workshop manual for T6.3543 diesel engines

©

Perkins Engines Limited
Peterborough England
1982

Publication No. 601 SER 0782 1058

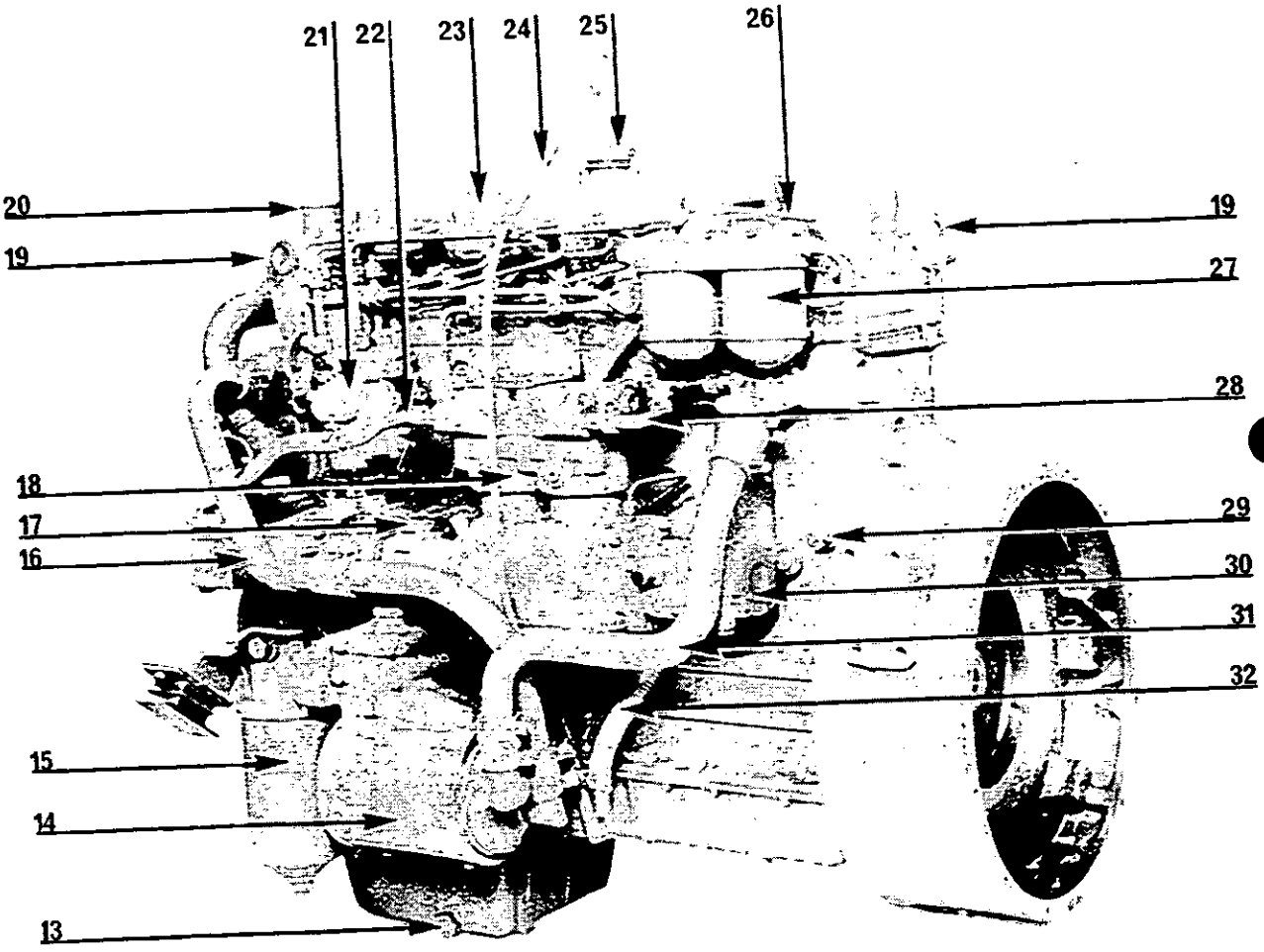
This publication supersedes the previous edition numbered 601 SER 0779 1058 and includes Amendment Page Set 1 issued in 1983.

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

Published by the Service Publications Department of Perkins Engines Ltd., and Printed in England by G. H. Fisher & Sons (Printers) Ltd.

:ON

:S OF AN



A2

VIEW OF LEFT HAND SIDE OF ENGINE

13. Sump Drain Plug
14. Lub. Oil Cooler
15. Lub. Oil Filter
16. Water Inlet Pipe to Oil Cooler
17. Compressor Coupling
18. Compressor
19. Lifting Hook
20. Water Outlet Connection
21. Fuel Injection Pump
22. Water Inlet Pipe to Compressor
23. Cylinder Head Top Cover
24. Dipstick
25. Lubricating Oil Filler
26. Atomiser
27. Twin Fuel Oil Filters
28. Water Outlet Pipe from Compressor
29. Cylinder Block Drain Tap
30. Power Steering Pump
31. Water Outlet Pipe from Oil Cooler
32. Breather Pipe

SECTION B
General Information

Engine Data

Type	Six cylinder, four stroke, direct injection
Bore	3.877/3.878 in (98,48/98,50 mm)
Stroke	5.0 in (127 mm)
Compression Ratio	16:1
Cubic Capacity	353.8 in³ (5,8 litre)
Firing Order	1, 5, 3, 6, 2, 4
Lubricating Oil Pressure	30 lbf/in² (2,1 kgf/cm²) -207 kN/m² minimum, at maximum engine speed and normal operating temperature.
Valve Tip Clearance (prior to Engine No. 3543U10342TL)	0.012 in (0,30 mm) COLD
Valve Tip Clearance (commencing Engine No. 3543U10342TL) Inlet	0.008 in (0,20 mm) COLD
Exhaust	0.018 in (0,46 mm) COLD

Rating Details

Standard Vehicle with Air Charge Cooler	
Gross Rated Output	155 b.h.p. (116 kW) at 2600 rev/min.
Maximum Torque	376 lbf ft (520 kgf m) at 1600 rev/min.
Combine Harvester with Air Charge Cooler	
Gross Rated Output	153 b.h.p. (114 kW) at 2500 rev/min.
Maximum Torque	376 lbf ft (520 kgf m) at 1600 rev/min.

The above ratings are "new engine" maximum and can vary according to application. For further details apply to the equipment manufacturer or the Service Department of Perkins Engines, Peterborough, England.

Recommended Torque Tensions

The following figures will apply with the components lightly oiled.

Component	Screw Size UNF	lbf ft	kgf m	Nm
Cylinder Head Nuts	½	95	13,1	129
Cylinder Head Setscrews	½	95	13,1	129
Cylinder Head Nuts with preformed integral washers				
Cold Torque	½	115	15,9	156
Hot Torque		105	14,5	142
Cylinder Head Setscrews with preformed integral washers				
Cold Torque	½	115	15,9	156
Hot Torque		105	14,5	142
Connecting Rod Nuts prior to Engine Number 3543U1384T	½	70	9,7	95
Connecting Rod Nuts (current)	½	75	10,4	102
Main Bearing Setscrews	⅝	180	24,9	244
Main Bearing Setscrews prior to Engine Number 3543U435T	⅝	150	20,7	203
Idler Gear Hub Nuts	⅜	36	5,0	49
Crankshaft Damper Setscrews (where fitted)	5/16	19	2,6	26
Sump to Cylinder Block, Setscrews	5/16	15	2,1	20
Flywheel Securing Setscrews	½	80	11,1	108
Camshaft Gear Retaining Setscrew	½	50	6,9	68
Crankshaft Pulley Setscrews	7/16	65	9,0	88
Piston Cooling Jet Banjo Bolt	⅜	20	2,7	27
Oil Cooler to Cylinder Block, Setscrews	7/16	50	6,9	68
Lub. Oil Filter to Oil Cooler, Setscrews	7/16	32	4,4	43
Atomiser Securing Nuts	5/16	12	1,7	16
Aux. Drive Shaft Gear to Shaft, Screws	5/16	22	3,0	30
Alternator Pulley Retaining Nut	7/16	30	4,1	41
Fuel Oil Lift Pump to Cylinder Block (to be re-torqued when hot)	5/16	20	2,7	27
Induction Manifold Setscrews (re-torque after 10 minutes see Page E.3)	⅜	24	3,3	32
High Pressure Fuel Pipe Nuts	12 x 1,5 mm	15	2,1	20
Thermostart		10	1,4	14
Thermostart Adaptor (where fitted)		10	1,4	14

Engine Weights

Bare engine, alternator, fuel and lubricating oil filters, compressor and lubricating oil cooler. Approx. dry weight = 960 lbs (435 kg)

Bare engine, alternator, fuel and lubricating oil filters, compressor, lubricating oil cooler, flywheel, flywheel housing, air charge cooler, starter motor and fan.

Not including radiator and clutch = 1180 lbs (536 kg)

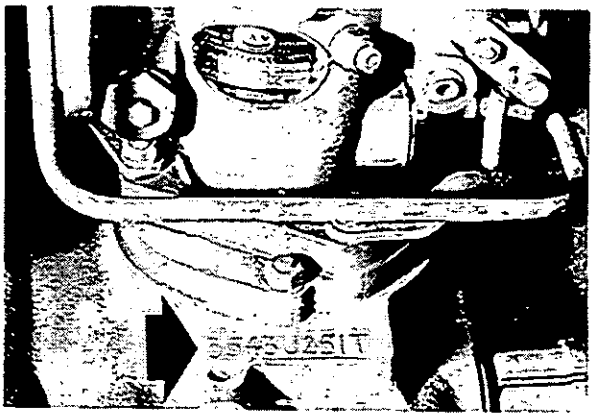
Engine Number

The engine number is stamped on top of the auxiliary drive housing, on the left hand side of the engine (see Fig. B.1).

With earlier engines, the number consisted of figures and letters e.g. 3543U251T.

A typical number for current engines is TP21531U500256C.

When requesting any service information or ordering spare parts, always quote the full combination to ensure accurate identification of the engine.



B1

De-rating for Altitude

Where the T6.3543 engine is required to operate at altitudes above 4,000 feet (1200 metres), it will be necessary to derate the engine because of the rarefied atmosphere. Details are available from Perkins Engines Ltd., Peterborough, England.

Any adjustments to the fuel pump for the purposes of de-rating the engine must be carried out by the accredited fuel pump dealer in the territory concerned.

Starting the Engine (See Fig. B2)

Ensure the "stop" control is in the "run" position.

Switch on the electrics by turning the switch to the "R" position.

Place the accelerator pedal or engine speed control in the maximum speed position.

Engage the starter motor by turning the switch to the "HS" position.

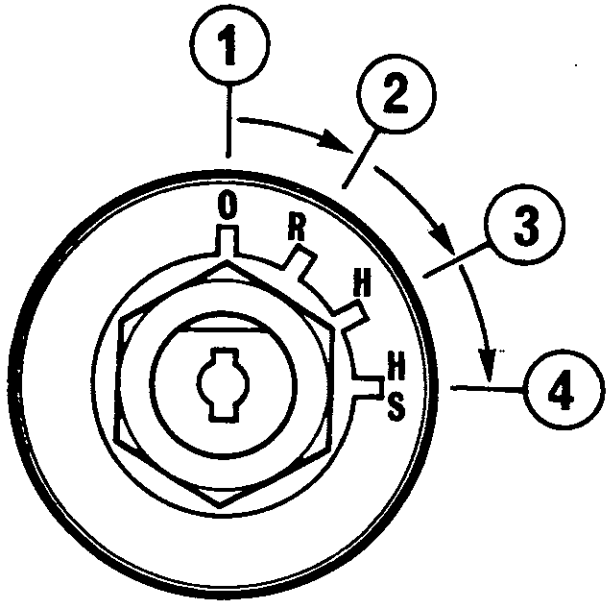
As soon as the engine starts return the switch to "R" position and check for satisfactory oil pressure 30-60 lbf/in² (2,1-4,2 kgf/cm²) -207-414 kN/m².

Do not rapidly increase and decrease engine speed immediately after starting.

If the engine fails to start at the first attempt always be sure the engine and starter motor have stopped rotating before re-engaging the starter motor.

Starting the Engine after disturbing oil feed pipe to the Turbocharger

Before starting the engine after having disturbed the oil feed pipe to the Turbocharger, release



B2

the oil feed pipe union at the Turbocharger and motor the engine over with the "STOP" control in the "STOP" position until lubricating oil issues from the union.

Tighten the union and use normal starting procedure as above.

Starting the Engine under difficult "COLD" conditions

The more common kind of starting aid is the electrically operated "Thermostart" fitted in the induction manifold and operated from the starting switch.

The "Thermostart" is supplied with fuel oil and in some applications a small reservoir is fitted and it may be necessary to turn "on" a tap between the "Thermostart" and its reservoir.

Check that the reservoir (if fitted) contains fuel oil by removing the top cover.

Turn the starter switch to the "H" position for fifteen to twenty seconds to enable the "Thermostart" to reach its operating temperature.

Adjust the engine speed control to maximum speed and turn the switch to the "HS" position to engage the starter motor.

If the engine fails to start, return the starter switch to the "H" position for a further ten seconds and then to the "HS" position again.

When the engine starts, return the starter switch to the "H" position until the engine responds to the throttle. Then return the switch to the "R" position. Check for satisfactory lubricating oil pressure and turn off the fuel supply to the "Thermostart", where applicable.

The use of alternative methods of "cold" starting aids will be found in the operator's handbook.

Stopping the Engine

A spring loaded control is located near the normal engine controls and functions by cutting off the fuel in the fuel injection pump.

To operate, pull the "stop" control and hold until the engine has completely stopped rotating. Ensure the stop control returns to its "run" position otherwise difficulty may be experienced in re-starting the engine.

Return starter switch to the "O" position.

Some engines may have a solenoid operated stop control on the fuel injection pump which is electrically operated by means of a switch.

Cold Starting Aid 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.

The T6.3543 engine is fitted with efficient cold starting equipment and no responsibility can be accepted for any damage caused by unauthorised starting aids.

Operating the Engine—Vehicle Applications

It is essential to maintain a reasonably high engine speed when climbing a gradient owing to the power characteristics of the turbocharged T6.3543 engine.

Do not overload the engine at low engine speed.

Before the engine becomes overloaded, change gear to increase engine speed.

Running in

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 coolant is first allowed to reach a temperature of at least 140°F (60°C).

SECTION C
Preventive Maintenance

As the following preventive maintenance attentions are general in application, they should be compared with the schedules specified by the manufacturer of the application to which the engine is fitted and where necessary, the shorter periods adopted.

The periods are given in Miles, Hours and Months and the maintenance work should be carried out at the period that comes first in the normal operation of the vehicle or machine. On stop-start low mileage work, the hours run are more applicable than the mileage covered.

Every Day or 8 Hours whichever occurs first

Check coolant level in radiator.

Check lub. oil level in sump with vehicle or machine standing level.

Check oil pressures (where gauge is fitted).

Ensure alternator cooling fan and slots are clear of chaff.

*In extreme dust conditions, empty dust bowl of dry type air filter or clean oil bath type air filter.

Every 5,000 Miles (7,500Km), 250 Hours or 4 Months whichever occurs first

†Drain and renew engine lubricating oil.

Renew lubricating oil filter element or canister.

Check drive belt tension

*Empty dust bowl of dry type air filter or clean oil bath type air filter.

Clean fuel water trap (where fitted).

Check for oil, water or fuel leaks.

Check that alternator slots, fan and air spaces are clear and unobstructed.

Lubricate dynamo rear bush (where fitted).

Clean compressor air filter (where fitted).

Every 10,000 Miles (15,000Km), 500 Hours or 12 Months whichever occurs first

Clean lift pump gauze strainer.

Renew final fuel filter elements, agricultural and industrial applications only.

Check hoses and clips.

*Clean element of dry type air filter or renew unless indicated earlier.

Every 20,000 Miles (30,000Km), or 1,000 Hours whichever occurs first

Renew final fuel filter elements, vehicle applications.

Decarbonise compressor cylinder head, and delivery line.

Clean turbocharger impeller and oil drain pipe.

Every 60,000 Miles (90,000Km), or 2,500 Hours whichever occurs first

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

Service atomisers.

Check and adjust valve tip clearances (see Page E.4).

Operators of engines are reminded that the above preventive maintenance periods are general in application. They should be compared with the schedules specified by the manufacturer of the application to which the engine is fitted and where necessary, the shorter periods should be adopted.

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

*The time limits for servicing air filters depend upon operating conditions and if dusty or similar adverse conditions prevail, the time limits given should be reduced. In extremely dusty conditions it may be necessary to service the filter more than once a day. Under such conditions, the correct maintenance will greatly assist in extending the life of the engine.

Where a *depression indicator* is fitted, this will give a positive indication that the element needs servicing and the periods given for servicing can be disregarded.

†The lubricating oil change period quoted is for this turbocharged engine using MIL-L-2104C oils. This period should be reduced if operating under dusty or adverse conditions.

Air Charge Cooler

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.

Post Delivery Checkover

After a customer has taken delivery of his Perkins Diesel engine, a general checkover of the engine must be carried out after the first 500/1000 miles (800/1600 km) or 25/50 hours in service.

The checkover should comprise the following points:—

1. Drain lubricating oil sump and refill to full mark on dipstick with new oil. Remove and clean sump strainer where possible. Change lubricating oil filter element or canister.
2. Remove cylinder head cover and set valve clearances (see Page E.4).
3. Check coolant level in radiator and inspect for leaks.
4. Check external nuts, setscrews, hose clips, mountings etc., for tightness.
5. Check belt tension.
6. Check electrical equipment and connections.
7. Check for lubricating and fuel oil leaks.
8. Check slow running speed.
9. Check general performance of engine.

Preservation of Laid-Up Engines

Where an application is to be laid up for several months it must be protected as follows:—

1. Clean all external parts.
2. Run engine until warm. Stop and drain the lubricating oil sump.
3. Throw away paper element in the lubricating oil filter, clean bowl and fit a new element or replace canister. Part fill bowl with new oil of an approved grade, a list of which appears in the Appendix.
4. Clean out breather pipe.
5. Fill lubricating oil sump to correct level with new oil of an approved grade.
6. Drain all fuel oil from fuel tanks and filters. Put into the fuel tank at least one gallon of one of the oils listed under "Recommended Oils for the Fuel System". If, because of the construction of the fuel tank, this quantity of oil is inadequate, break the fuel feed line before the first filter and connect a small capacity auxiliary tank.
7. Prime the fuel system.
8. Start engine and run it at half speed for 15 minutes when the oil will have circulated through the injection pump, pipes and injectors.
9. Seal the air vent in the tank or filler cap with waterproof adhesive tape.
10. Drain the cooling system by removing all drain plugs, including the oil cooler water drain plug. Where a fully water cooled compressor is fitted it will be necessary to drain by removing the drain plugs. To ensure complete draining check that the holes are not blocked by scale.
11. Remove the atomisers and spray into the cylinder bores ¼ pint (0,14 litre) of lubricating oil, divided between all cylinders.

    Rotate the crankshaft one complete revolution and replace atomisers.
12. Remove the air filter and any piping. Seal the air intake with water proofed adhesive tape.
13. Remove the exhaust pipe and seal the manifold port.
14. Remove fan and water pump driving belts.
15. Batteries
    (a) Remove the battery and top up the cells with distilled water.
    (b) Recharge.
    (c) Clean terminals and lightly smear with petroleum jelly.
    (d) Store in a cool, dry, dust free place. Avoid freezing risk.
    (e) Recharge once a month.
16. Starters and Generators

    Clean terminals and lightly smear with petroleum jelly. If vehicle or machine is to stand in the open, the generator, starter and control board must be protected against rain.

Recommended Oils for the Fuel System*

	Lowest Temperature during Lay-up
Esso IL815	25°F (— 4°C)
Esso IL1047	0°F (—18°C)
Shell Calibration Fluid "C" (U.K.)	0°F (—18°C)
Shell Calibration Fluid "B" (Overseas)	—70°F (—57°C)
Shell Fusus "A"	—15°F (—26°C)
Shell Fusus "A" R1476 (Old Type)	25°F (— 4°C)

No attempt should be made to restart the engine until the temperature has been at least 15°F (8°C) above that shown in the table for not less than 24 hours. Otherwise there may be difficulty in obtaining a free flow of fuel.

*The proprietary brands of oils listed may not be available in all parts of the world, but suitable oils may be obtained by reference to the oil companies. The specification should include the following:—

Viscosity: Should not be greater than 22 centistokes at the lowest ambient temperature likely to be experienced on re-starting.

Pour Point: Must be at least 15°F (8°C) lower than the lowest ambient temperature to be experienced on restarting and should be lower than the lowest temperature likely to be met during the lay-up period.

The oils selected are not necessarily suitable for calibrating or testing pumps.

Preparing the Engine for Return To Service

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

1. Thoroughly clean all external parts.
2. Remove adhesive tape from the fuel tank vent or filler cap.
3. Drain fuel tank to remove any remaining oil and condensed water and refill the tank with fuel oil.
4. Fit new filter element and vent the filter.
5. Vent and prime the fuel injection pump.
6. Replace the cylinder block, radiator, oil cooler water drain plugs and compressor drain plugs where necessary and fill the system with clean coolant. Check for leaks.
7. Rotate water pump pulley by hand to ensure freedom of water pump seals.
8. Refit water pump and generator driving belts.
9. Remove the rocker cover, lubricate rocker assembly with engine oil and replace cover.
10. Remove adhesive tape from the air intake, refit the air filter and any air intake pipe. Clean or renew the element of dry type air cleaner or refill the oil container with fresh oil of oil bath type air filter.
11. Remove adhesive tape from the exhaust manifold port and refit exhaust pipe.
12. Connect the battery.
13. Wipe the grease from the terminals and check that all connections are sound. If the starter is fitted with a Bendix type of drive, lubricate with a little light engine oil. Co-axial starters, except where they are fitted with dust covers, should be given the same treatment.
14. Check the level and condition of the oil in the sump. Change the oil if necessary, with new oil of an approved grade.
15. Start the engine in the normal manner, checking for oil pressure and generator charge.

Whilst the engine is reaching normal running temperature check that it is free from water and fuel leaks.

NOTE:

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

Frost Precautions

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

When draining the cooling system, ensure engine is level.

Should it be necessary to use anti-freeze it should conform to British Standard 3151, or have been approved by testing in accordance with British Standard 5117, Clause 5 to give at least as good a result as BS.3151.

The coolant solution containing 25 per cent anti-freeze manufactured to BS3151 in water in a properly maintained engine should maintain its anti-freeze and anti-corrosive properties throughout the winter season and in general, a safe life of 12 months may reasonably be expected.

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

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

SECTION D
Fault Finding

FAULT FINDING D2

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, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55.
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 air cleaner or 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. Incorrect aligned flywheel housing or flywheel.
50. Faulty thermostat.
51. Restriction in water jacket.
52. Loose fan belt.
53. Choked radiator.
54. Faulty water pump.
55. Choked breather pipe.
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.**

SECTION E
Cylinder Head

To remove the Cylinder Head

The T6.3543 cylinder head is not interchangeable with any other 6.354 or T6.354 engine type cylinder heads because of different cooling passages inside the head.

Drain the cooling system.

Disconnect battery terminals.

Remove air cleaner and trunking.

Disconnect and remove all connections to the turbocharger and remove the turbocharger, see Fig. E.1.

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 atomiser leak-off pipe assembly.

Remove atomisers, see Fig. E.2.

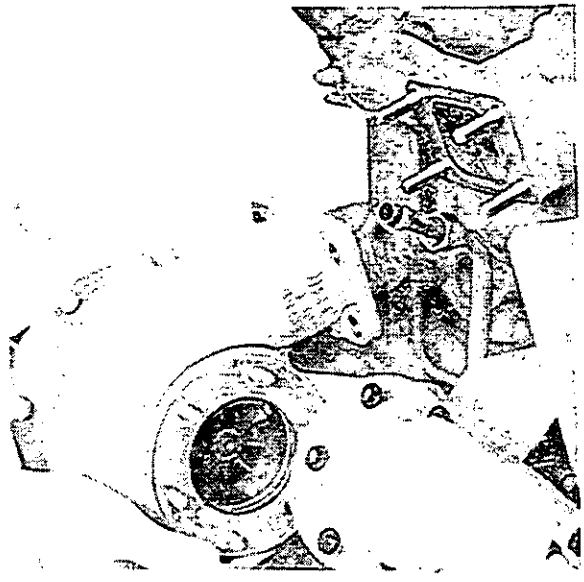
The bores in the cylinder head to accommodate atomisers are sealed with copper sleeves, see Fig. E.3. They are machine rolled and should be renewed if necessary as detailed on Page E.7.

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

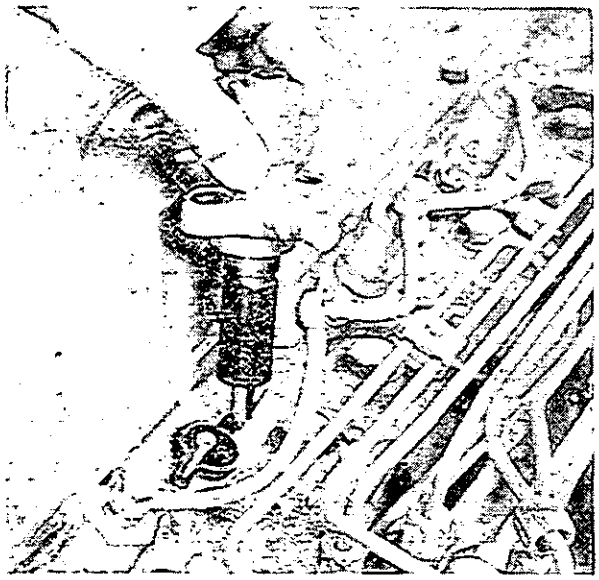
Remove rocker cover and gasket.

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

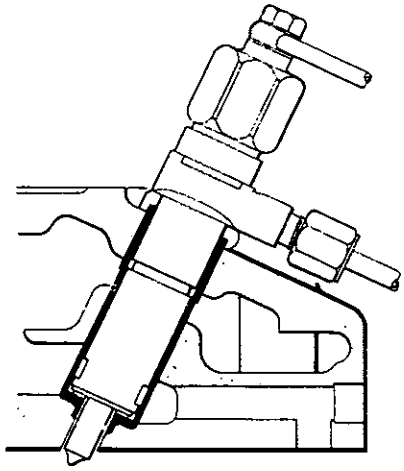
Remove cylinder head nuts and setscrews in reverse order of tightening sequence, see Fig. E.6.



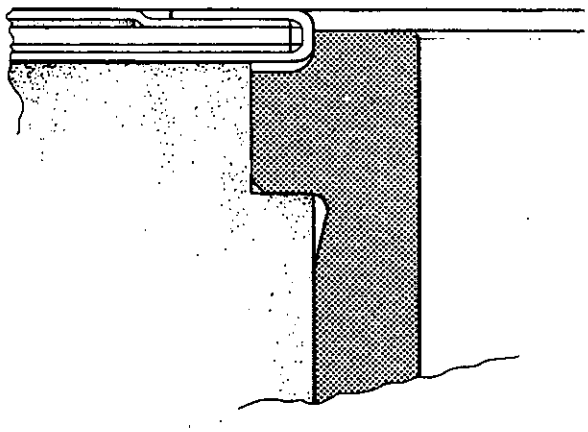
E1



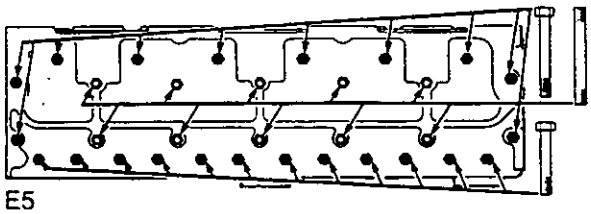
E2



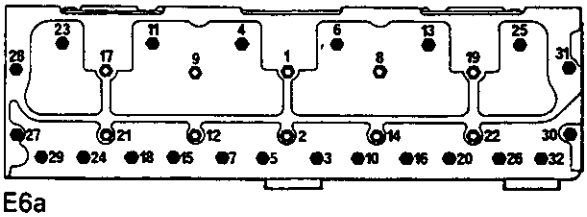
E3



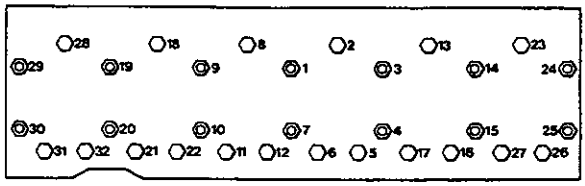
E4



E5



E6a



E6b

Note position of different length setscrews, see Fig. E.5.

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" Grade 542.

The cylinder head gasket fitted to the T6.3543 engine is not interchangeable with other 6.354 series engines. It is marked "TOP FRONT".

Using PERKINS HYLOMAR jointing compound spread evenly and thinly on both sides, fit the gasket, ensuring that the beading of the gasket is positioned in the recess around the cylinder liner, see Fig. E.4.

Lower the cylinder head in position without disturbing the gasket.

Lightly oil threads of cylinder head securing studs and setscrews.

Two types of cylinder head retaining setscrews and nuts are used.

Early engines have cylinder head setscrews and nuts with separate washers.

Later engines, from engine number ----- U610664G, have cylinder head setscrews and nuts with an integral washer face, with this, a new figure of eight sequence to tighten these nuts and screws has been introduced see Fig. E6b and an increased torque figure.

See Fig. E.5 for correct location of long and short setscrews.

Progressively tighten cylinder head securing nuts and setscrews in the order shown: for nuts and setscrews with separate washers until a torque of 95 lbf ft (131,1 kgf m) – 129 Nm see Fig. E6a;

and for nuts and setscrews with the integral washer face until a torque of 115 lbf ft (15,9 kgf m) 156 Nm (see Fig. E6b).

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.7.

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.

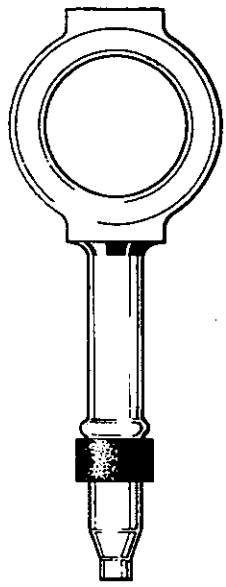
Set tappet clearances as detailed on Page E.4.

Refit atomisers with new copper sealing washers, and tighten nuts evenly to a torque of 12 lbf ft (1,7 kgf m) or 16 Nm.

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

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

Refit induction and exhaust manifolds. Two types of induction manifold joint can be found, i.e., the earlier steel/asbestos type and the later tin plated mild steel type incorporating a corrugation. Under no circumstances should either type be mixed, but fitted in complete sets. The corrugated joints are coated with lacquer and should be fitted DRY. They may be fitted either way round, but the notch (see Fig. E.8) should always be to the top. The manifold securing setscrews should be tightened to a torque of 24 lbf ft (3,3 kgf m) or 32 Nm starting from centre setscrews and working towards the ends. After at least ten minutes after fitting, re-torque the set-screws to the original figure. THIS IS IMPORTANT.



E7

Two types of exhaust manifold joint can also be found, i.e., the original steel/asbestos type and the later corrugated stainless steel type. These joints must not be mixed, but fitted in complete sets. When fitting corrugated stainless steel joints, the corrugation should be positioned so as to face the manifold.

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 and all connections to it, trunking and air cleaner.

Reconnect the battery.

Refill the cooling system.

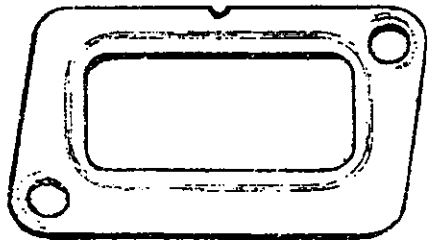
Bleed the fuel system of air as detailed on Page M.7 and start the engine.

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

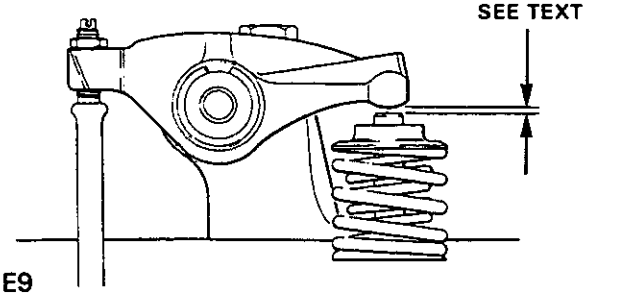
Shut the engine down, and retighten the cylinder head securing nuts and setscrews to 95lbfft (131,1kgfm) 129Nm for the nuts and setscrew with the separate washers or 105lbfft (14,5kgfm) 142Nm for the nuts and setscrew with the integral washer face, as fitted from engine number ----- U610664G.

Reset the valve clearances to 0.012in (0,30mm) cold for engines prior to Engine No. 3543U10342TL or 0.008in (0,20mm) — inlet valves and 0.018in (0,46mm) — exhaust valves — for engines commencing at Engine No. 3543U10342TL, cold.

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



E8



E9

To check or Adjust Valve Tip Clearances

For engines prior to Engine No. 3543U10342TL, the valve tip clearances should be set to 0.012in (0,30mm) by using a feeler gauge between the top of valve stem and rocker lever with the engine cold (see Fig. E.9).

NOTE: Commencing from Engine No. 3543U10342-TL, due to a change in cam profile, valve tip clearances are as follows:

Inlet .....0.008in (0,20mm) cold
Exhaust .....0.018in (0,46mm) cold

Correct valve tip clearances are important.

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.

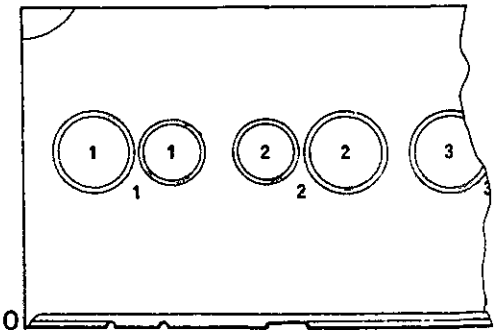
To Remove Valves

With early engines, valves were numbered 1 and 1, 2 and 2 etc., commencing at the front of the engine, with a corresponding number on the cylinder head (see Fig. E.10).

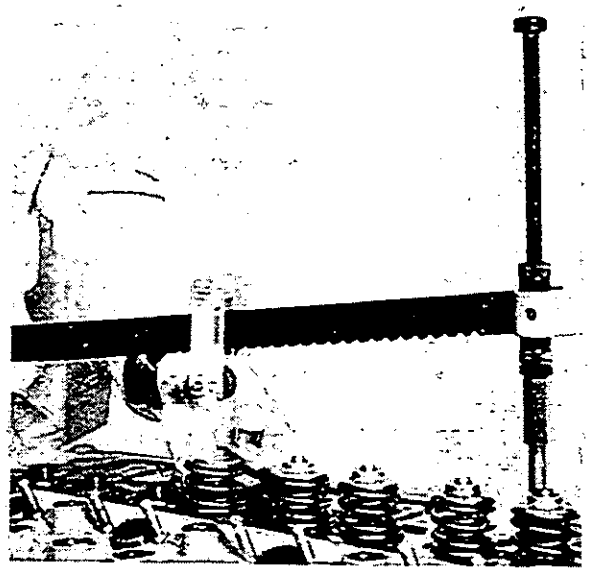
With current engines, valves are no longer marked, but if they are to be used again, they should be suitably marked to ensure they are replaced in their original positions.

Fit a suitable stud in one of the rocker assembly securing setscrew holes and using Tool No. 6118B, see Fig. E.11, depress valve springs and remove split collets.

Remove spring retaining caps, springs, oil deflectors from inlet valves and spring seating washers. Remove valves.



E10



E11

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.12 and E.13.

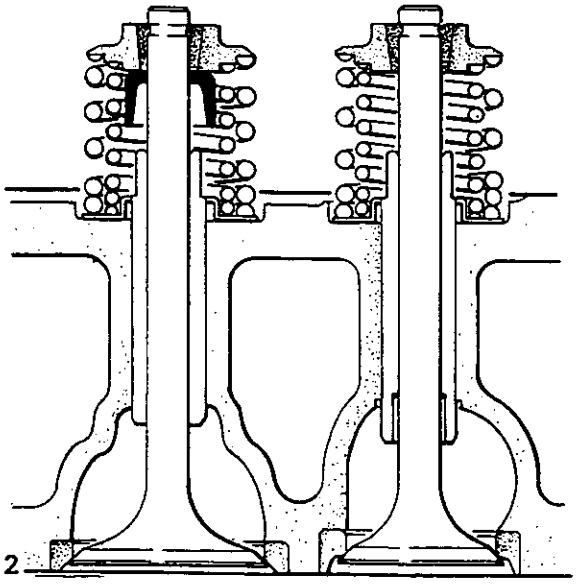
Two types of valve sealing arrangement can be found. Earlier arrangement is shown in Fig. E.12 whilst the later arrangement is shown in Fig. E.13.

To Fit Valves

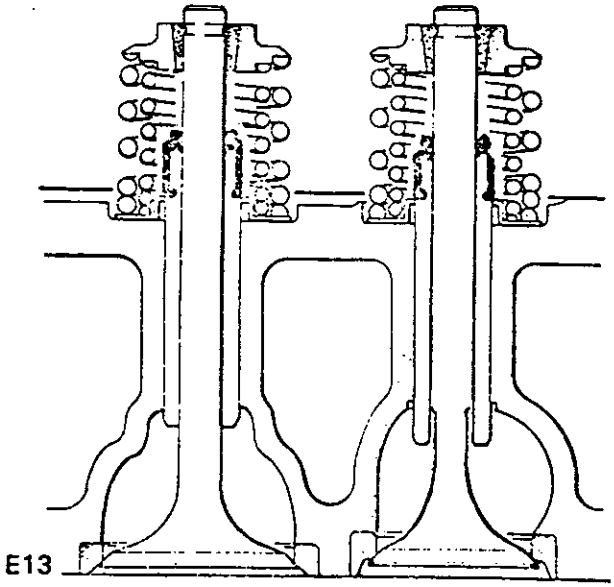
Lightly oil valve stems, and position the valves in their respective guides.

Later engines have chrome flashed valve stems with seals fitted to the valve guides. The exhaust valve guides for chrome flashed valves have no carbon brake counter bore: the carbon brake is a relief on the valve stem. Valves and guides are not individually interchangeable with the earlier types.

Position spring seating washers and fit oil deflectors onto the inlet valve stems with open end towards cylinder head.



E12



E13

Place inner and outer springs on seating washers with the damper coils towards the cylinder head, see Figs. E.12 or E.13.

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

Valve Guides

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

To fit new guides, press or drive out the worn guides, see Fig. E.14.

Smear the outer surface of the new guides with clean oil and using tool No. PD1C, see Fig. E.15, pull guide into the cylinder head using stop No. PD1C — 6 until 0.594in (5,08mm) of the guide is protruding from 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.

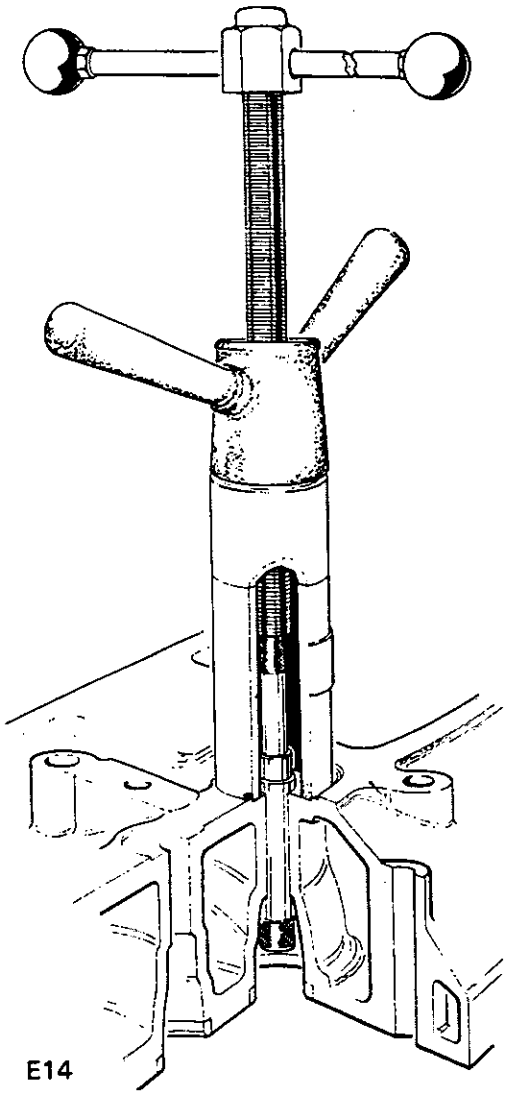
After cleaning head, check for cracks or other damage.

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

The cylinder head can be skimmed by a maximum of 0.012 in (0,3 mm) provided that nozzle protrusion does not exceed 0.224in (5,69mm), see Fig. E.16. This figure must not be obtained by the use of additional atomiser sealing 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.



E14

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).

Where engines have to meet the smoke legislation requirement BSAU 141a: 1971, then the production limits should not be exceeded.

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.

Number all new valves to correspond with the numbering of old valves.

When fitting new valves, ensure that the depths relative to the cylinder head face are not less than that quoted on Page E.9. Correct valve head depths are important.

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.

Valve Seat Inserts

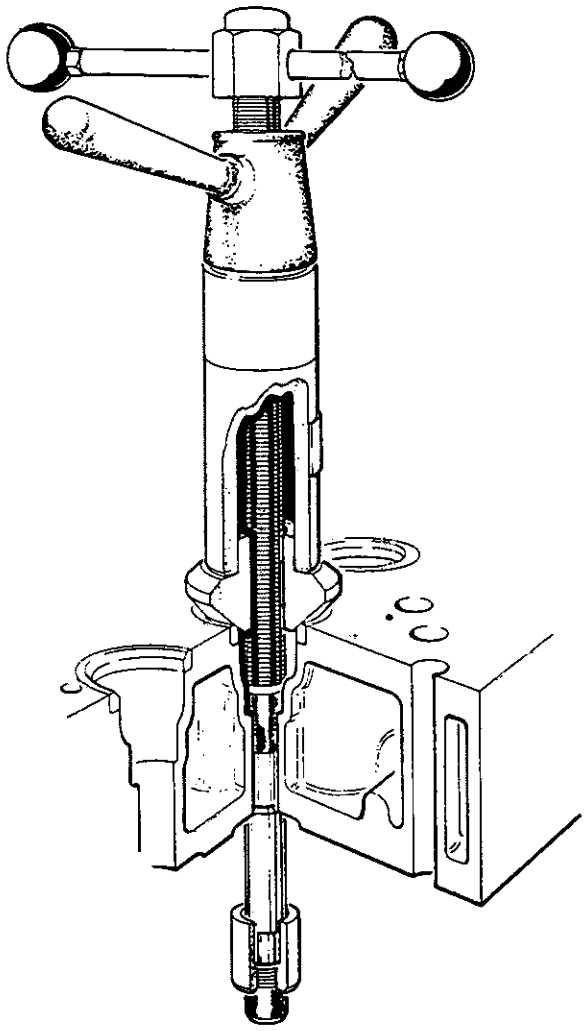
If the insert is damaged or unserviceable through wear, it must be removed and replaced with a new one.

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

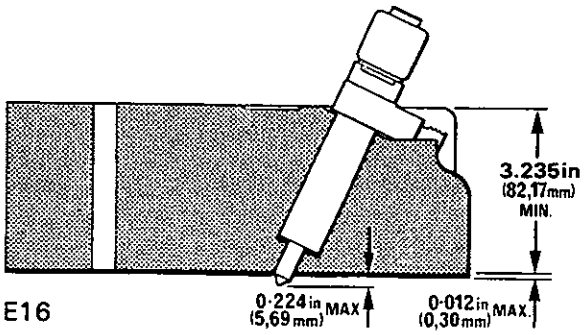
Press or machine out the old insert and remove all machining swarf and clean the insert recess.

Press in new guides as detailed on Page E.5.

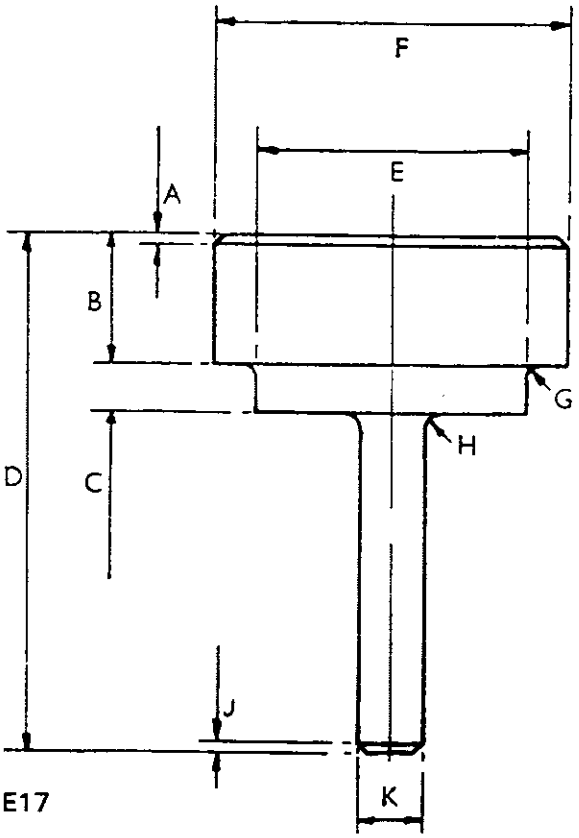
Using the valve guide bore as a pilot, press the insert home with the inserting tool, Fig. E.17. Do



E15



E16



E17

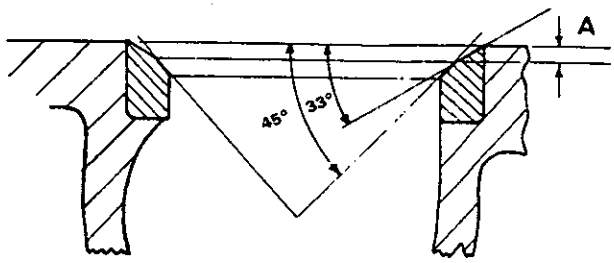
Key to Fig. E17

Inlet

A—1/16in (1,59 mm) at 45°
B—3/4in (19,05 mm)
C—0.250 in (6,35 mm)
D—3.0 in (76,20 mm)
E—1.582/1.583 in (40,18/40,21 mm)
F—2.009/2.019 in (51,03/51,28 mm)
G—1/32in (0,79 mm) radius
H—1/16in (1,59 mm) radius
J—1/16in (1,59 mm) at 45°
K—0.372/0.373 in (9,45/9,47 mm)

Exhaust

A—1/16in (1,59 mm) at 45°
B—3/4in (19,05 mm)
C—0.312 in (7,92 mm)
D—3.0 in (76,20 mm)
E—1.248/1.249 in (31,70/31,72 mm)
F—1.670/1.680 in (43,42/43,67 mm)
G—1/32in (0.79 mm) radius
H—1/16in (1,59 mm) radius
J—1/16in (1,59 mm) at 45°
K—0.372/0.373 in (9,45/9,47 mm)



E18

not hammer the insert home or use lubrication. Ensure that the insert is fully home and flush with the bottom of recess.

For inlet valve inserts using the valve guide bore as a pilot, machine the "flare" to the dimensions shown in Fig. E.18. Dimension A is 0.094/0.099in (2,39/2,52mm) for engines prior to Engine No. 3543U10342TL or 0.106/0.110in (2,69/2,79mm) for engines commencing at Engine No. 3543U10342TL.

Work as closely as possible to the minimum figure to allow for re-seating at a later date. When re-facing 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.

Atomiser Sleeve Renewal

The cylinder head must be removed before renewing an atomiser sleeve (see Fig. E.3).

The defective sleeve may be removed using tools 18G213A (5/8in in B.S.P. tap) and puller 18G213D.

After removing the sleeve, thoroughly clean the sleeve seating areas in the head and ensure that they are free from damage.

Annealing the new sleeve before fitment is not mandatory, but it will assist in obtaining a good seal.

Fit the new sleeve in position, gently tapping home if necessary.

The top of the sleeve should be rolled first using tool LC 173 (Fig. E.19) as follows:

(a) Lift the centre spindle and insert the body into the atomiser sleeve ensuring that the body flange abuts the rim of the sleeve and allow the centre spindle to drop.

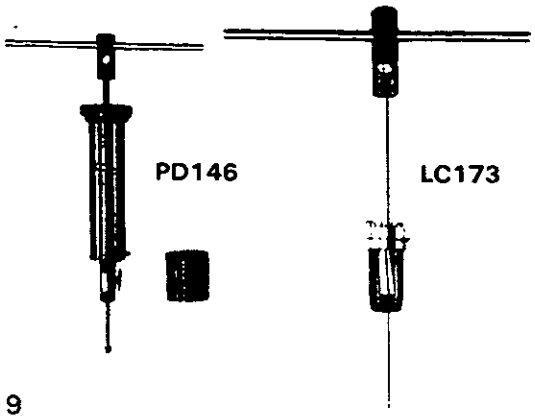
(b) Fit the tommy bar to the spindle, take up the slack and, using light pressure only, turn the spindle approximately twenty turns clockwise. The action of turning the spindle will automatically feed it downwards and expand the rollers; therefore only light pressure is needed.

(c) Unwind the spindle and remove the tool.

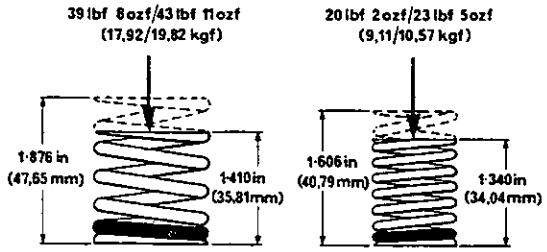
Fit the distance piece to the tool PD 146 (Fig. E.19) and roll the bottom seat using the same procedure as used for the top seat.

Pressure test the cylinder head.

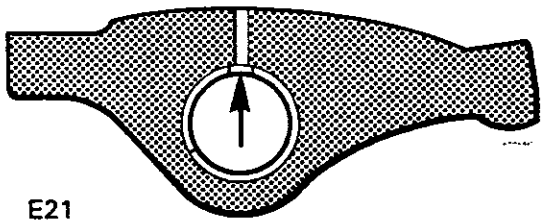
Note: Over-rolling can be detrimental to the sealing characteristics.



E19



E20



E21

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.20.

The inner springs require a load of 20.1/23.3 lbf (9,11/10,57 kgf) to compress them to fitted length 1.340 in (34,04 mm).

The outer springs require a load of 39.5/43.7 lbf (17,92/19,81 kgf) to compress them to fitted length 1.410 in (35,81 mm).

Rocker Shaft Assembly

To dismantle

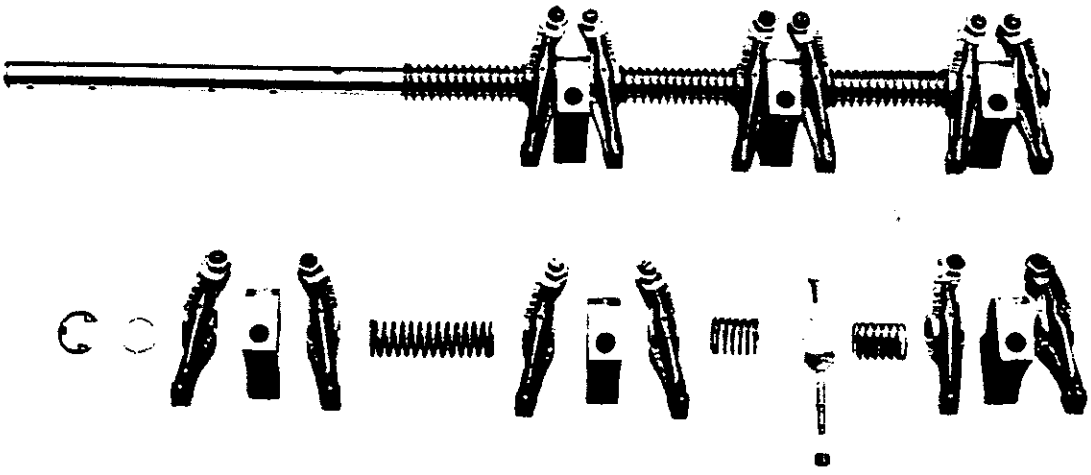
Remove circlips and washers from each end of shaft.

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.21.



E22

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

To assemble.

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.22.

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

Push Rods

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

DATA AND DIMENSIONS FOR CYLINDER HEAD ASSEMBLY

Cylinder Head

Cylinder Head Depth	3.235/3.265 in (82,17/82,93 mm)
Leak Test Pressure	30 lbf/in² (2,11 kgf/cm²) or 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 0.224 in (5,69 mm) after skimming.

Valve Guides

Inside Diameter	0.3743/0.3757 in (9,51/9,54 mm)
Outside Diameter	0.6268/0.6273 in (15,92/15,93 mm)
Internal Diameter of Counterbore (exhaust)	0.421/0.441 in (10,69/11,20 mm)
Depth of Counterbore (exhaust)	0.39125/0.42125 in (9,94/10,70 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 (61,12 mm)
Protrusion from Valve Spring Recess	0.594 in (15,09 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	1.739/1.749 in (44,17/44,42 mm)
Valve Face Angle	45°
Production Valve Head Depth below Cylinder Head Face (prior to Engine No. 3543U10342TL).	0.027/0.036 in (0,69/0,91 mm)
Production Valve Head Depth below Cylinder Head Face (commencing Engine No. 3543U10342TL)	0.040/0.050 in (1,02/1,27 mm)
Valve Head Depth below Cylinder Head Face — Max. Permissible after Servicing	0.060 in (1,52 mm)
Overall Length	4.831/4.847 in (122,71/123,11 mm)
Sealing Arrangement	Rubber Deflector

Exhaust Valve

Valve Stem Diameter	0.372/0.373 in (9,45/9,47 mm)
Clearance Fit of Valve in Guide	0.0013/0.0037 in (0,03/0,09 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°
Production Valve Head Depth below Cylinder Head Face (prior to Engine No. 3543U10342TL).	0.027/0.038 in (0,69/0,97 mm)
Production Valve Head Depth below Cylinder Head Face (commencing Engine No. 3543U10342TL)	0.040/0.050 in (1,02/1,27 mm)
Valve Head Depth below Cylinder Head Face — Max. Permissible after Servicing	0.060 in (1,52 mm)
Overall Length	4.846/4.862 in (123,09/123,49 mm)

Inner Valve Springs

Fitted length and Load	1.340 in (34,04 mm) at 20 lbf 2 ozf/23 lbf 5 ozf (9,11/10,57 kgf)
Number of Active Coils	4.9
Number of Damper Coils	1
Coiled	R.H.—Damper Coil to Cylinder Head

Outer Valve Springs

Fitted length and Load	1.410 in (35,81 mm) at 39 lbf 8 ozf/43 lbf 11 ozf (17,92/19,82 kgf)
Number of Active Coils	3.6
Number of Damper Coils	1
Coiled	L.H.—Damper Coil 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 (0,25/0,09 mm)

Push Rods

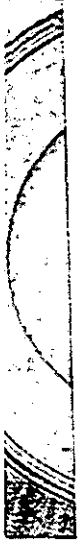
Overall Length of Push Rod	10.456/10.540 in (265,58/267,72 mm)
Shank Diameter	0.310/0.312 in (7,87/7,93 mm)

Approved Tools for Cylinder Head Assembly

Available from V.L. Churchill & Co. Ltd., Daventry, Northamptonshire, England.

Valve Spring Compressor	6118B
Adaptor for Valve Spring Compressor	PD 6118-4
Valve Guide Remover and Replacer	PD 1C
Adaptor for Valve Guide Remover	PD 1C-1
Stop for Valve Guide Replacer	PD 1C-6
Valve Seat Cutter Handle	316X
Valve Seat Cutter Pilot	316-12
Valve Seat Cutter Inlet	317-30
Valve Seat Cutter Exhaust	PD 317-22
Glaze Breaker	317G-30
Tension Wrench 50-170 lbf ft	13
Piston Height and Valve Depth Gauge	PD 41B
Atomiser Sleeve Remover	18G213D (puller) with 18G213A (tap)
Atomiser Sleeve Expander	LC 173 and PD 146

SECTION F
Pistons and Connecting Rods

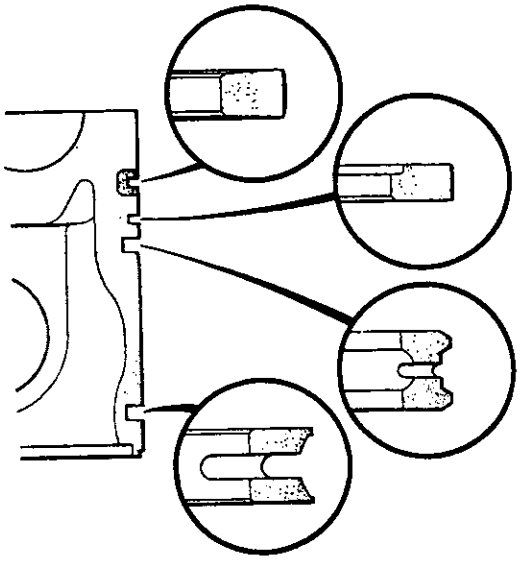


ons ai
n the p
embly,
rods
of pistc
ıe circl
pin is t
fluid tc
then pr

ɔn

ɔns for s
on ring
ngs fitt
excess
udgeon
fit of pir
ınecting
bores
r w in
ure
mandre
mall enc
m) is rec

5ir
127n



F7

To Fit Piston Rings

Piston ring layout, Fig. F.7, is as follows:-

No.1 Chrome Plated, Barrel Faced Compression
No.2 Chrome Plated, Flat Faced, Internally Stepped Compression
No.3 Chrome Faced, Spring Loaded Conformable Oil Control
No.4 Cast Iron, Slotted Oil Control

Fit rings as follows:-

Fit No.4 oil control ring.

Fit spring of No.3 oil control ring in groove, ensuring that latch pin enters both ends of spring, 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 internally stepped No.2 compression ring with "step" of ring and word "TOP" towards piston crown.

Fit barrel faced No.1 compression ring in top groove.

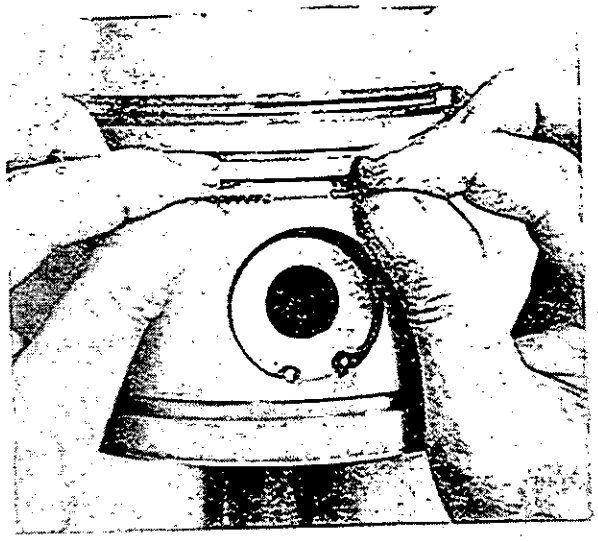
Ensure that ring gaps are equally spaced around piston and not in line.

To Fit Piston and Connecting Rod

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 opposite to the camshaft.

When pressing the assembly through the bore, care must be taken to avoid damage to the piston



F8

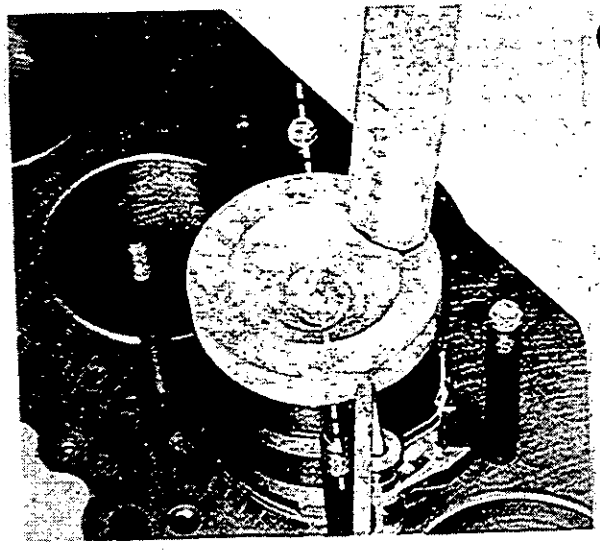
cooling jets. Fig. F.9 illustrates the piston position until the connecting rod big end has cleared the cooling jet area.

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.3.

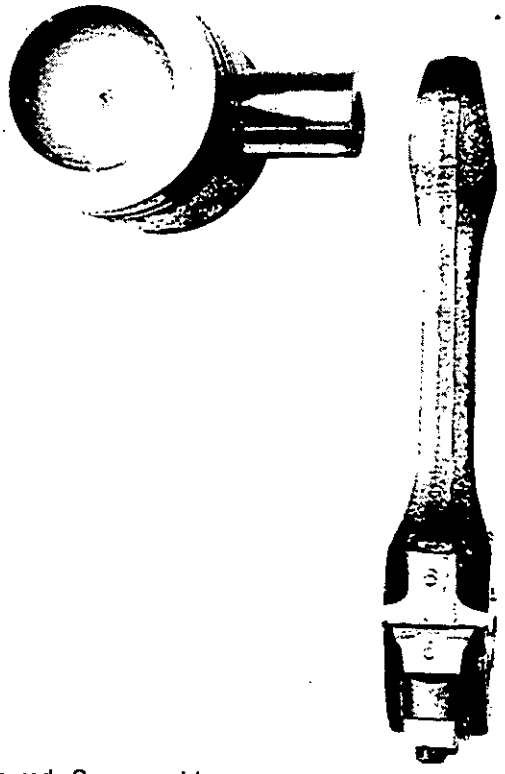
When the big end of the connecting rod has passed the piston cooling jets, turn the assembly back again to locate on the crankpin ensuring that upper half bearing is correctly located in big end and tabs fits in recess of rod, Fig. F.11. Also check that the word "FRONT" on the piston crown is towards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



F9



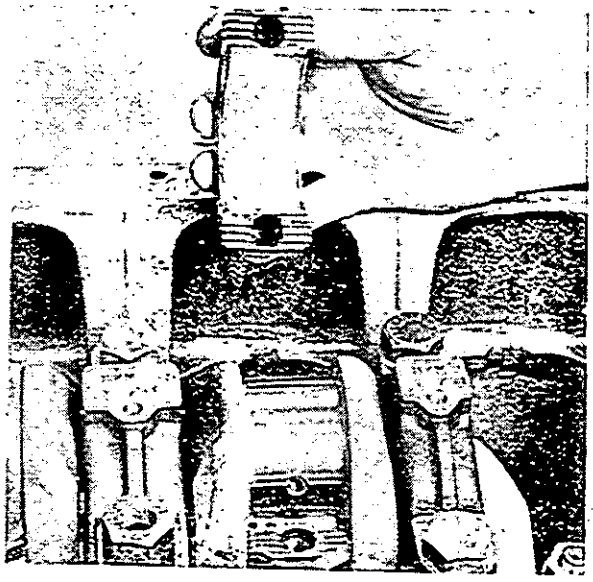
F10

of the rod. Secure with two nuts and tighten to a torque of 75lbfft (10,4kgfm-100Nm), or 70lbfft (9,7kgfm -96Nm) if prior to Engine No. 3543U1384T.

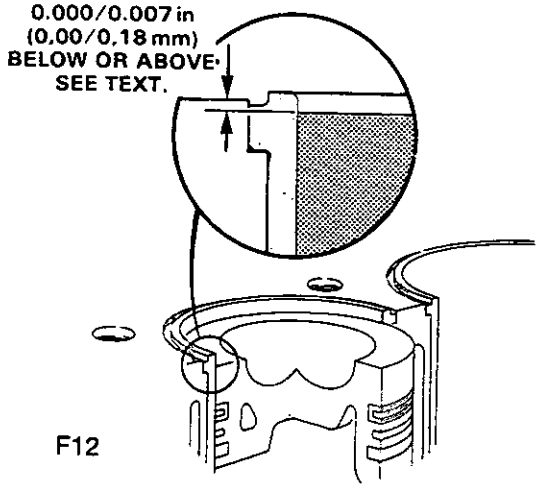
Check that, with piston in T.D.C. position and using piston height gauge PD 41B, the piston crown is 0.000/0.007in (0,00/0,18mm) **below** top face of cylinder block for engines prior to Engine No. 3543U10342TL or 0.000/0.007in (0,00/0,18mm) **above** the top face of the cylinder block for engines commencing at Engine No. 3543U10342TL, see Fig. F.12. This is important.

Where engines have to meet the smoke legislation requirements BSAU141a:1971, then production limits regarding piston heights must be maintained.

Fit the pipe from relief valve to piston cooling jet connection.



F11



F12

Fit lubricating oil suction pipe.

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

Refit the cylinder head, see Page E.3.

DATA AND DIMENSIONS FOR PISTONS AND CONNECTING RODS

All threads used are Unified Series. The following figures are based mainly upon those used in the factory for production.

Pistons

Type	Toroidal Cavity in Crown
Overall Height	4.2635in (108,29mm)
Piston Height in relation to Cylinder Block Top Face (prior to Engine No. 3543U10342TL)	0.000/0.007in (0,00/0,18mm) BELOW
Piston Height in relation to Cylinder Block Top Face (commencing Engine No. 3543U10342TL)	0.000/0.007in (0,00/0,18mm) ABOVE
Bore Diameter for Gudgeon Pin	1.49985/1.50005in (38,096/38,101mm)
Compression Ring Groove Width No. 1	Tapered
Compression Ring Groove Width No. 2	0.0958/0.0968in (2,43/2,46mm)
Scraper Ring Groove Width Nos. 3 and 4	0.190/0.191in (4,83/4,85mm)

Piston Rings

No. 1 Compression	Chrome Plated, Barrelled Faced
No. 2 Compression	Chrome Plated, Flat Faced, Internally Stepped
No. 3 Scraper	Chrome Plated, Oil Control Conformable
No. 4 Scraper	Cast Iron, Slotted, Oil Control
Compression Ring Width No. 1	Tapered
Compression Ring Width No. 2	0.0927/0.0937 in (2,35/2,38 mm)
Scraper Ring Width Nos. 3 and 4	0.1865/0.1875 in (4,74/4,76 mm)
No. 1 Ring Clearance in Groove	Tapered
No. 2 Ring Clearance in Groove	0.0021/0.0041 in (0,05/0,10 mm)
Nos. 3 and 4 Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Piston Ring Gap, Chrome Plated, 1st, 2nd and 3rd Rings	0.016/0.034 in (0,41/0,86 mm)
Piston Ring Gap, Cast Iron, 4th Ring	0.012/0.030 in (0,30/0,76 mm)

Ring gaps given are for when checking in an unworn portion of the cylinder bore.

Gudgeon Pin

Type	Fully Floating
Outside Diameter	1.4998/1.500 in (38,09/38,1 mm)
Length	3.250/3.2599 in (82,55/82,8 mm)
Fit in Piston Boss	Transition

Small End Bush

Type	Steel Backed, Lead Bronze Lined
Outside Diameter	1.660/1.661 in (42,16/42,19 mm)
Inside Diameter before Reaming	1.489/1.493 in (37,82/37,92 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)

Connecting Rod

Type	"H" Section, Wedge Shaped 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	1.65625/1.65725 in (42,07/42,09 mm)
Length from C/L of Big End to C/L of Small End	8.624/8.626 in (219,05/219,1 mm)

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Silicon Faced
Shell Thickness	0.0723/0.0726 in (1,836/1,844 mm)
Shell Width	1.245/1.255 in (31,62/31,88 mm)
Outside Diameter	2.646/2.6465 in (67,21/67,22 mm)
Inside Diameter	2.5008/2.5019 in (63,52/63,55 mm)
Bearing Running Clearance	0.0012/0.0031 in (0,03/0,08 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 in 5 in (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. F.5. With the small end bush fitted, the limit of +0.010 in (0.25 mm) is reduced to +0.0025 in (0.064 mm)

Approved Tools for Pistons and Connecting Rods

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England

Piston Ring Clamp	38 U 3
Connecting Rod Jig	335
Master Arbor (for use with 335)	336
Arbor Adaptor (for use with 335 and 336)	PD 336-6
Circlip Pliers	7066
Tension Wrench 50/170 lbf ft (6,9/23,5 kgfm)	13
Piston Height and Valve Depth Gauge	PD 41 B

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 — Flanged

Production liners are an interference fit of 0.001/0.003 in (0,025/0,076 mm) in the cylinder block and are bored and honed to a diameter of 3.877/3.878 in (98,48/98,50 mm).

The maximum permissible worn inside diameter of a liner, in service is 3.886 in (98,70 mm).

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

For service, a pre-finished liner is available having a transition fit of +0.001/-0.001 in (+0.025/-0,025 mm). The fitted internal bore diameter is 3.877/3.8795 in (98,48/98,54 mm).

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

Cylinder Liners — Flangeless

As from Engine Number 3543U8761TL, flangeless cylinder liners were introduced on vehicle engines.

The maximum permissible worn inside diameter of a liner in service is 0.008 in (0,20 mm).

If liners are found to be above this limit, then new production (interference fit) liners must be fitted and bored and honed to standard size.

To Remove Cylinder Liners

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

The liners should be pressed out from the bottom.

To Fit Flanged Liners

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

Apply engine oil to the cylinder block parent bore except for the top 2 in.

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

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

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

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

Finally, press the liner into the fully fitted position and wipe the top of the cylinder block to remove any surplus "Loctite".

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.

To Fit Flangeless Liners

Generally clean the parent bore and de-grease with "Loctite" Safety Solvent (aerosol can) as per the instructions on the can.

After de-greasing, the bores must not be touched by hand, nor must any form of grease or oil come into contact with them.

Generally clean the outside surface of the liner and de-grease with "Loctite" Safety Solvent (aerosol can) as per the instructions on the can.

After de-greasing, do not touch the outside surface of the liner except for a band 1 in (25 mm) wide at the top.

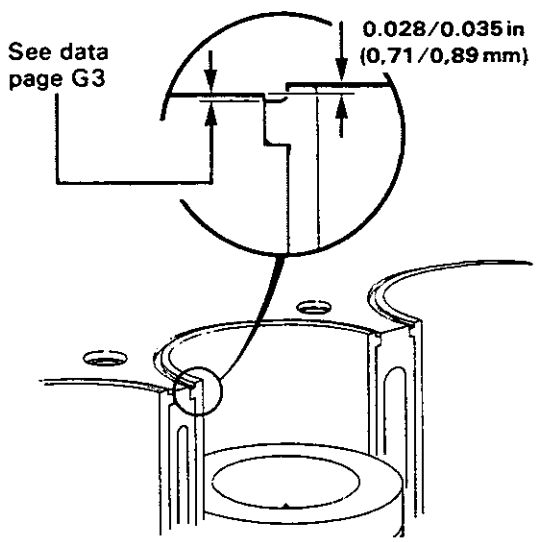
Apply bands of "Loctite" Retaining Compound, Grade 602, 1 in (25 mm) wide to the top of the cylinder block parent bore and midway down the length of the bore.

Locate the liner in the bore, taking care to only handle the top 1 in (25 mm) of the liner and press in to within 2 in of its final position.

Further de-grease the top area of the liner, using "Loctite" Safety Solvent to remove handling contamination.

Finally press into position so that the top of the liner protrudes 0.028/0.035 in (0,71/0,89 mm) above the top face of the cylinder block.

Allow at least 15 minutes to elapse, before commencing to machine the liners.



G1

DATA AND DIMENSIONS FOR CYLINDER BLOCK AND LINERS

All threads used are Unified Series or American Pipe Series. The following figures are based mainly upon those used in the factory for production.

Cylinder Block

Height between Top and Bottom Faces	17.367/17.375 in (441,12/441,32 mm)
Parent Bore Diameter for Flanged Cylinder Liner	4.0625/4.0635 in (103,19/103,21 mm)
Parent Bore diameter for Flangeless Cylinder Liner	4.0615/4.0625 in (103,16/103,19 mm)
Recess Depth for Cylinder Liner Flange	0.150/0.154 in (3,81/3,91 mm)
Recess Diameter for Cylinder Liner Flange	4.205/4.210 in (106,81/106,94 mm)
Main Bearing Parent Bore	3.166/3.167 in (80,42/80,44 mm)
Camshaft Parent Bore Diameter No. 1	2.000/2.001 in (50,8/50,83 mm)
Camshaft Parent Bore Diameter No. 2	1.990/1.992 in (50,55/50,6 mm)
Camshaft Parent Bore Diameter No. 3	1.980/1.982 in (50,29/50,34 mm)
Camshaft Parent Bore Diameter No. 4	1.970/1.972 in (50,04/50,09 mm)
Cylinder Block Dowel Bore Diameter	0.8125/0.8135 in (20,64/20,66 mm)

Cylinder Liners (Cast Iron—Flanged)

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 (0,025/0,076 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 (Production and early Service Liner Pt. No. 31358341)	0.144/0.146 in (3,66/3,71 mm)
Flange Thickness (current Service Liner Pt. No. 31358441)	0.150/0.152 in (3,81/3,86 mm)
Height of Liner above Cylinder Block Top Face	0.028/0.035 in (0,71/0,89 mm)
Depth of Liner Flange below Top Face of Cylinder Block (Production and early Service)	0.004/0.010 in (0,10/0,25 mm)
Relation of Liner Flange with Top Face of Cylinder Block (current Service)	+0.002/-0.004 in (0,05/0,10 mm)
Overall Length of Liner	8.941/8.954 in (227,1/227,43 mm)
Maximum Bore Wear (new liners are necessary)	0.008 in (0,2 mm)

Cylinder Liners (Cast Iron — Flangeless)

Type	Dry – Interference Fit
Outside Diameter of Liner	4.0655/4.0665 in (103,26/103,29 mm)
Interference Fit of Liner	0.003/0.005 in (0,08/0,13 mm)
Inside Diameter of Liner after Finish Honing	3.877/3.878 in (98,48/98,50 mm)
Maximum Oversize (Rebore)	+0.030 in (0,76 mm)
Height of Liner above Top Face of Cylinder Block	0.028/0.035 in (0,71/0,89 mm)
Overall Length of Liner	9.905/9.915 in (251,58/251,84 mm)
Maximum Bore Wear (new Liners or rebore as necessary)	0.008 in (0,20 mm)

Approved Tools for Cylinder Block and Liners

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England.

Cylinder Liner Remover/Replacer	PD 150
Cylinder Liner Remover/Replacer Adaptor Pads	PD 150-1B

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. 0.0075 in (0,19 mm) oversize thrust washers are available which may be combined with standard thrust washers to give an adjustment of 0.0075 in (0,19 mm) or when used on both sides of the bearing housing give an adjustment of 0.015 in (0,35 mm).

The maximum permissible crankshaft end float is 0.015 in (0,38 mm).

The crankshaft is 60 hour nitrided, and has provision for 12 bolt flywheel fixing.

H2

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 centre main bearing setscrew.

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.

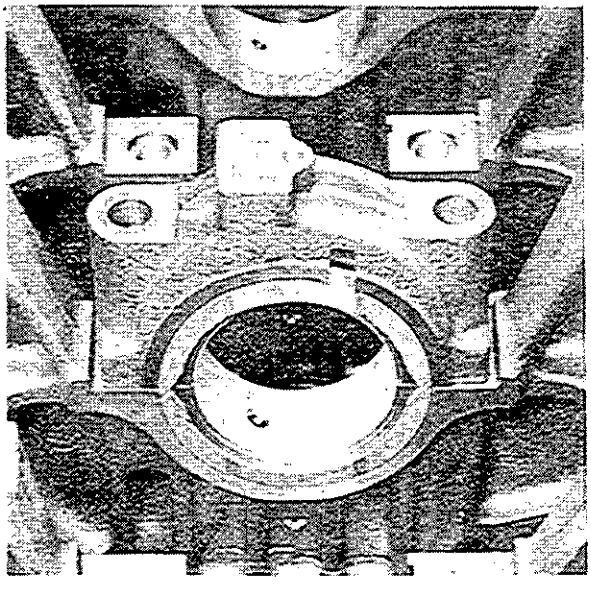
Refit the two bottom halves of the thrust washers to the bearing cap.

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 180lbfft (24,9kgfm) or 244Nm. See Page B.2. Recommended Torque Tensions for engines prior to number 3543U435T.

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 centre main bearing setscrew and sump. Refill the sump with lubricating oil of an approved grade.



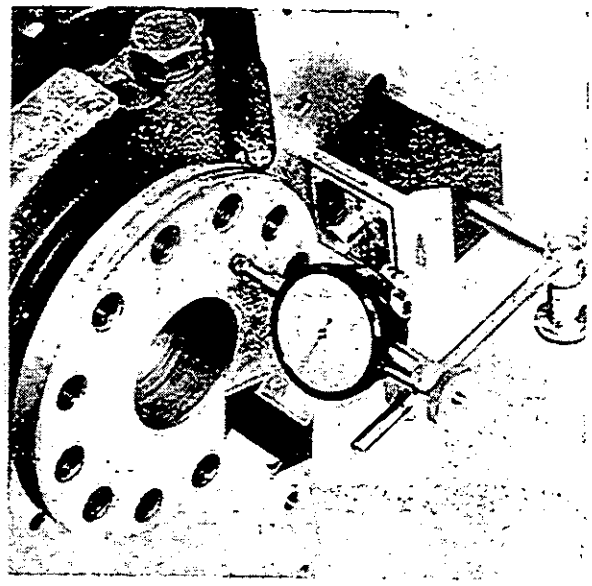
H1

To Remove Crankshaft

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

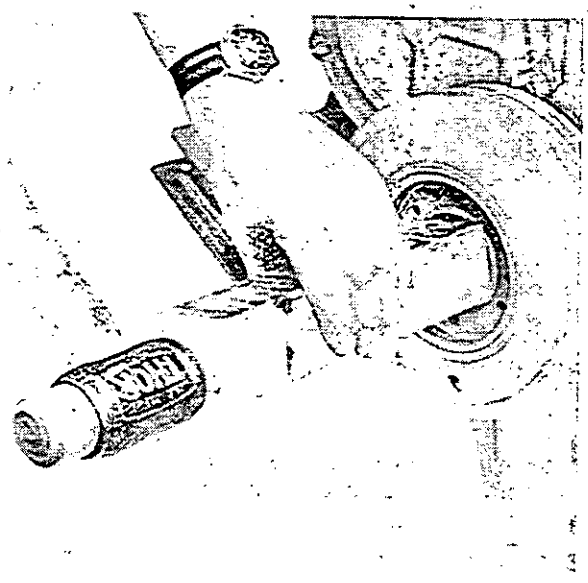
Drain and remove the sump, lubricating oil suction pipe and pipe from reducing valve to centre main bearing setscrew.

Remove the crankshaft pulley. Extractors should



H3

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.



H4

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

Remove flywheel and flywheel housing.

Remove rear main oil seal housing.

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 crankshaft can be reground -0.010 in (-0,25 mm) undersize without nitriding.

If facilities for nitriding after regrinding below -0.010 in (-0,25 mm) are not available then a factory replacement crankshaft should be obtained.

Before regrinding the crankshaft it should be crack detected. Demagnetise after crack detecting.

With a standard crankshaft, the minimum permissible worn diameter of the main journals is 2.997 in (76,12 mm) and of the crankpins is 2.4975 in (63,44 mm).

Maximum permissible ovality for main journals and crankpins is 0.0015 in (0,04 mm).

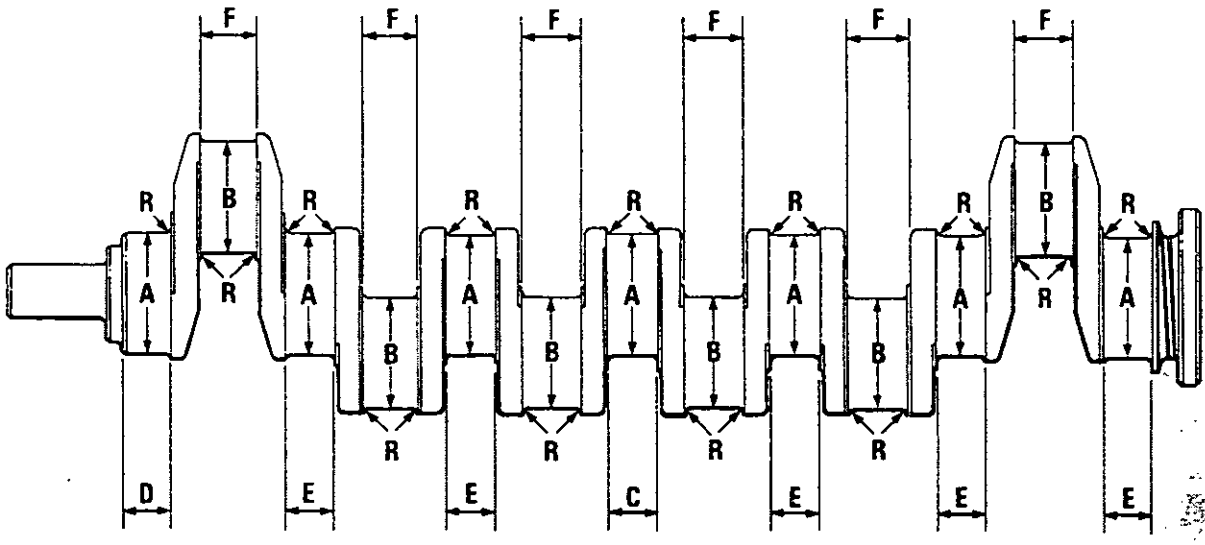
The crankshaft can be reground to 0.010 in (0,25 mm), 0.020 in (0,51 mm) and 0.030 in (0,76 mm) undersize, provided that:-

When regrinding, only very light cuts should be used, especially around the fillet radii and adequate cooling should be ensured.

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

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

If the crankshaft has been reground to less than 0.010 in (0,25 mm) undersize, it should be re-hardened by the 60 hour nitriding process and then crack detected and demagnetised. Finally the crankpins and main journals should be lapped to remove the residue from the nitriding process.



H5

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 fillet radii (R) and crankpins and journals must be maintained during regrinding.

To Fit Crankshaft

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

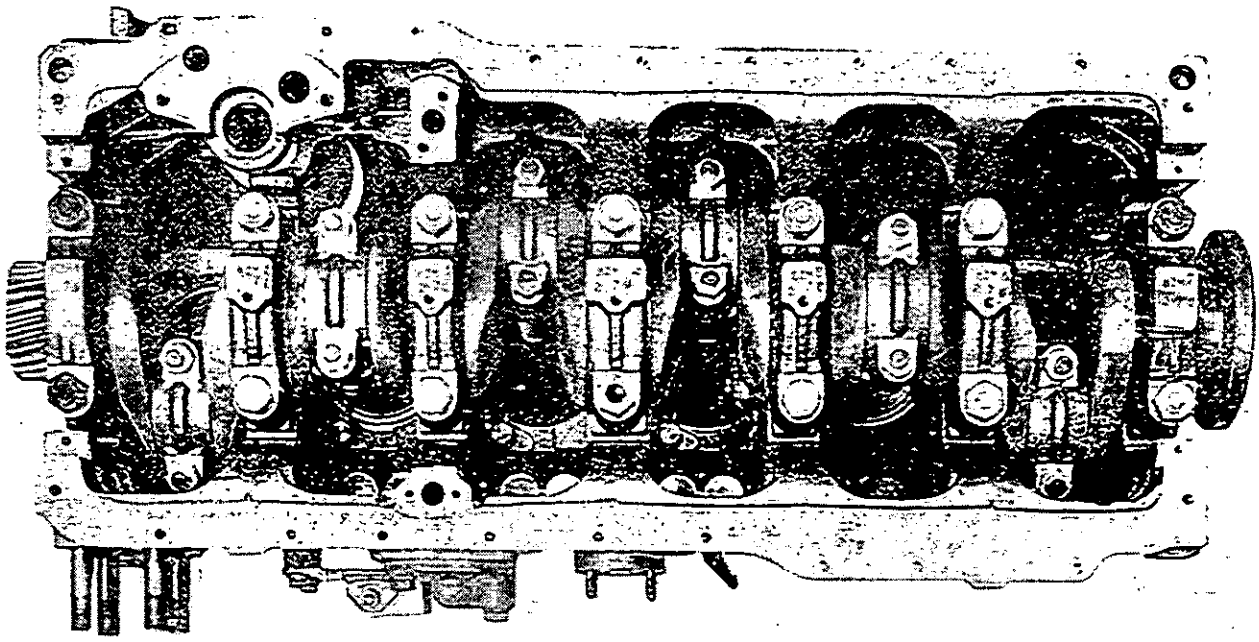
Check the main bearing setscrews for stretch or damage. If they are to be replaced, only use Perkins genuine spare parts.

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



H6

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.

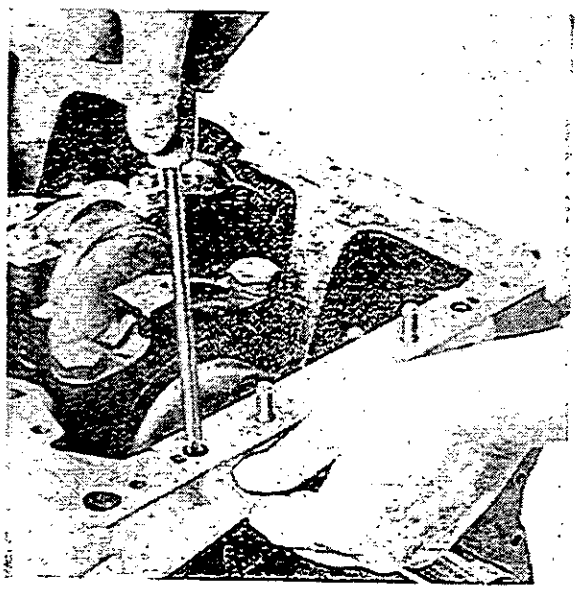
Fit a new shim washer to each main bearing cap setscrew and lightly oil.

Tighten the setscrews to a torque of 180lbfft (24,9kgfm) or 244Nm. See Page B.2 Recommended Torque Tension for engines prior to number 3543U435T.

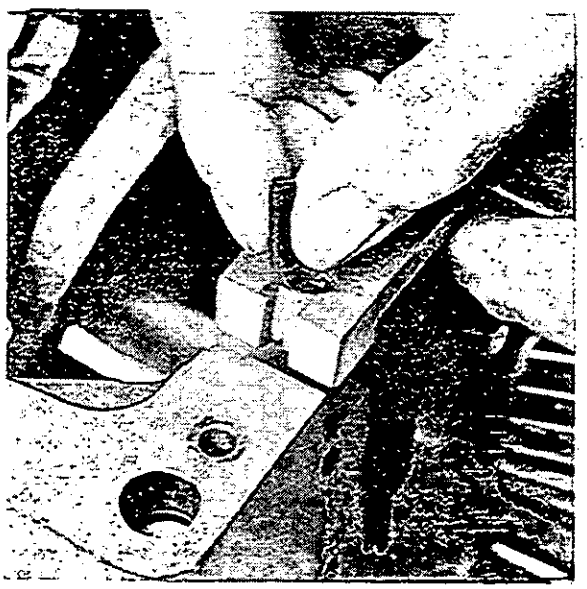
0.002/0.015 (0,05/0,38 mm). Oversize thrust washers may be fitted.

Refit the connecting rod caps and big end bearings.

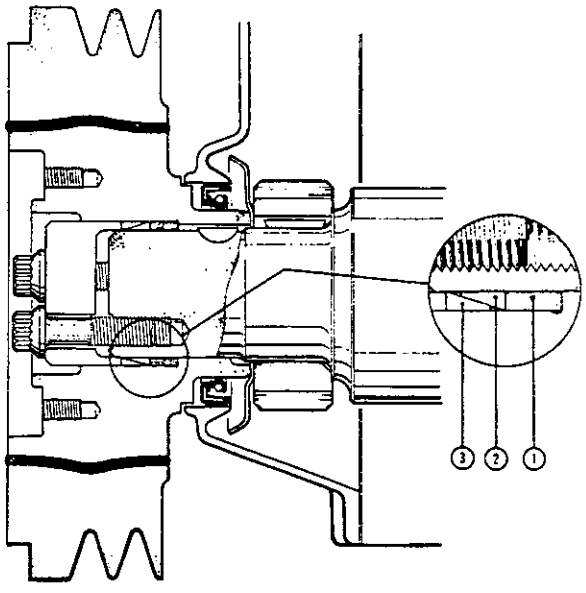
Refit the front and rear bridge pieces to the cylinder block using jointing compound between the bridge pieces and the cylinder block at the setscrew holes. Check with a straight edge to ensure that the end faces of the bridge pieces are flush with the end faces of the cylinder block, see Fig. H.7. Insert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



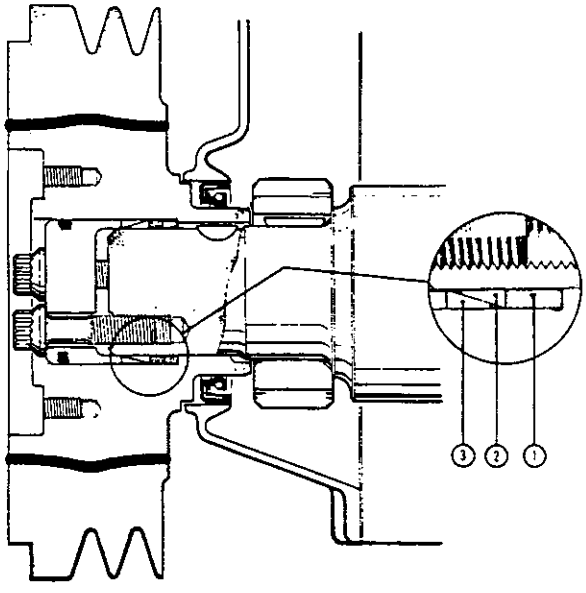
H7



H8



H9



H10

Fit new seals in the rear main oil seal housings and refit the housings.

Refit the pipe from reducing valve to centre main bearing setscrews, lubricating oil suction pipe and sump.

Fit the crankshaft oil thrower flange where fitted with the dished face outwards.

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

Two types of crankshaft pulley arrangement can be found. The earlier type is shown in Fig. H.9. The later type which incorporates an "O" ring with the crankshaft oil thrower deleted is shown in Fig. H.10. Pulleys and thrust blocks are not interchangeable.

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.

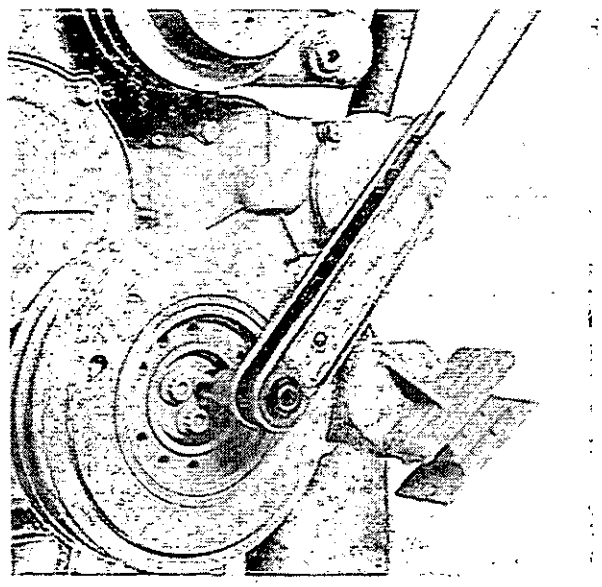
(c) Insert the spacer (1) into the pulley bore over the shaft, followed by the inner (2) and then the outer (3) locking elements, ensuring that the slots do not coincide, see Fig. H.9.

(d) Fit the thrust block with "O" ring (where applicable) into 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 65 lbf ft (9,0 kgf m) is achieved, see Fig. H.11.



H11

Check tightening torque on each screw.

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

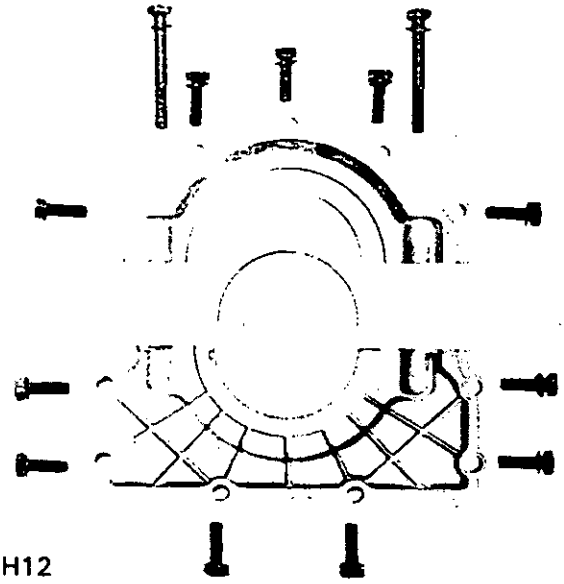
Rebuild engine into vehicle or machine. Fill the sump to the correct dipstick level with a recommended oil. Do not fire the engine until checking for lubricating oil at the turbocharger, see Page B.3.

To Fit Crankshaft Rope Type Rear Oil Seal and Housing, see Fig. H.12

The housing consists of two halves bolted around the rear of the crankshaft which has a shallow spiral oil return groove machined in it to a depth of 0.004/0.008 in (0,10/0,20 mm). The bore of the housing accommodates two rubber cored asbestos strips.

When fitting the seal, the following procedure should be adopted.

(a) Set up a half housing in a vice with the seal recess uppermost and settle approximately 1 in (25 mm) of the strip, at each end, into the



H12

ends of the groove, so that each end of the strip protudes 0.010/0.020 in (0,25/0,5 mm) beyond the half housing joint face.

(b) With the thumb or finger press the remainder of the strip into the groove working from the centre. Use a round bar to further bed in the strip by rolling and pressing its inner diameter.

(c) Fit the sealing strip to the other half housing in a similar manner.

(d) Fit a new joint using jointing compound on both sides.

(e) Spread a film of graphite grease over the exposed inside diameter of the strip.

(f) Assemble the half housings to the cylinder block and tighten the setscrews and housing clamping setscrews finger tight only.

(g) Tighten clamping setscrews to a torque of 6 lbf ft (0,83 kgf m) or 8 Nm.

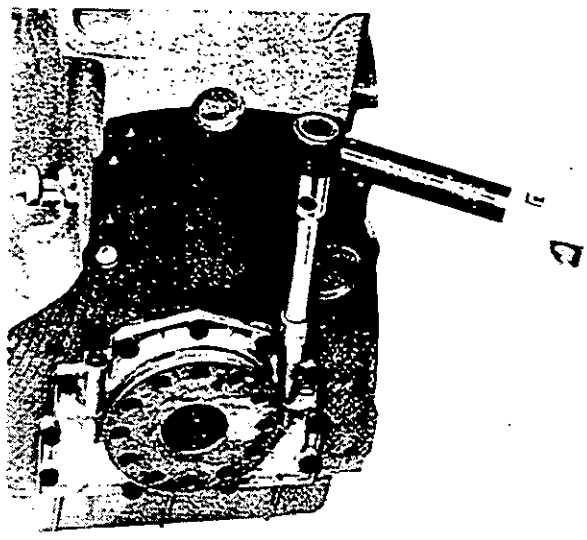
(h) Tighten setscrews in cylinder block to a torque of 12 lbf ft (1,66 kgf m) or 16 Nm.

(i) Finally tighten the clamping setscrews to a torque of 12 lbf ft (1,66 kgf m) or 16 Nm, see Fig. H.13.

Lip Type Crankshaft Rear End Oil Seal

On some engines, a circular, spring loaded, lip seal is fitted, which locates on the periphery of the flange of the crankshaft. On production, this seal is fitted with its rear face flush with the rear face of the single piece housing.

This type of 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 new seal.



H13

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

On production the seal is fitted with its rear face flush with the rear face of the housing. In service, when a new seal is to be fitted to a worn crankshaft, it should be pressed further into the housing, in the first instance to ⅛ in (3,2 mm) or, if this position has been used, to ¼ in (6,4 mm) from the rear face of the housing — see Fig. H.14. If all three positions have been used, it may be possible to machine the worn sealing area of the crankshaft flange, but not the spigot area on which the flywheel locates — see Fig. H.15. When a new seal is fitted to a new or reconditioned crankshaft, it should be fitted with its rear face flush with the housing.

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.

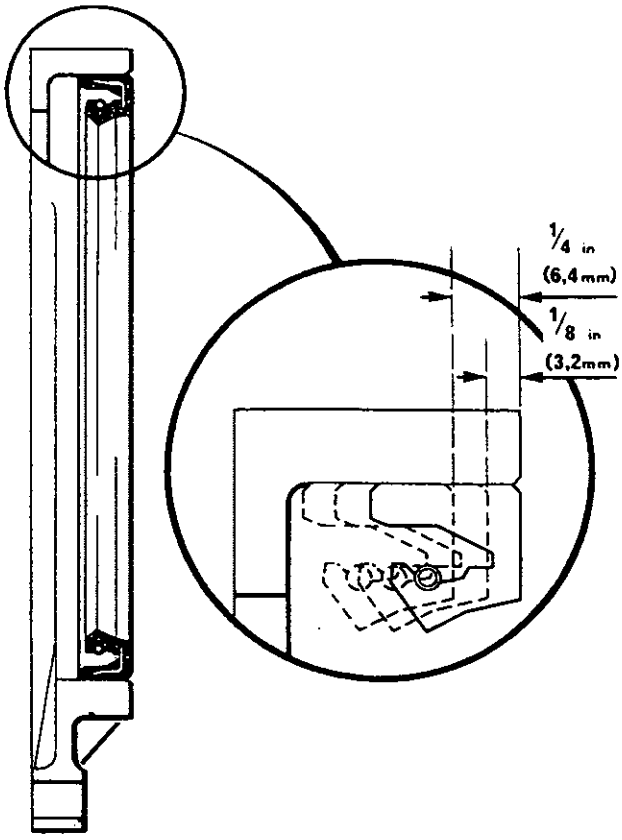
Press the seal into the housing to the required position, taking care that the seal is entered and pressed in squarely, otherwise damage to the outside diameter of the seal may occur, or if it is not square in the housing when fitted to the engine, it may leak.

The seal and housing should be fitted, using seal guide PD 145 (Churchill Tool) as follows:

Clean the faces of the cylinder block and 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 as previously detailed.

Ensure that the two dowels are fitted in the cylinder block. Coat both sides of the housing with Perkins



H14

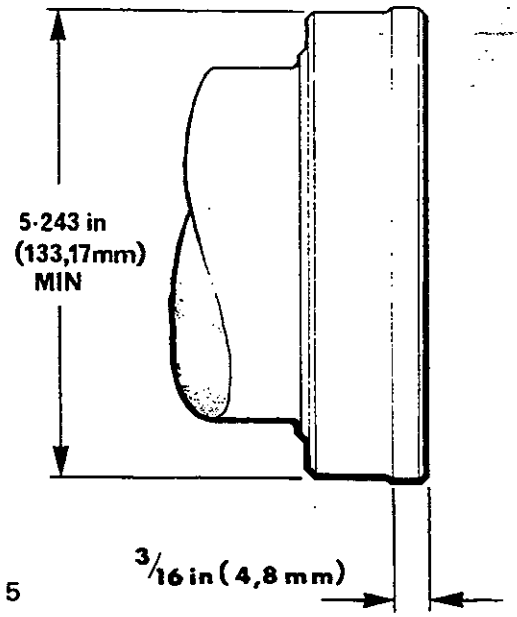
Hylomar jointing compound and position the joint over the dowels in the block.

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 its housing into position on the flange, locating the housing on its dowels.

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

The lip type seal assembly and its counterpart crankshaft are not interchangeable with previous types.



H15

DATA AND DIMENSIONS FOR CRANKSHAFT AND MAIN BEARINGS

All threads used are Unified Series. The following figures are based mainly upon those used in the factory for production.

Crankshaft

Overall Length	34.204/34.234 in (868,78/869,54 mm)
Main Journal Diameter	2.9984/2.9996 in (76,16/76,19 mm)
Maximum Permissible Ovality of Worn Journal	0.0015 in (0,04 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 (39,24/39,34 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)
Maximum Permissible Ovality of Worn Crankpin	0.0015 in (0,04 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) Max.
Oil Seal Helix Diameter (rope seals only)	3.124/3.125 in (79,35/79,38 mm)
Oil Seal Helix Width	0.060/0.080 in (1.52/2,03 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,1/0,2 mm)
Flange Diameter	5.248/5.250 in (133,3/133,35 mm)
Flange Width	0.500 in (12,7 mm)
Spigot Bearing Recess Depth	0.781 in (19,84 mm)
Spigot Bearing Recess Bore	1.849/1.850 in (46,96/46,99 mm)
Crankshaft End Float	0.002/0.015 in (0,05/0,38 mm)
Maximum Permissible Worn Crankshaft End Float	0.015 in (0,38 mm)
Regrind Undersizes, Main Journals and Pins	0.010 in (0,25 mm), 0.020 in (0,51 mm) and 0.030 in (0,76 mm)

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

Crankshaft Thrust Washers

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

Main Bearings

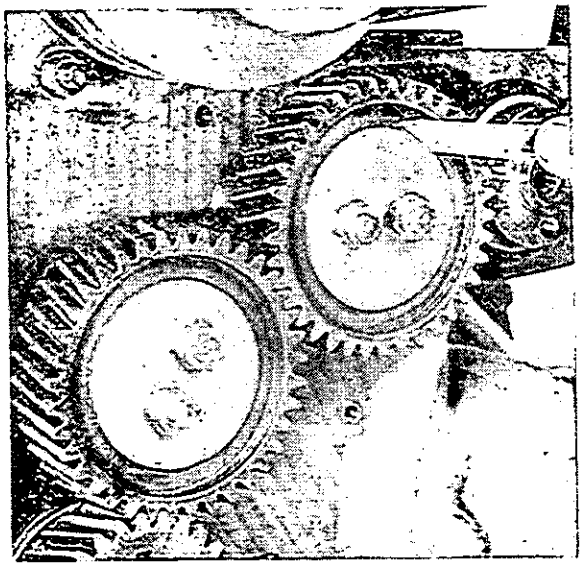
Type	Pre-finisned, Steel Backed, Aluminium Silicon Faced
Shell Width, Nos. 1, 2, 3, 5, 6 and 7	1.245/1.255 in (31,62/31,88 mm)
Shell Width, No. 4	1.435/1.445 in (36,45/36,7 mm)
Outside Diameter	3.166/3.167 in (80,42/80,44 mm)
Inside Diameter	3.0010/3.0026 in (76,225/76,266 mm)
Main Bearing Running Clearance	0.00198/0.00462 in (0,0545/0,1206 mm)
Shell Thickness	0.0822/0.0825 in (2,087/2,095 mm)

Approved Tools for Crankshaft and Main Bearings

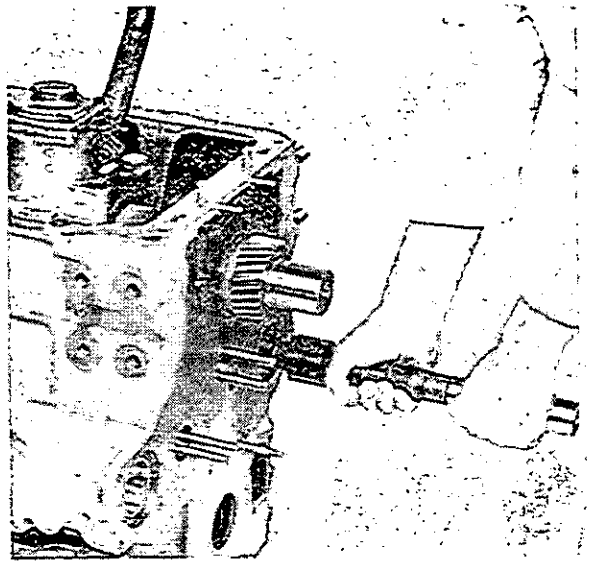
Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England.

Tension Wrench	150/400 lbf ft (20,7/55,3 kgf m) 4 RL
Tension Wrench	50/170 lbf ft (6,9/23,5 kgf m) 13

SECTION J
Timing Case and Drive



J7



J8

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 (5,0kgf 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 0.002/0.012 in (0,05/0,30 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 M.4.
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.

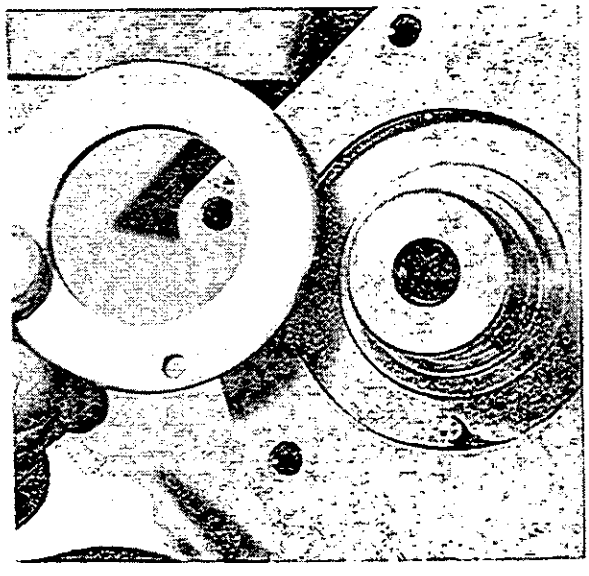
To Replace Camshaft and Tappets

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.

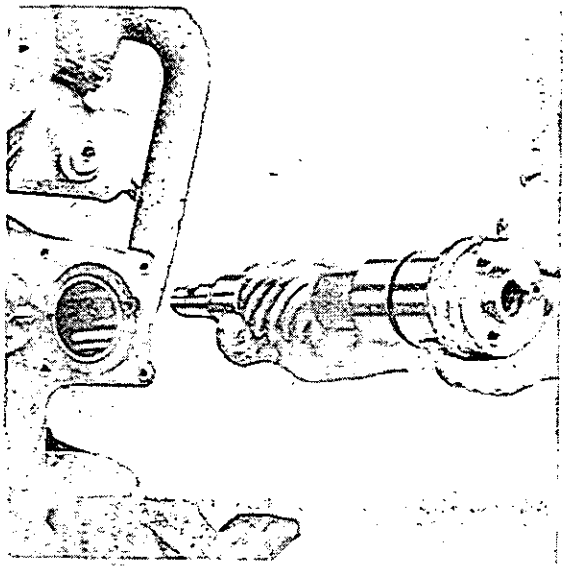
Adjust the valve clearances to 0.012 in (0,30 mm) cold. Refit the rocker cover.
Refill sump with lubricating oil of an approved grade.

To Remove Auxiliary Drive Shaft and Fuel Pump Drive Shaft

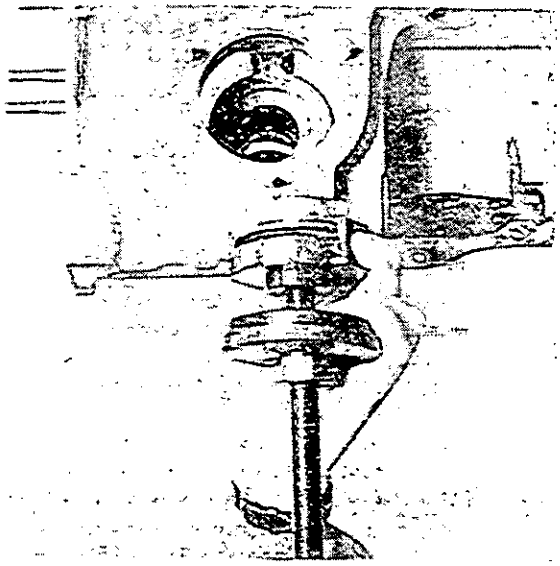
Remove the timing case, see Page J.2.
Remove the compressor and auxiliary pump (if fitted) and couplings.
Remove the fuel injection pump, see Page M.5.
With a twisting motion, withdraw the auxiliary



J9



J10



J12

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, the thrust collar and bush can now be withdrawn, see Fig. J.12.
The front and rear bushes for the auxiliary drive shaft are pre-finished white metal and can be renewed where necessary.

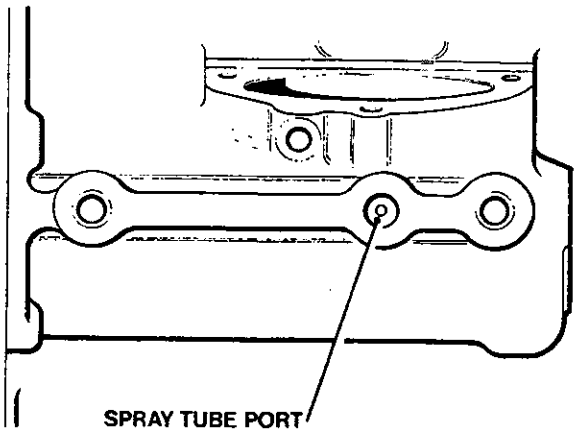
Auxiliary Drive Spray Tube

The auxiliary drive gears are lubricated by oil directed on to them by a spray tube in the auxiliary drive housing (see Fig. J.13). The spray tube is a push fit sealed with a "D" type plug.

This spray tube should be removed and cleaned during engine overhaul. Spares blocks are not fitted with this spray tube, therefore when replacing a block, always ensure that spray tube is transferred from the old block to the new one.

J11

PART SIDE VIEW ON AUX. DRIVE HOUSING



J13

To Refit Auxiliary Drive Shaft and Fuel Pump Drive Shaft see Fig. J.14

Refit the lower thrust collar assembly and press into position.

From engine number 3543U9782TL a design improvement has been made to the fuel pump/lubricating oil pump drive shaft and lower thrust collar.

The contact area between the lower thrust collar and bronze gear has been increased.

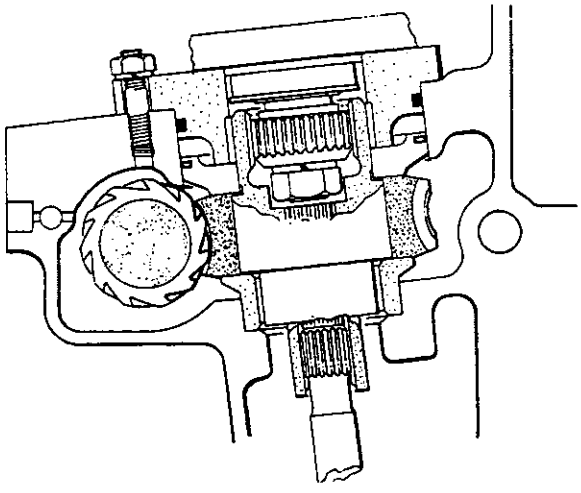
Material specification of the lower thrust collar has been changed to sintered material. With this change, the bush in the lower thrust collar was deleted, but subsequently introduced again at Engine No. 3543U11872TL.

Oil flutes have been incorporated in the thrust face of the lower thrust collar to improve lubrication (see Fig. J.15).

A small slot has been machined in the underside of the bronze gear (refer inset on Fig. J.15).

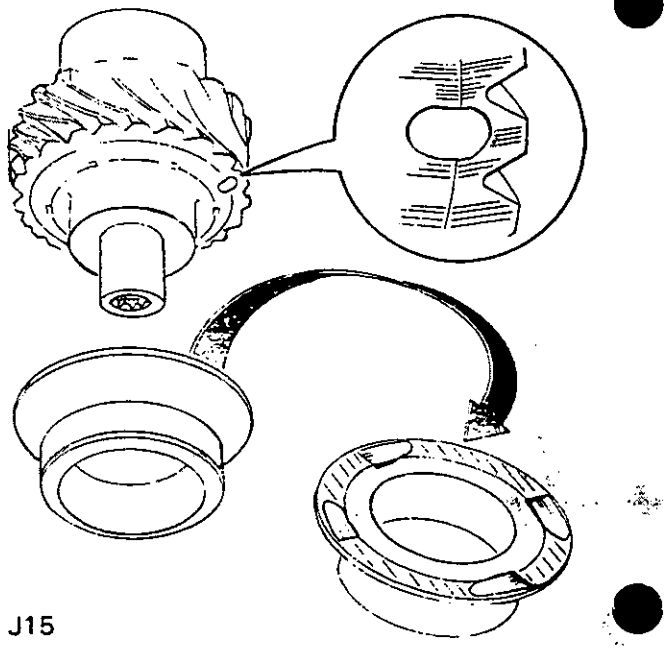
This slot connects the oil flutes in the thrust collar to the crankcase as the gear turns, allowing an intermittent flow of oil across the thrust face of the collar, improving lubrication.

The new bronze gear and lower thrust collar will replace the earlier ones as an assembly but not as individual items.



J14

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 and sealing ring, so that the timing mark scribed on flange is adjacent to the outside securing stud.

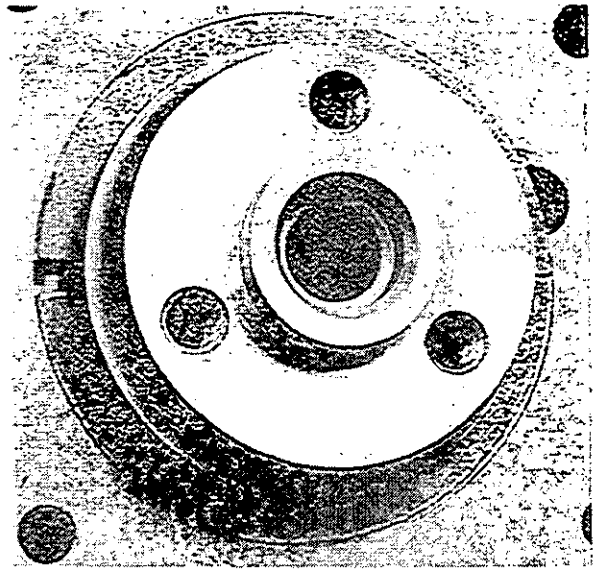


J15

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.16.
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.

Checking the Timing Gear Backlash

Remove the camshaft gear and auxiliary drive gear covers.



J16

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.

If not, replace the gears affected.

Checking Valve Timing

Turn the crankshaft until the valves on No. 6 cylinder are rocking and set the clearance on No. 1 inlet valve to 0.047 in (1,19 mm) for engines prior to Engine No. 3543U10342TL or 0.051 in (1,30 mm) for engines commencing at Engine No. 3543U10342TL.

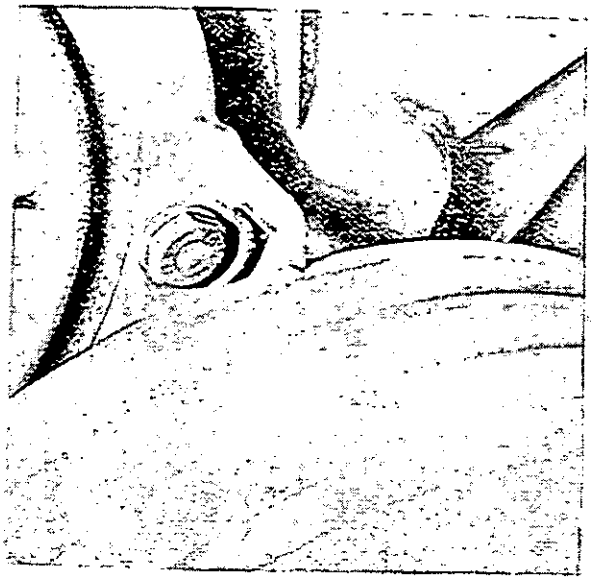
Turn the crankshaft in the normal direction of rotation until the pushrod of No. 1 inlet valve just tightens.

Check that Nos. 1 and 6 pistons are at T.D.C. by seeing if the timing pointer situated on the timing case is lined up with the notches on the crankshaft pulley periphery, see Fig. J.17. The valve timing tolerance is plus or minus 2½°.

With later engines, the timing pointer and crankshaft pulley mark has been deleted and to establish true T.D.C., the valve drop method (see page M5/6) should be adopted and suitable reference marks made.

The only error possible is in the fitting of the timing gears.

When the valve timing is found to be correct, reset the No. 1 inlet valve to 0.012 in (0,30 mm) or 0.008 in (0,20 mm) cold, see Page E.4.



J17

DATA AND DIMENSIONS FOR TIMING CASE AND DRIVE

All threads used are Unified Series. The following figures are based mainly upon those used in the factory for production.

Camshaft

No. 1 Journal Length	1.148 in (29,16 mm)
No. 1 Journal Diameter	1.9965/1.9975 in (50,71/50,74 mm)
No. 1 Journal Running Clearance	0.0025/0.0045 in (0,064/0,11 mm)
No. 2 Journal Length	1.375 in (34,93 mm)
No. 2 Journal Diameter	1.9865/1.9875 in (50,46/50,48 mm)
No. 2 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 3 Journal Length	1.375 in (34,93 mm)
No. 3 Journal Diameter	1.9765/1.9775 in (50,20/50,23 mm)
No. 3 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 4 Journal Length	1.125 in (28,58 mm)
No. 4 Journal Diameter	1.9665/1.9675 in (49,95/49,97 mm)
No. 4 Journal Running Clearance	0.0025/0.0055 in (0,065/0,14 mm)
Maximum Permissible Wear all Journals	0.002 in (0,05 mm)
Cam Lift (prior to Engine No. 3543U10342TL) Inlet and Exhaust	0.3003/0.3033 in (7,63/7,70 mm)
Cam Lift (commencing Engine No. 3543U10342TL)	
Inlet	0.3033/0.3063 in (7,70/7,78 mm)
Exhaust	0.3073/0.3103 in (7,81/7,88 mm)
Camshaft End Float	0.004/0.016 in (0,1/0,41 mm)
Maximum Permissible Worn Camshaft End Float	0.020 in (0,51 mm)
Width of Spigot for Thrust Washer	0.222/0.232 in (5,64/5,89 mm)
Oilways for Rocker Shaft Lubrication	No. 1 Journal

Camshaft Thrust Washer

Type	360°
Outside Diameter	2.872/2.874 in (72,95/73,0 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 (0,025/0,33 mm)
Internal Diameter	1.75 in (44,45 mm)
Thickness	0.216/0.218 in (5,49/5,54 mm)
Cylinder Block Recess Depth for Thrust Washer	0.213/0.216 in (5,41/5,49 mm)
Protrusion of Thrust Washer above Cylinder Block Front Face	0.000/0.005 in (0,00/0,13 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	1.875/1.8755 in (47,63/47,64 mm)
Fit of Gear to Crankshaft	-0.0005/+0.001 in (-0,012/+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)
Maximum Permissible Worn Idler Gear End Float	0.012 in (0,30 mm)

Timing Gear Backlash

All Gears	0.003/0.006 in (0,076/0,15 mm)

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)
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	1.25/1.2516 in (31,75/31,79 mm)
Running Clearance of Shaft in Bush	0.001/0.0036 in (0,025/0,09 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)
Clearance Fit of Thrust Washer in Cylinder Block	0.0005/0.0165 in (0,01/0,42 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

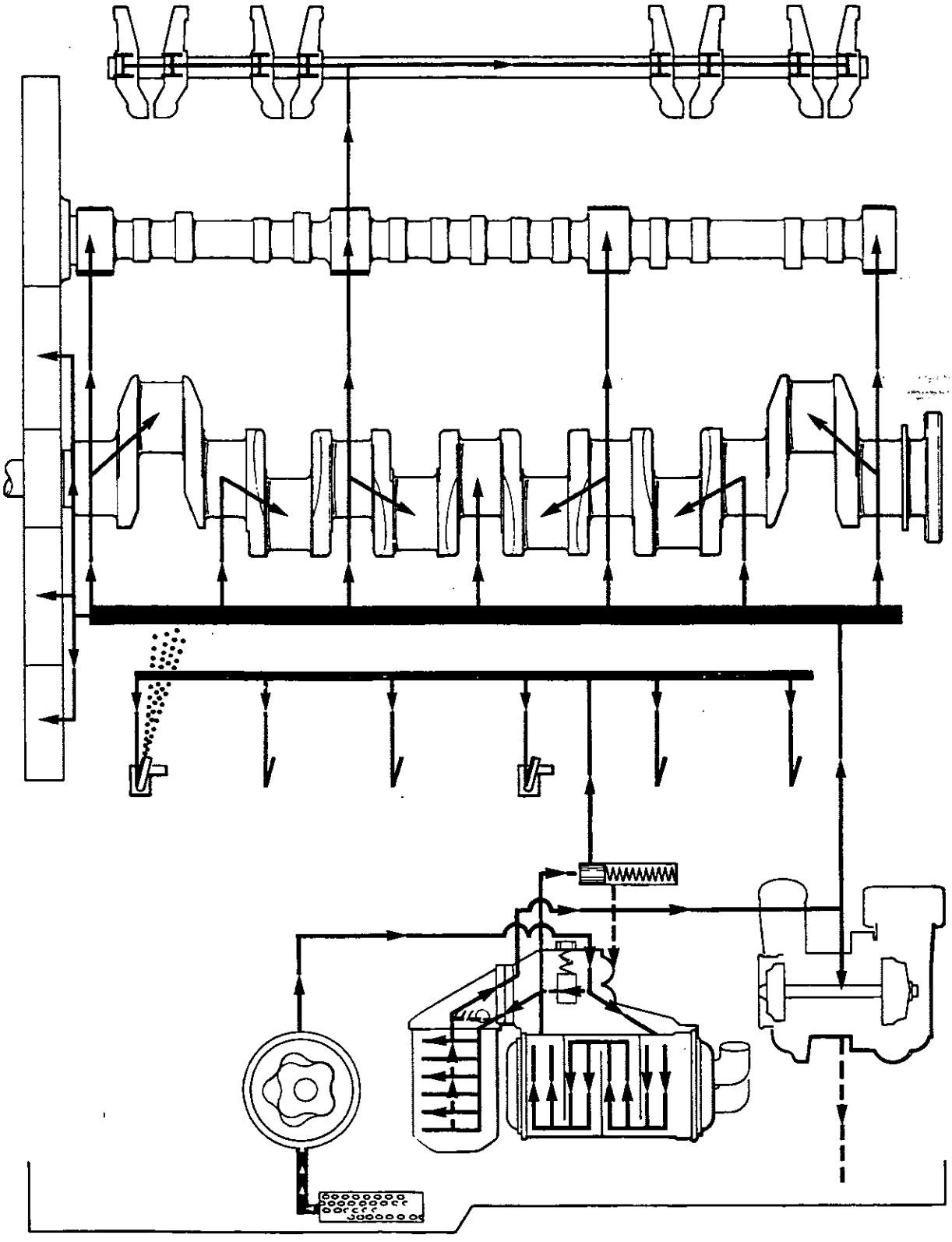
Bore Diameter in Cylinder Block for Fuel Pump Adaptor Plate and Upper Thrust Collar	3.500/3.5014 in (88,90/88,94 mm)
Fuel Pump Adaptor Plate Diameter	3.4986/3.4995 in (88,86/88,89 mm)
Fit of Plate in Cylinder Block	0.0005/0.0028 in (0,01/0,07 mm)
Outer Diameter of Upper Thrust Collar	3.496/3.498 in (88,80/88,85 mm)
Clearance of Upper Thrust Collar in Cylinder Block	0.002/0.0054 in (0,05/0,14 mm)
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)
Inside Diameter of Lower Thrust Collar (for bush)	1.7812/1.7828 in (45,24/45,28 mm)
Outside Diameter of Lower Thrust Collar Bush	1.7843/1.7857 in (45,32/45,36 mm)
Interference Fit of Bush in Lower Thrust Collar	0.0015/0.0045 in (0,04/0,11 mm)
Inner Diameter of Bush in Lower Thrust Collar Finished in Situ	1.6255/1.6266 in (41,29/41,32 mm)
Lower Diameter of Fuel Pump Drive Shaft	1.6214/1.6224 in (41,18/41,21 mm)
Clearance of Drive Shaft in Bush	0.0031/0.0052 in (0,08/0,13 mm)

Approved Tools for Timing Drive

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, England.

Timing Case Oil Seal Fitting Tool	PD 141
Adjustable Puller	PD 140
Adaptor for use with PD 140 removes fuel pump drive lower thrust collar	PD 140-2
Tension Wrench 50/170 lbf ft (6,9/23,5 kgf m)	13

SECTION K
Lubricating System



K1

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. 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.
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 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 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.

With earlier engines, the oil pressure was also controlled by a dump valve fitted in the side of the cylinder block.

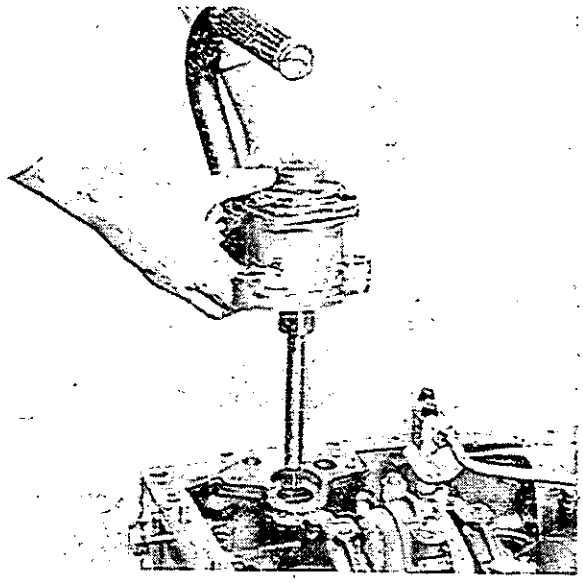
Both the filter and cooler are provided with a by-pass facility in the event of a blockage in either of the two components.

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 15 lbf ft (2,1 kgf m) -20 Nm.



K2

Oil Strainer

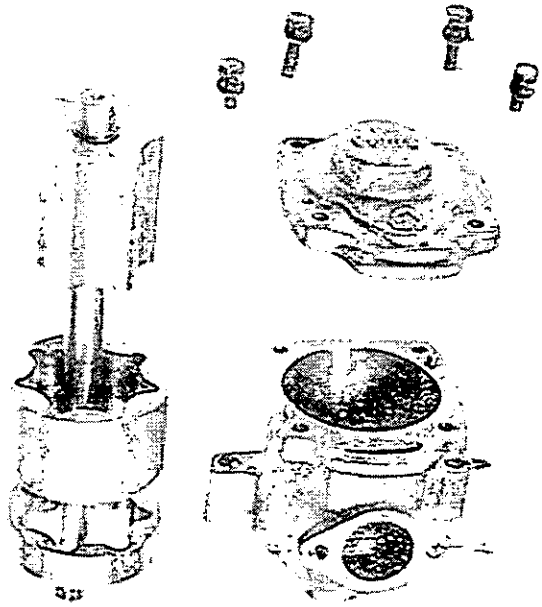
The oil strainer is part of the oil pump suction pipe. There is no periodic servicing on this strainer but it should be cleaned whenever the sump is removed.

To Remove Oil Pump

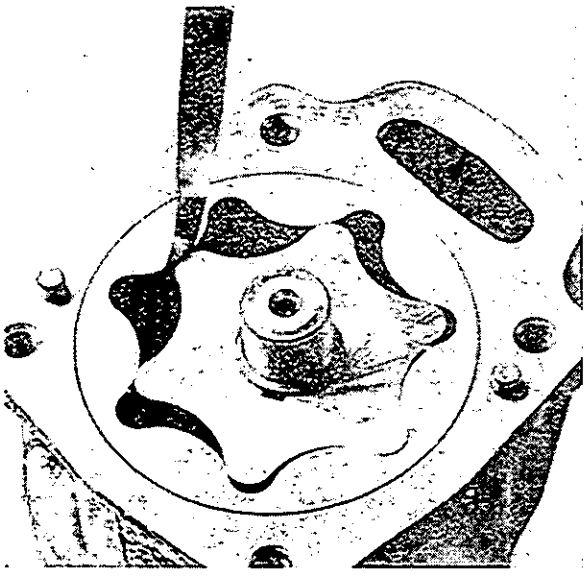
Remove the sump and then the setscrews securing the oil pump to cylinder block and withdraw the oil pump, see Fig. K.2.

To Dismantle Oil Pump, see Fig. K.3

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



K3



K4

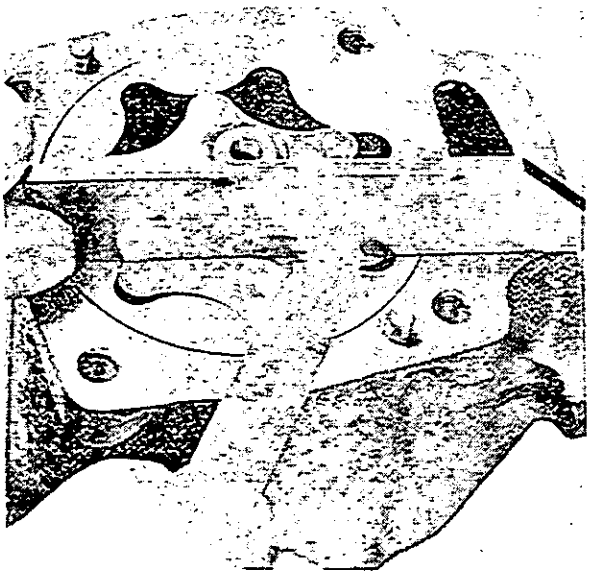
The shaft, inner and outer rotors can now be removed

Inspection of Oil Pump

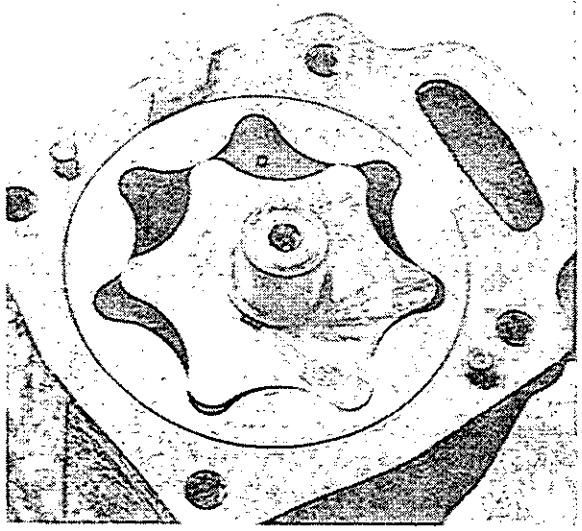
Inspect the rotors for cracks or scores.
Install the drive and driven rotors in the pump body. The two sections of the outer rotor can be fitted in any order.
Check clearances given on Page K.8, between inner and outer rotors, see Fig. K.4,. rotor end float, see Fig. K.5, and clearance between outer rotor and pump body, see Fig. K.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



K5



K6

dowels in position and with the joint faces smeared with a suitable jointing compound.

Prime pump with engine 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.

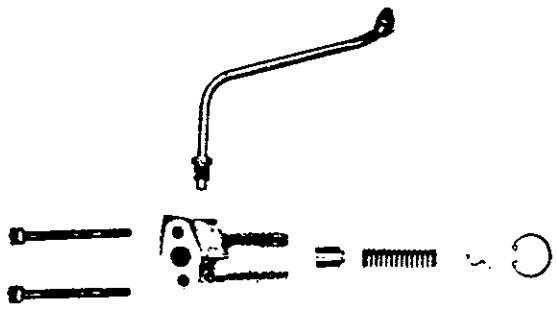
Refit the suction pipe and strainer.

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

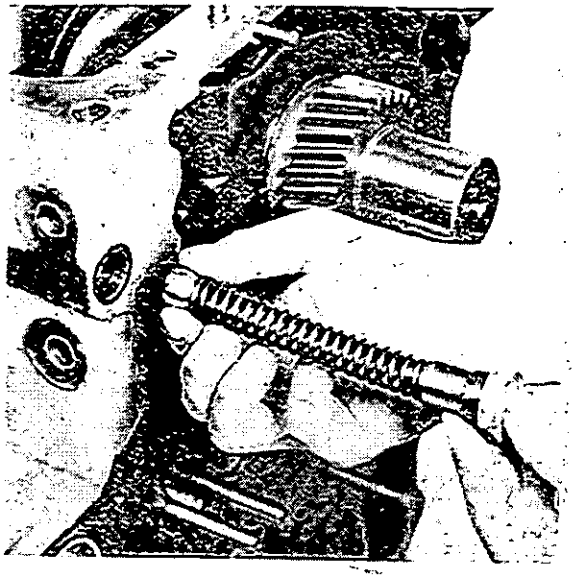
Before starting, motor engine with stop control in "non-run" position until oil pressure is registered.

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

Remove the sump and then the pipe from valve to centre main bearing setscrew.
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.



K7



K8

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 centre main bearing setscrew.
The first blow-off stage to feed the piston cooling jets should reach a steady flow at 30/37 lbf in² (2,11/2,6 kgf cm²) -207/255 kN/m², relief flow should commence at 50/60 lbf in² (3,52/4,22 kgf cm²) 345/414 kN/m².

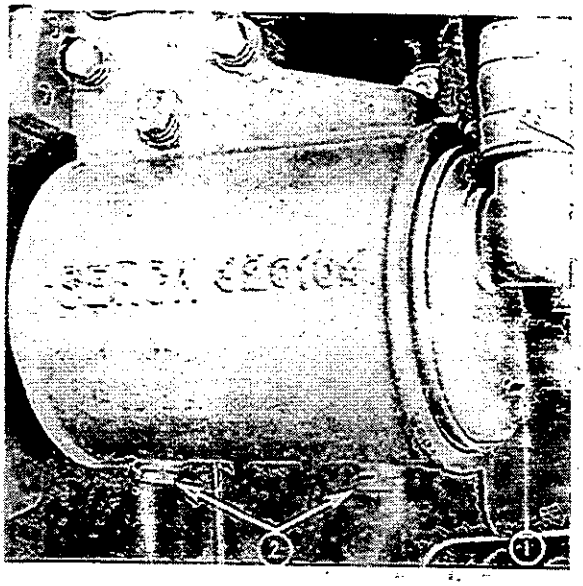
To Remove and Replace Dump Valve, see Fig. K.8 (Earlier Engines Only)

Remove the spring retaining plug and washer, taking care that the spring does not fly out due to its excessive tension.

Remove the spring and ball valve.
The valve comes into operation at 150 lbf in² (10,55 kgf cm²) 1034 kN/m² and relieves into the sump.
After cleaning the oil passages, refit the components in the reverse order of removal.

Oil Cooler

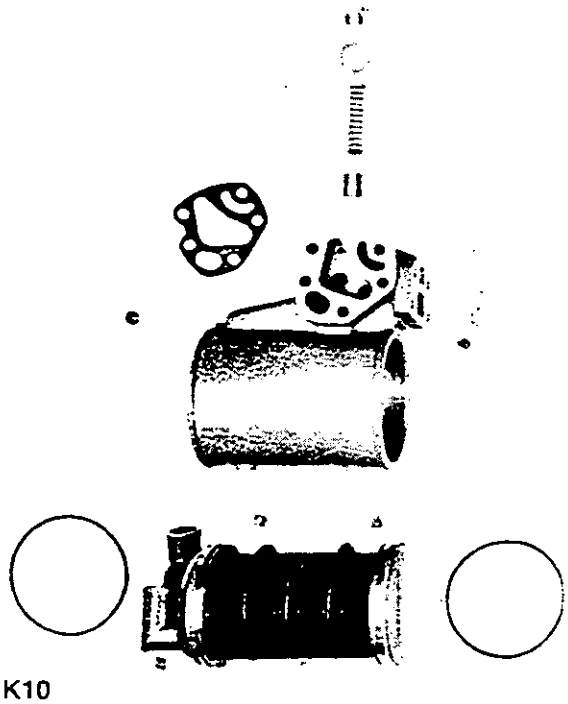
Oil passes through the cooler and is cooled by water flowing through the tubes. A valve is incorporated into the headcasting which allows oil to by-pass the cooler in the event of a restriction.



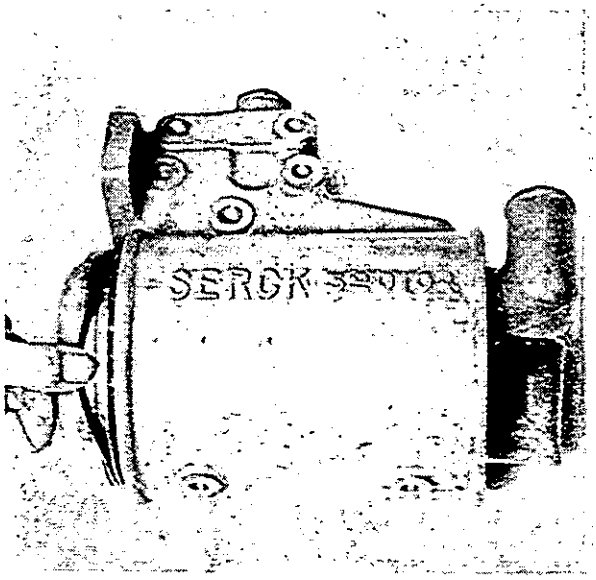
K9

To Remove Oil Cooler

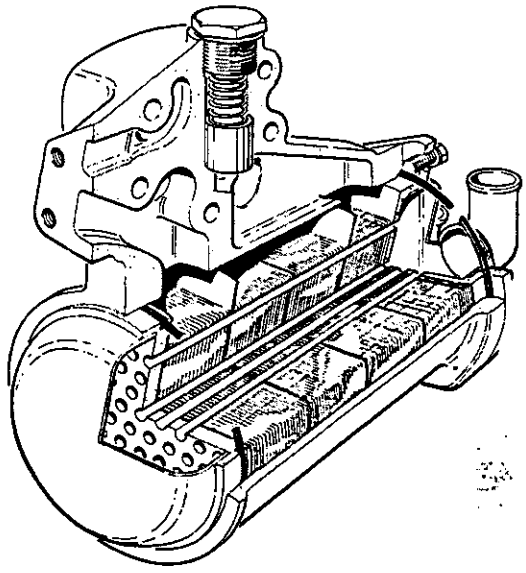
Drain the cooling system also the coolant from the cooler by removing the drain plug, see Fig. K.9 (1).
Drain the lubricating oil from the cooler by removing the two oil drain plugs, see Fig. K.9 (2).
Disconnect the coolant inlet and outlet connections.



K10



K11



K12

Remove the oil filter assembly from the cooler headcasting.
Release the five setscrews securing the cooler to the adaptor and remove the cooler.

To Dismantle Oil Cooler—Early Type, see Fig. K. 10

Remove locating screws and washers from both ends of cooler body.
Slide tube stack one way until "O" ring is just clear of body. This can be achieved by supporting the stack and knocking the mounting flange gently. Do not dent the end cap as this may affect the engine cooling.
Remove the exposed "O" ring, see Fig. K.11.
Push the tube stack back into the body and out of the opposite end until the other "O" ring is exposed and may now be removed.
The tube stack may now be removed from the body.

To Re-assemble Oil Cooler—Early Type

New "O" rings must always be used.
Lightly oil the rings, also the grooves and the seal tracks in the cooler body.
Fit one "O" ring in the groove at the ported end of the tube stack and enter the unported end into the body until it just exposes the seal groove at the other end.
Fit the other "O" ring in this groove, and push the tube stack back into the body until the recesses in the tube stack ends align with the locating screw holes in the body.
When positioning the tube stack for fitting new "O" rings, it must not be pushed into the body so far as to allow the rings to enter the oil ports. This could damage the rings and cause a leak.
Fit the two locating screws and washers.
After re-assembly, the oil cooler should be pressure tested as described.

To Dismantle Oil Cooler—Later Type see Fig.K.12

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 relief valve.
Withdraw spring and piston.

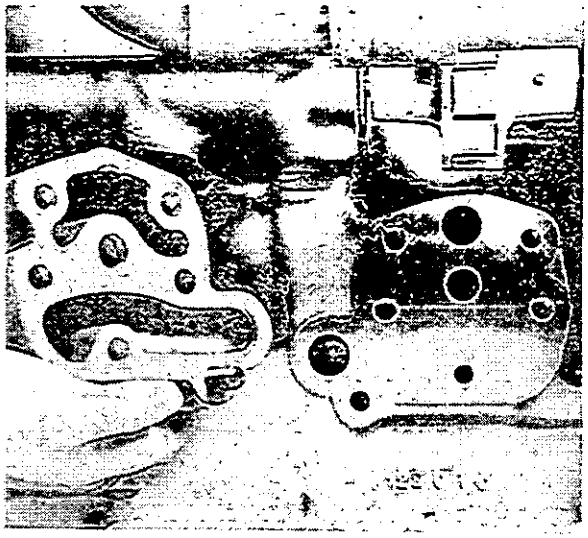
To Re-assemble Oil Cooler—Later Type

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 relief valve assembly may now be refitted into the headcasting.
Refit the water and oil drain plugs.

To Test 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



K13

water, ensuring absence of trapped air.
Pressurise water side with air at a pressure of 30 lbf/in² (2,11 kgf/cm²) 207 kN/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 90 lbf/in² (6,33 kgf/cm²) 620 kN/m² 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

The adaptor may be released by removing the securing setscrew, see Fig. K.13.
When refitting, use a new joint and suitable sealing compound and secure with setscrew, plain washer and spring washer.

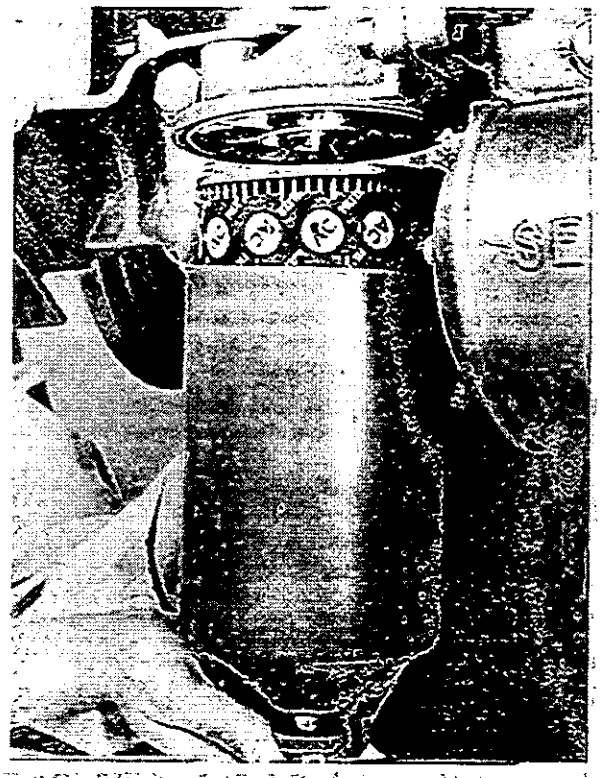
To Refit Oil Cooler

Refit the oil cooler to adaptor and secure with five setscrews, plain and spring washers.
Refit the oil filter with four setscrews and spring washers (early engines) or plain washers (current engines).
Reconnect the coolant 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.

Lubricating Oil Filters

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



K14

It is imperative therefore that lubricating oil filters are not neglected. Moreover, if the preventive maintenance periods recommended are carried out and the correct grade of oil used, a very long life can be obtained from the Perkins Engine.

To ensure cleanliness, filters are incorporated.

The sump strainer requires no special attention but should be cleaned whenever the sump is removed.

Main (full flow) Filter

This filter incorporates either a separate paper element fitting in a filter bowl or a screw on canister where the element is integral with the canister. Both elements should be renewed, not cleaned, at the appropriate time as given in Section C.

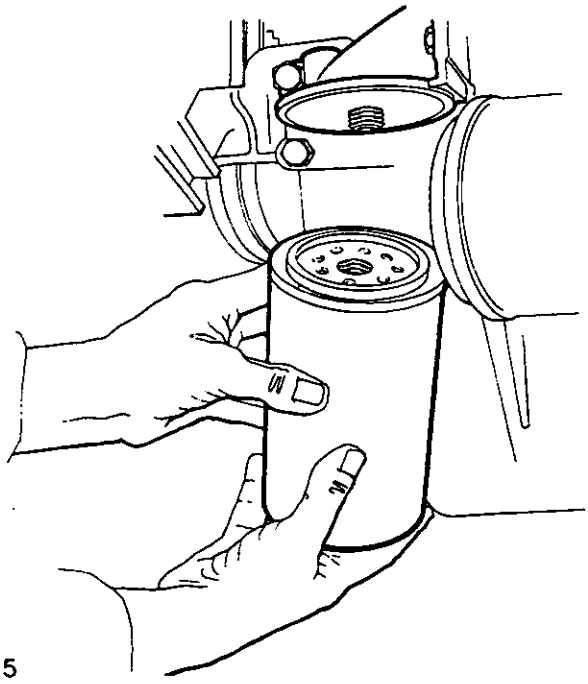
To Renew the Paper Element:

1. Unscrew the centre bolt at bottom of cover.
2. Lower filter bowl clear (see Fig. K.14).
3. Remove element and discard.
4. Before fitting new element, clean inside of filter bowl with cleaning fluid.
5. Ensure that the rubber joints are in good condition. If not, replace by new ones.
6. Start the engine and check for leaks. Check oil level after running and top up as necessary.

The bolt securing the filter bowl should be checked for tightness after the first 1,000 miles (1,500 km) or 25 hours running.

To Renew the Canister:

1. Unscrew and discard old oil canister (see Fig. K15).
2. Clean the filter head and the threaded adaptor.
3. Using clean engine lubricating oil, liberally oil the top seal of replacement canister.
4. Fill new canister with clean lubricating oil allowing time for the oil to filter through the element. Screw the replacement canister on to the filter head until seal just touches the head and then tighten by hand as detailed in the instructions on the canister. Where a tool is available, tighten to 15 lbf ft (2,07 kgf m) -20 Nm.
5. Run the engine and check for leaks. Check the oil level after running and top up as necessary.



K15

DATA AND DIMENSIONS FOR LUBRICATING SYSTEM

All threads used, except on some proprietary equipment, are Unified or American Pipe Series.
The following figures are based mainly upon those used in the factory for production.

Lubricating Oil Pressure at Maximum Engine Speed and Normal Working Temperature is 30/60 lbf/in² (2,11/4,22 kgf/cm²) -207/414 kN/m².

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	30/37 lbf/in² (2,11/2,6 kgf/cm² -207/255 kN/m²
Relief Flow Pressure Setting	50/60 lbf/in² (31,52/4,22 kgf/cm²) -315/414 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
Element Type	Paper
By-Pass Valve Setting	13/17 lbf/in² (0,91/1,20 kgf/cm²) -90/117 kN/m²
Torque Tension for Filter Bowl Retaining Setscrew	10 lbf ft (1,38 kgf m) -14 Nm

APPENDIX
LUBRICATING OILS

Lubricating oils for turbocharged engines should conform to the U.S. Ordnance Specification MIL-L-2104C.

Some of these oils are listed below. Any other oils which meet this specification are also suitable.

MIL-L-2104C OILS

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

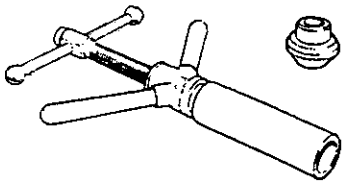
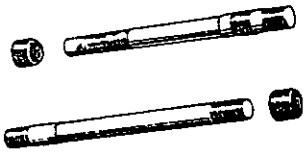
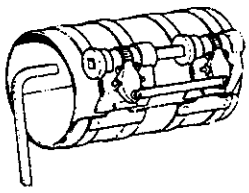
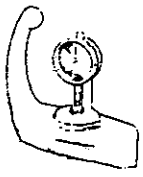
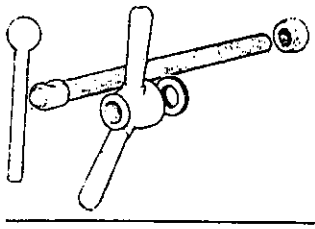
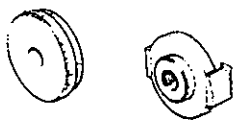
Where oils to the MIL-L-2104C Specification are not available, then oils to the previous MIL-L-45199B or Series 3 specification may continue to be used providing they give satisfactory service.

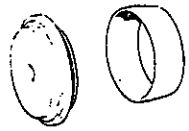
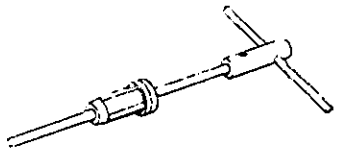
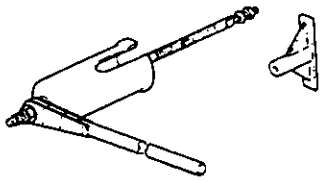
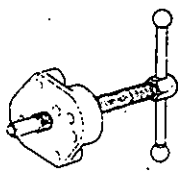
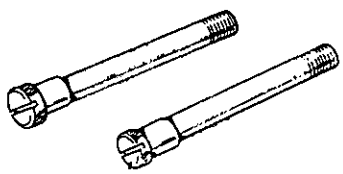
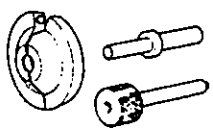
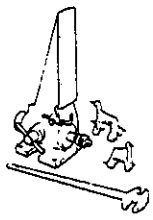
Lubricating oils for use in Perkins engines should have a minimum viscosity index of 80.

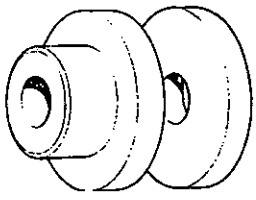
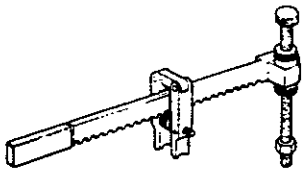
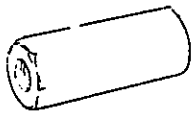
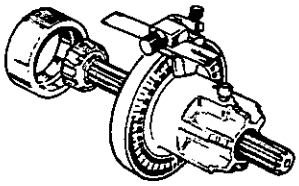
The above specifications are subject to alteration without notice.

Approved Service Tools

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

	Tool No.	Description
	PD.1D	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)
	PD.1D-1A	ADAPTOR FOR PD.1D A pair of puller bars fitted with knurled nuts. Suitable for 5/16" and ⅜" guides. The necessary distance piece from the adaptors below should also be used.
	PD.1D-6	ADAPTOR FOR PD.1D A 15 mm (19/32") distance piece used to replace valve guides to a set height.
	No. 8	PISTON RING SQUEEZER
	PD.41B	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	PD.140	CAMSHAFT BUSH/THRUST COLLAR REMOVER
	PD.140-2	FUEL PUMP THRUST COLLAR REMOVER/REPLACER ADAPTORS

	Tool No.	Description
	PD.145	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL)
	LC.173 (top) PD.146 (bottom)	INJECTION SLEEVE EXPANDER Expands the copper sleeve into the cast iron head to give watertight seal prior to injector fitting.
	PD.150A	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	ADAPTORS FOR PD.150 Suitable for cylinders of 3.6" dia. and 3.87" dia. Removal and replacement.
	155B	BASIC PULLER The cruciform head with multiple holes at different centres is used with adaptors listed below.
	PD.155-1	ADAPTORS FOR PD.155A Used to remove water pump pulleys. Also suitable to remove Camshaft Gears.
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.
	355	CON ROD JIG & 336 MASTER ARBOR

	Tool No.	Description
	336-102	ARBOR ADAPTOR Used with 335.
	6118B	VALVE SPRING COMPRESSOR
	6118B-5	ADAPTOR FOR 6118B
	MS67B	TIMING TOOL WITH ADAPTOR MS67B/8 Used for setting and checking Fuel Pump timing.
	MS73	ADJUSTABLE VALVE SEAT CUTTERS

EXAMPLES OF SERVICE FACILITIES

Service Publications

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

Workshop Manuals

Operators Handbooks

Crankshaft Regrinding

Fault Finding Guide

Engine Brake Testing Data

Etcetera

Service Instruction

PETERBOROUGH

Apply to Product Education Department for details.

SECTION L
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, into a gallery which directs some of it to the atomiser cooling sleeves.
A junction from the oil cooler inlet pipe allows coolant to flow into the compressor which is then reconnected to the oil cooler outlet pipe at a point close to the cylinder block.
The coolant from both circuits 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.
A cylinder block draining point is provided on the fuel pump side of the engine at the rear.

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.

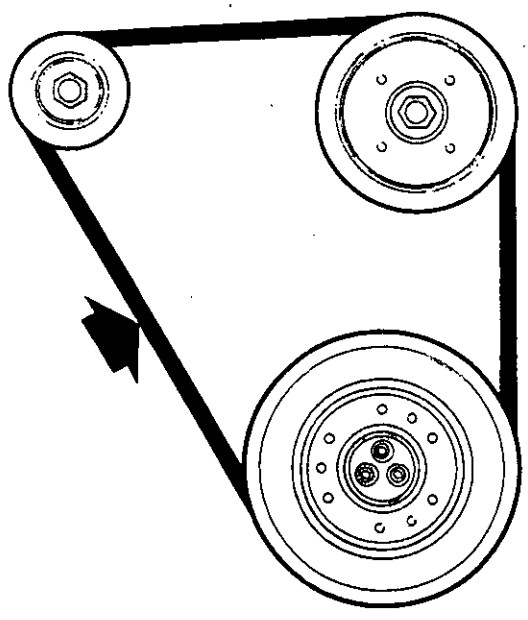
Belt adjustment is obtained by loosening the generator mounting bolt and altering the position of the generator on its mounting link.
The tension should be such that a pressure applied by the thumb on the longest unsupported stretch of belt should depress it approximately ⅜in (10 mm), see Fig. L.1.

To Remove and Refit Thermostats

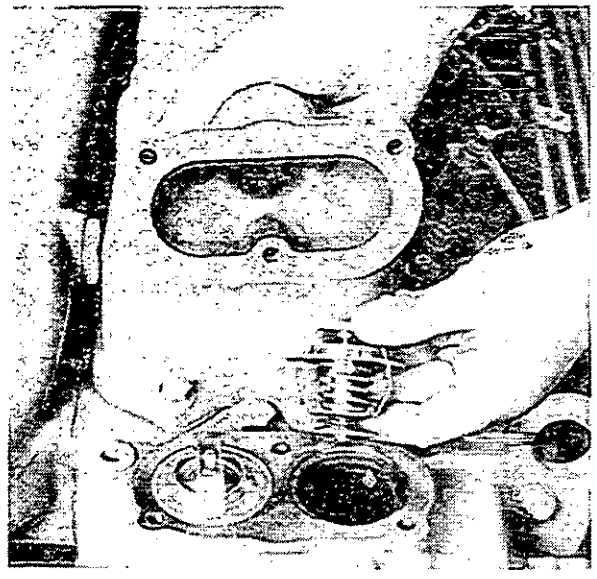
The water outlet connection forms the top half of the thermostat housing.
Drain the cooling system and disconnect the top radiator hose, remove three setscrews securing the water outlet connection and remove, see Fig. L.2.
The thermostats can now be withdrawn from the housing.
When replacing, ensure 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

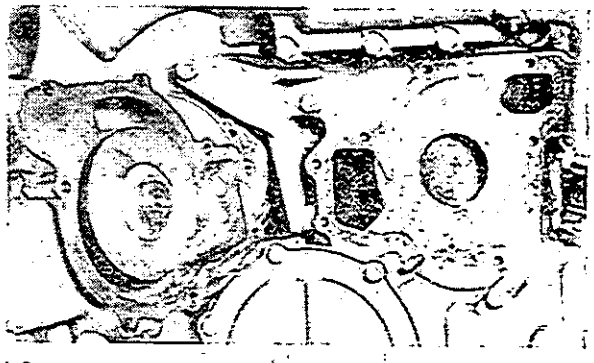
Suspend the thermostats in water and heat gradually.
With a thermometer, check that the thermostat starts to open at 177/183°F (80,6/83,9°C) and is fully open at 208°F (97,8°C).
The valve lift when fully open is 0.350 in (8,89 mm).



L1



L2



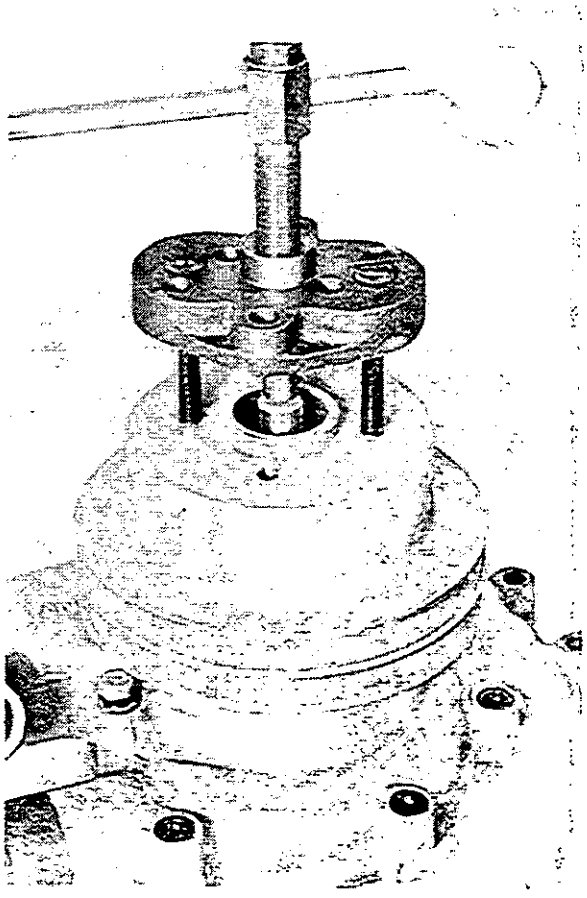
L3

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. L.3.

To Dismantle Water Pump

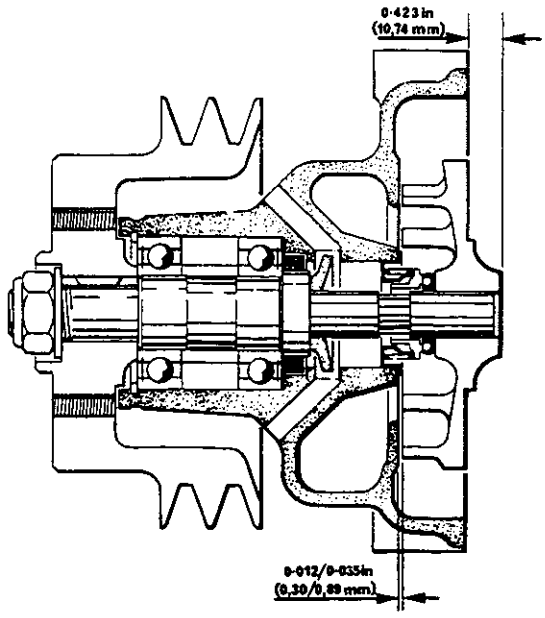
Remove the self locking nut and plain washer securing the water pump pulley and withdraw the pulley from the shaft, see Fig. L.4.
Press the shaft, complete with impeller, out of the body from the front.
Press the impeller from the shaft and remove the rear seal, counterface and flinger.
Remove the bearing retaining circlip from water pump body and press out the two bearings and distance piece.
The flange, retainer and front seal can now be withdrawn from the body.



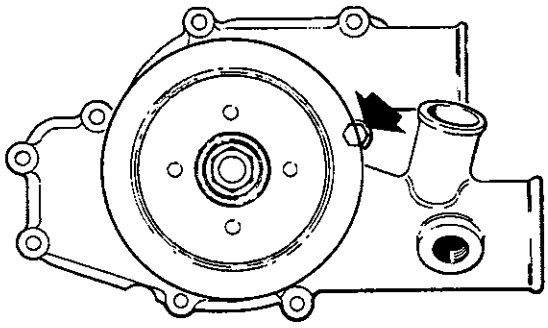
L4

To Re-assemble Water Pump, Fig. L.5

Press the two bearings onto the shaft with the distance piece in between, ensuring that the shielded face of each bearing, faces outwards.
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 between the two bearings with high melting point grease, 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.
Slide the rubber flinger over the impeller end of the shaft until the flat face butts against the bearing retaining flange.
With the brass casing coated 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.
Fit the ceramic counterface ensuring that the



L5

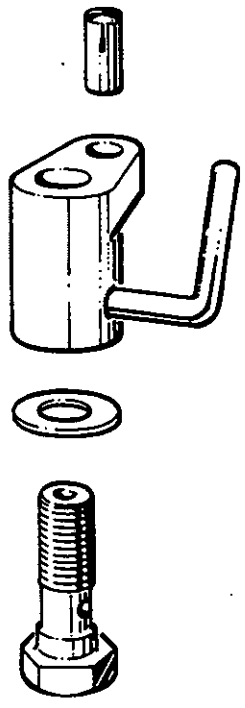


L6

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. L.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 of 0.423 in (10,74 mm) is obtained from rear face of impeller boss to rear face of pump body, see Fig. L.5. The clearance between impeller vanes and pump body, including end float should be 0.012/0.035 in (0,30/0,89 mm).
Fit plain and spring washers and pulley securing nut and tighten to a torque of 60 lbf ft (8,30 kgf m) -82 Nm. Spin the pump pulley to ensure freedom of movement.

To Refit Water Pump

Using a new joint, refit the water pump, securing with setscrews, nuts and spring washers to a torque of 20 lbf ft (2,77 kgf m) -27 Nm.



L7

Reconnect the hoses, fill the system with coolant.

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

Water Pump Seal

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

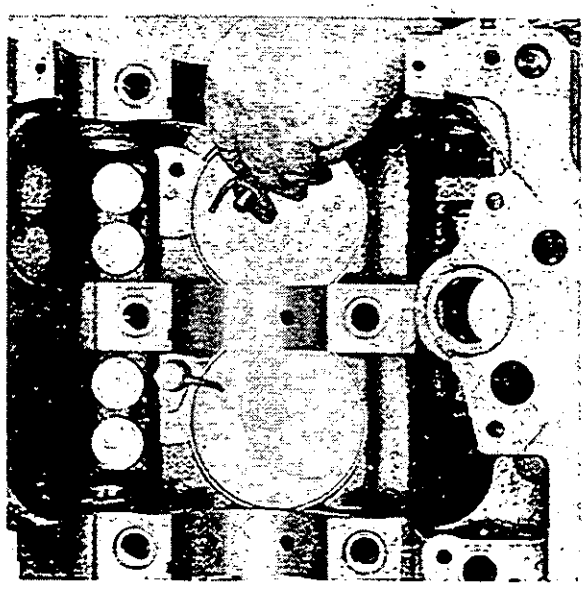
Piston Cooling Jets, see Fig. L.7

Cooled lubricating oil is directed, by means of nozzles 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.

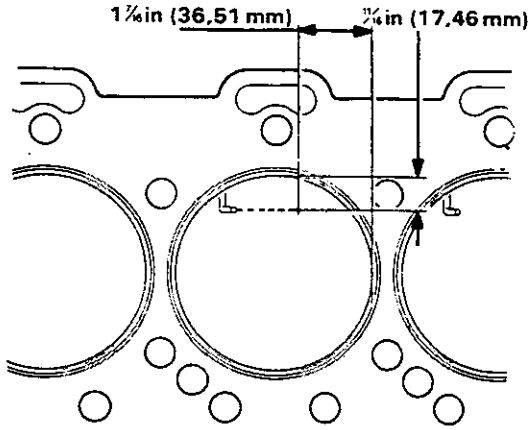
Oil is carried to the nozzles by means of a pipe from the pressure relief valve to a hollow setscrew securing the centre main bearing cap, thence to an auxiliary oil pressure rail drilled the length of the cylinder block above the camshaft chamber. This pressure rail is tapped in six places to accommodate the dowelled piston jet block where the nozzle is mounted.
The removal and refitting of the pressure relief valve is dealt with in the Lubricating Section K, on Page K.4.

To Remove Piston Cooling Jets

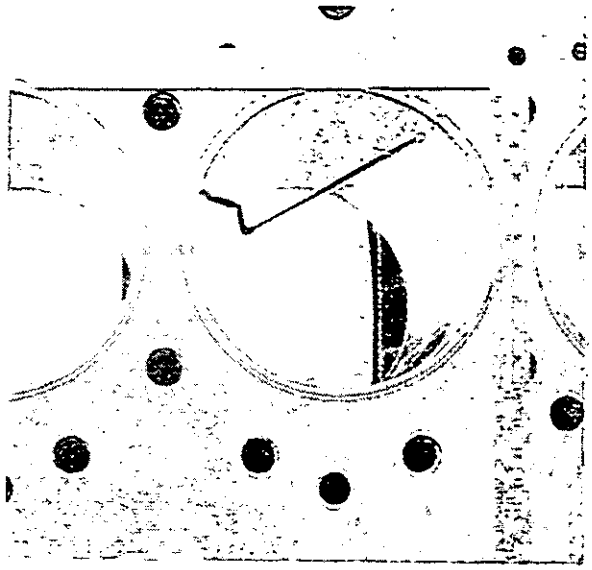
Drain the lubricating oil and remove sump, see Page K.3.
Remove the banjo bolt securing the jet body to the cylinder block.
The piston jet assembly can now be removed, see Fig. L.8.



L8



L9



L10

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 20 lbf ft (2,77 kgf m) -27 Nm.

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. L.9 and L.10 will show how this may be accomplished.

With a piston removed, insert a piece of ⅜ in (2,38 mm), rod into the jet nozzle so that it protrudes above the top of the cylinder bore.

Fig. L.9 shows the dimensions taken on the top face of the cylinder block and it will be seen that the measurements of 1¾ in (36,51 mm) and ¾ in (17,46 mm) are taken from two sides of the liner bore as illustrated.

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

Fig. L.10 illustrates how the correct nozzle angle may be achieved by the use of rules.

DATA AND DIMENSIONS FOR COOLING SYSTEM

All threads used, except perhaps on proprietary equipment, are Unified Series and American Pipe Series. The following figures are based mainly upon those used in the factory for production.

Cooling System

Type	Thermo-Syphon, Pump assisted.
Coolant Capacity	35 Imperial Pints (19,9 litres)

Thermostat

Type	Twin Wax Capsule fitted in parallel
Opening Temperature	177/183°F (80,6/83,9°C)
Fully open at	208°F (97,8°C)
Valve Lift	0.350 in (8,89 mm)

Water Pump

Type	Centrifugal.
Outside Diameter of Shaft for Pulley	0.7501/0.7506 in (19,053/19,065 mm)
Inside Diameter of Pulley Bore	0.7500/0.7508 in (19,05/19,07 mm)
Transition Fit of Pulley on Shaft	—0.0006/+0.0007 in (—0,015/+0,018 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 (0,013/0,046 mm)
Impeller Blade to Pump Body Clearance	0.012/0.035 in (0,3/0,89 mm) (including end float)

SECTION M
Air Filters and Fuel System

Dry type, replaceable element air filters are fitted and should receive service as indicated in the "Preventive Maintenance" section. Some installations are fitted with oil bath cleaners.
Where restriction indicators are fitted then the air cleaner should be serviced as indicated by this unit or at the period stated in "Preventive Maintenance" or whichever occurs first.

Air Charge Cooling see Fig. M.1

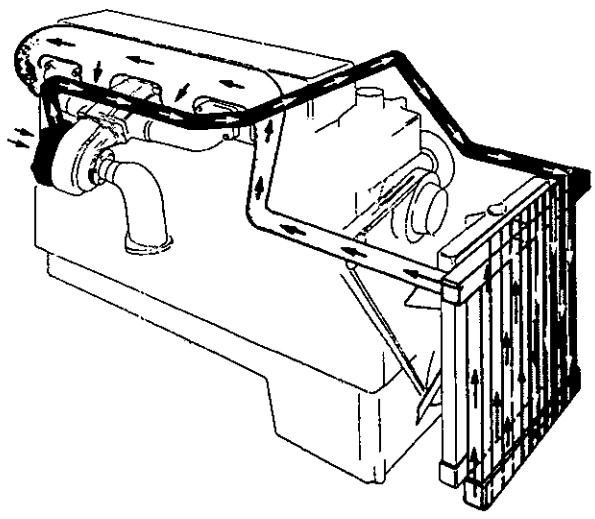
This is a method of cooling the air between the outlet of the compressor side of the turbocharger and the induction manifold by pushing the air through an "air cooling radiator" usually mounted in the same air stream as the engine water cooling radiator.

Restriction Indicator

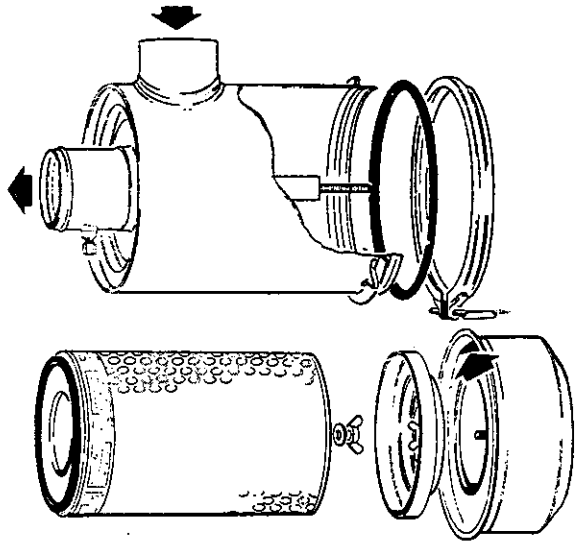
If an induction restriction indicator is not fitted, it is advisable to fit one between the air filter and the inlet of the turbocharger. An 18 in water gauge restriction indicator is suitable in most installations.

Dry Type Two Stage "Cyclopac", see Fig. M.2

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 ½ in (13 mm) of the dust entry slot in baffle.
DO NOT USE PETROL (GASOLINE) for cleaning



M1



M2

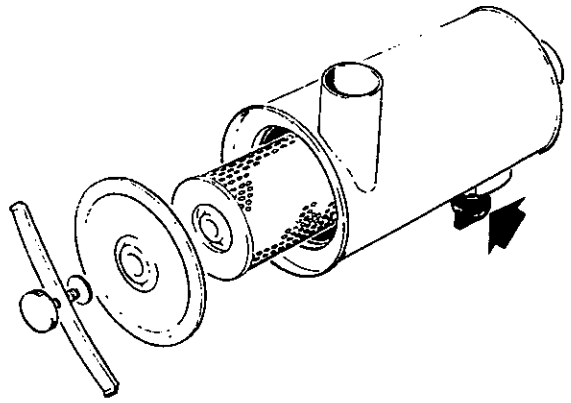
any part of the air cleaners.
Release the wing nut and remove filter element.
Dry dust can be removed from the element by blowing back from the clean side of the pleats by using air pressure not exceeding 100 lbf/in² (7 kgf/cm²) -690 kN/m².
If the element is contaminated by oil and/or soot, it can be 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.
Reassemble 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.

Dry Type Two Stage "Cyclone", see Fig. M.3

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



M3

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.

Reassemble the filter ensuring that all joints are leakproof.

Oil Bath Air Cleaner, see Fig. M.4

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.

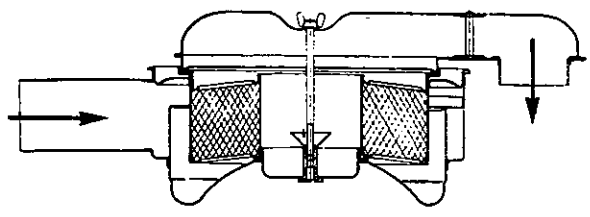
Refill the container with fresh engine lubricating oil, to the indicated level.

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.



M4

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. M.5

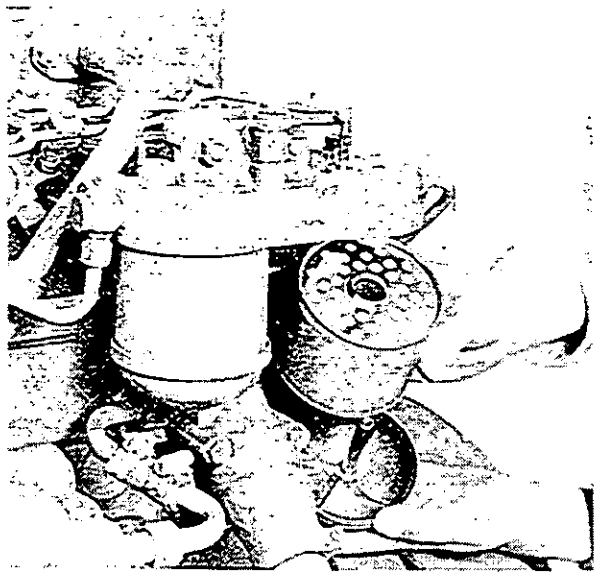
Thoroughly clean the exterior of the filter assembly.

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

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.



M5

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 M.7.

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.

Testing Lift Pump fitted to Engine

Disconnect the outlet fuel pipe.

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

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

Pressure Testing of Fuel Lift Pump in Position

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

Minimum Production Static Pressure			Minium Test Pressure (75% of Min. Production Pressure)		
lbf/in²	kgf/cm²	kN/m²	lbf/in²	kgf/cm²	kN/m²
6	0.42	41	4.5	0,31	31

To Remove and Fit Fuel Lift Pump, see Fig. M.6

Note: With earlier engines, the fuel lift pump was secured with studs and nuts. Later lift pumps are secured with setscrews and retaining plates.

Disconnect the inlet and outlet fuel pipes.

Remove the securing nuts and washers and remove the pump and joint.

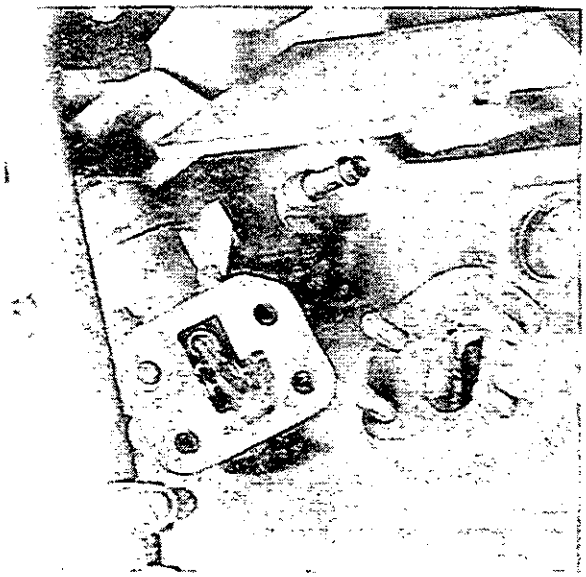
If difficulty is encountered in removing the lift pump from the engine, turn the crankshaft to rotate the camshaft eccentric to a position which will enable the rocker arm to withdraw.

Fit pump using a new joint, ensuring that the mating faces are clean.

The securing setscrews should be tightened to 20 lbf ft (2,7 kgf m) - 27 Nm and re-torqued when hot.

Re-connect pump inlet and outlet pipes.

Bleed the fuel system, Page M.7.



M6

To dismantle Fuel Lift Pump

Clean exterior and file mark the flanges of top and bottom bodies for guidance in reassembly. 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.

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.

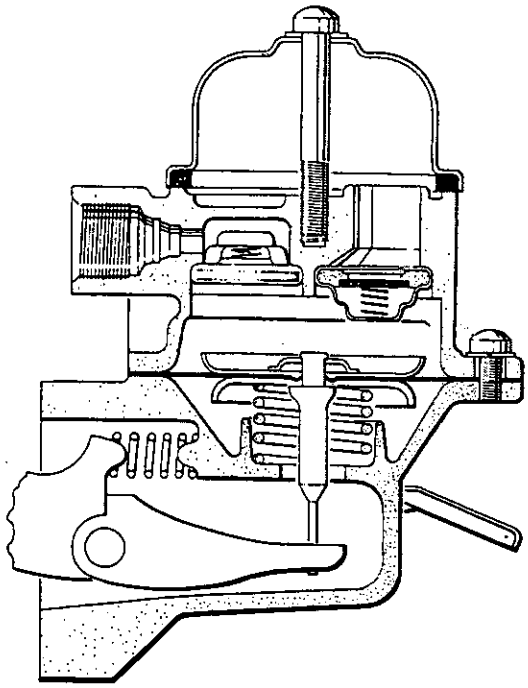
The rocker, pin, lever and return spring can now be examined for wear.

To Re-assemble the Lift Pump, see Fig. M.7

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



M7

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.

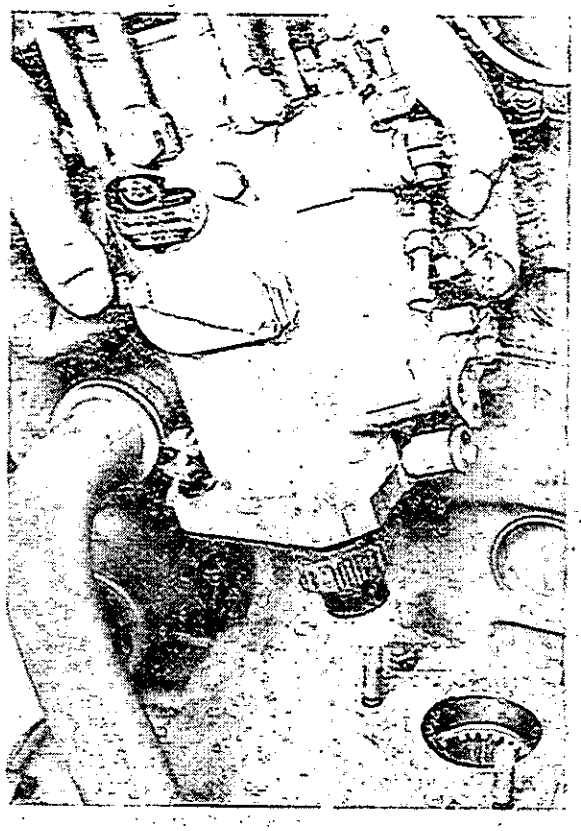
The domed cover may now be refitted, ensuring that the rubber sealing ring is correctly located.

Fuel Injection Pump

The fuel injection pump is a C.A.V. D.P.A. or Bosch EP/VA distributor type, vertically mounted on the auxiliary drive housing and is spline-coupled to the auxiliary drive worm-gear.

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.



M8

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, CAV or Bosch 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 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 three securing nuts and washers have been removed, see Fig. M.8.

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. M.9(1) for C.A.V. pumps or (X) and (Y) — see Fig. M.22 — for Bosch pumps. Secure the pump to the adaptor plate.

Refit the high and low pressure fuel pipes to the fuel pump.

Reconnect the throttle and stop lever controls and attach the return springs (C.A.V. pumps).

Bleed the fuel system as detailed on Page M.8.

If necessary, adjust the maximum and idling speeds. Details will be found on Page M.7.

Fuel Injection Pump Timing

With No. 1 piston at T.D.C. on compression and with the fuel pump removed, the slot in the fuel pump drive hub should be aligned with the slot in the fuel pump adaptor plate, see Fig. M.10.

If these slots do not align, remove the auxiliary drive gear cover plate from the front of the timing case and release the three securing screws and turn the auxiliary drive shaft by means of the screws until the slots do align.

In the case of early engines fitted with Bosch pumps, the slot in the fuel pump adaptor plate has been omitted.

In such an instance, to time the pump to the engine when the auxiliary drive gear has been removed, proceed as follows:

1. Set the engine to T.D.C. compression stroke on No. 1 cylinder observing that both rocker levers of No. 6 cylinder are rocking (i.e. overlap). In this position, remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston. With the aid of a dial indicator, obtain true T.D.C.
2. Position the fuel pump drive hub as shown in Fig. M.11.
3. Refit the auxiliary drive gear.

Refit the fuel pump, ensuring that the scribed lines on the pump mounting flange and adaptor plate align.

To check the commencement of injection, remove the inspection cover on the side of the mechanically governed fuel pump.

Note. The removal of the inspection plate will necessitate the breaking of the manufacturer's seal. This seal should be removed only by authorised personnel who must reseal when the cover is replaced, otherwise the guarantee may become void.

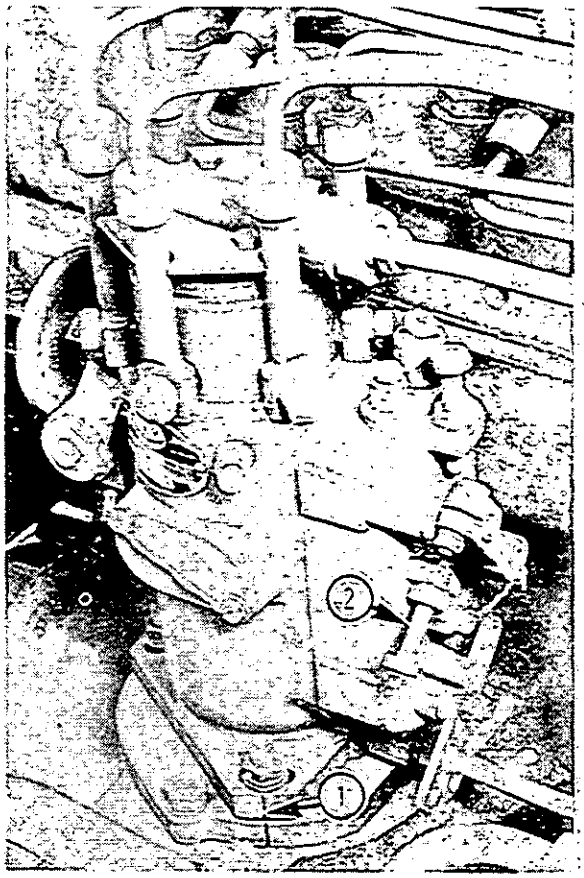
The removal of the inspection plate on C.A.V. pumps will reveal a rotor with scribed lines, each line bearing a letter.

Also visible is the open end of the circlip. The commencement of injection is indicated when the letter "F" on the rotor is aligned with the straight edge of the circlip, see Fig. M.12.

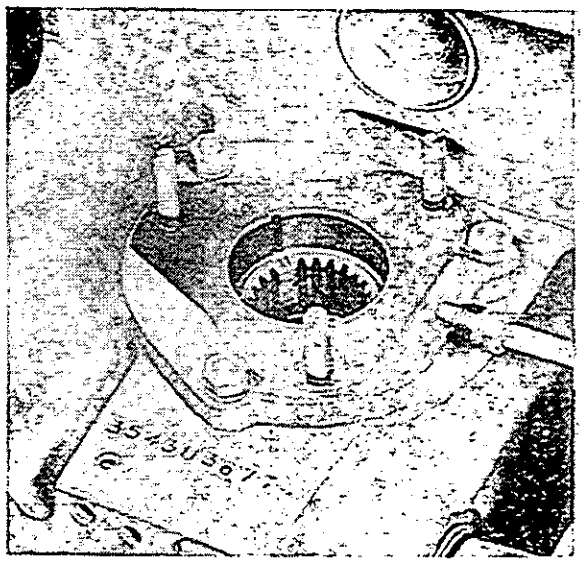
Removal of the inspection plate (A) — see Fig. M.22 — on Bosch pumps will reveal a scribed line (A) and a timing pointer (B) — see Fig. M.13. The commencement of injection is indicated when the scribed line is in alignment with the timing pointer.

Checking Fuel Injection Pump Timing

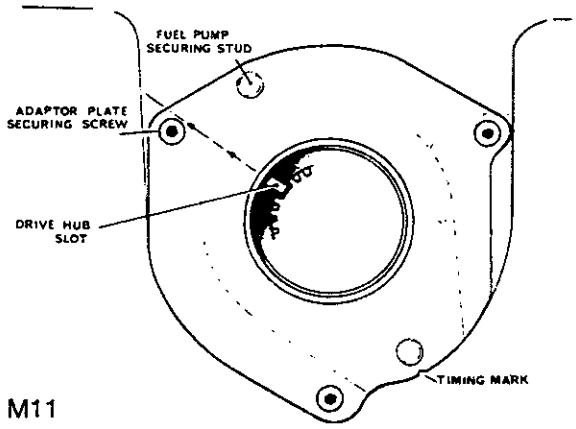
On C.A.V. pumps, it is necessary to set the position of the circlip by removing the pump from the engine and connecting No. 1 cylinder outlet connection on the pump to an atomiser tester and pump up to 30 atm (31 kgf/cm² or 440 lbf/in²). Turn the pump by hand in the normal direction of rotation until it "locks up". The squared end of the circlip should now be lined up with the letter F on the pump rotor.



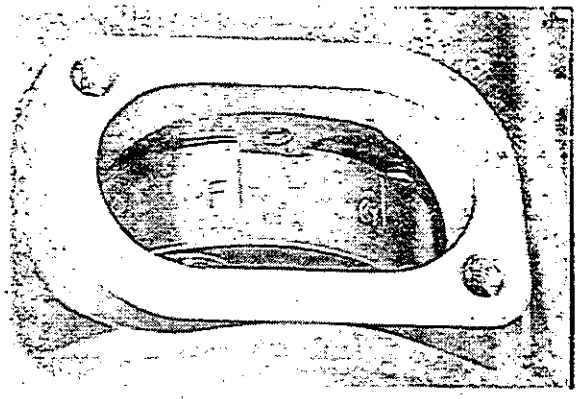
M9



M10



M11



M12

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

Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke. With the cylinder head cover removed, remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston.

With the aid of a clock gauge in contact with the tip of the valve stem, turn the crankshaft in the opposite direction to normal rotation approximately an eighth of a turn and then for C.A.V. pumps turn crankshaft in the normal direction of rotation until the gauge registers that the piston is 0.485 in (12,32 mm) B.T.D.C. and is equivalent to 32° angular movement of the flywheel B.T.D.C. and represents the commencement of injection.

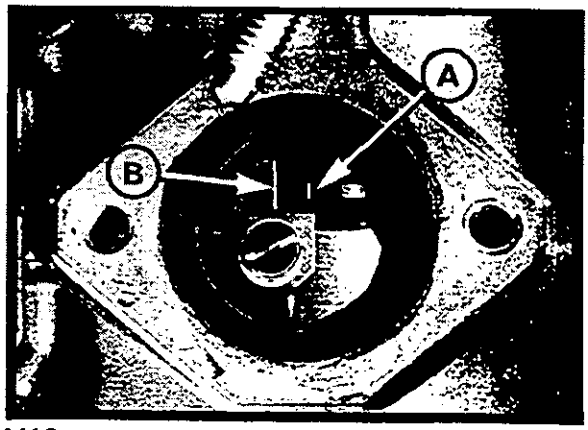
For Bosch pumps, set the crankshaft so that No. 1 piston is 0.157 in (4,00 mm) B.T.D.C., this being the equivalent of 18° B.T.D.C. on the flywheel.

For C.A.V. pumps 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 circlip. See Fig. M.12. For Bosch pumps the timing mark on the rotor (A) should align with the timing pointer (B). See Fig. M.13. Where two lines are provided on the pump rotor, the timing line marked "X" should be used.

Any discrepancy can be corrected by slackening the fuel pump securing nuts and turning the pump body until the marks align. Further adjustment can be made by turning the auxiliary drive shaft after first releasing the auxiliary drive gear securing screws.

When the timing is correct turn the engine in the normal direction of rotation until No.1 piston is at T.D.C. then refit the springs, spring cap and collets.

Refit the fuel pump inspection plate and reseal.



M13

Checking Fuel Pump Timing

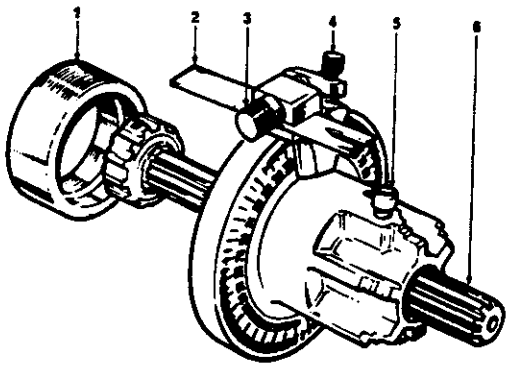
(Using Churchill Tool MS67B — see Fig. M.14)

Position the engine with No. 1 piston at T.D.C. compression and using tool No. 6118B, remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on the top of the piston. Reposition the inlet 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 and determine the exact T.D.C. position.

Remove the fuel injection pump

Release screw (5) — see Fig. M.14 — 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



M14

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 checking angle. This angle is given on Page M.12.

Fit the timing tool to the engine in the fuel pump position ensuring firstly that splined shaft with master spline is fully located in the 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 wrong stroke, in which case, remove the tool and set the engine on correct stroke.

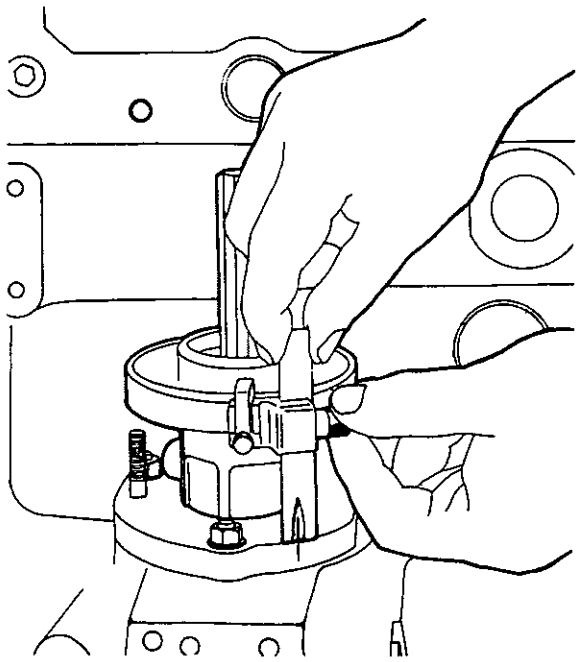
Slide the slotted pointer downwards so that the end of pointer abuts flange (see Fig. M.15).

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 the 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 M.5. Refit No. 1 inlet valve stem seal, valve springs, spring cap and collets. Then set valve clearance to 0.008 in (0,20 mm) or 0.012 in (0,30 mm) — see Page E.4.



M15

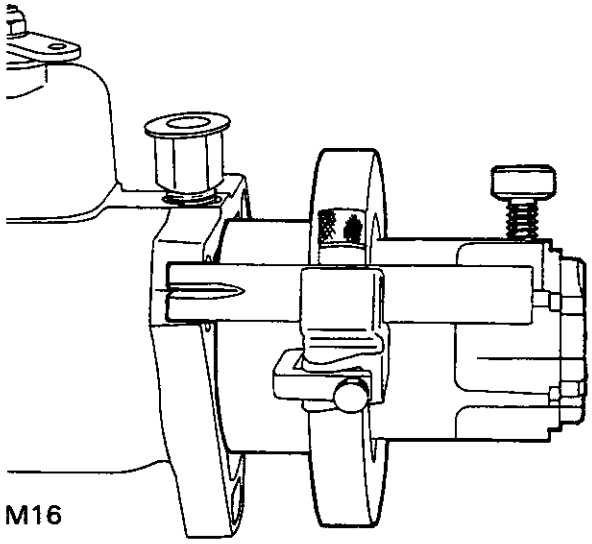
Checking Fuel Pump Marking Angle

Release screw (5) — Fig. M.14 — 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 C.A.V. pumps, connect No. 1 outlet connection of the pump (marked "X") to an atomiser tester and pump up to 30 atm, 440 lbf/in² or 31 kgf/cm². If a pressurising valve is fitted, this must be removed.

Release bracket screw (4) — see Fig. M.14 — and set bracket so that the chamfered edge is in line with the relevant pump marking angle (see Page M.12).



M16

Position the timing tool on pump drive using adaptor (1) — see Fig. M.14 — with master splines engaged and tool located on spigot (see Fig. M.16).

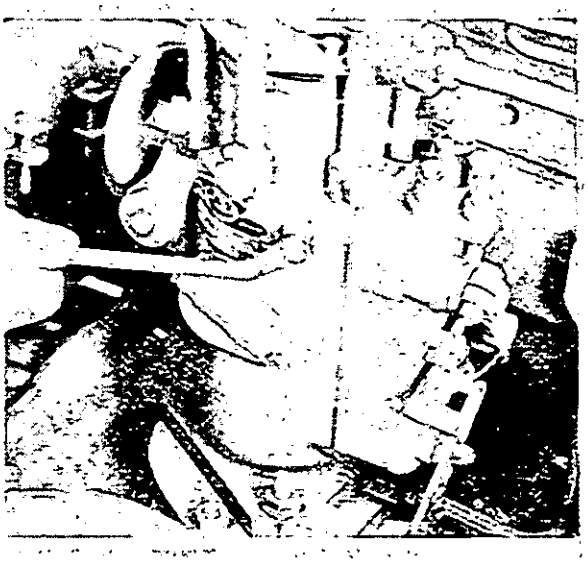
With C.A.V. pumps, turn the pump in the normal direction of rotation as shown on name plate until it "locks up".

With Bosch pumps, remove the vent plug in the hydraulic head and check that slot in the pumping plunger is pointing to No. 1 outlet (marked "A") — see Fig. M.17. **Ensure dirt does not enter the pump.** Fit special Bosch timing tool consisting of an extension KDEP 2931/2, measuring device KDEP 2931 and a dial indicator in place of the plug. Turn the pump and zero the dial indicator when the plunger is at B.D.C. Then turn the pump in the normal direction of rotation until 0.0392 in (1 mm) of lift is obtained on the pump plunger.

In these positions (for both C.A.V. and Bosch pumps), slide the pointer (2) of the timing tool — Fig. M.14 — forward until it is halfway over the pump flange and check that the timing mark on the flange is central to the slot in the pointer — see Fig. M.16.

With Bosch pumps, when refitting the vent plug, ensure that it is tightened to a torque of 40 lbf ft (5,53 kgf/m) or 54 Nm.

serious damage can be caused by lack of lubrication.



M19

The following method should be adopted:

C.A.V. Pumps

1. Slacken the vent valve on top of the mechanical governor housing, see Fig. M.18.
2. Slacken the vent valve on the hydraulic head locking screw, see Fig. M.19.
3. Slacken the vent screw on top of the twin fuel filters, see Fig. M.20.
4. Operate the priming lever on the fuel lift pump until fuel, free from air, issues from each venting point.

Tighten the screws in the following order:

Fuel filter vent screw.

Head locking vent valve.

Governor housing vent valve.

5. Slacken the pipe union at the fuel pump inlet, see Fig. M.21, and operate the lift pump until fuel oil, free from air, issues from around the threads. Tighten the union.
6. Slacken the unions at the atomiser ends of two of the high pressure pipes.

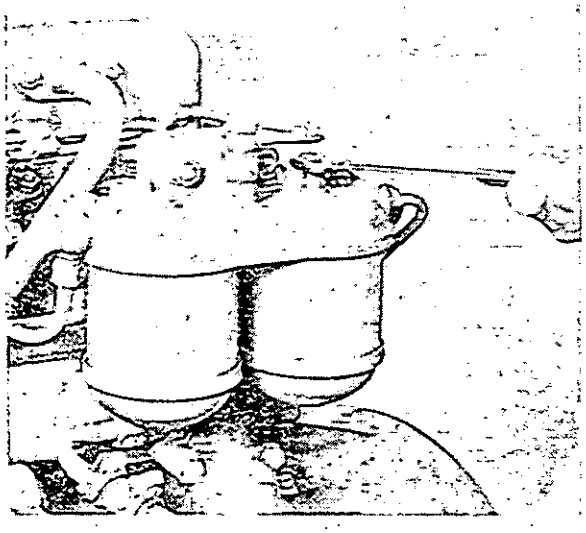
   Set the accelerator at the fully open position and ensure that the "stop" control is in the "run" position.

   Turn the engine until fuel oil, free from air, issues from around the threads and tighten the unions.

The engine is now ready for starting.

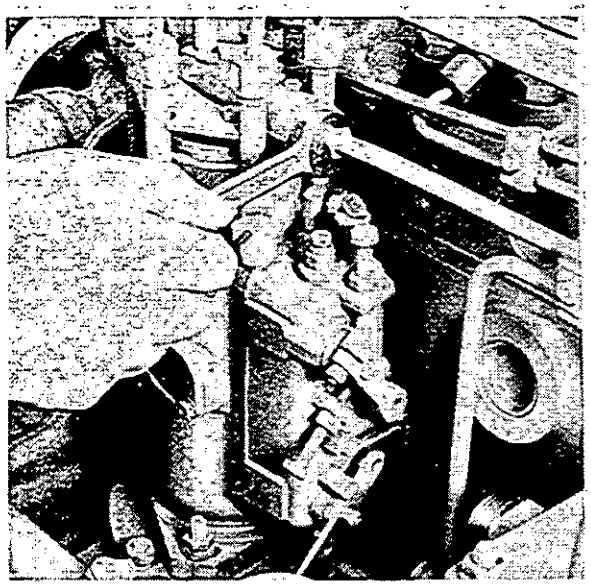
Bosch Pumps

1. Slacken the vent screw on the top of the final filter (see Fig. M.20).
2. Slacken the inlet connection on the fuel pump "B" (see Fig. M.22).
3. Slacken the outlet connection on the fuel pump "C" (see Fig. M.22). N.B. This connection is fitted with a non return valve and must not be fitted to the inlet port.

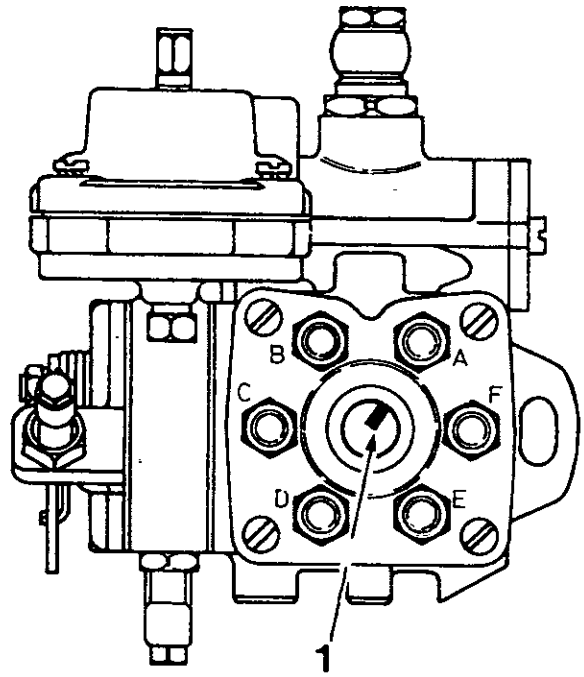


M20

4. Operate the priming lever on the fuel lift pump until fuel, free from air, issues from the final fuel filter venting point. Tighten the vent screw and continue to operate the lift pump until fuel, free from air, issues from the inlet connection ("B" Fig. M.22). Tighten the inlet connection and continue to operate the list pump until fuel, free from air, issues from the return connection on the fuel pump ("C" Fig. M.22) and tighten connection.
5. Thoroughly clean the top of the pump around the centre plug in the hydraulic head and slacken the plug "D" — Fig. M.22 — a MAXIMUM of half a turn — no more. Operate the priming lever on the lift pump until fuel, free from air, issues from around the plug. Tighten the plug to a torque of 40 lbf ft (5,53 kgf m) -55 Nm. N.B. THIS TORQUE FIGURE IS IMPORTANT.



M21



M17

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

The engine idling speed is adjusted by the idling screw — (2) — Fig. M.9 for C.A.V. pumps or (E) — Fig. M.22 for Bosch pumps.

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, C.A.V. or Bosch Dealer, alternatively, Service Dept., Perkins Engines Ltd., Peterborough.

Atomisers

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

Ensure that the atomiser is seated centrally and tighten securing nuts down evenly to a torque of 12 lbf ft (1,7 kgf m).

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.

Replacement atomisers should carry the code FN for C.A.V. pumps or VU for Bosch pumps. They should be fitted in complete sets.

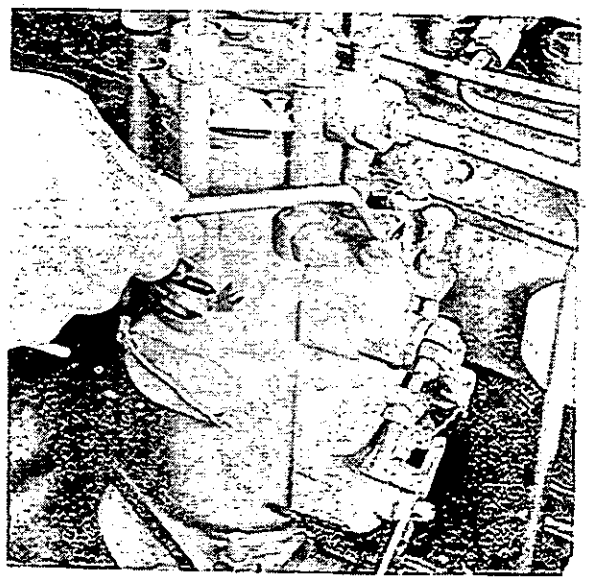
When servicing atomisers, the operating pressures should be set as given on Page M.12/13.

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 "crackling" 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.



M18

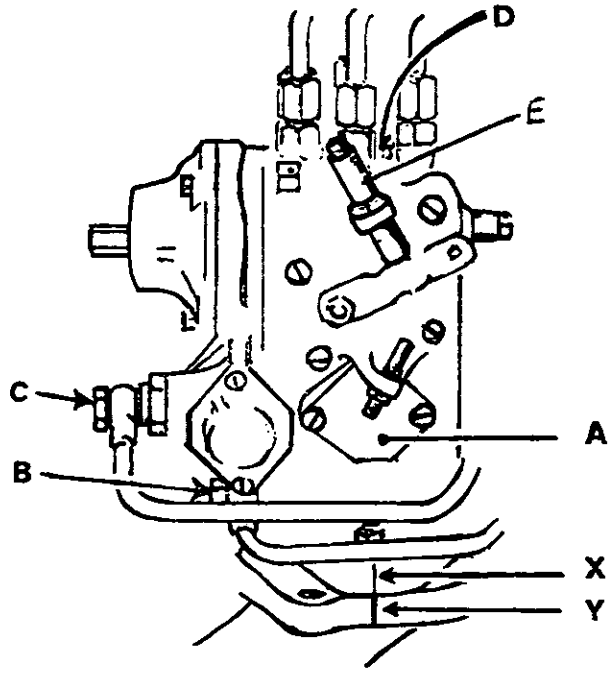
Bleeding the Fuel System

The air must be vented from the fuel system and the system primed with fuel oil whenever any disconnection in the fuel system has taken place, or when the system has been emptied of fuel.

No attempt must be made to start the engine until the injection pump has been vented and primed as

6. Slacken the nuts of two of the high pressure pipes at the atomiser end.
7. With the speed control in the maximum speed position, motor the engine over by means of the starter motor until fuel, free from air, issues from the connections. Tighten the connections.

The engine is now ready for starting.



M22

DATA AND DIMENSIONS FOR AIR FILTERS AND FUEL SYSTEM

Approved Fuel Oil Specifications

United Kingdom	BS. 2869:1967	Class A1 or A2
United States	VV-F-800a	Grades DF-A, DF-1 or DF-2
	A.S.T.M/D975-66T	Nos. 1-D or 2-D
France	(J.O.14/9/57)	Gas Oil or Fuel Domestique
India	1S:1460/1968	Grade Special or Grade A
Germany	DIN-51601 (1967)	— — — —
Italy	CUNA-Gas Oil	— — — —
	NC-630-01 (1957)	— — — —
Sweden	SIS.15 54 32 (1969)	— — — —
Switzerland	Federal Military Spec.	
	9140-355-1404 (1965)	— — — —

Fuel oils available in territories other than those listed above which are to an equivalent specification may be used.

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)
Diaphragm Spring Colour	Red

Fuel Filter

Type	Twin Parallel
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"
Static Timing Position	32° B.T.D.C.
Equivalent Piston Displacement	0.485 in (12,32 mm) B.T.D.C.
Engine Checking Angle	162°
Fuel Pump Marking Angle	146°

Fuel Injection Pump

Make	Bosch
Type	EP/VA
Pump Rotation	Anti-clockwise
No. 1 Cylinder Outlet	A
Static Timing Position	18° B.T.D.C.
Equivalent Piston Displacement	0.157 in (4,00 mm)
Engine Checking Angle	148°
Fuel Pump Marking Angle	139°

Atomisers

(early engines — CAV pump)

Make	C.A.V.
Holder	BKBL67S5299
Nozzle	BDLL150S6545
Setting Pressure	210 atm (3088 lbf/in² — 217 kgf/cm²)
Working Pressure	195 atm (2868 lbf/in² — 201 kgf/cm²)
Code	DL

(current engines — CAV pump)	
Make	C.A.V.
Holder	BKBL67S5299
Nozzle	BDLL150S6639
Setting Pressure	210 atm (3090 lbf/in² — 217 kgf/cm²)
Working Pressure	195 atm (2870 lbf/in² — 201 kgf/cm²)
Code	FN
(Bosch fuel pumps only)	
(early engines)	
Make	Bosch/C.A.V.
Holder	1431202151
Nozzle	BDLL150S6660
Setting Pressure	240 atm (3530 lbf/in² — 247 kgf/cm²)
Working Pressure	225 atm (3310 lbf/in² — 232 kgf/cm²)
Code	FK
(current engines)	
Make	OMAP
Holder	OKLL67S2929
Nozzle	OLL150S7574
Setting Pressure	250 atm (3680 lbf/in² — 258 kgf/cm²)
Working Pressure	225 atm (3310 lbf/in² — 232 kgf/cm²)
Code	VU

SECTION N
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.

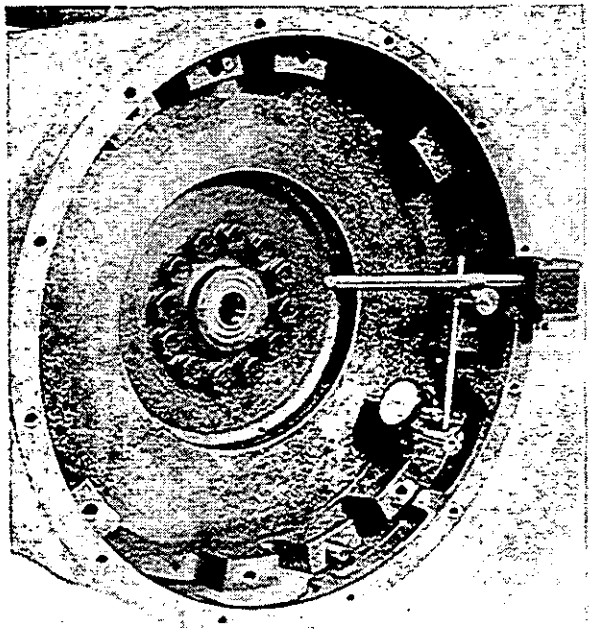
To Refit the Flywheel

Using suitable guide studs, refit the flywheel to the crankshaft flange and secure with setscrews and washers.

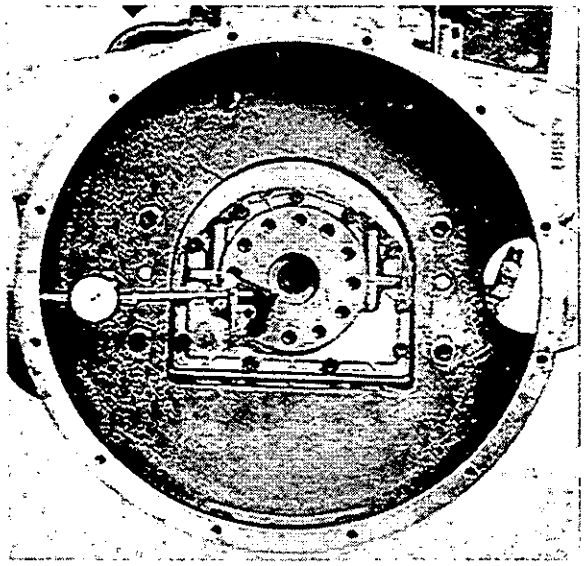
Tighten setscrews to a torque of 80 lbf ft (11,1 kgf m) - 110 Nm.

Flywheel Runout

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



N1



N2

Flywheel Alignment

The alignment of the flywheel face should be within the limit of 0.001 in (0,03 mm) per inch (25,4 mm) of flywheel radius from the crankshaft axis to the clock gauge plunger, see Fig. N.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

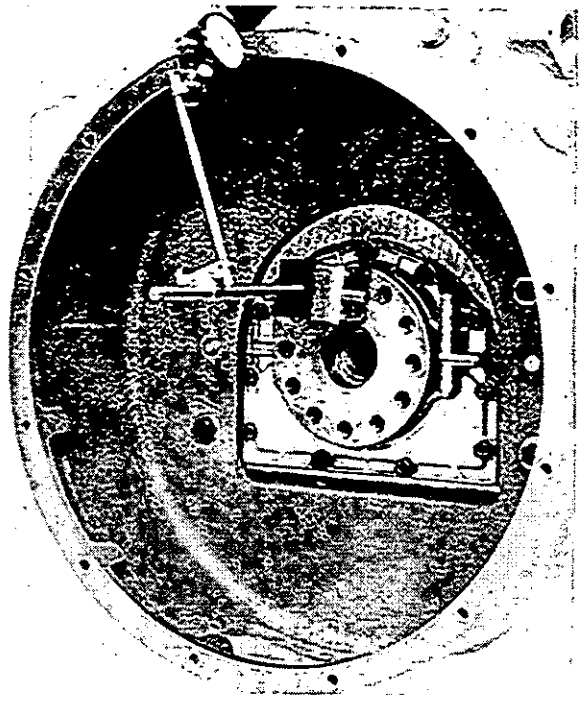
Ensure that the rear face of the cylinder block and the mating face of the housing are clean and free from burrs.

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. N.2 and N.3, are within the limits listed as follows:

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 a torque of 36 lbf ft (5,0 kgf m) -49 Nm.



N3

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 P
Turbocharger

The Holset 3LD turbocharger is fitted on the exhaust manifold outlet see Fig. A.1. It is lubricated by oil taken from the engine lubricating system. Oil pressure should never drop below 30 lbf/in² (2,11 kgf/cm²) or 207 kN/m² at normal running speed. Check this pressure regularly.

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

Every 20,000 miles (30,000 km) or 800 hours, clean the oil drain pipe from turbocharger to sump, also turbocharger impeller and cover.

The impeller and cover may be cleaned without removing the turbocharger from the engine if the following instructions are carried out:

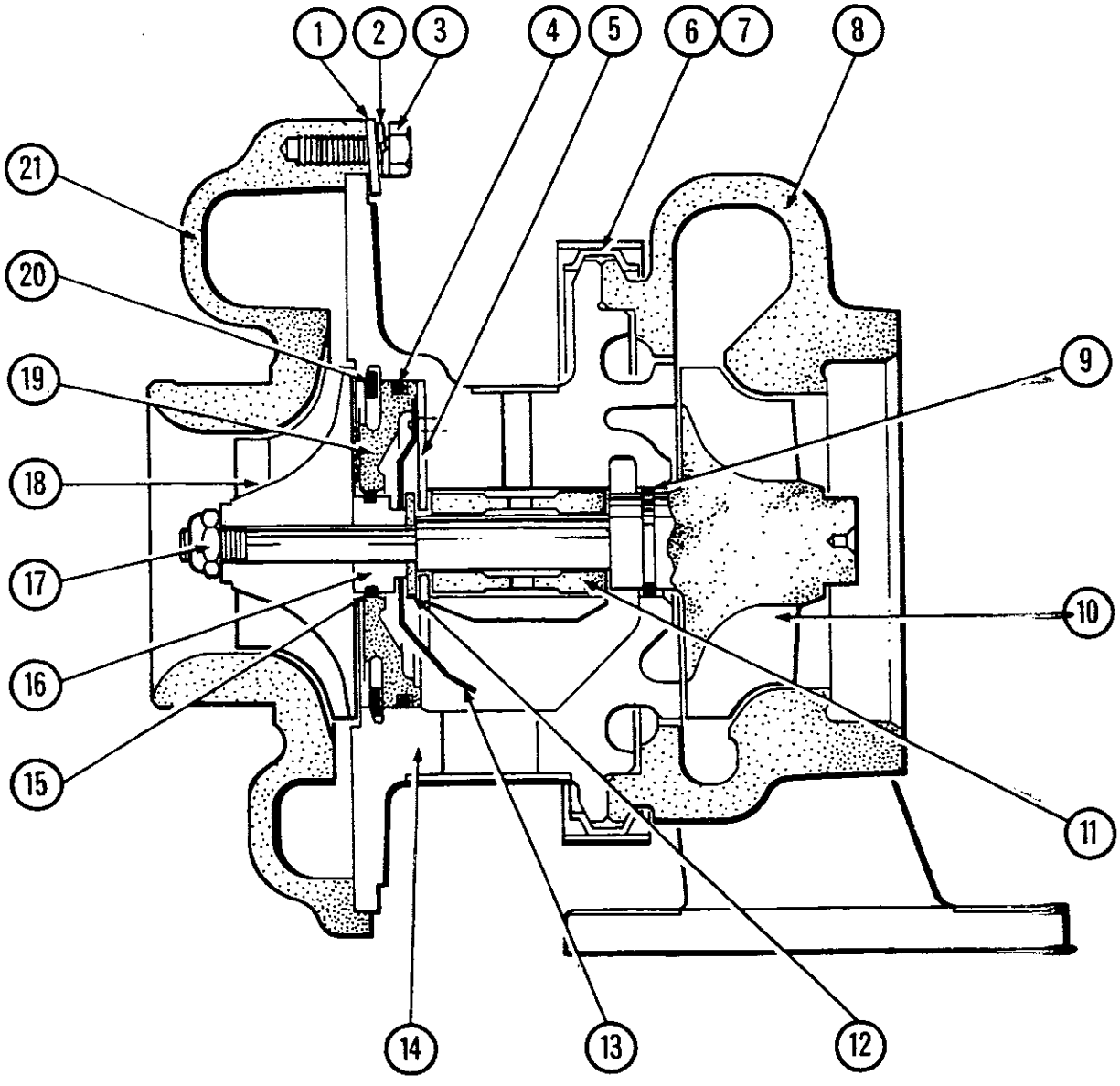
Remove oil feed pipe and oil drain pipe.

Numbers in brackets refer to numbers on the section drawing, Fig. P.1.

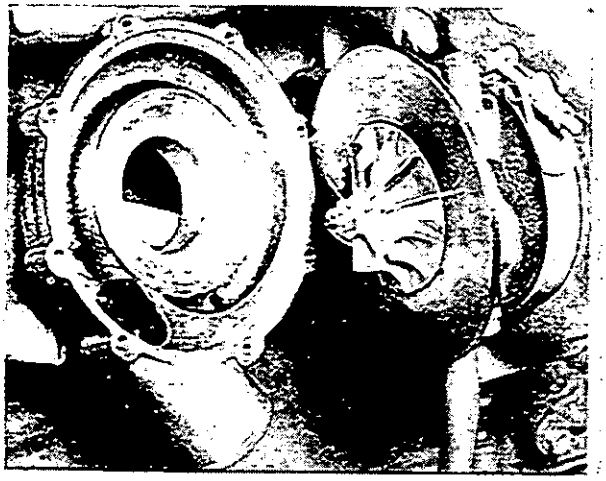
Mark relative positions of turbine housing (8), bearing housing (14), Compressor cover (21) and "V" clamp (7).

Remove the eight bolts (3) and associated lockwashers (2) fastening compressor cover (21) to bearing housing (14), and lift off cover (21) see Fig. P.2.

Remove the "V" clamp locknut and spring, then "V" clamp (7) back onto the bearing housing (14). Lift the core assembly clear of the turbine housing (8), see Fig. P.3.



P1



P2

Holding the turbine at the hub, remove the impeller locknut (17).

Slide impeller (18) off the shaft, see Fig. P.4.

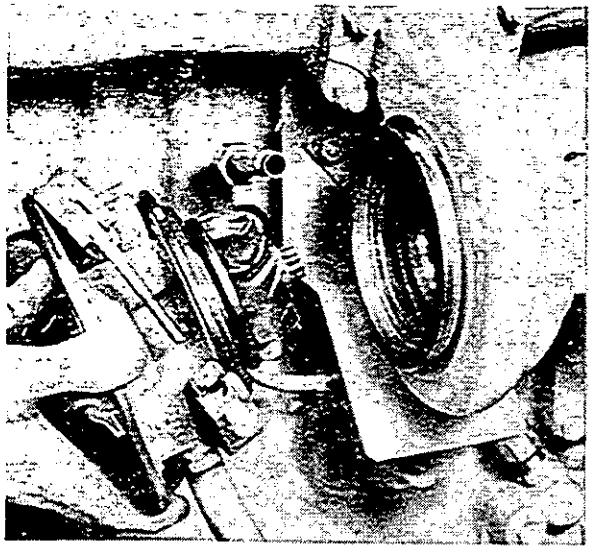
The impeller and cover may be washed in non-caustic cleaning fluid. A non-metallic brush or plastic scraper blade should be used to avoid scoring these parts.

Following cleaning, the parts removed should be examined and if found to be in a satisfactory condition, should be re-assembled in reverse order of the stripping sequence outlined above.

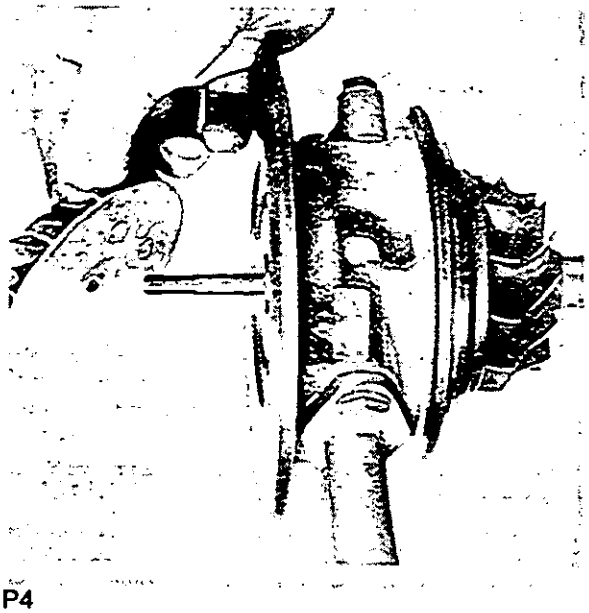
Refit oil pipes. Check for oil drain before firing the engine.

Fault Diagnosis

If the performance of the turbocharger is suspect, check the installation for the following faults:—



P3



P4

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 20 in (500 mm) 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 30 lbf/in² (2,1 kgf/cm²) -207 kN/m² under normal conditions of load.

If oil pressure is low, refer to Section K. 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 20 in (500 mm) 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.

Dismantling

Numbers in brackets refer to numbers on Sectional Drawing, Fig. P.1.

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), see Fig. P.2.

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), see Fig. P.3.

Holding the turbine at the hub, remove the impeller locknut (17).

Slide impeller (18) off the shaft, see Fig. P.4.

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 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 and shaft assembly.

Caution: Over expansion of piston ring will cause a permanent set or break the ring.

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 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.

Impeller (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 on Page P.6.

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 and shaft (10) into bearing housing (14), 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 13 lbf ft (1,8 kgf m) -18 Nm, bolt (3) to 15 lbf ft (0,7 kgf m) -7 Nm and "V" clamp locknut (6) to 10 lbf ft (1,4 kgf m) -13 Nm.

(e) On completion, spin shaft to ensure that 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 25—30 lbf ft (3,46—4,15 kgf m) -34/41 Nm and 60—65 lbf ft (8,3—8,99 kgf m) -81/88 Nm 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.

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. Ensure that the gaskets do not protrude into the openings of the manifold (and adaptor where fitted). The openings in the gaskets should preferably be $\frac{1}{16}$ in (1,6 mm) 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.

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.

SCHEDULE OF TOLERANCES

	Manufactured Dimensions	Allowable Dimensions after Service	Remarks
Total turbine wheel clearance	0.047/0.057 in (1,19/1,45 mm)	0.024 in (0,61 mm) min.	
Back turbine wheel clearance	0.015/0.0027 in (0,38/0,68 mm)	As Manufactured	Wheel pushed to compressor end.
Front turbine wheel clearance	0.024/0.038 in (0,61/0,96 mm)	0.024 in (0,61 mm) min.	
Total compressor wheel clearance	0.049/0.062 in (1,24/1,57 mm)	As Manufactured	
Back compressor wheel clearance	0.026/0.043 in (0,66/1,09 mm)	As Manufactured	Wheel pushed to turbine end.
Thrust clearance	0.004/0.008 in (0,10/0,20 mm)	As Manufactured	
Radial float at compressor wheel hub	0.015/0.021 in (0,38/0,53 mm)	0.024 in (0,61 mm) max.	
Bearing outside diameter	0.8714/0.8719 in (22,13/22,14 mm)	As Manufactured	
Bearing inside diameter	0.4815/0.4818 in (12,23/12,24 mm)	As Manufactured	
Thrust bearing width	0.105/0.107 in (2,67/2,72 mm)	0.104 in (2,64 mm) min.	
Squareness of back face of turbine wheel	0.002 in T.I.R. (0,05 mm T.I.R.)	As Manufactured	On Vee block at 1.375 in radius.
Eccentricity of small diameter of shaft	0.0006 in T.I.R. (0,01 mm T.I.R.)	As Manufactured	
Piston ring grooves on shaft	0.066/0.068 in (1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring groove on spacer sleeve	0.066/0.068 in (1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring width at turbine end	0.062/0.063 in (1,57/1,60 mm)		Replace at each service.
Piston ring width at compressor end	0.062/0.063 in (1,57/1,60 mm)		Replace at each service.
Bearing housing bore for piston ring	0.8750/0.8755 in (22,22/22,24 mm)	0.877 in (22,28 mm) max.	
Compressor insert bore	0.875/0.876 in (22,22/22,25 mm)	0.877 in (22,28 mm) max.	
Bearing housing bore at bearing	0.8750/0.8755 in (22,22/22,24 mm)	As Manufactured	
Turbine wheel outside diameter	2.977/2.975 in (75,62/75,56 mm)	2.980 in (75,69 mm) max.	
Shaft diameter at bearing	0.4803/0.4800 in (12,20/12,19 mm)	0.4799 in (12,19 mm) min.	

SECTION Q
Alternator and Starter Motor

ALTERNATOR

MODELS AC5 and 11AC

1. General

At the time of writing there are two types of alternator fitted to the T6.3543 engine, namely the AC5 and the 11 AC.

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 converts 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 AC 5 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. Dis-

connect alternator output terminal. Fit a good quality moving coil 0 — 100 amp ammeter in series with the alternator terminal and output lead. **The battery should be in a charged condition.**

(b) Close the warning light switch (master electric switch on dashboard) when the warning lamp should light up.

(c) Switch on a 10 — 15 amperes load such as lights, fans, etc., for fifteen minutes.

(d) Start engine and run at fast idle speed when
1. The warning light should go out.
2. The ammeter records a small charge dependent on engine speed.

(e) Increase engine speed momentarily to maximum speed, when the charging current should be about 30 amperes for 24 volt, and 53 amperes for 12 volt systems.

(f) With the alternator running at approximately half speed (engine speed about 1,500 rev min), switch off electrical load. Depending on the connection selected for the positive sensing wire LO, MED, or HI, the voltage should rise to 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. Fault Finding on 11AC

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

TEST 1.

Check the Field Isolating Relay

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

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

TEST 2.

Check the Alternator and Control Box

Leave the test ammeter connected, and disconnect cables 'F' and '—' from control unit and join them together. Remove link from field relay terminals and ensure they are connected to 'C1' and 'C2'. Start engine and run at charging speed.
Ammeter should indicate current values of 35 amps or more for 12 volt circuit or 22 amps or more for 24 volt circuit. A zero or low reading indicates a faulty alternator.

If satisfactory output is recorded, a faulty control unit is indicated.

TEST 3.

Checking or Adjusting the Voltage Setting

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

12 V (37423)/(37449)	13.9—14.3 volts
24 V (37444)/(37502)	27.9—28.3 volts
12 V (37429)	13.7—14.1 volts

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

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

ADJUSTMENT OF VOLTAGE SETTING

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

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

TEST 4.

Check of Alternator Output

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

Check Warning Light Control

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

6. Fault Diagnosis Procedure for 11AC

Alternator Fails to Charge

(a) Check driving belt for correct tension and wear.

(b) Apply Tests 1 and 2.

Low-Unsteady Charging Rate

(a) Check driving belt for correct tension and wear.

(b) Check for high resistance at battery terminals and in the circuit wiring and connection. Check all connections made to earth.

(c) Apply Test 2.

Flat Battery or Low State of Charge

(a) CHECK condition of battery with hydrometer and high rate discharge tester.

(b) Check driving belt for correct tension and wear.

(c) Check that the field isolating relay contacts open when master switch is off, otherwise battery will discharge through rotor winding.

(d) Check that flat or low battery is not caused by insufficient alternator output caused by abnormal electrical loads by applying Test 4.

Excessive Charge Rate to a Fully Charged Battery

(a) Apply Test 3.

Noisy Alternator

(a) Alternator loose in mounting brackets.

(b) Worn, frayed or loose drive belt.

(c) Worn bearings, fully out of alignment.

(d) Rotor damaged or pulley fan loose on shaft.

(e) Open circuited, or short circuited rectified diodes, or stator winding open-circuit.

(f) Loose pulley.

Alternator

MODEL 17ACR

Testing the 17ACR in Position

First check the driving belt for condition and tension. The nominal hot output at 6,000 rev/min (alternator speed) is 36 amps for the 17ACR. 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.

Note: De-rated 17ACR alternators, giving a hot output of 25 amps may be fitted to combine harvesters and similar applications where the engine is operating in dusty conditions.

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. Q.1, Q.2 or Q.3.

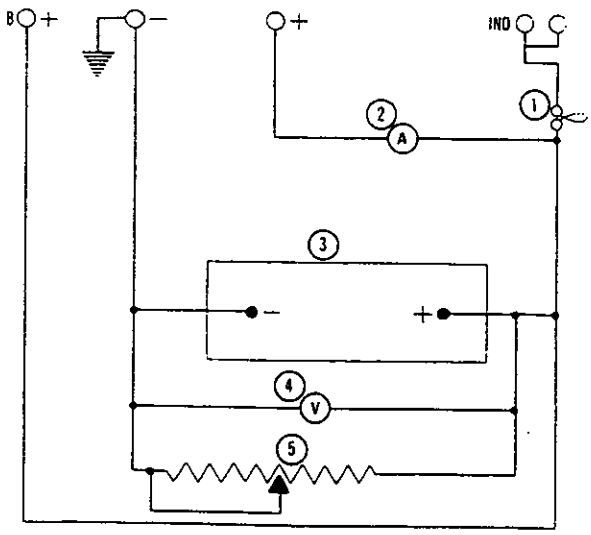
Value of components in Fig Q.1, Q.2 or Q.3, are as follows:

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

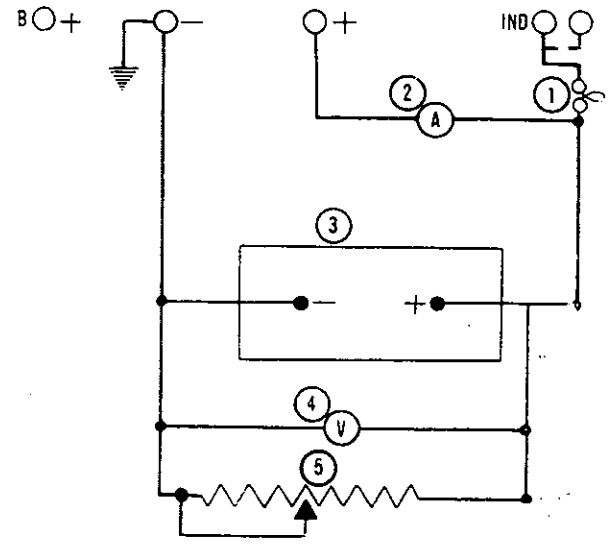
Observe carefully the polarity of battery and alternator terminals — reversed connections will damage the alternator diodes.

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

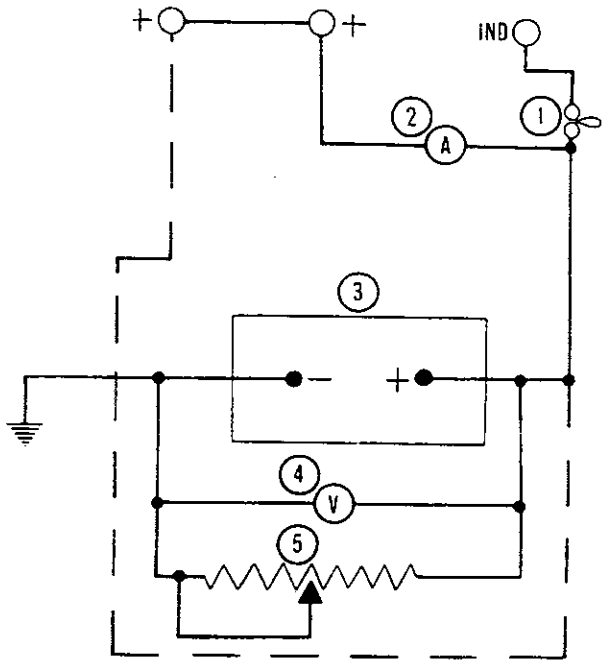
Start the engine. At 1,500 rev/min (alternator speed), the test circuit bulb should be extinguished. Increase engine speed until the alternator is running at 6,000 rev/min approximately, and adjust the variable resistance until the voltmeter reads 13.6 volts. The ammeter reading should then be approximately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



Q1
Test Circuit for 17ACR Alternators. Standard terminations, battery-sensed.



Q2
Test Circuit for 17ACR alternators with standard terminals and two piece connection plug (machine-sensed).



Q3
Test Circuit for 17ACR 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 "+".

necessitate the alternator being removed from the engine for further examination.

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

Regulator test

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

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

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

If the foregoing tests show the alternator and regulator to be satisfactorily performing, disconnect the test circuit and reconnect the alternator terminal connector. Now connect a low range voltmeter between the positive terminal of the alternator (the moulded terminal connector is open ended to facilitate this) and the positive terminal of the battery. Switch on battery load (headlights etc.), start the engine and increase speed until the alternator runs at approximately 6,000 rev/min. 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 of a 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 5 in (127,0 mm) nominal yoke diameter, and has a 21 slot armature.

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

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

Testing on the Vehicle

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

Difficulty in smooth engagement between starter and engine flywheel is probably due to dirt on the starter-shaft helices preventing free pinion movement. The shaft should be thoroughly cleaned with cleaning fluid followed by the application of a small quantity of Shell SB 2628 for temperate and cold climates, or Shell Retinex for hot climates.

MAINTENANCE

Brush Gear and Commutator

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

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

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

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

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

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

SECTION R
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), 200 hours or 4 months (whichever occurs firts).
Remove, dismantle and clean compressor air cleaner (if fitted).

Every 10,000 miles (15,000 km), 400 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 800 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 2,400 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 inserf and the forward half-coupling is 0.020/0.025 in (0,51/0,63 mm).
Should the clearance be be incorrect, the half-coupling can be moved on the shaft to obtain the correct clearance.

RECONDITIONING CLAYTON DEWANDRE TWIN 10 COMPRESSOR

Cylinder Head

Mark the cylinder head in relation to the cylinders.

Remove the cylinder head nuts and setscrews and break the joint with a hide hammer.

Remove delivery valve details. Delivery valve springs are accessible after removing the delivery cap or safety valve. Delivery valve seats are either screwed into the head from the top (R.H. thread) or pressed in from the bottom. Screwed in seats can be identified by a square or hexagonal hole through the seat.
The inlet valve details are retained by screwed or pressed in keepers staked by the cylinder head. Both types look similar, but pressed in types embody one or two holes through the keeper tapped B.S.F. or U.N.F. to accept withdrawal bolts. Screwed keepers can be removed by a peg spanner. After removing the keeper, take out spring, valve guide (if fitted), valve disc and seat. The valve seat may have been fitted with "Loctite" on assembly and may require tapping to free the bond.

Thoroughly clean out the water passages of the cylinder head, removing plugs as necessary. Remove all carbon, the piston crown can also be de-carbonised if necessary. Inspect all threads for damage.

Before reassembling, replace all plugs and ensure complete cleanliness. Insert inlet valve seat, flat side first, so that the seating portion faces outwards towards the bottom of the head, valve disc and spring. Screw or press the keeper fully in. Tighten screwed keepers to a torque of 30/35 lbf ft (4,15/4,84 kgf m) -41/48 Nm.

Stake the face of the cylinder head in three places around the keeper. Screwed types of delivery valve seats with the sealing ring (if fitted) should be inserted down the valve cap bore and screwed in fully to a torque of 5/8 lbf ft (0.69/1,11 kgf m) -6,8/10,8 Nm. Pressed in type delivery valve seats should have the valve discs located in the seat before the seat is pressed in. Place the delivery valve springs on the valves and the sealing washers on the delivery valve caps or cap and safety valve, and screw in to a torque of 65 lbf ft (8,99 kgf m) -88 Nm.

Place the cylinder head joint on the cylinders and locate the marks made before dismantling: fit and tighten the cylinder head nuts and setscrews to a torque of 16 lbf ft (2,21 kgf m) -22 Nm.

Pistons and Cylinders

Remove cylinder head as previously detailed.

Remove mounting bracket from compressor crankcase.

Mark each big end cap and connecting rod to ensure re-assembly. Remove the bolts and locking strips and detach the cap and bearing. Push the connecting rod up the bore and ease out the piston. Remove piston rings and clean carbon from ring grooves.

Remove the glaze from the cylinder bores.

Check bores for excessive wear, ovality or scores. If bores are scored, more than 0.002 in (0,06 mm) oval or if wear exceeds 0.005 in (0,127 mm), then the cylinders or liners must be replaced.

Check gudgeon pin clearance in small end bush. Limit is 0.0015 in (0,04 mm). If new bush has to be fitted, mark piston and gudgeon pin in relation to connecting rod before dismantling. Drill oil hole(s) through the bush from the top of the connecting rod before reaming.

Check new piston rings in cylinder bore. Compression ring gap should be 0.003/0.015 in (0,08/0,38 mm). Scraper ring gap should be 0.010/0.022 in (0,25/0,56 mm). Fit rings to piston ensuring that the internal recesses (or the word "TOP") face towards the piston crown.

Assemble pistons to connecting rods and with ring gaps spaced at 120° to each other, fit piston/connecting rod assemblies to cylinder block.

Fit new big end bearings, replace big end caps and tighten big end bolts to a torque of 10/12 lbf ft (1,38/1,66 kgf m) -13/16 Nm.

Refit compressor mounting bracket and tighten setscrews to 10 lbf ft (1,38 kgf m) -13 Nm.

Refit cylinder head as previously detailed.

Major Overhaul

Overhaul of the cylinder head and pistons/cylinders is covered separately under previous headings. To complete overhaul:—

Remove end cover from cylinder block.

Tap crankshaft at end opposite to cover to remove crankshaft and bearings. Renew oil seals where necessary. Test smoothness of bearings replacing faulty ones as necessary.

Refit crankshaft and bearings. Check end float of crankshaft — limit is 0.003/0.033 in (0,08/0,83 mm).

Refit crankshaft end cover.

Refit piston/connecting rod assemblies and cylinder head as previously described.

CLAYTON DEWANDRE SC6 COMPRESSOR DISMANTLING

Marking before dismantling

The compressor should have the following items marked to show the correct relationship prior 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 U.N.F. 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 0.002 in (0.05 mm) or tapered more than 0.003 in (0,08 mm) cylinder should be re-bored. The original cylinder bore is to the limits 2.6255/2.620 in (66,69/66,71 mm) and the clearance for the piston is 0.002/0.003 in (0,05/0,08 mm). Check for wear in cylinder bore and rectify in accordance with following table:

Wear in bore	Remedy
+0.005 in (0,13 mm)	Fit new standard rings.
+0.005/0.010 in (0,13/0,25 mm)	Bore out to +0.010 in (0,25 mm) and fit 0.010 in (0,25 mm) oversize piston and rings.
+0.015 in (0,38 mm)	Fit new 0.010 in (0,25 mm) oversize rings.
+0.015/0.020 in (0,38/0,51 mm)	Bore out to +0.020 in (0,51 mm) and fit 0.020 in (0,51 mm) oversize piston and rings.
+0.025 in (0,63 mm)	Fit new 0.020 in (0,51 mm) 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 0.0005/0.0025 in (0,01/0,06 mm). Install rings in cylinder and check that gaps are 0.003/0.007 in (0,08/0,18 mm). 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 0.0015 in (0,04 mm).

Inspect connecting rod bearing for correct fit on crankshaft journal. Clearance between rod journal and bearing must not be less than 0.001 in (0,02 mm) and not more than 0.003 in (0,08 mm). 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 0.874/0.8735 in (22,20/22,19 mm).

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 (9,51/9,54 mm). 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 (0,6 microns). A chamfer is also required at the top of the guide bore to an angle of 15° and to a depth of 0.102 in (2,59 mm). 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 0.003 in (0,08 mm) 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 3.75/4 lbf ft (0,51/0,55 kgf m) 5,1/5,4 Nm, 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 9/10 lbf ft (1,24/1,38 kgf m) -12/13 Nm.

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 2.257 in (57,33 mm).

The clearance of the compression rings in the piston grooves is 0.0005/0.002 in (0,012/0,051 mm) and that of the scraper rings is 0.0005/0.0025 in (0,012/0,063 mm). The gap of the compression and scraper rings in the cylinder is 0.003/0.007 in (0,08/0,18 mm).

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 0.0035 in (0,09 mm), whilst the clearance of the crankpins in the big end bearings should not exceed 0.003 in (0,08 mm).

The end float of the crankshaft is 0.004/0.012 in (0,10/0,30 mm).

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 0.0015 in (0,038 mm). 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 7/9 lbf ft (0,97/1,24 kgf m) 9,6/12 Nm.

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 8/9 lbf ft (1,11/1,24 kgf m) 11/12 Nm 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 crankcase. 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 45/50 lbf in (0,52/0,57 kgf m) -5,1/5,6 Nm.

Ensure valves have free movement after assembly.

Fit cylinder head/valve plate assembly with gasket to crankcase. Fit top 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 15/17 lbf ft (2,07/2,35 kgf m) -20/23 Nm progressively.

Fit mounting bracket with gasket to base of compressor with bolts and spring washers. Tighten bolts to 15/17 lbf ft (2,07/2,35 kgf m) -20/23 Nm 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 40/50 lbf in (0,46/0,58 kgf m) -4,5/5,6 Nm.

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 7/9 lbf ft (0,97/1,24 kgf m) - 9,6/12 Nm.

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	0.0005/0.0015 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	15/17 lbf ft (2,07/2,35 kgf m) - 20/23 Nm
End cover bolts	7/9 lbf ft (0,97/1,24 kgf m) - 9,6/12 Nm
Mounting bracket bolts	15/17 lbf ft (2,07/2,35 kgf m) - 20/23 Nm
Strainer mounting nuts	7/9 lbf ft (0,97/1,24 kgf m) - 9,6/12 Nm
Strainer adaptor screws	40/50 lbf in (0,46/0,58 kgf m) - 4,5/5,6 Nm
Big End Bolts	8/9 lbf in (1,11/1,24 kgf m) - 11/12 Nm

INDEX

INDEX (Continued)