

**workshop
manual for
4.154
diesel engines**

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Peterborough England

1992.

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This publication is written for world-wide use. In territories where legal requirements govern smoke emission, noise, safety factors etc., then all instructions, data and dimensions given must be applied in such a way that, after servicing, (preventive maintenance) or repairing an engine, it does not contravene the local regulations when in use.

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In addition to the above companies there are Perkins distributors in most countries. Perkins Power Sales and Service Ltd., Peterborough or one of the above companies can provide details.

SAFETY PRECAUTIONS

THESE SAFETY PRECAUTIONS ARE IMPORTANT. You must refer also to the local regulations in the country of use. Some items only apply to specific applications.

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, or equipment, is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. Attention: Some moving parts cannot be seen clearly while the engine runs.
- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.



- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil in a safe place to prevent contamination.
- Do not remove mobile equipment if the brakes are not in good condition.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Read and use the instructions relevant to asbestos joints.
- Fit only genuine Perkins parts.

ASBESTOS JOINTS

Some joints and gaskets contain compressed asbestos fibres in a rubber compound or in a metal outer cover. The "white" asbestos (Chrysotile) which is used is a safer type of asbestos and the risk of damage to health is extremely small.

The risk of asbestos from joints occurs at their edges or if a joint is damaged when a component is removed or if a joint is removed by abrasion.

To ensure that the risk is kept to a minimum, the procedures given below must be applied when an engine which has asbestos joints is dismantled or assembled.

- Work in an area with good ventilation.
- Do not smoke.
- Use a hand scraper to remove the joints—do not use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all loose asbestos debris with water and put it in a closed container which can be sealed for safe disposal.



POWERPART Consumable Products

Perkins have made available the products indicated below in order to assist in the correct operation, service and maintenance of your engine and your machine.

The instructions for the use of each product are given on the outside of each container.

These products are available from your Perkins distributor.

POWERPART Antifreeze

Protects the cooling system against frost and corrosion. See page A.8.

POWERPART De-Icer

Removes frost.

POWERPART Easy Flush

Cleans the cooling system.

POWERPART Easy Seal

Stops leakages from the cooling system.

POWERPART Foam Action Gasket Remover

Allows easy and rapid removal of old gaskets and joints.

POWERPART Hylomar

Universal jointing compound which seals joints.

POWERPART Hylosil

Silicone rubber sealant which prevents leakage through gaps.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. See page A.8.

POWERPART Lay-Up 2

Protects the inside of the engine and of other closed systems. See page A.8.

POWERPART Lay-Up 3

Protects outside metal parts. See page A.8.

POWERPART Moisture Dispersant and Rust Penetrant

Dries damp equipment and gives protection against corrosion. Passes through dirt and corrosion to lubricate and to assist removal of components.

POWERPART Retaining Compound

Retains components which have a transition or an interface fit, for example, pulleys, bushes etc..

POWERPART Studlock

Secures threaded fasteners. Recommended for fasteners which, normally, are not removed.

POWERPART Threadseal

Seals threads and pipe connections. Low pressure systems can be used immediately.

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FOREWORD

This Workshop Manual has been compiled for use in conjunction with normal workshop practice. Mention of certain accepted practices therefore, have been omitted in order to avoid repetition. Where the removal, dismantling, assembly or refitting of a part is straightforward it is omitted from the text. Similarly, references to renewing joints, cleaning joint faces, cleaning before inspection and re-assembly and removal of burrs and scale have largely been omitted, it being understood that these procedures will be carried out where applicable. It follows that any open ports of high precision components, e.g. fuel injection equipment, exposed by dismantling, will be blanked off until re-assembled, to prevent the ingress of foreign matter. The difference between the minimum and maximum dimensions which are given in the Manufacturing Data and Dimensions for the relevant component parts quoted in each of the sections in this manual is known as "the manufacturing tolerance". This tolerance is necessary as an aid to manufacture and its numerical value is an expression of the accuracy of the desired quality of workmanship.

If when carrying out a major overhaul it is found that a bush and corresponding shaft have worn and that the majority of wear has taken place in the bush it may be necessary to renew the bush only; however, good workshop practice will ensure that consideration will be given as to the advisability of returning worn parts to service with an expectation of life that will involve labour costs at an early date.

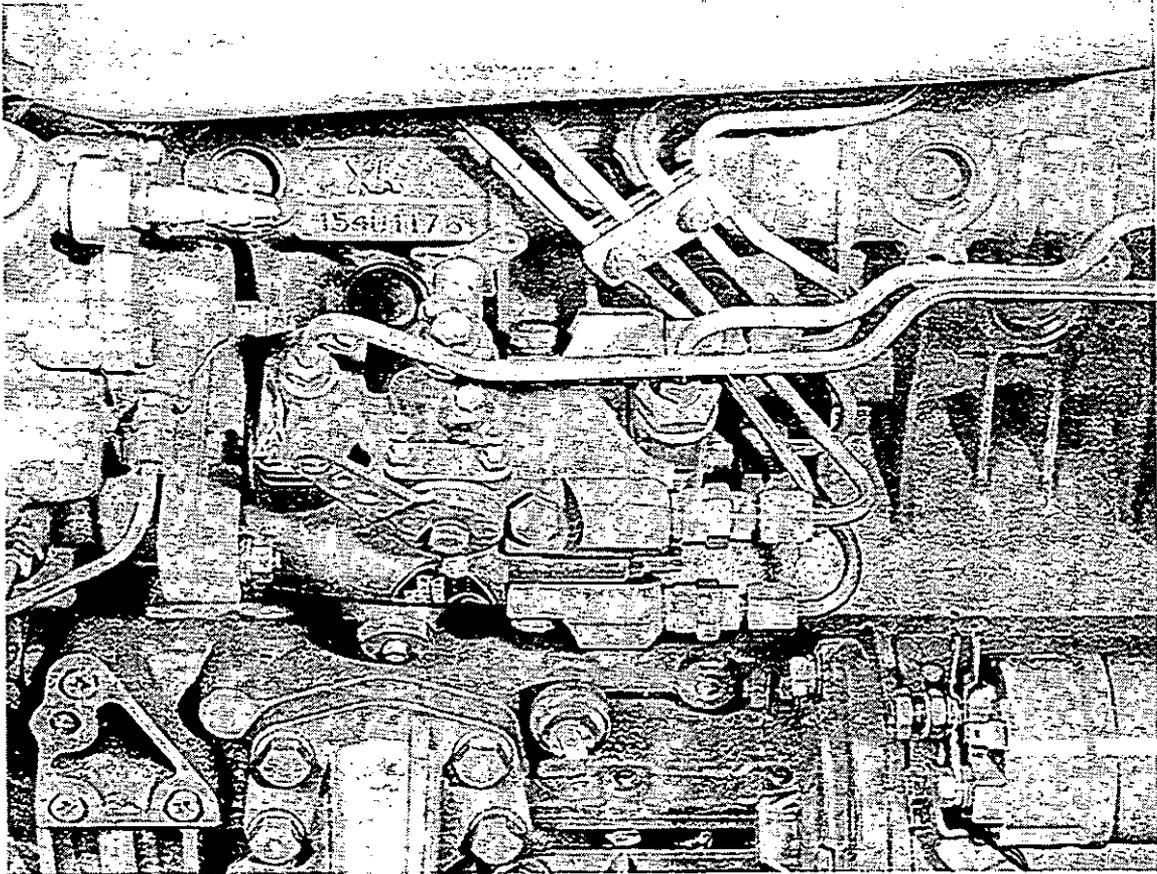
When setscrews or studs are fitted into holes which are tapped through into the inside of the engine, a suitable sealant must be used on the threads.

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side as viewed from the rear or fly-wheel end of the engine.

Unified Threads and Engine Number Location

All THREADS used on the 4.154 engine excepting proprietary equipment are Unified Series and American Pipe Series.

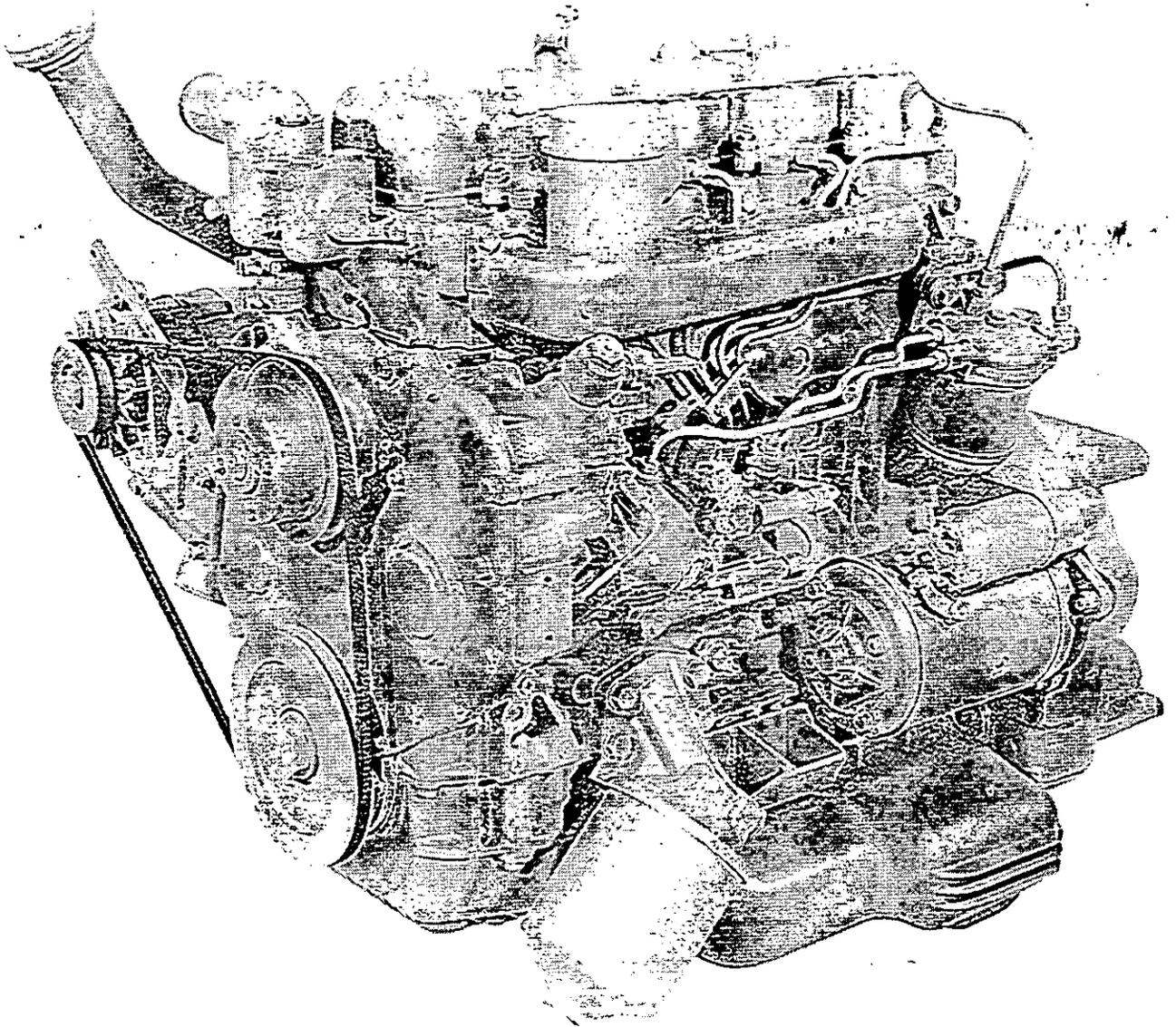
The ENGINE NUMBER is located on the cylinder block immediately behind the fuel pump. This number should be quoted in full when seeking information or ordering parts. The engine number consists of both letters and figures. A typical example for current engines is GA13870U510256D and for earlier engines, 154U251.



Location of Engine Number

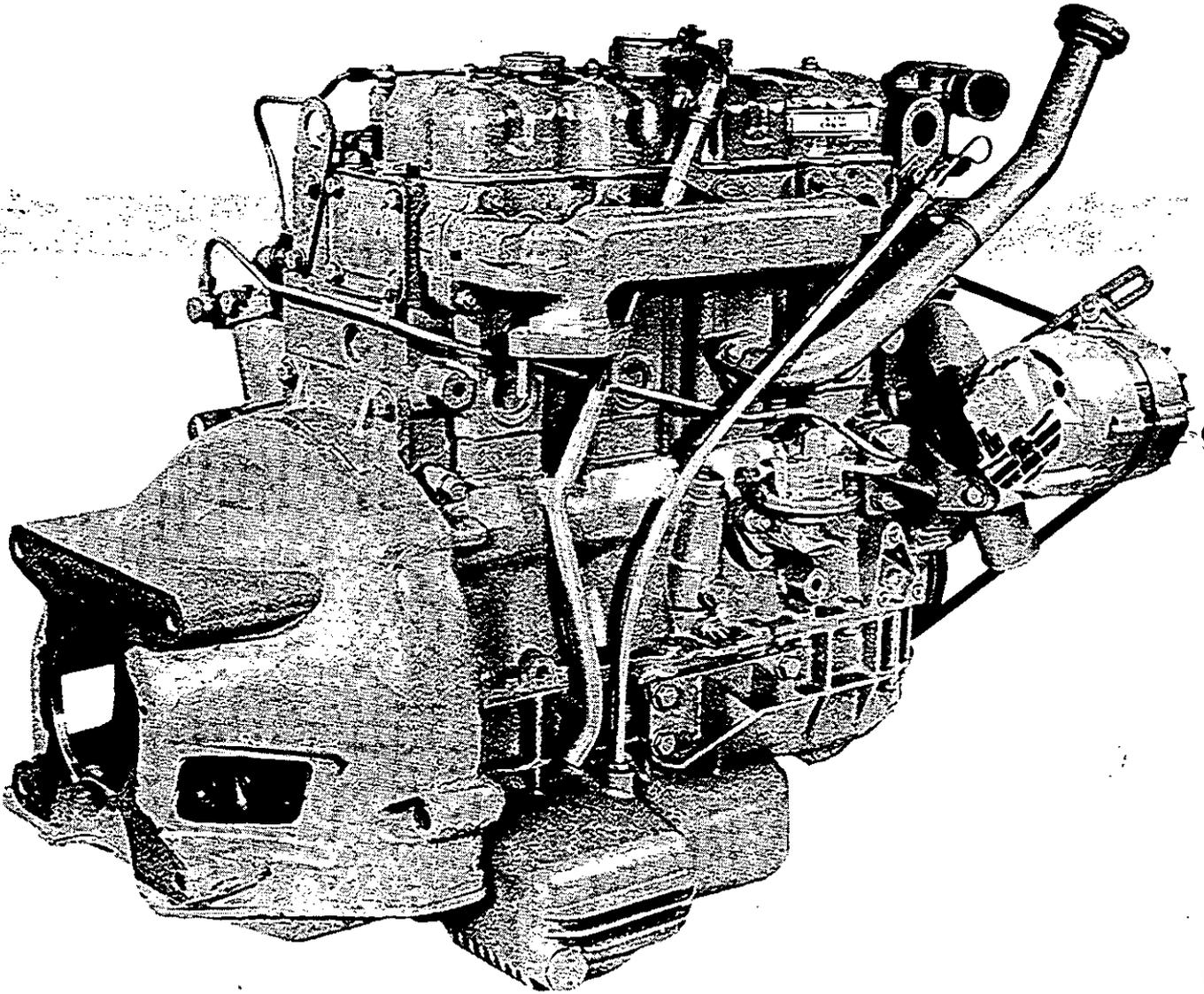
This manual is produced by the Technical Publications Department of Perkins Engines Limited and every endeavour is made to ensure that the information contained herein is correct at the date of publication, but due to continuous development the manufacturers reserve the right to alter this specification without notice.

ENGINE VIEWS

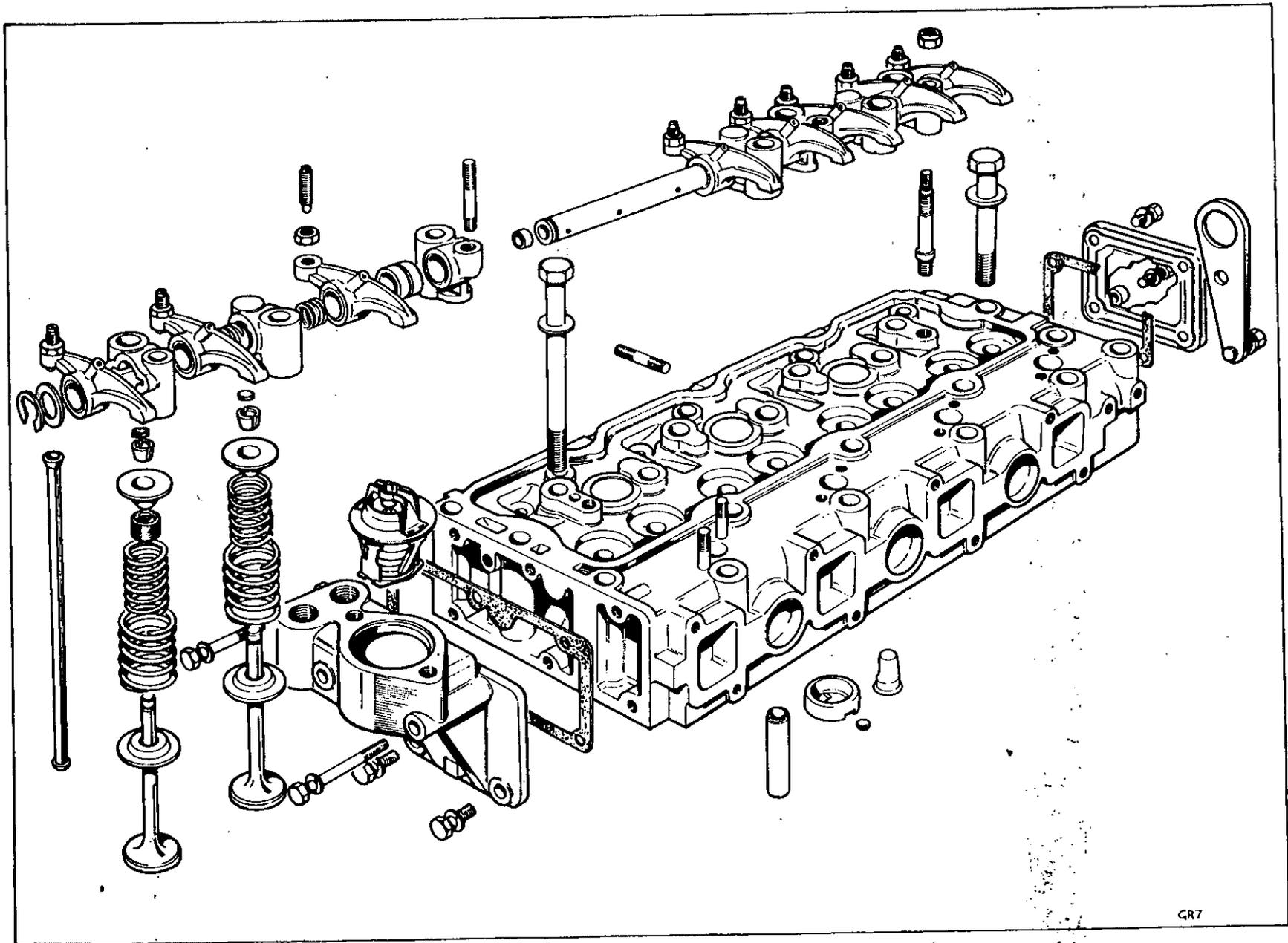


View of Front Left Hand Side of 4.154 Engine

Perkins engines are built to individual requirements to suit the applications for which they are intended and the engine views do not necessarily typify any particular specification.

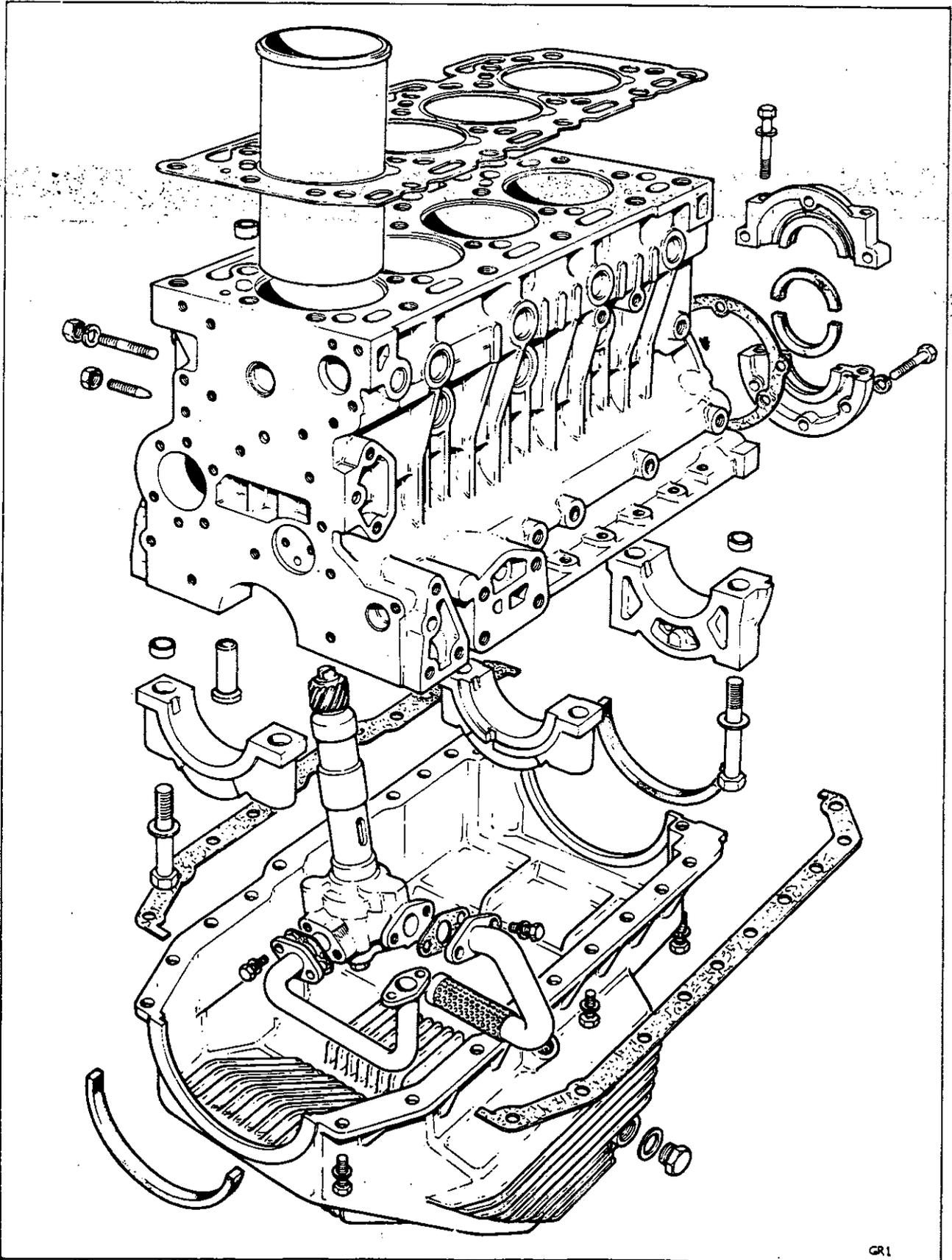


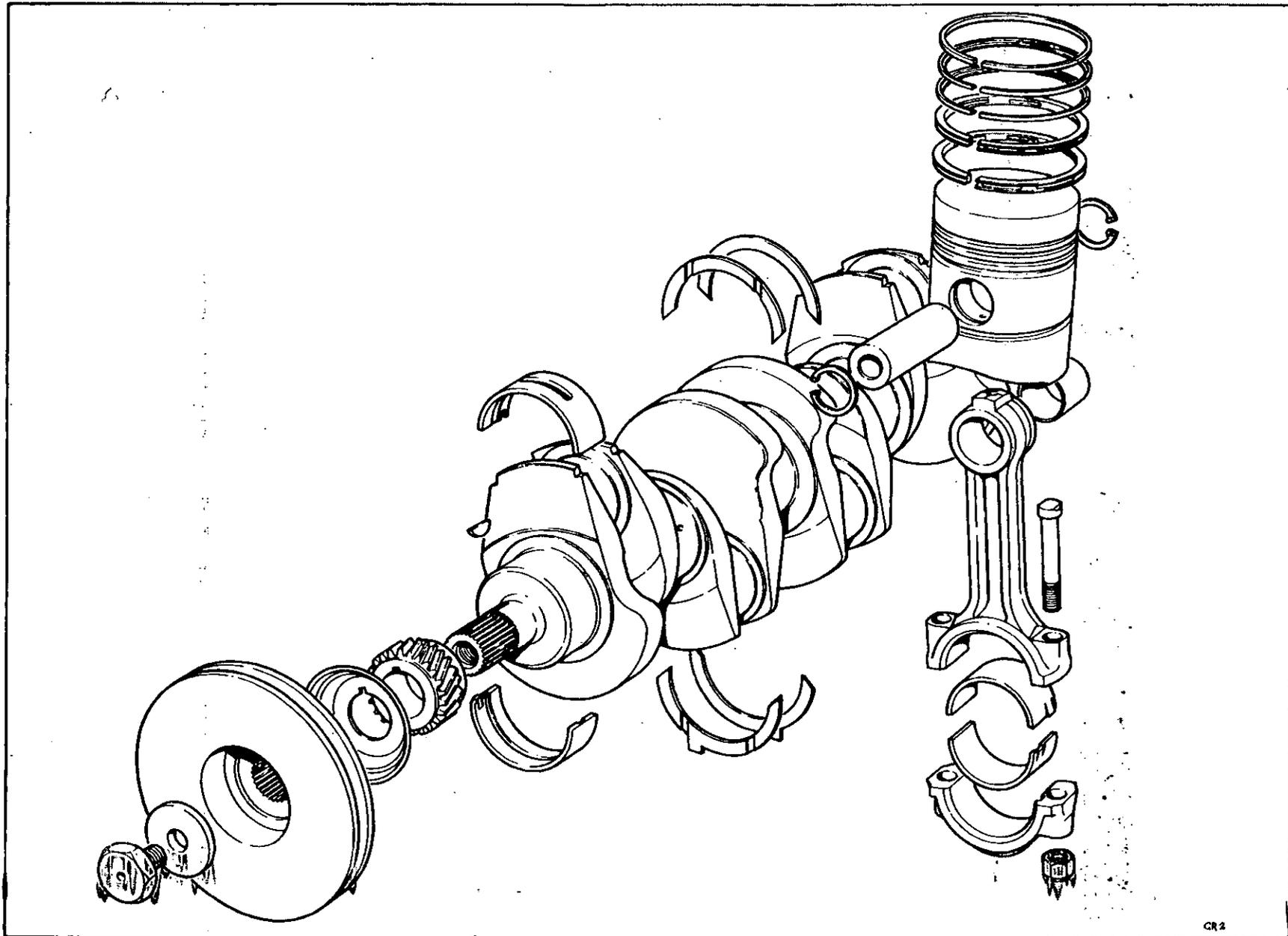
View of Rear Right Hand Side of 4.154 Engine



GR7

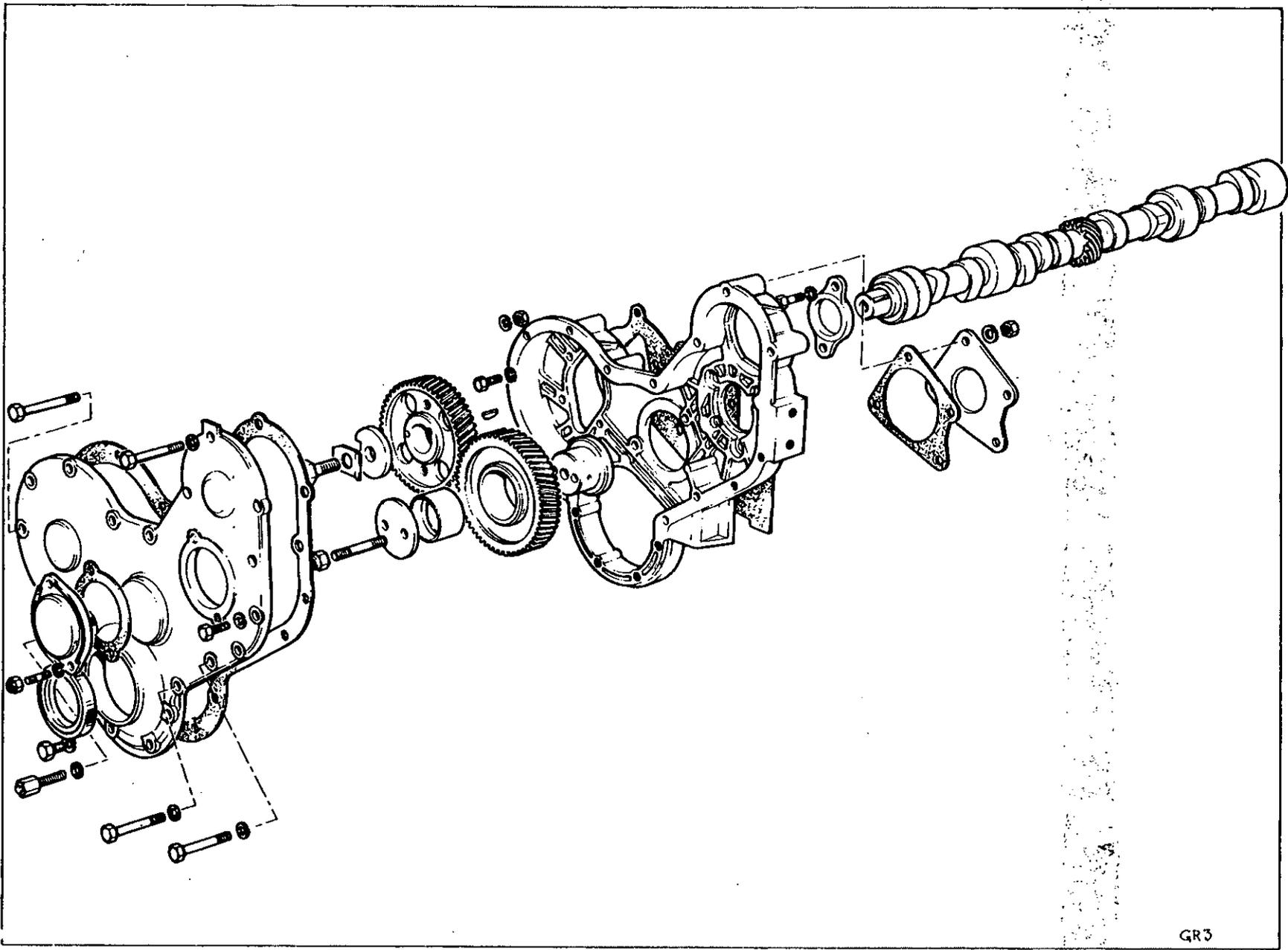
Exploded View of Cylinder Head Assembly





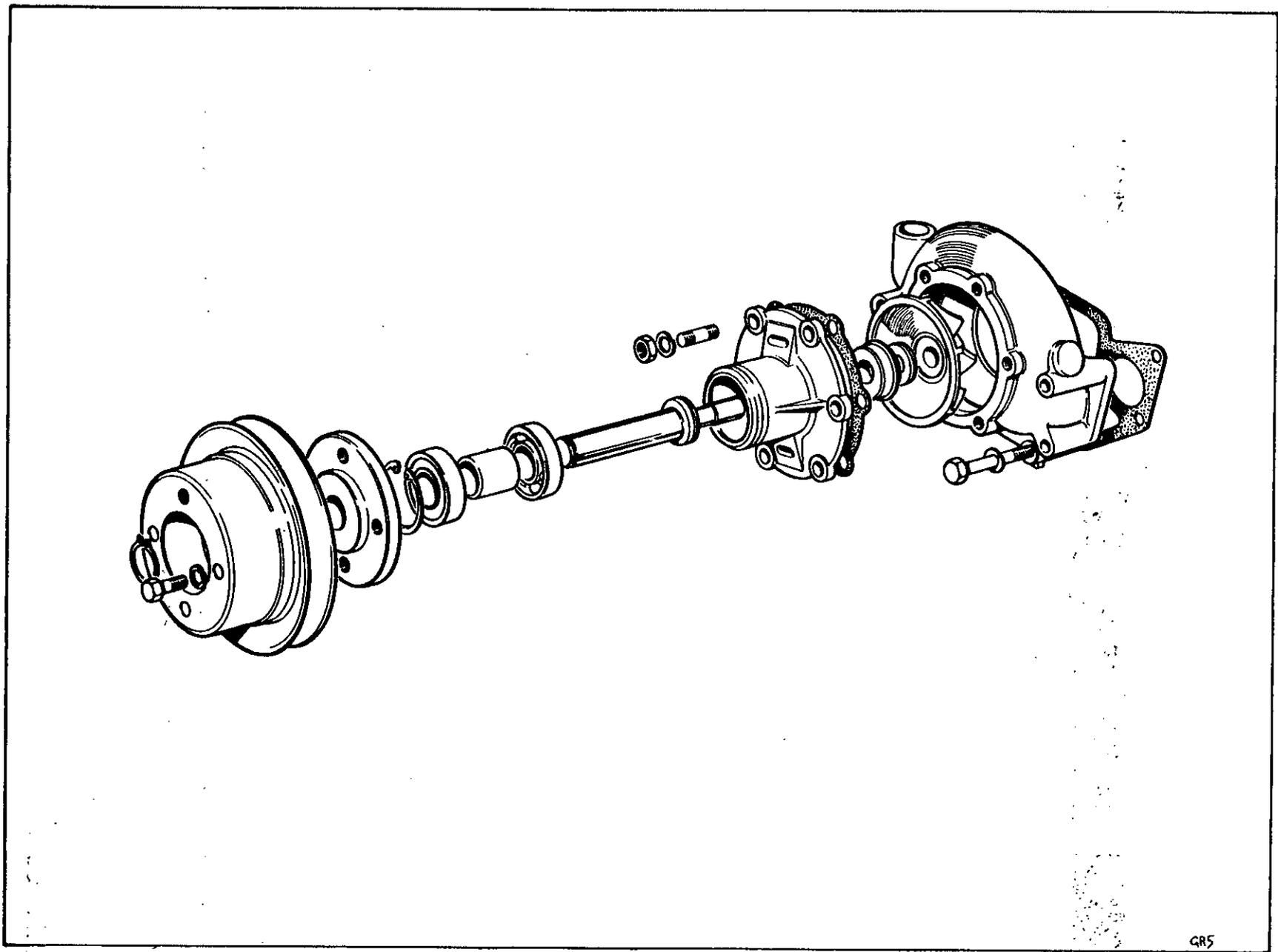
CR 2

Exploded Views of Crankshaft, Connecting Rod and Piston Assemblies



GR3

Exploded View of Timing Case, Drive and Camshaft Assembly



GR5

Exploded View of Water Pump Assembly

Section 'A'

GENERAL INFORMATION

ENGINE DATA

Type	Four Cylinder, Four Stroke, In-Line
Bore (Nominal, see page D.1.)	3.5 in (88,9 mm)
Stroke	4.0 in (101,6 mm)
Capacity	153.9 in ³ (2,523 litres)
Compression Ratio	21.5:1
Combustion System	Indirect Injection, Ante-Chamber (Perkins "H" type)
Firing Order	1 - 3 - 4 - 2
Valve Tip Clearance	0.012 in (0,30 mm) Cold

RATING DETAILS

Automotive type Applications

Hydraulic Governor	70 bhp (52 kw) at 3,600 rev/min
Maximum Torque	113 lbf ft (15,6 kgf m) at 2,000 rev/min

Agricultural type Applications

Mechanical Governor	62 bhp (46 kw) at 3,000 rev/min
Maximum Torque	113 lbf ft (15,6 kgf m) at 2,000 rev/min

Intermittently Operated Industrial Applications

Mechanical Governor	62 bhp (46 kw) at 3,000 rev/min
Maximum Torque	113 lbf ft (15,6 kgf m) at 2,000 rev/min

Variable Speed Light Duty Industrial Applications

Hydraulic Governor	70 bhp (52 kw) at 3,600 rev/min
Maximum Torque	113 lbf ft (15,6 kgf m) at 2,000 rev/min

Continuously Operated Industrial Applications

Mechanical Governor	55 bhp (41 kw) at 3,000 rev/min
Minimum Governed Speed	1800 rev/min

Note: The above ratings can vary according to application. For details of individual ratings, apply to Technical Services Department, Perkins Engines Ltd., Peterborough.

General Information A2

APPROXIMATE ENGINE WEIGHTS DRY

Engines with standard basic components, i.e. fuel injection pump, water and lubricating oil pumps, filters and electrics.

	lb	kg
Automotive	430	195
Industrial	400	180
Agricultural	430	195

Installed approximate weight of engines including all components, and flywheel, flywheel housing or backplate, fan, starter motor, air cleaner, but without clutch.

	lb	kg
Automotive	555	251
Industrial	550	250
Agricultural	565	255

DE-RATING FOR ALTITUDE

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, they should be de-rated.

The following table is given as a general guide, which may be applied on a percentage basis, where specific figures for a particular engine rating are not available:

Altitude	Maximum Fuel Delivery De-rating Measured at 800 rev/min Pump Speed
0 - 2,000 ft (600 metre)	No change
2,000 - 4,000 ft (1200 metre)	6%
4,000 - 6,000 ft (1800 metre)	12%
6,000 - 8,000 ft (2400 metre)	18%
8,000 - 10,000 ft (3000 metre)	24%
10,000 - 12,000 ft (3600 metre)	30%

Any necessary adjustments in this respect to the fuel pump, should be carried out by the C.A.V. dealer for the territory concerned. For any further information apply to Technical Services Department, Perkins Engines Ltd., Peterborough, or to Overseas Companies listed on Page 2.

SERVICE WEAR LIMITS

The following wear limits indicate the condition when it is recommended that the respective items should be serviced or replaced.

Cylinder Head Bow	Transverse	0.003 in (0,08 mm) concave 0.005 in (0,13 mm) convex
	Longitudinal	0.006 in (0,15 mm)
Maximum Bore Wear (when reboring or new liners are necessary)		0.006 in (0,15 mm)
Crankshaft Main and Big End Journals	Ovality	0.0005 in (0,01 mm)
	Wear	0.001 in (0,03 mm)
Maximum Crankshaft End Float		0.020 in (0,51 mm)
Valve Stem to Guide Bore		
Diametrical Clearance	Inlet	0.005 in (0,13 mm)
	Exhaust	0.006 in (0,15 mm)
Valve Head Thickness at Outer Edge		0.045 in (1,14 mm)
Rocker Clearance on Shaft		0.005 in (0,13 mm)
Camshaft Journals	Ovality and Wear	0.002 in (0,05 mm)
Camshaft End Float		0.015 in (0,38 mm)
Idler Gear End Float		0.015 in (0,38 mm)
Max. Top Piston Ring Lift		0.008 in (0,20 mm)

RECOMMENDED TORQUE TENSIONS

The following figures will apply with the components lightly oiled before assembly.

Component	Screw Size	lbf ft	kgf m	Nm
Cylinder Head Setscrews (also Secure Rocker Shaft bracket).....	1/2 in	85	11,7	115
Main Bearing Setscrews.....	1/2 in	85	11,7	115
Connecting Rod Nuts (non phosphated)	7/16 in	45	6,2	61
Connecting Rod Nuts (phosphated)	7/16 in	60	8,3	82
Flywheel Setscrews	1/2 in	80	11,1	108
Crankshaft Pulley Retaining Setscrews	5/8 in	123	17,0	166
Power Take-off Pulley Setscrews	3/8 in	32	4,5	43
Camshaft Gear Setscrew	1/2 in	50	6,9	68
Idler Gear Hub to Cylinder Block Nuts	5/16 in	21	2,9	28
Dynamo Pulley Nut	7/16 in	20	2,8	27
Alternator Pulley Nut	7/16 in	30	4,15	41
Atomiser Securing Nut	5/16 in	12	1,7	16
Lubricating Oil Filter Bowl Securing Setscrews	1/2 in	10	1,38	13
Fuel Pump Drive Gear Securing Setscrews	5/16 in	21	2,9	28
Atomiser Securing Nuts		12	1,7	16
High Pressure Fuel Pipe Nuts		15	2,1	20
Thermostart		10	1,4	13,6

If Connecting Rod Nuts are removed, they should be replaced by new ones.

OPERATING INSTRUCTIONS

Starting the engine.

If the weather or engine is warm, turn switch to position "R" and ensure the engine stop control is in the run position. Adjust the accelerator to the fully open position and engage the starter motor by turning the starter motor switch in a clockwise direction to the "heat start" position, see Fig. A.1. As soon as the engine starts release the starter switch to the "run" position.

Always be sure that the starter pinion and flywheel have stopped rotating before re-engaging the starter motor, otherwise the ring or pinion may be damaged.

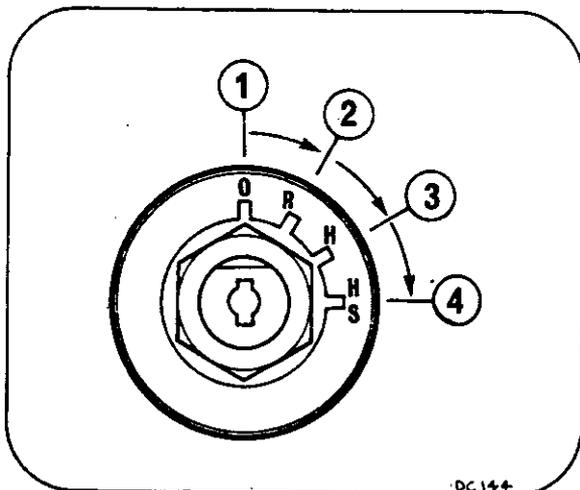
To Stop the engine

A spring loaded stop control is located near the normal engine controls and functions by cutting off the fuel at the fuel injection pump. To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the "run" position, otherwise difficulty may be experienced in restarting the engine. When the engine stops rotating, the switch can then be turned to the "off" position to switch off the electrical auxiliaries.

Cold Starting

Switch on, ensuring the engine stop control is in the "run" position. Turn on the fuel supply tap of the cold starting aid reservoir where fitted. Turn the starter switch to the "heat" position and hold it there for fifteen to twenty seconds.

With the accelerator in the fully open position, turn the starter switch to the "heat start" position, thereby engaging the starter motor. If the engine does not start after fifteen seconds, return the switch to the "heat" position for ten seconds and then re-engage the starter motor by switching to the "heat start" position. As soon as the engine starts, the switch should be released to the "run" position, and the tap on the cold starting reservoir (where fitted) turned off.



PREVENTIVE MAINTENANCE

Operators of 4.154 engines are reminded that the following Preventative Maintenance schedule is general in application, therefore he should compare the routine maintenance for his engine with the schedule specified by the manufacturer of the application to which the engine is fitted, and where necessary adapt the shorter periods also bearing in mind that on stop-start low mileage work, the hours run are more applicable than the mileage covered.

Whilst we have given specific periods for preventive maintenance, you should have due regard for the local regulations concerning your vehicle or machine and ensure that the engine is operating within those regulations.

It is good engineering practice to check for water, fuel and lubricating oil leaks and the tightness of nuts, set-screws and hose clips at each servicing period.

It should be noted that the maintenance periods given are on the assumption that the fuel and lubricating oils are to the specifications given in this workshop manual.

DAILY OR EVERY 8 HOURS whichever is soonest.

Check level of coolant.

Check level of lubricating oil in sump (make sure the vehicle or machine is standing level).

Check lubricating oil pressure (where gauge is fitted).

In extreme dust conditions, empty dust bowl on dry type air cleaner.

Under adverse agricultural conditions, clean chaff screens, radiators and centrifugal pre-filters.

4,000 MILES (6,000 km) 150 HOURS or 3 MONTHS, whichever is the soonest.

Drain and renew lubricating oil — Lubricating oil must meet the approved specification. See engine fluids page in the appendix.

Renew element in lubricating oil filter.

Empty dry air cleaner dust bowl.

Check fan belt tension — For engines rated at above 3,000 rev/min the fan belt tension should be checked monthly.

Clean water trap.

Where fitted, lubricate dynamo rear bush.

12,000 MILES (18,000 km) 450 HOURS or 12 MONTHS, whichever is the soonest.

Tractor and Industrial applications, renew the final fuel filter element.

Check and adjust valve tip clearance.

Clean element of dry type air cleaner, or renew, (if not indicated earlier)

24,000 MILES (36,000 km) 900 HOURS

Vehicle Applications, renew the final fuel filter element.

72,000 MILES (108,000 km) 2,700 HOURS

Arrange for examination and service of proprietary equipment, i.e. Compressor/Exhauster, Starter Motor, Dynamo etc.

Service atomisers.

The Kilometre conversions of miles are not accurate. They are periods in Kilometres which should be used in place of miles in relevant countries.

Running-in Procedure

It is not necessary to gradually run-in a new or factory rebuilt engine and any prolonged light load running during the early life of the engine can in fact prove harmful to the bedding in of piston rings and liners.

Full load can be applied on a new or factory rebuilt engine as soon as the engine is used, provided that the engine is first allowed to reach a coolant temperature of at least 140°F (60°C).

POST DELIVERY CHECKOVER

After a customer has taken delivery of his engine, a general checkover must be carried out after the first 500/1,000 miles (800/1,600 km) or 20/40 hours in service and must include the retightening of the cylinder head setscrews in the correct sequence. With the engine thoroughly warmed through, the checkover comprises the following:—

1. Drain the lubricating oil sump and refill to the correct level with clean new engine oil (Do not overfill).
2. Renew lubricating oil filter element (canister).
3. Tighten the cylinder head setscrews in the correct sequence (see fig. B.2) and to the correct torque of 85 lbf ft (115 Nm, 11,75 kgf m).
4. Reset the valve tip clearances to 0.012 in (0,30 mm) (see page B.5).
5. Check oil feed to rockers.
6. Check the tension of the fan belt (see page K.2.)
7. Check the tightness of all external nuts, set-screws, mountings, hose clips, etc.
8. Start the engine and check for any fuel, coolant or lubricating oil leaks.
9. Adjust idling speed if necessary.

General Information A6

PRESERVATION OF LAID-UP ENGINE

Introduction

The recommendations indicated below are designed to prevent damage to the engine when it is withdrawn from service for a prolonged period. Use these procedures after the engine is withdrawn from service. The instructions for the use of POWERPART products are given on the outside of each container.

Procedure

1. Completely clean the outside of the engine.
2. When a preservative is to be used, drain the fuel system and fill it with the preservative fuel. POWERPART Lay-Up 1 can be added to the normal fuel to change it to a preservative fuel. If preservative fuel is not used, the system can be kept full with normal fuel but the fuel must be drained and discarded at the end of the storage period together with the fuel filter element(s).
3. Operate the engine until it is warm. Then correct leakages of fuel, lubricating oil or air. Stop the engine and drain the lubricating oil from the sump.
4. Renew the canister(s) of the lubricating oil filter.
5. Fill the sump to the full mark on the dipstick with new and clean lubricating oil and add POWERPART Lay-Up 2 to the oil to protect the engine against corrosion. If POWERPART Lay-Up 2 is not available, use a correct preservative fluid instead of the lubricating oil. If a preservative fluid is used, this must be drained and the lubricating oil sump must be filled to the correct level with normal lubricating oil at the end of the storage period.
6. Drain the cooling system. In order to protect the cooling system against corrosion, fill it with an approved antifreeze mixture because this gives a protection against corrosion, see engine fluids page for the coolant specification.

Note: If protection against frost is not necessary and a corrosion inhibitor is to be used, it is recommended that you consult the Service Department, Perkins Power Sales and Service Limited, Peterborough.

7. Operate the engine for a short period in order to circulate the lubricating oil and the coolant in the engine.
8. Clean the engine breather pipe (if one is fitted) and seal the end of the pipe.
9. Remove the atomisers and spray POWERPART Lay-Up 2 into each cylinder bore. If this is not available, clean engine lubricating oil will give a degree of protection. Spray into the cylinder bores 140 ml (0.25 pint) of lubricating oil divided evenly between the cylinders.

10. Slowly turn the crankshaft one revolution and then fit the atomisers with new seat washers.
11. Remove the air filter. Then, if necessary, remove the pipe(s) installed between the air filter and induction manifold or turbocharger. Spray POWERPART Lay-Up 2 into the induction manifold or turbocharger. It is recommended that the spray time for the turbocharger is 50% longer than the spray time for the manifold, which is indicated on the container label. Seal the manifold or the turbocharger with waterproof tape.
12. Remove the exhaust pipe. Spray POWERPART Lay-Up 2 into the exhaust manifold or the turbocharger. It is recommended that the spray time for the turbocharger is 50% longer than the spray time for the manifold, which is indicated on the container label. Seal the manifold or the turbocharger with waterproof tape.
13. If the lubricating oil filler is fitted onto the rocker cover, remove the filler cap. If the lubricating oil filler is not fitted onto the rocker cover, remove the rocker cover. Spray POWERPART Lay-Up 2 around the rocker shaft assembly. Fit the filler cap or rocker cover.
14. Disconnect the battery. Then put the battery into safe storage in a fully charged condition. Before the battery is put into storage, protect the terminals against corrosion. POWERPART Lay-Up 3 can be used on the terminals.
15. Seal the vent pipe of the fuel tank or the fuel filler cap with waterproof tape.
16. Remove the drive belts and put them into storage.
17. In order to prevent corrosion, spray the engine with POWERPART Lay-Up 3. Do not spray the area inside the alternator cooling fan.

Note: After a period in storage, but before the engine is started, operate the starter motor with the engine stop control in the "stop" position until oil pressure is indicated. Oil pressure can be indicated either by a gauge or when a low pressure warning light is extinguished. If a solenoid stop control is used on the fuel injection pump, it must be disconnected for this operation.

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

FROST PRECAUTIONS

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

Should it be your policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is our experience that the best results are obtained from anti-freeze which conforms to British Standard 6580: MOD AL39. See engine fluids page for the engine coolant specification.

When draining a cooling system, ensure that the vehicle or machine is on level ground.

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

- (a) Locking of the impeller by ice due to the pump drain hole being blocked by sediment.
- (b) The locking of the seal through the freezing of globules of moisture between the seal and the insert.

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

1. Before starting the engine, turn the water pump by hand, this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.
2. If it is impossible to turn the pump by hand, the engine should be filled with warm water.

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

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

PREPARING THE ENGINE FOR RETURN TO SERVICE

When the engine is to be returned to service, the following procedure must be observed:—

1. Thoroughly clean all external parts of the engine.
2. Carry out attention to the fuel pump as described in the Fuel Pump Section on Page A.8.
3. Ensure that the cylinder block and radiator drain taps are correctly fitted in the closed position and fill the system with clean coolant. Check visually for leaks and remedy where necessary.
4. Rotate the water pump by hand to ensure freedom of the water pump seals.
5. Refit the fan belt and adjust to the correct tension.
6. Remove the cylinder head cover, lubricate the rocker assembly with engine oil and replace the cover.
7. Remove the adhesive tape from the air intake orifice and refit the air cleaner. Ensure that the gauze is clean and if it is the oil bath type, fill with clean engine oil to the correct level.
8. Refit any air intake pipe between the air cleaner and the air intake which may have been removed during laying-up procedure.
9. Remove the adhesive tape from the exhaust manifold orifice and refit the exhaust pipe using new joints.
10. Connect the battery or batteries into circuit, fully charged and topped up as necessary with distilled water.

Starters and Dynamos

11. Wipe the grease from the terminals and check that all connections are sound. If the starter is fitted with a Bendix type of drive, which proves sluggish in engagement when operated, the starter motor should be removed and the drive cleaned thoroughly in a suitable cleaning fluid. Lubricate with a little light engine oil before replacement.
12. Check the level and condition of the lubricating oil in the sump. Change the oil if necessary.
13. Start the engine in the normal manner checking for oil pressure and dynamo charge immediately.
14. Whilst the engine is attaining normal running temperature it is advisable to check that it is running normally and that it is free from water, fuel and lubricating oil leaks.

General Information A8

D.P.A. Distributor Pump

1. Remove the adhesive tape from the fuel tank vent or filler cap.
2. Drain the fuel tank to remove any remaining oil and condensed water, and refill the tank with fuel oil.
3. Fit a new filter element and vent the filter until oil flows free from air bubbles (see page L.8)
4. Air vent and prime the pump (see page L.7).

NOTE:

If the foregoing instructions are observed, the laying-up and returning to service should be carried out efficiently and without adverse affect on the engine. Perkins Engines Ltd., however, cannot accept liability for direct or consequential damage that might arise following periods of laying-up.

fault finding chart

Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55, 60.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

KEY TO FAULT FINDING CHART

- | | |
|---|--|
| 1. Battery capacity low. | 31. Worn cylinder bores. |
| 2. Bad electrical connections. | 32. Pitted valves and seats. |
| 3. Faulty starter motor. | 33. Broken, worn or sticking piston ring/s. |
| 4. Incorrect grade of lubricating oil. | 34. Worn valve stems and guides. |
| 5. Low cranking speed. | 35. Overfull air cleaner or use of incorrect grade of oil. |
| 6. Fuel tank empty. | 36. Worn or damaged bearings. |
| 7. Faulty stop control operation. | 37. Insufficient oil in sump. |
| 8. Blocked fuel feed pipe. | 38. Inaccurate gauge. |
| 9. Faulty fuel lift pump. | 39. Oil pump worn. |
| 10. Choked fuel filter. | 40. Pressure relief valve sticking open. |
| 11. Restriction in air cleaner or induction system. | 41. Pressure relief valve sticking closed. |
| 12. Air in fuel system. | 42. Broken relief valve spring. |
| 13. Faulty fuel injection pump. | 43. Faulty suction pipe. |
| 14. Faulty atomisers or incorrect type. | 44. Choked oil filter. |
| 15. Incorrect use of cold start equipment. | 45. Piston seizure/pick up. |
| 16. Faulty cold starting equipment. | 46. Incorrect piston height. |
| 17. Broken fuel injection pump drive. | 47. Damaged fan. |
| 18. Incorrect fuel pump timing. | 48. Faulty engine mounting (Housing). |
| 19. Incorrect valve timing. | 49. Incorrectly aligned flywheel housing, or flywheel. |
| 20. Poor compression. | 50. Faulty thermostat. |
| 21. Blocked fuel tank vent. | 51. Restriction in water jacket. |
| 22. Incorrect type or grade of fuel. | 52. Loose fan belt. |
| 23. Sticking throttle or restricted movement. | 53. Choked radiator. |
| 24. Exhaust pipe restriction. | 54. Faulty water pump. |
| 25. Cylinder head gasket leaking. | 55. Choked breather pipe. |
| 26. Overheating. | 56. Damaged valve stem oil deflectors (if fitted). |
| 27. Cold running. | 57. Coolant level too low. |
| 28. Incorrect tappet adjustment. | 58. Blocked sump strainer. |
| 29. Sticking valves. | 59. Broken valve spring. |
| 30. Incorrect high pressure pipes. | 60. Defective exhauster/leaking vacuum pipes. |

Section 'B'

CYLINDER HEAD

The cylinder head is a one piece high duty iron casting of "cross flow" design with the exhaust and inlet ports on opposing sides. The overhead valves are push rod operated through the rocker gear mounted on the top of the cylinder head, covered by a pressed steel cover which is provided with a breather pipe fitted to the right hand side of the engine. Each inlet valve has a synthetic rubber oil deflecting seal, both inlet and exhaust valves are provided with two springs retained by a hardened cap and split conical cotters. All valves

operate in cast iron guides pressed into the head. The upper part of the combustion chamber is hemispherical in shape, being formed by an inserted machined plug containing a throat connecting the chamber to the cylinder. Coolant is delivered to the cylinder head through jets to the valve bridge and fishtail area in the combustion chamber inserts. The cylinder head is secured to the cylinder block by twenty setscrews, seven of which also secure the rocker shaft to the cylinder head.

CYLINDER HEAD DIMENSIONS

Cylinder Head

Overall depth of Cylinder Head	3.248/3.252 in (82,5/82,6 mm)
Skimming allowance	Nil
Pressure for Water Leak Test	30 lbf/in ² (2.11 kgf/cm ²)—207 kN/m ²
Valve seat angle	45°
Bore for Valve Guide	0.500/0.501 in (12,7/12,73 mm)
Bore for Combustion Chamber Inserts	1.375/1.3766 in (34,92/34,96 mm)
Depth of bore for Inserts	0.425/0.4281 in (10,79/10,87 mm)

Combustion Chamber Inserts

Outside diameter of Insert	1.3724/1.374 in (34,86/34,9 mm)
Clearance fit of Insert in Bore	0.001/0.0042 in (0,02/0,11 mm)
Combustion Chamber Insert thickness	0.4252/0.426 in (10,80/10,82 mm)
Height of Insert in relation to Cylinder Head face	0.001 in (0,02 mm) above, 0.0029 in (0,07 mm) below.
Method of location	By Cylinder Block Face and Expansion Washer.

Valve Guides, Inlet and Exhaust

Outside diameter of Guide	0.50125/0.50175 in (12,73/12,74 mm)
Interference fit of Guide in Bore	0.00025/0.00175 in (0,01/0,04 mm)
Overall length of Guide	2.13 in (54,10 mm)
Guide protrusion above Valve Spring Seating Face	0.638/0.662 in (16,20/16,81 mm)
Valve Guide bore diameter	0.3145/0.3155 in (7,99/8,01 mm)

Cylinder Head B2

Valves, Inlet

Valve stem diameter	0.312/0.313 in (7,92/7,95 mm)
Clearance fit of Valve stem in Guide	0.0015/0.0035 in (0,04/0,09 mm)
Valve head diameter	1.591/1.598 in (40,41/40,59 mm)
Valve face angle	45°
Valve depth below Cylinder Head face (Production)	0.029/0.041 in (0,74/1,04 mm)
(Service)	0.060 in (1,52 mm)
Overall length of Valve	4.503/4.521 in (114,38/114,83 mm)
Sealing Arrangement	Synthetic Rubber Deflector

Valves, Exhaust

Valve stem diameter	0.312/0.313 in (7,92/7,95 mm)
Clearance fit of Valve stem in Guide	0.0015/0.0035 in (0,04/0,09 mm)
Valve head diameter	1.3937/1.4016 in (35,4/35,6 mm)
Valve face angle	45°
Valve depth below Cylinder Head face (Production)	0.027/0.040 in (0,69/1,02 mm)
(Service)	0.060 in (1,52 mm)
Overall length of Valve	4.503/4.521 in (114,38/114,83 mm)
Sealing arrangement	Nil

Valve Springs Inner

Fitted length	1.49 in (37,84 mm)
Load at fitted length	28 ± 1.4 lbf (12,7 ± 0,65 kgf)
Free length	1.74 in (44,19 mm)

Valve Springs Outer

Fitted length	1.59 in (40,38 mm)
Load at fitted length	40 ± 2.0 lbf (18,1 ± 0,91 kgf)
Free length	1.81 in (45,97 mm)

Rocker Levers

Rocker lever bore diameter	0.7188/0.7196 in (18,26/18,28 mm)
Outside diameter of Bush	0.7199/0.7207 in (18,29/18,30 mm)
Interference fit of Bush in bore	0.0003/0.0019 in (0,01/0,05 mm)
Inside diameter of Bush (fitted)	0.625/0.6258 in (15,87/15,89 mm)

Rocker Shaft

Outside diameter of Shaft	0.6234/0.6244 in (15,83/15,86 mm)
Clearance fit of Rocker Lever Bush on Shaft	0.0006/0.0024 in (0,01/0,06 mm)
Lubrication	No. 1 Bracket through Shaft to Rocker Levers

Push Rods

Overall length	8.5102/8.5412 in (216,16/216,94 mm)
Outside diameter	0.247/0.25 in (6,27/6,35 mm)

To Remove the Cylinder Head

The following parts are bracketed to the cylinder head which will have to be detached before the cylinder head can be removed.

Lubricating oil filler tube.

Engine breather pipe.

Fuel pipe from lift pump to fuel filter (bracketed to rear cover plate of cylinder head). See Fig. B.1.

Fuel filter.

Because the **ROCKER ASSEMBLY** is secured to the head by the cylinder head securing setscrews, it will be necessary to adopt the following procedure.

Remove the two self-locking nuts from studs locating in Nos. 1 and 7 rocker support brackets, counting from the front. Loosen all the cylinder head setscrews in the reverse order to that shown on Fig. B.2. Remove the seven setscrews securing the rocker assembly. The rocker assembly can now be removed.

Valves

To remove the valve collets use a valve spring compressor and a suitable adaptor.

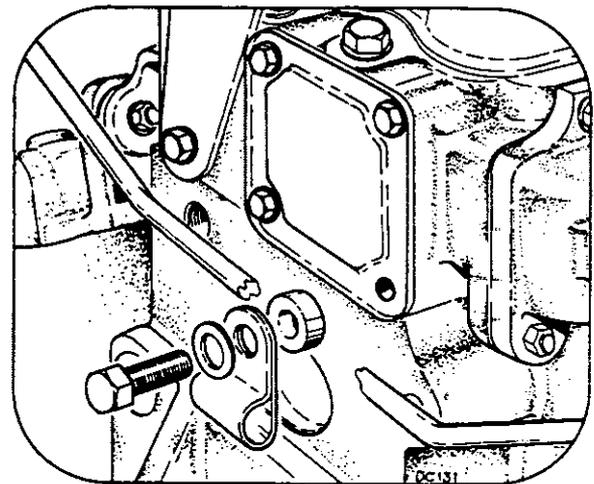
The valves are numbered to ensure refitment to their original positions. If servicing is necessary, check that the valve depths relative to the cylinder head face will be contained within the limits quoted on Page B.2. See Fig. B.3. Valve seat and valve angle is 45° for both inlet and exhaust valves. As narrow a seat as possible should be maintained.

When refitting the valve assembly into the cylinder head, take care that the rubber oil deflector on the inlet valve only is fitted onto the valve stem, open end facing downwards, under the valve spring cap, see Fig. B.3.

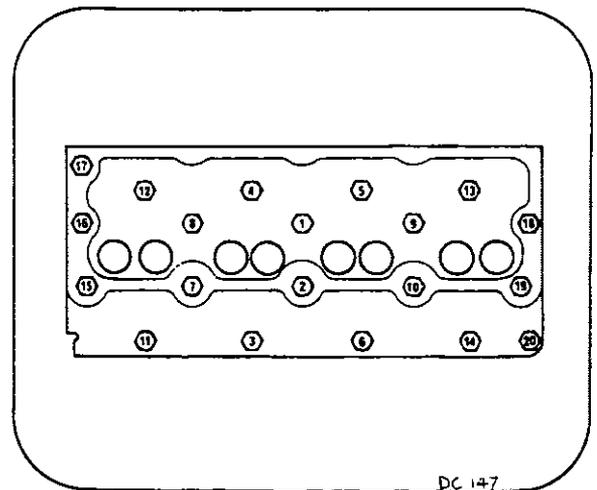
VALVE SEAT INSERTS cannot be fitted to the 4.154 engine.

Valve Guides

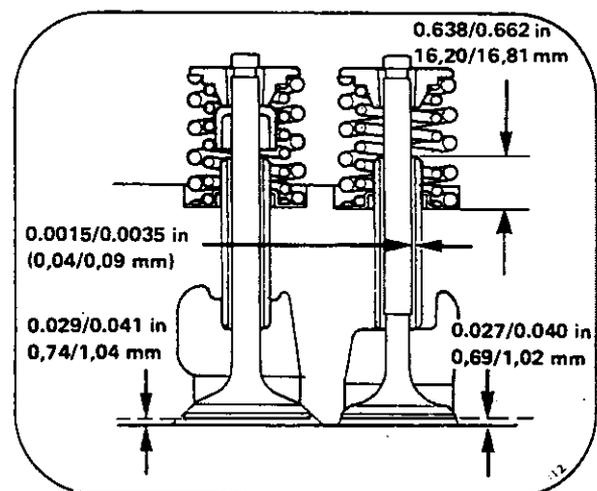
When renewing valve guides, remove the worn guides by using a suitable dolly and press. For the replacement of new guides use a special tool with adaptor to pull in, but care must be taken that when the pulling in of the guide is commenced, the operation must be continued until the guide is fully home. If the pulling of the guide into its location is halted before the operation is completed, difficulty is likely to be experienced in restarting. Use of the special stop will ensure correct guide protrusion as quoted on Page B1, see Fig. B.3.



B1

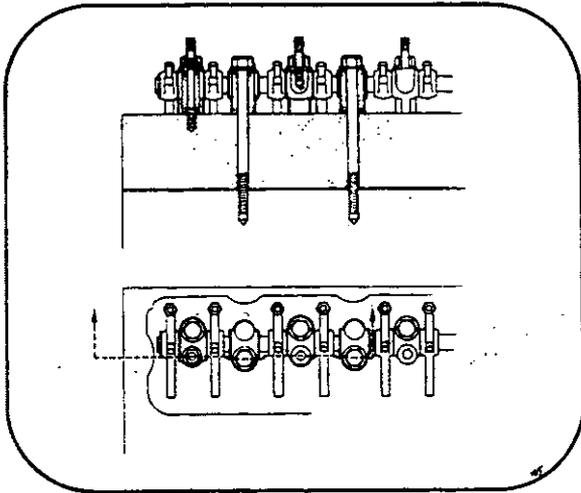


B2

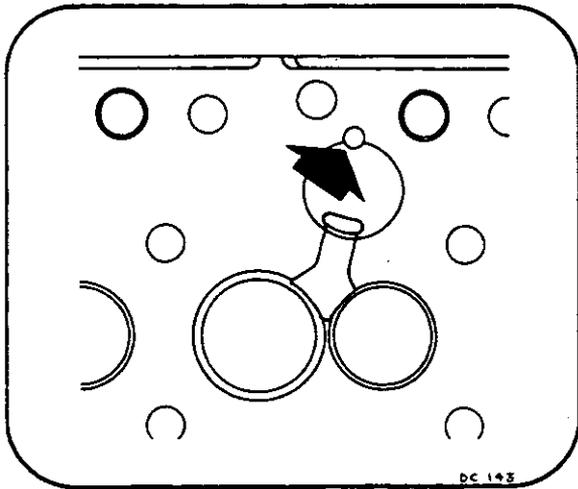


B3

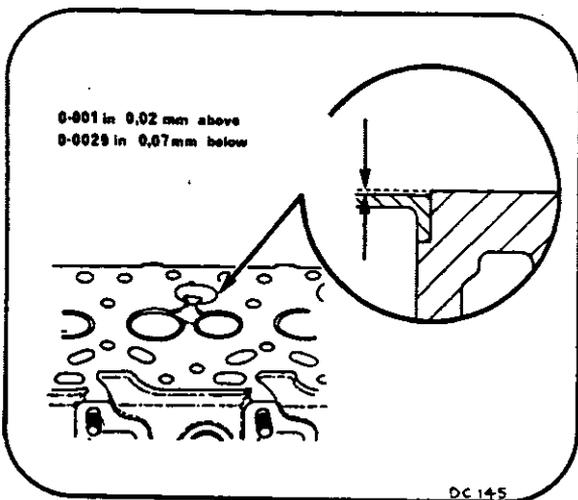
Cylinder Head B4



B4



B5



B6

Valve Springs

Check the valve springs for pressures developed at specific lengths against the figures quoted on Page B.2, and for any signs of deterioration caused by fatigue. It is advisable to fit new springs when an overhaul is undertaken.

Rocker Shaft Assembly

When dismantling, take note of the order of the support brackets for re-assembly, see Fig. B.4. The oil feed to the rockers is at the forward end of the cylinder head, and a drilling in the base of No. 1 support bracket locates with this hole, see Page 9.

Also note that the rocker shaft locating scallop is towards the front of the shaft.

Rocker Levers

If rocker lever bushes are found to be in need of replacement, rocker levers complete with bushes ready to fit are available.

Rocker level bushes are also available separately. With early engines, the oil hole in the bush should align with the oil hole in the rocker lever, but with later engines, after fitting the bush, it should be drilled with a 2 mm drill in line with the oil hole in the rocker lever. With the latter operation, ensure that all machining swarf is removed before assembling the rocker shaft.

Combustion Chamber Inserts

To remove the inserts use a short length of bar through the atomiser bore and tap out.

To replace, locate the inserts by means of the expansion washers, see Fig. B.5, to prevent the inserts from turning whilst the engine is in service.

When fitted, the height of the insert in relation to the cylinder head face should be checked against the figures quoted on Page B.1, see Fig. B.6.

Cylinder Head Distortion

The limits for cylinder head bow are given in SERVICE WEAR LIMITS on Page A.3. If examination reveals a dimension in excess of the limits quoted, a replacement cylinder head is recommended, as no allowance for skimming is provided.

Cylinder Head Gasket

Fit a new gasket when replacing the cylinder head. This is fitted DRY, and is located by two dowels in the cylinder block top face. See Fig. B.7.

Gaskets vary according to the pistons used, therefore ensure that the correct type is fitted.

Cylinder Head B5

Refitment of Cylinder Head

Before refitting the cylinder head, ensure that the oilway in the block top face and cylinder head is clean. Examine the PUSH RODS for straightness, and fit into their location.

The rocker assembly is fitted before securing the head, and is located by two studs in the cylinder head through Nos. 1 and 7 rocker support brackets and secured by two nuts. The rocker shaft is correctly positioned by the scallop which locates on the front securing stud. (Take care that the oilway in the base of No. 1 support bracket is clean and aligns with the corresponding oilway in the head. After fitting the cylinder head, replace the seven longest setscrews through the support brackets into the head and secure finger tight.

Replace the remaining thirteen setscrews and tighten them all progressively in the sequence shown in Fig. B.2, until a final torque of 85 lbf ft (11,7 kgf m-115 Nm) is achieved. This final torque tightening stage should be repeated.

Retighten the two rocker assembly securing nuts.

Valve Clearances

The valve tip clearance should be set with the engine cold at 0.012 in (0,3 mm) see Fig. B.8, using the following procedure:-

- (a) With the valves rocking on No. 4 cylinder (the period between the opening of the inlet valve and the closing of the exhaust valve), set the clearance on No. 1 cylinder.

- (b) With the valves rocking on No. 2 cylinder, set the clearance on No. 3 cylinder.
- (c) With the valves rocking on No. 1 cylinder, set the clearance on No. 4 cylinder.
- (d) With the valves rocking on No. 3 cylinder, set the clearance on No. 2 cylinder.

Atomisers

Refit the atomisers squarely into their locations using a new sealing washer, and ensure that the securing nuts are tightened evenly to a torque of 12 lbf ft (1,7 kgf m-16 Nm.)

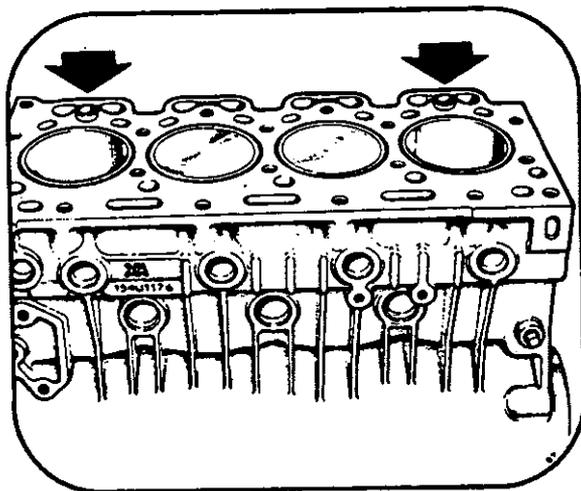
Engine Running Check

Before fitting the top cover, start the engine and run at a fast idle.

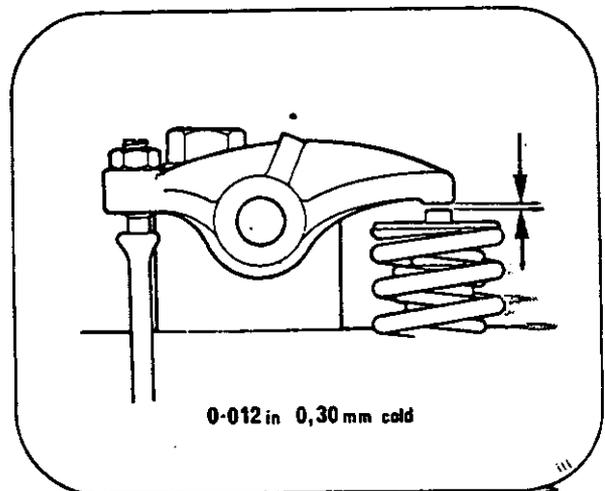
Check for satisfactory oil pressure where a gauge is fitted. Check that lubricant is reaching the rocker assembly. Check for fuel, oil and coolant leaks.

When the engine is thoroughly warmed through, shut down and re-torque the cylinder head securing setscrews. When the engine is cold, re-set the valve tip clearances to 0.012 in (0,30 mm).

Carry out this check again after 500/1,000 miles (800/1,600 km) or 20/40 hours in service.



B7



B8

Section C'

PISTONS AND CONNECTING RODS

The pistons are manufactured from high silicon aluminium alloy, flat topped with three compression rings, and one scraper ring above the gudgeon pin and one below it.

The gudgeon pins which are fully floating are located axially in the pistons by circlips.

The gudgeon pins are off-set, so ensure that the pistons and connecting rods are correctly assembled by means of the numbers on the piston crowns and connecting rod big ends as described later in this section.

The connecting rods are manufactured from molybdenum alloy steel stampings with an "H" section shank. The big ends are split at right angles to the rod axis, with each cap secured by two nuts and bolts. The big end bearing bores are fitted with replaceable thin wall aluminium-tin steel backed shell bearings, and the small end bores are fitted with steel backed bronze lined bushes.

PISTON AND ROD DIMENSIONS

Pistons

Type	Flat topped
Piston Height above Cylinder Block Top Face – Prior to Engine No. GA 000398C	0.000/0.004 in (0,00/0,10 mm)
Piston Height above Cylinder Block Top Face – Commencing Engine No. GA.....000398C	0.004/0.008 in (0,10/0,20 mm)
Bore Diameter for Gudgeon Pin	1.2495/1.250 in (31,74/31,75 mm)
Transition fit of Pin in Bore	0.00024 in clearance/0.00046 in interference (0,001/0,01 mm)
Compression Ring Groove Width top, 2nd and 3rd	0.096/0.097 in (2,44/2,46 mm)
Scraper Ring Groove Width 4th and 5th	0.1895/0.1905 in (4,81/4,84 mm)

Piston Rings

Compression, top	Chrome plated or Chrome inlay
Compression, 2nd and 3rd	Internally stepped
Scraper, 4th	Chrome plated, slotted
Scraper, 5th	Slotted
Compression Ring Width, top, 2nd and 3rd	0.093/0.0938 in (2,36/2,38 mm)
Ring Clearance in Grooves	0.0022/0.004 in (0,05/0,10 mm)
Scraper Ring Width, 4th	0.1868/0.1875 in (4,74/4,76 mm)
Ring Clearance in Groove	0.002/0.0038 in (0,05/0,10 mm)
Scraper Ring Width, 5th	0.1865/0.1875 in (4,74/4,76 mm)
Ring Clearance in Groove	0.002/0.004 in (0,05/0,10 mm)
Compression Ring Gap, top	0.014/0.027 in (0,36/0,69 mm)
Compression Ring Gaps, 2nd and 3rd	0.011/0.024 in (0,28/0,61 mm)
Scraper Ring Gap, 4th	0.014/0.027 in (0,36/0,69 mm)
Scraper Ring Gap, 5th	0.011/0.024 in (0,28/0,61 mm)

The ring gaps quoted are as measured in a clean un-worn part of the cylinder bore.

Gudgeon Pins

Type	Fully floating
Outside Diameter	1.24976/1.24996 in (31,74/31,75 mm)
Clearance fit in Small End Bush	0.00054/0.00175 in (0,01/0,04 mm)

Connecting Rods

Type	"H" Section
Big End Parent Bore	2.395/2.3955 in (60,83/60,84 mm)
Small End Parent Bore	1.375/1.376 in (34,92/34,95 mm)
Connecting Rod Big End Width	1.361/1.363 in (34,57/34,62 mm)
Length from centre line of Big End to centre line of Small End	6.8115/6.8135 in (173,01/173,06 mm)

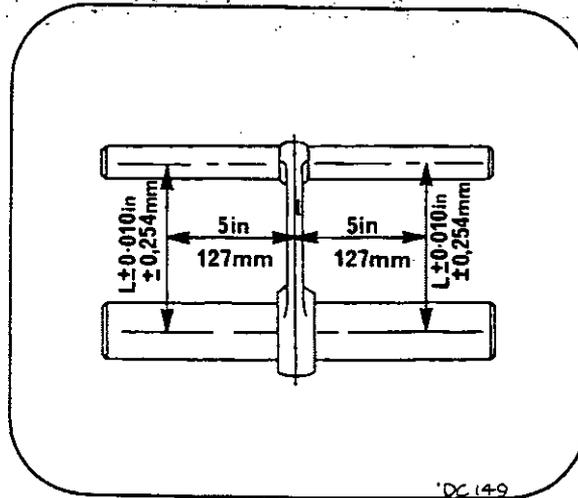
Pistons and Connecting Rods C2

Connecting Rod End Float	0.0095/0.0131 in (0,24/0,33 mm)
Big End Bolt Size	7/16 in (11,11 mm)
Thread of Bolt	U.N.F.
Type of Big End Nut	Self Locking

Note: When Big End nuts are removed, they must be replaced by new ones.

Connecting Rod alignment

Large and small end Connecting Rod bores must be square and parallel with each other within the limits of ± 0.010 in (0,25 mm) measured 5 in (127 mm) each side of the axis of the rod on the test mandrel as shown in Fig. C.1. With the small end bush fitted, the limit of ± 0.010 in (0,25 mm) is reduced to ± 0.0025 in (0,06 mm).



Small End Bushes

C1

Type	Steel Backed, Bronze lined
Length of Small End Bush	1.047/1.055 in (26,59/26,80 mm)
Outside Diameter	1.3785/1.380 in (35,01/35,05 mm)
Interference Fit of Bush in Rod	0.0025/0.005 in (0,06/0,13 mm)
Inside Diameter (finished bore in position after reaming)	1.2505/1.2515 in (31,76/31,79 mm)

Connecting Rod Bearings

Type	Steel backed, Aluminium Tin lined
Shell Width	1.1208/1.1280 in (28,47/28,65 mm)
Outside Diameter of Bearings	2.3955 in (60,85 mm)
Inside Diameter of Bearings	2.2504/2.2515 in (57,16/57,19 mm)
Connecting Rod Bearing Running Clearance	0.0014/0.003 in (0,04/0,08 mm)
Steel Thickness	0.0467/0.0582 in (1,19/1,48 mm)
Aluminium Tin Thickness	0.0138/0.0256 in (0,35/0,65 mm)

Removal of Piston and Rods

Sump

On some applications it will be found necessary to remove the engine from the chassis because the engine support brackets are fastened to the sump.

The pistons and connecting rods are removed from the cylinder block through the top of the cylinder bores, see Fig. C.2.

Big End Bearings

If examination reveals that there is no necessity to renew big end bearings, they should be suitably marked to ensure refitment to their original positions.

Gudgeon Pins

To facilitate the removal of the gudgeon pins from the pistons, immerse the pistons in a warm liquid 100-120°F (40-50°C), when the pins, after removal of the circlips, can be easily withdrawn.

Pistons and Rings

If new pistons are to be fitted, three grades are available dependant upon the condition of the liners.

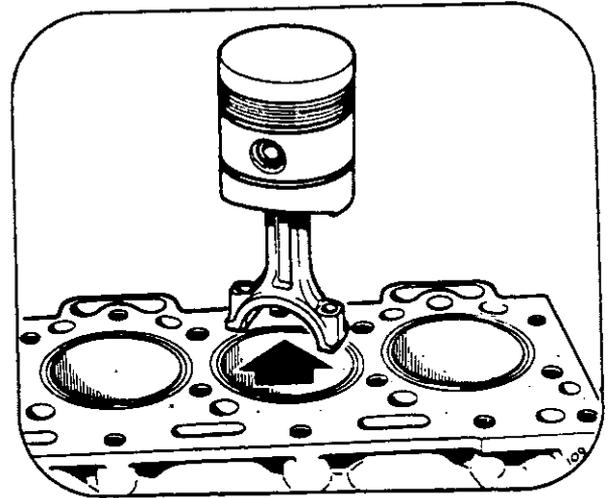
Standard service piston, untopped which requires topping to give the necessary piston height as quoted on Page C.1.

Standard service piston topped to give the correct piston height as given on Page C.1.

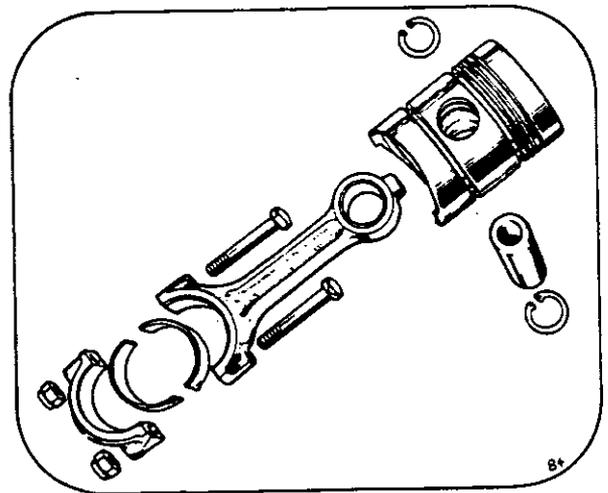
0.030 in (0.76 mm) oversize service piston, topped to give the correct piston height as given on Page C.1.

The maximum permissible worn ring lift of the top piston ring with a new ring fitted is 0.008 in (0.20 mm).

In a worn cylinder bore, the piston ring gap should be measured in the unworn, clean portion of the cylinder and checked against the dimensions quoted on Page C.1.

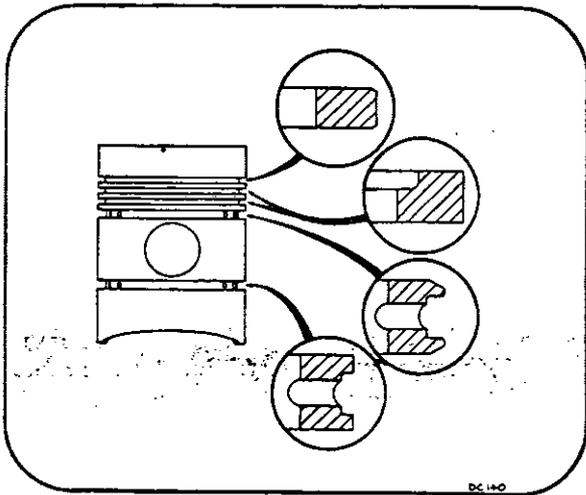


C2



C3

Pistons and Connecting Rods C4



C4

Connecting Rods

To renew small end bushes, remove the worn bushes by means of a suitable press and dolly. Press in the new bushes, making sure that the oil holes in the bush and rod small end align when fitted. Ream out the new bush to dimension quoted on Page C.2, ensuring squareness with big end bore. See Page C.2, for checking connecting rod parallelism and twist.

Assembly

If it is intended to utilise the existing pistons, ensure that they are relocated in their original positions relative to connecting rod and cylinder bores.

Engines commencing Engine No. 154U7705 have pistons with offset gudgeon pins and it is important that these pistons are correctly fitted.

When assembling topped pistons to connecting rods, always ensure that the letter "F" on the piston crown will be to the front of the engine.

Where untopped pistons are used, the crown will be left unmarked and in this instance, the letter "F" inside the piston skirt should be to the front of the engine.

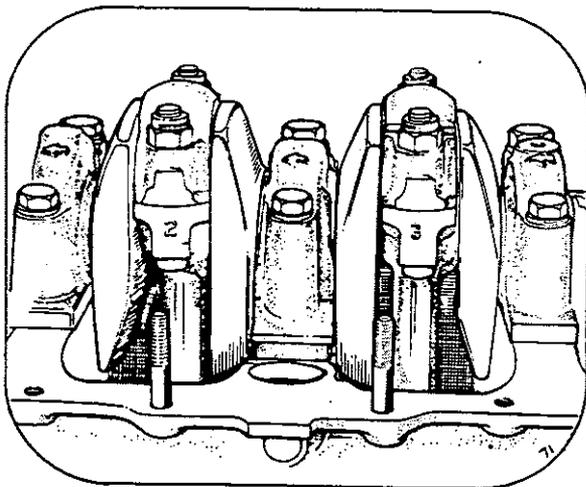
Heat the pistons in liquid to 100-120°F (40-50°C) for insertion of the gudgeon pin.

The piston ring layout is given on Page C.1, see Fig. C.4 for cross sectional diagram showing layout of rings, note the position of the internally stepped rings.

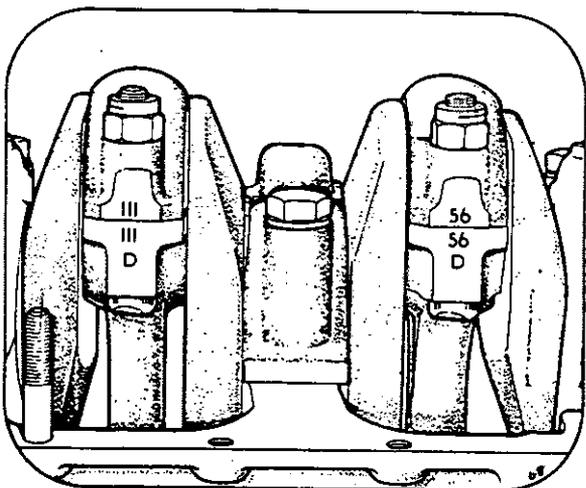
Use piston ring squeezer when inserting the pistons into the cylinder bores.

Where piston rings are marked "BTM", ensure that the marked face is to the skirt of the piston. Where rings are marked "TOP", ensure that they are fitted with the marked face to the crown of the piston.

Each connecting rod is stamped with the number of the cylinder to which it belongs counting from the forward end of the engine, (1,2,3,4). When the pistons are in the bores, these numbers are on the camshaft side of the engine, see Fig. C.5. On the opposite side of the connecting rod will be found an assembly number. These assembly numbers are repeated on the connecting rod cap and when assembling the caps to rods, these numbers must appear on the same side, see Fig. C.6. It will be noticed that each connecting rod assembly has its own assembly number. The letter etched beneath the



C5



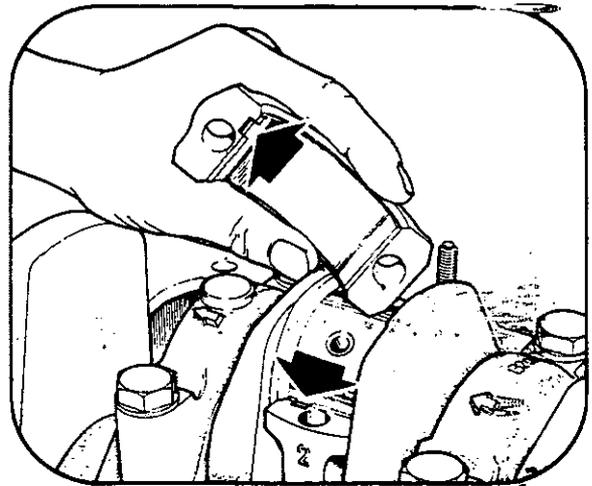
C6

assembly number (A to F) is the connecting rod weight code.

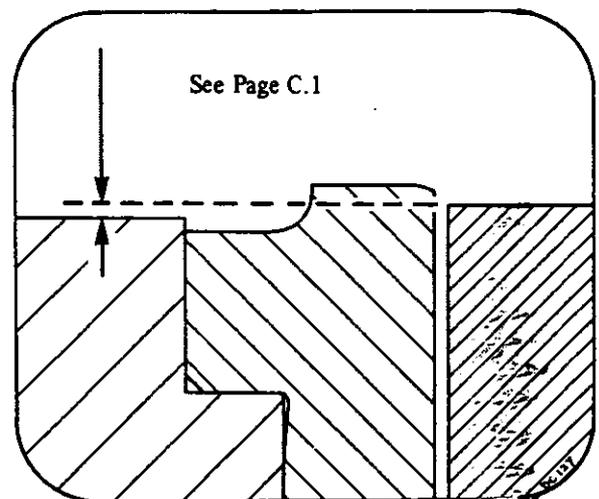
When refitting the connecting rod bearings, ensure that the locating tabs of the bearings are correctly located in the machined recesses of the rod and cap, see Fig. C.7.

Lubricate the bearing surfaces and fit the connecting rod to the crankpin. Examine the securing bolts for serviceability and renew if necessary. Renew the nuts and tighten evenly to a torque of 45 lbf ft (6,2 kgf m-61 Nm.) for non-phosphated nuts or 60 lbf ft (8,3 kgf m-82 Nm.) for phosphated nuts.

Piston height in relation to cylinder block top face, see Page C.1 can be checked with the piston at T.D.C. See Fig. C.8.



C7



C8

Section 'D'

CYLINDER BLOCK AND LINERS

The cylinder block is cast integrally with the crankcase in high duty cast iron. Flanged cast iron "dry" type cylinder liners are fitted.

Ventilation of the crankcase is by a breather pipe situated on the cylinder head top cover, which is fitted to the right hand side of the engine.

The crank case joint face does not extend below the crankshaft axis.

CYLINDER BLOCK AND LINER DIMENSIONS

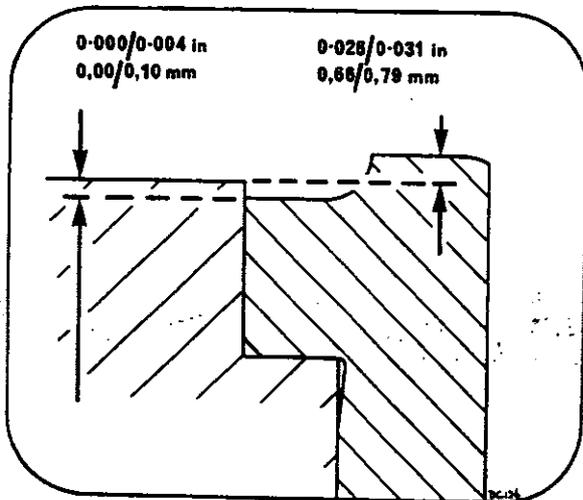
Cylinder Block

Total height of Cylinder Block from Head Face to Bottom Face	11.177/11.181 in (283,9/284,0 mm)
Parent Bore diameter for Cylinder Liner	3.8125/3.8135 in (96,84/96,86 mm)
Cylinder Block recess depth for Liner Flange	0.150/0.152 in (3,81/3,86 mm)
Cylinder Block Recess Bore	3.990/3.995 in (101,35/101,47 mm)
Main Bearing Parent Bore	2.916/2.917 in (74,07/74,09 mm)
No. 1 Bore for Camshaft	2.0472/2.0484 in (52,0/52,03 mm)
No. 2 Bore for Camshaft	2.0374/2.0386 in (51,75/51,78 mm)
No. 3 Bore for Camshaft	2.0275/2.0287 in (51,5/51,53 mm)
No. 4 Bore for Camshaft	2.0177/2.0189 in (51,25/51,28 mm)
Cylinder Block Tappet Bore diameter	0.5625/0.56375 in (14,29/14,32 mm)
Cylinder Block Crankshaft Thrust Washer Recess diameter	3.756/3.764 in (95,4/95,6 mm)

Cylinder Liners

Type	Dry Interference Fit
Outside diameter of Liner	3.8145/3.8155 in (96,89/96,91 mm)
Interference fit of Liner in Cylinder Block Parent Bore	0.001/0.003 in (0,02/0,08 mm)
Cylinder Liner Finished Bore	3.501/3.502 in (88,92/88,95 mm)
Cylinder Liner Flange Thickness	0.148/0.150 in (3,76/3,81 mm)
Depth of Flange BELOW Top Face of Cylinder Block	0.000/0.004 in (0,00/0,10 mm)
Cylinder Liner Flange Diameter	3.972/3.976 in (100,0/101,0 mm)
Height of Liner Collar ABOVE Flange	0.028/0.033 in (0,71/0,84 mm)
Height of Collar ABOVE Top Face of Cylinder Block	0.026/0.031 in (0,66/0,79 mm)
Clearance fit of Liner Flange in Cylinder Block Recess	0.014/0.023 in (0,35/0,57 mm)

Cylinder Block and Liners D2



D1

Cylinder Block

The top face of the cylinder block may be skimmed up to a maximum of 0.020 in (0,51 mm). Where this is necessary, the cylinder liner recess depth and piston height should be lowered by the same amount, and the cylinder block face (outside the gasket area) marked accordingly.

Cylinder Liners

If the worn inside diameter of the cylinder liner does not exceed 0.006 in (0,15 mm) from standard, new piston rings may be fitted.

If examination reveals a worn condition of 3.508 in (89,10 mm) or bore diameter dimensions in excess, the liner can be bored out to 3.531/3.532 in (89,69/89,71 mm), and 0.030 in (0,76 mm) oversize pistons fitted.

The limits for the flange recession, and liner collar protrusion may be checked on Page D.1, see Fig. D1.

To Renew Cylinder Liners

New production liners can be fitted to the engine. Remove all components from the cylinder block. The liners should be pressed out from the bottom. Lubricate the outside diameter of the new liner with clean oil.

Press in the new liners until they are fully home. The collar of the liner should protrude above the top face of the cylinder block by 0.026/0.031 in (0,66/0,79 mm). Bore and finish the liners to a dimension of 3.501/3.502 in (88,92/88,95 mm), and a final bore finish of 22/32 micro in (0,56/0,81 microns).

Section 'E'

CRANKSHAFT AND MAIN BEARINGS

The crankshaft is forged from chrome-molybdenum steel with integral balance weights on the front, rear and two centre webs. End float is controlled by steel backed, aluminium tin replaceable thrust washers located on both sides of the centre main bearing.

An oil thrower flange is provided at the rear end. A timing gear is fitted to the forward end of the crankshaft, located by a key.

Five main bearings are fitted, which are replaceable thin wall, aluminium tin lined, steel backed and retained by bearing caps of high duty cast iron which are located by dowels and secured by two high tensile steel setscrews.

CRANKSHAFT AND MAIN BEARING DIMENSIONS

Crankshaft

Main Journal Diameter	2.7485/2.749 in (69,81/69,82 mm)
Main Journal Width No. 1	1.391/1.421 in (35,4/36,1 mm)
Main Journal Width Nos. 2, 4 and 5	1.4335/1.4415 in (36,4/36,6 mm)
Main Journal Width No. 3	1.4365/1.4385 in (36,49/36,54 mm)
Main Journal Fillet Radii	9/64–5/32 in (3,57/3,97 mm)
Crankshaft Pin Diameter	2.2485/2.249 in (57,10/57,12 mm)
Crankshaft Pin Width	1.3725/1.3741 in (34,86/34,9 mm)
Crankshaft Pin Fillet Radii	1/8–9/64 in (3,2/3,57 mm)
Surface Finish, all Journals, Pins and Oil Seal Diameter	16 micro in max (0,4 microns max)
Crankshaft Journals and Pins Re-grind Undersizes	0.010, 0.020 and 0.030 in (0,25, 0,51 and 0,76 mm)
Oil Seal Helix Diameter	2.211/2.212 in (56,16/56,18 mm)
Oil Seal Helix Width	0.050/0.080 in (1,27/2,03 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,1/0,2 mm)
Crankshaft Flange Diameter	3.9985/3.9995 in (101,56/101,59 mm)
Crankshaft Flange Width	0.5 in (12,7 mm)
Spigot Bearing Recess Depth	0.875 in (22,22 mm)
Spigot Bearing Recess Bore	1.2495/1.251 in (31,74/31,77 mm)
Crankshaft End Float	0.003/0.015 in (0,08/0,38 mm)

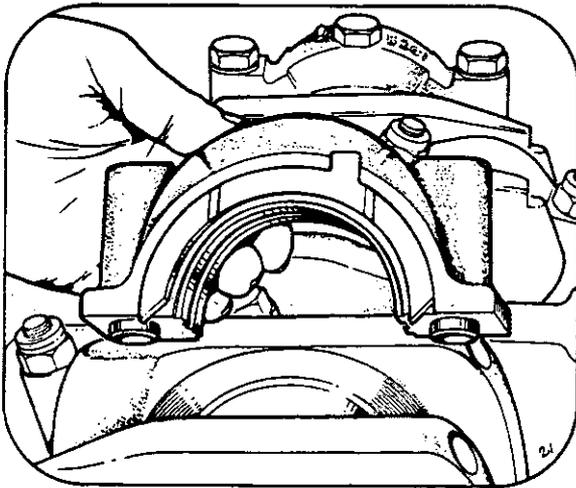
Main Bearings

Type	Steel backed, Aluminium Tin lined
Shell Width for all Journals	1.122/1.130 in (28,5/28,7 mm)
Outside Diameter of Bearings	2.917 in (60,84 mm)
Inside Diameter of Bearings	2.7515/2.753 in (69,89/69,93 mm)
Main Bearing Running Clearance	0.0025/0.0045 in (0,06/0,11 mm)
Steel Thickness	0.0625 in (1,59 mm) maximum
Aluminium Tin Thickness	0.0197 in (0,50 mm)

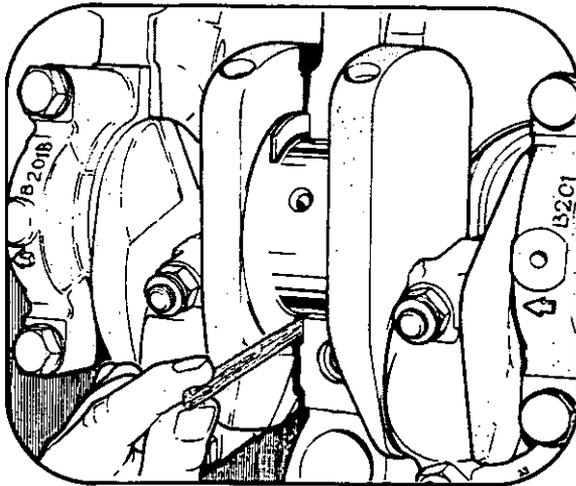
Crankshaft Thrust Washers

Type	Steel backed Aluminium Tin
Position in Engine	Centre Main Bearing
Thrust Washer Thickness STD (1)	0.0896/0.0915 in (2,26/2,32 mm)
Thrust Washer Thickness O/S (1)	0.0966/0.0985 in (2,45/2,50 mm)
Thrust Washer Diameter	3.744/3.756 in (95,1/95,4 mm)

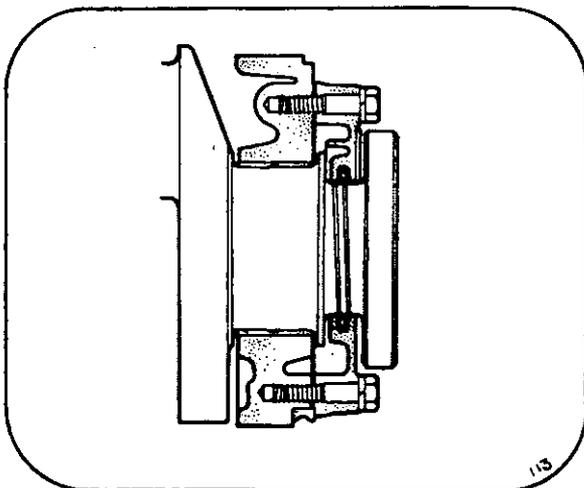
Crankshaft and Main Bearings E2



E1



E2



E3

Crankshaft End Float

If the thrust washers are to be renewed, remove the centre main bearing cap which provides the location for each of the two bottom halves of the thrust washers. With the cap removed, the two top halves of the washers are accessible, see Figs. E.1 and E.2.

The maximum permissible worn end-float is 0.020 in (0,51 mm). The fitting of oversize thrust washers can be used to bring the end float to within the production limits quoted on Page E.1.

Removal of Crankshaft

Remove the timing case, see Page F.3. Release the two rear main oil seal housing clamping setscrews before removing all main bearing caps, and mark the main bearings to their respective caps or journals if they are to be replaced.

Overhaul of Standard Size Crankshaft

The minimum permissible worn diameter of the main journals is 2.7475 in (69,78 mm), and for the big end journals 2.2475 in (57,08 mm). Maximum permissible ovality for crank pins and main journals is 0.0005 in (0,01 mm).

The crankshaft can be reground to - 0.010 in (-0,25 mm), - 0.020 in (-0,51 mm) and - 0.030 in (-0,76 mm) undersize.

Crankshaft Rear Oil Seal and Housing - See Fig. E.3.

If examination reveals the necessity to renew the oil seals the following procedure should be adopted.

With a half housing in a vice, and the seal recess uppermost, settle approximately 1 in (25 mm) of the seal, at each end, into the groove ensuring that each end of the seal projects 0.010/0.020 in (0,25/0,51 mm) beyond the half housing joint face.

Press the remainder of the seal into position starting from the centre and working outwards.

Using a suitable round bar, roll and press the seal into position.

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

To refit the assembly, proceed as follows:-

Thoroughly clean the joint and butt faces, removing all traces of the old joint.

Lightly coat the cylinder block and bearing cap side of the joint with jointing compound, and place the joint in position, ensuring that the securing holes are aligned.

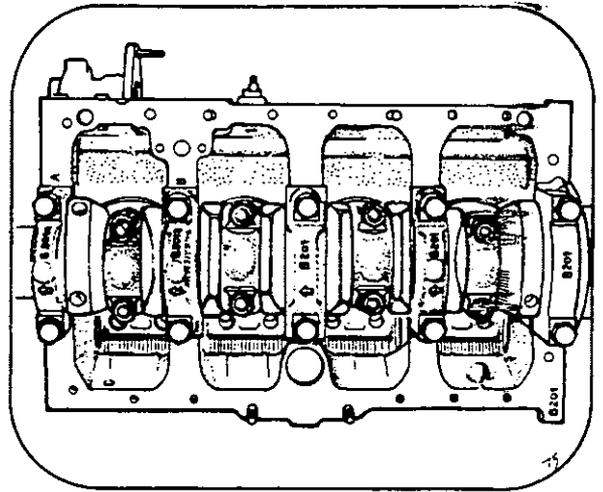
Lightly coat the butt faces of the half housings with jointing compound. Lubricate the exposed diameter of the rope seal with graphite grease.

Oil the crankshaft rear end around the oil return groove. Place the half housings in position on the engine and locate all setscrews in the cylinder block and bearing cap face, finger tight only.

Tighten the clamping bolts to a torque of only 6 lbf ft (0,83 kgf m)—8 Nm.

Tighten the setscrews in the cylinder block and bearing cap to a torque of 12 lbf ft (1,66 kgf m)—15 Nm.

Finally tighten the clamping bolts to a torque of 12 lbf ft (1,66 kgf m)—15 Nm.



E4

Main Bearing Caps

Each main bearing cap is identified in relation to the cylinder block by the block serial number which is stamped on the rear of the bottom face on the camshaft side. See Fig. E.4.

An arrow is cast on to each cap indicating the forward end of the engine to ensure correct fitment.

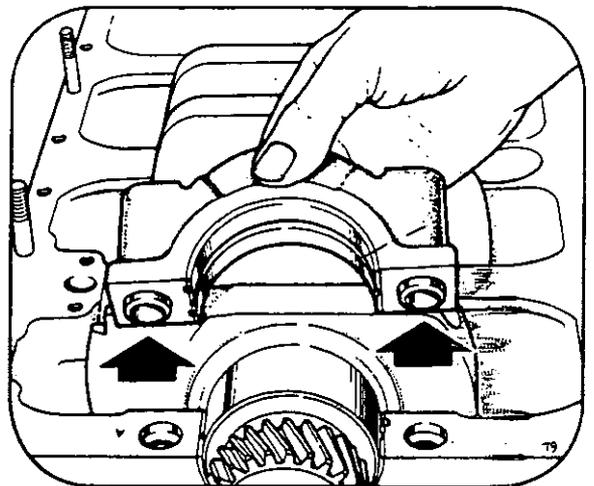
No. 1 cap (counting from the front) is stamped with an "A". A corresponding "A" is stamped on the block. See Fig. E.4. No. 2 cap is stamped with a "B" with corresponding letter stamped on the block.

No. 3 has no letter, but is the centre main bearing cap which carries the thrust washers and is therefore easily identified.

No. 4 cap has no identification and is similar to numbers 1 and 2, but as at this stage these are already located, its position is pre-determined.

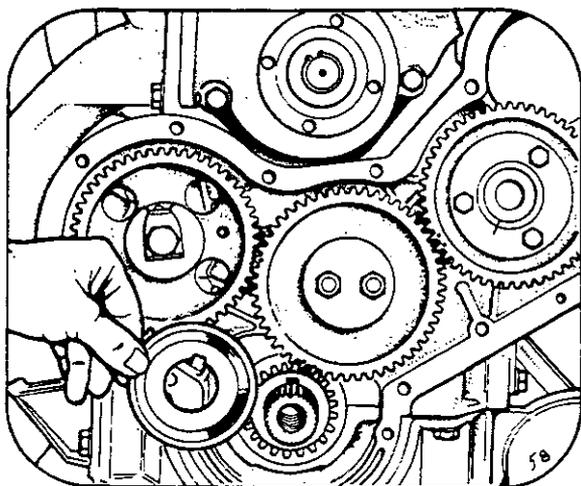
No. 5 cap is the rear main, and is drilled and tapped to carry the bottom half of the oil seal housing and is therefore easily identified.

To refit, ensure that the locating dowels are correctly positioned see Fig. E.5, and the cap is placed firmly over the crankshaft main journal. Tighten the securing setscrews to a torque of 85 lbf ft (11,7 kgf m)—115 Nm.



E5

Crankshaft and Main Bearings E4



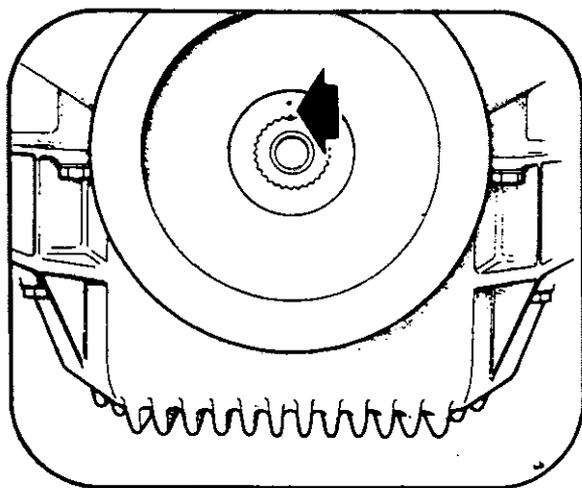
E6

Oil Thrower Flange

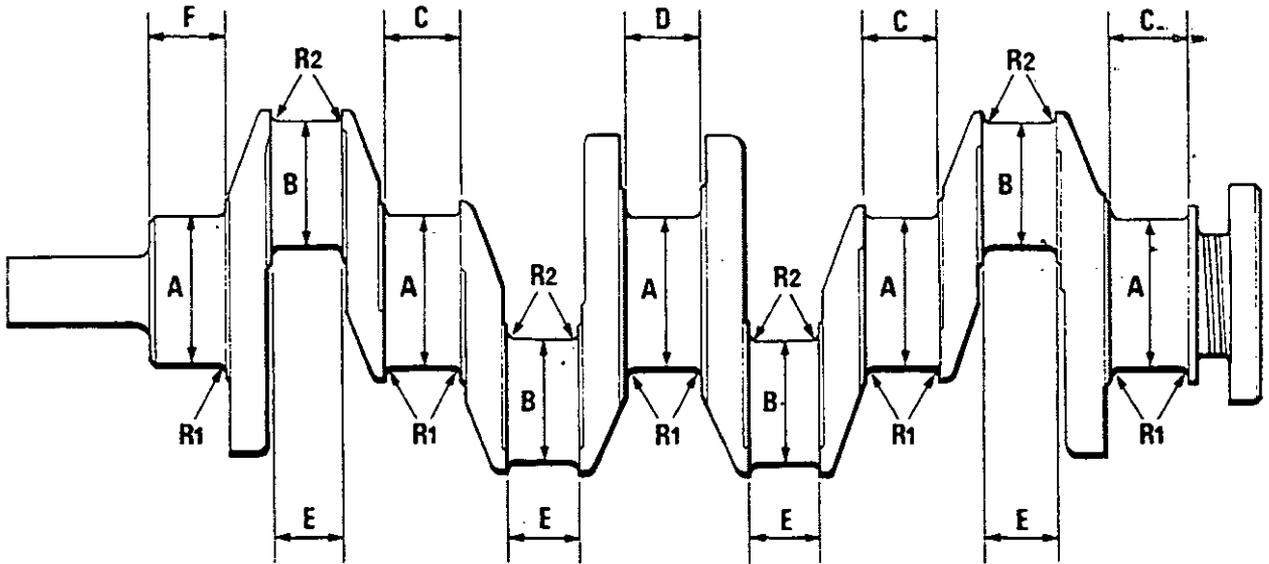
When refitting the crankshaft, do not omit to fit the oil thrower flange, see Fig. E.6, onto the front end of the crankshaft before fitting the timing case cover and crankshaft pulley.

Crankshaft Pulley

When fitting the crankshaft pulley, ensure that the timing marks on the end of the crankshaft and pulley align. See Fig. E.7. Tighten the pulley retaining set-screw to 123 lbf ft (17,0 kgf m)—167 Nm.



E7



Crankshaft Regrind Data

	0.010 in (0,25 mm) Undersize	0.020 in (0,51 mm) Undersize	0.030 in (0,76 mm) Undersize
A	2.7385/2.739 in (69,56/69,57 mm)	2.7285/2.729 in (69,30/69,32 mm)	2.7185/2.719 in (68,80/68,81 mm)
B	2.2385/2.239 in (56,86/56,87 mm)	2.2285/2.229 in (56,60/56,62 mm)	2.2185/2.219 in (56,35/56,36 mm)
C	1.4459 in (36,73 mm) maximum		
D	1.4416/1.4445 in (36,61/36,69 mm)	1.4466/1.4495 in (36,74/36,82 mm)	1.4516/1.4545 in (36,87/36,94 mm)
E	1.3806 in (35,07 mm) maximum		
F	1.4045 in (35,67 mm) maximum		
R1	0.146/0.157 in (3,71/3,99 mm) all journals		
R2	0.126/0.142 in (3,20/3,61 mm) all crankpins		

| Surface finish crankpins and journals 16 micro inches (0,4 microns) C.L.A. maximum.

| Surface finish all fillet radii 50 micro inches (1,3 microns) C.L.A. maximum.

Magnetic crack detection D.C. Flow – 2.5 amps A.C. Current – 1300 amps

Limits of taper and out of round for pins and journals:-

Taper 0.00025 in
(0,005 mm)

Out of Round 0.00025 in
(0,005 mm)

Maximum Run-out with the crankshaft mounted on the end main journals

Independent readings:-

Crankshaft Pulley
Diameter T.I.R.
0.002 in (0,05 mm)

Rear Oil Seal
Diameter T.I.R.
0.002 in (0,05 mm)

Flywheel Flange
Diameter T.I.R.
0.002 in (0,05 mm)

Journals T.I.R. – Run-out must not be opposed

Number 1. Mounting	Number 2. 0.003 in (0,08mm)	Number 3. 0.006 in (0,15mm)	Number 4. 0.003 in (0,08mm)	Number 5. Mounting
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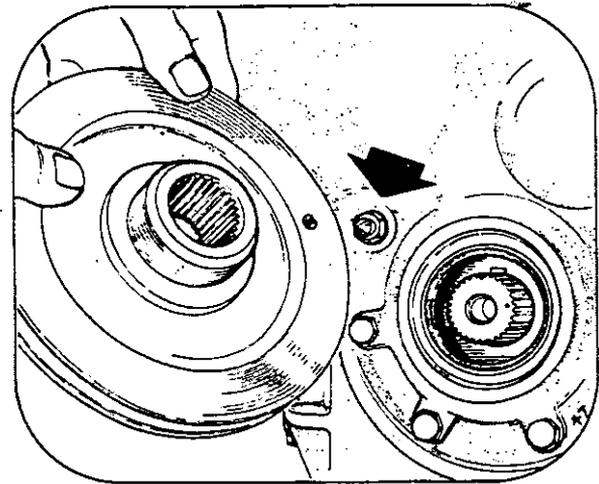
Section 'F'

TIMING CASE AND DRIVE

A helical gear drive is used, the timing gear train consisting of hardened steel crankshaft and idler gears driving cast iron camshaft and fuel pump gears, provision being made for fuel pump timing adjustment.

All gears are enclosed by an aluminium timing case and cover. A timing pin device is provided on the timing case front cover, situated behind the crankshaft pulley which can locate into the back of the pulley to facilitate the obtaining of T.D.C. No. 1 piston. See Fig. F.1.

The cast iron camshaft with chill hardened cams is supported in four bearings in the right hand side of the cylinder block. All the bearings are pressure lubricated by internal oilway drillings.



F1

CAMSHAFT AND TIMING GEAR DIMENSIONS

Camshaft

Journal Length, No. 1	1.18 in (29,97 mm)
Journal Diameter, No. 1	2.0437/2.0448 in (51,91/51,94 mm)
Journal No. 1 Clearance Fit	0.0024/0.0047 in (0,06/0,12 mm)
Journal Length, No. 2	1.0 in (25,4 mm)
Journal Diameter, No. 2	2.0339/2.035 in (51,66/51,69 mm)
Journal No. 2 Clearance Fit	0.0024/0.0047 in (0,06/0,12 mm)
Journal Length, No. 3	1.0 in (25,4 mm)
Journal Diameter, No. 3	2.0241/2.0252 in (51,41/51,44 mm)
Journal No. 3 Clearance Fit	0.0024/0.0047 in (0,06/0,12 mm)
Journal Length, No. 4	1.0 in (25,4 mm)
Journal Diameter, No. 4	2.0142/2.0154 in (51,16/51,19 mm)
Journal No. 4 Clearance Fit	0.0024/0.0047 in (0,06/0,12 mm)
Cam Lift	0.280/0.282 in (7,11/7,16 mm)
Eccentricity of Lift Pump Cam	0.095/0.098 in (2,41/2,49 mm)
Camshaft Spigot Diameter for Gear	1.1251/1.1257 in (28,58/28,59 mm)
Camshaft Spigot Width for Thrust Plate	0.2374/0.2401 in (6,03/6,10 mm)
Oilway for Rocker Lubrication	No. 1 Journal

Camshaft Thrust Plate

Type	Oil-impregnated Sintered Iron
Inside Diameter of Bore	1.4 in (35,5 mm)
Thrust Plate Thickness	0.233/0.2362 in (5,92/6,00 mm)
Camshaft End Float	0.0012/0.0071 in (0,03/0,18 mm)

Camshaft Gear

Inside Diameter of Gear Boss	1.125/1.126 in (28,57/28,60 mm)
Transition fit of Gear on Camshaft Spigot	0.0007 interference/0.0009 in clearance (0,018/0,023 mm)

Timing Case and Drive F2

Fuel Pump Gear, Hub and Adaptor for Hydraulically Governed Engines

Inside Diameter of Gear for Fuel Pump Drive Hub Spigot	1.7507/1.7516 in (44,47/44,49 mm)
Drive Hub Gear Spigot	1.7496/1.7503 in (44,44/44,46 mm)
Clearance fit of Gear on Hub Spigot	0.0004/0.002 in (0,01/0,05 mm)
Adaptor Parent Bore Diameter for Bushes	1.4063/1.4076 in (35,72/35,75 mm)
Outside Diameter of Bushes (2)	1.40625/1.40725 in (35,72/35,74 mm)
Interference fit of Bushes in Adaptor Parent Bore	0.0009/0.0013 in (0,02/0,03 mm)
Inside Diameter of Bushes	1.250/1.2516 in (31,75/31,79 mm)
Outside Diameter of Hub	1.248/1.249 in (31,70/31,72 mm)
Running Clearance of Drive Hub in Bushes	0.001/0.0036 in (0,02/0,09 mm)
Drive Hub End Float	0.005/0.011 in (0,13/0,28 mm)

Fuel Pump Gear for Mechanically Governed Engines

Inside Diameter of Gear for Fuel Pump Spigot	1.750/1.751 in (44,45/44,47 mm)
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Idler Gear and Hub

Idler Gear Bore Diameter	1.8898/1.8908 in (48,00/48,02 mm)
Idler Gear Bush Outside Diameter	1.8915/1.8924 in (48,04/48,07 mm)
Interference fit of Bush in Bore	0.0007/0.0027 in (0,02/0,07 mm)
Idler Gear Bush Bore	1.7327/1.7337 in (44,01/44,04 mm)
Outside Diameter of Hub	1.7303/1.7313 in (43,95/43,97 mm)
Clearance fit of Bushed Gear on Hub	0.0014/0.0034 in (0,03/0,09 mm)
Idler Gear Width	1.1320/1.1340 in (28,75/28,80 mm)
Hub Width	1.140/1.144 in (28,95/29,06 mm)
Idler Gear End Float	0.006/0.012 in (0,15/0,30 mm)
Cylinder Block Idler Hub Bore	1.732/1.733 in (43,99/44,02 mm)
Idler Gear Hub Spigot Diameter for Block	1.731/1.732 in (43,97/43,99 mm)
Size and Clearance fit of Spigot in Cylinder Block Bore	0.000/0.002 in (0,00/0,05 mm)
Timing Case Idler Hub Bore	2.3228/2.3240 in (58,99/59,03 mm)
Diameter of Spigot for Timing Case	2.3217/2.3229 in (58,97/59,00 mm)
Transition fit of Spigot in Timing Case Bore	0.0001/0.0023 in (0,00/0,06 mm)

Crankshaft Gear

Inside Diameter of Gear	1.2496/1.2505 in (31,74/31,76 mm)
Crankshaft Spigot for Gear Diameter	1.2494/1.250 in (31,73/31,75 mm)
Transition fit of Gear on Shaft	0.0004 interference/0.0011 in clearance (0,01/0,03 mm)

Timing Gear Backlash

All Gears	0.004 in (0,10 mm) minimum
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To Remove the Timing Case

The timing case is also attached to the sump by two setscrews, and to prevent damage to the sump joints take great care when separating the case from the sump joints or, lower the sump and completely renew the sump joints on reassembling.

If an attempt is to be made to remove the case without lowering the sump, then it is advisable to remove the idler gear hub. See Page F.4.

Prior to removal of timing case, it is necessary to remove the crankshaft pulley, front cover and all timing gears except the crankshaft gear.

On **hydraulically governed** engines, it will be necessary to remove the fuel pump drive hub using the following procedure:—

Remove fuel pump.

Remove drive hub locating circlip through the rear of adaptor housing. With the gear removed, the hub can now be withdrawn.

Remove exhauster unit (if fitted).

The timing case is located by a transitional fit on the idler gear hub. Hub removal may facilitate the removal of the timing case. See Page F.4.

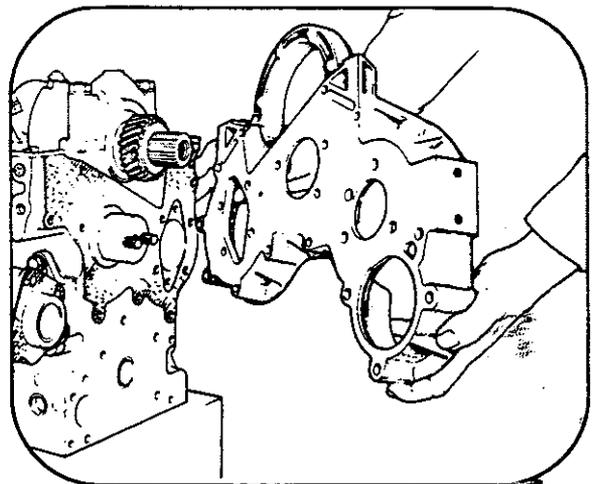
To Refit the Timing Case

With the sump fitted, remove the idler gear hub. Fit a new cork joint allowing a clean area between the butt ends of the cork and the case where the sump joint tongue can locate. Offer the timing case to sump and cylinder block, loosely locating by the setscrews, case to block and case to sump ensuring the cork and sump joints are correctly located. By adjustment of the timing case securing setscrews, the idler gear hub may now be fitted to the cylinder block and case.

With the sump removed, the timing case may be fitted over its locating idler gear hub, but on tightening the case to block setscrews ensure the bottom face of the timing case and crankcase are aligned, see Fig. F.2.

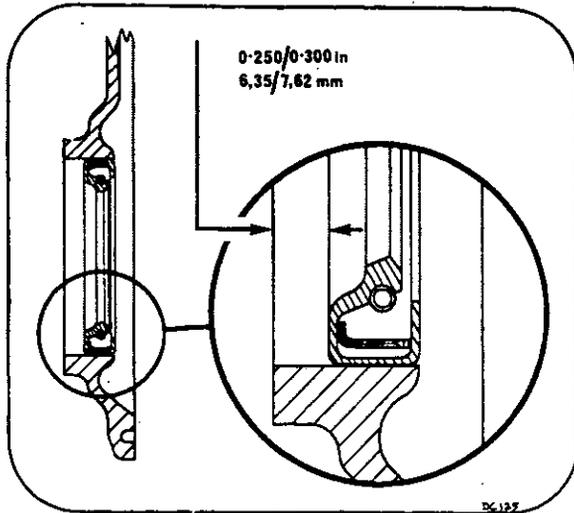
When fitting the sump joints and front and rear cork seals, ensure the tongues of the sump joints are located **under** the butt end of the cork.

On hydraulically governed engines, refit the fuel pump drive hub following the reverse procedure in the previous sub-section.

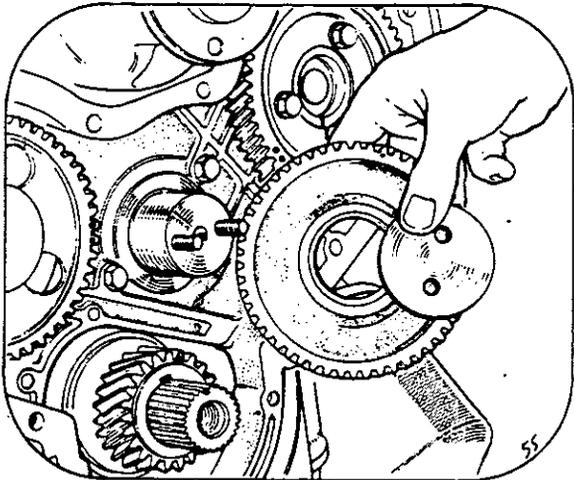


F2

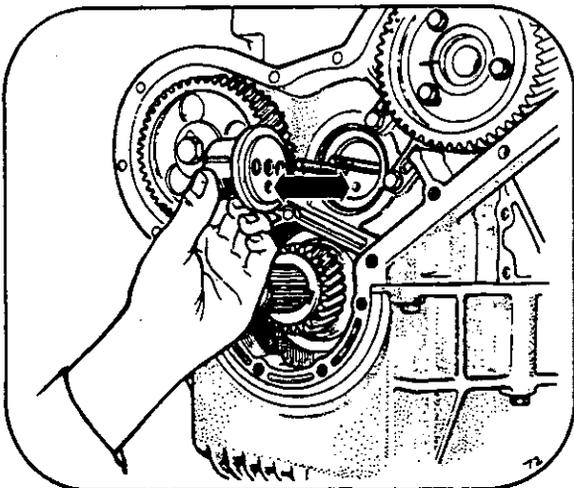
Timing Case and Drive F4



F3



F4



F5

Refit the timing gears ensuring that the timing marks align.

Refit timing case cover using the crankshaft pulley for correct location of oil seal and cover.

To Renew the Front Oil Seal (Front cover removed)

Press out the old seal from the timing case cover using a suitable dolly and press, supporting the cover in the area of the seal bore.

Press in the new seal from the front of the timing case cover to a dimension of 0.250/0.300 in (6,35/7,62 mm) from the front of the cover to the seal. See Fig. F.3.

To Remove Idler Gear and Hub

Remove nuts and retaining plate.

Withdraw gear, complete with bush from the hub. See Fig. F.4.

The idler gear hub, which is a transitional fit in the timing case, may be tapped out of its location. If difficulty is experienced, then the timing case should be removed.

To Refit the Idler Gear and Hub

The studs securing the hub are slightly off centre.

When refitting the hub, ensure that the oil drillings in both the cylinder block and hub are clear. See Fig. F.5.

Replace the gear on the hub with the timing marks correctly aligned. See Fig. H.1.

Fit the retaining plate, Fig. F.6, No. 1 and tighten two new self locking nuts to a torque of 21 lbf ft (2,9 kgf m)—28 Nm. Fig. F.6. No. 2.

Check the end float of the gear on the hub to a dimension of 0.006/0.012 in (0,15/0,30 mm). The maximum wear limit is 0.015 in (0,38 mm). See Fig. F.6.

NOTE: If the cylinder head assembly has not been disturbed, then the rocker assembly should be removed to allow the camshaft to be turned to facilitate the aligning of the timing marks.

To Remove the Camshaft Gear

Remove the setscrew and retaining washer.

Draw the camshaft gear off its keyed location on the camshaft, see Fig. F.7, using a puller, and adaptors.

With early engines, the camshaft gear setscrew was locked with a tabwasher. With later engines, the tabwasher is replaced with a plain washer, the hole in the gear for the location of the tabwasher being deleted.

To Refit the Camshaft Gear

Remove the idler gear to facilitate timing.

Fit the camshaft gear over the key of the camshaft and enter into keyway.

Draw the gear onto the camshaft by fitting the retaining washer and setscrew. Tighten the setscrew to a torque of 45 lbf ft (6,9 kgf m)—68 Nm.

NOTE: To enable the camshaft to be turned to facilitate the aligning of the timing marks, remove the rocker assembly if the cylinder head has not been disturbed.

Hydraulically Governed Fuel Pump Drive Assembly — Fig. F.8.

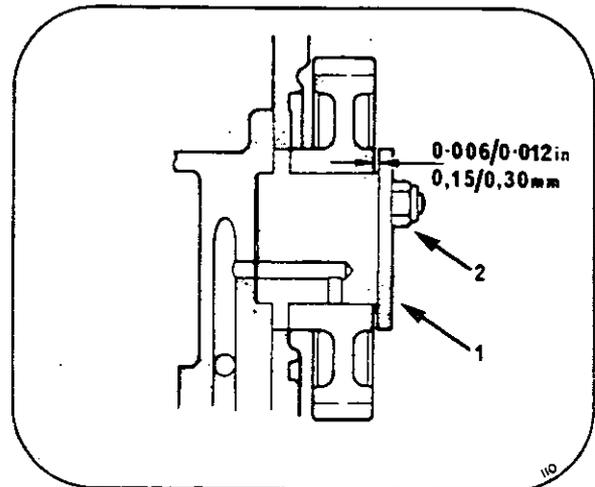
To Remove the Fuel Pump Gear

Remove the three setscrews securing the gear to the fuel pump drive hub, and ease the gear from its location.

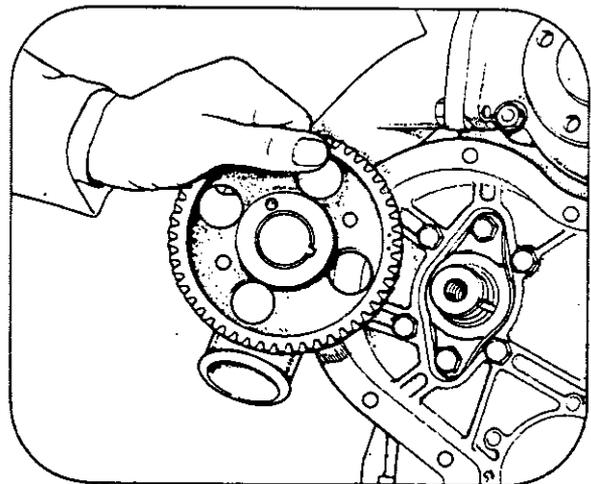
To Refit the Fuel Pump Gear

Remove the idler gear to facilitate timing.

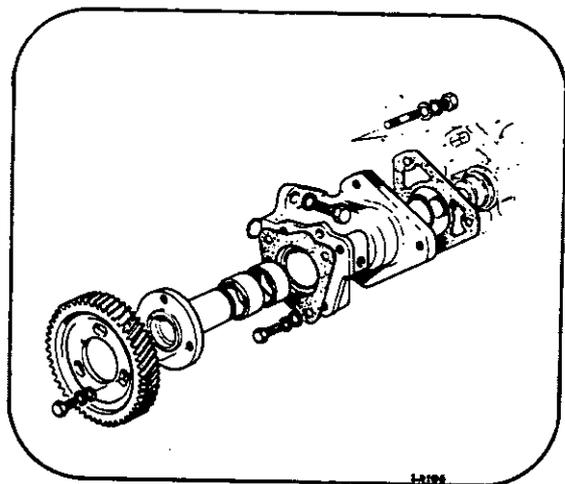
Refit the fuel pump gear so that the timing marks on the gear and hub are in alignment as shown in Fig. H.1.



F6



F7



F8

Timing Case and Drive F6

Refit idler gear and time engine. Check backlash which should be 0.004/0.008 in (0,10/0,20 mm).

To Fit New Fuel Pump Gear

In the event of a new fuel pump gear being required, this will be supplied without timing marks and to ensure correct fitment of the gear and timing of the fuel injection pump, the following procedure should be adopted.

Turn crankshaft until Nos. 1 and 4 pistons are at T.D.C., No. 1 piston being on compression stroke.

Remove fuel pump gear and idler gear.

Replace idler gear ensuring that timing marks on crankshaft gear, idler gear and camshaft gear coincide.

Turn crankshaft in opposite direction to normal direction for about quarter of a revolution. Then turn in normal direction until No. 1 piston is at its static timing point (see Page L.1.).

Remove fuel pump inspection plate (mechanically governed pumps) or plate embodying fuel return connection (hydraulically governed pumps) enabling the fuel pump rotor to be seen.

Then turn fuel pump driving hub until the scribed line on the rotor marked "A" or "C" (for hydraulically governed and mechanically governed pumps respectively) coincides with the squared end of the fuel pump timing circlip.

Ensuring timing gears and fuel pump shaft do not move, fit fuel injection pump gear and secure with three setscrews.

Turn crankshaft back slightly and then forward again to No. 1 piston on static timing point to check that fuel pump timing is correct.

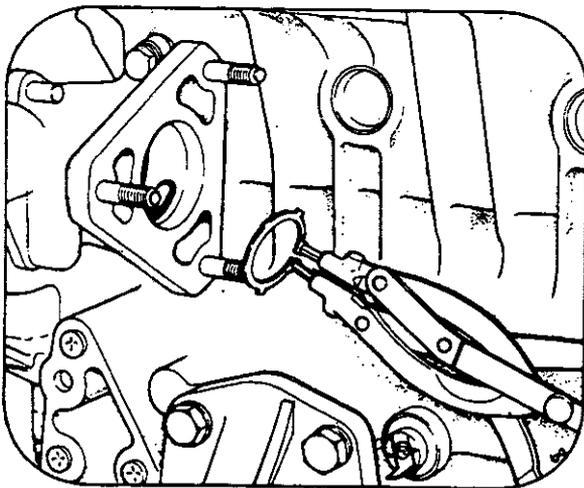
Bring crankshaft up to T.D.C. for Nos. 1 and 4 pistons, No. 1 piston being on its compression stroke and mark new fuel pump gear with a scribed line to coincide with the scribed line on the fuel pump driving hub: also stamp two dots on the new gear to coincide with the single dot on the idler gear.

When replacing a fuel pump gear on hydraulically governed engines, it will be necessary to adjust the timing gear backlash to within the limits prescribed on Page F.2. For method of adjustment, see Page F.7, sub section headed "To refit the Fuel Pump Adaptor Housing".

To Remove the Fuel Pump Drive Hub

Remove the fuel injection pump.

Remove the drive hub locating circlip through the rear of the adaptor housing, see Fig. F.9.



With the gear removed, withdraw the hub. See Fig. F.10.

To Refit the Fuel Pump Drive Hub

Following the reverse procedure, refit the hub.

Remove the idler gear to facilitate timing.

Refit the fuel pump gear as described in the previous sub-section.

To Remove the Fuel Pump Adaptor Housing

The fuel pump adaptor housing is secured to the cylinder block and rear face of the timing case. The fastening arrangement is by three setscrews within the timing case and two setscrews to the cylinder block.

To gain access to the three adaptor securing setscrews on the inside of the timing case, remove the fuel pump gear and drive hub; see the previous sub-sections.

If fitted, remove the exhauster unit, and oil feed pipe from adaptor housing to exhauster. Remove the idler gear. Remove the two remaining setscrews fastening the adaptor housing to cylinder block, and remove housing.

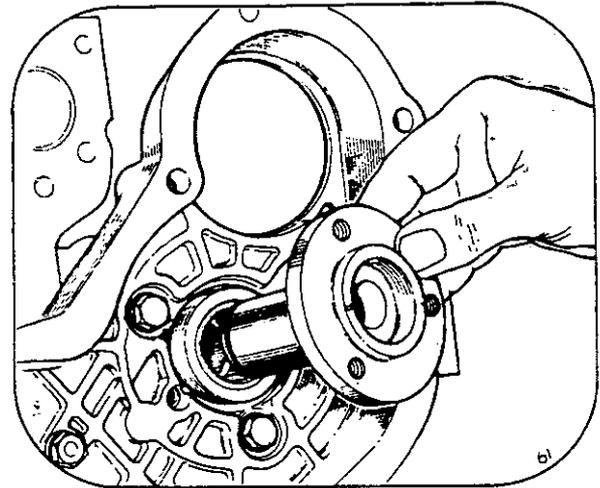
The bushes are an interference fit in the adaptor housing and can be replaced by using a suitable "dolly" and press. Fig. F.11 shows view of front face of the adapter housing showing the lub. oil drain hole.

To Refit the Fuel Pump Adaptor Housing

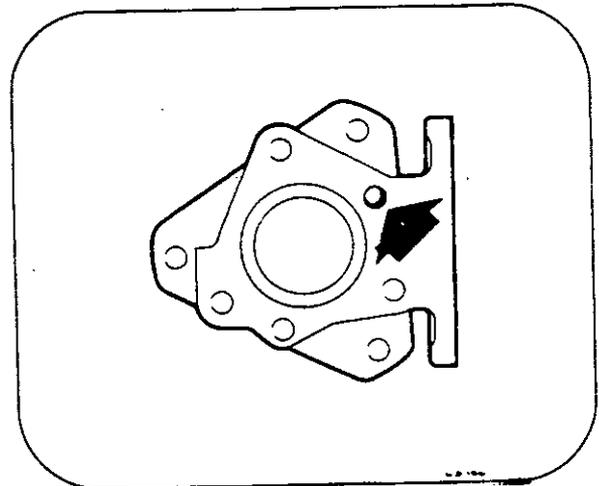
Replace the housing into its position at the rear of the timing case, using a new "O" ring oil seal, ensuring that it is properly located, see Fig. F.12.

Secure loosely with the setscrews to both the block and timing case BECAUSE THE FUEL PUMP GEAR/IDLER GEAR BACKLASH IS ADJUSTED BY MANIPULATION OF THE FUEL PUMP ADAPTOR HOUSING. DO NOT TIGHTEN THE SECURING SETSCREWS UNTIL THE ADJUSTMENT IS EFFECTED.

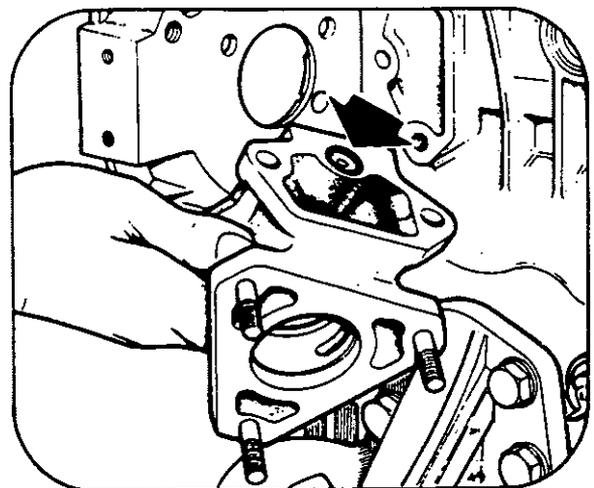
Refit the hub, fuel pump gear with timing marks aligned, and circlip.



F10

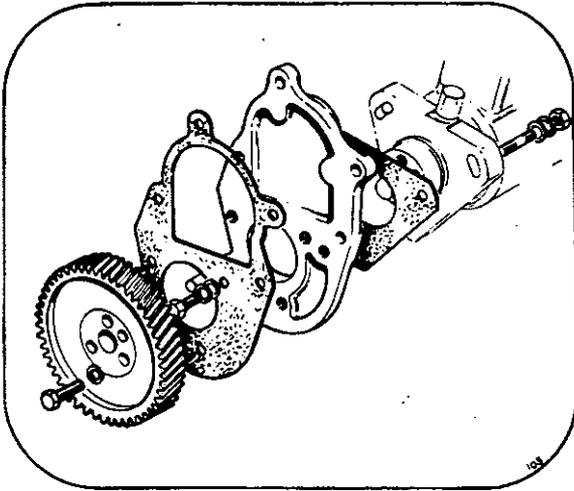


F11



F12

Timing Case and Drive F8



F13

Refit the idler gear, ensuring that the timing marks on the teeth of idler gear/fuel pump gear align.

TO ADJUST THE BACKLASH manipulate the adaptor housing until a figure of 0.004/0.008 in (0,10/0,20 mm) is obtained, and tighten the housing to block setscrews.

Remove the hub locating circlip and withdraw the gear and hub.

Tighten housing securing setscrews within the timing case.

Replace the gear and hub and circlip, and check backlash again.

IF THE TIGHTENING OF SECURING SETSCREWS HAS ALTERED THE BACKLASH SETTING, REPEAT THE PROCEDURE UNTIL IT IS WITHIN THE PRESCRIBED LIMITS.

Mechanically Governed Fuel Pump Drive Assembly – Fig. F.13.

To Remove the Fuel Pump Gear

The gear is dowelled to the fuel pump hub and secured by three setscrews and spring washers.

Before removal of the fuel pump gear, remove the idler gear.

To Refit the Fuel Pump Gear

The tightening torque for the fuel pump drive gear securing setscrews is 21 lbf ft (2,9 kgf m)–28 Nm.

Refit the idler gear, making sure that the timing marks align.

Because of the dowelled location of the fuel pump adaptor plate, **NO ADJUSTMENT FOR BACKLASH IS PROVIDED FOR.**

Crankshaft Gear

The crankshaft gear is a transitional fit, and is keyed onto the crankshaft. Should its removal become necessary, then this can be accomplished using a suitable puller.

To Remove the Camshaft and Tappets

Remove the rocker assembly and pushrods.

Remove the fuel lift pump.

Invert the engine, remove the sump and lubricating oil pump assembly, See Page J.3.

Remove the front timing case cover, idler gear and camshaft gear. See Page F.3.

Remove the camshaft thrust pad secured to the cylinder block by two setscrews, See Fig. F.14.

Withdraw the camshaft, taking the weight of the camshaft and exercising care to ensure that the cams and journals are not damaged, see Fig. F.15.

The tappets can be removed by lifting them out of their locations, see Fig. 16.

To Refit the Camshaft and Tappets

Reposition the tappets in their locations, after lubricating with clean engine oil.

Refit the camshaft into the cylinder block exercising the same care as used during its removal.

Secure the camshaft thrust pad to the cylinder block with two setscrews and spring washers.

Refit the camshaft gear and idler gear, see Page F.5 and F.4 ensuring that the timing marks align.

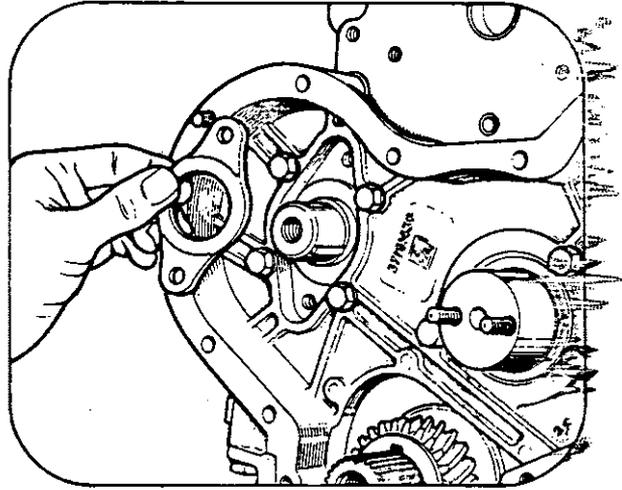
Refit the lubricating oil pump assembly, locating it with screw and locking nut in the cylinder block.

Refit the sump.

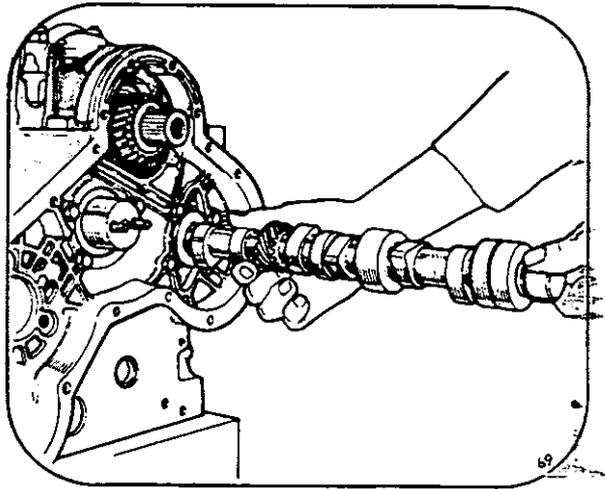
Revert the engine to its correct vertical position with the cylinder head (if fitted) uppermost.

Refit the fuel lift pump.

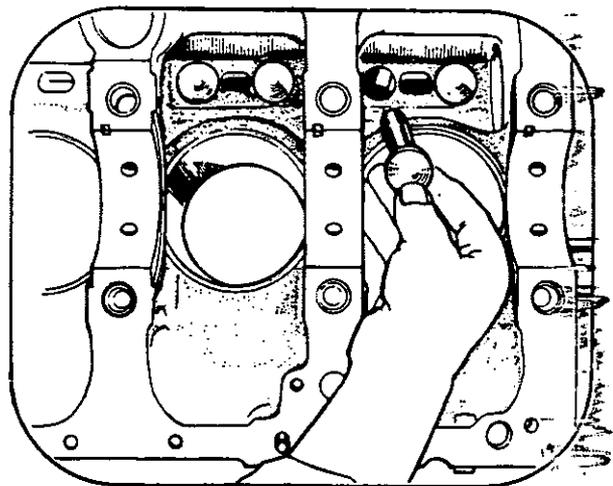
Refit the pushrods and rocker assembly. See Page B.5



F14



F15



F16

Section 'G'

FLYWHEEL AND FLYWHEEL HOUSING

To Remove the Flywheel

Six setscrews and plain washers secure the flywheel to the crankshaft flange. The setscrews are tightened to a torque of 80 lbf ft (11,1 kgf m)–108 Nm.

To facilitate safe flywheel removal, it is recommended that two diametrically opposed securing setscrews are removed and in their place, fit two suitably sized studs, finger tight only. The remaining setscrews can now be removed and the flywheel withdrawn under control.

Flywheel Ring Gear

The ring gear is shrunk on the flywheel.

When replacing the ring gear, the applied heat to the new ring should not exceed 480°F (250°C).

Attention should be paid to the chamfered "lead-in" edge of the ring gear, and its relative position on the flywheel.

To Refit the Flywheel

The securing arrangement of flywheel to crankshaft flange is by six setscrews and plain washers, into holes which are not equidistantly spaced. Fig. G.1 shows the spacing of the crankshaft flange tappings.

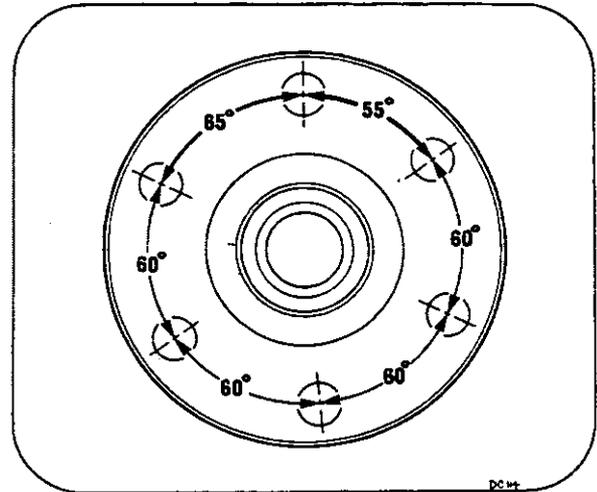
It is advisable to screw, finger tight only, two studs in the crankshaft flange positioned diametrically opposite to each other. This will enable the flywheel to be safely suspended whilst the securing setscrews are fitted. The studs can then be removed and replaced by the last two setscrews.

Flywheel Run-out

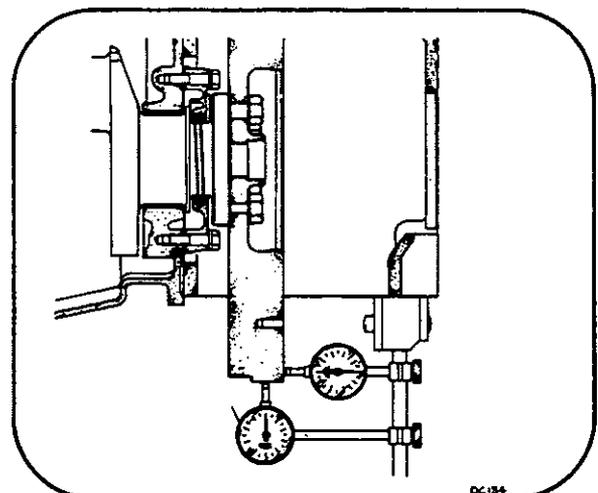
The outside diameter of the flywheel should be concentric within 0.012 in (0,30 mm) total indicator reading, to the crankshaft axis. See Fig. G.2.

Flywheel Alignment (Clutch Face)

The alignment of the flywheel face should be within the limit of 0.001 in (0,03 mm) per inch (25,4 mm) of flywheel radius from the crankshaft axis to the clock gauge plunger. See Fig. G.2. When carrying out this check, press the crankshaft one way to take up the end float while turning the flywheel.

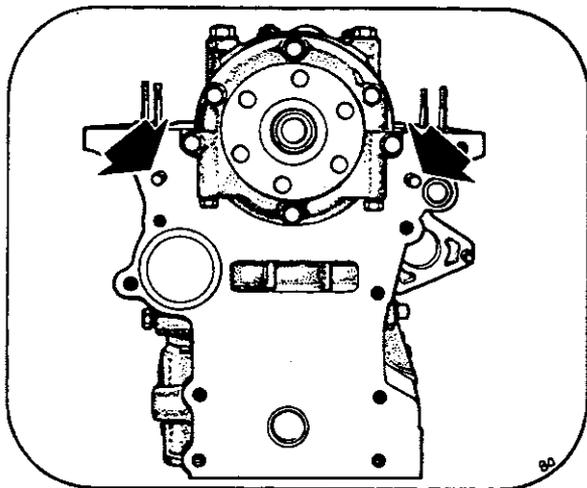


G1



G2

Flywheel and Flywheel Housing G2



G3

To Remove the Flywheel Housing

Remove the flywheel and starter motor.

Unscrew the securing setscrews and tap the housing carefully to dislodge it from the locating dowels.

To Refit the Flywheel Housing

Ensure that the rear face of the cylinder block and the mating face of the flywheel housing are clean and free from burrs.

Fit new dowels, see Fig. G.3 and secure housing to cylinder block sufficiently to allow for adjustment, if necessary.

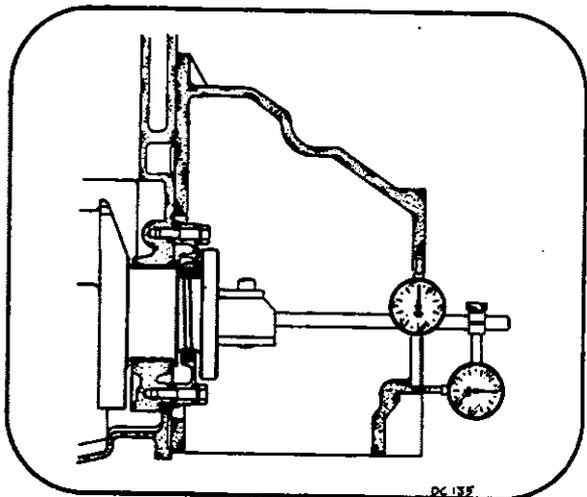
With a clock gauge, check that the alignment of the flywheel housing bore and face are within the limits listed as follows, see Fig. G.4.

Diameter of Housing Bore	Maximum Allowance Total Indicator Reading
Up to 14 1/4 in (362 mm)	0.006 in (0,15 mm)
14 1/4 to 20 1/8 in (362 to 511 mm)	0.008 in (0,20 mm)
20 1/8 to 25 1/2 in (511 to 648 mm)	0.010 in (0,25 mm)
25 1/2 to 31 in (648 to 787 mm)	0.012 in (0,30 mm)

Any adjustments which may be necessary to bring the flywheel housing to within the limits specified, must be carried out on the housing and not on the cylinder block face.

If the bore concentricity needs adjustment, the dowels must be removed and the necessary adjustments made, the dowel holes in the flywheel housing and/or cylinder block reamed in-line, and new oversize dowels fitted.

Tighten securing setscrews to a torque of 36 lbf ft (5,0 kgf m)—49 Nm.



G4

Section 'H'

TIMING

Timing H1

Because timing gears are fitted on the 4.154 engine, it is unlikely that timing will alter unless the gears are refitted in the wrong position during an overhaul.

The removal of the cylinder head does not affect the timing of the engine.

Timing Marks

When the engine is assembled in the factory, timing marks are stamped on the gears, see Fig. H.1. If the gears are removed it is not difficult to reset to the original timing.

Timing Pin

A timing pin on the front timing case cover which locates into the back of the crankshaft pulley, see Fig. F. 1 is a simple method of finding T.D.C. on No. 1 cylinder.

Before any attempt is made to turn the engine the timing pin should be returned to its original position.

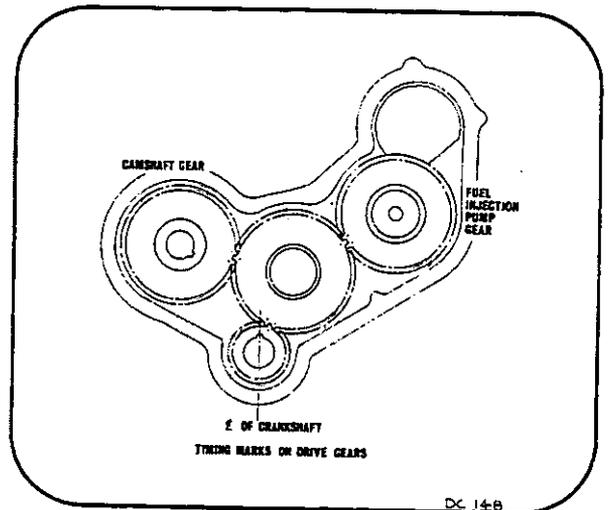
To Re-set to the Original Timing

It is assumed that the timing gears have been removed and the cylinder head is still secured. In order to re-fit them to their correct position it will be necessary to remove the rocker shaft to release the pressure from the camshaft. However, it is important to remember that on the 4.154 engine some of the setscrews securing the cylinder head also secure the rocker shaft brackets, and accordingly the following procedure must be adopted:

Drain the cylinder block of coolant.

Remove the atomisers.

Reduce the pressure on the cylinder head by slackening the setscrews by 1 1/3 flats to avoid distortion.



H1

Timing H2

Remove the rocker shaft.

Turn the crankshaft until No. 1 piston is at T.D.C., on compression stroke. At this point the keyway in the crankshaft spigot will be uppermost.

Fit the camshaft gear to its spigot, locating on the key and secure with setscrew and tab-washer.

Fit the fuel pump gear to the fuel pump or fuel pump drive hub and secure with setscrews.

Replace the idler gear so that the appropriate timing marks align as follows. The double dots on the idler gear to match with the single dot on the crankshaft gear, and the single dots on the idler gear to align with the double dots on both the camshaft and fuel pump gears, see Fig. H.1.

Secure the idler gear in position with the two lock nuts and retaining plate.

For backlash adjustment (hydraulically governed pumps only) refer to page F.7.

Replace the rocker shaft, re-torque the cylinder head, see Page B.5, replace the atomisers and refill the cylinder block with coolant.

Checking Valve Timing

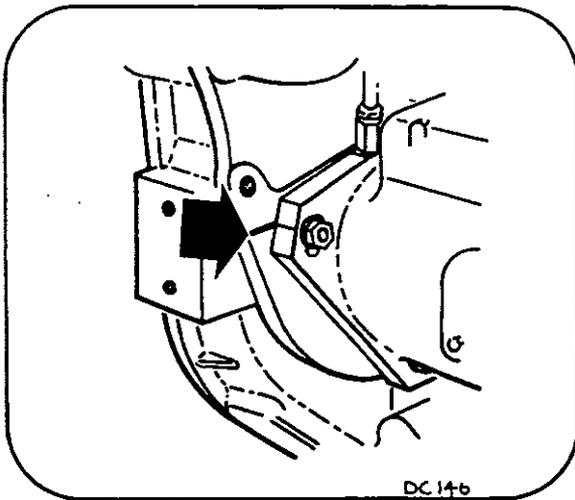
Turn the engine until No. 4 cylinder valves are in the "overlap" position, that is the period between the closing of the exhaust valve and the opening of the inlet valve. At this point set No. 1 inlet valve tip clearance to 0.040 in (1,02 mm). Turn the engine in the normal direction of rotation until the clearance is just taken up. In this position Nos. 1 and 4 pistons should be at T.D.C., if the timing has been set correctly. This can be checked by using the timing pin or flywheel markings. A tolerance of $2\frac{1}{2}$ (flywheel) degrees is permissible.

Should the timing be incorrect then the error will probably be due to the timing gears being incorrectly aligned.

When the timing has been set do not forget to re-set No. 1 inlet valve to the correct figure which is 0.012 in (0,30 mm) cold, and return the timing pin to its original position before attempting to turn the engine.

Fuel Pump Timing Marks

With mechanically governed pumps, the scribed line on the pump mounting flange should align with the scribed line on the rear of the mounting plate on the timing case, see Fig. H.2.



With hydraulically governed pumps, the scribed line on the pump mounting flange should align with the scribed line on the mounting flange of the fuel pump adaptor, see Fig. H.3.

To obtain access to the fuel pump rotor markings, it is necessary to remove the fuel return adaptor plate for hydraulically governed pumps, or the inspection cover on the side of the body of mechanically governed pumps.

It should be remembered that to gain access to these internal timing marks, the manufacturers' seals will have to be broken. These seals should therefore be removed only by authorised personnel who must reseal when the adaptor plate or cover is replaced, otherwise the guarantee may become void.

On the fuel pump rotor, inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip is also positioned inside the pump body which has to be set so that when the appropriate scribed line on the fuel pump rotor aligns with the squared end of the circlip, it denotes commencement of injection (static timing) – see Fig. H.5.

To set the timing circlip, it is necessary to remove the pump from the engine and fix the position of the circlip by connecting No. 1 cylinder outlet connection marked "w" on the pump to an atomiser tester and pump up to 30 atm (31 kgf/cm² or 440 lbf/in²). Turn the pump by hand in the normal direction of rotation until it "locks up". The squared end of the circlip should now be adjusted so that it aligns with the appropriate letter on the pump rotor.

Checking Fuel Pump Timing (Mechanically governed)

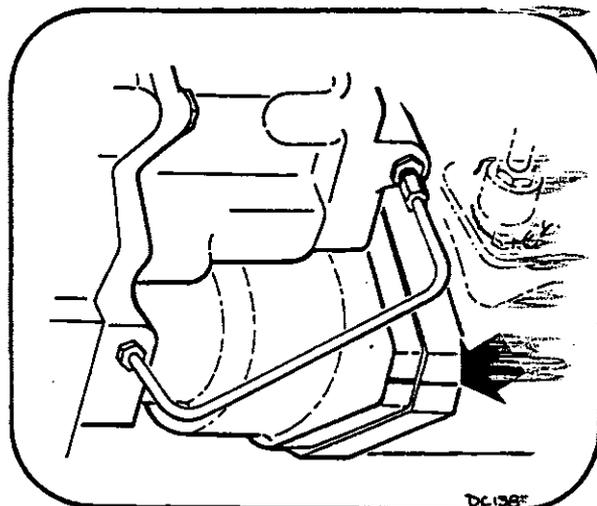
Ensure pump timing circlip is correctly positioned as previously described.

Ensure that the scribed lines on the fuel pump mounting flange and adaptor plate align.

Position No. 1 piston at T.D.C. on the compression stroke. This can be obtained by turning the engine until No. 4 cylinder valves are rocking and the timing pin engages in the pulley. Screw timing pin back into timing case.

Remove the collets and valve springs from one of the valves on No. 1 cylinder and allow the valve to rest on the crown of the piston.

With a clock gauge at zero and in contact with the stem of the valve resting on the piston crown see Fig. H.4, turn the engine AGAINST the normal direction of rotation until the valve has moved approximately 0.150 in (3.81 mm) down the cylinder bore. Then turn the engine back again in the normal direction of rotation (to take up the timing gear backlash) until the clock indicates 0.125 in (3.17 mm) B.T.D.C. This is equivalent to 18° angular movement of the fly-wheel B.T.D.C. and represents the static point of injection.



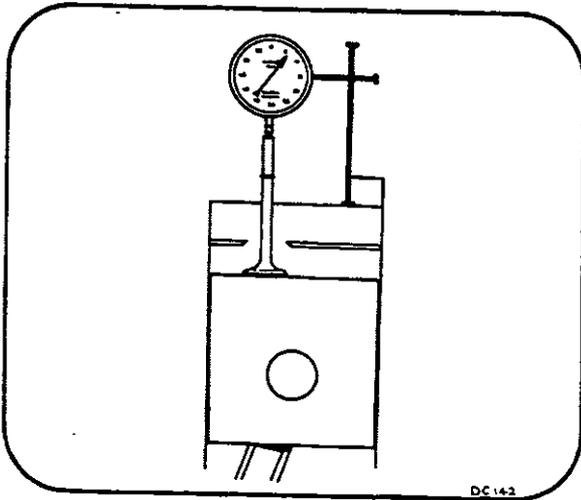
H3

The letter "C" on the fuel pump rotor should now align with the straight edge of the circlip

Any discrepancy can be corrected by slackening the fuel pump securing nuts and turning the pump body until the mark on the rotor is in line with the circlip.

When the timing is correct turn the engine in the normal direction of rotation until No. 1 piston is at T.D.C. then re-fit the springs and collets to the valve. Re-fit the fuel pump inspection plate and re-seal.

Timing H4



H4

DC 143

Checking Fuel Pump Timing (Hydraulically governed)

Ensure pump timing circlip is correctly positioned as previously described.

Ensure that the scribed lines on the fuel pump mounting flange and adaptor end plate align.

Position No. 1 piston at T.D.C. on the compression stroke. This can be obtained by turning the engine until No. 4 cylinder valves are rocking and the timing pin engages in the pulley. Screw timing pin back into timing case.

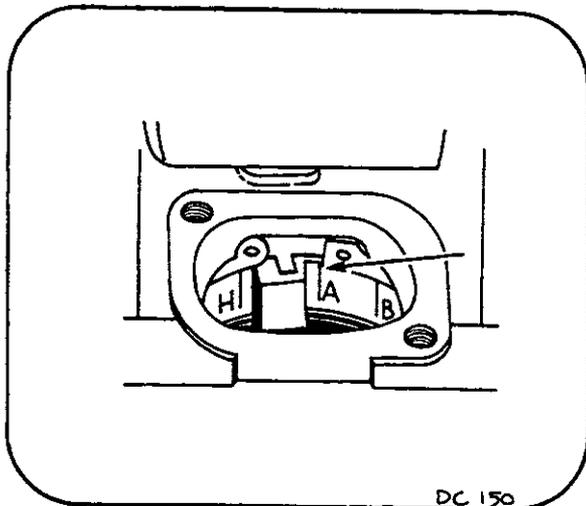
Remove the collets and valve springs from one of the valves on No. 1 cylinder and allow the valve to rest on the crown of the piston.

With a clock gauge at zero and in contact with the stem of the valve resting on the piston crown, see Fig. H.4, turn the engine AGAINST the normal direction of rotation until the valve has moved approximately 0.230 in (5.84 mm) down the cylinder bore. Then turn the engine back again in the normal direction (to take up the timing gear backlash) until the clock gauge indicates 0.205 in (5.21 mm) B.T.D.C. This is equivalent to 23° angular movement of the flywheel B.T.D.C. and represents the static point of injection.

The letter "A" on the fuel pump rotor should now align with the straight edge of the circlip, see Fig. H.5.

Any discrepancy can be corrected by slackening the three setscrews securing the fuel pump gear, and moving the rotor the approximate amount, or move the fuel pump body and re-mark the pump body flange.

When the timing is correct turn the engine in the normal direction of rotation until No. 1 piston is at T.D.C. then re-fit the springs and collets to the valve. Re-fit the fuel pump inspection plate and re-seal.



DC 150

H5

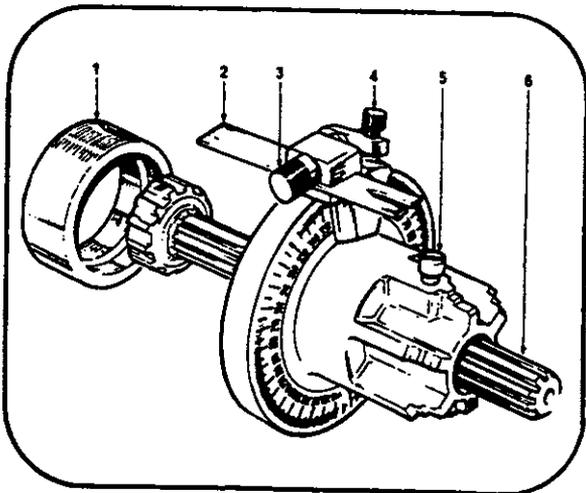
To Check Marking Angle of Fuel Injection Pump using Tool MS67B (Fig. H.6)

Release screw (5) and remove splined shaft (6). If pump has a slotted hub, the splined shaft should be retained with the small splined diameter to the rear to locate in the centre of the hub.

Ensure that the slotted pointer (2) is positioned with the slot to rear of tool and chamfered sides of slot outwards. At this stage, slotted end of pointer should be kept well back towards body of tool. Ensure that the flat in the washer fitted behind the pointer securing screw (3) is located over side of pointer.

Release bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant marking angle which is 290° for mechanically governed pumps or 298° for hydraulically governed pumps.

Position timing tool on pump drive shaft with master splines engaged and tool locating on spigot (see Fig. H.7). With dowel drive pumps, locate the splined shaft in hub, slide tool towards pump to rest on end of hub and lock shaft in tool (see Fig. H.8.)

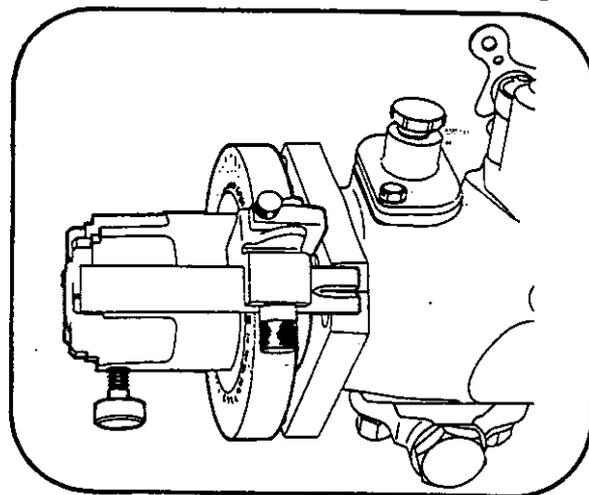


H6

Connect No. 1 outlet of pump body to an atomiser test rig and pump up to 30 atmospheres (31 kgf/cm²) or 440 lbf/in². If pressurising valve is fitted, this must be removed.

Turn pump in normal direction of rotation as shown on pump nameplate, until it locks.

In this position, slide pointer forward until it is halfway over pump flange and check that the timing mark is central to slot in pointer.



H7

Engine Checking Angle

If it is necessary to check the timing marks (engine checking angle) on the rear of the fuel pump adaptor housing or timing case, the following procedure using tool MS67B (see Fig. H.6) should be adopted:-

Hydraulically Governed Engines

Turn engine to T.D.C. on compression stroke by means of the timing pin.

Release screw (5) of timing tool and position splined shaft (6) in tool so that the relevant spline is to the front of tool.

Ensure that slotted pointer (2) is positioned with slot to front of tool and chamfered sides of slot outwards. At this stage, slotted end of pointer should be kept well back from front of body. Ensure that flat in washer fitted behind the pointer securing screw (3) is located over pointer.

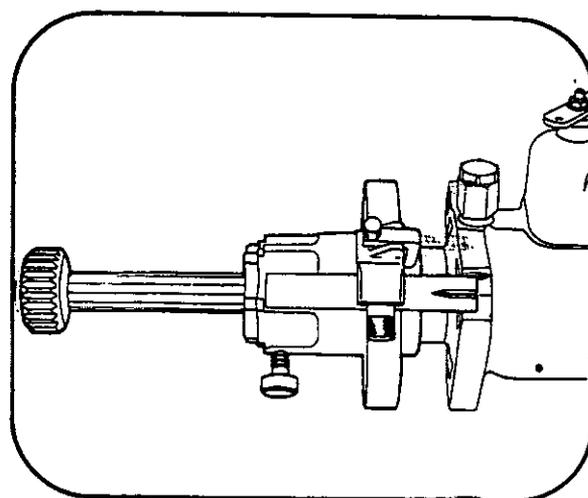
Release bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant engine checking angle which is $286\frac{1}{2}^{\circ}$.

Fit timing tool to engine in fuel pump position ensuring first that splined shaft with master spline engaged is fully located in pump drive shaft and then that register of tool is seated in fuel pump locating aperture. Lock splined shaft in tool. If pointer is 180° out, engine is probably on wrong stroke in which case, remove the tool and reset the engine on the correct stroke.

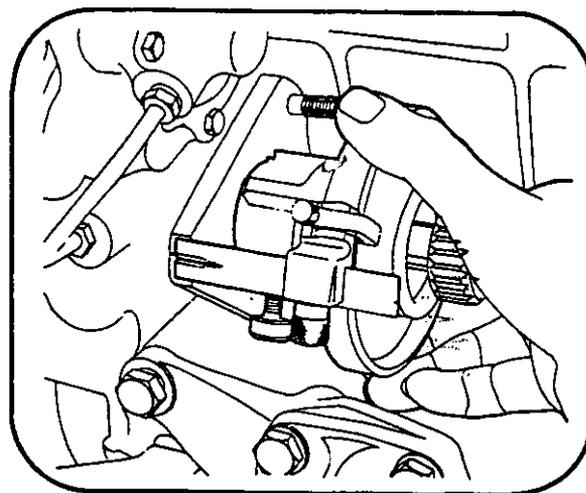
Slide slotted pointer forward so that slot is half way over fuel pump adaptor housing.

Turn timing tool by hand in opposite direction to pump rotation (shown on pump nameplate) to take up backlash and check that the scribed line coincides with the centre of the slot in pointer (see Fig. H.9).

Remove tool and fit the fuel pump as detailed on Page L.5.

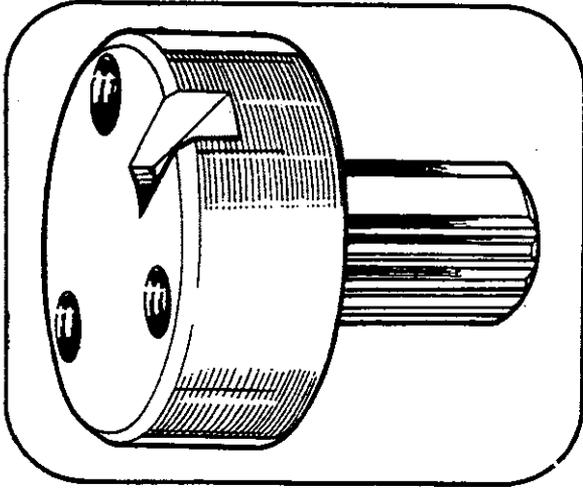


H8



H9

Timing H6



H10

Mechanically Governed Engines

Turn engine to T.D.C. on compression stroke by means of timing pin.

Fit adaptor PD67B-1 (see Fig. H.10) to fuel pump gear so that the dowel of gear locates in slot of adaptor and shaft of adaptor is towards rear of engine. Secure adaptor to gear using setscrews.

Release screw (5) or timing tool and remove splined shaft.

Ensure slotted pointer (2) of timing tool is positioned with slot to front of tool and chamfered sides of slot are outwards. At this stage, slotted end of pointer should be kept well back from front of body. Ensure that flat of washer fitted behind pointer securing screw (3) is located over pointer.

Release the bracket locking screw (4) and set bracket so that the chamfered edge is in line with the relevant engine checking angle which is 281° .

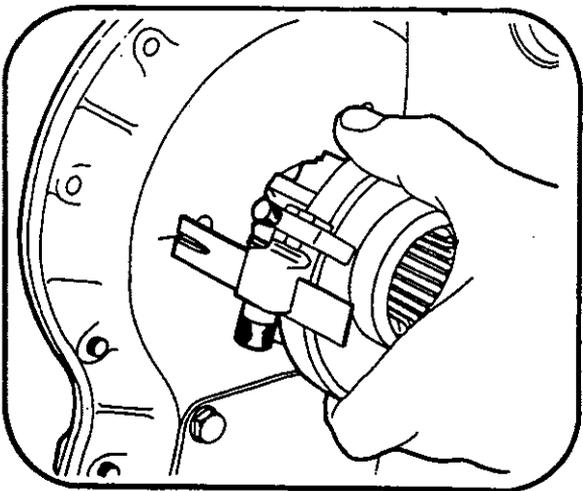
Pressing fuel pump gear and adaptor towards rear, locate splined shaft of adaptor into timing tool with master spline engaged and adaptor shaft in timing tool with rear face of adaptor abutting front face of timing tool.

Move tool forward, complete with gear, so that register of tool locates in pump aperture of timing case. If pointer is 180° out, engine is probably on wrong stroke and tool should be removed and engine set on correct stroke.

Slide slotted pointer forward to reach rear face of timing case and lock into position.

Take up backlash by turning tool against normal direction of rotation (shown on pump nameplate) and check that scribed line on the rear of the timing case coincides with the centre of the slot in the pointer (see Fig. H.11.)

Remove tool and adaptor from fuel pump gear and fit fuel pump to engine as detailed on Page L.5.



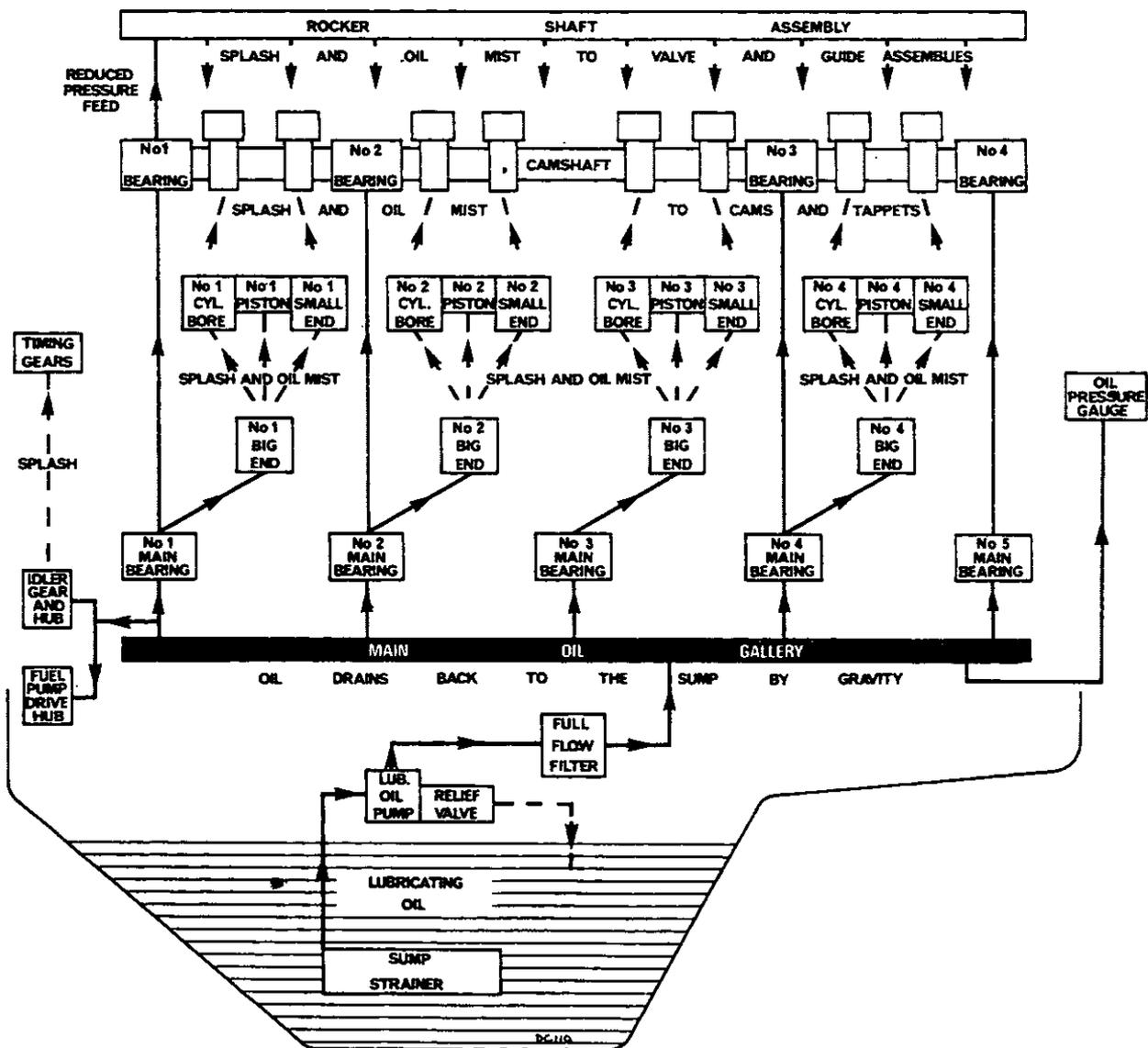
H11

Section J LUBRICATING SYSTEM

The lubrication of the engine is by full pressure feed from a rotor type oil pump driven by spiral gears from the camshaft. The oil is delivered via a full flow filter to the main oil gallery from which oil is fed by drillings through the main bearing housings to each of the five main bearings. A feed is taken off the drilling to No. 1 main bearing to lubricate the idler gear hub and timing gears. Drillings in the crankshaft distribute oil to the four big end journals, from which oil splash is thrown up to lubricate the cylinder bores and small ends. The four camshaft journals are lubricated directly by oilways from Nos. 1, 2, 4, and 5 crank-

shaft main bearings. An oil control feed is incorporated in No. 1 camshaft journal from which an oilway takes lubricant at a reduced pressure to the rocker shaft.

The oil pump is provided with a pressure relief valve which limits the maximum pressure, whilst the oil filter incorporates a by-pass valve which prevents the engine being starved of oil should the filter element become blocked.



Lubricating System J2

LUBRICATING OIL SYSTEM DATA AND PUMP DIMENSIONS

Lubricating Oil Pressure	30/60 lbf/in ² (2,1/4,2 kgf/cm ²) – 207/414 kN/m ² at maximum speed and normal operating temperature
Sump Capacity	Varies according to application
Dipstick Position	Either side of engine

Lubricating Oil Pump

Type	Rotor
Number of Lobes – Inner Rotor	Four
Number of Lobes – Outer Rotor	Five
Method of Drive	Spiral Gear driven from Camshaft
Bore in Cylinder Block for Lubricating Oil Pump	1.375/1.376 in (34,92/34,95 mm)
Outside Diameter of Lubricating Oil Pump Body	1.374/1.3746 in (34,90/34,91 mm)
Clearance Fit of Pump in Bore	0.0004/0.002 in (0,01/0,05 mm)

Lubricating Oil Pump Clearances

Inner Rotor to Outer Rotor	0.002/0.006 in (0,05/0,15 mm)
Outer Rotor to Pump Body	0.0052/0.010 in (0,13/0,25 mm)
Rotor End Float	0.001/0.005 in (0,02/0,13 mm)
Pump Body Bore for Drive Shaft	0.625/0.626 in (15,87/15,90 mm)
Outside Diameter of Shaft	0.623/0.6235 in (15,82/15,84 mm)
Running Clearance of Shaft in Bore	0.0015/0.003 in (0,04/0,08 mm)

Lubricating Oil Pump Drive Gear

Inside Diameter of Gear Bore	0.4965/0.497 in (12,61/12,62 mm)
Outside Diameter of Drive Shaft	0.4983/0.4986 in (12,66/12,67 mm)
Interference fit of Gear on Shaft	0.0013/0.0021 in (0,03/0,05 mm)
Drive Gear Backlash	0.0155/0.019 in (0,39/0,48 mm)

Lubricating Oil Pump Relief Valve

Type	Spring-Loaded Plunger
Pressure Setting	36/44 lbf/in ² (2,53/3,10 kgf/cm ²) – 248/303 kN/m ²
Relief Valve Bore	0.5605/0.5621 in (14,24/14,28 mm)
Outside Diameter of Plunger	0.5585/0.5595 in (14,18/14,21 mm)
Clearance of Plunger in Bore	0.001/0.0036 in (0,02/0,09 mm)
Length of Plunger	0.78125 in (19,84 mm)
Outside Diameter of Spring	0.389/0.405 in (9,88/10,29 mm)
Spring, Free Length	1.5625 in (39,69 mm)
Spring, Solid Length	0.812 in (20,62 mm)

Lubricating Oil Filter

Type	Full Flow
Element	Paper
By-pass Valve Setting	Opens between 8-12 lbf/in ² (0,56/0,84 kgf/cm ²) – 55/83 kN/m ²

Removal of Oil Sump

On some applications it will be found that the sump cannot be removed unless the engine is either supported, or removed from the chassis, because the engine bearers are secured to the sides of the sump.

To Refit the Oil Sump

Prior to refitting the sump, new crankcase to sump joints and new front and rear cork joints must be fitted.

Fit the new cork strips dry into the grooves formed by the timing case and cover at the front end and by the rear main bearing cap and rear main oil seal housing at the rear end, pressing the strips firmly into place, making sure that the butt ends of the cork strips sit onto the sump joints. At these points, apply non-hardening jointing compound to make an effective seal.

Offer the sump to its location, fit the retaining setscrews and nuts and tighten them to a torque of 15 lbf ft (2,07 kgf m)–20 Nm.

On some applications, the sump is fastened to the back of the flywheel housing by four setscrews. In this case, apply final torque to these setscrews first, to avoid possible misalignment of the flywheel housing.

If the sump is being fitted prior to fitment of the flywheel housing, apply a straight edge across the rear faces of the cylinder block and sump before tightening.

To Remove the Oil Pump

Drain the oil and remove sump.

Remove the two setscrews securing the oil delivery pipe flange to the cylinder block.

Release the locking nut and unscrew the oil pump locating screw, see Fig. J.6 No. 1, which will release the oil pump.

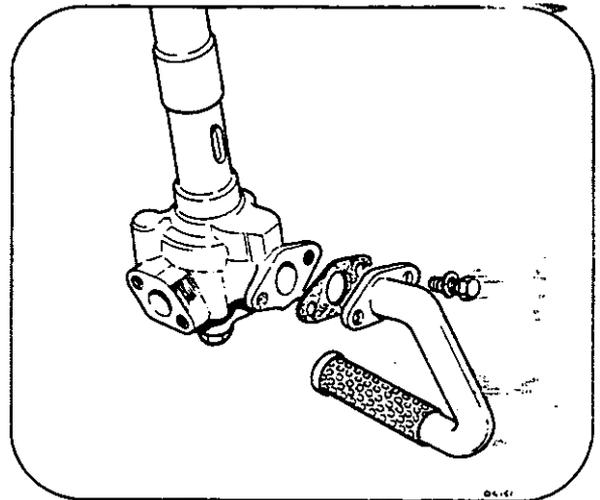
To Dismantle the Oil Pump and Relief Valve

Remove the delivery and suction pipes.

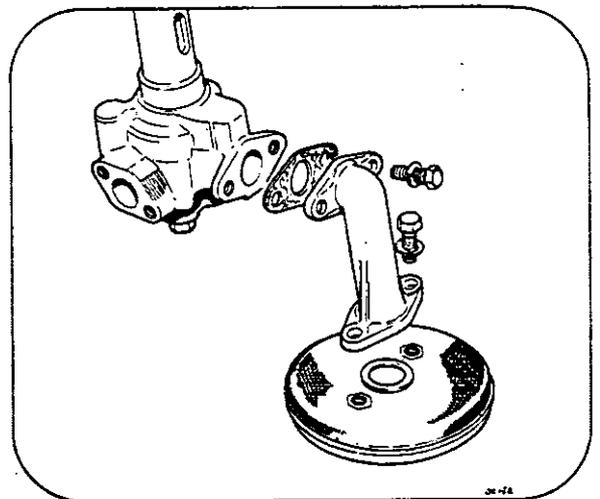
Fig. J.2, illustrates the earlier type suction pipe and strainer and Fig. J.3, the current version.

Remove the end cover.

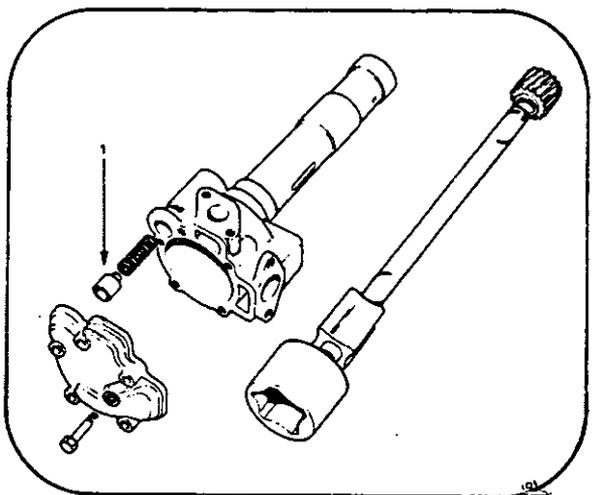
The relief valve plunger and spring can now be removed from the housing, see Fig. J.4, No. 1.



J2

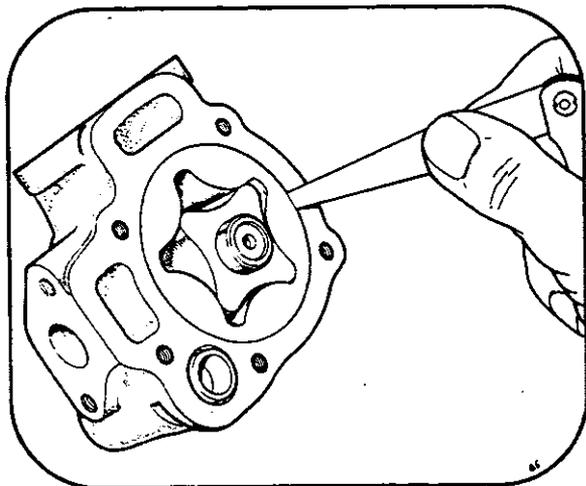


J3



J4

Lubricating System J4



J5

Remove the outer rotor, noting that there is a chamfer at one end.

The gear can now be removed using a suitable puller.

Withdraw the shaft complete with inner rotor from the pump body.

Examination and Re-Assembly of Oil Pump and Relief Valve

Refit the shaft and inner rotor into the pump housing, followed by the outer rotor, ensuring that the face which carries the chamfered edge enters the pump body first.

The following dimensional checks can now be carried out, see Page J.2.

Clearance between the inner and outer rotor, see Fig. J.5.

Clearance between the outer rotor and pump body.

End float of rotors. See Fig. J.6.

The lubricating oil pump clearances given on Page J.2, are applicable to a new pump. If wear is revealed affecting the pump performance, a replacement assembly must be fitted as individual parts are not available.

Press the oil pump drive gear onto the shaft until it is hard up against shoulder.

Replace the relief valve spring and plunger into their location.

Prime the interior of the pump with lubricating oil, refit the end cover, delivery and suction pipes, using new joints on the pipe flanges.

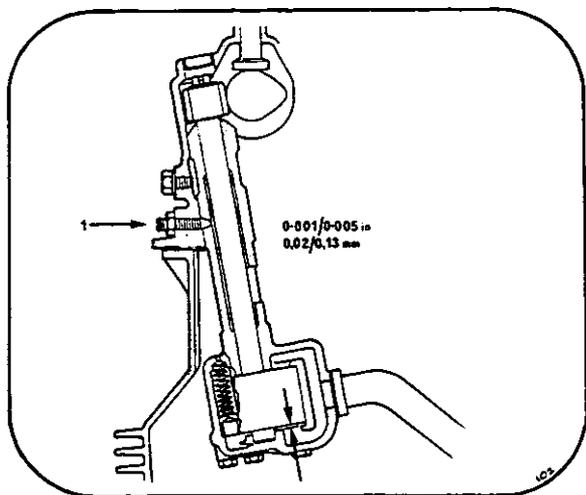
To Refit the Oil Pump

Fit the lubricating oil pump in position, and locate with the securing screw. Lock the screw with the lock-nut. Using a new joint, secure the delivery pipe flange to the cylinder block.

On some applications, a sump strainer is bracketed on to No. 4 main bearing housing.

Refit the sump, see Page J.3, and refill with the correct grade of oil, see Appendix.

When restarting the engine, allow for the oil pump and pipes to prime with oil before speeding the engine revolutions, or alternatively motor for 10/20 seconds with the fuel pump shut off.



J6

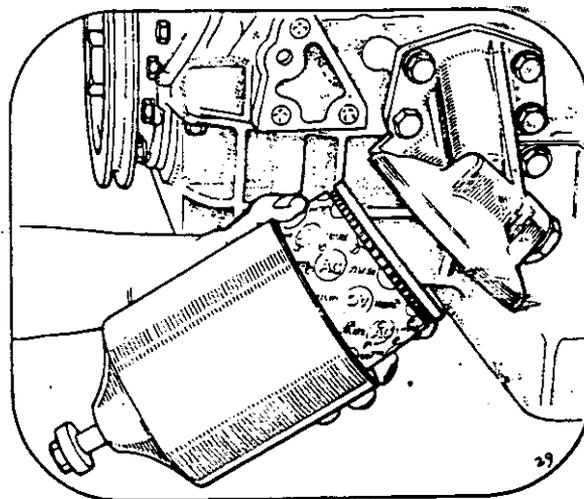
Oil Filters

There are two types of oil filter used. Earlier engines had a removable bowl and separate element whilst current engines have a spin-on filter which consists of a canister which is a combined casing and element.

Oil Filter – To Remove and Replace the Filter Element

Unscrew the setscrew at the bottom of the filter bowl and remove. See Fig. J.7.

Replace the filter element using new seals provided and tighten setscrews to a torque of 10 lbf ft (1,4 kgf m)–14 Nm.



J7

To Renew Spin-on Type Oil Filter Canister

Unscrew canister from filter head. See Fig. J.8.

Discard old canister

Clean filter head

Using clean engine oil, liberally oil top seal of replacement canister.

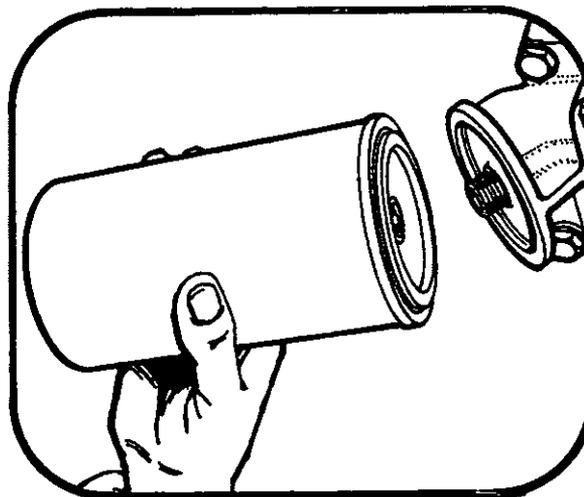
Fill new canister with clean lubricating oil allowing time for the oil to filter through the element. Screw the replacement canister onto filter until seal just touches head and then tighten by hand as per the instructions given on the canister. Where a tool is available tighten to 15 lbf ft (2,07 kgf m)–20 Nm.

Run engine and check for leaks.

Note: Always ensure that the correct replacement canister is fitted as it has internal valves to prevent drain back and a special tube stack is fitted.

Oil Filter Headcasting

The headcasting is secured by four setscrews and spring washers.

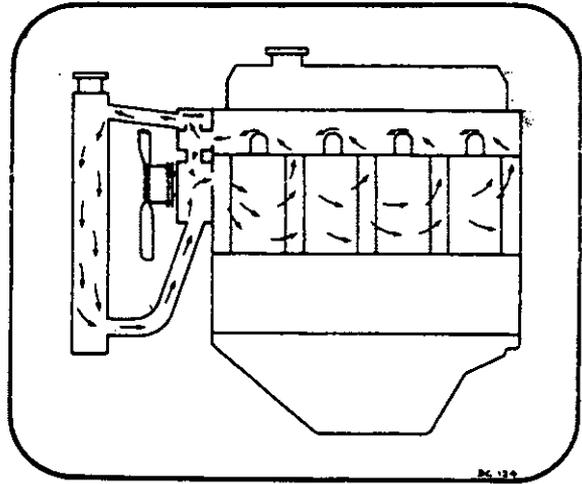


J8

Section 'K'

COOLING SYSTEM

A centrifugal type water pump, mounted on the front of the engine and belt driven from the crankshaft, delivers coolant directly into a gallery cast in the cylinder block. Coolant is delivered to the cylinder head through jets to the valve bridge and fishtail area in the combustion chamber inserts.



K1

COOLING SYSTEM DATA AND WATER PUMP DIMENSIONS

Type

Engine coolant — less radiator

Thermostatically-controlled, water-cooled, circulated by centrifugal type water pump. 11 Imperial pints (6.3 litres, 6.6 U.S. quarts) approximately.

Water Pump

Type

Outside Diameter of Shaft for Pulley Hub
 Inside Diameter of Pulley Hub Bore
 Interference fit of Pulley Hub on Shaft
 Inside Diameter of Water Pump Pulley Assembly
 Outside Diameter of Hub for Pulley Assembly
 Size and Clearance fit of Pulley to Hub
 Water Pump Impeller Bore
 Outside Diameter of Shaft for Impeller
 Interference fit of Impeller on Shaft
 Impeller to Pump Body Running Clearance
 Water Pump Seal, type
 Counter Face

Centrifugal

0.7873/0.7876 in (19,20/20,01 mm)
 0.7849/0.7857 in (19,94/19,96 mm)
 0.0016/0.0027 in (0,04/0,07 mm)
 1.613/1.616 in (40,97/41,05 mm)
 1.611/1.613 in (40,92/40,97 mm)
 0.000/0.005 in (0,00/0,13 mm)
 0.497/0.4975 in (12,62/12,64 mm)
 0.498/0.499 in (12,65/12,67 mm)
 0.0005/0.002 in (0,013/0,059 mm)
 0.015/0.030 in (0,38/0,76 mm)
 Synthetic Rubber — Carbon faced
 Rotating Ceramic

Thermostat

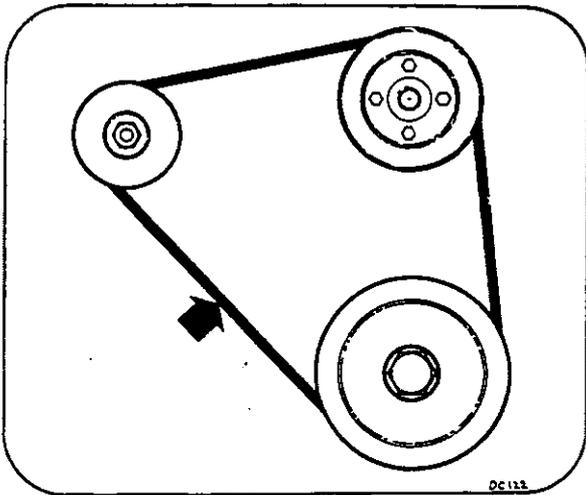
Type

Opening Temperature
 Fully Open at
 Travel at Fully Open Temperature

Wax

175° — 181°F (79.5° — 83.5°C)
 208°F (97.5°C)
 0.562 in (13,77 mm)

Cooling System K2



K2

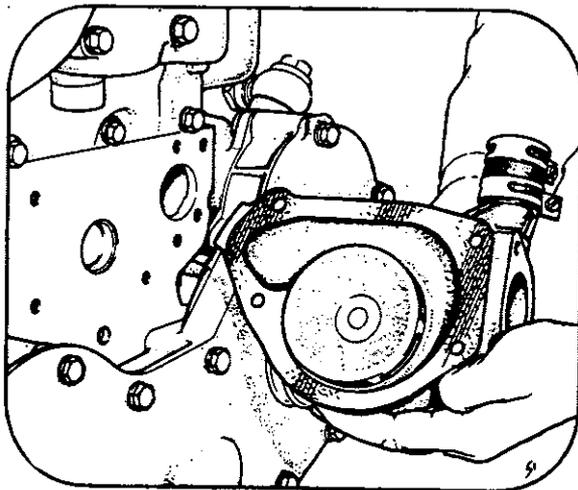
Fan Belt – to Adjust

Adjust by first slackening the generator adjusting lever setscrew, the lever to the generator support bracket and to support bracket bolts.

Move the generator so that the tension is such that without undue pressure, the thumb applied mid-way on the longest unsupported length of belt, can depress it approximately $\frac{3}{8}$ in. (10 mm), see Fig. K.2.

Tighten the generator adjusting lever setscrew and if the tension is still correct, tighten the remainder of mounting bolts.

When a new belt is fitted, it is advisable to recheck the tension after a short period of running. This is to allow for bedding-in and initial stretch which is common to new belts.



K3

To Remove the Water Pump

Remove the fan belt.

Remove the four setscrews and tabwashers securing the fan and pulley and remove both components.

On some applications a distance piece is fitted between the fan and pulley.

Remove the water inlet pipe which is flanged to the water pump by two setscrews and spring washers.

Disconnect the Water Pump By-Pass Hose

Unscrew the setscrew and spring washers securing the water pump and remove, see Fig. K.3.

To Dismantle the Water Pump See Fig. K.4 and K.5.

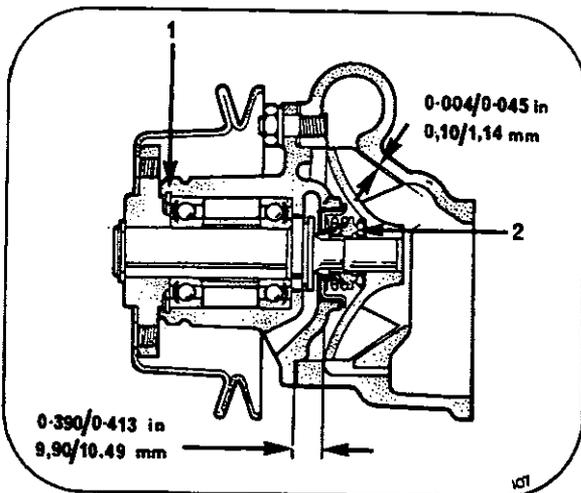
Remove the hub retaining circlip.

Remove the pulley hub by means of a suitable puller.

Press shaft complete with seals and impeller out of the impeller end of body.

Remove the bearing retaining circlip from the hub end of the pump body, see Figs. K.4 and K.5 No. 1, and with a mandrel, press the two shaft bearings and distance piece out through the front of the pump body.

The impeller can now be removed from the shaft using a suitable puller.



K4

Remove seal and counter face from shaft.

On some applications, the water pump body is in two parts. The splitting apart of these two halves will enable the shaft complete with impeller to be pressed out of the pump body.

To Re-assemble the Water Pump. See Fig. K.5.

Press the bearings and distance piece onto the shaft and pack half to two thirds of the space between the bearings, with high melting point grease.

Press the shaft complete with bearings into the front of the pump body and locate with the bearing retaining circlip. Supporting the shaft at the impeller end, press the pulley hub onto the shaft, and fit the retaining circlip. The mechanical seal can now be fitted over the impeller end of the shaft with the carbon face outwards, locating into a recess within the pump body.

The seal is followed by the ceramic counterface, with the ceramic face to the carbon face of the seal, see Figs. K.4 and K.5. No. 2.

Press the impeller onto the shaft until a clearance of 0.015-0.030 in (0,38-0,76 mm) is obtained between the impeller blades and the pump body.

When re-assembling a water pump of the type illustrated in Fig. K.4, the impeller should be pressed onto the shaft until a clearance of 0.390/0.413 in (9,90/10,49 mm) is obtained from the front face of the impeller to the joint face of the water pump body – see Fig. K.4.

Using a new joint, fasten the rear half of the pump body to the front half.

A running clearance of 0.004/0.045 in (0,10/1,14 mm) between the impeller blades and pump body should exist.

Water Pump Seal

If the engine is run without coolant, even for a few seconds, the heat built-up between the carbon seal and ceramic counterface is very rapid, resulting in the cracking of the ceramic. This often creates the misunderstanding that the cause of leakage is due to the incorrect assembly of the sealing arrangement of the water pump.

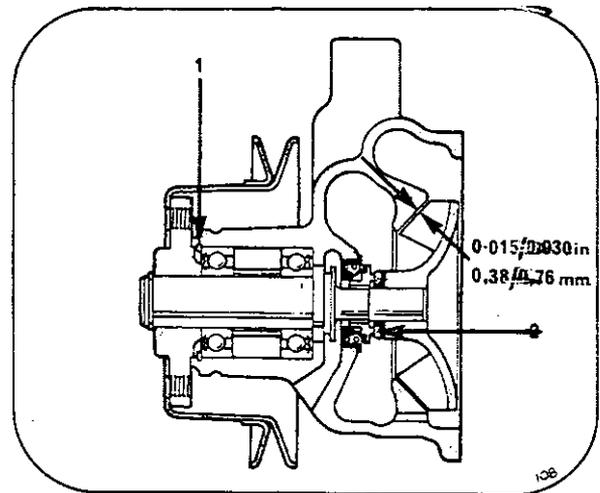
To Refit the Water Pump

Using a new joint and ensuring that the joint faces are clean, refit the water pump, securing with setscrews and spring washers to a torque of 15 lbf ft (2,07 kgf m)–20 Nm.

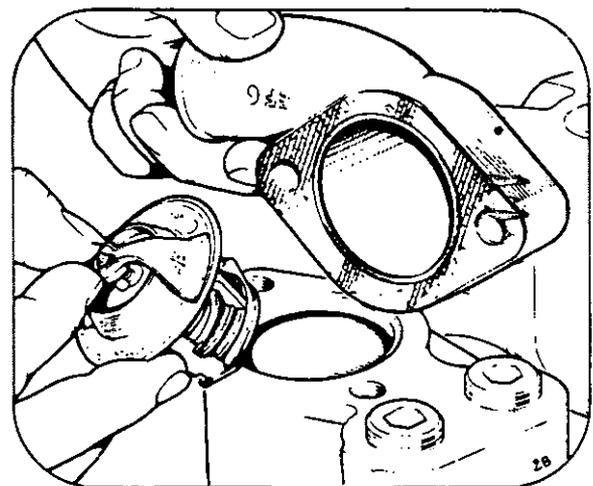
Reconnect the by-pass hose.

Refit the water inlet pipe to the water pump body, using a new joint, and tighten the setscrews to a torque of 15 lbf ft (2,07 kgf m)–20 Nm.

Refit the pulley and fan, securing with four setscrews and tabwashers, tightening to a torque of 21 lbf ft (2,9 kgf m)–28 Nm.



K5



K6

Refit the fan belt, see Page K.2.

To Remove the Thermostat

Remove two setscrews securing the top water connection.

Remove the thermostat, see Fig. K.6.

Cooling System K4

To Test the Thermostat

Immerse the thermostat in water and heat, checking the temperature of the water.

If the thermostat does not open within the required temperature range, see Page K.1, fit a replacement, because no adjustment is possible.

To Replace the Thermostat

A new joint should be fitted between the thermostat housing and the water outlet connection. On refilling with coolant, check for leaks.

Section 'L' FUEL SYSTEM

A distributor type fuel injection pump is mounted horizontally at the rear of the timing case on the left hand side of the cylinder block, and is driven by the fuel pump gear situated in the timing case.

of the cylinder block and is driven by an eccentric on the camshaft. The atomisers are positioned vertically on the fuel pump side of the cylinder head, and contain pintle type nozzles.

The fuel lift pump is mounted on the right hand side

FUEL SYSTEM DATA

Approved Fuel Specifications

For the approved fuel specification, refer to Engine Fluids page.

Fuel Lift Pump

Type	AC-DELCO, Series F.H.
Method of Drive	Eccentric on Camshaft
Spring Colour Code	Blue
Delivery Pressure	5-8 lbf/in ² (0,35-0,56 kgf/cm ²)-34/55 kN/m ²

Fuel Filter

Element type	Paper
Valve type	Ball check valve

Fuel Injection Pump

Manufacturer	C.A.V.
Type	D.P.A.
Pump Rotation	Clockwise viewed from drive end
Timing letter, hydraulically governed pump	'A'
Timing letter, mechanically governed pump	'C'
No. 1 Cylinder Outlet, both types	'W'

Engine Checking and Fuel Pump Marking Angles, Static Timing

	Engine Checking Angle (Degrees)	Fuel Pump Marking Angle (Degrees)	Static Timing	Piston Displacement
Hydraulically Governed	286½	298	23°	0.205 in (5,21 mm)
Mechanically Governed	281	290	18°	0.125 in (3,17 mm)

Fuel System L2

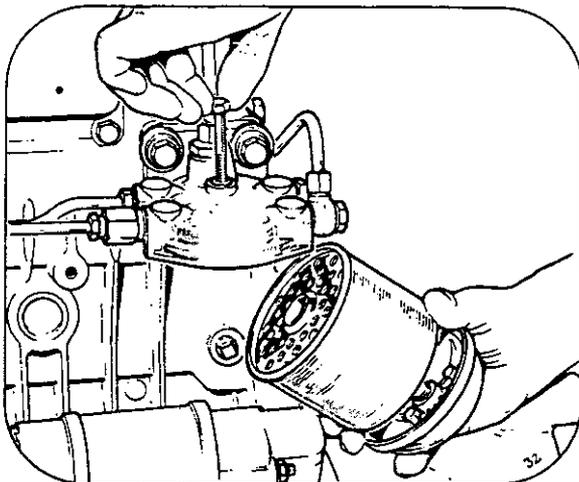
Atomisers	Automotive	Agricultural	Agricultural, Industrial and Marine
Manufacturer	C.A.V.	C.A.V.	C.A.V.
Atomiser Body	BKB35SD5247	BKB35SD5247	BKB35SD5247
Atomiser Nozzle	BDN4SD6346	BDN12SD6236	BDN4SD6769
Working Pressure	135 atm (139 kgf/cm ²) or 1980 lbf/in ²	135 atm (139 kgf/cm ²) or 1980 lbf/in ²	135 atm (139 kgf/cm ²) or 1980 lbf/in ²
Setting Pressure	150 atm (155 kgf/cm ²) or 2220 lbf/in ²	150 atm (155 kgf/cm ²) or 2220 lbf/in ²	150 atm (155 kgf/cm ²) or 2220 lbf/in ²
Identification Code	CJ	BW	GZ

Important Note

The type of fuel pump and atomisers fitted to the 4.154 engine may vary according to application and rating. Reference should therefore be made to the appropriate Parts Literature to ensure correct replacements are fitted in service.

Starting Aid

Manufacturer	C.A.V.
Type	Thermostart – Type 357
Voltage	12 volt
Maximum Current Consumption	12.9 amps at 11.5 volts
Full Flow Rate	4.3 – 4.9 cm ³ /min at 70°F (21°C)
Height of reservoir above Thermostart	4.5 – 10.0 in (11,4 – 25,4 cm)



L1

Fuel Filter – to Remove and Replace the Filter Element

Unscrew the filter bowl securing setscrew located in the centre of the headcasting. Lower the filter bowl clear, see Fig. L.1, and discard the old element together with the fuel contained in the bowl. Thoroughly clean the bowl in a suitable cleaning fluid. Do not use Gasoline (Petrol).

Replace the sealing rings.

Place the new element in the filter bowl and partially fill with clean fuel oil. Offer up the assembly squarely so that the top rim of the element locates centrally against the sealing ring in the filter headcasting.

Hold in this position whilst the securing setscrew is located and screwed home.

Prime the fuel system as detailed on Page L.7.

Fuel Lift Pump

The lift pump is fitted with a diaphragm, two non-return valves which are opposite in operation and a blue coloured diaphragm return spring. Deflection of the diaphragm is by means of an operating arm actuated by an eccentric on the camshaft. A hand primer is fitted to operate the pump when the engine is not running.

Testing the Lift Pump Fitted to the Engine

Disconnect the outlet fuel pipe.

Rotate the engine, or operate the hand priming lever. A spurt of fuel should emit from the outlet port once every two engine revolutions, or every time the hand priming lever is depressed.

NOTE: If the hand lever cannot be depressed, rotate the engine one complete revolution in order to turn the eccentric on the camshaft from its maximum lift position.

Pressure Checking of Fuel Lift Pumps in Position

Fit a 0–10 lbf/in² (0–0,7 kgf/cm²) or 0–70 kN/m² pressure gauge to the outlet of the pump. Ensure that there are no leaks at the connections between pump and gauge. Crank the engine for 10 seconds and note the maximum pressure on gauge. If the pressure recorded is less than 75% of the minimum production static pressure shown below, then rectify the pump. Also observe the rate at which the pressure drops to half the maximum figure obtained when cranking has ceased. If less than 30 seconds, rectify the pump.

Minimum Production Static Pressure			Min. Test Pressure (75% of Min. Production Pressure)		
lbf/in ²	kgf/cm ²	kN/m ²	lbf/in ²	kgf/cm ²	kN/m ²
5	0,35	34	3,75	0,26	25

To Remove the Lift Pump

Disconnect the fuel pipe, from the inlet and outlet ports.

Remove the two nuts and spring washers which secure the pump to the cylinder block, and withdraw the pump, See Fig. L.2.

To Dismantle the Lift Pump

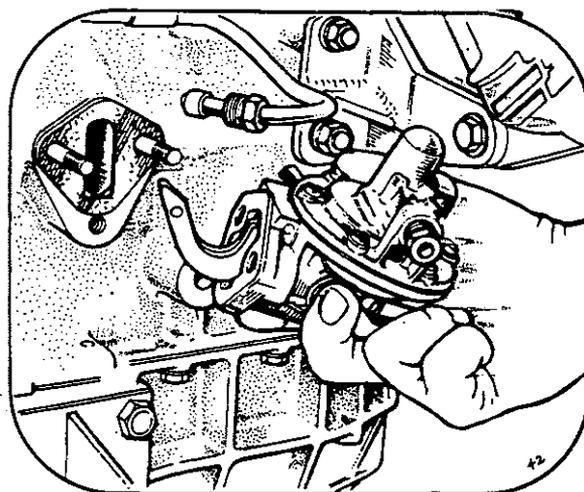
Before dismantling, make a file mark across the two flanges for location purposes when the pump is being reassembled. Remove the six cover screws and separate the two main parts, then remove the diaphragm assembly from the lower half by turning the diaphragm through 90° in either direction.

The valves are “staked-in”, and can be prised out by using a screwdriver or other suitable tool. Clean the casting so that new valves can be correctly seated. Press valves into position using a suitable “dolly”. Stake the casting around the valves in six places.

The rocker arm pin can be removed by securing the rocker arm in a vice, and tapping the face of the body with a soft mallet until the retainers are dislodged. The rocker, pin, lever and return spring can now be examined for wear.

To Re-assemble the Lift Pump

Fit the rocker arm assembly into the bottom half of the lift pump. Fit the rocker arm return spring making sure that it seats properly.



L2

Tap new retainers into the grooves in the casting, and stake over the open ends of the grooves.

Place the diaphragm assembly over the spring, with the pull rod downwards, locating the top of the spring in the diaphragm protector washer. Position the rod so that the notched blade locates into the rocker arm link. Press downwards on the diaphragm assembly so that the notches on the pull rod align with the rocker arm link and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.

When re-assembling the two pump halves, push the rocker arm towards the pump until the diaphragm is level with the body flanges. The cover assembly can now be placed in position, with the file marks aligned. Maintaining the pressure on the rocker arm, fit the securing screws and washers and tighten evenly.

To Refit the Fuel Lift Pump

Ensure that the pump flange and cylinder block pump mounting face is clean, and using a new joint, enter the pump operating lever into the aperture in the block. Fit the pump onto the mounting studs and secure with nuts and spring washers.

Fuel Injection Pump

IMPORTANT Unless proper test equipment and trained technicians are available, adjustment or maintenance of the fuel pump should not be attempted.

To Remove the Fuel Pump Hydraulically governed

Disconnect the stop and throttle controls from the fuel pump and remove the return springs.

Remove the high and low pressure fuel pipes from the fuel pump, and blank off all ports.

Remove the fuel pump securing nuts and plain and spring washers and withdraw the fuel pump. See Fig. L.3.

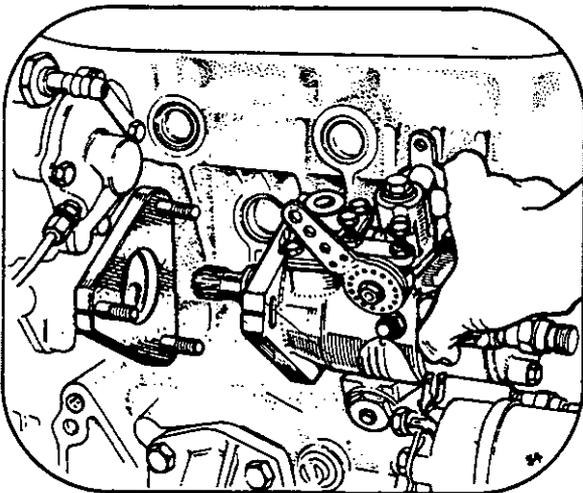
To Remove the Fuel Pump Mechanically governed

Disconnect the stop and throttle controls from the fuel pump and remove the return springs.

Remove the high and low pressure fuel pipes from the fuel pump and blank off all ports.

Remove the inspection cover from the timing case front cover, and remove the three setscrews and spring washers securing the fuel pump gear to the pump, taking care that they do not drop into the timing case.

Remove the fuel pump securing nuts and plain and spring washers and withdraw the fuel pump.



The fuel pump gear will remain in mesh with the idler gear, and will only drop against the inside of the timing case approximately 1/8 in (3,17 mm).

Precaution must be taken that the engine is not turned whilst the fuel pump gear is unfastened.

To Refit the Fuel Injection Pump Hydraulically governed.

Fit a new fuel pump mounting flange joint, and offer up the pump ensuring that the master spline on the shaft is correctly positioned to engage with the female spline within the fuel pump drive hub.

When the splines are in correct alignment the pump can be located on to the mounting studs on the adaptor housing until the mounting flanges meet, and the plain washers followed by the spring washers and securing nuts can be fitted.

Before tightening, align the timing marks scribed on the mounting flanges, see Fig. H.3.

Refit the high and low pressure fuel pipes, the control cables and springs. Fuel pump timing can be checked as detailed on Page H.4.

Prime the fuel system as described on Page L.7.

To Refit the Fuel Injection Pump Mechanically governed

Fit a new fuel pump mounting flange joint, and offer up the pump, fitting it to the mounting studs on the adaptor plate. Align the dowel location on the end of the pump drive shaft with the dowel on the pump gear. By manipulation of the gear and ensuring that it remains in mesh with the idler gear, refit the three setscrews and spring washers, and tighten to a torque of 21 lbf ft (2,9 kgf m) -28 Nm.

Refit the plain and spring washers and nuts to the pump mounting studs. Before tightening, align the timing marks on the pump mounting flange and the back of the adaptor plate, see Fig. H.2.

Refit the high and low pressure fuel pipes, the control cables and springs.

Fuel pump timing can be checked as detailed on Page H.3.

Prime the fuel pump system as described on Page L.7.

Maximum Speed Setting

The maximum speed screw is set and sealed by the manufacturers and must not be altered in any way unless factory authority is first obtained. Any adjustments should be carried out by experienced fuel pump technicians. The unauthorised removal of any seals on the pump may render the guarantee void.

When a fuel pump is supplied as a direct replacement, the governor maximum speed is set to a nominal figure only, and final adjustment must be made after the pump is fitted to the engine. In order to establish the correct setting which varies according to application, reference must be made to the setting code symbol, stamped on the plate fastened to the pump body.

For the purpose of setting the maximum speed stop, the last four figures shown on the fuel pump setting code is the maximum no load engine speed. Warm the engine and run up until this figure is reached; the maximum speed stop should then be set at this figure.

Atomisers

General

When replacing atomisers in the cylinder head it is essential that a new, correct type copper washer is fitted between the nozzle cap and the cylinder head.

When fitting the atomisers, the securing nuts should be tightened to 12 lbf ft (1,7 kgf m) or 16 Nm.

Trouble in Service

The first symptoms of atomiser troubles usually fall into one or more of the following headings:

Misfiring

Knocking in one or more cylinders

Engine overheating

Loss of power

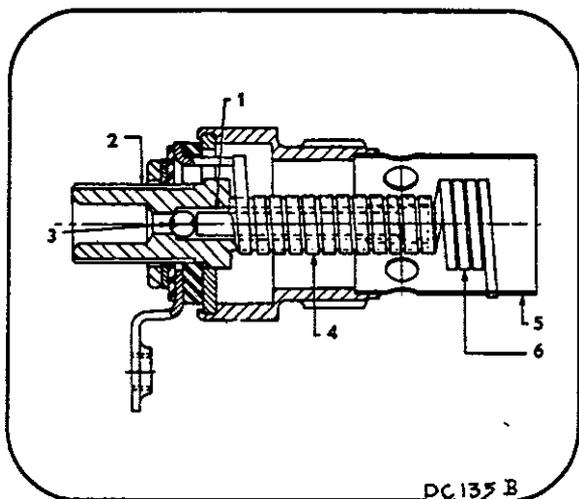
Smoky black exhaust

Increased fuel consumption

The particular faulty atomiser or atomisers may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tickover". If after slackening a pipe union nut the engine revolutions remain constant, this denotes a faulty atomiser. The complete unit should be withdrawn from the cylinder head and replaced by a known good serviceable unit to the correct code for the application.

NOTE: Care should be taken to prevent the hands or face from coming into contact with atomiser spray, as the working pressure will cause fuel oil to penetrate the skin.

Fuel System L6



L4

Maintenance

Atomisers should be taken out for examination at regular intervals. Refer to Preventative Maintenance, Page A.5.

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

A perfect atomiser, when tested by pumping fuel through it in the open air gives a short "pinging" sound as the fuel emerges from the holes. After the atomiser has been in service for some time, the "pinging" changes to a "crackling" sound. It is not until the atomiser sounds "dead" that its condition is likely to affect the running of the engine.

Fuel Pipes

The pipes should be clean, the olives should not be split or compressed otherwise leakage will result. Ensure when fitting, that the pipe fits squarely at both ends, and that the union nuts are not over-tightened. When changing an atomiser always slacken the union nuts or remove the pipe completely. Never bend the pipe.

When fitting the high pressure fuel pipes, the nuts should be tightened to 15 lbf ft (2,1 kgf m) or 20 Nm.

Starting Aid

The "Thermostart" starting aid, see Fig. L.4, is comprised of a tubular valve body carried in a holder which screws into the inlet manifold. The valve body is surrounded by a heater coil, an extension of which forms an ignitor coil. The valve body houses a needle, of which the stem holds a ball valve in position against its seating. The ignitor end of the unit has a perforated shield. Fuel oil from the reservoir enters through an adaptor.

When the unit is cold, the ball valve is held in a closed position. When the coil is energised by using the "heat" switch, see Fig. A.1, or button, the valve body is heated and expands, opening the ball valve and permitting the entry of fuel. The fuel is vapourised by the heat of the valve body and when the switch is turned to "heat and start" or both buttons are depressed, cranking the engine, air is drawn into the manifold. The vapour is ignited by the coil extension and continues to burn, heating the inlet air.

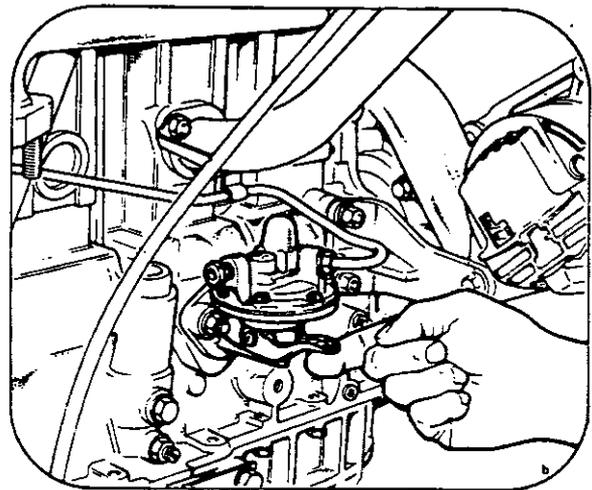
When the coil is switched off by releasing the "heat and start" switch or button and the engine is running, the cold air entering the inlet manifold rapidly cools the valve body and the valve closes.

In the event of difficult cold starting check that the reservoir feeding fuel to the starting aid is fully primed, and that fuel is reaching the starting aid. The cold start aid can be functionally checked by removing the air cleaner and watching the starting aid whilst it is being used.

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

A worn valve will cause fuel to leak into the inlet manifold causing a smoky exhaust and excessive fuel consumption.

4.154 engines are fitted with efficient starting equipment, and no responsibility can be accepted for any damage caused by unauthorised starting aids.



L5

Priming the Fuel System

The air must be vented from the fuel system whenever any fuel pipes between the fuel tank, fuel injection pump and atomisers have been disconnected, or when the system has been emptied of fuel.

No attempt must be made to start the engine until the fuel injection pump has been filled and primed as serious damage can be caused to the pump through lack of lubrication.

In the event of air entering the fuel system, it will be necessary to "bleed" the whole of the fuel system before starting can be effected. Proceed as follows.

Slacken the air vent valve on top of the governor housing (hydraulic governor) Fig. L.6; No. 1.

Slacken the vent valve fitted on the head locking screw of the fuel injection pump see Fig. L.6, No. 2.

Operate the hand priming lever see Fig. L.5, on the lift pump until fuel, free from air bubbles rises from each venting point.

Tighten the valves in the following order.

Head locking screw vent valve Fig. L.6, No. 2.
Governor housing vent valve, Fig. L.6, No.1.

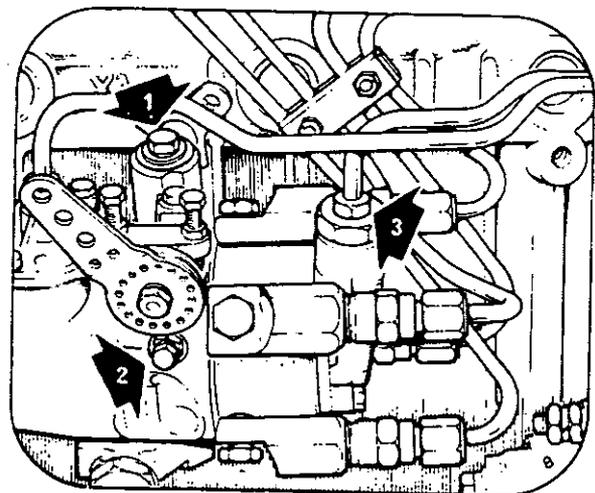
Slacken the union nut at the fuel injection pump inlet, Fig. L.6, No. 3, and operate the priming lever of the lift pump. Retighten the union nut when fuel, free from air bubbles, issues from around the threads.

The fuel filter is self-bleeding.

If fuel oil has been drained from the Thermostart fuel supply pipe, the pipe must be disconnected at the Thermostart and the engine turned until air free fuel comes from the pipe before the Thermostart is operated.

Slacken the union nuts at the atomiser ends of any two of the high pressure pipes.

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



L6

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

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

For engines fitted with mechanical type fuel pumps and fuel filters with air vent valves, the following procedure is necessary.

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

Slacken the vent screw on the hydraulic head locking screw on the side of the fuel injection pump body. Slacken the air vent screw near the top of the governor housing on the fuel injection pump. Operate the priming lever of the fuel lift pump.

When fuel, free from air bubbles issues from each vent point, tighten the connections in the following order:-

Filter head venting screw.

Head locking screw on the fuel injection pump.

Governor vent screw on fuel injection pump.

Slacken the pipe union nut at the fuel injection pump inlet, operate the priming lever on the fuel lift pump and retighten when fuel, free from air bubbles issues from around the threads.

Slacken the union nuts at the atomiser ends of the high pressure fuel pipes. Set the accelerator in the fully open position and ensure that the stop control is in the "run" position. Rotate the engine with the starter motor until fuel oil, free from air bubbles issues from all the fuel pipes. Some 30 to 60 seconds of rotation may be necessary before this condition is reached, and the time will be dependent upon the speed of rotation and the effectiveness of the bleeding operation described above. A fully charged battery in a temperate or warm climate will rotate the engine at upwards of 280 rev/min, and under these conditions, the remaining air should be expelled in under thirty seconds. Cold conditions or partially discharged batteries may take longer.

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

It must be realised that this whole operation must be carried out completely and no action to tighten connections must be made until all signs of air bubbles have disappeared. Unless care is taken with this operation, and this could take some four to five minutes of priming, failure to start will occur.

Section 'M' AIR CLEANER

Air Cleaner M1

General

Operating conditions play the most important part in deciding how frequently it is necessary to service the air cleaner. Vehicle or machines operating on normal road conditions usually experienced in the United Kingdom, or industrial engines operating in relatively clean conditions in which the concentration of dust is minimal, require the air cleaner to be serviced at regular intervals, as given on Page A.5. Any alteration in operating conditions which incorporate a deterioration in air conditions, must be accompanied by a revision of the air cleaner maintenance schedule.

Servicing – Dry Type Air Cleaners

Where an automatic dust ejector is fitted, it should be kept clean making sure that the lips of the rubber ejector close, but do not stick together.

An 18 in water gauge restriction indicator can be fitted which is pre-set to indicate when a filter element service is necessary.

When an element becomes contaminated, it should be discarded and replaced by a new one however, if a new element is unavailable, the element can be removed, and loose dirt particles disposed of by gently tapping the element. Alternatively it can be cleaned with a non-foaming detergent, but the subsequent life of the element will be shortened. Some manufacturers incorporate a "treated" element, which protects against oil and soot conditions experienced in heavy traffic.

Element Renewal

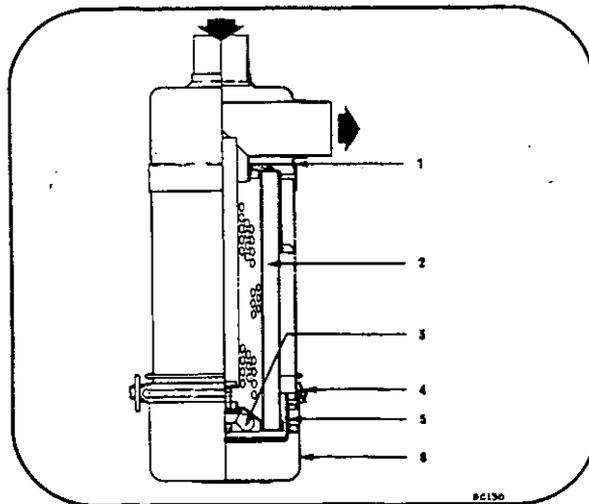
To remove the element, release the knurled nut and remove the clamp. The element can now be removed from the housing.

Depending on the installation of the air filter, care should be taken to prevent accumulated dirt from entering the inlet manifold. Before inserting the new or cleaned element, clean the inside of the filter housing with a clean cloth.

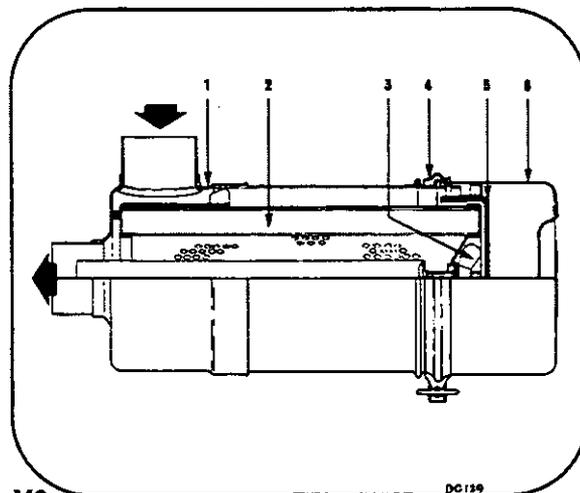
Servicing – Dry Type Air Cleaners Fitted with Dust Bowl (See Figs. M.1 and M.2.)

Dust level should not be allowed to build up to $\frac{1}{2}$ in (12,70 mm) from the slot in the dust cup baffle. Depending on conditions of service this could necessitate daily emptying of the dust bowl.

Check regularly for dead leaves or other foreign material in the intake area. Tighten wing bolt if necessary.



M1



M2

Key to numbered annotations in Figs. M.1 and M.2.

- 1 – Body assembly.
- 2 – Element assembly.
- 3 – Nut and Gasket assembly.
- 4 – Clamp assembly.
- 5 – Baffle skirt.
- 6 – Cup assembly.

Restriction Indicator

If a restriction indicator is fitted it should be located in the transfer piping between air cleaner outlet and engine manifold away from bends or elbows.

It will indicate by means of a visual signal when to service the element.

Element Renewal

Remove the clamp by unscrewing the pinhscrew, and drop the dust bowl complete with baffle assembly. Remove the baffle from the interior of the dust cup by lifting it out, which gives access to the dust for removal. On horizontally mounted air-cleaners note the arrows on the bottom of the dust bowl to indicate correct positioning for reassembly.

Remove wing bolt situated at the rear of the element, and remove the element.

Optional Service Method

The dirty air cleaner element can be cleaned, and if the following procedure is followed, it can be restored to give a limited period of service life. However, it is recommended that the element should be replaced after six cleanings or annually whichever is first.

Remove the element as described previously and direct clean dry air at no more than 100 lbf/in² (7,03 kgf/cm²) up and down the pleats on the clean side of the element. Immerse the element in a detergent air filter compound as instructed in the directions for use by the manufacturers.

Allow the element to soak for at least 10 minutes., Gently agitate element at end of soaking period to flush out dirt.

Rinse the unit with clean water to remove all loosened particles. Allow the element to dry. Do not oven dry, but a fan or air draft may be used to hasten drying.

Inspect the dried element by placing a bright light within the centre. Thin spots, pin holes or the slightest rupture will render the cartridge unfit for further use. Also examine the gasket for serviceability. If damaged, the element must be replaced.

A "treated" element can be cleaned using the procedure described above but the subsequent life of the element will be shortened.

Note: When replacing an air filter assembly, care should be taken that the correct assembly is fitted. Owing to the similar appearance of the vertically and horizontally mounted unit, it is possible to replace one with the other, and incorrectly connect the inlet and outlet trunking in the same manner as the displaced unit. However, the positions of the outlet and inlet ports of the two types of filter become transposed, and if connected incorrectly, damage to the engine would ensue. If in doubt, a visual examination through the ports of the filter assembly is necessary to ensure that the outlet port to the induction manifold of the engine is ducted through the interior of the filter element, and the inlet port is ducted to the area between the element and filter body.

Two-Stage Dry Type Air Cleaners with Multiple Filter Elements

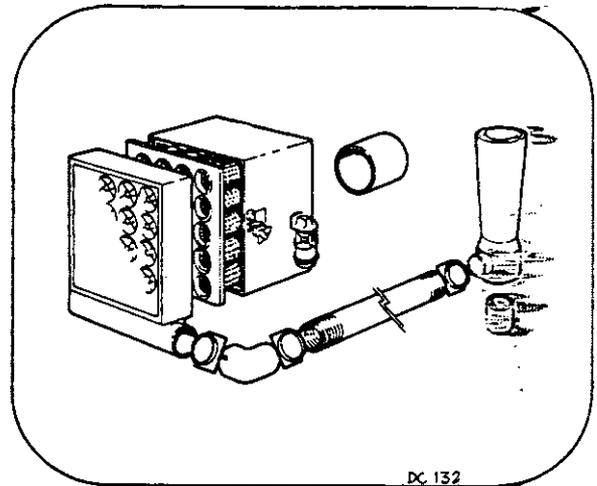
Extreme Heavy Duty. See Fig. M.3.

This type of air filter may be fitted where the application is designed to work in heavy concentrations of dust, and the most reliable method of ascertaining dust load within the air cleaner is by use of the restriction indicator which in this type incorporates a red indicator flag which gradually rises as the dirt trapped by the air cleaner increases the pressure drop. When the flag reaches the top position it locks in place, and the element should be changed. To re-set the indicator push the Re-set button.

A further check on the efficiency of the air cleaner system is by a Dust-Sight. This incorporates a metal tab placed directly in the air-stream, and a window through which the tab can be seen. The tab will deflect dust against the inside of the window, immediately clouding the glass. When the cleaner and induction system are working correctly the window stays clean. This device, where fitted, will be found in the trunking adjacent to the engine air intake or manifold.

If a restriction indicator or other device is not fitted, the replacement of the filter elements must be done on a regular schedule basis, in accordance with the maintenance advised in the vehicle or plant manufacturers hand book, but servicing of air cleaners can only be based on the prevailing conditions in which the application is working.

This type of air cleaner incorporates a pre-cleaning device in which heavy dust particles are initially removed from the air entering the filters and discharges into the engine exhaust gases via an aspirator. Pre-cleaned air then enters the filter elements for final cleaning, before entering the engine air intake.



M3

DC 132

Air Cleaner M4

Element Renewal

Unclamp the pre-cleaner panel and move to one side.

Pull out the dirty single unit, multiple element filter cartridge and replace with a new one.

Locate the pre-cleaner panel and re-clamp in place.

Warning

Under no circumstances should petrol/gasoline be used for cleaning any part, filter element or filter body, of the air cleaner.

Section N ELECTRICAL SYSTEM

Alternator

Manufacturer
Type
Rotation
Maximum output 12 volt (hot) 11AC
Maximum output 12 volt (hot) AC5
Alternator Cut-in Speed 11AC
Alternator Cut-in Speed AC5

Lucas or C.A.V.
11 AC or AC5
Clockwise viewed from drive end
43 amps at 13.5 volts
55 amps at 13.5 volts
1000 rev/min
1125 rev/min

Dynamo

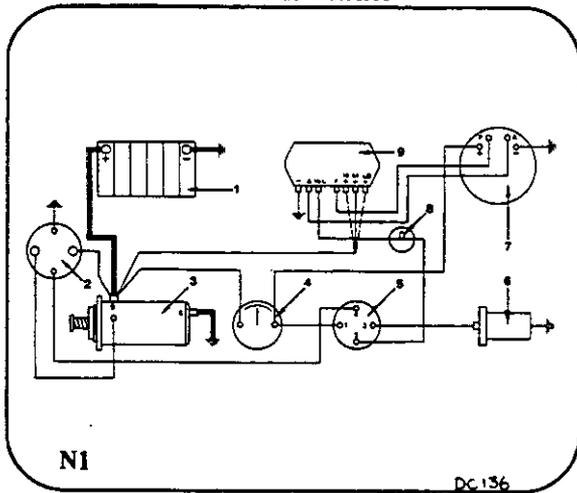
Manufacturer
Type
Rotation
Output
Dynamo Cut-in Speed

Lucas
C40A, 2-pole, 2-brush, shunt
wound, voltage control.
Clockwise viewed from drive end
11 amps maximum
10/50 rev/min

Starter Motor

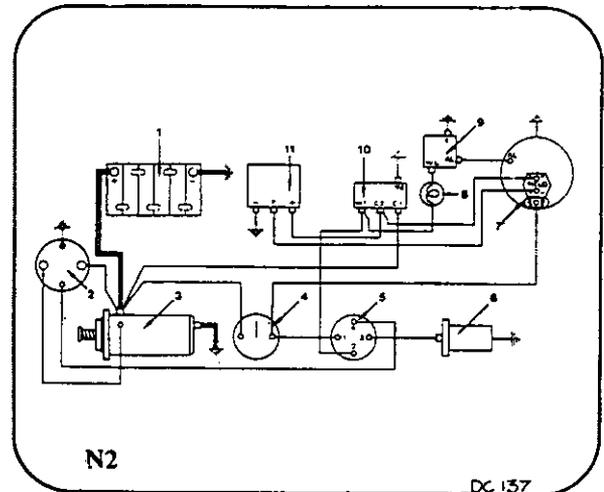
Manufacturer
Type
Number of teeth on Pinion
Maximum current
Starter Cable Resistance

Lucas
M45, CA45 or M50
10
800 amps or 1070 amps
0.0017 ohms



Key to Wiring Diagram incorporating AC5 Alternator.

- 1 - 12 Volt Battery.
- 2 - Starter Relay
- 3 - Starter Motor.
- 4 - Ammeter.
- 5 - Auxilliary Heat/Start Switch.
- 6 - Thermostart.
- 7 - AC5 Alternator.
- 8 - Alternator Warning lamp.
- 9 - 440 Regulator.



Key to Wiring Diagram incorporating 11AC Alternator.

- 1 - 12 Volt Battery.
- 2 - Starter Relay.
- 3 - Starter Motor.
- 4 - Ammeter.
- 5 - Auxilliary Heat/Start Switch.
- 6 - Thermostart.
- 7 - 11AC Alternator.
- 8 - Alternator Warning Lamp.
- 9 - 3AW Warning Light Unit.
- 10 - Field Isolating Relay.
- 11 - 4TR Control Unit.

Electrical System N2

ALTERNATOR

Models AC5 with 440 Regulator (See Fig. N.1.)
and 11AC with 4TR Control Box (See Fig. N.2.)

General

The alternator is driven by the engine in the same manner as a D.C. generator, namely, belt driven from the crankshaft pulley, but the advantage lies in its ability to provide higher maximum output at lower speeds, to cope with increased electrical load demanded by modern equipment and decreased road speeds owing to increased density of traffic, especially in built up areas. It is also much lighter in weight, output for output.

As opposed to the DC generator in which the armature windings rotate inside a stationary field system, the alternator has a rotating field system inside a stationary generating winding. When the rotor rotates inside the stator, the output produced is alternating current (AC). This is unsuitable for charging the battery which requires direct current (DC), so it is rectified by means of diodes which convert it to uni-directional flow to the battery.

The alternator voltage output is maintained within close limits by means of a control box which is fully transistorised and functions as fast switches.

Precautions

As previously described the diodes in the alternator function as one-way valves and the transistors in the regulator/control box operate as fast switches. Both are accurate and sensitive.

They do not wear out and seldom require adjustment, but because they are sensitive to voltage changes and high temperature, the following precautions are vital to prevent them from being destroyed.

- (a) DO NOT disconnect the battery whilst the engine is running. This will cause a voltage surge in the alternator charging system that will immediately ruin the diodes or transistors.
- (b) DO NOT disconnect a lead without first stopping the engine and turning all electrical switches to the off position.
- (c) DO NOT cause a short circuit by connecting leads to incorrect terminal. Always identify a lead to its correct terminal. A short circuit or wrong connection giving reverse polarity will immediately and permanently ruin transistors or diodes.
- (d) DO NOT connect a battery into the system without checking for correct polarity and voltage.
- (e) DO NOT "flash" connections to check for current flow. No matter how brief the contact the transistors may be ruined.

Maintenance

The alternator charging system will normally require very little attention, but it should be kept free from build-up of dirt, and a check made if it fails to keep the battery charged.

- (a) Regularly inspect the driving belt for wear and correct tension. It is important to ensure that all belts on a multiple belt drive have equal tension and are each carrying their share of the load. Slack belts will wear rapidly and cause slip which will not drive the alternator at the required speed. Drive belts which are too tight impose severe side thrust on the alternator bearings and shorten their life. Periodically ensure that the alternator is correctly aligned to the drive.
- (b) Do not replace faulty belts individually in a multi-belt system. A complete matched set of drive belts must always be used.
- (c) Keep the alternator clean with a cloth moistened in Kerosene or cleaning fluid. Ensure that ventilation slots and air spaces are clear and unobstructed.
- (d) Remove any dirt accumulated on the regulator/control box housing, and ensure that cooling air can pass freely over the casing.

Fault Finding on AC5

The AC5 alternator is so designed that a flow of current indicated either by the extinguishing of the warning light, or as shown on the ammeter, is sufficient evidence that the system is in proper working order. Therefore, no open circuit, voltage or current output checks should be performed on the installation UNLESS:-

- (a) The warning light fails to illuminate when the generator is stationary, and the switch is closed OR fails to become extinguished when the alternator is running.
- (b) No charging current is shown on ammeter.
- (c) The battery is flat.
- (d) The battery is "boiling" indicating loss of voltage control.

If any of the above symptoms occur, the procedure indicated below should be followed.

- (a) Connect a good quality moving coil voltmeter 0-50 volts range across the battery or regulator negative terminal, and one of the three positive terminals marked LO, MED, HI. Disconnect alternator output terminal. Fit a good quality moving coil 0-100 amp ammeter in series with the alternator terminal and output lead. The battery should be in a charged condition.

- (b) Close the warning light switch (master electric switch on dashboard) when the warning lamp should light up.
- (c) Switch on a 10–15 amperes load such as lights, fans, etc. for fifteen minutes.
- (d) Start engine and run at fast idle speed when
 - 1. The warning light should go out.
 - 2. The ammeter records a small charge dependant on engine speed.
- (e) Increase engine speed momentarily to maximum speed when the charging current should be about 30 amperes for 24 volts, and 53 amperes for 12 volt systems.
- (f) With the alternator running at approximately half speed, (engine speed about 1,500 rev/min) switch off electrical load. Depending on the connection selected for the positive sensing wire LO, MED or HI, the voltage should rise to 26/28 volts on 24 volt systems and 13/14 volts on 12 volt systems, then remain constant. At the same time the current reading should drop appreciably.

Any variance in the above data could indicate a fault and the following procedure should be adopted before disconnecting any components.

The regulator is a sealed unit and is non-repairable and if found to be faulty it must be replaced.

Warning Lamp does not light up when switched "On".

Check the bulb.

If no fault

Check all wiring connections at regulator, alternator and battery.

If no fault

Switch off, disconnect 'F' lead at regulator and connect it to the negative terminal.

Switch on. If warning lamp lights up, the regulator is faulty. If lamp fails to light up, the alternator is faulty.

Warning Lamp does not go out and Ammeter shows no output when running.

Check all regulator, alternator and battery connections.

If no fault

Switch off, disconnect 'F' lead at regulator and connect to regulator negative terminal.

Switch on, and run at fast idle.

If no output, alternator is faulty.

If output appears, regulator is faulty.

Warning lamp does not go out when running and Ammeter shows reduced output with full output only at maximum speed

or

Warning lamp goes out but Alternator delivers reduced output. Full output only at maximum speed.

Alternator faulty. Remove from installation and apply open circuit diode check.

Warning lamp flashes intermittently and Ammeter needle oscillates when battery is fully charged and no loads are switched in.

Check for excessive resistance in regulator negative sensing lead.

If no fault, regulator is faulty.

Batteries overcharging and Ammeter indicates high or full output all the time.

Check regulator positive sensing lead and its connection at regulator.

If no fault, regulator is faulty.

Fault Finding on 11AC

If the alternator does not produce its rated output of 43 volts for 12 volt and 23 volts for 24 volt circuit, the failure may be due to any unit or the associated wiring, and the following procedure should be followed.

Test 1

Check the Field Isolating Relay

Disconnect the earthed battery terminal and the cable from the alternator main output terminal. Connect a 0–60 DC ammeter between the terminal and disconnected cable. Link terminals 'C1' and 'C2' on the field relay. Reconnect the battery cable. Close the master switch, start engine and run at charging speed. If ammeter shows a charge the relay is faulty, or its wiring and connections.

If ammeter shows no charge, carry on with Test 2.

Test 2

Check the Alternator and Control Box

Leave the test ammeter connected, and disconnect cables 'F' and '-' from control unit and join them together. Remove link from field relay terminals and ensure they are connected to 'C1' and 'C2'. Start engine and run at charging speed.

Ammeter should indicate current values of 35 amps or more for 12 volt circuit. A zero or low reading indicates a faulty alternator. If satisfactory output is recorded, a faulty control unit is indicated.

Electrical System N4

Test 3

Checking or Adjusting the Voltage Setting

The regulator of the 4 TR control unit must be set on CLOSED CIRCUIT, when the alternator is under load. Also, the system must be stabilised before checking or resetting is carried out, and the battery must be in a well charged condition. Check the battery to control unit wiring, to ensure that the resistance of the complete circuit does not exceed 0.1 ohm. Any high resistance must be traced and remedied. Connect a test DC voltmeter (suppressed zero type) scale 12–15 volts for 12 volt installations or 24–30 volts for 24 volt installations, between the battery terminals, and note the reading with no electrical load. Disconnect battery earth cable and connect test ammeter between alternator main terminal and disconnected cable. Reconnect battery earth cable, and switch on an electrical load of approximately two amps, such as side and tail lights. Start engine and run at about 2000 rev/min for at least eight minutes. If the charging current is still greater than ten amps., continue to run engine until this figure is reached. Then compare the voltmeter reading with the appropriate setting limits, as specified for the particular control unit as follows.

12V (37423) (37449) 13.9 14.3 volts

(Part No. marked on upper edge of the moulded cover of Control Unit).

If reading obtained is stable but outside the appropriate limits the unit can be adjusted as follows.

Adjustment of Voltage Setting

Stop the engine and remove the control unit from its mounting. At the back of the unit is a sealed potentiometer aduster. Carefully scrape away the sealing compound. Then start the engine, and while running the alternator at charging speed, turn the adjuster slot – CLOCKWISE to INCREASE the setting or ANTI-CLOCKWISE to DECREASE it – until the required setting is obtained.

Recheck the setting by stopping the engine, then start again and slowly “run-up” to charging speed. If setting is now correct, remount the control unit, disconnect test meters and restore original wiring connections. If, after adjustment, the voltmeter reading remains unchanged, or increases in an uncontrolled manner, then the control unit is faulty and a replacement must be fitted.

Test 4

Check of Alternator Output

Disconnect battery earth cable, and connect test ammeter between the alternator main terminal and disconnected cables. Reconnect battery earth cable, and switch on the vehicle's full electrical load and leave on for 3 or 4 minutes. Leave load on, start engine and run at approximately 2000 rev/min. The alternator output should balance the load, and at the same time show a charge to the battery.

Check Warning Light Control

If warning light does not function either by remaining “on” or “off”, but the system is charging satisfactorily, connect voltmeter between the alternator “AL” terminal and earth. Reading should be 7.0–7.5 max (12 volt alternator) or 14.0–15.0 (24 volt alternator) Connect leads ‘E’ and ‘WL’ together. If warning lamp lights, the warning light control is faulty and should be replaced.

Fault Diagnosis Procedure for 11 AC.
Alternator Fails to Charge

- (a) Check driving belt for correct tension and wear.
- (b) Apply Tests 1 and 2.

Low-Unsteady Charging Rate

- (a) Check driving belt for correct tension and wear.
- (b) Check for high resistance at battery terminals and in the circuit wiring connection. Check all connections made to earth.
- (c) Apply Test 2.

Flat Battery or Low State of Charge

- (a) CHECK condition of battery with hydrometer and high rate discharge tester.
- (b) Check driving belt for correct tension and wear.
- (c) Check that the field isolating relay contacts open when master switch is off, otherwise battery will discharge through rotor winding.
- (d) Check that flat or low battery is not caused by insufficient alternator output caused by abnormal electric loads by applying Test 4.

Excessive Charge Rate to a Fully Charged Battery

- (a) Apply Test 3.

Noisy Alternator

- (a) Alternator loose in mounting brackets.
- (b) Worn, frayed or loose drive belt.
- (c) Worn bearings, fully out of alignment.
- (d) Rotor damaged or pulley loose on shaft.
- (e) Open circuited, or short circuited rectified diodes, or stator winding open-circuit.
- (f) Loose pulley.

**Dynamo
Models C40A and C40L**

General

The C40A is a non-ventilated unit. It will be found fitted to applications such as agricultural machines, which operate under exposed service conditions. The C40L is a ventilated dynamo and will be found on applications such as road vehicles, which operate under cleaner and more normal conditions.

Both types are shunt-wound two-pole two-brush machines arranged to work in conjunction with a compensated voltage control regulator unit. A ball bearing supports the armature at the driving end and a porous bronze bush at the rear supports the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of overcharging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

Routine Maintenance

Lubrication

Every 4,000 miles (6,000 km) or 150 running hours whichever is the sooner, inject a few drops of S.A.E. 30 engine oil into the hole marked "OIL" at the commutator end bearing housing.

Inspection of Brush Gear

Every 60,000 miles (90,000 km) or 2,400 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

Belt Adjustment

Every 4,000 miles (6,000 km) or 150 running hours, whichever is the sooner, inspect the dynamo driving belt, and if necessary adjust to take up any slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening the belt. At the same time check the dynamo pulley securing nut tightness. Pull to a torque of 15/20 lbf ft (2,07/2,8 kgf m).

Servicing

Testing in Position to Locate Fault in Charging Circuit.

1. Inspect the driving belt and adjust if necessary.
2. Check the connections on the commutator end bracket. The larger connector carries the main dynamo output and the smaller connector, the field current.
3. Switch off all lights and accessories, take off the cables from the terminals of the dynamo and connect the two terminals with a short length of wire.
4. Start the engine and set to run at normal idling speed.
5. Clip the negative lead of a moving coil type voltmeter, calibrated 0/20 volts, to one dynamo terminal and the positive lead to a good earthing point on the yoke.
6. Gradually increase the engine speed, when the voltmeter reading should rise rapidly and without fluctuation. Do not allow the voltmeter reading to reach 20 volts, and do not race the engine in an attempt to increase the voltage. It is sufficient to run the dynamo up to a speed of 1,000 rev/min. If the voltage does not rise rapidly and without fluctuation the unit must be dismantled for internal examination. Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced.

Starter Motor

Model M45G

General

This starter motor is a four-pole, four-brush earth return machine with series-parallel connected field coils.

A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft. The main features of this type of drive are as follows:—

- (a) Positive pinion engagement preventing the pinion being thrown out of mesh whilst starting.
- (b) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and over-load protection.
- (c) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.

Electrical System N6

- (d) Armature braking system to ensure rapid return to rest when the start button is released.

Routine Maintenance

- (a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection which must be clean and tight, the brush gear, and the commutator.
- (b) After the starter motor has been in service for 60,000 miles (90,000 km) or 2,400 running hours, whichever is the sooner, remove the starter motor from the engine and submit it to a thorough bench inspection.
 1. Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching, 5/16 in (7,9 mm) in length.
 2. Brush spring tension. Correct tension is 30/40 oz (0,85/1,13 kg) Renew springs if tension has dropped below 25 oz (0,71 kg).
 3. Skim commutator if it is pitted or badly worn.
 4. Check bearings for excessive side play of armature shaft.
 5. Check pinion movement.
 6. Clean and lubricate the indented bearing inside the pinion sleeve using Shell SB2628 grease for temperate and cold climates or Shell Retinex grease for hot climates.
 7. Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose.

Servicing

Testing in Position

Switch on the lamps. If the vehicle is not equipped with lighting, then connect a 0/20 voltmeter across the battery terminals before proceeding. Operate the starter control and watch for the following symptoms:—

1. The lamps dim (or voltmeter reading drops to about 6 volts), and the motor does not crank the engine.

Check battery (must be at least half-charged) and battery lugs (clean and a good earth connection). Check by hand-cranking that the engine is not abnormally stiff.

2. The lamps do not dim, the voltmeter reading remains steady at about 12 volts, and the motor does not crank the engine.

Connect voltmeter from solenoid terminal 'BAT', to starter yoke and operate starter;

No volts indicated:

- (a) Poor lug connections at battery
- (b) Bad earth connection
- (c) Broken starter lead, battery to starter.

Full volts i.e. 12/14 volts indicated.

- (a) Faulty solenoid switch.
- (b) Open circuit in starter — check brushes.

Starter Motor

Model — CA45

General Description

Designed for flange mounting, the CA45 starter motor has a uniform cylindrical shape with no surface protrusions. This is because the solenoid and main switch assemblies are housed within the drive end-shield, around (i.e. co-axially with) the armature shaft.

The essential feature of the co-axial starter is that, the Pinion alone moves axially to engage the engine flywheel. There is no longitudinal movement of the whole armature assembly, as in the axial types.

Smooth engagement of the pinion with the engine flywheel is constantly ensured by using two-stage operation of the solenoid and switch mechanisms. Thus the risk of damage to both pinion and flywheel, through faulty meshing, is practically eliminated.

In construction, the starter consists of three main sections, into which it can be easily dismantled.

1. The solenoid switch-gear and pinion assembly housed in the drive end-shield.
2. The armature, shaft and commutator assembly.
3. The yoke, pole-piece and field-coil assembly.

Ready access is possible therefore, to those parts most likely to require adjustment, such as the switch-gear and commutator assemblies.

Starter Motor

Model M50

General Description

The model M50 starter motor is a four pole machine of 5 in (127,0 mm) nominal yoke diameter, and has a 21 slot armature.

The drive is of pre-engaged, soleoid operated, push screw type, incorporating a five roller clutch.

The function of the clutch is to prevent the armature being rotated at high speeds in the event of the engaged position being held after the engine has started. The solenoid incorporates a two-stage switching arrangement which ensures that the motor develops its maximum torque only when full pinion-flywheel engagement has been achieved.

Testing on the Vehicle

Ensure that the battery is in a charged condition.

Switch on the lamps and operate the starter button. If the starter fails to function, but the lights maintain full brilliance, check the switch and battery connections to the starter and all external leads. Sluggish action of the starter can be caused by a poor or faulty connection.

Difficulty in smooth engagement between starter and engine flywheel is probably due to dirt on the starter-shaft helices preventing free pinion movement. The shaft should be thoroughly cleaned with cleaning fluid followed by the application of a small quantity of Acro Shell 6B or alternatively, Shell SB2628 grease for temperate and cold climates and Shell Retinex for hot climates.

Maintenance

Brush Gear and Commutator

Inspect the brushes at intervals to ensure that they are free in their guides and that the leads are quite free for movement, by easing back the brush springs and pulling gently on the flexible connections. If a brush is inclined to stick, remove it from its holder and clean the sides with a petrol moistened cloth.

Be sure to refit the brushes in their original positions to retain the "bedding". The brushes should be well bedded (i.e. worn to the commutator periphery) but if not, wrap a strip of very fine glass or carborundum paper firmly around the commutator with the abrasive side outwards. With the brushes in position, rotate the armature by hand in the normal working direction of rotation; until the correct brush shape is obtained. If the brushes are worn down so that the springs are no longer providing effective pressure, they should be renewed. Check the brush spring pressure by hooking a spring balance under the spring lip. The correct tension is 30/40 ozf (0,85/1,13 kgf).

It is essential that replacement brushes are the same grade as those originally fitted. Genuine spares should always be used. To remove the brushes, unscrew the four fixing screws, one to each brush. In re-assembling care must be taken to reconnect the field coil and interconnector leads, held by two of the fixing screws. Before inserting brushes in their holders, it is advisable to blow through the holders with compressed air or clean them with a cloth moistened with petrol.

The commutator should be clean, entirely free from oil or dirt. Any trace of such should be removed by pressing a clean dry fluffless cloth against it, while armature is hand rotated.

If the commutator is dirty or discoloured, tilt the brushes and wrap a strip of fine glass or carborundum paper (not emery cloth) round the commutator, with the abrasive side inwards. Rotate the armature by hand until the surface is even. Clean with a petrol moistened cloth.

If repair is necessary to the commutator or switch gear etc., the starter must be exchanged or repaired by an authorised agent.

Every 60,000 miles, (90,000 km) or 2400 running hours, whichever is the sooner, arrange for the examination and service of the starter motor.

Section 'P' EXHAUSTER

Description

The H.175 type exhauster is a high speed, rotary, sliding vane unit, with an eccentrically mounted rotor.

At all speeds, the rotor blades Fig. P.1, No. 2 are kept in contact with the bore of the body by centrifugal force, assisted by the hydraulic action of the oil beneath the blades. When the rotor turns Fig. P.1, No. 3, the spaces between the blades vary because of the eccentric mounting of the rotor in the exhauster body. As a blade passes the inlet port Fig. 1, No. 1 the space between it and the following blade increases and air is drawn from the vacuum reservoir. Further rotation decreases the space and the air is then compressed until the blade passed the discharge port Fig. P.5, No. 4 when the air, together with any surplus lubricating oil, is discharged to the engine crankcase.

The unit has an oil check valve Fig. P.1, No. 4, screwed into the inlet port to prevent oil from passing into the vacuum pipe and reservoir during operation.

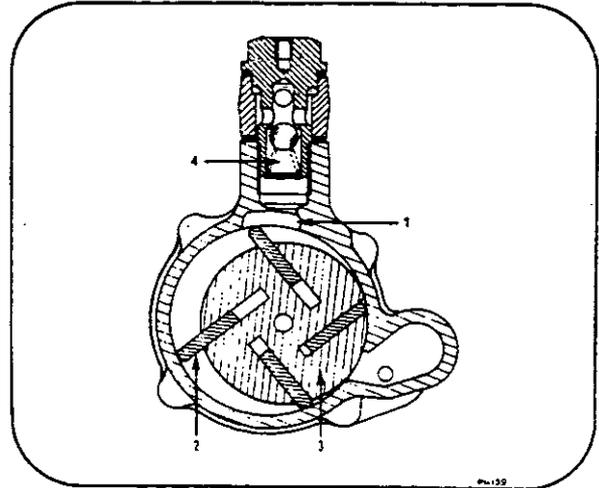
Mounting

The exhauster is mounted on the rear of the timing case by four setscrews entered into the front timing case cover, through the timing case and into the exhauster mounting flange. A location is also provided by a dowel on the fuel pump adaptor body locating into the exhauster mounting flange. See Fig. P.2.

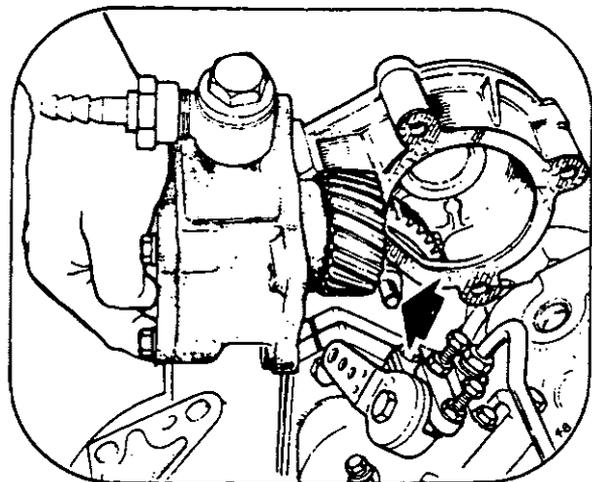
The exhauster is gear driven through an aperture in the back of the timing case, in train with the fuel pump gear.

Lubrication

Oil is fed into the exhauster through a drilling in the end cover Fig. P.5, No. 1, via a pipe from the fuel pump adaptor housing. From the drilling, oil enters an annular groove in the rear bearing housing. The oil passes through holes in the bearing Fig. P.5, No. 3, to an oilway drilled through the length of the rotor shaft and a further drilling from the centre oilway lubricates the front bearing Fig. P.5, No. 2. Oil also passes through holes in the rotor shaft communicating with the slots in the rotor. At the rear end of the shaft, oil is relieved through a passage into the air/oil discharge port.

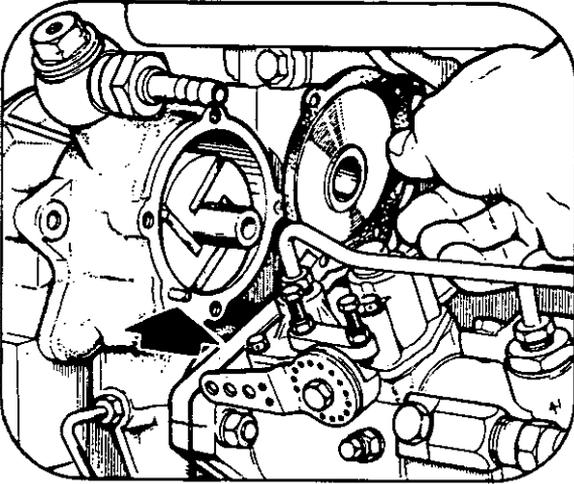


P1



P2

Exhauster P2



P3

Servicing the Exhauster Unit

Every 60,000 miles (90,000 km) or 2400 running hours.

Remove and dismantle the exhauster, and thoroughly clean and inspect for wear and damage.

After removing the grease and dirt from the exterior, clean with a solvent and brush.

Unscrew the nuts securing the end cover to the body and remove.

It will be noted that the end cover has a dowel location, see Fig. P.3. Mark the rotor blades in relation to the rotor and withdraw. Unscrew the oil check valve and union and remove the copper washers.

In order to remove the rotor from the body it will be necessary to remove the gear. The removal of the circlip will release the gear from the splined shaft.

Before examination, wash all parts in cleaning solvent. Clear the oilways in the rotor and body with compressed air.

Examine the body for cracks, and the bore for longitudinal ripples or lines. If this condition exists, the body should be renewed.

The rotor should be a good running fit in the plain bearings, and if found to be worn, the bearings should be replaced.

Examine the rotor and the blades for damage and check that the blades are a good sliding fit in the rotor slots.

Examine the oil check valve for damage, and replace if necessary.

To Reassemble

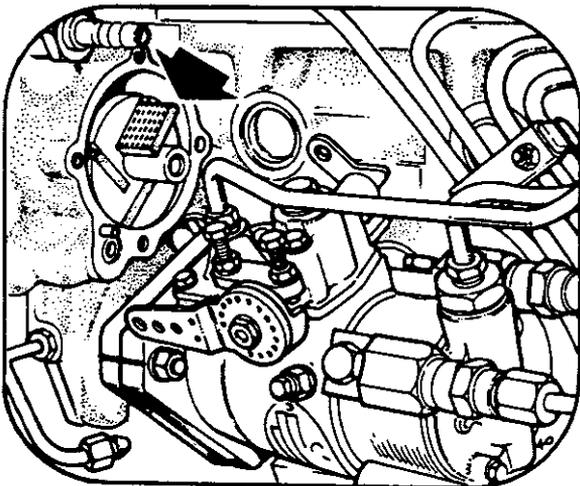
Lubricate all working parts with clean engine oil to prevent possible damage when the engine is started and until oil flow commences.

Replace the rotor into the exhauster body, refit the gear and secure with circlip.

Replace the rotor blades in the same position as before removal, see Fig. P.4.

Making sure that all traces of the old joint are removed, smear both sides of a new end cover joint with a suitable jointing compound, refit the end cover and secure with setscrews and spring washers.

The nameplate is secured by two of the setscrews.



P4

Exhauster P3

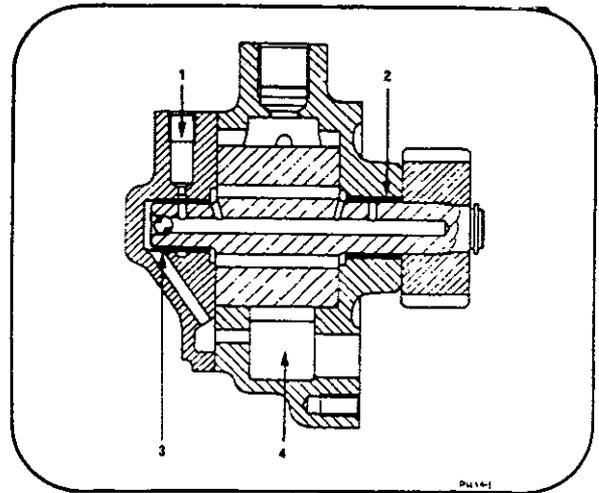
End float of rotor in the exhauster body should be 0.0015/0.0035 in (0,04/0,09 mm).

Rotate the rotor by hand to ensure that it turns without binding after tightening the end cover set-screws.

Screw the oil check valve and union, together with the copper washers and tighten.

Re-mount the exhauster unit onto the rear face of the timing case, using a new joint with sealing compound, locating the exhauster by means of the dowel in the fuel pump adaptor body.

Secure the exhauster unit by four setscrews and spring washers in the front timing case cover.



P5

Section Q

4.154 marine engine

General Data

Type	Four Cylinder, Four Stroke, In-Line	
Bore (Nominal)	3.5 in (88,9 mm)	
Stroke	4.0 in (101,6 mm)	
Cubic Capacity	153.9 in ³ (2,523 litres)	
Compression Ratio	21.5 : 1	
Combustion System	Indirect Injection	
Firing Order	1-3-4-2	
Rotation (viewed from rear of engine)	Left Hand Rotation	
Cooling System	Indirect (Heat Exchanger)	
Fresh Water Capacity	25 pints (14,2 litres)	
Cylinder Head Water Temperature	178°F (81°C)	
Maximum Permissible Sea Water Inlet Temperature	100°F (37,8°C)	
Lubricating Oil Pressure (engine)	30/60 lbf/in ² (2,1/4,2 kgf/cm ²)—207/414 kN/m ² at maximum speed and normal operating temperature.	
Lubricating Oil Sump Capacity*	15 IMP pints - 8,5 litres - 9 US quarts	
Total Lubricating Oil Capacity	16.5 IMP pints - 9,4 litres - 9,9 US quarts	
*Early 4.154M sumps had a capacity of 14 IMP pints - 8,0 litres - 8,4 US pints		
Lubricating Oil Pressure (gearbox)	110/150 lbf/in ² (7,73/10,55 kgf/cm ²)—758/1034 kN/m ² at normal operating temperature and speed. Low temperature or excessive speed may cause pressures of 200/250 lbf/in ² (14,06/17,58 kgf/cm ²)—1379/1724 kN/m ²	
Lubricating Oil (gearbox) capacities	Level	Inclined
Direct Drive	3 pints (1,71 litres)	2.2 pints (1,2 litres)
Reduction	4.7 pints (2,36 litres)	4.5 pints (2,51 litres)
Maximum Permissible Engine Compartment Temp.	160°F (70°C)	

Installation Angle

Engine may be installed at angles between 0° and 10° front end up, which allows for a further 3° rise underway. Engines can be installed on the level but should not operate with the front end down.

Battery Cable Resistance

Not to exceed 0.0017 OHM.

ENGINE RATING

General Pleasure Craft

Gross Output without Gearbox
62 bhp (47 kw) at 3000 rev/min

Nett Shaft Horsepower with Direct Drive Gearbox
58 shp at 3000 rev/min
Fuel Injection Pump Service Setting Code
LJ51/750/1/3190

Commercial Craft

Gross Output without Gearbox
62 bhp (47 kw) at 3000 rev/min

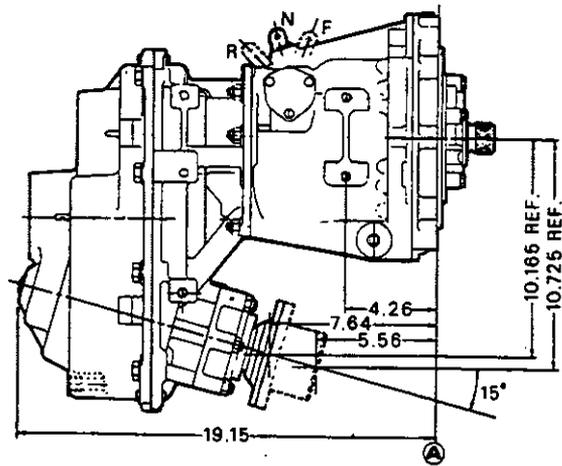
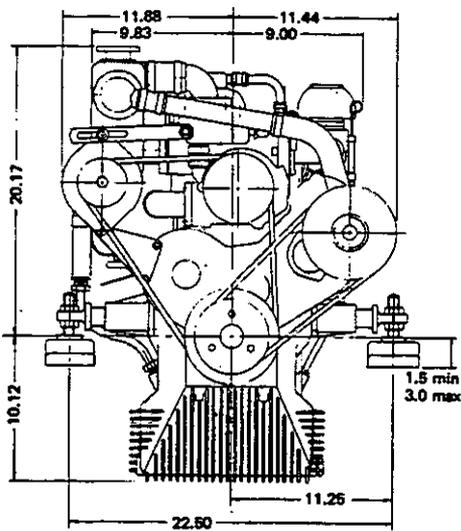
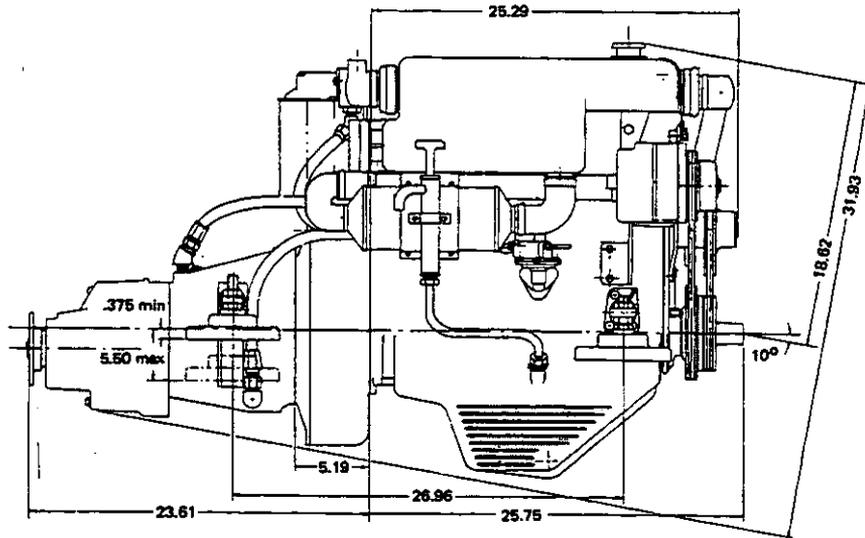
Nett Shaft Horsepower with 2:1 Reduction Gearbox
54 shp at 3000 rev/min

ENGINE WEIGHTS

Marine Engine with Flywheel Housing and Flywheel but less Gearbox
668 lb (299 kg)

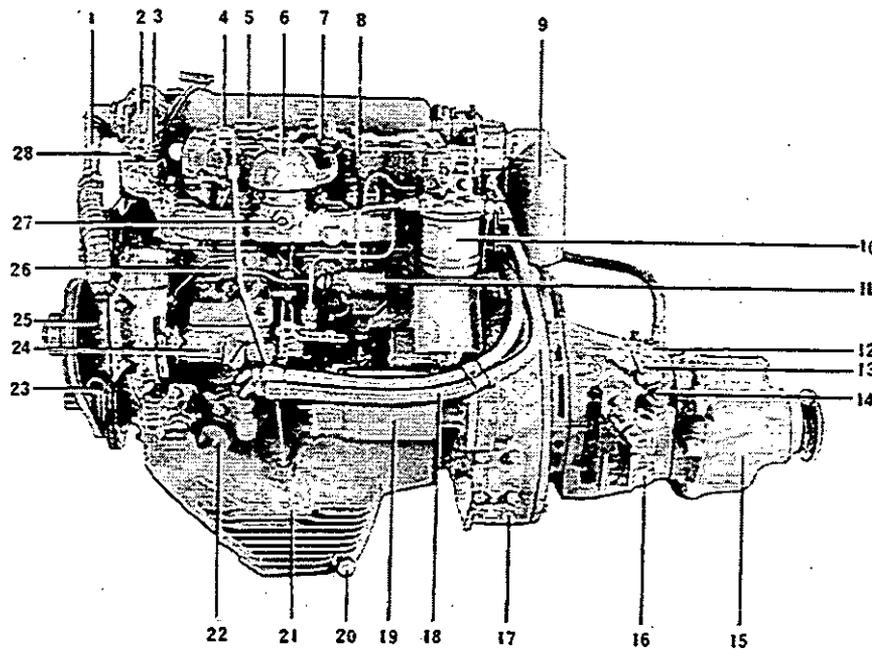
Marine Engine Including 2:1 Gearbox
803 lb (364 kg)

Dimensions



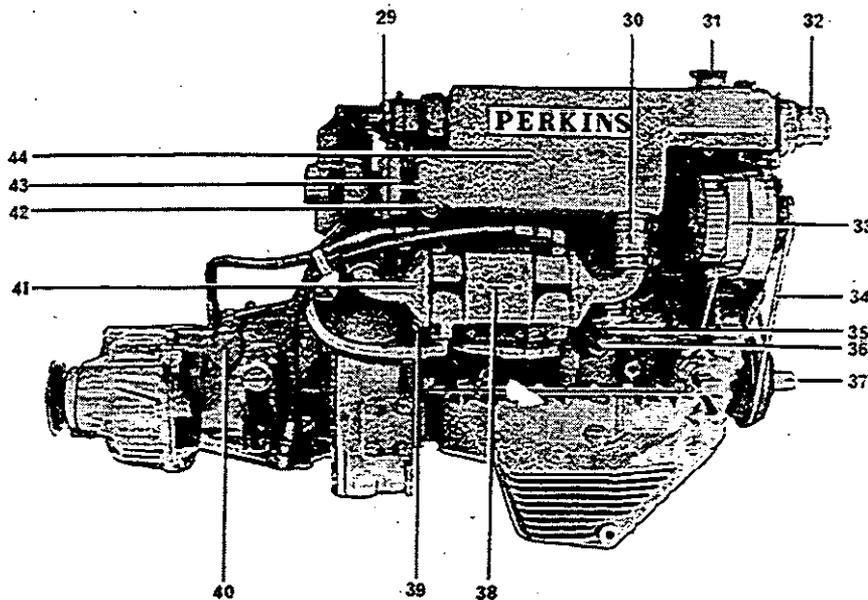
MODEL 71
WARNER "V" DRIVE

Engine Views



Perkins engines are built to individual requirements to suit the applications for which they are intended and these engine views do not necessarily typify any particular specification.

- | | |
|--|--|
| 1 Sea Water Pipe from Pump to Heat Exchanger. | 15 Reduction Gearbox. |
| 2 Fresh Water Pipe from Engine to Heat Exchanger. | 16 Forward and Reverse Gearbox. |
| 3 Water Temperature Sender. | 17 Flywheel Housing. |
| 4 Lubricating Oil Dipstick. | 18 Flexible Lubricating Oil Pipes. |
| 5 Lubricating Oil Filler Cap. | 19 Starter Motor. |
| 6 Induction Air Filter. | 20 Lubricating Oil Sump Drain Plug. |
| 7 Closed Circuit Breather Pipe. | 21 Lubricating Oil Sump. |
| 8 Atomiser. | 22 Engine Lubricating Oil Pressure Sender. |
| 9 Lubricating Oil Filter Canister. | 23 Sea Water Pump Inlet. |
| 10 Fuel Oil Filter. | 24 Fuel Injection Pump. |
| 11 Electrical Engine Stop Control Actuator. | 25 Sea Water Pump. |
| 12 Gearbox Lubricating Oil Pressure Sender (position). | 26 Engine Serial Number (position). |
| 13 Gearbox Control Lever. | 27 Cold Starting Adaptor. |
| 14 Gearbox Lubricating Oil Filler/Dipstick. | 28 Thermostat Housing. |



- | | |
|--|--|
| 29 Sea Water Outlet. | 38 Lubricating Oil Sump Drain Pump (position). |
| 30 Fresh Water Pipe to Lubricating Oil Cooler. | 39 Lubricating Oil Cooler Water Drain Plug (or tap). |
| 31 Fresh Water Filler Cap. | 40 Neutral Switch (position). |
| 32 Sea Water Inlet to Heat Exchanger. | 41 Lubricating Oil Cooler. |
| 33 Alternator. | 42 Heat Exchanger/Exhaust Manifold Fresh Water Drain Plug. |
| 34 Alternator/Fresh Water Pump Drive Belt. | 43 Exhaust Manifold Flange. |
| 35 Fuel Lift Pump. | 44 Header Tank/Heat Exchanger/Exhaust Manifold. |
| 36 Fuel Lift Pump Priming Lever. | |
| 37 Power Take-off Shaft. | |

Preventive Maintenance

If a Perkins marine diesel engine is to give long and troublefree service, it is imperative that it be maintained in accordance with the following Periodical Attentions:—

Daily or Every 8 hours (whichever occurs first)

- Check coolant level in header tank.
- Check sump oil level.
- Check engine and gearbox oil pressures (where gauge fitted).
- Check gearbox oil level.

Every 150 hours or 3 months (whichever occurs first)

- Drain and renew engine lubricating oil
- Renew lubricating oil filter canister
- Check both drive belt tensions.
- Clean air intake gauze or screen.
- Check engine for leakage of oil or water.
- Clean sedimenter/water trap.

Every 450 hours or 12 months (whichever occurs first).

- Renew final fuel filter element.
- Check hoses and clips.
- Drain and clean fuel tank.
- Renew gearbox lubricating oil
- Service atomisers.
- Check and adjust valve tip clearances.

Every 2,700 hours

- Arrange for examination and service of proprietary equipment, i.e. starter motor, generator etc.

Gearboxes

BORG-WARNER 71CR

Filling

Transmission fluid Type "A" should be added until it reaches the full mark on the dipstick. The unit should be turned over at idling speed for a short time to fill all circuits.

Procedure for checking oil level

The oil level should be checked immediately after shut-down and sufficient oil added to bring the level to the full mark on the dipstick. The dipstick assembly need not be threaded into the case to determine oil level. Later boxes have a plug type dipstick.

Oil Capacities

Type	U.S. Quarts	Level Imp. Pints	Litres
71C & CR	1.8	3.0	1.71
1.523 : 1	2.5	4.2	2.36
1.91 : 1	2.5	4.2	2.36
2.10 : 1	2.5	4.2	2.36
2.57 : 1	2.5	4.2	2.36
2.91 : 1	2.5	4.2	2.36
Inclined			
71C & CR	1.3	2.2	1.2
1.523 : 1	2.7	4.5	2.56
1.91 : 1	2.7	4.5	2.56
2.10 : 1	2.7	4.5	2.56
2.57 : 1	2.7	4.5	2.56
2.91 : 1	2.7	4.5	2.56

Oil Temperatures and Pressures

Oil pressure 100–150 lbf/in² (7,73–10,55 kgf/cm²) –758/1034 kN/m² at normal operating temperatures of 150–165°F (66,55–73,8°C). At low temperature or excessive speeds, pressures of 200–250 lbf/in² (14,06–17,58 kgf/cm²)–1379/1724 kN/m² may be obtained. A maximum transmission oil temperature of 190°F (87,6°C) is recommended.

PROPELLER SHAFT TRAILING (auxiliary yacht installations)

No precautions are necessary on auxiliary yacht installations when trailing the propeller with the engine out of use.

With the Borg Warner gearbox, the propeller can be trailed indefinitely.

Cooling System

A centrifugal type water pump, mounted on the front of the engine and belt driven from the crankshaft, delivers coolant directly into the cylinder block and head.

When the thermostat valve lifts, water is then passed through the combined heat exchanger/exhaust manifold/header tank unit. Following this, the fresh water is circulated through a dual engine and gearbox tubular lubricating oil cooler before returning to the engine fresh water pump.

An external by-pass arrangement allows the fresh water to circulate within the engine until the temperature allows the thermostat to open.

Sea water is circulated through the heat exchanger by means of a self-priming vane type pump before being expelled overboard or into a water injected exhaust system.

Sea Water Pump

The sea water pump is used in conjunction with the heat exchanger and is bracket mounted on to the timing case cover.

The pump is belt driven from the crankshaft pulley.

The pump is self priming but it is advisable to prime it when first commencing service or after the engine has been laid up for any considerable period.

To Remove the Sea Water Pump

Uncouple the inlet and outlet connections.

Unscrew the two nuts and bolts which attach the body of the pump to the bracket. The pump can now be freed of the drive belt and lifted off.

To Refit the Sea Water Pump

Secure the pump to the bracket in the reverse manner to the removal as described above.

In order to tension the drive belt, leave the pump to bracket securing nuts slack, lever the pump to tighten the belt and maintain the tension until the securing nuts have been tightened.

Check that sufficient tension is present to prevent the drive from slipping but not overtight which could damage the pump shaft bearings.

Recheck after a short period of running.

To Dismantle the Sea Water Pump

Remove the end cover fixed to the water pump body by six slotted screws and remove the rubber impeller and wear plate.

Remove the nut securing the pulley and draw off the pulley from the shaft.

A suitable press may be used to press out the impeller shaft together with the water pump bearing.

The cam in the impeller housing may then be detached by removing the single securing setscrew.

Remove the rubber seal in the impeller housing and "O" ring and seal in the bearing housing.

If wear indications are apparent on the impeller wear

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plate or water pump end plate, both of these may be reversed. In the case of the end plate it may be necessary to remove the stamped instructions by means of emery paper. This will remove the arrows showing the rotation of the impeller, but this rotation can be ascertained by turning the engine and noting the rotation of the pump coupling.

To Reassemble the Sea Water Pump

The reverse order to the procedure above should be adopted for the reassembly of the sea water pump.

Care should be taken when replacing the rubber impeller that the blades all lay in the same direction relative to the rotation of the pump i.e. blades trailing.

When the rubber impeller is being fitted, it must be coated with MARFAK 2HD grease or glycerine as an alternative.

When refitting the cam in the impeller housing, coat the top surface, rear face and securing setscrew hole with a suitable jointing compound.

It is possible to fit the cam to the housing one way only.

Cautionary Note

Because the water pump contains a rubber impeller it must not be run in a dry condition. If the craft is to be laid-up and the engine unused for a prolonged period of time, remove the rubber impeller and store it in a dark place. This is to prevent distortion of the impeller blades.

Before refitting the impeller, it should be immersed in hot water (80-90°C) for a few minutes and then left to dry. Then follow the "Reassemble" instructions as above.

Fresh Water Pump

The water pump for the closed circuit cooling is mounted on the front of the cylinder block and is belt driven from the crankshaft.

To Remove the Fresh Water Pump

Slacken the water pump/generator drive belt. Remove the four setscrews and spring washers securing the pulley to pulley hub and remove the pulley.

Loosen the rubber hose by-pass connection. Loosen the rubber hose connection from the pump inlet pipe (situated behind the alternator).

Remove the five setscrews and spring washers securing the water pump to the cylinder block. The water pump and joint may now be removed.

To Refit the Fresh Water Pump

Use a new joint. Ensure that the joint faces are clean. Refit the pump to the cylinder block front face, securing it with spring washers and setscrews.

Reconnect the by-pass and water inlet hoses. Refit the pulley. The water pump/generator drive belt may be refitted and the belt tensioned by slackening the generator adjusting lever setscrew and support bracket bolts.

Move the generator so that the belt is tightened, that when the thumb is applied to the stretch of belt between the crankshaft pulley and generator, it can be depressed

approximately 3/8 in (10 mm).

Secure the alternator support bracket bolts and the adjusting lever setscrew and check to ensure that the tension is correct.

To Dismantle the Fresh Water Pump

Remove the pulley hub retaining circlip and with a suitable tool, pull the hub off the shaft.

Separate the two halves of the water pump body by removing the six nuts and spring washers.

Press the shaft, complete with seals and impeller, out of the back or impeller end of the body.

Remove the bearing retaining circlip from the front or hub end of the pump body and with a mandrel, press the two shaft bearings and distance piece from out of the front of the body.

Remove the impeller from the shaft using a suitable puller.

To Re-assemble the Water Pump

See exploded view on page 11 (basic manual)

Press the bearings and distance piece onto the shaft and pack half to two thirds of the space between the bearings with high melting point grease.

Press the shaft complete with bearings into the front of the pump body and locate with the bearing retaining circlip, see Fig. K.4 No. 1 (basic manual).

Supporting the shaft at the impeller end, press the pulley hub onto the shaft, fitting the retaining circlip.

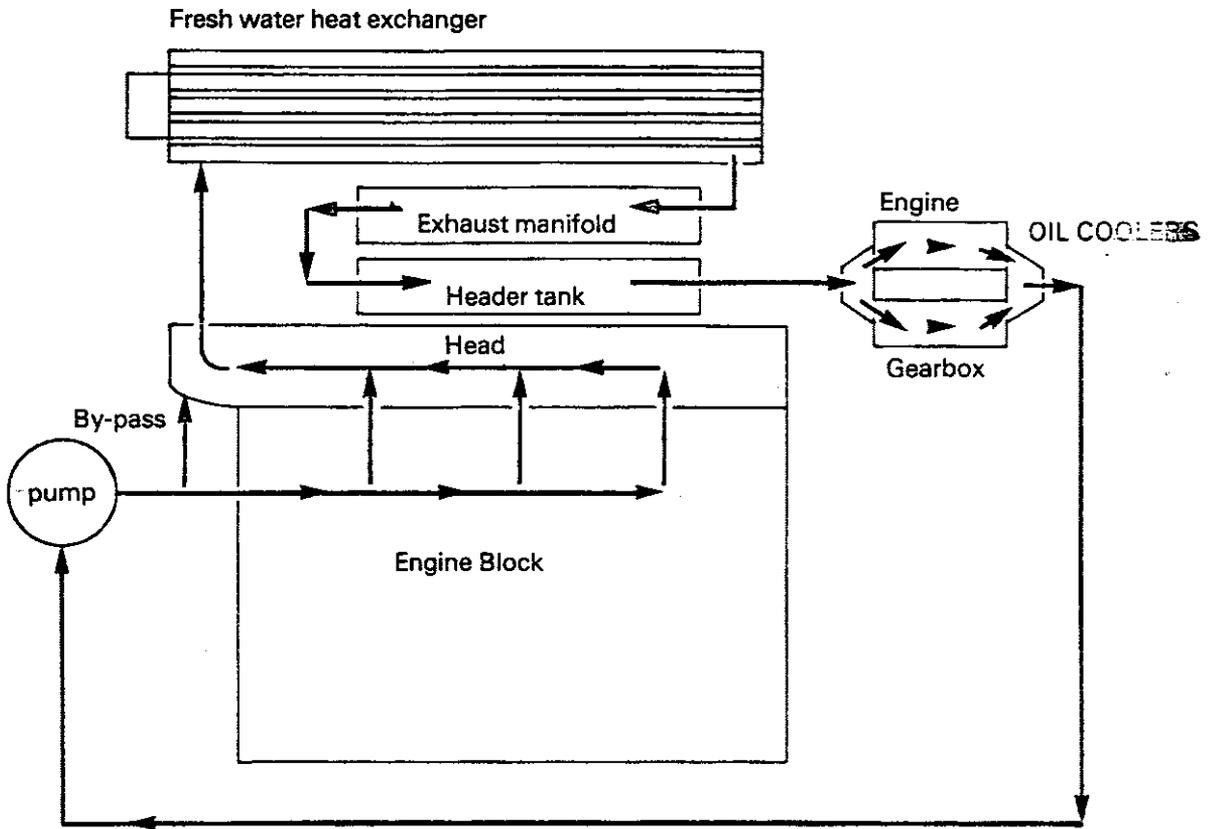
Smear the outside of the brass case of the seal with a suitable gap-filling compound which may now be fitted over the impeller end of the shaft with the carbon face towards the rear of the pump. The seal locates into a recess within the pump body.

Fit the ceramic counter face over the shaft so that the ceramic face is to the carbon face of the seal, see Fig. K.4 No. 2 (basic manual).

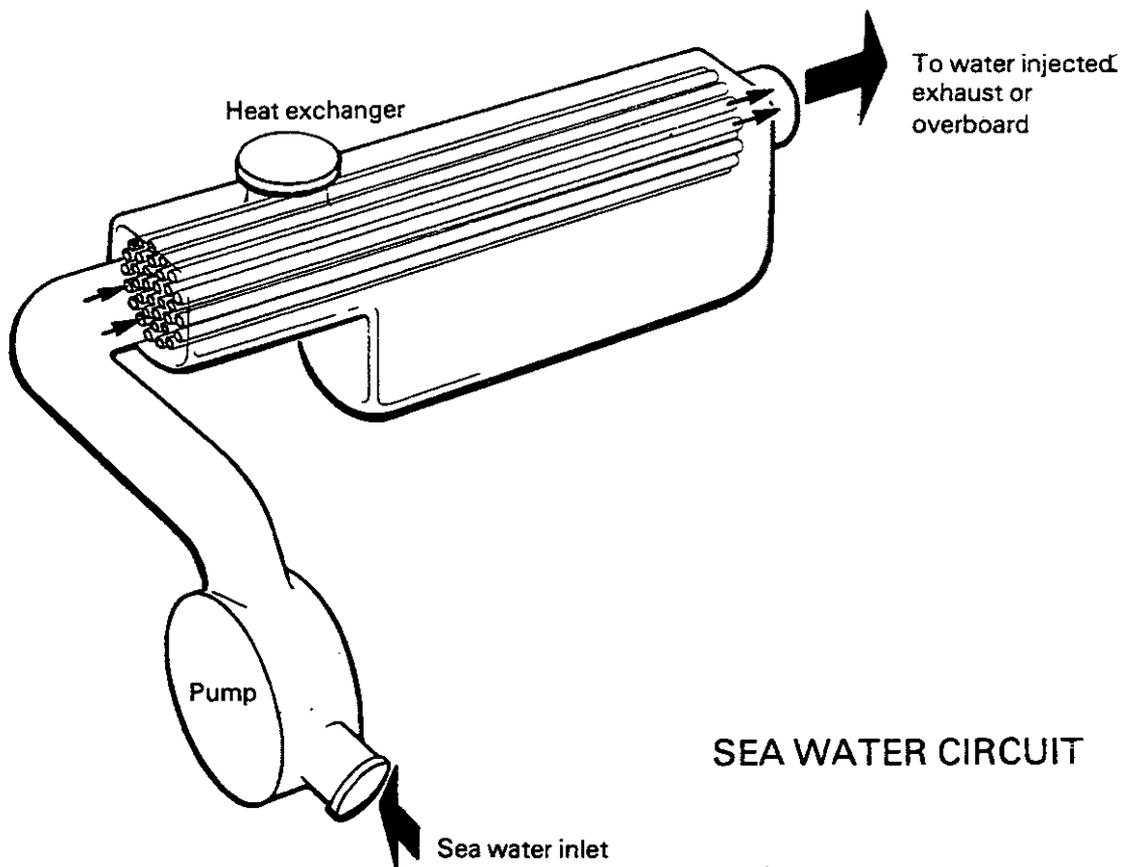
Press the impeller onto the shaft until a clearance of 0.390/0.413 in (9,90/10,49 mm) is obtained between the rear face of the front half of the pump body and the front face of the impeller, see Fig. K.4. (basic manual).

Using a new joint and ensuring that the joint faces are clean, fit the rear half of the water pump body securing with six nuts and spring washers and tighten to 15 lbf/ft (2,07 kgf/m)—20 Nm.

A running clearance of 0.004/0.045 in (0,10/1,14 mm) should now be obtained between the impeller blades and the inside of the rear half of the pump body, see Fig. K.4. (basic manual).



FRESH WATER SYSTEM



SEA WATER CIRCUIT

Heat Exchanger

(Refer to Engine views, page Q3)

The heat exchanger unit is combined with the exhaust manifold and header tank as a single assembly.

The function of the heat exchanger is to cool the fresh water in the closed circuit with sea water. This is achieved by passing the sea water through a series of small bore tubes and guiding the heated fresh water, piped from the engine, over the tubes with the aid of a number of brass baffles. Because the exhaust manifold is also contained in the heat exchanger/header tank assembly, the water acts as a cooling media for the manifold gas passages.

In order to clean a choked-up tube stack it is not necessary to remove the assembly from the engine.

To Remove the Tube Stack

Remove the fresh water filler cap, unscrew the water drain plug or open the tap, if fitted, and drain the water.

Loosen the two hose clips securing the end covers at both ends of the heat exchanger assembly and remove the end covers.

This will expose the tube stack which may now be drawn out from within the header tank.

Cleaning

If the tube stack is badly choked the best method of cleaning is to place the assembly in a hot, preferably boiling caustic soda solution.

This will loosen all foreign matter adhering to the unit. The outside of the tubes should be relatively clean as these are in the closed circuit.

The inside of the tubes, which have salt water passing through them, are more likely to require cleaning.

If the inside of the tubes are not so badly choked as to require using caustic soda, they can be cleaned by pushing a length of 1/8 in (3,18 mm) rod down the tubes in the opposite direction to the flow of water.

Care should be taken, when pushing the rod through the tubes, not to damage the tube walls.

Thermostat

The thermostat is situated in a housing attached to the front of the cylinder head and its function is to control the engine coolant temperature.

To Remove the Thermostat

Drain the fresh water coolant from the system by removing the filler cap from the top of the header tank and removing the drain plug from the bottom rear of the header tank/heat exchanger assembly. The cylinder block can be drained by removing the drain plug from the right hand side of the block, at the rear behind the lubricating oil/gearbox oil cooler.

Remove the two setscrews securing the top water connection situated on the top of the thermostat housing at the forward end of the cylinder head.

The top water connection may now be removed and the thermostat lifted out of its location.

To Test the Thermostat

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

Immerse the thermostat in a suitable container filled with water and gradually heat. Check the water temperature at frequent intervals with a thermometer and when the thermostat valve opens check that the temperature of the water corresponds with the figure which is stamped on the thermostat.

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

To Replace the Thermostat

Clean the two joint faces thoroughly. Place the thermostat in its location making sure that it is seated correctly.

Using a new joint and suitable jointing compound fit the top water connection and secure with setscrews and spring washers to a torque of 24 lbf/ft (3,32 kgf/m).

Refill the closed circuit cooling system with fresh water through the filler situated on the top of the header tank.

Water Pump Belt Adjustment

Slacken the nut and bolt securing the alternator to the adjusting lever.

Slacken the adjusting lever to thermostat housing securing setscrew.

Slacken the bottom support bracket nut and bolt to alternator.

Sideways movement of the alternator, limited by the adjustment lever should now be possible.

With the belt in position over the pulleys, pull the alternator away from the cylinder block until the drive belt is tensioned. Tighten the adjusting lever to alternator nut and test the tension in the following manner.

The tension should be adjusted so that, without undue pressure, the belt can be depressed approximately 3/8 in (10 mm) with the thumb applying pressure at a point midway along the longest unsupported length of the belt (between the alternator pulley and crankshaft pulley).

When the correct tension has been achieved, the alternator to bottom support bracket nut and bolt should be tightened followed by the adjusting lever to thermostat housing setscrew.

Incorrect adjustment of the belt can result in eventual failure. If the adjustment is too slack belt slip will occur. The efficiency of the water pump will be reduced which could lead to overheating. The output of the alternator would also be reduced.

If the adjustment is too tight the water pump and alternator bearings will be overloaded which will result in early failure.

New Belts

When a new driving belt is fitted it should be checked and readjusted after a short period of running to take up the initial stretch common to new belts.

To Remove the Engine/Gearbox Oil Cooler
(Refer to Engine views, page Q3).

If a sump drain pump is fitted it will have to be removed as follows:—

Unscrew the union securing the drain pump to the sump. The clamp which secures the pump body to the cooler support bracket with two nuts and bolts may now be removed to enable the pump assembly to be drawn out of the sump.

Care should be exercised when withdrawing the drain pump suction pipe from out of the sump to prevent damage to the pipe.

Drain off the fresh water coolant by removing the drain plug at bottom rear of the cooler body.

Loosen the clips from the hoses connecting the inlet to the cooler from the bottom outlet of the heat exchanger and the outlet from the cooler to the pipe taking the coolant back to the fresh water pump.

The flexible lubricating oil pipes may now be disconnected from the cooler.

Four nuts and bolts, two at the top and two at the bottom secure the clamp holding the cooler body to the support bracket; their removal will enable the clamp and cooler body to be detached.

To Clean the Oil Cooler

Because of its integral construction it is not possible to dismantle the oil cooler.

However, because only fresh water is used as the cooling medium blockage caused by foreign bodies is unlikely.

If it is necessary to clean the unit, firstly remove all traces of oil by dipping the unit in a container of kerosene or paraffin and drying thoroughly.

Prepare a solution of caustic soda in hot water in a container and immerse the cooler in it.

Engine Fluids

Fuel specification

To get the correct power and performance from your engine, use good quality fuel. The recommended fuel specification for Perkins engines is indicated below:

Cetane Number	45 minimum (Industrial, agricultural and marine use) 50 minimum (Vehicle use)
Viscosity	2.5/4.5 centistokes at 40°C
Density	0,835/0,855 kg/litre
Sulphur	0.5% of mass, maximum
Distillation	85% at 350°C

Cetane number: Indicates ignition performance. A fuel with a low cetane number can cause cold start problems and affect combustion.

Viscosity: Is the resistance to flow and engine performance can be affected if it is outside the limits.

Density: A lower density reduces engine power, a higher density increases engine power and exhaust smoke.

Sulphur: A high sulphur content (not normally found in Europe, North America or Australasia) can cause engine wear. Where only high sulphur fuels are available, it is necessary to use a highly alkaline lubricating oil in the engine or to renew the lubricating oil more frequently.

Distillation: This is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of light-weight hydrocarbons can affect the combustion characteristics.

Low temperature fuels:

Special winter fuels may be available for engine operation at temperatures below 0°C. These fuels have a lower viscosity and also limit the wax formation in the fuel at low temperatures. If wax formation occurs, this could stop the fuel flow through the filter.

If you need advice on adjustments to an engine setting or to the lubricating oil change periods, which may be necessary because of the standard of available fuel, consult your nearest Perkins distributor or the Perkins Power Sales and Service Ltd. Service Department.

Coolant specification

The quality of the coolant which is used can have a great effect on the efficiency and life of the cooling system, the recommendations indicated below can help to maintain a good cooling system and to protect it against frost and/or corrosion.

If the correct procedures are not used, Perkins cannot be held responsible for frost or corrosion damage.

- 1 If it is possible, use clean soft water in the coolant.
- 2 If antifreeze mixture, other than Perkins POWERPART, is used to prevent frost damage, it must have an ethanediol base (ethylene glycol) with a corrosion inhibitor. It is recommended that the corrosion inhibitor is of the sodium nitrate/sodium benzoate type. The antifreeze mixture must be an efficient coolant at all ambient temperatures and it must provide protection against corrosion. It must also have a specification at least as good as the requirements of the standards below:
BS.6580: MOD AL39: "Specification for corrosion inhibiting, engine coolant concentrate (antifreeze)".

Perkins POWERPART antifreeze exceeds the requirements of the above standards. The quality of the antifreeze coolant must be checked at least once a year, for example, at the beginning of the cold period. The coolant must be renewed every two years. The antifreeze mixture must consist of equal quantities of antifreeze and water. Concentrations of more than 50% of antifreeze must not be used because these can affect adversely the performance of the coolant.

3 When frost protection is not necessary, it is still an advantage to use an approved antifreeze mixture because this gives a protection against corrosion and also raises the boiling point of the coolant. If an antifreeze is not used, add a correct mixture of corrosion inhibitor to the water. Renew the mixture of water and corrosion inhibitor every six months or check it according to the inhibitor manufacturer's recommendations.

Attention: Certain corrosion inhibitor mixtures could cause damage to some engine components. It is recommended that you consult the Service Department, Perkins Power Sales and Service Limited, Peterborough if a corrosion inhibitor is to be used.

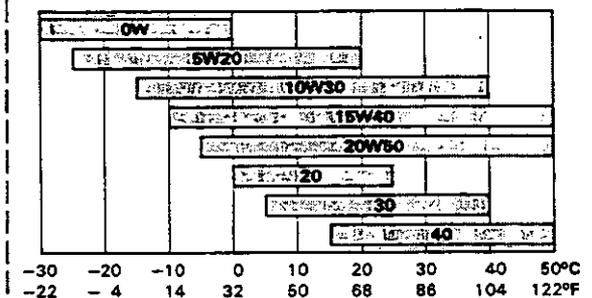
Lubricating oil specification

Use only a good quality lubricating oil which is equal to specification API CC/SE. Lubricating oils to specification API CD/SE or CCMC D4 can be used but are not recommended for the first 20/40 hours operation or where the engine is used mainly for light duty operations.

Attention: The type of lubricating oil to be used may be affected by the quality of the fuel which is available. For further details see "Fuel specification".

Always ensure that the correct viscosity grade of lubricating oil is used for the ambient temperature range in which the engine will run as shown in the chart.

Recommended S A E Viscosity Grades



Ambient temperature

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Glossary of Terms	Appendix	Description	J.1
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Distortion	B.4	To Refit	K.3
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Data	B.1	Rods, Connecting, Alignment	C.2
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Pistons, Data	C.1	Assembly	B.4
Description	C.1	Speed Setting, Fuel Pump	L.5
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