SERVICE MANUAL

220 and 330 cu. in.
BEDFORD
INDUSTRIAL DIESEL ENGINES

GENERAL MOTORS
POWER PRODUCTS EUROPE
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BD/SE/2

JULY 1975

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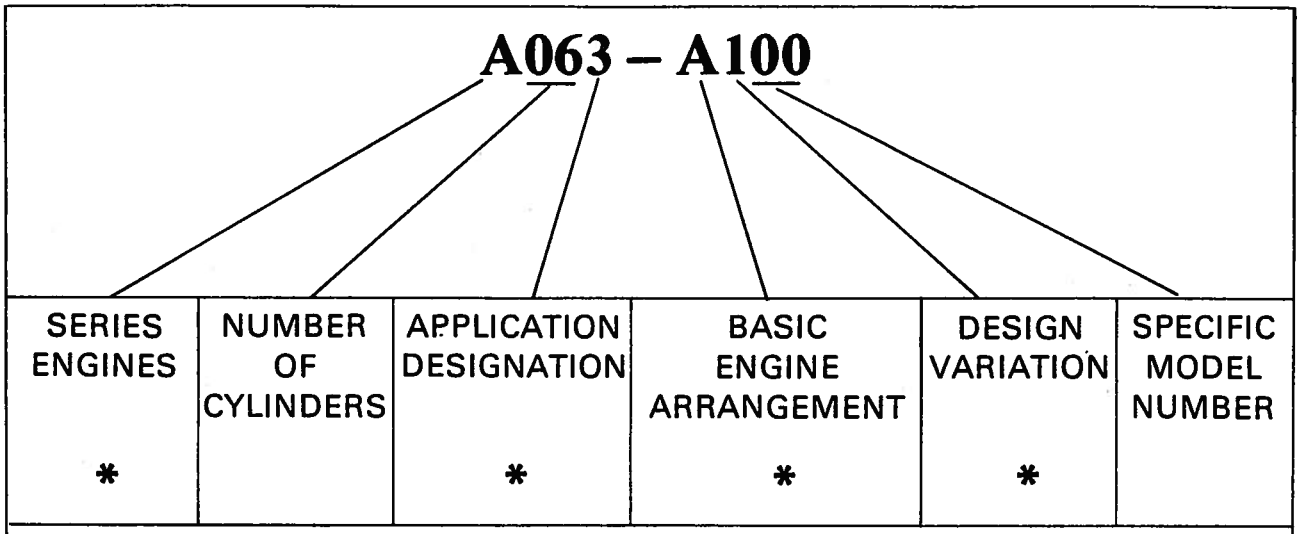
BEDFORD
MODEL DESCRIPTION CHART



* **SERIES ENGINE**

A—220/330 cu. in.
B—466 cu. in.
C—500 cu. in.

* **APPLICATION DESIGNATION**

A062-A100. MARINE
A063-A100. FAN TO FLYWHEEL INDUSTRIAL
A064-A100. POWER-BASE
A065-A100. GENERATOR
A067-A100. FAN TO FLYWHEEL AUTOMOTIVE
A068-A100. SPECIAL

* **BASIC ENGINE ARRANGEMENT**

A063-A100. STANDARD CRANKSHAFT
A063-B100. LARGE PALM CRANKSHAFT
A063-C100. EXTENDED NOSE CRANKSHAFT
B063-D100. INDUSTRIAL CRANKSHAFT

* **DESIGN VARIATION**

A063-A100. 2 VALVE HEAD
A063-A300. TURBOCHARGED

After determining which group a part is in, refer to the option plate and read the type number. From this information it will be possible to locate the parts required in the Parts Catalogue.

PRINCIPLES OF OPERATION

The Diesel Principle

The diesel engine is an internal combustion power unit in which the heat of fuel is converted into work within the cylinder of the engine.

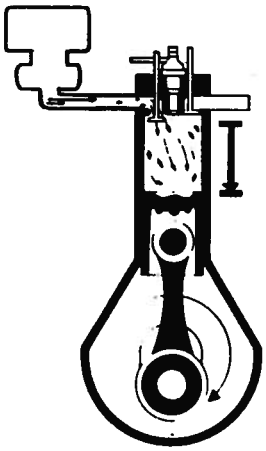
In this type of engine, air alone is compressed in the cylinder. Then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Four Stroke Principle (Otto Cycle)

The four stroke principle was conceived by Bear de Rochas and was first successfully applied to an engine in 1876 by Doctor Otto, hence it is sometimes known as the OTTO CYCLE.

In the four stroke engine the crankshaft has to complete two revolutions in order that the complete firing sequence of the engine can be completed. The four phases of the complete cycle are Induction, Compression, Explosion, Exhaust.

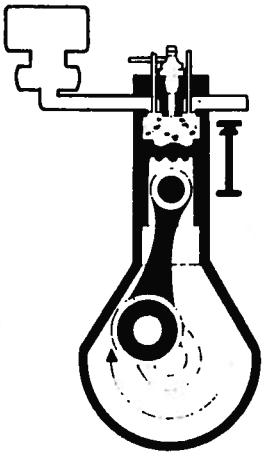
On the induction stroke the inlet valve is open, the piston moves down the bore and as it does so would reduce the pressure in the cylinder but for the air which enters via the inlet valve, this being open to the atmosphere. The inlet valve will close when the piston reaches the bottom of its stroke.



INTAKE STROKE

The piston will compress air which is now trapped within the combustion chamber as it travels up the bore, this is the compression stroke. When a gas is compressed it causes the temperature to rise. This can be understood by considering a car tyre after a journey. If the pressure is checked before and after a long journey it will be found to have increased. The temperature of the tyre will have increased during the journey, but the size of the tyre, or the volume of air will not have increased.

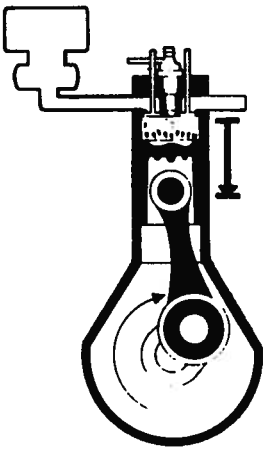
The rise of temperature of car tyres is caused by the flexing of the carcass as it passes over the road surface.



COMPRESSION STROKE

We have therefore a simple proof that if the volume remains constant and the temperature is increased the pressure will rise. The air in the cylinder has its pressure increased by the piston as the volume is reduced which will cause the temperature to rise. These facts were discovered by two scientists, Charles & Boyle, who have had two laws of physics named after them.

Just before the piston reaches the top of its stroke a quantity of fuel is injected into the cylinder via the injector, the heat already generated within the combustion chamber causes ignition of the atomized fuel. The fuel is burnt and this causes a rapid increase in pressure within the combustion chamber, the maximum expansion of the gases being timed to coincide with a point just after top dead centre. The piston is now being forced down the bore due to the pressure generated when the fuel was burnt.



EXPANSION OR POWER STROKE

GENERAL PROCEDURES

In many cases, a mechanic is justified in replacing parts with new material rather than attempting repair. However, there are times where a slight amount of reworking or reconditioning may save a customer considerable added expense. Crankshafts, valves and other parts are in this category. For example, if a cylinder is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse with a standard size piston and new piston rings, thereby saving the expense of new parts.

Various factors such as type of operation of the unit, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly, the various subassemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, water and fuel. On engines cooled by a heat exchanger the fresh water system and raw water system must both be drained. Lubricating oil should be drained from any power transmission attached to the engine.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the engine base and driven mechanism, should be mounted on an engine overhaul stand; then the various subassemblies should be removed from the unit. When only a few items need replacement, it is not always necessary to mount the engine on an overhaul stand.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks or a parts dolly.

CLEANING

Before removal of subassemblies from the engine (but after removal of the electrical equipment) the exterior of the engine should be thoroughly cleaned, ensure that exhaust and air intake are suitably sealed, if steam cleaning is used. Then after each subassembly is removed and disassembled, the individual parts should be cleaned.

Thorough cleaning of each part is absolutely necessary before a part can be satisfactorily inspected. Below are listed various items of equipment needed for general cleaning.

The cleaning procedure used for all ordinary cast iron parts is outlined under "Clean Cylinder Block" in Section 1.1, while any special cleaning procedure will be mentioned in the text wherever required.

Steam Cleaning

A Steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

A tank of sufficient size to contain the largest part which will require cleaning (usually the cylinder block) must be provided and provisions made for heating the cleaning solution to 180 degs. F.

This tank is filled with a commercial heavy-duty solvent which is heated to the above temperature. Large parts are lowered directly into the tank with a hoist; small parts are placed in a wire mesh basket and lowered into the tank. The parts are immersed in the cleaning tank long enough to loosen all grease and dirt.

When lowering components into the tank manilla rope slings should not be used as the chemicals used in degreasing tank will rot the rope causing a possibility that units could be dropped, it is advised that wire rope slings are used.

WARNING: Caustic based solvents should not be used for parts containing Aluminium. Check before using.

Rinsing Bath

Another tank of similar size containing hot water should be provided for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete the drying of parts without the use of air.

Rust Inhibiting

If parts are not to be used immediately after cleaning, they should be dipped in suitable inhibiting compound. Remove the rust proofing compound before instaling the part in an engine.

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will provide measurable data with limits which will determine which parts should be replaced, considerable judgement must be exercised by the inspector to examine the parts for wear and damage not in the specification.

The guiding factors in determining the usability of worn parts which are otherwise in good condition is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of the used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and oversize as well as standard sizes. Also available are service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gauges, such as dial bore guages, dial indicators, and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping, and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

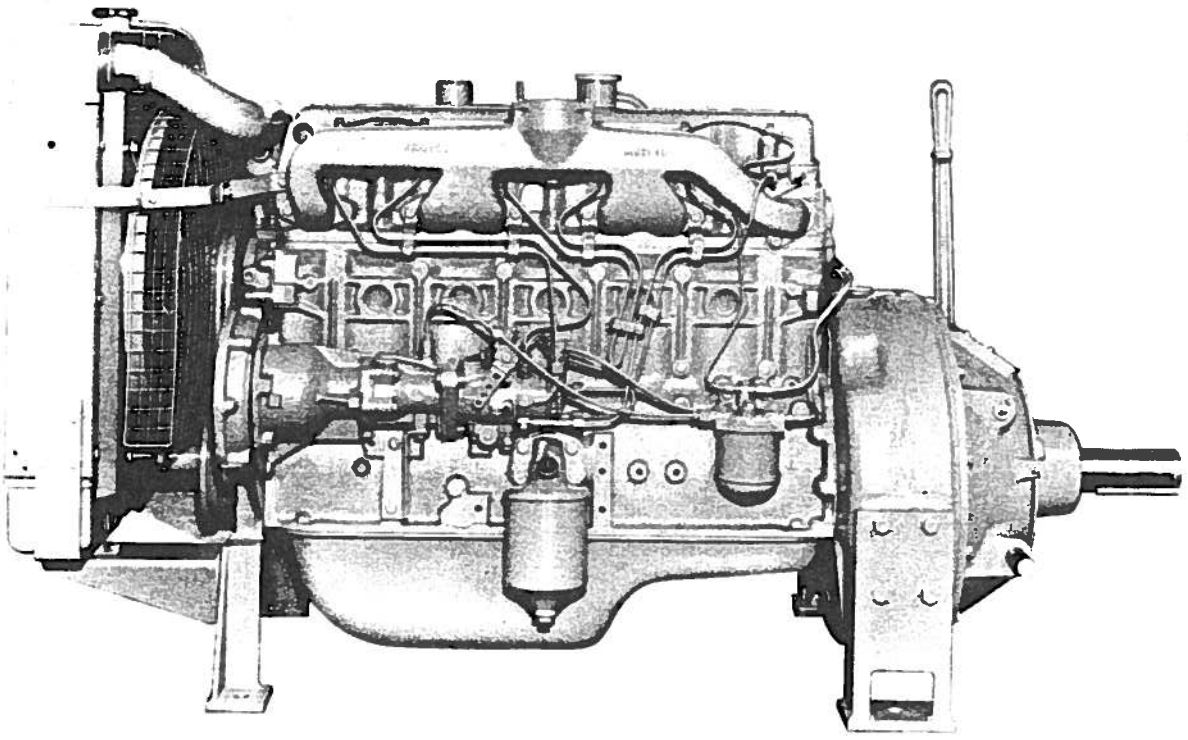
Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment, and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should if possible be located away from the disassembly and cleaning operation. Also, any machining operations should be removed as far as possible from the assembly area.

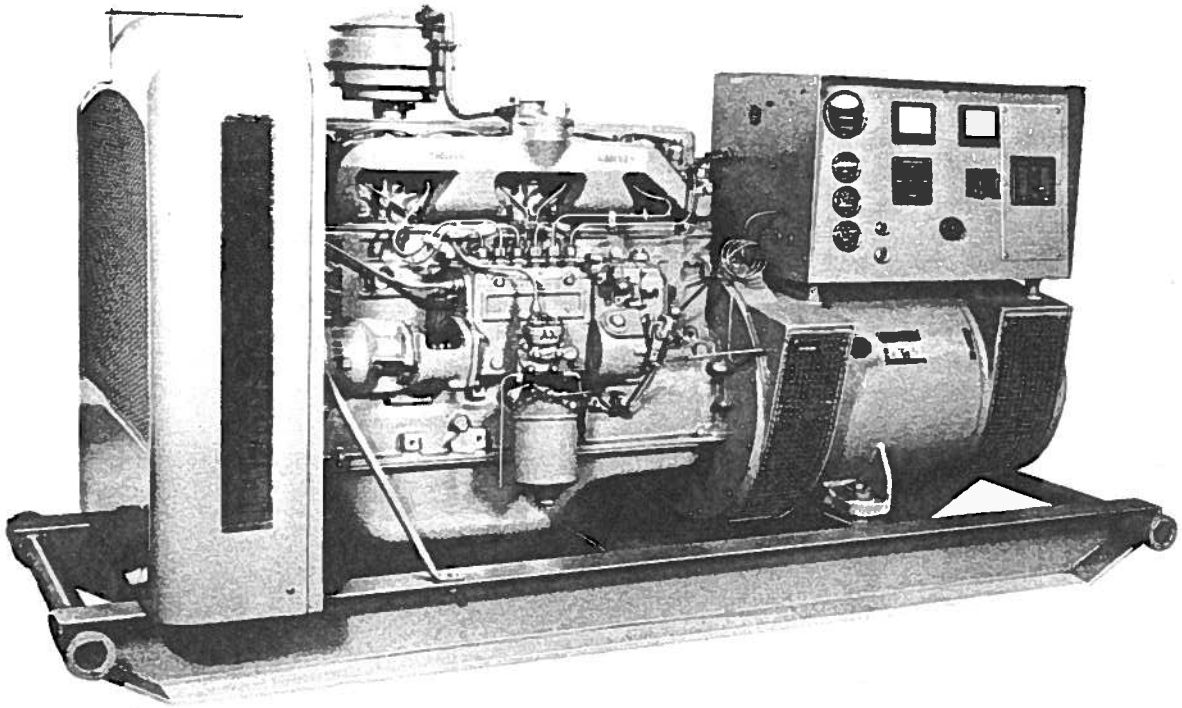
Particular attention should be paid to storing parts and subassemblies after removal and cleaning, and prior to assembly, in such a place or manner as to keep them clean. In case there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table or torque specifications at the end of each section for proper bolt, nut and stud torques.

An overhaul inspection check sheet will aid the mechanic in keeping a written record of the parts replaced and the repairs as they are made on the unit. It may also serve as a permanent record of the maintenance performed on a particular unit. A check sheet may be made similar to the one on pages 21 and 22.



External view of a 330 cu. in. engine.



External view of 330 cu. in. generator set.

OVERHAUL INSPECTION CHECK SHEET

NO.	INSPECT	OK	REPLACEMENT AND REMARKS
	CYLINDER BLOCK		
	Machined Surfaces & Tapped Holes		
	Dowels		
	Oil & Water Plugs		
	End Plates & Gaskets – Clean Surface		
	Bolts Tightened to Specified Torque		
	CYLINDER HEAD		
	Head Gasket & Seals		
	Injectors		
	Injector Securing Nuts, Tightened to Specified Torque		
	Rocker Arm Bolts Tight		
	Valve Clearance Checked		
	Inlet Valves		
	Exhaust Valves		
	CRANKSHAFT		
	Cleaned		
	Smooth Surfaces – Journals, Fillets and Seal Surfaces		
	Thrust Bearings Installed		
	Main Bearings Installed Including Seals		
	End Play		
	Front Keyway – Key		
	Seal Spacer or Cone, Pulley or Cap Installed. Front Cover, and Oil Seal Crank timing Gear, Oil Slingers		
	Bolts Tightened to Specified Torque		
	Front Cover Gaskets		
	CRANKSHAFT DAMPER		
	Check and Clean Damper		
	FLYWHEEL & FLYWHEEL HOUSING		
	Oil Seal Gaskets & Housing Installed		
	Flywheel Housing Clearance & Run Out		
	Bolts Tightened to Specified Torque		
	Flywheel Interference		
	CONNECTING RODS & PISTONS		
	Cylinder Bore & Piston O.D. Checked		
	Compression Rings		
	Oil Rings		
	Conn. Rod Bearing		
	Nuts Tightened – Conn. Rod Bolts		
	OIL PAN		
	Pan Gasket & Sealer		
	Pan Bolts Installed & Tightened		
	Drain Plugs & Gaskets		
	Oil Filter, Tube assembly – Tight		
	FRESH WATER PUMP		
	Water Pump Inlet & Outlet Packing		
	Thermo. Housing, Gaskets & Thermostats, Bypass Tube & Gaskets		

OVERHAUL INSPECTION CHECK SHEET (Cont'd)

NO.	INSPECT	OK	REPLACEMENT AND REMARKS
	CAMSHAFT		
	End Bearings		
	Intermediate Bearings Fitted in Place		
	Gear Lock Nut Tightened		
	Gear Timing & Markings Checked		
	End Play & Back Lash		
	Bolts Tightened		
	Tachometer Drive Nut & Accessory Drive Lock Nut		
	ROCKER SHAFT AND COVERS		
	Valve Rocker Cover & Gaskets		
	FUEL SYSTEM		
	Injection Pump Timing		
	Injection Pump, Drive Shaft Coupling, Check Tightness of Clamp Bolts		
	Injection Pump Carrier to Exhauster, Compressor or Housing		
	Check Tightness of All High Pressure Fuel Lines and Unions		
	Fuel Lift Pump, Operating Lever on Correct Face of Cam		
	Fuel Pipes from Lift Pump to Filter		
	Fuel Lift Pump Torque		
	Fuel Filter Connections		
	AIR CLEANER		
	Air Cleaner Inspection		
	Air Manifold Inspection		
	LUBRICATION OIL PUMP		
	Lube Oil Pump Overhauled		
	Outlet Pipe & Inlet Pipe, Screen & Gaskets		
	Filter Adaptor, Oil Cooler Housing & Gaskets		
	Oil Pressure Regulator		
	Bolts Tightened to Specified Torque		
	Check Suction Lines for Leak		
	ELECTRICAL SYSTEM		
	Starter		
	Generator		
	Voltage Regulator		
	MISCELLANEOUS		
	Inspection Approved		
	Lube Oil in Engine		
	Water Connected		
	Fuel Connected		
	Approved For Run In		

SECTION 1

ENGINE

Contents

INTRODUCTION

The manual contains instructions on the overhaul, maintenance and operation of the G.M. Bedford B10, B5 and OB5 Series (220, 330 with In-line fuel pump and 330 with D.P.A. fuel pump) Diesel Engines.

Full benefit of the long life and dependability built into these engines can be realised through proper operation and maintenance. The use of the correct procedures during an engine overhaul is of equal importance.

Personnel responsible for any work which is to be carried out on an engine should be familiar with the general items which are listed on page xix. The serviceman should also read the section of the book which is relevant to the particular system of the engine being worked upon. The book is subject to an updating service, therefore the recommended overhaul procedure may be varied from the time of a previous overhaul.

Specifications. Dimensional details and service data are listed under the heading 'Specifications' at the end of the relevant section.

Tools. Reference is made throughout the manual to special tools which are designed to facilitate service operations. The service tools are known as Riteway Service Tools and are available from:-

Kent-Moore Tools Limited,
Bow Street,
Birmingham 1,
England.

or:- The Kent-Moore Tools Company in your territory.

Reference is also made to 'Plastigauge' which is used for measuring bearing clearances. This can be obtained from the following:-

Buck & Hickman
264 Water Road,
Abbey Estate,
Alperton,
Wembley,
England

or

Perfect Circle Corp.,
Hagerstown,
Indiana,
U.S.A.

Each section is divided into numbered paragraphs for easier identification.

Illustrations are numbered in the bottom left hand corner with the section heading and paragraph number to which the illustration refers.

i.e. illustration number 1.2000-12 is associated with paragraph 12 of section 1.2000 (Cylinder head).

GENERAL DESCRIPTION

The engines which are covered in this manual are of either four (220 cubic inch), or six (330 cubic inch) cylinder in-line overhead valve configuration operating on the four (4) cycle principle.

Certain components used in the range are interchangeable betwēen the engines in this range.

The design features of the engine include pistons which have the combustion chambers formed within their crown and operate directly in the cylinder block. (See footnote 1, below).

The valves are heat treated upset forging. the inlet valves being 50 carbon steel while the exhaust valves have an Austenitic head and alloy steel stem, both inlet and exhaust operate in removable cast iron guides.

The water jacket has end to end water flow which enables the maximum gas seal between the cylinder block and cylinder head to be achieved. (See footnote 2 below).

The water pump is mounted directly to the cylinder block, no back plate being used, the pump is driven by 'V' belts which are tensioned by a pivot mounted generator and pulley assembly.

The camshaft and fuel injection pump are gear driven by a gear train mounted at the front of the engine. The oil pump is driven by a skew gear integral with the camshaft.

Fuel is drawn from the supply tank and enters a diaphragm fuel pump, fuel is then passed to the fuel filter and hence to the injection pump where it is pressurised and passes to the injectors via pipes which connect the injectors to the injection pump. The engine speed can be governed by either a mechanical, hydraulic or pneumatic governor.

Full pressure lubrication is supplied to all main, connecting rods, and camshaft bearings, also gear train and rocker shafts.

Oil is drawn from the oil pan through the intake screen and pipe to the oil pump from where it is delivered to the oil filter and oil cooler, if fitted. The oil then enters the gallery in the cylinder block, for distribution to the main bearings, connecting rod bearings, camshaft bearings, rocker arm mechanism and other functional parts.

The cooling system has a centrifugal water pump which circulates the engine coolant through the water jackets. The engine temperature is regulated by a thermostat.

Air for combustion is supplied through an air cleaner or silencer.

The engine is started using an electric starting system.

Footnote 1. Prior to S/N.P. & 1. 1900 on 330 cu. in. and P. & I. 1350 on 220 cu. in. liners were used.

Footnote 2. Prior to S/N.P. & 1. 1632 on 330 cu. in. and P. & I. 1350 on 220 cu. in. the conventional waterflow was used.

1.1000

CYLINDER BLOCK

CYLINDER BLOCK: (Description)

1. The cylinder block is a one piece chromium cast iron casting and is of the deep skirt type where the crankcase walls extend below the crankshaft centre line. The pistons operate direct in a linerless block, however, when wear takes place the cylinder block can be bored to accept pistons of a larger diameter, 3 diameters (0.005 in., 0.020 in. and 0.040 in.) being available for servicing. When the limit of oversize pistons has been reached it is possible to fit a cylinder liner which will enable standard sized pistons to be used again, it is only possible to use pistons to a maximum oversize of 0.020 inches when using liners.

2. The crankshaft is supported by detachable shell type bearings, five on the four cylinder engine and seven on the six cylinder engine. End float is controlled by thrust washers located on each side of the centre main bearing. An oil thrower formed on the rear of the crankshaft adjacent to the flywheel attaching flange assists the return of surplus oil to the oil pan through drain holes in the rear main bearing caps.

3. A strip type oil seal contacts the main bearing journal behind the oil thrower and a spring loaded lip type seal located in the timing cover contacts the spigot of the crankshaft pulley. Oil seal felts are installed between the joint faces of the front and rear main bearing caps and the crankcase.

CYLINDER BLOCK: (Removal)

4. Before performing any major servicing procedures to the cylinder block all external assemblies and components should be removed. Care must be taken when removing the fuel pump and lines to ensure that dirt does not enter into the fuel injection system.

5. All parts should be cleaned and stored ready for reassembly.

6. Remove the following items as described under their separate headings throughout this manual.

7. Clutch (8.1000), flywheel (1.4000), rocker gear (1.7100), cylinder head (1.2000), oil pan (4.7000), oil pump (4.1000), crankshaft (1.3000), connecting rod and pistons (1.6000), timing gears (1.7000) and (1.7200) and camshaft (1.7000).

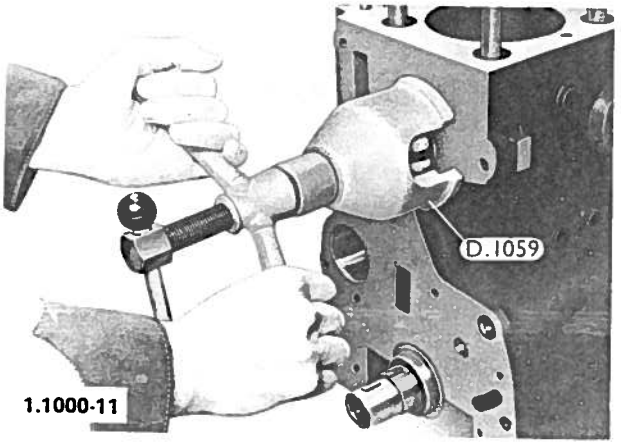
CYLINDER BLOCK: (Inspection and Overhaul)

8. Before attempting any inspection and overhaul procedures, the Cylinder block must be thoroughly cleaned and the water passages should be flushed and all sediment removed from the waterways. It will be found that a hose inserted into one of the transfer holes situated on the top face of the Cylinder block will enable the water passages to be flushed. Stand the block on the end so that the water pump fixing is face downwards, the block should be slightly raised from the floor to allow the water and sediment to flow freely from the block. The block can be considered clean when clear water emerges from the water pump (connecting) passages. The accumulation of external oil and grease should be removed by immersing the block in a degreasing tank. It is advisable that the oilways be cleaned using an air line.

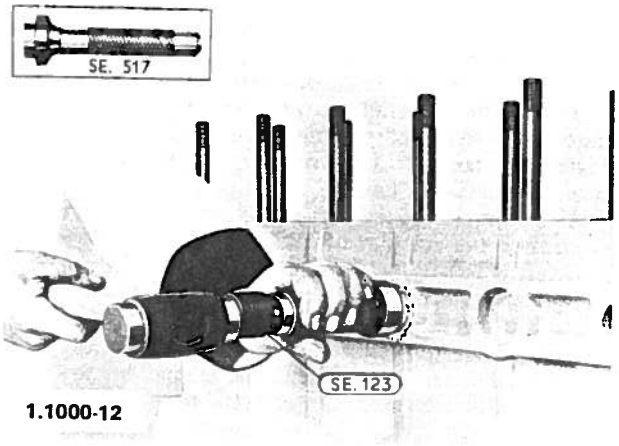
9. After completing the previous inspection and overhaul procedure, the cylinder block should be pressure tested. This test is left until all machining operations have been completed on the block, in case damage should be caused during the actual machining operations. Make up suitable plates to blank off the water jackets or water transfer holes and an attachment should be made in order that the air supply can be fitted to the water pump connection. The cylinder block should now be immersed in hot water, the temperature of which should be 180 deg. F. – 200 deg. F. and the block pressurised to a pressure of 40 P.S.I.

10. When pressurising the block, do not connect to a works air line but use a manually operated pump. Warm water should be used for this operation as it simulates actual running conditions and will thus cause any leak which should develop whilst running to appear. The leaks will appear as a series of bubbles in the water. However, care must be taken to discriminate air which is leaking from the cylinder block and air which is trapped during the immersion of the cylinder block into the water. After pressure testing in water ensure that machined surfaces such as bores are protected from rusting.

11. If leaks should occur around any of the cup plugs, the ones which leak must be replaced. The cup plugs can be removed using Extractor D.1059.



12. A replacement can be fitted, using a sealing compound around the cup plug before installing into the cylinder block. The plug should be driven into position using installer SE.123 or SE.517 depending upon the size of the cup plug.



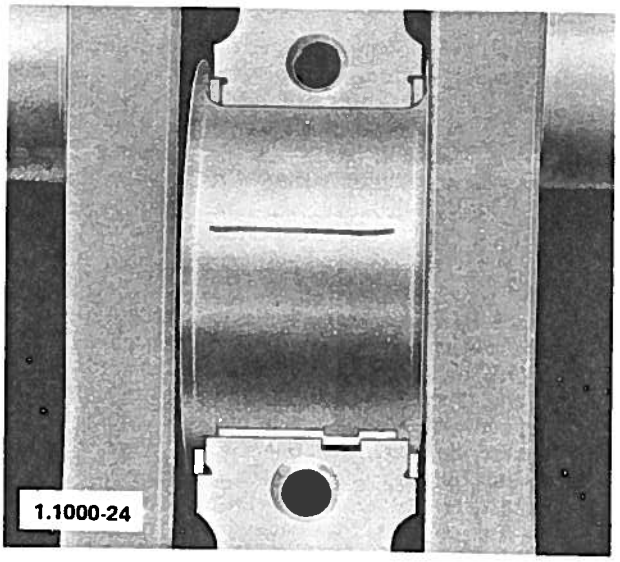
1.1000-12

13. Care should be taken that the plugs do not protrude beyond the machined faces of the block. If it has proved necessary to replace any cup plugs, the complete cylinder block should again be subjected to a pressure test.

14. The cylinder bores should be checked using a cylinder gauge. The wear should be checked over the full length of the piston travel taking particular care when checking the part of the bore where maximum wear takes place. This point is just below the highest point of piston ring travel.

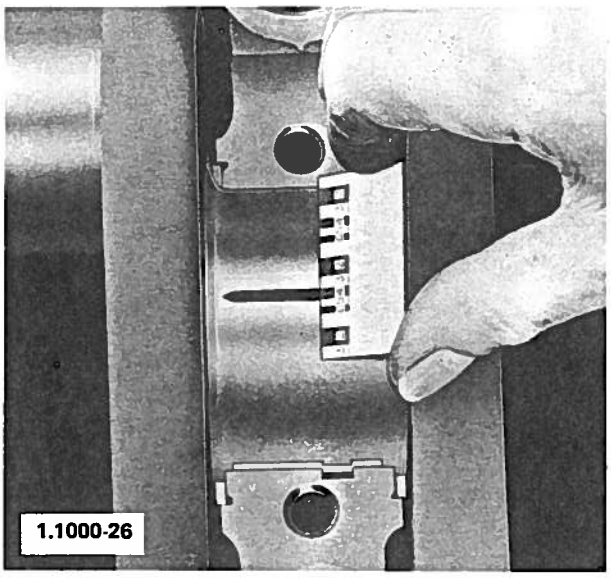

1.1000-14

15. Care should also be exercised when checking an area of the bore which is subject to scoring.
16. Should excessive scoring be noted in the bore the piston will have to be discarded. The cylinder block will now have to be rebored to accommodate the next largest size of piston available. Pistons are serviced in sets which are .005 inches oversize, this size is mainly intended for servicing engines, the bores of which have been glazed busted, or similarly lightly cleaned up. The other sizes available are .020 inches oversize and .040 inches oversize. If upon measuring the bore, it is realised that the largest size of piston has previously been fitted, the cylinder block should be bored to 4.246/4.247 inches and liners inserted.
17. After the liner has been fitted to the block it should be bored and honed to the limits specified for a standard piston.
18. The standard size pistons will be used after the insertion of liners. However, when liners are fitted, is is only possible to use pistons which are a maximum of .020 inches oversize.
19. On 330 cu. in. engines built prior to P. & I. 1900 and on 220 cu: in. engines built prior to P. & I. 1350 liners were fitted as standard. The servicing and replacement of liners is detailed under section 1.6000, connecting rod and pistons, as replacement liners are only serviced in complete piston and liner assemblies.
20. Replace the main bearing caps onto their respective main bearing housings.
21. The main bearing cap securing bolt threads and head faces should be coated with Extreme Pressure Hypoid Gear Oil, as used in rear axles, and tightened to a torque of 85 lb.ft.
22. The correct diameter of the bore should be 2.7520 inches to 2.7535 inches. Should it be required, shims are available in .002 and .003 inches sizes.
23. Remove the bearing caps and if it is thought that existing bearing shells may be re-usable, the upper shell should be replaced into the bearing housing in the cylinder block.
24. Replace the crankshaft which it is intended to use and check the clearance in between the bearing shells and crankshaft using "Plastigauge" which should be used in the following manner. It should be realized that steel, feeler strip should not be used or the bearing surface will be damaged. Wipe all oil from the bearing and main journal. it should be noted that Plastigauge is soluble in oil therefore, if either the bearing or the journal are not cleaned thoroughly, a false reading could be obtained.

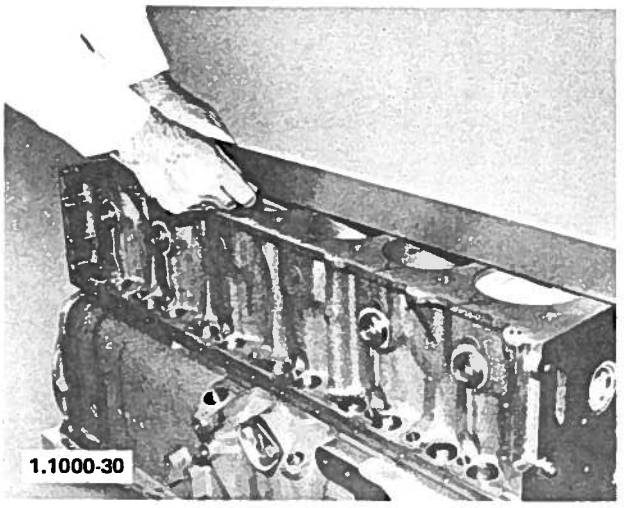

1.1000-24

IMPORTANT: Do not turn the crankshaft with the Plastigauge installed.

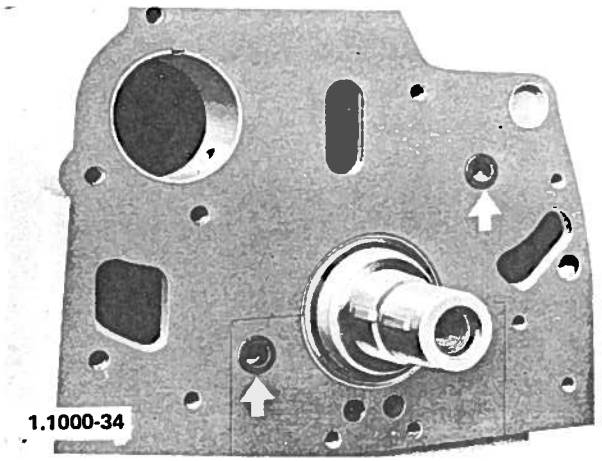
25. Remove the bearing cap. The flattened Plastigauge will be adhering to either the journal or the bearing and should not be removed at this stage.
26. Using the inch scale printed on one side of the Plastigauge envelope, measure the compressed Plastigauge at its widest point. The numbered graduation within the scale which more closely corresponds to the width of the Plastigauge indicates by its number the bearing clearance in thousandths of an inch. For example, the graduation marked '3' indicates .003 in. clearance.



27. The crankshaft should now be removed and also all bearing shells which if suitable for further use must be kept in the same sequence as they were taken from the engine.
28. The block alignment can be checked using new bearing shells and also a new crankshaft. The crankshaft should be installed with the bearing shells which are liberally coated with lubricating oil and the bearing cap retaining bolts fitted, tighten the bolts to a torque of 85 lbs.ft. The bolt being coated with E.P. gear oil.
29. The crankshaft should now rotate freely when turned by hand. It can now be assumed for servicing overhaul that the cylinder block is correctly aligned. If the shaft will not turn freely check alignment of shaft and if the crankcase is distorted, it will have to be replaced.
30. The top face of the cylinder block should now be checked for distortion using a straight edge. The straight edge should be placed on the top face of the cylinder block and using Feeler gauges checks should be made to ensure that there is not more than 0.005 inches distortion in a longitudinal plane. Whilst in a lateral plane, there should be not more than 0.003 inches distortion. Should these figures be exceeded, the



cylinder block top face should be remachined.
31. After machining, it is necessary to check the depth of the cylinder block from the top face to the main bearing caps face, this dimension should exceed 12.519 inches, whilst the standard unmachined block is between 12.529 inches to 12.534 inches.
32. After completing all the machining operations it is advised that the block should be pressure tested to check that no casting imperfections have appeared.
33. The front plate should now be thoroughly cleaned and all traces of old gasket and gasket cement removed.
34. Two new Neoprene sealing rings (arrowed) should be fitted to the cylinder block and also a new gasket.



35. The tront plate can now be mounted onto the cylinder block and located using the two dowels. Should it prove necessary, the plate should be tapped home using a hide faced or plastic faced hammer. Fit the five plate securing bolts and tighten to a torque of 13-15 lbs.ft.

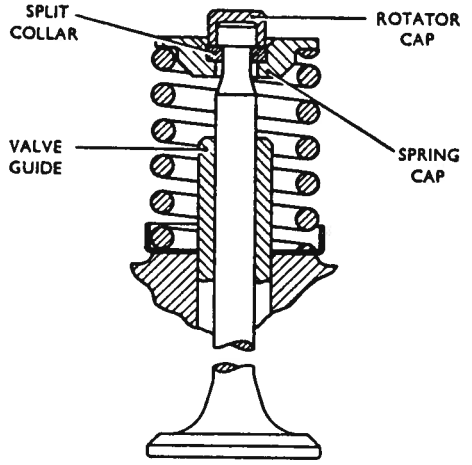
CYLINDER BLOCK: (Refitting)
36. The cylinder block is the centre of the engine assembly and as a consequence the rebuilding instructions are detailed in each group within this book, when full details are given for the attachment of components of sub-assemblies.

1.2000

CYLINDER HEAD

CYLINDER HEAD: (Description)

1. The cylinder head is a detachable one-piece chromium iron casting with inlet and exhaust ports individual to each cylinder. The valves, carried in renewable guides are operated via the rocker gear by cup type tappets and push rods. The valves and springs are retained by split collars located in the spring caps. In early engines the exhaust valves had special split collars and free release type rotator caps.



1.2000-1

2. On current engines exhaust valves are fitted without rotator caps and a shorter exhaust valve guide. The valves have a thin coating of aluminium sprayed over the seat face.

3. The face of the cylinder head is flat with no recesses to form the combustion chambers, as these are formed within the piston crowns.

4. On early engines the cylinder head was cooled by a conventional vertical water flow. This has now been superseded utilising a system known as "end to end waterflow". The advantages of this system compared with conventional vertical flow systems are that the waterways between the cylinder head and block gasket faces are eliminated. The water from head to block is transferred via two passages which are situated towards the rear of the engine on the exhaust side. This means that the cylinder head gasket now has but one purpose – to provide an efficient seal around the cylinder bores. With the elimination of the waterways the top of the cylinder block, and the lower face of the cylinder head are stronger and less subject to possible distortion than on an engine which employs a conventional vertical flow system of water passages. The absence of connecting waterways in the cylinder head enables local hot spots to be cooled more effectively than the conventional cooling system.

5. The cylinder head is retained on 220 cubic inch models by 10 bolts while on 330 cubic inch models the head is retained by 14 bolts. The gasket, which is used between the cylinder head and the cylinder block is laminated steel.

6. The injectors are housed in replaceable water cooled sleeves which are pressed into the cylinder head.

CYLINDER HEAD: (Removal)

7. Drain the cooling system and then remove the following items as detailed in their respective sections. Air Cleaner (3.1000), Rocker cover (1.7100), Injector pipes (2.5000), Exhaust Manifold (6.1000), Thermostat housing (5.2000) and Intake manifold (3.3000).

8. Disconnect the stop control and also the governor pipes from the fuel injection pump.

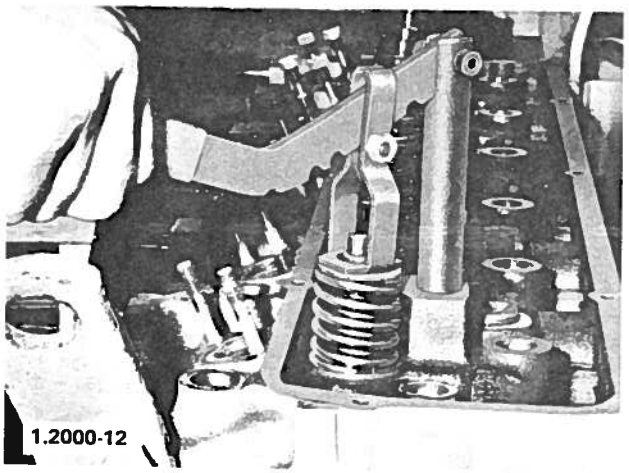
9. Remove the rocker gear, push rods (1.7100) and exhaust valve rotator caps where fitted. Extract the injectors (2.1000) and remove the push rod cover.

10. If the engine is fitted with a heat exchanger this will also have to be removed as detailed in 5.5000.

11. Remove the securing bolts or nuts and washers, and lift off the cylinder head and gasket. Care must be taken when lifting the head that it is not laid on the head studs, where used, otherwise the indentations on the head face caused by the studs, will cause head gasket failure.

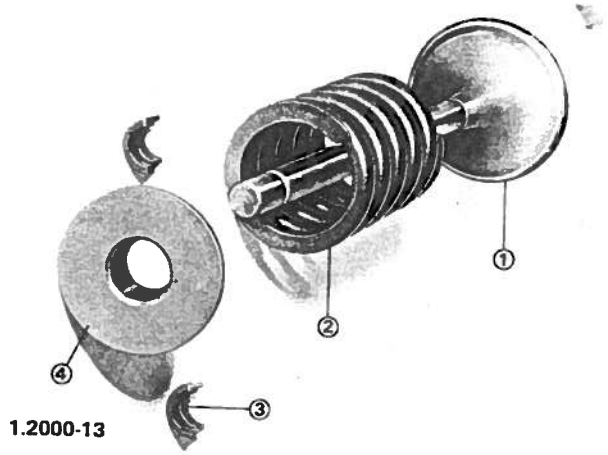
CYLINDER HEAD: (Inspection & Overhaul)

12. Remove the valves from the cylinder head, using a valve spring compressor to compress the springs, remove the collets from the valve stem and remove valves from cylinder head.



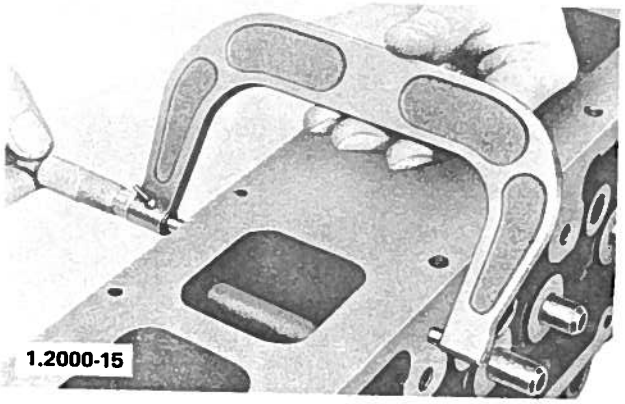
1.2000-12

13. Keep all valves, springs and collets in the same sequence, so that they can be replaced as an assembly in the valve guide from which they were removed.



1. Valve 2. Valve spring 3. Collets 4. Cap

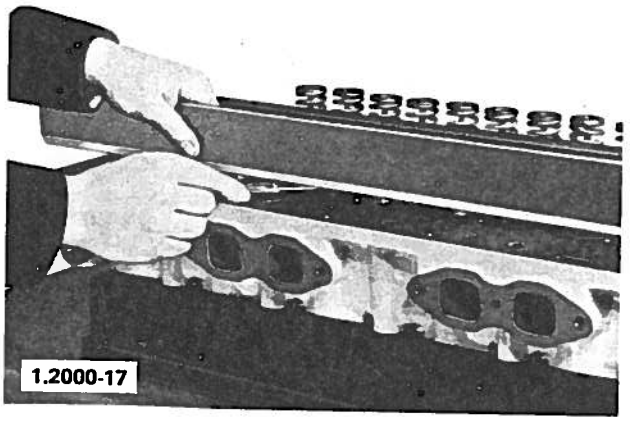
14. Check the depth of the cylinder head using a 4 to 5 inch micrometer, the head should have a depth of 4.2485 to 4.2515 inches, however, if refacing is required the head can be machined to a minimum depth of 4.2385 inches. If the latter dimension is exceeded the head will be rendered unsuitable for further service.
15. To determine the amount of material available for head refacing, measure the overall depth with the micrometer, and subtract the minimum depth of head (4.2383 inches) from the measured dimension.



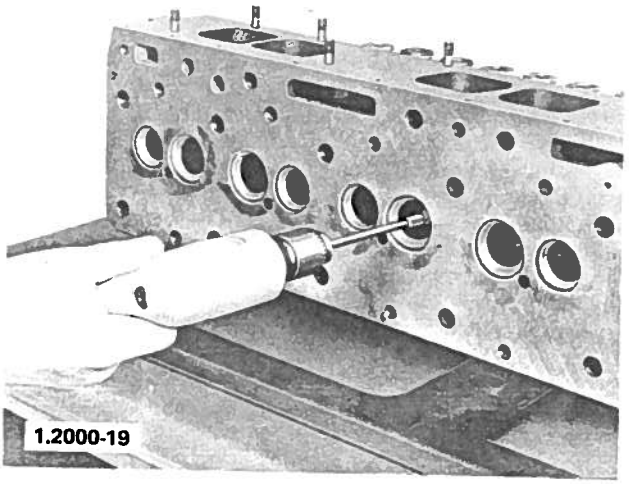
e.g. 4.2460 – measured dimension
4.2385 – minimum depth of head
0.0075

16. Therefore, in this instance the machinist can safely remove up to .0075 in. material.

17. The cylinder head should be checked for distortion, however, a check should first be made to ensure that the edges of the head casting are free from burrs. If the distortion of the head exceeds .005 inches in a longitudinal plane or .003 inches in a transverse plane it is necessary to machine the head, checking the dimensions as set out above. The manifold face of the cylinder head should also be checked for distortion, a maximum of .003 inches being allowed.

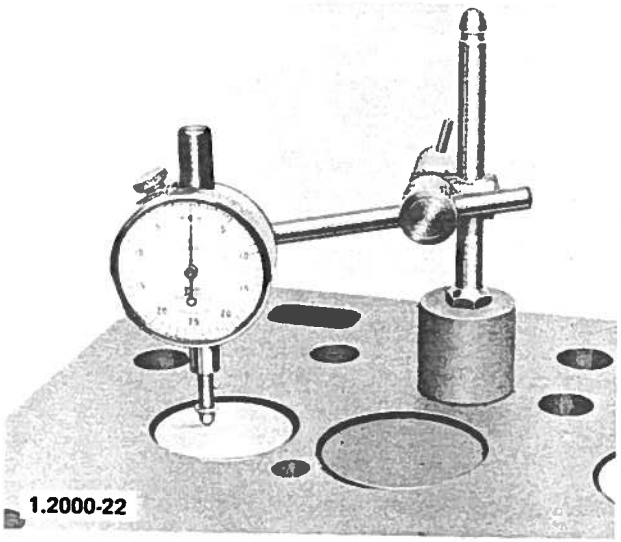


18. It is also important that checks be made on the valves, valve guides, valve springs and valve seats as detailed below; failure to follow this procedure can result in a valve touching a piston.
19. Clean the valve guide bore using a rotary wire brush and check for wear. The bore should be between 0.3427 and 0.3437 inches.



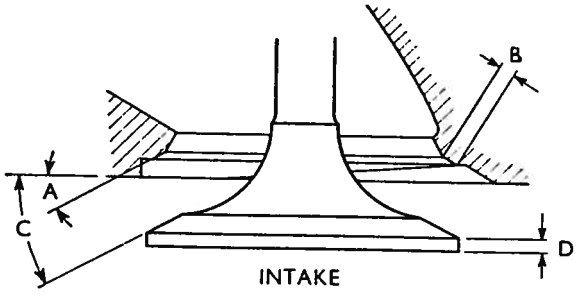
20. If the guide needs renewing, press the guide out of the head from the top using drift Z8378 and replace it using installer Z8562. This installer is made to fit both inlet and exhaust valve guides. The correct height of the guides will be obtained when the drift contacts the cylinder head.
21. Replace each valve into its respective valve guide and check the clearance between the stem and the guide, this should not exceed 0.005 ins. for the intake valves or 0.006 ins. for the exhaust valves.

22. Place an indicator dial on the face of the cylinder head and set to zero. If the valve head protrudes above the cylinder head face there is sufficient material to permit recutting the valve seating. If, however, the valve head is below the cylinder head face it must be noted which type of valve it is, inlet or exhaust. Assuming that it is an exhaust valve which is below the face of the cylinder head, the depth must be measured with the dial indicator and must exceed 0.041 inches, whilst the inlet valve must be 0.023 inches below the surface of the cylinder head. The depth of the valve into the cylinder head is most important; if it is too shallow the valve will hit the top of the piston.



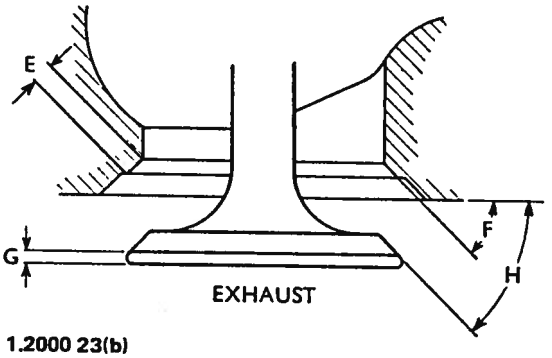
1.2000-22

23. For refacing valve seats use special equipment, noting that the seats should be kept within the specified limits shown in figures a and b below.



1.2000 23(a)

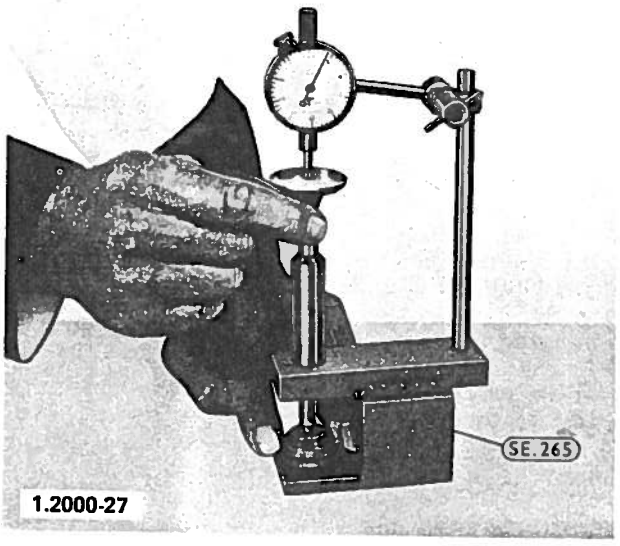
A. Valve seating angle 30°
B. Valve seating width .055 to .069 in.
C. Valve seat angle 29°
D. Valve head – minimum thickness .035 in. Valve head depth in relation to cylinder head face (minimum permissible) .023 in.



1.2000 23(b)

F. Valve seating angle 45°
E. Valve seating width .097 to .110 in.
H. Valve seat angle 44°
G. Valve head – minimum thickness .035 in. Valve head depth in relation to cylinder head face (minimum permissible) .041 in.

24. After refacing, check the valve seats and guides for concentricity.
25. Examine the valves for burnt heads, cracked seat faces and damaged or worn stems. The stem diameter of an intake valve should be .3409 to .3417 inches whilst an exhaust valve stem should be .3397 to .3407 inches.
26. On exhaust valves, check the dimension betweenthe valve stem end and the split collar land, the minimum permissible length being .2005 inches. If it is less than this specified limit the valve should be renewed. Examine the split collars for wear.
27. On early engines fitted with rotator caps on the valves, support the valve head uppermost in checking jig SE 265 and assemble the spring cap, split collars and rotator cap to the valve stem. Press the spring cap firmly downwards and check the valve lift, which should be .001 to .005 inches, between the valve stem and the rotator cap using a dial gauge as shown.

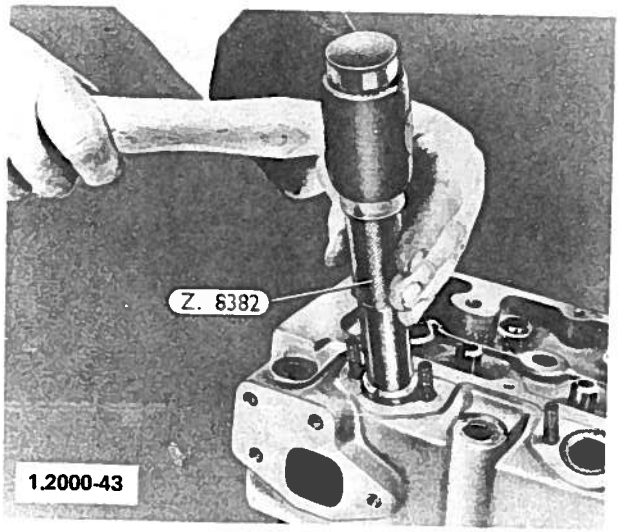


1.2000-27

28. Where binding or excessive end float is found renew the cap and/or collars. On current engines the rotator cap has been deleted from the exhaust valves. To compensate for this the seat of the new valve is aluminized.
29. Replacement valves of this type are ready for immediate installation.
30. In service, aluminized valves can be refaced by the procedure, and the same specified angles and head thickness, advocated for the previous type valves.
31. With the introduction of the revised exhaust valve it was necessary to shorten the valve guide to prevent the valve spring cap from bottoming with the spring fully compressed. The length of the new guide overall is 2.45 inches and the standing height above the cylinder machined face is 0.884 inches.
32. The valve springs should be checked to ensure that they are of the correct dimensions and spring rate, this can best be achieved by using a proprietary gauge similar to that shown below. The free length of the valve spring should be 1.9531 inches and when subjected to a load of 45-65 lbs. the spring should be 1.688 inches.

1.2000-32

33. Before reassembling the valves into the cylinder head. the head should be subjected to a pressure test which will check for cracks or other casting imperfections and also that the injector sleeve seal is satisfactory.
34. Make up a suitable plate and secure to the two cylinder head to cylinder block waterway ports, it is suggested that a gasket be used between the cylinder head and the blanking plate which can be secured by four bolts being passed through the head retaining stud holes. An adaptor should be made up and connected to the thermostat housing orifice, the adaptor can now be connected to an air supply. Immerse the cylinder head in a container of hot water 180°F – 200°F and pressurize by a hand or foot pump (not a works air line) to a pressure of 40 P.S.I. It is essential that hot water be used to simulate actual running conditions, the air bubbles will emerge from the head at the point of the fracture. Leaks may occur around the core plugs or the injector sleeves.
35. To renew the expansion plug at the front of the cylinder head proceed as follows.
36. Drill a hole in the plug, using grease on the drill to prevent swarf entering the water passages and prise out the plug.
37. Clean the counterbore of the plug orifice and coat with a jointing compound.
38. Make sure the edge of the new plug is free from damage and expand the plug in position with a flat faced drift.
39. To renew the cup plug at the rear of the cylinder head proceed as follows:
40. Remove the plug using extractor D1059 as shown in fig. 1.1000-11.
41. Carefully, clean the plug orifice in the cylinder head and coat with a jointing compound.
42. Drive home the new plug using installer SE 517.
43. Should a leak be noted around the injector tubes they must be replaced. Using sleeve removing tool VR 2059 extract the worn sleeve. VR 2059 incorporates a 7/8 – 14 UNF tap which enables the sleeve to be cut and extracted in one operation. Replace the sealing ring in the counterbore in the cylinder head, then drive a new sleeve fully home using installer Z8382.

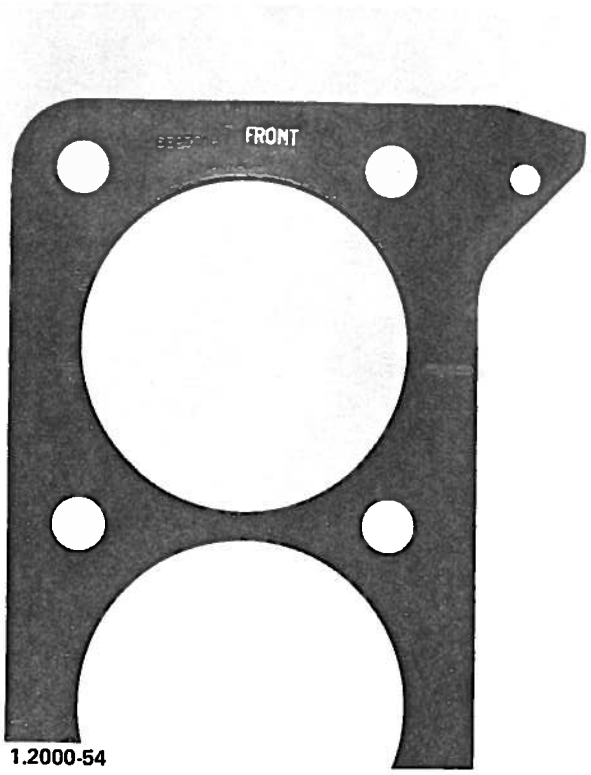


1.2000-43

44. If it has been necessary to replace a plug or an injector sleeve, the cylinder head should be pressure tested again to ensure that the replacement parts do not leak, or the cylinder head has not been further damaged while work has been carried out.
45. The cylinder head water passages should now be thoroughly flushed out to ensure all parts are clean before reassembly.

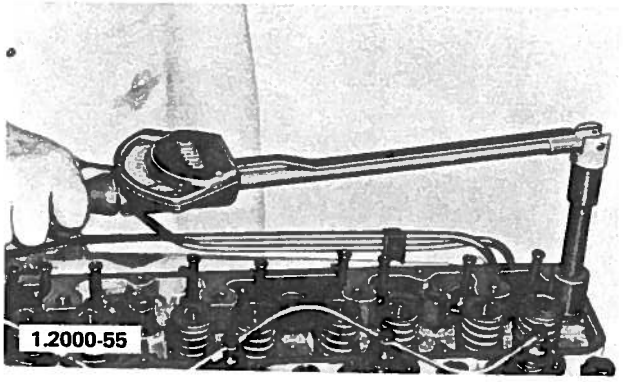
46. Lubricate the valve stems and guides with a mineral oil containing colloidal graphite, and install the valves in their respective positions in the cylinder head.
47. Before installing the valve spring, check to establish whether the assembled height of the springs is affected by refacing the valves and valve seats. The maximum spring assembled height is 1.74 inches.
48. Where the assembled height is outside the specified limit, use the special packing washer available, under the respective spring seat.
49. Do not use more than one washer under any one seat.
50. Install packing washers where required, then reassemble the valve spring seats, springs, spring caps and split collars in their original positions.

CYLINDER HEAD: (Refitting)
51. Ensure that the mating faces of both cylinder head and cylinder block are clean and free from burrs.
52. Wipe any surplus oil from the top of the pistons to avoid possible hydraulic lock when the engine is started.
53. Two recesses are machined at the rear end of the cylinder block top face to accommodate the two neoprene, water sealing rings. These two sealing rings must be renewed.
54. Fit a new head gasket, smearing both sides with Wellseal sealing compound, note that the gasket is fitted correctly, the front end of the gasket is marked FRONT.

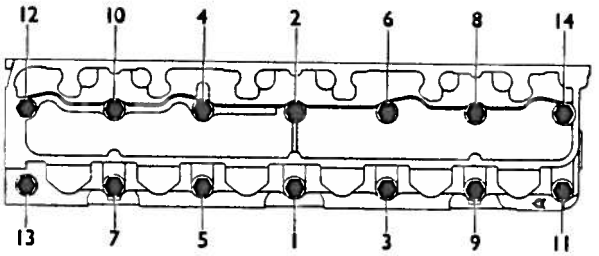


1.2000-54

55. Fit the cylinder head onto the cylinder block, smear the cylinder head nut washers where fitted, also the studs, nuts or bolts with E.P. gear oil and tighten to a torque of 115-120 lbs.ft. for 9/16 in. studs, 145-160 lbs.ft. for 5/8 in. studs or 107 lbs.ft. for bolts, whichever is applicable to the engine.


1.2000-55

56. Tightening of the head should be done gradually and evenly in the order shown.



1.2000-56

57. Place the rotator caps on their respective exhaust valve stems where used.

58. Refit the rocker gear (1.7100), injectors (2.1000) inlet manifold (3.3000), exhaust manifold (6.1000). thermostat housing (5.2000), injector pipes (2.5000), and air cleaner (3.1000). On engines which are cooled using a heat exchanger installation, refit the heat exchanger as detailed in (5.5000).

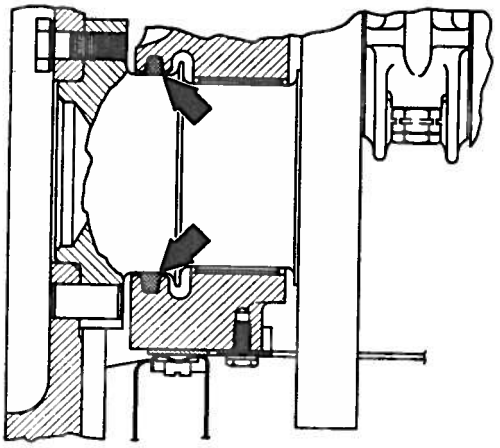
59. Warm up the engine to normal operating temperature, and with the engine running at idling speed, readjust the valve clearances to .013 inches as described under (1.7100).

1.3000

CRANKSHAFT

CRANKSHAFT: (Description)

1. The crankshaft which is a solid one piece carbon steel stamping, is supported by detachable lead bronze, steel backed shell type bearings, five on the four cylinder engine and seven on the six cylinder engine.
2. End float is controlled by thrust washers located on each side of the centre main bearing.
3. An oil thrower formed on the rear of the crankshaft adjacent to the flywheel attaching flange assists the return of surplus oil to the oil pan through drain holes in the rear main bearing cap.
4. A strip type oil seal (arrowed) contacts the main bearing journal behind the oil thrower, and a spring loaded lip type seal located in the timing cover, contacts the spigot of the crankshaft pulley. Oil seal felts are installed between the joint faces of the front and rear main bearing caps and the crankcase.

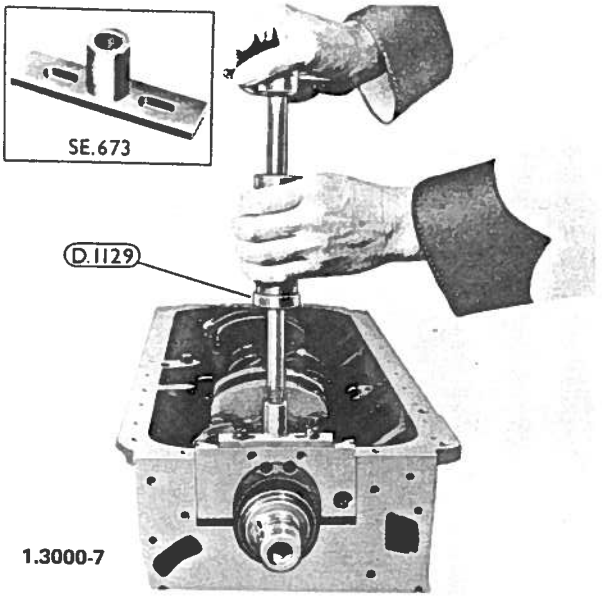


1.3000-4

5. Various types of crankshaft are available, depending on the application of the engine.

CRANKSHAFT: (Removal)

6. The oil pump (4.1000), flywheel housing (1.5000), crankshaft pulley (1.3300), vibration damper (1.3200), and front cover (1.3100) should be removed as detailed.
7. Remove the bolts which secure the main bearings using a slide hammer D1129 and bearing cap remover SE 673, remove the rear main bearing, clean all traces of existing felt seals from the block and bearing cap.

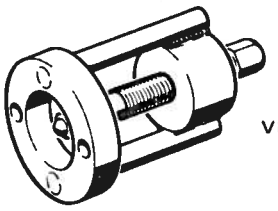


1.3000-7

8. Remove the remaining bearing caps, the big end nuts, and using a copper drift, punch the connecting rod bolt downward. This will enable the connecting rod bearings to be removed.

1.3000-8

9. Keep the main bearing bolts and bearing caps in the same sequence as they are fitted to the engine also the connecting rod bearing caps and their respective nuts and bolts.
10. The crankshaft gear must now be removed using drag VR 2032. This tool is fitted to the gear with two screws which are screwed into the tapped holes of the puller. The centre screw is tightened into the hole in which the crankshaft pulley retaining bolt is normally fitted, the gear will then be withdrawn from the crankshaft.



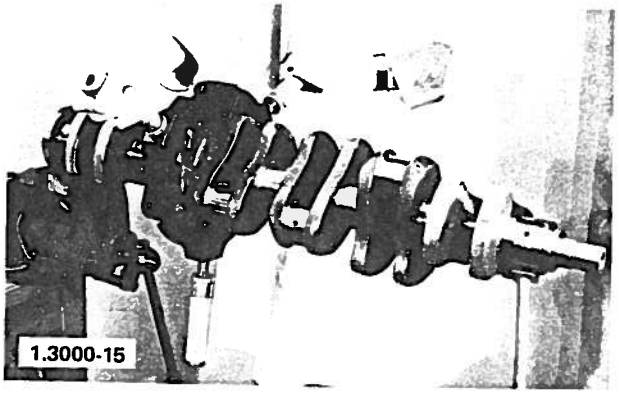
1.3000-10

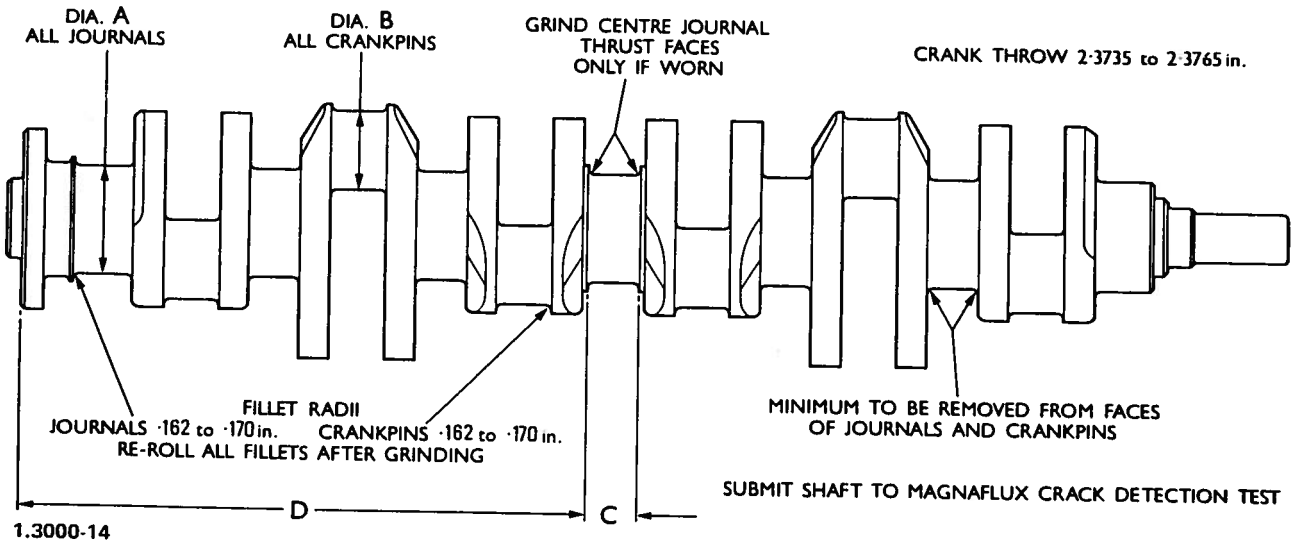
11. The crankshaft can now be lifted from the crankcase. Care must be taken to ensure that the crankshaft does not foul the timing gear case. Remove the upper bearing shells and keep in the same sequence.

CRANKSHAFT: (Inspection and Overhaul)
12. Using a 2–3 inch micrometer, measure the diameters of all the journals and crankpins. These should be measured at several points around the diameter. If the crankcase is not within the dimensions stated in the following table. it should be ground to within these limits.

Undersize	Dia "A"	Dia "B"
Standard	2.749 – 2.750 in.	2.374 – 2.375 in.
.10 in.	2.739 – 2.740 in.	2.364 – 2.365 in.
.20 in.	2.729 – 2.730 in.	2.354 – 2.355 in.
Thrust Washer O/S	**Dim. "C"**	**Dim. "D"**
Standard	1.810 – 1.814 in.	16.058 – 16.066 in.
.003	1.816 – 1.820 in.	16.055 – 16.063 in.
.006	1.822 – 1.826 in.	16.052 – 16.060 in.

13. Check the crankshaft for alignment by supporting the crankshaft in 'V' blocks and taking indicator readings on the main bearing journals. When checking the alignment of a worn crankshaft, allowance must be made for the possibility of the journals being 'out of round'.
14. When a crankshaft is being reground, only the minimum of material should be removed in order to bring the shaft within the specified dimensions.
15. After regrinding, the fillets should be re-rolled, using a Churchill hand rolling machine to .162 to .170 in. radii.



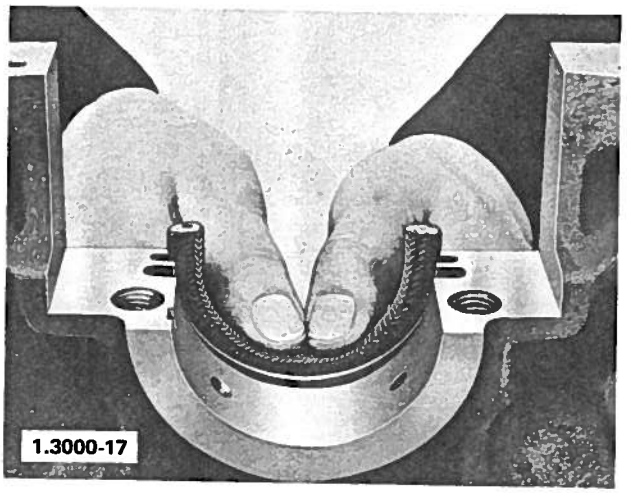


1.3000-14

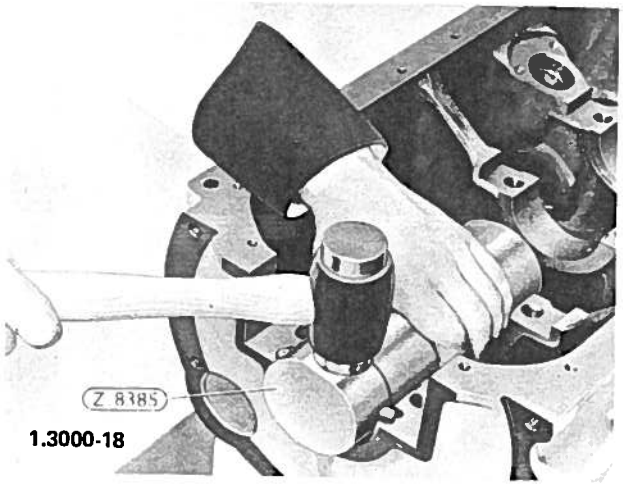
16. After completion of the machining, the crankshaft should be subjected to a Magnaflux crack detection test, full details of usage of crack detection equipment is supplied with the kit, these should be adhered to. Should storage before use be expected, the reconditioned shaft should be protected with a coating of corrosion inhibitor and stored in a vertical attitude.

CRANKSHAFT: (Refitting)

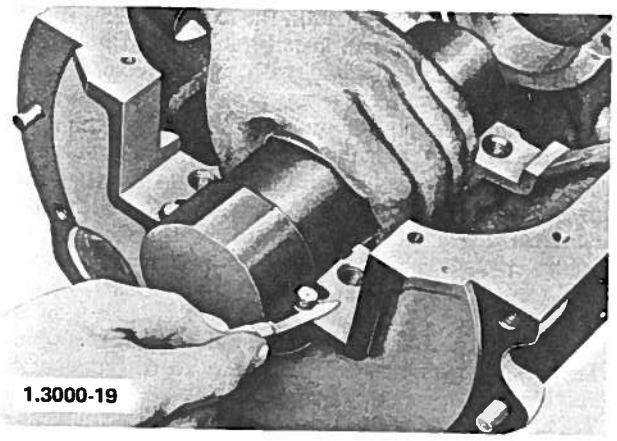
17. The original seal should be removed from the crankcase rear bearing and the groove thoroughly cleaned. A new seal should then be installed in the following manner. The strip seal is fitted into the crankcase bearing outer groove, and tool Z8385 placed as shown in the illustration.



18. Using a hide or plastic faced hammer, tap the tool and drive the seal into the groove.

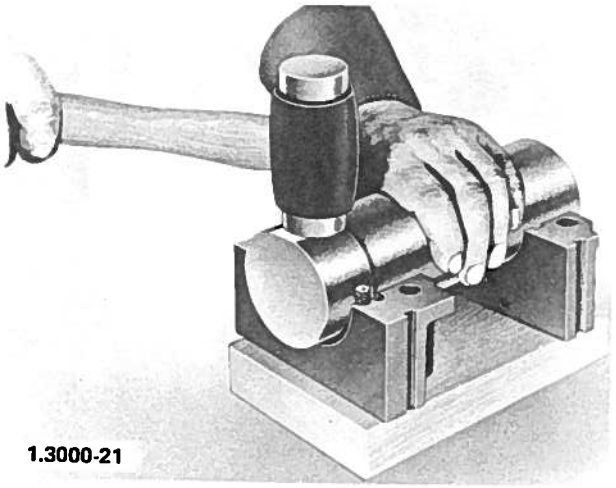


19. With the installer tool held firmly in position and using a sharp knife, cut off projecting ends of seal flush with the bearing cap locating face. Do not leave frayed ends to become trapped between the crankcase and bearing cap.



20. Install a new seal strip in the rear main bearing cap in a similar manner.

21. The same tool can be used and care should be taken to ensure that it is kept on the actual bearing. This can best be achieved by using the front main bearing cap as a guide for the seal installer. Rest the bearing caps on a block of wood to ensure uniform height.



22. Smear both the seals with a mineral oil based grease containing Molybdenum Disulphide. Fit the bearing shells into the block taking care that the tongues on the bearing shell fit into the recess journal housing. It will be noted that the bearings are of different design. The relative positions can be ascertained from the parts catalogue.

23. Lubricate the bearing shells with engine oil and replace the crankshaft, taking care when placing into position that the crankshaft does not foul the timing gear case.

24. Centralize the crankshaft endwise so that the upper halves of the thrust washers can be fed into position and located correctly. The Oil relief slots in the faces of the thrust washer should be adjacent to the thrust faces of the crankshaft. Assemble the lower halves of the thrust

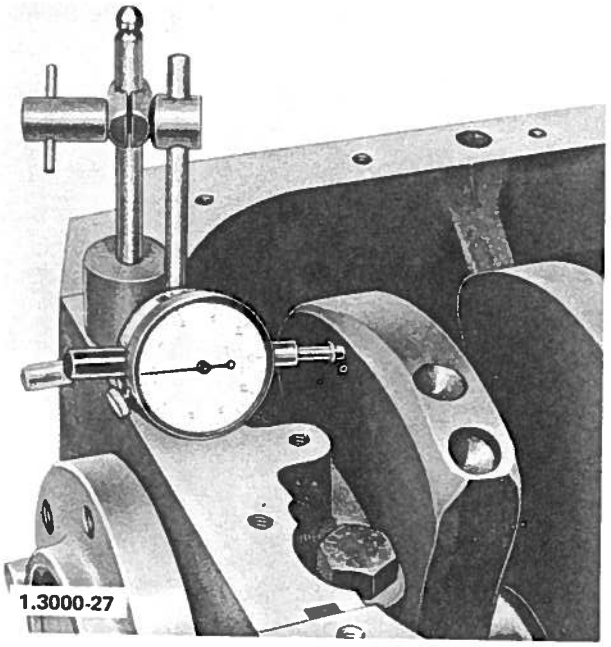
washers to the centre bearing cap. Use clean petroleum jelly in the recesses in the cap to hold the thrust washers in position, whilst the bearing cap is being fitted.

25. Place the bearing shells in the caps and commencing with the centre bearing, install the caps and bolts. The bolts should be lubricated with an Extreme Pressure Hypoid Gear oil as used in rear axles.

Note: When installing the main bearings, no scraping or adjustment by rubbing down the caps is permissible.

26. Before tightening the bolts which secure the centre main bearing cap, push the crankshaft forward until it contacts the rear upper thrust washers. With the crankshaft held in this position, push the cap rearward as far as possible and tighten the cap bolts. This will ensure that the thrust is taken evenly on both halves of the thrust washers Check that the crankshaft rotates freely. Tighten all main bearing cap bolts to a torque of 85 lbs.ft.

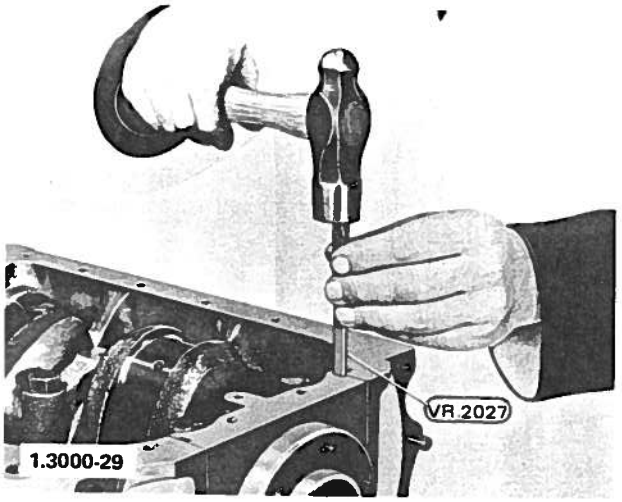
27. Fit a dial gauge to the front sump face of the engine and lever the crankshaft to the extreme limit of rearward movement, set the dial against the web of the crankshaft and set it to zero. With the dial gauge in the position in which it was set, lever the crankshaft forward and note the reading on the dial gauge.



28. The end float on the crankshaft should be 0.002 to 0.012 inches. If the end float exceeds the specified limits, adjustment can be obtained by using oversize thrust washers tabulated below.

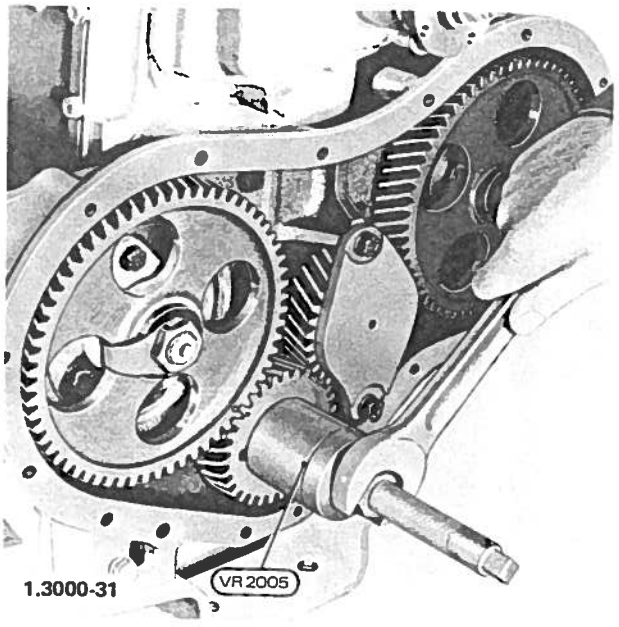
THRUST WASHERS	(THICKNESS)
Standard	.091 to .093 inches
.003 in. Oversize	.094 to .096 inches
.006 in. Oversize	.097 to .099 inches

29. Install the front and rear main bearing cap oil seals using drift VR2027. Coat the first piece of felt inserted in each seal groove with jointing compound and drive home this and subsequent felts with the drift and hammer.



30 Approximately six felts are required for each groove. Ensure that the felts are tightly packed, and leave about 3/32 in. of felt prejecting above the bearing cap face for compression, when the oil pan is installed.

31. Replace the crankshaft gear, using installer VR 2005 ensuring that the timing gear marks are in alignment.



32. Replace the following assemblies as detailed in their respective sections. Front cover (1.3100), vibration damper (1.3200), crankshaft pulley (1.3300), flywheel housing (1.5000), and oil pump (4.1000).

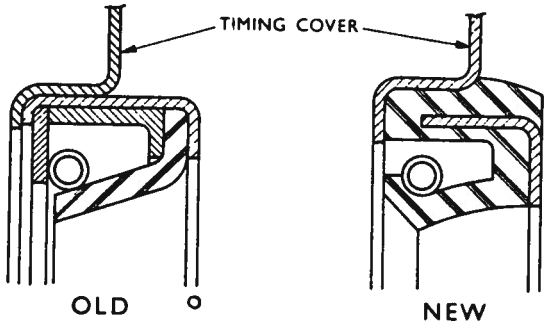
1.3100

FRONT COVER

FRONT COVER: (Description)
1. The front cover is a steel pressing attached to the front of the timing gear case and incorporates the crankshaft front oil seal.

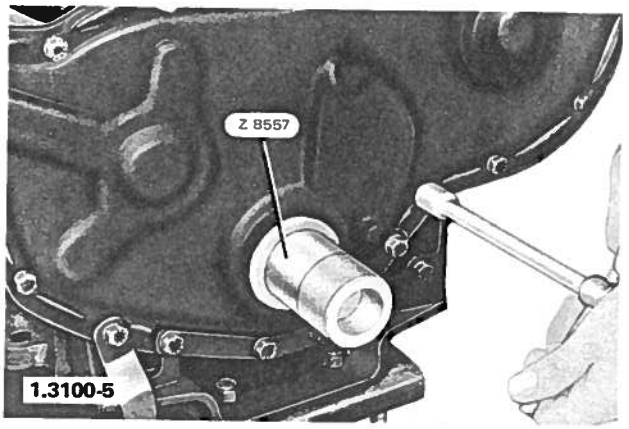
FRONT COVER: (Removal)
2. Remove the crankshaft pulley and vibration damper assembly as detailed in 1.3200. Remove the timing cover attaching bolts, spring washers and reinforcement strip, and lift away the timing cover.

FRONT COVER: (Inspection and Overhaul)
3. Thoroughly clean the front cover, check that no distortion has taken place by placing on a face plate and using feeler gauges. Should excessive distortion or damage be noted the plate must be renewed.
4. To renew the oil seal, drive out the old seal and thoroughly clean the recess in the cover. With the cover supported, press the seal into position so that the lip of the seal is towards the inside of the cover. On early engines it was necessary to smear the recess and the metal case of the oil seal with jointing compound, but due to the neoprene covering on the current seals this is now no longer necessary.



1.3100-4

FRONT COVER: (Refitting)
5. Check that the crankshaft oil thrower is in position with the concave side facing outwards and using a new gasket, fit the front cover to the timing gear case. Before tightening the cover bolts, locate the timing cover aligner Z8557 on the crankshaft spigot to ensure that the oil seal is concentric with the seal land. Tighten all bolts to a torque of 7 lb.ft. and withdraw the aligner.



1.3200

CRANKSHAFT DAMPER

CRANKSHAFT DAMPER. (Description)
1. The crankshaft vibration damper is of the rubber floating type combined with the crankshaft pulley, and situated on the nose of the crankshaft. The purpose of the damper is to damp out vibration periods which occur at certain engine speeds. The crankshaft damper is not fitted to 220 cu. in. engines.

CRANKSHAFT DAMPER: (Removal)
2. Remove the radiator (5.3000) and fan belts (1.3320), and unscrew the crankshaft pulley dog.
3. Using puller VR 2031 withdraw the pulley and damper assembly. If the engine is fitted with a long nosed crankshaft it may be necessary to fit longer bolts to the pulley.

CRANKSHAFT DAMPER: (Inspection & Overhaul)
4. The relative motion between parts of the damper assembly do not cause wear, but excessive running at critical speeds can cause decomposition of the rubber and should there be any signs of this occurring the damper should be replaced. The assembly should be checked for signs of physical contact with another solid body which may destroy the balance. Clean damper, using clean fuel oil, which should be dried immediately using compressed air. Trichlorethylene should not be used for cleaning purposes as this, like prolonged exposure to oil, is harmful to the rubber.

CRANKSHAFT DAMPER: (Refitting)
5. The crankshaft damper assembly should be aligned onto the crankshaft ensuring that the key on the crankshaft will enter the keyway on the damper assembly. The assembly can now be pressed onto the crankshaft using installer VR2005. Tighten the crankshaft pulley dog to a torque of 180-200 lbs.ft. the threads being clean and dry. Refit the fan belt (1.3320) and radiator (5.3000).

1.3300

CRANKSHAFT PULLEY

CRANKSHAFT PULLEY: (Description)

1. The crankshaft pulley, used on 220 cu. in. engines only, is a two groove pulley and fits on the crankshaft nose secured by the crankshaft starting dog assembly.

Note: On later models the starting dog assembly has been replaced by a bolt and two washers. See parts book for engine serial numbers.

CRANKSHAFT PULLEY: (Removal)

Static Application

2. Remove the radiator (5.3000), fan belts (1.3320) and unscrew the crankshaft pulley dog.
3. Withdraw the pulley using puller VR2031. If the engine is fitted with a long nose crankshaft it may be necessary to fit longer bolts.

Vehicular Application

4. Drain the radiator and disconnect the hoses, disconnect the exhaust pipe from the manifold. Remove the fan belt as detailed in section 1.3320. Remove the bolts securing the radiator cowl and withdraw the fan and cowl. Unscrew the crankshaft pulley dog.
5. Support the engine, remove the bolts securing the engine to its support brackets and slacken the nuts securing the front mountings to the support brackets. Raise the engine sufficiently to enable the support bracket to be tilted clear of the pulley. Withdraw the pulley using puller VR2031. If the engine is fitted with a long nose crankshaft it may be necessary to fit longer bolts to the puller.

CRANKSHAFT PULLEY: (Inspection and Overhaul)

6. Thoroughly clean the pulley assembly and an inspection for any metal defects should be carried out. If any defects are found the part should be replaced.

CRANKSHAFT PULLEY: (Refitting)

7. Install the pulley assembly, using installer VR2005 ensuring that the assembly is aligned onto the crankshaft and that the key on the crankshaft will enter the keyway on the pulley. If vehicular application, lower the engine and reconnect the front mountings to the support brackets.
8. Tighten the crankshaft pulley dog to a torque of 180-200 lbs.ft.. the threads being clean and dry.

1.3320

CRANKSHAFT PULLEY BELT

CRANKSHAFT PULLEY BELT: (Description)

1. The crankshaft pulley belts are of the Rawedge 'V' type. A set of two belts per engine are used on 220 and 330 cubic inch Bedfords.
2. The belts are driven from the crankshaft pulley, and are used to drive the alternator and fan.

CRANKSHAFT PULLEY BELT: (Removal)

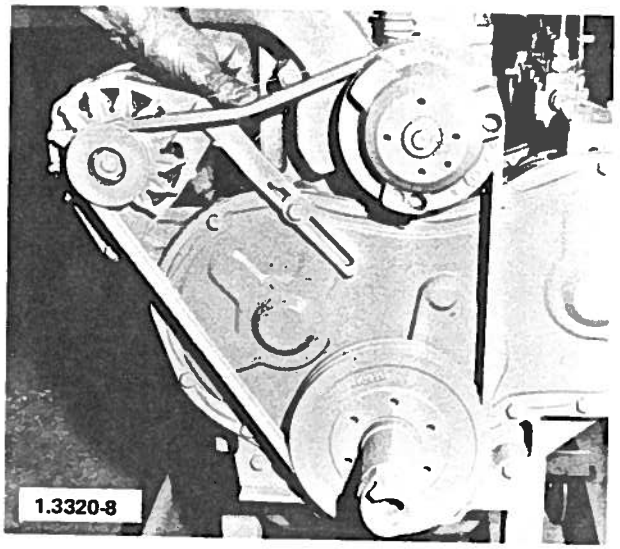
3. Slacken the generator attaching bolts, and the bolt securing the slotted brace to the generator. Pivot the generator towards the engine.
4. Rotate the engine with the starting handle and slip the belt over the edge of the generator pulley. Do not rotate the engine by pulling on the fan blades, as this is liable to cause subsequent fracture of the blades.
5. Remove the fan belt from the pulleys.

CRANKSHAFT PULLEY BELT: (Inspection and Overhaul)

6. Check the belts for fracture or frayed edges. Should one belt of the pair be damaged, both belts must be replaced, the belts being serviced in pairs only.

CRANKSHAFT PULLEY BELT: (Refitting)

7. Check that the pulleys are clean before fitting the belts and adjust to the correct tension as detailed below.
8. With the generator attaching bolts and the bolt securing the slotted brace slack, pivot the generator away from the engine to tighten the belts. The fan belt can be checked by depressing the belt ½ inch, midway between the fan and generator pulleys with a load of 8-10 lbs., when correct, tighten the generator bolts, including the bolt which secures the slotted brace to the engine.



Note: The adjustment of the belts is most important. A belt adjusted to tight will overload the water pump and generator bearings. A slack belt will slip and wear, and cause the engine to overheat.

9. A new belt set should be rechecked for tension after 1000 miles or 50 hours' service.

1.4000

FLYWHEEL

FLYWHEEL: (Description)

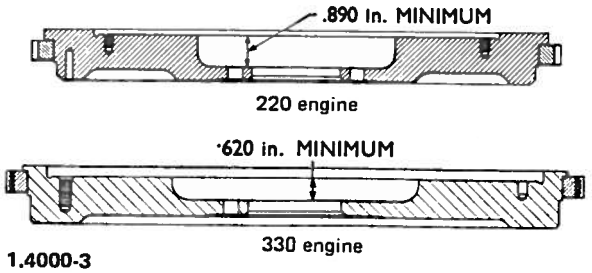
1. Several types of flywheels are available according to the application of the engine. All types however, have the timing marks on the outer edge and also on the inner face. This facilitates interchangeability of the flywheel housing; either automotive or industrial can be used. The ring gear for the flywheel is shrunk onto the rim of the flywheel.

FLYWHEEL: (Removal)

2. Remove the clutch (8.1000). and then remove the six (6) bolts and three (3) locking plates securing the flywheel to the crankshaft flange. Support the flywheel and tap it off the flange evenly with a copper hammer. **Note:** If the flywheel is not supported and is dropped during removal, it could cause serious physical injury to the serviceman.

FLYWHEEL: (Inspection & Overhaul)

3. Examine the friction face if used for scores or cracks, and check the dowels in the crankshaft flange for wear or slackness. Scores on the friction face can be removed by machining within the limits indicated below.



1.4000-3

4. Also check the flywheel attaching bolt holes for elongation due to running with the flywheel loose. If the flywheel has been loose, examine the crankshaft flange for embedded flywheel material due to fretting. Embedded material should be removed with a carborundum stone ensuring that the spigot bearing if fitted, is protected. Examine the flywheel bolts for signs of stretching or damaged threads, and the ring gear and starter pinion teeth for wear. If any section of the ring gear is unduly worn the gear should be renewed. If necessary, renew the starter pinion. Check the spigot bearing for wear or roughness, renew if necessary and repack the bearing with 4616-M or 4617-M grease.

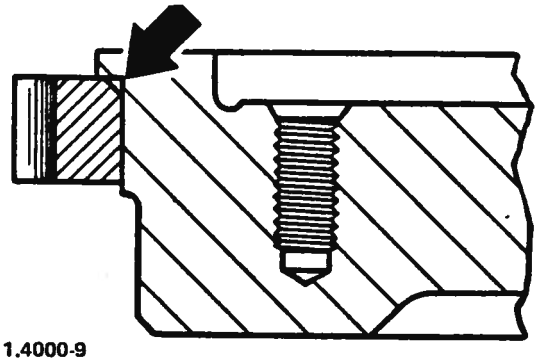
5. The following procedure should be followed to replace a worn or damaged flywheel ring gear:-

6. Using a hammer and a piece of hardwood as a drift remove the old gear from the flywheel by striking evenly and alternately, at points equally spaced around the gear.

7. Using emery cloth, polish three evenly spaced areas on the outer face of the new gear.

8. Heat the gear in a furnace or oven, if this equipment is not available place the gear on a suitable heavy iron plate and heat evenly with a blow torch. The temperature of the gear can be judged by the changing colour of the polished areas. The correct temperature has been reached when the colour has changed from purple to dark blue. Hold at this temperature for five minutes.
Note: Do not allow the temperature to exceed 608°F (320°C) dark blue colour. If the colour changes to light blue, the original heat treatment of the gear given during manufacture will be destroyed.

9. Quickly remove the scale from the face of the gear and position the gear on the flywheel so that the chamfered inner edge (arrowed) of the gear is towards the flange of the flywheel. If necessary, gently tap the gear home with a copper hammer, and allow to cool in air.

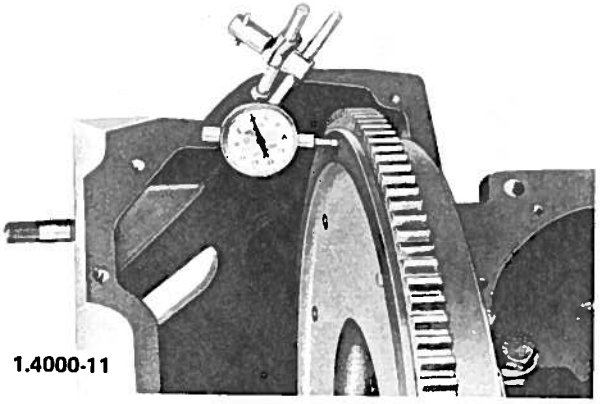


1.4000-9

FLYWHEEL: (Refitting)

10. Clean the mating faces of the flywheel and crankshaft. Fit the flywheel to the crankshaft ensuring that the flywheel is correctly aligned with the location dowel on the crankshaft. Using new lockwashers, tighten the flywheel bolts to a torque of 80 lbs.ft., on earlier engines the flywheel bolt torque was 65-70 lbs.ft. both types of bolt are to be tightened with clean dry threads.

11. Using a dial gauge check the rear face and rim of the flywheel for run out, which for the rear face should not exceed 0.004 in. and for the rim 0.005 in.



1.4000-11

1.5000

FLYWHEEL HOUSING

FLYWHEEL HOUSING: (Description)

1. The Flywheel housing varies according to the application of the particular engine.
2. The Flywheel housing is used to support the Starter (Cranking) Motor and provides mounting faces for attaching the engine to the equipment. The flange onto which the Transmission or P.T.O. fits is normally to an S.A.E. specification and adaptor rings can be used to convert from one S.A.E. size to another.

FLYWHEEL HOUSING: (Removal)

3. Remove the Flywheel as detailed in 1.4000.
4. The Starter (Cranking) Motor must next be removed, but before attempting this operation, ensure that the battery is disconnected. Remove the three securing nuts and spring washers, the Starter can now be removed.
5. When removing certain types of Starter Motors, it will be found that a spacer will be used between the housing and starter.
6. Ensuring that the housing is supported, the 7 bolts which secure the Flywheel housing to the Crankcase can be removed. The Flywheel housing should now be lightly tapped with a copper or hide hammer, in order that the housing can be removed from the locating dowels.

FLYWHEEL HOUSING: (Inspection and Overhaul)

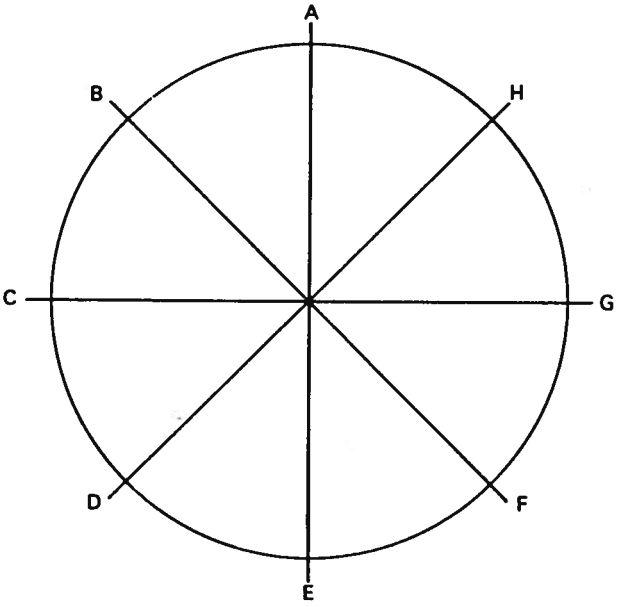
7. The Flywheel housing has no moving parts and thus is not subject to wear, however, incorrect storage can cause distortion and this should be checked. The housing should therefore consist of a visual check for damage and cracks which may have been inflicted. The bore and clutch housing mating flange must be inspected when the flywheel is installed.
8. If a new S.A.E. 2 or 3 Flywheel housing is fitted it is advised that the bore diameter be checked to ensure that it conforms to S.A.E. Standards.

	Bore diameter	−0.000 +0.005
S.A.E.2	17.625	
S.A.E.3	16.125	

This can be best achieved by using vernier gauges.

FLYWHEEL HOUSING: (Refitting)

9. Ensure that the faces of the Flywheel housing and the cylinder block are clean and free from burrs.
10. Align the housing onto the dowels which are in the crankcase and secure with 7 bolts. Tighten these bolts evenly to a torque of 38-40 lbs.ft.
11. The starter motor can now be refitted, using the spacer, if originally used, tighten the nuts to a torque of 22-27 lbs.ft.
12. To check the concentricity of the bore a dial indicator gauge should be used. The gauge being mounted on a suitable bracket which should be fabricated. When making a suitable bracket take care that the material is either thick enough or sufficiently well braced to prevent any vibration or deflection of the bracket being transmitted to the dial gauge. The bracket should be mounted on the crankshaft and screwed to the flywheel fixing holes located on the dowels.
13. If the injectors are fitted it is advised that they be slackened or removed, this will avoid having to turn the engine against the compression stroke.
14. Check the bore of the Flywheel housing, rotate the crankshaft until the gauge is at 12 o'clock and set at zero, rotate the crankshaft in an anticlockwise direction when viewing from the flywheel end of the engine. The readings on the dial indicator should be taken at 45 deg. intervals and all should be within 0.008 inches.
15. The face deviation should be checked using the dial indicator which should be re-positioned on the fabricated bracket so that the stylus is on the outer face. Set the dial indicator at zero after rotating the crankshaft in an anti-clockwise direction until it is at 12 o'clock. It is most important that the engine is only rotated in one direction when performing this test as the effect of the helical timing gears will be to keep the crankshaft at the extreme travel of the end float. Readings should be taken at 45 deg. intervals as the crankshaft is rotated. The maximum deviation allowed is 0.008 inches.



1.5000-15

16. When rotating the crankshaft attempt to keep the movement as smooth as possible, excessive jerking will tend to move the crankshaft in a linear direction thus moving the dial gauge to the flywheel housing.

17. After taking the readings continue the rotation until the original 12 o'clock position is reached when the dial indicator should again read zero. if this is not so the test should be repeated but first ascertain where movement has taken place and rectify the cause.
18. When making the above tests it must be realized that the zero on the dial gauge is purely a datum and readings either plus or minus will be obtained. The maximum plus reading and maximum minus reading should be added together, the result should be under .008 ins., example:-

Readings taken at 45 deg. intervals

A	B	C	D	E	F	G	H
0	+ 0.002	+ 0.002	+ 0.004	+ 0.003	0	– 0.002	– 0.001

19. If the dial were now set at zero at point G and new readings taken then obviously all would increase by .002 ins. and point D would be seen to be + 0.006 ins. from zero. Thus the deviation could be calculated by adding D & G together the result is 0.004 + .002 = .006. It will be realised that the plus and minus are only relative to the zero point and can be ignored the figures being thousandths of an inch of deviation from zero.
20. If the flywheel housing does not fall within the specified dimensions it should be discarded. Remove the bracket which the dial indicator gauge was fitted to and fit the flywheel to the crankshaft as detailed in 1.4000.

1.6000

CONNECTING ROD & PISTONS

CONNECTING ROD & PISTONS: (Description)

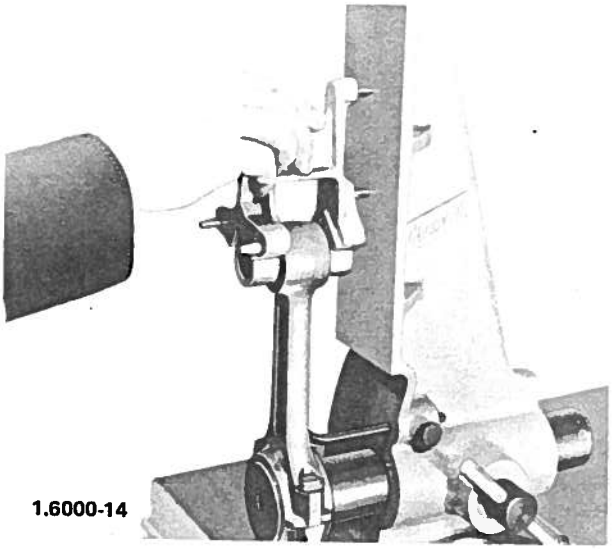
1. The connecting rod is manufactured of 1% chrome steel, case hardened. The bearing is an interchangeable thin shell which is of copper lead tin alloy. The piston pins are fully floating in steel backed bronze bushes, retained by circlips. The piston pin bush is lubricated by splash and oil mist, although on the earlier engines the rods were drilled lengthwise to supply oil to the piston pin, and a drilling through one side of each rod and bearing directed oil on the thrust side of the cylinders. The part numbers of the two rods are the same and care must be taken that all the rods fitted to an engine are the same type. The aluminium alloy pistons each carry five rings, three compression rings and one scraper ring above the pin and one scraper ring below the pin. The connecting rods are supported on detachable shell type bearings and the rod caps are secured by nuts and bolts.

CONNECTING ROD & PISTONS: (Removal)

2. Remove the cylinder head (1.2000), and oil sump (4.7000).
3. Mark each connecting rod end on the bosses of the rod and cap with the appropriate cylinder number (front cylinder being number one). Do not use a centre punch or file as such markings may cause fatigue failure.
4. The nuts can now be removed from the connecting rod bolts, then using a brass drift lightly tap the bolt from the connecting rod cap. The caps can now be removed.
5. Each connecting rod and cap is machined together in a non-interchangeable pair which can be identified by the manufacturers markings stamped on one side of both the rod and cap.
6. Clean the carbon from the top of the cylinder bores and withdraw the complete connecting rod and piston assembly through the top of the bore.

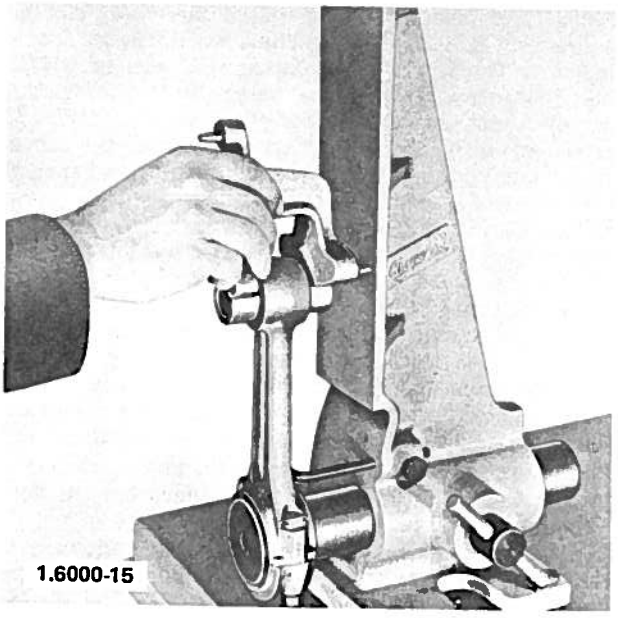
CONNECTING ROD & PISTONS: (Inspection & Overhaul)

7. Remove the rings from the piston using a piston ring expander. Discard the rings; using a pair of circlip pliers remove the piston pin circlips.
8. Immerse the piston in water which has been heated to a temperature of 150°F (65°C), the pin can now be pushed out.
9. The bearing shells can now be removed from the connecting rods and caps.
10. Check the fit of the piston pin in the connecting rod bush, if available, a new piston can be used as a gauge. Should excessive wear be present in the bush a new one should be fitted to the connecting rod. The worn bush should be pressed from the connecting rod and a new one pressed in, taking care to align the hole in the bush with the hole in the connecting rod.
11. Assemble the connecting rod and caps without the bearings and tighten the securing nuts to a torque of 60-65 lbs.ft.
12. Check the bore diameter of the connecting rod ends to ascertain if the cap or rod faces have been filed; if they have been filed the rod and cap should be scrapped. The correct diameter of the rod and cap assembly should be 2.5195 to 2.5200 inches. Check that the connecting rod bolt is a hand push fit into both connecting rod and cap.
13. The connecting rod should be checked for alignment using an alignment jig to check that both piston pin and connecting rod bearings are parallel in all planes. Ensure that the connecting rod is thoroughly cleaned before assembling to the jig, otherwise a false reading will result. With the jig illustrated, it is possible to check the connecting rod for parallelism and twist and also reset if necessary without altering the position of the rod or removing it from the jig.
14. Out of parallelism must not exceed 0.002 inches.



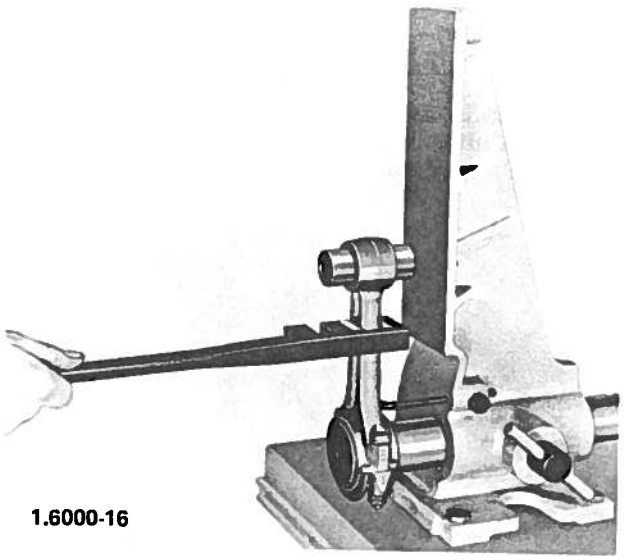
1.6000-14

15. Out of twist must not exceed 0.005 inches per 3 inches of checking mandrel, measured from the centre of the small end.



1.6000-15

16. Both sides of the connecting rod have a ground finish to improve the resistance to fatigue fracture. A resetting bar with soft jaws should be employed to avoid damaging these surfaces. If a heavy indentation in the rod is made during resetting operations, the rod should be discarded. Slight indentations and burrs should be blended to the main surface with a fine cut file and polished with fine emery cloth soaked in engine oil.



1.6000-16

17. Inspect the connecting rod bearings for wear, scores or surface cracks and check the bearing to crankpin clearance using plastigauge, which should be used in the following manner:-

18. It should be realised that a steel feeler strip should not be used or the bearing surface will be damaged.

19. Wipe all oil from the bearing and crankpin; it should be noted that plastigauge is soluble in oil therefore, if either the bearing or crankpin are not cleaned thoroughly a false reading could be obtained. Cut a length of Plastigauge of the correct thickness, i.e., 0.002 to 0.004 inches clearance range from the length supplied, do not stretch the Plastigauge as this will render it useless. Place the Plastigauge across the centre of the crankpin. Install the cap and bearing and tighten the bolts to a torque of 60-65 lb.ft.

IMPORTANT: Do not turn the crankshaft with the Plastigauge installed.

20. Remove the bearing caps, the flattened Plastigauge will be adhering to either the journal or the bearing and should not be removed until it has been measured using the inch scale printed on one side of the Plastigauge envelope, measure the compressed Plastigauge at its widest point. The numbered graduation within the scale which more closely corresponds to the width of the Plastigauge indicates by its number the bearing clearance in thousandths of an inch, e.g., the graduation marked '3' indicates .003 inch clearance.

21. If the clearance is excessive check with a micrometer the diameter of the crankpin, this should be within the dimensions given in the following table.

Crankpin Diameter

Standard Size	– 2.374 – 2.375 ins.
0.010 ins. undersize	– 2.364 – 2.365 ins.
0.020 ins. undersize	– 2.354 – 2.355 ins.

22. If the crankshaft is satisfactory then the bearing shells must be replaced with new ones of a suitable size. The connecting rod is now overhauled and ready for service.

23. The piston should be inspected for serviceability, the diameter being checked with a micrometer. Pistons should be measured at the top of the skirt immediately below the ring land and at right angles to the piston pin axis.

1.6000-23

24. The piston should be within the limits set out in the following table.

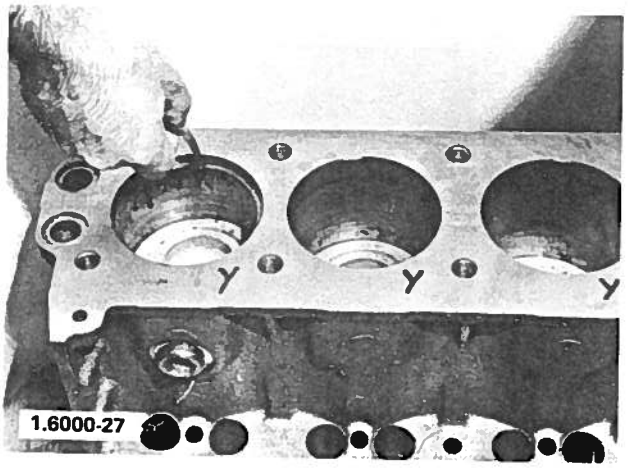
NOMINAL SIZE	GRADE	GRADED SIZE Measured at the top of the piston skirt and at right angles to the piston pin
Standard	Y W	4.0533 to 4.0527 ins. 4.0539 to 4.0533 ins.
0.005 in. O/S	Y W	4.0583 to 4.0577 ins. 4.0589 to 4.0583 ins.
0.020 in. O/S (Maximum for Liners)	Y W	4.0733 to 4.0727 ins. 4.0739 to 4.0733 ins.
0.040 in. O/S	Y W	4.0933 to 4.0927 ins. 4.0939 to 4.0933 ins.

25. Check the fit of the piston pin, which should be a hand push fit through each piston boss at a temperature of 65° to 75°F (18° to 24°C). If it is found necessary to warm the piston this should be done by immersing the piston into water which has been heated to the required temperature. Do not heat the piston with a naked flame or any other source of local heat. When checking the boss bore diameter use a new piston pin and check each boss individually, do not pass the piston pin through both bosses simultaneously.
26. Check each new piston ring by placing it approximately 2 inches down the cylinder bore, using a piston to keep it parallel with the top face of the cylinder block.
27. Measure the ring gap with a feeler gauge which should be within the following limits:-

Gap in cylinder bore on both 220/330 engines.

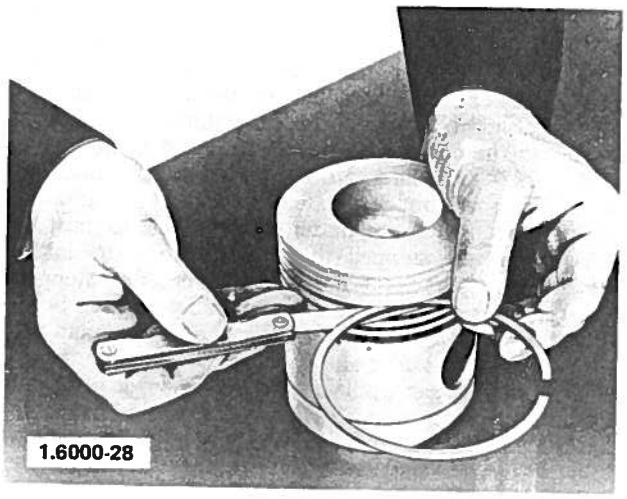
Top Compression Rings	– 0.013 to 0.025 ins.
Second & Third Rings	– 0.006 to 0.023 ins.
Scraper Rings	– 0.013 to 0.025 ins.

Piston Clearance in Cylinder bore – 0.0099 to 0.0111 ins.

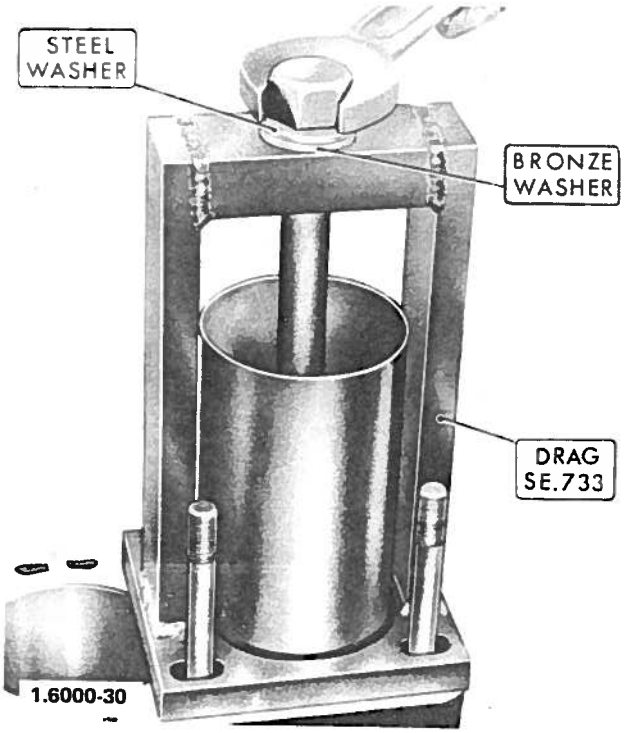


28. Check the clearance of rings in the piston grooves using a feeler gauge; if the clearances are excessive, renew the pistons. The correct clearance is detailed in the table below.

29. On engines prior to serial number P. & I. 1900 six cylinder engines and 1350 four cylinder engines a cylinder liner was used. For these engines new cylinder liners are serviced complete with pistons as selective

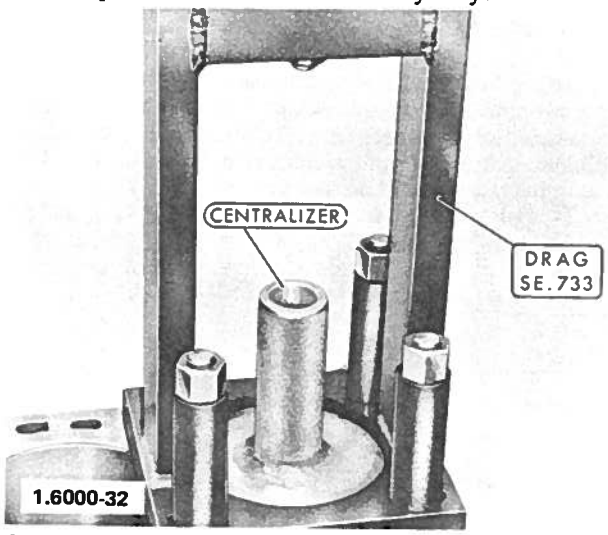


assemblies, therefore, measurement of piston to liner bore clearance and the checking of piston ring gaps prior to installation is unnecessary. Reboring or honing of the cylinder liners is not recommended and for this reason oversize pistons are not serviced.
30. To renew liners withdraw the old liner using puller D1165.

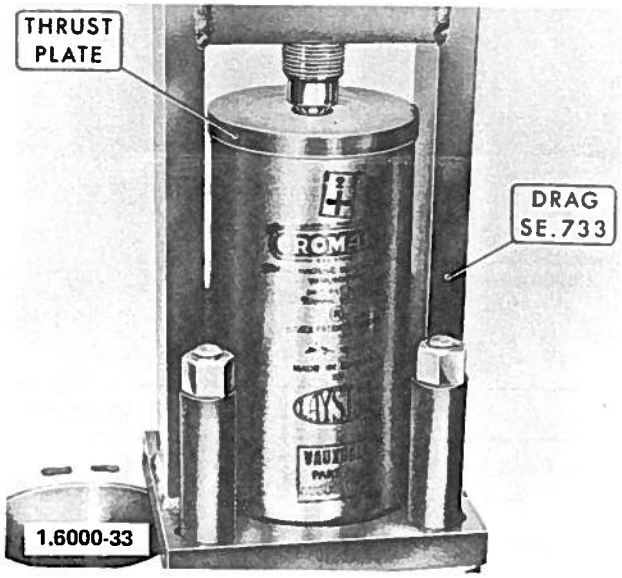


Piston rings	Width	Clearance in Piston grooves
Top compression ring	0.0928 to 0.0938 ins.	0.0045 to 0.0065 ins.
Second & Third (Stepped) Rings	0.0928 to 0.0938 ins.	0.0015 to 0.0035 ins.
Scraper rings	0.1865 to 0.1875 ins.	0.0015 to 0.0035 ins.

31. Smear the threads of the drag screw with molybdenum disulphide grease. To prevent the expansion of the liner an additional thrust plate has been developed. This is assembled to the centre bolt and aligned at right angles to the crankshaft and the liner located in the narrow groove, thus preventing distortion of the base of the liner. No attempt should be made to move a liner without this plate. This additional plate will not pass through the cylinder block bore and must be changed for the stepped thrust plate after the initial movement of the liner has taken place. The stepped plate will pass through the cylinder block bore. Thoroughly clean the new liners, cylinder bores and the top face of the cylinder block.
32. Assemble the centralizer of the drag in the bore and position the main assembly over the centralizer. Note that the puller can be installed one way only.

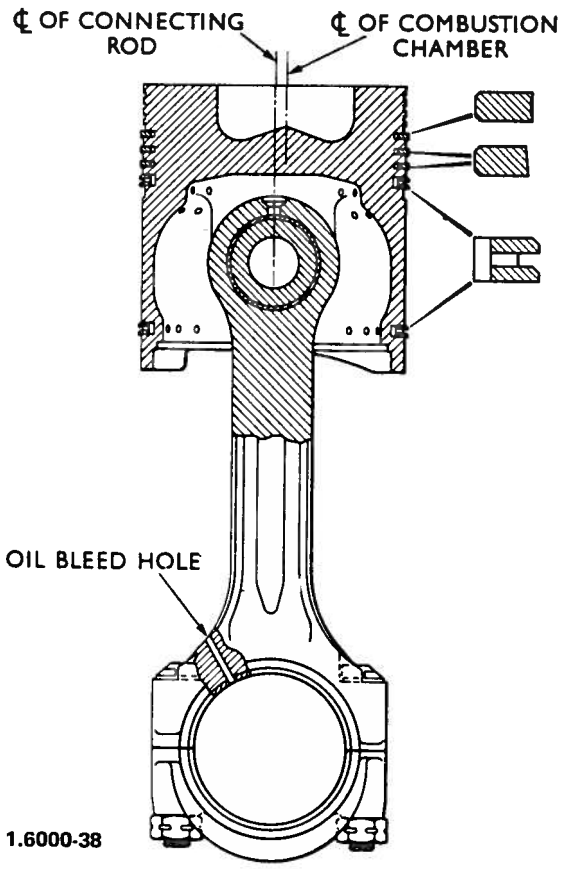


33. Assemble the four spacers to the cylinder head studs, install the nuts to secure the drag in position, and remove the centralizer. Smear the cylinder bore with engine oil. Assemble the dimpled thrust plate to the liner and enter the liner square in the chamfer in the top of the bore.



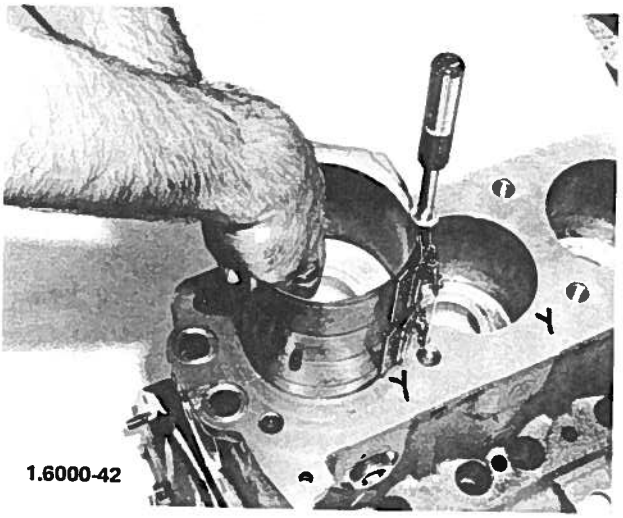
34. Screw down lightly on the thrust screw making sure that the ball of the screw is correctly located in the thrust plate, then continue until the flange of the liner is felt to just contact the cylinder block. Do not apply further pressure after contact has been made.
35. Finally, remove the drag and thrust plate.

CONNECTING ROD & PISTONS: (Refitting)
36. The piston should first be assembled to the connecting rod as follows: Fit a new circlip to one of the piston bosses and immerse the piston into water which has been heated to 150°F (65°C), it is essential that the complete piston is expanded evenly in order that the piston pin can be fitted; do not therefore, heat the piston locally. Locate the piston on the connection rod so that the combustion chamber is off-set away from the oil bleed hole side of the rod.
37. Push home the piston pin and secure the piston pin with a new circlip which should be fitted to the remaining piston boss. The piston pin should now be lubricated with a mineral oil containing colloidal graphite.
38. Assemble new piston rings to the piston using a piston ring expander. On current models an expander ring is fitted to the upper scraper ring.



39. When installing the piston rings check that they are installed in the correct way, either the TOP or BOTTOM of the ring is marked; should no mark be visible then it can be assumed that the ring has no special way of fitting.

40. Prior to installing the piston into the cylinder block, lubricate the cylinder bore, piston and rings with clean engine lubricating oil. Position the ring gaps away from the camshaft, but not in alignment, and the compression ring gaps equally spaced around the piston.
41. Install the piston and rod into the block; to perform this operation, it is necessary to fit a piston ring compressor, the rod can then be passed through the bore from the top face of the cylinder block taking care that the piston is situated so that the combustion chamber is offset from the camshaft.
42. Press the piston from the ring compressor into the bore.



1.6000-42

43. Fit the bearing shells to the connecting rod and connecting rod cap, lubricating with engine oil before locating onto the crankshaft; refit the connecting rod bolts and after fitting the connecting rod cap tighten the nuts to the connecting rod bolts to a torque of 60-65 lb.ft. The threads to be lubricated with extreme pressure oil, grade C, S.A.E. 140.

1.7000

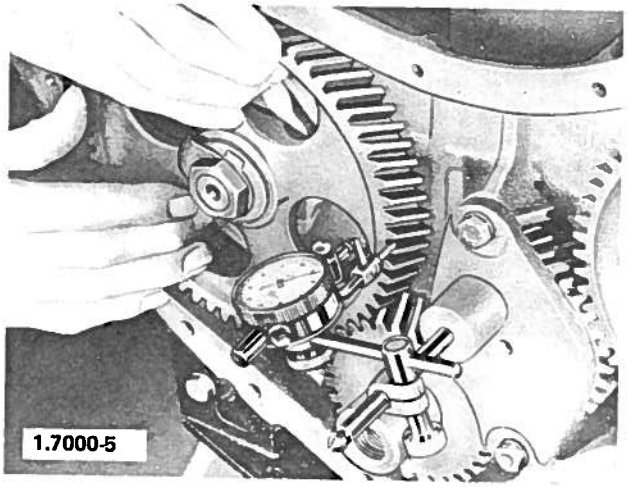
CAMSHAFT & DRIVING GEAR

CAMSHAFT & DRIVING GEAR: (Description)

1. The camshaft, supported in four detachable shell type bearings. is gear driven and incorporates an integral skew gear which drives the oil pump.
2. End float is controlled by a thrust plate located behind the camshaft gear and bolted to the crankcase.
3. The camshaft gear (62 teeth) is driven direct from the crankshaft gear (31 teeth). Therefore, the camshaft rotates once for every two revolutions of the crankshaft.

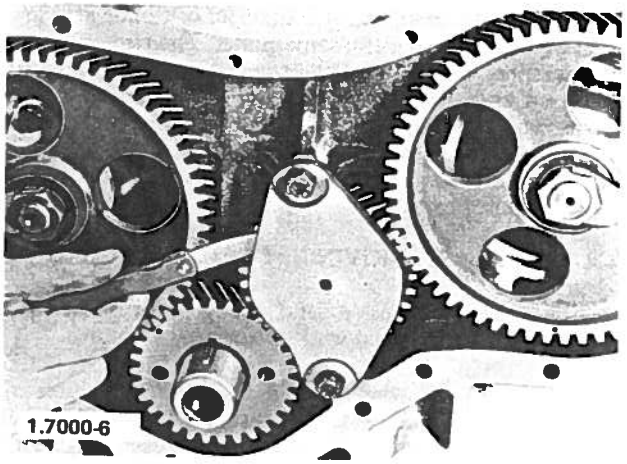
CAMSHAFT & DRIVING GEAR: (Removal)

4. Remove the front cover (1.3100). the tappets as detailed under rocker shaft and cover (1.7100), oil pump (4.1000) and on 330 cu. in. engines with D.P.A. type fuel injection pump the fuel lift pump (2.2020).
5. Check the backlash between the teeth of all gears which should be as follows:-

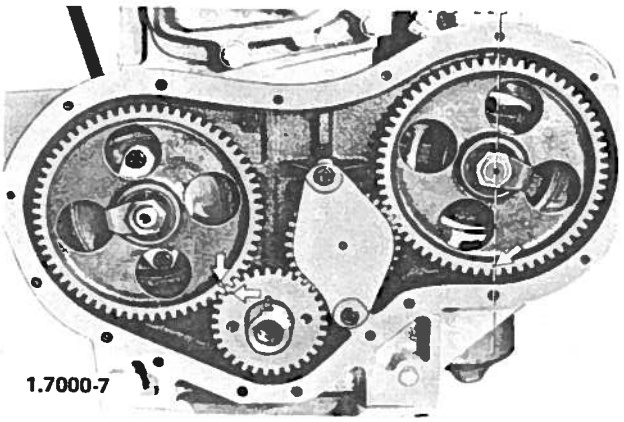

1.7000-5

Crankshaft and Camshaft Gears	– .0032 to .0058 ins.
Crankshaft and Idler Gears	– .0023 to .0072 ins.
Idler and Accessory Drive Gears	– .0026 to .0064 ins.

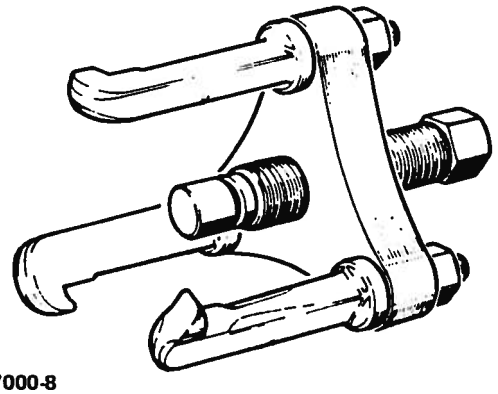
6. Check the end float of the idler gear with feeler gauges. The end float should be .003 to .009 inches. If backlash exceeds the above limits, or the gear teeth are damaged, the gears must be renewed.


1.7000-6

7. Rotate the engine until the timing marks are in line.

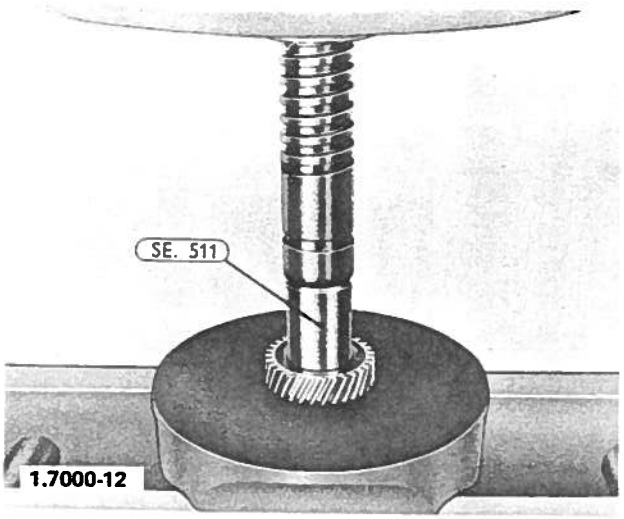

1.7000-7

8. Knock back the locking tab and remove the nut, tab washer and plain washer securing the camshaft gear which can now be withdrawn using puller VR2021 illustrated below.


1.7000-8

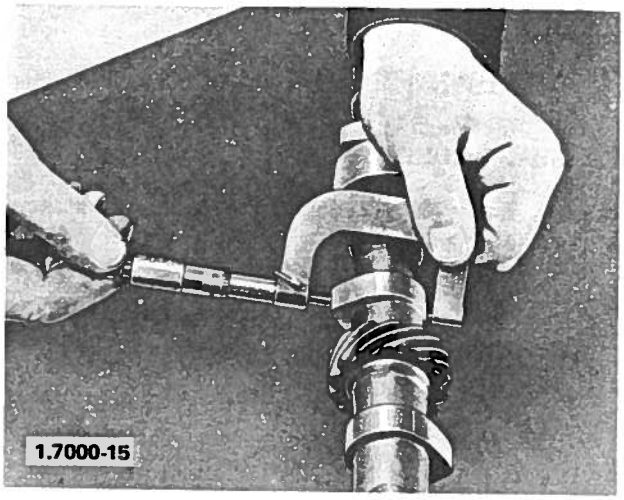
9. Remove the compressor, exhauster or timing gear in a similar manner using the same puller. The two bolts and lockwashers securing the idler gear hub should now be removed and the hub prised from the timing case. The thrust washers and idler gear can now be separated from the hub, and the seal ring from the cylinder block.
10. Withdraw the camshaft taking care not to damage the camshaft bearings.

CAMSHAFT & DRIVING GEAR: (Inspection & Overhaul)
11. Examine the camshaft and idler gear thrust face and also the thrust plate and washers for wear or scores.
12. Check the idler gear bush and hub for wear, if the bush requires renewing the old bush should be pressed out and a new one pressed in using drift SE 511. The bush must not protrude beyond either face of the gear bore.



13. Check that the key is in good condition and a snug fit in both the gear hub and the camshaft, also check the skew gear and oil pump drive gear for wear or damage. Examine the cams for pitting or wear on the cam peaks.
14. If the cams are badly pitted and need renewing the tappets should also be renewed. The camshaft may be used again providing the dimension from the base to the peak of the cam is not less than 1.653 inches.
15. The camshaft journals should also be checked with a micrometer, the diameters of which are tabulated below:

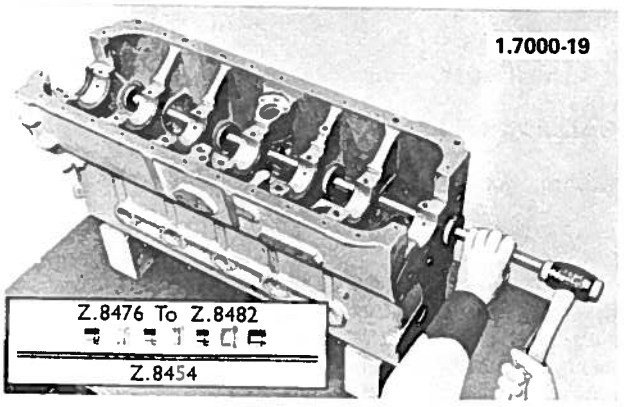
No. 1 (FRONT) 2.1360-2.1365 (2.1345)	No. 2 2.0460-2.0465 (2.0445)
No. 3 2.0030-2.0035 (2.0015)	No. 4 1.9730-1.9735 (1.9715)



16. The figures in brackets are the maximum permissible wear for engines in service, should these dimensions be exceeded the worn part must be replaced.
17. Check the camshaft bearing bores for wear using a telescopic gauge in conjunction with a micrometer. The dimensions should be as follows:

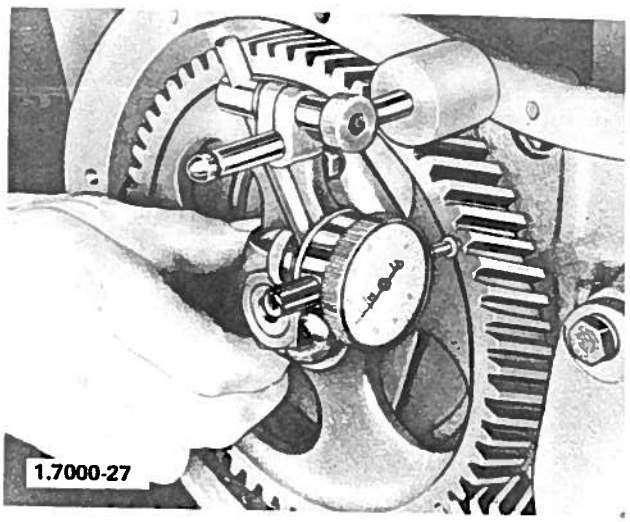
No. 1 (FRONT) 2.139-2.140 (2.141)	No. 2 2.049-2.050 (2.051)
No. 3 2.006-2.007 (2.008)	No. 4 1.976-1.977 (1.978)

18. If the bores are more than the figures in brackets the bearings must be replaced.
19. The flywheel housing will have to be removed as detailed in 1.5000 before replacing the camshaft bearings and then with the equipment shown below the following procedure should be adopted.

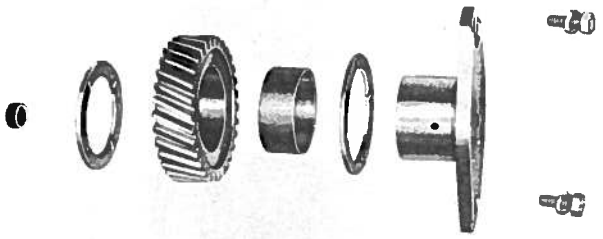


20. Insert the appropriate plug in the front (No. 1) bearing and drive it out of the crankcase. Remove the remaining bearings using the pilots to align and support the drift. When removing the rear bearing the expansion plug will be driven out with the bearing.
21. Replacement bearings with the bore diameter already finished to size are serviced, therefore, line boring is unnecessary.
22. When installing new bearings, commence with the rear bearing and work towards the front of the crankcase. To ensure that the oil holes in the new bearings line up with the oilways in the crankcase, locate the bearings so that the cut away in the bearing is at the top of the bearing housing and towards the front of the crankcase. After installing the bearings, clear away any overlapping metal which obstructs the oilways.
23. A new expansion plug should be fitted to the camshaft rear bearing. Check that there are no flats on the periphery of the plug. Use a sealing compound to obtain an oil tight joint, and use tool SE123 to install the plug. Check that when the plug is installed it does not project beyond the machined face of the crankcase, otherwise the flywheel housing will not seat on the rear of the crankcase.
24. Refit the flywheel housing as detailed in 1.5000.

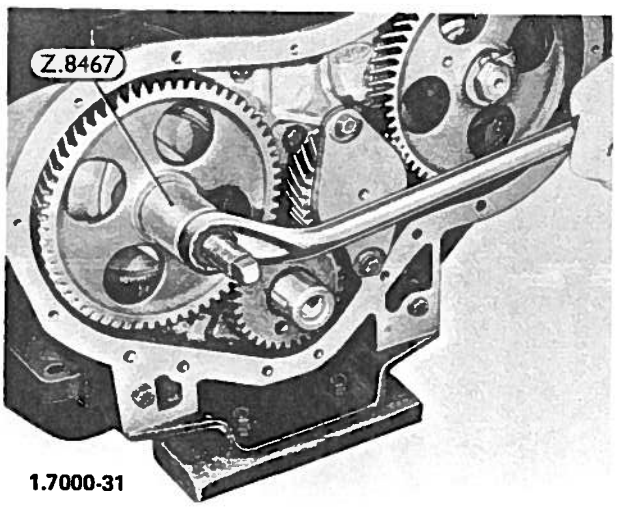
CAMSHAFT & DRIVING GEARS: (Refitting)
25. The camshaft bearings, should be lubricated with engine oil and the camshaft fitted to the crankcase.
NOTE: When fitting the camshaft the journal nearest the driving gear is of a larger diameter than the others, the smallest situated at the opposite end of the camshaft, and therefore cannot be fitted incorrectly.
26. Locate with the thrust plate, which should be secured with two bolts and lockwashers, tightened to a torque of 13-15 lbs.ft.
27. Check that the end float is between 0.002 and 0.012 inches, also check that the camshaft is free to rotate in the bearings.


1.7000-27

28. Install a new seal ring into the counterbore of the cylinder block.
29. Assemble the idler gear and thrust washers on the idler hub with the recessed face of the gear towards the hub flange. The larger of the two thrust washers must locate in the front of the gear.


1.7000-29

30. Insert the two bolts through the hub flange into the timing gear case and tighten to a torque of 14 lb.ft.
31. Ensuring that the timing marks are in line, fit the key into the keyway on the camshaft and replace the gear using installer Z8467. Replace the plain washer, tab washer and nut and tighten to a torque of 80-100 lb.ft., finally lock the nut with the tab washer



1.7000-31

32. Refit the fuel lift pump (2.2020), oil pump (4.1000), tappets (1.7100), and front cover (1.3100).

1.7100

ROCKET SHAFT & COVERS

ROCKER SHAFT & COVERS: (Description)

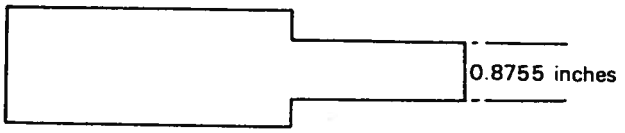
1. The overhead valves are actuated by pushrods which operate via tappets on the camshaft, the motion is transmitted by the rocker arms which pivot on the rocker shaft. The rocker arm has an adjusting screw which has a spherical end into which the cupped end of the push rod engages. The opposite end of the rocker arm operates onto the valve stem. The rocker arm is a carbon steel stamping with a bronze/steel split bearing bush inserted.
2. The valve mechanism is lubricated with oil which is a direct pressure feed from the camshaft bearings, the oil passing through the rocker shaft which has oilways drilled in it allowing the oil to lubricate the rocker arm bearings, a gravity oil return system being provided.
3. The rocker cover is a steel pressing which contains the flow and return orifices for the crankcase ventilating system. The oil filler is located on the top and the option plate is riveted onto the side of the rocker cover.

ROCKER SHAFT & COVERS: (Removal)

4. Remove the air cleaner as detailed in 3.1000.
5. Disconnect the pipe assembly between the tee piece and push rod cover or baffle chamber if fitted.
6. Remove the six cheese head screws which secure the rocker cover to the cylinder head and lift the cover from the cylinder head.
7. The clip which secures the oil pipe to the rocker shaft, should be removed, and the pipe lifted from the rocker shaft and cylinder head, the pipe is secured by the clip only.
8. The rocker shaft retaining screws can now be removed and the shaft assembly lifted from the cylinder head.
9. The push rods can now be lifted from the tappets. Take care not to lift the tappets from their respective bores, also it is advised that the push rods be kept in the order in which they are removed from the engine.
10. The push rod cover can be removed should it prove necessary for overhauling the cylinder block or operations such as camshaft removal. The cover is secured to the crankcase by twenty-nine bolts or twenty-one bolts, dependant on whether it is a four or six cylinder engine. A reinforcement strap is also used along the bottom edge of the push rod cover.
11. To remove an individual push rod, remove the rocker cover and rotate the engine until the valve corresponding to the rod is closed. Slacken the rocker adjusting screw until it is clear of the push rod, slide the rocker along the shaft and lift out the push rod. Again care must be taken not to lift the tappet out of the bore. When dealing with the end rockers the lock spring must be removed first.

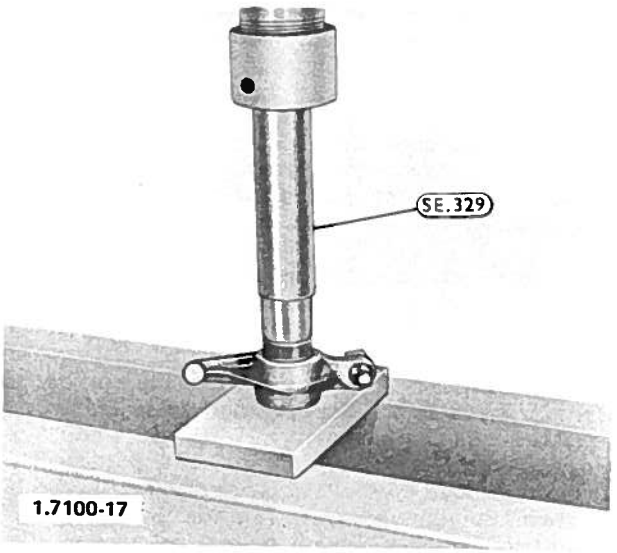
ROCKER SHAFT & COVERS:(Inspection & Overhaul)

12. Dismantle the rocker shaft assembly before inspecting the components, remove the locksprings from each end of the shaft and slide the rockers, brackets and springs off the shaft, the adjusting screws should now be removed from the rocker arms. Keep the rockers in the sequence in which they are removed from the rocker shaft.
13. Check the rocker shaft for wear, noting that wear occurs on the underside of the shaft, the diameter of the shaft should be 0.8729 – 0.8736.
14. Check that the shaft and plugs are secure and that the oil holes are clear. If any accumulation of sludge is evident, remove the plugs and clean the bore of the shaft, fit new plugs.
15. Examine the rocker bushes for wear by noting the clearance when placed over an unworn part of the shaft. The clearance should be 0.0009 – 0.0026 inches. Alternatively, a preferable method is to manufacture a gauge from a piece of 16 S.W.G. metal to the dimension given below.



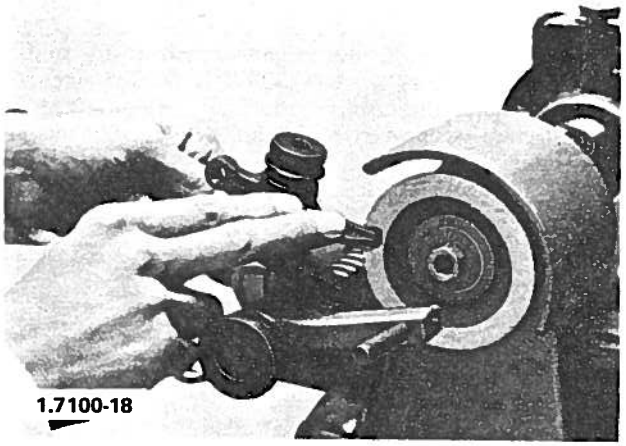
1.7100-15

16. The gauge should be inserted into the rocker arm bush and checks made whilst rotating the gauge, this will enable any ovality of the rocker bush to be noted. Should the bush be worn then it must be replaced. Two service bushes are required for each rocker to replace the original production bush.
17. With the split at the top, press the new bushes in from each side of the rocker, using drift SE 329 until the outer edges are flush. The gap between the bushes form the oilway. Hone out the bushes to 0.8745 to 0.8755 inches.



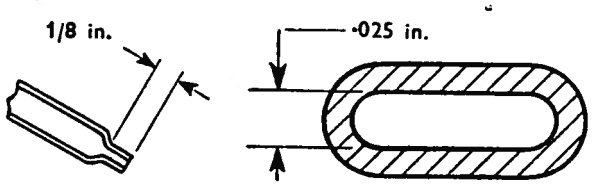
1.7100-17

18. Examine the rocker arm face for wear, if it is worn two ridges will be noted which correspond to the width of the valve stem, these should be refaced by grinding on suitable equipment, which will enable the original contour to be maintained.



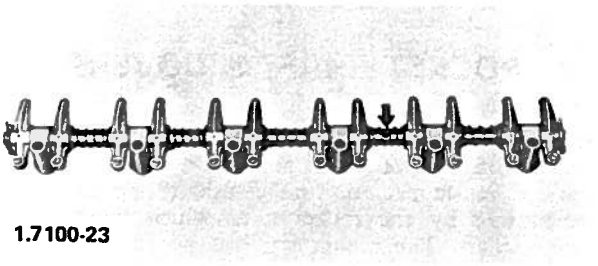
1.7100-18

19. The ball end of the rocker adjusting screws must be examined for wear. If wear is uneven or the end of the ball is polished, renew the screw, also the corresponding push rod.
20. Examine the lubricating oil supply pipe for cracks or any other damage, also check that the pipe and peg bores are clear and the crimped end conforms to dimensions below. A No. 72 drill will serve as a gauge for the aperture width.



1.7100-20

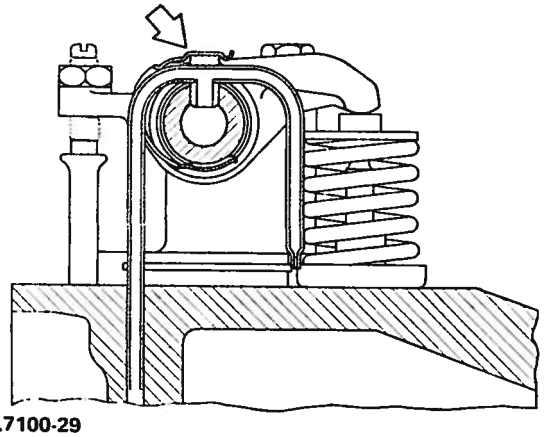
21. Inspect the cups and bottom faces of the push rods for wear. If a cup has worn excessively, renew the rod and the corresponding rocker adjusting screw. Check the push rod for run out which must not exceed 0.010 inches.
22. Examine each tappet for scores, pitting or cracks and if necessary reface the cam contact face. Prior to refacing measure the length of the tappet to determine whether there is sufficient metal to permit refacing. The minimum length of the tappet after refacing must not be less than 2.415 inches. Refacing must be carried out on suitable equipment incorporating a fine grit wheel. The ground face must be flat and as smooth as possible. The complete removal of all pitting is not essential.
23. Lubricate the rocker shaft, rocker arm bores and mounting bracket bores before assembling the components as shown in illustration 1.7100-23. The illustration is for a six cylinder engine. On four cylinder engines the oil hole (arrowed) is located between number 2 and 3 rockers.



1.7100-23

24. Assemble the conical tension springs which are located at the ends of the shaft assembly so that the wide coils contact the locksprings. Worn mounting brackets must be replaced.

ROCKER SHAFT & COVERS: (Refitting)
25 Check all mating faces and remove any traces of old gaskets before reassembling. Use new gaskets.
26. If the tappets were removed. lubricate the cam contact faces with a graphited lubricating compound before refitting the tappets into their relative positions in the crankcase.
27. Lubricate both ends of the push rod with engine oil and insert them into their appropriate tappets. Refit the push rod cover, and reinforcement strap and tighten the securing nuts to a torque of 7 lbs.ft. Place the rocker shaft assembly onto the cylinder head, fit a plain washer to each attaching bolt, check that the push rods are engaged with the tappets and adjusting screws and tighten the bracket bolts to a torque of 40-45 lbs.ft.
28. Rotate the engine without the injectors in the cylinder head and set the valve lash, this will need final adjustment when the engine is hot. Adjustment for valve clearance is provided by a screw and nut at the push rod end of each valve rocker. The correct clearance when the engine is hot is 0.013 inches for all valves.
29. Install the oil feed pipe assembly so that the peg is fully engaged with the shaft. Secure the pipe with its retaining clip, (arrowed) and check that the free end of the pipe is clear of the cylinder head top face.



1.7100-29

30. Turn the engine with the handle until the two valves of No. 4 cylinder (four cylinder engine) or No. 6 cylinder (six cylinder engine) are in the overlap position,

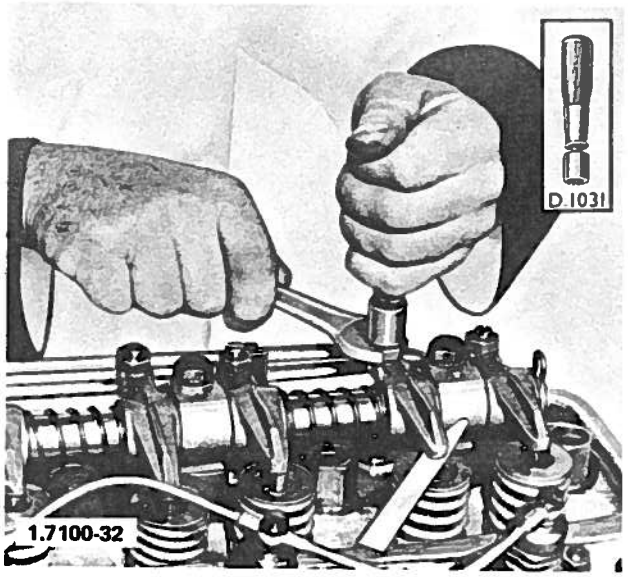
i.e., the exhaust valve about to close and the intake valve just commencing to open.

Note: If the adjustment of the valve clearances has been disturbed there is a possibility of the valve head contacting the top of the piston. The engine should therefore be turned slowly to avoid the risk of damage, and if any doubt exists the rocker adjustment screws should be slackened to give adequate clearance.

31. Adjust the intake and exhaust valve clearances on No. 1 cylinder which should be .013 inches when the engine is hot.

32. Check the remaining valve clearances in the same manner. Valve clearance should be checked in the following sequence:-

Valve overlap position on:	Adjust valve clearance on:
(4 cylinder engines)	
No. 4 cylinder	No. 1 cylinder
No. 2 cylinder	No. 3 cylinder
No. 1 cylinder	No. 4 cylinder
No. 3 cylinder	No. 2 cylinder
(6 cylinder engines)	
No. 6 cylinder	No. 1 cylinder
No. 2 cylinder	No. 5 cylinder
No. 4 cylinder	No. 3 cylinder
No. 1 cylinder	No. 6 cylinder
No. 5 cylinder	No. 2 cylinder
No. 3 cylinder	No. 4 cylinder



33. After the preliminary setting of the valve clearances, and whenever normal adjustment is carried out run the engine until normal operating temperature is obtained and with the engine running at idling speed readjust each valve clearance in turn.

34. Using a new gasket refit the rocker cover and tighten the securing screws to a torque of 6-8 lbs.ft.

1.7200

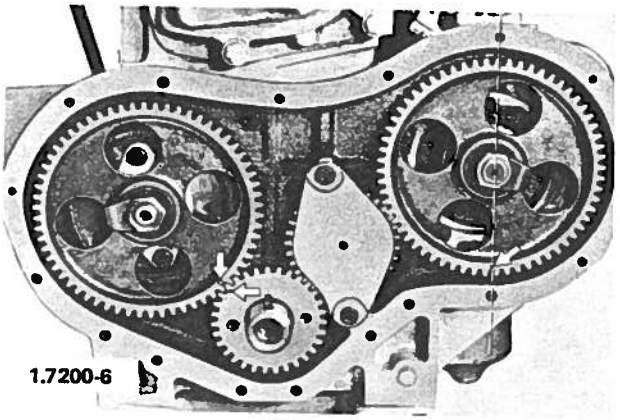
ACCESSORY DRIVE GEAR

ACCESSORY DRIVE GEAR: (Description)
1. The fuel injection pump is driven by either a driving shaft, or if fitted the compressor or exhauster crankshaft, the drive being transmitted from the engine crankshaft to the accessory drive gear via the idler gear. The gear on the engine crankshaft has 31 teeth, the idler gear 31 teeth and the accessory drive gear 62 teeth, which enables the fuel pump to rotate at one half the crankshaft speed. The need for reducing the speed of the fuel pump is because the engine is a four cycle, the piston moving up and down the cylinder twice for one operation of the injector.

ACCESSORY DRIVE GEAR: (Removal)
2. Remove the front cover (1.3100).
3. Rotate the engine until the timing marks are in line.
4. Knock back the locking tab and remove the nut securing the accessory drive gear. Remove the tab washer and plain washer and withdraw the gear using puller VR 2021.

ACCESSORY DRIVE GEAR: (Inspection & Overhaul)
5. Visually check the gear for any signs of wear particularly the keyway, should damage be apparent the gear should be renewed.

ACCESSORY DRIVE GEAR: (Refitting)
6. Refit the key into the keyway on the shaft and align the keyway in the gear to the key, press on the gear using tool Z8467, ensuring that the timing mark is in alignment with the two bolt holes in the gearcase.


1.7200-6

7. The plain washer, tab washer and nut should be fitted and tightened to 80-100 lbs.ft. torque and locked with the tab washer.

ENGINE SPECIFICATIONS

Except where maximum and minimum permissible limits are quoted, the following dimensions are the manufacturing limits for new parts.

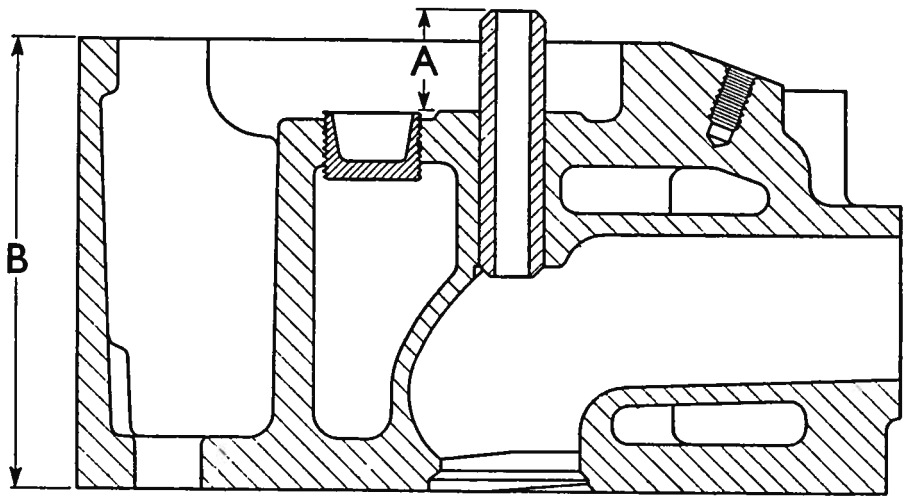
GENERAL DATA

	220 cu. in. ENGINE	330 cu. in. ENGINE
Number of Cylinders	4	6
Bore	4.0625 in.	4.0625 in.
Stroke	4.250 in.	4.250 in.
Piston Displacement	220 cu. in. (3,605 c.c.)	330 cu. in. (5,420 c.c.)
Firing Order	1, 3, 4, 2	1, 5, 3, 6, 2, 4
Compression Ratio	17 to 1	17 to 1
Brake Horse Power (Max. Rating)	65 at 2,600 r.p.m.	98 at 2,600 r.p.m.
Brake Horse Power (BS + 10% Overload)	61.5 at 2,500 r.p.m.	92 at 2,500 r.p.m.
Brake Horse Power (BS Continuous)	56 at 2,500 r.p.m.	83 at 2,500 r.p.m.
Brake Torque (Max. Rating)	154 lb.ft. at 1,400 r.p.m.	234 lb.ft. at 1,600 r.p.m.
Brake Torque (BS + 10% Overload)	147 lb.ft. at 1,400 r.p.m.	220 lb.ft. at 1,600 r.p.m.
Brake Torque (BS Continuous)	134 lb.ft. at 1,400 r.p.m.	195 lb.ft. at 1,600 r.p.m.

CYLINDER HEAD AND VALVE MECHANISM

Cylinder Head

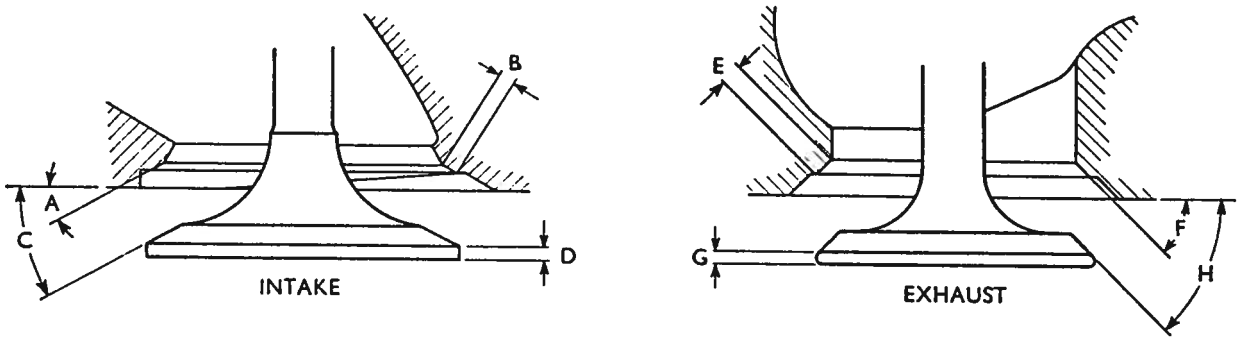
Depth of head	4.2485 to 4.2515 in.
Minimum depth after refacing	4.2385 in. (dimension 'B')
Distortion (maximum permissible):	
Longitudinally	.005 in.
Transversely	.003 in.
Manifold attaching faces	.003 in.



Cylinder head machining and valve guide height datum

Valve and Valve Seat Refacing Data

	INTAKE	EXHAUST
Valve seating angle	'A' – 30°	'F' – 45°
Valve seating width	'B' – .055 to .069 in.	'E' – .097 to .110 in.
Valve seat angle	'C' – 29°	'H' – 44°
Valve head – minimum thickness	'D' – .035 in.	'G' – .035 in.
Valve head depth in relation to cylinder head face (minimum permissible)	.023 in.	.041 in.



Valve seat refacing datum

	INTAKE	EXHAUST
Valve Clearance (hot)	.013 in.	.013 in.
Valves		
Stem diameter	.3409 to .3417 in.	.3397 to .3407 in.
Stem clearance in guide (maximum permissible)	.005 in.	.006 in.
End of stem to collar land (minimum permissible length)	–	.2005 in.
Rotator cap clearance	–	.001 to .005 in.
Valve lift (nominal)	.387 in.	.387 in.
Valve Guides		
Bore diameter	.3427 to .3437 in.	.3427 to .3437 in.
Length	2.84 in.	2.55 in.
Standing height above cylinder head machined face	49/64 in.	63/64 in. (dimension 'A' of cylinder head machining and valve guide height datum)

Valve Springs

Free length (approximately)	1 61/64 in.
Spring load at 1 11/16 in.	45 to 65 lb.

Valve Tappets

Diameter	1.1235 to 1.240 in.
Length after refacing (minimum)	2.415 in.

Valve Timing

Intake valve (maximum opening point)	108° (approx. 40½ teeth on flywheel) after top dead centre

Rockers and Shaft

Shaft diameter	.8729 to .8736 in.
Rocker bush bore diameter	.8745 to .8755 in.
Rocker clearance on shaft	.0009 to .0026 in.

Push Rods

Run-out (maximum)	.010 in.

CYLINDER BLOCK AND CLUTCH HOUSING

Cylinder Block

	220 and 330 cu. in. ENGINES
Depth of block, top face to main bearing cap face	12.529 to 12.534 in.
Minimum after facing	12.519 in.
Distortion, top face (maximum permissible):	
Longitudinally	.005 in.
Transversely	.003 in.
Depth of cylinder liner flange recess	—

Cylinder Liners

Fit in cylinder block	Press fit

Clutch Housing

Alignment:	
Bore	.005 in.
Face	.004 in.

PISTONS AND RINGS

Piston Pins

Diameter:	
Standard	1.3748 to 1.3750 in.
.001 in. oversize	1.3758 to 1.3760 in.
.003 in. oversize	1.3778 to 1.3780 in.
.005 in. oversize	1.3798 to 1.3800 in.
Length	3.2750 to 3.2800 in.
Fit in small end bush	.0004 to .0011 in. clearance
Fit in piston	Hand push fit through each piston boss at a temperature of 65° to 75°F. (18° to 24°C.)

Piston Rings

	WIDTH	CLEARANCE IN PISTON GROOVES
Top compression ring	.0928 to .0938 in.	.0045 to .0065 in.
Second and third (stepped) rings	.0928 to .0938 in.	.0015 to .0035 in.
Scraper rings	.1865 to .1875 in.	.0015 to .0035 in.

	220 and 330 cu. in. ENGINES
Ring gap in liner bore:	
Top compression ring	.013 to .025 in.
Second and third (stepped) rings	.006 to .023 in.
Scraper rings	.013 to .025 in.

Pistons

Clearance in cylinder liner	.0099 to .0111 in.
Ring grooves (width):	
Top compression ring	.0983 to .0993 in.
Second and third (stepped) rings	.0953 to .0963 in.
Scraper rings	.189 to .190 in.

CONNECTING RODS AND BEARINGS

Connecting Rods

Rod width	1.552 to 1.554 in.
Bearing housing bore diameter	2.5195 to 2.5200 in.
End float on crank pin	.006 to .012 in.
Bolt fit	Hand push fit
Rod alignment	Out of parallelism not to exceed .002 in. and twist .005 in. per 3 in. of checking mandrel measured from centre of small end

Bearings

Bearing bore diameter	2.377 to 2.378 in.
Bush bore diameter	1.3754 to 1.3759 in.

CRANKSHAFT AND BEARINGS

Crankshaft

Crankpin diameter	2.374 to 2.375 in.
Crankpin length	1.560 to 1.564 in.
Crankpin clearance in bearing	.002 to .004 in.
Main bearing journal diameter	2.749 to 2.750 in.

	FOUR CYLINDER ENGINES	SIX CYLINDER ENGINES
Main bearing journal length:		
No. 1 (front)	1.771 to 1.799 in.	1.781 to 1.809 in.
No. 2	1.432 to 1.442 in.	1.432 to 1.442 in.
No. 3	1.810 to 1.814 in.	1.432 to 1.442 in.
No. 4	1.432 to 1.442 in.	1.810 to 1.814 in.
No. 5	1.710 to 1.720 in.	1.432 to 1.442 in.
No. 6	–	1.432 to 1.442 in.
No. 7	–	1.710 to 1.720 in.

Journal clearance in bearing	.0020 to .0045 in.
Crankshaft end float	.002 to .012 in.
Timing gear spigot diameter	1.532 to 1.533 in.
Pulley spigot diameter	1.3775 to 1.3760 in.

Crankshaft Main Bearings

Bearing bore diameter	2.7520 to 2.7535 in.
Bearing housing in crankcase – bore diameter	2.916 to 2.917 in.
Thrust washers (thickness):	
Standard	.091 to .093 in.
.003 in. oversize	.094 to .096 in.
.006 in. oversize	.097 to .099 in.

Service Main Bearing Cap Shims

Thickness	.002 to .003 in.

Main Drive Pinion Spigot Bearing

Dimensions	15 x 35 x 11 mm.
Fit in crankshaft	.0006 in. clearance to .0009 in. interference

Crankshaft Pulley

Bore diameter	1.3740 to 1.3750 in.
Fit on crankshaft	.0005 to .0020 in. interference

CAMSHAFT AND BEARINGS

Journals

	No. 1 (Front)	No. 2	No. 3	No. 4
Diameter	2.1360 to 2.1365 in.	2.0460 to 2.0465 in.	2.0030 to 2.0035 in.	1.9730 to 1.9735 in.
Minimum permissible diameter	2.1345 in.	2.0445 in.	2.0015 in.	1.9715 in.
Clearance in bearings			.0025 to .0040 in.	
Maximum permissible clearance			.0065 in.	

Bearing Bores

Diameter	2.139 to 2.140 in.	2.049 to 2.050 in.	2.006 to 2.007 in.	1.976 to 1.977 in.
Maximum permissible diameter	2.141 in.	2.051 in.	2.008 in.	1.978 in.

Bearing Bores

Diameter	2.139 to 2.140 in.	2.049 to 2.050 in.	2.006 to 2.007 in.	1.976 to 1.977 in.
Maximum permissible diameter	2.141 in.	2.051 in.	2.008 in.	1.978 in.

Cams

Dimensions from the peak to the back of the cam (see Fig. 43 on page 20)	1.67837 in.
Minimum permissible dimension	1.653 in.

Camshaft Gear Spigot Diameter	1.2803 to 1.2808 in.
Camshaft End Float	.002 to .012 in.
Camshaft Thrust Plate Thickness	.253 to .258 in.

TIMING GEARS

Camshaft Gear

Bore diameter	1.2793 to 1.2803 in.
Shaft spigot diameter	1.2803 to 1.2808 in.
Fit on shaft	Zero to .0015 in. interference

Crankshaft Gear

Bore diameter	1.5315 to 1.5325 in.
Shaft spigot diameter	1.5320 to 1.5330 in.
Fit on shaft	.0005 in. clearance to .0015 in. interference

Air Compressor or Exhauster Gear

Bore diameter	.8637 to .8647 in.
Shaft diameter	.8647 to .8652 in.
Fit on shaft	Zero to .0015 in. interference

Idler Gear

Bush bore diameter	1.9995 to 2.0010 in.
Hub diameter	1.9980 to 1.9985 in.
Fit on hub	.001 to .003 in. clearance
Thrust washers (thickness)	.122 to .123 in.
End float	.003 to .009 in.

Backlash Between Gears

Camshaft and crankshaft gears	.0032 to .0058 in.
Crankshaft and idler gears	.0023 to .0072 in.
Idler and fuel pump gears	.0026 to .0064 in.

TIMING GEAR SHAFT AND HOUSING

Timing Gear

Bore diameter	.8637 to .8647 in.
Fit on timing gear shaft	Zero to .0015 in. interference

Shaft

Gear spigot diameter	.8647 to .8652 in.
Front bearing spigot diameter	1.1812 to 1.1815 in.
Rear bearing spigot diameter	.9843 to .9847 in.
Coupling spigot diameter	.7876 to .7881 in.

Housing

Front bearing bore diameter	2.4409 to 2.4421 in.
Rear bearing bore diameter	2.0470 to 2.0478 in.

Ball Bearing (Front)

Outside diameter	2.4404 to 2.4409 in.
Bore diameter	1.1807 to 1.1811 in.
Fit in housing	Zero to .0017 in. clearance
Fit on shaft	.0001 to .0008 in. interference

Ball Bearing (Rear)

Outside diameter	2.0466 to 2.0472 in.
Bore diameter	.9838 to .9842 in.
Fit in housing	.0012 in. clearance to .0002 in. interference
Fit on shaft	.0001 to .0008 in. interference

FLYWHEEL

Flywheel

Minimum permissible thickness – clutch friction face to bolt recess face after machining

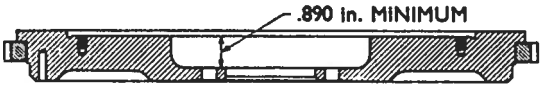
Run-out on rim	.005 in. Total indicator reading
Run-out on face	.004 in. Total indicator reading

Starter Ring Gear

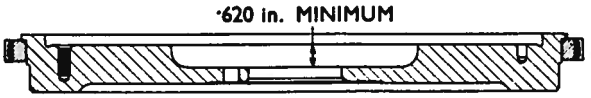
Number of teeth	134

Flywheel machining limit, four cylinder engines

Flywheel machining limit, six cylinder engines



Flywheel machining limit, four cylinder engine.



Flywheel machining limit, six cylinder engine.

TORQUE WRENCH DATA

Camshaft and Fuel Pump Gear Nuts	*80 to 100 lb.ft.
Connecting Rod Nuts	+55 to 60 lb.ft. – 60 to 65 lb.ft. (New Bolts)
Crankshaft Pulley Dog	*180 to 200 lb.ft.
Crankshaft Main Bearing Bolts	85 lb.ft.
Cylinder Head Nuts	
9/16 in.	†115 to 120 lb.ft.
5/8 in.	†145 to 160 lb.ft.
Cylinder Head Bolts	110 to 120 lb.ft.
Cylinder Head Studs	
9/16 in. diameter	*75 to 85 lb.ft.
5/8 in. diameter	*75 to 85 lb.ft.
Engine Front Mounting Bracket to Timing Gear Case	
3/8 in. bolts	*22 to 27 lb.ft.
7/16 in. nuts	*36 to 41 lb.ft.
1/2 in. nuts	*55 to 60 lb.ft.
Flywheel Bolts	*65 to 70 lb.ft.
Flywheel Housing	50 lb.ft.
Rocker Shaft Bracket Bolts	*40 to 45 lb.ft.

* Clean dry threads + Oiled threads † See Recommended Lubricants

STANDARD TORQUES

1/4 in. diameter	6 - 8 lb.ft.
5/16 in. diameter	13 - 15 lb.ft.
3/8 in. diameter	22 - 27 lb.ft.
7/16 in. diameter	36 - 41 lb.ft.
1/2 in. diameter	55 - 60 lb.ft.

RECOMMENDED LUBRICANTS

The following is a list of lubricants which the applicable oil manufacturers state are to the required specifications.

The order in which they appear does not imply any preference, nor is the list intended to be complete, as other oil manufacturers may produce oils to the required specifications.

Usage	BP	Castrol	Esso	Gulf	Mobil	Regent	Shell	Duckhams
*Engine	Energol DS1-20W	Castrol CR 20 or Deusol CR 20/1	Essofleet HDX 20/20W	Gulflube Motor oil HD 20/20W	Delvac oil S.120	Super RPM Delo Special SAE 20	Rotella T20/20W	Nol Diesel HD 20/1
Air Cleaner and Crankcase Breather	Energol SAE 50	Castrol Grand Prix	Essolube 40/50	Gulflube 50	Mobiloil BB	Havoline 50	Shell X-100 50	Nol 50
Clutch Fork Ball Clutch Release Bearing Sleeve Clutch Release levers Pins and Struts	Energrease C.3G	Castrol-ease Brake Cable Grease	Esso Graphite Grease	Gulfsil Grease G67/8G	Mobil Graphited Grease No. 3	Regent Grease 904	–	G.G. Grease or LBM 10 Grease
Brake Pedal Bearing Rollers	Energrease L2	Castrol-ease LM	Esso Multi-purpose Grease H	Gulfsil Grease G64A-2	Mobil-grease MP	Marfak Multi-purpose 2	Retinax A	LB 10 Grease
Main Drive Pinion Spigot Bearing Main Drive Pinion Splines Water Pump Bearings	Energrease N.3	Castrol-ease WB	Esso High Temperature Grease	Gulfsil Grease G64A-2	Mobil-grease No. 5	Marfak Multi-purpose 2	Retinax A or H	LB 10 Grease
Water Pump Seal	–	Castrol No. 3 Rubber Grease	TSD 803	–	–	–	Shell Rubber-Proof Grease	Q4590 Rubber Grease
Crankshaft Rear Bearing Oil Seals Cylinder Head Nuts, Studs and Washers		–	Esso MP Grease (moly)	–	Mobil-grease Special	–	Retinax AM	–
Camshaft Cams and Tappets Oil Pump Spindles Piston Pins Valve Stems	Acheson's Oildag							
Clutch Pedal Shaft	Duckham's Keenol							
Cylinder Liner Flanges Battery Terminals Earthing Points	Petroleum Jelly							

RECOMMENDED LUBRICANTS

OVERSEAS

Usage	Temperature Range	SAE Viscosity No.	GM Specification No.
*Engine	Above 32°C. (90°F.) 32° to – 12°C. (90° to 10°F.) –12° to –23°C. (10° to –10°F.)	30 20 10W	4712-M 4706-M 4705-M
Air Cleaner Crankcase Breather	0°C. (32°F.) 0°C. (32°F.)	50 20	4602-M or 4506-M 4603-M or 4501-M
Clutch Fork Ball Clutch Release Bearing Sleeve Clutch Release Levers Pins and Struts	All	–	4530-M
Brake Pedal Bearing Rollers	All	–	4534-M
Main Drive Pinion Spigot Bearing Main Drive Pinion Splines Water Pump Bearings	All	–	4616-M or 4617-M
Water Pump Seal	All	–	Castrol oil base grease harmless to rubber
Camshaft Cams and Tappets Oil Pump Spindles Piston Pins Valve Stems	All	–	Mineral oil containing colloidal graphite
Clutch Pedal Shaft	All	–	4550-M
Cylinder Liner Flanges Battery Terminals Earthing Points	All	–	4544-M
Crankshaft Rear Bearing Oil Seals Cylinder Head Studs, Nuts and Washers	All	–	Mineral oil base Grease containing molybdenum disulphide

*NOTE: Engine oils must be to a minimum standard in accordance with U.S. Defence Specification MIL-L-2104B.

TORQUE WRENCH DATA

INJECTOR SECURING NUTS	10-14 Nm (7 - 10 ft lbs)

D.P.A. Pumps (Mechanical)

DRIVE HUB SECURING SCREW	32 Nm (285 lb/in)
CAM ADVANCE SCREW	33 Nm (300 lb/in)
DRIVE PLATE SCREWS	18-19 Nm (160 lb/in)
TRANSFER PUMP ROTOR	7-8 Nm (65 lb/in)
END PLATE SCREWS	4-5 Nm (45 lb/in)
FUEL INLET ADAPTOR	81 Nm (720 lb/in)
FUEL INLET CONNECTION (STEEL END PLATE)	47-48 Nm (420 lb/in)
FUEL INLET CONNECTION (ALUMINIUM END PLATE)	41 Nm (360 lb/in)
HEAD LOCATING FITTING (WITH RUBBER GASKET)	33 Nm (300 lb/in)
HEAD LOCATING FITTING (WITH CORK GASKET)	39 Nm (350 lb/in)
HEAD LOCKING SCREWS	19-20 Nm (170 lb/in)
COVER SECURING NUTS	4-5 Nm (40 lb/in)
RIVE SHAFT SCREW (28.5 mm Long)	33 Nm (24 lb ft)
DRIVE SHAFT SCREW (31.7 mm Long)	36-37 Nm (27 lb ft)

D.P.A. Pumps (Hydraulic)

CAM ADVANCE SCREW	34 Nm (25 lb ft)
TRANSFER PUMP ROTOR	7-8 Nm (5.5 lb ft)
DRIVE PLATE SCREWS	18 Nm (13.3 lb ft)
END PLATE SCREWS	5 Nm (4 lb ft)
FUEL INLET CONNECTION	41 Nm (30 lb ft)
HEAD LOCATING FITTING (RUBBER GASKET)	33 Nm (300 lb/in)
HEAD LOCATING FITTING (CORK GASKET)	39 Nm (350 lb/in)
CAP NUT	15 Nm (130 lb/in)
HEAD LOCKING SCREWS	19 Nm (14 lb ft)
SPRING CAP & PISTON PLUG	28-29 Nm (21 lb ft)
PUMP SECURING-NUTS (BOTH TYPE GOVERNORS)	19 Nm (14 lb ft)
FUEL PUMP COVER (BOTH TYPE GOVERNORS)	10 Nm (7 lb ft)

In-Line Pumps

ELIVERY VALVE HOLDERS	54 Nm (40 lb ft)
BEARING HOUSING SCREWS	7-10 Nm (5-7 lb ft)
MOUNTING FLANGE SCREWS	7-10 Nm (5-7 lb ft)
CAMSHAFT NUT	62 Nm (46 lb ft)
BODY SCREWS	7 Nm (5 lb ft)
LIFT PUMP SECURING NUTS	16-20 Nm (12-15 lb ft)
BEARING	20-23 Nm (15-17 lb ft)
HOUSING SCREWS TO PUMP	7-10 Nm (5-7 lb ft)
REAR HOUSING TO FRONT HOUSING SCREWS	7-10 Nm (5-7 lb ft)
PUMP TO BRACKET	34 Nm (25 lb ft)
LIFT PUMP SECURING NUTS	7-10 Nm (5-7 lb ft)
INSPECTION COVER NUTS	5 Nm (4 lb ft)

Fuel Filter

FILTER TO BLOCK	30-37 Nm (22-27 lb ft)

Fuel Lines

FUEL LINE UNION	FINGER TIGHT + ⅓ TURN WITH WRENCH

2.0000

FUEL SYSTEM

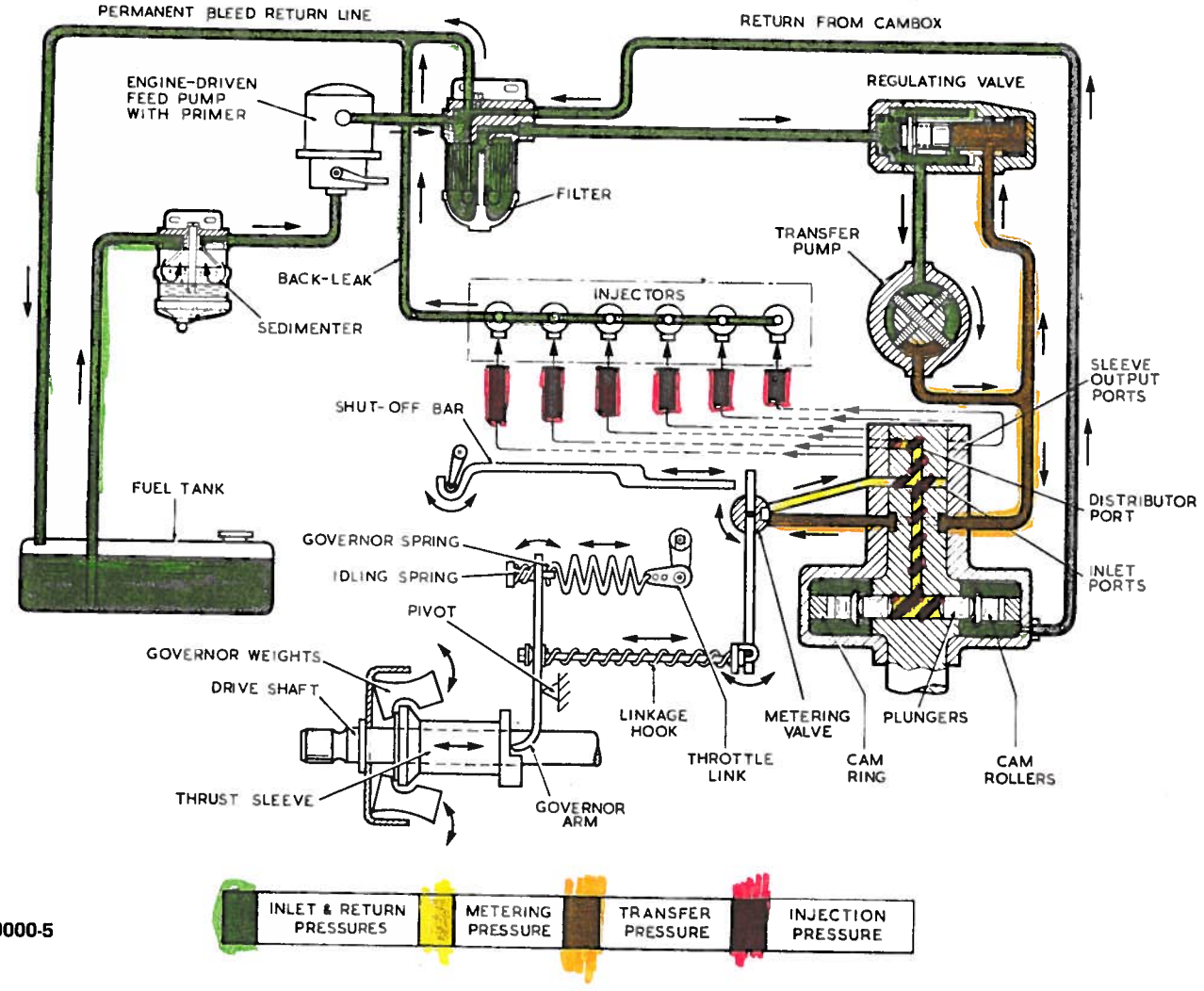
1. The performance of a diesel engine depends largely upon the proper functioning of its fuel injection system.

2. For maximum efficiency in operation, it is essential that the engine is supplied with its fuel quantities exactly timed and proportioned to the amount of work it is required to do.

3. The fuel system incorporates a governor controlled fuel injection pump, fuel lift pump, fuel filters and injectors.

4. Various types of fuel systems are used on GM Bedford Diesels. The 220 cu. in. using either an Inline pump manufactured by Simms Ltd or a DPA type manufactured by C.A.V. The 330 cu. in. uses either an Inline or DPA fuel pump both of which are manufactured by C.A.V. Limited.

5. A Typical fuel system utilising a DPA pump with a mechanical governor is shown below.



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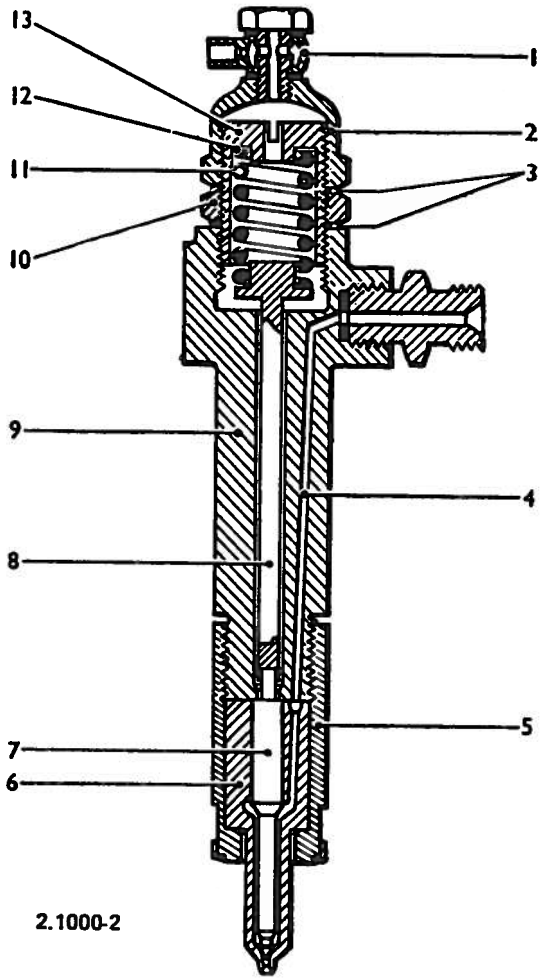
INJECTORS

INJECTORS (Description)

1. The injectors are located in sleeves pressed into the cylinder head. Each injector consists of two principal parts, a nozzle and valve and an injector body. The nozzle valve is held on its seat by a spring located in the injector body above the valve spindle. Four spray holes are provided in the tip of the nozzle to provide equal distribution within the combustion chamber.

2. Both 220 and 330 cu. in. engines utilise C.A.V. multi-hole injectors with the exception of 220 cu. in. engines with inline fuel injection pumps built prior to engine serial number 645685/P & I 2075. These engines used a Simms N1193 injector.



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C.A.V. Type

1. Leak off union.
2. Body cap nut.
3. Seal washers.
4. Fuel inlet passage.
5. Nozzle cap nut.
6. Nozzle.
7. Nozzle valve.
8. Nozzle valve spindle.
9. Injector body.
10. Spring cap locknut.
11. Nozzle valve spring.
12. Spring seat washer.
13. Spring cap nut.

NOTE: C.A.V. fuel injectors now have an externally threaded boss on the body for direct attachment to the injection pipe. No adaptor being used as illustrated.

INJECTORS (Removal)

3. Disconnect the leak off and high pressure pipes from the injectors as described in Section 2.5000.

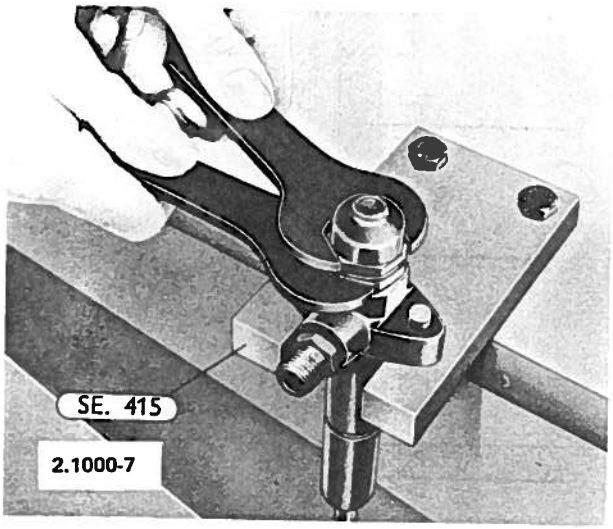
4. Unscrew the attaching nuts and remove the injectors from the cylinder head using puller D1122.

5. Place the injectors in a rack and deal with them in turn when testing and cleaning, to avoid intermixing the parts.

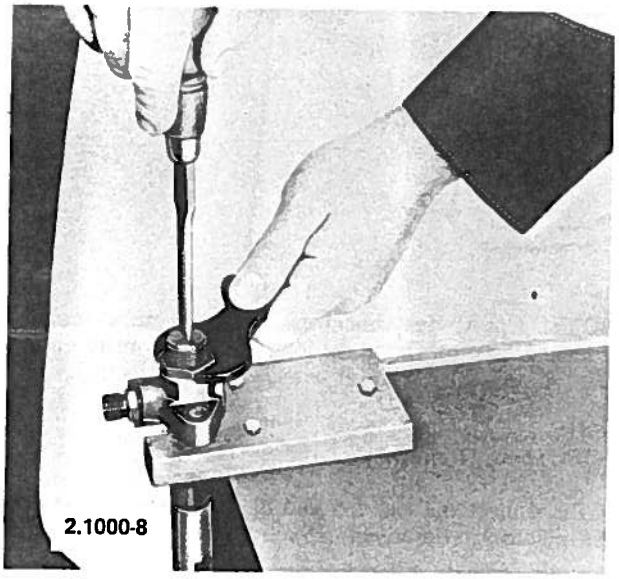
INJECTORS (Inspection and Overhaul)

6. Before disassembling the injector, it is advisable to clean away carbon from the nozzle, using a brass wire brush, and test the injector with suitable testing equipment for nozzle pressure setting and spray form, described on Page 4.

7. Place the injector on a holding jig SE415 and remove the injector body cap nut, seal washer and, on Simms Injectors, the spring cap nut and spring plate.

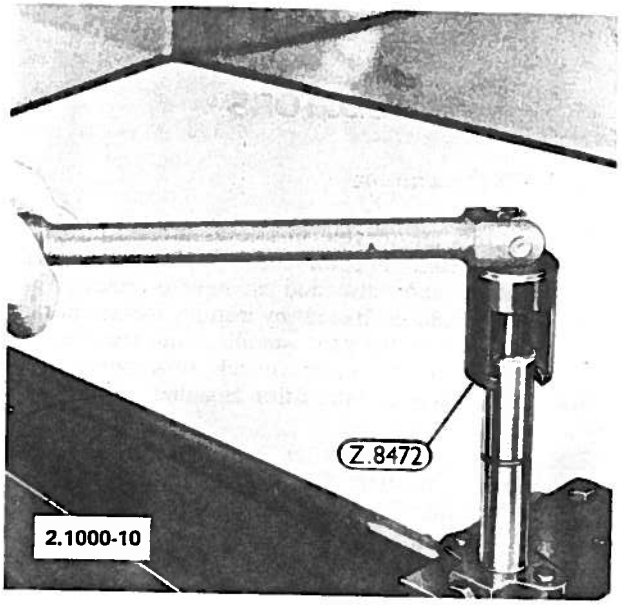


8. On C.A.V. injectors, remove the locknut, seal washer and spring cap nut.



9. Lift out the valve spring and seating washer, and the nozzle valve spindle.

10. Invert the injector and unscrew the nozzle cap nut, using wrench Z8472.

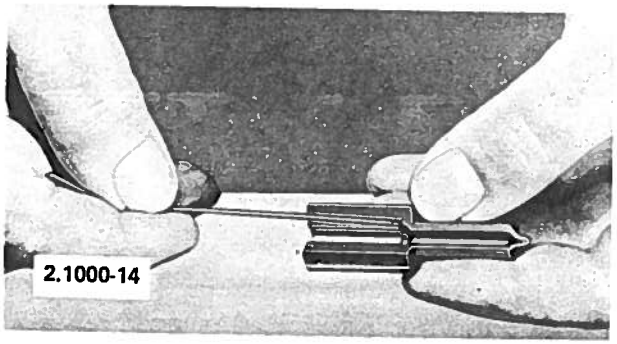


11. Remove the nozzle and valve, and immerse them in a tray containing Shell Fusus cleaning fluid, together with the nozzle holder body and the parts previously removed.

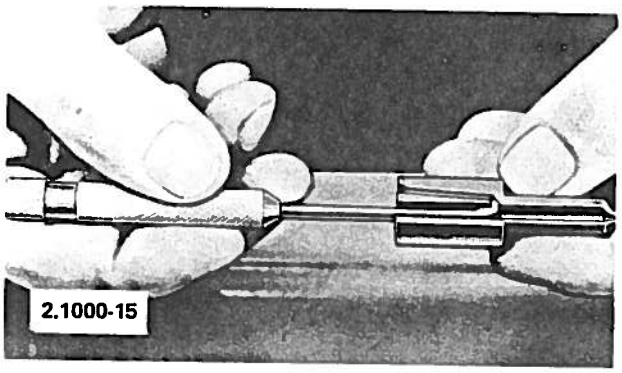
12. The injector components should be thoroughly cleaned using special cleaning equipment.

13. Using a brass wire brush and cleaning fluid, clean the remaining carbon from the exterior of the nozzle.

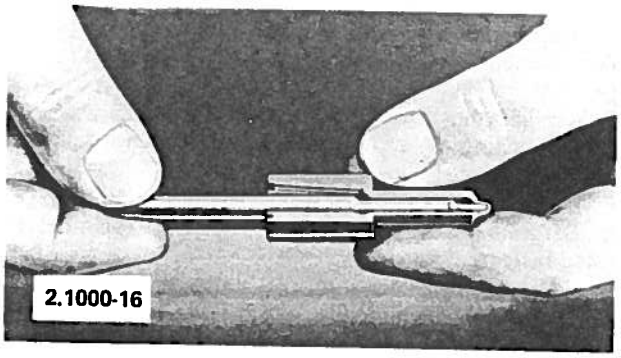
14. Clean out the three small feed channel bores in the nozzle with a drill or wire .067 in. diameter. These bores rarely become choked, and the insertion of a drill or wire will usually be sufficient to clear the channels. A sectioned nozzle is used to illustrate this operation.



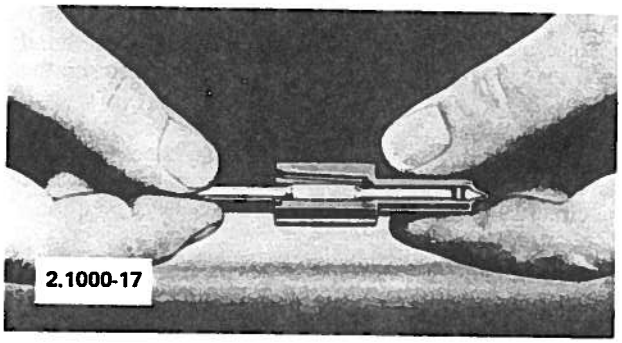
15. Taking care not to damage the valve spindle aperture, insert a nozzle groove scraper and remove any carbon adhering to the internal walls of the nozzle groove.



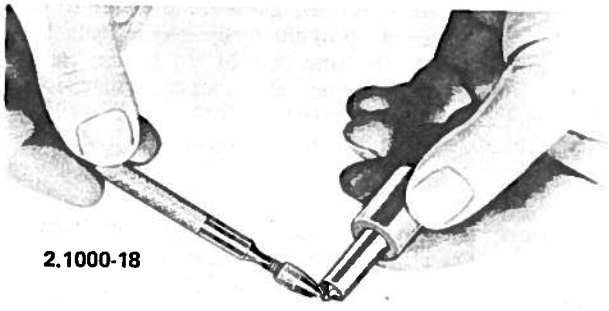
16. Clean the cavity in the nozzle dome below the valve seat, using a dome cavity scraper.



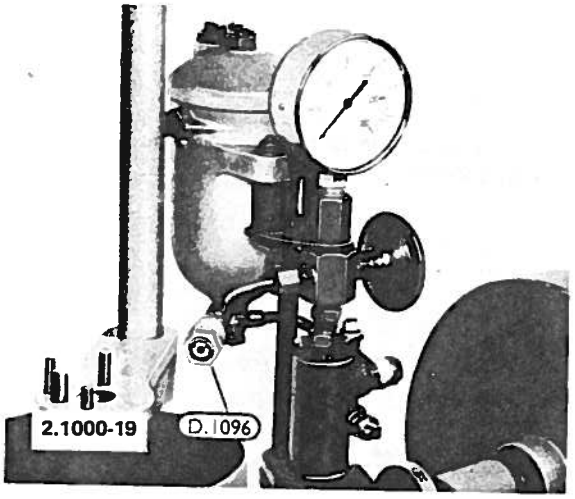
17. Using a nozzle seat scraper, clean all carbon from the valve seat.



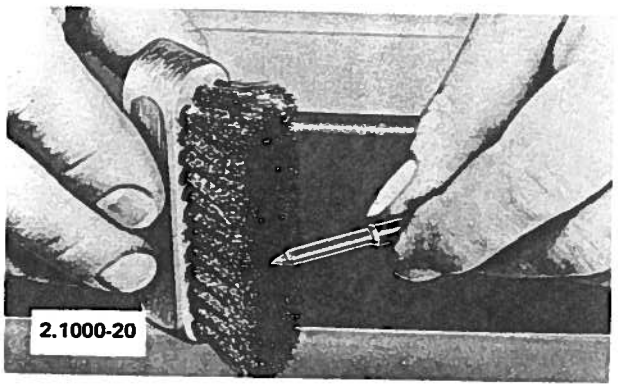
18. Clean the spray holes with a probing tool and cleaning wire.



19. Flush the nozzle, using flushing adaptor D1096 in conjunction with the testing equipment.

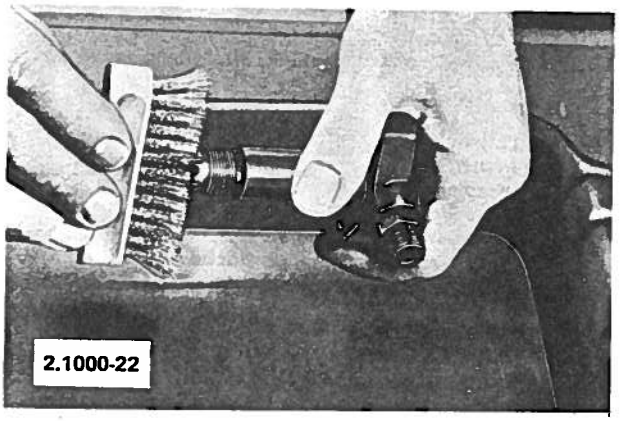


20. Clean the nozzle valve tip and stem using the brass wire brush.



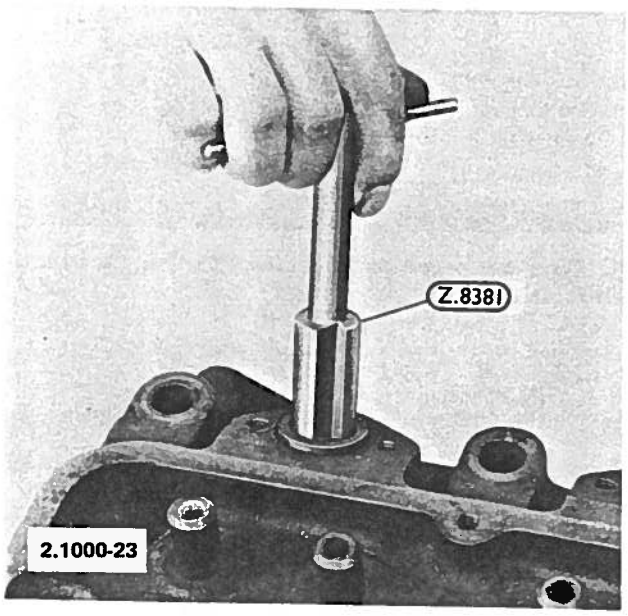
21. Check the nozzle for damage, and blueing due to overheating. If either of these conditions exist, the nozzle and valve must be renewed.

22. Ensure that the pressure surfaces of the nozzle and body are perfectly clean. These surfaces must register together to form a high pressure joint between the nozzle holder and the nozzle.

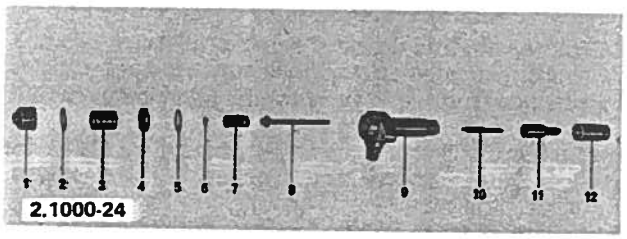


NOTE: In no circumstances must the valve and valve seat surfaces be reground, as this operation is a specialised process and any attempt without the necessary equipment will render the injector assembly useless.

23. Clean the injector sleeve and seat faces in the cylinder head, using cleaner Z8381. Use grease on the tool to prevent carbon dropping inside the head. If new sleeves are required see page 7 of section 1.2000.

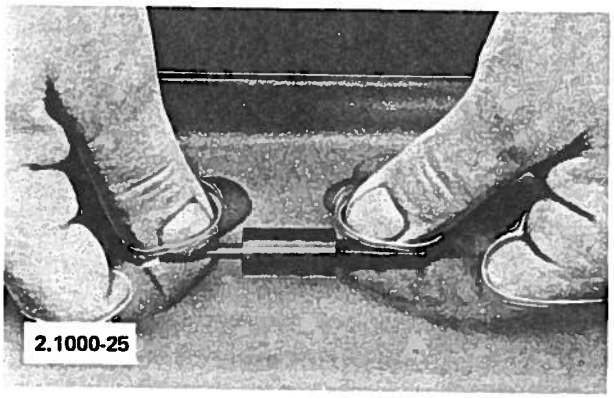


24. Before reassembling the nozzle valve to the body, flush the body through with clean Shell Fusus, or an equivalent cleaning oil to ensure that no particles of carbon remain in the body.



1. Body cap nut.
2. Seal washer.
3. Spring cap nut.
4. Spring cap locknut.
5. Seal washer.
6. Spring seat washer.
7. Nozzle valve spring.
8. Nozzle valve spindle.
9. Injector body.
10. Nozzle valve.
11. Nozzle.
12. Nozzle cap nut.

25. When assembling the nozzle valve into the nozzle, immerse both parts in cleaning fluid so that no dust in the atmosphere can fall on the mating surfaces. The valve must be a perfectly free sliding fit in the nozzle.



26. After ensuring that the pressure faces are clean, assemble the injector body and nozzle together so that the dowels in the injector body locate in the apertures in the nozzle pressure face. Replace the nozzle cap nut, taking care not to over-tighten.

27. Replace the valve spindle, spring and seat washer, spring adjusting cap nut and locknut, but do not tighten at this stage.

28. Before replacing the injectors the following tests should be carried out.

NOTE: When testing the injectors or working on the test equipment it is most important that the operators hands are not brought into contact with the spray as this has a strong penetrating force and can easily puncture the skin.

29. Connect the injector to the test equipment by means of the pressure pipe. Close the check valve to keep the pressure gauge out of the circuit and operate the hand lever several times in order to expel any air in the system.

30. To check the back leakage, open the check valve on the test equipment to bring the pressure gauge back into the circuit.

31. Set the injector opening pressure by means of the spring cap nut to within the limits of 180 to 200 atmospheres.

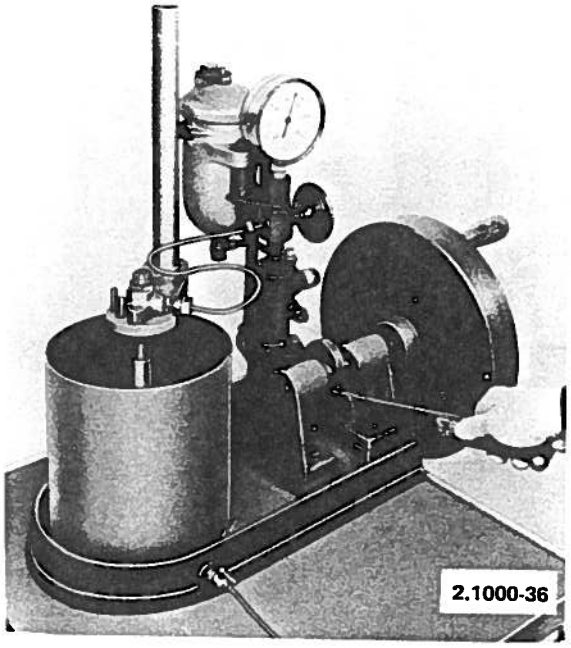
32. With the check valve still open, pump up again to just below this pressure.

33. Release the hand lever and allow the pressure to fall naturally, timing the drop of the gauge needle from 150 to 100 atmospheres. The time should not be less than 6 seconds, and not more than 60 seconds, when using Shell Fusus oil at a temperature of 50° – 70°F (10° – 21°C). These test figures are for injectors which have been in service.

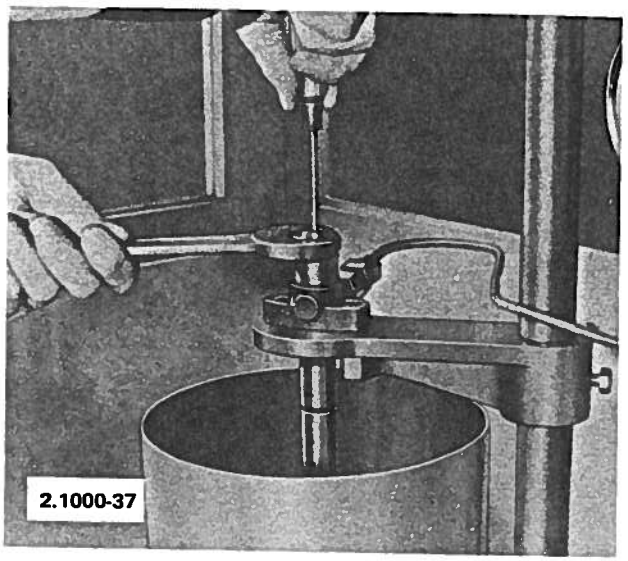
34. For new injectors the back leakage pressure to drop from 150 to 125 atmospheres at a temperature of 50° – 70°F (10° – 21°C) in not less than 10 seconds and not more than 45 seconds.

35. When carrying out this operation, check that no leakage occurs between the lapped pressure faces of the nozzle and the nozzle holder. If leakage does occur do not overtighten the nozzle cap nut in order to cure leakage, but slacken the spring cap nut right off, remove the nozzle cap nut and re-examine the pressure faces for signs of foreign matter or surface imperfections. Clean thoroughly, and if all appears correct, replace the components and reset. If the pressure drop time is still low, this indicates excessive leakage past the lapped portion of the valve, and both the valve and the nozzle should be renewed.

36. To set the pressure at which the valve should open, slowly move the hand lever downwards and carefully watch the pressure gauge for the highest recorded pressure before the needle flicks, indicating the opening of the valve. Any adjustment is effected by releasing the locknut and moving the spring cap nut inwards to increase pressure or outwards to decrease pressure.



37. On the Simms injectors the spring cap nut is accessible through the leak off hole.



38. The delivery pressure should be 175 atmospheres.

39. With the nozzle tip dry build up the pressure to 10 atmospheres below the delivery pressure set in the previous operation. The nozzle tip must remain dry and there must be no tendency for blobs of fuel to collect or drip. Slight dampness may be ignored.

40. The spray form should now be checked, with the check valve closed, operate the hand wheel at approximately 90 r.p.m. carefully observe the shape and nature of the sprays. The sprays should be finely atomised and have equal penetration into the surrounding atmosphere, and be free from coarse or solid streaks.

NOTE: The test equipment is not regarded as providing a suitable check for atomisation under working conditions, but merely gives an approximate indication of the working of the injector.

INJECTORS (Refitting)

41. Use new copper seating washers. Insert the injectors into the cylinder head and ensuring they are squarely on their seats tighten the securing nuts finger tight.

42. Finally, tighten the nuts evenly to a torque of 7-10 lbs.ft.

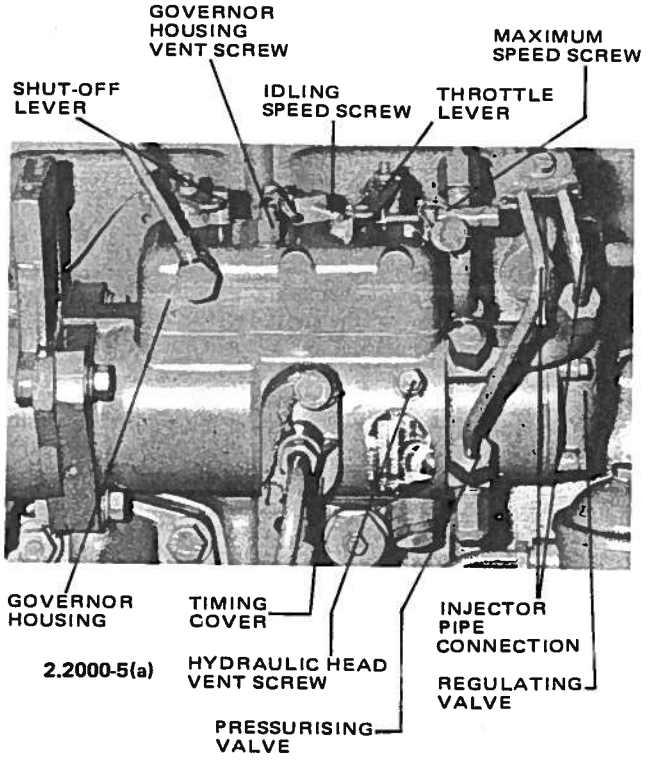
43. Before connecting the fuel pipes to the injectors, detailed in section 2.5000, rotate the engine with the starter to check for blow past the seat seal washer. If this condition is apparent, the securing nuts must be slackened and retightened to obtain a perfect joint.

2.2000

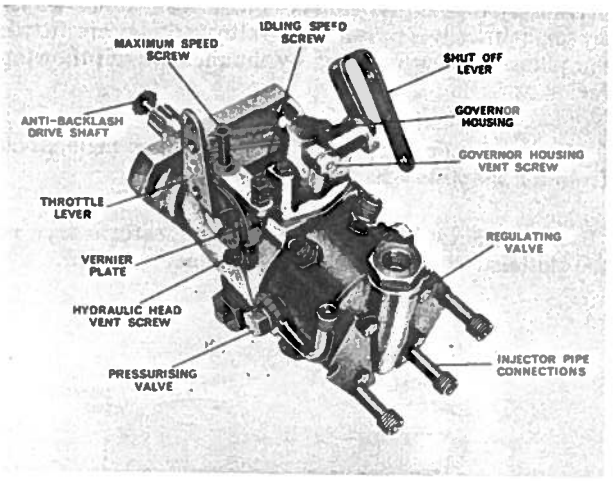
FUEL INJECTION PUMP DPA TYPE

DPA FUEL PUMP (Description)

1. The D.P.A. distributor type fuel injection pump manufactured by C.A.V. Limited, incorporates a sensitive all-speed governor, which forms a compact unit.
2. It is relatively simple in design and contains no ball or roller bearings, gears or highly stressed springs.
3. The pump is arranged for flange mounting on the engine, and is driven by a splined shaft. It is a self-contained, oil-tight, unit requiring no external lubrication system. The pump housing is completely filled with fuel oil under pressure during operation, so that all parts are adequately lubricated. Pressure maintained within the pump housing prevents the formation of air locks and the ingress of dust, water or other foreign matter which might impair the efficiency of the pump.
4. Pumping is effected by a single element, having twin opposed plungers, situated transversely in a central rotating member which also acts as a distributor. The rotor revolves in a stationary member, known as the hydraulic head. The pump plungers are operated by contact with cam lobes on a stationary internal cam ring. The fuel is accurately metered entering the pumping element, and the high pressure charges are distributed to the engine cylinders in correct firing order and at the required timing intervals through a system of ports in the rotor and the hydraulic head.
5. A mechanical fly-weight governor (a) or alternatively a simple hydraulic type (b) is embodied in the pump to give accurate control throughout the complete speed range of the engine and under all conditions of engine loading.

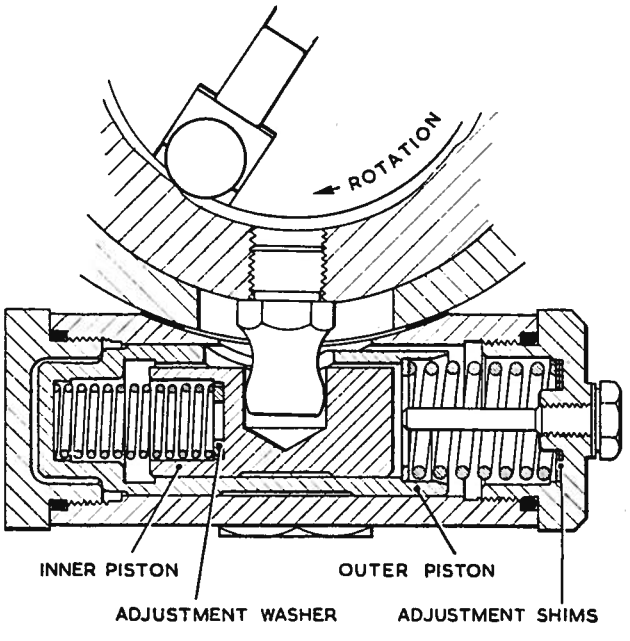


2.2000-5(a)



2.2000-5(b)

6. An automatic advance mechanism may also be fitted, if required to vary the point of commencement of injection.



2.2000-6

7. The employment of a single pumping element ensures uniformity of delivery to each of the engine cylinders and obviates the need to balance the deliveries from each of the high pressure delivery pipes necessary with all multi-element pumps.

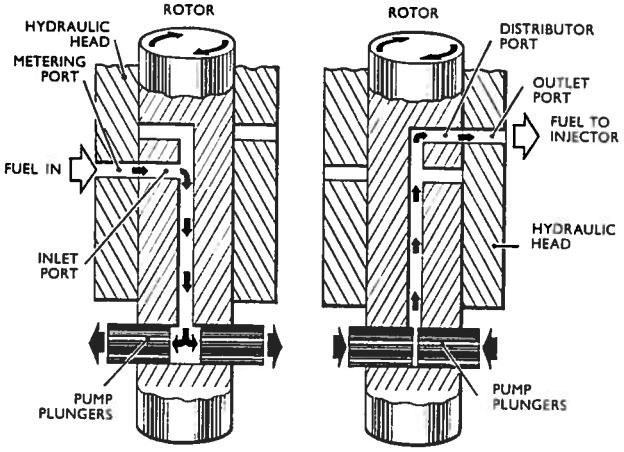
The Working Principle

8. The opposed plungers are actuated by cam rollers carried in shoes sliding in the rotor body. The cam ring is carried in the pump housing and has as many lobes as there are engine cylinders. The plungers move inwards

simultaneously as the rollers contact cam lobes which are diametrically opposite. No return springs are fitted, the plungers being returned by the pressure of inflowing fuel.

9. The working principle of the pump can be understood from the simplified diagrams below.

10. In 'A' the pumping and distributing rotor is seen in the stationary hydraulic head in the 'inlet' position.



A. Inlet Stroke B. Injection Stroke

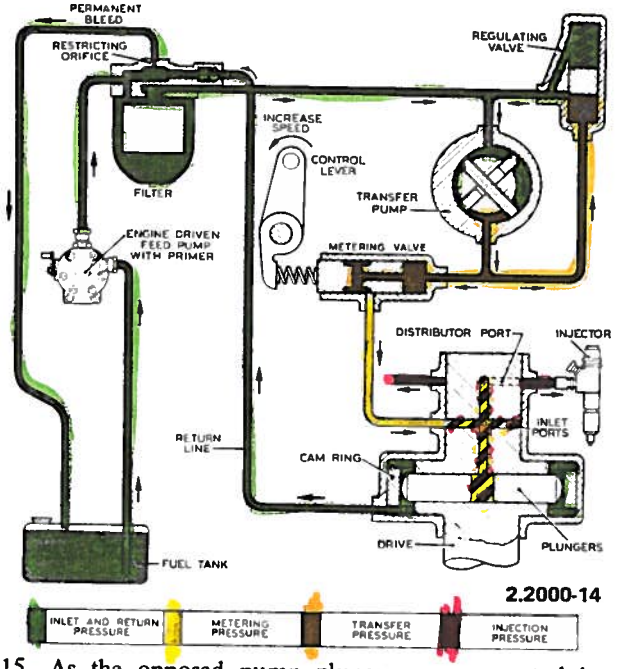
2.2000-10 2.2000-12

11. The pump plungers move outwards, under pressure of the fuel flowing in from a port in the hydraulic head known as the metering port, through an inlet port in the rotor to a central axial passage opening to the plunger chamber.

12. As the rotor turns, the inlet port is cut off 'B', and a second radial hole in the rotor, known as the distributor port, registers with an outlet port in the hydraulic head. At the same time the plungers make contact with the cam lobes, are forced inwards, and fuel passes up the central bore and out to one of the injectors.

13. In the rotor there are as many inlet ports as there are engine cylinders and a similar number of outlet ports in the hydraulic head.

14. When oil enters the main fuel inlet connection, it passes through a sliding vane transfer pump carried on the rotor inside the hydraulic head, through a metering valve and through fuel passages to the pumping element. The transfer pump increases the pressure of the fuel oil, and the metering valve, actuated by the engine control lever or by the governor, regulates the quantity of oil delivered to the pumping element.



2.2000-14

15. As the opposed pump plungers are separated by inflowing fuel, their outward displacement is determined by the amount of fuel oil delivered, which varies in accordance with the setting of the fuel metering valve. In consequence the rollers which operate do not follow the contour of the internal cam ring entirely but contact the cam lobes at points which vary according to the amount of plunger displacement. The maximum amount of fuel delivered at one charge can thus be regulated by restricting the outward limit of travel of the plungers.

16. The contour of the cam provides for relief of the pressure in the injector lines at the end of the injection cycle, and prevents 'dribble' at the nozzles.

17. The timing interval between pump injection is governed by the accurate spacing of the cam lobes and the delivery ports.

18. The pump rotor, is rotated by a splined drive shaft, driven by the engine through a splined coupling.

19. The end plate of the pump, mounted on the hydraulic head, houses a priming and regulating valve assembly, the functions of which are given in detail later.

20. On mechanically governed pumps, the governor weight assembly is mounted on the drive shaft and is completely contained within the pump housing. Suitable linkage transmits the movement of the governor weights to the control lever on the metering valve, the governor mechanism being enclosed in a cover mounted on the pump body.

21. The governor of a hydraulically governed pump is contained in a housing mounted on the pump body, the metering valve being operated by fuel at transfer pressure. A pump with this type of governor is smaller than the mechanical pump, but the pumping and distributing units are similar.

22. Apart from small losses which occur during the injection stroke, the total volume of fuel introduced into the element is passed to an injector. Metering is effected, therefore, by regulating the volume of fuel entering the element at each charging stroke. The volume of the charge is governed by two principal factors – the fuel

pressure in the metering port and the time available for fuel to flow into the element which the inlet port in the rotor and the metering port in the hydraulic head are in register. It is by controlling the pressure in the metering port that accurate metering is achieved.

23. Fuel oil enters the fuel injection pump at feed pressure and passes into the transfer pump which boosts the pressure to a level known as transfer pressure.

24. Transfer pressure is related to engine speed, and rises as the speed of rotation is increased. A predetermined relationship between transfer pressure and the speed of rotation is maintained by a regulating valve situated in the end plate of the pump.

25. Fuel at transfer pressure passes through passages in the hydraulic head to a metering valve which controls the flow of fuel through a metering port. The effective area of the metering port is controlled by movement of the metering valve, this being connected by suitable control linkage to the throttle pedal and the governor.

26. A pressure drop occurs as fuel passes through the metering orifice reducing the fuel pressure to a level known as metering pressure. The smaller the metering orifice the greater will be the decrease in pressure and vice versa.

27. Fuel at metering pressure passes to the inlet port, through an obliquely drilled passage in the hydraulic head.

28. At idling speeds both transfer pressure and metering pressure are at their minimum value. Opening of the throttle moves the metering valve element to a position where the effective area of the metering port is increased. This brings about an increase in metering pressure and a consequent increase in the quantity of fuel entering the pumping element at each charging stroke. The engine will then accelerate in response to increased fuelling until a speed corresponding to the position of the throttle is attained.

29. If the throttle is then closed, the effective area of the metering orifice is reduced, and engine speed will fall as the result of decreased fuelling.

30. When an engine is running at a fixed speed setting, the governor controls the position of the metering valve and maintains the selected speed within close limits by causing compensating changes of fuelling.

DPA FUEL INJECTION PUMP (Removal)

31. Throughly clean the area of engine which surrounds the fuel injection pump also the pipes from the fuel injection pump, this will prevent the ingress of dirt into the fuel system.

32. Disconnect all of the pipes from the fuel pump. When removing the fuel pipe between the fuel filter and fuel pump cover plate, on mechanically governed pumps, a tray should be placed underneath to catch the fuel oil. Check that the timing mark line is engraved across the pump carrier bracket and the fuel pump mounting bracket. Remove the throttle linkage and shut off all connections from the fuel pump levers, also any return springs that may be fitted.

33. Remove the three screws which secure the fuel pump to the fuel pump carrier bracket, the fuel pump can now be withdrawn by grasping and pulling the drive from the coupling.

DPA FUEL PUMP (Inspection and Overhaul)

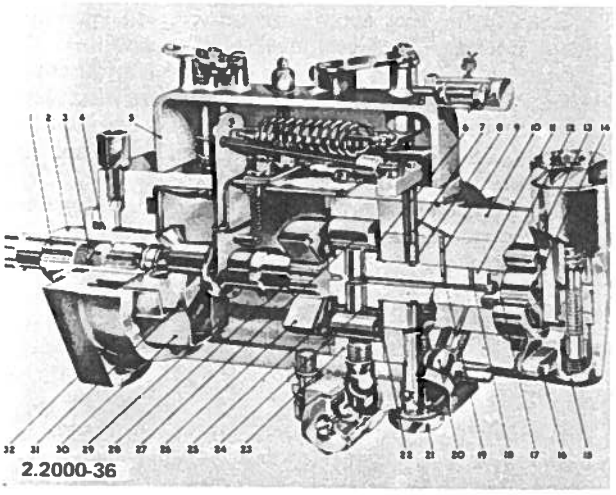
General Information

34. Dismantling, assembly and testing and adjustment of the pump are operations which demand the services of specially trained personnel and the use of certain special tools and apparatus.

35. Conditions of scrupulous cleanliness must be maintained in workshops where a pump overhaul is carried out, since even the smallest of abrasive dust particles can cause damage to the pump, impair its efficiency and considerably shorten its satisfactory working life.

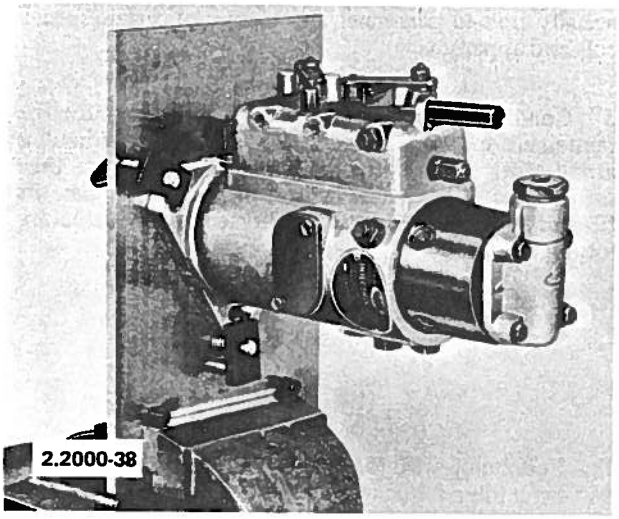
DPA Fuel Pump with Mechanical Governor

36. Dismantling sequence (annotations refer to 2.2000 – 36).

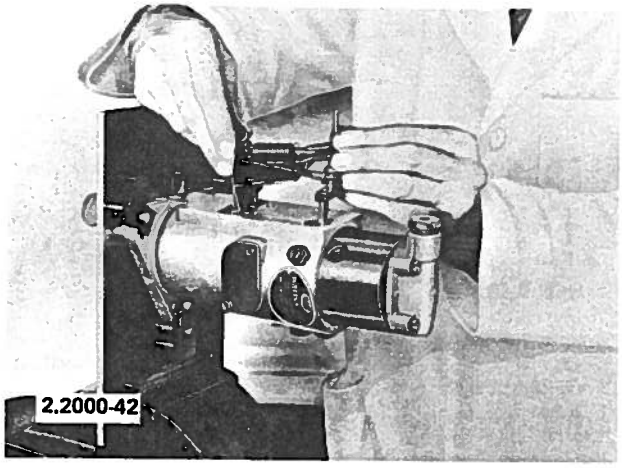


1. Quill shaft.
2. Drive hub.
3. Spring washer.
4. Oil seal.
5. Oil tight cover.
6. Adjusting plate.
7. Metering valve.
8. Metering valve chamber.
9. Metering port.
10. Hydraulic head.
11. Pumping & distributing rotor.
12. Transfer pump liner.
13. Oil seal.
14. Transfer pump rotor.
15. End plate.
16. End plate retaining bolt.
17. Sliding blades.
18. Distributor port.
19. Radial holes.
20. Injector pipe connections.
21. Head locating fitment.
22. Shoes.
23. Cam ring.
24. Pump plungers.
25. Adjusting plate.
26. Splined drive plate.
27. Cam rollers.
28. Drive shaft.
29. Thrust sleeve.
30. Carrier.
31. Governor weights.
32. Pump housing.

37. Remove the inspection cover from the side of the pump housing and drain pump.
38. Remove the quill shaft (1) and then secure the pump on the dismantling and assembly fixture, Part No. 7244/155, as illustrated below.



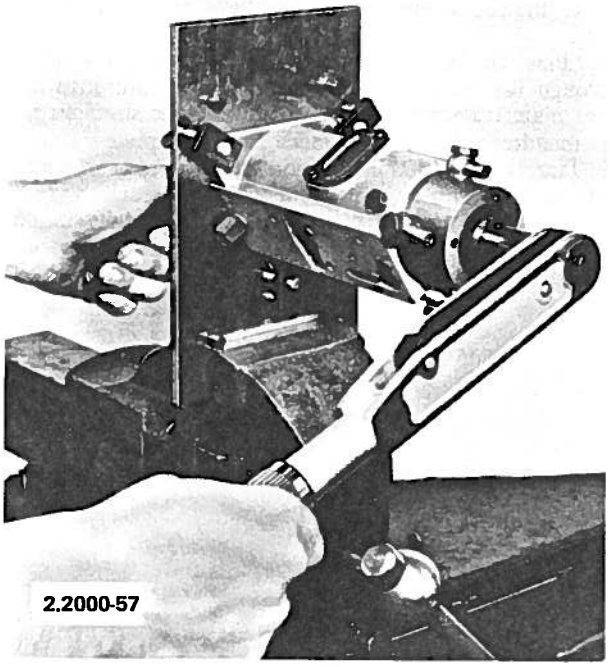
39. Remove the 'shut-off' and throttle levers from the control shaft.
40. Remove the two acorn nuts securing the governor control housing (5). Exert downward pressure on the throttle shaft while removing the governor control cover.
41. Knock down the tabs on the tab washers which lock the two governor control cover studs, and then remove the studs, the keep plate fitted beneath them, and the small screw securing the governor bracket.
42. Lift the complete governor control linkage, together with the metering valve (7) and the 'shut-off' arm from the pump housing.



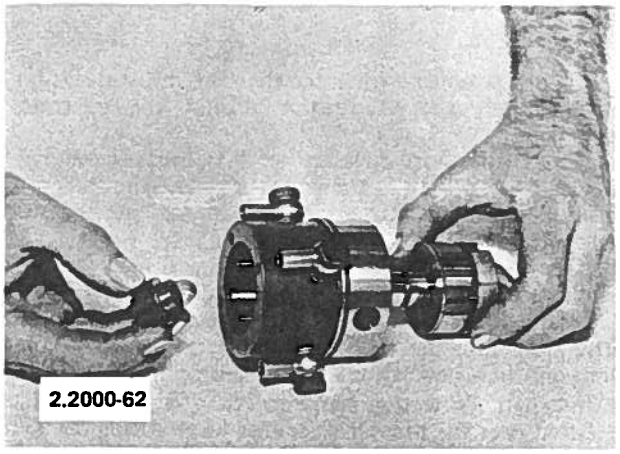
43. Disconnect the metering valve from the hook lever and protect the precision ground surface from damage and corrosion by immersing it in a bath of clean fuel oil.
44. Dismantle the control linkage.

45. When fitted, remove the automatic advance device as follows:-
46. Reverse the fixture in the vice so that the advance device is uppermost, and remove the nut from the advance device securing stud (if device has two point fixing).
47. Remove the cap and springs.
48. Unscrew the head locating fitting (21) withdrawing the advance device housing as the fitting is unscrewed.
49. Remove and discard the sealing gasket.
50. Unscrew the piston plug.
51. Withdraw the piston.
52. Withdraw the head locating fitting from the advance device housing and remove the washer and lower 'O' seal from the fitting. Care must be taken to ensure that the steel ball does not fall from the head locating fitting and sustain damage.
53. Dismantle the end plate, remove the fuel inlet connection and the spring fitted immediately below it.
54. Unscrew the four screws securing the end plate to the hydraulic head, lift off the end plate and remove the synthetic rubber seal fitted beneath it.
55. Invert the end plate and the complete valve assembly will fall from the valve chamber.
56. Lift the transfer pump vanes from the slots in the transfer pump rotor and then withdraw the transfer pump liner.

57. Hold the drive hub with Tool, Part No. 7144/773 and slacken the transfer pump rotor by using Tool, Part No. 7044/889. Do not remove the rotor at this stage.

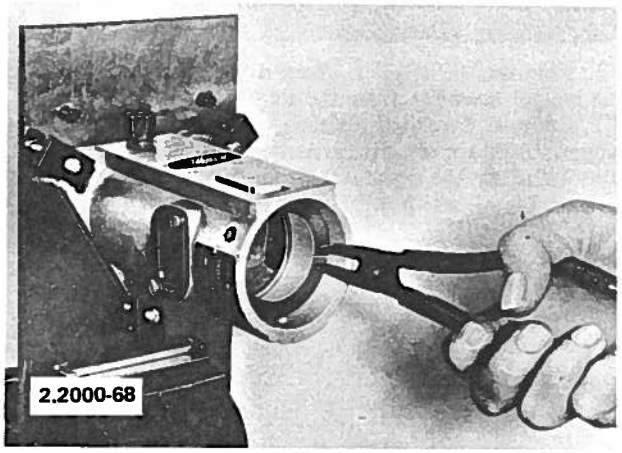


58. Remove the two head locking screws, and the single head locating screw. In pumps fitted with an automatic advance device the head locating screw is replaced by the head locating fitting which is removed with the advance device.
59. Remove the hydraulic head and the rotor as an assembly.
60. Hold the drive plate with Tool Part No. 7144/744 and slacken the two drive plate screws with Tool Part No. 7144/511A.
61. Remove the 'O' Seal from the annular groove in the periphery of the hydraulic head.
62. Unscrew the transfer pump rotor, and separate the pumping and distributing rotor from the hydraulic head. Do not allow the cam rollers to drop out.

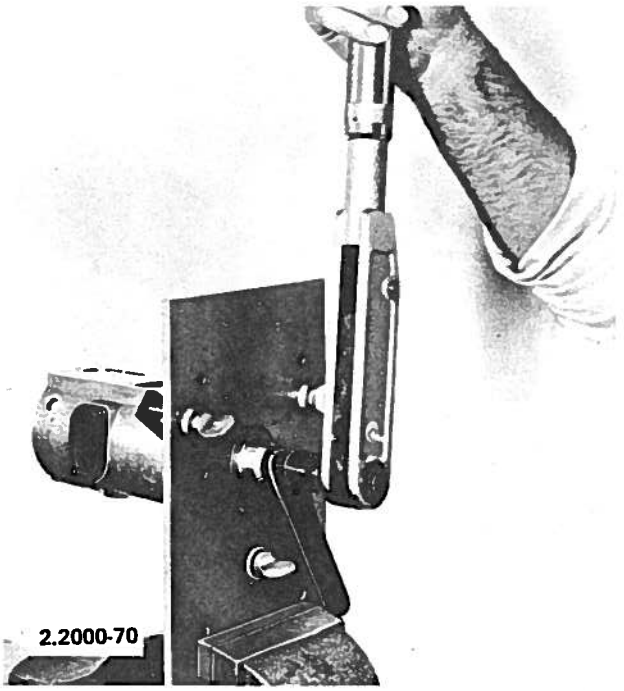


63. Remove the drive plate screws, thus releasing the drive plate, and dismantle the top and bottom adjusting plates and the actuating rollers and shoes from the rotor. Immerse the actuating rollers and shoes in clean fuel oil to protect them from damage and corrosion.

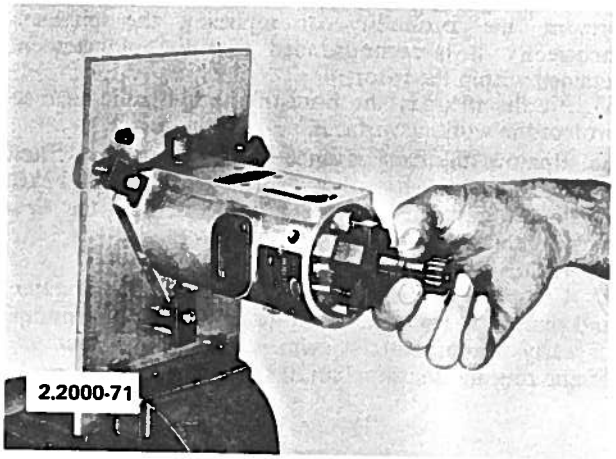
64. Retain the two pumping plungers in the bore of the rotor by two corks inserted in place of the actuating rollers. The pump plungers are mated to the bore and to prevent the possibility of replacing the plungers incorrectly it is recommended that the plungers be retained within the rotor.
65. Fit the rotor in the bore of the hydraulic head to protect the working surfaces.
66. Remove the cam advance screw from pumps fitted with advance devices using Tool, Part No. 7244/125B. When no advance device is fitted, remove the cam locating screw.
67. Withdraw the cam ring.
68. Compress the timing ring or circlip with circlip pliers and remove it from the pump housing. On some pumps of early manufacture a shim was fitted between the timing ring and the shoulder in the pump housing.



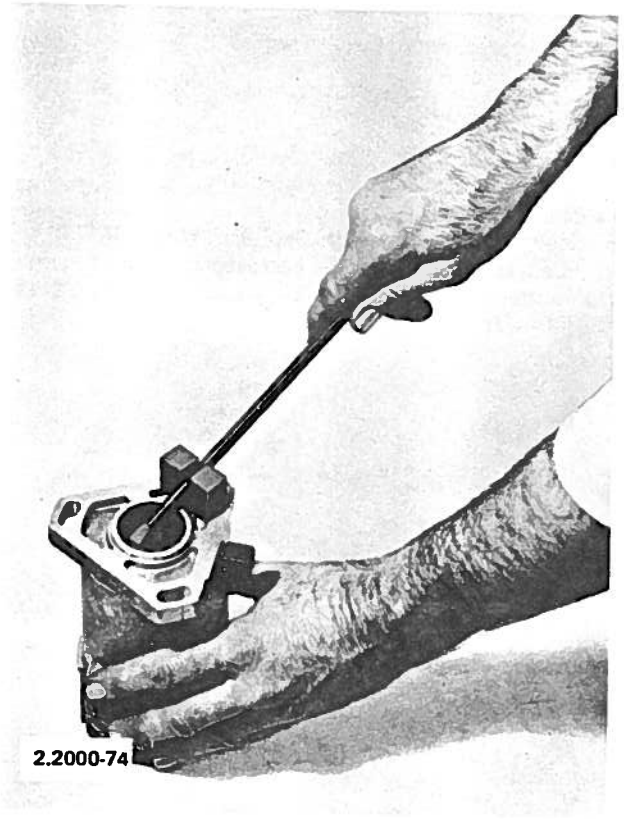
69. Hold the drive hub with Tool, Part No. 7144/773.
70. Slacken and remove the hub securing screw together with support washer and spring washer, using Tool, Part No. 7144/261.



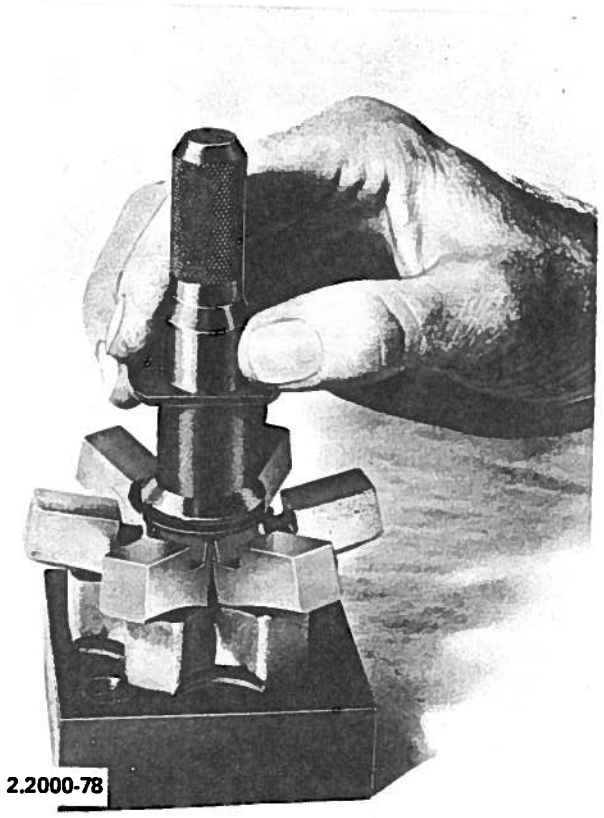
71. Withdraw the splined shaft together with the governor weight assembly.



72. Remove the 'O' seal from drive shaft and separate the weight assembly from the shaft.
73. Remove the thrust sleeve, thrust washer, and the weights from the weight carrier.
74. Withdraw the drive hub from the pump housing and extract the oil seal using Tool, Part No. 7044/893A.



75. Any parts which are showing any signs of scoring or wear should be replaced, also all seals and gaskets should be replaced with new parts.
76. Fit a new drive hub oil seal, driving it onto its seat with the special drift, Part No. 7144/260A. Insert the Perspex plug, Part No. 7144/13 in the seal. If the seal is correctly seated a continouous black line will be seen where the seal is viewed through the flanged end of the plug.
77. Pass the mandrel of Tool, Part No. 7144/894 through the weight carrier and fit the mandrel into the base plate trapping the carrier between the shoulder on the mandrel and the upper face of the base plate.
78. Place the weights in position on the upper surface of the weight carrier with the slot in each weight uppermost and nearest the mandrel. Each weight should be aligned with a carrier pocket and with its inner end resting against the mandrel.



79. Place the thrust washer and then the thrust sleeve on the mandrel, and in position against the governor weights.
80. Exert downward pressure on the thrust sleeve and the assembly will enter the weight carrier. Withdraw the mandrel and remove the assembly from the base plate of the tool.
81. Pass the drive hub through the oil seal in the pump housing, seating the hub flange against the housing.
82. With the governor weights uppermost, insert the drive shaft into the weight carrier (large threaded hole first) and fit a new 'O' seal in the groove in the surface of the shaft. Protection cap, Part No. 7044/900 should be fitted over the drive shaft splines when fitting the 'O' seal.
83. Slide the drive shaft and weight assembly into the pump housing and engage the drive shaft splines with the splines in the inner end of the drive hub. In this position the weight carrier is trapped between the end face of the drive hub and a shoulder on the drive shaft.

84. Fit the support washer in the recess between the two sets of splines in the drive hub, and secure the drive shaft to the drive hub by fitting the spring washer and socket head drive shaft screw.
85. Hold the drive hub with a special tool, Part No. 7144/773 and tighten the hub securing screw to a torque value of 285 lbs/in. using the adaptor Part No. 7144/261 and a standard torque wrench.
86. Compress the timing ring with the circlip pliers and seat it against the shoulder in the bore of the pump housing. The scribed timing mark should be positioned in the centre of the inspection aperture in the housing. Rings without a timing mark should be positioned so that the open ends of the circlip are at 180 degrees to the inspection aperture.
87. Place the cam ring in position against the timing ring. The direction indicated by an arrow on the visible face of the cam ring, should correspond with the direction of pump rotation marked on the nameplate.
88. Screw the cam advance screw into the cam ring and tighten to a torque value of 300 lbs/in. using the special adaptor Part No. 7244/125B or a socket and a standard torque wrench.
89. Place the bottom adjusting plate in position on the pumping and distributing rotor.

NOTE: In the correct position of assembly the 'cut-out' in the periphery of the adjusting plate is aligned with the 'cut-out' in the periphery of the rotor, and the eccentric slots in the adjusting plate are in line with the roller shoe guides.

90. Remove the corks retaining the twin plungers in the transverse bore in the rotor and insert the roller and shoe assemblies in the roller shoe guides. The contours of the projecting ears on the shoes should conform with the contour of the eccentric slots in the adjusting plate.
91. Fit the top adjusting plate, engaging two lugs with the bottom adjusting plate, locating the two plates one to the other with the adjusting slot co-incident with the scribed line.
92. Secure the drive plate to the end of the rotor by fitting and lightly tightening the two drive plate screws. The underside of the drive plate is recessed.
93. Fit the pumping and distributing rotor in the bore of the hydraulic head and secure by fitting and lightly tightening the transfer pump rotor.
94. Fit Tool Part No. 7144/262, to two of the high pressure outlets on the hydraulic head and connect to a nozzle testing outfit until a pressure of 30 atm. is obtained and turn the pump rotor until the plungers and the roller shoes are forced to the maximum fuel position. Set the roller-to-roller dimension in accordance with the test specification by moving the adjusting plates.
95. Hold the drive plate with Tool Part No. 7144/744 and tighten the drive plate screws to a torque value of 160 lbs./in. on plungers with a diameter up to and including 7.5 mm, using a standard torque wrench.

NOTE: For plunger diameters larger than 7.5 mm. refer to local C.A.V. dealer for torque value.

96. Disconnect the nozzle testing outfit and remove the stirrup pipe from the high pressure outlets on the hydraulic head.
97. Fit the external 'O' seal on the hydraulic head and lubricate the portion of the head which fits into the pump housing.
98. Slide the hydraulic head into the pump housing, engaging the splines on the inner end of the drive shaft with those of the drive plate. Rotate the head and rotor assembly to prevent damage to the 'O' seal as it enters the pump housing.
99. Secure the hydraulic head to the housing with the two locking screws. These screws should be left finger-tight until the advance device has been fitted.
100. Hold the drive hub with Tool, Part No. 7144/773 and tighten the transfer pump rotor to a torque value of 65 lbs./in. using Tool, Part No. 7044/889, and a standard torque wrench.
101. Fit the transfer pump liner in the counter bore in the end of the hydraulic head and the pump vanes in the slots of the transfer pump rotor. Rotate the liner to ensure that the vanes do not bind on the liner.
102. Assemble the end plate as follows:-
103. Place the priming spring in the base of the end plate chamber.
104. Fit new washer to regulating sleeve.
105. Insert the regulating piston into the bore of the regulating sleeve.
106. Holding the regulating sleeve so that the larger diameter is uppermost, insert the regulating spring above the piston and then insert the spigoted end of the sleeve plug to transfer pressure regulator if fitted.
107. Pass the nylon filter over the regulating valve assembly and insert the assembly, small end first, into the end plate ensuring that the regulating piston is retained within the regulating sleeve.
108. Fit the retaining spring.
109. Fit a new 'O' seal in the recess in the end face of the hydraulic head.
110. Engage the dowel on the inner face of the end plate with the slot in the transfer pump liner and then secure the end plate to the hydraulic head by fitting the four end plate screws. Tighten screws to a torque value of 45 lbs./in.
111. On a pump fitted with a steel end plate proceed as follows:-
Fit the sealing washer on the fuel inlet adaptor and screw it into the end plate. Tighten to a torque value of 720 lb./in. (8,2 kg.m.). Place the gauze filter in the fuel inlet adaptor and secure in place by fitting and tightening the fuel inlet connection to a torque value of 420 lb./in. (4.85 kg.m.).
112. If an aluminium end plate is fitted to the pump, then use the following assembly sequence:-
Fit a new washer to the fuel inlet connection, assemble to the end plate, and secure by tightening the fuel inlet connection to a torque value of 360 lb./in. (4.15 kg.m.).
113. Fitting the automatic advance device unit, proceeding as follows:-
114. Fit new 'O' seal to the piston spring cap, and the piston plug using protection cap, Part No. 7044/898.
115. Screw the piston plug into the device at the end where the fuel passage joins the cylinder.
116. Insert the piston in the bore of the housing with counterbored end outwards, and check for freedom of movement.
117. Fit the upper 'O' seal on the head locating fitting,

protecting the seal from damage by using the protection cap, Part No. 7044/897.

118. Place the end steel ball on its seating in the head locating fitting and then pass the fitting through the advance device housing.

119. Fit the lower 'O' seal and the washer on the head locating fitting, protecting the seal by using protection cap, Part No. 7044/18.

120. Place the sealing gasket in position against the pump housing.

121. Engage the cam advance screw with the piston, and screw the head locating fitting into the hydraulic head. The advance device housing should be drawn onto the jointing face progressively as the fitting is tightened. When a rubber jointing gasket is fitted tighten the head locating fitting to a torque value of 300 lb./in. and when a cork gasket is fitted, to a torque value of 350 lb./in.

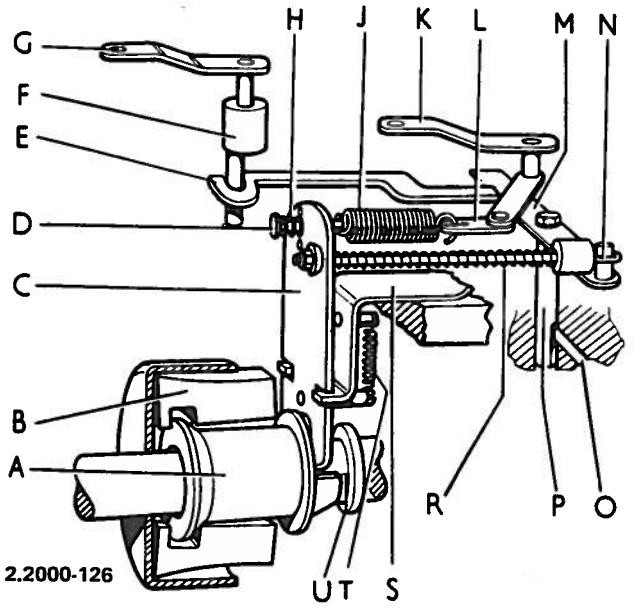
122. Tighten the two head locking screws to a torque value of 170 lb./in.

123. Check for freedom of movement, by moving the piston.

124. Insert the springs in the counterbored end of the piston and then fit the spring cap.

125. Fit the spring cap screw with the sealing washer and screw it into the spring cap.

126. Assemble the governor linkage as follows:- (annotations refer to illustration 2.2000-126).



Details for control mechanism of mechanical governor

A Thrust sleeve.	L Swivel link.
B Governor weights.	M Control lever.
C Governor control arm.	N Hook lever.
D Idling spring guide.	O Metering port.
E 'Shut-off' bar.	P Metering valve.
F 'Shut-off' shaft.	R Light spring.
G 'Shut-off' lever.	S Control bracket.
H Idling spring.	T Retaining spring.
J Governor spring.	U Drive shaft.
K Throttle lever.	

127. Engage the governor arm with the governor bracket and connect the two components with the small retaining spring.

128. Using protection cap, Part No. 7144/458A, fit the lower 'O' seals to the throttle and 'shut-off' shafts, and using protection cap Part No. 7144/459A, fit the upper 'O' seals. Pack the groove between the 'O' seals with Shell Alvania, No. 2 grease.

129. Fit the idling spring on the shank of the idling spring guide. Pass the guide through the specified hole in the governor arm and couple the governor spring to the guide. There are three holes in the governor arm; the correct hole to be used is indicated in the relevant test specification.

130. Slide the spring retaining block, the linkage spring and the spring retaining washer onto the hook lever. Pass the threaded end of the linkage hook through the governor arm, fit the pivot ballwasher and secure the assembly by fitting and tightening the securing nut.

131. Attach the hook end of the lever to the metering valve.

132. Connect the free end of the governor spring to the swivel link on the throttle shaft. Three holes are provided on the link; the one to be used is indicated in the relevant test specification or in pump code.

133. Reverse the fixture in the vice.

134. Fit the assembled governor control linkage on the pump housing, engaging the lower end of the governor arm with the thrust sleeve and inserting the metering valve into position in the hydraulic head.

135. Place the keep plate into position on the governor control bracket, and fit new tab washers on the governor cover studs. Pass the studs through the keep plate and the bracket and screw them into the pump housing to secure the governor control assembly. Lock tab washers. Fit and tighten the screw at the end of the bracket, near the metering valve.

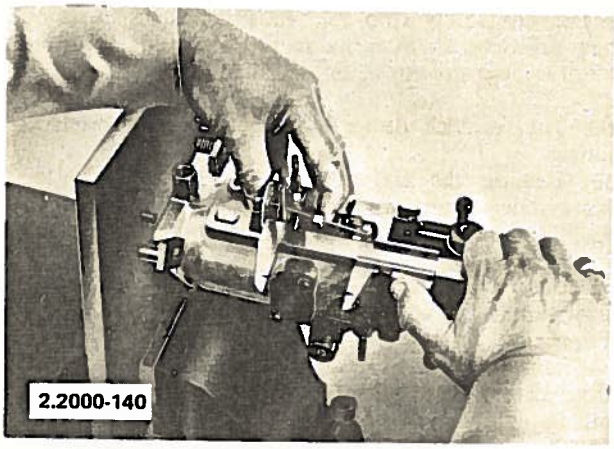
136. Fit the 'shut-off' lever. Two different types of 'shut-off' lever and 'shut-off' shaft are in general use. Levers of early manufacture were of steel strip, which was bent to engage the cranked 'shut-off' shaft. Levers of later manufacture are stamped from flat steel strip.

137. 'Shut-off' shafts of earlier manufacture have a bearing at each end – in the governor control cover and in the upper face of the pump housing. Shafts of a later manufacture have a single lengthened bearing in the governor control cover.

138. 'Shut-off' levers of the 'bent-strip' type are assembled to the crank on the 'shut-off' shaft and then passed through the slot in the governor bracket.

139. When a two bearing shaft is fitted in conjunction with the more recent stamped 'shut-off' lever, it is passed under a tab on the control cover stud locking washer and must be engaged with the shaft and passed through the slot in the bracket before the stud is fitted. Later type 'shut-off' bars can be placed in position after the control bracket has been secured, and are engaged by the control shaft when the governor cover is fitted.

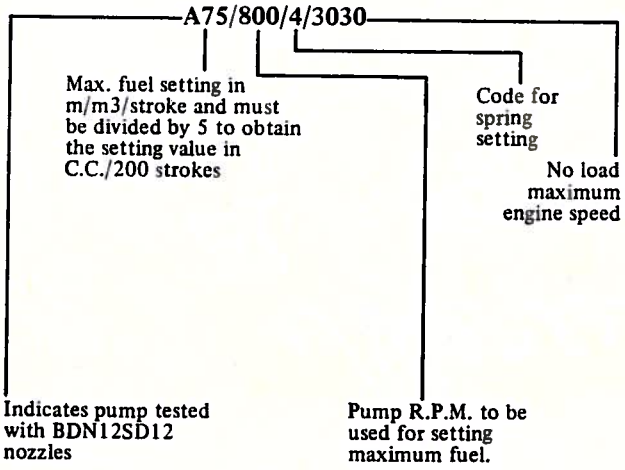
140. Set the internal dimension between one governor control stud and the metering valve lever pin to the dimension quoted in the test specification. Adjustment is made by screwing or unscrewing the nut on the end of the hook lever. Light pressure should be applied to the governor arm to hold the metering valve in the fully open position, and the vernier gauge must be held parallel to the axis of the pump.



141. Fit the spring into the correct hole on the governor arm and also the throttle link. The correct location can be determined from the following table:

Governing Arm	Throttle Arm	Code
1	1	1
1	2	2
1	3	3
2	1	4
2	2	5
2	3	6
3	1	7
3	2	8
3	3	9

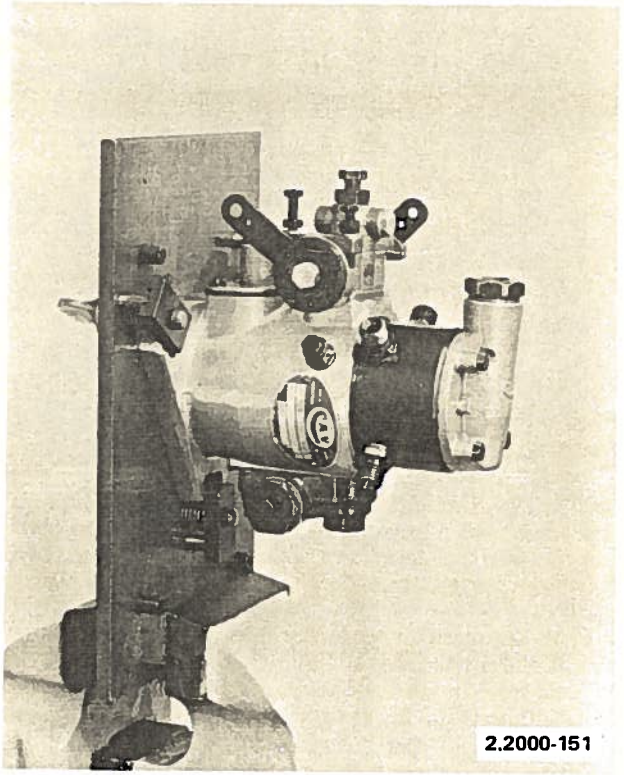
142. The correct code to which a particular pump is set can be identified by reference to the plate on the pump. EXAMPLE: The number is quoted as A75/800/4/3030. This enables the pump to be set and the engine RPM set.



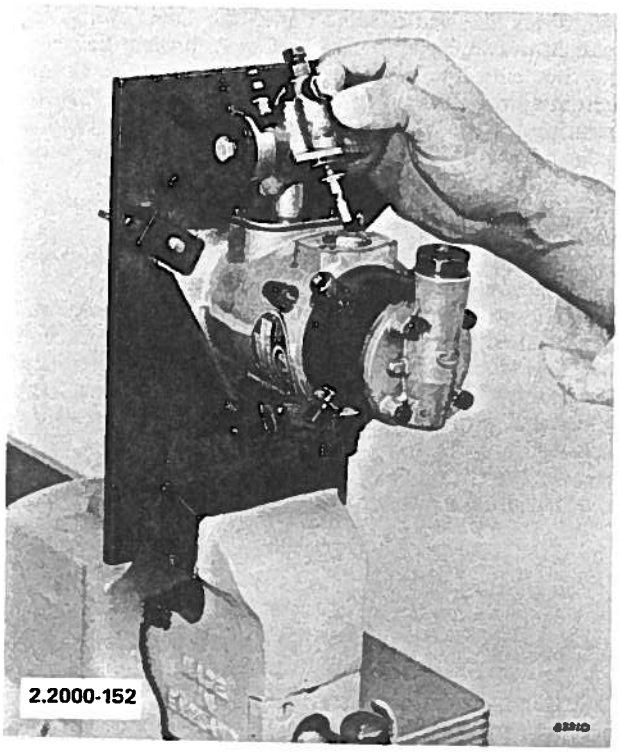
143. Fit a new control cover gasket on the upper face of the pump housing.
144. If a 'shut-off' shaft with a single bearing is to be fitted, press the shaft into the control cover, using protection cap, Part No. 7144/459A to protect the 'O' seal. The peg which engages the 'shut-off' bar must be close to the inside edge of the cover.
145. Press the throttle shaft into the cover, using the protection cap, Part No. 7144/459A to protect the seals, and then slide the cover over the securing studs. Before tightening the nuts on the securing studs ensure that the crank pin of the 'shut-off' shaft is engaged with the slot in the 'shut-off' lever. Tighten the nuts to a torque value of 40 lb./in. (0.46 kg.m.).
146. Fit the control levers on the throttle and 'shut-off' shafts.
147. Replace the inspection cover complete with gasket and secure in place with the cover retaining screws.
148. The identification label on the pump indicates the correct direction of rotation of the pump. To check that the label has not been replaced upside down, hold the pump with the drive end pointing downwards. The letters and numerals on the label should then read the right way up.
149. Before fitting the fuel pump to the engine it should be tested using a suitable test machine, see page 14.

D.P.A. PUMP WITH HYDRAULIC GOVERNOR

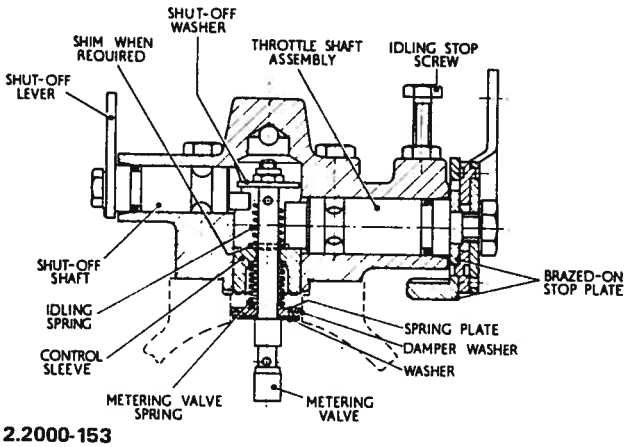
150. Remove the adjusting cover from the pump body and drain the fuel oil.
151. Remove the quill shaft and mount the pump on the dismantling and assembly fixture, Part No. 7244/155, and secure the fixture in a vice.



152. Remove the two screws holding the governor casing to the pump casing; withdraw the governor assembly and discard the joint washer.



153. The current type reversible governors have the stop plate brazed to the throttle shaft.

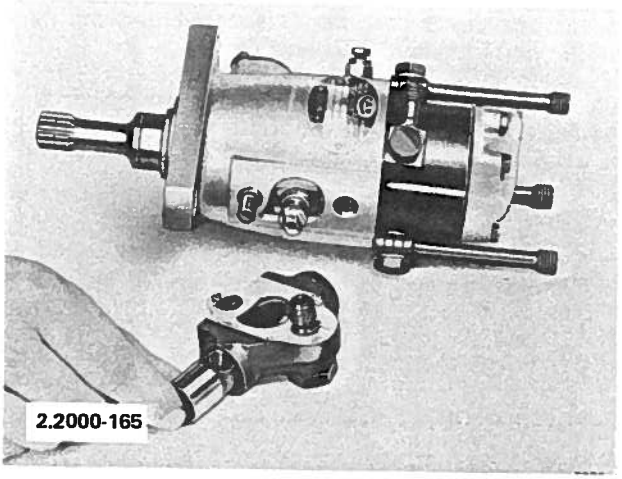


2.2000-153

154. Before dismantling an early type governor scribe a line across the edge of the stop plate, the vernier plate and the throttle lever as a guide to correct assembly. Note whether the throttle shaft is fitted on the left or right.
155. To dismantle the governor, proceed as follows:
156. Withdraw the shut-off shaft.
157. Remove the throttle shaft.
158. Withdraw the metering valve assembly.
159. Using tool, part Number 7044/895 to hold the metering valve, remove the securing nut from the upper end of the valve stem. Dismantle the shut-off washer, the idling spring if fitted, the control sleeve, the metering valve spring and the multi plate damper or the spring plate whichever is fitted.

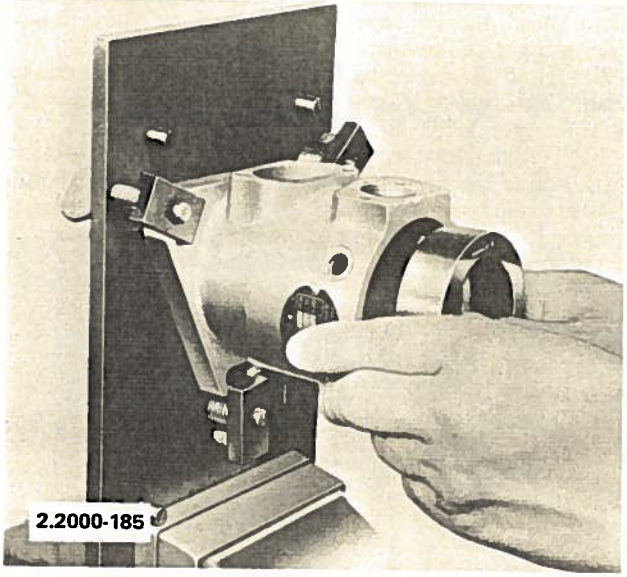
NOTE: The idling stop and the maximum speed stop screw positions are interchangeable. To avoid confusion, do not remove the screws unless renewal is necessary.

160. The advance device must next be removed, as follows:
161. Reverse the fixture in the vice, to bring the advanced device uppermost.
162. Slacken the piston plug. Remove the spring cap and springs.
163. Unscrew the head locating fitting, remove cap nut and withdraw the advance device housing as the fitting is unscrewed.
164. Remove the head locating fitting from the housing, taking care not to drop the steel ball. Remove the washer and lower oil seal.
165. Remove the piston plug and withdraw the piston.

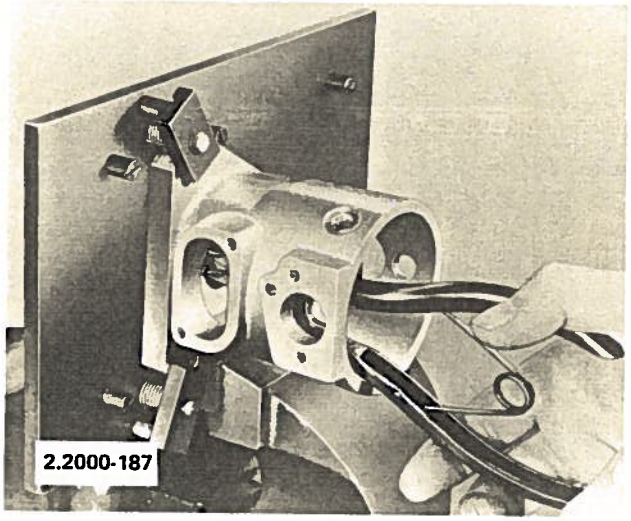


166. Remove the 'O' seal from the head locating fitting.
167. Unscrew the four screws holding the end plate to the hydraulic head, remove the end plate and the seal.
168. To dismantle the end plate, proceed as follows:
169. Remove the fuel inlet connection and the spring fitted immediately below it.
170. Remove the four hexagon head screws which secure the end plate to the hydraulic head, also the clamp plates.
171. Lift off the end plate and remove the synthetic rubber seal.
172. Invert the end plate and the complete regulating valve assembly will fall clear from the valve chamber.
173. Lift the fuel transfer pump blades from the slots in the rotor (see Fig. 2.2000-56) and withdraw the transfer pump liner.
174. Remove the pump outlet connections.
175. Hold the splined drive shaft with tool 7144/733 and using tool 7044/889, slacken but do not remove, the transfer pump rotor by turning in the direction indicated by the arrow on the rotor face. If the rotor is unmarked, slacken in the direction of pump rotation.
176. Remove the two head locking screws.
177. Remove the hydraulic head and rotor as an assembly.
178. Hold the drive plate with tool 7144/744 and slacken the two drive plate screws.
179. Remove the 'O' seal from the periphery of the hydraulic head.

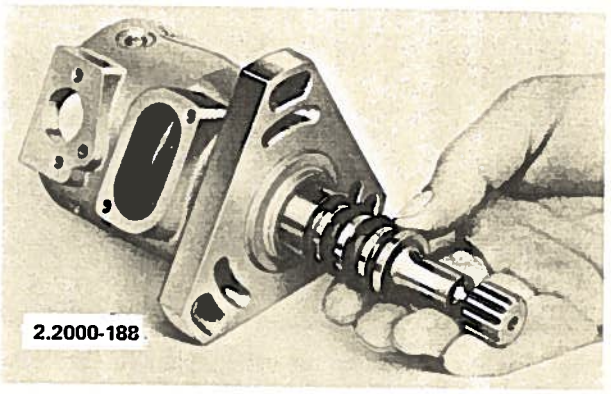
180. Remove the transfer pump rotor and separate pumping and distributor rotor from the hydraulic head. Do not allow the cam rollers to drop out.
181. Remove the drive plate screws to release the drive plate. Dismantle the top and bottom adjusting plates, the actuating rollers and the shoes from the rotor. Keep each roller with its respective shoe. Immerse the rollers and shoes in a bath of clean fuel oil to protect them.
182. Retain the twin pumping plungers in the transverse bore of the rotor by two corks inserted in place of the actuating rollers. The pump plungers are mated to the bore and should be retained therein to prevent incorrect replacement.
183. Fit the rotor in the bore of the hydraulic head to protect the working surfaces.
184. Remove the cam advance screw from the pump, using tool, part number 7244/125B. Lightly tap the advance screw before removal to free the cam ring.
185. Withdraw the cam ring.



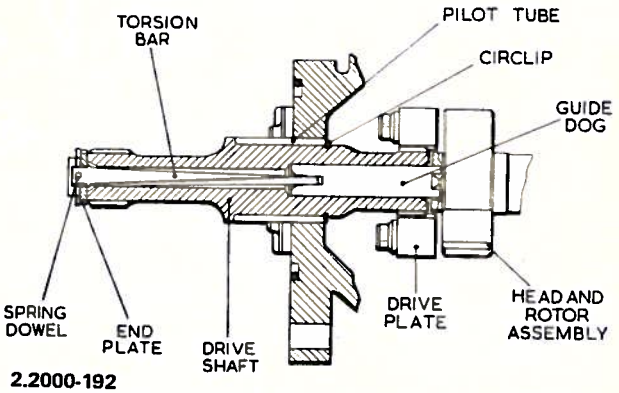
186. Compress the timing ring with circlip pliers and remove.
187. Remove the retaining circlip from the drive shaft, using circlip pliers.



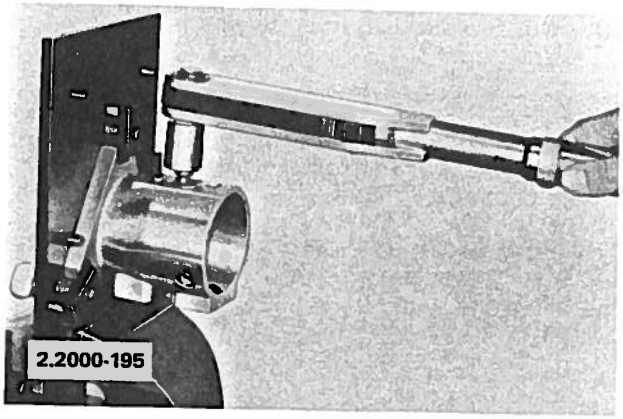
188. Withdraw the shaft from the pilot tube.



189. All dismantled parts should be kept in a covered bath of clean fuel oil until they are immediately required for reassembly. Then they must be assembled wet. Any parts showing signs of scoring or wear should be replaced also all seals and gaskets must be replaced with new parts.
190. The pump should then be assembled in the following sequence.
191. Slide the shaft into the pilot tube and secure it in position with the circlip. (No seals are fitted to the drive shaft on this type of drive).
192. Insert the guide dog, open end first, into the pump end of the drive shaft, and line up the slot in the guide dog with the master spline on the drive shaft. The torsion bar and end plate engage when fitting the pump to the engine on the test bench.



193. Compress the timing ring or circlip with the circlip pliers and seat it against the shoulders in the bore of the pump housing. Rings should be positioned so that the open ends of the circlip are at 180° to the inspection aperture.
194. Place the cam ring in position against the timing ring. The direction indicated by the arrow in the visible face of the cam ring must conform with the direction of pump rotation marked on the name plate.
195. Screw the cam advance screw into the cam ring and tighten to a torque value of 25 lb./ft. (3.45 kg.m.) using the special tool, Part No. 7244/125B and a standard torque wrench. Check the cam ring for freedom of movement after the cam advance screw has been fitted.

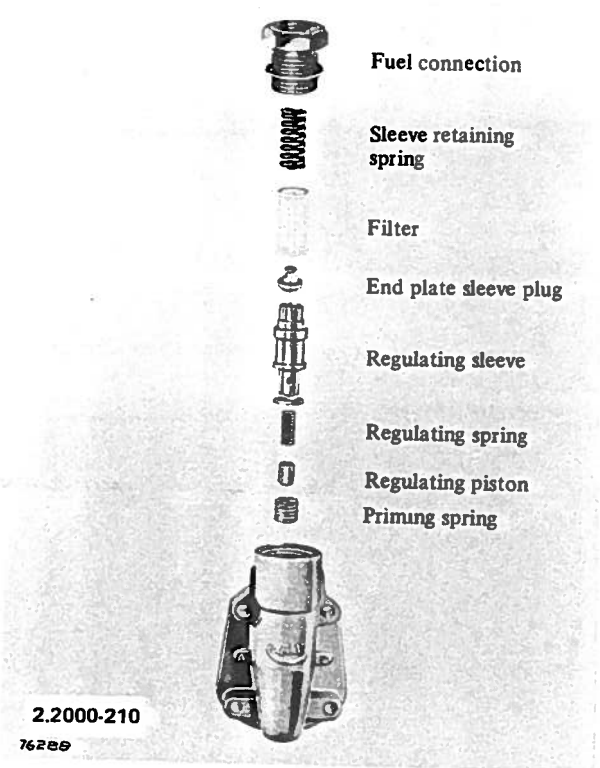


196. Place the bottom adjusting plate in position, chamfered edge uppermost, on the pumping and distribution rotor with the small cut-out in the periphery of the adjusting plate aligned with the cut-out flats in the rotor, and the eccentric slots in the plate in line with the roller shoe guides.
197. Fit the rotor in the bore of the hydraulic head, secure it by fitting and partly tightening the transfer pump rotor.
198. Remove the corks retaining the twin plungers in the transverse bore of the rotor. Insert the roller and shoe assemblies in the roller shoe guides. The projecting ears on the shoes must be placed in the eccentric slots on the adjusting plates and the contour of the ears must follow the contour of the slots.
199. Fit the top adjusting plate, engage the lugs with the cut-outs in the bottom adjusting plate, locate the two plates so that the adjusting slot coincides with the scribed line.
200. Secure the drive plate to the end of the rotor with the two drive plates screws partly tightened. The underside of the drive plate is recessed, and the holes are machined so that the plate can be assembled in only one way.
201. Fit tool No. 7144/262A to two of the high pressure outlet ports on the hydraulic head and connect it to a nozzle testing unit. Operate the nozzle testing unit to raise the pressure to 30 atmospheres. Turn the pump rotor until the plungers and rollers are forced to the maximum fuel position. Set the overall roller to roller dimension to the test specification figure by moving the adjusting plates.
202. Hold the drive plate with Tool, Part number 7144/744 and tighten the drive plate screws to a torque value of 13.3 lbs./ft. (1.85 kg.m.) where plunger diameter is up to 7.5 mm. then slacken and re-tighten to the same torque value. Drive plate screws must be tightened evenly to avoid rotor distortion which can cause sticking plungers.

NOTE: For plunger diameters longer than 7.5 mm. reference must be made to local C.A.V. dealer for torque value.

203. Disconnect the nozzle testing outfits and remove the stirrup pipe from the high pressure outlets on the hydraulic head.

204. Fit an external 'O' seal on the hydraulic head and lubricate the portion of the head which fits into the pump housing.
205. Check that the guide dog slot is aligned with the master spline on the drive shaft. Slide the hydraulic head into the pump housing and engage the drive shaft splines and guide dog with the guide plate splines and the two slots in the face of the rotor. Rotate the head and rotor assembly to prevent damage to the 'O' seal as it enters the pump housing.
206. Insert the pilot tool, Part No. 7144/508B or /508C into the metering valve bore to accurately locate the hydraulic head in the pump casing. To determine the correct pilot tool to fit the metering valve bore, examine the hydraulic head between the delivery outlets adjacent to the metering valve bore. If the number 6.375 is etched into the head use pilot tool 7144/508C. When no number is etched into the head pilot tool 7144/508B is the correct diameter for the metering valve bore.
207. Secure the hydraulic head to the housing by the two head locking screws only. Tighten these screws finger tight and remove the pilot tool.
208. Hold the drive shaft with tool 7144/773 and using tool 7044/889, tighten the transfer pump rotor to a torque value of 5.5 lb./ft. (0.75 kg.m.).
209. Fit the transfer pump liner in the counter bore in the end of the hydraulic head and the pump vanes in the slots in the transfer pump rotor. Rotate the liner to ensure that the vanes do not bind on the liner.
210. Assemble the end plate as follows:



211. Place the priming spring in the base of the end plate chamber.
212. Fit a new joint washer to the regulating sleeve.
213. Insert the regulating piston into the bore of the regulating sleeve.

214. Holding the regulating sleeve so that the larger diameter is uppermost insert the spigoted end of the sleeve plug or transfer pressure regulator if fitted.
215. Pass the nylon filter over the regulating valve assembly, small end first, into the end plate ensuring that the regulating piston is retained within the regulating sleeve.
216. Fit the retaining spring. Fit a new washer on the inlet connection, screw it into the end plate and lightly tighten.
217. Fit a new 'O' seal in the recess in the end face of the hydraulic head.
218. Engage the dowel on the inner face of the end plate with the slot in the transfer pump liner, and then secure the end plate and the clamp plates to the hydraulic head by fitting the four end plate screws to a torque value of 4 lb./ft. (.55 kg.m.).
219. Fit a new washer to the fuel inlet connection, assemble to the end plate, and secure by tightening the fuel inlet connection to a torque value of 30 lb./ft. (4.15 kg.m.).
220. To reassemble the Automatic Advance Device proceed as follows:
221. Invert the pump on the assembly fixture in the vice.
222. Fit a new 'O' seal to the piston spring cap and the piston plug, using protection cap 7044/898.
223. Screw the piston plug into the fuel passage end of the device.
224. Insert the piston in the bore of this device with the counterbored end outwards. Check for freedom of movement.
225. Fit the upper 'O' seal on the head locating fitting, protect the seal from damage with the protection cap 7044/897.
226. Place the steel ball on its seating in the head locating fitting and pass the fitting through the advance device housing.
227. Fit the 'O' seal on the head locating fitting, using the protection cap 7144/18 then fit the steel washer.
228. Place the sealing gasket in position against the pump casing.
229. Engage the cam advance screw in the piston. Screw the head locating fitting into the hydraulic head. The advance device should be drawn onto the joint face progressively as it is tightened. Fit the washer and cap nut on the advance device housing stud.
230. Tighten the head locating fitting to a torque of 300 lb./in. (3.45 kg.m.) if a rubber gasket is fitted or 350 lb./in. (4.03 kg.m.) where a cork gasket is fitted. On two bolt fitments used on later models 350 lb./in is the required torque. Tighten the cap nut to a torque of 130 lb./in.
231. Tighten the two head locking screws to a torque of 14 lb./ft. (1.95 kg.m.).
232. Move the piston to check the freedom of movement of the advance device.
233. Re-check the alignment of the head with the pilot tool.
234. Insert the springs in the counterbored end of the piston. Fit the spring cap.
235. Fit the sealing washer to the spring cap screw.
236. Tighten the spring cap and the piston plug to a torque value of 21 lb./ft. (2.90 kg.m.).
237. Assemble the governor as follows:
238. Using Fig. 2.2000 – 153 as a guide, assemble the thin bottom washer on the metering valve stem, then the dished floating washer with the open face uppermost and then the stepped damper washer with the smaller diameter uppermost. Fit the metering valve spring, the control sleeve (and the shim and idling spring if fitted) and finally the shut-off washer. Hold the metering valve with tool 7044/895 and screw the nut onto the thread of the metering valve stem and secure.
239. Insert the metering valve assembly into the metering valve orifice in the governor housing.
240. Using protection cap Part No. 7144/458A and 7244/186, fit a new 'O' seal to the throttle shaft. Insert the throttle shaft into the governor housing with the eccentric lug uppermost, and engage between the top surface of the control sleeve and the shut-off washer.
241. Fit a new 'O' seal in the shut-off shaft, using protection cap 7144/11. Fit the stop plate (if not a brazed on type), the vernier plate and the throttle arm to the throttle shaft, using the line scribed on the edge of the plate for accurate location. Ensure that the throttle shaft is not inadvertently inverted through 180°.
242. Press the 'shut-off' shaft into the housing ensuring that the 'flat' engages the lower face of the shut-off washer. This can be accomplished by pressing the metering valve stem fully into the housing when fitting the shaft.

NOTE: DO NOT fit the "shut-off" shaft so that the lug engages above the "shut-off" washer.

243. Fit the "shut-off" lever to the shaft and ensure that the shaft has not been rotated during fitting.
244. Fit a new jointing gasket on the face of the pump casing.
245. Insert the metering valve into the hydraulic head and seat the governor against the joint face on the pump casing. Check that the governor is located correctly and secure in place by fitting and tightening the two securing screws.
246. Fit new inspection cover gasket then fit and secure the inspection cover.
247. The identification label on the pump body indicates the correct rotation of the pump. To check that the label has not been incorrectly fitted, hold the pump with the drive end downwards, the lettering should then read the right way up.
248. After an overhaul both mechanical and hydraulically governed D.P.A. pumps should be subjected to the following tests. A separate test plan, quoting the dispatch numbers of the range of pumps to which it may be applied, is published for each different model manufactured.

PRESSURE TESTING

249. All pumps must be pressure tested after assembly both before and after being mounted on the test machine. This is accomplished as follows:-
250. Drain all fuel from the pump and connect an air line to the pump inlet connection. Do ensure that air supply is clean and free from water.

251. Seal off the low pressure outlet connection on the pump and completely immerse pump in a bath of clean fuel oil. On pumps fitted with the proportional pressurizing valve, which must be sealed off when pressure testing, take care not to disturb the joint between the outer connection and body of the valve which is sealed with "Loctite".
252. Raise the air pressure in the pump to 20 lb./sq. in. Leave pump immersed in oil for 10 minutes (no visual observations to be made during this period) so as to allow any trapped air in external pockets – such as the cavities in the end plate – to escape.
253. Observe for leaks after pump has been immersed for 10 minutes, if the pump is not leaking reduce the air pressure to 2 p.s.i. for 30 seconds; if there is still no leak increase the pressure to 20 p.s.i. If the pump is still leak free after 30 seconds it can be passed as satisfactory.

NOTE 1: Mechanical governor pump with single piece drive shaft and two oil seals. In addition to the above, the outer oil seal must be tested as described in Service Bulletin 6234 (SIN 12158) using tool 7144-760.

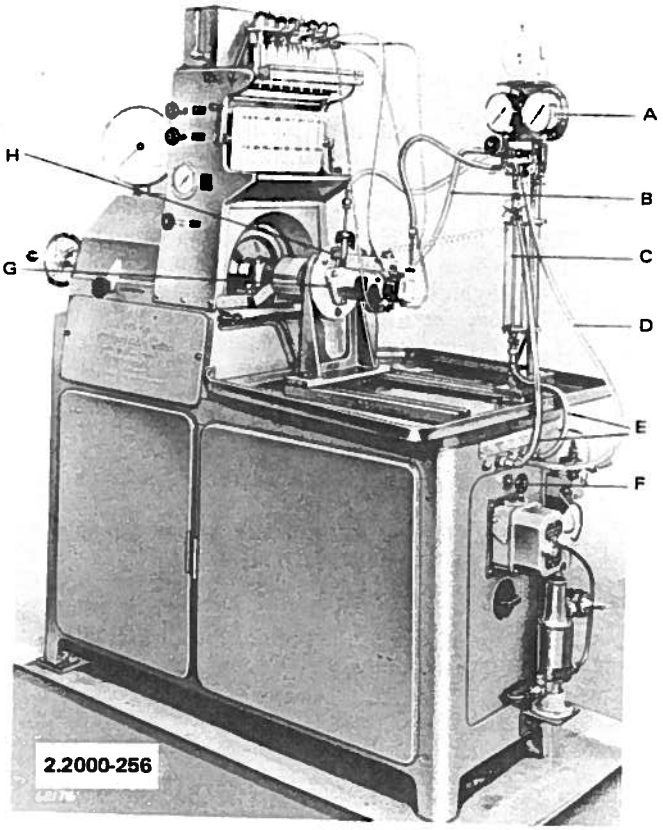
NOTE 2: Hydraulic governor pumps without drive shaft oil seal. It is necessary to stop the oil leaking past the drive shaft whilst pressure testing. Use sealing cap 7144-890 which fits over the pilot tube.

NOTE 3: Mechanically governed pumps without drive shaft oil seal. It is necessary to stop the oil leaking past the drive shaft whilst pressure testing. Tool 7144-760 may be used but it will be necessary to blank off the threaded connection (12 x 1.5 mm.) of the tool.

SEAL TESTING

254. Certain mechanically governed pumps have a single-piece drive shaft with two inward facing lipped oil seals. The gap in the circlip between the seals, line up with a tell tale hole in the pump body. The inner seal, nearest to the governor sleeve, is checked by the normal pressure test, leakage being indicated at the tell tale hole.
255. A special tool 7144/760 is used for testing the outer seal, and this consists of a flanged cylinder with three fixing studs, an air pressure connection and a sealing gasket. The tool is attached to the pump mounting flange and a supply of filtered air applied to the connection. The D.P.A. pump and the tool are immersed in a bath of fuel oil and air pressure applied at 4 lb./in.^{2} (0.28 kg./cm.^{2}) for 20 seconds. Bubbles at the tell tale hole will normally indicate an oil seal failure but first ensure that these are not caused by a faulty gasket.

CALIBRATING (see appropriate C.A.V. Test Plan on page 19-23).
256. A typical test machine, adapted for use with D.P.A. pumps is shown below incorporating the following features:



A Vacuum gauge.
B Transfer pressure pipe.
C Leakage measuring glass and cocks.
D Feed pipe.
E Return pipes.
F Fuel cock.
G Special drive adaptor.

257. A set of high pressure pipes each 34 inches (865 millimetres) in length, 6 millimetres in diameter and of 2 millimetre bore which coupled the outlet connections on the pump to matched set of injectors (type BDN 12SD12) set at 175 atmospheres opening pressure.
258. A fuel system which ensures an adequate fuel supply at constant pressure at the pump inlet. Delivery at pump inlet should be a minimum flow of 1,000 cm^3 per minute. If this figure is not obtained it is permissable to use 2 lb./in.^{2} pressure feed.
259. One pressure gauge and one vacuum gauge for testing the output and efficiency of the transfer pump.
260. The following precautions must be observed when testing the D.P.A. fuel pumps.
261. Ensure that the test machine is set to run in the corresponding direction of rotation to the pump undergoing test. Reversal of the pump prevents entry of oil and seizure may result from lack of lubrication.
262. Do not run the pump for long periods at high speed with low fuel output.

263. Do not run the pump for long periods with the 'shut-off' control in the closed position.
264. The correct test machine adaptor plate must be used. A plate with 50 mm. hole must never be used with a pump with 46 mm. spigot as seizure is probable.
265. Standard radial high pressure connections must be fitted prior to testing. Information is given in the test data and explanatory notes.
266. Prime the pump thoroughly before commencing test and at other times when indicated in the test plan.
267. To prime a pump, proceed as follows:-
268. Slacken the vent valves on the governor control casing and the head locking screw.
269. Connect the fuel feed pipe to the pump inlet; connect the back leakage pipe.
270. Turn on the fuel supply to fill the pump and run the pump at 100 rpm. When fuel oil free from bubbles issues from the vent retighten the valve.
271. Slacken the connections at the injector end of the high pressure pipes.
272. Run the pump at 100 rpm. When the fuel oil free from bubbles issues from all high pressure pipes, retighten all the connections.
273. Examine the pump after priming for oil leaks at all jointing faces, connections and oil seals. Pumps must be free from leaks both when running and when stationary.
274. Testing and adjustment are effected by carrying out the series of operations tabled in the test plan in the specified order. The purpose of each operation is indicated, and it will be noted that in addition to testing the overall efficiency of the pump, certain other functions are checked independently.

PUMP OUTPUT
275. The fuel delivery is checked at one or more speeds of rotation at full throttle by measuring the volume passing through each injector during 200 pump cycles. The pump test data quotes the average delivery, overall tolerance and the maximum permissable delivery variation (spread) between injectors.

SHUT OFF CONTROL
276. This is checked by running the pump at a specified speed (see test plan) with the 'shut-off' control closed. A maximum fuel delivery is quoted.

MAXIMUM FUEL SETTING
277. The maximum fuel delivery is checked at a specified speed, with the throttle and the 'shut-off' controls fully open. If the fuel delivery is not within the specified limits, adjust as follows:-
278. Slacken the screws securing the inspection cover and drain the pump.
279. Remove the inspection cover.
280. Slacken the two drive plate screws.
281. Engage tool, Part No. 7144/875 with the slot in the periphery of the adjusting plate.
282. Adjust the plate by lightly tapping the knurled end of the tool. The direction in which the drive plate is turned to increase or decrease fueling depends on the type of adjusting plates fitted.
283. Tighten the drive plate screws evenly to 18 lb./ft. then slacken and retighten to a direct torque of 21 lb./ft. using the adaptor 7144/482, spanner 7144/511A and a torque wrench. These torque figures are for use only when plungers up to 7.5 mm. diameter are used.
284. Replace and secure the inspection cover, refill the pump, vent as necessary and recheck the maximum fuel delivery. Repeat until the volumes are within the specified limits.

NOTE: Adaptor 7144/482 is used with the non-cranked ring spanner 7144/511 or 511A.

285. The centre of the ring spanner must be 66 mm. or 127 mm. from the centre of the adaptor.
286. The torque spanner and ring spanner must be in line when tightening the screws, and care must be taken to ensure that the spanner does not contact the side of the inspection aperture.

GOVERNOR TESTING
287. With the pump running at a speed greater than half the maximum permissible speed of the engine to which it will be fitted, the maximum speed stop is adjusted until a specified-fuel delivery is obtained. The volume of fuel specified is considerably less than the volume of fuel at the maximum fuel setting.
288. The speed of rotation is then reduced and the fuel delivery should increase to a specified volume approximately equal to the maximum fuel delivery.

NOTE: Final governor setting must be carried out on the engine, using a tachometer.

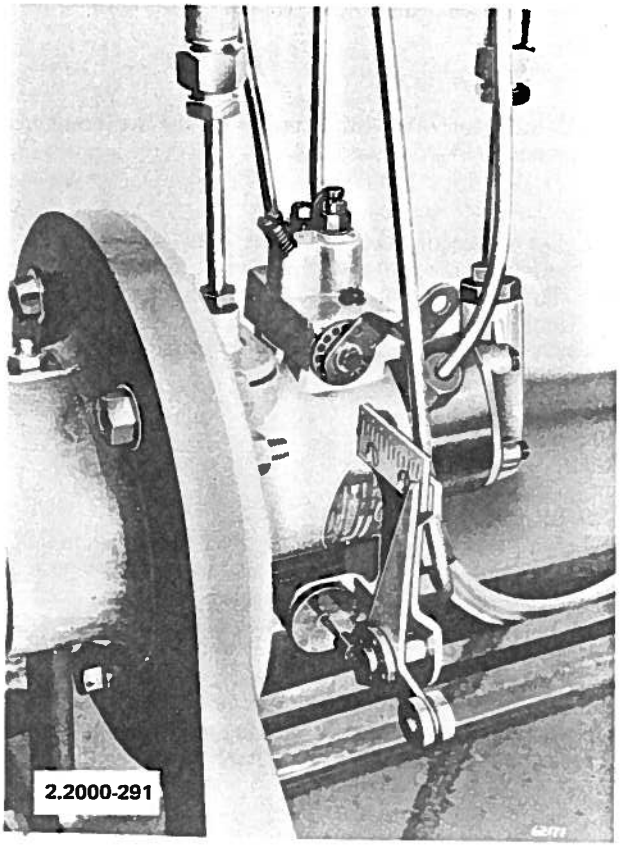
TRANSFER PUMP
289. Transfer pump vacuum is checked while running the pump at low speed, with the two-way cock in the fuel feed pipe turned to the position which cuts off the fuel supply and connects the pump inlet to the vacuum gauge. A given depression must be attained in a specified time.

NOTE: The pump may need to be re-primed after this test.

290. Transfer pressure is checked at one or more specified speeds. A special adaptor Part No. 7044/892, is screwed into the thread normally occupied by one of the head locking screws to enable a pipe to be fitted between the pump and the pressure gauge on the test machine. Transfer pressure can thus be read directly from the gauge.

SPEED ADVANCE DEVICE

291. The operation of this device is indicated on a special tool 7244/59 which consists of a gauge with a scale covering 0–18° and a feeler pin 7244/70. To fit these tools, proceed as follows:-



292. Remove the small screw from the piston spring cap on the advance device.
293. Pass the threaded bush of the feeler pin assembly through the hole in the tool bracket.
294. Insert the end of the plunger in the hole in the spring cap and screw the bush into the spring cap hole. This will clamp the bracket between the spring cap and the shoulder on the threaded bush.
295. Zero the gauge by moving the scale relative to the pointer.
296. A specified advance must be obtained at a number of different speeds of rotation, this checking the speed at which the device becomes effective, and the speed at which full advance is obtained.
297. Adjustment is made by increasing or decreasing the thickness of shims fitted between the piston spring and the spring cap. A single shim 0.5 millimetres in thickness is fitted during manufacture and must not be removed.
298. On completion of these tests, the drive shaft screw of a mechanically governed pump must be slackened and retightened three times to the required torque value of 24 lbs./ft. (3,3 kg.m.) where screw is 28,5 mm. long, or 27 lb./ft. (3,7 kg.m.) where screw is 31,7 mm. long. This is to prevent any risk of the screw slackening in service.

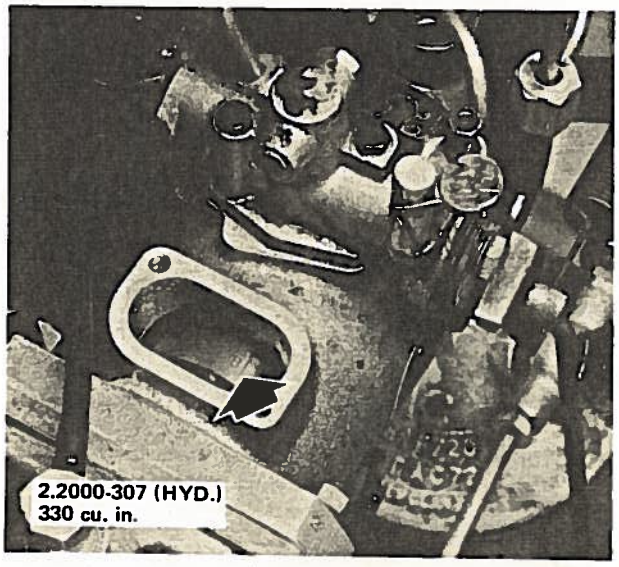
TIMING

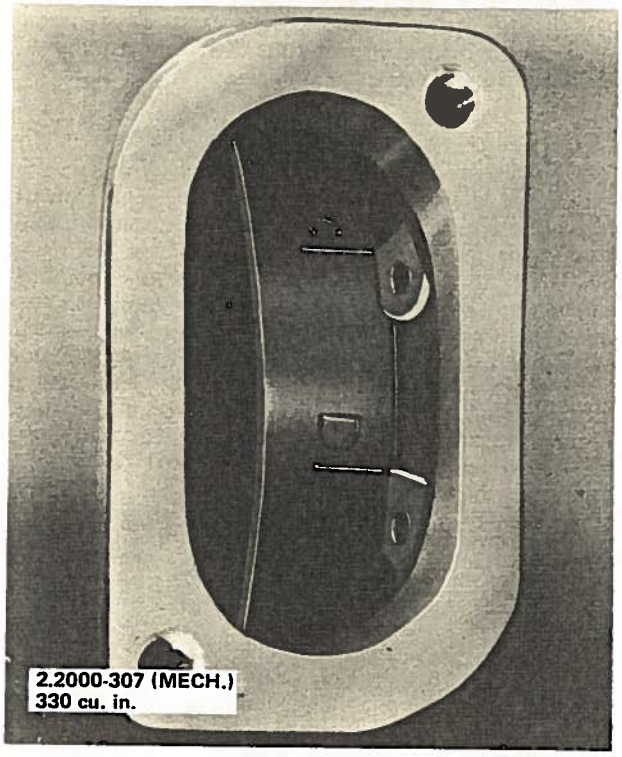
299. After testing, remove the pump from the test machine and drain by slackening the screws of the inspection cover. Tighten the screws. Connect the stirrup pipe 7144/262A (Part Number 7144/262) to the final outlet specified on the test plan and to the outlet diametrically opposite. Fit the relief valve 7144/155 (Part Number 7144/262) to the stirrup pipe and connect the complete tool through a high pressure pipe to a nozzle testing unit.
300. A pressure of 30 atmospheres applied by the pump forces the pump plungers apart as the pump is turned. Such movement brings the actuating rollers to a position where they will strike the cam lobes. When contact is made, resistance to further movement is encountered. With the pump held in this position the timing ring is moved until the scribed line on the ring is aligned with a specified mark on the drive plate.
301. The timing mark on the pump flange is made while the pump is held in the same position.
302. Tool Number 7244/26 is set to the specified indexing figure and is then engaged with the splines on the pump drive shaft. The line is scribed by passing a scriber down the scribing guide on the tool.

NOTE: When timing mechanically governed pumps, it is imperative that the pump's own quill shaft be used to compensate for any possible wear on the splines.

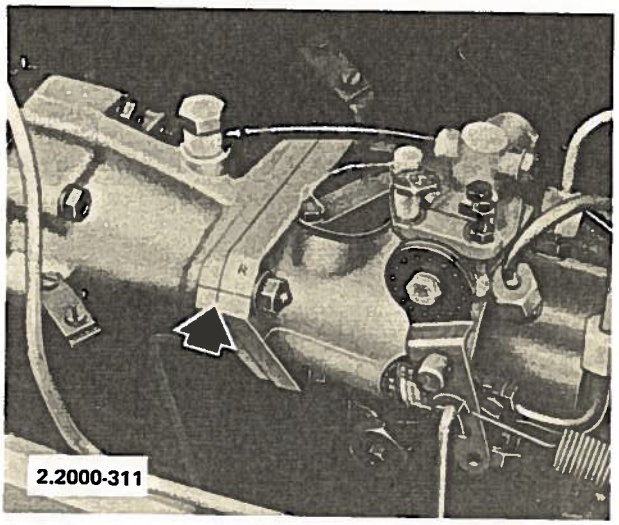
DPA FUEL INJECTION PUMP (Refitting)

303. Rotate the engine flywheel in the normal direction of rotation until its timing mark is aligned with the pointer in the flywheel housing timing aperture. The timing marks on the flywheel are as follows:-
U/C – Top dead centre.
2/6 – 26° B.T.D.C. 220 cu. in. engines – Mechanical governor.
1/6 – 16° B.T.D.C. 330 cu. in. engines – Mechanical governor.
2/4 – 24° B.T.D.C. 330 cu. in. engines – Hydraulic governor.
1/2 – 12° B.T.D.C. 330 cu. in. engines (turbocharged) – Mechanical governor.
2/0 – 20° B.T.D.C. 330 cu. in. engines (turbocharged) – Hydraulic governor.
304. Fit the torsion bar into the splines on the timing gear shaft coupling, care must be taken to line up with master splines.
305. Rotate the fuel pump shaft in the correct direction until the master spline on the pump is parallel with the narrow edge of the torsion bar, care must be taken to ensure accurate alignment or it will prove possible to knock the peg from the coupling, this would destroy all means of accurately timing the engine.
306. Slide the fuel injection pump onto the splines, aligning it with marks on the pump carrier and fit three nuts and washers which secure the pump to the carrier bracket, do not tighten at this time.
307. Remove the cover plate from the pump body and ensure that the timing mark on the pump rotor is aligned with the squared end of the circlip.
i.e. – B – 330 cu. in. hydraulic governed pump.
– D – 330 cu. in. mechanical governed pump.
– G – 220 cu. in. mechanical governed pump.


2.2000-307 (HYD.)
330 cu. in.


2.2000-307 (MECH.)
330 cu. in.

308. The engine must be held in the position detailed in paragraph 303, and the pump can be adjusted, it will be noted that the fixing studs enter into slots in the fuel pump which allows a radial adjustment. The shaft will be held in a fixed position by the engine and a radial movement of the fuel pump will enable the internal timing marks to be aligned.
309. Tighten the three pump securing nuts to a torque of 14 lbs./ft.
310. Fit the cover to the fuel pump and tighten to a torque of 7 lbs./ft., seal the two screws with wire through the two holes in the screw heads.
311. Mark the fuel pump carrier with a scribed line which will line up with the mark on the fuel pump. Should the fuel pump carrier housing already have a timing mark on, this must be eradicated before making a new mark.

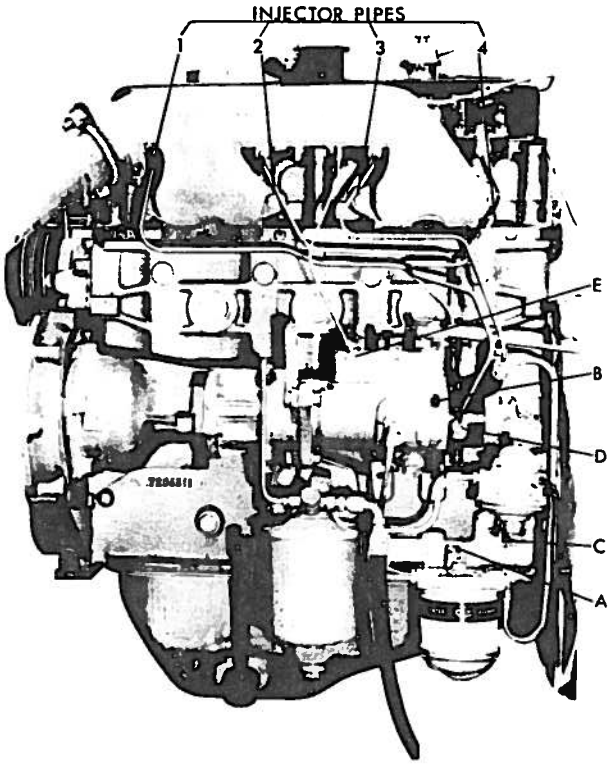

2.2000-311

312. Refit the fuel injection pipes and fit the pipe clamps into the original positions to prevent vibrations.
313. Refit the control rods to the throttle arm.
314. Vent the entire fuel system.

PRIMING AND VENTING THE FUEL SYSTEM

315. Whenever the fuel pipe lines are disconnected, such as when cleaning or renewing the filter elements, or if the fuel tank has been allowed to run dry, it will be necessary to air vent the system before attempting to start the engine.
316. Before priming and venting the system, ensure that the vent screws and surrounding areas are thoroughly clean so that dirt or other foreign matter does not enter the system. Ensure also that the glass bowl of the pre-filter (if fitted) has been cleaned, and refilled with new fuel by operating the feed pump priming lever.
317. Make provision for some spillage of fuel beneath engine and when an instruction calls for air free fuel, allow sufficient to bleed to achieve this.
318. Ensure adequate fuel is within the fuel tank and stop cock is open,.
319. Paragraphs 320 to 325 refer to hydraulically governed fuel pumps and paragraphs 326 to 330 refer to mechanically governed fuel pumps.
320. Carry out the following while operating the priming lever on the fuel feed pump.
321. Slacken the injection pump feed pipe banjo screw and allow fuel to flow until free of air. Tighten the banjo screw.
322. Slacken plug in unused outlet of the main filter bleed and then tighten plug.
323. Slacken the vent screw on the injector pump hydraulic head. Slacken the vent screw on the governor housing. When fuel, free from air, flows from the two vents, first tighten the hydraulic head vent screw, then the governor vent screw.
324. Slacken the banjo screw on top of the main filter, bleed, then tighten screw. This operation should remove the air from the drive housing, the leak back pipe and the filter.

325. Slacken any two high pressure injector pipe top unions, crank the engine (which may run on the other four cylinders), tighten the unions as soon as fuel, free from air begins to flow.
326. Slacken the hexagonal headed bleed (9/16 in. A.F.) on fuel filter head (Reference A), operate priming lever, on fuel lift pump (Reference C), at the same time, ensure any emergency stop fuel shut-off is de-activated, and continue to operate priming lever until air free fuel flows from bleed, at which time, bleed should be re-tightened.



2.2000-326

327. Slacken the hexagonal headed bleed screw (5/16 in. A.F.) (Reference B) and operate priming lever (Reference C) until air free fuel is expelled from bleed screw. Leave ½ turn open, crank for 5 seconds, then tighten.
328. Slacken the banjo pipe attachment (Reference E) actuate priming lever until air free fuel is expelled and leave slightly slack at this point.

NOTE: Omission of this operation will materially increase cranking time.

329. Slacken one or more injector pipes at the injector end, and the fuel pump at No. 4 pressurising valve (Reference D).

330. With the slackened pipes set stop lever to run position, de-activate any automatic shut-down system and crank engine until air free fuel is expelled from the slackened pipes. Tighten all pipes to No. 4 injector and its associated pressurising valve (Reference D), and attempt to start engine by cranking, and when engine commences to run, retighten pressurising valve connection at (D) and No. 4 injector line at injector end. Operate speeder lever to required engine speed and check that no leaks exist in the fuel system. Stop engine. Wipe clean any spilt fuel on engine or equipment.

IDLING ADJUSTMENT

331. The engine idling speed is controlled by a hexagon-head stop screw which contacts the throttle control lever on the governor housing.
332. With the engine at normal operating temperature, check the idling speed with a tachometer. If necessary adjust the idling screw so that the engine idles at the specified speed.
333. On vehicles equipped with an idling control knob on the instrument panel, ensure that the knob is screwed right in and that a small clearance exists between the nipple on the control wire and the throttle control lever, before adjusting the idling speed.

MAXIMUM SPEED ADJUSTMENT

334. The engine maximum speed is set by a hexagon headed stop screw on the governor housing. This screw is encased by a cover which is sealed against unauthorised interference.
335. With the engine running at normal operating temperature, move the throttle control lever on the governor housing by hand to the maximum speed position and check the engine speed with a tachometer. If the speed is not as specified, break the seal, remove the cover and adjust the screw. It is important that the specified maximum speed is not exceeded, therefore, this adjustment must not be attempted without a tachometer. Install and seal the cover.

D.P.A. TEST DATA PLANS

Basic Pump Specifications

220 cu. in. engine with mechanically governed DPA fuel pump.

Types 3249380 to 3249760.
Hydraulic head and transfer pump liner modified to provide for self venting.
Cambox pressurising valve.
Automatic speed advance device.
Clockwise rotation (looking on drive end).
Uprated drive with floating shaft (types 3249550 to 3249769 only)
Governor link length 53.5 mm. nominal ± 1.0 mm. (Types 3249380 – 3249429 only).
Governor link length 53.5 mm. nominal ± 0.5 mm. – 1.0 mm. (Types 3249550 – 3249589 only).
Governor link length 55.0 mm. nominal ± 0.5 mm. (Types 3249760 – 3249769).
Roller to roller dimension 49.9 mm.
Plunger diameter 8.0 mm. (types 3249380 to 3249429).
Plunger diameter 9.0 mm. (types 3249550 to 3249769).

330 cu. in. engines with hydraulically govemed DPA fuel pump.

Types 3266540 to 3266739.
Automatic speed advance device.
Transfer pressure adjuster.
Anti-backlash torsion bar.
Clockwise rotation (looking on drive end).
Roller to roller dimension 49.8 mm. (49.7 mm. on types 3266730 to 3266739 only).
Plunger diameter 9.0 mm.

330 cu. in. engines with mechanically governed DPA fuel pump.

Types 3268780 to 3268809.
Uprated drive with floating shaft.
Automatic start retard with speed advance device.
Clockwise rotation (looking on drive end).
Governor link length 53.0 mm. nominal ± 1.0 mm.
Roller to Roller dimension 49.9 mm.
Diameter of Plungers 9.0 mm.

Before Commencing Tests

Fit auto-advance measuring device and set the scale to zero.
Screw out anti-stall device (where fitted).
On hydraulically governed pumps, screw back transfer pressure adjuster in end plate to the minimum extent and then screw in 1½ turns minimum.

Shimming of Automatic Speed Advance Device

(1) A 0.5 mm. shim is fitted to the piston spring cap on assembly. This must not be removed.
(2) The amount of additional shimming that may be added to meet test requirements may vary from 0 to 3.0 mm.
(3) On hydraulically governed pumps, the throttle lever must point downwards. Fuel increase should be attained by a clockwise movement of the lever when looking directly upon it. The idling setting screw is therefore the one nearest to the end plate and the maximum speed setting screw is the one nearest the pump flange.

NOTE: The governor setting speed quoted is for test purposes only. The governor maximum speed screw must be finally set on the engine.

Test No.	Description	3268780 – 3268789	3268790 – 3268799	3268800 – 3268809		Requirements
		R.P.M.				
1	Priming	100 Max.	100 Max.	100 Max.		Fuel delivery from all injectors
2	Transfer pump vacuum	100	100	100		Note time to reach 16 in (406 mm) Hg Max time allowed 60 seconds
3	Transfer pressure	100	100	100		11 lb/in^2 (0.8 kg/cm^2) minimum
4	Advance position	200	200	200		4¾° to 5¼°
5	Transfer pressure	700	700	700		48 to 62 lb/in^2 (3.4 to 4.4 kg/cm^2)
6	Advance position	700	700	700		8¼° to 8¾°
7	Advance position	1000	1000	1000		9½° to 10½°
8	Transfer pressure	1000	1000	1000		58 to 72 lb/in^2 (4.1 to 5.1 kg/cm^2)
9	Back leakage	800	800	800		5 to 50 cc for 100 stroke time cycle
10	Max fuel delivery	Set to code shown on pump Name Plate*				Delivery tolerance +0 –0.2 cc Spread between lines not to exceed 1.2 cc
11	Max fuel delivery check	100 *	100 *	100 *		Average delivery to be not less than average at (10) minus 1.5 cc
12	Cut-off operation Shut-off lever closed	200	200	200		Average delivery not to exceed 1.0 cc
13	Throttle operation Throttle lever closed	200	200	200		Average delivery not to exceed 0.8 cc
14	Fuel delivery check	930 500 710	1100 750 1000	1000 1000 1300		Record average delivery
15	Governor setting	980 560 760	1180 820 1100	1140 1120 1460		Set throttle by max. speed adjustment screw to give maximum average delivery of 2.0 cc. No line to exceed 3.0 cc
16	Fuel delivery	930 500 710	1100 750 1000	1000 1000 1300		With throttle set as at (15) average delivery to be not less than average at (14) minus 0.4 cc
	Spring position code	3,6 4,7 1,2,5, 8,9	4 7 1	4 7 1		
17	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc				
		Lock stop screw				
18	Timing	Using outlet 'Y' (30 atm. pressure) set timing ring to letter 'D' on Drive Plate. With pump in this position set indexing tool to 331° and scribe line on Housing Flange.				
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading					

Test No.	Description	3249550 – 3249559	3249560 – 3249569	3249570 – 3249579	3249580 – 3249589	3249760 – 3249769	Requirements
		R.P.M.					
1	Priming	100	100	100	100	100	Fuel delivery from all injectors and control cover vent orifice
2	Transfer pressure	100	100	100	100	100	11 lb/in^2 (0.8 kg/cm^2) minimum
3	Cambox pressure	900	600 †	900	900	850 ††	6 to 10 lb/in^2 (0.4 to 0.7 kg/cm^2)
4	Advance setting	600	600	600	600	600	2¾° to 3¼° (Shim as required)
5	Full advance position	900	900	900	900	850	4¾° to 5¼°
6	Transfer pressure	900	600 †††	900	900	850 ††††	60 to 80 lb/in^2 (4.2 to 5.6 kg/cm^2)
7	Transfer pump vacuum	100	100	100	100	100	Note time to reach 20 in (508mm) Hg. Max. time allowed 20 seconds
8	Back leakage	600	600	600	600	600	5 to 100 cc for 100 stroke cycle time
9	Max. fuel delivery	Set to code shown on pump Name Plate*					Delivery tolerance +0 –0.2 cc. Spread between lines not to exceed 1.2 cc
10	Max. fuel delivery check	100 *	100 *	100 *	100 *	100 *	Average delivery to be not less than average at (9) minus 2.0 cc
11	Cut-off operation Shut-off lever closed	200	200	200	200	200	Average delivery not to exceed 0.8 cc
12	Throttle operation Throttle lever closed	200	200	200	200	200	Screw back anti-stall device and lock. Average delivery not to exceed 1.0 cc
13	Fuel delivery check	900 750	600	1270	1100	850	Record average delivery
14	Governor setting	960 810	640	1450	1170	900	Set throttle by maximum speed adjustment screw to give max average delivery of 2.0 cc. No line to exceed 2.5 cc. Lock stop screw
15	Fuel delivery check	900 850	600	1270	1100	850	With throttle set as at (14) average delivery to be not less than average at (13) minus 0.4 cc
	Spring position code	5 7	1 & 2	4	4	7	
16	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc					
		Lock stop screw					
17	Timing	Using outlet 'U' (30 atm. pressure) set timing ring to letter 'G' on Drive Plate With pump in this position set indexing tool to 113° and scribe line on Housing Flange					
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading						
†	5 to 10 lb/in^2 (0.35 to 0.7 kg/cm^2)						
††	6 to 11 lb/in^2 (0.4 to 0.8 kg/cm^2)						
†††	45 to 65 lb/in^2 (3.2 to 4.6 kg/cm^2)						
††††	58 to 78 lb/in^2 (4.1 to 5.5 kg/cm^2)						

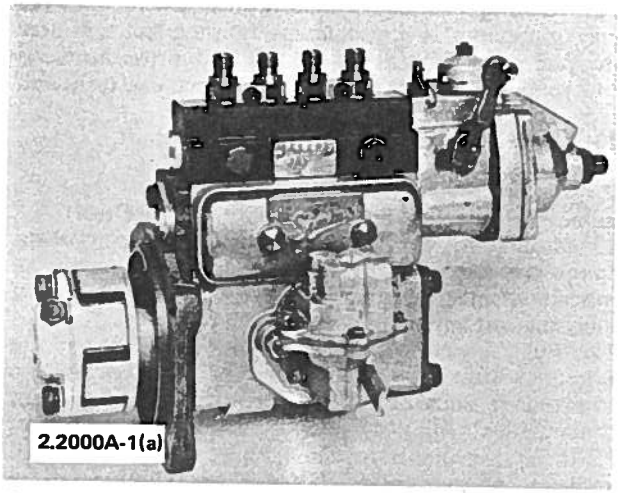
Test No.	Description	3249380 – 3249389	3249390 – 3249399	3249400 – 3249409	3249420 – 3249429	Requirements
		R.P.M.				
1	Priming	100 Max.	100 Max.	100 Max.	100 Max.	Fuel delivery from all injectors
2	Transfer pump vacuum	100	100	100	100	Note time to reach 20 ins (508 mm.) Hg. Max time allowed 20 seconds
3	Transfer pressure	100	100	100	100	11 lb/in^2 (0.8 kg/cm^2) minimum
4	Transfer pressure	800	800	800	800	65 to 80 lb/in^2 (4.6 to 5.6 kg/cm^2)
5	Cambox pressure	800	800	800	800	4 to 10 lb/in^2 (0.3 to 0.7 kg/cm^2)
6	Advance position	800	800	800	800	2¾° – 3¼° (Shim as required)
7	Advance position	1100	1100	1100	1100	3¾° – 4¼°
8	Back leakage	800	800	800	800	5 to 100 cc for 100 stroke time cycle
9	Max. fuel delivery	Set to code shown on pump Name Plate*				Delivery tolerance +0 –0.2 cc Spread between lines not to exceed 1.2 cc
10	Max. fuel delivery check	100 *	100 *	100 *	100 *	Average delivery to be not less than average at (9) minus 2.5 cc
11	Cut-off operation Shut-off lever closed	200	200	200	200	Average delivery not to exceed 0.8 cc
12	Throttle operation Throttle lever closed	200	200	200	200	Average delivery not to exceed 1.5 cc
13	Fuel delivery check	600	1300	900	1200	Record average delivery
14	Governor setting	650	1500	950	1270	Set throttle by maximum speed adjustment screw to give maximum average delivery of 2.0 cc. No line to exceed 3.0 cc
15	Fuel delivery check	600	1300	900	1200	With throttle set as at (14) average delivery to be not less than average at (13) minus 0.4 cc
	Spring position code	8	1	7	7	
16	Governor setting	At half speed stated on Name Plate set throttle to give average delivery of 2.0 cc				
		Lock stop screw				
17	Timing	Using outlet 'U' (30 atm Pressure) set timing ring to letter 'G' on Drive Plate With the pump in this position set indexing tool to 113° and scribe a line on the housing flange				
*	Use 30 seconds glass draining time and allow fuel to settle for 15 seconds before taking reading					

2.2000A

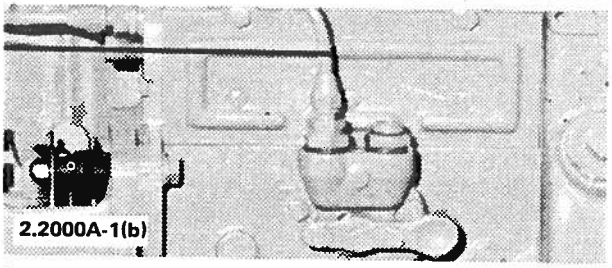
FUEL INJECTION PUMP INLINE TYPE

INLINE TYPE FUEL INJECTION PUMP (Description)

1. The Inline type of fuel injection pump used on 220 cu. in. engines is manufactured by Simms (a), while that used on 330 cu. in engines is manufactured by C.A.V. (b).



2.2000A-1(a)



2.2000A-1(b)

2. Both types of pump are of the cam operated spring return plunger design with a separate pumping element for each cylinder of the engine. The elements are arranged in line and operated vertically by the camshaft and roller tappet arrangement within the pump housing.

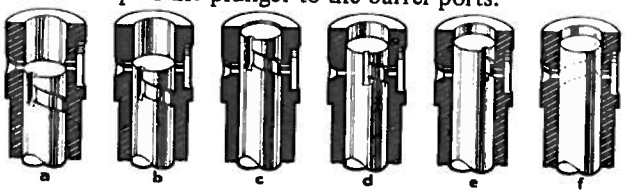
3. The injection pump has an eccentric on the camshaft to operate the fuel lift pump.

4. A pneumatic or mechanical type of governor can be fitted, the choice being dependent on the application for which the engine will be used.

Operation of C.A.V. In-line Fuel Pump

5. Fuel is supplied from the fuel lift pump to a fuel oil filter, after which it enters the fuel injection pump body and then the pump element, where the fuel is pressurised and fed via pipes to the injectors.

6. The stroke of each element plunger is constant and determined by the pump camshaft; the effective pumping movement however, depends on the relationship of the plunger to the barrel ports.

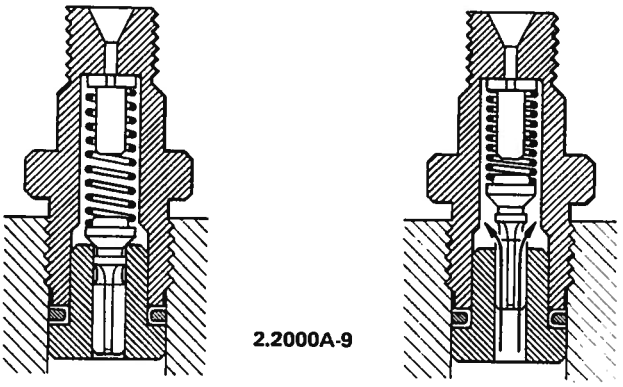


2.2000A-6

7. When the plunger is at the bottom of its stroke (see 'a' 2.2000A-6), fuel under pressure in the pump gallery flows through the two ports to fill the interior of the barrel.

8. As the plunger moves upwards, some of this fuel is forced out of the ports, until the plunger reaches the position shown at 'b' (2.2000A-6) when both ports are covered.

9. At this point further upward movement of the plunger increases the pressure on the fuel and causes the delivery valve to be opened, and the fuel enters the pipe connected to the injector.



Closed

2.2000A-9

Open

10. The pipe and drillings in the injector are kept constantly filled, by previous operations of the plunger and delivery valve, and the extra fuel forced in raises the pressure in the pipe until it is sufficient to lift the injector valve off its seat. This enables the fuel to be discharged as an atomised spray from the holes in the injector nozzle and penetrate the compressed air charge in the combustion chamber.

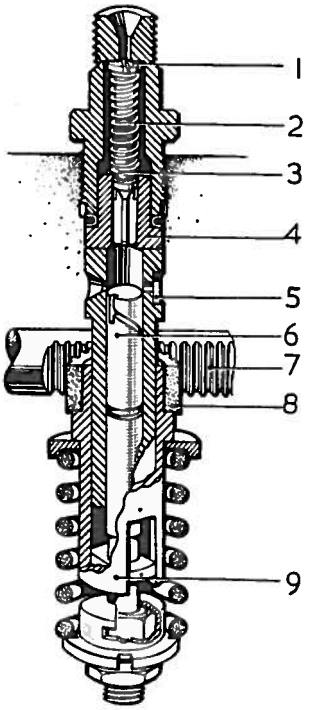
11. The fuel discharge continues until the edge of the helical plunger recess uncovers the spill port (see 'c' 2.2000A-6) when the fuel in the barrel flows down the vertical slot in the plunger and returns through the spill port to the fuel gallery.

12. The resulting drop of pressure in the barrel allows the delivery valve to close (see 2.2000A-9). In closing the delivery valve draws a small quantity of fuel out of the pipe connected to the injector. This reduces the residual pressure in the pipe and enables the injector valve to snap quickly on its seat, thus preventing dribble into the combustion chamber.

13. The effective stroke of the plunger is varied by the movement of the pump control rod, which simultaneously rotates all the plungers within their barrels, so that a wide or narrow section between the top of the plunger and the helical groove is in alignment with the spill port. Commencement of fuel delivery is therefore constant, but the end of the delivery stroke will depend on the load and speed at which the engine is operating. At 'c', 'd' and 'e' (2.2000A-6) a plunger is shown in the position for full load, half load and idling speeds respectively, whilst at 'f' the plunger is in the position required to stop the engine.

14. To enable the correct intervals between the commencement of delivery of fuel from the plungers to be maintained, the plungers can be raised or lowered by the adjustable tappets. Adjustment of the plungers to

ensure an equal delivery of fuel for a given control rod position is effected by slackening the quadrant clamp screw and turning the plunger within the barrel. These operations, known as phasing and calibrating, call for a high degree of skill by specially trained personnel and the use of specialised equipment, and should not otherwise be attempted.



1. Spring Peg.
2. Spring.
3. Delivery Valve.
4. Delivery Valve Seat.
5. Barrel.
6. Plunger.
7. Control Rod.
8. Quadrant.
9. Sleeve.

2.2000A-14

Operation of Simms Inline Fuel Pump

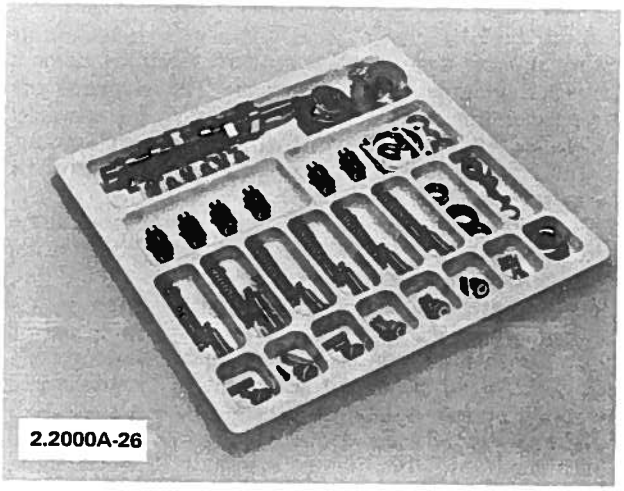
15. The Simms fuel injection pump operates on the same principle as the C.A.V. pump but there are some exceptions. Fuel delivery is controlled in the conventional manner by the helix on the element plunger, but instead of having a vertical slot on its periphery the plunger is drilled along its axis. Rotation of the plungers to vary the amount of fuel delivered is effected by forks clamped to the control rod and engaging arms projecting from the lower ends of the plunger.
16. Calibration is effected by slackening the clamping screw in the control fork and moving the latter along the control rod. Adjustment of the tappets for phasing the pump is carried out by exchanging spacers of graded thickness. These spacers are secured in the top of the tappet by a circlip. Clearance between the bottom of the plunger and the tappet is controlled by the use of bottom spring plates of graded thickness.

Inline Fuel Injection Pump (Removal)

17. Thoroughly clean the area of engine which surrounds the fuel injection pump, this will prevent the ingress of dirt into the fuel system.
18. Slacken the pinch bolt on the fuel pump coupling, access to this bolt is obtained through the coupling housing, it may be found necessary to rotate the engine before a spanner can be fitted.
19. Remove all fuel pipes to the fuel injection pump and lift pump. Care should be taken to ensure that no dirt enters the pump when the pipes are disconnected. Also remove the throttle linkage or pneumatic pipes as appropriate.
20. The two vertical bolts located underneath the fuel injection pump support at the governor end must next be removed. Do not take the bracket from the engine or the fuel injection pump will be left unsupported.
21. Remove the four bolts which secure the fuel injection pump to the coupling housing and withdraw the fuel pump from the engine. It may prove necessary to lever the coupling from the timing gear shaft, this will avoid any undue strain on the coupling.
22. Remove the key from the timing gear shaft.

Inline Fuel Injection Pump (Inspection & Overhaul)

23. **Dismantling, assembly, testing and adjustment of the pump are operations which demand the services of specially trained personnel and the use of certain special tools and test apparatus.**
24. Fuel injection equipment is manufactured to extremely fine tolerances and for this reason the components must be kept perfectly clean and not contaminated with dirt.
25. Ideally, the bench top should have a surface of either linoleum or zinc plate, if these are unobtainable a surface which can be easily cleaned and then covered with greaseproof paper.
26. It is important that all components pertaining to each element should be kept together in a separate container, filled with clean test oil to facilitate correct reassembly. These components include barrel and plunger, plunger spring, lower spring disc, delivery valve and guide, delivery valve holder and tappet etc.



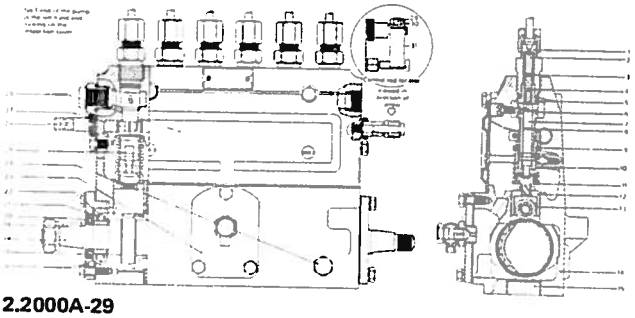
2.2000A-26

27. Under no circumstances should any component come into contact with files or scrapers, the use of grinding paste is also to be avoided.

C.A.V. Inline Fuel Injection Pump

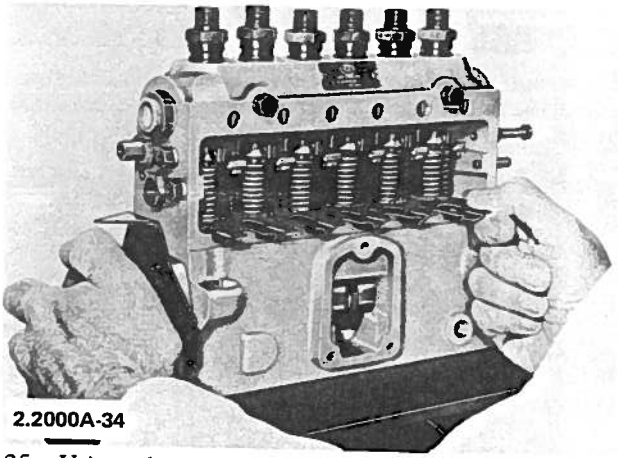
28. A calibration check should be carried out prior to dismantling, see page 8.
29. Annotations refer to 2.2000A-29.

1 Delivery valve holder
2 Delivery valve spring peg
3 Delivery valve spring
4 Delivery valve
5 Delivery valve seat and joint washer
6 Barrel locking screw and washer
7 Plunger
8 Plunger barrel
9 Upper spring plate
10 Plunger spring
11 Lower spring plate
12 Tappet assembly
13 Tappet adjusting screw and locknut
14 Pump housing
15 Base sealing cup
16 End plate
17 Oil seal
18 Camshaft
19 Key
20 Oil seal shim
21 Camshaft bearing
22 Camshaft shim
23 Cover plate
24 Drain plug and washer
25 Control sleeve
26 Control rod
27 Control quadrant
28 Inspection cover
29 Guide block bolt
30 Tab washer
31 Guide block



2.2000A-29

30. Remove drain plug and washer (24) and drain the lubricating oil from the lower chamber of the pump housing (14).
31. Remove the inspection cover (28) from the pump housing.
32. Remove the feed pump or cover plate (23) and the excess fuel device if fitted.
33. Mount the pump on the base plate, tool part number 7044-6A and secure in a bench vice with the pump housing vertical.
34. Turn the camshaft (18) and when each tappet assembly (12) reaches maximum height insert a tappet lifter, tool part number 7144-122, between the lower spring plate (11) and the locknut on the tappet assembly (12).



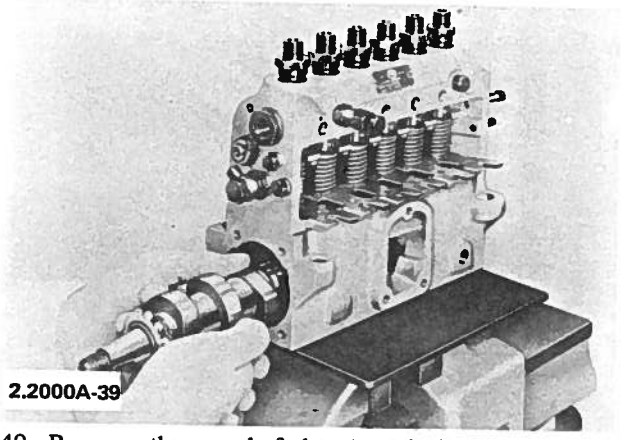
2.2000A-34

35. Using the coupling spanner, tool part number 7044-11, to hold the pump half-coupling, unscrew the camshaft nut with a box spanner.
36. Remove the half-coupling with the coupling extractor, tool part number 7044-8 and remove key (19).

37. From the coupling end of the camshaft remove the four bolts, spring washers and end plate (16).

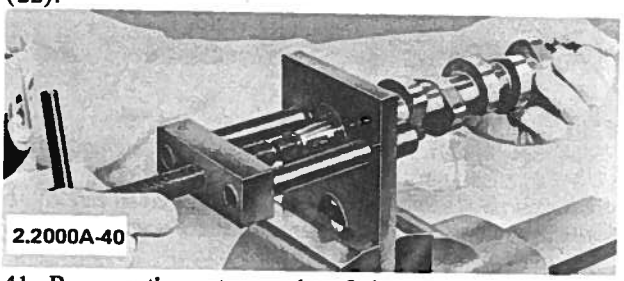
NOTE: The position of the small notch on the end of the camshaft; this must be located at the same end of the pump on assembly. If the camshaft assembly is at variance with the nameplate symbol its application must be checked with the test data sheet.

38. Remove governor, this is detailed on page 11 for mechanical or page 14 for pneumatic governors.
39. Withdraw the camshaft (18) complete with bearings (21) from the pump housing.



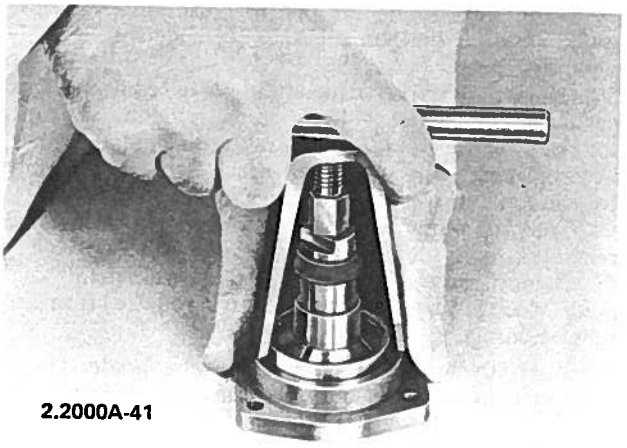
2.2000A-39

40. Remove the camshaft bearings (21) and the inner tracks of the bearings from the camshaft using the extractor tool part number 7144-436A. Note end position and thickness when removing camshaft shims (22).



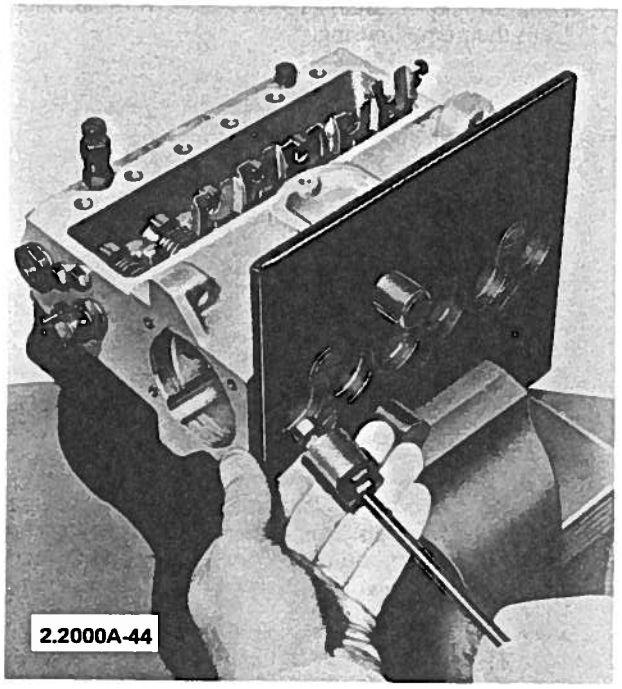
2.2000A-40

41. Remove the outer tracks of the bearings from both end plates using the collet type extractor, tool part number 7144-436B and then remove the oil seal shims (20).

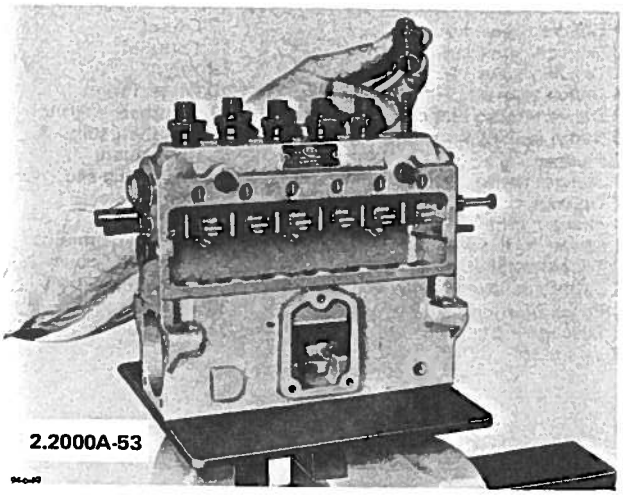


2.2000A-41

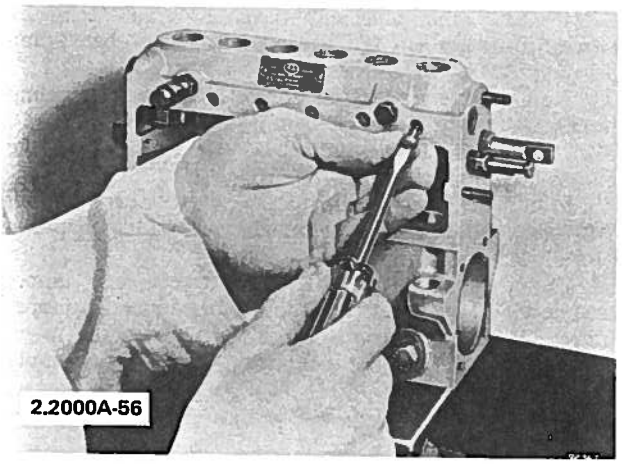
42. Turn the pump to a horizontal position, inspection window uppermost and securely lock the base plate in the bench vice.
43. Using tool part number 7044-815A tap the base sealing cups (15) into the cambox and remove.
44. Holding the tappet assembly (12) with the tappet holder, tool part number 7144-743A exert an upward pressure and withdraw tappet lifter and then the tappet assembly.



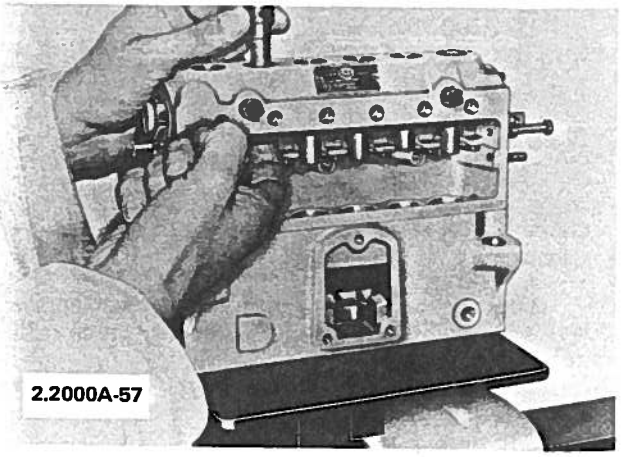
45. With the element plunger forceps, tool part number 7044-569, withdraw the plunger (7) and lower spring plate (11) through the base sealing holes.
46. Immerse the plunger (7) in a bath of clean test oil to protect the surfaces from damage. Place each plunger in sequence for assembly to its mated barrel.
47. Withdraw the plunger spring (10) and upper spring plate (9).
48. Keep the control quadrant (27) locked to the control sleeve (25) and do not disturb the setting.
49. After disengaging the control quadrant and sleeve assembly from the control rod (26) slide the assembly from the plunger barrel (8).
50. During complete dismantling it is convenient to carry out sequence 44 for each cylinder in turn, followed by 45, 46, 47, 48 and 49 in a similar manner, keeping the components of each element assembly together in a small clean container.
51. Turn the pump housing to the vertical position and securely lock in the bench vice.
52. Remove guide block bolt (29), tab washer (30) and guide block (31), and slide the control rod (26) from the pump housing.
53. Carefully unscrew the delivery valve holder (1) of each element from the pump housing and withdraw the delivery valve spring (3), delivery valve spring peg (2) and delivery valve (4).



54. Remove delivery valve seat and joint washer (5) using the delivery valve extractor, tool part number 7144-903C.
55. Assemble each delivery valve (4) to its mated delivery valve seat (5) and immerse in clean test oil to prevent damage.
56. Unscrew and remove barrel locking screw and washer (6).



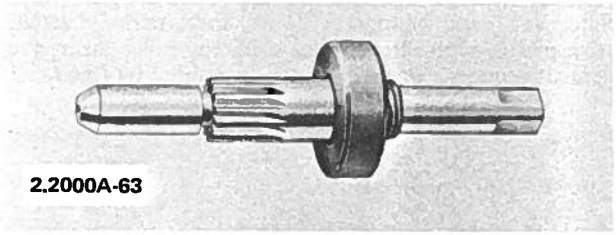
57. Push plunger barrel (8) upwards and withdraw from pump housing. Ensure the element bore is undamaged by this operation.



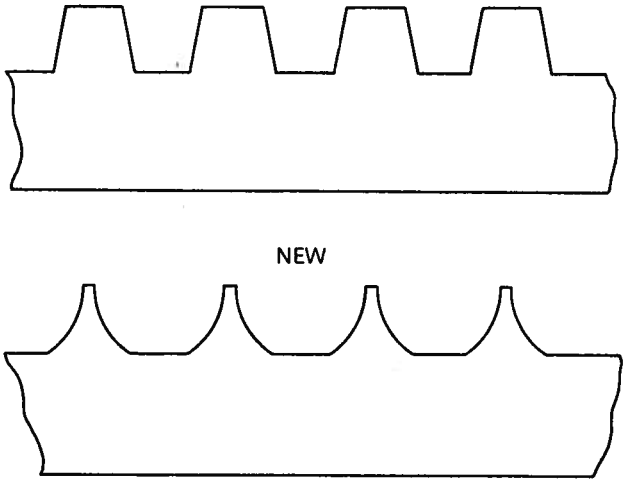
58. Assemble each plunger to its mated barrel and immerse in clean test oil.
59. When a pump is completely dismantled thoroughly clean all components. Do not use abrasive or fluffy cleaning materials.
60. The pump components should be inspected for scoring, pitting, corrosion and excessive wear. Discard defective parts.
61. The following components should be carefully inspected for signs of overheating and must be changed if this has taken place:-

the camshaft, camshaft bearings, outer and inner tracks, tappet rollers and bearings.

62. At each overhaul fit new oil seals, gaskets and sealing washers.
63. The barrel seats in the pump housing must be inspected for pitting or other signs of damage. If the surfaces are damaged or scored they should be **lightly skimmed** with the element barrel seat cutter, tool part number 7144-202. The minimum of material should be removed during this operation and in no circumstances must this exceed 0.25 mm. total depth.

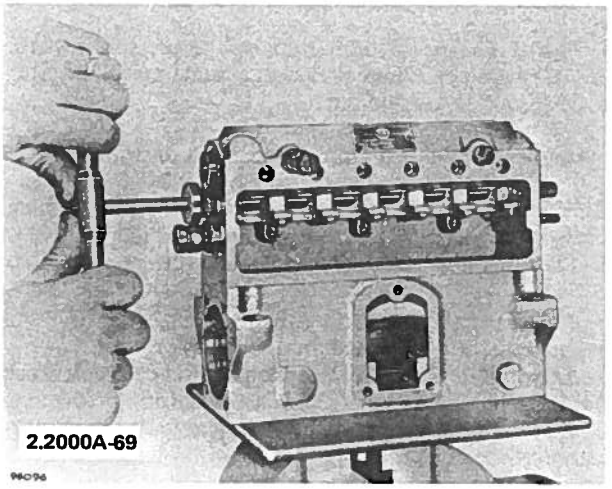


64. Check the control quadrant and control rod for excessive wear on the teeth which gives the appearance of knife edging.



2.2000A-64 WORN-KNIFE EDGE

65. Control rod bushes must be checked for wear and ovality by fitting a new control rod. Comparison of the sliding fits will show the state of the bushes.
66. If necessary worn bushes can be extracted after the locking rings have been removed with the bush locking key, tool part number 7044-658 and by using the control rod bush extractor, tool part number 7144-632.
67. New control rod bushes and locking rings can be assembled and secured using tools part numbers 7144-632 and 7044-658, and must then be reamed in-line. The freedom of the control rod depends on the accurate alignment of the bushes. The final fit must permit the control rod to slide easily, but not loosely in the bushes.
68. A special long shanked reamer, tool part number 7044-563 is used in conjunction with two reamer guides, tool part numbers 7044-562 and 7044-562A. These guides differ only in external diameter, 7044-562A being the smaller, is a snug fit in the new bush before reaming and 7044-562 a snug fit after reaming.
69. Reamer guide 7044-562A is fitted into one control rod bush. The shank of the reamer is then passed from the outside through the further bush, the pump housing and the core of the guide. Secure a wrench to the shank of the reamer and ream by carefully drawing-and-rotating in direction of the cutting edges through the bush.



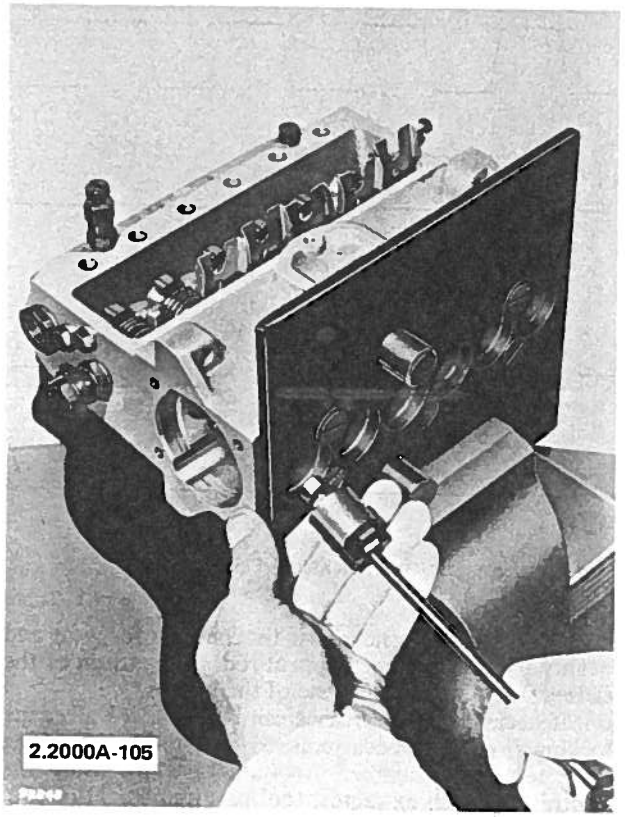
70. This operation is repeated at the opposite end using the larger reamer guide 7044-562 fitted in the newly reamed bush. On completion remove all swarf from the pump housing.
71. When checking the elements, all plungers should normally slide down the barrels under their own weight.
72. Thoroughly clean all components and prior to assembly drain and dip in clean test oil. Do not use cotton waste or cloth wipers of any kind.
73. Mount the pump housing on the base plate, tool part number 7044-6A.
74. Secure in a bench vice with the pump housing vertical.
75. Fit the plunger barrel (8) into its appropriate pump housing bore with the vertical groove in alignment with the barrel locking screw hole.
76. Assemble barrel locking screw and washer (6) ensuring they engage in the plunger barrel grooves before tightening. When tightened it should still be possible to move the plunger barrels (8) vertically until the locking screws contact the end of the groove.
77. Fit a new joint washer to the delivery valve and seat (5), seating each assembly on the upper face of the plunger barrel (8) by lightly tapping it into position using a dummy delivery valve holder and mallet.

78. Care must be taken to ensure that the delivery valve and seat are located squarely.
79. A dummy delivery valve holder is made by machining the lower thread off a spare delivery valve holder till the holder is an easy sliding fit into the pump housing bore.
80. Assemble the delivery valve spring peg (2) and delivery valve spring (3) into each delivery valve holder (1) and screw into position by hand.
81. Using a torque spanner tighten all the delivery valve holders to 54 Nm (5.5 kg.m. or 40 lb.ft.) when the pump is cold.
82. Turn the pump to a horizontal position, inspection window uppermost.
83. Dip each plunger (7) in clean test oil and using the element plunger forceps, tool part number 7044-569, carefully insert the plungers into their mating plunger barrels (8) gently rotating each one several times. Rotation must be free, without binding.
84. Put a piece of plastic or other suitable material over the tappet bores to prevent the plungers from falling out.
85. At this stage of the assembly, the pressure test for the element barrel seat leakage and pump housing porosity can be carried out.

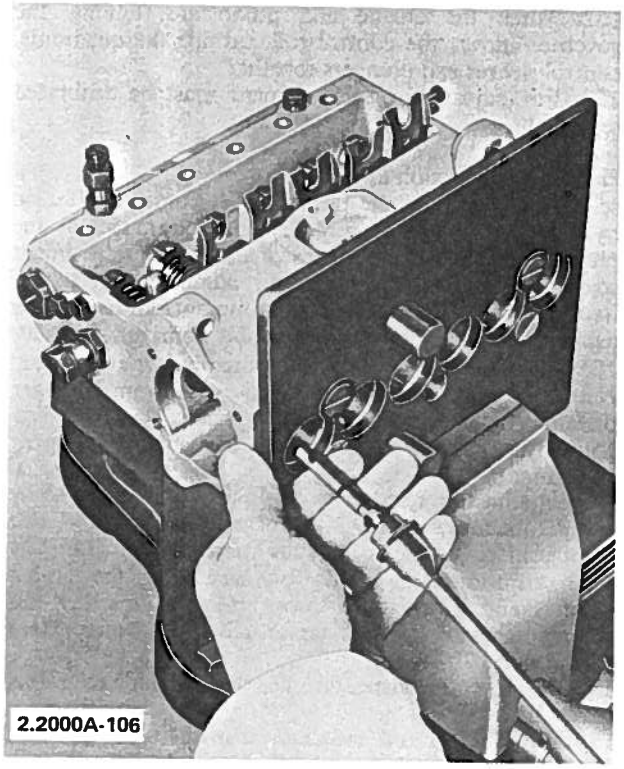
Barrel Seat Leakage & Pump Housing Porosity Test
86. Connect an air line to the fuel feed inlet.
87. Blank off any openings in the fuel gallery which allow air to escape into the atmosphere.
88. Turn on the air supply. Make sure the pressure does not exceed 207 kN/m^2 (2.1 kg/cm^2 or 30 lb/in^2).
89. Immerse the pump in a bath of clean test oil and examine the housing and barrel seat for leakage.
90. Air bubbles will indicate the position of fuel leakage points and these must be cured before proceeding further with the assembly. A slight leak past the plunger can be ignored.

NOTE: When it is necessary to skim the barrel seats, remove only a light skim of material which must not exceed 0.25 mm. using the element barrel seat cutter, tool part number 7144-202. (Fig. 2.2000A-63).

91. If an air supply is not available carry out the following procedure using a C.A.V. nozzle setting outfit.
92. Change the setting outfit standard gauge for a 1379 kN/m^2 (14.1 kg/cm^2 or 0 to 200 lb/in^2) gauge.
93. Wipe off all oil from the housing and connect the nozzle setting outfit to the pump fuel inlet using a suitable adaptor. Blank off all vents subsequent to venting the system.
94. Pump the nozzle testing outfit up to a pressure of 207 kN/m^2 (2.1 kg/cm^2 or 30 lb/in^2).
95. Examine the housing for signs of oil leakage and repair as necessary.
96. When the leakage test is satisfactorily completed remove the pieces of plastic covering the tappet bores and withdraw all plungers keeping them in their correct sequence.
97. Mount the pump horizontally in the bench vice, inspection window uppermost.
98. Slide the control rod (26) into the control rod bushes and assemble the guide block (31) tab washer (30), guide block bolt (29) and tighten.
99. Centralise the control rod (26) lengthways in the pump housing by aligning the drill indentations equidistant at each end with the pump housing.
100. If the control quandrants (27) have been removed from the control sleeves (25), they should be assembled, taking care that the scribed lines on the sleeve and quadrant are aligned before the clamping screw is tightened. The quadrant lug should be in line with the adjusting holes on the quadrant sleeve. New quadrants will not be scribed and the clamping screw heads should always be positioned towards the governor.
101. Holding the quadrant lugs vertical, slide the control sleeve assembly onto the plunger barrel (8) engaging the teeth of the quadrant and control rod so that the quadrant is in mid travel position.
102. Check that the control rod has complete freedom of movement after fitting each sleeve.
103. Slide the upper spring plate (9) onto the top of the control sleeve (25) and seat it against the shoulder in the pump housing.
104. Assemble the plunger springs (10) in position against the upper spring plates.
105. Dip in clean test oil and assemble the lower spring plates (11) and plungers (7) to their mated barrels, through the pump housing base sealing holes, using the element plunger forceps, tool part number 7044-569.



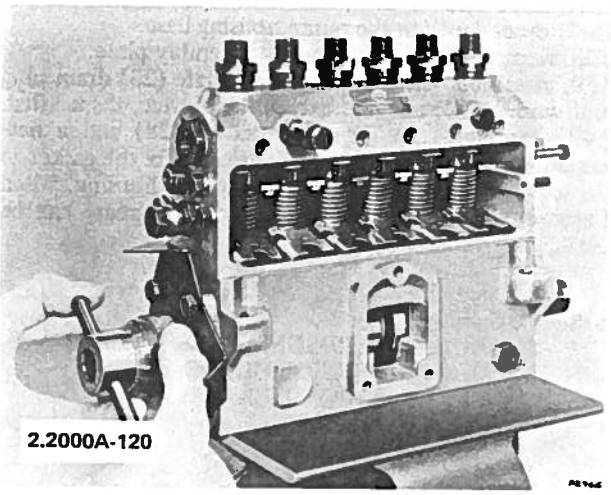
106. Using the tappet holder, tool part number 7144-743A, align the tappet assembly (12) in a horizontal position with the tappet bore in the pump housing.



107. Engage the hexagon of the head clearance adjusting screw on the tappet assembly (12) with the hexagon in the bore of the lower spring plate (11).
108. Correctly assembled, the plunger helix will be at the front facing the inspection window.
109. Press the tappet assembly upwards against the plunger spring until it is possible to insert a tappet lifter, tool part number 7144-122, under the lower spring plate (11). Withdraw the tappet holder.

NOTE: Operations 101 to 107 are applied to each element.

110. Assemble new oil seals (17) to both end plates. Replace the oil seal shims (20) and press in the outer tracks of the camshaft bearings.
111. Assemble the camshaft end float adjustment shims (22) of equal thickness to each end of the camshaft (18).
112. Fit the bearing inner tracks to the camshaft (18).
113. Press the camshaft bearings (21) onto the bearing inner tracks.
114. Assemble and secure the governor housing or one end plate to the pump housing.
115. With reference to the test data sheet locate the small notch on the camshaft at the correct end of the pump.
116. Fit protection cap, tool part number 7044-684 and pass the camshaft through the pump housing end plate without damaging the oil seal.
117. Remove the protection cap and fit it to the opposite end of the camshaft.
118. Slide remaining end plate over the protected camshaft without damaging the oil seal and secure with spring washers and bolts.
119. Remove the protection cap from the camshaft.
120. Check the camshaft end float using the camshaft end play gauge, tool part number 7044-634.



121. The camshaft end play gauge consists of a steel barrel and thimble. The barrel is graduated from 1 to 10 mm. The thimble is graduated in hundredths of a mm.

Operation
122. Turn the thimble to zero on the barrel and screw the gauge securely onto the end of the camshaft.
123. Strike the end of the gauge squarely and firmly with a hide mallet to position the camshaft at the further end of its movement.
124. Turn the thimble till it lightly touches the end plate and take a reading.
125. Strike the opposite end of the camshaft squarely and firmly with a hide mallet.
126. Turn the thimble clockwise until it lightly touches the end plate and take a second reading.
127. The difference between the two readings gives the dimension of the camshaft end float.
128. The end float must be within 0.05 to 0.15 mm., and is controlled by the thickness of the shims between the inner bearing tracks and the shoulders on the camshaft. Make sure the full end float of the camshaft is measured.
129. If shimming is required, it must be arranged equally at each end of the camshaft.
130. When the end float is within the specified limits turn the camshaft several times by hand to ensure it is free.
131. With the key (19) securely fitted into the slot in the camshaft (18), assemble the half-coupling and secure with spring washer and nut, using the coupling spanner, tool part number 7044-11 and box spanner.
132. Complete the assembly of the governor if fitted.
133. Withdraw the tappet lifters after rotating the camshaft till each cam is top dead centre for each element.
134. Turn the camshaft by hand and at the same time move the control rod backwards and forwards through its full travel. There must be no tightness or binding with the control rod or camshaft in any position.

135. For convenience the plunger head clearance can now be set, for details see section on Phasing.
136. Fit a new set of base sealing cups (15) into the pump housing base using the base closing plug punch, tool part number 7044-815A.
137. The base sealing cups must be inserted by the shouldered end of the punch to ensure they are set to the correct depth in the pump housing base.
138. Remove the pump from the assembly plate.
139. Assemble the blanking cover plate (23) drain plug and washer (24) and the excess fuel device, if specified.
140. Assemble the inspection cover (28) and a new gasket. Use Cascosel M1168 adhesive to fix the gasket to the cover before assembly to the pump housing. When Cascosel is not available a good quality grease can be used.

Adhesive Supplied by:

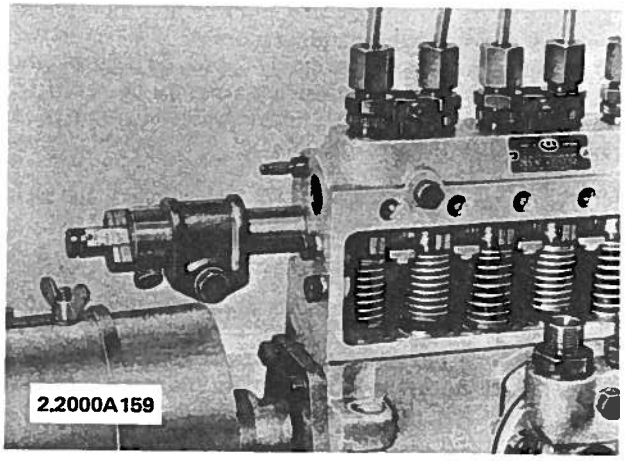
ARABOL EDWARDSON ADHESIVES LTD
RIVERSIDE HOUSE
AMWELL END
WARE
HERTS.

PUMP TESTING

141. The injection pump must accurately meter minute quantities of fuel under all conditions of engine load and speed, and it must deliver the fuel to each cylinder at the exact time at which the engine requires it. To ensure these functions are carried out efficiently, each C.A.V. fuel injection pump is tested and accurately adjusted before it leaves the works.
142. The final setting is indicated by a line scribed across each quadrant and control sleeve.
143. After a pump has been overhauled it should be tested and re-adjusted before it is fitted to the engine.
144. The test data required to adjust and set a pump for its particular application is published by C.A.V. in the form of test plans. It is essential that reference be made to the particular test plan before any attempt is made to set a pump.
145. Special equipment is required to carry out the tests correctly and it is recommended that the work is done by a C.A.V. agent.
146. Pump testing is carried out in two parts PHASING and CALIBRATION.
147. Phasing consists of adjusting the pumping elements so that they start to inject fuel at the correct angular interval in camshaft degrees. The interval for in-line pumps is 360 degrees camshaft angle divided by the number of elements in the pump.
148. It is also necessary to determine the point at which the adjustment has to be made. This is the 'port closed' position the point at which the rising plunger closes the ports through which fuel has entered the element barrel.
149. The injection of fuel into the engine begins after the port closes, following an interval which depends on plunger diameter, cam profile, speed of camshaft, pipe length, the setting of the injector spring and volume of unloading valve.
150. Calibrating the pump consists of making an adjustment for the equalising of fuel output from each pumping line.
151. When the pump is working, the output of each element depends on the position of the helical edge of the plunger helix in relation to the spill port of the barrel, a position which can be varied by turning the plunger in the barrel.
152. When the engine and pump are running, the governor moves the control rod, turning the quadrants, control sleeves and plungers together.
153. For adjustment each element must be calibrated separately.

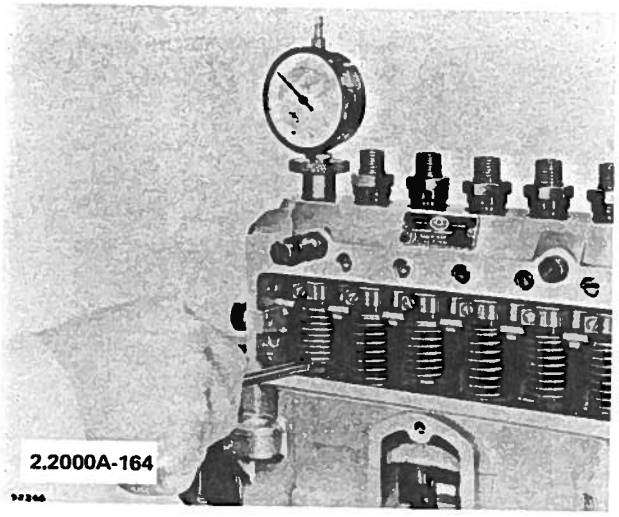
Phasing the Injection Pump

154. Adjustment of the phase of AA pumps is effected by increasing or decreasing the head clearances of the plunger in its barrel by means of the tappet adjustment screw. During this adjustment the plunger at the top of its travel must NOT strike against the bottom face of the delivery valve seating or considerable damage will result.
155. Adjustment is correct when the plunger at top dead centre has a head clearance of 0.5 ± 0.15 mm., unless a different figure is given in the test plan.
156. The following tools are available for tappet adjustment:
Tappet adjusting spanner – tool part number 7044-914.
Tappet locknut spanner – tool part number 7144-180.
Tappet lifter – tool part number 7144-122.
157. Adjustment is made by slackening the tappet locknut and turning the lower spring plate which has small notches to take the tappet adjusting spanner, tool part number 7044-914.
158. Remove the inspection cover (28) and excess fuel device if fitted.
159. Fit control rod indicator and set to zero. After setting the zero position open the control rod to 10 mm. and lock the indicator by means of the knurled locking screw.

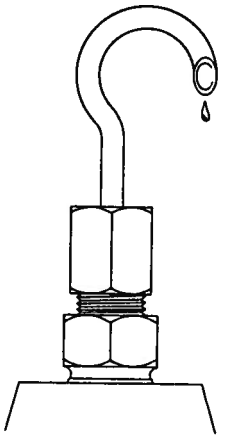


160. Secure the injection pump to a suitable test bench.
161. Set plunger head clearance if not already carried out on assembly.
162. The direction of the camshaft rotation and the amount of head clearance is detailed on the pump test plan, these instructions must be strictly followed.
163. Remove the delivery valve holder (1), delivery valve spring peg (2), delivery valve spring (3), delivery valve (4) and delivery valve seat and joint washer (5).

164. Set the plunger head clearance gauge, tool part number 7044-838 to zero on a surface plate and screw it into the tapped hole normally occupied by No. 1 delivery valve holder until the stem touches the top of the element barrel.



165. Turn the camshaft until the top dead centre mark on the coupling is aligned with the vertical line on the bearing end plate. No. 1 plunger is now at top dead centre.
166. Loosen the tappet lock nut (13) using the tappet locknut spanner, tool part number 7144-180.
167. With the stem of the plunger head clearance gauge resting on the top face of the element plunger, carefully raise or lower the lower spring plate by the tappet adjusting screw, using tappet adjusting spanner, tool part number 7044-914 until the gauge registers the required head clearance.
168. Tighten the tappet locknut.
169. Remove the plunger head clearance gauge from No. 1 element. Replace delivery valve seat complete with joint washer (5) on the upper face of its appropriate plunger barrel (8) and seat the delivery valve seat by lightly tapping it into position using a dummy delivery valve holder and mallet.
170. This operation must be carried out whenever the delivery valve seats are returned to the pump housing.
171. Care must be taken to ensure that the delivery valve and seat are located squarely.
172. A dummy delivery valve holder is made by machining the lower thread off a spare delivery valve holder till the holder is an easy sliding fit into the pump housing bore.
173. Assemble delivery valve holder (1).
174. Do not replace the delivery valve (4), delivery valve spring peg (2) and delivery valve spring (3).
175. Connect a short length of pipe, swan neck in shape, to the delivery valve holder, with the outlet end chamfered to improve the observation of the fuel cut off point.

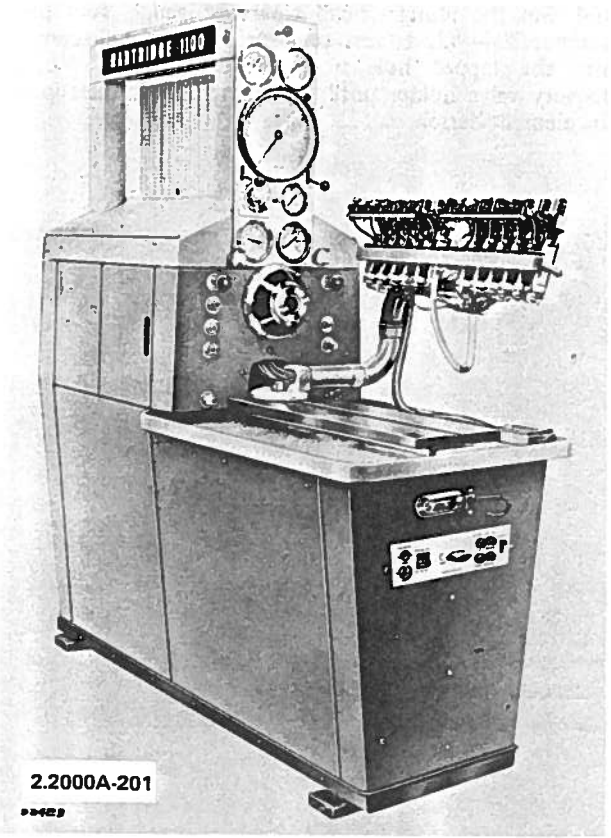


176. The point of injection must now be found and the complete phasing operation carried out as follows:
177. Ensure that No. 1 cam is at top dead centre.
178. Connect the pump fuel inlet to the fuel supply of the test bench and loosen one of the air vent plugs. Allow fuel to flow until it is free of air bubbles then tighten the air vent plug.
179. Rotate the camshaft until No. 1 plunger is at bottom dead centre, fuel will now flow from the fuel chamber into No. 1 element and out through the swan neck pipe. Fuel cannot pass through the remaining elements since their delivery valves are in position.
180. Turn the camshaft in the direction of rotation until No. 1 plunger starts to lift.
181. As the plunger gradually closes the barrel port, the flow of fuel from the swan neck pipe will diminish. Continue to rotate the camshaft very slowly until the exact point at which the flow ceases is established. This is the point of port closure.
182. Take care that the plunger is rising in its stroke or a false reading will be obtained.
183. Set the graduated disc to zero, taking care not to disturb the camshaft.
184. Check that the camshaft has not turned by repeating the operation in sequences 180, 181, and 182. Turn off the fuel.
185. Remove the swan neck pipe, wash No. 1 delivery valve (4), delivery valve spring (3) and spring peg (2) in clean test oil, and assemble to the pump. Tighten the delivery valve holder to a torque of 54 Nm (5.5 kg/m or 40 lb/ft.).
186. The camshaft is now set on No. 1 element at the point to which the adjustment of the remaining elements is correlated and they must now be set to inject at their correct intervals.
187. **In the following instruction the pump is assumed to be a six cylinder type with an injection sequence of 1-5-3-6-2-4.**
188. Remove the delivery valve holder (1), delivery valve spring peg (2), delivery valve spring (3), and delivery valve (4), but not the delivery valve seat and joint washer (5) of No. 5 element. Replace the delivery valve holder (1) and fit the swan neck pipe. Turn on the test oil, which will now flow from the pipe outlet.
189. Turn the camshaft and check the point of port closure for this element.

190. It should be within a few minutes of 60 degrees, but if the difference is in excess of ± 0.5 degrees for a 4 stroke engine or ± 1 degree for a 2 stroke engine, adjustments must be made to the lower spring plate by adjusting the tappet screw as described in paragraph 167.
191. Adjustment is made by slackening the tappet locknut and turning the lower spring plate which has small notches to take the tappet adjusting spanner, tool part number 7044-914.
192. Check the port closed position against the phasing disc. If the point of port-closure is found to be early, the lower spring plate (11) must be lowered; if the point of port closure is late, the lower spring plate (11) must be raised. Lock the tappet nut (13) after adjustment.
193. Turn off the test oil.
194. Remove the swan neck pipe and holder and delivery valve seat (5). Check that the head clearance is 0.5 ± 0.15 mm. with the plunger head clearance gauge tool part number 7044-838 as described in paragraph 167, unless otherwise detailed in the Test Data sheet.

NOTE: When adjusting No. 1 element, the head clearance is determined first, and then the point of port closure. When succeeding elements are adjusted, the correct port closing point is set first and the head clearance checked afterwards.
195. If the head clearance of any element is not within the required limits after phasing, the clearance on No. 1 element must be increased or decreased within the tolerance of ± 0.15 mm. and the pump must be completely rephased.
196. Remove the gauge, and assemble the delivery valve seat and joint washer (5), delivery valve (4), delivery valve spring (3), delivery valve spring peg (2) and delivery valve holder (1).
197. Tighten the delivery valve holder to a torque of 54 Nm (5.5 Kg/m or 40 lb./ft.).
198. Phase and check the head clearance of the remaining elements in the correct firing order.
199. Finally recheck the setting of No. 1 element in relation to the disc marking. If any discrepancy is found, the complete phasing operation must be repeated.
200. Assemble the feed pump to the injection pump.

Calibrating the Injection Pump
201. When the phasing tests have been completed the next operation is to ensure that all the elements will supply equal amounts of fuel. 'Calibration' is the term applied to the process of obtaining this balanced output. A test machine is essential for this process and a typical test machine is illustrated.



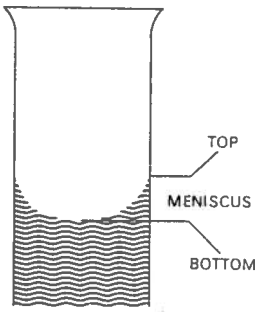
202. Before a pump leaves the factory it is accurately adjusted and the final setting is indicated by a line scribed on each control quadrant and control sleeve.
203. Slight alterations to the original setting may be needed after extended running, due to wear on the element, quadrant and delivery valve. The adjustment will be small and the new setting lines should be scribed after the calibration of fuel deliveries.
204. The quantity of fuel delivered by each element, and the point at which these quantities are balanced and checked will depend on the pump specification detailed in the test plan for a given application.
205. Accurate measurement and adjustment of output can be made only by trained and skilled personnel using a suitable power driven calibrating machine, and it is strongly recommended that the work is carried out by a C.A.V. agent.
206. The test machine must be capable of driving the pump at the speeds given in the test plan and should be able to maintain any selected speed within close limits. It must supply filtered test oil to the injection pump by gravity or pressure feed, and the filter must be of a quality which will give complete protection to the pump.
207. Each pump has a specific output according to its application and care must be taken to ensure that the correct test plan is to hand before calibrating.
208. A study of the test plan will show the different outputs which must be obtained at different control rod settings for given speeds.
209. The output from each pumping element during calibration is measured over 100 pumping strokes, unless otherwise specified in the test plan.

210. The test machine is fitted with an automatic trip mechanism which diverts the fuel away from the measuring glasses when the required number of strokes are completed.
211. Mount test nozzle BDN 12SD 12B set at 175 atmospheres on the test machine.

NOTE: The following sets of test injectors are available on the unit exchange system direct from Leslie Hartridge Limited, Buckingham, England.

Set of 6	Part Number 7244-106
Set of 8	Part Number 7244-108

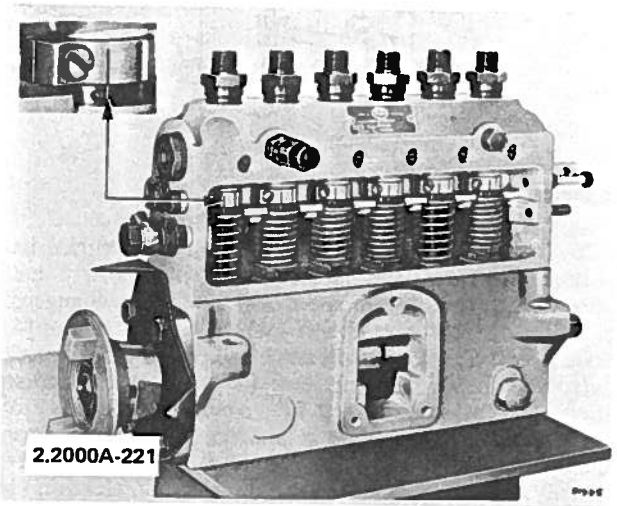
212. The connection between the test nozzle and the high pressure outlet of the pump is made by a pipe 6 mm. outside diameter x 2 mm. internal diameter and 600 mm. long, or as specified in the test plan.
213. Before setting the control rod opening position, as specified in the test plan, the zero position of the control rod indicator must be checked.
214. Before calibration, the pump, injectors and injector pipes must be thoroughly vented; an operation normally carried out with the pump driven at 200 rpm.
215. After venting, set the control rod to the first position given in the test plan and lock it with the control rod indicator locking screw. The test plan shows the fuel outputs that must be obtained at the different control settings for specific speeds.
216. The pump is now driven at the prescribed speed and the individual element outputs checked over 100 pumping strokes or as specified in the test plan. When recording the level of the fuel in the measuring glass, take care to read the level at the lowest point of the meniscus.



2.2000A-216

217. Minor adjustments to individual elements must be followed by a complete check at the same control rod opening rpm and over 100 strokes.
218. Calibration is now carried out at the other control rod openings specified in the test plan, and adjustments made as necessary.
219. Individual element output is adjusted by slackening the quadrant screw and moving the quadrant sleeve so that it alters the position of the plunger control helix in relation to the fuel port. The quadrant clamping screw must be tightened after the adjustment has been made.
220. When carrying out adjustments it should be noted that to increase fuel delivery the control sleeve is rotated towards the governor. Only a small movement of the control sleeve is necessary to alter the fuel supply.

221. When the adjustments have been carried out and the tests completed, new setting lines should be drawn on the control sleeve and quadrant. Camera black can be used to remove the old setting line on the control sleeve.

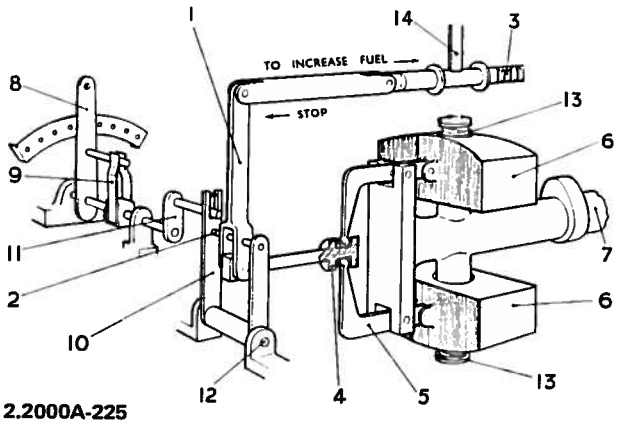


2.2000A-221

222. Refit excess fuel device if specified.
223. Maximum fuel output must now be set in accordance with the test plan and pump application. The method varies with the type of governor.

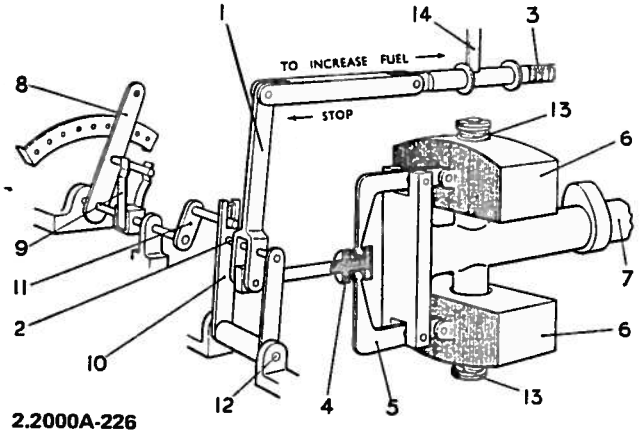
C.A.V. Mechanical Governor

224. The speed of a diesel engine is determined by the load and amount of fuel delivered. The governor is arranged to control the latter, increasing or decreasing it to compensate for any changes in load which tend to cause variation in speed. The C.A.V. unit is a conventional centrifugally operated spring opposed fly-weight type. A suitable linkage converts the changing position of the weights to a longitudinal movement operating the rod controlling the fuel output of the injection pump. The position of the throttle lever also affects the fuel output of the fuel injection pump, the two controls being interconnected with a series of links and moving pivots, to understand this we must consider a series of sketches (2.2000A-225, 2.2000A-226 and 2.2000A-228).
225. The important feature which must be clearly grasped if the governor operation is to be understood, is that lever (1) floats on two pivots (2) and (4) and can be moved by thrust at either point. It is the combination of these two – from the governor (via 4) and from the control lever (via 2) – operating on the fuel control rod (3), which enables the speed to be held at any desired point anywhere within the range. The following examples show how this is effected.



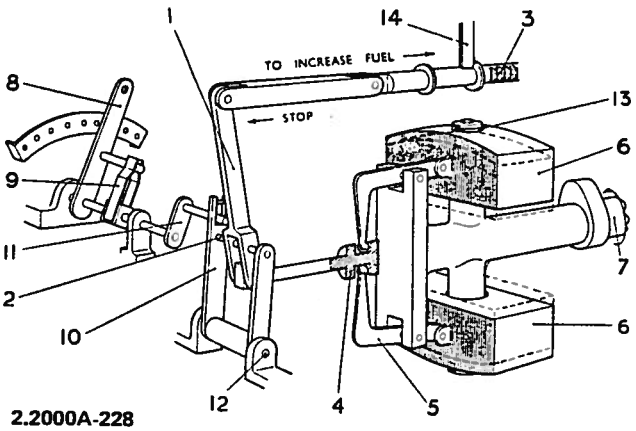
2.2000A-225

226. In Figure 2.2000A-225 assume that the engine has settled down to run steadily at approximately half speed. Any variation in speed will result in a change of position of the fly-weights (6) which will shift point (4) to the left if speed decreases or to the right if speed increases. This will swing lever (1) on pivot (2) and so move the fuel control rod (3) to alter the quantity of fuel injected. It should be clear from the sketch that an increase of speed will cause rod (3) to move to the left, to reduce fuel supply to check the speed and vice versa if speed increases. Under these conditions therefore, the governor acts as a normal fixed speed Hartnell type. It is now desired to increase speed and control lever (8) is moved to the right to the three-quarter position.



2.2000A-226

227. The results of this are:-
(a) Pivot (2) is thrust to the right, causing lever (1) to swing on pivot (4) and push control rod (3) to the right, increasing the fuel supply. Owing to the relative lengths of lever (1) above and below pivot (2) a small movement of the control lever (8) will cause a relatively large movement of rod (3) and the engine will accelerate rapidly.
(b) The relatively large movement of the top end lever (1) may force rod (3) to the maximum fuel stop (14) at the limit of its travel before the desired amount of movement of the control lever (8) has been effected. The remaining movement of lever (8) could then only be obtained by moving pivots (4) to the right, which would mean forcing the fly-weights apart against their spring pressure. This would apply heavy loading on the linkage and is obviously undesirable. Spring loading (9) of the control lever (8) is therefore provided to absorb this excess movement until the fly-weights move outwards normally with increasing speed.
228. As the engine accelerates, the fly-weights will move outwards to a position corresponding to the desired higher speed range, and the results of this (2.2000A-228) will be:-
(a) Pivot (4) and pivot (2) will move to the right, thereby allowing spring (9) to regain its equilibrium and take up its normal position.
(b) The flyweights (6) now turning through a greater radius and acting on pivot (4) will move lever (1) about the new centre of pivot (2) causing fuel control rod (3) to shift to the left, decreasing the fuel supply as the speed rises.
(c) The governor is now operating at the selected higher speed range. The positions of pivot (2) and pivot (4) which are now to the right of the half-speed position will be retained by spring (9) and any movement of the fly-weights (6) due to speed variation will be transmitted through pivots (4) and (2) and lever (1) to the control rod (3).



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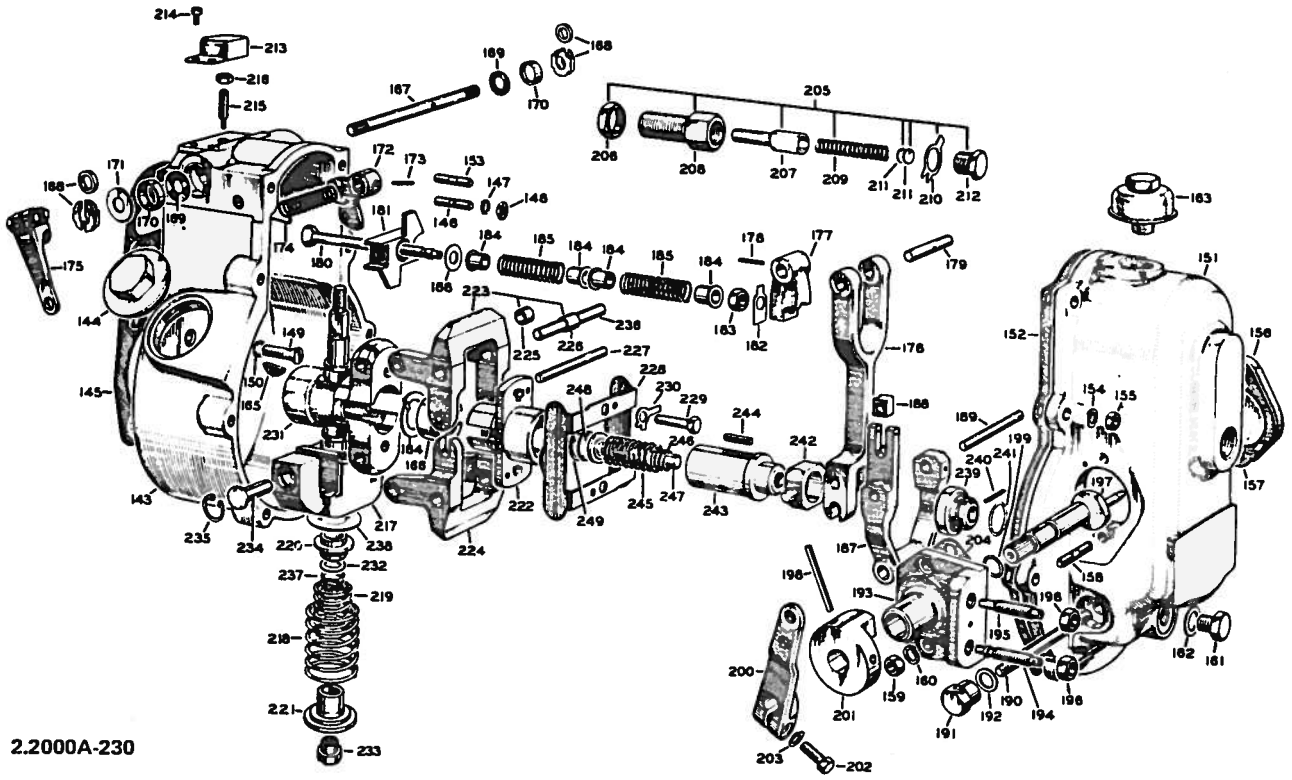
229. When it is desired to run the engine at a lower speed, the control lever (8) is moved to the left. The governor weights and linkage will move to the positions required, following a reverse sequence of events, and give satisfactory control over the selected lower speed range.
230. The numbers in brackets in the following pages refer to illustration 2.2000A-230.



231. The main essential to guarantee satisfactory operation of the C.A.V. mechanical governor is that all moving parts are free from any binding within the joints.
232. The linkage which transmits the movement from the weights to the control rod should be free, it is advised to visually check all pivots and bearings for wear.
233. Check the bushes fitted to the bellcrank levers (223) and (224) also the element support sleeve (231). Should these bushes (225) and (226) require replacement remove existing bushes from the casting and press new ones into place, ream to the correct size using reamer C.A.V. tool number 7044-114.
234. Check the bores into which the pivot pins (234) locate in the weights (217) should these show any wear the weights should be replaced, these are not serviced singularly, only in matched pairs.
235. Remove from the governor all external connections also the oil filler plug (144) and the oil level plug (161).
236. Drain all the oil from the governor.
237. Two hexagon nuts (191) will be noted sealed with wire, this wire should be removed and the nuts removed, this will allow the timing lever and fork fulcrum pin (190) to be withdrawn.
238. Remove the two nuts (159) which secure the control lever (200) and flange assembly (193) the entire assembly can be withdrawn from the end cover (151).
239. Remove the eight screws which secure the end cover and remove end cover (151) this will expose the operating components of the governor.
240. The control rod linkage (177) can now be unscrewed from the control rod and the assembly withdrawn by swinging down through 90° and unhitching the forked lever.
241. Examination of the governor weights will show two screws (229) which are located parallel to the pump camshaft. These screws should be removed, in order that the plate (228) which they secured can be withdrawn towards the governor linkage hence exposing a pin (227) which the plate secured.
242. Turn the pump camshaft until such time as the pin (227) is in a position opposite to the extension of the housing, the pin can then be pressed upwards and finally removed using only fingers. This will enable the governor linkage to be withdrawn from the governor weights.
243. Remove the brass element guide bush (222) from the end of the camshaft, at this point of the dismantling procedure the bush should not be attached in any way and can be lifted out, exposing the governor weight assembly securing nut (166).
244. Remove the nut (166) which secures the governor weight assembly to camshaft using tool (C.A.V. Tool number 7044-112B) and withdraw the governor weights assembly using extractor (C.A.V. Tool number 7044-8). The large portion of the extractor is screwed into the governor weight assembly as far as possible, the hexagon screw is then tightened against the camshaft which will result in the weight assembly being drawn from the camshaft. During this operation care must be taken that the weights are in fact being removed and not the threads failing.
245. Remove the key (150) from the keyway in the camshaft.
246. Remove linkage from control rod, this can be achieved by removing the lock tab and one screw.
247. Remove from the rear cover housing (151), the auxiliary idling stop (205). Should this require further

disassembly, grip the unit in a vice and remove the plug (212) which will expose the spring (209) and the plunger (207).
248. In order to disassemble the weights further for possible overhaul, proceed as follows:-
(a) Place weights in a vice (with jaws protected) and compress springs with pressure on upper spring plate (221) remove the adjusting nut (233) with C.A.V. tool number 7044-65, repeat for the other weight.
(b) Remove circlips (235) which retain pins (234) this will enable the two bellcrank levers (223 and 224) to be removed from the element support sleeve (231).
249. Remove the excess fuel hood (213) which will expose the excess fuel adjusting screw (215) remove this screw. Remove from the spindle the stop lever (175). With a screw driver remove the spring clip (168) and discard the clip. The pawl (172) is located on the spindle (167) by a pin (173) this pin must now be driven from the pawl which will allow the spindle to be withdrawn from the housing. The pawl spring (174) can now be removed. Remove all seals and discard.
250. During the assembly of the governor, check for freedom of all moving parts.
251. Assemble the bellcrank levers (223) and (224) to the element support sleeve (231) using the pivot pin (236).
252. Fit the weights (217) to the bell crank levers (223) and (224) using pins (234) and fit the pin retaining circlip (235).
253. The excess fuel device spindle seals (170) can now be fitted to governor housing also the pawl spring (174) and pawl (172) located in the housing, these being held in position whilst the spindle (167) is passed through the housing. Locate the pawl to the spindle with pin (173). Fit new spring clips (168) to spindle, refit the control lever (175).
254. Re-fit the control linkage assembly to the fuel injection pump control rod with one screw and one lock tab, tighten screw and lock the tab.
255. Re-fit the woodruff key (165) to key way on fuel injection pump cam and fit the governor weight assembly to the camshaft, fit the spring washer and nut (166) and tighten to a torque of 500 lbs./ins. (5.7 kg.m.). (Use C.A.V. tool number 7044-112B).
256. Fit the brass element guide bush (222) taking care to fit the correct way, the slotted end fitting nearest to the fuel injection pump camshaft.
257. Screw the forked control link assembly to the control rod assembly.
258. Slide the assembly to fit the overide element inside the element guide bush, rotate the governor weight assembly and camshaft until such time as it is possible to insert the element bell crank swivel pin (227), retain this pin with the element retaining case (228). Fit the two locktabs and screws which secure the element retaining case and tighten, lock the locktabs.
259. Fit with a new gasket in the rear housing cover and secure with eight lockwashers and nuts.
260. Insert through the lower pair of holes in the rear housing cover the timing lever and fork swivel pin (190). Fit new sealing washers (192) and cap nut (191). It will be noted that the cap nuts are screwed to the timing lever and fork swivel pin, not the rear housing cover, when tightening grip one cap nut with a spanner and tighten the other.
261. Fit the lever and flange assembly (193) with a new gasket taking care to locate the eccentric on the camshaft adjusting lever (197) into the hole on the block (188). Secure assembly with two spring washers and two nuts, tighten nuts.
262. Replace the oil filler plug and drain plug with a new sealing gasket.

C.A.V. Pneumatic Governor
263. This governor operates through its sensitivity to pressure variations between two pitot tubes situated at a butterfly valve in the intake manifold venturi. To obtain a full understanding of the operation of the pneumatic governor it must be realised that as the airspeed increases over a body the pressure falls, this is called depression the converse also being true, the application of this information will be understood at a later time.
264. The butterfly valve located in the air intake venturi is controlled via the throttle linkage and the pneumatic governor in its turn controls the position of the pump control rod, thus metering the fuel delivery according to the load imposed on the engine. This type of governor controls both the idling speed and the maximum speed of the engine.
265. At idling speed, the air to the engine is drawn mainly past the front pitot tube of the venturi, and a depression is created in the pipe leading to the rear chamber of diaphragm unit. As the front chamber is maintained at atmospheric pressure, the diaphragm contacts the stem of the damper valve and progressively admits an increasing supply of air from the rear pitot tube of the venturi. This has the effect of damping out any tendency for the control rod to oscillate excessively and cause the engine to hunt.
266. As the butterfly valve is opened, the depression at the front pitot tube is reduced, allowing the diaphragm and control rod to move towards the maximum fuel position, thus increasing the fuel supplied to the engine. With the consequent increase in engine speed, the depression felt at the front pitot tube is restored and the control rod is withdrawn until a state of balance is obtained with the diaphragm return spring. When the engine is under load, continued opening of the butterfly valve produces a progressive increase in the quantity of fuel delivered until the control rod contacts the maximum fuel stop screw.
267. When the stop control is operated, the toggle lever pushes against the diaphragm pull rod, causing the pump control rod to turn the element plungers to the no-delivery position.
268. To obtain extra fuel for starting under extremely cold conditions, the stop control lever is pulled outwards, this allows the governor mechanism to move the pump control rod further forward and provide the extra fuel required.
269. The C.A.V. Pneumatic Governor is a very simple device using very few moving parts, and it is advised that the unit be tested as follows before disassembly is commenced.
270. Disconnect the flexible pipes from the governor. NOTE: the engine MUST NOT be started whilst these pipes are disconnected.
271. Remove the inspection cover from the fuel injection pump, this will enable the position of control rod to be observed.

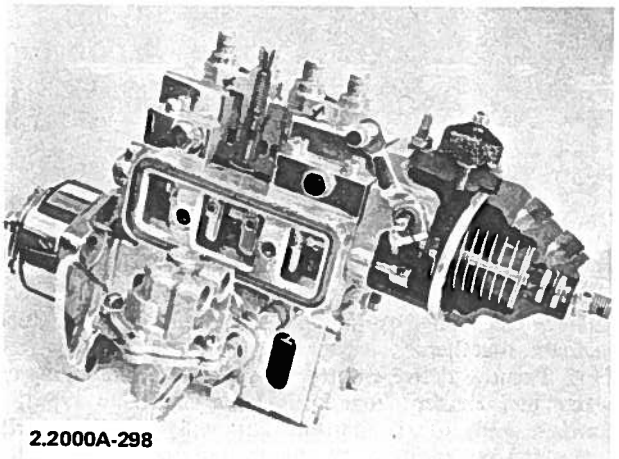
272. Operate the stop control, thus moving the diaphragm and control rod to the 'no fuel' position.
273. Place fingers over the unions to seal the diaphragm.
274. Release the stop control.
275. Observe the movement of the control rod, after a small initial movement the control rod should remain stationary. Should the rod continue to move, check for any sign of air leaks, if none are visible the diaphragm must be inspected.
276. Remove the four screws which secure the governor diaphragm cover, taking care to hold cover carefully as it retains the main spring, remove cover and spring.
277. Insert a small screwdriver blade into the slot which will be noted in the upper right hand corner of the governor housing, carefully prise the diaphragm ring from its seat, taking care not to damage the diaphragm assembly. The diaphragm assembly is located in the guide block by two dogs which pass through a slot in the block, the diaphragm assembly should, therefore, be removed by exerting a twisting action to enable the dogs to be withdrawn through the slot. Should the diaphragm be damaged the entire assembly should be replaced, the leather diaphragm not being serviced individually.
278. Remove the stop lever and also the shaft retaining clip. On the shaft is a pawl which is located by a pin which should be driven out, this will enable the shaft to be withdrawn, also the pawl and spring to be removed. This operation need not be carried out if this portion of the governor needs no attention or the housing is not to be removed from the fuel pump.
279. Remove the locktab and one screw which secures the guide block to the control rod, with finger pressure, push the control rod to the full fuel position, this will enable the guide block to be removed by sliding it to a position which would be attained when the engine is idling. Should the latch spring or latch be damaged the entire guide block assembly should be renewed.
280. Remove the control rod guide bolt and the three screws which attach the governor housing to the pump, remove and discard the gasket.
281. Position the governor housing complete with a new gasket against the fuel injection pump and fix with three screws.
282. Fit the control rod guide bolt and tighten.
283. Push the control rod to the full fuel position, place the guide block into position and pull the control rod to the no fuel position, fit the screw and locktab, tighten screw and lock.
284. Place the pawl and spring in their respective positions in the housing and renew the seal on shaft and fit the shaft. Drive the locating pin into place. Fit a new spring retaining clip and the control lever.
285. Slide the dogs in the diaphragm connecting rod through the slot in the guide block, rotate the diaphragm assembly until it is possible to locate the tab, on the diaphragm assembly, into the slot in the governor housing. Lock the tab.
286. Replace the main spring, also the governor diaphragm cover, secure with four screws.
287. It is most important that satisfactory operation of the governor is ensured before starting the engine, with the inspection cover off the pump operate the stop control, thus moving the diaphragm and control rod to the 'no fuel' position.
288. Place fingers over the unions to seal the diaphragm.
289. Release the stop control.
290. Observe the movement of the control rod, after a small initial movement the control rod should remain stationary. Should the rod continue to move, check for air leaks which must be located and rectified.

CAUTION

291. After completion of an engine overhaul ensure that there are no air leaks between the venturi unit and the induction pipe on the engine, and that the flexible pipe is correctly fitted and the unions tightened. Check the diaphragm unit for leaks and ensure that the controls are connected and function correctly when the throttle is operated. The air filter must be fitted before the engine is started.
292. The fuel pump with the governor attached should be mounted on the test machine and connected to the air system.
293. Run the test machine at 600 rpm and ensure that the fuel injection pump is delivering fuel.
294. With the pump, evacuate the air in the system, the control rod should commence to move away from the maximum fuel position when a depression of between 15 in. and 16 in. of water is obtained.
295. Should the control rod not move at the required depression the diaphragm should be checked for leaks and all leaks found, cured. The pneumatic governing system relies on the air connections all being perfect and this should always be remembered when testing a pneumatic governor.
296. THE ENGINE MUST NOT BE STARTED BEFORE THE VENTURI UNIT, FLEXIBLE PIPES, OR THE AIR FILTER ARE FITTED AND THE RECOMMENDED CHECKS FOR AIR TIGHTNESS ARE CARRIED OUT.
297. Failure to observe this warning may result in serious damage to the engine caused by over-speeding. Should the engine be inadvertently started under these conditions, pull the stop control knob on the instrument panel or the stop lever at the side of the governor and hold in 'stop' position until the engine ceases to run.

SIMMS INLINE FUEL INJECTION PUMP

298. Before disassembly of the fuel injection pump the governor must be removed, this is detailed on page 21 for pneumatic and page 18 for mechanical.



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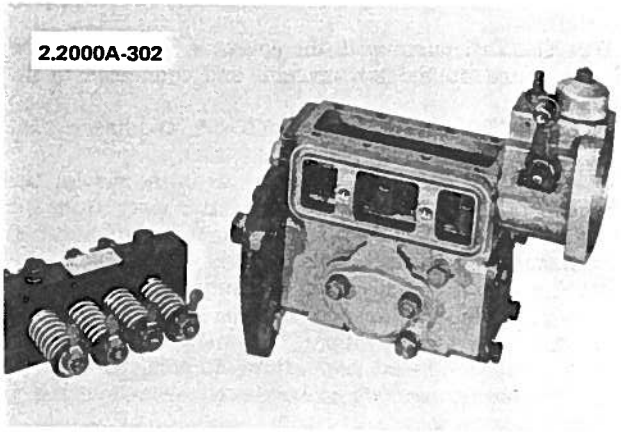
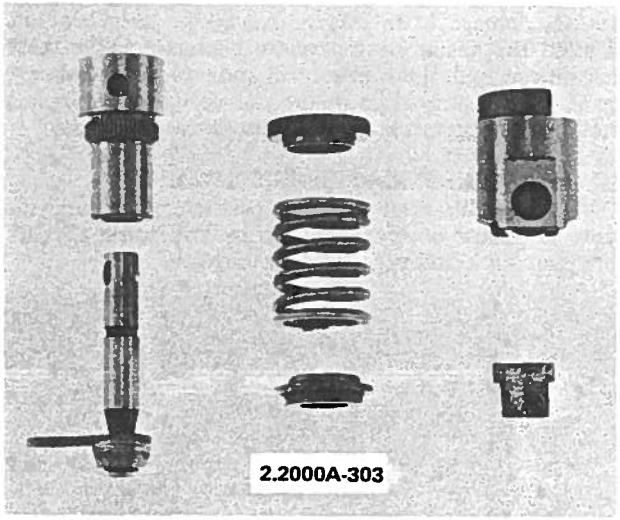
299. Remove the fuel lift pump which is secured by two nuts.
300. Remove captive bolts which will enable the inspection cover and sealing ring to be removed.
301. With a hand maintaining a pressure on the pump body, slacken the Allen screws which secure the pump body to the pump unit housing. The screws should be slackened off evenly around the pump body. It should be realised that the plunger return springs will be exerting an upwards force on the pump body.
302. Lay the pump on its side and gently ease off the pump body, making sure that the plungers, lower spring discs and plunger return spring do not fall off.



303. Remove plungers, lower spring discs and plunger return springs and keep in groups for each fuel element. Remove the delivery valve holder clamps, screws and spring washers.



304. Unscrew the delivery valve holders using Riteway Tool Z8473 and remove, together with volume reducers and delivery valve springs, keeping items for each fuel element together.
305. Remove delivery valves, keeping items belonging to each fuel element together. Use a mallet to tap the bottom ends of the barrels. This will free the barrels from the serrations in the pump body and at the same time push out the delivery valve guides and joint rings.
306. Remove the tappets, lifting them out and taking care to keep them in their correct order so that when reassembled they go back into the tappet bores from which they were removed.
307. Remove from inside the cambox the two 'T' pieces which are located between each pair of tappets. These 'T' pieces are not fixed in any way.
308. At the drive end of the pump is a control rod cover with a bush attached, this is located with a screw which attaches it to the cambox, remove this screw, the cover can then be withdrawn.
309. Slacken with an Allen Key the screws which locate the forks onto the control rod, the control rod can now be removed from the cambox via the bush which was removed from the end of the cambox. Remove forks from inside cambox.
310. Unscrew and remove camshaft nut. Remove flange, then remove the Woodruff Key from the camshaft.

NOTE: It is not necessary to dismantle the coupling. When all securing bolts etc. have been removed, the in-line pump can be removed by pulling the two halves of the coupling apart. When replacing, the insert is assembled between the two halves which can only be located in the correct position due to the dowel pin on the end of one of the two screws.

311. On pneumatic governed pumps remove the screws which retain the bearing housing located at the governor end of the fuel pump, and tap the camshaft with a soft mallet at the coupling end. This action will break the liquid jointing seal and remove bearing housing from cambox.
312. Remove the four screws which retain the bearing housing at the coupling end of the pump and tap the camshaft from the governor end with a soft mallet. This action will break the liquid jointing seal and remove bearing housing from the cambox. The camshaft can now be removed from the cambox.
313. The components should next be subjected to the following inspection before reassembly.
314. Visually inspect the camshaft bearings, should they be coloured blue they are no longer serviceable due to overheating. Overheating can be caused by lack of lubricating oil or no end float when the pump was assembled. Should the bearing life appear to be short, check that the pump is aligned correctly to the engine.
315. Check the fit of the tappet with the cambox body. If excessive, worn parts must be replaced.
316. Check that the tappet pad is not worn. If it is required to renew a tappet pad, the spring circlip should be removed and tappet plate replaced, refit spring circlip.
317. Remove the pin from the tappet, this is just a push fit, and remove roller and bearing, replace any worn parts and assemble.
318. Use a new control rod and check that the bushes are not worn, if they are, they must be replaced, also the existing control rod should be checked for wear. Any worn parts must be replaced and when new components are fitted care must be taken to ensure that there is no binding as this will affect the operation of the fuel pump and governor.
319. Check all threads and examine castings for any sign of damage.

320. During the assembly great care must be taken to ensure absolute cleanliness of all parts, also replace all seals and gaskets.

321. Pack the camshaft bearing with grease (Mobilgrease MP) and replace the camshaft into the cambox.

322. Apply a sealing compound to the bearing housing (on pumps with pneumatic governor) or fit a gasket (on pumps with mechanical governor). Fit the bearing housing situated at the governor end of the cambox, tighten screws to a torque of 5-7 lbs./ft.

323. Apply a sealing compound (Wellseal Liquid Jointing or Hylomar L33 or equivalent) to the mounting flange. Fit with four screws the mounting flange situated at the coupling end of the cambox and tighten the screws to a torque of 5-7 lbs./ft.

324. Check the end float on the camshaft, using camshaft end float gauge Hartridge Tool 89559 and Extension 89559/3 also Dial Indicator Hartridge Tool 23764 as follows:-

325. Screw gauge assembly to threaded portion of camshaft.

326. Press the camshaft to the full limit of its travel and zero the dial Indicator Gauge, this is achieved by rotating rim of the instrument.

327. Pull the camshaft to the opposite extreme of travel, the travel should be between 0.002 in. – 0.006 in. Should adjustment be required, shims should be fitted, they are available in 0.004 in. and 0.008 in. sizes, it will be necessary to remove the bearing housing to insert the shims.

328. Fit the key and coupling.

329. Position the driving flange and secure with the camshaft nut. Tighten to a torque of 45.8 lbs./ft.

330. Insert the control rod into the cambox taking care that the chamfer in the hole where the link locates is on the correct side. Feed the control forks onto the control rod and fit rod into the bush at the governor end of the cambox. Fit control rod cover with bush attached and secure with screw. Locate No. 1 fork about 1.0 millimetre from the end of the squared section of the control rod. Space the remaining forks equally along the control rod then tighten the fork screws. Check that the control rod moves freely.

331. Insert 'T' pieces into the slots in the cambox, these are not retained in any way.

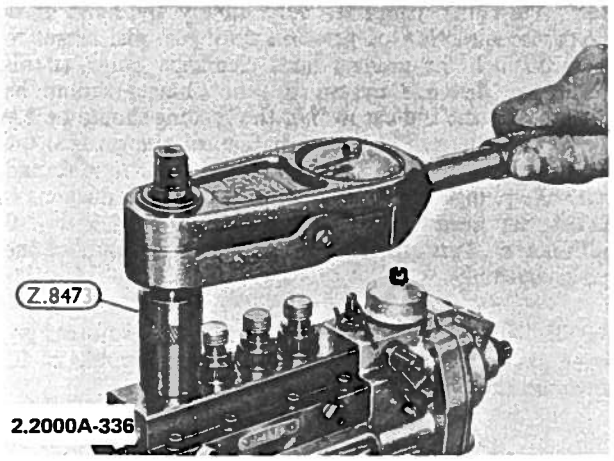
332. Fit the tappets ensuring that each one is fitted in its original tappet bore, it should be noted that the cut out in the tappet should go towards the inspection window.

333. The pump elements (Barrels and Plungers) and delivery valve assemblies are assembled wet from clean test oil.

334. Replace the element barrels into their original positions in the pump body noting the fitting of the master spline, also replace the delivery valve guides.

335. Fit new nylon joint rings onto the valve guides also fit the delivery valves. Fit the delivery valve springs, volume reducers and delivery valve holders.

336. Tighten the delivery valve holders to a torque of 40-45 lbs./ft.



337. Ensure that existing components are mated with any existing components which may have been used previously.

338. Should the pump being rebuilt consist of the original components, the following three paragraphs should be adhered to.

339. Place the lower spring disc into position on the plunger also the plunger return spring onto the lower spring disc. The lower spring disc has shoulders on it which enable it to be located accurately.

340. Insert each plunger into its orginal barrel.

341. Lay the cambox on its side (inspection cover side downwards). Then assemble the body (with plunger arms pointing downwards) on the cambox; ensure that the plunger arms locate in the control rod forks. Fit the body screws while maintaining a light pressure on the body (against the plunger return springs); tighten the screws equally in turn to 5 lbs./ft. Check that the lower spring discs are correctly seated and that the control rod moves freely.

342. Refit the fuel lift pump and secure with two nuts, tighten to a torque of 12-15 lbs./ft.

343. Should the pump being rebuilt have new components fitted, follow the instructions detailed in the following paragraph.

344. Lay the pump body on its side and then assemble each plunger, but without its return spring and lower spring disc, in its respective barrel. Assemble the body on the cambox so that the plunger arms locate in the control rod forks as described previously and secure it with two screws at diagonally opposite corners.

Phasing

345. The pump should be placed on a suitable test machine which is equipped with a device for measuring the angular rotation of the camshaft, also a supply of test oil.

346. Remove from No. 1 element the delivery valve holder and also the spring, delivery valve and volume reducer, replace with the plunger head clearance gauge (Hartridge Tool No. 89558/4), which should be used in conjunction with dial indicator (Hartridge Tool No. 23764).

347. Rotate the camshaft by hand until No. 1 plunger is at the bottom of its stroke also check that the control rod is in maximum fuel position. Zero the dial indicator and turn on the fuel supply.

348. Turn the camshaft very slowly by hand in a clockwise direction of rotation until fuel just ceases to flow through the plunger head clearance gauge, at this point the distance moved by the plunger should be checked on the indicator dial, the reading should be 2.9 to 3.1 millimetres. Turn camshaft until plunger is at the top of its stroke then set the dial indicator to zero and raise the plunger to its maximum travel. This distance is called the head clearance and should be 1.5 to 2.0 millimetres. Turn off the supply of fuel and remove the gauge assembly.

NOTE: The travel of the plunger can be adjusted by using graduated tappet spacers which are supplied in 12 different thicknesses.

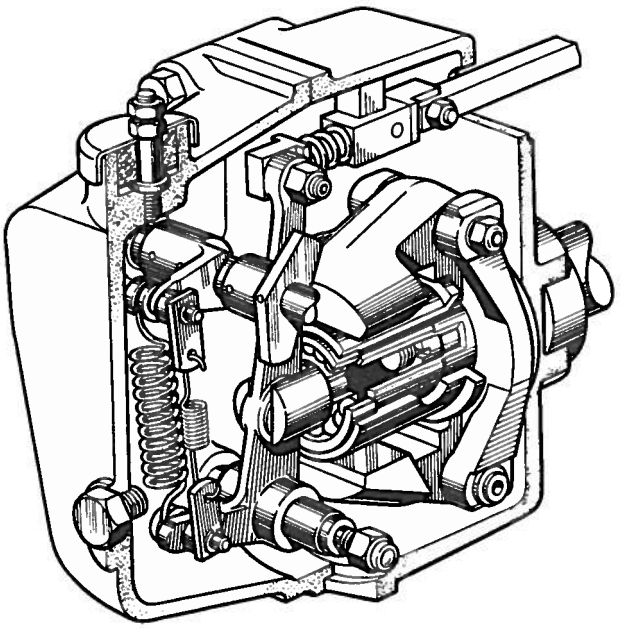
349. Fit spill pipe (Simplex Tool No. P.A.77610) in place of plunger head clearance gauge assembly and turn on supply of fuel. Rotate the camshaft slowly in a clockwise direction and watch for fuel to completely stop flowing from the spill pipe, at this point set the degree plate pointer to zero.
350. Remove the spill pipe from No. 1 element and replace the delivery valve holder parts. Tighten the delivery valve holder to a torque of 40-45 lbs./ft.
351. Refer to the element which supplies fuel to the next cylinder in the firing order which is 1, 3, 4, 2 and remove the delivery valve, fit the spill tube and check the point at which the fuel ceases to spill from tube as detailed in paragraph 349. This point should be 90° ± 0.5° from the previous point of port closure. It will be realised therefore that the spill points should be 0° 90°, 180°, 270°.
352. Should any adjustments be necessary the tappet spacers must be changed, varying the thickness by 0.1 mm. will make a change of 0.5° camshaft movement, it is possible to advance the timing by adding a thicker spacer and to retard the timing with a thinner spacer. If a particular element is incorrect it is advised that it be rectified before proceeding to the next element.
353. Recheck the point of port closure in the first element to ensure that the datum is still correct after setting all the other elements.
354. Check head clearance on elements 2, 3 and 4 as detailed in paragraph 348.
355. The fuel pump is now phased and the pump body should be removed from the cambox, it was only secured with two screws for the above operations.
356. Assemble the pump body to the cambox as detailed previously.
357. Fit governor to fuel pump, this operation is detailed fully in paragraph 435 page 22 for the pneumatic and paragraph 397 page 20 for mechanical governors.

Calibration

358. Mount the unit on a power driven test bench equipped with a tachometer and measuring vessels, so that the volume of fuel delivered by a given number of strokes can be measured.
359. Run test machine and thoroughly wet all pipes and glass tubes with test oil before attempting to take any readings. To obtain consistent readings the same procedure should always be followed. After completion of a test run the measuring cylinders should be left to drain for 30 seconds, another 15 seconds should be allowed for any fuel left in the tubes to drain back before commencing another test.
360. Adjust the maximum fuel stop screw on the governor so that number four element pumps the correct amount of fuel at the rpm stated on the test sheet. When this element is satisfactory lock the maximum fuel stop screw, the other three can be set to the same output by slackening the socket head screws and moving the control forks along the control rod.
361. Check the operation of the excess fuel device.
362. Set the control rod into the position given on test sheet at this point no fuel should be delivered.
363. Check that the control rod is free in movement, set the pump running at 250 rpm and with idling delivery set and the control lever in idling position, operate the stop control and return it to the run position, the control rod should immediately return and fueling start again.

SIMMS MECHANICAL GOVERNOR

364. The speed of a diesel engine is determined by the load being applied and the amount of fuel delivered. The governor is arranged to control the latter increasing or decreasing it to compensate for any changes in load which tend to cause a variation in speed.
365. The Simms mechanical governor is a conventional centrifugally operated spring-opposed fly-weight type. A suitable linkage converts the changing position of the weights to a longitudal movement operating the rod controlling the output of fuel from the injection pump. The position of the throttle lever also effects the fuel output of the injection pump the two controls being interconnected.



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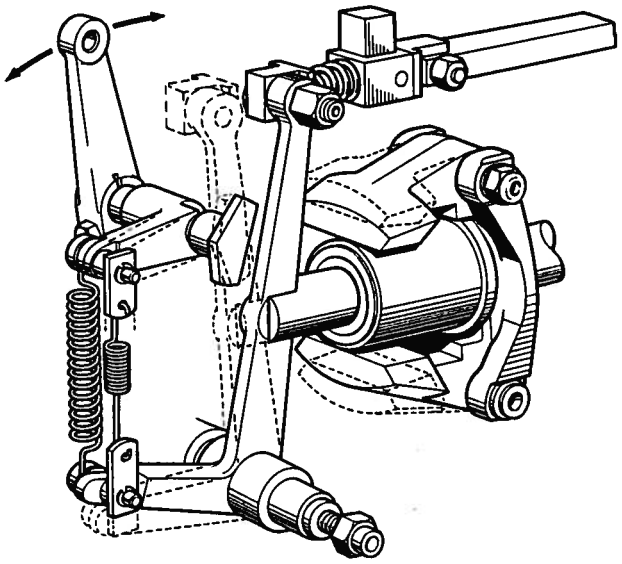
366. Movement of the throttle lever is transmitted via the governor springs to the crank lever which is directly acted by the governor fly-weights.

Operation

367. The mechanical governor operates due to a balance of forces generated between the governor spring tension and centrifugal force of the governor weights.



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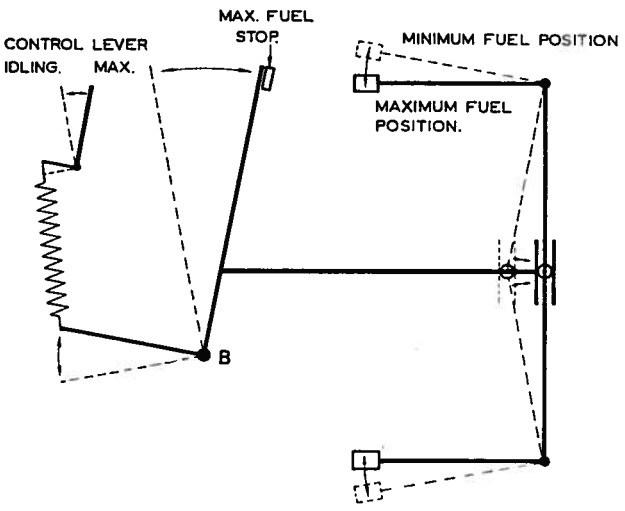
368. Let us now assume that we are about to start the engine, with no load on it, the throttle lever will therefore be moved to the full fuel position. Movement of this lever will result in a load being applied directly to the governor spring which will move point 'A' on the crank lever in a clockwise direction. The crank lever being pivoted at point 'B', will rotate in a clockwise direction, this will result in the fuel pump control rod being pushed to the full fuel position, also the governor weights which are connected to the hub sleeve will be pressed inwards to the furthest extent of their travel.



2.2000A-368

369. When the engine starts and accelerates the governor weights will rotate, the centrifugal force throwing the governor weights outwards, the toe on the weight being so arranged that when the weights move, the motion is transmitted to the hub sleeve, which moves in a horizontal direction. The hub sleeve, which is in contact with the crank lever will, therefore, move the crank lever to the position shown dotted in Fig. 2.2000A-368. This position of the lever will move the control rod in the fuel injection pump towards the no fuel position.

370. To stop the weights moving outwards immediately the engine starts, two springs are fitted between the crank lever and the throttle lever, the light one controlling the idle speed of the engine and the other maximum speed. It will be noted that the light spring is operating all the time whilst the heavy spring only operates at higher speeds, this is achieved by providing elongated hooks at each end, therefore allowing the crank lever to move only under the influence of the light spring during initial movement.

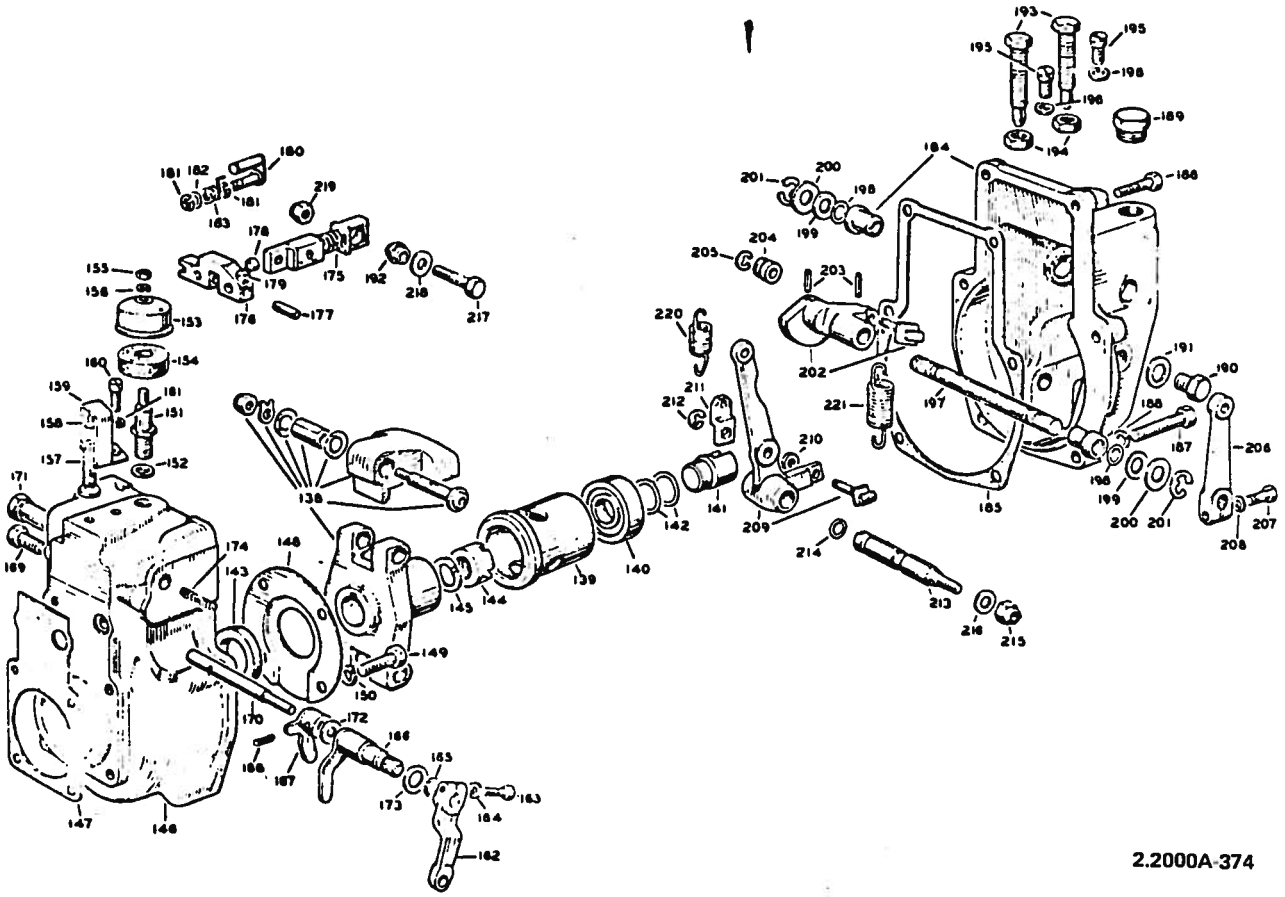
371. As the fuel injection pump control rod moves towards the no fuel position, the engine rpm will be reduced due to the decrease in the amount of fuel being supplied, this reduction in rpm will result in the governor weights generating less centrifugal force, which allows the springs to exert a force on the crank lever and push the control rod towards a full fuel position. Thus it will be realised that although the throttle lever has not been moved the engine speed will be kept constant, and will, in fact, keep constant at a speed relative to the throttle lever position.

372. When the excess shaft is pressed, the excess fuel catch is moved away from the control link allowing the control rod to move forward to the excess fuel position. When the engine starts and increases speed, the control rod moves to the closed position. The excess fuel catch is returned by spring pressure to its normal position, limiting the fuel to normal maximum delivery.

373. It can be seen, therefore, that the speed control lever position (limited by suitable stops) sets the maximum speed at which full power is developed.

Disassembly

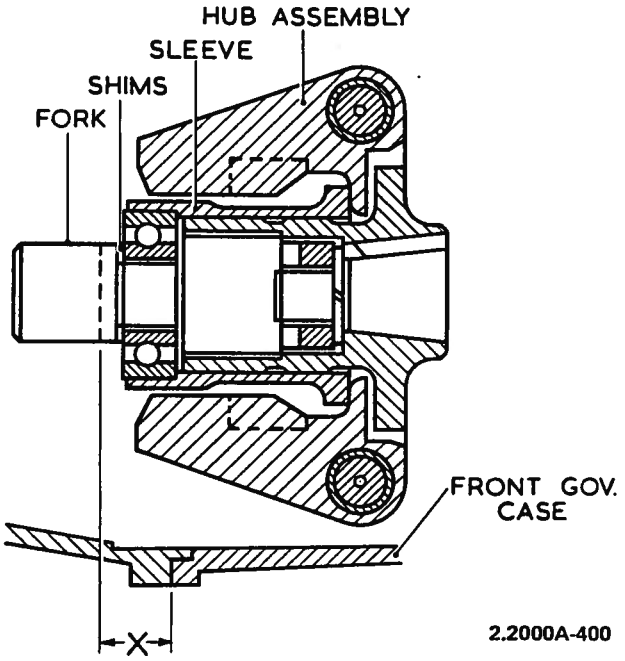
374. The numbers in brackets refer to Fig. 2.2000A-374.



2.2000A-374

375. Unscrew the bolt securing the control lever (206) to the cross shaft (197) and remove the lever.
376. Unscrew the six set bolts securing the governor rear half housing to the front half.
377. Pull away the governor rear half enough to allow the removal of nyloc nut (219) and bolt (217) which secures the crank lever (209) to the telescopic link (175). Remove governor rear half.
378. Withdraw the sleeve (139) containing the ball bearing (140) and fork (141) from the governor weight assembly.
379. Slacken screw (178) and remove the control rod link (176) from the control rod. Remove groverlock pin (168) from max. fuel stop lever (167).
380. Remove the excess fuel shaft bearing (171), and the shaft (170) can now be withdrawn, care should be taken not to drop the return spring (174) and the maximum fuel stop lever (167). Remove spring clip (163) and stop control assembly (166) can now be removed. The stop lever (162) may now be removed from the stop control assembly (166).
381. Remove the governor weight assembly by means of a governor hub key, (Hartridge tool 87744) which will remove the retaining nut (144) and pull governor mass from the camshaft using Hartridge Tool No. 7044-8.
382. Remove the governor front half by unscrewing the four set bolts.
383. To dismantle the governor rear half, remove the lower spring plate (211) which secures the idling spring to the lower crank lever, by removing the 'E' clip. Note which way the springs are looped in the spring plates.
384. The two governor springs (221 and 220) may be removed now.
385. Unscrew the nyloc nut (215) holding the crank lever fulcrum shaft (213), withdraw the shaft and remove the crank lever (209).
386. Remove the maximum and idling stops (193).
387. To dismantle the control lever cross shaft assembly (194), tap out the taper pins (203) from the stop control and spring arm assembly (202).
388. Remove arm (206) also the 'E' clips (208) and withdraw the cross-shaft (197) taking careful note of any shims that may be fitted.
389. Thoroughly clean all parts of the governor before attempting to re-assemble, use new gaskets and self locking nuts.
390. Insert control lever cross shaft (197) in the governor rear half, assembling the stop control (206) and spring arm (202) at the same time.
391. Replace the taper pins (203) which fix the cross shaft assembly, refit any shims (199) that are fitted and replace the 'E' clips (201) which hold the cross shaft in position.
392. If the cross shaft or bushes have been renewed, fit shims as required to give the cross shaft an end float of .05 to .25 millimetres.
393. Screw in the maximum and idling speed stop screws, ensuring that the control stop is the right way round.
394. Screw the crank lever fulcrum shaft (213) into the rear half casing, assembling the crank lever (209) on it at the same time. Replace the old nyloc nut (215) with a new one and screw it onto the shaft.
395. Assemble the governor springs on the spring arm and crank lever, secure the spring plates holding the secondary spring with 'E' clips.

396. In the front half of governor housing, fit the stop lever (166) locate this with washer (173) and spring clip (165). In the opposite side of the housing insert the excess fuel shaft (170) and at the same time, fit the maximum stop lever (167) also washer (172). The shaft should now be positioned so that the shoulder protrudes through the stop lever (166). Locate the maximum stop lever (167) with the groverlock pin (168). Fit the spring (174) and the bearing (171) which is screwed into the housing. Tighten bearing (171) to 15 to 17 lb./ft.
397. Assemble the front half of the housing with the gasket to the fuel pump, also the oil baffle (148) and secure with four screws and spring washers tightened to a torque of 5-7 lbs./ft.
398. Fit the link (176) to the control rod, tighten the locating screw and lock nut.
399. Replace the governor weight assembly and secure with the governor hub key (Hartridge Tool No. 87744).
400. Insert the sleeve containing the bearing and fork between the governor weights and on to the governor hub. If a new hub, sleeve, bearing or fork has been fitted, add or remove shims to give the correct dimensions 19.5 – 19.7 millimetres between the front governor case face and fork, with the weights fully open and without the governor gasket fitted. Dimension is marked X on Fig. 2.2000A-400.



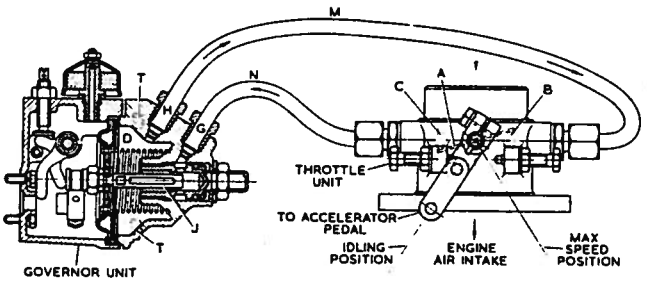
2.2000A-400

Governor Type	Dimension "X"
B. N. Z. Weights closed.	13.7 – 13.9 mm.
A. Weights closed, with excess fuel device in gov.	13.7 – 13.9 mm.
A. Weights closed and no excess device in gov.	10.7 – 10.9 mm.
M. Weights open.	19.5 – 19.7 mm.

401. Connect the telescopic link to the crank lever in the governor rear half and secure the two halves together by means of the six set bolts, tighten to a torque of 5-7 lbs./ft.
402. Replace the control lever (206) on the cross shaft (197) and tighten the fixing bolt.
403. When re-assembly has been completed, the governor and its linkage must move with freedom but without undue slackness.
404. Lubricate by filling to the oil level plug, with clean engine lubrication oil, over filling should be avoided.
405. The pump and governor should be tested together on a fuel injection test bench. The complete unit should be set to the appropriate specification giving speed and delivery settings as follows:-
406. To set the maximum delivery stop, hold the control lever on the governor in the full delivery position by means of a tension spring.
407. Run the pump at the correct speed and take readings in calibrating glass for number of strokes stated on the data sheet. Adjust the maximum stop screw until the correct delivery is obtained. Screw the stop down to reduce, and up to increase delivery.
408. Seal the maximum stop screw.
409. The maximum and idling speeds can be adjusted within the designed speed range of the governor by the stop provided. Do not adjust when the stops have been sealed.

SIMMS PNEUMATIC GOVERNOR

410. The Simms G P pneumatic governor fitted to the 'Minipump' uses the suction created in the engine induction pipe to control the fuel pump.
411. The governor consists of the throttle control unit mounted on the air intake of the engine, the governor unit mounted on the injection pump and the suction pipes connecting the throttle and governor units.



2.2000A-411

412. The throttle unit is mounted between the engine air intake and the air cleaner and contains a butterfly throttle valve 'A' which is connected to the driver's throttle lever. This throttle controls the speed of the engine, there being no direct connection between the driver's control and the fuel pump.
413. The governor unit is mounted on the end of the injection pump and comprises a housing containing a diaphragm which is attached to the pump control rod by the governor link, when the pump is at rest, this is held in the maximum fuel delivery position by the governor spring.
414. The pneumatic governor units are fitted with a soft leather cup. In this type of unit, the circumference of the leather cup is held in a pressed alloy rim, the centre of the cup being riveted between two dished plates and mounted on the governor guide and damping valve.

415. The diaphragm assembly is retained in the governor front half by the pressure between the front and rear halves when they are bolted together, the alloy rim acting as a jointing. The governor guide engages the link assembly, which is connected to the control rod by the link screw, transmits the movement of the diaphragm assembly, to the injection pump.

416. The governor spring is positioned between the dished plate and the rear wall of the governor, keeping the control rod in the maximum delivery position when the pump is at rest. The damping valve guide assembly is screwed into the rear of the governor housing for anti-surge adjustment, an external locknut secures it in position.

417. The stop control lever, when operated, causes the stop lever bearing upon the link to move the control rod to the 'no delivery' position, the position of the maximum fuel stop screw and trip limiting the backward motion of the maximum stop lever.

418. Under very cold climatic conditions, starting of diesel engines may be difficult unless a certain amount of excess fuel is available, and in order to provide this extra fuel an excess fuel device is embodied in the governor and Minipump as applied to the 220 cu. in. Bedford Engine. This device is designed to control the maximum fuel position of the injection pump control rod during normal operation and, at the time of starting from cold to permit the control rod being moved to a position in which excess fuel for easy starting will be delivered.

419. A stop lever is provided which moves the pump control rod to the no delivery position when it is desired to stop the engine.

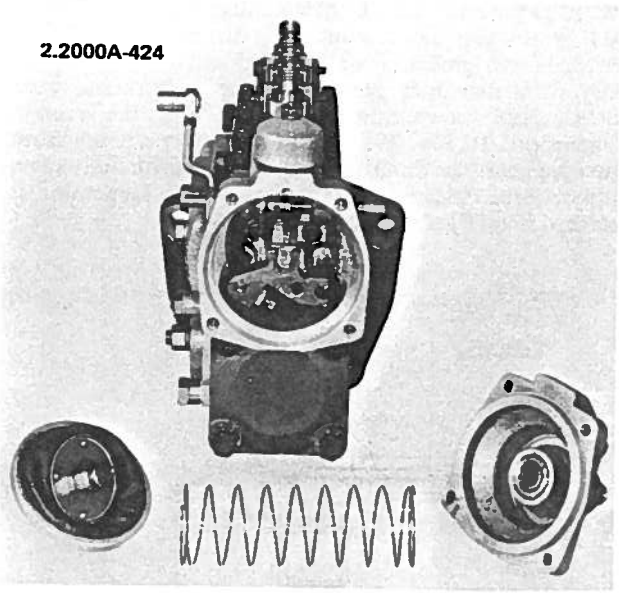
420. When the throttle valve is moved to the closed position an increased suction is created on the engine side of the throttle valve. This is transmitted through the suction pipe 'M' to the diaphragm which is drawn back against the pressure of the spring, thus moving the pump control rod so as to reduce the fuel delivery. Closing the throttle therefore, reduces the engine speed, while by opening the throttle, the suction on the diaphragm is reduced so that the spring moves the pump control rod towards the increased fuel delivery position, thus increasing the speed of the engine.

421. If the throttle is held in a fixed position the engine will run at a correspondingly constant speed with a variation of only 5 to 10 per cent between full load and no load on the engine. The governor is therefore, of the variable speed type, for it will govern at any selected speed within the designed speed range of the engine.

422. The purpose of the damping valve is to prevent hunting or surging of the engine at idling speeds. This is accomplished by adjusting the valve guide 'J' so that when the diaphragm is in the slow running position, the tapered portion of the valve will admit air from the port 'G' via the external groove and cross holes in the valve guide 'J' into the chamber 'D', if the diaphragm moves too far towards the stop position due to surges in the engine speed. As the valve guide is connected to the auxilliary suction pipe 'N', it is therefore at approximately atmospheric pressure. The damping valve, therefore, acts in the same way as a buffer spring and prevents excessive oscillations of the diaphragm at idling speeds.

423. To understand this, consider the operation of the governor at maximum speed, that is, with the throttle valve fully open. The depression in the air intake will then be very small, and the maximum speed of the engine is determined by the increasing air velocity, which as the engine speed increases, causes a gradual increase on the port 'B', and this, transmitted to the diaphragm draws back the pump control rod and limits the speed of the engine.

424. To dissasemble the governor, remove the Phillips type screws securing the governor rear half to the front half and remove the rear half and governor spring. The diaphragm can be withdrawn by lifting the diaphragm rod and disconnecting from the control rod linkage, the rod slots into the linkage and is not retained in any way. Care must be taken not to damage the leather diaphragm or the rim.



425. Slacken the locknut and unscrew the tapered locking screw, this screw is visible when viewed from the underside of governor and locates the link to the control rod. Removal of screw will enable the link to be withdrawn from the control rod.

426. Slacken the pinch bolt which clamps the stop lever and remove the lever from splines.

427. Remove groverlock pin, then unscrew from the opposite side of the governor housing the bearing, which also contains the excess fuel device return spring. This will allow the excess shaft to be withdrawn. Remove the clip which locates the fuel shut off lever and its associated bush. The bush assembly can now be removed from the governor housing. Remove three hex headed screws and remove governor front housing.

428. To remove the filter element for cleaning or renewal the retaining nut should be unscrewed and the breather cap lifted clear, when the filter element may be withdrawn.

429. Should further dismantling be considered necessary, the maximum stop lever trip pin may be unscrewed from the governor body, this stop is located on the opposite side of the governor to the stop lever. The maximum fuel stop can be removed after removal of

the locknut from the upper surface of the governor housing. The actual maximum fuel stop may be removed by unscrewing from the governor housing and removed from inside the governor.
430. Inspect the diaphragm for tears, perforations or other signs of wear or damage, if there is the slightest doubt about its condition the diaphragm assembly must be replaced as detailed in paragraphs 431, 432 and 433.
431. Remove the damaged diaphragm from the shaft, which is fitted by two nuts.
432. Soak a new diaphragm for at least half an hour in oil (Shell Calibration Fluid 'C'), this will soften the leather and keep it pliable.
433. Assemble the new diaphragm assembly onto the shaft, the washer fitting against the shoulder on the shaft, the diaphragm, the lock nut and finally the special nut which also engages on the linkage.
434. The filter element should be washed in paraffin and allowed to dry and then dipped in Gargoyle Vactric Extra Heavy Oil, and allowed to drain before fitting.
435. Fit front of governor housing to the fuel injection pump with three hexagon head screws, tighten to a torque of 5 lbs./ft.
436. Fit the maximum fuel stop, the screwdriver slot should be positioned on the outside of the governor housing also fit the locknut.
437. Fit the bush and control lever assembly and locate with a spring clip.
438. Place the maximum stop lever into position and hold with fingers, pass the excess fuel spindle through the bushes and fit the groverlock pin which locates the maximum stop lever on the spindle.
439. Fit the bush and return spring to the governor housing.
440. Place the link into its guide shaft and onto the fuel injection pump control rod, fit the tapered screw and lock nut and tighten.
441. Set the pump control rod to 23.0 millimetres.
442. Coat the damping valve and guide bush with colloidal graphite 'Oildag'.
443. Fit the diaphragm ensuring that it is correctly located within the slot in the link.
444. Fit the governor spring and rear of governor housing taking care that the spring is correctly located in the metal centre disc of the diaphragm. Ensure that the shaft enters into the damping valve, tighten the Phillips head screws carefully.
445. The screws should be tightened gradually, first tightening one a little then its opposite number thus ensuring an even pressure on the diaphragm rim.
446. The governor should be tested for leakage by pushing in the diaphragm so as to compress the spring, seal the two suction pipe connections by placing finger and thumb over the inlet connections and then release the diaphragm. If no leakage exists, the diaphragm will remain extended with the spring compressed; but if the diaphragm returns to the compressed position, then a leakage, in or around the diaphragm exists, which will affect the operation of the governor.

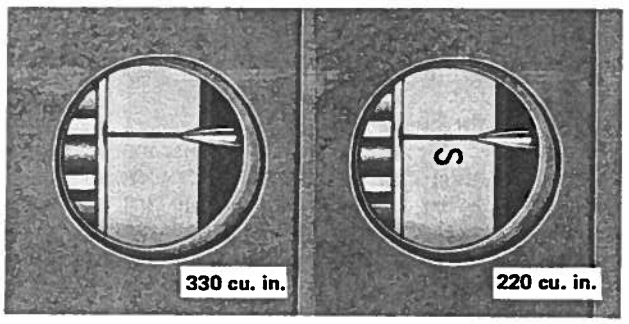
Adjustment of Governor
447. Before the injection pump is fitted to the engine, the maximum fuel stop, on the front end of the pump control rod, must be set on a test bench, so that the pump delivers the correct quantity of fuel for the type of engine to which it is to be fitted.
448. The adjustment of the governor can only be carried out on the engine as follows:-
449. Set the maximum speed stop on the throttle unit so that the engine develops the maximum specified speed, running light.
450. Set the idling stop screw on throttle unit to obtain slow running speed, when fitted, slacken locknut and adjust damping valve guide 'J' until steady idling is obtained.
451. Finally re-tighten locknut.
452. Care should be taken when adjusting the valve guide to keep the locknut finger-tight against the governor housing, thus ensuring that no air leaks pass the screw threads.

NOTE: In no circumstances should the engine be run without the throttle unit (venturi), inlet manifold or with either of the two suction pipes disconnected.

453. The governor requires no lubrication or attention in service, except that in dusty conditions of operation the gauze pad in the air cleaners should be removed and washed in paraffin. If defective operation of the governor is suspected, the rear half of the governor unit can be removed by unscrewing the four Phillips head screws and diaphragm inspected.

Inline Fuel Injection Pump (Refitting)
454. Place the key onto the keyway of the drive shaft and slide the pump coupling onto the drive shaft, fit the four bolts which secure the fuel injection pump to the coupling housing and also the two bolts which secure the pump to the bracket, tighten the bolts to a torque of 25 lbs./ft.
455. Tighten pinch bolt.
456. Refit all fuel pipes, throttle linkage and pneumatic pipes as appropriate.

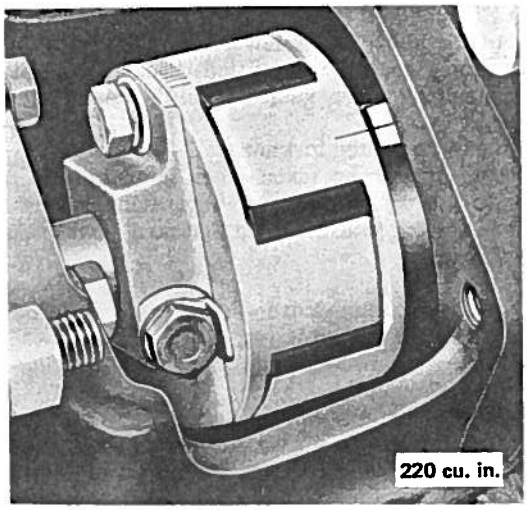
Fuel Injection Pump Timing
457. Rotate the engine until the spill timing mark on the pump coupling approaches the pointer on the pump.
458. Continue to rotate the engine until the spill timing mark on the flywheel is in the centre of the clutch housing timing aperture.

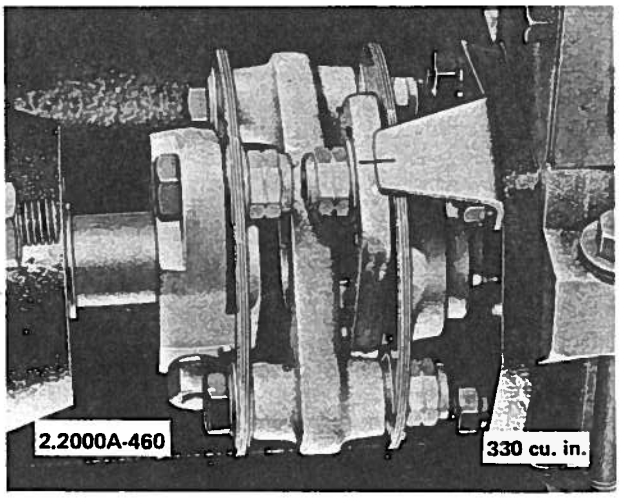


2.2000A-458

459. With the engine in this position, the timing mark on the pump coupling should be in line with the pointer on the pump. If necessary, reset the pump timing as detailed below.

460. Slacken the two bolts through the pump coupling rear flange on the six cylinder engine or coupling front flange on the four cylinder engine, and rotate the pump coupling to bring the marks in alignment.





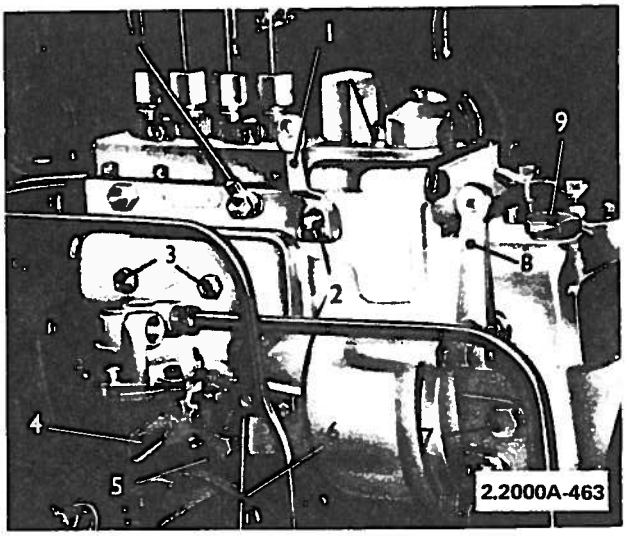
461. Re-tighten the two bolts.

Air Venting the Fuel System

462. Whenever the fuel pipe lines are disconnected such as when cleaning or renewing the filter elements, or if the fuel tank has been allowed to run dry it will be necessary to air vent or bleed the system before attempting to start the engine. The air venting procedure is as follows:-

Engines fitted with AC Fuel Filter and Simms 'In-line' Fuel Injection Pump

463. Slacken off the centre plug in the filter head and operate the priming lever on the fuel lift pump. Continue operating the lever until fuel, free from air bubbles, is discharged. Tighten the plugs as fuel is being discharged.



1. Stop Control Lever.
2. Excess Fuel Device.
3. Side Cover Bolts.
4. Fuel Feed Pump Priming Lever.
5. Drain Plug.
6. Oil Level Tube.
7. Mechanical Governor Level Plug.
8. Speed Control Lever.
9. Filler Plug – Mechanical Governor.

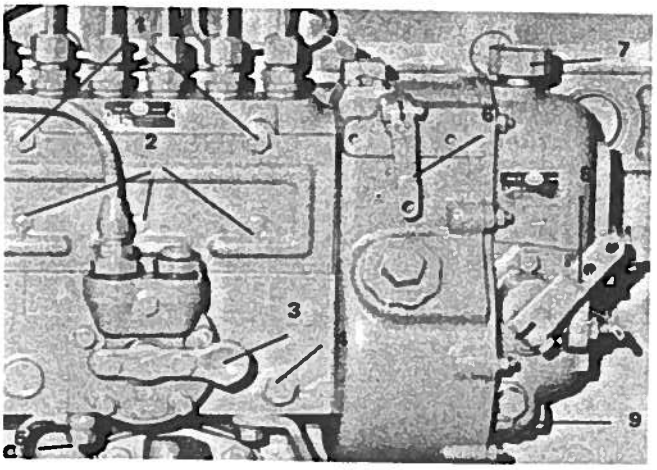
464. Slacken the plugs directly above the pump side cover, operate lift pump until fuel, free from air, is being discharged. Tighten screw as air free fuel is being discharged.

Engines fitted with C.A.V. In-Line Type Fuel Pump

465. Slacken the air vent plug at the top of the fuel filter.

466. Operate the priming lever of the fuel feed pump until fuel, free from air bubbles, is discharged from the air vent. Tighten the air vent plug as fuel is being discharged.

467. Similarly, slacken the two air vent plugs immediately above the fuel injection pump inspection cover and operate the priming lever until fuel, free from air bubbles, is being discharged from the air vents. Tighten the air vent plugs as fuel is being discharged.



2.2000A-467

1. Air Vent Plugs.
2. Side Cover Screws.
3. Feed Pump Priming Lever.
4. Pump Drain Plug.
5. Oil Level Tube.
6. Stop Control and Excess Fuel Device.
7. Breather and Oil Filler – Mech. Governor. .
8. Speed Control Lever.
9. Level Plug – Mech. Governor.

2.2020

FUEL LIFT PUMP

Fuel Lift Pump (Description)

1. The spring loaded diaphragm type pumps are mounted in one of three positions, dependent upon the type of fuel injection pump fitted. The pumps can be of either AC or CAV manufacture.
2. Engines fitted with inline fuel pumps have the lift pump fitted directly onto the side of the injection pump.
3. DPA injection pumps fitted to 330 cu. in. engines have the lift pump mounted on the right hand side of the crankcase operated by an eccentric on the camshaft.
4. The 220 cu. in. engines fitted with DPA injection pumps, the lift pump is mounted on a bracket which is in turn fitted to the left hand side of the crankcase at the rear of the injection pump.
5. A hand priming lever is provided on the side of all lift pumps for use in venting the fuel system.

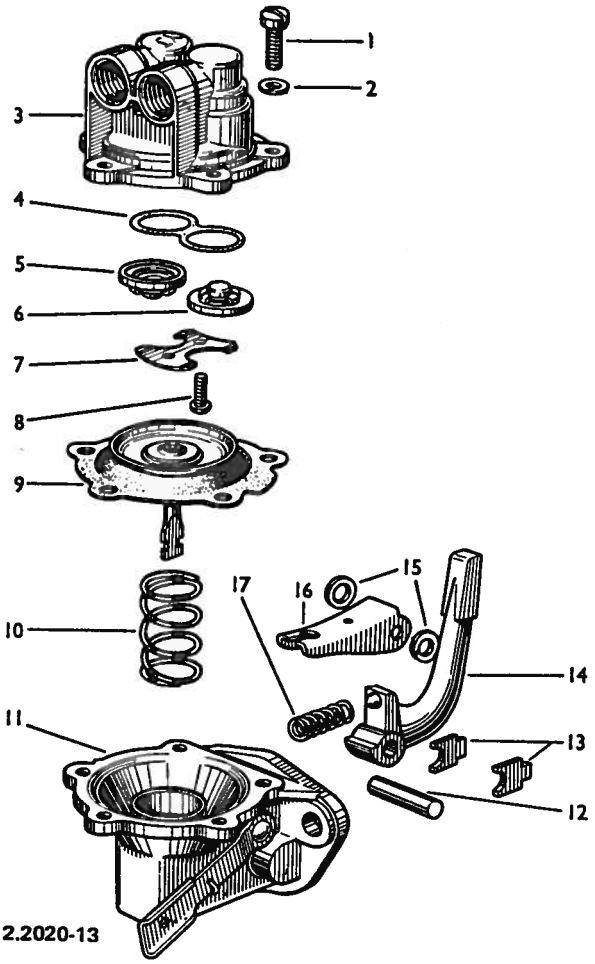
Fuel Lift Pump (Removal)

6. Clean all dirt from the pump casing and fuel pipe unions.
7. Disconnect the fuel pipes from the pump. It is advisable to plug the ends of the pipes to stop the ingress of foreign matter.
8. Remove the securing nuts and lockwashers, and withdraw the lift pump from its mounting.

Fuel Lift Pump (Inspection and Overhaul)

AC FUEL LIFT PUMP USED ON INLINE FUEL PUMPS FITTED TO 220 CU. IN. ENGINES

9. Before separating the cover from the body, mark the flanges to enable the two components to be located correctly when reassembling.
10. Remove the screws securing the cover to the body and separate the two components.
11. Disengage the diaphragm pull rod from the link by turning the assembly through 90°. Remove the diaphragm and spring.
12. Remove the screws securing the valve retainer plate to the cover and remove the plate and valve. On some pumps the valves are fixed and should not be removed.
13. Remove the staked metal and retainers securing the rocker arm pin. Remove the rocker arm assembly and spring, and disassemble the pin and spacing washers.

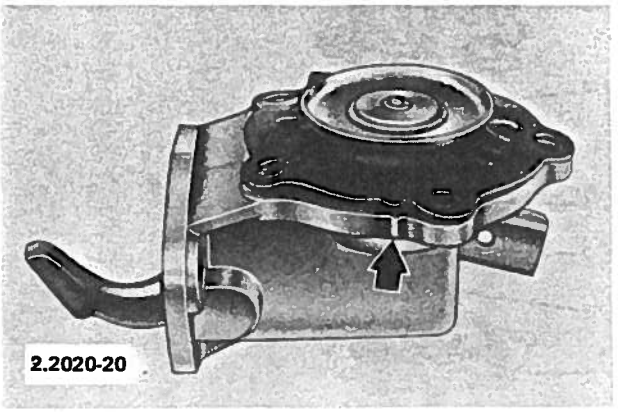


2.2020-13

1. Cover Screw.
2. Lockwasher.
3. Pump Cover.
4. Gasket.
5. Inlet Valve.
6. Outlet Valve.
7. Valve Retainer Plate.
8. Retainer Plate Screw.
9. Diaphragm and Pull Rod.
10. Diaphragm Spring.
11. Pump Body.
12. Rocker Arm Pin.
13. Pin Retainers.
14. Rocker Arm.
15. Spacing Washers.
16. Rocker Arm Link.
17. Rocker Arm Spring.

14. Wash all parts in clean paraffin or fuel oil.
15. Examine the contact faces of the rocker arm for wear.
16. Examine the diaphragm for hardness, cracks or deterioration.
17. Check the condition of the diaphragm spring.
18. Check the pump attaching flange for distortion and reface if necessary.
19. Replace the diaphragm spring.

20. Locate the pull rod in the slot in the link. Press down and turn the diaphragm through 90° so that the pip on the diaphragm is in line with the location mark cast on the pump body.



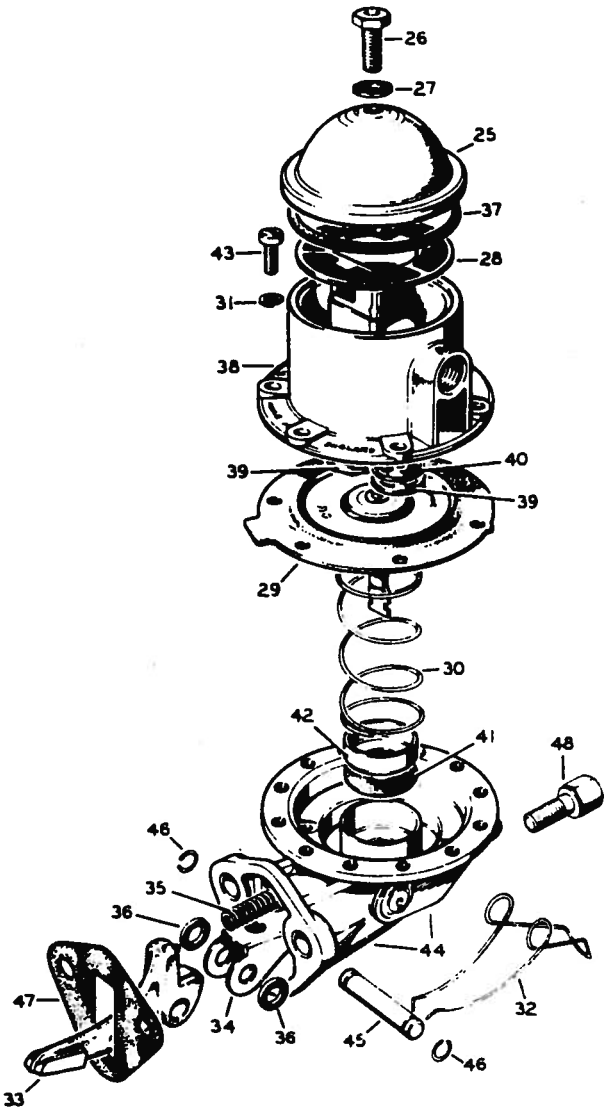
21. Replace the valves and unions. The valves are identical in construction but the inlet valve should be installed with the spring towards the bottom of the pump, and the outlet valve with the spring upwards.
22. When assembling the cover to the pump body, depress the rocker arm until the diaphragm is level with the body face. Install the cover, screws and lock washers and tighten only sufficiently to just engage the heads of the screws with the lockwashers. Release the rocker arm and finally tighten the screws diagonally and evenly.
23. Secure the rocker arm pin retainers by staking the body metal on both sides.

AC FUEL LIFT PUMP USED WITH DPA INJECTION PUMPS

24. Inspection and overhaul of these lift pumps is similar to the previous AC lift pump with the exception of the filter cover, filter and gasket fitted above the valves.
25. These parts should be washed in clean paraffin or fuel oil, inspected and renewed if necessary.

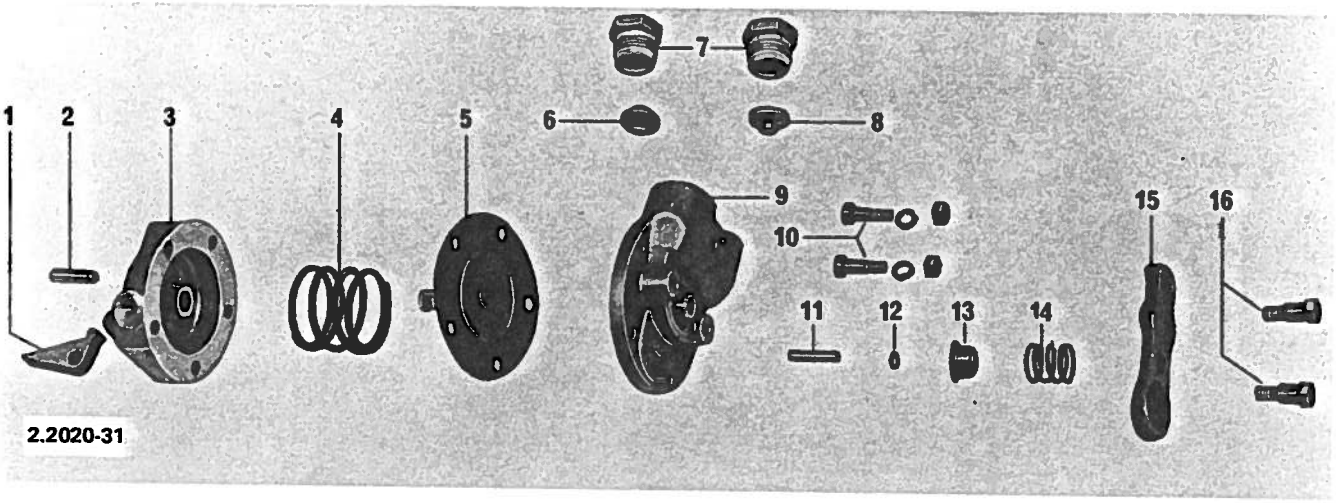
CAV FUEL LIFT PUMP USED ON INLINE FUEL PUMPS FITTED TO 330 CU. IN. ENGINES

26. Break the locking wire and remove the two shouldered screws which secure the pump hand operating lever, remove the lever and also the spring, push rod, spring cap and sealing ring.
27. Remove the two bolts which secure the two halves of the fuel pump together, separate the two halves.
28. Drive the pivot pin from the pump body and remove the bellcrank lever.
29. Carefully remove the diaphragm, complete with spindle, also the operating spring.
30. Remove the inlet and outlet valves from the front portion of the pump.
31. Wash all parts in clean paraffin or fuel oil.

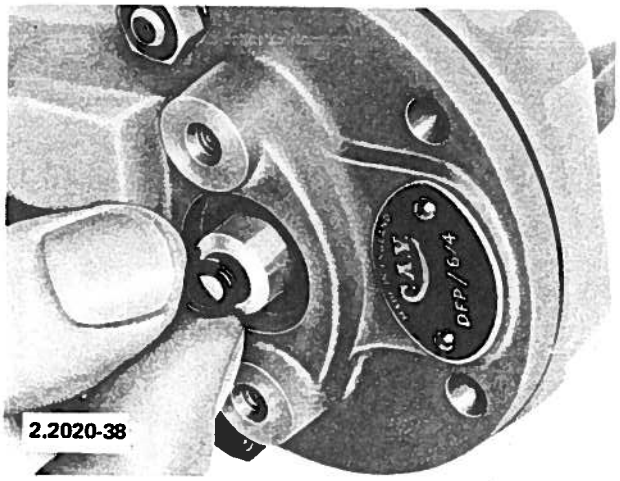


2.2020-24

25. Cover Filter.
26. Screw – Filter Cover.
27. Washer Filter Cover.
28. Screen – Filter.
29. Diaphragm Assy.
30. Spring Diaphragm.
31. Lockwasher – Upper Casting Screw.
32. Spring – Primer Lever.
33. Rocker Arm.
34. Rocker Arm Link.
35. Rocker Arm Spring.
36. Washer – Rocker Arm Pin.
37. Gasket – Filter Cover.
38. Body – Upper Casting.
39. Valve Assy.
40. Gasket Valve.
41. Oil Seal.
42. Retainer – Oil Seal.
43. Screw – Upper Casting.
44. Body – Lower Casting.
45. Pin Rocker Arm.
46. Clip – Rocker Arm Pin.



32. Examine the contact faces of the bellcrank and diaphragm push rod for signs of wear, should excessive wear be visible the wom parts should be renewed.
33. Examine the diaphragm for hardness, cracks or deterioration. Check the condition of the diaphragm spring.
34. Check the pump attaching flange for distortion and reface if necessary, also check the fuel injection pump mating surface.
35. Fit the inlet and outlet valves, the valves are interchangeable but must be fitted as follows, outlet valve dome upwards, inlet valve dome downwards, fit the valve retaining union.
36. Fit the diaphragm operating spring, locate the diaphragm push rod into pump body. Care must be taken to line the holes in the diaphragm with the holes in the pump cover, also note that groove in the diaphragm push rod is parallel with the holes for the bellcrank pivot pin.
37. Press the diaphragm until such a time as the groove in the push rod is visible, engage the bellcrank lever and insert bellcrank pivot pin through holes in the pump body casting and bellcrank.
38. Replace the 'O' ring seal, for the push rod which is actuated by the hand priming lever. Fit the push rod.



39. Join the two halves of the pump and secure with two special nuts and bolts.
40. Fit the spring and spring cap for the hand priming pump lever, fit lever, also the shouldered screws which retain the lever, prevent screws from turning by locking with wire.

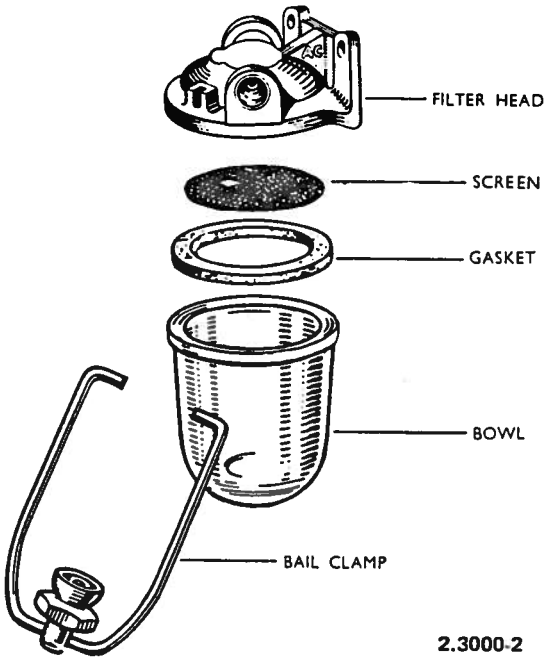
Fuel Lift Pump (Refitting)
41. Remove all traces of old gasket from the face of the fuel injection pump or cylinder block and fit a new gasket.
42. Fit the fuel lift pump over the studs (retaining), take care that the rocker arm of the lift pump is on the front of the camshaft where applicable.
43. Tighten lift pump securing nuts to a torque of 5-7 lbs./ft.
44. Ensure that both fuel feed pipes are clean and refit to the fuel lift pump.
45. On Simms fuel injection pumps, remove the inspection cover and top up the camshaft chamber with engine oil until the oil flows from the leak-off pipe at the rear of the feed pump. Replace inspection cover and tighten nuts to a torque of 4 lbs./ft.
46. Air Vent the fuel system.

2.3000

FUEL FILTER

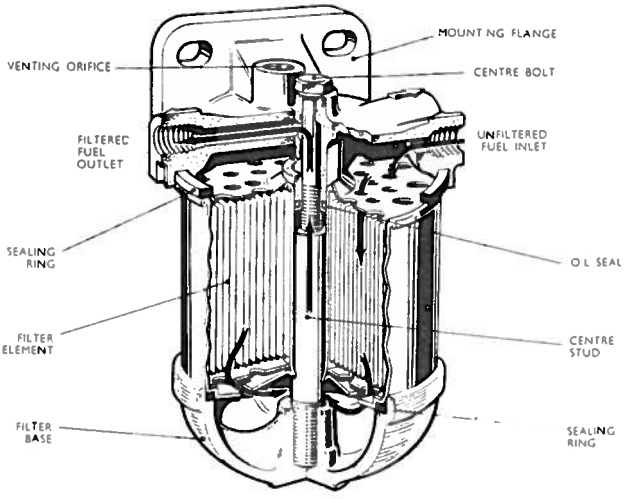
Fuel Filter (Description)

1. The fuel system incorporates two filters, a pre-filter and a main filter.
2. The pre-filter consists of a glass bowl sediment trap and filter screen clamped to the filter head which embodies inlet and outlet pipe connections.



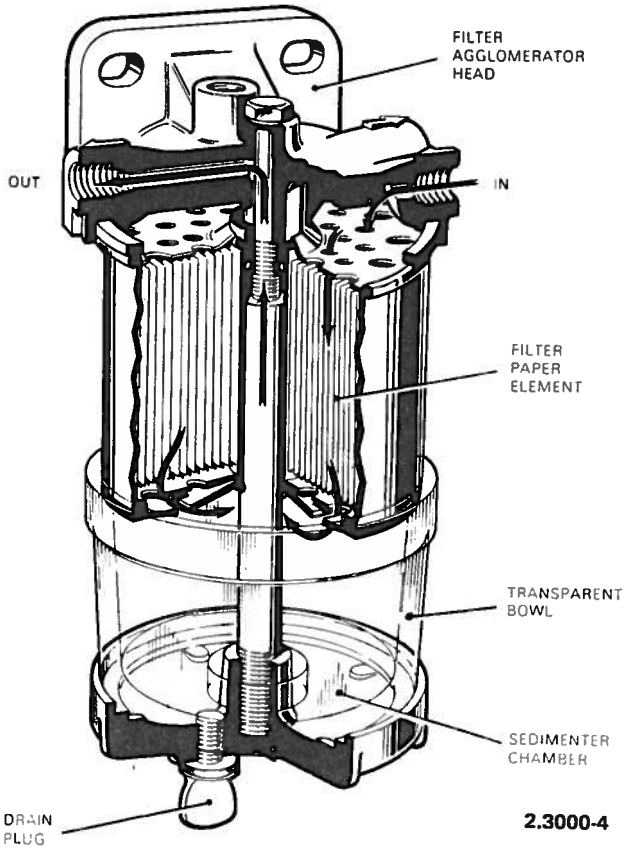
2.3000-2

3. The main filter incorporates a paper type element carried in a detachable filter casing. Inlet and outlet connections are provided in the filter head which also includes the air vent plugs. A drain plug is located in the bottom of the element casing on some filters.



2.3000-3

4. Some engines incorporate an agglomerator in place of the main filter. This consists of the standard filter with either a glass or aluminium bowl fitted below.



2.3000-4

5. The agglomerator element is designed to carry out a dual function of filtration and water separation. The fuel flows downwards through the element, the fine pores of which isolate and retain the solid particles. Simultaneously the fine water droplets which are forced through the pores of the filter, agglomerate into larger droplets which are then deposited in the base. The fuel, free from dirt and water, flows up the centre tube to the outlet connections in the filter head.

Fuel Filter (Removal)

6. Clean the exterior of both the pre-filter and the main filter.
7. Disconnect all fuel pipes to the inlet and outlet parts of the filters. To stop the ingress of foreign matter the ends of the pipes should be plugged.
8. Both the pre-filter and the main filter are retained by two screws through the filter heads into the crankcase.
9. Remove the retaining screws and lift the complete filter assemblies from the crankcase.

Fuel Filter (Inspection and Overhaul)

10. The only overhaul necessary on the fuel filter assemblies is a periodic examination of the components and replacement of any defective parts. However the following points on maintenance should be noted.

Cleaning the Pre-Filter

11. To clean the pre-filter remove all dirt from the exterior of the filter.
12. Remove the bowl and filter screen and clean in paraffin or fuel oil.
13. Examine the bowl, gasket and filter screen for damage and replace where necessary.
14. Reassemble the parts to the filter head and air vent the fuel system as described in 2.2000 page 23.

Flushing the Main CAV Filter

15. To flush the main fuel filter remove the drain plug from the bottom of the filter casing.
16. Operate the priming lever on the fuel feed pump until clean fuel oil flows from the filter.
17. Replace and tighten the drain plug.
18. Air vent the fuel system.

Renewing the Main Filter Element

19. To renew the main filter element it is not necessary to remove the complete filter assembly.
20. Remove all dirt from the exterior of the filter.
21. Unscrew the centre bolt at the top of the filter and remove the casing.
22. Drain the casing, remove and discard the element.
23. Wash the casing in clean paraffin or fuel oil and dry with compressed air. Do not use a rag for this purpose.
24. Where supplied, install a new gasket and/or sealing ring. Check that the gasket is correctly located and free from kinks.
25. Check the condition of the element spring.
26. Install the spring and on the AC filter, the steel washer in the casing.
27. Install the element, replace the casing and tighten the centre bolt.
28. Air vent the filter.

Fuel Filter (Refitting)

29. Using a new gasket refit the filter assembly and tighten the two retaining screws to a torque of 22-27 lbs./ft.
30. Unplug the fuel pipes and reconnect.
31. Air vent the complete fuel system.

2.5000

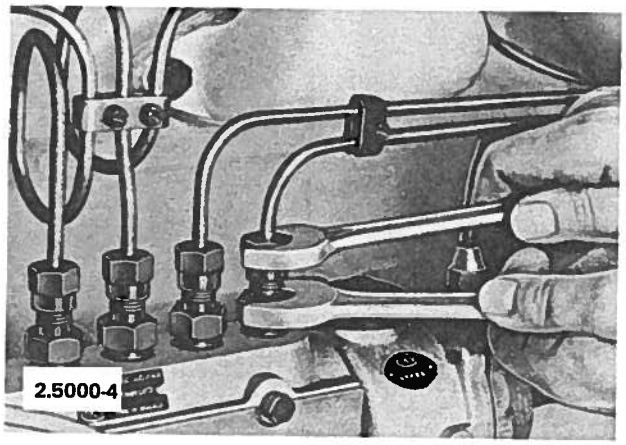
FUEL LINES

Fuel Lines (Description)

1. The fuel lines are manufactured from special bundy tubing, which is seamless. The pipes are connected to both the fuel injection pump and the injectors with a union and a nipple.

Fuel Lines (Removal)

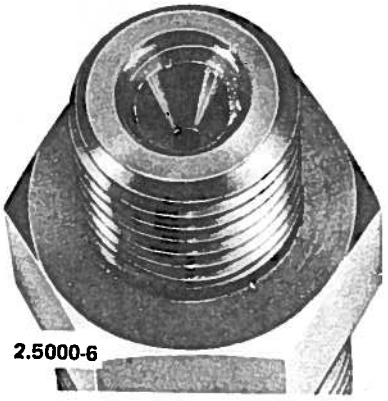
2. Before disconnecting the pipes, clean the area in the vincinity of the pipe unions, to prevent foreign matter entering the feed drillings of the injector or the delivery valve holder. A small particle of dirt on the lapped finished surfaces of an injector or delivery valve is sufficient to render them inoperative.
3. Disconnect the union nuts from the injectors.
4. Disconnect the union nuts from the delivery valve holders. Use one wrench to hold the delivery valve holder and another to unscrew the union nut.


2.5000-4

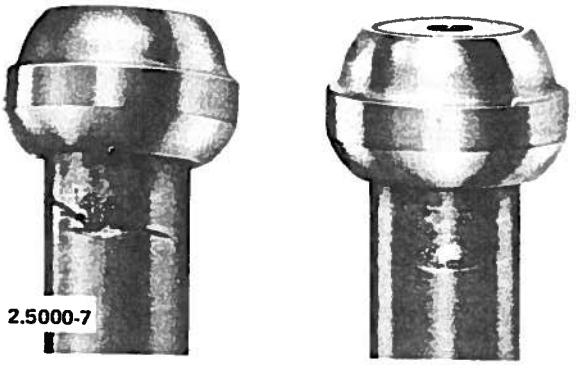
5. Remove the clips securing each pair of pipes. Remove the pipes, and seal the injectors and delivery valve holder union orifices.

Fuel Lines (Inspection and Overhaul)

6. Inspect the seating in the delivery valve holder, and in the pipe adaptor of the injector. These seats may be distorted due to previous overtightening of the unions. An example of this distortion is shown below. Renew the part if distortion is seen. Otherwise uneven pressure on the nipple and a bending stress on the pipe will occur.

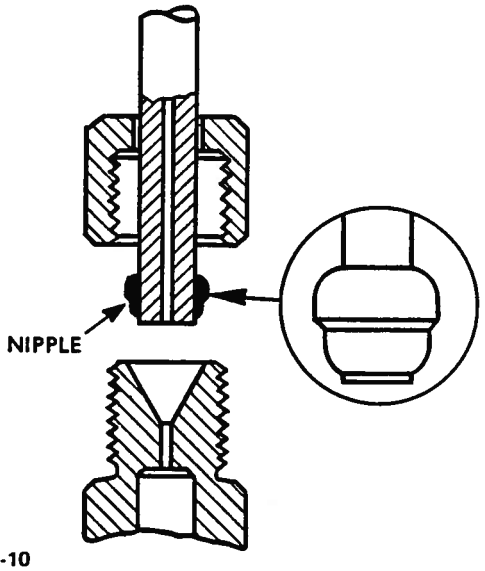

2.5000-6

7. Inspect the pipe for damage, especially the area close to each nipple and ensure that the pipe has not been grooved by contact with the union nut. A pipe so grooved or marked by a blow or deep scratch must be rejected. Such a groove can develop into a crack as shown at 'A' and 'B' in Fig. 2.5000-7.


2.5000-7

Fuel Lines (Refitting)

8. When installing a pipe the following precautions MUST be taken:-
9. Whether the pipes are new or used they must be throughly cleaned both inside and outside. Wash off in clean fuel oil or paraffin and blow dry with clean DRY compressed air. Finally, flush the bore of the pipes with fuel oil or Shell Fusus oil from a filtered supply. Check that the contact surfaces and threads of the valve holder and adaptor are clean.
10. Place the pipe in position and check that each end enters its seating along the centre line of the valve holder or adaptor. Tighten the union nuts finger tight only, and check that the pipe is centrally disposed where it emerges from each nut. Also ensure that the pipe remains in a true line with the valve holder or adaptor.



2.5000-10

11. Offer up a clip to the pipe and check that the pipe is in such relationship to its adjoining pipe that the clip will span the two without either being strained.

12. If any adjustment of the pipe is necessary, never attempt this while the pipe is installed. The pipe must be reformed, by hand, over as much of its length as possible. Local bending will cause failure.
13. If it is necessary to reform the pipe, ensure that the bore of the pipe is flushed before installing.
14. When satisfied with the disposition of the pipe, tighten the union nuts carefully, adopting the following procedure:-
15. Screw down the union nuts finger tight, then tighten a further third of a turn with a wrench. This applies to existing or new pipes. Over tightening will lead to early failure of the pipe.
16. Install the pipe clips, noting that the pipes must not be strained into the clips.

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SECTION 3

AIR SYSTEM

Contents

3.0000
AIR SYSTEM SPECIFICATIONS

AIR CLEANER

Type	Manufacturer
Standard - Oil Bath	A.C.
Heavy Duty - Centrifugal/Oil Bath	A.C.
Marine - Wire Mesh	A.C.

TURBOCHARGERS

Type	Manufacturer
FO1	CAV
3LD	HOLSET

Bearing End Float (CAV)	0.1 mm - 0.3 mm (0.004" - 0.012")
Piston Groove Thrust Wear (CAV)	0.1778 mm (0.007") maximum clearance
Shaft Concentricity Test (CAV)	0.005 mm (0.0002") maximum eccentricity
Clearance Between Turbine Blades and Exhaust Outlet (CAV)	0.2794 - 0.6096 mm (0.011" - 0.024")

TORQUE WRENCH DATA

Manifold retaining bolts	18-20 Nm (13-15 lb ft)
Turbocharger Impeller (CAV)	14 Nm (10 lb ft)
Shaft Nose Nut (CAV)	11 Nm (8 lb ft)
Turbine Casing Bolts (CAV)	8.5 Nm (75 lb in)
Compressor Casing Bolts (CAV)	8.5 Nm (75 lb in)
Locknut (Holset)	17.6 Nm (13 lb ft)
Compressor Casing Bolts (Holset)	6.8 Nm (5 lb ft)
V Clamps Locknut (Holset)	13.6 Nm (10 lb ft)

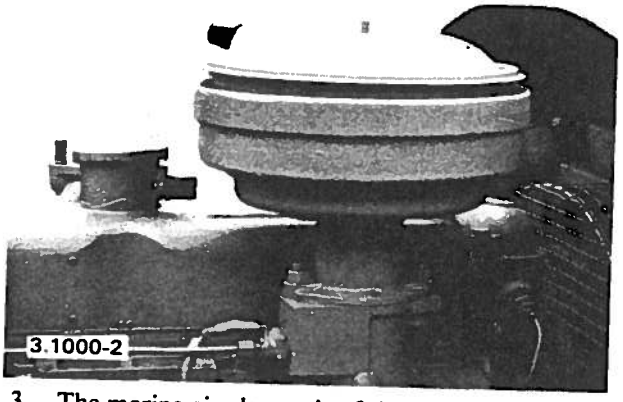
3.1000

AIR CLEANER

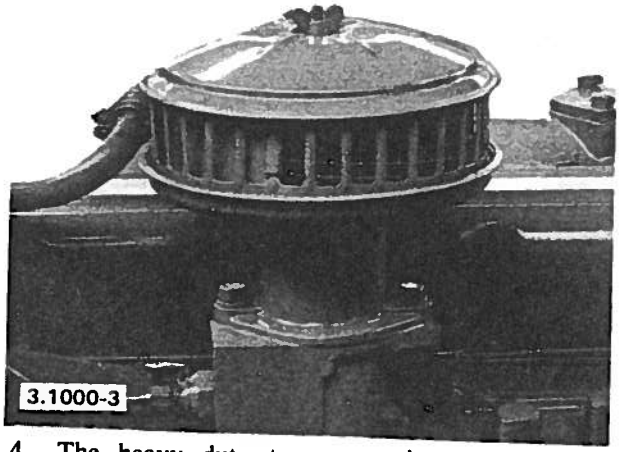
AIR CLEANER (Description)

1. There are three types of air cleaners fitted to the 220/330 cu. in. engines – standard, marine and heavy duty. The cleaner is mounted onto the inlet manifold or venturi assembly and secured with a clip.

2. The standard air cleaner is of the oil bath type comprising an oil bath, filter element, seal ring, cover and retaining nut.

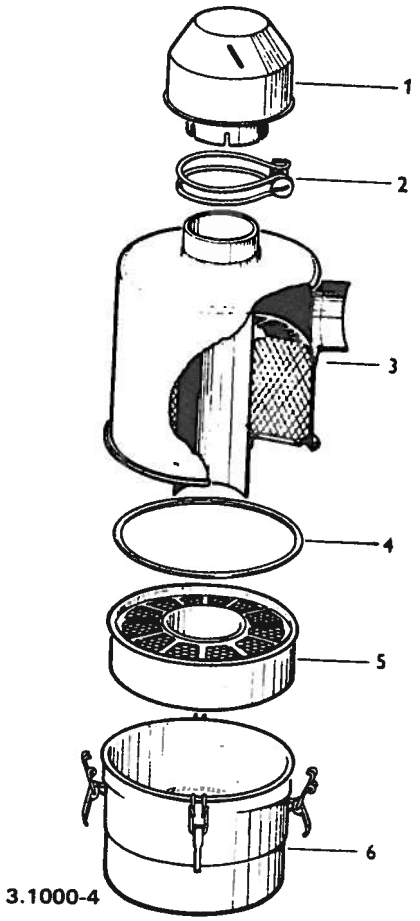


3. The marine air cleaner is of the wire mesh type and is fitted the same as the standard duty air cleaner.



4. The heavy duty type comprises a main body containing a fixed filter element, a detachable oil bath, filter element and centrifugal pre-cleaner. These are arranged so that air entering the intake manifold first passes through three separate stages of filtration.

5. Entering the centrifugal pre-cleaner at the top of the air cleaner assembly, a whirling motion is imparted to the ingoing air. A high proportion of the dust particles in the air are thrown outwards, by centrifugal force to the periphery of the casing where it is ejected through the two outlet slots. After leaving the centrifugal casing, the whirling motion of the air stream is converted to a straight directional flow by vanes and it passes down the central tube in the main body of the air cleaner.



1. Centrifugal pre-cleaner
2. Clip
3. Main body & Fixed filter element
4. Gasket
5. Detachable filter element
6. Oil Bath

6. On reaching the lower end of the central tube, the air impinges on the surface of the oil contained in the oil bath at the base of the air cleaner and the air flow is then deflected upwards to the lower (detachable) wire mesh filter element. Heavy particles of dust are deposited directly into the oil while lighter particles are trapped by the filter element and subsequently washed back into the oil bath by oil which is carried upward into the filter with the air stream. To ensure that the later stages of cleaning are effective, it is essential that the correct grade of oil, see paragraph 19, is contained in the oil bath and that it is maintained at the level marked on the inside of the oil bath casing.

7. After passing through the lower filter element the air is finally filtered by the fixed element in the main body of the air cleaner.

AIR CLEANER (Removal)

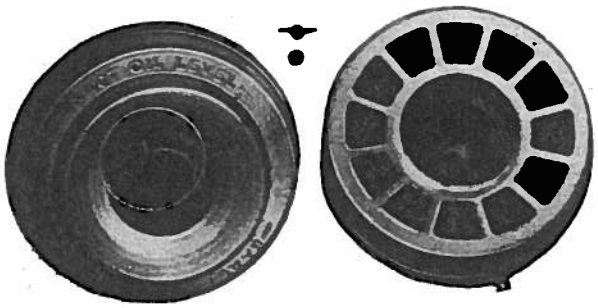
8. Detach the crankcase ventilator pipe, where fitted, and the support bracket from the air cleaner.
9. Slacken the securing clip and lift away the air cleaner from the inlet manifold or venturi assembly. Ensure the cleaner is kept vertical to avoid spilling the oil.

AIR CLEANER (Inspection and Overhaul)

10. Air cleaners should be cleaned at least every one hundred hours or at more frequent intervals, depending on the operating conditions.

Standard Duty Air Cleaners

11. Remove the nut and lift off the cover and gasket. Lift out the filter element and rinse in clean paraffin. Blow out the element to remove all traces of cleaning fluid. Drain the oil from the oil bath and clean out any sediment. Check the condition of the gasket and renew if necessary. Refill the oil bath, with one of the recommended lubricants on page 3, to the level indicated and install the filter element, gasket and cover.



3.1000-11

NOTE: It is not necessary to re-oil the filter element as this is done automatically when the engine is running.

Marine Air Cleaner

12. Unscrew the wing nut at the top of the cleaner and remove the cover and filter element. Rinse the element in clean paraffin (Kerosene) and shake it to remove all traces of paraffin (Kerosene).
13. Replace the element and refit the top cover.

Heavy Duty Air Cleaner

14. Slacken the clip securing the centrifugal pre-cleaner to the main cleaner, and remove any dust or foreign matter from the side of the cowl, and the vanes in the inlet tube.
15. Remove the detachable bottom element and oil container by releasing the four toggle clips fitted around the rim of the oil container. Lift out the element and rinse in clean paraffin (Kerosene). When clean, allow the element to drain thoroughly. Drain the oil from the oil bath and, if necessary, remove any sludge which may have accumulated in the base. Refill the oil container with fresh oil to the level indicated on the case. For recommended oil see paragraph 19.

Note: It is important to ensure that the paraffin (Kerosene) used in cleaning the filter has completely dried off before re-assembling. Failure to observe these precautions may lead to uncontrolled racing of the engine caused by the paraffin or oil being drawn into the air supply.

16. It is not necessary to re-oil the element as this is done automatically when the engine is running. When installing the element ensure that the gasket fitted on top of the flange is in good condition and correctly located.
17. Depending on the operating conditions it will be necessary to periodically clean out the upper element, which is attached inside the main body. To do this remove the main body from the engine and after dismantling the oil container and element, wash the main body in a container of clean paraffin (Kerosene), draining thoroughly before reassembly.

AIR CLEANER (Refitting)

18. Place the air cleaner back onto the inlet manifold or venturi assembly. Refit the crankcase ventilation pipe and then retighten the air cleaner securing clip.

Recommended Lubricants

UNITED KINGDOM

19. The order in which the following recommended brands are listed does not imply any preference. All lubricants shown are equally recommended.

BP	CASTROL	DUCKHAMS	ESSO	GULF	MOBIL	REGENT	SHELL
Energol SAE 50	Castrol Grand Prix	NOL 50	Essolube 40/50	Gulflube 50	Mobiloil B.B.	Havoline 50	Shell X-100 50

OVERSEAS

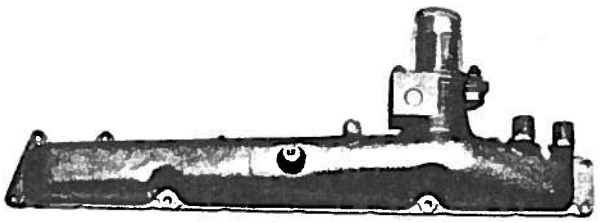
TEMPERATURE RANGE	SAE VISCOSITY No.	GM SPECIFICATION No.
Above 0°C (32°F)	50	4602-M or 4506-M
Below 0°C (32°F)	20	4603-M or 4501-M

3.3000

AIR INLET MANIFOLD

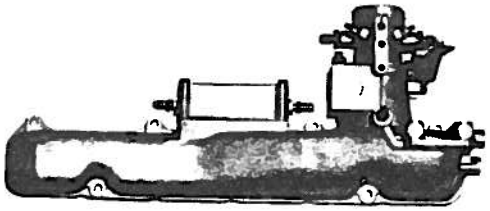
AIR INLET MANIFOLD (Description)

1. The air inlet manifold is an aluminium casting with an inlet onto which the air cleaner adaptor is fitted.



3.1000-1

2. The air cleaner can be directly mounted to the air cleaner adaptor, or remotely mounted with hoses of suitable diameters.
3. A tapped hole in the boss, situated on the inlet is provided to take the cold starting aid igniter. When a cold start aid is not required the orifice is fitted with a plug.
4. On some 220 cu. in. engines a pneumatically governed fuel injection pump is used, where this occurs a venturi is fitted between the air cleaner and the manifold inlet port in place of the air cleaner adaptor, and a damping chamber is located on top of the manifold.



3.3000-4

AIR INLET MANIFOLD (Removal)

5. Remove the air cleaner as described in section 3.1000 and the breather pipe as described in 4.8000.
6. Disconnect the throttle and idling controls from the linkage on the venturi.
7. Disconnect the pipes from the pneumatic governor, venturi and damping chamber.
8. Plug the ends of the pipes and fuel pump governor to prevent ingress of foreign matter.

NOTE: On no account must the engine be rotated or started when the governor pipes are disconnected as no control on the engine speed can be exercised. Should the engine be inadvertently started under these conditions, pull the stop control knob on the instrument panel or the stop lever at the side of the governor, and hold in the stop position until the engine ceases to run.

9. Remove the securing nuts and washers and lift away the manifold.

AIR INLET MANIFOLD (Inspection and Overhaul)

10. Examine the manifold for cracks especially around the attaching flanges. Check the manifold joint face for distortion. Slight bowing of the face can be corrected by placing the manifold on a flat block of hard wood and applying light blows with a hide hammer. Correct local distortion with a fine cut file.

3.3000-10

AIR INLET MANIFOLD (Refitting)

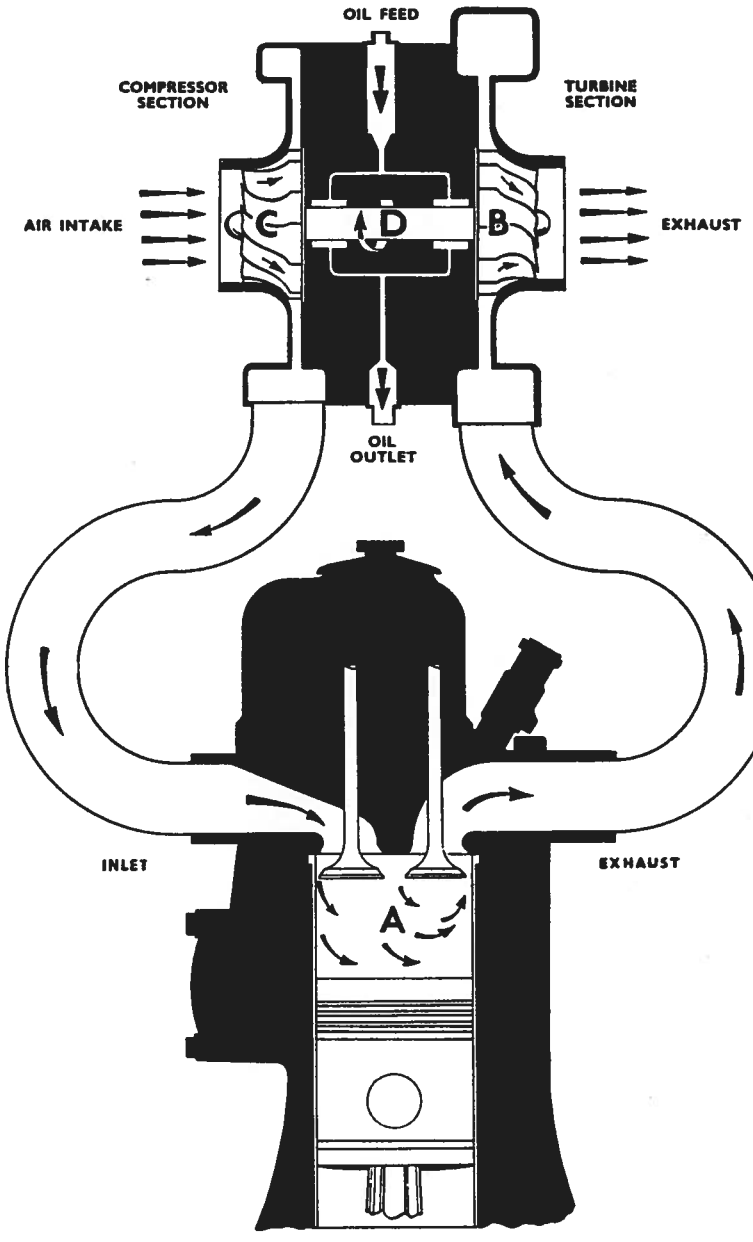
11. Replace the manifold onto the cylinder head ensuring that the faces are clean and tighten the nuts to a torque of 13-15 lbs. ft.
12. Remove the plugs from the fuel pipes and reconnect the pipes to the filter, venturi and damping chamber where fitted.
13. Reconnect the throttle linkage and replace the air cleaner and breather pipes as described in 3.1000 and 4.8000 respectively.

3.5000

TURBOCHARGER

TURBOCHARGER (Description)

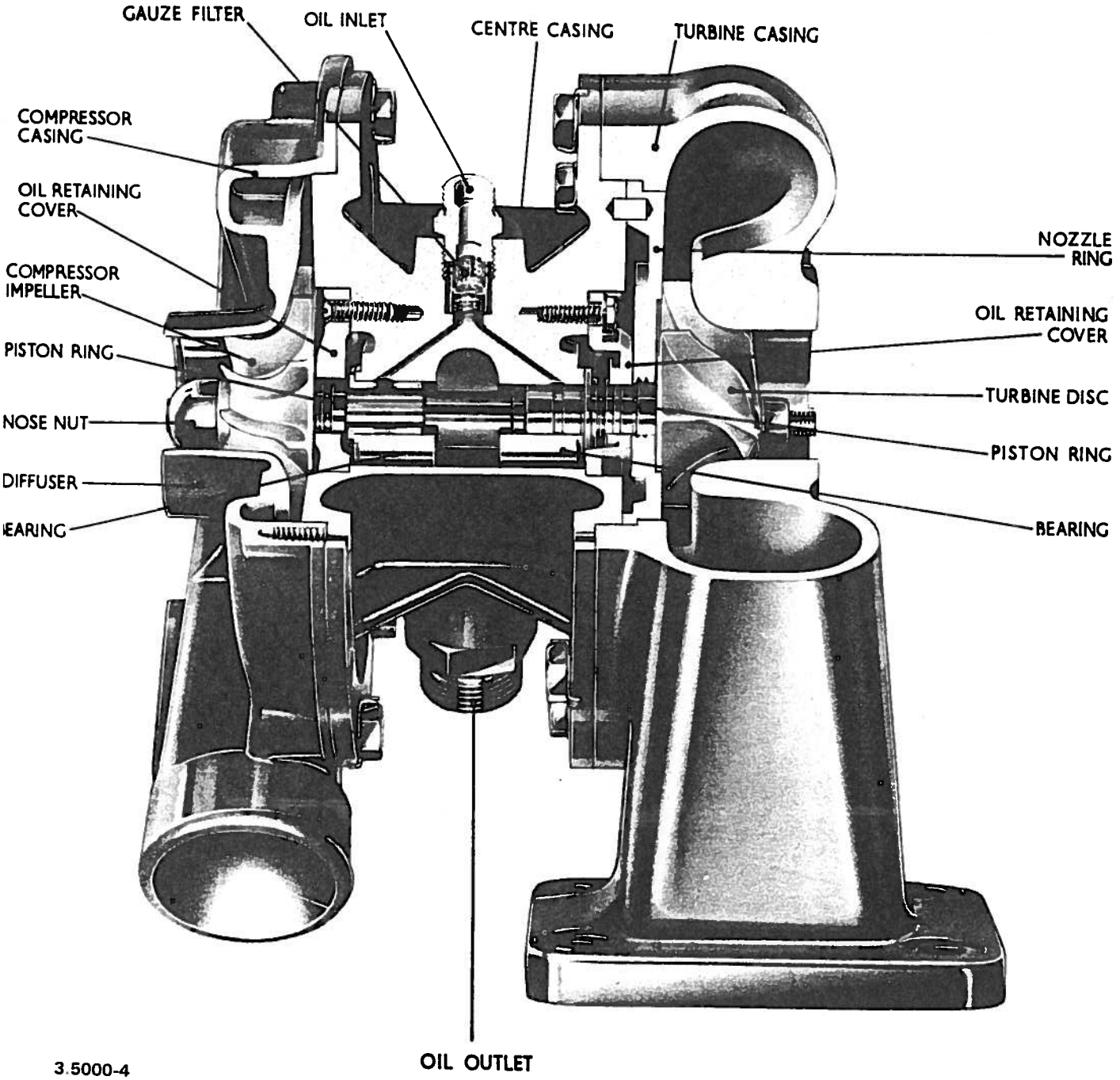
1. Two types of turbocharger are fitted to 330 cu. in. engines. Up to serial number P & I 4665 a CAV turbocharger was used and at P & I 4666 a turbocharger manufactured by Holset Engineering Co. was introduced.
2. Turbochargers are mounted on the exhaust manifold of the engine and obtain their motive power from the exhaust gases expelled by the engine cylinders.
3. The turbine rotor (B) and the compressor rotor (C) are mounted on a common shaft (D). As the turbine is driven by the exhaust gases it drives the compressor rotor which delivers air under pressure to the engine. More air is fed to each cylinder (A), and therefore more fuel can be burnt in a given time than would be possible in a normally aspirated engine. This results in a proportionate increase in engine power.



3.5000-3 DIESEL ENGINE CYLINDER

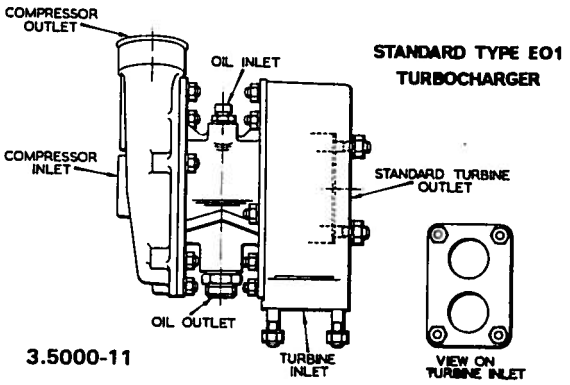
CAV TURBOCHARGER

4. The turbocharger casing comprises an aluminium or iron centre casing, a compressor housing of aluminium, a backplate and a turbine housing of chrome iron. The centre casing carries the rotating assembly and is interposed between the compressor and the turbine housing.



3.5000-4

5. The rotating assembly consists of a compressor turbine, drive shaft and exhaust turbine. The drive shaft and exhaust turbine being permanently fixed together.
6. High precision plain, fully floating bearings are used to mount the rotating assembly in the centre casing.
7. The bearings are lubricated and cooled by the engine oil system. Oil under pressure enters the turbocharger at the inlet union and is directed via a chip tray to each bearing via a gauze filter and an orifice washer. The oil is then drained back into the engine sump.
8. Between the centre casing and turbine casing is the nozzle ring, which is a flat plate fitted with vanes for deflection of exhaust gases. The angle at which the vanes are inclined is of a critical value varying according to the type of turbocharger and is included in the type symbol.
9. The nozzle ring also functions as a gas baffle to prevent gas entering the centre casing. The bore of the nozzle ring through which the drive shaft passes is grooved to form a gas seal.
10. Oil retaining covers at each side of the centre casing prevent the ingress of oil from the centre casing to the turbine and compressor casings. The piston rings fitted to the drive shaft, located in the bores of the oil retaining covers.
11. The inlet and outlet connections for the exhaust gases and charging air, and lubricating oil are shown in the next column.



12. An air cleaner is fitted to the air intake of the turbochargers, which has a capacity 50% greater than that used on the normal aspirated engines.

CAV Type Symbol Explanation

Example E 01 A 77 A 5 51

Design Change Letter

Basic Size

Rotor Assy & Turbine Casing (See Flow Table)

Nozzle Vane Angle in Degrees (Also stamped on nozzle ring)

Radial Position of Turbine Casing (See Figure 3.5000-78)

Radial Position of Compressor Casing (See Figure 3.5000-104)

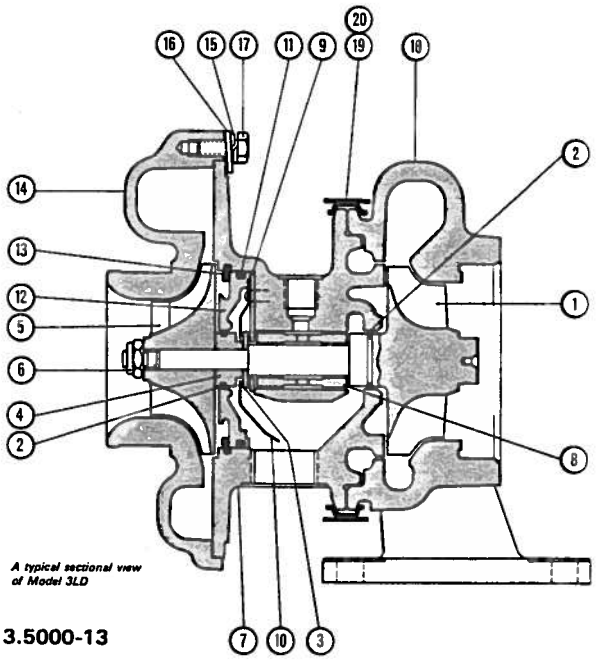
Symbol Number—Special Features

Flow Table

Compressor Casing Flow	Number of Turbine Entries and Flow Sizes								
	0000			000			00		0
	Large	Standard	Small	Large	Standard	Small	Large	Standard	Small
Large		Q		V	P		U	N	
Standard		C	J	E	B	H	O	A	G
Small		M	T		L	S		K	R

HOLSET TURBOCHARGER

13. The Holset turbocharger is a robust and durable unit capable of giving high performance for many thousands of hours if the manufacturers simple recommendations are observed.



A typical sectional view of Model 3LD

3.5000-13

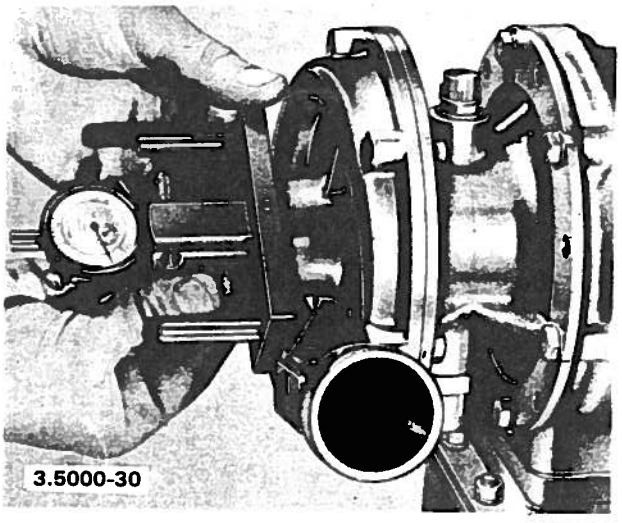
1. Shaft & Turbine Wheel Assembly
2. Piston Ring
3. Thrust Ring
4. Spacer Sleeve
5. Compressor Wheel
6. Locknut
7. Bearing Housing and Pin Assembly
8. Bearing
9. Thrust Plate
10. Oil Deflector
11. 'O' Ring
12. Insert
13. Retaining Ring
14. Compressor Cover
15. Lockwasher
16. Washer
17. Bolt
18. Turbine Housing
19. 'V' Clamp
20. Locknut–'V' Clamp

14. The compressor wheel and turbine wheel are fixed at opposite ends of a common shaft which rotates in a central bearing. The complete rotating assembly including thrust and sealing arrangements is known as the rotor assembly and is designed to rotate at speeds up to 120,000 revolutions per minute under normal conditions.
15. Welded together to form a single part, the shaft and turbine wheel is dynamically balanced as a combined unit. The compressor wheel is made as a separate component and is also dynamically balanced. A new compressor wheel can, therefore, be fitted to any new turbine wheel and shaft assembly without special balancing equipment, although it is advisable to check balance rotors after long service or possible damage.
16. Also mounted on the shaft is a thrust ring and grooved sleeve which accommodates a sealing ring at the compressor end. A piston ring type oil seal is provided at the turbine end.
17. Oil is supplied to the bearing from the engine lubricating system and enters the bearing housing at 'A' (Fig. 3.5000-13) draining back to the engine sump at 'B'.
18. The bearings are fully floating and the stability of the rotor assembly is maintained throughout its speed range by the oil films formed between the bearing, the shaft and the housing. Stabilising forces are generated upon the establishment of oil pressure and commencement of rotation; while the unit is stationery, however, a certain amount of play can be felt in the rotor which is normal.
19. Each turbocharger manufactured by Holset is individually tested on specially designed equipment. In view of the high rotational speeds the turbocharger housing is designed to retain a burst rotor, although the design of the bearing system would normally prevent the rotor reaching burst speed in service. There is, therefore, an adequate safety margin.

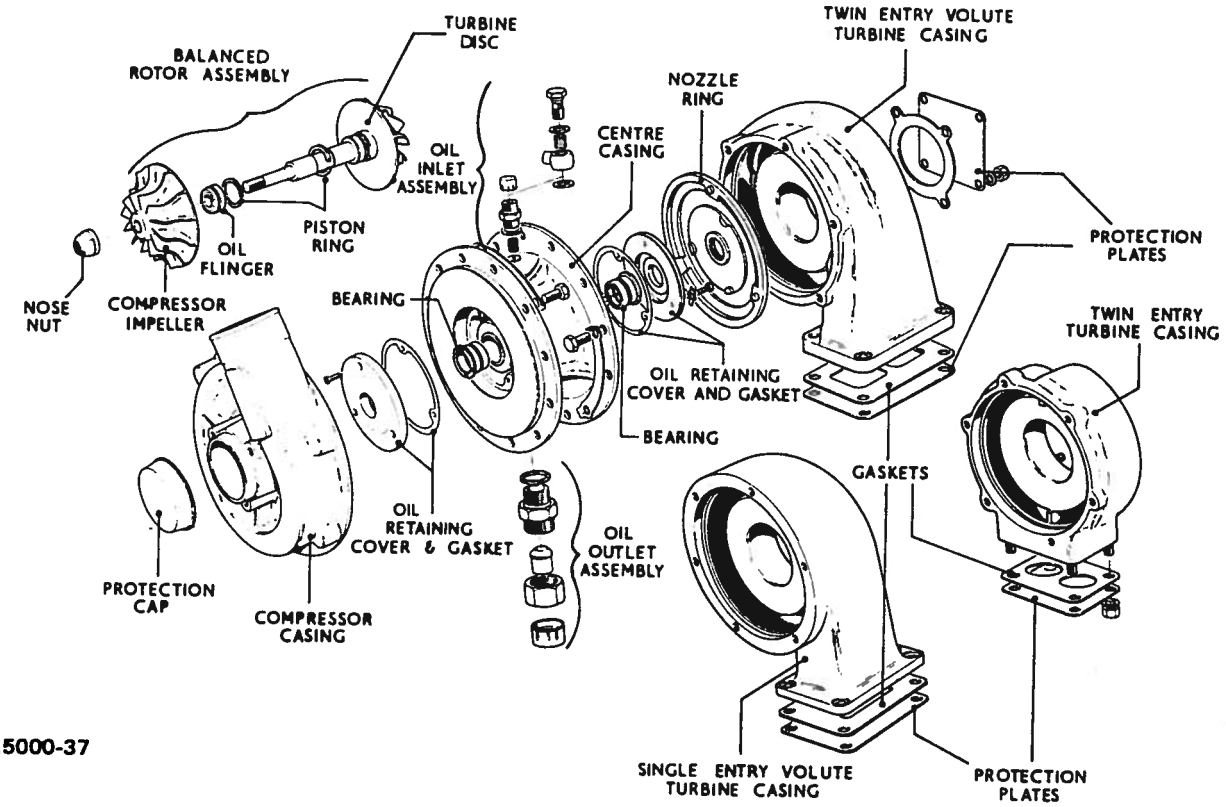
Turbocharger (Removal)
20. On marine engines, disconnect the breather pipe between the air cleaner and crankcase, by releasing the clips around the connecting hose, and then remove the air cleaner by releasing the clip attaching the air cleaner to the turbocharger.
21. Unscrew the banjo bolts to release the oil inlet pipe from the top of the turbocharger and also the two nuts securing the oil drain pipe.
22. The pipe connecting the turbocharger to the inlet manifold should next be removed. This is accomplished by releasing the two clips on the hose at the turbocharger end and securing nuts at the inlet manifold end.
23. On a marine engine, remove the two bolts which secure the turbocharger to its mounting bracket.
24. Finally, the four bolts securing the turbocharger to the exhaust manifold should be removed.

Turbocharger (Inspection and Overhaul)
25. Due to the simplicity of a turbocharger, very little maintenance is required between overhaul periods, which should be carried out every 3,000 hours under normal running conditions.
26. At this stage, the turbocharger should be completely dismantled and inspected as described below, however, the following routine checks should be carried out when the engine is undergoing its normal servicing.
27. Ensure that the air filter is thoroughly cleaned out. Dirty air filters cause restricted air flow and subsequent loss of performance. In severe cases the depression caused in the turbocharger casing due to the restricted air cleaner can be high enough to pull oil from the bearings, resulting in poor lubrication and excessive engine oil consumption.
28. Check all turbocharger hoses and pipe connections for air and exhaust leaks as these can result in reduced performance.
29. Ensure engine oil filter elements are changed regularly and that the oil supply lines to the turbocharger are in good condition and not leaking at unions. In conjunction with the oil filter element change, remove, clean and refit the gauze from the turbocharger oil inlet.
WARNING A turbocharger runs at very high speed and the bearings require a constant supply of clean oil for lubrication and cooling. Therefore, before starting an engine, after an oil change, or whenever the oil supply has been disconnected, it is essential that the turbocharger oil lines and filters are primed. Unless this action is taken, oil starvation and subsequent bearing failure will result. At normal working conditions of the engine, the lubricating oil feed pressure should never be allowed to fall below 30 psi.

CAV Turbochargers
30. Every 1500 hours a bearing check should be carried out in situ. This can be carried out on CAV turbochargers with an end float gauge, part number 7244-7, in the following manner.

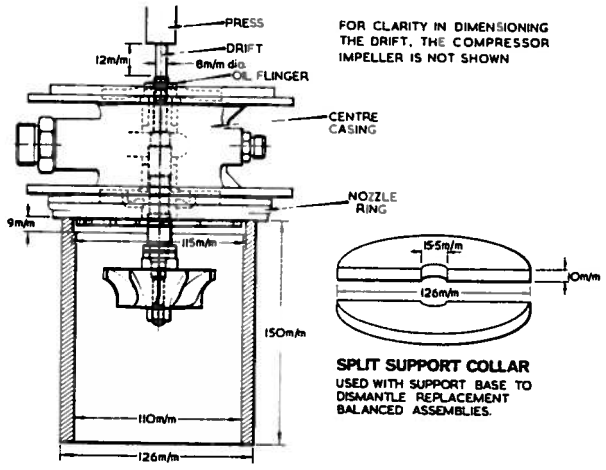

3.5000-30

31. Screw the plunger to the end of the drive shaft. Press on end of plunger, to take up end float of shaft, towards turbine end.
32. Fit the body and plate, (legs away from turbocharger) over the plunger so that the aperture in the body locates over the tapping provided for the plunger lifting screw.
33. Fit the lifting screw.
34. Ensure that the dial gauge arm is touching the end of the plunger and that the clamp screw is tight.
35. Zero dial gauge.
36. Move the plunger axially by means of the lifting screw and note the gauge reading which must be between 0.004″–0.012″ (0.1mm–0.30mm). If end float exceeds maximum limits, the bearings are worn and must be replaced.
37. The following illustration will be of assistance in overhauling the CAV Turbocharger.



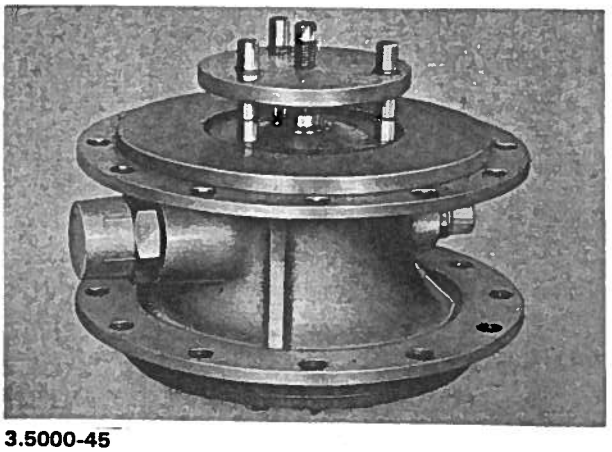
3.5000-37

38. Place the turbocharger on a bench and remove the six bolts and locking tabs from the compressor casing.
39. Remove the compressor casing. To avoid damage to the machined surfaces, sharp instruments must not be used to lever the flange faces apart. If necessary gently knock the casing with a hide mallet.
40. Remove the six bolts and locking tabs from the turbine casing. The turbine casing can be withdrawn by securing three 1'' UNF bolts into the three tappings on the periphery of the centre casing. Gradual and even tightening of the bolts will lift the turbine casing away from the centre casing. On some earlier models the three tappings are not provided and the turbine casing should be gently knocked adrift with a hide mallet.
41. Hold the flats provided on the turbine disc or the end of the drive shaft in a vice and unscrew the compressor nose nut, using a special spanner CAV part number 7144-907.
42. Place the centre casing into a suitable support base and using a suitable drift, press out the drive shaft from the compressor impeller. Place a soft rag under the turbine disc to prevent damage.



3.5000-42

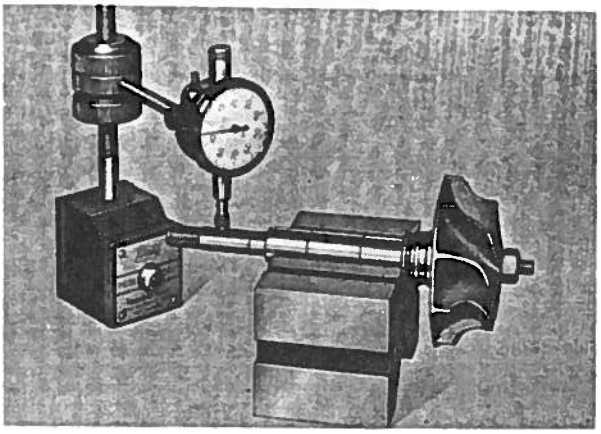
43. Remove the piston ring from the turbine end of the shaft. Carefully lever off the nozzle ring, which is held by dowels, from the turbine side of the centre casing. Place the centre casing into a vice and remove the oil outlet and inlet unions together with the inlet orifice, washer and filter.
NOTE: The centre casing must be held in the vice by the centre section not by the outer flanges.
44. With the centre casing in the vice, release the locking tabs and remove the three bolts securing the turbine oil retaining cover. Reverse the casing in the vice, and remove the three screws securing the compressor retaining cover.
45. Remove the centre casing from the vice and place face down on the bench. Screw the three legs of special tool CAV Part Number 7144-922 into the three holes of the oil retaining cover at the compressor end and place the adaptor (part of the special tool) into the centre bore of the oil flinger. Screw the centre bolt against the plug and slowly withdraw the retaining cover.



3.5000-45

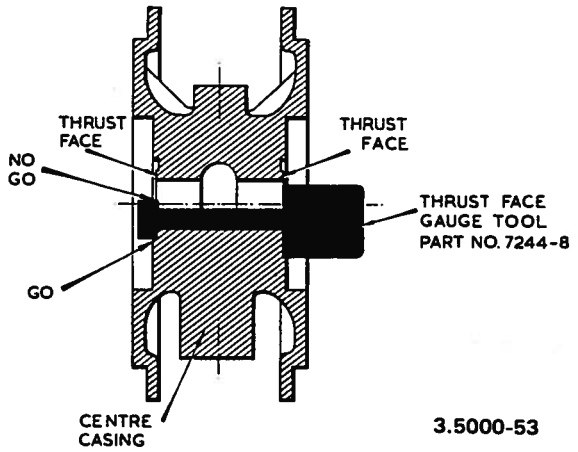
46. Remove the compressor end bearing and then hold the centre casing in the vice and remove turbine and oil retaining cover by using a suitable drift against the remaining bearing face. Discard both of the cover gaskets.
47. Having completely dismantled the turbocharger, all parts should be thoroughly washed, perferably in a proprietary brand of cleaning fluid. Highly carbonised parts may require soaking for 24 hours. All traces of grease must be removed before reassembly.
48. Visibly examine all parts for wear or fractures and renew where necessary.
49. The piston ring grooves of the drive shaft and oil flinger must be examined for thrust wear to the side faces. Thrust wear should only occur on the drive shaft groove furthermost from the turbine disc, and can be checked by the following method.
50. Using special tool (CAV part number 7244-11) insert a new, clean standard piston ring into the shaft drive groove. With the ring in a compressed position, insert a feeler gauge between the piston ring and the groove face. Check the reading at several positions. If the clearance exceeds 0.007'' in any position the complete balanced rotor assembly must be returned to CAV Limited for a modification to enable an oversize piston ring to be fitted. Assemblies with this modification have an 'X' stamped on the centre of the drive shaft for identification purposes. Such an assembly must be fitted with an oversize piston ring when an overhaul becomes necessary.
51. Check the compressor impeller and turbine disc for evidence of rubbing on the edges of the blades. Ensure that the impeller is a tight fit, on the drive shaft and that the shaft is free from corrosion. Check the shaft journals for score marks and surface wear. Carry out a

concentricity test as shown below. Maximum eccentricity must not exceed 0.0002" (0.005 mm). Renew the complete assembly if the figure exceeds this value.



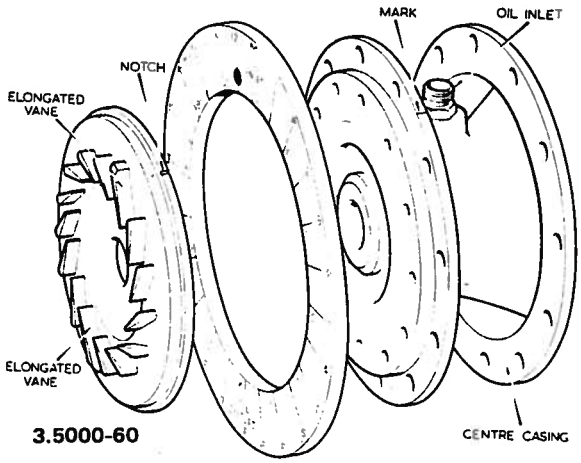
3.5000-51

52. Check for damage to the nose nut, shaft collar and oil flinger, also examine piston ring grooves for damage, as distinct from thrust face wear. If any part other than the piston ring is damaged or defective, the complete rotating assembly must be renewed. Rotating assemblies are supplied in the assembled form and must be dismantled before fitting to the turbacharger, using the split collar shown in Fig. 3.5000-45.
53. Check the centre casing for thrust face wear with the special tool, CAV part number 7244-8. Examine for evidence of rubbing of compressor impeller.



3.5000-53

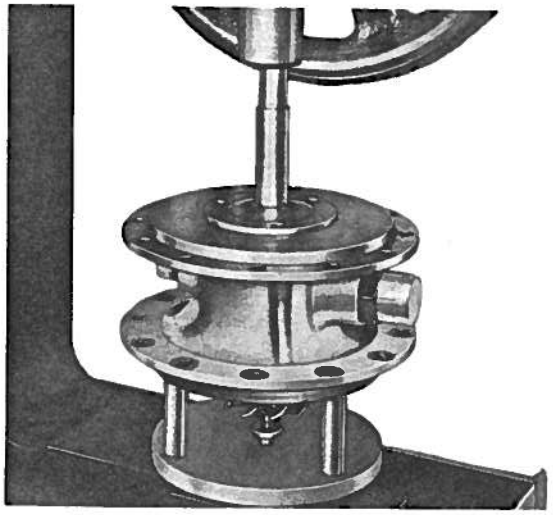
54. Check the compressor casing for signs of rubbing on intake radius and casing for signs of cracks.
55. Inspect the nozzle ring for cracks or distortion and replace if defective. The nozzle vane angle is stamped on the front face of the ring. When ordering a new ring ensure that the part number corresponding to the correct vane is given. Check gas seal bore with go/no-go gauge (part number 7144-906). The tolerance on the gas seal 0.957" Go, 0.964" No-Go. Clean the seal grooves with cleaning tool 7144-905.
56. Examine the turbine casing for heat cracks, particularly in the vicinity of the inlet dividing boss. Check the outlet radius for signs of rotor rubbing. If contact has taken place between the casing and rotor, both the casing and the balanced rotating assembly must be renewed.
57. Finally check the oil retaining covers and renew where necessary.
58. Place centre casing on a flat surface with the nozzle ring dowel holes uppermost. Using clean engine oil, lubricate each bearing surface and insert a new bearing into the turbine head of the centre casing bore. Ensure that the bearing is free to revolve.
59. Using a new oil retaining cover gasket, refit the spigotted oil retaining cover to the turbine side of the centre casing and secure in position with the three bolts and locking tabs.
60. Fit the casing positioning tool, part number 7244-4, to the turbine side of the centre casing, ensuring that the oil inlet and outlet marked on the tool, coincide with the inlet outlet on the centre casing.
NOTE: The large connection hole in the centre casing is the outlet.



3.5000-60

61. Ascertain from the type symbol stamped on the compressor cover outlet, the position code letter (e.g. E10A55B5SI). Fit the nozzle ring so that the notch on the circumference locates against the code letter marked on the tool. For two entry Volute type turbochargers, use letter marked on tool for Volute type. Remove tool after nozzle ring location.
62. Using tool 7244-11 fit a new piston ring on the drive shaft and where applicable to the oil flinger in the following manner.
63. Slide a new ring on the tapered end of the shaft.
64. Place the tool on the drive shaft or oil flinger so that the new ring is parallel to the piston ring groove on the shaft.
65. Gently push the piston ring into the groove, using a knurled ring to achieve a steady pressure. Ascertain the correct size of the piston ring beforehand. When the shaft is marked in the centre with an 'X', an oversize piston ring must be fitted (to turbine end only).
66. When fitting or handling piston rings, care must be taken not to distort them.

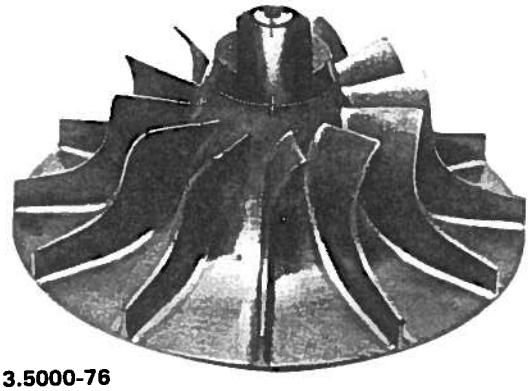
67. Fit the turbine and shaft into the turbine side of the centre casing.
NOTE: The piston ring must be centralised in its groove on the drive shaft before the shaft can be pushed fully home.
68. Place the centre casing on support base, part number 7144-937 and ensure that the adjustable stop on the support base is set so as to position the turbine and drive shaft **fully** into the centre casing.
69. Fit a retaining cover gasket to the centre casing.
70. With the bevelled edge uppermost, fit the oil flinger into the bore of the compressor end oil retaining cover. Place this assembly on the shaft and align the screw holes in the cover with those of the centre casing. Use tool 7144-936 to press the oil flinger and retaining cover into position.



3.5000-70

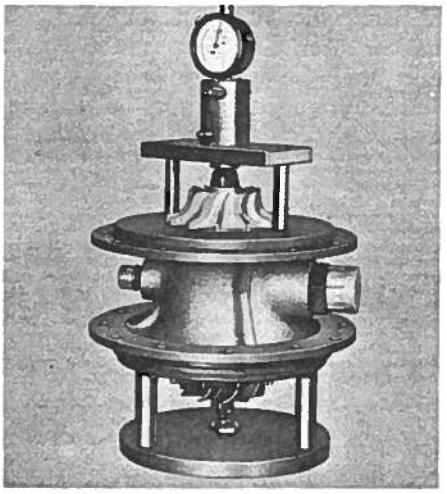
71. Screw the retaining cover down, using new screws which must be lightly coated with 'Loctite' grade 'D' or a compound of similar specifications.
72. The compressor impeller is an interference fit on the drive shaft and must be heated before fitting, if the impeller will fit without heating, it will be unfit for service.
73. Heat the impeller to 180·C (356·F) maximum and place it onto the drive shaft. Ensure that the scribed line on the end of the drive shaft is aligned with the scribed line on the impeller and ease the impeller fully home.
74. Screw tool, part number 7144-933 on to the drive shaft.
75. Remove the centre casing assembly from the support base and place into a vice holding the flats at the end of the drive shaft or turbine disc. If the drive shaft is provided with flats the assembly must be held in a vice by these flats and not by the securing nut. On models fitted with a nut, welded into position, it is permissible to hold the assembly by the flats on the nut. Insert a torque wrench and tighten the impeller to a torque of 10 lbs. ft. Remove the torque wrench and tool, part number 7144-933.

76. Apply a small amount of sealer to shaft and fit nose nut. Using tool number 7144-907, tighten nut to a torque of 8 lbs. ft. After tightening, the scribed line on the nose nut and the scribed line on the impeller must be within $\frac{1}{4}$" of each other.



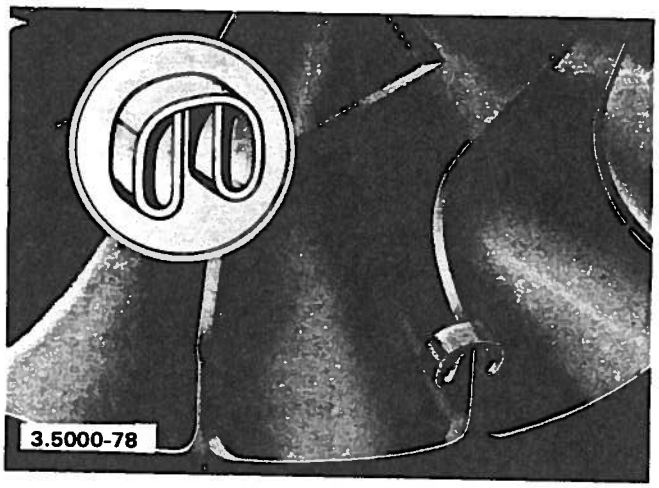
3.5000-76

77. Remove the assembly from the vice and fit it to the support base, part number 7144-937, with nozzle ring towards the base and check the end float by using gauge, part number 7244-7, illustrated below. End float must be between 0.004" (0.1 mm) and 0.008" (0.2 mm).

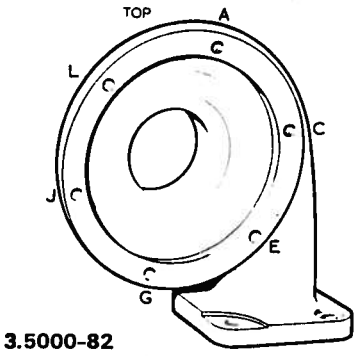


3.5000-77

78. Before final assembly of the turbine casing it must be established that a clearance of 0.011 to 0.024" exists between the turbine blades and the exhaust outlet radius on the casing. To do this, fit a 0.020" clip, part number 7144-727B to one of the turbine blades, see below, and refit turbine casing to centre casing. Tighten down on two opposite studs and check that the rotor assembly is free to turn. If it is prevented from doing so, remove the turbine casing and reduce the size of the clip. If there is no contact between 0.020" clip and the outlet radius when the casing is tightened down, a larger clip size must be fitted. When a clip between 00.11" and 0.024" just makes a brush contact (evident by a slight scraping noise) with the outlet radius, the clearance is correct.

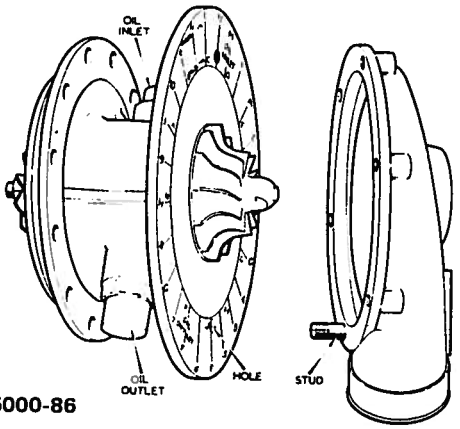


79. When clearance is satisfactory, unbolt the turbine casing **and remove the clip.** Refit turbine casing ensuring that the dividing webs cast in the casing locate against the elongated vanes on the nozzle ring. Bolt the casing in position using six bolts and locking tabs and tighten to a torque of 75 lbs. inch.
80. For positioning turbine casings where a plain nozzle ring without vanes is fitted the following procedure applies.
81. Ascertain from the type symbol, the turbine casing position (e.g. EO1A-A5V1).
82. Bring the centre and turbine casings together so that the oil inlet lies between the two uppermost fixing holes, L & A in Fig. 3.5000-82



3.5000-82

83. Move the centre casing until the fixing hole slightly to the right of the oil inlet on the centre casing matches with the fixing bolt marked with the appropriate letters as denoted in Fig. 3.5000-82.
84. Bolt the casing into position.
85. Fit a 0.020″ clip, part number 7144-727B, to a compressor blade, see Fig. 3.5000-78 and carry out the procedure described above, until a clip between 0.011″ and 0.030″ just makes a brush contact with the inlet radius on the compressor casing.
86. When the clearance is satisfactory, unbolt the compressor casing **and remove the clip.** Fit casing positioning tool, part number 7244-4, to compressor side of centre casing so that the oil inlet and outlet positions on casing and tool coincide. Ascertain from the positioning code stamped on the compressor outlet, the casing positioning code number (e.g. E01A55B5S1)
Note the stud hole in the centre casing corresponding to the code number marked on the periphery of the positioning tool. Remove tool and refit compressor casing so that the stud nearest to the compressor outlet is located in the stud hole corresponding to the code number.



3.5000-86

87. Bolt down compressor casing using six bolts and locking washer, to a final torque of 75 lbs. in.
88. Refit orifice washer and gauze filter (domed insert uppermost) to oil inlet bore. Refit oil inlet union using a new washer and a small amount of 'Loctite' grade AVV on union threads. (The union can be fitted either way).
89. Fit oil outlet union, using a new washer and Loctite grade AVV on union threads.
90. If the turbocharger is not to be fitted to the engine immediately, blanking covers must be fitted to both the compressor inlet and turbine outlet and also to the oil inlet and outlet. This is most important if foreign matter is to be prevented from entering the turbocharger during storage and transit. Similar care must also be taken when fitting a turbocharger or when working on the engine, to ensure that loose articles are not left where they could find their way into the turbocharger.

Overhaul Holset Turbocharger
91. Refer to the sectional view (Fig. 3.5000-13) for itemised parts in the following text.
92. Clamp the unit upright in a vice on the turbine inlet flange.
93. Mark the relative positions of the turbine housing (18), bearing housing (8), compressor cover (14) and V clamp (19).
94. Remove the eight bolts (17) and associated lockwashers (15) fastening the compressor cover (14) to the bearing housing (7) and lift off cover.
95. Remove the 'V' clamp locknut and spring the 'V' clamp (19) back on to the bearing housing (7). Lift the core assembly clear of the turbine housing (18).

96. Holding the turbine wheel at the hub with a 5/8" A/F ring spanner, remove the compressor locknut (7) with a ½" A/F spanner.
97. Slide the compressor wheel (5) off the shaft.
98. Using circlip pliers Seeger A/1 remove the large retaining ring (13) which retains the compressor insert (12). Two screwdrivers should be used to lift the insert from the bearing housing (7). Remove the 'O' ring (11) from the insert.
99. The individual parts of the thrust assembly can now be lifted out.
(a) Spacer sleeve (4) which can be gently pushed out of the insert (12).
(b) Oil deflector (10) positioned by two groove pins.
(c) Thrust ring (3)
(d) Thrust plate (9)
100. The groove pins are a press fit in the bearing housing (7) and should not be removed.
101. Remove the shaft and turbine wheel assembly (1) together with its piston rings (2).
102. Insert fingertip into bore of the bearing (8) and remove.
103. Carefully expand and remove the piston rings (2) from both the spacer sleeve and turbine wheel and shaft assembly. Over expansion of the piston rings will cause a permanent set or breakage.
104. Soak all parts in a commercially approved cleaner until all deposits have been loosened. Caustic solutions **must not** be used as damage would be caused to certain parts.
105. Use a plastic scraper or bristle type brush on all aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.
106. Clean all drilled passages with a compressed air jet.
107. Ensure surfaces adjacent to wheels on stationary housings are free of deposits and are clean and smooth.
108. After cleaning, all parts should be inspected as follows:
109. Shaft and Turbine wheel assembly (18)
(a) Inspect bearing journals for excessive scratches and wear. Minor scratches may be tolerated.
(b) Inspect the piston groove walls for scoring. Minor scratches are acceptable.
(c) Check carefully for cracked, bent or damaged blades, but do not attempt to straighten blades.
110. Bearings (8) must be replaced for excessive scratches and wear.
111. Replace spacer sleeve (4) if piston ring groove or spacer are damaged.
112. Replace the bearing housing (7) if the bearing or piston ring bores are excessively scratched or worn.
113. Thrust ring (3); Thrust plate (9)
(a) Replace if thrust faces are mutilated. Minor scratches are acceptable.
(b) Replace thrust plate if the faces are worn excessively, unevenly or are severely scratched and otherwise mutilated.
(c) The small feed grooves in the thrust plate must be clean and free from obstructions.
114. Compressor wheel (5). Check carefully for cracked, bent or damaged blades, but do not attempt to straighten blades.
115. Replace 'O' ring (11) if section through ring has taken a permanent set, indicated by flats on the sides of the ring.
116. When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence.
117. Assembly of the unit is the reverse of dismantling, but it is advised that the following points be noted, if a satisfactory re-build is to be obtained.
118. Lubricate bearings, thrust assembly, piston rings and rotor shaft, with clean engine oil.
119. When replacing the turbine wheel and shaft (1) into the bearing housing (7), and spacer sleeve (4) into the insert (12) do not force the piston rings into the bore as an off-centred ring will fracture, causing the shaft to bind.
120. The large retaining ring (13) should have the levelled side facing outwards.
121. Torque the locknut (6) to 13 ft/lbs (17.6 newton/metres), bolt (17) to 5 ft/lbs (6.8 newton/metres) and 'V' clamp locknut (20) to 10 ft/lbs (13.6 newton/metres).
122. On completion of assembly spin the shaft to ensure that it rotates freely.

Turbocharger (Refitting)

123. Before refitting the turbocharger to the engine, carry out the following installation checks.
124. Inspect the bore of the air intake tube and renew the tube if the rubber lining is loose or has deteriorated.
125. Check the air intake system for loose nuts and bolts.
126. Check the air intake system for cleanliness and foreign matter.
127. Inspect the exhaust manifold for foreign matter.
128. Inspect the oil drain line, ensure the line is not clogged.
129. Inspect the oil supply line for clogging, deterioration or possibility of leaks under pressure. Renew if serviceability is doubtful.
130. Check the turbocharger mounting pad on the manifold to make certain that all of the old gasket has been removed.
131. Place new gaskets between the turbocharger and exhaust manifold, ensure gasket does not protrude into the opening of the manifold.
132. Mount the turbocharger on the engine and secure with the mounting bolts.
133. Fill the bearing housing of the turbocharger with clean engine oil, through the oil inlet port, then connect the oil supply pipe. Leave the oil drain pipe disconnected.

134. Connect the air inlet pipe and outlet pipes, taking care to check all joints for possible leaks, also ensure that the piping is not producing strain on the compressor cover.
135. Connect the exhaust outlet flange, using a new gasket. It is recommended that an anti-seize compound be applied to the bolt threads.
136. If the engine lubricating oil change period is due, it is advisable to change the oil and renew the filter element before operating the turbocharger.
137. Crank the engine without firing until a steady flow of oil runs from the turbocharger.
138. Connect the oil drain pipe to the engine connections.

SECTION 4

LUBRICATION SYSTEM

Contents

4.0000
LUBRICATION SYSTEM SPECIFICATIONS

OIL PUMP

Driving Impeller Spindle Diameter	14.24-14.26 mm (.5607"-.5612")
Driving Impeller Spindle End Float	.076-.152 mm (.003"-.006")
Driving Impeller Spindle Clearance in Body	.023-.053 mm (.0009"-.0021")
Driven Impeller Spindle Diameter	14.30-14.31 mm (.5629"-.5634")
Driven Impeller Spindle Fit in Body	.003-.033 mm (.0001"-.0013")
Backlash Between Impeller Teeth	.08-.25 mm (.003"-.010")
Driving Impeller Bore Diameter	14.23-14.24 mm (.5602"-.5607")
Driven Impeller Bore Diameter	14.33-14.34 mm (.5642"-.5647")
Driving Impeller Fit on Spindle	Zero-.0254 mm (Zero-.001") Interference
Driven Impeller Fit on Spindle	.02-.046 mm (.0008"-.0018") Interference
Impeller End Float in Body	.05-.13mm (.002"-.005")
Impeller Overall Length	39.6-39.62 mm (1.559"-1.560")
Impeller Radial Clearance in Body	.04-.09 mm (.0015"-.0035")
Oil Pressure Relief Valve Plunger Diameter	15.84-15.86 mm (.6235"-.6243")
Oil Pressure Relief Valve Plunger Clearance in Bore	.02-.06 mm (.0007"-.0025")
Oil Pressure Relief Valve Spring Free Length	112-113 mm (4.42"-4.45")
Oil Pressure Relief Valve Spring Load at 65.5 mm (2.58")	7.7-8.2 kg. (17-18 lb)
Driving Gear Bore Diameter	14.24-14.25 mm (.5607"-.5612")
Driving Gear Fit on Spindle	0.0127 mm (.0005") Clearance 0.0127 mm (.0005") Interference
Driving Gear Thrust Washer Thickness	2.26-2.39 mm (.089"-.094")

OIL FILTER

Make and Type	AC 720 - Full Flow
Element	AC 72
Element Spring Load at 31.77 mm (1.25")	7-9 kg. (15-20 lb)

OIL DISTRIBUTION

Oil Pressure (Hot)	241-345 KPa (35-50 lb/sq in)
Oil Pressure Switch Operating Pressure	21-34 KPa (3-5 lb/sq in)

OIL PAN CAPACITIES

Four-cylinder, 220 cubic inch, standard sump:	
Total	14 Imp. Pints (8 Litres)
Refill	11 Imp. Pints (6 Litres)
Refill With Filter Element Change	13 Imp. Pints (7 Litres)
Four-Cylinder, 220 cubic inch, pressed steel deep sump:	
Total	11 Imp. Pints (6 Litres)
Refill	8 Imp. Pints (5 Litres)
Refill With Filter Element Change	11 Imp. Pints (6 Litres)
Six-cylinder, 330 cubic inch, standard sump:	
Total	17 Imp. Pints (10 Litres)
Refill	14 Imp. Pints (8 Litres)
Refill With Filter Element Change	16 Imp. Pints (9 Litres)
Six-cylinder, 330 cubic inch, pressed steel deep sump:	
Total	19 Imp. Pints (11 Litres)
Refill	16 Imp. Pints (9 Litres)
Refill With Filter Element Change	18 Imp. Pints (10 Litres)
Six-cylinder, 330 cubic inch, cast aluminium deep sump (off-highway):	
Total	16 Imp. Pints (9 Litres)
Refill	13 Imp. Pints (7 Litres)
Refill With Filter Element Change	15 Imp. Pints (8 Litres)

VENTILATION SYSTEM

MAXIMUM DEPRESSION IN INCHES OF WATER

Engine	Speed of Engine (rpm)			
	1000	1500	2000	2600
220 cu in	0.5	0.8	1.1	1.3
330 cu in	0.3	0.9	1.6	3.0

TORQUE WRENCH DATA

Oil pump cover retaining bolts	8-11 Nm (6-8 lb ft)
Oil pump retaining bolts	18-20 Nm (13-15 lb ft)
Oil filter centre bolt	14 Nm (10 lb ft)
Oil filter retaining bolts (Industrial)	49-56 Nm (36-41 lb ft)
Oil filter retaining bolts (Marine)	30-37 Nm (22-27 lb ft)
Oil pan retaining screws	8-11 Nm (6-8 lb ft)
Vent system baffle chamber	8-11 Nm (6-8 lb ft)

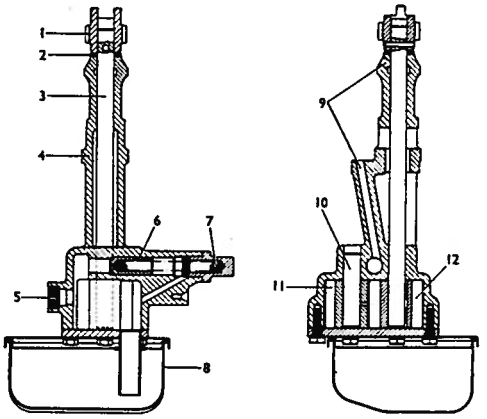
4.1000

OIL PUMP

Oil Pump (Description)

1. Lubrication is by forced feed system embodying full flow filtration. Oil is circulated through the system by a gear type pump mounted in a boss on the right hand side of the crankcase.

2. The pump is driven by a skew gear integral with the camshaft. The pump driving spindle is carried direct in the bore of the pump body and has a helical tooth impellor pressed and keyed to its lower end. The driving impellor meshes with the driven impellor, which rotates freely on a spindle pressed into the pump body. A bottom cover bolted to the pump body incorporates a suction pipe and gauze screen.



4.1000-2

1. Driving gear
2. Thrust washer
3. Driving impeller spindle
4. Pump body
5. Delivery port
6. Relief valve plunger
7. Spring
8. Gauze screen
9. Driving gear and spindle oil feed drillings
10. Driven impeller spindle
11. Driven impeller
12. Driving impeller

3. A spring loaded oil pressure relief valve is incorporated, and a pipe connects the delivery port to a vertical drilling in the crankcase which leads to the oil filter.

Oil Pump (Removal)

4. Remove the oil pan as detailed in 4.7000.

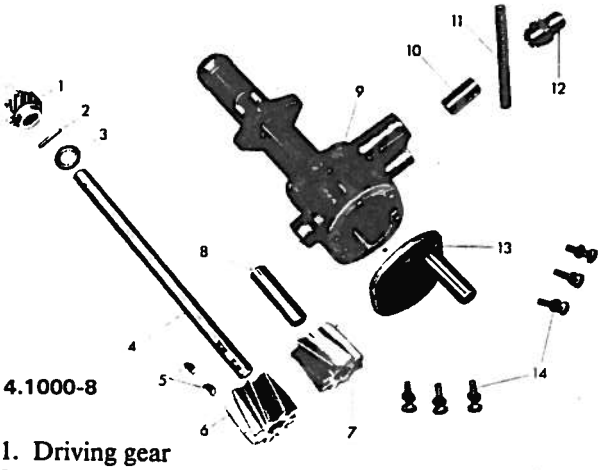
5. Unscrew the delivery pipe from the crankcase.

6. Remove the two fixing bolts and washers and withdraw the complete pump assembly.

Oil Pump (Inspection and Overhaul)

7. Remove the oil delivery pipe from the pump body.

8. Prise up the gauze retaining clips and remove the screen. Unscrew the bolts securing the screen retainer, cover the suction tube to the pump body and remove the screen retainer with the screw and suction tube.



4.1000-8

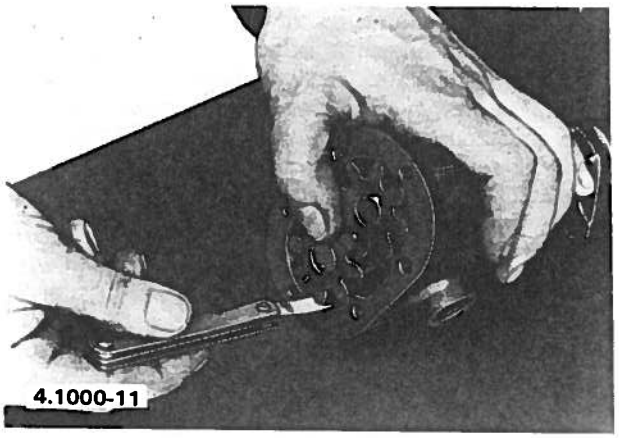
1. Driving gear
2. Gear rivet
3. Thrust washer
4. Driving impeller spindle
5. Driving impeller keys
6. Driving impeller
7. Driven impeller
8. Driven impeller spindle
9. Pump body
10. Relief valve plunger
11. Spring
12. Relief valve plug
13. Cover and suction tube
14. Cover attaching bolts

9. Examine the machined face of the cover for wear or scores. If the wear or depth of scoring is not excessive the cover can be refaced.

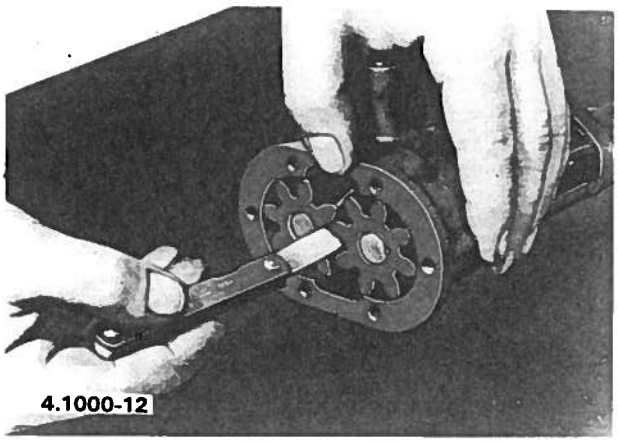
10. Using a flat bar and feeler gauges check the end float of the impellers in the body which should be between .002" and .005".

4.1000-10

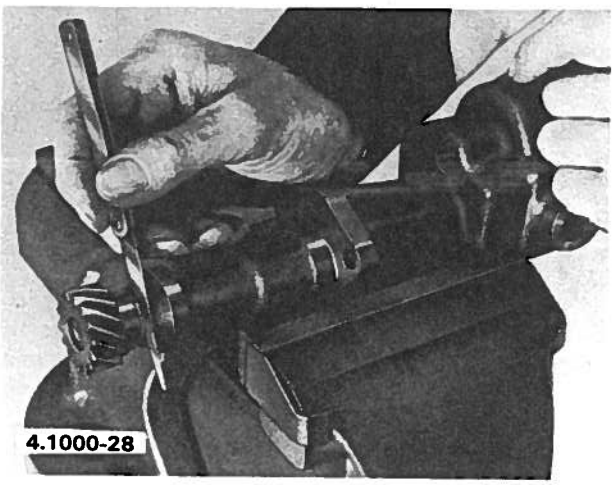
11. With the aid of feeler gauges check the radial clearance of the impellers in the body. This should be between .0015" and .0035".



12. Again with the aid of feeler gauges, check the backlash between the impeller teeth which should be between .003" and .010".



13. If in any of these checks, the limits are exceeded the pump should be dismantled and parts renewed where necessary.
14. Prior to dismantling the pump, mark the end of the impellers to identify them when reassembling.
15. Withdraw the driven impeller and spindle.
16. Drive out the rivet securing the driving gear to the spindle and using a soft metal drift, tap the spindle out of the gear. This will enable the driving impeller and spindle to be withdrawn from the body.
17. Unscrew the relief valve plug and withdraw the spring and plunger.
18. All components should now be inspected for wear.
19. The driving spindle bores in the body should be examined for wear by checking the clearance of an unworn part of the spindle.
20. Examine the oil pressure relief valve plunger, and the plunger bore in the body for wear or scores. The plunger should slide freely without slackness. The clearance in the bore should be .0007" to .0025".
21. The valve spring should be examined for damage and its free length and rate should be checked. The free length should be between 4.42" and 4.45", and with a load of 17 to 18 lbs. it should be 2.58 inches.
22. Examine both impeller spindles, impeller teeth and the end faces for wear and scores. The driven impeller spindle should be a press fit on the body. If there is any sign of slackness, renew the spindle and if necessary the pump body.
23. To renew the driven impeller spindle, drive out the old spindle from outside the impeller chamber, then press in the new spindle until its outer end is 1/64 inch below the cover attaching face.
24. To renew the driving spindle or impeller, press out the spindle and transfer the two keys to the new spindle. Align the keys with the keyway in the impeller and press on the impeller until its end face is flush with the end of the spindle. If the existing impeller is being refitted remove any burrs or roughness from the teeth with a fine carborundum stone. After stoning remove all traces of swarf. Ensure that the face previously marked will be towards the bottom of the pump when refitting.
25. Examine the driving gear for worn or chipped teeth and the thrust face for scores. A new thrust washer must be used when refitting the gear.
26. Lubricate the spindles with mineral oil containing colloidal graphite and install the driving impeller spindle into the body.
27. The driving spindle can now be installed, when this operation is being performed the lower end of the spindle must be held against a dolly of lesser diameter than the impeller bore, otherwise the spindle may be pressed further through the impeller. This could cause the spindle to foul the pump cover or create misalignment of the rivet holes, if the original spindle is to be reinstalled.
28. When a new driving impeller spindle is being installed, use a 3/16 inch diameter drill for drilling the rivet hole. Refit the gear rivet, check that the driving spindle end float is within .003" to .006" and stake the gear rivet.



29. Ensuring that the previously marked face is towards the bottom of the pump, install the driven impeller.

30. Refit the relief valve plunger, spring and plug. Replace the cover and screen retainer and tighten the six securing bolts to a torque of 6-8 lbs. ft. Refit the screen by pressing the screen retaining clips back into position.
31. Refit the oil delivery pipe.

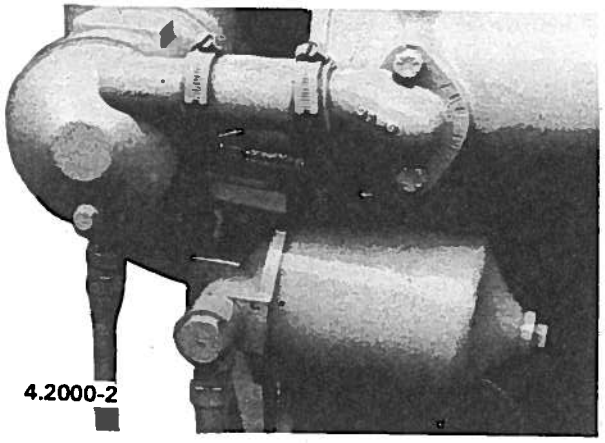
Oil Pump (Refitting)
32. Place the oil pump into position and secure with the two bolts tightening to a torque of 13-15 lbs. ft. Screw the delivery pipe to the crankcase.
33. Replace the oil pan as detailed in 4.7000.

4.2000

LUBRICATING OIL FILTER

Lubricating Oil Filter (Description)

1. The AC full flow oil filter is fitted directly to the cylinder block with four screws, the lubricating oil passing through oilways in the cylinder block. However, on engines fitted with a lubricating oil cooler, a cast adaptor is fitted to the block in a position normally occupied by the filter. The filter is fitted to the adaptor and then the whole assembly is fitted to the cylinder block using four longer screws.
2. On marine engines a cast adaptor is fitted to the block in the position normally occupied by the filter. The filter is then fitted to a bracket attached to the front end of the water cooled exhaust manifold. Oil pipes are led from the adaptor block attached to the cylinder block to the filter.



4.2000-2

3. The filter incorporates a spring loaded ball valve in the outlet port which allows oil to by-pass the filter element should it become choked.
4. A hole is tapped into the filter head to accommodate a pressure switch for use with the low oil pressure warning lamp.

Lubricating Oil Filter (Removal)

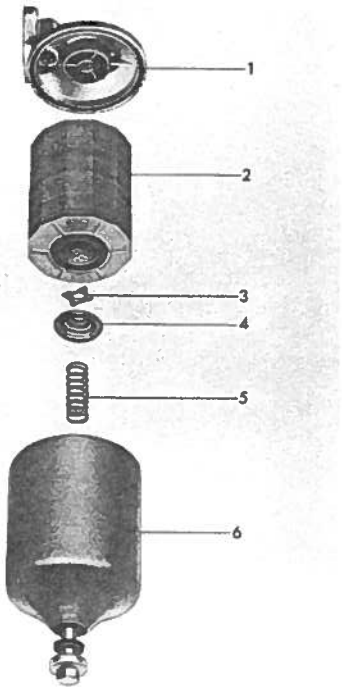
5. Thoroughly clean the area around the oil filter assembly.
6. Disconnect the electrical connections to the pressure switch, if fitted.
7. Remove the four screws which secure the filter to either the cylinder block or the adaptor and lift out the filter from the engine.

Note: On 220 engines prior to serial number P & I 1350 and 330 engines prior to serial number P & I 1900 only two securing screws were used.

8. On marine engines, the filter inlet and outlet pipes should be disconnected after provision has been made to catch any oil in the system. The two filter retaining nuts, bolts and washers should next be removed and the filter lifted from the engine.

Lubricating Oil Filter (Inspection and Overhaul)

9. There are no moving parts in the lubricating oil filter assembly except the relief valve. The inspection, therefore, consists of a visual check for damage caused by knocks, mis-assembly of shell into head or over-torqued centre bolt.
10. The filter element must be changed every 200 hours.
11. Unscrew the filter casing centre bolt and withdraw the casing and element assembly. Hold the casing upright to avoid spilling of oil.



4.2000-11

1. Filter head
2. Filter element
3. Element centralizer
4. Spring retainer
5. Spring
6. Filter casing

12. Drain the oil from the casing and discard the element.
13. Remove the gasket from the filter head.
14. Thoroughly clean the inside of the filter head and casing. Install a new gasket ensuring that it locates correctly and is free from kinks.
15. Install a new element in the casing and bolt the assembly to the filter head. Before tightening the bolt, check that the casing is located correctly on the gasket. Tighten to 1.4 kg/m (10 lbs ft.).
16. Top up the oil pan with the recommended oil and run the engine for two or three minutes to allow oil to circulate. Recheck the oil level and examine for oil leaks.

Lubricating Oil Filter (Refitting)

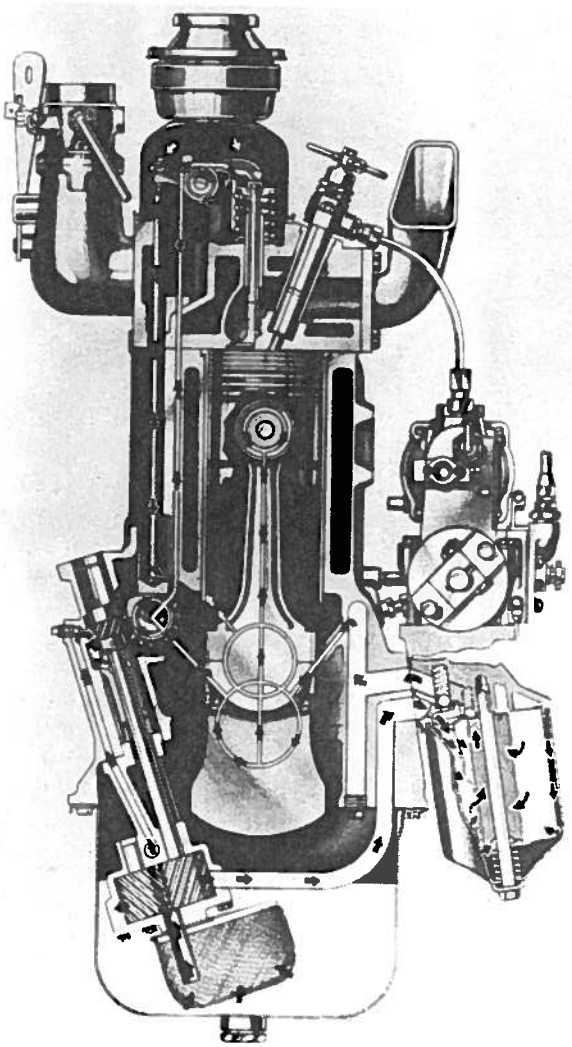
17. Clean all traces of old gaskets from the cylinder block or adaptor and also ensure all parts are clean.
18. Refit the filters using a new gasket, tighten the securing screws to a torque of 36-41 lbs. ft. (48.8-55.6 newton/metres) and 22-27 lbs. ft. (29.8 - 36.6 newton/metres) on marine engines.
19. Reconnect any mechanical or electrical connections to the pressure switch.
20. On marine engines the oil pipes should be reconnected between the oil cooler and adaptor block and the oil cooler and filter.

4.3000

OIL DISTRIBUTION

Oil Distribution (Description)

1. Oil drawn from the screen into the pump impeller chamber is discharged through the oil filter element to the main oil gallery where it then flows down oilways to the crankshaft main bearings, and thence through oilways in the crankshaft to the connecting rod bearings. A bleed hole in each rod directs oil on the thrust side of the cylinder walls.



4.3000-1

2. The camshaft bearings are lubricated through oilways from the main bearings. An oilway in the front intermediate camshaft journal directs oil at every camshaft revolution through a vertical drilling in the cylinder block and head to the oil pipe connected to the rocker shaft. After lubricating the rockers, surplus oil drains down the push rod tubes and lubricates the rods, tappets and camshaft arms before returning to the oil pan. The camshaft skew gear is lubricated by oil discharged from the oil pump impeller chamber through a drilling in the pump body and crankcase. Surplus oil then lubricates the pump spindle through a drilling in the upper end of the spindle housing.

3. The timing gears are lubricated by a jet of oil fed from the front main bearing through oilways drilled in the main bearing cap and bearing, and the timing gear case. The idler gear hub is separately lubricated from the main gallery, the oil passing through the oilways drilled in the hub and crankcase.

4. When the oil pressure reaches a predetermined figure (3-5 lb/sq. in.), the pressure switch diaphragm flexes and separates its contacts thus extinguishing the warning light. Should the pressure drop below the specified limit whilst the engine is running, the diaphragm, regaining its original position, closes the contacts and illuminates the lamp.

5. The oil pressure is maintained within specified limits by the pressure relief valve. Excess pressure displaces the valve plunger and uncovers the port connecting the oilway to the suction side of the pump. As soon as the excess pressure is relieved the spring returns the plunger to its original position.

Oil Distribution (Removal)

6. With the exception of marine engines, the only serviceable parts of the oil distribution system are the rocker feed pipe, oil delivery pipe, oil pump screen and various oil seals.

7. Remove the oil pan as detailed in 4.7000.

8. Unscrew the two sleeve nuts from the ends of the delivery pipe and remove the pipe.

9. Prise up the gauze screen retaining clips and remove the screen.

10. The removal of the rocker feed pipe is described under section 1.7100 and the removal of oil seals are described in the various sections in which they appear.

11. For removal of the oil piping on marine or industrial engines with heat exchangers fitted, the sleeve nuts should be loosened and the pipes withdrawn. It must be remembered that some oil will remain in these pipes and the appropriate action taken to avoid spillage.

Oil Distribution (Inspection and Overhaul)

12. Lubricating oil distribution pipes require only a visual inspection for damage, which if found the pipe must be replaced.

Oil Distribution (Refitting)

13. Attach the gauze screen to the fuel pump and press down the retaining clips.

14. Refit the delivery pipe between the oil pump and crankcase and tighten the two sleeve nuts.

15. The pipes between the oil filter, heat exchanger and/or crankcase can be repositioned and the sleeves tightened.

4.4000

OIL COOLER

Oil Cooler (Description)

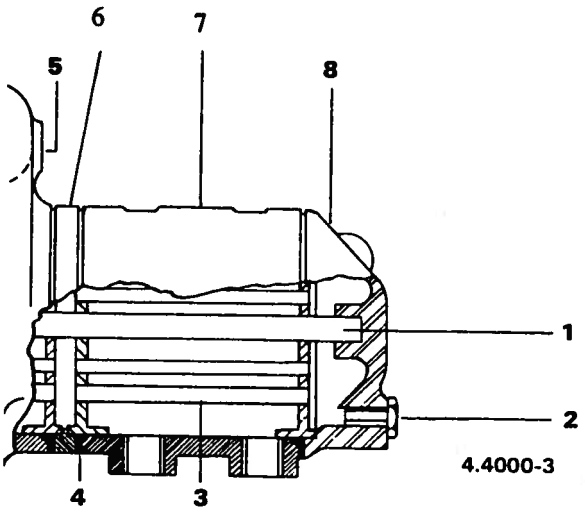
1. Two types of oil cooler are used on 220 and 330 cu. in. engines:
   (a) air blast and
   (b) water cooled
2. The air blast cooler is of light alloy construction and is fitted on the front of the radiator by a bracket assembly. Oil is cooled by air passing between the finned tubes of the oil cooler through which the oil is flowing. The oil is directed to and from the oil cooler by hose assemblies attached to the oil filter adaptor.

4.4000-2

1. Oil cooler
2. Hose assembly
3. Oil filter adaptor
4. Oil filter

3. On engines fitted with a heat exchanger, a small aluminium cylinder attached to the header tank houses the oil cooler. The cooling of the oil is achieved by passing raw water through a series of tubes surrounded by the oil which requires cooling.

4. Hose assemblies allow the flow of oil between the engine and oil cooler.



4.4000-3

1. Tie rod
2. Sea water drain plug
3. Oil cooler tube stack
4. Tube stack seals
5. Heat exchanger drain plug
6. Spacing ring
7. Oil cooler body
8. End cover

Oil Cooler (Removal)

5. Place a pan beneath the oil cooler hose assemblies to catch any oil in the system.
6. Remove the air blast oil cooler by unscrewing the two hose connections beneath the oil cooler, then remove the four nuts which attach the cooler to the radiator.
7. Removal, inspection, overhaul and refitting of the combined heat exchanger and oil cooler is described in section 5.5000

Oil Cooler (Inspection and Overhaul)

8. To cleanse the oil cooler prepare a solution of one part muriatic acid to nine parts of water. Add one pound of oxalic acid and 0.01 of a gallon of pyridine to every 5 gallons of solution required.
Note: The tank used to mix the solution must be of an acid resistant material.
9. Plug the oil inlet and outlet ports, immerse the cooler in the solution. Remove immediately when the bubbling and foaming action has ceased, (approximately 1 to 2 minutes).
10. Flush thoroughly with warm clean water. Repeat the operation if necessary.
11. Remove a plug from either the inlet or outlet port and attach an air hose with a maximum pressure of 170 lb/sq. in. Submerge the cooler in water. Air bubbles indicate any leaks that have occurred which will necessitate replacement of the cooler.

Oil Cooler (Refitting)

12. Refit the oil cooler to the radiator bracket assembly by fitting the four retaining nuts and bolts.
13. Reconnect the hose assemblies.

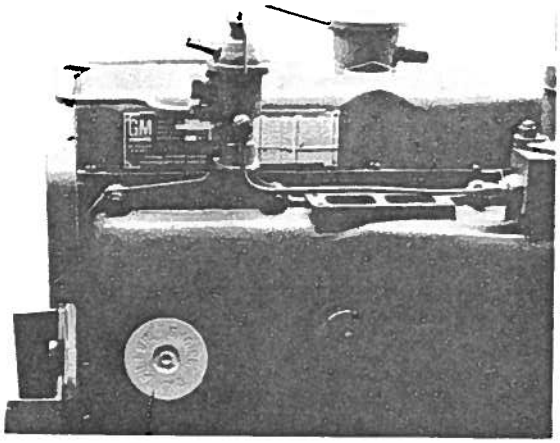
4.5000

OIL FILLER

Oil Filler (Description)

1. The oil filler cap is situated on top of the rocker cover although on some engines a second filler tube and cap are fitted to either the oil sump or side cover to enable easier filling.

Standard filler cap



Special filler cap

4.5000-1

Oil Filler (Removal)

2. A 90° anticlockwise turn is all that is required to remove the oil filler cap.
3. The filler tube is part of a welded assembly and therefore no further disassembly is necessary.

Oil Filler (Inspection and Overhaul)

4. The oil filler tube and cap require only a visual inspection for damage, which if found the cap or tube assembly must be replace.

Oil Filler (Refitting)

5. Fill the engine with the correct quantity and grade of oil. The grade of oil is shown under the recommended lubricants at the end of section 1 and the recommended quantities are listed below.

CAPACITIES

Engine Oil Sump:

Four cylinder, 220 cubic inch, Standard sump:

Total	14 Imp. Pints (8 Litres)
Refill	11 Imp. Pints (6 Litres)
Refill with filter element change	13 Imp. Pints (7 Litres)

Four cylinder, 220 cubic inch, Pressed steel deep sump:

Total	11 Imp. Pints (6 Litres)
Refill	8 Imp. Pints (5 Litres)
Refill with filter element change	11 Imp. Pints (6 Litres)

Six-cylinder, 330 cubic inch, Standard sump:

Total	17 Imp. Pints (10 Litres)
Refill	14 Imp. Pints (8 Litres)
Refill with filter element change	16 Imp. Pints (9 Litres)

Six-cylinder, 330 cubic inch, Pressed steel deep sump:

Total	19 Imp. Pints (11 Litres)
Refill	16 Imp. Pints (9 Litres)
Refill with filter element change	18 Imp. Pints (10 Litres)

Six-cylinder, 330 cubic inch, Cast aluminium deep sump (Off-Highway);

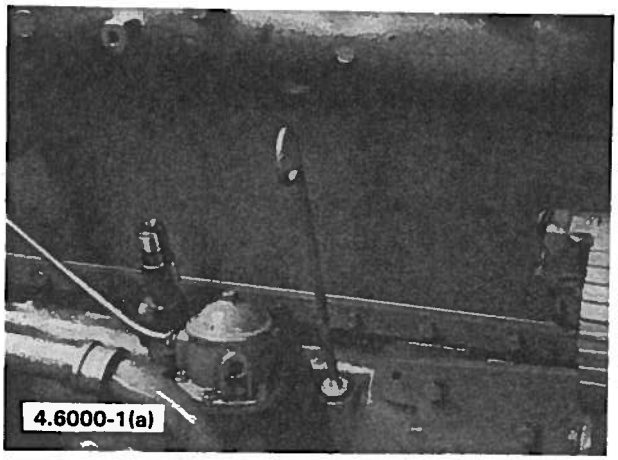
Total	16 Imp. Pints (9 Litres)
Refill	13 Imp. Pints (7 Litres)
Refill with filter element change	15 Imp. Pints (8 Litres)

4.6000

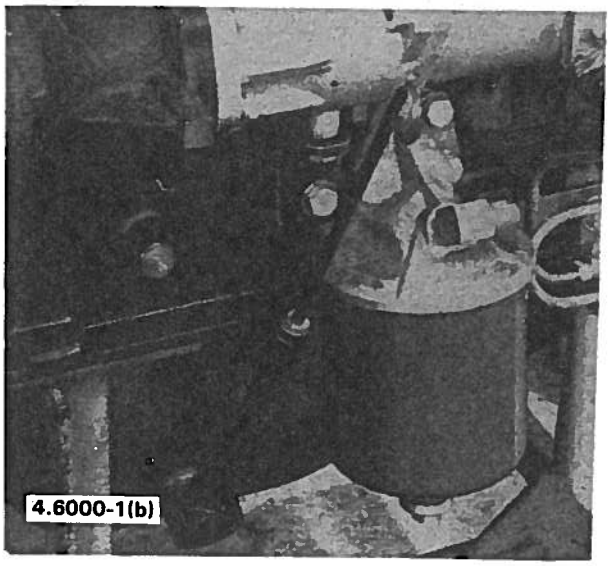
DIPSTICK

Dipstick (Description)

1. The dipstick is used to determine the quantity of oil in the engine oil pan. It is located either (a) on the side cover or (b) a dipstick tube, welded to the oil pan.

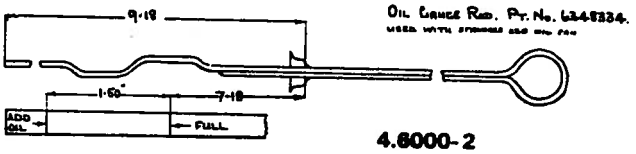


4.6000-1(a)



4.6000-1(b)

2. The dipstick has two marks scribed at the end with oil filling instructions.



4.6000-2

3. The oil should never be allowed to drop below the 'ADD OIL' mark, nor should oil be allowed above the 'FULL' mark.

4. The oil level should be checked daily with the engine stopped. If the engine has been running, ten minutes should be allowed for oil to drain into the sump before taking a reading.

Dipstick (Inspection and Overhaul)

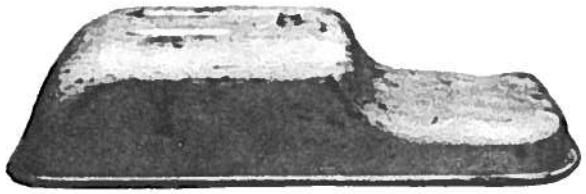
5. The dipstick requires only a visual inspection for damage, which if found, must be replaced.

4.7000

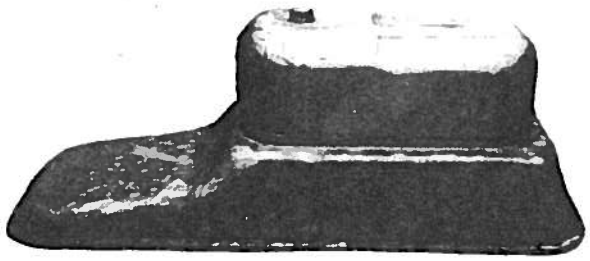
OIL PAN

Oil Pan (Description)

1. The 220 and 330 cu. in. engines may be equipped with either (a) a standard or (b) a deep sump, both of which can be treated for marine use. Dependent on the model application the oil pans may be provided with an inclination angle of 10°, 12°, 15°, 30°, or 45°.



4.7000-1(a)



4.7000-1(b)

2. Some oil pans have an oil filler and/or dipstick tube fitted.

Oil Pan (Removal)

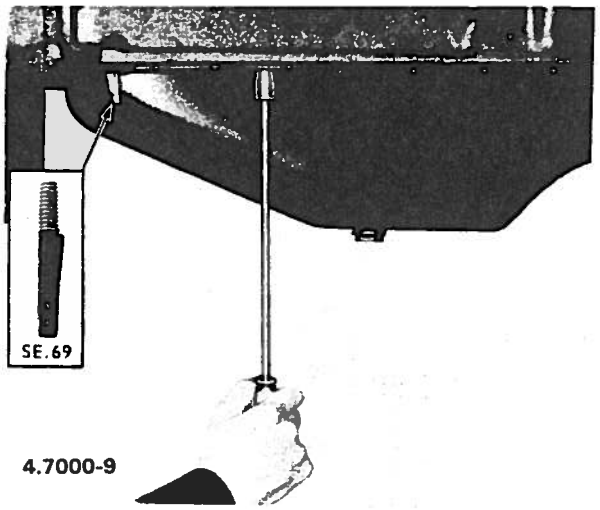
3. Place a tray beneath the sump, remove the drain plug and drain the oil.
4. Replace the drain plug.
5. Remove the securing screws, using screwdriver D1058 and lower the oil pan and gasket.

Oil Pan (Inspection and Overhaul)

6. There are no moving parts within the oil pan, therefore no wear could take place, however, a visual check for signs of damage or corrosion should be carried out.

Oil Pan (Refitting)

7. Clean any pieces of the old gasket from the cylinder block and oil pan.
8. Using a new gasket refit the oil pan. To facilitate the assembly of the oil pan, screw two retainers SE69 into the crankcase, one each side, so that the oil pan will locate accurately and prevent displacement of the gasket.
9. Tighten all screws evenly to a torque of 6-8 lbs. ft. (1 kg/m), using screwdriver D1058.



4.7000-9

10. Refill the oil pan with a recommended oil (see recommended lubricants at the end of section 1) to the full mark on the dipstick.
11. Run the engine and check for oil leaks.

4.8000

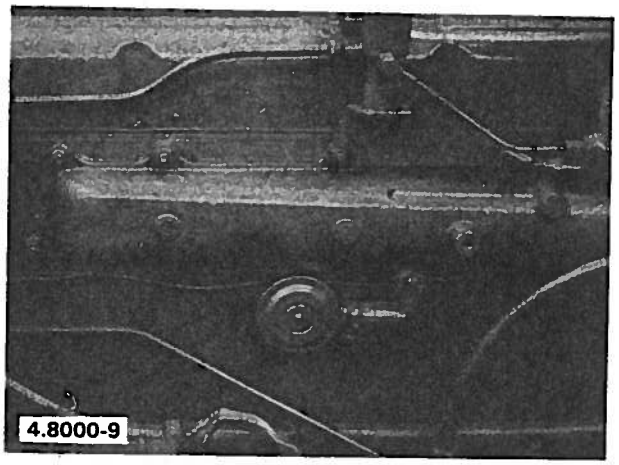
VENTILATION SYSTEM

Ventilation System (Description)

1. The ventilation system is designed to ensure that at all times when the engine is running a depression exists in the crankcase.
2. For maximum depression refer to the following table:

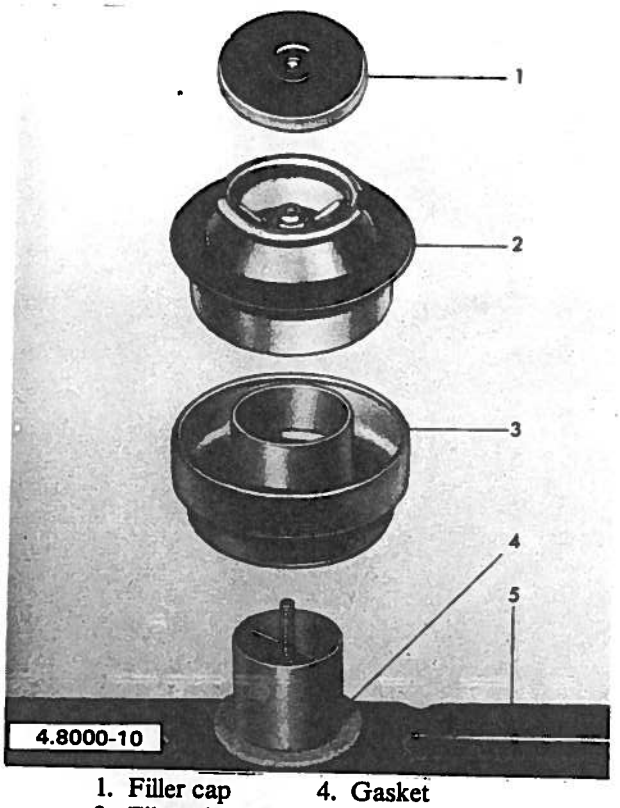
Inches of Water				
Engine	Speed of Engine (rpm)			
	1000	1500	2000	2600
220 cu.in.	0.5	0.8	1.1	1.3
330 cu. in.	0.3	0.9	1.6	3.0

3. Various ventilating systems have been used since the first engines were built. Each system has been described individually in the following paragraphs.
4. Originally on the six cylinder engines the crankcase was ventilated through a pipe connected to an outlet in the push rod cover. On the four cylinder engines the pipe was attached to a baffle chamber which communicated with the crankcase immediately above the oil pump drive gear.
5. The upper end of the pipe on both engines was connected to the air cleaner, and an oil bath type breather was mounted on the rocker cover.
6. The crankcase was ventilated by air drawn through the oil bath breather and after circulating round the crankcase, extracted through the outlet pipe by the air cleaner.
7. At engine serial numbers P & I 0148 on four cylinder engines and P & I 1229 on six cylinder engines, the combined oil filler and oil bath breather was deleted in favour of a plain filler neck with a sealing cap. This was introduced to improve the anti sludging characteristics. The filler neck was interconnected via a pipe between the push rod cover and the engine air cleaner, and had no provision for entry of cold air into the crankcase or rocker cover.
8. The current ventilation system was introduced at serial number P & I 10933 on four cylinder engines, and P & I 7571 on six cylinder engines.
9. This system consists of a vent. valve attached to the push rod cover with a rubber elbow connection to a stub pipe in the underside of the inlet manifold. This system is identical for both four and six cylinder engines.



Ventilation System (Removal)

10. On the original system the crankcase breather can be removed by first lifting away the oil filler cap and then releasing the nut securing the filter element to the rocker cover. The oil bath and element can now be withdrawn.



1. Filler cap
2. Filter element
3. Oil bath
4. Gasket
5. Rocker cover

11. On all systems unscrew the clips securing the hoses, elbows etc., and remove the pipes.
12. If a baffle chamber is fitted this can be removed by unscrewing the two retaining nuts and lifting the baffle chamber from its seating.
13. To remove the current vent valve, after withdrawing the rubber elbow, unscrew the clip and withdraw the vent valve from the push rod cover outlet.

Ventilation System (Inspection and Overhaul)

14. The crankcase breather used on early engines should be inspected for damage and then cleaned prior to reassembly as described in paragraphs 15-17 inclusive.
15. Rinse the element in paraffin/kerosene and blow out with compressed air.
16. Empty the oil bath and clean out any sediment.
17. Install the oil bath and refill to the indicated level with the recommended oil. Install the filter element, retaining nut, and oil filler cap.
18. All other components should be visually inspected for damage, especially rubber hoses.

Ventilation System (Refitting)

19. On engines with a baffle chamber apply a sealant on the inside of the connector and press the baffle chamber into position. Add the two retaining nuts and tighten to 6-8 lbs/ft (8.1-10.8 newton/metres).
20. Replace the vent valve, where fitted, onto the push rod cover outlet and tighten the clip.
21. Replace all the pipes and hoses into their respective positions and tighten all the clamps.
22. The crankcase depression should now be checked as follows:
23. Remove the dipstick.
24. Prepare a bung with a short length of tube installed so that a manometer can be connected, this assembly should be installed in the dipstick hole.
25. With the engine running a depression must always be noted within the crankcase, the maximum which should be obtained is shown in the table on page one.
26. To decrease the crankcase depression, the hole into the trunking from the stub pipe should be decreased. Should it be desired to increase the depression the diameter of the hole should be increased.

SECTION 6

EXHAUST SYSTEM

Contents

6.1000

EXHAUST MANIFOLD

EXHAUST MANIFOLD (DESCRIPTION)

1. The Bedford 220 and 330 cu in engines use either an air cooled or a water cooled exhaust manifold.
2. The air cooled exhaust manifold is a one piece casting secured by four and eight bolts or studs for 220 and 330 cu in engines respectively. A gas tight joint is ensured by the use of gaskets between the cylinder head and exhaust manifold jointing faces, although on early engines the manifold was attached direct to the cylinder head.
3. There are two types of outlet on the air cooled exhaust manifolds, one for automotive engines (a) and a vertical outlet (b) for industrial engines.

a. Automotive

b. Industrial

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4. On marine engines a water cooled exhaust manifold is used. The exhaust manifold chamber is surrounded by a casing which retains the coolant. The coolant is the raw water from the heat exchanger unit which passes from the heat exchanger through the outer cavity of the exhaust manifold and is then exhausted.

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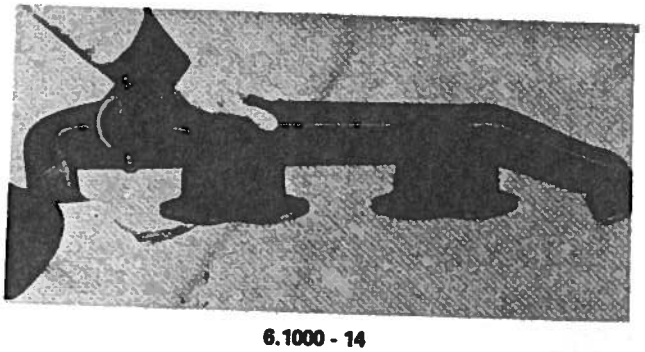
EXHAUST MANIFOLD (REMOVAL)

5. **Air Cooled.** If the engine is installed in a machine disconnect any exhaust pipe from the manifold. Remove and discard the manifold securing nuts or bolts. The manifold can now be removed from the engine.
6. **Water Cooled.** If the engine is installed in a vessel the raw water coolant must be drained before attempting any removal, this is detailed in 5.6000.
7. Disconnect the exhaust pipe from the manifold by removing the six screws from the rear end of the manifold.
8. Slacken the hose clamps and remove the exhaust water pipe from the rear of the manifold.
9. Slacken the hose clamps, which retain the supply hose, remove hose.
10. Remove the two ⅜" screws which secure the oil filter to the bracket which is fixed to the exhaust manifold. Care must be taken at this stage to remember that on early engines, the oil filter is not firmly fixed to the engine.
11. Support the manifold and remove the screws which secure it to the cylinder head, care must be taken not to damage the fuel pipes from fuel pump to injectors, on some engines the pipe clamps are fitted to the exhaust manifold fixing screws.
12. Remove manifold and manifold gasket, if fitted.

EXHAUST MANIFOLD (INSPECTION AND OVERHAUL)

13. **Air Cooled.** Examine the manifold for cracks, particularly around the attaching flanges.
14. Check for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.



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15. **Water Cooled.** Remove the loose scale and carbon that might have accumulated on the internal walls of the exhaust manifold.
16. Clean all traces of the gasket, if fitted, from the exhaust manifold, and also the cylinder head.
17. Examine the manifold for cracks, particularly around the attaching flanges.
18. Make up and fit a plate suitable for sealing the entire exhaust end of the manifold, a rubber gasket is recommended to obtain a seal between the plate and manifold. Remove the water inlet and outlet elbows from the manifold casting, make a plate and fit as above over the water outlet. The water inlet should be covered with a similar plate but with a fitting suitable for connecting an air supply. Do not cover the ports which fit adjacent to the cylinder head.
19. Immerse the exhaust manifold in a container of hot water 82°-88°C (180°-200°F) and pressurise by hand or foot pump (not a works air line) to 207 KPa (30 P.S.I.). It is essential that hot water is used

as this simulates actual operating conditions, if the manifold should have any leaks air will be observed escaping either from the ports or the exterior of the manifold.
20. Remove the manifold from the water tank, remove the fittings and blanking plates. Dry the manifold with compressed air.
21. Check the manifold for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.

EXHAUST MANIFOLD (REFITTING)

22. **Air Cooled.** Ensure that the manifold joint faces are clean and free from burrs.
23. Fit the manifold together with gaskets and secure with the retaining screws. Tighten the screws to a torque of 34 Nm (25 lb ft).
24. **Water Cooled.** Ensure that the manifold joint faces are clean and free from burrs.
25. Fit the manifold gaskets in place, this can be achieved by inserting the fixing screws and spring washers into holes in the manifold and laying the gaskets in place, located by the screws.
26. Offer the manifold to the cylinder head and secure with screws which are not injector pipe bracket attaching points.
27. Refit the injector pipe brackets taking care to refit the clamps in their original positions, this positioning is important in order to prevent the vibration of the pipes.
28. Tighten the manifold securing screws to a torque of 34 Nm (25 lb ft).
29. Refit the oil filter to its mounting bracket on front of the exhaust manifold.
30. Inspect the coolant supply hose and clips and refit, tighten hose clips.
31. Refit after inspection the exhaust water pipe and tighten clips.
32. Refit the exhaust pipe to the manifold.
33. Before starting the engine, check that the end cover has been refitted to the raw water pump, this is detailed in 5.6000. After the engine has been run, check the tightness of all fixings and that no water or exhaust leaks exist.

DESCRIPTION

The exhaust manifold is a one-piece casting incorporating flanged pipes, secured by bolts to the left-hand side of the cylinder head. The manifold is attached direct to the cylinder head making a gas tight joint without the aid of gaskets or jointing medium.

EXHAUST MANIFOLD

Removal

1. Remove the fuel injection pipes (page 22 of section 2).
2. Disconnect the front exhaust pipe from the manifold.
3. Remove the bolts and lock washers securing the manifold to the cylinder head, and lift away the manifold.

Inspection

1. Examine the manifold for cracks, particularly around the attaching flanges.
2. Check for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.

Installation

Note the following:

1. Ensure that the manifold joint faces are clean and free from burrs.
2. Tighten the manifold securing screws to a torque of 25 lbs/ft.
3. Check the manifold attaching nuts after the engine has warmed up.

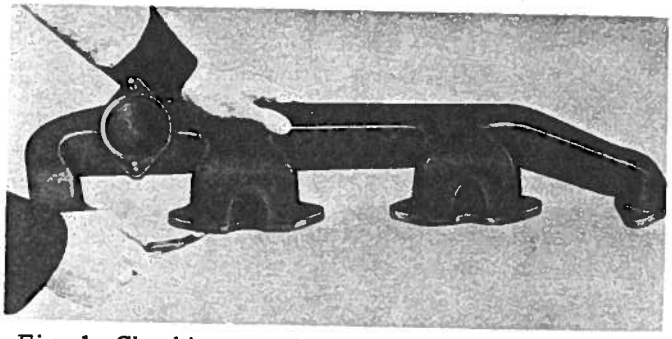


Fig. 1. Checking an exhaust manifold for distortion

EXHAUST MANIFOLD (WATER COOLED)

A water cooled exhaust manifold is fitted to engines equipped for marine use or heat exchanger cooling. The exhaust manifold chamber is surrounded by a casing which retains the coolant. The coolant is the raw water from the heat exchanger unit which passes from the heat exchanger through the outer cavity of the exhaust manifold and is then exhausted.

Remove Exhaust Manifold

1. Drain the raw water from the cooling system, the raw water pump end cover must be removed for this operation. The pump is situated at the front of the engine, on the right hand side of the engine when viewed from the rear.
2. Disconnect the exhaust pipe from the manifold by removing the six screws from the rear end of the manifold.
3. Slacken the hose clamp and remove exhaust water pipe from rear of manifold.
4. Slacken the hose clamps which retain the water supply hose and remove the hose.
5. Remove the two 3/8" screws which secure the oil filter to the bracket which is fixed to the exhaust manifold. Care must be taken at this stage to remember the oil filter is not firmly fixed to the engine.
6. Support the manifold and remove the screws which secure it to the cylinder head, care must be taken not to damage the fuel pipes from fuel pump to injectors, on some engines the pipe clamps are fitted to the exhaust manifold fixing screws.

7. Remove manifold and manifold gasket, if fitted.

Inspection

1. Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold.

2. Clean all traces of the gasket, if fitted, from the exhaust manifold, and also cylinder head.

3. Examine the manifold for cracks, particularly around the attaching flanges.

4. Make up and fit a plate suitable for sealing the entire exhaust end of the manifold, a rubber gasket is recommended to obtain a seal between the plate and manifold. Remove the water inlet and outlet elbows from the manifold castings, make a plate and fit as above, covering the water outlet. The water inlet should be covered with a plate similar to that used on the outlet, but with a fitting suitable for connecting to an air supply. Do not cover the ports which fit adjacent to the cylinder head.

5. Immerse the exhaust manifold in a container of hot water 180° - 200°F and pressurise by hand or foot pump (Not works air line) to 30 P.S.I. It is essential that hot water be used as this simulates actual operating conditions, if the manifold should have any leaks air will be observed escaping either from the ports or the exterior of manifold.

6. Remove manifold from water tank remove fittings and blanking plates, dry manifold with compressed air.

7. Check for distortion of the joint face on a surface plate. Slight distortion can be corrected with a fine cut file.

Installation

1. Ensure that the manifold joint faces are clean and free from burrs.

2. Install manifold gasket in place, this can be achieved by inserting fixing screws, and spring washers into holes in manifold and laying gasket in place, located by screws.

3. Offer manifold to cylinder head and secure with screws which are not injector pipe bracket attaching points.

4. Re-fit injector pipe brackets taking care to refit clamps in the original position, this positioning is important in order to prevent vibration of pipes.

5. Tighten manifold securing screws to a torque of 25 lb. ft.

6. Re-fit oil filter to mounting bracket on front of exhaust manifold.

7. Re-fit after inspection coolant supply hose and clips, tighten hose clips.

8. Re-fit after inspection exhaust water pipe and tighten clips.

9. Re-fit the exhaust pipe to manifold.

10. Before starting engine check that the end cover has been refitted to the raw water pump, after engine has been run check tightness of all fixings and that no water or exhaust leaks exist.

COOLING

INDEX

Have you read the General Notes on page viii ?

DESCRIPTION

The cooling system is pressurized and incorporates a radiator, fan, water pump and thermostat.

Radiator

The filler cap on all models is of the bayonet fitting pressure/vent type (Fig. 1) equipped with a vacuum valve and a pressure valve.

Water Pump

The pump (Fig. 2) is a belt driven, centrifugal type with a self-adjusting spring-loaded seal. The pump body is bolted to the cylinder block and has a rotor chamber communicating with the water passages in the block and radiator outlet pipe. A rotor, pressed on the rear end of a shaft contacts the self-adjusting seal, in the front of which a water thrower is fitted in line with vent holes in the body. The shaft is supported in two single-row bearings housed in the front end of the body. The bearings are packed with lubricant during initial assembly and periodic lubrication is unnecessary. The bearing and shaft assembly is retained by a circlip and oil seals protect the outer and inner ends of the respective bearings.

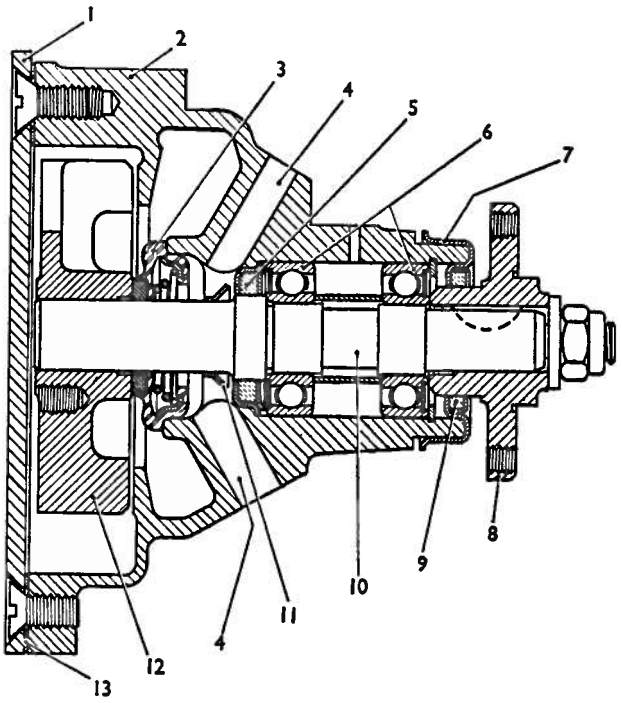


Fig. 2. Water pump - sectioned view

1. Back plate
2. Pump body
3. Seal assembly
4. Ventilation hole
5. Oil seal
6. Shaft bearings
7. Seal retainer
8. Pulley flange
9. Oil Seal
10. Pump shaft
11. Water thrower
12. Rotor
13. Gasket

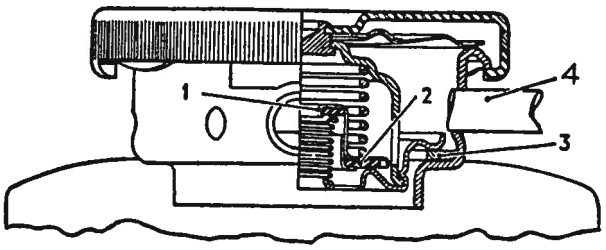


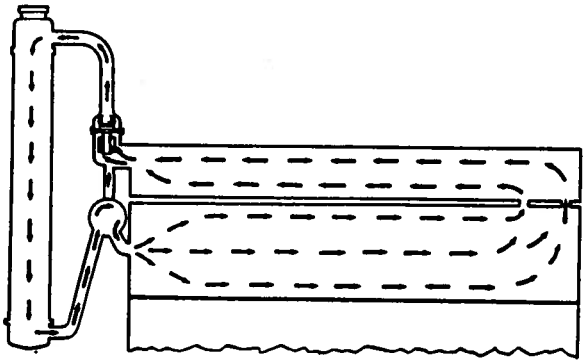
Fig. 1. Part sectioned view of radiator filler neck and cap

1. Vacuum valve
2. Pressure valve
3. Filler cap seal
4. Overflow pipe

5.0000

COOLING SYSTEM

1. The cooling system which is pressurised incorporates a water pump (5.1000), thermostat (5.2000), radiator (5.3000), fan (5.4000), fan guard (5.4100) and some engines utilise a water filter (5.7000).
2. On marine engines a raw water system is also used which includes the heat exchanger (5.5000) and raw water pump (5.6000).
3. Two systems of operation have been used. Prior to serial numbers P & I 1350 on 220 cu in engines, and P.I. 1900 on 330 cu in engines a conventional flow was used, from these points an end to end waterflow has been utilised.
4. With the conventional flow, water entered the pump rotor chamber from the radiator bottom tank, through water passages in the cylinder block and around the valve seats and injector sleeves in the cylinder head. After circulating in the head and cylinder block the water flowed from the head through the open thermostat and into the radiator top tank, where it passed down through the cooling element.



5.0000 - 4

5. The end to end water flow eliminates all waterways at the cylinder head and block gasket faces in favour of an arrangement concentrating the transfer of water through a connection at the rear of the engine. With the elimination of the waterways, the top of the cylinder block, and the lower face of the cylinder head are stronger and less liable to distortion.
6. When the engine of either cooling system is cold, circulation through the radiator is prevented by the thermostat being closed. At the same time a limited circulation in the engine prevails as water is able to flow through the by-pass connection leading to the pump. When the water temperature has risen sufficiently to open the thermostat valve, normal circulation is restored.
7. The pressurised cooling system, by raising the boiling point of water, gives additional protection against overheating for high altitude conditions, tropical temperatures and hard driving. The pressure is limited by the filler cap pressure valve which allows steam and water to escape through the overflow pipe, whenever the pressure exceeds the specified limit. Any depression within the system as the engine cools is relieved by the cap vacuum valve which admits air through the overflow pipe.

DRAINING THE COOLING SYSTEM

8. The cooling system incorporates two drain taps. One tap is located in the radiator bottom tank and the other in the side of the cylinder block.
9. To prevent the formation of an air lock it is essential to remove the radiator filler cap prior to draining the cooling system.

CORROSION PREVENTATIVE

10. To prevent corrosion of the interior of the cooling system, and consequent silting up of the radiator and cooling system, a quantity of soluble oil type corrosion preventative is added to the cooling system before leaving the factory. This forms an emulsion with the cooling water and deposits an anticorrosive film. Additions of corrosion preventative should be made at regular intervals of at least once a month or whenever the cooling system is refilled after discarding anti-freeze, to maintain the cooling system in a clean condition.

ANTI-FREEZE

11. It is most important that a 'permanent' (ethylene glycol) type of anti-freeze is used in the cooling system. The engine is designed to operate at a relatively high temperature which will cause an alcohol type of anti-freeze to evaporate rapidly.
12. The process of protecting the cooling system against frost by adding anti-freeze is well known. What is not so generally known is the degree of frost protection afforded by a specific quantity of anti-freeze.
13. When adding anti-freeze it must be appreciated that the quantity will depend upon the degree of low temperature protection required. The various degrees of protection are classified and explained under the following three headings. In addition, the specified data, at the end of the section, gives the lowest approximate temperature at which each of the various degrees of protection are provided by the different quantities of anti-freeze.

COMPLETE PROTECTION TEMPERATURE

14. This is the lowest temperature at which the entire cooling system will remain free from ice crystals so that the engine can be operated immediately from cold without risk of freezing or boiling.

SAFE LIMIT TEMPERATURE

15. This is the lowest temperature at which the coolant, containing ice crystals, will remain mushy. With this condition the engine can be safely rotated but not operated immediately from cold. To prevent any risk of boiling, the engine must be run at a fast idling speed for at least five minutes with the radiator covered before the engine is loaded.
16. When the temperature is below the 'Safe Limit' it will be necessary to raise the temperature of the coolant before the engine can be safely rotated. The method to adopt in raising the coolant temperature will depend on the facilities available, but where possible it is preferable to allow the coolant to thaw naturally.

LOWER PROTECTION LIMIT TEMPERATURE

17. This is the lowest temperature which can be withstood without serious risk of cracked castings.

PRELIMINARY OPERATIONS FOR ANTI-FREEZE

18. Before adding anti-freeze, the cooling system should be checked for cleanliness and if necessary reverse flushed.

REVERSE FLUSHING

19. The advantage of reverse flushing is that the cooling system is flushed in the direction contrary to that of the normal circulation, and any sludge or deposits which have lodged in the radiator can be forced out more readily. Similarly, by reverse flushing the cylinder block and head it is possible to remove sludge and deposits from the base of the water jackets.

20. To obtain the best results from reverse flushing, it is necessary to introduce water and compressed air into the cooling system with the aid of Flushing Gun D. 1022.

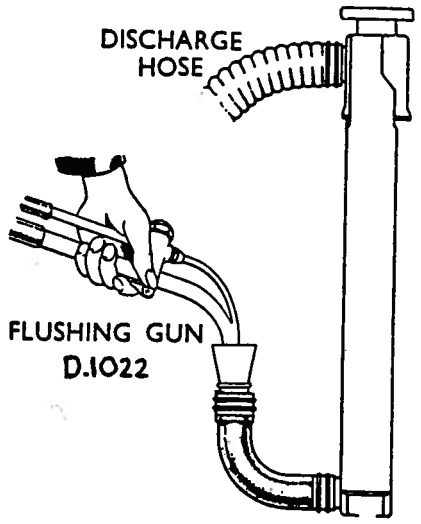
21. Drain the cooling system.

22. Disconnect the radiator top hose and connect discharge hose to the radiator inlet pipe.

23. Disconnect the bottom hose from the water pump and insert the flushing gun into the hose.

24. Connect the appropriate hoses on the flushing gun to suitable water and air supplies. Always use warm water for flushing a warm engine.

25. Turn on the water, and when the radiator is full, inject air in very short bursts. Keep the water running all the time to enable the radiator to fill between bursts of air. Flush in this manner until the water from the discharge hose runs clean.



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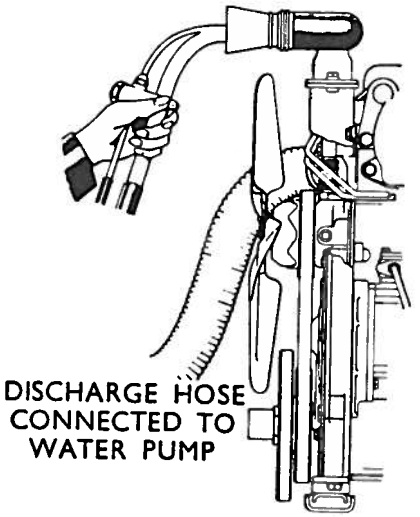
26. Inject air very carefully as there is a danger of building up excessive pressure if the radiator element is badly clogged. If it is suspected that the radiator is partially blocked with foreign matter, it should be flow tested as described on Page 00 of Section 5.3000.

27. Remove the water outlet and withdraw the thermostat. Where necessary, disconnect the heater hoses from the engine and plug the hose connections.

28. Refit the outlet and connect the hose for insertion of the flushing gun. Connect the discharge hose to the water pump inlet. Insert the flushing gun and proceed as for the radiator.



5.0000 - 28

29. After reverse flushing and before filling with anti-freeze mixture, inspect the condition of the water hoses, and check the hose connections for tightness. If a water filter is used ensure the correct element is used for anti-freeze solutions.

30. Mix the required quantity of anti-freeze with an equal quantity of clean water, pour the mixture into the cooling system and top up with water. Hard water is preferable, as corrosion is less likely to occur with hard water than with soft water. Over-filling the radiator will cause loss of anti-freeze mixture through the overflow. To avoid this wastage, only enough mixture should be added to bring the coolant level to 1 inch below the bottom of the filler neck.

NOTE. Account must be taken for cabin heater circuits when determining the quantity of anti-freeze required.

31. Upon completion, refit the thermostat. Remove the plugs and reconnect the hoses.

32. Refill the cooling system, and check for leaks.

33. A 20% solution of anti-freeze will safeguard the engine against cracking of the engine castings down

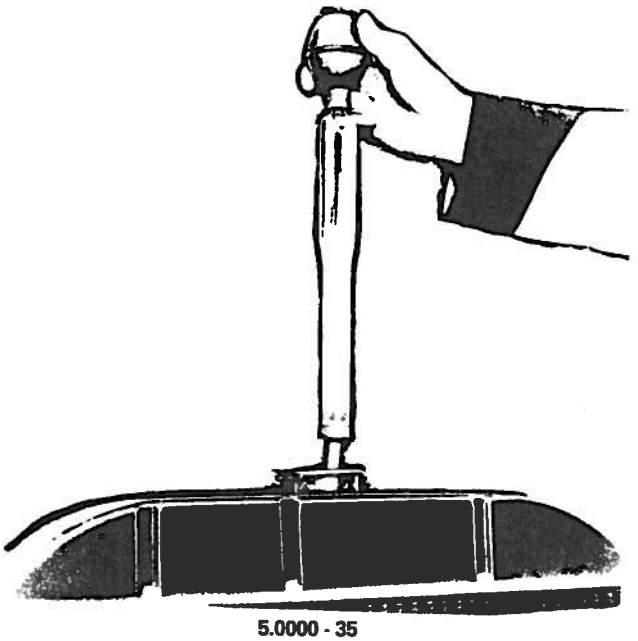
to about 35° of frost (-3°F or -22°C), but the manufacturers' recommendations should be adhered to.

34. When topping up the cooling system, it is essential that only anti-freeze solution of the correct strength should be used. The use of plain water will dilute the solution in the system and reduce the degree of protection.

35. The strength of the anti-freeze solution in the system can be established by means of an anti-freeze tester. The tester records the specific gravity of the solution on a percentage scale and also provides temperature compensation on a thermometer correction scale.

36. When warm weather returns, the anti-freeze mixture should be drained and the process of reverse flushing repeated.

37. When a raw water pump is fitted, it is advisable to drain the system when not in use as this is not protected by the anti-freeze in the engine coolant. To drain, remove the cover plate which is held by six screws, remove drain plugs from the heat exchanger and withdraw the impeller which should be stored in a dark place until required.



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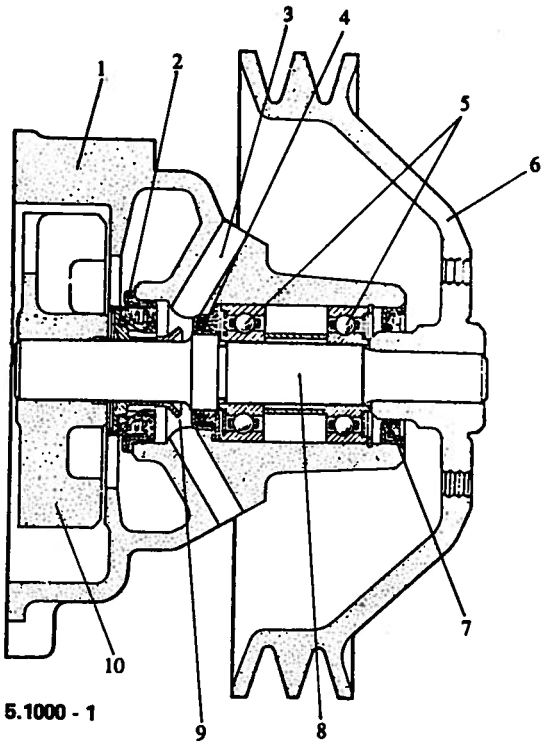
5.1000

FRESH WATER PUMP

FRESH WATER PUMP (DESCRIPTION)

1. The water pump is a belt driven centrifugal type with a self adjusting spring loaded seal.



5.1000 - 1

1. Pump Body
2. Seal Assembly
3. Ventilation Hole
4. Oil Seal
5. Shaft Bearings
6. Pulley
7. Oil Seal
8. Pump Shaft
9. Water Thrower
10. Rotor

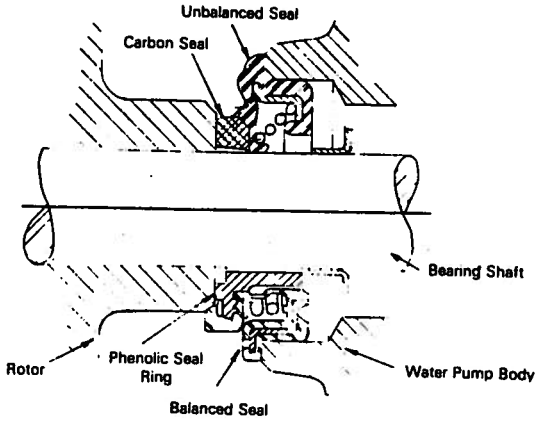
2. The pump body is bolted directly to the cylinder block and has a rotor chamber communicating with the water passages in the block and radiator outlet pipe.

3. On early engines a backplate was fitted between the cylinder block and the pump body. The deletion of this backplate had the effect of moving the pulley and fan closer to the engine and a longer spindle, together with a longer alternator mounting stud was necessary to correct the alignment of the pulley belts. This change occurred at serial number P & I 1350 on 220 cu in engines and P & I 1900 on 330 cu in engines. Care should therefore be exercised when ordering spare parts.

4. A rotor pressed onto the rear end of the shaft contacts a balanced self adjusting seal with a phenolic face in the front of which is a water thrower fitted in line with ventilation holes in the pump body.

5. On early engines an unbalanced seal, FIG 5a, with a carbon ring seal was used. The change became effective when the water system pressure was increased to 48 KPa (7 P.S.I.). With the new balanced seal, FIG 5b, the water pressure assists the retention of the seal against the rotor.

Fig. 5a



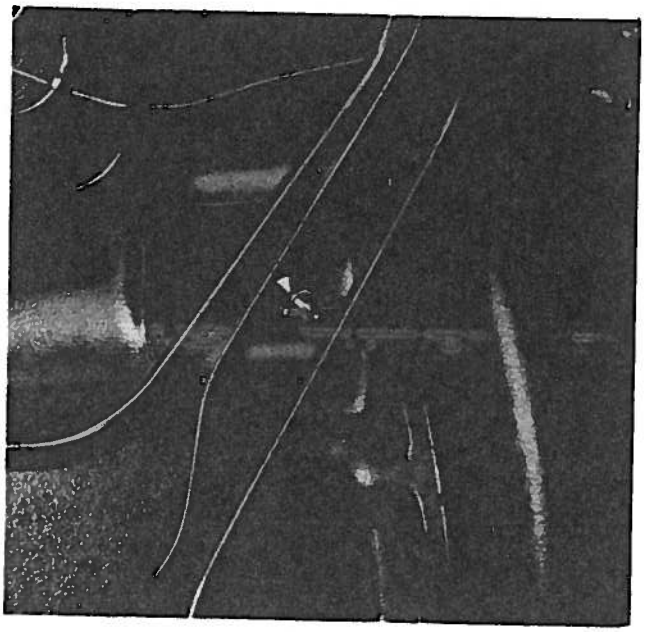
5.1000 - 5

6. The water pump shaft has had various changes to the diameter and from serial number 698239/7066 on 220 cu in engines and 706983/7024 on 330 cu in engines the spindle has been case hardened. Again care is required when ordering parts.

7. The shaft is supported in two single row bearings housed in the front end of the body. The bearings are packed with lubricant during initial assembly and periodic lubrication is unnecessary. The bearing and shaft assembly is retained by a circlip and oil seals protect the outer and inner ends of the respective bearings.

FRESH WATER PUMP (REMOVAL)

8. Drain the cooling system by first removing the radiator filler cap to prevent an air lock, and then opening the two drain taps. One located in the radiator bottom tank and the other in the side of the cylinder block.



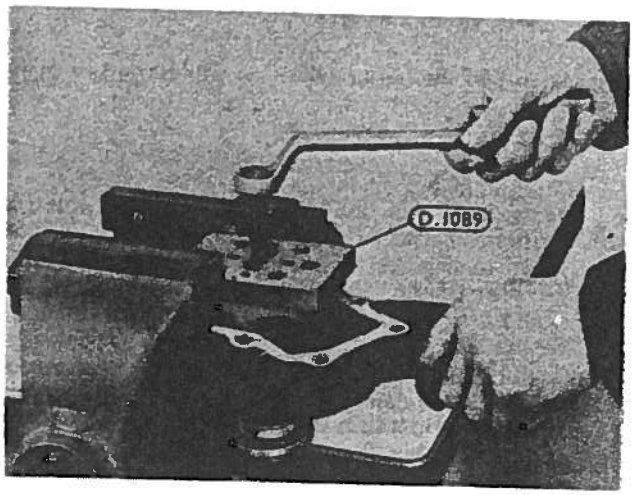
5.1000 - 8

9. Remove the radiator (5.3000), fan (5.4000) and crankshaft pulley belt (1.3320).

10. Disconnect the hose from the water pump, and slacken the clip securing the by-pass hose.
11. Remove the pump securing nuts, release the by-pass pipe from the hose and lift away the pump.

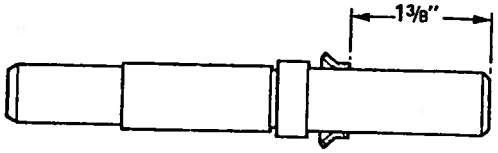
FRESH WATER PUMP (INSPECTION AND OVERHAUL)

12. Remove the pump backplate if fitted.
13. Using puller D1089, withdraw the rotor.



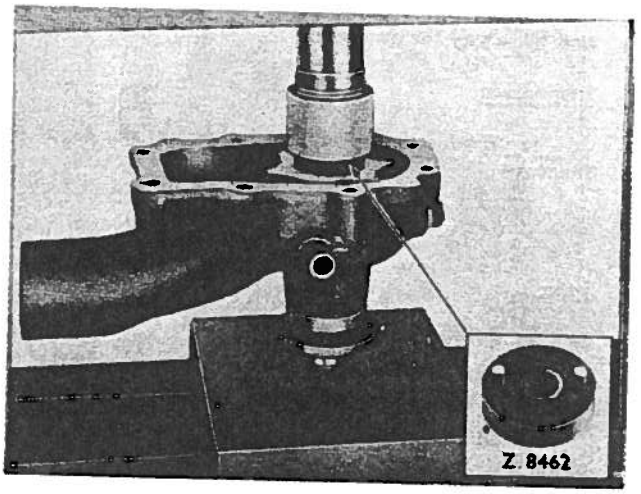
5.1000 - 13

14. Withdraw the pulley flange. On early engines the pulley flange was retained by a nut and plain washer.
15. Prise off the oil seal retainer from the front of the pump body, and remove the bearing circlip.
16. Withdraw the seal from the rotor chamber and tap the bearing and shaft assembly from the body.
17. Withdraw the bearings, distance piece and oil seal from the shaft.
18. Wash and examine the bearings and check the fit of the bearings in the body and on the shaft.
19. Check the water thrower for slackness or damage. If a new thrower is required it should be fitted 1⅜" from the shaft end as illustrated below.



5.1000 - 19

20. Examine the rotor for cracks or corrosion, particularly around the hub and impeller. Examine the seal contact face of the rotor for wear. If worn renew the rotor.
21. Discard the water pump seal assembly and the front and rear oil seals.
22. Moisten the new oil seal felts with engine oil and line up the pips on the seal cup with the location in the bore of the body.
23. Pack the bearings with the recommended grease (see recommended lubricants at rear of section 1). Install the bearings with the shielded ends away from each other and with the distance piece between the two.
24. Install the pulley flange and on earlier engines fit the retaining nut and washer.
25. Smear the seal face and the locating recess in the pump body with the recommended grease.
26. Press on the rotor, using installer Z8462. The installer ensures that the rotor is located to provide the correct clearance between the impellers and the pump body.



5.1000 - 26

27. Refit the backplate if fitted.

FRESH WATER PUMP (REFITTING)

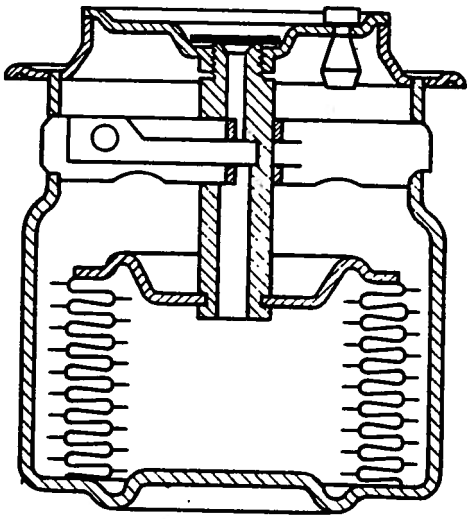
28. Ensure that the pump attaching faces are cleaned, and fit a new gasket smeared each side with jointing compound.
29. Place the pump into position and tighten the retaining nuts to a torque of 30-37 Nm (22-27 lb ft).
30. Reconnect the hoses and tighten the securing clips.
31. Refit the crankshaft pulley belt (1.3320), fan (5.4000) and radiator (5.3000).
32. Refill the cooling system and check for any water leaks.

5.2000

THERMOSTAT

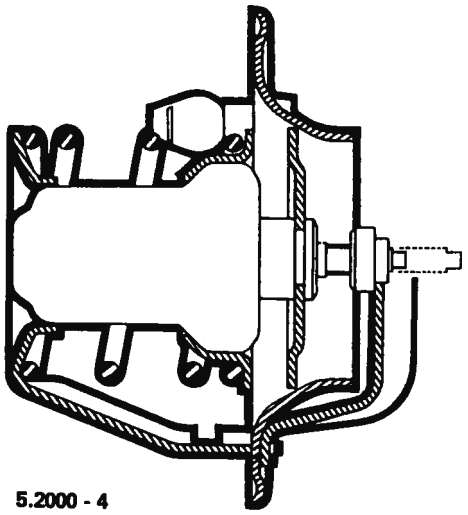
THERMOSTAT (DESCRIPTION)

1. Two types of thermostats have been used on 220 cu in and 330 cu in engines. Initially a metal-bellows type was used and then at serial numbers P & I 2538 (220 cu in) and P & I 4300 (330 cu in) a wax capsule type was introduced.
2. Both types of thermostats are valves designed to control engine temperature by regulating coolant flow to the radiator.
3. The metal bellows type is a device filled with a volatile liquid which controls a mushroom valve. When the engine is cold this valve is closed and on starting the engine the flow of water to the radiator is temporarily restricted. Due to this, the temperature of the water in the engine will quickly rise, thus ensuring rapid warming up. The heat so generated will gradually expand the bellows so opening the valve, and ultimately permitting a full flow of water to the radiator.



5.2000 - 3

4. The wax capsule type is also motivated by the temperature of the engine coolant. When the engine and coolant are cold the thermostat valve remains closed, restricting the flow of coolant until it reaches a temperature high enough to react off the sensitive wax element. When the pre-determined temperature is reached, the thermoresponsive wax capsule expands and deforms an elastomeric moulding which, in conjunction with the piston, produces an axial force. This causes the element to push away from the static piston and start to open the valve, thus allowing the coolant to flow and circulate through the radiator. If conditions are such that the coolant temperature continues to rise, the valve will open further until the fully open position is reached.



5.2000 - 4

5. Once the engine has reached normal operating temperature the thermostat continues to maintain engine temperatures at a constant level by increasing or decreasing the flow of coolant through the radiator as necessary.
6. When the valve is closed a limited circulation of coolant is allowed to prevent the differential expansion of engine parts due to the formation of local hot spots. A small bleed hole, which is sealed with a jiggle pin when the engine is running, assists in preventing the formation of air locks when filling the cooling system.
7. The thermostat is contained in a housing bolted to the cylinder head and a connection is provided for the radiator inlet hose. A by-pass, communicating with the water pump, is incorporated to relieve the thermostat valve of pressure when closed, and an electrically operated temperature gauge is installed.

THERMOSTAT (REMOVAL)

8. Drain the radiator.
9. Remove the two bolts securing the water outlet to the thermostat housing.
10. Lift the outlet clear of the housing and withdraw the thermostat.
11. If the engine is fitted with a heat exchanger, the heat exchanger will have to be removed, this is detailed in section 5.5000. The thermostat can be withdrawn immediately upon removal of the heat exchanger.

THERMOSTAT (INSPECTION & OVERHAUL)

12. To test the efficiency of the thermostat, suspend the thermostat and a thermometer in a container of warm water and heat the water. Agitate the water to ensure uniform temperature. Do not allow the

thermostat or thermometer to rest on the bottom of the container, as this will result in a false reading.
13. Check that the thermostat commences to open at 77° - 82°C (170° - 179°F) and is fully open at 93°C (199°F). The valve lift being 9.14 mm (0.36") minimum.
14. If the thermostat does not coincide with the above readings it should be discarded.

THERMOSTAT (REFITTING)

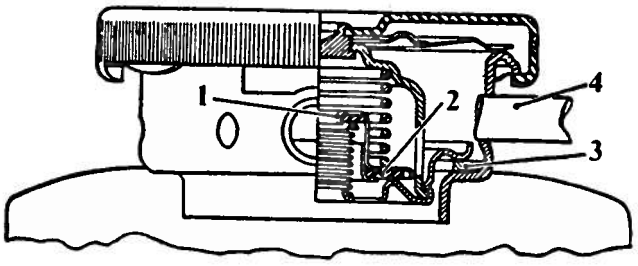
15. Place the thermostat into its housing.
16. Using a new gasket replace the water outlet and tighten the bolts evenly to a torque of 18-20 Nm (13-15 lb ft).
17. Check and refit hose to radiator.
18. Refill the cooling system as described in section 5.0000.

5.3000

RADIATOR

RADIATOR (DESCRIPTION)

1. Two types of radiator, temperature and tropical, are used on 220 and 330 cu in engines. The radiator consists of a film type cooling element with top and bottom tanks reinforced by side straps.
2. The top tank incorporates the filler neck, overflow and inlet pipes. The bottom tank provides a connection for the outlet pipe and drain tap. The radiator also carries a shroud and is mounted on two bearers supported by two side brackets.
3. The filler cap is of the bayonet fitting pressure/vent type equipped with a vacuum valve and a pressure valve.



1. Vacuum Valve
2. Pressure Valve
3. Filler Cap Seal
4. Overflow Pipe

5.3000 - 3

4. When a temperate or tropical radiator is used on normally aspirated engines, a 457 mm (18") fan must be used, which can be either pusher or puller type depending upon the application. On 330 cu in engines utilising a turbocharger a 508 mm (20") pusher fan must be used with a special distance piece and 95.25 mm (3¾") long bolts.

RADIATOR (REMOVAL)

5. To remove the radiator the cooling system must be drained. This is described in Section 5.0000.
6. The top and bottom hoses should now be disconnected from the radiator and the securing nuts and bolts removed, which will enable the radiator to be lifted from its mountings.
7. Remove the mounting insulators and ferrules.
8. If during overhaul or repairs to the engine the radiator is left empty and is allowed to dry out, any sediment or deposits will harden and cause an obstruction in the element water passages.
9. Where a radiator is temporarily out of service, reverse flush it as described in Section 5.0000, seal the inlet and outlet pipes with plugs and slowly fill the radiator with water avoiding any air locks.

RADIATOR (INSPECTION AND OVERHAUL)

10. To locate the source and to effect minor repairs of leaks in the radiator the procedure specified in paragraphs 11 to 16 must be followed.
11. Seal the radiator filler neck and the inlet and outlet pipes with plugs taking care to leave the overflow tube connection unobstructed.
12. Connect the air supply to the radiator overflow pipe, and completely submerge into a test tank of water.
13. Use a hand pump to gradually increase the air pressure in the radiator to within 48-69 KPa (7-10 P.S.I.). Do not exceed the maximum. The use of factory air lines is not encouraged because exceeding the maximum pressure will cause permanent distortion to the radiator.
14. Check carefully for rising air bubbles from the radiator and trace the source of the leakage.
15. Remove the radiator from the tank and seal the leak with solder having a tin content of 33%.
16. Repeat the pressure test.
17. For major repair to cooling elements or tanks, the tanks must be removed, repaired and installed as specified in paragraphs 18-25 inclusive.
18. Remove the overflow pipe and drain tap.
19. Remove the tanks by applying a blow flame to the strap ends soldered to the top tank, and along the seams where the tanks join the cooling elements. Where the top tank has been removed, any deposits which only occur in the top 50 mm (2") of the water channels can be removed, with a feeler strip of suitable thickness. Take care not to damage the element. Invert the radiator and flush out the deposits.
20. Place the bottom tank, open side upwards, on a fixture and position the cooling element on the tank. The tank flanges must be flush with the element.
21. Tack solder the tank to the cooling element at each corner.
22. Use a chisel-shaped gas bit to complete the soldering operation. Do not apply more solder than is necessary for a sound joint, as surplus solder may enter the tank and obstruct water passages in the element.
23. Reverse the cooling element top to bottom and place it in position on the upturned top tank.
24. Re-attach the strap assembly and overflow pipe and replace the drain tap.
25. Test the radiator for leaks as described previously.
26. If the radiator is to be placed in stock, the necessary anti-corrosion precautions must be taken, using Shell Ensus Fluid.

FILLER CAP

27. A faulty or badly sealed filler cap will allow the coolant to boil at a lower temperature than the desired engine operating temperature.
28. The boiling point of water at atmospheric pressure is 100°C (212°F), but all modern cooling systems are pressurised in order to raise the boiling point of the coolant. The boiling point is raised approximately 1.7°C (3°F) for every 6.89 KPa (1 P.S.I.) of pressurisation but this is affected by the addition of anti-freeze and other additives to the

coolant water. However, for general purposes a 48 KPa (5 P.S.I.) pressure filler cap will raise the boiling point to 112°C (223°F).

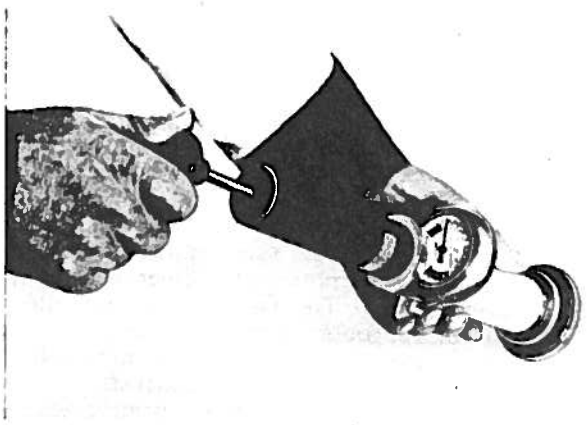
29. The best method of testing a filler cap is to use a pressure cap tester to ensure the pressure valve lifts at the correct pressure, i.e. 22-31 KPa (3.25-4.5 P.S.I.) for a 28 KPa (4 P.S.I.) cap or 43-50 KPa (6.25-7.25 P.S.I.) for a 48 KPa (7 P.S.I.) cap.

RADIATOR (REFITTING)

30. Place the radiator onto its mountings and tighten the retaining nuts.

31. Connect the top and bottom hoses and secure them with jubilee clips.

32. Refill the cooling system to one inch below the filler neck. Check for leaks from the hose connections and replace any worn or defective hoses.



5.3000 - 29

5.4000

FAN

FAN (DESCRIPTION)

1. Except for marine engines a 4 or 6 bladed fan is fitted as standard equipment on 220 cu in and 330 cu in engines.
2. Fans can be of the pusher or puller type and can be of various diameters depending on the application of the engine.
3. The fan is attached to the water pump pulley by four retaining bolts.

FAN (REMOVAL)

4. Removal of the fan is achieved by removing the four retaining bolts, and lifting the fan and spacers from the water pump pulley.

FAN (INSPECTION AND OVERHAUL)

5. If a fan blade is damaged in any way, no attempt should be made to repair or re-use the damaged part. A bent or damaged fan should always be replaced with a new assembly.
6. It is essential that fan assemblies remain in proper balance, and proper balance cannot be assured once an assembly has been bent or damaged. A fan that is not in proper balance could fail and fly apart during subsequent use, creating an extremely dangerous condition.

FAN (REFITTING)

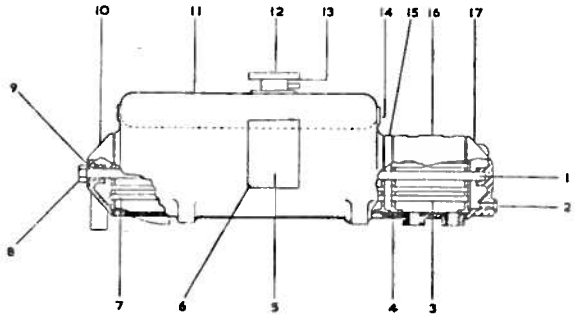
7. Replace the spacers, fan and four retaining bolts and tighten to a torque of 43-52 Nm (32-38 lb ft).

5.5000

HEAT EXCHANGER

HEAT EXCHANGER (DESCRIPTION)

1. The purpose of the heat exchanger assembly is to provide a header tank, which allows for expansion and de-aeration of the fresh water, also a means of cooling the engine cooling water and engine lubricating oil. The cooling of the water and oil is achieved by passing the raw water through a series of tubes which are surrounded by the liquid which requires cooling.
2. The unit consists of a corrosion resistant aluminium alloy casing providing the header tank and a machined compartment in which the water heat exchanger tube stack is located, also a small aluminium cylinder in which the oil cooler tube stack is located. A tube stack comprises of a series of tubes running between two end plates and a tie bar which passes between the two raw water end covers and joins the whole assembly together.



1. Tie Rod
2. Raw Water Drain Plug
3. Oil Cooler Tube Stack
4. Tube Stack Seals
5. Name Plate
6. Rivet
7. Heat Exchanger Tube Stack
8. Rod Cap Nut
9. Cap Nut Washer
10. End Cover
11. Body Heat Exchanger
12. Filler Cap
13. Filler Neck
14. Drain Plug
15. Spacing Ring
16. Oil Cooler Body
17. End Cover

5.5000 - 2

HEAT EXCHANGER (REMOVAL)

3. Drain the entire cooling system.
4. Drain the engine oil.
5. Disconnect the three water hoses:
   a. Heat exchanger to raw water pump pipe.
   b. Heat exchanger to exhaust manifold.
   c. Heat exchanger to fresh water pump.
6. Disconnect the two oil pipes from the oil cooler.
7. Remove the two screws attaching the header tank to the engine thermostat housing and the two screws attaching the two stays to the header tank.
8. Lift the heat exchanger from the engine.

HEAT EXCHANGER (OVERHAUL AND INSPECTION)

9. A thorough cleaning and inspection for leaks caused by ill fitting seals or corrosion comprise the overhaul and inspection procedure. To perform these operations it is necessary to dismantle as follows.
10. Remove the brass cap nut from the end cover, this cover can now be removed.
11. The opposite end cover complete with tie rod can now be withdrawn, care should be taken to support the oil cooler and the spacing ring after the tie rod has been removed, as this is not attached in any way to the main casing.
12. The 'O' seals can now be removed from the end of the tube stacks. This will allow the tube stacks complete to be withdrawn from their respective casings.
13. If the tube stack appears to be badly choked, it should be placed in a solution of 2.5 kg (5.5 lbs) of best brown potash to 22.75 litres (5 UK galls) of water. This will loosen all foreign matter adhering to them. The inside of the tubes which have sea water passing through them are more likely to require cleaning. If these are badly choked, they can be cleaned by pushing a length of 3 mm (⅛ inch) dia brass rod down the tube, so as to dislodge all foreign matter. The end of the brass rod should be free from sharp edges. It is IMPORTANT when doing this to push the rod through the tubes in the opposite direction to that in which the water flows. The other components should be cleaned before assembly, and as these contain no hidden surfaces no special instructions are required.
14. The general procedure for assembly is exactly the opposite to disassembly of the unit. Care should be taken to ensure that the rod cap nut is tightened to a torque of 34 Nm (25 lb ft).
15. All seals should be replaced and care should be taken to ensure that sealing surfaces are clean and free from burrs.
16. The heat exchanger water circuits should be pressure tested at 207 KPa (30 P.S.I.) after major overhauls and the oil cooler tested at 689 KPa (100 P.S.I.). The procedure to follow is detailed below.
17. The fresh water outlet should be plugged and a similar plug with an adaption for connecting an air supply should be fitted to the fresh water inlet.
18. Immerse the unit in hot water 82°-93°C (180°-200°F) and pressurise to 207 KPa (30 P.S.I.). If the heat exchanger is porous, air bubbles will be observed. Great care should be taken when releasing the air pressure.
19. Similar adaptors should be fabricated and the oil cooler tested in the same manner as paragraph 18, but the pressure to be 689 KPa (100 P.S.I.)

HEAT EXCHANGER (REFITTING)

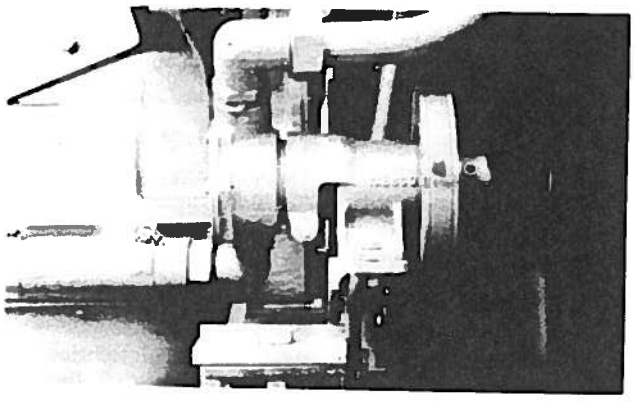
20. Using new thermostat gasket, refit the heat exchanger. Secure the four retaining screws to a torque of 18-20 Nm (13-15 lb ft).
21. Refit the water hoses and oil pipes.
22. Refill the cooling systems and lubricating system.

5.6000

RAW WATER PUMP

RAW WATER PUMP (DESCRIPTION)

1. The raw water used for lowering the temperature of the engine is circulated through the heat exchanger by a positive displacement pump.



5.6000 - 1

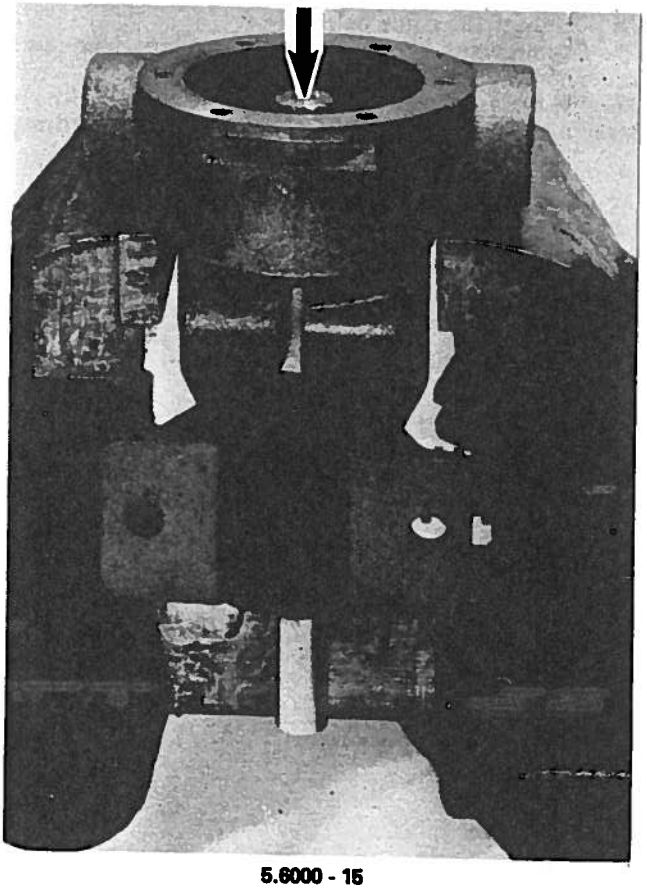
2. The pump drive shaft is supported by pre-lubricated bearings with a seal at each end to prevent leakage of lubricant and a seal to prevent water leakage along the shaft.
3. An impeller splined to the end of the drive shaft is self lubricated by the water being pumped through and SHOULD NOT BE RUN DRY longer than normally required for the pump to prime itself.
4. A wear plate in the impeller compartment prevents pump housing wear. This plate may be reversed if wear on the impeller side becomes excessive.
5. The pump can be operated in a clockwise or anticlockwise direction. Raw water is drawn into the pump through the inlet opening and discharged through the outlet opening, both openings being located on the top of the pump housing, details of the direction of flow and direction of rotation being given on the pump end cover plate.
6. The pump is driven by a belt which connects the pump to a pulley on the nose of the crankshaft.
7. The pump is not fitted with a drain tap and in freezing conditions the pump must be drained by loosening the end cover and allowing to drain out, retighten the cover before attempting to use the pump.

RAW WATER PUMP (REMOVAL)

8. Drain the raw water system.
9. Disconnect the two hoses between the pump and oil cooler pipe and pump to heat exchanger.
10. Remove the two screws which secure the pump to the mounting brackets, remove the belt from the pump drive pulley and remove the pump from the engine.

RAW WATER PUMP (INSPECTION AND OVERHAUL)

11. No special tools are required for the overhaul of the raw water pump, proceed in the following manner:-
12. Remove the six screws which retain the end cover and gasket, discard the gasket.
13. Withdraw the impeller from the housing by grasping a blade on each side of the impeller with pliers and pulling the impeller off the shaft, care must be taken not to damage the impeller.
14. Remove the cam locking screw and remove the cam. The wear plate which is located with a pin and retained by the cam can now be withdrawn. Place the pump in a position such that the shaft is vertical and remove the circlip which retains the seal.
15. Place the pump in a vice supporting the water outlets, remove the pinch bolt which clamps the pump housing to the bearing housing. Tap the shaft lightly in a downward direction, this will separate the two castings of the assembly and also remove the shaft from the seals in the pump.



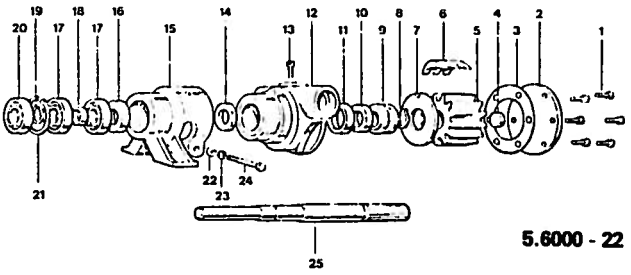
5.6000 - 15

16. Remove the remaining seals from the pump housing and the slinger from the shaft.
17. Turn the bearing housing so that the drive pulley is upwards and replace in the vice, remove the driving pulley, the seal may now be prised from the housing and discarded.

18. Remove the large circlip which retains the bearings in the housing.
19. Turn the bearing housing such that the splined end of the drive shaft is uppermost and replace in the vice, the shaft may now be tapped downwards removing the shaft and bearings from the housing.
20. The circlip which retains the bearings on the shaft can now be removed and the bearings and spacer withdrawn with a puller.
21. The remaining seal in the housing can now be removed by tapping from the housing, in the direction away from the pump, and the seal discarded.
22. The pump should be reassembled using new parts where necessary by following the preceding instructions in reverse, it should be noted that a non-hardening sealant must be applied to the cam retaining screw. The exploded view of the water pump can be used as a guide when reassembling.

RAW WATER PUMP (REFITTING)

23. Fit the raw water pump to the mounting bracket, do not tighten the screws at this stage.
24. Connect the drive belt.
25. Connect the two hoses to the pump inlet and outlet pipes and secure with the clips.
26. Check the alignment of the pulleys with a straight edge across the faces of the pulleys, adjust if necessary, this will prevent excessive wear on the drive belt.
27. Adjust the drive belt to give a deflection of 0.3 mm (1/64") per 25 mm (1") of span with a load of 0.9-1.2 kg (2-2¾ lbs) and tighten the pump securing screws to 30-36 Nm (22-27 lb ft.)



5.6000 - 22

1. Screw, Cover Retaining
2. Pump, End Cover
3. Gasket, End Cover
4. Spline Seal
5. Impeller
6. Cam
7. Wearplate
8. Retaining Ring
9. Seal
10. Seal Seat
11. Seat Cup-Rubber
12. Body, Water Pump
13. Cam Screw
14. Slinger
15. Bearing Housing
16. Seal
17. Bearings
18. Spacer
19. Retaining Ring-Bearing
20. Seal
21. Retaining Ring-Bearing
22. Nut
23. Washer - Spring Lock
24. Bolt, Hexagon Head
25. Shaft

5.0000

COOLING SYSTEM SPECIFICATIONS

CAPACITIES

	220 cu in	330 cu in
Cylinder Block	8 Litres (14 IMP PTS)	10 Litres (18 IMP PTS)
Standard Radiator	7 Litres (12 IMP PTS)	7 Litres (12 IMP PTS)
Tropical Radiator	7 Litres (12 IMP PTS)	11 Litres (20 IMP PTS)
Total System Capacity = Cylinder Block + Radiator		
Marine Engine Complete With Heat Exchanger	11 Litres (19 IMP PTS)	13 Litres (23 IMP PTS)

ANTI-FREEZE

Type ..... Ethylene Glycol

The following table gives the % of ethylene glycol anti-freeze required for protecting the cooling system within the temperature quoted.

TOTAL CAPACITY	COMPLETE PROTECTION				SAFE LIMIT		LOWER PROTECTION LIMIT	
	-8°C (17°F)	-15°C (5°F)	-23°C (-10°F)	-34°C (-29°F)	-14°C (7°F)	-24°C (-12°F)	-21°C (-5°F)	-40°C (-38°F)
11 Litres (19 IMP PTS)	3.5	5.5	7.5	9.5	5.5	8.0	6.5	10.0
13 Litres (23 IMP PTS)	4.0	6.5	9.0	11.5	6.5	9.5	8.0	12.0
15 Litres (26 IMP PTS)	4.5	7.5	10.5	13.0	7.5	10.5	9.0	13.5
17 Litres (30 IMP PTS)	5.5	8.5	12.0	15.0	9.0	12.0	10.5	15.5
21 Litres (38 IMP PTS)	6.5	11.0	15.0	19.0	11.0	15.5	14.5	19.5

WATER PUMP

Housing Bore Dia	34.986 to 35.001 mm (1.3774 to 1.3780 ins)
Bearing Dia	34.9885 to 35.001 mm (1.3775 to 1.3780 ins)
Bearing Fit in Body	.0127 mm Clearance to .01524 mm Interference (.0005 in Clearance to .0006 in Interference)
Shaft Dia.	15.9055 to 15.9182 mm (.6262 to .6267 ins)
Rotor Bore Dia.	15.8420 to 15.8674 mm (.6237 to .6247 ins)
Rotor Fit on Shaft	.0381 to .0762 mm (.0015 to .0030 in) Interference
Rotor Hub Thickness	21.59 to 21.72 mm (.850 to .855 ins)
Pulley Flange Bore Dia.	13.8252 to 13.8506 mm (.5443 to .5453 ins)
Shaft Dia.	13.8278 to 13.8405 mm (.5444 to .5449 ins)
Pulley Flange Fit on Shaft	.0229 mm (.0009 in) Clearance to .0152 mm (.0006 in) Interference

THERMOSTAT

Type	Metal Bellows or Wax Capsule
Opening Temperature	77°-82°C (170°-179°F)
Fully Open Temperature	93°C (199°F)
Valve Lift	9.14 mm (0.36 in) Minimum

RADIATOR

Radiator Leak Test Pressure	48-69 KPa (7-10 lb/sq in)

RADIATOR FILLER CAP

Opening Pressure 28 KPa (4 p.s.i.) Cap	22 to 31 KPa (3.25 to 4.5 lbs/sq in)
Opening Pressure 48 KPa (7 p.s.i.) Cap	43 to 50 KPa (6.25 to 7.25 lbs/sq in)

HEAT EXCHANGER

Water Circuit - Pressure Test	207 KPa (30 lbs/sq in)
Oil Cooler - Pressure Test	689 KPa (100 lbs/sq in)

RAW WATER PUMP

Drive Belt Adjustment	0.3 mm (1/64") per 25 mm (1") With Load of 0.9-1.2 Kg (2-2¼ lbs)

TORQUE SPECIFICATIONS

Water Pump Retaining Nuts	30-37 Nm (22-27 lb ft)
Thermostat Water Outlet Bolts	18-20 Nm (13-15 lb ft)
Fan Retaining Bolts	43-52 Nm (32-38 lb ft)
Heat Exchanger Retaining Screws	18-20 Nm (13-15 lb ft)
Raw Water Pump Retaining Screws	30-36 Nm (22-27 lb ft)

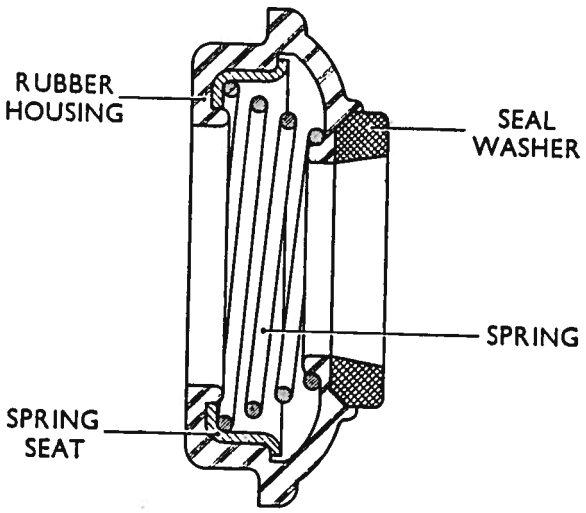


Fig. 3. Seal assembly - sectioned view

Thermostat

A metal-bellows type thermostat (Fig. 4) is used to control the coolant temperature. A valve, operated by movement of the bellows, has a small seepage hole to prevent air lock when filling the system. The thermostat is contained in a housing bolted to the cylinder head and a connection is provided for the radiator inlet hose. A by-pass, communicating with the water pump, is incorporated to relieve the thermostat valve of pressure when closed, and an electrically operated temperature gauge is installed.

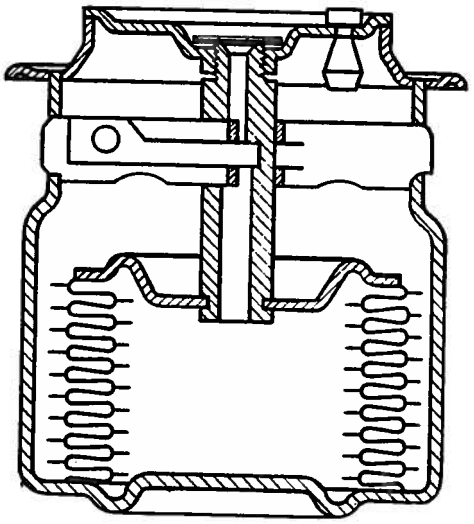


Fig. 4. Thermostat assembly - sectioned view

OPERATION

Water which has entered the pump rotor chamber from the radiator bottom tank is discharged through the water passages in the cylinder block and around the valve seats and injector sleeves in the cylinder head. After circulating in the head and cylinder block the water flows from the head through the open thermostat and into the radiator top tank, where it passes down through the cooling element.

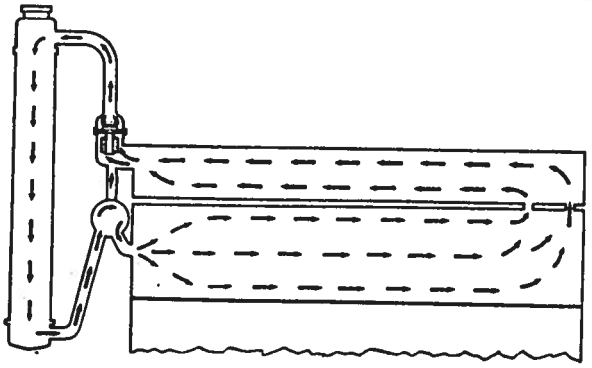


Fig. 5. Cooling water circulation diagram

When the engine is cold, circulation through the radiator is prevented by the thermostat being closed. At the same time a limited circulation in the engine prevails as water is able to flow through the by-pass connection leading to the pump. When the water temperature rise is sufficient to open the thermostat valve, normal circulation is restored.

The pressurized cooling system, by raising the boiling point of the water, gives additional protection against overheating for high altitude conditions, tropical temperatures and hard driving. The pressure is limited by the filler cap pressure valve which allows steam and water to escape through the overflow pipe, whenever the pressure exceeds the specified limit. Any depression within the system as the engine cools, is relieved by the cap vacuum valve which admits air through the overflow pipe.

COOLING SYSTEM MAINTENANCE

Draining the Cooling System

The cooling system incorporates two drain taps. One tap is located in the radiator bottom tank and one in the side of the cylinder block. The tap in the radiator does not drain the cylinder block.

To prevent the formation of an air lock it is essential that the radiator filler cap is removed prior to draining the cooling system.

Corrosion Preventative

To prevent corrosion of the interior of the cooling system, and consequent silting up of the radiator cooling element, a quantity of soluble oil type corrosion preventative is added to the cooling system before the vehicle leaves the factory. This forms an emulsion with the cooling water and deposits an anti-corrosive film. Additions of corrosion preventative should be made at regular intervals of at least once a month or whenever the cooling system is refilled after discarding anti-freeze, to maintain the cooling system in a clean condition.

Anti-Freeze

It is most important that a 'permanent' (ethylene glycol) type of anti-freeze is used in the cooling system. The engine is designed to operate at a relatively high temperature which will cause an alcohol type of anti-freeze to evaporate rapidly.

The process of protecting the cooling system against frost by adding anti-freeze is well known. What is not so generally known is the degree of frost protection afforded by a specific quantity of anti-freeze.

When adding anti-freeze it must be appreciated that the quantity will depend upon the degree of low temperature protection required. The various degrees of protection are classified and explained under the following three headings. In addition, the specified data gives the lowest approximate temperature at which each of the various degrees of protection are provided by the different quantities of anti-freeze.

Complete Protection Temperature

This is the lowest temperature at which the entire cooling system will remain free from ice crystals so that the engine can be operated immediately from cold without risk of freezing or boiling.

Safe Limit Temperature

This is the lowest temperature at which the coolant, containing ice crystals, will remain mushy. With this condition the engine can be safely rotated but not operated immediately from cold. To prevent any risk of boiling, the engine must be run at a fast idling speed for at least five minutes with the radiator covered before the engine is loaded.

When the temperature is below the 'Safe limit' it will be necessary to raise the temperature of the coolant before the engine can be safely rotated. The method to adopt in raising the coolant temperature will depend on the facilities available, but where possible it is preferable to allow the coolant to thaw naturally.

Lower Protection Limit Temperature

This is the lowest temperature which can be withstood without serious risk of cracked castings.

Preliminary Operations for Anti-Freeze

Before adding anti-freeze, the cooling system should be checked for cleanliness and if necessary reverse flushed (page 5)

Remember to use warm water for flushing or filling the cooling system of a warm engine.

After reverse flushing and before filling with anti-freeze mixture, inspect the condition of the water hoses, and check the hose connections for tightness.

Adding the Anti-Freeze

Mix the required quantity of anti-freeze (page 13) with an equal quantity of clean warm water, pour the mixture into the cooling system and top up with water. Hard water is preferable, as corrosion is less likely to occur with hard water than with soft water. Overfilling the radiator will cause loss of anti-freeze mixture through the overflow. To avoid this wastage, only enough mixture should be added to bring the coolant level to 1 in. below the bottom of the filler neck.

NOTE: When using anti-freeze with a corrosion preventative observe the 'Important Note' under the heading 'Corrosion Preventative'.

To prevent dilution and so maintain frost protection in service, it is important that only anti-freeze mixture of the correct strength is used when topping up.

The strength of the anti-freeze solution in the cooling system can be established by means of an anti-freeze tester. The tester (Fig. 5a) records the specific gravity of the solution on a percentage scale and also provides temperature compensation on a

thermometer correction scale.

When warm weather returns, the anti-freeze mixture should be drained and the process of reverse flushing repeated.

Reverse Flushing

The advantage of reverse flushing is that the cooling system is flushed in the direction contrary to that of the normal circulation, and any sludge or deposits which have lodged in the radiator can be forced out more readily. Similarly, by reverse flushing the cylinder block and head it is possible to remove sludge and deposits from the base of the water jackets.

To obtain the best results from reverse flushing, it is necessary to introduce water and compressed air into the cooling system with the aid of Flushing Gun D.1022 as shown in Fig.6.

NOTE: Always use warm water for flushing a warm engine.

1. Drain the cooling system.

2. Disconnect the radiator top hose and connect a discharge hose to the radiator inlet pipe.

3. Disconnect the bottom hose from the water pump and insert the flushing gun into the hose.

4. Connect the appropriate hoses on the flushing gun to suitable water and air supplies.

5. Turn on the water, and when the radiator is full, inject air in very short bursts. Keep the water running all the time to enable the radiator to fill between bursts of air. Flush in this manner until the water from the discharge hose runs clean.

Fig.5a Using an Anti-Freeze Tester to check the strength of the anti-freeze solution

Inject air very carefully as there is a danger of building up excessive pressure if the radiator element is badly clogged. If it is suspected that the radiator is partially blocked with foreign matter, it should be flow tested (page 9).

6. Remove the water outlet and withdraw the thermostat. Where necessary, disconnect the heater hoses from the engine and plug the hose connections.

7. Refit the outlet and connect the hose for insertion of the flushing gun. Connect the discharge hose to the water pump inlet. Insert the flushing gun and proceed as for the radiator.

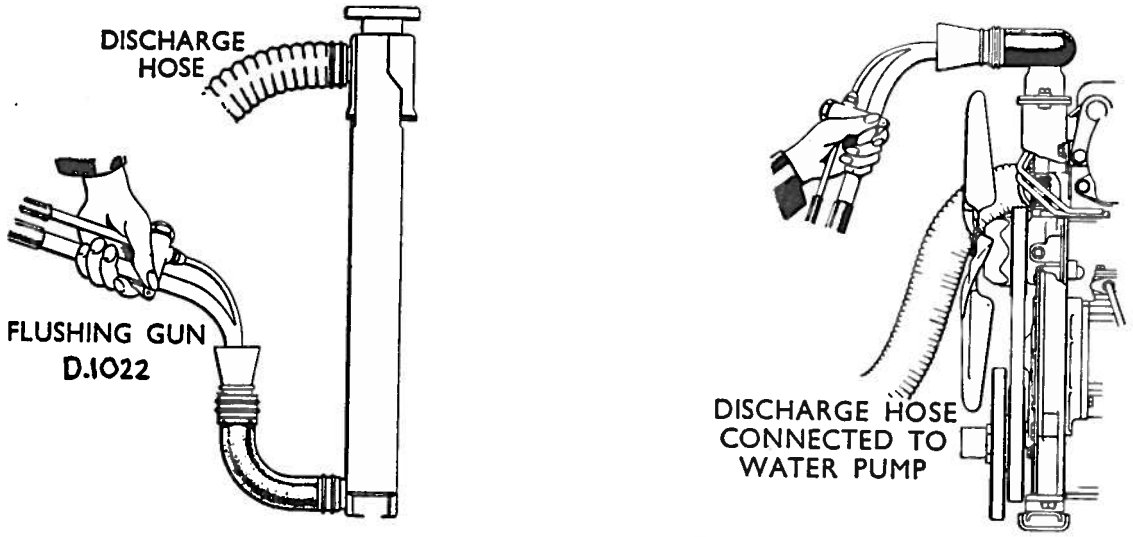


Fig.6.Diagrammatic sketches showing connections for reverse flushing the radiator, cylinder block and head

8. Upon completion, refit the thermostat. Remove the plugs and reconnect the hoses.

9. Refill the cooling system, and check for leaks.

RADIATOR FILLER CAP

Pressure Test

When investigating cooling system complaints or reconditioning a radiator, a test must be made to ensure that the pressurized cooling system is operating within the specified pressure limits.

This test involves a check on the operation of the filler cap valves, and a pressure check on the seating face in the filler neck. Fig. 7 shows these checks being made with a pressure cap tester.

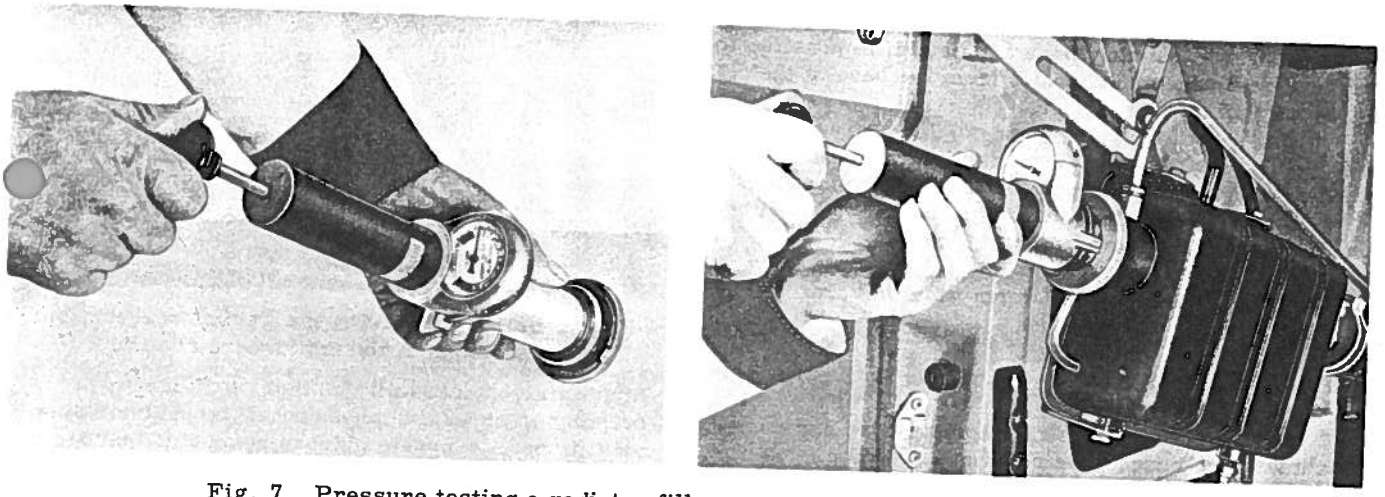


Fig. 7. Pressure testing a radiator filler cap and the seating in the filler neck

FAN BELT

Adjustment

1. Slacken the generator attaching bolts and the bolt securing the slotted brace to the generator.

2. Pivot the generator away from the engine to tighten the belt, or towards the engine if the belt is too tight. The fan belt tension can be checked by depressing the belt $\frac{1}{2}$ inch, midway between fan and generator pulleys with a load of 8-10 lb, when correct, tighten the generator bolts, including the bolt which secures the slotted brace to the engine.

NOTE: The adjustment requires care. A belt adjusted too tight will overload the water pump and generator bearings. A slack belt will slip and wear, and cause the engine to overheat.

Removal

1. Slacken the generator attaching bolts, and the bolt securing the slotted brace to the generator. Pivot the generator towards the engine as far as possible.

2. Rotate the engine with the starting handle and slip the belt over the edge of the generator pulley. Do not rotate the engine by pulling on the fan blades, as this is liable to cause subsequent fracture of the blades.

3. Remove the fan belt from the crankshaft pulley and withdraw the belt.

Installation

Note the following:

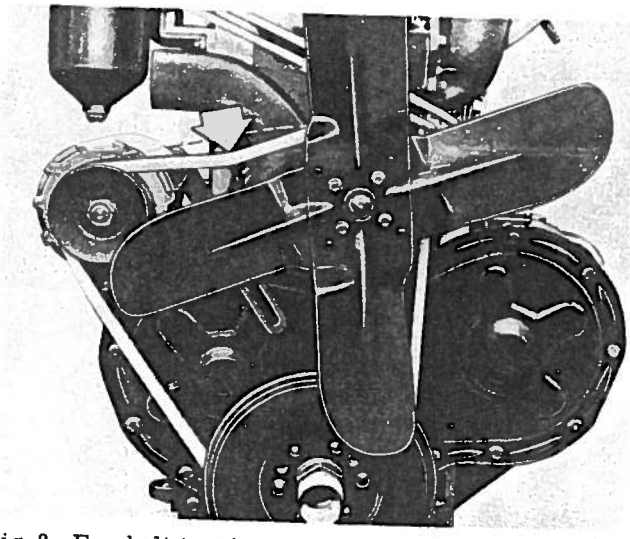


Fig. 8. Fan belt tension check point (see tension data on page 10)

1. Check that the pulleys are clean before fitting the belt.

2. Adjust the fan belt tension.

NOTE: A new fan belt should be rechecked for tension after 1,000 miles or 50 hours service.

FAN

Removal

1. Slacken the generator attaching bolts, also the bolt securing the slotted brace to the generator. Pivot the generator towards the engine as far as possible.

2. Remove the bolts and lockwashers securing the fan and water pump pulley to the pump flange, and lift away the fan.

Inspection

1. Examine the fan for distortion and signs of fracture.

2. Check for slack rivets. Slight slackness may be corrected with a suitable rivet snap and dolly.

Installation

Note the following:

Adjust the fan belt tension as detailed on previous page.

THERMOSTAT

Removal

1. Drain the radiator.

2. Remove the two bolts securing the water outlet to the thermostat housing.

3. Lift the outlet clear of the housing and withdraw the thermostat.

Inspection

1. Suspend the thermostat and a thermometer in a container of water and heat the water. Agitate the water to ensure uniform temperature. Do not allow the thermometer or thermostat to rest on the bottom of the container, as this will result in a false reading.

2. Check that when the standard thermostat is fitted the valve commences to open at 170° to 179°F (77° to 82°C) and is fully open at 199°F (93°C) The valve left being 23/64 inches minimum. When the optional thermostat is fitted the valve commences to open at 156° to, 168°F (69° to 76°C) and is fully open at 185°F (85°C). The valve left being 15/64 inches minimum.

Installation

Note the following:

Renew the water outlet gasket and tighten the bolts evenly.

WATER PUMP

Removal

1. Drain the cooling system (page 4).

2. Remove radiator. (Depending on installation).

3. Remove the fan and pulley.

4. Disconnect the hose from the water pump, and slacken the clip securing the by-pass hose.

5. Remove the pump securing bolts, release the by-pass pipe from the hose and lift away the pump.

Disassembly

1. Remove the pump back plate and gasket.

2. Using Puller D.1089, withdraw the rotor (Fig.9).

3. Remove the nut and plain washer securing the pulley flange. Withdraw the flange and remove the key from the shaft.

4. Prise off the oil seal retainer from the front of the pump body, and remove the bearing circlip.

5. Withdraw the seal from the rotor chamber, and tap the shaft and bearing assembly from the body.

6. Withdraw the bearings, distance piece and oil seal from the shaft.

Inspection

1. Wash and examine the bearings as described on page . Check the fit of the bearings in the body and on the shaft.

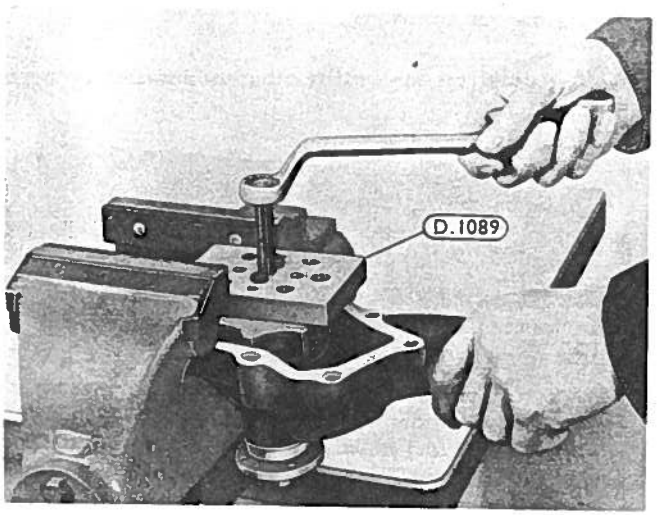


Fig.9. Withdrawing the rotor

2. Check the water thrower for slackness or damage. If a new thrower is required, it should be installed as shown in Fig.10.

3. Examine the rotor for cracks or corrosion, particularly around the hub and impellers. Examine the seal contact face of the rotor for wear. If worn, renew the rotor.

4. Renew the water seal.

Reassembly

Note the following:

1. Moisten the new oil seal felts with engine oil, and line up the pips on the seal cup with the location in the bore of the body.

2. Pack the bearings with the recommended grease. Install the bearings so that the shielded sides are away from each other.

3. Install the pulley flange as shown in Fig.2.

4. Smear the seal face and the locating recess in the pump body with the recommended grease.

5. Press on the rotor, using Installer Z.8462 (Fig.11). The installer ensures that the rotor is located to provide the correct clearance between the impellers and the pump body.

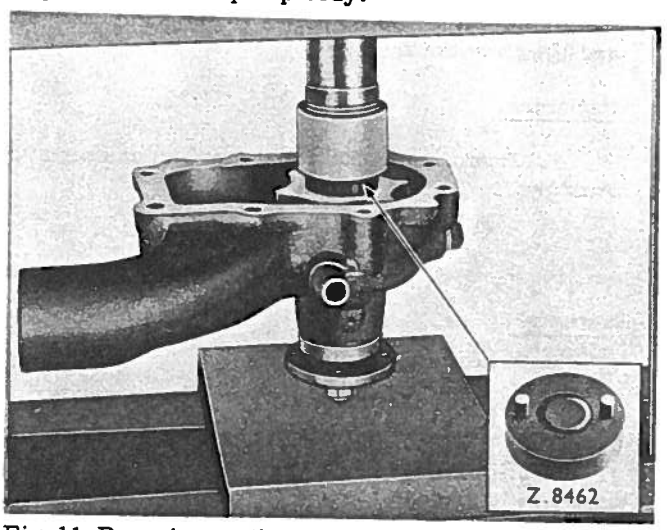


Fig.11. Pressing on the pump rotor, using the installer shown inset. The installer pegs engage the rotor.

Installation

Note the following:

1. Ensure that the pump attaching faces are clean, and fit a new gasket smeared each side with jointing compound.

2. Adjust the fan belt tension (page 6).

3. After refilling the cooling system, check for water leaks.

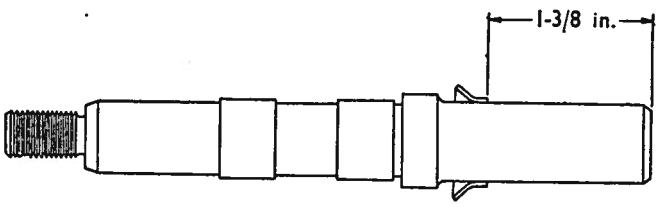


Fig.10. Location of water thrower on pump shaft

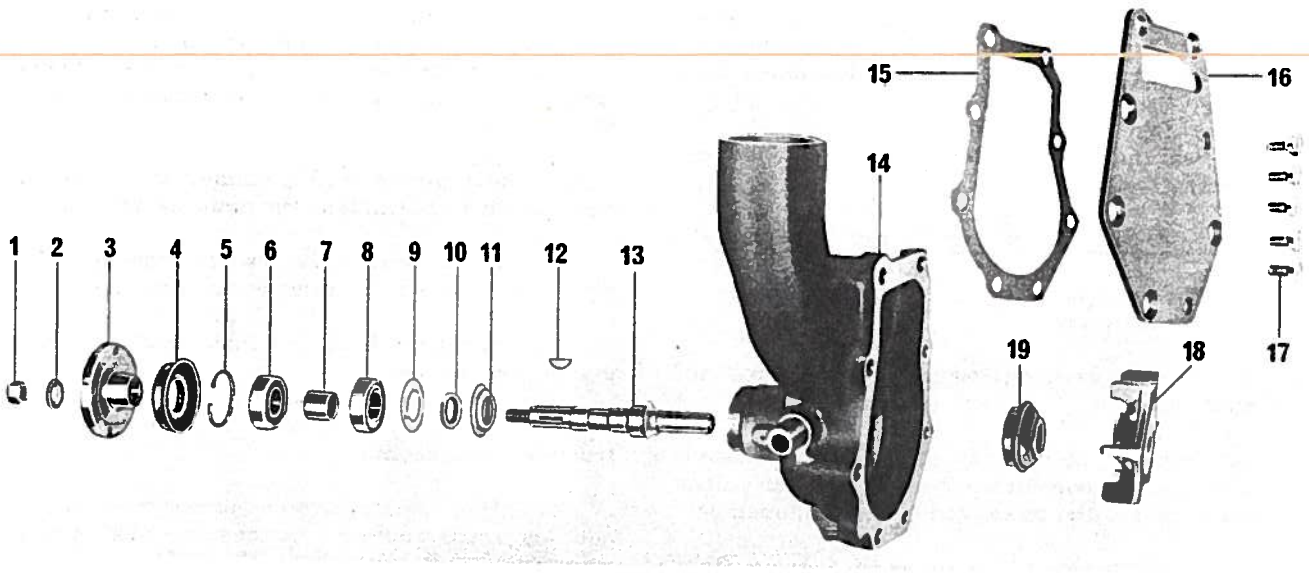


Fig.12. Water pump - exploded view

1. Self-locking nut
2. Plain washer
3. Pulley flange
4. Front oil seal and retainer
5. Circlip
6. Front bearing
7. Distance piece
8. Rear bearing
9. Oil seal retainer
10. Oil seal felt
11. Oil seal cup
12. Pulley flange key
13. Pump shaft
14. Pump body
15. Gasket
16. Back plate
17. Back plate screws
18. Pump rotor
19. Seal assembly

RADIATOR

NOTE: If during engine or vehicle repair the radiator is left empty and allowed to dry out, any sediment or deposits will harden and cause obstruction in the element water passages. Where a radiator is temporarily out of service, seal the inlet and outlet pipes with suitable plugs and fill the radiator with water.

Flow Test

The efficiency of the radiator can be checked by measuring the rate at which water, fed at a constant head of two feet, flows through it (see under 'Specifications'). Obstructions in the water passages of the element, due to accumulated foreign matter or defective radiator repairs, will alter the rate of flow and cause loss of power and possible damage to the engine through overheating.

Removal

1. Drain the cooling system (page 4).

2. Disconnect the hoses from the radiator.

3. Undo securing bolts and remove radiator.

Inspection

1. Flow test the radiator.

2. Check the operation of the filler cap valves (page 6).

Overhaul

Minor Repairs to Cooling Element or Tanks

1. Using a test tank, locate the source of leakage as follows:

(a) Seal the radiator filler neck and the inlet and outlet pipes with plugs.

(b) Connect the air supply to the radiator overflow pipe or vent pipe adaptor, and completely submerge the radiator in the tank.

(c) Gradually increase the air pressure in the

radiator to within the specified limits. Do not exceed the maximum. Check carefully for rising air bubbles from the radiator and trace the source of the leakage.

2. Seal the leak with solder and repeat the pressure test.

Major Repairs to Cooling Element or Tanks

1. The procedure for removing and installing the tanks is as follows:

(a) Remove the overflow pipe (where fitted) and the drain tap.

(b) Remove the tanks by applying a blow-flame to the strap ends soldered to the top tank, and along the seams where the tanks join the cooling element.

Where the top tank has been removed, any deposits, which only occur in the top 2 in. of the water channels, can be removed with a feeler strip of suitable thickness. Take care not to damage the element. Invert the radiator and flush out the deposits.

(c) Place the bottom tank, open side upwards, on a fixture and position the cooling element on the tank. The tank flanges must be flush with the element.

(d) Tack the tank to the cooling element at each corner.

(e) Use a chisel-shaped gas bit to complete the soldering operation. Do not apply more solder than is necessary for a sound joint, as surplus solder may enter the tank and obstruct water passages in the element.

(f) Reverse the cooling element top to bottom and place it in position on the upturned top tank.

(g) Re-attach the strap assembly and overflow pipe (where fitted) and replace the drain tap.

2. Test the radiator for leaks as described under the previous heading.

3. Flow test the radiator to ensure that it is free from obstruction.

4. If the radiator is to be placed in stock, the necessary anti-corrosion precautions must be taken, using Shell Ensis fluid.

Filling

1. To avoid wastage of anti-freeze mixture during the winter months, the coolant level should not be less than 1 in. below the bottom of the radiator filler neck. Overfilling will cause loss of fluid through the overflow.

2. Check for leaks from the hose connections.

COMBINED HEAT EXCHANGER & OIL COOLER

The purpose of the heat exchanger assembly is to provide a header tank which allows for expansion and evaporation of the fresh water, also a means of cooling the engine cooling water and the engine lubricating oil. The cooling of the water and oil is achieved by passing the raw water through a series of tubes which are surrounded by the liquid which requires cooling.

The unit consists of an aluminium casing providing the header tank and a machined compartment in which the water heat exchanger tube stack is located, also a small aluminium cylinder in which the oil cooler tube stack is located. A tube stack comprises of a series of tubes running between two end plates and a tie bar which passes between the two raw water end covers and joins the whole assembly together.

Disassembly

1. Remove the two raw water pipes from their respective covers.

2. Disconnect the two oil pipes from the oil cooler.

3. Remove the brass cap nut.

4. This end cover can now be removed.

5. The opposite end cover complete with tie rod can now be withdrawn; care should be taken to support the oil cooler and the spacing ring after the tie rod has been removed. This is not attached in any way to the main casing.

6. The 'O' seals can now be removed from the end of the tube stacks. This will allow the tube stacks complete to be withdrawn from their respective casings.

7. The main aluminium casing nut can now be removed from the engine if necessary; this will entail disconnection of the fresh water hose, removing the screws attaching the header tank to the engine thermostat housing and two screws each side attaching the stays.

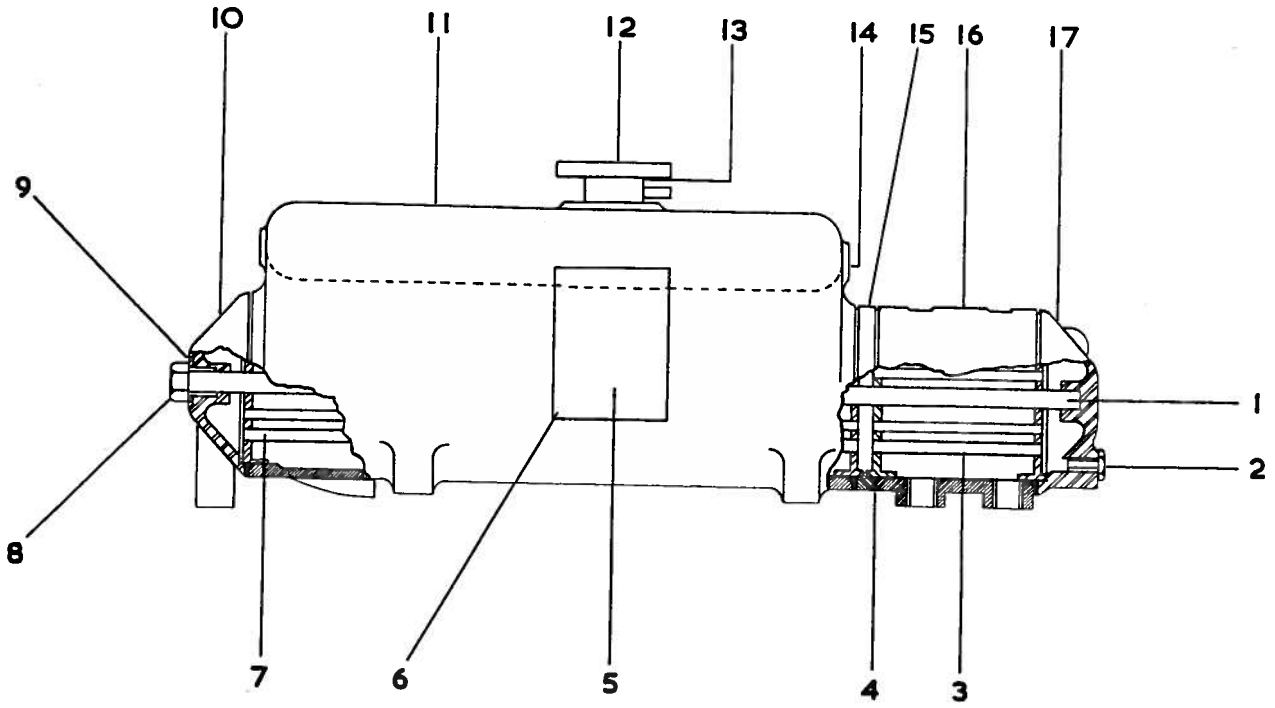


Figure 13
Combined Heat Exchanger and Oil Cooler Sectioned View

1. Tie Rod
2. Sea Water Drain Plug
3. Oil Cooler Tube Stack
4. Tube Stack Seals
5. Nameplate
6. Rivet
7. Heat Exchanger Tube Stack
8. Rod Cap Nut
9. Cap Nut Washer
10. End Cover
11. Body Heat Exchanger
12. Filler Cap
13. Filler Neck
14. Drain Plug
15. Spacing Ring
16. Oil Cooler Body
17. End Cover

Cleaning

If the tube stack appears to be badly choked, they should be placed in a de-greasing plant. This will loosen all foreign matter adhearing to them. The inside of the tubes which have sea water passing through them are more likely to require cleaning. If these are badly choked, they can be cleaned by pushing a length of 1/8" diameter brass rod down the tube so as to dislodge all foreign matter. The end of the brass rod should be free from sharp edges. It is IMPORTANT when doing this to push the rod through the tubes in the opposite direction to that in which the water flows. The other components should be cleaned before assembly, and as these contain no hidden surface, no special instructions are required.

Re-Assembly

General procedure is exactly the opposite to disassembly of the unit. Care must also be taken to ensure that the Rod Cap Nut is tightened to a torque of 25 lbs/ft.

All seals should be replaced and care should be taken to ensure that sealing surfaces are clean and free from burrs.

The heat exchanger water circuits should be pressure tested at 30 P.S.I. after major overhauls and the oil cooler tested at 100 P.S.I. The procedure to be followed is as follows.

1. The oil outlet from the oil cooler should be plugged with a suitable plug, a similar plug should be adapted for a fitting suitable for connecting to an air supply and fitted to the oil inlet.

2. Immerse unit in hot water 180° - 200°F and pressurise to 100 P.S.I. if the oil cooler is porous air bubbles will be observed. Great care should be taken when releasing air pressure.

3. Similar adaptors should be fabricated and the fresh water passages tested in a similar manner to that described in paragraph 2, the pressure to be 30 P.S.I.

RAW WATER PUMP (JABSCO)

The raw water for lowering the temperature of the engine is circulated through the heat exchanger by a positive displacement pump.

The pump drive shaft is supported by pre-lubricated bearings with a seal at each end to prevent leakage of lubricant and a seal to prevent water leakage along the shaft.

An impeller splined to the end of the drive shaft is self lubricated by the water being pumped and SHOULD NOT BE RUN DRY, longer than normally required for the pump to prime itself.

A wear plate in the impeller compartment prevents pump housing wear. This plate may be reversed if wear on the impeller side becomes excessive.

The pump can be operated in a clockwise or anti-clockwise direction. Raw water is drawn into the pump through the inlet opening and discharged through the outlet opening, both openings being located on the top of the pump housing, details of the direction of flow and direction of rotation being given on the pump end cover plate.

Remove the pump assembly complete from the engine and disassemble as follows.

1. Drain raw water system.

2. Disconnect the water hoses from pipe, do not disturb the unions.

3. Remove pump holdown screws.

4. Remove the six screws which retain the end cover, remove end cover and gasket, discard the gasket.

5. Withdraw the impeller from housing by grasping a blade on each side of the impeller with pliers and pulling impeller off the shaft, care must be taken not to damage the impeller.

6. Remove the cam locking screw and remove the cam. The wear plate which is located with a pin and retained by the cam, can now be withdrawn.

7. Place the pump in a position such that the shaft is vertical and remove the circlip which retains the seal.

8. Place the pump in a vice supporting the water outlets, remove the pinch bolt which clamps the pump housing to the bearing housing. Tap the shaft arrowed in Fig. 14 lightly in a downwards direction, this will separate the two castings of the assembly and also remove the shaft from the seals in the pump.

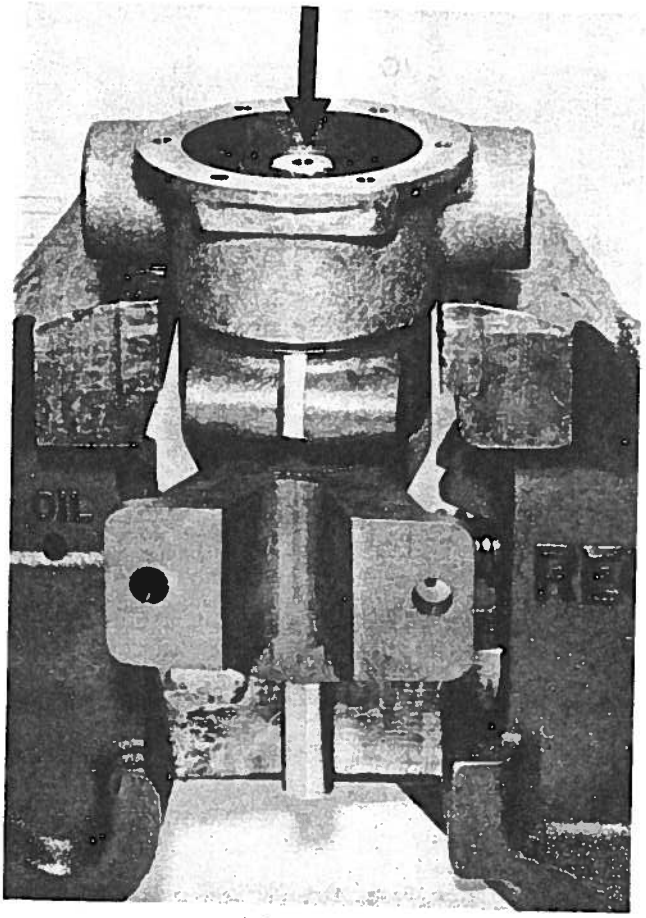


Figure 14
Jabsco Raw Water Pump, separating bearing housing from pump housing see paragraph 8.

9. Remove from the pump housing the remaining seals and the slinger from the shaft.

10. Turn the bearing housing so the drive pulley is upwards and replace in the vice, remove the driving pulley, the seal may now be prised from the housing and discarded.

11. Remove the large circlip which retains bearings in housing.

12. Turn bearing housing such that the splined end of drive shaft is uppermost and replace in vice, the shaft may now be tapped downwards removing shaft and bearings from housing.

13. The circlip which retains bearings on shaft may now be removed and bearings and spacer withdrawn with a puller.

14. The remaining seal in bearing housing can now be removed by Tapping from the housing, in the direction from the pump, this seal can now be discarded.

15. The pump may be assembled using new parts where necessary by following the above instructions in reverse, however it must be noted that a non-hardening sealant must be applied to the cam retaining screw.

The pump is not fitted with a drain tap and in freezing conditions the pump must be drained by loosening the end cover and allowing water to drain out, retighten the cover before attempting to use the pump.

When refitting the raw water pump to the mounting bracket care must be taken that the alignment of pulleys is perfect, or excessive wear will take place on the drive belt. It is advised that a straight edge be placed across the faces of the two pulleys as a check of alignment, this can be adjusted by adjusting the water pump before finally tightening the fixing screws.

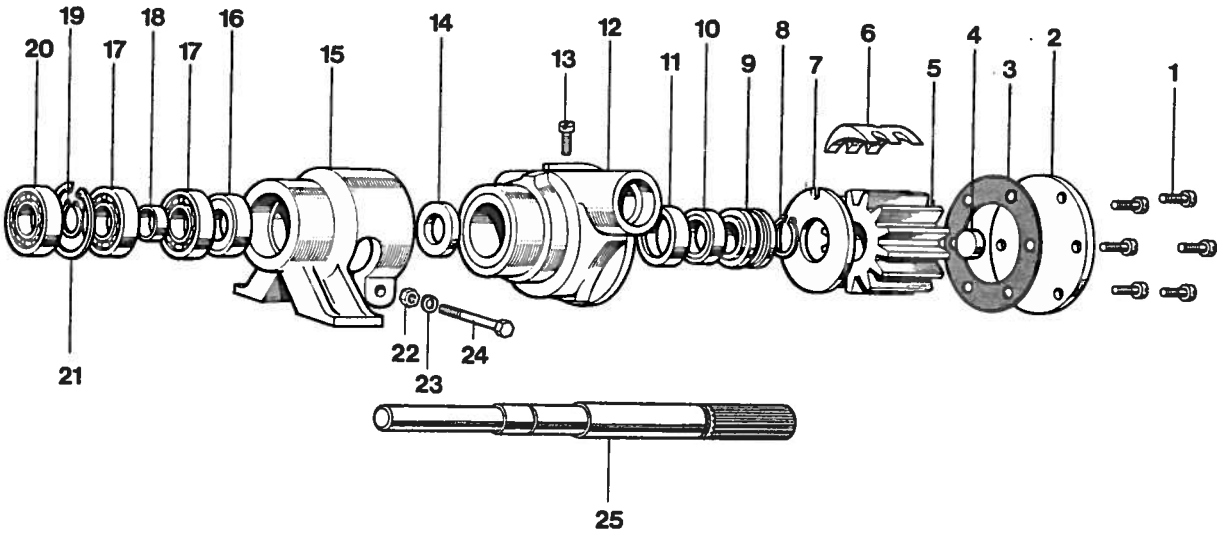


Figure 15

Jabsco Water Pump Exploded View

1. Screw, Cover Retaining
2. Pump, End Cover
3. Gasket, end Cover
4. Spline Seal
5. Impeller
6. Cam
7. Wearplate
8. Retaining Ring
9. Seal
10. Seal Seat
11. Seat Cup Rubber
12. Cam Screw
13. Body, Water Pump
14. Slinger
15. Bearing Housing
16. Seal
17. Bearing
18. Spacer
19. Retaining Ring Bearing
20. Seal
21. Retaining Ring, Bearing
22. Nut
23. Washer, Spring Lock
24. Bolt, Hexagon Head
25. Shaft

SPECIFICATIONS

(Manufacturing Limits)

GENERAL DATA

Cooling System Capacity (nominal)

	FOUR CYLINDER	SIX CYLINDER
Temperate Climate	27 Imp.Pts.	30.9 Imp.Pts.
Tropical Climate	(To be issued later)	42.9 Imp.Pts.
Radiator Leak Test Pressure	15 lb./sq.in.	

ANTI-FREEZE SPECIFICATIONS

Refer to 'Corrosion Preventative' and 'Anti Freeze' on Page 3 of this section.

FAN

Overall Diameter	
Four cylinder engine	$17\frac{3}{4}$ in.
Six cylinder engine	17 in.
Four and six cylinder (Blower Type)	18 in.

FAN BELT

Angle of Vee	42°
Depth	$^{13}/_{32}$ in.
Width (nominal)	$^{3}/_{4}$ in.
Belt Tension	Belt should depress $\frac{1}{2}$ in. midway between fan and generator pulleys under load of 8 to 10 lb.

RADIATOR FILLER CAP

Pressure Valve (opening pressure)	$3\frac{1}{4}$ to $4\frac{1}{4}$ lb./sq.in. (Standard)

THERMOSTAT

	STANDARD	OPTIONAL
Opening Temperature	170° to 179° F. (77° to 82° C.)	156° to 168° F. (69° to 76° C.)
Fully Open Temperature	199°F. (93°C.)	185°F. (85°C.)
Valve Lift	$^{23}/_{64}$ in. min.	$^{15}/_{64}$ in. min.

WATER PUMP

Bearings		
Fit in body	.0005 in. clearance to .0006 in. interference	(Housing bore dia. 1.3774 to 1.3780 in. (Bearing dia. 1.3775 to 1.3780 in.
Rotor		
Fit on shaft	.0015 to .0030 in. interference	(Shaft dia. .6262 to .6267 in. (Rotor bore dia. .6237 to .6247in.
Hub thickness	.850 to .855 in.	
Pulley Flange		
Fit on shaft	.0009 in. clearance to .0006in. interference	(Shaft dia. .5444 to .5449in. (Flange bore dia. .5443 to .5453 in.