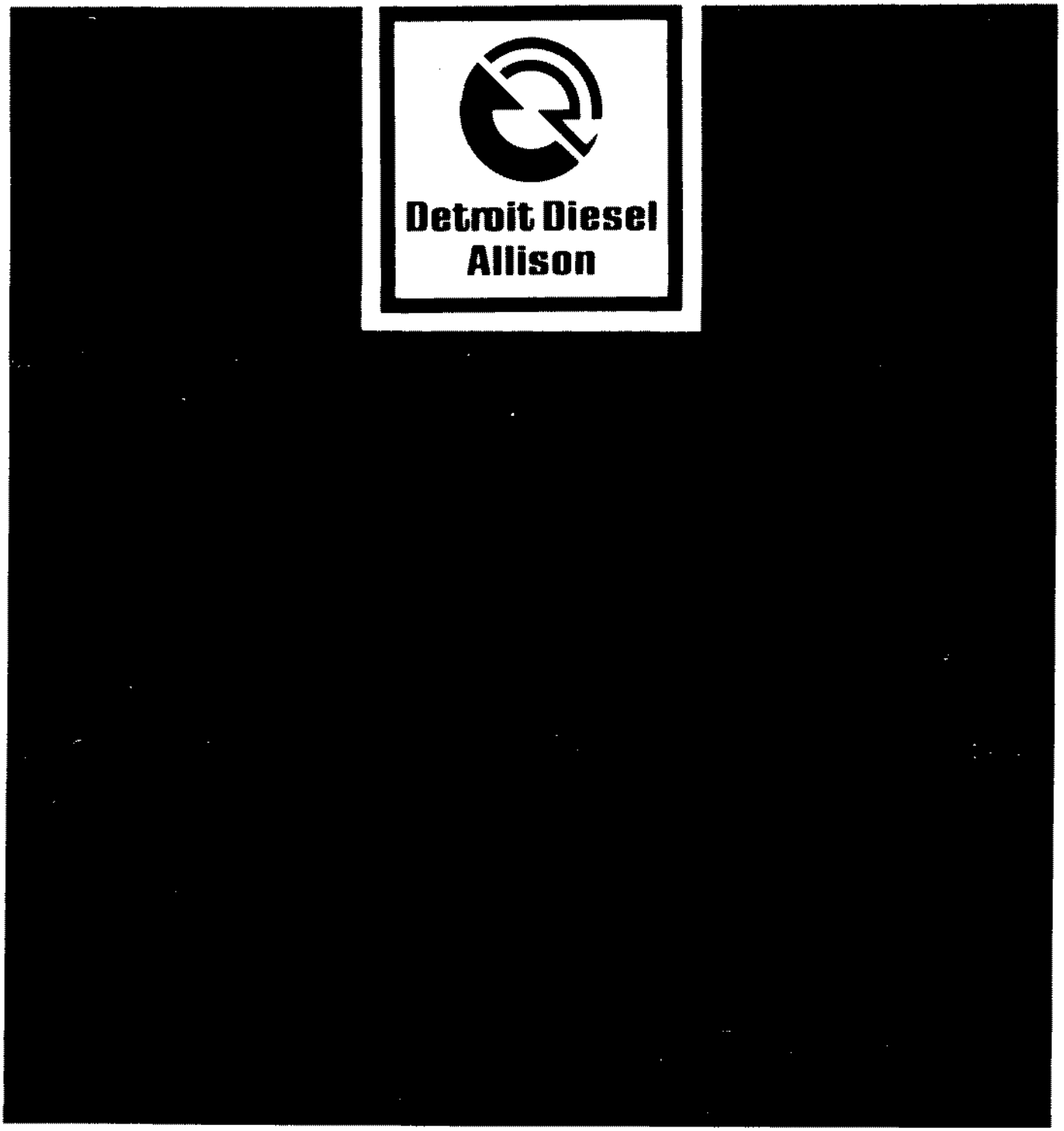
GM Bedford Diesel



Updating Service Check Sheet

Replacement sheets will be issued at intervals. Insert the pages in your manual and record the date of release on this check sheet.

~~220/330–1~~	220/330–9	220/330–17	220/330–25	220/330–33
~~220/330–2~~	220/330–10	220/330–18	220/330–26	220/330–34
~~220/330–3~~	220/330–11	220/330–19	220/330–27	220/330–35
~~220/330–4~~	220/330–12	220/330–20	220/330–28	220/330–36
~~220/330–5~~	220/330–13	220/330–21	220/330–29	220/330–37
~~220/330–6~~	220/330–14	220/330–22	220/330–30	220/330–38
~~220/330–7~~	220/330–15	220/330–23	220/330–31	220/330–39
220/330–8 MARCH 1980	220/330–16	220/330–24	220/330–32	220/330–40

SERVICE MANUAL

220 and 330 cu. in.

BEDFORD
INDUSTRIAL DIESEL ENGINES

Detroit Diesel Allison
Division of General Motors Limited

**P.O. Box No. 6, London Road, Wellingborough,
Northamptonshire, England, NN8 2DL**

Tel: Wellingborough 71122 (STD CODE 0933)

Telex: 31329 Cables: Genmopower Wellingborough

BD/SE/2 **MARCH 1980**

TABLE OF CONTENTS

INTRODUCTION

This manual contains instructions on the overhaul, maintenance and operation of the GM Bedford 220 and 330 cubic inch Diesel Engines. 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 numbered to which the illustration refers i.e. Illustration Number 1.2000-12 is associated with paragraph 12 of section 1.2000 (Cylinder Head).

Full benefit of the long life and dependability built into these engines can be realised through proper operation and maintenance. The use of 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 procedures which are listed on page 13. 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 procedures 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.

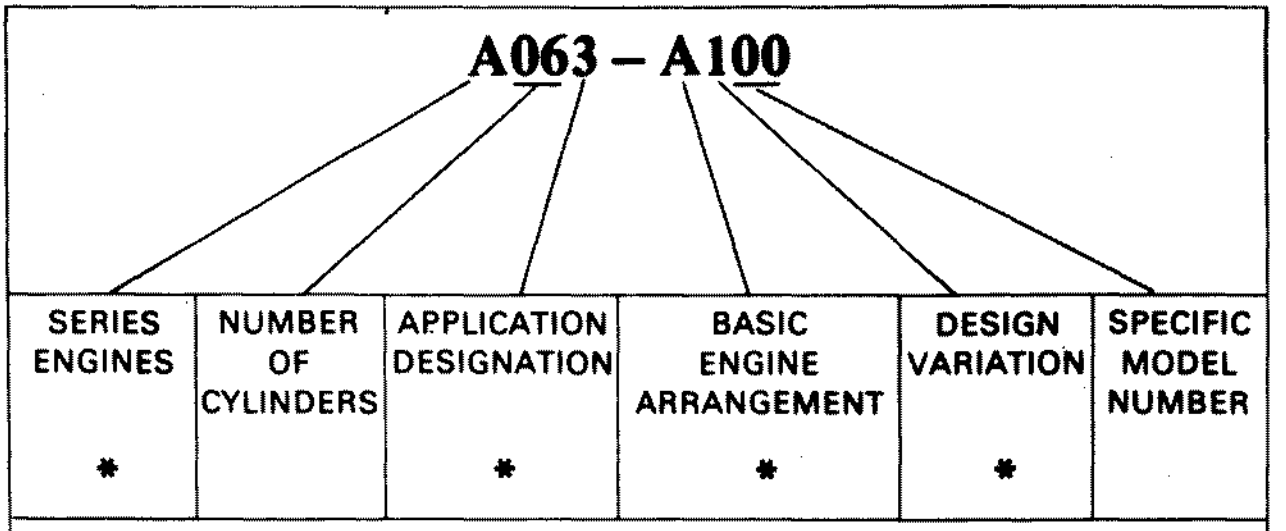
Reference is made throughout the manual to special tools which are designed to facilitate service operations. The service tools are known as Riteway service tools and are available from:-

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

Reference is also made to "Plastigauge" which is used for measuring bearing clearances, this can be obtained from:-

Buck & Hickman, 264 Water Road, Abbey Estate,
Alderton, Wembley
or Perfect Circle Corp. Hagerstown, Indiana, U.S.A.

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

MODEL IDENTIFICATION

The engine model number, serial numbers and build of the engine are stamped on an Option plate attached to the rocker cover. In any communication with the factory the information given on the plate must be quoted.

GM

BEDFORD DIESEL

MODEL No. A063-A100
SERIAL No. 640181/3517
MAX. R.P.M. NO LOAD
RATED B.H.P. [ ] AT [ ]

GENERAL MOTORS LIMITED,
WELLINGBOROUGH, ENGLAND.

GROUP	TYPE	GROUP	TYPE	GROUP	TYPE
1.3300	4	5.4000	NIL		
1.3320	NIL	6.1000	14		
1.4000	59	7.1000	NIL		
1.7100	6	7.4400	23		
2.5000	8	12.6000	NIL		
3.3000	NIL				
4.7000	12				

The serial number will be noted as being two series of digits which are separated by an oblique stroke. The first series of digits are those allocated by Vauxhall Motors thus covering items which they produce, the second being allocated by the Power & Industrial Division of General Motors Ltd., and covering parts fitted by P. & I.

The complete build of the engine is given on the option plate and when used in conjunction with the Parts Catalogue (Form No. BD/SP/1), the complete build of the engine can be determined. It will be noted that the option plate has columns headed group and type, the groups being functionally related parts.

For example, Group 1.2000 is titled Cylinder Head, this group of parts includes items which are fitted to the cylinder head, valves injector retaining studs, valve springs, valve guides, etc.

Before a replacement part can be acquired the group number must be known and this can be determined from the following list:-

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.

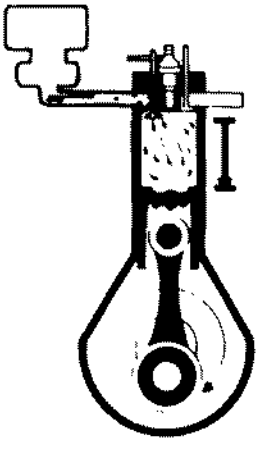
In this type of engine, air alone is compressed in the cylinder. Then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

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.

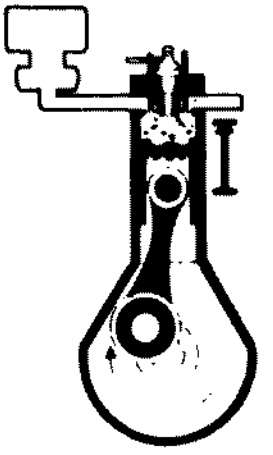
On the induction stroke the inlet valve is open, the piston moves down the bore and as it does so would reduce the pressure in the cylinder but for the air which enters via the inlet valve, this being open to the atmosphere. The inlet valve will close when the piston reaches the bottom of its stroke.



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.

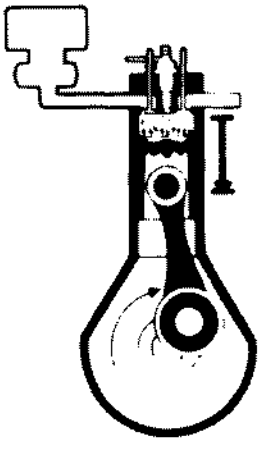
The rise of temperature of car tyres is caused by the flexing of the carcass as it passes over the road surface.



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.

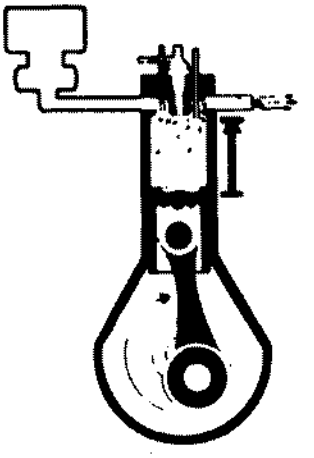
Just before the piston reaches the top of its stroke a quantity of fuel is injected into the cylinder via the injector, the heat already generated within the combustion chamber causes ignition of the atomized fuel. The fuel is burnt and this causes a rapid increase in pressure within the combustion chamber, 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

The exhaust stroke completes the cycle, the piston being forced up the bore by the energy being generated in the other cylinders. During this stroke the exhaust valve is open thus the exhaust gases are expelled by the action of the piston, when top dead centre is reached the exhaust valve will be closed and the complete firing sequence will now be repeated.

It will be realised from the foregoing that for the completion of one (1) complete firing sequence the crankshaft will have completed two (2) complete revolutions. However, to ensure the correct valve opening and fuel injection point, the camshaft and the injector pump will only complete one (1) revolution per firing sequence, therefore the camshaft and fuel pump only rotate at half the camshaft or engine speed, this can more readily be understood by referring to the illustrations.



EXHAUST 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.

SAFETY

When using a degreasing tank take care that wire rope slings are used to lower and raise parts into the tank. If a manilla rope is used the action of the degreasing agent will destroy the natural oils within the rope hence causing the rope to rot. On visual examination the rope will appear to be clean and as new, however, the damage is caused internally and the rope considerably weakened, this can cause an accident to the operator. Care should always be taken not to inhale the fumes from the degreasing plant as these may be toxic.

Electricity can be the serviceman's best friend enabling him to use power driven tools and lights which are portable and easily connected to the nearest power supply, the cable used for the connection being flexible can be placed anywhere, the only governing factor being its length. Whenever using any appliance which is powered by electricity care should be taken that the cable is not laid across any sharp objects which could cut the insulation material of the cable, similarly, trucks, barrows, etc., should not be driven across the cable, as this action could also cause damage to the cable. The plug which is used on the cable should be the correct size for the socket, not bare ends of wire pushed into the socket. Electrical equipment should be checked by a qualified electrician at regular intervals, servicing is as important for the continued safety of electrical appliances as regular maintenance is to the reliability of an engine. A fuse is provided as a "safety valve". Should anything electrical fail in the equipment a short circuit condition could be created causing a very high current to flow which would cause the conductor to heat and possibly ignite the insulation material thus causing a fire in the workshop, the fuse is fitted in the circuit to prevent this happening. If the current exceeds a given amount the fuse wire is designed to melt thus "switching" off the supply of current. The ration between the fuse's current carrying capacity and that of the cable specific ratio therefore, if a fuse is replaced it must be replaced with one of the correct value. Should the replacement fuse fail it could be due to either too many or too large appliances being operated on the one circuit, the remedy here is to remove one or more pieces of equipment or a piece of equipment with a defect. In any instance, it is advisable to contact a qualified electrician, "it is better to be safe than sorry". This old English saying is very true when dealing with electricity.

Many references are made in the book to the use of compressed air for drying components after various cleaning operations, this is a recognised way of cleaning and drying components. When performing this operation great care must be taken to ensure that the airstream does not come into contact with flesh. The air is delivered from the nozzle at a high pressure and could, especially if directed on skin which has recently suffered a cut or other abrasion cause the skin and flesh to be lifted from the body. The reasons are equally valid arguments which can be applied to persons who dry their hands with compressed air after washing.

When lifting any heavy components check that the lifting tackle is sufficient to carry the loads being imposed on it, also that the anchorage is strong enough. It is no use having tackle which can lift 2 tons if the beam to which it is attached breaks when a load of 1 ton is applied, it should therefore be realised that the beam must have a lifting capacity equal to or in excess of the tackle. The slings which are used should be checked for signs of fraying which seriously weaken them, whenever practical it is advised that hooks be used through suitable holes in the object which is being lifted, this safety precaution will prevent the possibility of the load slipping. Whenever a lifting operation is required do not lift any higher than is necessary to clear an obstruction and also keep all personnel clear of the object being lifted.

When working on an object to which you require access to the underside do not hang it on lifting tackle but block it securely on blocks so it cannot fall on the serviceman, you can still leave the lifting gear attached as an additional safety precaution.

When a serviceman is called to investigate a problem on a machine the operator of the machine should always be asked to demonstrate, and at all times to operate the machine. This will prevent any possibility of the machine inadvertently moving and possibly causing injury to persons or damage to their property.

Converter stall checking should be regarded as another potentially dangerous task which a serviceman can be called upon to perform. Care should be taken that no persons or property are in line with the vehicle or vessel which would move should the restraining means fail.

Whenever you are working always remember that an accident to you can be prevented with your help.

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.

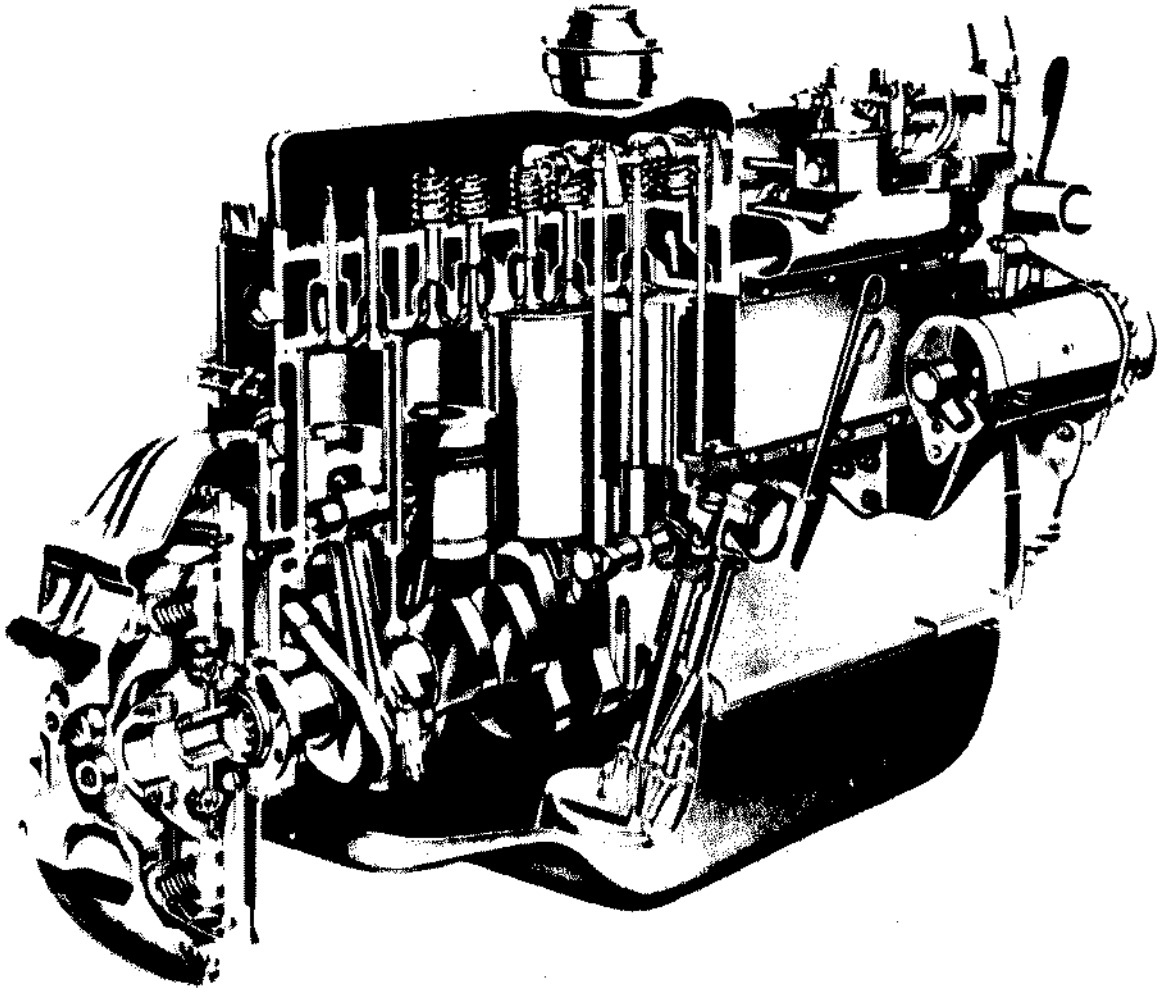
Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment, and space will be repaid many times.

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.

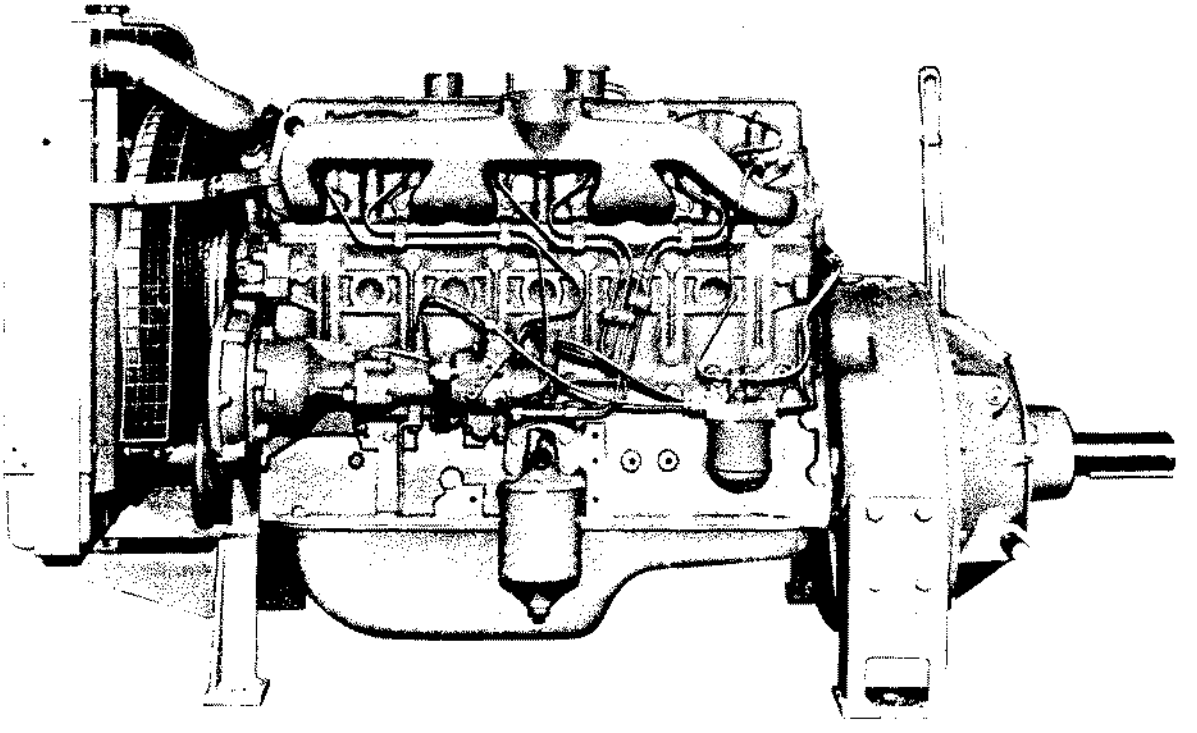
When assembling an engine or any part thereof, refer to the table or torque specifications at the end of each section for proper bolt, nut and stud torques.

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.

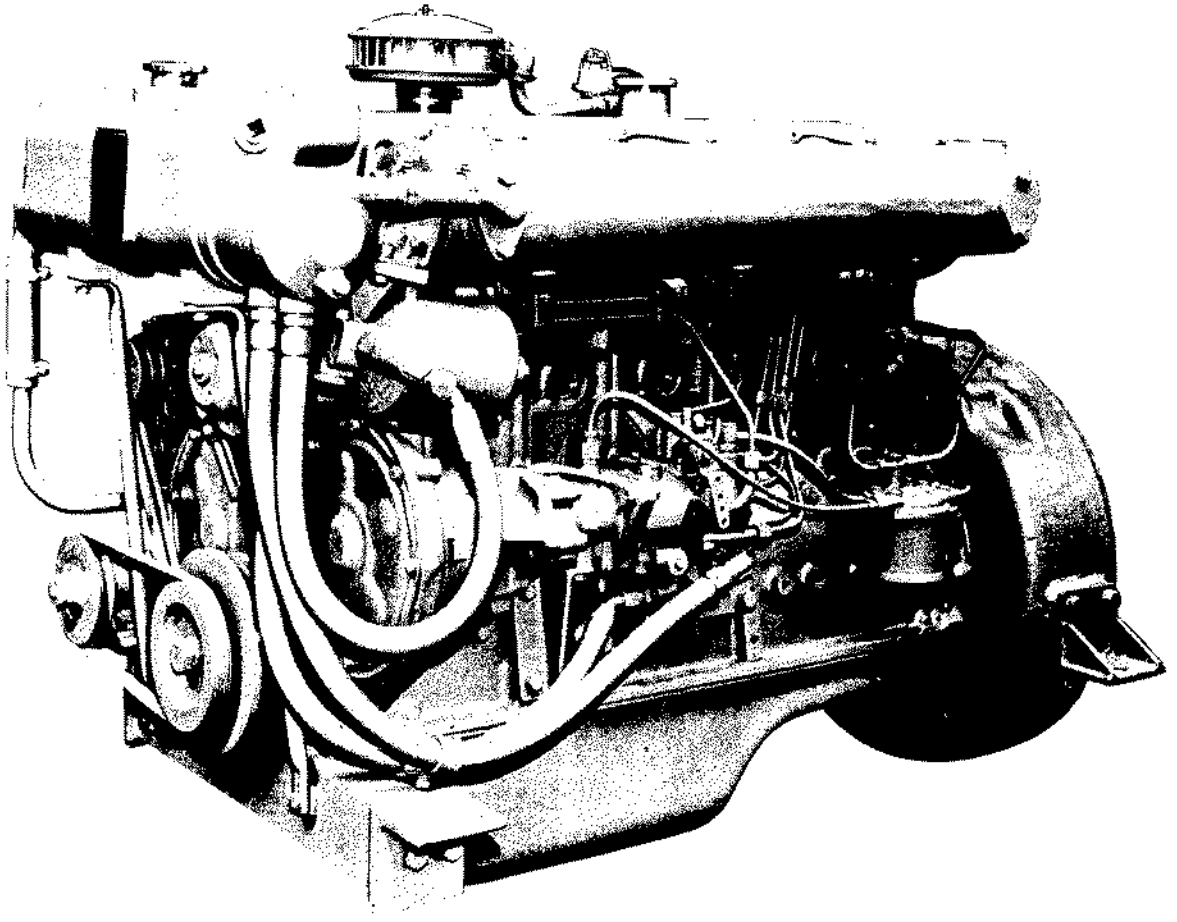


Cut-away view of 330 cu. in. engine.

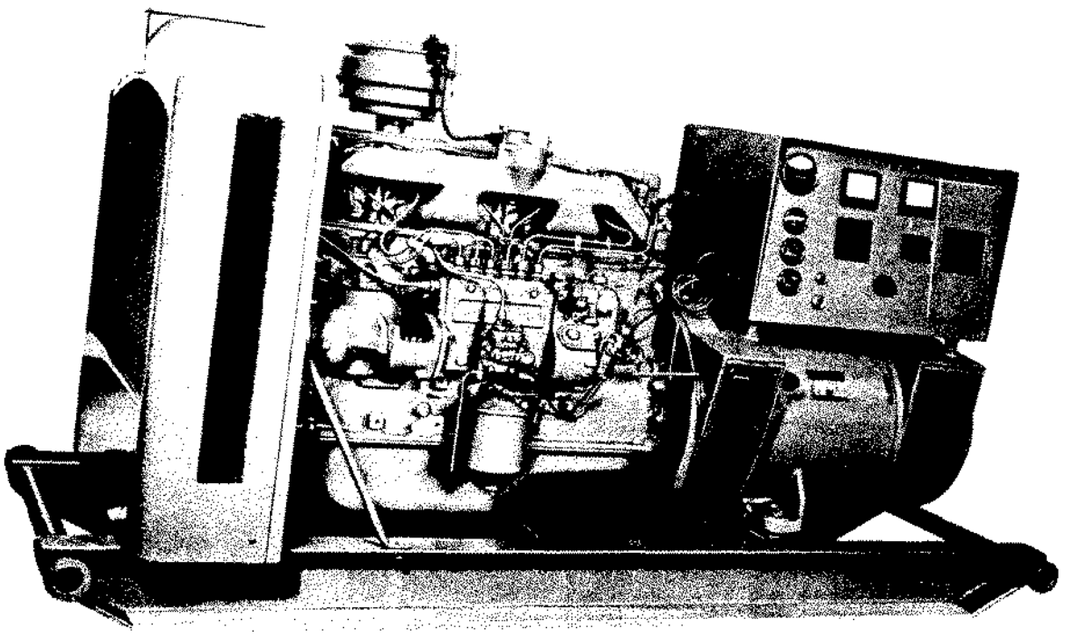
NOTE: The use of liners has now been discontinued on current 330 cu. in. engines except for service purposes.



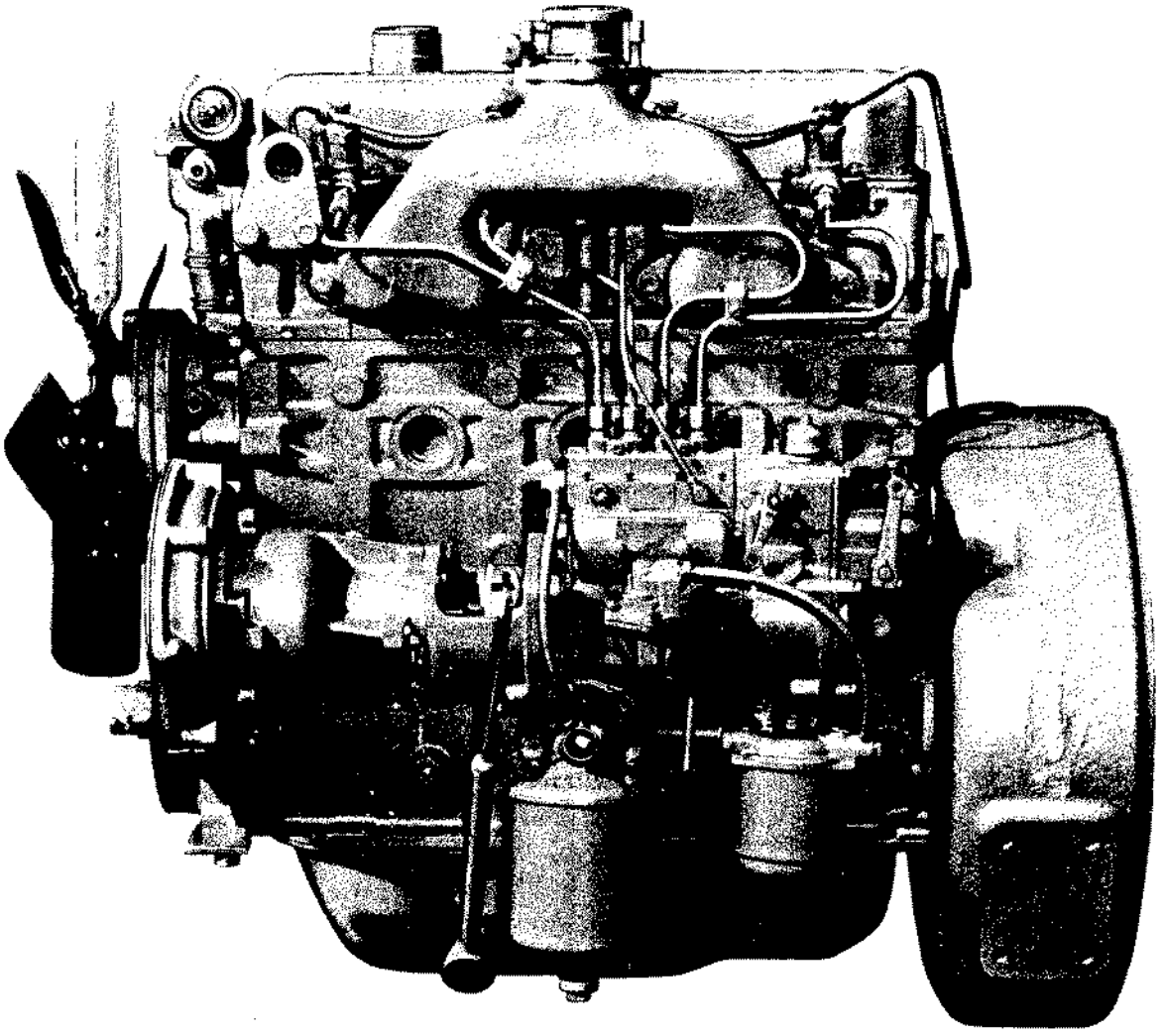
External view of a 330 cu. in. engine.



External view of 330 cu. in. marine engine.



External view of 330 cu. in. generator set.



External view of a 220 cu. in. engine.

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

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).

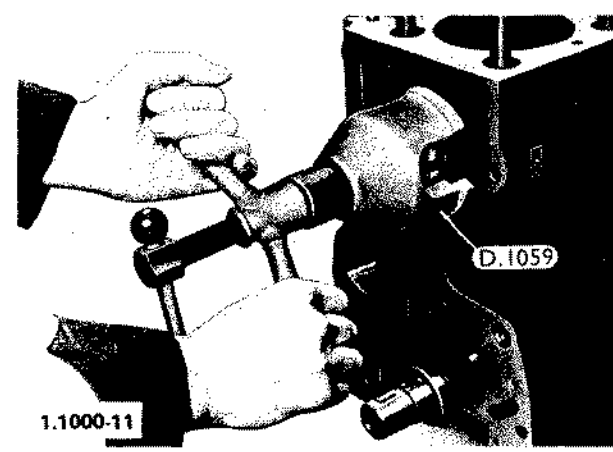
CYLINDER BLOCK: (Inspection and Overhaul)

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.

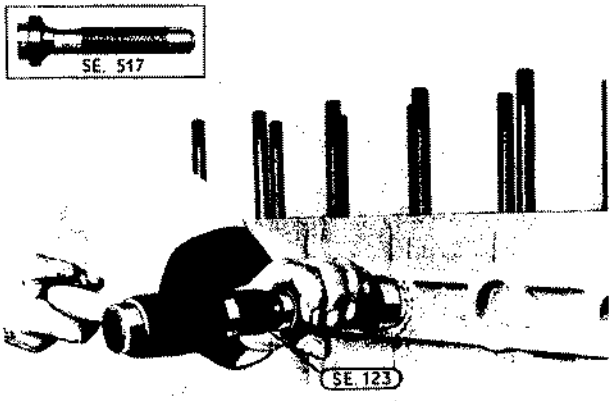
9. After completing the previous inspection and overhaul procedure, the cylinder block should be pressure tested. This test is left until all machining operations have been completed on the block, in case damage should be caused during the actual machining operations. Make up suitable plates to blank 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.



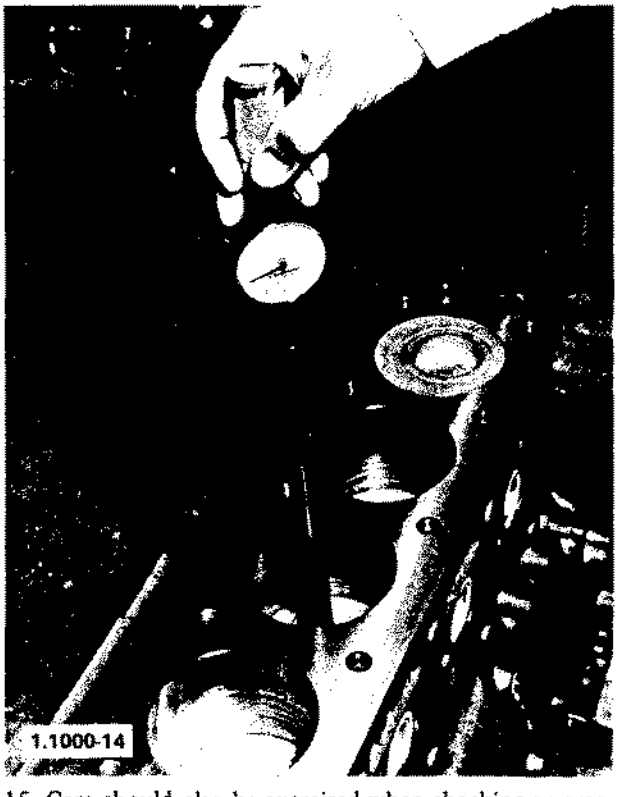
12. A replacement can be fitted, using a sealing compound around the cup plug before installing into the cylinder block. The plug should be driven into position using installer SE.123 or SE.517 depending upon the size of the cup plug.



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.

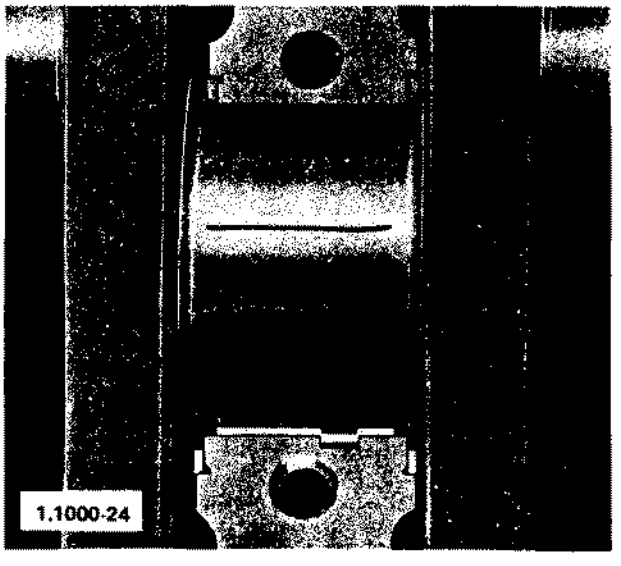
20. Replace the main bearing caps onto their respective main bearing housings.

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.

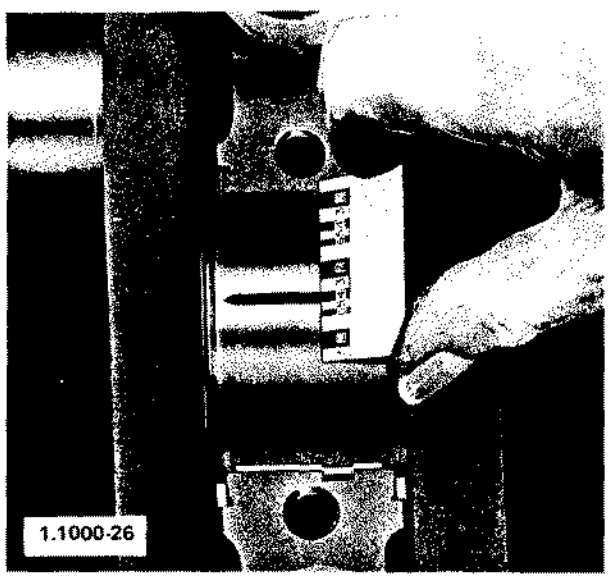
24. Replace the crankshaft which it is intended to use and check the clearance in between the bearing shells and crankshaft using "Plastigauge" which should be used in the following manner. It should be realized that steel, feeler strip should not be used or the bearing surface will be damaged. Wipe 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.



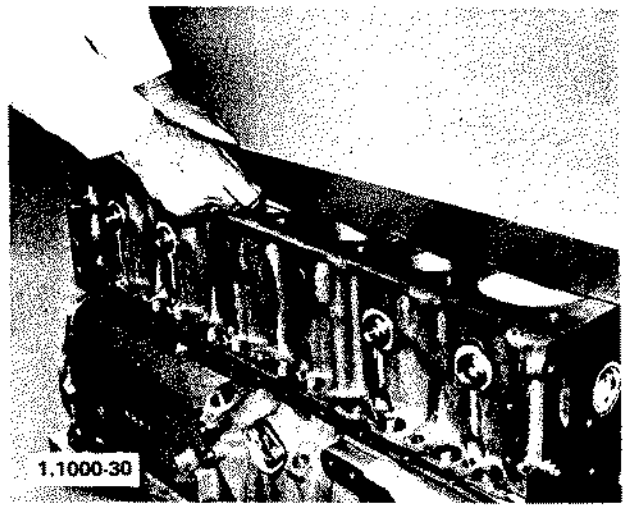
1.1000-24

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

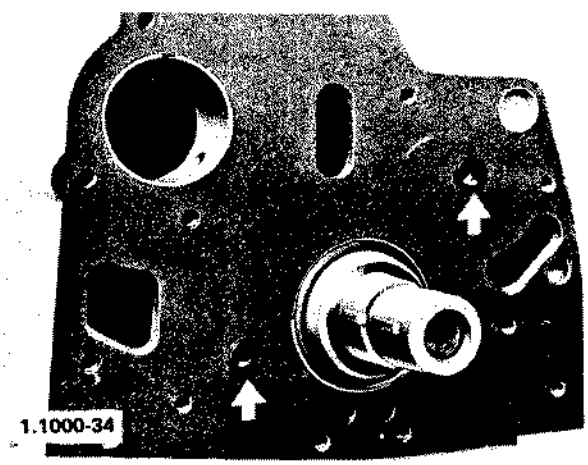
25. Remove the bearing cap. The flattened Plastigauge will be adhering to either the journal or the bearing and should not be removed at this stage.
26. Using the inch scale printed on one side of the Plastigauge envelope, measure the compressed Plastigauge at its widest point. The numbered graduation 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 front 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.

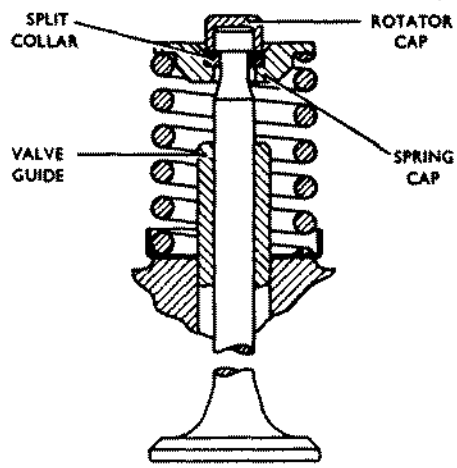
CYLINDER BLOCK: (Refitting)
36. The cylinder block is the centre of the engine assembly and as a consequence the rebuilding instructions are detailed in each group within this book, when full details are given for the attachment of components of sub-assemblies.

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.

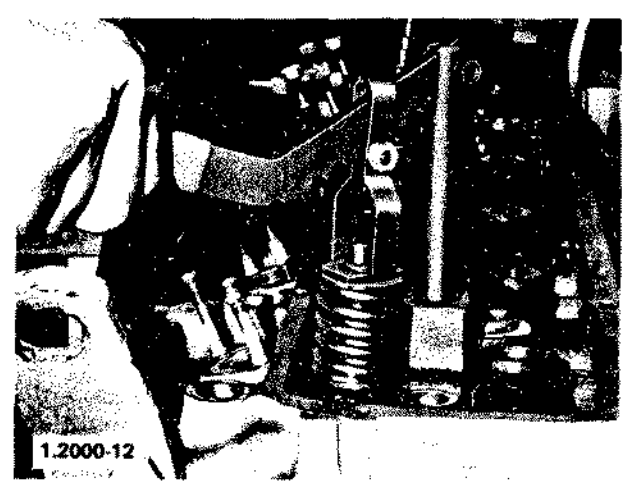
9. Remove the rocker gear, push rods (1.7100) and exhaust valve rotator caps where fitted. Extract the injectors (2.1000) and remove the push rod cover.

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.

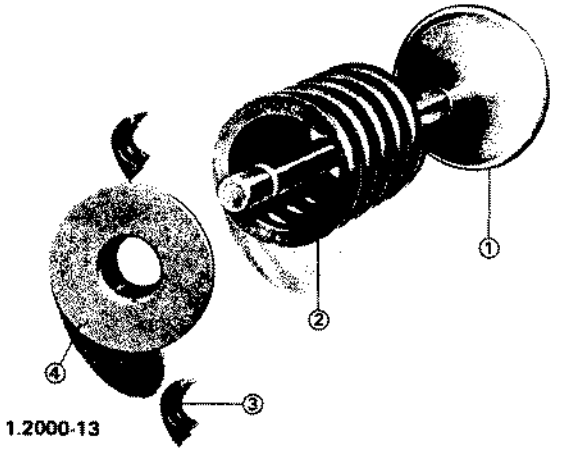
CYLINDER HEAD: (Inspection & Overhaul)

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.



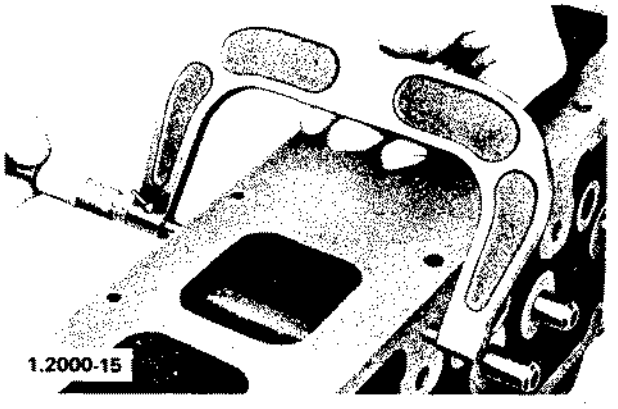
1.2000-12

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.

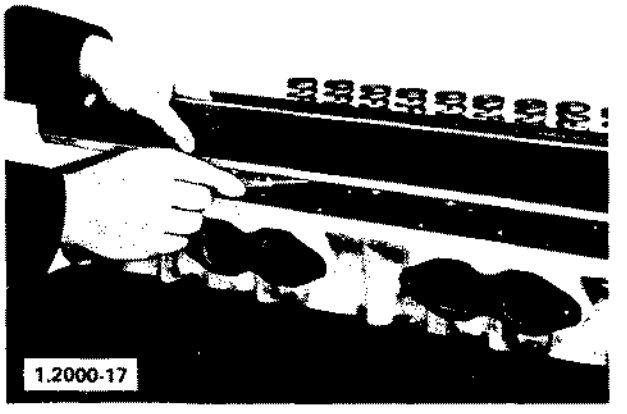


e.g. 4.2460 – measured dimension
4.2385 – minimum depth of head

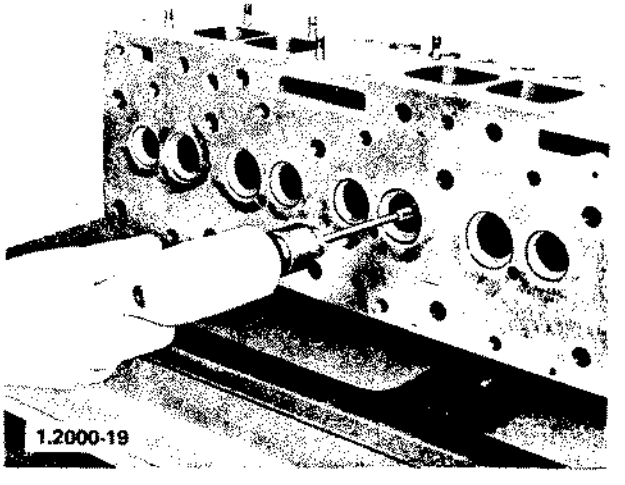
0.0075

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.

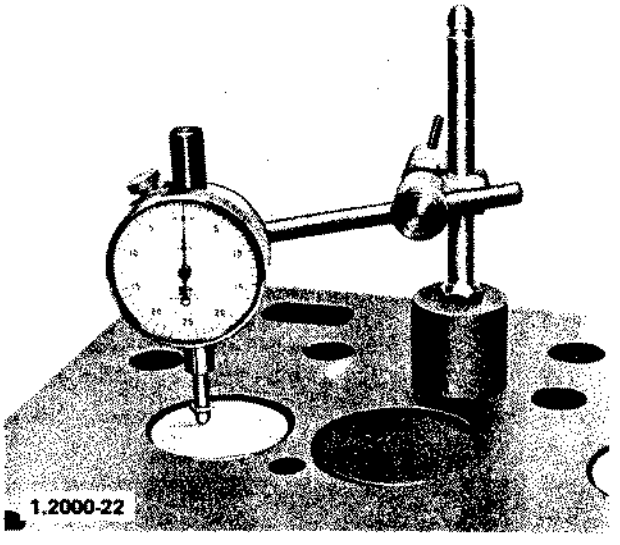


18. It is also important that checks be made on the valves, valve guides, valve springs and valve seats as detailed below; failure to follow this procedure can result in a valve touching a piston.
19. Clean the valve guide bore using a rotary wire brush and check for wear. The bore should be between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

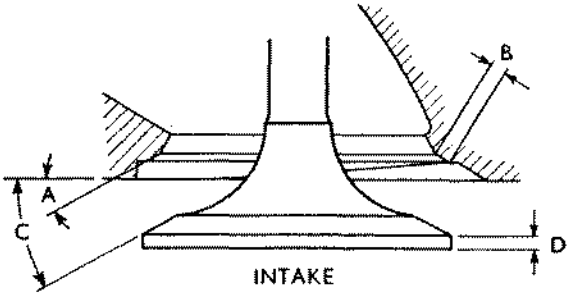


20. If the guide needs renewing, press the guide out of the head from the top using drift Z8378 and replace it using installer Z8562. This installer is made to fit both inlet and exhaust valve guides. The correct height of the guides will be obtained when the drift contacts the cylinder head.
21. Replace 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.

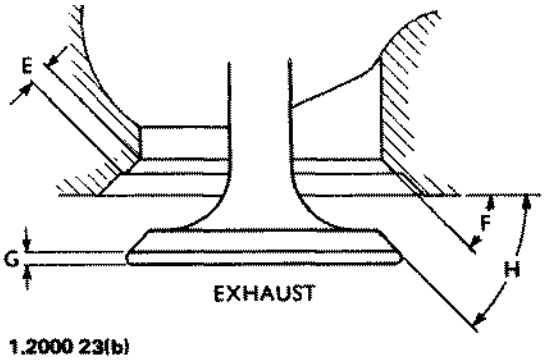


23. For refacing valve seats use special equipment, noting that the seats should be kept within the specified limits shown in figures a and b below.



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)

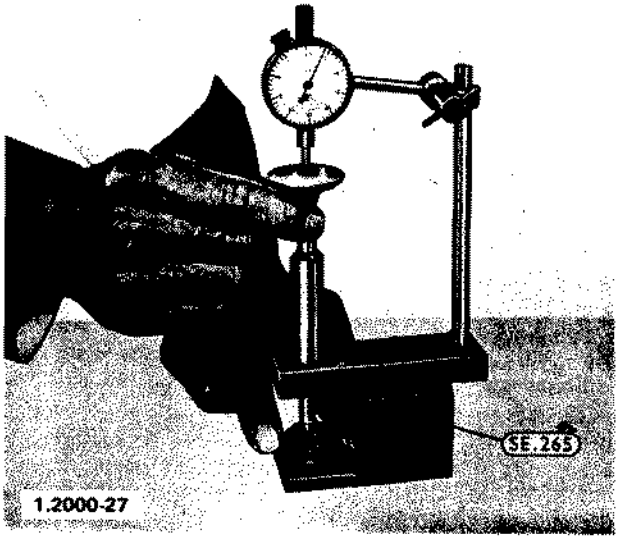
F. Valve seating angle 45°
E. Valve seating width .097 to .110 in.
H. Valve seat angle 44°
G. Valve head – minimum thickness .035 in. Valve head depth in relation to cylinder head face (minimum permissible) .041 in.

24. After refacing, check the valve seats and guides for concentricity.

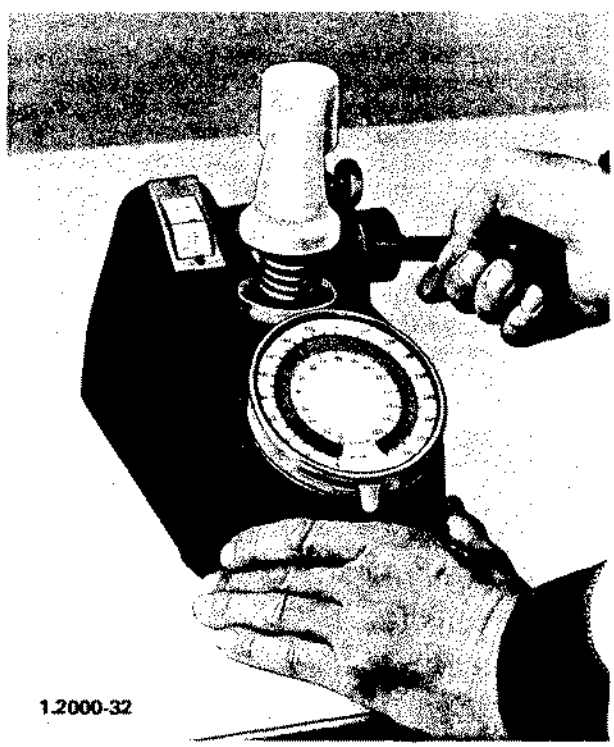
25. Examine the valves for burnt heads, cracked seat faces and damaged or worn stems. The stem diameter of an intake valve should be .3409 to .3417 inches whilst an exhaust valve stem should be .3397 to .3407 inches.

26. On exhaust valves, check the dimension between the 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.

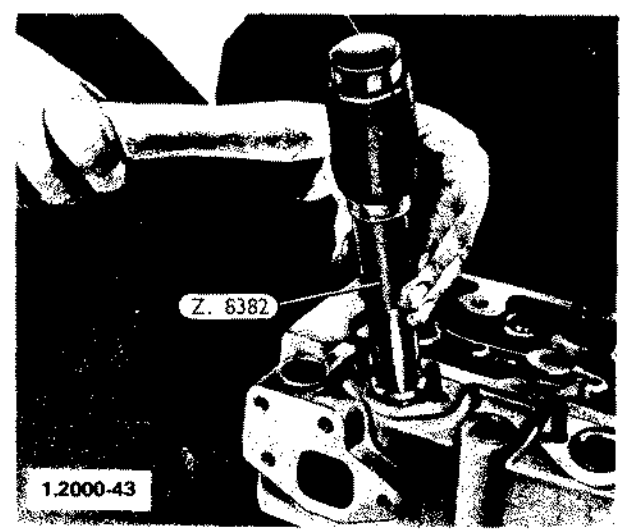
27. On early engines fitted with rotator caps on the valves, support the valve head uppermost in checking jig SE 265 and assemble the spring cap, split collars and rotator cap to the valve stem. Press the spring cap firmly downwards and check the valve lift, which should be .001 to .005 inches, between the valve stem and the rotator cap using a dial gauge as shown.



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.

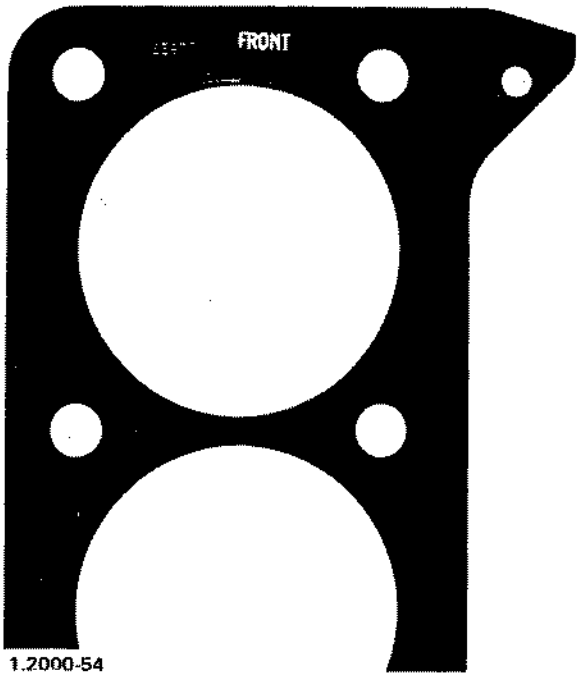


1.2000-43

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.

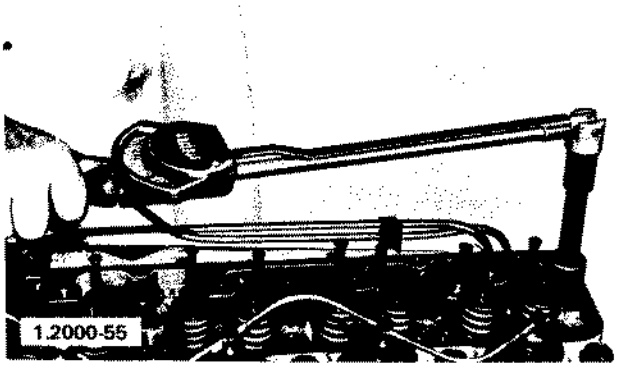
46. Lubricate the valve stems and guides with a mineral oil containing colloidal graphite, and install the valves in their respective positions in the cylinder head.
47. Before installing the valve spring, check to establish whether the assembled height of the springs is affected by refacing the valves 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.

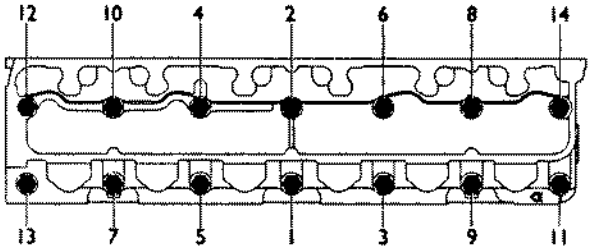


1.2000-54

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).

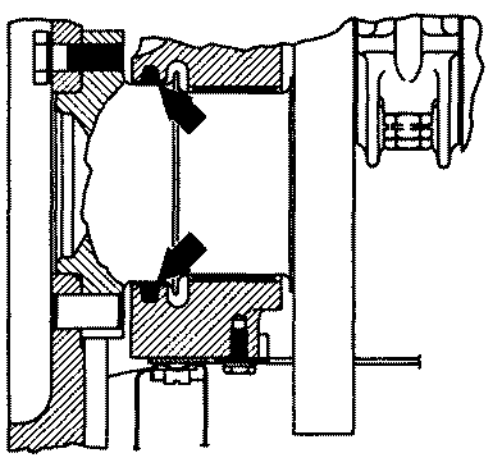
59. Warm up the engine to normal operating temperature, and with the engine running at idling speed, readjust the valve clearances to .013 inches as described under (1.7100).

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.

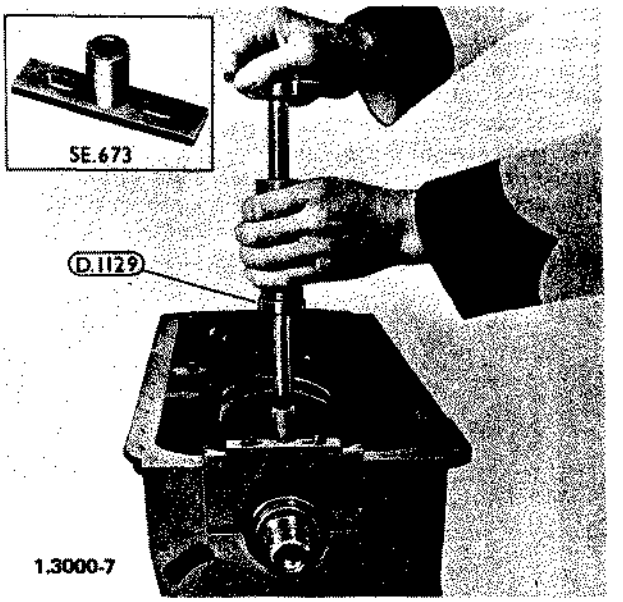


1.3000-4

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

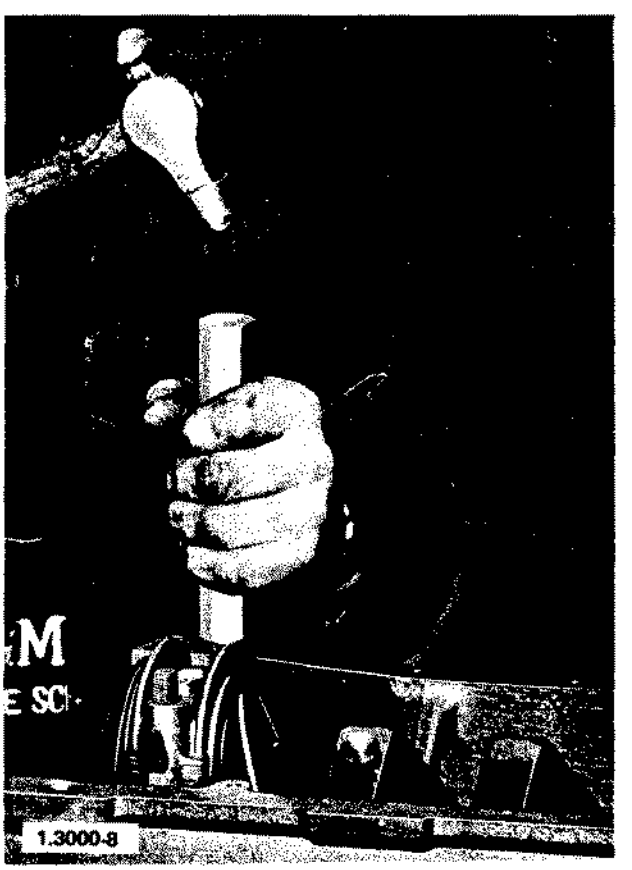
CRANKSHAFT: (Removal)

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.



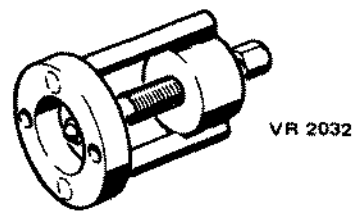
1.3000-7

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.



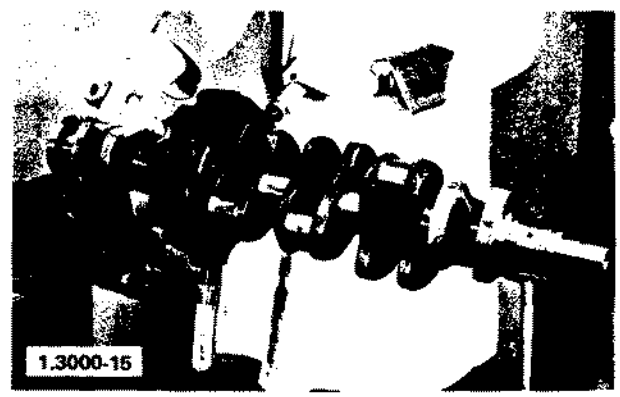
1.3000-10

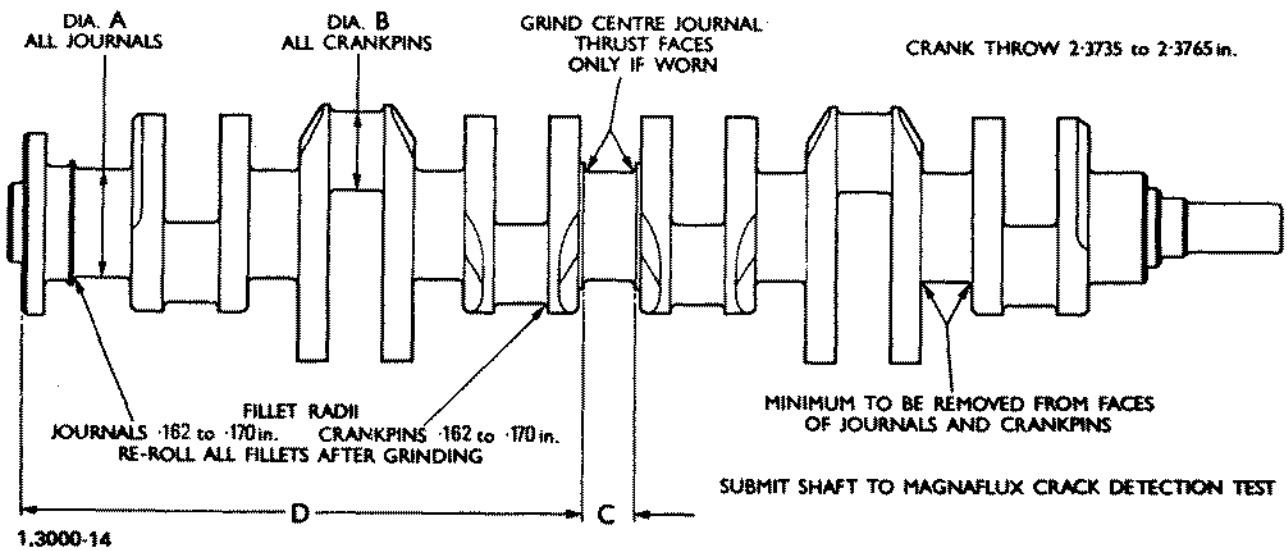
11. The crankshaft can now be lifted from the crankcase. Care must be taken to ensure that the crankshaft does not foul the timing gear case. Remove the upper bearing shells and keep in the same sequence.

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.



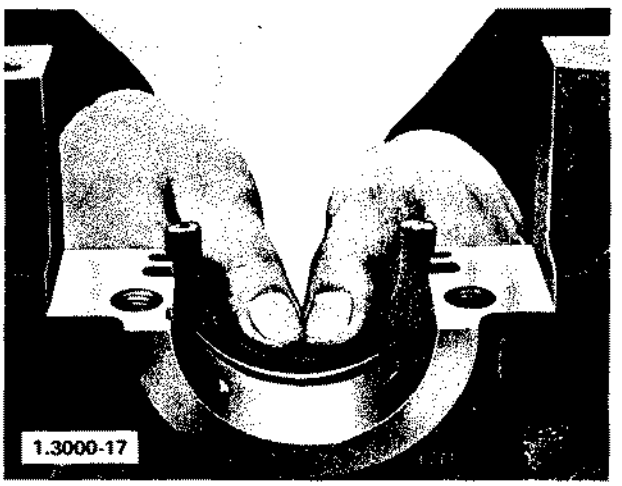


1.3000-14

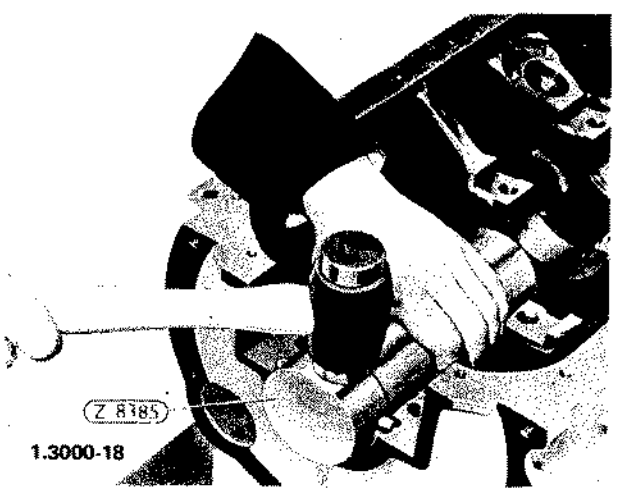
16. After completion of the machining, the crankshaft should be subjected to a Magnaflux crack detection test, full details of usage of crack detection equipment is supplied with the kit, these should be adhered to. Should storage before use be expected, the reconditioned shaft should be protected with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

CRANKSHAFT: (Refitting)

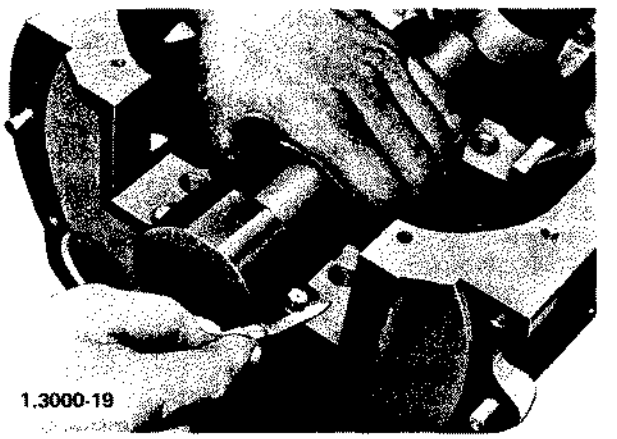
17. The original seal should be removed from the crankcase rear bearing and the groove thoroughly cleaned. A new seal should then be installed in the following manner. The strip seal is fitted into the crankcase bearing outer groove, and tool Z8385 placed as shown in the illustration.



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

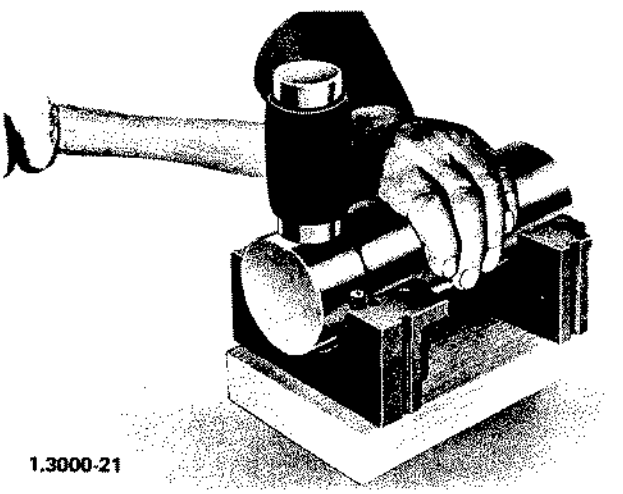


19. With the installer tool held firmly in position and using a sharp knife, cut off projecting ends of seal flush with the bearing cap locating face. Do not leave frayed ends to become trapped between the crankcase and bearing cap.



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

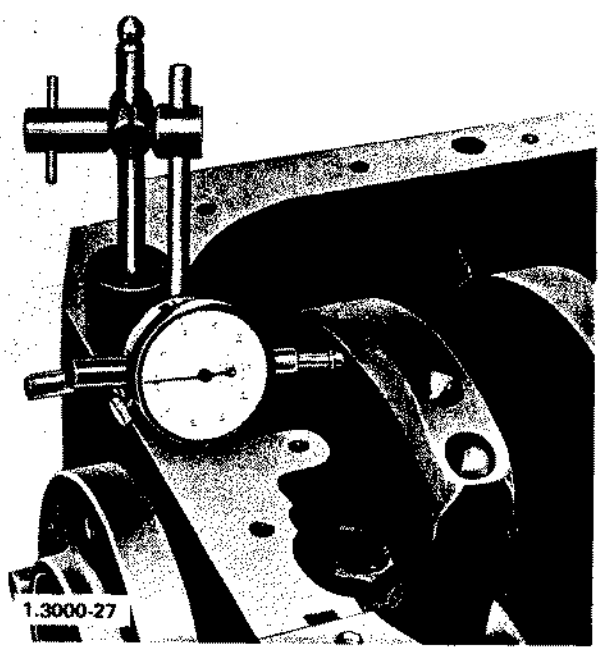
washers to the centre bearing cap. Use clean petroleum jelly in the recesses in the cap to hold the thrust washers in position, whilst the bearing cap is being fitted.

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.

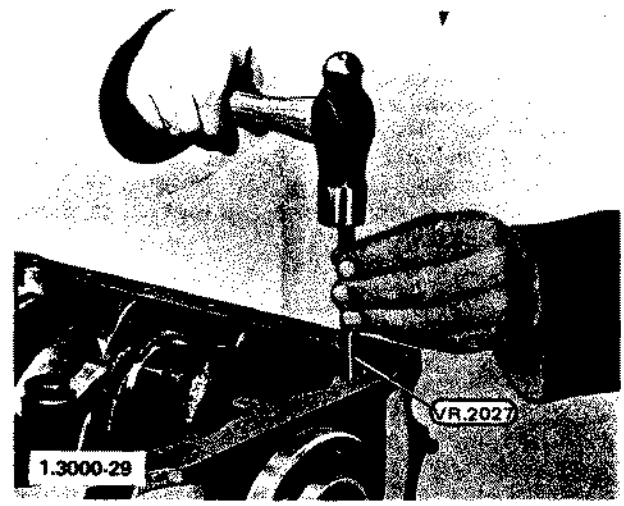
27. Fit a dial gauge to the front sump face of the engine and lever the crankshaft to the extreme limit of rearward movement, set the dial against the web of the crankshaft and set it to zero. With the dial gauge in the position in which it was set, lever the crankshaft forward and note the reading on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

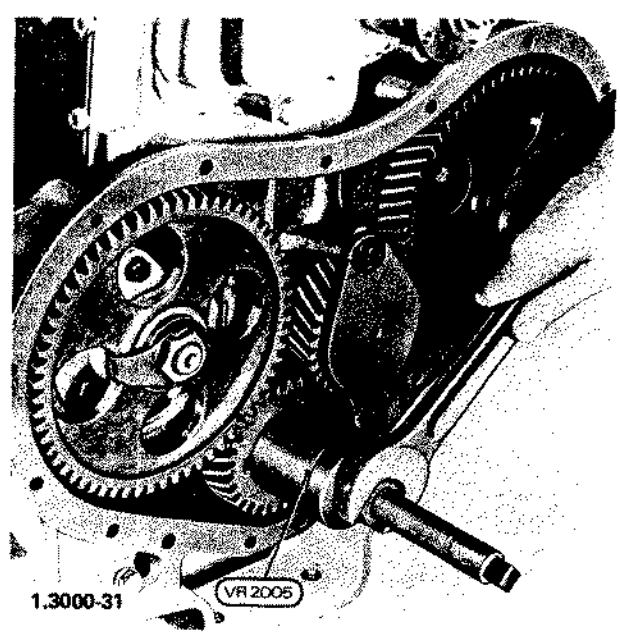
THRUST WASHERS	(THICKNESS)
Standard	.091 to .093 inches
.003 in. Oversize	.094 to .096 inches
.006 in. Oversize	.097 to .099 inches

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).

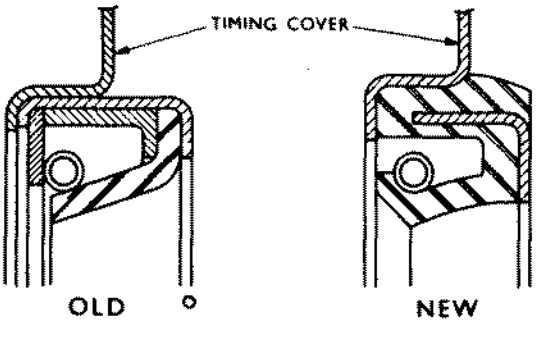
1.3100

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.

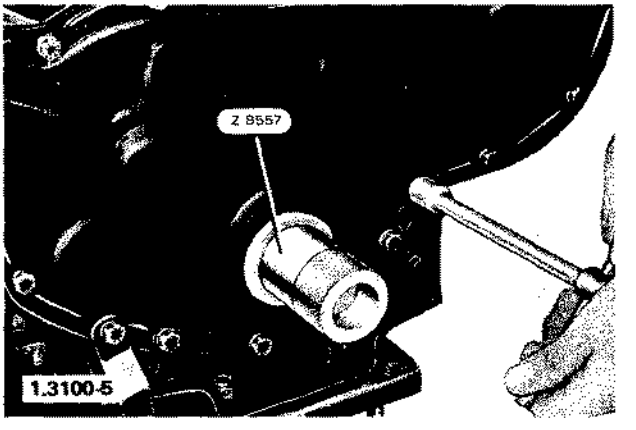
FRONT COVER: (Removal)
2. Remove the crankshaft pulley and vibration damper assembly as detailed in 1.3200. Remove the timing cover attaching bolts, spring washers and reinforcement strip, and lift away the timing cover.

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 2145 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 VR2145. 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 VR2145. 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

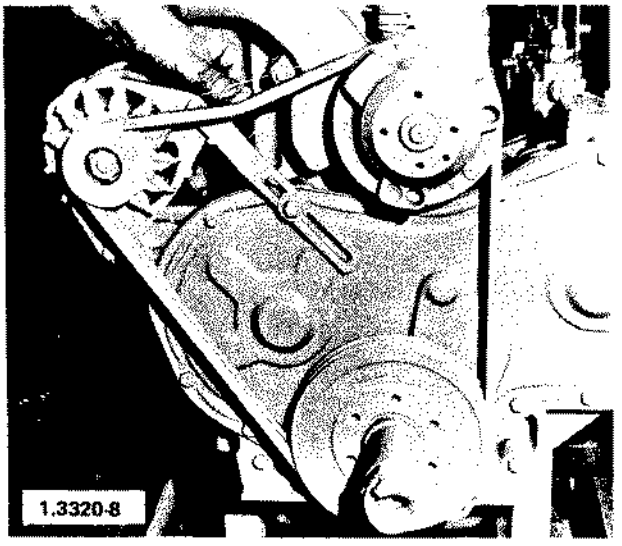
CRANKSHAFT PULLEY BELT

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)

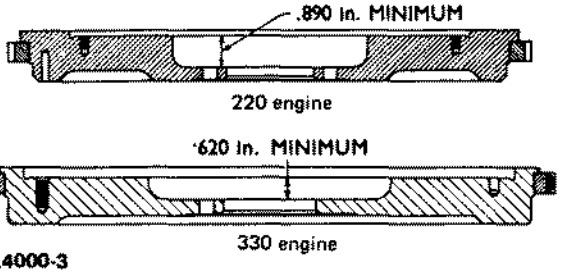
1. Several types of flywheels are available according to the application of the engine. All types however, have the timing marks on the outer edge and also on the inner face. This facilitates interchangeability of the flywheel housing; either automotive or industrial can be used. The ring gear for the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

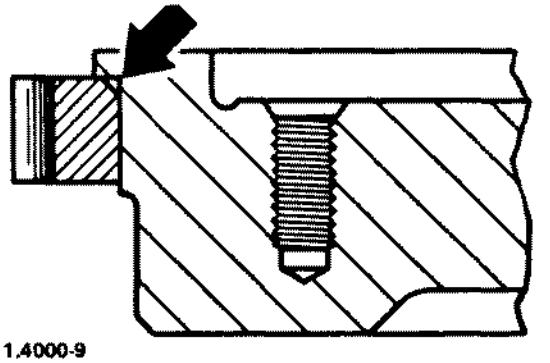
6. Using a hammer and a piece of hardwood as a drift remove the old gear from the flywheel by striking evenly and alternately, at points equally spaced around the gear.

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.

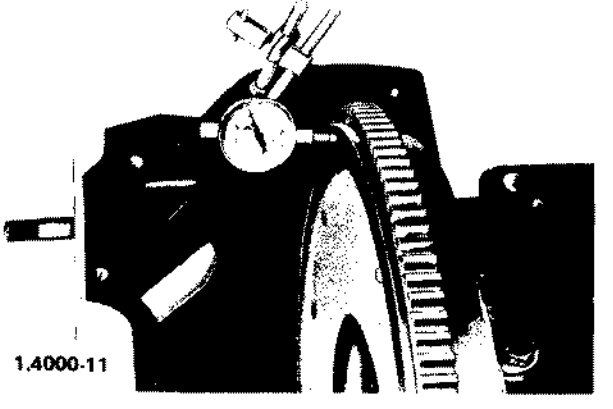


1.4000-9

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)

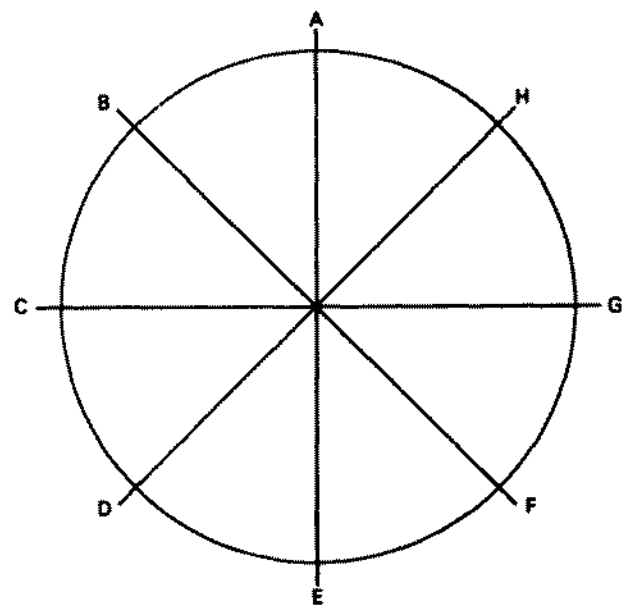
7. The Flywheel housing has no moving parts and thus is not subject to wear, however, incorrect storage can cause distortion and this should be checked. The housing should therefore consist of a visual check for damage and cracks which may have been inflicted. The bore and clutch housing mating flange 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.

		−0.000
	Bore diameter	+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)

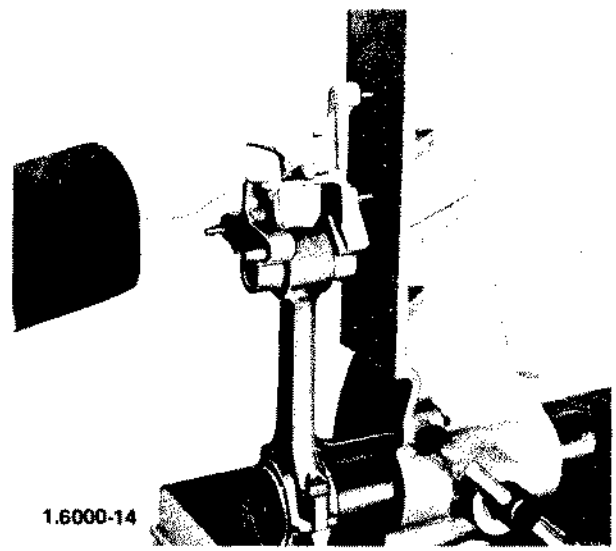
1. The connecting rod is manufactured of 1% chrome steel, case hardened. The bearing is an interchangeable thin shell which is of copper lead tin alloy. The piston pins are fully floating in steel backed bronze bushes, retained by circlips. The piston pin bush is lubricated by splash and oil mist, although 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)

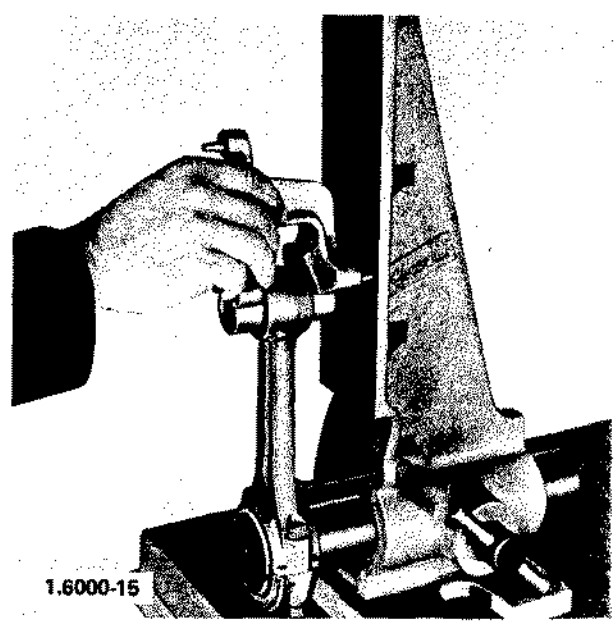
2. Remove the cylinder head (1.2000), and oil sump (4.7000).
3. Mark each connecting rod end on the bosses of the rod and cap with the appropriate cylinder number (front cylinder being number one). Do not use a centre punch or file as such markings may cause fatigue failure.
4. The nuts can now be removed 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)

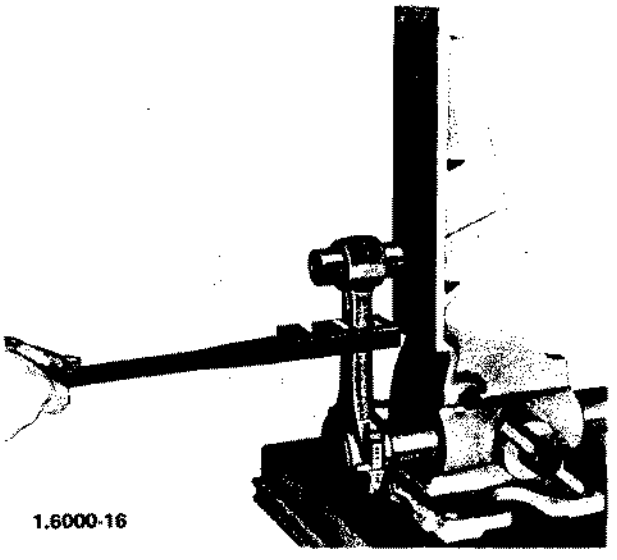
7. Remove the rings from the piston using a piston ring expander. Discard the rings; using a pair of circlip pliers remove the piston pin circlips.
8. Immerse the piston in water which has been heated to a temperature of 150°F (65°C), the pin can now be pushed out.
9. The bearing shells can now be removed 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.



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.

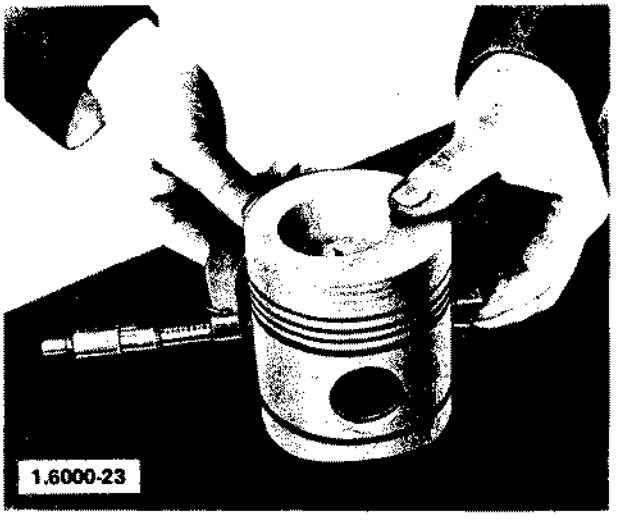
20. Remove the bearing caps, the flattened Plastigauge will be adhering to either the journal or the bearing and should not be removed until it has been measured using the inch scale printed on one side of the Plastigauge envelope, measure the compressed Plastigauge at its widest point. The numbered 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.



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

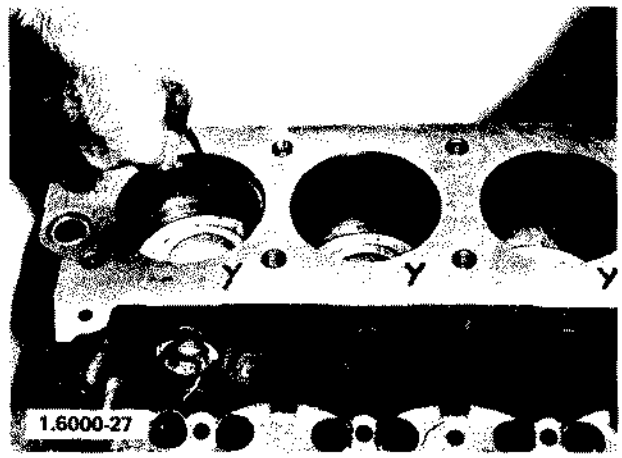
NOMINAL SIZE	GRADE	GRADED SIZE Measured at the top of the piston skirt and at right angles to the piston pin
Standard	Y W	4.0533 to 4.0527 ins. 4.0539 to 4.0533 ins.
0.005 in. O/S	Y W	4.0583 to 4.0577 ins. 4.0589 to 4.0583 ins.
0.020 in. O/S (Maximum for Liners)	Y W	4.0733 to 4.0727 ins. 4.0739 to 4.0733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

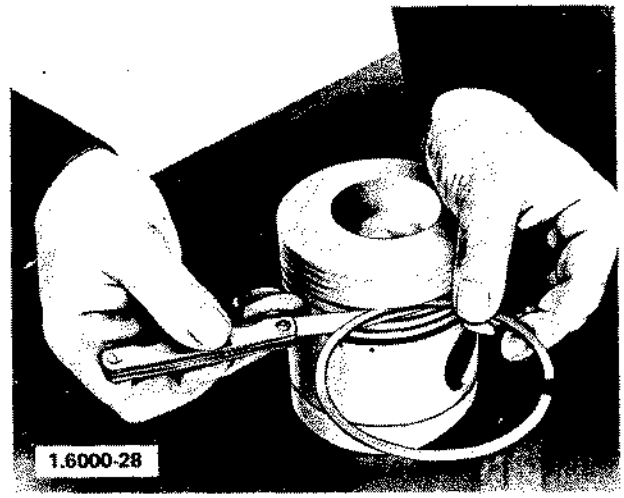
Top Compression Rings	– 0.013 to 0.025 ins.
Second & Third Rings	– 0.006 to 0.023 ins.
Scraper Rings	– 0.013 to 0.025 ins.

Piston Clearance in Cylinder bore
– 0.0099 to 0.0111 ins.

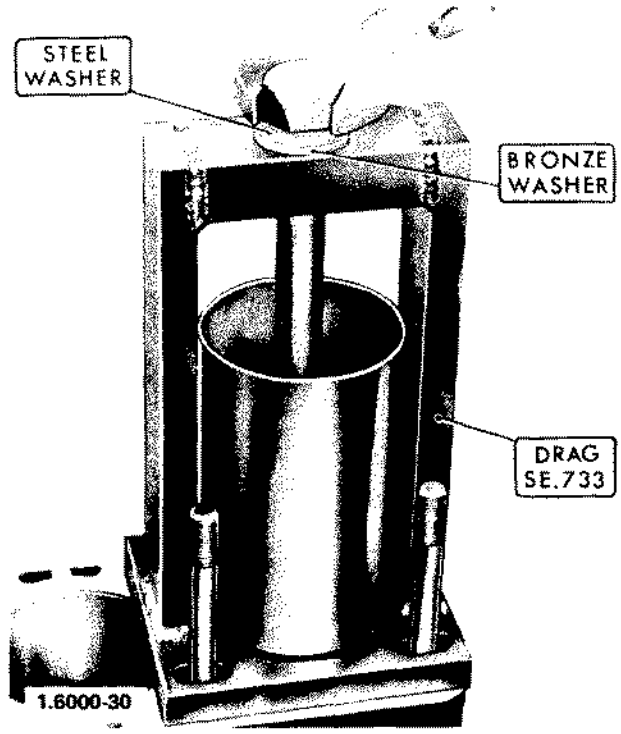


28. Check the clearance of rings in the piston grooves using a feeler gauge; if the clearances are excessive, renew the pistons. The correct clearance is detailed in the table below.

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

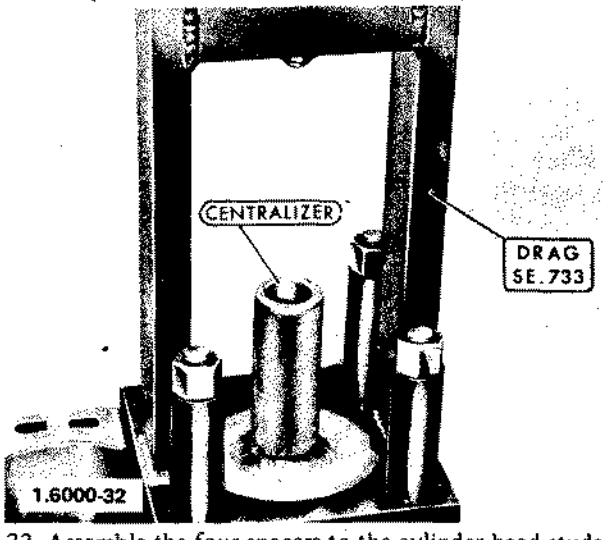


assemblies, therefore, measurement of piston to liner bore clearance and the checking of piston ring gaps prior to installation is unnecessary. Reboring or honing of the cylinder liners is not recommended and for this reason oversize pistons are not serviced.
30. To renew liners withdraw the old liner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

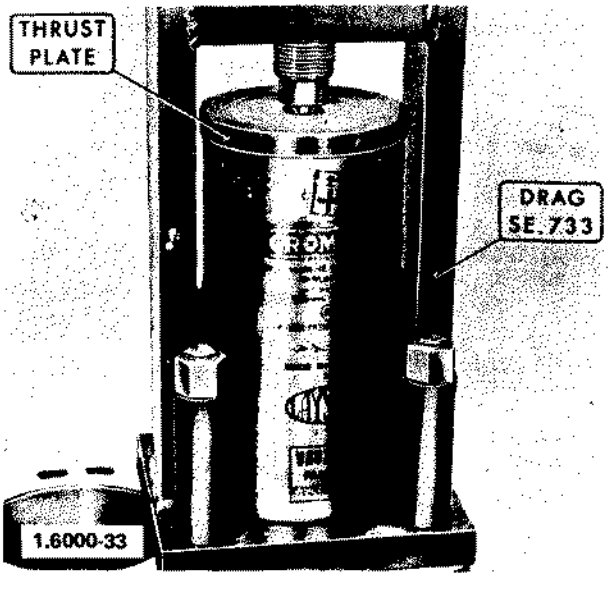


Piston rings	Width	Clearance in Piston grooves
Top compression ring	0.0928 to 0.0938 ins.	0.0045 to 0.0065 ins.
Second & Third (Stepped) Rings	0.0928 to 0.0938 ins.	0.0015 to 0.0035 ins.
Scraper rings	0.1865 to 0.1875 ins.	0.0015 to 0.0035 ins.

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.



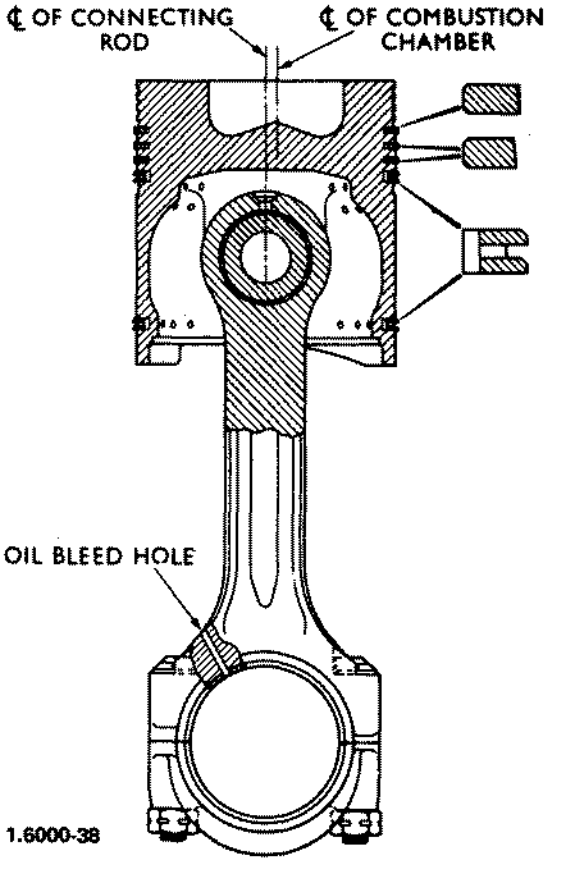
33. Assemble the four spacers to the cylinder head studs, install the nuts to secure the drag in position, and remove the centralizer. Smear the cylinder bore with engine oil. Assemble the dimpled thrust plate to the liner and enter the liner square in the chamfer in the top of the bore.



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.

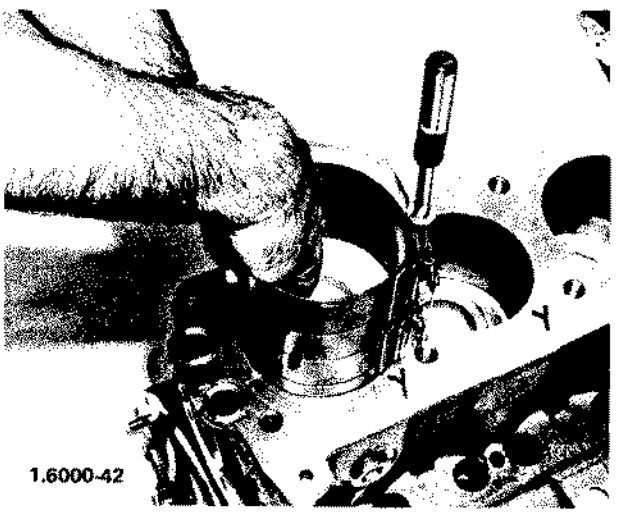
CONNECTING ROD & PISTONS: (Refitting)

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.



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

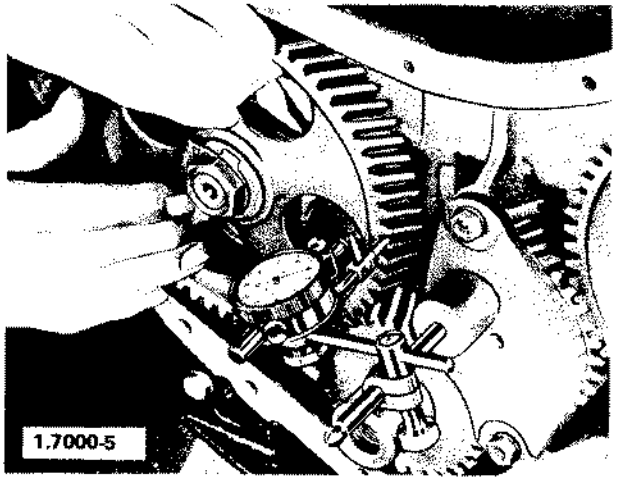
CAMSHAFT & DRIVING GEAR

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.

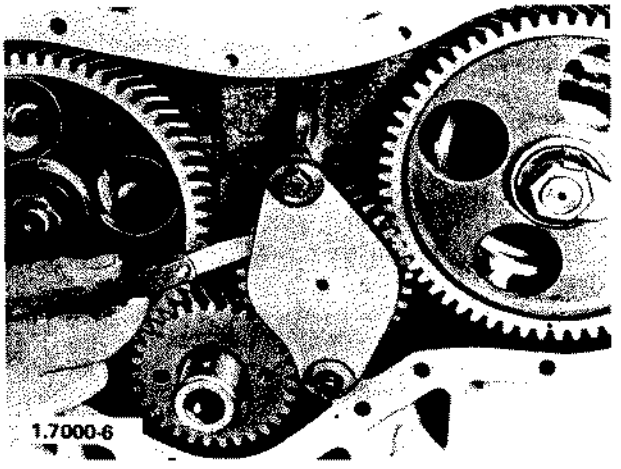
CAMSHAFT & DRIVING GEAR: (Removal)

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:-

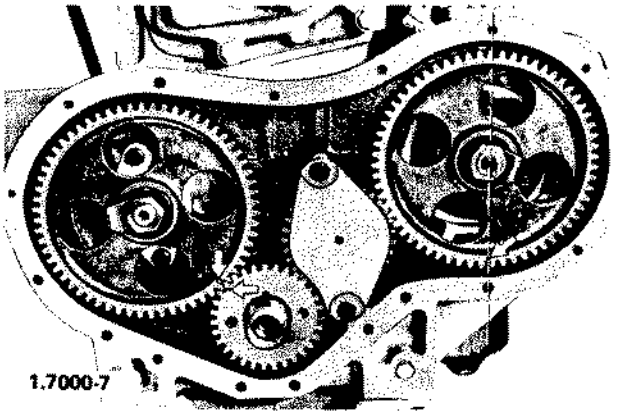


Crankshaft and Camshaft Gears	— .0032 to .0058 ins.
Crankshaft and Idler Gears	— .0023 to .0072 ins.
Idler and Accessory Drive Gears	— .0026 to .0064 ins.

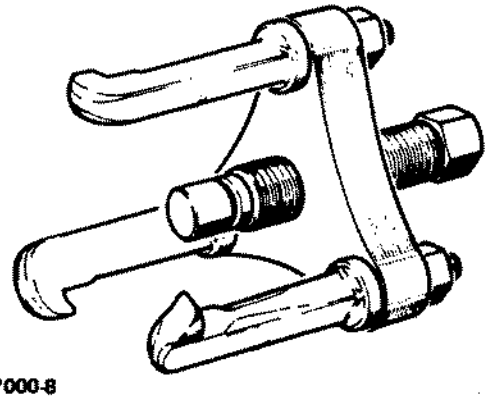
6. Check the end float of the idler gear with feeler gauges. The end float should be .003 to .009 inches. If backlash exceeds the above limits, or the gear teeth are damaged, the gears must be renewed.



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

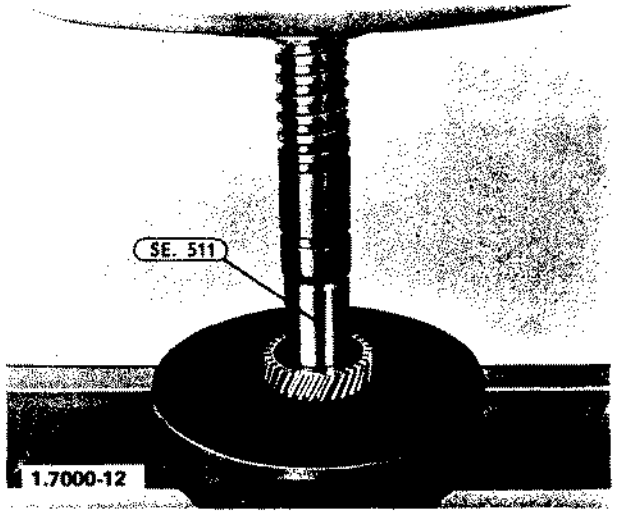


8. Knock back the locking tab and remove the nut, tab washer and plain washer securing the camshaft gear which can now be withdrawn using puller VR2021 illustrated below.



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.



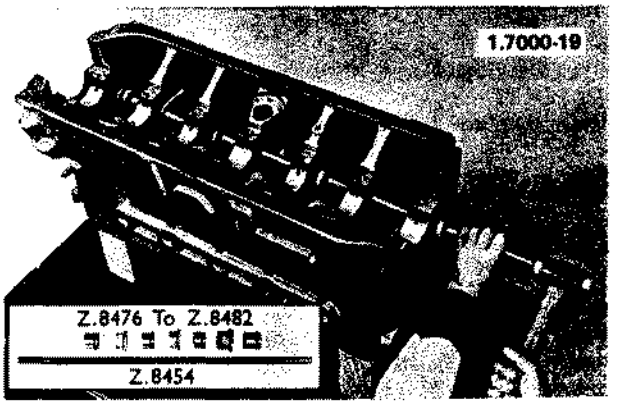
13. Check that the key is in good condition and a snug fit in both the gear hub and the camshaft, also check the skew gear and oil pump drive gear for wear or damage. Examine the cams for pitting or wear on the cam peaks.
14. If the cams are badly pitted and need renewing the tappets should also be renewed. 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:

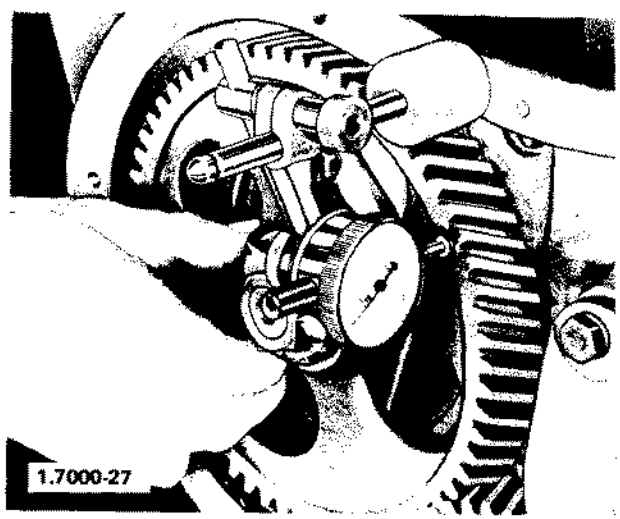
No. 1 (FRONT) 2.139-2.140 (2.141)	No. 2 2.049-2.050 (2.051)
No. 3 2.006-2.007 (2.008)	No. 4 1.976-1.977 (1.978)

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.

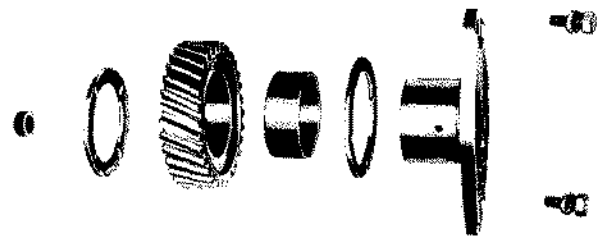


20. Insert the appropriate plug in the front (No. 1) bearing and drive it out of the crankcase. Remove the remaining bearings using the pilots to align and support the drift. When removing the rear bearing the expansion plug will be driven out with the bearing.
21. Replacement bearings with the bore 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.

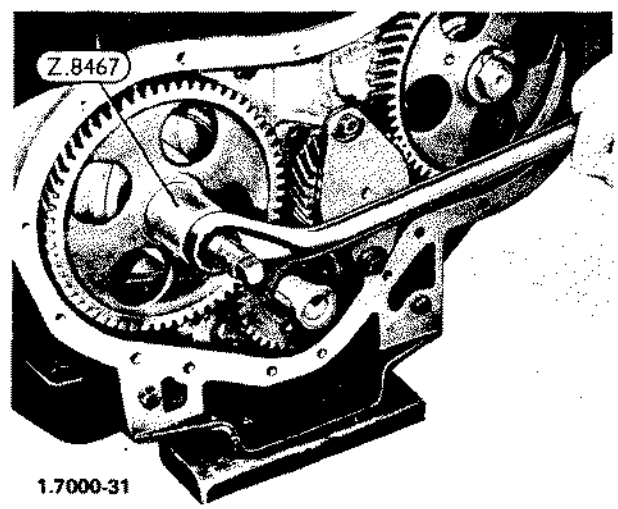
CAMSHAFT & DRIVING GEARS: (Refitting)
25. The camshaft bearings, should be lubricated with engine oil and the camshaft fitted to the crankcase.
NOTE: When fitting the camshaft the journal nearest the driving gear is of a larger diameter than the others, the smallest situated at the opposite end of the 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)

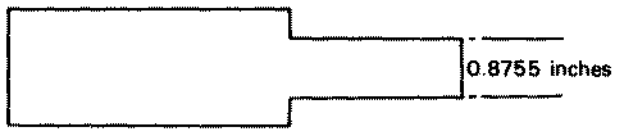
1. The overhead valves are actuated by pushrods which operate via tappets on the camshaft, the motion is transmitted by the rocker arms which pivot on the rocker shaft. The rocker arm has an adjusting screw which has a spherical end into which the cupped end of the push rod engages. The opposite end 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.

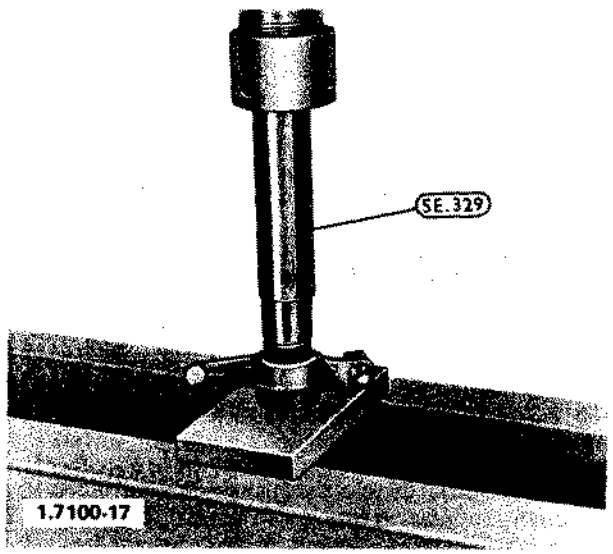
ROCKER SHAFT & COVERS:(Inspection & Overhaul)

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.



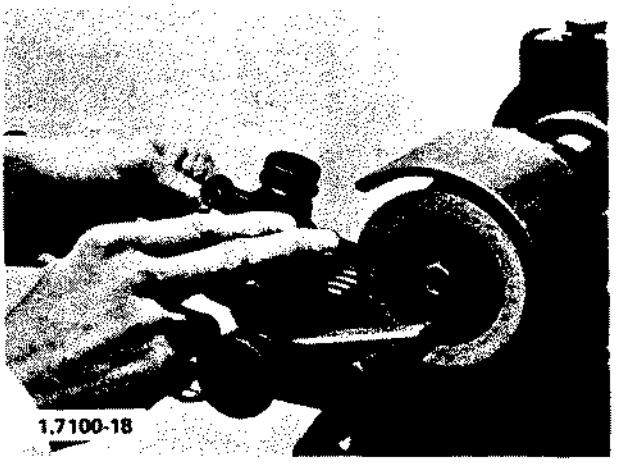
1.7100-15

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.

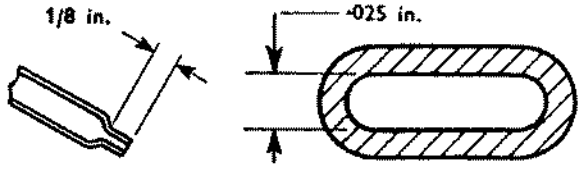


1.7100-17

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.

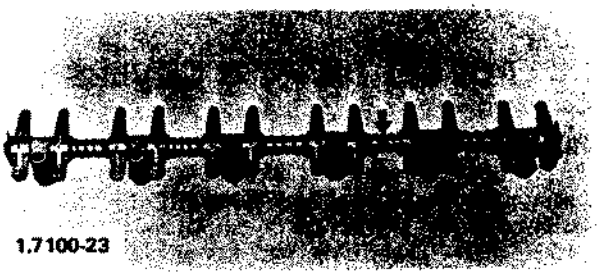

1.7100-18

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.



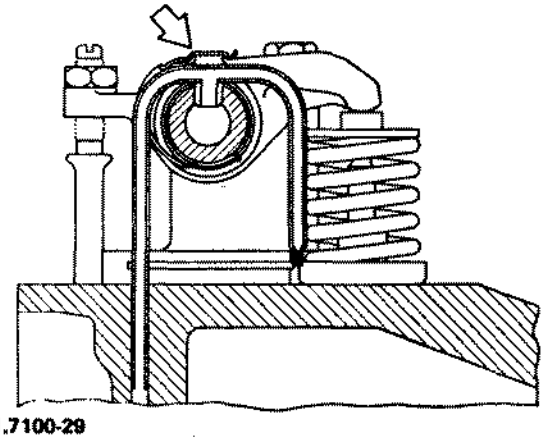
1.7100-20

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,

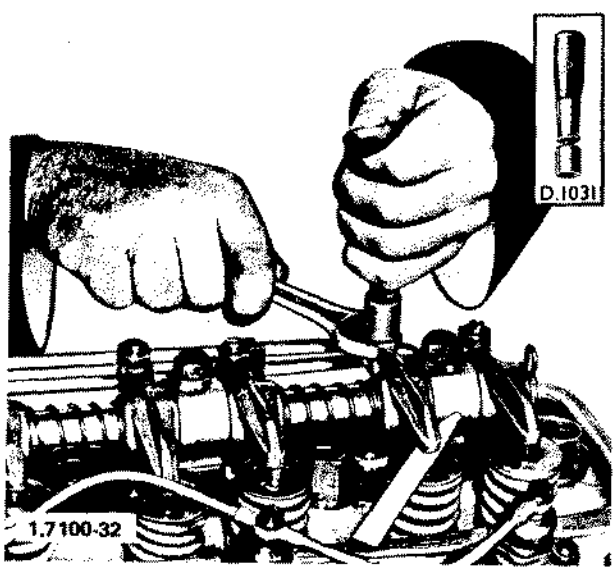
i.e., the exhaust valve about to close and the intake valve just commencing to open.

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

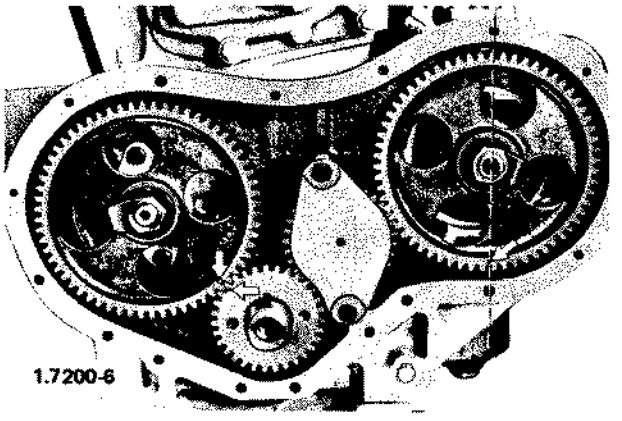
ACCESSORY DRIVE GEAR

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.



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.

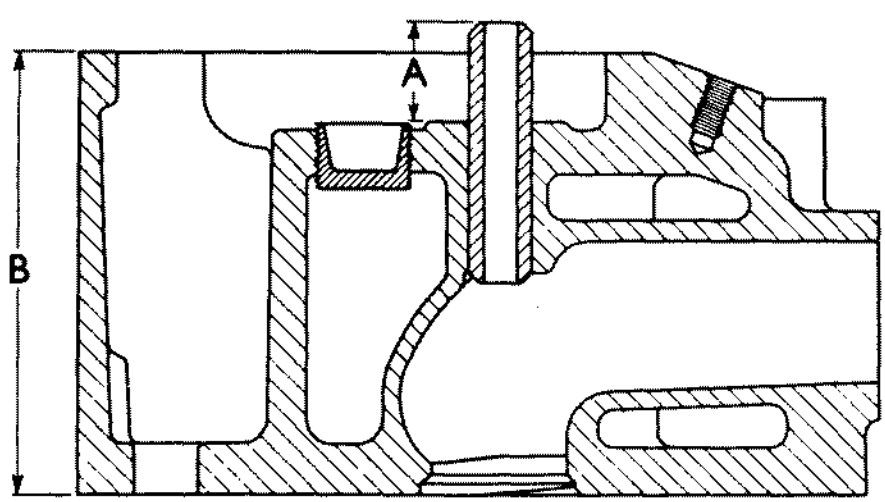
GENERAL DATA

	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

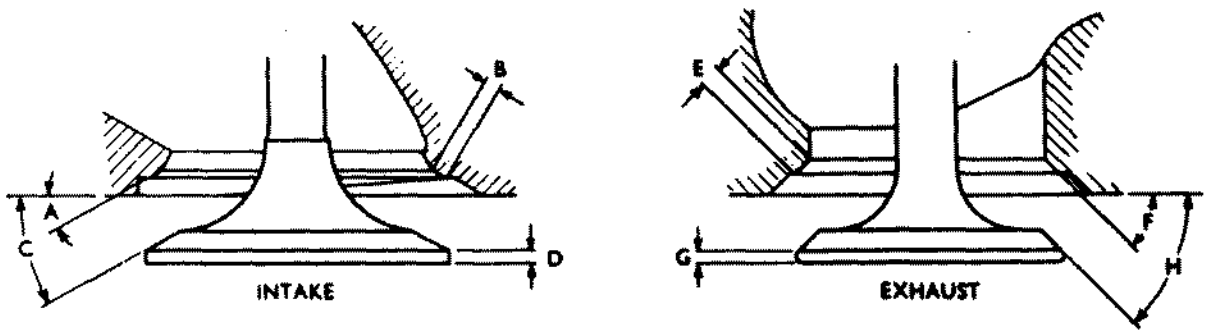
Depth of head	4.2485 to 4.2515 in.
Minimum depth after refacing	4.2385 in. (dimension 'B')
Distortion (maximum permissible):	
Longitudinally	.005 in.
Transversely	.003 in.
Manifold attaching faces	.003 in.



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 Bearing	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							

SECTION 2

FUEL SYSTEM

Contents

2.0000

FUEL SYSTEM

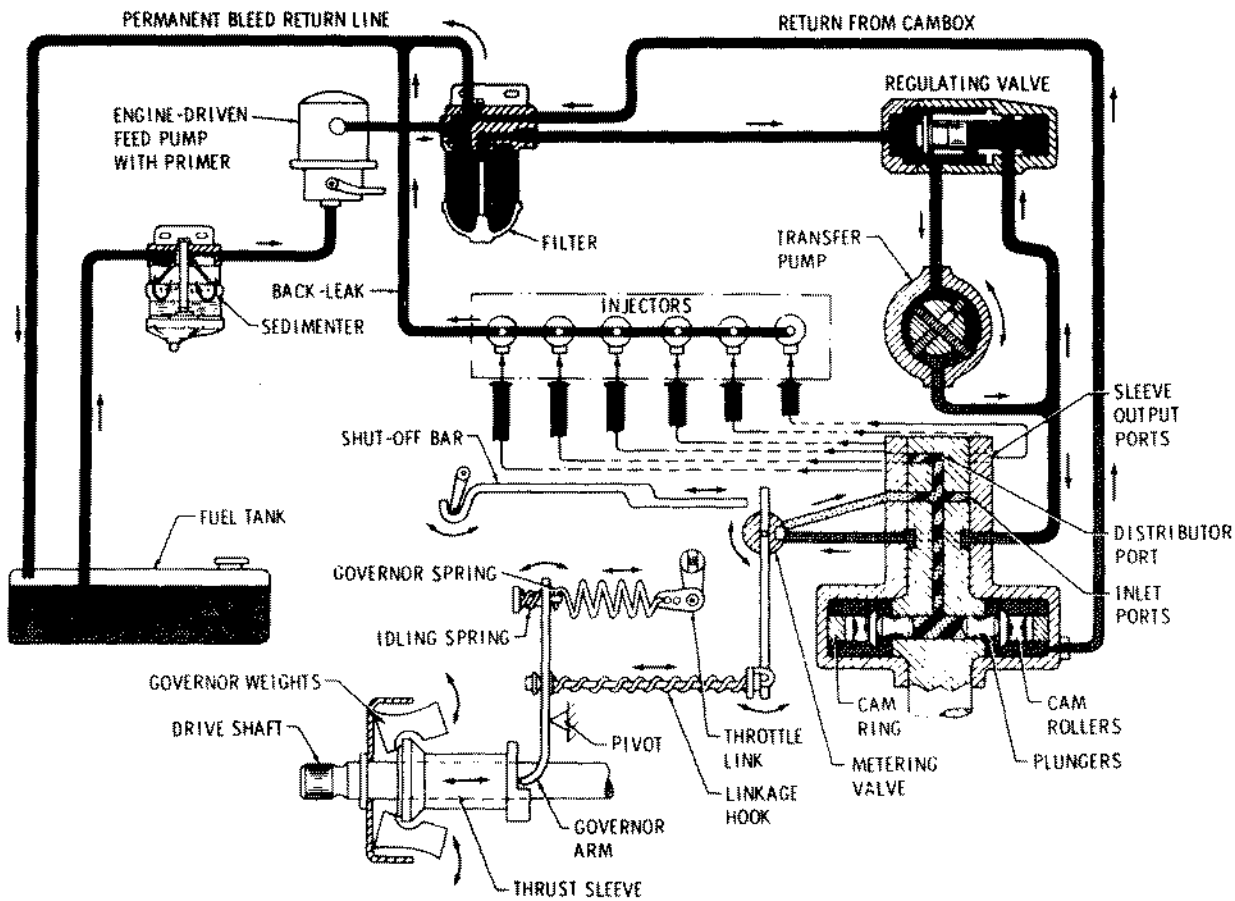
1. The performance of a diesel engine depends largely upon the proper functioning of its fuel injection system.

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.



2.0000-5

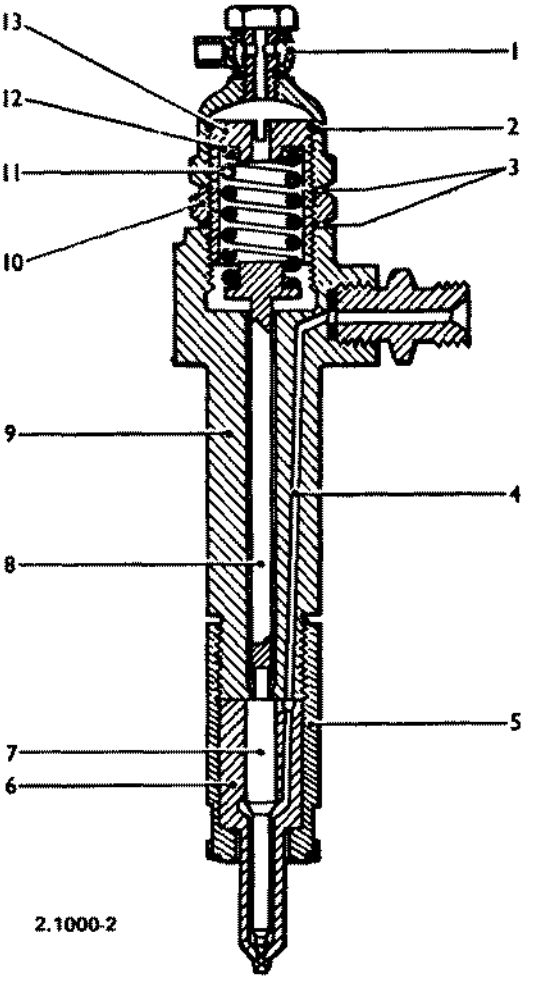
2.1000

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.



2.1000-2

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.

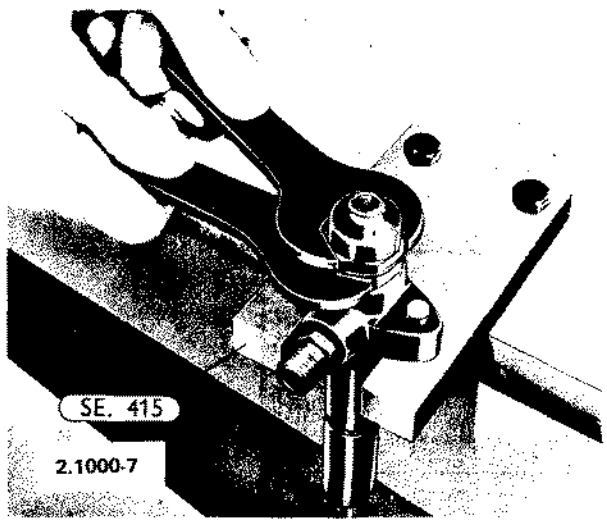
4. Unscrew the attaching nuts and remove the injectors from the cylinder head using puller D1122.

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

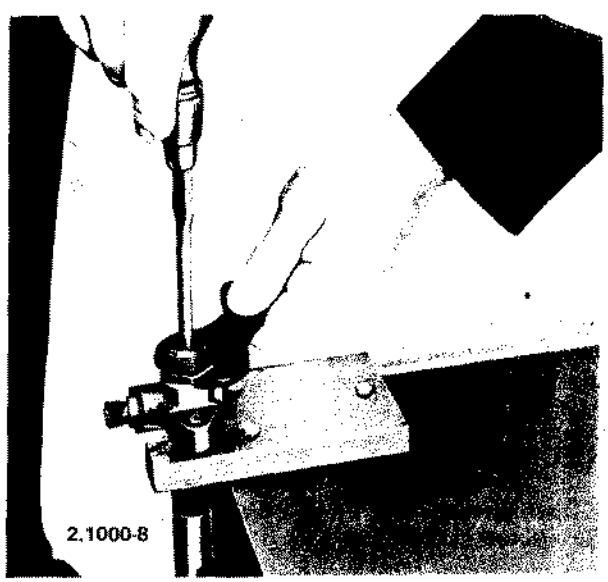
INJECTORS (Inspection and Overhaul)

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.

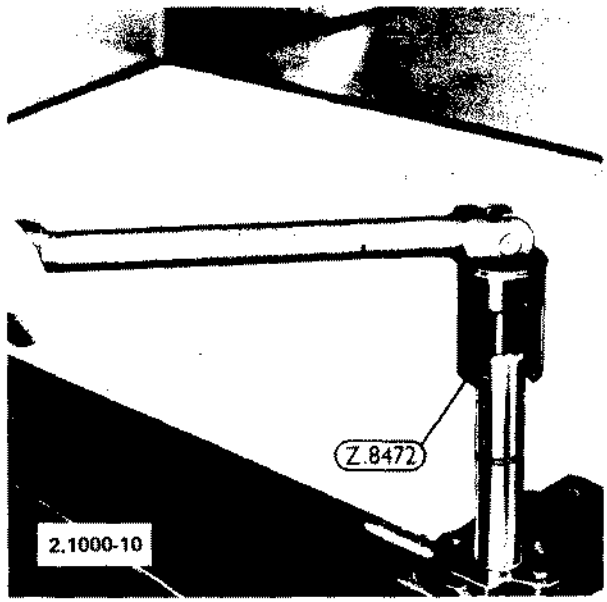


8. On C.A.V. injectors, remove the locknut, seal washer and spring cap nut.



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.

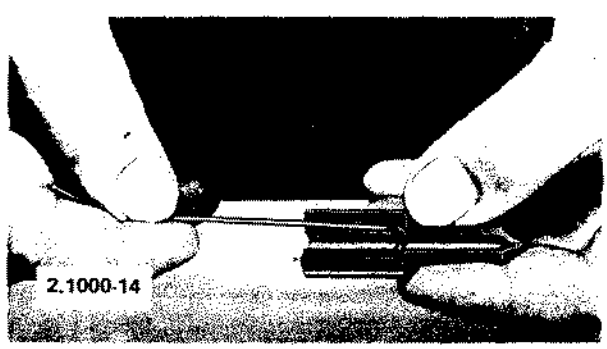


11. Remove the nozzle and valve, and immerse them in a tray containing Shell Fusus cleaning fluid, together with the nozzle holder body and the parts previously removed.

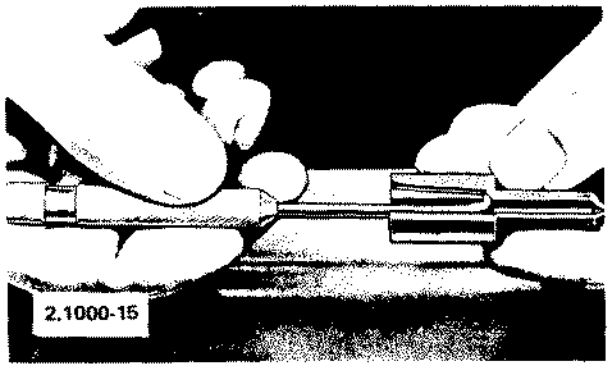
12. The injector components should be thoroughly cleaned using special cleaning equipment.

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

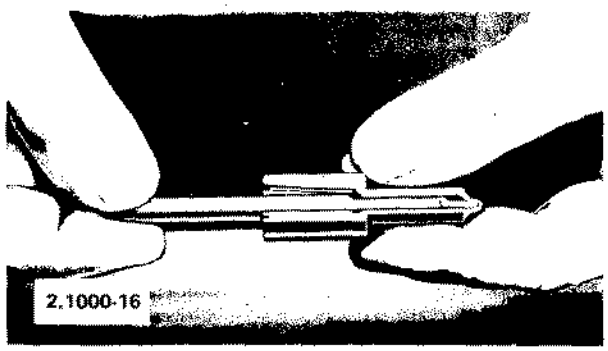
14. Clean out the three small feed channel bores in the nozzle with a drill or wire .067 in. diameter. These bores rarely become choked, and the insertion of a drill or wire will usually be sufficient to clear the channels. A sectioned nozzle is used to illustrate this operation.



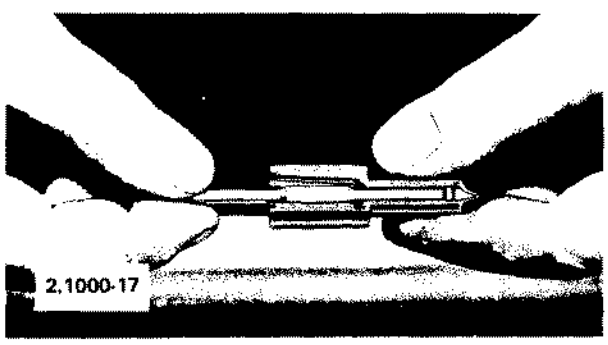
15. Taking care not to damage the valve spindle aperture, insert a nozzle groove scraper and remove any carbon adhering to the internal walls of the nozzle groove.



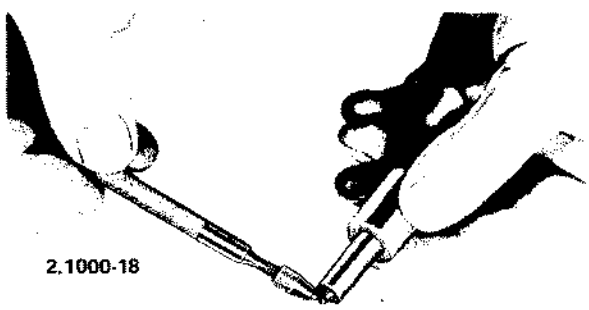
16. Clean the cavity in the nozzle dome below the valve seat, using a dome cavity scraper.



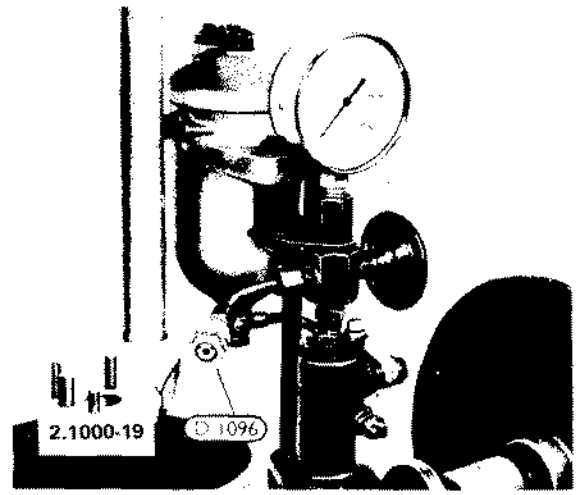
17. Using a nozzle seat scraper, clean all carbon from the valve seat.



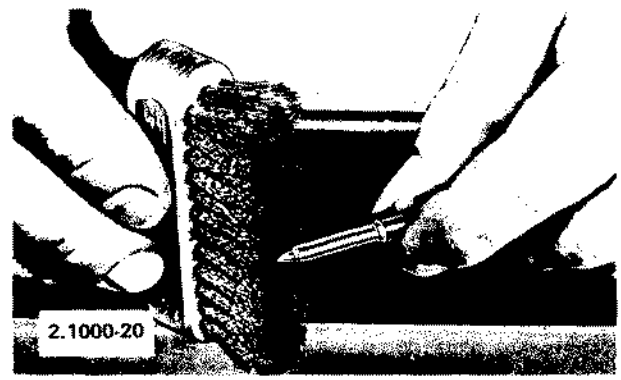
18. Clean the spray holes with a probing tool and cleaning wire.



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

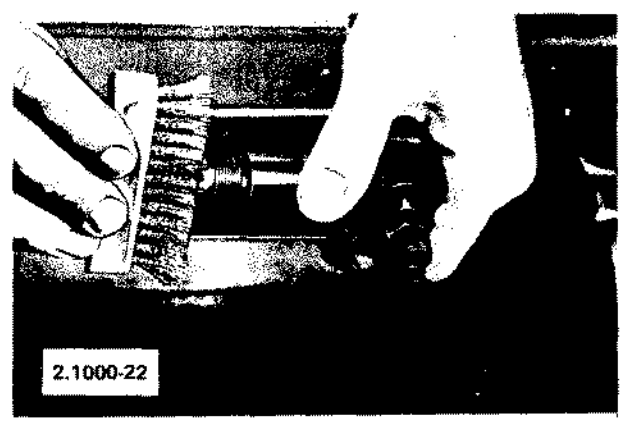


20. Clean the nozzle valve tip and stem using the brass wire brush.



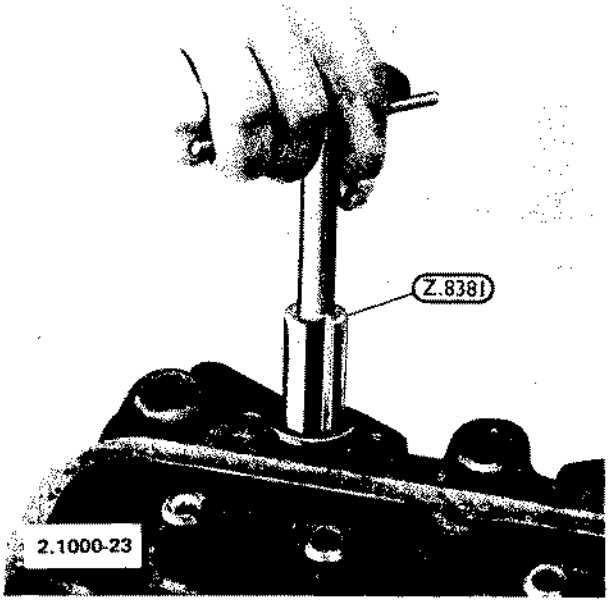
21. Check the nozzle for damage, and blueing due to overheating. If either of these conditions exist, the nozzle and valve must be renewed.

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.

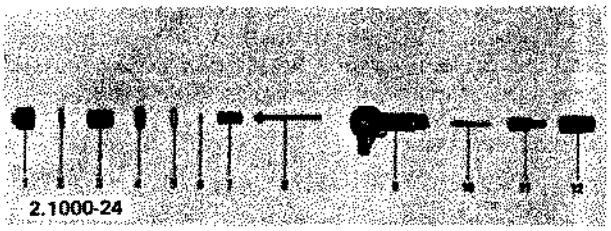


NOTE: In no circumstances must the valve and valve seat surfaces be reground, as this operation is a specialised process and any attempt without the necessary equipment will render the injector assembly useless.

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.

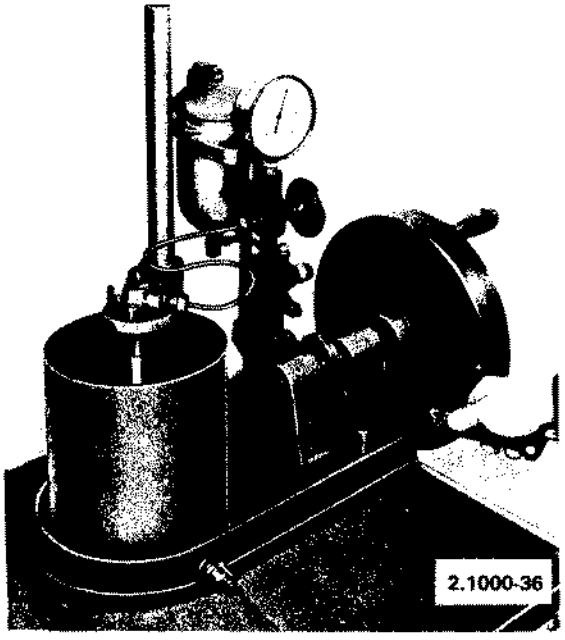
32. With the check valve still open, pump up again to just below this pressure.

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.

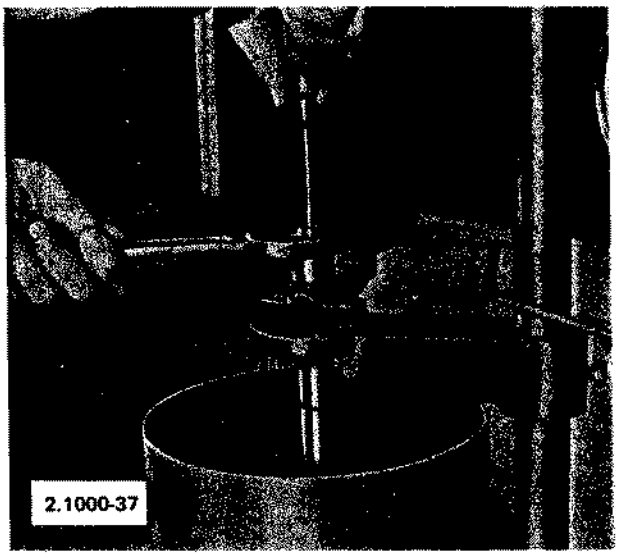
34. For new injectors the back leakage pressure to drop from 150 to 125 atmospheres at a temperature of 50° – 70°F (10° – 21°C) in not less than 10 seconds and not more than 45 seconds.

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.

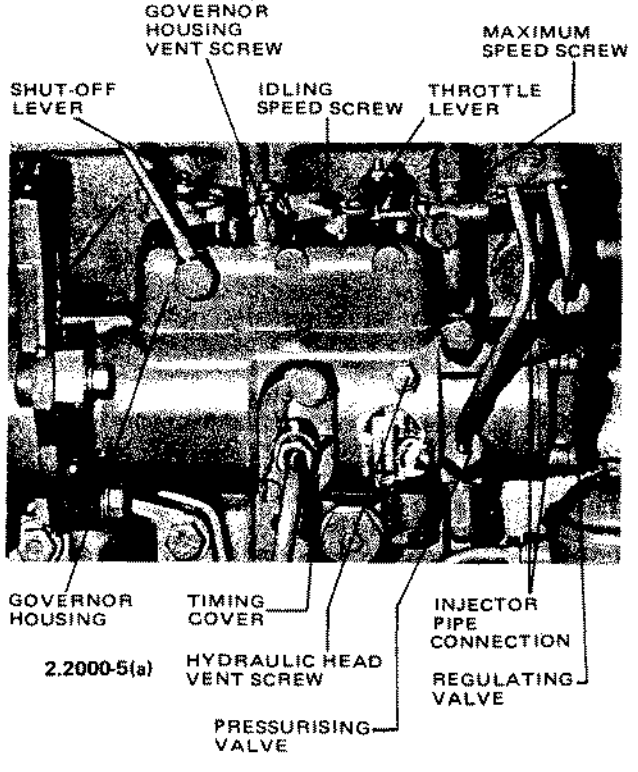
43. Before connecting the fuel pipes to the injectors, detailed in section 2.5000, rotate the engine with the starter to check for blow past the seat seal washer. If this condition is apparent, the securing nuts must be slackened and retightened to obtain a perfect joint.

2.2000

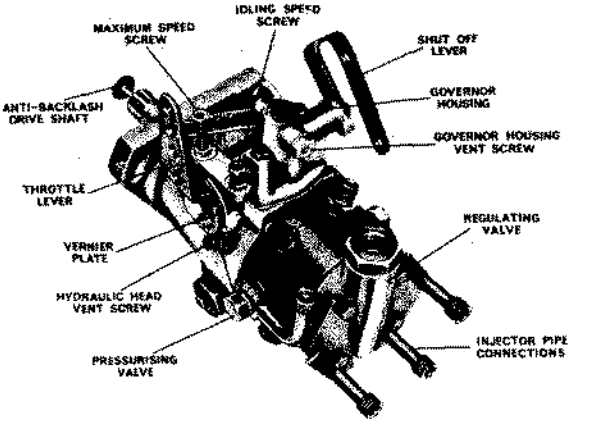
FUEL INJECTION PUMP DPA TYPE

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.

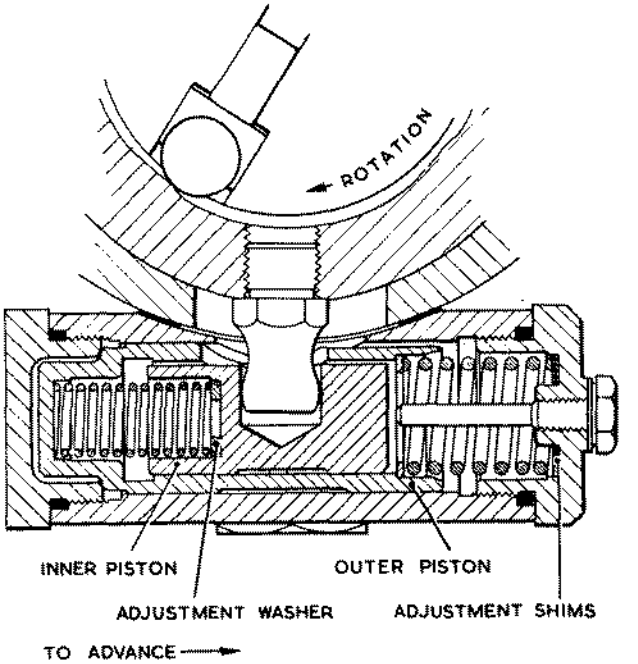


2.2000-5(a)



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.

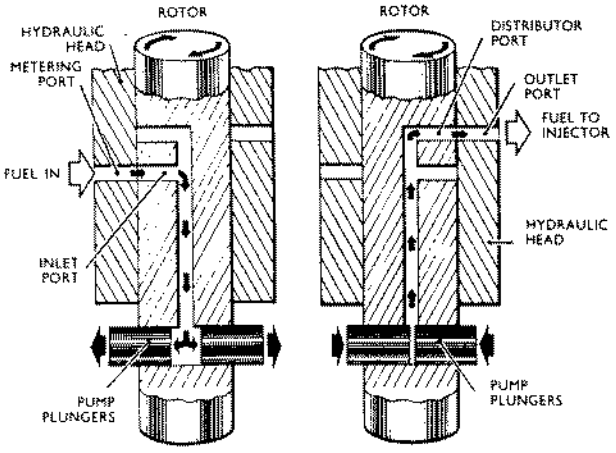
The Working Principle

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

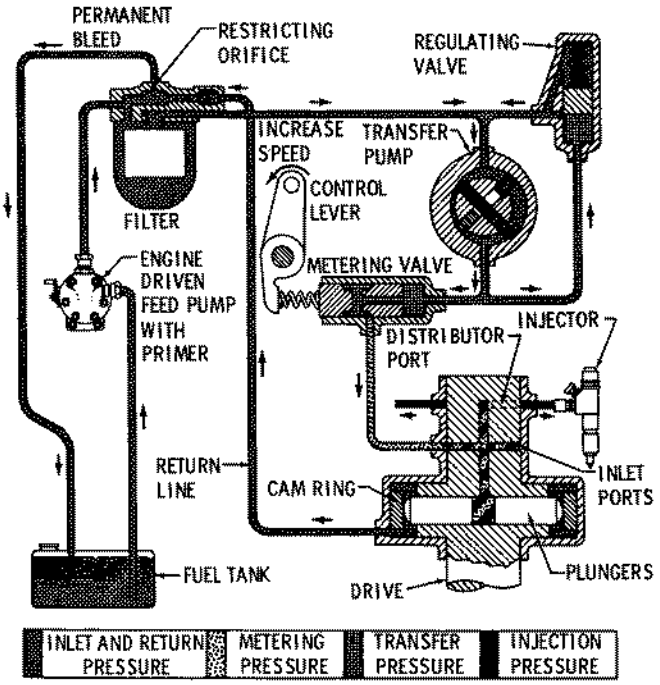
2.2000-10 2.2000-12

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.



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)

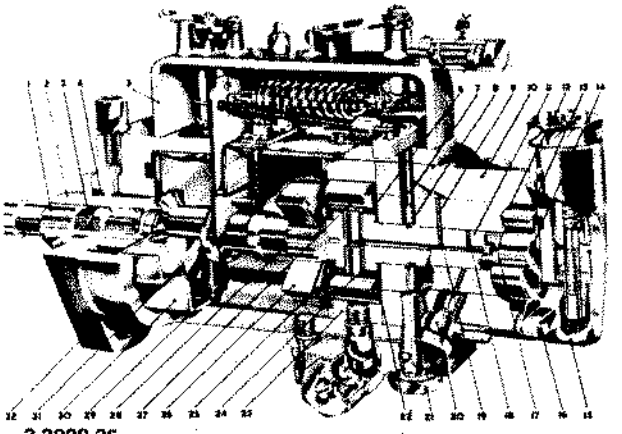
General Information

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

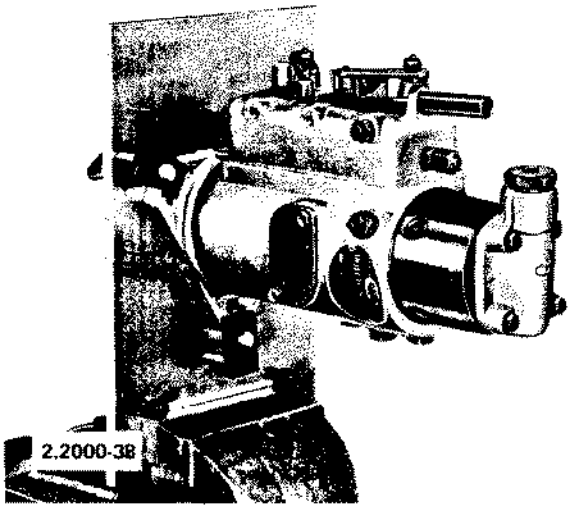
36. Dismantling sequence (annotations refer to 2.2000 – 36).



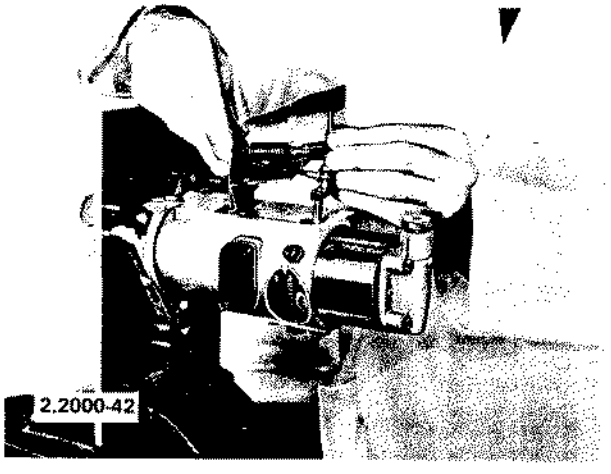
2.2000-36

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.

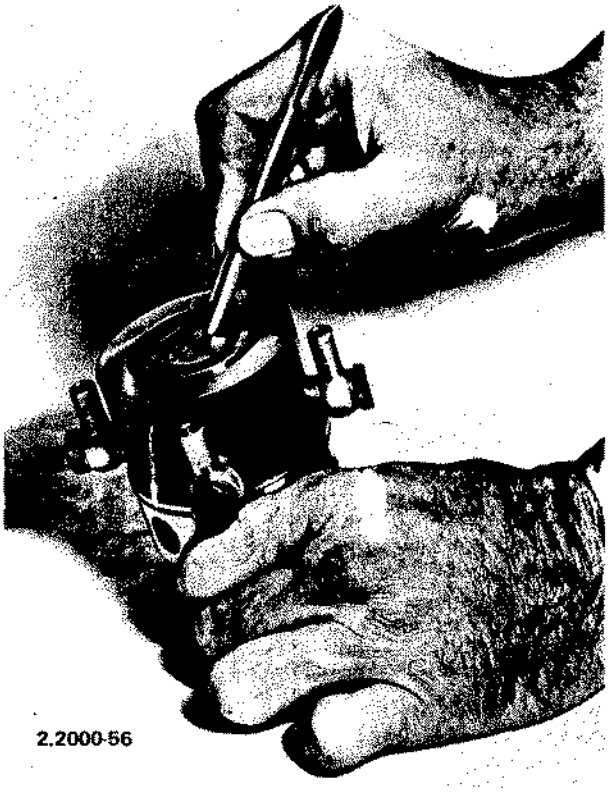


39. Remove the 'shut-off' and throttle levers from the control shaft.
40. Remove the two acorn nuts securing the governor control housing (5). Exert downward pressure on the throttle shaft while removing the governor control cover.
41. Knock down the tabs on the tab washers which lock the two governor 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.

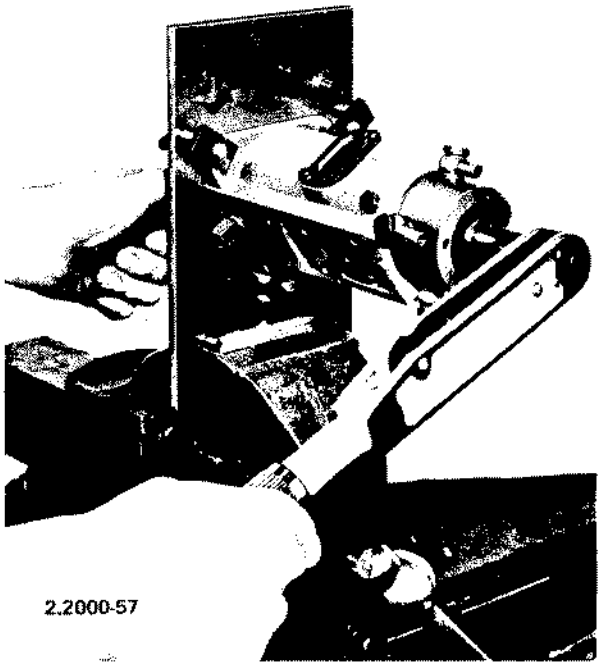


43. Disconnect the metering valve from the hook lever and protect the precision ground surface from damage and corrosion by immersing it in a bath of clean fuel oil.
44. Dismantle the control linkage.

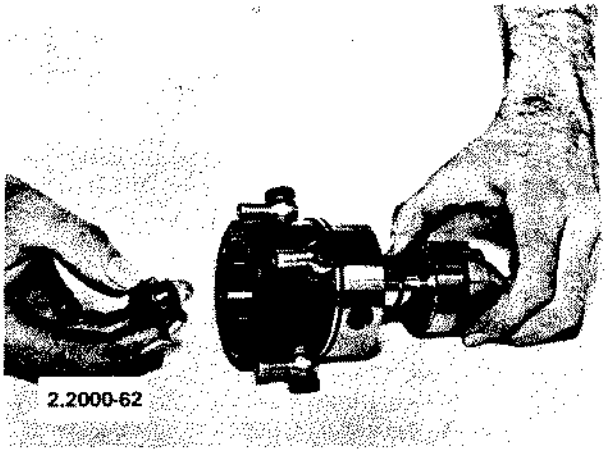
45. When fitted, remove the automatic advance device as follows:-
46. Reverse the fixture in the vice so that the advance device is uppermost, and remove the nut from the advance device securing stud (if device has two point fixing).
47. Remove the cap and springs.
48. Unscrew the head locating fitting (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.

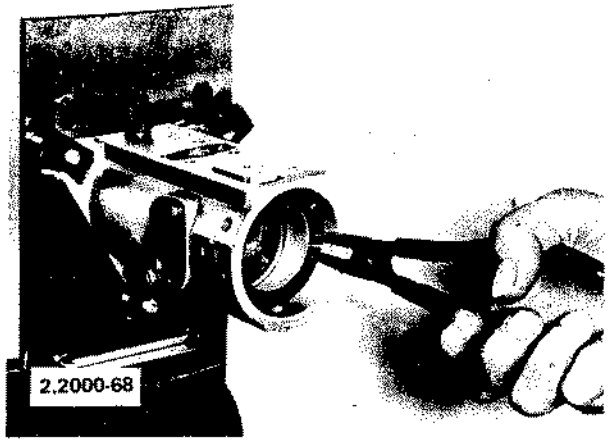


58. Remove the two head locking screws, and the single head locating screw. In pumps fitted with an automatic advance device the head locating screw is replaced by the head locating fitting which is removed with the advance device.
59. Remove the hydraulic head and the rotor as an assembly.
60. Hold 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.