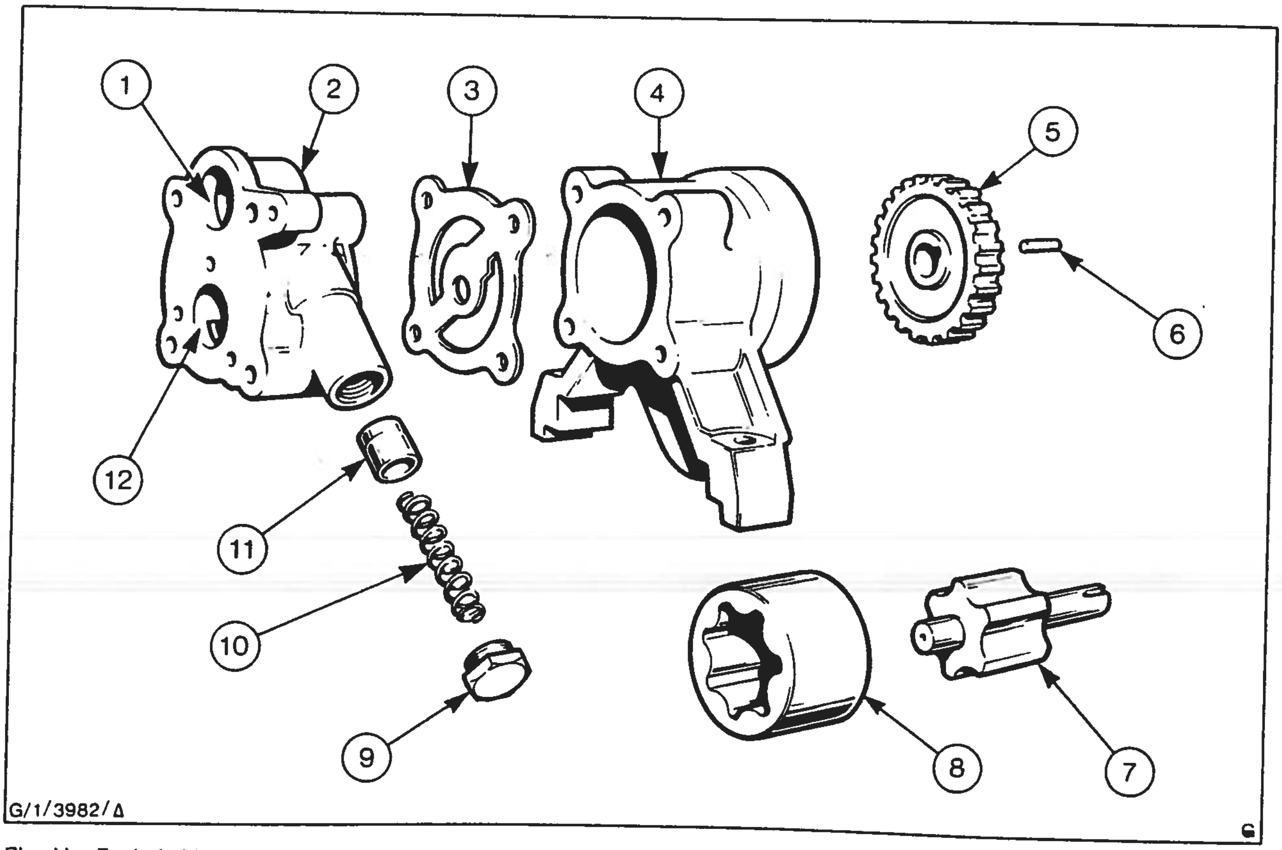

Fig. 11 - Exploded View of Motofides Type Oil pump

1. Pump Outlet
2. End Cover (Die Cast)
3. Thrust Plate
4. Pump Body
5. Drive Gear
6. Roll Pin
7. Inner Rotor and Shaft
8. Outer Rotor
9. Valve Cap
10. Pressure Relief Valve Spring
11. Plunger
12. Pump Inlet

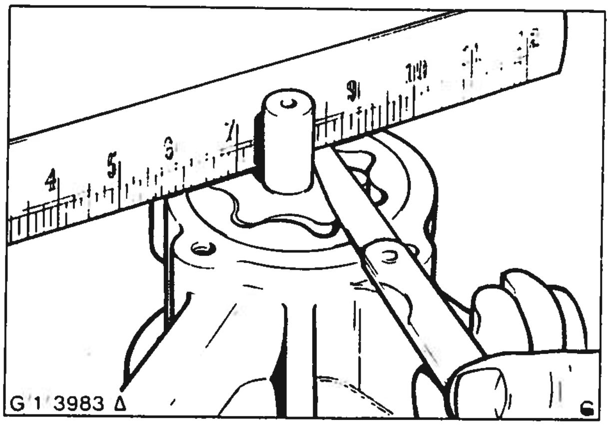

Fig. 12 - Measure Pump Rotor End Float

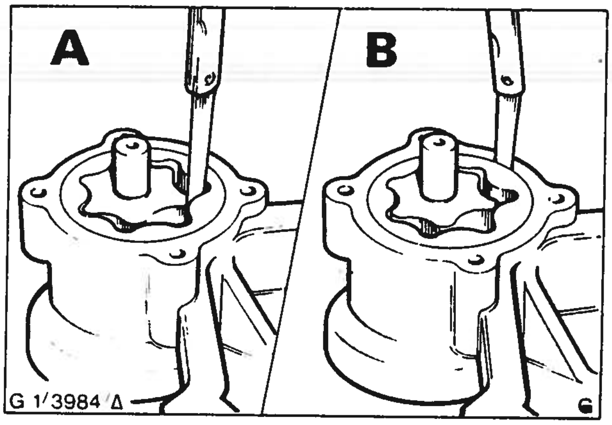

Fig. 13 - Measuring Rotor Lobe/Body Clearance
A. Checking Inner to Outer Rotor Clearance
B. Checking Outer Rotor to Pump Body Clearance

3. Apply Loctite 290 (FORD Specification GE SM46 4500A) to the roll pin and carefully press it into the hole taking care not to disturb the gear end float. Check that the pump rotates freely.

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

5. Fit the cover plâte, and the thrust plate when fitted, and tighten the bolts to the specified torque.

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

7. Ensure the pump rotates freely.

8. Replace pump and oil pan as described under 'Oil Pump Installation' (operations 61 to 65 inclusive) and 'Oil Pan Installation' (operations 71 to 75 inclusive) in Section 1.

OIL FILTER ELEMENT RENEWAL

1. Unscrew the oil filter element and allow the oil to drain into a suitable container. Discard the element.

2. Fill a new filter element with clean engine oil of the specified grade, then screw the element onto the filter head until it contacts the 'O' ring seal. Turn the element a further 1/6 to a 1/4 turn BY HAND ONLY.

3. On turbocharged engines, prime the turbocharger as described in Section 4.

4. Check the engine oil level and top up as necessary with engine oil to specification.

5. Start the engine and check for oil leakage. Rectify as necessary.

SPECIFICATIONS

Engine	2722	2723	2725	2726T	2728T
Oil Temperature (max)	116°C (241°F)				110° (230°F)
Oil pressure (min) 1600 min / 2000 rpm	2,8 bar 3,2 bar	2,1 bar 2,9 bar			2.65 bar 3,1 bar
Service oil fill capacity (including filter) Engine with Front Well Oil Pan	9,1 litre (16 pt)	13,6 litre (24 pt)			—
Engine with Rear Well Oil Pan	9,1 litre (16 pt)	13,6 litre (24 pt)			—
Engine with Shallow Oil Pan	9,1 litre (16 pt)	13,6 litre (24 pt)			20 litre (35,2 pt)
Engine with High Inclination Oil Pan	10,8 litre (19 pt)	22,5 litre (40 pt)			—
Oil filter capacity	1 litre (1,76 pt)				
Oil Type	To meet Ford Specification SM-2C-1017A				
Oil Grade (viscosity) Below 20°C Between 0°C and 32°C Above 30°C	SAE 10W SAE 20W/20 SAE 30				
Oil Pump Type	Bi-rotor				
Delivery in litres (gallons)/min Engine with Front Well Oil Pan Engine with Rear Well Oil Pan Engine with Shallow Oil Pan	36,37 (8,0) at 2000 rpm				88,65 (19,5) at 2600 rpm
Engine with High Inclination Oil pan	27,9 (6,13) at 1000 rpm	36,37 (8,0) at 1000 rpm			—
Idler gear end float	—				0 to 0,35 mm (0 to 0,014 in)
Rotor End Float	0,127 mm (0,005 in) max				
Clearance - drive gear to pump housing	0,13 to 0,38 mm (0,005 to 0,015 in)				Front faces of drive and idle gears to be flush
Clearance - inner to outer rotor lobes	0,229 mm (0,009 in) max				
Clearance - outer rotor to pump housing	0,304 mm (0,012 in) max				

SEALERS

Oil Pump Drive Gear Retaining Roll Pin Sealer Pressure Relief Valve Cap Sealer End Cover Sealer - Motofides only	GE-SM4G-4500-A FPM-2G-9120-A SLM-4G-9111-A

TIGHTENING TORQUES

	Nm	Kgm	lbf ft
Oil Pump - 2728T Engine Only			
End cover plate retaining bolts	16 to 20	1,6 to 2,0	12 to 15
Pressure relief valve cap	25 to 28	2,5 to 2,8	18 to 21
Oil Pump - Engines(Except 2728T) Fitted with Front Well, Rear Well or Shallow Oil Pans End cover plate retaining bolts			
Holborn Eaton pumps	19 to 22	1,9 to 2,2	14 to 16
Motofides pumps	16 to 20	1,6 to 2,0	12 to 15
Oil Pump - Engines (Except 2728T) Fitted with High Inclination Oil Pans End cover plate retaining bolts	16 to 20	1,6 to 2,0	12 to 15

CONTENTS

GENERAL DESCRIPTION

Cooling of all 2720 range engines is by means of a pump assisted thermo-syphon system in which coolant is circulated around the cylinders and through the cylinder head.

For industrial applications, a conventional radiator is employed in conjunction with an engine driven fan. The actual size and type of radiator used (open or sealed) will be determined by the requirements of the installation. Various sizes of fan can be employed; both water pump mounted and high level mounted types are employed. Rapid warming-up is achieved by the use of a thermostat(s) mounted in the cylinder head water outlet position.

For marine applications, the engines are fitted with fresh water cooled exhaust manifolds; the turbocharger housing is also water cooled from the exhaust manifold. The inter-cooler fitted to the 2728T engine is connected into the 'raw' water circuit. The raw water system components are fitted by the mariniser and include a heat exchanger, oil cooler and a raw water pump driven from the PTO position on the rear of the timing gear housing. Figs. 1 and 2 show the water cooling circuits for the 2726T and 2728T marine engines respectively.

The fresh water circuit can be an open or sealed type and a thermostat is fitted between the water cooled exhaust manifold and the fresh water pump.

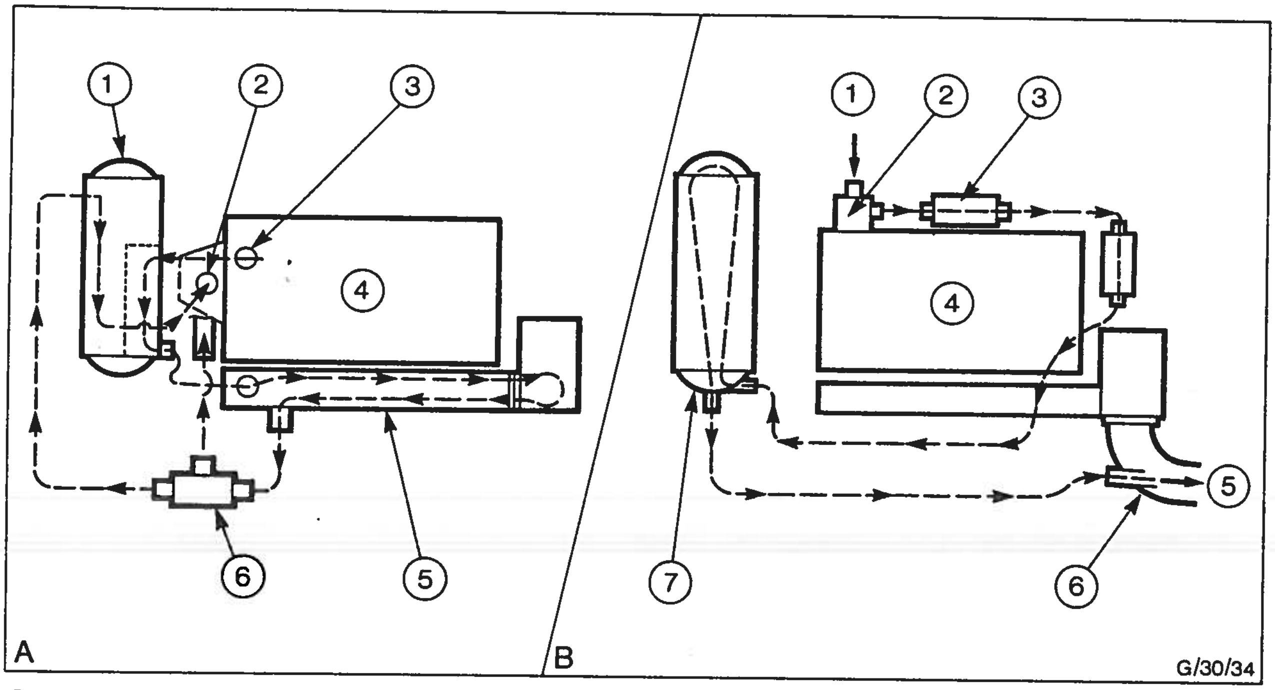

Fig. 1 - Cooling Circuit for 2726T Marine Engine
A. Fresh Water Circuit
1. Heat Exchanger Circuit
2. 2 O'Clock Water Pump Inlet
3. Cylinder Head Outlet
4. Engine
5. Water Cooled Exhaust Manifold and Turbocharger
6. Full Flow By-Pass Thermostat (to 5 o'clock inlet)

B. Raw Water Circuit
1. Water Inlet
2. Raw Water Pump
3. Engine Oil Cooler
4. Engine
5. Water Outlet
6. Exhaust Elbow
7. Heat Exchanger

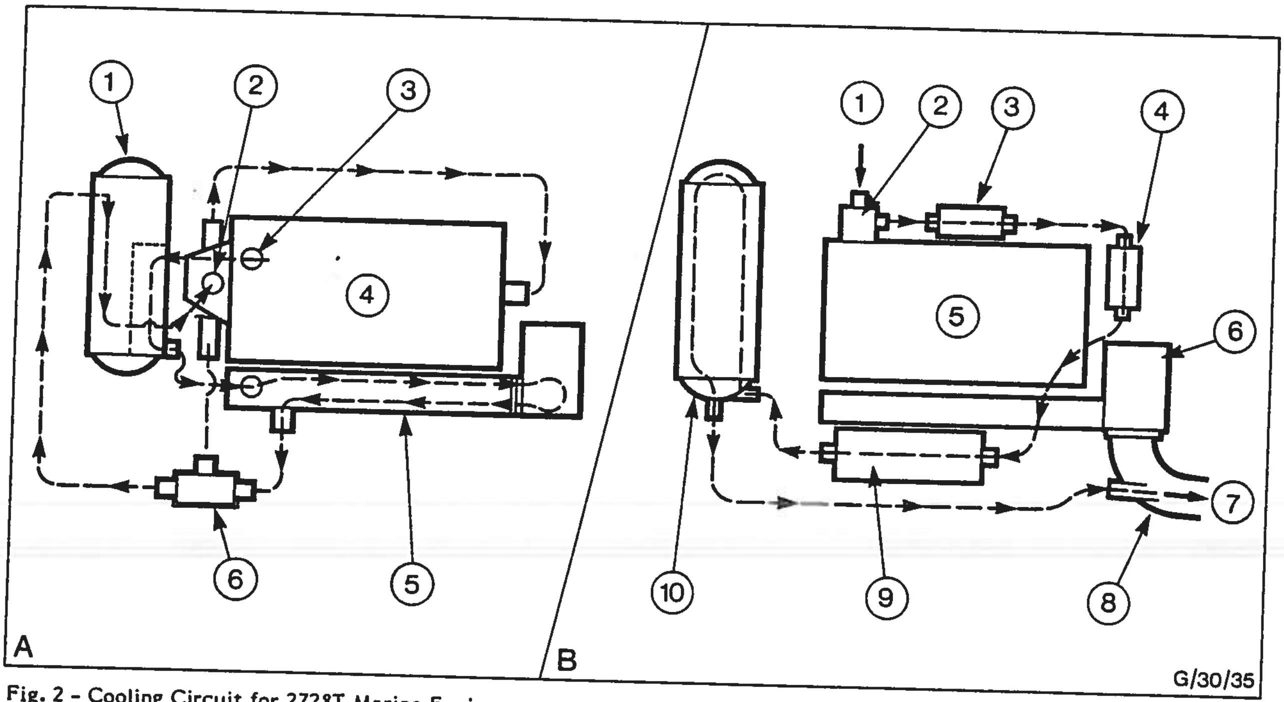

Fig. 2 - Cooling Circuit for 2728T Marine Engine

A. Fresh Water Circuit
1. Heat Exchanger
2. 2 O'Clock Water Pump Inlet
3. Cylinder Head Outlet
4. Engine
5. Water Cooled Exhaust Manifold and Turbocharger
6. Full Flow By-Pass Thermostat (to 5 o'clock inlet)

B. Raw Water Circuit
1. Water Inlet
2. Raw Water Pump
3. Engine Oil Cooler
4. Transmission Oil Cooler
5. Engine
6. Exhaust Manifold and Turbocharger
7. Water Outlet
8. Exhaust Elbow
9. Charge air cooler
10. Heat exchanger

WATER PUMPS

General Information - Naturally Aspirated and Turbocharged Industrial Engines

The same standard pump can be fitted to 4 and 6 cylinder engines. It is designed for industrial applications and has a 25,4 mm (1,0 in) diameter shaft, heavy duty bearings and a 'cassette' type of seal. It can be fitted with a single or twin sheave drive pulley - refer to Fig. 3.

In place of the standard water pump a 'low loss' fan drive system can be fitted. This is basically the standard water pump fitted with a single sheave drive pulley having an extended hub. On this extended hub, an additional fan pulley assembly is fitted with its own bearings - see Fig. 4. This arrangement enables the fan to be driven at a lower speed than the water pump.

General Information - Turbocharged Marine and Combine Harvester Engines

These engines are fitted with the automotive type of water pump which has an additional water outlet connected to the rear of the cylinder block. This arrangement ensures more efficient water circulation. This type of pump is not designed to carry a fan - see Fig. 5.

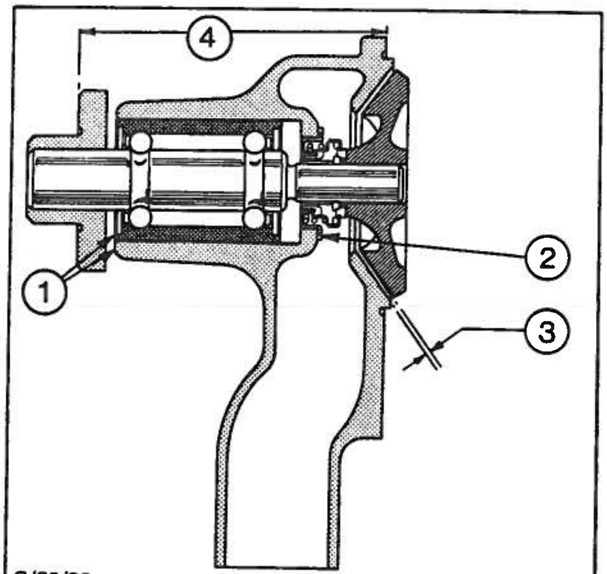

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Fig. 3 - Water Pump Assembly for All Engines Except 2728T
1. Bearing Outer Race Flush with Housing
2. Spring Cage of Seal Correctly Seated
3. Impeller to Housing Clearance
4. Correct Pulley Hub Position: 127 mm (5,0 in)

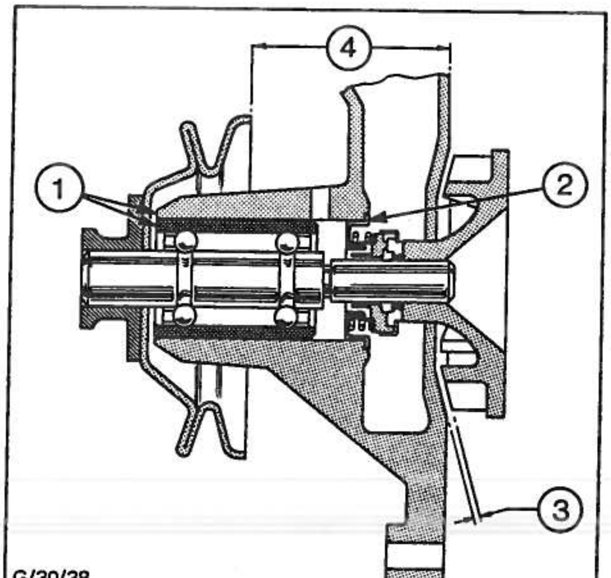

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Fig. 5 - Water Pump Assembly for 2728T Engines
1. Bearing Outer Race Flush with Housing
2. Spring Cage of Seal Correctly Seated
3. Impeller to Housing Clearance
4. Correct Pulley Position

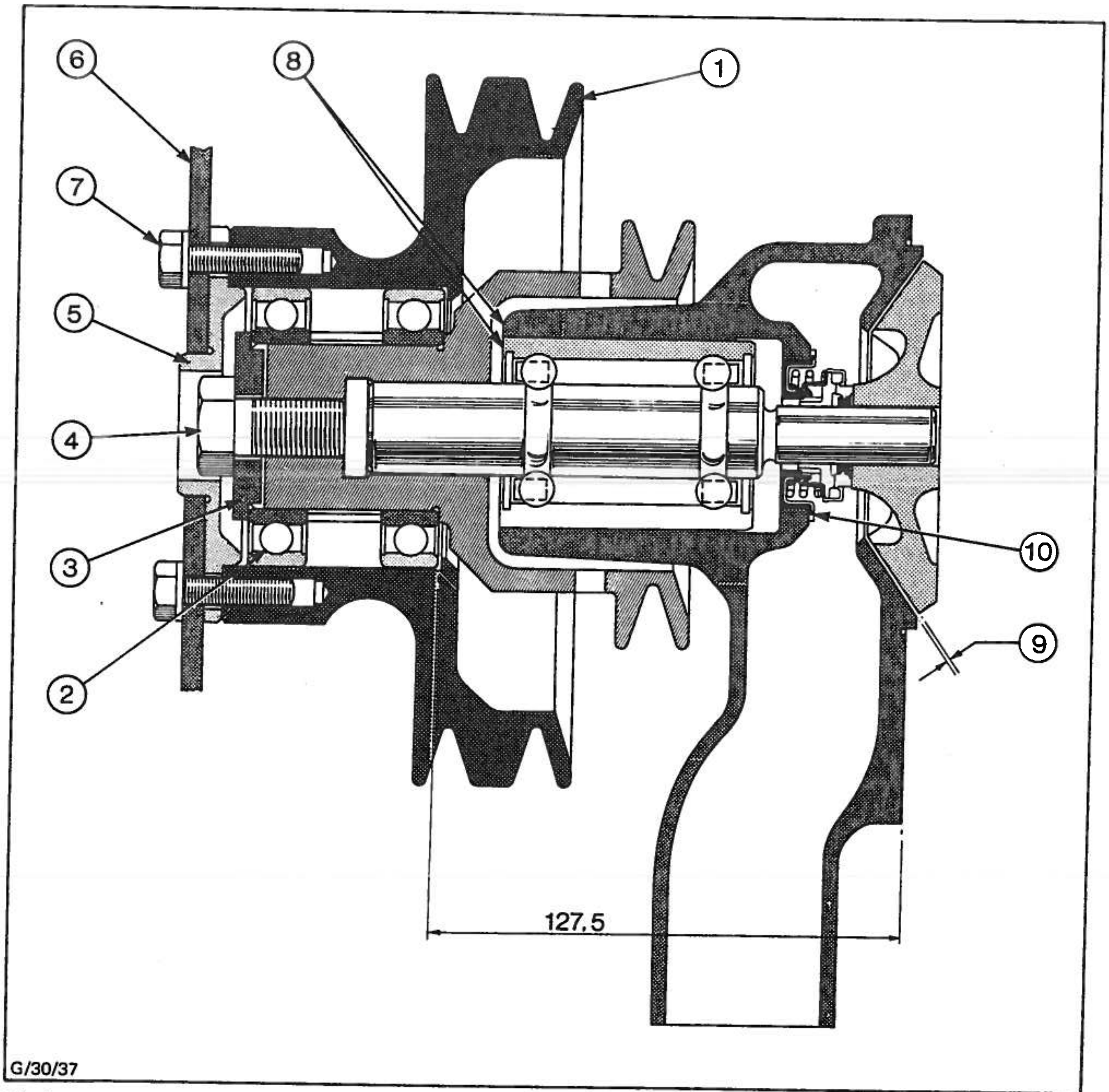

Fig. 4 - Water Pump Assembly for 'Low Loss' Fan Drive System

1. Fan Pulley
2. Fan Hub Bearing
3. Bearing Retainer Inner Plate
4. Fan Hub Retaining Bolt
5. Bearing Retainer Outer Plate
6. Fan
7. Fan Retaining Bolt
8. Bearing Outer Race Flush with Housing
9. Impeller to Housing Clearance
10. Spring Cage of Seal Correctly Positioned

WATER PUMP OVERHAUL

1. Remove radiator/header tank filler cap(s).

2. Place a suitable clean receptacle under each drain cock.

NOTE: One drain cock is located in the cylinder block below the alternator, the other is situated at the bottom of the radiator (industrial applications) or in the water cooled exhaust manifold (marine engines).

3. Open drain cocks and allow coolant to drain from system. Retain coolant if it is to be used again - refer to text under the heading 'Coolant' for method used to determine the antifreeze concentration present and/or the use of corrosion inhibitor.

Removal - 'Low Loss' Fan Drive System

1. Slacken and remove fan securing bolts while gripping fan pulley drive belt.

2. Detach fan and bearing retainer outer plate - refer to Fig. 4.

3. Slacken fan hub retaining bolt while gripping pump pulley drive belt.

4. Remove drive belts and detach water hose(s).

5. Remove pump securing bolts/nuts and detach pump from engine. Discard gasket.

Removal - Turbocharged Marine and Combine Harvester Engines

1. Remove drive belts and detach water hoses.

2. Remove pump securing bolts/nuts and detach pump from engine. Discard gasket.

Removal - Naturally Aspirated and Turbocharged Industrial Engines

1. Slacken and remove fan securing bolts while gripping drive belt(s).

2. Detach fan.

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

3. Slacken and remove pulley retaining bolts while gripping drive belt(s).

4. Remove drive belt(s) and pulley.

5. Detach water hose(s).

6. Remove pump securing bolts/nuts and detach pump from engine. Discard gasket.

Dismantling

On 'Low Loss' fan drive systems, remove the fan hub retaining bolt and bearing retainer inner plate and detach the fan hub.

1. As shown in Fig. 6, support the pump housing on the bed of a suitable press with sufficient clearance to allow the impeller to be pressed out. Push the bearing, shaft and impeller out by pressing on the shaft.

CAUTION: DO NOT ATTEMPT TO REMOVE THE PULLEY WITH A CLAW TYPE OF EXTRACTOR AS THIS MAY EASILY RESULT IN THE PULLEY BEING DISTORTED.

2. Support the front face of the impeller on a padded surface and press out and discard the bearing and shaft assembly and the seal assembly.

Cleaning/Inspection

Clean the pump housing, pulley and impeller in a general cleaning solvent. Examine the components for obvious damage, pulley distortion and impeller erosion. Check the dimensions of the impeller bore, the pulley bore and the bearing outer race bore in the pump housing. Components exceeding the specified maximum value will not provide the necessary interference fit and should be renewed.

Assembly

1. Place the pump housing on the bed of a suitable press, with the pulley end upwards. Press a new bearing and shaft assembly into the housing as follows:

a) Small diameter end of shaft innermost - see Fig. 3, 4 or 5 as applicable.

b) Outer edge of outer bearing race to be flush with front edge of pump housing - see Fig. 3, 4 or 5 as applicable.

CAUTION: APPLY FORCE ONLY TO THE OUTER RACE - NOT TO THE SHAFT.

2. Ensure the shaft is clean and free of oil or grease, then hold the seal assembly by the red retainer and slide the assembly (large diameter inwards) onto the shaft. Push it firmly into position using the special tool shown in Fig. 7 to ensure that pressure is exerted on both parts of the assembly simultaneously. The tool should be made locally to the dimensions shown.

CAUTION:
1. DO NOT SEAT THE SPRING CAGE BY PRESSING ON THE STEEL END OF THE ASSEMBLY.

2. DO NOT DISMANTLE THE SEAL ASSEMBLY IN ANY WAY, EITHER BEFORE OR AFTER INSTALLATION. THE RED COLOURED RETAINER WILL AUTOMATICALLY DISSOLVE DURING INITIAL OPERATION ON THE ENGINE.

3. Stand the assembly on the pulley end of the shaft and press the impeller onto the shaft until the specifed impeller to housing clearance is obtained - see Fig. 3, 4 or 5.

NOTE: A screw press is recommended for this operation.

4. Place the pulley nose down on the bed of the press and align/insert the shaft squarely over the pulley/hub. Apply force onto the impeller end of the shaft (NOT the impeller) until the pulley/hub is set to the specified position - see Fig. 3, 4 or 5.

5. Check that the rotating components turn freely.

On 'Low Loss' fan drive system only:

Slide fan pulley assembly onto the water pump pulley hub and secure with the bearing retainer inner plate and bolt - see Fig. 4.

Replacing Pump on Engine

1. Remove all traces of old gasket from pump mating face on cylinder block.

2. Position pump on cylinder block, using new gasket and secure with the bolts/nuts tightened to the specified torque value.

3. Replace water hose(s) and tighten clips.

4. On turbocharged marine and combine harvester engines replace drive belt(s) and adjust to give the correct tension.

5. On naturally aspirated and turbocharged industrial engines, replace the drive pulley and fan and fit the drive belt. Grip the drive belt while tightening the fan/pulley retaining bolts to the specified torque value.

6. On 'Low Loss' fan drive systems, fit the pump drive belt and grip it while tightening the fan pulley retaining bolt to the specified torque value. Fit the bearing retainer outer plate and fan and secure with the six bolts - see Fig. 4. Fit fan drive belt and grip it while tightening fan securing bolts to specified torque value.

7. Adjust all drive belts to the correct tension and close drain cocks.

8. Fill system with the correct coolant and check for leaks. Under no circumstances may the engine be started without liquid in the cooling system.

On engines with water cooled manifolds, run engine slowly for 30 minutes with the coolant filler cap removed to allow any trapped air to disperse.

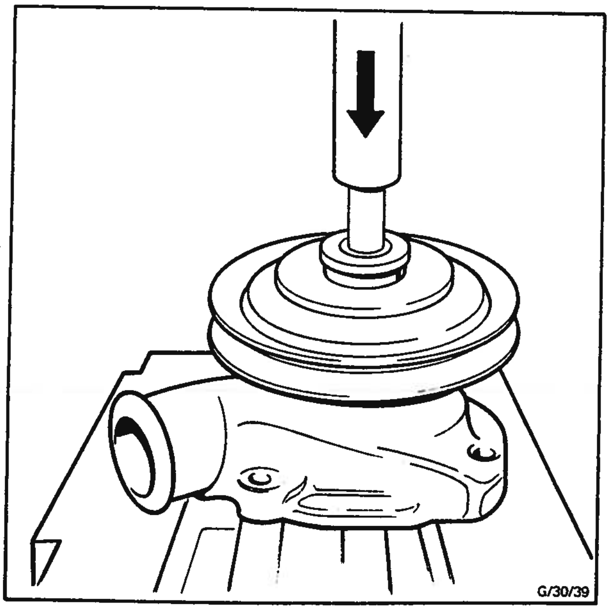

Fig. 6 - Extracting Shaft and Bearing

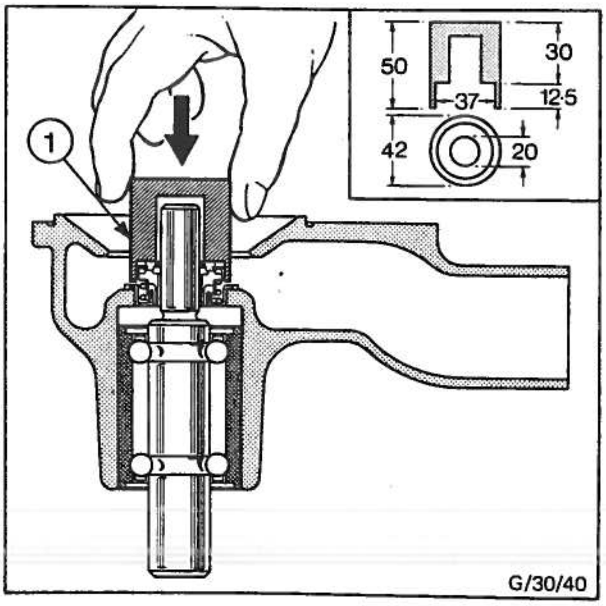

Fig. 7 - Fitting the Seal Assembly
1. Locally made fitting tool. All dimensions are in millimetres.

THERMOSTATS

General Information

The 2722 engine uses a single thermostat which opens at the coolant temperature specified. It is located in the cylinder head and is retained by the bolted-on water outlet connection used for industrial applications. The same thermostat is used for marine applications but the engine is supplied without the water outlet connection to enable the special marine equipment to be fitted; the thermostat is situated in the external pipework.

The industrial versions of the 2723, 2725 and 2726T engines are equipped with twin thermostats which operate at different coolant temperatures and incorporate a full flow radiator by-pass facility. Both thermostats are located in a special housing which is bolted to the cylinder head in place of the water outlet connection. The housing is ribbed internally to ensure that each thermostat can only be fitted in it's correct position. A specially designed water outlet connection bolts to the top of the housing and retains the thermostats. The primary thermostat has an extended centre shaft which carries an additional valve to close off the by-pass port - Fig. 8 illustrates the complete operating sequence.

Marine versions of 2723, 2725 and 2726T engines and the 2728T intercooled engine use a single thermostat situated in the external pipework. The twin thermostat housing is not fitted so allowing the special marine equipment to be connected to the cylinder head water outlet port.

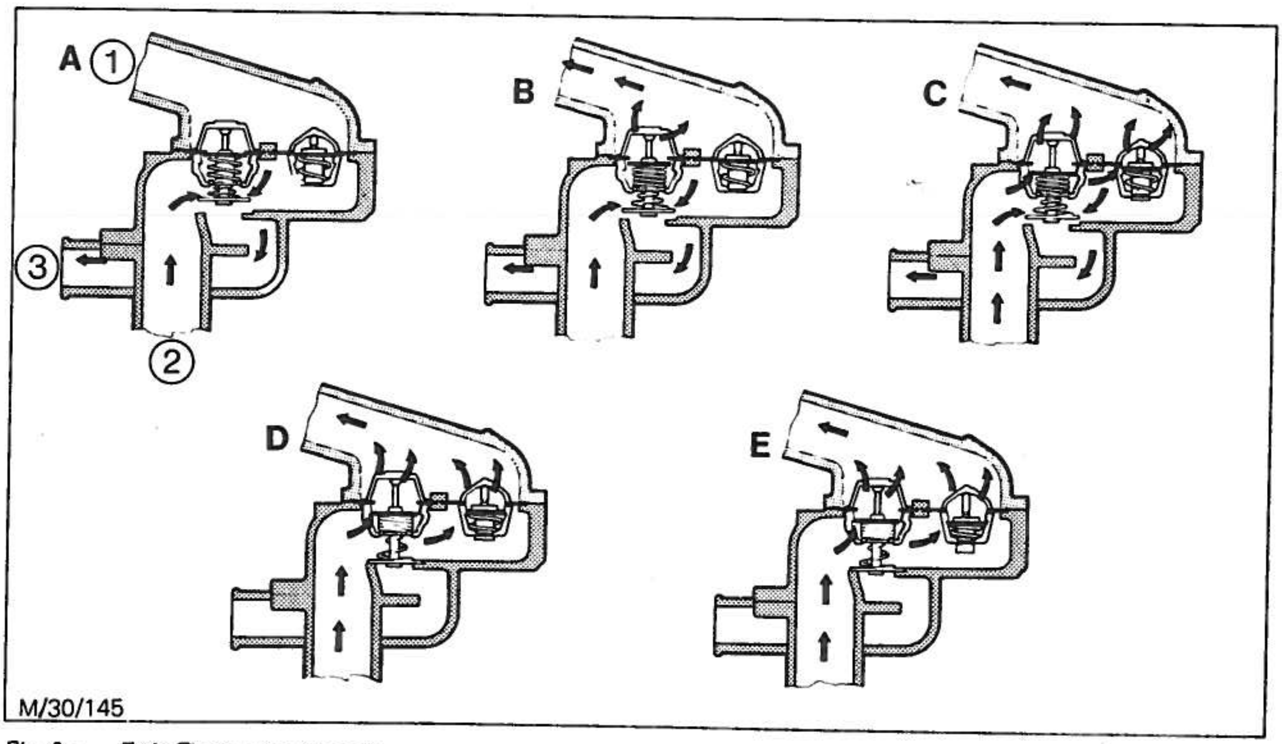

Fig. 8 - Twin Thermostat Operation

A. Primary and Secondary Thermostats Closed. By-Pass Valve Open
B. Primary Opening, By-Pass Closing, Secondary Closed
C. Primary Opening, By-Pass Closing, Secondary Opening
D. Primary Fully Open, Secondary Opening, By-Pass Closed
E. Primary and Secondary Fully Open, by-Pass Valve Closed

1. Coolant Flow to Radiator
2. Coolant Flow from Engine
3. Coolant Flow to By-Pass

Checking/Renewing Thermostats - Industrial Engines

1. Drain coolant - see under 'Water Pump Overhaul'.

NOTE: It is not necessary to drain off all the coolant.

2. Where applicable, disconnect the wire from the temperature sensitive switch situated in the top of the thermostat housing.

3. Slacken hose clip and detach hose from water outlet connection.

4. Remove screws and lift off the water outlet connection.

5. Discard gasket and clean mating faces of water outlet connection and housing.

6. Clear away any remaining gasket debris, then lift out the thermostat(s).

7. Suspend the thermostat to be tested in a water filled metal container so that it is submerged but not touching the container - see Fig. 9.

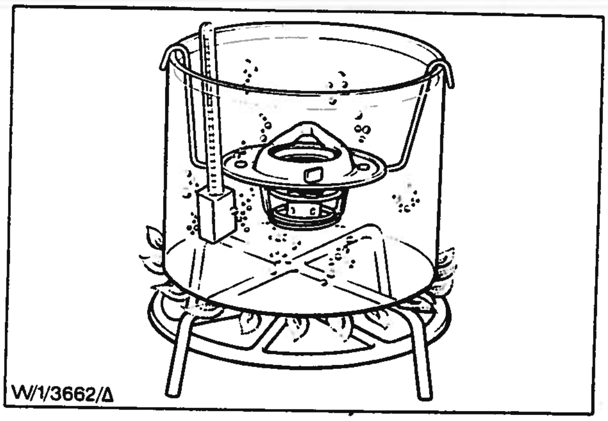

Fig. 9 - Testing the Thermostat

8. Gradually heat the water while checking the water temperature with an accurate thermometer. DO NOT let the thermometer touch the container.

9. Observe the temperatures at which the thermostat starts to open and when it is fully open. Compare results with the specified figures. If outside the stated limits, the thermostat must be rejected.

10. Carefully clean the recessed seat(s) in the housing, then install the thermostat(s) making sure that it is fully seated in its recess.

NOTE: On twin thermostat applications ensure that the correct pair of thermostats are installed (one has two valves).

11. Fit the water outlet connection, using a new gasket and tighten the screws to the specified torque figure.

12. Re-fit the hose and tighten the clip. Where applicable, re-connect the wire to the temperature sensitive switch. Close drain cocks.

13. Re-fill the system slowly with the original coolant or with new coolant of the correct type and mixture - see under 'Coolant'.

14. Check for leaks, run the engine and top-up as necessary. On engines with water cooled manifolds, run engine slowly with coolant filler cap removed to allow any trapped air to disperse.

COOLANT

The coolant used may contain either anti-freeze or corrosion inhibitor depending on the circumstances under which the engine operates.

Anti-Freeze Solutions

WARNING: Antifreeze contains Monoethylene Glycol and other constituents which are toxic if taken internally and can be absorbed in toxic amounts on repeated or prolonged skin contact. Persons using antifreeze are recommended to adhere to the following precautions:

1. Antifreeze must never be taken internally. If antifreeze is swallowed accidentally, medical advice should be sought immediately.

2. Precautions should be taken to avoid skin contact with antifreeze. In the event of accidental spillage onto the skin, antifreeze should be washed off as soon as practicable. If clothing is splashed with antifreeze, it should be removed and washed before being worn again, to avoid prolonged skin contact.

3. For regular and frequent handling of antifreeze, protective clothing (plastic or rubber gloves, boots and impervious overalls or aprons) must be used to minimise skin contact.

It is preferable always to use a mixture of 50% 'Motorcraft Antifreeze Super-Plus' to 50% water. The Coolant Concentrate should comply with Ford Specification M97B-18C. This will give protection against freezing down to -36°C (-34°F) and will also greatly reduce corrosion in the engine cooling system.

Motorcraft Antifreeze products are fully compatible, and Super-Plus can be safely used for topping-up engines previously filled with Motorcraft Antifreeze Plus. The improved performance characteristics of Super-Plus will be reduced, however. It should be noted that mixing the pink Super-Plus Antifreeze with blue/green Motorcraft Antifreeze will result in a brown coloured fluid, which is unrelated to performance.

Motorcraft Antifreeze Super-Plus can be used to top-up engines previously filled with a proprietory antifreeze. No serious deficiency should occur provided that the total antifreeze concentration in the cooling system is maintained at recommended levels.

The table (Fig. 25) shows the protection provided when weaker solutions are used.

NOTE: When these concentrations (less than 50%) are used, the coolant should be drained and the system flushed after every winter season.

IF AN ANTIFREEZE MIXTURE IS NOT BEING USED IN FROSTY WEATHER, IT IS ESSENTIAL THAT THE COOLING SYSTEM IS DRAINED PRIOR TO THE ENGINE STANDING IDLE AND REFILLED IMMEDIATELY BEFORE THE ENGINE IS USED AGAIN.

NOTES: When refilling the cooling system on engines fitted with water cooled manifolds, the engine should be run slowly for half an hour with the pressure cap removed to allow any air locks in the cooling system to disperse.

Disconnecting the hose from the manifold outlet connection will also assist in expelling any trapped air.

Volume of 'Motorcraft Antifreeze Super-Plus' in water	Protection Down to
10%	-8°C (17°F)
15%	-13°C (9°F)
20%	-19°C (-2°F)
25%	-29°C (-20°F)
50%	-36°C (-33°F)

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Fig. 10 - Antifreeze Solutions

Corrosion Inhibitor Solutions

A corrosion inhibitor is available as an alternative to antifreeze or where the antifreeze concentration is below the specified limit.

The inhibitor will protect water pumps, core plugs, thermostat housings and radiators against corrosion when used at the correct concentration.

THE INHIBITOR IS NOT AN ANTIFREEZE.

a) Plain water in cooling system:

Add the corrosion inhibitor concentrate to the vehicle coolant in the ratio of 2 1/2% by volume, i.e. 1 part inhibitor to 39 parts of water. This proportion has the anti-corrosion properties of a 50% concentration of 'Motorcraft Antifreeze-Plus' but will not provide any frost protection.

NOTE: Where a vehicle cooling system has previously been neglected with regard to frost protection, the cooling system should be flushed out before adding the inhibitor.

b) Weak antifreeze solution in cooling system

The inhibitor may be added to the vehicle coolant to supplement the antifreeze corrosion resisting properties as follows:

Test the antifreeze concentration using a suitable hydrometer.

A reading of 1080 represents a 50% antifreeze concentration.

A reading of 1040 represents a 25% antifreeze concentration.

A reading of 1000 represents plain water.

If the hydrometer reading is 1080 or above, no inhibitor need be added. If the hydrometer reading is 1040 add half the quantity required for plain water. If a reading in the region of 1000 is obtained, add inhibitor as described for plain water - see (a).

The addition of the inhibitor will not increase the frost protecting properties of the coolant.

NOTE: Adding the inhibitor will not alter the hydrometer reading, therefore, a note should be made on the vehicle records and a label attached to the cooling system filler cap recording the date and amount of inhibitor added. The cooling system should be topped up with water/inhibitor mixture consisting of 1 part inhibitor to 39 parts of water.

The effective life of the inhibitor is similar to that of 'Motorcraft Antifreeze-Plus' (2 years), therefore the cooling system should be drained and refilled with a plain water/inhibitor mixture after this period of time.

Draining and Flushing the Cooling System

Drain the cooling system as described under 'Water Pump Overhaul'. If the flow ceases, probe the cocks carefully to dislodge any sediment that may be causing a temporary blockage.

Flush the system through with a hose until clean water emerges; allow all water to drain out, then close the drain cocks before refilling the system.

NOTES: When refilling the cooling system on engines fitted with water cooled manifolds, the engine should be run slowly for half an hour with the pressure cap removed to allow any air locks in the cooling system to disperse.

Disconnecting the hose from the manifold outlet connection will also assist in expelling any trapped air.

THERMOSTART SYSTEM

Description - See Fig. 10

When selected, this system assists engine starting in cold weather conditions by pre-heating the air in the intake manifold. The system consists of a reservoir which supplies fuel to thermostart element(s) fitted in the air intake ducting. A pre-heater selection button on the driver's instrument panel controls the operation.

The reservoir is connected by pipe line to the injection pump fuel gallery so that it is constantly supplied during engine running. The removable lid of the reservoir incorporates a plate valve controlled and gauze protected vent. The valve closes when the reservoir is full, surplus fuel flowing out through an overflow and back to the tank via the leak-off pipe. An outlet at the base of the reservoir feeds fuel to the element(s).

The element consists of a thermally controlled ball valve and a combined heating and igniter coil contained within a body and shield assembly. The element is fitted into a boss on the air intake manifold.

Operation

In the non-energised state, the ball valve is held closed by a rod in the tubular valve casing.

With the ignition switch in the running position, depression of the pre-heater button energises the element coil. As the coil heats up, the valve casing expands axially to move the rod away from the ball valve. Fuel then flows by gravity from the reservoir to be warmed and vapourised by the heater and ignited by the igniter portion of the coil. Cranking the engine draws air through dilution holes in the element shield to mix freely with the burning fuel in the intake manifold.

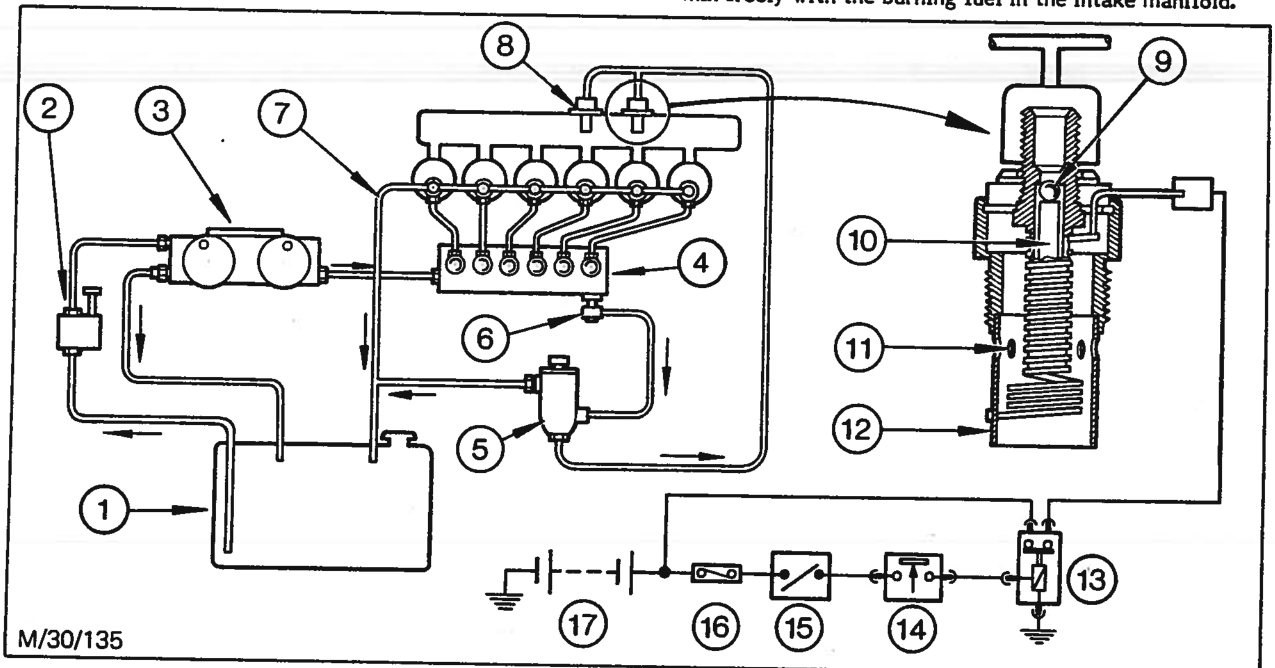


Fig. 10 - Thermostart System Schematic

1. Fuel Tank
2. Fuel Lift Pump
3. Fuel Filters
4. Injection Pump
5. Reservoir
6. Injection Pump Gallery Outlet
7. Leak-Off Pipe
8. Thermostart Element(s)
9. Ball
10. Rod
11. Dilution Holes
12. Shield
13. Thermostart Relay
14. Pre-Heater Button
15. Ignition Switch
16. Fusebox
17. Battery

Servicing

1. Disconnect the battery.

2. Disconnect the electrical connector and fuel pipe from the thermostart element. Allow the fuel to drain into a container.

3. Unscrew the element from the intake manifold and fit a protective cap to the element and the manifold (Fig. 11).

4. Disconnect the pipes from the reservoir and remove the reservoir.

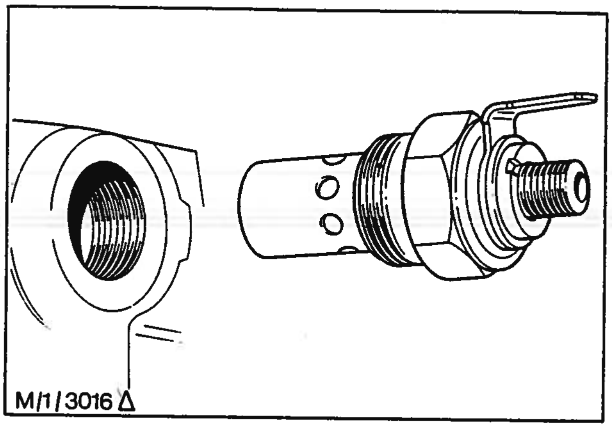


Fig. 11 - Removing/Replacing Thermostart Element

5. Remove the reservoir cover and clean the bowl and cover with kerosene or test oil. Dry the vent filter with low pressure compressed air and re-assemble the unit with a new gasket.

6. Clean the element by brushing lightly with a soft bristled brush.

7. Install the reservoir and reconnect all the fuel pipes except the overflow pipe.

8. Prime the system by operating the lift pump priming plunger until fuel flows from the reservoir. Reconnect the pipe.

9. Install the thermostart element into the manifold and connect the fuel pipe and the electrical connector.

10. Reconnect the battery and operate the thermostart pre-heater button. Check that the inlet manifold radiates warmth in the vicinity of the element. If not, investigate the fuel supply and/or electrical continuity to the element. Rectify and/or renew the element as required.

HIGH PRESSURE FUEL PIPES

Fuel is supplied from the injection pump to the injectors through high pressure steel pipes. Each pipe has an individual shape and cannot therefore be fitted in any position other than to its own cylinder. The pipe ends are suitably formed to connect without using separate olives and the pipes are clamped to each other to reduce vibration.

INJECTORS

Description - Refer to Fig. 12

The following description embraces both CAV and Bosch injectors. Although slightly different in appearance, the two makes are interchangeable providing that injectors for NA engines are not mixed with those for TC engines.

Fitted into machined recesses in the cylinder head, each injector is retained by two bolts. The recesses are angled towards the centre of each piston's combustion bowl.

Each injector is basically a spring loaded needle valve acting as an on-off valve in a 4 hole nozzle. The nozzle, valve and an adaptor plate are retained to the nozzle holder of the injector by a cap nut. Dowel pins in the adaptor plate ensure that the fuel drilling is correctly aligned.

The upper, larger diameter of the needle valve is an accurately ground and lapped fit in the nozzle. These two component parts are classed as a pair for replacement purposes. The annular area formed between the two diameters of the valve spindle is the area on which the valve lifting force is subjected. The lower end of the valve spindle is ground and lapped to form a fuel tight fit on the nozzle seat.

The four spray holes in the nozzle are provided in differently angled pairs. This arrangement accommodates the injector installation angle to result in even distribution into the piston bowl.

A calibrated, self lubricating fuel leakage is permitted between the close fitting diameters of the needle valve and the nozzle. This flow returns to the tank via a 'leak-off' pipe connection at the top of the injector.

Operation - Refer to Fig. 12

As the injection pump delivery valve opens, pressure is felt on the annular face of the needle valves' larger diameter. When fuel pressure overcomes spring pressure, the valve will open. Flow through the spray holes creates a pressure drop which allows the valve to close until pressure rises again. This very rapid, repetitive action causes a 'chattering' or 'buzzing' noise which is audible during bench testing. The very high fuel pressure and minute spray holes combine to create a high degree of atomisation.

Adjustment to the valve operating pressure can only be made by dismantling and reshimming the spring - see under 'Servicing'.

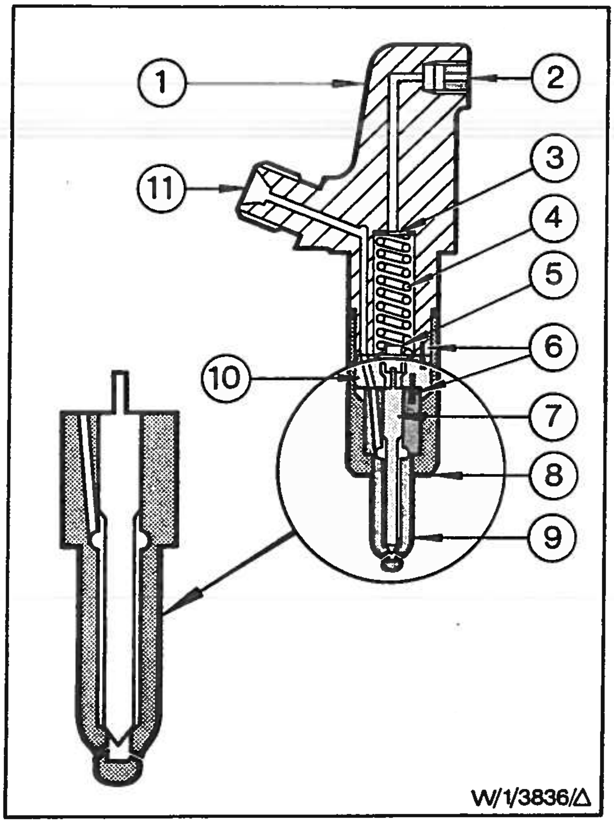


Fig. 12 - Injector
1. Nozzle Holder
2. Leak-Off Connector
3. Shim
4. Spring
5. Spring Seat
6. Dowel Pins
7. Needle Valve
8. Cap Nut
9. Nozzle
10. Adaptor Plate Assembly
11. Inlet Connection

Servicing

The complete procedure for dismantling, overhauling, assembling and testing injectors is given in the separate publication '2720 Range Fuel Injection Equipment'. Consequently, the information following will only cover removing, testing and replacing injectors.

Removing

1. Disconnect the engine breather pipe from the rocker cover.

2. Remove the rocker cover and discard the gasket.

NOTE: If only one injector is to be removed, proceed directly to operation 6. If several injectors are to be removed, it will be found easier to remove the rocker shaft assembly as detailed in operations 3, 4 and 5 following.

3. Slacken each rocker shaft pedestal retaining bolt approximately one turn at a time until all are loose, then remove them - see Fig. 13.

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

5. 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.

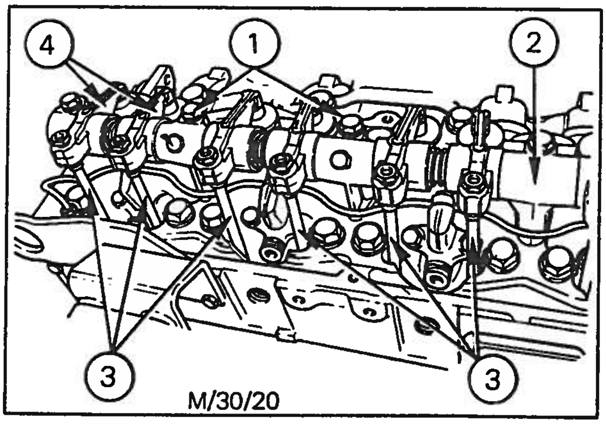


Fig. 13 - Removing Rocker Shaft Assembly
1. Rocker Shaft Pedestal Retaining Bolts
2. Rocker Shaft Assembly
3. Push Rods
4. Rocker Arms

6. Slacken the large oil seal nut (Fig. 14). Where necessary, remove high pressure pipe clamps to gain access.

7. Unscrew the gland nut securing the high pressure delivery pipe to the injector.

CAUTION: DO NOT BEND THE DELIVERY PIPE(S). IF NECESSARY, UNCLAMP AND DISCONNECT BOTH ENDS OF THE PIPE(S).

8. Unscrew and remove the banjo bolt from leak-off pipe.

9. Unscrew securing bolts and withdraw injector. Discard 'O' ring.

10. Remove seating washer from recess in cylinder head and discard it.

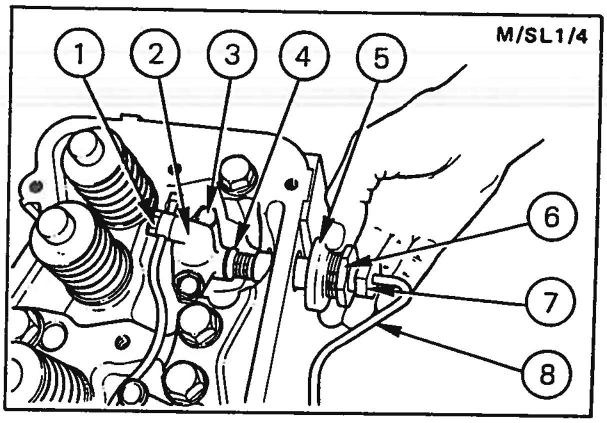


Fig. 14 - Removing Injector
1. Leak-Off Pipe Banjo Bolt
2. Injector
3. Injector Retaining Bolt
4. 'O' Ring
5. Oil Seal
6. Oil Seal Nut
7. High Pressure Pipe Gland Nut
8. High Pressure Pipe

11. Repeat operations 6 to 10 inclusive for all other injectors to be removed. If new or reconditioned injectors are not being fitted immediately, fit blanking plugs or caps to the cylinder head apertures and all open pipe connections.

Testing

⚠WARNING: When testing injectors, great care should be taken to ensure that the atomised spray from the nozzle does not come into contact with the hands or any other part of the body. The high pressures involved with the atomisation of the test oil may cause it to penetrate the skin and cause possible blood poisoning. Goggles, gloves and suitable protective clothing should be worn during testing.

1. Fit a protective cap to the inlet union and thoroughly clean the injector with kerosene or test oil.

2. Remove the protective cap and connect the injector to the tester - see Fig. 15. Carefully wipe the nozzle completely dry.

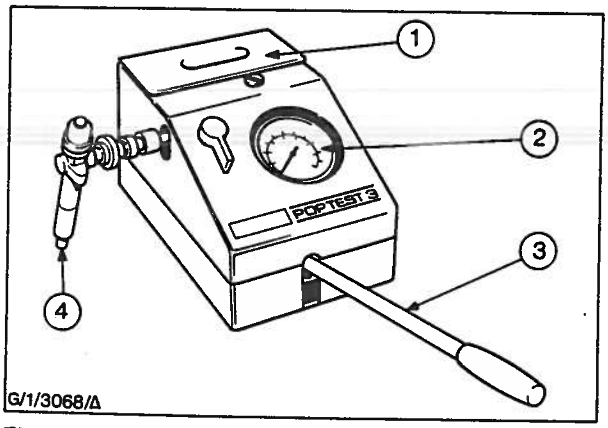


Fig. 15 - Typical Injector Tester
1. Oil Supply Tank
2. Pressure Gauge
3. Pump Handle
4. Injector

3. With the pressure gauge valve closed, operate the hand pump several times to expel air from the unit, then open the valve.

4. Pump sufficiently to raise the pressure until the gauge flickers. This indicates the pressure required to lift the needle from its nozzle seat. Recheck, note the pressure and allow it to reduce. Compare the result with the specified 'setting' or 'working' pressure, as appropriate.

NOTE: A correctly operating injector will emit a 'chattering' sound while spraying.

5. Increase the pressure to the upper specified back leak test pressure. Start a stop watch and note the time for the pressure to fall naturally through 50 bars, i.e. to the lower specified test pressure. Compare the time taken with the specified time/oil temperature.

6. Check that the nozzle tip is perfectly dry, then increase the pressure to approximately 10 bars (145 lb/in^2) below the pressure required to lift the needle. While maintaining this pressure constant, check that droplets of fuel do not collect or drip from the nozzle face for at least 6 seconds. (A slight dampness is acceptable).

7. Close the tester valve and operate the hand pump at approximately 1 1/2 strokes per second. A correct spray pattern will be formed with fuel emitting from all holes in the nozzle and free from irregular streaks.

CAUTION: AT CERTAIN OPERATING PRESSURES A PARTIALLY BLOCKED NOZZLE HOLE MAY PRODUCE A GOOD SPRAY PATTERN. BECAUSE OF THIS FACT, ALL INJECTORS REMOVED FROM ENGINES WITH POWER LOSS OR SMOKING COMPLAINTS SHOULD BE OVERHAULED BEFORE TESTING.

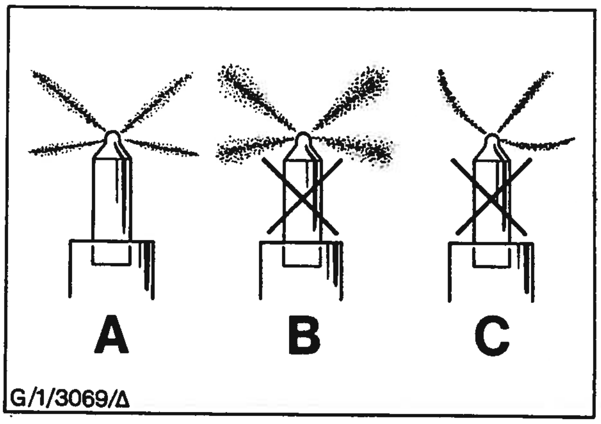


Fig. 16 - Typical Spray Patterns
A. Good
B. Reject - Poor Atomisation
C. Reject - Blocked Spray Hole

Replacing

1. Ensure that the cylinder head injector aperture is thoroughly clean, then fit new sealing washer - see Fig. 17.

2. Fit a new 'O' ring seal to the injector.

3. Insert the injector into the cylinder head and fit but do not tighten the securing bolts - see Fig. 17.

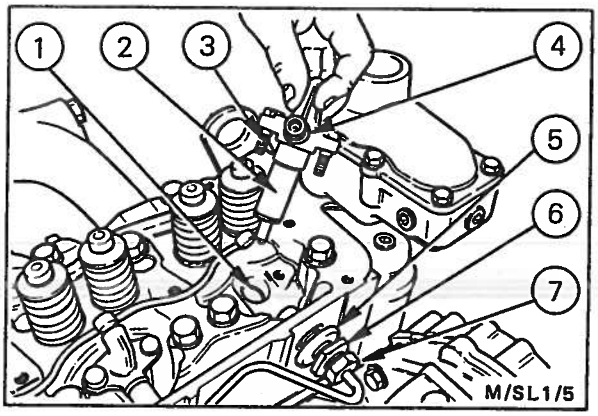


Fig. 17 - Replacing Injector
1. Recess for Copper Sealing Washer
2. Injector
3. Injector Retaining Bolt
4. 'O' Ring
5. Oil Seal
6. Oil Seal Nut
7. High Pressure Pipe Gland Nut

4. Insert the leak-off pipe banjo bolt (Fig. 14) and tighten it by hand only.

5. Connect the high pressure pipe to the injector and hand tighten the gland nut.

6. Repeat operations 1 to 5 inclusive for each other injector being installed.

7. Tighten all injector securing bolts evenly to the specified torque, then tighten the delivery pipe unions and the leak-off pipe banjo bolts to the specified torque.

8. Tighten the oil seal nuts to the specified torque and reclamp any slackened delivery pipes.

NOTE: Before replacing the rocker shaft and/or cover, carry out the 'Injector Leak-Off Rail Pressure Test'.

9. Install the pushrods 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.

10. Adjust the valve clearances as detailed in Section 1.

11. Replace the rocker cover with a new gasket and tighten screws to the specified torque value.

12. Replace the engine breather pipe.

INJECTOR LEAK-OFF RAIL - PRESSURE TEST

The injector leak-off rail should be pressure tested whenever it is refitted to the engine or if dilution of the engine lubrication oil by fuel oil is suspected.

1. Disconnect the battery.

2. Remove the external leak-off pipe banjo connection at the rear of the cylinder head and fit a single outlet banjo connection securely in its place - see Fig. 18.

3. Connect a cooling system pressure tester to the banjo connection and pressurise the leak-off rail to 0,7 bar (10 lb/in^2).

If the pressure remains constant for 10 seconds or longer, the system is satisfactory - proceed to operation No. 8.

If the pressure cannot be maintained or begins to drop in less than 10 seconds, a leak is indicated - continue with operation No. 4.

4. Check and eliminate the external connections and the pressure tester as the source of leak.

5. Recheck and, if the leak persists, remove the rocker cover for access to the leak-off rail and the injectors.

6. Inspect the leak-off rail and connections for damage and security. If the rail is cracked or split, fit a new rail. If the leak is from a banjo connection to an injector, remove the banjo bolt, check the bolt and banjo faces for scoring or damage and renew or rectify as required.

NOTE: The leak-off rail banjo's are made from a soft material designed to eliminate the need for sealing washers between the faces and the banjo bolts. This material is easily scored and leakages can result.

7. Recheck and when the test pressure can be maintained satisfactorily, refit the rocker cover, using a new gasket.

8. Remove the pressure test equipment and the banjo connection. Refit the external leak-off pipe and tighten the banjo bolt securely.

9. Reconnect the battery.

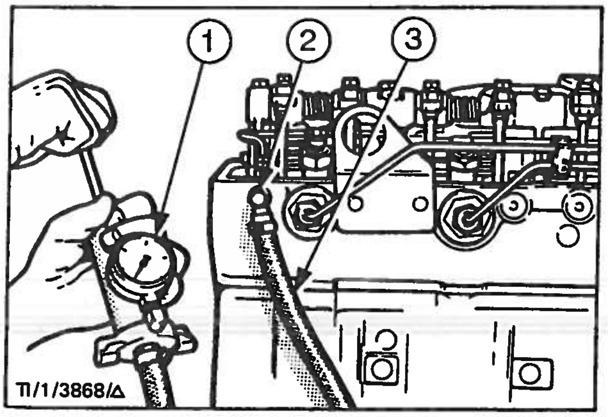


Fig. 18 - Pressure Testing the Leak-Off Rail
1. Cooling System Pressure Tester
2. Suitable Banjo Connector
3. Connecting Hose

FUEL INJECTION PUMP

Introduction

Two types of fuel injection pumps are used with the 2720 range of engines. Those with automotive or G.P. (general purpose) governing are lubricated by a pressure fed system, the oil feed being taken direct from the engine oil filter head; the oil return to the engine is via a drilling in the pump mounting flange which communicates with the engine timing gear case. The drive gear on these pumps has slotted holes to provide fine timing adjustment.

Injection pumps with Class 'A' or combine harvester governing do not have an external oil feed, lubrication being by means of an oil filled cambox. The drive gear on these pumps is not adjustable with respect to the hub, fine timing adjustment being obtained by means of slotted holes in the pump mounting flange which enable the complete pump to be rotated slightly.

Apart from the differences outlined, the two types of injection pump are very similar in construction. The following descriptive text, although written specifically for the automotive governed pump, covers both types; where any significant differences occur, they will be dealt with in the text.

Description

General

The fuel injection pump delivers precisely equal quantities of high pressure fuel to each injector in the correct firing order. Control of fuel flow to vary engine power is by means of the 'speed control lever' on the pump. A control to provide a rich fuel condition for easy engine starting in cold weather is incorporated and also a means of stopping the fuel flow.

The injection pump is mounted on the rear face of the engine timing gear housing and is comprised of two main components, namely the pump housing and the pump body. The light alloy housing encloses and supports a multi-lobed camshaft and associated tappets which operate spring loaded pumping plungers called 'elements'. The elements, one for each engine cylinder, are contained in the steel pump body mounted on the housing. The governor control mechanism is housed in the forward section of the pump housing.

Pumping Section

Camshaft and Drive Gear:

The camshaft is supported in two tapered roller bearings. Forward of the front (No. 1 cylinder) cam, the shaft is flanged to attach the governor weight carrier.

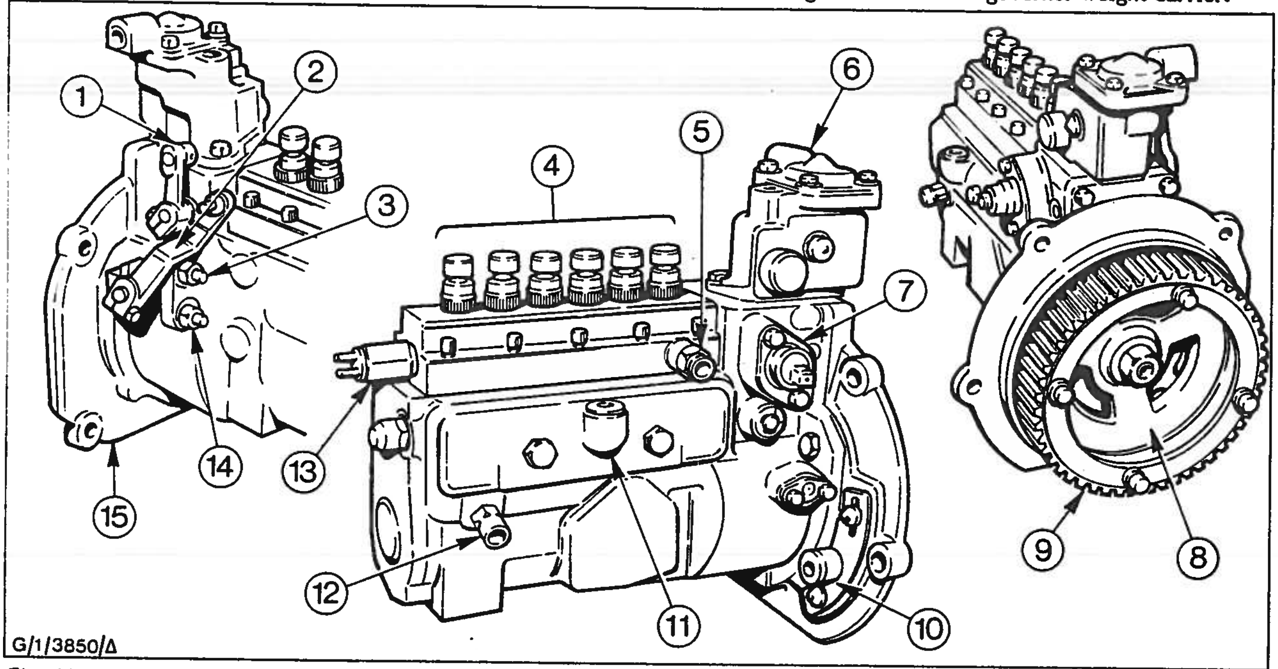


Fig. 19 - CAV Fuel Injection Pump (Automotive and G.P. Governed Type Shown)

1. Stop Control Lever
2. Speed Control Lever
3. Idle Speed Stop
4. Delivery Valves
5. Fuel Gallery Airbleed
6. Boost Control Unit
7. Excess Fuel Solenoid
8. Drive Hub
9. Drive Gear Ring
10. Timing Tool Adaptor
11. Oil Fill Plug (Initial Fitment Only)
12. Pressure Oil Feed Connection
13. Fuel Inlet
14. Maximum Speed Stop
15. Mounting Flange

The forward end of the shaft is tapered, keyed and threaded to mount and secure a drive hub. On automotive and G.P. Governed pumps, a ring gear is bolted to the hub via elongated holes which permits gear adjustment during pump timing.

On Class 'A' and combine harvester governed pumps, the drive hub and gear are in one piece.

A timing tool adaptor is installed on the outer face of the pump mounting flange; a threaded plug normally closing the aperture. During pump fitment a special tool is fitted with a plunger which locates in a hole in the drive hub. When so aligned, the No. 1 plunger inlet port has 'just closed', indicating the injection timing position.

Tappets:

Hardened steel tappets operate in plain bores in the pump housing. Each tappet embodies a hardened steel roller fitted on a floating steel bush and pin. A flat is machined on the upper outer diameter of each tappet body to allow the tappets to be radially positioned with an 'E' shaped locating plate ('T' shaped on Class 'A' and combine harvester governed pumps). This arrangement allows the tappets to reciprocate while maintaining the roller in correct alignment with the cam lobes.

Each tappet body is fitted with a circlip retained 'phasing spacer'. The spacers are available in varying thicknesses to provide a means (during pump calibration only) of adjusting the plunger 'phase angles' i.e. the angle of camshaft rotation between successive injections.

Lubrication - Automotive and G.P. Governed Pumps

The camshaft, bearings, tappets and governor flyweights are lubricated by engine oil from a tapping on the engine oil filter/cooler assembly. The oil enters the pump via a metering adaptor fitted on the side of the pump housing. A knife edge type oil seal is fitted on the governor front cover to prevent oil draining through the front bearing. This creates an oil bath in the housing up to an overflow drain hole in the front cover through which the oil returns to the engine system.

Lubrication - Class 'A' and Combine Harvester Governed Pumps

The cambox and governor housing are kept filled with lubricating oil to the correct level by means of the filler and level plugs. Fuel oil leakage past the pumping plungers mixes with the lubricating oil, necessitating regular oil changing. A drain plug is provided for this purpose.

Pump Elements - See Figs. 20 and 21

Each pump element includes a pump plunger, its cylinder barrel and a delivery valve. The elements are contained in the steel pump body fitted on the upper section of the pump housing.

The plungers and barrels are produced as very accurately machined and graded 'pairs' to produce a close sliding and leak free fit. The upper side of each barrel is drilled at different levels with an (upper) 'inlet' port and a (lower) 'spill' port. A master serration locates the barrels radially to ensure correct relationship with a helical groove in the plungers.

The area surrounding the barrel ports is formed into a 'fuel gallery' which interlinks all the barrels and is fed with fuel from the engine mounted filter(s). To provide a self clearing air bleed, an outlet to the tank is permitted via a restrictor and a disc valve. The restriction ensures that an adequate supply of fuel is always maintained in the gallery and the valve prevents fuel syphoning back to the tank during non-running periods.

A circular diaphragm type of pulsation damper is fitted on the side of the pump body of naturally aspirated engines where automotive or G.P. governing is employed. The damper is connected to the fuel gallery to assist smoothing out fuel pressure fluctuations caused by the interval between successive injections.

Plungers:

Each plunger is an accurately machined and ground rod with an arm fitted to its lower end to affect partial rotation. A deep annular groove on the mid length of the plunger connects with a shallow spiral on the upper length surface. Any leakage between the plunger and barrel is 'collected' in the annular groove and passed back to the fuel gallery via the spiral. Coil springs between the pump body and a spring seat on the plunger stem maintain the plungers in contact with the tappets.

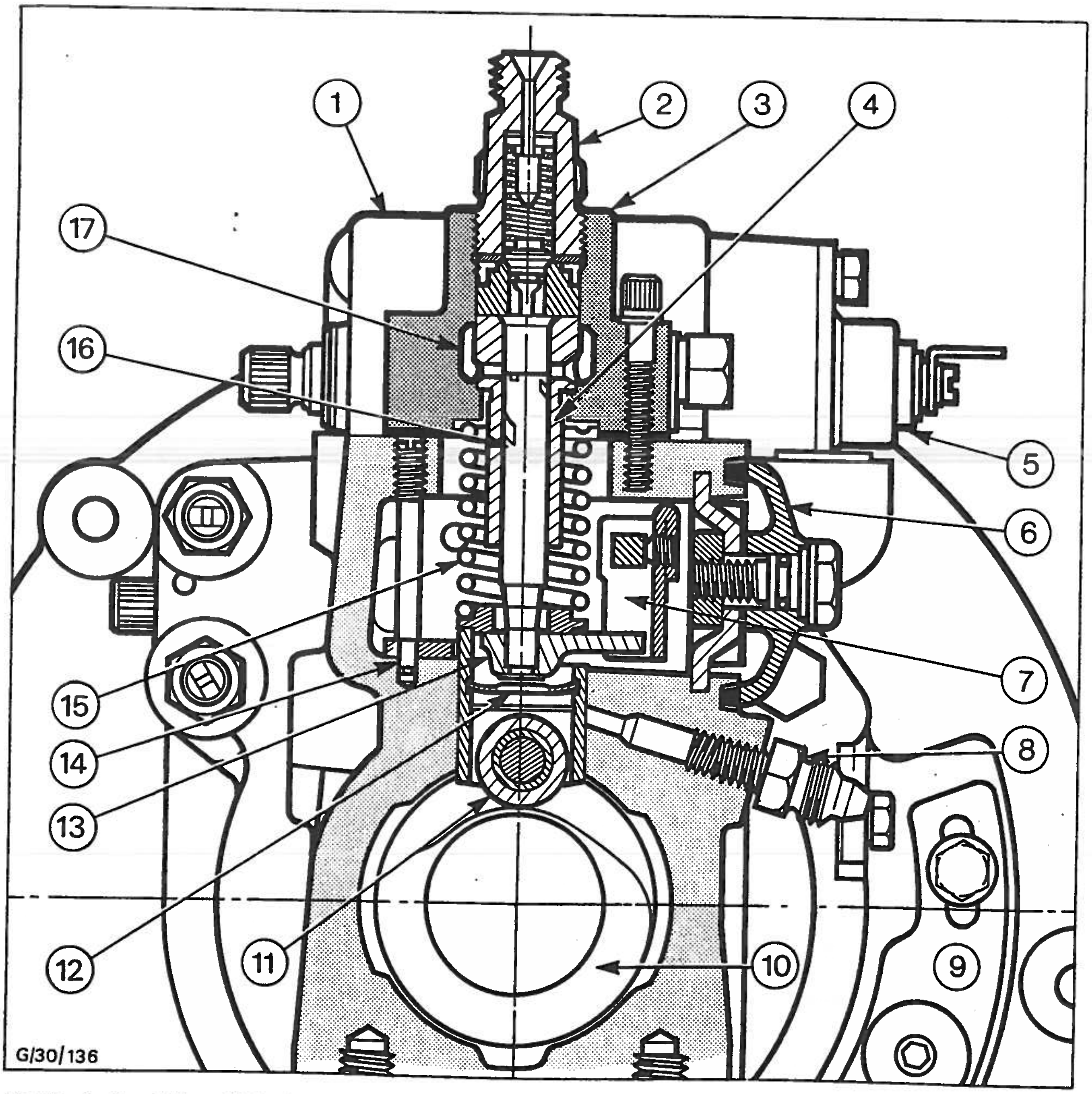


Fig. 20 - Sectional View of Injection Pump
1. Pump Housing
2. Delivery Valve Holder
3. Pump Body
4. Barrel
5. Excess Fuel Solenoid (automotive and G.P. governed pumps only)
6. Side Cover
7. Control Fork
8. Oil Metering Adaptor (automotive and G.P. governed pumps only)
9. Timing Tool Adaptor Plate (automotive and G.P. Governed pumps only)
10. Camshaft
11. Tappet Roller
12. Phasing Spacer
13. Plunger Control Arm
14. Tappet Locating Plate/Screw (automotive and GP governed pumps only)
15. Plunger Spring
16. Plunger
17. Fuel Gallery

A helically shaped groove is machined in the upper side of the plungers and connected by a drilled hole to a central drilling in the crown. As the plunger(s) move upward during their delivery stroke, fuel will be pressurised until the helical groove contacts the spill groove. The radial positioning of the groove in relation to the port thus determines the effective stroke of the plungers.

Radial movement is affected by the arm attached to the lower end of each plunger. The outer end of the arms locate in 'forks' which are locked onto a control rod. The open sided, box type forks permit the plunger arms to reciprocate during pumping. Any backward or forward movement of the control rod (through action of the governor mechanism) is therefore transmitted simultaneously to all plungers. The movement ranges from fuel cut-off through maximum to an 'excess fuel' position.

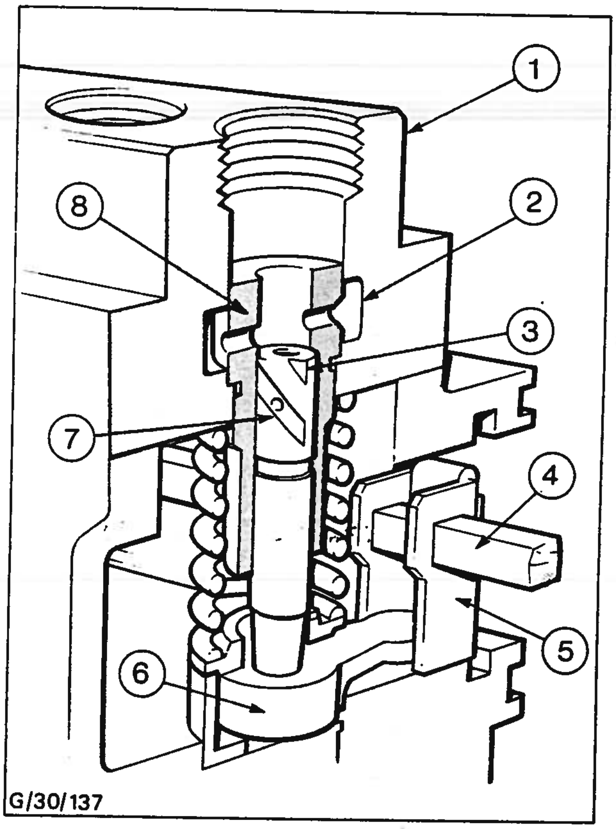


Fig. 21 - Pump Element Arrangement
1. Pump Body
2. Fuel Gallery
3. Starting Groove
4. Control Rod
5. Control Fork
6. Plunger Arm
7. Fuel Metering Groove
8. Barrel

The edge of each plunger crown incorporates a 'starting groove'. The groove is operative only when the plungers are in the excess fuel position and functions by delaying the point at which the inlet port closes. This retards the point (in terms of piston position) at which fuel pressure is sufficient to cause injection. As the engine accelerates to idle speed the governor/control rod mechanism repositions the plungers to nullify the starting groove and excess fuel position.

Delivery Valves - See Fig. 22

These valves are contained in the 'delivery valve holders' which form the outlet of each element. The valves fulfil three functions, viz:

a) Prevent delivery line draining during the plungers intake stroke.

b) Assist pressure build up during injection stroke.

c) Cause rapid pressure reduction in injection line at end of delivery.

Each valve is basically a poppet valve with a fluted stem sliding in a guide. A small piston land formed between the valve face and guide flutes is an accurate fit in the guide. As the plunger opens the barrel port at the end of the delivery stroke, the valve piston first 'plugs' the guide bore. Further downward movement increases the volume above the piston by an amount equal to the pistons movement. This action allows the delivery pipe pressure to fall very rapidly (much quicker than by conical valve only) to effect 'dribble free' closing of the injector.

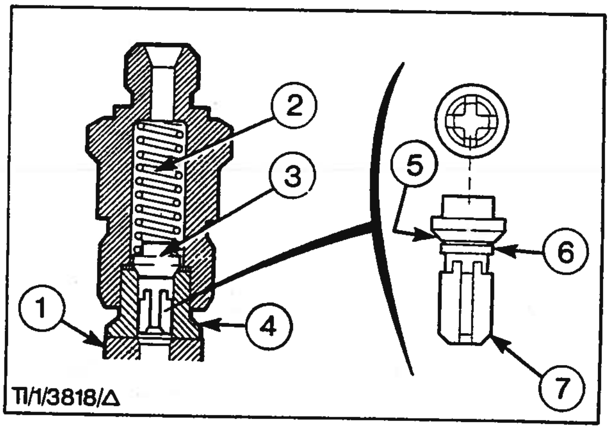


Fig. 22 - Delivery Valve Detail
1. Barrel
2. Spring
3. Delivery Valve
4. Valve Guide
5. Conical Seat
6. Piston
7. Flutes

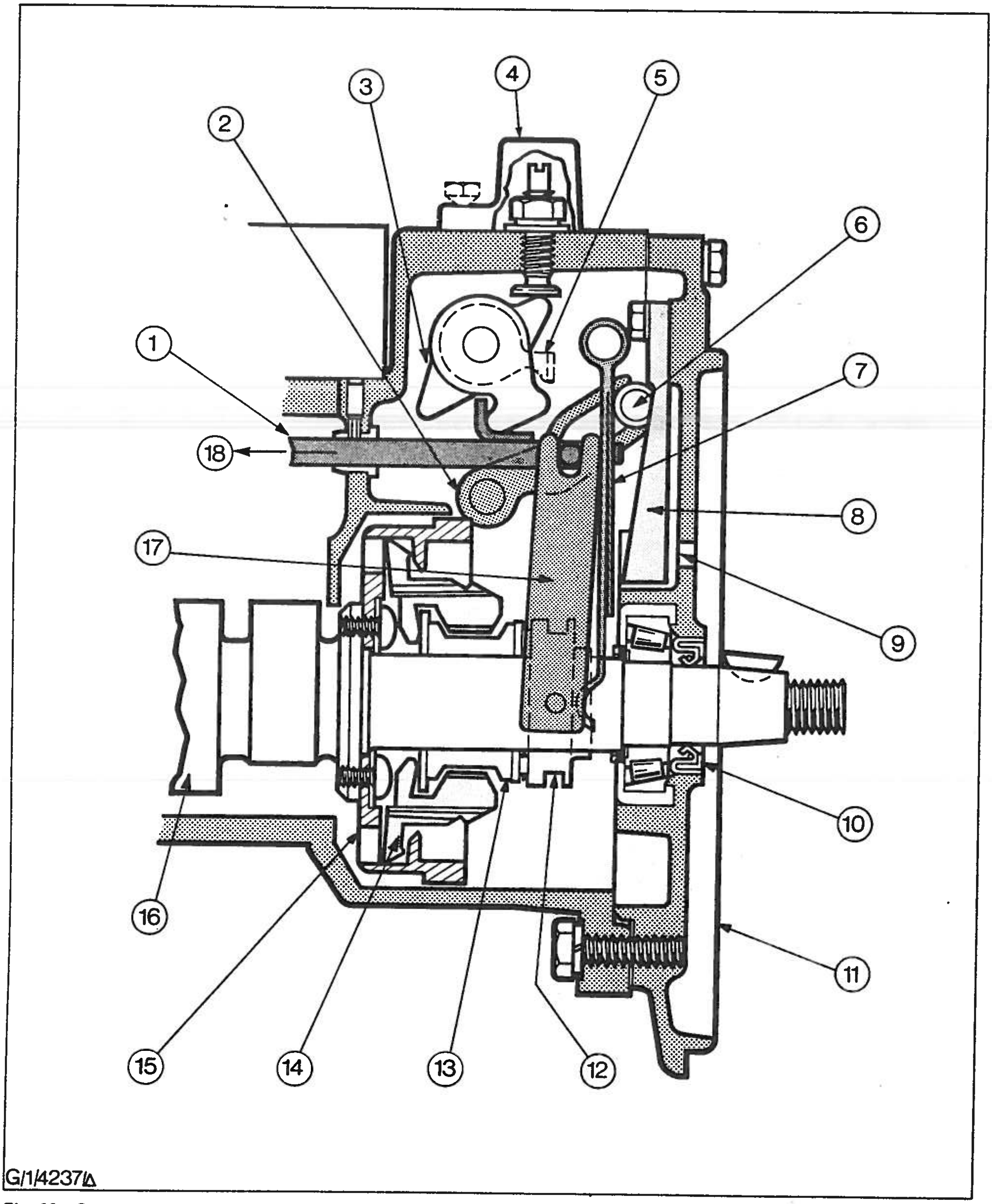


Fig. 23 - Governor Assembly Schematic

1. Control Rod
2. Roller Control Lever moved by Speed Control Lever
3. Maximum Stop Lever
4. Maximum Fuel Stop (NA Engines)
5. Stop Control Lever
6. Roller
7. Governor Spring
8. Ramp
9. Oil Level Hole
10. Oil Seal
11. Cover (Mounting Flange)
12. Thrust Pad
13. Sleeve
14. Flyweights
15. Carrier
16. Camshaft
17. Rocking Lever
18. Direction for Minimum Fuel

Governor Section - See Fig. 23

The governor assembly maintains accurate and sensitive control of the engine speed for any given throttle setting and co-ordinates demands for starting and stopping the engine. The assembly is located at the front end of the injection pump housing and enclosed by the pump mounting flange.

The governor consists of a flyweight mechanism operating in opposition to a throttle lever tensioned spring. A carrier for the flyweights is secured onto a flange of the pump camshaft with four screws.

Six steel flyweights (four on Class 'A' and two on combine harvester governed pumps) are positioned in the carrier, with their inner arms located behind a thrust washer and spool shaped sleeve. Forward of the sleeve a grooved thrust pad is separated from the sleeve by a needle roller race and a thrust washer. The legs of an inverted 'U' shaped governor leaf spring press against the thrust pad. The spring is pivoted on a spindle at the top of the casing and is positioned vertically in close relationship to a ramp on the governor casing front cover.

The throttle control shaft passes through both sides of the governor housing with the speed control lever clamped to one end. Internally, the shaft mounts a forked lever which passes through the legs of the governor leaf spring and carries a dumb bell shaped roller. Movement of the control shaft causes the roller to move up or down the inclined ramp. The movement changes the governor spring force in relation to the position of the thrust pad.

A rocking lever translates the position of the thrust pad into pump plunger control rod position. The lever is pivoted to the side of the governor housing, a pin in the lower end fitting into a groove of the thrust pad. The upper end is attached to the control rod by a sliding fork and pin.

Control Rod and Associated Equipment - See Figs 23 and 24

The control rod to which the pumping plunger control forks are attached is supported in two bushes. The forward bush is mounted in the governor to pump housing dividing wall and the rear bush in an end cover in the pump housing rear wall. On some engines, the bush is incorporated in an idling speed damper, fitted in place of the end cover.

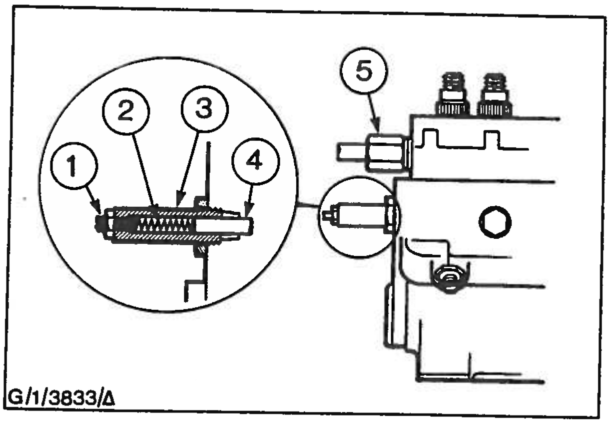


Fig. 24 - Control Rod Idling Damper
1. Adjustment Screw
2. Spring
3. Bush Retainer
4. Control Rod and Bush
5. Fuel Inlet Connection

The idling speed damper comprises an adjustable spring 'buffer' for the control rod. This prevents the rod moving past the idling position into a no-delivery position during a rapid deceleration.

A bracket is riveted to the control rod where it operates in the governor section of the pump. The bracket has two functions:

1) To relate the position of the control rod to the camlike maximum (fuel) stop lever. (This 'lever' is mounted on a cross shaft in the upper section of the casing).

2) To provide the point of leverage through which the stop control lever can move the control rod rearward into a 'no-delivery' position.

Engine Stop Control:

A stop control lever is fitted on the engine facing side of the pump and operated by a cable or other form of linkage.

The lever controls an internally spring loaded shaft on which a camlike stop control lever is fitted. When operated, the lever pushes on the control rod bracket to rotate the pump plungers into a 'no-delivery' condition. As the control is relaxed, an externally mounted spring returns the lever to the run position and the governor spring returns the control rod to the selected fuel position.

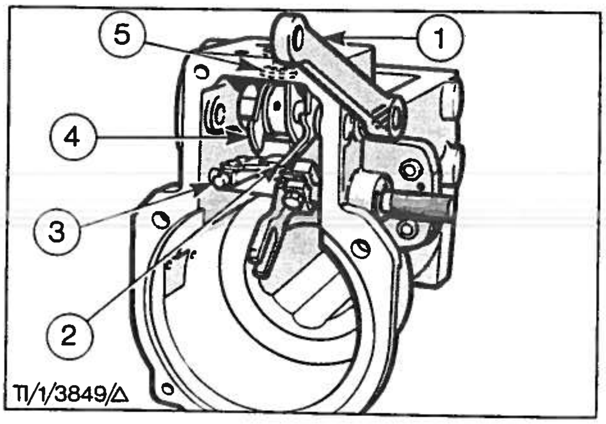


Fig. 25 - Engine Stop Control
1. External Stop Control Lever (in Stop position)
2. Stop Control Lever in Pump
3. Control Rod
4. Maximum Stop Lever
5. Maximum Fuel Stop

Excess Fuel Device:

This device is a means of overriding the maximum fuel stop so that the control rod can be moved into an 'excess' fuel condition.

On Class 'A' and combine harvester governed pumps, the device takes the form of a push button situated on the outside of the governor housing. To select excess fuel, the button is depressed while moving the speed control lever to the maximum speed position. When the speed control lever is returned towards the idling speed position, the excess fuel button is released automatically, thus returning the control rod to a normal fuel condition. An additional unit enables the excess fuel device to be operated from a remote position automatically.

On automotive and G.P. governed pumps, the device consists of a solenoid which, when operated, pulls the maximum (fuel) stop lever clear of the control rod bracket. Operation during starting depends on whether or not the 'excess fuel temperature switch' contacts are closed. (See Fig. 26). The switch is fitted on the engine thermostat housing to sense the metal temperature (not the coolant temperature). At or below 0 to 8°C (32 to 46°F) the closed contacts will complete a circuit to the solenoid when the starter relay is energised. Depressing the accelerator pedal will then cause the control rod to move into the excess fuel position.

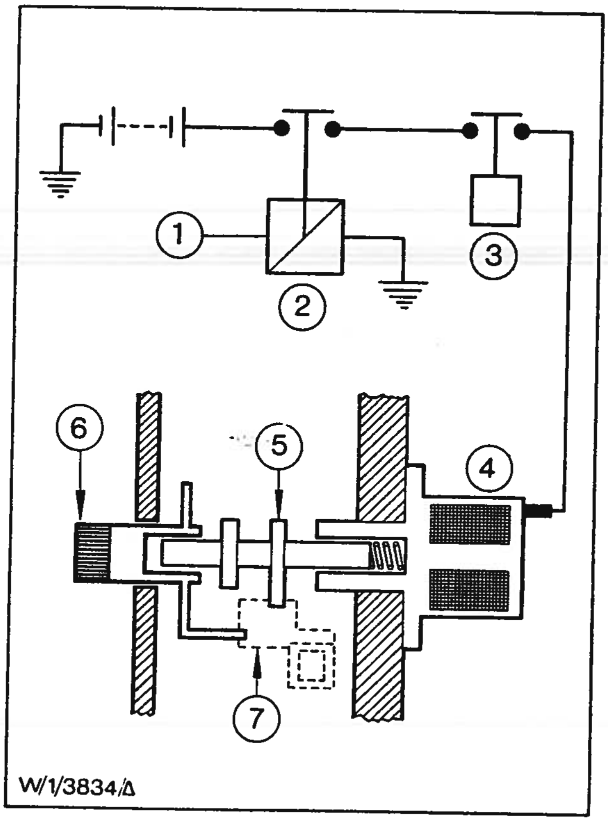


Fig. 26 - Excess Fuel Device Schematic
1. Ignition Switch Contacts
2. Starter Relay
3. Excess Fuel Temperature Switch
4. Excess Fuel Solenoid
5. Maximum Stop Lever
6. Engine Stop Lever Shaft
7. Control Rod Bracket

Boost Control Unit - Turbocharged Engines Only

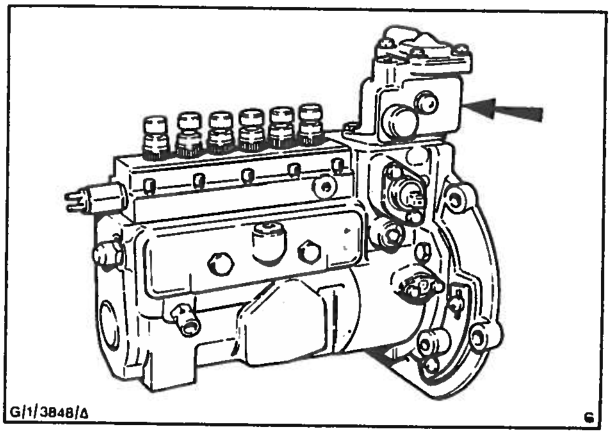


Fig. 27 - Boost Control Unit

This unit prevents overfuelling during acceleration in the low turbocharger speed range by controlling fuel flow in relation to manifold air pressure.

Bolted to the top of the pump governor (Fig. 27), the unit functions as a variable position maximum fuel stop. The casing is divided into two chambers, the upper containing a spring loaded piston type diaphragm assembly. A cover plate encloses the diaphragm and is connected by sensing pipeline to the intake manifold.

As illustrated in Fig. 28, a central rod is connected to the diaphragm and passes through a guide bush in the casing into the lower chamber. The fork end of a camplate is pivoted to the lower end of the rod. The opposite end of the camplate is enclosed in a 'C' shaped shoe and pivoted into the slotted block of the maximum fuel adjuster. This second pivot is so positioned to create a small lever between the pivot and the centre line of the block. A maximum fuel stop rod is fitted in the casing as shown. The rod is a free floating relay between the 'C' shaped shoe and the maximum fuel stop lever in the governor casing.

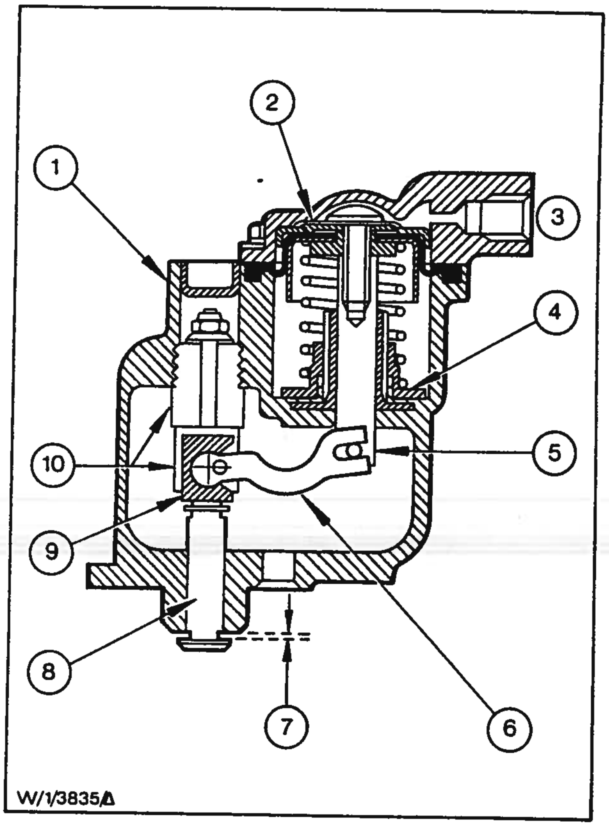


Fig. 28 - Boost Control Unit Semi-Schematic
1. Casing
2. Diaphragm and Piston Assembly
3. Air Connection
4. Spring Seat (Adjuster)
5. Rod
6. Camplate
7. Effective Movement of Rod
8. Fuel Stop Rod
9. Shoe
10. Maximum Fuel Adjuster and Slotted Block

The illustration shows the unit in the 'zero-boost' condition. The fully relaxed diaphragm rod position creates maximum camplate leverage in a downward (fuel restricting) direction. This position is relayed to the maximum fuel stop lever in the governor to determine the 'maximum fuel stop' for the current (turbocharger output) condition. As turbocharger output increases with speed, the higher manifold air pressure overcomes the diaphragm spring to reset the stop.

Adjustments on the vehicle are not permitted. Three points of adjustment are provided for use during calibration on a test rig:

a) Maximum Fuel Adjusting Screw. This hollow 'screw' is threaded into the casing to provide an adjustable mounting point for the slotted block. Turning the screw will reset the maximum fuel stop by raising or lowering the camplate pivot.

b) Diaphragm Spring Load. The lower spring seat is threaded onto the diaphragm rod guide bush. The edge of the seat is serrated to mate with a leaf spring and form a 'click' type of adjustment.

c) Zero boost. This adjustment (not shown) sets the zero boost position of the diaphragm by setting the maximum upward position of the rod pivot pin.

The adjuster is in the form of a thumb operated wheel nut which acts as a pivot stop.

Access to all adjustments is through a side cover plate which is secured by a tamperproof bolt.

OPERATION

Low Pressure System

Fuel is drawn through the water separator filter (if fitted) and/or the lift pump filter by action of the lift pump. The pressure forces fuel through the engine mounted filters and pressurises the injection pump fuel gallery. Pressure in the gallery is maintained by the self-idling action of the lift pump and limited by the relief valve on the engine mounted filter.

During engine running a small constant bleed occurs from the gallery through the restrictor/NRV assembly. The bleed, which ensures the clearance of any air in the system is normally connected to the leak-off line from the injectors. On engines with thermostart systems, the gallery bleed supplies the thermostart reservoir. Overflow from the reservoir rejoins the leak-off line to return to the tank.

High Pressure Generation - See Fig. 29

Given that the injection pump shut off lever is in the normal running position, high pressure is developed by the pump elements immediately camshaft rotation occurs. The sequence of events during the cycle of a pumping element is described and illustrated as follows.

At position 'A' the plunger is at the bottom of its stroke and fuel under lift pump pressure fills the pumping element via the two ports in the barrel.

As the camshaft rotates, the plunger rises until position 'B' is reached where fuel can no longer enter the element.

NOTE: During starting, when the plungers are in their starting fuel position, the barrel port closure is delayed by the starting groove. This function 'retards' the point (in terms of crankshaft degrees) at which pressure is sufficiently developed to cause injection. Further upward movement of the plunger compresses the fuel and begins to lift the delivery valve off its seat.

When the fuel pressure is sufficient to lift the delivery valve completely off its seat and the piston is clear of its guide (position 'C'), fuel passes along the pipe line to the injector.

The fuel pressure developed by the plunger lifts the injector needle valve off its seating and allows fuel in a highly atomised state to be sprayed into the cylinder. Fuel continues to be injected until the plunger reaches position 'D' where the helical groove contacts the spill port. At this position the fuel in the pumping chamber dissipates to low pressure via the central drilling and helical groove in the plunger. The reduction in pressure in the element causes the delivery valve to close rapidly.

The sudden reduction in pressure as the delivery valve closes is sufficient to allow the injector needle valve to snap shut under the force of its spring. This prevents fuel dribbling from the injector which would result in carbon build up on the injector tip.

Although the plunger continues to rise to the top of the stroke, the helical groove in the plunger prevents pressure being developed. The cam holds the plunger at the top of its stroke until that particular engine cylinder is on compression stroke again. This prevents the engine running in the reverse direction in the event of a backfire.

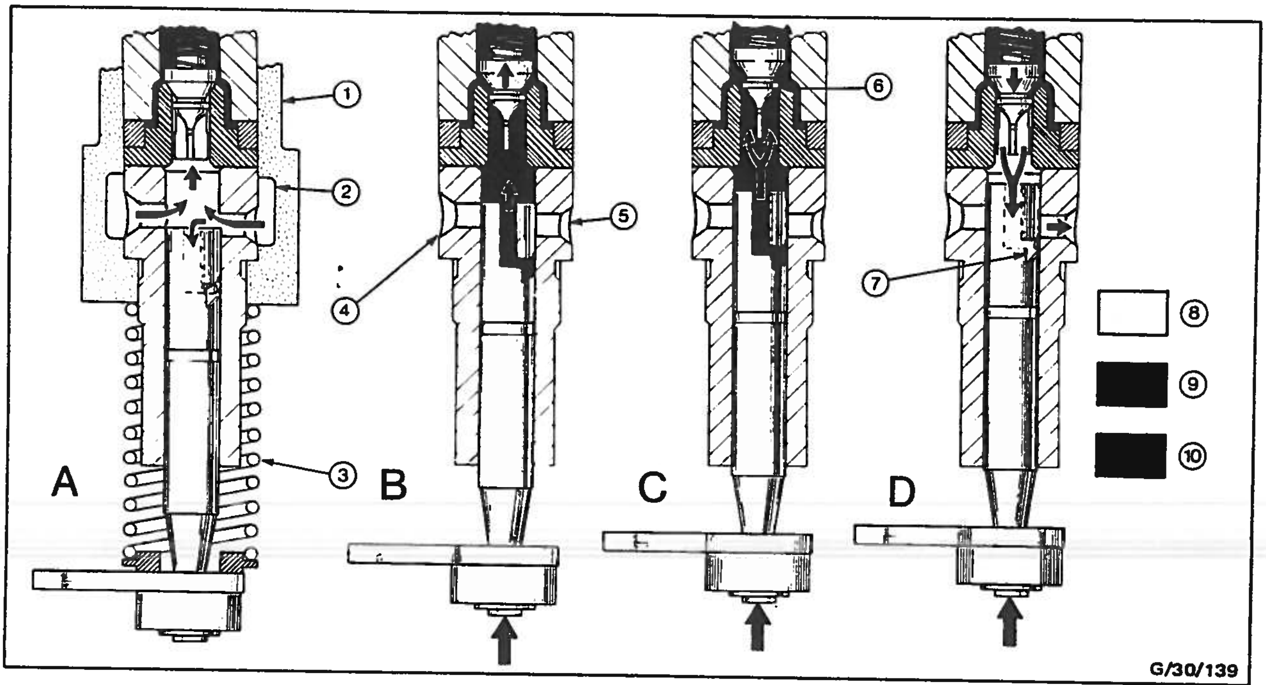


Fig. 29 - Pumping Element Action

1. Pump Body
2. Fuel Gallery
3. Plunger Spring
4. Inlet Port
5. Spill Port
6. Delivery Valve Piston
7. Helical Groove
8. Lift Pump Pressure
9. Injection Pressure
10. Delivery Line Residual Pressure

A. Element Filling
B. Inlet Port Shut
C. Injection
D. Spill Port Open

Fuel Control

The mount of fuel injected into the engine cylinders is entirely dependent upon the effective stroke of the pump plungers, i.e. inlet port closed to spill port open. This can be changed by turning the plungers to a new rotary position in their barrels, thereby altering the helical groove position in relation to the spill port.

The plungers are rotated in their barrels by means of arms attached to the base of each plunger, which in turn engage into forks on the control rod. Causing the control rod to move forward increases the effective stroke, whilst moving it rearwards decreases the stroke. The control rod is connected to the governor by a rocking lever, so that movement of the flyweights alters the volume of fuel delivered and thus controls the engine speed.

Since the governor flyweight force is opposed by the governor spring force, fuel delivery (and therefore engine speed) will be constant when the two forces are equal.

Static to Idling Speed - See Fig. 30

Before starting the engine and without any depression of the accelerator pedal, the governor flyweights will be fully closed and the plunger control rod will be in the maximum fuel position.

In cold weather conditions where the engine temperature is at or below 0 to 8°C (32 to 46°F) the excess fuel device should be operated. Where an automatic excess fuel device is fitted, the temperature switch will energise the excess fuel solenoid when the starter motor engages. In the pump this moves the maximum stop lever clear of the control rod bracket. Depression of the accelerator pedal will then cause the rod to move into the excess fuel position. This device is assisted by the starting groove on the plungers which together function to deliver a high volume supply at a retarded piston position.

As the engine starts and accelerates, governor flyweight centrifugal force increases. (At this point, the accelerator pedal should be released to idle, or acceleration will continue to maximum speed).

With the speed control lever in the idling position, the 'dumb-bell' shaped roller is at the top of the ramp and the governor spring load is small. Under these conditions the flyweights are thrown outward and the rocking lever pushes the control rod rearwards. This movement reduces the effective stroke of the element plungers to reduce the fuel quantity. Acceleration now reduces until centrifugal force falls enough to equal spring force. This balanced condition holds the control rod in a position suitable to result in the specified idling speed.

As the control rod resets towards the idle position, excess fuel and starting groove functions are automatically cancelled. The excess fuel solenoid de-energises as soon as the starter key is released. The excess fuel temperature switch will monitor the engine temperature during operation to determine and control the excess fuel requirement during any further engine starting.

If speed increases or decreases without changing the acclerator pedal setting, the flyweight force or the spring force (whichever is the greater) will reset the control rod to maintain the selected speed. When the accelerator pedal is depressed, the pump responds as described in the following text for maximum speed.

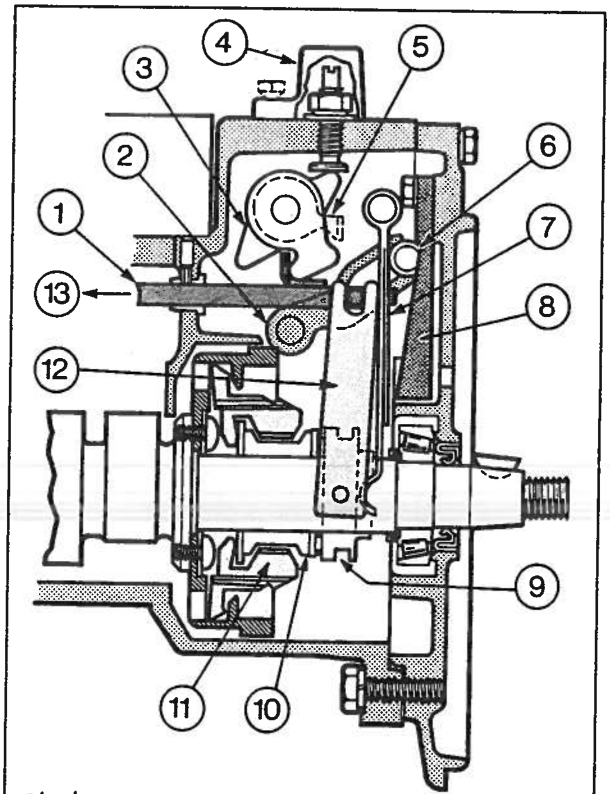


Fig. 30 - Governor Assembly
1. Control Rod
2. Roller Control Lever - moved by Speed Control Lever
3. Maximum stop lever
4. Maximum Fuel Stop (NA Engines)
5. Stop Control Lever
6. Roller
7. Governor Spring
8. Ramp
9. Thrust Pad
10. Sleeve
11. Flyweights
12. Rocking Lever
13. Direction for Minimum Fuel

Maximum Speed

Moving the speed control lever to the maximum position causes the roller to move down the ramp to increase governor spring load. The spring load is then sufficient to overcome the centrifugal force of the governor weights and move the sleeve and thrust pad along the camshaft.

This motion is transmitted to the control rod by the rocking lever which pulls the rod forwards, increasing the volume of fuel injected with subsequent rise in engine speed. The maximum fuel position is reached when the control rod bracket contacts the maximum fuel stop camlike lever which in turn contacts the maximum fuel stop in the top of the governor housing. (On turbo-charged engines the lever contacts the fuel stop rod in the boost control unit).

Should the engine speed continue to increase when the control rod has reached this position, the centrifugal force of the governor weights will overcome the spring load and move the sleeve and thrust pad along the camshaft. The rocking lever will then push the control rod to reduce the volume of fuel delivered until engine speed falls.

The engine speed is therefore at all times proportional to the governor spring load, enabling accurate and sensitive speed control to be maintained throughout the engine speed range.

SERVICING THE FUEL INJECTION PUMP

The complete procedure for dismantling, overhauling, assembling and testing injection pumps is given in the separate publication '2720 Range Fuel Injection Equipment'. Consequently, the following information covers only removal, replacement and timing of the injection pump plus checks and adjustments that can be made while the pump is mounted on the engine.

Removing the Injection Pump

1. Disconnect the battery and, where fitted, detach the excess fuel electrical connection from the pump.

2. Disconnect the engine stop control cable or linkage and the throttle return spring and linkage.

3. Disconnect all fuel and oil pipes from the pump. On turbocharged engines, disconnect the boost control pipe.

4. Remove the pump flange securing bolts and lift out the pump. Fit a suitable blanking plate or cover over the gear housing aperture and fit blanking caps or plugs to all open ended pipes and connectors.

If the pump has automotive or G.P. governing and is to be renewed, remove the four outer socket headed screws from the pump driving gear and retain the gear ring, plate and screws for fitting to the new pump - see Fig. 31. Examine for satisfactory condition and renew parts as necessary.

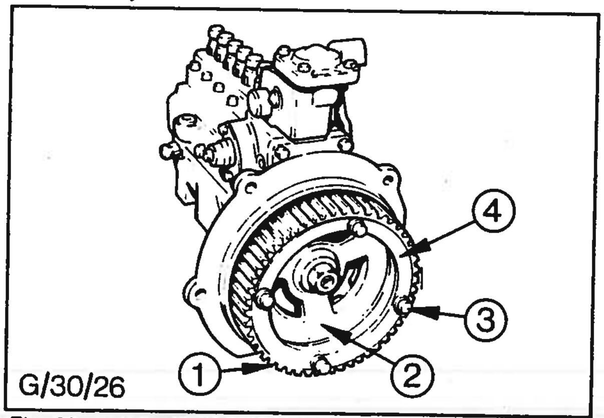


Fig. 31 - Injection Pump Drive Gear - Automotive and G.P. Governed Pumps Only

1. Ring Gear
2. Drive Hub
3. Clamping Screws
4. Clamping Plate

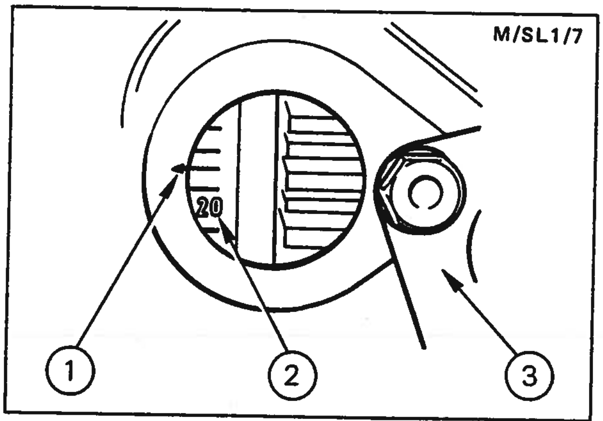


Fig. 32 - Engine Timing

1. Timing Mark on Housing
2. Timing Scale on Flywheel
3. Timing Aperture Cover

Replacing the Injection Pump

1. 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 T.D.C. on No. 1 cylinder is indicated against the timing mark on the edge of the timing aperture (Fig. 32). No. 1 cylinder must be on the compression stroke.

NOTE: If the correct piston stroke is in doubt, remove the rocker cover and 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.

2. If a new pump with automotive or G.P. governing is being installed, fit the ring gear and plate in position, but do not fully tighten the screws (Fig. 31). Drain any oil from the fuel gallery of the new pump.

3. Remove the blanking plug from the timing bush or aperture on the pump mounting flange - refer to Fig. 33 or 34 as appropriate.

4. Rotate the pump drive gear until the timing hole is centred in the bush or flange aperture then screw the timing tool (23-507 or 23-504) into position - see Fig. 33 or 34 as appropriate. Rotate the drive gear slightly as necessary to engage the tool plunger in the hole in the gear.

5. On automotive and G.P. governed pumps, remove the adjustment cover plate on the front of the timing cover (Fig. 35).

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

NOTE: In the case of automotive or G.P. governed pumps, 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.

7. In the case of automotive or G.P. governed pumps, 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 and replace and tighten the blanking plug.

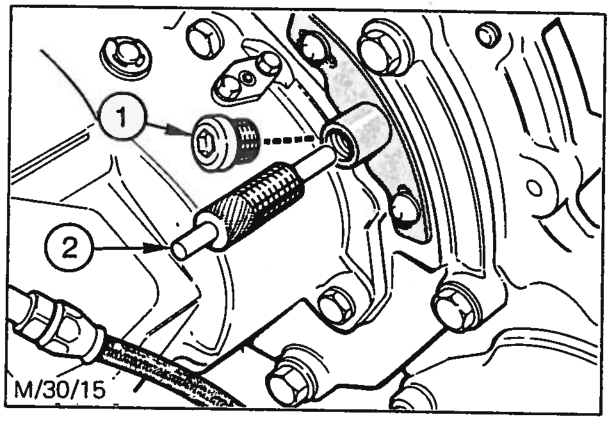


Fig. 33 - Injection Pump Timing - Automotive and G.P. Governed Pumps
1. Timing Bush Blanking Plug
2. Timing Tool 23-507

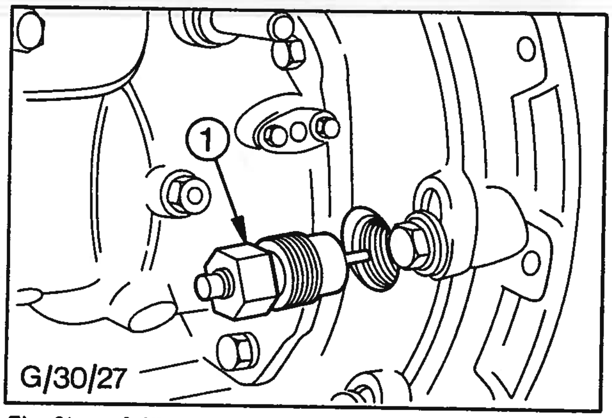


Fig. 34 - Injection Pump Timing - Class 'A' and Combine Harvester Governed Pumps
1. Timing Tool No. 23-504

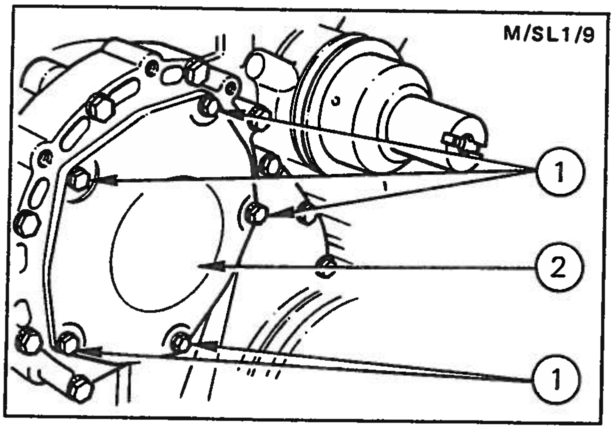


Fig. 35 - Removing Injection Pump Timing Aperture Cover Plate - Automotive and G.P. Governed Pumps
1. Securing Bolts
2. Cover Plate

8. Connect the high pressure pipes, the oil feed pipe (where applicable) and the fuel inlet pipe to the pump, tightening the unions to the specified torque figures. On turbocharged engines, reconnect the boost control pipe.

9. Reconnect the throttle cable or linkage and spring and the engine stop control cable or linkage.

10. Where applicable, reconnect the excess fuel electrical connection.

11. On thermostart reservoirs which have been disconnected, reconnect all except the overflow pipe. Where no thermostart(s) are fitted, remove the fuel pipe from injection pump non-return valve.

12. Prime the system by operating the priming pump until air free fuel flows from the pump non-return valve or thermostart overflow. Refit the pipe.

13. On new pumps with automotive or G.P. governing only, remove the oil filler plug and insert the specified quantity of engine oil. Refit and tighten the plug.

14. In the case of Class 'A' or combine harvester governed pumps, remove the oil filler and level plugs and top up with new engine oil as necessary. Refit and tighten plugs - see Fig. 36.

15. Connect the battery.

Checking/Adjusting the Injection Pump Timing

Carry out operations 1 and 2 under 'Replacing the Injection Pump' then proceed as follows:

1. Screw the appropriate timing tool into position. If the pump is correctly timed, the tool plunger will engage in the hole in the drive gear hub. If the tool plunger will not engage, carry out the following operations as applicable:

2. On automotive and G.P. governed pumps, remove the adjustment cover plate (Fig. 35) and slacken the four drive gear clamping screws. Rotate gear slightly as necessary until tool plunger engages, then tighten clamping screws to recommended torque value. Check that correct flywheel marking is still indicated. Replace the timing cover adjustment plate and tighten the securing screws (Fig. 35).

3. On Class 'A' and combine harvester governed pumps, slacken injection pump securing bolts and rotate complete pump until tool plunger engages. If necessary, slacken high pressure pipe clamps to assist pump movement. Tighten pump securing bolts and check that correct flywheel marking is still indicated.

4. Remove timing tool and replace and tighten blanking plug.

5. Replace flywheel timing aperture cover plate and tighten securing screw.

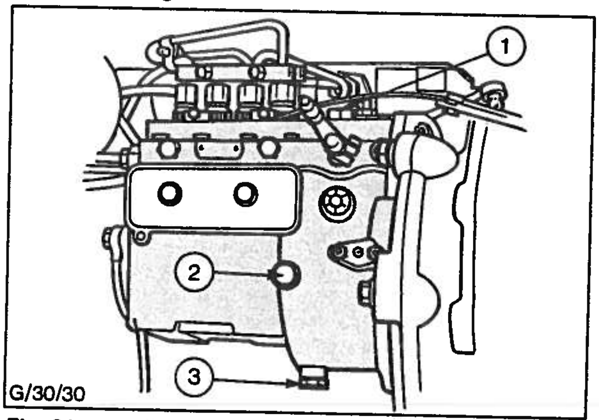


Fig. 36 - Injection Pump Oil Plugs (Class 'A' and Combine Harvester Governing Only)
1. Filler Plug
2. Level Plug
3. Drain Plug

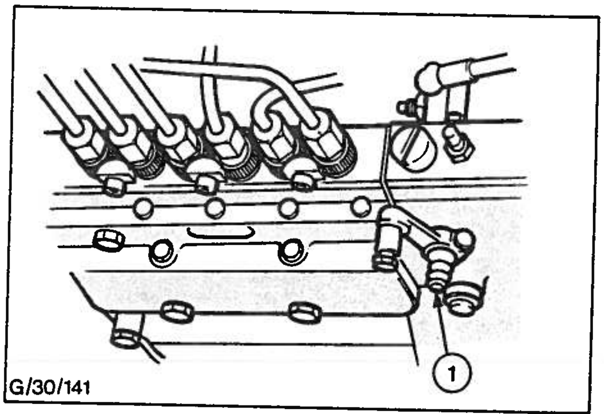


Fig. 37 - Excess Fuel Control - Manual Type
1. Excess Fuel Button

CHECKS AND ADJUSTMENTS ON THE ENGINE

Excess Fuel Operation - Class 'A' and Combine Harvester Governed Pumps with Manual Operation

1. Move the fuel injection pump throttle lever to the maximum fuel delivery position and hold.

2. Press the excess fuel button (Fig. 37) in until a distinct 'click' is heard.

3. Release the throttle lever allowing it to return to the idle position.

4. Move the fuel injection pump stop control lever to the 'no fuel' delivery position. The excess fuel button should now throw out.

5. If the button does not throw out, then ease back the gaiter on the excess fuel shaft and apply a few drops of clean engine oil to the shaft. Work the shaft in and out until it is free; the throttle should be held in the idle position.

6. Test for button 'throw out' again as formerly described. If sticking occurs the shaft may be bent; if so, it must be renewed - refer to separate publication '2720 Range Fuel Injection Equipment' for overhaul procedures.

Excess Fuel Operation - Automotive and G.P. Governed Pumps and Class 'A' and Combine Harvester Governed Pumps with Optional Automatic Operation

Operation during starting depends on whether or not the 'excess fuel temperature switch' contacts are closed (see Fig. 38). The switch is fitted on or near the engine thermostat housing to sense the metal temperature (not the coolant temperature). At or below 0 to 8°C (32 to 46°F) the closed contacts will complete a circuit to the solenoid when the starter relay is energised. Operating the throttle lever will then cause the control rod to move into the excess fuel position.

If the temperature is too high for normal operation, the solenoid can be tested by connecting its 'Lucar' blade terminal directly to the battery positive terminal with a length of insulated wire. The solenoid should be heard to 'click' when the connection is made and again when the wire is removed. If no 'click' can be heard the solenoid is probably faulty and should be renewed - refer to the separate publication '2720 Range Fuel Injection Equipment'.

Idling Speed Adjustment

1. Run the engine until normal operating temperature is reached, then adjust the idling speed stop screw (Fig. 39) to give the idling speed recommended by the equipment manufacturer. Blip the throttle to ensure a consistent return to this setting.

2. Where an idling damper is fitted, remove the cover at the front of the pump (Fig. 39), slacken the locknut and unscrew the damper screw approximately five turns.

3. When the idle speed adjustment is completed, screw in the damper screw until it just begins to affect the idling speed, then unscrew it half a turn and tighten the locknut. Replace cover.

NOTE: A completely cold engine, with the correct idling adjustment, may stall but will run satisfactorily after approximately 30 seconds warm-up. Do not increase the idling speed to compensate for this stalling condition when the engine is cold.

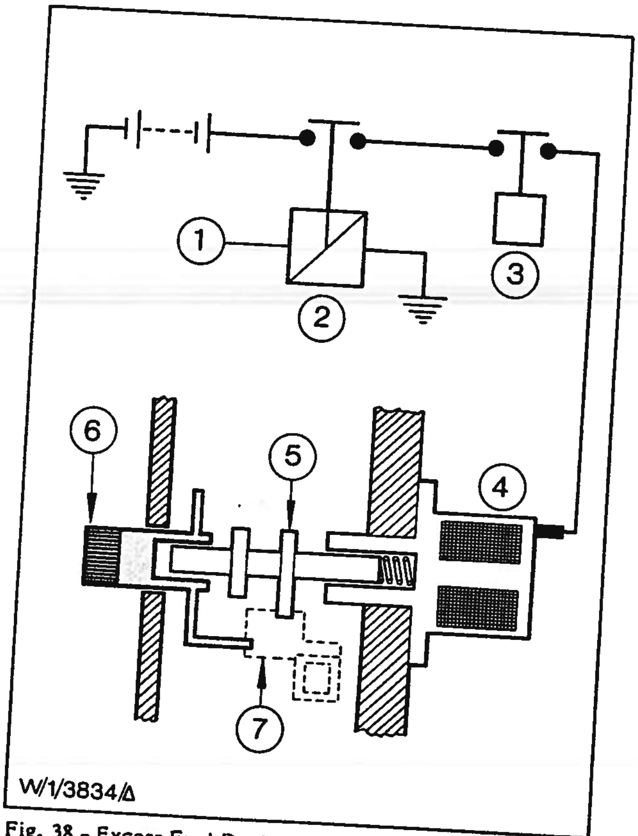


Fig. 38 - Excess Fuel Device Schematic
1. Ignition Switch Contacts
2. Starter Relay
3. Excess Fuel Temperature Switch
4. Excess Fuel Solenoid
5. Maximum Stop Lever
6. Engine Stop Lever Shaft
7. Control Rod Bracket

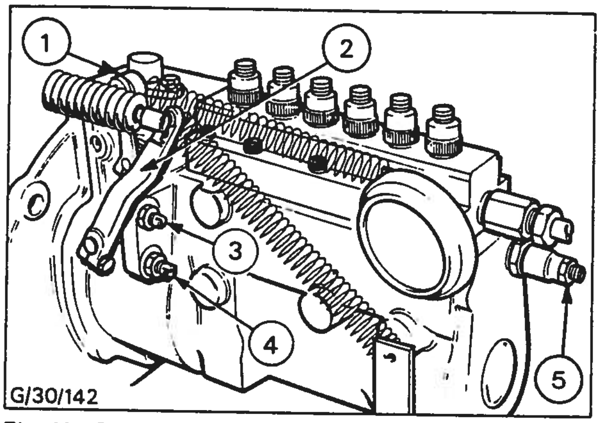


Fig. 39 - Speed Adjustments
1. Stop Control Lever
2. Speed Control Lever
3. Idle Speed Stop Screw
4. Maximum Speed Stop Screw
5. Idling Speed Damper (Cover Removed)

MAXIMUM NO-LOAD SPEED ADJUSTMENT

1. With the engine running at normal operating temperature, with no load applied, operate the throttle control to hold the governor control lever against the maximum speed stop. Adjust the stop screw (see Fig. 39) to give the specified no-load speed.

2. Tighten the locknut and seal the adjusting screw.

TURBOCHARGER

DESCRIPTION

The turbocharger consists of three main sections; the compressor housing, the turbine housing and the central core assembly - refer to Fig. 40.

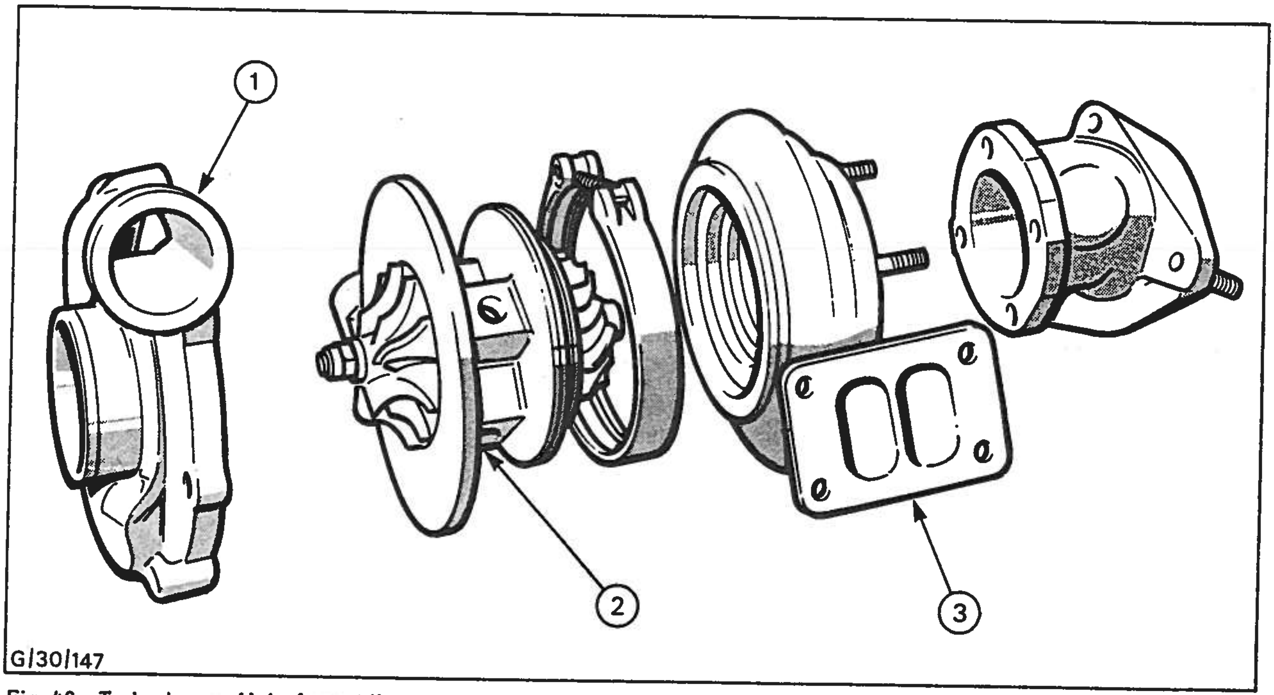


Fig. 40 - Turbocharger Main Assemblies
1. Compressor Housing 2. Centre Core (or Rotor) Assembly 3. Turbine Housing

The Compressor Housing

The compressor housing is made of aluminium alloy and is partly machined locally inside to ensure a very close fit around the compressor wheel. This close fit reduces the air leakage back past the compressor wheel to a minimum and contributes to a high volumetric efficiency in the compressor.

The Turbine Housing

The turbine housing is made of high heat-resistant cast iron and is also machined locally inside, like the compressor housing, for close fit with the turbine wheel for high volumetric efficiency.

The Central Core Assembly

The central core contains a finely machined bore for the bearing, which being fully floating, is a running fit in the housing. An oil drilling in the housing conveys oil to the bearing. The axial location of the shaft and wheel assembly relative to the housing is controlled by a bronze thrust plate which is located in the housing by a pair of dowels, a circular insert and a large circlip. The insert together with a spacer sleeve on the shaft, provide an air seal between the compressor housing and the bearing cavity by means of a sealing 'piston' ring which is held in a groove in the spacer sleeve.

Exhaust gas sealing between the turbine housing and the bearing cavity is similarly effected by two 'piston' ring seals. However, in this case the rings are held in grooves machined in a shoulder on the shaft itself immediately behind the turbine wheel.

The compressor wheel is a separate component made of high strength aluminium alloy secured to the shaft by a self-locking nut. The turbine wheel is made of high-grade heat and creep resistant steel and is integral with the shaft. The tin-plated bronze bush type bearing has an internal and external recess machined in the middle. Six oil drillings in the bush connect the inner and outer recesses and permit lubricating oil under pressure to flow first to the inner recess and then, between the shaft and the bearing. An oil deflector plate is fitted between the thrust plate and the housing insert to limit the amount of oil leaving the bearing at the compressor end from reaching the compressor 'piston' sealing ring. Normally, pressure outboard of the 'piston' sealing ring is in excess of the pressure in the bearing housing; except when the air cleaner element is blocked causing increased lubricating oil consumption.

Lubrication

An external feed pipe supplies oil to the turbocharger and is specially shaped to form a small reservoir. When the engine has been stationary for a period, overnight for instance, the lubricating oil in the galleries and in the turbocharger bearing tends to drain away. This small pocket of oil assists in initial lubrication of the turbocharger bearing on start-up while the main lubricating oil feed system to the turbocharger is priming.

OPERATION - Refer to Fig. 41

The exhaust gases, as they leave the exhaust manifold, enter the turbine housing by a passage cast in the housing, which connects tangentially with a hollow annular ring. The annular ring is of progressively decreasing cross-sectional area and is also part of the casting. The hot gas, still expanding, progresses round this ring and reaches a very high velocity. At this point the gas enters the outer periphery of the turbine wheel and catches the blades of the turbine wheel, driving it round at very high speed. The gas leaves at the centre, or 'eye', of the turbine and is directed into the exhaust pipe.

The turbine wheel and the compressor wheel, since they are directly connected, run at the same speed. Clean air, from the air cleaner, is drawn into the compressor housing at the 'eye' of the compressor wheel, it is caught by the compressor wheel blades and whirled round with the wheel at very high speed. At this speed the air acquires 'weight' and is flung outwards by centrifugal force into a hollow annular ring and is discharged, at approximately twice atmospheric pressure, tangentially into a feed pipe which is connected to the engine inlet manifold.

REMOVING THE TURBOCHARGER

1. Disconnect and remove the turbocharger oil feed pipe and oil return pipe.

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

3. Remove nuts securing turbocharger to support plate and detach the exhaust outlet elbow and/or the exhaust pipe. Discard gasket(s). Remove turbocharger support plate and bracket from cylinder block.

4. Remove bolts securing turbocharger to exhaust manifold and detach the turbocharger. Discard the gasket. Protect turbocharger from ingress of dirt and foreign bodies until it is overhauled and/or replaced on the engine.

TURBOCHARGER OVERHAUL - GARRETT AIRESEARCH TYPE

Dismantling

1. Clean the exterior of the assembly before dismantling. Dry clean if possible. DO NOT use any caustic solvents.

2. Carefully mark and also note the position of the housings and backplate relative to the centre housing for correct reassembly.

3. Bend back the locktabs, remove the bolts, clamps and lockplates, and separate the compressor and turbine housings from the centre housing assembly. If the housings are tight, tap them off with a soft faced hammer.

CAUTION: ONCE THE HOUSINGS ARE REMOVED TAKE EXTREME CARE NOT TO DAMAGE THE COMPRESSOR OR TURBINE BLADES. IF A TURBINE OR COMPRESSOR WHEEL IS DAMAGED IT CANNOT BE REPAIRED AND THE WHEEL MUST BE RENEWED.

4. Mount the centre housing assembly in a suitable fixture to stop the turbine wheel turning. If the nut on the turbine end of the shaft has not been ground off for balancing this may be located in a socket held in a vice. Otherwise manufacture a simple fixture as shown in the illustration, Fig. 42.

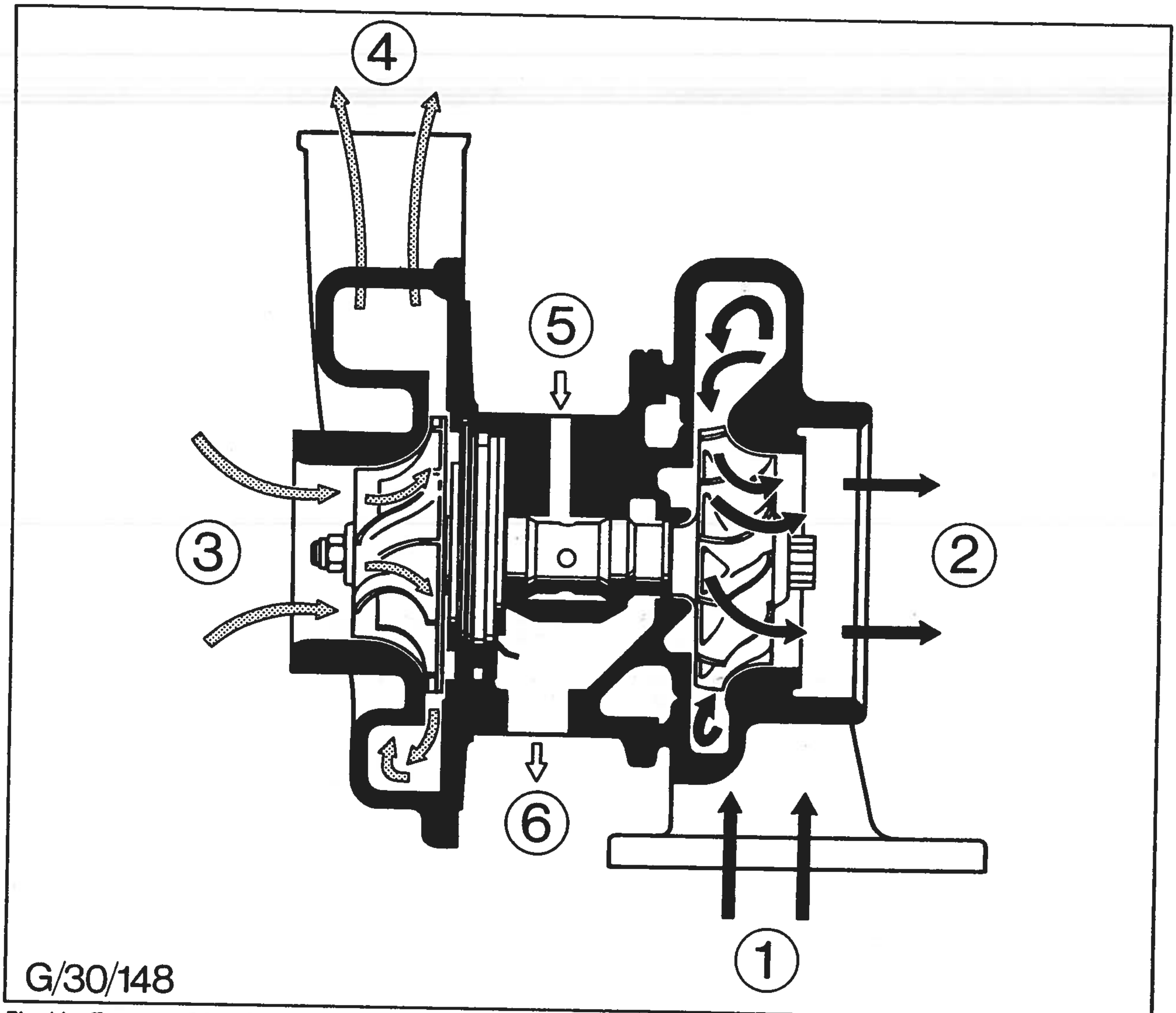


Fig. 41 - Turbocharger Operation
1. Exhaust Gases from Manifold
2. Exhaust Gases to Exhaust Pipe/Silencer
3. Air Inlet
4. Compressed Air to Inlet Manifold
5. Lubricating Oil Inlet
6. Lubricating Oil Drain

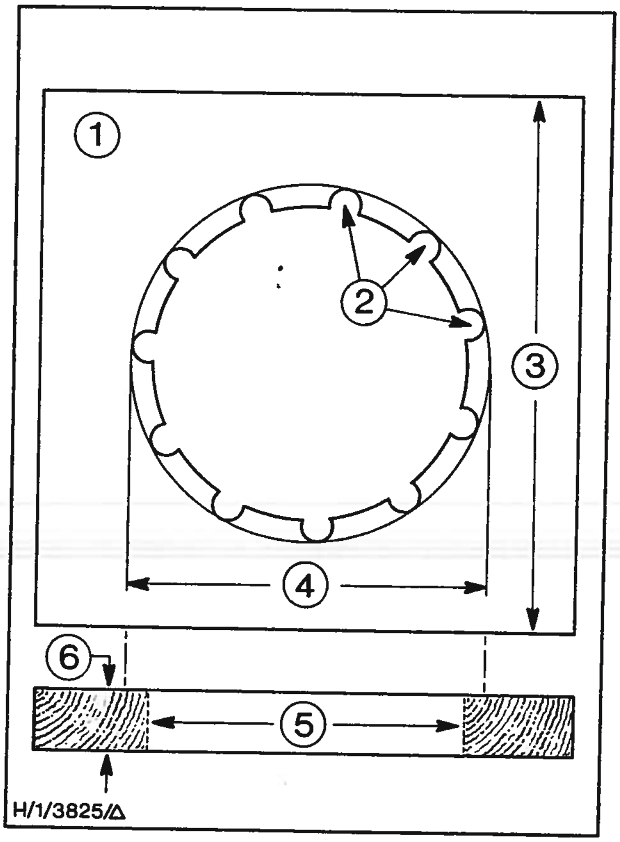


Fig. 42 - Holding Fixture Dimensions
1. Plywood or Hardwood Block
2. 11 Holes 8 mm (0,3125 in) Dia. Equidistant
3. 115 mm (4,5 in)
4. 75 mm (3,0 in)
5. 66 mm (2,625 in)
6. 12 mm (0,5 in)

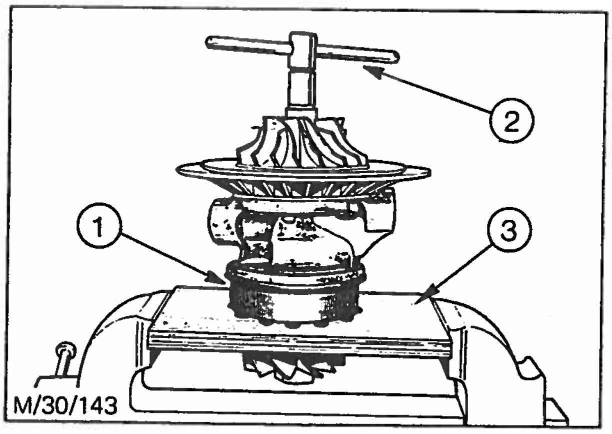


Fig. 43 - Compressor Wheel Locknut Removal
1. Centre Housing Group Located in Fixture
2. T-Handled Wrench
3. Fixture Held in Vice

5. Using a T-handled wrench slacken the compressor wheel locknut, applying equal pressure to both ends of the 'T' to avoid possible bending of the shaft (Fig. 43).

6. Support the turbine wheel, remove the compressor wheel locknut and lift the compressor wheel off the shaft.

7. Withdraw the turbine wheel and shaft out of the housing, keeping the shaft central until clear of the bearings. At the same time the turbine wheel shroud, which is not secured, can be lifted off.

8. Remove the locktabs and bolts, and separate the backplate from the housing. Tap the plate off with a soft faced hammer if it is tight.

9. Remove the thrust bearing and collar.

10. Remove the outer circlips and the bearings from the centre housing. Remove the inner circlips.

Cleaning and Inspection

Before cleaning, inspect all parts for signs of rubbing, burning or other damage which might not be evident after cleaning.

Soak all the parts in clean, non-caustic, carbon solvent. After soaking remove all dirt particles using a soft bristle brush as necessary, and blow dry.

Inspect all components for signs of damage, corrosion, wear or deterioration.

Turbine Wheel:

The turbine wheel and shaft assembly must not show signs of rubbing, scoring, scratching or seizure in the bearings. The shaft must not be bent, or the threads damaged. The turbine blades must not be torn, chipped or worn to a feather edge.

Compressor Wheel:

The compressor wheel must not show signs of wear, rubbing or damage by dirt or other materials. The bearing faces and bore of the wheel must be free from scores or signs of 'pick-up'.

The piston seal grooves and surfaces must not show signs of wear, rubbing or scoring of sealing surfaces.

Housings:

The housings must not show signs of contact with rotating parts. Oil and air passages must be clean and free from obstructions. If the bearing bores in the centre housing are damaged or worn, renew the housing.

Thrust Bearing:

Renew the thrust bearing and collar if they show signs of wear, scoring, nicks, varnish deposits or deeply embedded grit.

Minor surface damage can be removed from any component by polishing or burnishing with abrasive cloth. Use silicon carbide cloth for aluminium parts and polishing (crocus) cloth for steel parts.

Assembly - Refer to Figs. 44 and 45

NOTE: The internal parts of the turbocharger rotate at very high speeds. It is of particular importance that scrupulous attention is given to cleanliness to prevent the ingress of foreign matter during assembly. DO NOT use fluffy cloths or cleaning materials.

1. Install the inner circlips, lubricate and install the bearings and secure them in the centre housing with the outer circlips.

2. Fit the new piston ring seal to the turbine shaft, install the shroud over the end of the centre housing and, holding the turbine wheel upright, gently slide the shaft through the shroud and bearings. Take care to ensure that the piston ring seal locates correctly in the end of the centre housing and is not damaged on entry.

3. Fit the new piston ring seal to the thrust collar, assemble the collar to the thrust bearing and carefully install the assembly over the end of the shaft so that the thrust bearing locates on the anti-rotating pegs and lies flat against the centre housing.

NOTE: The anti-rotating pins are offset to ensure correct fitting.

4. Ensure that the thrust spring is correctly located in the backplate. Place the new seal ring into the groove in the centre housing, fit the backplate over the end of the shaft to locate over the end of the thrust collar, engage the piston ring seal in the bore of the backplate taking care not to damage the seal on entry. Align the mounting bolt holes using the marks made on dismantling, install the bolts with new lockplates, evenly tighten them to the specified torque and secure the locktabs.

5. Fit the compressor wheel over the end of the shaft, lightly oil the threads and face of the locknut and screw it onto the shaft. Using a T-handle torque wrench or torque driver (to avoid any possibility of bending the shaft), carefully tighten the locknut to the specified torque and then through a further angle of 90°.

6. Locate the compressor housing to the backplate, line it up correctly with the marks made on dismantling, install the clamps, lockplates and bolts and tighten them to the specified torque.

7. Locate the turbine housing to the centre housing, line it up correctly with the marks made on dismantling. Apply the specified anti-seize compound to the bolt threads, install the clamps, lockplates and bolts and tighten them to the specified torque.

8. Push the turbine shaft fully one way then the other and check that it rotates freely in all positions without rubbing or binding.

9. Fit protective covers to all openings until the turbocharger is fitted to the engine.

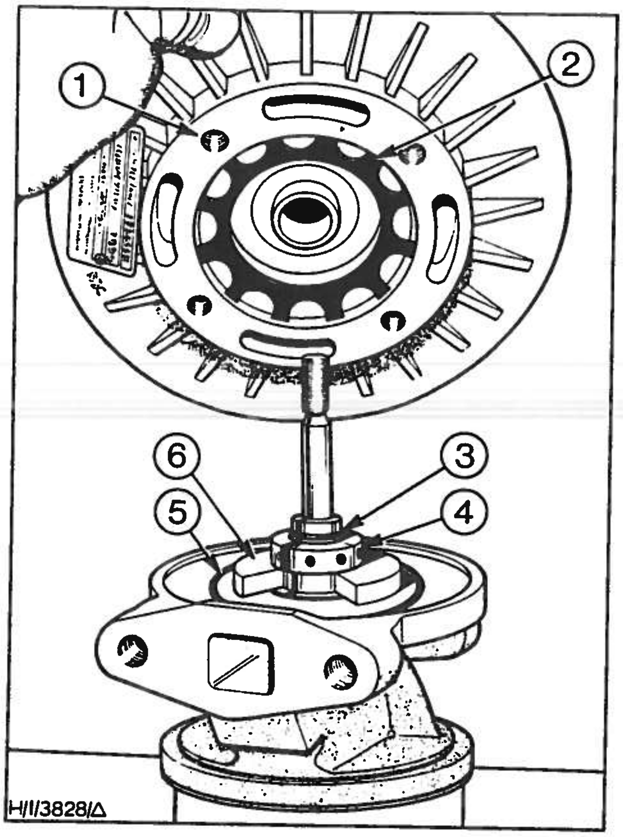


Fig. 45 - Thrust Bearing and Backplate Installation
1. Backplate
2. Thrust Spring
3. Piston Ring Seal
4. Thrust Collar
5. Seal Ring
6. Thrust Bearing

TURBOCHARGER OVERHAUL - HOLSET TYPE - Refer to Fig. 46

Dismantling

1. Clamp unit upright in vice on turbine inlet flange.

2. Mark relative positions of turbine housing (24), bearing housing (20), compressor diffuser (4) and compressor housing (1).

3. Knock back all tabs on lockplates fitted to turbine housing bolts (16) and also compressor housing and diffuser bolts, if fitted.

4. Remove bolts (7) and clamping plates (6) fastening compressor housing (1) to compressor diffuser (4) and lift off housing.

5. Remove bolts (16) and clamping plates (18) fastening turbine housing (24) to bearing housing (20) and lift the core assembly clear of the turbine housing.

6. Holding the turbine wheel at the hub in a suitable fixture, remove the impeller locknut (2).
Note: Left Hand Thread. Take care not to bend the shaft.

7. Slide the compressor impeller (3) off the shaft.

8. Remove bolts (19) fastening compressor diffuser (4) to bearing housing (20). Remove compressor diffuser (4) with oil slinger (9) from shaft. Push out oil slinger (9) from compressor diffuser (4) and remove 'SQ' ring seal (5) from rear of compressor diffuser.

9. Lift out oil baffle (10).

10. Remove the three screws (11) retaining thrust bearing (12). Lift out thrust bearing (12) and thrust collar (13).

11. Remove shaft and wheel (23) together with its seal (split ring) (22) and lift turbine heat shield (21) off shaft.

12. Remove outboard retaining ring (14) at compressor end. Insert finger tip into bearing (15) and remove. Remove inboard retaining ring (14).

13. Remove outboard retaining ring (14) at turbine end. Insert finger tip into bearing (15) and remove. Remove inboard retaining ring (14).

8. Push the turbine shaft fully one way then the other and check that it rotates freely in all positions without rubbing or binding.

9. Fit protective covers to all openings until the turbocharger is fitted to the engine.

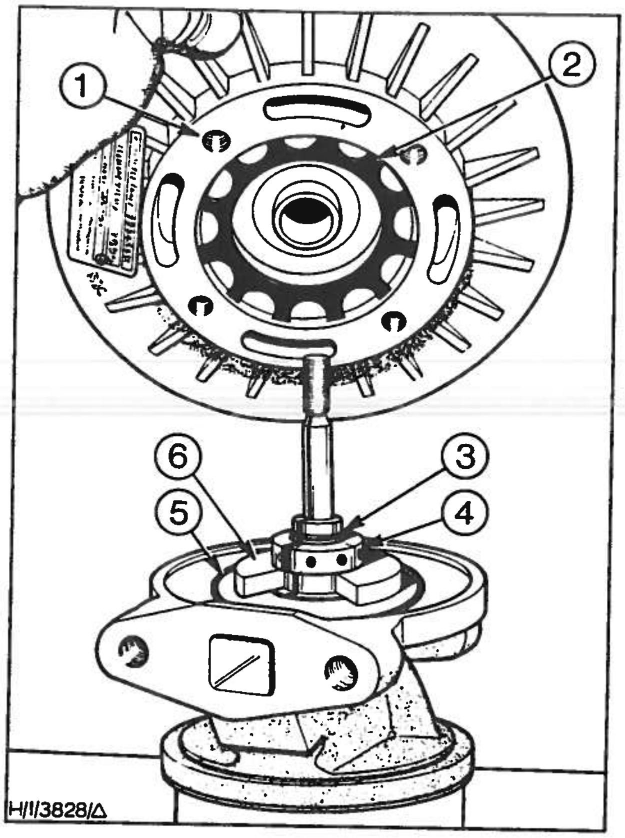


Fig. 45 - Thrust Bearing and Backplate Installation
1. Backplate
2. Thrust Spring
3. Piston Ring Seal
4. Thrust Collar
5. Seal Ring
6. Thrust Bearing

TURBOCHARGER OVERHAUL - HOLSET TYPE - Refer to Fig. 46

Dismantling

1. Clamp unit upright in vice on turbine inlet flange.

2. Mark relative positions of turbine housing (24), bearing housing (20), compressor diffuser (4) and compressor housing (1).

3. Knock back all tabs on lockplates fitted to turbine housing bolts (16) and also compressor housing and diffuser bolts, if fitted.

4. Remove bolts (7) and clamping plates (6) fastening compressor housing (1) to compressor diffuser (4) and lift off housing.

5. Remove bolts (16) and clamping plates (18) fastening turbine housing (24) to bearing housing (20) and lift the core assembly clear of the turbine housing.

6. Holding the turbine wheel at the hub in a suitable fixture, remove the impeller locknut (2).
Note: Left Hand Thread. Take care not to bend the shaft.

7. Slide the compressor impeller (3) off the shaft.

8. Remove bolts (19) fastening compressor diffuser (4) to bearing housing (20). Remove compressor diffuser (4) with oil slinger (9) from shaft. Push out oil slinger (9) from compressor diffuser (4) and remove 'SQ' ring seal (5) from rear of compressor diffuser.

9. Lift out oil baffle (10).

10. Remove the three screws (11) retaining thrust bearing (12). Lift out thrust bearing (12) and thrust collar (13).

11. Remove shaft and wheel (23) together with its seal (split ring) (22) and lift turbine heat shield (21) off shaft.

12. Remove outboard retaining ring (14) at compressor end. Insert finger tip into bearing (15) and remove. Remove inboard retaining ring (14).

13. Remove outboard retaining ring (14) at turbine end. Insert finger tip into bearing (15) and remove. Remove inboard retaining ring (14).

Cleaning and Inspection

Use a commercially approved cleaner only. Caustic solutions will damage certain parts and should NOT be used.

Soak parts in cleaner until all deposits have been loosened.

Use a plastic scraper or bristle type brush on aluminium parts. Vapour blast may also be used provided the shaft and other bearing surfaces are protected.

Clean all drilled passages with compressed air jet.

Make certain that surfaces adjacent to wheels on stationary housings are free of deposits and are clean and smooth.

Shaft and Wheel

Inspect bearing journals for excessive scratches and wear. Minor scratches may be tolerated.

Inspect seal (split ring) groove walls for scoring. Minor scratches are acceptable.

Check carefully for cracked, bent or damaged blades but DO NOT ATTEMPT TO STRAIGHTEN BLADES.

Thrust Parts

Renew if thrust faces are mutilated. Minor scratches are acceptable.

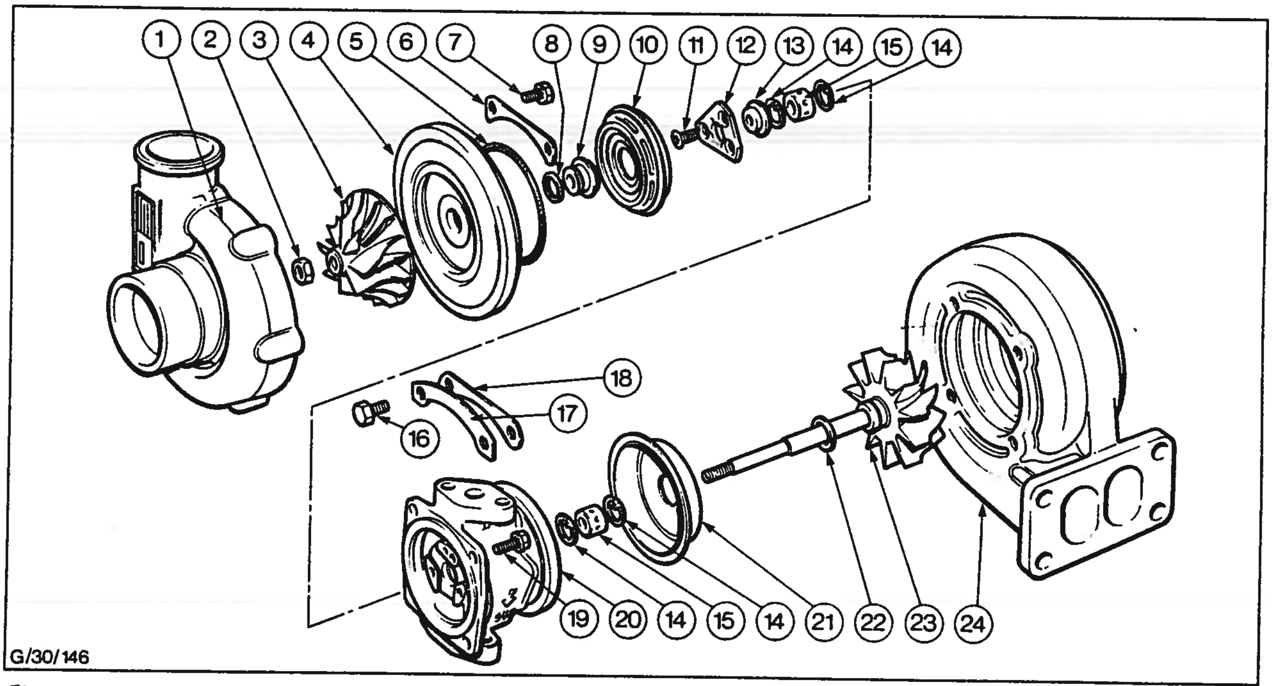


Fig. 46 - Exploded View of Holset Turbocharger

1. Compressor Housing
2. Locknut
3. Compressor Impeller
4. Compressor Diffuser
5. 'SQ' Ring Seal
6. Clamping Plate
7. Hex Head Setscrew and Washer
8. Seal (Split Ring)
9. Oil Slinger
10. Oil Baffle
11. Flat Head Capscrew
12. Thrust Bearing
13. Thrust Collar
14. Retaining Ring
15. Bearing
16. Hex Head Capscrew
17. Lockplate
18. Clamping Plate
19. Hex Head Setscrew and Washer
20. Bearing Housing
21. Heat Shield
22. Seal (Split Ring)
23. Shaft and Wheel
24. Turbine Housing

Renew thrust bearing if faces are worn excessively, unevenly or are severely scratched and otherwise mutilated.

The small feed grooves in the thrust bearing must be clean and free of obstruction.

Compressor Impeller

Check carefully for cracked, bent or damaged blades, but DO NOT ATTEMPT TO STRAIGHTEN BLADES.

Bearings

Renew bearings if excessively scratched or worn.

Bearing Housing

Renew bearing housing if bearing or seal (split ring) bores are excessively scratched or worn.

Rotor Parts

Check the rotor for balance (assembly instructions and Holset Publication "Balancing Turbochargers" gives details).

'SQ' Ring Seal

Renew if section through ring has taken a permanent set or if broken or damaged.

Compressor Housing

Inspect profile for damage due to contact with rotor. Slight damage may be tolerated, otherwise replace the housing with a new one.

Turbine Housing

Inspect profile for damage due to contact with rotor, cracks, flaking or signs of overheating. Slight damage may be tolerated otherwise renew the housing.

Assembly

When the turbocharger has been thoroughly cleaned, inspected and any damaged parts renewed, assembly can commence. It is advised that the following points be noted if a satisfactory rebuild is to be obtained.

a) The rotor should be check-balanced within 0,002 oz in (1,44 gm mm) at each end, and the parts suitably marked to ensure correct alignment (correlation) during subsequent re-assembly.

b) When replacing the retaining rings (14), ensure that the bevelled face is toward the bearing (15).

c) Lubricate bearings, bearing housing bore, thrust parts, seals (split ring) and rotor shaft with clean engine oil.

1. Replace inboard retaining ring (14) at turbine end, insert bearing (15) and secure with outboard retaining ring (14).

2. Replace inboard retaining ring (14) at compressor end, insert bearing (15) and secure with outboard retaining ring (14).

3. Ensure that split ring seal (22) is in position on the rotor shaft, place heat shield (21) on the housing (20), then slide the shaft carefully through the heat shield and bearings. Do not force the split ring seal (22) into the housing bore, as an off-centre ring will fracture, causing the shaft to bind.

4. Slide thrust collar (13) and thrust bearing (12) into position and secure bearing with the three screws (11). Tighten screws to specified torque value, using suitable adaptor.

5. Replace oil baffle (10).

6. Insert split ring seal (8) into compressor diffuser (4); do not force it into the bore as an off-centre ring will fracture causing the shaft to bind. Push the oil slinger (9) fully into position in the compressor diffuser.

7. Insert 'SQ' ring seal (5) in the compressor diffuser (4) and slide the diffuser over the shaft and up to the housing (20); take care not to trap or damage the 'SQ' ring seal. Secure the diffuser to the housing with the four setscrews and washers (19) tightened to the specified torque value.

8. Slide the compressor impeller (3) onto the shaft and screw on the locknut (2). Note that it has a left hand thread.

9. Hold the turbine wheel hub in a suitable fixture and tighten the impeller locknut to the specified torque, using a 'T' handled torque wrench to avoid bending the shaft. Remove from fixture and check that rotor spins freely.

10. Using a dial gauge indicator, check axial travel of the shaft between extreme positions. Total travel should be within 0,10 mm to 0,16 mm (0,004 in to 0,006 in). (This reading may be less if a great deal of oil was smeared on the thrust parts and bearings during assembly).

11. Mount the dial gauge indicator on the housing so that the anvil is resting on the compressor impeller boss and check extreme radial travel of the shaft by pushing the impeller towards and away from the dial indicator. Total travel should be within the following limits:

H1C/D: 0,46 mm to 0,30 mm (0,018 in to 0,012 in)
H2A: 0,47 mm to 0,31 mm (0,0185 in to 0,012 in)

12. Assemble bearing housing (20) to turbine housing (24) in the correct relative positions - refer to marks made when dismantling. Secure assembly with the two clamping plates (18) and lockplates (17) and four setscrews (16). Tighten screws to the specified torque value and check that rotor can spin freely. Bend up corners of lockplates to secure screw heads.

13. Assemble the compressor housing (1) to the diffuser (4) in the correct relative position - refer to marks made when dismantling. Secure assembly with the three clamping plates (6) and six setscrews and washers (7). Tighten screws to the specified torque value, then check that rotor can still spin freely.

14. Fit protective covers to all openings until the turbocharger is fitted to the engine.

Replacing the Turbocharger

1. Inspect air intake system for cleanliness and to ensure absence of foreign material.

2. Inspect exhaust manifold to ensure absence of foreign bodies.

3. Inspect oil drain line. Make certain that line is not clogged.

4. Inspect oil supply line for clogging, deterioration or possibility of leaking under pressure.

5. Inspect the turbocharger mounting pad on the manifold to make certain that all of the old gasket has been removed.

6. Assemble the turbocharger to the exhaust manifold using a new gasket. Secure with the four nuts tightened to the specified torque value.

7. Assemble the turbocharger support plate and bracket into position, placing a new gasket between support plate and turbocharger. DO NOT tighten the nuts securing the turbocharger to the support plate as a new gasket will be needed when fitting the exhaust pipe and/or elbow.

8. Connect the hose between turbocharger and inlet manifold and tighten hose clips.

9. On industrial engines connect the hose between turbocharger and air inlet pipe and tighten hose clips.

10. Connect the turbocharger oil feed pipe and oil return pipe but do not tighten the oil feed pipe union at the turbocharger.

11. Operate the starter motor while holding the injection pump fuel shut-off lever in the stop position. Crank the engine until oil flows from the turbocharger oil feed pipe, then tighten the connection and dry up the spilt oil. Crank again until oil pressure is indicated on the gauge (or the warning light goes out) and check for oil leaks.

NOTE: Before running the engine, the following 'Start-up Procedure' must be followed.

Start-Up Procedure

Serious damage to the turbocharger bearing can result from inadequate lubrication if the following recommendations are not observed.

Prior to the first start after a turbocharger has been newly installed or if, for any reason, the oil supply to the turbocharger has been disconnected, you should ensure that the turbocharger housing is filled with engine oil before reconnecting the oil feed pipe - see under 'Replacing the Turbocharger', Operation No. 11.

In the above circumstances, or in cases where the engine is being started for the first time after an oil change or after a period of 4 weeks or more without use, the following procedure shuld be used.

1. Fully pull out the stop control.

2. Crank the engine with the starter motor for 15 seconds.

3. Push the stop control fully in.

4. Start the engine and allow to idle (1000 rpm maximum).

5. Observe the oil pressure gauge or oil pressure warning light. If oil pressure is not registered on the gauge, or if the oil pressure warning light is not extinguished in the first few seconds of idling, stop the engine immediately and contact your dealer.

On every start up the engine should be allowed to idle (1000 rpm maximum) for 30 seconds before operating on load, to ensure an adequate oil supply to the turbocharger bearing. The engine should also be allowed to idle without load for two minutes before shut-down to enable the oil to dissipate the heat from the turbocharger bearing.

NOTE: Standby Generator and Alternator Sets. Because standby generator and alternator sets make fewer starts and stops than other industrial applications, the idling requirement of the stop/start procedure can be waived without undue risk of reduced life.

However, the recommended start-up procedure must be carried out for engines which have been inoperative for periods of four weeks or more.

Thermostarts are fitted as standard equipment on Turbocharged engines. It is recommended that this starting aid is used on every initial engine start. If, however, the engine has been 'shut down' for less than one hour, the thermostart operation can be waived.

Where possible, disconnect the driven equipment before starting.

SPECIFICATIONS

INJECTION PUMP

Make	C.A.V.	
Type	In-line with Mechanical Governor	
Rotation	Clockwise (from Drive End)	
Engine/Governing	**Injection Pump Part No.**	**CAV Pump Part No.**
2722/G.P.I	826F-9A543-DBB	P5510/2
2722/G.P.II	826F-9A543-DCB	P5513/2
2722/Class A, 1500/1800	826F-9A543-DDA	P5537/A
2722/Automotive	826F-9A543-DAC	P5485/3
2723/G.P.I.	826F-9A543-EBB	P5515/2
2723/Class A, 1500/1800	826F-9A543-EDA	P5538/A
2723/Automotive	826F-9A543-EAB	P5486/2
2723/Combine	826F-9A543-ECA	P5542
2725/G.P.I	826F-9A543-FCB	P5519/2
2725/G.P.II	826F-9A543-FDB	P5520/2
2725/Class A, 1500/1800	826F-9A543-FFA	P5539/A
2725/Automotive	826F-9A543-FAC	P5487/3
2725 Combine	826F-9A543-FEA	P5543
2726T/G.P.	826F-9A543-HCB	P5523/2
2726T/Class A, 1500/1800	826F-9A543-HFA	P5540/A
2726T/Automotive	826F-9A543-HAB	P5488/2
2726T/Marine*	826F-9A543-HHA	P5488/2E
2728T/Marine*	826F-9A543-HDB	P5525/2

* Fitted with two-lead (insulated return) excess fuel solenoid.

Oil Priming Quantities - Automotive and G.P. Governed Pumps Only (See Section 2 for Oil Specification)

4 cylinder engines	215 ml
6 cylinder engines	430 ml

Injection Timing to No. 1 Engine Cylinder: See Following Table

Idle Speed: See Following Table

Maximum No-Load Speed: See Following Table

Engine/Governing	Pump Timing B.T.D.C.	Engine Idling Speed in RPM	Engine Maximum No Load Speed in RPM
2722/G.P.I	22°	625 to 675	2705 to 2715
2722/G.P.II	22°	625 to 675	2815 to 2825
2722/Class A, 1500/1800	24°	850 to 950	1565 to 1575 1880 to 1890
2722/Automotive	22°	625 to 675	2915 to 2920
2723/G.P.I.	23°	625 to 675	2705 to 2715
2723/Class A, 1500/1800	26°	850 to 950	1565 to 1575 1880 to 1890
2723/Automotive	22°	625 to 675	2915 to 2920
2723/Combine	24°	1150 to 1250	2645 to 2650
2725/G.P.I	22°	625 to 675	2705 to 2715
2725/G.P.II	22°	625 to 675	2815 to 2825
2725/Class A, 1500/1800	24°	850 to 950	1565 to 1575 1880 to 1890
2725/Automotive	22°	625 to 675	2915 to 2920
2725/Combine	25°	1150 to 1250	2640 to 2645
2726T/G.P.	24°	625 to 675	2600 to 2610
2726T/Class A, 1500/1800	24°	850 to 950	1565 to 1575 1880 to 1890
2726T/Automotive	24°	625 to 675	2720 to 2730
2726T/Marine	24°	625 to 675	2720 to 2730
2728T/Marine	24°	625 to 675	2760 to 2770

NOTE: The maximum no-load speeds shown for combine engines are applicable to a residual load of 18,75 kW.
The maximum no-load speeds shown for all other engines are applicable to a residual load of 7,5 kW.

EXCESS FUEL TEMPERATURE SWITCH	
Contacts Close (Decreasing Temperature)	+3° to -3°C (37° to -22°F)
Contacts Open (Increasing Temperature)	5° to 11°C (41° to 52°F)

OIL BATH AIR CLEANER	
Oil Specification	FORD SM-2C-1017A

INJECTORS - CAV

Engine/Governing	Injector Part No.	CAV Injector Part No.	CAV Nozzle Part No.
2722/G.P.I	826F-9K546-DAB	LRB 6700807	6801018
2722/G.P.II	826F-9K546-DAB	LRB 6700807	6801018
2722/Class A, 1500/1800	826F-9K546-DAB	LRB 6700807	6801018
2722/Automotive	826F-9K546-DAB	LRB 6700807	6801018
2723/G.P.I	826F-9K546-DAB	LRB 6700807	6801018
2723/Class A, 1500/1800	826F-9K546-DAB	LRB 6700807	6801018
2723/Automotive	826F-9K546-DAB	LRB 6700807	6801018
2723/Combine	826F-9K546-DAB	LRB 6700807	6801018
2725/G.P.I	826F-9K546-DAB	LRB 6700807	6801018
2725/G.P.II	826F-9K546-DAB	LRB 6700807	6801018
2725/Class A, 1500/1800	826F-9K546-DAB	LRB 6700807	6801018
2725/Automotive	826F-9K546-DAB	LRB 6700807	6801018
2725/Combine	826F-9K546-DAB	LRB 6700807	6801018
2726T/G.P.	826F-9K546-HAA	LRB 6700805	6801016
2726T/Class A, 1500/1800	826F-9K546-HAA	LRB 6700805	6801016
2726T/Automotive	826F-9K546-HAA	LRB 6700805	6801016
2726T/Marine	826F-9K546-HAA	LRB 6700805	6801016
2728T/Marine	826F-9K546-HBA	LRB 6700806	6801017

Engine/Governing	Setting Pressure - New or Reconditioned with new spring that has not exceeded 10 hours life in an engine	Working Pressure - for Injectors that have exceeded 10 hours in an engine
2722/G.P.I 2722/G.P.II 2722/Class A, 1500/1800 2722/Automotive	208 to 218 bar (3016 to 3160 lbf/in^2)	197 bar (1407 lbf/in^2)
2723/G.P.I 2723/Class A, 1500/1800 2723/Automotive 2723/Combine	208 to 218 bar (3016 to 3160 lbf/in^2)	197 bar (1407 lbf/in^2)
2725/G.P.I 2725/G.P.II 2725/Class A, 1500/1800 2725/Automotive 2725/Combine	208 to 218 bar (3016 to 3160 lbf/in^2)	197 bar (1407 lbf/in^2)
2726T/G.P.I 2726T/Class A, 1500/1800 2726T/Automotive 2726T/Marine	208 to 218 bar (3016 to 3160 lbf/in^2)	197 bar (1407 lbf/in^2)
2728T/Marine	208 to 218 bar (3016 to 3160 lbf/in^2)	197 bar (1407 lbf/in^2)

Nozzle Holes	
Quantity:	Four (all types)
Diameter:	Type 6801018: 0,295 to 0,305 mm Type 6801016: 0,325 to 0,335 mm Type 6801017: 0,335 to 0,345 mm

Back Leakage Time

	Test Oil Ambient Temperature		Back Leak Time in Seconds
	°C	°F	
For a fall in pressure from 150 to 100 bar (2175 to 1450 lb/in^2)	10	50	7 to 34,5
	16	60	6 to 30
	21	70	5,5 to 27
	27	80	5 to 24
	32	90	4,5 to 21

Test Oil	Shell Calibration Fluid 'B' or 'C' or Equivalent

HOLSET TURBOCHARGERS

	Model H1C/D		Model H2A	
	mm	in	mm	in
Centre (Bearing) Housing				
Bearing bore diameter	15,875 - 15,885	0,6250 - 0,6254	15,875 - 15,885	0,625 - 0,6254
Seal (piston ring) bore diameter	19,305 - 19,330	0,760 - 0,7610	19,305 - 19,330	0,760 - 0,7610
Turbine Wheel Assembly				
Shaft journal diameter	10,972 - 10,980	0,432 - 0,4323	10,972 - 10,980	0,432 - 0,4323
Piston ring groove width	1,680 - 1,730	0,0661 - 0,0681	1,680 - 1,730	0,0661 - 0,0681
Journal Bearings				
Inside diameter	11,006 - 11,013	0,4333 - 0,4336	11,006 - 11,013	0,4333 - 0,4336
Outside diameter	15,801 - 15,811	0,6221 - 0,6225	15,801 - 15,811	0,6221 - 0,6225
Rotating Assembly				
Radial movement at compressor impeller hub	0,300 - 0,458	0,0118 - 0,018	0,282 - 0,464	0,0111 - 0,0138
Total end float	0,100 - 0,155	0,0039 - 0,0061	0,100 - 0,155	0,0039 - 0,0061
Turbine speed at normal full speed/full load engine conditions	125,000 rpm		110,000 rpm	

GARRETT AiRESEARCH TURBOCHARGER TYPE TA 3503

Turbine Speed at Maximum Rated Power 100,000 rpm

	mm	in
Centre Housing		
Bearing bore diameter	15,80 - 15,81	0,6220 - 0,6223
Seal bore diameter	17,75 - 17,81	0,699 - 0,701
Turbine Wheel Assembly		
Journal diameter	10,152 - 10,16	0,3997 - 0,4000
Seal hub diameter	17,32 - 17,35	0,682 - 0,683
Ring groove width	1,64 - 1,74	0,0645 - 0,0735
Backplate		
Seal bore diameter	12,687 - 12,713	0,4995 - 0,5005
Thrust Collar		
Bearing groove width	4,42 - 4,44	0,1740 - 0,1748
Ring groove width	1,621 - 1,659	0,0638 - 0,0653
Thrust Bearing Thickness	4,36 - 4,37	0,1716 - 0,1720
Journal Bearing		
Outside diameter	15,70 - 15,71	0,6182 - 0,6187
Inside diameter	10,19 - 10,20	0,4010 - 0,4014
Impeller Bore	6,345 - 6,353	0,2498 - 0,2501
Rotating Assembly		
Radial clearance of shaft Bearings	0,076 - 0,165	0,003 - 0,0065
End float	0,025 - 0,102	0,0005 - 0,004

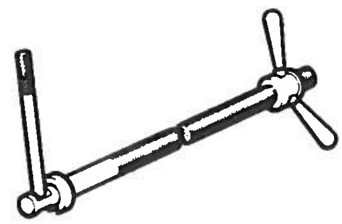
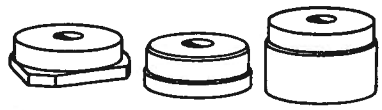
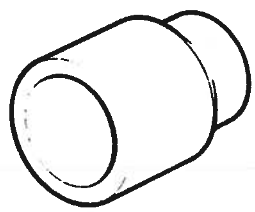
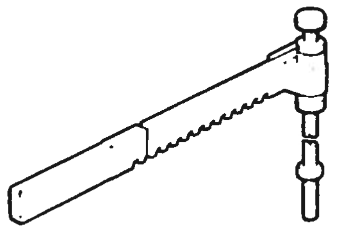
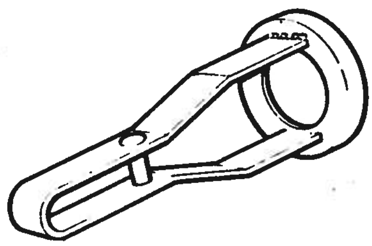
Turbocharger Turbine Housing Bolts - Anti-seize compound: FORD Specification SAM-1C-9107 A

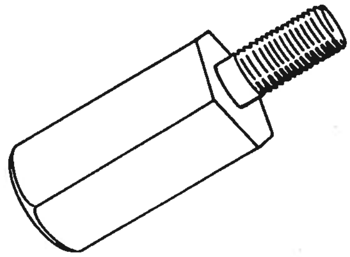
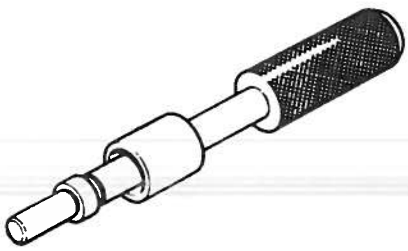
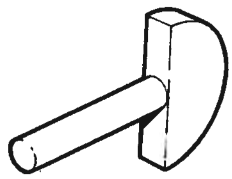
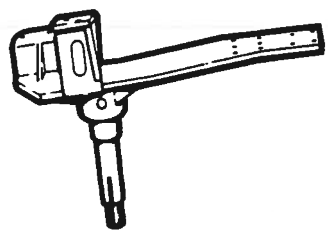
TIGHTENING TORQUES

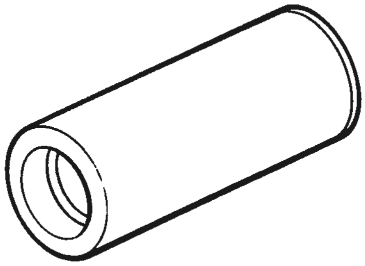
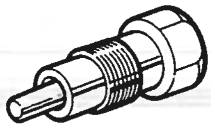
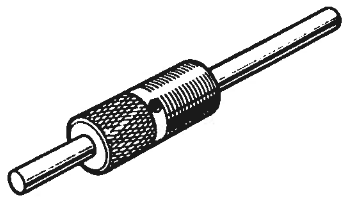
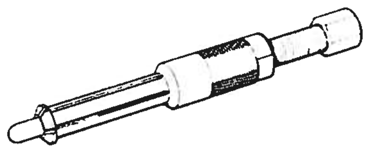
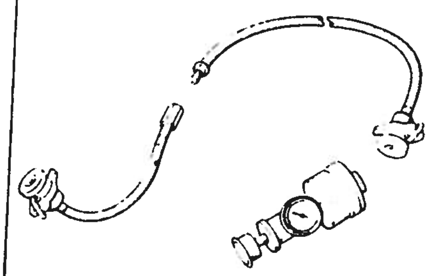
	Nm	kgf m	lbf ft
Fuel Lift Pump - Standard Low Pressure Type			
Pump retaining nuts	20 to 25	2,0 to 2,5	15 to 18
Cover plate securing screw	5,1 to 6,2	0,5 to 0,6	3,8 to 4,6
Fuel Lift Pump - High Pressure Type			
Pump retaining bolts	9 to 11	0,9 to 1,1	7 to 8
Pre-filter banjo bolt	30 to 40	3,0 to 4,1	22 to 29
Priming plunger assembly	45 to 55	4,6 to 5,6	33 to 40
Inlet and outlet adaptors	30 to 40	3,0 to 4,1	22 to 29
Plunger spring plug	80 to 100	8,2 to 10,2	60 to 74
Fuel Filter Retaining (Centre) Bolt	6,8 to 9,5	0,7 to 1,0	5 to 7
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 bolts	16 to 20	1,6 to 2,0	12 to 15
Rocker pedestal bolts	23 to 30	2,3 to 3,0	17 to 22
Rocker cover retaining screws	4,0 to 5,5	0,4 to 0,6	3 to 4
Fuel Injection Pump			
Injection pump securing bolts	22 to 27	2,2 to 2,7	16 to 20
Delivery pipe unions (high pressure)	17 to 20	1,8 to 2,0	12 to 15
Low pressure pipe unions	11 to 16	1,1 to 1,7	8 to 12
Drive ring gear locking bolts } Automotive & G.P. governed pumps only	20 to 25	2,0 to 2,5	15 to 18
Drive gear hub nut } Automotive & G.P. governed pumps only	60 to 65	6,1 to 6,6	44 to 48
Filler, level and drain plugs	4 to 6,8	0,4 to 0,7	3 to 5
Bleed screws	4 to 6,8	0,4 to 0,7	3 to 5
Turbochargers - General			
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 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
Support plate to support bracket bolts	41 to 51	4,2 to 5,2	30 to 38
Oil feed pipe flange bolts	20 to 25	2,0 to 2,5	15 to 18
Oil drain pipe flange bolts	20 to 25	2,0 to 2,5	15 to 18
Turbocharger - Garret AiResearch Type			
Thrust bearing screws	4,5	0,45	3,4
Bearing housing to diffuser bolts	5,7	0,58	4,2
Diffuser to compressor housing bolts	5,7	0,58	4,2
Bearing housing to turbine housing bolts	11,3	1,13	8,3
Compressor impeller locknut	14	1,4	10
Turbocharger - Holset Type			
Bearing housing to backplate bolts	8,5 to 10	0,9 to 1,0	6,5 to 7,5
Compressor housing to backplate bolts	11,5 to 14,5	1,2 to 1,5	8,5 to 10,5
Bearing housing to turbine housing bolts	11,5 to 14,5	1,2 to 1,5	8,5 to 10,5
Compressor impeller locknut - 1st stage	2,0 to 2,2	0,21 to 0,23	1,5 to 1,7
2nd stage	Tighten through a further 90°		

SPECIAL TOOLS AND EQUIPMENT

All the special tools listed are available from:
V. L. Churchill Limited, P.O. Box 3, Churchill Way, Daventry, Northants. England. Telephone: 03272 4461. Telex 31326

Tool No.	Description	Identification
21-022	Camshaft Bearing Remover/Installer	
21-022-51A	Adaptor for 21-022	
21-022-53	Adaptor for 21-022	
21-024	Valve Spring Compressor	
21-024-02	Adaptor for 21-024	

Tool No.	Description	Identification
21-516	Adaptor for 21-024	
21-500	Valve Guide Remover/Installer	
21-506	Crankshaft Rear Seal Installer	
21-535	Engine Mounting Bracket	
21-536	Crankshaft Front Seal Installer	

Tool No.	Description	Identification
21-537	Valve Stem Seal Installer	
23-504	CAV Pump Timing Tool - Class 'A' and Combine Harvester Governed Pumps	
23-507	CAV Pump Timing Tool - G.P. and Automotive Governed Pumps	
21-036	Clutch Pilot Bearing Remover	
STU 3375515	Pressure Regulator Pump Used for Injector Leak-Off Rail Test	

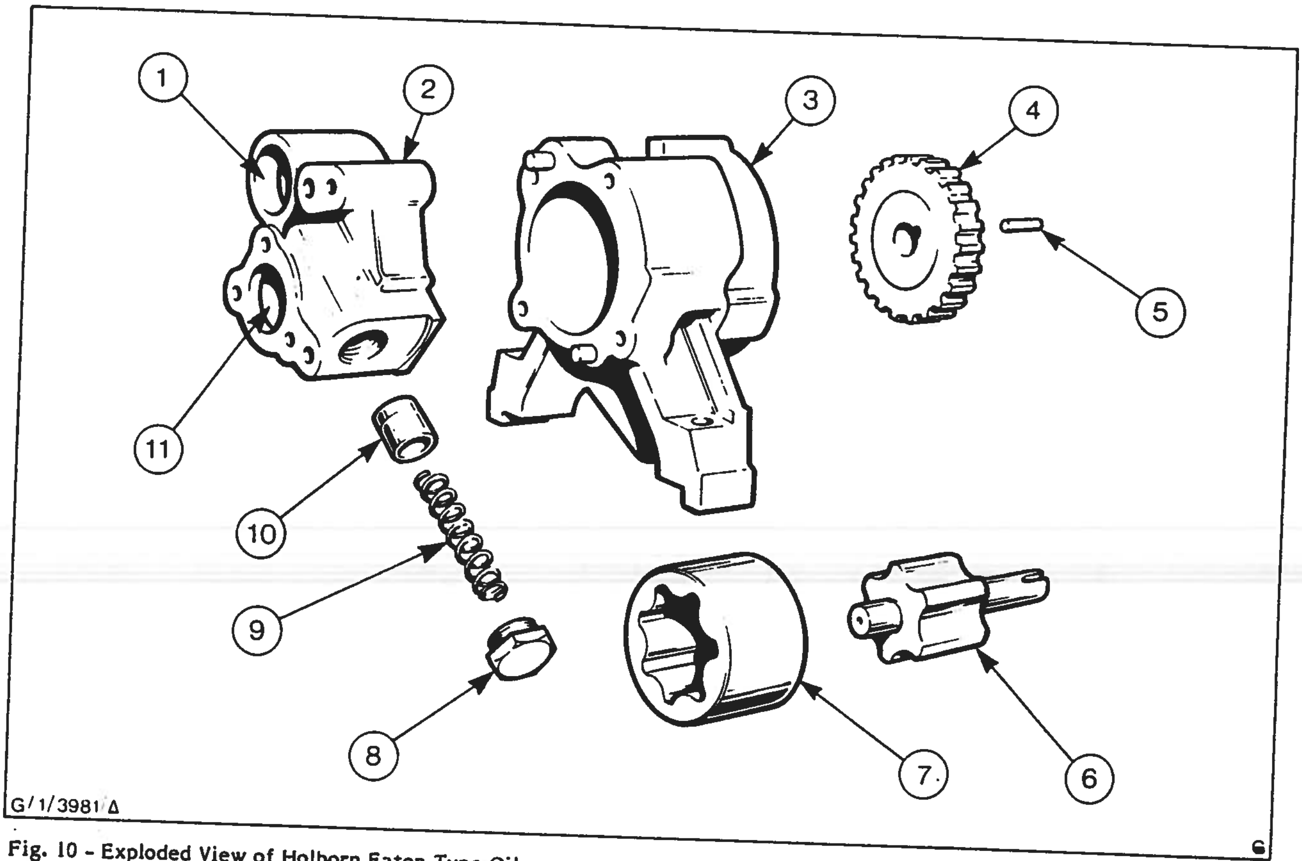


Fig. 10 - Exploded View of Holborn Eaton Type Oil pump

1. Pump Outlet
2. End Cover (Cast Iron)
3. Pump Body
4. Drive Gear
5. Roll Pin
6. Inner Rotor and Shaft
7. Outer Rotor
8. Valve Cap
9. Pressure Relief Valve Spring
10. Plunger
12. Pump Inlet