressed by hand into their respective grooves and are required to project 0.010/0.020 in. beyond the joint face at each end of the groove in the seal housing.

A projection exceeding that quoted above should be avoided, because excess may not settle in the housing groove, but will splay over the joint face as the half housings are pulled together. Thus the half housings may be held slightly apart and so result in a leakage of lubricant.
This projection serves to ensure intimate contact between the end faces of the strips, when the housing halves are united on the crankshaft. It should be realised that any gap at this joint when the strips are fitted will defeat the purpose of this particular sealing medium.

Due to the interference between the strips and the relevant grooves in the seal housings, it is possible that the strips may not fully bed into the grooves, giving the impression they are too long. Each rubber-asbestos seal is of the correct length and must not be trimmed at any time.

Fig. L.9 shows the top half of the seal fitted to the cylinder block.

To fit new seals proceed as follows :—

1, Set up in turn, one half housing in a vice with the seal recess uppermost

2. Press approximately one inch of the new asbestos strip into each end of the groove in the housing, allowing the strip to project 0.010/0.020 in. beyond either end of the joint face.

3. The middle of the strip will bulge out of the groove and should be pushed in with the fingers, working from the centre, until well bedded in the groove. Use a round bar of metal to further bed in the strip by rolling and pressing ensuring that the strip projections at each end remain as set.

4. Fit seal to other half housing in a similar manner.

5. Remove all traces of the old joint when refitting the housings and use new joints and jointing compound. Lightly coat with liquid jointing compound the joint faces between the two half housings and smear the exposed inside diameter of the asbestos strips with lubricating oil of a minimum consistency of S.A.E. 40 before assembly.

6. Replace the half housings and retain them loosely in position with the six setscrews and washers.

7. Refit the two long clamping bolts and self-locking nuts and fully tighten.

8. Fully tighten the six setscrews securing the half housings of the oil seal retainer to the rear main bearing cap and cylinder block.

9. Replace the transmission adaptor plate on the dowels at the rear of the cylinder block and secure in position.

10. Refit the flywheel and check the run-out (Section S).

TIMING CASE AND DRIVE (M)

To Remove the Timing Case Cover.

Depending on the application to which the engine is fitted, the water pump may be mounted either on the front of the cylinder head, (high position type) or alternatively, on the front of the timing case cover, (low position type).

(a) In the case of an engine fitted with a low position water pump, proceed as follows :—

1. Slacken the dynamo mounting bolts, remove the adjusting arm completely and ease the fan belt off the pulleys.
2. Bend back the lock washer on the crankshaft dog-nut and unscrew the nut which has a normal right hand thread.
3. Withdraw the crankshaft pulley.
4. Release the clips on the hoses from the water pump except those on the by-pass pipe from the thermostat housing to the pump. Here it is advisable to remove the two setscrews securing the by-pass adaptor to the thermostat housing.
5. Undo the one setscrew and three nuts securing the water pump to the timing case cover and remove the pump complete with back-plate and the by-pass adaptor.
   NOTE :—The water pump must be removed so that access may be gained to all the setscrews securing the cover to the timing case.
6. Remove the 14 setscrews including the one securing the breather pipe clip to the cover, the 5 nuts on the bottom of the case and the one truss-headed screw at the top.
7. Remove the timing case cover taking care not to damage the crankshaft oil seal which is located in it.

(b) If the engine is fitted with a high position water pump, removal of the timing case

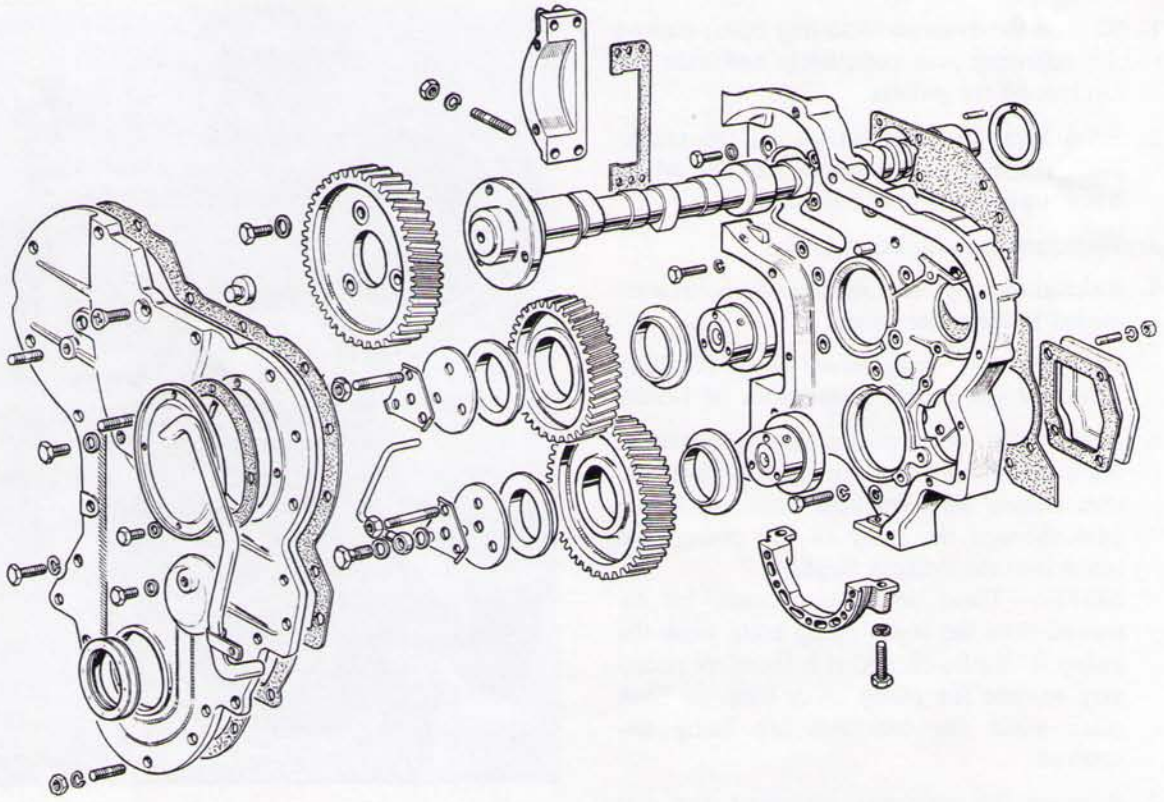


Fig. M.1.
Exploded view of Timing Case, Camshaft and Drive.

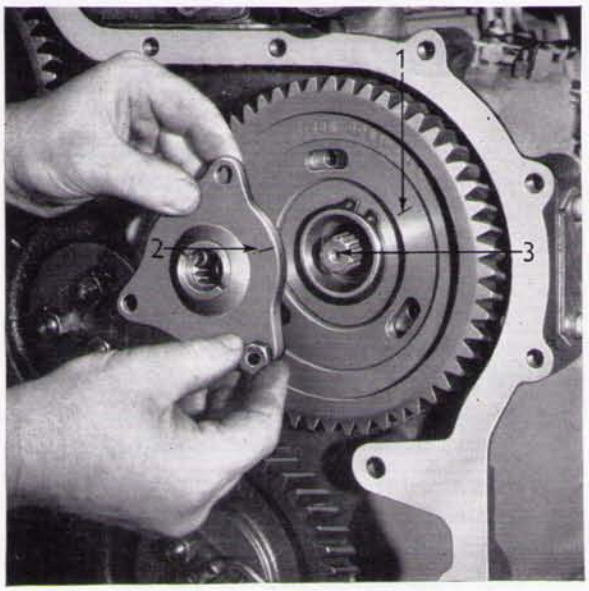


Fig. M.2.
Fitting Fuel Pump Gear Adaptor.
1. Timing Mark. 2. Gear Adaptor.
3. Quill Shaft.

cover should be as follows :—

1. Slacken the dynamo mounting bolts, remove the adjusting arm completely and ease the fan belt off the pulleys.
2. Bend back the lock washer on the crankshaft dog-nut and unscrew the nut which has a normal right hand thread.
3. Withdraw the crankshaft pulley.
4. Release the clips and remove the hoses connected to the water pump.
5. Disconnect the temperature gauge capillary tube and the heater connections (if fitted).
6. Remove the three small setscrews located at the back of the water pump back plate and then release the three large setscrews which pass through the body of the pump, and screw into the cylinder head.
   NOTE :—These setscrews cannot be removed from the water pump body while the pulley is still fitted, and it is therefore necessary to ease the pump away from its back plate while the setscrews are being unscrewed.
7. Remove the setscrews including the one securing the breather pipe clip to the cover, the 5 nuts on the bottom of the case and the one truss-headed screw at the top.
8. Remove the timing case cover taking care not to damage the crankshaft oil seal which is located in it.

To Renew the Crankshaft Front Oil Seal.

1. Carefully extract the oil seal from the timing case cover by tapping it evenly around from the back. The seal will come out through the front of the timing case cover.
2. Locate the new seal in the bore of the cover from the front.
3. Tap the new seal into position using a suitable dolly. It is preferable to insert the seal 3/32 in. below the front face of the timing case cover to ensure concentricity.

To Replace the Timing Case Cover.

1. Clean the joint faces of the timing case and its cover.
2. Using a new joint, refit the cover and slide the crankshaft pulley into position thus en-

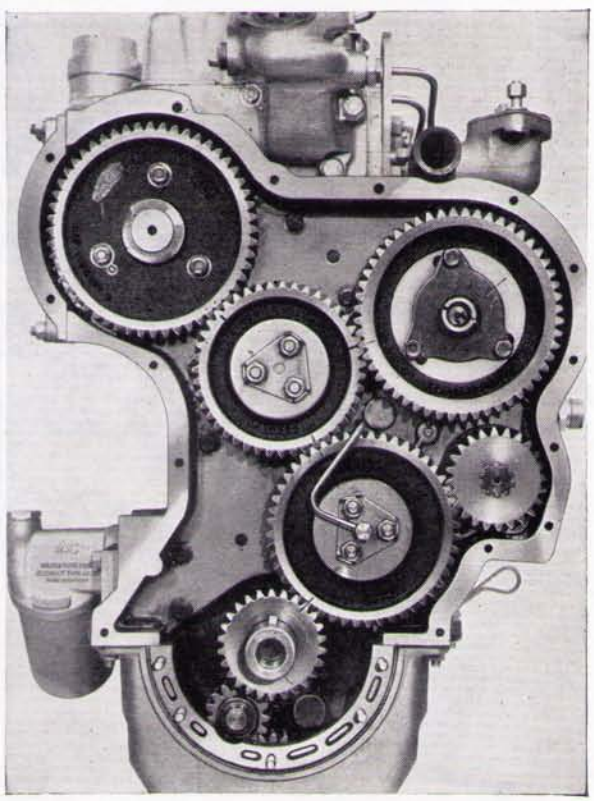


Fig. M.3.
Arrangement of Timing Gears showing Timing Marks.

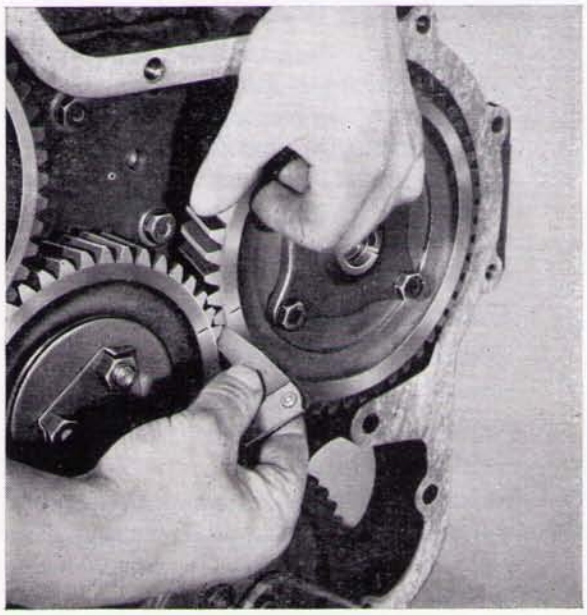


Fig. M.4.
Checking Backlash between Timing Gears.

suring concentricity of pulley and oil seal. Tighten some of the setscrews and then if necessary remove the pulley to gain access to the nuts at the bottom of the cover.

3. Refit the water pump with hoses, and by-pass adaptor (low position type).
4. Replace the crankshaft pulley, dog nut and the lock washer which must be bent over one of the flats of the nut once the latter has been tightened.
5. Bolt the dynamo adjusting arm to its stud on the timing case and having fitted the fan belt and set it at the correct tension, (See Section Q) tighten the locking setscrew.

Timing Gears.

The camshaft and fuel pump are gear driven by a hardened steel gear on the crankshaft through two idler gears mounted on hubs, bolted to the front of the cylinder block. The fuel pump, camshaft and idler gears are machined from high duty cast iron and if an exhauster or auxiliary hydraulic pump is fitted this is driven by a steel gear running in mesh with the lower idler gear. The cast aluminium timing case has bolted to it, an aluminium half moon bridge piece and is itself bolted to the front of the cylinder block. Around the outside of the bridge piece is fitted a cork sealing strip against which the lubricating oil sump seals.

By removing the inspection cover, to which the engine breather pipe is attached, access can be gained to the fuel pump drive gear to allow adjustment to the fuel pump timing. This is provided for by slotted holes in the fuel pump gear, Fig. M.2 allowing movement between it and the gear adaptor, once the securing setscrews are slackened. All the timing gears are suitably marked. These marks must be aligned when No. 1 piston is at top dead centre on its compression stroke. (See Fig. M.3). It will be appreciated that these timing marks will not align at every rotation of the crankshaft when No. 1 piston is at top dead centre on compression.

To Check Timing Gear Back-Lash.

1. Remove the timing case cover.
2. Check the back-lash between the gears as seen in Fig. M.4 using a feeler gauge. The

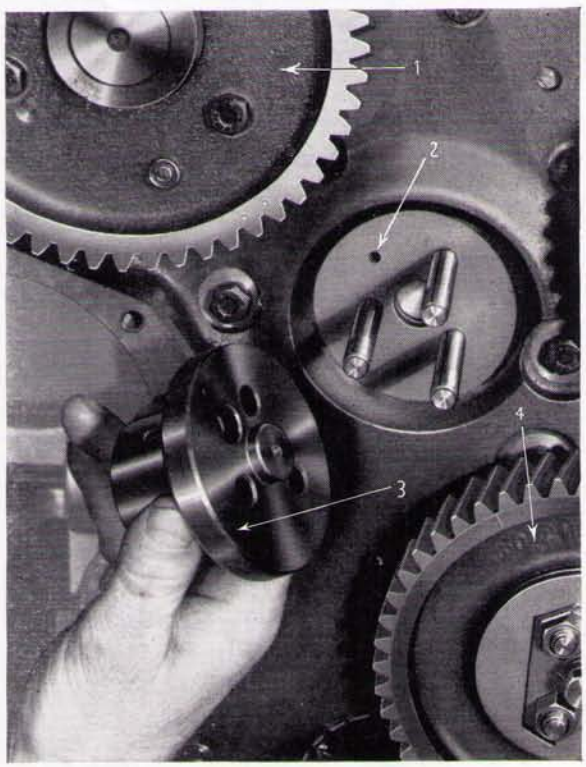


Fig. M.5.
Idler Gear Hub, removed from its studs.
1. Camshaft Gear.
2. Upper Idler Oil Feed Hole.
3. Upper Idler Gear Hub.
4. Lower Idler Gear.

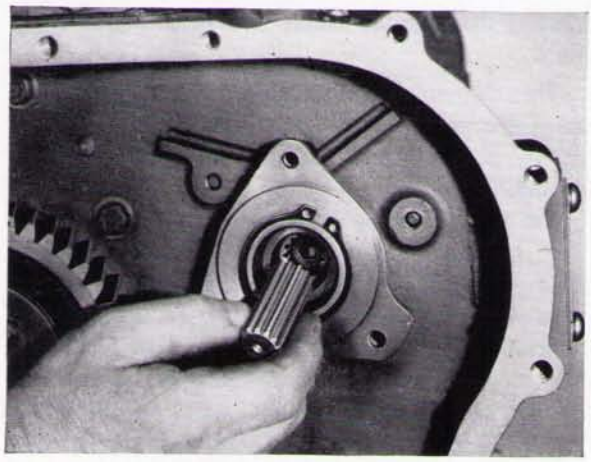


Fig. M.6.
Removing the Fuel Pump Quill Shaft.

back-lash should be between 0.003 in. and 0.006 in. (0,076 mm to 0,152 mm).

3. If the back-lash of the timing gears is within these limits, replace the timing case cover. If not, replacement gears, which are pre-marked on production, should be fitted, where necessary.

To Remove the Idler Gears and Hubs.

1. Remove the locking wire on the banjo bolt securing the oil pipe to the lower idler gear hub.
2. Release the banjo bolt and remove the oil pipe by withdrawing it from its locating hole in the back of the timing case.
3. Knock back the tab washers and remove the three securing nuts.
4. Remove the locking washer and idler gear retaining plate.
5. Remove the lower idler gear.
6. Remove the upper idler gear in a similar manner.
7. The idler gear hubs may now be removed from the studs located in the front of the cylinder block (See Fig. M.5).

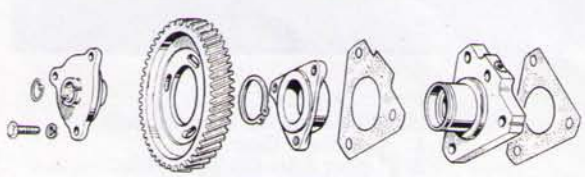


Fig. M.7.
Exploded view of Fuel Pump Drive.

To Replace the Idler Gears and Hubs.

1. The studs on which the hubs locate, are so positioned that the hubs will fit in one position only and the boss at the rear of the hub locates in the machined face of the cylinder block. Fit the lower and upper idler gear hubs which are interchangeable.
2. Turn the crankshaft to T.D.C. No. 1 and No. 4 cylinders, i.e. with the key-way at the front of the crankshaft uppermost.
3. Remove the rocker cover and release the rocker assembly.
4. Replace the two idler gears, ensuring that all timing marks align.
5. Replace the idler gear retaining plates, which will only fit in one position on the studs. The lower retaining plate has a threaded hole to take the oil pipe banjo bolt.
6. Fit new locking washers and replace the securing nuts. Bend the tab washers to lock the nuts.
7. Replace the oil pipe and banjo bolt to the lower idler gear retaining plate. The upper end of the oil pipe must locate in a hole in the back of the timing case immediately above the lower idler gear.

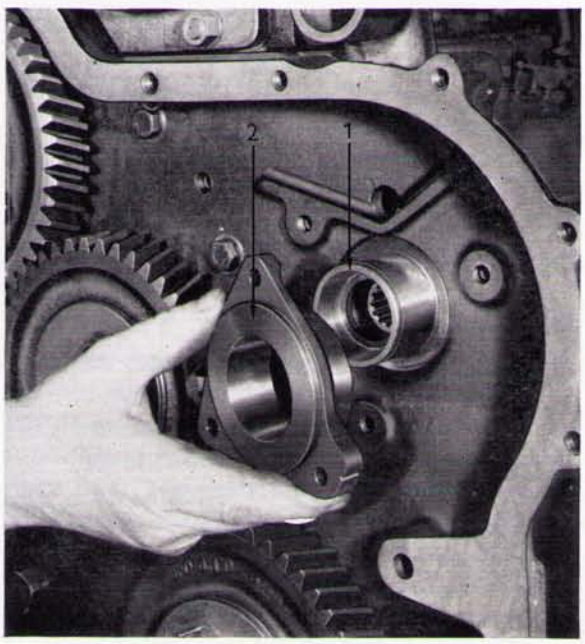


Fig. M.8.
Fuel Pump Gear Hub removed from its Carrier.
1. Gear Carrier. 2. Gear Hub.

8. Secure the banjo bolt with locking wire.
9. Secure the rocker assembly, adjust the tappets and fit the rocker cover.

To Remove the Camshaft Gear.

1. Release and remove the three securing setscrews and washers.
2. The camshaft gear may now be removed from the camshaft.

To Replace the Camshaft Gear.

1. Remove the upper idler gear and release the rocker assembly. On the hub of the camshaft will be seen the letter "D" stamped adjacent to a fixing hole and on the camshaft gear another letter "D" will also be seen stamped in a similar position. Offer the camshaft gear to the camshaft, ensuring that the holes with the letters stamped adjacent to them are in line.
2. Replace and secure the three setscrews and washers.
3. Turn the camshaft until the tappets of No. 4 cylinder are rocking. This is the approximate position for aligning the timing marks.
4. Fit the upper idler gear and having aligned all the timing marks secure the rocker assembly.

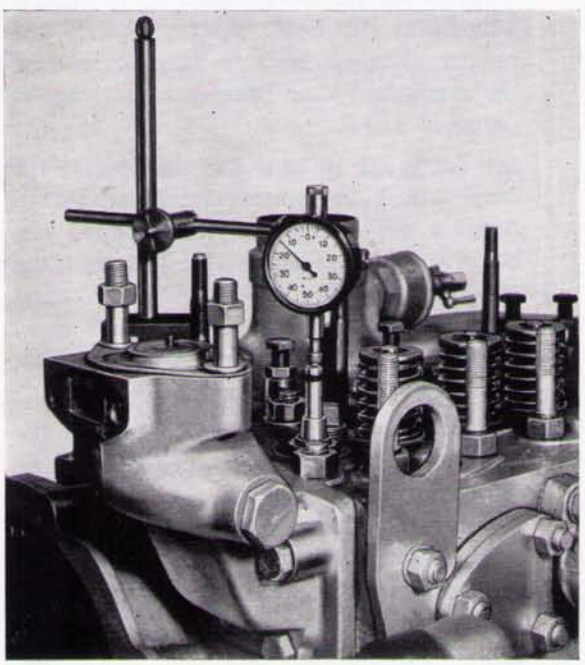


Fig. M.9.
Setting the Crankshaft at T.D.C. by dropping a Valve on to the Piston.

Fig. M.10.
Fuel Pump with Inspection Cover removed to show Rotor.
1. Scribed line on Circlip. 2. Scribed line on Rotor.

To Remove the Fuel Pump Gear.

1. Remove the upper idler gear and release the rocker assembly.
2. Remove the three securing setscrews and spring washers on the fuel pump gear.
3. Remove the driving gear adaptor leaving the splined quill shaft in the fuel pump (See Fig. M.2). A circlip which retains the fuel injection pump quill shaft in position is located in the front of the adaptor. Fig. M.6 shows the removal of the quill shaft.
4. The fuel pump drive gear may now be removed from the hub, which may also be withdrawn from the carrier by hand, once the retaining circlip has been removed, See Fig. M.8.

To Replace the Fuel Pump Gear.

1. Fit the fuel pump gear to the hub.
2. A timing mark will be seen scribed on the gear adaptor. This mark must align with the timing mark on the inner front face of the fuel pump gear. Replace the gear adaptor to the gear taking care to engage the master spline on the fuel pump quill shaft within the corresponding spline in the adaptor.

3. With the timing marks aligned, replace and secure the setscrews and washers.
4. Replace the upper idler gear ensuring all timing marks align. Secure the rocker assembly and reset the tappets. In production, the timing marks on the adaptor and the inner front face of the fuel pump gear are omitted, so should it be necessary to renew either the fuel pump gear or the adaptor, the following procedure should be adopted.

To Renew the Fuel Pump Gear.

1. Remove the old gear.
2. Fit the new gear and adaptor with the setscrews positioned mid-way in the slotted holes of the fuel pump gear. Tighten the setscrews and fit the upper idler gear, ensuring that all timing marks on the timing gear train align.
3. Remove the inspection plate of the fuel pump
4. Position the crankshaft at T.D.C. with No. 1 piston on compression (i.e. with the tappets of No. 4 cylinder rocking).
5. Remove the rocker shaft assembly.
6. Remove the spring from the exhaust valve of No. 1 cylinder, allowing the valve to drop on to the top of the piston.
   NOTE : At this stage it is advisable to tie a piece of string or wire to the valve stem to prevent its dropping into the cylinder and necessitating the removal of the cylinder head.

Fig. M.11.
Removing the Camshaft.

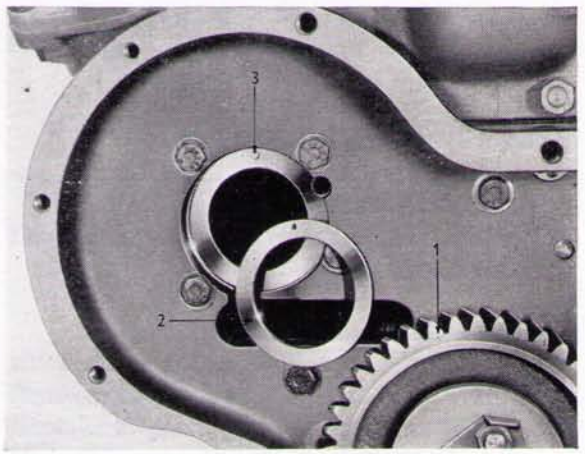


Fig. M.12.
The Camshaft Thrust Washer removed from its location.
1. Upper Idler Gear. 2. Thrust Washer
3. Dowel.

7. Set up a dial indicator gauge as shown in Fig. M.9, with the plunger resting on the top of the valve stem.
8. To accurately position the crankshaft at T.D.C., turn it backwards slightly, and then forwards until the pointer of the gauge starts to reverse its direction. At this point the piston has reached T.D.C. and is starting to move down the bore again. By careful adjustment the exact point at which the pointer changes direction may be reached the crankshaft thus being accurately positioned at T.D.C.
9. Set the gauge to zero and then rotate the crankshaft in the opposite direction to that of rotation until the piston has dropped just below 0.1915 in. (4.86 mm). Then turn the crankshaft in the usual direction of rotation until the piston is 0.1915 in. (4.86 mm.) below T.D.C. At this point, the crankshaft is positioned with No. 1 piston 20° B.T.D.C.
10. At this point also, the scribed line on the fuel pump rotor, marked with the letter 'A' for hydraulically governed pumps or 'C' for mechanically governed pumps should be in line with the mark on the lower lobe of the timing circlip.

    Should this not be so, then release but do not remove the setscrews securing the fuel pump gear and adaptor. Turn the triangular adaptor in the required direction in relation

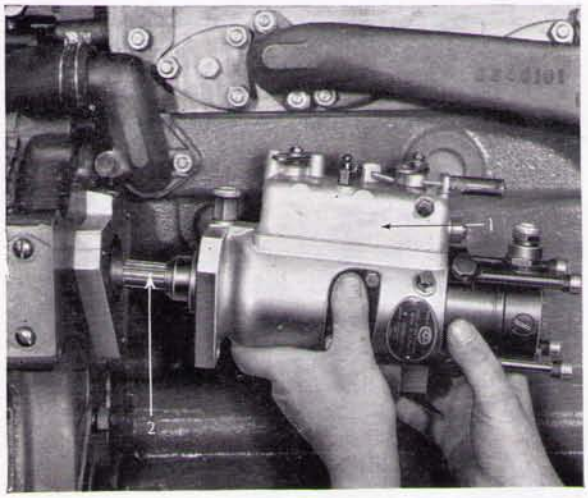


Fig. M.13.
Removing the Fuel Injection Pump.
1. Fuel Injection Pump. 2. Quill Shaft.

to the fuel pump gear until the 'C' mark or 'A' mark on the rotor aligns with the scribed line on the circlip as seen in Fig. M.10.

11. Tighten the securing setscrews of the fuel pump gear and adaptor and replace the inspection cover of the fuel injection pump.
12. Chisel mark the inside front face of the fuel pump gear in alignment with the timing mark on the adaptor. See Fig. M.2.

NOTE : It is important to note that the breaking of the seals of the fuel injection pump should only be carried out by experienced persons authorised by the Service Signholder who must reseal with suitable identifiable seals.

To Renew the Fuel Pump Gear Adaptor.

1. Turn the engine until all the timing marks align. This may easily be carried out by removing the upper idler gear and releasing the rocker assembly. All the gears may then be turned to an approximate position to enable the refitting of the upper idler gear with all the timing marks aligned.
2. Remove the old fuel pump gear adaptor and refit the new one, which will only fit in one position due to the fact that the securing holes are off-set.
3. Fit a new circlip in the adaptor to retain the quill shaft in position.
4. Set the crankshaft at T.D.C. by the method described under the heading " To Renew the Fuel Pump Gear " on page M.5. Then, with the dial gauge set to zero, rotate the crankshaft in the opposite direction to that of normal rotation until the piston has travelled 0.1915 in. down the bore. At this point, the line on the lower lobe of the circlip must align with the appropriate mark on the rotor as detailed in item 10 under the heading "To Renew the Fuel Pump Gear."
5. Tighten the securing setscrews and replace the fuel pump inspection cover.
6. Chisel mark the adaptor in alignment with the scribed line on the inner front face of the gear.

To Remove the Camshaft.

1. Remove timing case cover.
2. Turn engine to T.D.C. No. 1 cylinder on compression with all timing marks aligned as already detailed.
3. Remove the rocker shaft assembly.
4. Unscrew the three setscrews securing the camshaft gear and remove the latter.

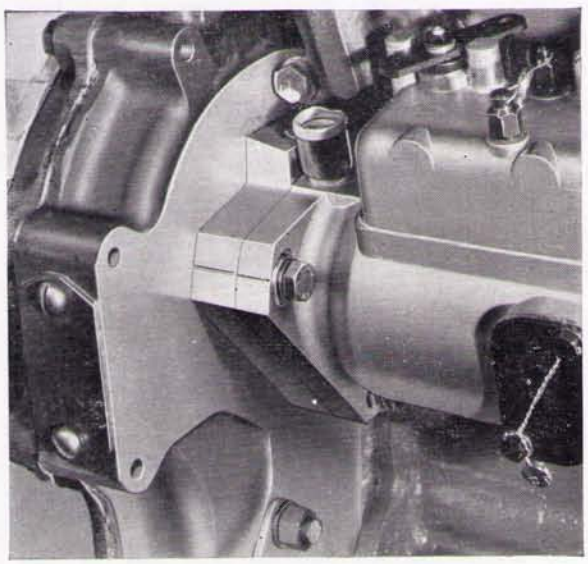


Fig. M.14.
The Fuel Injection Pump fitted, with the Timing marks on the Flange aligned.

5. Lift the tappets and remove the camshaft from its location in the cylinder block, taking care not to damage the journals, cams, or the tappets. See Fig. M.11.

To Replace the Camshaft.

1. Ensure that the camshaft thrust washer is correctly located in the cylinder block, the dowel in the block fitting in the corresponding hole in the thrust washer. See Fig. M.12.
2. Lift the tappets and carefully replace the camshaft, turning it continually and taking care not to damage the journals, cams or tappets.
3. With the engine still at T.D.C., No. 1 piston on compression, position the camshaft so that when its timing gear is replaced with the timing mark aligned with that of the upper idler gear, the letter "D" on the camshaft hub will line up with the letter "D" on the front face of the gear. When this condition has been attained, replace the three securing setscrews and tighten them.
4. Replace the timing case cover.
5. Refit the rocker shaft and reset the tappets.
6. Replace the cylinder head cover using a new cork joint if the existing one is damaged or compressed.

Camshaft Thrust.

The camshaft end float is taken up by a boss on the timing case cover and a thrust washer in the cylinder block. Access to the thrust washer is gained by removing the camshaft. The thrust washer may then be removed from its locating dowel (Fig. M.12).

The thrust washer may be located in the cylinder block up to 0.008 in. proud of the block face and not more than 0.003 in. below.

To Remove the Timing Case.

1. Drain the lubricating oil from the sump
2. Remove the timing case front cover.
3. Remove the dynamo.
4. Release the high pressure and low pressure fuel pipes and remove the fuel injection pump and quill shaft. Fig. M.13.
5. Disconnect the vacuum pipe and oil feed pipe from the exhauster which should next be removed. It is secured to the timing case by four nuts and once these are removed it may be withdrawn.
6. Remove the rocker shaft assembly and two idler gears.
7. Lift the tappets and withdraw the camshaft, followed by the camshaft thrust washer (See Fig. M.11).
8. Remove the fuel pump gear adaptor, gear, carrier and hub.
9. Remove the sump, which will come away from the half moon bridge piece at the front leaving the latter attached to the timing case.
10. Remove the setscrews securing the timing case to the block and tap the case lightly from the back to free it.

To Replace the Timing Case.

1. Clean the front and bottom faces of the cylinder block and remove the cork seals from around the half moon bridge piece and rear main bearing cap.
2. Fit a new timing case joint to the front of the cylinder block, and replace the timing case tightening all the securing setscrews.
3. Using a new sump joint and cork seals refit the sump.
4. Fit the lower idler gear with the crankshaft at T.D.C. aligning the relevant timing marks.
5. Replace the camshaft thrust washer taking care to locate it on its dowel and then refit the camshaft with its gear attached turning it until the tappets of No. 4 cylinder are "rocking." In this position the gear will be approximately positioned for aligning the timing marks.
6. Refit the fuel pump timing gear mechanism in the reverse order to that of dismantling, aligning the timing marks on the adaptor and gear.
7. Fit the fuel injection pump and quill shaft passing the setscrews through the front of the pump and the carrier plate, so that they locate in the timing case. Line up the timing marks on the fuel pump flange, the carrier flange and the back of the timing case, before tightening the setscrews. (See Fig. M.14).
8. Fit the upper idler gear, aligning all the timing marks.
9. The remainder of the assembly procedure may now be carried out in the reverse order to that of dismantling.

TIMING (N)

General.

The timing or re-setting of the timing of the Four 192 and Four 203 engine can simply and quickly be carried out if the following instructions are borne in mind.

It is well to remember that the removal of the cylinder head does not in any way affect the timing of the engine.

Timing Marks.

When the engine is timed at the factory, certain marks are stamped on the gears so that if for any reason the timing has to be disturbed, the engine can be easily re-set to its original timing.

The method of marking is as follows :—

With the engine timing correctly set, the engine is turned until No. 1 piston is at Top Dead Centre on its compression stroke. In this position, markings are made on the idler gears which coincide with corresponding marks on camshaft, fuel pump and crankshaft gears (see Fig. M.3).

A further marking is made on the fuel pump drive gear which, when it coincides with a mark on the fuel pump gear adaptor, denotes the original positions of these two components.

Fuel Pump Timing Marks.

On the fuel pump mounting flange is a scribed line which, when the fuel pump is fitted, should coincide with the scribed line on the fuel pump carrier plate (see Fig. M.14). A further line is provided on the rear of the timing case. Providing these three scribed lines are in alignment and the fuel pump gear correctly fitted and aligned (see previous remarks), then the fuel pump timing should be correct.

To Re-Set Engine Timing.

1. Remove atomisers.
2. Position the crankshaft so that No. 1 piston is at T.D.C. At this point the crankshaft pulley key-way will be uppermost and the T.D.C. mark on the flywheel front face will align with the mark at the side of the inspection hole in the transmission adaptor plate.
3. Fit the camshaft gear, ensuring that the letter " D " stamped adjacent to one of the setscrews holes aligns with the corresponding "D" on the hub.
4. Fit the fuel pump gear and adaptor with the two scribed lines in alignment. See Fig. M.2.
5. See that the fuel pump is correctly fitted with the scribed lines on the mounting flange carrier plate and timing case in-line. (See Fig. M.14).
6. With the crankshaft gear fitted, replace the two idler gears, ensuring that the timing marks coincide. (See Fig. M.3).
7. After testing the engine, final adjustments may be necessary to find the most suitable injection point.

To Re-Set Fuel Pump Timing.

In the event of a new fuel pump gear or fuel pump gear adaptor being fitted, the fuel pump gear will be pre-marked in respect of the scribed line which coincides with the line on the upper idler gear, but as no markings denoting the original position of the fuel pump drive gear and adaptor will be provided, it will be necessary to re-set the fuel pump timing using the timing marks inside the pump itself.

On the fuel pump rotor ; inside the fuel pump body are a number of scribed lines, each one bearing an individual letter. A timing circlip also bearing a scribed line is positioned inside the pump and pre-set so that when the appropriate scribed line on the fuel pump rotor coincides with the scribed line on the circlip (see Fig. M.10), it denotes commencement of injection (static timing point).

On mechanically governed pumps, the letter " C " is utilised on the fuel pump rotor, and in the case of hydraulically governed pumps, the letter " A " should be used.

To obtain access to the fuel pump rotor markings, it is necessary to remove the inspection plate on the side of mechanically governed pumps or the plate on the top of hydraulically governed pumps which also embodies the fuel pump return connection to the fuel filter.

To re-set the timing when a new fuel pump gear

or gear adaptor is being fitted, proceed as follows :—

Ensure that the fuel pump is correctly fitted with the scribed line on the mounting flange coinciding with the scribed line on the fuel pump carrier plate (See Fig. M.14).

The scribed line on the fuel pump carrier plate should also coincide with the scribed line on the rear of the timing case.

Position the crankshaft so that No. 1 piston is at T.D.C. on compression. At this point the crankshaft pulley key-way will be uppermost, and the T.D.C. mark on the flywheel front face will align with the mark at the side of the inspection hole in the transmission adaptor plate.

Fit the camshaft gear ensuring the letter " D " stamped adjacent to one of the fixing holes is in alignment with the letter " D " stamped on the camshaft hub.

Fit the fuel pump gear and gear adaptor. It will be noted that the holes in the fuel pump gear are slotted to allow for adjustment, and when fitting the fuel pump gear adaptor, the securing setscrews should be in the midway position.

Replace idler gears, ensuring the timing marks coincide.

Turn the crankshaft backwards for half a turn and then in the normal direction of rotation until the static timing mark on the flywheel front face aligns with the mark on the outside of the inspection hole in the transmission adaptor plate.

Remove the inspection plate on the fuel pump enabling the rotor to be seen.

With No. 1 piston at the static timing point on its compression stroke, the scribed line on the fuel pump rotor marked with the letter A or C (for hydraulically or mechanically governed pumps respectively) should align with the scribed line on the circlip.

If it does not, then the necessary adjustment should be made by releasing the fuel pump gear adaptor securing setscrews and turning the adaptor on the slotted holes in the fuel pump gear the required amount to bring the respective scribed marks into alignment.

After testing the engine, final adjustments may be necessary to find the perfect injection point.

When the fuel pump timing is correct, mark the fuel pump drive gear and/or adaptor, to denote the relative position of these two components as shown in Fig. M.2.

LUBRICATING SYSTEM (P)

Description.

The lubricating system is of the forced feed type, the oil being circulated, under pressure, by a rotor type pump bolted to the front main bearing cap and driven via an idler gear by the crankshaft gear. Oil is drawn through a sump filter screen and a suction pipe before entering the oil pump. It is then pumped through a pipe to a drilling in the cylinder block and then to a full flow filter on the camshaft side of the engine.

A plunger type relief valve is provided in the lubricating oil pump body to control the maximum oil pressure.

From the full flow filter the oil then passes by way of a crosswise drilling to the main oil gallery drilled lengthwise through the fuel pump side of the crankcase.

Passages through the main bearing housing webs, carry the oil from the gallery to the main bearings. The oil then passes through drilled holes in the crankshaft to the big end bearings.

The cylinder bores and gudgeon pins are splash lubricated from the big ends.

Lubrication of the timing gear idler hubs is by a force feed.

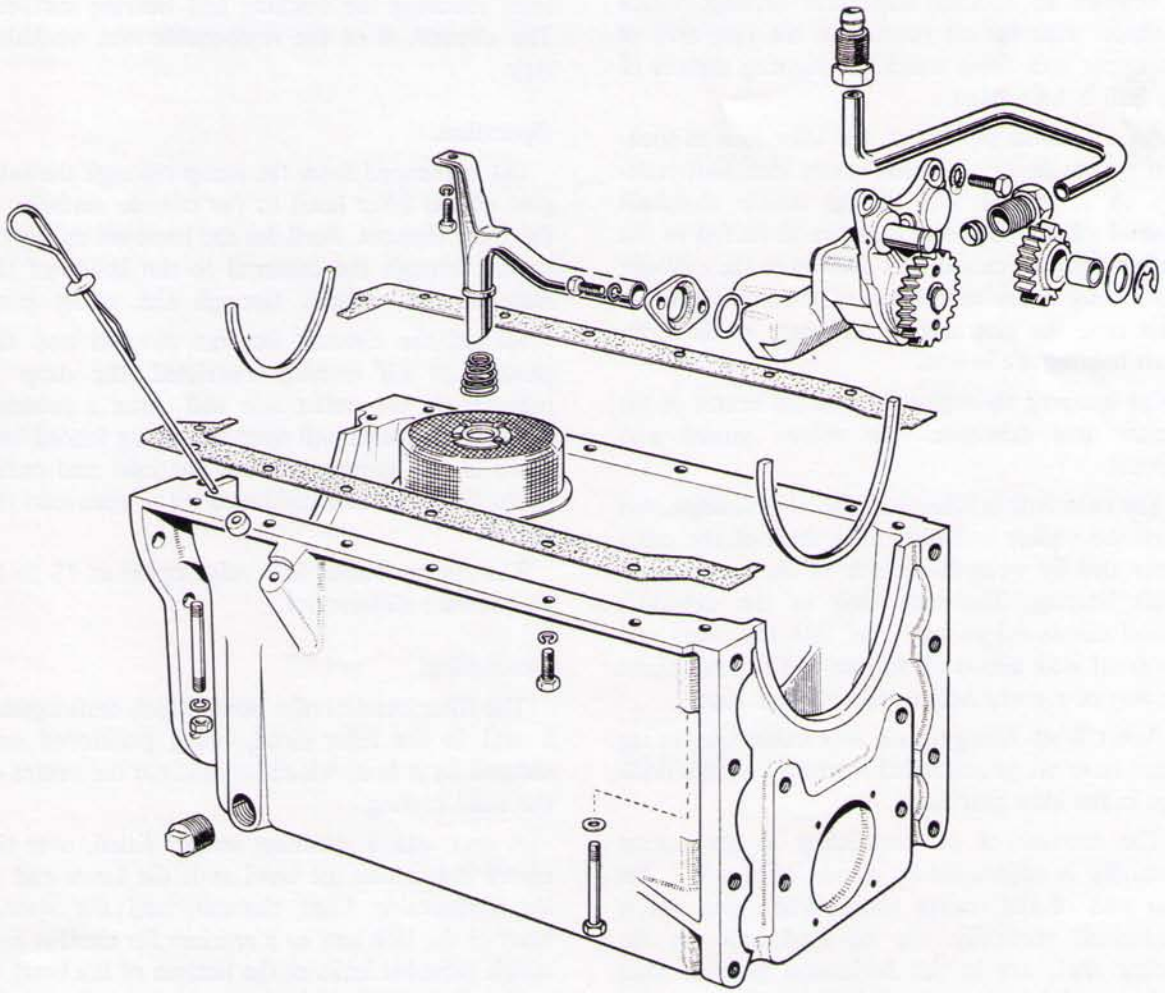


Fig. P.2.
Exploded view of Lubricating Oil Sump and Oil Pump.

Lower Hub.

A drilling from the front face of the cylinder block into the main bearing oil gallery, is aligned with a drilling which passes through the axis of the hub, connecting with a transverse hole in the hub, through which oil is fed to the bearing surfaces of the hub and gear.

Secured to the gear retaining plate is a pipe, the other end of which is located in a blind hole in the timing case to prevent the pipe from turning. A small hole in the pipe allows oil to spray on to the teeth of the lower idler gear.

Upper Hub.

A transverse drilling across the front of the cylinder block from the main oil gallery feeds oil under pressure to an external pipe located on the camshaft side of the engine. This pipe in turn is coupled to another transverse drilling, which connects with the oil passage in the rear face of the upper hub, from which the bearing surface of the hub is lubricated.

An extension pipe from the idler hub lubrication system feeds oil to the centre camshaft bearing. A machined slot in the centre camshaft journal allows oil under pressure to be fed to the rocker shaft by means of a drilling in the cylinder head, once every revolution of the camshaft, i.e. each time the slot and the drillings in the camshaft bearing are in line.

Oil escaping through a hole in the centre of the rocker arm lubricates the valves, guides and tappets.

The camshaft is lubricated by oil draining down from the rocker assembly. The level of the oil is controlled by weirs either side of the centre camshaft bearing. The rear weir in the camshaft tunnel allows oil to spill over into the sump and the front weir allows oil to pass to the timing case by way of a cored hole in the cylinder block.

Apart from being splash lubricated the timing gears have oil, pressure fed to them through drillings in the idler gear hubs.

The amount of oil circulating to the rocker assembly is adjustable by means of a slot in the rear end of the rocker shaft. When this slot is positioned vertically, the oil feed holes in the rocker shaft are in the horizontal position thus giving a minimum amount of oil circulating to the rockers. If the slot is horizontal then the hole is located immediately below the rocker feed hole and allows maximum circulation. In production the slot is set at 30 degrees from the vertical and a punch mark on the rear pedestal indicates this position.

Lubricating Oil Filters.

The oil filtering apparatus consists of an Oil Sump Strainer and a Main Full Flow Filter.

The gauze sump strainer fits over the oil pump suction pipe. After a period there may be a tendency for sludge to collect around this strainer, which should then be removed from the engine sump and thoroughly washed in fuel oil or kerosene.

The Main Full Flow Filter is mounted on the right hand side of the engine crankcase, preventing any dirt or foreign matter in the lubricating oil from reaching the working and bearing surfaces. The element is of the replaceable non washable type.

Operation.

Oil is pumped from the sump through the inlet port of the filter head to the outside surfaces of the filter element. Particles are removed as the oil passes through the material to the inside of the element and escapes through the outlet port.

Should the element become clogged and the passage of oil severely restricted, the drop in pressure on the outlet side will cause a pressure differential, which will open the spring loaded ball valve in the by-pass between the inlet and outlet ports, thus allowing unfiltered oil to pass into the engine.

The spring loaded ball valve opens at 13 to 17 lb. pressure differential.

Description.

The filter consists of a bowl, which seats against a seal in the filter head, being positioned and secured by a bolt, which screws into the centre of the head casting.

A seal with a retaining washer fitted, over the centre bolt inside the bowl seals the lower end of the replaceable filter element, and the special head of the bolt acts as a retainer for another seal which prevents leaks at the bottom of the bowl.

The filter head is formed with inlet and outlet passages both connected with a by-pass passage

closed by a spring-loaded ball valve, retained in the head by a threaded plug and fibre washer. The upper end of the element is closed by a seal, retained in the filter head.

Dismantling.

Unscrew the centre bolt at the bottom of the filter bowl, (Fig. G.2) and lower the bowl and bolt, see Fig. G.3. The bolt cannot be withdrawn from the bowl completely. The seal retainer and spring, located over the bolt inside the bowl cannot be removed from the bolt.

Remove the large ring seal from the recess in the filter head and the smaller seal also retained in the head. Release and remove the by-pass plug, washer, spring and ball from the head.

Re-assembly.

Replace the ball and spring in the by-pass passage and secure with the plug and fibre washer. Accurately position the large ring seal and smaller inner seal in the head. Place the filter element over the centre bolt and offer up the bowl assembly to the head. As the bowl is offered to the head, care should be taken to ensure the bowl locates squarely within the recess of the head. Tighten the centre bolt.

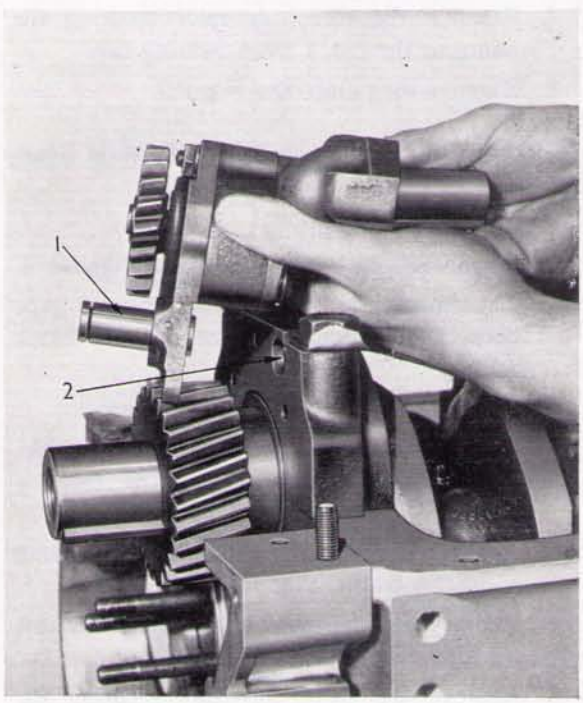


Fig. P.3.
Removing the Lubricating Oil Pump from the Front Main Bearing Cap.
1. Idler Shaft Protrusion. 2. Dowel Hole.

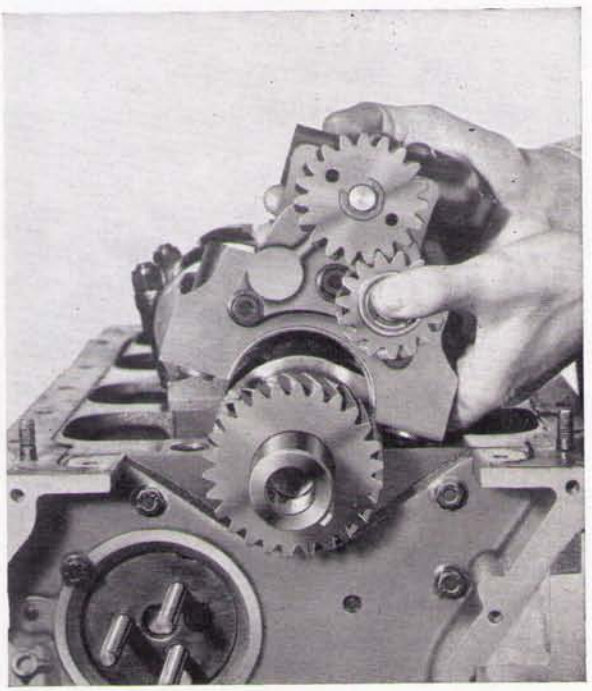


Fig. P.4.
Removing the Lubricating Oil Pump complete with Main Bearing Cap.

The Oil Pump.

The oil pump is secured to the front main bearing cap by three setscrews, a protrusion of the idler gear shaft locating in a hole in the bearing cap to give positive location.

The bushed idler gear which is free to rotate on a shaft, pressed and pinned to the pump body, transmits the drive from the crankshaft gear to the oil pump gear.

The oil pump drive gear is pressed and keyed on to the pump driven shaft on the other end of which is pressed and pinned a four lobed drive rotor. This rotor meshes with a five lobed driven rotor, which is free to rotate in the cast iron pump body.

As the pump rotors rotate, the pockets formed between the rotor lobes increase and then decrease in volume to propel oil from the suction side to the pressure side of the pump.

A pressure relief valve mounted on the pressure side of the pump body controls the maximum oil

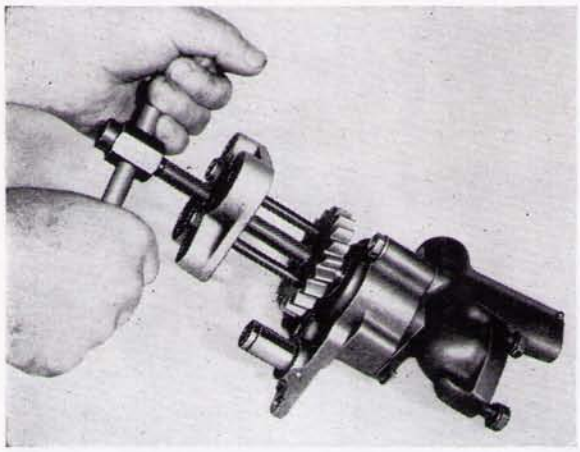


Fig. P.5.
Withdrawing the Lubricating Oil Pump Drive Gear.

pressure at 50 to 65 lbs. per square inch, any excess oil returning direct to the sump.

The oil pump delivers 5.35 gallons per minute at an engine speed of 2,000 r.p.m.

The lubricating oil pump and gear drive may be dismantled with just the sump removed, but this entails removing the pump complete with the front main bearing cap. If, on the other hand, the timing case cover is removed, the pump may be unbolted from the bearing cap leaving the latter in position.

To Remove the Pump from the Bearing Cap.

1. Remove the sump.

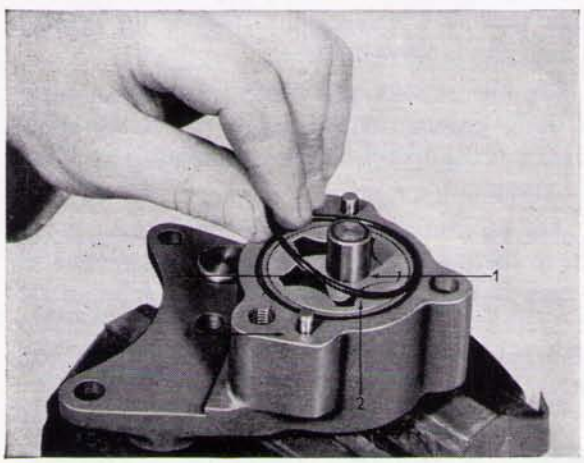


Fig. P.6.
Removing the "O" Sealing Ring.
1. Inner Rotor.
2. Outer Rotor.
3. "O" Sealing Ring.
4. Pump Body.

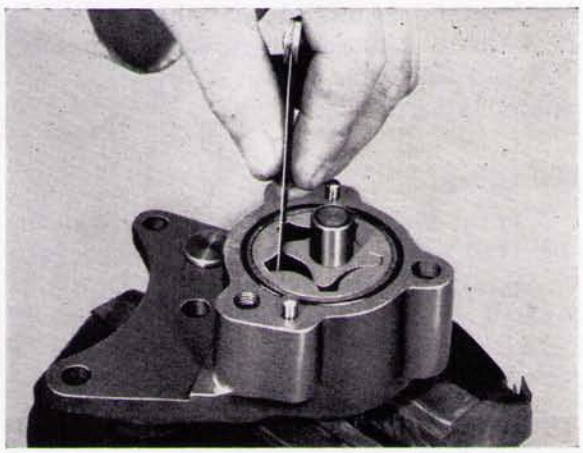


Fig. P.7.
Checking Clearance between the Inner and Outer Rotor.

2. Disconnect and remove the suction pipe.
3. Disconnect and remove the pressure pipe between the pump and the cylinder block drilling.
4. Remove timing case cover, see page M.1.
5. Remove the half-moon bridge piece.
6. Remove the idler gear circlip, the idler gear and thrust washer.
7. Remove the three setscrews securing the pump to the No. 1 main bearing cap.
8. Remove the pump. See Fig. P.3.

To Remove the Pump complete with Main Bearing Cap.

1. Remove the sump.
2. Disconnect the suction pipe and remove it.
3. Disconnect and remove the pressure pipe between the pump and the cylinder block drilling.
4. Remove the half-moon bridge piece.
5 Knock back the setscrew locking tabs on No. 1 main bearing cap and remove the setscrews.
6. Remove No. 1 main bearing cap and pump as one assembly. (See Fig. P.4).
7. Remove the idler gear circlip and withdraw the idler gear and thrust washer.
8. Remove the three setscrews securing the pump to No. 1 main bearing cap.
9. Separate the oil pump from the No. 1 main bearing cap.

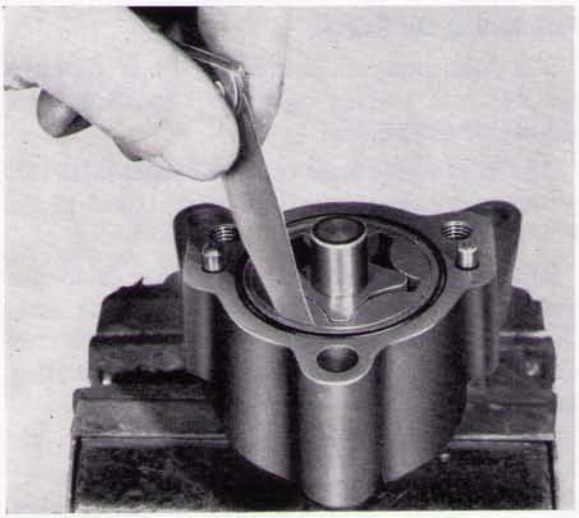


Fig. P.8.
Checking the Clearance between the Outer Rotor and the Pump Body.

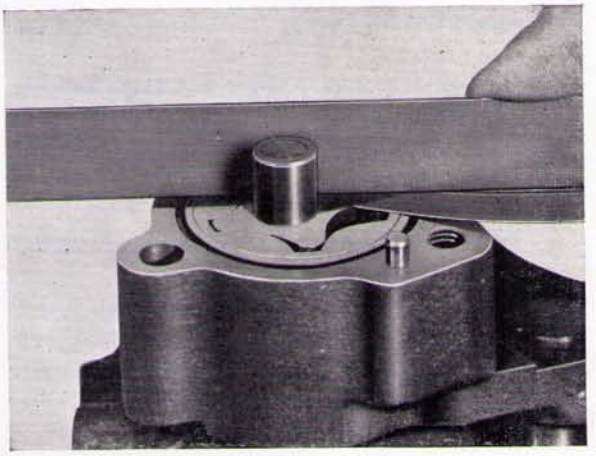


Fig. P.9.
Checking the Clearance between the top of the Rotors and the surface of the Pump.

To Dismantle.

1. With the pump assembly suitably held in a vice, remove the pump drive gear by using a suitable tool. See Fig. P.5.
2. Remove the key from the keyway of the drive shaft.
3. Unscrew the two truss-headed screws and the nut securing the end plate to the pump body.
4. Remove the end cover and relief valve.
5. Carefully remove the drive and driven rotor from the pump body.
6. Dismantle the relief valve by removing the split pin and shims (where fitted), the spring retaining cap, spring and plunger type relief valve.
7. Remove the "0" sealing ring from the pump body. See Fig. P.6.

Inspection.

1. Thoroughly clean all the parts and inspect the rotors for cracks or scores.
2. Install the drive and driven rotors in the pump body and check the clearance between the maximum diameter of the inner rotor and the minimum diameter of the outer or driven rotor at all points. The chamfered edge of the outer rotor enters the pump body first. If the clearance exceeds 0.006 in. renew the pump. See Fig. P.7.
3. Check the clearance between the driven rotor and the pump body, see Fig. P.8. If the clearance exceeds 0.010 in., renew the pump.
4. Check the clearance between the top of the rotors and the surface of the pump body with a feeler gauge and straight edge. See Fig. P.9. If the clearance exceeds 0.003 in. renew the pump.

To Assemble.

1. Fit the drive and driven rotors in the body entering the chamfered end of the outer rotor to the body first, and replace the "0" sealing ring and end plate.
2. Refit the two truss-headed screws and securing nut.
3. Replace the key in the keyway of the drive shaft and refit the drive gear to the shaft. The flat face of the gear faces outwards and should be pressed on to the shaft level with the circlip groove.
4. Fit retaining circlip.
5. Replace the relief valve component parts and ensure that the relief valve lifts at 50 to 65 lb. per square inch either by a suitable test rig or by blanking off the outlet port and applying an air pressure suitably measured.

To Replace the Oil Pump.

1. Fit the oil pump to the No. 1 main bearing cap with the protrusion of the idler shaft fully locating in the machined dowel hole in the cap.

2. Replace the idler gear, washer and circlip.

3. If the pump has been removed with No. 1 bearing cap, then it will be necessary to replace the latter and secure with new tab washers and the setscrews tightened to the recommended torque (see page B.2).

4. Replace the oil delivery pipe and suction pipe complete with its support bracket.

Lubricating Oil Sump.

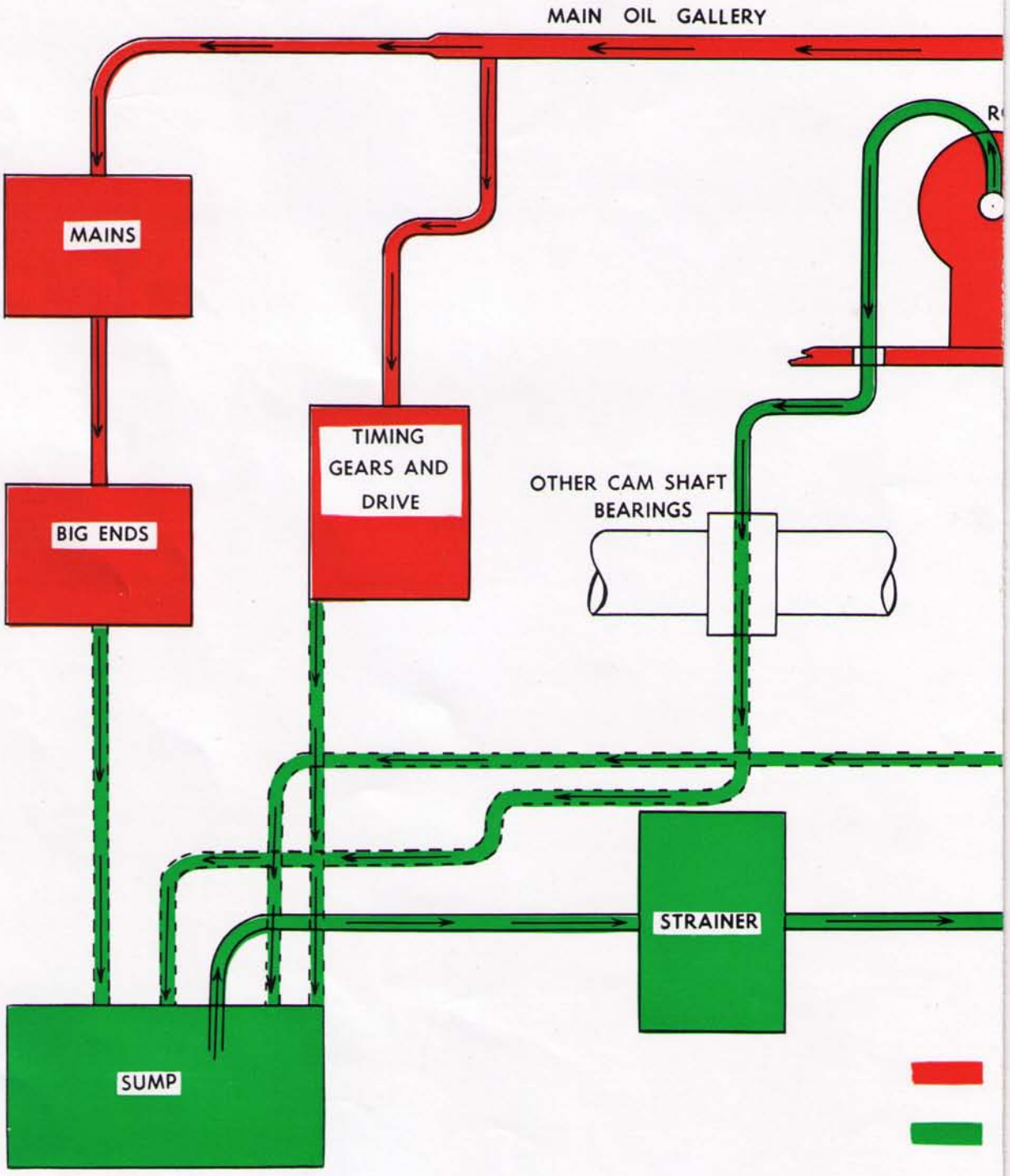
The lubricating oil sump may be of different patterns with varying capacities depending upon the engine application.

The front seal is made on a cork insert fitted in a groove in a half-moon bridge piece, bolted to the base of the timing case.

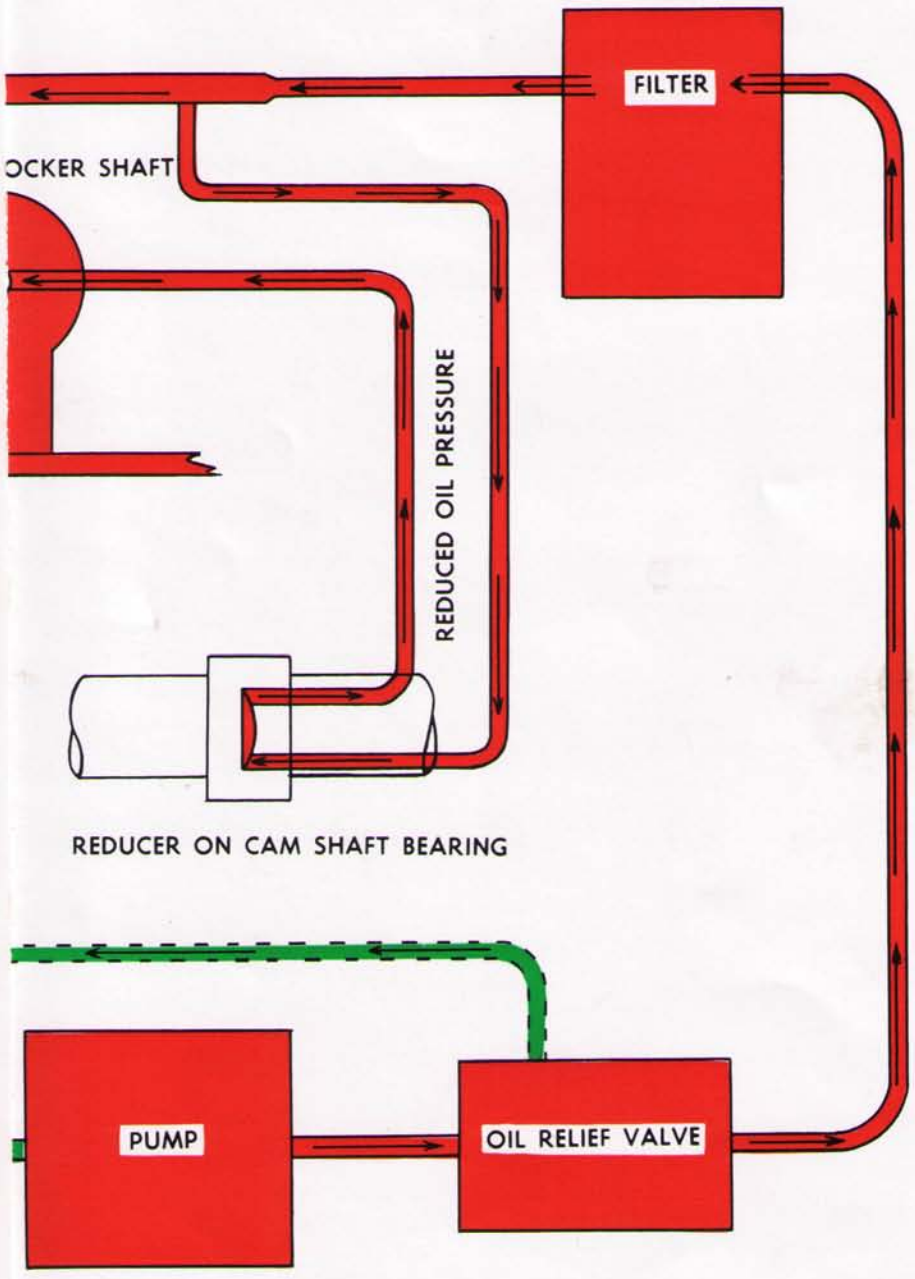
The side flanges bolt directly to the crankcase with the appropriate joints inserted, and the semi-circular cut away at the rear seals on a cork insert fitted in a groove in the rear main bearing cap.

The dipstick provided with each application will show the correct oil level, but as this may differ in various applications, care should be taken that only the correct dipstick is used.

Fig. P.1. Lubricating Oil



Diagram



OIL UNDER PRESSURE

OIL UNDER SUCTION AND RETURN TO SUMP

WATER PUMP (Q)

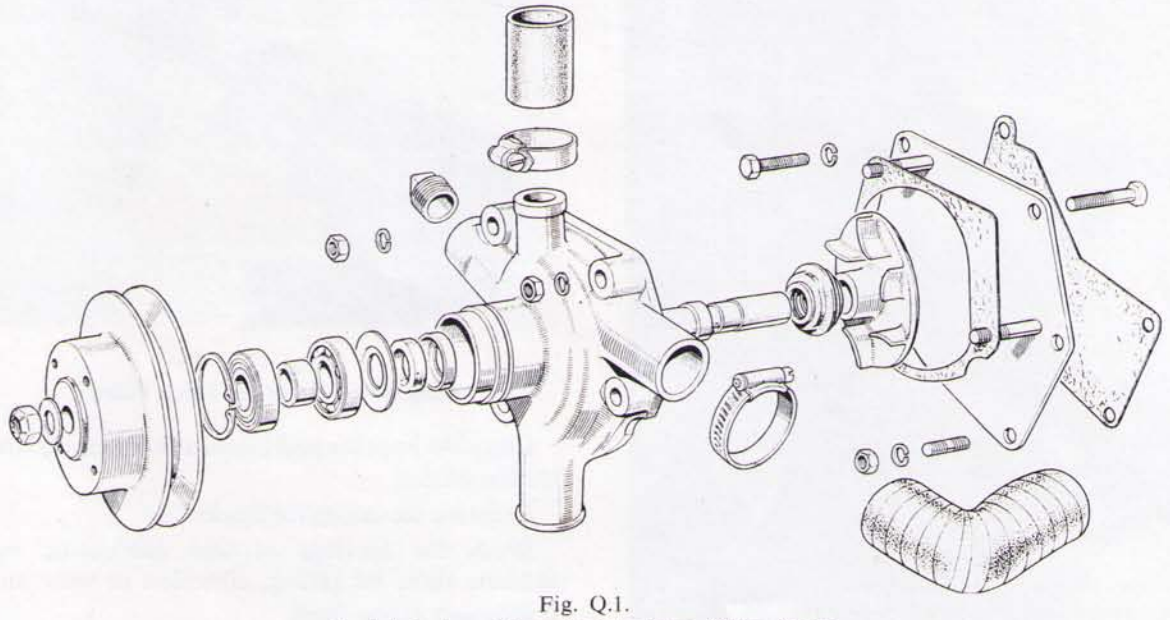


Fig. Q.1.
Exploded view of Low Position Type Water Pump.

A centrifugal type water pump is fitted to the timing case front cover or on the front of the cylinder head depending on application, and is belt driven from the crankshaft pulley. Provision is made on the water pump pulley for the fitment of a pressed steel fan.

The cooling water circulation is from the pump, via a cored passage, cast in the left hand side of the cylinder block, the coolant being directed to the cylinder head through cored holes immediately below the combustion chambers.

The cylinder block is subsequently cooled by thermosyphon action.

The water outlet from the cylinder head is taken through a thermostat housing mounted at the front of the cylinder head, the housing incorporating a by-pass return to the water pump.

To Remove the Water Pump (High Position Type).

1. Release the hose clips and remove the hoses connected to the pump.
2. Remove the temperature gauge capillary tube and the cab heater connections (if fitted).
3. Undo the dynamo stay bracket and ease the fan belt off the pulley.
4. Unscrew the three small setscrews located at the back of the water pump back plate.
5. Release the three setscrews which pass through the pump body into the cylinder head. These cannot be removed from the body while the pulley is still fitted, so the pump must be eased from the back plate while the setscrews are being unscrewed.

To Remove Water Pump (Low Position Type).

1. Release the clips on the hoses from the water pump except those on the by-pass pipe from the thermostat housing to the pump. Here it is advisable to remove the two setscrews securing the by-pass adaptor to the thermostat housing.
2. Release the securing bolt on the dynamo adjusting arm and remove the fan belt.
3. Disconnect the temperature gauge capillary tube and cab heater connections (if fitted).
4. Undo the one setscrew, and three nuts, securing the water pump to the timing case cover, and remove the pump complete with back plate and by-pass adaptor. See Fig. Q.2.

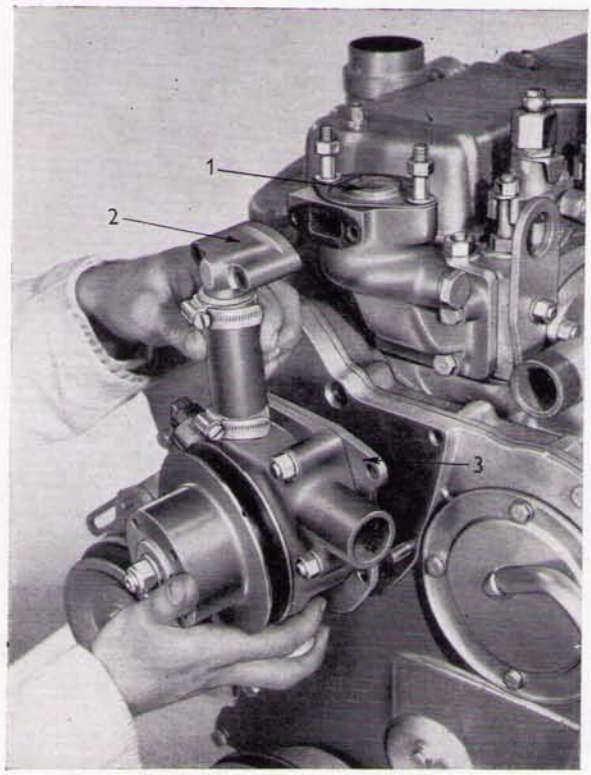


Fig. Q.2.
Removing Water Pump.
1. Thermostat. 2. By-pass Adaptor.
3. Water Pump Back Plate.

To Dismantle Water Pump.

1. Remove the self locking nut securing the water pump pulley to the shaft and remove with washer.
2. Remove the water pump pulley from the front of the shaft. See Fig. Q.3.
3. Press the shaft complete with impeller out of the body. See Fig. Q.4.
4. Remove the front bearing circlip.
5. Press out the bearings and distance piece as shown in Fig. Q.5.
6. Extract the rear seal.
7. If the impeller is to be removed from the shaft it should be set up as shown in Fig. Q.6.

Inspection.

If the water pump shaft shows signs of wear in the region of the bearings, the shaft must be renewed, for a shaft worn in this region will allow the inner race of the bearings to rotate on it.

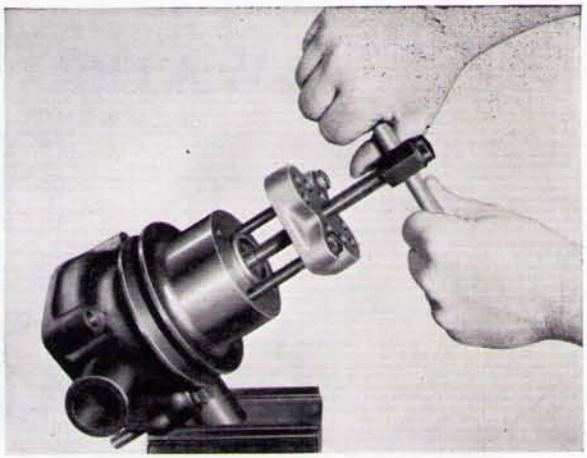


Fig. Q.3.
Withdrawing the Water Pump Pulley.

Clean the impeller and examine it for cracks and broken blades.

Examine the casing for cracks.

Wash the bearings in thin lubricating oil, examine them for pitting, corrosion or wear and if necessary renew them.

To Re-assemble the Water Pump.

1. Fit the felt seal and seal housing in the body followed by the seal retaining plate which is "dished" and must be fitted so that the centre of the plate will not contact the rear bearing when the latter is fitted.

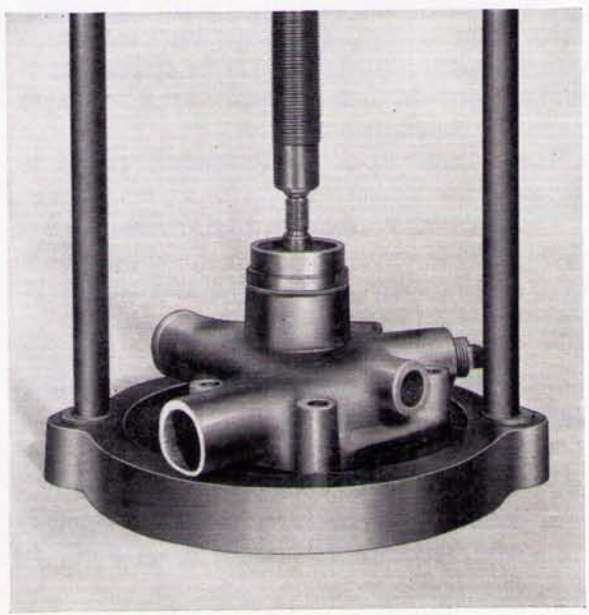


Fig. Q.4.
Pressing Water Pump Shaft out of Body.

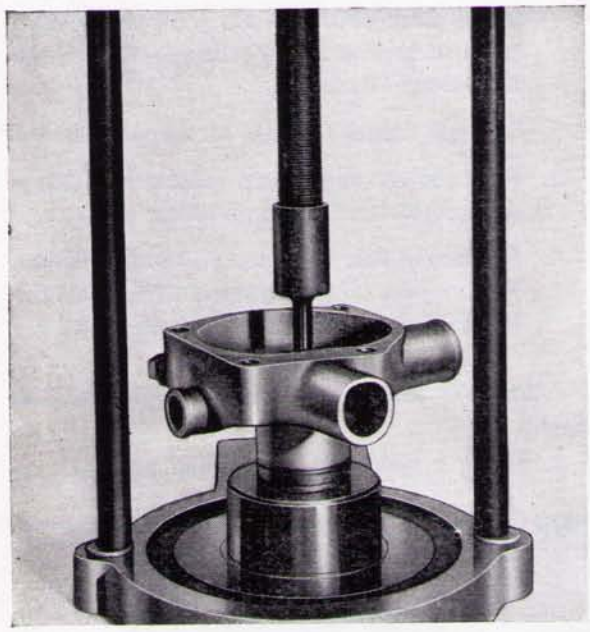


Fig. Q.5.
Pressing Bearings out of Pump.

2. Smear the bearings, and half fill the space between them, with high melting point grease and then press the bearings and distance piece as one assembly into the body, ensuring that the bearing end covers face outwards, i.e. towards the ends of the shaft. See Fig. Q.7.

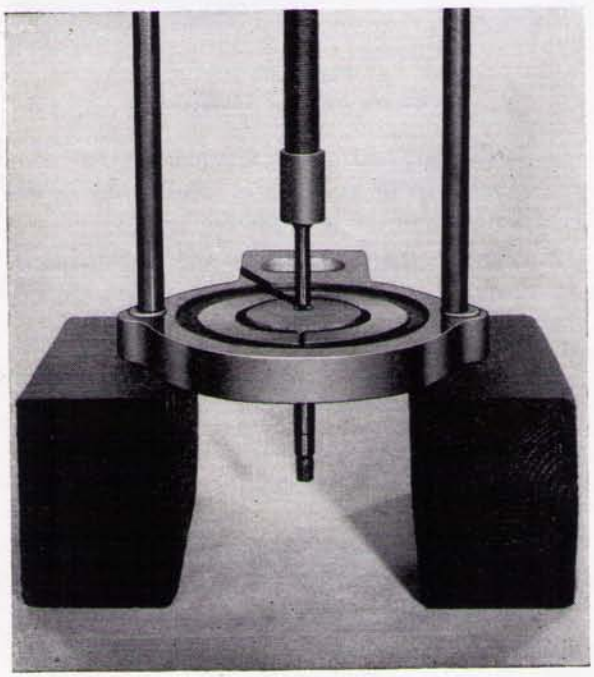


Fig. Q.6.
Pressing Shaft out of Impeller.

3. Re-fit the bearing retaining circlip in its groove forward of the front bearing.
4. Press the shaft into the pump.
5. Locate the pulley in tool (See Fig. Q.8) and place the body over it so that the shaft enters the hole in the pulley. Press the shaft into the pulley.
6. Re-fit the rear seal and turn the pulley by hand to ensure that there is no resistance to motion. If the shaft appears to be tight, tap the rear end of it with a hide hammer.

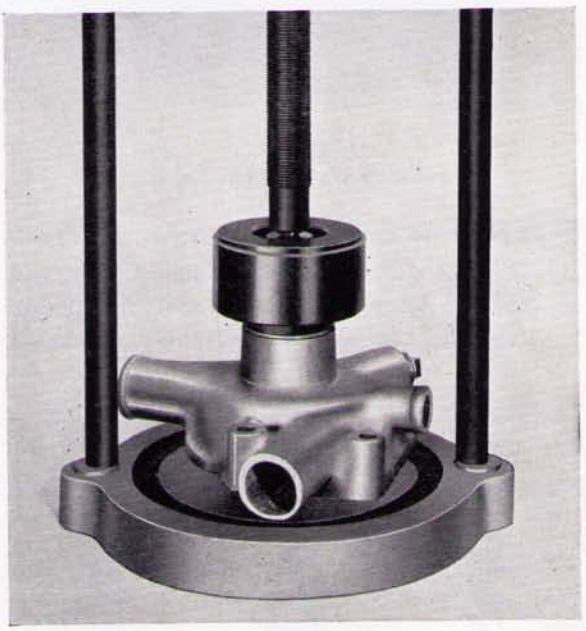


Fig. Q.7.
Replacing the Bearings.

7. Press the impeller on to the shaft (See Fig. Q.9) until the clearance between the front of the impeller blades and the body is 0.015/0.025 in. (0.381/0.635 mm). This should be checked with a feeler gauge as shown in Fig. Q.10. At this point, a straight edge placed across the back face of the pump body should also contact the back face of the impeller.
8. Re-fit the plain washer and self-locking nut, tightening the latter to a torque of 55/60 lbs. ft.

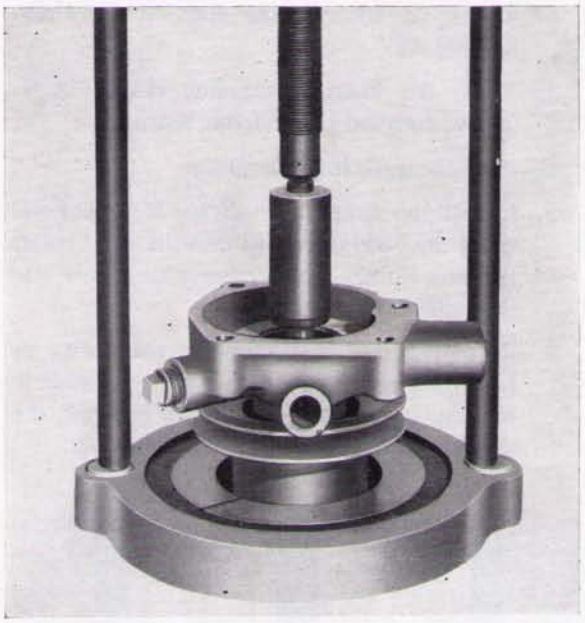


Fig. Q.8.
Refitting Water Pump Pulley.

To Replace the Water Pump (Low Position Type).

1. Clean the back face of the pump body, and employing a new joint, refit the pump, locating the hoses as the pump is offered

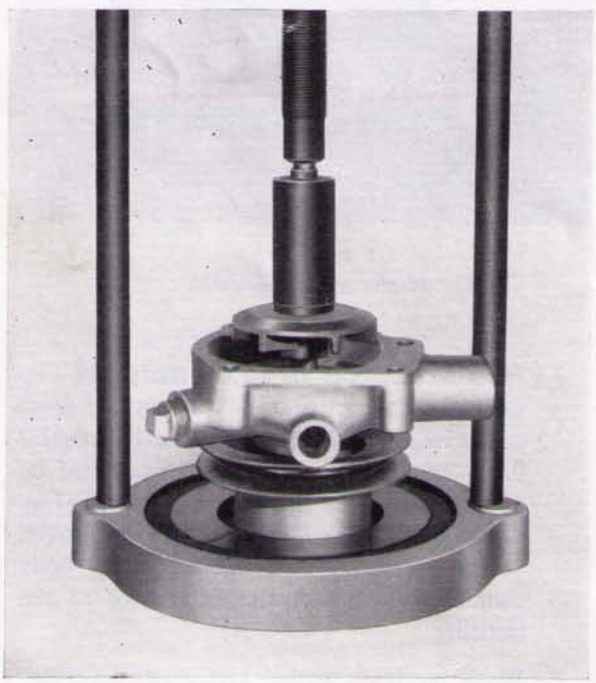


Fig. Q.9.
Replacing Impeller on to Shaft.

to the front cover. A new joint should also be fitted beween the by-pass adaptor and the thermostat housing.

2. Securely tighten the clips on the water hoses.
3. Refit the cab heater and temperature gauge connections (where applicable).
4. Fit the fan belt on to the pulleys and adjust the position of the dynamo to tension the belt (See Page Q.5 for correct tension).

To Replace the Water Pump (High Position Type).

1. Using a new joint, locate the pump to its

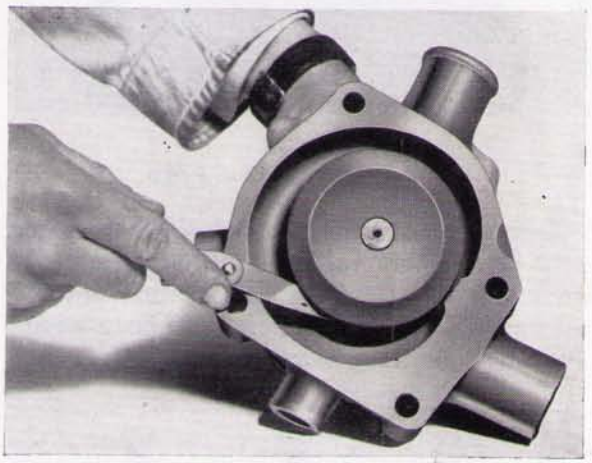


Fig. Q.10.
Checking Impeller Clearance

back plate and having secured the front set-screws, screw in the three smaller ones from the back of the back plate.

2. Replace the water hoses and tighten their clips.
3. Refit the cab heater and temperature gauge connections.
4. Refit and tension the fan belt. See Page Q.5 for correct tension.

Fan Belt.

A single V-type belt is used to drive the dynamo and water pump from the crankshaft pulley.

Correct fan belt adjustment is important, otherwise the belt itself may be damaged or undue strain may be put upon the dynamo or water pump bearings.

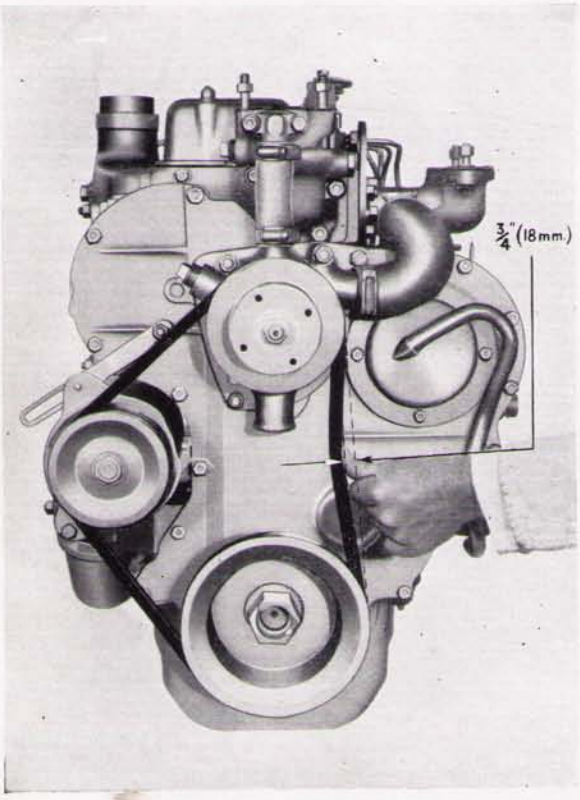


Fig. Q.11.
Checking Fan Belt Tension.

There is provision for fan belt adjustment by moving the dynamo on its mounting and it is important that this adjustment be released when a new fan belt is fitted, for any attempt to strain the belt over the pulleys will undoubtedly cause damage to the belt.

To Adjust the Fan Belt.

The correct tension of the belt is such that when it is depressed by hand midway between the fan belt pulley and crankshaft pulley, the deflection is approximately ¾ of an inch. See Fig. Q.11. A new belt will "bed-in" and may require adjusting after a few hours service. To tighten the belt, slacken the dynamo securing bolts. Swing the dynamo outwards and retighten the bolts securely.

To Renew the Fan Belt.

The fan belt should be renewed when it becomes frayed, or stretched to an extent where no further adjustment can be made.

1. Slacken the dynamo mounting bolts and move the dynamo towards the engine.
2. Slip the belt over the edge of the dynamo pulley taking care not to damage the pulley. If necessary slide the belt up and over the leading edge of the pulley in the same direction it rotates and then turn the engine over to bring the belt off the pulley. The belt may then be taken from the water pump pulley and crankshaft pulley.
3. Pass the new belt around the water pump and crankshaft pulleys and engage it in the dynamo pulley. Readjust the belt tension as previously described and tighten the dynamo mounting bolts.

Thermostat.

A bellows type thermostat is fitted in the water outlet body.

To Remove.

1. Remove the water hose between the top of the radiator and the water outlet connection adaptor, or water pump in the case of the high position type.
2. Remove the two nuts and washers securing the adaptor to the thermostat housing, or water pump.
3. Remove the adaptor and joint thereby disclosing the thermostat.
4. Remove the thermostat from the recess in the housing.

Testing the Thermostat.

If it is suspected that the thermostat is not operating correctly it may be tested in the following manner :

Immerse the thermostat in a suitable container of water and gradually heat. Check the water temperature at frequent intervals with an accurate thermometer. The valve should commence to open at 176 degrees F.

If the thermostat does not function properly no attempt should be made to adjust it. Replace with a new unit.

FUEL INJECTION SYSTEM (R)

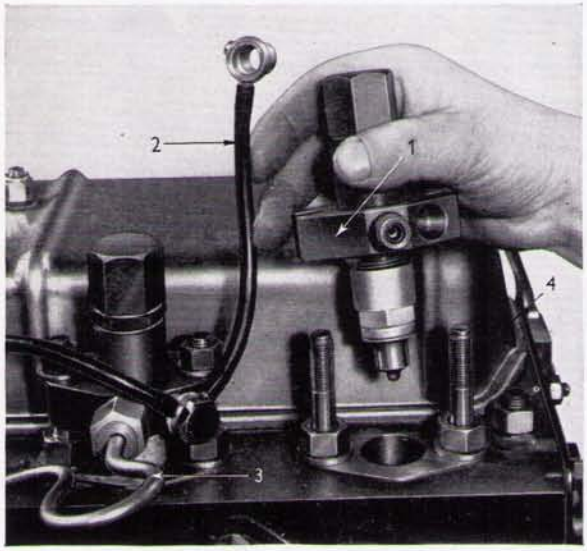


Fig. R.1.
An Atomiser removed from the Cylinder Head.
1. Atomiser.
2. Leak-off Pipe.
3. Fuel Injection Pipe.
4. Securing Stud.

Important Note: The type of fuel pump, fuel injection pipes and atomisers fitted to the Four 192 and Four 203 engine may vary according to application and engine rating. Reference should therefore be made to the appropriate parts Literature to ensure correct replacements are fitted in service.

Diesel fuel is drawn from the main supply tank and passed into the system by means of a diaphragm type lift pump. Before reaching the fuel injection pump, it is passed through a series of filters to ensure absolute cleanliness. The fuel injection pump then meters the fuel in predetermined quantities and delivers it at timed intervals to the atomisers. The utmost cleanliness should always be observed in storage and transference of the fuel to the fuel tank. This will eliminate undue stress on the lift pump valves and the fuel filters and obviate one potential cause of engine failure. It is recommended that special attention be paid at all times to fuel filter maintenance if the costly, precision built, fuel injection pump is to be fully protected and allowed to give the lengthy, trouble free period of service of which it is capable.

Fuel Injection Pump.

This is a D.P.A. type distributor pump of British manufacture. Governing is by either mechanical or hydraulic equipment which is built into the pump. It is flange mounted and is secured to the timing cover together with the fuel pump carrier plate by three screws. The type, serial number, and direction of rotation of the pump are indicated on an identification plate attached to the pump body. On variable speed applications an Advance and Retard mechanism is fitted to provide automatic variations of the injection timing in conjunction with variations in loading of the engine. Drive is obtained by means of a splined quill shaft from the fuel pump gear adaptor, Fig. M.2. To simplify removal and refitting of the pump, the quill shaft has a master spline and external marks are provided on the pump mounting flange, Fig. M.14. No effort should be made to interfere with the pump mechanism or settings unless the proper facilities and the appropriate manufacturer's literature are available.

Where service is required, this should be obtained from the fuel pump manufacturer's agents.

To Remove the Fuel Pump.

1. Remove the four fuel injection pipes noting the index letter "U" stamped adjacent to No. 1 outlet union.
2. Remove the fuel supply and return pipes.

N.B.—Suitable caps should be fitted to all pump connections to prevent the ingress of foreign matter.

3. Disconnect the engine speed and stop control linkages from the levers.
4. Remove the three setscrews from the pump mounting flange and withdraw the pump from the engine. (Fig. M.13). Where the pump is fitted with a detachable quill shaft, this should be kept with its respective pump.

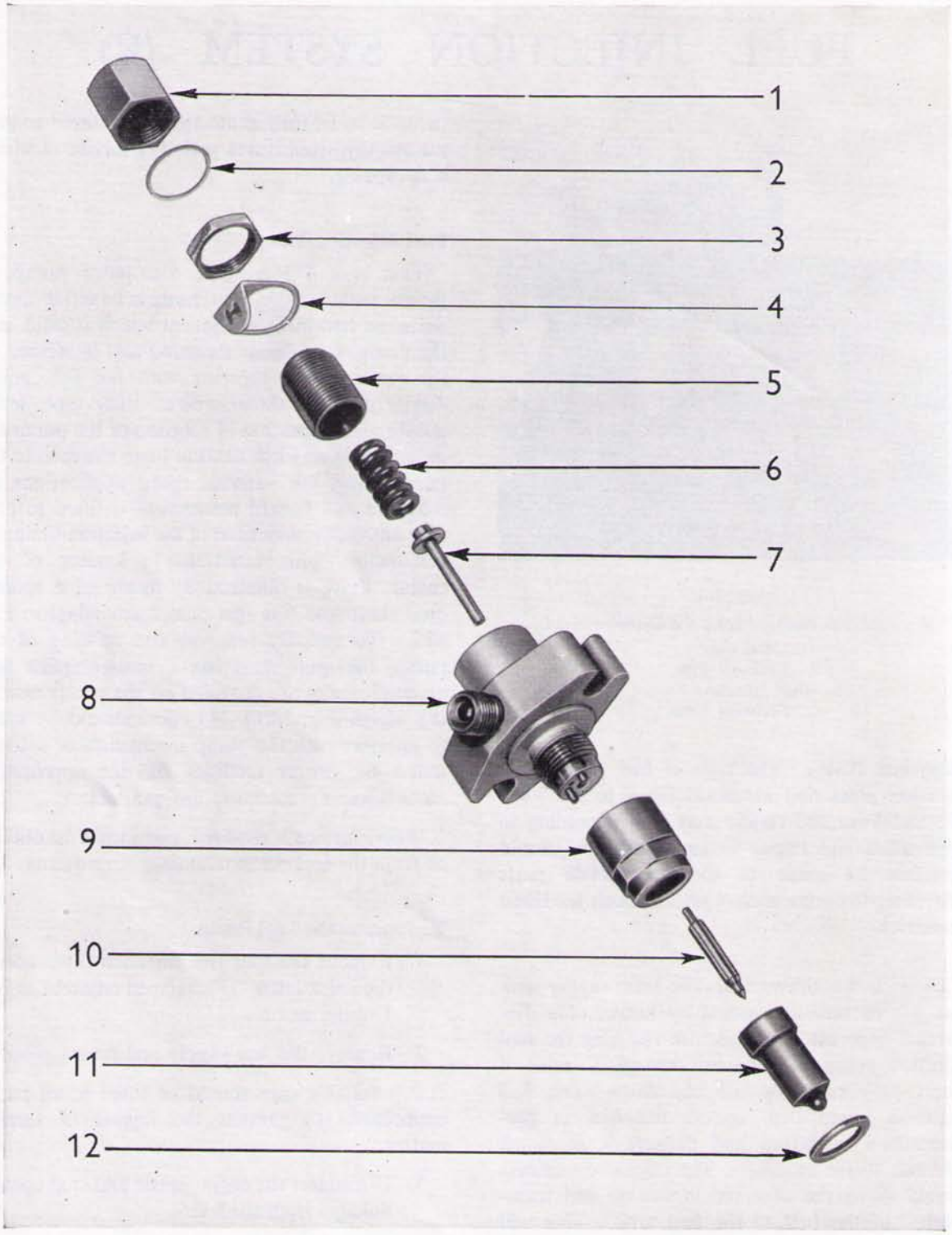


Fig. R.2.

Exploded view of an Atomiser.

1. Nozzle Holder Cap Nut.
2. Cap Nut Washer.
3. Locknut.
4. Identification Tab Washer.
5. Spring Cap.
6. Spring.
7. Spindle.
8. Nozzle Body.
9. Nozzle Cap Nut.
10. Needle.
11. Nozzle.
12. Copper Washer.

To Replace the Fuel Pump.

1. Fit a new joint to the face of the carrier plate.
2. Fit the quill shaft to the pump and position the master spline so that when the pump is offered up to the engine it will engage with the splines in the fuel pump gear adaptor.
3. Align the marks on the hub and pump flanges, fit the three setscrews and tighten. (Fig. M.14).
4. Connect the throttle and stop controls.
5. Connect the fuel supply pipes and fuel injection pipes.
6. Bleed the fuel system as described in Section C.

To check the fuel pump timing refer to Section N.

The Lift Pump.

This is positioned on the right hand side of the engine, and is fixed to a flange on the camshaft chamber by two studs and nuts. Operation is by the pump lever contacting a cam on the engine camshaft.

The pump is of the diaphragm type and incorporates a glass bowl pre-filter.

A hand-primer is fitted to enable the fuel system to be bled when the engine is stationary.

Fuel Pipes.

These are formed of high pressure steel tubing, suitably shaped for each individual cylinder, and fitted with nuts and nipples in production. They are serviced as an assembly and if faulty should be replaced complete.

When fitting, no bending should be necessary. Offer both nipples to their respective unions and tighten the nuts alternately a little at a time.

Never slacken one end of a fuel pipe (e.g. when changing atomisers) leaving the other end tight. Always remove the pipe entirely.

Never use undue force on a union nut in an attempt to obtain a seal. This will only result in damage to the nipple, union nut, and thread.

Fuel Filters.

As previously stated, the first filter is a glass bowl pre-filter incorporated in the lift pump. The secondary filter is a paper-element type, the element of which is always discarded and replaced and never washed. Unlike the lub. oil filter no by-pass valve is incorporated, therefore, should the element become blocked, fuel supply to the engine will be limited, resulting in loss of power, and ending in complete stoppage. Maintenance is described in Section G.

Atomisers.

Each atomiser consists of a steel body, held to the cylinder head by means of a flange and two studs, Fig. R.1.

The joint between the atomiser and cylinder head is made by a copper washer between the lower face of the nozzle cap nut and the recess in the cylinder head.

Identification is by lettered tab washers fixed to the atomiser body. See page R.5.

No attempt should be made to interfere with the atomiser or its settings unless the proper facilities and the appropriate manufacturer's literature are available.

A dismantled atomiser is shown in Fig. R.2.

A leak-of system couples the atomisers to the fuel tank and to the secondary fuel filter. Through this, atomiser leak-off and excessive fuel from the injection pump is returned to the fuel tank.

The joint between the atomiser and cylinder head is made by a special copper washer between the lower face of the nozzel cap nut and the recess in the cylinder head.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only this type of copper washer is used to make this joint. The recess in the cylinder head, the faces of the copper washer and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leakproof joint is to result.

It is advisable to fit a new joint washer when the atomiser is replaced, after having been removed for any reason.

Ensure that the old washer has been removed from the cylinder head or atomiser.

This joint washer should be an easy, but not loose fit for the atomiser nozzle and it is because

this is such an important feature that only washers specially made for the purpose should be used and none other. On no account should ordinary sparking plug washers be used.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so " nipped " in the cylinder head.

Maintenance.

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise, because of the different conditions under which engines operate.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested twice yearly. For detailed times refer to Periodical Attentions, Section F.

It is no use taking atomisers out for attention unless an atomiser testing pump is available or spare atomisers of the correct type are at hand for substitution.

The better the conditions of fuel filtration and cooling, the less attention the atomisers will need and so the longer will be their efficient life.

In this connection, since there is no other item upon which the performance of the engine depends so much, it pays the user to see that the engine never runs with any of its atomisers out of order.

Troubles in Service.

The first symptoms of atomiser trouble usually fall under one or more of the following headings:

1. Misfiring.
2. Knocking in one, or more cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast ' Tick-over.' This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

The nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round, atomiser nozzle outwards, and the unions re-tightened.

After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly ' wet ' or ' streaky ' or obviously to one side, or the atomiser nozzle ' dribbles ' then the complete unit should be replaced, the faulty atomiser being securely wrapped in clean greaseproof paper or rag with the protection cap on the nozzle for attention on the maintenance bench.

Great care should be taken to prevent the hand from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

Examination and Testing.

An atomiser testing pump should be available. This outfit has been specially designed to provide a reliable means of testing and setting the atomisers. It is made up of parts similar to the injection equipment fitted to engines.

The doubtful atomiser should be fitted nozzle downwards, and still unwiped to an atomiser testing pump.

No observations should be made until at least ten full strokes of the hand pump have been given to expel all air from the system.

The pressure at which the spray breaks should then be recorded and checked against the recommended pressure which is 120 atmospheres.

The spray should now be observed for uniformity at a rate of pumping of not less than 20 strokes per minute.

Each should be a misty spray spreading to about 3 inches diameter at about one foot away from the atomiser nozzle, then breaking into a very fine mist. There should be two sprays from each atomiser nozzle, one pointing outwards from the top hole, and the other pointing downwards from the lower hole, when the atomiser is in a position corresponding to its working position.

An atomiser is good for service if, when operating the atomiser testing pump at the above speed, it gives two effective sprays as above described.

An atomiser is dirty and requires reconditioning if (a) when proceeding as above it throws out solid wet jets and not broken up spray or (b) if either of the holes are choked or partially choked so that spray issues from one hole in the atomiser only or appreciably more spray issues from one hole than the other.

As the engine idles at about 500 r.p.m. the atomiser is never called upon to work in the engine more slowly than 250 injections per minute. Thus by taking the atomiser spray at 20 strokes per minute, ample margin is allowed.

When removing an atomiser from the testing pump, close the valve by rotating the hand-wheel and screw off the union nut a little at a time so that the pressure falls gradually.

All atomisers are set to operate at a pressure of 120 atmospheres before leaving the works. After the atomiser has been in service for some time, the opening pressure tends to fall, but provided that the atomiser nozzle holes do not choke up, there is no need to adjust the pressure.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT A PROPER TESTING PUMP AND PRESSURE GAUGE AS DESCRIBED ABOVE. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT

Atomiser Identification.

All atomisers have a tab washer fitted below the Body Cap Nut and are stamped with an Identification Code Letter.

When servicing an atomiser it is important to ensure that it is fitted with the appropriate tab washer before replacement in the engine. If incorrect atomisers are fitted to an engine, loss of power may result.

Re-conditioned atomisers will have their body cap nuts painted green, new atomisers will be unpainted.

Atomisers can be identified by the code letter stamped on the tab washer fitted under the atomiser cap nut. The code letters are as follows :

Four 192.

Vehicle	H
Agricultural and Industrial (Mech. Governor)	J
Industrial (Hydraulic Governor)	H

Four 203.

Vehicle	H
Agricultural and Industrial (Mech. Governor)	J
Industrial (Hydraulic Governor)	H

The different letters in the same Group indicate internal differences (other than pressure setting) and/or external diferences which are not readily recognisable. Conversely, Atomisers set at the same pressure and having the same internal characteristics, but which are not interchangeable by reason of obvious physical differences, carry the same Code Letter.

FLYWHEEL & FLYWHEEL HOUSING (S)

To Remove the Flywheel.

1. Remove gearbox and bell housing.
2. Evenly unscrew the setscrews securing the clutch assembly and detach the unit.
3. Knock back the tabs of the locking washers of the flywheel securing setscrews.
4. Remove the six setscrews and lift the flywheel from the crankshaft flange.
5. Remove the clutch pilot bearing (if fitted).

To Renew the Flywheel Ring Gear.

The flywheel ring gear is shrunk on to the flywheel and to remove it partly cut through the gear and chisel cut it from the flywheel. Alternatively, localised heat in a flame form would expand the ring gear sufficiently to tap it off the flywheel.

1. Clean the location of the flywheel front face.
2. Heat the new ring gear to an approximate temperature of 475 degrees F.
3. Fit the gear over the flywheel with the lead-in on the teeth facing the front of the flywheel and allow to cool.

Alignment of the Flywheel Housing.

Where a flywheel housing is fitted, it is most important that it be correctly aligned with the crankshaft. Misalignment may give rise to difficulty in changing gear, etc. If the housing has been removed, as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows :—

See that the face of both the rear of the cylinder block and flywheel housing are perfectly clean and free from burrs.

Set the housing on to the studs and tighten, but not overtight so as to allow adjustment.

Alignment of the Flywheel Housing Bore.

Secure the base of a "clock" gauge to the flange of the crankshaft.

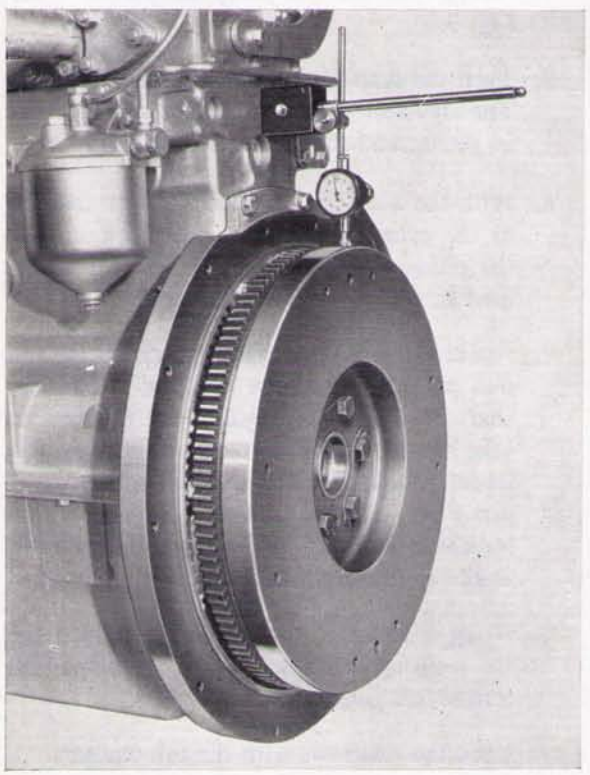


Fig. S.1.
Checking Flywheel Periphery Run-out.

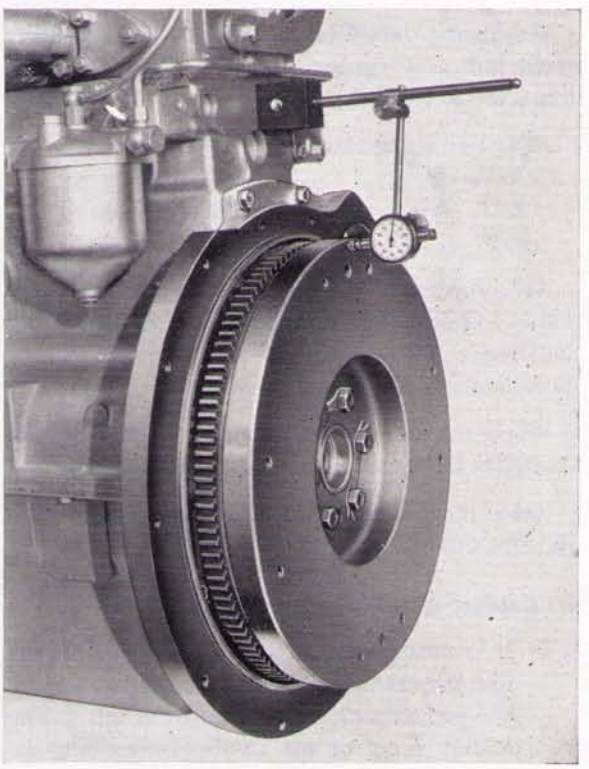


Fig. S.2.
Checking Flywheel Back-face Run-out.

Set the needle of the gauge to the interior of the bored hole in the flywheel housing.

Turn the crankshaft and check that this hole is truly central. The housing is adjusted until the bored hole is central.

For convenience in turning the engine it is advisable to release (but not remove) the nuts holding the atomisers in place.

The hole in the flywheel housing should be truly central with the crankshaft within the following limits (total indicator reading).

Flywheel Housing Dia.	Deviation
30″ —23″	.010″ (0.25 mm.)
22⅞″ 16¼″	.008″ (0.20 mm.)
16⅛″—12⅜″	.006″ (0.15 mm.)

Alignment of the Flywheel Housing Face.

With the face of the 'clock gauge' still bolted to the crankshaft flange, adjust the 'clock' so as to set the needle against the vertical machined face of the flywheel housing, and again, turning the crankshaft, check that this face is perpendicular to the crankshaft axis.

This facing should be within the following limits (total indicator reading) of being truly at right angles to the crankshaft axis.

Flywheel Housing Dia.	Deviation
30″ —23″	.010″ (0.25 mm.)
22⅞″ 16¼″	.008″ (0.20 mm.)
16⅛″—12⅜″	.006″ (0.15 mm.)

All adjustments to bring the flywheel housing within the limits must be on the flywheel housing and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the housing is properly aligned to the above limits, tighten the securing nuts evenly.

Ream the dowel holes and fit the correct length and size dowels.

To Replace the Flywheel.

1. It is most essential before fitting a flywheel that the crankshaft flange face and periphery are perfectly clean and free from burrs. The mating faces of the flywheel must also be absolutely clean and free from burrs. Failure to observe these conditions may result, in the flywheel running out of balance.

2 It will be noted that there is a seventh untapped hole in the crankshaft flange, which is at bottom centre when the crankshaft is at T.D.C. Nos. 1 and 4 pistons. Mount the flywheel to the crankshaft flange so that the untapped hole in the flange is in line with the seventh, unused smaller hole in the flywheel. This ensures the flywheel timing marks are in a correct position in relation to the crankshaft.

3. Engage the six securing setscrews with three new locking washers and tighten sufficiently to hold the flywheel to the crankshaft.

4. It is most important that the flywheel run out be checked to ensure that it will not run out of balance, so before tightening the six setscrews, secure the base of a 'clock' gauge to the cylinder block. Then, with the flywheel at top centre, set the plunger of the 'clock' on the periphery at T.D.C. See Fig. S.1.

5. Turn the crankshaft and check the run out. The flywheel should run truly within 0.012 in. (0.30 mm.) total indicator reading.

6. With the base of the 'clock' gauge secured to the cylinder block, set the clock so that the plunger rests against the vertical machined face of the flywheel. See Fig. S.2.

7. Again turn the crankshaft and check the run out, at the same time pressing a hammer shaft or similar tool against the flywheel to take up the crankshaft end float. The flywheel should be within 0.0005 in. (0.0127 mm.) per inch of flywheel diameter (total indicator reading) of being truly at right angles to the crankshaft axis.

8. Using a suitable torque wrench tighten the six securing setscrews to the recommended torque (see page B.2).

9. Lock the setscrews with the tab washers.

SCHEDULE OF CLEARANCES AND TOLERANCES

All threads used on the Four 192 and Four 203 engines excepting proprietary equipment are Unified Series and American Pipe Series.

These threads are not interchangeable with B.S.F. and although B.S.W. have the same number of threads per inch as the Unified Coarse Series, interchanging is not recommended due to a difference in thread form.

1. The data regarding clearances and tolerances is given as a guide for personnel engaged upon major overhauls.
2. The figures in the column "Permissible Dimensions" are the drawing sizes to which the parts are made. These dimensions are given in limit form and represent the minimum and maximum sizes to which parts may be accepted when new, as, for example, $\frac{1.298}{1.2985}$ quoted for a shaft diameter.
3. The difference between the minimum and maximum dimensions quoted in para. 2 is known as the manufacturing tolerance. This tolerance is necessary as an aid to manufacture and its numerical value is an expression of the accuracy of the design. It may also be considered as a numerical expression of the desired quality of workmanship. For the example referred to in para. 2 the tolerance is 0.0005.
4. If, when carrying out a major overhaul it is found that a bush and corresponding shaft have worn and that the majority of wear has taken place in the bush it may be necessary to renew the bush only. Similarly, if the majority of wear has taken place on the shaft it might only be necessary to renew the shaft.
5. During the overhaul of worn components personal initiative must be exercised at all times. It is obviously un-economical to return worn parts to service with an expectation of life which may involve labour costs again at an early date.
6. Further information can be obtained on request from the Service Division, Perkins Engines Ltd., Peterborough, England.

To ensure you obtain the best results from your engine and to safeguard your own guarantee, fit only genuine Perkins parts. These are readily obtainable throughout the world.

Schedule of Building Clearances and Tolerances to be adhered to when overhauling Engines to Factory Standards. (Engines Type Four 192 and Four 203).

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE		REMARKS
		inches	mm.	inches	mm.	
	OIL PUMP					
37714002	Oil Pump Housing (Dia. of Pocket)	1·603 1·604	40·716 40·741			
	Oil Pump Housing (Depth of Pocket)	1·125 1.126	28·574 28·600			
	Oil Pump Housing (Bore dia. for Shaft)	0·500 0·501	12·7 12·725	0·0015 0·003	0·038 0·076	
0750375	Shaft, Oil Pump (Dia.)	0·498 0·4985	12·649 12·662			
0410245 0410256	Gears, Oil Pump Drive (Backlash)			0·012 0·018	0·305 0·457	
	CAMSHAFT					
0140034	Camshaft No. 1 Journal Dia.	1·869 1·870	47·47 47·50	0·002 0·005	0·05 0·127	
	No. 1 Hole (Bushed) for Shaft in Cyl. Block ...	1·872 1·874	47·548 47·599			
	No. 2 Journal Dia. ..	1·859 1·860	47·22 47·24	0·004 0·008	0·101 0·203	
	No. 2 Hole for Shaft in ... Cylinder Block	1·864 1·867	47·345 47·422			
	No. 3 Journal Dia. ...	1·839 1·840	46·71 46·74	0·004 0·008	0·101 0·203	
	No. 3 Hole for Shaft in ... Cylinder Block	1·844 1·847	46·84 46·914			
	Cam Lift	0·3085 0·3165	7·83 8·04			
	Timing Gears (Backlash)			0·003 0·006	0·076 0·152	
	CYLINDER BLOCK (Four 192 only)					
	Cylinder Block (for Camshaft bores see Camshaft Assembly)					
	Height of Block between top and bottom faces ...	13·7395 13·7445	348·98 349·11			

Schedule of Building Clearances and Tolerances to be adhered to when overhauling Engines to Factory Standards. (Engines Type Four 192 and Four 203).

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION inches	PERMISSIBLE DIMENSION mm.	PERMISSIBLE CLEARANCE inches	PERMISSIBLE CLEARANCE mm.	REMARKS
	CYLINDER BLOCK (cont.)					
	Cylinder bores (finished Dia.) ...	3·501 3·502	88·925 88·95			Add 0·030in. or 0,762 mm. to these dimensiones when re-bored.
	Parent bore Dia. before fitting liners) ...	3·6865 3·6875	93·637 93·662	0·002 tight	0·050 tight	
0530002	Cylinder Liner (Outside Dia.) ...	3·6895 3·6905	93·713 93·738	0·004 tight	0·101 tight	
0630030	Piston (Depth of Crown below top face of Cylinder Block)			0·000 0·005	0·000 0·127	Measured with crank and piston at T.D.C.
	Comp. Ring Grooves (Width) ...	0·0957 0·0967	2·43 2·456	0·0019	0·048	
0640083 0640011	Compression Ring (Width)	0·0938 0·0928	2·382 2·357	0·0039	0·099	
0640083	Top Compression Ring Gap (Closed) ...			0·010 0·015	0·254 0·381	Permissible gap in unworn cylinder, see footnote for gap in worn cylinder.
0640011	2nd Compression Ring Gap (Closed) ...			0·009 0·013	0·228 0·330	
0630030	Scraper Ring Groove (Width)	0·252 0·253	6·4 6·426	0·002	0·050	
0640003	Scraper Ring (Width)	0·249 0·250	6·324 6·35	0·004	0·101	
	Scraper Ring Gap (Closed) ...			0·009 0·013	0·228 0·330	Permissible gap in unworn cylinder, see footnote for gap in worn cylinder.

NOTE :—When fitting Piston Rings to a worn cylinder, ring gaps should be checked at *bottom* of cylinder.

	CYLINDER BLOCK (Four 203 only)					
	Cylinder Block (for Camshaft bores, see Camshaft Assembly)					
	Height of Block between top and bottom faces	13·7395 13·7445	348·98 349·11			
	Cylinder Bores Internal Dia.	3·6005 3·603	91·45 91·52			Pre-finished

Schedule of Building Clearances and Tolerances to be adhered to when overhauling Engines to Factory Standards. (Engines Type Four 192 and Four 203).

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION inches	PERMISSIBLE DIMENSION mm.	PERMISSIBLE CLEARANCE inches	PERMISSIBLE CLEARANCE mm.	REMARKS
	CYLINDER BLOCK (cont.)					
	Parent Bore (Dia. before fitting Liners)	3·6875 3·6885	93·662 93·687	0·001	0·025	Transition Fit
0530024	Cylinder Liner (Outside Dia.)	3·6875 3·6885	93·662 93·687	0·001	0·025	
0630079	Piston (Depth of Crown below top face of Cylinder Block			0·000 0·005	0·000 0·127	Measured with crank and piston at T.D.C.
	Compression Ring Grooves (Width)	0·0957 0·0967	2·431 2·456	0·0019	0·048	
0640135 0640136	Compression Ring Width	0·0928 0·0938	2·357 2·382	0·0039	0·099	
	Compression Ring Gap (Closed)			0·009 0·013	0·022 0·033	Permissible gap in unworn cylinders, see footnote for gap in worn cylinders.
0630079	Scraper Ring Groove (Width)	0·252 0·253	6·4 6·426	0·002	0·05	
0640134	Scraper Ring (Width)	0·249 0·250	6·324 6·350	0·004	0·101	
	Scraper Ring Gap (Closed)			0·009 0·013	0·022 0·033	Permissible gap in unworn cylinder, see footnote for gap in worn cylinders.
	NOTE :—When fitting Piston Rings to a worn cylinder, ring gaps should be checked at the *bottom* of cylinders.					
	CRANKSHAFT AND CONNECTING RODS					
0210007	Connecting Rod Big End (Parent Bore)	2·395 2·3955	60·833 60·846			
0050399	Bearing, Connecting Rod, Big End (Bore Dia.)	2·251 2·252	57·175 57·200	0·002	0·05	Standard Size only. For under sizes subtract 0·010 in., 0·020 in. or 0·030 in.
31315126	Crankshaft Crankpins (Dia.)	2·2485 2·249	57·111 57·124	0·0035	0·089	
0210007	Connecting Rod, Big End (Width)	1·5502 1·5525	39·375 39·433	0·0095	0·241	
31315126	Crankshaft, Crankpins (Width)	1·562 1·5635	39·674 39·712	0·0133	0·337	

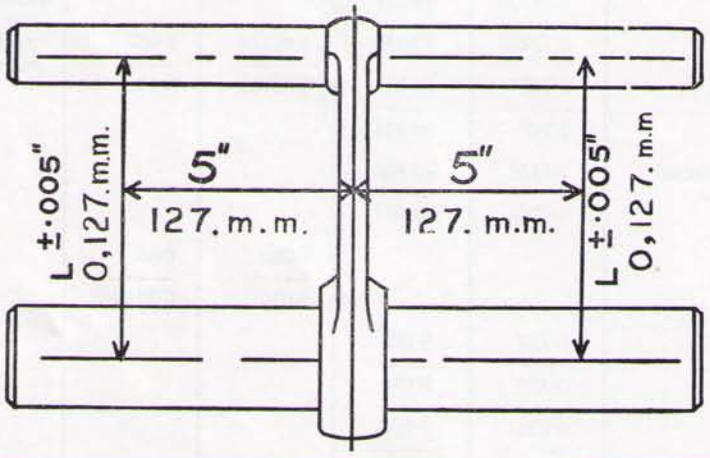
Schedule of Building Clearances and Tolerances to be adhered to when overhauling Engines to Factory Standards. (Engines Type Four 192 and Four 203).

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE		REMARKS
		inches	mm.	inches	mm.	
	CRANKSHAFT AND CONNECTING RODS (cont.)					
0050119	Bush, Connecting Rod Small End (Bore)	1·2505 1·2515	31·763 31·788	0·0005	0·0127	Bushes provided with with reaming allowance.
0610516	Gudgeon Pin ... (Dia.)	1·24975 1·250	31·743 31·75	0·00175	0·044	
	Connecting Rod, alignment between Small and Big End Bearing Bores (Parallelism) Ditto (Twist)					Alignment measured between mandrels through Big and Small End bores. (See fig. 1).
37112241	Housings, Main Bearings (Bore)	2·9165 2·9175	74·079 74·104			
0050340/ 1/2/3	Main Bearings ... (Bore)	2.75126 2·75276	69·881 69·920	0·00226	0·057	Standard Size only For undersizes subtract 0·010 in, 0·020 in., or 0·030 in.
31315126	Crankshaft, Main Journals ... (Dia.)	2·7485 2·749	69·811 69·824	0·00426	0·108	
	Crankshaft, No. 5 Main Journal (Length)	1·8742 1·8762	47·606 47·657			
	Crankshaft End Float			0·002 0·010	0·05 0·254	
0920940 0920849	Thrust Washers, Standard (Width)	0·123 0·125	3·124 3·174			
0920940A 0920849A	Thurst Washers, Oversize (Width)	0·1305 0·1325	3·314 3·365			
	CYLINDER HEAD AND VALVE GEAR					
0520429 0520430	Rocker Lever (Bore Dia.)	0·6245 0·62575	15·862 15·894	0·00075	0·019	
0750143	Shaft, Rocker (Dia.)	0·62225 0·62375	15·805 15·843	0·0035	0·088	
0420002	Guide, Valve (Bore Dia.)	0·314 0·3155	7·976 8·01	0·002	0·050	New clearance of valve face below cylinder head face 0·066″or 1,676 mm. Exh. and Inl. Seat should not be recut unless essential when clearance must not exceed 0·140″ or 3,556 mm. Exh. and Inlet.
0910001/2	Valves, Inlet and Exhaust (Stem Dia.)	0·311 0·312	7·899 7·925	0·0045	0·114	
0780007	Valve Spring, Inner Free Length	1·365 1·405	34·67 35·68			

Schedule of Building Clearances and Tolerances to be adhered to when overhauling Engines to Factory Standards. (Engines Type Four 192 and Four 203).

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION inches	PERMISSIBLE DIMENSION mm.	PERMISSIBLE CLEARANCE inches	PERMISSIBLE CLEARANCE mm.	REMARKS
	CYLINDER HEAD AND VALVE GEAR (contd.)					
0780006	Valve Spring, Outer Free Length	1·783 / 1·803	45·29 / 45·80			
0860012	Tappet, Valve (Shank Dia.) ...	0·62225 / 0.62375	15·805 / 15·843	0·00075 / 0·0035	0·019 / 0·088	
0290034	Hole in Cylinder Head for Tappet (Dia.)	0·6245 / 0·62575	15·862 / 15·894			

FIG. 1



Large and small end Connecting Rod Bores must be square and parallel with each other within the limits of plus or minus 0.005" measured 5" each side of the axis o the rod on test mandrel as shown in Fig. 1. With he small end bush fitted the limit of plus or minus 0.005" is reduced to plus or minus 0.0015".

EXHAUSTERS (U)

Fig. U.1.
Removing Bearing and Shaft Collar.

Description.

The A.350 type exhauster, which is fitted to certain Four 192, and Four 203 engines, is a rotary sliding vane pump, with an eccentrically mounted rotor.

The exhauster body and end covers are of cast iron, and house an aluminium rotor, die-cast on to a steel shaft. The rotor has four equi-spaced slots to accommodate fibre blades.

The shaft runs in a sintered bronze plain bearing in the rear end cover, and a roller race in the drive end cover, or, alternatively, two sintered bronze bearings. Drive end covers with a roller race have two shaft seals which contact a hardened steel collar pressed on to the rotor shaft. The seals are arranged to prevent ingress of air and dirt, and leakage of oil from the exhauster. Drive end covers with a plain bearing have only one seal, preventing oil leakage.

The shaft drive end is splined to take the drive gear.

The intake port in the exhauster is pipe-connected to the vacuum reservoir. The outlet port formed in the end cover of the exhauster aligns with the aperture in the timing case.

Lubrication is by engine pressure feed, oil entering through a connection in the rear end cover to an annular groove in the bearing housing. The oil passes through a hole in the bearing to oilways in the rotor shaft communicating with the slots in the rotor. The oil passes through the end of the rotor slots to lubricate the drive end roller bearing. When a plain bearing is fitted in the drive end cover, it receives oil through an extension of the main oilway in the rotor shaft. A passage in the drive end cover to the vacuum side of the pump relieves oil pressure on the seal.

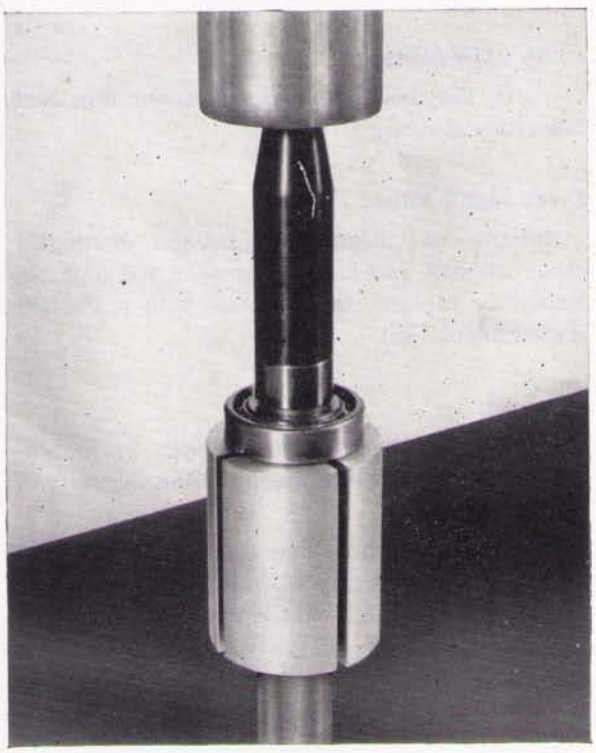


Fig. U.2.
Pressing Bearing onto Rotor Shaft.

Operation.

At all speeds the rotor blades are kept in contact with the bore of the body by centrifugal force, assisted by the hydraulic action of the oil beneath the blades. When the rotor turns, the spaces between the blades vary because of the eccentric mounting of the rotor in the exhauster body. As a blade passes the inlet port, the space between it and the following blade is increasing and air is drawn from the vacuum reservoir. This air is then compressed and expelled, with the lubricating oil, through the outlet port to the engine timing case.

Servicing of Exhauster.

Periodic Inspections and Preventive Maintenance.

Weekly or Every 1,000 Miles.

Check the vacuum lines and fittings. (Vacuum leakage may occur through the line, or reservoir mounted non-return valve if the valve seat is dirty or pitted). Examine the exhauster for evidence of oil leakage, particularly at end cover joints, and at shaft oil seal.

Check the oil supply line for leaks at fittings and connections.

Every 5,000 Miles.

Check the mounting and end cover nuts and bolts for tightness.

Every 50,000 Miles.

Remove and dismantle exhauster, thoroughly clean all parts and inspect for wear and damage. Repair or replace the exhauster with a Factory Replacement Unit.

Removal.

Disconnect oil and vacuum pipes at the exhauster and plug open ends to prevent the entry of foreign matter.

Undo the four nuts that secure the exhauster to the timing case, and withdraw the unit complete with its driving gear, from the studs.

Dismantling.

Using suitable extractors remove driving gear.

Mark the end covers in relation to the body to ensure correct location on re-assembly.

Unscrew four setscrews and remove rear end cover with rubber sealing ring.

Mark the blades in relation to the rotor.

Withdraw the rotor and fibre blades from the body.

Unscrew four socket headed screws, and remove drive end cover, with joint or rubber ring.

Remove rear end cover circlip, blanking disc, and rubber oil seal ring, if fitted.

NOTE :—Further dismantling of the rotor assembly need be undertaken only if, after inspection, it is found necessary to renew the bearing or shaft collar.

Cleaning and Inspection.

Cleaning.

Wash the roller bearing, where fitted, in thin flushing oil or white spirit and blow dry with compressed air. Spinning the bearing with compressed air should be avoided, otherwise damage to the rollers and race will occur.

Wash the remaining components in cleaning solvent, and clear the rotor and drive end cover oilways with compressed air.

Inspection of Parts.

Examine the roller bearings, where fitted, for discolouration, wear, pitting and cracked races. Rotate slowly to examine for roughness. To renew, see " Overhaul " Section. Premature failure may have been caused by shortage of oil.

Examine plain bearing(s) for excessive wear. To renew, see " Overhaul " Section.

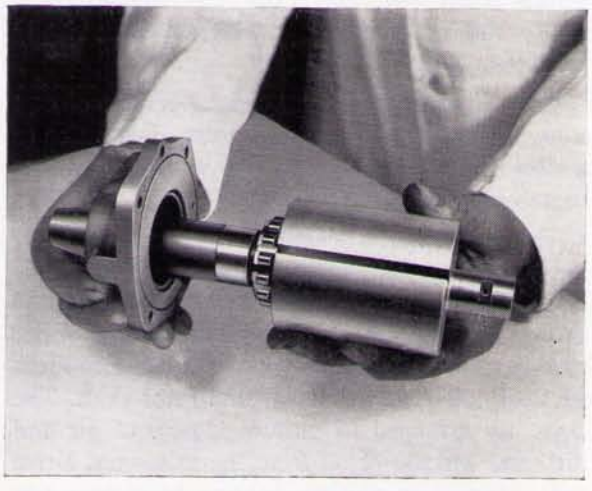


Fig. U.3.

Inspect rotor and shaft for cracks and damage, and the shaft seal collar for wear. To renew collar, see " Overhaul " Section.

Check fit of blades in rotor slots ; replace any worn or damaged blades.

Examine the seal(s) carefully to see that the sealing edge is pliable, intact and sharp. Wear or deterioration is caused primarily by dirty oil and grit. Ineffective seals should be replaced. See " Overhaul " Section.

Examine the body for cracks and damage, and the bore for longitudinal ripples or lines. If these are only slight the body is still serviceable, if excessive the body should be renewed.

Examine the end covers, and replace if cracked or scored.

Overhaul.

End Cover Bearings and Seals—To Renew.

Roller outer race : Tap end cover face several times on to a wooden block, suitably recessed to accommodate the race. Press new race fully into housing.

Seals : Remove circlip, if fitted, and seal outer back plate, and remove seals from cover. Fit new seals with inner seal lip facing inwards, and the other outwards. Replace back plate and circlip.

With recessed end cover, remove bearing outer race as above, and withdraw inner back plate. Press outer back plate and seals from cover using a bar or tube $1\frac{5}{16}$ in. diameter. Inspect back plates for damage and renew if necessary. Insert outer back plate, press in new seals arranged as above, replace inner back plate, smaller diameter first, and press race into housing.

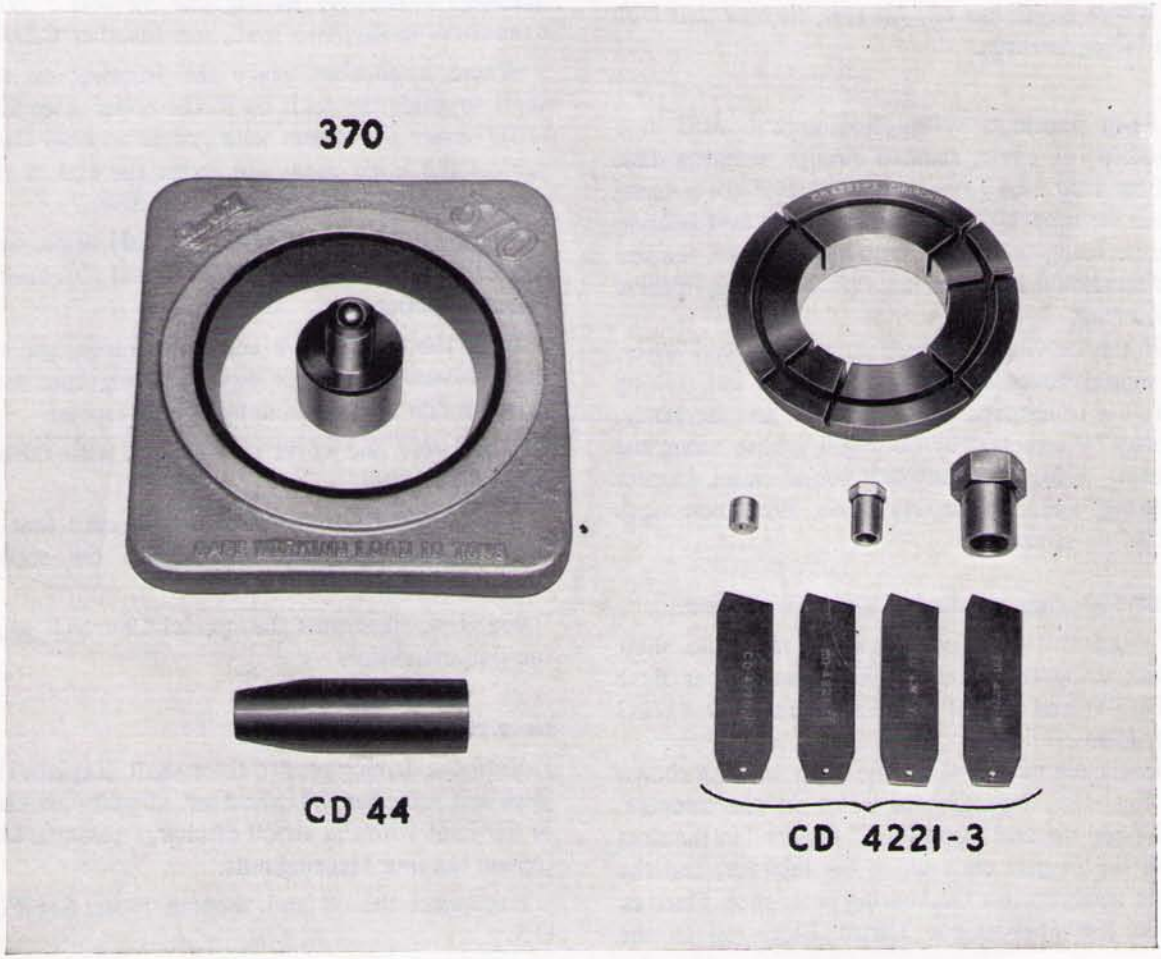


Fig U.4.
Churchill Tools for Exhauster.

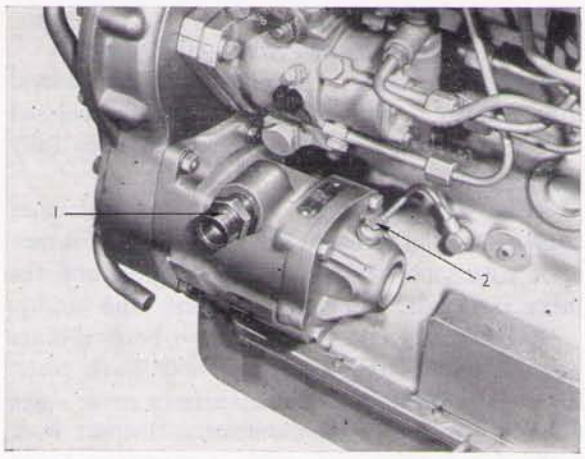


Fig. U.5.
Exhauster Mounted on Engine.
1. Vacuum Pipe Union. 2. Oil Feed.

Where cover has one oil seal, fit new seal with lip facing inwards.

Plain Bearings. When bearing is housed in a blanked off cover, remove circlip, blanking disc, rubber ring, and press bearing out of cover using a bar or tube $1\frac{1}{16}$ in. diameter. Press new bearing into housing until $\frac{1}{8}$ in. below cover face. Similar action should be taken for a plain bearing in drive end cover.

If the bearing is housed in a blank end cover, it should be extracted, or machined out, taking care not to damage the housing. In an emergency, it may be removed by cutting a groove along the bearing, using a narrow half round chisel. Inspect housing, and remove any burrs. Press new bush fully into cover.

Roller Bearing and Shaft Collar—To Renew.

Withdraw roller bearing inner race and shaft collar using the Churchill Universal Taper Base C.D. 370, and special withdrawal tool C.D. 4221-3 Fig. U.4.

Insert the adaptor into the taper base as shown in Fig. U.1. Position the rotor in the adaptor, drive end up, and insert four " fingers " in the slots with the pegged ends set in the adaptor, and the other ends against the bearing inner race. Place or screw the appropriate Thrust Block on to the shaft, and, while supporting the rotor under the Taper Base, press the bearing and collar off the shaft.

Lightly grease the shaft, and, using the Installer C.D. 44, press bearing inner race on to shaft.

NOTE :—There will be a slight clearance between the bearing and the rotor face. See Fig. U.2.

Similarly fit collar with recessed shoulder against the bearing.

NOTE :—The rotor assembly should be supported on the bed of the press by a tubular spacer placed over the shaft, and not by the rotor or shaft itself.

Re-assembly.

Lubricate all moving parts with clean engine oil and renew joint and/or rubber ring(s).

NOTE :—No special tools are required to re-assemble exhausters having one oil seal. With exhausters having two seals, use Installer C.D.44.

Where applicable, place the Installer on the shaft to guide the seals on to the collar. (See Fig. U.3). Smear the rollers with grease to hold them against the inner race, and insert the end of the rotor assembly into the drive end cover.

Assemble cover to body as originally fitted, with rubber ring or joint, and secure. Dowel pins ensure correct location.

Hold the body, drive end downwards, and replace blades into rotor slots, making sure that marks made during dismantling correspond.

Install rear end cover on to body, with rubber ring, and secure.

Rotate the rotor by hand to be sure that it turns without binding, and tighten the socket headed screws.

Fig. U.4. illustrates the special Churchill tools for this exhauster.

Installation.

Refit the driving gear to rotor shaft. Replace the joint and remount the exhauster, aligning the hole in the joint with the air/oil discharge passage, and tighten the four securing nuts.

Reconnect the oil and vacuum pipes. See Fig. U.5.

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APPROVED SERVICE TOOLS

Available from V. L. Churchill & Co. Ltd., Great South West Road, Bedfont, Feltham, Middx., England.

PD 1C Valve Guide Remover and Replacer.
Engine Type : All.
With this tool all valve guides can be removed and replaced provided puller bars are available.

PD 1C-1 Puller Bars.
Engine Type : All.
Two bars are supplied for use with PD 1C to suit nominal $\frac{5}{16}$" and $\frac{3}{8}$" i/d Bore Guides.

PD 1C-2 Valve Guide Replacing Stop.
Engine Type : Four 99.
Remarks. See PD 1C-4.

PD 1C-3 Valve Guide Replacing Stop.
Engine Type : Six 354.
Remarks. See PD 1C-4.

PD 1C-4. Valve Guide Replacing Stop.
Engine Type :

P3	P3/152	P3/144	Three 144
Three B152	Three 152	P4	Four 192
Four B192	Four 203	P6	Six 288
Six B305	Six 305		

When the valve guide is replaced using one of the above end stops it will ensure that the guide protrudes the correct amount above the top face of the cylinder head.

PD 2 Auxiliary Drive Assembly Gauge.
Engine Type : S6.
The gauge is used to align the drive shaft of the assembly with the cylinder block.

PD 17 Valve Head Depth Gauge.
Engine Type :

P3	P3/152	P3/144	Three 144
Three B152	Three 152	P4	Four 192
Four B192	Four 203	P6	Six 288
Six B305	Six 305	L4	Four 270
R6	F340		

This tool enables the mechanic to quickly check whether the inlet or exhaust valves have exceeded the maximum depth.

PD 27 Piston Assembly Ring (Std.)
Engine Type : S6.
This ring has an internal taper enabling the piston to be refitted with ease and prevents damage to piston rings.

PD 28 Piston Assembly Ring +0·030".
Engine Type : S6.
Remarks : See PD 27.

PD 55 Piston Assembly Ring.
Engine Type : L4 Four 270
Remarks : See PD 27.

PD 85 Piston Assembly Ring (Std.)
Engine Type : R6 F340
Remarks : See PD 27.

PD 88 Piston Assembly Ring +0·030".
Engine Type : R6 F340
Remarks : See PD 27.

PD 94 Piston Assembly Ring.
Engine Type : Four 99
Remarks : See PD 27.

PD 107 Piston Assembly Ring.
Engine Type :

P3/152	Three B152	Three 152
Six B305	Six 305	Four 203

Remarks : See PD 27.

D16153 Piston Assembly Ring (Std.)
Engine Type :

P3	P3/144	Three 144
P4	Four 192	P6
Six 288	Four B192	

Remarks : See PD 27.

D26153 Piston Assembly Ring +0·030".
Engine Type : as for D16153.
Remarks : See PD 27.

PD 131 Piston Assembly Ring (Std.).
Engine Type : Six 354.
Remarks : See PD 27.

PD 132 Piston Assembly Ring +0·030".
Engine Type : Six 354.
Remarks : See PD 27.

PD 37 Flywheel Runout-Gauge.
Engine Type : All.
With this tool a check can speedily be made on the alignment of the flywheel, flywheel housing or back plate.

PD 38B Crankshaft Gear, Sprocket, Water Pump and Water Pump Pulley Remover.
Engine Type : This is controlled by adaptors available. Details below.
Sprockets or crankshaft gears cannot be removed with this tool when the shaft is in situ.

PD 38B-1 Crankshaft Sprocket Remover Adaptor.
Engine Type :

P3	P3/152	P4
P6	Six 288	Six B305
Six 305	R6	F340

This Adaptor is used with PD 38B.

PD 38B-2 Crankshaft Gear Remover Adaptor.
Engine Type : Four 99.
Remarks : See PD 38B-1.

PD 38B-3 Crankshaft Gear Remover Adaptor.
Engine Type :

P3/144	Three 144	Three B152
Three 152	L4	Four 270

Remarks : See PD 38B-1.

PD 38B-4 Crankshaft Gear Remover Adaptor.
Engine Type : Six 354.
Remarks : See PD 38B-1.

PD 38B-5 Water Pump Impeller Remover Adaptor.
Engine Type : All.
The Impeller can be removed with ease and safety.

PD 38B-6 Water Pump Pulley Remover Adaptor.
Engine Type : Three 152.
Remarks : See PD 38B-1.

6200B/1 Small End Reaming Fixture.
Engine Type : All.
The correct small end bush reamers must be available to complete the job. Details as follows :

PD 39A Set of Small End Bush Reamers.
Engine Type :

P3	Six 305	P3/144	Three 144
Three 152	P3/152	P4	Four 192
Four B192	Three 152	P6	Six 288
Six B305	Four 203		

Two reamers are supplied in a set. The first reamer to be used is marked low. The second reamer is marked high which will give required dia.

PD 6200-7 Set of Small End Bush Reamers.
Engine Type :

L4	Four 270	R6	F340

Remarks : See PD 39.

PD6200-2 Small End Bush Reamer.
Engine Type : Four 99
This is an adjustable reamer.

PD6200-3 Set of Small End Bush Reamers.
Engine Type : Six 354
Remarks : See PD 39.

PD 40 Exhauster Alignment Gauge.
Engine Type : P6 R6 F340
Used for checking the exhauster alignment when the cylinder head is removed. See PD 87.

PD 87 Exhauster Alignment Gauge (Sleeve Type).
Engine Type :

P6	Six 288	Six B305
R6	F340	Six 305

Used for checking the exhauster alignment. (Couplings must be removed).

PD 41B Piston Height Gauge.
Engine Type : All.
Used for checking piston height.

PD 46B Turning Handle Dog Box Spanner.
Engine Type :

P3	P3/152	P3/144	Three 144
Three B152	Three 152	P4	Four 192
Four B192	Four 203	P6	Six 288
Six B305	Six 305	L4	Four 270
R6	Six 354		

This is a heavy duty box double ended spanner complete with turning bar 1″ Whit. × 2″ A.F.

PD 47 Cylinder Head Nut Wrench.
Engine Type : L4 Four 270
This is a $\frac{3}{4}$″ AF long socket to remove and replace cylinder head nuts, fitted at the base of the atomiser securing studs, (L4 engine only).

PD 83 Cylinder Head Nut Wrench.
Engine Type :

P3/144	Three 144	Three B152
Three 152	R6	F340

This is $\frac{11}{16}$″ A.F.
Remarks : See PD 47.

D6050 Cylinder Head Nut Wrench.
Engine Type :

P3	P4	P6
Six 288	Six B305	Six 305

This is $\frac{3}{8}$″ Whit.
Remarks : See PD 47.

PD 49 Fuel Pump Adaptor Remover.
Engine Type : P3/144 P3/152 L4
To remove drive adaptor from fuel pump camshaft.

PD50-C Cylinder Liner Remover and Replacer.
Engine Type :

L4	Four 270	Four 99
P3/152	Three B152	Three 152
Four 203	Six B305	Six 305

One of the following adaptor sets must be ordered to complete the operation.
Note : L4, Four 270 and Four 99 are wet linered engines and do not require a replacing tool.

PD 50C-1 Cylinder Liner Remover Adaptor.
Engine Type : L4, Four 270.
Completes PD 50-C for removing liners.

PD 50C-2 Cylinder Liner Remover Adaptor.
Engine Type : Four 99.
Completes PD 50C for removing liners.

PD 50C-3 Cylinder Liner Remover Adaptor.
Engine Type :

P3/152	Three B152	Three 152
Four 203	Six B305	Six 305

Completes PD 50C to remove and replace liners.

PD 91 Cylinder Bore Dial Gauge.
Engine Type : All.
This gauge has been developed to cover cylinder and bearing bores from 1″ to 4$\frac{3}{8}$″

PD 155A Small Adjustable Puller
Engine Type : All.
With suitable adaptors can be used to remove water pump pulley, oil pump drive gears and camshaft gear see adaptor details.

PD 155A-1 Small Adjustable Puller Adaptors.
Engine Type :

R6	P3/144	Three 144	Three B152
Three 152	Four 192	Four B192	Four 203

Water Pump Pulley.

Six 305	L4	Four 270	Four 99

Removes water pump pulleys only on above engines.
Six 354
Removes water pump pulley and camshaft gear. Two screw legs $\frac{5}{16}$″ dia. U.N.F.

PD 155A-2 Small Adjustable Puller Adaptors.
Engine Type : P3 P4 P6
Removes low position water pump pulley. Two screw legs. ($\frac{5}{16}$" dia. Whit.)

PD 155A-4 Small Adjustable Puller Adaptor.
Engine Type :
P3/144 Three 144 Three B152
Three 152 Four 192 Four B192
Four 203
Removal of oil pump gear. Two screw legs. ($\frac{1}{4}$" Dia. U.N.F.)

No. 3. Tension Wrench.
Engine Type : All.
$\frac{1}{2}$" square drive 25—170 lbs. ft.

316 X Valve Seat Cutter Handle.
Engine Type : All except Six 354.
This tool is required for operation of all cutters and pilots.

316-10 Valve Seat Cutter Pilot
Engine Type :
P3 P3/152 P3/144 Three 144
Three B152 Three 152 P6 Four 192
Four B192 Four 203 P4 Four 99
Six 288 Six B305 Six 305
This pilot is suitable for all guides that have a nominal $\frac{5}{16}$" i/d.

316-12 Valve Seat Cutter Pilot.
Engine Type :
L4 Four 270 R6 F340
S6
This pilot is suitable for all guides that have a nominal $\frac{3}{8}$" i/d.

PD317-23 Valve Seat Cutter Exhaust.

PD317-26 „ „ „ Inlet.

317-G22 Glaze Breakers.

317-G25 „ „
Engine Type :
P3 P3/152 P3/144 Three 144
Three B152 Three 152 P6 Four 192
Four B192 Four 203 P4 Six 288
Six B305 Six 305
The above cutters have been designed to cut seats to the correct angle and at the same time reduce seat width. It is strongly recommended that the glaze breakers to be used first as this will greatly reduce chattering of the cutters.

PD317-25 Valve Seat Cutter Exhaust.

PD317-29 „ „ „ Inlet.

317-G30 Glaze Breaker.
Engine Type : L4 Four 270 R6 F340
Remarks : See PD 317-23.

PD317-27 Valve Seat Cutter Exhaust

PD317-34 „ „ „ Inlet

317-G27 Glaze Breaker.
Engine Type : S6.
Remarks : See PD 317-23.

PD317-18 Valve Seat Cutter Exhaust.

PD317-22 „ „ „ Inlet.

317-G19 Glaze Breaker.
Engine Type : Four 99.
Remarks : See PD317-23.

FC 9900 Atomiser Tester.
Engine Type : All.
This is a portable tester fitted with a paper filter element.

7065 Circlip Pliers.
Engine Type : All.
Two types of points are available $\frac{1}{2}$" shaft size. $\frac{1}{2}$"—1" "B" Shaft size 1"—3".

355 Connecting Rod Alignment Jig.
Engine Type : All.
Enables a quick check to be made on the alignment of connecting rods—various adaptors are required. See below.

336 Multi-Purpose Con. Rod Arbor.
Engine Type : All.
Required with the above tool.

PD 336-1 Adaptor.
Engine Type :
P3 Three 152 P3/144 Three 144
Three B152 P3/152 P4 Four 192
Four B192 Four 203 P6 Six 288
Six B305 Six 305
This adaptor is fitted into the big-end bore when checking the alignment (Thin wall bearings only).

PD 336-2 Adaptor.
Engine Type : P3 P4 P6
Remarks : See PD 336-1.
(Thick wall bearings only).

PD 336-3 Adaptor.
Engine Type : L4 Four 270
Remarks : See PD 336-1.

PD 336-4 Adaptor.
Engine Type : R6 F340
Remarks : See PD 336-1.

PD 336-5 Adaptor.
Engine Type : Four 99
Remarks : See PD 336-1.

PD 336-6 Adaptor.
Engine Type : Six 354
Remarks : See PD 336-1.

6118 Valve Spring Compressor.
Engine Type : All.
This valve spring compressor has been designed to remove valve springs without removing the cylinder head, provided the adaptors are available.

PD6118-1 Valve Spring Compressor Adaptor.
Engine Type : Four 99
The adaptor is fitted to one of the rocker shaft securing studs.

PD6118-2 Valve Spring Compressor Adaptor.
Engine Type :

P3	P3/152	P4	P6
Six 288	Six B305	Six 305	S6

Remarks : See PD 6118-1.

PD6118-3 Valve Spring Compressor Adaptor.
Engine Type :

P3/144	Three 144	Three B152	Three 152
Four 192	Four B192	Four 203	L4
Four 270	R6	F340	

Remarks : See PD 6118-1.

PD6118-4 Valve Spring Compressor Adaptor.
Engine Type Six 354
Remarks : See PD 6118-1.

PD 130 Fuel Pump Allen Screw Wrench.
Engine Type : Four 192 Four 203 Four 99
Use to remove the Allen screw securing D.P.A. fuel pump.

PD 42B Small End Bush Remover Main Tool.
Engine Type : All.
Enables a new small end bush to be drawn into the small end of con. rod and at the same time will displace the old bush ; adaptors are required. See below.

PD 42B-1 Small End Bush Remover Adaptor.
Engine Type :

P3	P3/152	P3/144	Three 144
Three B152	Three 152	P4	Four B192
Four 192	Four 203	P6	Six 288
Six B305	Six 305		

An adaptor to suit the small end bore.

PD 42B-2 Small End Bush Remover Adaptor.
Engine Type :

L4	Four 270	R6	F340

Remarks : See PD 42B-1.

PD 42B-3 Small End Bush Remover Adaptor.
Engine Type : Four 99
Remarks : See PD 42B-1.

PD 42B-4 Small End Bush Remover Adaptor.
Engine Type : Six 354
Remarks : See PD 42B-1.

6000C Compression Tester.
Engine Type : See adaptor details.

6000C-3 Compression Tester Adaptor.
Engine Type :

P3	P3/152	P3/144	Three 144
Three B152	Three 152	P4	Four 192
Four B192	Four 203	P6	Six 288
Six B305	Six 305	L4	R6
F340			

This adaptor replaces the atomiser for compression testing.

6000C-4 Compression Tester Adaptor.
Engine Type : Six 354 Four 270
Remarks : See 6000C-3.

6000C-5 Compression Tester Adaptor.
Engine Type Four 99
Remarks : See 6000C-3. This adaptor is for the older type of cylinder head with screw in lock nuts.

APPROVED LUBRICATING OILS

Normal Working Temperature	0°F. to 30°F.	30°F. to 80°F.	80°F. or over
S.A.E. Designation	10W	20/20W	30
Esso Petroleum Co. Ltd. **Imperial Oil Ltd.**	Essolube HD 10 Estor HD 10W Marvelube Heavy Duty 10W	Essolube HD 20 Estor HD 20 Marvelube Heavy Duty 20—20W	Essolube HD 30 Estor HD 30 Marvelube Heavy Duty 30
Shell Mex and B.P. Ltd.	Shell Rotella Oil 10W BP Energol Diesel D—SAE 10W	Shell Rotella Oil 20/20W †Shell Tractor Oil Universal BP Energol Diesel D—SAE 20W †BP Energol Tractor Oil Universal	Shell Rotella Oil 30 †Shell Tractor Oil Universal BP Energol Diesel D—SAE 30 †BP Energol Tractor Oil Universal
Alexander Duckham & Co. Ltd.	Duckhams HD 10/Mil	Duckhams HD 20/Mil	Duckhams HD 30/Mil
Regent Oil Co. Ltd. **Caltex/Texaco**	RPM Delo Special SAE 10 Ursa Oil HD 10W	RPM Delo Special SAE 20 Ursa Oil HD 20	RPM Delo Special SAE 30 Ursa Oil HD 30
Mobil Oil Co. Ltd.	Mobiland Diesel 10 Delvac Oil 910 Mobiloil 10W	Mobiland Diesel 20 Delvac Oil 920 Mobiloil Arctic	Mobiland Diesel 30 Delvac Oil 930 Mobiloil A
Vigzol Oil Co. Ltd.	A 10W Diesel Engine Oil	A 20/20W Diesel Engine Oil	A 30 Diesel Engine Oil
C. C. Wakefield & Co.	Castrol CR 10 Agricastrol HD 10	Castrol CR 20 Agricastrol HD 20	Castrol CR 30 Agricastrol CR 30
Germ Lubricants Ltd.	Germil 100 Series	Germil 200 Series	Germil 300 Series
Gulf Oil Group of Companies **&** **British American Oil Company**	Gulflube Motor Oil XHD 10W Gulflube Motor Oil HD 10W Peerless Heavy Duty 10W	Gulflube Motor Oil XHD 20/20W Gulflube Motor Oil HD 20/20W Peerless Heavy Duty 20/20W	Gulflube Motor Oil XHD 30 Gulflube Motor Oil HD 30 Peerless Heavy Duty 30

†For use in tractor applications only.

And other reputable detergent oils to approved specification including : Any lubricating oils which have passed Approval Tests for the U.S. Ordnance Specification MIL-L-2104A and British Ministry tests DEF.2101B (which are equivalent) in their S.A.E. 10 and 30 grades, with a viscosity index of 80 minimum shall be deemed equally acceptable.

Where conditions of service warrant (*e.g.*, continuous heavy load operation) the grades shown in the right hand column may be used in lieu of those shown in the first and centre columns.

The above Specifications are subject to alterations without notice.

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