workshop manual for T6.3544, 6.3544 and 6.3724 diesel engines

Perkins Engines Limited

Peterborough England

1989

Publication No. TPD10891146E

CONTENTS

	Section
ENGINE PHOTOGRAPHS	A
TECHNICAL DATA	B
OPERATING AND MAINTENANCE	C*
FAULT FINDING	D
CYLINDER HEAD	E
PISTONS AND CONNECTING RODS	F
CYLINDER BLOCK AND LINERS	G
CRANKSHAFT AND MAIN BEARINGS	H
TIMING CASE AND DRIVE	J
TIMING	K
LUBRICATING SYSTEM	L
COOLING SYSTEM	M
AIR CLEANERS AND FUEL SYSTEM	N
FLYWHEEL AND FLYWHEEL HOUSING	P
TURBOCHARGER	Q
ALTERNATOR AND STARTER MOTOR	R
COMPRESSOR	S
EXHAUSTER	T
APPROVED SERVICE TOOLS	U
INDEX	
MARINE SUPPLEMENT	

*Operating and maintenance information can be found in section 3 of the multi-lingual 6.3544 SERIES User's Handbooks.

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.

Most of the general information which is included in the multi-lingual 6.3544 SERIES User's Handbooks has not been repeated in this workshop manual and the two publications should be used together.

Reference to renewing joints and cleaning off joint faces, has to a great extent been omitted from the text, it being 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 where present, burrs and scale are to be removed.

It follows that any open ports of high precision components, e.g. fuel injection equipment, exposed by dismantling, will be blanked off until re-assembled, to prevent the ingress of foreign matter.

When fitting setscrews or studs into holes which are tapped through into the interior of the engine, a suitable sealant should be used.

New type M.E.A.S. (micro encapsulated anaerobic sealant) fasteners are being introduced so that jointing compounds or other sealants need not be used when the fasteners are fitted in through holes into oil or waterways.

The identification of these fasteners, as supplied, is by a red, blue, or other colour sealant around the fastener threads.

With M.E.A.S. sealed studs, the sealed end must be fitted into the cylinder head/cylinder block etc.

Ensure that the threaded holes have a 1,59mm (1/16in) 45° chamfer, so that when the new fasteners are fitted the M.E.A.S. sealant is not removed.

If the fasteners have to be removed and fitted again, the threads must be cleaned and a suitable sealant used.

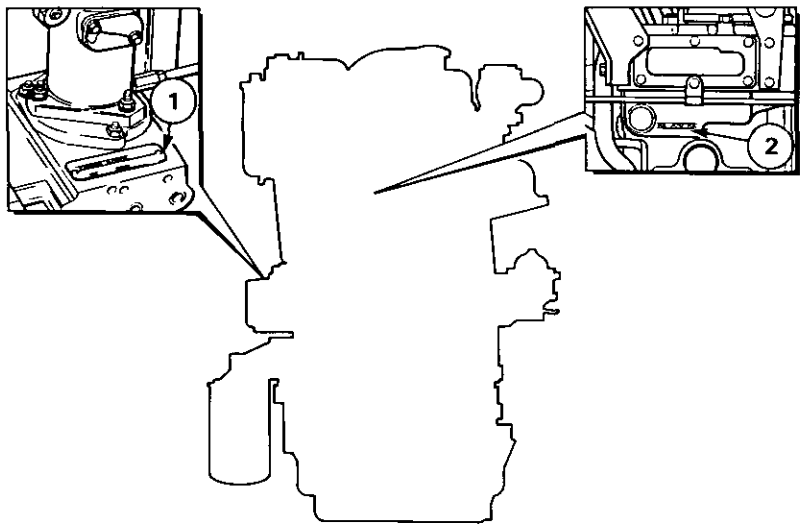
Throughout this manual, whenever "left" or "right" hand side of the engine is referred to, it is that side of the engine when viewed from the flywheel end.

Engine Number location

With earlier engines, the engine number was stamped on the auxiliary drive housing immediately below the fuel injection pump – see Figs. A1 and A3 (item 10). It consists of figures and letters, e.g., 3544U251T. The first three figures represent the cubic capacity, i.e., 354 in^3: the fourth figure denotes the engine model and the letter "U" signifies that the engine was built in the United Kingdom. The last group of figures comprises the engine serial number. Other letters which may follow the serial number denote specific information, i.e., a letter "T" indicates a turbocharged engine: a letter "L" indicates a lip type seal on the rear end of the crankshaft.

For current engines, the engine number consists of fifteen letters and figures, a typical number being TW30016U510256D. The latest engines have the engine number stamped on a label which is fitted to the top face of the auxiliary drive housing, see (1) in the illustration. Some engines also have the number stamped on the rear face of the cylinder block, see (2) in the illustration.

In all cases, the engine number when quoted, should be **in full.**



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 temperature of at least 140° F (60° C).**

SAFETY PRECAUTIONS

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

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, or equipment, is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. Attention: Some moving parts cannot be seen clearly while the engine runs.
- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil in a safe place to prevent contamination.
- Do not move mobile equipment if the brakes are not in good condition.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Fit only genuine Perkins parts.

ASBESTOS JOINTS

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

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

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

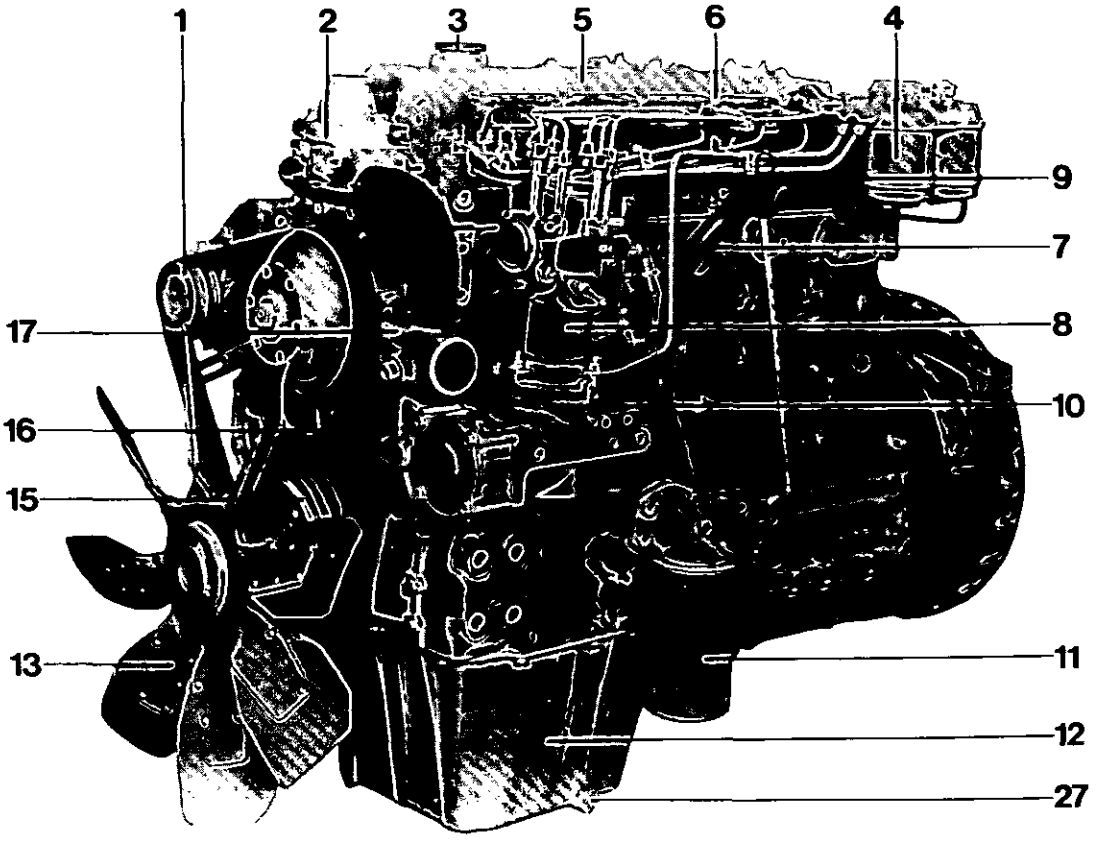
- Work in an area with good ventilation.
- Do not smoke.
- Use a hand scraper to remove the joints — do not use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all loose asbestos debris with water and put it in a closed container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

SECTION A
Engine Photographs

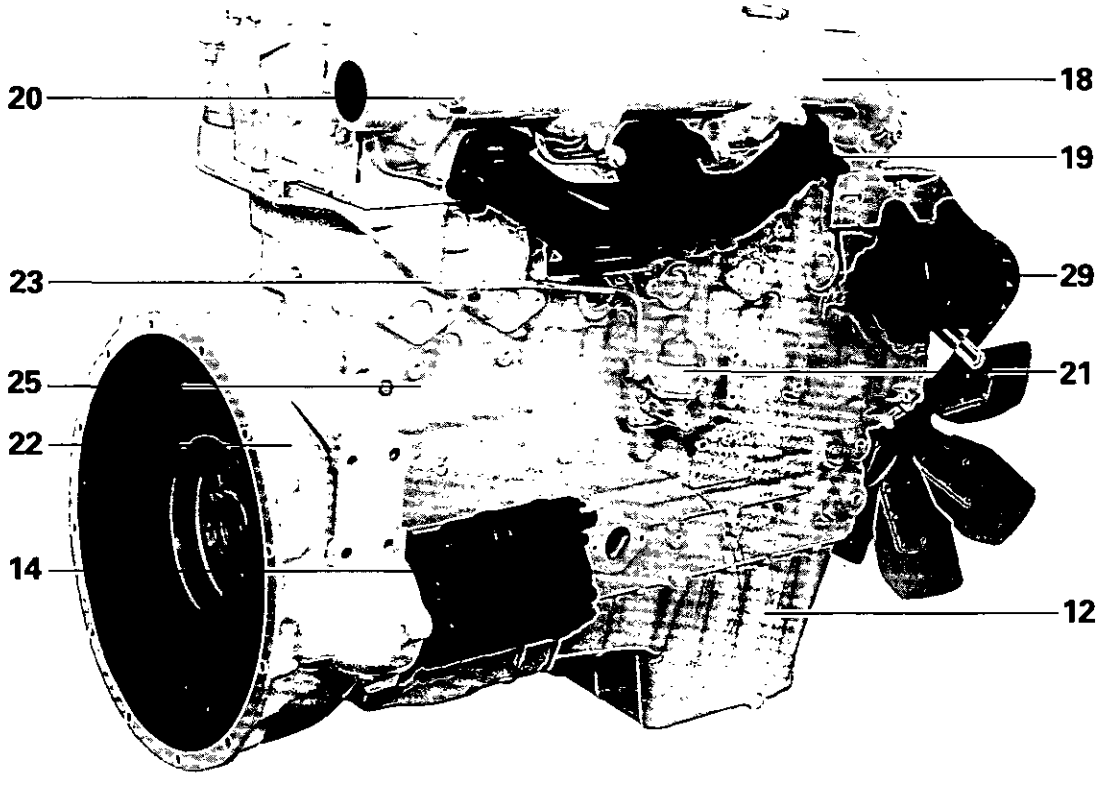
Perkins Engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.

Index to Engine Photographs

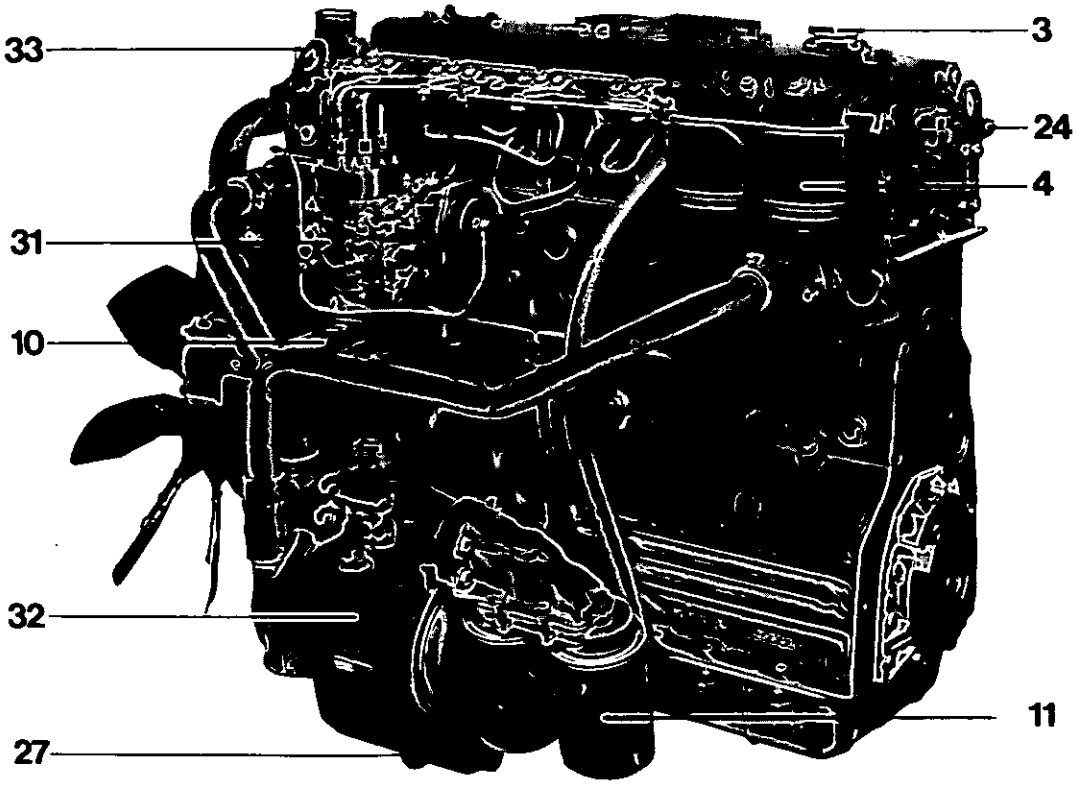
1. Alternator Pulley
2. Thermostat Housing and Water Outlet
3. Lubricating Oil Filler
4. Fuel Oil Filter
5. Cylinder Head Cover
6. Atomiser
7. Breather Pipe
8. Fuel Injection Pump (C.A.V.)
9. Dipstick
10. Engine Number Location
11. Lubricating Oil Filter
12. Sump
13. Fan
14. Starter Motor
15. Crankshaft Pulley and Vibration Damper
16. Fan Belts
17. Water Pump
18. Induction Manifold
19. Exhaust Manifold
20. Thermostart Unit
21. Fuel Lift Pump
22. Flywheel Housing
23. Fuel Pipe from Lift Pump to Final Fuel Filters
24. Rear Lifting Bracket
25. Cylinder Block Drain Point
26. Turbocharger
27. Sump Drain Plug
28. Oil Feed Pipe to Turbocharger
29. Alternator
30. Oil Drain Pipe from Turbocharger
31. Fuel Injection Pump (Bosch)
32. Lubricating Oil Cooler
33. Front Lifting Bracket
34. Integral Air Charge Cooler and Induction Manifold



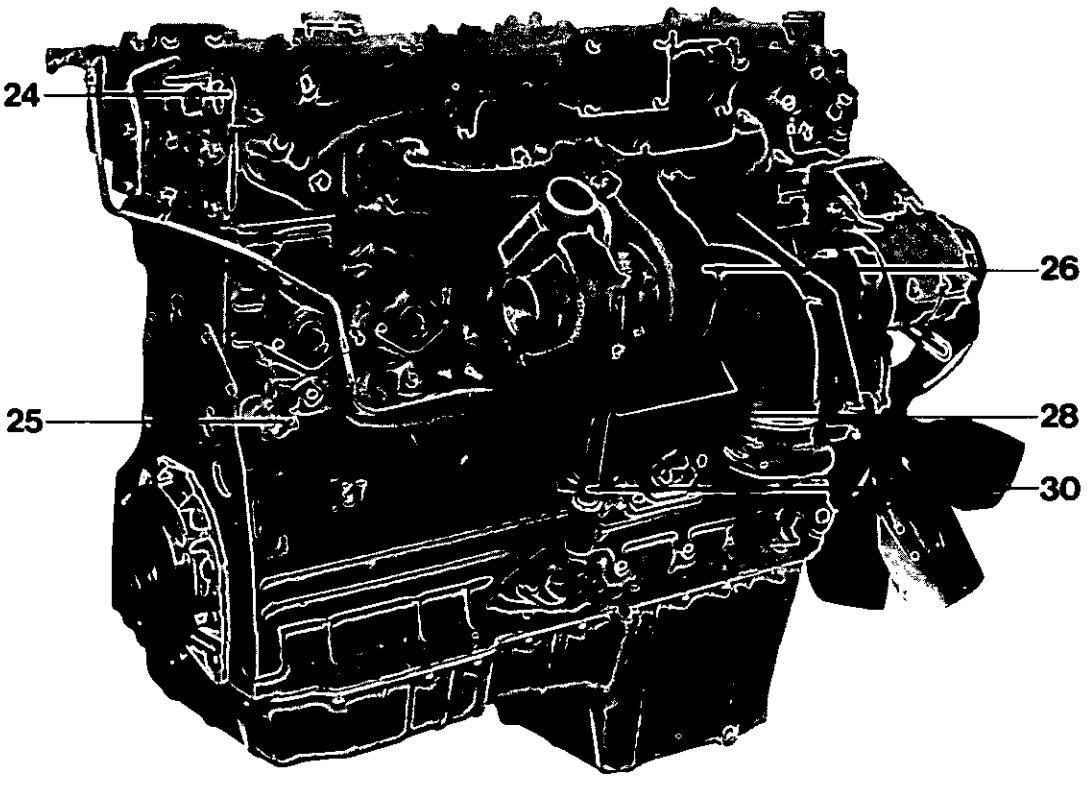
A.1 View of Fuel Pump Side of 6.3544 Engine



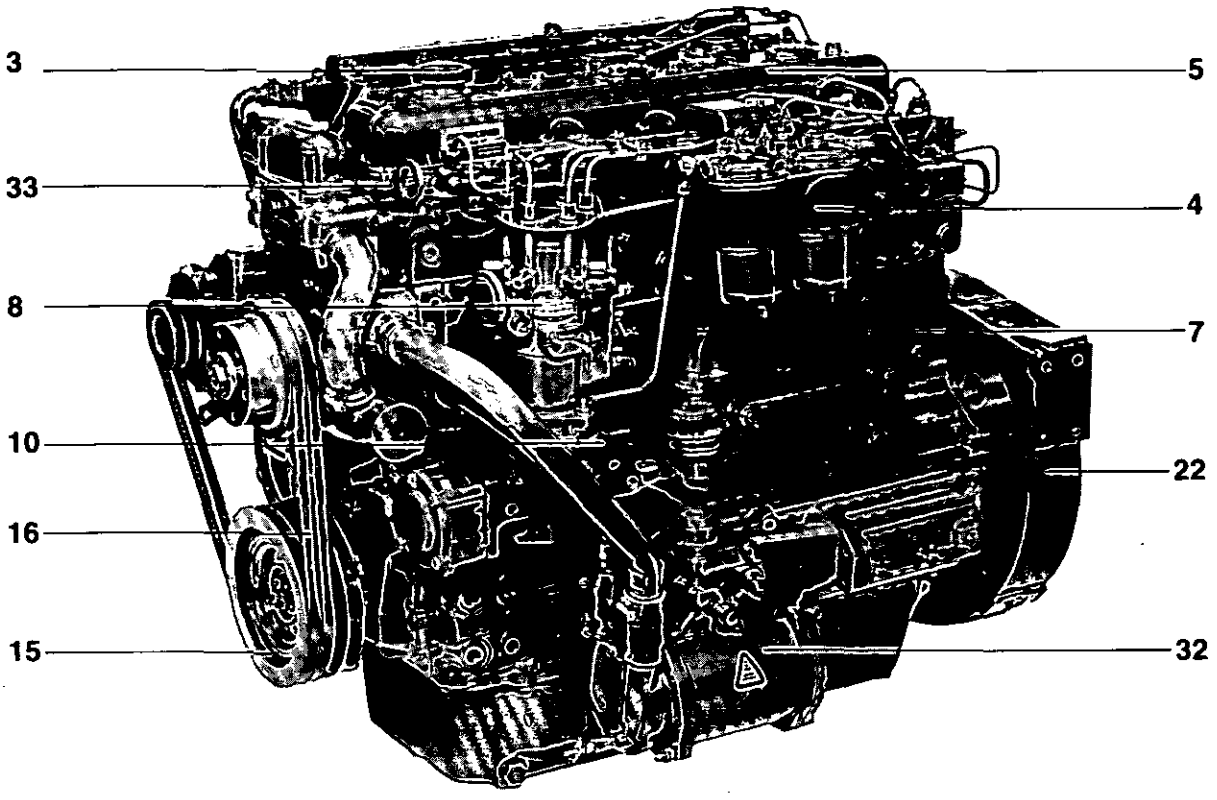
A.2 View of Camshaft Side of 6.3544 Engine



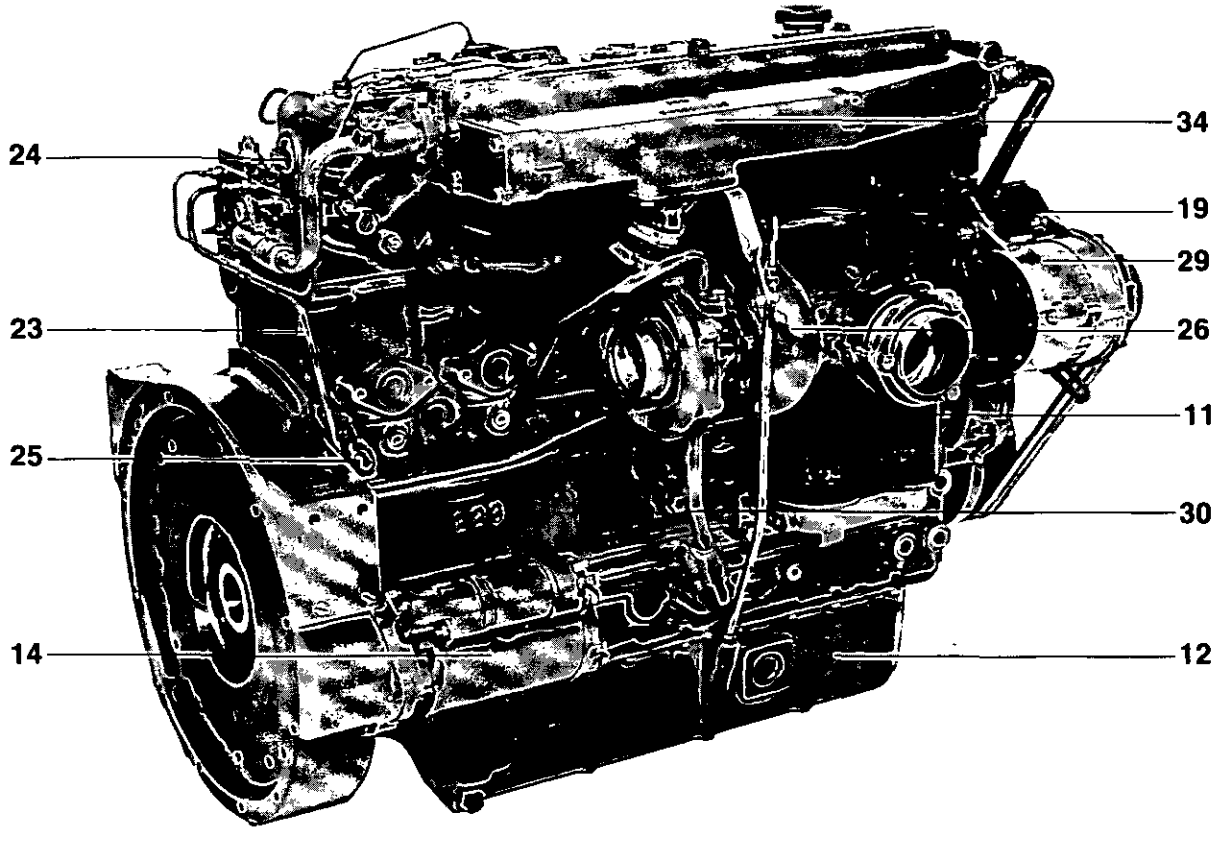
A.3 View of Fuel Pump side of T6.3544 Engine



A.4 View of Camshaft Side of T6.3544 Engine



A.5 View of Fuel Pump Side of T6.3544CC (Air Charge Cooled) Engine



A.6 View of Camshaft Side of T6.3544CC (Air Charge Cooled) Engine

SECTION B
Technical Data

Bore (T6.3544 and 6.3544 engines)	3.875 in (98,4 mm)*
Bore (6.3724 engines)	3.975 in (101 mm)*
Stroke	5 in (127 mm)
No. of cylinders	6
Cubic capacity (T6.3544 and 6.3544 engines)	354 in³ (5,8 litres)
Cubic capacity (6.3724 engines)	372 in³ (6,1 litres)
Compression ratio:	
T6.3544 engines	15.5: 1
North America vehicle T6.3544	16: 1
6.3544 engines	16: 1
6.3724 engines	16: 1
Firing order	1, 5, 3, 6, 2, 4
Combustion system	Direct injection
Cycle	4 stroke
Valve clearance (cold)	
Inlet	0.008 in (0,20 mm)
Exhaust	0.018 in (0,45 mm)
Lubricating oil pressure	30 lbf/in² (2,1 kgf/cm²) or 207 kN/m² minimum at maximum working speed and normal operating temperature.
Turbocharger boost pressures (measured at induction manifold) T6.3544 engines only	11-13.5 lbf/in² (0,80-0,95 kgf/cm²) or 76-93 kN/m² These pressures will vary according to application, engine loads and speeds. They are for guidance purposes only.

*Nominal—for actual bore size see Page B.3.

Details of ratings

T6.3544CC Vehicle	119 kW (159 bhp) at 2,600 rev/min
Maximum torque	502 Nm (370 lbf ft) at 1,600 rev/min
T6.3544 Vehicle	115 kW (155 bhp) at 2,600 rev/min
Maximum torque	498 Nm (367 lbf ft) at 1,700 rev/min
T6.3544 North America vehicle	104 kW (140 bhp) at 2,600 rev/min
Maximum torque	470,5 Nm (347 lbf ft) at 1,700 rev/min
T6.3544 Agricultural and Industrial	107 kW (143 bhp) at 2,500 rev/min
Maximum torque	469 Nm (346 lbf ft) at 1,600 rev/min
6.3544 Premium Vehicle	95,5 kW (128 bhp) at 2,800 rev/min
Maximum torque	380 Nm (280 lbf ft) at 1,500 rev/min
6.3544 Agricultural and Industrial	91 kW (122 bhp) at 2,600 rev/min
Maximum torque	384 Nm (283 lbf ft) at 1,400 rev/min
6.3724 Agricultural engines	90 kW (121 bhp) at 2,500 rev/min
Maximum torque	396 Nm (292 lbf ft) at 1,450 rev/min

The above ratings are maximum and can vary according to application.

Engine weights

Typical dry weight	940 - 960 lb (425 - 435 kg)
Typical installed weight	1100 - 1170 lb (500 - 530 kg)

Recommended torque tensions

The following figures will apply with the components lightly lubricated with clean engine oil

	Screw size UNF	lbf ft	kgf m	Nm
Cylinder head nuts and setscrews (with formed washer face) — cold	½	115	15,9	156
Cylinder head nuts and setscrews (with formed washer face) — hot	½	105	14,5	142
Cylinder head nuts and setscrews (with separate washers)	½	95	13,1	129
Cylinder head setscrews	5/16	28	3,9	38
Connecting Rod Nuts (Cadmium Plated)	½	75	10,4	102
Connecting Rod Nuts (Phosphated)	½	95	13,1	129
Main bearing setscrews	⅝	200	27,7	270
Idler gear hub nuts	⅜	36	5,0	49
Fuel lift pump setscrews	5/16	20	2,8	27
Sump securing setscrews	5/16	15	2,1	20

(continued)—

Recommended torque tensions (continued)

The following figures will apply with the components lightly oiled.

Component	Screw size UNF	lbf ft	kgf m	Nm
Flywheel securing setscrews	½	80	11,1	108
Flywheel housing securing setscrews (standard) ...	⅜	36	5,0	49
Flywheel housing securing setscrews (standard) ...	7/16	45	6,2	61
Flywheel housing securing setscrews (Durlok*) ...	⅜	67	9,3	91
Flywheel housing securing setscrews (Durlok*) ...	7/16(UNC)	104	14,4	141
Camshaft gear setscrews ...	½	50	6,9	68
Crankshaft pulley setscrews (cadmium plated) ...	7/16	65	9,0	88
Crankshaft pulley setscrews (phosphated)	7/16	92	12,7	125
Piston cooling jet banjo bolt (where fitted)	⅜	20	2,8	27
Rocker shaft bracket setscrews or nuts	7/16	55	7,6	75
Oil cooler to cylinder block, setscrews (where fitted)	7/16	50	6,9	68
Lubricating oil filter setscrews	7/16	30	4,1	40
Atomiser Securing nuts/setscrews	5/16	12	1,7	16
Auxiliary drive shaft gear setscrews	5/16	22	3,0	30
High pressure fuel pipe nuts	12 x 1,5 mm	15	2,1	20
Alternator pulley nut	7/8	27	3,7	37
	9/16	27	3,7	37
	5/8	40	5,6	60
	M17	44	6,1	60
Thermostart unit		10	1,4	13
Thermostart insulating adaptor		10	1,4	13

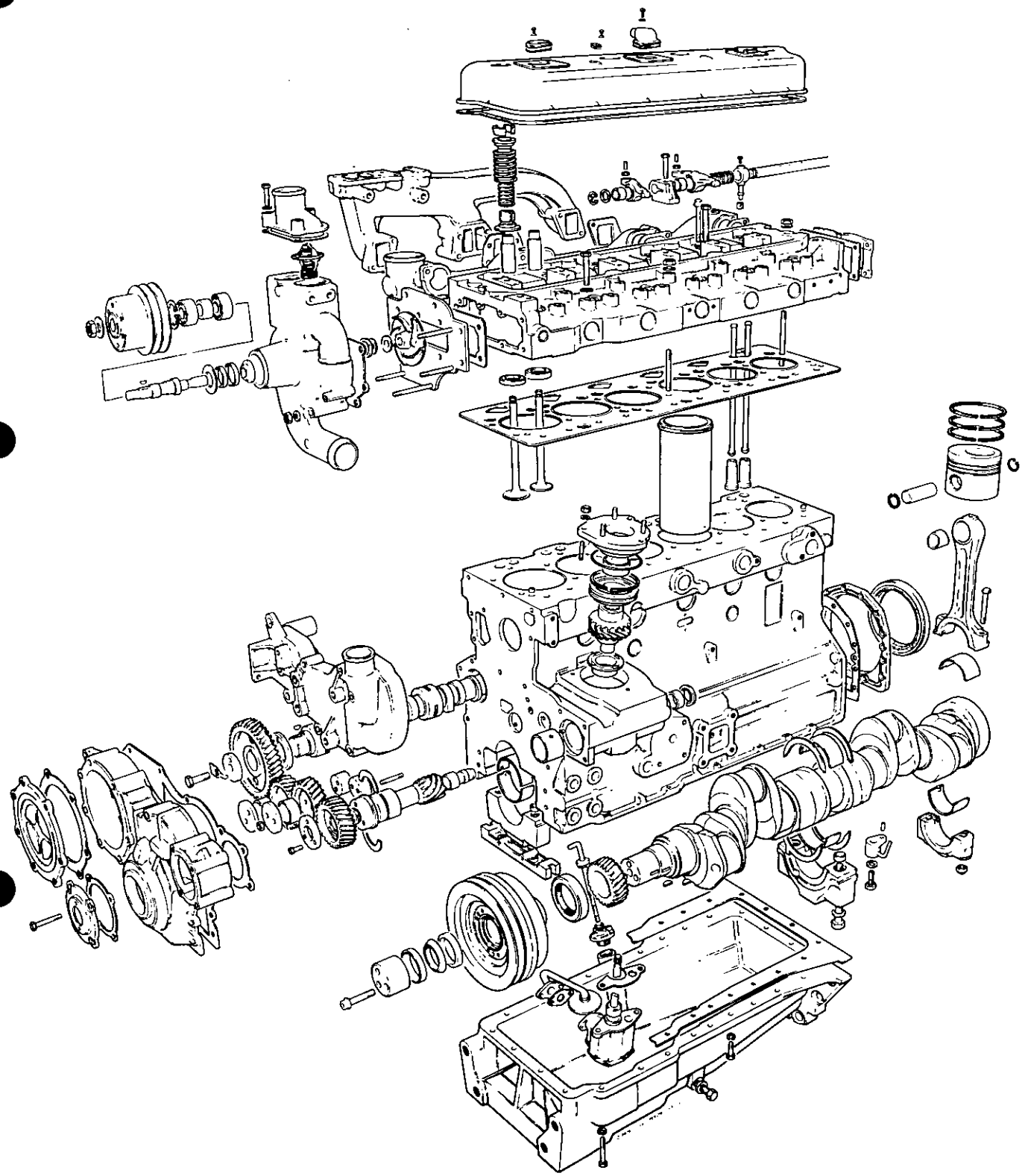
*Durlok setscrews have a formed washer face with radial serrations.

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

Altitude	Maximum fuel delivery de-rating*
0/2000 ft (600 metre)	No change
2000/4000 ft (1200 metre)	6%
4000/6000 ft (1800 metre)	12%
6000/8000 ft (2400 metre)	18%
8000/10000 ft (3000 metre)	24%
10000/12000 ft (3600 metre)	30%

*Measured at setting speed given on pump setting code.

It should be noted that the above information only applies to **naturally aspirated engines.** For **turbocharged engines** apply to Service Department, Perkins Engines Ltd., Peterborough or one of the Companies listed on Page 2.



MANUFACTURING DATA AND DIMENSIONS

All threads used, except perhaps on proprietary equipment are Unified Series and American Pipe Series.

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

Cylinder Block

Height between Top and Bottom Faces	17.367/17.375 in (441,12/441,32 mm)
Parent Bore Diameter for Cylinder Liner (T6.3544/6.3544)	4.0625/4.0635 in (103,19/103,21 mm)
Parent Bore Diameter for Cylinder Liner (6.3724)	4.1025/4.1035 in (104,20/104,23 mm)
Recess Depth for Cylinder Liner Flange	0.150/0.154 in (3,81/3,91 mm)
Recess Diameter for Cylinder Liner Flange (T6.3544/6.3544)	4.205/4.210 in (106,81/106,94 mm)
Recess Diameter for Cylinder Liner Flange (6.3724)	4.245/4.250 in (107,82/107,95 mm)
Main Bearing Parent Bore	3.166/3.167 in (80,42/80,44 mm)
Camshaft Bore Diameter, No. 1	2.000/2.001 in (50,80/50,83 mm)
Camshaft Bore Diameter, No. 2	1.990/1.992 in (50,55/50,60 mm)
Camshaft Bore Diameter, No. 3	1.980/1.982 in (50,29/50,34 mm)
Camshaft Bore Diameter, No. 4	1.970/1.972 in (50,04/50,09 mm)

Cylinder Liners (Cast Iron—Flanged)—T6.3544/6.3544

Type	Dry—Interference Fit—Production Dry—Transition Fit—Service
Outside Diameter of Production Liner	4.0645/4.0655 in (103,24/103,26 mm)
Interference Fit of Production Liner	0.001/0.003 in (0,03/0,08 mm)
Inside Diameter of Production Liner after Finish Honing	3.877/3.878 in (98,48/98,50 mm)
Transition Fit of Service Liner	-0.001/+0.001 in (-0.025/+0.025 mm)
Inside Diameter of Service Liner after fitting	3.877/3.8795 in (98,48/98,54 mm)
Flange Thickness	0.150/0.152 in (3.81/3.86 mm)
Height of Liner above Cylinder Block Top Face	0.026/0.037 in (0,66/0,94 mm)
Position of Liner Flange Relative to Top Face of Cylinder Block	+0.002/-0.004 in (+0,05/-0,10 mm)

Cylinder Liners (Cast Iron—Flanged)—6.3724

Type	Dry—Interference Fit—Production
Outside Diameter	4.1045/4.1055 in (104,25/104,28 mm)
Interference Fit of Liner	0.001/0.003 in (0,03/0,08 mm)
Inside Diameter of Liner after Finish Honing	3.9785/3.9795in (101,05/101,08mm)
Flange Thickness	0.150/0.152in (3,81/3,86mm)
Height of Liner above Cylinder Block Top Face	0.028/0.035in (0,71/0,89mm)
Position of Liner Flange relative to Cylinder Block Top Face	+0.002/-0.004 in (+0,05/-0,10mm)

Pistons (T6.3544)

Type	Toroidal Cavity in Crown
Piston Height in Relation to Cylinder Block Top Face	0.000/0.007 in (0,00/0,18 mm) above
Bore Diameter for Gudgeon Pin	1.5000/1.5002 in (38,100/38,105 mm)
Compression Ring Groove Width, No. 1	Tapered
Compression Ring Groove Width, No. 2	0.0955/0.0963 in (2,43/2,45 mm)
Scraper Ring Groove Width, No. 3	0.1885/0.1893 in (4,79/4,81 mm)

Pistons (T6.3544 North America vehicles)

Type	Re-entrant Combustion Chamber in Crown
Piston Height in Relation to Cylinder Block Top Face	0.000/0.007 in (0,00/0,18 mm) above
Bore Diameter for Gudgeon Pin	1.5000/1.5002 in (38,100/38,105 mm)
Compression Ring Groove Width, No. 1	Tapered
Compression Ring Groove Width, No. 2	0.0959/0.0967in (2,44/2,46mm)
Scraper Ring Groove Width, No. 3	0.1900/0.1908in (4,83/4,85mm)

Pistons (6.3544)—3 Ring

Type	Toroidal Cavity in Crown
Piston Height in Relation to Cylinder Block Top Face	0.000/0.007in (0,00/0,18mm) above
Bore Diameter for Gudgeon Pin	1.3751/1.3754in (34,928/34,935mm)
Compression Ring Groove Width, No. 1	0.0959/0.0978in (2,44/2,48mm)
Compression Ring Groove Width, No. 2	0.0959/0.0970in (2,44/2,46mm)
Scraper Ring Groove Width, No. 3	0.1885/0.1893in (4,79/4,81mm)

Pistons (6.3544) 5 Ring

Type	Toroidal Cavity in Crown
Piston Height relative to Cylinder Block Top Face	0.000/0.007in (0,00/0,18mm) above
Bore Diameter for Gudgeon Pin	1.37485/1.37520in (34,921/34,930mm)
Compression Ring Groove Width, No. 1	0.0957/0.0967 in (2,43/2,46 mm)
Compression Ring Groove Width, No. 2	0.0957/0.0967 in (2,43/2,46 mm)
Compression Ring Groove Width, No. 3	0.0957/0.0967 in (2,43/2,46 mm)
Scraper Ring Groove Width, No. 4	0.2525/0.2535 in (6,41/6,44 mm)
Scraper Ring Groove Width, No. 5	0.2525/0.2535 in (6,41/6,44*mm)

Pistons (6.3724)

Type	Toroidal Cavity in Crown
Piston Height Relative to Cylinder Block Top Face	0.007/0.014 in (0,18/0,36 mm)
Bore Diameter for Gudgeon Pin	1.37485/1.37505 in (34,921/34,926 mm)
Compression Ring Groove Width, No. 1	0.0977/0.0987 in (2,48/2,51 mm)
Compression Ring Groove Width, No. 2	0.0957/0.0966 in (2,43/2,46 mm)
Scraper Ring Groove Width, No. 3	0.1895/0.1905 in (4,81/4,84 mm)
Scraper Ring Groove Width, No. 4	0.1895/0.1905 in (4,81/4,84 mm)

Piston Rings (T6.3544)

No. 1 Compression	Chrome or Molybdenum Faced Wedge
No. 2 Compression	Tapered Face
No. 3 Scraper	Chrome Faced Oil Control Conformable
Compression Ring Width, No. 1	Wedge
Compression Ring Width, No. 2	0.0930/0.0935in (2,36/2,37mm)
Scraper Ring Width, No. 3	0.1860/0.1875in (4,72/4,76mm)
No. 1 Clearance in Groove	Wedge
No. 2 Clearance in Groove	0.002/0.0038in (0,05/0,10mm)
No. 3 Clearance in Groove	0.0010/0.0033in (0,03/0,08mm)
Piston Ring Gap — No. 1	0.010/0.026in (0,25/0,66mm)
Piston Ring Gap — No. 2	0.012/0.030in (0,30/0,76mm)
Piston Ring Gap — No. 3	0.010/0.033in (0,25/0,84mm)

Piston Rings (T6.3544 North America vehicles)

No. 1 Compression	Chrome faced wedge
No. 2 Compression	Tapered face
No. 3 Scraper	Chrome faced oil control conformable
Compression Ring Width, No. 1	Wedge
Compression Ring Width, No. 2	0.0930/0.0935 in (2,36/2,37 mm)
Scraper Ring Width, No. 3	0.1860/0.1875 in (4,72/4,76 mm)
No. 1 Clearance in Groove	Wedge
No. 2 Clearance in Groove	0.0024/0.0037in (0,061/0,094mm)
No. 3 Clearance in Groove	0.0025/0.0048 in (0,06/0,122 mm)
Piston Ring Gap — No. 1	0.012/0.022 in (0,30/0,56 mm)
Piston Ring Gap — No. 2	0.012/0.022 in (0,30/0,56 mm)
Piston Ring Gap — No. 3	0.010/0.033 in (0,25/0,84 mm)

Piston Rings (6.3544 — 3 ring pack)

No. 1 Compression	Chrome Barrel Faced Internally Chamfered
No. 2 Compression	Chrome Taper Faced
No. 3 Scraper	Chrome Faced Oil Control Conformable
Compression Ring Width, No. 1	0.0930/0.0935 in (2,36/2,37 mm)
Compression Ring Width, No. 2	0.0930/0.0935 in (2,36/2,37 mm)
Scraper Ring Width, No. 3	0.1860/0.1875 in (4,72/4,76 mm)
No. 1 Clearance in Groove	0.0024/0.0048in (0,06/0,12mm)
No. 2 Clearance in Groove	0.0024/0.0040in (0,06/0,10mm)
No. 3 Clearance in Groove	0.0010/0.0033in (0,03/0,08mm)
Piston Ring Gap — No. 1	0.010/0.028in (0,25/0,71mm)
Piston Ring Gap — No. 2	0.008/0.024in (0,20/0,61mm)
Piston Ring Gap — No. 3	0.010/0.033in (0,25/0,84mm)

Piston Rings (6.3544— 5 ring pack)

No. 1 Compression	Plain
Nos. 2 and 3 Compression	Internally Stepped
No. 4 Scraper	Chrome Faced Oil Control Conformable
No. 5 Scraper	Slotted Oil Control
Compression Ring Width, Nos. 1, 2 and 3	0.0928/0.0938in (2,36/2,38mm)
Scraper Ring Width, Nos. 4 and 5	0.249/0.250in (6,32/6,35mm)
Nos. 1, 2 and 3 Clearance in Groove	0.019/0.0039in (0,05/0,10mm)
Nos. 4 and 5 Clearance in Groove	0.0025/0.0045in (0,06/0,11mm)
Piston Ring Gaps – Cast Iron	0.012/0.030in (0,30/0,76mm)
Piston Ring Gaps – Chromed	0.016/0.034in (0,41/0,86mm)

Piston Rings (6.3724)

No. 1 Compression	Parallel Chrome Inlay
No. 2 Compression	Chrome Plated Internally Stepped or Internally Chamfered
No. 3 Scraper	Chrome Plated, Spring Expander
No. 4 Scraper	Slotted Oil Control
Compression Ring Width, Nos. 1 and 2	0.0928/0.0938 in (2,36/2,38 mm)
Scraper Ring Width Nos. 3 and 4	0.1865/0.1875 in (4,74/4,76 mm)
No. 1 Clearance in Groove	0.0039/0.0059 in (0,10/0,14 mm)
No. 2 Clearance in Groove	0.0019/0.0039 in (0,05/0,10 mm)
Nos. 3 and 4 Clearance in Groove	0.002/0.004 in (0,05/0,10 mm)
Piston Ring Gaps, Nos. 1, 2 and 3	0.016/0.034 in (0,41/0,86 mm)
Piston Ring Gap, No. 4	0.012/0.030 in (0,30/0,76 mm)

Gudgeon Pin (T6.3544)

Type	Fully Floating
Outside Diameter	1.4998/1.5000 in (38,095/38,100 mm)
Length	3.250/3.2599 in (82,55/82,80 mm)
Clearance Fit in Piston Boss	0.0000/0.0004 in (0,000/0,0010 mm)

Gudgeon Pin (6.3544 and 6.3724)

Type	Fully Floating
Outside Diameter	1.3748/1.3750 in (34,920/34,925 mm)
Length	3.297/3.312 in (83,74/84,12 mm)
Clearance Fit in Piston Boss	0.00012/0.00055 in (0,003/0,014 mm)

Small End Bush (T6.3544) (Includes North America vehicle engines)

Type	Steel Backed, Lead Bronze Lined
Outside Diameter	1.65975/1.66125 in (42,16/42,20 mm)
Inside Diameter after Reaming	1.50075/1.5015 in (38,12/38,14 mm)
Clearance between Small End Bush and Gudgeon Pin	0.00075/0.0017 in (0,019/0,043 mm)

Small End Bush (6.3544 and 6.3724)

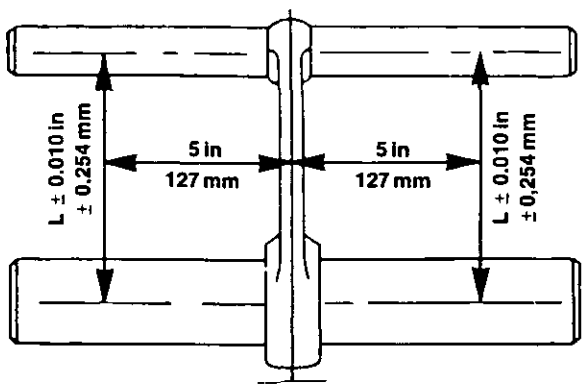
Type	Steel Backed, Lead Bronze Lined
Outside Diameter	1.535/1.5365 in (38,99/39,03 mm)
Inside Diameter after Reaming	1.3758/1.3765 in (34,94/34,96 mm)
Clearance between Small End Bush and Gudgeon Pin	0.0008/0.0017 in (0,020/0,043 mm)

Connecting Rod

Type	H Section T6.3544—Wedge Shaped Small End 6.3544—Parallel Shape Small End
Cap Location to Connecting Rod	Serrations
Big End Parent Bore Diameter	2.646/2.6465 in (67,21/67,22 mm)
Small End Parent Bore Diameter, T6.3544	1.65625/1.65725 in (42,07/42,09 mm)
6.3544 and 6.3724	1.5313/1.5323 in (38,90/38,92 mm)
Length from C/L of Big End to C/L of Small End	8.624/8.626 in (219,05/219,10 mm)

Connecting Rod Alignment

Large and small end bores must be square and parallel with each other within the limits of ± 0.010 in (0,25 mm) measured 5 in (127 mm) each side of the axis of the rod on a test mandrel as shown in Fig. B.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).



B.1

Crankshaft

Overall Length	33.844 in (859,64 mm) — nominal
Main Journal Diameter	2.9984/2.9996 in (76,16/76,19 mm)
Main Journal Length, No. 1	1.454/1.484 in (36,93/37,69 mm)
Main Journal Length, Nos. 2, 3, 5, 6 and 7	1.545/1.549 in (39,24/39,35 mm)
*Main Journal Length, No. 4	1.738/1.741 in (44,15/44,22 mm)
*Fillet Radii—Main Journals	0.145/0.156 in (3,68/3,96 mm)
Crankpin Diameter	2.4988/2.4998 in (63,47/63,49 mm)
*Crankpin Length	1.5885/1.5915 in (40,35/40,42 mm)
*Fillet Radii—Crankpins	0.145/0.156 in (3,68/3,96 mm)
Surface Finish—all pins and journals	16 micro-inches (0,4 microns)
Regrind Undersizes, Journals and Pins	—0.010, 0.020 and 0.030 in (—0,25, 0,51 and 0,76 mm)
Flange Diameter	5.247/5.249in (133,27/133,32mm)
Spigot Bearing Recess—Depth	0.579/0.609 in (14,71/15,47 mm)
Spigot Bearing Recess—Bore	2.046/2.047 in (51,97/51,99 mm)
Crankshaft End Float	0.002/0.015 in (0,05/0,38 mm)

*Fillet radii and surface finish must be maintained during crankshaft regrinding. Length of No. 4 main journal must not exceed 1.759in (44,68mm) after regrinding. Where necessary, use oversize thrust washers to suit. Length of crankpins not to exceed 1.5965 in (40,55 mm) after regrinding. For crankshaft journal run-out, see Page H.4.

IMPORTANT NOTE: See remarks on Page H.3 concerning the regrinding of 60 hour Nitrided crankshafts.

Crankshaft Thrust Washers

Type	Steel Backed, Lead Bronze Faced
Position in Engine	Centre Main Bearing
Thrust Washer Thickness—Standard	0.089/0.091in (2,26/2,31mm)
Thrust Washer Thickness—Oversize	0.0965/0.0985in (2,45/2,50mm)
Thrust Washer Outside Diameter	4.088/4.098 in (103,84/104,09 mm)
Thrust Washer Inside Diameter	3.42/3.43 in (86,87/87,12 mm)

Main Bearings

Type	Pre-finished, Steel Backed, Aluminium Silicon Faced
Shell Width, Nos. 1, 2, 3, 5, 6 and 7	1.240/1.255in (31,50/31,88mm)
Shell Width, No. 4	1.435/1.445in (36,45/36,70mm)
Outside Diameter	3.166/3.167in (80,42/80,44mm)
Inside Diameter	3.0010/3.0026in (76,225/76,266mm)
Main Bearing Running Clearance	0.0018/0.0042in (0,046/0,107mm)
Shell Thickness	0.0822/0.0825in (2,088/2,096mm)

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Silicon or Aluminium Tin Faced
Shell Width	1.245/1.255in (31,62/31.88mm)
Outside Diameter	2.646/2.6465in (67,21/67,22mm)
Inside Diameter	2.5008/2.5019in (63,52/63,55mm)
Bearing Running Clearance	0.0012/0.0031in (0,030/0,08mm)
Shell Thickness	0.0723/0.0726in (1,836/1,844mm)

Camshaft

No. 1 Journal Length	1.085in (27,56mm)
No. 1 Journal Diameter	1.9965/1.9975in (50,71/50,74mm)
No. 1 Journal Running Clearance	0.0025/0.0045in (0,06/0,11mm)
No. 2 Journal Length	1.438in (36,53mm)
No. 2 Journal Diameter	1.9865/1.9875in (50,46/50,49mm)
No. 2 Journal Running Clearance	0.0025/0.0055in (0,06/0,14mm)
No. 3 Journal Length	1.438in (36,53mm)
No. 3 Journal Diameter	1.9765/1.9775in (50,20/50,23mm)
No. 3 Journal Running Clearance	0.0025/0.0055in (0,06/0,14mm)
No. 4 Journal Length	1.156in (29,37mm)
No. 4 Journal Diameter	1.9665/1.9675in (49,95/49,98mm)
No. 4 Journal Running Diameter	0.0025/0.0055in (0,06/0,14mm)
Cam Lift—Inlet (non-vehicle)	0.2959/0.2989in (7,516/7,592mm)
Cam Lift—Exhaust (non-vehicle)	0.3025/0.3055in (7,684/7,760mm)
Cam Lift—Inlet (vehicle only)	0.2999/0.3029in (7,617/7,694mm)
Cam Lift—Exhaust (vehicle only)	0.3036/0.3066in (7,711/7,788mm)
Camshaft End Float	0.004/0.016in (0,10/0,41mm)
Width of Spigot for Thrust Washer	0.222/0.232in (5,64/5,89mm)

Camshaft Thrust Washer

Type	360°
Outside Diameter	2.872/2.874 in (72,95/73,00 mm)
Cylinder Block Recess Diameter for Thrust Washer	2.875/2.885 in (73,03/73,28 mm)
Clearance Fit of Washer in Recess	0.001/0.013 in (0,03/0,33 mm)
Internal Diameter	1.750 in (44,45 mm)
Thickness	0.216/0.218 in (5,49/5,54 mm)
Cylinder Block Recess Depth for Thrust Washer	0.215/0.218 in (5,46/5,54 mm)
Relationship of Thrust Washer to Cylinder Block Front Face	−0.002/+0.003 in (−0,05/+0,08 mm)

Cylinder Head

Cylinder Head Depth	3.735/3.765 in (94,87/95,63 mm)
Leak Test Pressure	30 lbf/in² (2,11 kgf/cm²) -207 kN/m²
Valve Seat Angle	45°
Valve Guide Parent Bore Diameter	0.6247/0.6257 in (15,87/15,89 mm)
Skimming Allowance	0.012 in (0,30 mm) Providing that nozzle protrusion does not exceed 0.184 in (4,67 mm) for T6.3544 engines or 0.136 in (3,45 mm) for 6.3544 and 6.3724 engines after skimming.

Valve Guides

Inside Diameter	0.3743/0.3757 in (9,51/9,54 mm)
Outside Diameter	0.626/0.6265 in (15,90/15,91 mm)
Interference Fit of Guide in Cylinder Head	0.0011/0.0026 in (0,03/0,07 mm)
Overall length, Inlet	2.281 in (57,94 mm)
Overall length, Exhaust	2.406 in (61,11 mm)
Protrusion above Valve Spring Recess	0.594 in (15,09 mm)
Counter bore, Exhaust only	0.421/0.441 in (10,69/11,20 mm) dia. for length of 0.406 in (10,3 mm)

Inlet Valve

Valve Stem Diameter	0.3725/0.3735 in (9,46/9,49 mm)
Clearance Fit of Valve in Guide	0.0008/0.0032 in (0,02/0,08 mm)
Maximum Permissible Worn Service Clearance of Valve in Guide	0.005 in (0,13 mm)
Valve Head Diameter	1.736/1.746 in (44,09/44,35 mm)
Valve Face Angle	45°
Valve Head Depth below Cylinder Head Face— Production Limits	0.040/0.050 in (1,02/1,27 mm)
Overall Length	4.831/4.847 in (122,71/123,11 mm)
Sealing Arrangement	Rubber seal fitted to valve guide

Exhaust Valve

Valve Stem Diameter	0.371/0.372 in (9,42/9,45 mm)
Clearance Fit to Valve in Guide	0.0023/0.0047 in (0,06/0,12 mm)
Maximum Permissible Worn Service Clearance of Valve in Guide	0.006 in (0,15 mm)
Valve Head Diameter	1.467/1.477 in (37,26/37,52 mm)
Valve Face Angle	45°
Valve Head Depth below Cylinder Head Face— Production Limits	0.040/0.050 in (1,02/1,27 mm)
Overall Length	4.845/4.865 in (123,06/123,57 mm)
Sealing Arrangement	Rubber seal fitted to valve guide

Inner Valve Springs (short)

Fitted length and Load	1.340 in (34,04 mm) at 20.1/23.2 lbf (9,12/10,52 kgf) (89,4/103,2N)
Number of Active Coils	4.9
Number of Damper Coils	1
Coiled	R.H.—Damper Coil to Cylinder Head

Inner Valve Springs (long)

Fitted length and Load	1.563 in (39,70 mm) at 14.63/16.67 lbf (6,64/7,56 kgf) (65,1/74,2N)
Number of Active Coils	7
Number of Damper Coils	2
Coiled	R.H.—Damper Coils to Cylinder Head

Outer Valve Springs (short)

Fitted length and Load	1.410 in (35,81 mm) at 39.5/43.7 lbf (17,91/19,82 kgf) (175,7/194,4N)
Number of Active Coils	3.6
Number of Damper Coils	1
Coiled	L.H.—Damper Coil to Cylinder Head

Outer Valve Springs (long)

Fitted length and Load	1.780 in (45,20 mm) at 38/43 lbf (17,25/19,52 kgf) (169,2/191,5 N)
Number of Active Coils	5.8
Number of Damper Coils	2
Coiled	L. H. — Damper Coils to Cylinder Head

Tappets

Overall Length	2.96875 in (75,41 mm)
Tappet Shank Diameter	0.7475/0.7485 in (18,91/19,01 mm)
Cylinder Block Tappet Bore Diameter	0.750/0.75125 in (19,05/19,08 mm)
Running Clearance of Tappet in Bore	0.0015/0.00375 in (0,04/0,09 mm)
Outside Diameter of Tappet Foot	1.1875 in (30,16 mm)

Rocker Shaft

Overall Length	26.03125 in (661,19 mm)
Outside Diameter	0.7485/0.7495 in (19,01/19,04 mm)

Rocker Levers and Bushes

Internal Bore Diameter of Rocker Lever for Bush	0.875/0.8762 in (22,22/22,26 mm)
Outside Diameter of Bush	0.877/0.8785 in (22,28/22,31 mm)
Interference Fit of Bush in Rocker Lever	0.0008/0.0035 in (0,02/0,09 mm)
Internal Diameter of Bush (after reaming in situ)	0.7505/0.7520 in (19,06/19,10 mm)
Clearance of Bush to Rocker Shaft	0.001/0.0035 in (0,03/0,09 mm)

Push Rods

Overall Length of Push Road	10.456/10.540 in (265,58/267,72 mm)
Shank Diameter	0.310/0.312 in (7,87/7,93 mm)

Camshaft Gear

Number of Teeth	56
Bore Diameter	1.375/1.376 in (34,93/34,95 mm)
Outside Diameter of Camshaft Hub	1.3751/1.3757 in (34,93/34,94 mm)
Fit of Gear to hub	-0.0007/+0.0009 in (-0,018/+0,023 mm)

Auxiliary Drive Gear

Number of Teeth	28
Bore Diameter	1.000/1.001 in (25,4/25,43 mm)
Maximum Adjustment in Slotted Holes	10°

Crankshaft Gear

Number of Teeth	28
Bore Diameter	1.875/1.876 in (47,63/47,65 mm)
Crankshaft Diameter for Gear	1.875/1.8758 in (47,63/47,64 mm)
Fit of Gear to Crankshaft	-0.0008/+0.001 in (-0,020/+0,025 mm)

Idler Gears and Hubs

Number of Teeth	37
Bore Diameter	2.0625/2.0643 in (52,39/52,43 mm)
Outside Diameter of Bush	2.06625/2.06825 in (52,48/52,53 mm)
Inside Diameter of Bush (finished in situ)	1.8750/1.8766 in (47,63/47,67 mm)
Outside Diameter of Hub	1.8714/1.873 in (47,53/47,57 mm)
Clearance of Hub inside Bush	0.002/0.0052 in (0.05/0,13 mm)
End Float of Gears	0.002/0.012 in (0,05/0,30 mm)

Timing Gear Backlash

All Gears	0.003 in (0,08 mm) minimum

Auxiliary Drive Shaft Assembly

Drive Shaft—Overall Length	10.25 in (260,35 mm)
Number of Teeth on Worm	11
Outside Diameter of Worm	1.865/1.870 in (47,37/47,5 mm)
Diameter of Front Journal	1.9355/1.9365 in (49,16/49,19 mm)
Diameter of Rear Journal	1.248/1.249 in (31,7/31,72 mm)

Drive Shaft Bush—Front

Outside Diameter of Bush	2.1283/2.1303 in (54,06/54,11 mm)
Housing Diameter for Bush	2.125/2.1262 in (53,98/54,01 mm)

continued . . .

Interference Fit in Housing	0.0021/0.0053 in (0,05/0,13 mm)
Inside Diameter of Fitted Bush	1.9375/1.9397 in (49,21/49,27 mm)
Running Clearance of Shaft in Bush	0.001/0.0042 in (0,025/0,11 mm)

Drive Shaft Bush—Rear

Outside Diameter of Bush	1.4086/1.4105 in (35,78/35,83 mm)
Housing Diameter for Bush	1.4063/1.4076 in (35,72/35,75 mm)
Interference Fit in Housing	0.001/0.0042 in (0,025/0,11 mm)
Inside Diameter of Fitted Bush	1.25/1.2519 in (31,75/31,80 mm)
Running Clearance of Shaft in Bush	0.001/0.0039 in (0.025/0,10 mm)

Auxiliary Drive Thrust Washers

Thickness	0.1875/0.1905 in (4,76/4,84 mm)
Cylinder Block Recess Depth for Thrust Washer	0.184/0.187 in (4,67/4,75 mm)
Outside Diameter	2.806/2.812 in (71,27/71,42 mm)
Inside Diameter of Cylinder Block Recess	2.8125/2.8225 in (71,44/71,69 mm)
Protrusion of Thrust Washer in Cylinder Block	0.0005/0.007 in (0,01/0,17 mm)
Groove Width on Drive Shaft	0.193/0.1965 in (4,9/4,99 mm)
Groove to Thrust Washer Clearance	0.0025/0.009 in (0,064/0,23 mm)

Hydraulically Loaded Wormwheel

Bore Diameter in Cylinder Block for Fuel Pump Adaptor Plate and Upper Thrust Collar	3.500/3.5014 in (88,90/88,94 mm)
Fuel Pump Adaptor Plate Diameter	3.4986/3.4995 in (88,86/88,89 mm)
Fit of Plate in Cylinder Block	0.0005/0.0028 in (0,01/0,07 mm)
Outer Diameter of Upper Thrust Collar	3.496/3.498 in (88,80/88,85 mm)
Clearance of Upper Thrust Collar in Cylinder Block	0.002/0.0054 in (0,05/0,14 mm)
Bore Diameter in Cylinder Block for Lower Thrust Washer	2.2491/2.2499 in (57,13/57,15 mm)
Width of Groove in Upper Thrust Collar	0.0957/0.0967 in (2,43/2,46 mm)
Upper Thrust Collar Sealing Ring Thickness	0.0928/0.0938 in (2,36/2,38 mm)
Clearance of Sealing Ring in Groove	0.0019/0.0039 in (0,05/0,10 mm)
Inner Diameter of Bush in Fuel Pump Adaptor Plate	1.875/1.8766 in (47,63/47,67 mm)
Upper Diameter of Fuel Pump Drive Shaft	1.8714/1.873 in (47,53/47,57 mm)
Clearance of Drive Shaft in Adaptor Plate Bush	0.002/0.0052 in (0,05/0,13 mm)
Inner Diameter of Upper Thrust Collar	1.886/1.89 in (47,90/48,01 mm)
Clearance of Drive Shaft in Upper Thrust Collar	0.013/0.0186 in (0,33/0.47 mm)
Current Engines:—	
Lower Thrust Collar Bore for Bush	1.7812/1.7828 in (45,24/45,28 mm)
Outer Diameter of Bush	1.7843/1.7857 in (45,32/45,36 mm)
Interference Fit of Bush in Thrust Collar	0.0015/0.0045 in (0,04/0,11 mm)
Inner Diameter of Bush (after finishing in situ)	1.6255/1.6266 in (41,29/41,32 mm)
Lower Diameter of Fuel Pump Drive Shaft	1.6214/1.6224 in (41,18/41,22 mm)
Clearance of Shaft in Bush	0.0031/0.0052 in (0,08/0,13 mm)
Early Engines:—	
Inner Diameter of Lower Thrust Collar	1.625/1.6266 in (41,28/41,32 mm)
Lower Diameter of Fuel Pump Drive Shaft	1.6214/1.6230 in (41,18/41,22 mm)
Clearance of Drive Shaft in Collar	0.002/0.0052 in (0,05/0,13 mm)

Sump

Sump Capacity (typical)	26 Imperial Pints (14,8 Litres)
Minimum to Maximum mark on Dipstick	5 Imperial Pints (2,84 Litres)
Strainer Position	Suction Pipe of Lubricating Oil Pump

Oil Pump

Type	Rotor

Oil Pump Clearance

Inner Rotor to Outer Rotor	0.003/0.005 in (0,08/0,13 mm)
Outer Rotor to Pump Body	0.006/0.013 in (0,15/0,33 mm)
Inner and Outer Rotor End Clearance	0.0005/0.0025 in (0,01/0,06 mm)

For replacement purposes, the whole pump assembly must be replaced.

Relief Valve

First Stage Pressure Setting (T6.3544 only)	30/37 lbf/in² (2,11/2,6 kgf/cm²) 207/255 kN/m²
Relief Flow Pressure Setting	50/60 lbf/in² (3,52/4,22 kgf/cm²) 348/414 kN/m²
Length of Plunger	0.9375 in (23,81 mm)
Outside Diameter of Plunger	0.7158/0.717 in (18,18/18,21 mm)
Inside Diameter of Valve Housing Bore	0.718/0.7192 in (18,24/18,27 mm)
Clearance of Plunger in Bore	0.001/0.0034 in (0,03/0,09 mm)
Free Length of Spring	2.3125 in (58,74 mm)
Spring Fitted Length and Load	2.1875 in (55,56 mm) at 3 lbf 8 ozf (1,58 kgf)

Lubricating Oil Filter

Type of Filter	Full Flow Replaceable Canister
Element Type	Paper
By-Pass Valve Setting	8/12 lbf/in² (0,56/0,84 kgf/cm²) 55/83 kN/m²

Cooling System

Type	Thermo-Syphon, Pump assisted.
Coolant Capacity	38 Imperial Pints, (21,6 litres)

Thermostat

Type	Twin Wax Capsule fitted in parallel (By-pass blanking)
Opening Temperature	170/185°F (77/85°C) or 153/167°F (67/75°C)
Fully open at	198/208°F (92/98°C) or 185/190°F (85/88°C)
Valve Lift	0.358in (9,1 mm minimum)

Water Pump

Type	Centrifugal
Outside Diameter of Shaft for Pulley	0.8742/0.8747 in (22,20/22,22 mm)
Inside Diameter of Pulley Bore	0.8750/0.8758 in (22,23/22,25 mm)
Clearance Fit of Pulley on Shaft	0.0003/0.0016 in (0,01/0,04 mm)
Outside Diameter of Shaft for Impeller	0.5012/0.5018 in (12,73/12,75 mm)
Diameter of Impeller Bore	0.5000/0.5007 in (12,70/12,72 mm)
Interference Fit of Impeller on Shaft	0.0005/0.0018 in (0,013/0,046 mm)
Impeller Blade to Pump Body Clearance	0.027/0.035in (0,69/0,89mm)

Fuel Lift Pump

Type of Pump	A.C. Delco X D Series
Method of Drive	Eccentric on Camshaft
Delivery Pressure	6/10 lbf/in² (0,43/0,70 kgf/cm²) or 41/69 kN/m²
Diaphragm Spring Colour	Red

Fuel Filter

Type	Twin Parallel or single
Element Type	Paper

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Pump Rotation	Anti-clockwise
Timing Letter	"F"
No. 1 Cylinder Outlet	"X"

Make	Bosch
Type	Rotary
Pump Rotation	Anti-clockwise
No. 1 Cylinder Outlet	D

Fuel Injection Pump Static Checking Angles

The relevant timing information can be found by reference to the prefix letters or prefix letters and figures of the setting code adjacent to the word "Set" on the fuel pump identification plate and the table below. The engine checking angle is for use with timing tool MS67B and the engine set with No. 1 piston at TDC compression stroke.

Prefix Letters	Engine Checking Angle (Degrees)	Fuel Pump Marking Angle (Degrees)	Static Timing BTDC (Degrees)	Piston Displacement
T6.3544				
C.A.V. pumps				
CY	153	145	16	0.124in (3,15mm)
DY	160	144	32	0.483in (12,27mm)
JY	159	144	30	0.426in (12,82mm)
LX	159	144	30	0.426in (10,82mm)
LY	153	145	16	0.124in (3,15mm)
MY	159	144	30	0.426in (10,82mm)
PY	160	144	32	0.483in (12,27mm)
TX	159	144	30	0.426in (10,82mm)
VR	159	144	30	0.426in (10,82mm)
XX	159	144	30	0.426in (10,82mm)
YX	160	144	32	0.483in (12,27mm)
ZX	159	144	30	0.426in (10,82mm)
Bosch pumps				
EY (L21-2)	135*	125½*	19	0.175in (4,45mm)
FY (L21-3)	135*	127½*	15	0.110in (2,79mm)
KY (L107)	123*	118*	10	0.049in (1,24mm)
VX (L21 or L73)	135*	127*	16	0.124in (3,15mm)
6.3544				
C.A.V. pumps				
AY	160	146	28	0.373in (9,47mm)
BY	160	146	28	0.373in (9,47mm)
EX	160	146	28	0.373in (9,47mm)
FX	160	146	28	0.373in (9,47mm)
GY	162	154	16	0.125in (3,18mm)
HY	162	154	16	0.125in (3,18mm)
MR (except below)	158	144	28	0.373in (9,47mm)
MR from eng. no. U780699P	158	147	22	0.233in (5,92mm)
MX (except below)	160	146	28	0.373in (9,47mm)
MX/4/2640	161	146	30	0.426in (10,82mm)
MX/5/2420 from eng. no. 728207L	159	146	26	0.325in (8,26mm)
MX/5/2530	161	146	30	0.426in (10,82mm)
PX (except below)	160	146	28	0.373in (9,47mm)
PX list TW31012 only	159	146	26	0.325in (8,26mm)
SX	159	146	26	0.325in (8,26mm)
TY	153	141½	23	0.254in (6,45mm)
WR	160	146	28	0.373in (9,47mm)
WX	157	144	26	0.325in (8,26mm)
6.3724				
SX	161	146	30	0.426in (10,82mm)

* The settings given for the Bosch fuel pumps are with the pump set at 1 mm plunger lift. It is important that these pumps are not fitted at the static timing positions given for the CAV pumps. The code given in brackets is stamped on the side of the pump.

Atomisers

Code	Holder	Nozzle	Setting Pressure			Working Pressure		
			atm	lbf/in²	(MN/m²)	atm	lbf/in²	(MN/m²)
FL	BKBL67S5299	BDLL150S6673	215	3160	(21,8)	200	2940	(20,3)
FN	BKBL67S5299	BDLL150S6639	210	3087	(21,3)	195	2866	(19,8)
GD	BKBL67S5299 or 2645C305	BDLL150S6730 or 2645C612	215	3160	(21,8)	200	2940	(20,3)
GG	BKBL67S5299	BDLL150S6737	210	3087	(21,3)	210	3087	(21,3)
GH	BKBL67S5299	BDLL150S6738	210	3087	(21,3)	210	3087	(21,3)
GK	KBEL62S9/13	DLLA150S741	275	4042	(27,9)	275	4042	(27,9)
GL	BKBL67S5151	BDLL150S6730	175	2572	(17,7)	170	2500	(17,2)
GX	KBEL64S21	DLLA140S287	250	3675	(25,3)	250	3675	(25,3)
HC	LRB67014* or 2645C307	JB6801014 or 2645C613	245	3601	(24,8)	245	3600	(24,8)
HE	LRB67014*	JB6801019	230	3381	(23,3)	230	3381	(23,3)
HK	BKBL67S5299	BDLL135S6834	215	3160	(21,8)	215	3160	(21,8)
HP	LRB67014* or 2645C307	JB6801014 or 2645C613	225	3307	(22,8)	225	3307	(22,8)
HS	BKBL67S5299 or 2645C305	BDLL150S6730 or 2645C612	215	3160	(21,8)	200	2940	(20,3)
HT	LRB67014* or 2645C307	JB6801019	200	2940	(20,3)	200	2940	(20,3)
HU*	LRB67014	JB6801022	220	3234	(22,3)	220	3234	(22,3)
RA	KBEL64116	DLLA140P44	250	3675	(25,3)	250	3675	(25,3)
RB	2645C304	2645C606	250	3675	(25,3)	250	3675	(25,3)
VU	2645C564	2646866	250	3675	(25,3)	225	3307	(22,8)
XX	2645C307	2645C613	245	3601	(24,8)	245	3601	(24,8)
Y	BKBL67S5151	BDLL150S6329	175	2572	(17,7)	170	2500	(17,2)

*In these atomisers the pressure is adjusted by a change of shims.

Electrical System ... ... 12 or 24 volt

Alternator

Make	Lucas								
Type	17ACR (derated)	17ACR	18ACR	A115	A133/55	25ACR	A133/65	A127	
Voltage	12V	12V	12V	12V	12V	12V	12V	12V	
Max. output (hot)	28A	35A	45A	45A	55A	65A	65A	55A	
Make	C.A.V.				Perkins				
Type	AC5 & AC5R		AC5 & AC5R		LR135		LR150		
Voltage	12V		24V		12V		12V		
Max. output (hot)	60A		30A		35A		50A		

Starter motor

Make	Lucas		C.A.V.		Perkins
Type	M50	M127/2,8	CA45	CA45	S12-84
Voltage	12V	12V	12V	24V	12V
Starter cable resistance	0.0017Ω	0.0017Ω	0.0017Ω	0.0034Ω	0.0017Ω
No. of teeth on pinion	10	10	10	10	10

Starting Aid

Make	C.A.V. – Thermostart
Maximum Current Consumption	12.5/13.5A at 11.5V
Flow Rates through Thermostart	3,5/5,0 ml/min

SERVICE WEAR LIMITS

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

Cylinder Head Bow Transverse	0.005 in (0,13 mm)
Longitudinal	0.010 in (0,25 mm)
Maximum Bore Wear (when new liners are necessary)	0.008 in (0,20 mm)
Crankshaft, Main and Big End Journal, Ovality and Wear	0.0015 in (0,04 mm)
Maximum Crankshaft End Float	0.020 in (0,51 mm)
Valve Stem to Guide Bore Clearance, Inlet	0.005 in (0,13 mm)
Exhaust	0.006 in (0,15 mm)
Valve Head Depth below Cylinder Head Face	0.060 in (1,52 mm)
Rocker Clearance on Rocker Shaft	0.005 in (0,13 mm)
Camshaft Journals, Ovality and Wear	0.002 in (0,05 mm)
Camshaft End Float	0.021 in (0,53 mm)
Idler Gear End Float	0.015 in (0,38 mm)

SECTION D
Fault Finding

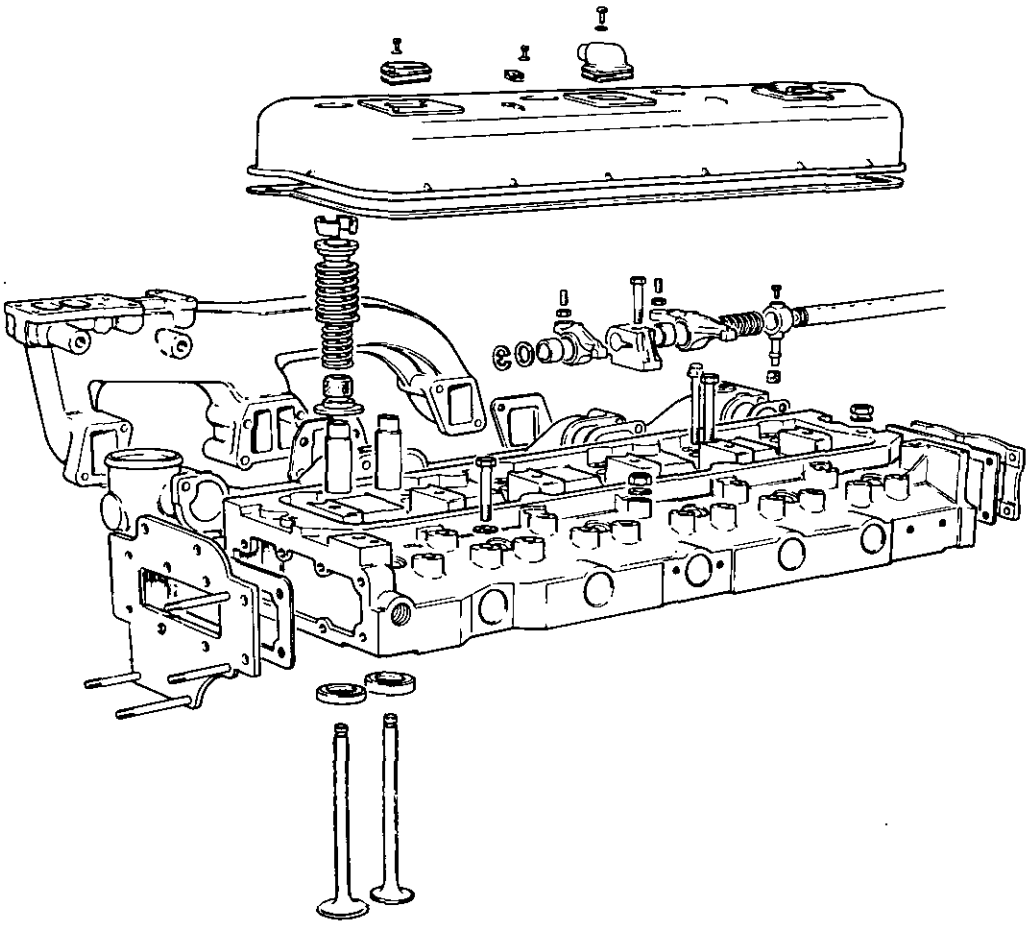
Fault Finding Chart

FAULT	POSSIBLE CAUSE
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 60, 62, 63.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33, 63.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 60.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 61.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55, 64.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

Key to Fault Finding Chart

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

SECTION E
Cylinder Head



To Remove the Cylinder Head

The T6.3544, 6.3544 or 6.3724 cylinder head is not interchangeable with any other 6.354 or T6.354 engine type cylinder heads.

Drain the cooling system.

Disconnect battery terminals.

Remove air cleaner and trunking.

Remove exhaust pipe from exhaust manifold (6.3544 engines only).

Disconnect and remove all connections to the turbocharger and remove the turbocharger, see Fig. E.1. (T6.3544 engines only).

Remove electrical connections to the cylinder head and induction manifold. Remove fuel pipe to thermostart in the manifold.

Remove the water outlet connection.

Remove the induction and exhaust manifolds.

The fuel pipe from lift pump to fuel filters should be removed, releasing the clip from the back of the cylinder head. The fuel filters may also be removed.

All high pressure pipes between fuel injection pump and the atomisers should be removed together with the atomisers leak-off pipe assembly.

Remove atomisers, see Fig. E.2.

Disconnect the breather pipe from the rocker cover and cylinder block. Remove the breather pipe.

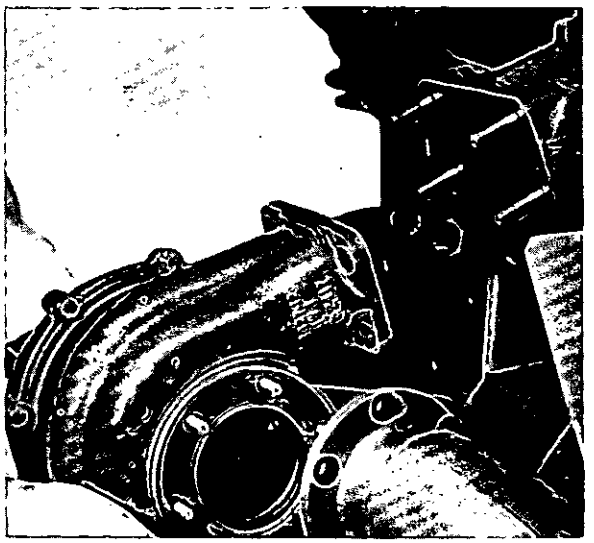
Remove rocker cover and gasket.

Release rocker assembly bracket securing setscrews and lift off rocker assembly. Remove the push rods.

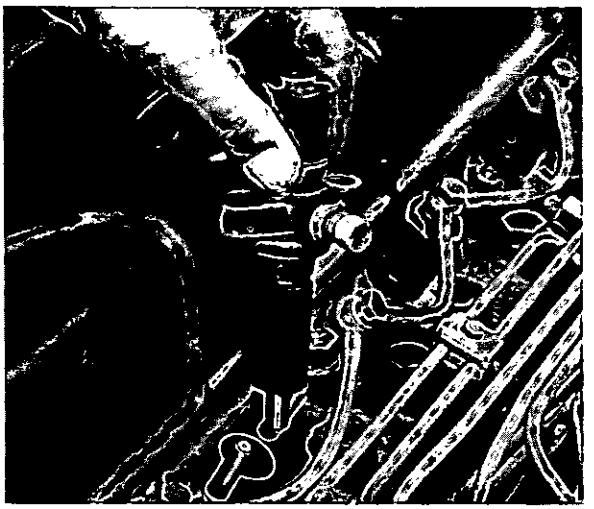
Remove cylinder head nuts and setscrews in reverse order of tightening sequence, see Fig. E.4.

Note position of different length setscrews, see Fig. E.3.

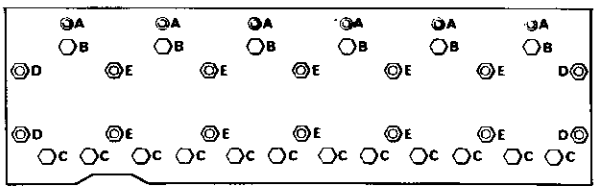
Remove cylinder head.



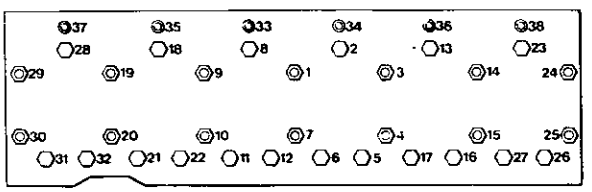
E.1



E.2



E.3



E.4

To Fit the Cylinder Head

Ensure the head face, cylinder block top face and bores are clean and that the rocker assembly oil feed passage in the cylinder head is clean.

Any cylinder head studs removed from the cylinder block should be refitted with "Loctite".

The cylinder head gasket fitted to the T6.3544 and 6.3544 engine is not interchangeable with other 6.354 series engines. It is marked "TOP FRONT".

A different cylinder head gasket is used on 6.3724 engines due to the larger bore size.

The cylinder head gasket must be fitted dry. Fit the gasket ensuring it is correctly located over the two dowels.

Lower the cylinder head in position without disturbing the gasket.

Lightly oil threads of cylinder head securing studs and setscrews.

See Fig. E.3 for correct location of long and short setscrews.

The cylinder head fasteners should be tightened gradually and evenly in the correct sequence (Fig. E.4).

The earlier cylinder head fasteners (1 to 32), which are fitted with separate washers, should be tightened to 95lbfft (13,1kgfm) or 130Nm.

When the early cylinder head gasket, part number 36812611, is used with flanged fasteners (1 to 32), the fasteners should be tightened to 115lbfft (15,9kgfm) 156Nm.

Currently, the flanged cylinder head fasteners are tightened in the factory by a new method that removes the necessity for the fasteners to be tightened again with the engine hot. A similar "No hot torque" method (see page E4) can be used in service if flanged fasteners are used with cylinder head gasket, part number 36812613. If this method is not used, the flanged fasteners should be tightened as shown earlier and will have to be tightened again when the engine is hot.

The small setscrews (33 to 38) should be tightened to 28lbfft (3,9kgfm) or 38Nm.

Replace push rods.

Renew the rocker assembly feed pipe oil seal, lightly oiling its inner and outer surfaces, and placing it in the oil feed drilling.

Examine and replace the rocker assembly, ensuring that the oil feed pipe, which has a lead in, locates correctly into the drilling, when the seal will butt against the convolution, see Fig. E.5.

The rocker assembly securing setscrews, studs and nuts should be tightened down progressively from the centre outwards to a torque of 55lbfft (7,60kgfm) or 75Nm. Set valve clearances to 0.008in (0,20mm) for inlet valves and 0.018in (0,45mm) for exhaust valves, engine hot or cold, as detailed on Page E5.

Refit atomisers with new copper sealing washers. Ensure that a serviceable dust seal is fitted to the atomiser. Earlier dust seals consisted of a single piece rubber seal, later arrangements use a two piece dust seal which consists of a plastic or aluminium spacer and a rubber seal. The spacer must be fitted directly under the atomiser flange with the soft rubber seal up against the spacer at the nozzle end of the atomiser. Now tighten nuts/setscrews evenly to a torque of 12lbfft (1,7kgfm) or 16Nm.

Note: Different atomiser seating washers are used on naturally aspirated and turbocharged engines. The seating washers for naturally aspirated engines are 0.080in (2,03mm) thick and for turbocharged engines, 0.028in (0,71mm) thick. It is important that the correct atomiser seating washers are fitted.

For the T6.3544 North America vehicle engines the atomiser seating washer is 0.080in (2,03mm) thick.

Top entry atomisers which are used on some 6.3544 series engines can be fitted incorrectly with the atomiser turned 180° out of position. In this position, the nozzle holes will not spray into the combustion chamber correctly and this will cause a power loss and an increase in smoke emission.

These atomisers must be fitted with the leak off connection toward the fuel injection pump side.

Refit all high pressure fuel pipes, leak-off pipes and the fuel filters.

Tighten high pressure pipe nuts to a torque of 15lbfft (2,1kgfm) or 20Nm.

Refit fuel pipe from lift pump to filters, this pipe is clipped on to back of cylinder head.

Refit induction and exhaust manifolds.

Inlet manifolds have corrugated joints which are coated with lacquer and should always be fitted dry. The joints are not symmetrical and can be fitted incorrectly. With the earlier joints, the larger joint should be fitted with parallel edge uppermost and the smaller joint with the wider spaced hole and the word "CORROJOINT" to the bottom.

Later joints have a 1/16 in (1,63mm) radius in the top edge and must always be fitted with this radius uppermost. The manifold securing setscrews should be tightened to a torque of 24lbfft (3,3kgfm) or 32Nm. After at least ten minutes after fitting, retorque the setscrews to the original figure. THIS IS IMPORTANT. With exhaust manifold joints, turbocharged engines have corrugated stainless steel joints, whereas naturally aspirated engines can have a set of steel asbestos or corrugated stainless steel joints fitted. Steel asbestos joints should be fitted with jointing compound, but the corrugated joints should be fitted dry and so positioned that the corrugations should face the manifold.

A one piece exhaust/induction manifold joint with an integral heat shield is fitted to some engines which have the top exhaust manifold outlet. An improved rocker assembly cover gasket is also fitted to these engines.

When the gaskets need to be renewed the same type gasket must be used.

Refit the water outlet connection.

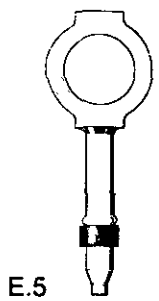
Connect the electrical lead, fuel feed and return pipes to the thermostart unit and container.

Connect any other electrical lead (i.e. water temperature gauge).

Refit the turbocharger (T6.3544 engines only) and all connections to it.

Refit trunking and air cleaner.

Refit exhaust pipe to exhaust manifold (6.3544 or 6.3724 engines only).



E.5

Reconnect the battery.

Refill the cooling system.

Bleed the fuel system of air as detailed on Page N8 and start the engine.

Check the oil flow to the rocker shaft assembly and allow the engine to warm up.

Shut the engine down, and retighten the cylinder head securing nuts and setscrews to the correct torques as detailed previously.

Flanged fasteners, numbers 1 to 32, not tightened by the "No hot torque" method should be tightened again to 105lbfft (14,5kgfm) or 142Nm.

When retightening cylinder head nuts/setscrews, the *engine coolant temperature should not be less than* 170°F (77°C).

If the nut/setscrew moves when retightening, then tighten up to the torque quoted on Page B.1.

If the nut/setscrew does not move before the correct torque is achieved, then slacken off 1/12 to 1/6 (30° to 60°) of a turn and retighten to the correct figure. After retightening all the nuts/setscrews, the first 10 positions should be rechecked without further slackening off, to ascertain they are still tightened to the correct torque.

Reset the valve clearances to 0.008 in (0,20 mm) for inlet valves and 0.018 in (0,45 mm) for exhaust valves hot or cold.

Refit the rocker cover joint, rocker cover and breather pipe.

To put a rocker cover joint on correctly it must first be fitted to the rocker cover by use of a suitable Bostic type contact adhesive. The adhesive must be applied according to the *manufacturer's instructions. This procedure will ensure that* there is a good seal all round the cover.

When replacing the cylinder head cover, ensure that the cover retaining nuts are screwed fully home against the rocker shaft bracket retaining nuts.

Where a washer is fitted under the head of each of the rocker cover nuts, a washer is also fitted between the rocker bracket securing nut and the cover nut. Where a washer face is formed integral with the cover nut, a separate washer must not be fitted under the cover nut or between the cover nut and the rocker bracket nut.

"No Hot Torque" Method to Tighten Cylinder Head Fasteners

Check the setscrews and studs for distortion with a straight edge held along the threads. *If there is a visual reduction in* the diameter of that part of the thread that has not been in engagement with the cylinder block or nut, the setscrew or stud must not be used again.

Lightly lubricate the threads and the flange face of each fastener with clean engine oil. New fasteners are supplied already lubricated.

Put the cylinder head gasket, the cylinder head and the fasteners in position. Gradually and evenly tighten the main (½ UNF) fasteners to 80lbfft (11,1kgfm) 100Nm in the sequence 1 to 32 (Fig. E.4).

Check again that all the main fasteners are to the correct torque.

Tighten the fasteners, in the correct sequence, a further part of a turn according to the length of the setscrew or stud. The shorter setscrews (C in Figs. E.3 and E.6) must be turned a further 150° (2½ flats). The longer setscrews (B) and the nuts (E) on the shorter studs must be turned a further 180° (3 flats). The nuts (D) on the longer studs must be turned a further 210° (3½ flats).

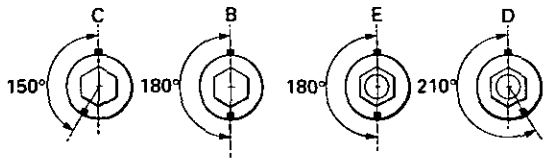
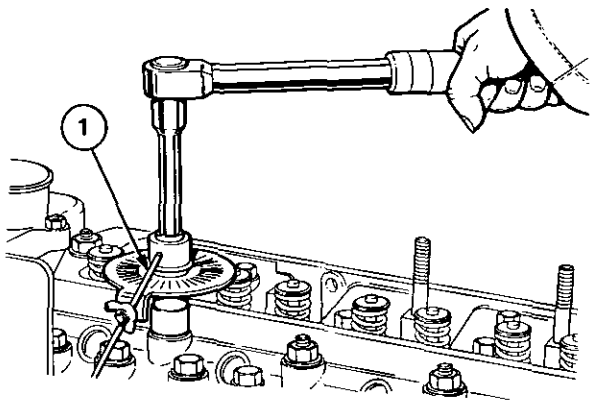
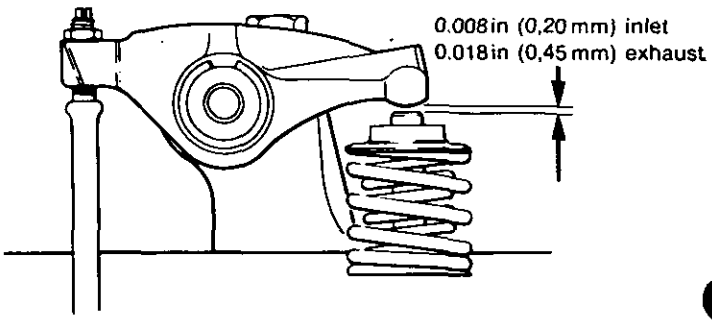


Fig. E.6



E.7



E.8

A special tool, number MS.1531, (Fig. E.7) can be used for this operation. To use the tool, fit it between the socket spanner and the handle. Position the stop (1 in Fig. E.7) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Turn the pointer to align with the zero mark on the degree dial. Tighten the setscrew or the nut until the pointer *on the tool is at the correct angle for the length of* the setscrew/stud.

If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew and nut (Fig. E.6). Make another mark on the edge of each fastener at the correct angle (counter clockwise) according to the length of the setscrew/stud. Tighten each fastener, in the correct sequence, until the mark on the flange of the fastener is next to and in line with the mark on the cylinder head.

Tighten the 5/16 UNF setscrews gradually and evenly in the sequence 33 to 38 (Fig. E.4) to 28lbfft (3,9kgfm) 38Nm.

To Check or Adjust Valve Tip Clearances

The valve tip clearances should be set to 0.008in (0,20mm) for inlet and 0.018in (0,45mm) for exhaust by using a feeler gauge between top of valve stem and rocker lever, with the engine hot or cold, see Fig. E.8.

When setting valve clearances, the following procedure should be adopted.

With the valves rocking on No. 6 cylinder (i.e. the period between opening of inlet valve and closing of exhaust valve) set the clearances on No. 1 cylinder.

With valves rocking No. 2—set clearances No. 5.
With valves rocking No. 4—set clearances No. 3.
With valves rocking No. 1—set clearances No. 6.
With valves rocking No. 5—set clearances No. 2.
With valves rocking No. 3—set clearances No. 4.

To Remove Valves

Fit a suitable stud in one of the rocker assembly securing setscrew holes and using Tool No. 6118B and adaptor PD.6118-4, see Fig. E.9, depress valve springs and remove split collets.

Remove spring retaining caps, springs, oil seals and spring seating washers. Remove valves.

If the valves are to be used again, they should be suitably marked to ensure they are replaced in their original positions.

Valve Assembly

Two springs are fitted to each valve, the outer springs are left hand coiled and the inner springs right hand coiled.

A sectional view of a fitted valve assembly is shown in Fig. E.10.

To Fit Valves

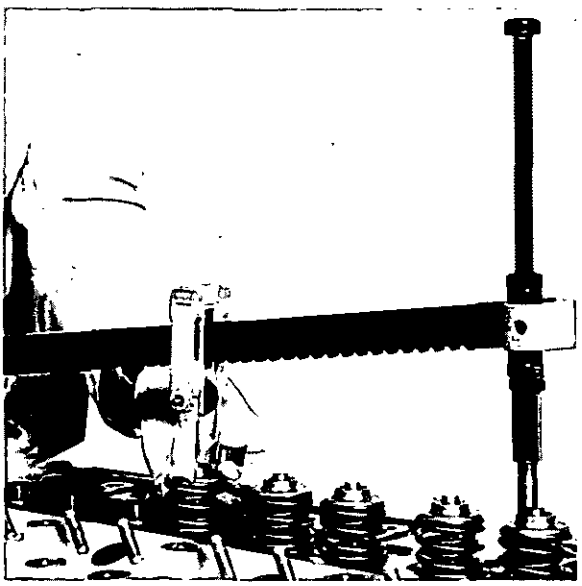
Lightly oil valve stems, and position the valves in their respective guides.

Position spring seating washers and fit oil seals onto valve guides.

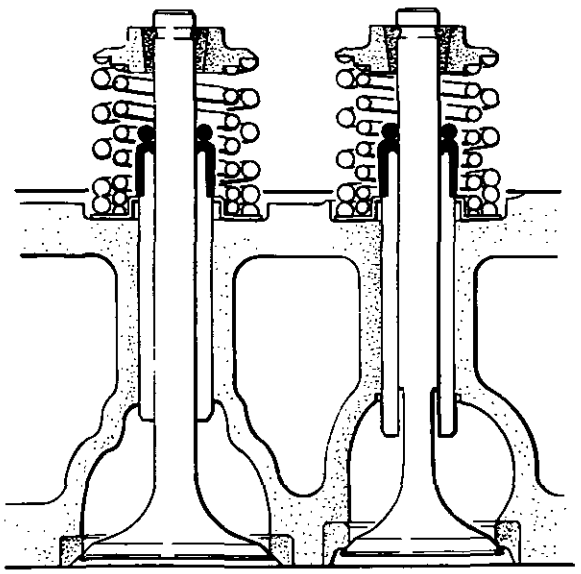
Note: Engines rated at 149kW (200bhp) or above must be fitted with exhaust valves which have "Nimonic" heads. Standard valves must not be used.

Place inner and outer springs on seating washers with the damper coils towards the cylinder head, see Fig. E.10.

Position the valve spring retaining caps and with a suitable compressor, depress the springs and fit the split collets.



E.9



E.10

Valve Guides

Examine valve guides for wear. The maximum permissible worn clearance of inlet valve stem in guide is 0.005in (0,13mm), and exhaust valve stem in guide is 0.006in (0,15mm) and if the clearance with new valve fitted exceeds this figure the guide should be replaced.

The exhaust valve guides are slightly longer than the inlet guides and the exhaust valve guides used on current 6.3544 and 6.3724 engines have a counterbore at the bottom of the valve bore.

To fit new guides, press or drive out the worn guides, see Fig. E.11.

Smear the outer surface of the new guides with clean oil and using tool No. PD1C, see Fig. E.12, pull guide into the cylinder head using stop No. PD1C — 6 until 0.594in (15,08mm) of the guide is protruding above the valve spring recess.

Cylinder Head Overhaul

If water jacket of cylinder head shows sign of scale, a proprietary descaling solution should be used in accordance with the manufacturer's instructions.

After cleaning head, check for cracks or other damage.

Maximum permissible longitudinal bow of cylinder head is 0.010in (0,25mm) and transverse bow is 0.005in (0,13mm).

The cylinder head can be skimmed by a maximum of 0.012in (0,3mm) provided that nozzle protrusion does not exceed 0.184in (4,67mm) for T6.3544 engines or 0.136in (3,45mm) for 6.3544 and 6.3724 engines with the atomiser seating washers in position, see Fig. E.13. This figure must not be obtained by the use of additional atomiser seating washers.

When grinding in valves, it is essential that no signs of pitting are left on the seatings.

Care should be taken to avoid unnecessary grinding away of the seat.

After grinding, check the valve head depths relative to the cylinder head face, using tool PD41B. The maximum permissible depth for both inlet and exhaust valves after servicing is 0.060 in (1,52 mm).

After any grinding or machining operation has been carried out, all parts should be washed in cleaning fluid.

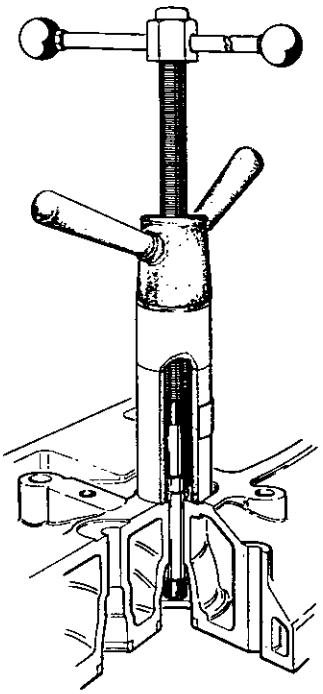
Valves and Valve Seats

Examine valves for cracks. Check wear of valve stems and their fit in the valve guides.

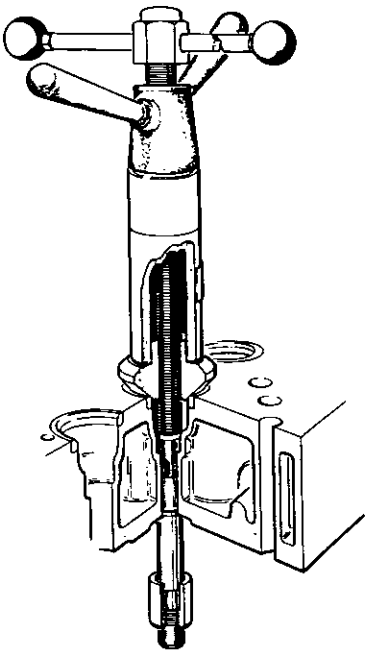
When fitting new valves, valve depths relative to the cylinder head face is not less than 0.040in (1.02mm).

The valve seats in the cylinder head should be reconditioned by means of valve seat cutters as listed in approved tools at the end of this section, or specialised grinding equipment at an angle of 45°.

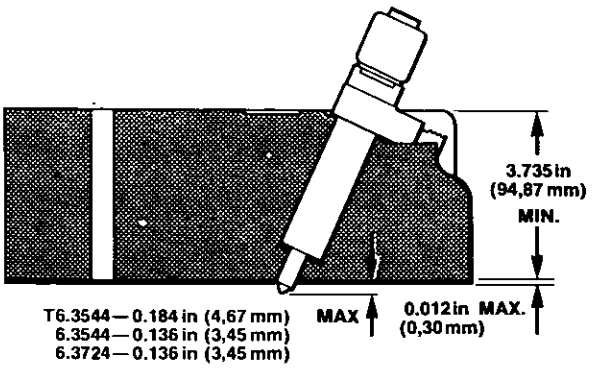
After reconditioning, valves and seats should be lightly ground in, keeping as narrow a seat as possible, and after grinding, the valve head depth should be checked.



E.11



E.12



E.13

Valve Seat Inserts

Valve seat inserts are fitted as standard on T6.3544 engines, but are not fitted on 6.3544 or 6.3724 production engines.

If valve seats become damaged or unserviceable through wear, inserts can be fitted to 6.3544 and 6.3724 engines or the inserts replaced on T6.3544 engines.

Press out the existing valve guide and clean the guide bore.

Press in new guides as detailed on Page E6.

Using the valve guide as a pilot, machine the recess in the cylinder head to the dimensions given in Fig. E.14 for 6.3544 or 6.3724 engines; or machine out the old insert for T6.3544 engines.

Remove all machining swarf and clean the insert recess.

Using the valve guide bore as a pilot, press the insert home with the inserting tool, Fig. E.15. Do not hammer the insert home or use lubrication. Ensure that the insert is fully home and flush with the bottom of recess.

Using the valve guide bore as a pilot, machine the "flare" on inlet valve seat inserts to the dimensions shown in Fig. E.16. Dimension A is 0.106/0.110in (2,69/2,79mm).

Cut the valve seat at an included angle of 90° so that the valve head depth below the cylinder head face is within the production limits of 0.040/0.050in (1,02/1,27 mm).

Work as closely as possible to the minimum figure to allow for re-seating at a later date. When refacing a valve the included angle of the contact face is 90°.

Lightly grind in valve and valve seat, keeping as narrow a seat as possible.

If the cylinder head has been skimmed, the insert will have to be surface ground on its back face so that, with insert fitted, faces of insert and cylinder head are level.

Valve Springs

A new set of springs should be fitted at every major overhaul.

Examine the springs with regard to squareness of ends and pressures developed at fitted lengths.

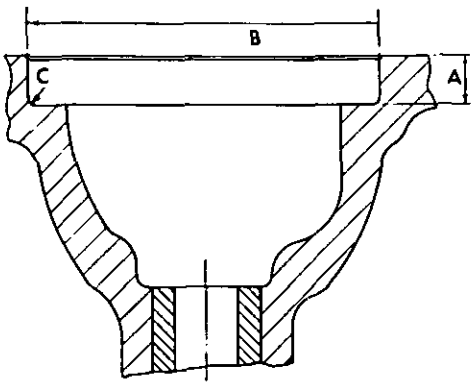
Two types of valve springs can be found according to the camshaft fitted. They are of different lengths the longer valve springs having a flat valve spring cap.

The shorter inner valve springs require a load of 20.1/23.3 lbf (9,13/10,58 kgf) to compress them to a fitted length of 1.340 in (34,04 mm).

The shorter outer valve springs require a load of 39.5/43.7 lbf (17,93/19,84 kgf) to compress them to a fitted length of 1.410 in (35,81 mm).

The longer inner valve springs require a load of 14.63/16.67 lbf (6,64/7,57 mm) to compress them to a fitted length of 1.563 in (39,70 mm).

The longer outer valve springs require a load of 38/43 lbf (17,25/19,52 kgf) to compress them to a fitted length of 1.780 in (45,20 mm).



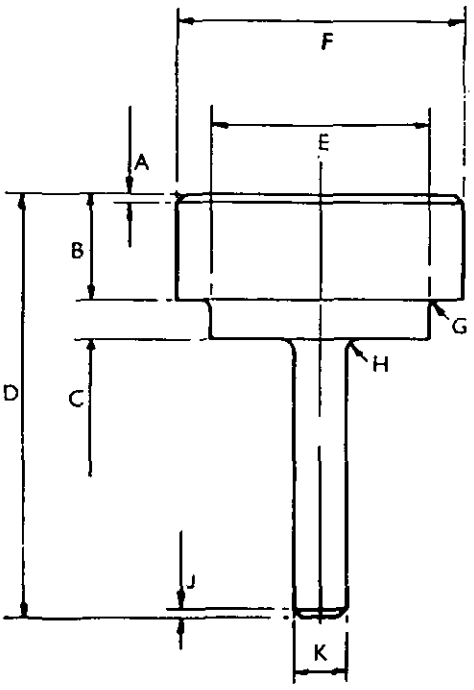
E.14

Inlet

A—0.283/0.288in (7,19/7,32mm)
B—2.0165/2.0175in (51,22/51,24mm)
C—Radius 0.015in (0,38mm) Max.

Exhaust

A—0.375/0.380in (9,53/9,65mm)
B—1.678/1.679in (42,62/42,65mm)
C—Radius 0.015in (0,38mm) Max.



E.15

Inlet

inches (mm)

A 0.063 (1,59) at 45°	F 2.009/2.019 (51,03/51,28)
B 0.750 (19,05)	G 0.031 (0,79) radius
C 0.250 (6,40)	H 0.063 (1,59) radius
D 3.0 (76,2)	H 0.063 (1,59) at 45°
E 1.582/1.583 (40,18/40,21)	K 0.372/0.373 (9,45/9,47)

Exhaust

inches (mm)

A 0.063 (1,59) at 45°	F 1,670/1,680 (42,42/42,67)
B 0.750 (19,05)	G 0.031 (0,79) radius
C 0.312 (7,92)	H 0.063 (1,59) radius
D 3.0 (76,2)	H 0.063 (1,59) at 45°
E 1.248/1.249 (31,70/31,72)	K 0.372/0.373 (9,45/9,47)

Rocker Shaft Assembly

To dismantle.

Remove circlips and washers from each end of shaft.

Withdraw rocker levers, springs and support brackets.

Remove the locating screw from the rocker oil feed connection and withdraw the connection.

Examine rocker lever bores and shaft for wear. The levers should be an easy fit on the shaft without excessive side play and there should be no indentation where the rocker taps the valve tip.

To renew the rocker lever bushes, press out the worn bushes and press in the new bushes making sure that the oil holes are in line, see Fig. E.17.

Ream out to a diameter of 0.7505/0.7520in (19,06/19,10mm).

To assemble.

Note: An oil connection of zinc alloy is used instead of a brass connection on the latest engines. When a zinc alloy connection is used, a shim (part number 33117426) must be fitted each side of the connection.

If a brass oil connection is to be renewed, order shims as a zinc alloy connection will be supplied.

Fit oil feed connection to rocker shaft and secure with locating screw, ensuring that the screw enters the locating hole in the shaft.

Fit the support brackets, springs and rocker levers in the correct order, see Fig. E.18.

Fit securing washer and circlip to each end of the shaft.

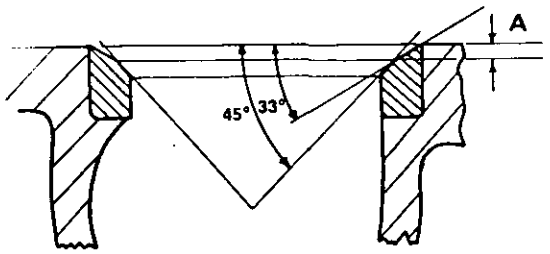
Push Rods

Check push rods for straightness. If any are bent, fit replacements.

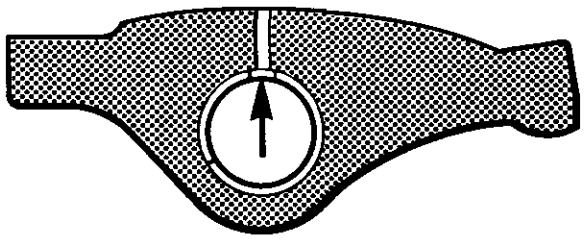
Breather Vent Valve

On 6.3544 engines, a vent valve is sometimes fitted between the rocker cover and the inlet manifold. This unit can be cleaned in petrol (gasoline) or paraffin (kerosene) noting the following critical points:—

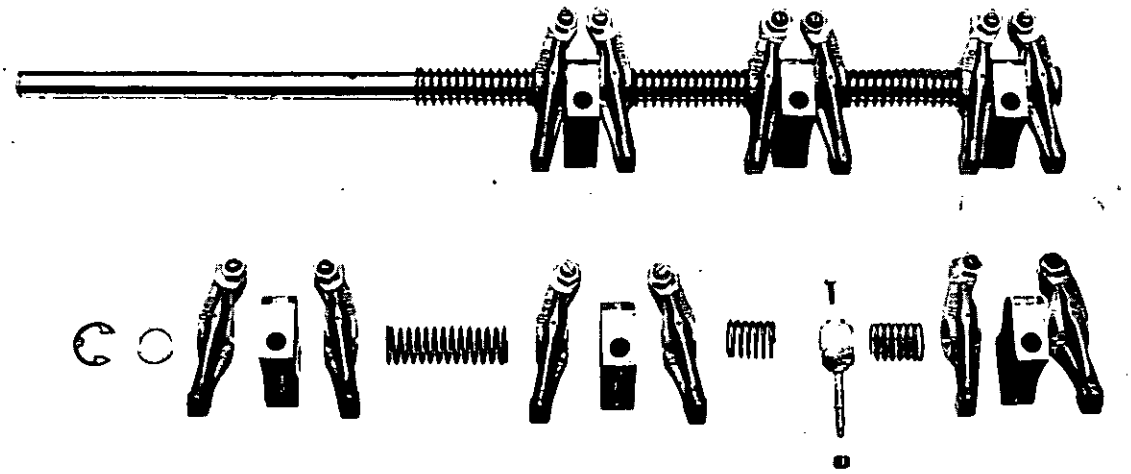
1. Before cleaning, it is essential to seal off the small hole in the top cover of the unit.
2. If an air line is used to dry out the unit, this must be a low pressure air blast or irreparable damage will result.



E.16

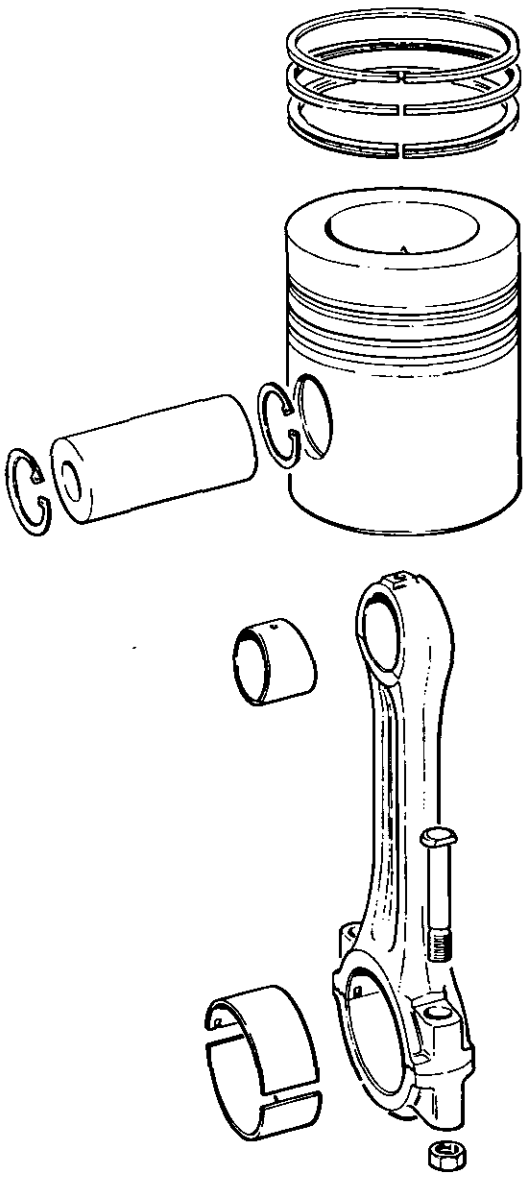


E.17



E.18

SECTION F
Pistons and Connecting Rods



The pistons fitted to the T6.3544 and 6.3544 engine have an insert in the top ring groove and are not common to the 6.354 engine series.

Nor are T6.3544 and 6.3544 pistons interchangeable as the turbocharged piston has a larger gudgeon pin.

For T6.3544 North America vehicle engines pistons and rings see page F.6.

To remove Piston and Rod Assembly See Fig. F.1.

Remove cylinder head, Page E.2.

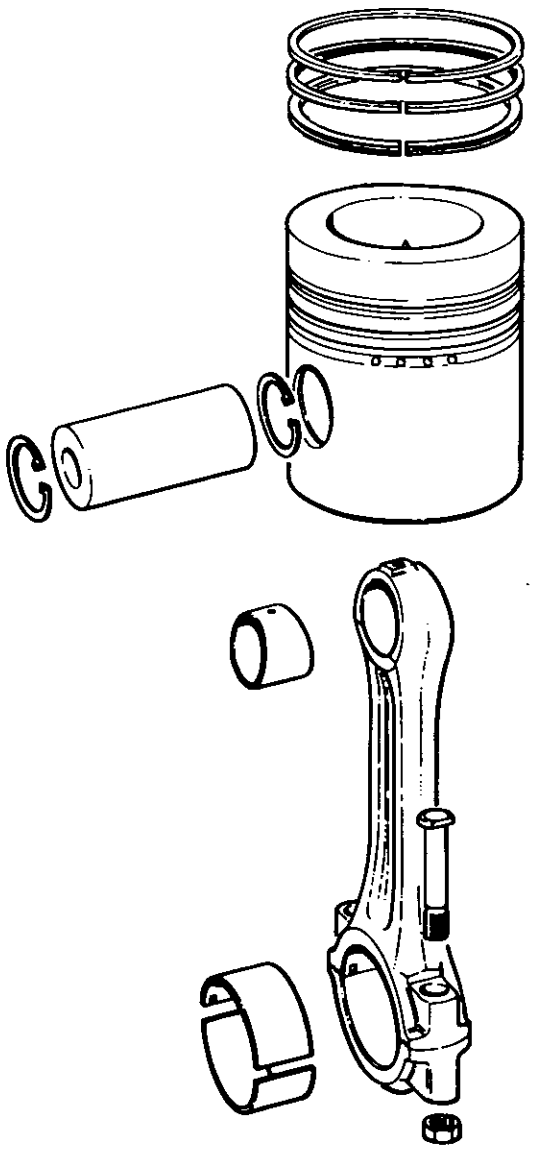
Drain lubricating oil, remove sump and lubricating oil suction pipe. Page L.3.

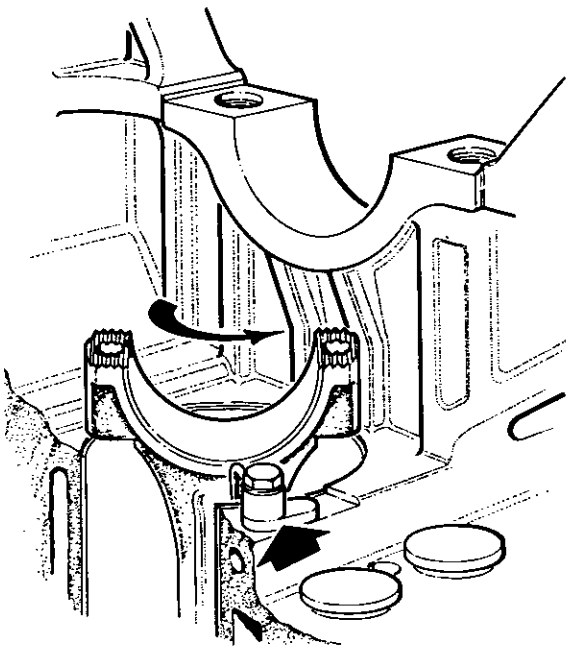
Remove pipe from the reducing valve to piston cooling feed connection (T6.3544 engines only).

When pushing the piston and rod assemblies from out of the top of the cylinders, care must be taken to avoid damage to the piston cooling jets situated in the crankcase, see Fig. F.2. (T6.3544 engines only).

Remove the nuts from the big end bolts.

Remove the big end caps, bearing shells and bolts.





F.2

Turn connecting rods in an anti-clockwise direction and press the piston assemblies from out of the top of the cylinder bores, see Fig. F.3.

The pistons, connecting rods and caps are marked with their respective cylinder number and should be kept together as an assembly with the relevant big end bearings.

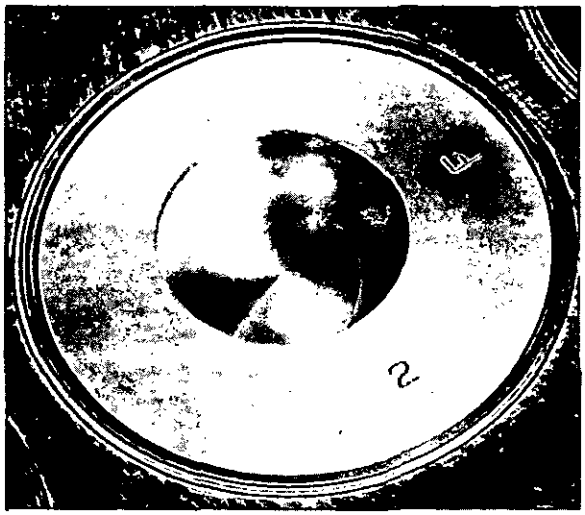
To Remove Pistons and Rings from Connecting Rods

An exploded view of a piston and connecting rod assembly is shown in Fig. F.1.

Note: The number of piston rings per piston can vary according to engine type and application (see Page F4).

Using a ring scissor tool, remove the rings from the pistons.

F.3



F.4

If the pistons are to be used again, note the markings on the piston crown, see Fig. F.4, so that on re-assembly, they can be fitted to the connecting rods in their original positions, i.e. thrust side of piston to thrust side of the engine.

Remove the circlips and withdraw the gudgeon pin. If the pin is tight in the piston bore, heat the piston in fluid to a temperature of 100/120°F (40/50°C), then press the gudgeon pin out.

Inspection

Check pistons for scoring or other damage.

Check piston ring grooves by checking clearance of new rings fitted in grooves. If clearance is found to be excessive new pistons must be fitted.

Examine gudgeon pin and piston bores for wear and check fit of pin in small end bush.

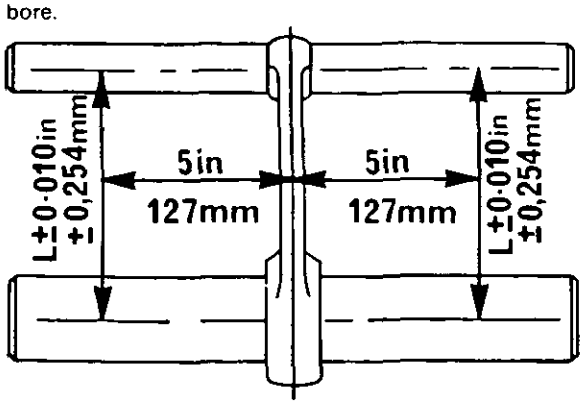
Check connecting rod alignment. The large and small end bores must be square and parallel to each other within the limits of ±0.010in (0,25mm) measured 5in (127mm) each side of axis of rod on test mandrel as shown in Fig. F.5.

With the small end bush fitted, the limit of ±0.010in (0,25mm) is reduced to ±0.0025in (0,06mm).

To Renew Small End Bush

Using suitable adaptor, press out worn bush.

Remove any sharp edges from around small end parent bore.



F.5

Press in new bush ensuring that oil hole in bush aligns with drilling in rod.

Hone out bush to finished diameter of 1.50075/1.5015in (38,12/38,14mm), for turbocharged engines or 1.3758/1.3765in (34,94/34,96 mm) for naturally aspirated engines.

With naturally aspirated engines the connecting rod small end is parallel faced and the small end bush requires no further machining.

With turbocharged engines, the small end of the connecting rod is wedge shaped and the small end bush should be machined to suit the contours of the wedge.

Remove all burrs.

Check for parallelism and twist with big end bore.

To Check Piston Ring Gaps

In a worn cylinder, piston ring gaps should be checked at extreme top of cylinder after any carbon has been removed, see Fig. F.6.

For piston ring gaps, see Page B4.

To Assemble Pistons and Connecting Rods

Assemble the piston, rod and gudgeon pin, and fit new circlips.

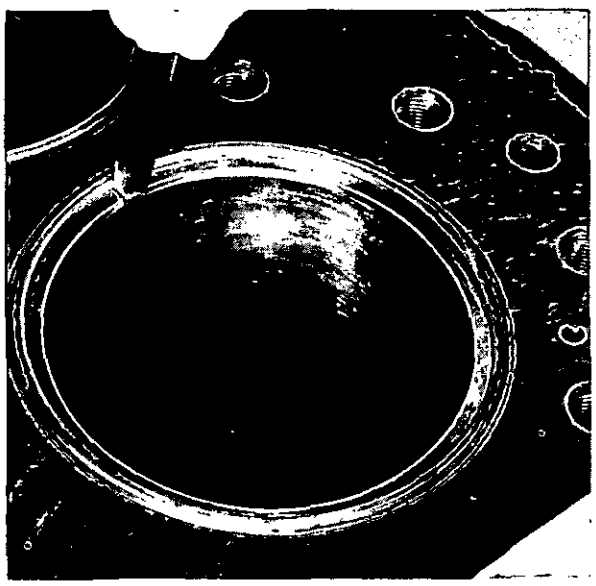
If necessary, warm the piston to 100/120°F (40/50°C) to fit the gudgeon pin.

If the old pistons are being used ensure they are assembled to the original connecting rods and in the same position as originally assembled.

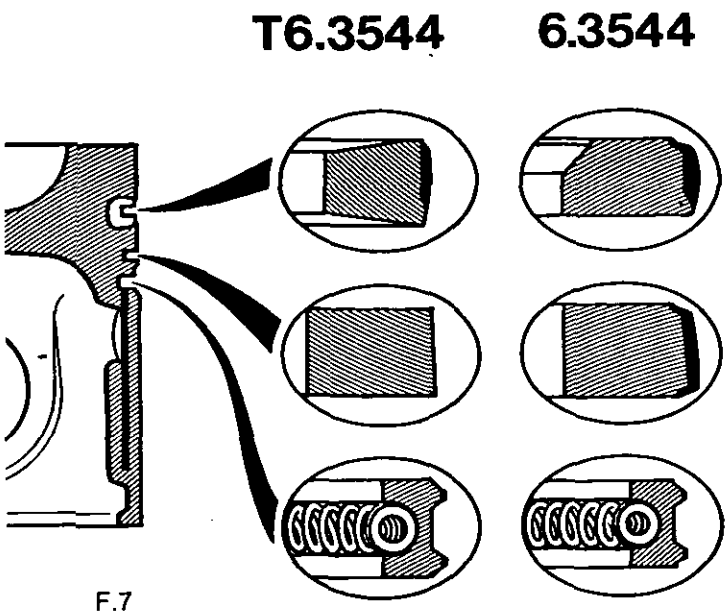
The toroidal cavity should be to the same side as the markings on the connecting rod and cap.

If new parts are being fitted, mark piston crown and adjacent faces of rod and cap with their corresponding cylinder number.

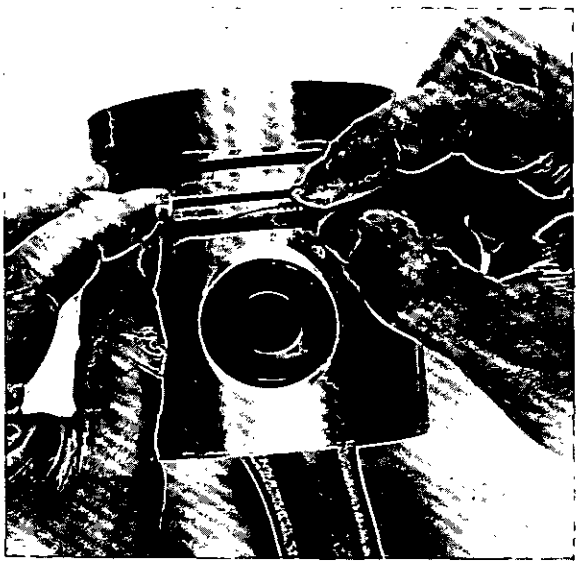
The big end bearing shell tabs are fitted on the opposite side of the rod to the rod/bearing cap numbers.
On fitment the rod/bearing cap number must be toward the fuel injection pump side of the engine.



F.6



F.7



F.8

To Fit Piston Rings

Piston ring layouts are as follows :—

T6.3544 (Fig. F.7)

No. 1 Chrome Barrel Faced Wedge Compression

No. 2 *Taper Faced.*

No. 3 Chrome Faced, Spring Loaded Conformable Oil Control.

Fit rings as follows :—

Fit spring of No. 3 oil control ring in groove ensuring that the latch pin enters both ends of the ring, see Fig. F.8.

Position oil control ring over spring with spring correctly located in groove of ring and ring gap diametrically opposite to latch pin.

Fit taper faced No. 2 compression ring in the second groove with the word "TOP" or the manufacturer's identification mark towards the piston crown.

Fit barrel faced No. 1 compression ring in top groove with the word "TOP" or manufacturer's identification towards piston crown.

Ensure that the ring gaps are equally spaced around the piston and not in line.

6.3544 Premium Engines (Fig. F.7)

No. 1 Chrome Barrel Faced Compression, Internal *Chamfer.*

No. 2 Chrome Taper Faced Compression, Parallel.

No. 3 Chrome Faced, Spring Loaded Conformable Oil Control.

Fit rings as follows :—

Fit No. 3 as detailed for T6.3544 engine.

Fit taper faced No. 2 compression in the second groove with word "TOP" or manufacturer's identification mark towards piston crown.

Fit No. 1 compression ring in the top groove with the internal chamfer and the word "TOP" or the manufacturer's mark towards the piston crown.

Ensure that the piston ring gaps are equally spaced around the piston and not in line.

6.3544 Standard Engines

No. 1 Chrome Insert Compression.

No. 2 Internally Stepped Compression.

No. 3 Internally Stepped Compression.

No. 4 Slotted Oil Control.

No. 5 Slotted Oil Control.

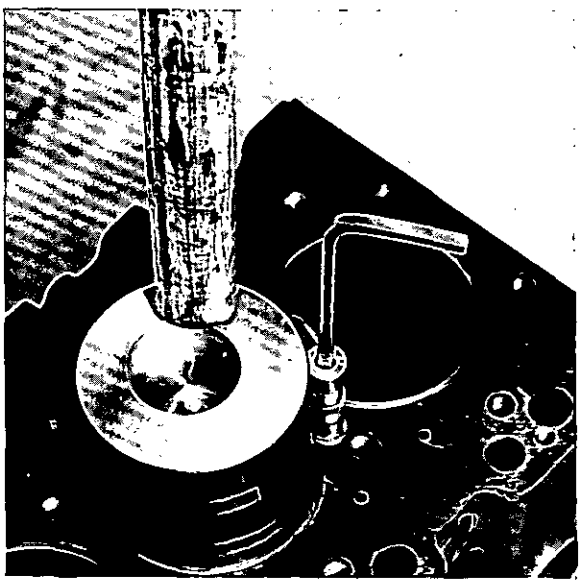
Fit rings as follows :—

Fit No. 5 ring in bottom ring groove.
Fit No. 4 ring in fourth ring groove.

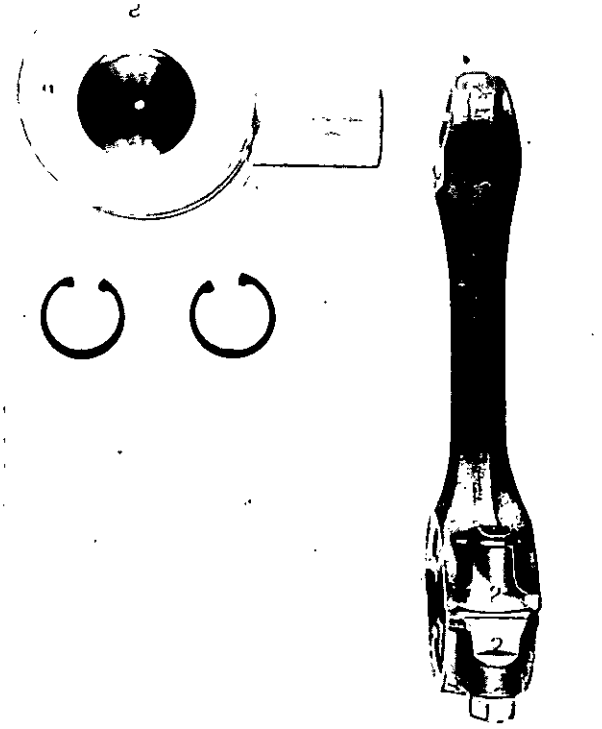
Fit Nos. 3 and 2 rings in the third and second ring grooves with the internal step and the word "TOP" or manufacturer's marks towards the piston crown.

Fit No. 1 ring in top ring groove.

Ensure that the piston ring gaps are equally spaced around the piston and not in line.



F.9



F.10

6.3544 Combine Engines

No. 1 Chrome Insert Compression.

No. 2 Internally Stepped Compression.

No. 3 Internally Stepped Compression.

No. 4 Chrome Faced, Spring Loaded Conformable Oil Control.

No. 5 No ring fitted.

Fit rings as follows :—

Fit spring of No. 4 ring in fourth groove ensuring that the latch pin enters both ends of the ring, see Fig. F.8.

Position oil control ring over spring with spring correctly located in groove of ring and the ring gap diametrically opposite to the latch pin.

Fit Nos. 3 and 2 rings in third and second ring grooves with the internal step and the word "TOP" or the manufacturer's marks towards the piston crown.

Fit No. 1 ring in top ring groove.

Ensure that the piston ring gaps are equally spaced around the piston and not in line.

6.3724 Engines

No. 1 Chrome Insert Parallel Compression.

No. 2 Chrome Faced Internally Stepped or Internally Chamfered Compression.

No. 3 Chrome Faced, Spring Loaded Conformable Oil Control.

No. 4 Slotted Oil Control.

Note: With later Combine engines, the No. 4 slotted control ring is not fitted.

Fit rings as follows :—

Fit No. 4 oil control ring in bottom groove.

Fit spring of No. 3 oil control ring in third ring groove

F.11

ensuring latch pin enters both ends of ring, see Fig. F.8.

Position No. 3 oil control ring over spring correctly located in groove of ring and ring gap diametrically opposite to latch pin.

Fit No. 2 compression ring with internal step of chamfer and word "TOP" or manufacturer's mark towards crown of piston.

Fit No. 1 compression ring in top ring groove

Ensure that the piston ring gaps are equally spaced around the piston and not in line.

To Fit Piston and Connecting Rod

If necessary, deglaze cylinder bore, see Section G.

Clean cylinder bore, piston and bearings and liberally coat with clean engine oil.

Compress piston rings with ring clamp 38U3 and enter the assemblies in the top of their respective cylinder bores, see Fig. F.9. The piston and rod number must relate to the cylinder into which it is being fitted, see Fig. F.10, and the rod identification number must be toward the fuel injection pump side of the engine.

With turbocharged engines, when pressing the assembly through the bore, care must be taken to avoid damage to the piston cooling jets.

Note: Piston cooling jets are not fitted to naturally aspirated engines.

With the respective crankpin in B.D.C. position, ensure that the big end is turned to avoid contact with the piston cooling jets, see Fig. F.2.

When the big end of the connecting rod has passed the piston cooling jets, turn the assembly back again to locate on the crankpin ensuring that upper half bearing is correctly located in big end and tabs fit in recess of rod, Fig. F.11. Also check that the letter "F" or arrow on the piston crown is towards the front of the engine.

Fit cap with lower half bearing correctly positioned and numbers of cap and rod coinciding, Fig. F.10.

Refit the two securing bolts so that the flat on the head of each bolt is located against the shoulder of the rod. Secure with new nuts and tighten to a torque of 75 lbf ft (10,4 kgf m) or 102 Nm for cadmium plated nuts or

95 lbf ft (13,1 kgf m) — 129 Nm for phosphated nuts.

Cadmium plated nuts have a silver colour finish whilst the phosphated have a dull black colour finish.

Check that, with piston in T.D.C. position and using piston height gauge PD 41B, the piston crown is 0.000/0.007 in (0,00/0,18 mm) above the cylinder block top face.

The piston height for naturally aspirated engines was formerly 0.0073/0.015 in (0,19/0,38 mm) above the cylinder block face and, when checking earlier engines, either of the two heights are acceptable.

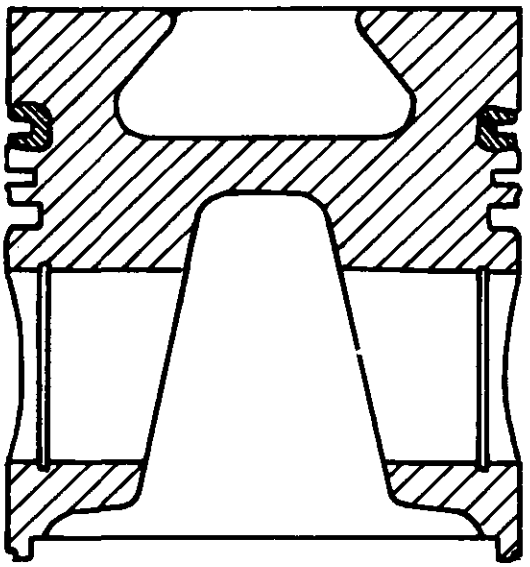
Where new production pistons are used, then these must be topped as necessary to bring them within the above limits.

Fit the pipe from relief valve to piston cooling jet connection. (T6.3544 only).

Fit lubricating oil suction pipe.

Refit the lubricating oil sump, Page L.3, and refill with lubricating oil to correct specification.

Refit the cylinder head, see Page E.2.



F.12

The T6.3544 North America vehicle engines are fitted with aluminium silicon alloy pistons with a re-entrant combustion chamber in the crown see Fig. F.12. A steel insert is fitted in the top ring groove and two compression and one scraper piston rings are used.

The pistons are cooled by lubricating oil pressure jets.

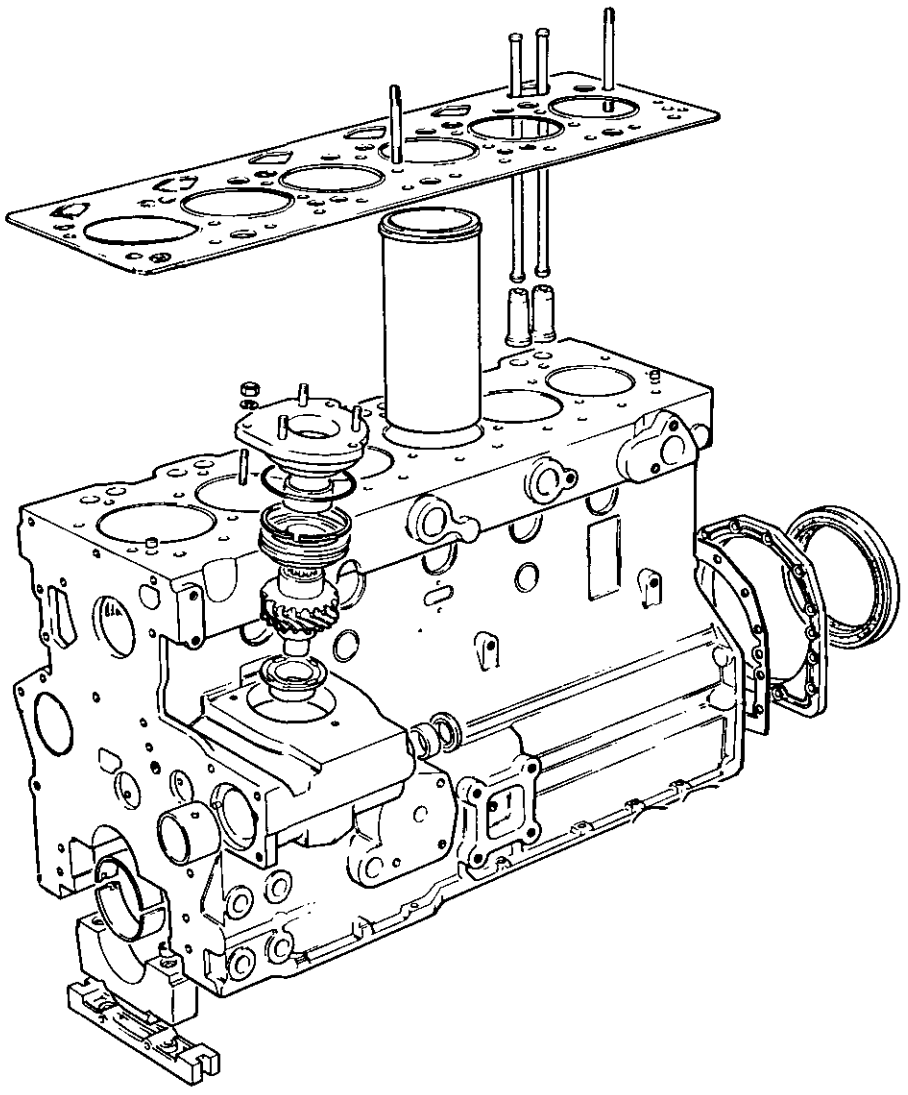
Oversize pistons are not available as the cylinder liners cannot be bored oversize.

The method used to remove and dismantle piston and ring assemblies is the same as used for other T6.3544 engines.

The height of the piston crown relative to the top face of the cylinder block is 0.000/0.007 in (0,000/0,18 mm) above the top face.

The pistons have hard anodised crowns and **must not be topped.** In production, three grades of pre-topped pistons are supplied for the high, medium and low requirements and the letters H, M and L are stamped on the piston crown. To change pistons in service, the same grade of piston **MUST** be used.

SECTION G
Cylinder Block and Liners



Cylinder Block

The top face of the cylinder block cannot be machined as this would interfere with the liner flange recess depth.

Cylinder Liners

Production liners are an interference fit, of 0.001/0.003 in (0.025/0.076mm) in the cylinder block and are bored and honed to a diameter of 3.877/3.878in (98,48/98,50mm) for T6.3544 and 6.3544 engines or 3.9785/3.9795in (101,05/101,07mm) for 6.3724 engines.

The maximum permissible worn inside diameter of a liner, in service is 3.886in (98,70mm) for T6.3544 and 6.3544 engines or 3.9875in (101,28mm) for 6.3724 engines.

An engine with perfect or little worn cylinder bores can sometimes consume an excessive amount of lubricating oil due to glazing. When fitting new piston rings to cure this problem, it is essential that the cylinder bores are first de-glazed.

A tool is available for de-glazing, marketed under the trade name of "Flex-Hone", manufactured by Brush Research Manufacturing Co. Inc., Los Angeles, California, U.S.A. under the registered trade mark U.S. Patent Nos. 3384915 and 3871139 and British Patent Nos. 1,230503 and 18450, which is ideal for this purpose as it does not remove any appreciable amount of metal and produces a good quality cross hatch pattern.

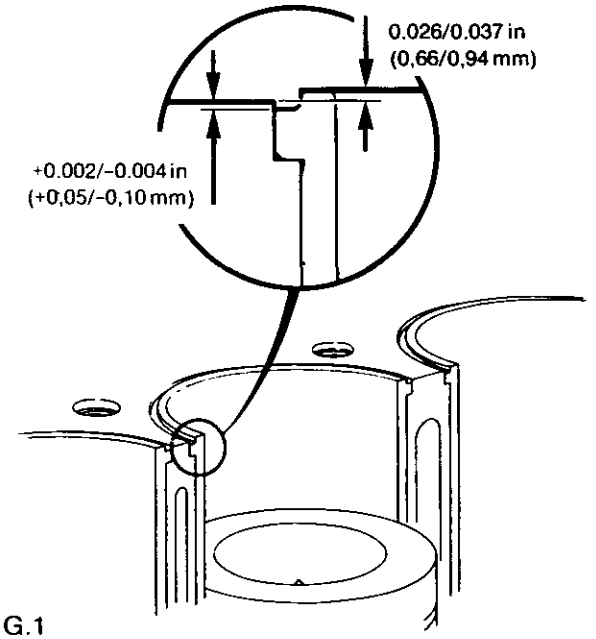
It can often be used with the engine in situ if used with a hand held electric power drill on low speed. Brand new "Flex-Hones" are to be used for one minute in a slave bore to remove all loose material and sharp edges.

1. Grade 80sc "Flex-Hone" is to be used. The "Flex-Hone" size is to be determined by measuring the bore diameter and selecting the "Flex-Hone" of the nearest size larger than the bore.
2. Remove the piston cooling jets as fitted on turbocharged engines. Guard the main journals and pins by tying clean dry rags around them. Where possible use cardboard shields to prevent debris contamination of adjacent parts of the engine.
3. Lubricate the bore with clean engine oil and also smear engine oil on the balls of the "Flex-Hone".
4. Rest the "Flex-Hone" against the cylinder block and switch on whilst pressing into the bore. Do not force the tool into the bore whilst it is not rotating.
5. Pass the tool up and down the bore once per second for 30-50 seconds and remove it whilst it is still rotating.
6. Thoroughly wash the bores to remove all the residue from the honing operation, using a coarse brush and paraffin.
7. Dry the bores using a clean rag and carefully remove the the masking. Thoroughly clean all parts of the engine that have been affected by the honing operation.
8. Refit the piston cooling jets on turbocharged engines (Section M).

This tool is equally successful in producing a good quality bedding-in finish on new cylinder bores, after boring out to finished size.

Enquiries concerning details and supply of the "Flex-Hone" in the U.K. or outside the U.S. where no Brush Research Distributor is available, should be addressed as follows:

Nicro (Leamington) Ltd.
Unit 19A, Chalford Industrial Estate,
Chalford, Nr. Stroud, Gloucestershire GL6 8NT.
Telephone: (0453) 884966
Telex: 437104



G.1

If the liners are found to be worn over the acceptable limit, they cannot be bored oversize.

For service in T6.3544 and 6.3544 engines, a pre-finished liner is available having a transition fit of +0.001/-0.001in (+0,025/-0,025mm). The fitted internal bore diameter is 3.877/3.8795in (98,48/98,54mm).

The liners can be renewed using tools PD 150 and PD 150-1B.

To Renew Service Cylinder Liners

Remove all components from the cylinder block, including the piston cooling jets. They should be carefully handled to prevent misalignment in refitting.

Piston cooling jets are not fitted to naturally aspirated engines.

The liners should be pressed out from the bottom.

Fit the new liners as follows:

It is pointed out that all pre-finished liners can be a 0.001in (0,03mm) interference fit in the parent bore, i.e. if a liner on top limit is fitted in a bottom limit parent bore.

A tight liner should never be hammered in but should be pressed or drawn into the bore using a suitable dolly and press or puller.

Generally clean the parent bore and degrease the top 2 in (50mm) and the liner flange recess using "Loctite" Safety Solvent (aerosol can) as per instructions on can.

Apply engine oil to the cylinder block parent bore except for the top 2in (50mm).

Generally clean the outside surfaces of the liner and degrease using "Loctite" Safety Solvent (aerosol can) as per instructions on can.

Locate the liner in the bore and press in to within approximately 2in (50mm) of its final position.

Further degrease the flange area of the liner using "Loctite" Safety Solvent to remove handling contamination.

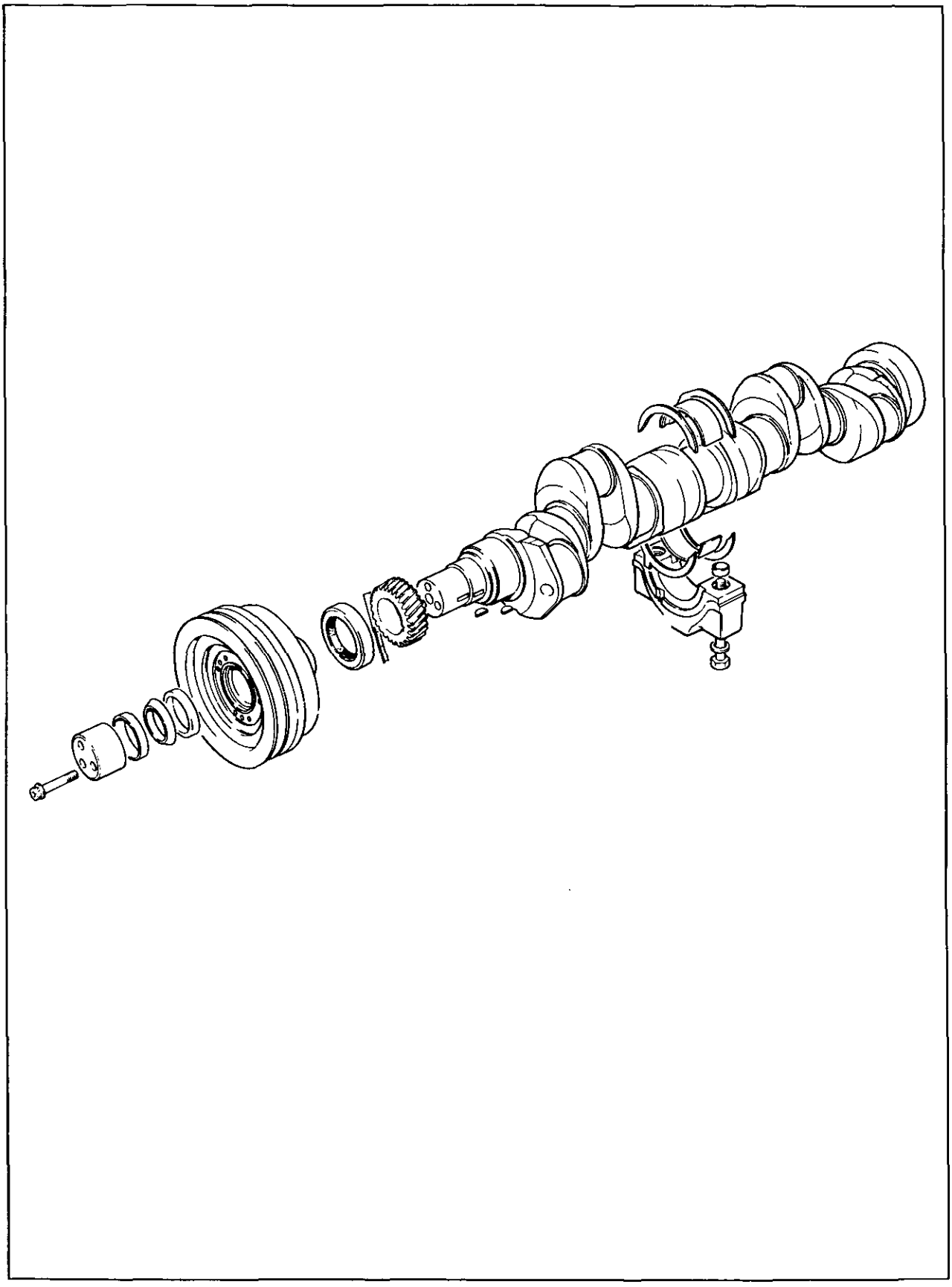
Apply a band of "Loctite" Retaining Compound, Grade 602, 1in (25mm) wide around the top of the liner immediately under the flange. Also liberally apply the "Loctite" to the base of the flange recess.

Press the liner into the fully fitted position and wipe the top of the cylinder block to remove any surplus "Loctite". The top of the liner should protrude 0.026/0.037in (0,66/0,94mm) above the top face of the cylinder block and the liner flange should be within 0.002in (0,05mm) above the top face of the block to 0.004in (0,10mm) below the top face of the block.

It is advisable to allow a settling period to elapse after fitting before checking the fitted internal bore diameter of the liner.

However, allow at least 15 minutes to elapse before commencing to fit pistons as this time lag is required to allow the "Loctite" to reach handling strength. Full cure strength is achieved after 3 hours.

SECTION H
Crankshaft and Main Bearings



The crankshaft runs in seven pre-finished replaceable shell bearings.

End float of the crankshaft is controlled by four thrust washers which are located on both sides of the centre main bearing housing, see Fig. H.1. 0.0075in (0,19mm) oversize thrust washers are available which may be combined with standard thrust washers to give an adjustment of 0.0075in (0.19mm) or when used on both sides of the bearing housing give an adjustment of 0.015in (0,35mm).

The maximum permissible crankshaft end float is 0 020in (0,51mm).

The crankshaft has provision for 12 bolt flywheel fixing.

To Renew Thrust Washers

Renewal of thrust washers can be carried out without the removal of crankshaft as follows:

Drain the lubricating oil and remove the sump, oil suction pipe and pipe from reducing valve to cylinder block (T6.3544 engines only).

Remove the centre main bearing cap (No. 4).

Remove the two bottom half thrust washers.

Remove the two top halves of the thrust washers by sliding them round the crankshaft and out of the recesses machined in the cylinder block main bearing housing, see Fig. H.2.

Liberally oil the two upper halves and slide them into the recesses on either side of the centre main bearing housing.

Refit the two bottom halves of the thrust washers to the bearing cap.

Clean and oil crankshaft journal and place the cap in position ensuring that the block serial number stamped on the cap reads in line with other caps.

Tighten the main bearing cap setscrews to a torque of 200lbf ft (27,7kgf m), or 270Nm.

Check the crankshaft end float by using a feeler gauge between the thrust washer and crankshaft web or by using a dial test indicator on one end of the crankshaft, see Fig. H.3.

Refit suction pipe, pipe from reducing valve to cylinder block (T6.3544 only) and sump. Refill the sump with lubricating oil of an approved grade.

To Remove Crankshaft

It will be necessary to remove the engine from vehicle or machine.

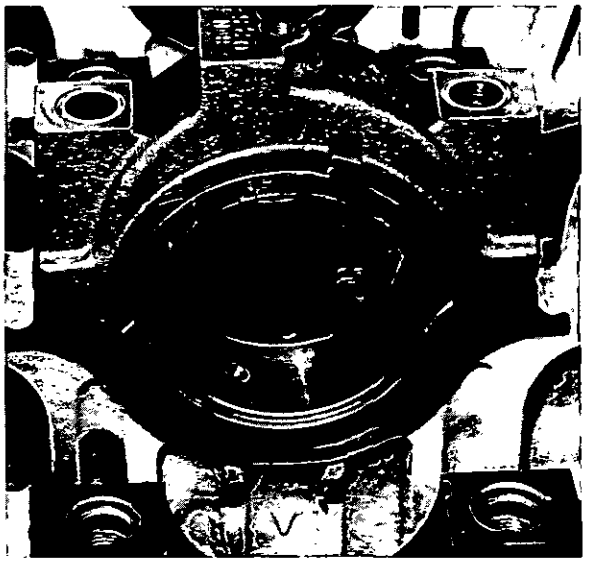
Drain and remove the sump, lubricating oil suction pipe and pipe from reducing valve to the cylinder block (T6.3544 only).

Remove the crankshaft pulley. Extractors should not be used as the pulley will probably be destroyed and the crankshaft damaged. Remove the three securing screws. If the pulley does not immediately become free the locking rings can be released by hitting the front face of the pulley inner hub, see Fig. H.4.

Remove camshaft gear, auxiliary drive gear and timing case, see Page J.2.

Remove flywheel and flywheel housing.

Remove rear main oil seal housing.



H.1

H.2

Remove front and rear bridge pieces from the cylinder block bottom face, with the rubber oil seals.

Remove connecting rod caps and big end bearings. Keep bearings with appropriate caps. Take care not to damage the piston cooling jets.

Remove the main bearing caps and half bearings.

Lift out the crankshaft and remove the upper half bearings, making note of fitted positions.

Crankshaft regrinding

The crankshafts of naturally aspirated engines have induction hardened journals and crankpins. The part numbers of these crankshafts are 31323288, 31323294, 3131H023 and 3131H024. Induction hardened crankshafts which also have their fillet radii hardened are fitted to some turbocharged engines. The part numbers of these crankshafts are 31323283 and 3131H025. Induction hardened crankshafts can be reground to 0.010in (0,25mm), 0.020in (0,51mm) or 0.030in (0,75mm) undersize on diameter. Induction hardened crankshafts need not be hardened after they have been reground undersize.

Crankshafts hardened by the 60 hour nitriding process are fitted to some turbocharged engines. The part numbers of these crankshafts are 31323281 and 3131H021. These crankshafts may be reground to 0.010in (0,25mm) undersize without re-nitriding. Subsequent regrinding to 0.020in (0,51mm) or 0.030in (0,75mm) undersize will require the crankshaft to be hardened by the 60 hour nitriding process. If the crankshaft is to be reground 0.020in (0,51mm) or 0.030in (0,75mm) undersize, grind to 0.0015/0.002in (0,04/0,05mm) above the finished size. This will leave an allowance to grind off the white compound layer formed by the nitriding process. After nitriding the crankshaft, it is not permissible to regrind the fillet radii.

Nitrocarburised (Tufftrided or Sursulfed) crankshafts are fitted to some turbocharged engines. The part numbers of these crankshafts are 31323292 and 3131H022. These crankshafts must be nitrocarburised after each regrinding operation.

Generally, the part number of the crankshaft is stamped on the front of the crankshaft nose, but some later crankshafts may have the last four figures of the part number stamped on the front of the first web.

When re-grinding, the operation calls for specialised equipment and great care.

Using a Prince type grinder with a Universal Grinding Wheel Company wheel to Grade WA-80 JE (or equivalent), remove the white compound layer formed by the Nitriding process to achieve finished size. The collar faces of the crankshaft should be lightly flashed but not ground at this operation and the fillet radii should be maintained at 0.145/0.156in (3,68/3,96mm). This will leave the compound layer in the radii and collars. When removing the compound layer, a grinding wheel speed of 880 rev/min and a crankshaft working speed of 16 rev/min for main journals and 8 rev/min for pins should be observed and a hand feed of approximately 0.0005in (0,01mm) per revolution of crankshaft. An adequate supply of coolant (Walker Century A305) should be used.

Where facilities for re-Nitriding are not available, then a factory replacement crankshaft should be fitted.

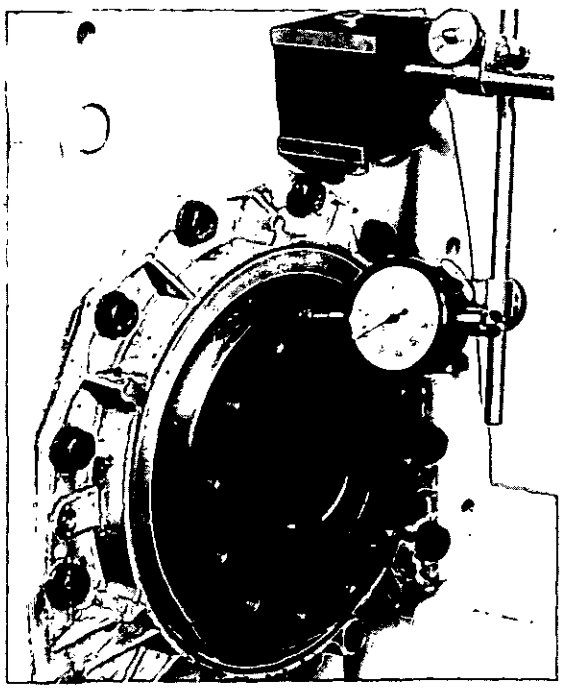
Nitrided crankshafts cannot be straightened.

Before regrinding a crankshaft, it should be crack detected. De-magnetize after crack detecting.

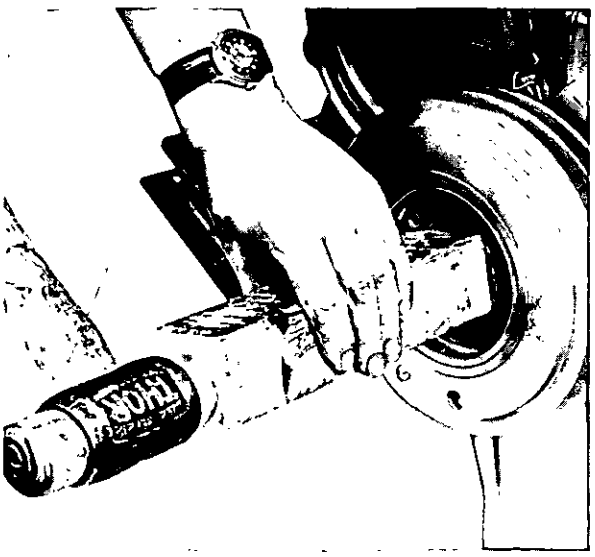
Data for crankshaft re-grinding is given on Page H.4.

After regrinding, the sharp corners on the oil holes should be removed and the crankshaft crack detected and de-magnetized.

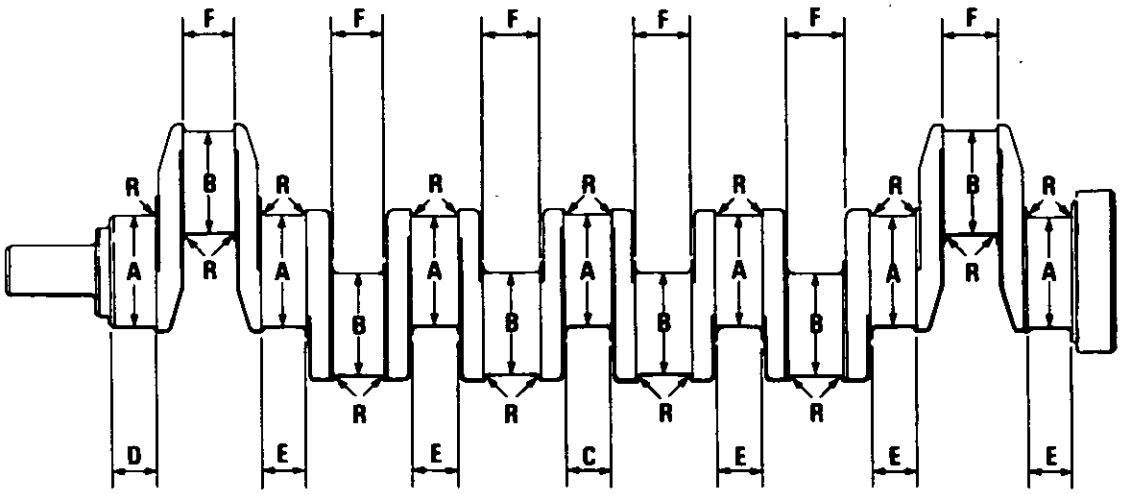
Note: It is important that the radii on the main journals and crankpins are maintained.



H.3



H.4



H.5

The regrind dimensions are as follows see Fig. H.5.

	0.010 in (0,25 mm)	0.020 in (0,51 mm)	0.030 in (0,76 mm)
A	2.9884/2.9896 in (75,91/75,94 mm)	2.9784/2.9796 in (75,65/75,68 mm)	2.9684/2.9696 in (75,40/75,43 mm)
B	2.4888/2.4898 in (63,22/63,24 mm)	2.4788/2.4798 in (62,96/62,99 mm)	2.4688/2.4698 in (62,70/62,73 mm)
C	1.759 in (44,68 mm) maximum		
D	1.489 in (37,82 mm) maximum		
E	1.554 in (39,47 mm) maximum		
F	1.5965 in (40,55 mm) maximum		
R	0.145/0.156 in (3,68/3,96 mm) radius all pins and journals		

| Surface finish of 16 micro inches (0,4 microns) of the crankpins, journals and the fillet radii (R) must be maintained during regrinding.

Maximum run-out with the crankshaft mounted on the end main journals.

Independent readings.

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

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

Number 1	Number 2	Number 3	Number 4
Mounting	0.004 in (0,10 mm)	0.008 in (0,20 mm)	0.010 in (0,25 mm)

Number 5	Number 6	Number 7
0.008 in (0,20 mm)	0.004 in (0,10 mm)	Mounting

The difference in run-out between any two adjacent bearings must not be greater than 0.004 in (0,10 mm).

To Fit Crankshaft

Ensure that the oilways in the cylinder block and crankshaft are free from obstruction.

Check the main bearing setscrews for stretch or damage. If they are to be replaced, only use Perkins genuine spare parts.

Clean the bearing housings; place the top half bearings in position and liberally oil.

Position the crankshaft.

Oil the two upper thrust washers and slide into the recesses on either side of the centre main bearing housing.

Clean the main bearing caps and place the lower halves of the bearings, with the tabs correctly located, into position. Liberally oil and place the caps in position making sure that the cap to cylinder block locating

thimbles are in place and that the caps, which are numbered one to seven are fitted to the relevant main bearing housings. Care must also be taken to ensure that the caps are fitted so that the cylinder block serial number, which is stamped on the cylinder block bottom face as well as on each cap, read in line, see Fig. H.6.

Before fitting the centre main bearing cap, place the lower halves of the thrust washers into the recesses on either side of the cap.

Fit a new shim washer to each main bearing cap setscrew and lightly oil.

Note: The washers for the setscrews of the main bearing caps are not fitted on the latest engines.

Tighten the setscrews to a torque of 200lbfft (27,7kgfm) or 270Nm.

Check the crankshaft end float for a clearance of 0.002/0.015 (0,05/0,38mm). Oversize thrust washers may be fitted.

Refit the connecting rod caps and big end bearings.

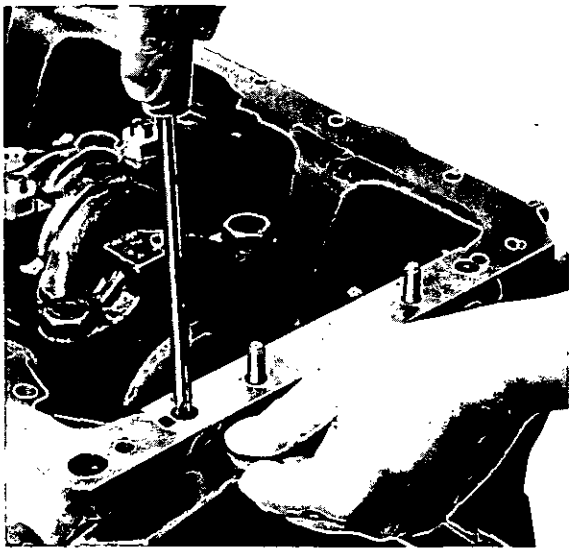
Refit the front and rear bridge pieces to the cylinder block using jointing compound between the bridge pieces and the cylinder block at the setscrew holes. Check with a straight edge to ensure that the end faces of the bridge pieces are flush with the end faces of the cylinder block, see Fig. H.7. Insert new rubber oil seals, see Fig. H.8.

A cast iron bridge piece has been introduced which uses POWERPART Hylosil instead of the rubber seal in the groove at each end of the bridge piece.

The earlier and the latest bridge pieces are the same except the groove at each end of the new bridge pieces is cast and is off-centre.

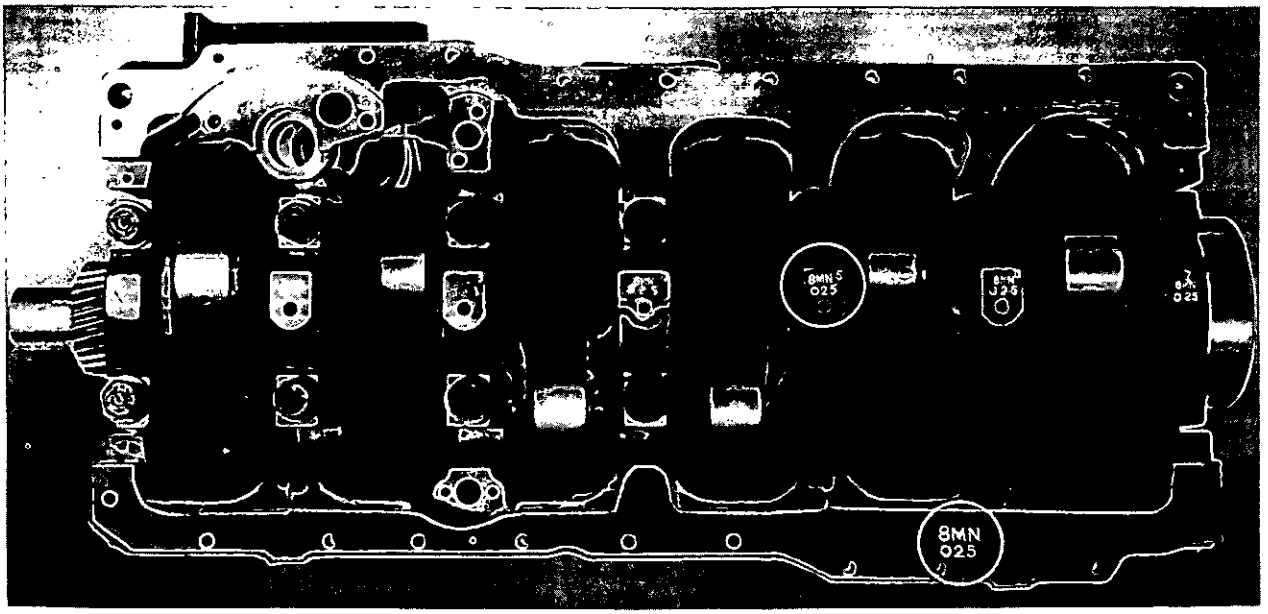
The latest engines have setscrews instead of studs to fasten the sump to the rear bridge piece. The threads of the setscrews have a sealant that is applied by the manufacturer. When these fasteners are to be fitted again, ensure that the threads of the fasteners and of the bridge piece are clean and a suitable sealant is applied to the threads of the fasteners.

The procedure used to fit the latest bridge piece is the



H.7

H.8



H.6

same as given for the earlier bridge piece, except for the instructions given below.

Apply a ⅛in (3,0mm) bead of POWERPART Hylosil along the corner in the top of the recesses in the cylinder block for the bridge piece.

When the bridge piece is in position and the capscrews have been tightened, inject POWERPART Hylosil into the groove at each end of the bridge piece until the groove is completely full.

Note: When the sump joint is removed, damage can occur to the Hylosil seal in the grooves of the bridge piece. If the seal is damaged, apply sufficient Hylosil to completely fill the grooves.

Fit new seal in the rear main oil seal housing and refit the housing.

Refit the pipe from reducing valve to cylinder block (T6.3544 only) lubricating oil suction pipe and sump.

Refit the timing case, camshaft gear and auxiliary drive gear, see Page J.2.

Refit the crankshaft pulley employing the following recommended procedure.

(a) Remove oil and grease from pulley bore, shaft, locking elements and spacer, but do not use a degreasing solution. Do not expand the rings beyond their free state.

(b) *Fit pulley to shaft, lining up key and keyway.*

(c) Insert the spacer (1) into the pulley bore over the shaft, followed by the inner (2) and then the outer (3) locking elements, ensuring that the slots do not coincide, see Fig. H.9.

Note: Where power take-off at the front end of the crankshaft is critical, then two pairs of locking elements are fitted — see Fig. H.9 (2) and (3).

(d) Fit the thrust block (5) with "O" ring (4) into the pulley bore.

(e) Lightly oil screw threads and underside of screw heads before fitting. Do not use molybdenum disulphide.

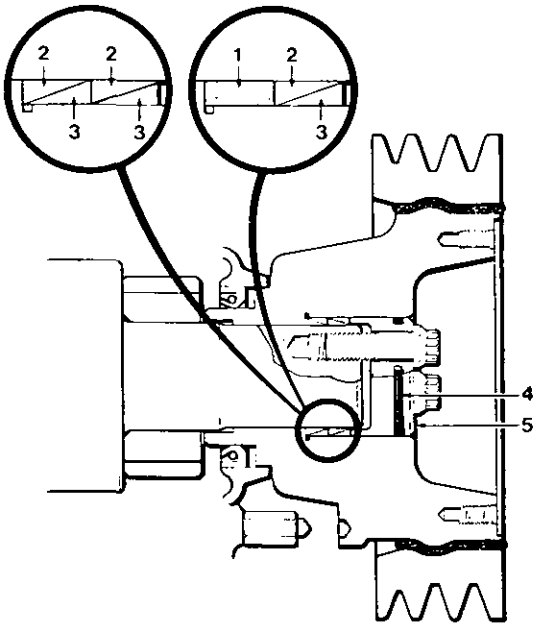
(f) Push pulley fully home and tighten setscrews to establish a firm connection.

(g) Tighten screws evenly and in several stages until a final torque of 65lbfft (9,0kgfm) or 88 Nm is achieved, see Fig. H.10.

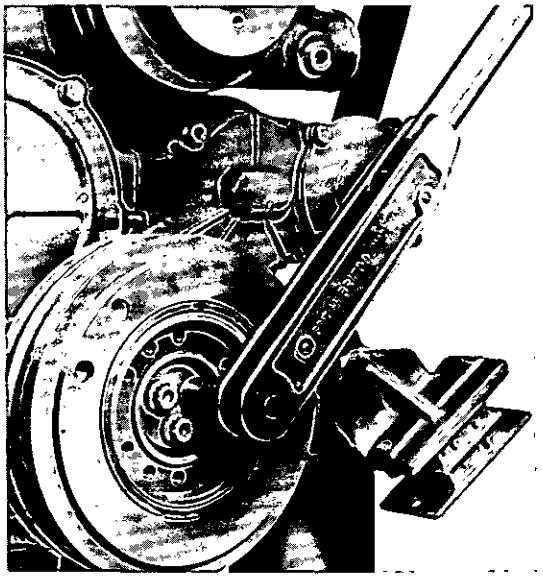
Check tightening torque on each screw.

Refit and correctly align the flywheel housing and flywheel, see Page P.2.

Rebuild engine into vehicle or machine. Fill the sump to the correct dipstick level with a recommended oil. With turbocharged engines do not fire the engine until checking for lubricating oil at the turbocharger.



H.9



H.10

Crankshaft Rear Oil Seal

A circular spring loaded lip seal locates on the periphery of the rear flange of the crankshaft.

This seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to the crankshaft. Any visual damage across the lip of a new seal will cause leakage and prevent bedding in of the seal.

To Fit Oil Seal in its Housing

Earlier seals have a flat rear face, as shown in Fig. H.11 whereas the latest seal has a dust lip protruding from the rear face, as shown in Fig. H.12.

On production, the old type seal was fitted flush with the rear face of the housing (Fig. H.11) but the new type seal is fitted deeper into the housing at "A", Fig. H.12.

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 ⅛in (3,2mm) for old type seals or position "B" for new type seals or, if this position has been used, to ¼in (6,4mm) for old type seals or position "C" for new type seals.

If a new type seal is used in place of an exisiting old type seal, position "C" should be used if the old seal was fitted ⅛in (3,2mm) 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, but not the spigot area on which the flywheel locates – See Fig. H.13.

When a new seal is fitted to a new or reconditioned crankshaft in service, it should be fitted in the production position, but if the latest seal is not to be used in a wet back end application, it can be fitted flush with the housing rear face ("D", Fig. H.12).

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

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

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

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

To Fit Oil Seal and Housing

The seal and housing should be fitted, using seal guide PD145C, as follows:—

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

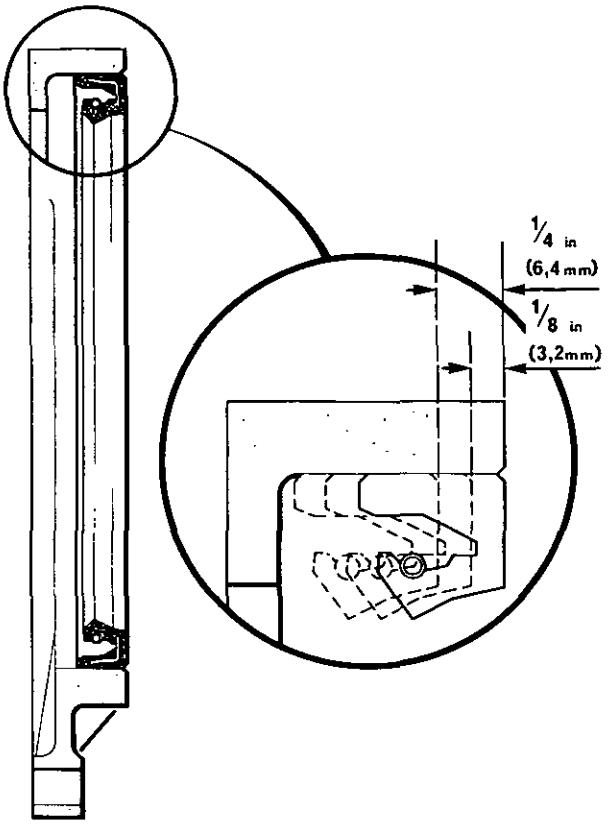
Check that the seal and the outside diameter of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position in the housing, as detailed above.

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

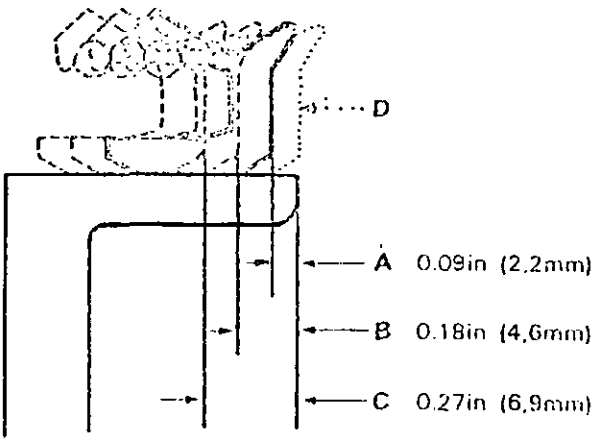
Using clean engine lubricating oil, lubricate the crankshaft flange, the seal and the seal guide. The lubrication of the seal is necessary to prevent damage that may be caused by initial dry running.

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

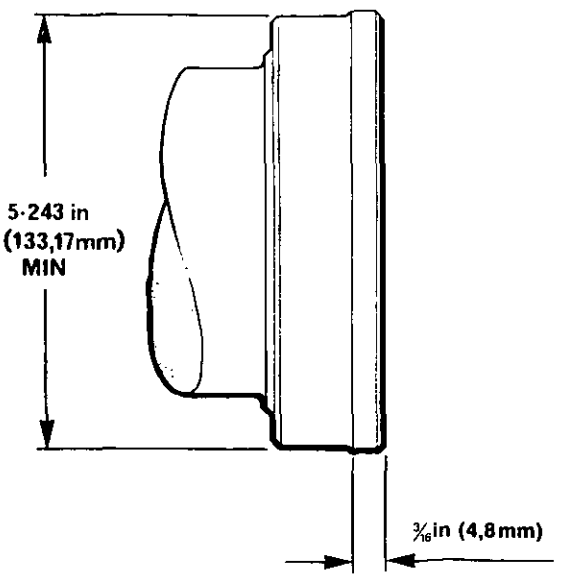
Withdraw the guide and secure the housing with setscrews and washers.



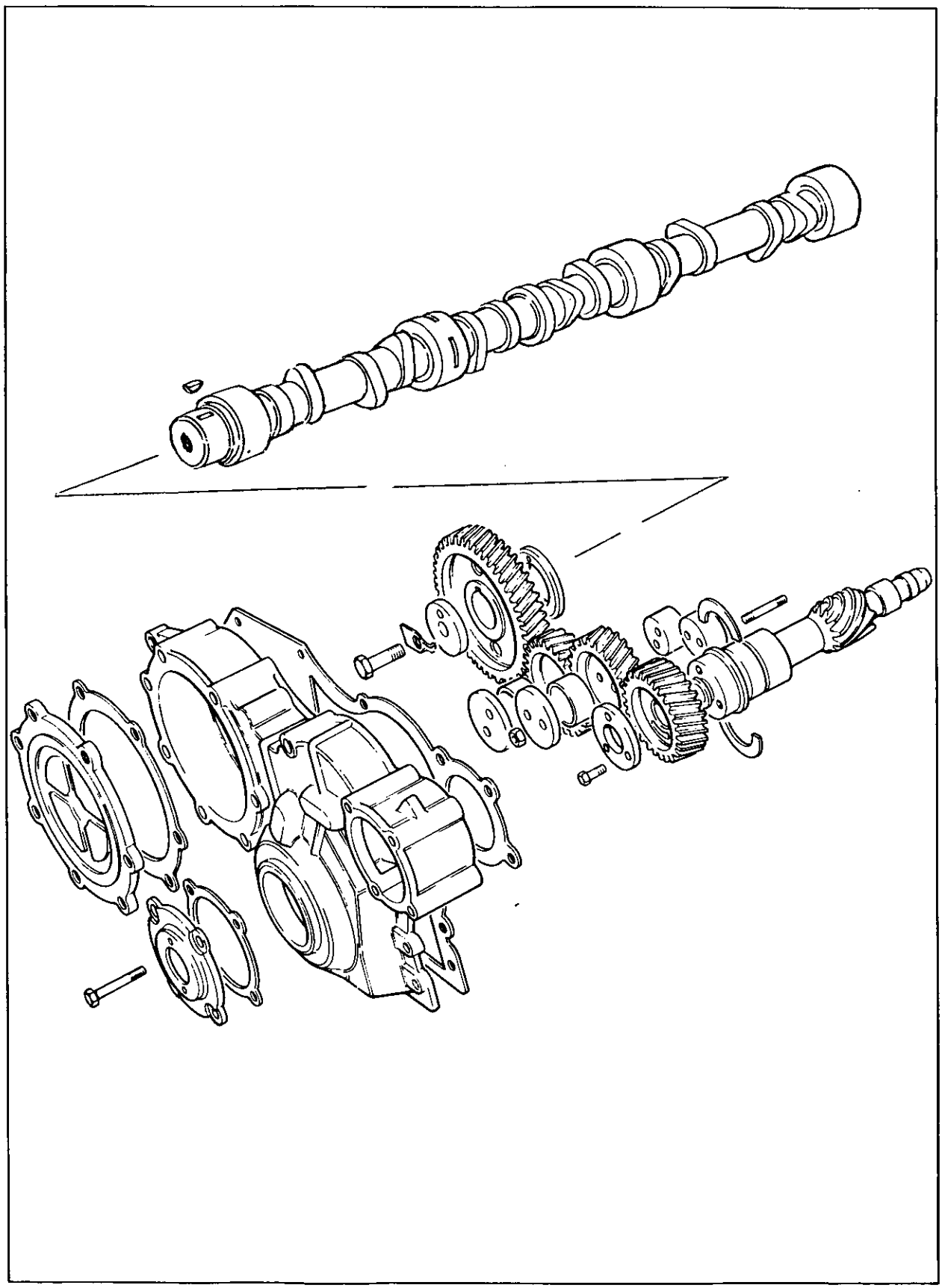
H.11



H.12



SECTION J
Timing Case and Drive



To Remove Timing Case, Camshaft Gear and Auxiliary Drive Gear

Slacken the generator mounting bolts and remove the drive belts.

Where necessary, remove the water pump.

Remove the crankshaft pulley, see Page H.2.

Remove the camshaft gear and auxiliary drive gear covers.

The camshaft gear securing setscrew and washers can now be removed. Extract the gear from the camshaft, see Fig. J.2.

Note: The threads of the removal holes in the camshaft gear have been changed from 5/16in UNF to M8 x 1,25mm on the latest engines. Gears with metric threads will have a letter 'M' formed on the front face of the gear near one of the threaded holes.

Metric adaptor screws PD.155B-5 can be obtained from V.L. Churchill Limited for use with the removal tool PD.155B or the latest removal tool PD.155C.

Remove the retaining plate securing the auxiliary drive gear to the auxiliary drive shaft hub and withdraw the gear, see Fig. J.3.

The timing case securing setscrews, lower nuts and timing case can now be removed.

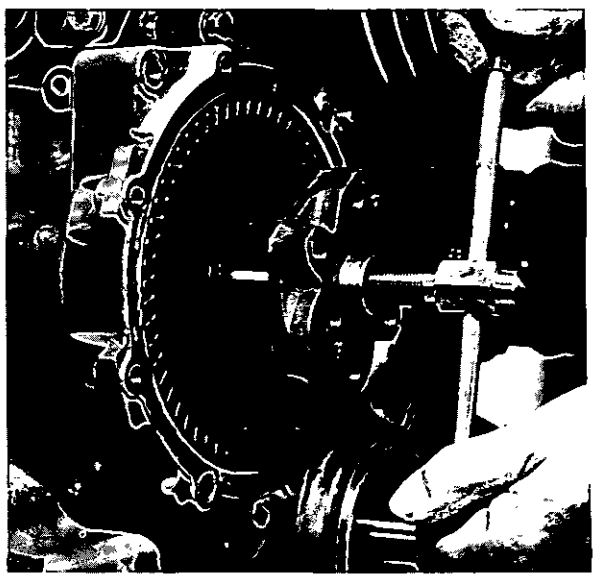
To Renew Crankshaft Front Oil Seal

Using a press, remove the oil seal from the timing case. Alternatively, the seal may be tapped out.

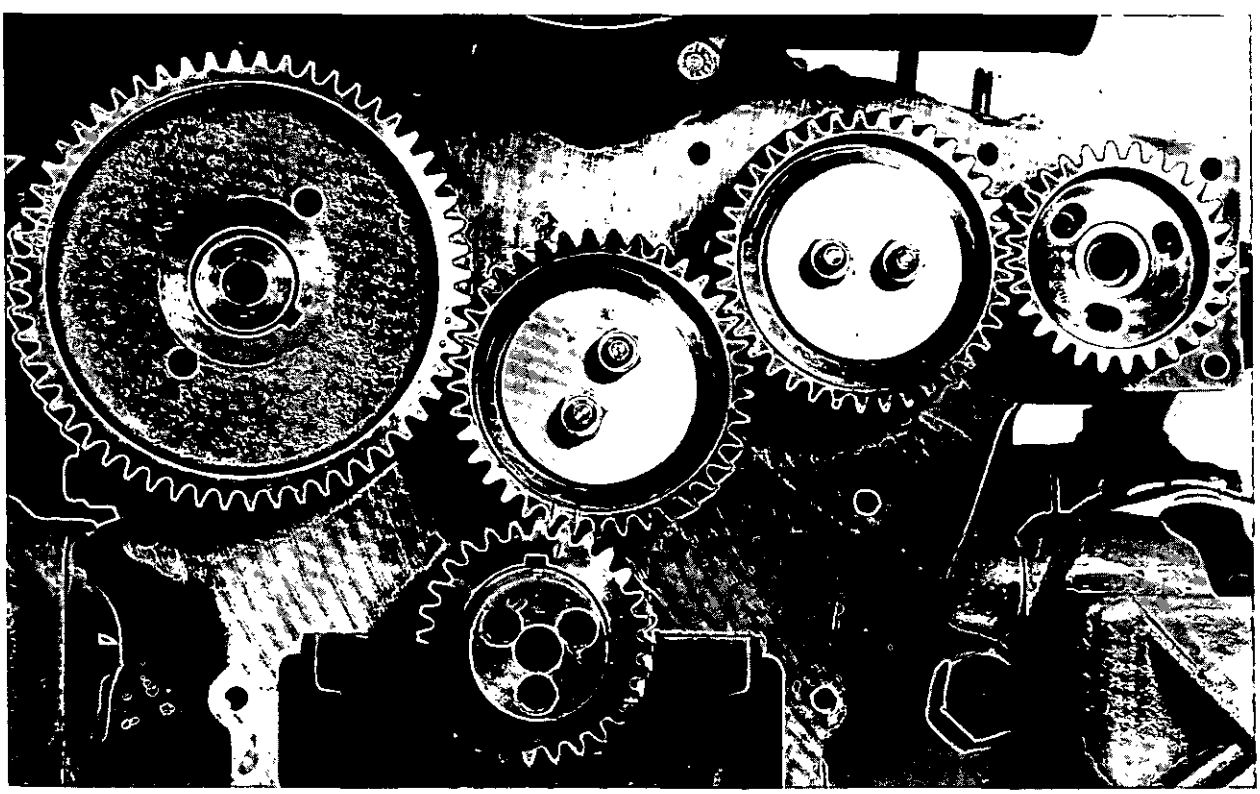
Early seals were black with a flat front face. Later seals were red and also had a flat front face. Current seals are black and have a protruding dust seal lip at the front. An oil thrower is fitted between the crankshaft gear and pulley with the early black seals but this is removed and a spacer or longer pulley is fitted with the later red and black seals.

If the latest seal, with a dust seal lip, is used in place of an earlier type seal, a clean locating surface for the dust lip must be provided on the pulley boss. Clean paint, etc. from the pulley for a distance of 3/8in (9mm) forward of the lip seal location.

Press the seal into position from the front until the flat front face of the seal is 0.265/0.285in (6,73/7,24mm) below the front face of the timing case, see Fig. J.4.



J.2



J.1

To Refit Timing Case, Camshaft Gear and Auxiliary Drive Gear

Remove the rocker cover and slacken the rocker assembly securing setscrews.

Turn the crankshaft until Nos. 1 and 6 pistons are at T.D.C. with the keyway in the crankshaft gear at T.D.C.

If the double dot on the lower idler gear is not in line with the single dot on the crankshaft gear, remove the idler gear and replace with the marks in line.

Position the timing case with a new joint on the cylinder block by means of two opposite setscrews fitted loosely. Centralise the case by locating the timing case centralising tool PD.163 on the crankshaft and in the seal housing and tighten the assembly by means of the crankshaft pulley setscrews and the washer provided. Do not overtighten. Tighten all the timing case setscrews and nuts and remove the tool. If the centralising tool is not available, the crankshaft pulley can be used to centralise the case, but, as this method utilises the inside diameter of the seal which is soft, the case may not be truly central and leaks may occur.

If the latest type of crankshaft oil seal with a protruding dust seal lip at the front is fitted, ensure that the centralising tool has a suitable recess in it to clear the dust seal lip.

Position the camshaft so that the key is aligned with the keyway in the camshaft gear and at the same time, the timing marks on the camshaft and idler gears are aligned.

Draw the gear onto the camshaft by fitting the gear retaining washer, tabwasher, shimwasher and setscrew. Tighten the setscrew to a torque of 50lbf ft (6,9kgf m) or 68Nm, and lock with the tabwasher.

Refit the camshaft gear cover plate.

Before fitting the auxiliary drive gear, remove the fuel injection pump, see Page N.6. and turn the auxiliary drive shaft until the slot in the vertical fuel pump drive hub aligns with the slot in the fuel pump adaptor plate, see Fig. K.2.

With the engine set in this position, fit the auxiliary drive gear so that the three setscrew holes in the shaft are within the three slots of the gear.

Secure the gear with the retaining plate and setscrews.

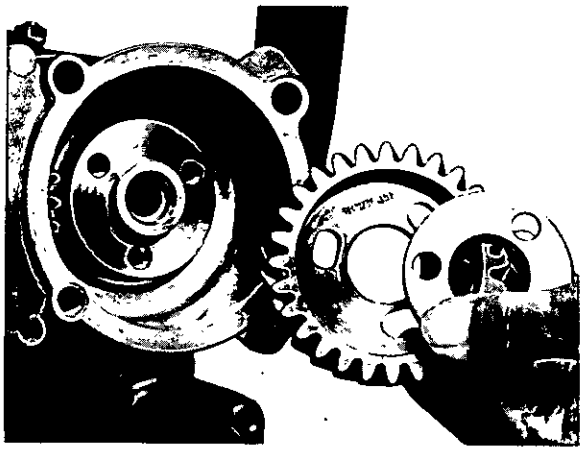
Refit the auxiliary drive gear cover plate.

Refit the fuel injection pump, see Page N.6.

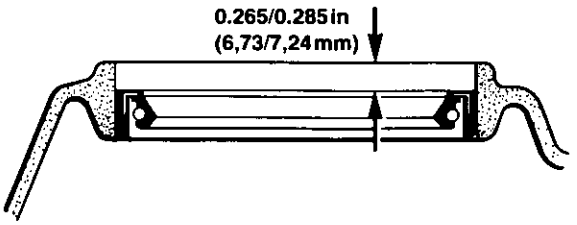
Tighten the rocker assembly and adjust the valve clearances to 0.008in (0,20mm) for inlet valves and 0.018in (0,45mm) for exhaust valves cold and replace the cover.

Refit the crankshaft pulley, see Page H.6.

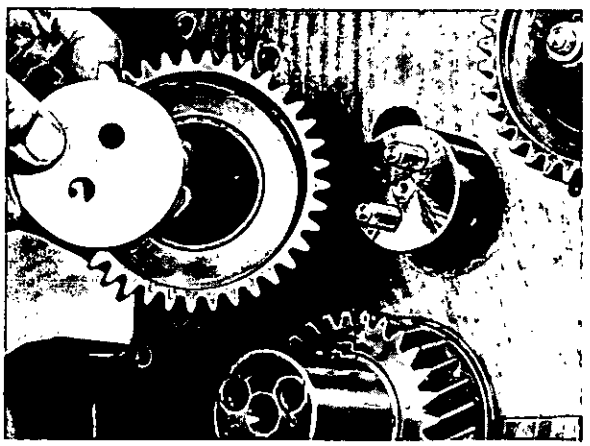
Fit the drive belts and retighten the generator.



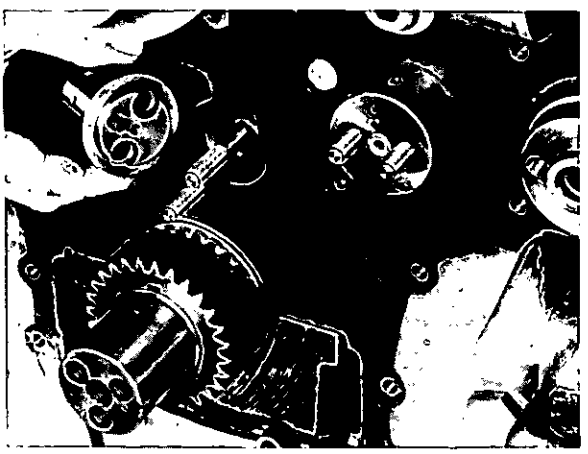
J.3



J.4



J.5



J.6

To Remove Idler Gears and Hubs

Remove the timing case, see Page J.2.

Remove the self locking nuts securing each idler gear thrust plate.

Remove the retaining plates and withdraw the gears, see Fig. J.5.

Withdraw the hubs.

To Refit Idler Gears and Hubs

Turn the crankshaft until Nos. 1 and 6 pistons are at T.D.C. with the keyway in the crankshaft gear at T.D.C.

Refit the idler gear hubs, located by dowels, see Fig. J.6. Ensure that the oilways are clear.

Refit the idler gears and retaining plates so that the timing marks on the lower idler gear align with the timing marks on the crankshaft gear.

Using new self locking nuts, tighten to a torque of 36 lbf ft (5,0 kgf m) or 49 Nm.

Refit the timing case, camshaft gear and auxiliary drive gear, see Page J.2.

Check the end float which should be 0.004/0.016 in (0,10/0,41 mm), see Fig. J.7.

To Remove Camshaft and Tappets

Remove the timing case, see Page J.2.

Remove the rocker cover, rocker assembly and withdraw the pushrods.

Remove the fuel lift pump, see Page N.5.

Turn the engine on its side and remove the sump.

Remove the camshaft thrust ring and withdraw the camshaft, see Fig. J.8.

Remove the tappets.

To Replace Camshaft and Tappets

Refit the tappets, camshaft and sump.

Fit the camshaft thrust ring so that it is correctly positioned on the dowel, see Fig. J.9.

Check the protrusion of the thrust ring beyond the cylinder block front face which should be within the limits of 0.000/0.005 in (0,00/0,13 mm).

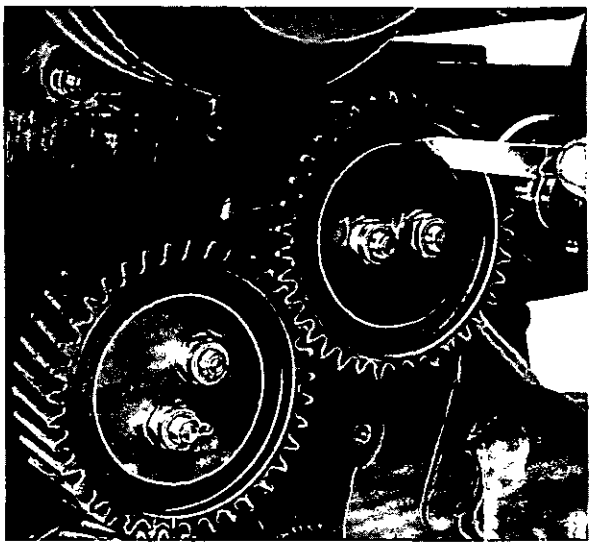
Refit the fuel lift pump and connections.

Fit the timing case and refit the timing gears, see Page J.2.

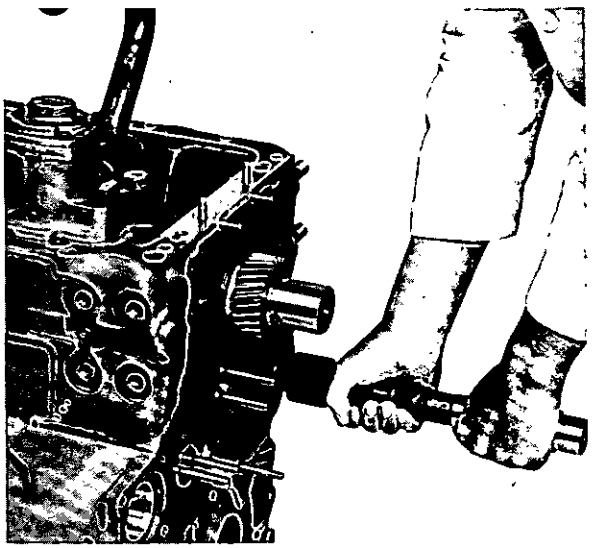
Refit the pushrods and rocker assembly.

Adjust the valve clearances to 0.008 in (0,20 mm) for inlet valves and 0.018 in (0,45 mm) for exhaust valves cold. Refit the rocker cover.

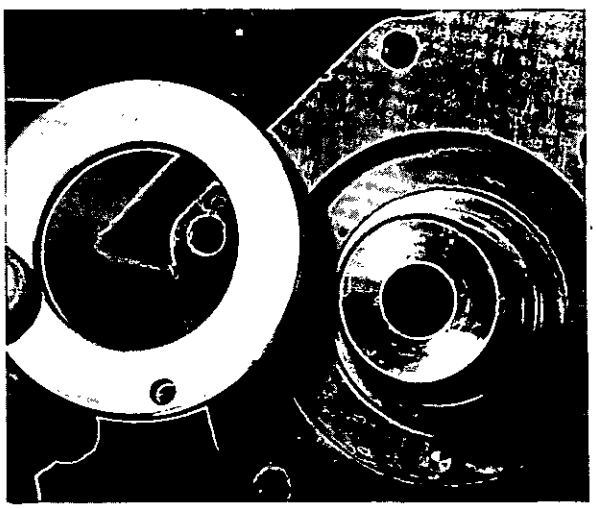
Refill sump with lubricating oil of an approved grade.



J.7



J.8



J.9

To Remove Auxiliary Drive Shaft and Fuel Pump Drive Shaft

Remove the timing case, see Page J.2.

Remove the compressor and auxiliary pump (if fitted) and couplings.

Remove the fuel injection pump, see Page N.6.

With a twisting motion, withdraw the auxiliary shaft and the two 180° half thrust washers, see Fig. J.10.

Remove the fuel pump adaptor plate complete with rubber sealing ring and bush.

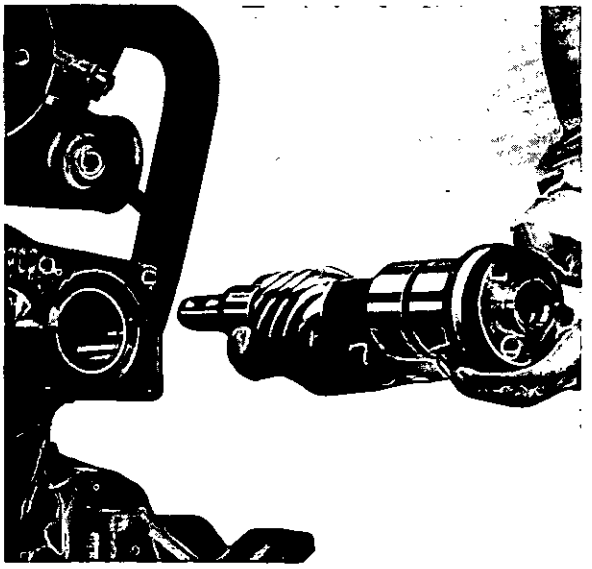
Withdraw the upper thrust collar complete with piston ring seal, see Fig. J.11.

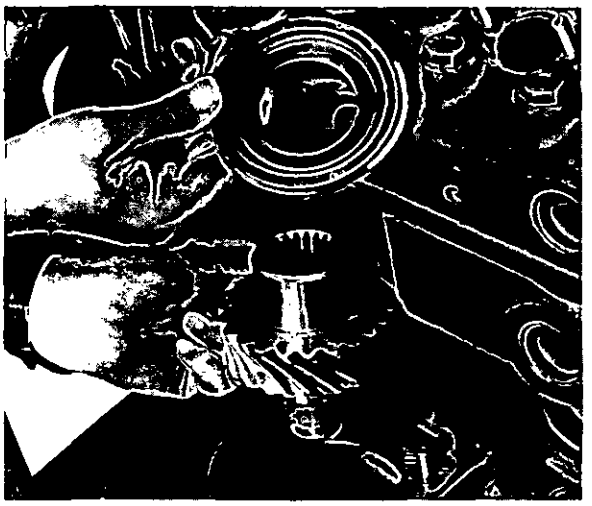
The fuel injection pump and lubricating oil pump drive shaft complete with wormwheel can now be pulled up and removed, see Fig. J.11.

The wormwheel is shrunk on and punch peened to the drive shaft. In the event of the gear requiring renewal, the gear and shaft assembly should be replaced. The lower thrust collar and bush will remain in its location in the cylinder block and can be removed by removing the sump and lubricating oil pump.

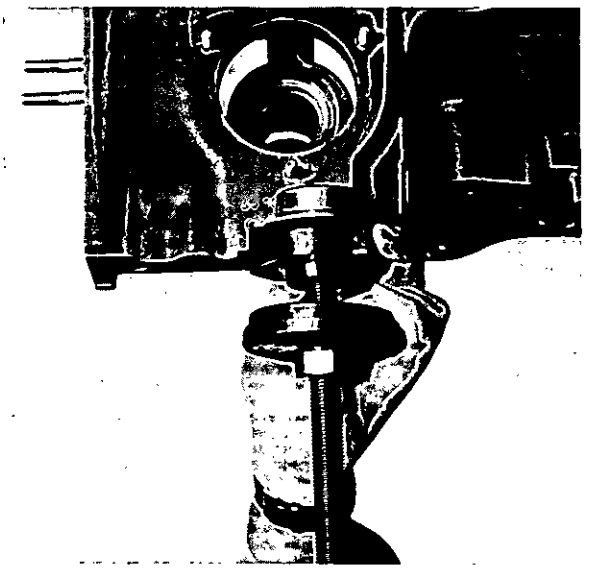
With the use of a special tool PD 140 with adaptor 140-3 the thrust collar and bush can now be withdrawn, see Fig. J.12. Some earlier engines did not have a bush fitted.

Where necessary, renew the auxiliary drive shaft front and rear bushes in the cylinder block. It is advisable that these be drawn into the block by means of a suitable threaded bar and adaptors.





J.11



J.12

To Refit Auxiliary Drive Shaft and Fuel Pump Drive Shaft see Fig. J.13.

Refit the lower thrust collar assembly and press into position.

The wormwheel and fuel pump drive assembly can now be fitted.

Fit the upper thrust collar with the piston ring seal in its location.

Refit the lubricating oil pump and sump, filling with oil to an approved grade.

Fit the fuel pump adaptor plate assembly, complete with bush sealing ring and joint, so that the timing mark scribed on flange is adjacent to the outside securing stud.

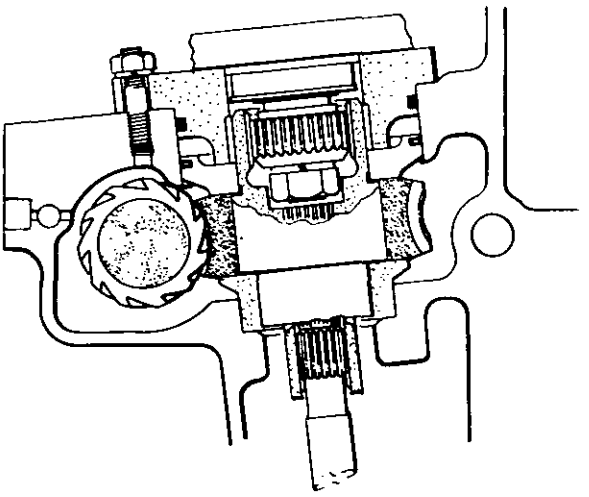
Where oil leaks past the adaptor plate "O" ring occur in service, the "O" ring should be renewed and a joint (Pt. No. 36822118) fitted between the adaptor plate and the cylinder block.

Fit the auxiliary drive shaft into position with the thrust washer halves fitted around the groove in the shaft, finally locating in the cylinder block recess with two opposite butt faces located by a dowel, see Fig. J.14.

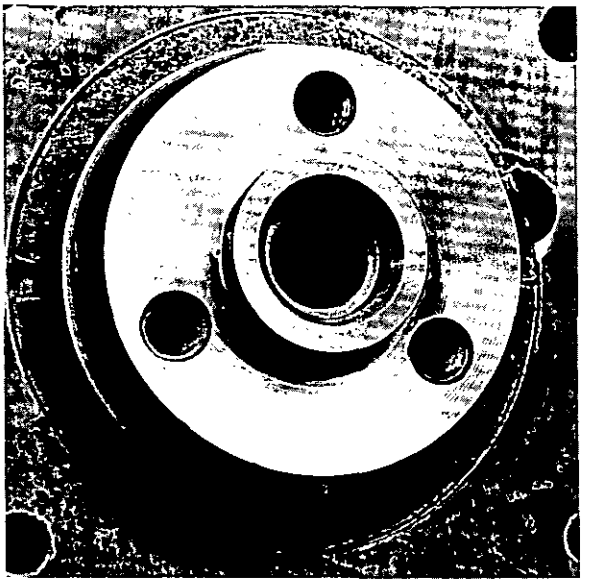
The end float of the drive shaft is controlled by the clearance between the thrust washers, (which are held in position by the timing case) and the groove of the drive shaft.

The end float is between 0.0025 in and 0.009 in (0,064 mm and 0,23 mm).

Replace the timing case, timing gears and fuel pump.



J.13



J.14

Auxiliary Drive Spray Tube

The auxiliary drive gears are lubricated by oil directed onto them by a spray tube.

The spray tube is a push fit in the auxiliary drive housing and sealed with a "D" plug.

During engine overhaul, this spray tube should be removed and cleaned.

New cylinder blocks supplied as loose parts are not fitted with this spray tube, therefore when renewing a cylinder block, ensure that the tube is transferred from the old block, or a new one fitted (see Fig. J.15).

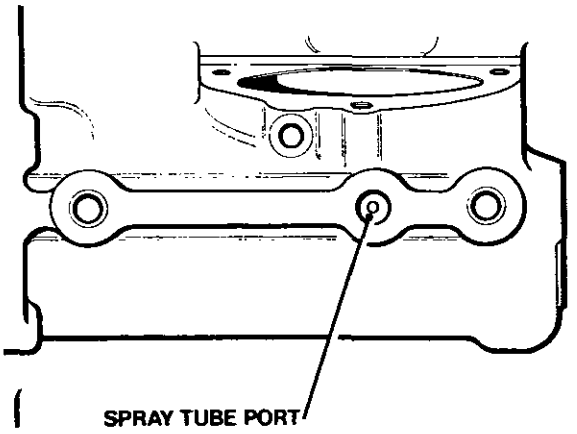
Checking the Timing Gear Backlash

Remove the camshaft gear and auxiliary drive gear covers.

Check the backlash between the timing gears using a clock gauge or feeler gauges.

The backlash should be 0.003 in (0,08 mm) minimum.

PART SIDE VIEW ON AUX. DRIVE HOUSING



J.15

SECTION K
Timing

Timing Marks

The crankshaft, main idler and camshaft gears are stamped to ensure that they are assembled correctly, see Fig. K.1.

The stamped teeth of the crankshaft and the camshaft gears will be in mesh with the main idler gear when the piston of number 1 cylinder is at top dead centre (TDC) on the compression stroke. The stamped teeth of the main idler may not necessarily be in mesh in this position, due to the different speeds at which the gears rotate.

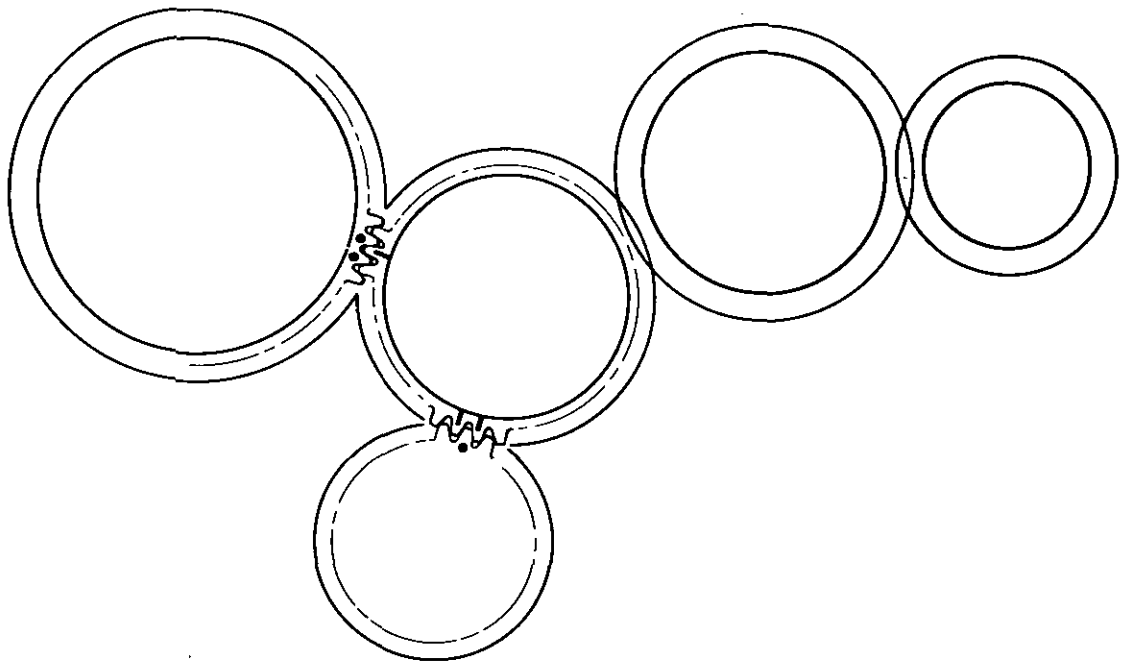
The auxiliary drive gear and its idler gear are not stamped as the auxiliary drive gear has slots for the adjustment of the drive for the fuel injection pump.

How to Set the Accurate TDC Position of Number 1 Piston

This procedure can be used where there are no marks on the engine to set the piston of number 1 cylinder to TDC.

Remove the rocker cover. Turn the crankshaft, clockwise from the front, until the push rod for the inlet valve of number 6 cylinder just tightens. Remove the valve spring(s) from the first valve using Churchill tool 6118B. Fit a suitable collar near the top of the valve stem to prevent the valve from falling into the cylinder if the crankshaft is turned too far.

Put a dial test indicator in position so that the plunger of the dial gauge is on the top of the valve stem and with a reading on the gauge. Turn the crankshaft slowly clockwise, from the front, until the clockwise movement of the dial gauge pointer stops. Continue to turn the crankshaft slowly in the same direction until the pointer of the dial gauge just starts to move counter-clockwise. The angular position between these two points is the accurate TDC position. This is because there is a small crankshaft movement without any vertical movement of the piston. If necessary, a pointer could be fitted in a suitable position to assist in the accurate location of the correct point.



K.1

To Reset Engine Timing

It is assumed that the timing case and all the timing gears have been removed and require replacing with the knowledge that the valve and fuel pump timing will be to the original setting.

To reset the timing to the original markings, proceed as follows:

Remove the rocker assembly, push rods and atomisers.

Turn the engine crankshaft until Nos. 1 and 6 pistons are at T.D.C.

That this has been obtained may be checked by observing that the keyway for the crankshaft gear is at T.D.C.

Place the two idler gears in position on their respective hubs, making sure that the double line timing mark on the left hand gear is opposite the single line timing mark on the crankshaft gear (see Fig. K.1). Then tighten the securing nuts to the correct torque (see page B.2).

Replace the timing case and secure it to the cylinder block.

Fit crankshaft pulley as detailed on Page H.6.

With the engine still in the T.D.C. position, refit the camshaft gear with the double dot timing mark opposite the single dot timing mark on the idler gear.

Draw gear onto camshaft and fit washer, tab washer, shim washer and retaining setscrew. Tighten setscrew to the correct torque (see page B.2) and lock with tab washer.

Set the piston of number 1 cylinder to the accurate TDC position (see page K2). Turn the fuel pump drive shaft until the machined slot in the fuel pump driving hub is in line with the machined slot in the fuel pump adaptor plate (see Fig. K.2).

Fit the fuel pump drive gear with the part number to the front so that the three setscrew holes coincide with the holes in the fuel pump drive shaft when it is in mesh with the idler gear and secure in this position.

Ensure when fitting the gear, that the two machined slots remain in line.

Fit timing gear covers to the timing case.

Fit the fuel pump ensuring that the scribed line on its pump flange coincides with the scribed line on the fuel pump adaptor plate (see Fig. K.5).

With later Bosch fuel pumps, this scribed line is on the top of the mounting flange.

Remove the dial test indicator and fit the valve spring(s) to the first valve.

Fit the push rods and the rocker shaft. Set the valve clearances.

Fit the atomisers and fuel pipes.

Basic Timing of the Fuel Injection Pump

Set the piston of number 1 cylinder at TDC on the compression stroke; the inlet valve of number 6 cylinder has just opened and the exhaust valve is not fully closed.

The slot in the master spline of the drive for the fuel injection pump should be in alignment with the slot in the adaptor plate of the fuel pump, see Fig. K.2. With the drive for the fuel injection pump in this position and the fuel pump fitted, the mark on the adaptor plate should be in alignment with the mark on the flange of the fuel pump, see Fig. K.5.

How to Check the Basic Timing (CAV and Bosch Fuel Injuction Pumps)

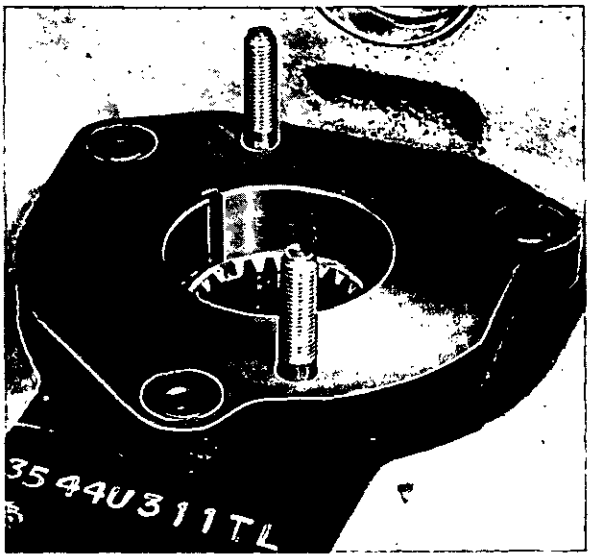
Set the piston of number 1 cylinder at TDC on the compression stroke; the inlet valve of number 6 cylinder has just opened and the exhaust valve is not fully closed, see page K.2.

Remove the fuel injection pump and ensure that the slot in the fuel pump driving hub is in alignment with the slot in the fuel pump adaptor plate.

If these slots are not in line, the necessary adjustment should be made on the fuel pump drive gear, through the aperture in the timing case.

This adjustment may be effected by slackening off the three gear securing setscrews and turning the auxiliary drive shaft by means of the setscrews.

When the timing is found to be correct, refit the fuel pump ensuring the scribed line on the mounting flange coincides with the scribed line on the fuel pump adaptor plate (see Fig. K.5).



K.2

How to Check the Engine Check Angle (with Churchill Tool MS.67B)

Set the piston of number 1 cylinder at TDC on the compression stroke; the inlet valve of number 6 cylinder has just opened and the exhaust valve is not fully closed, see Page K2.

Remove the fuel injection pump.

Release screw (5) — Fig. K.3. — and position splined shaft (6) so that the larger splined adaptor is to the front of the tool.

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

Release the bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant engine check angle. This angle can be obtained by reference to the fuel pump setting code and table given on Page B11.

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

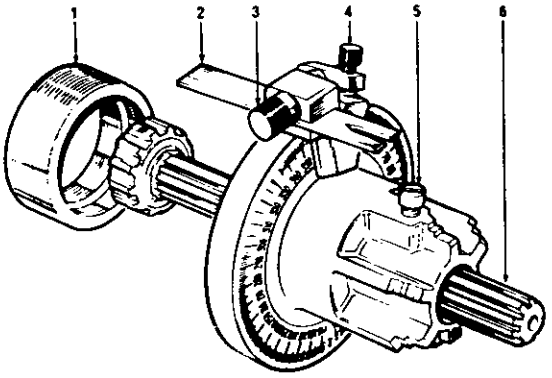
Slide the slotted pointer downwards so that the end of pointer abuts flange — see Fig. K.4.

Turn timing tool by hand in opposite direction to pump rotation (shown on pump nameplate) to take up backlash and then check that timing mark on fuel pump adaptor is in line with slot of pointer. If timing mark does not align, the position of the auxiliary drive shaft should be altered relative to its drive gear. The holes in the auxiliary drive gear are slotted to allow for adjustment.

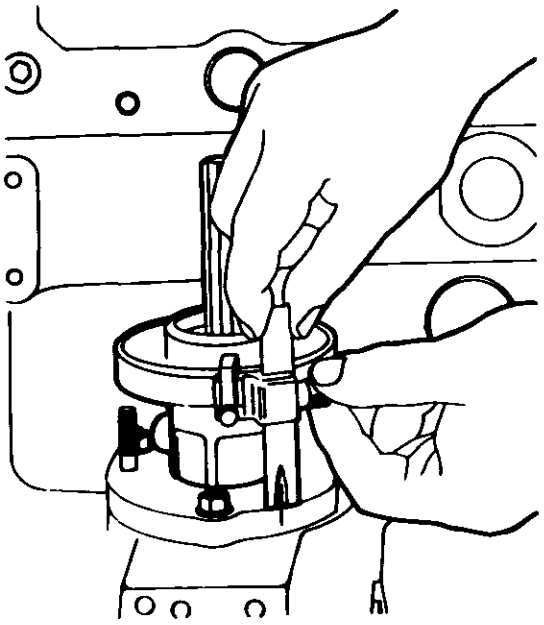
When engine timing is correct, remove the tool.

Where necessary, the fuel pump marking angle can be checked by using timing tool as described later.

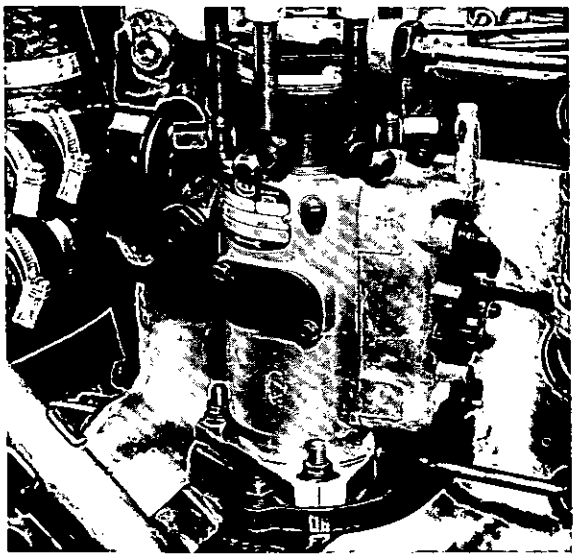
Refit fuel pump to engine as given on Page N6. Remove the dial test indicator from the first valve. Refit No. 1 inlet valve stem seal, valve springs, spring cap and collets. Then set valve clearance to 0.008in (0,20mm).



K.3



K.4



K.5 (C.A.V. Pump)

How to Check the Timing of a CAV Fuel Injection Pump

There is a rotor in the pump bearing a number of scribed lines, each one having an individual letter (see Fig. K.6). A timing circlip is positioned inside the pump which has to be set so that when the appropriate scribed line on the fuel pump rotor aligns with the straight edge of the circlip, it denotes commencement of injection (static timing).

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 (X) (see Fig. N.12) on the pump to an atomiser tester and pump up to 30atm 440lbfin^2 or (31kgfcm^2). 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 letter "F" on the pump rotor.

Ensure the fuel pump is correctly fitted with the scribed line on the mounting flange coinciding with the mark on the fuel pump adaptor plate.

Position the crankshaft so that No. 1 piston is at TDC on its compression stroke.

Remove the rocker cover.

Remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston.

Reposition the valve stem seal to the collet groove to prevent the valve from dropping into the cylinder.

With the aid of a dial gauge in contact with the end of the valve now sitting on No. 1 piston, it will be necessary to position the crankshaft so that the piston will be at its static timing point (see Page B11).

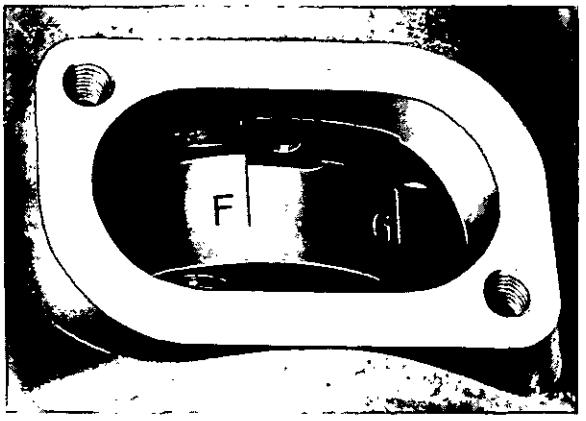
To do this, turn the crankshaft in the opposite direction to normal rotation, approximately an eighth of a turn BTDC and then forward until the required position is registered on the dial gauge. This enables the backlash in the timing gears to be taken up.

Remove the flat inspection plate on the fuel pump enabling the rotor to be seen.

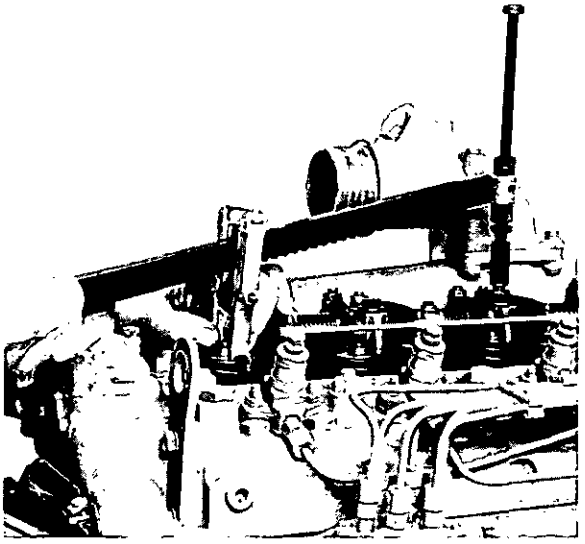
With No. 1 piston at the static timing point on its compression stroke, the scribed line on the rotor marked 'F' should align with the straight edge of the timing circlip. See Fig. K.6.

If the timing marks do not align, release the nuts securing the fuel pump and twist the pump body in the required direction until the marks align. Further adjustment can be made by turning the auxiliary drive shaft, after first releasing the auxiliary drive gear securing setscrews.

If after both these adjustments, the timing marks do not align, it could mean the auxiliary drive gear has been fitted incorrectly.



K.6



K.7

How to Check the Timing of a Bosch Fuel Injection Pump

Ensure fuel pump is correctly fitted to engine as described under "To Reset Engine Timing" on Page K2.

With the rocker cover removed, set the piston of number 1 cylinder at TDC on the compression stroke; the inlet valve of number 6 cylinder has just opened and the exhaust valve is not fully closed.

Thoroughly clean the fuel pump around the vent plug in the hydraulic head.

Remove the central plug from the end of the pump (C, Fig. N.14) and fit one of the timing tool assemblies given below:—

Bosch: Body 1688 130 045, Extension 1683 458 019 and Dial Indicator 1687 233 012.

Churchill: Adaptor MS107 and Dial Indicator SM991A.

Ensure dirt does not enter the pump.

Ensure that the dial indicator plunger is depressed at least 0.118in (3mm) to cover the plunger lift which is 0.110in (2,8mm).

Turn the engine in each direction to obtain BDC of the pump plunger and set the dial indicator to zero at this point.

Reposition the crankshaft at TDC No. 1 cylinder compression and using tool No. 6118B, remove the collets, spring cap and springs from No. 1 inlet valve (see Fig. K.7) and allow the valve to rest on the top of the piston. Reposition the valve stem seal to the collet groove to prevent the valve from dropping into the cylinder.

Position a dial indicator with the plunger resting on top of the valve stem, determine exact TDC position and zero the dial indicator, see Fig. K.8.

Turn the crankshaft in the opposite direction to normal rotation approximately ⅛ of a turn and then turn in the normal direction of rotation until the dial indicator indicates that the piston is in the correct position for the static timing angle of the fuel injection pump, see page B11.

At this position, the dial indicator on the fuel pump should read 0.0394in (1mm) — see Fig. K.8.

Adjust timing as necessary by releasing the three screws securing the auxiliary drive gear to the auxiliary drive shaft.

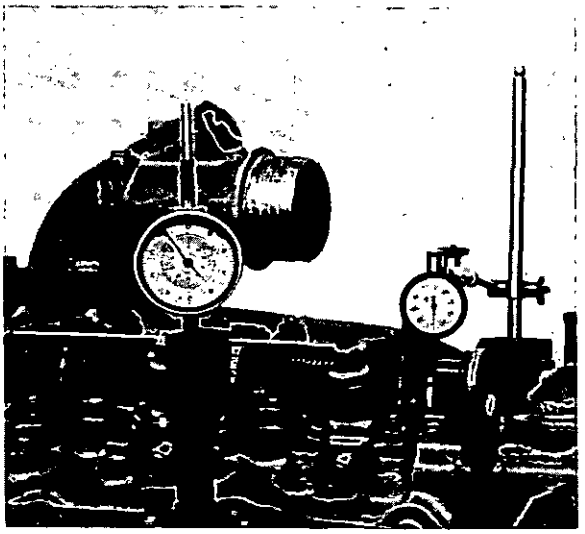
If the plunger lift is in excess of 1mm, turn the auxiliary drive shaft clockwise and then anti-clockwise until 1mm lift is obtained. Secure the gear ensuring the gear backlash is taken up by holding the gear against the normal direction of rotation.

If the plunger lift is less than 1mm, turn the auxiliary drive shaft anti-clockwise until 1mm lift is obtained. Secure the gear ensuring the gear backlash is taken up by holding the gear against the normal direction of rotation.

Recheck timing as previously detailed.

When timing is correct, turn the engine in the normal direction of rotation until No. 1 piston is at TDC Refit valve stem oil seal, valve springs, spring cap and collets. Reset valve clearance to 0.008in (0,20mm).

Remove the special timing tool from the fuel pump and refit the plug. If the large inspection plug was removed, tighten it to 40lbfft (5,5kgfm or 54Nm or if the small vent plug was removed tighten it to 7lbfft (104Nm) or 1,0kgfm. If the low pressure fuel pipes have been disturbed, bleed the system as described on Page N7.



K.8

How to Check the Mark Angle of the Fuel Injection Pump (with Churchill Tool MS.67B)

Release screw (5) — Fig. K.3 — and remove splined shaft (6).

Ensure slotted pointer (2) is positioned with slot to rear of tool and chamfered side 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.

With CAV pumps, connect No. 1 outlet connection of the pump (marked "X"), see Fig. N.12, to an atomiser tester and pump up to 30atm 440lbf in² or (31kgf cm²). If a pressurising valve is fitted, this must be removed.

Release bracket screw (4) — see Fig. K.3 — and set bracket to that the chamfered edge is in line with relevant pump marking angle (see Page B11).

Position timing tool on pump drive with master splines engaged and tool located on spigot — see Fig. K.9.

With CAV pumps, turn the pump in the normal direction of rotation as shown on name plate until it "locks up".

With Bosch pumps, ensure that the keyway in the fuel pump drive shaft is in line with No. 1 outlet marked "D", see Fig. N.13 on the hydraulic head.

Remove the central plug from the end of the pump (C, Fig. N.14) and fit one of the timing tool assemblies given below:—

Bosch: Body 1688 130 045, Extension 1683 458 019 and Dial Indicator 1687 233 012.

Churchill: Adaptor MS107, and Dial Indicator SM991A.

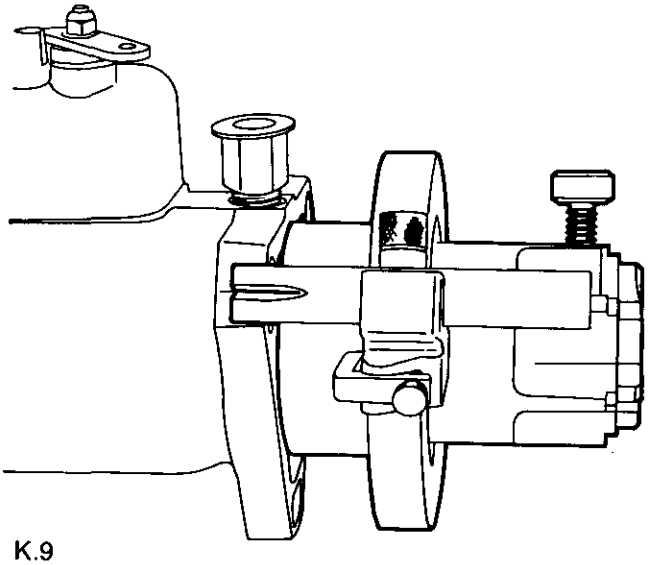
Ensure dirt does not enter the pump.

Turn the pump against the normal direction of rotation and zero the dial indicator when the plunger is at BDC Then turn pump in normal direction of rotation unit 0.0394in (1mm) of lift is obtained on the pump plunger.

In these positions (for both CAV and Bosch pumps) slide the pointer (2) of the timing tool — Fig. K.3 — forward until it is halfway over the pump flange and check that timing mark on the flange is central to the slot in the pointer — see Fig. K.9.

If necessary, remove incorrectly positioned mark and make a new mark in the correct position on the pump flange.

Remove timing pool from Bosch pumps and refit the plug. If the large inspection plug was removed, tighten it to 40lbf ft (54Nm), 5,5kgf m or, if the small vent plug was removed, tighten it up to 7lbf ft (10Nm), 1,0kgf m.



K.9

Checking Valve Timing

1. Turn the crankshaft until the valves on No. 6 cylinder are rocking. In this position, set the clearance on No. 1 inlet valve to one of the following clearances according to the part number which is stamped on the rear of the camshaft:

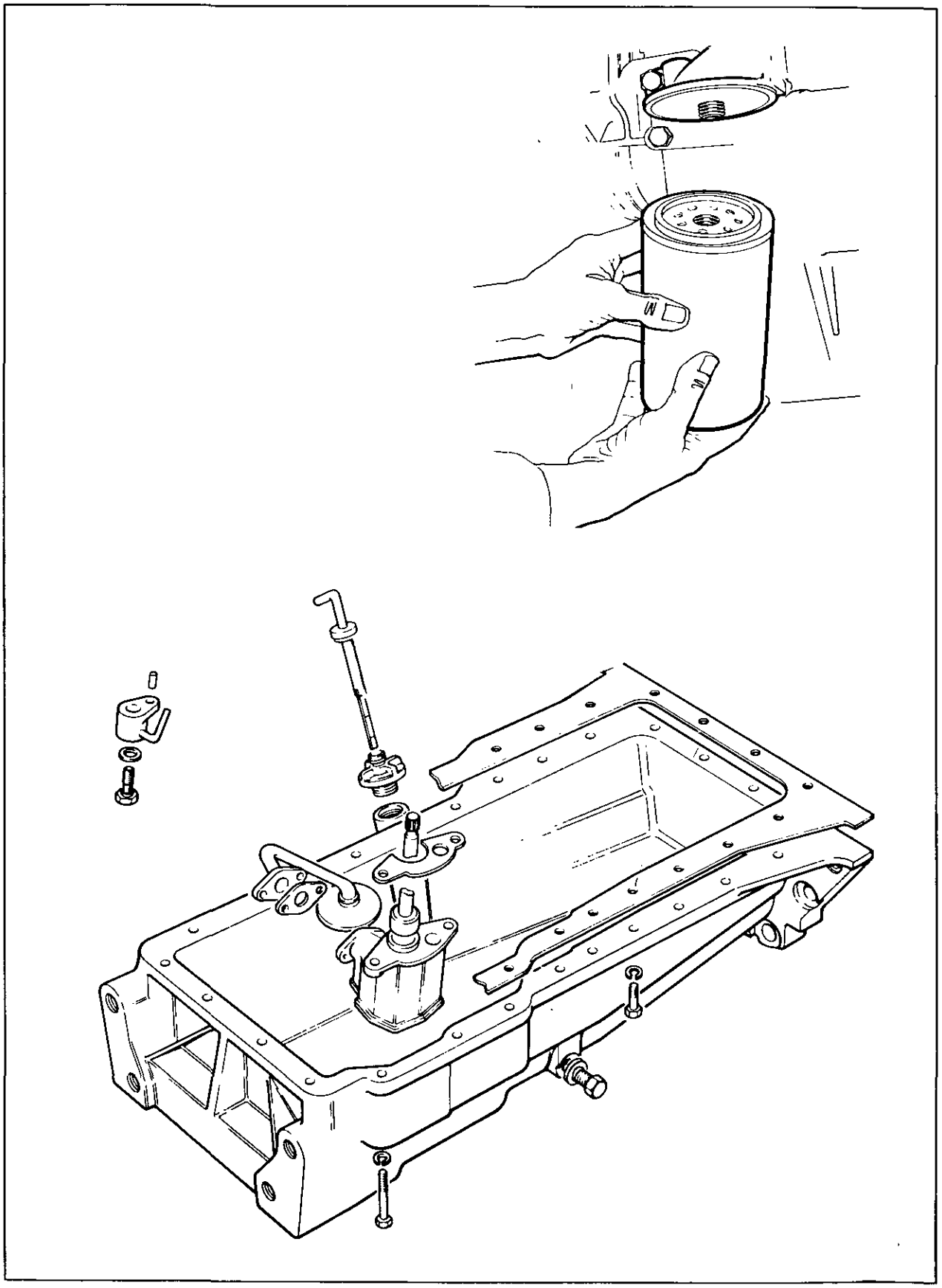
Camshaft Part No.	Clearance
31416207	0.051in (1,30mm)
31416222	0.026in (0,66mm)
31416302	0.051in (1,30mm)
31416303	0.047in (1,19mm)
31416304*	0.060in (1,52mm)

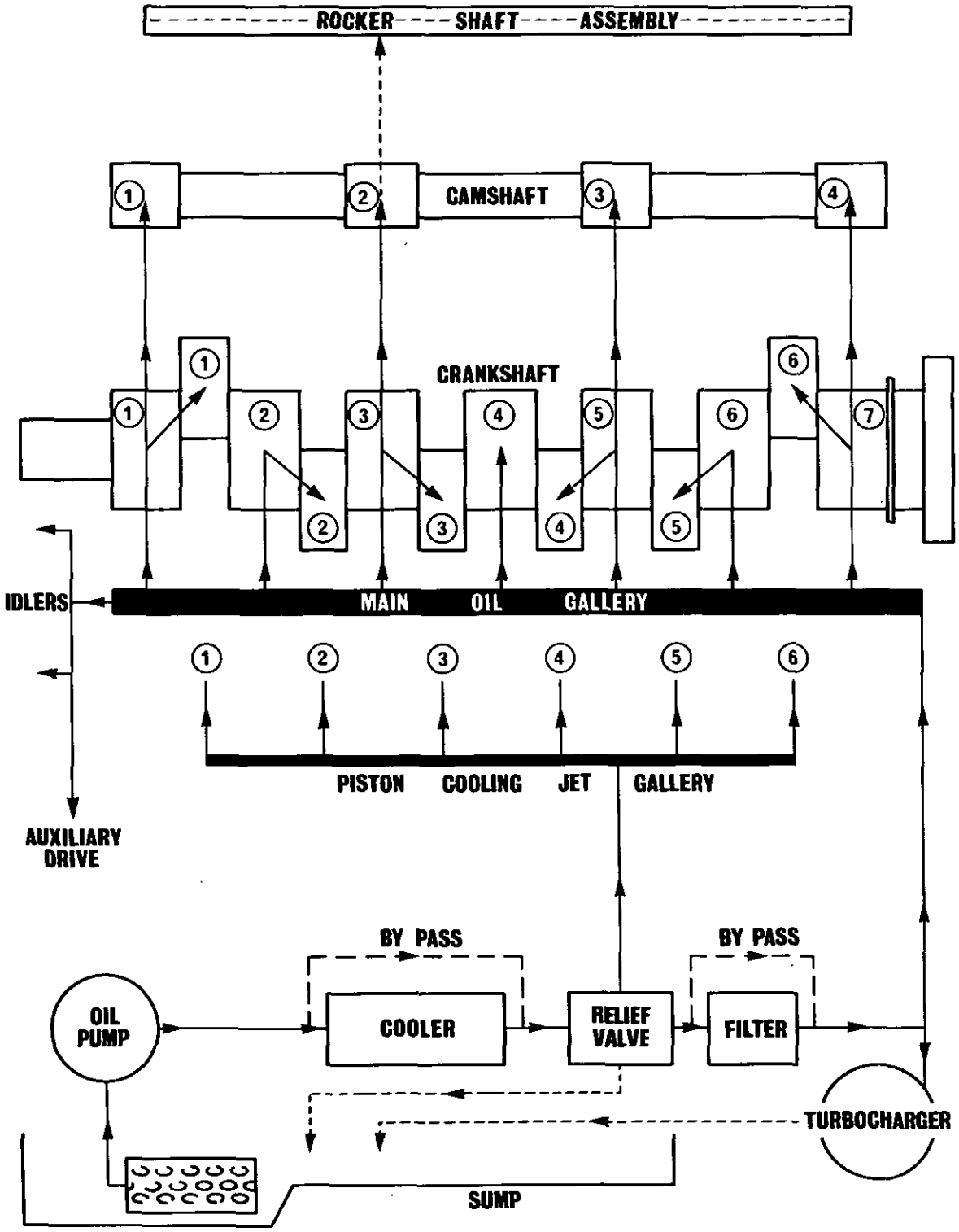
2. Turn the crankshaft in the normal direction of rotation until the push rod of No. 1 inlet valve just tightens.
3. Check that Nos. 1 and 6 pistons are at TDC The valve timing tolerance is plus or minus 2½°.
4. When the valve timing is found to be correct, reset valve clearance to 0.008in (0,20mm) cold.

*Includes T6.3544 North America vehicle engine.

Note: There is no adjustment provided for value timing. If the timing is found to be incorrect, then the gears can only be one or more teeth out of correct mesh.

SECTION L
Lubricating System





L.1

Note: Piston cooling is only applicable to most turbocharged engines except current T6.3544 engines fitted to generating sets and an oil cooler is not always fitted to naturally aspirated engines. By-pass valves are not incorporated in oil coolers fitted to naturally aspirated engines.

Oil Circulation

The lubricating oil pump draws oil through the suction pipe and strainer to an oil cooler, cooled by water from the engine cooling system. Oil coolers are not always fitted to naturally aspirated engines. From the oil cooler, oil passes through a full flow filter to the main pressure rail drilled the length of the cylinder block.

Drillings in the crankcase webs feed oil from the main gallery to the main bearings and drillings in the crankshaft carry oil to the big-end bearings. Through drillings in Nos. 1, 3, 5 and 7 crankcase webs, oil passes from the main bearings to lubricate the camshaft bearings.

No. 2 camshaft bearing supplies a controlled feed of oil to the rocker shaft assembly which escapes through a small bleed hole in each rocker lever to lubricate the valves and springs.

With most turbocharged engines, the pistons are cooled by lubricating oil being sprayed on their undersides by piston cooling jets.

Pistons fitted to naturally aspirated engines are not cooled and cooling jets are not fitted.

The feed for the piston cooling jets is controlled by a two stage pressure relief valve situated after the oil cooler and comes into operation at a specified pressure after oil is flowing freely to the main working parts of the engine.

Lubrication for the timing gears is taken from the oil passages connecting the pressure rail with the front main bearing and auxiliary drive.

The two idler gear hubs intersect these drillings and oil is passed through the hubs to radial drillings in the idler gears to lubricate the teeth of the gear train.

The auxiliary drive shaft bearings are lubricated by a drilling from the pressure rail to the front auxiliary drive shaft bearing. The oil then passes around a groove in the bearing journal and through a further drilling along the outer side of the auxiliary drive housing to the rear auxiliary drive shaft bearing.

Lubricant for the upper fuel pump bearing is also taken from this drilling.

Also connected with the outer drilling is a small spray tube, which directs oil onto the wormwheel and wormgear.

Oil pressure is controlled by a pressure relief valve that returns excess oil to the sump.

The filter is provided with a by-pass facility in the event of blockage.

Oil coolers fitted to naturally aspirated engines do not have by-pass valves.

To Remove Sump

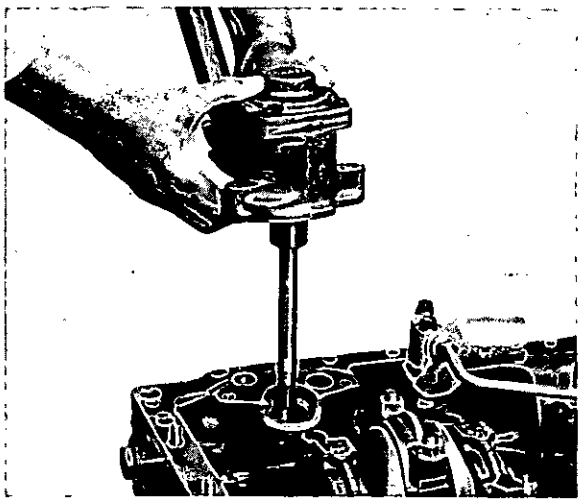
Lower the sump by releasing all flange setscrews and nuts.

To Replace Sump

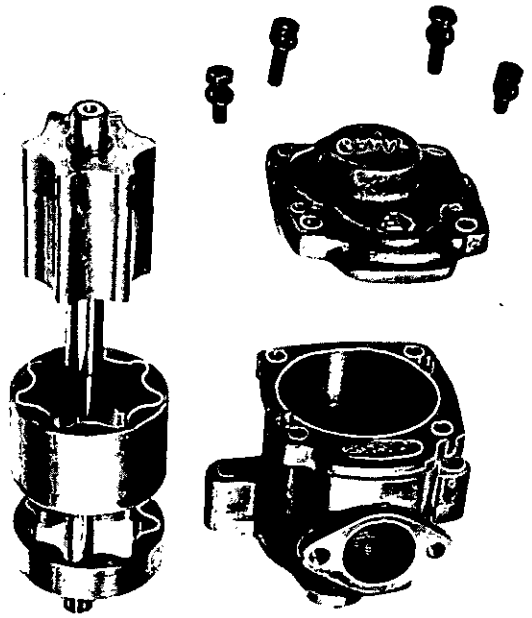
Place the sump in position and secure by fastening the nuts on the four studs located in the bridge pieces.

The securing setscrews can now be inserted.

Tighten the setscrews and nuts to a torque of 15lbfft (2,1kgfm) or 20Nm.



L.2



L.3

Oil Strainer

The oil strainer is part of the oil pump suction pipe. There is no periodic servicing on this strainer but it should be cleaned whenever the sump is removed.

To Remove Oil Pump

Remove the sump and then the setscrews securing the oil pump to cylinder block and withdraw the oil pump, see Fig. L.2.

To Dismantle Oil Pump, see Fig. L.3

Remove the suction pipe and bottom cover of the oil pump.

The shaft, inner and outer rotors can now be removed.

Inspection of Oil Pump

The inner rotor may have 4 or 6 lobes and the outer rotor 5 or 7 lobes.

Inspect the rotors for cracks or scores.

Install the drive and driven rotors in the pump body. The two sections of the outer rotor can be fitted in any order.

Check clearances given on Page B9, between inner and outer rotors, see Fig. L.4, rotor end float, see Fig. L.5, and clearance between outer rotor and pump body, see Fig. L.6.

These clearances are applicable to a new pump and are to be used as a guide.

If the pump is faulty, it must be replaced as a complete unit as parts are not supplied individually.

To Re-assemble and Refit Oil Pump

With the inner and outer rotors fitted into the pump body, refit the end cover with the locating dowels in position and with the joint faces smeared with a suitable jointing compound.

Prime the pump with clean lubricating oil.

The oil pump assembly and joint can now be fitted into its location in the cylinder block and secured with two setscrews and washers.

Refit the suction pipe and strainer.

Replace the sump, and refill with oil to an approved grade.

To Remove and Dismantle the Pressure Relief Valve Assembly see Fig. L.7

Remove the sump and then the pipe from valve to the cylinder block (T6.3544 only).

Release the two securing setscrews and remove the valve.

Remove the circlip which will enable the spring seat, spring and plunger to be withdrawn from the valve bore.

To Assemble and Refit the Pressure Relief Valve Assembly

Replace the plunger, spring and spring seat in the valve bore and refit the circlip.

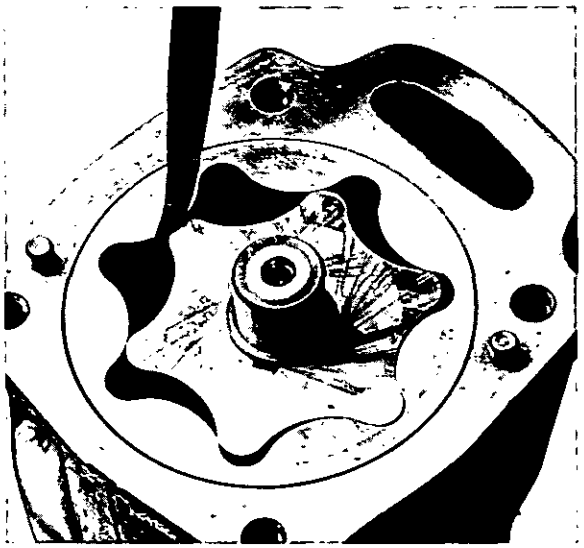
Using a new joint, refit the valve assembly to the cylinder block.

Refit pipe from valve to the cylinder block. (T6.3544 only).

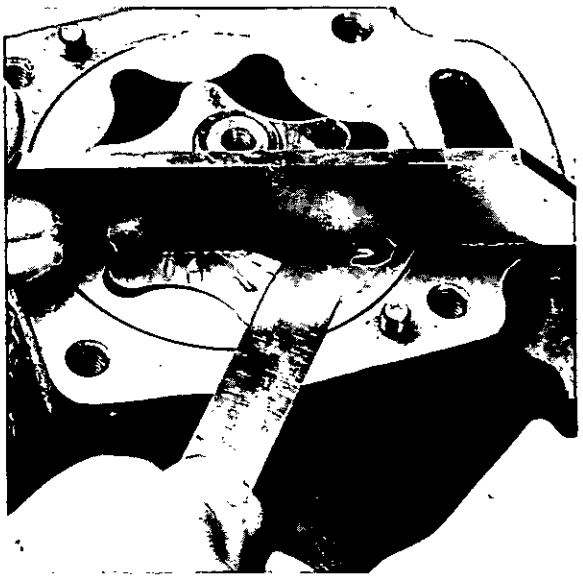
With turbocharged engines, the first blow off stage to feed the piston cooling jets should reach a steady flow at 30/37lbf/in² (2,11/2,60kgf/cm²) or 207/255kN/m², relief valve flow should commence at 50/60lbf/in² (3,52/4,22kgf/cm²) or 343/414kN/m².

With naturally aspirated engines, there is only one blow off stage, when the relief valve flow should commence at 50/60lbf/in² (3,52/4,22kgf/cm²) or 343/414kN/m².

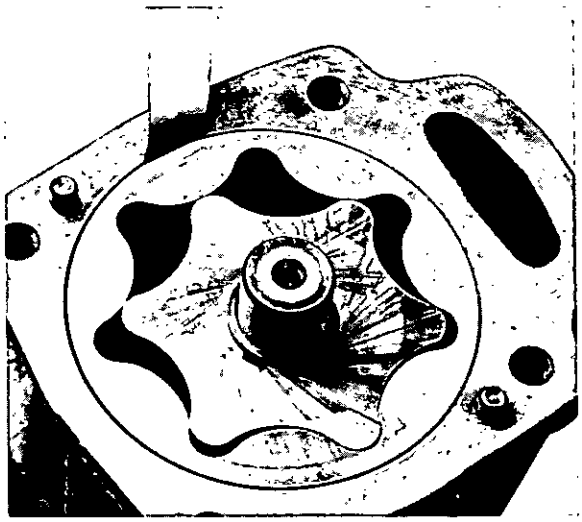
Refit the sump and fill with lubricating oil to an approved grade.



L.4



L.5



L.6

Oil Coolers

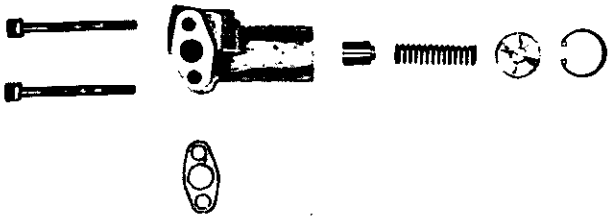
Oil coolers are fitted to turbocharged engines and some naturally aspirated engines.

Four different types of cooler are utilised. For turbocharged engines having the cooler on the left hand side of the engine, see Figs. L.8 and L.9.

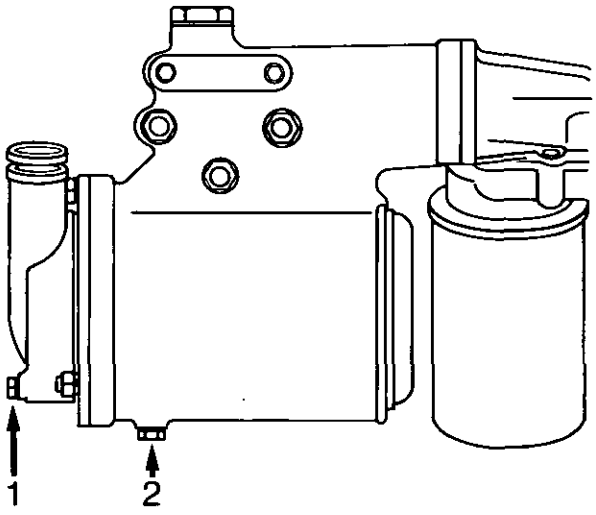
The oil cooler fitted to the right hand side of turbocharged engines is shown in Fig. L.10. This cooler has two filter canisters fitted on the top of the cooler and the cooler incorporates the oil pressure relief valve.

Where an oil cooler is fitted to the left hand side of naturally aspirated engines, this is shown in Fig. L.11, and where fitted to the right hand side of naturally aspirated engines, then this is shown in Fig. L.12.

Oil passes through the cooler and is cooled by water flowing through the tubes. A valve is incorporated into the headcasting which allows oil to by-pass the cooler in the event of a restriction, where the oil cooler is fitted to the left hand side of turbocharged engines. Oil coolers fitted to the right hand of turbocharged engines or either side of naturally aspirated engines do not have by-pass valves.



L.7



L.8

1. Coolant Drain Plug
2. Lubricating Oil Drain Plug

To Remove Oil Cooler

Drain the cooling system also the coolant from the cooler by removing the drain plug. Drain the lubricating oil from the cooler by removing the oil drain plug. Disconnect the cooler inlet and outlet connections.

Remove the oil filter assembly (where fitted) or canisters from the cooler casting.

Release the five setscrews securing the cooler to the adaptor or cylinder block and remove the cooler.

To Dismantle Oil Cooler

Turbocharged Engines—Left Hand Mounting
(see Figs. L.8 and L.9)

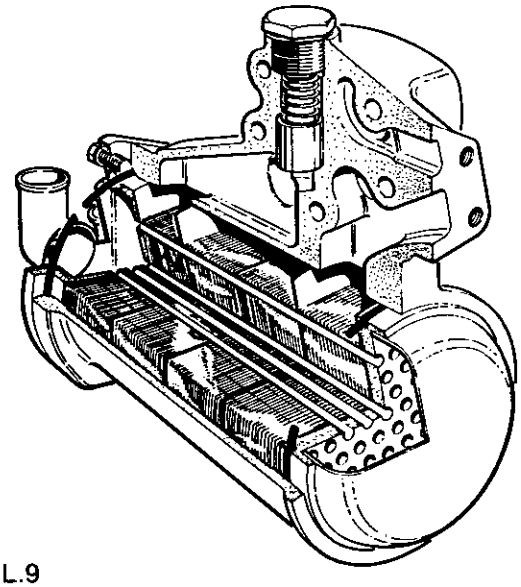
Remove three nuts and washers securing the flanged tube stack to the cooler body.

Withdraw the tube stack from out of the cooler body.

Remove the "O" rings.

Remove plug and washer from the cooler bypass valve.

Withdraw spring and piston.



L.9

To Re-assemble Oil Cooler

Turbocharged Engines — Left Hand Mounting

New "O" rings must always be used.

Lightly oil the rings and their respective locations.

The first "O" ring should then be fitted to the flanged end of the tube stack, by placing it over the opposite end and sliding it over the full length of the stack until its location is reached.

The second "O" ring may now be fitted into the groove on the unported end of the tube stack.

Carefully insert the tube stack into the cooler body until the flange locates onto the studs and secure with spring washers and nuts.

The bypass valve assembly may now be refitted into the headcasting.

Refit the water and oil drain plugs.

To Dismantle Oil Cooler

Turbocharged Engines— Right Hand Mounting
(see Fig. L.10)

Remove rear clamp plate.

Remove rear "O" ring.

Unscrew three nuts at front of cooler and withdraw tube stack out of front of cooler body complete with front plate which is integral with tube stack.

Remove front "O" ring.

To remove oil pressure relief valve, remove end plate and pipe (which relieves oil to crankcase) and withdraw spring and plunger.

To re-assemble cooler, reverse order of dismantling. New "O" rings should be used which should be lightly oiled before fitting.

To Dismantle Oil Cooler

Naturally Aspirated Engines— Left Hand Mounting
(see Fig. L.11)

Remove screw complete with locking tab at each end of the cooler.

Slide the tube stack to the left and remove the right hand side "O" ring.

Remove the tube stack to the right and remove the left hand side "O" ring.

To re-assemble cooler, reverse order of dismantling. New "O" rings should be used which should be lightly oiled before fitting.

A new oil cooler assembly was introduced from engine number TW---- U747552M. The latest oil cooler is fitted to the left side of both naturally aspirated and turbocharged engines. The latest oil coolers have a new tube stack fitted that has an oil seal instead of an "O" ring, see Fig. L. 11A. The latest tube stack and oil seal assembly is interchangeable with the earlier tube stack.

To dismantle the latest oil cooler

Remove the setscrew and the lock plate from each end of the oil cooler.

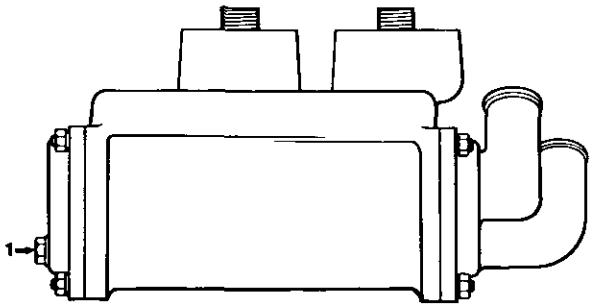
Push on the coolant drain plug (or tap) end of the tube stack to remove it through the coolant connection end of the cooler. Remove and discard the oil seal on the tube stack and the "O" rings at each end of the cooler body.

To assemble the latest oil cooler

Fit a new oil seal to the tube stack. Ensure that the seal is fitted to the correct baffle and that the lip is toward the coolant drain plug (or tap), see Fig. L.11A. Ensure that the lip of the seal is not damaged.

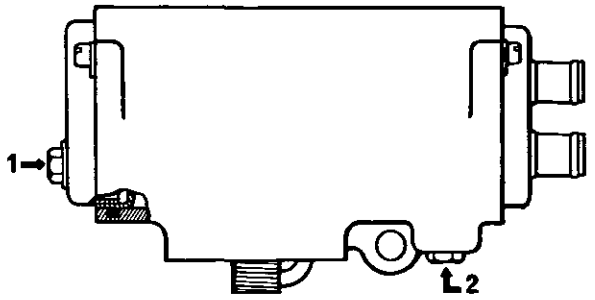
Lightly lubricate the new "O" rings with clean engine oil and fit them in their recesses at each end of the cooler body.

Fit the lock plate and the setscrew at the coolant connection end of the cooler. This will prevent damage to the lip of the oil seal if the tube stack is pushed in too far, as the tube stack must not be pulled back. Lightly lubricate the oil seal with clean engine oil. Push the tube stack into the cooler body until the end of the tube stack touches the lock plate; do not damage the lock plate. Ensure that the coolant connection end of the tube stack enters the cooler body at the coolant drain plug (or tap) end of the cooler. Ensure that the coolant drain plug (or tap) is at the bottom and the coolant connections are vertical when the tube is fitted. Fit the lock plate and the setscrew at the other end of the cooler and tighten the setscrews of both lock plates.



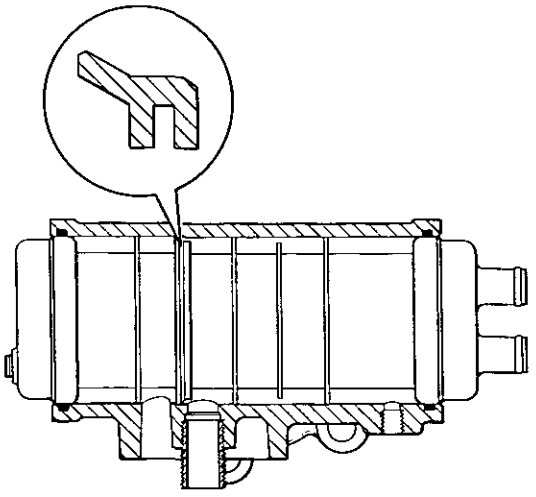
L.10

1. Coolant Drain Plug



L.11

1. Coolant Drain Plug
2. Lubricating Oil Drain Plug



L. 11A

To Dismantle Oil Cooler

Naturally Aspirated Engines — Right Hand Mounting
(see Fig. L.12)

Remove single screw and locking tab at top of cooler.

Remove three screws at bottom of cooler and remove clamp plate.

Push tube stack down and remove top "O" ring.

Remove tube stack out of top of cooler body and remove bottom "O" ring.

To re-assemble cooler, reverse the order of dismantling. New "O" rings should be used, these being lightly oiled before fitting.

With this cooler, where the coolant feed is taken from the side of the cylinder block, if it is necessary to replace the adaptor which is a push fit in the block, then it must be fitted using Loctite Retaining Compound Grade 75.

To Test an Oil Cooler

Suitable adaptors, incorporating pressure connections must be fabricated to blank off oil ports and water connections.

To test water side
Fill water side with water and immerse the unit in water, ensuring absence of trapped air.

Pressurise water side with air at a pressure of 30lbf/in² (2,11kgf/cm²) or 207kN/m² and examine for leaks.

To test oil side
With water side filled with water and unit immersed in water, pressurise oil side at a pressure of 90lbf/in² (6,33kgf/cm²) or 620kN/m² for turbocharged engines or 60lbf/in² (4,22kgf/cm²) or 414kN/m² for naturally aspirated engines. Test for two minutes and examine for leaks.

The tube stack should be rejected if bubbles persist from the water inlet or outlet connections.

Adaptor — Cooler to Cylinder Block
(where fitted)

The adaptor may be released by removing the securing setscrew, see Fig. L.13.

When refitting use a new joint and suitable sealing compound and secure with setscrew, plain washer and spring washer.

To Refit Oil Cooler

The joint, lubricating oil cooler to adaptor block, must be fastened to the oil cooler flange with an approved adhesive; "Bostik" clear, "Evostik" or Dunlop SN1901.

There must not be any sealant between the joint and the adaptor block. This side of the joint must be fitted dry.

Refit the oil cooler to adaptor or cylinder block and secure with five setscrews, plain and spring washers.

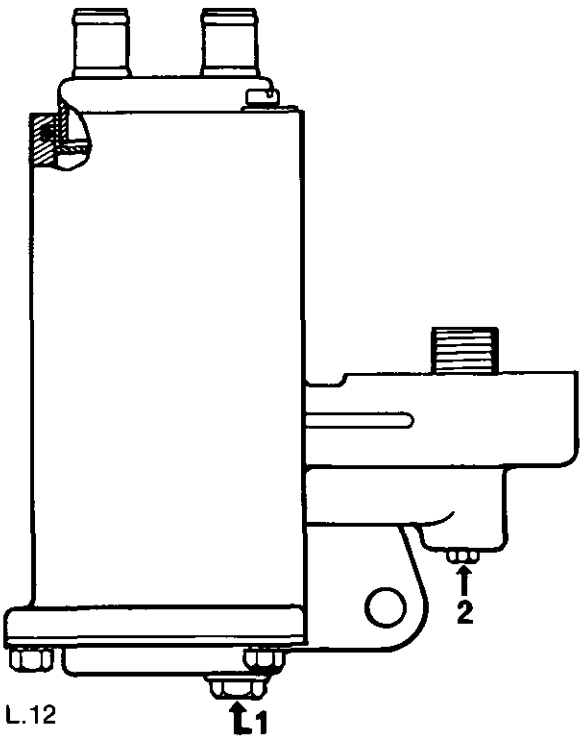
Refit the oil filter with four setscrews and spring washers or refit filter canisters.

Reconnect the cooler inlet and outlet connections.

Ensuring that the water and oil drain plugs are fitted, refill the cooling system.

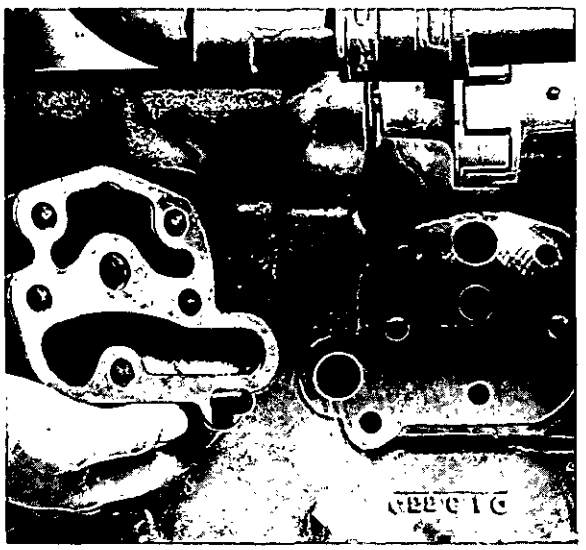
Start the engine, but do not speed the engine until oil pressure is achieved.

Check for oil and water leaks.



L.12

1. Coolant Drain Plug
2. Lubricating Oil Drain Plug



L.13

To Renew Lubricating Oil Filter Element

Unscrew filter canister from filter head casting (see Fig. L.14).

Check that threaded adaptor is secure in head casting.

Discard old canister.

Clean filter head.

Prime the new canister with lubricating oil allowing time for the oil to filter through the element.

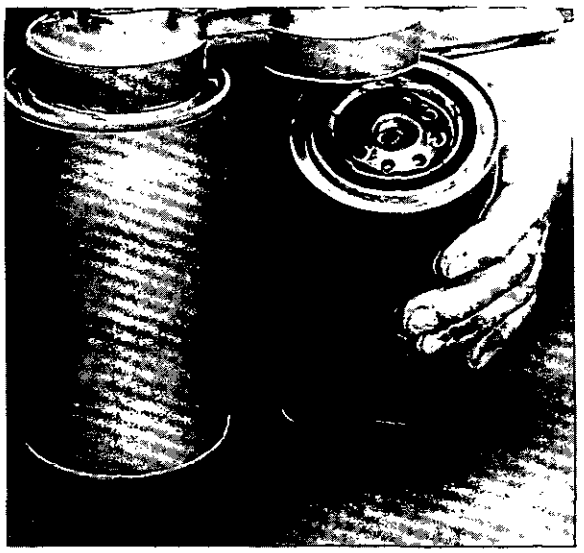
Using clean engine oil, liberally oil the top seal of the replacement canister.

Screw replacement canister onto filter head until the seal just touches the head and then tighten by hand as per the instructions on canister. Where a tool is available, tighten to 15lbfft (2,07kgfm) or 20Nm.

Run engine and check for leaks.

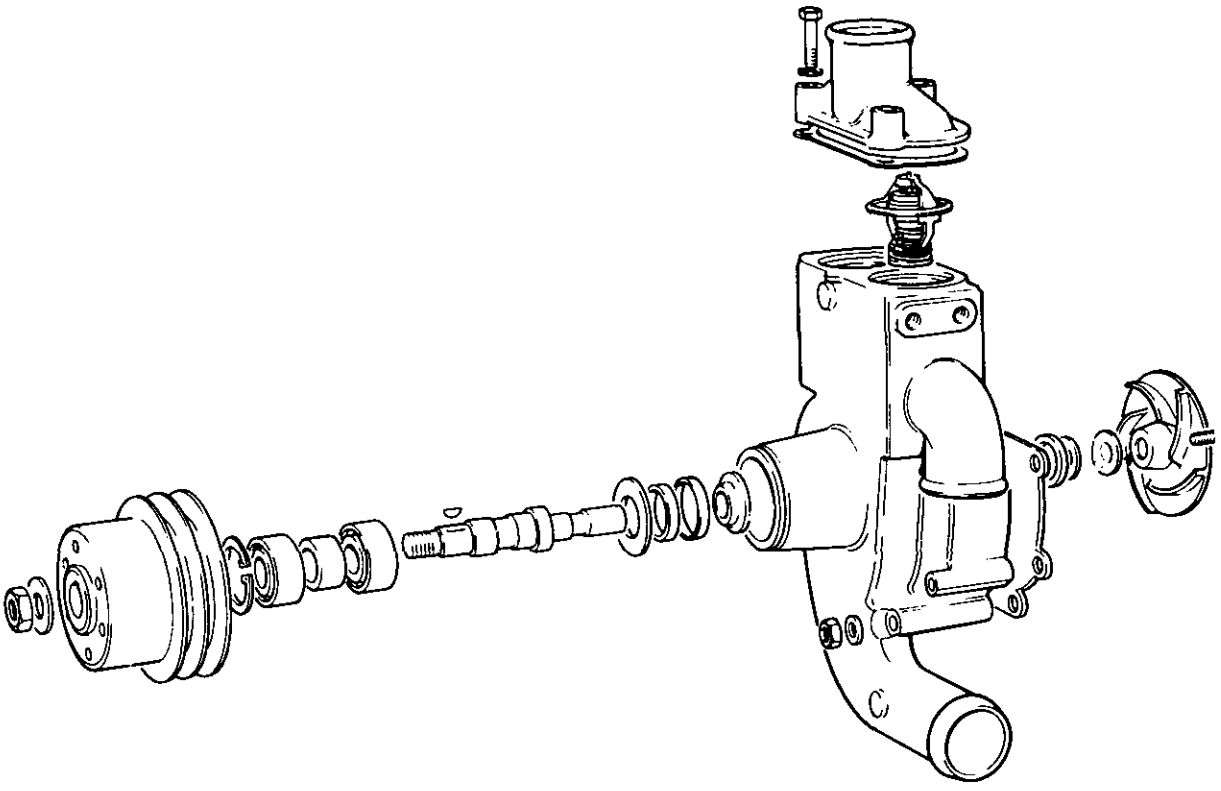
Where twin filters are fitted, both canisters should be replaced at the same time.

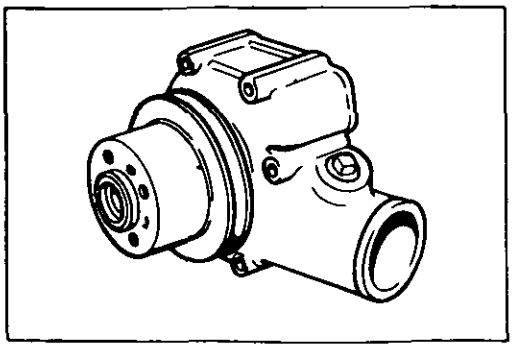
Note: The oil filter canisters have internal valves to prevent drain back and a special tube stack, so always ensure that the correct replacement is fitted.



L.14

SECTION M
Cooling System





Circulation of the coolant is assisted by an impeller type water pump mounted on the front of the cylinder block, driven by twin belts from the crankshaft pulley.

From the twin volute water pump, the coolant flows from one outlet into the cylinder block and up into the cylinder head. Coolant from the other outlet is piped into the oil cooler where it circulates and is then piped into the rear of the cylinder block. It then flows up into the cylinder head.

Where the oil cooler is fitted to the left hand side of naturally aspirated engines, the coolant feed is sometimes taken from the side of the cylinder block and in this case, the adaptor which is a push fit in the block must be fitted with Loctite Retaining Compound Grade 75.

Where no engine oil cooler is fitted, then all the coolant flows into the front of the cylinder block.

The coolant exits from the front of the cylinder head into a twin thermostat chamber, and when the thermostats are in the open position, allows the coolant to pass into the radiator.

Until the coolant reaches a specified temperature, however, the thermostats will be in a closed position denying access to the radiator and the coolant will flow into a by-pass and back into the water pump.

Fan Belts

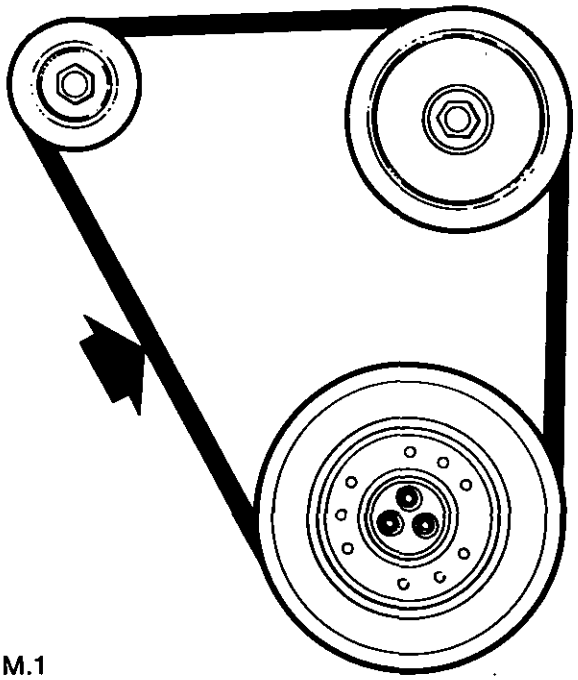
Twin belts are used to drive the generator and water pump.

The fan may be mounted on either the water pump pulley or direct to the crankshaft pulley.

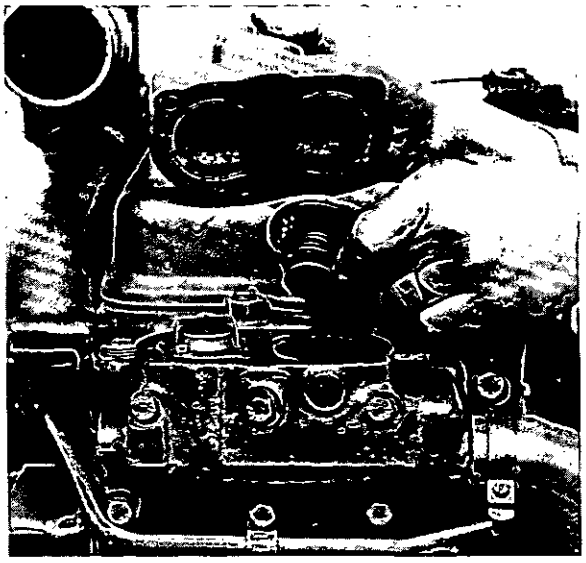
New belts should be fitted in pairs and the tension checked after a short period of running to allow for the initial stretch.

Belt adjustment is obtained by loosening the generator mounting bolt and altering the position of the generator on its mounting link.

The tension should be such that a pressure applied by the thumb on the longest unsupported stretch of belt should depress it approximately ⅜in (10mm), see Fig. M.1.



M.1



M.2

To Drain the Cooling System

Ensure that the vehicle or machine is on level ground.

Remove the radiator filler cap.

Remove the drain plug from the side of the cylinder block to drain the engine. Ensure that the drain hole does not have any restriction.

Open the tap or remove the drain plug at the bottom of the radiator to drain the radiator. If a tap or plug is not fitted to the radiator, disconnect the bottom radiator hose.

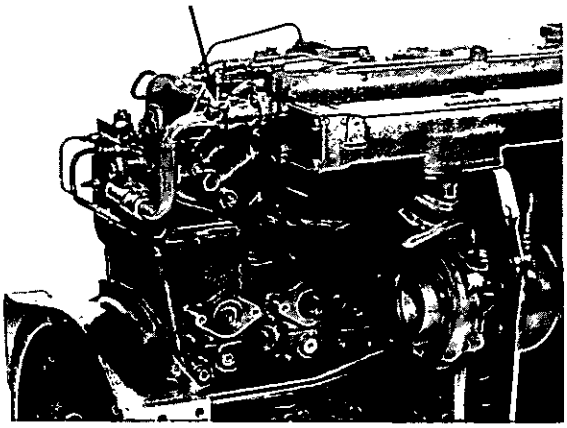
If an oil cooler is fitted, drain the coolant from it by removing the drain plug from the end cap of the cooler.

Where necessary, flush the system with clean water.

Fit the drain plugs and radiator cap. Where necessary, close the radiator tap or connect the radiator hose.

If the engine is to be left drained during freezing conditions, remove one of the coolant hose connections at the cooler and insert 0.5 U.K. pints (250ml) of undiluted antifreeze into the cooler.

NOTE:
When draining or filling the cooling system of a T6.3544CC engine (integral induction manifold and air charge cooler) the vent plug on the outlet connection of the cooler should be removed (see Fig. M.3) and the plug replaced when the system has been filled.



M.3

To Remove and Refit Thermostats

The water outlet connection forms the top half of the thermostat housing.

Drain the cooling system and disconnect the top radiator hose, remove three setscrews securing the water outlet connection and remove, see Fig. M.2.

The thermostats can now be withdrawn from the housing.

When replacing, ensure that the jiggle pins are free to move.

Ensure that only by-pass thermostats are fitted.

Refit the water outlet connection correctly placing a new joint, connect the top water hose and refill the cooling system. Check for leaks.

To Test the Thermostats

Suspend the thermostats in water and heat gradually.

Check with a thermometer that the thermostat starts to open and is fully open at the temperatures given on page B10. The nominal temperature of valve operation is stamped on the bottom of the thermostat.

The minimum valve lift when fully open is 0.358in (9.1mm).

To Remove Water Pump

Remove the drive belts.

Drain the cooling system and disconnect the hoses.

The water pump securing setscrews and nut can now be released and the water pump removed, see Fig. M.4.

To Dismantle Water Pump

Remove the self locking nut and plain washer securing the water pump pulley and withdraw the pulley from the shaft, see Fig. M.5.

Press the shaft, complete with impeller, out of the body from the front.

Press the impeller from the shaft and remove the rear seal, counterface and flinger. Latest pumps have one-piece seals with an integral counterface and a flinger is not fitted.

Remove the bearing retaining circlip from water pump body and press out the two bearings and distance piece.

Where applicable, the flange retainer and front seal can now be withdrawn from the body. The front felt seal assembly is not fitted to latest pumps and can be discarded provided that the latest one-piece rear seal, shaft and longer bearing distance piece are to be fitted.

To Re-assemble Water Pump, Fig. M.6

If the latest one-piece seal with an integral counterface is to be fitted to an earlier pump, the felt seal assembly and the flinger can be discarded. A new shaft and a longer bearing distance piece (to allow for the removal of the felt seal flange) will be supplied with the new seal.

Press the two bearings onto the shaft with the distance piece in between, ensuring that the shielded face of each bearing faces outwards.

Where applicable, fit the front seal assembly — retainer with felt seal inside — into its location, with felt face towards the front of the pump.

Grease the bearings and half fill the space betwen the two bearings with high melting point grease. Where applicable, fit the flange over the impeller end of the shaft with the dished face to the bearings and press the complete shaft and bearing assembly into the pump body from the pulley end.

Fit the circlip into its recess in the pump body immediately forward of the front bearing.

Where applicable, slide the rubber flinger over the impeller end of the shaft until the flat face butts against the bearing retaining flange.

If the rear seal has a brass casing, coat its locating surface with jointing compound. Fit the rear seal over the impeller end of the shaft and press onto its flange location in the pump body with the contact face outwards.

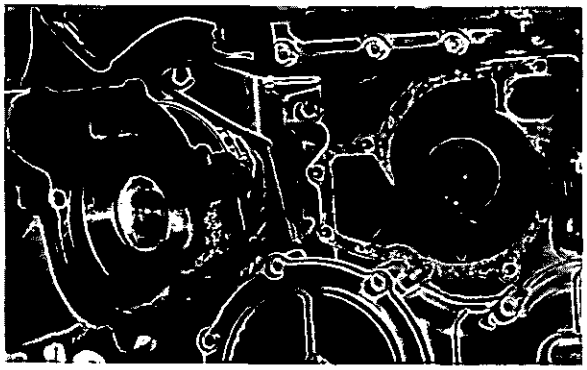
Rotate the shaft and check for undue resistance.

Where applicable, fit the ceramic counterface ensuring that the ceramic face bears against the carbon face of the spring loaded seal.

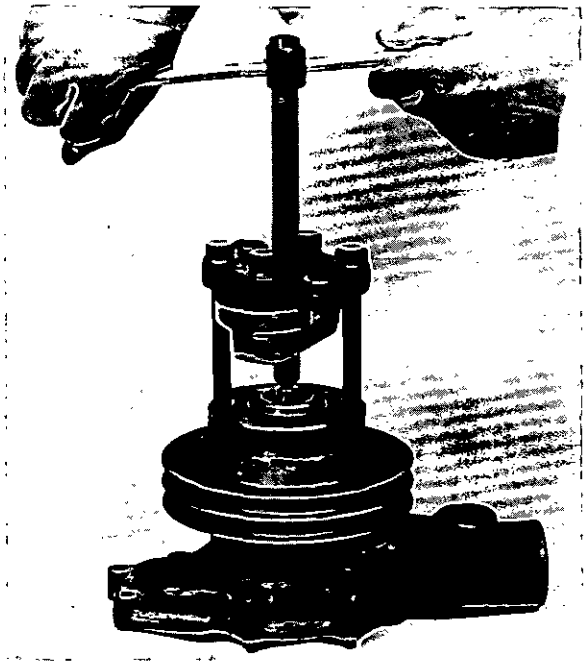
Before fitting the pulley, insert the captive setscrew and washer in its respective hole, see Fig.M.6.

Fit pulley driving key and press on pulley making sure there is no rearward movement of shaft.

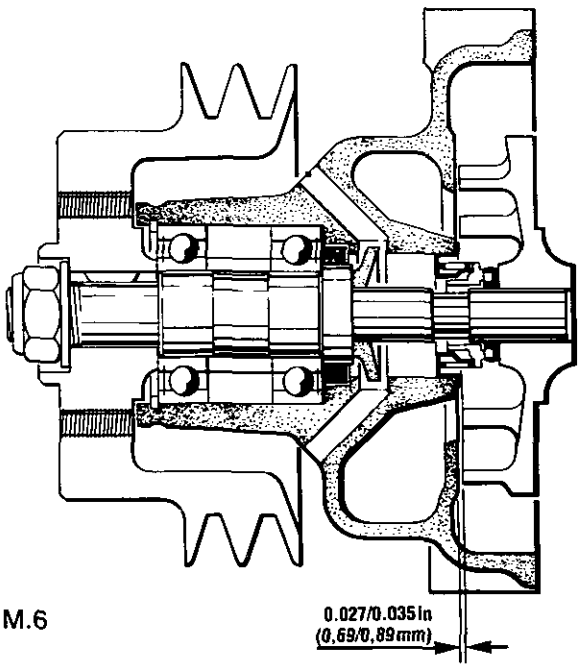
Press impeller onto shaft until a clearance is obtained between impeller vanes and pump body 0.027/0.035in (0,69/0,89mm) — see Fig. M.6.



M.4



M.5



M.6

Fit plain washer, spring washers and pulley securing nut and tighten to a torque of 60lbfft (8,30kgfm) or 82Nm. Spin the pump pulley to ensure freedom of movement.

A new water seal has been fitted to the latest water pumps. The seal has a brass body and is interchangeable with the earlier seal.

It is important that the seal is not contaminated by oil or grease and, if it is held in the hand, it should be held by the edge of the flange.

Do not damage the ring of green sealant applied to the body of the water seal just behind the flange.

To fit the new water seal

To press the seal onto the shaft, a tool can be made of any suitable material to the dimensions shown in Fig.M.6A. The tool will not allow axial distortion of the inner part of the seal while the seal is pressed onto the shaft. The tool is for use with the new seal, but it can also be used for the earlier seal. The tool is a looser fit on the earlier seal, so ensure that the hole in the tool is aligned with the shaft as the seal is fitted.

Support the pulley end of the shaft. With the ring of sealant on the body of the seal towards the bearings, use the tool to press the seal onto the shaft. Ensure that the seal is pressed onto the shaft until the bottom of the seal flange is in complete contact with the pump body.

Ceramic Seals

If an engine is run without coolant in the water pump, the heat build-up between the carbon seal and the ceramic counter face is very rapid, resulting in the cracking of the ceramic.

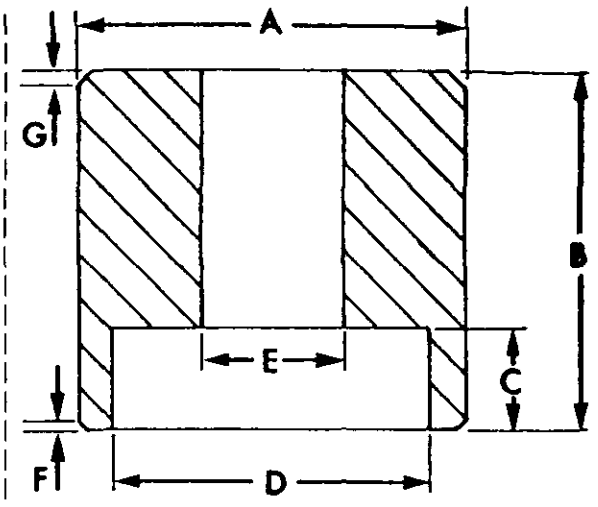
This can cause a misunderstanding that the leakage of the water from the pump is due to the incorrect assembly of the sealing arrangement in the water pump.

To Refit Water Pump

Using a new joint, refit the water pump, securing with setscrews, nuts and spring washers to a torque of 20lbfft (2,77kgfm) or 27Nm.

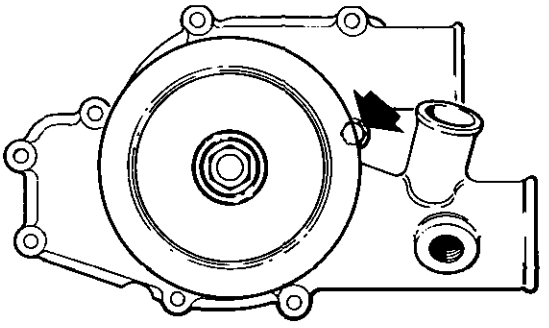
Reconnect the hoses, fill the system with coolant.

Refit the drive belts, start the engine and check for leaks.



A 1.73in (44,0mm)
B 1.57in (40,0mm)
C 0.44in (11,2mm)
D 1.41in (35,8mm)
E 0.63in (16,1mm)
F 0.04in (1,0mm) at 45°
G 0.08in (2,0mm) at 45°

M.6A



M.7

Piston Cooling Jets, see Fig. M.8

Piston cooling jets are fitted to most turbocharged engines only. They are not fitted to normally aspirated engines.

Cooled lubricating oil is directed, by means of spray jets situated at the base of each cylinder liner, onto the underside of each piston crown where it circulates, dispersing heat from the combustion area. The oil then drains back into the sump.

Oil is carried to the spray jets by means of a pipe from the *relief valve to an oil gallery in the cylinder block which* connects with an auxiliary oil pressure rail drilled the length of the cylinder block above the camshaft chamber.

This pressure rail is tapped in six places to accommodate the dowelled piston spray jet block.

The removal and refitting of the pressure relief valve is dealt with in the Lubricating Section L, on Page L4.

To Remove Piston Cooling Jets

Drain the lubricating oil and remove sump, see Page L3.

Remove the banjo bolt securing the jet body to the cylinder block.

The piston jet assembly can now be removed, see Fig. M.9.

To Refit Piston Cooling Jet

The body should be fitted to the cylinder block making sure that the dowel locates correctly.

Insert the banjo bolt with washer fitted and tighten to a torque of 20lbfft (2,77kgfm) or 27Nm. Refit the sump, and fill with lubricating oil of an approved grade.

Nozzle Positioning

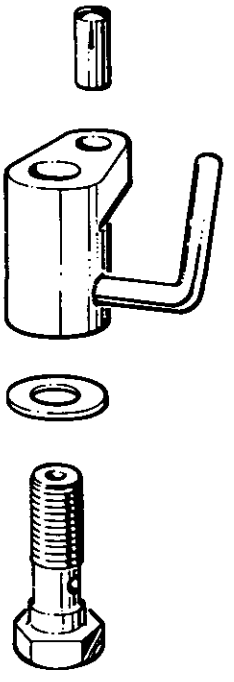
In the event of a nozzle of a piston cooling jet becoming misaligned, it is important that the condition is rectified and the illustrations in Figs. M.10 and M.11 will show how this may be accomplished.

With a piston removed, insert a piece of 3/32in (2,38mm), rod (such as welding rod) into the jet nozzle so that it protrudes above the top of the cylinder bore.

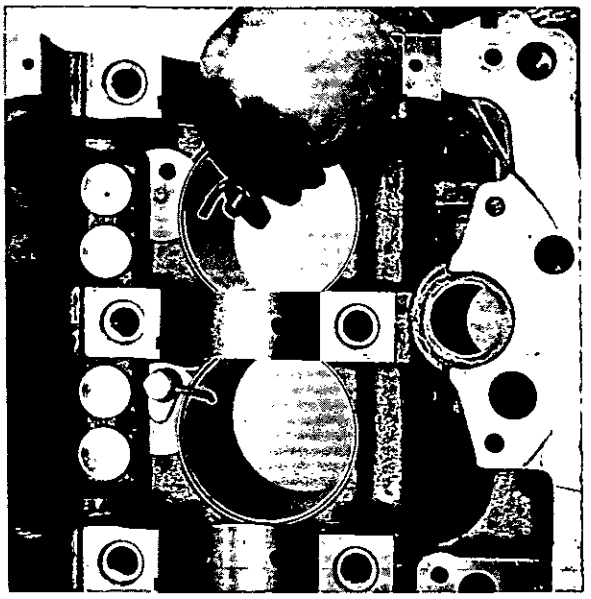
Fig. M.10 shows the dimensions taken on the top face of the cylinder block and it will be seen that the measurements of 1.781in (45,24mm) and 0.641in (16,28mm) are taken from two sides of the liner bore as illustrated.

The rod should project at a point where the lines drawn from two measurements intersect.

Fig. M.11 illustrates how the correct nozzle angle may be achieved by the use of rules.



M.8



M.9

Charge cooler (integral air/water)

No preventive maintenance is necessary on the intercooler as the air passing over the cooling fins is clean. If the turbocharger oiler seals leak, this may necessitate the removal and cleaning of the intercooler. The intercooler is a sealed unit and no repairs are possible except perhaps by specialists.

The charge cooler should be removed and fitted with the inlet manifold attached and the manifold, intercooler and top cover treated as a complete assembly. In the case of tractors this assembly will have to be removed before the exhaust manifold can be removed.

The air charge cooler can be removed and dismantled as follows:

Drain coolant system — remove air bleed screw on coolant outlet elbow of charge cooler to ensure that coolant drains from cooler.

Disconnect coolant, air and fuel pipes. Release pipe clips and support brackets.

Remove charge cooler/manifold assembly from engine.

Remove coolant pipe flanges from top cover and manifold. Note "O" ring fitted in groove in flange bore.

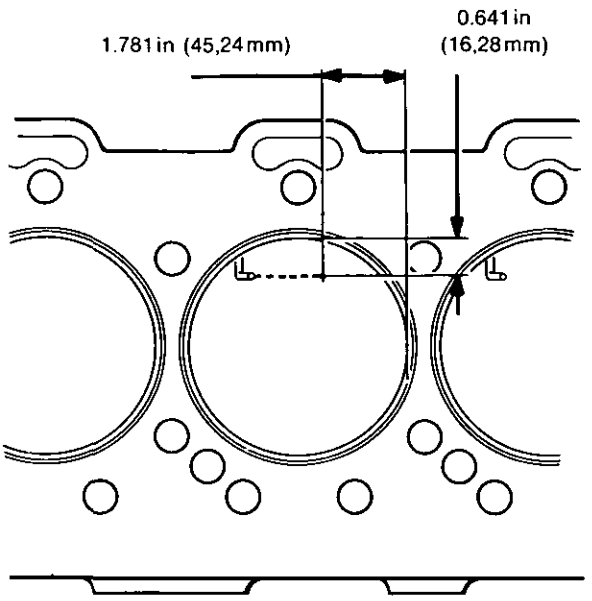
Remove setscrews securing top cover and manifold flanges.

Slide the top cover over the coolant pipe by lifting the *opposite end of the cover to clear the intercooler.*

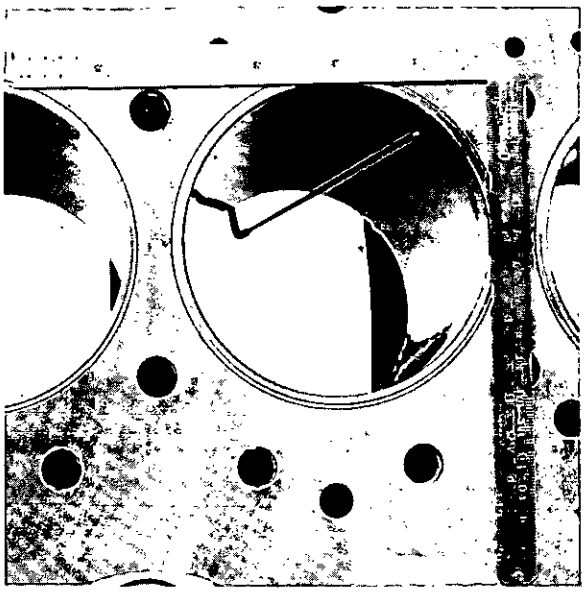
Slide the intercooler out of the manifold by lifting the non-pipe end of the intercooler to clear the manifold.

Reassemble and refit in reverse order. Fit new joints with Hylomar. Remove air bleed screw when filling coolant system — if top of radiator is below intercooler, the system may have to be topped up after a short period of running.

The coolant flow for the charge cooler is from the water pump outlet — through the intercooler — back to the water pump inlet for tractor engines or the rear of the cylinder head for combine engines.

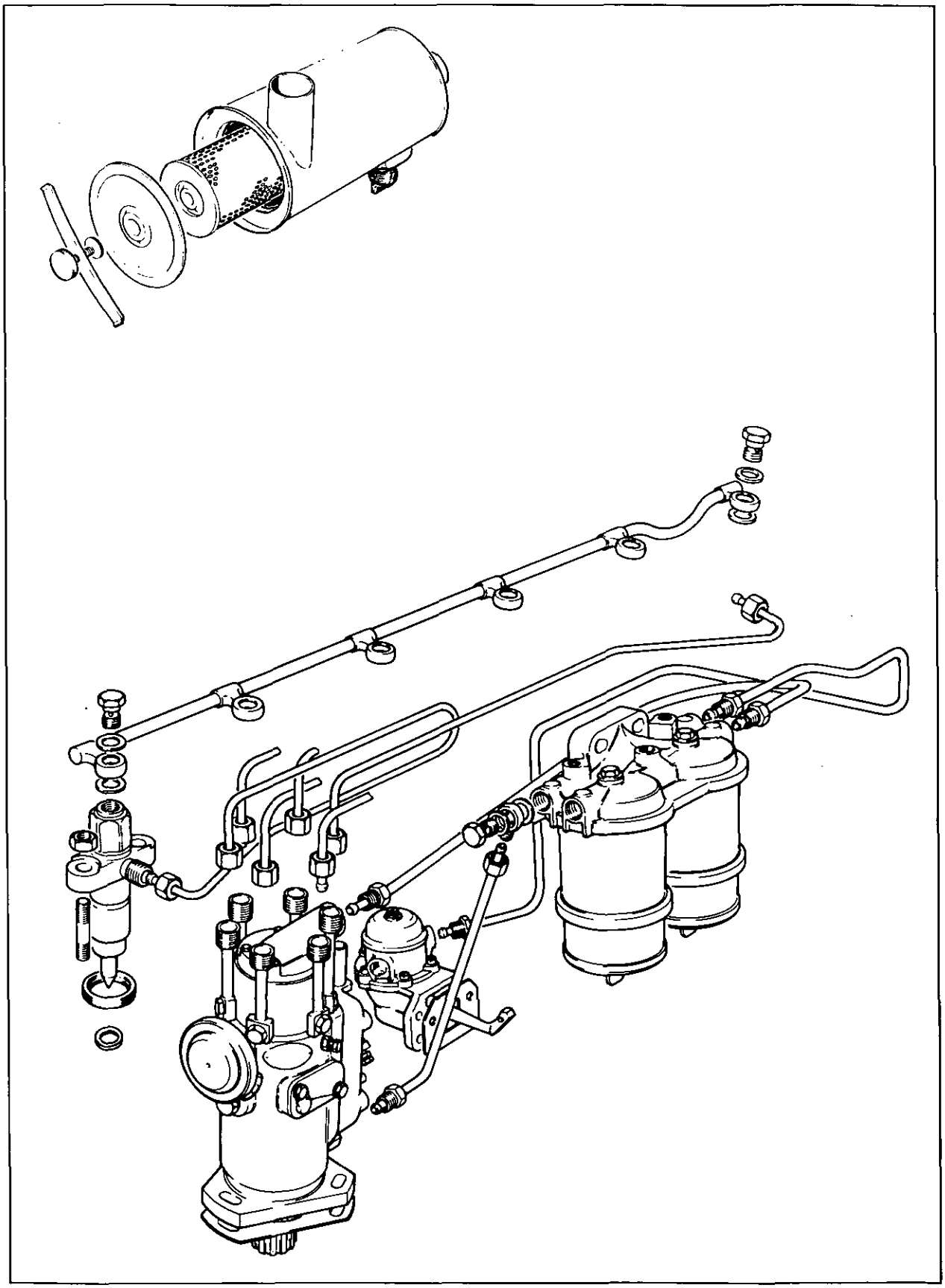


M.10



M.11

SECTION N
Air Filters and Fuel System



Air Cleaners

Operating conditions play an important part in deciding how frequently it is necessary to service the air cleaner. Where the cleaner has a dust bowl fitted, the amount of dust present in the bowl when removed, will show whether it is being emptied at the correct time for the prevailing conditions. If the dust bowl is allowed to become full, it will reduce the life of the element.

If an automatic dust ejector is fitted, it should be kept clean and the lips of the rubber ejector checked to see that they close, but do not adhere together.

Where a restriction indicator is fitted, this will give a positive indication that the air cleaner element needs attention and eliminates haphazard servicing. If you do not have a restriction indicator fitted, then you should consider having one fitted on the trunking between the air cleaner and turbocharger/induction manifold. A 22in (559mm) water gauge indicator fitted on the cleaner outlet is suitable for the majority of cases. It should be remembered that the indicator does not show the amount of dust present in the dust bowl.

The type of air cleaner fitted to your vehicle or machine depends upon the manufacturer of your equipment. Usually, guidance for the servicing is shown on the body of the air cleaner, but the following advice may also help.

Dry Type Two Stage "Cyclopac", see Fig. N.1

Unclamp the dust bowl, remove the baffle plate and clean out the bowl.

The dust in the bowl must not be allowed to reach within ½in (13mm) of the dust entry slot in baffle. DO NOT USE PETROL (GASOLINE) for cleaning any part of air cleaners.

Release the wing nut and remove filter element.

Dry dust can be removed from the element by blowing back from the clean side of the pleats by using air pressure not exceeding 100 lbf/in² (7 kgf/cm²) or 689 kN/m².

If the element is contaminated by oil and/or soot, it can be cleaned in warm water using a suitable non-foaming detergent as recommended by the air cleaner manufacturer.

Allow, the element to soak for about ten minutes and then agitate. Spray clean water onto the "clean" side of the element rinsing thoroughly and allow to dry, do not use oven heat.

NEVER FIT a wet element as water may be inducted by the engine carrying dust with it.

Examine the element for pin holes, thin areas, or other damage by placing a bright light inside the element.

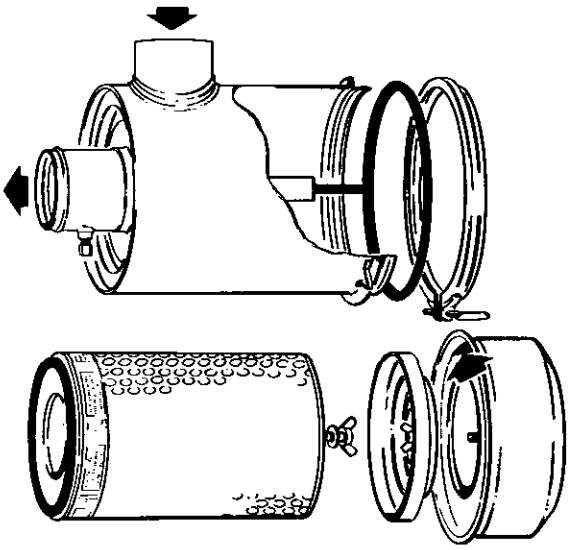
The element should be renewed after six cleanings or once a year, whichever occurs first.

Clean the inside of the filter body and fins, making sure no dirt enters the air filter outlet.

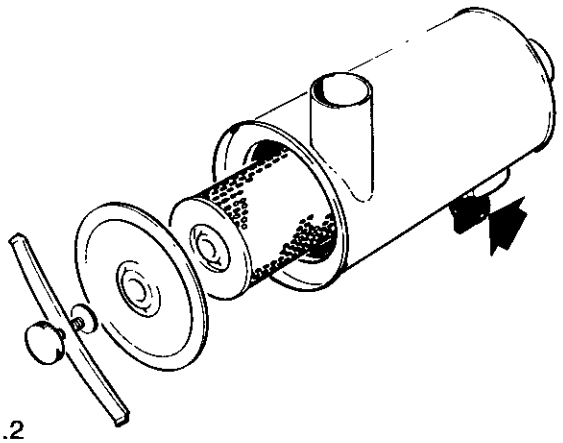
Check all hoses and joints for condition and security.

Re-assemble air cleaner unit.

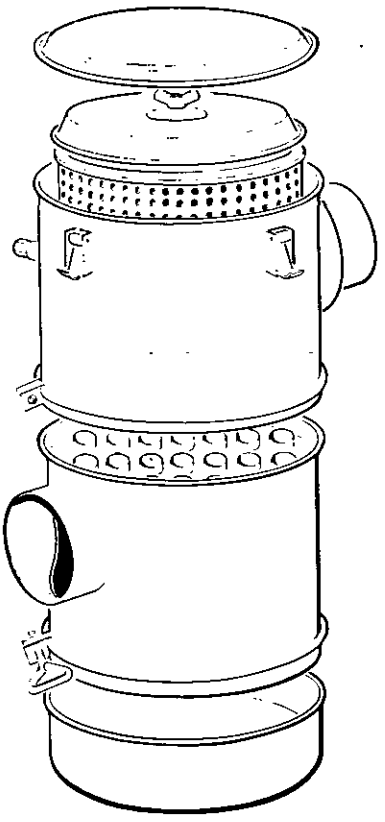
If an automatic dust ejector (vacuator) is fitted, it should be kept clean and the lips of the rubber ejector checked to see that they close but do not adhere together.



N.1



N.2



N.3

Dry Type Two Stage "Cyclone", see Fig. N.2

Unscrew the clamping screw and remove the element retaining strip. Remove the seal plate and element.

If the element is blocked by dry dust, clean by carefully hand tapping the element or by directing low pressure compressed air on to the clean side of the element.

If the element is contaminated by oil or soot, it can be partially restored by washing in a suitable non foaming detergent solution.

After washing, rinse out thoroughly by directing clean water on to the clean air side of the element and allow to dry — do not oven dry. **Never fit a wet element** to the filter as dust may be carried through the element by water.

Inspect the cleaned element by placing a bright light inside and looking through the element. Any thin spots, pin holes or other damage will render the element unfit for further use.

The element should be renewed after six detergent washes or annually, whichever occurs first.

Clean the inside of the filter body and dry thoroughly — do not use petrol (gasoline) for cleaning.

Inspect the joints and hoses and renew where necessary.

Re-assemble the filter ensuring that all joints are leakproof.

Dry Type Two Stage "Duo-Dry", see Fig. N.3

Dust Bowl

Unclamp the dust bowl, empty out the dust and clean the bowl — do not use petrol (gasoline) for cleaning. The dust in the bowl must never be allowed to build up to 1 in (25 mm) of the bottom of the tubes.

Element

Clean the top of the cleaner and then unclip and remove the top cover. Unscrew the wing nut and remove the inner cover and element.

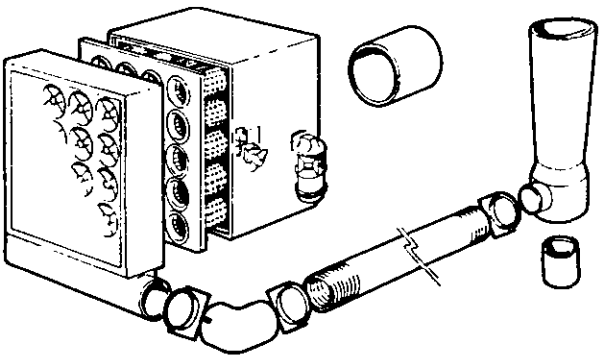
Clean and inspect the element as detailed for the "Cyclopac" cleaner, bearing in mind that the clean side of the element of the "Duo-Dry" cleaner illustrated is the outside of the element.

Clean the inside of the body — do not use petrol. If the tubes are not too dirty, they can be cleaned with a stiff fibre brush but, if heavily contaminated, the tube body should be removed and cleaned with compressed air or warm water not exceeding 150° F (65° C).

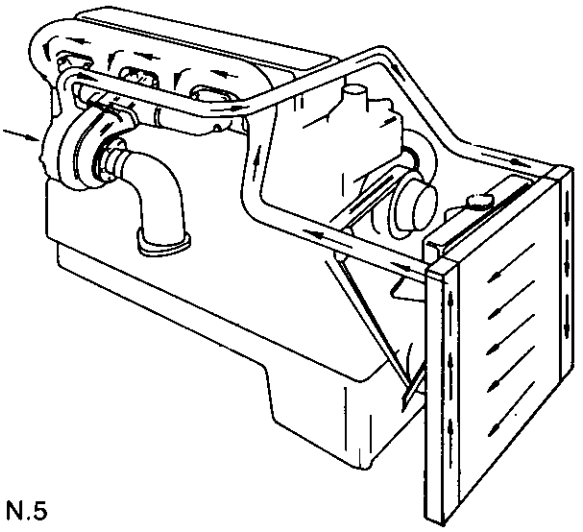
Inspect all joints and hoses and renew where necessary.

Re-assemble the cleaner ensuring that all parts are dry and all joints are leakproof.

If the tube body has been removed, tighten the clamp between it and the upper body before tightening the mounting clamp.



N.4



N.5

Dry Type, Multi-Element "Rotopamic", see Fig. N.4

The elements of this type cleaner should not be cleaned but the complete filter cartridge should be renewed when necessary.

Release the clamps and remove the moisture eliminator or pre-cleaner panel. Clean the openings in the panel of any dust, soot, etc.

Remove the filter cartridge and clean the interior of the cleaner housing— do not use petrol (gasoline).

Fit the new cartridge in position ensuring a positive seal by pressing around the edges of the cartridge — do not press in the centre.

Refit the moisture eliminator or pre-cleaner panel and reclamp in position.

Oil Bath Air Cleaner, see Fig. N.6

To service the oil bath type cleaner, the lid should be removed and the element lifted out.

Drain the oil from out of the container and clean the dirt and sludge from the container using a suitable cleaning fluid.

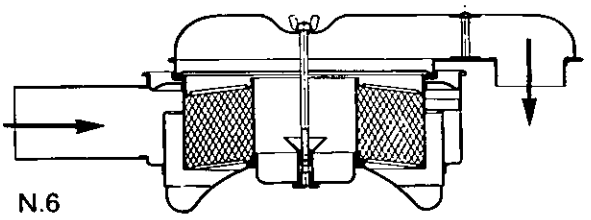
Refill the container with fresh engine lubricating oil, SAE40 grade, to the indicated level.

The element should be cleaned in a bath of Kerosene. *Do not use petrol (gasoline) for cleaning purposes.*

Replace the cleaned element in the container.

Refit the lid, making sure that the lid seats properly on the seal.

Do not exceed the indicated level mark when refilling the oil container, because oil could be drawn into the engine leading to uncontrolled engine speed and excessive engine wear.



N.6

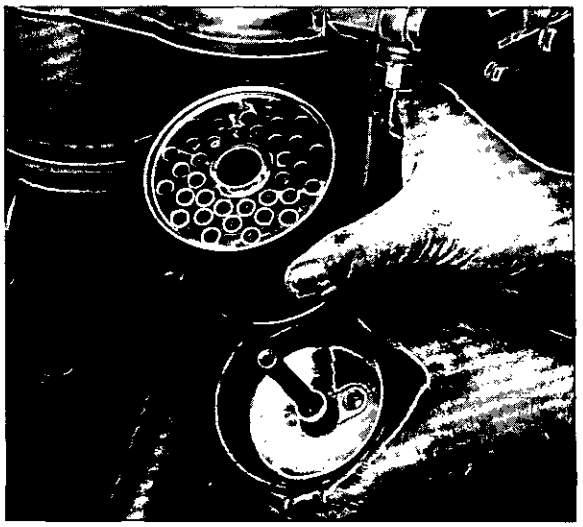
Air Charge Cooling (T6.3544 engines only)

T6.3544CC engines have an air charge cooler integral with the induction manifold (see Figs. A.5 and A.6).

Another method of cooling the air between the outlet of the compressor side of the turbocharger and the induction manifold is by pushing air through an 'air cooling radiator' usually mounted in the same air stream as the engine water cooling radiator (see Fig. N.5).

To maintain maximum efficiency, the cooler radiator fins should be checked periodically to ensure that no foreign matter is obstructing the flow of air.

Under no circumstances should the radiator be "muffed" or "blanked off" in an attempt to raise the temperature in the driver's cab because this will impede the flow of air through the charge cooler.



N.7

FUEL SYSTEM

Fuel Filters

Twin bowl, parallel flow fuel filters are situated at the rear of the engine on the left hand side, bracketed to the cylinder head, in most applications.

To Renew Fuel Filter Elements, see Fig. N.7

Thoroughly clean the exterior of the filter assembly.

Supporting the base of one of the filter bowls, unscrew the setscrew in the centre of the cover of each filter.

Lower filter base plate and discard the dirty element.

Repeat the procedure with the twin filter.

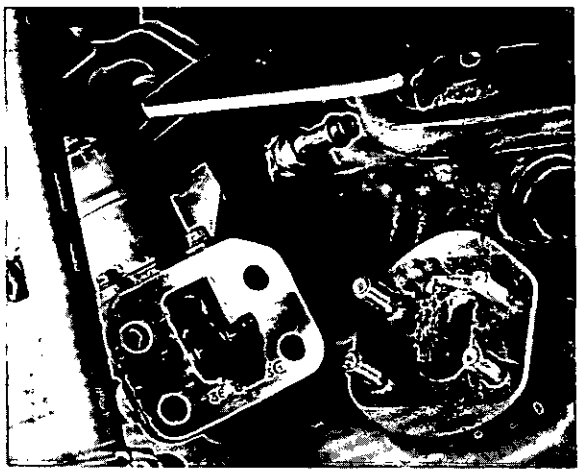
Thoroughly clean the filter heads and bases in a suitable cleaning fluid.

Inspect sealing rings and renew if damaged in any way.

Place a base squarely on bottom of new element and offer up assembly squarely to a filter head so that the top rim of the element locates centrally against the sealing rim in filter head. Hold in this position whilst securing setscrew is located and screwed home.

Repeat the procedure with the twin filter.

After the fuel filter has been re-assembled, the fuel system should be bled as detailed on Page N8.



N.8

Fuel Lift Pump

The mechanical diaphragm type fuel lift pump is operated by an eccentric on the camshaft and is mounted on the right hand side of the cylinder block, below the turbocharger. It is fitted with a hand priming lever.

Pressure Checking of Fuel Lift Pumps

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

Minimum Production Static Pressure
6lbf/in² (0,42kgf/cm²) 41kN/m².

Minimum Test Pressure
(75% of Min. Production Pressure
4.5lbf/in² (0,31kgf/cm²) 31kN/m².

To Remove and Fit Fuel Lift Pump, see Fig. N.8

Disconnect the inlet and outlet fuel pipes.

Remove the setscrews and retaining plates and remove the pump and joint.

If difficulty is encountered in removing the lift pump from the engine, turn the crankshaft to rotate the camshaft eccentric to a position which will enable the rocker arm to withdraw.

Fit pump using a new joint, ensuring that the mating faces are clean.

Damage can be caused to the pump operating lever if the pump is fitted to the engine with the pump driving eccentric on the camshaft in the maximum lift position. This problem is most likely if the four pump fasteners are not tightened evenly.

Therefore when the pump is fitted to an engine (especially a four bolt pump) ensure that the camshaft eccentric is on minimum lift, rotating the engine if necessary, and also that the pump fasteners are tightened evenly.

A loss of maximum engine power can occur if the lift pump is damaged during fitment.
The securing setscrews should be tightened to 20lbf ft (2,8kgf m) or 27Nm and re-torqued when hot.

Re-connect pump inlet and outlet pipes.

Bleed the fuel system, Page N8.

To Dismantle Fuel Lift Pump

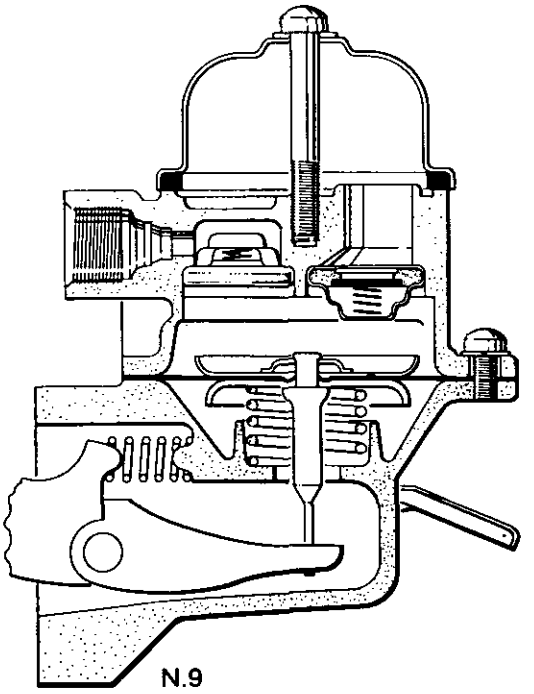
Clean exterior and file mark the flanges of top and bottom bodies for guidance in re-assembly. Remove the domed end cover and seal.

The gauze filter may now be lifted off.

Release the five setscrews securing the two halves of the pump and separate the two halves.

Turn the diaphragm assembly through 90° and lift the diaphragm and pull rod assembly from the body.

The diaphragm and pull rod assembly are serviced as an assembly and no attempt should be made to separate the layers of the diaphragm.



N.9

The valves are "staked in" and can be prised out using a screwdriver or other suitable tool. Clean the casting so that new valves can be correctly seated.

Press valves into position using a suitable "dolly". Stake the casting around the valves in six places.

The rocker arm pin can be removed by securing the rocker arm in a vice and tapping the body with a soft mallet until the retainers are dislodged.

The rocker, pin, lever and return spring can now be examined for wear.

To Re-assemble the Fuel Lift Pump, see Fig. N.9

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

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

Fit the spring into its location and place the diaphragm and pull rod assembly over the spring with the pull rod downwards locating the top of the spring in the diaphragm protector washer.

Position the rod so that the notched blade locates into the rocker arm link.

Press downwards on the diaphragm assembly so that the notches on the pull rod align with the rocker arm link and twist it through 90° in either direction, this action will engage and retain the pull rod in the fork of the link.

When re-assembling the two pump halves, push the rocker arm towards the pump until the diaphragm is level with the body flanges. The top half can now be placed in position with the file marks aligned.

Maintaining the pressure on the rocker arm, fit the securing screws and washers and tighten evenly.

Refit the gauze filter.

The domed cover may now be refitted, ensuring that the rubber sealing ring is correctly located.

Fuel Injection Pump

The fuel injection pump is a C.A.V., D.P.A. or Bosch distributor type, vertically mounted on the auxiliary drive housing and is spline-coupled to the auxiliary drive wormgear.

The pump is a compact, oil tight unit, lubricated throughout by fuel oil and requires no separate lubrication system.

Speed control is maintained by a mechanical governor and automatic variation of the commencement of injection is obtained with an automatic advance unit.

With Bosch fuel injection pumps, a boost control is fitted at the side of the pump. Its function is to vary the fuel into the engine depending on load. Ensure that all connections of the boost sensing pipe are in good condition.

Unless proper test equipment and the relevant Test Data for the fuel pump is available, adjustment or maintenance of the fuel pump should be referred to the Perkins Distributor or an accredited fuel pump agent.

To Remove the Fuel Injection Pump

Disconnect the stop and throttle controls from the pump and remove the return springs (C.A.V. pumps).

The Bosch fuel pump has a combined speed/stop control lever. Under no circumstances should the speed/stop control lever be removed when removing a Bosch fuel pump as it will upset the the settings making it necessary to put it on a test machine to reset it.

Remove the high and low pressure fuel pipes from the pump.

The fuel pump can now be withdrawn after the securing nuts and washers have been removed, see Fig. N.10.

To Fit the Fuel Injection Pump

Fit the fuel pump ensuring that the master spline on the fuel pump shaft will enter the female spline within the vertical drive shaft.

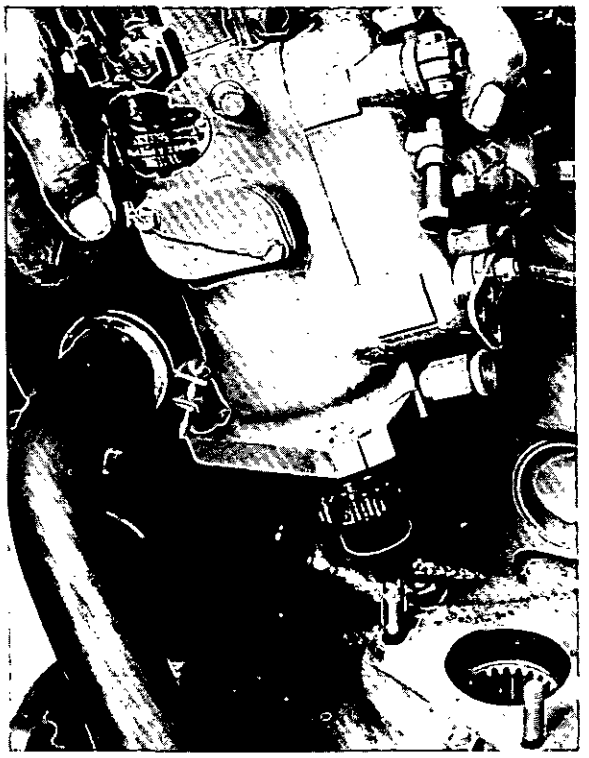
Position the fuel pump so that the scribed line on the fuel pump mounting flange aligns with the scribed line on the adaptor plate, see Fig. N.11(1). Secure the pump to the adaptor plate.

Refit the high and low pressure fuel pipes to the fuel pump. Ensure that the high pressure pipes are fitted to the high pressure outlets of the fuel injection pump in the correct sequence, see Fig. N.12 (CAV fuel pumps) or Fig. N.13 (Bosch fuel pumps).

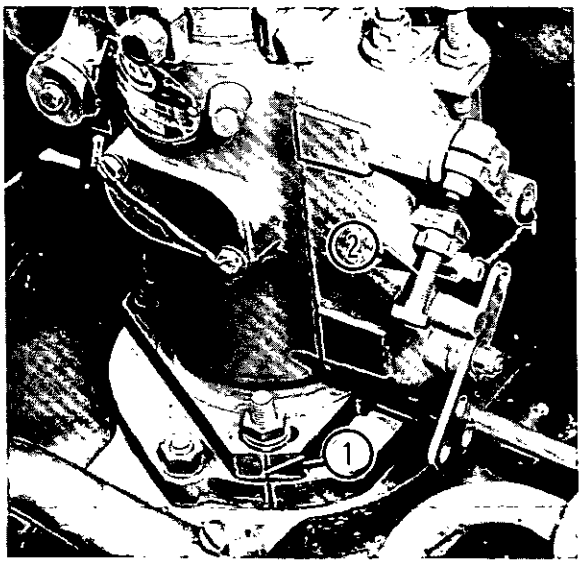
Reconnect the throttle and stop lever controls and attach the return springs.

Bleed the fuel system as detailed on Page N8.

If necessary, adjust the maximum and idling speeds. Details will be found on this page and on Page 7.



N.10 **(C.A.V. Pump)**



N.11 **(C.A.V. Pump)**

Maximum Speed Setting

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

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

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

Under no circumstances should the engine be allowed to operate at higher rev/min than specified or severe damage to the engine may result.

Idling Speed Setting

With C.A.V. pumps the engine idling speed is adjusted by the idling screw, see Fig. N.11 (2). With Bosch pumps, the idling speed adjusting screw is at the rear of the pump.

With the engine warm, turn the screw clockwise to increase the speed or anti-clockwise to decrease it.

The idling speed will vary, according to application. For details, apply to your Perkins Distributor or an accredited fuel pump Dealer, alternatively, Service Dept., Perkins Engines Ltd., Peterborough.

Atomisers

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

Different atomiser seating washers are used on naturally aspirated and turbocharged engines. The seating washers for naturally aspirated engines are 0.080in (2,03mm) thick and for turbocharged engines, 0.028in (0,71mm) thick. It is important that the correct atomiser seating washers are fitted.

See page E3 for guidance on latest type of atomiser dust seal and also top entry type atomisers.

Ensure that the atomiser is seated centrally and tighten securing nuts/setscrews down evenly to a torque of 12lbfft (1,7kgfm) or 16Nm.

When fitting the high pressure pipes, tighten the unions to 15lbfft (2,1kgfm) or 20Nm.

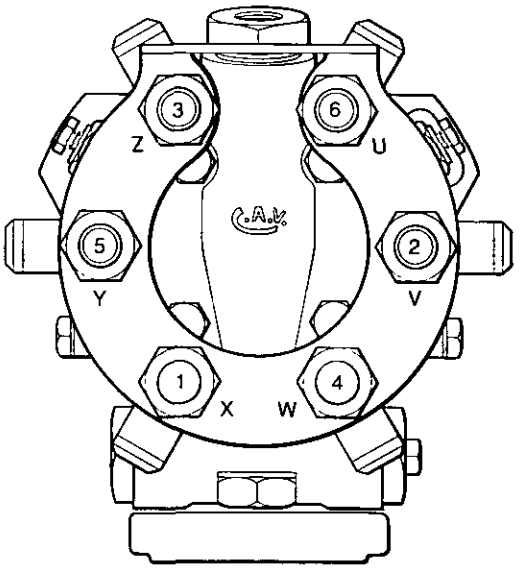
A faulty atomiser can be determined by releasing the fuel pipe union nut of each atomiser in turn, with the engine running at a fast "tick-over". If after slackening a pipe union nut, the engine revolutions remain constant, this denotes a faulty atomiser.

No attempt should be made to service or reset the pressure of an atomiser unless the proper testing pump and pressure gauge is available.

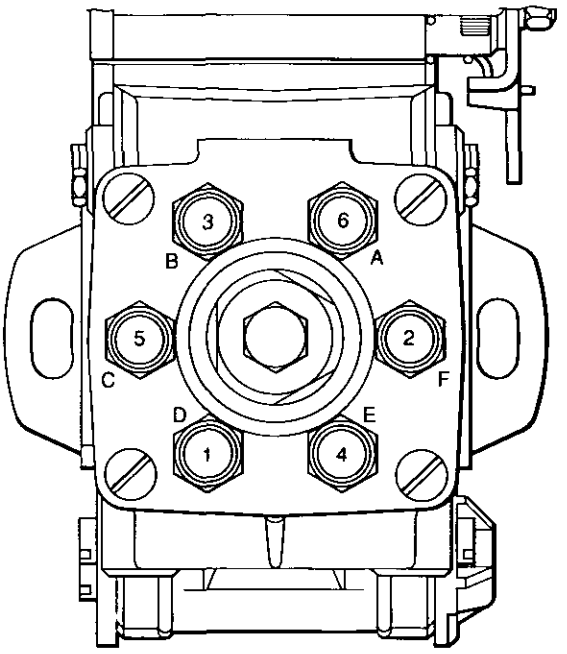
An atomiser, when tested by pumping fuel through it gives a short "pinging" sound as the fuel emerges. After the atomiser has been in service for some time, it makes a "cracking" sound. It is not until it sounds "dead" that its condition is likely to affect the running of the engine.

Note: Do not allow the hands or face to come into contact with the atomised jet of fuel, as the working pressure will cause the fuel oil to penetrate the skin.

When changing an atomiser always remove the pipe entirely. Never bend the pipe.



N.12



N.13

How to Eliminate Air from the Fuel System

If air enters the system, it must be eliminated before the engine can be started.

Air can enter the system if:

- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

In order to eliminate air from the fuel system, proceed as follows:

Fuel filter with twin elements: Loosen the vent plug (1 in Fig. N.14), the banjo connection bolt (2) or the straight connection (3).

Fuel filter with a single element: Loosen the banjo connection bolt (1 in Fig. N.15).

Operate the priming lever on the fuel lift pump (Fig. N.16) until fuel, free from air, comes from the filter vent point. Tighten the vent plug, banjo connection bolt or the straight connection. *If the drive cam of the fuel lift pump is at the* point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be turned one revolution.

CAV fuel injection pumps: Loosen the union nut (1 in Fig. N.17). Operate the priming lever of the fuel lift pump until fuel, free from air, comes from the union nut. Tighten the union nut.

Bosch fuel injection pumps: Loosen the banjo connection bolt (1 in Fig. N.18) and union nut (2). Operate the lever of the fuel lift pump until fuel, free from air, comes from the banjo connection. Tighten the banjo connection bolt. Continue to operate the lever of the fuel lift pump until fuel, free from air, comes from the union nut. Tighten the union nut.

Ensure that the manual stop control is in the "run" position. If an electrical stop control is used, turn the start key to the "R" position.

CAV fuel injection pumps: Loosen the vent screw in the lock screw of the hydraulic head (3 in Fig. N.17) and the vent screw on the governor cover of the fuel injection pump (2). Operate the priming lever of the fuel lift pump until fuel, free from air, comes from the vent screw in the lock screw of the hydraulic head. Tighten the vent screw. Continue to operate the priming lever of the fuel lift pump until fuel, free from air, comes from the vent screw on the governor cover. Tighten the vent screw.

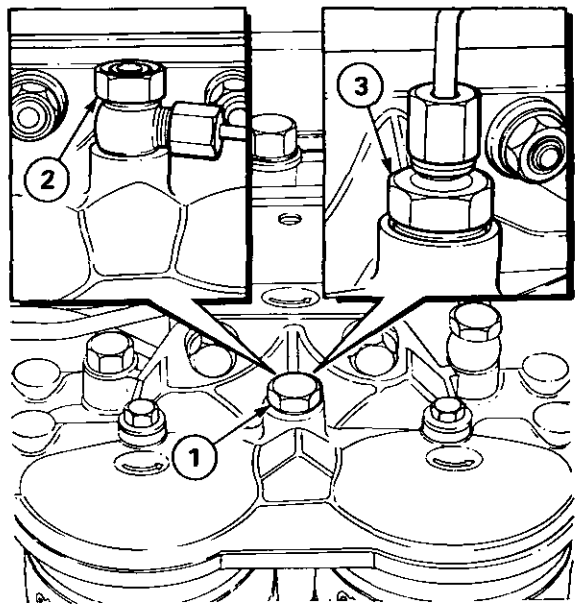
Bosch fuel injection pumps: Clean the top of the fuel pump. Loosen the vent screw (3 in Fig. N.18) a maximum of half a turn. Operate the lever of the fuel lift pump until fuel, free from air, comes from the vent screw. Tighten the vent screw.

Loosen the union nut(s) (1 in Fig. N.19) at the thermostart(s) (if fitted) and operate the lift pump until fuel, free from air, comes from the connection(s). Tighten the union nut(s) at the thermostart(s).

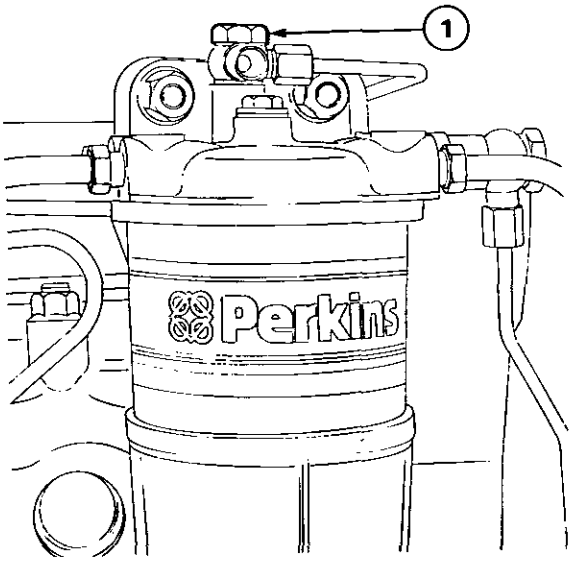
Loosen the union nuts of the high-pressure pipes (1 in Fig. N.20) at two of the atomisers. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections.

The engine is now ready to start.

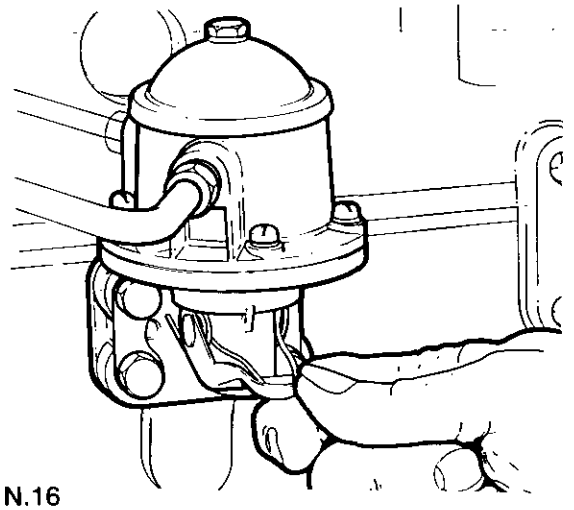
If the engine runs correctly for a short time and then stops *or runs roughly, check for air in the fuel system. If there is air* in the fuel system, there is probably a leakage in the low pressure system.



N.14



N.15



N.16

Thermostart

The thermostart is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device where it is ignited by an ignition coil when the engine is turned and air is drawn into the manifold.

Thermostart Failure

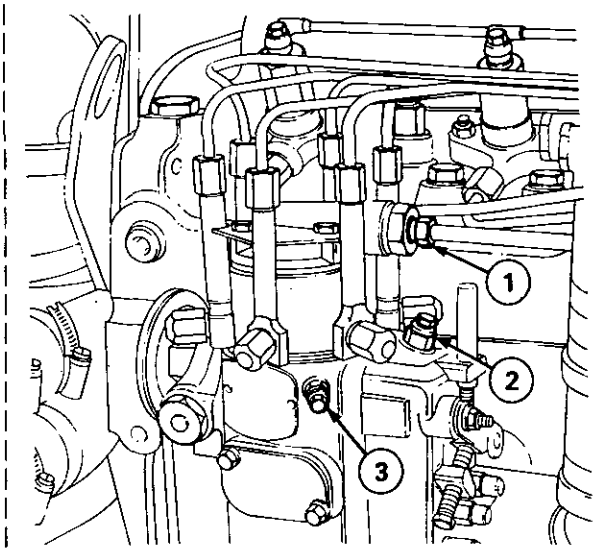
In the event of difficult starting, check that fuel is reaching the start aid in the induction manifold by disconnecting the fuel pipe.

If fuel is reaching the start aid satisfactorily, check that the start aid is functioning by disconnecting the piping at the induction manifold and watching the cold start aid whilst it is being used. When the switch is turned to "H" (heat) position, the element should become red hot, and on engagement of the starter motor, it should burst into flame.

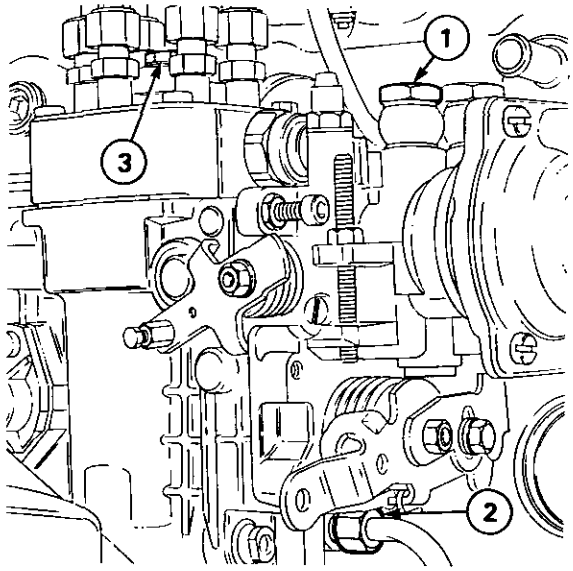
Where a thermostart unit has to be replaced, care must be taken not to exceed the torque load as given on Page B.2. Excessive torque loading can crack the insulating adaptor causing an electrical short and hard starting characteristics.

To prevent thermostart damage, it is essential that the thermostart is not operated dry. After any operation which allows fuel to drain from the thermostart feed pipe, the pipe must be disconnected at the thermostart and all air bled from the pipe before the thermostart is operated.

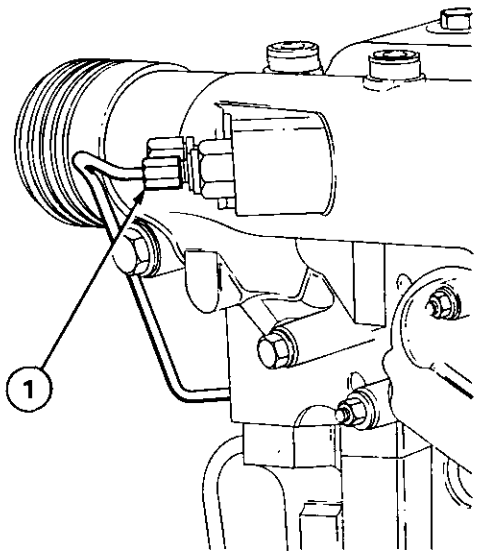
The T6.3544 and 6.3544 engine is fitted with efficient cold starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.



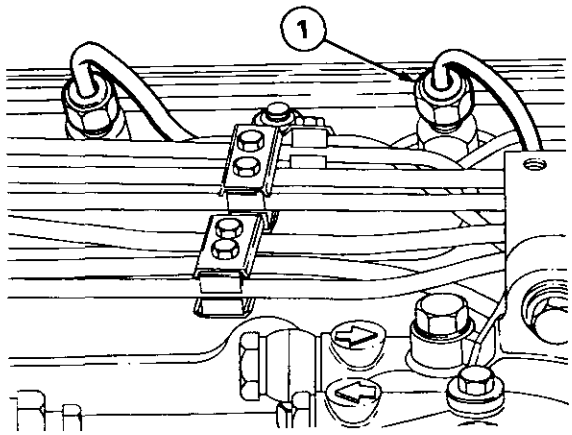
N.17



N.18

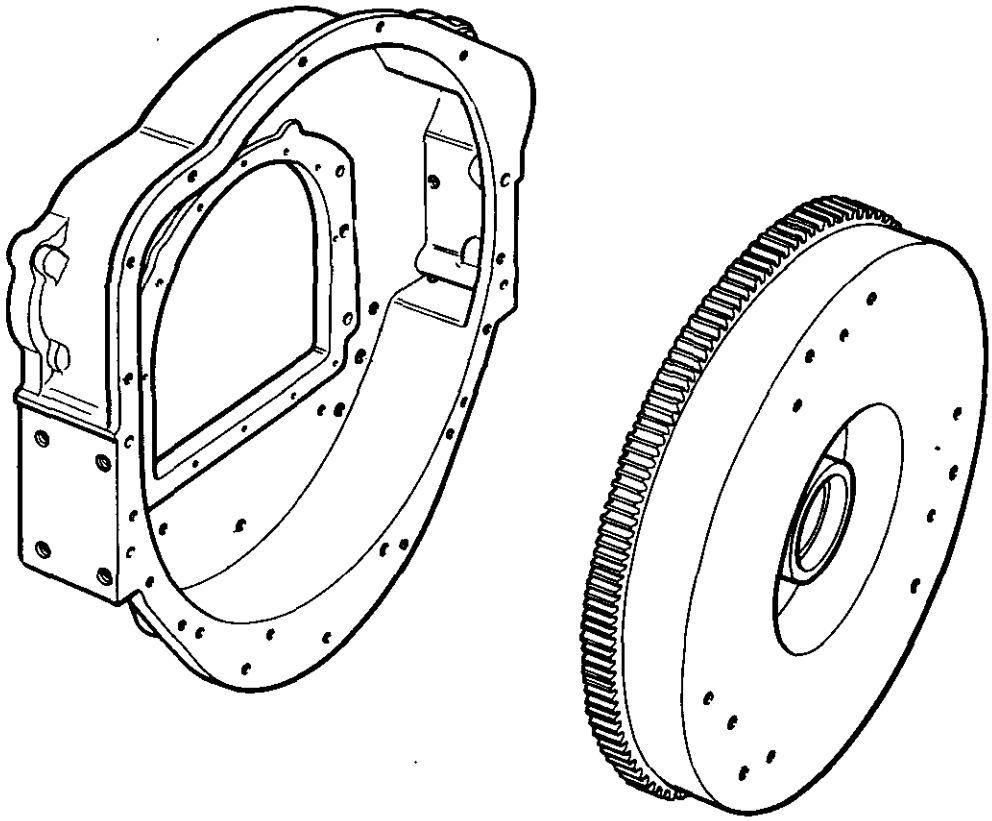


N.19



N.20

SECTION P
Flywheel and Flywheel Housing



To Remove the Flywheel

Remove the twelve setscrews and washers which secure the flywheel to the crankshaft flange.

It is advisable to fit suitable guide studs to prevent the flywheel from dropping as it clears the crankshaft flange.

Flywheel Ring Gear

The ring gear is shrunk on to the flywheel.

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

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

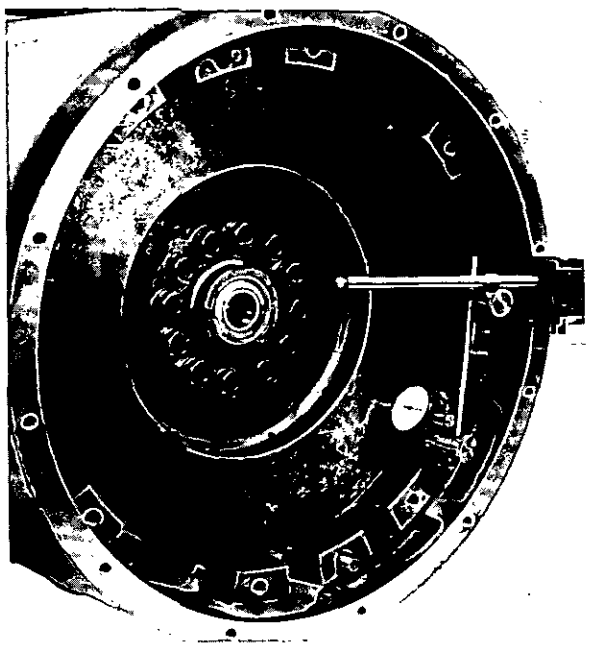
To Refit the Flywheel

Using suitable guide studs, refit the flywheel to the crankshaft flange and secure with setscrews and washers.

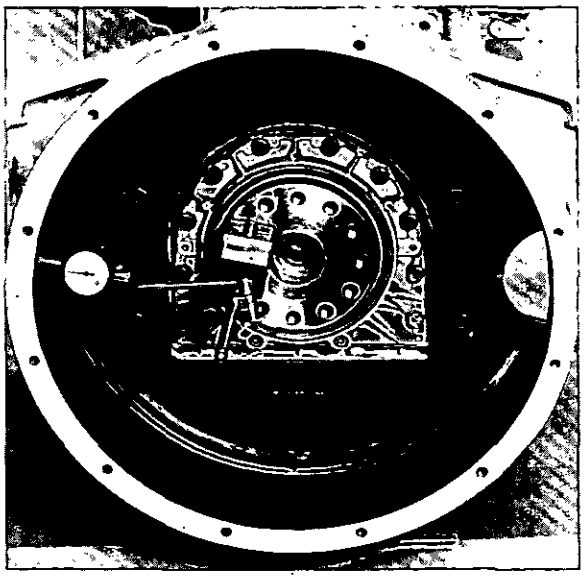
Tighten setscrews to a torque of 80lbfft (11,1kgfm) or 108Nm.

Flywheel Runout

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



P.1



P.2

Flywheel Alignment

The alignment of the flywheel face should be within the limit of 0.001in (0,03mm) per inch (25,4mm) of flywheel radius from the crankshaft axis to the clock gauge plunger, see Fig. P.1.

When carrying out this check, press the crankshaft one way to take up the end float whilst turning the flywheel.

To Remove the Flywheel Housing

Remove the starter motor and flywheel.

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

To Refit the Flywheel Housing

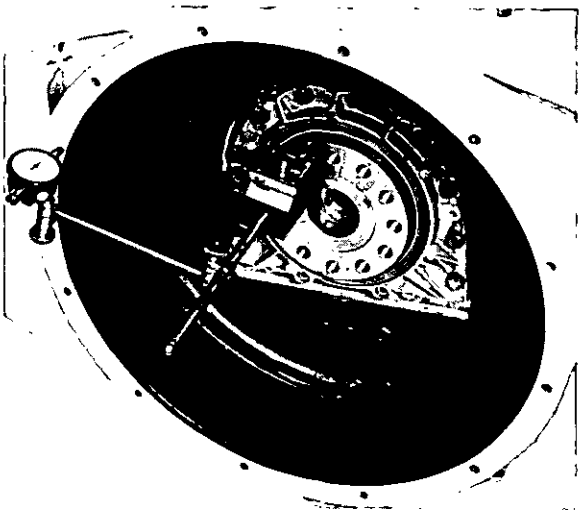
Ensure that the rear face of the cylinder block and the mating face of the housing are clean and free from burrs.

Fit new dowels, and secure housing to cylinder block to allow for adjustment, if necessary.

With a clock gauge, check that the alignment of the flywheel housing bore and face, see Figs. P.2 and P.3, are within the limits listed on Page P.3.

All adjustments to bring the housing within these limits must be carried out on the housing and not on the cylinder block.

Tighten the securing setscrews to torque given on page B.2.

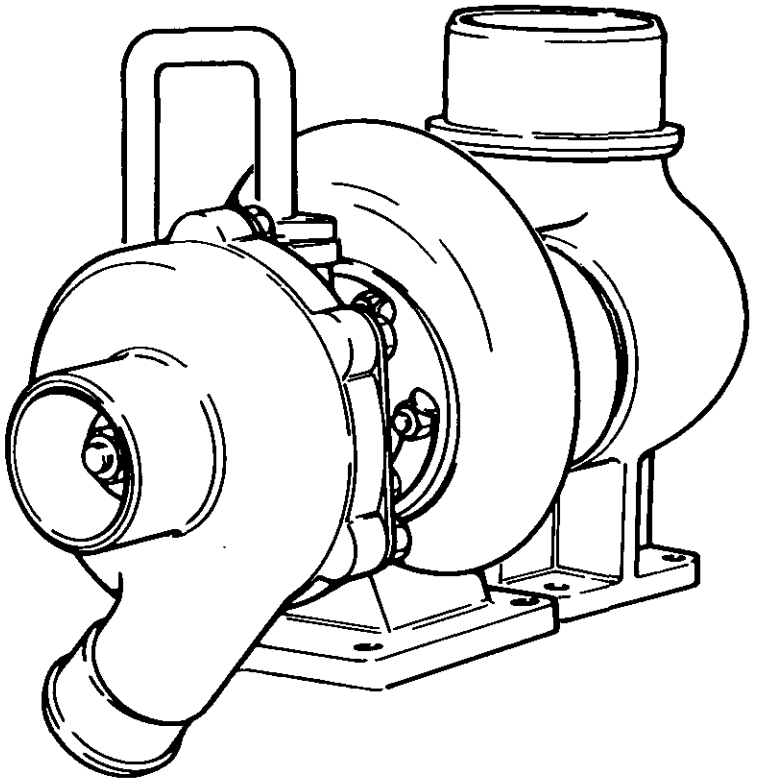


P.3

Diameter of housing Bore	Limit-Total Indicator Reading
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 the housing within these limits must be carried out on the housing and not on the cylinder block.

SECTION Q
Turbocharger



T6.3544 Engines only

The turbocharger is fitted on the exhaust manifold outlet, see Fig. A.4. It is lubricated by oil taken from the engine lubricating system. Oil pressure should never drop below 30lbf/in^2 (2,11kgf/cm^2) or 207kN/m^2 at normal running speed. Check this pressure regularly.

The maximum boost pressure should be 11 – 13.5lbf/in^2 (0,80 – 0,95kgf/cm^2) or 76 – 93kN/m^2 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 (30,000km) or 1,000 hours, clean the oil drain pipe from turbocharger to sump, also turbocharger compressor wheel and cover.

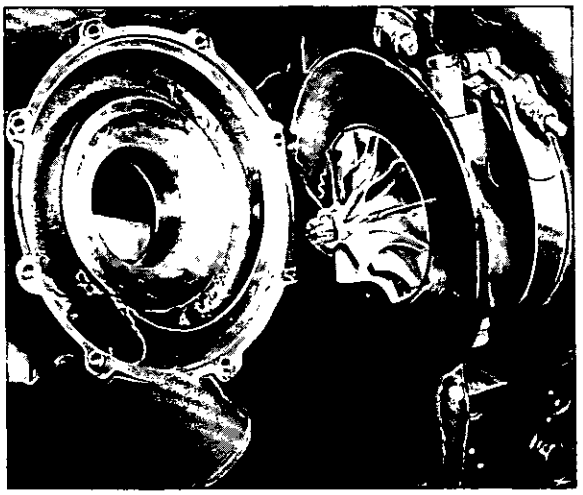
The compressor wheel and cover may be cleaned without removing the turbocharger from the engine (Fig. Q.1).

Remove the air inlet duct and compressor housing and check for dirt or dust build up.

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 housing 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.



Q.1

Fault Diagnosis

If the performance of the turbocharger is suspect, check the installation for the following faults:

Excessive air inlet depression.

Low or high air delivery pressure.

Low oil pressure and/or low oil flow.

Restricted exhaust from turbine.

Fuel pump or injection faults.

Check and rectify in accordance with the following paragraphs:

Excessive air inlet depression: The air depression at the entry to the compressor, that is in the ducting after the air filter and immediately before the compressor cover, should not exceed a 20in (500mm) head of water.

If the depression is excessive, the cause will be due to a restriction of inlet air by a dirty air filter.

Service the air filter.

Low or high air delivery pressure: The pressure will vary according to the engine rating, speed and load.

If the pressure is low, the probable cause is a dirty or damaged compressor, incorrect fuelling of the engine fuel pump, or leaking manifold joints.

Check that the injection pump fuelling has not been disturbed and if satisfactory, remove the turbocharger from the engine for inspection.

A higher reading may also indicate incorrect injection pump fuelling or damage to the turbine.

Action as for low pressure.

Low oil pressure and/or oil flow: The oil delivery pressure should not be less than 30lbf/in^2 (2,1kgf/cm^2) or 207kN/m^2 under normal conditions of load.

If oil pressure is low, refer to Section L. Clean bores of the feed and return pipes and check the connections for obstruction.

Restricted exhaust from the turbine: A restriction of the exhaust from the turbine will affect engine performance. If the back pressure is more than 20in (500mm) head of water, check the exhaust system for obstruction and rectify as necessary.

Reconditioning

When a turbocharger is removed from an engine, it is imperative that all terminations of oil connections are sealed immediately, to prevent the entry of dirt.

During all stages of turbocharger dismantling, examination and rebuilding, care must be taken to ensure that no damage is caused to components.

Holset 3LD

Dismantling

Numbers in brackets refer to numbers on Sectional Drawing, Fig. Q.2.

Clamp unit upright in vice on turbine inlet flange.

Mark relative positions of turbine housing (8), bearing housing (14), compressor cover (21) and "V" clamp (7).

Remove the eight bolts (3) and associated lockwashers (2), fastening compressor cover (21) to bearing housing (14) and lift off cover (21).

Remove the "V" clamp locknut and spring "V" clamp (7) back onto bearing housing (14). Lift the core assembly clear of the turbine housing (8).

Holding the turbine wheel at the hub, remove the compressor locknut (17).

Slide compressor wheel (18) off the shaft.

Using circlip pliers, remove the large retaining ring (20) which retains compressor insert (19). Two screwdrivers should be used to lift insert (19) from bearing housing (14).

Remove "O" ring (4) from insert (19).

The individual parts of the thrust assembly can now be lifted out.

(a) Spacer sleeve (16) which can be gently pushed out of the insert (19).

(b) Oil deflector (13) positioned by two groove pins.

(c) Thrust ring (12).

(d) Thrust plate (5).

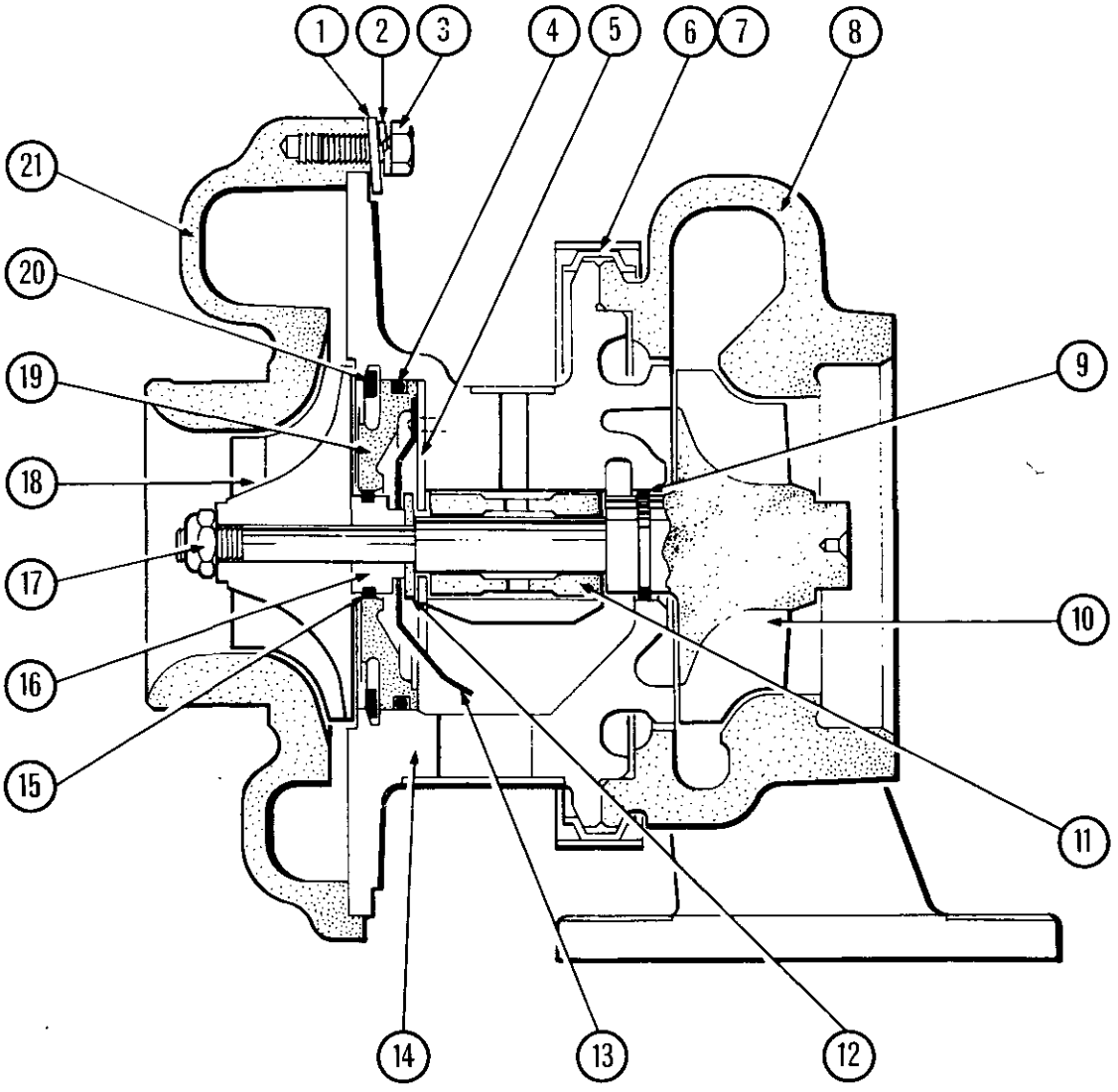
Note: The groove pins are a press fit in the bearing housing (14) and should not be removed.

Remove shaft and turbine wheel assembly (10) together with its piston rings (9) and (15).

Insert fingertip into bore of bearing (11) and remove.

Carefully expand and remove piston rings (9) and (15) from both the spacer sleeve and turbine wheel and shaft assembly.

Caution: Over expansion of piston ring will cause a permanent set or break the ring.



Q.2

Cleaning Procedure

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

Soak parts in cleaner until all deposits have been loosened.

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

Clean all drilled passages with compressed air jet.

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

Internal Parts Inspection

Shaft and turbine wheel assembly (10).

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

(b) Inspect piston ring groove walls for scoring. Minor scratches are acceptable.

(c) Check carefully for cracked, bent or damaged blades, but **do not attempt to straighten blades.**

Bearing (11).

Replace bearings if excessively scratched or worn.

Bearing Housing (14).

Replace housing if bearing or piston ring bores are excessively scratched or worn.

Spacer Sleeve (16).

Replace if piston ring groove or spacer are damaged.

Thrust ring (12): thrust plate (5).

(a) Replace if thrust faces are damaged. Minor scratches are acceptable.

(b) Replace thrust plate (5) if faces are worn excessively, unevenly, severely scratched or otherwise damaged.

(c) The small feed grooves in the thrust plate (5) must be clean and free from obstruction.

Compressor wheel (18).

Check carefully for cracked, bent or damaged blades but **do not attempt to straighten blades**.

"O" ring (4).

Replace if section through ring has taken a permanent set; *indicated by flats on the sides of the ring.*

A schedule of tolerances which includes allowable dimensions after service, is given below.

Re-assembly

When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence.

Assembly of the unit is the reverse of dismantling, but the following points should be noticed.

(a) Lubricate bearings, thrust assembly, piston rings and rotor shaft, with clean engine oil.

(b) When replacing turbine wheel and shaft (10) into bearing housing (4), and spacer sleeve (16) into insert (19), do not force piston rings into bore as an off-centred ring will fracture, causing the shaft to bind.

(c) The large retaining ring (20) should have bevelled side *facing outwards.*

(d) Torque locknut (17) to 13lbfft (1,8kgfm) or 17Nm, bolt (3) to 5lbfft (0,7kgfm) or 7Nm and "V" clamp locknut (6) to 10lbfft (1,4kgfm) or 13Nm.

(e) On completion, spin shaft to ensure it rotates freely.

Note: If during the dismantling of the turbocharger, the lubricating oil feed and drain pipe adaptors were removed from the bearing housing, these should, on re-assembly, be torqued to 30lbfft (4,15kgfm) or 41Nm and 65lbfft (8,99kgfm) or 89Nm respectively.

The unit is now ready for fitting to the engine. If it is not intended to mount the turbocharger on the engine immediately after assembly, then the gas and oil connections must be sealed off to prevent the entry of dirt.

HOLSET 3LD
SCHEDULE OF TOLERANCES

	Manufactured Dimensions	Allowable Dimensions after Service	Remarks
Total turbine wheel clearance	0.047/0.057in (1,19/1,45mm)	0.024in (0,61mm) min.	
Back turbine wheel clearance	0.015/0.027in (0,38/0,68mm)	As Manufactured	Wheel pushed to compressor end.
Front turbine wheel clearance	0.024/0.038in (0,61/0,96mm)	0.024in (0,61mm) min.	
Total compressor wheel clearance	0.049/0.062in (1,24/1,57mm)	As Manufactured	
Back compressor wheel clearance	0.026/0.043in (0,66/1,09mm)	As Manufactured	Wheel pushed to turbine end.
Thrust clearance	0.004/0.008in (0,10/0,20mm)	As Manufactured	
Radial float at compressor wheel hub	0.015/0.021in (0,38/0,53mm)	0.024in (0,61mm) max.	
Bearing outside diameter	0.8714/0.8719in (22,13/22,14mm)	As Manufactured	
Bearing inside diameter	0.4815/0.4818in (12,23/12,24mm)	As Manufactured	
Thrust bearing width	0.105/0.107in (2,67/2,72mm)	0.104in (2,64mm) min.	
Squareness of back face of turbine wheel	0.002in T.I.R. (0,05mm T.I.R.)	As Manufactured	On Vee block at 1.375in radius.
Eccentricity of small diameter of shaft	0.0006in T.I.R. (0,01mm T.I.R.)	As Manufactured	
Piston ring grooves on shaft	0.066/0.068in (1,68/1,73mm)	0.066/0.070in (1,68/1,79mm)	
Piston ring groove on spacer sleeve	0.066/0.068in (1,68/1,73mm)	0.066/0.070in (1,68/1,79mm)	
Piston ring width at turbine end	0.062/0.063in (1,57/1,60mm)		Replace at each service.
Piston ring width at compressor end	0.062/0.063in (1,57/1,60mm)		Replace at each service.
Bearing housing bore for piston ring	0.8750/0.8755in (22,22/22,24mm)	0.877in (22,28mm) max.	
Compressor insert bore	0.875/0.876in (22,22/22,25mm)	0.877in (22,28mm) max.	
Bearing housing bore at bearing	0.8750/0.8755in (22,22/22,24mm)	As Manufactured	
Turbine wheel outside diameter	2.977/2.975in (75,62/75,56mm)	2.980in (75,69mm) max.	
Shaft diameter at bearing	0.4803/0.4800in (12,20/12,19mm)	0.4799in (12,19mm) min.	

Airesearch T-04B (see Fig. Q.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. As each part is removed, place in a clean container to prevent loss or damage.

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.

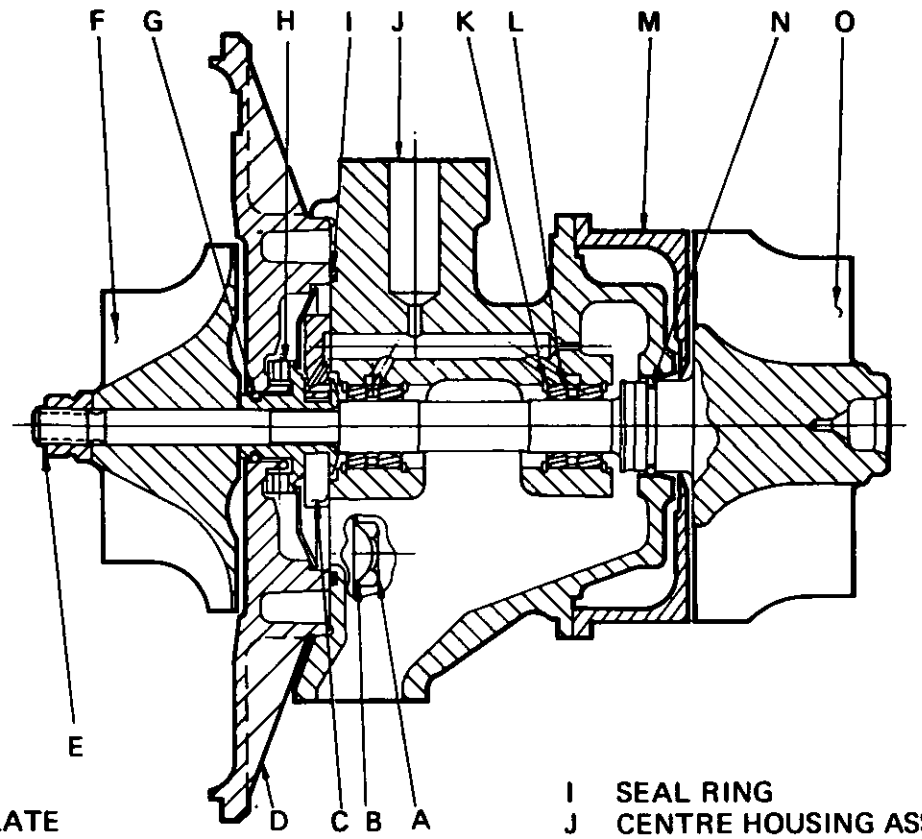
Remove bearings and retainers from centre housing. Discard *rubber sealing ring.*

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.



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

Q.3

Internal Parts Inspection

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.

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 bearing 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 79lbfin (104kgfcm) or 8,93Nm 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 20lbfin (23kgfcm) or 2,26Nm. Then continue to tighten until length of shaft increases by 0.0055/0.0065in (0,14/0,16mm). Tighten nut by using T-handled wrench to avoid side load which may cause *shaft to bend. Check axial end play for 0.001/0.004in (0,03/* 0,10mm) travel. If equipment is not available to measure shaft stretch, this alternative method may be used: after installing impeller nut and tightening to 20lbfin (23kgfcm) or 2,26Nm continue to tighten through an angle of 90°.

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 130lbfin* (150kgfcm) or 14,09Nm.

Orientate turbine housing to centre housing. Coat bolt heads with a high temperature thread lubricant. Install bolts, clamps *and lockplates. Tighten bolts to 130lbfin (150kgfcm) or* 14,09Nm. 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.

Schwitzer 3LM and S.76

Dismantling

Numbers in parentheses () refer to key numbers in Fig. Q.4.

Clamp the edge of turbine housing (22) mounting flange in vice. Mark the relative positions of turbine housing, bearing housing (13) and compressor cover (1).

Remove the setscrews (15), lock plates (16) and clamp plates (17). Lift the assembly from the turbine housing. Place on work bench with turbine wheel (21) up.

Remove setscrews (12) and clamp plates (11). Remove core assembly from compressor cover (1).

Invert core assembly and place in turbine housing which is clamped in vice.

Hold the end of turbine wheel with $^{11}/_{16}$in A/F socket wrench, remove the compressor nut (2). Remove the compressor wheel (3). **Use extreme care in handling the compressor wheel as the blades bend very easily.**

Remove the snap ring (8) using suitable pliers. Note the position of bevel on the outer edge of the snap ring; it must be replaced the same way on re-assembly.

Remove the insert (6) from the bearing housing, remove the thrust sleeve (4), piston ring (5) and the oil deflector (7) from the shaft.

Remove "O" ring (9) from the insert.

Remove piston ring (19) from the thrust sleeve. Both "O" ring and piston ring must be renewed on re-assembly. Separate the oil deflector from the thrust sleeve. Lift thrust bearing (10) out of bearing housing. The thrust bearing must be renewed when re-assembling.

Remove the shaft and bearing housing from the turbine housing (22).

Separate shaft and wheel assembly (21) from the bearing housing. **Care must be taken not to damage the compressor wheel or the shaft.**

Remove the bearing (14). Renew the bearing when re-assembling.

Separate the backplate (18) and gasket (20), if fitted, from the bearing housing. Where a gasket is fitted it must be renewed when re-assembling.

Remove the piston ring (19) from the shaft and wheel assembly. The piston ring must be renewed on re-assembly.

Do not remove the pins in the bearing housing.

Cleaning

Before cleaning, inspect all parts for signs of rubbing, burning or other damage.

Clean all parts in clean non-caustic carbon solvent. After soaking, use a stiff bristle brush to remove all dirt particles. Oil and air passages must be clean and free from obstructions.

Blow dry with clean jet of compressed dry air.

Following the cleaning, the parts should be examined and, if found to be in satisfactory condition, re-assembled in the reverse order of the stripping sequence.

Parts Inspection

It is suggested that all parts to be re-used should be checked and measured after the parts have been throughly cleaned.

A. Bearing Housing and Groove Pin Assembly

1. Inspect for cracks or fractures, pitting of the gasket (from corrosion or hot gas corrosion) and other machined surfaces, or distortion of turbine end flange. Renew the parts if condition is excessive.
2. Visually check the bearing bore for surface cracks. Renew if bore condition is sub-standard.

   Reference maximum bore diameters are:

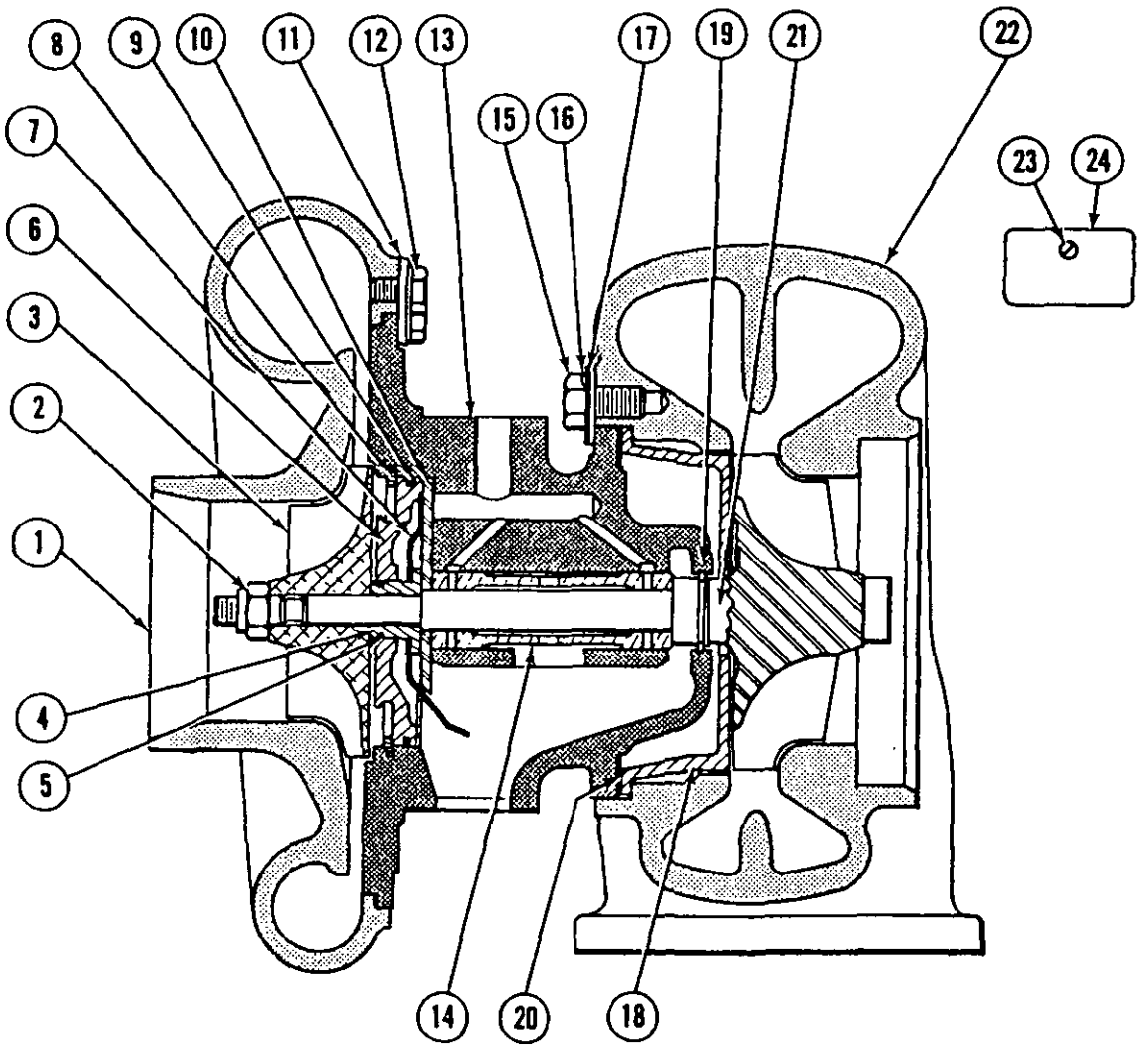
Standard	– 0.7505in (19,06mm)
.010 Oversize rebuilt	– 0.7605in (19,32mm)
.020 Oversize rebuilt	– 0.7705in (19,57mm)

   Note: The bore diameter of a rebuilt turbocharger is coded by the last digit of the serial number.

Standard	– 9
010 Over	– 0
020 Over	– 8

B. Compressor Wheel

1. Inspect for evidence of bent, burred or eroded vanes and wear marks on the back. Renew if damaged. **Do not attempt to straighten bent vanes.**



Q.4

C. Turbine Wheel and Shaft Assembly

1. Inspect the wheel for evidence of bent, burred or eroded vanes and wear marks on the back face. Renew if damaged. **Do not attempt to straighten bent vanes.**
2. Check the hub for marks (from high speed contact with the bearing housing bore) and for damage of the seal ring groove. Renew if damaged or wear is excessive.
3. Inspect the bearing journals for evidence of any damage or wear. Renew the journal if necessary.

   Minimum journal diameter 0.440in (11,18mm).
4. Measure the concentricity between the large and small shaft diameters with a dial indicator and vee block. Limit of eccentricity is 0.0006in (0,015mm) T.I.R. Renew if not within limit.

D. Compressor Cover

Check for damage from wheel contact, renew if damage is excessive. It is permissible to polish out any small nicks in the cover contour.

E. Turbine Housing and Backplate

Check for damage from wheel contact and evidence of excessive temperature damage to internal flanged surfaces, such as surface cracking and pitting or distortion. Renew if cracked. It is permissible to polish out small nicks in the contour.

F. Small Internal Parts

1. Fit new compressor seal ring in the insert bore. Check for full circle of contact and measure ring gap with feeler gauge. Gap range 0.002/0.007in (0,05/0,18mm). Renew *insert if ring fit is out of the limit.*
2. Inspect the thrust sleeve for evidence of wear and scratches. Renew if damage is excessive.

Re-assembly

Numbers in parentheses () refer to key numbers in Fig. Q.4.

Check each part before re-assembly. The following items must be renewed when the turbocharger is rebuilt:

Compressor nut (2)	Bearing (14)
Piston ring (5)	Lock plates (16)
"O" ring (9)	Piston ring (19)
Thrust bearing (10)	Gasket (20) – where applicable

Fix the turbine housing (22) securely in vice with the four threaded holes facing upwards.

Oil piston ring (19) and fit in ring groove of shaft and wheel assembly (21), being careful not to over-expand the ring. Position the bearing housing (13) with turbine end up. Fit *gasket (20), where applicable, and turbine backplate (18).*

The separate backplate has no attachment to the bearing housing, its position is fixed when the bearing housing and the turbine housing are clamped together. A few models do not require a gasket (20).

Oil the piston ring area of the shaft and wheel assembly. Fit into bearing housing using care to avoid damage to piston ring.

Holding the end of the shaft to prevent the shaft wheel from falling out of the bearing housing, place sub-assembly in turbine housing wheel end down.

Oil the bearing (14) and slip bearing down over the shaft into the bearing housing bore.

Oil the thrust faces on both sides of thrust bearing (10). Place thrust bearing bronze side up over shaft and groove pins engaging pins to holes in thrust bearing. Some models have only one groove pin.

Place oil deflector (7) on thrust sleeve (4).

Oil the piston ring (5) and fit on thrust sleeve using care not to over expand the piston ring.

Oil the "O" ring and fit into groove of insert (6).

Oil the thrust sleeve and fit the small end in hole of the insert from the concave side, taking care not to damage the piston ring.

Oil the thrust cavity in bearing housing and fit insert/oil deflector/thrust sleeve sub-assembly over the shaft into the bearing housing, aligning oil deflector with oil drain cavity in bearing housing. Take care not to damage "O" ring.

Using suitable pliers, fit snap ring (8) into the groove with the flat side against the insert. Ensure the snap ring is securely in position.

Mount a dial indicator on the bearing housing with the stem of the indicator on the end of the shaft. Make sure that the turbine end of the bearing housing is correctly seated in the turbine housing. Move the shaft vertically to determine turbine wheel contour clearance. The clearance must be between 0.018in (0,46mm) and 0.049in (1,24mm). If clearance is not within these tolerances, dismantle unit to determine the cause. Look for burrs, dirt particles or incorrectly assembled parts. If after re-assembly it is still out of the permitted tolerance, do not use.

Install compressor wheel (3) on shaft.

Remove any oil from the shaft threads and apply 2 drops of "Loctite 601" (or equivalent locking agent) to the shaft threads. Using a socket wrench on the turbine wheel lug to prevent the shaft from turning, tighten the compressor nut to 13lbfft (17,6Nm).

Mount the dial indicator on the bearing housing with stem on the end of the shaft, measure the end play. The tolerance is 0.002/0.005in (0,05/0,13mm). **This is a dry (no oil) reading.** If not within tolerance, dismantle and look for burrs, dirt particles or incorrect assembly. Re-assemble and if still out of tolerance, do not use.

Place compressor cover (1) on the bench with wheel cavity upwards. Lubricate the small diameter of the shaft with grease or oil and place the turbocharger core assembly in compressor cover with the turbine wheel up.

Check turbine wheel clearance between back face of the turbine wheel and plate on opposite sides of the shaft. Clearance tolerance must be 0.017/0.049in (0,43/1,24mm). If clearance is not within the limits, dismantle and inspect as with previous components, if on re-assembly still not to tolerance, do not use.

Ensure that the location marks previously made on the compressor cover and bearing housing are in line and fit the four clamp plates (11) with setscrews and locking washer (12). Tighten setscrews to 5lbfft (6,8Nm). Use care not to overtighten screws as damage can be caused to the aluminium compressor cover.

Turn unit over and place in the turbine housing. Apply anti-seize compound to threads and setscrews (15).

Ensure that the location marks previously made on the turbine housing and bearing housing are in line.

Fit clamp plates (17), lock plates (16) and setscrews.

Tighten the setscrews to 12lbfft (16,3Nm) and lock the tabs to setscrews.

Remove completed turbocharger from the vice.

Installation Check List

Inspect the air intake system and the exhaust manifold for cleanliness and foreign matter.

Inspect the oil drain line and make sure it is not clogged.

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

Inspect the turbocharger mounting pad on the manifold to make certain that all the old gasket has been removed. On some applications an adaptor is fitted between the turbocharger and exhaust manifold assembly. The adaptor is secured to the manifold by four stud nuts and washers and it should be ascertained that all traces of the old gasket have been removed from it.

Install a new gasket between the turbocharger and exhaust manifold. In cases where an adaptor is fitted, it will be necessary to install a gasket between the adaptor and the manifold assembly before placing the turbocharger gasket over the four turbocharger locating studs fitted in the adaptor. Ensuring that the gaskets do not protrude into the openings of the manifold (and adaptor where fitted). The openings in the gaskets should preferably be 0.06in (1,6mm) away from the edge of the openings in the manifold and adaptor.

Install turbocharger and tighten mounting bolts or securing nuts.

Connect the oil supply line but leave the oil drain line disconnected.

Connect the compressor inlet and outlet piping. Check all joints for possible leaks. Make certain that the piping is not exerting a strain on the compressor cover.

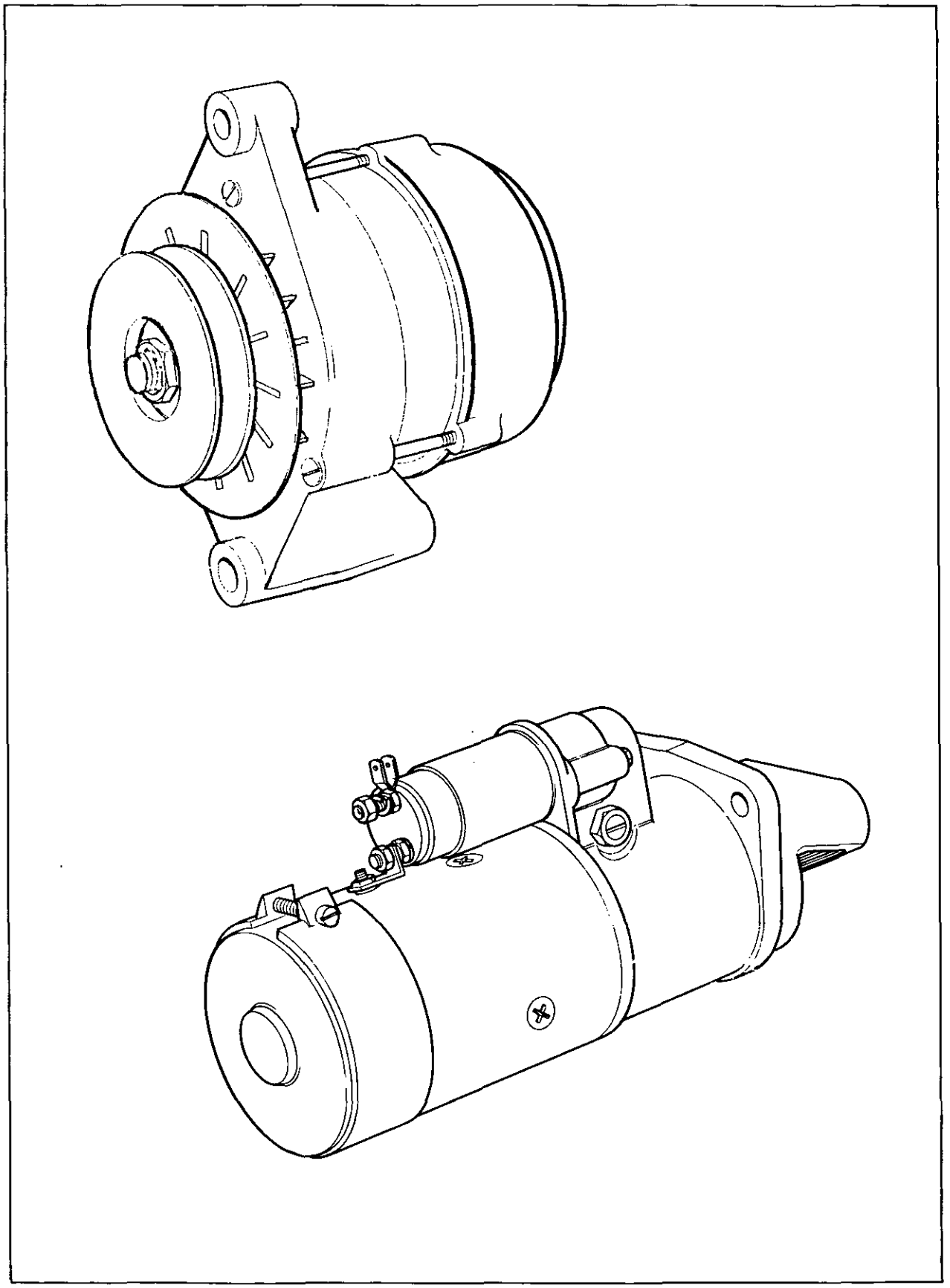
Connect exhaust pipe.

Motor the engine without firing (i.e. by operating stop control), until a steady flow of oil comes from the oil drain line.

Stop motoring and connect oil drain pipe connection.

Note: When the turbocharger is put into service, it is not advisable to run up to maximum speed or boost during the first 500 miles or 25 hours of running.

SECTION R
Alternator and Starter Motor



ALTERNATOR

Models AC5, 17ACR (derated), 17ACR, 18ACR, 25ACR or A133/65.

1. General

At the time of writing there are five types of alternator fitted to the T6.3544 and 6.3544 engine, namely the AC5, 17ACR, 18ACR, 25ACR and A133/65.

These are driven by the engine in the same manner as a DC Generator, namely, belt driven from the crankshaft pulley, but the advantage lies in their ability to provide higher maximum output at lower speeds, to cope with increased electrical load demanded by modern equipment and decreased road speeds owing to increased density of traffic, especially in built up areas. They are also much lighter in weight, output for output.

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

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

2. Precautions

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

They do not wear out and seldom require adjustment, but because they are sensitive to voltage changes and high temperature, the 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.

3. 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 unobstructed.

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

4. Fault Finding on AC5

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

(a) The warning light fails to illuminate when the generator is stationary, and the switch is closed OR fails to become extinguished when the alternator is running.

(b) No charging current is shown on ammeter.

(c) The battery is flat.

(d) The battery is "boiling", indicating loss of voltage control.

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

(a) Connect a good quality moving coil voltmeter 0—50 volts range across the battery or regulator negative terminal, and one of the three positive terminals marked LO, MED, HI. If an ammeter is not part of the applications circuit, fit a good quality moving coil 0—100 amp ammeter in the alternator to battery positive line. **The battery should be in a charged condition.**

(b) Close the warning light switch (master electric switch on dashboard) when the warning lamp should light up.

(c) Switch on a 10—15 amperes load such as lights, fans, etc.

(d) Start engine and run at fast idle speed when
1. The warning light should go out.
2. The ammeter records a small charge dependent on engine speed.

(e) Increase engine speed momentarily to maximum speed, when the charging current should be about 30 amperes for 24 volts — 55 amperes for 12 volt systems.

(f) With the alternator running at approximately half speed (engine speed about 1,500 rev min), switch off electrical load. Depending on the connection selected for the positive sensing wire LO, MED, or HI, the voltage should rise to between 26 and 28 volts on 24 volt systems and 13—14 volts on 12 volt systems and then remain constant. At the same time the current reading should drop appreciably.

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

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

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

Check the bulb.

If no fault

Check all wiring connections at regulator, alternator and battery.

If no fault

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

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

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

Check all regulator, alternator and battery connections.

If no fault.

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

Switch on, and run at fast idle.

If no output, alternator is faulty.

If output appears, regulator is faulty.

Warning Lamp does not go out when running and Ammeter shows reduced output with full output only at maximum speed or Warning Lamp goes out but Alternator delivers reduced output. Full output only at maximum speed.

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

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

Check for excessive resistance in regulator negative sensing lead.

If no fault, regulator is faulty.

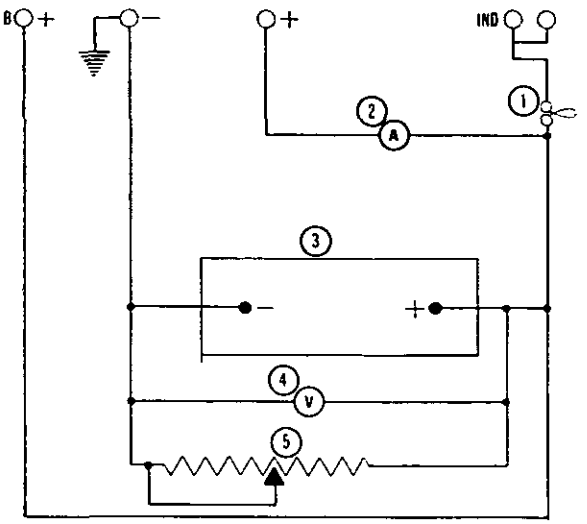
Batteries overcharging and Ammeter indicates high or full output all the time.

Check regulator positive sensing lead and its connection at regulator.

If no fault, regulator is faulty.

5. Testing the 17ACR, 18ACR, 25ACR and A133/65 in Position

First check the driving belt for condition and tension. The nominal hot outputs at 6,000 rev/min (alternator speed) are given on Page B12. 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.



Test Circuit for 17ACR alternators.
Standard terminations, battery-sensed.

R.1

Alternator Output Test with Regulator Inoperative

Withdraw the cable connector(s) 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. R.1, R.2 or R.3.

Value of components in Figs. R.1, R.2 and R.3 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.

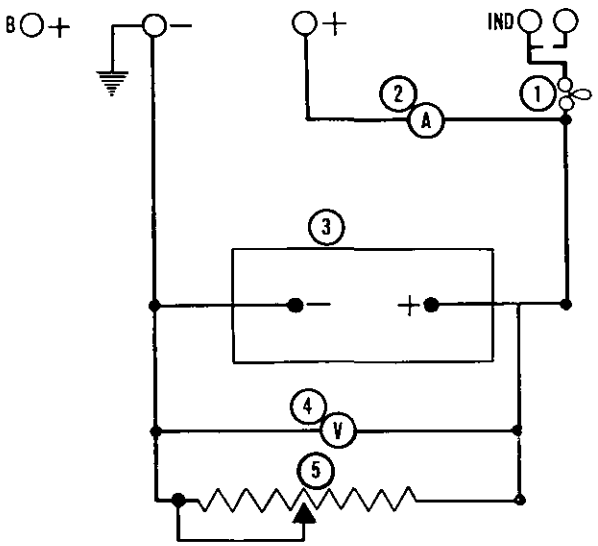
Failure of one or more of the diodes will be indicated in the above test by effect on alternator output, and also in some instances by abnormally high alternator temperature and noise level.

Regulator Test

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

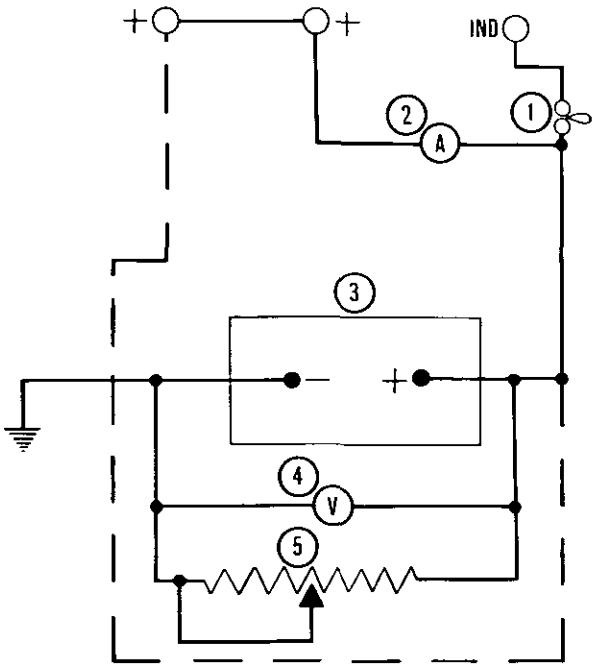
Disconnect the variable resistor and remove the earth connection from the regulator green lead or connector strip to frame.

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.



Test Circuit for 17ACR alternators with standard terminals and two piece connection plug (machine-sensed).

R.2



Test Circuit for 17ACR, 18ACR, 25ACR and A133/65 alternators with European terminations and single 3 terminal connector plug (machine-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 of "+".

R.3

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. Note the voltmeter reading.

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

Model M50

General Description

The model M50 starter motor is a four pole machine of 5in (127,0mm) 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 ensures that the motor develops its maximum torque only when full pinion-flywheel engagement has been achieved.

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 Acro Shell 6B or its equivalent.

MAINTENANCE

Brush Gear and Commutator

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

Be sure to refit the brushes in their original positions to retain the "bedding". The brushes should be well

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

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.

Model CA45

General Description

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

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

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

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

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

Ready access is possible therefore, to those parts most likely to require adjustment, such as the switchgear 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 Acro Shell 6B or its equivalent.

MAINTENANCE

Brush Gear and Commutator

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

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

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 re-connect 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.

SECTION S
Compressor

The air compressor is a single or twin cylinder water cooled unit which is bracket mounted on the cylinder block and driven from the auxiliary drive.

Should it be necessary to drain the engine cooling system to prevent damage by frost, the Clayton Dewandre compressor must also be drained. Drain plugs are provided on the compressor cylinder block. With the Bendix Westinghouse compressor, only the cylinder head is water cooled and this will be automatically emptied when the engine is drained.

If leakage in the braking system is not excessive, failure of the compressor to maintain adequate air in the system, or to charge the system in a reasonable *time, usually denotes loss of efficiency due to wear.* This wear could be in the cylinder head (valves and seats) or cylinders (piston assemblies). Another sign of wear is excessive oil passing through to the reservoir.

Preventive Maintenance

Every 5,000 miles (7,500 km), 250 hours or 4 months (whichever occurs first).

Remove, dismantle and clean compressor air cleaner (if fitted).

Every 10,000 miles (15,000 km), 500 hours or 12 months (whichever occurs first).

Visually check all unions, pipe fittings, etc., for looseness or leakage.

Check cylinder head bolts for correct tightness.

Check end covers for oil leaks.

Check that compressor mounting is secure.

Every 20,000 miles (30,000 km) or 1,000 hours
Uncouple delivery port and check the head passages for excessive carbon deposits which, if present, must be removed by dismantling the cylinder head.

Check compressor delivery line for carbon deposits, clean or replace line as necessary.

Every 60,000 miles (90,000 km) or 2,500 hours
Dismantle compressor, thoroughly clean all parts and *inspect for wear or damage. Repair or replace all* worn or damaged parts or replace with Factory Reconditioned Unit.

To Remove the Compressor

Drain the engine cooling system and compressor of coolant.

Remove hydraulic pump which may be fitted to rear of compressor.

Remove steadying bracket between compressor cylinder head and engine cylinder head.

Remove all connections to and from compressor.

Unscrew compressor mounting bolts and remove compressor from engine.

To Replace Compressor

The replacement of the compressor is a reversal to removal.

When the compressor is fitted, check that the clearance between the rubber insert and the forward half-coupling is 0.020/0.025 in (0,51/0,63 mm).

Should the clearance be incorrect, the half-coupling can be moved on the shaft to obtain the correct clearance.

CLAYTON DEWANDRE SC6 COMPRESSOR

Dismantling

Marking before dismantling
The compressor should have the following items marked to show the correct relationship to dismantling.

1. Position of cylinder head in relation to cylinder and crankcase.
2. Position of end-cover(s) in relation to crankcase.
3. Position of crankshaft in relation to crankcase.

Removing and Dismantling Cylinder Head and Cylinder

Remove the unloader cap and copper washer and withdraw the unloader plunger assembly and spring.

Remove the delivery valve cap and copper washer, and remove delivery valve spring and seat retaining spring.

Unscrew the four nuts and washers from cylinder head studs and lift off cylinder head. Remove the joint.

Remove the delivery valve and screw out the valve seat.

Withdraw inlet valve spring guide. (A simple extractor can be made from two ¼in UNF bolts and a strip of metal formed to bridge the guide.) Remove the inlet valve spring, inlet valve and valve seat.

Withdraw cylinder and remove the joint.

Removing and Dismantling Piston and Connecting Rod Assemblies

Remove the compressor mounting bracket and joint.

Turn the crankshaft to B.D.C. position and release the tabs of the locking strap. Unscrew the two bolts and remove the connecting rod cap. Withdraw piston assembly and replace connecting rod cap.

Remove the piston rings from the piston. If the piston is to be detached from the connecting rod, release one gudgeon pin retaining circlip and press the gudgeon pin from the piston and connecting rod.

Removing Crankshaft

Remove drive key from crankshaft.

Unscrew the four setscrews or nuts together with washers securing the rear end-cover to crankcase. Withdraw the end-cover, plain bearing, thrust washer (where fitted) and joint.

Unscrew the four setscrews or nuts securing the drive end-cover, and withdraw the end-cover complete with crankshaft and joint. Tap crankshaft with bearing from drive end-cover.

Cleaning

Ensure that all carbon is removed from the cylinder head. Check that the air passages in the head and the oilways in the crankcase, where applicable, rear end-cover and crankshaft are clear and clean.

Clean inlet and discharge valves, not damaged or worn excessively, by lapping them on a sheet of crocus cloth held on a flat surface.

Inspection of Parts

Cylinder

Check cylinder bore for excessive wear, out-of-round or scoring. If scored or out-of-round more than 0.002in (0,05mm) or tapered more than 0.003in (0,08mm) cylinder should be rebored. The original cylinder bore is to the limits 2.6255/2.620in (66,69/66,71mm) and the clearance for the piston is 0.002/0.003in (0,05/0,08mm). Check for wear in cylinder bore and rectify in accordance with following table:

Wear in bore	Remedy
+0.005in (0,13mm)	Fit new standard rings.
+0.005/0.010in (0,13/0,25mm)	Bore out to +0.010in (0,25mm) and fit 0.010in (0,25mm) oversize piston rings.
+0.015in (0,38mm)	Fit new 0.010in (0,25mm) oversize rings.
+0.015/0.020in (0,38/0,51mm)	Bore out to +0.20in (0,51mm) and fit 0.020in (0,51mm) oversize piston and rings.
+0.025in (0,63mm)	Fit new 0.020in (0,51mm) oversize rings.

Piston and Connecting Rod

Inspect piston for scores, cracks or damage of any kind. Check fit of rings in ring grooves, clearance should be 0.0005/0.0025in (0,01/0,06mm). Install rings in cylinder and check that gaps are 0.003/0.007in (0,08/0,18mm). Check fit of gudgeon pin in piston and connecting rod. Gudgeon pin should be a light press fit in piston and clearance in the connecting rod bush should not exceed 0.0015in (0,04mm).

Inspect connecting rod bearing for correct fit on crankshaft journal. Clearance between rod journal and bearing must not be less than 0.001in (0,02mm) and not more than 0.003in (0,08mm). Check connecting rod for cracks or damage.

Crankshaft and Bearings

Examine ball bearings for discoloration, pitting wear and cracked races. Rotate slowly to check for roughness. Defective bearings should be removed, using a well-fitting extracting tool. Press new bearing on to crankshaft, using a suitable length of tube, until it contacts shoulder.

Inspect crankshaft for wear and check threads, shaft ends, keyways and drive keys for damage. The crank pin diameter should be within the limits 0.874/0.8735in (22,20/22,19mm).

Crankshaft and End-covers

Inspect oil seal carefully, ensuring that sealing edge is intact and sharp. If an oil leak has been observed at the crankshaft end, a new seal must be fitted. Lip of seal should face inwards.

Examine crankcase, end-cover and mounting bracket for damage and cracks. Check bearing bores for wear. The ball race should be a light press fit in end-cover and the crankshaft should be a neat sliding fit in the plain bearing. Inspect crankshaft thrust washer for wear (where fitted).

Cylinder Head

Inspect cylinder head for cracks and unloader plunger guide bush for wear. Check that unloader plunger is a neat sliding fit in the guide. If it is necessary to replace the unloader piston guide, this will be found to have an undersized bore, and will require reaming in situ to 0.3745/0.3755 in (9,51/9,54mm). Ensure that the bore is machined square to the underside of the cylinder head. The maximum finish of the guide bore should be 25 micro inches (0,6microns). A chamfer is also required at the top of the guide bore to an angle of 15° and to a depth of 0.102in (2,59mm). Make sure that the guide and chamfer angle are free from burrs. Examine unloader plunger seal ring for wear. Inspect inlet and delivery valves and seats. If valves are grooved deeper than 0.003in (0,08mm) where they contact the seat, they should be replaced. If not badly grooved they can be refaced by lapping on crocus cloth. Valve seats, if showing slight scratches, may be reclaimed by lapping with fine grinding paste. If badly pitted or scratched, use a seating reamer before lapping.

Renew delivery valve spring and check remaining springs for corrosion, fatigue or permanent set.

Re-assembly

Lubricate all internal parts with clean engine oil to prevent possible damage until the oil supply is functioning.

Install the crankshaft, complete with bearing, into the drive end-cover. Insert the crankshaft into the crankcase and secure the drive end-cover, ensuring that the joint is correctly positioned over the oil drain ports.

Position the thrust washer in the rear end-cover with the steel face towards the plain bearing and the tab located in the slot. Assemble the rear end-cover with joint and secure. Check the crankshaft to ensure free rotation and then tighten end-cover nuts or bolts. Fit the drive key to the crankshaft.

Refit the piston rings, ensuring that sides marked "Top" are uppermost, and assemble the piston to the connecting rod. Assemble the connecting rod on the crankshaft, tighten the bolts to a torque of 4lbfft (0,55kgfm) or 5,4Nm, and turn up the tabs of the locking strap. Space the piston ring gaps and assemble the cylinder, with joint, over the piston.

Assemble the cylinder head. Lightly smear the outside diameters of the inlet valve seat and spring guide with "Loctite", or equivalent, sealing compound. Insert the inlet valve seat, inlet valve and valve spring and press the spring guide into position. Screw in the delivery valve seat, using a wrench inserted in the hexagonal hole through the centre of the fitting, and tighten securely. Place the delivery valve on the seat and position the springs. Screw in the valve cap together with the copper washer. Lightly smear the unloader plunger with "Dow-Corning" grease, and insert the spring and plunger complete with the spring circlip. Screw in the unloader cap together with copper washer.

Place the joint on the cylinder and correctly position the cylinder head on the studs. Tighten nuts progressively to a torque of 10lbfft (1,38kgfm) or 13,6Nm.

Invert the compressor and apply clean engine oil over the crankshaft and on the cylinder wall. Assemble the mounting bracket and joint.

BENDIX WESTINGHOUSE TWIN 9 COMPRESSOR

To Dismantle Compressor

Remove filter assembly, filter element and adaptor plate.

Remove top cover and cylinder head/valve plate assembly.

Remove valve plate from cylinder head. Mark valves, springs and valve cages to identify position.

Remove mounting bracket and gasket.

Mark connecting rods and caps to identify position.

Release big end securing bolts and remove piston/connecting rod assembly. (Note it is important to release big end bolts before the bolts securing the end cover).

Remove gudgeon pins to release pistons from connecting rods.

Remove piston rings.

Remove end cover.

Remove plastic cover from non-drive end of compressor (if fitted).

Remove crankshaft with thrust washer.

Remove all seals, "O" rings and gaskets.

Reconditioning

All gaskets, seals and "O" rings should be renewed.

The cylinder head and associated parts, and the pistons should be cleaned of any carbon present. The valve discs, springs and valve guides should be renewed. The valve seats may be lapped with a fine grinding paste, but if there is any appreciable wear, the valve plate should be renewed.

The unloading pistons must be a neat sliding fit in the guide bushes. If wear is apparent, renew the pistons or bushes as necessary.

The maximum permissible worn diameter of the cylinder bores is 2.257in (57,33mm).

The clearance of the compression rings in the piston grooves is 0.0005/0.002in (0,012/0,051mm) and that of the scraper rings is 0.0005/0.0025in (0,012/0,063mm). The gap of the compression and scraper rings in the cylinder is 0.003/0.007in (0,08/0,18mm).

If the piston rings are being refitted and are bedded for more than the 30% of the width or if new rings are being fitted, the glaze on the cylinder bores must be broken.

The clearance of the crankshaft in the main bearings should not exceed 0.0035in (0,09mm), whilst the clearance of the crankpins in the big end bearings should not exceed 0.003in (0,08mm).

The end float of the crankshaft is 0.004/0.012in (0,10/0,30mm).

The gudgeon pin should be a light press fit in the piston and the clearance of the pin in the small end of the connecting rod should not exceed 0.0015in (0,038mm). Renew gudgeon pin circlips if necessary.

To Re-assemble Compressor

Clean all parts, remove all jointing compound and gaskets. Ensure that all oilways and water passages are clean and free from obstruction. Lightly oil all bearing surfaces, journals and thrust washer faces.

Fit oil seals to crankcase and end cover.

Fit crankshaft to crankcase ensuring that oil seal is not damaged by the edges of the slot in the crankshaft.

Fit thrust washer to crankshaft.

Coat joint face of end cover with sealing compound and fit end cover to crankcase securing with setscrews and spring washers.

Tighten setscrews to 9lbfft (1,24kgfm) or 12,2Nm.

Ensure that end float of crankshaft is correct.

Fit connecting rod to piston. Fit gudgeon pin and secure with circlip.

Fit piston rings to piston, ensuring that the ring gaps are equally spaced around the piston. The two compression rings on each piston must be fitted with the internal steps or chamfers towards the piston crown. Rings are usually marked with the word "top" or "bottom" on the appropriate face to aid correct fitting.

Lubricate piston rings and cylinder bores thoroughly with clean engine oil before fitting pistons in cylinders.

Fit piston/connecting rod assemblies in crankcase, ensuring that they are fitted with the tooling hole in the connecting rod facing inwards towards the centre line of the compressor.

Fit big end caps and secure with bolts and tabwashers. Tighten bolts to 9lbfft (1,24kgfm) or 12,2Nm and lock tabwashers.

Ensure compressor has free rotation.

Fit "O" rings to unloader pistons, lubricating assemblies with Silicone Fluid MS200. Fit unloader piston assemblies to crankshaft. Fit spring and saddle. Ensure that unloader pistons have free movement.

Fit inlet and exhaust valves, springs and valve guides to cylinder head. Fit valve plate to cylinder head with gasket and secure with countersunk screw. Tighten screw to 50lbfin (0,57kgfm) or 5,6Nm.

Ensure valves have free movement after assembly.

Fit cylinder head/valve plate assembly with gasket to crankcase. Fit cover with gasket to cylinder head. Secure with nuts and spring washers where studs are fitted and with bolts and spring washers at tapped hole

positions. Tighten nuts and bolts to 17lbfft (2,35kgfm) or 23Nm progressively.

Fit mounting bracket with gasket to base of compressor with bolts and spring washers. Tighten bolts to 17lbfft (2,35kgfm) or 23Nm progressively.

Where required, fit plastic cover to non drive end of compressor and crankshaft.

Coat joint face of filter adaptor with sealing compound and fit plate to crankcase. Secure with countersunk screws tightened to 50lbfin (0,58kgfm) or 5,6Nm.

Fit new filter element to filter body. Fit retaining plate and retain with bolts and spring washers.

Fit filter assembly to adaptor plate and secure with nuts and spring washers tightening to a torque of 9lbft (0,124kgfm) or 12,2Nm.

Fit key to drive end of crankshaft.

Finally protect all ports to prevent ingress of foreign matter.

Data and Dimensions for Bendix Westinghouse Twin 9 Compressor

Cylinder bore diameter	2.250/2.251 in (57,15/57,18 mm)
Max. permissible worn bore diameter	2.257 in (57,33 mm)
Clearance of piston skirt in bore	0.0023/0.0043 in (0,06/0,11 mm)
Clearance of compression rings in piston grooves	0.0005/0.002 in (0,012/0,051 mm)
Clearance of scraper rings in piston grooves	0.0005/0.0025 in (0,012/0,063 mm)
Compression ring gap in cylinder	0.003/0.007 in (0,08/0,18 mm)
Scraper ring gap in cylinder	0.003/0.007 in (0,08/0,18 mm)
Crankpin diameter	1.2495/1.250 in (31,74/31,75 mm)
Big end running clearance	0.005/0.0015 in (0,012/0,038 mm)
Max. permissible worn big end bearing running clearance	0.003 in (0,076 mm)
Main journal diameter	1.2482/1.2491 in (31,70/31,73 mm)
Main bearing running clearance	0.0009/0.0028 in (0,02/0,07 mm)
Max. permissible worn main bearing running clearance	0.0035 in (0,09 mm)
Crankshaft end float	0.004/0.012 in (0,10/0,30 mm)
Max. permissible end float on worn compressor	0.017 in (0,43 mm)

Recommended Torques

Cylinder head bolts/nuts	17 lbf ft (2,35 kgf m) or 23 Nm
End cover bolts	9 lbf ft (1,24 kgf m) or 12,2 Nm
Mounting bracket bolts	17 lbf ft (2,35 kgf m) or 23 Nm
Strainer mounting nuts	9lbf ft (1,24kgf m) or 12,2 Nm
Strainer adaptor screws	50lbf in (0,58kgf m) or 5,6 Nm
Big End Bolts	9lbf ft (1,24kgf m) or 12,2 Nm

Drive Coupling (Holset)

With the compressor fitted to the engine and the coupling assembly in place on the auxiliary drive shaft the distance between the two halves of the coupling (see Fig. S.1 dim. C) must be adjusted to the value given in the table below. When fitting the coupling, ensure that the scribed lines on the outside of the flanges are in line.

Coupling diameter	Dimension C	Diff. between C1 and C2
3.875in (98,4mm)	0.146/0.250in (3,71/6,35mm)	0.068in (1,71mm)
3.00in (76,2mm)	0.125/0.187in (3,18/4,75mm)	0.052in (1,32mm)

The parallel alignment can be checked with a straight edge and feeler gauge to dimension B as shown in Fig. S.1.

To check the angular alignment find the difference between C1 and C2 as shown in Fig. S.1. If this difference is the same as or less than the dimension given in the chart above any angular misalignment will be 1° or less which is satisfactory.

On later engines the coupling setscrews and separate tab washers have been replaced by washer-faced setscrews only. These setscrews should be tightened to 18lbfft (24,4Nm), 2,5kgfm.

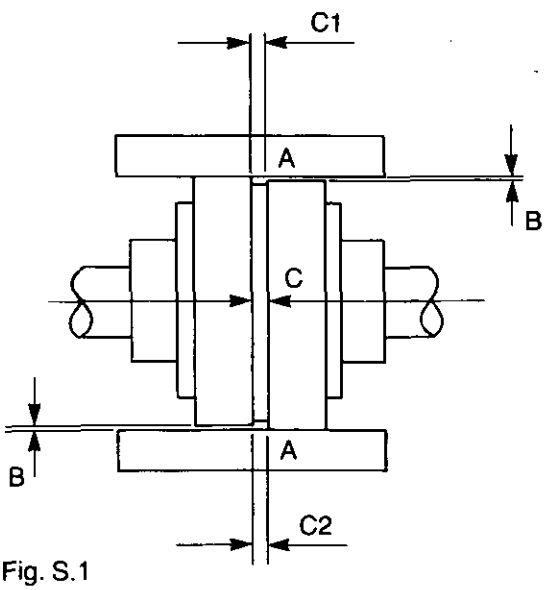


Fig. S.1

A. Straight edge
B. Max. 0.006in (0,15mm)
C. Gap between coupling halves
C1. Max. gap
C.2 Min. gap

SECTION T
Exhausters

DESCRIPTION

The A.350 type exhauster is a rotary sliding vane pump, with an eccentrically mounted rotor.

The unit is bolted directly against the side of the engine crankcase and is driven through a flexible coupling, by a shaft which is connected to the timing gears and also drives the fuel pump. The exhauster body and end covers are of cast iron, and house an aluminium rotor die-cast on to a steel shaft. The rotor has four equi-spaced slots to accommodate fibre blades. The shaft runs in sintered bronze plain bearings fitted in the end cover, which, if bored straight through, also contain seals to prevent the ingress of air and dirt and the leakage of oil from the exhauster. The drive end of the shaft is machined to accept a Woodruff key, thus ensuring non-slip drive. The intake port in the exhauster is pipe-connected to the vacuum reservoir, and the outlet port formed in the base of the exhauster aligns with an aperture in the engine crankcase.

Lubrication is by engine pressure feed, oil entering through a connection in the rear end cover to an annular groove in the bearing housing, from which it passes through a hole in the bearing to oilways in the rotor shaft, communicating with the slots in the rotor. The plain bearing fitted in the drive end cover receives oil through an extension of the main oil way in the rotor shaft, a passage in the drive end cover to the vacuum side of the pump relieving oil pressure on the seal.

OPERATION

At all speeds the rotor blades are kept in contact with the bore of the body by centrifugal force, assisted by the hydraulic action of the oil beneath the blades. When the rotor turns, the spaces between the blades vary, because of the eccentric mounting of the rotor in the exhauster body. As a blade passes the inlet port the space between it and the following blade increases and air is drawn from the vacuum reservoir. This air is then compressed and expelled with the lubricating oil through the outlet port to the engine crankcase.

SERVICING EXHAUSTER

Periodic Inspection and Preventive Maintenance

Weekly or every 5,000 miles

Examine the vacuum lines and fittings. Vacuum leakage may occur through the line or reservoir mounted non-return valve, if the valve seat is dirty or pitted. Should leakage occur, the exhauster will pressurise the engine crankcase, resulting in oil leakage at the crankshaft seals and other joints. Examine the exhauster for evidence of oil leakage, particularly at the end cover joints and at the shaft oil level. Check the oil supply line for leaks at fittings and connections.

Every 10,000 miles

Check the mounting setscrews and end cover retaining screws for tightness.

Every 60,000 miles

Remove and dismantle the exhauster, thoroughly clean all parts and inspect them for wear and damage. If the exhauster is well worn it will be advisable to return it to Perkins Engines Ltd., in exchange for a factory reconditioned unit.

To Remove the Exhauster

Disconnect the oil vacuum pipes at the exhauster and plug the open unions to prevent the entry of foreign matter. Release the driving coupling from the end of the rotor shaft. Unscrew the setscrews which secure the exhauster to the crankcase, and remove the unit from the engine.

Dismantling

Mark the end covers in relation to the body to ensure correct location on re-assembly. Unscrew the four socket-headed screws and remove the rear end cover with the rubber sealing ring. Mark the blades in relation to the rotor and withdraw the rotor complete with blades from the body. Unscrew the four socket-headed screws and remove the drive end cover with its rubber sealing ring.

CLEANING AND INSPECTION

Cleaning

Wash all the components in cleaning solvent and clear the rotor and drive end cover oil ways with compressed air.

Inspection of Parts

Examine the bushes for excessive wear. To renew them see "Overhaul" section. Inspect the rotor and shaft for cracks and damage, check the fit of the fibre blades in the rotor slots and replace any worn or damaged blades. Examine the seals carefully to see that the sealing edges are pliable, intact and sharp. Seals rendered ineffective (usually by dirty oil and grit) should be renewed as prescribed in the section headed "Overhaul". Examine the body for cracks and damage and the bore for longitudinal

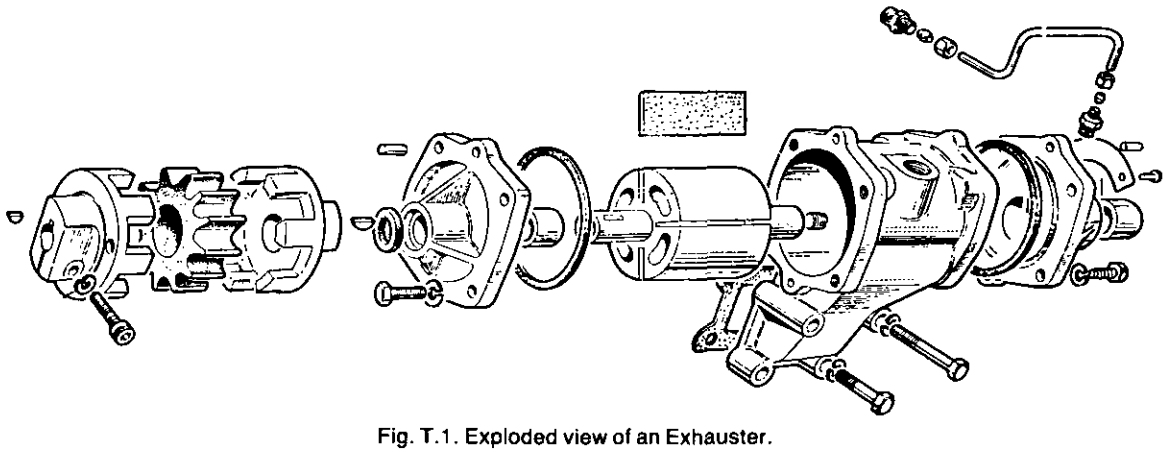


Fig. T.1. Exploded view of an Exhauster.

ripples or lines. If these are only slight the body is still serviceable, if excessive the body should be renewed. Examine the end covers, and renew them if they are cracked or scored.

OVERHAUL

To renew End Cover Bearings and Seals

Drive End Cover

Extract the seal from the drive end cover and press in the new one until the steel seal holder abuts against the shoulder in the cover. With the seal removed, press the worn plain bearing out of the cover using a bar or tube 1 1/16 in diameter. Press the new bearing into the cover until it is 1/8 in below the cover face.

Rear End Cover

Blank end covers are not fitted with seals. The bearing should be extracted or machined out taking care not to damage the housing, or in an emergency it may be removed by cutting a groove along the bearing, using a narrow half round chisel. Inspect the housing, remove any burrs and press the new bush fully into the cover. Where the rear end has been bored straight through and blanked off, the circlip should be removed followed by the blanking disc and 'O' ring, which acts as a seal. The bush may then be pressed out of the cover, using a bar or tube, 1 1/16 in diameter. When replacing these components it is advisable to fit the circlip in its groove and then refit the blanking disc followed by a new 'O' ring. The new bush should be pressed into the cover until it slightly compresses the 'O' ring against the blanking disc, the resulting reduction in internal diameter of the 'O' ring ensuring an effective seal on the shaft. The large rubber 'O' rings which seal the gaps between the exhauster body and the end covers, should be renewed if they appear to be in any way compressed or damaged.

Re-assembly

Lubricate all moving parts with clean engine oil.

Carefully insert the shaft into the drive end cover, avoiding damage to the seal.

With the large rubber 'O' ring fitted in its groove in the cover, assemble the latter to the body, locating the dowels in their respective holes.

Hold the body, drive end downwards, and replace the blades in the rotor slots, making sure that the marks made during dismantling correspond.

Install the rear end cover with its rubber 'O' ring on to the body (ensuring that the dowels locate in their respective holes) and tighten the socket-headed screws.

Turn the rotor by hand to make sure that it revolves freely.

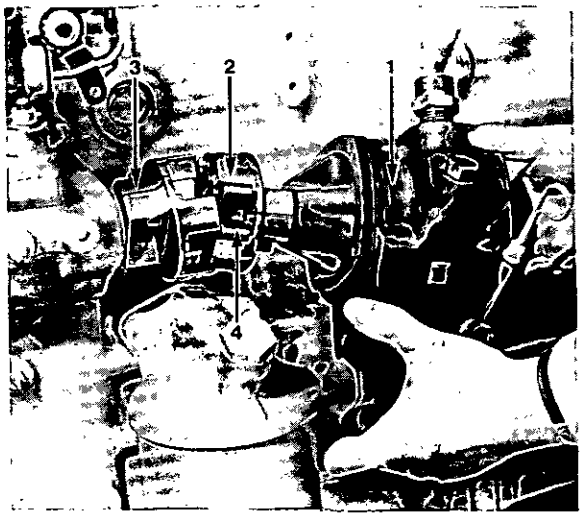


Fig. T.2. Removing Exhauster.

1. Exhauster.
2. Exhauster Coupling (Driven Half).
3. Exhauster Coupling (Drive Half).
4. Rubber Coupling.

Installation

Replace the joint and remount the exhauster securely to the engine crankcase, with the coupling halves fitted loosely on the shafts.

Where there are scribed lines on the outside of the coupling flanges, these must be in line.

Ensure that there is approximately 1/8 in (3mm) between auxiliary shaft oil seal and front half coupling.

Where Simms couplings are fitted (Fig. T.2), ensure that there is a nominal clearance of 3/64 in (1,2mm) between the rubber coupling and each half coupling. Where Holset couplings are fitted, check the parallel and angular alignment with a straight edge and feeler gauges as shown in Fig. T.3.

When the alignment is correct tighten the coupling setscrews and in the case of earlier Holset couplings lock the setscrews with the tab washers. Later Holset couplings have washer faced setscrews without tabwashers and these setscrews must be tightened to 18 lbf ft (24 Nm) 2,5 kgf m.

Reconnect the oil feed and vacuum pipes.

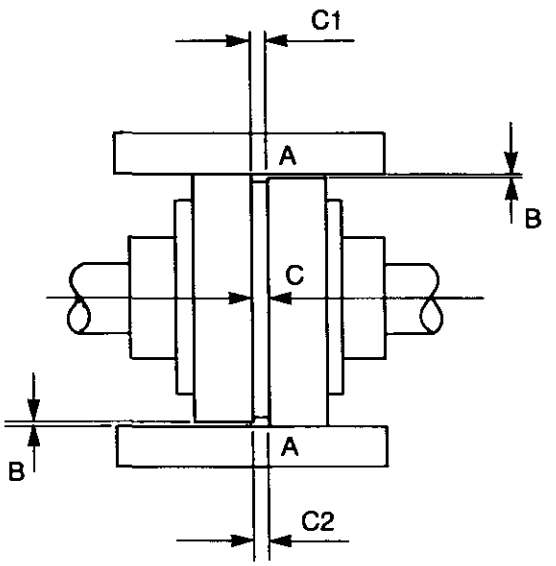


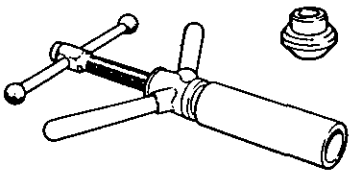
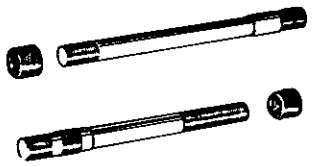
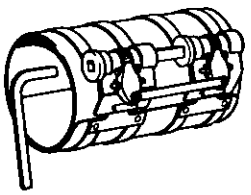
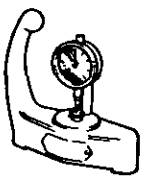
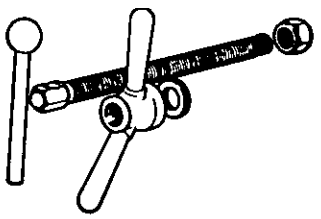
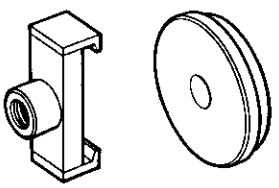
Fig. T.3

A.	Straight edge	C1. Max. gap
B.	Max. 0.006 in (0,15 mm)	C.2 Min. gap
C.	Gap 0.125/0.187 in (3,18/4,75 mm)	Max. difference C1-C2, 0.052 in (1,32 mm)

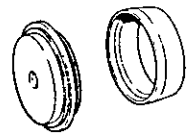
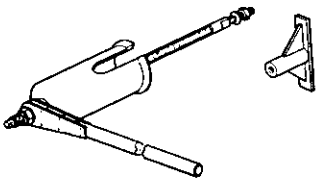
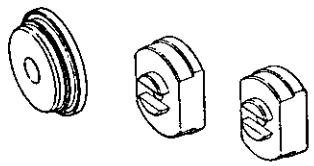
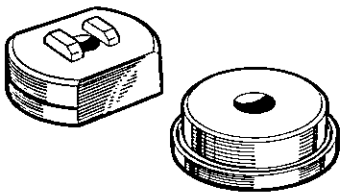
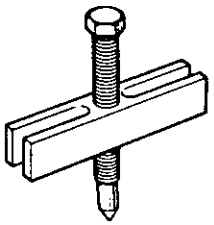
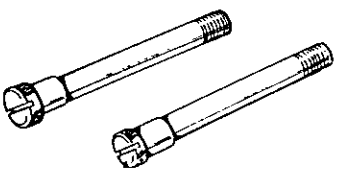
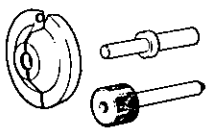
SECTION U
Approved Service Tools

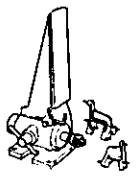
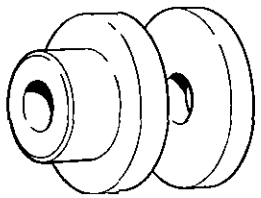
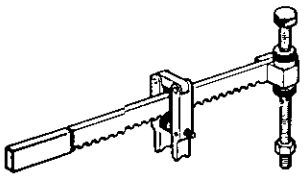
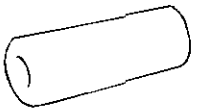
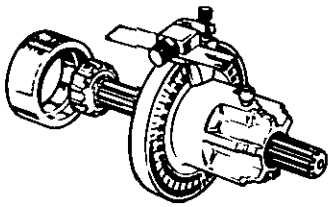
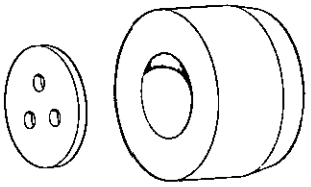
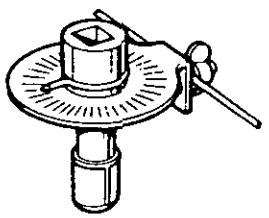
Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England, NN11 4NF.

The numbers shown in brackets after the Churchill tool number are the part numbers of equivalent Perkins tools. Perkins tools are available through your Perkins Distributor.

	Tool No.	Description
	PD.1D (21825026)	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)
	PD.1D-1A (21825027)	ADAPTOR FOR PD.1D OR 21825026 A pair of puller bars fitted with knurled nuts. Suitable for 5/16" and 3" guides. The necessary distance piece from the adaptors below should also be used.
	PD.1D-6 (21825030)	ADAPTOR FOR PD.1D OR 21825026 A 19/32" (15mm) distance piece used to replace valve guides to a set height.
	No. 8 (21825018)	PISTON RING SQUEEZER
	PD.41B (21825019)	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	PD.140	CAMSHAFT BUSH/THRUST COLLAR REMOVER
	PD.140-3	FUEL PUMP THRUST COLLAR REMOVER/REPLACER ADAPTORS

APPROVED SERVICE TOOLS—U2

	Tool No.	Description
	PD.145	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL)
	PD.150A (21825052)	CYLINDER LINER REMOVER/REPLACER (MAIN TOOL) For Field Service replacement of single liners. Not advised for complete overhaul. For this work use adaptors with a hydraulic ram unit.
	PD.150-1B (21825054)	ADAPTORS FOR PD.150 Suitable for cylinders of 3.6" dia. and 3.87" dia. Removal and replacement.
	PD.150-7A (21825057)	ADAPTORS FOR PD.150 Suitable for cylinders of 3.97" dia. Removal and replacement.
	PD.155C	BASIC PULLER For the removal of gears or pulley. Used with the adaptors below.
	PD.155A-1 PD.155B-5	ADAPTORS FOR PD.155B or PD.155C With UNF threads. ADAPTORS FOR PD.155B or PD.155C With Metric threads.
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.

	Tool No.	Description
	335	CON ROD JIG & 336 MASTER ARBOR
	336-102	ARBOR ADAPTOR Used with 335
	6118B-4 (21825020)	VALVE SPRING COMPRESSOR
	6118B-4 (21825023)	ADAPTOR FOR 6118B
	MS67B	TOOL FOR CHECKING FUEL INJECTION TIMING
	PD.163 (21825042)	TIMING CASE CENTRALISING TOOL.
	MS 73 (21825064)	ADJUSTABLE VALVE SEAT CUTTERS
	MS.1531	ANGLE GAUGE TO TIGHTEN CYLINDER HEAD FASTENERS

INDEX

Alternator AC5, 17ACR, 18ACR, 25ACR and A133/65
- Precautions R2
- Maintenance R2
- Fault Finding AC5 R2
- Testing 17ACR, 18ACR, 25ACR and A133/65 R3
- Data B12

Altitude, De-rating B2
Amendment Status Page 2
Atomisers
- Data B12
- General N7
- Pressure Setting B12

Belt, Fan, Adjustment M2
Bearing, Main, Data and Dimensions B6
Bearing, Main, To Fit H4
Block, Cylinder G2
Block, Cylinder, Data and Dimensions B3
Bush, Auxiliary Drive Shaft Front, Data and Dimensions B8
Bush, Auxiliary Drive Shaft Rear, Data and Dimensions B9
Bush, Connecting Rod, Small End, Data and Dimensions B5
Bush, Connecting Rod, to Renew F3

Case, Timing, To Remove J2
Case, Timing, To Refit J3
Camshaft, Data and Dimensions B6
Camshaft, To Remove J4
Camshaft, To Replace J4
Compressor
- Preventive Maintenance S2
- To Remove S2
- To Replace S2

Compressor SC6
- Dismantling S2
- *Cleaning* S2
- Inspection of Parts S3
- Re-assembly S3

Compressor, Twin 9
- Data and Dimensions S5
- To Dismantle S4
- To Re-assemble S4
- To Recondition S4

Cooler, Air Charge (integral air/water) M7
Cooler, Air Charge, Description N4
Cooler, Oil
- To Remove L5
- To Dismantle L5, 6 and 7
- To Re-assemble L5, 6 and 7
- To Test L7
- To Refit L7

Cooler Adaptor
- Oil Cooler to Cylinder Block L7

Cooling System, Data B10
Cooling System, Description M2
Cooling System, To Drain M3

Crankshaft
- Data and Dimensions B6
- Description H2
- Description H2
- To Regrind H3
- To Fit H4

Data, Engine B1

Exhaust Smoky, Fault Finding D2

Fault Finding Chart D2
Filter
- Air, Dry Type N2
- Air, General N2
- *Air, Oil Bath Type* N4
- Fuel, Data B10
- Fuel, To Renew Element N4
- Lubicating Oil, Data and Dimensions B10
- Lubricating Oil, To Renew L8

Foreword Page 5
Flywheel, Alignment P2
Flywheel, To Remove P2
Flywheel, To Refit P2
Flywheel, Runout P2
Fuel System Bleeding N8

Gasket, Cylinder Head E2
Gear
- Auxiliary Drive Shaft, Data and Dimensions B8
- Auxiliary Drive Shaft, To Remove J2
- Auxiliary Drive Shaft, To Refit J3
- Camshaft, Data and Dimensions B8
- Camshaft, To Remove J2
- Camshaft, To Refit J3
- Crankshaft, Data and Dimensions B8
- Flywheel Ring P2
- Hydraulically Loaded Wormwheel, Data and Dimensions B9
- Idler, Data and Dimensions B8
- Idler, To Remove J4
- *Idler, To Refit* J4
- Timing, Backlash B8
- Timing, Backlash, Checking J6

Guide, Valve, Data and Dimensions B7
Guides, Valve E6

Head, Cylinder
- Data and Dimensions B7
- To Remove E2
- To Overhaul E6
- To Fit E3

Housing, Flwyheel, Alignment Limits P3
Housing, Flywheel, To Remove P2
Housing, Flywheel, To Refit P2
Hub, Idler Gear, Data and Dimensions B8
Hub, Idler Gear, To Remove J4
Hub, Idler Gear, to Refit J4

Inserts, Valve Seat E7

Jets, Piston Cooling
- Description J6
- Nozzle Positioning M6
- To Refit M6
- To Remove M6

Liner, Cylinder G2
- *Data and Dimensions* B3
- To Renew G2

Lubricating Oil
- Circulation L3
- Operating Pressure B1
- High Pressure, Fault Finding D2
- Low Pressure, Fault Finding D2

Misfire, Engine, Fault Finding D2

Number, Engine Location *Page 5*

Overheating, Engine, Fault Finding D2

Pin, Gudgeon, Data and Dimensions B5
Piston and Rod
- To Assemble F3
- Data and Dimensions B3-B4
- To Dismantle F2
- Inspection F3

INDEX (continued)

- To Remove F2
- To Fit F5

Power Lack, Fault Finding D2
Pressure, Crankcase, Fault Finding D2
Pulley, Crankshaft, To Fit H6
Pulley, Crankshaft, To Remove H2
Pump, Fuel Injection
- Idling Speed Setting N7
- Maximum Speed Setting N7
- Data B10
- Description N5
- Basic Timing K3
- To Check Timing K3
- To Remove N6
- To Fit N6

Pump, Fuel Lift
- Data B10
- Dismantling N5
- Re-assembly N5
- To Remove and Fit N5

Pump, Lubricating Oil
- Clearances B9
- Data B9
- Inspection L4
- To Dismantle L3
- To Re-assemble and Refit L4
- To Remove L3

Pump, Water
- Data and Dimensions B10
- To Dismantle M4
- To Re-assemble M4
- To Remove M4
- To Refit M5

Push Rod, Data and Dimensions B8
Push Rod E8

Rating, Details B1
Restriction Indicator N2
Ring, Piston, Data and Dimensions B3-B5
Rings, Piston, To Fit F4
Rings, Piston, To Check Gaps F3
Rockers, Data and Dimensions B8
Rod, Connecting
- Alignment F3
- Data and Dimensions B5
- Bearings, Data and Dimensions B6
- Inspection F3
- To Remove F2
- To Replace F4

Safety Precautions Page 6
Seal, Crankshaft Front End Oil, To Renew J2
Seal, Crankshaft Rear End Oil, To Fit H7
Seal, Rocker Shaft Oil Feed Connection, Fitting E3
Shaft, Auxiliary Drive, To Remove J5
Shaft, Auxiliary Drive, To Refit J6
Shaft, Auxiliary Drive Assembly, Data and Dimensions B8
Shaft, Fuel Injection Pump Drive, To Remove J4
Shaft, Fuel Injection Pump Drive, To Refit J5
Shaft, Rocker, Data and Dimensions B8
Shaft, Rocker, Dismantling and Assembly E8
Spring, Inner Valve, Data and Dimensions B7
Spring, Outer Valve, Data and Dimensions B7
Springs, Valve E7
Starter Motor M50
- General Description R4
- Maintenance R4
- Testing on Vehicle R4

Starter Motor CA45
- General Description R5
- Maintenance R5
- Testing on Vehicle R5

Starting, Difficulty, Fault Finding D2
Sump
- Data B9
- To Remove L3
- To Replace L3

Strainer, Lubricating Oil L3

Tappets, Data and Dimensions B8
Tappets, To Remove J4
Tappets, To Replace J4
TDC, How To Set M3
Thermostat
- Data B10
- Testing M3
- To Remove and Refit M3

Thermostart N9
Timing, Fuel Injection, Checking K3
Timing, Fuel Injection, Basic K3
Timing, Fuel Injection Static, Position B11
Timing Valve, Checking K7
Tools, Approved Service U1
Torque, Recommended Tensions B1
Turbocharger T-04B
- Cleaning Q5
- Dismantling Q5
- Fault Diagnosis Q2
- Inspection Q6
- Installation Check List Q9
- Re-assembly Q6
- Reconditioning Q2

Turbocharger 3LD
- Cleaning Q4
- Dismantling Q3
- Fault Diagnosis Q2
- Inspection Q4
- Installation Check List Q9
- Re-assembly Q4
- Reconditioning Q2

Turbocharger 3LM & S-76
- Cleaning Q7
- Dismantling Q6
- Fault Diagnosis Q2
- Inspection Q7
- Installation Check List Q7
- Re-assembly Q8
- Reconditioning Q2

Valves
- Assembly E5
- Exhaust, Data and Dimensions B7
- Inlet, Data and Dimensions B7
- Inspection E6
- Seats, Valve E6
- Tip Clearances E5
- To Fit E5
- To Remove E5

Valve, Oil Pressure Relief
- Removal and Dismantling L4
- Re-assembly and Refitting L4
- Data and Dimensions B9

Washers, Auxiliary Drive Thrust, Data and Dimensions B9
Washer, Camshaft Thrust, Data, B7
Washer, Crankshaft Thrust, Data and Dimensions B6
Washer, Crankshaft Thrust, To Renew H2
Weights, Engine B1

workshop manual supplement for 6.3544M Series Range 4 Series 6 HD Series marine diesel engines

Perkins Group Limited
Peterborough England
1991

The publication supersedes the previous complete marine manual, edition 601 SER0689 1155.

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

Published by Perkins Power Sales and Service Limited and printed in England by Fisherprint Ltd.

Foreword

Since the basic design of the 6.3544 marine engines is similar to that of the 6.3544 Series engines, they can be serviced to a large extent in accordance with the instructions given in the appropriate sections of the 6.3544 Series Workshop Manual and the HD Power and Range 4 Users Handbooks.

However certain special components are fitted to marine engines and it is for the servicing of these items that this supplement has been prepared.

Those items that are different or additional to the non-marine engine are shown in this supplement under the appropriate main heading.

For further information refer to the 6.3544 Series Workshop Manual and the HD Power and Range 4 Users Handbooks.

The different models and types of engines covered in this supplement are listed below:

6.3544M Series: 6.3544, T6.3544, H6.3544, HT6.3544

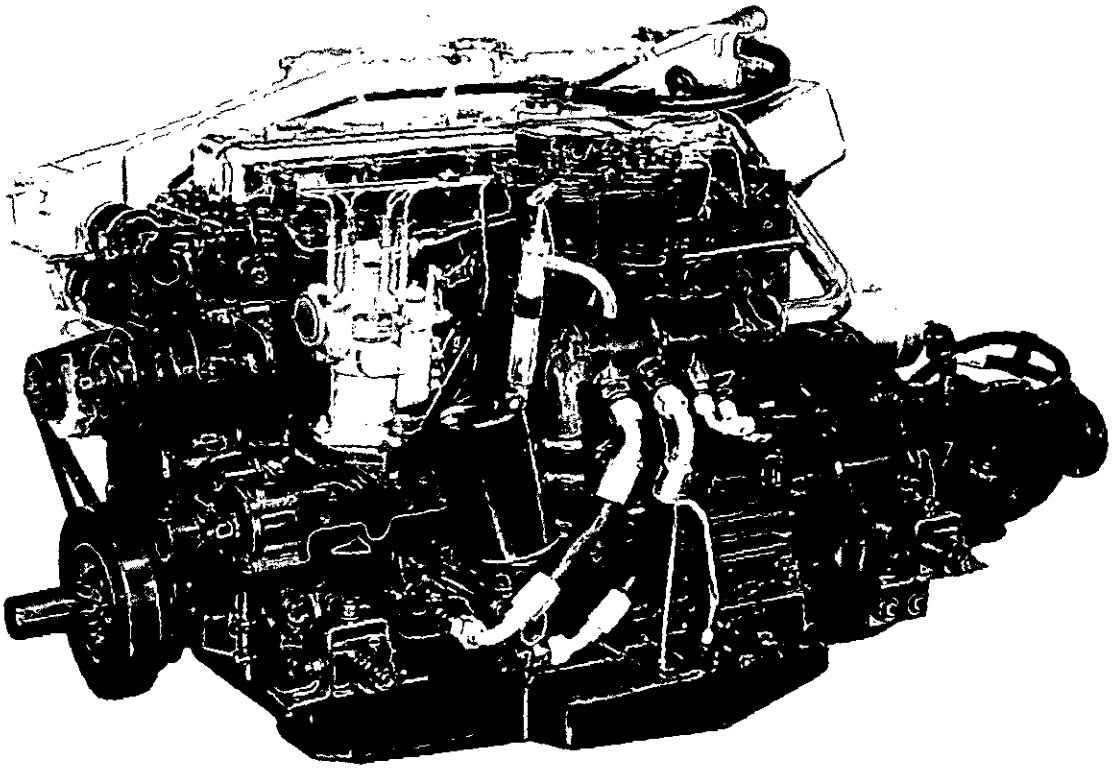
Range 4 Series: M135, M165T, M200Ti, M240Ti, M275Ti

6HD Series: 6HD100, 6HD150T, 6HD185T

Note: Unless stated otherwise, the information given in this supplement also applies to all six cylinder models of the Range 4 and 6HD Series engines.

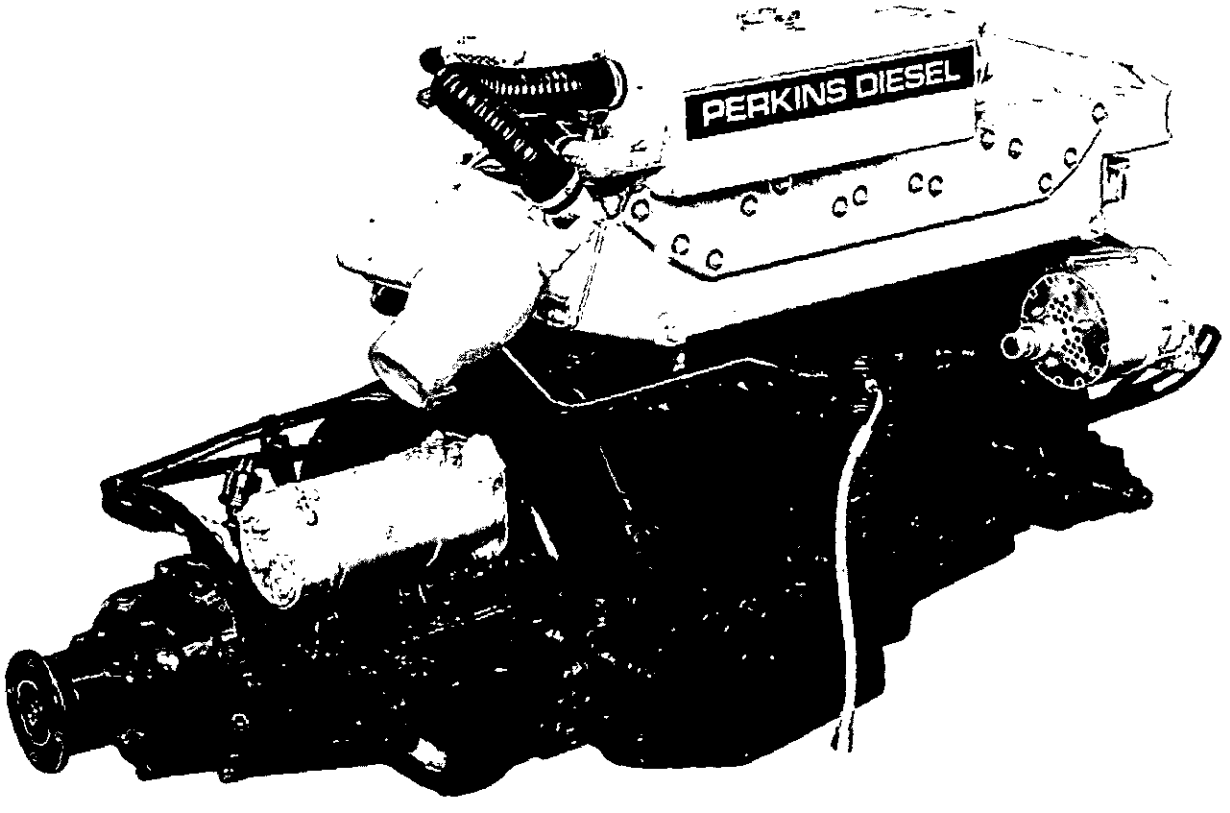
CONTENTS

	Section
ENGINE VIEWS	A
GENERAL DATA	B
CYLINDER HEAD	E
PISTONS AND CONNECTING RODS	F
TIMING	K
LUBRICATING SYSTEM	L
COOLING SYSTEM	M
AIR CLEANERS AND FUEL SYSTEM	N
TURBOCHARGER	Q
ALTERNATOR AND STARTER MOTOR	R



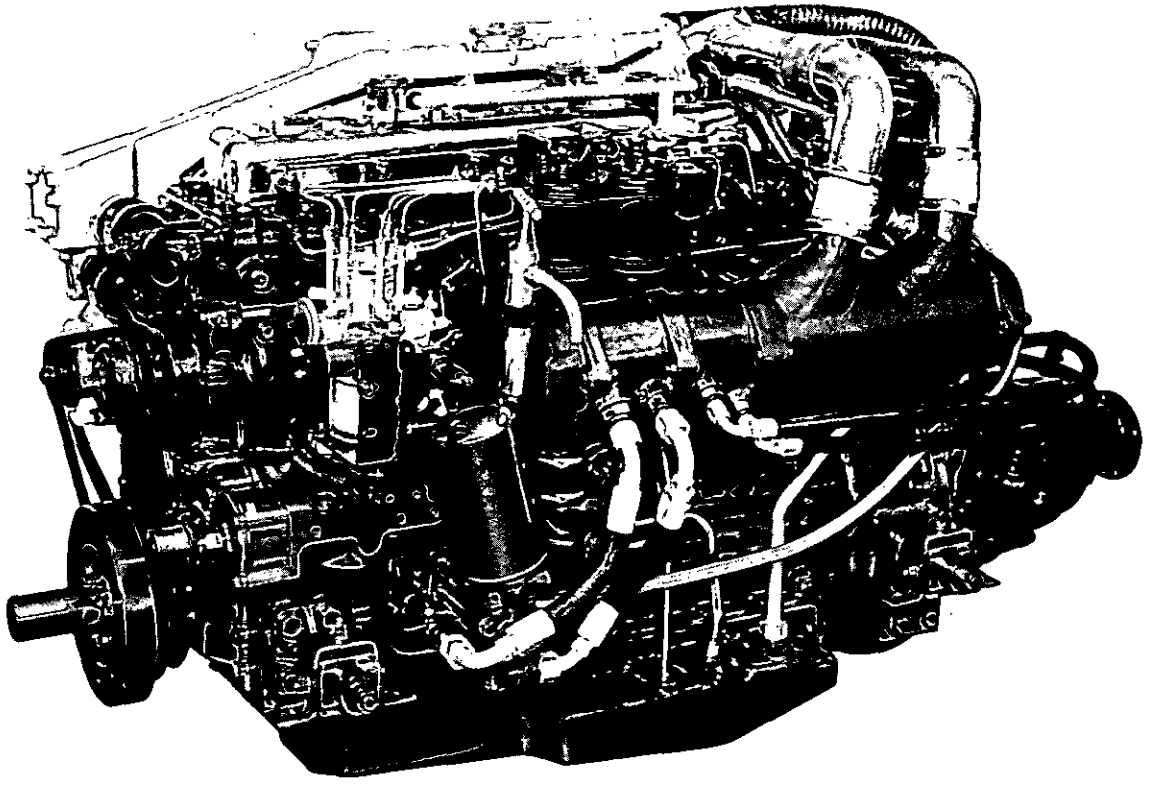
View of Fuel Pump Side of 6.3544M Engine.

A.1

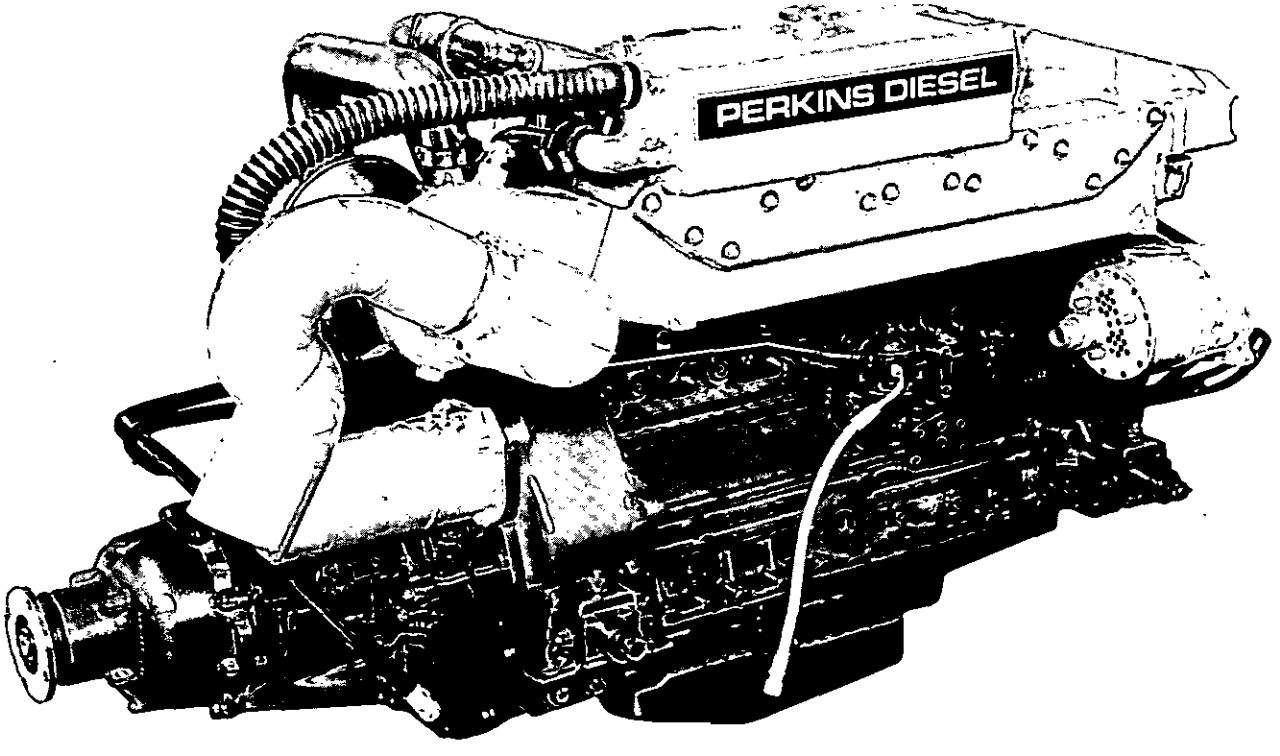


View of Camshaft Side of 6.3544M Engine.

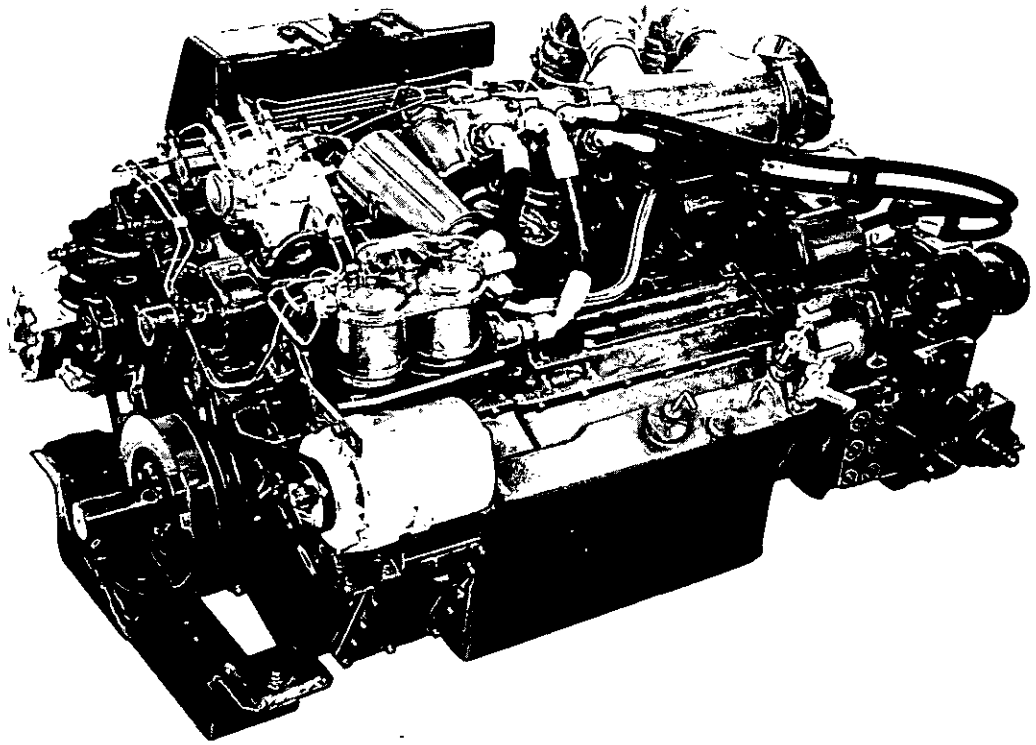
A.2



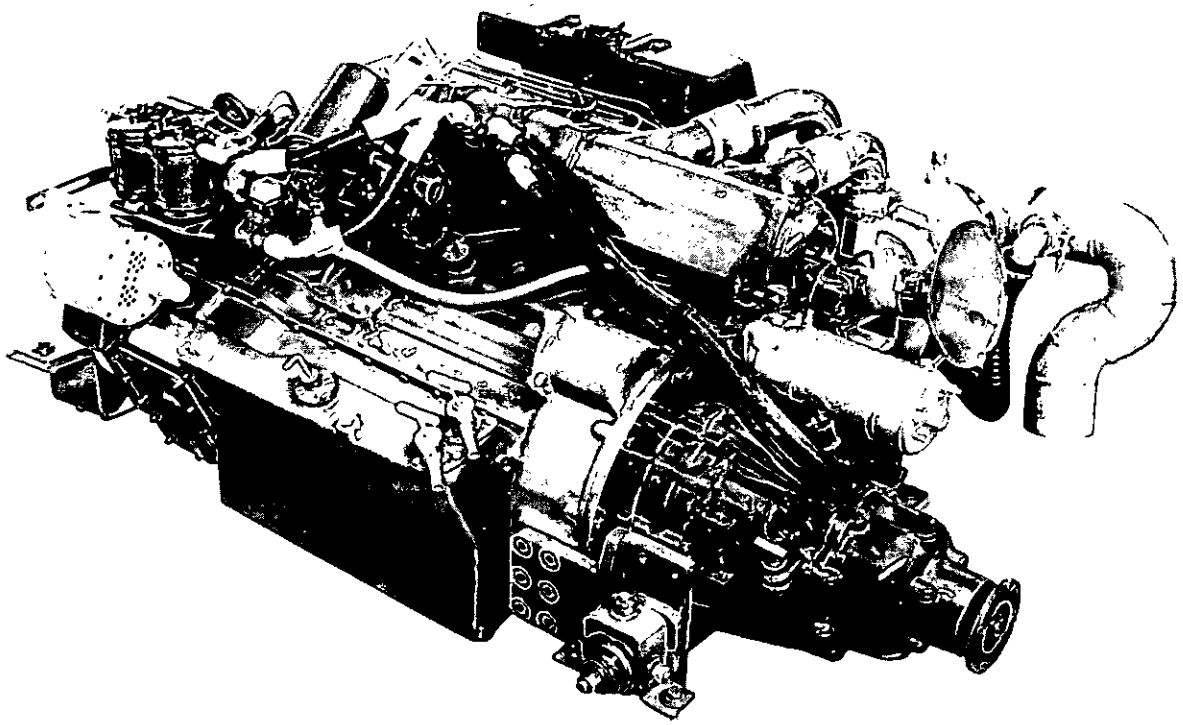
A.3 View of Fuel Pump Side of T6.3544M Engine.



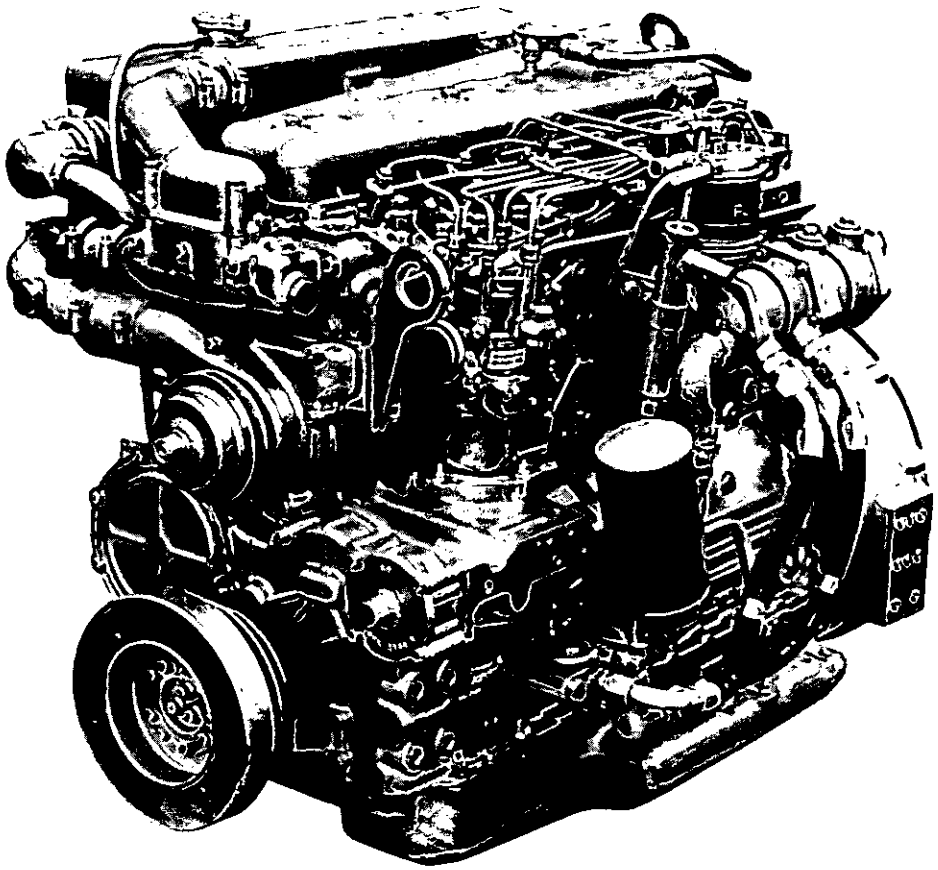
A.4 View of Camshaft Side of T6.3544M Engine.



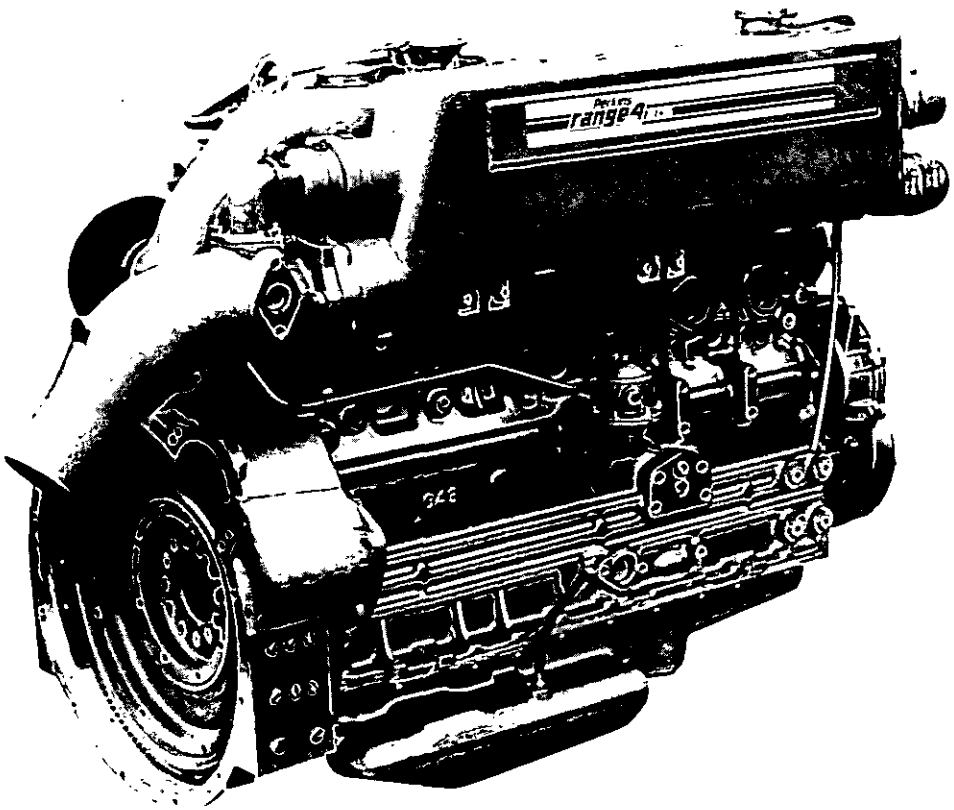
A.5 Front View of HT6.3544M Engine.



A.6 Rear View of HT6.3544M Engine.



A.7 View of Fuel Pump Side of 6.3544M Engine.



A.8 View of Camshaft Side of 6.3544M Engine.

General Data B

Ratings

Application	Rating* kW	bhp	rev/min
T6.3544M			
Pleasure craft (high rating)	186,5	250	2800
Pleasure craft and commercial light duty	164	220	2600
Alternative rating	160	215	2800
Pleasure craft and commercial light duty	138	185	2400
Alternative rating	138	185	2800
Pleasure craft and commercial light duty	112	150	2400
On-board generating set	86	115	1500
6.3544M			
Pleasure craft and commercial light duty	89,5	120	2800
Alternative rating	85	114	2500
Commercial heavy duty	74	99	2000
On-board generating set	57,5	77	1500

*Gross output without gearbox.

Engine weights (dry)

Specification	T6.3544 with No. 3 SAE backend lb	kg	6.3544 with No. 3 SAE backend lb	kg	6.3544 with low profile bell housing lb	kg
Including backend but less gearbox	1289	585	1229	557	1216	552
Including Borg Warner 10-14 with 1.58:1 reduction gear	1492	677	1432	650	1419	644
Including Twin Disc MG 506 gearbox	1517	688	1457	661	1444	655
Including MRF 350HD M111B – 2 gear	1605	728	1545	701	1532	695
Including MRF 350HD M111B – 3 gear	1615	733	1555	705	1542	699

Gearbox oil capacities

Transmission	0° Installation angle Imp pints	litres	US quarts	15° Installation angle Imp pints	litres	US quarts
Borg Warner direct drive	3.5	2,0	2.1	2.83	1,6	1.7
Reduction Gear CR2 (10/14)	4.16	2,36	2.5			
Twin Disc MG 506	8.0	4,54	4.8			
Twin Disc MG 502	3.5	2,0	2.1			
Self Change MRF 350HD M111B	16-20	9,1-11,3	9.6-12.0			

Gearboxes should be filled to the 'full mark' on dipstick (where fitted).

Gearbox lubricant specifications

Borg Warner ..... Type 'A' Suffix 'A' Automatic Transmission Fluid

Twin Disc ..... Oils used in these gearboxes must be consistent with a high quality engine oil. Viscosity grades will depend on the ambient temperature in the region of operation, e.g.,

0°F to 32°F (-18° to 0°C)	SAE 20 engine oil (BP Vanellus M20W or equivalent)
Above 32°F (0°C)	SAE 30 engine oil (BP Vanellus M30 or equivalent)

Self Change MRF 350HD M111B ..... SAE 30 engine oil for tropical and temperate regions – 32°F (0°C) and above
SAE 20 engine oil for arctic regions – 0°F (-18°C) to 32°F (0°C)

Cooling system

Type ..... Thermo-syphon, pump assisted

Coolant capacity
Vertical engines ..... 53.7 Imp pints (30,5 litres) 32.2 US quarts
Horizontal engines ..... 56.32 Imp pints (32 litres) 33.8 US quarts

Sea water pump

Make ..... Jabsco

Type ..... Self priming, Neoprene rubber impeller

Fuel injection pump static checking angles

The relevant timing information can be found by reference to the prefix letters or prefix letter and figures of the setting code adjacent to the word 'Set' on the fuel pump identification plate and the table below. The engine checking angle is for use with timing tool MS67B and the engine set with No. 1 piston at T.D.C. compression stroke.

Prefix Letters T6.3544	Engine checking angle (degrees)	Fuel pump marking angle (degrees)	Static timing BTDC (degrees)	Piston displacement
SY	160	144	32	0.483 in (12,26 mm)

Atomisers

Code	Holder	Nozzle	Setting Pressure atm	lbf/in²	(MN/m²)	Working Pressure atm	lbf/in²	(MN/m²)
FU	BKBL67S5299	BDLL150SY6688	210	3087	(21,3)	195	2866	(19,8)
GT	BKB67S5299	BDLL135S6776	215	3160	(21,8)	215	3160	(21,8)
HA	BKBL67S5299 or 2645C305	BDLL150S6798 or	215	3160	(21,8)	215	3160	(21,8)
HB	BKBL67S5299 or 2645C305	BDLL150S6799 or	215	3160	(21,8)	215	3160	(21,8)
HE	LRB67014* or 2645C307	JB6801019	230	3381	(23,3)	230	3381	(23,3)
HR	LRB67014*	JB6801045	270	3970	(27,3)	270	3970	(27,3)

***In this atomiser the pressure is adjusted by a change of shims.**

Cylinder Head

To remove the cylinder head

Drain the cooling system.

Disconnect battery terminals.

Remove exhaust pipe from exhaust outlet pipe.

Where applicable, remove the turbocharger (Fig. E.1), as detailed in Section Q.

Remove electrical connections to the cylinder head and induction manifold. Remove fuel pipe to thermostart in the manifold.

Remove the water outlet connection.

Remove the multi-cooler, see Fig. E.2 or the mani-cooler and induction manifold.

The fuel pipe from lift pump to fuel filters should be removed, releasing the clip from the back of the cylinder head. The fuel filters may also be removed.

All high pressure pipes between fuel injection pump and the atomisers should be removed together with the atomisers leak-off pipe assembly.

Remove atomisers, see Fig. E.3.

Disconnect the breather pipe from the rocker cover.

Remove rocker cover and gasket.

Release rocker assembly bracket securing setscrews and lift off rocker assembly. Remove the push rods.

Remove cylinder head nuts and setscrews in reverse order of tightening sequence, see Fig. E.4.

Note position of different length setscrews, see Fig. E.4.

Remove cylinder head.

To fit the cylinder head

Ensure the head face, cylinder block top face and bores are clean and that the rocker assembly oil feed passage in the cylinder head is clean.

Any cylinder head studs removed from the cylinder block should be refitted with 'Loctite'.

The cylinder head gasket is marked 'TOP FRONT'.

The cylinder head gasket must be fitted dry. Fit the gasket ensuring it is correctly located over the two dowels.

Lower the cylinder head in position without disturbing the gasket.

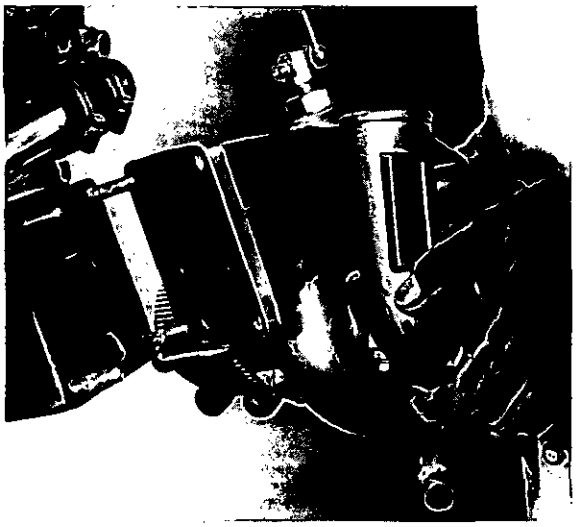
Lightly oil threads of cylinder head securing studs and setscrews.

See Fig. E.5 for correct location of long and short setscrews.

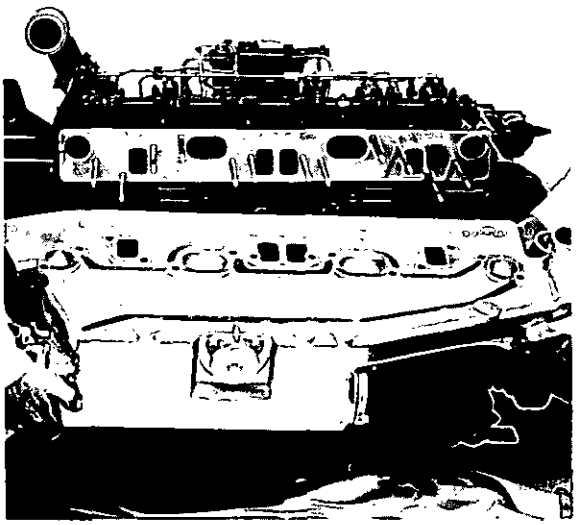
The cylinder head fasteners should be tightened gradually and evenly in the correct sequence (Fig. E.4).

The earlier cylinder head fasteners (1 to 32), which are fitted with separate washers, should be tightened to 95 lbf ft (13,1 kgf m) 130 Nm.

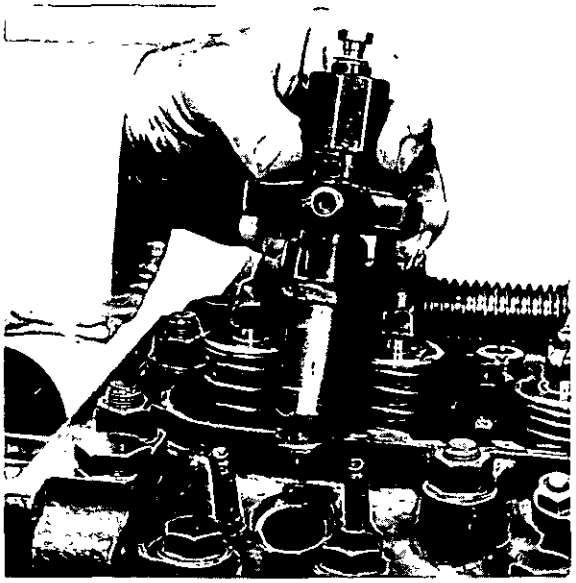
When the early cylinder head gasket, part number 36812611, is used with flanged fasteners (1 to 32), the fasteners should be tightened to 115 lbf ft (15,9 kgf m) 156 Nm.



E.1



E.2



E.3

MARINE SUPPLEMENT – E2

Currently, the flanged cylinder head fasteners are tightened in the factory by a new method that removes the necessity for the fasteners to be tightened again with the engine hot. A similar 'No hot torque' method (see Page E3) can be used in service if flanged fasteners and cylinder head gasket, part number, 36812613 are used. If this method is not used, the flanged fasteners should be tightened as shown earlier and will have to be tightened again when the engine is hot.

The small setscrews (33 to 38) should be tightened to 28 lbf ft (3,9 kgf m) 38 Nm.

Replace push rods.

Renew the rocker assembly feed pipe oil seal, lightly oiling its inner and outer surfaces, and placing it in the oil feed drilling.

Examine and replace the rocker assembly, ensuring that the oil feed pipe, which has a lead in, locates correctly into the drilling, when the seal will butt against the convolution, see Fig. E.6.

The rocker assembly securing nuts should be tightened down progressively from the centre outwards to a torque of 55 lbf ft (7,60 kgf m) or 75 Nm. Set valve clearances to 0.008 in (0,20 mm) for inlet valves and 0.018 in (0,45 mm) for exhaust valves, engine cold, as detailed on Page E5 of the 6.3544 Series Workshop Manual.

Refit atomisers with new copper seating washers. Ensure that a serviceable dust seal is fitted to the atomiser. Earlier dust seals consisted of a single piece rubber seal, later arrangements use a two piece dust seal which consists of a plastic or aluminium spacer and a rubber seal. The spacer must be fitted directly under the atomiser flange with the soft rubber seal up against the spacer at the nozzle end of the atomiser. Now tighten nuts/setscrews evenly to a torque of 12 lbf ft (1,7 kgf m) or 16 Nm.

Note: Different atomiser seating washers are used on naturally aspirated and turbocharged engines. The seating washers for naturally aspirated engines are 0.080 in (2,03 mm) thick and for turbocharged engines, 0.028 in (0,71 mm) thick. It is important that the correct atomiser seating washers are fitted.

Refit all high pressure fuel pipes, leak-off pipes and the fuel filters.

Tighten high pressure pipe nuts to a torque of 15 lbf ft (2,1 kgf m) or 20 Nm.

Refit fuel pipe from lift pump to filters, this pipe is clipped on to back of cylinder head.

Refit multi-cooler, or induction manifold and mani-cooler.

A steel/asbestos one piece gasket is fitted between the multi-cooler and cylinder head, sealing the exhaust and induction ports. This gasket should be fitted dry.

Refit the water outlet connection.

Connect the electrical lead, fuel feed pipes to the thermostart unit if fitted.

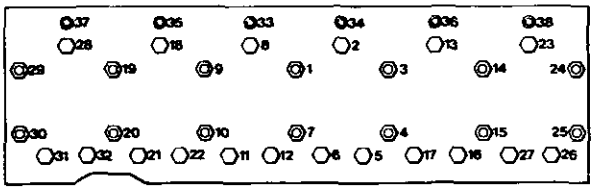
Connect any other electrical lead (i.e. water temperature gauge).

Refit the turbocharger, where applicable, as detailed in Section Q.

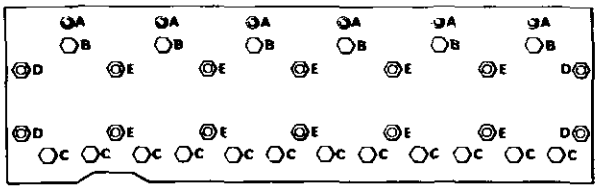
Refit exhaust pipe to exhaust outlet pipe.

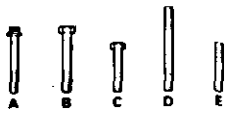
Reconnect the battery.

Refill the cooling system.

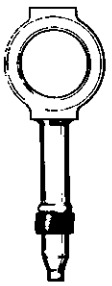


E.4





E.5



E.6

Bleed the fuel system of air as detailed on Page N8 of the 6.3544 Series Workshop Manual and start the engine.

Check the oil flow to the rocker shaft assembly and allow the engine to warm up.

Shut the engine down, and tighten the cylinder head securing nuts and setscrews to the correct torques as detailed previously, using the following procedure.

Ensure that the coolant outlet temperature is at least 170°F (77°C). If a nut or setscrew does not move before the correct torque is achieved, slacken off 1/12 to 1/6 of a turn (30° to 60°) and then retighten to the correct torque. Flanged fasteners not tightened by the 'No hot torque' method should be retightened to 105 lbf ft (14,5 kgf m) 142 Nm. After retightening all the nuts and setscrews, the first ten positions of the tightening sequence should be rechecked without further slackening off to ascertain that they are still tightened to the correct torque.

Reset the valve clearances to 0.008 in (0,20 mm) for inlet valves and 0.018 in (0,45 mm) for exhaust valves hot or cold.

Refit the rocker cover gasket, rocker cover and breather pipe.

To put a rocker cover joint on correctly it must be first fitted to the rocker cover by use of a suitable Bostic type contact adhesive. The adhesive must be applied according to the manufacturers instructions. This procedure will ensure that there is a good seal all around the cover.

When replacing the cylinder head cover, ensure that the cover retaining nuts are screwed fully home against the rocker shaft bracket retaining nuts. Where a washer is fitted under the head of each of the rocker cover nuts, a washer is also fitted between the rocker bracket securing nut and the cover nut. Where a washer face is formed integral with the cover nut, a separate washer must not be fitted under the cover nut or between the cover nut and the rocker bracket nut.

'No hot torque' method to tighten cylinder head fasteners

Check the setscrews and studs for distortion with a straight edge held along the threads. If there is a visual reduction in the diameter of that part of the thread that has not been in engagement with the cylinder block or nut, the setscrew or stud must not be used again.

Lightly lubricate the threads and the flange face of each fastener with clean engine oil. New fasteners are supplied already lubricated.

Put the cylinder head gasket, the cylinder head and the fasteners in position. Gradually and evenly tighten the main (½in UNF) fasteners to 80 lbf ft (11,1 kgf m) 100 Nm in the sequence 1 to 32 (Fig. E.4).

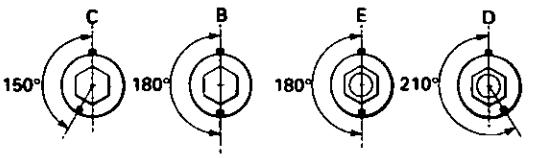
Check again that all the main fasteners are to the correct torque.

Tighten the fasteners, in the correct sequence, a further part of a turn according to the length of the setscrew or stud. The shorter setscrews (C in Figs. E.5 and E.7) must be turned a further 150° (2½ flats). The longer setscrews (B) and the nuts (E) on the shorter studs must be turned a further 180° (3 flats). The nuts (D) on the longer studs must be turned a further 210° (3½ flats).

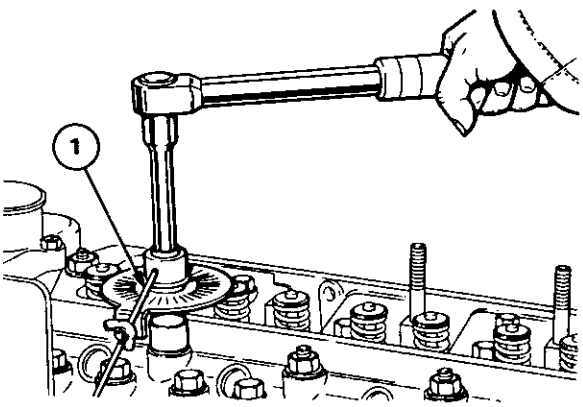
A special tool, number MS 1531, (Fig. E.8) can be used for this operation. To use the tool, fit it between the socket spanner and the handle. Position the stop (1 in Fig. E.8) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Turn the pointer to align with the zero mark on the degree dial. Tighten the setscrew or the nut until the pointer on the tool is at the correct angle for the length of the setscrew/stud.

If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew and nut (Fig. E.7). Make another mark on the edge of each fastener at the correct angle (counter clockwise) according to the length of the setscrew/stud. Tighten each fastener, in the correct sequence, until the mark on the flange of the fastener is next to and in line with the mark on the cylinder head.

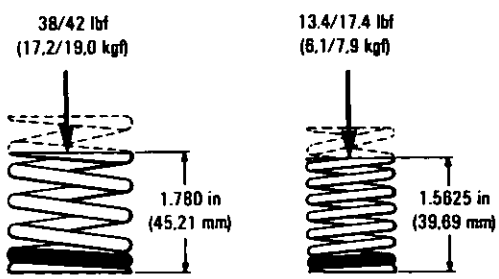
Tighten the 5/16 in UNF setscrews gradually and evenly in the sequence 33 to 38 (Fig. E.4) to 28 lbf ft (3,9 kgf m) 38 Nm.



E.7



E.8



E.9

Valve Springs

A new set of springs should be fitted at every major overhaul.

Examine the springs with regard to squareness of ends and pressure developed at fitted lengths, see Fig. E.9.

New inner springs require a load of 13.4/17.4 lbf (6,1/7,9 kgf) to compress them to the fitted length of 1.5625 in (39,69 mm).

New outer springs require a load of 38/42 lbf (17,2/19,0 kgf) to compress them to the fitted length of 1.780 in (45,21 mm).

Manifolds

The exhaust and induction manifolds are an integral part of the multi-cooler used on T6.3544 engines, see Section M. The multi-cooler is made from a corrosion resistant aluminium material. Fresh water contained in the multi-cooler acts as a cooling medium for the exhaust manifold gas passages (see Fig. M.12) so reducing the risks of fire hazard.

The induction manifold is also contained in the multi-cooler casting assembly, but is separated from the main hot water jacket by a cast-in air gap to prevent heat transference from the water to the in-going air (See Fig. M.12).

On naturally aspirated engines a mani-cooler unit is fitted which contains the heat exchanger header tank and exhaust manifold, see Fig. M.12A. Unlike the multi-cooler the induction manifold and thermostats are not included within the mani-cooler assembly.

TECHNICAL DATA

Inner valve springs

Fitted length and load	1.5625 in (39,69 mm) at 13.4/17.4 lbf (6,1/7,9 kgf)
Number of active coils	7
Number of damper coils	2
Coiled	R.H. – damper coil to cylinder head

Outer valve springs

Fitted length and load	1.780 in (45,21 mm) at 38/42 lbf (17,2/19,0 kgf)
Number of active coils	5.5
Number of damper coils	2
Coiled	L.H. – damper coil to cylinder head

Pistons and Connecting Rods F

The pistons fitted to 6.3544 and most T6.3544 engines have a toroidal cavity in the crown, the cavity shape being different for the naturally aspirated and turbo-charged engines.

The pistons fitted to the T6.3544 engine rated at 164 kW (220 bhp) have a squish lip re-entrant bowl in the crown and the crown of these pistons is hardened.

The small end of the T6.3544 connecting rod is wedge shaped.

Only pre-topped pistons are available as service replacements for the T6.3544 engine rated at 164 kW (220 bhp) whereas pre-topped service or untopped production pistons are available for the remaining applications. Where pre-topped service pistons are used, the piston height may be lower than the bottom limit given above.

To fit piston rings

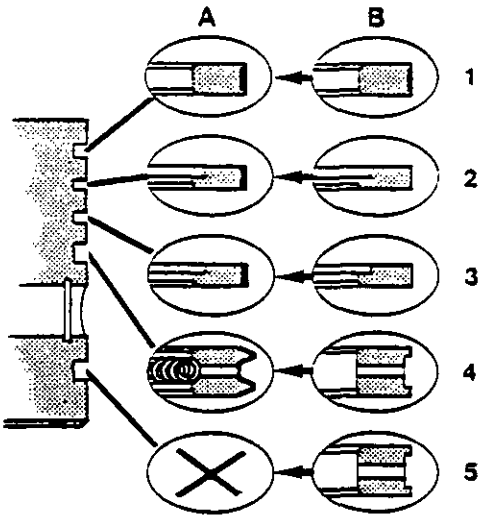
Old arrangement:
No. 1 chromium insert compression.
No. 2 and No. 3 internally stepped compression.
No. 4 and No. 5 maxigroove scraper.

New arrangement:
No. 1 chromium insert compression.
No. 2 and No. 3 chromium plated internally stepped compression.
No. 4 chromium plated spring loaded scraper.
No. 5 no ring fitted.

These rings must be fitted as shown in Fig. F.1 and as described in the previous text.

Note: The later arrangement gives improved oil control.

Piston ring layouts for later 6.3544 engines, Fig. F.1 are as follows:



F.1

A = new arrangement
B = old arrangement

TECHNICAL DATA

Pistons (T6.3544 – 164 kW – 220 bhp rating)

Type	'Squish Lip' re-entrant bowl in crown
Piston height in relation to cylinder block top face	0.000/0.007 in (0,00/0,18 mm) above
Bore diameter for gudgeon pin	1.50004/1.50028 in (38,101/38,107 mm)
Compression ring groove width, No. 1	Tapered
Compression ring groove width, No. 2	0.0959/0.0967 in (2,44/2,46 mm)
Scraper ring groove width, No. 3	0.1900/0.1908 in (4,83/4,85 mm)

Piston rings (6.3544) – 4 rings in 5 groove piston

No. 1 compression	Chrome inserted face, parallel
No. 2 and No. 3 compression	Chrome faced internally stepped or chamfered, parallel
No. 4 scraper	Chrome faced, spring loaded conformable
No ring fitted in the fifth groove.	
Compression ring width No. 1	0.0928/0.0938 in (2,36/2,38 mm)
Compression ring width No. 2 and No. 3	0.0927/0.0937 in (2,36/2,38 mm)
Scraper ring width No. 4	0.2485/0.2500 in (6,31/6,35 mm)
No. 1 clearance in groove	0.0019/0.0039 in (0,050/0,10 mm)
No. 2 and No. 3 clearance in groove	0.002/0.004 in (0,05/0,10 mm)
No. 4 clearance in groove	0.0025/0.0050 in (0,06/0,13 mm)
No. 1, No. 2, No. 3 and No. 4 piston ring gap	0.016/0.034 in (0,41/0,86 mm)

Timing K

Checking valve timing

From engine number TW-----U626522G, the camshaft was changed from part number 31416207 to part number 31416303.

1 Turn the crankshaft until the valves on No. 6 cylinder are rocking. In this position, set the clearance on No. 1 inlet valve to 0.051 in (1,30 mm) for camshaft part number 31416207 or 0.047 in (1,19 mm) for camshaft part number 31416303.

2 Turn the crankshaft in the normal direction of rotation until the push rod of No. 1 inlet valve tightens.

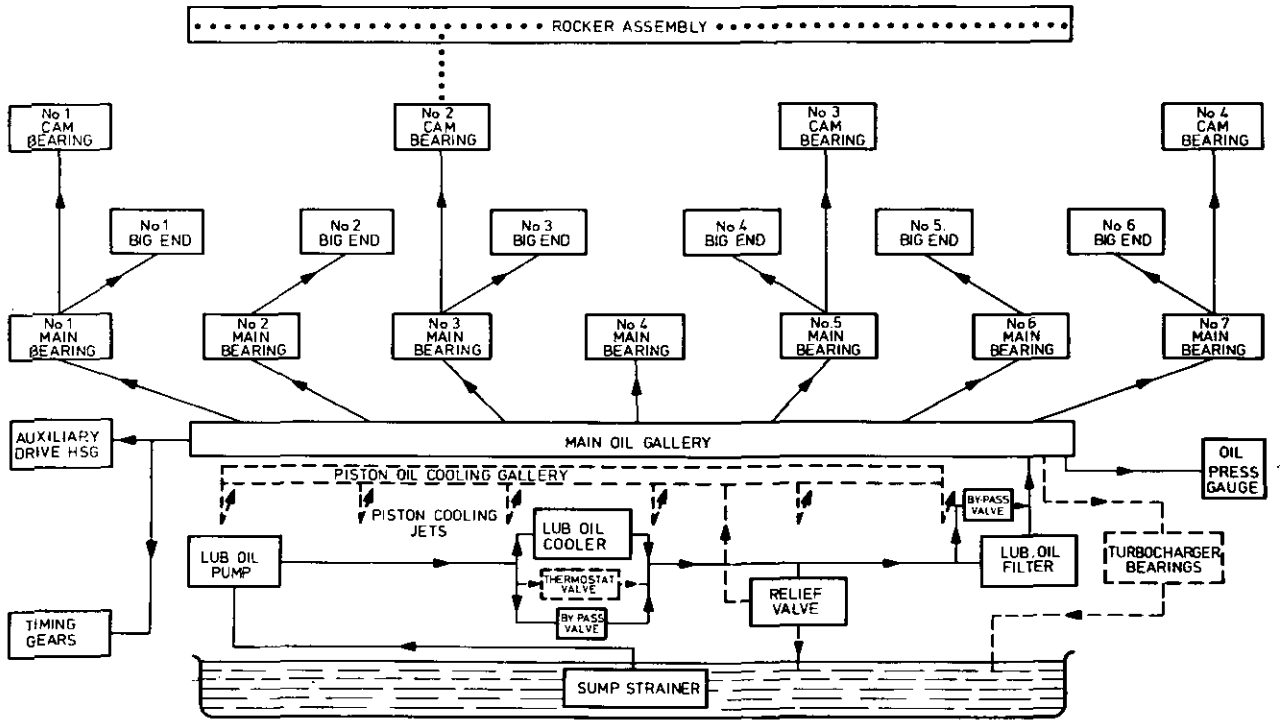
3 Check that Nos. 1 and 6 pistons are at T.D.C. The valve timing tolerance is plus or minus 2½°.

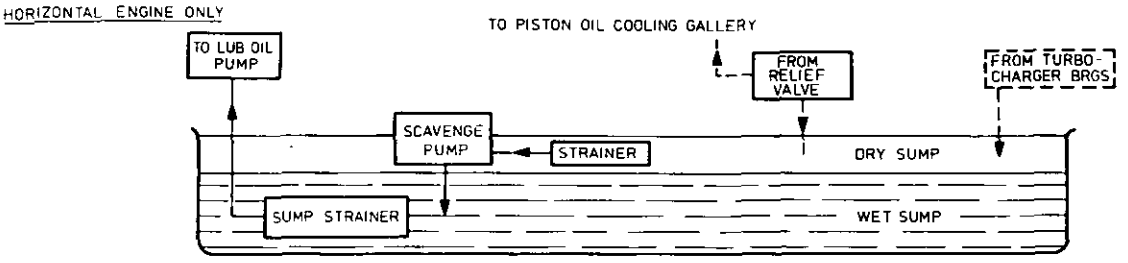
4 When the valve timing is found to be correct, reset valve clearance to 0.008 in (0,20 mm) cold.

If the timing is found to be incorrect, then the gears can only be one or more teeth out of correct mesh.

Note: There is no adjustment provided for valve timing.

Lubrication System L





L.1

••• REDUCED OIL FLOW

Note: Piston cooling is only applicable to turbocharged engines.

Oil circulation

The lubricating oil pump draws oil through the suction pipe and strainer to an oil cooler, cooled by water from the engine seawater cooling system. From the oil cooler, oil passes through a full flow filter to the main pressure rail drilled the length of the cylinder block.

Drillings in the crankcase webs feed oil from the main gallery to the main bearings and drillings in the crankshaft carry oil to the big-end bearings. Through drillings in Nos. 1, 3, 5 and 7 crankcase webs, oil passes from the main bearings to lubricate the camshaft bearings.

No. 2 camshaft bearing supplies a controlled feed of oil to the rocker shaft assembly which escapes through a small bleed hole in each rocker lever to lubricate the valves and springs.

With turbocharged engines, the pistons are cooled by lubricating oil being sprayed upon them by piston cooling jets.

Pistons fitted to naturally aspirated engines are not cooled and cooling jets are not fitted.

The feed for the piston cooling jets is controlled by a two stage pressure relief valve situated after the oil cooler and comes into operation at a specified pressure after oil is flowing freely to the main working parts of the engine.

Lubrication for the timing gears is taken from the oil passages connecting the pressure rail with the front main bearing and auxiliary drive.

The two idler gear hubs intersect these drillings and oil is passed through the hubs to radial drillings in the idler gears to lubricate the teeth of the gear train.

The auxiliary drive shaft bearings are lubricated by a drilling from the pressure rail to the front auxiliary drive shaft bearing. The oil then passes around a groove in the bearing journal and though a further drilling along the outer side of the auxiliary drive housing to the rear auxiliary drive shaft bearing.

Lubricant for the upper fuel pump drive bearing is also taken from this drilling.

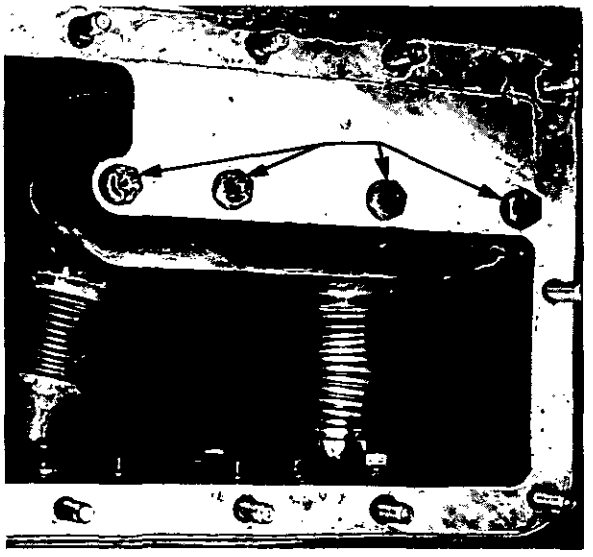
Also connected with the outer drilling is a small spray tube, which directs oil onto the wormwheel and wormgear.

Oil pressure is controlled by a pressure relief valve that returns excess oil to the sump.

Both the filter and cooler and provided with a by-pass facility in the event of blockage in either of the two components.

To remove sump (vertical engines)

Lower the sump by releasing all flange setscrews and nuts.



L.2

To replace sump

Place the sump in position and secure by fastening the nuts on the four studs located in the bridge pieces.

The securing setscrews can now be inserted.

Tighten the setscrews and nuts to a torque of 15 lbf ft (2,1 kgf m) or 20 Nm.

To remove sump (horizontal engines)

Remove inspection plate from front end of sump base by removing nuts and washers.

Remove four setscrews and washers holding the sump cast in oilways connecting flange to bellows type oil pump connection flange, see Fig. L.2-A.

Remove sump and flange to bellows flange joint, see Fig. L.3.

To replace sump

Ensure flange joint is placed correctly on top of bellows pipe connection flange. Note hole sizes, see Fig. L.3.

Locate sump in position ensuring joints are correctly located.

Fit and tighten the four setscrews and washers, holding bellows oil pipe flange to sump flange, ensuring joint is still in position.

Refit and tighten sump setscrews.

Refit sump inspection panel.

Oil strainer

The oil strainer on vertical engines is part of the oil pump suction pipe. There is no periodic servicing on this strainer but it should be cleaned whenever the sump is removed.

The lubricating oil sump on horizontal engines has cast in oilways which are connected to the oil pumps by bellows type oil pipes. The sump is so designed that the oil chamber is integral as a sump assembly. Oil is picked up from the dry side of the sump by being drawn through a gauze screen set over the cast in scavenge oilway to the scavenge oil pump through the bellows type pipe and then deposited into the oil chamber through the cast in sump oil return oilway. The oil is then drawn through the sump strainer by the engine lubricating oil pump and fed through the engine lubricating system (see Fig. L.4).

The lubricating oil strainer can be removed from the sump by unscrewing the large nut out of the inner wall of the sump, the gauze strainer being attached to the nut, see Fig. L.5.

The shaft, inner and outer rotors can now be removed.

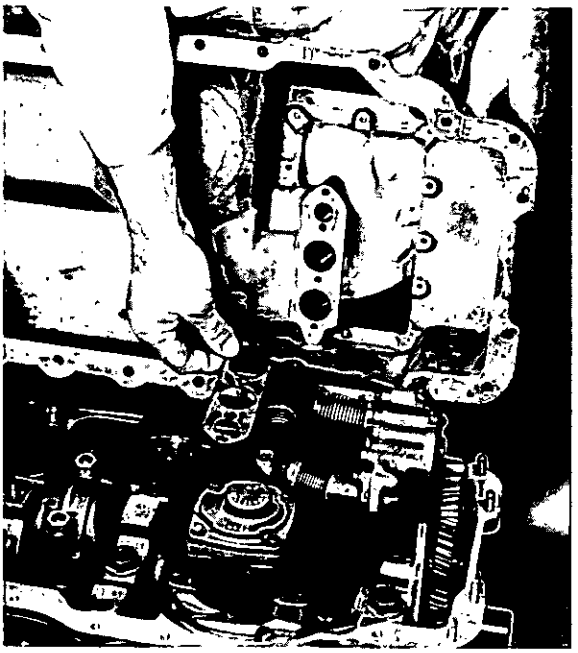
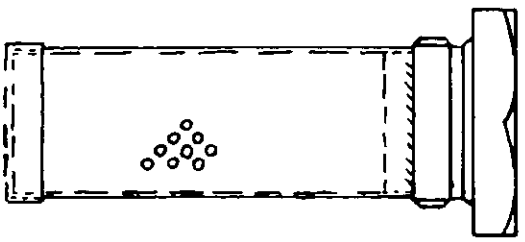
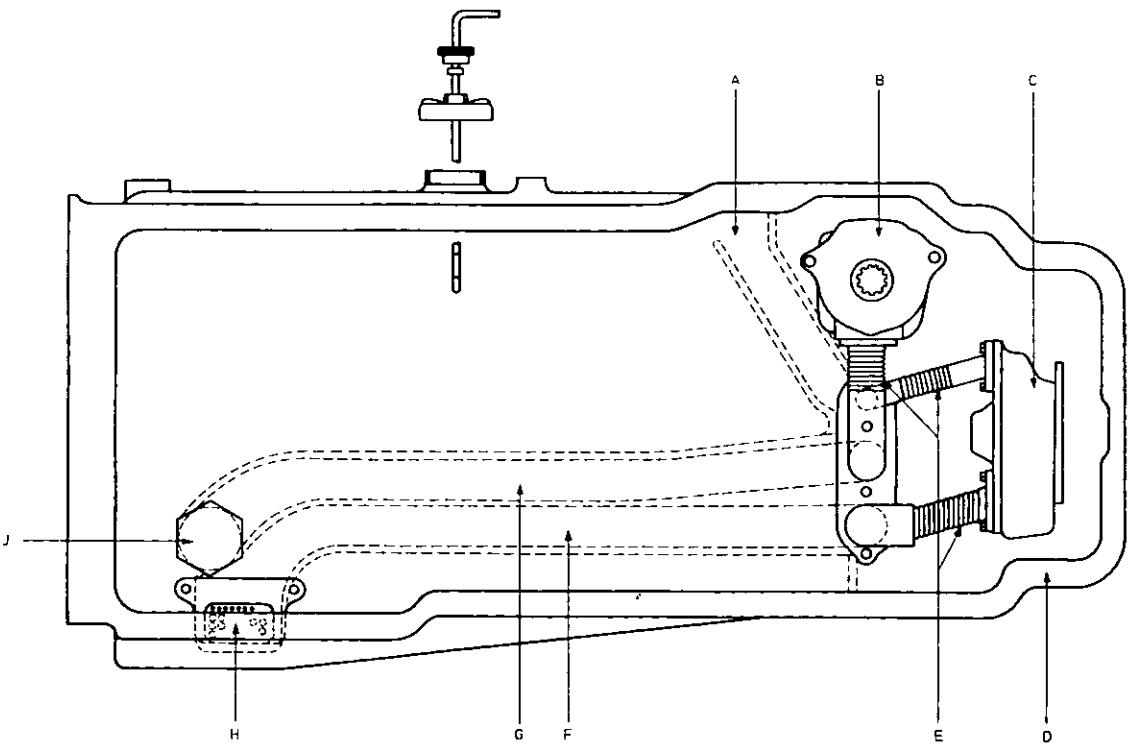


Fig. L.3.



L.5

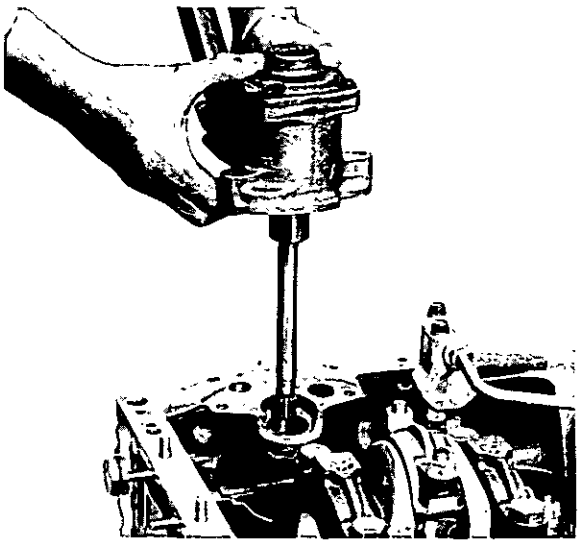


A SCAVENGE PUMP OILWAY RETURN TO WET CHAMBER
B LUBRICATING OIL PUMP
C SCAVENGE OIL PUMP
D LUBRICATING OIL SUMP
E LUBRICATING OIL FLEXIBLE PIPE ASSEMBLY
F SCAVENGE OIL PUMP SUCTION OILWAY
G LUBRICATING OIL PUMP SUCTION OILWAY
H SCAVENGE OIL STRAINER
J LUBRICATING OIL STRAINER
- - - - - - - SHOWS INTERNALLY CAST OILWAYS

L.4

To remove oil pump

Remove the sump and then the setscrews securing the oil pump to cylinder block and withdraw the oil pump, see Fig. L.6.



L.6

To dismantle oil pump, see Fig. L.7

Remove the suction pipe and bottom cover of the oil pump. The shaft, inner and outer rotors can now be removed.

Inspection of oil pump

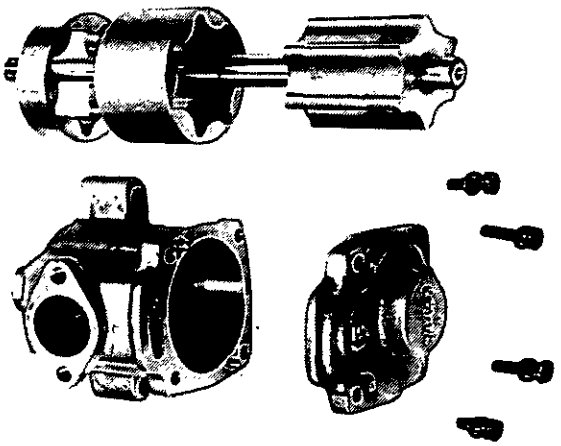
Inspect the rotors for cracks or scores.

Install the drive and driven rotors in the pump body. The two sections of the outer rotor can be fitted in any order.

Check clearances given on Page B9 of the 6.3544 Series Workshop Manual, between inner and outer *rotors, see Fig. L.8, rotor end float, see Fig. L.9 and* clearance between outer rotor and pump body, see Fig. L.10.

These clearances are applicable to a new pump and are to be used as a guide.

If the pump is faulty, it must be replaced as a complete unit as parts are not supplied individually.

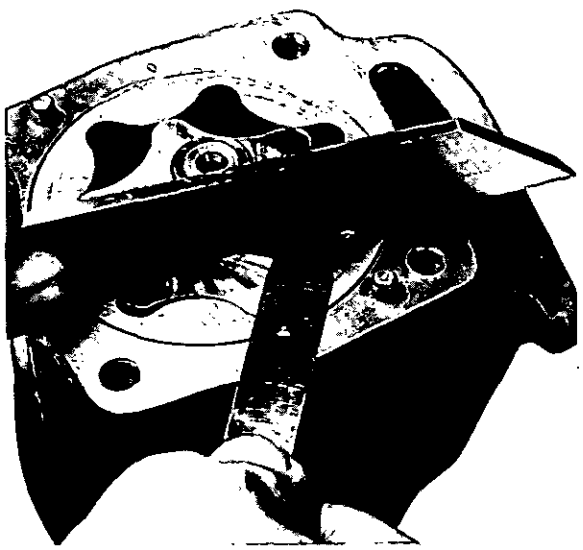


L.7

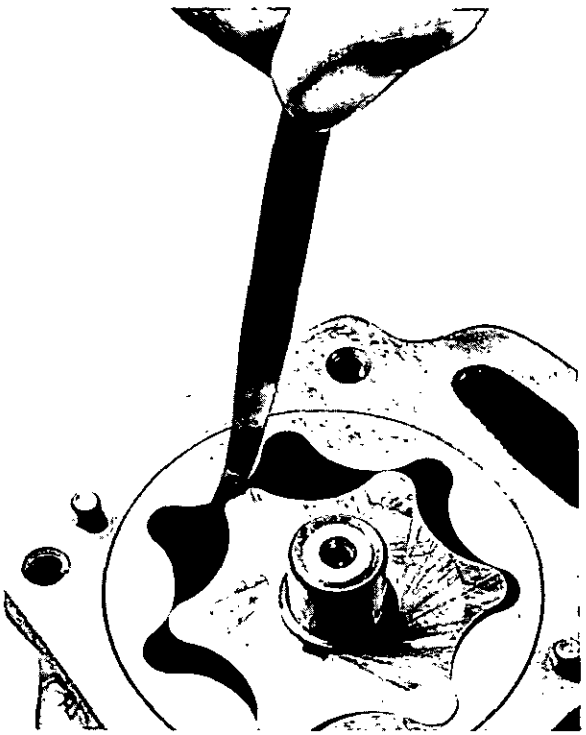
To re-assemble and refit oil pump

With the inner and outer rotors fitted into the pump body, refit the end cover with the locating dowels in position and with the joint faces smeared with a suitable jointing compound.

Prime the pump with clean engine lubricating oil.



L.9



L.8

The oil pump assembly and joint can now be fitted into its location in the cylinder block and secured with two setscrews and washers.

Refit the suction pipe and strainer.

Replace the sump, and refill with oil to an approved grade.

To remove and fit scavenge pump
(horizontal engines)

Remove sumps (see previous headings).

Remove bellows type pipe cluster and flange by removing setscrews holding suction and delivery pipe to main oil pump and scavenge pump, see Fig. L.11.

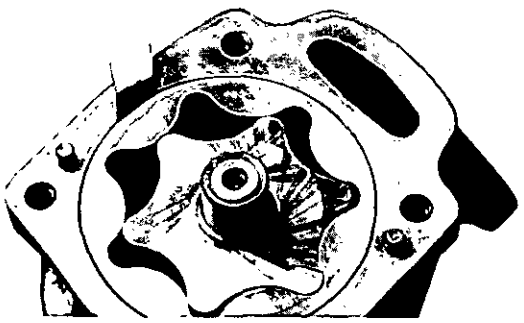
Remove timing case (see Page J2 of the 6.3544 Series Workshop Manual).

Remove oil pump idler gear circlips and idler gear from shaft, see Fig. L.12.

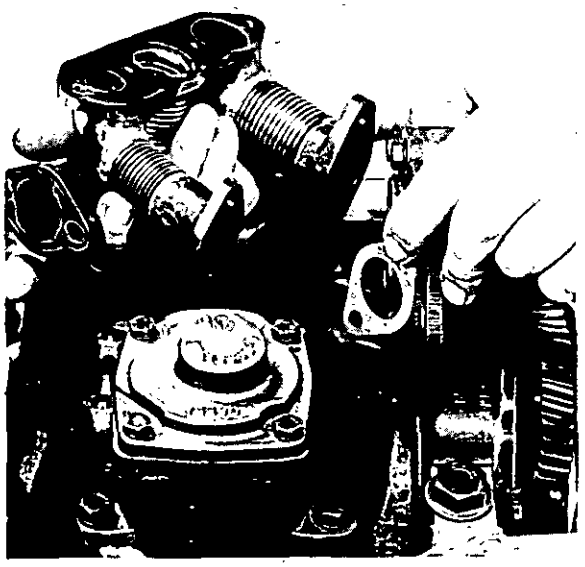
Remove three setscrews attaching oil pump to front main bearing cap and remove oil pump, see Fig. L.13.

The scavenge pump may be removed with the timing case in situ with the following procedure. Remove the two exposed setscrews. The idler gear circlip should then be removed. Slide the idler gear away from the oil pump body until it abuts against the timing case. Loosen the setscrew located behind the idler gear to its fullest extent which will allow it to clear the setscrew hole in the front main bearing cap. The pump can then be moved forward towards the front of the engine until the shaft location is clear of the front main bearing cap allowing the pump to be removed.

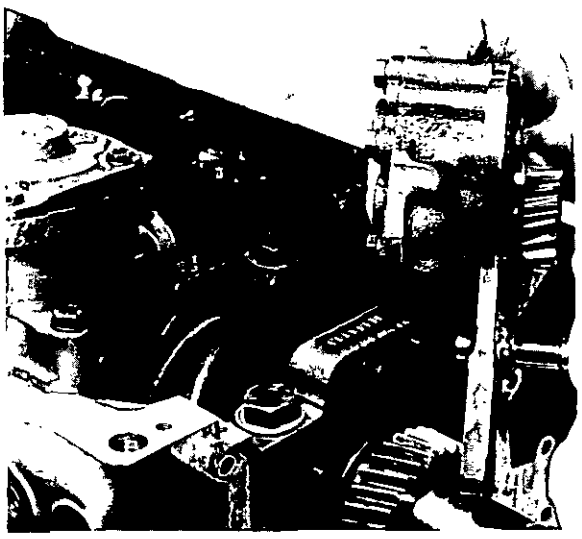
Fitting of the scavenge pump is effected by reversing the order of removal.



L.10



L.11



L.13

L.12

To dismantle scavenge pump

Remove six setscrews securing end plate to scavenge pump body.

Remove end plate.

At this stage of disassembly, it is possible to check the gear clearances and end float.

Gear clearances can be checked by inserting a feeler gauge between the gears, the clearance being 0.009/ 0.015 in (0,23/0,38 mm), see Fig. L.14.

The clearance between the outside of the gears and the pump body should not exceed 0.0065 in (0,16 mm), see Fig. L.15.

End float of the gears may be measured with a straight edge and feelers and should not exceed 0.008 in (0,20 mm) with the joint in position.

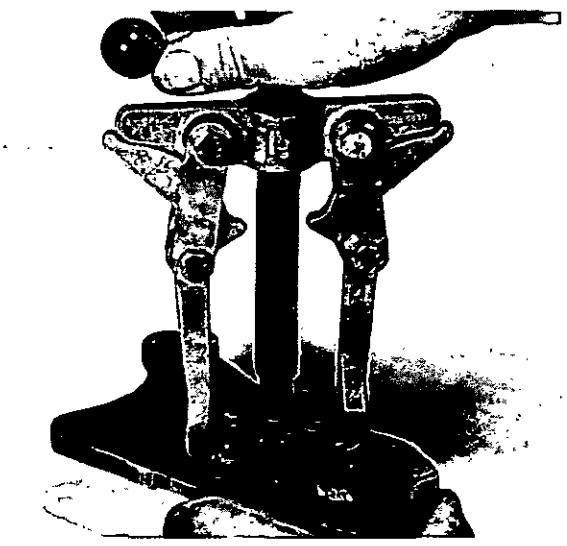
The pump may now be completely dismantled by removing the drive gear and removing the pump body from the mounting bracket. To remove the drive gear, an extractor should be used, see Fig. L.16.

Re-assembly of the scavenge pump may be effected by reversing the sequence of dis-assembly. New joints should be used with jointing compound.

Check that the scavenge pump rotates freely and prime with clean engine lubricating oil before fitting to engine.

L.14

L.15



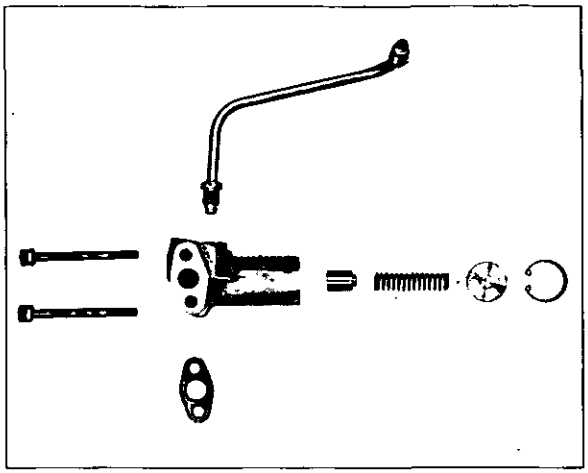
L.16

To remove and dismantle the pressure relief valve assembly see Fig. L.17

Remove the sump and then the pipe from valve to the cylinder block (T6.3544 only).

Release the two securing setscrews and remove the valve.

Remove the circlip which will enable the spring seat, spring and plunger to be withdrawn from the valve bore.



L.17

To assemble and refit the pressure relief valve assembly

Replace the plunger, spring and spring seat in the valve bore and refit the circlip.

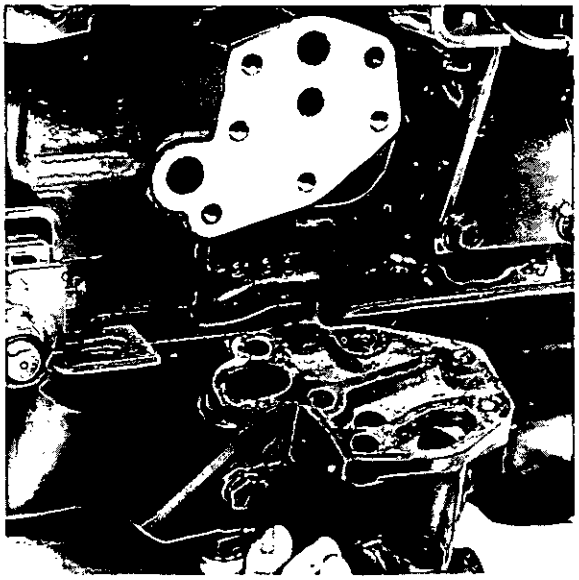
Using a new joint, refit the valve assembly to the cylinder block.

Refit pipe from valve to the cylinder block (T.6.3544 only).

With turbocharged engines, the first blow off stage to feed the piston cooling jets should reach a steady flow at 30/37 lbf/in² (2,11/2,60 kgf/cm²) or 207/255 kN/m², relief valve flow should commence at 50/60 lbf/in² (3,52/4,22 kgf/cm²) or 343/414 kN/m².

With naturally aspirated engines, there is only one blow off stage, when the relief valve flow should commence at 50/60 lbf/in² (3,52/4,22 kgf/cm²) or 343/414 kN/m².

Refit the sump and fill with lubricating oil to an approved grade.



L.18

Oil coolers

Oil coolers for both engine and gearbox lubricating oil are fitted to naturally aspirated and turbocharged engines. With turbocharged engines, the oil cooler also incorporates an air charge cooler.

Oil (and air in the case of turbocharged engines) passes over the cooler tubes and is cooled by raw water passing through the tubes.

For removal and cleaning of the oil cooler, reference should be made to Section M. Under normal circumstances, oil coolers will require little attention, providing the sea water intake screen is kept clean.

To test oil coolers

Suitable adaptors, incorporating pressure connections, must be fabricated to blank off oil parts, water and air connections.

The engine, gearbox, and on turbocharged engines, air charge cooler has to be tested as an assembly.

To test the water side of oil coolers and air charge cooler (where fitted), fill water side with water and pressurise the water side with air at a pressure of 30 lbf/in² (2,1 kgf/cm²) or 207 kN/m² and examine for leaks.

To test oil side of oil coolers, with the water side filled with water and the units immersed in water, pressurise the oil side with air at a pressure of 60 lbf/in² (4,2 kgf/cm²) or 414 kN/m². Check for leaks.

To test air side of the air charge cooler (where fitted), follow procedure for checking oil side of cooler, but at a pressure of 30 lbf/in² (2,1 kgf/cm²) or 207 kN/m². Check for leaks.

Adaptor – filter to cylinder block

The adaptor may be released by removing the securing setscrews, see Fig. L.18.

When refitting, use a new joint and suitable sealing compound and secure with setscrews, plain washers and spring washers.

Lubricating oil filter

The lubricating oil filter is mounted on the cylinder block in an inverted position. The canister incorporates an internal stack pipe and an anti-drain valve which prevent excessive oil spillage during filter changes. The housing incorporates a filter pressure differential by-pass valve when fitted to naturally aspirated engines.

On turbocharged engines, the filter adaptor housing incorporates a Vernet temperature/pressure sensitive by-pass valve, see Fig. L.19. The operation of the valve ensures that cold lubricating oil by-passes the oil cooler so accelerating the warming up of the lubricating oil. The start to close temperature of the valve, i.e., the point at which lubricating oil starts to flow through the cooler is 176°F (80°C) with a fully closed temperature of 202°F (94°C). As well as being temperature sensitive, the valve is pressure sensitive and is able to by-pass oil from the cooler in the event of there being a blockage.

The Vernet valve can be removed for cleaning by unscrewing the valve head nut from the filter adaptor housing, see Fig. L.20. This can be cleaned in paraffin (kerosene) or a proprietary cleaner.

To renew lubricating oil filter element

Unscrew filter canister from filter head casting (see Fig. L.21).

Check that threaded adaptor is secure in head casting.

Discard old canister.

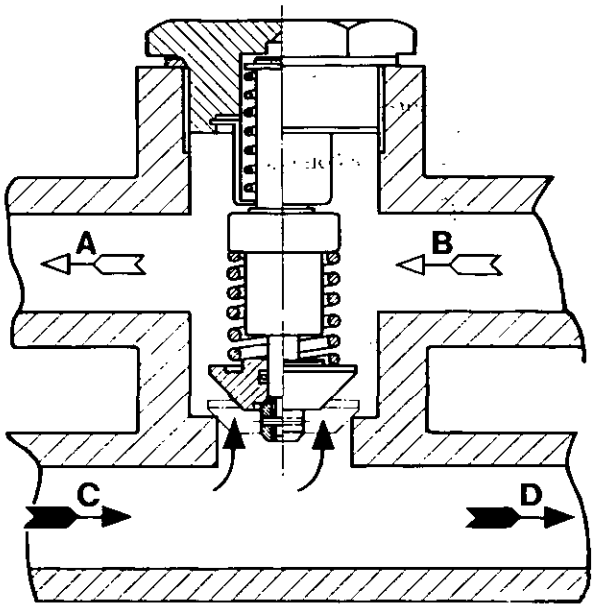
Clean filter head.

Prime the new canister with lubricating oil allowing time for the oil to filter through the element.

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

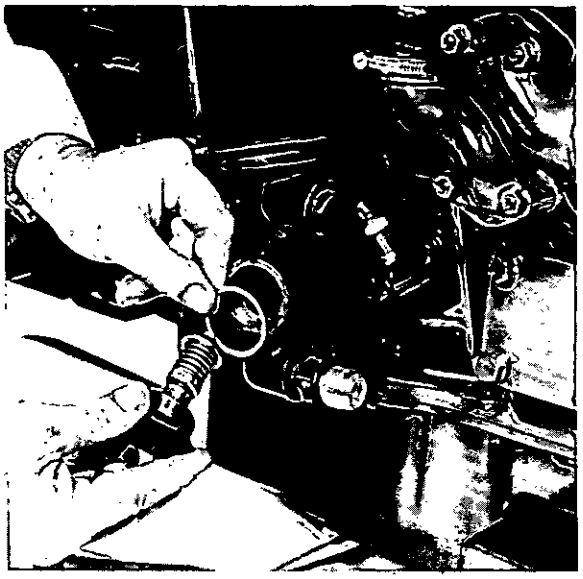
Screw replacement canister onto filter head until the seal just touches the head and then tighten by hand as per the instructions on canister. Where a tool is available, tighten to 15 lbf ft (2,07 kgf m) or 20 Nm.

Run engine and check for leaks.



A To engine oil filter.
B From engine oil cooler.
C From lubricating oil pump.
D To engine oil cooler.

L.19



L.20

L.21

TECHNICAL DATA

Lubricating oil scavenge pump (horizontal engines only)

Type	Gear
Inside diameter of pump body	1.760/1.762 in (44,70/44,75 mm)
Outside diameter of gears	1.749/1.750 in (44,42/44,45 mm)
Radial clearance between gears and body	0.005/0.0065 in (0,13/0,17 mm)
Depth of pump body	1.563/1.565 in (39,70/39,75 mm)
Length of gears	1.559/1.560 in (39,60/39,62 mm)
Gear end float (with joint)	0.005/0.008 in (0,13/0,20 mm)
Gear backlash	0.009/0.015 in (0,23/0,38 mm)
Inside diameter of driven gear bushes	0.625/0.626 in (15,87/15,90 mm)
Outside diameter of driven shaft	0.6228/0.6238 in (15,82/15,84 mm)
Running clearance of driven gear bushes on shaft	0.0012/0.0032 in (0,03/0,08 mm)
Bore diameter of drive gear	0.7187/0.7199 in (18,25/18,28 mm)
Outside diameter of drive gear shaft	0.7507/0.7512 in (19,06/19,08 mm)
Transition fit of drive gear on shaft	+0.00025/-0.00125 in (+0,006/-0,03 mm)
Inside diameter of drive shaft bush – front	0.625/0.626 in (15,87/15,90 mm)
Outside diameter of drive shaft – front	0.6230/0.6238 in (15,82/15,84 mm)
Running clearance of driven gear bushes on shaft	0.0012/0.003 in (0,03/0,08 mm)
Bore diameter of drive gear	0.6245/0.6258 in (15,86/15,90 mm)
Outside diameter of drive shaft – rear	0.6226/0.6238 in (15,82/15,84 mm)
Running clearance of drive shaft in bush – rear	0.0007/0.003 in (0,02/0,08 mm)

Lubricating oil scavenge pump drive gear

No. of teeth	16
Bore diameter of gear	0.6220/0.6225 in (15,80/15,81 mm)
Outside diameter of drive shaft	0.6230/0.6238 in (15,82/15,84 mm)
Interference fit of gear on shaft	0.0005/0.0018 in (0,01/0,05 mm)

Lubricating oil scavenge pump idler gear

No. of teeth	31
Inside diameter of idler gear bush	0.6245/0.6258 in (15,86/15,90 mm)
Outside diameter of idler gear shaft	0.623/0.6238 in (15,82/15,84 mm)
Running clearance of idler gear on shaft	0.0007/0.0028 in (0,02/0,07 mm)

Cooling System M

The engine is indirectly cooled using either a multi-cooler (T6.3544) or a mani-cooler (6.3544) both fitted on the right hand side. The multi-cooler, which was also used on a few early naturally aspirated engines, consists of an aluminium casting which embodies the exhaust and induction manifold, heat exchanger and header tank as a complete assembly. The multi-cooler has twin thermostats located in the front.

The majority of naturally aspirated engines are fitted with the mani-cooler which incorporates the exhaust manifold, heat exchanger and header tank. The twin thermostats are located in a conventional housing and water outlet connection arrangement fitted to the front of the cylinder head.

Combined engine and gearbox oil coolers, and in the case of some turbocharged engines, an air charge cooler (E.G.A. cooler) is situated on the opposite side of the engine to the multi or mani-cooler.

The cooling system incorporates two water pumps, i.e., a neoprene impeller sea water pump and a centrifugal fresh water pump.

Horizontal engines incorporate a supplementary header tank attached to the top of the multi-cooler to raise the level of the fresh water coolant above the cylinder head. To obviate airlocks, an air bleed point is situated at the front and rear of the cylinder head with small copper pipes leading to the header tank.

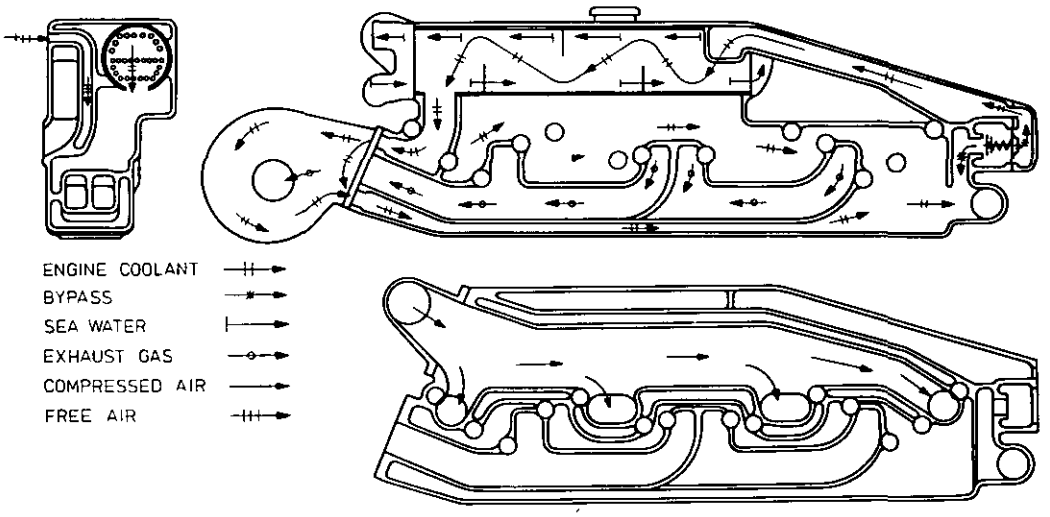
On turbocharged engines, the turbocharger is attached to the rear of the multi-cooler at the exhaust manifold outlet. Cast in waterways match to the turbocharger so that the turbocharger water cooling is integral with the multi-cooler exhaust manifold cooling.

A sea water pump of similar external dimensions is fitted to the fuel pump side of naturally and turbocharged engines, driven form the auxiliary drive shaft. A different size internal cam plate gives the sea water pump on turbocharged engines, an increased output.

The sea water coolant is drawn from the raw water intake sea cock/strainer and delivered under pressure through the combined engine, gearbox oil coolers and in the case of most turbocharged engines, air charge cooler, mounted on the fuel pump side of the engine. Then the

Multi-cooler operation (T6.3544M)

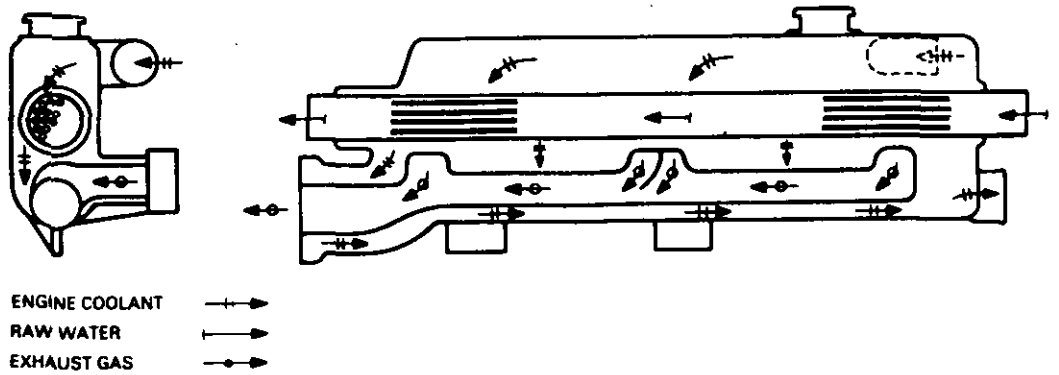
Fig. M.1 shows the flow system of coolant, raw water, air and exhaust gases within the multi-cooler assembly.



M.1

Mani-cooler operation (6.3544M)

Fig. M.2 shows the flow system of coolant, raw water and exhaust gases within the mani-cooler assembly.



M.2

coolant is passed by a copper pipe across the rear of the engine to the multi-cooler or mani-cooler, heat exchanger inlet and then out, either to a water injection bend for exhaust cooling or overboard for a dry exhaust.

Circulation of the closed coolant system is by means of a centrifugal water pump mounted on the front of the cylinder block just above the timing gear case and is belt driven from the crankshaft pulley. Coolant is drawn from the front of the multi-cooler or mani-cooler and delivered via the water pump into the cylinder block. Cooling of the cylinder block and head is effected by impeller assisted thermosyphon action. After circulation through the engine, the coolant is discharged through the front of the cylinder head or to the thermostat by-pass housing attached to the front of the multi-cooler.

The coolant if cold (thermostats in closed position) discharges through the by-pass back to the water pump. As the temperature rises and the thermostats open, the by-pass is gradually closed off by the thermostat by-pass blanking valve, until a flow of coolant passes through the multi-cooler or mani-cooler and over the tube stack, maintaining the engine coolant at the engine working temperature and then back through the front of the multi-cooler to the water pump for discharge through the cooling system, see Figs. M.1 and M.2.

The upper part of the multi-cooler and mani-cooler forms the header tank and heat exchanger for the engine coolant and a pressurised filler cap set at 7 lbf/in² (0,49 kgf/cm²) or 48 kN/m² is provided.

The operating temperature of the closed coolant system should be in the region of 179/203°F (82/95°C) measured at the cylinder head outlet.

When checking the closed coolant level in the multi-cooler header tank, it will be found that the coolant just covers the top deck of the multi-cooler, underneath the filler cap.

If the coolant level is slightly down, the top deck may not be covered giving a false impression of a low coolant level. When this occurs, care should be taken when topping up the coolant level, not to fill rapidly as only a small amount of coolant may be needed to bring the coolant to its correct level. Rapid filling could mean coolant running out over the engine and possibly saturating component parts.

Where a multi-cooler or mani-cooler requires leak testing, it should be air leak tested from both sides at an air pressure of 30 lbf/in² (2,1 kgf/cm²) or 207 kN/m². Suitable adaptors incorporating connections will be required to blank off the multi-cooler or mani-cooler connections. Once pressurised, the whole assembly should be immersed in water and checked for air leaks.

Filling the closed circuit cooling system

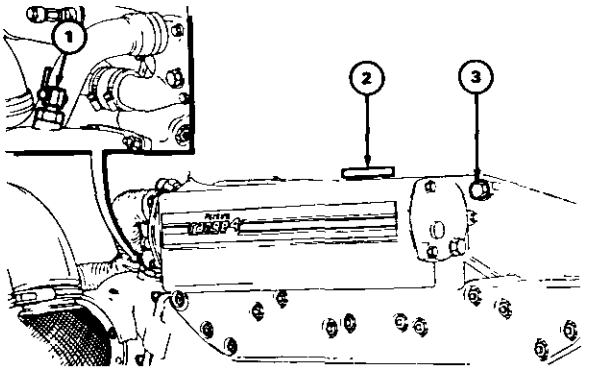
6.3544M engines

Ensure that a coolant of the correct specification is used, see Coolant specification page 5.03 in the HD Power and Range 4 Series Users Handbooks.

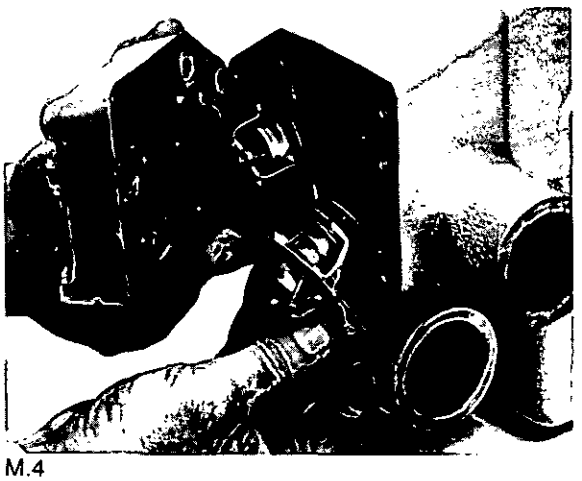
Remove the filler cap of the header tank and fill the coolant system slowly until the coolant level reaches the filler tube.

Wait for five to ten minutes and check the coolant level, add coolant if necessary. Fit the filler cap.

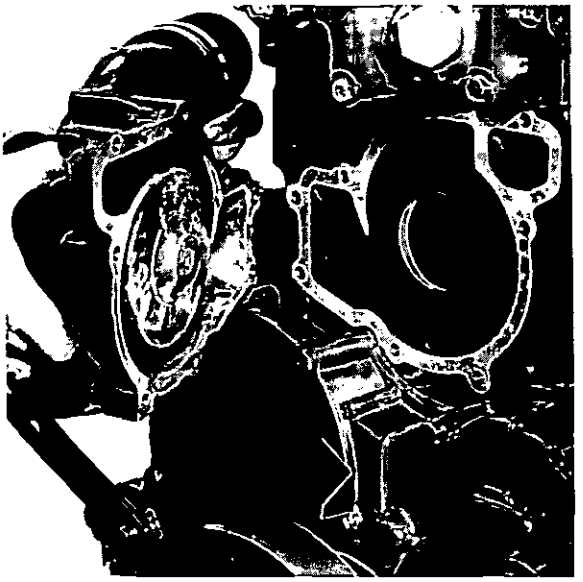
Start the engine and when it has reached its normal temperature of operation, stop it and let it cool.



M.3



M.4



M.5

Remove the filler cap of the header tank and add coolant slowly until the level of the coolant reaches the filler tube. Fit the filler cap.

T6.3544M engines

Ensure that a coolant of the correct specification is used, see Coolant specification page 5.03 in the HD Power and Range 4 Series Users Handbooks.

Remove the vent plug (3 in Fig. M.3): this plug was not fitted on earlier engines. Remove the filler cap (2) of the header tank. Open the vent tap (1) on top of the turbocharger.

The coolant system must be filled very slowly or air could become trapped in the multi-cooler. Fill the system until coolant, free of air, flows from the vent tap on the turbocharger. Close the vent tap.

Continue to fill the system until coolant, free of air, flows from the vent in the heat exchanger/manifold assembly.

Wait for five to ten minutes, add coolant as necessary during this period. Fit the vent plug.

Continue to fill the system until the level of the coolant reaches the bottom of the filler tube. Fit the filler cap.

Start the engine and, when it has reached its normal temperature of operation, stop it and let it cool.

Remove the filler cap and add coolant until the level of the coolant reaches the bottom of the filler tube. Fit the filler cap.

Air can become trapped in the multi-cooler and cause the engine to overheat if the coolant system is not filled correctly.

The procedure which follows should be used if the engine overheats after the coolant system has been filled:

Stop the engine and allow it to cool.

Turn the filler cap (2 in Fig. M.3) slowly to release the pressure. When the pressure has been released, remove the filler cap.

Remove the vent plug (3) to release the trapped air from the multi-cooler.

Slowly add coolant to the header tank until coolant free of air, flows from the vent. Fit the vent plug. The coolant added to the system must consist of the same original mixture as used to fill the system.

Continue to add coolant to the system slowly, until the level of the coolant reaches the bottom of the filler tube. Fit the filler cap.

Operate the engine and check that it runs at the correct temperature.

To remove and refit thermostats – for engines fitted with multi-cooler

The thermostat housing and cover plate forms the upper front part of the multi-cooler and the cover plate has to be removed before gaining access to the twin thermostats, see Fig. M.4.

Drain the cooling system and remove setscrews and nuts and washers to release the thermostat housing cover plate, see Fig. M.4.

The thermostats can now be withdrawn from the housing.

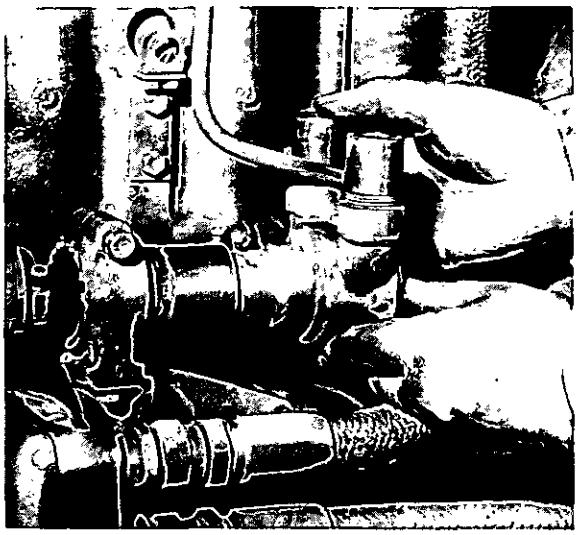
When replacing, ensure that the bleed hole situated in the housing just above and between the thermostats is clear of obstructions.

Ensure that only the correct thermostats with by-pass valves are fitted.

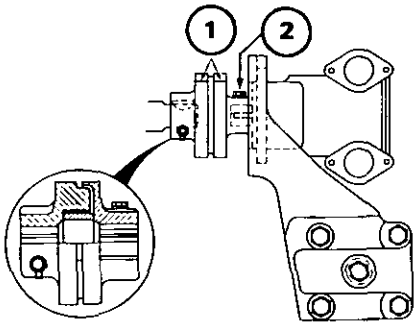
Refit the cover plate using a new joint. Refill the cooling system.

To remove and refit thermostats – for engines fitted with mani-cooler

The water outlet connection forms the top half of the thermostat housing.



M.6



M.7

Drain the cooling system and disconnect the top hose, remove three setscrews securing the water outlet connection and remove.

The thermostats can now be withdrawn from the housing.

When replacing, ensure that the jiggle pins are free to move.

Ensure that only by-pass thermostats are fitted.

Refit the water outlet connection correctly placing a new joint, connect the top water hose and refill the cooling system. Check for leaks

Sea Water Pump

This pump is mounted on the port side of the engine and is driven by the auxiliary drive shaft. The water pump should never be run in a dry condition and if the engine is withdrawn from service for a length of time, the neoprene rubber impeller should be removed at the commencement of the storage period. This may be effected by removing the water pump end plate (see Fig. M.11) and the impeller can be removed by means of suitable pliers, see Fig. M.10.

To remove and fit the sea water pump

6.3544M engines

To remove

Close the sea cock.

Disconnect the hose connections at the pump. This will drain the raw water circuit.

Release the clamp screw (1 in Fig. M.6) of the pump bracket (2) and release the clamp screw (3) of the coupling.

Withdraw the pump from the bracket. Ensure that the coupling and the fibre drive disc do not fall when the pump is withdrawn. Also ensure that the key in the pump shaft is not lost.

To fit

Push the pump into the bracket (2 in Fig. M.6) and fit the coupling to the pump shaft, ensure that the key is completely inside the coupling. Tighten the clamp screw (3) of the coupling. Fit the fibre drive disc between the two halves of the coupling and push the pump forward until the drive disc is just held by the contact faces of the coupling. Ensure that the drive coupling is square and then tighten the clamp screw of the bracket (1).

Connect the hose connections at the pump.

If necessary, open the sea cock.

T6.3544(M) engines

To remove

Close the sea cock.

Disconnect the hose connections at the pump. This will drain the raw water circuit.

Release the clamp screw (2 in Fig. M.7) of the coupling.

Release the setscrews which hold the support bracket to the cylinder block.

Remove the pump together with the bracket. Ensure that the coupling and the drive disc do not fall when the pump and the bracket are removed. Also ensure that the key in the pump shaft is not lost.

Mark the relative position of the pump to the bracket. Release the three setscrews, nuts and washers and remove the pump from the bracket.

To fit

Fit the pump to the bracket with the marks aligned.

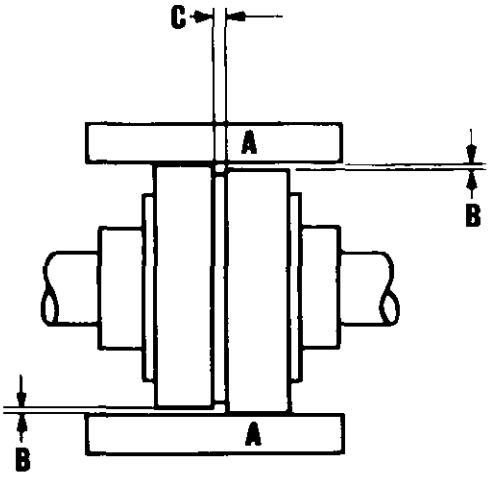
Loosely fit the drive disc and coupling to the pump shaft.

Fit the pump and bracket assembly, engage the drive disc and coupling with the coupling on the auxiliary drive shaft. Ensure that the marks (1 in Fig. M.7) on the outside edge of the couplings are in line. Tighten the setscrews which hold the bracket to the cylinder block.

Check the coupling alignment with a straight edge and feeler gauges (Fig. M.8). The parallel misalignment should not be greater than 0.006 in (0,15 mm). There should not be a greater variation than 0.050 in (1,27 mm) in the distance between the couplings when measured at the top, bottom and sides. If the coupling alignment is correct, tighten the clamp screw of the coupling. If the coupling alignment is not correct, loosen the setscrews which hold the bracket to the cylinder block and reposition the bracket. The gap between the coupling halves should be 0.125/0.187 in (3,18/4,75 mm). The gap can be adjusted by altering the position of the pump coupling on the shaft.

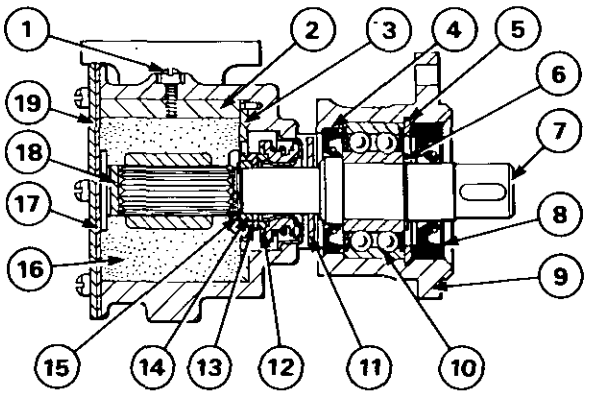
Connect the hose connections at the pump.

If necessary, open the sea cock.



A Straight Edge B.0.006 in (0,15 mm) maximum
C 0.125/0.187 in (3,18/4,75 mm)

M.8



M.9

To dismantle the sea water pump

Close the sea cock and drain the sea water system.

Remove the pump.

Remove the end cover (19 in Fig. M.9) and its joint (17).

Remove the rubber plug (18) from the end of the impeller (16).

Remove carefully the impeller from the shaft (7) with suitable levers or with long nose pliers (Fig. M.10).

Release the cam plate screw (1) by two or three turns and lightly hit the top of the screw to separate the cam plate (2) from the pump body. Remove the screw and the cam plate.

Remove the wear plate (3).

Remove the circlip (15) which retains the seal seat (13).

Remove the key from the shaft then remove the seal (8), if a seal is fitted, from the drive end of the bearing housing (9). Remove the inner and outer circlips (6 and 5).

Press the shaft and the bearing out through the drive end of the housing with the use of a suitable adaptor. Ensure that the flinger (11) is not lost.

Remove the seal seat together with its rubber seal (14). With a suitable adaptor (the shaft could be used), remove the seal (12) from the body of the pump.

Remove the rubber flinger (11).

Remove the seal (4) from the bearing housing.

Support the inner race of the bearing and press the shaft out of the bearing from the drive end.

To assemble the pump

Ensure that all the components are clean and that new seals are used.

Support the inner race of the bearing (10) and press the shaft (7) into the bearing until the bearing is in correct with the flange of the shaft. Fit the circlip (6).

Fit the inner seal (4) into the bearing housing (9). Ensure that the garter spring is toward the drive end of the housing.

Support the pump body at the impeller end. With the use of a suitable adaptor on the outer race of the bearing, press the shaft and bearing into the bearing housing. Ensure that the splines of the shaft are toward the impeller end of the body. Fit the circlip (5).

Fit the outer seal (8) into the bearing housing (if a seal is fitted). Ensure that the garter spring is toward the drive end.

Fit the flinger (11) onto the shaft.

Ensure that the carbon face of the seal (12) is clean. With the use of a suitable adaptor that will press on the flange of the seal, press the seal into the impeller housing. Ensure that the carbon face of the seal is toward the impeller end of the pump. Ensure that the ceramic face of the seal seat (13) is clean. Push the seal seat together with its rubber seal (14) onto the shaft until the seal seat is in contact with the carbon face of the seal. Fit the circlip (15).

Put the wear plate (3) into position in the impeller housing with the dowel in its location. If the wear plate is worn on one face, fit it with the face that is not worn toward the impeller.

Apply a suitable jointing compound to the top face and to the front face (wear plate end) of the cam plate (2). Also apply jointing compound to the thread of the screw (1) for the cam plate. Fit the cam plate and tighten the screw.

Apply Marfak 2HD grease to the blades of the impeller (16) and fit it on the shaft with the blades bent counter-clockwise (as seen from the cover end), see Fig. M.11. If the blades are slightly worn, the impeller can be fitted with the original front end to the rear. Fit the rubber plug (18) in the end of the impeller.

Apply jointing compound to both faces of a new joint (17). Fit the joint to the body with the wide area of the joint over the cam plate. Fit the end cover (19) and the screws. Tighten the screws gradually and evenly.

Fit the key to the shaft.

Multi-cooler

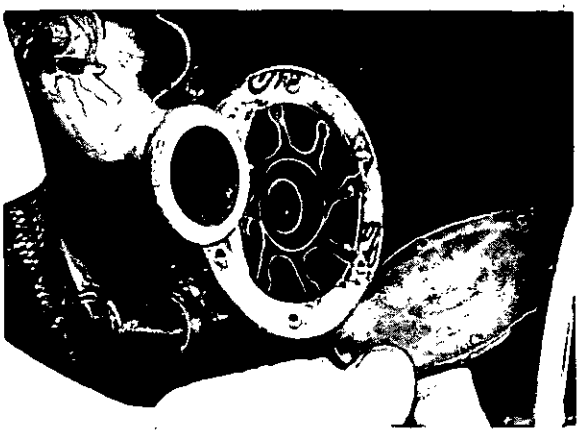
Dismantling and removal (Fig. M.12)

Remove inlet and outlet raw water pipes from rear end cover of the heat exchanger part of the multi-cooler.

Remove front cover plate from heat exchanger section by releasing the three setscrews.

Remove the rubber 'O' ring from the end of the tube stack.

M.10



M.11

Remove rear cover plate in the same way, noting the flat neoprene joint with centre bar.

Slide out tube stack (providing there is sufficient room) noting the tube stack flange joint which is between the tube stack flange and multi-cooler casing.

The multi-cooler aluminium casing can now be removed from the engine if necessary. This will entail removal of:

(a) Turbocharger, (Turbocharged engines only).

(b) Exhaust and water injection elbow (naturally aspirated engines only).

(c) Induction connections to and from air charge cooler.

The twin thermostats may also be removed from the front of the multi-cooler by the removal of the thermostat cover plate and setscrews, see Fig. M.4.

If the thermostat seats or the inner rear wall of the by-pass chamber show indications of bad erosion a one piece nylon insert can be fitted into each thermostat by-pass bore. These inserts are available from, and can be fitted at, your Perkins marine distributors. On later engines these inserts are fitted as standard.

Cleaning the multi-cooler heat exchanger section

If the tube stack appears to be badly fouled up, the best method of cleaning is to use a non caustic crystalline solvent approved by the manufacturers of the equipment.

Usually, the fresh water side, i.e., the outside of the tubes is relatively clean as these are on the closed water

circuit. The inside of these tubes which have the raw water (sea water) passing through them is more likely to require cleaning. If these are not badly scaled enough to require the solution treatment above, they can be cleaned by pushing a length of $\frac{1}{8}$ in (3,2 mm) diameter steel rod down the tubes to dislodge all foreign matter. It is important to note that when carrying out this exercise, the rod should be pushed through the tubes in the opposite direction to that in which the water flows. Do not use undue force to push the rod through the tubes.

The other components of the assembly should be cleaned before re-assembly and as these have no hidden features, no special instructions are considered necessary.

Re-assembly of multi-cooler heat exchanger section

If the multi-cooler main aluminium casing has been removed, it is advisable to refit this to the engine before re-assembly of the tube stack, providing installation conditions allow for the re-assembly in situ. It is possible to assemble the multi-cooler before fitting to the engine.

To assist in the correct assembly of the rear end cap, joints and tube stack, the setscrew holes in the multi-cooler, for holding the end cap in position are off-set. The outer periphery of the two joints and the tube stack flange have three small scallops which must be lined up correctly to match up with the setscrew holes.

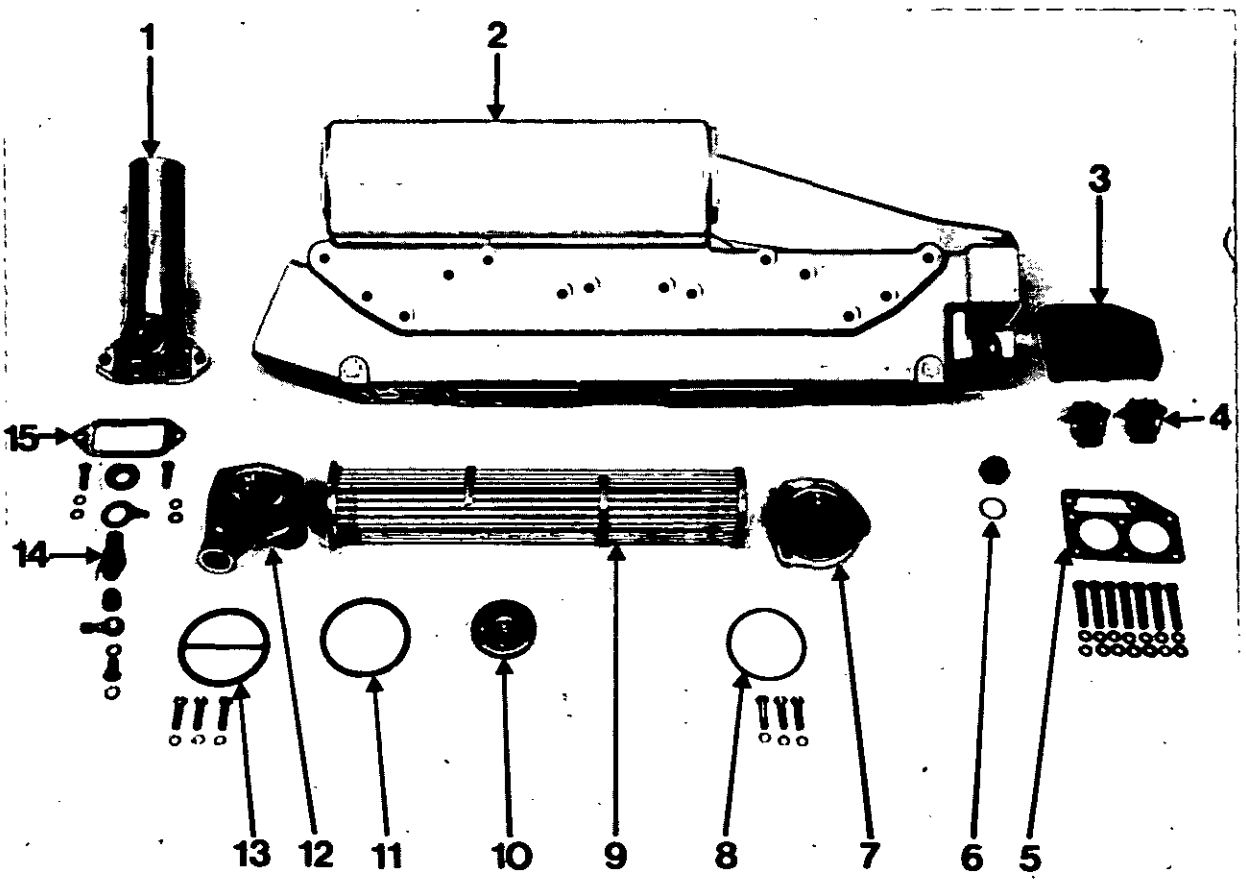
As an additional check, it should be ensured that the rear end cap bridge wall, across the centre of the end cap and the bar across the outer joint should match up with the groove across the end of the tube stack and that the connections in the end cap face the correct direction. This will ensure that there are two sealed chambers in the end cap ensuring the correct flow of sea water through the tube stack.

To assemble

Place the flat joint over the tube stack until it abuts against the tube stack flange with the scallops in the outer periphery of the joint and tube stack lined up correctly.

Slide the tube stack in position into the multi-cooler casing from the gearbox end, ensuring that the scallops are lined up correctly with the setscrew holes in the main casing.

Place joint with bar across the centre in position on the



M.12

1 Air intake connection.
2 Multi-cooler body.
3 Thermostat cover plate.
4 Twin thermostats.
5 Thermostats cover plate joint.
6 Coolant blanking/drain plug.
7 Heat exchanger end cap.
8 Tube stack/end cap sealing 'O' ring.
9 Tube stack.
10 Pressure cap.
11 Sealing ring joint, tube stack to multi-cooler body.
12 Sea water cooling inlet and outlet end cap.
13 Inlet and outlet cap joint, end cap to tube stack.
14 Thermostart unit.
15 Air intake connection joint.

tube stack ensuring that the bar across the joint seats into the groove across the face of the tube stack. A little grease on the joint face will enable the joint to be maintained in position.

Place end cap in position ensuring bridge wall across the cap centre is in line with the joint bar and the tube stack groove, and that the connections on the end cap face the correct direction.

Fit the three setscrews and washers and tighten setscrews progressively.

Note: Joints and 'O' ring should be renewed if badly worn, deformed or damaged.

Mani-cooler

Dismantling and removal (Fig. M.12A)

Shut the raw water inlet valve or cock and also drain the engine coolant by removing the relevant plugs in the base of the mani-cooler body.

Remove the raw water inlet and outlet pipes and black neoprene end connections from front and rear of the heat exchanger unit respectively.

If the installation allows sufficient space remove the heat exchanger tube stack from either end. If it is necessary to take the mani-cooler off the engine in order to take out the tube stack for cleaning purposes remove the coolant inlet connection at the top/front of the mani-cooler.

Remove the coolant outlet connection at the bottom/front of the mani-cooler complete with by-pass connection from the thermostat housing.

Remove the exhaust outlet connection from the rear of the mani-cooler.

Refit the neoprene end covers and clip them firmly to the body of the heat exchanger, this will keep the tube stack safely in position during removal of the assembly.

Remove the top fasteners of the support bracket from the underneath of the mani-cooler body.

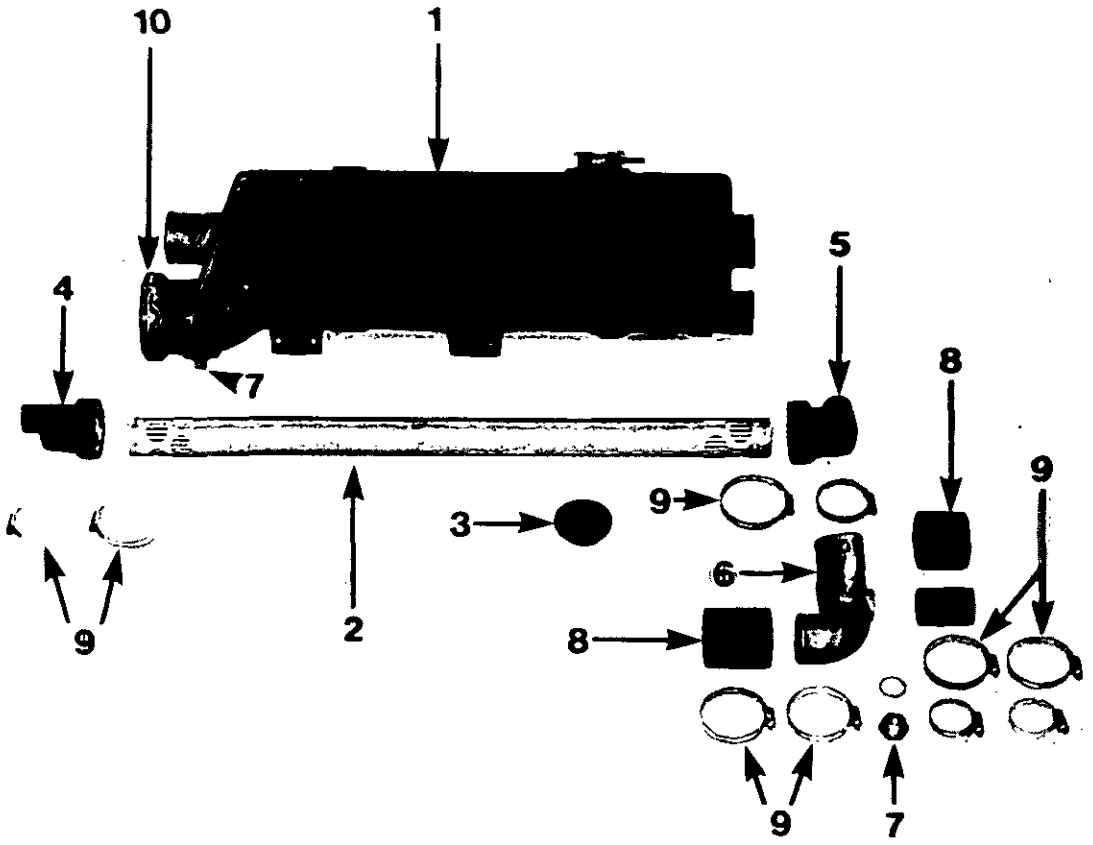
Remove the nuts and washers form the exhaust manifold retaining studs on the cylinder head.

Note: These washers may not all be the same; on some engines the washers used on the centre two studs are specially shaped and washers from the front or rear pair of studs will not fit. Hence take care to put these washers back in their correct position on re-assembly.

The mani-cooler body may now be removed from the engine.

Cleaning the mani-cooler heat exchanger section

The method of cleaning for the mani-cooler tube stack is the same as that given for the multi-cooler, see Page M5.



M.12A

1 Mani-cooler body.
2 Tube stack.
3 Pressure cap.
4 Raw water outlet end connection.
5 Raw water inlet end connection.
6 Coolant inlet connection.
7 Coolant blanking/drain plug.
8 Hose connections.
9 Hose clips.
10 Exhaust outlet flange.

Re-assembly of mani-cooler heat exchanger section

Re-assembly is the reverse of the dismantling procedure outlined above.

When positioning the tube stack back in the mani-cooler body ensure that the protrusion of it out of the body is equal at each end, approximately 1 in (25 mm) to give adequate support and a good seal inside the neoprene and connections.

Note: Hoses, connections or clips must be renewed if they are badly deformed, worn or damaged.

After re-assembly the raw water coolant systems must be checked for leakage.

Engine Gearbox and Air Charge Coolers (E.G. and E.G.A. Coolers)

Most turbocharged engines are fitted with a combined engine, gearbox and air charge cooler (E.G.A. cooler), see Fig. M.13.

Naturally aspirated and some turbocharged engines have only an engine and gearbox cooler (E.G. cooler), see Fig. M14.

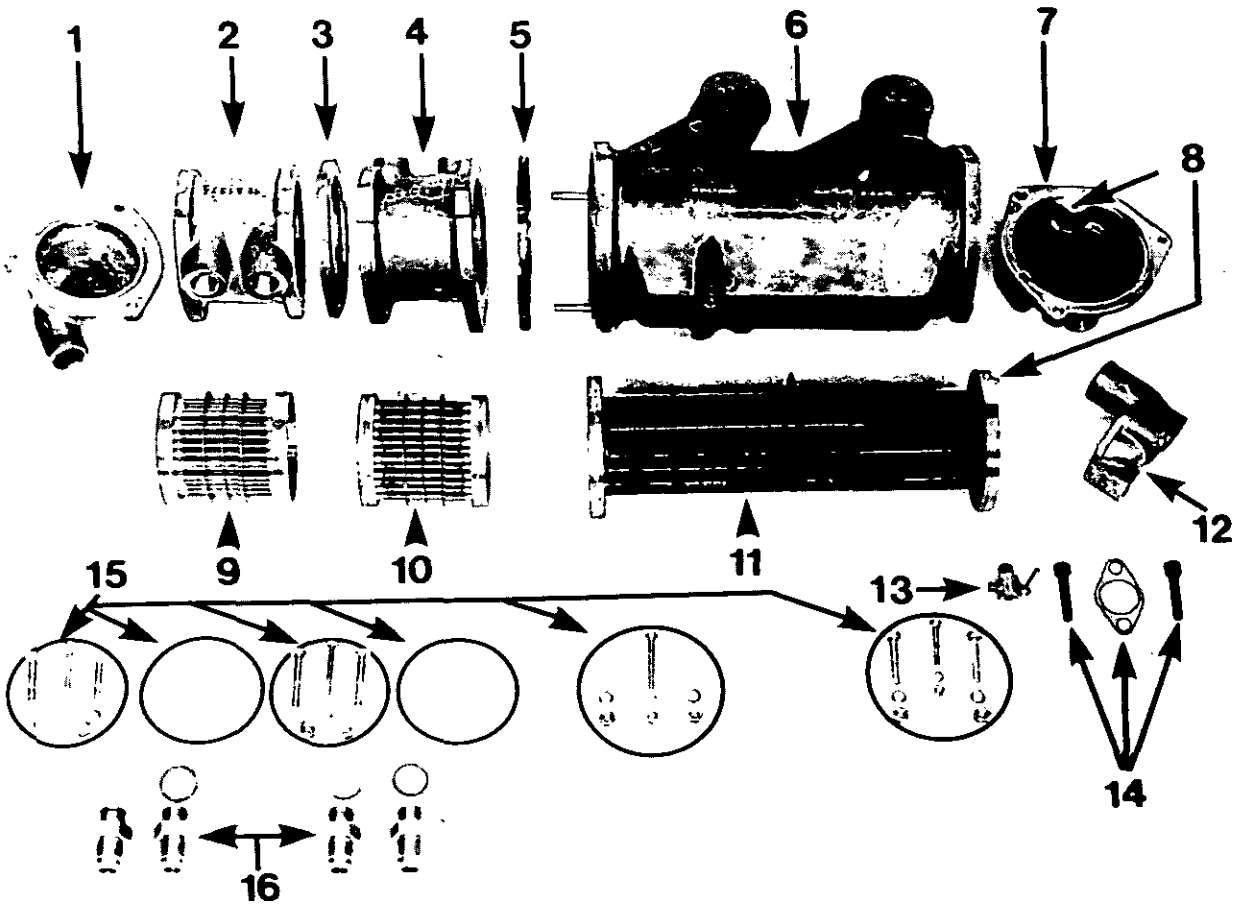
The E.G.A. and E.G. coolers are fitted as complete assemblies.

To clean the tube stacks of the coolers, which are separate units in their own rights (although part of a complete assembly) different methods of removal are needed, depending on the part requiring attention.

Air charge cooler

To remove the tube stack from the air charge cooler, it is necessary to disconnect the two oil coolers from the air charge cooler body.

These can be separated from the air charge cooler by removing the three bolts, nuts and washers and distance piece. The oil coolers can be left attached to their flexible oil pipes which should have the pipe nuts eased to allow slight movement, which will facilitate positioning of the oil coolers, if sufficient room is available to remove the tube stack with the air charge cooler body in position, it may



M.13

1 Raw water inlet end cover.
2 Engine oil cooler body.
3 Distance piece.
4 Gearbox oil cooler body.
5 Distance piece.
6 Air charge cooler body.
7 Raw water outlet end cover.
8 Tube stack location pin and hole.
9 Engine oil cooler tube stack.
10 Gearbox oil cooler tube stack.
11 Air charge cooler tube stack.
12 Raw water outlet connection.
13 Raw water drain tap.
14 Raw water outlet connection joint and setscrews.
15 Seating 'O' rings, setscrews, nuts and washers.
16 Connections and washers for flexible oil pipes.

be left in situ.

Remove oil coolers as detailed above.

Remove raw water outlet pipe connection.

Remove raw water outlet end cap by unscrewing three setscrews.

Remove 'O' ring seals from both ends of tube stacks.

Slide tube stack out of casing.

The method of cleaning is the same as that given for the multi-cooler tube stack. Testing details are given on Page L7.

The air pipe from the turbocharger to the air charge cooler (if fitted) and the return pipe to the inlet manifold of the multi-cooler can be removed and cleaned out with paraffin or a proprietary cleaner. Thoroughly dry the pipes inside and outside before re-assembly.

Engine oil cooler

The engine oil cooler forms part of the combined cooler but can be removed as a separate unit for servicing.

Disconnect flexible oil connections, tying plastic bags over the ends to catch any residual oil and to keep the ends clean.

Disconnect raw water inlet hose.

Remove engine oil cooler from gearbox oil cooler by unbolting three bolts, nuts and washers. The distance piece between the two coolers will be loose and should be removed with the cooler.

Remove end cap by unscrewing three setscrews.

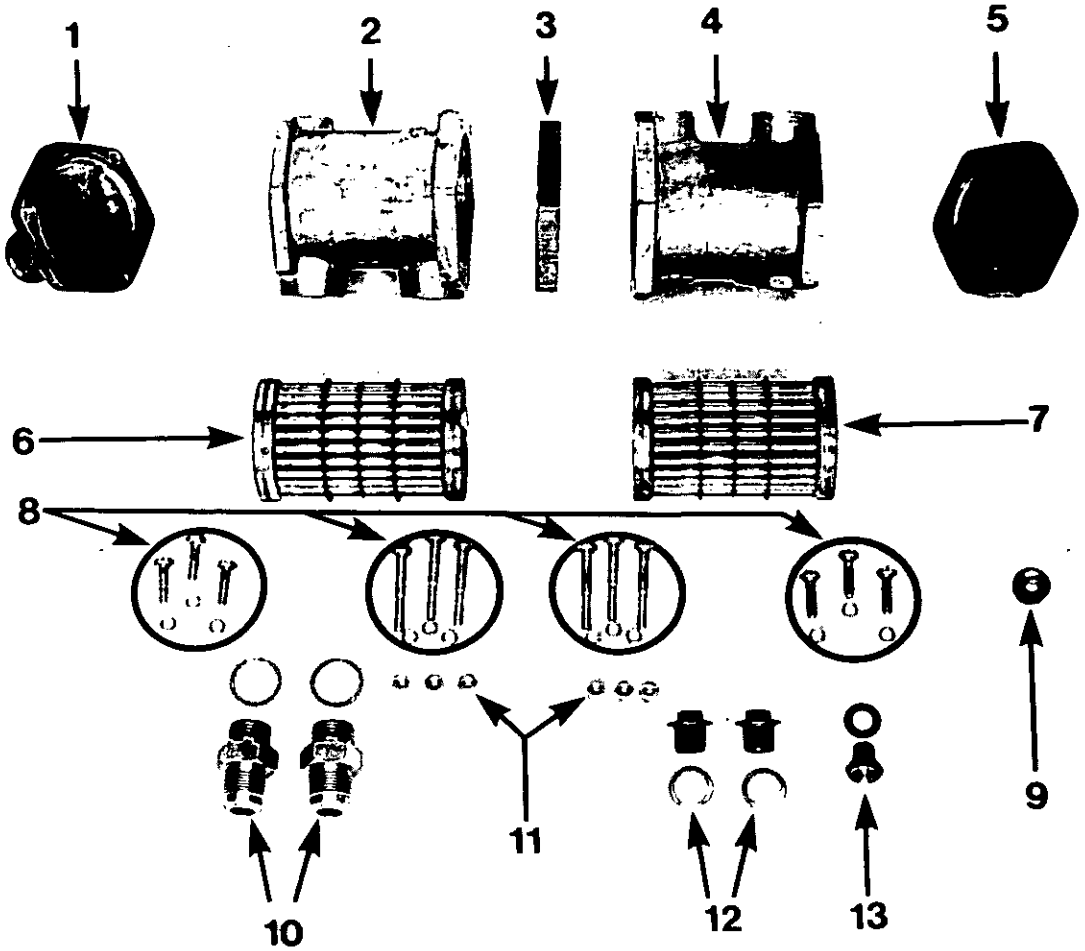
Remove 'O' ring seals from both ends of the tube stack and slide tube stack from its outer casing.

The method of cleaning is the same as for the multi-cooler tube stack. Testing details are given on Page L7.

Gearbox oil cooler

This is dismantled in the same way as the engine oil cooler except for removal from the engine, where it will be necessary to remove the engine oil cooler at the same time.

On turbocharged engines, it is situated between the air charge cooler (where fitted) and engine oil cooler and it will be necessary to disconnect the gearbox cooler from



M.14

1 Raw water inlet end cover.
2 Engine oil cooler body.
3 Distance piece.
4 Gearbox oil cooler body.
5 Raw water outlet end cover.
6 Engine oil cooler tube stack.
7 Gearbox oil cooler tube stack.
8 Sealing 'O' rings, setscrews and washers.
9 Raw water blanking/drain plug.
10 Connections and washers for flexible oil pipes.
11 Nuts.
12 Blanking plugs and washers for gearbox oil cooler.
13 Oil blanking/drain plug.

the air charge cooler before removing the gearbox oil cooler from the engine oil cooler.

On naturally aspirated engines, it is necessary to disconnect the engine oil cooler from the gearbox oil cooler, then remove the raw water outlet end cap, 'O' ring seal and slide the tube stack towards the gearbox end of the engine for removal, providing there is sufficient room. The outer casing can then be removed for cleaning. Where there is insufficient room to remove the tube stack with the casing in situ, the cooler assembly may be removed completely and dis-assembled on the workbench, *see Figs. M. 13 and M.14.*

The method of cleaning is the same as for the multi-cooler tube stack. Testing details are given on Page L7.

Re-assembly of E.G. and E.G.A. coolers

The position of each tube assembly in the E.G. and E.G.A. coolers as fitted to earlier engines is very important.

These earlier types of coolers are identified by the position of the gearbox oil inlet and outlet connections. On the early coolers they are located at the bottom of the cooler such that the flexible oil pipes run beneath the cooler assembly, see Engine photographs A.1 and A.2 in Section A.

If the tube stacks are not fitted correctly, especially after overhaul of the E.G.A. cooler, they can cause low engine oil pressure (caused by high engine oil temperature) and/or high gearbox oil temperature or reduce the power of the engine. If any of these problems occur check the position of the tube assemblies.

To ensure the tube assemblies are fitted correctly their *end plates are stamped with a letter 'O' see items A and* B in Fig. M.15. These markings must be in line with and next to the inlet and outlet connections of the relevant section of the cooler assembly. Fig. M.15 is a view from the rear of the engine; the shaded area represents the oil cooler bodies and the upper area is the air charge cooler body.

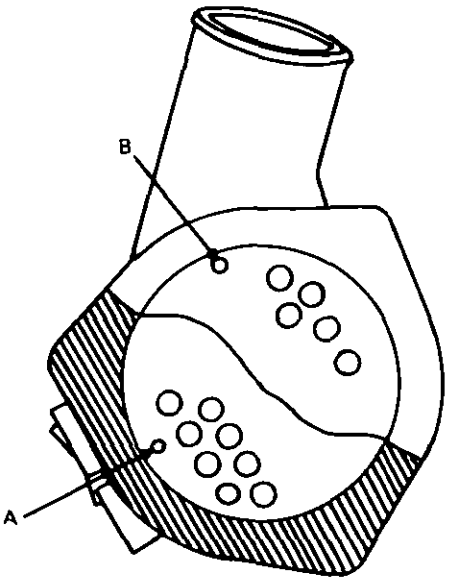
The markings enable the highest point of the centre baffle plate of each tube assembly to be between the *inlet and outlet ports so that the oil and the air pass* correctly over the tube assembly resulting in the correct degree of cooling.

With the latest type of E.G. and E.G.A. cooler the oil pipe connections into and out of the gearbox oil cooler are positioned on the top of the cooler – see Figs. M.13 and M.14.

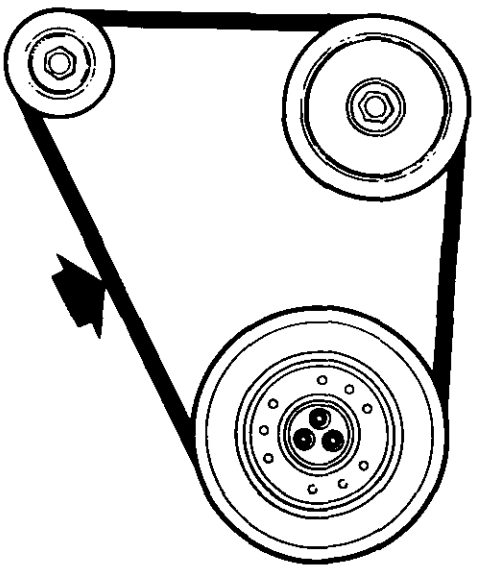
The latest gearbox oil cooler unit is suitable for use with gearboxes which utilise high oil pressures.

The specific position of the tube stack within the latest engine oil and gearbox oil cooler is not important as there are no asymmetric baffles. However positive location is achieved by means of one smaller diameter fastener out of the three.

For the air charge cooler, which has a critical position due to the centre baffle, there is a pin on the rear end of the tube stack which locates in a hole in the near end water outlet cover; this will ensure correct assembly (see Fig. M.15).



M.15



M.16

Drive Belts

Vertical engines have a single belt to drive the water pump and alternator, and is tensioned by altering the position of the alternator on its slotted mounted link arm.

Horizontal engines have twin belts, one to drive the alternator which is tensioned by the alternator link arm, and the other to drive the water pump. This belt is tensioned by means of a jockey pulley which is adjustable by loosening a nut and bolt which passes through the centre of the pulley to a slotted bracket.

Belt tension should be such that a pressure applied by the thumb on the longest unsupported length of the belt should depress it approximately ⅜ in (10 mm), see Fig. M.16.

TECHNICAL DATA

Fresh water pump

Type	Centrifugal
Outside diameter of shaft for pulley	0.7492/0.7497 in (19,03/19,04 mm)
Inside diameter of pulley bore	0.7500/0.7508 in (19,05/19,07 mm)
Clearance fit of pulley on shaft	0.0003/0.0016 in (0,01/0,04 mm)
Outside diameter of shaft for impeller	0.6262/0.6267 in (15,91/15,92 mm)
Diameter of impeller bore	0.6249/0.6257 in (15,87/15,89 mm)
Interference fit of impeller on shaft	0.0005/0.0018 in (0,01/0,05 mm)
Impeller blade to pump body clearance	0.027/0.035 in (0,69/0,89 mm)

Lubricating oil cooler

Type	Sea water cooled
Pressure test:	
Water side	30 lbf/in² (2,11 kgf/cm²) or 207 kN/m²
Oil side	60 lbf/in² (4,22 kgf/cm²) or 414 kN/m²

Oil cooler by-pass valves

Type (Naturally aspirated and turbocharged)	Pressure differential spring loaded ball
Pressure setting	23.6 lbf/in² (1,66 kgf/cm²) or 163 kN/m²
Type (Turbocharged only)	Temperature/Pressure sensitive
Valve closing temperature	197/202°F (92/94°C)
Pressure setting	18/22.5 lbf/in² (1,12/1,58 kgf/cm²) or 124/155 kN/m²

Multi-cooler

Serk	Combined exhaust/inlet manifolds, header tank and heat exchanger
Leak test air pressure	30 lbf/in² (2,11 kgf/cm²) or 207 kN/m² both sides

Mani-cooler

Bowman	Combined exhaust manifold, header tank and heat exchanger
Leak test air pressure	30 lbf/in² (2,11 kgf/cm²) or 207 kN/m² both sides

Air charge cooler

Leak test pressure – water side	30 lbf/in² (2,11 kgf/cm²) or 207 kN/m²

Air Filters N

Air filter

A gauze type filter screen is fitted to T6.3544 and 6.3544 marine engines. This varies according to engine type.

Turbocharged engines have a mesh screen covering the entrance to the air intake bell housing of the turbo-charger.

Vertical naturally aspirated engines have a mesh screen across the air intake port of the multi-cooler or mani-cooler.

Horizontal naturally aspirated engines have a round cap type with mesh side screens placed on the entrance to the air intake pipe.

These should be cleaned in accordance with Preventive Maintenance, (see Page 4.03 of the HD Power and Range 4 Series Users Handbooks), with a suitable cleansing fluid.

Turbocharger Q

T6.3544 marine engines only

The Perkins turbocharged 6.3544 marine engine is fitted with a Holset H1B, H1C or H2A water cooled turbocharger. The turbocharger is mounted to the multi-cooler exhaust manifold outlet and is held in position by four studs, nuts and washers. The turbocharger's lubricating oil is taken from the engine's lubricating system. The oil pressure at the turbocharger will be 30 lbf/in² (2,11 kgf/cm²) or 207 kN/m² at normal running speed.

The maximum boost pressure will be between 11-15 lbf/in² (0,77-1,05 kgf/cm²) 76-103 kN/m², depending on application, engine load and speed.

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

Every 1,000 hours clean the oil drain pipe on the turbocharger to the sump, also the turbocharger compressor impeller and housing. The compressor and housing can be cleaned without removal from the engine.

To clean turbocharger impeller

Disconnect the turbocharger compressor inlet and outlet connections.

Mark the edges of the compressor casing and the backplate or housing to facilitate reassembly.

Remove the compressor casing securing setscrews, locking washers and clamping washers or plates and remove the compressor casing (Fig. Q.1), taking care not to damage the impeller.

Clean the compressor casing and impeller using a non caustic cleaning solution and a soft brush. Check the reason for any excessive build up of foreign matter and rectify.

Press the impeller towards the turbine casing and turn the rotating assembly by hand to check for binding or rubbing. Whilst turning the assembly, listen carefully for any unusual noises. If binding or rubbing is evident, remove the turbocharger for dismantling and inspection.

Position the compressor casing on the backplate or housing with the location marks in line. Fit the clamping washers or plates, locking washers and securing setscrews and tighten the setscrews to 50 lbf in (58 kgf cm), 5,6 Nm.

Reconnect the compressor inlet and outlet connections.

To remove turbocharger

Drain the closed circuit cooling system. Open the tap on the top of the turbine casing whilst the system is being drained.

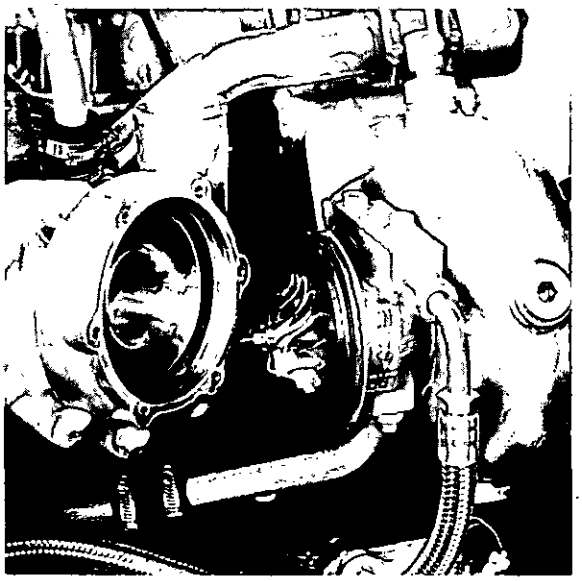
Disconnect the turbocharger compressor inlet and outlet connections.

Disconnect the exhaust pipe and remove the turbocharger outlet elbow.

Disconnect the turbocharger oil supply and oil drain pipes.

Release and remove the turbocharger.

Remove and clean the oil drain pipe, where necessary.



Q.1

Blank off the open engine connections.

To fit turbocharger

Remove the blanks from the open engine connections. Where necessary, fit the oil drain pipe to the engine

Using a new gasket fit the turbocharger to the exhaust manifold outlet, ensuring that the identification tab of the joint is fitted at the top.

Reconnect oil drain pipe, using a new joint.

Pour 4 to 5 fluid ounces (110/140 ml) of clean engine oil through the oil inlet port of the turbocharger housing, turning the rotating assembly by hand to pass oil over the bearing surfaces.

Connect the compressor inlet and outlet pipes.

Fit the exhaust outlet elbow and connect the exhaust pipe.

Refill the closed circuit cooling system. Open the tap on the top of the turbine housing whilst the system is being filled and close it when coolant comes out of the tap.

Reposition the oil supply pipe with a new joint but leave the setscrews loose.

Motor the engine over on the starter motor without firing (by operating the stop control) until a steady flow of oil comes from the oil pipe and then tighten the pipe flange setscrews.

Run the engine and check for leaks – the engine should be run at idling speed for 3 to 4 minutes to allow for proper oil circulation before the speed is increased.

Dynamic balancing

If any major part of the rotating assembly is changed, the assembly must be checked on a dynamic balancing machine to ensure that it is balanced within 0.002 oz in (1,5 gm mm) at each end. If facilities are not available for this specialist operation, a new core unit or turbocharger should be fitted.

Dismantling H1B turbocharger (Fig. Q.2)

1 Clean the exterior of the turbocharger with a non caustic cleaning solution.

2 Hold the unit upright with the turbine inlet flange held in a vice.

3 Mark the relative positions of the turbine housing (30), bearing housing (25) and compressor cover (40).

4 Remove the six setscrews (43) and associated washers (41)(42), fastening the compressor cover to the bearing housing and lift off the cover.

5 Remove the circlip (31) from the turbine housing and lift the core assembly clear of the housing.

6 *Ensure that balancing alignment marks are visible* on the front end of the rotor shaft and the compressor impeller boss. There should be an etched mark on the impeller boss which corresponds with a nick in the end of the shaft to ensure correct reassembly in a balanced condition.

7 Holding the turbine wheel hub in a suitable fixture, remove the compressor impeller locknut (10) – **note left hand thread**. Take care not to bend the shaft, it is advisable to use a 'T' handled spanner to prevent side loading.

8 Slide the compressor impeller (9) off the shaft.

9 Lift off the compressor backplate (26) together with the flinger sleeve (8) and remove the 'O' ring (44). Push out the flinger sleeve from the backplate.

10 Lift off the oil deflector (19) and the thrust ring (7)

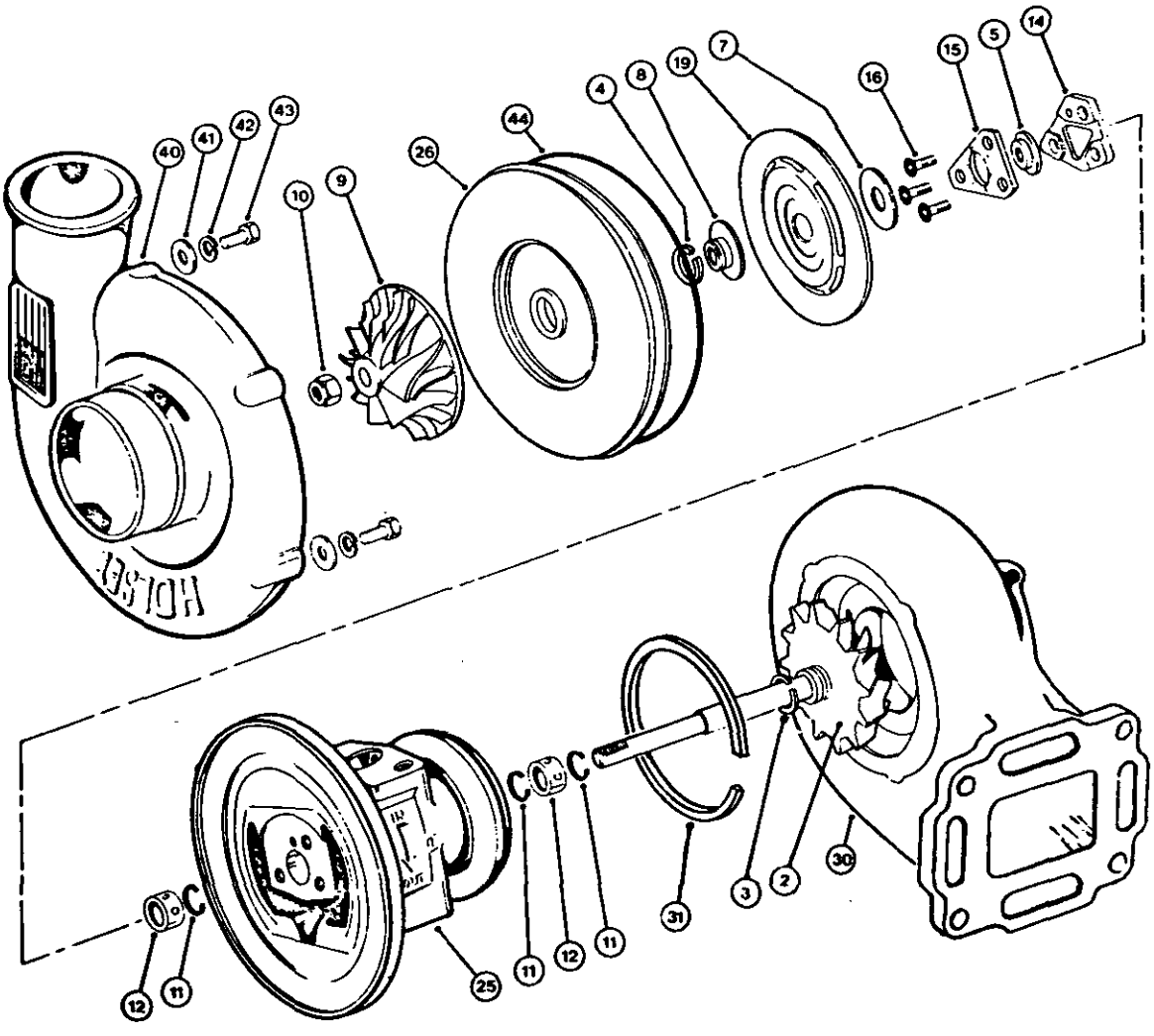
11 Using a 'Torx' head driver tool T20/TX20 and a 'Torx' 2800 adaptor, remove countersunk screws (16). Some turbochargers have Allen socket countersunk screws and locking washers fitted.

12 Lift off thrust bearing (15), thrust collar (5) and spacer plate (14).

13 Remove the shaft and wheel assembly (2) together with its piston ring (3).

14 Insert a finger tip into the compressor end bearing (12) and remove the bearing. Remove the inboard snap ring (11) using circlip pliers.

15 Remove the outboard snap ring (11) at the turbine end. Insert a finger tip into the bearing (12) and remove the bearing. Remove the inboard snap ring (11).



Dismantling H2A and H1C turbocharger (Fig. Q.3)

1 Clean the exterior of the turbocharger with a non caustic cleaning solution.

2 Hold the unit upright with the turbine inlet flange held in a vice.

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

4 Knock back the locking tabs on the lockplates (17) fitted to the turbine housing setscrews (16) and also the compressor housing and diffuser setscrews, if fitted.

5 Remove the setscrews (7), locking washers and the clamping plates (6) securing the compressor housing to the compressor diffuser (4) and lift off the housing.

6 Remove the setscrews (16), lockplates and clamping plates (18) securing the turbine housing to the bearing housing and lift the core assembly clear of the turbine housing.

7 Ensure that the balancing alignment marks are visible on the front end of the rotor shaft and the compressor impeller boss. There should be an etched mark on the impeller boss which corresponds with a nick in the end of the shaft to ensure correct reassembly in a balanced condition.

8 Holding the turbine wheel hub in a suitable fixture, remove the compressor impeller locknut (2) – **note left hand thread**. Take care not to bend the shaft, it is advisable to use a 'T' handled spanner to prevent side loading.

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

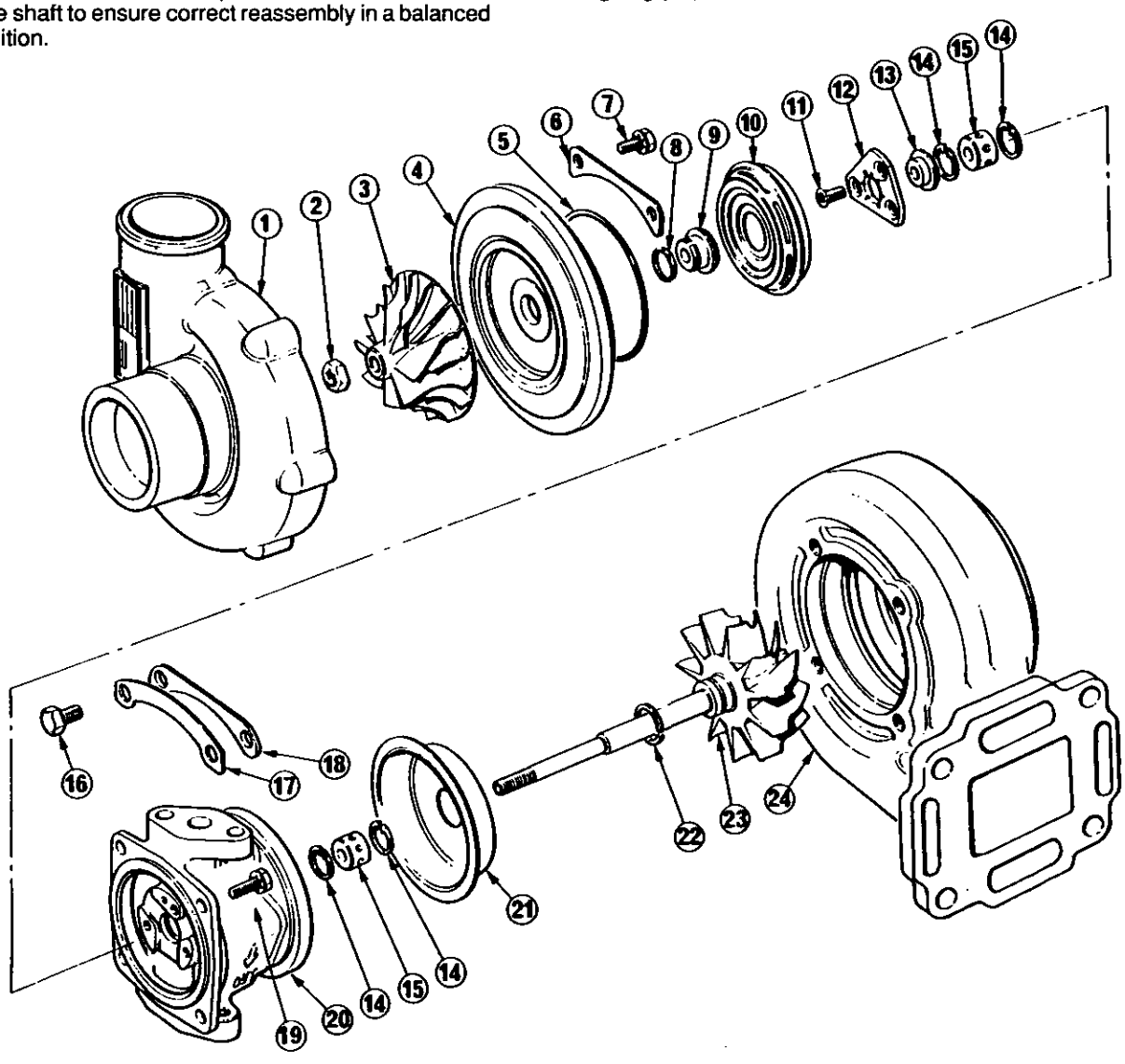
10 Remove the setscrews (19) and locking washers securing the compressor diffuser to the bearing housing. Remove the compressor diffuser with the oil slinger (9) from the shaft. Push out the oil slinger from the diffuser and remove the piston ring (8). Remove the 'SQ' ring seal (5) from the rear of the diffuser.

11 Lift out the oil baffle (10).

12 Using a 'Torx' head driver tool T20/TX20 and a 'Torx' 2800 adaptor, remove the countersunk screws (11), retaining the thrust bearing (12). Lift out the thrust bearing and the thrust collar (13).

13 Remove the shaft and wheel assembly (23) together with its piston ring (22) and lift turbine heat shield (21) off the shaft.

14 Remove the outboard retaining ring (14) at the compressor end. Insert a finger tip into the bearing (15) and removing the bearing. Remove the inboard retaining ring (14).



Q.3

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

Cleaning procedure

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

2 Soak parts in cleaner until all deposits have been loosened.

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

4 Clean out drilled passages with compressed air jet.

5 Make certain that housing surfaces adjacent to the wheels are free of deposits and are clean and smooth.

Internal parts inspection

1 Shaft and turbine wheel assembly

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

(b) Inspect piston ring groove walls for scoring. Minor scratches are acceptable.

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

2 Thrust parts

(a) Replace if thrust faces are mutilated. Minor scratches are acceptable.

(b) Replace thrust bearing if faces are worn excessively, unevenly or are severely scratched or otherwise mutilated.

(c) The small feed grooves in the thrust bearing must be clean and free from obstruction.

3 Compressor impeller

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

4 Bearing

Replace bearings for excessive scratches and wear.

5 Bearing housing

Replace bearing housing if bearing or piston ring bores are excessively scratched or worn.

6 Rotor parts

Where possible, check the rotor for balance.

7 'O' ring or 'SQ' ring

Replace if section through ring has taken a permanent set or if broken or damaged. The 'O' ring has a round section and the 'SQ' ring has a square section.

8 Turbine housing

Inspect profile for damage due to contact with rotor, cracks, flaking or signs of overheating. Slight damage may be tolerated, otherwise replace the housing. It is also advisable to ensure that the water passages are free from obstruction and that all plugs are water tight.

9 Compressor cover

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

To assemble turbocharger

When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence. Assembly of the unit is the reverse procedure of dismantling, but it is advised that the following points be noted if a satisfactory rebuild is to be obtained.

1 If a new compressor impeller or a new turbine shaft is to be fitted, the rotating assembly must be dynamically balanced. When assembling the rotating assembly, ensure that the etched marks on the impeller, oil flinger and thrust collar (and rings) are in line with the nick in the end of the shaft so that the assembly is correctly balanced.

2 When replacing the bearing retaining rings (snap rings), ensure that the bevelled face is towards the bearing.

3 Lubricate the bearings, bearing housing bore, thrust parts, piston rings and rotor shaft with clean engine lubricating oil.

4 When fitting the turbine wheel and shaft into the bearing housing and the oil flinger into the compressor backplate or diffuser, do not force the piston ring into the bore as an off-centre ring will fracture causing the shaft to bind.

5 Fit new countersunk screws to secure the thrust bearing and tighten to 40 lbf in (46 kgf cm) 4,5 Nm. New screws are pre-treated with the correct amount of appropriate retaining compound.

6 Tighten the compressor locknut to 60 lbf in (69 kgf cm) 6,8 Nm for H1B turbochargers or 150 lbf in (173 kgf cm) 16,9 Nm for H2A and H1C turbochargers. Take care not to bend the shaft – it is advisable to use a type of spanner that will not impose a side loading, e.g. a double universal socket spanner.

7 Position a dial test indicator with its plunger on the end of the shaft and check that the shaft end float is 0.004/0.006 in (0,10/0,15 mm). The end float may be less than 0.004 in (0,10 mm) if a great deal of oil was smeared on the thrust parts and bearings during assembly.

Position the plunger of the indicator on the compressor impeller boss at right angles to the shaft and check the radial movement of the shaft by moving the impeller towards and away from the indicator. The total travel should 0.011/0.017 in (0,28/0,43 mm) for H1B turbochargers and 0.012/0.0185 in (0,30/0,47 mm) for H2A and H1C turbochargers.

8 When assembling the compressor cover or diffuser to the bearing housing, ensure that the sealing ring is not damaged during fitting.

9 H1B – Secure the bearing housing to the turbine housing with the retaining circlip ensuring that the bevel face of the circlip is towards the compressor end. Tighten the compressor cover setscrews to 75 lbf in (86,4 kgf cm) 8,5 Nm.

10 H2A and H1C – Secure the compressor diffuser setscrews and the compressor housing setscrews to

75 lbf in (86,4 kgf cm) 8,5 Nm and the turbine housing setscrews to 180 lbf in (207 kgf cm) 20,3 Nm.

11 Check that the rotor spins freely.

12 H2A and H1C – Knock the lockplates over the turbine housing setscrews and, if fitted, the compressor housing and diffuser setscrews.

TECHNICAL DATA

Turbocharger

Make	Holset
Type – 164 kW (220 bhp) rating	H2A
– all other ratings	H1B or H1C
Maximum boost pressure – H2A	12/15 lbf/in² (0,84/1,05 kgf/cm²) 83/103 kN/m²
– H1B, H1C	11/14 lbf/in² (0,77/0,98 kgf/cm²) 76/97 kN/m²

The boost pressure will vary according to application, engine load and speed and the pressures given above are for guidance only.

Alternator and Starter Motor R

Electrical equipment

The following information is given as a general guide towards the servicing of the electrical equipment fitted to the 6.3544 and T6.3544 marine engine, but this can vary on different electrical layouts, in which case, the procedures laid down by the installer of the engine may have to be followed.

The 6.3544 and T6.3544M engine are fitted with the AC5 or the AC7 alternators 24V output as standard fittings, with AC5 12V alternator being available as an optional if required.

This information is provided by and published by permission of C.A.V. Limited.

Alternators

General precautions.

The diodes in alternators function as one-way valves and the transistors in the regulator operate as fast switches. Both are accurate and very sensitive. They do not wear and never need attention or adjustment, but, because they are sensitive to voltage changes and high temperatures the following precautions are vital to prevent their destruction:

1 Never disconnect the battery while the alternator is running. This will cause a voltage surge in the system, damaging diodes and transistors.

2 Never disconnect any electrical lead without first stopping the alternator and turning all switches to the 'OFF' position.

3 Always identify a lead to its correct terminal before this connection. A short circuit or reverse polarity will destroy diodes and transistors.

4 Never connect a battery into the system without checking for correct polarity and correct voltage.

5 Never 'flash' connections to check for current flow. No matter how brief the 'flash', the transistors may be destroyed.

6 Never experiment to try to adjust or repair the system unless you have had training on alternators and you have the correct test equipment and technical data.

7 Never earth the field circuit.

8 Never run the alternator on an open circuit.

9 Never attempt to polarise an alternator.

10 When using a battery charger, disconnect the battery cables.

11 Never apply a battery voltage direct to the regulator or alternator field terminals as this will damage the transistors.

12 Disconnect the alternator terminal if any electrical welding is to be carried out on parts that are connected to the engine in any way, as the intense magnetic field created by the 'make' and 'break' arc may cause damage to the diodes.

13 Do not check for continuity of the alternator or regulator with an insulation tester such as a 'wee Megger', etc.

14 Ensure the regulator is mounted in such a position that the ambient temperature does not exceed 160°F (70°C).

15 Never mount the regulator directly or indirectly to the engine.

16 Always disconnect the battery before connecting test instruments (except volt meter) or before replacing any unit or wiring.

General maintenance

Maintenance is limited to eliminating the build-up of dirt and corrosion.

1 To enhance cooling, keep the alternator clean with a cloth moistened in kerosene. Ensure that the ventilation slots or air spaces are clear and unobstructed.

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

3 The drive belt on the alternator should be in good condition and have the correct tension (see Section M). A slack belt will slip, wear and may not drive the alternator at the correct speed, if at all. Too tight a belt will create a severe side thrust on the alternator bearings, considerably reducing their life.

4 Check battery fully charged.

Testing procedure with AC5 or AC7

No open circuit, voltage or current output checks should be performed on the installation unless:

1 The warning light fails to illuminate when the alternator is stationary and the warning light switch is closed, or fails to distinguish when the alternator is running.

2 No charging current shows on an ammeter.

3 The battery is flat, indicating insufficient charging current.

4 The battery is boiling, indicating a loss of voltage control.

If any of the above conditions appear in the charging system, the procedure indicated in 'Fault Finding' should be followed.

Unless a fault occurs, the voltage setting will remain constant throughout the life of the equipment.

Check operation of a newly wired system

All terminal connections must be made according to the application manufacturers wiring diagram. Observe the following:

1 Check Polarity. Check correct connections to the regulator.

2 Disconnect the regulator if it is necessary to make wire insulation tests.

3 Test for 'earth' may be made using a 24 volt supply providing a series resistor is used to limit the maximum current to 0.5 AMPERES.

Test equipment required

1 A good quality moving coil volt meter, 0-50 volts range.

2 A good quality moving coil ammeter, 0-100 AMPERES range.

Test procedure

Connect the volt meter across the battery. Disconnect the alternator output lead at the alternator and connect the ammeter in series with the alternator terminal and the output lead.

The battery should be in a charged condition.

The system is in correct working order when the following is observed:

1 Close the warning light switch (switch on the application master electrical switch on the dashboard) when the warning light should light up.

2 Switch on a 10-15 AMPERE load such as lights etc. and leave on for 10-15 minutes.

3 Start the engine and run at fast idle speed when:

(a) warning light should go out.

(b) the ammeter records a small charge current dependent on the engine speed.

4 Momentarily increase the engine speed to near maximum, when the charging current should be about 30 AMPERES for an AC524 alternator or at least 40A for an AC7 alternator.

5 Run the alternator at approximately 3,000 rev/min (engine speed about 1,500 rev/min) and switch off the electrical load as detailed in paragraph 2, dependent upon the connection selected at the regulator for the positive sending lead (H, M or L) the voltage should rise to between 26 and 28 volts and then remain constant. At the same time the current reading on the ammeter should drop appreciably.

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

The regulator is non-repairable sealed unit and if suspected of being faulty is must be removed.

On some applications the regulator is incorporated in a suppression box and if the box is suspected to being faulty, your local C.A.V. agent should be contacted.

The testing of the regulator in this arrangement is covered under the normal Fault Finding procedure.

Fault Finding

For any particular fault, the checking procedure should be carried out in the sequence given.

Warning light does not appear when switched 'ON'.

Check the bulb.

No fault.

Check all wiring connections at regulator, alternator and battery.

No fault.

Switch OFF, disconnect 'F' lead at the regulator and connect it to the regulator negative terminal. Switch ON. If warning light appears, the regulator is faulty. If warning light does not illuminate, the alternator is faulty.

Warning light does not go out and ammeter shows no output with engine running

Check all wiring connections at regulator, alternator and battery.

No fault.

Switch OFF, disconnect 'F' lead at regulator and connect to regulator negative terminal. Switch ON. Run engine at fast idle.

No output – alternator faulty.

Output appears – regulator faulty.

Warning light does not go out when engine is running and ammeter shows reduced output. Full output only at maximum speed.

or

Warning light goes out but alternator gives reduced output. Full output only at maximum speeds.

Alternator faulty, probably open circuit diode.

Warning light flashes intermittently, ammeter needle flickers with battery fully charged and no load switched on.

Excessive resistance or poor connections in regulator negative sensing lead.

No fault.

Faulty regulator.

Starter motor

Maintenance

Very little maintenance is necessary between overhauls beyond occasionally checking the brushes for wear and the commutator for cleanliness.

Brush gear

The brush gear should be effectively insulated and clear of any obstruction. The brushes should be free and any sticking brushes rectified by cleaning the brush holders. Ensure the brushes are bedded in to at least 80% of their contact and are re-fitted in their original positions. The brushes should be changed if their length has been reduced to 0.5 in (12,7 mm) or less.

Replacement brushes must be of the correct grades and bedded in for use. Brushes must only be replaced in complete sets. When replacing the CA45 commutator cover, ensure that the windows are fully covered and that the cover fixing screw is at the bottom when the starter is mounted on the engine. This is important as water may enter the starter if the cover is not correctly positioned.

Commutator

The surface of the commutator should be clean. If it is dirty or badly discoloured and cannot be cleaned in situ, remove the complete armature assembly in accordance

with the manufacturers instructions and clean the commutator, using very fine glass paper. Ensure that all pieces of dust and abrasives are blown off before reassembly.

'ON Engine' Fault Finding

If the starter does not function correctly, check that the battery is fully charged and that all connections are clean and tight. A defective starter switch or badly worn starter brushes can also cause malfunctioning.

Difficulty in obtaining a smooth engagement between the pinion and flywheel may be due to incorrect flywheel to pinion clearance. This should be 0.125 in +/-0.031 in (3,18 mm, +/-0,79 mm) between the face of the flywheel and engaging face of the pinion.

Fitting starter motor to engine

When fitting a starter motor, check there is at least 0.010 in (0,5 mm) clearance between the starter motor and the cylinder block at all points. The starter motor securing setscrews should be tightened to a torque of 50 lbf ft (6,9 kgf m).

TECHNICAL DATA

Electrical system	12V or 24V

Alternator

Make	CAV			Motorola	
Type	AC5	AC5	AC7	9AR	9AR
Voltage	12V	24V	24V	12V	24V
Max. Output (hot)	55A	30A	55A	70A	40A

Starter Motor

Make	CAV	
Type	CA45G	CA45G
Voltage	12V	24V
Starter cable resistance	0.0017Ω	0.0034Ω
No. of teeth on pinion	10	10 or 11