# workshop manual for 3.1522, 3.1524 & T3.1524 diesel engines



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*This publication is written for world wide use. In territories where legal requirements govern engine 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 the engine, it does not contravene the local regulations when in use.*

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| | |
|---|---|
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In addition to the above, there are Perkins distributors in most countries. Perkins Engines Ltd., Peterborough or one of the above companies can give details.

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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, has been purposely omitted in order to avoid repetition.

Reference to renewing joints and cleaning off joint faces, has not always been made as it is understood that this will be carried out where applicable.

Similarly, it is understood that in re-assembly and inspection, all parts are to be thoroughly cleaned, and burrs and scale are to be removed if necessary.

All open ports of high precision components, e.g. fuel injection equipment, exposed by dismantling, should be blanked off until re-assembled, to prevent the ingress of dust and dirt.

When fitting setscrews into "through" holes into the interior of the engine, a suitable sealant should be used.

Note: Some setscrews may already have sealant coated threads. These can be identified by the colour of the threads which will be red, blue etc.

Throughout this manual, whenever the "left" or "right" hand side of the engine is referred to, it is that side of the engine when viewed from the flywheel end.

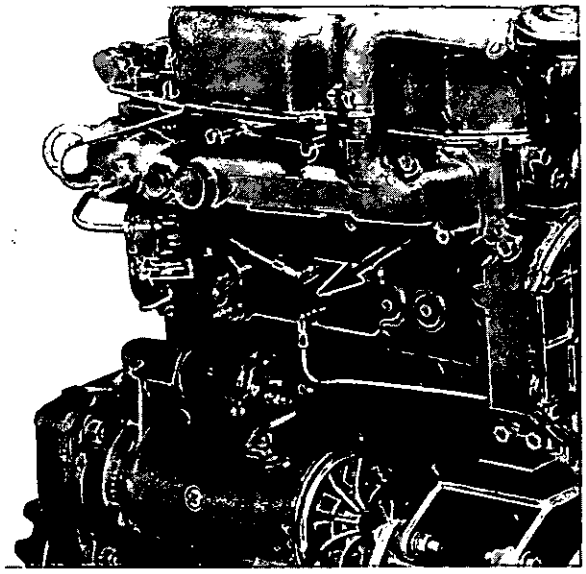
This publication is produced by the Technical Publications Department of Perkins Engines Ltd. and every endeavour is made to ensure that the information contained in this manual is correct at the date of publication, but due to continuous development, the manufacturers reserve the right to alter this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

3.1522 Series Workshop Manual, May 1984

## ENGINE NUMBER

The engine number is stamped on the right hand side of the cylinder block, forward of the fuel lift pump, as shown on the right.

The engine number consists of fifteen letters and figures, e.g. CJ30060U510251F and the full combinations should be quoted in the correct sequence when requesting information or ordering parts.



Location of Engine Number

## 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).**

# SAFETY PRECAUTIONS

THESE SAFETY PRECAUTIONS ARE IMPORTANT. Reference must also be made to the local regulations in the country of operation.

Do not use these engines in marine applications.

Do not change the specification of the engine.

Do not smoke when you put fuel in the tank.

Clean away any fuel which has fallen and move material which has fuel contamination to a safe place.

Do not put fuel in the tank during engine operation (unless really necessary).

Never clean, lubricate or adjust the engine during operation (unless you have had the correct training when extreme caution must be used to prevent injury).

Do not make any adjustments you do not understand.

Ensure the engine is not in a position to cause a concentration of toxic emissions.

Persons in the area must be kept clear during engine and equipment or machine operation.

Do not permit loose clothing or long hair near parts which move.

Keep away from parts which turn during operation. Note that the fan can not be seen clearly while the engine runs.

Do not run the engine with any safety guards removed.

Do not remove the radiator cap while the engine is hot and the coolant is under pressure as dangerous hot coolant can be discharged.

Do not use salt water or any other coolant which can cause corrosion in the cooling system.

Keep sparks or fire away from batteries (especially during charge) or combustion can occur. The battery fluid can burn and is also dangerous to the skin and especially the eyes.

Disconnect the battery terminals before you make a repair to the electrical system.

Only one person must be in control of the engine.

Ensure the engine is operated only from the control panel or operator's position.

If your skin comes into contact with high pressure fuel, get medical assistance immediately.

Diesel fuel can cause skin damage to some persons. Use protection on the hands (gloves or special skin protection solutions).

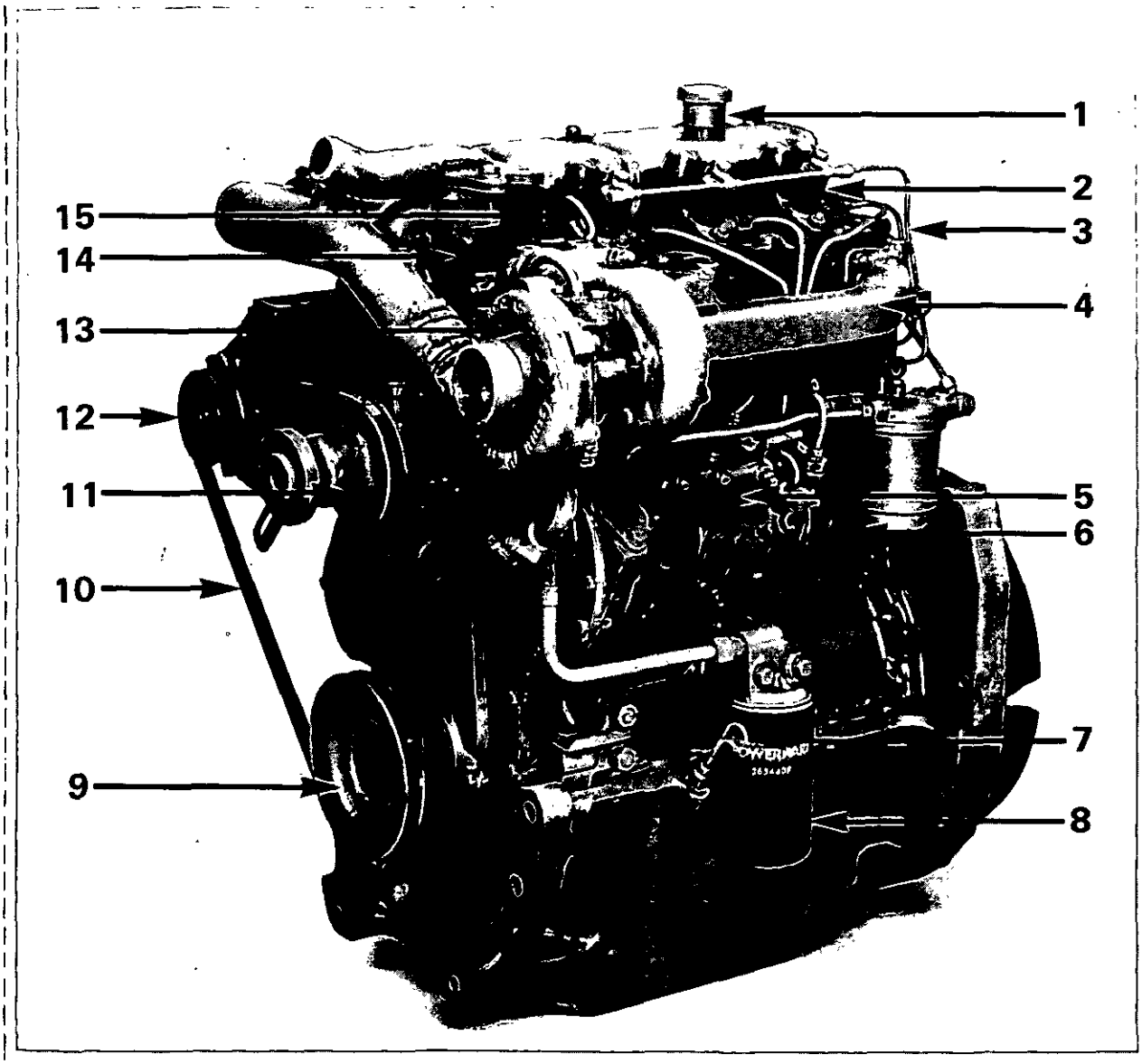
Do not move equipment unless the brakes are in good condition.

Ensure that the transmission drive control is in 'out of drive' position before the engine is started.

Fit only correct Perkins parts.

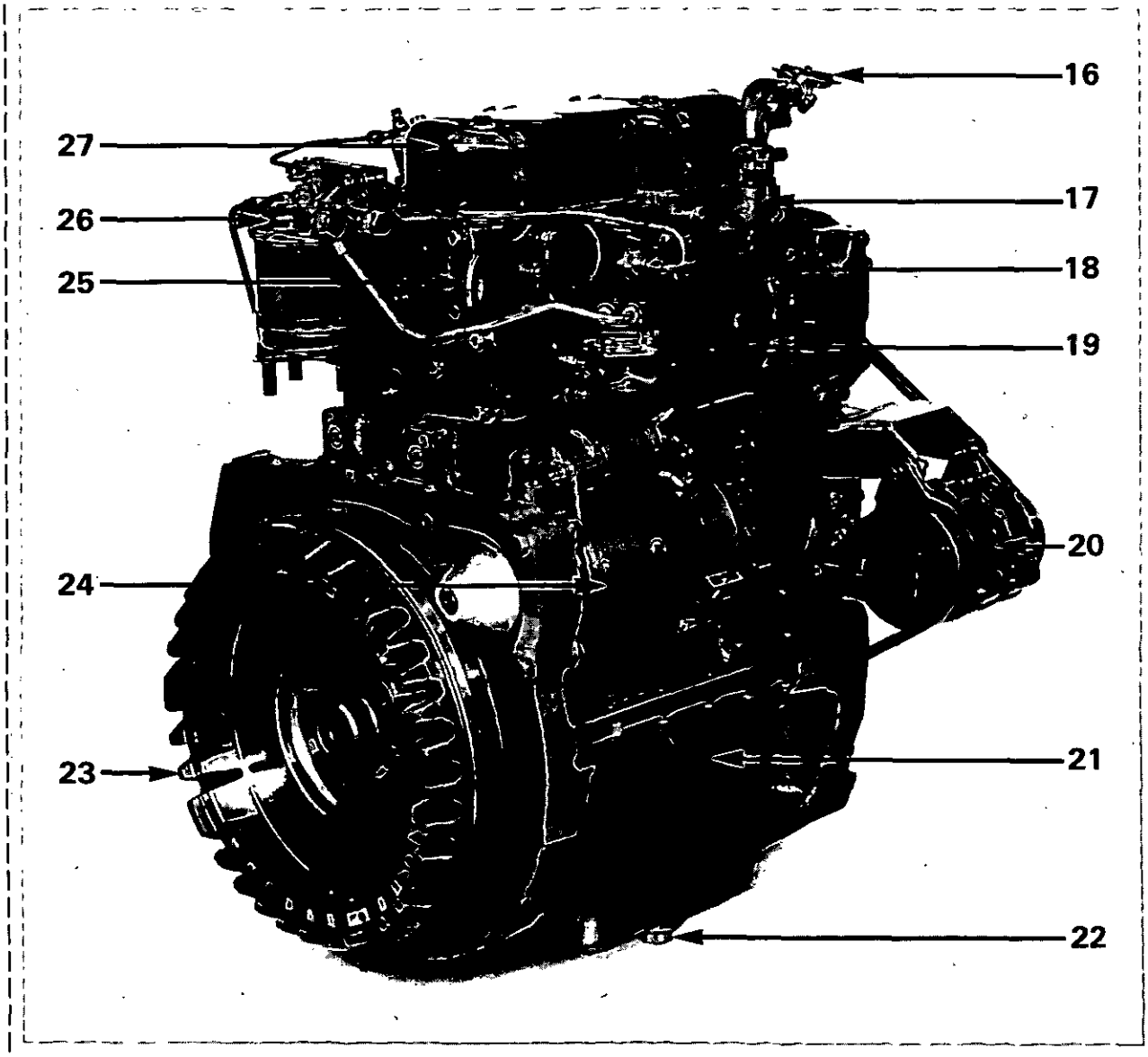
## ENGINE VIEWS

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




View of Front Left Hand Side of T3.1524 Engine.

1. Lubricating oil filler.
2. Atomiser.
3. Atomiser leak off pipe.
4. Exhaust manifold.
5. Fuel injection pump.
6. Cylinder block drain plug.
7. Sump dipstick.
8. Lubricating oil filter.
9. Crankshaft pulley.
10. Drive belt.
11. Water pump pulley.
12. Alternator pulley.
13. Turbocharger.
14. Thermostat housing.
15. Front lift bracket.




View of Rear Right Hand Side of 3.1522 Engine.

16. Breather valve.
17. Induction manifold.
18. Thermostart.
19. Fuel lift pump.
20. Alternator.
21. Lubricating oil sump.
22. *Sump drain plug.*
23. Flywheel.
24. Starter motor.
25. Rear lift bracket.
26. Fuel filter.
27. Rocker cover.

# SECTION A

# Technical Data

# TECHNICAL DATA—A.2

## Engine Data

| | |
|---|---|
| Type | Three Cylinder, Four Stroke, Direct Injection |
| Bore | 3.6 in (91,44 mm) Nominal |
| Stroke | 5 in (127 mm) |
| Cubic Capacity | 152 in³ (2,5 litres) |
| Compression Ratio (3.1522) | 19 :1 |
| Compression Ratio (3.1524) | 16.5 : 1 |
| Compression Ratio (T3.1524) | 15.5 : 1 |
| Engine Rotation | Clockwise from front |
| Firing Order | 1, 2, 3 |
| Tappet Clearances | Inlet—0.008 in (0,20 mm), Exhaust —0.0125 in (0,32 mm) |
| Lubricating Oil Pressure | 30 lbf/in² (2,1 kgf/cm²) — 207 kN/m² minimum at *maximum engine speed and normal operating temperature.* |
| **Turbo boost pressure** (measured at induction manifold)* | 6.0 lbf ft (0.42 kgf/cm²) 41 kN/m² |

*Variable according to application, load and speed.

## Recommended Torque Tensions

| | |
|---|---|
| Cylinder Head Nuts/Setscrews | 70 lbf ft (9,68 kgf m) — 95 Nm |
| Con. Rod Nuts (Cadmium Plated) | 45 lbf ft (6,22 kgf m) — 61 Nm |
| Con. Rod Nuts (Phosphated) | 60 lbf ft (8,3 kgf m) — 81 Nm |
| Main Bearing Setscrews | 110 lbf ft (15 kg m) — 150 Nm |
| Idler Gear Hub Retaining Setscrew | 50 lbf ft (6,9 kgf m) — 68 Nm |
| Camshaft Gear Retaining Setscrews | 21 lbf ft (2,9 kgf m) — 28 Nm |
| Balance Weight Setscrews | 55 lbf ft (7,6 kgf m) — 75 Nm |
| Flywheel Setscrews | 78 lbf ft (10,8 kgf m) — 106 Nm |
| Flywheel Housing/Adaptor Plate Setscrews | 36 lbf ft (5,0 kgf m) — 49 Nm |
| Atomiser Securing Nuts | 12 lbf ft (1,7 kgf m) — 16 Nm |
| Crankshaft Pulley Retaining Setscrew — with $\frac{3}{16}$ in (4,8 mm) thick washer | 105 lbf ft (14,5 kgf m) — 142 Nm |
| Crankshaft Pulley Retaining Setscrew — with 0.35 in (8,9 mm) thick washer | 240 lbf ft (33,2 kgf m) — 325 Nm |
| Alternator Pulley Nut | 42 lbf ft (5,8 kgf m) — 51 Nm |
| High Pressure Fuel Pipe Nuts | 15 lbf ft (2,1 kgf m) — 20 Nm |
| Thermostart and Adaptor | 10 lbf ft (1,4 kgf m) — 13,6 Nm |

Where self-locking nuts are employed and have for any reason been removed, they must be renewed.

## Approximate Dry Weights

| | |
|---|---|
| Bare engine with alternator but no flywheel or backplate | 463 lb (210 kg) |
| Typical installed weight | 680 lb (308 kg) |

## Engine Rating

| | |
|---|---|
| Maximum Gross Output (3.1522) | 44.5 bhp (33.2 kw) at 2,500 rev/min |
| Maximum Torque | 118 lbf ft (16,3 kgf m or 160 Nm) at 1,400 rev/min |
| Maximum Gross Output (3.1524) | 52.0 bhp (39,0 kW) at 2,500 rev/min |
| Maximum Torque | 128 lbf ft (17,8 kgf m or 174 Nm) at 1,350 rev/min |
| Maximum Gross Output (T3.1524) | 55.0 bhp (41,0 kW) at 2,500 rev/min |
| Maximum Torque | 140 lbf ft (19,4 kgf m) or 180 Nm at 1,500 rev/min |

The above quoted rating is maximum under BS.AU 141a : 1971 conditions and can vary according to application. For further information apply to the Service Department of one of the Perkins Companies listed on Page 2.

## De-Rating for Altitude

Where engines are called upon to operate in rarefied atmospheres occasioned by altitude, such engines 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.

For turbocharged engines and any further information, apply to the Service Department of one of the Perkins Companies listed on Page 2.

| Altitude | Maximum fuel delivery de-rating* |
|---|---|
| 0 — 2,000 ft ( 600 metre) | No change |
| 2,000 — 4,000 ft (1,200 metre) | 6% |
| 4,000 — 6,000 ft (1,800 metre) | 12% |
| 6,000 — 8,000 ft (2,400 metre) | 18% |
| 8,000 — 10,000 ft (3,000 metre) | 24% |
| 10,000 — 12,000 ft (3,600 metre) | 30% |

*Measured at setting speed given in pump setting code.

**Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer for the territory concerned.**

# MANUFACTURING DATA & DIMENSIONS

The following data of clearances and tolerances are given as a guide for personnel engaged upon major overhauls and the figures are mainly those used in the factory for production purposes.



## Cylinder Block

| | |
|---|---|
| Height of Cylinder Block between Top and Bottom Faces | 13.7405/13.7435 in (349,01/349,08 mm) |
| Parent Bore Dia. for Cylinder Liner | 3.6875/3.6885 in (93,66/93,69 mm) |
| Depth of Recess for Liner Flange | 0.148/0.152 in (3,76/3,86 mm) |
| Dia. of Recess for Liner Flange | 3.820/3.825 in (97,03/97,16 mm) |
| Main Bearing Parent Bore Dia. | 2.9165/2.9175 in (74,08/74,10 mm) |
| Parent Bore for No. 1 Camshaft Bearing Bush | 2.0000/2.0012 in (50,80/50,83 mm) |
| Internal Dia. of No. 1 Camshaft Bearing Bush | 1.872/1.874 in (47,55/47,60 mm) |
| Camshaft Bore Dia. — No. 2 | 1.864/1.876 in (47,35/47,42 mm) |
| Camshaft Bore Dia. — No. 3 | 1.844/1.847 in (46,84/46,91 mm) |

## Cylinder Liners

| | |
|---|---|
| Type — Production Liner | Dry — Interference Fit |
| — Service Liner | Dry — Pre-finished — Transition Fit |
| Outside Dia. of Production Liner | 3.6895/3.6905 in (93,71/93,74 mm) |
| Outside Dia. of Service Liner | 3.6875/3.6885 in (93,66/93,69 mm) |
| Interference Fit of Production Liner in Block | 0.001/0.003 in (0,03/0,08 mm) |
| Transition Fit of Service Liner in Block | 0.001/0.001 in (0,03/0,03 mm) |
| Inside Dia. of Finished Production Liner in Block | 3.6015/3.6025 in (91,48/91,50 mm) |
| Inside Dia. of Service Liner in Block | 3.6025/3.6035 in (91,50/91,53 mm) |
| Outside Dia. of Liner Flange | 3.803/3.808 in (96,60/96,72 mm) |
| Flange Thickness | 0.148/0.150 in (3,76/3,81 mm) |
| Relationship of Liner Flange Top Face to Top Face of Cylinder Block | 0.004 in (0,10 mm) Above to 0.004 in (0,10 mm) Below |
| Maximum Bore Wear (new liner needed) | 0.007 in (0,178 mm) |

## Pistons, 3.1522

| | |
|---|---|
| Type | "Squish Lip" Re-entrant Chamber in Crown. Four Ringed Piston has Steel Rail in Top Groove, Three Ringed Piston has Armoured Top Ring Groove. |

## Pistons, 3.1524, T3.1524

| | |
|---|---|
| Type | Cavity in Crown, Three Ringed Piston |
| All Engines. | |
| Piston Height in relation to Cylinder Block Top Face | 0.0012 in (0,03 mm) **ABOVE** to 0.0065 in (0,17 mm) **BELOW.** |
| Centre-line of Gudgeon Pin to Piston Crown | Grade H — 2.4329/2.4349 in (61,80/61,85 mm)<br>Grade L — 2.4274/2.4289 in (61,66/61,69mm) |
| Bore Diameter for Gudgeon Pin | 1.2499/1.2501 in (31,747/31,753 mm) |
| Top Ring Groove Width (Four Ringed Piston Only) | 0.0957/0.0977 in (2,43/2,48 mm) |
| All Other Compression Ring Groove Widths | 0.0957/0.0967 in (2,43/2,46 mm) |
| Oil Control Ring Groove Width | 0.1895/0.1905 in (4,81/4,84 mm) |
| Maximum Permissible Top Ring Clearance (with new ring fitted) | 0.007 in (0,18 mm) |

## Piston Rings, 3.1522

| | |
|---|---|
| Top Compression | Chrome Inserted, Copper Plated |
| 2nd or 2nd and 3rd Compression | Internally Stepped, Copper Plated |
| Oil Control | Chrome Faced, Coil Spring Loaded |

## Piston Rings, 3.1524, T3.1524

| | |
|---|---|
| Top Compression | Tapered Semi Inlay, Chrome Faced Compression |
| Second Compression | Tapered Face Compression |
| Oil Control | Spring Loaded, Laminated Scraper |

All Engines.

| | |
|---|---|
| Top Ring Width... ... ... ... ... | 0.0928/0.0938 in (2,36/2,38 mm) |
| 2nd or 2nd and 3rd Ring Width ... ... ... | 0.0927/0.0937 in (2,35/2,38 mm) |
| Oil Control Ring Width ... ... ... ... | 0.1860/0.1865 in (4,72/4,73 mm) |
| Top Ring Clearance in Groove (4 Ring Piston only) ... | 0.0019/0.0049 in (0,05/0,12 mm) |
| All Other Ring Clearances in Groove ... ... | 0.002/0.004 in (0,05/0,10 mm) |
| Ring Gap — Top ... ... ... ... | 0.012/0.023 in (0,30/0,74 mm) |
| Ring Gap — 2nd or 2nd and 3rd ... ... ... | 0.008/0.025 in (0,20/0,64 mm) |
| Ring Gap — Oil Control ... ... ... ... | 0.010/0.030 in (0,25/0,76 mm) |

## Gudgeon Pins

| | |
|---|---|
| Type ... ... ... ... ... ... | Fully Floating |
| Outside Dia. of Gudgeon Pin ... ... ... | 1.24975/1.25000 in (31,744/31,750 mm) |
| Fit in Piston Boss ... ... ... ... | Transition |
| Clearance Fit in Small End Bush ... ... ... | 0.0005/0.00175 in (0,01/0,04 mm) |

## Small End Bushes

| | |
|---|---|
| Type ... ... ... ... ... ... | Steel Backed, Lead Bronze Lined |
| Outside Dia. ... ... ... ... ... | 1.3785/1.3800 in (35,01/35,05 mm) |
| Length ... ... ... ... ... | 1.048/1.058 in (26,62/26,87 mm) |
| Inside Dia. after Reaming... ... ... ... | 1.2505/1.2515 in (31,76/31,79 mm) |

## Connecting Rods

| | |
|---|---|
| Type ... ... ... ... ... ... | "H" Section |
| Big End Parent Bore Dia.... ... ... ... | 2.3950/2.3955 in (60,83/60,85 mm) |
| Small End Parent Bore Dia. ... ... ... | 1.37475/1.37620 in (34,92/34,96 mm) |
| Big End Width ... ... ... ... ... | 1.5502/1.5525 in (39,38/39,43 mm) |
| Big End Side Clearance on Crankpin ... ... | 0.0095/0.0198 in (0,24/0,50 mm) |
| Length Between Bore Centres ... ... ... | 8.811/8.813 in (223,80/223,85 mm) |

## Connecting Rod Alignment

Large and small end bores must be square and parallel to 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 test mandrel as shown in Fig. A.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).*

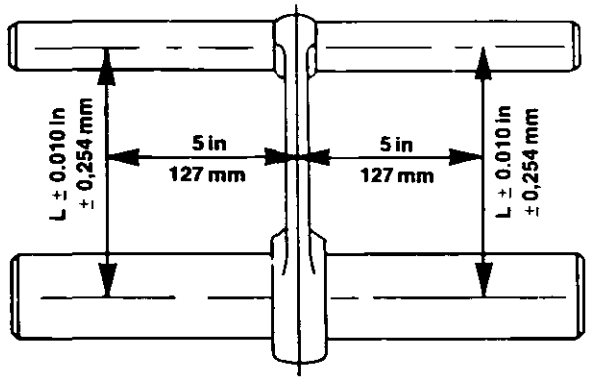



Fig. A.1

## Connecting Rod Bearings

| | |
|---|---|
| Type ... ... ... ... ... ... | Pre-finished, Steel Backed, Aluminium Tin Lined |
| Shell Thickness ... ... ... ... ... | 0.07150/0.07175 in (1,816/1,822 mm) |
| Inside Dia. ... ... ... ... ... | 2.2515/2.2525 in (57,19/57,21 mm) |
| Bearing Running Clearance ... ... ... | 0.002/0.004 in (0,06/0,10 mm) |

## Crankshaft

| | |
|---|---|
| Main Journal Dia. | 2.7485/2.7493 in (69,81/69,83 mm) |
| Main Journal Length —Nos. 2 and 3 | 1.2147/1.2227 in (30,85/31,06 mm) |
| Main Journal Length — No. 4 | 1.8427/1.8457 in (46,80/46,88 mm) |
| Main Journal Fillet Radii | 0.094/0.109 in (2,39/2,77 mm) |
| Crankpin Dia. | 2.2484/2.2492 in (57,11/57,13 mm) |
| Crankpin Length | 1.562/1.570 in (39,67/39,88 mm) |
| Crankpin Fillet Radii | 0.156/0.172 in (3,96/4,37 mm) |
| Surface Finish — All Pins and Journals | 8/16 micro inches (0,2/0,4 microns) |
| Crankshaft End Float | 0.002/0.015 in (0,05/0,38 mm) |
| Regrind Undersizes— Main Journals and Pins | 0.010 in (0,25 mm), 0.020 in (0,51 mm), 0.030 in (0,76 mm) |
| Crankshaft Main and Crankpin Journal maximum Wear and Ovality | 0.0015 in (0,038 mm) |

## Crankshaft Thrust Washers

| | |
|---|---|
| Type | Steel Backed, Aluminium Tin Faced |
| Position in Engine | Cylinder Block, Rear Main Bearing Housing |
| Thrust Washer Thickness — Standard | 0.121/0.123 in (3,07/3,12 mm) |
| Thrust Washer Thickness — Oversize | 0.1285/0.1305 in (3,26/3,31 mm) |

## Main Bearings

| | |
|---|---|
| Type | Steel Backed, Aluminium Tin Lined |
| Shell Width — No. 1 | 1.264/1.274 in (32,11/32,36 mm) |
| Shell Width — Nos. 2 and 3 | 0.927/0.937 in (23,55/23,80 mm) |
| Shell Width — No. 4 | 1.532/1.542 in (38,91/39,17 mm) |
| Shell Thickness | 0.08250/0.08275 in (2,096/2,102 mm) |
| Inside Dia. | 2.7510/2.7525 in (69,88/69,91 mm) |
| Main Bearing Running Clearance | 0.0017/0.0040 in (0,04/0,10 mm) |

## Camshaft

| | |
|---|---|
| No. 1 Journal Dia. | 1.869/1.870 in (47,47/47,50 mm) |
| Running Clearance in Bush | 0.002/0.005 in (0,05/0,13 mm) |
| No. 2 Journal Dia. | 1.859/1.860 in (47,22/47,24 mm) |
| Running Clearance | 0.004/0.008 in (0,10/0,20 mm) |
| No. 3 Journal Dia. | 1.839/1.840 in (46,71/46,74 mm) |
| Running Clearance | 0.004/0.008 in (0,10/0,20 mm) |
| Maximum Permissible Journal Wear and Ovality | 0.002 in (0,05 mm) |
| Cam Lift | 0.311/0.314 in (7,90/7,98 mm) |
| Gear Spigot Dia. | 1.9985/1.9995 in (50,76/50,79 mm) |
| Camshaft End Float | 0.004/0.016 in (0,10/0,41 mm) |

## Cylinder Head

| | |
|---|---|
| Depth | 2.985/3.015 in (75,82/76,58 mm) |
| Permissible Cylinder Head Bow | Transverse 0.003 in (0,076 mm) max.<br>Longitudinal 0.006 in (0,152 mm) max. |
| Skimming Allowance on Head Face | 0.012 in (0,30 mm) maximum, providing nozzle protrusion does not exceed 0.249 in (6,32 mm) after skimming. |
| Leak Test Pressure | 30lbf/in² (2,11 kgf/cm²) or 207 kN/m² |
| Valve Seat Angle | 35° (110° included angle) |
| Tappet Bore in Cylinder Head | 0.6245/0.6258 in (15,86/15,90 mm) |
| Valve Guide Bore in Cylinder Head | 0.4995/0.5005 in (12,69/12,71 mm) |

## Valve Guides

| | |
|---|---|
| Inside Dia. | 0.3141/0.3155 in (7,98/8,01 mm) |
| Outside Dia. | 0.5021/0.5026 in (12,75/12,77 mm) |
| Interference Fit of Guide in Cylinder Head | 0.0016/0.0031 in (0,04/0,08 mm) |
| Overall Length — Inlet | 2.204/2.234 in (55,98/56,74 mm) |
| Overall Length — Exhaust | 2.423/2.453 in (61,54/62,31 mm) |
| Inlet Guide Protrusion above Spring Seating Face | 0.362/0.376 in (9,19/9,55 mm) |
| Exhaust Guide Protrusion above Spring Seating Face | 0.580/0.594 in (14,73/15,09 mm) |

## Inlet Valves

| | |
|---|---|
| Valve Stem Dia. | 0.311/0.312 in (7,90/7,92 mm) |
| Clearance Fit of Valve in Guide | 0.0021/0.0045 in (0,05/0,11 mm) |
| Maximum Stem/Guide Clearance (Service) | 0.006 in (0,152 mm) |
| Valve Face Angle | 35° |
| Valve Head Depth below Cylinder Head Face | 0.052/0.064 in (1,32/1,63 mm) |
| Maximum Permissible Valve Head Depth in Service | 0.069 in (1,75 mm) |
| Overall Length | 4.486/4.512 in (113,94/114,60 mm) |
| *Sealing Arrangement* | *Spring Loaded Rubber Seal* |

## Exhaust Valves

| | |
|---|---|
| Valve Stem Dia. | 0.311/0.312 in (7,90/7,92 mm) |
| Clearance Fit of Valve in Guide | 0.0021/0.0045 in (0,05/0,11 mm) |
| Maximum Stem/Guide Clearance Service) | 0.0055 in (0,14 mm) |
| *Valve Face Angle* | 35° |
| Valve Head Depth below Cylinder Head Face | 0.063/0.0755 in (1,60/1,92 mm) |
| Maximum Permissible Valve Head Depth in Service | 0.086 in (2,18 mm) |
| Overall Length | 4.486/4.512 in (113,94/114,60 mm) |

## Valve Springs

| | |
|---|---|
| Fitted Length | 1.500 in (38,10 mm) |
| Load at Fitted Length | 22.75 lb ± 2 lb (10,34 kg ± 0,90 kg) |

## Inner Valve Springs (Inlet Valves Only)

| | |
|---|---|
| Fitted Length | 1.1875 in (30,16 mm) |
| Load at Fitted Length | 8.0 lb ± 1 lb (3,63 kg ± 0,45 kg) |

## Tappets

| | |
|---|---|
| Outside Dia. of Shank | 0.6222/0.6237 in (15,80/15,84 mm) |
| Clearance Fit in Cylinder Head | 0.0008/0.0036 in (0,02/0,09 mm) |

## Rocker Shaft

| | |
|---|---|
| Outside Dia. | 0.6223/0.6238 in (15,81/15,84 mm) |

## Rocker Levers

| | |
|---|---|
| Bore Dia. | 0.62450/0.62575 in (15,86/15,89 mm) |
| Clearance Fit on Rocker Shaft | 0.0007/0.00345 in (0,02/0,09 mm) |
| Maximum Rocker Clearance on Shaft | 0.005 in (0,13 mm) |

## Camshaft Gear

| | |
|---|---|
| No. of Teeth | 50 |
| Gear Bore Dia. | 1.9995/2.001 in (50,79/50,83 mm) |
| Clearance Fit of Gear on Spigot | 0.0000/0.0025 in (0,00/0,06 mm) |

## Idler Gear and Hub

| | |
|---|---|
| No. of Teeth | 90 |
| Bore Dia. of Gear | 2.1250/2.1266 in (53,98/54,02 mm) |
| Dia. of Hub | 2.1230/2.1238 in (53,92/53,94 mm) |
| Clearance of Gear on Hub | 0.0012/0.0036 in (0,03/0,09 mm) |
| Gear Width | 1.3175/1.3225 in (33,47/33,59 mm) |
| Bearing Length of Hub | 1.3275/1.3325 in (33,72/33,85 mm) |
| Gear End Float | 0.005/0.015 in (0,13/0,38 mm) |
| Maximum Gear End Float (Service) | 0.018 in (0,46 mm) |

### Crankshaft Gear

| | |
|---|---|
| No. of Teeth | 25 |
| Dia. of Bore | 1.4995/1.5010 in (38,09/38,13 mm) |
| Spigot Dia. of Crankshaft | 1.5000/1.5005 in (38,10/38,11 mm) |
| Transition Fit of Gear on Crankshaft | 0.001/0.001 in (0,03/0,03 mm) |

## Fuel Pump Gear

| | |
|---|---|
| No. of Teeth | 50 |
| Dia. of Bore | 1.750/1.751 in (44,45/44,48 mm) |
| Pump Spigot Dia. | 1.7480/1.7488 in (44,40/44,42 mm) |
| Clearance Fit of Gear on Spigot | 0.0012/0.003 in (0,03/0,08 mm) |

## Timing Gear Backlash

| | |
|---|---|
| All Gears | 0.003 in (0,08 mm) minimum |

## Lubricating Oil Pump Idler Gear

| | |
|---|---|
| No. of Teeth | 21 |
| Inside Dia. of Gear Bore | 0.750/0.751 in (19,05/19,08 mm) |
| Outside Dia. of Bush | 0.7520/0.7535 in (19,10/19,14 mm) |
| Interference Fit of Bush in Gear | 0.0010/0.0035 in (0,03/0,09 mm) |
| Inside Dia. of Bush — Fitted | 0.6562/0.6572 in (16,67/16,69 mm) |
| Dia. of Gear Shaft | 0.6548/0.6553 in (16,63/16,64 mm) |
| Running Clearance of Gear on Shaft | 0.0009/0.0024 in (0,02/0,06 mm) |
| Gear End Float | 0.008/0.023 in (0,20/0,58 mm) |

## Lubricating Oil Pump Drive Gear

| | |
|---|---|
| No. of Teeth | 19 |
| Internal Dia. of Gear Bore | 0.4962/0.4972 in (12,60/12,63 mm) |
| Pump Drive Shaft Dia. | 0.4990/0.4995 in (12,67/12,69 mm) |
| Interference Fit of Gear on Shaft | 0.0018/0.0033 in (0,05/0,08 mm) |

## Lubricating Oil Pump Clearances

| | |
|---|---|
| Inner Rotor to Outer Rotor | 0.0025/0.0045 in (0,06/0,11 mm) |
| Inner Rotor End Clearance | 0.0015/0.0035 in (0,04/0,09 mm) |
| Outer Rotor End Clearance | 0.001/0.003 in (0,03/0,08 mm) |

## Lubricating Oil Relief Valve

| | |
|---|---|
| Dia. of Bore in Pump Body | 0.5605/0.5625 in (14,24/14,29 mm) |
| Outside Dia. of Plunger | 0.5585/0.5595 in (14,19/14,21 mm) |
| Clearance of Plunger in Bore | 0.001/0.004 in (0,03/0,10 mm) |
| Load at 1.28 in (32,5 mm) Spring Length | 8 lbf ± 0.24 lbf (3,63 kgf ± 0,11 kgf) 35,59 N ± 1,07 N |
| Pressure Setting | 50/65 lbf/in² (3,52/4,57 kgf/cm²) or 345/448 kN/m² |

## Lubricating Oil Filter

| | |
|---|---|
| Type of Filter | Full Flow |
| Element Type | Renewable Canister |
| By-pass Setting | 8.0/12.0 lbf/in² (0,56/0,84 kgf/cm²) or 55/83 kN/m² |

## Lubricating Oil Sump

| | |
|---|---|
| Capacity for Industrial Engines — To Full Mark | 12.0 Imp. pints (6,8 litres) 7,2 U.S. quarts |

The above figures are general and can vary according to application. Fill to "FULL" mark on dipstick.

## Cooling System

| | |
|---|---|
| Type | Thermo Syphon — Pump Assisted |
| Coolant Capacity — Engine Only | 8.5 Imp. pints (4,8 litres) 5.1 U.S. quarts |

## Thermostat

| | |
|---|---|
| Type | Wax |
| Opening Temperature | 176/183°F (80/84°C) |
| Fully Open Temperature | 208°F (98°C) |

## Water Pump

| | |
|---|---|
| Type | Centrifugal |
| Pulley Bore Dia. | 0.6239/0.6247 in (15,85/15,87 mm) |
| Shaft Dia. | 0.6262/0.6267 in (15,91/15,92 mm) |
| Interference Fit of Pulley on Shaft | 0.0015/0.0028 in (0,04/0,07 mm) |
| Impeller Bore Dia. | 0.6250/0.6257 in (15,88/15,89 mm) |
| Shaft Dia. | 0.6262/0.6267 in (15,91/15,92 mm) |
| Interference Fit of Impeller on Shaft | 0.0005/0.0017 in (0,01/0,04 mm) |
| Clearance between Impeller Blades and Body | 0.010/.020 in (0,25/0,51 mm) |

## Approved Fuel Oil Specifications

When adjusted to factory standards, these engines will operate correctly on diesel fuel to one of the specifications which follow.

**France**
AFNOR NF M 15/007 (1978)

**Germany**
DIN 51601 : 1978

**India**
IS : 1460/1974 Grade HSD

**Italy**
CUNA Gas Oil NC 630 01 (1971)

**Sweden**
SIS : 15 54 32 (1981)

**Switzerland**
Federal Military Specification 9140 335 1404 (1965)

**United Kingdom**
BS 2869 : 1983 Class A1 or A2

**United States**
Federal VV/F/800c Grades DF-A, DF-1 or DF-2
ASTM D975 66T Numbers 1D or 2D

## Fuel Lift Pump

| | |
|---|---|
| Type ... ... ... ... ... ... | AC Delco |
| Method of Drive ... ... ... ... | Eccentric on Camshaft |
| Static Pressure (No Delivery) ... ... ... | 6.0/10.0 lbf/in² (0,4/0,7 kgf/cm²) — 41/69 kN/m² |

## Fuel Injection Pump

| | |
|---|---|
| Make ... ... ... ... ... ... | CAV |
| Type ... ... ... ... ... ... | DPA |
| Pump Rotation ... ... ... ... ... | Clockwise (from drive end) |
| Timing Letter ... ... ... ... ... | E |
| No. 1 Cylinder Outlet ... ... ... ... | Z |

## Engine Checking and Fuel Pump Marking Angles, Static Timing

The correct marking angles and static timing can be found by reference to the prefix letters and figures of the setting code adjacent to the word "Set" on the fuel pump identification plate. Engine checking and fuel pump marking angles are for use with timing tool MS67B and adaptor PD67B-1.

| Engine Type | Prefix Letters | Engine Checking Angle (Degrees) (with engine at No. 1 TDC Compression) | Fuel Pump Marking Angle (Degrees) | Static Timing (BTDC—Degrees) | Piston Displacement |
|---|---|---|---|---|---|
| 3.1522 | XW50E | 29 | 36 | 14 | 0.092 in (2,37 mm) |
| 3.1524 | WW47E | 25 | 35 | 20 | 0.192 in (4,87 mm) |
| | ZW | 25 | 37 | 24 | 0.275 in (6,98 mm) |
| | WW49L | 25 | 35 | 20 | 0.192 in (4,87 mm) |
| T3.1524 | YW | 27 | 35 | 16 | 0.124 in (3,15 mm) |

## Atomisers

| Engine Type | Code Letters | Holder (C.A.V.) | Nozzle (C.A.V.) | Setting Pressure atm (kgf/cm²) lbf/in² | Working Pressure atm (kgf/cm²lbf/in² |
|---|---|---|---|---|---|
| 3.1522 | GS | BKBL67S5446 | BDLL150S6771 | 250 (258) 3670 | 235 (243) 3450 |
| 3.1524 | EE | BKBL67S5336 | BDLL150S6771 | 255 (263) 3747 | 240 (248) 3530 |
| T3.1524 | HN | BKBL67S5336 | BDLL150S6771 | 255 (263) 3747 | 240 (248) 3530 |

## Alternator

| | |
|---|---|
| Make ... ... ... ... ... ... | Lucas |
| Type ... ... ... ... ... ... | 15, 17 or 18 ACR |
| Maximum Output (Hot) ... ... ... ... | 15 ACR — 28A<br>17 ACR — 36A<br>17 ACR (De-rated) — 25A<br>18 ACR — 45A<br>LR 135 Series — 35A<br>LR 150 Series — 50A |

## Starter Motor

| | |
|---|---|
| Make ... ... ... ... ... ... | Lucas |
| Type ... ... ... ... ... ... | M45G, M50, M127/2,8, CA45, S12-84, S12-85 |
| No. of Teeth on Pinion ... ... ... ... | 10 |
| Starter Cable Resistance ... ... ... ... | 0.0017 ohms maximum |

**Note:** The above electrical data is general and can vary with individual applications.

# SECTION B
# Maintenance

## Preventive Maintenance

Operators of 3.1522 series engines are reminded that the following Preventive Maintenance are general in application: therefore the operator should compare the routine maintenance for his engine with the schedules specified by the manufacturer of the application to which the engine is fitted and where necessary adopt the shorter periods.

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

**Keep engine clean.**

## DAILY OR EVERY 8 HOURS (WHICHEVER OCCURS FIRST)

Check level of coolant.

Check level of oil in sump.

Check oil pressures (where gauge fitted).

In extreme dust conditions, clean oil bath air cleaner and empty dust bowl on dry type air cleaner.

## EVERY 200 HOURS, 5,000 MILES (7500 Km) OR FOUR MONTHS (WHICHEVER OCCURS FIRST)

Check drive belt tension.

Clean oil bath air cleaner.

Empty dust bowl on dry type air cleaner.

Clean fuel water trap (where fitted).

Clean lift pump pre-filter (where fitted).

Check engine for leakage of oil and water.

## EVERY 400 HOURS, 1,000 MILES (15000 Km) OR TWELVE MONTHS (WHICHEVER OCCURS FIRST)

Drain and renew lubricating oil. Refer to list of Lubricating Oils in Section J.

Renew lubricating oil filter canister.

Renew intermediate and final fuel filter elements. Check hoses and clips.

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

Check and adjust tappets. See Page C.7.

## EVERY 800 HOURS, 20000 MILES (30000 Km) (WHICHEVER OCCURS FIRST)

Service atomisers.

## EVERY 1,000 HOURS

Check turbocharger impeller, clean if necessary.

## EVERY 2,400 HOURS

Arrange for examination and service of proprietary equipment, i.e. compressor, exhauster, starter motor, etc.

## Post-Delivery Checkover

After a customer has taken delivery of his Perkins Diesel engine, it is advisable. in his own interest, that a general checkover of the engine be carried out after the first 25 hours in service.

It is also recommended that the following procedure be adopted where an engine has been laid up for a considerable period before it is again put into service.

The checkover should comprise the following points:—

1. Drain lubricating oil sump and re-fill up to the full mark on the dipstick with new clean oil (Do not overfill).
2. Renew the lubricating oil filter canister.
3. Check external nuts and hose clips for tightness.
4. Check and adjust tappet clearances, as detailed on Page C.7.
5. Check fuel pipes from tank to fuel injection pump for leaks.
6. Check for lubricating oil leaks, and rectify if necessary.
7. Check cooling system for leaks and inspect radiator water level.
8. Check fan belt for tension.
9. Carry out test to check general performance of engine.
10. Check engine mounting bolts for tightness.

It is assumed that electrical equipment will have already been checked for such points as rate of charge, effectiveness of connections and circuits, etc.

Thereafter maintenance periods should be in accordance with the instructions given previously.

## Protection of an engine not in service

The recommendations given below are to ensure that damage is prevented when an engine is removed from service for an extended period. Use these procedures immediately the engine is removed from service. The instructions for the use of POWERPART products are given on the outside of each container.

1. Thoroughly clean the outside of the engine.

2. Where a preservative fuel is to be used, drain the fuel system and fill 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 charged with normal fuel but this will have to be drained and discarded at the end of the storage period together with the fuel filter.

3. Run the engine until it is warm. Correct any fuel, lubricating oil or air leakage. Stop the engine and drain the lubricating oil sump.

4. Renew the lubricating oil filter canister.

5. Fill the sump to the full mark on the dipstick with clean new lubricating oil or with a correct preservative fluid. POWERPART Lay-Up 2 can be added to the lubricating oil to give protection against corrosion during the period in storage. If a preservative fluid is used, this must be drained and normal lubricating oil used when the engine is returned to service.

6. Drain the cooling system, see page B.4. To give protection against corrosion, it is better to fill the cooling system with a coolant that has a corrosion inhibitor, see 'Engine Coolant' on page B.4. If frost protection is needed, use an antifreeze mixture. If no frost protection is needed, use water with an approved corrosion inhibitor mixture.

7. Run the engine for a short period to send the lubricating oil and coolant around the engine.

8. Clean out the engine breather pipe and seal the end of the pipe. (3.1522 engines, clean the breather vent valve, see page C.8).

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 (1/4 pint) of lubricating oil divided evenly between the three cylinders.

10. Slowly turn the crankshaft one revolution and then install the atomisers complete with new seat washers and new dust seals.

11. Remove the air filter/cleaner and any pipe installed between it and the 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 manifold spray time given on the container label. Seal the manifold or turbocharger with waterproof tape.

12. Remove the exhaust pipe. Spray POWERPART Lay-Up 2 into the exhaust manifold or turbocharger. It is recommended that the spray time for the turbocharger is 50% longer than the manifold spray time given on the container label. Seal the manifold or turbocharger with waterproof tape.

13. Remove the rocker cover. Spray POWERPART Lay-Up 2 around the rocker shaft assembly. Fit the filler cap.

14. Disconnect the battery and put it into safe storage in a fully charged condition. Before the battery is put into storage, give the battery terminals a protection 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 belt and put it into storage.

17. To prevent corrosion, spray the engine with POWERPART Lay-Up 3. Do not spray inside the alternator cooling fan area.

**Note:** Before the engine is started after a period in storage, operate the starter motor with the engine stop control in the 'off' position until oil pressure shows on the oil pressure gauge or the oil warning light goes out. If a solenoid stop control is used, this will have to be disconnected for this operation.

If the engine protection is done correctly according to the above recommendations, no corrosion damage will normally occur. Perkins Engines Ltd. are not responsible for any damage that occurs in relation to a service storage period.

## Engine Coolant

The quality of the coolant used can have a large effect on the efficiency and life of the cooling system. The recommendations given below can be of assistance in the maintenance of a good cooling system with frost and/or corrosion protection.

1. Where possible, use clean soft water.

2. If an antifreeze mixture is used to prevent frost damage, it must have an ethylene glycol (ethanediol) base. An antifreeze that is to one of the standards given below or to an equal standard is acceptable if the pH value is kept within the range of 7.0 - 8,5 when diluted.

| | | |
|---|---|---|
| **U.K.** | BS 3151:1959 | 'Ethanediol Antifreeze Type B with Sodium Benzoate and Sodium Nitrite Inhibitors'. |
| **U.S.A.** | ASTM D3306-74 | 'Ethylene Glycol Base Engine Coolant'. |
| **Australia** | AS 2108-1977 | 'Antifreeze Compounds and Corrosion Inhibitors for Engine Cooling Systems'. |

When Perkins POWERPART antifreeze is used, the correct mixtures of antifreeze and water are as given

below. Perkins POWERPART Antifreeze fully passes the above standards.

| Lowest temperature of protection needed | Volume of POWERPART antifreeze % | Mixture ratio by volume POWERPART antifreeze: water |
|---|---|---|
| −12°C ( 10°F) | 25 | 1:3 |
| −18°C ( 0°F) | 33 | 1:2 |
| −25°C (−13°F) | 40 | 1:1.5 |
| −37°C (−34°F) | 50 | 1:1 |
| −60°C (−76°F) | 66 | 2:1 |

*The quality of the antifreeze coolant must be checked* at least once a year, for example, at the start of the cold period.

*If the correct procedures are not used, Perkins Engines* Ltd. can not be held responsible for any frost or corrosion damage.

3. *When frost protection is not necessary, it is still an* advantage to use an approved antifreeze mixture (see 2) as this gives a protection against corrosion and also raises the boiling point of the coolant. A minimum concentration of 25% by volume of antifreeze is necessary, but it is our recommendation that 33% concentration by volume is used.

   If an antifreeze is not used, add a correct corrosion inhibitor mixture to the water.

When draining the water circulating system it is not enough merely to open the radiator drain tap. The one on the cylinder block must also be opened. This tap is at the rear of the cylinder block, near the flywheel housing.

Where a pressurised radiator filler cap is fitted, this should be removed before draining the cooling system.

When draining the cooling system, ensure that the engine is level.

When the engine is drained, in the majority of applications 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 gland.

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

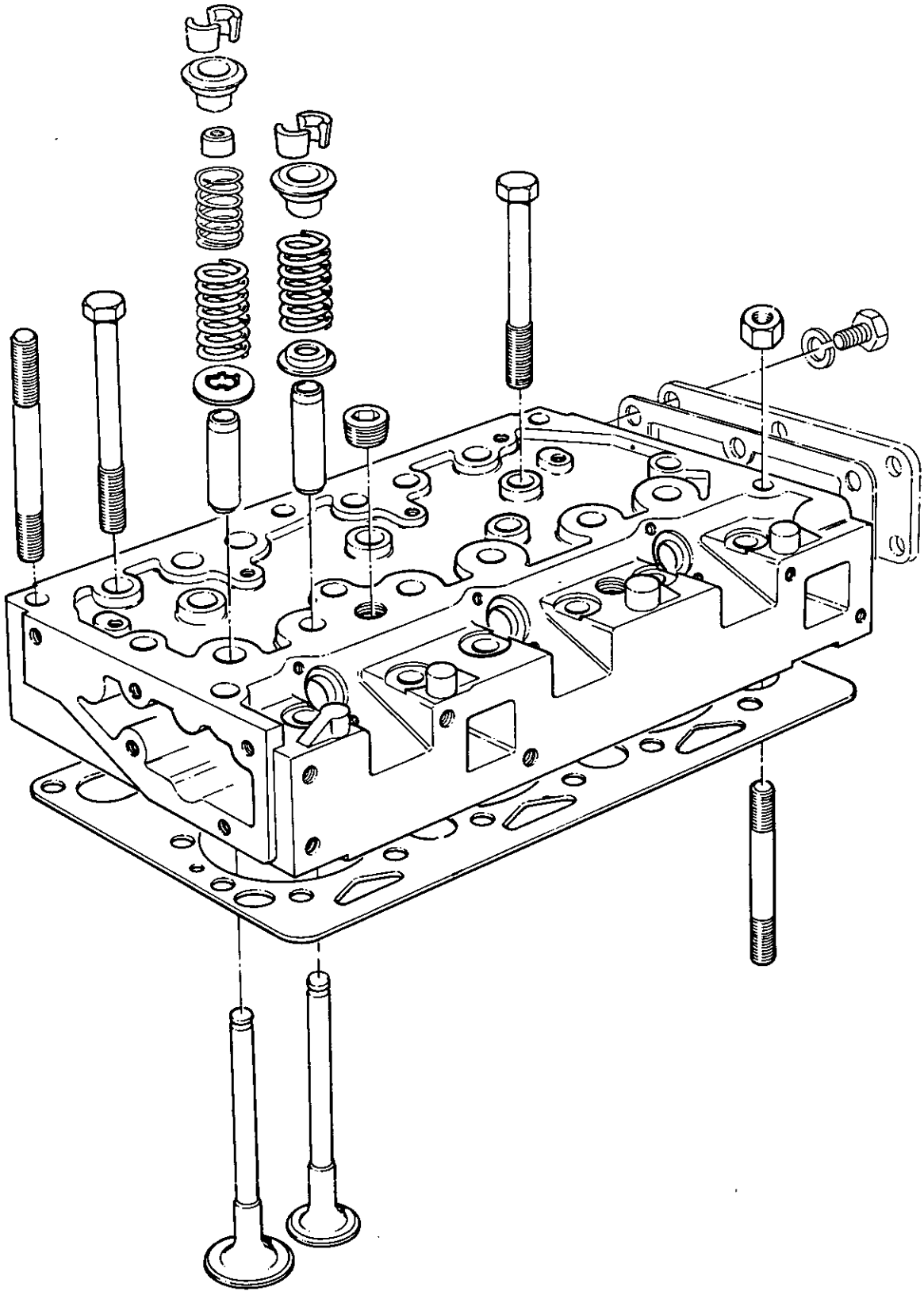
1. Before starting the engine, turn the fan and water pump by hand; this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.
2. If it is impossible to turn the pump by hand, the radiator and engine should be filled with warm water.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the 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.

# SECTION C
# Cylinder Head





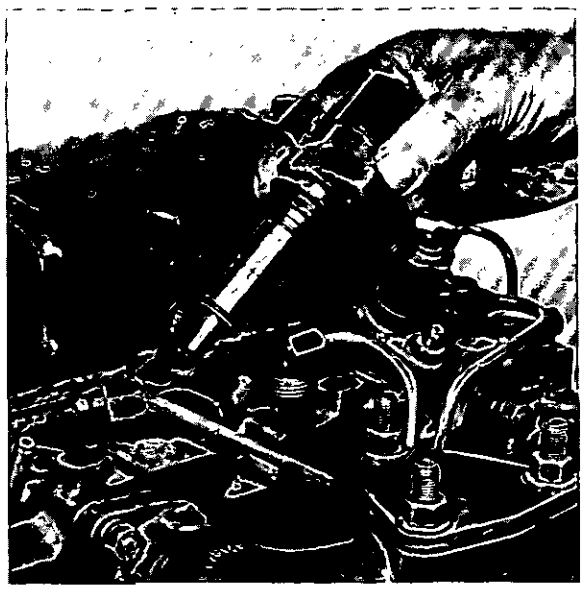


Fig. C.1
Removing Atomiser.

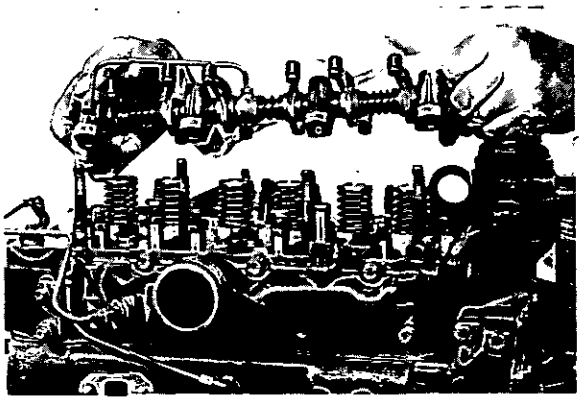


Fig. C.2
Removing Rocker Shaft Assembly.

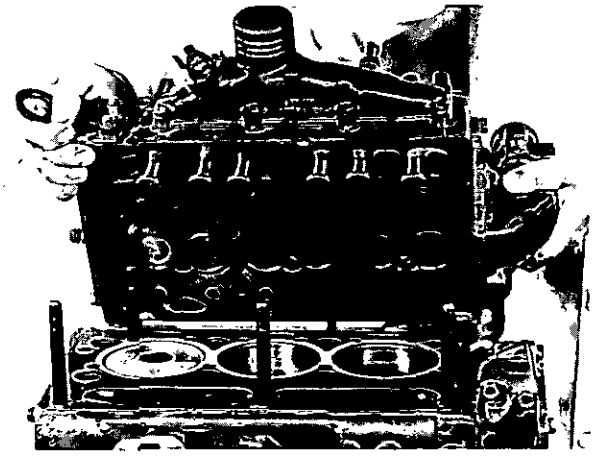


Fig. C.3
Removing Cylinder Head Assembly.

The cast iron cylinder head is fitted with replaceable valve guides which are a press fit in the head, different type guides being used for inlet and exhaust valves. The valves and valve seats are machined to an angle of 35° (110° included angle).

Two valve springs (one on T3.1524 engines) are fitted to each inlet valve and a single spring to each exhaust valve. Valve stem seals are fitted to the inlet valves only and the stems of these valves are chrome plated.

The adjustable tappets operate in holes bored and reamed in the right hand side of the cylinder head.

## To Remove Cylinder Head

1. Drain water from radiator and cylinder block.
2. Disconnect battery terminals.
3. Detach water connections from thermostart housing on front of cylinder head.
4. Remove crankcase vent valve and hose from rocker cover and induction manifold (3.1522 engines).
5. Remove air cleaner.
6. Detach cold starting equipment connections.
7. Remove the oil pipe from camshaft oil reducer to cylinder head.
8. Disconnect exhaust pipe from engine exhaust manifold. Remove turbocharger (T3.1524 engines).
9. Remove injection pipes from fuel pump to atomisers.
10. Remove atomiser leak-off pipes.
11. Remove atomisers (See Fig. C.1).
12. Where necessary, remove fuel filter and fuel pipe from filter to cold starting aid. Detach clip securing fuel pipe to rear of cylinder head.
13. Remove cylinder head cover.
14. Disconnect oil pipe to rocker shaft and remove rocker shaft assembly, complete with oil pipe (Fig. C.2).
15. Remove the cylinder head nuts/setscrews in the reverse order to the tightening sequence in Fig. C.14.
16. Remove cylinder head (Fig. C.3). Do not insert a screwdriver or any other sharp instrument between cylinder head and block. Place head on a flat surface, preferably wood, to avoid damage.

**Warning:** Cover the fuel pump delivery ports with suitable protective caps.

## To Remove Valves

The faces of the valves and the cylinder head should be suitably marked before dismantling so that the valves can be refitted to their original positions.

Depress the spring cap and springs by means of a valve spring compressor and remove the two half conical collets. A special tool and adaptor (Fig. C.4) can be used to compress the valve springs, with the head resting on a flat surface.

Remove the spring caps, springs, seals and seating washers and the valves can be removed.

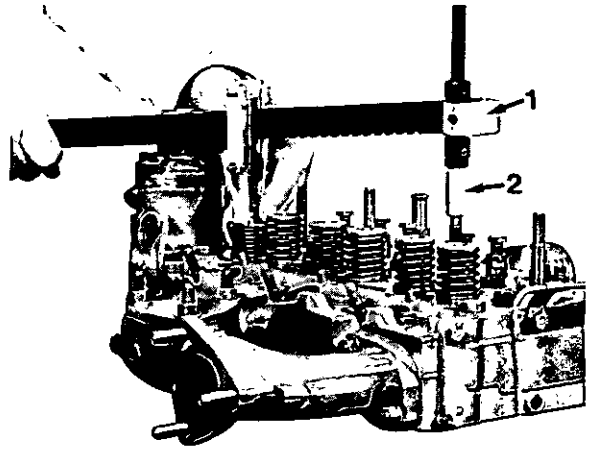



Fig. C.4
Removing Valve Springs.
1. Tool 21825020. 2. Adaptor 21825022.

C

## Valve and Valve Seat Reconditioning

The valve face and seat angle is 35° (110° included angle).

Only the minimum of metal should be removed to clean up the contact faces of the valves and valve seats otherwise the valve may sink too far below the cylinder head face. The maximum permissible service valve head depth below the cylinder head face is 0.069 in (1,75 mm) for inlet valves and 0.086 in (2,18 mm) for exhaust valves (Fig. C.5). The valve head depth should be checked before reconditioning to determine if new parts are necessary. Tool 21825019 can be used to check the valve head depths (Fig. C.6).

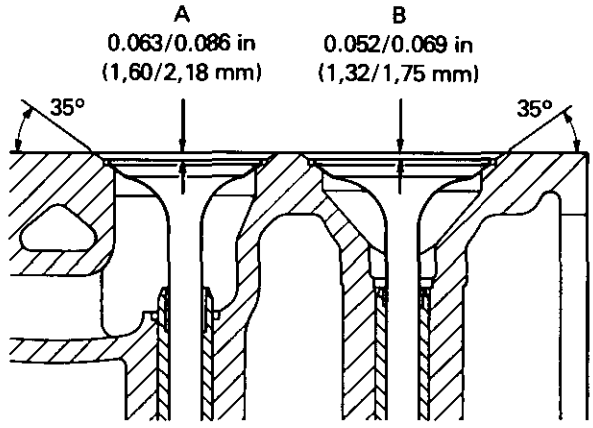



Fig. C.5
Valve Head Depths
A. Exhaust. B. Inlet.

If the cylinder head requires skimming or the valve guides need renewing, this should be done before the valve seats are reworked.

The valve seats can be recut using cutter 21825069 for inlet and 21825068 for exhaust. The pilot, MS. 150-8 and handle MS. 76 are for use with these cutters.

Position the pilot (Fig. C.7) in the valve guide with the expandable section inside the guide and the shoulder of the pilot approximately $\frac{1}{8}$ in (3 mm) above the guide. Tighten the pilot in the guide using the knurled nut and a pin in the pilot hole. Adjust the blades of the cutter to approximately the same location in their slots with the pointed ends inwards and tighten the blade screws, finger tight only. Ensure that the blades are clean before use.

Lower the cutter into position on the pilot, with the 35° blades towards the seat — do not drop the cutter on to the seat as the blades are brittle and can easily be chipped. Fit the handle to the cutter and cut the

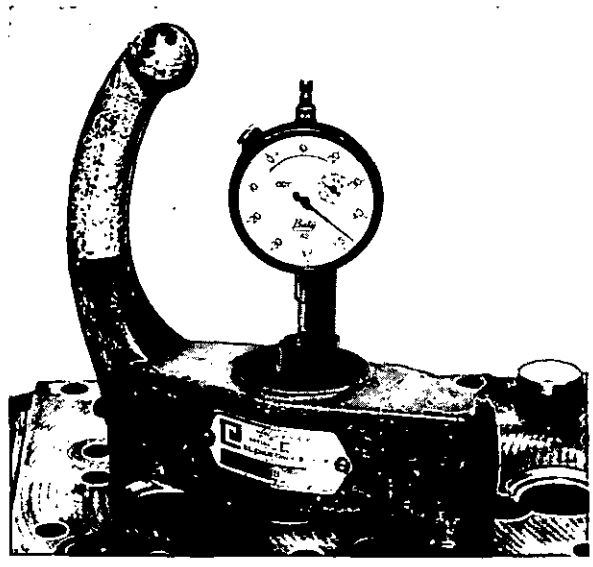


Fig. C.6
Checking Valve Depth using Tool 21825019.

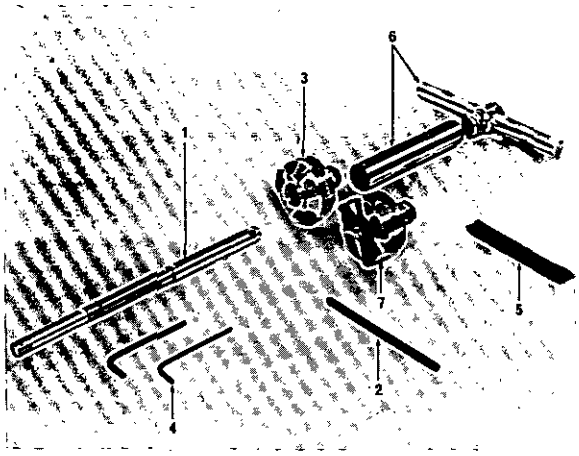



Fig. C.7
Valve Seat Cutter Tool.

1. Pilot
2. Puller Pin
3. Seat Cutter
4. Keys
5. Cleaning Brush
6. Cutter Handle
7. Valve Seat Width Reducer

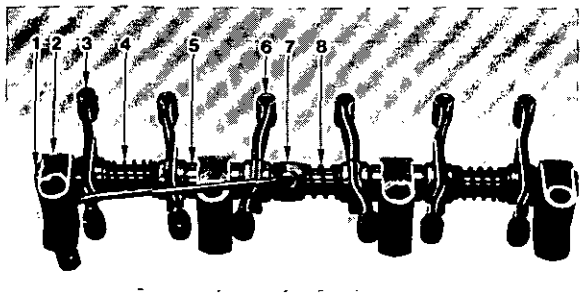



Fig. C.8
Rocker Assembly

1. Circlip
2. Bracket
3. Left Hand Lever
4. Long Spring
5. Distance Piece
6. Right Hand Lever
7. Oil Feed Pipe
8. Short Spring

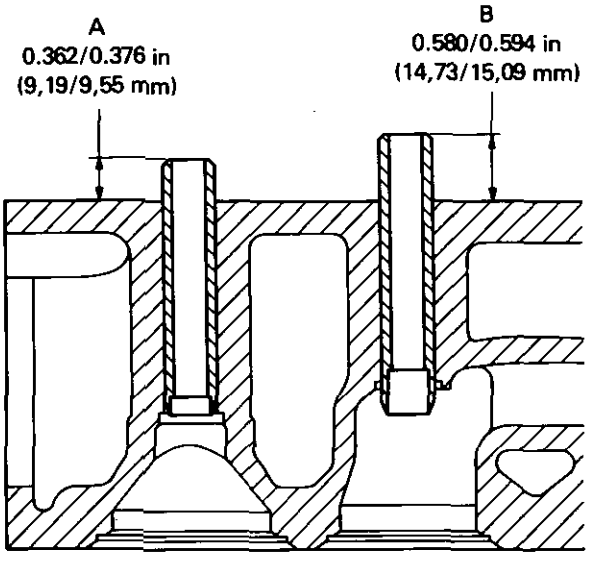



Fig. C.9
Valve Guide Protrusion
A. Inlet. B. Exhaust.

seat by turning the cutter clockwise using only very light hand pressure and ensuring that the pressure is applied centrally above the pilot. Only very few turns should be necessary to achieve a good seat which will have a velvety finish not polished or shiny.

The seat width can be reduced, where necessary, or the valve head recess in the seat can be cleaned up using an appropriate flat cutter.

After cutting the seat, clean the cylinder head and check the contact between the valve and the seat, lapping in the valve if necessary. Check the valve head depth below the cylinder head face as detailed above.

Mark each valve with its appropriate cylinder number.

## Rocker Levers and Bushes

Wash the rocker shaft assembly thoroughly in paraffin.

Examine the rocker bushes for wear. The rockers should be an easy fit on the shaft without excessive side play.

If the rocker bushes are worn, it will be necessary to replace with a new rocker. The rockers are supplied as a complete assembly and new bushes cannot be fitted.

When dismantling rocker shaft assemblies make careful note of the order of assembly of the various parts, supports, distance pieces, springs and rockers, so that re-assembly may be facilitated and that left and right-hand rockers are correctly placed and come opposite their respective tappets and valves. (See Fig. C.8). Ensure that slot in end of shaft will be towards front of engine.

On later engines, the slot has been removed and correct location of the shaft is ensured by a dowel through one of the rocker shaft brackets.

## Valve Guides

Examine the valve guides for wear, if necessary replace with new guides.

Clean the new guides, removing any burrs.

The guides for the inlet valves are $\frac{7}{32}$ in (5,5 mm) shorter than the exhaust valve guides and care should be taken to ensure that the correct guide is fitted. The inside diameter of the guides is counterbored at one end and this counterbore must be fitted towards the valve seat. When fitted, the valve guide protrusion above the spring seating face of the cylinder head should be 0.362/0.376 in (9,19/9,55 mm) for inlet guides and 0.580/0.594 in (14,73/15,09 mm) for exhaust guides (Fig. C.9).

| Tool 21825026 with puller bar 21825027 can be used for
| removing and fitting valve guides and valve guide stops
| 21825033 for inlet and 21825029 for exhaust valve
| guides will ensure correct protrusion (Fig. C.10).

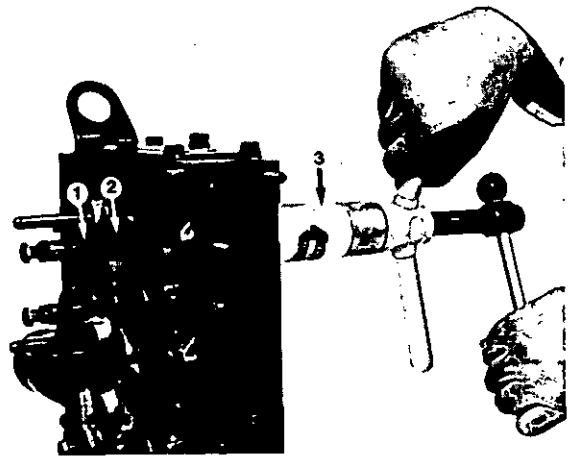



Fig. C.10
Fitting Valve Guide
| 1. Puller Bar 21825027.
| 2. Inlet Guide Stop 21825033.
| Exhaust Guide Stop 21825029.
| 3. Main Tool 21825026.

## Tappets

The tappets slide in holes bored in the cylinder head. The wear, under normal conditions, is negligible.

The tappets can be removed through the bottom face of the cylinder head after the tappet clearance adjustment setscrews and locknuts have been removed.

## Cylinder Head Overhaul

Wash out and thoroughly clean the water passages in the head, subsequently drying out and finally cleaning with compressed air. If the water jacket shows signs of excessive scale, a proprietary brand of descaling solution should be used.

If possible, the cylinder head should be water tested for leaks with warm water at a pressure of 30 lbf/in² (2,11 kgf/cm²) 207 kN/m².

All studs on the cylinder head and the top face of the cylinder block should be examined for looseness, damaged threads, etc. The cylinder head securing nuts and setscrews should also be checked for damaged threads and stretching.

Check all joint faces, especially the bottom face of the cylinder head and the top face of the cylinder block, for damage.

Check the bottom of the cylinder head for distortion. The maximum permissible bow is 0.003 in (0,08 mm) across the head and 0.006 in (0,15 mm) along the head.

The head can be skimmed by a maximum of 0.012 in (0,30 mm) providing the nozzle protrusion does not exceed 0.249 in (6,32 mm) after skimming (Fig. C.11). Shim washers or extra atomiser seating washers must not be used to reduce the nozzle protrusion. After the head has been skimmed the valve head depths must be checked and the seats recut, if necessary, as detailed under "Valve and Valve Seat Reconditioning".

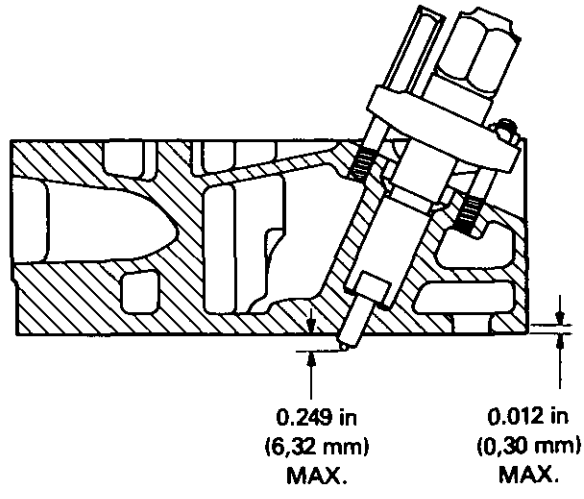



Fig. C.11
Cylinder Head Skimming Limits.

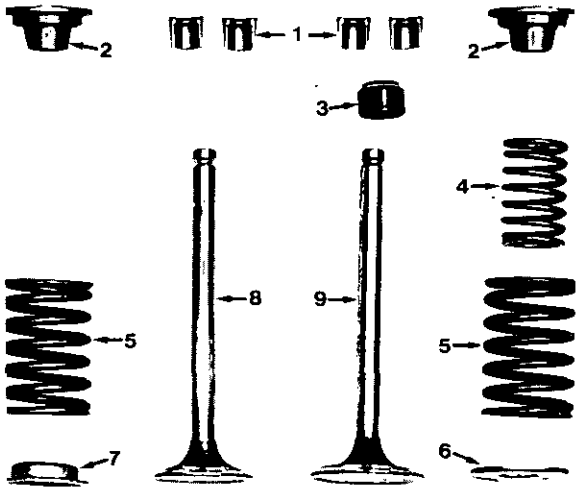



Fig. C.12
Valve and Spring Assemblies.

1. Split Collets
2. Spring Cap
3. Stem Seal
4. Inner Spring
5. Outer Spring
6. Double Spring Seating Washer
7. Single Spring Seating Washer
8. Exhaust Valve
9. Inlet Valve

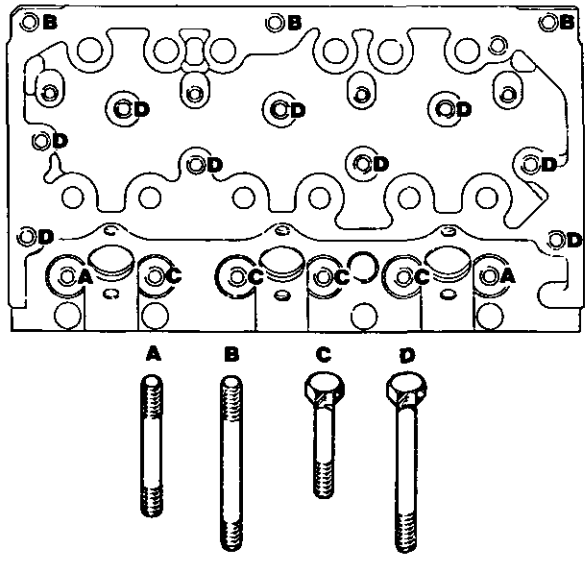



Fig. C.13
Cylinder Head Stud/Setscrew Positions.

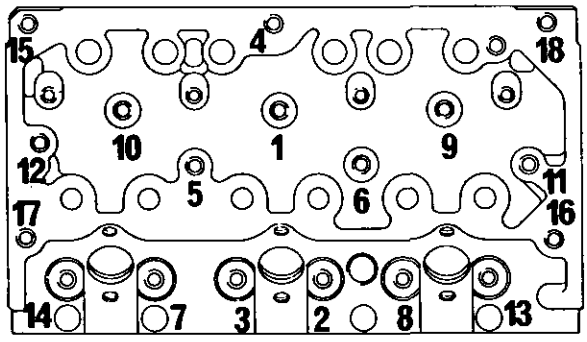



Fig. C.14
Cylinder Head Tightening Sequence.

## To Refit Valves

When fitting the valves, ensure that the stems are lubricated with clean engine oil and that they are fitted in their correct positions as previously marked.

After positioning the valves, fit the spring seating washers, seals (inlet valve guides only), springs, spring caps and collets. Two springs (one on T3.1524 engines) are fitted to each inlet valve (Fig. C.12) and a single spring to each exhaust valve and the inlet valve spring seating washers have locating tabs on their inside diameters. When compressing the valve springs ensure that the valve spring caps remain central and do not score the valve stems.

## To Refit Cylinder Head

Ensure that the two gasket location studs are fitted at each end of the left hand row of tapped holes in the top of the cylinder block. These two positions correspond with the two close toleranced location holes of the cylinder head gasket. Three studs are also fitted outboard of the camshaft tunnel although some earlier engines have setscrews fitted in these positions. When fitting the studs, ensure that the shorter threaded ends are fitted in the cylinder block. The stud positions are shown in Fig. C.13.

After ensuring that the top face of the block is perfectly clean, fit a new cylinder head gasket without any jointing compound.

When the underface of the cylinder head is perfectly clean, the head may be lowered into position on its studs and the setscrews fitted as shown in Fig. C.13.

Tighten the cylinder head nuts/setscrews progressively in the order given in Fig. C.14 to the torque given on Page A.2.

Replace atomisers (See Page L.7).

Replace rocker shaft assembly with the two long nuts and shim washers fitted to the front and third rocker brackets and the two self locking nuts and plain washers fitted to the other brackets. Before tightening the securing nuts the rocker shaft should be set so as to ensure correct lubrication of the assembly. The correct position for the shaft is when the slot in the end of the shaft is set 40° after the vertical position, i.e., with the slot pointing towards the sharp corner at the top of the bracket (See Fig. C.15).

On later engines the slot has been removed and correct location of the shaft is ensured by a dowel through one of the rocker assembly brackets (See 1, Fig. C.16).

When the rocker shaft is correcty positioned, tighten the securing nuts and set the tappet clearances, as detailed later.

Refit rocker cover and breather.

Connect up pipes and make connections as listed under "To Remove the Cylinder Head".

Provision is made in the cylinder head water outlet for the housing of a thermostat which must be fitted. On no account must the engine be started without a thermostat fitted, otherwise overheating of the engine may occur.

Run engine until normal operating temperature is reached and then remove rocker shaft and atomisers and retighten cylinder head nuts and setscrews as detailed below.

With coolant outlet temperature at least 170°F (77°C), tighten nuts and setscrews in the order given in Fig. C.14 to torque given on Page A.2. If a nut or setscrew does not move before correct torque is achieved, slacken off 1/12 to 1/6 of a turn and then retighten to correct figure. After retightening all the nuts and setscrews, the first 10 positions of the tightening sequence should be rechecked without further slackening off to ascertain that they are still tightened to the correct torque.

Refit all necessary components — it is advisable to fit a new rocker cover joint.

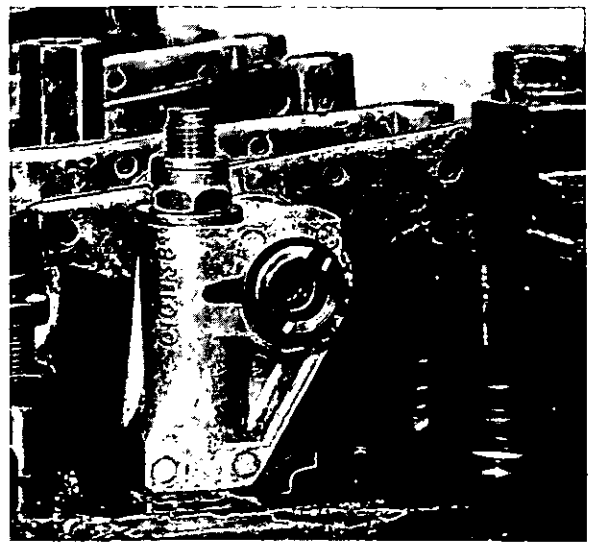


Fig. C.15
Rocker Shaft Slot Position.

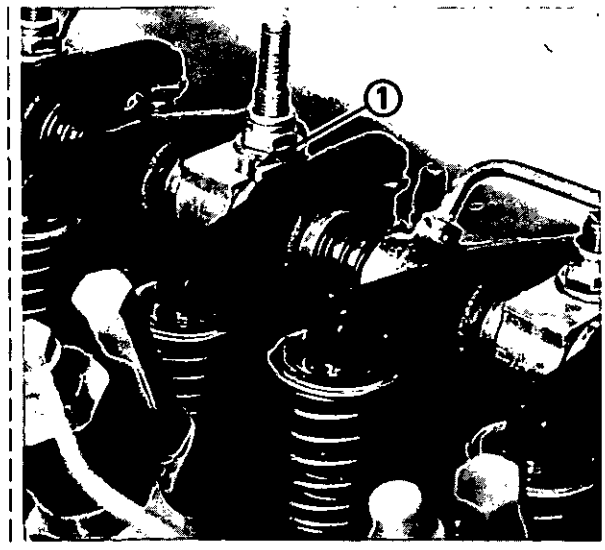



Fig. C.16
Rocker Shaft Location Dowel.

## Adjusting Tappet Clearances

Tappet clearances for the inlet valves should be set to 0.008 in (0,20 mm) and for the exhaust valves the clearances should be set to 0.0125 in (0,32 mm).

To adjust clearances (Fig. C.17) proceed as follows:—

Turn the crankshaft until the valves of No. 1 cylinder are rocking (inlet valve opening and exhaust valve closing).

In this position, check and adjust clearances, as necessary, on Nos. 4 and 6 valves (No. 1 valve at front of engine).

Temporarily mark the crankshaft pulley and the adjacent point on the timing case cover and turn the crankshaft one complete revolution (360°) until the marks re-align.

In this position, adjust the clearances on Nos. 1, 2, 3 and 5 valves.

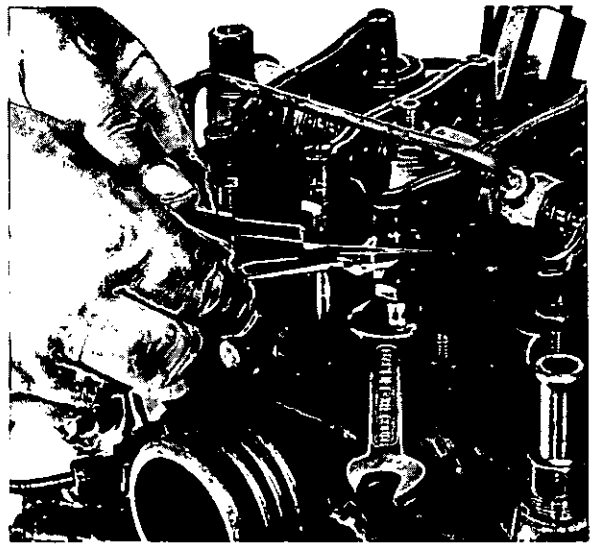


Fig. C.17
Adjusting Tappet Clearance.

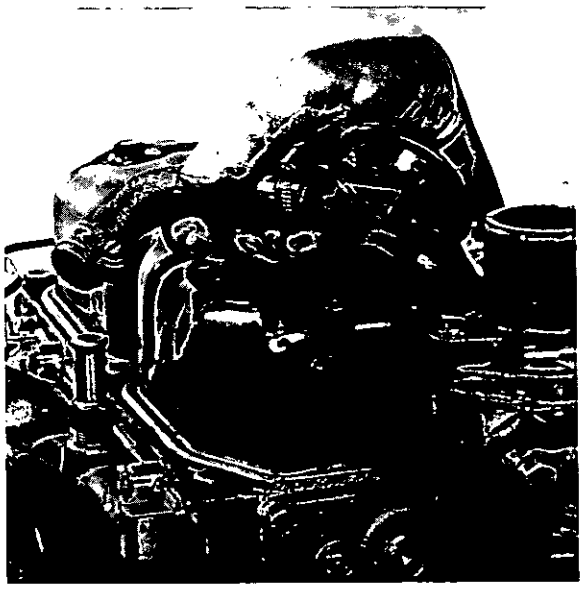


Fig. C.18
Removing Crankcase Vent Valve.

## Crankcase Vent Valve (3.1522 engines)

A closed circuit vent valve is fitted between the cylinder head cover and induction manifold (See Fig. C.18).

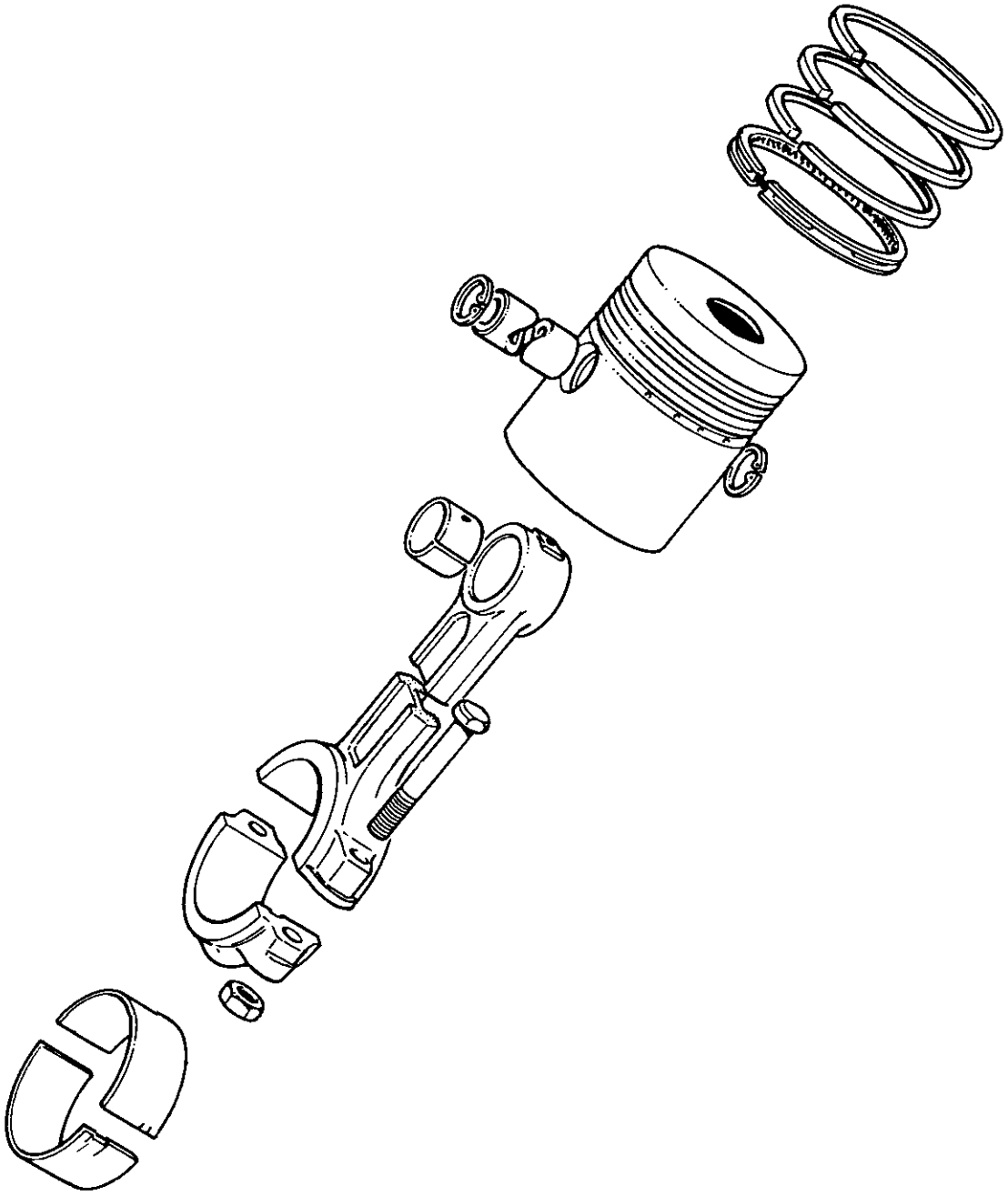
Sludging of the unit is very rare, but when it does occur, it can be remedied by a very brief cleansing in petrol, (gasolene) or paraffin (kerosene), **noting the following critical points:**—

1. Before cleansing, it is **essential** to seal off the small breather hole in the top pressing.

2. If any air line is used to dry out the unit, this must be a low pressure air blast or irreparable damage will result.

# SECTION D
# Pistons and Connecting Rods





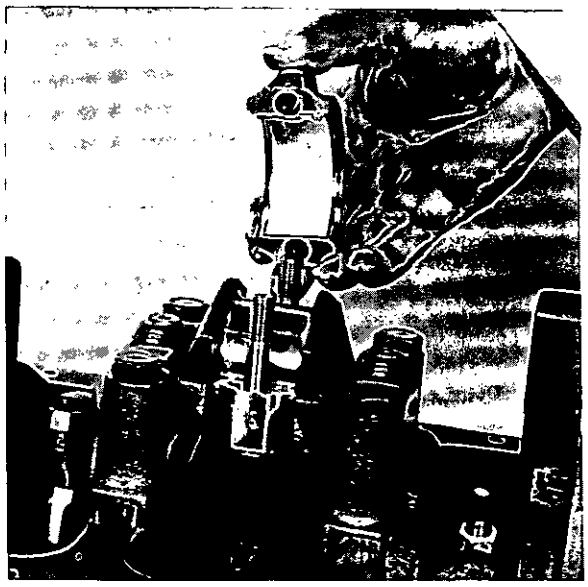


Fig. D.1
Removing Connecting Rod Cap.

3.1522 engine pistons are made of special light aluminium alloy with a "Squish Lip" re-entrant chamber in the crown. 3.1524 and T3.1524 engine pistons have a semi-spherical cavity in the crown.

They are secured to the connecting rods by means of fully floating gudgeon pins which work in thin wall steel backed lead bronze lined bushes fitted in the small ends of the connecting rods. Circlips are provided in the pistons to secure the gudgeon pins in position.

Engines fitted into fork lift truck applications incorporate pistons with four rings. 3.1524, T3.1524 engines and other applications use three ringed pistons. Four ringed pistons have a steel rail fixed in the top of the top groove whereas three ringed pistons have an insert into which the top groove is machined.

The connecting rod big ends are split at right angles to the axis of the rods, the caps being secured by two bolts and nuts.

Always ensure that big end nuts are renewed, once they are removed.

The big end bearings are of the thin wall type consisting of a thin steel shell lined with aluminium tin.

To ensure correct replacement, the pistons are marked 1 to 3, number 1 being at the front of the engine. The number can be found stamped on each piston crown.

The connecting rods and caps, are also marked on one side with a number corresponding to their position in the engine.

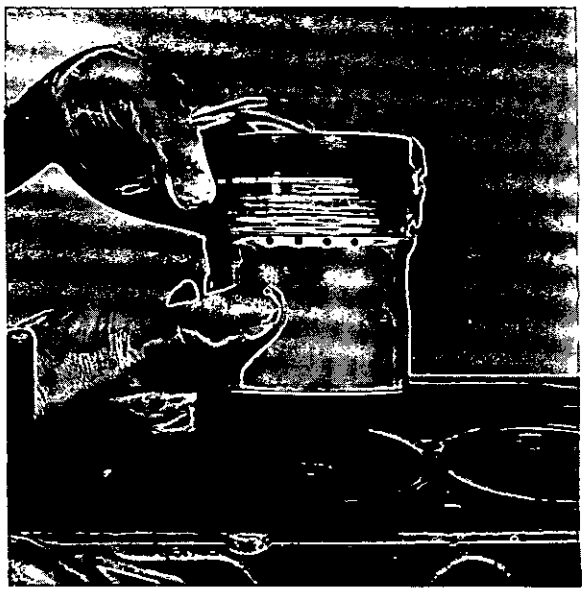


Fig. D.2
Removing Piston.

## To Remove Pistons and Connecting Rods

1. Remove cylinder head assembly (See Page C.2).
2. Remove sump (See Page J.5).
3. Remove oil pump (See Page J.5).
4. Turn crankshaft until one connecting rod is at bottom centre. Remove bolts and nuts securing connecting rod cap.
5. Remove connecting rod cap and both top and bottom half bearing shells (Fig. D.1).
6. The piston and connecting rod can then be pushed out of top of cylinder block (Fig. D.2).
7. Continue operations until all three pistons and connecting rods have been removed.
8. Keep all pistons, connecting rods, caps, bearing shells, bolts and nuts together as separate assemblies, each to each as marked.

## To Remove Gudgeon Pins

Remove circlips from pistons.

Gudgeon pins can now be removed and connecting rods separated from pistons. If pins are tight in pistons, warm latter in liquid to a temperature 100° to 120°F (38—49°C) which will free pins.

## To Fit New Small End Bushes

The small end bushes are a press fit in the connecting rods.

Press out old bushes using a suitable press.

Remove any sharp edges around connecting rod small end parent bores.

Press in new bushes using a suitable dolly, at the same time ensuring that oil holes in bushes coincide with the holes in top of connecting rods (Fig. D.3).

Ream out new bushes in situ to suit their respective *gudgeon pins (See Page A.4), and check for parallel*ism and twist.

## To Assemble Piston and Connecting Rod

If original pistons are to be used again they should be re-assembled to their respective connecting rods, i.e. piston stamped No. 1 should be fitted to connecting rod stamped No. 1.

Pistons should be fitted with offset cavity in crown towards side of connecting rod that is marked with identification number (Fig. D.4).

Offer connecting rod to piston and insert gudgeon pin. To do this it is advisable to warm pistons in liquid to a temperature of 100° to 120°F (38° to 49°C). Gudgeon pin can then easily be pushed into position.

Fit circlips to piston. It is difficult to advise as to when new circlips should be fitted, but in the event of an engine being in service for a lengthy period, it is advisable that new circlips be used, during reassembly.

## Fitting New Rings

Piston and rings should be thoroughly washed to remove any oil and grease.

Check piston rings for correct gap (See Page A.3). When checking gap of coil spring loaded scraper ring, spring should be fitted in ring to expand it against cylinder liner.

In worn cylinder bores, gaps should be checked at unworn top of bore, after any carbon has been removed (Fig. D.5).

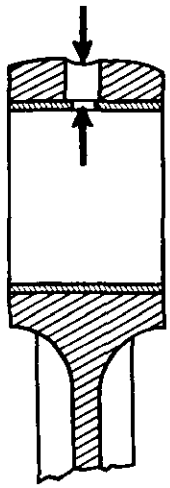


Fig. D.3
Connecting Rod Bush Hole Alignment.

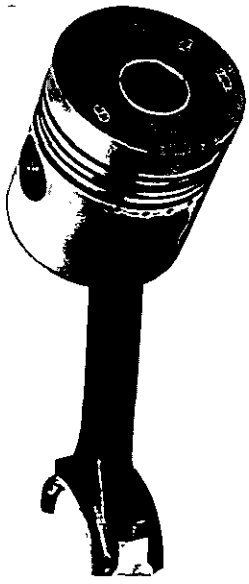


Fig. D.4
Piston Cavity and Con. Rod Mark Relationship.

Fig. D.5
Checking Piston Ring Gap.

D

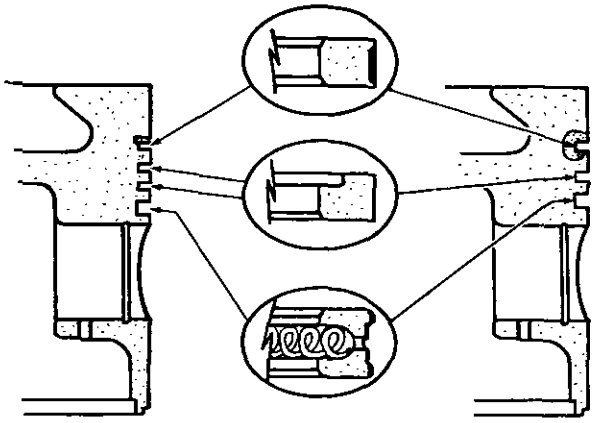


Fig. D.6
Piston Ring Positions.

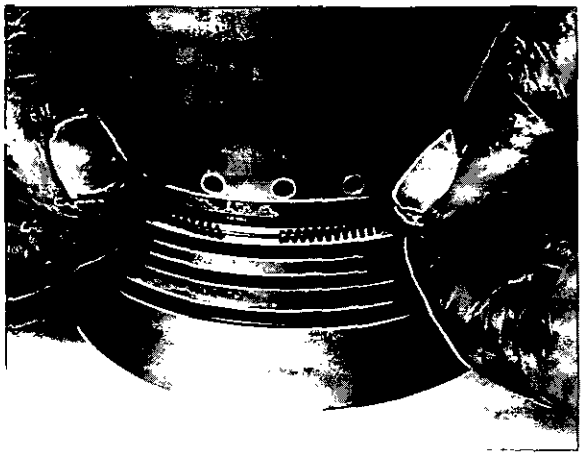


Fig. D.7
Fitting Oil Control Ring Spring.

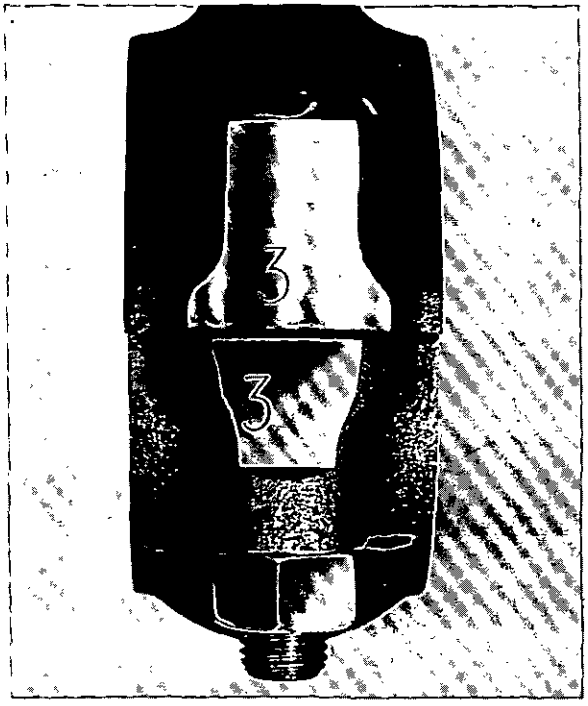



Fig. D.8
Connecting Rod and Cap Markings.

*The compression rings have a thin copper plating* on their periphery to assist in the initial bedding in. This plating will quickly disappear in service giving a ring gap 0.003/0.006 in (0,08/0,15 mm) larger than gap measured with plating on ring.

Fit rings to piston in the following positions (reading from top of piston as shown in Fig. D.6).

## 3.1522 engines

*Chrome inlaid compression.*

Internally stepped compression.

(Internally stepped compression).

Chrome faced, coil spring loaded, scraper ring.

## 3.1524/T3.1524 engines

Tapered semi inlay, chrome face compression.

Taper face compression.

Chrome face, coil spring loaded scraper.

To fit coil spring loaded scraper ring, fit coil spring in piston groove, ensuring that latch pin enters both ends of spring (Fig. D.7) and then fit ring over spring with spring locating in recess in ring and ring gap diametrically opposite to latch pin.

When fitting internally stepped rings, stepped edge should be fitted towards top of piston.

When fitting new rings to original pistons, clean out piston ring grooves using old ring from appropriate groove.

Pistons should be carefully examined for bruising of ring grooves and to ensure that rings move truly in their grooves. In addition piston skirt should be examined and if there is any scoring piston must not be used again.

## To Refit Pistons and Connecting Rods

Connecting rods and caps, are plainly marked to indicate their original position in the engine (Fig. D.8). The numbers are stamped on that side of connecting rod and cap *which is machined to take* locating lips of big end bearings.

Before fitting pistons, cylinder bores should be given a liberal coating of clean lubricating oil.

When fitting pistons and connecting rods to cylinder *block and crankshaft, ensure that side* of connecting rod which is stamped with the number goes to fuel pump side of engine.

Ensure that letter "F", word "Front" or arrow marked on piston crown (Fig. D.9) is towards front of engine. If identifying marks have been removed by piston topping, ensure that cavity in piston crown is towards fuel injection pump side of engine and mark front side of piston crown with a suitable stamp.

Insert pistons and connecting rods into cylinder bores from the top, ensuring piston and rod stamped No. 1 are fitted into No. 1 bore and No. 2 into No. 2 bore and so on commencing from front of engine.

To minimise the possibility of breaking piston rings it is advisable to use a ring compressor (Fig. D.10). Take care not to damage the rings. Should piston accidentally drop partly into cylinder bore and is held suspended by a piston ring it must be taken out again and the ring examined to see if it is cracked or broken.

Turn crankshaft until appropriate crankpin is at bottom centre, pull connecting rod to crankpin and insert the half bearing.

Fit cap and cap half bearing, ensuring that markings on connecting rod and cap coincide.

The nuts used on big end bolts should not be used a second time but should be renewed whenever they are removed.

Tighten connecting rod nuts using a torque wrench set to tension given on page A.2.

Rotate crankshaft by hand and note that all parts move freely.

Check piston height in relation to top face of cylinder block as described below.

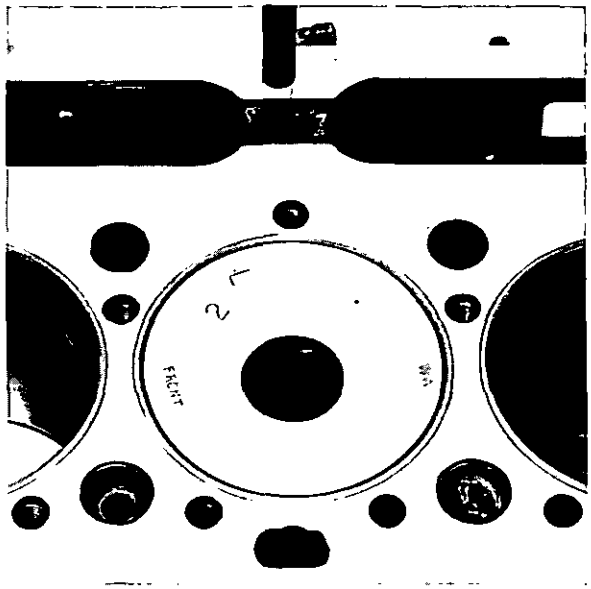



Fig. D.9
Piston Position Marking.

D

## Fitting New Pistons

It is important that correct piston height in relation to cylinder block top face is maintained when a new piston is fitted. For 3.1522 engines, top of piston should be between 0.0012 in (0,03 mm) above to 0.0065 in (0,17 mm) below top face of cylinder block. 3.1524 and T3.1524 engines, the piston height position should be 0.001/0.006 in (0,025/0,152 mm) below top face of cylinder block.

On production, correct height is achieved by using three different height grades of piston. The grade is stamped on top of piston, "H" for high, "M" for medium and "L" for low.

In service, "H" and "L" grades are available. "L" grade pistons can be used to replace "M" or "L" grade pistons but, if used to replace "H" grade pistons, they could be below recommended height which may result in a loss in performance. "H" grade pistons can be used to replace existing "H" grade pistons without any machining but, if used to replace

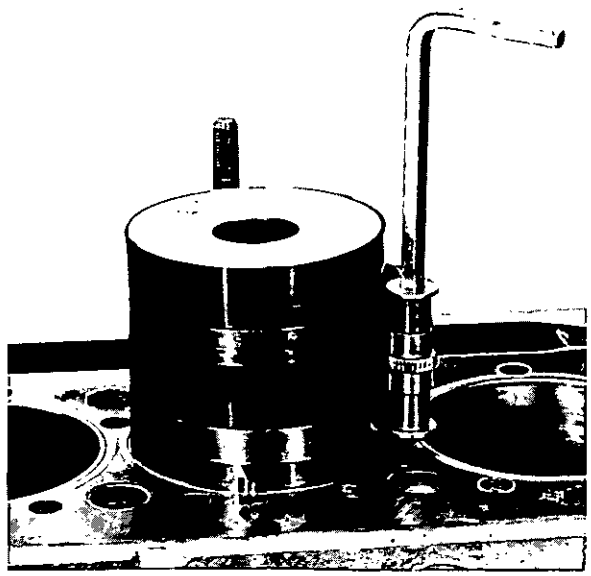


Fig. D.10
Piston Ring Clamp in Position.

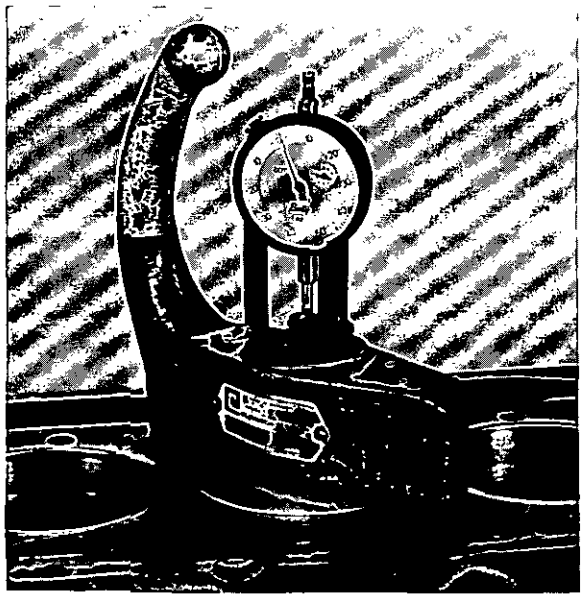


Fig. D.11
*Checking Piston Height.*

"M" or "L" grade pistons, piston crown will have to be skimmed as detailed below.

To determine amount it may be necessary to remove from piston crown, piston assembly and connecting rod should be fitted to cylinder block and crankshaft as previously described.

When assembled, turn crankshaft to bring piston to T.D.C. and check distance between piston crown and top face of cylinder block. Tool 21825019 can be used to check piston height (Fig. D.11).

Carry out this operation with each new piston in turn, making a note of amount of metal to be removed from each piston. After skimming necessary amount from each piston, remove sharp edge from rim of orifice in crown using 360 grit emery paper to give a blend radius of 1/64 to 1/32 in (0,4 to 0,8 mm) as shown in Fig. D.12.

Refit piston assemblies to engine as detailed under *previous heading and recheck piston height. If piston* heights are all correct, stamp top of pistons with appropriate cylinder numbers and front end indication.

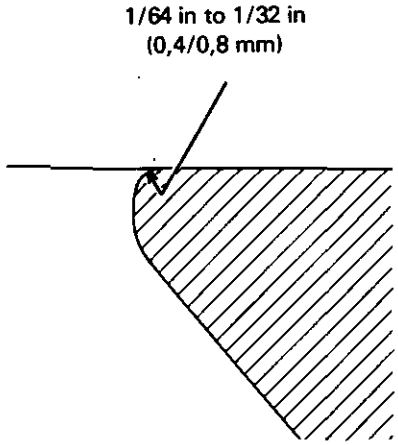
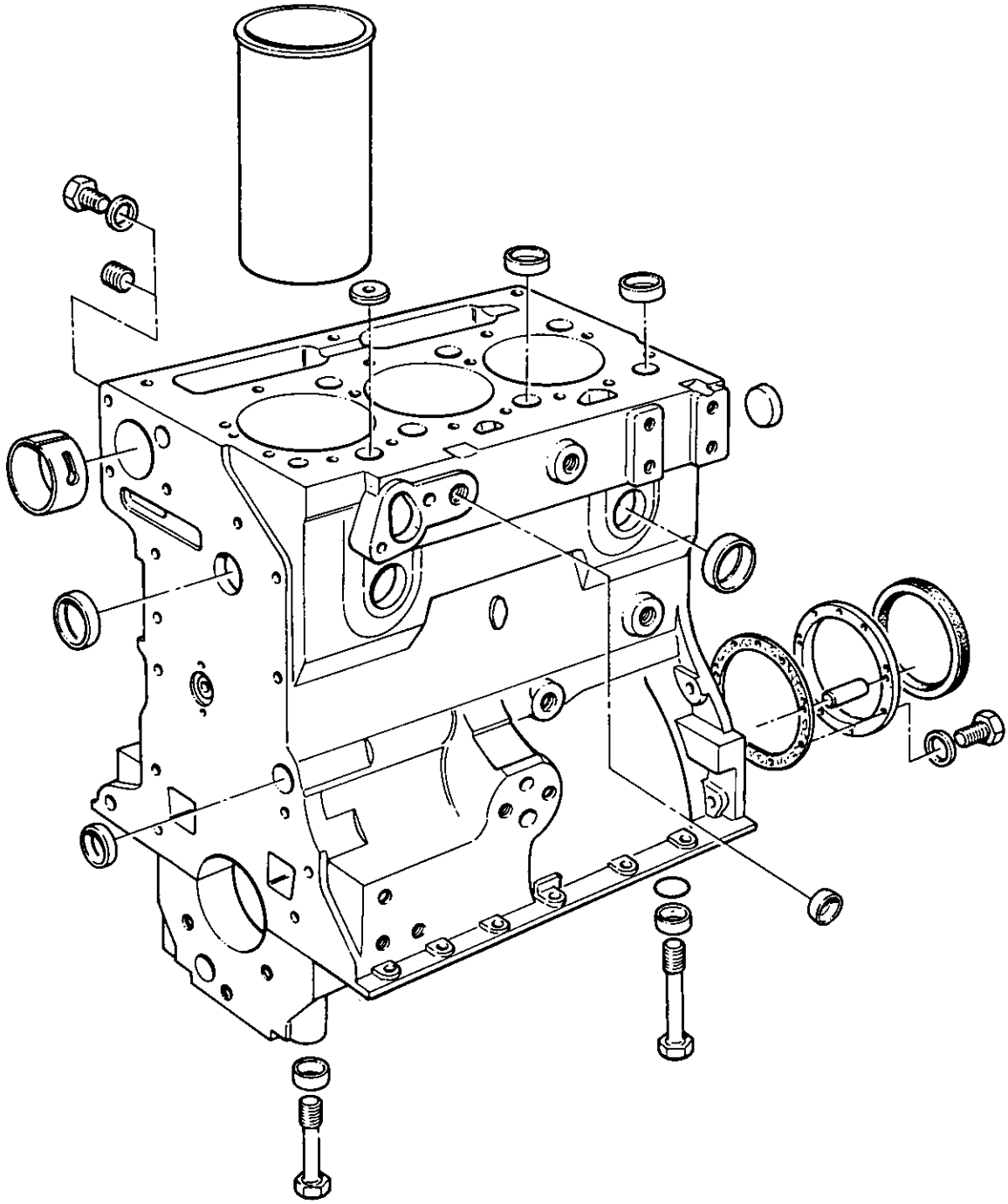



Fig. D.12
3.1522 Piston Orifice Lip Radius.

# SECTION E
# Cylinder Block and Liners



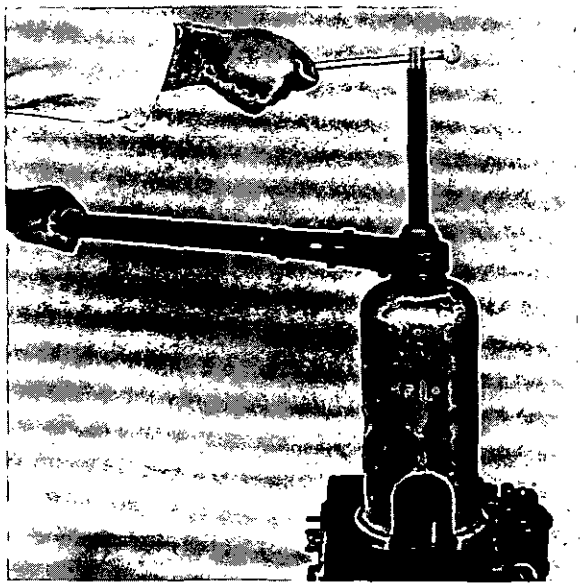


Fig. E.1
Removing Cylinder Liner using Tool 21825052 and Adaptor 21825054.

The cylinder block is fitted with renewable thin wall *cast iron flanged dry cylinder liners. Production* cylinder liners are an interference fit and require boring and honing to size after fitting whereas service liners are a transitional fit and being prefinished, require no further machining after fitting.

The cylinder liners cannot be rebored. When they are worn to an extent whereby engine performance is affected, they should be renewed.

A pre-finished bush is fitted in the block to provide a bearing for the front camshaft journal. When renewing this bush, ensure that the oil hole in the bush corresponds with the oil passage in the block and the end of the bush marked "FRONT" is fitted towards the front of the block.

## To Remove Liners

1. Remove cylinder head as detailed in Section H.
2. Remove piston and connecting rod assemblies, crankshaft and all component parts of cylinder block as detailed in appropriate sections of this manual.
3. Remove cylinder head studs from cylinder block.
4. Press or draw liners out through top of cylinder block (Fig. E.1) ensuring no damage is done to *parent bores (cast iron production liners are an* interference fit and should be removed with a heavy duty press).

Note: Cylinder Liner Remover/Replacer 21825052 with Adaptor 21825054 can be used for replacement of single liners without taking engine out of application. Centre thread and ratchet of tool should be lubricated with Shell Spirex Oil or its equivalent.

## Preparation for Fitting New Liners

After removal of old liners, parent bore must be thoroughly cleaned both in top recess of liner flange and in parent bore itself.

A check must be made to ensure that the whole areas *of contact with liners in cylinder block are free from* burrs, corrosion or damage. Remove any burrs present.

Ensure that new liner is thoroughly clean before fitting. If cleaning fluid is used to wash liner, it is important that liner be thoroughly dried and well oiled before fitting.

Throughout whole operation, extreme cleanliness is essential as entry of smallest particle of grit or other foreign matter is sufficient to cause local distortion of liner bore.

## To Fit New Liners

1. Lubricate outside diameter of liners with clean oil which should be applied by means of a pressure can. The use of a brush is not recommended.

2. Press or draw in new liners (Fig. E.2) using a suitable adaptor ensuring that flanges at top of liners do not foul counter-bore at top of parent bore thus causing distortion at top of internal diameter of liner.

   When fully home, top face of liner flange should be between 0.004 in (0,10 mm) above to 0.004 in (0,10 mm) below top face of cylinder block.

   In order to effect this, it is permissible to use shims under the cylinder liner flange. These are 0.005 in (0,13 mm) thick. Part No. 33127107. Before fitting a cylinder liner, depth of flange and appropriate recess in cylinder block should be measured to ascertain whether a shim or shims (if any) are required to give correct liner height in relation to cylinder block top face.

   The fit of new liners in the parent bore is a transition fit, that is limits extend from minus 0.001 in (0,03 mm) to plus 0.001 in (0,03 mm).

3. It is advisable to allow a settling period to elapse before checking fitted internal bore diameter of liner (Fig. E.3). The acceptable limit is 3.6015/3,6025 in (91,48/91,50 mm). Each new liner should be checked in three positions — top, centre and bottom; readings being taken transversely and parallel to centre line of cylinder block at each position.

4. Having fitted new liners, remainder of re-assembly operations are a reversal of removal procedure.

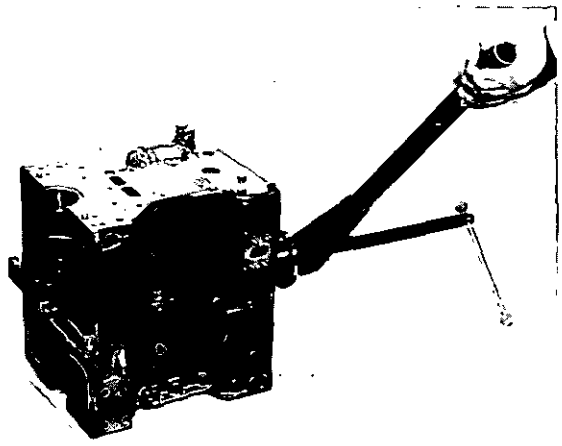
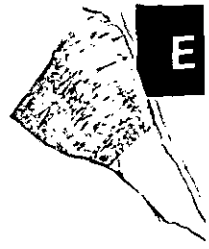


Fig. E.2
*Fitting Cylinder Liner.*



E

35 thou
25 thou Blad

Redhead International

QTP P210
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## Unbored Cast Iron Liners

If desired and where necessary boring equipment is available, unbored cast iron liners (as used in factory production) may be used to replace existing cast iron liners. These are an interference fit in cylinder block as compared with transitional fit of pre-finished liners and require boring and honing in situ to a diameter of 3.6015/3.6025 in (91,48/91,50 mm).

For best results bores should be diamond honed at an inclusive angle of 30° to 35° followed by plateau honing at an inclusive angle of 15° to 35° to a finish of 32/48 micro inches (0,8/1,2 microns) centre line average.

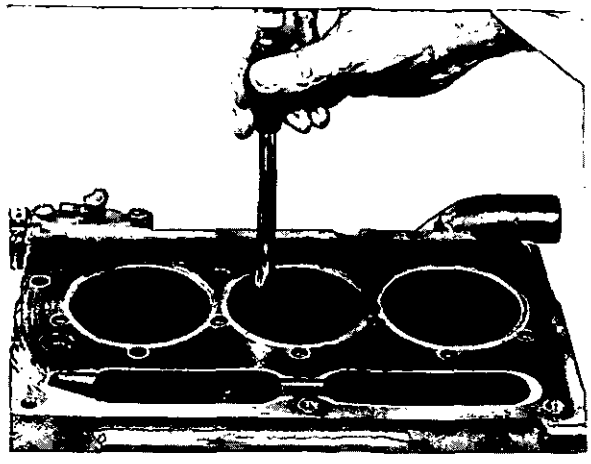


Fig. E.3
Checking Cylinder Liner Bore.

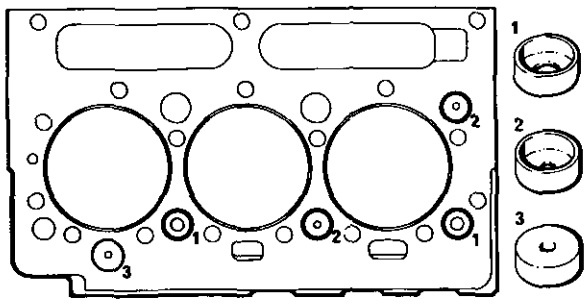


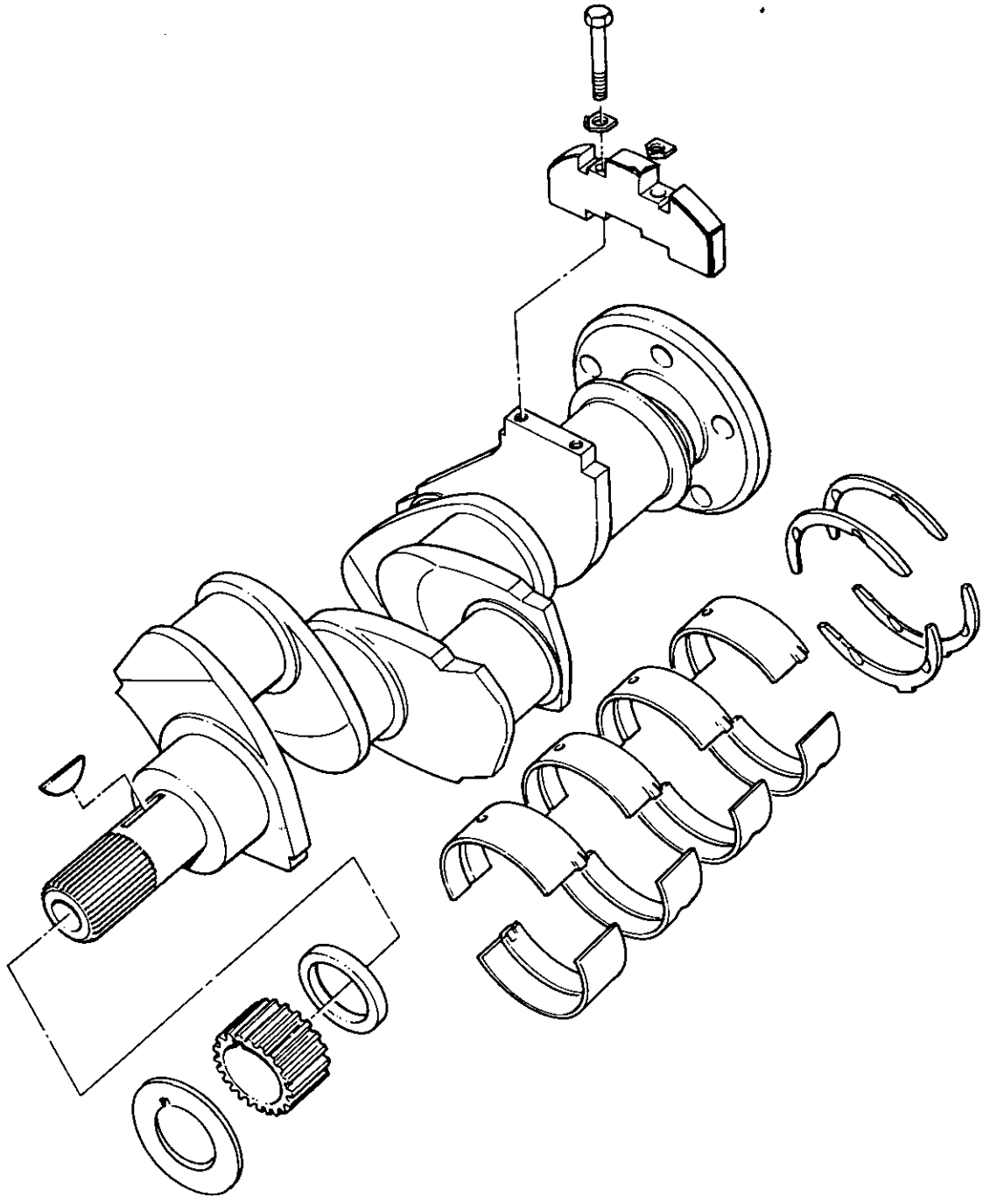

Fig. E.4
Coolant Restriction Plug Positions.

## Coolant Restriction Plugs

Some of the water passages at top of cylinder block are fitted with restriction plugs. If these are removed for any reason, ensure that correct size of restriction plug is fitted into its relevant position as shown in Fig. E.4 and that plugs do not protrude above cylinder block face.

Plug (3) is fitted in cylinder block before top face is machined on production and if this plug is renewed, thickness of the new plug will have to be reduced so that top face of plug, when fitted, is flush with top face of block.

# SECTION F
# Crankshaft and Main Bearings



## CRANKSHAFT AND MAIN BEARINGS—F.2

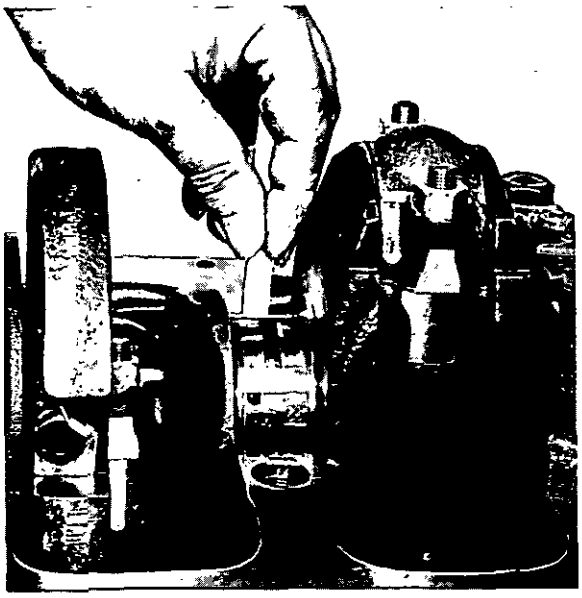


Fig. F.1
Removing Top Half Main Bearing.

The crankshaft runs in four pre-finished replaceable shell bearings lined with aluminium tin.

The crankshaft is fitted with two cast iron counter weights, one at the front crank web and one at the rear crank web to give full rotating balance.

The main bearings are located in position by tabs fitting into slots machined in the bearing housings.

The crankshaft rear end oil seal is a spring loaded rubber lip seal that locates on the periphery of the crankshaft palm.

### Fitting New Main Bearings and Thrust Washers

Under normal circumstances, by the time main bearings and thrust washers require renewing, crankshaft will need to be removed for regrinding. However, if for any reason one or more of bearings or thrust washers have to be renewed or removed for inspection, this can be carried out without removing crankshaft from engine, but engine may have to be removed from the application.

1. To remove a main bearing, take off cap of bearing in question. For rear main bearing cap, flywheel and rear lip seal housing will have to be removed.
2. Do not remove more than one bearing cap at a time.
3. Slacken remaining bearing cap setscrews one or two turns.
4. Remove lower half of bearing from bearing cap.
5. With a suitable piece of wood push out top half of bearing by rotating it on crankshaft, applying tool to side opposite bearing lip. (See Fig. F.1). Locating lips are on camshaft side of engine.
6. Inspect bearing shells and if they require renewing, insert a new half bearing in the top, inserting plain end first. Fit new half bearing to cap.
7. Replace cap and tighten setscrews lightly before proceeding to next bearing.
8. Having replaced bearing and caps, pull down setscrews with a torque wrench set to tension given on page A.2.

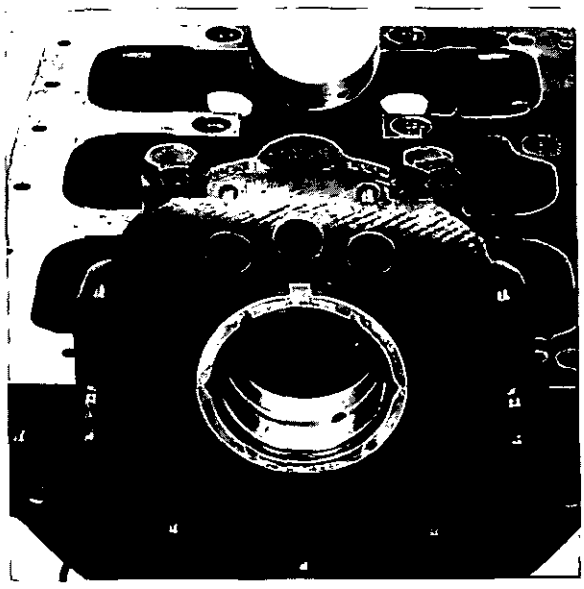


Fig. F.2
Position of Rear Crankshaft Thrust Washers.

The thrust washers fit in recesses provided on either side of rear main bearing housing and cap (Fig. F.2).

1. To renew thrust washers, remove rear main bearing cap. Before doing this it will be necessary to remove flywheel and rear oil seal housing.
2. Remove the two bottom half thrust washers from main bearing cap.
3. The two top half thrust washers can be removed by sliding them round from one side with a piece of wood or similar material and rotating them until they can be removed (Fig. F.3).
4. To fit new thrust washers, lightly coat the two upper halves with lubricating oil and slide in recesses provided on either side of rear main bearing housing. Steel side of the thrust washers should be towards bearing housing.
5. Renew main bearing cap "O" rings. Lightly coat rear main bearing cap butt faces, outboard of grooves machined in the faces, with Perkins (Hylomar) Jointing Compound, as shown in Fig. F.7. Ensure that compound cannot enter grooves.
6. Place the two lower halves on either side of rear main bearing cap and replace cap.
7. Bearing cap securing setscrews should be pulled down with a torque wrench set to tension given on page A.2. Check crankshaft end float (Fig. F.4).
8. Finally secure rear oil seal housing, flywheel, sump, etc.

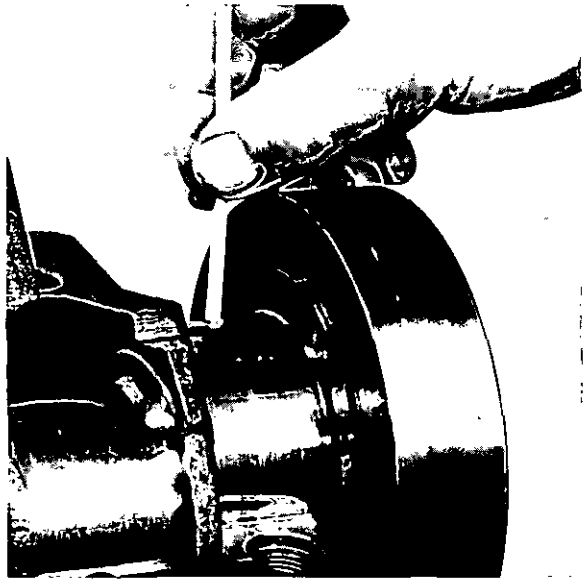


Fig. F.3
Removing Upper Half Thrust Washer.



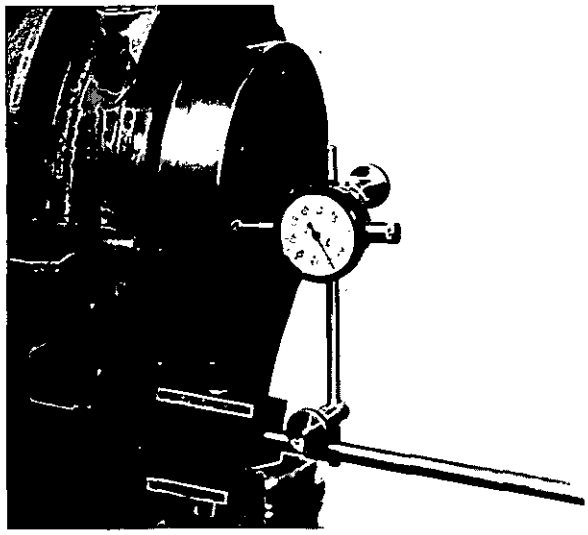


Fig. F.4
Checking Crankshaft End Float.

## To Remove Crankshaft

1. Remove sump and lubricating oil pump (See Page J.5).
2. Remove water pump (See Page K.2).
3. Remove crankshaft pulley.
4. Take off timing case front cover and remove idler gear.
5. Remove starter motor, flywheel and flywheel housing. When removing flywheel, fit two guide studs in crankshaft flange for support.
6. Remove connecting rod caps and big-end bearings.
7. Remove rear oil seal housing.
8. Release main bearing setscrews and remove main bearing caps and lower half bearings, keeping respective bearings and caps together.
9. Lift out crankshaft (Fig. F.5) and remove upper half bearings. Mark bearings to ensure refitment in original positions.

Should it be necessary to remove crankshaft gear, ensure that timing mark is to the front when gear is fitted. Distance piece between gear and crankshaft should be fitted with chamfer to the inside.

If main bearings are to be used again, they should be suitably marked so that they may be replaced in same position from which they were removed.

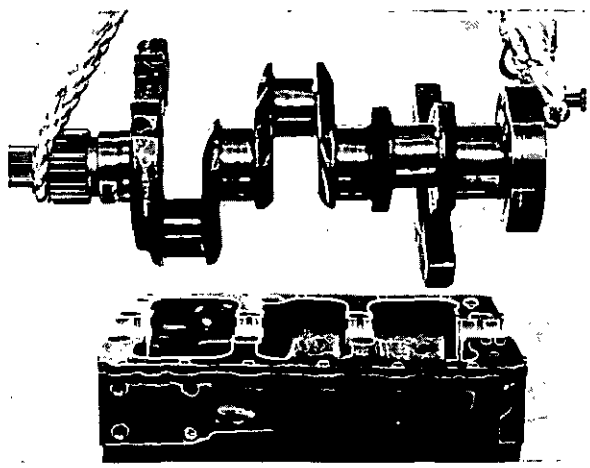


Fig. F.5
Removing Crankshaft.

## Balance Weights

Should it at any time be necessary to renew crankshaft balance weights, these are normally supplied in wired pairs and must be fitted as a pair. Should a single balance weight require replacing, this must be done selectively so that there is no greater weight variation than 1 oz (0,28 g) between individual weights.

## Regrinding Crankshaft

The crankshaft is hardened by the Tufftride process and it will be necessary to re-harden crankshaft after any regrinding is carried out. If facilities are not available for Tufftriding, crankshaft can be re-hardened by the 20 hour nitriding process or, if this is not possible, a replacement crankshaft should be fitted.

Before proceeding to regrind crankshaft, the following points should be checked to ensure it is suitable for further machining.

(a) Crankshaft should be crack-detected before re-grinding. It must, of course, be remembered to demagnetise crankshaft after crack-detecting, in order to remove any polarisation which may be present.

(b) Main journal and crankpin diameters should be checked to ascertain next appropriate size to which crankshaft can be reground, i.e. —0.010 in (0,25 mm), —0.020 in (0,54 mm), or —0.030 in (0,76 mm). See Fig. F.6.

If crankshaft requires to be reground below —0.030 in (0,76 mm) a new crankshaft must be fitted.

During regrinding, all limits must be adhered to, and main journals and crankpins must be free from grinding marks.

After regrinding, sharp corners on oil holes should be removed and crankshaft crack-detected again and demagnetised. Finally crankshaft must be re-hardened.

**Note:** It is important that RADII on the main journals and crankpins are maintained. If these are neglected, a fatigue fracture is liable to occur.

The crankshafts of engines fitted with Lip Type rear oil seals have a rear flange with an extended width of over one inch (25 mm) to provide a seat for the lip seal (Page F.6). If all the three positions for this seal have been used, the sealing area of the flange may be reground to a minimum diameter of 5.243 in (113,17 mm), leaving an unmachined diameter for a distance of 3/16 in (4,8 mm) from the rear end.

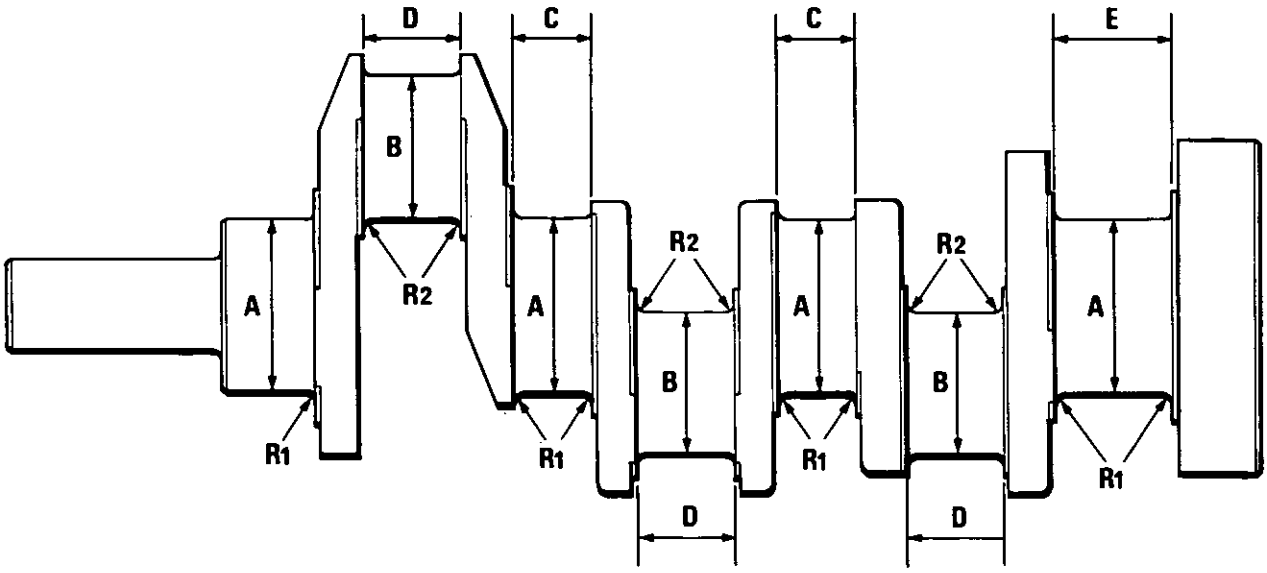



Fig. F.6
Crankshaft Regrinding.

| | 0.010 in (0,25 mm) Undersize | 0.020 in (0,51 mm) Undersize | 0.030 in (0,76 mm) Undersize |
|---|---|---|---|
| A | 2.7385/2.7393 in (69,56/69,58 mm) | 2.7285/2.7293 in (69,30/69,32 mm) | 2.7185/2.7193 in (69,05/69,07 mm) |
| B | 2.2384/2.2392 in (56,86/56,88 mm) | 2.2284/2.2292 in (56,60/56,62 mm) | 2.2184/2.2192 in (56,35/56,37 mm) |
| C | 1.2277 in (31,18 mm) maximum | | |
| D | 1.570 in (39,38 mm ) maximum | | |
| E | 1.861 in (47,27 mm) maximum | | |
| R1 | 0.094/0.109 in (2,39/2,77 mm) all journals | | |
| R2 | 0.156/0.172 in (3,96/4,37 mm) all crank pins | | |

Surface finish of crankpins, journals and fillet radii 16 to 8 micro inches (0,4/0,2 microns) C.L.A.

Only the minimum of metal should be ground off to ensure removal of the seal wear grooves and the surface finish should be the same as the crankpins and journals.

It is not necessary to re-Tufftride the flange after this operation.

## To Fit Crankshaft

1. Ensure that all oil-ways are clear.
2. Check main bearing setscrews for stretch or damage to threads. Affected setscrews must be scrapped.

   In no case should setscrews other than those supplied by the engine manufacturer be used as they are of special heat treated high-grade steel.
3. Clean bearing housings and place top half bearings in position.
4. Place crankshaft in position.
5. Lightly smear the two upper thrust washers with lubricating oil and slide in recesses provided on either side of rear main bearing housing, with steel side of washers towards housing.
6. Renew main bearing cap "O" rings (Fig. F.7).
7. Lightly coat rear main bearing cap butt faces, outboard of the grooves machined in the faces, with Perkins (Hylomar) Jointing Compound as shown in Fig. F.7. Ensure that compound cannot enter grooves.
8. Fit lower halves of main bearings to bearing caps and lubricate with clean engine oil. Place in position ensuring that thrust washers are fitted correctly to No. 4 main bearing cap.
9. When replacing main bearing caps, ensure that they are fitted in their respective positions, also that they are fitted correct way round. The inner caps are numbered 2 and 3, from front of engine. Each cap is also marked with a serial number and when fitted, this number should read in line with serial number stamped on cylinder block bottom face (See Fig. F.8).

For final tightening of setscrews, a torque wrench should be used, set to tension given on page A.2.

When refitting crankshaft pulley, ensure that pulley setscrew is tightened to correct torque as given on Page A.2. For majority of applications, pulley is secured with a 1½ in (38 mm) A/F setscrew and a 0.35 in (8,9 mm) thick washer and this arrangement employs a higher torque than pulleys fitted with a similar setscrew or a 1⅛ in (29 mm) A/F setscrew and a $\frac{3}{16}$ in (4,8 mm) thick washer.

Re-assemble engine as required and to instructions given for the various operations.

## Crankshaft Rear End Oil Seal

A circular, spring loaded, lip seal is fitted, which locates on periphery of flange of crankshaft.

This type of seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to crankshaft. Any visual damage across lip

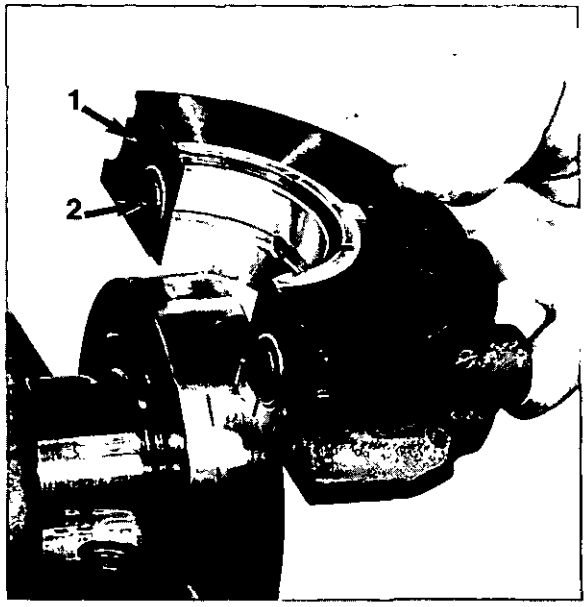



Fig. F.7
Fitting Rear Main Bearing Cap.

1. Jointing Compound 2. 'O' Ring and Dowel

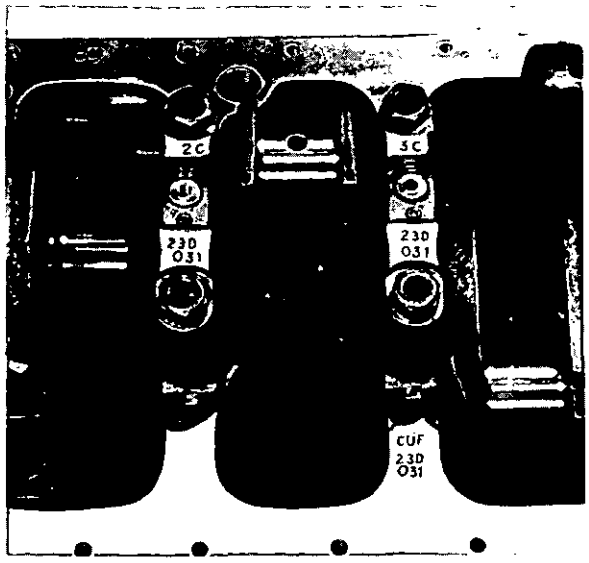



Fig. F.8
Main Bearing and Cylinder Block Markings.

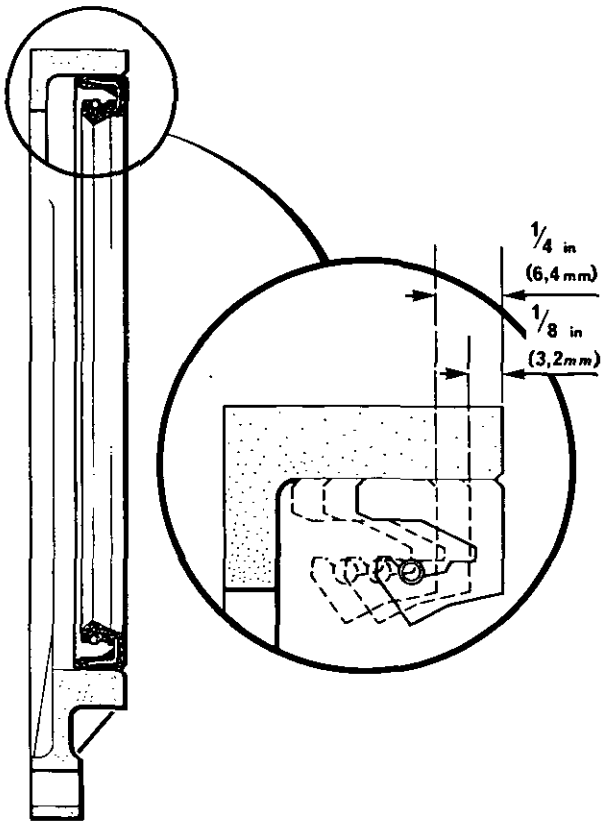



Fig. F.9
Fitting Rear Oil Seal in Housing (Early).

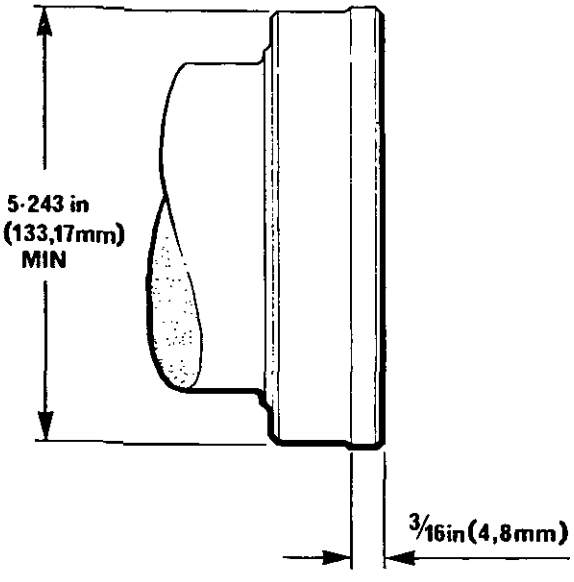



Fig. F.10
Crankshaft Palm Machining Limits.

of a new seal will cause leakage and prevent bedding in of new seal.

The seal is designed to function correctly with direction of rotation of engine and for identification purposes, seal is marked with an arrow.

Earlier seals have a flat face as shown in Fig. F.9. Later seals have a protruding dust lip from the rear face as shown in Fig. F.11.

## To Fit Lip Seal in its Housing

On production, the old type seal was fitted flush with the rear face of the housing (Fig. F.9) but the new type seal is fitted deeper into the housing at 'A', Fig. F.11.

In service, when a new seal is fitted to a worn crankshaft, it should be pressed further into the housing. In the first instance it can be pressed in to 1/8 in (3,2 mm) for old type seals or position 'B' for new type seals or, if this position has been used, to 1/4 in (6,4 mm) for old type seals or position 'C' for new seals.

If a new type seal is used in place of an existing old type seal, position 'C' should be used if the old seal was fitted 1/8 in (3,2 mm) below the housing face.

If all three positions have been used, it may be permissible to machine the worn sealing area of the crankshaft flange (See Page F.4).

When a new seal is fitted to a new or reconditioned crankshaft in service, it should be fitted in the production position, but if latest seal is not to be used in a wet back end application, it must be fitted flush with the housing rear face ('D', Fig. F.11).

When pressing in the latest type seal, ensure that the adaptor has a suitable recess to clear the protruding dust lip. The PD145C can be used with both type seals.

Before fitting seal in housing, carefully examine seal for damage, especially on lip and outside diameter.

Using clean engine lubricating oil, lubricate outside diameter of seal and inside diameter of housing.

Press seal into housing to required position, taking care that seal is entered and pressed in squarely, otherwise damage to outside diameter of seal may occur, or if it is not square in housing when fitted to engine, it may leak.

The seal and housing should be fitted, using seal guide PD 145C as follows:—

Clean faces of cylinder block and oil seal housing, and outside diameter of crankshaft flange.

Check that seal and outside diameter of crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in correct position as previously detailed.

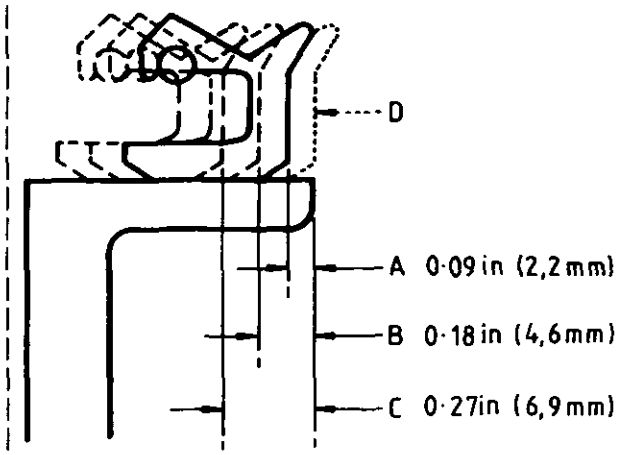



Fig. F.11
Fitting Rear Oil Seal in Housing (Later).

Ensure that the two dowels are fitted in cylinder block. Coat both sides of joint with Perkins (Hylomar) Jointing Compound and position over dowels in block.

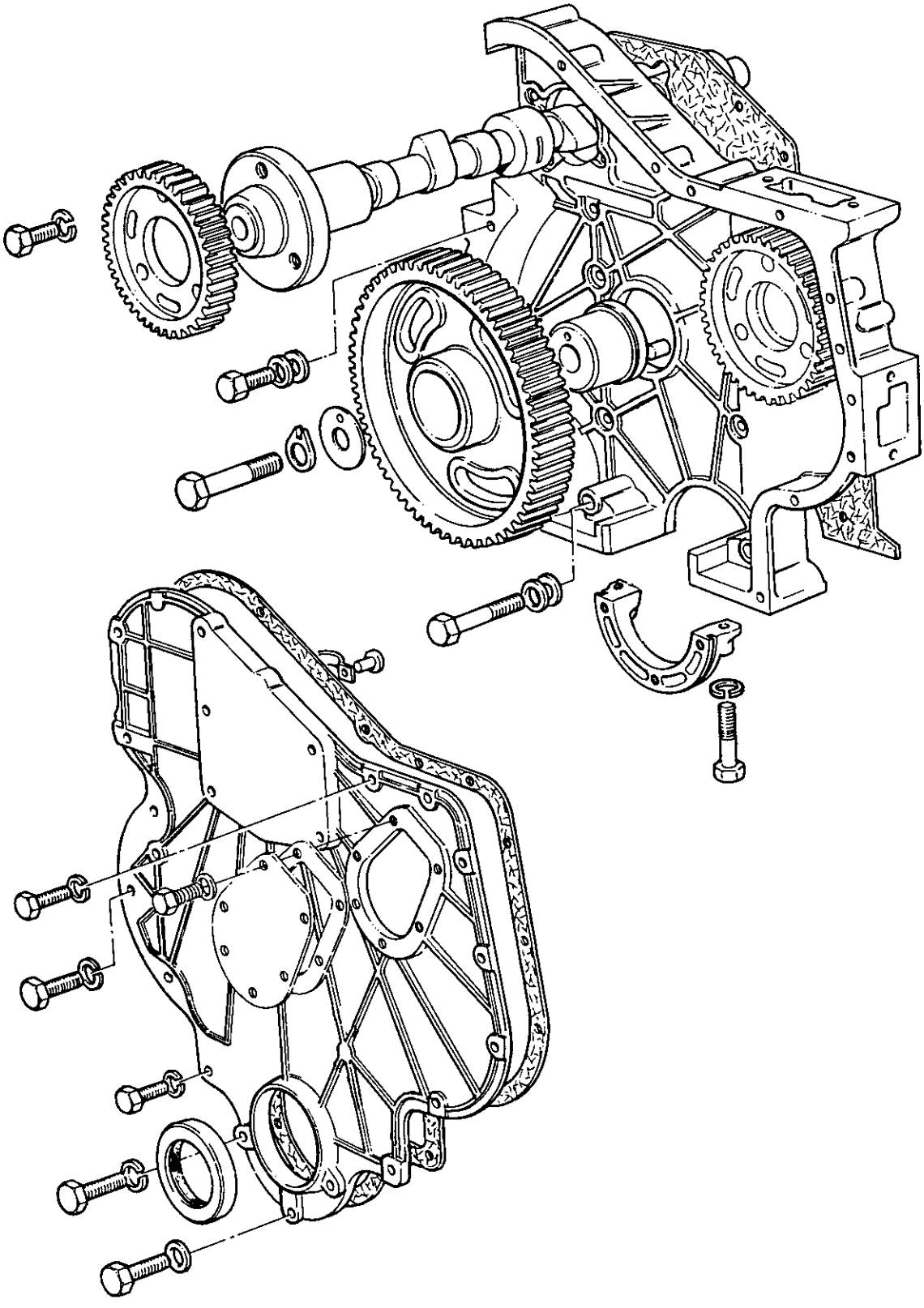
Using clean engine lubricating oil, lubricate crankshaft flange, seal and seal guide. Lubrication of seal is necessary to prevent damage that may be caused by initial dry running.

Position seal and housing on seal guide, locate guide on crankshaft flange and gently press seal and its housing into position on flange, locating housing on its dowels.

Withdraw the guide and secure the housing with set-screws and washers.

F

# SECTION G
# Timing Case and Drive



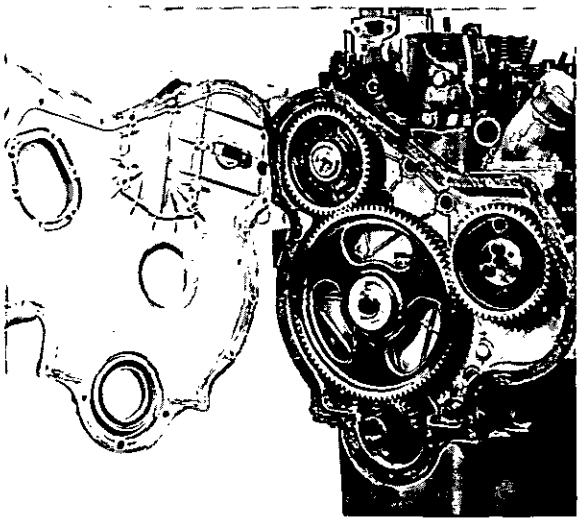


Fig. G.1
Removing Timing Case Cover.

The camshaft is carried high up on the right hand side of the cylinder block, the construction of which eliminates push rods.

It is driven from the front of the crankshaft by means of gears which also drive the fuel pump.

The timing gears are enclosed by a die-cast timing case cover.

## Camshaft Bush No. 1 Bearing

No. 1 camshaft bearing housing in the cylinder block is bushed.

Using a suitable tool and adaptor, worn bush may be extracted and replaced by a new prefinished bush. Ensure that bush is fitted with word "Front" to front of block and oil hole and drilling aligned.

## To Remove Timing Case Cover

1. Slacken generator mounting bolts and remove fan belt.
2. Slacken off hose clips on hoses fitted to water pump and remove water pump.
3. Remove crankshaft pulley.
4. Remove generator.
5. Remove generator brackets and adjusting linkage.
6. Remove timing case cover setscrews. Two long bolts pass through timing case to secure a cover at rear of timing case, blanking off power take off bore. In addition to the two long bolts passing through timing case to secure generator brackets, a further long bolt passes through timing case cover, above position of generator brackets. The bottom setscrew below the front oil seal is fitted with an aluminium washer.
7. Remove timing case cover (Fig. G.1) taking care not to damage crankshaft front oil seal which is located in timing case cover.

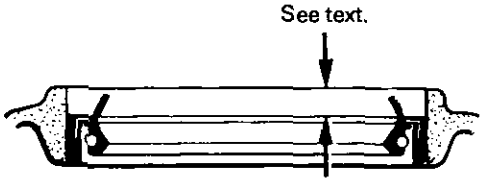



Fig. G2
Cankshaft Front Oil Seal Position.

## To Renew Crankshaft Front Oil Seal

1. Press out old seal from timing case cover using a suitable dolly and supporting cover in vicinity of seal bore.
2. Press in new seal with spring loaded lip towards inside of cover until flat front face of seal is .625 in (16 mm) below front face of timing case cover (Fig. G.2). Later engines are fitted with a black 'Viton' type seal and the depth of this seal from the front face of the timing case cover is 0.375 in (9,35 mm) (Fig. G.2).

## To Refit Timing Case Cover

1. Clean jointing faces of timing case and its cover using a new joint, refit cover and water pump taking care not to damage front crankshaft oil seal as cover is entered over crankshaft front end.
2. For purposes of centralising cover around crankshaft, fit pulley to crankshaft and fix position of cover to timing case by two or three setscrews. Remove pulley and refit all setscrews to timing case.
3. Replace crankshaft pulley, washer and setscrew, tightening setscrew to torque given on Page A.2.
4. Refit hoses to water pump and tighten clips.
5. Replace generator bracket, generator and fan belt and tighten generator retaining bolts.

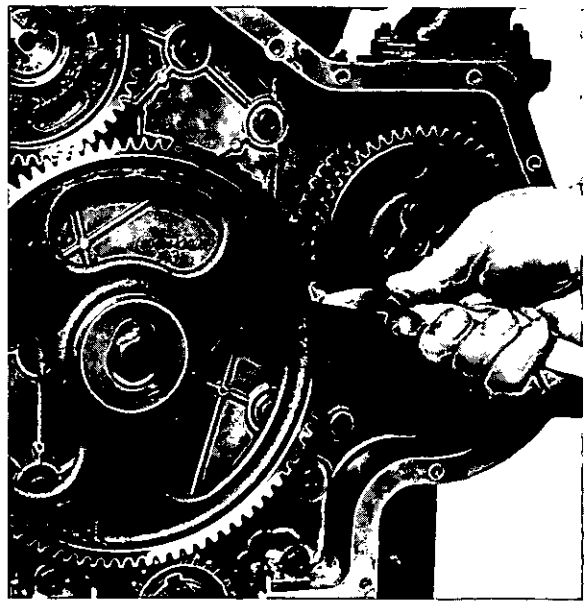


Fig. G.3
Checking Timing Gear Backlash.

## Timing Gears

The camshaft and the fuel pump gears are driven by the crankshaft gear through an idler gear. All the gears are suitably marked during production to facilitate re-timing, the marks being made with No. 1 piston at top dead centre on its compression stroke. It will be appreciated that these timing marks will not align at every rotation of the crankshaft where No. 1 piston is at T.D.C. compression, due to the different rotational speeds of the gears.

If it is necessary to replace any of the timing gears, ensure that there is a minimum backlash of 0.003 in (0,08 mm) — see Fig. G.3.

## To Remove Idler Gear and Hub

1. Turn crankshaft until marked teeth of crankshaft and camshaft gears are in mesh with idler gear.
2. Bend back locking washer on idler gear retaining setscrew, and remove setscrew, locking washer and idler gear retaining plate.
3. Remove idler gear from its hub (Fig. G.4).
4. Remove idler gear hub from its machined location in timing case.

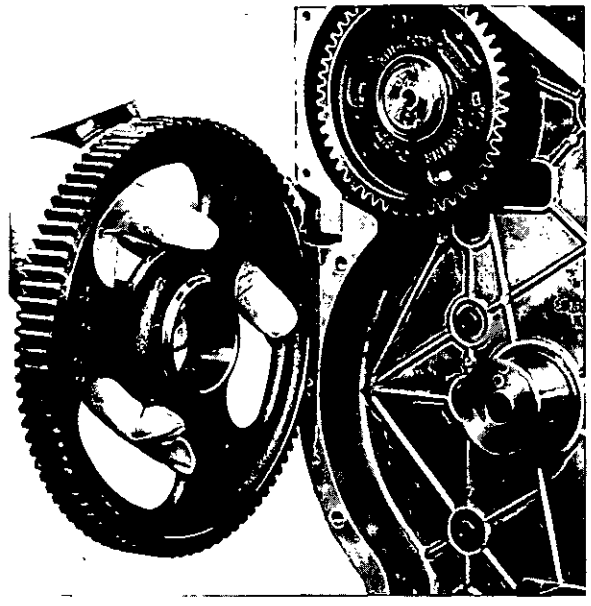


Fig. G.4
Removing Idler Gear.

## To Refit Idler Gear and Hub

1. Ensure that crankshaft, camshaft and fuel pump gears are positioned as shown in Fig. H.1 with their marked teeth towards the idler gear position. If crankshaft or camshaft needs to be turned, rocker shaft may have to be removed to prevent a piston striking a valve.
2. Replace idler gear hub so that small locating peg is entered into through drilling in hub, ensuring

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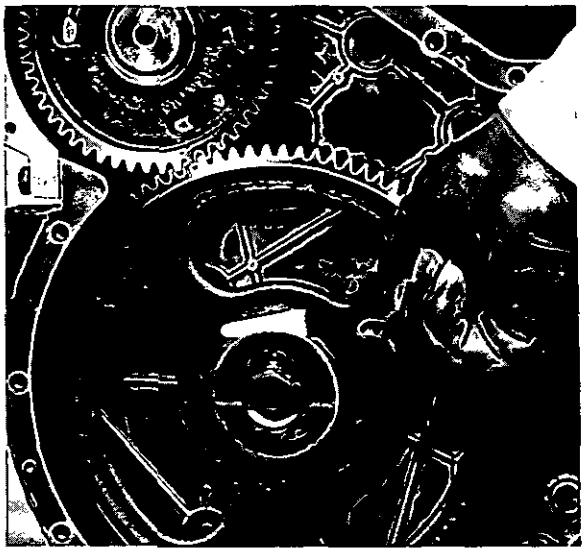

Fig. G.5
Checking Idler Gear End Float.

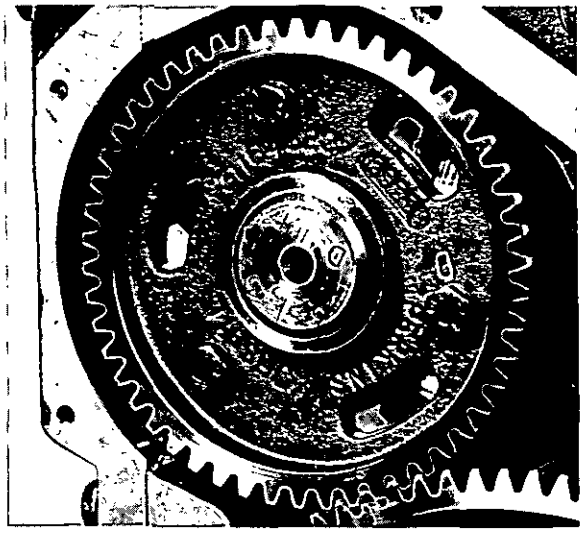

Fig. G.6
Camshaft Gear Alignment Marks.

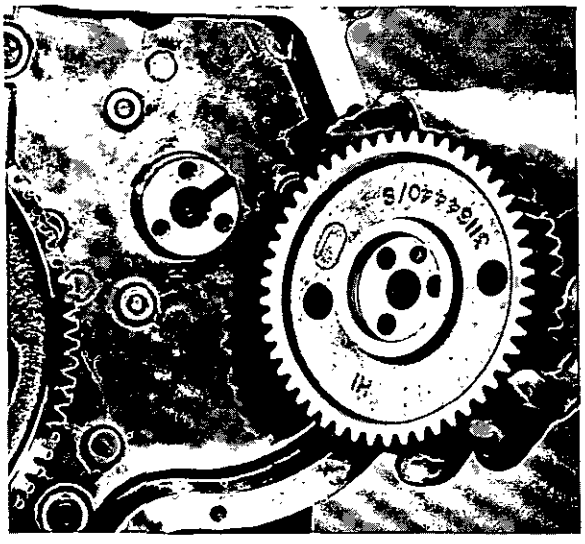

Fig. G.7
Removing Fuel Pump Gear.

hub is fully located. The flange of the hub should be flush with timing case.

3. Fit idler gear on hub with long tapered centre boss towards cylinder block and timing marks aligned.
4. Replace idler gear retaining plate, locking washer and retaining setscrew. Fully tighten setscrew and bend up locking washer. Ensure that idler gear has end float on hub (Fig. G.5). End float should be between 0.005 in to 0.015 in (0,13 to 0,38 mm).

## To Remove Camshaft Gear

1. Turn crankshaft until marked teeth of crankshaft and camshaft gears are in mesh with idler gear.
2. Release and remove the three securing setscrews and shakeproof washers.
3. Camshaft gear may now be removed from camshaft.

## To Refit Camshaft Gear

1. Remove idler gear and, if necessary, release the rocker assembly to facilitate turning of camshaft.
2. On spigot of camshaft will be seen the letter "D" stamped adjacent to a fixing hole and on camshaft gear another letter "D" will also be seen stamped adjacent to a fixing hole (Fig. G.6). Offer camshaft gear to camshaft, ensure holes with letter "D" stamped adjacent them are in line. On no account secure gear to camshaft by slotted holes.
3. Replace and secure the three washers and setscrews.
4. Turn camshaft until Nos. 4 and 6 cams are upright, this can be checked by watching the tappets, and this is the approximate position for aligning timing marks.
5. Fit idler gear, aligning all timing marks and secure rocker assembly, where necessary.

## To Remove Fuel Pump Gear

1. Turn crankshaft until marked tooth of fuel pump gear is in mesh with idler gear.
2. Remove the idler gear.
3. Release and remove fuel pump gear securing setscrews.
4. Remove fuel pump gear, taking care not to damage the dowel (Fig. G.7).

## To Refit Fuel Pump Gear

1. If necessary fit dowel into fuel pump gear.
2. Refit gear locating dowel between gear and fuel pump.
3. Refit and secure washers and setscrews.
4. Refit idler gear, aligning all timing marks.

## To Remove Camshaft

1. Remove rocker shaft assembly as previously described.
2. Remove timing case cover as previously detailed.
3. Turn crankshaft until marked teeth of crankshaft and camshaft gears are in mesh with idler gear.
4. Remove fuel lift pump (See Section L).
5. Lift tappets and remove camshaft and gear from its location in cylinder block taking care not to damage journals, cams or tappets (Fig. G.8).

## To Refit Camshaft

1. Where necessary, remove idler gear and re-position with marked teeth in mesh with marked teeth of crankshaft and fuel pump gears.
2. Lift tappets, and carefully fit camshaft and gear continually turning camshaft. Take care not to damage journals, cams or tappets. Make sure timing marks on idler gear and camshaft are aligned correctly.
3. Refit fuel lift pump.
4. Replace timing case cover.
5. Refit rocker shaft and reset tappets.
6. Replace cylinder head cover.

## Camshaft Thrust

The camshaft end float is taken up by a steel spring rivetted to the timing case front cover. This can be seen in Fig. G.1.

## To Remove Timing Case

1. Remove timing case cover as previously detailed.
2. Release and remove rocker shaft assembly.
3. Remove sump (See Section J).
4. Remove timing case bottom cover (Fig. G.9).
5. Remove idler gear as detailed previously. It is easier to remove the idler gear hub when the timing case is removed.
6. Remove fuel lift pump.
7. Lift tappets and remove camshaft, complete with its gear, taking care not to damage cams or bearing journals.
8. Release the three setscrews and remove driving gear from fuel injection pump.
9. Remove all cables and pipes from fuel injection pump. When removing the high pressure pipes from pump, release pipes at atomiser end and remove pipes completely.
10. Unscrew and release the three nuts, spring washers and plain washers securing fuel pump flange to timing case and remove fuel injection pump. Ensure that all inlet and outlet connections

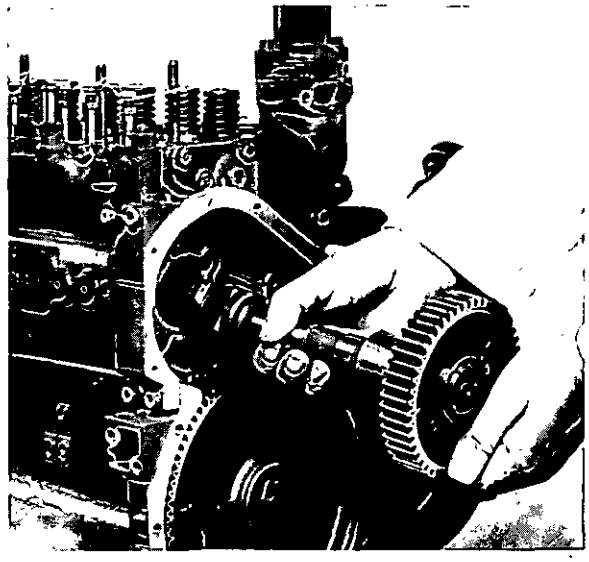

Fig. G.8
Removing Camshaft and Gear

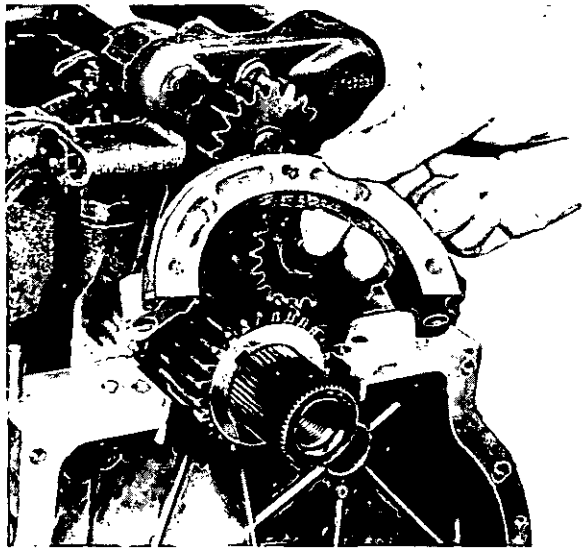

Fig. G.9
Removing Timing Case Bottom Cover.

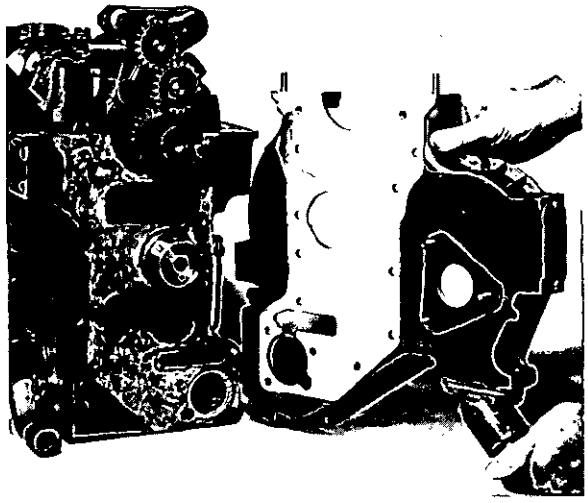

Fig. G.10
Removing Timing Case.

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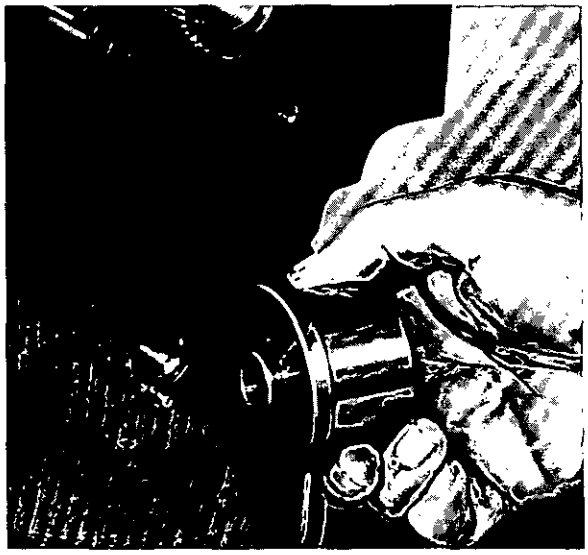


Fig. G.11
Fitting Idler Gear Hub.

Fig. G.12
Fitting Timing Case Bottom Cover.

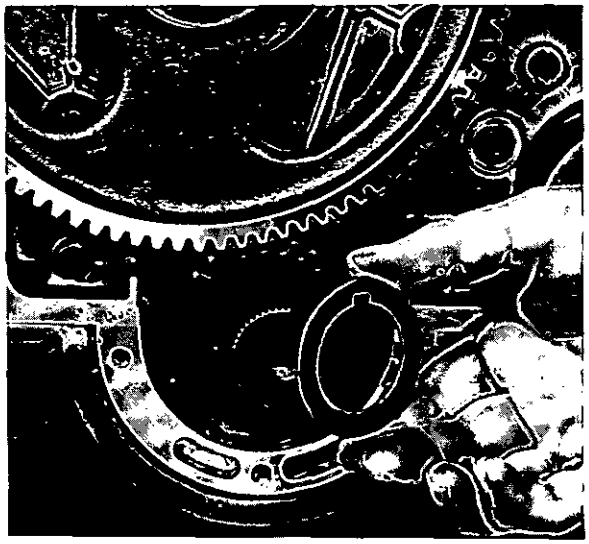


Fig. G.13
Fitting Crankshaft Pulley Spacer Washer.

of fuel injection system are effectively sealed against ingress of dust and dirt by use of suitable caps and plugs.

11. Remove setscrews, shakeproof and shim washers securing timing case to block and with a light tap remove timing case from cylinder block (Fig. G.10).
12. Remove idler gear hub.

## To Refit Timing Case

1. For purpose of correct location of timing case, it is advisable to fit and fully locate idler gear hub to cylinder block (Fig. G.11).
2. Fit a new joint to cylinder block front face and refit timing case.
3. Refit timing case bottom cover ensuring it is correctly aligned with front face of timing case (Fig. G.12).
4. Secure fuel injection pump to back of timing case ensuring scribed lines on pump flange and back face of timing case are in line.
5. Turn engine crankshaft until No. 1 piston is at top dead centre (key on the front of the crankshaft vertically upwards).
6. Fit fuel pump gear to fuel pump, locating dowel between gear and pump.
7. Lift tappets and replace camshaft and its gear, turning camshaft as it is being entered into camshaft tunnel.
8. Refit idler gear on its hub with long tapered flange of gear towards cylinder block and marked teeth of crankshaft gear, fuel pump gear and camshaft gears in mesh with marked teeth of idler gear.
9. Refit sump (Section J).
10. Where necessary, fit crankshaft pulley spacer washer (Fig. G.13).
11. Refit timing case cover.
12. Refit all fuel pipes and controls.

## Fitting New Timing Case

In the event of a new timing case being required, this will not be marked with a scribed line for the correct alignment of fuel injection pump. After fitting timing case as detailed previously, fuel injection pump timing should be checked by one of the two methods given in Section H and rear of timing case scribed with a line corresponding to line on pump flange or slot in timing tool pointer.

# SECTION H
# Timing

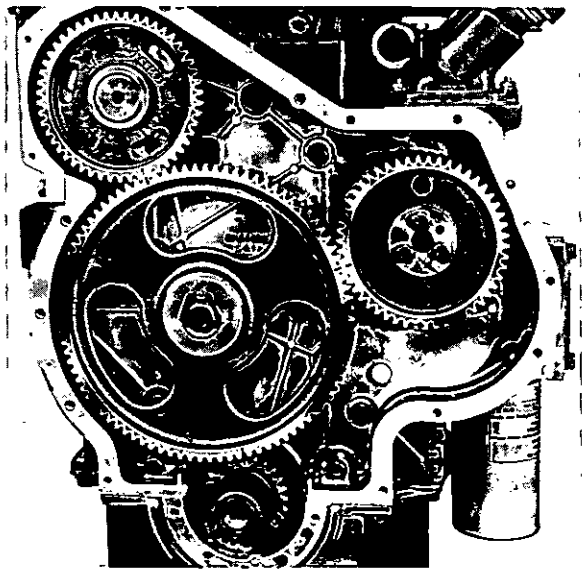


Fig. H.1
Timing Gear Markings.

The timing or the resetting of the timing can be simply and quickly carried out if the following instructions are borne in mind.

It is well to remember that the removal of the cylinder head does not in any way affect the timing of the engine.

## Timing Marks

When the engine is timed at the factory, certain marks are stamped on the gears, so that if for any reason the timing has to be broken, then the engine can easily be reset to its original timing.

The method of marking is as follows:—

With the engine timing correctly set, the engine is turned until No. 1 piston is at T.D.C. on its compression stroke. In this position, scribed lines or centre punch marks are marked on the idler gear to correspond with lines or centre punch marks on the camshaft, fuel pump and crankshaft gears respectively (See Fig. H.1).

Due to the different rotational speeds of the gears, these marks will not align at every rotation of the crankshaft where No. 1 piston is at T.D.C. compression stroke.

## Fuel Injection Pump Timing Marks

On the fuel pump mounting flange is a scribed line which, when the fuel pump is fitted should coincide with a scribed line on the rear face of the timing case (See Fig. H.2). Providing these scribed lines are in alignment and the fuel pump gear correctly fitted, then the fuel pump timing should be correct.

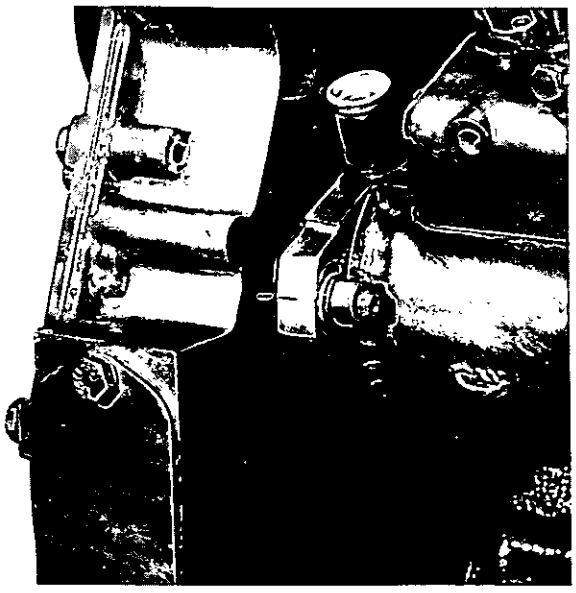


Fig. H.2
Fuel Injection Pump Timing Marks.

## To Reset Engine Timing

Remove atomisers.

Position crankshaft so that crankshaft gear key is at T.D.C. Where necessary,fit crankshaft gear ensuring that the timing mark is towards the front. When turning crankshaft, it may be necessary to remove rocker shaft assembly to prevent a piston hitting a valve.

Fit camshaft gear ensuring letter "D" stamped adjacent to one of the fixing holes is in alignment with letter "D" stamped on camshaft hub.

Fit fuel pump gear. This is dowelled and will only go on in one position.

Check that fuel pump is correctly fitted to engine with scribed line on mounting flange in line with scribed line on rear face of timing case (Fig. H.2).

With crankshaft gear fitted, replace idler gear ensuring timing marks coincide (Fig. H.1).

The timing can be checked as detailed below.

## To Check Valve Timing

Turn engine until maximum lift is obtained on No. 3 cylinder exhaust valve.

In this position, set clearance between rocker lever and No. 1 inlet valve to 0.0315 in (0,80 mm).

Now turn engine in normal direction of rotation until tappet of No. 1 inlet valve just tightens.

At this point, No. 1 piston should be within 2½° of T.D.C. This can be ascertained by checking the T.D.C. mark on the flywheel or, in some instances, by means of a timing pin fitted in the timing case cover. The pin, when unscrewed, should enter a timing drilling in the rear face of the crankshaft pulley when No. 1 piston is at T.D.C.

There is no adjustment for valve timing. If the timing is incorrect and the gear is correctly fitted to the camshaft, then the timing gears are probably one or more teeth out of correct mesh.

When timing is found to be correct, adjust valve clearance of No. 1 inlet valve to 0.008 in (0,20 mm).

## To Check Fuel Pump Timing Using Pump Rotor Marks

A circlip is provided inside the pump for timing purposes and when correctly set the squared end of this circlip should line up with the relevant scribed line on the fuel pump rotor at the commencement of injection to No. 1 cylinder (Static Timing Position).

Each scribed line on the pump rotor has an identifying letter adjacent to it (Fig. H.3).

To obtain access to these timing marks, it is necessary to remove the inspection plate on the left hand side of the pump body.

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 "Z") to an atomiser tester and pump up to

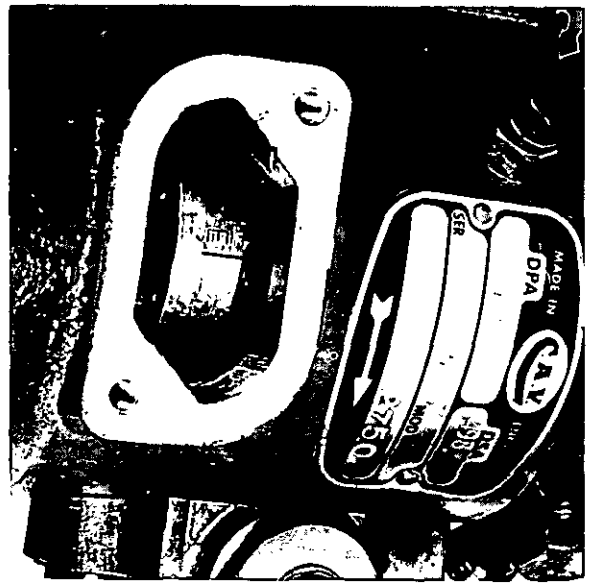



Fig. H.3
Fuel Pump Rotor Timing Marks.

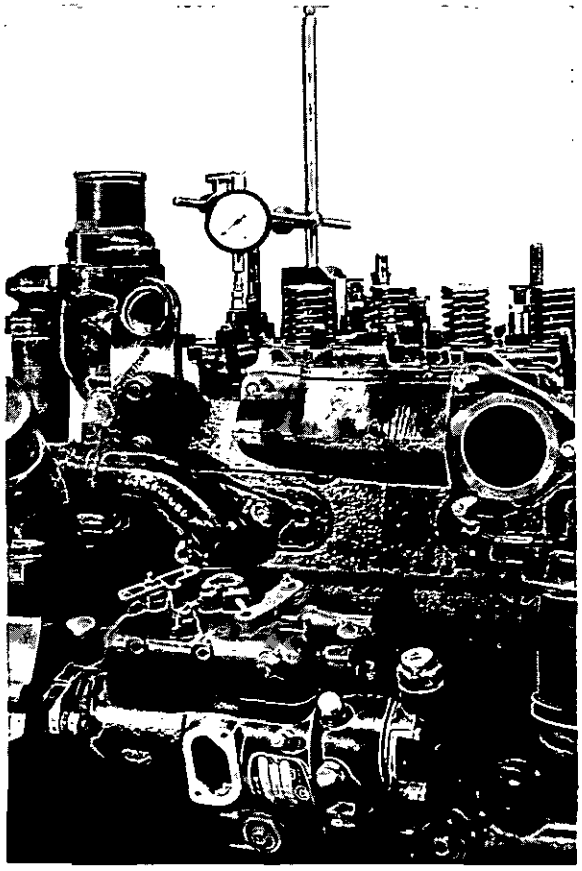


Fig. H.4
Checking Fuel Pump Timing Using Rotor Marks.

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 until it lines up with the line marked "E" on the pump rotor.

Check the pump timing as follows:—

Ensure fuel pump circlip is correctly positioned as previously described.

With No. 1 piston at T.D.C. on compression, i.e. with exhaust valve of No. 3 cylinder fully open remove valve springs from No. 1 inlet valve and allow valve to drop onto piston crown.

Secure a piece of wire or string around valve stem to prevent valve from dropping into cylinder bore.

Mount a dial indicator gauge to register on top of No. 1 inlet valve stem (Fig. H.4) and zero at T.D.C.

Turn engine in opposite direction to rotation approximately 1/8th of a revolution.

Then turn crankshaft in normal direction of rotation until piston is at 0.092 in (2,37 mm) B.T.D.C.

At this point, scribed line on fuel pump rotor marked with letter "E" should be in line with squared end of circlip (see Fig. H.3).

If appropriate line on fuel pump rotor does not align with timing circlip, then the necessary adjustment should be made by turning fuel pump in required direction on rear of timing case.

NOTE: It is important to note that the breaking of the seals of the fuel injection pump should only be carried out by authorised personnel who must reseal with suitable identifiable seals.

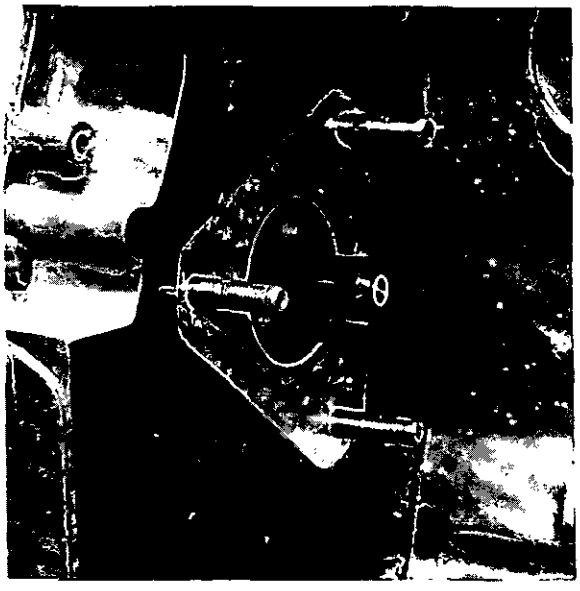


Fig. H.5
Timing Tool Adaptor in Position.

## To Check Fuel Pump Timing Using Tools MS67B and Adaptor PD67B-1

1. Turn engine in normal direction of rotation until No. 1 piston is at T.D.C. on compression stroke. i.e. with exhaust valve of No. 3 cylinder fully open. The T.D.C. position can be obtained, on some applications, by means of a marked position on the flywheel or by use of a timing pin fitted to the timing case cover which, when unscrewed, enters a timing drilling in the rear face of the crankshaft pulley. If neither of these methods is available, T.D.C. can be found by using a dial indicator gauge on the top of a valve as detailed in the previous timing checking method.
2. Fit adaptor PD67B-1 (Fig. H.5) to fuel pump gear so the dowel of gear locates in slot of adaptor and shaft of adaptor is towards rear of engine. Secure adaptor to gear using setscrews.

3. Release screw (5, Fig. H.6) of timing tool MS67B and remove splined shaft (6). The adaptor ring (1) is not used with this engine type.
4. Ensure slotted pointer (2) of timing tool 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 of washer fitted behind pointer securing screw (3) is located over pointer.
5. Release bracket securing screw (4) and set bracket so that the chamfered edge is in line with relevant engine checking angle (see Page A.9).
6. Pressing fuel pump gear and adaptor towards rear, locate splined shaft of adaptor into timing tool with master spline engaged and lock adaptor shaft in timing tool with rear face of adaptor abutting front face of timing tool.
7. 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 on wrong stroke and tool should be removed and engine set on correct stroke. The fuel pump gear should be held centrally whilst engine is turned.
8. Slide slotted pointer forward to reach rear face of timing case and lock into position.
9. Take up backlash by turning tool against normal direction of rotation (shown on pump nameplate) and check that scribed line on rear of timing case coincides with centre of slot in pointer (Fig. H.7). Remark line if necessary or, if no line exists, scribe a line outwards from centre of slot. If line is 7° or more from slot this would probably indicate that timing gears are incorrectly fitted and gears should be refitted.
10. Remove tool and adaptor from the fuel pump gear and fit fuel pump to engine as detailed on Page L.6.

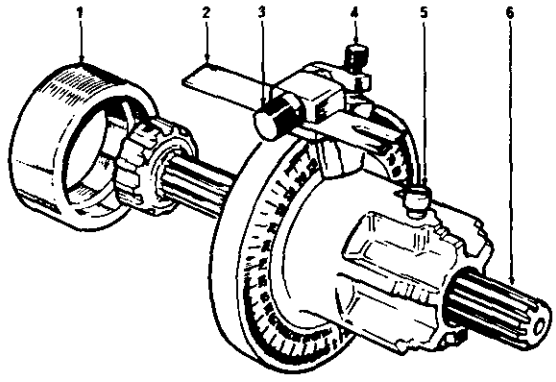



Fig. H.6
Timing Tool.

1. Adaptor Ring
2. Pointer
3. Pointer Securing Screw
4. Bracket Securing Screw
5. Shaft Securing Screw
6. Splined Shaft.

H

## Checking Marking Angle of Fuel Injection Pump using Tool MS67B

1. Release screw (5, Fig. H.6) and position splined shaft with the small splined diameter to rear to locate in centre of the fuel pump hub.
2. Ensure that slotted pointer (2) is positioned with 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 flat in washer fitted behind pointer securing screw (3) is located over side of pointer.

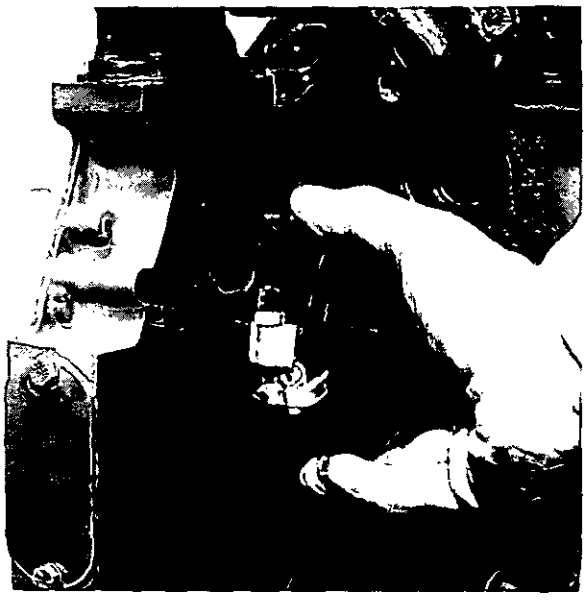


Fig. H.7
Checking Timing Mark using Timing Tool.

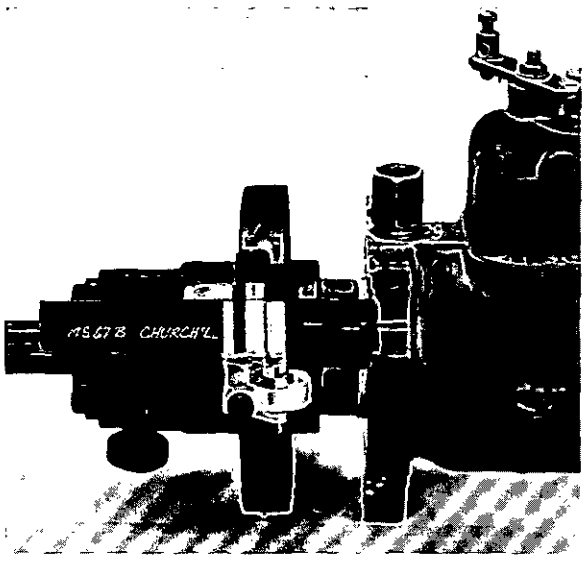
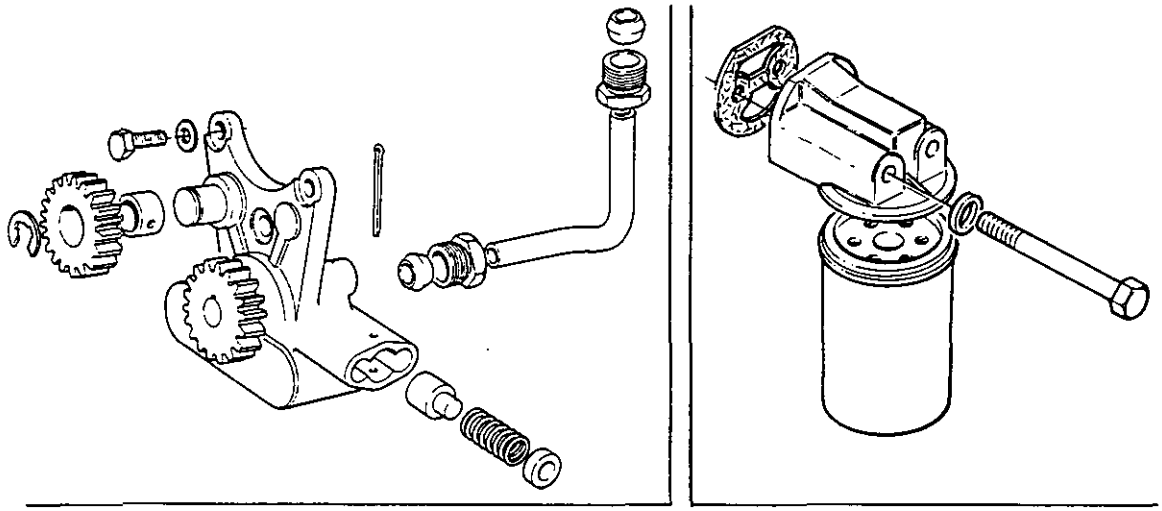
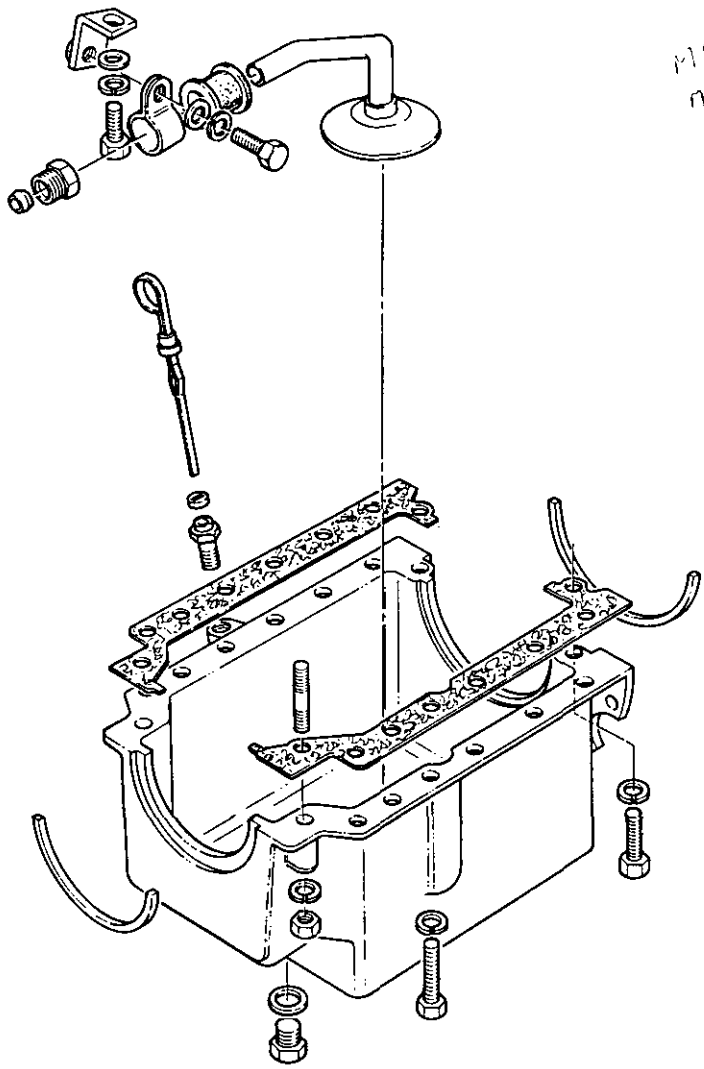


Fig. H.8
Checking Fuel Pump Flange Marking.

3. Release bracket screw (4) and set bracket so that chamfered edge is in line with relevant fuel pump marking angle (See Page A.9).
4. Position timing tool with splined shaft in hub, slide tool towards pump to rest on end of hub and lock shaft in tool (Fig. H.8).
5. Connect No. 1 outlet of pump to an atomiser tester and pump up to 30 atm (31 kgf/cm²) or 440 lbf/in². If pressurising valve is fitted, this must be removed.
6. Turn pump in normal direction of rotation as shown on pump nameplate until it locks.
7. *In this position, slide pointer forward until it* is halfway over pump flange and check that timing mark is central to slot in pointer. Remark line, if necessary.

# SECTION J
# Lubricating System





M126
M130

## LUBRICATING SYSTEM—J.2

The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specifications given at the end of this Section. Care should be taken that the oil chosen is that specified for the climatic conditions under which the engine is operated.
The sump should be fitted with a suitable lubricant to the correct level but do not attempt to overfill above the full mark. Before filling or checking the dipstick, ensure the application is on level ground.

### Oil Circulation

The system of lubrication (Fig. 1) comprises pressure feed to main and big end bearings, camshaft bearings, rocker shaft and timing drive and on T3.1524 engines, the turbocharger bearings.

The pump draws oil through the strainer from the sump and delivers it by a pipe inside the crankcase through a drilling in the side of the cylinder block to the lubricating oil filter.

Oil passes through the filter and then through an internal drilling in the cylinder block to the pressure rail which is a horizontal drilling running the entire length of the left hand side of the cylinder block.

On T3.1524 engines a pipe from the filter head feeds oil to the turbocharger.

Surplus oil is returned to the sump through a pipe fitted between the turbocharger and the front of the timing case.

Holes drilled in the cylinder block feed oil from the pressure rail to the main bearings and holes in the crankshaft webs carry oil to the big end bearings. *Surplus oil returns to the sump.*

An oil seal prevents oil leaking along the crankshaft at the rear end and oil thrown from this seal returns to the sump.

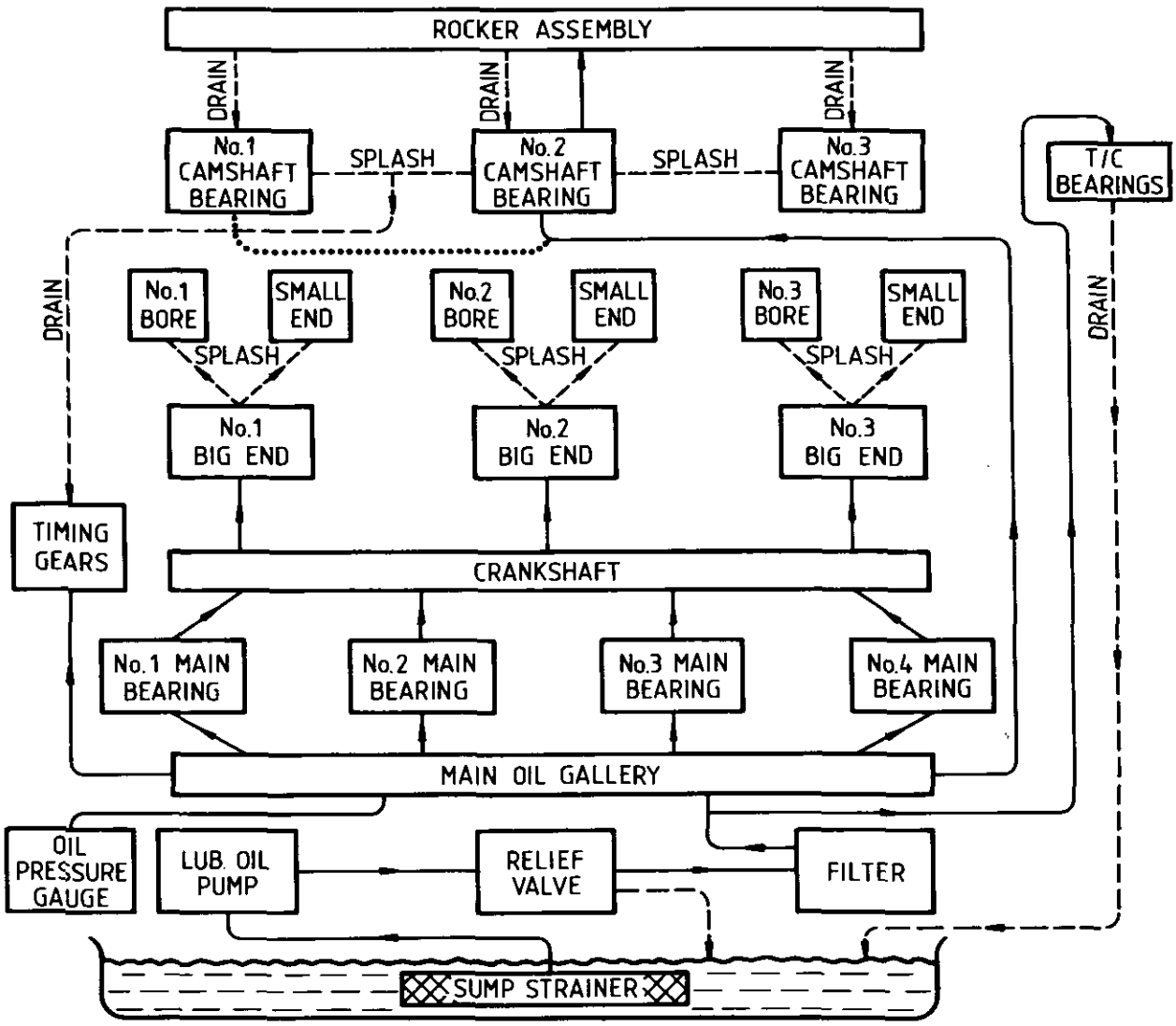



Fig. J.1
Lubricating Oil Diagram.

The small end bushes are lubricated by splash and lubricating oil mist.

Running across the front of the cylinder block is an internal passage which connects with the pressure rail. The oil comes out from this passage on the camshaft side of the engine and is delivered along an external pipe to the lower drilling in the centre camshaft bearing. With a number of engines, this feed is also taken externally to the front camshaft bearing.

As the camshaft revolves, a machined slot in the centre camshaft journal momentarily joins up the two drillings in the bearing and allows a reduced oil flow through the upper drilling in the camshaft tunnel. The oil then flows through a pipe to the cylinder head whence another pipe conveys it to the hollow rocker shaft which feeds oil to the rocker lever bushes, etc.

The overflow of oil from the rocker shaft flows from the cylinder head into the camshaft tunnel and from the front of the tunnel on to the timing gears and then returns to the sump.

Further lubrication for the timing gears is provided by means of a drilling in the block between the horizontal drilling referred to previously and the idler gear hub. Oil from this drilling escapes through a hole in the idler gear boss.



## Oil Pressure

See that oil pressure is registered on the gauge.

The actual pressure may vary with individual engines but the minimum oil pressure at maximum engine

speed and normal working temperature should be 30 lbf/in² (2,1 kgf/cm²) or 207 kN/m².

There will be a pressure drop whilst idling and a slight decrease in normal working pressure when the engine is hot.

If the oil pressure as registered on the gauge is below normal, check the following in the order given below.

1. Dipstick. Ensure sump oil level is up to "full' mark.
2. Oil pressure gauge. Check for accuracy with master gauge.
3. Lubricating oil filter. May be choked. Renew canister.
4. Sump strainer. May be choked. Remove, clean and replace.
5. Lubricating oil pump. Ensure that suction and delivery pipe unions are tight.
6. Oil pressure relief valve. Foreign matter may be preventing valve from closing.

Fig. J.2
Removing Lubricating Oil Filter.

## Lubricating Oil Filters

The importance of using clean lubricating oil in the first place, and providing means to ensure that it is always clean in use, is hardly second to the importance of cleanliness in respect of the fuel.

It is imperative, therefore, that lubricating oil filters are not neglected. Moreover, if the periodical attentions herein recommended are carried out and the correct grade of clean oil used, a very long life can be obtained from the Perkins engine.

To ensure cleanliness, filters are incorporated.

This strainer requires no special attention, but it should be cleaned every time the sump is removed.

## Main (Full Flow) Filter

This filter incorporates a screw-on canister where the element is integral with the canister. This should be renewed — not cleaned, at the appropriate time, as given in Section B.

## To Renew Lubricating Oil Filter Element

1. Unscrew and discard old oil canister (Fig. J.2).
2. Clean filter head and threaded adaptor.
3. Using clean engine lubricating oil, liberally oil top seal of replacement canister.
4. Fill new canister with clean engine lubricating oil, allowing time for oil to filter through element. This process can be speeded up by depressing rubber flap valve through one of inlet holes at top of canister.
5. Screw replacement canister on to filter head until seal just touches head and then tighten by hand as detailed in instructions on canister. Where a tool is available, tighten to 15 lbf ft (2,07 kgf m) or 20 Nm.
6. Run engine and check for leaks. Check oil level after running and top up as necessary.

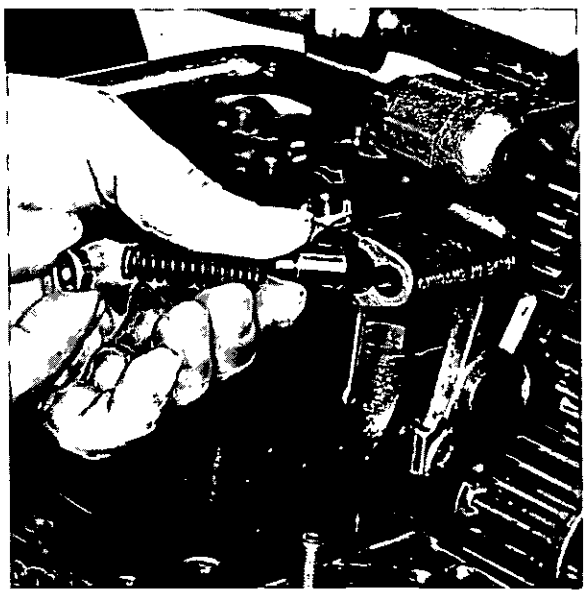


Fig. J.3
Removing Oil Pressure Relief Valve.

## Oil Pressure Relief Valve

The oil relief valve which is located in the oil pump body (Fig. J.3) prevents the pressure becoming excessive when the oil is cold.

The relief valve comprises a spring loaded plunger.

When the pre-determined pressure setting is exceeded, the valve opens and some of the oil is released to return to the sump. That continues until the oil warms up and flows at the desired pressure. The valve then closes.

No attempt should be made to adjust the pressure setting other than by the renewal of parts.

## To Remove Sump

Remove drain plug and drain off oil.

Remove dipstick.

Where necessary, remove setscrews securing rear of sump to flywheel housing.

Remove all setscrews and nuts securing sump to cylinder block and timing case and lower the sump.

## To Refit Sump

Remove all traces of old joints and cork strips from timing case bottom cover and rear main bearing cap.

Lightly smear crankcase faces with a thin coating of jointing compound and place joints in position ensuring all holes line up.

When placing joints in position, it is important that mitred ends go right up into recesses of timing case bottom cover and rear main bearing cap, as in Fig. J.4.

Lightly coat cork joints with jointing compound and place in the grooves provided in timing case bottom cover and rear main bearing cap.

Place sump in position and screw setscrews lightly home.

Where applicable, replace setscrews securing rear of sump to flywheel housing.

Tighten setscrews and nuts securing sump to cylinder block and timing case.

Replace dipstick and sump drain plug.

Refill sump to the correct level with oil, run engine and check for leaks.

## To Remove Oil Pump

Remove sump (see previous heading).

Remove the three setscrews at bottom of timing case front cover and the two nuts at bottom of timing case when timing case bottom half can be removed.

Disconnect delivery pipe from oil pump to cylinder block.

Remove circlip and move idler gear forward.

Unscrew the three setscrews securing oil pump to front main bearing cap and remove oil pump (Fig. J.5).

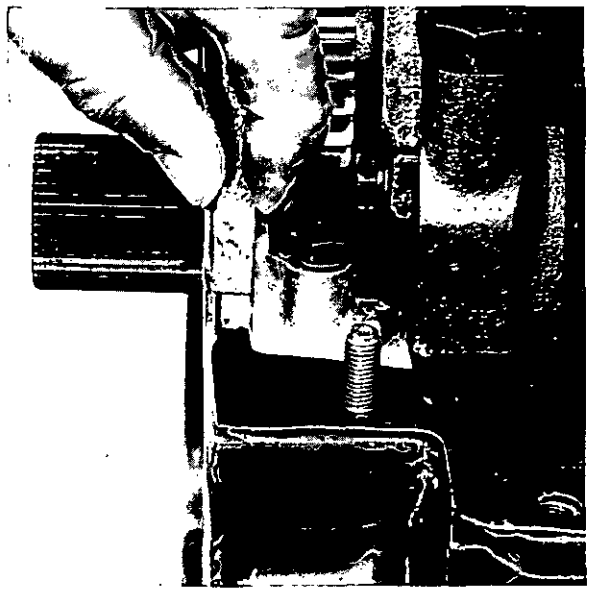


Fig. J.4
Fitting Front Cork Joint.

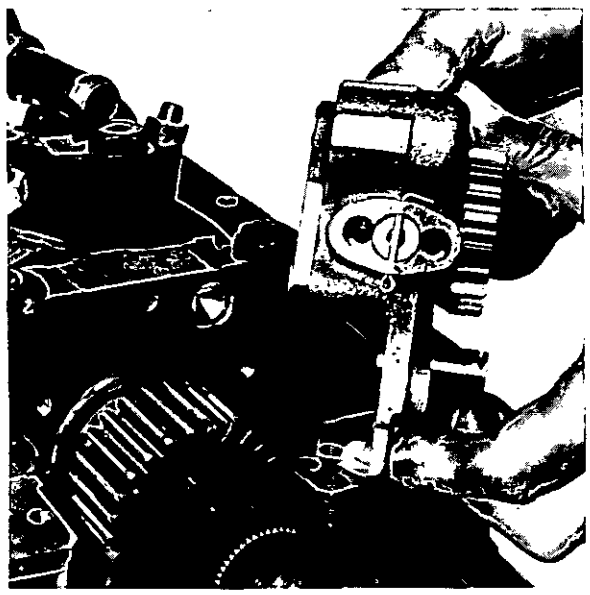


Fig. J.5
Removing Oil Pump.

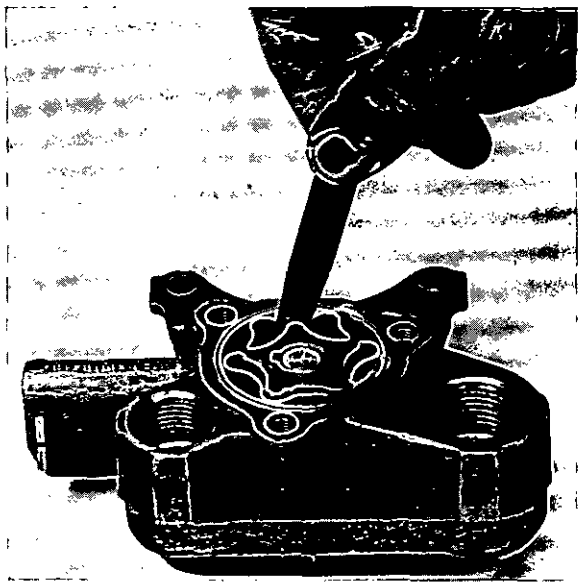


Fig. J.6
Checking Oil Pump Rotor Clearance.

## To Dismantle Oil Pump

Remove suction and delivery pipes.

Remove idler gear.

The oil pump gear should not be removed as this could destroy the interference fit of the gear and individual parts of the pump are not available as spare parts.

Using a special screwdriver, unscrew the three screws and remove the pump end plate.

Remove outer rotor from pump body.

The oil relief valve is located in the body of the lubricating oil pump.

The breaking pressure is set and adjusted before the engine leaves the works.

## Inspection

The clearances for new pumps are given in Section A.

1. Thoroughly clean all parts and inspect the rotors for cracks or scores.
2. Install outer rotor in pump body making sure chamfered edge of rotor enters pump body first. Check clearance between maximum diameter of inner rotor and minimum diameter of outer rotor at all points (Fig. J.6).
3. Check the clearance between top of rotors and end of pump body with feeler gauges and straight edge (Fig. J.7).

**NOTE:** Should an oil pump be worn to such an extent it adversely effects the working oil pressure then a replacement pump should be obtained. The component parts of the oil pump are not supplied individually therefore if any parts require replacing a replacement assembly should be fitted.

Fig. J.7
Checking Oil Pump Rotor End Float.

## To Re-assemble Oil Pump

Refit outer rotor into pump body with chamfered edge innermost.

Refit end cover and secure with screws.

### To Refit Oil Pump

Prime lubricating oil pump with oil before fitting.

If timing case and front main bearing cap are fitted, fit idler gear to shaft without securing with circlip.

Fit oil pump to front main bearing cap and secure with three setscrews. Locate delivery pipe whilst pump is being positioned.

Secure idler gear with circlip.

Refit suction and delivery pipes to and from oil pump.

Refit timing case bottom half and secure with two nuts and washers to timing case top half.

Refit the three setscrews at the bottom of timing case front cover.

Refit sump in accordance with previous instructions.

Before starting, the engine should be turned over whilst operating the stop control, until oil pressure is registered.

# LUBRICATING OILS

Lubricating oils for naturally aspirated engines should meet the requirments of the U.S. Ordnance Specification MIL-L-46152 or MIL-L-2104C. Lubricating oils for turbocharged engines and engines installed in Heavy Duty Earthmoving Equipment should meet the U.S. Ordnance Specification MIL-L-2104C.

**Note:** Operators are advised not to use a lubricating oil to the MIL-L-2104C specification in naturally aspirated engines for the first 500/1,000 miles (25/50 hours) of operation.

Some of these oils are listed below and on the following page. Any other oils which meet these specifications are also suitable.

**MIL-L-46152 OILS**

| Company | Brand | S.A.E. Designation | | |
|---|---|---|---|---|
| | | 0°F (-18°C) to 30°F (-1°C) | 30°F (-1°C) to 80°F (27°C) | Over 80°F (27°C) |
| **B.P. Ltd.** | Vanellus M | 10W | 20W | 30 |
| | Vanellus M | | 20W/50 | 20W/50 |
| **Castrol Ltd.** | Castrol/Deusol CRX | 10W | 20 | 30 |
| | Castrol/Deusol CRX | 10W/30 | 10W/30 | 10W/30 |
| | Castrol/Deusol CRX | | 20W/50 | 20W/50 |
| | Deusol/RX Super | | 20W/40 | 20W/40 |
| **A. Duckham & Co. Ltd.** | Fleetol HDX | 10 | 20 | 30 |
| | Q Motor Oil | | 20W/50 | 20W/50 |
| | Fleetol Multi V | | 20W/50 | 20W/50 |
| | Fleetol Multilite | 10W/30 | 10W/30 | 10W/30 |
| | Farmadcol HDX | | 20 | 30 |
| **Esso Petroleum Co. Ltd.** | Essolube XD-3 | 10W | 20W | 30 |
| | Essolube XD-3 | | 15W/40 | 15W/40 |
| **Mobil Oil Co. Ltd.** | Delvac 1200 Series | 1210 | 1220 | 1230 |
| | Delvac Special | 10W/30 | 10W/30 | 10W/30 |
| **Shell** | Rimula X | 10W | 20W/20 | 30 |
| | Rimula X | 10W/30 | 10W/30 | 10W/30 |
| | Rimula X | | 15W/40 | 15W/40 |
| | Rimula X | | 20W/40 | 20W/40 |
| | Rotella TX | 10W | 20W/20 | 30 |
| | Rotella TX | | 20W/40 | 20W/40 |
| **Total Oil Co. Ltd.** | Total Super HD | | 20W/20 | 30 |
| | Total HD2-M | 10W/30 | 20W/40 | 20W/50 |
| | Total HD3-C (Rubia S) | 10W | 20W/20 | 30 |
| | Total HD3-C (Rubia TM) | | 15W/40 | 15W/40 |
| | Total Universal Tractor Oil (Multagri) | | 20W/30 | 20W/30 |
| | Total Super Universal Tractor Oil (Multagri TM) | | 20W/30 | 20W/30 |

J

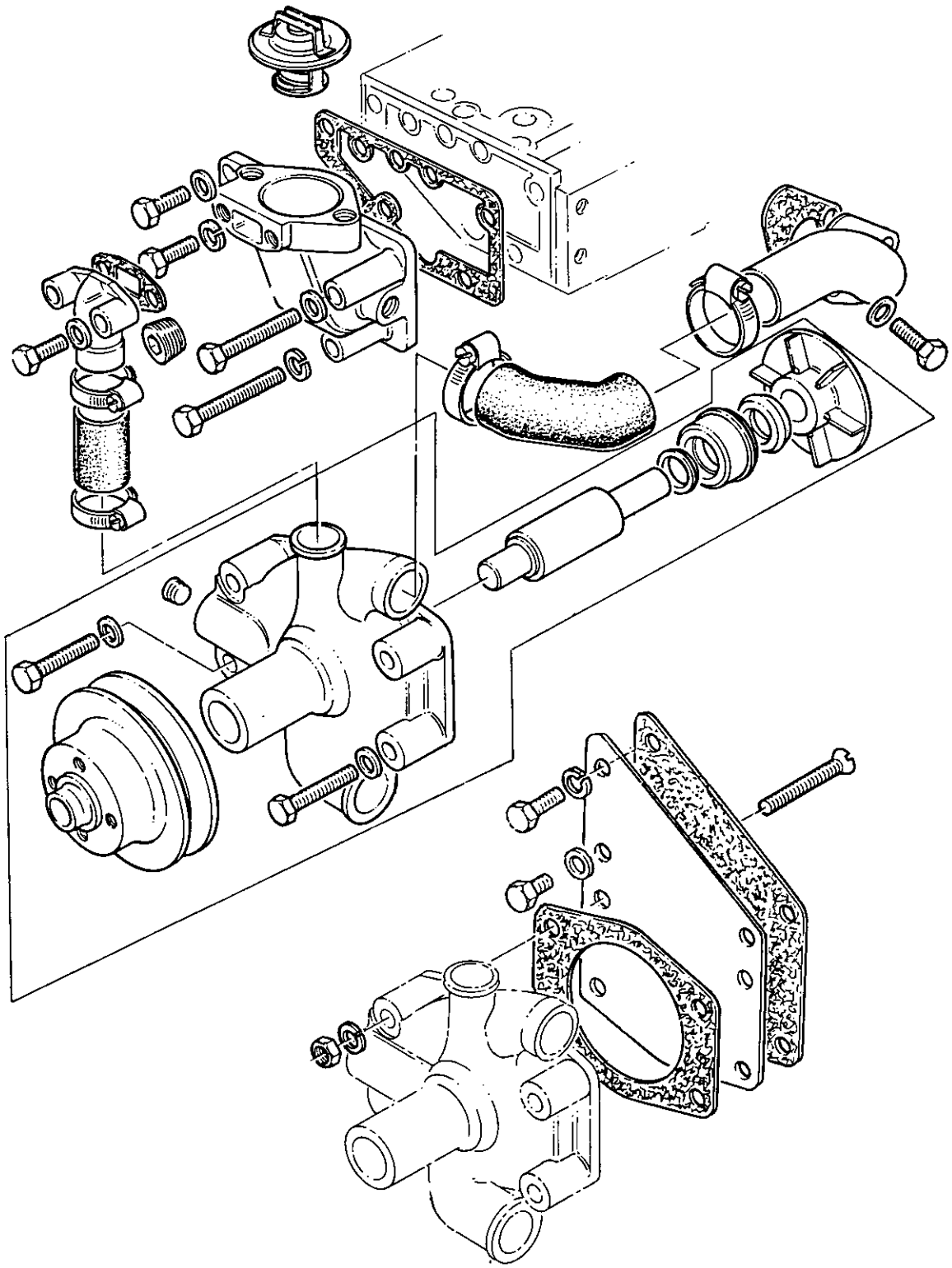
**MIL-L-2104C OILS**

| Company | Brand | S.A.E. Designation | | |
|---|---|---|---|---|
| | | 0°F (-18°C) to 30°F (-1°C) | 30°F (-1°C) to 80°F (27°C) | Over 80°F (27°C) |
| **B.P. Ltd.** | Vanellus C3 | 10W | 20W/20 | 30 |
| **Castrol Ltd.** | Castrol/Deusol CRD | 10W | 20 | 30 |
| | Deusol/RX Super | | 20W/40 | 20W/40 |
| | Agricastrol HDD | 10W | 20 | 30 |
| | Agricastrol MP | | 20W/30 | 20W/30 |
| | Agricastrol MP | | 20W/40 | 20W/40 |
| **A. Duckham & Co. Ltd.** | Fleetol 3 | 3/10 | 3/20 | 3/30 |
| | Farmadcol 3 | 3/10 | 3/20 | 3/30 |
| **Esso Petroleum Co. Ltd.** | Essolube D-3HP | 10W | 20W | 30 |
| | Essolube XD-3 | 10W | 20W | 30 |
| | Essolube XD-3 | | 15W/40 | 15W/40 |
| **Mobil Oil Co. Ltd.** | Delvac 1300 Series | 1310 | 1320 | 1330 |
| **Shell** | *Rimula CT* | 10W | 20W/20 | 30 |
| | Rimula X | 10W | 20W/20 | 30 |
| | Rimula X | 10W/30 | 10W/30 | 10W/30 |
| | Rimula X | | 15W/40 | 15W/40 |
| | Rimula X | | 20W/40 | 20W/40 |
| | Rotella TX | 10W | 20W/20 | 30 |
| | Rotella TX | | 20W/40 | 20W/40 |
| **Total Oil Co. Ltd.** | Total HD3-C (Rubia S) | 10W | 20W/20 | 30 |
| | Total HD3-C (Rubia TM) | | 15W/40 | 15W/40 |
| | Total Super Universal Tractor Oil (Multagri TM) | | 20W/30 | 20W/30 |

Lubricating oils for use in Perkins Diesel engines should have a minimum viscosity index of 80.

The above specifications are subject to alteration without notice.

# SECTION K
# Cooling System



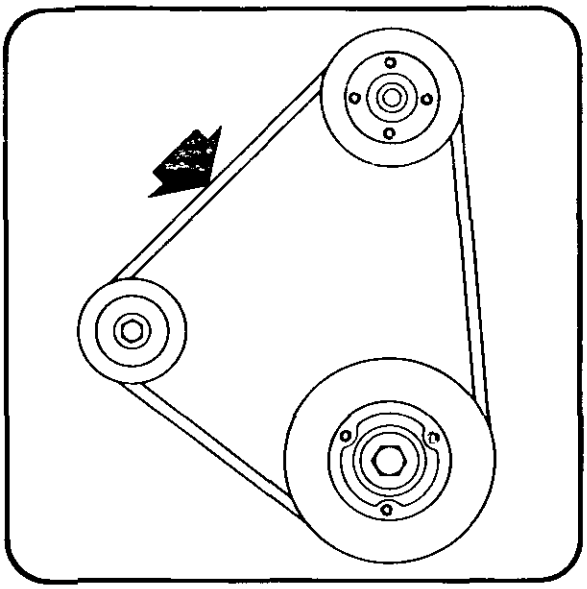


Fig. K.1
Checking Fan Belt Tension.

The cooling water is circulated by a centrifugal type pump which is mounted on the front of the timing case cover. It is driven by a Vee-belt from the engine crankshaft and provision is made for fitting a fan on the front of the water pump pulley.

The pump does not require greasing as the bearings are treated with a special quality grease before assembly.

## Fan Belt Adjustment

Belt tension should be adjusted so that, without undue pressure, the belt can be depressed approximately $\frac{3}{8}$ in (10 mm) with the thumb applying pressure at a point midway between the water pump and generator pulleys (Fig. K.1).

Adjustment of the belt tension is achieved by altering the position of the generator. Release the generator adjusting link and support bracket bolts, move the generator to give the correct tension and then tighten the bolts and recheck the tension.

When a new belt has been fitted, it is advisable to check the belt tension after a few hours running to ensure that no initial stretching has occurred.

Fig. K.2
Removing Water Pump and Backplate.

## To Remove Water Pump

Remove fan.

Slacken generator securing setscrews and remove fan belt.

Remove water pump inlet and outlet hose connections.

Disconnect by-pass connection from thermostat housing.

Release the three setscrews securing backplate to timing case and cover and the two setscrews securing pump to cover and remove pump complete with backplate (Fig. K.2).

Remove the two nuts and countersunk screws and separate backplate and water pump.

## To Dismantle Water Pump (Fig. K.3)

Remove water pump pulley (3) using tool 21825006 (See Fig. K.4). The tapped holes in the pulley can be utilised for this purpose.

Press water pump shaft (2) complete with bearings and impeller (7) out through rear of pump body (1). Press shaft and bearing assembly out of impeller.

Remove ceramic counterface (6), seal (5) and thrower (4) from shaft.

The shaft and bearings are manufactured as one component and cannot be dismantled.

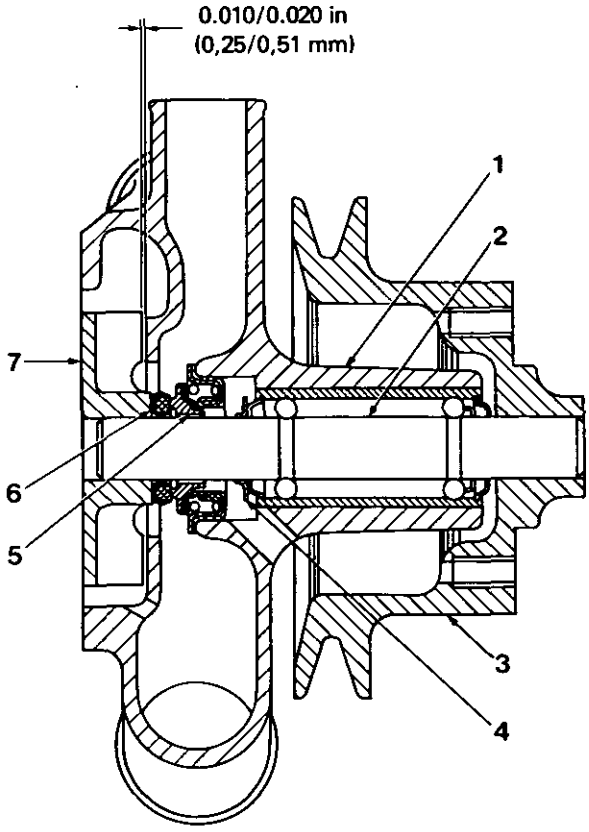



Fig. K.3
Water Pump Assembly.

1. Pump Body
2. Shaft and Bearing Assembly
3. Pulley
4. Thrower
5. Seal
6. Ceramic Counterface
7. Impeller

## To Re-assemble Water Pump (Fig. K.3)

With shorter end foremost, press shaft and bearing assembly (2) into rear of water pump body (1) until bearing housing end is flush with front of water pump body.

Replace water thrower (4).

Fit seal (5) with carbon face to rear of pump and flange against machined face of body.

Fit ceramic counter face (6) to shaft with ceramic insert towards seal.

Supporting shaft at front end, press impeller (7) with blades inwards onto rear of shaft until a dimension of 0.010 in (0,25 mm) to 0.020 in (0,51 mm) is obtained between blades of impeller and pump body (See Fig. K.5).

Spin assembly to ensure freedom of rotation.

Position any pump securing setscrews that cannot be fitted with the pulley in position. These setscrews are fitted with aluminium sealing washers.

Supporting shaft at impeller end, press on water pump pulley until front end of pulley is flush with front end of shaft.

Recheck the clearance between impeller blades and pump body, and spin assembly to ensure freedom of movement.

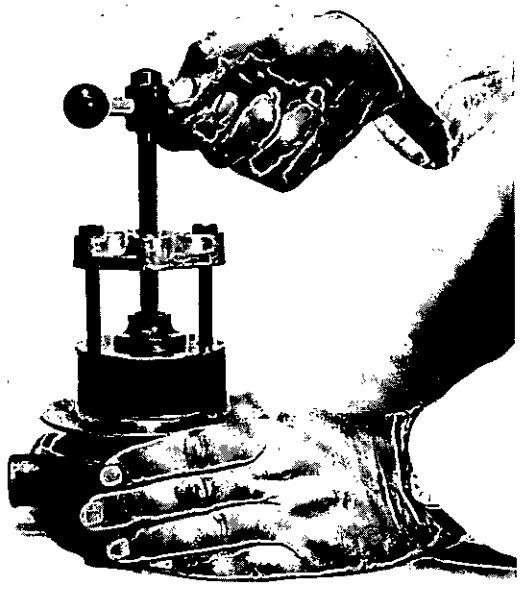


Fig. K.4
Removing Water Pump Pulley.

Fig. K.5
Checking Water Pump Impeller Clearance.

## To Refit Water Pump to Engine

Fit new water pump joint, suitably coated with jointing compound.

Fit pump to backplate and secure with countersunk screws, spring washers and nuts.

Fit pump and backplate assembly to timing case cover and secure with setscrews. The setscrews that screw into the timing case are fitted with spring washers and those that screw into the cover are fitted with aluminium washers.

Using a new joint, suitably coated with jointing compound, refit by-pass connection to thermostat housing and secure with setscrews and aluminium washers.

Connect water pump inlet and outlet hose connections.

Refit fan belt and adjust tension (See Page K.2).

Refit fan.

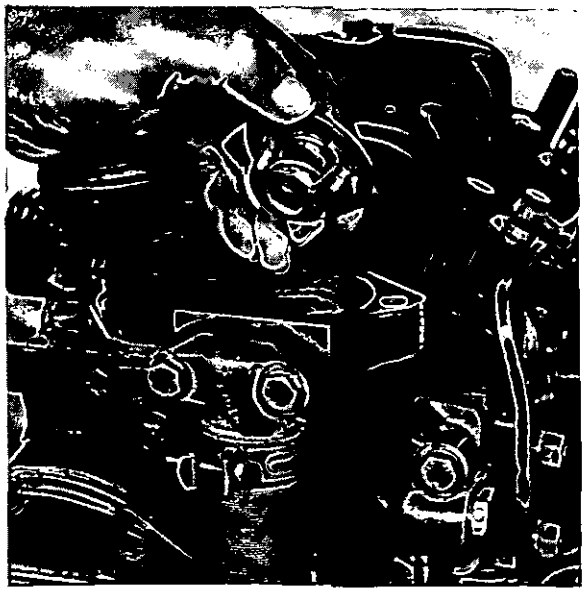


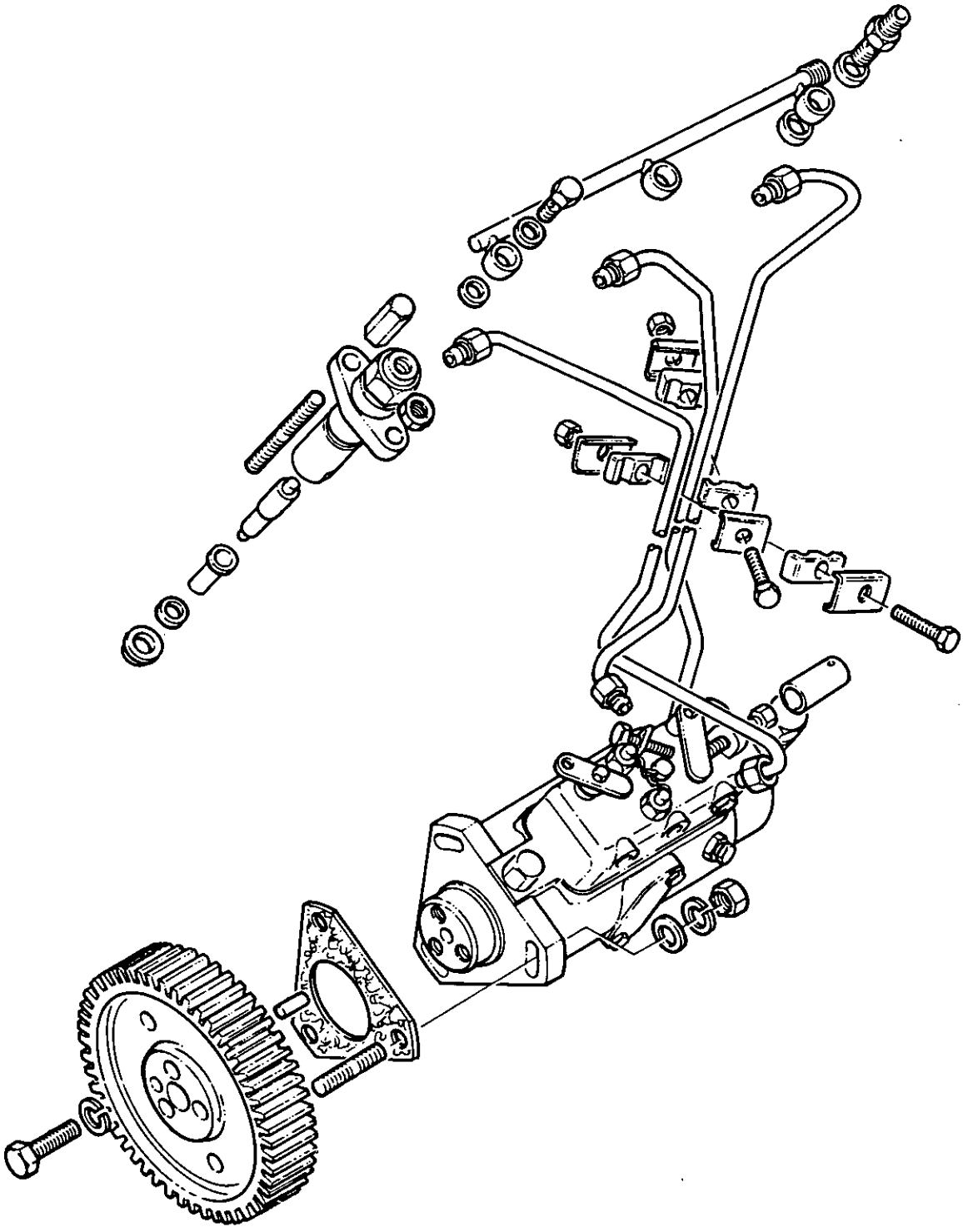
Fig. K.6
Removing Thermostat.

## Thermostat

A thermostat is fitted in the cylinder head water outlet to assist in providing a shorter warming up period for the engine. The thermostat can be removed after the water outlet connection and joint have been removed (Fig. K.6). When refitting the thermostat, ensure that the jiggle pin in the top of the thermostat is free to move in its location or the bleed hole is clear.

To check the thermostat, suspend it in water and heat gradually. With a thermometer, check that the thermostat operates at the temperatures given in Section A. If it is faulty, it should be renewed — no attempt should be made to adjust a faulty thermostat.

# SECTION L
# Fuel System



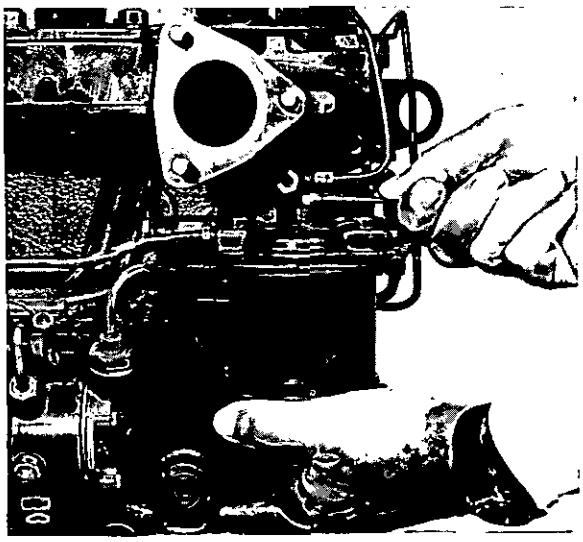


Fig. L.1
Unscrewing Fuel Filter Setscrew.

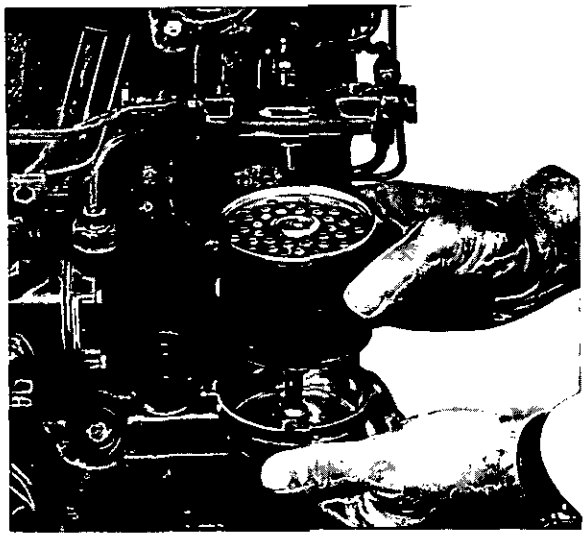


Fig. L.2
Removing Fuel Filter Element.

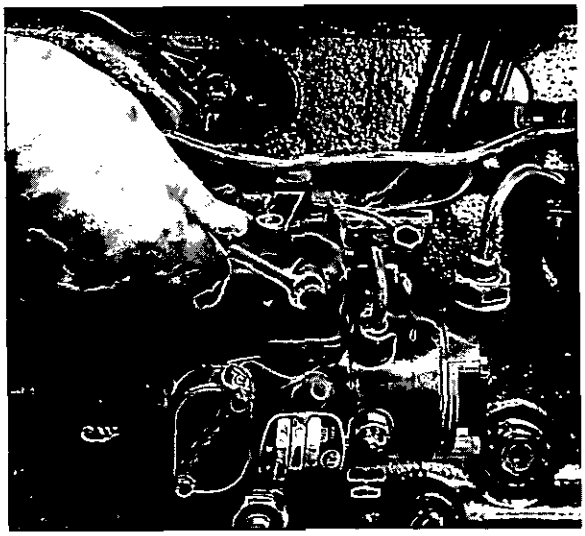


Fig. L.3
Slackening Governor Vent Screw.

The principal components of the equipment for delivering the fuel oil to the engine cylinders are as follows:

Filters

Fuel lift pump

Fuel Pump

Atomisers

The fuel lift pump "lifts" the fuel from the tank to the pump which conveys it in measured quantities, and at appropriate intervals, to the atomisers.

The normal course of the fuel from the tank to the engine is by way of: first, the fuel pre-filter, then the fuel lift pump; then the final fuel filter; the fuel pump and the atomisers.

Two conditions are essential for efficient operation.

First, that the fuel oil should be clean, free from water, suspended dirt, sand and other foreign matter and should conform to one of the specifications given in Section A.

Second, that the fuel reaches the fuel pump in a perfectly clean state.

Fuel should be filtered before entering the tank.

## Fuel Oil Filters

Great care has been taken in the design of the engine to ensure that only clean fuel oil reaches the fuel pump.

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

The second filter consists of a water trap fitted in the fuel line upstream of the lift pump.

This pre-filter should be dismantled and the gauze strainer cleaned in accordance with the Preventive Maintenance quoted in Section B unless the condition of the fuel warrants more regular attention.

After cleaning, ensure that good joints are made when re-assembling this filter as any leakage of air here may cause air locks in the fuel system.

On certain engines, an intermediate fuel filter is fitted and is identical with the following final fuel filter.

The third and final filter is a paper element type filter, It is not possible to clean the paper element. It should be renewed.

## To Renew Element

1. Unscrew setscrew in centre of top filter cover (Fig. L.1).
2. Drop filter bottom cover clear (Fig. L.2).
3. Remove element and discard.
4. Before putting new element into position, clean the filter top and bottom covers.
5. Ensure that the rubber joints are in good condition, if not, replace with new joints.

After re-assembling filter, system should be bled as instructed later.

## Bleeding the Fuel System

In the event of air entering the fuel system, it will be necessary to bleed the system to remove it. Air can enter the system as a result of running out of fuel, leaks in the system, changing filter elements or disturbance of fuel connections.

To bleed the system, proceed as follows:—

1. Slacken air vent screw on side of the governor control cover of fuel injection pump (Fig. L.3).
2. Slacken vent screw fitted in hydraulic head locking screw on side of fuel pump body (Fig. L.4).
3. Operate priming lever of fuel lift pump (Fig. L.5) and when fuel, free from air bubbles, issues from each venting point, tighten hydraulic head vent screw and then governor cover vent screw.
4. Slacken pipe union nut at fuel pump inlet (Fig. L.6). Operate priming lever and retighten when fuel oil, free from air bubbles, issues from around threads.
5. Slacken unions at atomiser ends of two of the high pressure pipes.
6. Set accelerator at the fully open position and ensure that "stop" control is in the "run" position.
7. Turn engine until fuel oil, free from air bubbles, issues from both fuel pipes.
8. Tighten unions on both fuel pipes and engine is ready for starting. If fuel has been drained from thermostart feed pipe, the pipe must be disconnected at thermostart and all air bled from pipe before thermostart is operated.

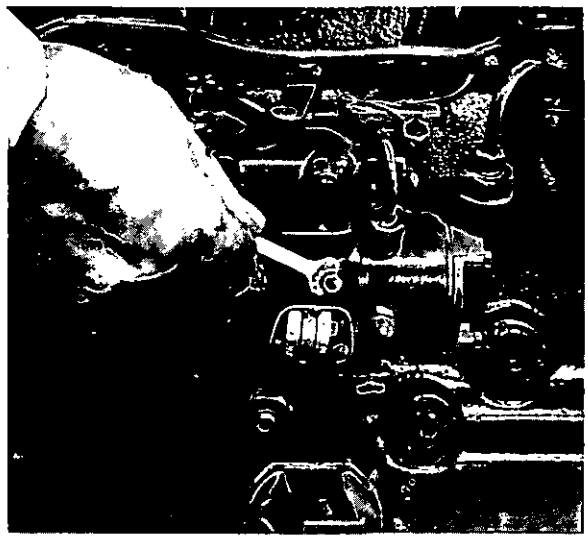


Fig. L.4
Slackening Body Vent Screw.

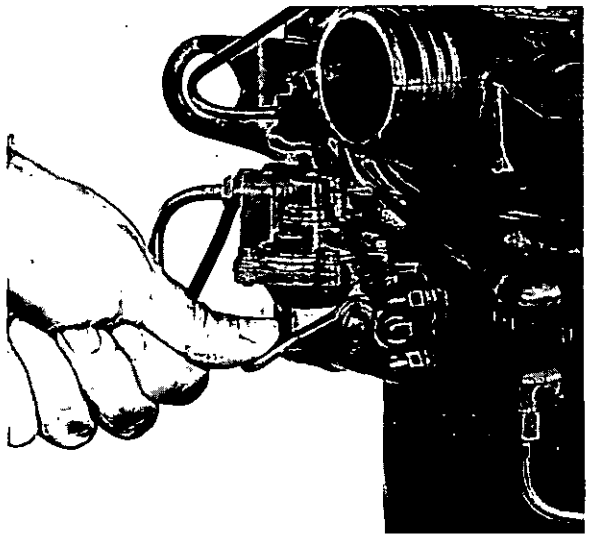


Fig. L.5
Operating Fuel Lift Pump Priming Lever.

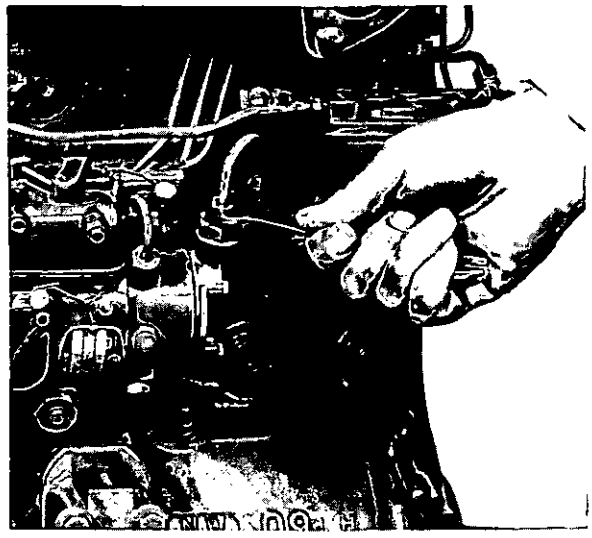


Fig. L.6
Slackening Pump Inlet Connection.

L

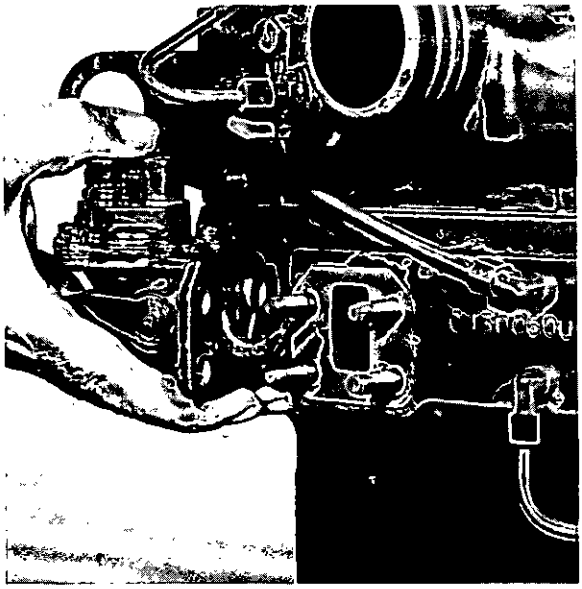


Fig. L.7
Removing Fuel Lift Pump.

## Fuel Lift Pump

The lift pump is of the diaphragm type. It is fitted to side of camshaft tunnel and is driven by an eccentric on engine camshaft.

A hand primer is incorporated in the pump so that pump can be operated without engine running in order to prime or bleed fuel system.

To use this primer, pump by hand until pipes, lift pump, filters and fuel pump are full of fuel oil.

## Testing Lift Pump Fitted to Engine

Disconnect outlet fuel pipe.

Crank engine, or operate hand priming lever (Fig. L.5). A spurt of fuel should emit from outlet port once every two engine revolution, or every time hand priming lever is depressed.

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

## Pressure Checking of Fuel Lift Pump in Position

Fit a 0-10 lbf/in² (0-0,7 kgf/cm²) or 0-70 kN/m² pressure gauge to outlet of pump. Ensure that there are no leaks at connections between pump and gauge. Crank engine for ten seconds and note maximum pressure on gauge. If the pressure recorded is less than 4.5 lbf/in² (0,3 kgf/cm²) or 31 kN/m² then rectify pump. Also observe rate at which pressure drops to half maximum figure obtained when cranking has ceased. If less than thirty seconds, rectify pump.

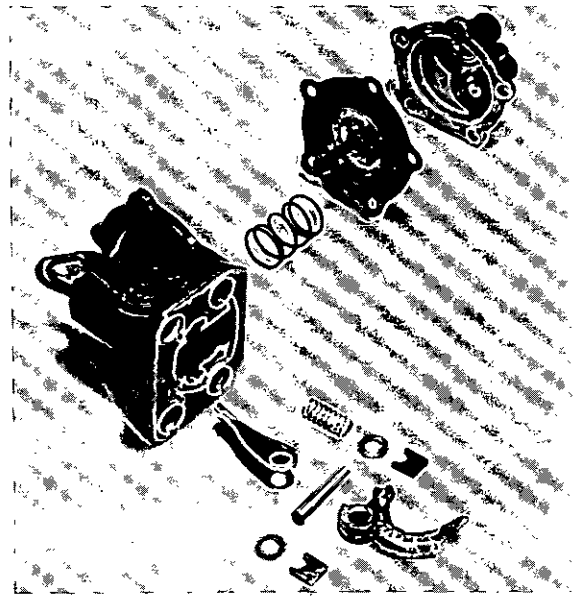


Fig. L.8
Fuel Lift Pump Assembly.

## To Remove Lift Pump

Disconnect fuel pipe, from inlet and outlet ports.

Remove the four nuts and spring washers which secure pump to cylinder block, and withdraw pump (Fig. L.7).

## To Dismantle Lift Pump (Fig. L.8).

Before dismantling, make a file mark across the two flanges for location purposes when pump is being reassembled. Remove the five cover screws and separate the two main parts, then remove diaphragm assembly from lower half by turning 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 casting so that new valves can be correctly seated. Press valves into position using a suitable "dolly". Stake casting around the valves in six places.

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

## To Re-assemble Lift Pump

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

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

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

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

## To Refit Fuel Lift Pump

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

## Fuel Injection Pump

The fuel pump is of the distributor type. Its working parts are made to extremely fine limits and mis-handling in any shape or form, or the entry of the smallest particle of dirt into its working parts may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before the pump is reached.

When requesting information regarding the fuel pump, the type and number should be quoted. This can be obtained from a plate fitted to the fuel pump body.

Where service is required, this should be obtained from the fuel pump manufacturer's agents.

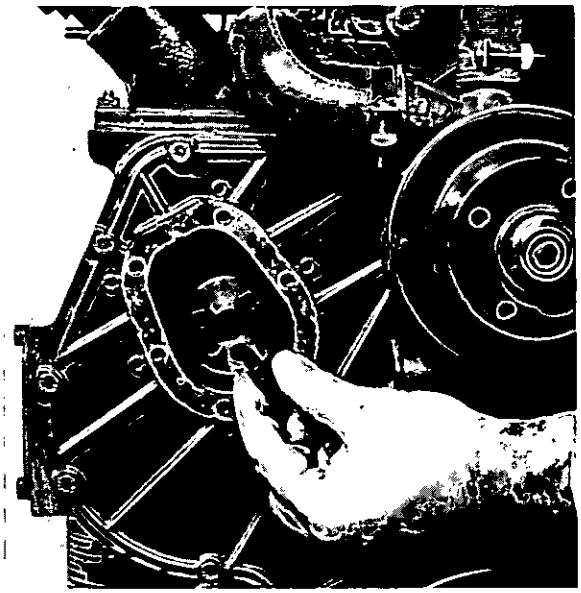


Fig. L.9
Removing Fuel Pump Gear Setscrews.

## To Remove Fuel Injection Pump

The fuel injection pump is secured to the back of the timing case on the left hand side of the engine. The fuel pump gear is secured to the pump shaft by three setscrews and located by a dowel.

Remove pump as follows:—

1. Remove fuel pipes from pump and blank off pump connections.
2. Disconnect throttle and stop controls at pump.
3. Remove cover plate situated on left hand side of timing case front cover directly in front of fuel pump mounting position.
4. Carefully remove the three setscrews and washers securing gear to fuel pump shaft (Fig. L.9), taking care not to drop them into timing case. If gear is loose, ensure that it does not fall heavily on to aluminium stop of timing case as this could snap off allowing fuel pump gear to come out of mesh with idler gear. If gears do come out of mesh, it could affect fuel pump timing.
5. Release and remove the three nuts, plain and spring washers securing fuel pump to back of timing case.
6. Remove fuel injection pump (Fig. L.10). If pump gear is still tight on pump drive, support gear as pump is withdrawn to prevent it falling heavily on to gear stop and coming out of mesh. **Do not turn crankshaft with pump removed and gear loose in timing case.**

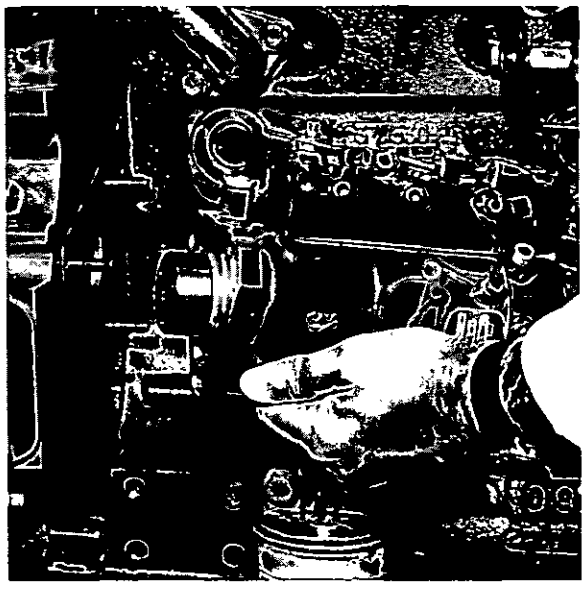


Fig. L.10
Removing Fuel Injection Pump.

## To Refit Fuel Injection Pump

1. Check that slot in fuel pump shaft is in approximate relative position to dowel in gear and position pump on back of timing case. Fit pump securing nuts and washers but do not tighten nuts.
2. Ensure that dowel in fuel pump gear is located in slot in pump shaft and secure the gear to the shaft by the three setscrews and washers.
3. Position fuel pump with scribed line on flange in line with scribed line on back of timing case and tighten securing nuts.
4. Refit cover plate to timing case front cover.
5. Refit fuel pipes to pump.
6. Bleed fuel system as detailed on Page L.3.
7. Reconnect throttle and stop controls.
8. Run engine and check for leaks. Where a new pump has been fitted, it will be necessary to set the maximum no load speed as detailed below.

## Maximum No Load Speed Setting

When fitting a replacement fuel pump, it should be noted that the governor maximum speed is set to a nominal figure only and final adjustment must be made on the engine.

The maximum no load speed can be established from the fuel pump setting code. A typical code is XW50E600/8/2470. It is the last group of figures which indicates the no load speed and in this case, it would be 2470 rev/min (crankshaft speed).

The maximum no load speed should be set as follows:

Having firstly run the engine until it has obtained normal running temperature, a suitable tachometer should be brought to register on either the crankshaft or auxiliary equipment (as applicable).

With the engine running at full throttle, take a reading.

Should it be in excess of the figure stamped on the fuel pump, decrease the throttle maximum setting by screwing in the adjusting screw or vice versa if the reverse applies, until the tachometer reading coincides with the correct setting.

The adjustment should now be locked and sealed by authorised personnel and the tachometer reading checked to ensure that it is still correct.

## Fuel Pipes

No two of the pressure pipes from the fuel pump to the atomisers are alike. Keep this in mind when replacing.

Examine the nipples which will be found on each end of these pipes.

If the union nuts at any time have been over-tightened, the nipples may have been damaged. If so, leakage will result and the complete fuel pipe will have to be replaced.

Offer up the pipe to the fuel pump and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

When fitting the pipe, tighten the unions alternately a little at a time, first one end and then the other.

If the pipe is square to the unions at each end as described above, no appreciable force will be needed to make a good joint.

If the union is tightened excessively, the nipple may be damaged. The same danger exists if the pipe is not square to and central with the union.

The correct torque for the high pressure fuel pipe unions is 15 lbf ft (2,1 kgf m) or 20 Nm.

When changing an atomiser, always remove the pipe entirely. Never undo only one end leaving the other tight. Never bend the pipe.

## Atomisers

Each atomiser is held to the cylinder head by means of a flange and two studs.

A one piece collar type dust seal is fitted on earlier engines but later engines have an improved two piece arrangement which consists of a soft rubber sealing ring or sleeve and a rigid spacer which presses down onto the rubber sealing ring.

The joint between the atomiser and cylinder head is made by a special thin copper washer between the lower face of the nozzle cap nut and the recess in the cylinder head.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only the correct washer is used to make this joint. The recess in the cylinder head, the faces of the copper washer and the corresponding face on the nozzle holder cap nut should be perfectly clean if a leakproof joint is to result.

It is advisable to fit a new joint washer and rubber dust seal when the atomister is replaced, after having been removed for any reason. The plastic spacer must be fitted above the rubber dust seal.

Ensure that the old washer has been removed from the cylinder head or atomiser.

This joint washer should be an easy, but not loose fit for the atomiser nozzle.

The atomiser can now be fitted in place, care being taken to see that it is an easy fit in the cylinder head and on the holding down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should then be tightened down evenly in order to prevent the atomiser nozzle being canted and so "nipped" in the cylinder head. This is very important since any unevenness in tightening down may cause distortion of the atomiser nozzle, resulting in its failure and will most certainly result in blowby.

The correct torque for the atomiser securing nuts is 12 lbf ft (1,7 kgf m) or 16 Nm.

## Maintenance

Atomisers should be taken out for examination at regular intervals. However long this interval should be is difficult to advise, because of the different conditions under which engines operate.

A thin metal heatshield is fitted around the 3.1522 engine atomiser nozzle and this heatshield must be renewed whenever the atomiser is dismantled.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if the atomisers are tested yearly. For detailed times refer to Preventive Maintenance page B.2.

It is no use taking atomisers out for attention unless an atomiser testing pump is available or spare atomisers are at hand for substitution.

The nearer the ideals of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need, and so the longer their efficient life. In this connection, since there is no other item upon which the performance of the engine depends so much, it pays the user handsomely to see that the engine never runs with any of its atomisers out of order.

## Troubles in Service

The first symptoms of atomiser trouble usually fall under one or more of the following headings:

1. Misfiring.
2. Knocking in one (or more) cylinders.
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black).
6. Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast 'Tick-over'. This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

After stopping the engine the nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round, atomiser nozzle outwards, 'unwiped' on its pipe, and the unions re-tightened.

After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly 'wet' or 'streaky' or obviously to one side, or the atomiser 'dribbles', the complete unit should be replaced, the faulty unit being securely wrapped in clean greaseproof paper or rag for attention on the maintenance bench.

Great care should be taken to prevent the hand from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin with ease.

## Atomiser Pressures

The relevant pressures can be ascertained by reference to the atomiser code letters and the table give in Section A. The code letters are stamped on the atomiser body.

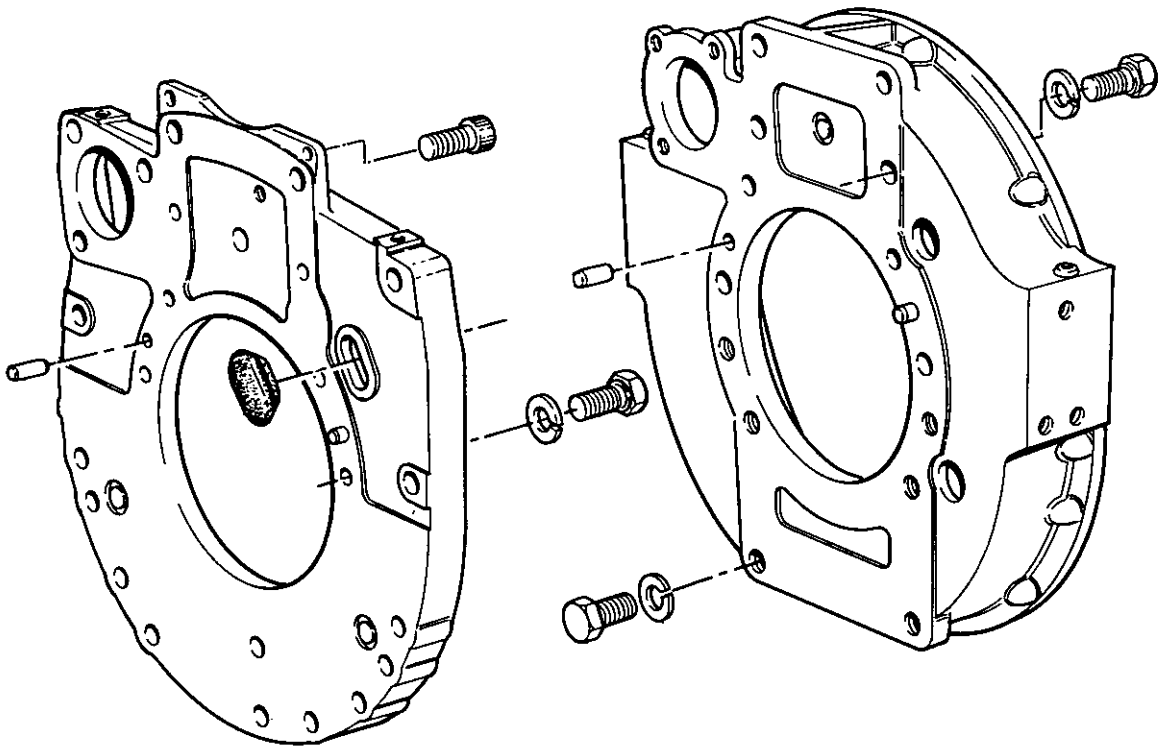
The "Setting Pressure" is the pressure at which a new atomiser is set and is slightly high to allow for the initial fall of of pressure that occurs in the first few hours of operation. The "Working Pressure" is the pressure at which a used atomiser can be checked.

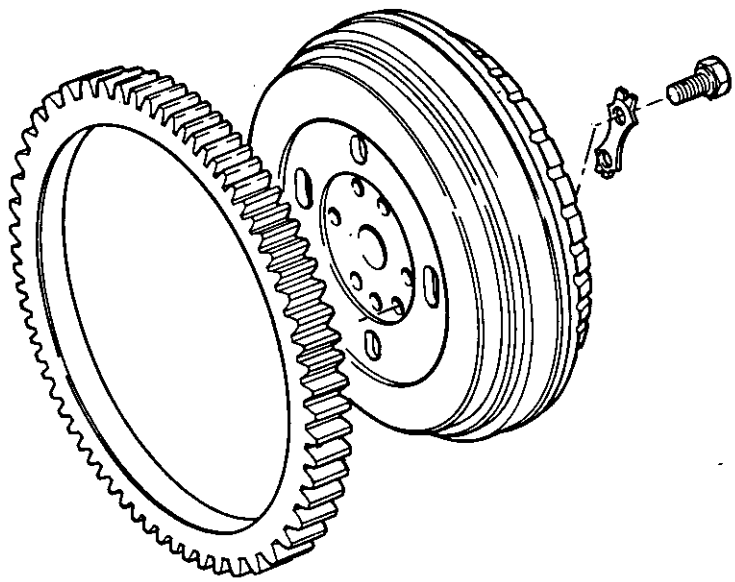
After reconditioning, the atomiser should be set to the Setting Pressure if a new spring has been fitted or to the Working Pressure if the existing parts have been reftted.

No attempt should be made to service or reset the pressure of an atomiser unless the proper equipment is available.

When renewing atomisers, reference should be made to the appropriate Parts List to ensure fitment of the correct type.

# SECTION M
# Flywheel and Flywheel Housing





## To Remove Flywheel

1. Remove gearbox and bell housing.
2. Evenly unscrew setscrews securing clutch assembly and detach the unit.
3. Knock back tabs of locking washers of flywheel securing setscrews.
4. Remove flywheel. To facilitate safe removal, it is recommended that two diametrically opposed securing setscrews are removed and in their place, fit two suitably sized studs, finger tight only. Remaining setscrews can now be removed and flywheel withdrawn under control.
5. Remove clutch pilot bearing (if fitted).

## To Renew Flywheel Ring Gear

The flywheel ring gear is shrunk on to the flywheel and to remove it partly cut through the gear and chisel cut it from the flywheel. Alternatively, localised heat in a flame form would expand the ring gear sufficiently to tap if off the flywheel.

1. Clean location of flywheel front face.
2. Heat new ring gear to an approximate temperature of 475°F (246°C).
3. Fit gear over flywheel with lead-in on teeth facing front of flywheel and allow to cool.

## Alignment of Flywheel Housing

Where a flywheel housing is fitted, it is most important that it be correctly aligned with the crankshaft. Misalignment may give rise to difficulty in changing gear, etc. If the housing has been removed, as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows:

See that the face of both the rear of the cylinder block and flywheel housing are perfectly clean and free from burrs.

Position housing on block and tighten but do not overtighten securing setscrews so as to allow adjustment.

## Alignment of Flywheel Housing Bore

Secure base of a "clock" gauge to crankshaft flange.

Set plunger of gauge to rest on inside of flywheel housing bore.

Turn crankshaft and check that this bore is truly central. Where necessary, adjust housing to centralise bore.

For convenience in turning engine it is advisable to release (but not remove) nuts holding atomisers in place.

Flywheel housing bore should be truly central with crankshaft within following limits (total indicator reading).

| Diameter of housing | Deviation |
|---|---|
| Up to 14.25 in (362 mm) | 0.006 in (0,15 mm) |
| 14.25 to 20.125 in (362 to 511 mm) | 0.008 in (0,20 mm) |
| 20.125 to 25.5 in (511 to 648 mm) | 0.010 in (0,25 mm) |
| 25.5 to 31,0 (648 to 787 mm) | 0.012 in (0,30 mm) |

## Alignment of Flywheel Housing Face

With base of 'clock gauge' still secured to crankshaft flange, adjust 'clock' so as to set plunger against vertical machined face of flywheel housing, and again, turning crankshaft, check that this face is perpendicular to crankshaft axis. When carrying out this check, take up crank-end float whilst turning crankshaft.

This facing should be within following limits (total indicator reading) of being truly at right angles to crankshaft axis).

| Diameter of housing | Deviation |
|---|---|
| Up to 14,25 in (362 mm) | 0.006 in (0,15 mm) |
| 14.25 to 20.125 in (362 to 511 mm) | 0.008 in (0,20 mm) |
| 20.125 to 25.5 in (511 to 648 mm) | 0.010 in (0,25 mm) |
| 25.5 to 31.0 in (648 to 787 mm) | 0.012 in (0,30 mm) |

All adjustments to bring flywheel housing within limits must be on flywheel housing and under NO CONDITIONS must rear of cylinder block be interfered with.

When housing is properly aligned to above limits, tighten securing setscrews to torque given on Page A.2.

Where necessary ream dowel holes and fit correct length and size dowels.

**To Refit Flywheel**

1. It is most essential before fitting a flywheel that crankshaft flange face and periphery are perfectly clean and free from burrs. Mating faces of flywheel must also be absolutely clean and free from burrs. Failure to observe these conditions may result, in flywheel running out of balance.
2. It will be noted that there is a seventh untapped hole in the crankshaft flange, which is at bottom centre when crankshaft is at T.D.C. No. 1 piston With aid of guide studs mount flywheel to crankshaft flange so that untapped hole in flange is in line with seventh, un-used smaller hole in flywheel.
3. Engage securing setscrews with three new locking washers and tighten sufficiently to hold flywheel to crankshaft.
4. It is most important that flywheel run out be checked to ensure that it will not run out of balance, so before tightening setscrews, secure base of 'clock' gauge to cylinder block. Then set plunger of 'clock' on periphery of flywheel (See Fig. M.1).
5. Turn crankshaft and check run out. The flywheel should run truly within 0.012 in (0,30 mm) total indicator reading.
6. With base of 'clock' gauge secured to cylinder block, set clock so that plunger rests against vertical machined face of flywheel (See Fig. M.2).
7. Again turn crankshaft and check run out, at the same time pressing a hammer shaft or similar tool against flywheel to take up crankshaft end float. The flywheel should be within 0.0005 in per inch (0,005 mm per cm) of flywheel diameter (total indicator reading) of being truly at right angles to crankshaft axis.
8. Using a suitable torque wrench tighten securing setscrews to recommended torque (See Page A.2).
9. Lock setscrews with tab washers.

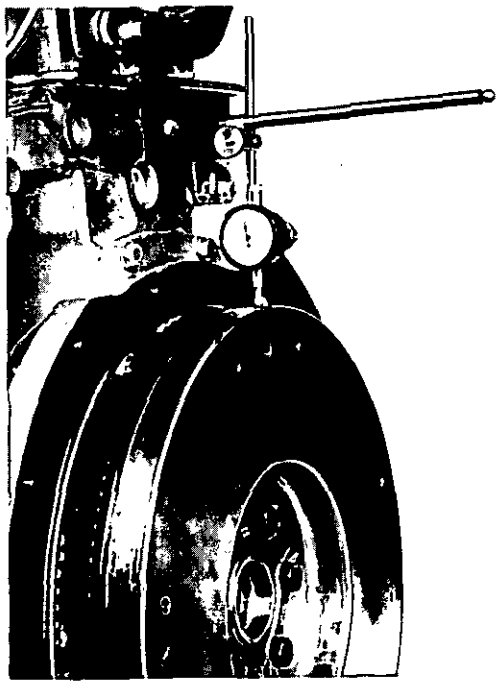


Fig. M.1
Checking Flywheel Periphery Run-Out.

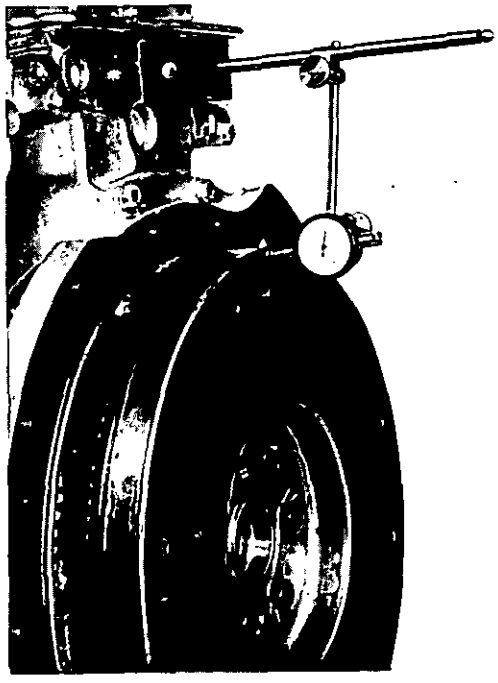
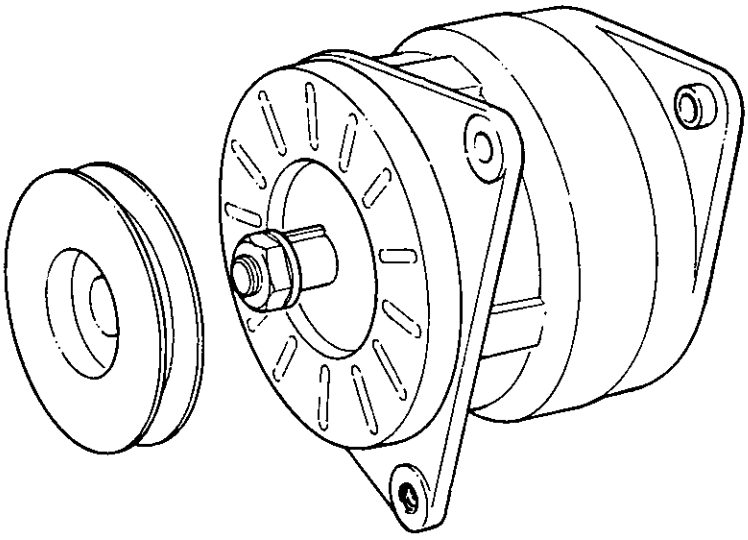
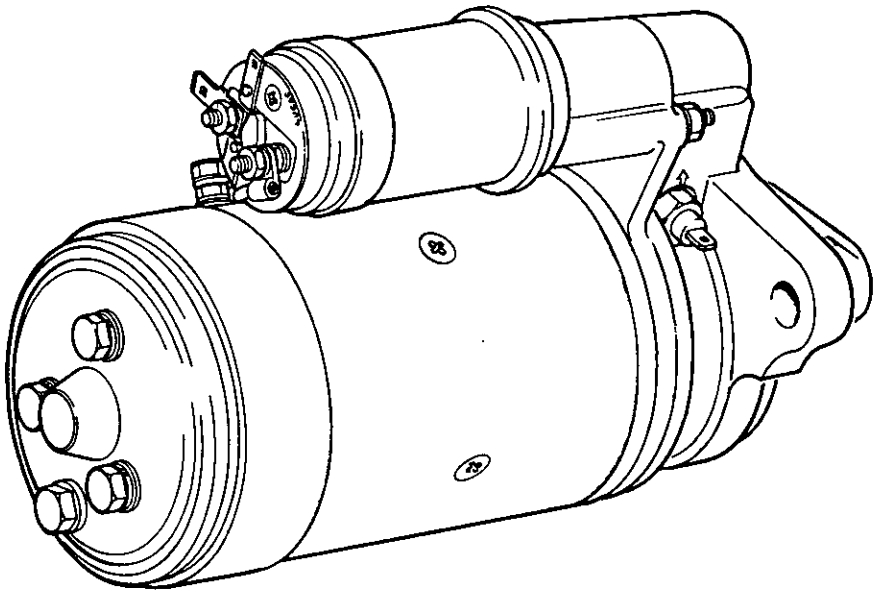


Fig. M.2
Checking Flywheel Back Face Run-Out.

# SECTION N
# Alternator & Starter Motor





## ALTERNATOR
## Models 15ACR, 17ACR, 18ACR A115/45 and LR Series

### Precautions

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 terminals. 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.

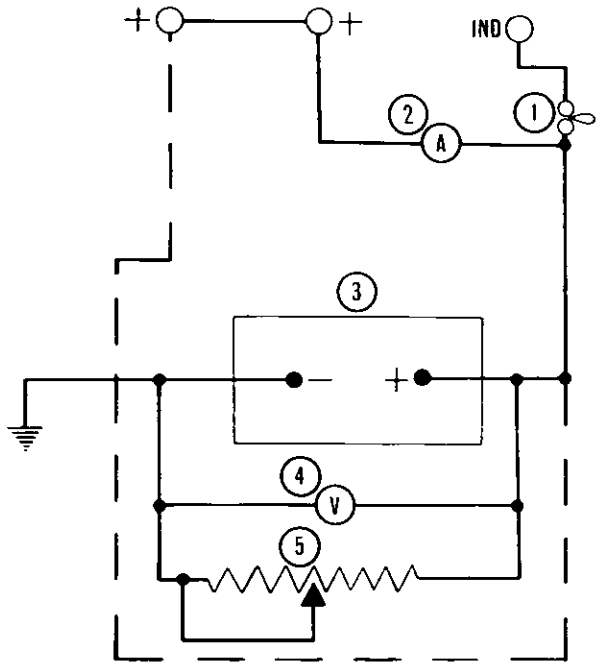



Fig. N.1

Test Circuit for 15ACR, 17ACR, A115/45 and LR series alternators with European terminations and single 3 terminal connector plug (machined-sensed). Broken line cable connection applies to battery-sensed, in which case, the connections between the two '+' terminals will not apply and the broken line terminal will be marked 'S' instead '+'.

### 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 belts 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 fluids. Ensure that ventilation slots and air spaces are clear and unstructed.

(d) Remove any dirt accumulated on the regulator/control box housing, and ensure that cooling air can pass freely over the casing.

## Testing the Alternator in Position

First check the driving belt for condition and tension. The nominal hot outputs at 6,000 rev/min (alternator speed) are as follows:—

| | |
|---|---|
| 15ACR – 28A | A115/45 – 45A |
| 17ACR – 36A | LR135 series – 35A |
| 17ACR (De-rated) – 25A | LR150 series – 50A |
| 18ACR – 45A | |

The de-rated 17ACR alternator is used on some applications operating under extremely dusty conditions.

These figures may be exceeded slightly when the alternator is running cold. To avoid misleading results, the following test procedure should therefore be carried out with the alternator running as near as possible to its normal operating temperature.

## Alternator Output Test with Regulator Inoperative

Withdraw the two part connector from the alternator, remove the moulded cover (secured by two screws) and earth the regulator green lead or connector strip to frame.

Connect an external test circuit to the alternator output terminals as shown in Fig. N.1.

Value of components in Fig. N.1 are as follows:—

1. 12 volt 2.2 watt bulb.
2. 0 — 60 ammeter.
3. 12 volt battery.
4. 0 — 20 moving coil voltmeter.
5. 0 — 15 ohm 35 amp variable resistor.

Observe carefully the polarity of battery and alternator terminals — reversed connections will damage the alternator diodes.

The variable resistor across the battery terminals must not be left connected for longer than is necessary to carry out the following test.

Start the engine. At 1,500 rev/min (alternator speed), the test circuit bulb should be extinguished. Increase engine speed until the alternator is running at 6,000 rev/min approximately, and adjust the variable resistance until the voltmeter reads 13.6 volts. The ammeter reading should then be approximately equal to the rated output (see previous heading). Any appreciable deviation from this figure will necessitate the alternator being removed from the engine for further examination.

Failure of one or more of the diodes will be indicated in the above test by effect on alternator output, and also in some instances by abnormally high alternator temperature and noise level.

## Regulator Test

The following test assumes the alternator to have been tested and found satisfactory.

Disconnect the variable resistor and remove the earth connection from the regulator green lead or connector strip to frame.

With the remainder of the test circuit connected as for the alternator output test, start the engine and again run the alternator up to 6,000 rev/min until the ammeter shows an output current of less than 10 amperes. The voltmeter should then give a reading of 13,6 — 14,4 volts. Any appreciable deviation from this (regulating) voltage means that the regulator is not functioning properly and must be replaced.

If the foregoing tests show the alternator and regulator to be satisfactorily performing, disconnect the test circuit and reconnect the alternator terminal connector. Now connect a low range voltmeter between the positive terminal of the alternator (the moulded terminal connector is open ended to facilitate this) and the positive terminal of the battery. Switch on battery load (headlights, etc.), start the engine and increase speed until the alternator runs at approximately 6,000 rev/min.

Transfer the voltmeter connections to the negative terminals of the alternator and battery and again note the meter reading.

If the reading exceeds 0.5 volt on the positive side or 0.25 volt on the negative side, there is a high resistance in the charging circuit which must be traced and remedied.

# STARTER MOTOR
# MODELS M50, M127/2,8 and CA45

## General Description — M50, M127/2,8

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, solenoid-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 ensure that the motor develops its maximum torque only when full pinion-flywheel engagement has been achieved.

## General Description — CA45

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.

## Testing on the Application

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 Shell SB2628 grease for template and cold climates or Shell Retinex grease for hot climates on M50 starter motors or an S.A.E. 90 oil for CA45 starter motors.

## 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 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 inter-connector 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.

# STARTER MOTOR
# MODELS M45, S12-84 and S12-85

## General Description

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:

Positive pinion engagement preventing the pinion being thrown out of mesh whilst starting.

Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and overload protection.

Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.

Armature braking system to ensure rapid return to rest when the starter button is released.

## Testing on the Application

Switch on the lamps. If the application 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:

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). 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', and starter yoke, 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.

## MAINTENANCE

### Brush Gear and Commutator

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.

After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching, $\frac{5}{16}$ in (7,9 mm) in length.

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).

Skim commutator if it is pitted or badly worn.

Check bearings for excessive side play of armature shaft.

Check pinion movement.

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.

Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for the purpose.

N

# SECTION T
# Turbocharger

## T3.1524 Engines only

The turbocharger is fitted on the exhaust manifold outlet, see page 7. It is lubricated by oil taken from the engine lubricating system. Oil pressure should never drop below 30 lbf/in² (2,11 kgf/cm²) or 207 kN/m²at normal running speed. Check this pressure regularly.

The maximum boost pressure should be 6.0 lbf/in²(0,42 kgf/cm²) or 41.0 kN/m² when the engine is running at maximum speed and full load.

With some engines where it is not possible to fully load the engine, the boost pressure will be somewhat lower.

No attention need be paid to the speed of the turbocharger since this varies automatically with the speed and load of the engine.

## Maintenance

Every 20,000 miles (30,000 km) or 1,000 hours, clean the oil drain pipe from turbocharger to sump, also turbocharger compressor wheel and cover.

Remove the air inlet duct and compressor housing and check for dirt or dust build-up (see Fig. T.1).

Remove all foreign matter—determine and correct cause of build up.

Use soft brush on compressor wheel as uneven deposits can affect rotor balance and cause bearing failure.

With the compressor housing removed push the compressor wheel towards the turbine wheel and turn rotating assembly by hand: check for binding and rubbing. Listen carefully for unusual noises. If binding or rubbing is evident, remove the turbocharger for dismantling and inspection.

## To Remove Turbocharger

*Disconnect turbocharger inlet and outlet connections.*

Disconnect exhaust pipe.

Remove oil supply pipe and release oil drain pipe.

Release turbocharger outlet assembly from the cylinder block.

Remove turbocharger from exhaust manifold, (see Fig. T.2).

Seal open engine connections.

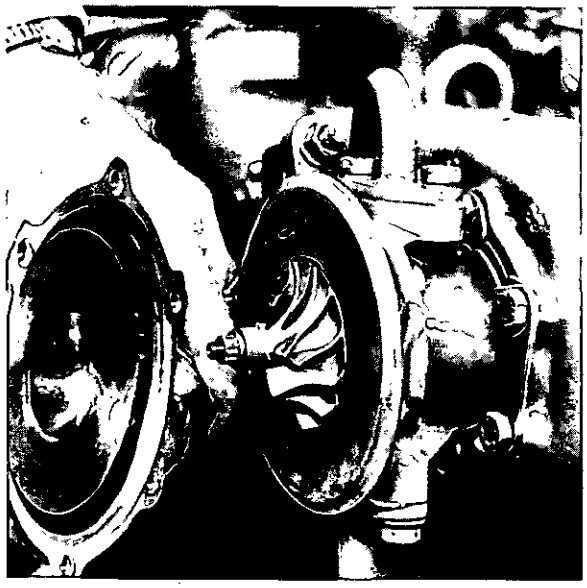


Fig. T.1
*Removing compressor housing.*

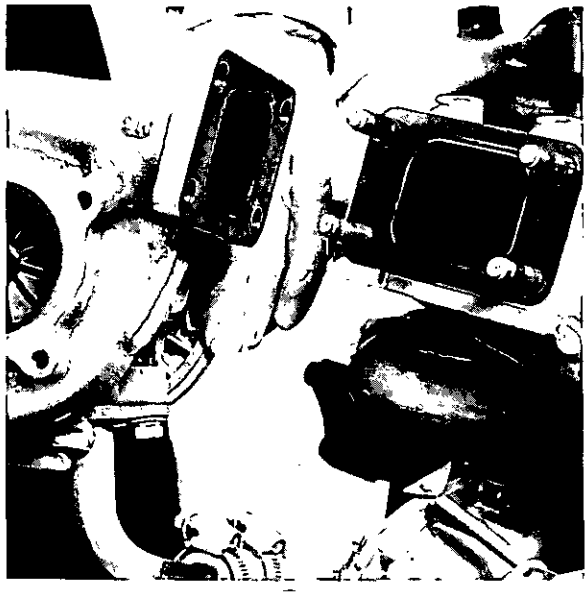


Fig. T.2
Removing turbocharger.

## Airesearch T-31 (see Fig. T.3)

### Dismantling

Clean the exterior with a pressure spray of a non-caustic cleaning solvent before dismantling. Dismantle only as required to make necessary inspection or repairs.

Remove the bolts, clamps and lockplates which hold the compressor and turbine housings to the centre housing group. Tap the housings with a soft faced hammer if force is needed for removal.

**Note:** Exercise caution when removing housings to prevent damage to compressor or turbine wheel. Once damaged, they cannot be repaired. Never attempt to straighten bent compressor or turbine blades—replace the faulty component.

Place the centre housing group in a suitable holding fixture which will prevent the turbine wheel from turning.

*Use a T-handled wrench when removing the compressor* wheel locknut to avoid possible bending of the shaft.

Lift the compressor wheel off the shaft. Remove the shaft wheel from the centre housing keeping shaft central with bearings until clear of centre housing.

**Note:** The turbine wheel shroud is not retained to the centre housing and will fall free when the shaft wheel is removed.

Remove lockplates and bolts from back plate.

Tap backplate with soft mallet to remove from recess in centre housing.

Remove thrust collar and thrust bearing from centre housing.

Remove bearings and retainers from centre housing. Discard rubber sealing ring.

### Cleaning

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

Soak all parts in clean non-caustic carbon solvent. After soaking, use a stiff bristle brush and remove all dirt particles. Dry parts thoroughly.

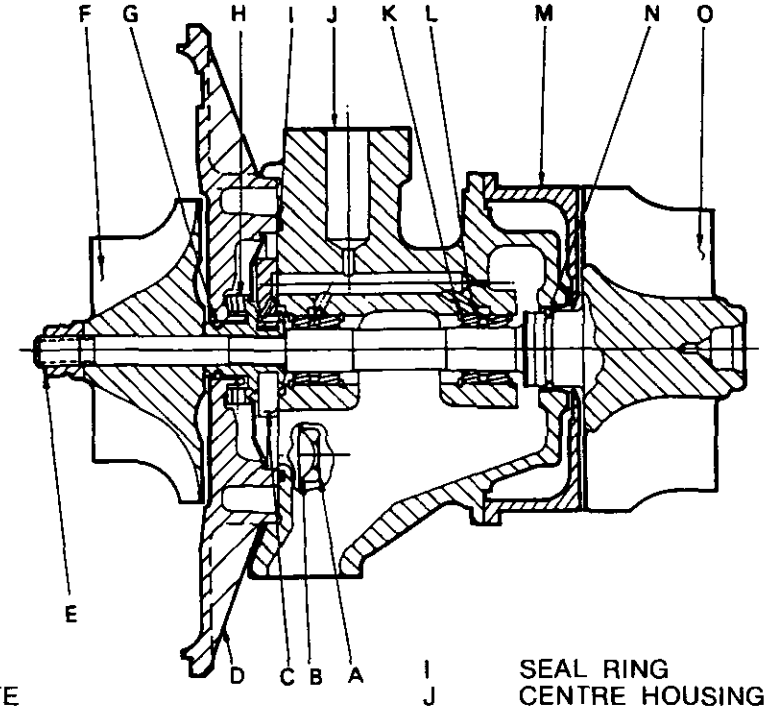
**Note:** Normally a light accumulation of carbon deposits will not affect turbine operation.

### Internal Parts Inspection (see Fig. T.4).

Parts must not show signs of damage, corrosion or deterioration. Threads must not be nicked, crossed or stripped.

The turbine wheel must show no signs of rubbing and vanes must not be torn or worn to a feather edge. The shaft must show little signs of scoring, scratches or seizure with the bearings.

The compressor must show no signs of rubbing or damage from foreign matter. The compressor wheel bore must not be chafed.




| | | | |
|---|---|---|---|
| A | BOLT | I | SEAL RING |
| B | LOCK PLATE | J | CENTRE HOUSING ASSEMBLY |
| C | THRUST BEARING | K | RETAINING RING |
| D | BACKPLATE ASSEMBLY | L | BEARING |
| E | LOCK NUT | M | SHROUD |
| F | COMPRESSOR WHEEL | N | PISTON RING, TURBINE |
| G | PISTON RING COMPRESSOR | O | SHAFT WHEEL ASSEMBLY |
| H | THRUST COLLAR | | |

*Fig. T.3*

Seal parts must show no signs of rubbing or scoring of the running faces. Housings must show no signs of contact with rotating parts. Oil and air passages must be clean and free from obstructions.

Burnish or polish out minor surface damage. Use silicon carbide abrasive cloth for aluminium parts and crocus abrasive cloth for the steel parts. Thoroughly clean parts before re-assembly.

Replace any parts which do not meet requirements.

Replace the following parts: seal ring, lockplates, piston rings, turbine housing bolts, journal bearings, bearing retaining rings and compressor wheel locknut. If thrust bearing and thrust collar show signs of nicks, scores, varnish deposits or foreign matter embedments–replace. Also, a close inspection of bearing bores in the centre housing should be made and if any of the above conditions exist, replace the centre housing.

## Re-assembly

Check each part prior to installation to ensure cleanliness. Exercise care to prevent entry of foreign matter during assembly.

Check thrust collar piston ring groove for nicks or burns.

Assemble in the following manner:

Install inboard bearing retainers. Lubricate bearings with clean engine oil. Fit bearings and outer bearings retainers.

Place turbine wheel upright. Gently guide shaft through shroud and centre housing bearings. Place thrust bearing over thrust collar.

Fit piston ring on thrust collar. Place thrust collar over shaft so that thrust bearing is flat against the centre housing and engages the centre housing anti-rotating pins.

Install seal ring in groove in centre housing.

Ensure that thrust spring is installed in back plate. Align mounting holes of centre housing and backplate and install over shaft and thrust collar. Use care not to break piston ring when engaging seal into back plate bore. Back plate is easily installed if open end position is engaged into back plate bore first.

Install compressor backplate, bolts and lockplate. Tighten to 79 lbf in (104 kgf cm) or 8,93 Nm and secure lockplates.

Fit compressor wheel. The larger face of the locknut and the front face of the impeller must be smooth and clean. Lightly oil threads and face of nut and tighten to 20 lbf in (23 kgf cm) or 2,26 Nm. Then continue to tighten until length of shaft increases by 0.0055/0.0065 in (0,14/0,16 mm). Tighten nut by using T-handled wrench to avoid side load which may cause shaft to bend. Check axial end play for 0.001/0.004 in (0,03/0,10 mm) travel. If equipment is not available to measure shaft stretch, this alternative method may be used: after installing impeller nut and tightening to 20 lbf in (23 kgf cm) or 2,26 Nm continue to tighten through an angle of $110^{0}$.

Check for clearance between wheel shroud and turbine wheel.

Orientate compressor housing to centre housing. Fit the six bolts and three lockplates. Tighten bolts to 130 lbf in (150 kgf cm) or 14,09 Nm.

Orientate turbine housing to centre housing. Coat bolt heads with a high temperature thread lubricant. Install bolts, clamps and lockplates. Tighten bolts to 130 lbf in (150 kgf cm) or 14,09 Nm. Bend up lockplates.

After assembly, push the rotating assembly as far as possible from the turbine end and check for binding. Repeat check, pushing from compressor end.

If the unit is to be stored, lubricate internally and install protective covers on all openings.

**Note:** The turbocharger does not require testing after overhaul.

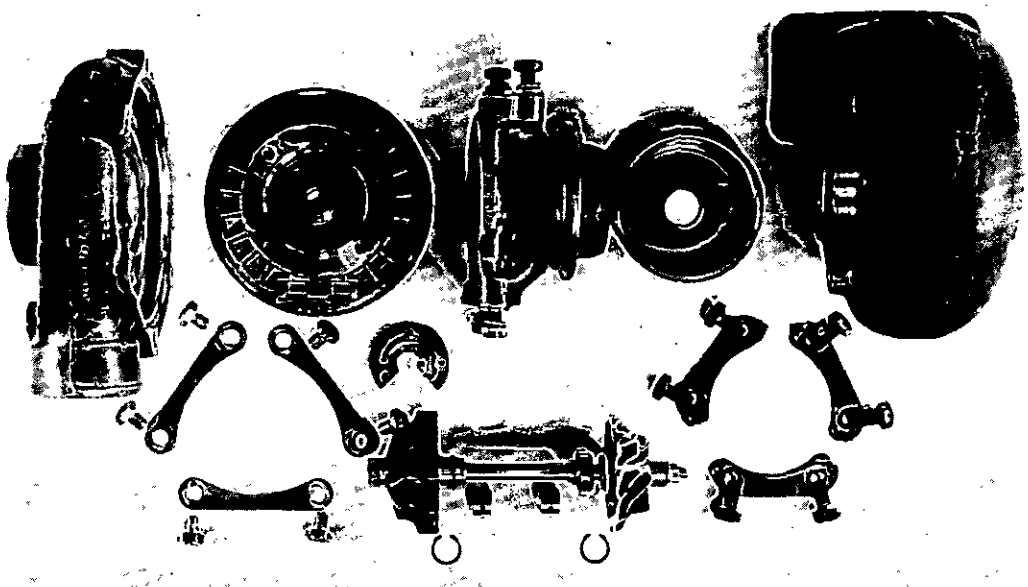


Fig. T.4

## To Fit Turbocharger

Remove seals from open engine connections.

Fit turbocharger to exhaust manifold, use a new gasket.

Fit turbocharger outlet assembly to cylinder block.

Fit oil drain pipe, use a new gasket.

Pour 4 to 5 (fluid ounces (110/114 ml) of clean engine oil through oil inlet port of turbocharger central housing. Turn rotation assembly by hand to pass oil over bearing surfaces.

Connect compressor inlet and outlet pipes and exhaust pipe.

Fit oil supply pipe but do not tighten setscrews.

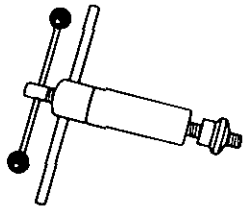
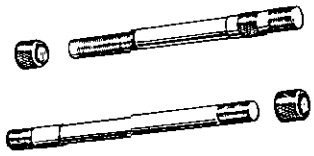
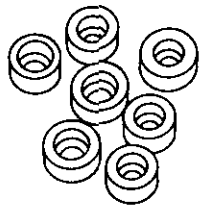
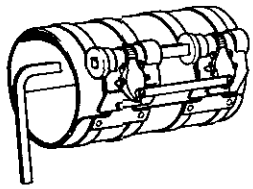
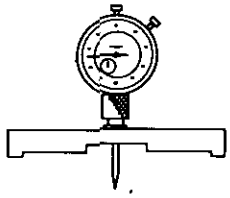
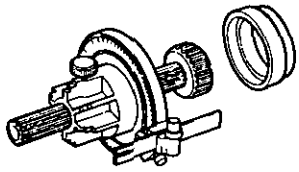
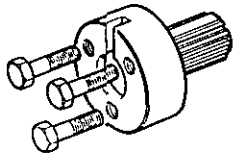
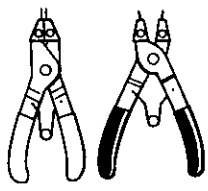
Operate the stop control and turn engine by the starter motor until a steady flow of oil comes from the oil supply pipe.

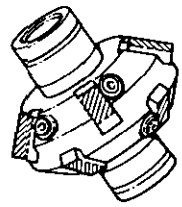
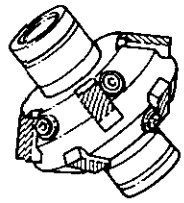
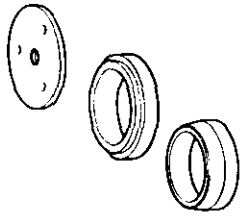
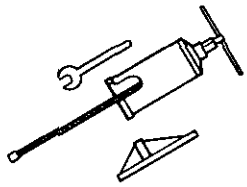
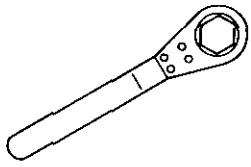
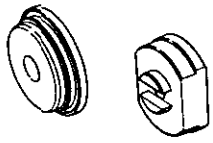
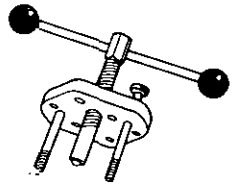
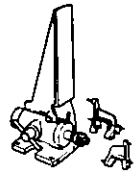
Tighten pipe flange setscrews.

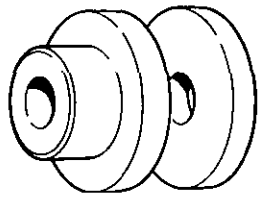
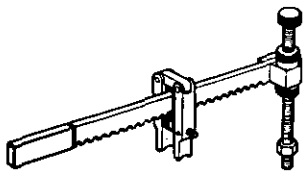
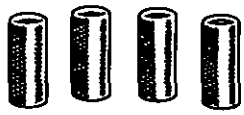
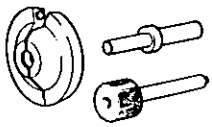
Start the engine and check for leaks, The engine must be run at idling speed for three to four minutes to allow the lubricating oil to flow before the engine speed is increased.

# APPROVED SERVICE TOOLS

The majority of these tools are available from your Perkins Distributor. Those marked with an asterisk are available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

| | Tool No. | Description |
|---|---|---|
|  | 21825026 | VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)— EARLY ENGINES ONLY |
|  | 21825027 | ADAPTOR FOR 21825026<br>A pair of puller bars fitted with knurled nuts. Suitable for 5/16" and 3/8" guides. |
|  | 21825029 | ADAPTOR FOR 21825026<br>A 15 mm (19/32 in) distance piece used to replace exhaust valve guides to a set height. |
| | 21825033 | ADAPTOR FOR 21825026<br>A 9,5 mm (3/8) distance piece used to replace inlet valve guides to a set height. |
|  | 21825018 | PISTON RING SQUEEZER |
|  | 21825019 | PISTON HEIGHT AND VALVE DEPTH GAUGE<br>A simple method of quickly checking piston height. |
|  | MS.67B* | UNIVERSAL TIMING GAUGE<br>For checking fuel injection pump timing. |
|  | PD.67B-1* | ADAPTOR FOR MS.67B<br>For use with mechanically governed fuel injection pump. |
|  | 21825017 | CIRCLIP PLIERS<br>(internal and external) |

| | Tool No. | Description |
|---|---|---|
|  | 21825068 | 35° EXHAUST VALVE SEAT CUTTER<br>*Used with handle MS.76 and pilot MS.150-8. |
|  | 21825069 | 35° INLET VALVE SEAT CUTTER<br>*Used with handle MS.76 and pilot MS.150-8. |
|  | PD.145C* | CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL) |
|  | 21825052 | CYLINDER LINER REMOVER/ REPLACER (MAIN TOOL)<br>For Field Service replacement of single liners. Not advised for complete overhaul. For this work use adaptors with a hydraulic ram unit. |
|  | 21825053 | CYLINDER LINER REMOVER/INSTALLER RATCHET WRENCH<br>For use with 21825052 where space is limited. |
|  | 21825054 | ADAPTORS FOR 21825052<br>Suitable for cylinders of 3.6" dia. Removal and replacement. |
|  | 21825006 | BASIC PULLER<br>Cruciform head with multiple holes at different centres complete with adaptors. |
|  | 355* | CON ROD JIG & 336 MASTER ARBOR |

| | Tool No. | Description |
|---|---|---|
|  | 336-102* | ARBOR ADAPTOR<br>Used with 335. |
|  | 21825020 | VALVE SPRING COMPRESSOR |
|  | 21825022 | ADAPTOR FOR 21825020 |
|  | MF.200-26* | WATER PUMP OVERHAUL KIT<br>Used with 370 Taper Base and Press. |

# EXAMPLES OF SERVICE FACILITIES

## Service Publications

The following Service Literature may be purchased through your local Perkins Distributor.

Workshop Manuals

Operators Handbooks

Crankshaft Regrinding

Fault Finding Guide

Engine Brake Testing Data

Installation and Maintenance Guide for Static Standby Engines

Etcetera

## Service Instruction

PETERBOROUGH

Apply to Product Education Department for details.

# USE ONLY GENUINE PERKINS PARTS

**To ensure you obtain the best results from your engine and to safeguard your own guarantee, fit only genuine Perkins Parts. These are readily obtainable throughout the world.**

# Index

# POWERPART Consumable Products

To give assistance in the correct operation, service and maintenance of your engine and machine, Perkins Engines Ltd., have made available the products shown below.

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**
Gives corrosion protection and also a more efficient coolant in hot conditions. See Page

**POWERPART Lay-Up 1**
A diesel fuel additive for protection against corrosion. See Page

**POWERPART Lay-Up 2**
Gives inside protection to the engine and other closed systems. See Page

**POWERPART Lay-Up 3**
Gives outside protection to any metal parts. See Page

**POWERPART De-Icer**
To remove frost.

**POWERPART Silent Spray**
Silicone lubrication to lubricate and prevent noise from hinges, slide doors, etc.

**POWERPART Damp Displacer**
To make damp electrical equipment dry and to give future protection.

**POWERPART Hylomar**
Universal sealing compound to seal joints.

**POWERPART Hylosil**
Silicone rubber sealant to prevent leakage.

**POWERPART Impact Adhesive**
To keep joints in position during installation and other general attachment purposes.

**POWERPART Solvent**
To thoroughly clean metal faces before assembly.

**POWERPART Locking Agent**
Used to securely install fasteners, sleeves, etc.