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SERVICE MANUAL

Volume 1

Ford

Industrial
Power
Products

Ford
Industri Produkter

industriprodukter SERVICE - MEDDELANDE

1

JANUARI 1984

Motorserie 2720

BETRÄFFANDE: Rättelser av servicehandbok

Gällande upplaga (september 1982) av servicehandboken för serie 2720 innehåller en del felaktigheter i Del 1.

V.g. rätta kopian (kopiorna) enligt följande:

Sid. 23 Andra meningen i paragraf 4, spalt 2, skall lyda "Om motorn förses med nya hylsor skall kolvkylningsmunstyckena avlägsnas för att undvika skador eller blockering."

Sid. 57 Cylinderfodrets utskjutning ovanför eller nedanför cylinderblockets övre yta
Denna skall vara "0,0254 mm", inte "0,254 mm ".

Sid. 57 Mantelns diameter – standardstorlek
Detta skall vara "2722 och 2725 motorer", inte "2722 och 2723 motorer".

Industrial Power Products

INDUSTRIAL PRODUCTS SERVICE MANUAL FOR 2720 RANGE ENGINES

VOL. I – BASE ENGINE

Naturally aspirated industrial or marine engines
2722 - 4 Cyl. 4,150 litre (254 cu in)
2723 - 6 Cyl. 5,950 litre (363 cu in)
2725 - 6 Cyl. 6,220 litre (380 cu in)

Turbocharged industrial or marine engine
2726T - 6 Cyl. 5,950 litre (363 cu in)

Turbocharged and intercooled marine engine
2728T - 6 Cyl. 5,950 litre (363 cu in)

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Industrial Power Products

WARNING: The following health and safety recommendations should be carefully observed.

Carrying out certain operations and handling some substances can be dangerous or harmful to the operator if the correct safety precautions are not observed. Some such precautions are recommended at the appropriate points in this book.

Whilst it is important that the recommended safety precautions are observed, care near machinery is always necessary, and no list can be exhaustive. Always be on your guard!

The following recommendations are for general guidance:

1. Always wear correctly fitting protective clothing which should be laundered regularly.

Loose or baggy clothing can be extremely dangerous when working on running engines or machinery.

Clothing which becomes impregnated with oil or other substances can constitute a health hazard due to prolonged contact with the skin even through underclothing.

2. So far as practicable, work on or close to engines or machinery only when they are stopped. If this is not practicable, remember to keep tools, test equipment and all parts of the body well away from moving parts of the engine or equipment - fans, drive belts and pulleys are particularly dangerous.

3. Avoid contact with exhaust pipes, exhaust manifolds and silencers when an engine is, or has recently been running; these can be very hot and can cause severe burns.

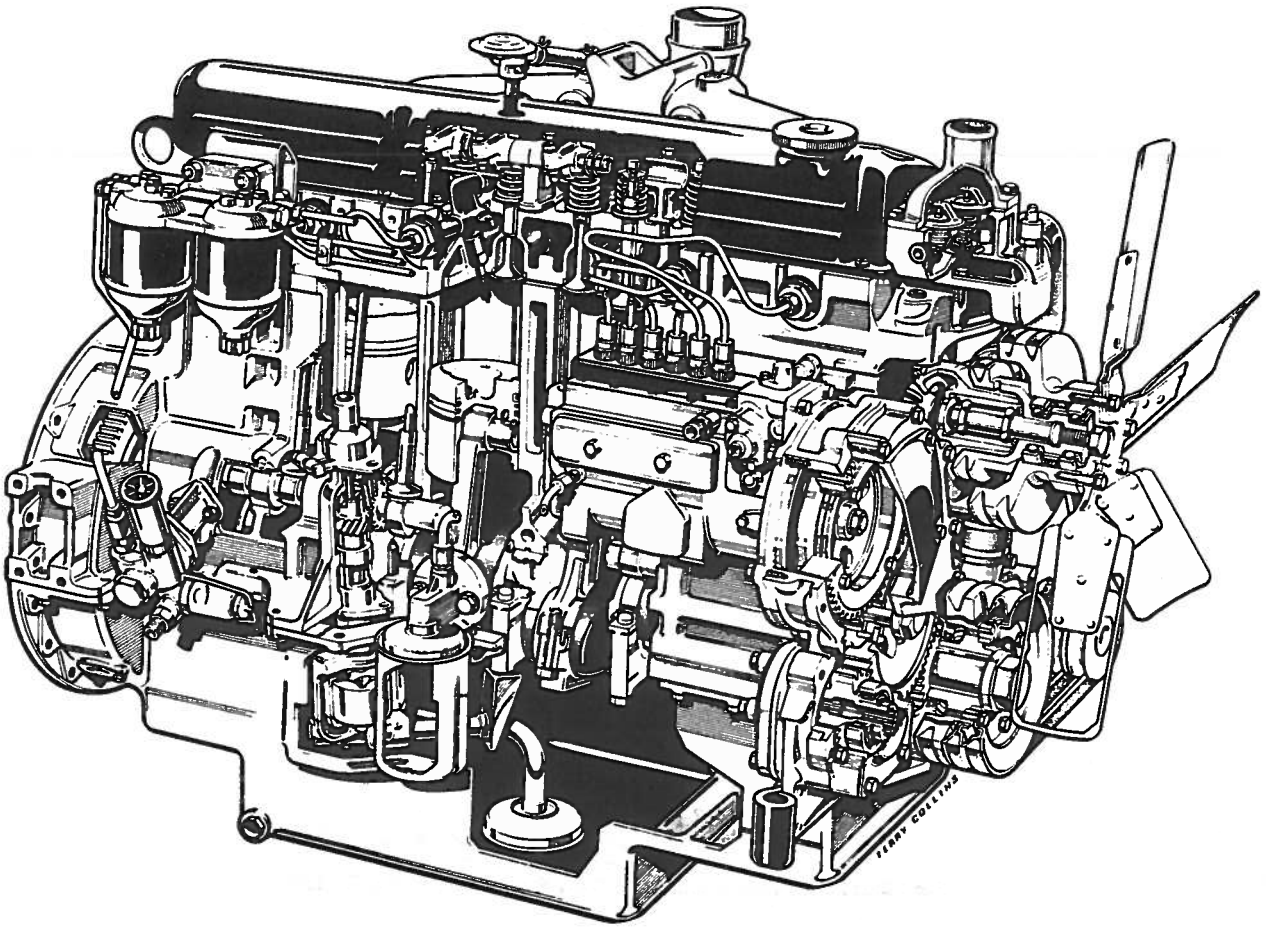
4. Many liquids used in engines or vehicles are harmful if taken internally or splashed into the eyes. In the event of accidentally swallowing gasoline (petrol), oil, diesel fuel, anti-freeze, battery acid, etc. do NOT encourage vomiting and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

Wear protective goggles when handling liquids which are harmful to the eyes; these include ammonia and battery acid. If any of these substances are splashed in the eyes, wash out thoroughly with clean water and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

FOREWORD

Where the terms 'Right' or 'Left' occur in this publication, they refer to the respective sides of the engine when viewed from the rear or flywheel end.

Pistons and valves are numbered from the front or timing cover end of the engine commencing at No. 1.



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GENERAL DESCRIPTION

All Ford 2720 range diesel engines are of in-line cylinder configuration working on the direct injection principle.

The combustion chamber is formed in the piston crown and the overhead valves are operated by push rods from the camshaft which is gear driven from the crankshaft. Standard and heavy duty PTO (power take-off) engines are available, the drive being taken from the timing gears.

A compressor or exhauster can be driven from the rear PTO drive position and, depending on the type of compressor selected, a power steering pump or PTO drive flange can also be added to the compressor.

A heavy duty PTO can be driven from the front or rear of the timing gear housing according to the engine build selected.

The 6-cylinder engines are available in turbocharged form, the type of turbocharger and associated manifolding fitted depending on the engine application.

Water cooled turbochargers and exhaust manifolds are fitted to marine engines and the 2728T engine has a water cooled charge air cooler (intercooler) fitted.

The fuel injection pump is an in-line type with a separate pumping element for each engine cylinder; it contains a mechanical governor to ensure that the selected engine speed remains constant despite variations in the driven load.

Governors are available with characteristics suitable for G.P. (general purpose), automotive, Class 'A' or combine harvester applications.

ENGINE IDENTIFICATION

Identification of the cylinder block, and therefore of the basic engine type can be made by reference to the two raised machined pads on the top edge and the stamped area on the lower edge of the cylinder block. An additional stamped code is sometimes included for marine insurance approved type identification. As shown in Fig. 1, all these identification points are on the fuel injection pump side of the engine.

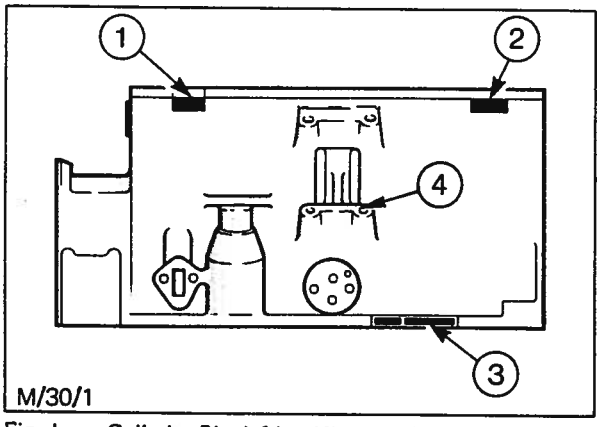

Fig. 1 - Cylinder Block Identification Codes
1. Engine Capacity
2. Engine Type/Build Date
3. No. of Cylinders
4. Marine Insurance Approved Type Identification

Engine Capacity

Code	Engine Capacity & Type
254	4,2 litre (254 cu in)
365NA	6,0 litre (365 cu in)
380NA	6,2 litre (380 cu in)
365TC	6,0 litre (365 cu in)

Note: NA = Naturally Aspirated
TC = Turbocharged

Number of Cylinders

One digit (1) is stamped for each cylinder.

1111 = 4 cylinder engine
111111 = 6 cylinder engine

Marine Insurance Approved Type Identification
where applicable, an identification code is stamped,

e.g. LRS QC142 = Lloyds
NV E 1760/1 = Det Norske Veritas

ORIGINAL ENGINE BUILD DATA PLATE

During engine production, an original engine build data plate is fitted on the right hand side of the cylinder block on the flywheel housing (Fig. 2). This plate identifies in millimetres the crankshaft main journal diameter (crank mains), main bearing cap/cylinder block inside diameter (block mains), and the crankshaft big end journal diameter (crank pins).

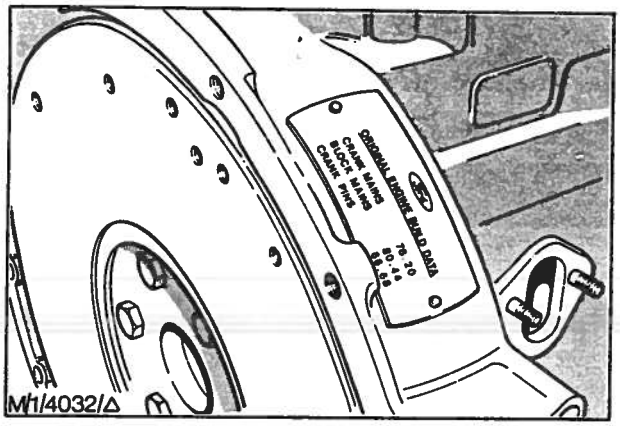

Fig. 2 - Location of Original Engine Build Data Plate

Four possible combinations of sizes may be encountered, and these are identified by the colour of the plate and the dimensions on the plate - see Fig. 3.

SERVICE ENGINES

Service engines are fitted with a service cylinder data plate, giving dimensions in millimetres of crank main bearing diameter, crank big end bearing diameter, block main bearing diameter, and block cam bearing diameter - see Fig. 4.

The service cylinder data plate is fitted in place of the original engine build data plate.

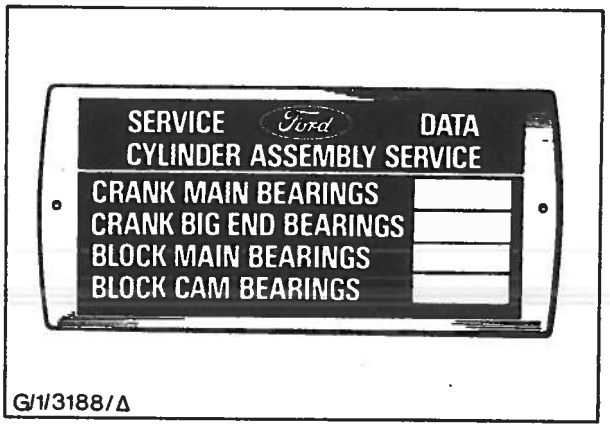

Fig. 4 - Service Cylinder Data Plate

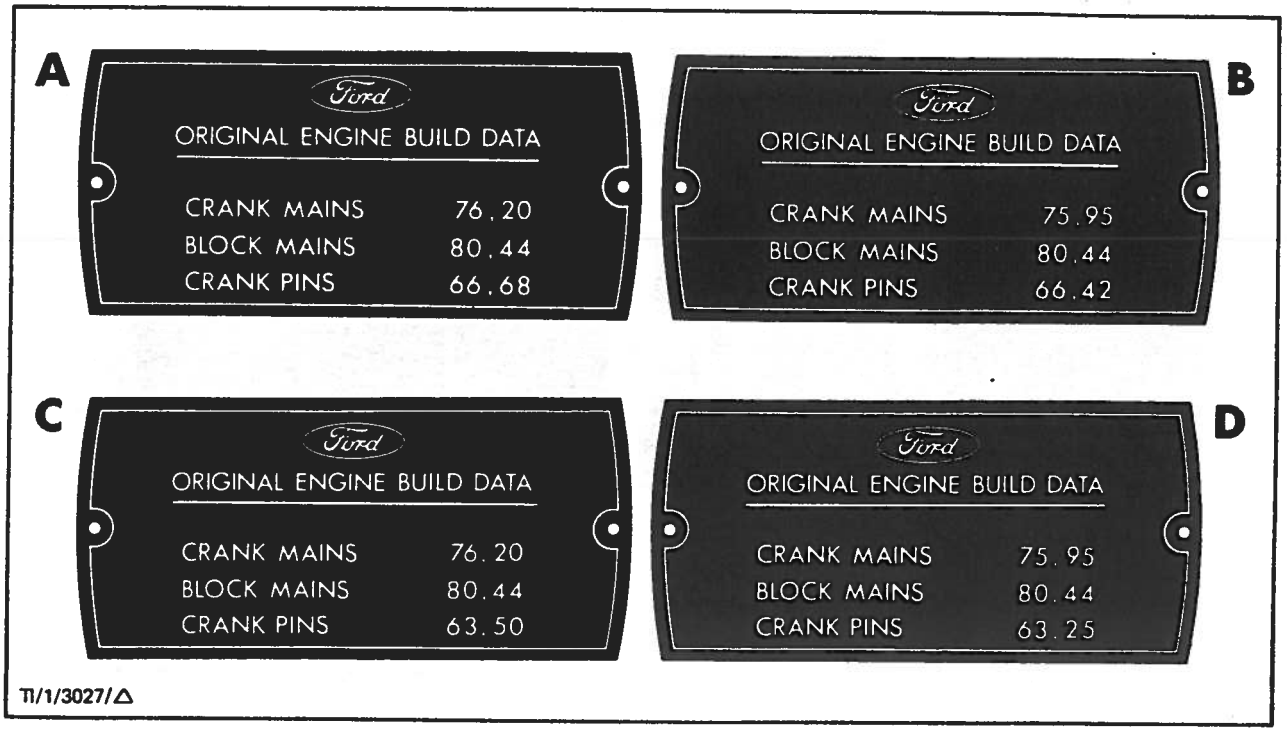

Fig. 3 - Original Engine Build Identification Plates
A. Green Plate - 2722, 2723 & 2725
B. Blue Plate - 2722 & 2723
C. Black Plate - 2726T & 2728T
D. Orange Plate - 2726T & 2728T

SERVICE IDENTIFICATION PLATE

This plate (Fig. 5) is fixed to the top surface of the engine rocker cover. Positions 1 to 11 on the plate refer to various engine details as listed.

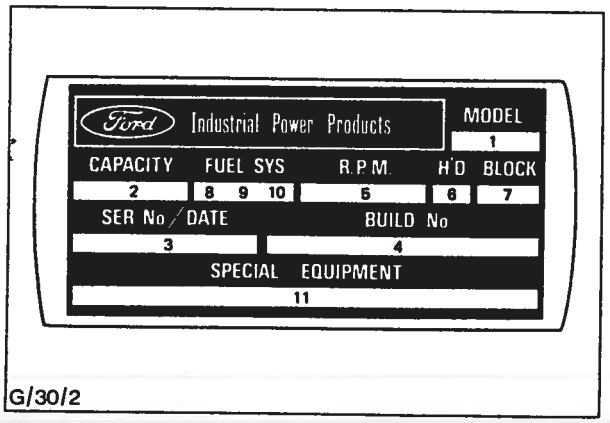

Fig. 5 - Service Identification Plate

1. Engine Model Identification
2. Engine Capacity in Litres
3. Engine Serial Number/Date
4. Selective Build Number indicates the complete engine specification. The digit to the extreme right-hand side, is the Build Chart Issue Number
5. Engine Operating rpm. An asterisk denotes speed set by customer
6. Cylinder Head Type:
7. Block Type:
   - A Standard with Standard 28,5 Nm PTO
   - B Standard with Heavy Duty 142 Nm PTO
   - C Intercooled with Standard 28,5 Nm PTO
8. Injection Pump Manufacturer:
   - A CAV/Simms
   - B Bosch
9. Type of Governor Fitted to Injection Pump
   - A General Purpose
   - B Class 'A'
   - C Automotive
   - D Combine Harvester
10. Special Injection Equipment Fitted
11. This box is provided for Equipment Manufacturers' use when extra equipment is fitted outside the Ford Motor Company. Reference should be made to the Equipment Manufacturer for any information or parts required.

FAULT DIAGNOSIS

The following fault diagnosis procedures have been devised as a methodical guide when the cause of a fault is not obvious. It is not intended that the procedures should necessarily be followed in sequence.

This section covers the diagnosis of engine faults but it may also be necessary to refer to other sections of the manual for fault diagnosis procedures covering fuel, electrical, cooling and starting systems.

Before commencing, observe the symptoms and ask the following questions:

1. Did the fault occur suddenly or 'grow' over a period of time?
2. Were there any warning signs?
3. Has this fault occurred before on the same machine?
4. Could any previous repair or maintenance have contributed to the fault?
5. Is the fault caused indirectly by a malfunction in some other system or component?
6. If the engine still runs, is it safe to continue to make further checks?

Begin by eliminating the most obvious causes - these are usually the ones that can be seen or checked easily without, or by minimum removal of components.

Recheck for an easily overlooked solution before commencing complex or lengthy dismantling procedures.

1. Engine Fails To Crank Or Cranks Sluggishly

	Possible Causes		Remedy
a	Faulty battery or loose connections	a	Refer to Volume 2, Section 2.
b	Faulty starter motor or electrical circuit	b	Refer to Volume 2, Section 2.
c	Engine prevented from turning by mechanical seizure or hydraulic lock	c	Attempt to turn the engine backwards. If it will turn, then turn it forwards again and if it comes to a sudden stop check for a hydraulic lock caused by presence of oil in a cylinder bore; or a mechanical lock caused by such as a broken or damaged valve or valve gear. If the engine will not turn either way check for; engine seizure, starter motor jammed in mesh with the flywheel, or mechanical lock caused by broken or damaged engine components.
d	Laborious cranking at low temperatures caused by thick or incorrect grade of engine oil, partial seizure or high residual load	d	Drain and refill with correct specified grade of engine oil suitable for ambient temperatures.

2. Engine Cranks Satisfactorily But Is Difficult to Start Or Will Not Start

	Possible Causes		Remedy
a	Engine stop control not fully disengaged.	a	Check stop control cable or linkage and lever on injection pump. Rectify as necessary.
b	Fuel tank empty.	b	Refill tank and bleed fuel system.
c	Fuel system fault.	c	Refer to Fault Diagnosis, Section 4.
d	Incorrect valve timing and/or valve clearances.	d	Check and adjust to specification.
e	Wear or internal fault in engine.	e	Carry out compression test to ascertain: i) Leaking or damaged valves. ii) Leaking cylinder head. iii) Worn, damaged or broken pistons and/or piston rings. Carry out complete or partial overhaul as required.

3. Engine Knocks Or Has Abnormal Mechanical Noise Possibly Accompanied By Continuous Or Intermittent Vibration

	Possible Causes		Remedy
a	Loose engine component or flywheel.	a	Check all engine mounted components for security of mountings. Check security of flywheel. Tighten as necessary.
b	Engine mountings are loose or worn.	b	Check security of engine mountings. Tighten or renew as necessary.
c	Fuel system fault, uneven running or engine misfiring.	c	Refer to Fault Diagnosis, Section 4.
d	Cooling fan blades fouling or damaged.	d	Check that clearance exists between fan blades and cowl and/or radiator, that fan is not damaged or distorted and that no other component is fouling fan blades.
e	Starter motor stuck in engagement.	e	Remove starter motor, check flywheel ring gear for damage and inspect and repair starter motor as detailed in Volume 2, Section 2.
f	Worn or damaged engine driven component.	f	Check for noisy operation of: Air compressor, alternator, water pump, fuel injection pump, turbocharger (where fitted). Renew or repair as necessary.
g	Worn or maladjusted valve gear.	g	Check valve gear and rocker shaft for wear. Adjust valve clearances as necessary.
h	Excessive wear or internal damage in engine.	h	Dismantle and check for worn or damaged timing gears, crankshaft and camshaft bearings, pistons and/or connecting rods. Overhaul or renew as necessary.

4. Engine Lacks Power

	Possible Causes		Remedy
a	Accelerator linkage prevented from attaining maximum fuel setting.	a	Check accelerator pedal and linkage and injection pump controls for full and free movement. Rectify as necessary.
b	Fuel or air intake system fault, including turbocharger (where fitted).	b	Refer to Fault Diagnosis, Section 4.
c	Exhaust system restriction.	c	Check the exhaust pipes and silencer for blockage or damage. Renew or repair as necessary.
d	Engine operating temperature incorrect.	d	Refer to Fault Diagnosis, Section 3.
e	Incorrect valve timing and/or valve clearances	e	Check and adjust to Specification.
f	Low compression pressures.	f	Carry out compression test to identify fault.
	ONE OR TWO ISOLATED LOW PRESSURES:		
	i) Incorrect valve clearances.		i) Check and adjust clearances to specification. Repeat compression test.
	ii) Leaking cylinder head gasket. (May cause two adjacent low pressures).		ii) Check for pressure blow past into adjacent cylinders or for pressurisation of the cooling system. Repair as necessary.
	iii) Burnt or damaged valves. Holed or badly damaged piston. (Usually causes heavy blue exhaust smoke).		iii) Pour some clean engine oil into the affected cylinder to act as a temporary seal and repeat the compression test. If the pressure does not rise significantly, remove the cylinder head. Check and repair as necessary.
	iv) Sticking or broken piston rings.		iv) Repeat the compression test with oil in the cylinder. If the pressure rises significantly, remove the cylinder head to verify the fault. Repair or overhaul as necessary and locate and rectify cause.
	ALL COMPRESSIONS LOW BUT EVEN:		
	Worn pistons, rings and/or cylinder bores. Sticking piston rings. Usually accompanied by increased engine smoke. If not a high mileage engine, could be caused by lubrication or cooling system fault.		Repeat the compression test with oil in the cylinders. If the pressure rises significantly, this indicates a loss of pressure past the pistons. Repair or overhaul as necessary and locate and rectify cause of fault if applicable.

5. Excessive Exhaust Smoke

Possible Causes	Remedy
BLACK SMOKE	
a Fuel system fault.	a Refer to Fault Diagnosis, Section 4.
WHITE SMOKE	
a Fuel system fault (usually indicated by pungent smell).	a Refer to Fault Diagnosis, Section 4.
b Coolant leak into cylinder/s.	b Check cylinder head gasket for leaks or damage. Check cylinder head and block for cracks or damage. Repair or renew as necessary.
BLUE SMOKE (indicates engine is burning lubricating oil).	
a Engine oil level too high.	a Reduce to the correct level. Refer to Fault No. 6 if high level was not caused by overfilling.
b Worn engine or damaged components.	b Carry out compression test to check for worn or damaged pistons and/or piston rings. Check valves, valve guides and inlet valve stem seals for wear and/or damage. Repair or overhaul as necessary.
c Incorrect grade of engine oil.	c Drain and refill with correct specified grade of oil.
d On turbocharged engines a blocked or restricted air intake can cause the turbocharger to suck engine oil past its seals into the air intake.	d Overhaul air cleaner or remove restriction.

6. Increase in Engine Oil Level Possibly Accompanied By Smell Of Fuel Oil

Possible Causes	Remedy
a Prolonged running at below engine normal operating temperature.	a Cooling system fault. Refer to Fault Diagnosis, Section 3. Change engine oil and filter.
b Prolonged operation at idle speed	b Change engine oil and filter. Revise operating procedures or increase frequency of oil changes.
c Injectors faulty, loose, damaged or not seating correctly. (Can also cause uneven running and/or black smoke).	c Renew or overhaul injectors as required.
d Injector leak-off rail leaking, damaged or fractured.	d Refer to 'Injector Leak-off Rail Pressure Test' in Section 4. Repair or renew as necessary.
e Coolant leakage into lubricating system.	e Check cylinder head gasket for leaks. Check oil cooler (where fitted) for internal leaks or damage. Rectify as necessary.

7. Engine Oil Pressure Low

Possible Causes	Remedy
a Low oil level.	a Top up with engine oil of the specified grade. Inspect the engine for signs of leakage. If no leakage is evident and the engine exhaust shows blue smoke, refer to Fault No. 5.
b Oil pressure gauge faulty.	b Check oil pressure using a master pressure gauge. Refer to Fault Diagnosis, Section 2 if gauge is faulty.
c Engine oil dirty and filter blocked.	c Change oil and renew filter.
d Oil diluted with fuel oil.	d Refer to Fault No. 6.
e Badly worn crankshaft bearings. Usually indicated by knocking or increased engine noise. May result from adverse operating conditions or from faulty oil pump.	Remove oil pan, check condition of crankshaft and bearings. Check condition of oil sump. Overhaul or renew as necessary.

8. High Oil Consumption

The oil consumption of an engine free from defects will vary depending on operating conditions. It is not possible, therefore, to predict what the 'normal' oil consumption of an engine should be. However, once the engine is 'bedded-in' oil consumption should remain constant. As the engine wears, this consumption may gradually increase until such time as it is considered unacceptable and corrective action is necessary. If a previously stable oil consumption increases rapidly, a fault is indicated.

	Possible Causes		Remedy
a	Oil level too high.	a	Check and adjust oil level. If high level was not due to overfilling, refer to Fault No. 6.
b	Oil leakage	b	Steam clean the engine and stand the machine over a clean area. Run the engine until it is thoroughly warm. Check for leaks. It is sometimes difficult to identify the true source of oil leaks. Meticulous attention should be paid to obtaining a correct identification before commencing dismantling. Particular attention should be paid to apparent rear crankshaft seal leaks to ensure that the source is not behind the flywheel.
c	Incorrect grade or type of oil.	c	Drain oil, and refill with oil to the correct specification. Recheck oil consumption.
d	Inlet valve stem seals worn, damaged or displaced.	d	Remove rocker cover, check and renew seals as necessary.
e	Engine wear and/or damage.	e	Engine damage which causes increased oil consumption, normally also results in increased engine noise and can readily be identified, i.e. broken piston and/or rings. Carry out a compression test to identify fault and overhaul as necessary.
f	Air compressor passing oil (usually indicated by presence of oil in air pressure circuits).	f	Remove and overhaul or renew the compressor.

In order to determine an oil consumption level where high consumption is suspected, carry out the following procedure:

i) Carry out the Fault Diagnosis steps above to eliminate oil leaks or obvious faults as reason for excessive consumption.

ii) Start and run the engine to obtain normal operating temperature. Switch off and allow to stand for 10 minutes. Adjust the oil level carefully and exactly to the 'full' mark on the dipstick.

iii) Run the engine in normal service for a minimum of 20 hours keeping an accurate record of quantities of oil added.

iv) Check and correct the engine oil level as in (ii) and, using the service hours run and quantity of oil added, calculate the average oil consumption.

NOTE: High oil consumption caused by engine wear or component damage allowing the engine to burn oil is usually indicated by considerable blue exhaust smoke.

ENGINE TESTING
(Engine in vehicle/installation)

Compression Test Using Dieseltune "Diestester' (or equivalent)

In order to check the engine compression pressures, it is necessary to remove all the injectors. Fuel injection equipment is machined to extremely fine limits, and every precaution should be taken to avoid damage to the injectors when they are removed.

The following procedure details the use of the Dieseltune "Diestester'. If other equipment is used, follow the manufacturer's instructions.

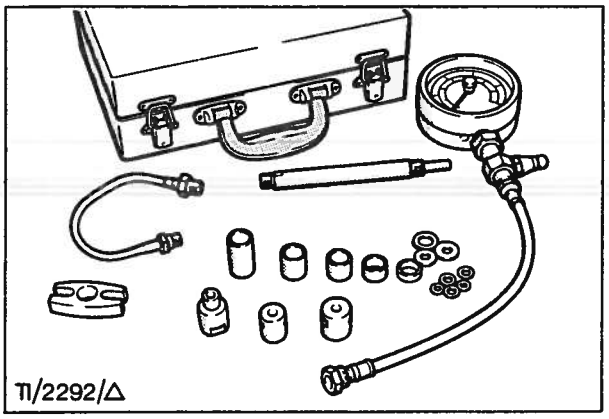

Fig. 6 - Dieseltune 'Diestester' Equipment

The 'Diestester' equipment consists of a pressure gauge assembly, a stem, and a series of spacers and adaptors - see Fig. 6.

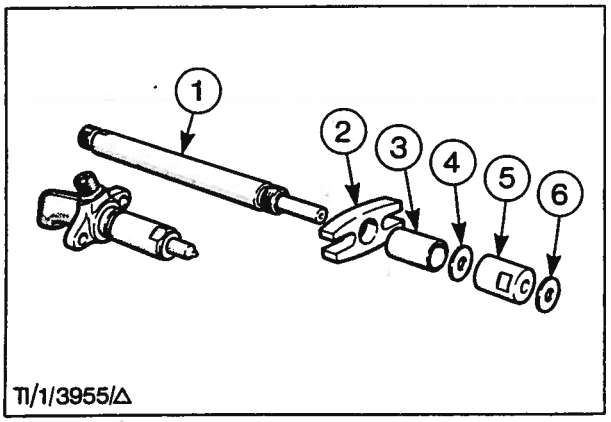

Fig. 7 - Tester Components
1. Stem Assembly
2. Clamping Plate
3. 38 mm (1,5 in) Spacer
4. Sealing Washer
5. 25 mm (1,0 in) Adaptor
6. Sealing Washer

1. If the engine will start, run it and allow it to reach normal operating temperature.

2. Stop the engine and remove all the injectors as detailed in Section 4.

3. Select the 25 mm (1,0 in) long x 20 mm ($^{13}/_{16}$ in) diameter adaptor, and the 38 mm (1,5 in) long spacer. Select a suitable copper sealing washer for the stem assembly, and for the adaptor. Assemble the components as shown in Fig. 7 and check:

a) That the overall length of the assembly (from clamping plate to end of adaptor) is approximately the same as the injector body - see Fig. 8.

b) That the length of stem protruding from the adaptor is less than the length of the injector nozzle - see Fig. 8.

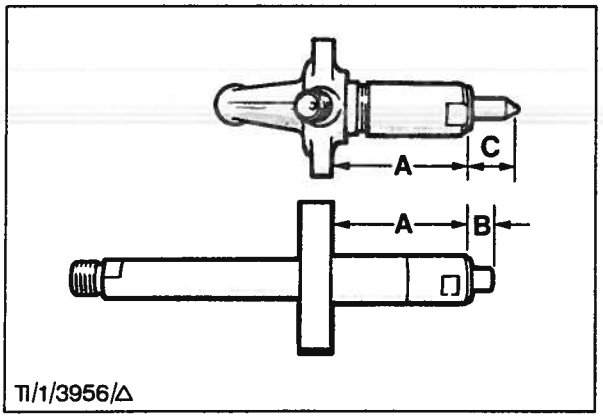

Fig. 8 - Assembling Tester Components
Dimension 'A' to be approximately equal - Dimension 'B' to be less than 'C'

4. Fit the stem and adaptor assembly into the first injector aperture, and tighten the clamping plate securely. Connect the pressure gauge assembly to the stem, and tighten securely.

5. Secure the engine stop control lever on the injection pump in the 'no delivery' position.

6. Crank the engine by the starter, and continue to 'crank' until the pressure gauge is indicating a steady pressure. Note the pressure obtained.

7. Repeat the operation for the remaining cylinders.

8. Compare the pressure readings obtained from each cylinder with those specified. If the pressure variation is outside the specified limits, or if all cylinder pressures are low, engine damage or wear is indicated (see Fault Diagnosis).

NOTE: Specified compression pressures are for normal atmospheric conditions at sea level. At altitudes considerably above sea level, proportionally lower compression pressures will be obtained.

9. Remove and dismantle the test equipment.

10. Check the injector apertures to ensure that they are clean and free from any carbon deposits.

11. Refit the injectors and bleed the system as detailed in Section 4 and refit the valve cover.

12. Start the engine and allow it to run for a short period. Check for oil or fuel leaks. Rectify any leakage as necessary.

CHECKING ENGINE OIL PRESSURE

The following procedure details the use of the Churchill '500X' Pressure Gauge which is a multiple gauge unit. If other equipment is used, follow the manufacturer's instructions.

If the vehicle/installation is equipped with a reliable and accurate oil pressure gauge, only operations 3 to 5 inclusive need be carried out.

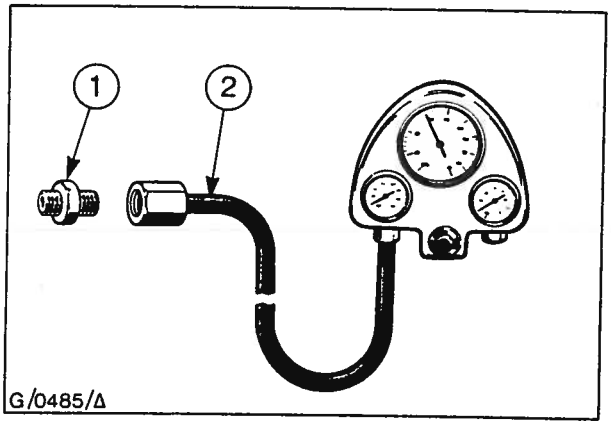

Fig. 9 - Multiple Gauge Unit '500X'
1. Adaptor
2. Flexible Hose

1. Check that the engine oil level is above the 'MIN' mark on the dipstick.

2. Disconnect the electrical connection from the oil pressure sender unit, remove the sender unit from the cylinder block (some oil may drain), connect the gauge unit into the block using a suitable adaptor and connecting pipe.

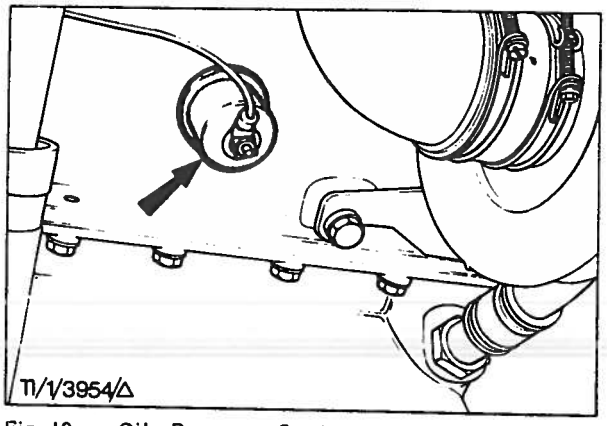

Fig. 10 - Oil Pressure Sender Unit and Electrical Connection

3. Start the engine and allow it to attain normal operating temperature. Increase the engine speed to maximum 'no load' speed and note the indicated engine oil pressure.

4. Allow the engine to idle for a few seconds and repeat the test.

5. Compare the results with the specified pressure and if it is not within the specified limits refer to Fault Diagnosis to establish the likely cause(s). Rectify as necessary.

6. Stop the engine. Disconnect the gauge and remove the adaptor from the engine. Mop up any oil spillage and clean the tapped hole.

7. Refit the oil pressure sender unit and tighten to the specified torque. Refit the electrical connection.

8. If the pressure readings are satisfactory, check the engine oil level and 'top-up' with fresh specified grade engine oil if necessary.

DISMANTLING THE BASIC ENGINE

In order to give the maximum amount of information, Figs. 11 to 16 inclusive cover a wide range of engine types and optional equipment. Consequently, some items such as dipsticks may be shown on both the left hand and right hand side of engines - this is brought about by the different types of oil pans illustrated.

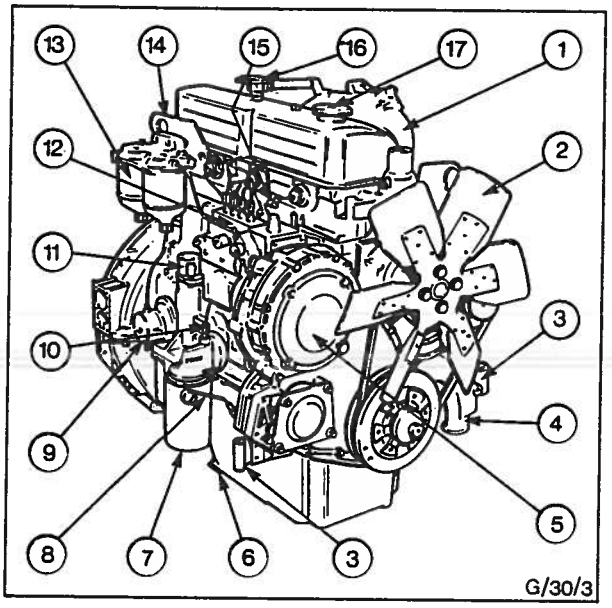

Fig. 11 - 4 Cylinder Naturally Aspirated Engine

1. Inlet Manifold
2. Fan
3. Mounting Bracket
4. Water Inlet Extension Tube
5. Timing Adjustment Cover Plate
6. Oil Drain Plug
7. Oil Filter
8. Dipstick
9. Fuel Lift Pump
10. Injection Pump Oil Feed Pipe
11. Mechanical Hourmeter
12. Injection Pump
13. Fuel Filter
14. Lifting Bracket
15. High Pressure Pipe Clamp
16. Crankcase Ventilation Valve
17. Oil Filler Cap

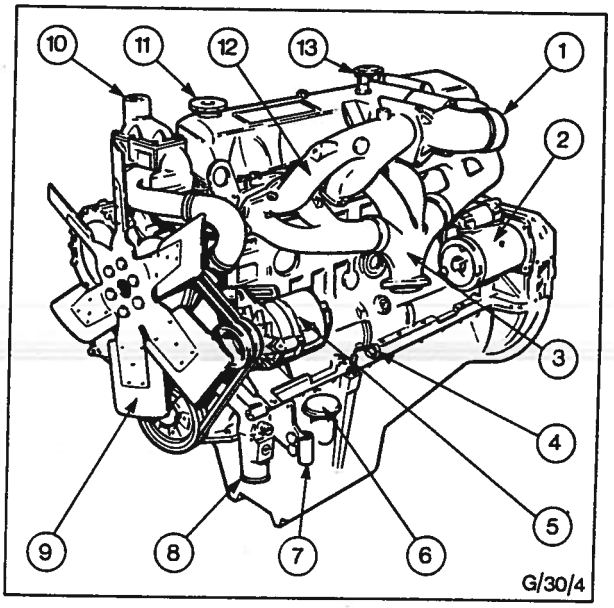

Fig. 12 - 6 Cylinder Naturally Aspirated Engine

1. Inlet Manifold Adaptor
2. Starter Motor
3. Exhaust Manifold
4. Dipstick
5. Alternator
6. Low Level Oil Filler
7. Mounting Bracket
8. Water Inlet Extension Tube
9. Fan
10. Water outlet connection
11. Oil Filler
12. Inlet Manifold
13. Crankcase Ventilation Valve

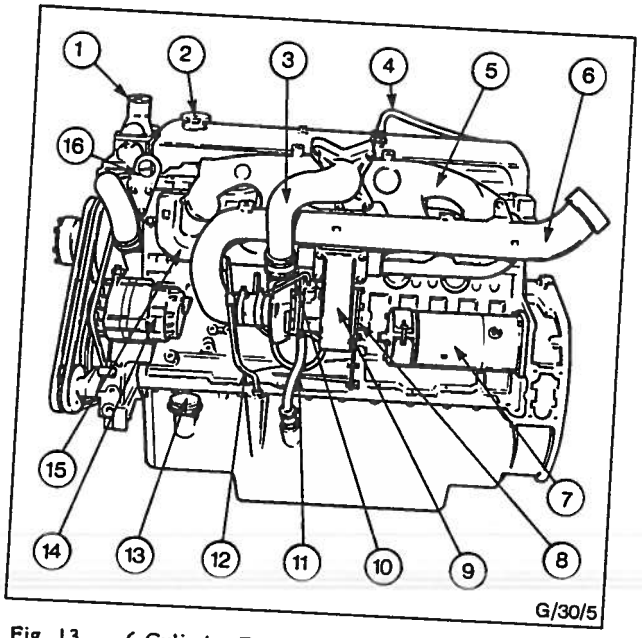

Fig. 13 - 6 Cylinder Turbocharged Industrial Engine

1. Water Outlet Connection
2. Oil Filler
3. Inlet Manifold Adaptor
4. Crankcase Ventilation Pipe
5. Inlet Manifold
6. Air Inlet Pipe
7. Starter Motor
8. Turbocharger Support plate
9. Turbocharger
10. Turbocharger Oil Feed Pipe
11. Turbocharger Oil Drain Pipe
12. Dipstick Tube
13. Low Level Oil Filler
14. Alternator
15. Exhaust Pipe
16. Lifting Bracket

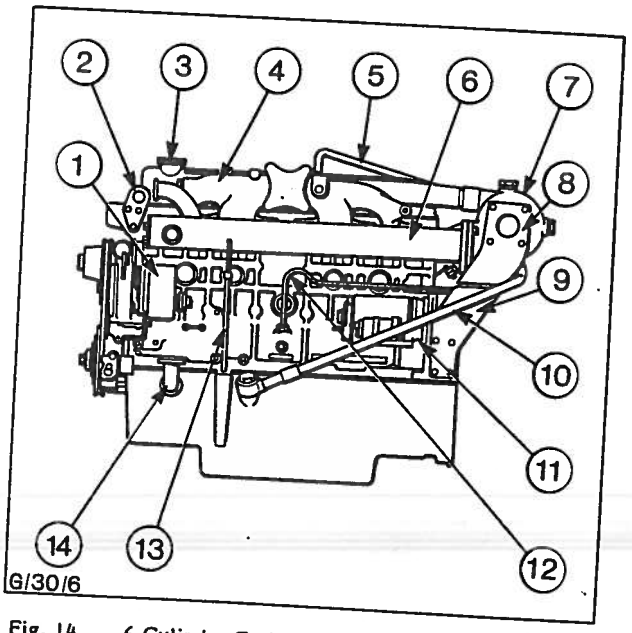

Fig. 14 6 Cylinder Turbocharged Marine Engine

1. Alternator
2. Lifting Bracket
3. Oil Filler Cap
4. Inlet Manifold
5. Crankcase Ventilation Pipe
6. Exhaust Manifold
7. Turbocharger
8. Turbocharger Support Plate
9. Turbocharger Mounting Bracket
10. Turbocharger Oil Drain Pipe
11. Starter Motor
12. Turbocharger Oil Feed Pipe
13. Dipstick Tube
14. Low Level Oil Filler

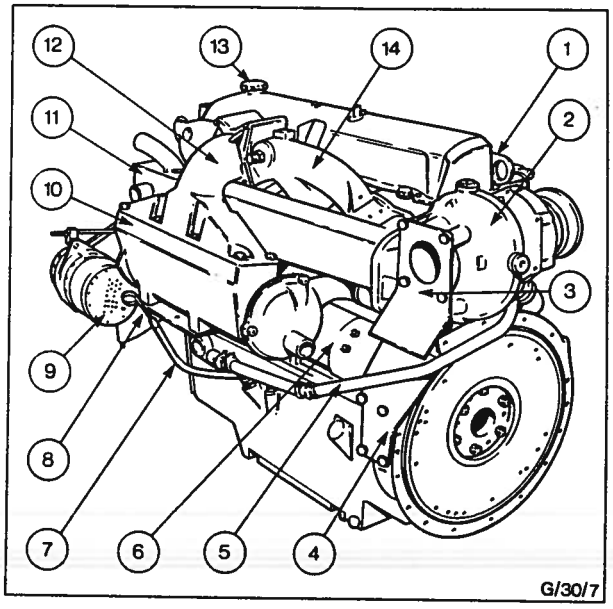

Fig. 15 - 6 Cylinder Intercooled Marine Engine

1. Lifting Bracket
2. Turbocharger
3. Turbocharger Support Plate
4. Turbocharger Mounting Bracket
5. Turbocharger Oil Drain Pipe
6. Starter Motor
7. Dipstick Tube
8. Dipstick
9. Alternator
10. Intercooler
11. Exhaust Manifold
12. Inlet Manifold Adaptor
13. Oil Filler
14. Inlet Manifold

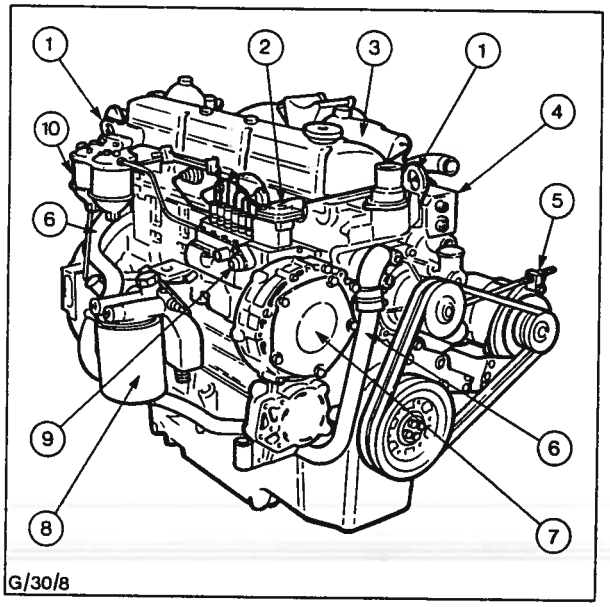

Fig. 16 - 6 Cylinder Intercooled Marine Engine

1. Lifting Brackets
2. Injection Pump Boost Control
3. Inlet Manifold
4. Water Cooled Exhaust Manifold
5. Alternator Drive Belt adjuster
6. Split Flow Water Tube
7. Injection Pump Timing Aperture Cover
8. Oil Filter
9. Injection Pump Automatic Excess Fuel Solenoid
10. Fuel Filter

DISMANTLING THE ENGINE
(Engine Removed from Vehicle/Installation)

This dismantling sequence assumes that the following equipment (where applicable) has been removed from the engine:

a) Equipment (other than alternator or water pumps) driven from the crankshaft pulley, flywheel or timing gear PTO including associated air and water pipes.

b) Exhaust pipe/silencer, air cleaner, clutch and flywheel housing adaptor.

NOTE: Some engine ancillaries such as fuel filters, fan, starter motor, alternator, etc. may already have been detached from the engine during its removal from the vehicle/installation.

REMOVING ENGINE ANCILLARIES - Refer to Figs. 11 to 16 inclusive

1. Disconnect and remove the turbocharger oil feed pipe and oil return pipe. Detach pipe connecting injection pump boost control and inlet manifold.

2. Slacken clips securing hose between turbocharger and inlet manifold adaptor. On the turbocharged industrial engine, slacken clips securing hose between turbocharger and air inlet pipe, unscrew securing bolts and remove the pipe.

3. Remove nuts securing turbocharger to support plate and detach the exhaust outlet elbow; on marine engines the nuts securing the turbocharger to the support plate would have been removed when the exhaust pipe was detached from the engine. Discard gasket(s).

Remove turbocharger support plate and bracket from cylinder block. Remove nuts securing turbocharger to exhaust manifold and detach the turbocharger. Protect turbocharger from ingress of dirt and foreign bodies.

4. Remove inlet manifold and, on inter-cooled engines, the inter-cooler complete with mounting bracket. Discard all gaskets.

5. Remove exhaust manifold and discard gaskets.

6. Remove starter motor.

7. Fit engine mounting bracket 21 535 to the engine as shown in Fig. 17. Lift engine with a suitable hoist, using the cylinder head lifting brackets and mount the engine on the stand (200B) as illustrated.

8. Withdraw dipstick and, in the case of a high level dipstick, remove the dipstick tube from the oil pan. Unscrew and discard the oil filter canister.

9. Remove low pressure fuel pipes connecting fuel lift pump, fuel filters and injection pump.

10. Remove fuel lift pump and (where fitted) the pre-filter unit.

11. Remove fuel filters complete with mounting bracket.

12. Loosen or remove the high pressure fuel pipe clamps as necessary to enable the large oil seal nuts to be slackened off.

13. Unscrew the gland nuts from the injectors and the injection pump and remove the high pressure fuel pipes.

14. Fit blanking plugs/caps to all injection equipment apertures, including pipe ends.

15. Where applicable, detach oil feed pipe from between oil filter head and injection pump. Remove filter head from cylinder block and discard gasket. Remove oil pressure sender unit.

16. Where fitted, detach the lead connecting injection pump automatic excess fuel solenoid to temperature sensitive switch on the thermostat housing.

17. Unscrew the three retaining bolts and remove the injection pump.

18. Slacken and remove fan securing bolts while gripping fan pulley drive belt(s) and detach the fan. On 'Low Loss' Fan Drive System, also detach the bearing retainer outer plate which is retained by the fan securing bolts.

NOTE: On single belt drives, the pulley can be removed at the same time.

19. Remove water pump drive belt(s) and detach water hose(s). On turbocharged inter-cooled marine engines, remove the complete split flow tube assembly connecting the water pump to the rear of the cylinder block.

20. Remove water pump securing bolts/nuts and detach pump from engine. Discard the gasket.

On 2728T engines, remove the centre bolt and detach the pump back plate; discard the gasket. On marine engines, remove the raw water pump from the PTO drive at the rear of the timing gear housing.

21. Remove alternator. Remove the water pump extension tube (where fitted) together with the engine mounting bracket or spacers, as applicable.

DISMANTLING THE BASIC ENGINE

22. Remove thermostat housing and lift out the thermostat(s).

23. Remove oil pan drain plug(s) and drain off the engine oil into a suitable receptacle.

24. Remove the rocker cover.

25. Slacken each rocker shaft pedestal retaining bolt approximately one turn at a time until all are loose, then remove them.

26. Tie the two end rockers in position to keep the complete assembly together, then lift off rocker shaft assembly complete.

27. Remove push rods in sequence and mark them to ensure that they are replaced in their original positions when assembling them later. Do not dislodge the valve stem caps.

REMOVING INJECTORS - Refer to Fig. 18

28. Remove banjo bolts from leak-off pipe, then unscrew gland nut and remove leak-off pipe from cylinder head.

29. Unscrew two retaining bolts and remove each injector. Discard 'O' ring. Remove copper sealing washers from recesses in cylinder head and discard them.

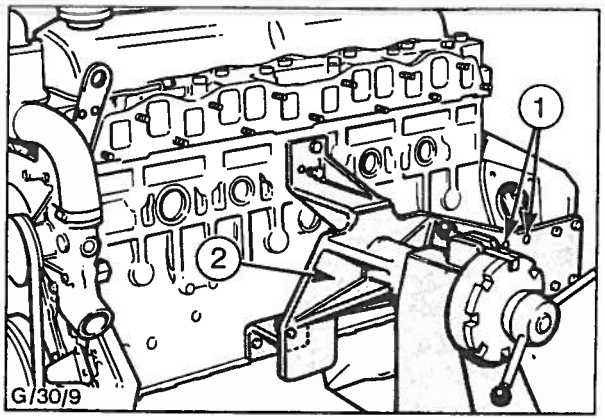

Fig. 17 - Engine Mounted on Stand (200B)
1. Holes for Mounting 4 Cylinder Engine
2. Mounting Bracket (21-535)

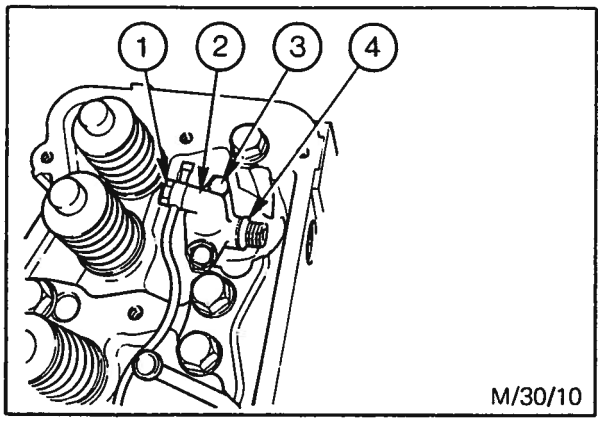

Fig. 18 - Removing Injectors
1. Leak-Off Pipe Banjo Bolt
2. Injector
3. Injector Retaining Bolt
4. 'O' Ring

REMOVING CYLINDER HEAD

30. Slacken each cylinder head bolt a little at a time in the reverse order to the tightening sequence shown in Fig. 19, then remove all bolts.

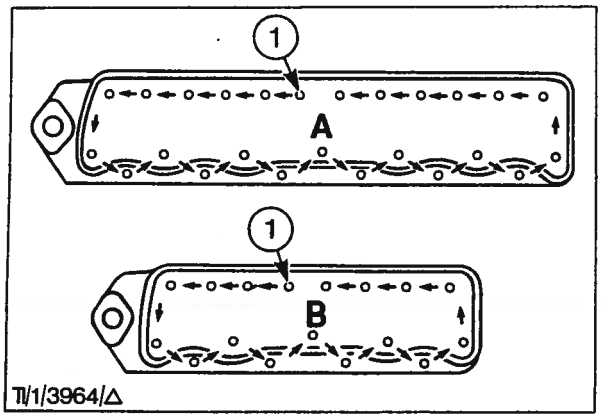

Fig. 19 - Cylinder Head Bolts Tightening Sequence
A. 6 Cylinder Engines
B. 4 Cylinder Engines
1. Start here when tightening
Reverse sequence to slacken

31. Using a hoist attached to the cylinder head lifting bracket, remove the cylinder head carefully, taking care not to damage the head and block mating faces. Valve and guide removal is detailed under 'Cylinder Head Overhaul'.

REMOVING CRANKSHAFT PULLEY

32. On all engines except 2728T, remove the crankshaft pulley retaining bolt, and remove the crankshaft pulley, using a suitable puller if necessary - see Fig. 20.

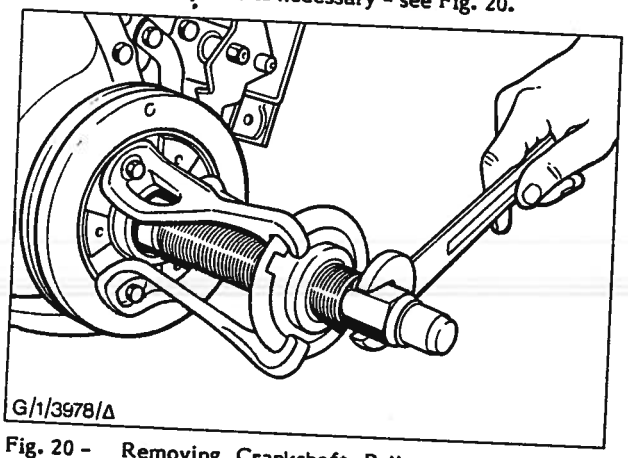

Fig. 20 - Removing Crankshaft Pulley - All Engines Except 2728T

33. On 2728T engines remove the four bolts retaining the crankshaft pulley locking sleeve and remove the locking sleeve. Strike the face of the pulley a firm blow with a soft faced mallet to release the Ringfeder locking mechanism and remove the pulley, the locking rings and the spacer ring - see Fig. 21.

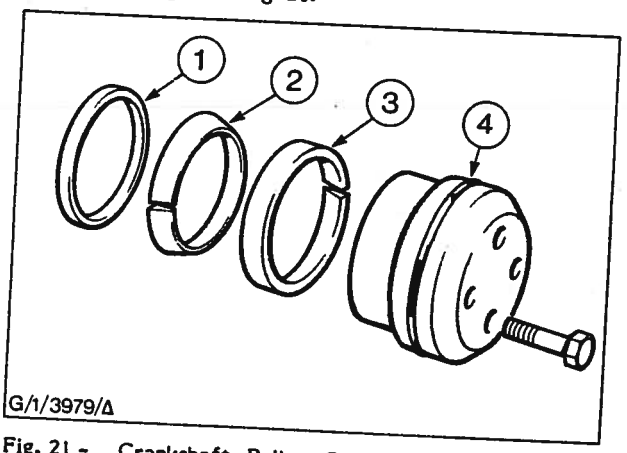

Fig. 21 - Crankshaft Pulley Retaining Components - 2728T Engine (Ringfeder Locking Mechanism)
1. Spacer Ring
2. Internal Locking Ring
3. External Locking Ring
4. Locking Sleeve

REMOVING FLYWHEEL

34. Remove the flywheel retaining bolts and, using tw suitable bolts in the threaded holes as pullers, tighte the bolts evenly one turn at a time and withdraw th flywheel off the crankshaft - see Fig. 22.

CAUTION: ENSURE THAT THE FLYWHEEL I ADEQUATELY SUPPORTED DURING REMOVAL.

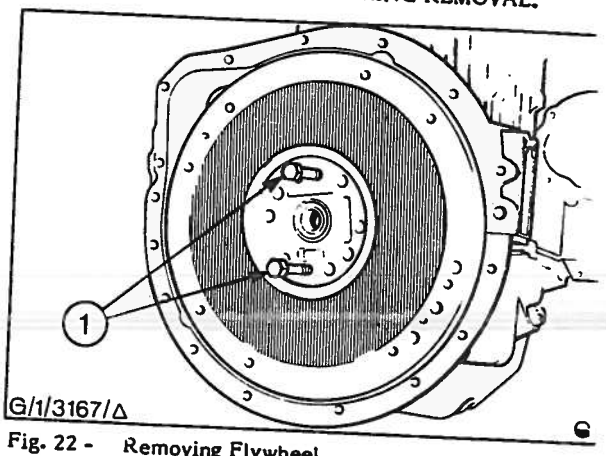

Fig. 22 - Removing Flywheel
1. Flywheel Withdrawal Bolts

REMOVING OIL PUMP

35. Ensure the oil pan has been completely drained of engine oil and invert the engine on the stand.

36. Slacken and remove the bolts and nuts and carefully separate the oil pan from the cylinder block.

2722, 2723, 2725 & 2726T Engines not fitted with high inclination oil pans.

37. Bend up the lock tabs securing the oil pick-up pipe union nut to the oil pump, and unscrew the union - see Fig. 23. Remove the pick up pipe support bracket bolt from the main bearing cap and withdraw the pick up pipe from the pump. Remove the bolts securing the pump to the cylinder block and carefully withdraw the pump.

2728T intercooled engines only

38. Unscrew the bolts securing the pick-up pipe to the pump and withdraw the pipe from the pump - see Fig. 24. Remove the bolts securing the delivery pipe to the cylinder block and remove the delivery pipe and the adaptor. Remove the nuts securing the oil pump to the front main bearing cap and carefully remove the pump and idler gear assembly.

Oil pump overhaul is detailed in Section 2, 'Lubrication System'.

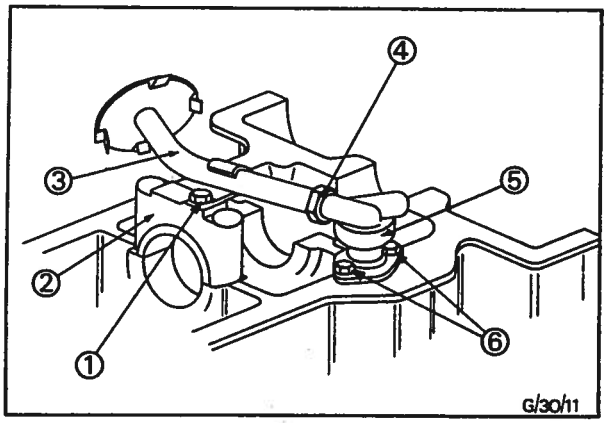

Fig. 23 - Oil Pump Removal/Replacement - 2722, 2723, 2725 and 2726T Engines not fitted with High Inclination Oil Pans

1. Support Bracket Bolt
2. Main Bearing Cap
3. Pick-up Pipe
4. Pick-up Pipe Union
5. Oil Pump
6. Oil Pump Securing Bolt

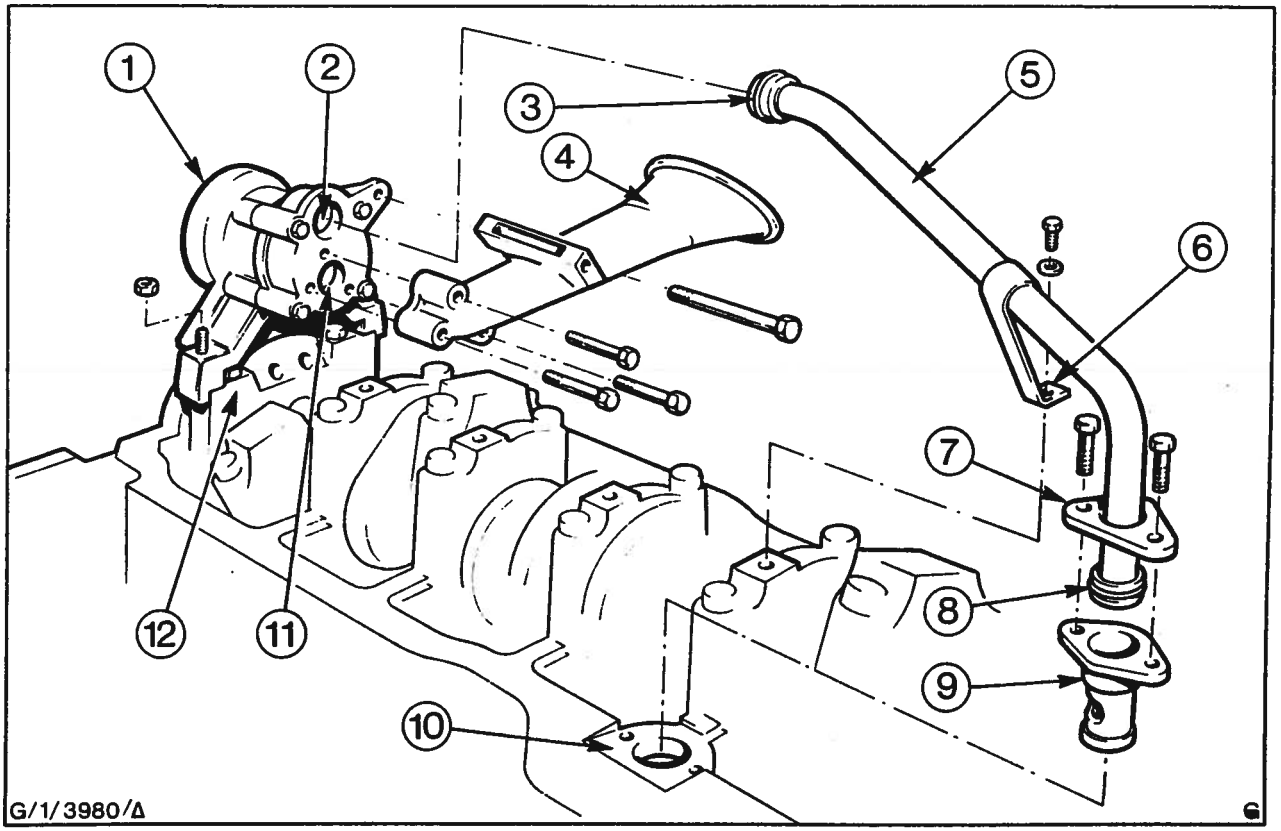

Fig. 24 - Oil Pump Removal/Replacement - 2728T Engines

1. Oil Pump
2. Pump Outlet
3. 'O' Ring
4. Pick-Up Pipe
5. Delivery Pipe
6. Support Bracket
7. Loose Flange
8. 'O' Ring
9. Flanged Adaptor
10. Cylinder Block Lower Flange
11. Pump Inlet
12. Front Main Bearing Cap

2722, 2723, 2725 and 2726T engines fitted with high inclination oil pans - see Fig. 25.

38. a) Remove all bolts and lockwashers retaining the pump and pipes then remove the pump from the spigot location in the block.

b) Remove the gauze screens by turning through 90° to release.

c) Bend back the locking plate tabs and unscrew the pipe unions and remove the pipes.

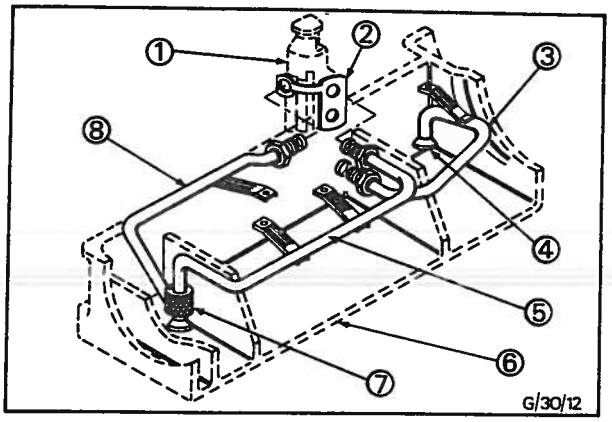

Fig. 25 - Oil Pump and Piping for High Inclination Oil Pans

1. Scavenge Pump
2. Lock Plate
3. Scavenge Pipe
4. Gauze Screen
5. Delivery Pipe
6. Oil Pan
7. Diffuse Box
8. Oil Reservoir Feed Pipe

REMOVING TIMING GEARS AND HOUSING

IMPORTANT: On 2728T intercooled engines, the oil pan must be removed first before attempting to remove the timing gear housing. On all other 2720 range engines, the timing gear housing can be removed first if required.

39. Slacken the bolts securing the timing gear housing cover and, noting the positions of the various different length bolts, remove the bolts and cover.

40. Support the cover and drift out the oil seal. Retain the spacer(s) for reassembly.

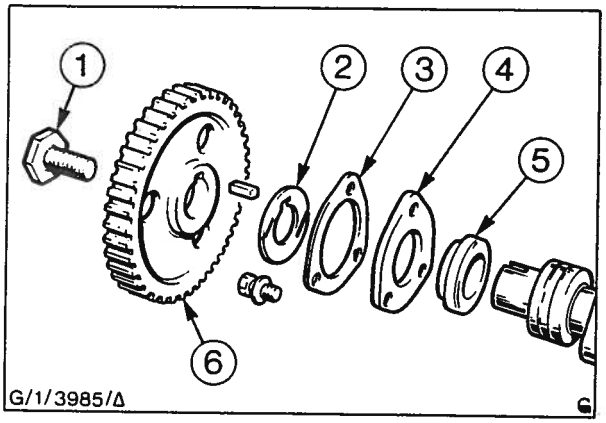

Fig. 26 - Camshaft Gear Assembly

1. Gear Retaining Bolt
2. Thrust Washer
3. Retaining Plate
4. Thrust Plate
5. Thrust Collar
6. Camshaft Gear

41. Lock the camshaft gear to stop it turning and remove gear retaining bolt - see Fig. 26. Using a suitable puller remove the camshaft gear. Remove the thrust washer.

42. Remove the three bolts securing the camshaft gear lockplate and thrust plate to the front of the engine, remove the two plates and the camshaft thrust collar. (Fig. 26).

43. Remove the timing gear housing retaining bolts and carefully separate the housing from the block. Retain the locating ring if this also falls free with the housing.

44. Remove the crankshaft gear, if necessary, using a suitable puller.

REMOVING CAMSHAFT, CRANKSHAFT AND PISTONS

45. Ensure that the cam followers are all clear of the cam lobes and carefully withdraw the camshaft from the front of the engine.

CAUTION: Take great care to ensure that the camshaft lobes do not damage the camshaft bearing liners as the shaft is withdrawn.

46. Lift out the cam followers and retain in numerical sequence for reassembly in the same positions.

47. Taking each piston and connecting rod assembly in turn remove the big end bearing cap bolts or nuts and remove the bearing cap. Disengage the big end from the crank pin and using a suitable soft drift (wooden hammer shaft) tap the piston and rod assembly out through the top of the cylinder bore. It may be necessary to scrape away the carbon from the top of the cylinder bore to ease removal. Ensure that the piston, connecting rod and cap are suitably identified for reassembly in the same positions and facing the correct way round relative to one another and to the engine block.

48. Remove the main bearing cap bolts, lift off the bearing caps and bearing liners (shells) and, using a suitable sling and hoist, lift the crankshaft from the crankcase.

49. Remove the upper bearing liners and thrust washers.

50. Ensure all bearing caps and liners are suitably identified for reassembly in their original positions.

COMPONENT TESTING AND RENEWAL

GENERAL

Thoroughly clean and dry all parts.

Ensure all old gaskets and sealing materials are cleaned off mating faces and that all threaded holes are sound and free from debris and swarf. Damaged threads may be restored using Helicoil inserts and following the manufacturers instructions. Check to ensure all studs are secure and undamaged.

Any loose or damaged studs must be refitted or renewed using the specified sealant and tightened to the specified torque value.

If the lubricating oil system is suspect in any way (i.e. bearing failure) or the block is being rebored and/or new cylinder liners fitted, the oil gallery plugs must be removed to enable all oil passageways to be thoroughly cleaned out.

If the original pistons are being refitted, remove all carbon deposits from the piston crown.

OIL PAN

Check to ensure the oil pan mating faces are clean and free from burrs or damage and that the oil pan itself is free from cracks. Check to ensure that the drain plug thread insert is secure and that the filler/tube adaptor is not loose or leaking.

A new drain plug insert or an oversize filler/tube adaptor may be installed, if necessary - refer to 'Lubrication System', Section 2.

CYLINDER BLOCK

Check the cylinder bores visually for scoring caused by broken rings and for uneven wear pattern. On turbocharged engines, cylinder liners showing signs of scuffing, glazing or uneven wear patterns must be renewed.

Check all the main bearing housings and side cheeks and the rear main bearing oil return groove for damage caused by badly worn centre main thrust washers allowing excessive end float of the crankshaft, or siezed bearing liners rotating and blocking off the oil supply.

On 2728T intercooled engines, ensure the piston cooling nozzles are clean and undamaged (Fig. 27). If the engine is being rebored the piston cooling nozzles should be removed to avoid damage or blockage. Push the nozzles out by hand towards the bearing housing.

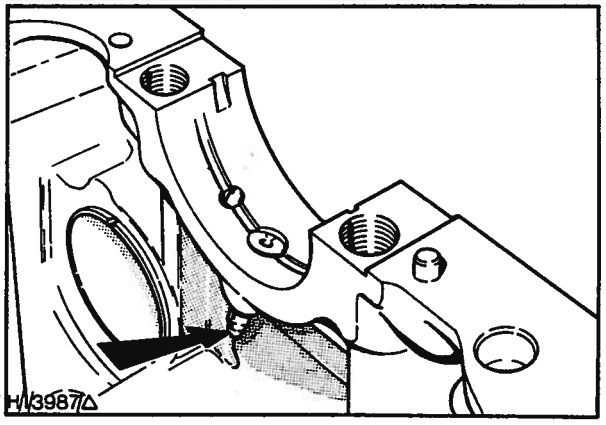

Fig. 27 - Piston Cooling Nozzle (Front Main Bearing Housing Illustrated)

Inspect the cam follower bores for scoring or scuffing which could cause seizure of the cam followers.

Check the camshaft bearings for scoring or excessive wear.

If any one bearing requires renewal all the other bearings should also be renewed otherwise camshaft alignment may be affected.

If the camshaft bearing bores are damaged oversize bearings are available. As the bearing bores will require to be accurately machined to specified oversize diameter (see Specifications) this particular operation can only be carried out where line boring facilities are available.

To install new bearings see 'Camshaft Bearing Renewal'.

Using an internal micrometer, measure and record the diameter of each cylinder bore at the following three points, both in line with, and at 90° to, the crankshaft axis - see Fig. 28.

1. Immediately below the highest point reached by the piston top ring.

2. 80 mm (3,15 in) from the top of the cylinder block face.

3. 200 mm (7,90 in) from the top of the cylinder block face.

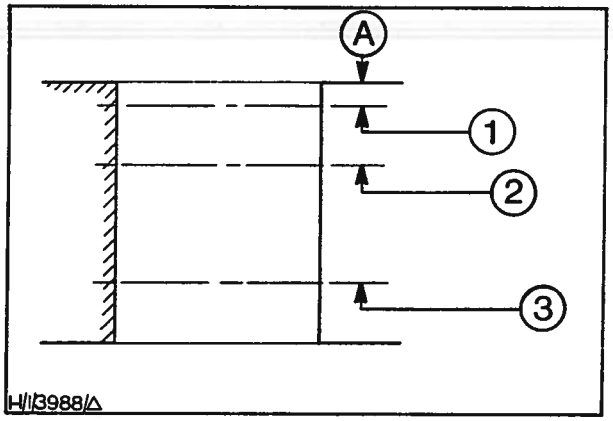

Fig. 28 - Cylinder Bore Wear Measuring Locations (See Text)
A. Cylinder Block Face

Calculate the average of the six diameters measured. This gives the mean bore diameter which should be used in conjunction with the Specification to establish piston skirt to bore clearance figures.

On new cylinder blocks the measurement is taken as at 2 only.

PISTONS AND CONNECTING RODS

Remove the piston rings, identifying them so that each ring can be refitted later (if serviceable) in the same groove in the piston from which it came.

Remove all carbon deposits from the ring grooves.

Remove the piston pin circlips and warm the piston in hot water. Push out the piston pin and separate the piston from the connecting rod - see Fig. 29. Keep each piston with its respective connecting rod.

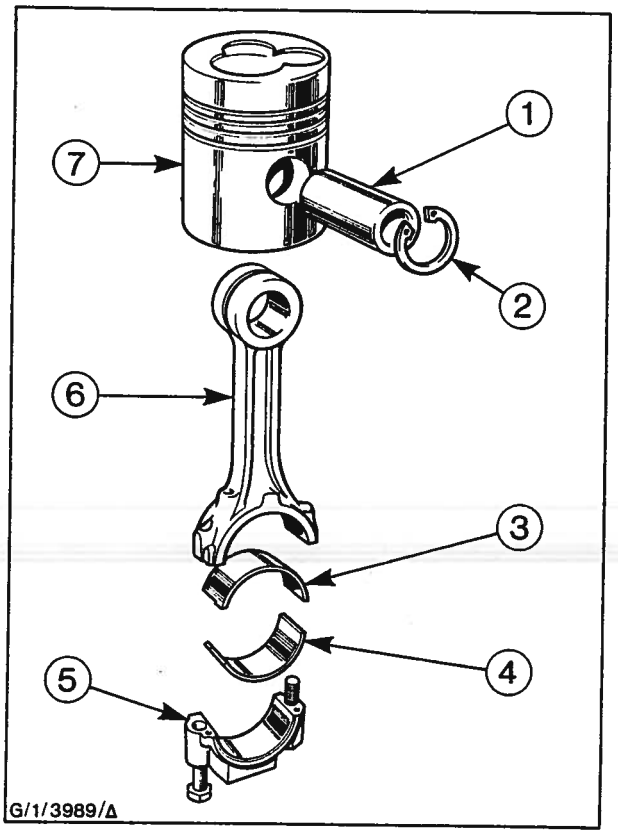

Fig. 29 - Piston and Connecting Rod Assembly
1. Piston Pin
2. Circlip
3. Upper Bearing Liner
4. Lower Bearing Liner
5. Bearing Cap
6. Connecting Rod
7. Piston

The piston must be free from scuffing or scoring and the piston ring lands sound and undamaged around the full circumference of the piston.

Measure the diameter of the piston at 90° to the piston pin at the piston grade point - see Fig. 30 and refer to 'Specifications'.

Calculate the piston clearance by subtracting this measurement from the mean diameter of the cylinder bore.

If the specified clearances cannot be achieved the pistons must be renewed, or if the cylinder bores are worn or damaged they may be rebored to fit oversize pistons (see specifications).

Measure the width of the piston rings and ensure they are within the specified limits.

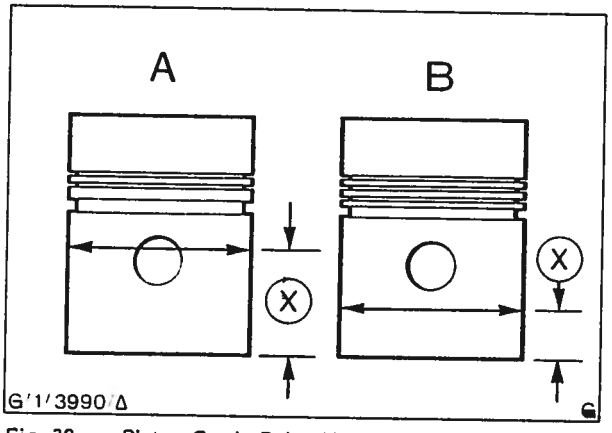

Fig. 30 - Piston Grade Point Measuring Locations
A. Naturally Aspirated Engines
B. Turbocharged Engines
X. See Specifications

Locate each ring in turn in its respective cylinder bore and ensure the ring gap is within the specified limits - see Fig. 31.

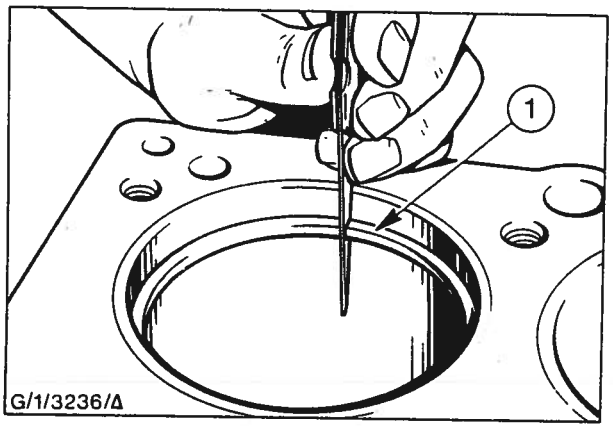

Fig. 31 - Checking Piston Ring Gap in Cylinder Bore
1. Piston Ring

Install the rings in their respective grooves in the piston with the TOP mark uppermost and measure the ring clearances as follows:

Top Compression Ring (Tapered Section) on Turbocharged Engines.

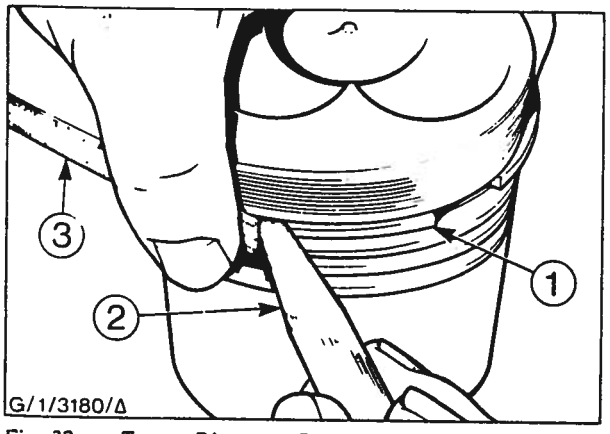

Fig. 32 - Taper Ring to Groove Clearance Check - Turbocharged Engines
1. Top Compression Ring
2. Feeler Gauge
3. Steel Rule

Hold the piston in one hand with a small steel rule held by the thumb so that it bridges the top ring groove - see Fig. 32.

With the index finger press the top ring from the opposite side of the piston, against the steel rule.

Measure the ring to groove clearance by inserting a feeler gauge as near as possible to the point where the ring touches the steel rule. The feeler gauge must be inserted to the full depth of the groove.

All Other Rings (Including Oil Control)

Hold the ring in the approximate installed position and measure the clearance between the ring and the groove at three equi-distant points around the piston - see Fig. 33.

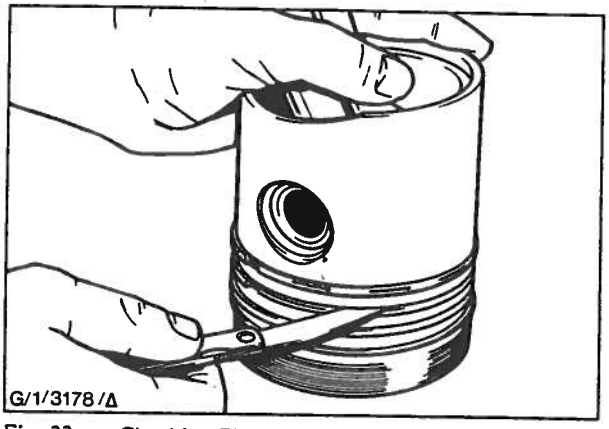

Fig. 33 - Checking Piston Ring to Groove Clearance

Measure the piston pin bore at two points in both sides at approximately 45° to the vertical plane using a suitable dial gauge - see Fig. 34.

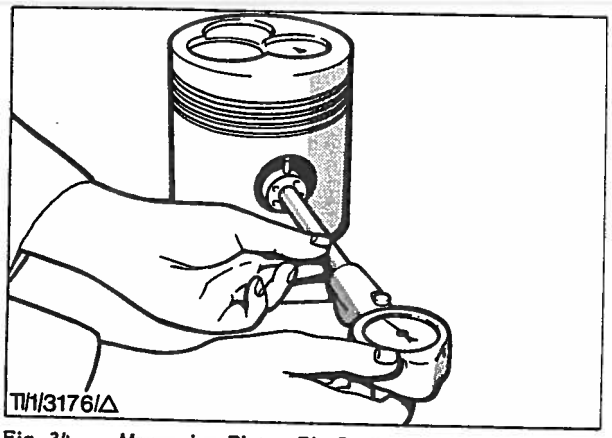

Fig. 34 - Measuring Piston Pin Bore

If the specified clearances cannot be achieved with the original components, or by fitting new rings and/or piston pins, the pistons must be renewed.

Check to ensure the big end bearing housing is undamaged and that the side cheeks are not damaged to scored. If the engine has suffered a major failure the rods must be checked for twist or bend.

Measure the small end bush bore (piston pin bore) using a suitable dial gauge - see Fig. 35. If the bore is not within the specified limits a new connecting rod must be fitted.

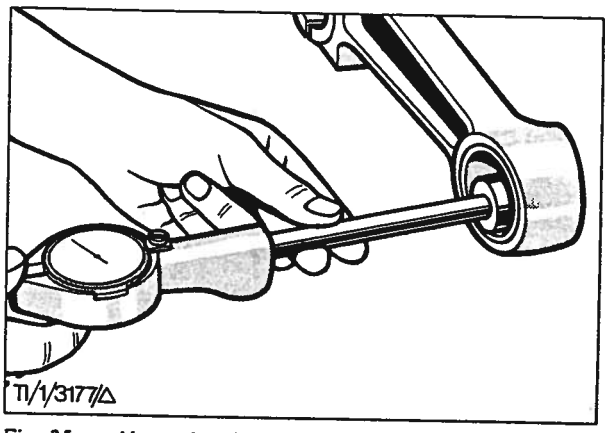

Fig. 35 - Measuring Connecting Rod Bush Diameter

NOTE: The combustion space is closely controlled by means of length graded connecting rods. The connecting rods can be identified by a grade stamp. When repairing or rebuilding these engines it is essential that all connecting rods are the same grade as those originally fitted. If a new or a reground crankshaft is to be fitted then a complete set of connecting rods may be required to maintain the 'bump height' clearance. To establish the connecting rod grade for each cylinder the procedure detailed in 'Assembling the Engine' must be carried out.

CRANKSHAFT AND BEARINGS

The crankshaft journals must be free from scoring or excessive wear.

Measure the diameter of each journal in at least four places and ensure that it is within the specified limits of wear, taper and ovality.

Measure the length of the centre main journal against the specified dimensions in order to ensure that the crankshaft end float can be maintained within the specified limits (using oversize thrust washers, if necessary).

Check to ensure all oil supply holes are clear and that the rear main oil seal wiping surface is free from damage which may render the oil seal ineffective.

On 6 cylinder engines, if the crankshaft is to be renewed or reground, unscrew and remove the front adaptor plug.

Check to ensure that the flywheel mounting flange bolt hole threads are sound, and that the flange itself is free from burrs or damage which may cause misalignment of the flywheel.

If the crankshaft is considered serviceable, check the main and big end bearing liners for scoring, pitting or excessive wear. A properly fitted bearing will appear dull grey after a reasonable period of service, indicating it has been running on an oil film. Bright spots indicate a metal to metal condition of contact and black spots indicate excessive clearance, and these bearings must be renewed as must those which are chipped, flaked or scored.

If the bearing surfaces appear serviceable, measure the thickness of each liner to ensure they are within the specified limits.

NOTE: Original assembly bearing liners are 'graded', see Specifications.

CAMSHAFT BEARING RENEWAL

NOTE: Service camshaft bearings are 'pre-sized' and do not require machining after being installed.

1. Remove the timing gear housing locating ring (if not already removed) - see Fig. 36.

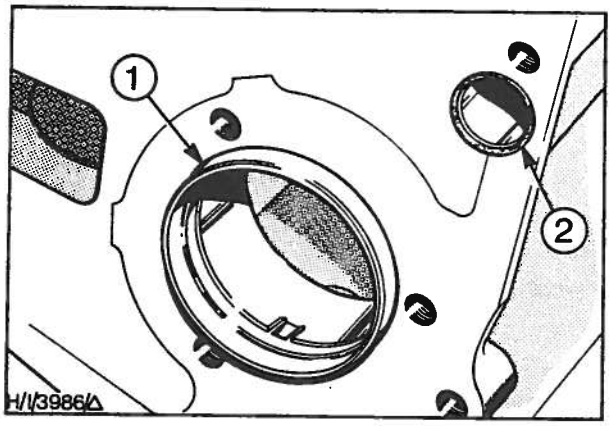

Fig. 36 - Cylinder Block Front Face
1. Timing Gear Housing Locating Ring
2. Oil Gallery Seal 'O' Ring

2. Drive out the expansion plug in the rear of the camshaft bearing housing.

3. Remove the camshaft bearing bushes using Special Tool No. (21-022) and Adaptor Kit (21-022-51A and 21-022-53). Select the stepped cylindrical adaptor whose small end will spigot into the bearing bush (see illustration Fig. 38).

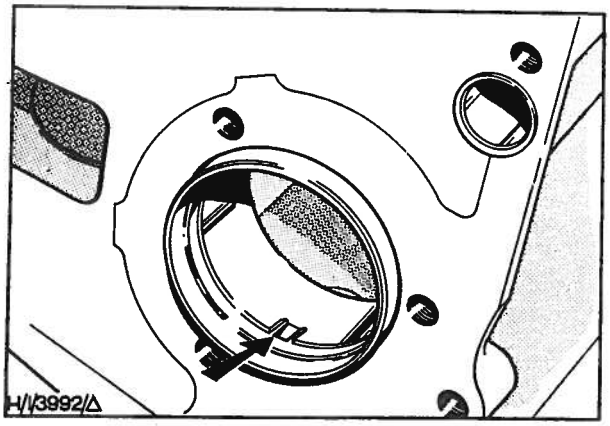

Fig. 37 - Camshaft Front Bearing Tang

4. Bend up the tang on the camshaft front bearing (Fig. 37).

5. With the open end of the tool against the outer face of the front or rear camshaft bearing boss and the screwed centre bar passing through the intermediate bearing boss(es), position the adaptor with its small end spigoted into the bearing to be removed.

6. Fit the 'C' plate in the groove in the centre bar behind the adaptor and by rotating the main handle withdraw the bearing from its boss.

7. Repeat the operation for each bearing.

NOTES:
(i) The front bearing has a copper/lead bearing surface while the rest have white metal, and it is essential to ensure that the front bearing is of the correct type.

(ii) In order that the lubrication holes line up correctly, the new bearings must be installed with the split to the right side of the engine and the notch to the rear. The notch must be positioned vertically and toward the sump face of the engine.

8. Install the new bearings using the Special Tool No. (21-022) and Adaptor Kit (21-022-51A and 21-022-53). Select the stepped adaptor used previously together with the two guides which must be used to ensure the bushes are pulled squarely into position (see illustration). Assemble the guide and bush onto the screwed rod, with the spigoted end of the adaptor fitted into the bearing being installed.

9. Fit the 'C' plate onto the centre bar behind the adaptor and rotate the main handle to draw the bearing into the housing until is is flush with the face.

10. Repeat the operation for each of the bearings.

11. After fitting the front bearing, bend the tang into the locating hole in the cylinder block - see Fig. 37.

12. Fit a new expansion plug into the rear face of the cylinder block. Apply a thin film of specified sealer to the outer periphery of the plug and around the plug bore before pressing into position. The sealer must be kept clear of the camshaft bearing.

13. Lubricate the bearings with clean engine oil and install the camshaft carefully to avoid damaging the bearings. Check to ensure it rotates freely.

NOTE: If a new camshaft is being installed the phosphate coating on the journals must be burnished off in a continuous rotating movement, in the normal direction of rotation.

CYLINDER LINER RENEWAL - 2726T AND 2728T ENGINES ONLY

This operation is described using an EPCO Flexiforce Cylinder Liner Press (FF 138). Alternative equipment may be used providing a suitable replacer plate is available to give the specified protrusion of the new liner when assembled into the block.

1. Assemble the four support legs into the cylinder pressure plate and the main pressure plate onto the opposite end of the legs - see Fig. 39.

2. Locate the assembly over the liner to be removed and retain with a locating bolt into one of the cylinder head stud holes.

3. Insert the long pull rod through the cylinder bore and assemble the remover plate, washer and nut to the lower end.

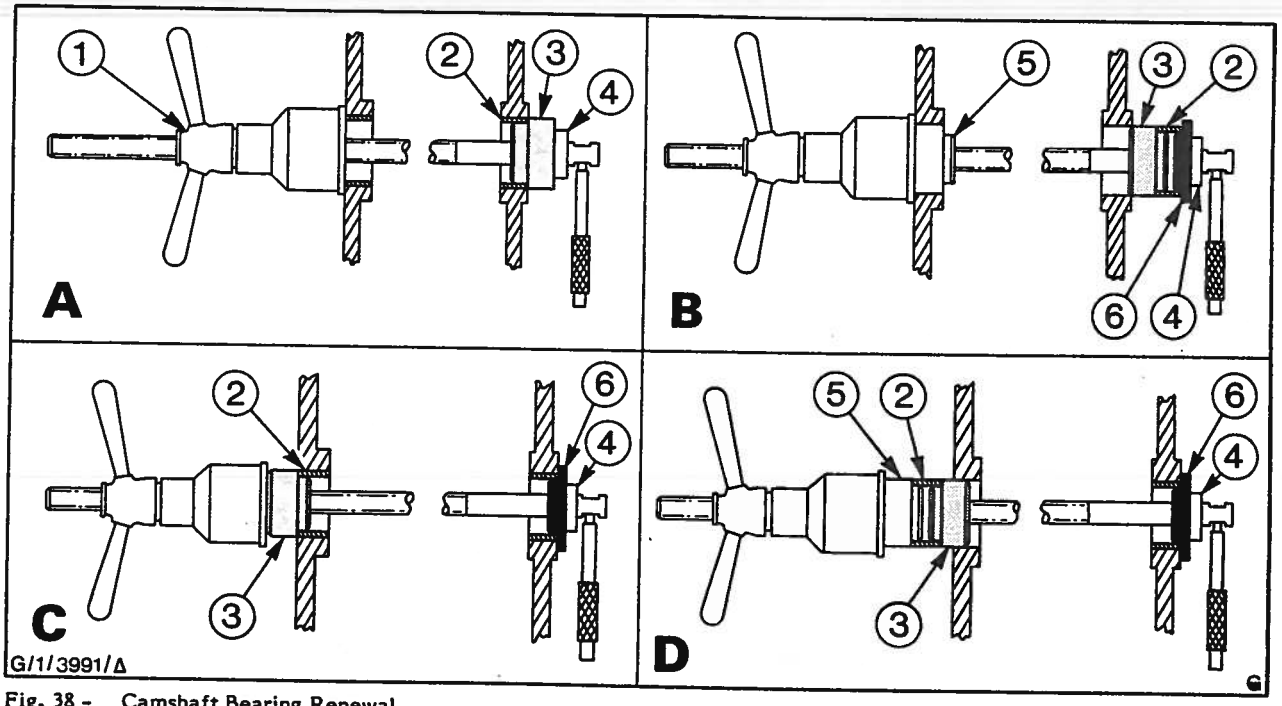

Fig. 38 - Camshaft Bearing Renewal
A. Removing an Intermediate Bearing
B. Installing an Intermediate Bearing
C. Removing a Front or Rear Bearing
D. Installing a Front or Rear Bearing
1. Main Tool Remover/Installer No. 21-022
2. Bearing
3. Long Adaptor/Locator
4. Parts of Tool No. 21-022-51A
5. Short Adaptor/Locator
6. Shouldered Locator/Installer

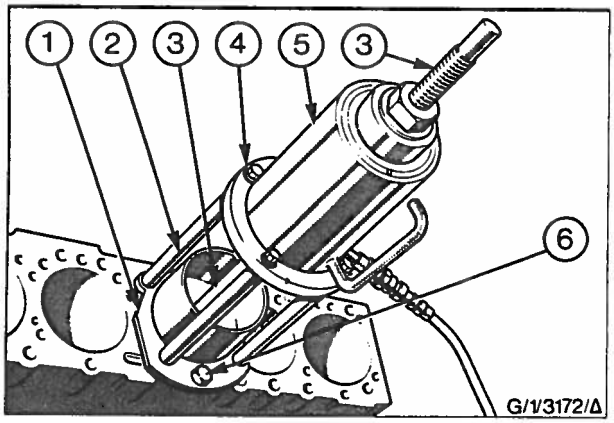

Fig. 39 - Cylinder Liner Removal
1. Cylinder Pressure Plate
2. Support Legs
3. Pull-Rod
4. Ram Pressure Plate
5. Ram Assembly
6. Retaining Bolt

4. Position the ram assembly over the pull rod and locate the ram base into the ram pressure plate. Pass the pull rod through the ram and retain the washer and nut.

5. Ensure the remover plate is correctly located in the lower end of the liner and tighten the upper nut to nip the assembly together.

6. Connect the hydraulic pump to the ram, close the pressure release valve and operate the pump to withdraw the liner.

7. When the ram reaches the end of its stroke release the pressure and allow the ram to return to the free position. Adjust the length of the pull rod by tightening the upper nut, close the pressure release valve and operate the pump to further withdraw the liner.

8. Repeat the operation until the liner is fully withdrawn.

9. Thoroughly clean and degrease the cylinder block bore and the new cylinder liner.

10. Coat the outside surface of the new cylinder liner with Locquic Primer T (FORD Specification SM4G-4647-A) and allow to dry.

11. Apply a 75 mm (3 in) wide band of Loctite Sealer (FORD Specification EM4G-64) to the top of the cylinder block bore.

12. Enter the liner into the block, internal chamfer uppermost, using a hide mallet. Check that the liner is perfectly square with the cylinder block using a square against the cylinder block face in at least four places.

13. Assemble the two long pull rods together using the pull rod coupler, and assemble the cross beam with a nut and washer to the lower end. Pass the assembly through the cylinder bore and liner locating the cross beam across the bottom face of the crankcase - see Fig. 40.

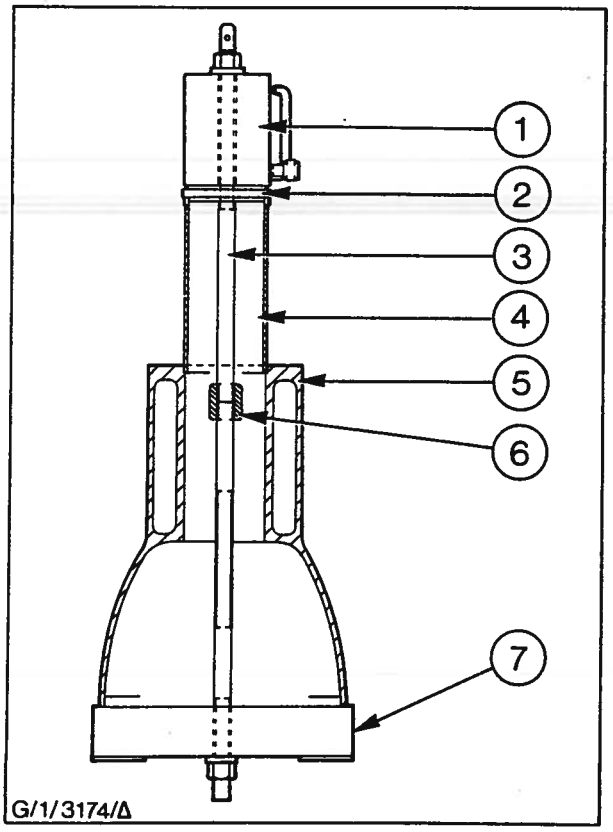

Fig. 40 - Fitting Cylinder Liner
1. Ram
2. Replacer Plate
3. Pull-Rod
4. Liner
5. Cylinder Block
6. Coupler
7. Crossbeam

14. Slide the replacer plate over the top of the pull rod and locate the groove on to the top of the liner.

15. Place the ram assembly over the pull rod and against the replacer plate. Fit the nut and flat washer and tighten to nip the assembly together.

Adjust the length of the pull rod by tightening the upper nut, close the pressure release valve and operate the pump to further press the liner into the block.

16. Connect the hydraulic pump to the ram, close the pressure release valve and operate the pump two or three strokes to pressurise the system and take up any free play. Check to ensure that the cross beam is central under the bore and that the liner is still perfectly square with the block and operate the pump to press the liner into the block. Check to ensure the liner is entering the block squarely.

17. When the ram reaches the end of its stroke, release the pressure and allow the ram to return to the free position.

18. Repeat the operation until the liner is fully home and the replacer plate is flush against the cylinder block face. (The groove in the replacer plate should give the correct liner protrusion).

NOTE: Maintain the operations in an as continuous a sequence as possible. Do not allow the pressing operation to stop any longer than is absolutely necessary to adjust the pull rod nut.

19. Remove the press and check the liner protrusion.

CYLINDER HEAD OVERHAUL

The following dismantling instructions exclude the rocker shaft assembly, push rods and injectors which would have been removed when dismantling the engine.

1. Remove the valve stem caps in sequence so that each cap can be replaced on the same valve during assembly.

2. Using the Valve Spring Compressor and Adaptors (21-024, 21-024-02, and 21-516) depress each valve spring in turn and remove the collets, retainers, springs, seats, seals and valves. Retain each assembly in a numbered sequence for reassembly to the same position in the head.

CLEANING AND INSPECTION

Thoroughly clean the cylinder head in a kerosene bath, using a soft metal scraper to clean away carbon deposits. Ensure all water and oil passages are flushed clean. Clean gasket faces with a blunt scraper. Dry the head with compressed air. Scrape carbon from the valves and clean them on a buffing wheel.

Examine the head visually for obvious damage; cracks, scored flange faces, bent studs, damaged threads or loose valve guides. Tap the valve seat inserts lightly to detect any looseness. Mark any seats which are loose, worn, burnt or otherwise require renewal.

Where required, check the cylinder head for cracks using dye penetrant or magnetic detection methods. Reject a cracked head.

Check the cylinder head-to-block face for longitudinal and transverse bowing. If outside the specified limits the head may be skimmed to restore flatness.

NOTE: Skimming will require valve seat renewal to enable counterbore recutting. This is essential to maintain valve seat to head face relationship.

Measure the valve guide bores for wear and ovality with a small bore gauge. Where a gauge is not available, use a new valve to estimate any wear. Mark worn guides for renewal.

RESURFACING

An end mill (carbide tool tip cutter) of 250 mm (10 in) minimum diameter must be used for resurfacing the head. Under no circumstances is grinding permitted.

A tool tip speed of 1,22 m/s (240 ft/min), a tool feed speed of 0,076 mm (0,003 in) per rev/min per tool tip and a tool cutting angle of 0,10 to 0,25 mm (0,004 to 0,010 in) positive must be adopted to achieve the required surface finish of 2032 to 3048 nanometres (80 to 120 micro inches).

When clamping the head to the machine table, the 'bowed' condition must be maintained to ensure that it will be removed by the machining process.

After resurfacing, renew the valve seats as described elsewhere in this section.

VALVE GUIDE RENEWAL

Using Valve Guide Installer/Remover Tool (21-500) or a suitable press, remove the valve guide(s). Check the cylinder head bore for scoring or tearing. Carefully stone out any damage, removing only the burred material.

Using the special tool or a bench press, insert the new guide (internally chamfered end facing outwards) to the specified protrusion - see Fig. 41.

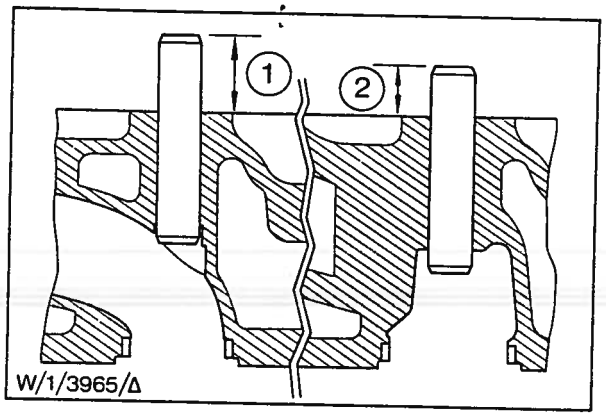

Fig. 41 - Valve Guide Protrusion
1. Exhaust
2. Inlet

Check the valve guide/seat concentricity by carrying out a 'blueing' check and recut or relap the seats as required.

VALVE SEAT INSERT RENEWAL

This operation requires special equipment beyond the scope of this manual, however, the following points should be observed:

Remove the inserts by machining. Any other method may cause irreparable damage to the cylinder head.

Remove only the minimum amount of material (if any) to clean up the insert recess. If the cylinder head face has been skimmed, recut the recess by an amount equal to the skimming cut. Where oversize inserts are to be fitted, recut in depth and diameter to accommodate the larger insert.

Maintain concentricity with the existing counterbore and use the cylinder head upper face as the datum for measurements.

Shrink the new seats in liquid nitrogen for a minimum period of 5 minutes before fitting.

After fitment, cut the seats to the smallest possible specified width and check for 100% circumferential contact. Lap in lightly as required.

NOTE: Due to the design difference of valve seat and valve face angle, it is not necessary to attempt to gain full seat width contact.

Label the valves as per their lapped position.

VALVES AND VALVE CAPS

Examine the valves and reject any which are burnt, pitted, cracked, bent or worn beyond specified limits. Discard any valve cap which is grooved or valve collets which are worn. Although it is preferable to renew all valves during overhaul, otherwise serviceable valves may be refaced and refitted provided that the specified valve protrusion is maintained.

Remove only the minimum amount of metal to correct any fault then lap the valves to the seats with grinding paste. Check the seating with engineers blueing compound, checking for a 100% minimum, but narrow band of contact.

NOTE: Label the valves after lapping to ensure they will be fitted to their respective seats.

Thoroughly clean all traces of lapping compound from the valves and seat inserts.

VALVE SPRINGS

Except where the springs are to be renewed, examine for broken or distorted coils. Measure the spring load against the specified length and renew springs which do not come within the limits.

PUSH RODS

Examine the rods generally, check for bend and for worn ball and socket ends. Where required, determine serviceability by blue checking against a new cam follower and rocker arm adjusting screw.

ROCKER SHAFT ASSEMBLY - SEE FIG. 42

Dismantle the assembly by removing the shaft locking bolts and sliding all components from the shaft(s). Remove each component in sequence so that it can be replaced in the same position when assembling. Remove and discard the shaft cup plugs. Clean all components in kerosene and ensure all oilways are clear.

Measure the rocker shaft diameter in the rocker arm areas. Discard if grooved or worn beyond limit.

Examine the rocker arms for cracks, worn or grooved valve pads and worn bushes. Check the condition of the adjusting screw ball end and the self locking property (torque required to turn) of the screw against the specified limits. Discard any arm assembly which does not meet specifications.

Examine the shaft supports for cracks.

Examine the springs for general conditions and check the 'load to compress to specified length'. Renew any which do not conform to the limits.

Using a suitable tool, press new cup plugs in the shaft(s). For 6 cylinder engines, note that only the outermost end of each shaft is recessed for the plug. The inner end must be left open for the passage of oil.

Lubricate the shaft(s) and assemble the components into the order shown. Fit new lock washers, then correctly locate and tighten the intermediate support bolts to the specified torque.

NOTE: On 6 cylinder engines, the inner end of each 'half shaft' is a sliding fit in the central support, the actual positions being determined during installation to the engine.

Use string, locking wire or large, old 'O' rings to 'tie' the assembly together until it is required for installation.

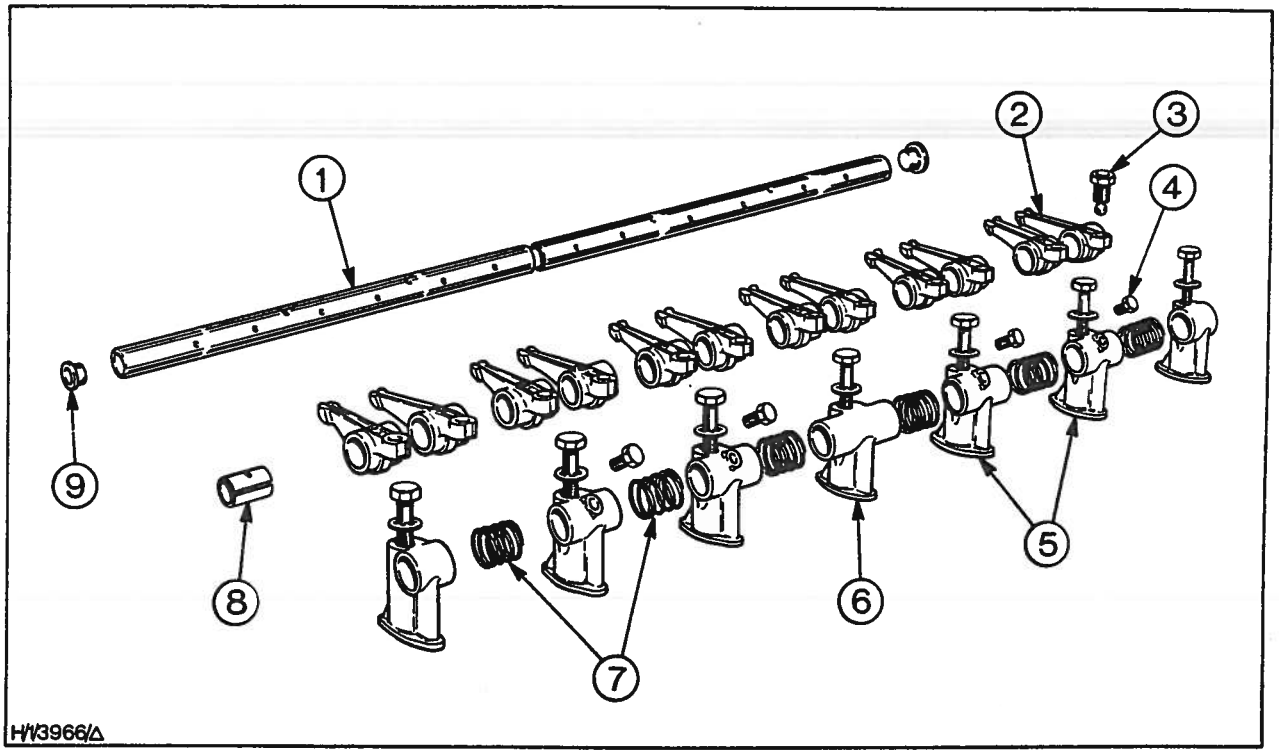

Fig. 42 - Rocker Shaft Assembly Exploded - 6 Cylinder Engines

1. Rocker Shafts
2. Rocker
3. Adjusting Screw
4. Shaft Locking Bolt
5. Support Pillars
6. Support Pillar with Oil Feed
7. Spacer Springs
8. Bush
9. Cup Plug

FITTING THE VALVES

Lightly lubricate the valve guides and insert the valves in their respective positions. Use a piece of wood to hold the valves onto their seats while the cylinder head is face down.

Position the valve spring seating washers and fit new seals to all valve stems as follows:

Inlet Valves of Naturally Aspirated engines: Fit spring loaded type seals only to these valves. Install the seals with the Seal Installer (21-537) - see Fig. 43.

CAUTION: FAILURE TO INSTALL THE SEALS CORRECTLY CAN CAUSE HIGH OIL CONSUMPTION AND SEVERE CARBONING OF THE INLET PORTS.

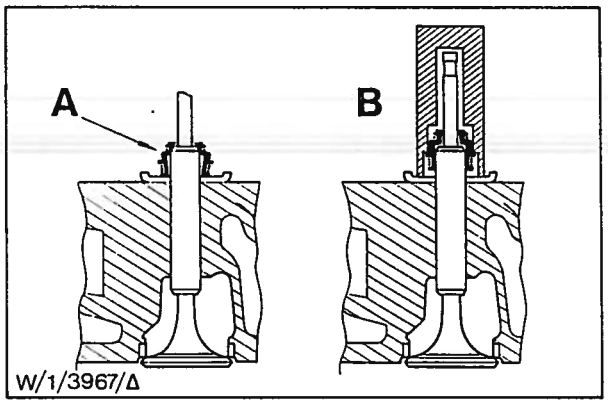

Fig. 43 - Fitting Inlet Valve Stem Seals on Naturally Aspirated Engines
A. Incorrectly installed causing enlarged sealing edge
B. Correctly installed using Tool No. 21-537

All other valves: Fit plastic umbrella type seals.

Position the valve springs and retainers, compress the springs with the special tool (21-024, 21-024-02, and 21-506) and fit the collets.

NOTE: Exhaust valve springs are longer than inlet springs before fitting and are identified by a painted yellow line. Both inlet and exhaust valve springs may be fitted either way up.

Lightly lubricate and install the valve stem caps.

CAUTION: IF AN INLET VALVE SEAL OF A NATURALLY ASPIRATED ENGINE IS REMOVED FOR ANY REASON - TEMPORARY OR OTHERWISE, IT LOSES ITS OIL CONTROLLING CAPABILITY. ALWAYS FIT A NEW SEAL AND DESTROY THE OLD.

CLUTCH PILOT BEARING

Extract the bearing using Remover, Tool No. 21-036. Drive the new bearing into position, using a hardwood block and a mallet.

NOTE: Bush type bearings must be driven home until the underside of the flange is in contact with the flywheel face. Ball type bearings must be installed so that the outer end is flush with the housing.

FLYWHEEL RING GEAR RENEWAL

1. Remove the six countersunk screws retaining the ring gear to the flywheel.

2. If an oven with heat control is available, heat the flywheel and ring gear to 190°C (375°F) and remove the ring gear using a hammer and a blunt nosed chisel.

3. If an oven with heat control is not available support the flywheel in a sturdy vice taking great care not to damage the flywheel face, and cut through the ring gear between two of the teeth and in line with one of the retaining screw holes using a sharp hacksaw. Cut into the ring gear as far as possible taking care not to cut into the flywheel.

4. Take a sharp chisel and a heavy hammer and drive the chisel into the cut from the outer (toothed) edge again taking care not to damage the ring gear register. The ring gear should snap across the line of the cut and will spring apart.

5. Clean the flywheel. Lightly stone off any burrs but do not clean the ring gear register with emery cloth or similar materials as this could upset the interference fit of the ring gear.

6. Screw locating studs into two diametrically opposite retaining bolt holes in the flywheel.

7. If an oven with heat control is available, heat the ring gear to 190°C (375°F).

8. If an oven with heat control is not available, support the ring gear on a flat heat resistant surface (e.g. fire brick) and heat the ring gear evenly using a suitable heating torch (NOT a cutting torch) to 190°C (375°F). To ensure the ring gear is not overheated use a 190°C (375°F) Tempilstick crayon or equivalent. Stroke the ring gear several times with crayon whilst applying heat. The crayon will leave a chalk mark until the temperature is reached when a liquid smear will appear.

CAUTION: OVERHEATING WILL SOFTEN THE RING GEAR.

9. Locate the ring gear over the two locating studs and tap it firmly and evenly into place while still hot.

10. Remove the locating studs.

11. Apply specified sealer to the retaining screw threads and tighten to the specified torque.

ASSEMBLING THE ENGINE

GENERAL

Lubricate all moving parts and threads with clean engine oil as assembly proceeds unless otherwise instructed.

Use only the specified sealers where indicated.

BASIC ENGINE ASSEMBLY

1. Mount the engine on the Stand (200B) using Mounting Bracket (21-535).

2. Check, renew, or refit as necessary all blanking plugs, expansion plugs, union adaptors and studs removed during overhaul and cleaning.

3. On the threaded main oil gallery plugs (front, side and rear) apply specified sealer to the leading threads before fitting. Tighten to the specified torque.

4. On the oil gallery core plug (rear), the tachometer drive blanking plug and the cylinder block rear water jacket core plug (4 cylinder engines only) apply specified sealer around the plug bore and drive the plug firmly home - see Fig. 44.

CAUTION: DO NOT ALLOW THE SEALER TO CONTACT THE CAMSHAFT REAR BEARING.

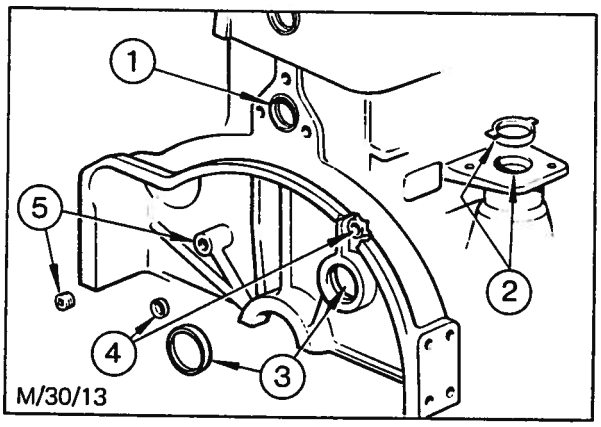

Fig. 44 - Cylinder Block Blanking Plugs
1. Rear Water Jacket Core Plug (4 cylinder only)
2. Tachometer Drive Blanking Plug
3. Camshaft Bore Rear Cup Plug
4. Oil Gallery Core Plug
5. Main Oil Gallery Threaded Plug (also front, and side when not fitted with Turbocharger)

5. On the camshaft bore rear cup plug, apply specified sealer to the outer periphery of the plug and around the plug bore and drive the plug firmly home. DO NOT allow the sealer to contact the camshaft rear bearing.

6. On the water pump studs, apply specified sealer to the leading threads before fitting. Tighten to the specified torque.

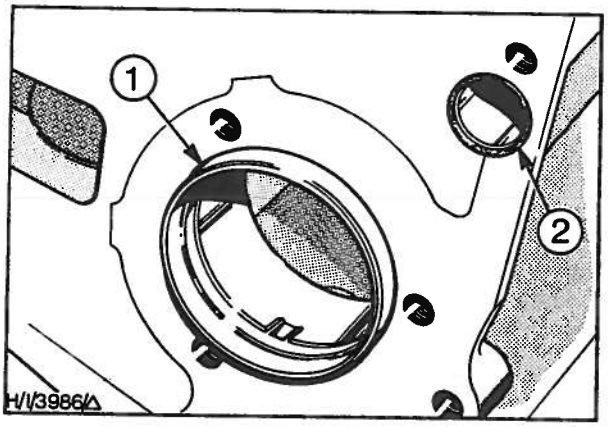

Fig. 45 - Cylinder Block Front Face
1. Timing Gear Housing Locating Ring
2. Oil Gallery Seal 'O' Ring

7. Place the timing gear housing locating ring into the counterbore in the camshaft front bearing housing, and tap it firmly against the stop using a soft faced mallet (Fig. 45.).

8. Invert the engine to bring the crankcase oil pan face uppermost.

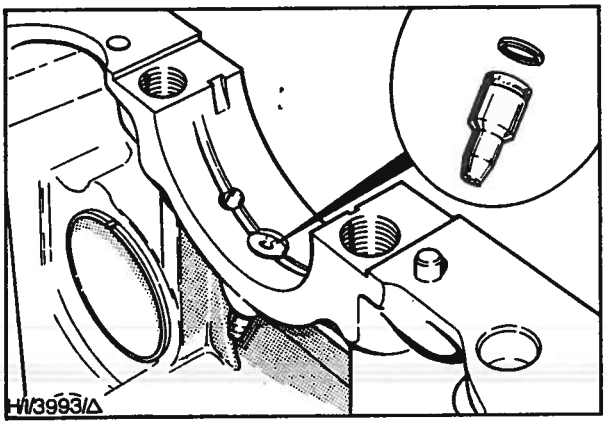

Fig. 46 - Piston Cooling Nozzle

9. On 2728T intercooled engines, if the piston cooling nozzles have been removed, fit new 'O' rings to the nozzles and fit the nozzles into the main bearing housings (Fig. 46). Lightly lubricate the 'O' rings to aid assembly. Ensure the nozzles do not protrude into the bearing housings.

NOTE: The centre main bearing housing is not fitted with a piston cooling nozzle.

10. Ensure the front main bearing cap locating dowels are in position and driven firmly home.

CAMSHAFT INSTALLATION

11. Locate the camfollowers into their respective bores in the block.

12. Enter the camshaft into the block taking great care not to score or damage the bearing liners on the cam lobes.

NOTE: When fitting a new camshaft to a heavy duty PTO engine, only the specified heavy duty camshaft must be used.

CRANKSHAFT INSTALLATION

13. Install the graphited fibre rope type seal into the groove in the rear main bearing cap and the cylinder block. DO NOT use any sealer or adhesive. Tap the seal fully home into the respective grooves using Seal Installer 21-506 as shown in Fig. 47.

With each half seal held with the installer, trim the ends of the seal with a sharp knife or scalpel to leave 0,635 to 0,762 mm (0,025 to 0,030 in) proud of the face. Trim off any frayed threads.

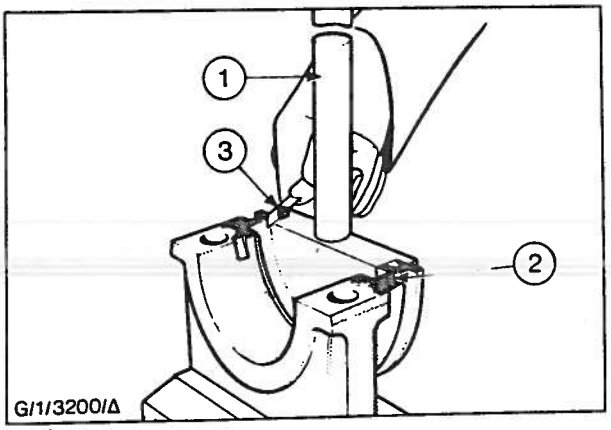

Fig. 47 - Fitting Crankshaft Rear Oil Seal - (Main Bearing Cap Shown)
1. Installer (21-506)
2. Seal
3. Trim Seal

14. Ensure the main bearing housings and caps are perfectly clean and dry and fit the main bearing liners into their respective positions, with the locating tongues engaged in the slots.

NOTE: The liners with oil holes and a continuous oil groove fit into the block, those without oil holes fit into the caps. The centre and rear main bearing cap liners only, have a continuous oil groove.

15. Fit the centre main bearing upper thrust washers into position ensuring that the tongues are located in the anchor slots - see Fig. 48.

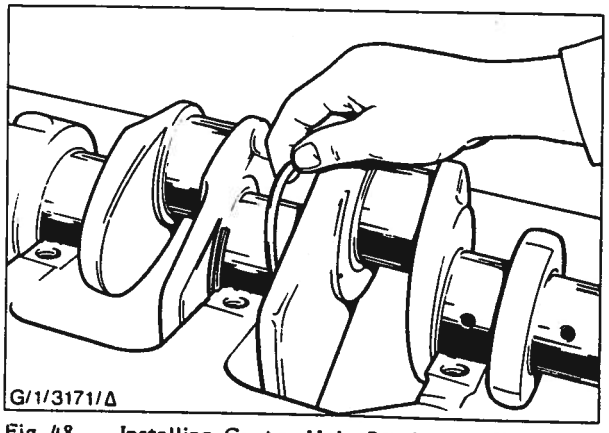

Fig. 48 - Installing Centre Main Bearing Upper Thrust Washers

16. Thoroughly lubricate the bearing liners and crankshaft main journals. Apply a smear of grease (FORD Specification SGM-1C-9001A) to the running surface of each half of the rear main oil seal.

17. Carefully lower the crankshaft into the block taking care not to disturb or damage the centre main bearing thrust washers.

18. Locate the centre main lower thrust washers into the centre main bearing cap and fit it to the block. Tighten the bolts finger tight. Fit the intermediate and front main bearing caps and liners into their respective positions and tighten the bolts finger tight.

19. Lever the crankshaft backwards and forwards axially to ensure the centre main bearing cap is centralised and tighten the bolts to the specified first stage torque. Check crankshaft rotation.

20. Ensure that the rear main bearing cap and block mating faces are clean and dry, and apply specified sealer to the cylinder block at the areas shown in Fig. 49.

CAUTION: (i) THIS SEALER HARDENS ON CONTACT WITH METAL AND THE JOINT MUST NOT THEREFORE BE LEFT IN A DISMANTLED CONDITION ANY LONGER THAN IS ABSOLUTELY NECESSARY.

(ii) IT IS ESSENTIAL THAT THE SEALER IS APPLIED WITH A FINE TIPPED NOZZLE TO THE AREAS SHOWN.

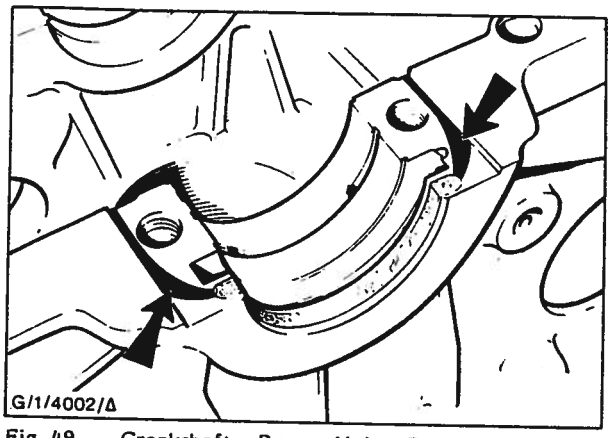

Fig. 49 - Crankshaft Rear Main Bearing Housing (Apply Sealer in areas shown)

21. Fit the rear main bearing cap and tighten the bolts to the specified first stage torque.

22. Tighten the remaining main bearing cap bolts in turn to the specified first stage torque, checking the crankshaft rotation after tightening each cap.

23. Check the crankshaft end float. Lever the crankshaft forward to take up end float in one direction, and insert feeler blades between the crankshaft thrust washer and the crankshaft to check that the end float is within the specified limits - see Fig. 50.

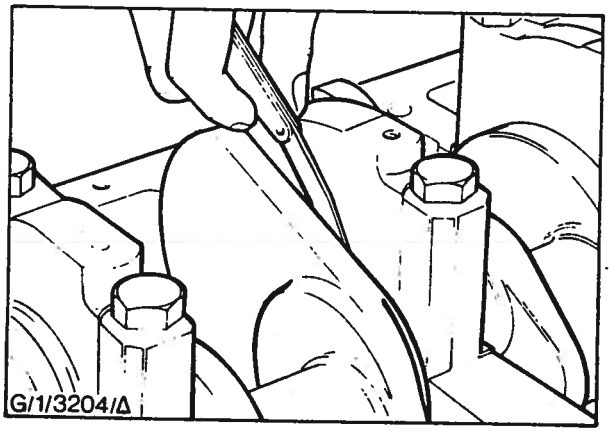

Fig. 50 - Measuring Crankshaft End-Float

24. Fit oversize thrust washers if the end float is excessive and recheck as before.

25. Tighten the main bearing cap bolts in turn to the specified second stage torque again checking the crankshaft rotation after tightening each cap.

CRANKSHAFT GEAR INSTALLATION

26. Fit the crankshaft gear key into the crankshaft, stepped end toward the front end of the crankshaft.

27. Heat the crankshaft gear to 82°C (185°F) in a suitable hotplate, oven or oil bath, and fit it over the crankshaft, shouldered face outermost, aligning the keyway with the key in the crankshaft. Push or drive it fully home against the shoulder.

TIMING GEAR HOUSING INSTALLATION

28. Locate a new 'O' seal ring into the counterbore at the end of the oil gallery on the front face of the block and position the timing gear housing (using a new gasket) over the locating ring - see Fig. 51.

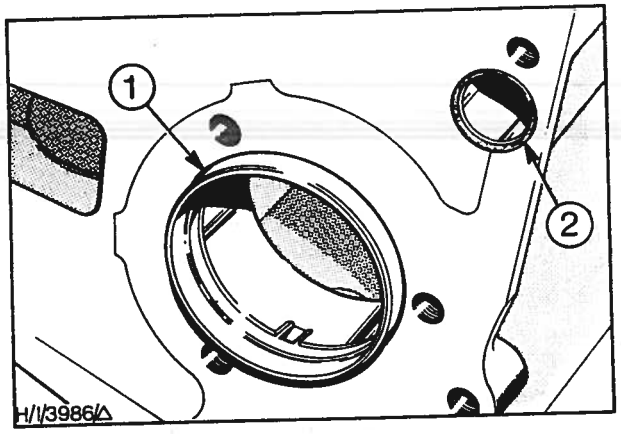

Fig. 51 - Cylinder Block Front Face
1. Timing Gear Housing Locating Ring
2. Oil Gallery Seal 'O' Ring

29. Fit the camshaft thrust collar, shouldered face outermost, the thrust plate (well lubricated), and the lockplate. Fit the bolts but do not tighten - see Fig. 52.

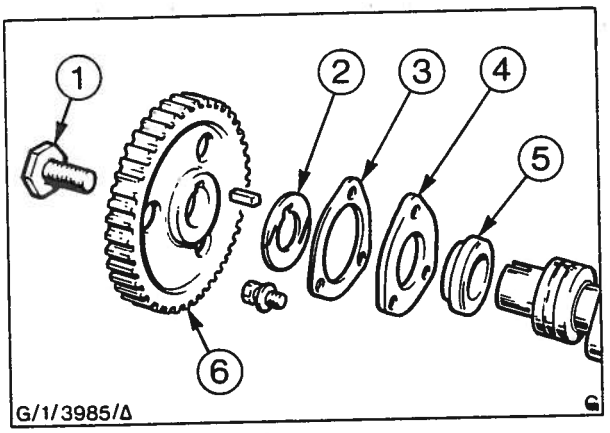

Fig. 52 - Camshaft Gear Assembly
1. Gear Retaining Bolt
2. Thrust Washer
3. Retaining Plate
4. Thrust Plate
5. Thrust Collar
6. Camshaft Gear

30. On 2728T Intercooled engines, check the alignment of the lower face of the timing gear housing in relation to the lower face of the crankcase. Looking from the front of the engine in the inverted position, the faces on the left side must be flush, with the right side as near flush as possible or to within a maximum of 0,18 mm (0,007 in) misalignment either above or below the face - refer to Figs. 53 and 54.

Check that the three studs are secure - see Fig. 53. if new studs are fitted apply the specified sealant to the threads when screwing them into position.

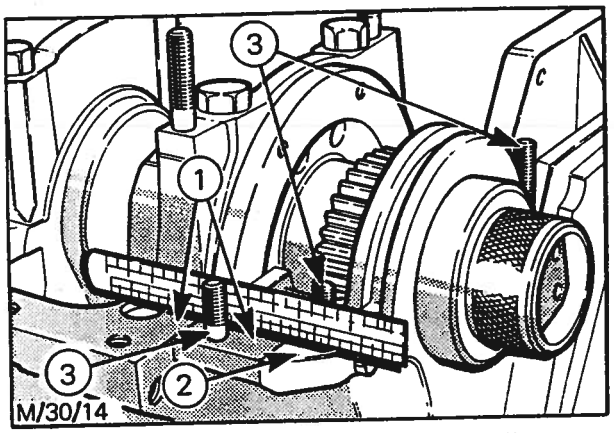

Fig. 53 - Timing Gear Housing and Cover Alignment (Left Hand Side on 2728T Engines)
1. Housing Flush with Block Face
2. Cover Parallel to Housing and Block
3. Oil Pan Studs

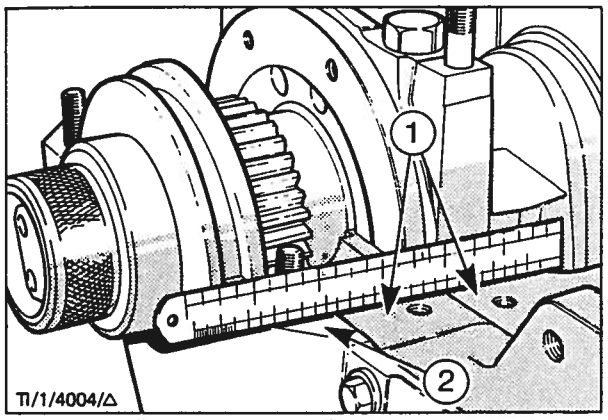

Fig. 54 - Timing Gear Housing and Cover Alignment (Right Hand Side) on 2728T Engines)
1. Housing Flush to within a maximum of 0,18 mm (0,007 in) Misalignment
2. Cover Parallel to Block

31. Nip the camshaft thrust plate bolts to secure the housing in position then tighten all the bolts in the sequence shown to the specified torque - refer to Fig. 55 or 56.

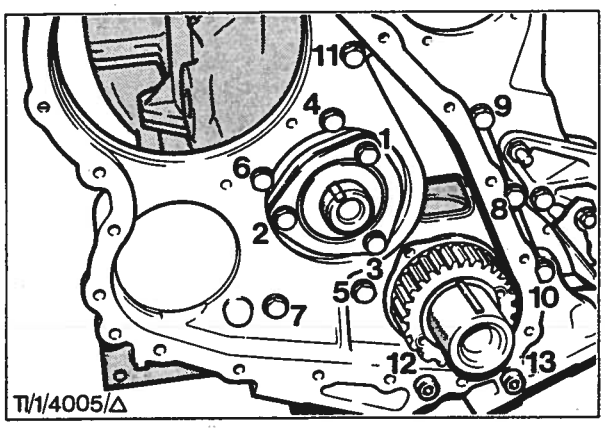

Fig. 55 - Timing Gear Housing Bolt Tightening Sequence - 4 Cylinder Engines

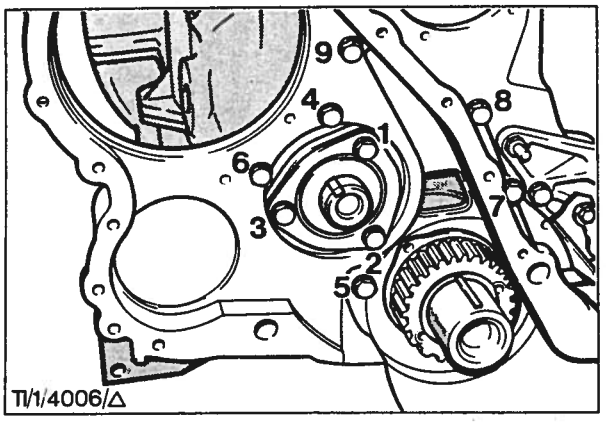

Fig. 56 - Timing Gear Housing Bolt Tightening Sequence - 2728T Engines

32. Fit the thrust washer, grooved face innermost, and the camshaft key to the camshaft.

CAMSHAFT GEAR INSTALLATION

33. Rotate the crankshaft and camshaft to bring both shafts in correct relationship to one another so that the timing marks on both gears will line up with one another when the camshaft gear is fitted. Fit the camshaft gear on to the camshaft ensuring that the keyway and the timing marks are correctly aligned - see Fig. 57. DO NOT hammer the gear on to the shaft. If the gear is too tight to fit easily, heat the gear to 82°C (180°F) before fitting it onto the shaft.

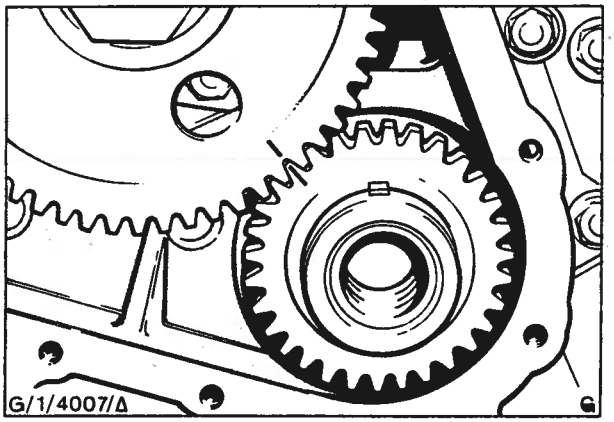

Fig. 57 - Camshaft and Crankshaft Gear Timing Marks in Alignment

34. Tighten the camshaft gear retaining bolt to the specified torque.

NOTE: If a heavy duty PTO camshaft is fitted, the special long gear retaining bolt must be used. The long bolt must not be used with standard duty camshafts - probe the depth of the hole with a piece of stiff wire to establish the type of camshaft fitted.

35. Check the camshaft end float using a dial gauge and magnetic base. If the end float is excessive the thrust collar and thrust washer must be renewed.

36. On 6 cylinder engines, if the crankshaft has been renewed, fit the crankshaft pulley adaptor insert. Apply four drops of specified sealer to the leading threads before assembly and tighten to the specified torque.

FRONT COVER INSTALLATION

37. Position a new gasket onto the front face of the timing gear housing.

38. Place the front cover onto the housing using the Housing Aligner/Seal Installer (21-536) to position the cover assembly over the crankshaft.

39. Fit the bolts and flat steel washers ensuring that the correct length bolts and socket headed bolts, when used, are installed in the correct locations.

40. On all except 2728T engines, tighten the bolts gradually and evenly to the specified torque.

41. On 2728T engines check to ensure that the lower face of the cover is parallel and flush to within 0,152 mm (0,006 in) with the crankcase lower face. Tighten the bolts evenly and gradually to the specified torque.

42. Remove the Housing Aligner/Seal Installer Tool.

CRANKSHAFT PULLEY SEAL INSTALLATION

43. After the timing housing cover has been installed and the Aligner Tool No. 21-536 removed, check the crankshaft pulley hub outer diameter at the point where it runs in the front oil seal. If the seal is in contact with a highly polished ring, remove one or both spacers (one spacer only on the 2722 engine) before installing the oil seal - see Fig. 58. This will enable the seal to run on an unpolished part of the pulley hub. Failure to do this could result in an overheated seal and subsequent oil leakage.

44. Locate the oil seal, lipped edge inwards as shown in the inset of Fig. 58 and push it fully home using tool No. 21-536. DO NOT use any sealant for this operation.

45. Invert the engine to bring the top face of the block uppermost.

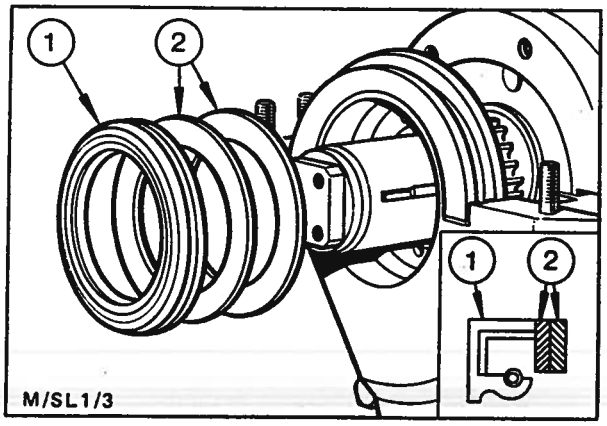

Fig. 58 - Assembling Crankshaft Pulley Oil Seal into Timing Gear Housing Cover
1. Oil Seal
2. Spacers

PISTON AND CONNECTING ROD ASSEMBLY AND INSTALLATION

If the original crankshaft is being used, then the original connecting rods, if serviceable, or new rods of the same grade length can be used in reassembly. If a new or reground crankshaft is being used it may be necessary to fit different grade rods in order to maintain the piston protrusion (bump height) within the specified limits - see under 'Checking Bump Height'.

46. Assemble each piston to its respective connecting rod. Heat the piston in hot water, locate the small end of the connecting rod into the piston ensuring that the arrow or notch on the piston crown and 'F' or 'Front' mark on the connecting rod are facing the same way (Fig. 59) and insert the piston pin into the piston and through the connecting rod. Fit the two retaining circlips.

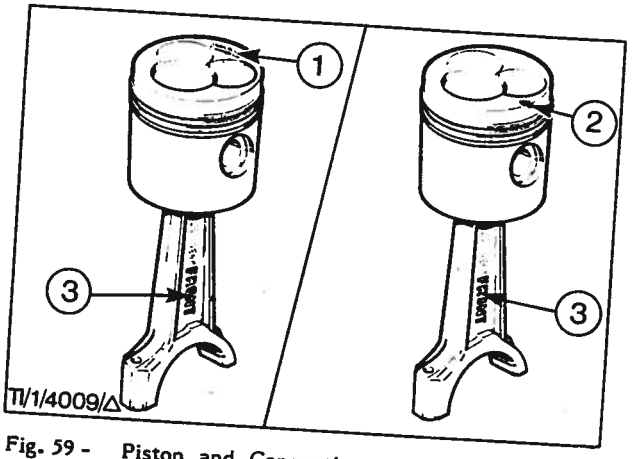

Fig. 59 - Piston and Connecting Rod 'Fitting' Marks (Towards Front of Engine)
1. Arrow on Piston Crown Pointing towards front of Engine
2. Cut Out in Piston Crown
3. 'FRONT' on Connecting Rod Web

47. Assemble the piston rings into their respective grooves on the piston ensuring that the 'TOP' marked face is uppermost.

NOTE: (i) Turbocharged engines have one tapered upper compression ring, two lower chamfered compression rings and one oil control ring - see Fig. 60 (A).

(ii) All naturally aspirated engines have one plain upper compression ring, one lower chamfered compression ring and one oil control ring - see Fig. 60 (B).

(iii) It is particularly important that the lower compression rings on all engines are assembled the correct way up as the effect of the slight chamfer on the face of the ring if inverted will be to induce lubricating oil into the combustion space giving rise to smoke and excessive oil consumption.

48. Rotate the crankshaft to bring the respective journal to its lowest point.

49. Position the ring gaps at 90° to one another (turbocharged engines) or 120° (naturally aspirated engines) and using a suitable piston ring clamp, locate the piston and rod assembly into its bore ensuring that the 'FRONT' marks face the front of the engine.

50. Use a soft wooden drift and tap the assembly into the bore, taking care that the lower end of the connecting rod does not foul the crankshaft - see Fig. 61.

51. Working from the bottom of the engine, place the upper half of the big end bearing liner into the connecting rod, and draw the rod into place over the big end journal. Thoroughly lubricate the journal with new engine oil.

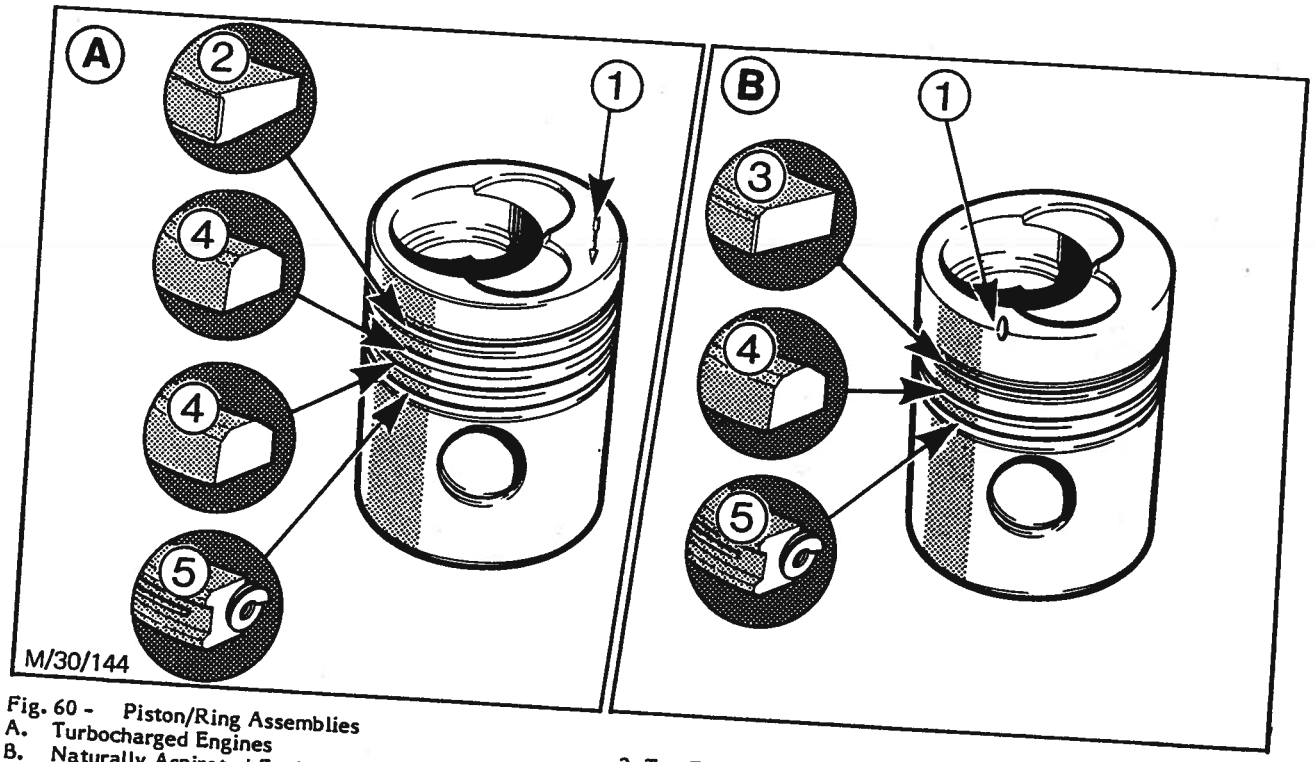

Fig. 60 - Piston/Ring Assemblies
A. Turbocharged Engines
B. Naturally Aspirated Engines
1. 'FRONT' Mark on Piston
2. Top Taper Compression Ring
3. Top Plain Compression Ring
4. Lower Compression Ring(s)
5. Oil Control Ring

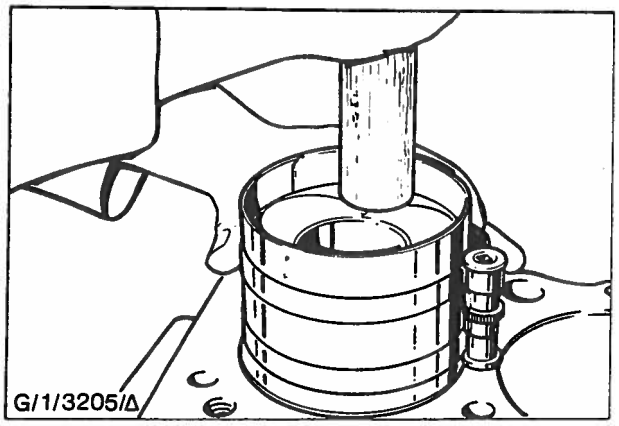

Fig. 61 - Fitting Piston to Cylinder Block

52. Locate the lower half of the big end bearing liner into the connecting rod cap and fit the cap over the journal onto the connecting rod. Tighten the nuts or bolts evenly to the specified first stage torque.

53. Check that the crankshaft can be turned in its normal direction of rotation without using excessive effort, then tighten the nuts or bolts to the specified second stage torque.

CHECKING 'BUMP' HEIGHT

54. Rotate the crankshaft to bring the piston to Top Dead Centre (TDC). Use a dial gauge and magnetic base to ensure piston is at maximum height while applying a load to the top of the piston - see Fig. 62.

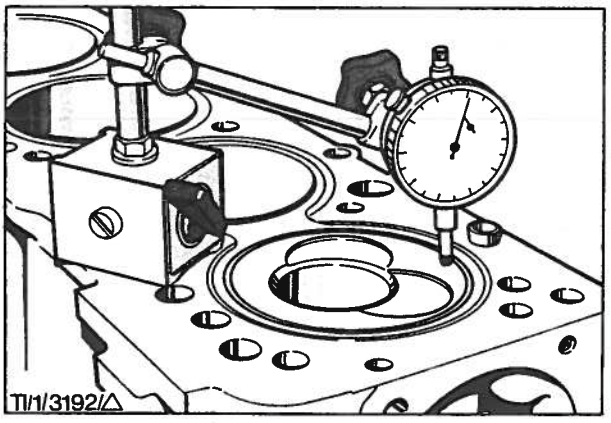

Fig. 62 - Measuring Piston 'Bump Height'

55. Measure and record the protrusion of the piston above the face of the block in at least three places and note the maximum and minimum protrusion (Fig. 63). Calculate the average of the three readings. If the figure is within the specified limits for piston protrusion (bump height) the existing connecting rod length is satisfactory. If, however, the piston protrusion is outside the limits with the grade of rod fitted, it will be necessary to remove the piston and rod assembly and fit a longer or shorter grade of rod as required. Refer to specifications, for rod grades.

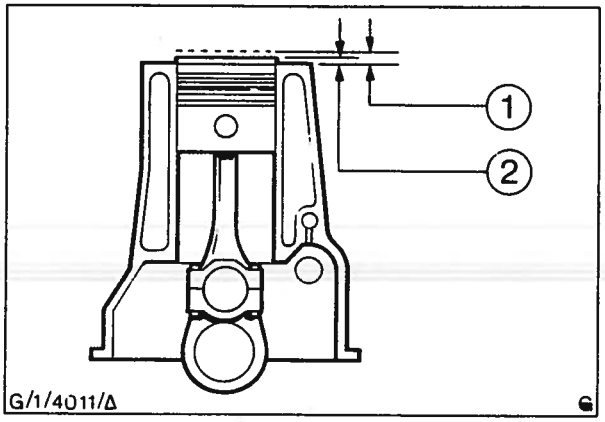

Fig. 63 - Piston Protrusion
1. Maximum Protrusion
2. Minimum Protrusion

56. Check crankshaft rotation after fitting each piston and rod assembly. Investigate and rectify cause if excessive effort is required to rotate crankshaft. When all pistons have been checked for bump height and finally installed, check to ensure rotational effort is within the specified limits.

OIL PUMP INSTALLATION

2722, 2723, 2725, 2726T engines not fitted with high inclination oil pans.

57. Check to ensure that the oil pump is well lubricated and the shaft rotates freely. Lubricate the drive gear with Hypoid 90 oil (FORD Specification EM-2C-29).

58. Locate the pump assembly into the cylinder block and tighten the retaining bolts to the specified torque - see Fig. 64.

59. Fit a new union nut lock tab washer to the pick-up pipe orifice, if not already fitted.

60. Locate the pick up pipe into the pump and the support bracket to main bearing cap. Tighten the union nut to the specified torque. Check to ensure the union nut has fully secured the pipe. Tighten the support bracket bolt to the specified torque. Peen over the union nut lock tab to secure.

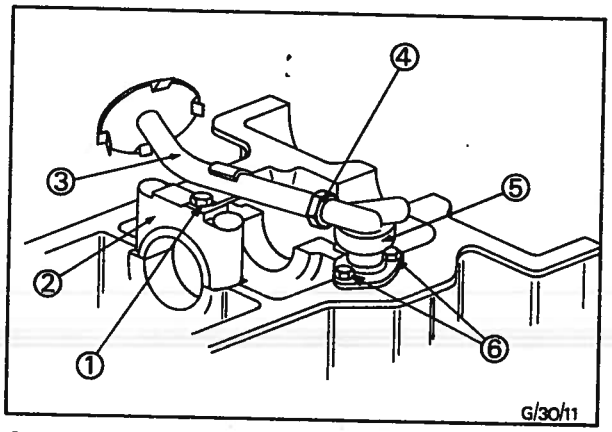

Fig. 64 - Oil Pump Removal/Replacement - 2722, 2723, 2725 and 2726T Engines Not Fitted with High Inclination Oil Pans

1. Support Bracket Bolt
2. Main Bearing Cap
3. Pick-Up Pipe
4. Pick-Up Pipe Union
5. Oil Pump
6. Oil Pump Securing Bolt

2728T Intercooled Engines - Refer to Fig. 66

61. Check that the pump mounting studs in the front main bearing cap are secure and undamaged. Studs should be renewed or refitted as necessary, applying the specified sealer to the leading threads and tightening to the specified torque.

62. Check to ensure that the pump is well lubricated and idler gear rotates freely.

63. Ensure that the main bearing cap shoulders and the pump mounting faces are perfectly clean and dry and mount the pump over the two studs. Engage the idler and crankshaft gear teeth. Ensure that the pump is square and flush to the main bearing cap and tighten the nuts to the specified torque.

64. Locate the flanged adaptor into the oil delivery hole in the block. Fit new 'O' rings to both ends of the delivery pipe and assemble it, first into the oil pump, then into the adaptor in the cylinder block. Align the bolt holes in the loose flange and the adaptor with the block; fit and tighten the bolts to the specified torque.

65. Locate the adaptor with a new gasket on to the pump, fit a new 'O' ring to the pick up pipe and locate the pipe into the adaptor and the support bracket to the main bearing cap. Tighten the bolts to the specified torque.

2722, 2723, 2725 and 2726T engines fitted with high inclination oil pans.

1. Locate a new union locking plate on the pump and insert the pipes into their correct locations but do not tighten or lock the unions until the pump is secured to the engine and the pipes correctly aligned - see Fig. 65.

2. Secure the pipe brackets to the block, tighten the pipe unions and bend the locking plate to lock the unions.

3. Fit the gauze screens.

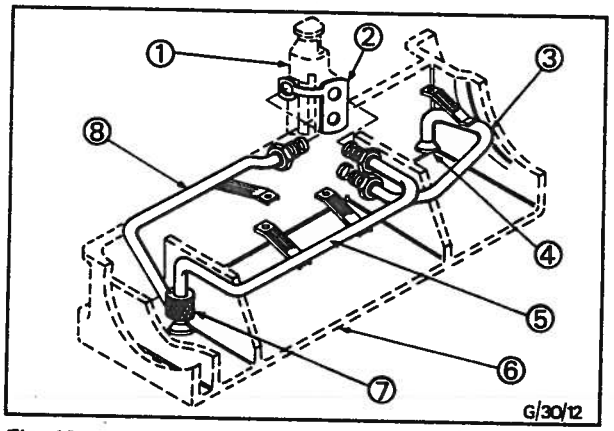

Fig. 65 - Oil Pump and Piping for High Inclination Oil Pans

1. Scavenge Pump
2. Lock Plate
3. Scavenge Pipe
4. Gauze Screen
5. Delivery Pipe
6. Oil Pan
7. Diffuse Box
8. Oil Reservoir Feed Pipe

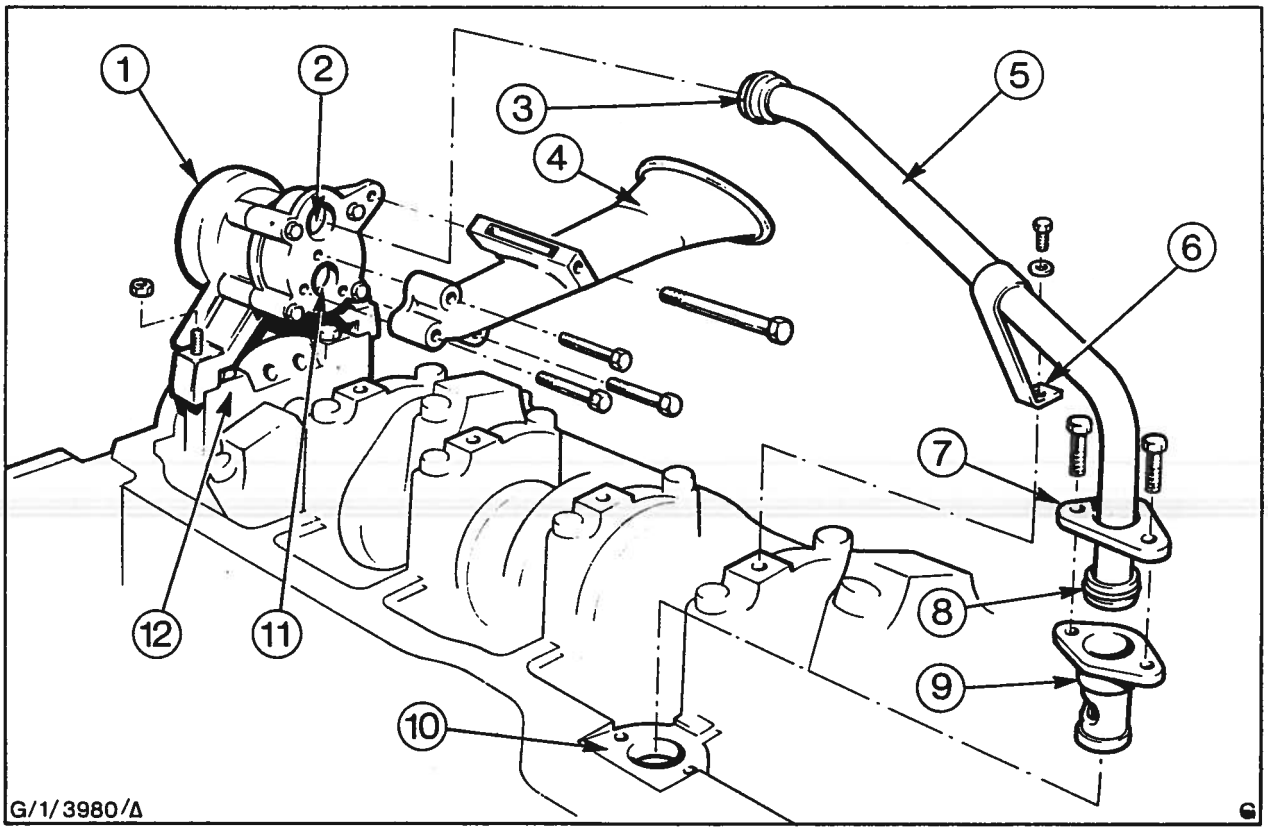

Fig. 66 - Oil Pump Removal/Replacement - 2728T Intercooled Engine

1. Oil Pump
2. Pump Outlet
3. 'O' Ring
4. Pick Up Pipe
5. Delivery Pipe
6. Support Bracket
7. Loose Flange
8. 'O' Ring
9. Flanged Adaptor
10. Cylinder Block Lower Flange
11. Pump Inlet
12. Front Main Bearing Cap

OIL PAN INSTALLATION

NOTE: Before commencing to fit the oil pan, ensure that the four studs (all except 2728T engine) or the five studs (2728T engine) are in position - see Figs. 53 and 67.

CAUTION: THE SPECIFIED SEALER DRIES RELATIVELY QUICKLY AND SHOULD NOT BE ALLOWED TO FORM A SKIN DURING AN ASSEMBLY SEQUENCE. ONCE STARTED, THE PROCEDURE SHOULD BE PROGRESSED THROUGH TO TORQUE TIGHTENING WITHOUT ANY IDLE PERIOD.

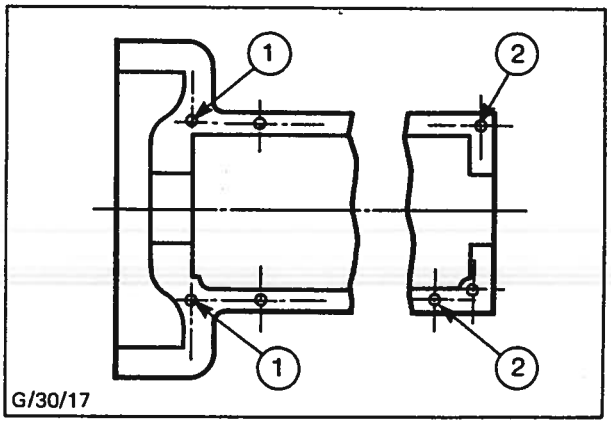

Fig. 67 - Oil Pan Studs
1. Studs for all engines
2. Studs for all engines except 2728T

NOTE: The three studs for 2728T engines not shown here are located in the timing gear housing and cover - see Fig. 53.

All Engines Except 2728T

66. Position the rear seal, dry, onto the rear main bearing cap then apply a small spot of specified sealer into and from each foot as shown in Fig. 68.

67. Position the side gaskets to the block, ensuring that the rear ends fit over the rear seal feet.

NOTE: A small amount of sealer may be used along the block flange to retain the gaskets in position, if necessary.

68. Fit the front seal in position with the feet over the gaskets, then apply a spot of sealer to the joints where the front and rear seals adjoin the gaskets - see Fig. 68.

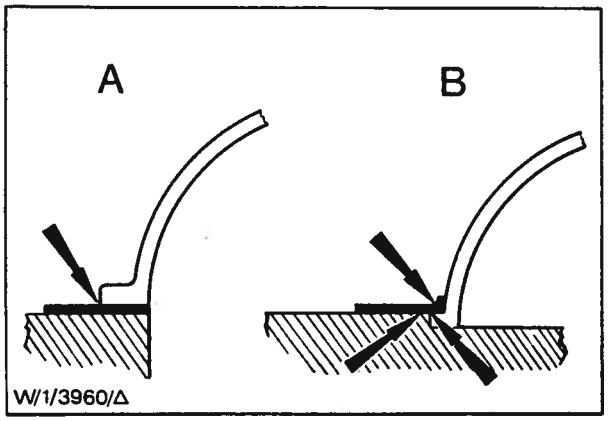

Fig. 68 - Oil Pan Gaskets and Seals Installation for All Engines Except 2728T
A. Front
B. Rear
Apply Sealer to Areas as Shown

69. Check to ensure that the rear face of the oil pan is flush to within 0,15 mm (0,006 in) max below the rear (clutch housing mating) face of the cylinder block. The oil pan must not stand proud of the cylinder block.

70. Fit the oil pan carefully over the four studs without dislodging the seals or gaskets and enter all bolts and nuts finger tight only.

2728T Engines

71. Check that the two locating dowels are in position - see Fig. 71.

72. Apply a small bead of specified sealer to the flange joint lines of the front housing and to the rear of the block oil pan rail as shown in Fig. 69 and 70.

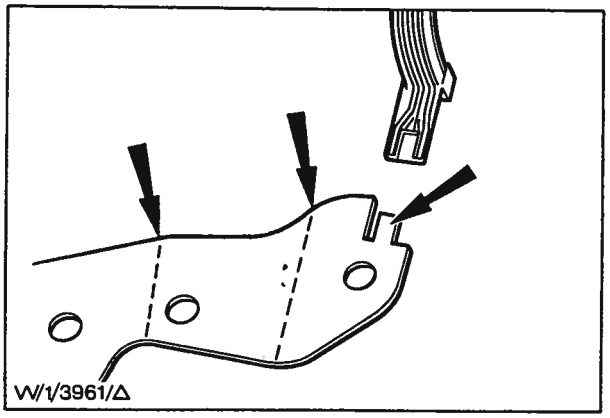

Fig. 69 - Oil Pan Front Seal and Gasket Installation - 2728T Engine
Apply Sealer to Block/Housing/Cover
Joint Lines and Gasket/Seal
Interlocked Joint where shown

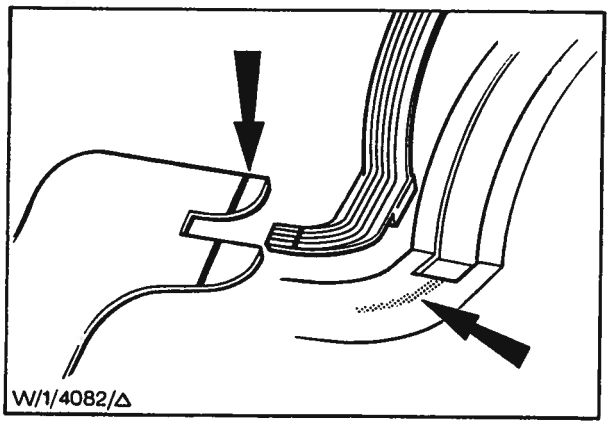

Fig. 70 - Oil Pan Rear Seal and Gasket Installation - 2728T Engines
Apply Sealer to Joint and Oil Pan Rail Areas indicated.

73. Position the front and rear seals and gaskets to the block flange, ensuring correct interlocking of cut-outs and tongues - see Figs. 69 and 70.

NOTE: A small amount of sealer may be used along the block flange to retain the gaskets in position, if necessary.

74. Apply a spot of sealer to each interlocked joint and fit the oil pan over the five studs carefully without dislodging the seals or gaskets. Fit all bolts and nuts finger tight only. Check to ensure that the rear face of the oil pan is flush to within 0,15 mm (0,006 in) max below the rear (clutch housing mating) face of the cylinder block. The oil pan must not stand proud of the cylinder block.

All Engines:

75. Starting at the fourth pair of bolts from the rear and working forwards, tighten all bolts, nuts and washers in pairs (left to right), to the specified torque. Return to the starting position and continue rearwards, again working in pairs. Fit drain plug(s).

New Oil Pan Installation - 2728T Engines Only - Refer to Fig. 71

76. Before fitting any seals or gaskets, drift out the two dowels and place the oil pan onto the crankcase. Loosely insert at least four bolts (two each side) and check that the rear face of the oil pan is radially aligned and flush to within 0,15 mm (0,006 in) max below the rear (clutch housing mating) face of the cylinder block. The oil pan must not stand proud of the cylinder block.

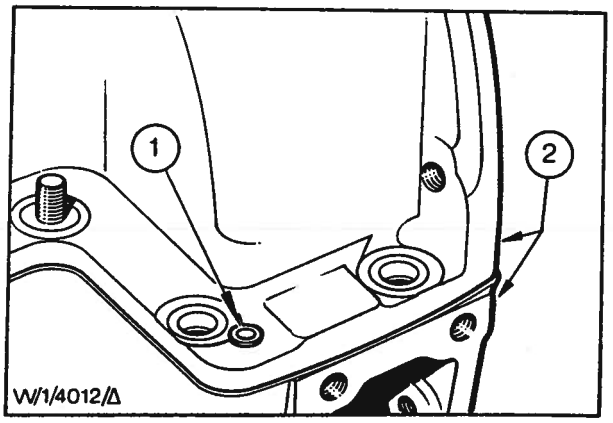

Fig. 71 - Oil Pan Rear Alignment - 2728T Engines
1. Locating Dowel
2. These Faces Flush - see text

77. Tighten the four bolts to secure the oil pan. Using the two dowel holes in the block as guides, ream the oil pan dowel holes to 9,5 to 9,7 mm (0,375 to 0,383 in) diameter.

78. Refit the dowels and check that the alignment has not been disturbed.

79. Remove the oil pan and clean off all swarf from the oil pan and block.

80. Fit the oil pan as described under 'Oil Pan Installation.

FLYWHEEL INSTALLATION

81. Fit, or check that the flywheel locating dowel is fitted, to the crankshaft flange.

82. Locate the flywheel over the dowel and on to the flange, fit and progressively and evenly tighten the retaining bolts to the specified torque.

83. Using a dial gauge and magnetic base check that the flywheel run out is within the specified limits when measured at 140 mm (5,50 in) radius - see Fig. 72.

84. If the run out is excessive, remove the flywheel and check the flange and flywheel mating faces for burrs or swarf. Lightly stone off any burrs and thoroughly clean off any dirt and/or swarf. Reassemble and recheck the run out as before.

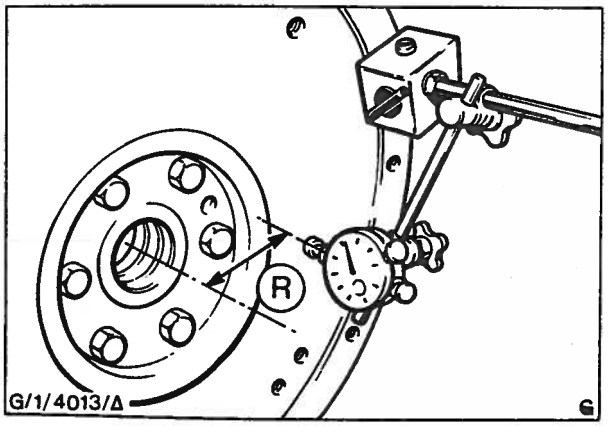

Fig. 72 - Checking Flywheel Run-Out
R = 140 mm (5,50 in)

CRANKSHAFT PULLEY INSTALLATION

86. Wipe a smear of grease around the inner periphery of the timing cover oil seal.

All Engines Except 2728T:

87. Locate the crankshaft pulley on to the crankshaft ensuring the key and keyway are aligned and push fully home. Fit the retaining bolt and tighten to the specified torque.

2728T Engines:

88. Fit new 'O' rings to the grooves in the crankshaft adaptor and the locking sleeve. Use a small quantity of engine oil to aid assembly.

89. Locate the crankshaft pulley onto the crankshaft ensuring the key and keyway are aligned and push fully home.

90. Insert the spacer and the two locking rings in the order shown in Fig. 73, with the gaps opposite to one another. Fit the locking sleeve and the four bolts ensuring the locking rings are pushed fully and squarely into position.

91. Tighten the bolts evenly to the specified torque.

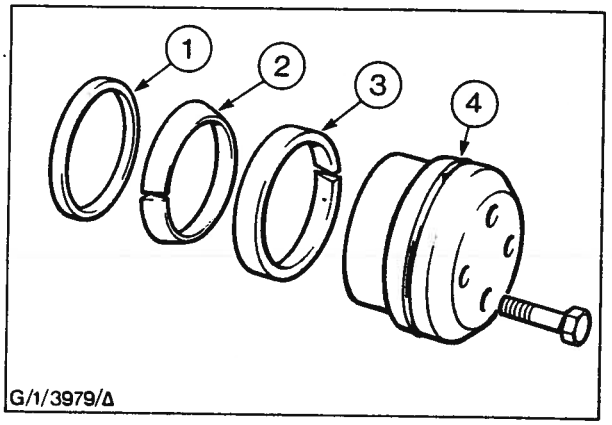

Fig. 73 - Crankshaft Pulley Retaining Components - 6 Cylinder Engines (Ringfeder Locking Mechanism)

1. Spacer Ring
2. Internal Locking Ring
3. External Locking Ring
4. Locking Sleeve

CYLINDER HEAD INSTALLATION

92. Rotate the engine on the stand to bring the block face uppermost.

93. Ensure the block and head faces are clean and dry.

94. Check to ensure the locating dowels are fitted into the counterbores of the two head bolt threads and the water circulating passage at the positions shown in Fig. 74.

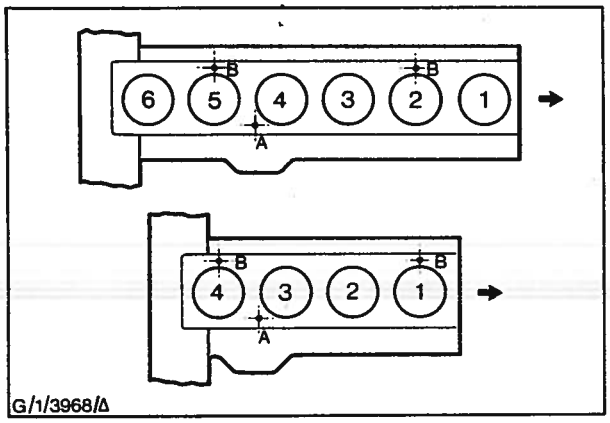

Fig. 74 - Cylinder Head/Gasket Locating Dowels
A. Dowel in Water Gallery
B. Dowels in Head Bolt Holes

95. Positon a new gasket over the locating dowels on to the block.

96. Using the built-in lifting brackets and a suitable sling and hoist locate the cylinder head carefully onto the block ensuring that the gasket is not disturbed.

97. Insert and hand tighten all the cylinder head bolts and remove the sling and hoist.

98. Tighten the cylinder head bolts by increments, in the sequence shown in Fig. 75 to the specified torque.

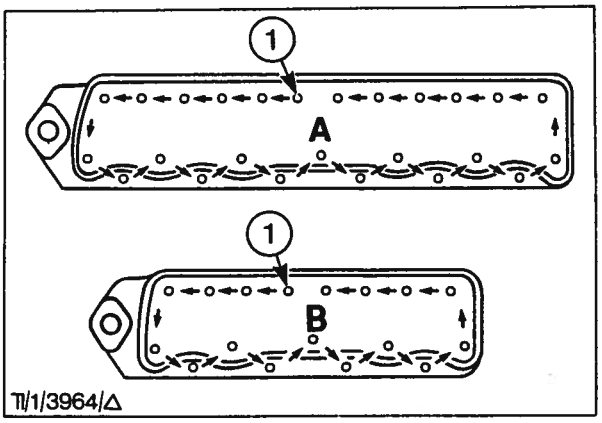

Fig. 75 - Cylinder Head Bolts Tightening Sequence
A. 6 Cylinder Engines
B. 4 Cylinder Engines
1. Start here when tightening

99. When all bolts have been tightened, further tighten each bolt in the same sequence, by exactly 90°.

CAUTION: MARK EACH BOLT HEAD AS TIGHTENING PROCEEDS TO ENSURE NO BOLT IS EITHER MISSED OR DUPLICATED.

INSTALLING INJECTORS AND VALVE GEAR

100. Ensure that the cylinder head injector apertures are thoroughly clean, then fit new sealing washers - see Fig. 76.

101. Fit a new 'O' ring seal to each injector assembly.

102. Insert the injectors into the cylinder head and fit but do not tighten the securing bolts - see Fig. 77.

103. Place the leak-off pipe in position and fit but only hand tighten the leak-off pipe banjo bolts. Tighten the gland nut securing the leak-off pipe to the cylinder head connection.

104. Tighten the injector securing bolts evenly to the specified torque, then tighten the leak-off pipe banjo bolts to the specified torque.

105. Install the pushrods and valve caps into the same positions as when removed, position the rocker shaft assembly, locating the adjuster ball ends into the push rod cups, and gradually and evenly tighten the retaining bolts to the specified torque - see Fig. 78.

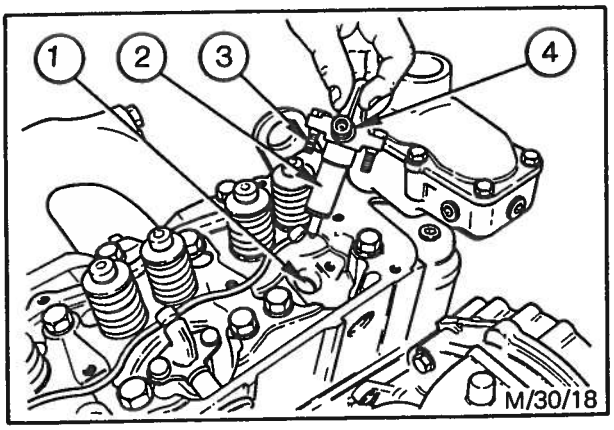

Fig. 76 - Replacing Injectors
1. Recess or Copper Sealing Washer
2. Injector
3. Injector Retaining Bolt
4. 'O' Ring

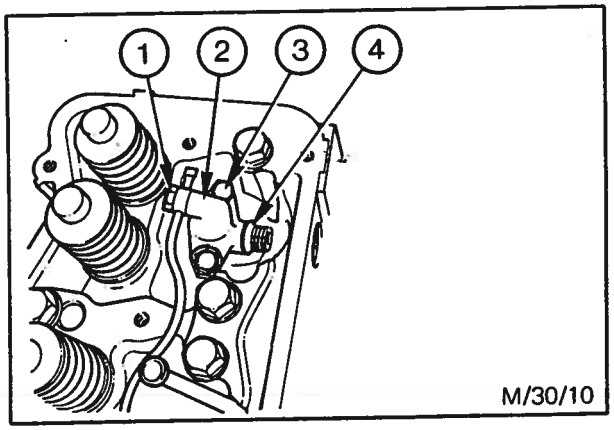

Fig. 77 - Replacing Injectors
1. Leak-Off Pipe Banjo Bolt
2. Injector
3. Injector Retaining Bolt
4. 'O' Ring

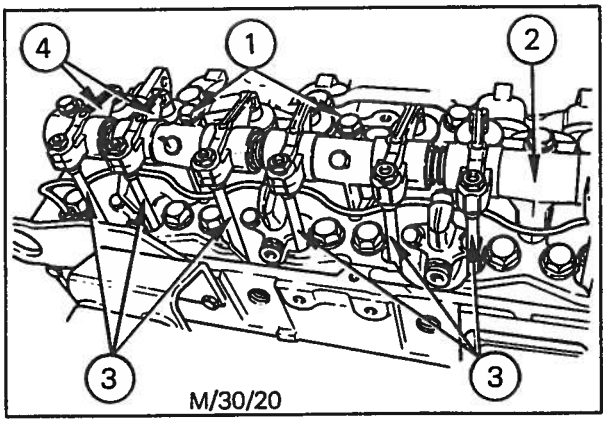

Fig. 78 - Installing Valve Gear
1. Rocker Shaft Pedestal Retaining Bolts
2. Rocker Shaft Assembly
3. Push Rods
4. Rocker Arms

SETTING VALVE CLEARANCES

106. Following the sequence shown below, rotate the crankshaft in the direction of rotation and adjust the valves to the specified clearances.

4 cylinder engines

Valves Open	Adjust Valves
1 and 6	3 and 8
2 and 4	5 and 7
3 and 8	1 and 6
5 and 7	2 and 4

6 cylinder engines

Valves Open	Adjust Valves
1 and 4	9 and 12
8 and 10	3 and 5
2 and 6	7 and 11
9 and 12	1 and 4
3 and 5	8 and 10
7 and 11	2 and 6

To adjust the valve clearance, insert the correct thickness feeler gauge between the rocker pad and the valve cap. Turn the adjusting screw with a ring spanner or socket until the correct clearance is obtained. This is when the feeler gauge is just gripped between the rocker pad and the valve cap but can be moved with a slight pull - see Fig. 79.

NOTE: The adjusting screw is designed to be self locking. If it does not feel tight enough, unscrew it until a positive clearance is obtained (not less than 0,25 mm (0,010 in) and then check the torque required to turn the screw. If less than specified, renew the rocker arm assembly.

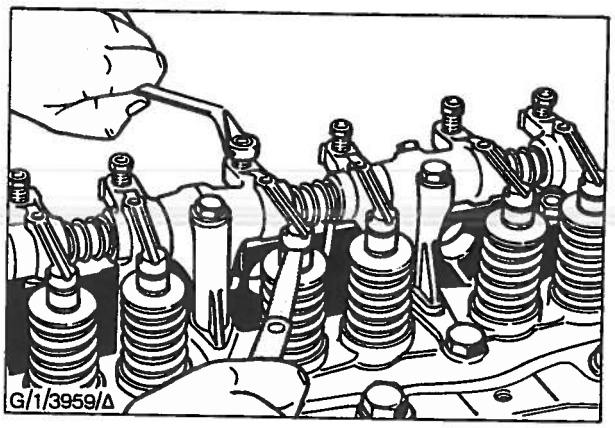

Fig. 79 - Adjusting Valve Clearance

ASSEMBLING ENGINE ANCILLARIES

THERMOSTATS

107. Test the thermostat(s) if necessary, as described in Section 3 then fit housing, thermostat(s) and cover, as appropriate, with new gaskets. If removed, replace or fit a new temperature sensitive switch.

WATER PUMP

All Engines Except 2728T

108. Position pump on cylinder block, using a new gasket, and secure with the bolts/nuts tightened to the correct torque value. Where applicable, fit hose between water pump and thermostat housing and tighten clips.

109. Fit the extension tube to the cylinder block and locate the connecting hose between pump and tube. Ensure that the engine mounting bracket or spacers (as appropriate) are in position when inserting the securing bolts. Tighten bolts to the correct torque value and tighten hose clips.

2728T Engine Only

110. Locate a new gasket over the studs and assemble the back plate to the cylinder block. Fit the set bolt in the centre of the back plate and tighten to the specified torque - see Fig. 80.

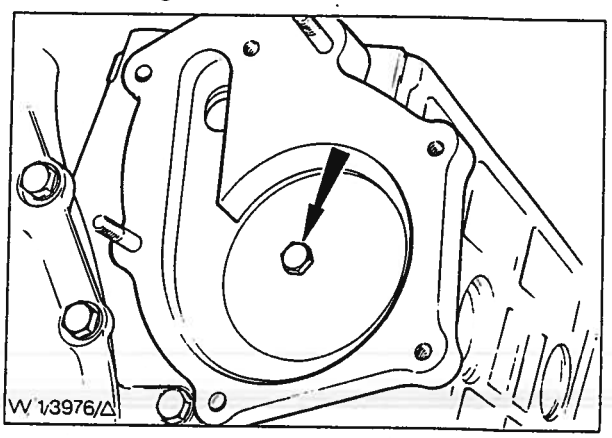

Fig. 80 - Water Pump Backplate Showing Retaining Set Bolt Behind Pump on 2728T Engine

111. Locate the pump, using a new gasket over the studs and on to the back plate. Tighten the nuts first then the bolts to the specified torque - see Fig. 81.

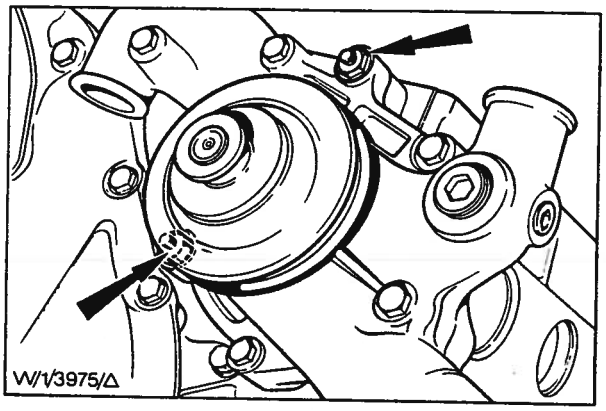

Fig. 81 - Water Pump Mounting Nuts and Bolts on 2728T Engine

Arrowed Studs Pass Through Backplate into Block - Tighten These First

112. Replace the complete split flow water tube assembly connecting the water pump to the rear of the cylinder block. Tighten all clips and support bracket bolts.

Raw Water Pump - Marine Engines

113. Fit the raw water pump to the PTO drive at the rear of the timing gear housing.

Alternator

114. Assemble the alternator on to its mounting bracket but do not fully tighten bolts at this stage.

'Low Loss' Type Water Pumps

115. Place the bearing retainer outer plate, centre boss outwards, on the fan pulley hub. Position the fan on the bearing retainer boss and secure with the four bolts.

Standard Water Pump - All Engines Except 2728T

116. Place the fan on the water pump hub and secure with the 4 or 6 bolts. On single belt drive pumps, assemble the pulley onto the pump hub before installing the fan.

DRIVE BELTS

117. Fit the drive belt(s) and adjust the alternator position to achieve the correct belt tension - see Fig. 82 or 83.

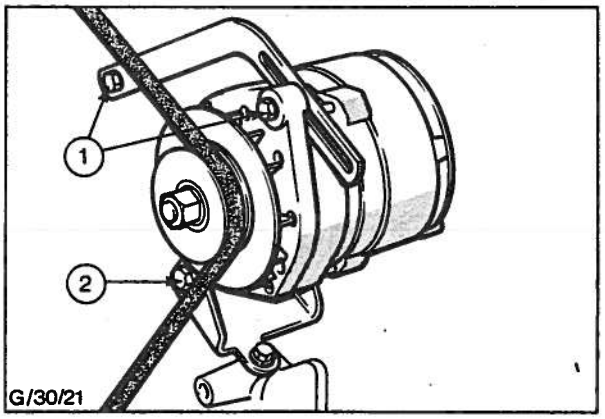

Fig. 82 - Alternator Drive Belt Adjustment
1. Adjusting Bolts
2. Mounting Bolts

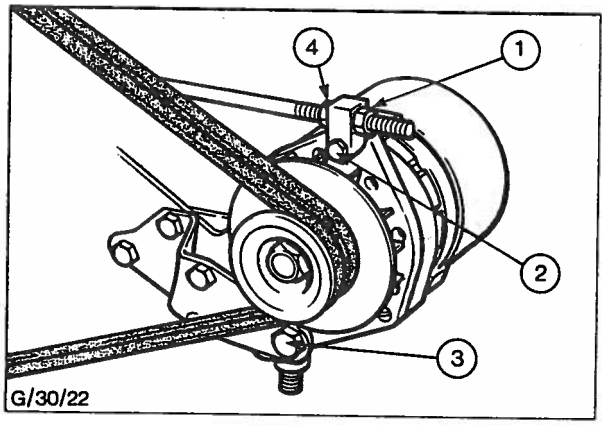

Fig. 83 - Alternator Drive Belt Adjustment
1. Locking Nut
2. Adjusting Bolts
3. Mounting Bolts
4. Adjusting Nut

On 'Low Loss' drive systems, the fan belts must be adjusted separately by means of the idler pulley positioning - see Fig. 84.

Where no alternator is fitted, a special idler pulley is installed instead; this must be positioned to give the correct belt tension - see Fig. 85.

The high level fan fitted to some 4 cylinder engines, is positioned by the two adjusting bolts located at the top of the fan pulley bearing bracket - see Fig. 86. The two securing bolts must be slackened when carrying out belt adjustments.

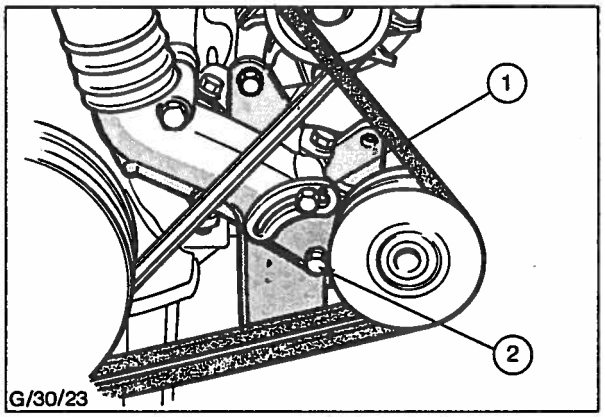

Fig. 84 - Drive Belt Adjustment - 'Low-Loss' Fan Drive Water Pump
1. Adjusting Bolt
2. Mounting Bolt

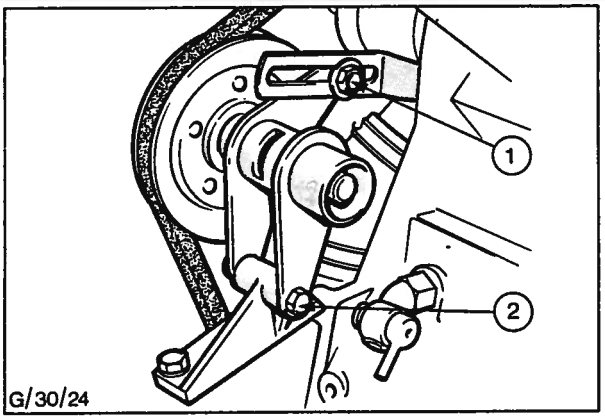

Fig. 85 - Drive Belt Adjustment - No Alternator Fitted
1. Adjusting Bolt
2. Mounting Bolt

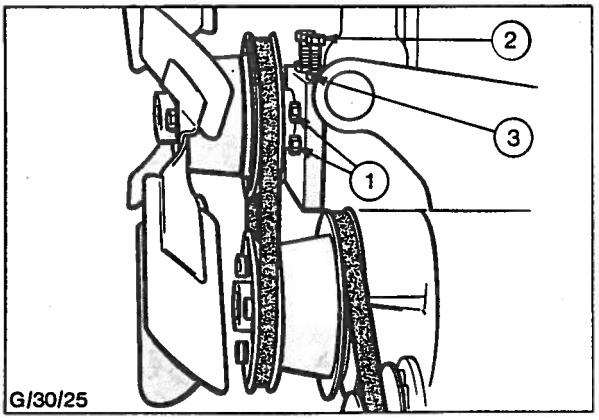

Fig. 86 - Drive Belt Adjustment - High Level Fan
1. Fan Bearing Housing Securing Bolts
2. Adjusting Bolts
3. Locknuts

After drive belt(s) have been correctly tensioned, tighten fan securing bolts while gripping drive belt(s).

INJECTION PUMP

118. Remove the timing aperture cover from the flywheel housing and turn the engine in the normal direction of rotation until the specified number of degrees before TDC on No. 1 cylinder is indicated against the timing mark on the edge of the timing aperture (Fig. 87). No. 1 cylinder must be on the compression stroke.

NOTE: If the correct piston stroke is in doubt, check that both pushrods of No. 1 cylinder are free to rotate. If they are not, rotate the crankshaft through 360° and check the flywheel marking again.

AUTOMOTIVE AND G.P. GOVERNED INJECTION PUMPS - Carry out operations 119 to 124 inclusive then continue with operation 129.

119. New pumps only. Fit the ring gear and plate into position, but do not fully tighten the screws (Fig. 88). Drain any oil from the fuel gallery of the new pump.

120. Remove the blanking plug from the timing bush on the injection pump mounting flange (Fig. 89).

121. Rotate the pump drive hub until the timing hole is centred in the bush aperture, then screw the timing tool (23-507) into position. Rotate drive gear slightly as necessary to engage the plunger in the drive gear hub hole.

122. Remove the adjustment cover plate on the front of the timing cover (Fig. 90).

123. Fit a new 'O' ring to the pump mounting flange and install the pump carefully, tightening the bolts to the specified torque.

NOTE: If the pump flange holes cannot be aligned with the holes in the engine timing gear case, slacken the four drive gear clamping screws to enable the pump to be rotated slightly, relative to the gear.

124. Tighten the drive gear clamping screws to the specified torque and check that the correct flywheel marking is still indicated. Replace the timing cover adjustment plate and the flywheel timing aperture cover and tighten the securing screws. Remove the timing tool (23-507) and replace the timing bush cap.

CLASS 'A' AND COMBINE HARVESTER GOVERNED INJECTION PUMPS - Carry out operations 125 to 128 inclusive then continue with operation 129.

125. Remove blanking plug from injection pump mounting flange - see Fig. 91. Rotate the pump drive gear until the hole in the gear is centred in the hole in the flange, then screw the timing tool (23-504) into position - see Fig. 1. Rotate the drive gear slightly, as necessary, to engage the timing tool plunger in the hole.

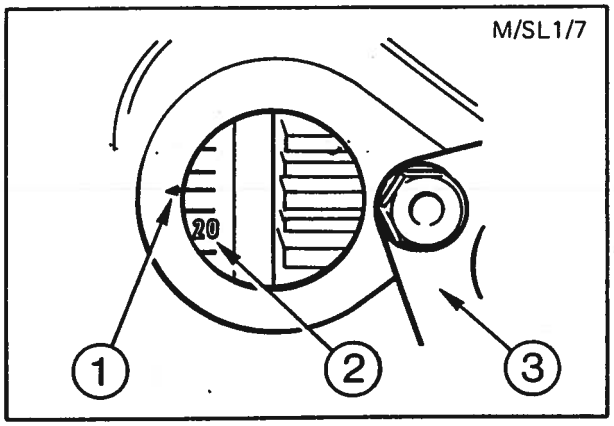

Fig. 87 - Engine Timing
1. Timing Mark on Housing
2. Timing Scale on Flywheel
3. Timing Aperture Cover

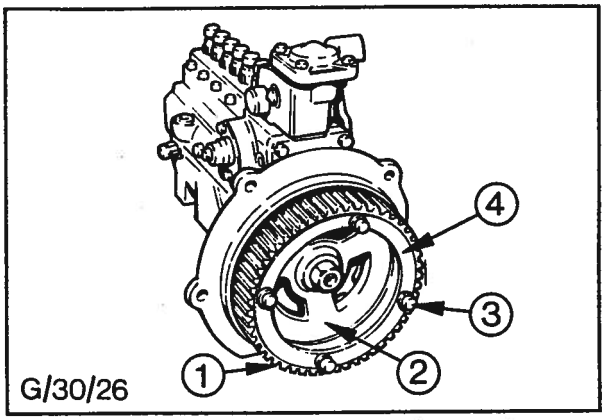

Fig. 88 - Injection Pump Drive Gear
1. Ring Gear
2. Drive Hub
3. Clamping Screws
4. Clamping Plate

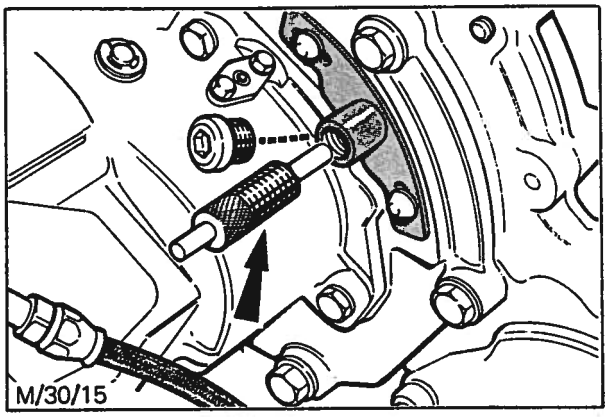

Fig. 89 - Injection Pump Timing - Automotive and G.P. Governed Pumps
1. Timing Bush Blanking Plug
2. Timing Tool 23-507

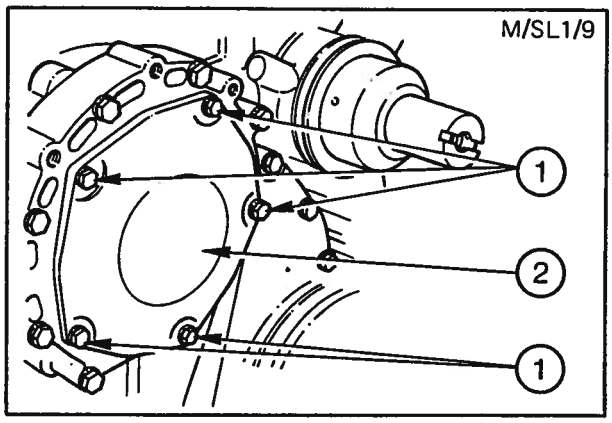

Fig. 90 - Removing Injection Pump Timing Aperture Cover Plate
1. Securing Bolts
2. Cover Plate

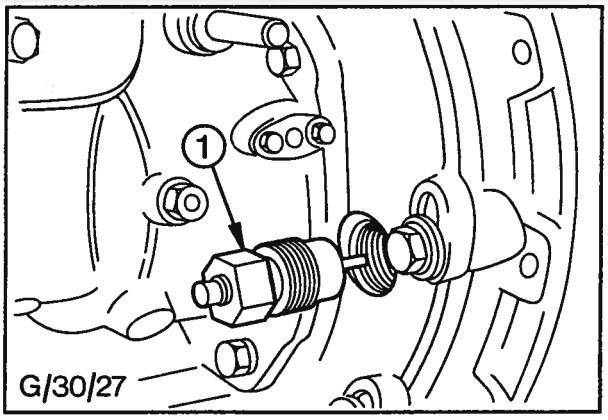

Fig. 91 - Injection Pump Timing - Class 'A' and Combine Harvester Governed Pumps
1. Timing Tool 23-504

127. Fit a new 'O' ring to the pump mounting flange and install the pump carefully; tighten the bolts and nut to the specified torque.

128. Check that the correct flywheel marking is still indicated, then replace the flywheel timing aperture cover and the injection pump timing aperture sealing plug.

129. Where applicable, replace the lead connecting the automatic excess fuel solenoid to the temperature sensitive switch on the thermostat housing.

130. Secure oil filter head to cylinder block using a new gasket. Tighten bolts to specified torque value. Where applicable, fit the oil feed pipe between oil filter head and injection pump. On turbocharged engines replace pipe connecting injection pump boost control to inlet manifold.

131. Remove all blanking plugs/caps from high pressure pipes, injectors and injection pump.

132. Connect the high pressure fuel pipes to the injection pump but do not fully tighten gland nuts at this stage.

133. Unscrew large oil seal nut fully - see Fig. 92.

134. Connect high pressure feed pipe and tighten gland nut to the specified torque value.

135. Tighten large oil seal nut.

136. Repeat operations 133, 134 and 135 for remaining injectors.

137. Tighten high pressure fuel pipe gland nuts at the injection pump to the specified torque value.

138. Replace any high pressure pipe clamps - see Fig. 93.

139. Carry out the leak-off pipe pressure test described in Section 4.

140. Replace rocker cover, using a new gasket.

141. Replace the fuel filters complete with mounting bracket.

142. Replace fuel lift pump and (where fitted) the pre-filter unit.

143. Replace the low pressure fuel pipes connecting fuel lift pump, fuel filters and injection pump.

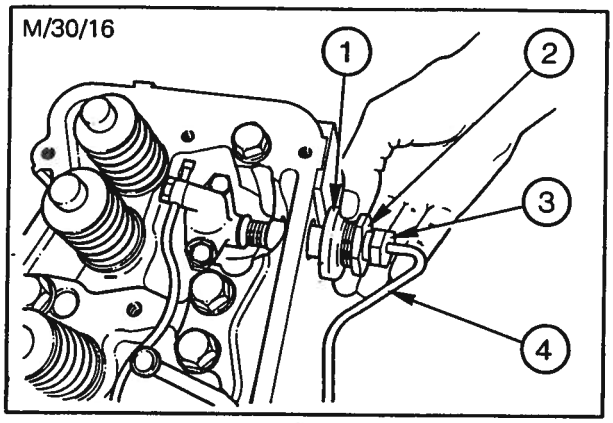

Fig. 92 - Replacing High Pressure Fuel Pipes
1. Oil Seal
2. Oil Seal Nut
3. High Pressure Pipe Gland Nut
4. High Pressure Pipe

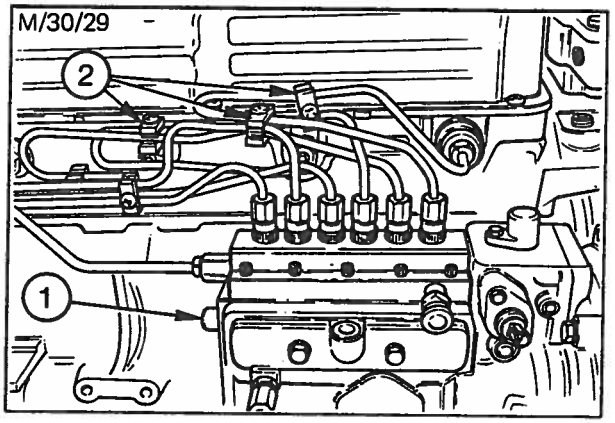

Fig. 93 - Replacing Injection Pump
1. Idling Damper Adjustment Cover
2. High Pressure Fuel Pipe Clamps

144. If a new injection pump with automotive or G.P. governing has been fitted, remove the oil filler plug and insert the specified quantity of clean engine oil. Refit and tighten the plug.

145. Where an injection pump with Class 'A' or combine harvester governing has been installed, remove the level and filler plugs and top up with clean engine oil as required - see Fig. 94.

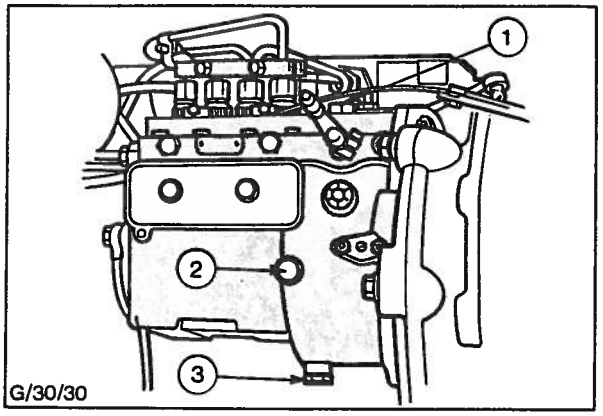

Fig. 94 - Injection Pump Oil Plugs (Class 'A' and Combine Harvester Governing only)
1. Filler Plug
2. Level Plug
3. Drain Plug

146. Where applicable, replace the dipstick tube in the oil pan.

147. Replace the dipstick and, if removed, the oil pressure sender unit.

148. Prime the new oil filter with clean engine oil and screw it into position; tighten by hand only - do NOT use a strap wrench or similar device.

149. Using a suitable hoist attached to the cylinder head lifting brackets, take the weight of the engine and detach the mounting bracket from the stand (200B). Remove the mounting bracket from the engine.

150. Replace the starter motor and tighten bolts to the specified torque value. If removed, replace the cylinder block coolant drain plug or tap.

151. Check that the manifold mounting studs are secure in the cylinder head.

NOTE: It is imperative that the special shouldered studs, in the positions shown are fully tightened or they may prevent the manifolds fitting flush to the cylinder head - see Fig. 95.

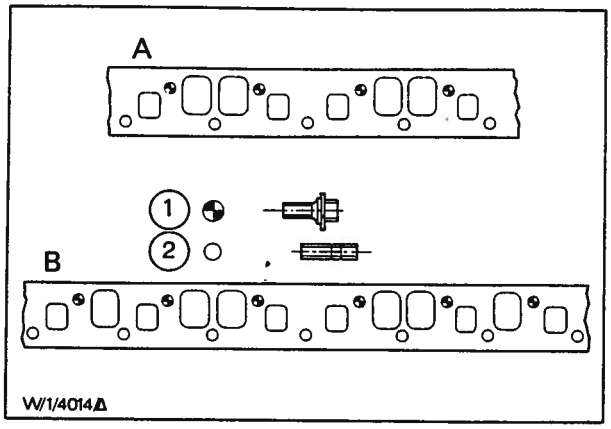

Fig. 95 - Manifold Stud Positions
A. 4 Cylinder Engines
B. 6 Cylinder Engines
1. Special Studs with Integral Washer in Position
2. Plain Studs in Positions Marked

152. Assemble the manifold gasket over the studs.

NOTE: On turbocharged engines the gasket has eyelets and is 'handed'. The full flange of the eyelet must be against the cylinder head.

If the exhaust manifold has been dismantled, stagger the gaps of the piston type sealing rings in the exhaust manifold joints when assembling.

153. Assemble the manifolds to the cylinder head and retain with flat washers and the special nuts (copper colour). Tighten the nuts evenly to the specified torque.

154. Where applicable, replace the inter-cooler complete with mounting bracket.

155. Where applicable, assemble the turbocharger to the exhaust manifold using a new gasket. Secure with the four nuts tightened to the correct torque value. Fit the support plate and bracket to turbocharger and cylinder block, placing a new gasket between support plate and turbocharger. DO NOT tighten the nuts securing the turbocharger to the bracket as a new gasket will be required when fitting the exhaust pipe after the engine is installed.

156. Install the hose connecting the turbocharger and inlet manifold adaptor or intercooler and tighten clips. On industrial engines, replace the air inlet pipe and connecting hose to turbocharger; tighten securing bolts and hose clips.

157. Replace the turbocharger oil feed and return pipes.

INSTALLING THE ENGINE

Because of the various vehicles/installations in which the engine can be fitted, it is not possible to give detailed instructions. However, after the engine has been installed and BEFORE it is started, the following points should be noted.

1. The cooling system must be filled with coolant to the correct level.

2. The oil pan must be filled with the correct grade and quantity of new lubricating oil meeting Ford Specification SM-2C-1017A. In the case of turbocharged engines, the turbocharger must be primed with engine oil and the recommended start-up procedure followed - refer to Section 4.

3. Injection pumps must contain the specified amount of engine oil - refer to Specifications, Section 4.

4. The fuel system must contain sufficient fuel of the correct type and be bled to remove all air - refer to Section 4.

5. The battery must contain the correct amount of electrolyte and be adequately charged - refer to Volume 2, Section 2.

SPECIFICATIONS

General

Type		OHV Direct Injection Diesel				
		Naturally Aspirated			Turbocharged	
		2722	2723	2725	2726T	2728T
Number of Cylinders		4	6	6	6	
Bore	mm (in)	107,21 (4,221)	104,80 (4,126)	107,21 (4,524)	104,80 (4,126)	
Stroke	mm (in)	114,80 (4,524)	114,80 (4,524)	114,80 (4,524)	114,80 (4,524)	
Capacity	cm^3 (in^3)	4149,5 (253,2)	5946,7 (362,9)	6224,3 (379,8)	5946,7 (362,9)	
Compression Ratio		15,9:1	15,9:1	15,9:1	15,45:1	14,7:1
Firing Order		1,2,4,3	1,5,3,6,2,4	1,5,3,6,2,4,	1,5,3,6,2,4	
Number 1 Cylinder		Front of Engine				

POWER RATINGS

	Power Measuring Standard	2722	2722	2723	2725	2725
		Standard Power GP I	High Power GP II	Standard Power GP I	Standard Power GP I	High Power GP II
Intermmittent Power Output	BS 5514 (ISO 3046)	54,5 kW @ 2500 rpm	58,5 kW @ 2600 rpm	76,2 kW @ 2500 rpm	84,6 kW @ 2500 rpm	90,0 kW @ 2600 rpm
	BS 649	58,9 kW @ 2500 rpm	63,4 kW @ 2600 rpm	80,5 kW @ 2500 rpm	88,7 kW @ 2500 rpm	94,7 kW @ 2600 rpm
	DIN 6270	54,3 kW @ 2500 rpm	58,3 kW @ 2600 rpm	76,0 kW @ 2500 rpm	84,3 kW @ 2500 rpm	89,8 kW @ 2600 rpm
Intermittent Torque Output	BS 5514 (ISO 3046)	232 Nm @ 1500 rpm	261 Nm @ 1600 rpm	325 Nm @ 1500 rpm	354 Nm @ 1500 rpm	380 Nm @ 1600 rpm
	BS 649	241 Nm @ 1500 rpm	269 Nm @ 1600 rpm	333 Nm @ 1500 rpm	362 Nm @ 1500 rpm	387 Nm @ 1600 rpm
	DIN 6270	231 Nm @ 1500 rpm	260 Nm @ 1600 rpm	324 Nm @ 1500 rpm	353 Nm @ 1500 rpm	378 Nm @ 1600 rpm

	Power Measuring Standard	2726T	2726T Marine	2728T
Intermittent Power Output	BS 5514	107,5 kW @ 2400 rpm	111,9 kW @ 2400 rpm	-
	BS 649	111,9 kW @ 2400 rpm	-	-
	BS AU 141a 1971	118 kW @ 2400 rpm	114,0 kW @ 2400 rpm	149 kW @ 2450 rpm
	DIN 6270	107,6 kW @ 2400 rpm	-	-
Intermittent Torque Output	BS 5514	461 Nm @ 1700 rpm	457 Nm @ 2000 rpm	-
	BS 649	473 Nm @ 1700 rpm	-	-
	BS AU 141a 1971	498 Nm @ 1700 rpm	491 Nm @ 1700 rpm	600 Nm @ 1800 rpm
	DIN 6270	462 Nm @ 1700 rpm	-	-

CYLINDER BLOCK

NOTE: Standard size cylinder bore diameters are graded at a point 80 mm (3,15 in) from the top of the bores across the cylinder block (the 'Grade Point'). Bores which fall between grades are categorized in the lower grade.

Bore Diameter - Standard		
2723 engine	Grade 1	104,770 to 104,795 mm (4,1248 to 4,1258 in)
	Grade 2	104,795 to 104,820 mm (4,1258 to 4,1268 in)
2726T and 2728T engines	Grade 1	104,783 to 104,795 mm (4,1253 to 4,1258 in)
	Grade 2	104,795 to 104,818 mm (4,1258 to 4,1263 in)
2722 and 2725 engines	Grade 1	107,188 to 107,213 mm (4,2200 to 4,2210 in)
	Grade 2	107,213 to 107,238 mm (4,2210 to 4,2220 in)
Cylinder Bore Taper - Maximum		0,0013 mm (0,0005 in) small at the top of the bore, Bores must NOT be small at the bottom of the bore.
Cylinder Liners - 2726T and 2728T engines only		
Bore Diameter in the Cylinder Block for the Cylinder Liner	Grade 1	108,966 to 108,991 mm (4,290 to 4,291 in)
	Grade 2	108,991 to 109,016 mm (4,291 to 4,292 in)
Cylinder Liner Outside Diameter	Grade 1	108,953 to 108,979 mm (4,289 to 4,290 in)
	Grade 2	108,979 to 109,004 mm (4,290 to 4,291 in)
Cylinder Liner Protrusion above or below the Top Face of the Cylinder Block		0,254 mm (0,001 in) max below face to 0,127 mm (0,005 in) max above face
Bore Diameter for Main Bearing Liners		
Standard Size		80,429 to 80,459 mm (3,1665 to 3,1676 in)
Oversize 0,381 mm (0,015 in) - Service Only		80,810 to 80,843 mm (3,1815 to 3,1826 in)
Bore Diameter for Camshaft Bearing Bush		
Standard Size		58,750 to 58,775 mm (2,313 to 2,314 in)
Oversize 0,508 mm (0,02 in) - Service Only		59,260 to 59,285 mm (2,333 to 2,334 in)

PISTON, PISTON RINGS AND PISTON PIN

Piston

NOTE: Standard Size pistons are graded by skirt diameter measured at 90° to the piston pin bore at a graded height (X) from lower edge of piston.

2722, 2723 and 2725 engines		X = 56,3 mm (2,217 in)
2726T and 2728T engines		X = 25,6 mm (1,01 in)
Skirt Diameter - Standard Size		
2723 engine	Grade 1	104,658 to 104,682 mm (4,1204 to 4,1213 in)
	Grade 2	104,683 to 104,707 mm (4,1314 to 4,1223 in)
2722 and 2723 engines	Grade 1	107,076 to 107,100 mm (4,2156 to 4,2165 in)
	Grade 2	107,101 to 107,125 mm (4,2166 to 4,2175 in)
NOTE: For 2722, 2723 and 2725 engines	Graded Pistons are not supplied in service	
2726T and 2728T engines	Grade 1	104,592 to 104,618 mm (4,1178 to 4,1188 in)
	Grade 2	104,618 to 104,693 mm (4,1188 to 4,1198 in)
Skirt Diameter - Oversize (Measured at the Grade Point)		
2723 engine		
- Oversize 0,381 mm (0,015 in)		105,089 to 105,113 mm (4,137 to 4,138 in)
0,889 mm (0,035 in)		105,597 to 105,621 mm (4,157 to 4,158 in)
1,397 mm (0,055 in)		106,105 to 106,129 mm (4,177 to 4,178 in)
2722 and 2725 engines		
- Oversize 0,381 mm (0,015 in)		107,507 to 107,531 mm (4,2326 to 4,2335 in)
0,889 mm (0,035 in)		108,015 to 108,039 mm (4,2526 to 4,2535 in)
1,397 mm (0,055 in)		108,523 to 108,547 mm (4,2726 to 4,2735 in)

Piston Skirt Clearance in the Cylinder Bore - at the grade point	
2722, 2723 and 2725 engines	0,088 to 0,137 mm (0,0035 to 0,0054 in)
2726T and 2728T engines	0,152 to 0,203 mm (0,006 to 0,008 in)
Piston Crown Protrusion (Bump Height)	
Height above the Cylinder Block Top Face at T.D.C. (See Connecting Rod Length)	0,152 to 0,381 mm (0,006 to 0,015 in)
Piston Ring Grooves	
Number of Ring Grooves	
2722, 2723, 2725 engines	3
2726T and 2728T engines	4
Width of Ring Grooves for - Top Compression Ring	
2726T and 2728T engines	Tapered Ring
2722, 2723 and 2725 engines	2,465 to 2,485 mm (0,097 to 0,098 in)
Second Compression Ring	2,445 to 2,465 mm (0,096 to 0,097 in)
Third Compression Ring - (2726T and 2728T engines only)	2,444 to 2,469 mm (0,096 to 0,097 in)
Oil Control Ring	
2726T and 2728T engines	4,800 to 4,826 mm (0,189 to 0,190 in)
2722, 2723 and 2725 engines	4,767 to 4,787 mm (0,188 to 0,189 in)
Piston Pin Bore Diameter	
2722, 2723 and 2725 engines	36,508 to 36,516 mm (1,4373 to 1,4376 in)
2726T and 2728T engines	40,991 to 41,001 mm (1,6138 to 1,6142 in)
Piston Rings	
Piston Ring Gap	
2722, 2723 and 2725 engines	
Compression Rings - All	0,33 to 0,58 mm (0,013 to 0,023 in)
Oil Control Ring	0,33 to 0,71 mm (0,013 to 0,028 in)
2726T and 2728T engines	
Compression Rings - Top	0,43 to 0,64 mm (0,017 to 0,025 in)
Second and third	0,33 to 0,58 mm (0,013 to 0,023 in)
Oil Control Ring	0,33 to 0,58 mm (0,013 to 0,023 in)
Colour Code - Standard Rings	
2726T and 2728T engines - Violet	
2723 engines - Green	
2722 and 2725 engines - Orange	
Piston Ring Width	
2722, 2723 and 2725 engines	
Compression Rings - Top	2,362 to 2,375 mm (0,0930 to 0,0935 in)
- Second	2,351 to 2,375 mm (0,0926 to 0,0935 in)
Oil Control Ring	4,717 to 4,737 mm (0,1857 to 0,1865 in)
2726T and 2728T engines	
Compression Rings - Top	Tapered
- Second and Third	2,351 to 2,375 mm (0,0926 to 0,0935 in)
Oil Control Ring	4,717 to 4,737 mm (0,1857 to 0,1865 in)
Piston Ring to Piston Groove Clearance	
2722, 2723 and 2725 engines	
Compression Rings - Top	0,090 to 0,123 mm (0,0035 to 0,0048 in)
- Second	0,070 to 0,114 in (0,0028 to 0,0045 in)
Oil Control Ring	0,030 to 0,070 mm (0,0012 to 0,0028 in)
2726T and 2728T engines	
Compression Rings - Top	0,000 to 0,127 mm (0,0000 to 0,0050 in)
- Second and Third	0,069 to 0,118 mm (0,0027 to 0,0047 in)
Oil Control Ring	0,064 to 0,109 mm (0,0025 to 0,0043 in)

Piston Pin	
Outside Diameter	
2722, 2723 and 2725 engines	36,502 to 36,510 mm (1,4371 to 1,4374 in)
2726T and 2728T engines	40,985 to 40,993 mm (1,6136 to 1,6139 in)
Clearance in Piston Bosses at 20°C (68°F)	
NOTE: Piston pins are fitted selectively to pistons to obtain the specified clearance. These components should be retained as matched sets if re-assembling to an engine.	
Selective Fit	0,002 to 0,010 mm (0,00008 to 0,00040 in)
Length	
2722, 2723 and 2725 engines	85,80 to 86,20 mm (3,378 to 3,394 in)
2726T and 2728T engines	86,74 to 87,12 mm (3,415 to 3,430 in)
CONNECTING RODS	
Length - Centre of Big End to Centre of Small End	
NOTE: Grade letter is centre letter of the three identifying letters on big end thrust face. Graded rods are used to control 'Bump Height' (See Piston specifications).	
Grade A	203,175 to 203,251 mm (7,999 to 8,002 in)
Grade B (Plus 0,076 mm (0,003 in))	203,251 to 203,327 mm (8,002 to 8,005 in)
Grade C (Plus 0,152 mm (0,006 in))	203,327 to 203,403 mm (8,005 to 8,008 in)
Grade D (Plus 0,228 mm (0,009 in))	203,403 to 203,479 mm (8,008 to 8,011 in)
Big End Bore Diameter (Steel)	
2723 engine	67,208 to 67,223 mm (2,6460 to 2,6466 in)
All other engines	70,879 to 70,894 mm (2,7905 to 2,7911 in)
Small End Bore Diameter (Steel)	
2722, 2723 and 2725 engines	39,67 to 39,72 mm (1,562 to 1,564 in)
2726T and 2728T engines	44,08 to 44,13 mm (1,7354 to 1,7374 in)
Small End Bush Bore Diameter	
2722, 2723 and 2725 engines	36,523 to 36,541 mm (1,4379 to 1,4386 in)
2726T and 2728T engines	41,006 to 41,024 mm (1,6144 to 1,6151 in)
Small End Bush to Piston Pin Clearance	0,013 to 0,039 mm (0,0005 to 0,0015 in)
End Float on Crankpin	0,076 to 0,279 mm (0,003 to 0,011 in)
CRANKSHAFT, CRANKSHAFT BEARINGS AND OIL SEAL	
Main Bearing Journals	
Diameter - Standard Size	
2722, 2723 and 2725 engines	
Standard Size 1	76,200 to 76,230 mm (3,0000 to 3,0012 in)
Standard Size 2	75,946 to 75,976 mm (2,9900 to 2,9912 in)
2726T and 2728T engines	76,205 to 76,225 mm (3,0002 to 3,0010 in)
Diameter - Service Regrind	
2722, 2723, 2725, 2726T and 2728T engines	
Standard Size 1	
Undersize - 0,254 mm (0,010 in)	75,958 to 75,971 mm (2,9905 to 2,9910 in)
- 0,508 mm (0,020 in)	75,704 to 75,717 mm (2,9805 to 2,9810 in)
- 0,762 mm (0,030 in)	75,450 to 75,463 mm (2,9705 to 2,9710 in)
- 1,016 mm (0,040 in)	75,196 to 75,209 mm (2,9605 to 2,9610 in)
2722, 2723 and 2725 engines - Standard Size 2	
Undersize - 0,254 mm (0,010 in)	75,704 to 75,717 mm (2,9805 to 2,9810 in)
- 0,508 mm (0,020 in)	75,450 to 75,463 mm (2,9705 to 2,9710 in)
- 0,762 mm (0,030 in)	75,196 to 75,209 mm (2,9605 to 2,9610 in)

Length		
Front		32,89 to 33,15 mm (1,295 to 1,305 in)
Centre		45,695 to 45,745 mm (1,799 to 1,801 in)
Rear		46,51 to 46,76 mm (1,831 to 1,841 in)
Intermediate		35,43 to 35,69 mm (1,395 to 1,405 in)
Runout		
Runout of Intermediate and Centre Bearings Journals with Crankshaft Mounted on Front and Rear Journals	4 Cyl.	0,064 mm (0,025 in) T.I.R. Maximum
	6 Cyl.	0,051 mm (0,002 in) T.I.R. Maximum
Thrust Faces		
Taper on Each Face		0,051 mm (0,002 in) Maximum
Runout at Outside Edge		0,013 mm (0,0005 in) T.I.R. Maximum
Crankpin Bearing Journals		
Diameter - Standard Size		
2723 engine		
Standard Size 1		63,492 to 63,512 mm (2,4997 to 2,5005 in)
Standard Size 2		63,213 to 63,258 mm (2,4887 to 2,4905 in)
2722 and 2725 engines		
Standard Size 1		66,654 to 66,675 mm (2,6242 to 2,6250 in)
Standard Size 2		66,400 to 66,421 mm (2,6142 to 2,6150 in)
2726T and 2728T engines		66,654 to 66,675 mm (2,6242 to 2,6250 in)
Diameter - Service Regrind		
2723 engine - Standard Size 1		
Undersize - 0,254 mm (0,010 in)		63,246 to 63,258 mm (2,4900 to 2,4905 in)
- 0,508 mm (0,020 in)		62,992 to 63,004 mm (2,4800 to 2,4805 in)
- 0,762 mm (0,030 in)		62,738 to 62,750 mm (2,4700 to 2,4705 in)
- 1,016 mm (0,040 in)		62,484 to 62,496 mm (2,4600 to 2,4605 in)
2723 engine - Standard Size 2		
Undersize - 0,254 mm (0,010 in)		62,992 to 63,004 mm (2,4800 to 2,4805 in)
- 0,508 mm (0,020 in)		62,738 to 62,750 mm (2,4700 to 2,4705 in)
- 0,762 mm (0,030 in)		62,484 to 62,496 mm (2,4600 to 2,4605 in)
2722 and 2725 engines - Standard Size 1		
Undersize - 0,254 mm (0,010 in)		66,408 to 66,421 mm (2,6145 to 2,6150 in)
- 0,508 mm (0,020 in)		66,154 to 66,167 mm (2,6045 to 2,6050 in)
- 0,762 mm (0,030 in)		65,900 to 65,913 mm (2,5945 to 2,5950 in)
- 1,016 mm (0,040 in)		65,646 to 65,659 mm (2,5845 to 2,5850 in)
2722 and 2725 engines - Standard Size 2		
Undersize - 0,254 mm (0,010 in)		66,154 to 66,167 mm (2,6045 to 2,6050 in)
- 0,508 mm (0,020 in)		65,900 to 65,913 mm (2,5945 to 2,5950 in)
- 0,762 mm (0,030 in)		65,646 to 65,659 mm (2,5845 to 2,5850 in)
2726T and 2728T engines - Standard Size 1		
Undersize - 0,254 mm (0,010 in)		66,408 to 66,421 mm (2,6145 to 2,6150 in)
- 0,508 mm (0,020 in)		66,154 to 66,167 mm (2,6045 to 2,6050 in)
- 0,762 mm (0,030 in)		65,900 to 65,913 mm (2,5945 to 2,5950 in)
- 1,016 mm (0,040 in)		65,646 to 65,659 mm (2,5845 to 2,5850 in)
Length		42,160 to 42,266 mm (1,660 to 1,664 in)

Main and Crankpin Bearing Journals	
Fillet Radii	4,32 to 4,83 mm (0,17 to 0,19 in)
Ovality - Maximum Permitted	
- Crankpin	0,006 mm (0,00025 in)
- Main	0,010 mm (0,00040 in)
Taper - Maximum Permitted	0,013 mm (0,0005 in)
Main Bearing Liners	
Thickness - Standard	
Standard Size 1	2,071 to 2,080 mm (0,08250 to 0,08215 in)
Standard Size 2	2,198 to 2,207 mm (0,08750 to 0,08715 in)
Thickness - Service Regrind	
Standard Size 1	
Undersize - 0,254 mm (0,010 in)	2,198 to 2,207 mm (0,08655 to 0,08690 in)
- 0,508 mm (0,020 in)	2,325 to 2,334 mm (0,09155 to 0,09190 in)
- 0,762 mm (0,030 in)	2,452 to 2,461 mm (0,09655 to 0,09690 in)
- 1,016 mm (0,040 in)	2,579 to 2,588 mm (0,10155 to 0,10190 in)
Standard Size 2	
Undersize - 0,254 mm (0,010 in)	2,325 to 2,334 mm (0,09155 to 0,09190 in)
- 0,508 mm (0,020 in)	2,452 to 2,461 mm (0,09655 to 0,09690 in)
- 0,762 mm (0,030 in)	2,579 to 2,588 mm (0,10155 to 0,10190 in)
NOTE: For 0,381 mm (0,015 in) oversize bearing housings, liners are 0,191 mm (0,0075 in) thicker than dimensions specified above.	
Length - Front and Intermediate	26,29 to 26,67 mm (1,035 to 1,050 in)
- Centre and Rear	35,81 to 36,19 mm (1,410 to 1,425 in)
Clearance - Main Bearing Liner to Journal	0,038 to 0,086 mm (0,0015 to 0,0034 in)
Thrust Washer	
Thickness	
Standard	2,311 to 2,362 mm (0,091 to 0,093 in)
Oversize - 0,063 mm (0,0025 in)	2,375 to 2,426 mm (0,0935 to 0,0955 in)
- 0,127 mm (0,0050 in)	2,438 to 2,489 mm (0,0960 to 0,0980 in)
- 0,190 mm (0,0075 in)	2,502 to 2,553 mm (0,0985 to 0,1005 in)
- 0,254 mm (0,010 in)	2,565 to 2,616 mm (0,101 to 0,103 in)
- 0,381 mm (0,015 in)	2,692 to 2,743 mm (0,106 to 0,108 in)
- 0,508 mm (0,020 in)	2,819 to 2,870 mm (0,111 to 0,113 in)
Clearance (Crankshaft End Float)	0,050 to 0,254 mm (0,002 to 0,010 in)
Crankpin Bearing Liners (Big End)	
Thickness - Standard	
2723 engine	
Standard Size 1	1,821 to 1,830 mm (0,07170 to 0,07205 in)
Standard Size 2	1,948 to 1,957 mm (0,07670 to 0,07705 in)
2722, 2725, 2726T and 2728T engines	
Standard Size 1	2,075 to 2,084 mm (0,08170 to 0,08205 in)
Standard Size 2	2,202 to 2,211 mm (0,08670 to 0,08705 in)

Thickness - Service Regrind	
2723 engine - Standard Size 1	
Undersize - 0,254 mm (0,010 in)	1,948 to 1,957 mm (0,07670 to 0,07705 in)
- 0,508 mm (0,020 in)	2,075 to 2,084 mm (0,08170 to 0,08205 in)
- 0,762 mm (0,030 in)	2,202 to 2,211 mm (0,08670 to 0,08705 in)
- 1,016 mm (0,040 in)	2,329 to 2,338 mm (0,0917 to 0,09205 in)
2723 engine - Standard Size 2	
Undersize - 0,254 mm (0,010 in)	2,075 to 2,084 mm (0,08170 to 0,08205 in)
- 0,508 mm (0,020 in)	2,202 to 2,211 mm (0,08670 to 0,08705 in)
- 0,762 mm (0,030 in)	2,329 to 2,338 mm (0,09170 to 0,09205 in)
2722, 2725T, 2726T and 2728T engines - Standard Size 1	
Undersize - 0,254 mm (0,010 in)	2,202 to 2,211 mm (0,08670 to 0,08705 in)
- 0,508 mm (0,020 in)	2,329 to 2,338 mm (0,09170 to 0,09205 in)
- 0,762 mm (0,030 in)	2,456 to 2,465 mm (0,09670 to 0,09705 in)
- 1,016 mm (0,040 in)	2,583 to 2,592 mm (0,10170 to 0,10205 in)
2722, 2725, 2726T and 2728T engines - Standard Size 2	
Undersize - 0,254 mm (0,010 in)	2,329 to 2,338 mm (0,09170 to 0,09205 in)
- 0,508 mm (0,020 in)	2,456 to 2,465 mm (0,09670 to 0,09705 in)
- 0,762 mm (0,030 in)	2,583 to 2,592 mm (0,10170 to 0,10205 in)
Width	33,655 to 34,036 mm (1,325 to 1,340 in)
Clearance - Crankpin Bearing Liner to Journal	
Standard	0,036 to 0,086 mm (0,0014 to 0,0034 in)
Service Regrind	0,036 to 0,079 mm (0,0014 to 0,0031 in)
End Float	0,076 to 0,279 mm (0,003 to 0,011 in)

NOTE: If crankshaft bearings are re-used they should always be fitted to their original housings.

Crankshaft Oil Seal

Seal Protrusion Above Cylinder Block/Rear Main Bearing Cap Face

- Both Sides, Both Faces	0,635 to 0,762 mm (0,025 to 0,030 in)

Crankshaft Turning Torque

Crankshaft Only in Block	Nm	Kgm	lbft
2722 engine	8 to 16	0,8 to 1,7	6 to 12
2723, 2725, 2726T and 2728T engines	11 to 20	1,1 to 2,0	8 to 15
Complete Engine less Injectors and Driven Equipment			
2722 engine	34 to 61	3,5 to 6,2	25 to 45
2723 and 2725 engine	47 to 75	4,8 to 7,6	35 to 55
2726T and 2728T engines	41 to 68	4,1 to 6,9	30 to 50

CAMSHAFT AND CAMFOLLOWERS (Tappets)

Camshaft

Cam Lift - Maximum	7,87 mm (0,310 in)
Bearing Journal Diameter	55,48 to 55,50 mm (2,1842 to 2,1850 in)
Bearing Journal Clearance	
Front	0,038 to 0,076 mm (0,0015 to 0,0030 in)
Intermediate and Rear	0,025 to 0,064 mm (0,0010 to 0,0025 in)
End Float	0,050 to 0,533 mm (0,002 to 0,021 in)

Camfollowers (Tappets)

Stem Diameter	17,475 to 17,488 mm (0,6880 to 0,6885 in)
Length - Cup to Face	56,75 to 57,25 mm (2,2343 to 2,2539 in)
Clearance - Camfollower to Cylinder Block	0,012 to 0,063 mm (0,0005 to 0,0025 in)

TIMING GEARS

Number of Teeth	
Crankshaft Gear	35
Camshaft Gear	70
Fitting	
Camshaft Gear to Camshaft	0,042 mm (0,0016 in) to 0,002 mm (0,0008 in) Interference
Crankshaft Gear to Crankshaft	0,0000 mm (0,00 in) to 0,50 mm (0,002 in) Interference
Temperature - Crankshaft and Camshaft Gears	82°C (180°F)
Backlash	
Crankshaft Gear to Camshaft Gear	0,025 to 0,279 mm (0,001 to 0,011 in)
Camshaft Gear to Injection Pump gear	0,025 to 0,279 mm (0,001 to 0,011 in)

NOTE: Crankshaft and Camshaft Gears are graded for mesh and identified by a coloured paintspot. Gears should be matched Red/Red, Yellow/Yellow, Blue/Blue, but should matching colours be unavailable in service alternative pairing of gears MAY give the specified backlash.

CAUTION: BACKLASH MUST BE WITHIN THE SPECIFIED LIMITS OR DAMAGE MAY OCCUR FROM INCORRECT MESHING OF THE GEARS.

Basic Engine Timing - Refer to Section 4.

FLYWHEEL AND STARTER RING GEAR

Runout of Flywheel Face at a radius of 140 mm (5,5 in)	0,178 mm (0,007 in) T.I.R. Maximum
Number of Teeth on Ring Gear	128
Fitting Temperature of Ring Gear	190°C (375°F)

CYLINDER HEAD, VALVE GUIDES AND VALVE SEAT INSERTS

Cylinder Head	
Datum Face	Rocker Cover Face
Height - (new)	92,68 to 92,81 mm (3,649 to 3,654 in)
- minimum after re-surfacing	92,17 to 92,30 mm (3,629 to 3,634 in)
Bow/twist within	0,254 mm (0,010 in) Max. Overall
Valve Guide	
Length	76,2 mm (3,0 in)
Diameter - Internal	9,528 to 9,558 mm (0,3751 to 0,3763 in)
- External - Standard	15,893 to 15,905 mm (0,6257 to 0,6262 in)
Protrusion Above the Top Face	
- Inlet	18,29 mm (0,72 in)
- Exhaust	26,67 mm (1,05 in)
Valve Seat Insert Recess - Standard Size	
Diameter - Inlet	46,876 to 46,901 mm (1,8455 to 1,8465 in)
- Exhaust	39,764 to 39,789 mm (1,5655 to 1,5665 in)
Depth - Inlet and Exhaust	6,553 to 6,832 mm (0,258 to 0,269 in)
Valve Seat Insert Recess - Oversize	0,254 mm (0,010 in)
Diameter - Inlet	47,130 to 47,155 mm (1,8555 to 1,8565 in)
- Exhaust	40,018 to 40,043 mm (1,5755 to 1,5765 in)
Depth - Inlet and Exhaust	6,807 to 7,085 mm (0,268 to 0,279 in)

Valve Seat Insert - Standard Size		
Outside Diameter	- Inlet	46,977 to 46,990 mm (1,8495 to 1,8500 in)
	- Exhaust	39,865 to 39,878 mm (1,5695 to 1,5700 in)
Thickness	- Inlet and Exhaust	6,794 to 6,845 mm (0,2675 to 0,2695 in)
Valve Seat Insert - Oversize 0,254 mm (0,010 in)		
Outside Diameter	- Inlet	47,231 to 47,244 mm (1,8595 to 1,8600 in)
	- Exhaust	40,119 to 40,132 mm (1,5795 to 1,5800 in)
Thickness	- Inlet and Exhaust	7,048 to 7,099 mm (0,2775 to 0,2795 in)
Valve Seat Face Width		1,60 to 2,38 mm (0,063 to 0,094 in)
Valve Seat Angle		30° 00' to 30° 30'
VALVES		
Head Diameter	- Inlet	45,47 to 45,72 mm (1,790 to 1,800 in)
	- Exhaust	38,15 to 38,40 mm (1,502 to 1,512 in)
Stem Diameter	- Inlet	9,474 to 9,500 mm (0,373 to 0,374 in)
	- Exhaust	9,456 to 9,482 mm (0,3723 to 0,3733 in)
Stem to Guide Clearance	- Inlet	0,028 to 0,084 mm (0,0011 to 0,0033 in)
	- Exhaust	0,045 to 0,102 mm (0,0018 to 0,0004 in)
Angle of Valve Seat		29° 00 to 29° 30'
Valve Head Protrusion compared to Head Face		
- Inlet		+ 0,254 to - 0,508 mm (+ 0,010 to - 0,020 in)
- Exhaust		+ 0,431 to + 1,016 mm (+ 0,017 to + 0,040 in)
VALVE SPRINGS		
Inlet		
Number of Coils		7,5 Total
Free Length of Spring		58,7 mm (2,31 in)
Spring Load at a length of		
	- 40 mm (1,56 in)	71,21 to 76,66 kg (157 to 169 lb)
	- 50 mm (1,97 in)	28,12 to 30,84 kg (62 to 68 lb)
Identification		Blue Paint Line
Exhaust		
Number of Coils		7,98 Total
Free Length of Spring		69,93 mm (2,753 in)
Spring Load at a length of		
	- 40 mm (1,56 in)	70,31 to 77,56 kg (155 to 171 lb)
	- 50 mm (1,97 in)	46,11 to 50,96 kg (102 to 112 lb)
Identification		Yellow Paint Line
ROCKER SHAFT, ROCKERS AND PUSH RODS		
Rocker Shaft		
Diameter		18,872 to 18,898 mm (0,743 to 0,744 in)
Number of Springs		
- 4 Cylinder Engines		4
- 6 Cylinder Engines		6
Load of Rocker Shaft Spring		1,81 to 2,27 kg at 26,92 mm (4 to 5 lb at 1,06 in)
Rocker - Bore Diameter		18,923 to 18,949 mm (0,7450 to 0,746 in)
Push Rod - Length (Cup to Ball)		301,88 to 302,64 mm (11,89 to 11,91 mm)

SPECIFICATIONS

Type of System	Pump Assisted Thermo-Syphon	
Thermostats	Starts to Open	Fully Open
2722 engine - industrial or marine	80-84°C (176-183°F)	94°C (201°F)
2723, 2725, 2726T and 2728T marine engines	80-84°C (176-183°F)	96°C (205°F)
2723, 2725 and 2726T industrial engines Primary Secondary	 75-79°C (167-174°F) 80-84°C (176-183°F)	 91°C (196°F) 96°C (205°F)
Minimum Travel of Valve	9,1 mm (0,360 in)	
Antifreeze	FORD Specification SSM 97B 9103A	
Corrosion Inhibitor	FORD Specification SSM 97B 9100	

SPECIFICATION - Water Pumps

Type of Engine	Turbocharged Marine and Combine Harvester	Naturally Aspirated and Turbocharged Industrial	'Low Loss' Fan Drive System
Bearing Outer Race dia.	38,087 to 38,10 mm (1,499 to 1,500 in)	51,987 to 52,000 mm (2,0467 to 2,0472 in)	51,987 to 52,000 mm (2,0467 to 2,0472 in)
Bearing Outer Race-Bore In Pump Housing	38,06 to 38,08 mm (1,498 to 1,499 in)	51,940 to 51,97 mm (2,0449 to 2,0461 in)	51,940 to 51,97 mm (2,0449 to 2,0461 in)
Impeller Shaft Dia.	15,905 to 15,918 mm (0,6262 to 0,6267 in)	15,905 to 15,918 mm (0,6262 to 0,6267 in)	15,905 to 15,918 mm (0,6262 to 0,6267 in)
Impeller Bore	15,85 to 15,875 mm (0,624 to 0,625 in)	15,850 to 15,875 mm (0,6240 to 0,6250 in)	15,850 to 15,875 mm (0,6240 to 0,6250 in)
Pulley/Pulley Hub Shaft Dia.	18,948 to 18,961 mm (0,745 to 0,746 in)	25,008 to 25,017 mm (0,9846 to 0,9849 in)	25,008 to 25,017 mm (0,9846 to 0,9849 in)
Pulley/Pulley Hub Bore	18,893 to 18,918 mm (0,744 to 0,745 in)	24,948 to 24,965 mm (0,9822 to 0,9828 in)	24,967 to 24,988 mm (0,9830 to 0,9838 in)
Impeller Clearance between Front of Vanes and Housing	0,508 mm (0,20 in)	0,508 (0,020 in)	0,508 mm (0,020 in)

TIGHTENING TORQUES

	Nm	Kgm	lbf ft
Water Pumps			
Pump securing bolts/nuts (all versions)	18 to 22	1,8 to 2,2	13 to 16
Fan securing bolts (including 'Low Loss Fan' System)	16 to 20	1,6 to 2,0	12 to 15
'Low Loss Fan' pulley retaining bolt	100	10,2	74
Thermostats			
Water outlet connection securing bolts/nuts	20 to 25	2,0 to 2,5	15 to 18

CONTENTS

CONTENTS (Continued)

GENERAL DESCRIPTION

The principle working components of the fuel system are the lift pump, injection pump and injectors. Together with the tank and filters these items make up the basic system which provides direct injection of fuel into the engine cylinders.

The fuel lift pump is mounted on the right hand, rear end of the cylinder block and is operated by an eccentric on the engine camshaft. Its function is to draw fuel from the tank and provide a constant supply to the injection pump.

The injection pump is an integrated assembly of pumping and governing units mounted on the rear of the timing gear housing and driven by the timing gears.

In the pumping section of the injection pump, spring loaded, fuel fed pumping plungers are operated by an internal camshaft. Each plunger delivers fuel to its respective injector at high pressure and in the correct engine firing order. To vary the quantity of fuel delivered in accordance with specific throttle demand or condition, the plungers are collectively linked to the governing section via a 'control rod'.

The governing section receives a signal of engine speed from the camshaft mounted flyweights. This 'signal' combines with other signal inputs of starting, stopping and power demand (throttle setting) to position the plunger control rod. The flyweight type governor provides automatic idle speed control and restricts maximum engine speed to a pre-set limit.

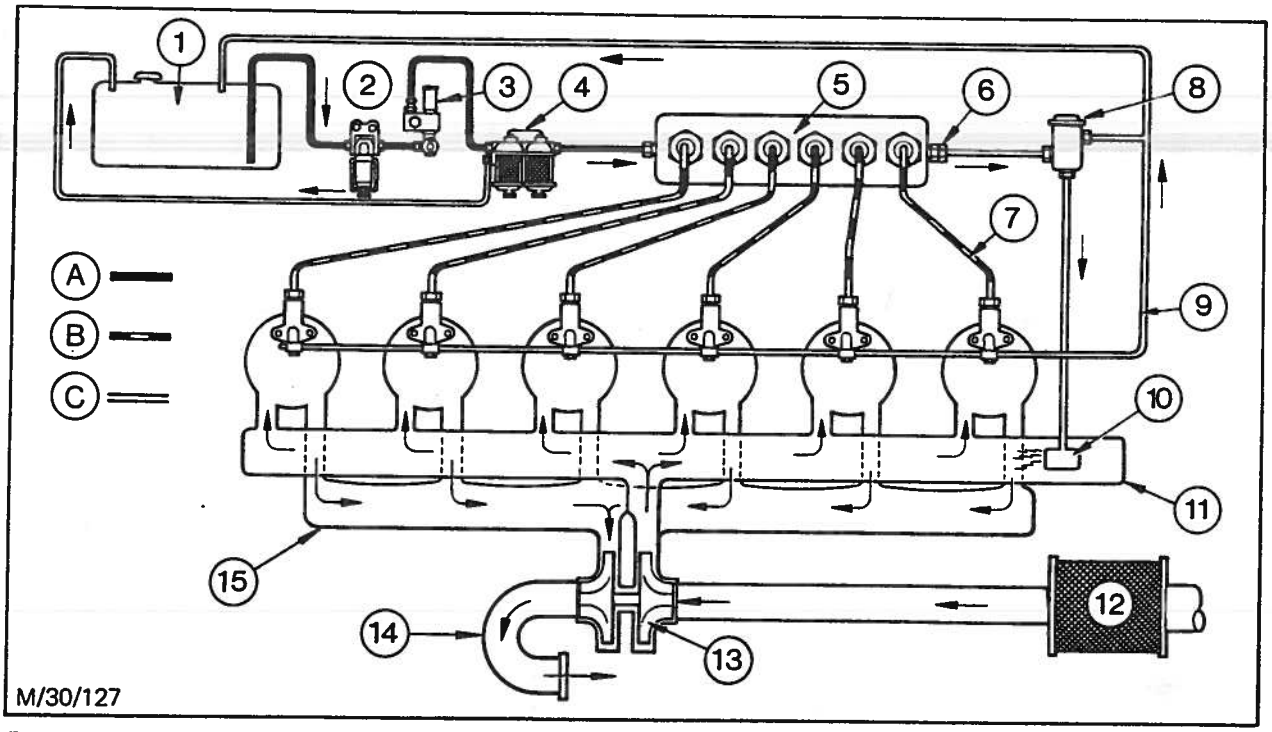

Fig. 1 - Typical Fuel System Schematic (Turbocharged engine shown)
A. Low Pressure Fuel Path
B. High Pressure Fuel Path
C. Leak-off Fuel Return to Tank and Thermostart Feed Paths

1. Tank
2. Water Separator Filter (when fitted)
3. Lift Pump and (when fitted) Pre-Filter Unit
4. Engine Mounted Filters and Pressure Relief Valve Assembly
5. Injection Pump
6. Fuel Gallery Air Bleed
7. High Pressure Delivery Pipes to Injectors
8. Thermostart Reservoir
9. Leak-Off Pipe to Tank
10. Thermostart Element(s)
11. Intake Manifold
12. Air Cleaner
13. Turbocharger
14. Exhaust Elbow/Exhaust Pipe
15. Exhaust Manifold

On turbocharged engines the boosted intake manifold pressure results in higher volumetric efficiency and increased engine power output. A 'boost control' on the injection pump of these engines is fitted to prevent excessive overfuelling during acceleration.

The fuel injectors act as spring loaded on/off valves, providing a high degree of atomisation while open. A calculated, self lubricating internal leakage is allowed to return to the tank via a 'leak-off' pipe.

Stopping the engine is achieved principally by moving the pump plungers into a 'non-delivery' condition. This is achieved by means of a stop lever which moves the plunger control rod to the required position.

To enhance engine starting performance, the injection pump is capable of operating briefly in an overfuelling condition. This device places the pump plungers in an 'excess fuel' position.

Automotive and G.P. governed injection pumps have an integral automatic excess fuel facility which is temperature sensitive. All other injection pumps have a manually operated excess fuel device but an automatic device is available as an option.

For extreme cold weather conditions a thermostart system may be fitted as an option (mandatory on turbocharged engines).

This system pre-heats the air to the combustion chambers by igniting a small flow of low pressure fuel in the air intake manifold.

FUEL LIFT PUMP

Operation of Standard Pump - Refer to Fig. 2

The eccentric on the camshaft operates the fuel pump rocker arm and link and pulls the diaphragm inwards against the pressure of the return spring. This creates a partial vacuum in the pump chamber, causing the inlet valve to open and draw fuel into the diaphragm chamber.

Further movement of the camshaft eccentric allows the rocker arm to return and the diaphragm is pushed outwards by the return spring, causing the inlet valve to close and the outlet valve to open. The fuel is then forced through the replaceable element filter to the injection pump. The pulsator diaphragm works in sympathy with the pump diaphragm and reduces fuel delivery surge.

When the injection pump is full of fuel, pressure created in the diaphragm chamber holds the diaphragm in against the action of the return spring until fuel is delivered by the injection pump.

During the time the diaphragm is held in by the fuel pressure, the rocker arm idles on the camshaft eccentric without operating the link.

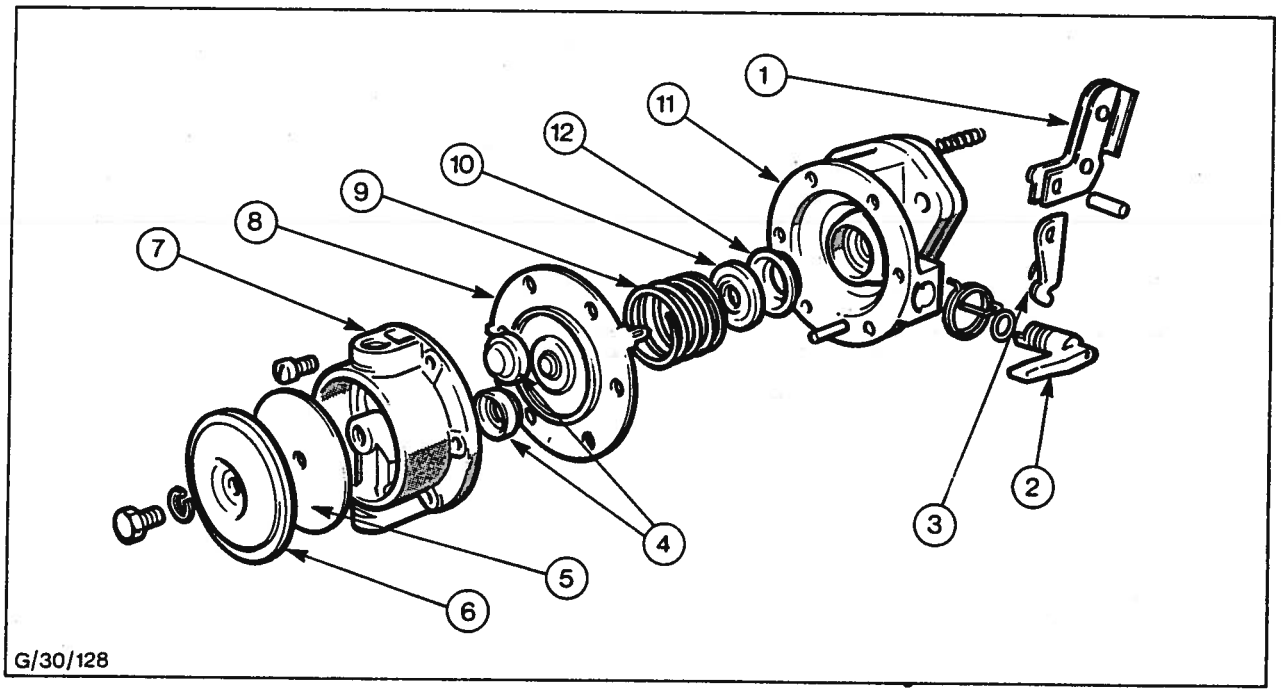

Fig. 2 - Exploded View of Standard Pump

1. Rocker Arm
2. Priming Lever
3. Rocker Arm Link
4. Valves
5. Pulsator Diaphragm
6. Cover
7. Outer Body
8. Pump Diaphragm
9. Return Spring
10. Oil Seal Retainer
11. Inner body
12. Oil Seal

Operation of High Pressure Pump - Refer to Figs. 3 and 4

The fuel lift pump is mounted to an adaptor at the rear of the engine block.

A plunger rod housed in the adaptor contacts the eccentric on the camshaft at one end and the fuel lift pump plunger rod at the other end.

On rotation of the engine, the eccentric cam forces the plunger rods and plunger in the direction of the pump suction chamber; fuel is thereby forced out of the suction chamber through the balancing channel into the compression chamber. At the same time the plunger spring is compressed.

The fuel is then forced out of the compression chamber, through the balancing channel to the fuel filter and the injection pump.

As the eccentric cam goes beyond the highest point, the plunger is forced back by the plunger spring.

At the same time, the receding plunger creates a vacuum in the suction chamber, the suction valve opens and fuel is again drawn from the fuel tank.

If more fuel than necessary is pumped, the pressure in the compression chamber rises. This pressure acts through the balancing channel on the plunger against the force of the plunger spring. If the force exerted by the plunger is exceeded by the force exerted by the pressure in the compression chamber, the plunger no longer moves as far towards the cam, and so the amount of fuel pumped is reduced.

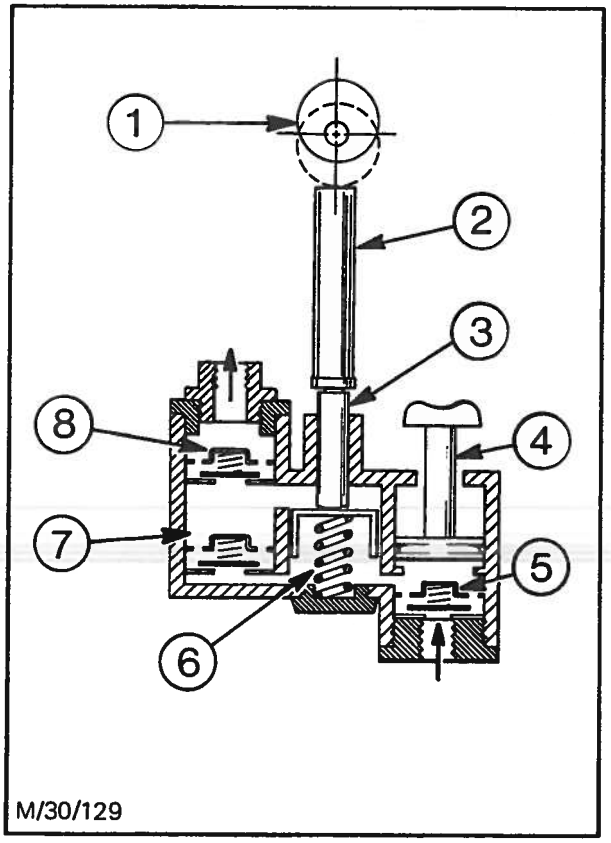

Fig. 3 - High Pressure Pump Shown in Diagramatic Form

1. Camshaft Eccentric
2. Adaptor Rod
3. Plunger Rod
4. Priming Pump
5. Inlet Valve
6. Plunger Return Spring
7. Transfer Valve
8. Outlet Valve (AC Delco Pumps Only)

TESTING THE FUEL LIFT PUMP

Providing there are no air leaks or obstruction in the fuel system, a quick check on the pump efficiency can be made as follows:

1. Remove the air bleed screw from the inlet side of the fuel filter.

2. Operate the hand priming lever in the normal manner when there should be a well defined surge of fuel for each working stroke of the pump. If no resistance of the diaphragm spring can be felt, it is likely that the diaphragm is held down, due to the operating lever being on the high point of the camshaft eccentric, and it will be necessary to rotate the engine approximately one turn.

If the pump does not operate correctly, check the inlet depression and delivery pressure by Diagnosis Test Set, Gang Gauge Set No. 500-X or suitable vacuum and pressure gauges.

FUEL PUMP INLET DEPRESSION TEST

1. Operate the lift pump hand primer to fill the injection pump fuel gallery.

2. Disconnect the fuel inlet pipe from the pump and connect the vacuum gauge to the pump inlet union.

3. Start the engine and allow to run at idling speed. The vacuum readings should be at least 21,59 cm (8,5 in) of mercury.

4. Stop the engine and check the leak-down time for the specific pumps as follows:

Standard Pump - 0,0172 bar (0,0176 kgf/cm^2 or 0,25 lbf/in^2) in 25 minutes

High Pressure Pump - 0,207 bar (0,21 kgf/cm^2) or 3 lbf/in^2) in 25 minutes

Should the reading drop quicker than this, it indicates an air leak or faulty outlet valve.

5. Bleed the fuel system as described in the appropriate section.

NOTE: This test can be carried out at any connection between the lift pump and fuel tank to check for air leaks in the fuel system as a whole. By starting the tests at the fuel tank and working towards the fuel lift pump, it will be possible to determine the faulty component.

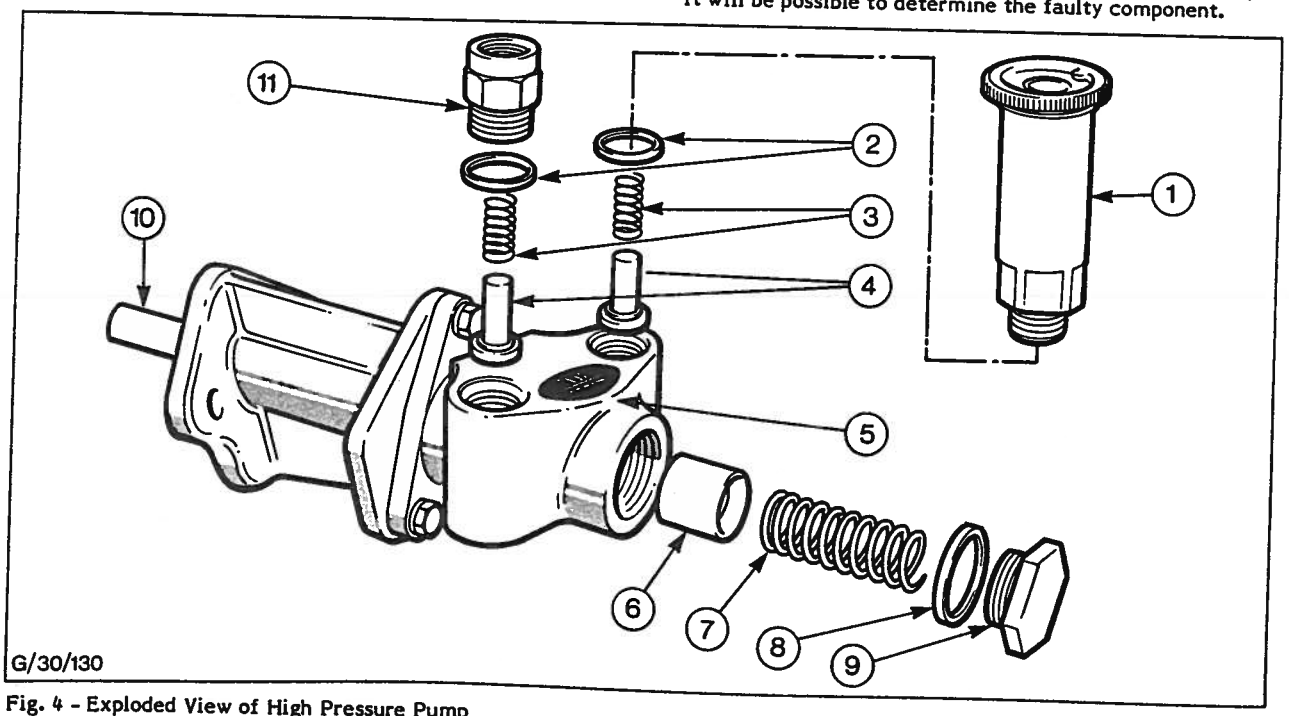

Fig. 4 - Exploded View of High Pressure Pump
1. Primer Plunger Assembly
2. Seal
3. Spring
4. Valve
5. Body
6. Plunger Sleeve
7. Spring
8. Seal
9. Plug
10. Plunger Rod
11. Connector

FUEL PUMP DELIVERY PRESSURE TEST

1. Operate the lift pump hand primer to fill the injection pump gallery.

2. Disconnect the fuel outlet pipe from the pump and connect the pressure gauge to the pump outlet.

3. Start the engine and observe the pressure at idling speed. Increase the speed and check throughout the speed range that the pressure is between:

0,34 to 0,55 bar (0,35 to 0,56 kgf/cm^2 or 5 to 8 lbf/in^2) standard pump
1,03 to 1,24 bar (1,05 to 1,27 kgf/cm^2 or 15 to 18 lbf/in^2) high pressure pump

NOTE: Low fuel pump pressure may affect engine performance due to lack of fuel.

4. Bleed the fuel system.

Servicing the Standard Fuel Lift Pump - see Fig. 2

1. Disconnect the fuel inlet and outlet pipes from the lift pump. Where applicable, remove banjo bolt and detach pre-filter unit.

2. Remove the two securing nuts and detach the lift pump from the cylinder block. Discard gasket.

3. Unscrew the bolt securing the pump cover plate and remove the cover plate and pulsator diaphragm.

4. Mark the positions of the two halves of the pump adjacent to the small tab on the pump diaphragm. Remove the six securing screws and separate the two halves of the pump.

5. If necessary, punch back the staking and remove the two valves from the outer body.

6. Drive out the pin securing the priming lever and withdraw the lever and spring. The priming lever shaft has a flat at its end which locates behind a lug on the diaphragm spring seat.

7. Push the pump diaphragm down against the return spring pressure and disengage the pull rod from the operating link.

8. If necessary, carefully punch back the staking locating the rocker arm pivot pin, tap out the pin and remove the rocker arm and link. Take care not to lose the small spring fitted between the rocker arm and the housing.

9. Thoroughly clean all parts with kerosene or test oil.

10. Insert the inlet and outlet valves, ensuring that they are in their correct positions. The inlet valve is the lower one and is assembled to the outer body with the spring nearest to the pump diaphragm. The outlet valve fits the other way round. Secure each valve by staking the body at four points.

11. Assemble the rocker arm, link and pin to the inner body, locating the return spring between the rocker arm and the housing. Stake the housing at either end of the pivot pin to ensure that it is securely retained.

12. Locate the return spring on the pump diaphragm spring seat and assemble the diaphragm to the inner body with the lug on the spring seat adjacent to the priming lever bore and the small tab next to the mark on the body. Engage the link with the pull rod.

13. Compress the pump diaphragm and return spring and insert the priming lever shaft, with the 'O' sealing ring in the outer groove, into the inner body so that the flat is located behind the spring seat lug. Locate the priming lever return spring in the small hole. Replace the priming lever retaining pin, which locates in a groove in the shaft and drive home.

14. Locate the two halves of the pump body together in the marked positions, insert the six screws until fingertight. Operate the rocker arm a few times to centralise the diaphragm and tighten the screws, holding the rocker lever fully down.

15. Replace the pump cover plate and pulsator diaphragm and secure with a screw and lock-washer. Tighten to the specified torque value.

16. Locate a new gasket on the cylinder block mounting studs, place the lift pump in position and secure with the two nuts and washers. Tighten nuts to the specified torque value.

17. Where applicable, secure the pre-filter unit to the pump with the banjo bolt and washers and tighten bolt to the specified torque value.

18. Connect the fuel inlet and outlet pipes and bleed the system - see under 'Bleeding the Fuel System'.

Servicing the High Pressure Fuel Lift Pump - See Fig. 4

1. Disconnect the fuel inlet and outlet pipes from the lift pump. Where applicable, remove banjo bolt and detach the pre-filter unit.

2. Remove the three securing bolts and detach the lift pump from the adaptor. Discard gasket.

3. Unscrew and remove the fuel inlet and outlet adaptors with their washers.

4. Unscrew the priming plunger assembly.

5. Withdraw the valve springs and valves.

6. Unscrew the plug, remove the sealing washer and withdraw the spring, plunger sleeve and rod.

7. Thoroughly clean the pump body and all parts with kerosene or test oil.

8. Examine the valves and ensure correct seating in the housing. If satisfactory, refit valves together with springs.

9. Screw in the priming plunger assembly, using new sealing washers.

10. Replace inlet and outlet adaptors using new sealing washers.

11. Examine plunger rod and plunger sleeve for damage or excessive wear, then, if serviceable, insert them into pump body and check that they move easily. Replace spring and secure with plug fitted with new sealing washer.

12. Ensure that the pump mounting face is clean, fit a new gasket and secure the pump to the adaptor housing with the three bolts and washers. Tighten bolts to the specified torque value.

13. Where applicable, secure pre-filter unit to the pump with banjo bolt and washers. Tighten bolt to specified torque value.

14. Connect fuel inlet and outlet pipes.

15. Bleed the system as detailed under 'Bleeding the Fuel System'.

FUEL FILTERS

Pre-Filter Unit

This filter is attached to the lift pump by a banjo-bolt and receives fuel directly from the tank. The element comprises a fine mesh cage enclosed in a transparent glass bowl and retained by a thumb screw tensioned 'stirrup' - see Fig. 5.

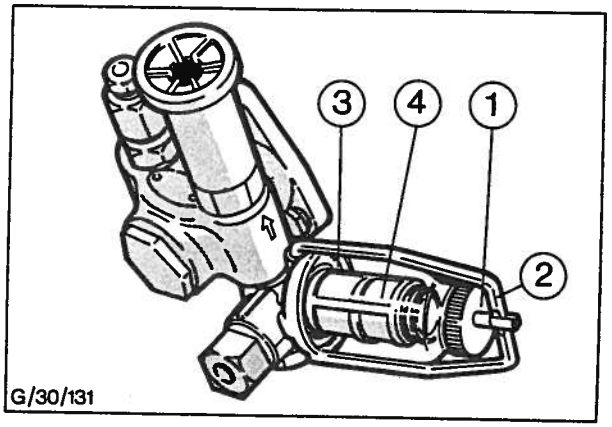

Fig. 5 - Pre-Filter Unit
1. Knurled Clamping Knob
2. 'Stirrup'
3. Glass Bowl
4. Filter Element

To clean the pre-filter unit proceed as follows:

1. Fully slacken off the knurled clamping knob and swing the 'stirrup' to one side.

2. Remove glass bowl and detach filter element.

3. Wash filter element and bowl thoroughly in clean test oil and dry bowl with non-fluffy rag.

4. Place filter element in glass bowl, spring first, then assemble bowl to housing, ensuring that the element spigot enters the recess in the housing.

5. Swing 'stirrup' into position and tighten clamp knob sufficiently to ensure a good seal. Do not overtighten.

6. Bleed the fuel system - see under 'Bleeding the Fuel System'.

7. Run the engine and check for fuel leaks.

Engine Mounted Filters - See Fig. 6

The filter assembly protects the high pressure components in the injection pump and injectors against damage from dirt. Each paper element is in the form of a renewable canister, secured between the filter head and base plate by a central bolt. A drain cap on each base plate allows water checks to be accomplished. Bleed screws on the filter head permit air to be bled from the system where necessary.

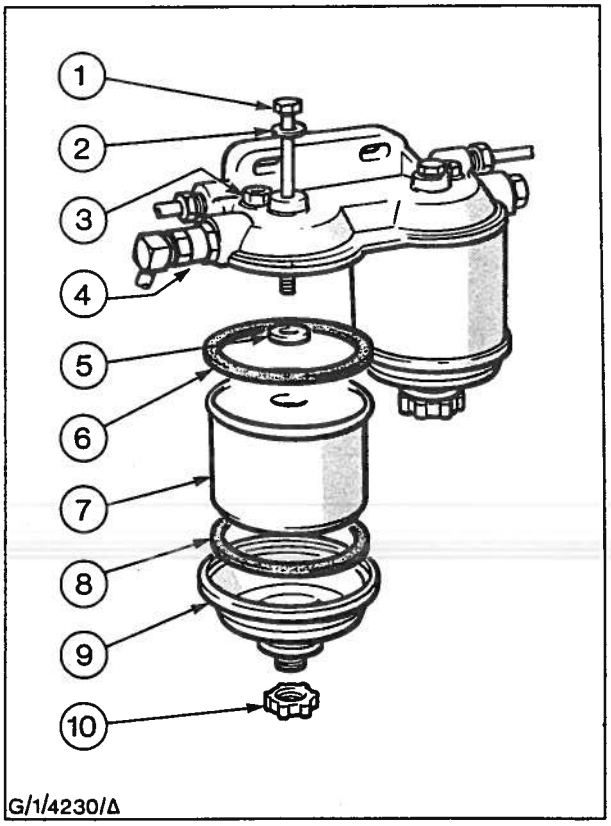

Fig. 6 - Engine Mounted Fuel Filter Unit
1. Centre Bolt
2. Sealing Washer
3. Bleed Screw
4. Lift Pump Relief Valve
5. Seal - Inner
6. Seal - Outer
7. Filter Element
8. Seal - Outer
9. Bowl
10. Drain Cap

Renew fuel filter elements as follows:

1. Turn off the fuel supply tap.

2. Unscrew the drain caps and allow the filter contents to drain into a suitable container.

3. Remove the filter element centre bolts to detach the elements and base plates. Discard the elements and all sealing rings.

4. Clean the base plates with clean test oil or kerosene and hand tighten the drain caps.

5. Fit one new large and one new small sealing ring onto the underside of each filter head. Assemble the base plates with new elements and sealing rings and secure centrally to the filter heads with the centre bolts and new sealing rings. Tighten the bolts to the specified torque.

6. Dry off any spilt fuel, turn on the fuel supply tap, then operate the priming pump to check for leaks. Rectify as necessary.

BLEEDING THE FUEL SYSTEM

Although the system is of a self purging nature, the following procedure will hasten the clearance of air from the system following any large component fitment, i.e. filter or injection pump.

1. After a filter change, remove the bleed screws from the engine mounted filters. Operate the priming pump until air free fuel flows, then refit the bleed screws.

2. After an injection pump fitment, disconnect the pipe from the fuel gallery non-return valve (NRV). Operate the priming pump until air free fuel flows from the valve, then reconnect the pipe.

3. If a thermostart reservoir has been emptied, disconnect its overflow pipe and operate the priming pump until the bowl is full. Reconnect the pipe.

4. After any of the above operations, dry off any spilt fuel, operate the priming pump and check that all reconnections are dry.

AIR CLEANERS

Clean the Air Cleaner Element - Engine Mounted Oil Bath Type

1. Slacken clips securing air cleaner hose and remove hose.

2. Remove wing bolt (Fig. 7) and detach complete air cleaner assembly from engine.

3. Detach cover and lift out filter element. Wash element in gasoline and allow to dry.

4. Dip element in new engine oil and leave to drain.

5. Wash out air cleaner body with gasoline, stand body on level surface and fill with new engine oil to the level mark.

6. Fit filter element in body and replace cover.

7. Fit air cleaner assembly on the engine and secure with the wing bolt.

8. Replace hose and tighten clips.

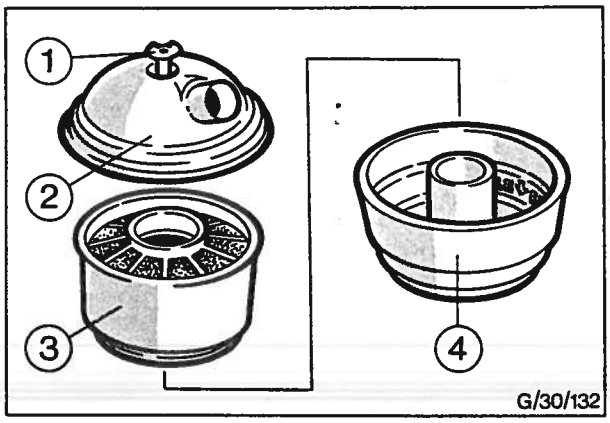

Fig. 7 - Oil Bath Air Cleaner
1. Wing Bolt
2. Cover
3. Filter Element
4. Air Cleaner Body

Empty the Air Cleaner Dust Cap and/or Renew Paper Element

1. Slacken off the clamp screw and remove the clamp and dust cup - see Fig. 8.

NOTE: On some air cleaners, the dust cup is retained by a moulded plastic knob which must be unscrewed.

2. Empty all dust from the cup.

3. Remove the wing nut and washer and extract the element from the air cleaner body.

4. Clean the element by directing the compressed air nozzle up and down the pleats on the inside of the element. Maintain a reasonable distance between the nozzle and element.

5. Check the condition of the element by placing a bright light inside. The slightest hole in the element will render it unfit for further use. Replace by a new element if necessary.

6. Insert the element in the air cleaner body, replace the washer and screw on and tighten the wing nut.

7. Replace the dust cup and clamp.

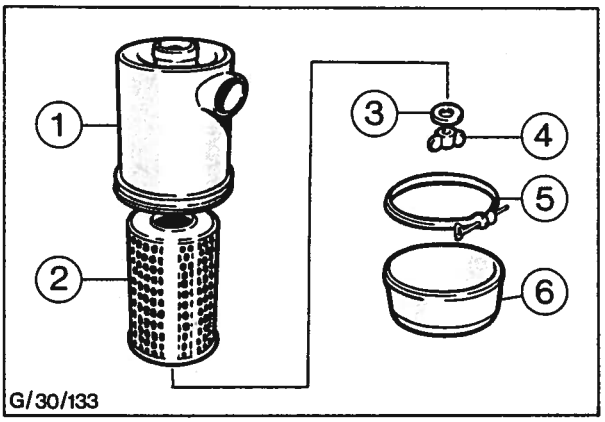

Fig. 8 - Paper Element Air Cleaner
1. Body
2. Element
3. Washer
4. Wing Nut
5. Clamp
6. Dust Cup

NOTE: The level of dust in the cup should not be allowed to build up excessively; empty more frequently than specified if necessary.
If a restriction indicator is fitted (Fig. 9) the air cleaner should be serviced when the red signal shows.

A type now in common use has a red signal that automatically locks in the fully exposed position, indicating the need for air cleaner service. After the element is cleaned or replaced, the indicator is reset by pressing the rubber button at the base of the body.

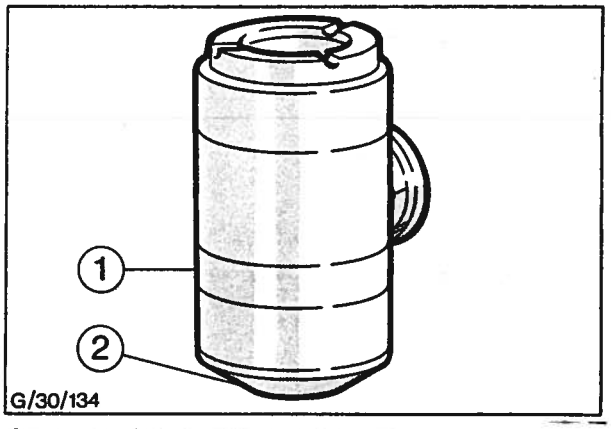

Fig. 9 - Air Cleaner Restriction Indicator
1. Red Signal
2. Reset Button

VALVE CLEARANCE, TIMING AND LIFT

Clearance (Hot and Cold - All Valves)	
2722, 2723 and 2725 engines	
- PDI Only Setting	0,33 mm (0,013 in)
- In Service Setting	0,41 mm (0,016 in)
2726T and 2728T engines	
- PDI Only Setting	0,38 mm (0,015 in)
- In Service Setting	0,46 mm (0,018 in)
Timing	Camshaft and Crankshaft Gear Timing Marks
Lift (Maximum)	11,02 mm (0,43 in)

FAN BELT

Tension (Total Deflection)	13,0 mm (0,50 in) Measured Mid-way between Alternator and Water Pump Pulleys
Compression Pressures at Cranking Speed	
Minimum for Each Cylinder	20,7 bar (300 lb/in^2)
Maximum Variation between Cylinders	5,5 bar (80 lb/in^2)

ENGINE LUBRICATION - Refer to Section 2

SEALERS AND ADHESIVES

	FORD Specification
Cylinder Block	
Taper Plug Sealer	SJM-4G-9102-A
Core Plug Retaining Sealer	SM-4G-4645-AA
Camshaft Plug and Blanking Plug Sealer	EM-4G-44-A
Lift Pump Studs to Block Sealer	SJM-4G-9102-A
Water Pump Studs to Block Sealer	SPM-4G-9102-A
Fuel Injection Pump and Compressor Studs	SDM-4G-9107-A
Cylinder Liner	
Primer	SM-4G-4647-A
Sealing Compound	EM-4G-64
Main Bearing Cap to Cylinder Block	SDM-4G-9105-A
Sump Gasket Sealer	SPM-2G-9121-A
Ring Gear Retaining Screw Sealer	EM-4G-52
Oil Pump	
Mounting Studs to Main Bearing Cap Sealer - 2728T Engines Only	SPM-2G-9102-A
2728T Engine	
Front Housing Cup Plug Sealer	SM-4G-4645-A
Front Housing Studs Sealer	SPM-4G-9120-A
Front Timing Cover Studs Sealer	SPM-4G-9120-A
Crankshaft Insert Sealer	SDM-4G-9102-A
Thermostat Housing Connectors Sealer	SJM-4G-9102-A
Exhaust System	
Anti Seize Compound	SAM-1C-9107-A

TIGHTENING TORQUES

	Nm	Kgm	lbft
Cylinder Block			
Main oil gallery plugs (front and rear)	27 to 34	2,8 to 3,5	20 to 25
Main oil gallery cross drilling plug	27 to 34	2,8 to 3,5	20 to 25
Connector - turbocharger oil feed	34 to 40	3,5 to 4,1	25 to 30
Fuel lift pump mounting studs	19 to 24	1,9 to 2,5	14 to 18
Oil pan locating studs	31 to 39	3,2 to 4,0	23 to 29
Water pump mounting stud	19 to 24	1,9 to 2,5	14 to 18
Oil pressure sender unit	19 to 22	1,9 to 2,2	14 to 16
Drain cock/plug	20 to 27	2,0 to 2,8	15 to 20
Crankshaft mainbearing cap bolts,			
1st stage	149 to 156	15,2 to 15,9	110 to 115
final stage	156 to 163	15,9 to 16,6	115 to 120
Connecting rod cap nuts (2723 engine only)			
1st stage	60 to 75	6,1 to 7,6	45 to 55
final stage	75 to 82	7,6 to 8,3	55 to 60
Connecting rod cap bolts (all engines except 2723)			
1st stage	108 to 115	11 to 11,7	80 to 85
final stage	115 to 122	11,7 to 12,4	85 to 90
Crankshaft pulley (all engines except 2728T)			
Centre bolt	313 to 340	31,8 to 34,6	230 to 250
Crankshaft pulley (2728T only)			
Locking sleeve bolts	25 to 30	2,5 to 3,0	18 to 22
Insert to crankshaft	80 to 110	8,2 to 11,2	59 to 81
Flywheel retaining bolts	102 to 122	10,4 to 12,4	75 to 90
Oil filter head to cylinder block bolts	50 to 62	5,1 to 6,3	37 to 46
Timing Gears			
Timing gear housing to cylinder block bolts	34 to 40	3,5 to 4,1	25 to 30
Camshaft thrust plate bolts	34 to 40	3,5 to 4,1	25 to 30
Camshaft gear retaining bolt	203 to 210	20,7 to 21,4	150 to 155
Timing gear housing cover			
5/16 UNC bolts	19 to 22	1,9 to 2,2	14 to 16
3/8 UNC bolts	30 to 34	3,0 to 3,5	22 to 25
Timing gear housing cover inspection plate bolts (Automotive and G.P. governed pumps only)	8 to 11	0,8 to 1,1	6 to 8
Timing gear housing studs - oil pan location (2728T engine only)	31 to 39	3,2 to 4,0	23 to 29
Cylinder Head			
Inlet and exhaust manifold studs	37 to 40	3,8 to 4,0	27 to 30
Cylinder head retaining bolts			
1st stage	60 to 75	6,1 to 7,6	45 to 55
2nd stage	122	12,4	90
3rd stage		Tighten through a further 90°	
Rocker shaft pedestal bolts	23 to 30	2,3 to 3,0	17 to 22
Valve clearance adjusting screw (inherent torque)	12 to 35	1,2 to 3,5	9 to 26
Rocker cover retaining screws	4 to 5,5	0,4 to 0,6	3 to 4
Fuel filter mounting bracket retaining bolts	31 to 39	3,1 to 4,0	23 to 29
Injectors			
Injector retaining bolts	17 to 22	1,8 to 2,2	12 to 16
High pressure fuel pipes			
gland nuts	17 to 20	1,8 to 2,0	12 to 15
oil seal nuts	22 to 27	2,2 to 2,8	16 to 20
Injector leak-off pipe banjo bolt	16 to 20	1,6 to 2,0	12 to 15
Injection Pump			
Drive gear hub nut (Automotive & G.P. governed pump only)	60 to 65	6,1 to 6,6	44 to 48
Drive ring gear locking bolts (Automotive & G.P. governed pump only)	20 to 25	2,0 to 2,5	15 to 18
Pump mounting bolts (Automotive & G.P. governed pump only)	22 to 27	2,2 to 2,7	16 to 20
Filler, level and drain plugs (Automotive & G.P. governed pump only)	4 to 6,8	0,4 to 0,7	3 to 5
Bleed screws (Automotive & G.P. governed pump only)	4 to 6,8	0,4 to 0,7	3 to 5
Fuel Lift Pump			
Adaptor to cylinder block nuts	19 to 24	1,9 to 2,5	14 to 18
Pump retaining nuts - std. low pressure pump	20 to 25	2,0 to 2,5	15 to 18
Pre-filter banjo bolt	30 to 40	3,0 to 4,1	22 to 29
Pump retaining bolts - high pressure pump	9 to 11	0,9 to 1,1	7 to 8
Low Pressure Fuel Pipe Unions	11 to 16	1,1 to 1,7	8 to 12

TIGHTENING TORQUES

	Nm	Kgm	lbft
Fuel Filters			
Filter element retaining bolt	6,8 to 9,5	0,7 to 1,0	5 to 7
Bleed screws	6,8 to 9,5	0,7 to 1,0	5 to 7
Oil Pump - 2728T Engine Only			
Pump mounting studs in crankshaft main bearing cap	10 to 15	1,0 to 1,5	7 to 11
Pump securing nuts	40 to 50	4,1 to 5,1	29 to 37
Pick-up pipe to pump bolts	20 to 25	2,0 to 2,5	15 to 18
Delivery pipe flange to cylinder block bolts	18 to 22	1,8 to 2,2	13 to 16
Delivery pipe support,bracket bolt	18 to 22	1,8 to 2,2	13 to 16
Oil Pump - Engines (Except 2728T) with Front Well, Rear Well or Shallow Oil Pans			
Pump securing bolts	18 to 22	1,8 to 2,2	13 to 16
Pick-up pipe to pump union nut	75 to 88	7,6 to 9,0	55 to 65
Pick-up pipe support bracket bolt	18 to 22	1,8 to 2,2	13 to 16
Oil Pump - Engines (Except 2728T) with High Inclination Oil Pans			
Pump securing bolts	18 to 22	1,8 to 2,2	13 to 16
Pick-up pipes to pump gland nuts	75 to 88	7,6 to 9,0	55 to 65
Pick-up pipes support bracket bolts	18 to 22	1,8 to 2,2	13 to 16
Oil Pan			
Securing bolts/nuts	30 to 33	3,0 to 3,3	22 to 24
Drain plug(s)	47 to 54	4,8 to 5,5	35 to 40
Water Pump			
Pump back plate securing bolt (2728T Engine only)	18 to 22	1,8 to 2,2	13 to 16
Pump securing bolts/nuts	18 to 22	1,8 to 2,2	13 to 16
Water pump extension tube bolts	43 to 50	4,4 to 5,1	32 to 37
Split flow water tube to cylinder block bolts (2728T engine only)	31 to 39	3,1 to 4,0	23 to 29
Thermostats			
Housing to cylinder head securing bolts (twin thermostats only)	18 to 22	1,8 to 2,2	13 to 16
Water outlet connection to housing or cylinder head nut/bolts	20 to 25	2,0 to 2,5	15 to 18
Electrical			
Starter motor securing bolts - CAV	33 to 39	3,4 to 4,0	24 to 29
- Lucas	50 to 55	5,1 to 5,6	37 to 40
Alternator mounting and adjusting bolts	16 to 20	1,7 to 2,0	12 to 15
Fans and Drive Belt Tensioning			
Fan securing bolts (including 'Low Loss' fan)	16 to 20	1,6 to 2,0	12 to 15
Idler pulley mounting and adjusting bolts	16 to 20	1,6 to 2,0	12 to 15
Turbochargers			
Turbocharger mounting studs - exhaust manifold	20 to 25	2,0 to 2,5	15 to 18
Exhaust pipe/elbow mounting studs - turbocharger	15 to 20	1,5 to 2,0	11 to 15
Turbocharger to exhaust manifold nuts	41 to 51	4,2 to 5,2	30 to 38
Turbocharger to support plate nuts	20 to 25	2,0 to 2,5	15 to 18
Support plate to support bracket bolts	41 to 51	4,2 to 5,2	30 to 38
Support bracket to cylinder block bolts			
5/16 UNC bolts	18 to 22	1,8 to 2,2	13 to 16
7/16 UNC bolts	50 to 62	5,1 to 6,3	37 to 46
Oil feed pipe flange bolts	20 to 25	2,0 to 2,5	15 to 18
Oil feed pipe cylinder block connection	34 to 40	3,5 to 4,1	25 to 30
Oil drain pipe flange bolts	20 to 25	2,0 to 2,5	15 to 18
Oil drain pipe adaptor to oil pan	54 to 61	5,5 to 6,2	40 to 45
Intercooler			
Intercooler to inlet manifold duct screws (both ends)	20 to 25	2,0 to 2,5	15 to 18
Intercooler to support bracket bolts	20 to 25	2,0 to 2,5	15 to 18
Support bracket to cylinder block bolts	50 to 62	5,1 to 6,3	37 to 46

CONTENTS

GENERAL DESCRIPTION

All 2720 range engines are equipped with high output bi-rotor oil pumps incorporating a pressure relief valve.

The pumps used on engines fitted with front well, rear well or shallow oil pans, incorporate a reservoir which retains oil within the rotor assembly; this feature ensures rapid priming and prevents air locks from occurring.

Engines fitted with high inclination oil pans employ a slightly different oil pump and án alternative oil pick-up pipe layout with two gauze filters.

The 2728T engine has its oil pump mounted on the crankshaft front main bearing cap; it is driven from a gear on the crankshaft via an idler gear. All other engines have the oil pump mounted on the base of the cylinder block, the drive being taken from a skew gear on the camshaft.

As illustrated in Fig. 1, the oil pump draws oil through a coarse gauze filter(s) and pumps it through the full flow, spin-on canister type oil filter into the main oil gallery. The filtered oil is then directed at full pressure to the following:

i) Crankshaft main and big-end journals.

ii) Camshaft bearing bushes.

iii) Where fitted, compressor crankshaft bearing bushes.

iv) Turbocharger bearings (where fitted) via an external pipe.

v) Fuel injection pump, via a pipe from the oil filter mounting block (automotive and G.P. governed pumps only).

vi) Piston cooling jets, on 2728T engines only, which are tapped into the main bearing support webs and direct a continuous flow of oil to the underside of each piston crown.

Offset drillings in one of the camshaft journals direct a metered oil feed to the centre pedestal of the valve rocker shaft support, to lubricate the shaft and the valve gear. A spiral groove in the camshaft front bearing journals provides an oil feed to the gears in the timing cover. Oil is returned to the holes and drillings in the cylinder head and block castings.

The filter head on 2728T engines has built-in connections for the mandatory oil cooler and incorporates a pressure relief valve which operates when the engine is cold to allow the oil to by-pass the cooler and so warm up more quickly. The by-pass also acts as a protection against excessive pressure which might damage the cooler.

On 2722, 2723, 2725 and 2726T engines, an oil filter adaptor is available to enable an oil cooler to be connected if required. This adaptor is fitted between the filter head and cylinder block and contains a pressure relief valve.

The full flow filter assembly is fitted with a by-pass facility which acts if the filter element becomes blocked.

The engine may be refilled with oil via the rocker cover mounted filler cap or (except for 2728T engines) through the low level filler, mounted on the oil pan.

Various types of oil pan can be fitted to all engines except the 2728T model. In all cases, the oil pan incorporates the lower half of the flywheel housing.

The oil pan is sealed to the lower face of the crankcase by rubber asbestos composition gaskets and, at the front and rear by synthetic rubber seals.

On turbocharged engines, the oil return pipe from the turbocharger is connected directly into the top of the oil pan. A magnetic drain plug is fitted into a threaded insert in a boss in the bottom of the well. Two drain plugs are fitted to high inclination oil pans.

On 2722, 2723 and 2725 engines, a low level dipstick is fitted. On 2726T and 2728T engines, a longer dipstick tube is fitted to enable a high level dipstick to be employed.

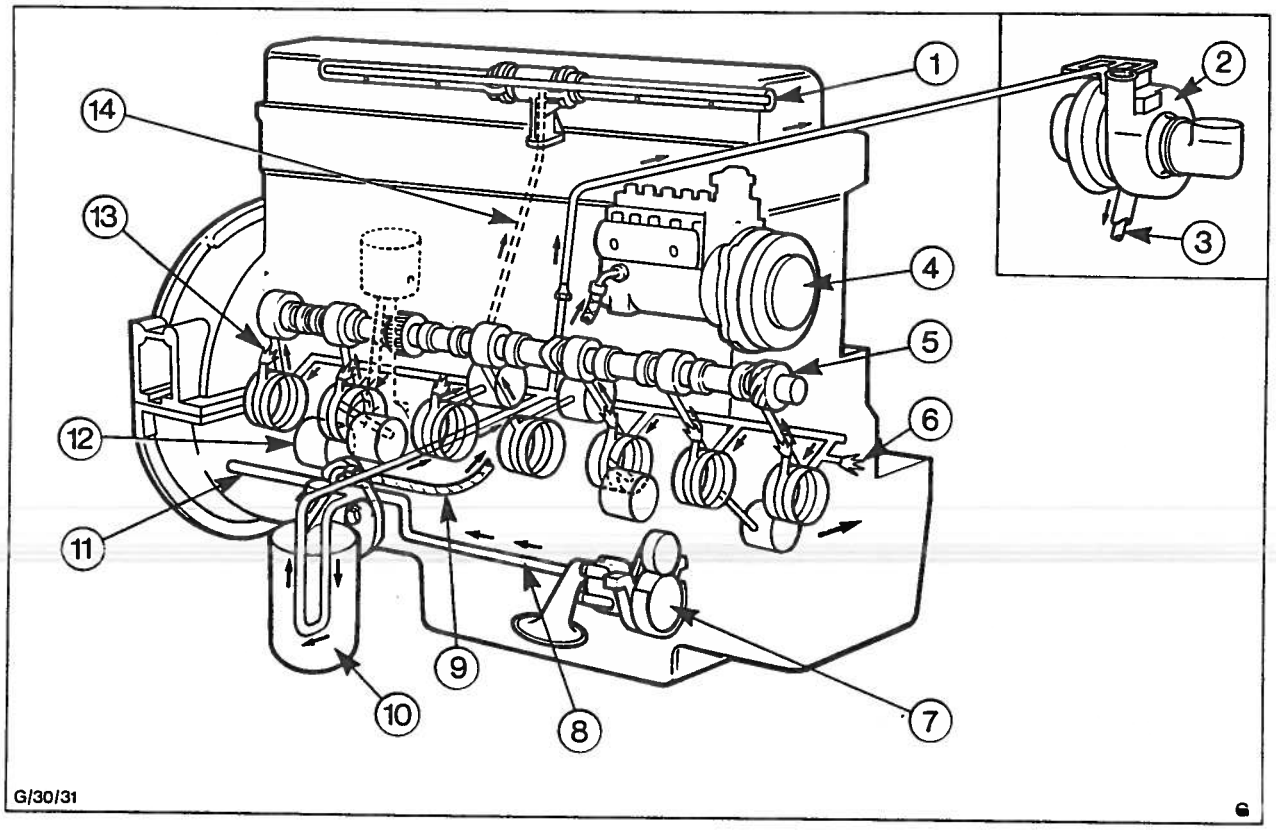

Fig. 1 - Engine Oil Lubricating Circuit (Schematic) - 2728T Engine Illustrated

1. Rocker Shaft
2. Turbocharger
3. Oil Drain to Oil Pan
4. Fuel Injection Pump
5. Camshaft Bearings
6. Spray to Timing Gear
7. Oil Feed Pipe to Main Oil Gallery
8. Feed Pipe to Main Oil Gallery
9. Feed Pipe to Fuel Injection Pump
10. Oil Filter
11. Main Oil Gallery
12. Big End Bearings
13. Main Bearing and Piston Cooling Nozzle
14. Metered Oil Feed to Rocker Shaft

Oil Pan Repairs

If a drain plug insert has become dislodged a new 3/4 in - 24NS2 insert (service part) must be fitted using a 'Helicoil' inserting tool of the prewind type (Fig. 2) in the following manner:

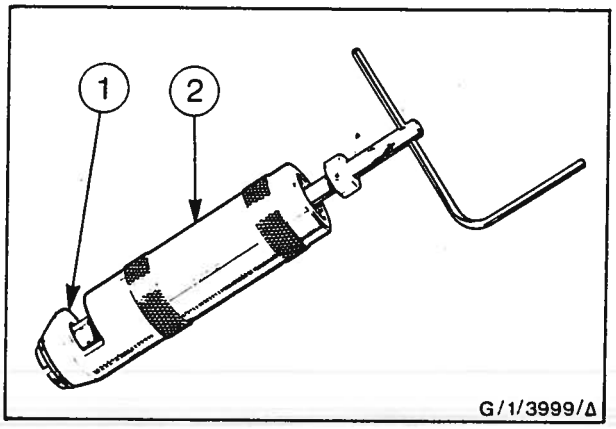

Fig. 2 - Helicoil Inserting Tool
1. Chamber
2. Tool Body

1. Withdraw the handle from the tool body until the mandrel is clear of the chamber.

2. Locate the insert in the chamber with the tang towards the nozzle.

3. Push the handle into the tool body to engage the slot in the mandrel with the tang.

4. Rotate the handle clockwise gently pushing the handle until the insert engages with the nozzle. Continue rotating the handle until the insert starts to appear from the end of the nozzle.

5. Place the tool squarely over the drain plug hole and without applying any end pressure, wind the insert into the oil pan until the insert is 1,6 to 2,4 mm (0,063 to 0,095 in) below the face of the boss - see Fig. 3.

6. Break the tang off using a pull and push action with a pair of long nosed pliers.

7. Stake the oil pan thread at the start of the insert to prevent the insert unwinding.

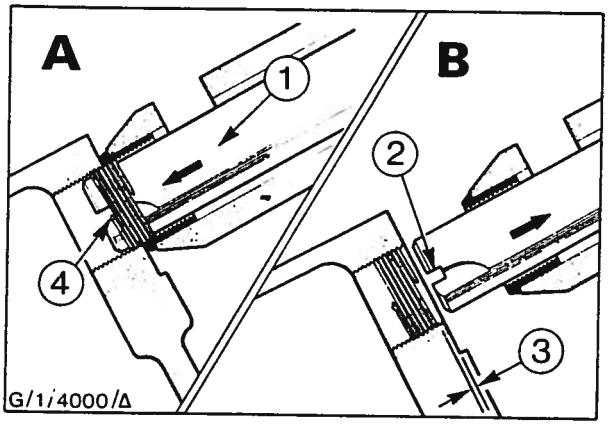

Fig. 3 - Installing Oil Pan Insert
A. Winding In Insert
B. Insert Installed
1. Mandrel
2. Slot
3. Install Insert below Face
4. Tang

OIL PUMP SERVICING

When installing a service cylinder assembly supplied without an oil pump, the existing oil pump must be either renewed or overhauled as detailed in the following text - see appropriate heading.

OIL PUMP OVERHAUL - 2722, 2723, 2725 and 2726T Engines (except where fitted with a high inclination oil pan)

Remove the oil pan and pump from the engine as described under 'Dismantling the Basic Engine' in Section 1 (Operations 35, 36 and 37).

Either one of the two types of pump may be fitted, 'Holborn Eaton' or 'Motofides'. Complete pumps are interchangeable, individual components other than the skew drive gear are not. When obtaining spares the pumps may be identified from the assembly part number cast into the main body of the pump.

Dismantling - Refer to Fig. 4

1. Support the pump in a soft jawed vice, drive gear end downward.

2. Slacken and carefully remove the pressure relief valve cap and remove the spring and plunger.

3. Remove the bolts securing the cover plate and the pick up pipe union lock tab.

4. Carefully remove the cover plate from the pump body, if necessary, by tapping with a soft faced mallet.

CAUTION: DO NOT USE LEVERS OR SCREWDRIVERS TO PRISE OFF THE COVER PLATE, AS IRREPARABLE DAMAGE COULD BE DONE TO THE MATING FACES. HOLBORN EATON PUMPS HAVE TWO HOLLOW DOWELS LOCATING THE COVER PLATE TO THE PUMP BODY.

5. Mark the outer rotor to ensure reassembly the same way round and remove it from the pump body.

6. Clean and dry the rotors, the cover plate and the pump body interior and check for scoring or excessive wear. If the pump body and cover plate are scored, the pump should be renewed. If the rotors are only scored or worn these can be renewed separately as a matched pair.

7. Place a straight edge across the pump face and measure the clearance to the face of the inner rotor (rotor end float) - see Fig. 5. Refit the outer rotor and measure the clearance between the outer rotor and the pump body, and between the rotor lobes - see Fig. 6. If the clearances are not within the specified limits the rotors should be renewed.

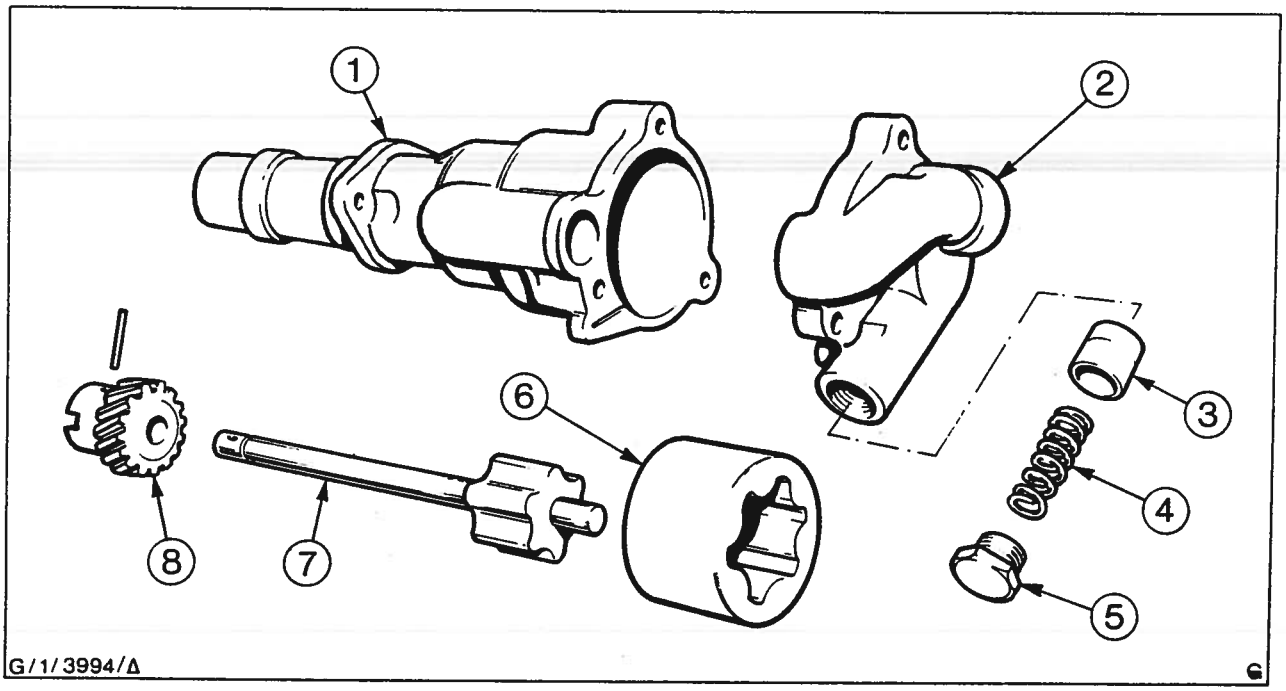

Fig. 4 - Oil Pump Used on 2722, 2723, 2725 and 2726T Engines Not Fitted with High Inclination Oil Pans
1. Pump Body
2. Cover
3. Pressure Relief Valve Plunger
4. Pressure Relief Valve Spring
5. Valve Cap
6. Outer Rotor
7. Inner Rotor and Shaft
8. Skew Drive Gear

8. Remove the outer rotor and, using a 4 mm pin punch, drift out the pin retaining the skew gear to the shaft. Remove the gear and withdraw the inner rotor and shaft assembly.

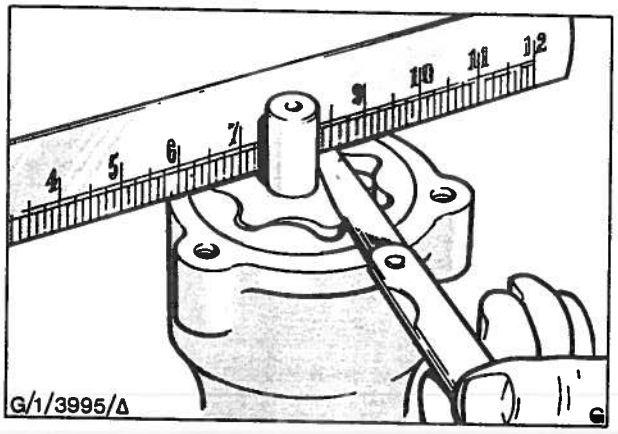

Fig. 5 - Measuring Pump Rotor End Float

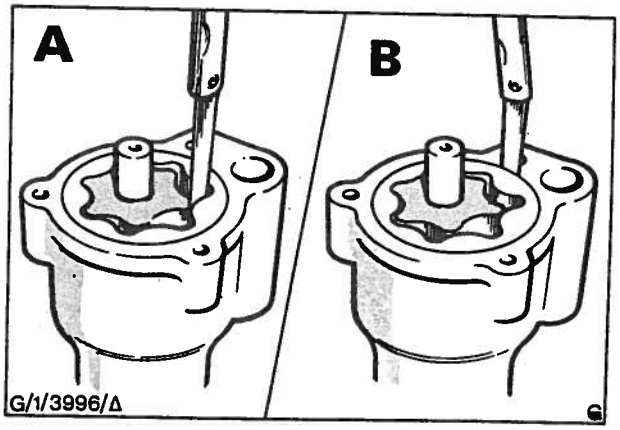

Fig. 6 - Measuring Rotor Lobe/Body Clearance
A. Checking Inner to Outer Rotor Clearance
B. Checking Outer Rotor to Pump Body Clearance

Cleaning and Inspection

Thoroughly clean and dry all parts.

Check the shaft and the bearings in the pump body and the cover plate for scoring or excessive wear.

NOTE: Bearings are not available separately for in service renewal.

If the bearings and pump body are considered satisfactory, but the condition of the rotors is suspect, temporarily install new inner and outer rotors and check the inner rotor end float, the rotor lobe clearance and outer rotor to body clearance as described previously. If the clearances are still not within the specified limits the pump assembly must be renewed.

Check the skew gear for scoring or excessive wear. If a new camshaft or a service cylinder assembly is being installed a new gear must be fitted.

The pressure relief valve plunger and seat should be examined to ensure good face to face contact, and the spring should stand upright when placed on end onto a flat surface. It should also be free from localised 'bright' marks on the outsides of the coils indicating a 'waisting' and possible weakening of the spring.

Reassembly - Refer to Fig. 7

1. Fit the inner rotor and shaft assembly into the pump body.

2. Press the skew gear onto the shaft until a clearance of 0,13 to 0,38 mm (0,005 to 0,015 in) is obtained between the gear and the pump body, with the rotor flush with the end plate face (Fig. 7).

NOTE: If the existing rotor is being used the gear must be turned to bring the pin hole at 90° to the original.

3. Drill and ream a hole 4,94 to 4,98 mm (0,194 to 0,196 in) through the shaft and gear, drive in the retaining pin and peen both ends to secure.

4. Fit the outer rotor, ensuring that it is the correct way round.

5. On Motofides pumps (no locating dowels) apply a very light smear of Loctite 510 (FORD Specification SLM-4G-9111-A) to the pump body to cover plate mating face. DO NOT allow the sealer to contact the pump rotor either when being applied or when the cover bolts are tightened.

6. Fit the cover plate and bolts, fit a new union nut lock plate to the bolt adjacent to the inlet orifice and tighten the bolts to the specified torque.

7. Fit the pressure relief valve plunger and spring, apply one spot of the specified thread lock sealant to the valve cap threads and tighten to the specified torque.

8. Ensure the pump rotates freely.

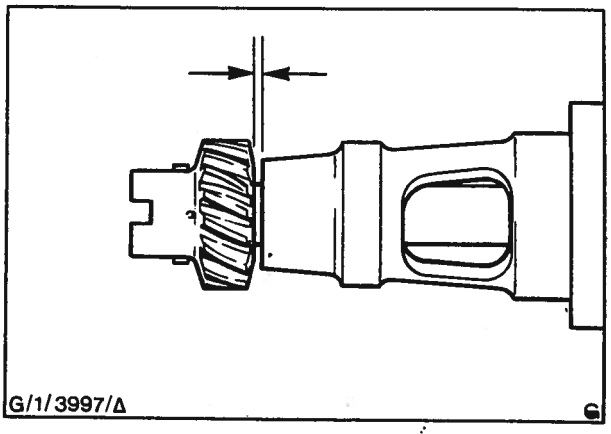

Fig. 7 - Skew Gear to Pump Body Clearance

9. Replace the pump and oil pan as described under 'Oil Pump Installation' (operations 58, 59 and 60) and 'Oil Pan Installation' (operations 66 to 70 inclusive and 75) in Section 1.

OIL PUMP OVERHAUL - 2722, 2723, 2725 and 2726T ENGINES FITTED WITH HIGH INCLINATION OIL PANS

Remove the oil pan and pump from the engine as described under 'Dismantling the Basic Engine' in Section 1 (operations 35, 36 and 38a, 38b and 38c).

Dismantling and Checking - Refer to Figs. 8 and 9

1. Remove the four retaining bolts and remove the end plate.

2. Check the oil pump for wear. Place a straight edge across the face of the pump housing and check the clearance between the straight edge and both parts of rotor. If this exceeds the clearance specified, the pump housing can be lapped to bring the clearance within tolerance.

3. Inner to outer rotor clearance and outer rotor to pump housing clearance should be measured with a feeler gauge, see Fig. 9; if these exceed the clearances specified, the inner and outer rotor should be renewed.

4. Remove the inner and outer scavenge rotors, and remove the woodruff key from the shaft.

5. Remove the lower pump body and the oil pressure relief plunger and spring.

6. The same checks for wear should be carried out on the delivery rotors as on the scavenge rotors. See operation 3. Should the clearance exceed the specified tolerance fit a new shaft and inner and outer rotors.

7. If it is necessary to renew the delivery rotors and shaft or skew gear, remove the outer rotor. Drive out the retaining pin securing the skew gear to the drive shaft and pull off the gear. The inner rotor and shaft can now be removed from the upper housing.

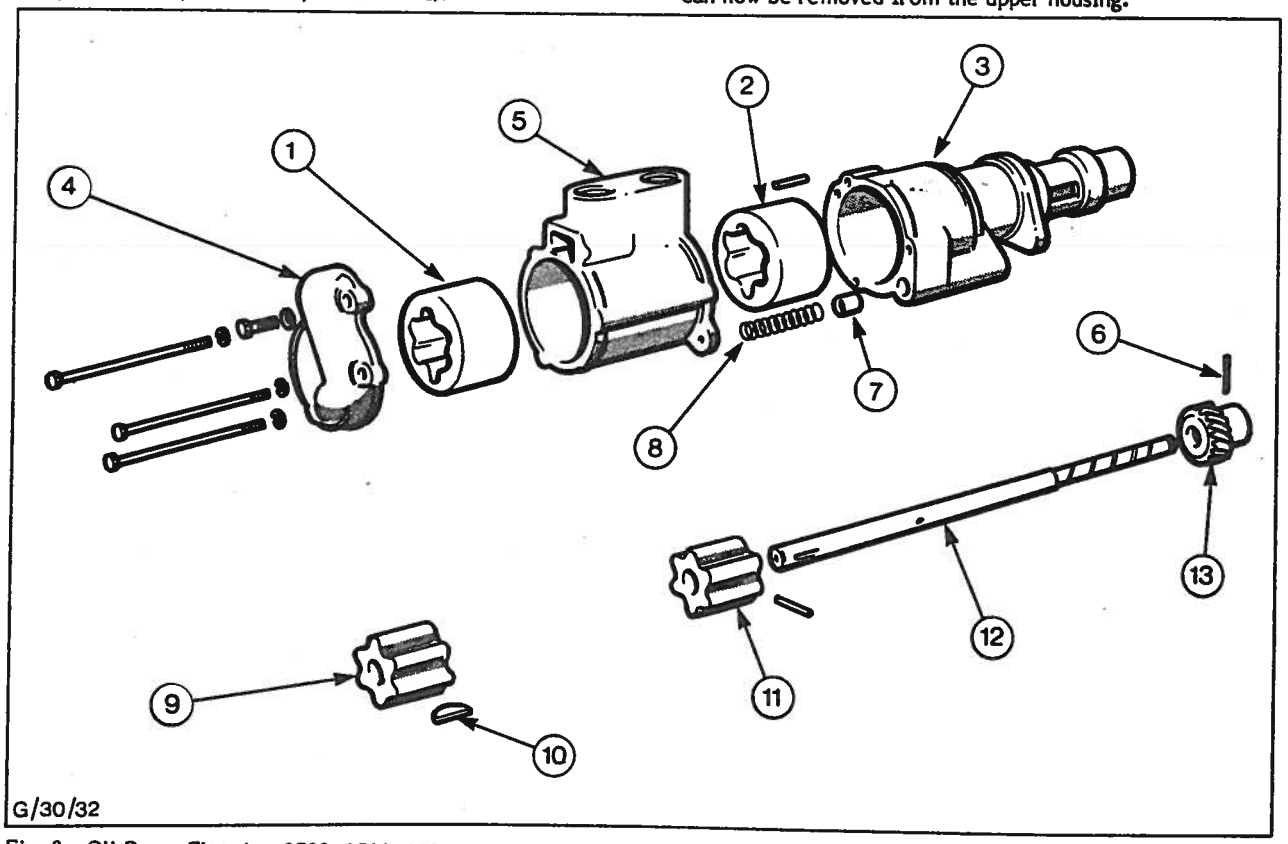

Fig. 8 - Oil Pump Fitted to 2722, 2723, 2725 and 2726T Engines with High Inclination Oil Pan

1 and 9 Scavenge Rotor Assembly
2, 11 and 12 Shaft and Rotor Assembly
3. Upper Pump Housing
4. End Plate
5. Lower Pump Housing
6. Pin
7. Pressure Relief Plunger
8. Pressure Relief Spring
10. Woodruff Key
13. Skew Gear

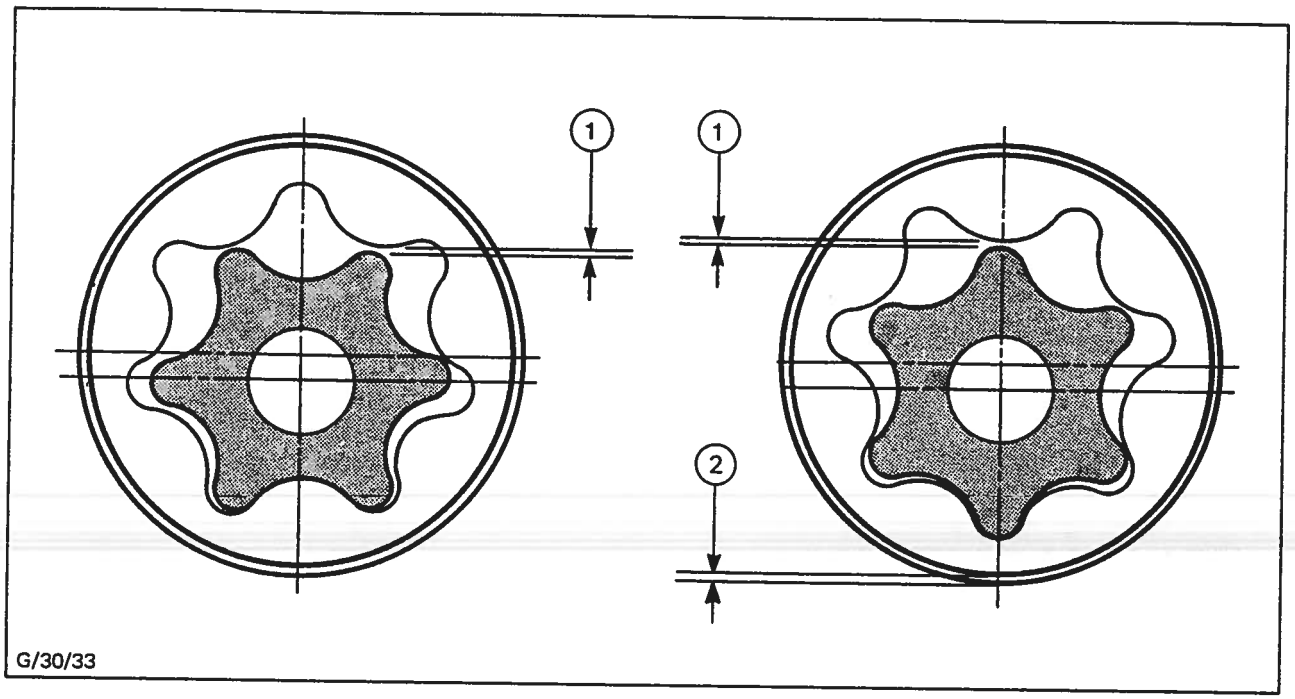

Fig. 9 - Measuring Rotor Clearance - 2722, 2723, 2725 and 2726T Engines Fitted with High Inclination Oil Pans
1. Inner to Outer Rotor
2. Outer Rotor to Pump Housing

Assembly - Refer to Fig. 7

1. If the pump has been completely dismantled, slide the new drive shaft and main inner rotor into the upper housing.

2. Press the skew gear onto the drive shaft end until there is a clearance of 0,178 to 0,305 mm (0,007 to 0,012 in) between the gear and pump housing.

3. Supporting the shaft at the rotor end, drill and ream 3,175 mm (0,125 in) diameter hole diametrically through the gear hub and shaft 13,72 mm (0,540 in) from the slotted end.

4. Fit the gear retaining pin and peen the ends over securely to prevent it becoming loose in service.

5. Replace the outer rotor, chamfered end first, and insert the oil pressure relief plunger and spring in the upper pump housing.

6. Slide the lower pump housing onto the shaft and fit the woodruff key in the shaft.

7. Replace inner rotor and outer rotor, chamfered end first, into the lower pump housing.

8. Fit the end plate and secure with the four bolts and lockwashers, ensuring that each is in its correct location, and then tighten to the specified torque value.

9. Ensure that the pump rotor revolves freely.

10. Replace pump and oil pan as described under 'Oil Pump Installation' (operations 1, 2 and 3) and 'Oil Pan Installation' (operations 66 to 70 inclusive and 75) in Section 1.

OIL PUMP OVERHAUL - 2728T ENGINE ONLY

Remove oil pan and pump as described under 'Dismantling the Basic Engine' (Operations 35, 36, 38a, 38b and 38c) in Section 1.

Either one of two types of pump may be fitted, 'Holborn Eaton or Motofides'. Complete pumps are interchangeable, individual components except for the idler and drive gears are not. Idler and drive gears will not normally be available for in service renewal. If these are badly worn then the pump assembly complete should be renewed. The pumps may be identified from the assembly part number cast into the pump body mounting. For service identification Holborn Eaton pumps have a cast iron rear cover plate, Motofides a cast aluminium cover plate with a steel thrust plate between this cover and the pump main body.

Dismantling - Refer to Fig. 10 or 11

1. Support the pump in a soft jawed vice, drive gear downwards.

2. Slacken and carefully remove the pressure relief valve cap and remove the spring and plunger.

3. Remove the bolts securing the cover plate, and the thrust plate, when fitted. Do not prise off the cover with levers or screwdrivers as damage could be caused to the mating faces.

4. Mark the outer rotor to ensure reassembly the same way round and remove it from the pump body.

5. Clean and dry the rotors, the cover plate and the pump body interior and check for scoring or excessive wear. If the pump body and cover plate, or thrust plate when fitted, are scored, the pump should be renewed. If the rotors are scored or worn these can be renewed separately as a matched pair.

6. As shown in Fig. 12, place a straight edge across the pump face and measure the clearance to the face of the inner rotor (rotor end float). Refit the outer rotor and measure the clearance between the outer rotor and the pump body, and between the rotor lobes (Fig. 13). If the clearances are not within the specified limits the rotors should be renewed.

7. Remove the outer rotor and support the pump on a press allowing room under the pump body for the inner rotor to be pressed out.

CAUTION: THE ROTOR MUST BE PRESSED, NOT DRIFTED, OUT OF THE PUMP BODY.

8. Using a mandrel of suitable shape or diameter to clear the drive gear retaining roll pin press the shaft and rotor assembly out of the gear. Restrain the rotor to prevent damage. Remove the roll pin.

Cleaning and Inspection

Thoroughly clean and dry all parts.

Check the shaft and the bearings in the pump body and the cover plate for scoring or excessive wear.

NOTE: Bearings are not available separately for in service renewal.

If the bearings and pump body are considered satisfactory, but the condition of the rotors is suspect, temporarily install new inner and outer rotors and check the inner rotor end float, the rotor lobe clearance and outer rotor to body clearance as described previously. If the clearances are still not within the specified limits the pump assembly must be renewed.

The pressure relief valve plunger and seat should be examined to ensure good face to face contact, and the spring should stand upright when placed on end onto a flat surface. It should also be free from localised 'bright' marks on the outsides of the coils indicating a 'waisting' and possible weakening of the spring.

Reassembly

1. Fit the inner rotor and shaft assembly into the pump. Support the pump on a press, locate the drive gear onto the rotor shaft and, while ensuring that the drive gear teeth align with the idler gear, press the gear onto the shaft until the specified clearance is obtained between the gear and the pump body.

2. Support the pump, restrain the gears to prevent them rotating, and drill a hole 1/8 in diameter and 11,9 mm (0,47 in) deep at the mating periphery of the gear and shaft. Ensure that the drill does not contact the bearing. Clean off all swarf.