Perkins Phaser and 1000 Series

Models AA to AH and YA to YE

WORKSHOP MANUAL

Phaser **4 and 6 cylinder diesel engines for automotive applications**

1000 Series **4 and 6 cylinder diesel engines for agricultural and industrial applications**

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1

General information

Introduction

This Workshop Manual has been written to provide assistance in the service and overhaul of Perkins Phaser and 1000 Series engines. It should be used in conjunction with normal workshop practise and information contained in current service bulletins. Mention of certain accepted practices therefore, has been purposely omitted in order to avoid repetition. For overhaul procedures the assumption is made that the engine is removed from the application.

Most of the general information which is included in the relevant User's Handbook has not been repeated in this workshop manual and the two publications should be used together.

Where the information applies only to certain engine types, this is indicated in the text.

The details of some operations will be different according to the type of fuel injection pump which is fitted. The specific pump type used can be found by reference to the manufacturer's identification plate on the pump body but, generally, the type of pump fitted is as shown below:

- Lucas/Delphi - DPA, DPS and DP200 Series
- Bosch - EPVE and MW
- Stanadyne - DB2 and DB4.

When reference is made to the "left" or "right" side of the engine, this is as seen from the flywheel end of the engine.

Special tools have been made available and a list of these is given in Chapter 16, Special tools. Reference to the relevant special tools is also made at the beginning of each operation.

Data and dimensions are included in Chapter 2, Specifications.

Read and remember the "Safety precautions" on page 5. They are given for your protection and must be used at all times.

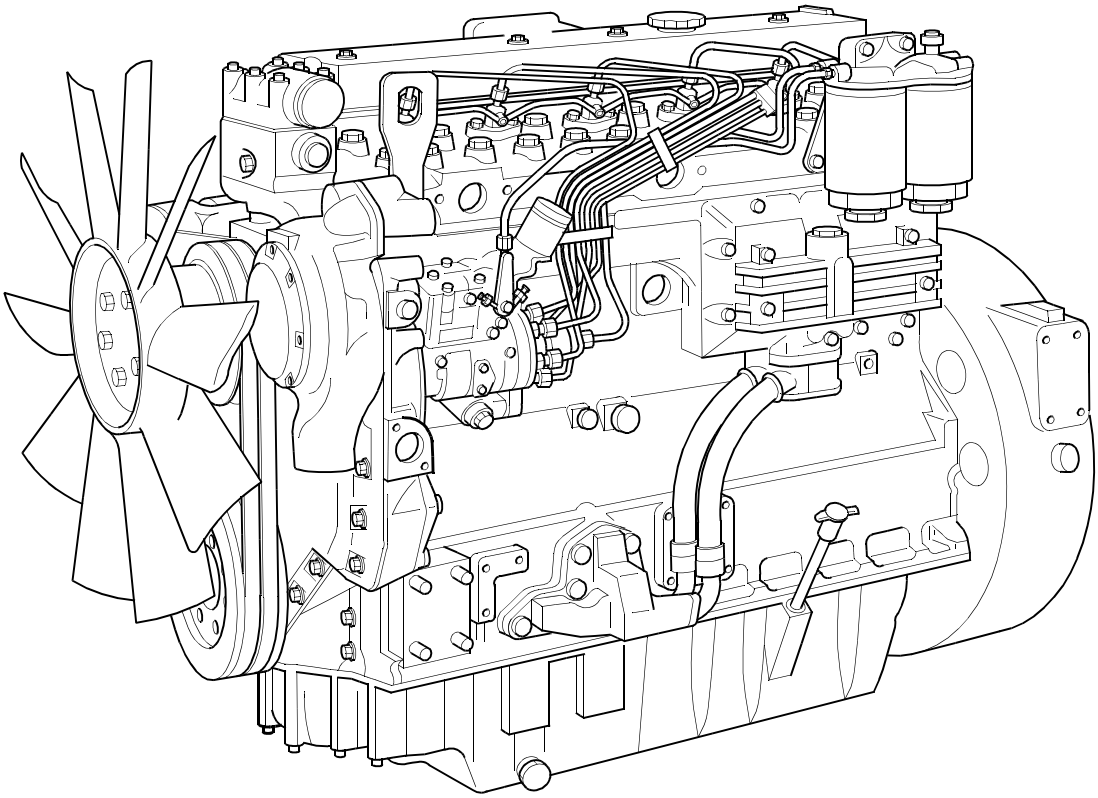
Danger is indicated in the text by two methods:

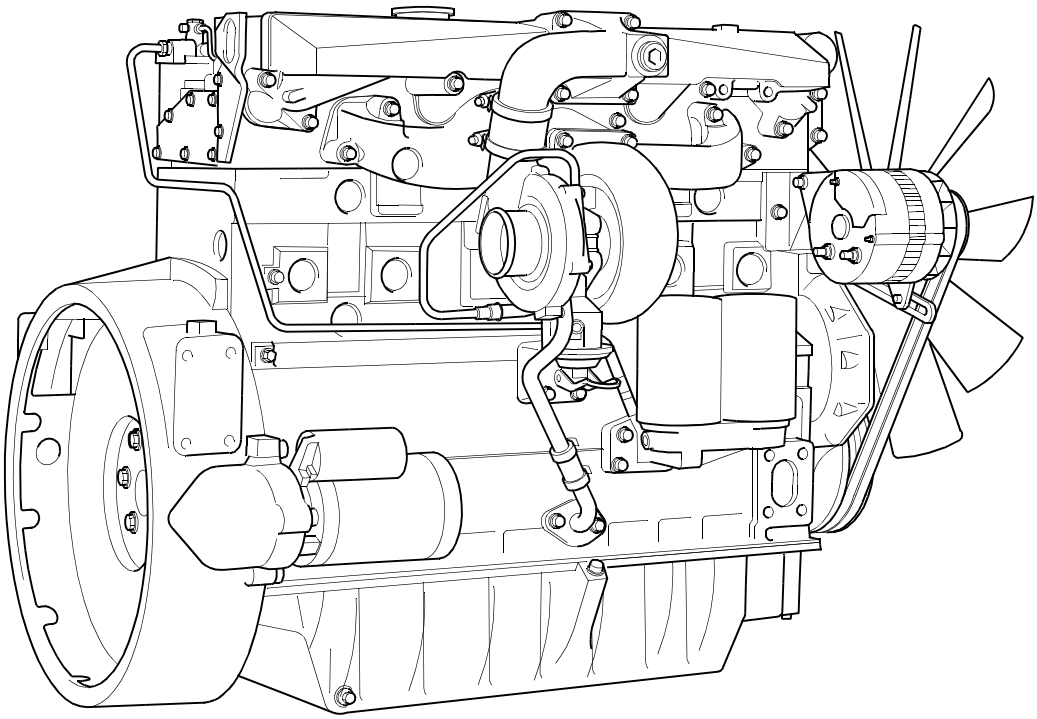
Warning! *This indicates that there is a possible danger to the person.*

Caution: *This indicates that there is a possible danger to the engine.*

Note: Is used where the information is important, but there is not a danger.

Engine views





Engine identification

The Perkins Phaser and 1000 Series engines have been designed for specific applications, as shown below:

- Phaser for automotive applications
- 1000 Series for agricultural and industrial applications.

Each series consists of both four and six cylinder engines, each of which will have four basic engine types - naturally aspirated, compensated, turbocharged and turbocharged/intercooled.

There are different models in each series.

Phaser engines are named according to their approximate power output, for example:

Phaser 110T - four cylinder engine rated at 106 bhp ("T" indicates that the engine is turbocharged).

Phaser 210Ti - six cylinder engine rated at 210 bhp ("Ti" indicates that the engine is turbocharged and intercooled).

1000 Series engines are identified by a system of numbers and letters, for example:

1006-6TW - six cylinder engine of six litres ("TW" indicates that the engine is turbocharged and intercooled).

In this Workshop Manual, the different engine types are indicated by their code letters. These are the first two letters of the engine number as indicated below:

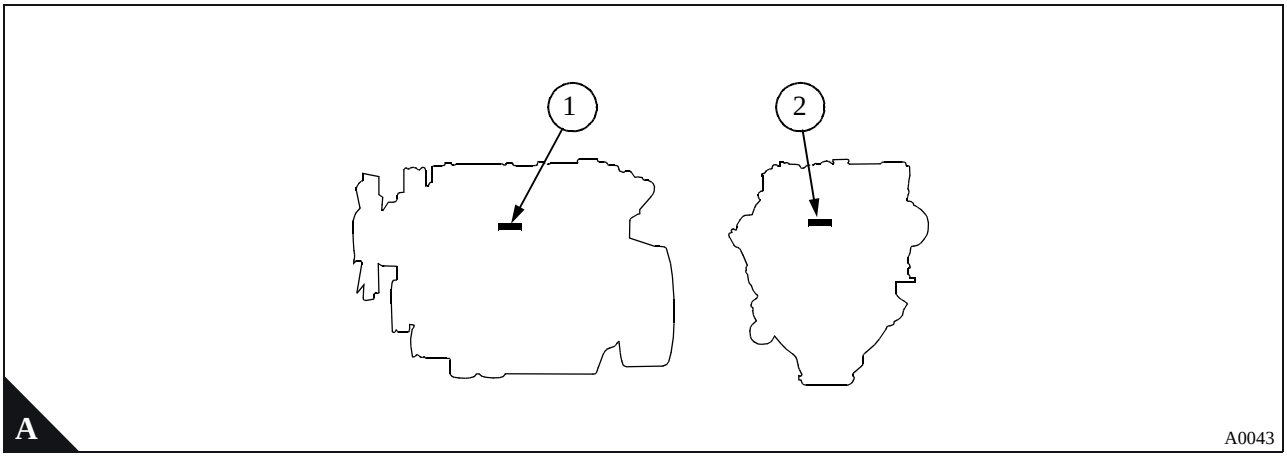
Code letters	Engine type
AA	Four cylinder, naturally aspirated
AB	Four cylinder, turbocharged
AC	Four cylinder, compensated
AD	Four cylinder, turbocharged and intercooled
AE	Four cylinder, turbocharged and intercooled designed to conform to the USA emission legislation
AG	Four cylinder, naturally aspirated with belt driven coolant pump
AH	Four cylinder, turbocharged with belt driven coolant pump
YA	Six cylinder, naturally aspirated
YB	Six cylinder, turbocharged
YC	Six cylinder, compensated
YD	Six cylinder, turbocharged and intercooled
YE	Six cylinder, turbocharged and intercooled designed to conform to the USA emission legislation

Continued

The engine number is stamped on a label which is fastened to the left side (A1) or rear (A2) of the cylinder block. An example of an engine number is **AB30126U510256N**.

Further information about the engine number system can be found in the relevant User's Handbook.

Note: If you need parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.



Safety precautions

These safety precautions are important. You must refer also to the local regulations in the country of use. Some items only refer to specific applications.

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme care must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine or auxiliary equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation.

Warning! *Some moving parts cannot be seen clearly while the engine runs.*

- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed circuit of the cooling system.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operators position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets of clothing.
- Discard used lubricating oil in a safe place to prevent contamination.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes. Refer to "Viton seals" on page 7.
- Read and use the instructions relevant to "Engine lift equipment" on page 8.

Continued

- Always use a safety cage to protect the operator when a component is to be pressure tested in a container of water. Fit safety wires to secure the plugs which seal the hose connections of a component which is to be pressure tested.
- Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.
- Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and debris away from the inlet and outlet ports of the turbocharger and prevent contact with hot surfaces.
- Fit only genuine Perkins parts.

Asbestos joints

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

- The risk of asbestos from joints occurs at their edges or if a joint is damaged when a component is removed or if a joint is removed by abrasive action.
- To ensure that the risk is kept to a minimum, the precautions given below must be applied when an engine which has asbestos joints is dismantled or assembled.
- Work in an area with good ventilation.
- Do not smoke.
- Use a hand scraper to remove the joints - do not use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all asbestos debris with water and put it in a closed container which can be sealed for safe disposal.

Viton seals

Some seals used in engines and in components fitted to engines are made of Viton.

Viton is used by many manufacturers and is a safe material under normal conditions of operation. If Viton is burned, a product of this burnt material is an acid which is extremely dangerous. Never allow this burnt material to come into contact with the skin or with the eyes.

If it is necessary to come into contact with components which have been burnt, ensure that the precautions which follow are used:

- Ensure that the components have cooled.
- Use Neoprene gloves and discard the gloves safely after use.
- Wash the area with calcium hydroxide solution and then with clean water.
- Disposal of components and gloves which are contaminated must be in accordance with local regulations.

If there is contamination of the skin or eyes, wash the affected area with a continuous supply of clean water or with calcium hydroxide solution for 15-60 minutes. **Obtain immediate medical attention**.

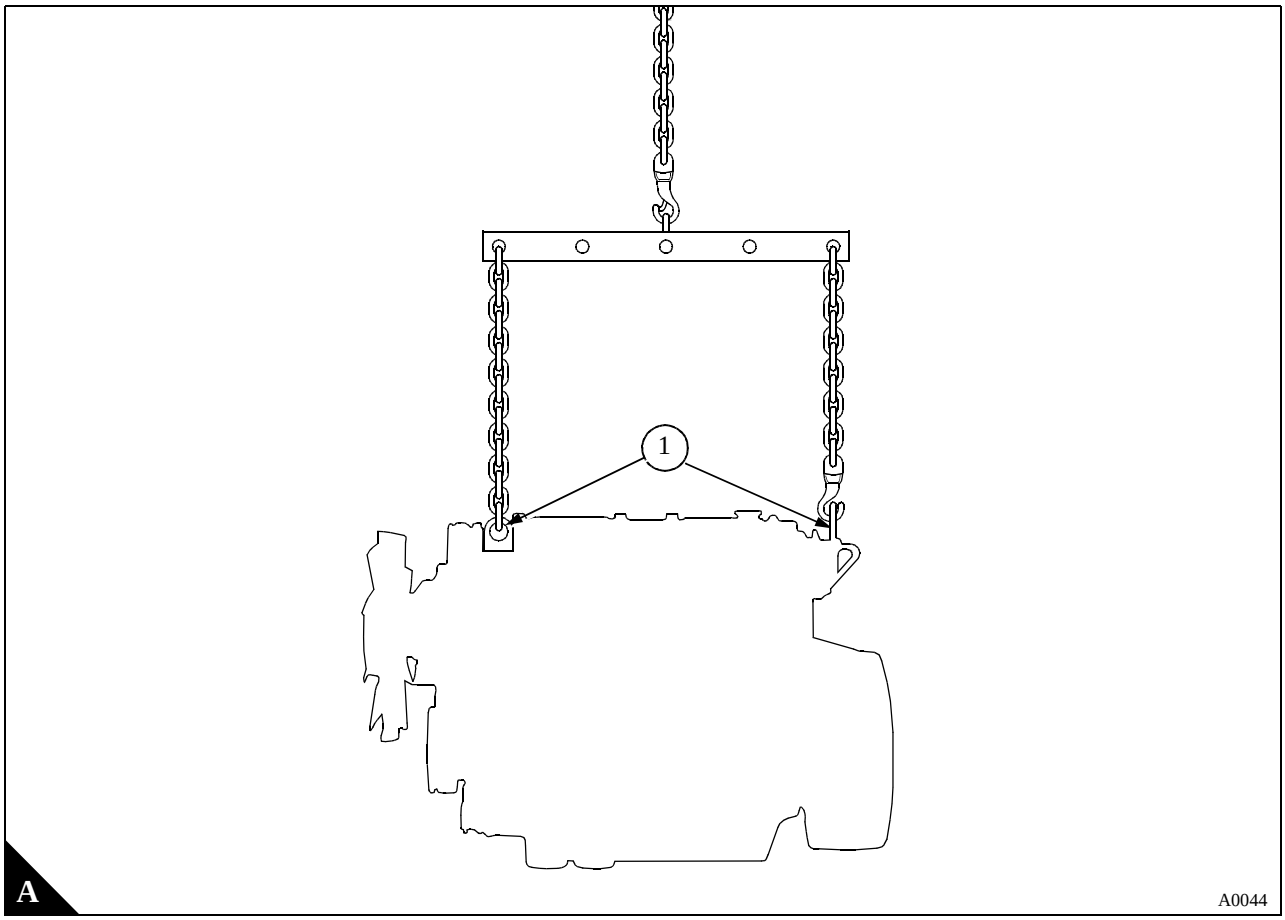
Engine lift equipment

The maximum weight of the engine without coolant, lubricant or a gearbox fitted will vary for different applications. It is recommended that lift equipment of the minimum capacity listed below is used:

- Four cylinder engines: 500 kg (1100 lbs)
- Six cylinder engines: 600 kg (1320 lbs)

Before the engine is lifted

- Always use lift equipment of the approved type and of the correct capacity to lift the engine. It is recommended that lift equipment of the type shown in (A) is used, to provide a vertical lift directly above the engine lift brackets (A1). Never use a single lift bracket to raise an engine.
- Check the engine lift brackets for damage and that they are secure before the engine is lifted. The torque for the setscrews for the engine lift brackets is 44 Nm (33 lbf ft) 4,5 kgf m.
- To Prevent damage to the rocker cover, ensure that there is clearance between the hooks and the rocker cover.
- Use lift equipment or obtain assistance to lift heavy engine components such as the cylinder block, cylinder head, balancer unit, flywheel housing, crankshaft and flywheel.



POWERPART consumable products

Perkins have made available the products recommended below in order to assist in the correct operation, service and maintenance of your engine and your machine. The instructions for the use of each product are given on the outside of each container. These products are available from your Perkins distributor.

POWERPART Antifreeze

Protects the cooling system against frost and corrosion. Part number 21825166.

POWERPART Easy Flush

Cleans the cooling system. Part number 21825001.

POWERPART Gasket and flange sealant

To seal flat faces of components where no joint is used. Especially for aluminium components. Part number 21820518.

POWERPART Gasket remover

An aerosol for removal of sealants and adhesives. Part number 21820116.

POWERPART Griptite

To improve the grip of worn tools and fasteners. Part number 21820129.

POWERPART Hydraulic threadlock

To retain and seal pipe connections with fine threads. Especially suitable for hydraulic and pneumatic systems. Part number 21820121.

POWERPART Industrial grade super glue

Instant adhesive designed for metals, plastics and rubbers. Part number 21820125.

POWERPART Lay-Up 1

A diesel fuel additive for protection against corrosion. Part number 1772204.

POWERPART Lay-Up 2

Protects the inside of the engine and of other closed systems. Part number 1762811.

POWERPART Lay-Up 3

Protects outside metal parts. Part number 1734115.

POWERPART Metal repair putty

Designed for external repair of metal and plastics. Part number 21820126.

POWERPART Pipe sealant and sealant primer

To retain and seal pipe connections with coarse threads. Pressure systems can be used immediately. Part number 21820122.

POWERPART Radiator stop leak

For the repair of radiator leaks. Part number 21820127.

Continued

POWERPART Retainer (high strength)

To retain components which have an interference fit. Part number 21820638.

POWERPART Retainer (oil tolerant)

To retain components which have a transition fit. Part number 21820603.

POWERPART Safety cleaner

General cleaner in an aerosol container. Part number 21820128.

POWERPART Silicone adhesive

An RTV silicone adhesive for applications where low pressure tests occur before the adhesive sets. Used for sealing flange where oil resistance is needed and movement of the joint occurs. Part number 21826038.

POWERPART Silicone RTV sealing and jointing compound

Silicone rubber sealant which prevents leakage through gaps. Part number 1861108.

POWERPART Stud and bearing lock

To provide a heavy duty seal to components that have a light interference fit. Part number 21820119.

POWERPART Threadlock and nutlock

To retain small fasteners where easy removal is necessary. Currently Loctite 222e. Part number 21820119 or 21820120.

POWERPART Universal jointing compound

Universal jointing compound which seals joints. Part number 1861117.

2

Specifications

Basic engine data

Number of cylinders:

AA, AB, AC, AD, AE, AG, AH 4
YA, YB, YC, YD, YE 6
Cylinder arrangement .. .. In-line
Cycle ... ... Four stroke
Direction of rotation . ... Clockwise from the front

Induction system:

AA, AG, YA .. .. Naturally aspirated
AB, AH, YB .. .. Turbocharged
AC, YC. ... ... Altitude compensated
AD, AE, YD, YE ... ... Turbocharged/intercooled
Combustion system . ...Direct injection
Nominal bore ... ... 100 mm (3.937 in)
Stroke .. .. 127 mm (5.000 in)

Compression ratio:

AA, AG, YA 16.5:1
Certain YA engines 17.5:1
AB, AC, AD, AH, YB, YC, YD 16.0:1
AE, YE 17.5:1
Certain AD engines . ...17.25:1 or 17.5:1

Cubic capacity:

- Four cylinder engines ... ... 4 litres (243 in^3)
- Six cylinder engines .. .. 6 litres (365 in^3)

Firing order:

- Four cylinder engines 1, 3, 4, 2
- Six cylinder engines 1, 5, 3, 6, 2, 4

Valve tip clearance (cold):

Inlet .. .. 0,20 mm (0.008 in)
Exhaust ... ... 0,45 mm (0.018 in)

Lubricating oil pressure (minimum at maximum engine speed and normal engine temperature):

Engines without piston cooling jets .. .. .207 kpa (30 lbf/in^2) 2,1 kgf/cm^2
Engines with piston cooling jets ... ... .280 kpa (40 lbf/in^2) 2,8 kgf/cm^2

Data and dimensions

Note: This information is given as a guide for personnel engaged on engine overhauls. The dimensions which are shown are those which are mainly used in the factory. The information applies to all engines, unless an engine type code is shown.

Cylinder head

Angle of valve seat:

Exhaust 46° ... ... (88° included angle)
Inlet ... ... 46° (88° included angle) or 31° (118° included angle)
Diameter of parent bore for valve guide. ... ... 15,87/15,89 mm (0.6247/0.6257 in)
Leak test pressure . ... 200 kPa (29 lbf/in^2) 2,04 kgf/cm^2
Head thickness .. .. 102,79/103,59 mm (4.047/4.078 in)
Minimum permissible thickness after head face has been machined ... ...102,48 mm (4.035 in)
AE, YE engines.. ... ... See Operation 3-17

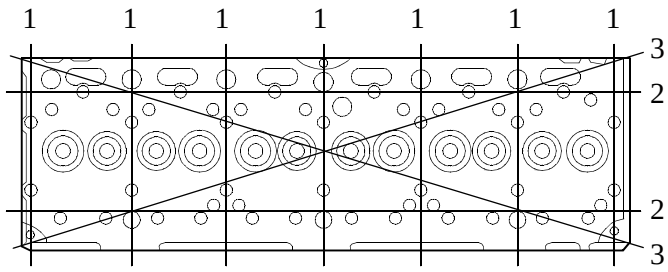
Maximum permissible distortion of cylinder head

Four cylinder engines

A1... ... ...0,08 mm (0.003 in)
A2... ... ...0,15 mm (0.006 in)
A3... ... ...0,15 mm (0.006 in)

Six cylinder engines

A1... ... ...0,13 mm (0.005 in)
A2... ... ...0,25 mm (0.010 in)
A3... ... ...0,25 mm (0.010 in)



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Inlet and exhaust valves

Inlet valves

Diameter of valve stem ... 9,46/9,49 mm (0.3725/0.3735 in)
Clearance in valve guide ... 0,02/0,10 mm (0.0008/0.0039 in)
Maximum clearance in valve guide ... 0,13 mm (0.005 in)
Diameter of valve head ... 44,86/45,11 mm (1.766/1.776 in)
Angle of valve face ... 45° or 30°
Full length ... 122,66/123,07 mm (4.829/4.845 in)
Seal arrangement ... Rubber seal fitted to valve guide

Depth of valve head below the face of cylinder head AA, AB, AC, AD, AG, AH, YA, YB, YC:

Production limits ... 1,27/1,60 mm (0.050/0.063 in)
Service limit ... 1,85 mm (0.073 in)
AD vehicle applications fitted with an intercooler ... 1,37/1,68 mm (0.054/0.066 in)
YA engines fitted with original valve seat inserts ... 1,37/1,68 mm (0.054/0.066 in)

Depth of valve head below the face of cylinder head YD:

Production limits ... 1,37/1,68 mm (0.054/0.066 in)
Engine build list YD 80571 ... 1,27/1,60 mm (0.050/0.063 in)

AE, YE engines:

Production limits (for 45° valves) ... 1,37/1,62 mm (0.054/0.064 in)
Service limit ... 1,85 mm (0.073 in)
Production limits (for 30° valves) ... 1,27/1,76 mm (0.050/0.069 in)
Service limit (for 30° valves) ... 2,01 mm (0.079 in)

Note: The inlet valve depth for certain engine types fitted with valve seat inserts can vary. The complete engine number must be given to the distributor when parts are needed.

Exhaust valves

Diameter of valve stem ... 9,43/9,46 mm (0.371/0.372 in)
Clearance in valve guide ... 0,05/0,13 mm (0.002/0.005 in)
Maximum clearance in valve guide ... 0,15 mm (0.006 in)
Diameter of valve head ... 37,26/37,52 mm (1.467/1.477 in)
Angle of valve face ... 45°
Full length ... 123,07/123,57 mm (4.845/4.865 in)
Seal arrangement ... Rubber seal fitted to valve guide

Depth of valve head below face of cylinder head AA, AB, AC, AD, AG, AH, YA, YB, YC:

Production limits ... 1,28/1,60 mm (0.050/0.063 in)
Service limit ... 1,85 mm (0.073 in)
AD vehicle applications fitted with an intercooler ... 1,47/1,79 mm (0.058/0.070 in)
YA engines fitted with original valve seat inserts ... 1,47/1,79 mm (0.058/0.070 in)

Depth of valve head below face of cylinder head AE, YD, YE:

Production limits ... 1,47/1,79 mm (0.058/0.070 in)
Service limit ... 1,85 mm (0.073 in)
Engine build list YD 80571 ... 1,28/1,60 mm (0.050/0.063 in)

Note: The exhaust valve depth for certain engine types fitted with valve seat inserts can vary. The complete engine number must be given to the distributor when parts are needed.

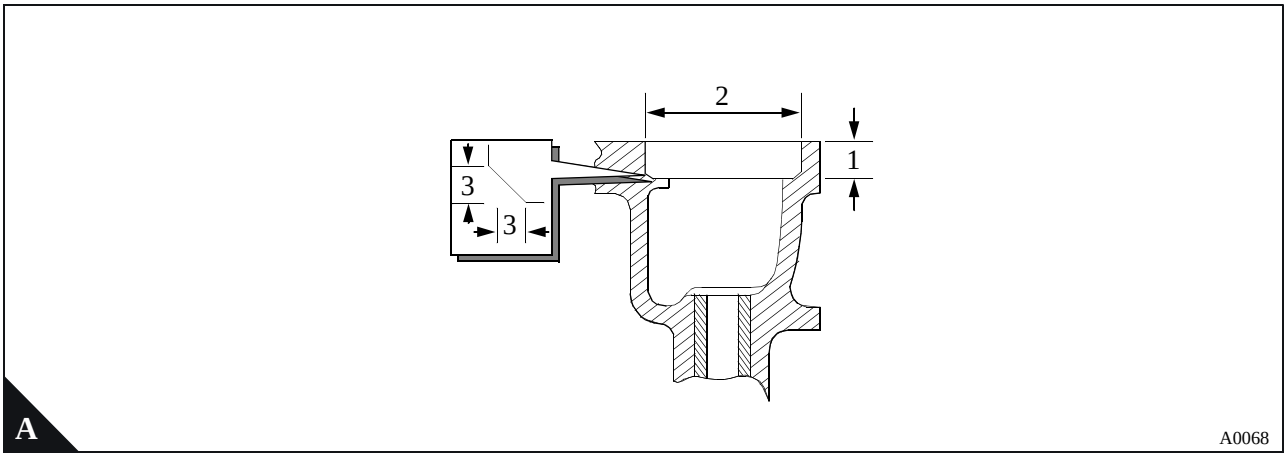
Dimensions of recesses for valve seat inserts

Inlet

A1... ... ... 7,19/7,32 mm (0.283/0.288 in)
A2... ... ... 51,22/51,24 mm (2.0165/2.0175 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum

Exhaust

A1... ... ... 9,52/9,65 mm (0.375/0.380 in)
A2... ... ... 42,62/42,65 mm (1.6780/1.6790 in)
A3... ... ... .Radius 0,38 mm (0.015 in) maximum



Valve seat insert tool

Inlet (for 45° valves)

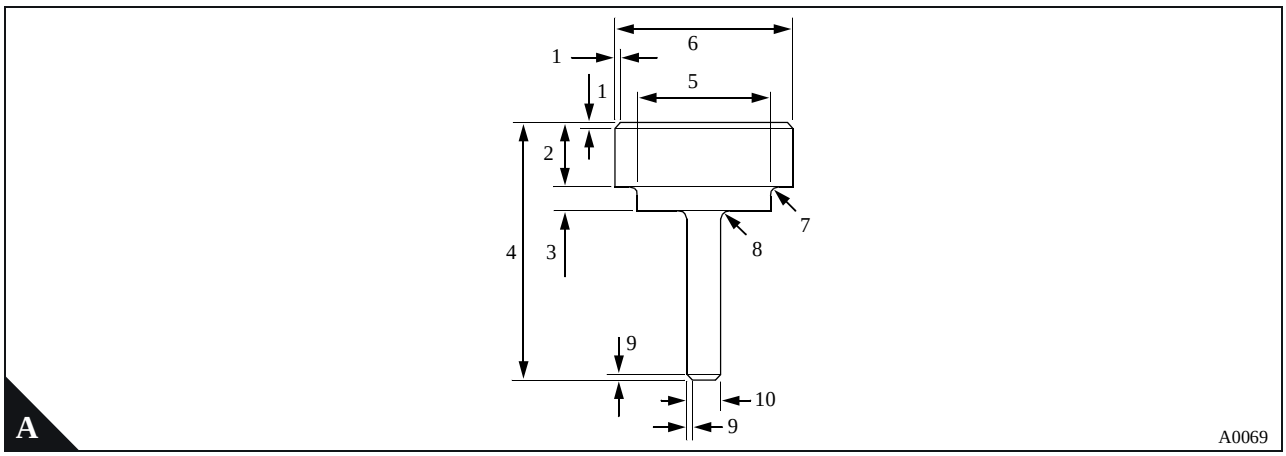
A1 ... 1,59 mm (0.063 in)
A2 ... 19,05 mm (0.750 in)
A3 ... 6,35 mm (0.250 in)
A4 ... 76,20 mm (3.00 in)
A5 ... 37,26/37,28 mm (1.467/1.468 in)
A6 ... 51,00/51,23 mm (2.008/2.017 in)
A7 ... 0,79 mm (0.031 in)
A8 ... 1,59 mm (0.063 in)
A9 ... 1,59 mm (0.063 in)
A10 ... 9,45/9,47 mm (0.372/0.373 in)

Inlet (for 31° valves)

A1 ... 1,59 mm (0.063 in)
A2 ... 19,05 mm (0.750 in)
A3 ... 3,00 mm (0.118 in)
A4 ... 76,20 mm (3.00 in)
A5 ... 35,30/35,60 mm (1.390/1.402 in)
A6 ... 43,94/43,99 mm (1.730/1.732 in)
A7 ... 0,79 mm (0.031 in)
A8 ... 1,59 mm (0.063 in)
A9 ... 1,59 mm (0.063 in)
A10 ... 9,45/9,47 mm (0.372/0.373 in)

Exhaust (for 45° valves)

A17 ... 1,59 mm (0.063 in)
A2 ... 19,05 mm (0.750 in)
A3 ... 7,92 mm (0.312 in)
A4 ... 76,20 mm (3.00 in)
A5 ... 32,58/32,84 mm (1.283/1.293 in)
A6 ... 42,39/42,62 mm (1,669/1.678 in)
A7 ... 0,79 mm (0.031 in)
A8 ... 1,59 mm (0.063 in)
A9 ... 1,59 mm (0.063 in)
A10 ... 9,45/9,47 mm (0.372/0.373 in)



Valve guides and valve springs

Valve guides

Inside diameter ... 9,51/9,56 mm (0.3744/0.3764 in)
Outside diameter ... 15,90/15,91 mm (0.6260/0.6265 in)
Interference fit of valve guide in cylinder head ... 0,03/0,07 mm (0.0012/0.0027 in)

Full length:

Inlet ... 57,94 mm (2.281 in)
Exhaust ... 61,10 mm (2.406 in)
Protrusion from bottom of recess for valve spring ... 15,10 mm (0.594 in)

Double valve springs (outer)

Fitted length ... 35,8 mm (1.41 in)
Load at fitted length ... 176/195 N (39.5/43.7 lbf) 18/20 kgf
Number of active coils ... 3.6
Number of damper coils ... 1
Direction of coils ... Left hand - damper coil to cylinder head

Double valve springs (inner)

Fitted length ... 34,0 mm (1.34 in)
Load at fitted length ... 89/104 N (20/23 lbf) 9/11 kgf
Number of active coils ... 4.9
Number of damper coils ... 1
Direction of coils ... Right hand - damper coil to cylinder head

Single valve springs

Fitted length ... 40,0 mm (1.57 in)
Load at fitted length ... 312/344 N (70.1/77.3 lbf) 31,8/35,1 kgf
Number of active coils ... 4.5
Number of damper coils ... 0
Direction of coils ... Left hand

Tappets, rocker shaft, rocker levers and bushes

Tappets

Diameter of tappet stem ... 18,99/19,01 mm (0.7475/0.7485 in)
Diameter of tappet bore in cylinder block ... 19,05/19,08 mm (0.7500/0.7512 in)
Clearance of tappet in cylinder block ... 0,04/0,09 mm (0.0015/0.0037 in)

Rocker shaft

Outside diameter ... 19,01/19,04 mm (0.7485/0.7495 in)

Rocker levers and bushes

Diameter of parent bore for bush ... 22,23/22,26 mm (0.8750/0.8762 in)
Outside diameter of bush ... 22,28/22,31 mm (0.8770/0.8785 in)
Interference fit of bush in rocker lever ... 0,020/0,089 mm (0.0008/0.0035 in)
Internal diameter of fitted bush when reamed ... 19,06/19,10 mm (0.7505/0.7520 in)
Clearance between rocker lever bush and rocker shaft ... 0,03/0,09 mm (0.001/0.0035 in)
Maximum permissible clearance between rocker lever bush and rocker shaft ... 0,13 mm (0.005 in)

Pistons and piston cooling jets

Pistons (naturally aspirated engines)

Type. ... "Quadram" combustion bowl, controlled expansion, inserted top ring groove
Diameter of bore for gudgeon pin ... 34,928/34,934 mm (1.3751/1.3754 in)
Height of piston above top face of cylinder block ... 0,14/0,36 mm (0.005/0.014 in)
Width of groove for top ring ... 2,57/2,59 mm (0.101/0.102 in)
Width of groove for second ring... 2,55/2,57 mm (0.100/0.101 in)
Width of groove for third ring ... 4,03/4,06 mm (0.1587/0.1598 in)

Pistons (turbocharged engines)

Type. ... "Quadram" combustion bowl, controlled expansion, inserted top ring groove, reduced diameter top land
Diameter of bore for gudgeon pin ... 38,103/38,109 mm (1.500/1.5004 in)
Height of piston above top face of cylinder block ... 0,14/0,36 mm (0.005/0.014 in)
Width of groove for top ring ... Tapered
Width of groove for second ring... 2,56/2,58 mm (0.1008/0.1016 in)
Width of groove for third ring ... 4,04/4,06 mm (0.1591/0.1598 in)

Pistons (turbocharged AE, YE,YD (1), AD (1) engines)

Type. ... "Fastram" combustion bowl, controlled expansion, inserted top ring groove, high top ring groove
Diameter of bore for gudgeon pin ... 39,7003/39,7009 mm (1.5355/1.5358 in)
Difference between height grades... 0,046 mm (0.0018 in)
Height of piston above top face of cylinder block ... 0,38/0,50 mm (0.015/0.020 in)
Width of groove for top ring ... Tapered
Width of groove for second ring... 2,56/2,58 mm (0.1008/0.1016 in)
Width of groove for third ring ... 4,04/4,06 mm (0.1591/0.1598 in)

(1) Some AD and YD lists are fitted with fastram pistons which are designed for use in emission controlled areas. Some of these pistons are non-expansion controlled.

Piston cooling jets (turbocharged engines)

Valve open pressure ... 178/250 kPa (26/36 lbf/in^2) 1,8/2,6 kgf/cm^2

Piston rings

Early naturally aspirated engines

Top compression ring ... Barrel face, molybdenum insert, with chamfer at the top of the inner face
Second compression ring ... Taper face, cast iron
Oil scraper ring ... Coil spring loaded, chromium faced
Width of top ring ... 2,48/2,49 mm (0.097/0.098 in)
Width of second ring ... 2,48/2,49 mm (0.097/0.098 in)
Width of third ring ... 3,98/3,99 mm (0.1566/0.1571 in)
Clearance of top ring in groove ... 0,08/0,11 mm (0.003/0.004 in)
Clearance of second ring in groove... 0,06/0,09 mm (0.002/0.003 in)
Clearance of third ring in groove ... 0,04/0,08 mm (0.002/0.003 in)
Gap of top ring... 0,40/0,85 mm (0.016/0.033 in)
Gap of second ring ... 0,30/0,76 mm (0.012/0.030 in)
Gap of third ring... 0,38/0,84 mm (0.015/0.033 in)

Later naturally aspirated engines

Top compression ring ... Barrel face, molybdenum insert, with chamfer at the top of the outer face and a step on the inner face
Second compression ring ... Tapered outer face with a step, cast iron
Oil scraper ring ... Coil spring loaded, chromium faced
Width of top ring ... 2,48/2,49 mm (0.097/0.098 in)
Width of second ring ... 2,48/2,49 mm (0.097/0.098 in)
Width of third ring ... 3,98/3,99 mm (0.1566/0.1571 in)
Clearance of top ring in groove ... 0,08/0,11 mm (0.003/0.004 in)
Clearance of second ring in groove ... 0,06/0,09 mm (0.002/0.003 in)
Clearance of third ring in groove ... 0,04/0,08 mm (0.002/0.003 in)
Gap of top ring ... 0,28/0,63 mm (0.011/0.025 in)
Gap of second ring ... 0,40/0,65 mm (0.016/0.033 in)
Gap of third ring ... 0,38/0,84 mm (0.015/0.033 in)

Turbocharged engines

Top compression ring ... Barrel face, molybdenum insert, wedge
Second compression ring ... Taper face, cast iron
Oil scraper ring ... Coil spring loaded, chromium face
Width of top ring ... Wedge
Width of second ring ... 2,48/2,49 mm (0.097/0.098 in)
Width of third ring ... 3,98/3,99 mm (0.156/0.157 in)
Clearance of top ring in groove ... Wedge
Clearance of second ring in groove ... 0,07/0,11 mm (0.003/0.004 in)
Clearance of third ring in groove ... 0,05/0,08 mm (0.002/0.003 in)
Gap of top ring ... 0,35/0,80 mm (0.014/0.031 in)
Gap of top ring with internal step ... 0,35/0,70 mm (0.014/0.028 in)
Gap of second ring ... 0,30/0,76 mm (0.012/0.030 in)
For second rings with outside step ... 0,40/0,85 mm (0.016/0.033 in)
Gap of third ring ... 0,38/0,84 mm (0.015/0.033 in)

Connecting rods and bearings

Connecting rods (naturally aspirated engines)

Type ... 'H' section, square shape small end
Location of cap to connecting rod ... Serrations
Diameter of parent bore for big end ... 67,21/67,22 mm (2.6460/2.6465 in)
Diameter of parent bore for small end ... 38,89/38,92 mm (1.531/1.532 in)
Length between centres ... 219,05/219,10 mm (8.624/8.626 in)

Connecting rods (turbocharged engines)

Type ... 'H' section, wedge shape small end

Location of cap to connecting rod:

Vehicle applications ... Flat joint face with dowels
Non-vehicle applications ... Serrations
Diameter of parent bore for big end ... 67,21/67,22 mm (2.6460/2.6465 in)
Diameter of parent bore for small end ... 42,056/42,083 mm (1.655/1.656 in)
Length between centres ... 219,05/219,10 mm (8.624/8.626 in)

Connecting rod bearings

Type:

- Naturally aspirated engines ... Steel back, aluminium/tin bearing material
- Turbocharged engines ... Steel back, lead bronze bearing material with lead finish

Width:

- Naturally aspirated engines ... 31,62/31,88 mm (1.245/1.255 in)
- Turbocharged engines ... 31,55/31,88 mm (1.240/1.255 in)

Thickness at centre of bearings:

- Naturally aspirated engines ... 1,835/1,842 mm (0.0723/0.0725 in)
- Turbocharged engines ... 1,835/1,844 mm (0.0723/0.0726 in)

Bearing clearance:

- Naturally aspirated engines ... 0,035/0,081 mm (0.0014/0.0032 in)
- Turbocharged engine ... 0,030/0,081 mm (0.0012/0.0032 in)

Available undersize bearings ... -0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Gudgeon pins and small end bushes

Gudgeon pins (naturally aspirated engines)

Type ... Fully floating
Outside diameter ... 34,920/34,925 mm (1.3748/1.3750 in)
Clearance fit in piston boss ... 0,003/0,014 mm (0.0001/0.0006 in)

Gudgeon pins (turbocharged engines)

Type ... Fully floating
Outside diameter ... 38,095/38,100 mm (1.4998/1.5000 in)
AE, YE and 110 Ti and 135 Ti AD lists ... 39,694/39,700 mm (1.5628/1.5630 in)
Clearance fit in piston boss ... 0,003/0,014 mm (0.0001/0.0006 in)

Small end bushes (naturally aspirated engines)

Type ... Steel back, lead-bronze or lead-bronze tin bearing material
Outside diameter ... 38,94/39,03 mm (1.535/1.536 in)
Inside diameter (reamed) ... 34,94/34,96 mm (1.3758/1.3765 in)
Clearance between bush in small end and gudgeon pin ... 0,020/0,043 mm (0.0008/0.0017 in)

Small end bushes (turbocharged engines)

Type ... Steel back, lead bronze bearing material
AE, YE, and certain AD lists **(1)** ... Steel back, lead bronze tin bearing materials
Outside diameter ... 42,16/42,19 mm (1.6600/1.6613 in)
Inside diameter (reamed) ... 38,12/38,14 mm (1.5008/1.5015 in)
AE, YE and certain AD lists **(1)** ... 39,719/39,738 mm (1.5637/1.5645 in)
Clearance between bush in small end and gudgeon pin ... 0,020/0,043 mm (0.0008/0.0017 in)
AE, YE ... 0,010/0,035 mm (0.0004/0.0014 in)
Certain AD lists **(1)** ... 0,023/0,044 mm (0.0009/0.0017 in)

(1) AD lists which are subject to emission legislation.

Crankshaft

Diameter of main journals:

- Four cylinder engines .. .. 76,16/76,18 mm (2.998/2.999 in)
- Six cylinder engines. ... ... 76,159/76,190 mm (2.9984/2.9996 in)

Maximum wear and ovality on journals and crank pins . ... 0,04 mm (0.0016 in)
Width of front journal.. ... ... 36,93/37,69 mm (1.454/1.484 in)
Width of centre journal ... ... 44,15/44,22 mm (1.738/1.741 in)
Width of all other journals .. .. 39,24/39,35 mm (1.545/1.549 in)
Diameter of crank pins ... ... 63,47/63,49 mm (2.499/2.500 in)
Width of crank pins ... ... 40,35/40,42 mm (1.589/1.591 in)
Diameter of flange.. ... ... 133,27/133,37 mm (5.247/5.251 in)

Depth of recess for spigot bearing:

- Four cylinder engines .. .. 20,22/20,98 mm (0.796/0.826 in)
- Six cylinder engines. ... ... 14,72/15,48 mm (0.579/0.609 in)

Bore of recess for spigot bearing:

- Four cylinder engines .. .. 46,96/46,99 mm (1.849/1.850 in)
- Six cylinder engines. ... ... 51,97/51,99 mm (2.046/2.047 in)

Crankshaft end-float... ... ... 0,05/0,38 mm (0.002/0.015 in)
Maximum permissible end-float . ...0,51 mm (0.020 in)
Fillet radii of journals and crank pins.. ... ... 3,68/3,96 mm (0.145/0.156 in)
Undersize journals and crank pins. ... ... -0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Crankshaft heat treatment

Induction hardened ... ... .Part numbers 31315662, 31315992, 31315993 and 3131H024
Nitrocarburised... ... ...Part numbers 31315661, 31315991 and 3131H022
60 hour Nitride ... ... Part number 3131H021
Nitreg . ... Part number 3131H031

Crankshaft overhaul

***Cautions*:**

- *The “Nitreg” process is a special factory process that needs specialist equipment and personnel with the correct training. Do not use any other heat treatment process on these crankshafts.*
- *In service it is not possible to regrind the “Nitreg” crankshaft for overhaul purposes. A “new for old” crankshaft is available.*

Notes:

- Induction hardened crank shafts need not be hardened after they have been machined undersize.
- Nitrocarburised crankshafts must be hardened again each time they are machined. These crankshafts must be nitrocarburised or, if this process is not available, they can be nitrided for 20 hours. If neither process is available a new crankshaft, or Power Exchange crankshaft, must be fitted.
- Crankshafts which have been nitrided for 60 hours can be reground 0,25 mm (0.010 in) without the need to harden them again.
- Check the crankshaft for cracks before and after it is ground. Demagnetise the crankshaft after it has been checked for cracks.
- After the crankshaft has been machined remove any sharp corners from the lubricating oil holes.
- Surface finish and fillet radii must be maintained.

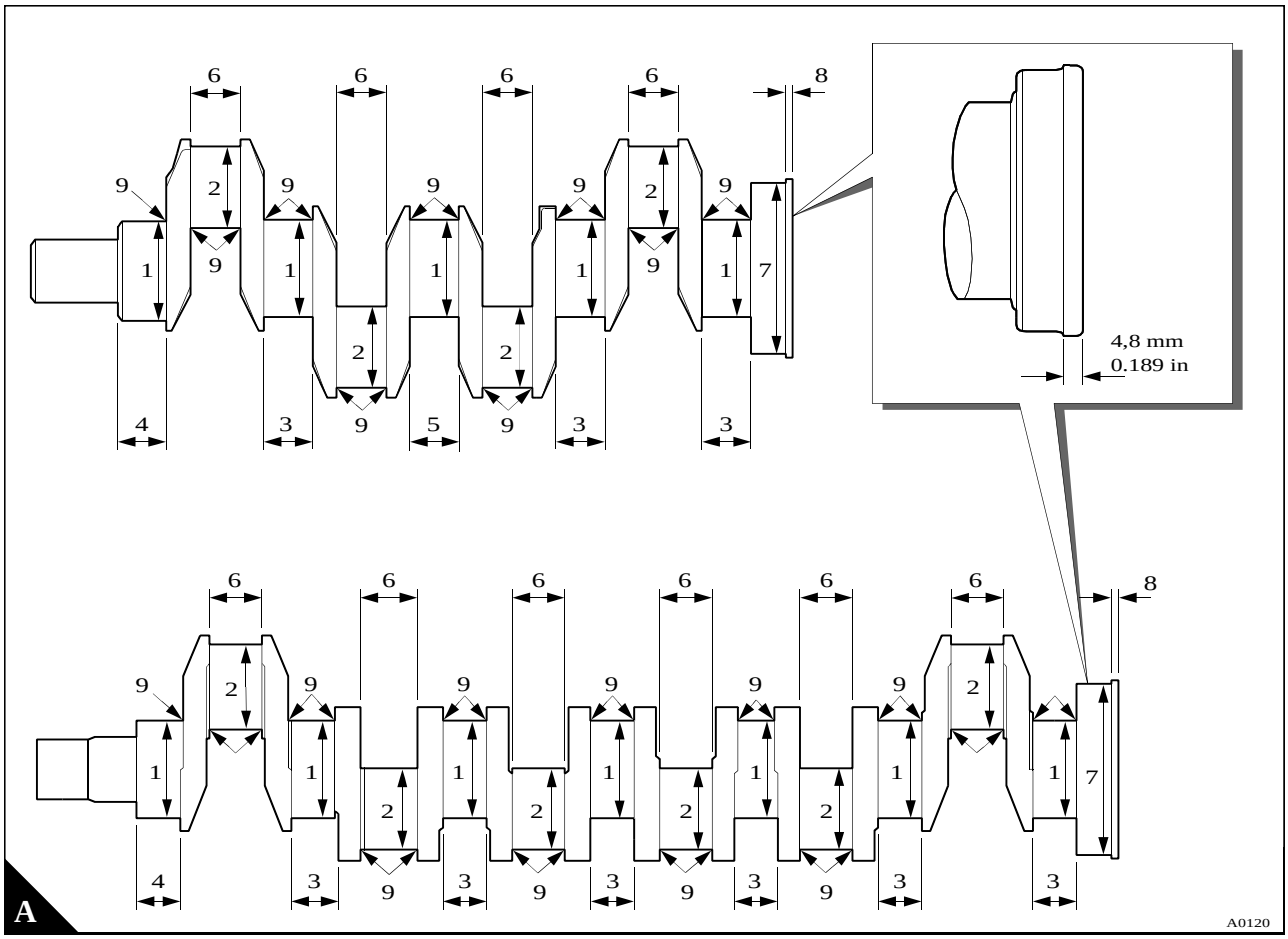
Continued

The finished sizes for crankshaft journals (A) which have been ground undersize are given in the table below:

Item	0,25 mm (0.010 in)	0,51 mm (0.020 in)	0,76 mm (0.030 in)
1	75,905/75,926 mm (2.9884/2.9892 in)	75,651/75,672 mm (2.9784/2.9792 in)	75,397/75,418 mm (2.9684/2.9692 in)
2	63,216/63,236 mm (2.4888/2.4896 in)	62,962/62,982 mm (2.4788/2.4796 in)	62,708/62,728 mm (2.4688/2.4696 in)
3	39,47 mm (1.554 in) maximum	-	-
4	37,82 mm (1.489 in) maximum	-	-
5	44,68 mm (1.759 in) maximum	-	-
6	40,55 mm (1.596 in) maximum	-	-
7	133,17 mm (5.243 in) minimum	-	-
8	Do not machine this diameter	-	-
9	3,68/3,96 mm (0.145/0.156 in)	-	-

Surface finish for journals, crank pins and fillet radii must be 0,4 microns (16 micro inches).

Surface finish for seal area of crankshaft palm must be 0,4/1,1 microns (16/43 micro inches).



With the crankshaft on mountings at the front and rear journals, the maximum run-out (total indicator reading) at the journals must not be more than shown below:

Journal	4 cylinder crankshafts	6 cylinder crankshafts
1	Mounting	Mounting
2	0,08 mm (0.003 in)	0,10 mm (0.004 in)
3	0,15 mm (0.006 in)	0,20 mm (0.008 in)
4	0,08 mm (0.003 in)	0,25 mm (0.010 in)
5	Mounting	0,20 mm (0.008 in)
6	-	0,10 mm (0.004 in)
7	-	Mounting

Run-out must not be opposite. The difference in run-out between one journal and the next must not be more than 0,10 mm (0.004 in).

Run-out on the crankshaft pulley diameter, rear oil seal diameter and the rear flange diameter must not be more than 0,05 mm (0.002 in) total indicator reading.

Crankshaft bearings and thrust washers

Main bearings

Four cylinder engines:

Type (All bearings) .. .. Steel back, 20% tin-aluminium bearing material

Six cylinder engines:

Centre bearing and all Phaser 210Ti bearings ... . Steel back, lead bronze bearing material with lead finish
All other bearings. ... ... Steel back, 20% tin-aluminium bearing material

Bearing width

Four cylinder engines:

Centre bearing. ... ... 36,32/36,70 mm (1.430/1.445 in)
All other bearings. ... ... 31,62/31,88 mm (1.245/1.255 in)

Six cylinder engines:

Centre bearing. ... ... 36,32/36,70 mm (1.430/1.445 in)
All other bearings. ... ... 30,86/31,12 mm (1.215/1.225 in)

Bearing thickness at centre

Four cylinder engines:

All bearings.. ... ... 2,083/2,089 mm (0.0820/0.0823 in)

Six cylinder engines:

Centre bearing and all Phaser 210Ti bearings ... ... 2,087/2,096 mm (0.0822/0.0825 in)
All other bearings. ... ... 2,083/2,089 mm (0.0820/0.0823 in)

Bearing clearance

Four cylinder engines:

All bearings.. ... ... 0,057/0,117 mm (0.0022/0.0046 in)

Six cylinder engines:

Centre bearing and all Phaser 210Ti bearings ... ... 0,035/0,110 mm (0.0014/0.0043 in)
All other bearings. ... ... 0,047/0,117 mm (0.0018/0.0046 in)
Available undersize bearings... ... ... -0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Crankshaft thrust washers

Type. ... ... Steel back, lead bronze bearing material
Position ... ... Each side of centre main bearing

Thickness:

Standard.. ... ... 2,26/2,31 mm (0.089/0.091 in)
Oversize .. .. 2,45/2,50 mm (0.096/0.098 in)

Balancer unit

Diameter of drive shaft for front bearing ... 28,562/28,575 mm (1.1245/1.1250 in)
Diameter of drive shaft for rear bearing ... 23,787/23,800 mm (0.9365/0.9370 in)
Number of teeth on gear of drive shaft ... 21
Backlash from gear of drive shaft to idler gear ... 0,17/0,29 mm (0.007/0.011 in)
End-float of drive shaft ... 0,13/0,30 mm (0.005/0.012 in)
Diameter of bore for front bearing of drive shaft ... 34,912/34,937 mm (1.3745/1.3755 in)
Diameter of bore for rear bearing of drive shaft ... 29,972/29,993 mm (1.1800/1.1808 in)
Diameter of bore for idler gear ... 47,64/47,65 mm (1.8755/1.8760 in)
Diameter of hub of idler gear ... 38,09/38,10 mm (1.4996/1.5000 in)
End-float of idler gear ... 0,07/0,23 mm (0.003/0.009 in)
Thickness of thrust washer for idler gear ... 4,14/4,29 mm (0.163/0.169 in)
Number of teeth on idler gear ... 37
Inside diameter of bushes in balancer frame and end cover (fitted) ... 38,133/38,174 mm (1.5013/1.5029 in)
Diameter of spigots for balance weights ... 38,054/38,069 mm (1.4982/1.4988 in)
Fit of spigot in bush ... 0,064/0,120 mm (0.0025/0.0047 in)
End-float of balance weights ... 0,19/0,40 mm (0.007/0.016 in)
Backlash of gears on balance weights ... 0,10/0,27 mm (0.004/0.011 in)
Backlash of drive gear to spline on balance weight ... 0,05/0,20 mm (0.002/0.008 in)
Number of teeth on drive gear ... 24
Number of teeth on spline on balance weight ... 16

Timing case and drive assembly

Camshaft

Diameter of number 1 journal ... 50,71/50,74 mm (1.9965/1.9975 in)
Diameter of number 2 journal ... 50,46/50,48 mm (1.9865.1.9875 in)
Diameter of number 3 journal:

Four cylinder engines ... 49,95/49,98 mm (1.9665/1.9675 in)
Six cylinder engines ... 50,20/50,23 mm (1.9765/1.9775 in)
Diameter of number 4 journal:

Six cylinder ... 49,95/49,98 mm (1.9665/1.9675 in)
Clearance of all journals ... 0,06/0,14 mm (0.0025/0.0055 in)
Cam lift:

Inlet ... 7,62/7,69 mm (0.2999/0.3029 in)
Exhaust ... 7,71/7,79 mm (0.3036/0.3066 in)
Maximum permissible ovality and wear on journals ... 0,05 mm (0.021 in)
End-float:

Production limits ... 0,10/0,41 mm (0.004/0.016 in)
Service limit ... 0,53 mm (0.021 in)
Width of spigot for thrust washer ... 5,64/5,89 mm (0.222/0.232 in)

Camshaft thrust washer

Type ... 360°
Depth of recess in cylinder block for thrust washer ... 5,46/5,54 mm (0.215/0.218 in)
Thickness of thrust washer ... 5,49/5,54 mm (0.216/0.218 in)
Relationship of thrust washer to front face of cylinder block ... -0,05/+0,08 mm (-0.002/+0.003 in)

Camshaft gear

Number of teeth ... 56
Diameter of bore ... 34,93/34,95 mm (1.3750/1.3760 in)
Outside diameter of hub of camshaft ... 34,90/34,92 mm (1.3741/1.3747 in)
Clearance fit of gear on hub ... 0,008/0,048 mm (0.0003/0.0019 in)

Fuel pump gear

Number of teeth ... 56

Bore:

AE, YE ... 36,00/36,06 mm (1.417/1.419 in)
All other engine types ... Tapered

Clearance fit on hub:

AE, YE ... 0,003/0,075 mm (0.0001/0.0030 in)

Crankshaft gear

Number of teeth ... 28
Diameter of bore ... 47,625/47,650 mm (1.8750/1.8760 in)
Diameter of hub for gear on crankshaft ... 47,625/47,645 mm (1.8750/1.8758 in)
Transition fit of gear on crankshaft ... -0,020/+0,048 mm (-0.0008/+0.0010 in)

Idler gear and hub

Number of teeth ... 63
Diameter of bore of gear ... 57,14/57,18 mm (2.2495/2.2512 in)
With needle roller bearings ... 69,01/69,03 mm (2.717/2.718 in)
Width of gear and split bush assembly (fitted in position) ... 30,14/30,16 mm (1.186/1.187 in)
Inside diameter of flanged bushes (fitted in position) ... 50,78/50,80 mm (1.9999/2.000 in)
Outside diameter of hub ... 50,70/50,74 mm (1.9960/1.9975 in)
With needle roller bearing ... 54,987/55,000 mm (2.1648/2.1654 in)
Clearance of bushes on hub ... 0,04/0,10 mm (0.0016/0.0039 in)

End float of gear:

Production limits ... 0,10/0,20 mm (0.004/0.008 in)
With needle roller bearings ... 0,24/0,33 mm (0.009/0.013 in)
Service limit ... 0,38 mm (0.015 in)
Backlash for all gears ... 0,08 mm (0.003 in) minimum

Idler gear and hub for the Bendix compressor

Number of teeth ... 32
Diameter of bore of gear ... 55,010/55,025 mm (2.1657/2.1663 in)
Outside diameter of hub ... 50,000/49,990 mm (1.9960/1.9975 in)
End float of gear with needle roller bearing fitted ... 0,12/0,16 mm (0.005/0.006 in)
Backlash gear ... 0,07 mm (0.003 in) minimum

Cylinder block assembly

Cylinder block

Height between top and bottom faces ... 441,12/441,33 mm (17.367/17.375 in)
Diameter of parent bore for cylinder liner ... 104,20/104,23 mm (4.103/4.104 in)
Depth of recess for flange of cylinder liner ... 3,81/3,91 mm (0.150/0.154 in)
Diameter of recess for flange of cylinder liner ... 107,82/107,95 mm (4.245/4.250 in)
Diameter of parent bore for main bearing ... 80,416/80,442 mm (3.1660/3.1670 in)

Camshaft bore diameter

Four cylinder engines:

Number 1 (for bush) ... 55,56/55,59 mm (2.188/2.189 in)
Number 2 ... 50,55/50,60 mm (1.990/1.992 in)
Number 3 ... 50,04/50,09 mm (1.970/1.972 in)

Six cylinder engines:

Number 1 (for bush) ... 55,56/55,59 mm (2.188/2.189 in)
Number 2 ... 50,55/50,60 mm (1.990/1.992 in)
Number 3 ... 50,29/50,34 mm (1.980.1.982 in)
Number 4 ... 50,04/50,09 mm (1.970/1.972 in)
Bore of bush for number 1 camshaft journal ... 50,79/50,85 mm (2.000/2.002 in)

Cylinder liners

Type:

Production ... Dry, interference fit, flanged
Service ... Dry, transition fit, flanged
Service ... Dry, transition fit, flanged, with flame ring
Partially finished liner ... Dry, interference fit, flanged, with flame ring

AE, YE, 110Ti and 135Ti AD lists:

Production ... Dry, interference fit, flanged, with flame ring
Outside diameter of production liner ... 104,25/104,28 mm (4.105/4.106 in)
Interference fit of production liner ... 0,03/0,08 mm (0.001/0.003 in)
Inside diameter of production liner ... 100,00/100,03 mm (3.937/3.938 in)
Transition fit of service liner ... +/- 0,03 mm (+/- 0.001 in)
Inside diameter of service liner (fitted) ... 100,04/100,063 mm (3.9385/3.9395 in)
Inside diameter of service liner with a flame ring (fitted) ... 100,00/100,063 mm (3.937/3.939 in)
Maximum permissible wear of liner bore ... 0,25 mm (0.010 in)
Thickness of flange ... 3,81/3,86 mm (0.150/0.152 in)
Relative position of top of liner flange to top face of cylinder block ... 0,10 mm (0.004 in) above
... 0,10 mm (0.004 in) below

Partially finished liner

Inside diameter of partially finished liner ... 99,162/99,415 mm (3.9040/3.9139 in)
Interference fit of partially finished liner in parent bore ... 0,025/0,076 mm (0.003/0.001 in)
Hone angle (cross hatch) ... 30°/35°
Final finish grade, silicon carbide (Plateau hone) ... 0,65/1,3 micrometers
Inside diameter of finished liner ... 100,00/100,03 mm (3.937/3.938 in)

Engine timing (Bosch EPVE fuel injection pump)

Fuel injection pump

Type ... ... Early EPVE without a locking screw
Direction of rotation from drive end ... ... Clockwise
Outlet for number 1 cylinder ... ... "C"

Note: For details of the later model Bosch EPVE fuel injection pumps fitted with a locking screw, see "Bosch EPVE fuel injection pump (with a locking screw)" on page 278.

Static timing

The engine check angle must be used with special tool 21825610 and with the engine set with number 1 piston at top dead centre (TDC) on compression stroke. The pump mark angle and the piston displacement are checked with the pump plunger set at 1,00 mm (0.039 in) plunger lift.

The code letters are included in the setting code stamped on the side of the fuel injection pump. Some fuel pumps may have the setting code stamped on a modification plate which is fastened to the flange of the pump. If a modification plate is fitted, use the code letters stamped on this plate.

A typical setting code is 2643J603DK/1/3020; in this example the code letters are "DK".

Fuel pump code letters	Engine check angle (degrees)	Pump mark angle (degrees)	Static timing position before TDC (degrees)	Piston displacement	
				mm	in
BK	308	314	12	1,78	0.070
CK	308	314	12	1,78	0.070
DK	306	313	14	2,42	0.095
EK	308.5	315.5	14	2,42	0.095
EK(1)	306.5	315.5	18	3,99	0.157
EL	-	-	9	-	-
EM	288.5	295.5	14	2,42	0.095
FM	289	295	12.5	1,93	0.076
JM	-	-	6	-	-
JM(3)	-	-	2	-	-
JM(4)	-	-	TDC	-	-
KC(2)	-	-	TDC	-	-
KL(2)	-	-	TDC	-	-
ML(2)	-	-	TDC	-	-
PM	-	-	12	-	-
SK	-	-	9	-	-
TL(2)	-	-	TDC	-	-
VM	-	-	2 ATDC	-	-

(1) Engines to build list YA80433 with the data plate of the fuel injection pump stamped J609.
(2) The cold start device (KSB) must be energised before the timing is set, see Operation 11-19.
(3) Engines to build lists AD70229 and AD70230.
(4) Engines to build list AD80643

Engine timing (Bosch in-line fuel injection pump)

Fuel injection pump

Fuel pump type .. .. MW
Direction of rotation from drive end ... ... Clockwise
Outlet for number 1 cylinder... ... ... Drive end of fuel pump

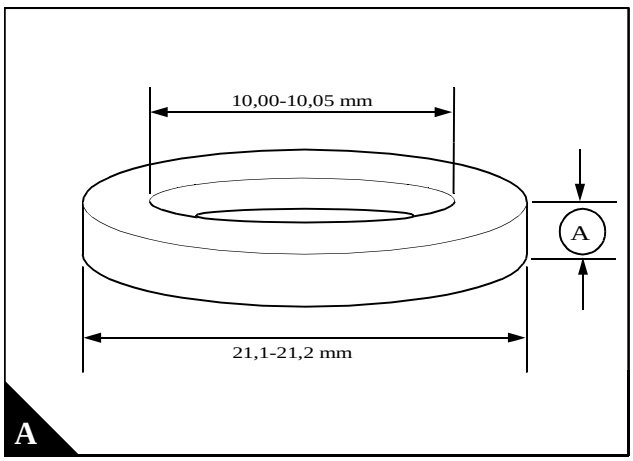
Static timing

The piston position probe 21825630 or 21825947 is used to set the engine check angle to 100° BTDC.

A locally made washer (A) must be fitted onto the piston position probe when the engine check angle is less than 100° BTDC.

The thickness of the piston position probe washer, dimension A, for a particular engine is shown in the table below. The general dimensions for the piston position probe washer are shown in (A).

Fuel pump code	Engine check angle (degrees)	Piston position probe washer thickness (mm)
WM	98	2,302
HL	100	-
LC	100	-
MC	100	-
VK	100	-



Engine timing (Lucas CAV/Delphi DPA and DPS) fuel injection pump

Fuel injection pump

Type. ... ... DPA or DPS
Direction of rotation from drive end . ... Clockwise

Outlet for number 1 cylinder:

- AA, AB, AC, AD. ... ... Letter "W"
- YA, YB, YC, YD. ... ... Letter "Y"

Static timing

The engine check angle must be used with special tool 21825610 and with the engine set with number 1 piston at top dead centre (TDC) on the compression stroke. The pump is checked with the pump set at the start of injection for number 1 cylinder.

The code letters are included in the setting code stamped on the data plate of the fuel injection pump. Some fuel pumps may have the setting code stamped on a modification plate which is fastened to the flange of the pump. If a modification plate is fitted, use the code letters stamped on this plate.

A typical setting code is 2643C601BM/4/2860; in this example the code letters are "BM".

Fuel pump code letters	Engine check angle (degrees)	Pump mark angle (degrees)
AK	325.5	336
AM	282	290.5
BF	326	334
BM	281	291
CM	282.5	291.5
DM	282.25	290.5
FK	325.5	336
GK	325	336
GM	282	290.5
HK	326	336
HM	282	291
JK	325	334
KK	325	334
LK	327	337.5
LK**(1)**	328	337.5
MK	326	336
MK**(2)**	325	336
PK	326	334
RK	328	336
RM	282.5	290.5
TK	327	334
UK	326	334
XM	282	291

(1) Effective from engine list YA 31257.
(2) Effective from engine list YA 50532.

Engine timing (Stanadyne fuel injection pump)

Fuel injection pump

Type ... ... Stanadyne DB2 or DB4

Outlet for number 1 cylinder:

- Four cylinder engines .. .. 8 o'clock position as seen from the rear of the pump
- Six cylinder engines. ... ... 9 o'clock position as seen from the rear of the pump

Direction of rotation from drive end ... ... Clockwise
Fuel system ... ...Self-vent

Static timing

The engine check angle must be used with special tool 21825610 and with the engine set with the piston of the number 1 cylinder at top dead centre (TDC) on the compression stroke. The pump is checked with the pump set at the start of injection for the number one cylinder.

Fuel pump code letters	Engine check angle (degrees)	Pump mark angle (degrees)
AC	282	291
AL	326	336
BL	326	336
CL	327	333
CL (1)	-	247.5
DL	332	338
FL	326	333
GL	326	332
HC	282	290.5
JL	325	334.5
KM	282	290
LM	282	287
LM (2)	288.5	295
MM	282	287
MM (3)	288.5	295
NC	282	294
SL	331.5	338
SM	282	291
TC	282	290
TM	282	290.5
UC	228.5	296
VL	326	389
XK	325	331.5
YK	325	334.5
YL	330	338
ZK	326	334
ZM (4)	282	287
ZM (5)	282	289

(1) Pin timed fuel injection pump.
(2) For engines fitted fuel injection pumps part numbers 2643U211 and 2643U213.
(3) For engines fitted fuel injection pump part number 2643U214.
(4) Effective from pump serial number 7665964.
(5) Effective from pump serial number 7665965.

Aspiration system

Turbocharger

The make and type of turbocharger fitted is marked on the turbocharger identification plate; as a general guide the make and type of turbocharger fitted are as follows:

AB ... ... Garrett T31 or Schwitzer S2A
AC ... ... Schwitzer S2A
AD ... ... Schwitzer S2A
AE ... ... Garrett T25
AH ... ... Garrett T25
YB ... ... Garrett T04B, TBP4 or Schwitzer S2B
YD ... ... Schwitzer S76
YE ... ... Garrett TBP4

Waste-gate test pressure for rod movement of 1,00 mm (0.039 in)

The turbocharger part number is on the turbocharger identification plate, which is fitted to the body of the turbocharger.

Turbocharger part number	Waste-gate pressure			Turbocharger part number	Waste-gate pressure		
	(kPa)	(lbf/in^2)	(kgf/cm^2)		(kPa)	(lbf/in^2)	(kgf/cm^2)
2674A053	113-120	16.4-17.4	1,20-1,28	2674A081	88-98	12.8-14.2	0,90-1,00
2674A054	110-120	16.0-17.4	1,12-1,22	2674A082	88-92	12.8-13.3	0,90-0,93
2674A055	120-130	17.4-18.9	1,22-1,32	2674A084	118-128	17.1-18.5	1,20-1,30
2674A056	120-130	17.4-18.9	1,22-1,32	2674A085	88-98	12.8-14.2	0,90-1,00
2674A057	118-126	17.1-18.3	1,20-1,28	2674A086	118-128	17.1-18.6	1,20-1,30
2674A058	118-126	17.1-18.3	1,22-1,32	2674A087	101-109	14.7-15.6	1,03-1,11
2674A059	118-126	17.1-18.3	1,20-1,28	2674A128	101-109	14.6-15.8	1,02-1,11
2674A062	113-120	16.4-17.4	1,15-1,22	2674A129	101-109	14.6-15.8	1,02-1,11
2674A063	92-98	13.3-14.2	0,93-0,99	2674A130	113-120	16.4-17.4	1,15-1,22
2674A064	110-103	15.9-14.9	1,11-1,04	2674A131	101-109	14.6-15.8	1,02-1,11
2674A067	120-130	17.4-18.9	1,22-1,32	2674A138	113-120	16.4-17.4	1,15-1,22
2674A068	110-103	15.9-14.9	1,11-1,04	2674A139	120-130	17.4-18.9	1,22-1,32
2674A072	120-130	17.4-18.9	1,22-1,32	2674A144	113-120	16.4-17.4	1,15-1,22
2674A075	118-126	17.1-18.3	1,20-1,28	2674A146	113-120	16.4-17.4	1,15-1,22
2674A077	113-120	16.4-17.4	1,15-1,22	2674A149	133-143	19.3-20.7	1,35-1,45
2674A078	110-120	16.0-17.4	1,12-1,22	2674A150	145-155	21.0-22.5	1,47-1,58
2674A079	120-130	17.4-18.9	1,22-1,32	2674A306	143- 153	20.8- 22.2	1,46- 1,56

Lubrication system

Lubricating oil pump (four cylinder engines)

Type ... Differential rotor, gear driven
Number of lobes ... Inner rotor 6, outer rotor 7

Clearance of outer rotor to body:

Without balancer unit ... 0,15/0,34 mm (0.006/0.013 in)
With balancer unit ... 0,31/0,45 mm (0.012/0.017 in)
Clearance of inner rotor to outer rotor ... 0,04/0,13 mm (0.0015/0.0050 in)
End-float of rotor assembly ... 0,03/0,10 mm (0.001/0.004 in)

Lubricating oil pump (six cylinder engines)

Type ... Differential rotor, gear driven

Number of lobes:

Inner rotor ... 4
Outer rotor ... 5
Clearance of outer rotor to body ... 0,15/0,34 mm (0.006/0.013 in)
Clearance of inner rotor to outer rotor ... 0,04/0,13 mm (0.0015/0.0050 in)

End clearance YA, YC:

Inner rotor ... 0,05/0,12 mm (0.002/0.005 in)
Outer rotor ... 0,04/0,11 mm (0.0015/0.0044 in)

End clearance (six cylinder turbocharged engines):

Inner rotor ... 0,043/0,118 mm (0.0017/0.0046 in)
Outer rotor ... 0,031/0,106 mm (0.0012/0.0042 in)

Idler gear for lubricating oil pump

End float ... 0,03/0,33 mm (0.001/0.013 in)
Inside diameter of bush (fitted) ... 22,23/22,26 mm (0.875/0.866 in)
Outside diameter of idler shaft ... 22,19/22,21 mm (0.873/0.874 in)
Clearance of bush of idler gear on shaft ... 0,020/0,066 mm (0.0008/0.0026 in)

Oil pressure relief valve (standard)

Diameter of bore for plunger ... 18,24/18,27 mm (0.718/0.719 in)
Outside diameter of plunger ... 18,16/18,18 mm (0.715/0.716 in)
Clearance of plunger in bore ... 0,06/0,11 mm (0.002/0.004 in)

Length of spring (fitted):

- Four cylinder engines ... 59,8 mm (2.4 in)
- Six cylinder engines ... 55,6 mm (2.2 in)

Load on spring (fitted):

- Four cylinder engines ... 15,9/23,1 N (3.6/5.2 lbf) 1,6/2,4 kgf
- Six cylinder engines ... 12,9/18,6 N (2.9/4.2 lbf) 1,3/1,9 kgf

Pressure to open valve (four cylinder engines):

- Without piston cooling jets ... 340/395 kPa (49/57 lbf/in^2) 3,4/4,0 kgf/cm^2
- With piston cooling jets ... 415/470 kPa (60/68 lbf/in^2) 4,2/4,8 kgf/cm^2
- Six cylinder engines ... 345/414 kPa (50/60 lbf/in^2) 3,5/4,2 kgf/cm^2

Oil pressure relief valve (with balancer)

Diameter of bore for plunger ... ... 16,00/16,03 mm (0.630/0.631 in)
Outside diameter of plunger ... ... 15,95/15,98 mm (0.628/0.629 in)
Clearance of plunger in bore ... ... 0,02/0,08 mm (0.0008/0.003 in)
Length of spring (fitted) ... ... 42,7 mm (1.7 in)

Load on spring (fitted):

- Engines without piston cooling jets ... ... .24/30 N (5.4/6.7 lbf) 2,4/3,1 kgf
- Engines with piston cooling jets ... ... .34/38 N (7.6/8.5 lbf) 3,5/3,9 kgf

Pressure to open valve:

- Engines without piston cooling jets ... ... 414 kPa (60 lbf/in^2) 4,2 kgf/cm^2
- Engines with piston cooling jets ... ... 523 kPa (76 lbf/in^2) 5,3 kgf/cm^2

Oil filter

Type. ... ... Full flow, screw-on type canister
Pressure to open by-pass valve in filter... ... ... 55/83 kPa (8/12 lbf/in^2) 0,6/0,8 kgf/cm^2
Pressure to open by-pass valve in oil cooler... ... ... 172 kPa (25 lbf/in^2) 1,8 kgf/cm^2

Fuel system

Fuel lift pump (four cylinder engines)

Type ... A.C.Delco, type XD
Method of drive ... Eccentric on camshaft of engine
Static pressure (no delivery) ... 42/70 kPa (6/10 lbf/in^2) 0,4/0,7 kgf/cm^2
Test pressure (75% of minimum static pressure) ... 31 kPa (4.5 lbf/in^2) 0,32 kgf/cm^2

Fuel lift pump (six cylinder engines)

Type ... A.C.Delco, type LU
Method of drive ... Eccentric on camshaft of engine
Static pressure (no delivery) ... 34,5/55,2 kPa (5/8 lbf/in^2) 0,35/0,56 kgf/cm^2
Test pressure (75% of minimum static pressure) ... 26 kPa (3.75 lbf/in^2) 0,26 kgf/cm^2

Fuel filter

Type ... Twin parallel flow or single element

Fuel lift pump (AE, YE - four and six cylinder engines)

Type ... Bosch, FP/KG24MW304
Method of drive ... Eccentric on camshaft of engine or on camshaft of fuel injection pump

Fuel filter

Type ... Twin parallel flow or single element

Fuel lift pump (engines with a Bosch in-line fuel injection pump)

Type ... Bosch, FP/KG24MW304
Method of drive ... Eccentric on camshaft of engine or on camshaft of fuel injection pump

Fuel filter

Type ... Twin parallel flow or single element

Atomiser service settings

Code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in^2)	MPa
HU	2645A302	2645A604	220	3233	22,3
HV	2645A302	2645A606	250	3674	25,3
HZ	2645A302	2645K603	220	3233	22,3
JA	2645A302	2645A607	250	3674	25,3
JB	2645A302	2645A608	250	3674	25,3
JE	2645A302	2645A608	220	3233	22,3
JF	2645A304	2645A606	250	3674	25,3
JG	2645A304	2645A607	230	3380	23,3
JH	2645A302	2645A612	250	3674	25,3
JJ	2645A302	2645A611	250	3674	25,3
JK	2645A302	2645A613	220	3233	22,3
JL	2645A304	2645A614	250	3674	25,3
JR	2645A304	2645A615	250	3674	25,3
JS	2645A304	2645A612	250	3674	25,3
JT	2645A304	2645A616	250	3674	25,3
JU	2645A302	2645A617	220	3233	22,3
JY	2645A302	2645A621	250	3674	25,3
KC	2645L309	2645A625	286	4203	29,0
KD	2645L310	2645A626	290	4262	29,4
KE	2645L311	2645A627	290	4262	29,4
KF	2645L311	2645A628	290	4262	29,4
KG	2645L314	2645A629	290	4262	29,4
KN	2645L315	2645A635	290	4262	29,4
KP	2645L318	2645A636	290	4262	29,4
KU	2645L317	2645A627	290	4262	29,4
KW	2645L311	2645K609	290	4262	29,4
NJ	2645L304	2645L607	220	3233	22,3
NK	2645L305	2645L609	225	3307	22,8
NL	2645L305	2645L608	225	3307	22,8
NM	2645L304	2645L611	230	3380	23,3
NN	2645L303	2645L612	230	3380	23,3
NP	2645L304	2645L613	220	3233	22,3
NR	2645L303	2645L614	230	3380	23,3
NS	2645L303	2645L612	250	3674	25,3
NT	2645L304	2645L615	230	3380	23,3
NU	2645L303	2645L605	220	3233	22,3
NV	2645L304	2645L616	220	3233	22,3
NW	2645L303	2645L613	220	3233	22,3
NX	2645L306	2645L617	290	4262	29,4
PC	2645L310	2645L622	290	4262	29,4
PD	2645L310	2645L622	275	4041	27,9
PE	2645L306	2645L617	280	4115	28,4
RD	2645F303	2645F603	247	3630	25,0
RE	2645F304	2645F604	247	3630	25,0
RF	2645F304	2645F605	247	3630	25,0
RH	2645F304	2645F608	247	3630	25,0
RK	2645F304	2645F610	266	3902	27,0

Code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in^2)	MPa
RM	2645F306	2645F611	247	3630	25,0
RN	2645F306	2645F612	247	3630	25,0
RP	2645F309	2645F611	247	3630	25,0
RR	2645F307	2645F614	247	3630	25,0
RS	2645F307	2645F615	247	3630	25,0
RT	2645F308	2645F616	247	3630	25,0
RU	2645F310	2645F617	247	3630	25,0
RV	2645F311	2645F610	247	3630	25,0

Note: The code letters are stamped on the side of the atomiser body just below the connection for the nut of the high pressure pipe.

Cooling system

Coolant pump (four cylinder engines and early six cylinder engines)

Type. ... ... .Centrifugal, gear driven
Outside diameter of shaft for drive gear .. ..15,91/15,92 mm (0.6262/0.6257 in)
Diameter of bore of drive gear. ... ...15,85/15,88 mm (0.6244/0.6252 in)
Interference fit of drive gear on shaft... ... ...0,03/0,06 mm (0.0012/0.0024 in)
Diameter of bore of impeller ... ...15,87/15,89 mm (0.6249/0.6257 in)
Outside diameter of shaft for impeller.. ... ...15,91/15,92 mm (0.6264/0.6268 in)
Interference fit of impeller on shaft .. ..0,02/0,05 mm (0.0007/0.0020 in)
Diameter of bearing . ...29,99/30,00 mm (1.1807/1.1811 in)
Diameter of bore for bearing ... ...29,96/29,98 mm (1.1795/1.1803 in)
Interference fit of bearing in pump body .. ..0,01/0,04 mm (0.0004/0.0016 in)
Dimension of impeller boss to front face of pump body (fitted) - early engines ... .8,1/8,5 mm (0.319./0.335 in)
Dimension of impeller boss to front face of pump body (fitted) - latest engines (1).. .7,1/7,5 mm (0.28./0.30 in)
Dimension of gear from rear face of pump body (fitted) .. ..0,6/2,6 mm (0.024/0.102 in)

(1) Impeller part number 3746X071.

Coolant pump (six cylinder engines and later four cylinder engines)

Type. ... ... .Centrifugal, gear driven
Outside diameter of shaft ... ...18,95/18,96 mm (0.7460/0.7465 in)
Diameter of bore of drive gear. ... ...18,90/18,92 mm (0.7441/0.7449 in)
Interference fit of drive gear on shaft... ... ...0,03/0,06 mm (0.0012/0.0024 in)
Diameter of bore of impeller ... ...15,87/15,89 mm (0.6249/0.6257 in)
Outside diameter of shaft for impeller.. ... ...15,91/15,92 mm (0.6264/0.6268 in)
Interference fit of impeller on shaft .. ..0,02/0,05 mm (0.0007/0.0020 in)
Diameter of bore for bearing ... ...38,06/38,08 mm (1.4983/1.4993 in)
Diameter of bearing . ...38,09/38,10 mm (1.4995/1.5000 in)
Interference fit of bearing in pump body .. ..0,01/0,04 mm (0.0004/0.0016 in)
Dimension of impeller boss to front face of pump body (fitted) ... ... .7,7/8,0 mm (0.303./0.315 in)
Dimension of gear from rear flat face of pump body (fitted) ... ...21,0/21,5 mm (0.827/0.846 in)
Dimension of gear from rear face of bearing (fitted) ... ...0,47/1,53 mm (0.018/0.060 in)

Auxiliary coolant pump (fitted to certain intercooled engines)

Type. ... ... Centrifugal, belt driven
Outside diameter of shaft for pulley. ... ...15,001/15,009 mm (0.5906/0.5909 in)
Inside diameter of bore of pulley . ...14,935/14,956 mm (0.5879/0.5888 in)
Interference fit of pulley on shaft . ...0,05/0,07 mm (0.0019/0.0028 in)
Diameter of bore of impeller ... ... 15,875/15,893 mm (0.625/0.6257 in)
Outside diameter of shaft ... ...15,9055/15,9182 mm (0.6263/0.6267 in)
Interference fit of impeller on shaft .. ..0,01/0,04 mm (0.0004/0.0016 in)
Impeller to body clearance .. ..0,64/0,89 mm (0.025/0.035 in)

Coolant pump

Type. ... ... Centrifugal, belt driven
Outside diameter of shaft for pulley. ... ...24,587/24,600 mm (0.9679/0.9685 in)
Inside diameter of bore of pulley . ...24,628/24,648 mm (0.9696/0.9704 in)
Clearance fit of pulley on shaft ... ...0,03/0,06 mm (0.001/0.002 in)
Diameter of bore of impeller ... ...15,872/15,893 mm (0.6248/0.6257 in)
Outside diameter of shaft for impeller.. ... ...15,9055/15,9182 mm (0.6263/0.6267 in)
Interference fit of impeller on shaft .. ..0,01/0,04 mm (0.0004/0.0016 in)
Impeller to body clearance .. ..0,69/0,89 mm (0.027/0.035 in)
Diameter of bearing . ... 62,000 mm (2.440 in)
Diameter of bore for bearing ... ... 62,019/62,000 mm (2.441/24.000 in)
Interference fit of bearing in pump body .. ..0,01/0,04 mm (0.0004/0.0016 in)

Thermostat

Type:

Four cylinder engines. ... ...Single, wax element, by-pass blanking
Six cylinder engines... ... ... .Twin, wax element, by-pass blanking

Nominal temperature stamped on thermostat by-pass valve	"Start to open" temperature	"Fully open" temperature	Minimum valve lift, fully open
82 °C (180 °F)	77/85 °C (170/185 °F)	92/98 °C (198/208 °F)	9 mm (0.35 in)
71 °C (160 °F)	67/75 °C (153/167 °F)	85/88 °C (185/190 °F)	9 mm (0.35 in)

Fan drive housing

Early engines:

Bore of housing for bearing ... ... 41,98/41,99 mm (1.6527/1.6531 in)
Outside diameter of bearing... ... ... 41,99/42,00 mm (1.6531/1.6535 in)
Interference fit of bearing in housing.. ... ... 0,00/0,02 mm (0.0000/0.0008 in)
Bore of hub ... ... 21,946/21,958 mm (0.8640/0.8645 in)
Outside diameter of shaft... ... ... 21,987/22,000 mm (0.8656/0.8661 in)
Interference fit of shaft in hub ... ... 0,029/0,054 mm (0.0011/0.0021 in)
Maximum permissible end-float of shaft ... ...0,25 mm (0.010 in)

Latest engines:

Bore of housing for bearing ... ... 41,97/41,98 mm (1.6524/1.6527 in)
Outside diameter of bearing... ... ... 41,99/42,00 mm (1.6531/1.6535 in)
Interference fit of bearing in housing.. ... ... 0,01/0,03 mm (0.0004/0.0012 in)
Bore of hub ... ... 21,938/21,958 mm (0.8637/0.8645 in)
Outside diameter of shaft... ... ... 21,987/22,000 mm (0.8656/0.8661 in)
Interference fit of shaft in hub ... ... 0,029/0,062 mm (0.0011/0.0024 in)
Maximum permissible end-float of shaft ... ... 0,25 mm (0.010 in)

Flywheel and flywheel housing

Limits for flywheel housing run-out and alignment (total indicator reading)

Diameter of housing flange bore		Maximum limit (total indicator reading)	
mm	in	mm	in
362	14.25	0,23	0.009
410	16.14	0,25	0.010
448	17.63	0,28	0.011
511	20.11	0,30	0.012
584	22.99	0,36	0.014
648	25.51	0,41	0.016
787	30.98	0,48	0.019

Electrical equipment

Note: The information which follows is general and can change with specific applications.

Alternators

Make and type ... ... Lucas, AC5RA, AC5RS, A127 and Butec 5524

Rating:

Lucas:

AC5RA and AC5RS ... ... 12V/60A or 24V/40A
A127 ... ... 12V/55A or 12V/65A

Butec:

5524 ... ... 24V/55A
Rotation ... ... Clockwise from drive end

Starter motors

Make and type ... ... CAV M45G, CAV S115 or Lucas M127

Voltage:

M45G and S115 ... ... 12V or 24V
M127 ... ... 12V
Number of teeth on pinion 10

Maximum starter cable resistance at 200 °C (680 °F):

12V ... ... 0.0017 ohms
24V ... ... 0.0034 ohms

Starting aid

Type ... ... Electrically operated heater, with a fuel supply
Voltage ... ... 12V (dropping resistor used on 24V system)
Flow rate of fuel through starting aid ... ... 3,5/5,9 ml/min

Auxiliary equipment

Wabco compressor

Type ... Wabco 159 or 229

Number of teeth on compressor drive gear:

- Early compressor ... 26
- Latest compressor ... 42

Inside diameter of drive gear:

- Early compressors ... 23,750/23,775 mm (0.9350/0.9360 in)
- Latest compressors ... 23,773/23,790 mm (0.9359/0.9366 in)

Outside diameter of compressor drive shaft ... 23,753/23,765 mm (0.9352/0.9356 in)
Transition fit of gear on shaft of early compressors ... - 0,015/+0,022 mm (-0.0006/+0.0009 in)
Clearance fit of gear on shaft of latest compressors ... 0,008/0,037 mm (0.0003/0.0014 in)
Bore for bush ... 19,000/19,030 mm (0.7480/0.7492 in)
Inside diameter of bush ... 15,875/15,900 mm (0.625/0.626 in)
Outside diameter of bush ... 19,050/19,075 mm (0.075/0.7510 in)
Interference fit of bush in compressor casing ... 0,020/0,075 mm (0.0008/0.0030 in)

Compressor drive assembly for Wabco compressors

Early engines:

Number of teeth on idler gears ... 27
Inside diameter of idler gear ... 22,23/22,25 mm (0.875/0.876 in)
Outside diameter of shaft for idler gears ... 22,23/22,24 mm (0.8750/0.8756 in)
Transition fit of gears on shaft ... -0,01/+0,.02 mm (-0.0004/+0.0008 in)
Inside diameter of front bearing ... 24,987/25,003 mm (0.9837/0.9844 in)
Outside diameter of shaft for front bearing ... 25,014/25,026 mm (0.9848/0.9853 in)
Interference fit of bearing on shaft ... 0,011/0,039 mm (0.0004/0.0015 in)
Housing bore for front bearing ... 61,948/61,966 mm (2.4389/2.4396 in)
Outside diameter of front bearing ... 61,983.62,004 mm (2.4403/2.4411 in)
Interference fit of front bearing ... 0,017/0,056 mm (0.0007/0.0022 in)
Outside diameter of shaft for rear bush ... 15,82/15,85 mm (0.6228/0.6240 in)
Clearance fit of shaft in bush ... 0,025/0,08 mm (0.001/0.003 in)

Latest engines:

Number of teeth on front idler gear ... 26
Number of teeth on rear idler gear ... 39
Inside diameter of idler gears ... 22,25/22,27 mm (0.8760/0.8768 in)
Outside diameter of shaft for idler gears ... 22,23/22,24 mm (0.8750/0.8756 in)
Clearance fit of gears on shaft ... 0,01/0,04 mm (0.0004/0.0016 in)
Inside diameter of front bearing ... 24,987/25,003 mm (0.9837/0.9844 in)
Outside diameter of shaft for front bearing ... 25,002/25,011 mm (0.9843/0.9847 in)
Interference fit of bearing on shaft ... 0,002/0,021 mm (0.0001/0.0008 in)
Housing bore for front bearing ... 61,912/61,931 mm (2.4375/2.4382 in)
Outside diameter of front bearing ... 61,987/62,000 mm (2.4404/2.4409 in)
Interference fit of front bearing ... 0,06/0,09 mm (0.002/0.003 in)
Outside diameter of shaft for rear bush ... 15,82/15,85 mm (0.623/0.624 in)
Clearance fit of shaft in bush ... 0,025/0,080 mm (0.001/0.003 in)

Bendix compressor

Type ... Bendix 1W150R or 1W250R
Number of teeth on compressor drive gear ... 28
Taper of compressor drive shaft ... 1 in 8

Thread sealant

When setscrews or studs are fitted into holes which are tapped through the cylinder block, a suitable sealant must be used to prevent leakage.

Micro encapsulated anaerobic sealant (M.E.A.S) fasteners have been introduced instead of jointing compounds or other sealants when the fasteners are fitted in through holes into oil or coolant passages. The identification of these fasteners, as supplied, is by a red, blue, or other colour sealant around the fastener threads.

With M.E.A.S. sealed studs, the sealed end must be fitted into the cylinder head / cylinder block etc. Ensure that the threaded holes have a 1,59 mm (0.0625 in) 45° chamfer, to ensure that when the new fasteners are fitted the M.E.A.S. sealant is not removed. If the fasteners have to be removed and fitted again, the threads must be cleaned and a suitable sealant used.

Note: New setscrews have sealant applied by the manufacturer to the first 13,0 mm (0.50 in) of the threads. If the setscrews are to be used again, clean the old sealant from the male and female threads and apply new sealant, POWERPART Threadlock and Nutlock to the setscrews.

Recommended torque settings

The torque tensions below apply to components lubricated lightly with clean engine oil before they are fitted.

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder head assembly				
Setscrews, cylinder head	$^1/_2$ UNF	See Operation 3-10		
Fasteners, rocker shaft brackets:				
Aluminium brackets	M12	40	30	4,1
Cast iron and sintered steel brackets	M12	75	55	7,6
Cap nuts, rocker cover	M12	20	15	2,1
Cap nuts, aluminium rocker cover (with shim washer)	M12	30	22	3,0
Setscrews, inlet manifold to cylinder head	M10	44	33	4,5
Nuts (plated), exhaust manifold to cylinder head	M10	44	33	4,5
Nuts (non-plated), exhaust manifold to cylinder head	M10	50	37	5,1
Setscrews, engine lift bracket	M10	44	33	4,5
Piston and connecting rod assemblies				
Nuts, connecting rods	$^1/_2$ UNF	125	92	12,7
Setscrews, connecting rods	$^1/_2$ UNF	155	114	15,8
Banjo bolts, piston cooling jets	$^3/_8$ UNF	20	15	2,0
Crankshaft assembly				
Setscrews, main bearings	$^5/_8$ UNF	265	196	27,0
Setscrews, crankshaft pulley	$^7/_{16}$ UNF	115	85	11,8
Setscrews, viscous damper to crankshaft pulley	M12	75	55	7,6
Cap screws, viscous damper to crankshaft pulley	M8	35	26	3,6
Cap screws, rubber bonded damper to crankshaft pulley	M8	35	26	3,6
Setscrews, rear oil seal housing to cylinder block	M8	22	16	2,2
Torxscrew, rear oil seal housing to cylinder block	M8	22	16	2,2
Cap screws, bridge piece to cylinder block	M6	16	12	1,6
Cap screws, rear oil seal housing to bridge piece	M8	18	13	1,9
Cap screws, rear oil seal housing to bridge piece	M6	13	10	1,3
Torxscrew, rear oil seal housing to bridge piece	M8	18	13	1,9
Setscrew, idler gear hub of balancer unit	M12	93	68	9,5
Nut, drive gear of balance weight	$^1/_2$ UNF	82	60	8,4
Setscrews, rear cover of balancer frame	M10	54	40	5,5
Setscrews, oil transfer plate (balancer unit)	M10	30	22	3,1
Setscrews, oil pump to balancer frame	M8	27	20	2,8
Setscrews, balancer to cylinder block	M10	54	40	5,5
Timing case and drive assembly				
Setscrews, timing case to cylinder block	M8	22	16	2,2
Setscrews, timing case to cylinder block	M10	44	33	4,5
Setscrews, hub of idler gear	M10	44	33	4,5
Setscrew, camshaft gear	M12	78	58	8,0
Setscrew, camshaft gear (for engines, with 45 mm long setscrew)	M12	100	74	10,0
Setscrews, timing case cover to timing case	M8	22	16	2,2
Nuts, timing case cover to timing case	M8	22	16	2,2

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Cylinder block				
Setscrews, fitted instead of piston cooling jets	$^3/_8$ UNF	27	20	2,8
Aspiration system				
Nuts, turbocharger to manifold	M10	44	33	4,5
Setscrew, breather cover	M6	9	7	0,9
Fuel system				
Nuts, high-pressure fuel pipes	M12	22	16	2,2
Setscrews, atomiser	M8	12	9	1,2
Setscrews, fuel lift pump	M8	22	16	2,2
Nut for gear of fuel injection pump	M14	80	59	8,2
Cap screw for gear of in-line fuel injection pump (AE, YE engines)	M8	44	33	4,5
Nut for hub of in-line fuel injection pump (AE, YE engines)	M18	115	84	11,8
Nuts for adaptor plate of in-line fuel injection pump (AE, YE engines)	M10	44	33	4,5
Nuts for flange of fuel injection pump	M8	22	16	2,2
Locking screw for Bosch VE fuel injection pump shaft	M10	27	20	2,8
Locking screw for DP 200 fuel injection pump shaft	10 A/F	10	7	1,0
Lubrication system				
Plug, lubricating oil sump	$^3/_4$ UNF	34	25	3,5
Setscrews, oil pump to front bearing cap	M8	22	16	2,2
Setscrews, cover for oil pump	M8	28	21	2,9
Fasteners, lubricating oil sump	M8	22	16	2,2
Cooling system				
Setscrews, fan drive housing to timing case	M10	44	33	4,5
Setscrews, fan drive pulley to hub	M8	22	16	2,2
Setscrews, fan drive pulley to hub	M10	44	33	4,5
Setscrews, fan	M8	22	16	2,2
Connector, oil cooler to oil filter head	$^3/_4$ UNF	58	42	5,8
Setscrews, coolant pump to timing case	M8	22	16	2,2
Nut, auxiliary coolant pump pulley	$^1/_2$ UNF	70	52	7,1
Setscrew, intercooler flange to inlet manifold	M6	7	5	0,7
Setscrew, intercooler body to inlet manifold	M8	22	16	2,2
Temperature switch (plastic thermostat housing)	-	4	3	0,4
Plug (plastic thermostat housing)	$^1/_2$ NPSI	4	3	0,4
Plug (plastic thermostat housing)	$^3/_4$ NPSI	4	3	0,4
Flywheel and housing				
Setscrews, flywheel to crankshaft	$^1/_2$ UNF	105	77	10,7
Setscrews, cast iron flywheel housing to cylinder block	M10	44	33	4,5
Stamped 8.8	M12	75	55	7,6
Stamped 10.9	M10	63	46	6,4
Stamped 10.9	M12	115	85	11,7
Setscrews, aluminium flywheel housing to cylinder block	M10	70	52	7,1
Setscrews, flywheel housing to cylinder block (paper joint)	M10	70	52	7,1

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Electrical equipment				
Nut, alternator pulley:				
CAV AC5RA and AC5RS	$^5/_8$ UNF	55	40	5,6
Lucas A127, and motorola, 22mm A/F	M17	80	59	8,2
Lucas A127, and motorola, 24mm A/F	M17	80	59	8,2
Bosch 55A	M14	50	37	5,1
Bosch 55A	M16	50	37	5,1
Butec 5524	$^5/_8$ UNF	55	40	5,6
Setscrew, side bracket to front bracket	M12	75	55	7,6
Setscrew adjusting lever to alternator	M8	11	8	1,1
Setscrew adjusting lever to bracket	M8	11	8	1,1
Fuelled start aid to induction manifold	$^7/_8$ UNF	31	23	3,1
Port heater aid to induction manifold	M22	60	44	6,1
Auxiliary equipment				
Nut, compressor drive gear:				
6,4 mm (0.25 in) thick	$^3/_4$ UNF	80	59	8,2
10 mm (0.4 in) thick	$^3/_4$ UNF	130	95	13,3
Nuts for gears of auxiliary drive assembly:				
6,4 mm (0.25 in) thick	$^3/_4$ UNF	80	59	8,2
10 mm (0.4 in) thick	$^3/_4$ UNF	130	95	13,3
Nut for gears of auxiliary drive assembly	M20	130	95	13,3

Compression test data

Tests have shown that many factors affect compression pressures. Battery and starter motor condition, ambient conditions and the type of gauge used can give a wide variation of results for a given engine.

It is not possible to give accurate data for compression pressure, but tests have shown that the results should be within 2000/3500 kPa (300/500 lbf/in^2) 21,0/35,0 kgf/cm^2 for diesel engines.

Compression tests should only be used to compare between the cylinders of an engine. If one or more cylinders vary by more than 350 kPa (50 lbf/in^2) 3,5 kgf/cm^2, then those cylinders may be faulty.

Compression tests should not be the only method used to show the condition of an engine, but they should be used together with other symptoms and tests.

How to do a compression test

Caution: *Before the compression test, ensure that the battery is in good condition and that it is fully charged. Also ensure that the starter motor is in good condition.*

1 Ensure that the valve tip clearances are set correctly, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

2 Remove the atomisers.

3 Fit a suitable gauge into the atomiser hole of the cylinder to be tested.

Caution: *Ensure that the engine cannot start:*

4 Disconnect the stop solenoid or put the stop control in the no-fuel position.

5 Operate the starter motor and note the pressure indicated on the gauge.

6 Repeat for each cylinder.

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3

Cylinder head assembly

General description

In a diesel engine there is little carbon deposit and for this reason the number of hours run is no indication of when to overhaul a cylinder head assembly. The factors which indicate when an overhaul is necessary are how easily the engine starts and its general performance.

The cylinder head assembly has two valves fitted for each cylinder, each fitted with double or single valve springs, according to the engine application. The double springs have damper coils which are fitted towards the top face of the cylinder head.

In most engines the face angle of the valves is 45°, but some engines have inlet valves with a face angle of 30°. The angle of the valve seats in the cylinder head are either 46° or 31°.

The valves move in phosphated guides which can be renewed. The exhaust valve guide has a counterbore at the bottom and is a little longer than the inlet valve guide.

Both valve stems are fitted with oil seals which fit over the top of the valve guides.

Turbocharged engines and some naturally aspirated engines have valve seat inserts fitted in the cylinder head for both inlet and exhaust valves. Engines which do not have valve seat inserts fitted as standard, in production, can have them fitted in service.

Rocker cover

To remove **Operation 3-1**

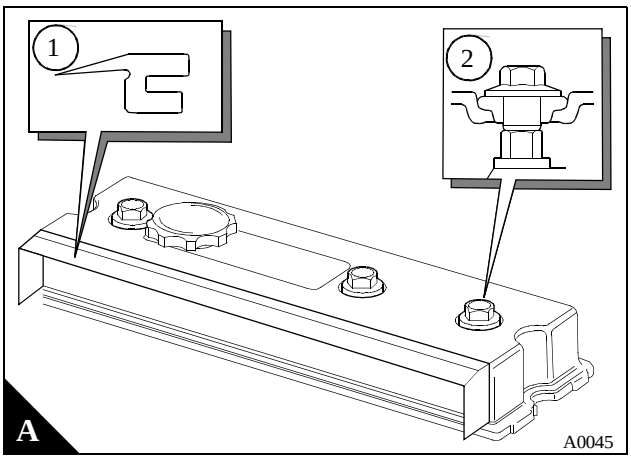
Engines are supplied with either an aluminium rocker cover (A) or with rocker covers made of a composite material (B). The aluminium cover on some engines, has a dust seal which is fitted between the rocker cover and the induction manifold. The dust seal of the composite rocker cover is fitted permanently to the side of the rocker cover with adhesive.

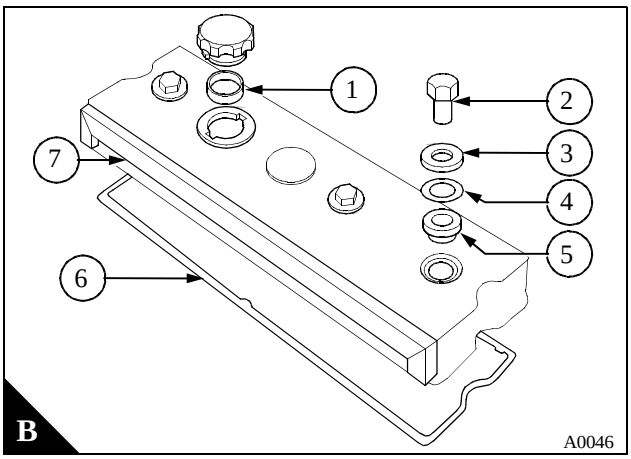
1 Disconnect the breather pipe.

2 Remove the cap nuts (A2/B2) together with the steel washers (B3) and the shim washers (B4) from the top of the rocker cover.

3 Lift off the rocker cover and the joint (B6). For aluminium covers, remove the rocker cover dust seal (A1/B7).

Caution: *When the rocker cover is fitted, the cap nuts are tightened onto the nuts of the rocker brackets. During removal of the cap nuts, it is possible to loosen the nuts of the rocker brackets. The nuts of the rocker brackets should be tightened to the correct torque every time the cover is removed.*





To fit **Operation 3-2**

1 Check the seal of the oil filler cap (A1), the sealing washers (A5), the steel washer (A3) and, if fitted, the shim washer (A4) for the cap nuts (A2).

2 Check the condition of the rocker cover joint (A6) and of the dust seal (A7). If necessary, the joint and the seal can be removed and renewed.

3 Clean the joint face of the cylinder head and fit the rocker cover together with the dust seal.

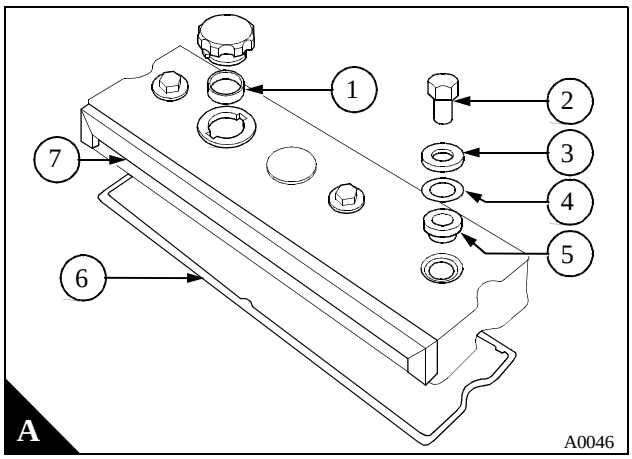
4 Fit the sealing washers, the steel washers, the shims (if fitted) and the cap nuts.

Caution: *Damage to the sealing washer can occur if the cap nut is not tightened centrally through the sealing washer and the rocker cover. If the sealing washer is damaged it must be renewed.*

5 Tighten the cap nuts to 20 Nm (15 lbf ft) 2,1 kgf m.

Notes:

- The latest engines have an extra shim washer (A4) fitted between the cap nut sealing washer and the steel washer for the cap nut. If shim washers are fitted to aluminium rocker covers, tighten the cap nuts to 30 Nm (22 lbf ft) 3,0 kgf m. If shim washers are fitted to composite rocker covers, tighten the cap nuts to 20 Nm (15 lbf ft) 2,1 kgf m.
- Some earlier 1000 Series engines have a rocker cover joint that has a ribbed bottom face. When this joint is fitted, ensure that the flat face of the joint is towards the rocker cover.



Rocker assembly

To remove and to fit **Operation 3-3**

To remove

1 Remove the rocker cover, see Operation 3-1.

2 Release evenly and gradually the fasteners of the rocker shaft brackets; begin with the end brackets and move toward the centre. Remove the fasteners and the washers and lift off the rocker assembly.

Note: The washers between the fasteners and the rocker brackets have been removed on the latest engines and new flange faced nuts and setscrews have been fitted.

3 Remove the rubber oil seal (A) from the oil supply connection or from the oil supply hole in the cylinder head.

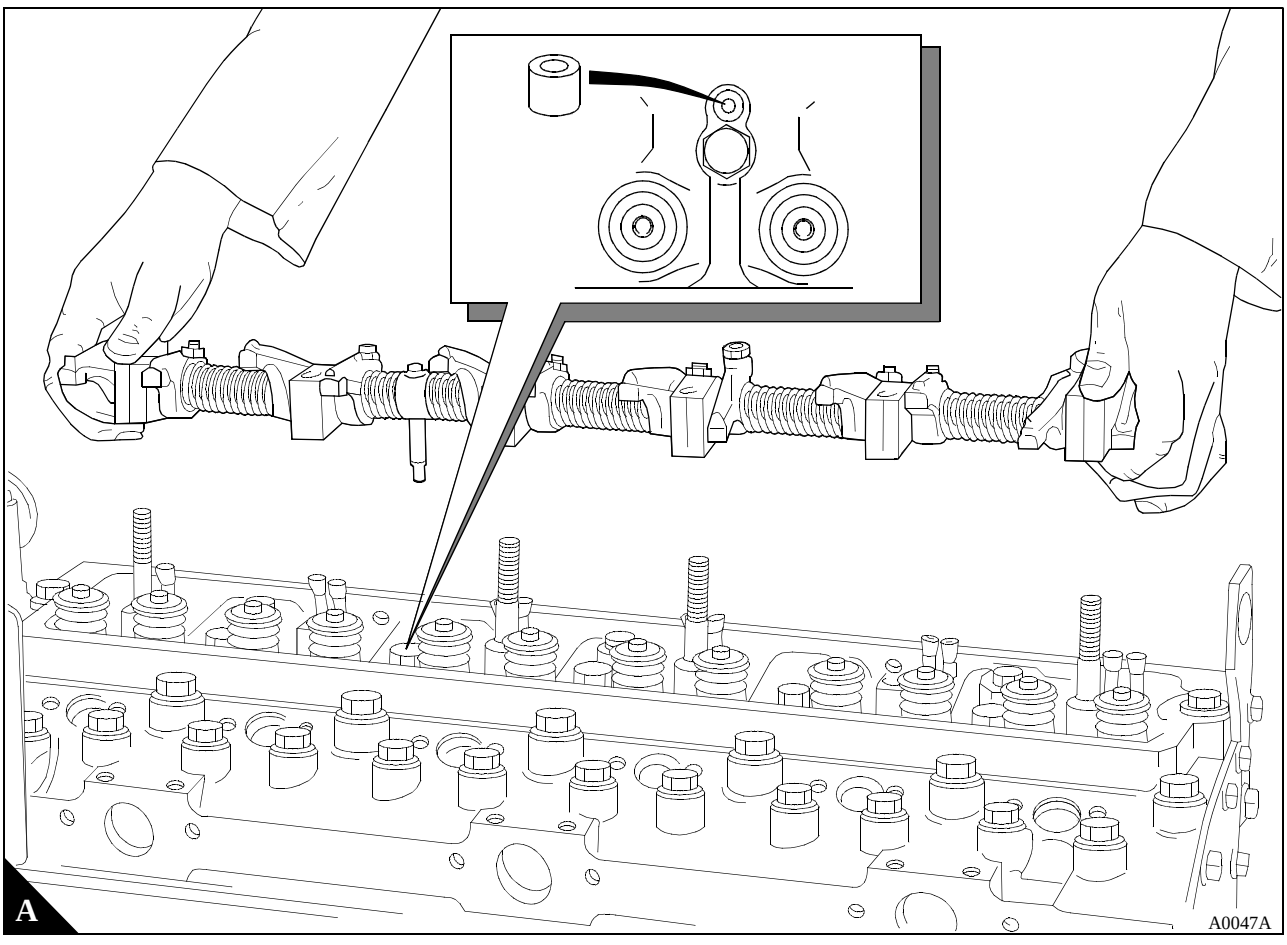
To fit

1 Fit a new rubber oil seal in the oil supply hole in the cylinder head (A).

2 Check that the push rods fit correctly in the sockets of the tappets. Fit the rocker assembly; ensure that the oil supply connection is fitted correctly into the oil seal. Check that the ends of the adjustment screws fit correctly in the sockets of the push rods.

3 Fit the washers (if fitted) and fasteners of the rocker shaft brackets and tighten the fasteners evenly and gradually; begin with the inner fasteners and work towards the end fasteners. Tighten the fasteners evenly to the correct torque according to the material of the rocker shaft brackets:

- Aluminium: 40 Nm (30 lbf ft) 4,1 kgf m.
- Cast iron: 75 Nm (55 lbf ft) 7,6 kgf m.
- Sintered steel: 75 Nm (55 lbf ft) 7,6 kgf m.



To dismantle and to assemble **Operation 3-4**

To dismantle

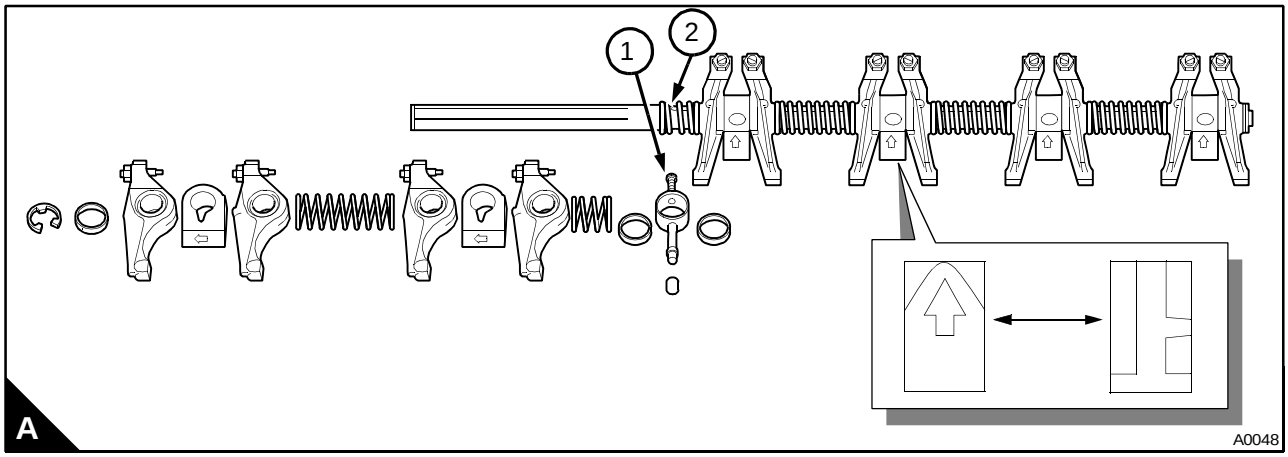
1 Remove the clips from both ends of the rocker shaft. Ensure that the ends of the rocker shaft are not damaged. Release the location screw (A1) for the oil supply connection.

2 Dismantle the assembly and make a note of the position of each component to ensure that they can be assembled more easily.

To assemble

1 Ensure that the oil holes in the rocker shaft and in the rocker levers are not restricted.

2 Lubricate the components with clean engine lubricating oil before assembly. Assemble the components in the correct order (A) and ensure that the location screw (A1) for the oil supply connection is fitted correctly in the hole (A2) in the rocker shaft. Fit the clips to the ends of the rocker shaft.



To inspect and to correct **Operation 3-5**

To inspect

1 Clean and inspect all the components for wear and any other damage. Check the clearance of the rocker levers on the rocker shaft. If the clearance is larger than 0,13 mm (0.005 in), renew the rocker lever bush and/or the rocker shaft.

To correct

1 To renew the rocker lever bush, press out the old bush with a suitable mandrel.

2 Align the lubrication hole of the new bush on the same side as the rocker lever lubrication hole and press the bush into position.

3 Ream the bush in the rocker lever to give a clearance on the rocker shaft of 0,03/0,09 mm (0.001/0.004 in). Clean thoroughly the bush and check that the oil hole is free from debris.

Note: The rocker levers used on some low rated engines do not have bushes.

Valve tip clearances

To check and to adjust (four cylinder engines) **Operation 3-6**

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine hot or cold, the correct clearances are 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).
- The sequence of valves from number 1 cylinder is shown in the table below. Number 1 cylinder is at the front of the engine.

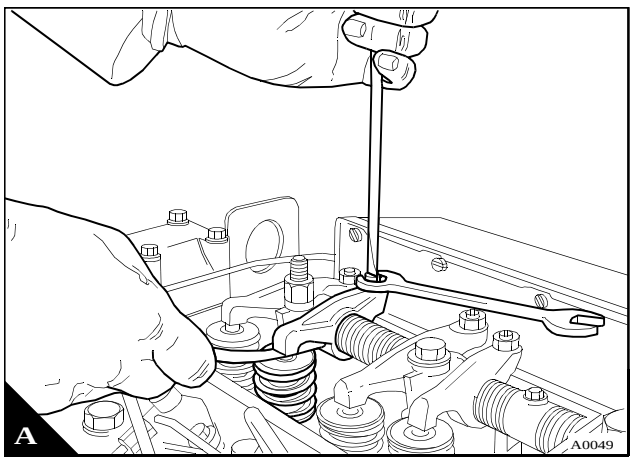
1 Rotate the crankshaft in the normal direction of rotation until the inlet valve (B8) of number 4 cylinder has just opened and the exhaust valve (B7) of the same cylinder has not closed completely. Check the clearances of the valves (B1 and B2) of number 1 cylinder and adjust them, if necessary.

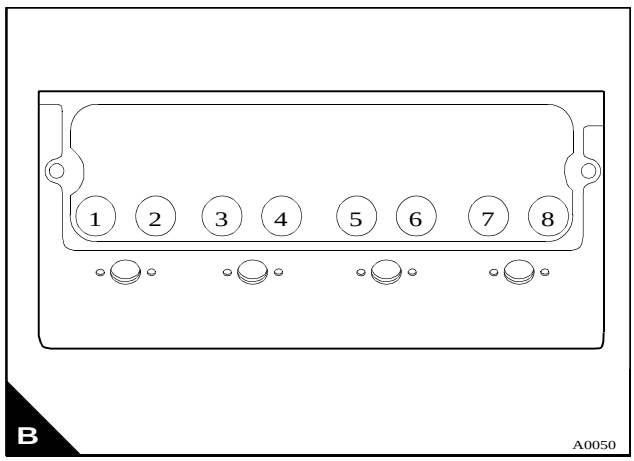
2 Set the valves (B3 and B4) of number 2 cylinder as indicated above for number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

3 Set the valves (B1 and B2) of number 1 cylinder. Then check / adjust the clearances of the valves (B7 and B8) of number 4 cylinder.

4 Set the valves (B5 and B6) of number 3 cylinder. Then check / adjust the clearances of the valves (B3 and B4) of number 2 cylinder.

Cylinder and Valve number	**1**		**2**		**3**		**4**	
	1	2	3	4	5	6	7	8
Valve I = Inlet E = Exhaust	I	E	E	I	I	E	E	I





To check and to adjust (six cylinder engines) **Operation 3-7**

Notes:

- The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine hot or cold, the correct clearances are 0,20 mm (0.008 in) for the inlet valves and 0,45 mm (0.018 in) for the exhaust valves. The valve positions are shown at (B).
- The sequence of valves from number 1 cylinder is shown in the table below. Number 1 cylinder is at the front of the engine.

1 Rotate the crankshaft in the normal direction of rotation until the inlet valve (B12) of number 6 cylinder has just opened and the exhaust valve (B11) of the same cylinder has not closed completely. Check the clearances of the valves (B1 and B2) of number 1 cylinder and adjust them, if necessary.

2 Set the valves (B4 and B3) of number 2 cylinder as indicated above for number 6 cylinder. Then check / adjust the clearances of the valves (B9 and B10) of number 5 cylinder.

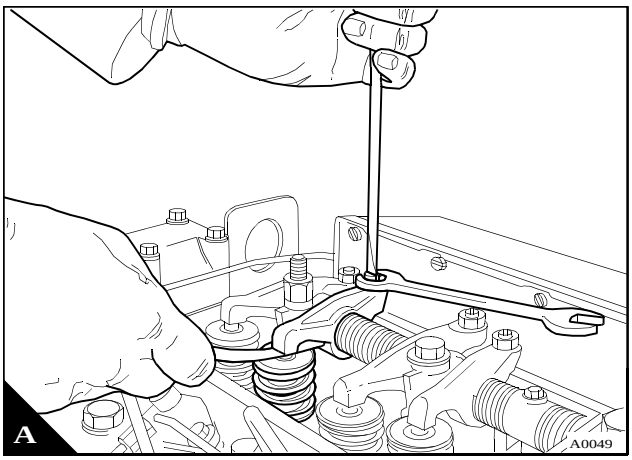
3 Set the valves (B8 and B7) of number 4 cylinder. Then check / adjust the clearances of the valves (B5 and B6) of number 3 cylinder.

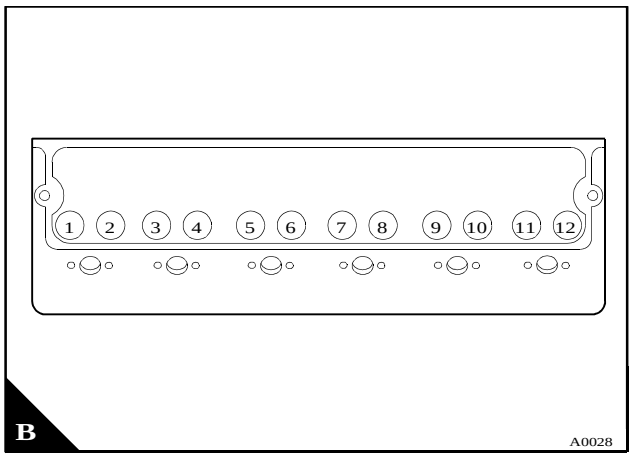
4 Set the valves (B1 and B2) of number 1 cylinder. Then check / adjust the clearances of the valves (B11 and B12) of number 6 cylinder.

5 Set the valves (B9 and B10) of number 5 cylinder. Then check / adjust the clearances of the valves (B3 and B4) of number 2 cylinder.

6 Set the valves (B5 and B6) of number 3 cylinder. Then check / adjust the clearances of the valves (B7 and B8) of number 4 cylinder.

Cylinder and Valve number	**1**		**2**		**3**		**4**		**5**		**6**	
	1	2	3	4	5	6	7	8	9	10	11	12
Valve I = Inlet E = Exhaust	I	E	E	I	I	E	E	I	I	E	E	I





Valve springs

To change the valve springs (with cylinder head fitted) **Operation 3-8**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825932	Setscrew adaptor used with 21825932	21825673
Stud adaptor used with 21825666	21825672		

Note: Steps 1 to 12 refer to a change of valve springs for a single cylinder.

Warning! *Wear eye protection during this operation.*

1 Remove the rocker cover, see Operation 3-1.

2 Rotate the crankshaft in the normal direction of rotation until the inlet valve of the relevant cylinder has just opened and the exhaust valve has not fully closed. In this position the piston will be at approximately top dead centre (TDC).

3 Remove the rocker assembly, see Operation 3-3.

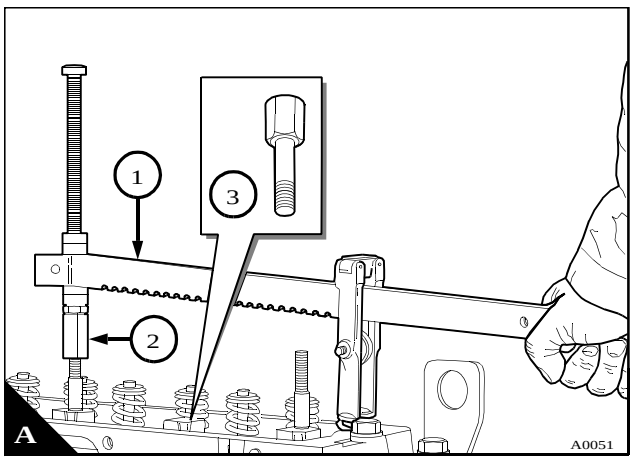
4 Fit the valve spring compressor (A1) and the relevant adaptor (A2 or A3).

5 Compress the valve spring(s) and remove the collets. Ensure that the valve springs are compressed squarely or damage to the valve stem can occur.

Caution: *Do not rotate the crankshaft while the valve springs are removed.*

6 Release the valve spring compressor and remove the valve spring caps and valve spring(s).

7 Put the new valve springs in position. If double valve springs are fitted, ensure that the closed damper coils are towards the cylinder head, see Operation 3-12.



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8 Fit the valve spring caps.

Caution: *Ensure that the valve springs are compressed squarely or damage can occur to the valve stem.*

9 Fit the valve spring compressor, compress the valve springs and fit the collets. Remove the valve spring compressor.

10 Fit the rocker assembly, see Operation 3-3.

11 Check the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

12 Fit the rocker cover, see Operation 3-2.

Note: If other or all of the valve springs are to be changed, they can be changed two cylinders at a time. The sets of cylinders are:

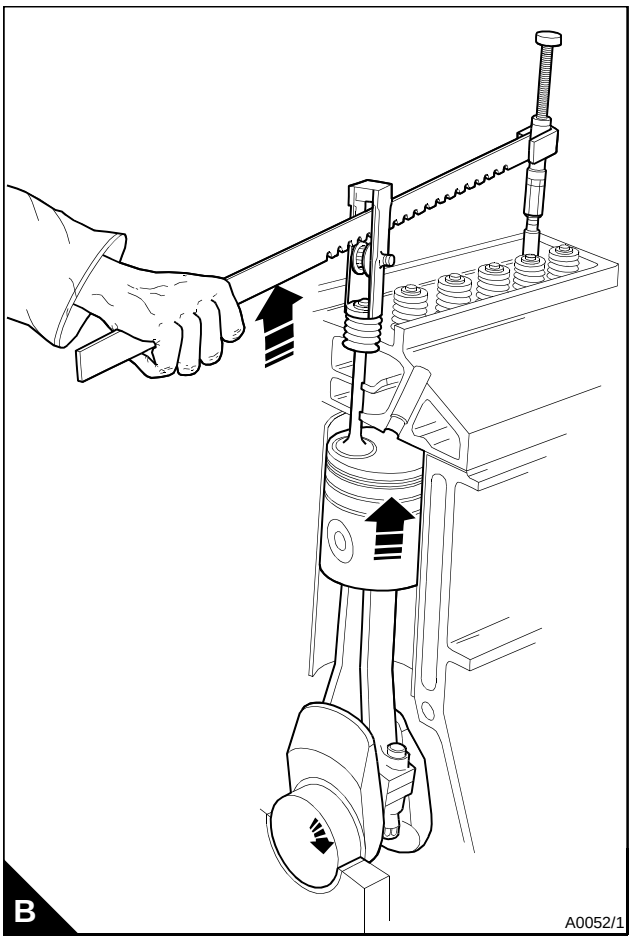
- For 4 cylinder engines: 1 and 4, 2 and 3
- For 6 cylinder engines: 1 and 6, 2 and 5, 3 and 4

If the rocker assembly has been removed, piston TDC can be found as follows

1 Fit the valve spring compressor and compress the valve springs to open the valve.

2 Rotate the crankshaft, by hand, in the normal direction of rotation until the piston touches the valve.

3 Continue to rotate the crankshaft, and at the same time, release pressure on the valve spring compressor until the piston is at TDC (B).



Cylinder head assembly

To remove — Operation 3-9

1 Drain the cooling system.

2 Disconnect the battery terminals.

3 Remove the air filter/cleaner hose at the induction manifold.

4 For engines fitted with turbochargers, remove the air filter/cleaner hose at the compressor inlet of the turbocharger.

5 Remove the pipe which is fitted between the fuelled starting aid in the induction manifold and the fuel filter. Disconnect the electrical connection.

6 For engines fitted with a boost control device, remove the boost control pipe which is fitted between the induction manifold and the top of the fuel injection pump.

7 Remove the induction manifold.

8 For engines fitted with turbochargers, disconnect all connections to the turbocharger and remove the turbocharger, see Operation 9-1.

9 Remove the exhaust manifold.

10 Remove the low-pressure fuel pipes which are fitted between the fuel injection pump and the fuel filter.

Note: Where a Bosch fuel injection pump is fitted, keep the fuel outlet banjo bolt with the fuel injection pump.

11 Remove the fuel pipe fitted between the fuel lift pump and the fuel filter. Remove the fuel filter bracket together with the fuel filter.

12 Remove the high-pressure fuel pipes.

Caution: *Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high-pressure pipes are released. Fit suitable covers to all open connections on the fuel injection pump.*

13 Remove the atomiser leak-off pipe.

14 Remove the atomisers, see Operation 11-7. Fit suitable covers to the nozzles and the open connections.

15 If a compressor is fitted, remove the coolant pipe which is fitted between the cylinder head and the compressor, then remove the coolant pipe which is fitted between the by-pass connection and the compressor.

16 Release the clip of the coolant by-pass hose at the cylinder head. Release the setscrews and remove the coolant by-pass connection and the hose.

17 Disconnect the coolant temperature sender unit.

18 For turbocharged and some naturally aspirated four cylinder engines, remove the oil cooler, see Operation 12-21.

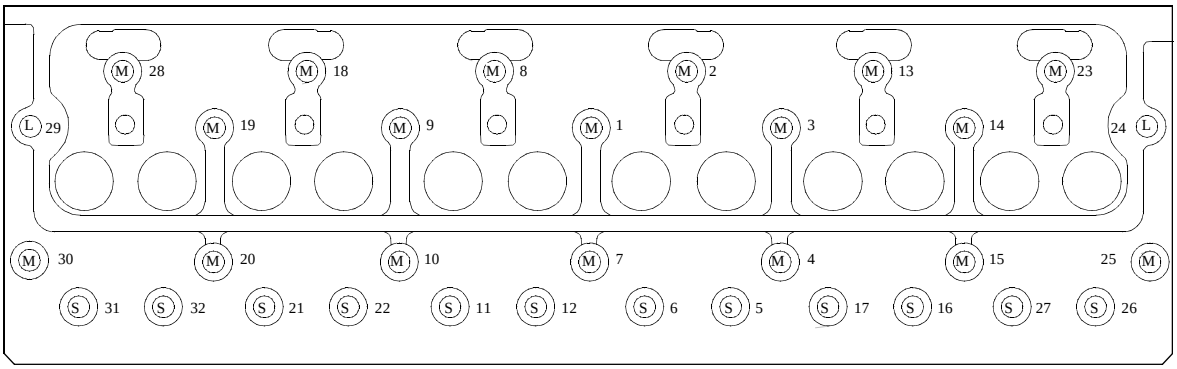
19 Remove the rocker cover, see Operation 3-1.

20 Remove the rocker assembly, see Operation 3-3.

21 Remove the push rods.

Continued

22 Release the cylinder head setscrews evenly and gradually in the reverse sequence to that shown in (A) for six cylinder engines or (B) for four cylinder engines.



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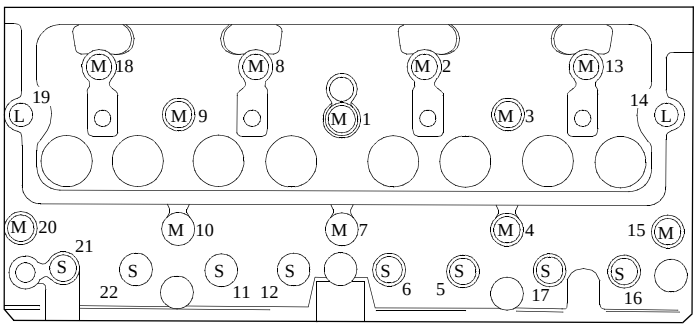

B

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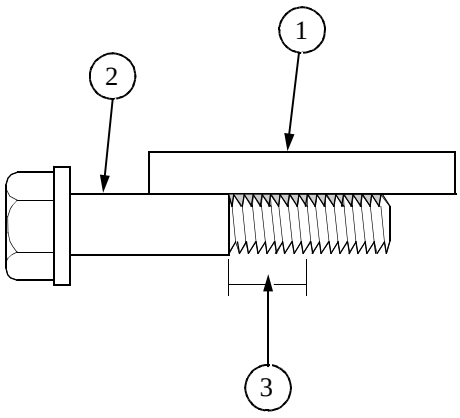
23 Check the setscrews for distortion with a straight edge (C1) held along the setscrew (C2). If there is a visual reduction in the diameter of the thread (C3) that has not been in engagement with the cylinder block, the setscrew must be discarded.

Caution: *Do not use a lever to separate the cylinder head from the cylinder block.*

24 Remove the cylinder head and put it on a surface that will not damage the face of the cylinder head.



C

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To fit **Operation 3-10**

Special requirements

Special tools	
Description	**Part number**
Angle gauge (to tighten cylinder head setscrews)	21825607

1 Clean the bottom face of the cylinder head and top face of the cylinder block. Ensure that there is no debris in the cylinder bores.

Notes:

- Early engines have two 6 mm (0.236 in) location pins (A1), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head gasket in the correct position before the cylinder head is fitted.
- Latest engines have two 8 mm (0.315 in) location pins (A1), one at each end of the cylinder head, pressed into the cylinder block to hold the cylinder head gasket in the correct position before the cylinder head is fitted.

***Cautions*:**

- *To prevent damage to the cylinder head gasket, ensure that the location pins are pressed in the cylinder block before the cylinder head is fitted.*
- *The cylinder head gasket must be fitted without jointing compound.*

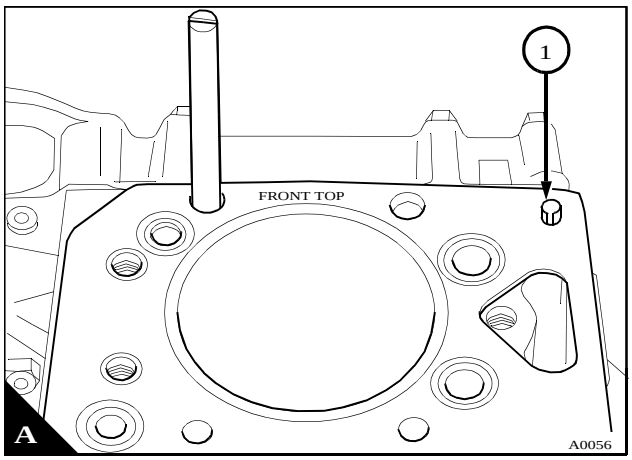
2 Put the cylinder head gasket in position; It is stamped "FRONT TOP" for correct assembly (A).

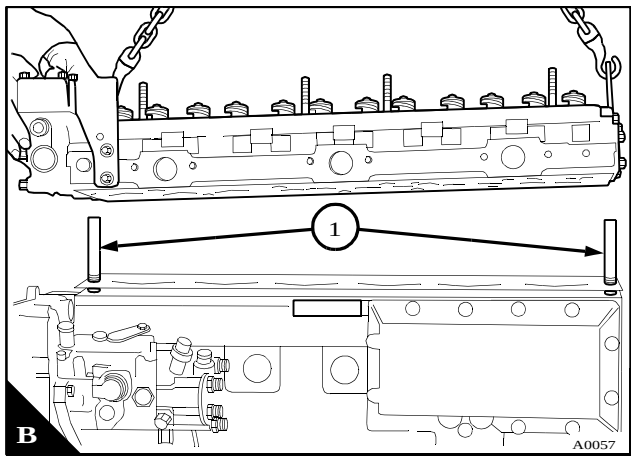
3 To ensure the cylinder head is fitted into the correct position, fit two suitable $^{1}/_{2}$ UNF guide studs (B1) in positions 15 and 20 (Operation 3-9/B) or positions 25 and 30 (Operation 3-9/A). Put the cylinder head in position.

4 Lightly lubricate the threads of the cylinder head setscrews and the thrust faces of the setscrew heads. Engage some of the setscrews in their correct positions and remove the guide studs. Engage the remainder of the setscrews in their correct positions.

5 Gradually and evenly tighten the setscrews to 110 Nm (80 lbf ft) 11,1 kgf m in the sequence shown in Operation 3-9 (A/B).

6 Repeat step 5 to ensure that all the setscrews are tightened to the correct torque.





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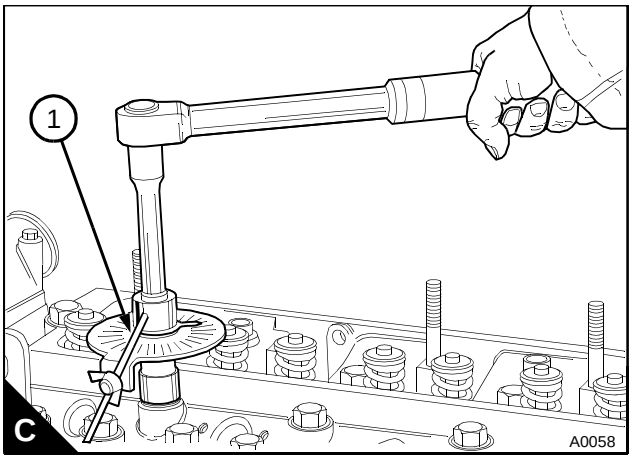
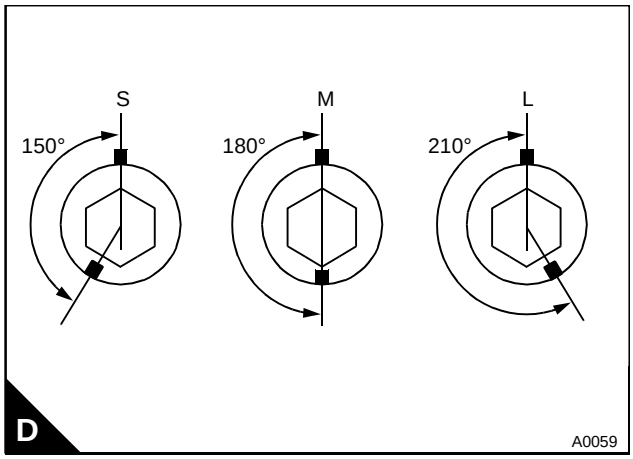
7 Tighten the setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews, see Operation 3-9 (A/B). Short setscrews (S) must be turned a further 150° (2.5 flats). Medium length setscrews (M) must be turned a further 180° (3 flats). Long setscrews (L) must be turned a further 210° (3.5 flats). A special tool (C) can be used for this operation.

Fit the tool between the socket and the handle. Position the stop (C1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Rotate the pointer to align with the relevant angle on the degree dial for the length of setscrew. Tighten the setscrew until the pointer on the tool is aligned with the zero position on the degree dial.

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





8 Put the push rods in position. Ensure that the end of each push rod fits correctly in the tappet socket.

9 Fit the rocker assembly, see Operation 3-3.

10 Set the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.

11 Fit the atomisers, see Operation 11-7.

12 Fit the high-pressure fuel pipes; tighten the connection nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

Caution: *Where access to the fuel injection pump outlet unions is possible, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets when the connections of the high pressure pipes are tightened.*

13 Fit the fuel filter and the bracket. Fit the low-pressure fuel pipes between the fuel injection pump and the fuel filter.

14 Fit the coolant by-pass connection; tighten the setscrews and hose clip.

15 If a compressor is fitted, fit the coolant pipe between the cylinder head and the compressor, then fit the pipe between the coolant by-pass and compressor.

16 For turbocharged and some naturally aspirated four cylinder engines, fit the oil cooler, see Operation 12-21.

Continued

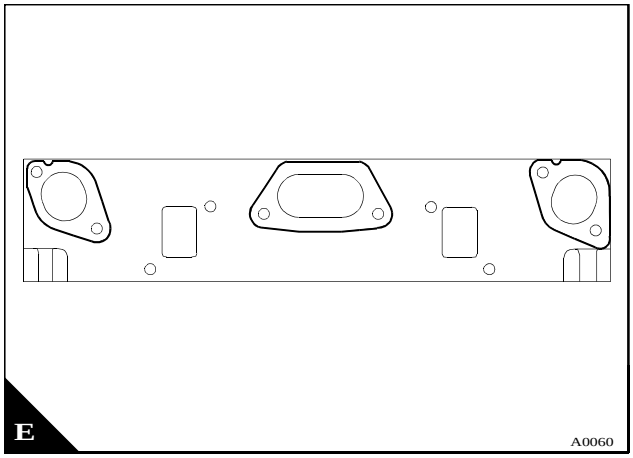
Note: There are three types of joints for the exhaust and induction manifold: asbestos, asbestos free and metal. The joints fitted to an engine must be of the same material and should be changed as a set.
If joints made from different materials are fitted to an engine, the manifolds may leak or break. This will cause a loss of engine performance and could cause internal damage to the engine.

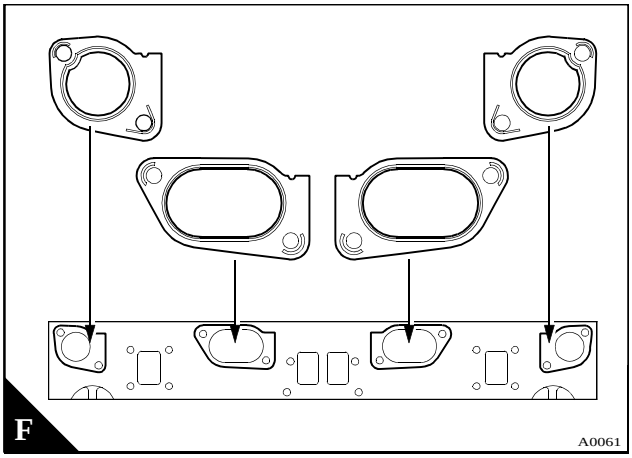
17 Fit the exhaust manifold. The manifold joints are fitted without jointing compound.

18 For engines fitted with turbochargers, fit the turbocharger, see Operation 9-2.

19 For four cylinder engines: Fit the induction manifold. Ensure that the manifold joints for the front and rear positions are fitted with the notch at the top left when the manifold is fitted to the cylinder head (E). The manifold joint for the centre position can be fitted either way. Fit the joints without jointing compound. The latest four cylinder engines are fitted with a one piece induction manifold joint.

For six cylinder engines: Fit the induction manifold. Ensure that the joints are fitted with the notch at the top and the straight edge towards the centre (F). Fit the joints without jointing compound. Some of the latest six cylinder engines are fitted with a one piece induction manifold joint. The latest six cylinder engines are fitted with a one piece induction manifold joint.





20 Fit the fuel pipe between the fuel filter and the fuel lift pump.

21 Fit the fuel pipe between the fuel filter and the fuelled starting aid in the induction manifold. Connect the electrical connection to the cold start device.

22 For engines fitted with boost control devices, fit the boost control pipe between the induction manifold and the top of the fuel injection pump.

23 Fit the electrical connection to the coolant temperature sender unit.

24 Connect the coolant outlet and the hoses for the cab heater. Tighten the clips.

25 Fill the cooling system.

26 Connect the air filter/cleaner.

27 Connect the battery.

28 Eliminate air from the fuel system:

- Bosch EPVE fuel injection pumps, see Operation 11-25.
- Bosch MW fuel injection pumps, see Operation 11-30.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46.
- Stanadyne fuel injection pumps, Operation 11-54.

29 Start the engine and run it at low speed. Check that oil flows from the holes in the rocker levers. If the oil flow is correct, fit the rocker cover, see Operation 3-2.

Note: It is not necessary to tighten the cylinder head setscrews again with the engine hot or after a limited period in service.

Valves and valve springs

To remove **Operation 3-11**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825932	Setscrew adaptor	21825673
Stud adaptor	21825672		

1 Remove the cylinder head, see Operation 3-9.

2 Clean the bottom face of the cylinder head and check the depth of the heads of the valves below the face of the cylinder head, see Operation 3-13.

3 Make a suitable mark on the heads of the valves to ensure that the valves can be fitted in their original positions, if they are to be used again.

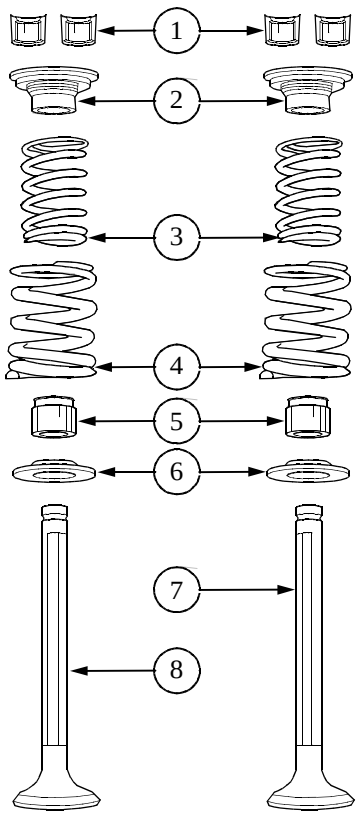
Warning! *Wear eye protection during this operation.*

Caution: *Ensure that the valve springs are compressed squarely or the valve stem can be damaged.*

4 Use the valve spring compressor and the relevant adaptor to compress the valve spring(s) and remove the collets (A1).

5 Release the valve spring compressor and remove the valve spring cap (A2), valve spring(s) (A3/A4), valve stem seal (A5) and the valve seat washer (A6).

6 Repeat steps 4 and 5 for the other valves.



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To fit **Operation 3-12**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825666	Setscrew adaptor	21825673
Stud adaptor	21825672		

Note: The components of the valve assembly are shown in (A). Certain engines are fitted with single valve springs.

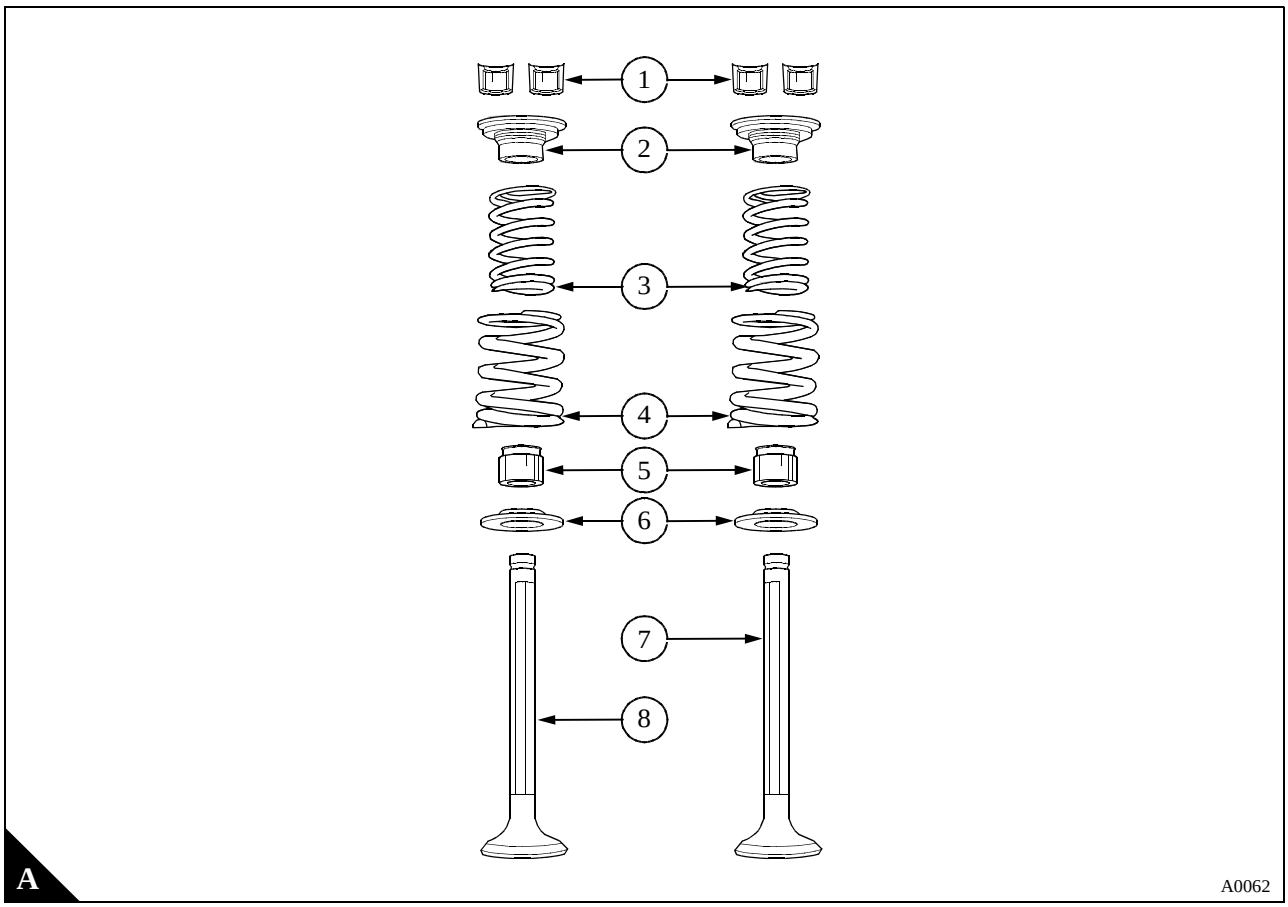
Warning! *Wear eye protection during this operation.*

1 Lubricate the valve stems (A7 and A8) with clean engine oil and fit the valves in their respective guides.

2 Fit the spring seat washers (A6). Fit new valve stem seals (A5) on the valve guides. If double valve springs are used, fit the inner and outer valve springs (A3 and A4) on the spring seat washers with their damper coils toward the cylinder head. If single valve springs are used, the spring does not have a damper coil and it can be fitted with either end to the cylinder head. Fit the valve spring caps (A2).

Caution: *Ensure that the valve springs are compressed squarely or damage can occur to the valve stem.*

3 Use the valve spring compressor and the relevant adaptor to compress the valve spring(s) and fit the collets (A1).



To inspect and to correct — Operation 3-13

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gauge, valve depth	21825496	Dial gauge for use with 21825496	21825617

1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed.

2 Ensure that the heads of the valves and the bottom face of the cylinder head are clean.

3 Put the valve depth gauge on the face of the cylinder head and zero the dial gauge.

4 Carefully put the valve depth gauge in position over the head of each valve (A) and make a note of the measurement. The maximum depth, in service, is given in the relevant Data and dimensions for "Inlet and exhaust valves" on page 29.

5 If a valve is below the depth limit, check the valve depth with a new valve in position. If the valve depth is still below the limit and a valve seat insert is fitted, the insert must be renewed.

6 Where a valve seat insert is not fitted, the bottom face of the cylinder head can be machined to reduce the valve depth, or an insert can be fitted, see Operation 3-19.

Caution: *If the bottom face of the cylinder head is to be machined, ensure that the thickness, of the cylinder head will not be less than 102,48 mm (4.035 in) after the cylinder head has been machined.*

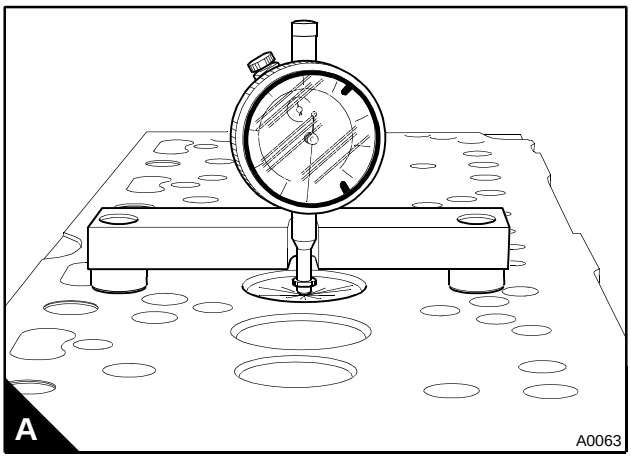
Notes:

- On AE and YE engines the protrusion of the atomiser nozzle below the bottom face of the cylinder head must not be more than 4,82 mm (0.190 in).
- The nozzle protrusion must be measured with the nozzle seat washer fitted.

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

8 Check that the seat faces of the valves are not badly burnt or damaged. Seat faces of valves which are damaged can be ground on a special machine. Valves which have only a little damage can be lapped to their valve seats. When new valves are fitted, the valve depths must be checked, see step 1.

9 Check that the load on the valve springs is correct at their fitted length, refer to the relevant Data and dimensions for "Valve guides and valve springs" on page 32. Fit new valve springs at every complete engine overhaul.



Valve guides

To inspect **Operation 3-14**

The maximum clearance (A5), between the valve stem and the bore of the guide is 0,13 mm (0.005 in) for inlet valves and 0,15 mm (0.006 in) for exhaust valves.

If the clearance, with a new valve fitted, is more than the limit, then a new valve guide (A4) must be fitted.

It is recommended that the procedure given below is used to check the valve guide clearance:

1 Put a new valve in the valve guide.

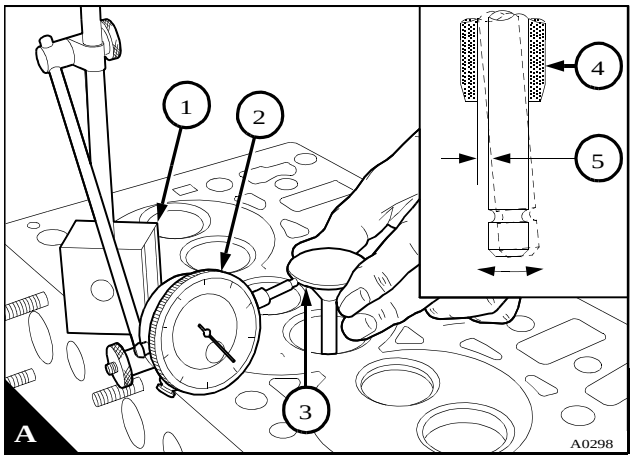
2 Put a dial test indicator with a magnetic base (A1) onto the face of the cylinder head.

3 With the valve lifted 15,0 mm (0.6 in) and the gauge (A2) in contact with the edge of the valve head (A3), move the valve radially away from the gauge. With the valve held in this position, set the gauge zero.

4 Move the valve radially across the axis of the cylinder head towards the gauge. Make a note of the reading on the gauge. If the reading is equal to or greater than the data given below, a new valve guide (A4) must be fitted.

Maximum permissible clearance with a valve lift of 15,0 mm (0.6 in):

- Inlet guide: 0,24 mm (0.009 in)
- Exhaust guide: 0,32 mm (0.013 in)



To remove **Operation 3-15**

Special requirements

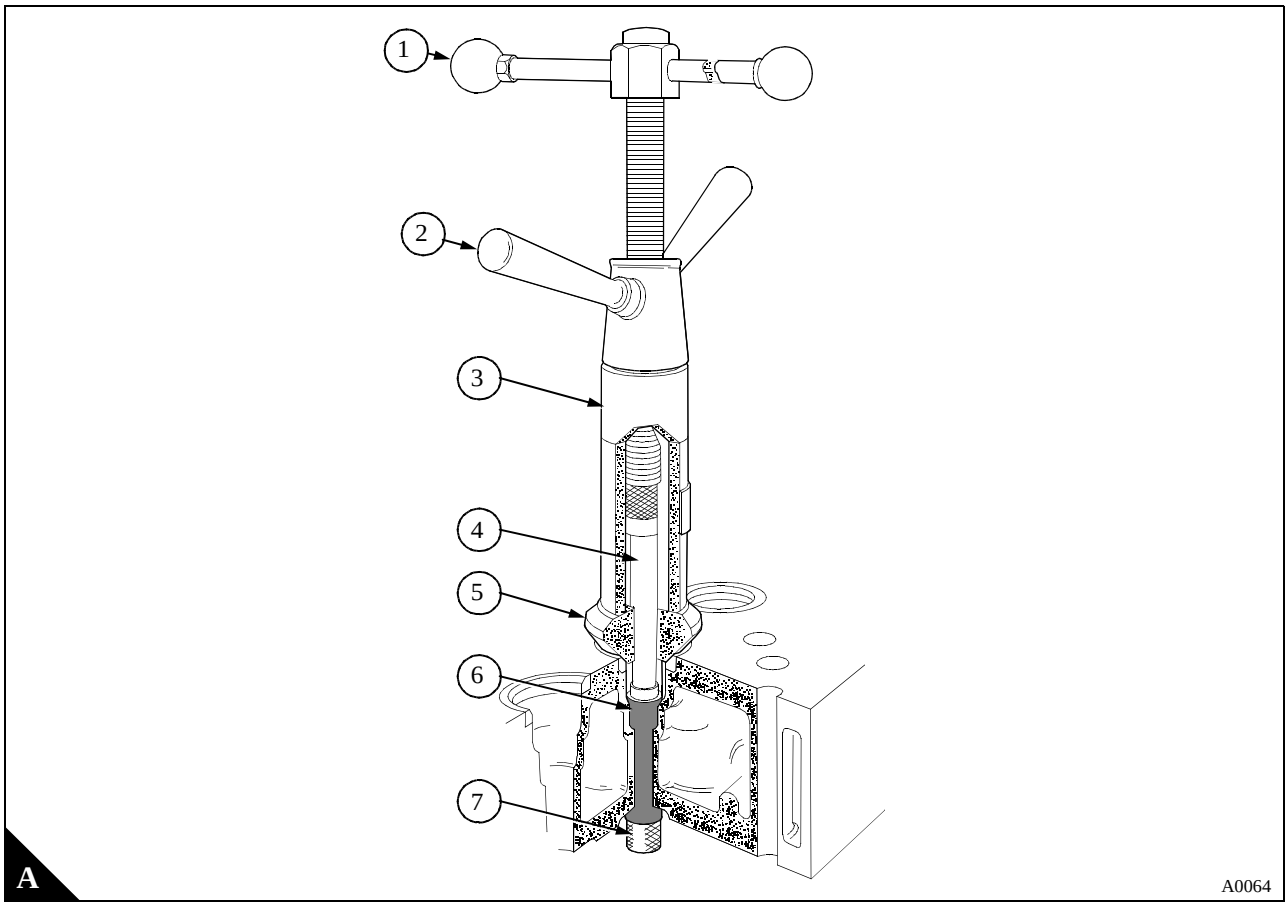
Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for valve guides	21825478	Adaptor used with 21825478	21825479

1 Fit the adaptor (A4), 21825479, into the remover/replacer tool (A3), 21825478.

2 With the adaptor fitted to the tool, put the spacer (A5) in position on the tool. Pass the adaptor through the valve guide and put the spacer and tool in position on the valve seat.

3 Fit the attachment (A7) to secure the adaptor to the valve guide.

4 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide out of the cylinder head.



To fit **Operation 3-16**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for valve guides	21825478	Adaptor used with 21825478 and 21825479	21825482
Adaptor used with 21825478	21825479		

1 Clean the parent bore in the cylinder head for the valve guide.

2 Lubricate the outer surface of the new valve guide (A6) with clean engine lubricating oil.

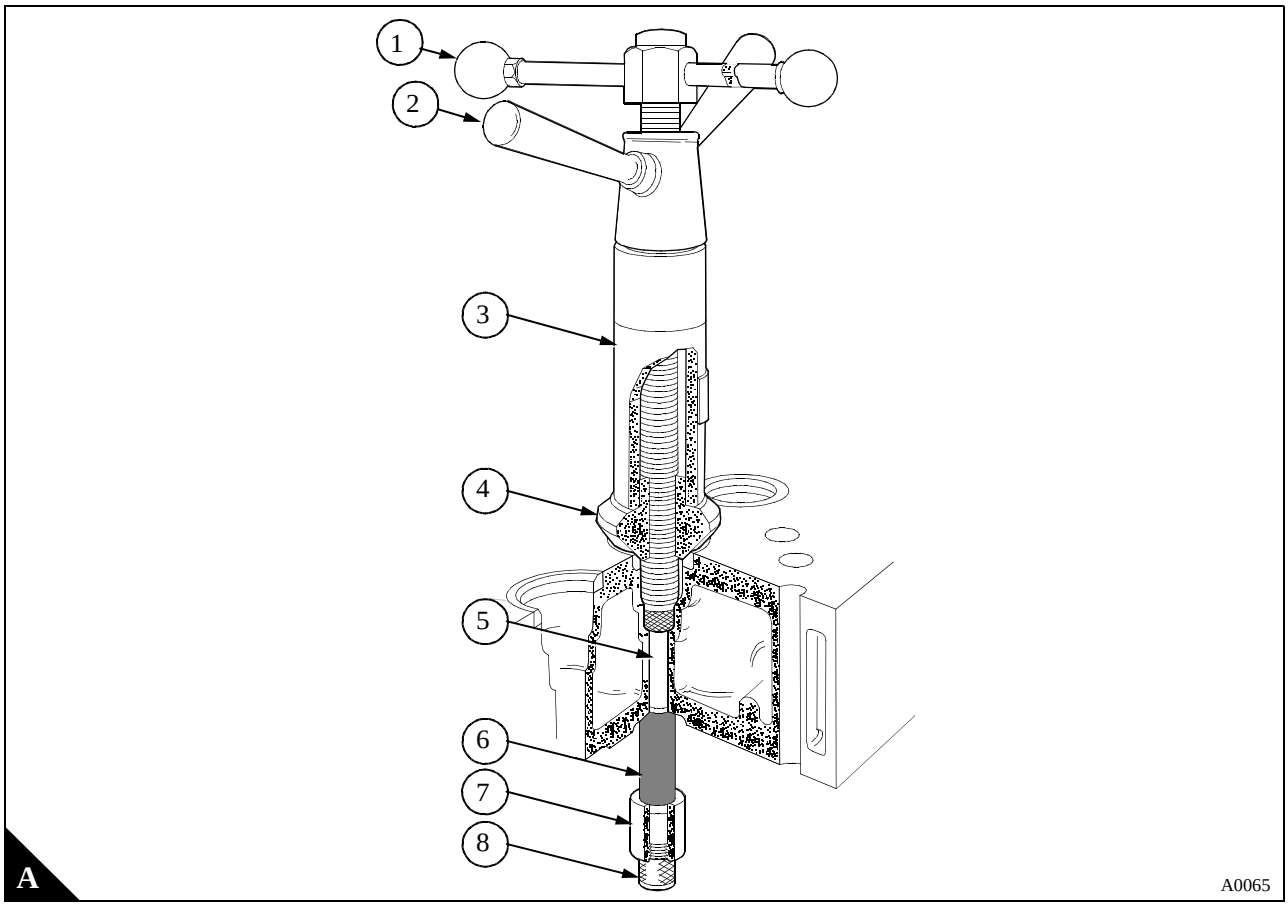
3 Fit the adaptor (A5), 21825479, into the remover/replacer tool (A3), 21825478

4 With the adaptor fitted to the tool, put the spacer (A4) in position on the tool. Pass the adaptor through the cylinder head and put the spacer and tool assembly in position on the valve seat.

5 Put the valve guide in position on the adaptor and fit the distance piece (A7), 21825482. Fit the attachment (A8) to secure the valve guide to the adaptor.

6 Hold the top handle (A1) and turn the bottom handle (A2) clockwise to pull the valve guide until the distance piece contacts the cylinder head.

7 When the valve guide is fitted correctly, the top of the valve guide will have a protrusion of 15,10 mm (0.594 in) above the valve spring seat.



Cylinder head

To inspect and to correct — Operation 3-17

1 Remove the cylinder head assembly, see Operation 3-9.

2 Remove the thermostat housing.

3 Inspect the cylinder head for signs of gas or coolant leakage.

4 Remove the valve springs and the valves, see Operation 3-11.

5 Clean the face of the cylinder head and the passages for coolant and for lubricating oil. The water jacket can be cleaned with a special solvent which must be used in accordance with the manufacturer's instructions.

6 Test the cylinder head for leaks at the pressure given in the relevant Data and dimensions for the "Cylinder head" on page 28.

7 When the cylinder head is thoroughly clean, check it for cracks. Inspect carefully the areas around the valve seats and around the holes for the atomiser nozzles.

8 The bottom face of the cylinder head can be machined if: there is distortion, see step 9; there are deep scratches; or, for engines without valve seat inserts, the valve depths are below the service limit.

9 Use a straight edge and feeler gauges to check the cylinder head for distortion across and along its bottom face, see "Maximum permissible distortion of cylinder head" on page 28. If the distortion is more than the given limit, the bottom face can be machined.

Caution: *Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 102,48 mm (4.035 in) after the cylinder head has been machined.*

Notes:

- On AE and YE engines the protrusion of the atomiser nozzle below the bottom face of the cylinder head must not be more than 4,82 mm (0.190 in).
- The nozzle protrusion must be measured with the nozzle seat washer fitted.

Caution: *After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth.Work to the minimum limit to allow for later wear.*

10 Check the valve seats for wear and for damage.

11 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-15 and Operation 3-16.

12 Where there is little damage, the valve and valve seat can be lapped. When the valve seats are lapped keep the seat as narrow as possible and ensure that all the compound used to lap the valve and the seat is removed.

13 More badly damaged valve seats can be corrected by use of the cutter tool, see Operation 3-18, or new inserts can be fitted, see Operation 3-19.

To correct a valve seat with a valve seat cutter **Operation 3-18**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Cutter for 46° inlet valve seats (1)	21825632	Pilot for use with valve seat cutters (1)	21825555
Cutter for 31° inlet valve seats	21825642	Handle set for use with valve seat cutters (1)	21825610
Cutter for exhaust valve seats (1)	21825631		

(1) Included in set of adjustable cutters for valve seats under part number 21825518.

1 Before any work is done on the valve seats, new valve guides must be fitted, see Operation 3-15 and Operation 3-16.

2 Fit the pilot in the valve guide and tighten the pilot.

3 Select the relevant cutter. Set the blades of the cutters to the diameter of the valve seat to be cut. Fit the cutter on the pilot and fit the handle (A). Ensure that the cutter is not allowed to fall on to the seat as this can damage the blades.

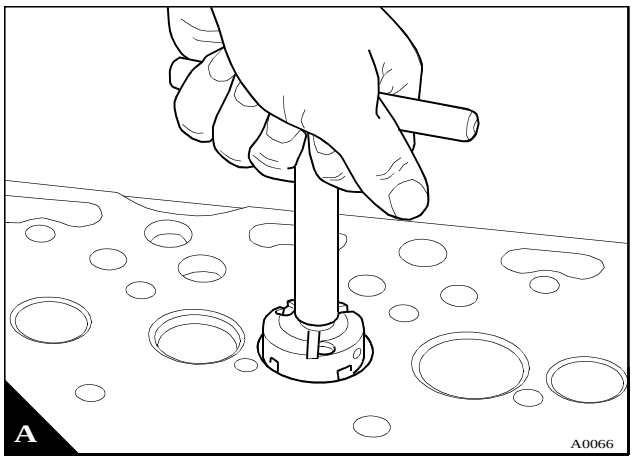
4 Carefully turn the cutter in a clockwise direction. Remove only the minimum material to ensure a good seat. Keep the seat as narrow as possible.

5 When the seat is cut, remove the cutter and the pilot. Remove any debris from the area of the valve seat and the port.

6 Fit the valve and lightly lap the valve and the seat.

7 Check that the valve depth is within limits, refer to the relevant Data and dimensions for "Inlet and exhaust valves" on page 29.

Note: If a valve seat has become too damaged or too worn to correct, a valve seat insert can be fitted, see Operation 3-19. Turbocharged engines and some naturally aspirated engines have valve seat inserts fitted as standard and these inserts can be renewed.



To fit valve seat inserts **Operation 3-19**

1 Remove the valve guide and clean the bore into which the guide is to be fitted.

2 Fit new valve guides, see Operation 3-15 and Operation 3-16.

3 With the bore of the new valve guide used as a pilot, machine the recess in the cylinder head to the dimensions given in "Dimensions of recesses for valve seat inserts" on page 30, or machine out the old insert. Remove all debris and clean the insert recess.

4 If the bottom face of the cylinder head has been machined, the insert will have to be surface ground on the back face to ensure that there is no protrusion of the insert above the bottom face of the cylinder head. After the back of the insert has been ground, ensure that the outer edge of the back face has a 0,9/1,3 mm (0.035/0.051 in) chamfer at 30° to the vertical.

5 With the bore of the valve guide used as a pilot, and with the rear face of the insert towards the cylinder head, press in the insert with the valve seat insert tool, see "Valve seat insert tool" on page 31. Do not use a hammer on the insert and do not use lubrication. Use a hydraulic press or a hand press in one continuous movement. Ensure that the bottom of the insert is in contact with the bottom of the recess.

6 Cut the valve seat at an included angle of 88° for 46° valve seats or 118° for 31° valve seats, see Operation 3-18, and lap the valve on to the valve seat. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, refer to the relevant Data and dimensions for "Inlet and exhaust valves" on page 29.

Note: Work as near as possible to the minimum figure to allow for future wear on the valve seat.

4

Piston and connecting rod assemblies

General description

The pistons used in Phaser and 1000 Series engines have either a "Quadram" (A) or a "Fastram" (B) combustion chamber in the top of the piston. These combustion chambers are designed to give an efficient mix of fuel and air.

The latest engines have pistons, with a "Fastram" combustion chamber and are available with different height grades.

The pistons have two compression rings and an oil control ring. The groove for the top ring has a hard metal insert to reduce wear of the groove. Axial location of the fully floating gudgeon pin is by circlips.

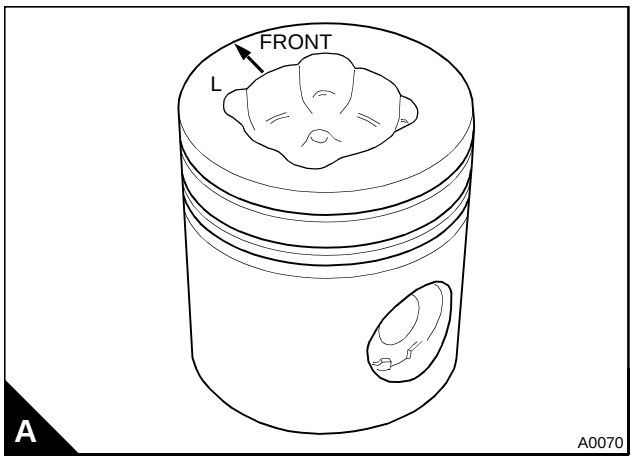
Controlled expansion pistons have a steel insert in the piston skirt.

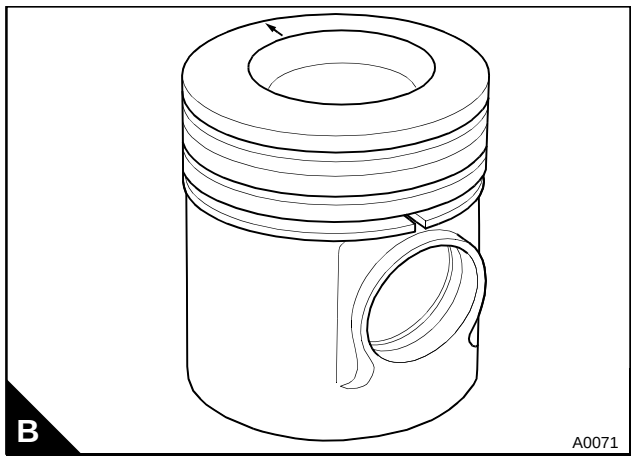
Note: Controlled expansion piston are fitted on all naturally aspirated four cylinder engines (type AA).

Caution: *The latest controlled expansion pistons must not be mixed in the engine with the early pistons.*

Turbocharged engines which are rated higher than 2300 rev/min have an anodised area on the top face of the piston.

Turbocharged engines have cooling jets fitted in the cylinder block to spray lubricating oil onto the inner surface of the pistons.





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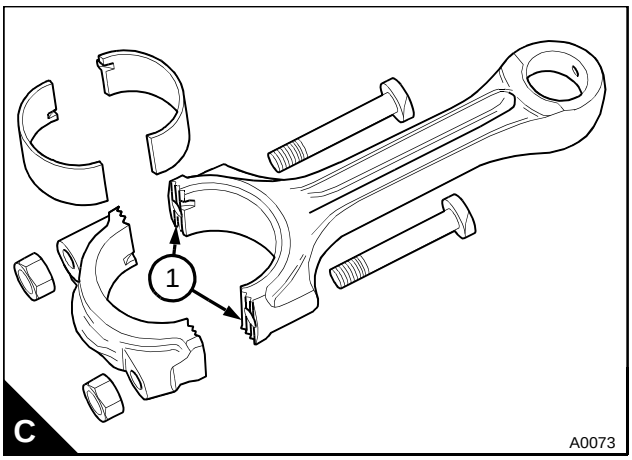
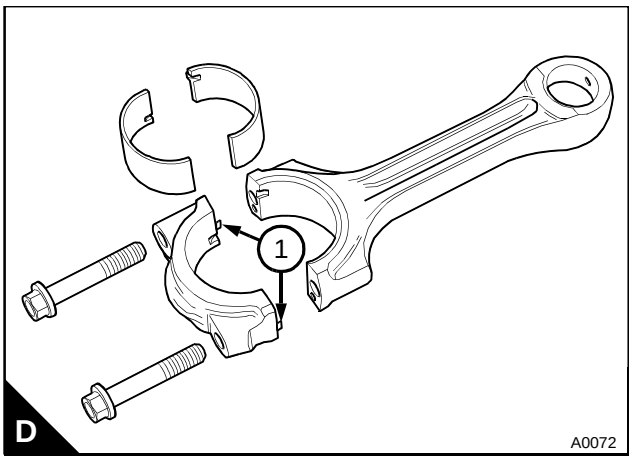
The connecting rods are machined from "H" section forgings of molybdenum steel. The connecting rods of turbocharged engines have wedge shaped small ends. Generally, the location of the bearing caps to the connecting rods is made by serrations (C1) and the cap is retained by two nuts and bolts (C).

On some turbocharged engines, used in vehicle applications, the location of the bearing cap to the connecting rod is made by dowels (D1) fitted in the bearing cap (D). The faces of these connecting rods and caps are flat and the caps are retained by two setscrews.

Note: Always use the engine identification number to order new parts.





Big end bearing

To remove — Operation 4-1

1 Drain the engine lubricating oil.

2 Remove the lubricating oil sump, see Operation 10-3.

3 Remove the lubricating oil strainer and suction pipe, see Operation 10-4, or remove the balancer unit, see Operation 5-21.

4 Rotate the crankshaft until the relevant connecting rod is at its lowest position.

5 Release the nuts and remove the bearing cap. Remove the bolts from the connecting rod. If the bearing cap is retained by setscrews, the location of the bearing cap will be by two dowels. To remove these bearing caps, release the setscrews by approximately four threads. Lightly hit the heads of the setscrews with a soft face hammer to separate the connecting rod from the bearing cap. Remove the setscrews and the bearing cap.

6 Remove the lower half of the shell bearing from the cap, but keep it with its relevant cap.

7 Carefully push the connecting rod up the cylinder bore just enough to allow access to the upper half of the shell bearing. Remove the bearing from the connecting rod. Keep the bearings from the connecting rod and cap together.

Caution: *Do not allow the connecting rods to hit the piston cooling jets, if fitted. If a cooling jet is hit, check its alignment, see Operation 4-14, and renew it, if necessary.*

To fit — Operation 4-2

1 Clean the bearing faces of the connecting rod and the crank pin.

2 If the cap has dowels for location on the connecting rod, ensure that the dowel protrusion is 3,0/4,5 mm (0.12/0.18 in) above the cap faces. Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil. Fit the upper half of the shell bearing to the connecting rod; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod to the crank pin; ensure that the assembly number on the connecting rod is on the same side as the other connecting rods.

3 Clean, lubricate and fit the lower half of the shell bearings into the cap; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod bolts with the flat side of the head of the bolts towards the connecting rod. Fit the cap to the connecting rod. Ensure that the assembly number on the cap is the same as that on the connecting rod and that both of the assembly numbers are on the same side (B).

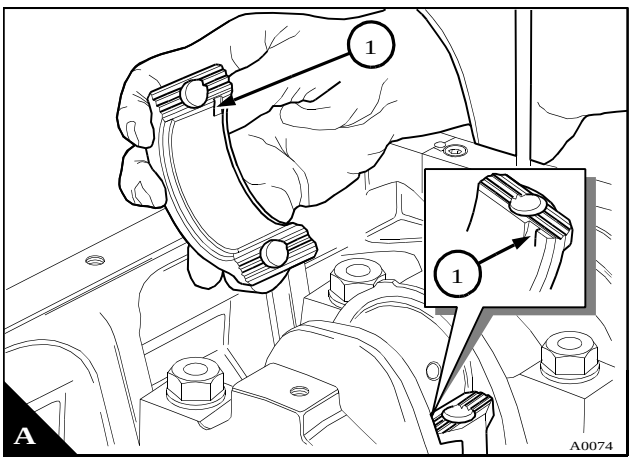
Note: When the fasteners are nuts, new nuts must be fitted.

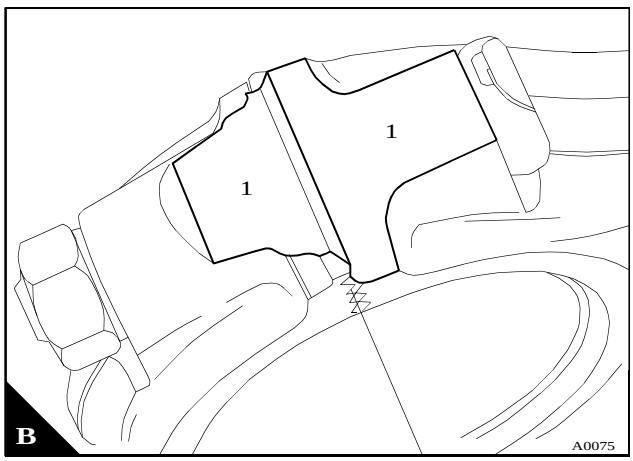
4 Tighten the fasteners gradually and evenly to the recommended torque of 155 Nm (114 lbf ft) 15,8 kgf m for setscrews, or 125 Nm (92 lbf ft) 12,7 kgf m for nuts.

5 Ensure that the crankshaft rotates freely.

6 Fit the lubricating oil strainer and suction pipe, see Operation 10-4, or fit the balancer unit, see Operation 5-22.

7 Fit the lubricating oil sump, see Operation 10-3, and fill the sump to the correct level with lubricating oil of an approved grade.





To inspect — Operation 4-3

1 Check the bearings and the crank pin for wear or other damage, renew if necessary.

Piston and connecting rod

To remove — Operation 4-4

1 Drain the lubricating oil and the cooling system.

2 Remove the cylinder head assembly, see Operation 3-9.

3 Remove all carbon from the top of the bores of the cylinder liners.

4 Remove the lubricating oil sump, see Operation 10-3.

5 Remove the lubricating oil strainer and suction pipe, see Operation 10-4, or remove the balancer unit, see Operation 5-21.

6 Remove the big end caps and the big end bearings from the connecting rods, see Operation 4-1.

Caution: *Do not allow the connecting rods to hit the piston cooling jets, if fitted. If a cooling jet is hit, check its alignment, see Operation 4-14, and renew it, if necessary.*

7 Turn the connecting rods 90° to prevent contact with the piston cooling jets. Push the pistons and the connecting rods out through the top of the cylinder liners. Keep the bearings and caps together to ensure that they can be fitted in their original positions.

8 Inspect the crank pins for damage.

To fit **Operation 4-5**

Special requirements

Special tools	
Description	**Part number**
Piston replacer tool	21825615

1 Ensure that the piston, the cylinder bore, the crank pin and the big end of the connecting rod are clean. Lubricate the piston and the cylinder liner with clean engine lubricating oil.

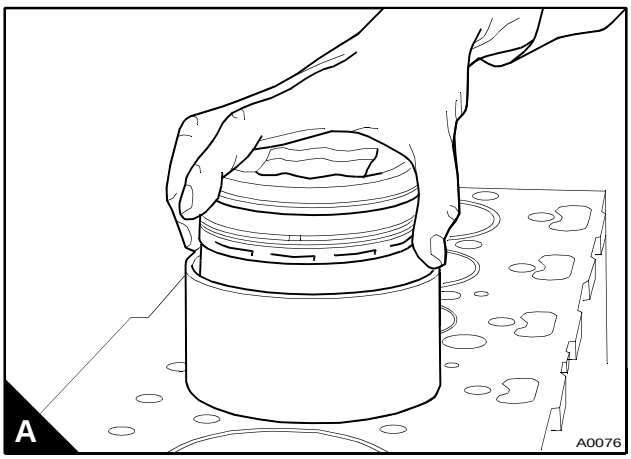
2 Rotate the crankshaft until the relevant crank pin is at its lowest position. Lubricate the crank pin with clean engine lubricating oil.

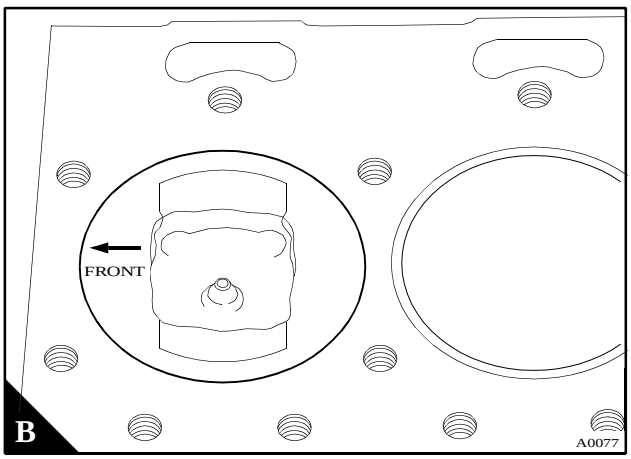
3 Fit the upper half of the shell bearings to the connecting rod. Ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil.

4 Put the piston replacer tool in position at the top of the relevant cylinder. The tool has a tapered bore to compress the piston rings when the piston and connecting rod assembly is fitted. Ensure that the smaller end of the tapered bore is towards the face of the cylinder block.

5 Put the piston ring gaps 120° apart. Pass the connecting rod through the piston replacer tool and allow the piston to enter the tool. The arrow or "FRONT" mark on the top of the piston must be towards the front of the engine. In this position the combustion bowl in the top of the piston will be towards the fuel injection pump side of the engine.

6 Push the piston and connecting rod assembly through the piston replacer tool (A) and onto the crank pin. If piston cooling jets are fitted, the piston and connecting rod assembly must be rotated to ensure that the connecting rod will not hit the piston cooling jet as the assembly is fitted. When the connecting rod has passed the piston cooling jet, rotate the connecting rod until the arrow or "FRONT" mark on top of the piston is towards the front of the engine (B).





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7 Clean the connecting rod cap and the lower half of the shell bearings. Fit the bearing to the cap; ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil. Fit the cap and ensure that the assembly number is the same as that on the connecting rod and that the numbers are on the same side.

8 Fit the fasteners; ensure that the flat side of the head of the bolts is towards the connecting rod. When the fasteners are nuts, new nuts must be fitted. Tighten the fasteners gradually and evenly to the recommended torque of 155 Nm (114 lbf ft) 15,8 kgf m for setscrews, or 125 Nm (92 lbf ft) 12,7 kgf m for nuts.

9 Check that the crankshaft will rotate freely.

10 Check the piston height above the top face of the cylinder block, see Operation 4-6.

11 Fit the lubricating oil strainer and suction pipe, see Operation 10-4, or fit the balancer unit, see Operation 5-22.

12 Fit the lubricating oil sump, see Operation 10-3.

13 Fit the cylinder head assembly, see Operation 3-10.

14 Fill the sump to the correct level with lubricating oil of an approved grade.

15 Fill the cooling system.

To check the piston height above the cylinder block **Operation 4-6**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Piston height tool	21825496	Dial gauge for use with 21825496	21825617

1 Put the piston height tool on the face of the cylinder block and rotate the gauge dial to the zero position.

2 Rotate the crankshaft until the piston is approximately at top dead centre (TDC). Carefully put the tool over the top of the piston with the plunger of the gauge in contact with the piston above the axis of the gudgeon pin (A).

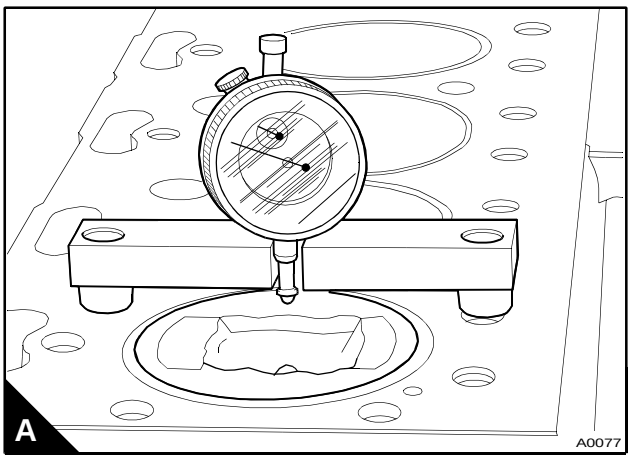
3 Rotate the crankshaft to ensure that the piston is at the highest position and make a note of the gauge indication.

For engines fitted with "Quadram" pistons, the piston height above the face of the cylinder block should be 0,14/0,36 mm (0.005/0.014 in).

For engines fitted with "Fastram" pistons, grades A to L, the piston height above the top face of the cylinder block should be 0,38/0,50 mm (0.015/0.020 in)

Notes:

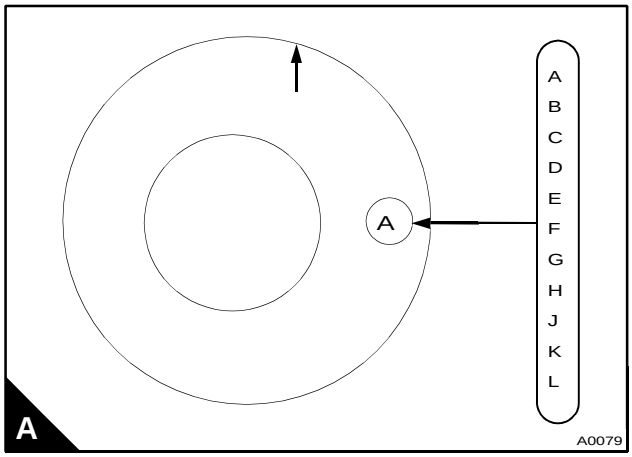
- Two "Quadram" piston heights can be used in the factory: "H" - high, "L" - low. In service only "L" pistons are supplied. If an "L" piston is used instead of an "H" piston, the height may be up to 0,19 mm (0.0075 in) below the bottom limit.
- The top of the piston should not be machined.
- If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder.

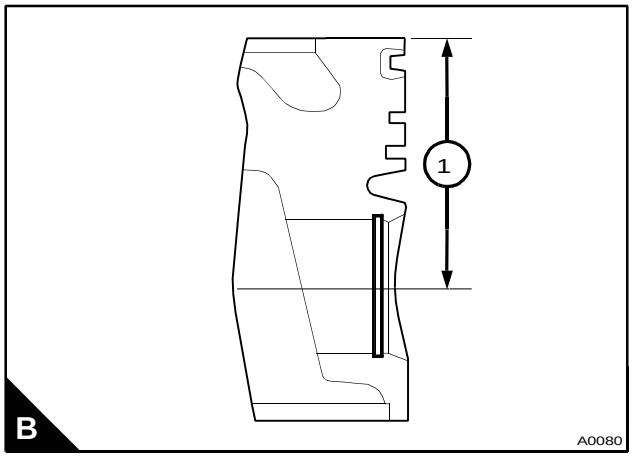


To check piston height grade of a “Fastram” piston **Operation 4-7**

For engines fitted with earlier "Fastram "pistons there are five height grades (A to E) of piston in production and in service.

The latest "Fastram" pistons are supplied in six height grades (F to L) in production and in service. Identification of the height grade is by the letter for each piston which is stamped on the top of the piston (A). The letter A or F is the highest grade and letter E or L is the lowest grade. The difference between the grades is 0,045 mm (0.0018 in).





If a new piston is fitted, ensure that it is of the correct height grade. The height grade can be checked by measurement, from the centre of the gudgeon pin to the top of the piston (B1). The dimensions for each grade are listed in the table below:

Piston grade letter	Piston height dimension (mm)	Latest equivalent grade
A (1)	70,334	G
B (1)	70,289	H
C (1)	70,244	J
D (1)	70,199	K
E (1)	70,154	L
F	70,391	
G	70,345	
H	70,299	
J	70,253	
K	70,207	
L	70,161	

(1) Earlier engines

Notes:

- The earlier piston grades A to E are now not supplied as a part. The latest equivalent grades G to L shown in the table above are to be used instead.
- The top of the piston must not be machined.

Piston rings

The piston used in the Phaser and 1000 Series engines have two compression rings and an oil control ring. All the piston rings are above the gudgeon pin. Piston rings have different design features. To ensure that the correct type is obtained always use the engine identification number to order new parts.

Caution: *Only expand the ring gaps enough to ensure that the ends of the rings do not damage the piston when the ring is removed or put into position.*

To remove and to fit **Operation 4-8**

To remove

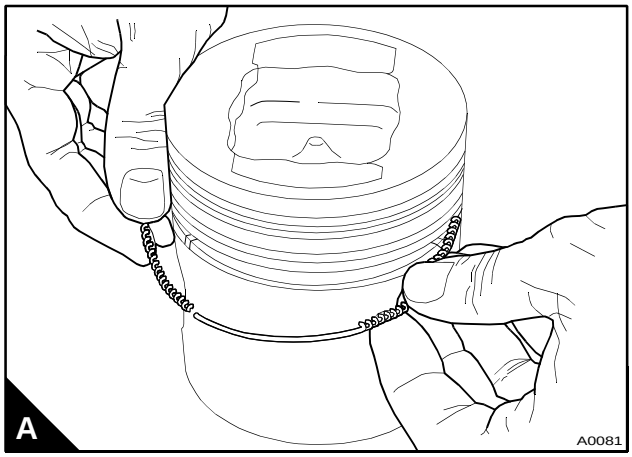
Remove the piston rings with a suitable ring expander. Keep the rings with their relevant piston.

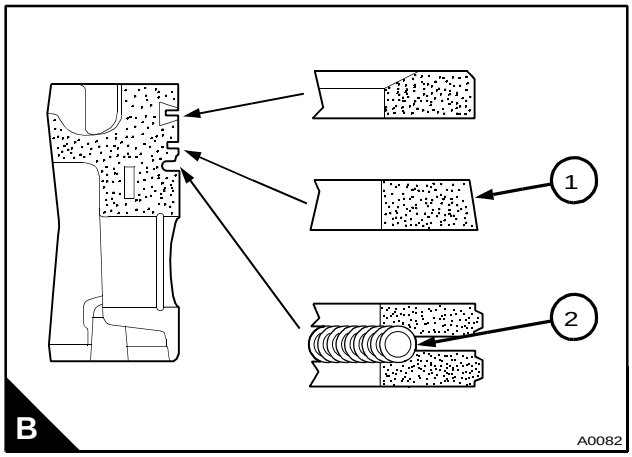
To fit

Use a suitable piston ring expander to fit the piston rings.

1 Fit the spring of the oil control ring in the bottom groove with the latch pin inside both ends of the spring (A). Fit the oil control ring over the spring (B2, C2 or D3). Ensure that the ring gap is at 180° to the latch pin.

2 Fit the cast iron ring with the taper face (B1 or C1) to the second groove with the word "TOP", or the manufacturer's symbol, towards the top of the piston.





New second rings have a green identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

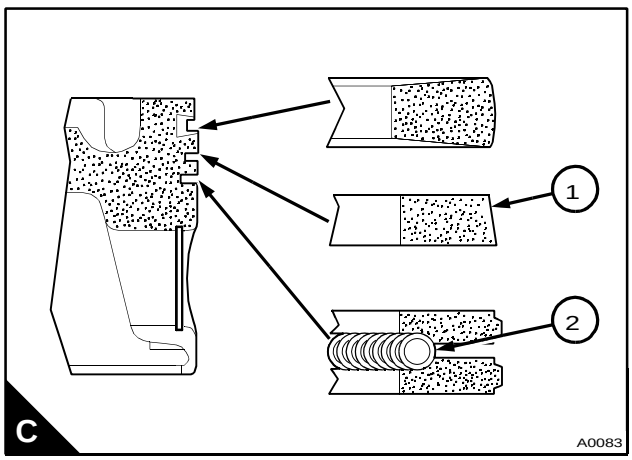
The second ring on some engines has an outside step (D2) at the bottom of the tapered face.

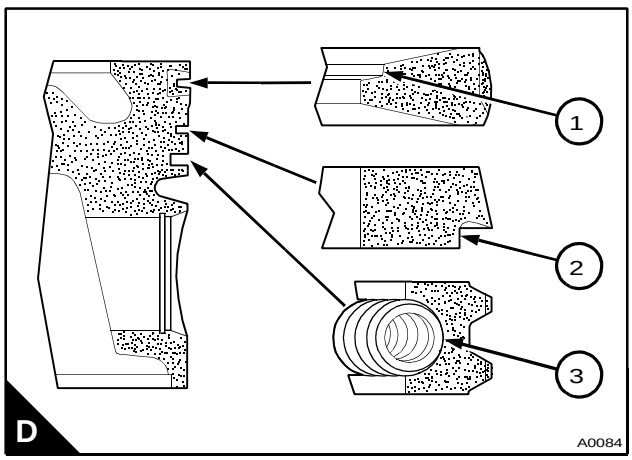
3 Fit the chromium plated top ring, the manufacturer's symbol or the word 'TOP' must be towards the top of the piston.

New top rings have a red or blue identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

The top ring on some engines has an internal step (D1) on the top face.

4 Ensure that the ring gaps are 120° apart.





Piston and connecting rod assembly

To dismantle and to assemble — Operation 4-9

To dismantle

1 Remove the piston rings, see Operation 4-8.

2 Remove the circlips which retain the gudgeon pin.

3 Put a mark on the piston to indicate the cylinder number as shown on the connecting rod. Put the mark on the piston on the same side as the mark on the big end to ensure that they are assembled correctly (A).

Caution: *Do not scratch or stamp the top of the piston, use a permanent ink marker to make a mark on the piston.*

4 Push the gudgeon pin out by hand. If the gudgeon pin is tight, heat the piston to 40/50 °C (100/120 °F) for easy removal of the gudgeon pin.

To assemble

1 Clean the bore of the small end bush and lubricate it with clean engine lubricating oil.

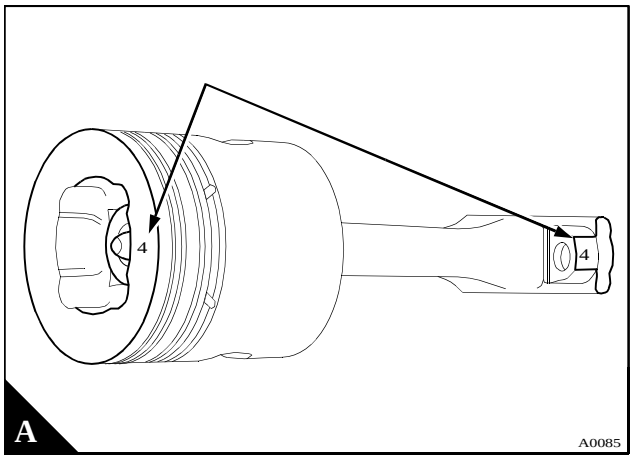
2 Fit a new circlip in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.

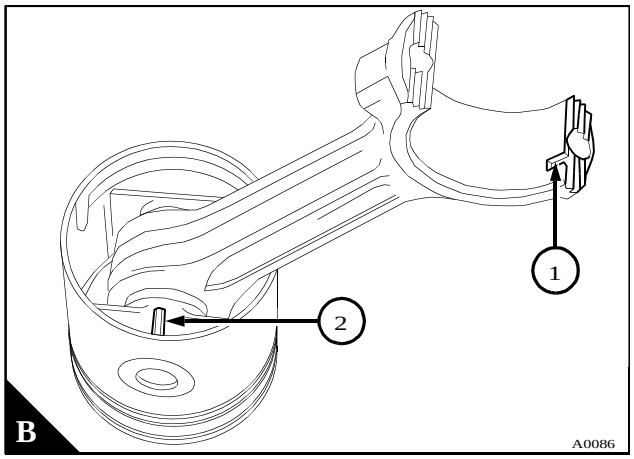
3 With the piston upside down, put the connecting rod in position with the recess for the location of the big end bearing (B1) on the same side as the lug on the gudgeon pin boss (B2). If the original piston is used, ensure that it is assembled to the correct connecting rod and is used in the original cylinder. Engines with "Fastram" pistons have six piston height grades, if a new piston is fitted, ensure that it is of the correct height grade, see Operation 4-7.

4 Lubricate the gudgeon pin bosses with clean engine lubricating oil and push in the gudgeon pin towards the circlip. If the gudgeon pin is a tight fit in the piston, heat the piston to 40/50 °C (100/120 °F) before the gudgeon pin is fitted.

5 Fit a new circlip in the groove in the other gudgeon pin boss. Ensure that it fits correctly in the groove.

6 Fit the piston rings, see Operation 4-8.





Piston and piston rings

To inspect — Operation 4-10

1 Check the piston for wear and other damage.

2 Check that the piston rings are free to move in their grooves and that the rings are not broken.

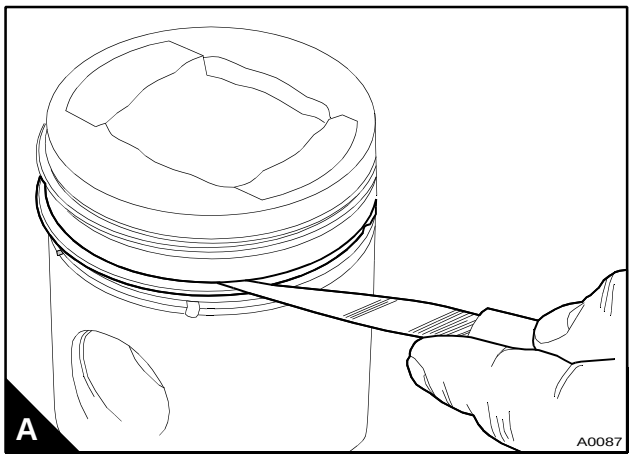
3 Remove the piston rings, see Operation 4-8, and clean the piston ring grooves and the piston rings.

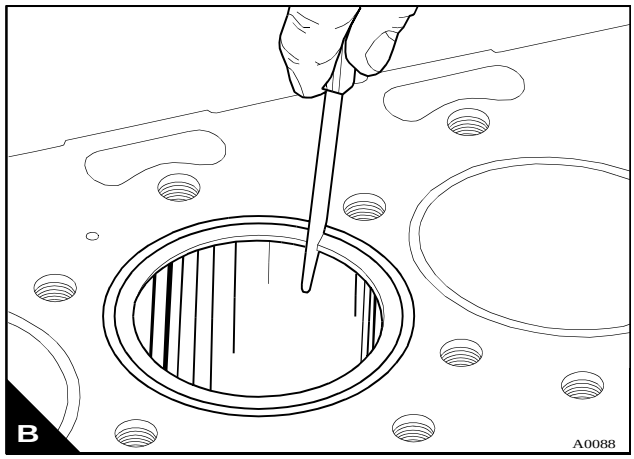
4 Fit new piston rings in the grooves and check for wear of the grooves with feeler gauges (A). Compare the piston ring clearance in the groove to that given for new components in the relevant Data and dimensions for "Pistons and piston cooling jets" on page 33, and renew the piston if necessary.

Note: Some pistons have a tapered top groove and the piston ring is wedge shaped, see Operation 4-8 (C/D). When this occurs the top piston ring clearance cannot be checked by this method.

5 Clean all carbon from the top of the cylinder liners. Fit the piston rings in the top part of the cylinder liner and measure the ring gap with feeler gauges (B). The coil spring must be fitted to the oil control ring when the gap of this piston ring is measured.

The piston ring gaps for new components are given in the relevant Data and dimensions for "Pistons and piston cooling jets" on page 33.





Connecting rod

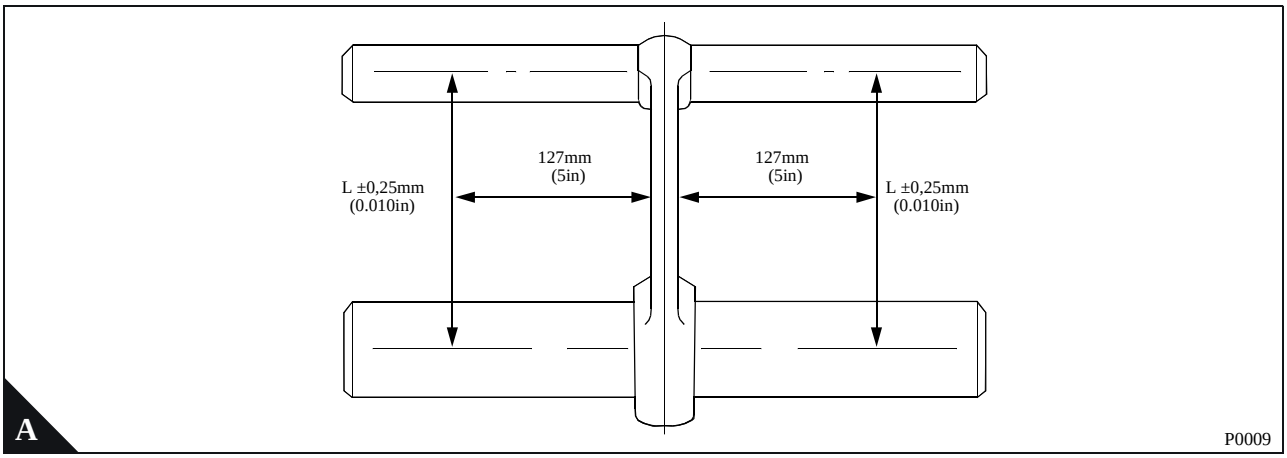
To inspect — Operation 4-11

1 Check the connecting rod for distortion (A).

Note: The large and small end bores must be square and parallel with each other within the limits of +/- 0,25 mm (0.010 in) measured 127 mm (5.0 in) each side of the connecting rod axis on a test mandrel. With the small end bush fitted, the limits are reduced to +/- 0,06 mm (0.0025 in).

2 Check the small end bush for wear or for other damage and renew it, if necessary.

3 Check the fit of the gudgeon pin in the small end bush and check the gudgeon pin for wear. Refer to the relevant Data and dimensions for "Gudgeon pins and small end bushes" on page 35.



Small end bush

To remove and to fit — Operation 4-12

1 Press out the old bush with a suitable adaptor.

2 Clean the connecting rod bore and remove any sharp edges.

3 Press in the new bush. Ensure that the lubrication hole in the bush is on the same side as, and is aligned with, the hole in the top of the connecting rod.

4 Ream the bush to get the correct clearance between the gudgeon pin and the bush. Refer to the relevant Data and dimensions for "Gudgeon pins and small end bushes" on page 35.

Note: On turbocharged engines the small end is wedge shaped. After the small end bush has been fitted, machine the bush to the shape of the small end and remove any sharp edges.

Piston cooling jets

To remove and to fit — Operation 4-13

To remove

1 Release the valve assembly and remove the piston cooling jet assembly (A).

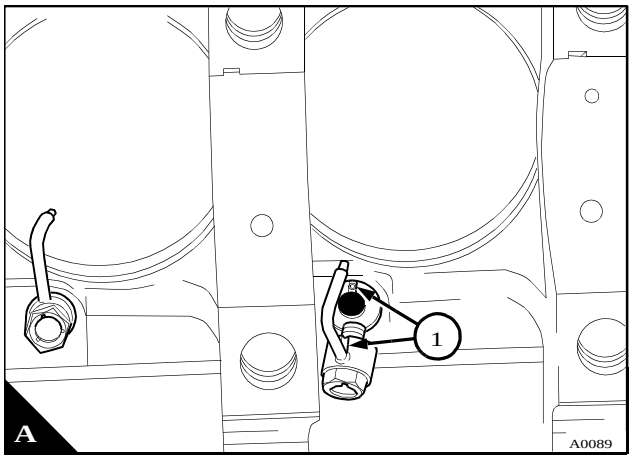
Note: The crankshaft is removed in A to show clearly the piston cooling jet.

To fit

1 Check that the ball moves freely against spring pressure in the valve assembly and that the jet tube is not damaged. Renew the valve assembly and/or the body as necessary.

2 Fit the piston cooling jet; ensure that the assembly is fitted correctly on the dowel in the cylinder block. Tighten the valve assembly to 20 Nm (15 lbf ft) 2,0 kgf m.

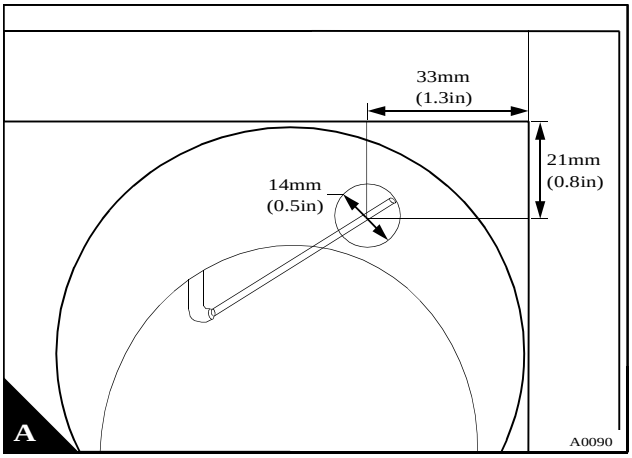
Note: Latest engines have the dowel fitted in the cooling jet instead of the cylinder block.



To check the jet alignment **Operation 4-14**

1 Insert a 1,70 mm (0.067 in) diameter rod, of suitable length, into the jet. If a suitable rod is not available, reduce the end of a thicker rod to 1,70 mm (0.067 in) diameter for a length of 16,00 mm (0.630 in).

2 When the rod is inserted into the jet it must extend out of the top of the cylinder within the area shown in (A).



5

Crankshaft assembly

General description

The crankshaft is a chrome-molybdenum forging which has five main journals for four cylinder engines and seven main journals for six cylinder engines, and on some engines it has been case hardened with the “Nitreg” process.

Note: It is not possible to regrind the nitreg crankshaft for service overhaul purposes.

End-float is controlled by two half thrust washers on both sides of the centre main bearing.

The main bearings have steel backs with a aluminium/tin bearing material except the centre main bearing of six cylinder engines, which has a bearing material of lead bronze with a lead finish. The main bearing caps are made of cast iron or spheroidal graphite (SG) iron.

Note: The bearing material of all the main bearings used on Phaser 210Ti engines is lead bronze with a lead finish.

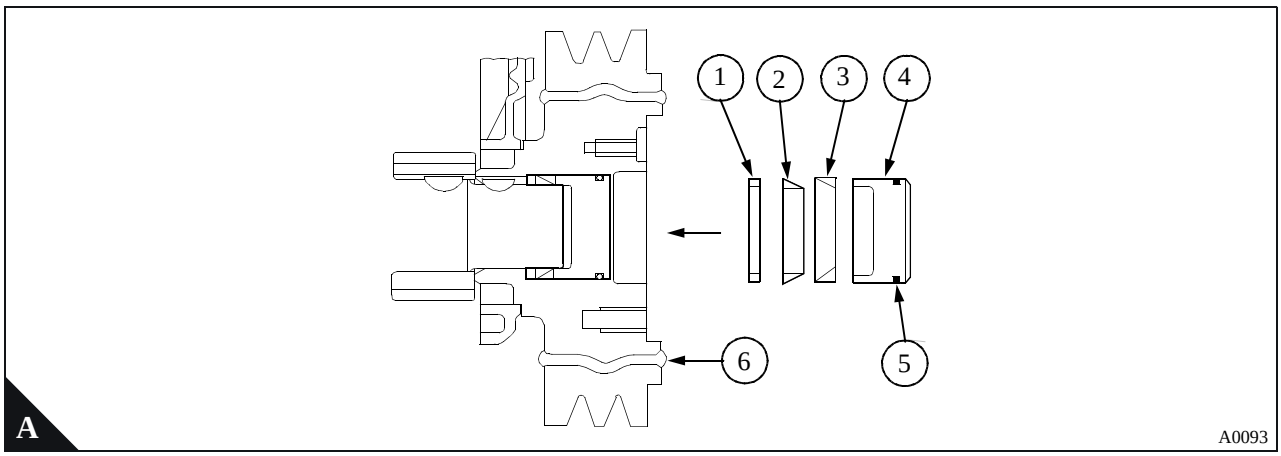
The front and the rear oil seals are Viton lip seals with a dust lip to the outside of the main lip and with oil return grooves on the face of the main lip. Engines which have a flywheel housing that is oil filled have an arrangement which uses two "Viton" lip seals. These seals are narrower than the standard seal and are fitted back to back on the crankshaft palm. They do not have a dust lip.

Warning! *Read the safety precautions for "Viton seals" on page 7.*

The crankshaft pulley of the four cylinder engine, usually fitted without a damper, is held in position by a plain thrust block and three setscrews. The nose of the crankshaft is serrated for location.

The location of the front pulley of six cylinder engines is by a key in the crankshaft nose and the pulley is held in position by a tapered rings arrangement (A).

An integral damper, with a rubber insert (A6) is built into the pulley of early six cylinder engines and some four cylinder engines.



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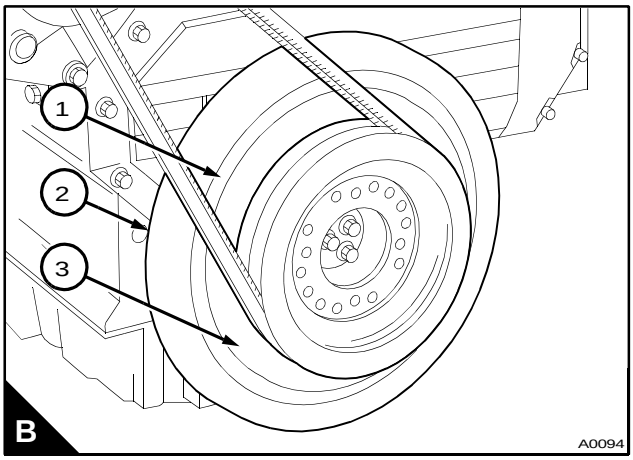
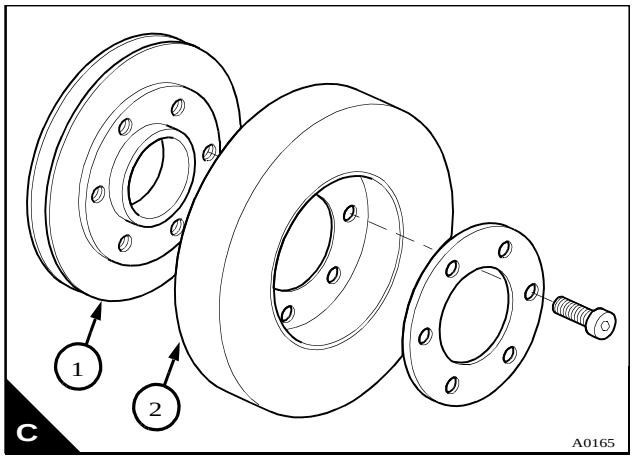
Later six cylinder vehicle engines have a separate plate damper which has an outer plate (B2), bonded by a rubber insert (B1) to an inner plate (B3) and fastened to the rear face of the crankshaft pulley. The latest six cylinder engines have a viscous damper (C2) which is fastened to the front or rear face of the pulley (C1). All of the dampers are designed for the suppression of torsional vibrations in the engine crankshaft.

A balancer unit is fitted to certain four cylinder engines which have rigid mountings or which are part of the chassis or frame. The purpose of the balancer unit is to reduce the effect of the out-of-balance forces to an acceptable condition.





Crankshaft pulley

To remove and to fit (four cylinder engines) — Operation 5-1

On certain engines a water immersion seal (A) is fitted to the timing case cover, see Operation 6-3 and Operation 6-4. The water immersion seal has a flexible front lip that protrudes onto the boss of the crankshaft pulley.

The plastic mandrel (A1) supplied with the seal must be fitted to the seal immediately the crankshaft pulley is removed. This will ensure that the front lip of the seal will retain its correct shape. If the mandrel is not available, use the seal adaptor 21825946 which is part of the seal replacer tool 21825577.

To remove

1 Remove the drive belt(s), see Operation 14-3.

2 Release the three setscrews (B2) which hold the pulley and remove the setscrews, the thrust block(B1) and the pulley (B3).

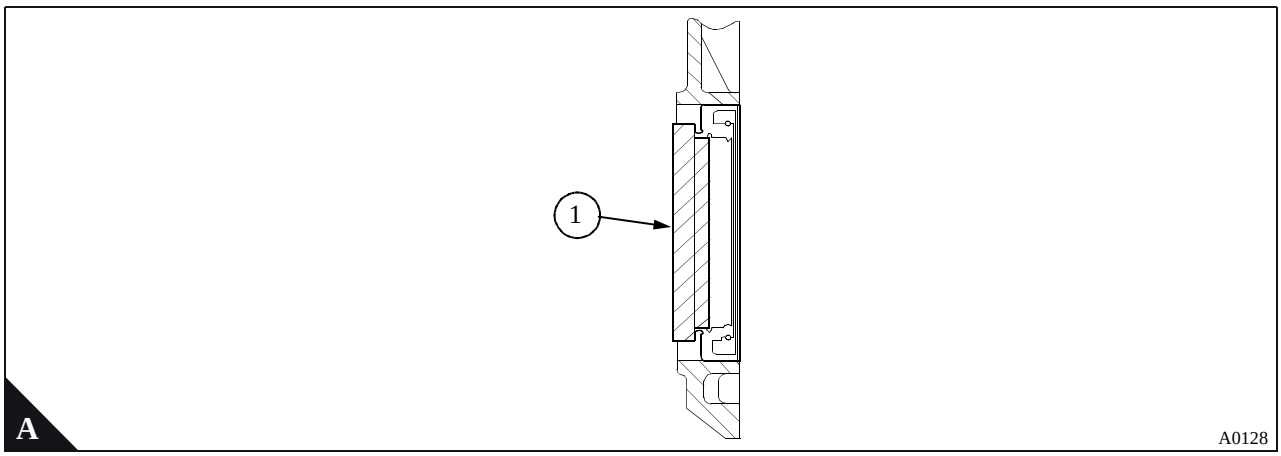
3 Clean the components and check for damage. Renew damaged components.

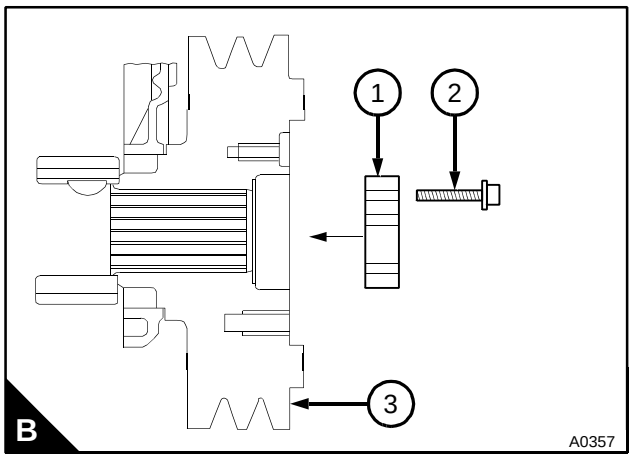
To fit

1 Put the pulley (B3) in position on the crankshaft. Lubricate lightly the threads of the setscrews (B2) with clean engine lubricating oil. Lubricate the main lip of the seal with clean engine oil. Fit the hub and the setscrews (B2)and tighten the setscrews (B2) gradually and evenly to 115 Nm (85 lbf ft) 11,8 kgf m.

2 Check each setscrew (B2) again to ensure that they are still to the correct torque.

3 Fit the drive belt(s), see Operation 14-3.





Crankshaft pulley and damper

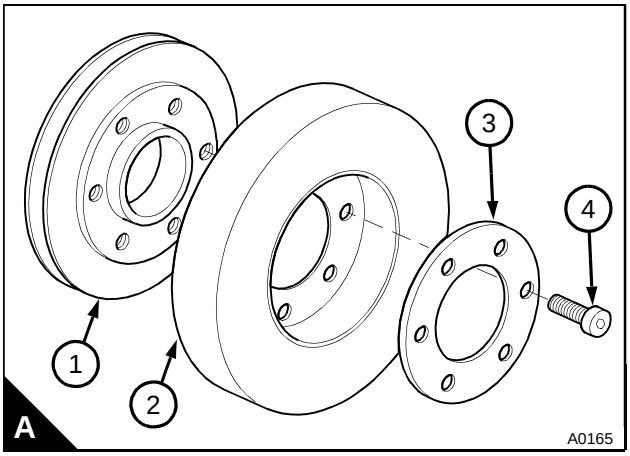
To remove (six cylinder engines) — Operation 5-2

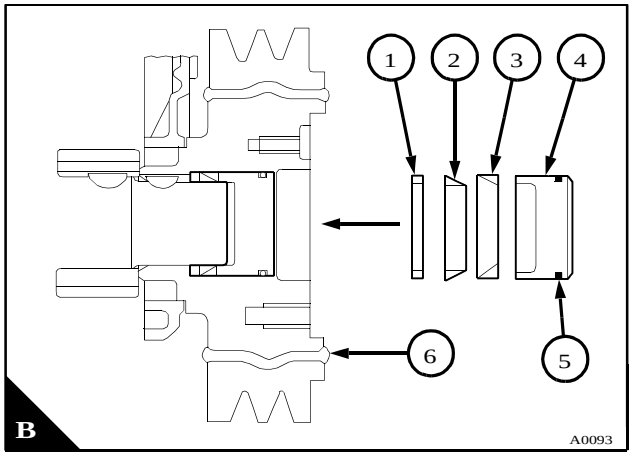
Caution: *A viscous damper (A2) should be renewed if there is impact damage to the outer casing or if there is leakage of the viscous fluid from the cover plate. Check for damage in the area around the holes for the damper fasteners.*

1 Remove the drive belts, see Operation 14-3.

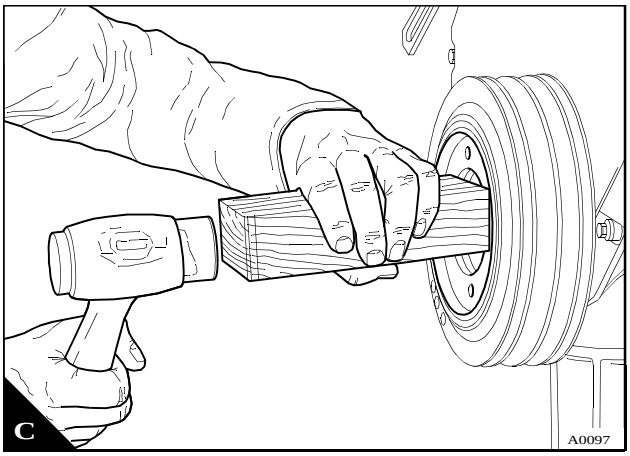
Warning! *The crankshaft pulley and damper assembly is heavy and must be given support before removal.*

2 Release the fasteners which secure the clamp ring (A3) for the damper to the pulley, if one is fitted, and remove the damper.





3 Remove the three setscrews and the thrust block (B4). If the pulley is not free, **do not use an extractor to remove the pulley**. Hold a wooden block against the inner hub of the pulley and with a hammer, lightly hit the wooden block towards the rear (C) to loosen the tapered rings.



To fit (six cylinder engines) **Operation 5-3**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820118

1 If the damper is fitted to the rear face of the pulley, fit the damper to the pulley with its inner flange against the rear face of the pulley. If a viscous damper is fitted, put the damper in position on the face of the pulley (A1). Fit the clamp ring (A3) or the washers.

Notes:

- On some engines the viscous damper is fitted to the rear of the pulley.
- If a clamp ring with a chamfer on the outside edge of the ring is used, ensure that the chamfer is towards the damper when the ring is fitted. Clamp rings may be fitted to viscous or plate dampers.

Apply POWERPART Threadlock and nutlock to the cap screws (A4) for the clamp ring and tighten the cap screws gradually and evenly to 35 Nm (26 lbf ft) 3,6 kgf m. For viscous dampers fitted with M12 setscrews tighten the fasteners to 75 Nm (55 lb ft) 7,6 kgf m.

Caution: *Do not use a degreasing solution.*

2 Clean thoroughly the nose of the crankshaft, the bore of the pulley and the tapered rings components. Do not expand the tapered rings.

3 Put the pulley on the crankshaft with the key engaged and push the pulley towards the rear.

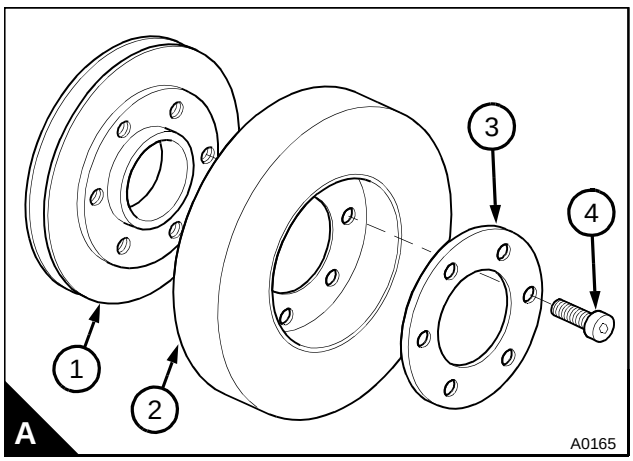
4 Fit the spacer (B1), then the inner ring (B2) and then the outer ring (B3). Ensure that the ring gaps are not aligned.

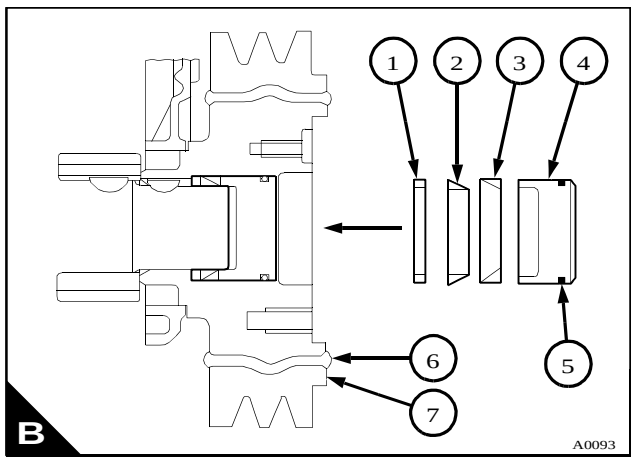
Caution: *It can be very difficult to remove the pulley if the tapered rings are not fitted correctly.*

5 Lubricate lightly the "O" ring (B5) and the threads and the thrust faces of the setscrews with clean engine oil. Put the thrust block (B4) and setscrews in position.

6 While the pulley is pressed to the rear, tighten the setscrews gradually and evenly to 115 Nm (85 lbf ft) 11,8 kgf m. Apply the torque again to ensure the pulley is fully tightened.

7 Fit the drive belts, see Operation 14-3.





To inspect **Operation 5-4**

1 When an integral pulley and damper (A) or a separate plate damper (B) is fitted. The assembly should be renewed if:

- The rubber insert (A6) or (B1) between the hub and the outer ring is split.
- The rubber insert is damaged by oil or solvents
- There is movement of the pulley or outer ring on the hub.

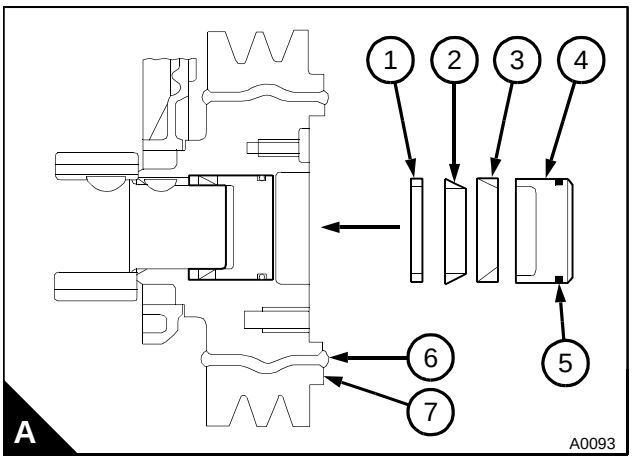
Check for cracks and wear in the area around the holes for the damper fasteners.

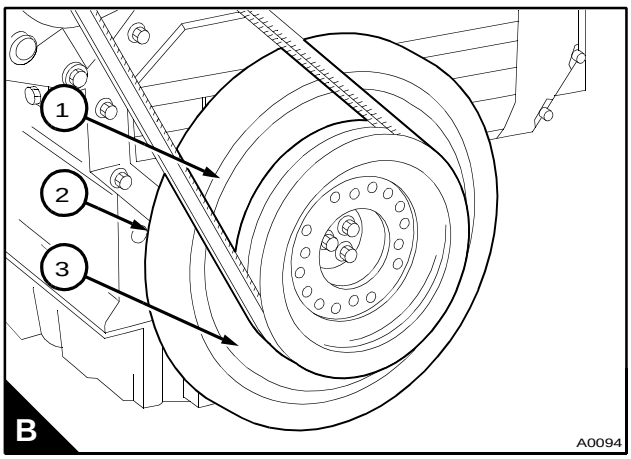
Caution: *Do not use excessive force to lever the damper away from the engine.*

2 Remove any paint or dirt in four positions 90° apart on the face (A7) or (B2) of the damper, above the rubber insert. Use a lever to move the damper forward and eliminate the crankshaft end-float. Fit a dial test indicator on the front cover of the timing case. Measure the alignment of the damper face at four locations, 90° apart. The maximum permissible difference between the maximum and minimum figures obtained is:

- Integral pulley and damper: 0,18 mm (0.007 in).
- Separate plate damper: 0,60 mm (0.024 in).

3 Remove any paint or dirt from the circumference of the damper. Fit a dial test indicator on the front cover of the timing case.





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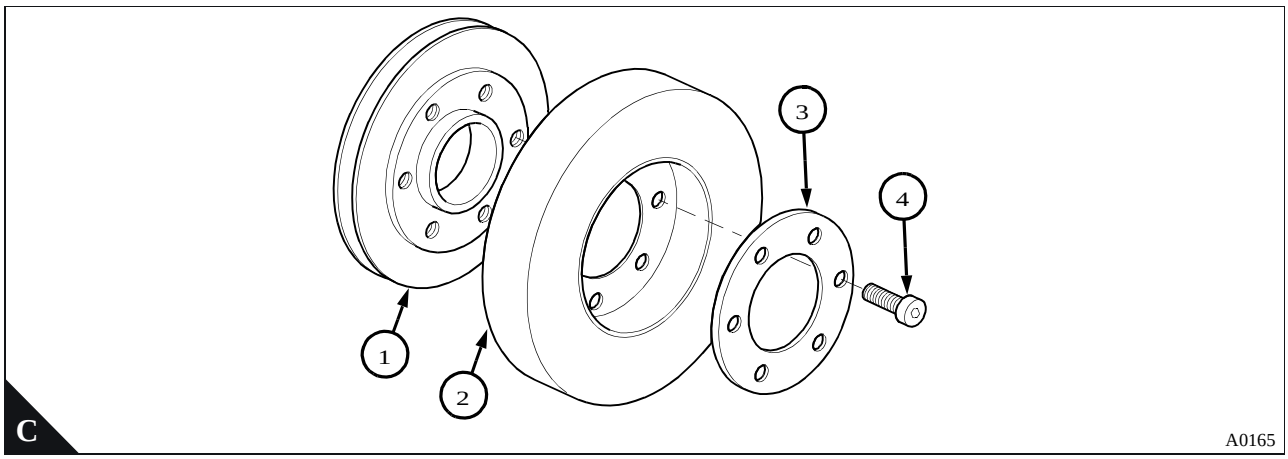
4 Rotate the crankshaft slowly one complete revolution and measure for run-out on the circumference of the damper with the dial test indicator. The maximum permissible difference between the maximum and minimum figures obtained is:

- Integral pulley and damper: 0,12 mm (0.005 in).
- Separate plate damper: 0,80 mm (0.032 in).

5 A viscous damper (C1) must be renewed if there is impact damage to the outer casing or if there is leakage of the viscous fluid from the cover plate. Check for damage in the area around the holes for the damper fasteners.



Rear oil seal assembly

Introduction

Early engines have a two-piece rear end oil seal assembly, the oil seal can be renewed and fitted to different depths in the housing to allow for wear on the crankshaft palm, see Operation 5-7.

Later engines have a one-piece rear end oil seal assembly, the oil seal can not be renewed in the housing, the complete assembly must be renewed. If the crankshaft palm has a wear groove caused by the old oil seal assembly, a wear sleeve must be fitted to the crankshaft palm before the new assembly is fitted, see Operation 5-8.

Note: The rear end oil seal assembly must be replaced with the same type of assembly, they are not interchangeable as the machining of the cylinder block and bridge piece are not the same.

Engines with a flywheel housing that is oil filled.

This arrangement for the crankshaft rear oil seal is for engines which have a flywheel housing that is filled with oil. This arrangement uses two lip seals which are narrower than the standard seal and are fitted back to back on the crankshaft palm.

The front seal prevents leakage of oil from the engine and the rear seal prevents leakage of oil from the flywheel housing. A cover and joint are used to prevent leakage of oil past the setscrews which retain the flywheel housing to the rear face of the cylinder block. An "O" ring is used to seal between the cover and the seal housing. Oil leakage past the "O" ring or one of the oil seals will pass through a hole in the seal housing between the two seals. The oil will then pass through two cast grooves in the front face of the flywheel housing. These grooves are in the 4 o’clock and 8 o’clock positions.

Continued

To remove and to fit (one-piece assembly) **Operation 5-5**

Notes:

- The seal for the (one-piece) assembly fitted to later engines cannot be renewed, if the seal needs to be renewed, the complete assembly must be renewed.
- If the crankshaft palm has a wear groove caused by the old oil seal assembly, a wear sleeve must be fitted to the crankshaft palm before the new assembly is fitted, see Operation 5-8.
- An alignment tool is required to fit the rear end oil seal assembly, see page 113.

Caution: *The new rear end oil seal assembly includes a plastic sleeve (A2) that is fitted to the inside of the seal (A3). This is to protect the oil seal from damage when it is fitted to the crankshaft palm (A1). The plastic sleeve must remain inside the seal until the seal is fitted. When the seal is fitted, the plastic sleeve will be pushed out of the oil seal housing. The plastic sleeve must be discarded after the seal is fitted. Because the new rear end oil seal assembly is pre-waxed, there is no need to lubricate the palm or the seal before it is fitted.*

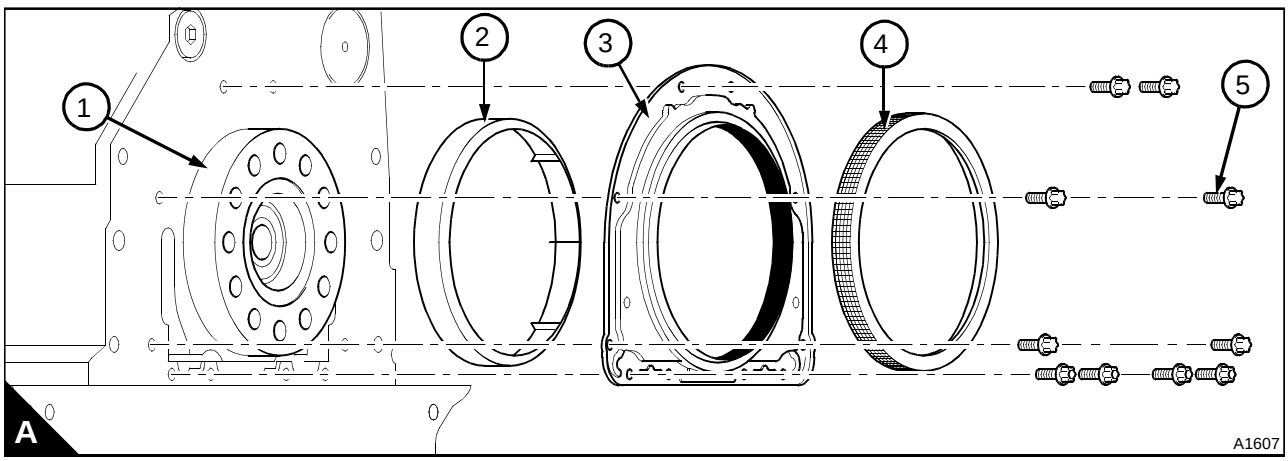
To remove

1 Remove the drive components from the rear end of the engine.

2 Remove the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.

3 Remove the setscrews from the housing and remove the assembly.

4 Inspect the seal for wear or for damage to the main lip and renew the assembly, if necessary. If there is only a small scratch across the lip, renew the assembly.



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To fit

1 Ensure that all parts and surfaces of the engine block are clean and free from oil, grease and dirt.

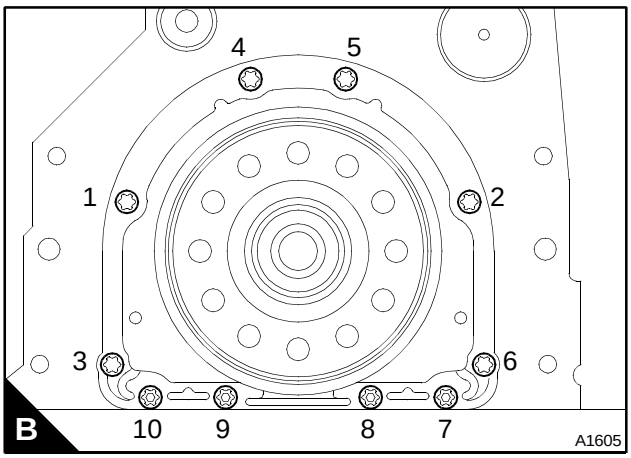
2 Place the new rear assembly onto the crankshaft palm, push the seal on until the seal housing contacts the cylinder block face.

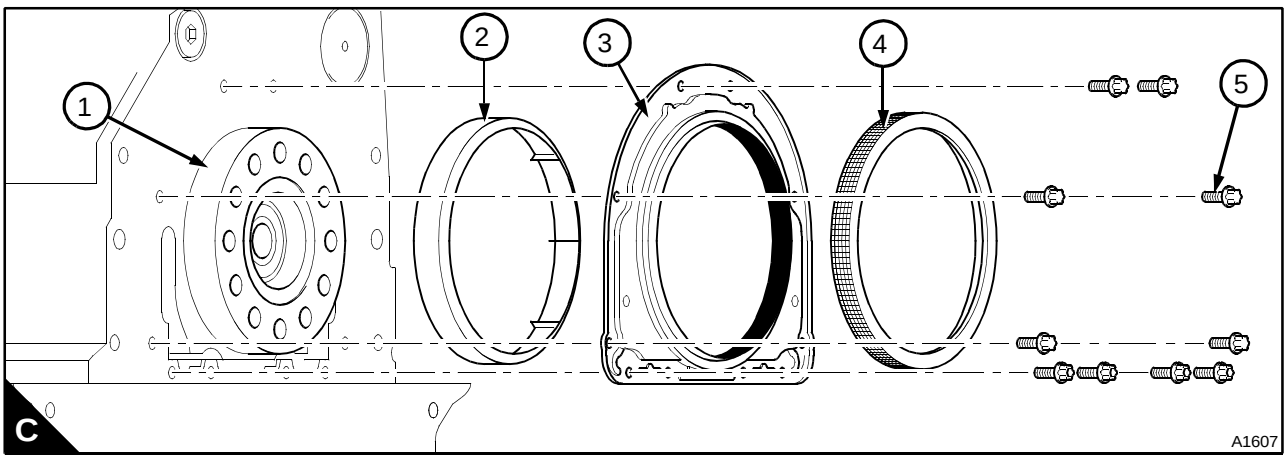
3 Place the alignment tool (C4) over the oil seal assembly housing (C3), this will centralise the seal to the crankshaft palm.

4 With the alignment tool in position fit the setscrews (C5). Tighten screws 1 and 2 (A) to 22 Nm (16 lbf 2.2 Kgf m), remove the alignment tool, tighten the remaining setscrews in sequence (A) to 22 Nm (16 lbf 2.2 Kgf m).

5 Fit the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.

6 Fit the drive components to the rear end of the engine.





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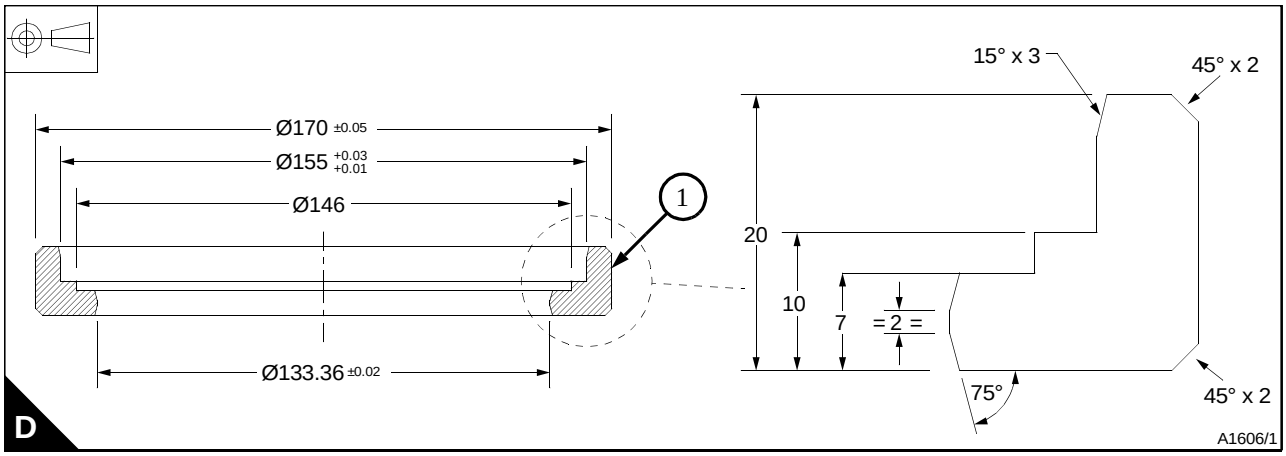
Alignment tool

The alignment tool is not currently available and must be manufactured locally to the following specifications:

1 Outer surface (D1) to be knurled.
2 All sharp edges to be removed.
3 All dimensions in millimetres.
4 To be made from material EN 32, harden 0.5 mm deep.



To remove and to fit (two-piece assembly) **Operation 5-6**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Crankshaft rear oil seal adaptor	21825540	POWERPART Threadlock and nutlock	21820117 or 21820118
		POWERPART Silicone rubber sealant	1861108

To remove

1 Remove the drive components from the rear end of the engine.

2 Remove the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.

3 Remove the setscrews and the cap screws from the housing and remove the housing and seal assembly.

4 Inspect the seal for wear or for damage to the main lip and renew the seal, if necessary. If there is only a small scratch across the lip, renew the seal.

Continued

To fit

1 Clean the faces of the cylinder block, the oil seal housing and the crankshaft flange.

2 Check that the seal and the outer circumference of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position in the housing.

3 Ensure that the two dowels (A4) are fitted in the cylinder block. Put a new joint (A3) in position on the dowels, no jointing compound is necessary.

4 Put the seal replacer tool on the crankshaft flange. Lubricate the crankshaft flange, the main lip of the seal and the seal replacer tool with clean engine lubricating oil. The lubrication of the seal is necessary to prevent damage to the seal when the engine is first started.

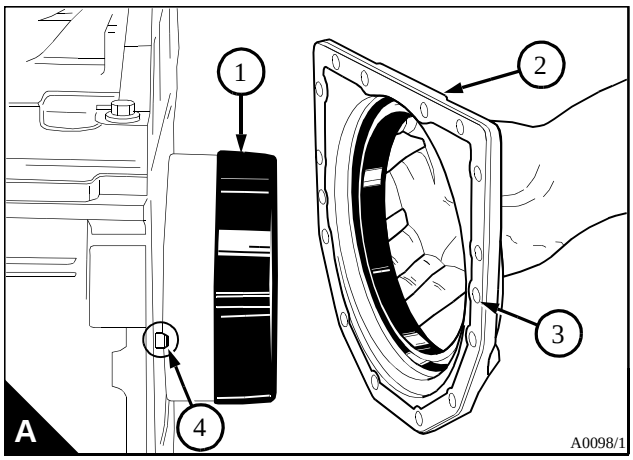
5 Put the seal and housing (A2) on the replacer tool (A1) and carefully push the assembly into position on the crankshaft flange and onto the dowels. Remove the tool, fit the setscrews and the cap screws (B1). Tighten the setscrews to (see table below) and tighten the cap screws to (see table below).

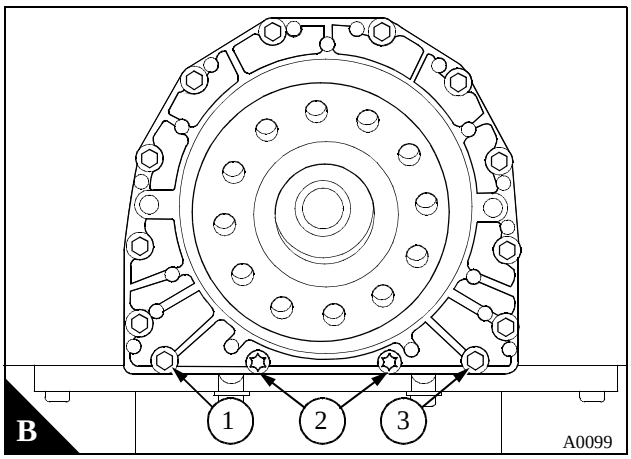
Rear end oil seal torques

Position	Quantity	Description	Thread size	Torque (Nm)	Torque (lbf ft)	Torque (kgf m)
B1 to B3 (clockwise)	12	Setscrews, oil seal housing to cylinder block	M8	22	16	2,2
B2	2	Torxscrews, early engines	M8	22	16	2,2
B2	2	Capscrews, earliest engines	M8	18	13	1,9
B2	2	Capscrews, earliest engines	M6	13	10	1,3

6 Fit the flywheel, see Operation 13-1 and the flywheel housing, see Operation 13-3.

7 Fit the drive components to the rear end of the engine.





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To renew the rear end oil seal (two-piece assembly) **Operation 5-7**

Special tools	
Description	**Part number**
Replacer tool for rear oil seal	21825540

Note: The oil seal of the one-piece rear end oil seal assembly cannot be renewed, the complete assembly must be renewed, see Operation 5-5.

For the two-piece assembly there are three positions in which the seal can be fitted in the housing (A).

- Position "1" (A1) is used when a new seal is first fitted in service.
- Position "2" (A2) is used when a new seal is fitted in service and the crankshaft flange is worn in positions "1".
- Position "3" (A3) can be used with a new seal in service, if a wet clutch is not used and the crankshaft is new or the crankshaft palm area has been corrected. Ensure that the seal is fitted square in the housing.

If all positions have been used it is permissible to grind the crankshaft flange, refer to the Data and dimensions for "Crankshaft" on page 36.

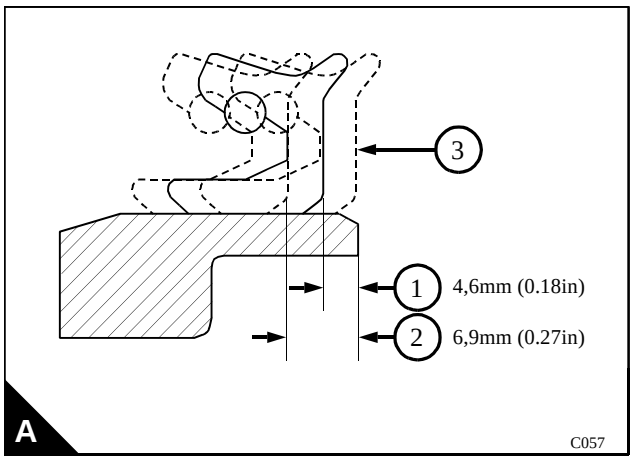
1 Remove the seal and housing assembly, see Operation 5-6.

2 Put the engine side of the housing on a suitable support and press out the seal with a suitable adaptor.

3 Lubricate the outer circumference of the seal and the bore of the seal housing with clean engine lubricating oil.

4 Put the engine side of the housing on a suitable support. Put the seal into position on the flywheel end of the bore with the spring of the seal towards the housing.

5 Use a press and the replacer tool, 21825540, to fit the seal at the correct depth. The special tool has two sides and is used in accordance with either position "1" or "2". Press the seal into the housing to the correct position with the relevant side of the tool.



To remove and to fit a wear sleeve **Operation 5-8**

To remove

1 Remove the rear end oil seal, see Operation 5-5, or Operation 5-6.

2 With a sharp tool mark a deep line along the length of the sleeve.

3 Insert a suitable thin blade between the crankshaft palm and the sleeve next to the marked line, the wear sleeve will separate along the marked line.

4 Remove the wear sleeve. Use a suitable cleaner to remove any sealant from the crankshaft palm.

To fit

1 Ensure that the crankshaft palm is dry and free from oil, dirt and sealant.

2 Remove any rough spots from the crankshaft palm surface.

3 Apply a small continuous bead of sealant (A2) that does not harden (Loctite 518) to the inner surface of the wear sleeve 5,0 mm (0.197 in) from the flange end of the sleeve (A1).

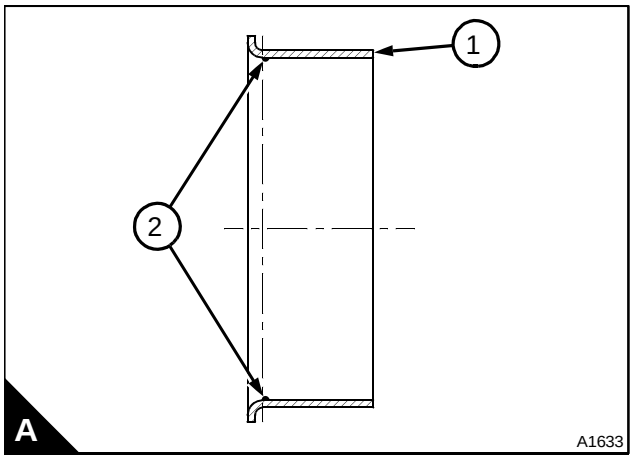
Caution: *The wear sleeve must be fitted within five minutes of applying the sealant.*

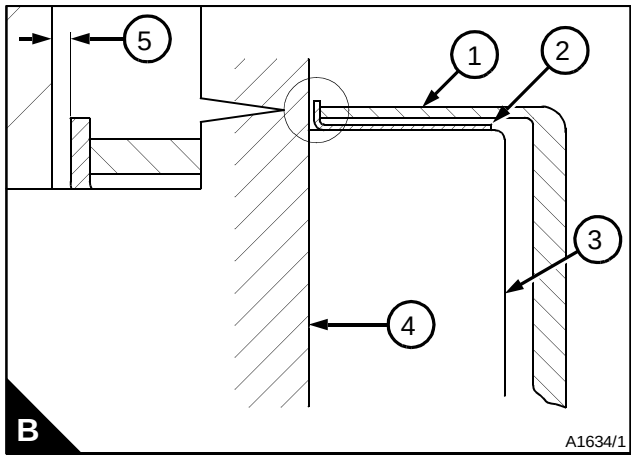
4 Ensure that the crankshaft is fully forward in the engine.

5 Place the wear sleeve on to the crankshaft palm (B3), use the tool (B1) that is supplied with the new wear sleeve and a suitable hammer, to force the wear sleeve (B2) over the crankshaft palm leaving a gap (B5) of 0,4/0,6 mm (0.016/0.024 in).

6 Remove the tool and measure the gap (B5) between the wear sleeve flange and the cylinder block (A) in two places 180° apart. The correct gap is between 0,4/0,6 mm (0.016/0.024 in).

7 Fit a new rear end oil seal, see Operation 5-5 or Operation 5-6.





Rear oil seal assembly (engines with a flywheel housing that is oil filled)

To remove **Operation 5-9**

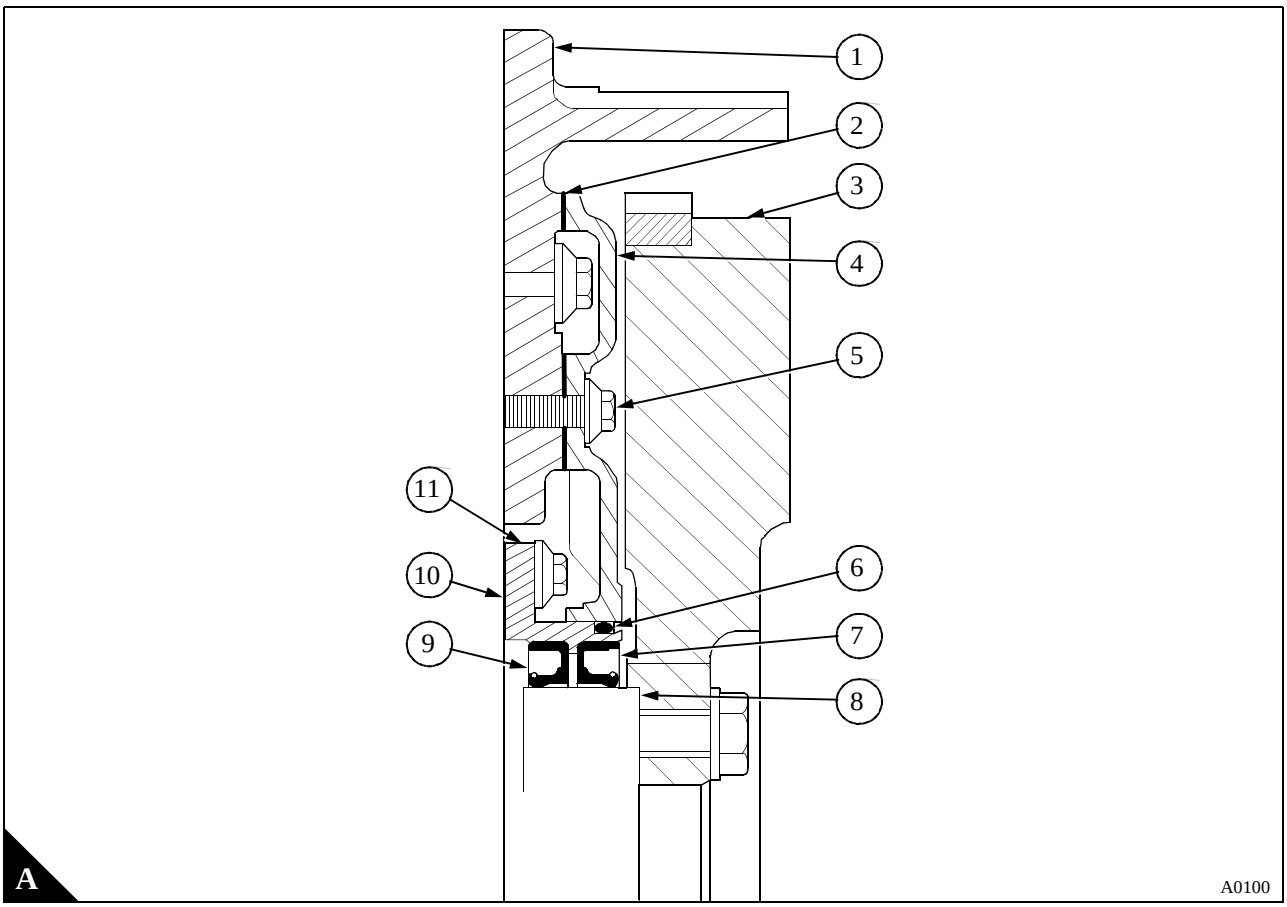
This arrangement for the crankshaft rear oil seal is for engines which have a flywheel housing that is filled with oil. This arrangement uses two lip seals which are narrower than the standard seal and are fitted back to back on the crankshaft palm.

The front seal (A9) prevents leakage of oil from the engine and the rear seal (A7) prevents leakage of oil from the flywheel housing. A cover (A4) and joint (A2) are used to prevent leakage of oil past the setscrews which retain the flywheel housing (A1) to the rear face of the cylinder block. An "O" ring (A6) is used to seal between the cover and the seal housing. Oil leakage past the "O" ring or one of the oil seals will pass through a hole in the seal housing between the two seals. The oil will then pass through two cast grooves in the front face of the flywheel housing. These grooves are in the 4 o'clock and 8 o'clock positions.

1 Release the setscrews which retain the flywheel and remove the flywheel (A3).

2 Release the setscrews (A5) which retain the cover (A4) and remove the cover. On later covers their are two integral lugs to enable the use of a lever to remove the cover. Remove the joint (A2) and clean the joint faces of the cover and flywheel housing.

3 Release the setscrews and the cap screws and washers which retain the housing (A11) for the rear oil seals and remove the housing. Clean the joint faces of the seal housing and cylinder block.



To fit **Operation 5-10**

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Replacer tool for rear oil seal	21825540	POWERPART Threadlock and nutlock	21820117 or 21820118
		POWERPART Silicone RTV sealing and jointing compound	1861108

1 Clean the crankshaft palm (A8) and check for wear in the seal location areas. If there is wear, a "Wear-Sleeve" (A1), part number 21825188, can be fitted, see Operation 5-12.

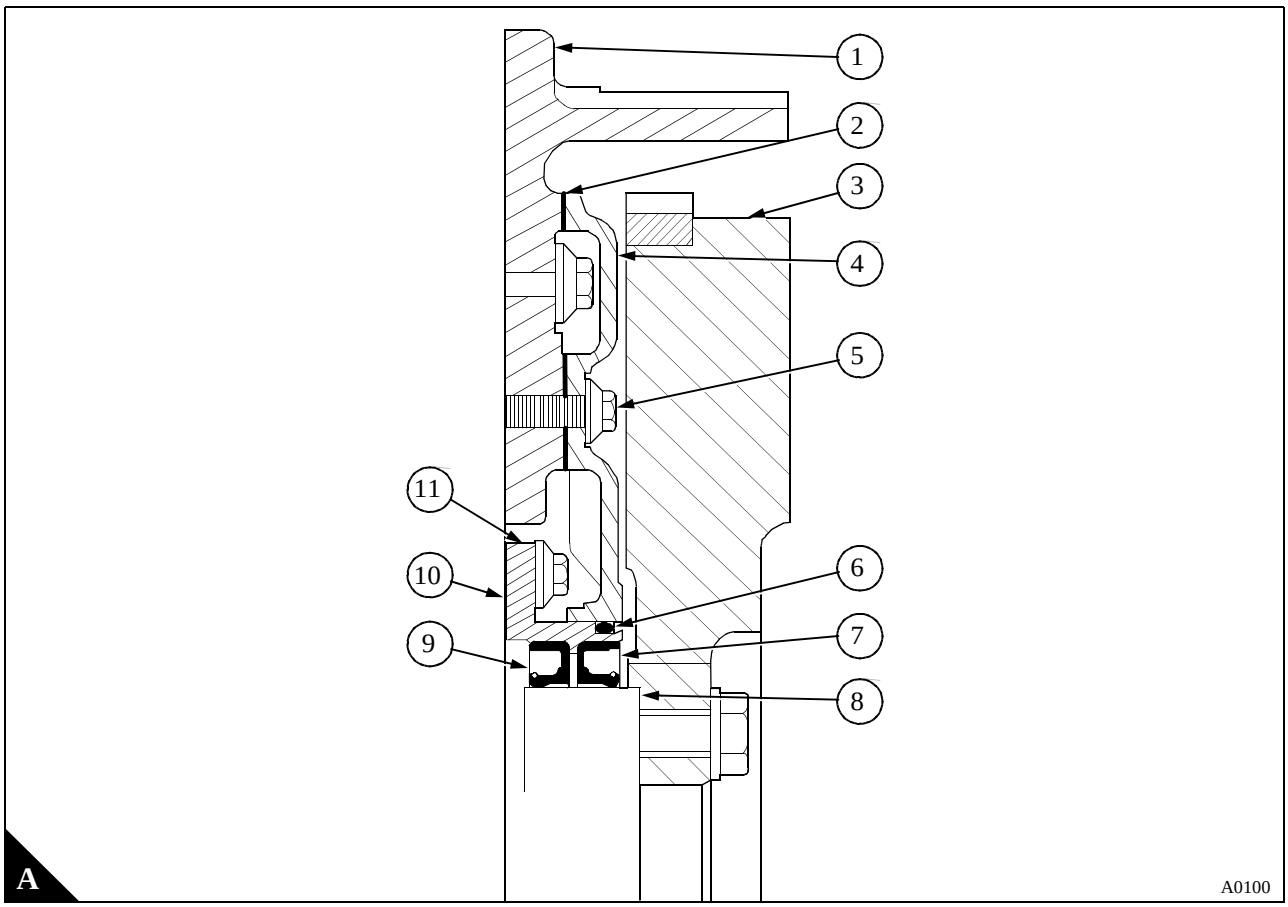
Note: If a "Wear-Sleeve" is not available the crankshaft palm can be machined to give a minimum diameter of 133,17 mm (5.243 in). Do not machine the last 2,5 mm (0.10 in) of the crankshaft palm as this is necessary for flywheel location. A "Wear-Sleeve" must not be fitted if the crankshaft palm has been machined undersize.

2 Ensure that the dowels for the oil seal housing are fitted in the cylinder block. Put a new joint (A10) in position on the dowels, no jointing compound is necessary.

3 Put the seal replacer tool, which is used for standard seals, on the crankshaft palm. Lubricate lightly the crankshaft palm, the seal replacer tool and the lip of the seals with clean engine lubricating oil.

4 Put the seal and housing assembly onto the seal replacer tool and carefully push the assembly onto the dowels. Remove the seal replacer tool, fit the setscrews and the cap screws together with their washers. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m and the cap screws to 13 Nm (10 lbf ft) 1,3 kgf m.

5 Fit a new "O" ring (A6) in its recess in the seal housing and lightly lubricate it with clean engine oil.



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6 Apply a suitable jointing compound to one side of a new cover joint to hold the joint in position. Put the joint in position on the flywheel housing. Put the cover into position on the joint and fit the setscrews. New setscrews have a sealant applied by the manufacturer. If these setscrews are to be used again, the threads of the setscrews and the threads in the flywheel housing must be cleaned. A suitable sealant, for example POWERPART Threadlock and nutlock, must then be applied to the setscrew threads. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf. m.

7 Ensure that the location faces of the flywheel and crankshaft are clean and free from damage. Fit the flywheel and the setscrews together with their washers. Tighten the setscrews to 105 Nm (77 lbf ft) 10,7 kgf m.

8 If the starter motor is removed from the engine, clean the flange face of the starter motor and the face of the flywheel housing. Apply a 2,0 mm (0.080 in) continuous bead of POWERPART Silicone RTV sealing and jointing compound to the flange face of the starter motor near to the spigot before the starter motor is fitted.

Caution: *If the engine is to be operated before oil is added to the flywheel housing, the rear oil seal must not be fitted until after the engine has run.*

To renew the rear oil seals **Operation 5-11**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Threadlock and nutlock	21820117 or 21820118	POWERPART Silicone RTV sealing and jointing compound	1861108
POWERPART Gasket and flange sealant	21820518		

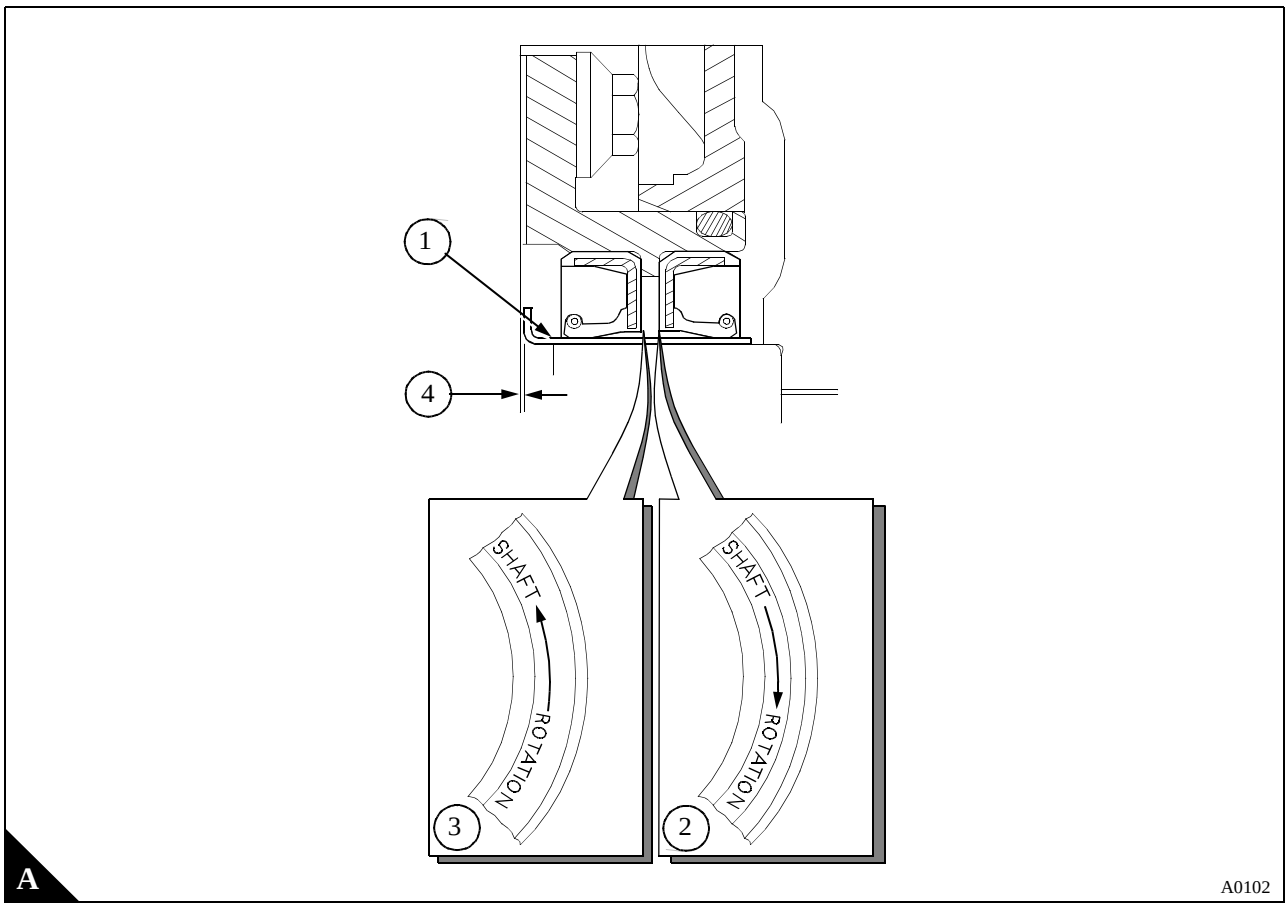
1 Remove the seals from the housing with a suitable lever. Ensure that the seal housing is not damaged. Do not try to press the seals out of the housing as there is a shoulder in the housing (A).

2 Clean thoroughly the oil seal housing. Inspect the oil seals for damage. If only a small scratch can be seen across the lip of the seal, do not fit the seal.

3 Before the oil seals are fitted into the housing ensure that the correct seal is fitted to the correct side of the housing. Each of the seals has an arrow (A2) and (A3) on the flat face of the seal. This arrow indicates the correct direction of shaft rotation for the seal.

4 Lubricate lightly the outer circumference of the front oil seal and the bore of the housing for the front seal with clean engine oil.

5 With the flywheel side of the seal housing on a suitable support, press the new front seal into the housing.Use a suitable tool which will apply pressure only to the flat inside face of the seal. Use only enough pressure to ensure that the flat face of the seal is against the shoulder in the housing. Too much pressure could damage the shoulder.



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6 Lubricate lightly the outer circumference of the front oil seal and the bore of the housing for the front seal with clean engine oil.

7 With the engine side of the seal housing on a suitable support, carefully press the rear oil seal onto the shoulder in the housing with the same tool as for the front seal. Ensure that the seal is against the shoulder in the housing.

Caution: *The rear oil seal must not be fitted if the engine is to be operated before the oil is added to the flywheel housing. The seal must be fitted to the seal housing after the engine has been run.With the engine side of the seal housing on a suitable support, carefully press the rear oil seal onto the shoulder in the housing with the same tool as for the front seal. Ensure that the seal is against the shoulder in the housing.*

To fit and remove a "Wear-Sleeve" Operation 5-12

Special requirements

Consumable products	
Description	**Part number**
POWERPART Gasket and flange sealant	21820518

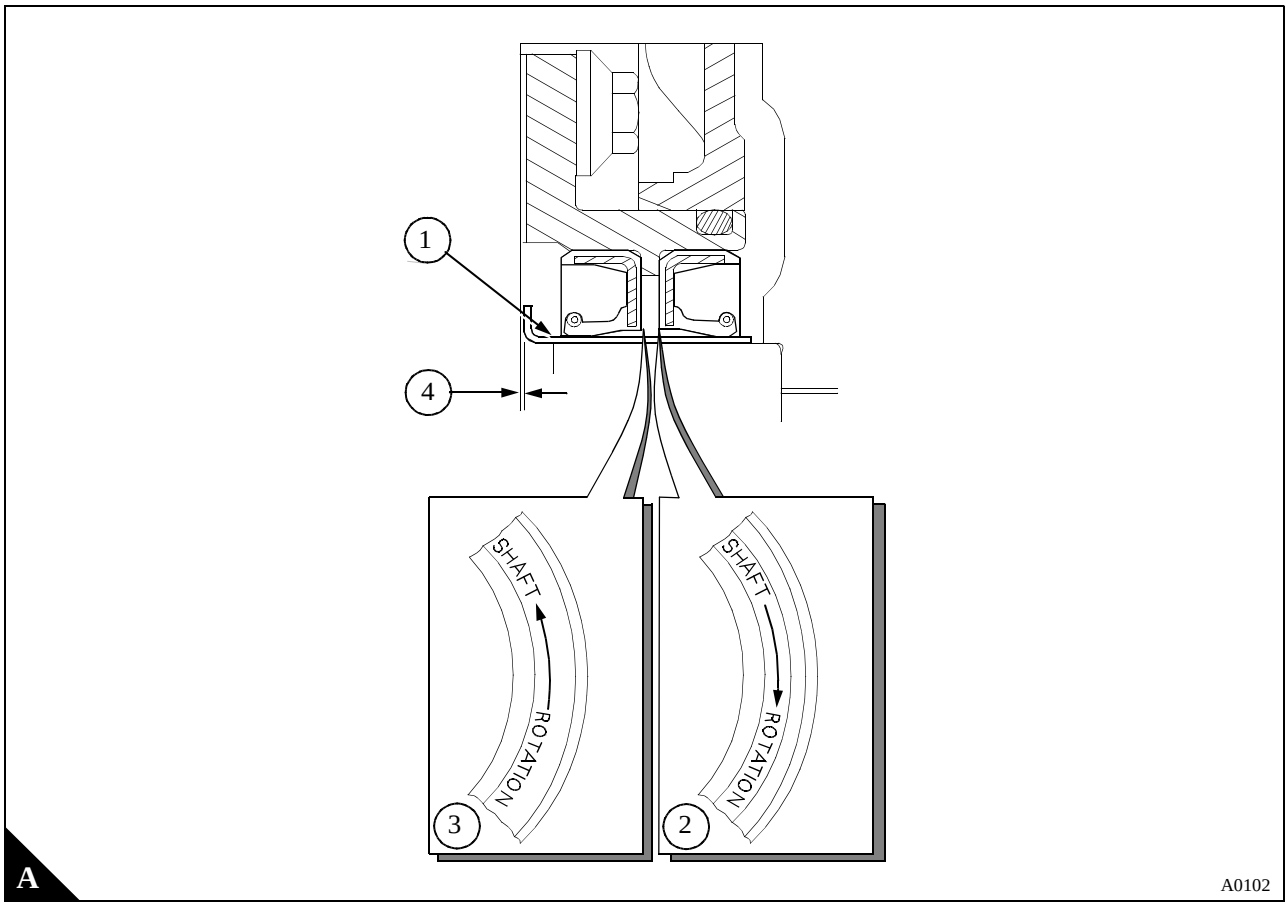
1 Clean the crankshaft palm and remove sharp edges or rough areas from the crankshaft palm.

2 Ensure that the sleeve (A1) is clean. Apply a narrow bead of POWERPART Gasket and flange sealant around the bore of the sleeve 5 mm (0.2 in) from the front face of the flange. The sleeve must be fitted not more than five minutes after the gasket and flange sealant has been applied.

3 Ensure that the crankshaft is fully forward. Use a suitable adaptor and a hammer to carefully drive the sleeve onto the crankshaft palm. The sleeve must be fitted with a clearance of 0,4/0,6 mm (0.016/0.024 in) between the rear face of the cylinder block and the front face of the sleeve flange (A4). Ensure that this clearance is equal all around the flange of the sleeve. Do not try to pull the sleeve backwards as damage could occur to the sleeve.

4 Fit a new joint for the oil seal assembly. Lubricate lightly the sleeve and the lip of the oil seals with clean engine oil and fit the assembly. Fit a new joint to the flywheel housing and fit the cover. Fit the flywheel.

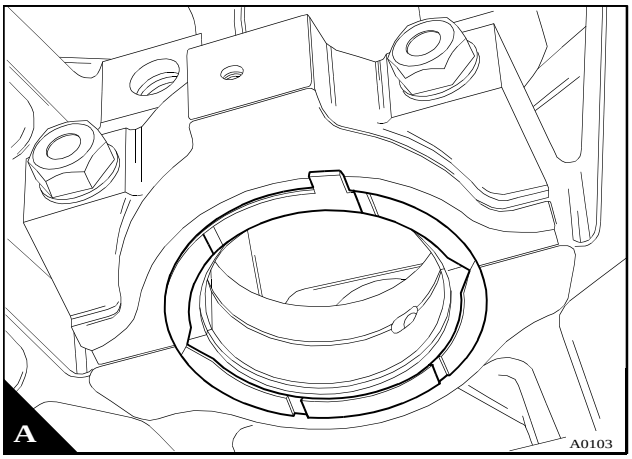
5 To remove a sleeve, make a deep scratch with a sharp scriber along the full length of the sleeve. Insert the edge of a thin blade at the end of the scratch mark. Turn the blade to make a split along the scratch mark and pull the sleeve apart. If only the flange is removed, a recommendation of the sleeve manufacturer is to spread the sleeve. To do this use a small hammer and a suitable punch with a round end. Make one or more lines of small distortions across the full width of the sleeve. This should increase the diameter of the sleeve enough to enable its removal.



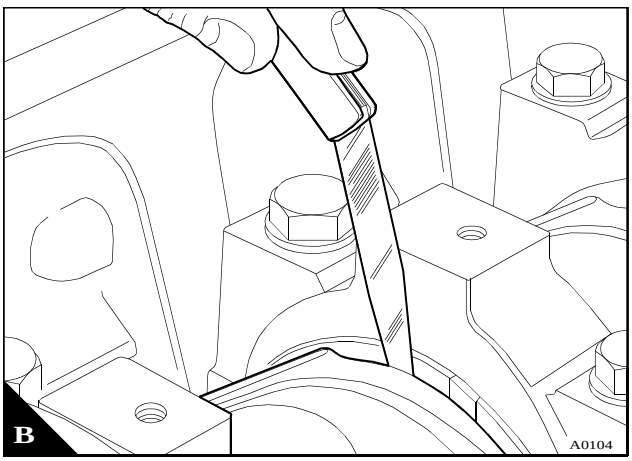
Thrust washers

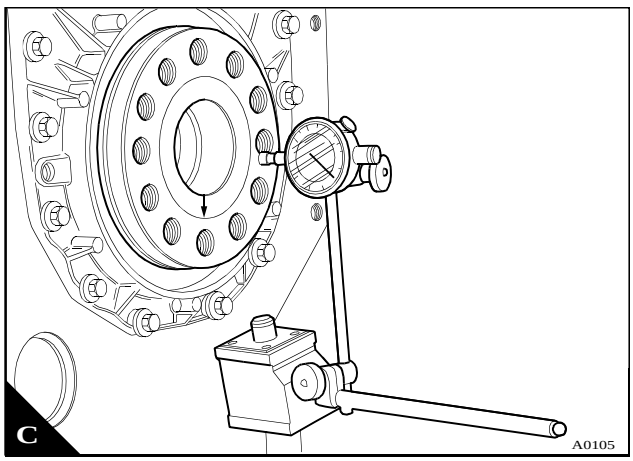
To check crankshaft end-float **Operation 5-13**

The axial movement of the crankshaft is controlled by two half thrust washers fitted both sides of the centre main bearing (A).



The end-float can be checked with a feeler gauge between a thrust washer and the crankshaft (B), or with a dial test indicator on one end of the crankshaft to check the movement (C).





If the end-float is more than the tolerance given in the relevant Data and dimensions for the "Crankshaft" on page 36, thrust washers which are 0,019 mm (0.0075 in) oversize can be fitted.

The oversize thrust washers can be fitted to one or to both sides of the main bearing. They are fitted instead of the standard size washer, to reduce the end-float to the factory tolerances.

Note: Ensure that oversized thrust washer are fitted as a pair to the same side of the crankshaft.

To remove and to fit **Operation 5-14**

To remove

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 If necessary, remove the balancer unit, see Operation 5-21.

3 If necessary, remove the lubricating oil strainer and suction pipe, see Operation 10-4.

4 Release the setscrews of the centre main bearing and remove the main bearing cap complete with the lower half thrust washers.

5 Press down one end of each upper half thrust washer, with a suitable tool made of a soft material (A1), to slide the washer from its recess. Where necessary, move the crankshaft to the front or to the rear to loosen a tight washer.

To fit

1 Lubricate the thrust washers with clean engine lubricating oil.

2 Slide the upper half thrust washers into their recesses in the cylinder block. Ensure that the sides of the thrust washers which have the grooves are against the crankshaft.

Note: Ensure that oversized thrust washer are fitted as a pair, and to the same side of the crankshaft.

3 Fit the lower half thrust washers to the main bearing cap with the location tags in their recesses.

4 Ensure that the location thimbles are fitted correctly in the main bearing cap or in the cylinder block.

5 Ensure that the bearing is fitted correctly in the cap and that the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.

6 Fit the cap with the location tags of both half of the shell bearings to the same side (B1).

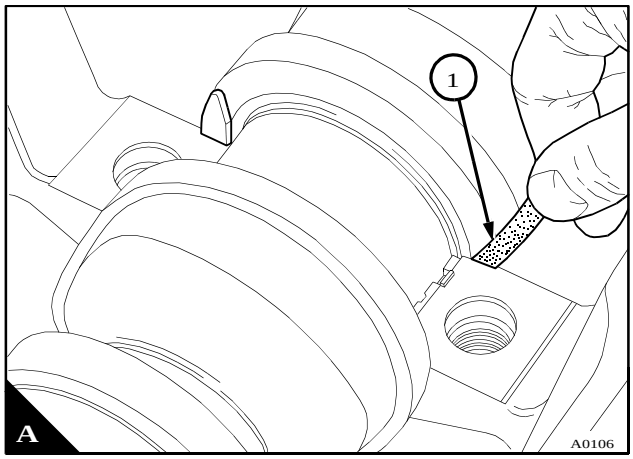
7 Inspect the setscrews for damage and for distortion and renew them if necessary. Lightly lubricate the setscrew threads with clean engine lubricating oil. Fit the setscrews and tighten the setscrews gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

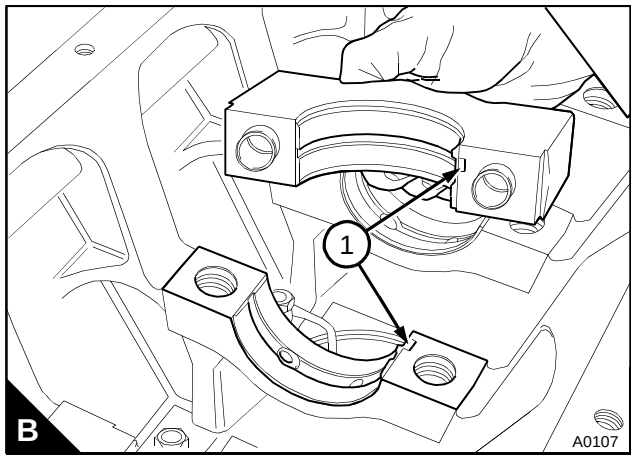
8 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-13.

9 If necessary, fit the balancer unit, see Operation 5-22.

10 If necessary, fit the lubricating oil strainer and the suction pipe, see Operation 10-4.

11 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.





Main bearings

To remove (with the crankshaft in position) **Operation 5-15**

If the rear main bearing is to be removed with the crankshaft in position, the flywheel, the flywheel housing, the rear oil seal housing and the bridge piece will have to be removed.

Note: Except for engines with a balancer unit fitted, the front main bearing can only be removed if a suitable spanner is available that will enable the torque to be applied correctly to the setscrews of the main bearing cap. If a suitable spanner is available, the front main bearing cap can be removed together with the oil pump. For six cylinder engines, it will be necessary to remove the suction pipe and strainer and the delivery pipe. For four cylinder engines, either the balancer unit or the suction pipe and strainer, the delivery pipe and the relief valve will have to be removed.

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

2 Remove all necessary components to get access to the specific bearing cap.

3 Release the setscrews of the bearing cap and remove the bearing cap. Remove the lower half of the shell bearing from the cap.

4 With a suitable tool, push the upper half of the shell bearing from the side opposite to the location tag to remove the bearing tag from its recess in the bearing housing. Carefully rotate the crankshaft to release the bearing from its housing. Keep the bearing halves in their relevant positions.

To fit (with the crankshaft in position) **Operation 5-16**

1 Clean the upper half of the shell bearing and lubricate the bearing surface with clean engine lubricating oil.

Caution: *Only the upper half of the bearing has lubrication holes, theae must be fitted into the recess of the cylinder block.*

2 Fit the plain end of the upper half of the bearing between the crankshaft journal and the side of the bearing housing which has the recess for the location tag. Slide the bearing into its housing until the tag on the bearing is fitted correctly in its recess in the housing.

3 Clean the lower half of the bearing and cap, lubricate the bearing surface with clean engine lubricating oil.

4 Fit the bearing into the cap with the tag of the bearing fitted correctly in the recess in the cap.

5 Ensure that the location thimbles are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both bearings on the same side (A1).

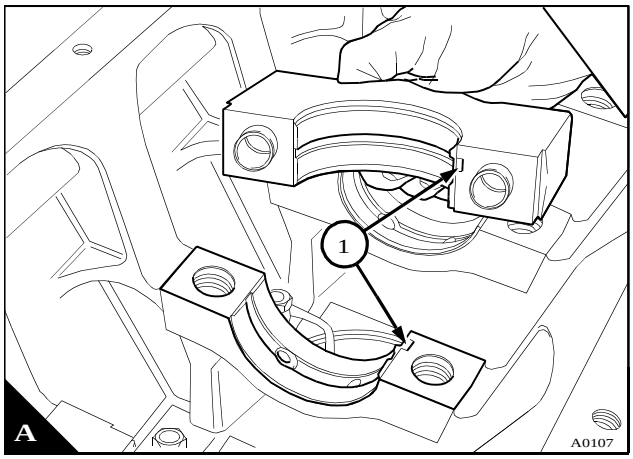
6 Inspect the setscrews for damage and for distortion and renew them if necessary. Lightly lubricate the setscrew threads with clean engine lubricating oil. Fit the setscrews and the washers and tighten the setscrews gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

Note: Washers are not fitted between the setscrews and the bearing caps on the latest engines.

7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, see Operation 5-13.

8 Fit all the components which were removed for access to the main bearing cap.

9 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.



To inspect **Operation 5-17**

1 Inspect the bearings for wear and for other damage. If a bearing is worn or damaged, renew both halves of the shell bearings and check the condition of the other bearings.

Crankshaft

To remove — Operation 5-18

Warning! *Use lift equipment or obtain assistance to lift heavy engine components such as the balancer unit, flywheel housing, crankshaft and flywheel.*

Note: It is recommended that this operation is completed with the engine is upside for safety reasons.

1 Before the engine is removed from the vehicle or from the machine, drain the lubricating oil and the coolant.

2 Remove the lubricating oil sump, see Operation 10-3.

3 Remove the fan, see Operation 12-18, the drive belts, see Operation 14-3, the fan drive pulley and housing, see Operation 12-19, and the coolant pump, see Operation 12-4 or Operation 12-11.

4 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

5 Remove the alternator and its mounting bracket, see Operation 14-4.

6 Remove the compressor and its drive assembly, or remove the exhauster, see Chapter 15, Auxiliary equipment.

7 Remove the timing case cover, see Operation 6-1.

8 Remove the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-14 or Operation 11-16.
- Bosch MW fuel injection pumps, see Operation 11-26.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-31.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-38.
- Stanadyne fuel injection pumps, Operation 11-47.

9 Remove the timing gears and the timing case, see Chapter 6, Timing case and drive assembly.

10 Remove the flywheel, see Operation 13-1, and the flywheel housing, Operation 13-3.

11 Remove the rear oil seal housing, see Operation 5-5 or Operation 5-9.

12 If a balancer unit is fitted, remove it, see Operation 5-21. If a balancer unit is not fitted, remove the lubricating oil suction pipe and strainer, the lubricating oil pump, the delivery pipe and the relief valve (four cylinder engines) and the lubricating oil crossover pipe, if fitted, see Chapter 10, Lubrication system.

13 Remove the bridge piece and the rubber seals. Later engines may not have rubber seals fitted.

14 Remove the caps of the connecting rods. Keep the bearings and caps together. Remove the bolts of the connecting rods and carefully push the pistons towards the top of their bores.

15 Ensure that the tops of the main bearing caps are stamped with their relevant position number. Remove the main bearing caps, the lower half of the shell bearings and the upper and lower thrust washers. Keep the bearings with their relevant caps.

16 Lift out the crankshaft. Remove the upper half of the bearings and keep each bearing with its relevant lower half and cap.

To fit **Operation 5-19**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Gasket and flange sealant	21820518	POWERPART Silicone RTV sealing and jointing compound	1861108

Warning! *Use lift equipment or obtain assistance to lift heavy engine components such as the balancer unit, flywheel housing, crankshaft and flywheel.*

1 Ensure that all lubricating oil passages are clean and free from restriction.

2 Clean the main bearing housings and the upper half of the bearings. Fit the shell bearings with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.

3 Ensure that the main journals of the crankshaft are clean. Put the crankshaft in position on the upper bearings.

4 Clean and lubricate the upper half thrust washers and slide them into their recesses on both sides of the bearing housing. Ensure that the slotted sides of the thrust washers are towards the crankshaft.

5 Clean the bearing caps and the lower half of the bearings. Fit the bearings to the caps with the location tags fitted correctly in their recesses. Lubricate the bearings with clean engine lubricating oil.

6 Clean the lower half thrust washers and lubricate them with clean engine lubricating oil. Fit the thrust washers on both sides of the bearing cap for the centre main bearing.

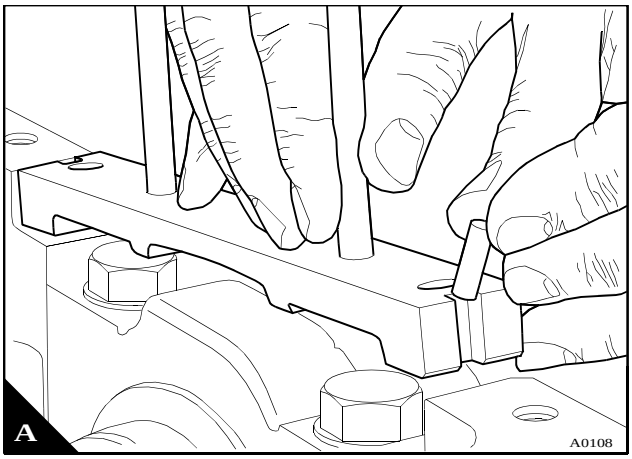
7 Check that the location thimbles for the main bearing caps are fitted correctly in the caps or in the cylinder block. Fit the bearing caps in their correct positions (as shown by the position number stamped on the top of the cap) with the location tags of the bearings on the same side. In this position the serial numbers stamped on the bearing caps will be in line. The serial number stamped on the bearing caps must be the same as the number stamped on the bottom face of the cylinder block. The third and fifth bearing caps of six cylinder engines are not stamped with a serial number.

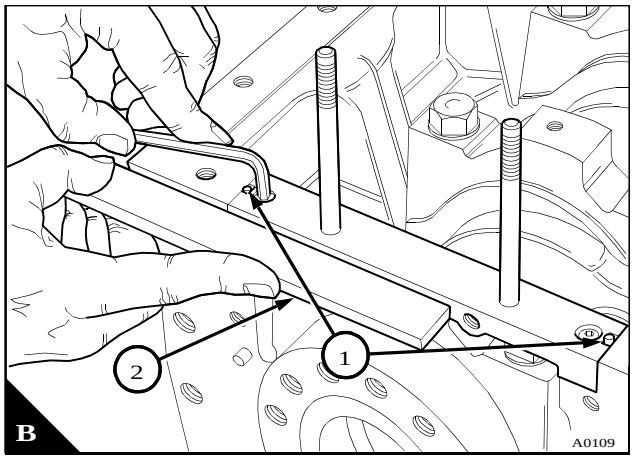
8 Fit the setscrews and the washers to the main bearing caps and tighten the setscrews gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

Note: Washers are not fitted between the setscrews and the bearing caps on the latest engines.

Continued

9 For earliest engines fitted with rubber seals: Clean the bridge piece and the location areas for the bridge piece in the cylinder block. Apply a narrow strip of POWERPART Silicone RTV sealing and jointing compound in the corners and around the thread holes of the bridge piece seat in the cylinder block. Fit the bridge piece and the two rubber seals (A). The rubber seals will be a little higher than the bridge piece when they are fitted correctly. Use a straight edge (B2) to ensure that the bridge piece is in line with the rear face of the cylinder block. Tighten the bridge piece cap screws (B1) to 16 Nm (12 lbf ft) 1,6 kgf m.

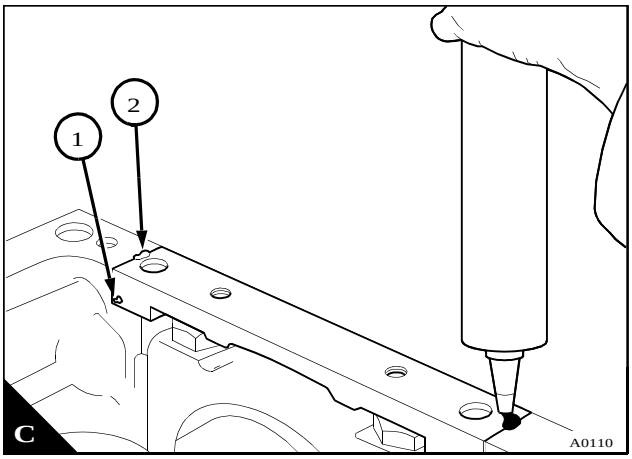




For later engines fitted with POWERPART Gasket and flange sealant: A bridge piece has been introduced which uses POWERPART Gasket and flange sealant instead of the rubber seal in the groove at each end of the bridge piece. The groove at each end of the new bridge piece is cast and is off-centre. The procedure to fit the new bridge piece is the same as for the earlier bridge piece, except for the instructions given below. Apply a $^{1}/_{8}$ in (3,0 mm) bead of POWERPART Gasket and flange sealant along the corner in the top of the recess in the cylinder block for the bridge piece.

When the bridge piece is in position and the cap screws have been tightened, inject POWERPART Gasket and flange sealant into the groove (C2) at each end of the bridge piece. Continue to inject sealant until the groove is completely full and the sealant leaves the lower groove (C1) at the front and rear of the bridge piece.

It may be necessary to stop the sealant at one side of the lower groove in order to ensure it will flow from the opposite side of the groove.



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10 Fit the connecting rod caps, see Operation 4-5. Rotate the crankshaft two turns to ensure free movement.

11 If necessary, fit the balancer unit, see Operation 5-22. If a balancer unit is not used, fit the lubricating oil pump, the lubricating oil suction pipe and strainer, the delivery pipe and the relief valve (four cylinder engines) and if necessary, the lubricating oil crossover pipe, see Chapter 10, Lubrication system.

12 Fit the rear oil seal housing see Operation 5-5 or Operation 5-10.

13 Fit the flywheel housing, see Operation 13-3, and the flywheel, see Operation 13-1.

14 Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

15 Fit the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-15 or Operation 11-17.
- Bosch MW fuel injection pumps, see Operation 11-27.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-32.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-39.
- Stanadyne fuel injection pumps, Operation 11-48.

16 Fit the timing case cover, see Operation 6-2.

17 Fit the compressor and its drive assembly or fit the exhauster, see Chapter 15, Auxiliary equipment.

18 Fit the alternator and its mounting bracket, see Operation 14-4.

19 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

20 Fit the coolant pump, see Operation 12-5 or Operation 12-12, the fan drive pulley and housing, see Operation 12-19, the drive belts, see Operation 14-3, and the fan, see Operation 12-18.

21 Fit the lubricating oil sump, see Operation 10-3.

22 After the engine has been installed, fill the lubricating oil sump to the correct level with an approved oil. Fill the cooling system.

To inspect **Operation 5-20**

Check the crankshaft for wear and other damage. The maximum permissible wear and ovality on the crankshaft journals and crank pins is 0,04 mm (0.0016 in).

Note: It is not possible to regrind the nitreg crankshaft for service overhaul purposes.

The main journals and the crank pins of standard size crank shafts can be machined to 0,25mm (0.010 in), 0,50mm (0.020 in) or 0,75 mm (0.030 in) undersize on diameter, see "Crankshaft" on page 36. Special undersize bearings are available.

If the seal has been used in all of the service positions, the crankshaft palm can be machined to remove the wear marks. Further information can be found in the relevant Data and dimensions for the "Crankshaft" on page 36.

Balancer unit

To remove — Operation 5-21

1 Drain the lubricating oil from the sump and remove the sump, see Operation 10-3.

Warning! *The weight of the unit is approximately 25 kg (55 lb).*

2 Provide a support for the balancer unit before release of the setscrews from the engine.

3 Release the setscrews and lower carefully the balancer unit. Make a note of the positions of the setscrews of different lengths.

To fit **Operation 5-22**

1 Ensure that the contact faces of the cylinder block and of the balancer unit are clean and that the two thimbles (A1) are fitted correctly to the cylinder block.

2 Set the piston of number 1 cylinder to TDC, see Operation 8-1.

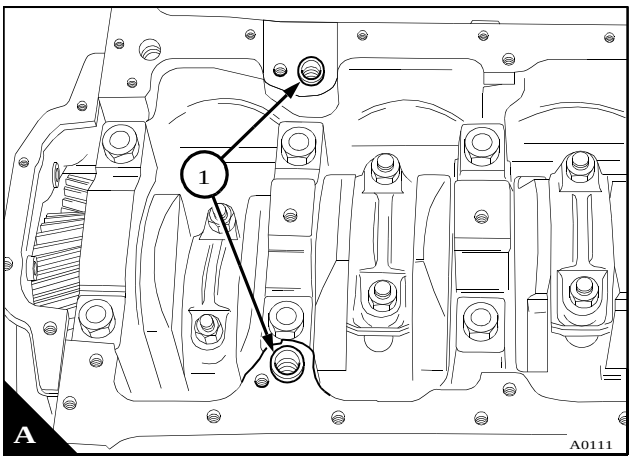
3 Before the balancer unit is fitted, ensure that the flat faces of the balance weights are level with each other (B1) and the weights hang down away from the cylinder block (B2). The timing of the balance weights to the drive shaft is correct when the large hole and small hole in the front of the drive shaft gear are in the positions shown in the illustration (B).

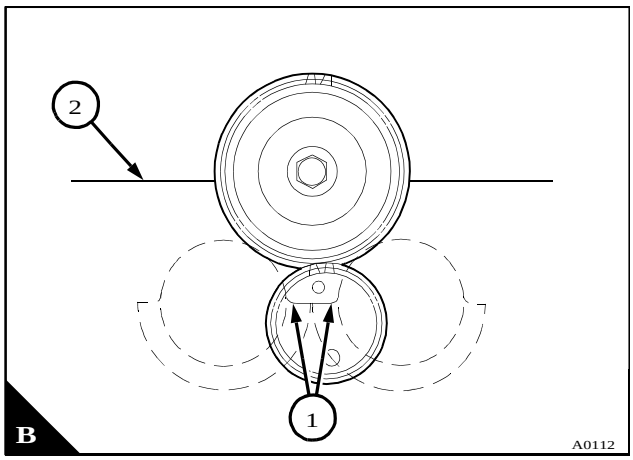
Note: If the gear position shown in (B) cannot be obtained, then the balancer must be partially dismantled and the timing corrected, see step 6 of Operation 5-24.

4 Fit the balancer unit to the cylinder block with the correct screws in the centre positions of the balancer frame. Ensure, when the idler and crankshaft gears are in mesh, that the flat faces of the balance weight are level with each other and that they are towards the cylinder block. Check that the balancer unit is fitted correctly on the thimbles and fit the remainder of the setscrews in their correct position. Tighten the setscrews to 54 Nm (40 lbf ft) 5,5 kgf m.

5 Rotate the crankshaft through two turns to ensure that it is free to rotate.

6 Fit the lubricating oil sump, see Operation 10-3, and fill the sump to the correct level with an approved oil.





To dismantle **Operation 5-23**

1 Remove suction pipe (A9).

2 Remove the balance weight cover (A8).

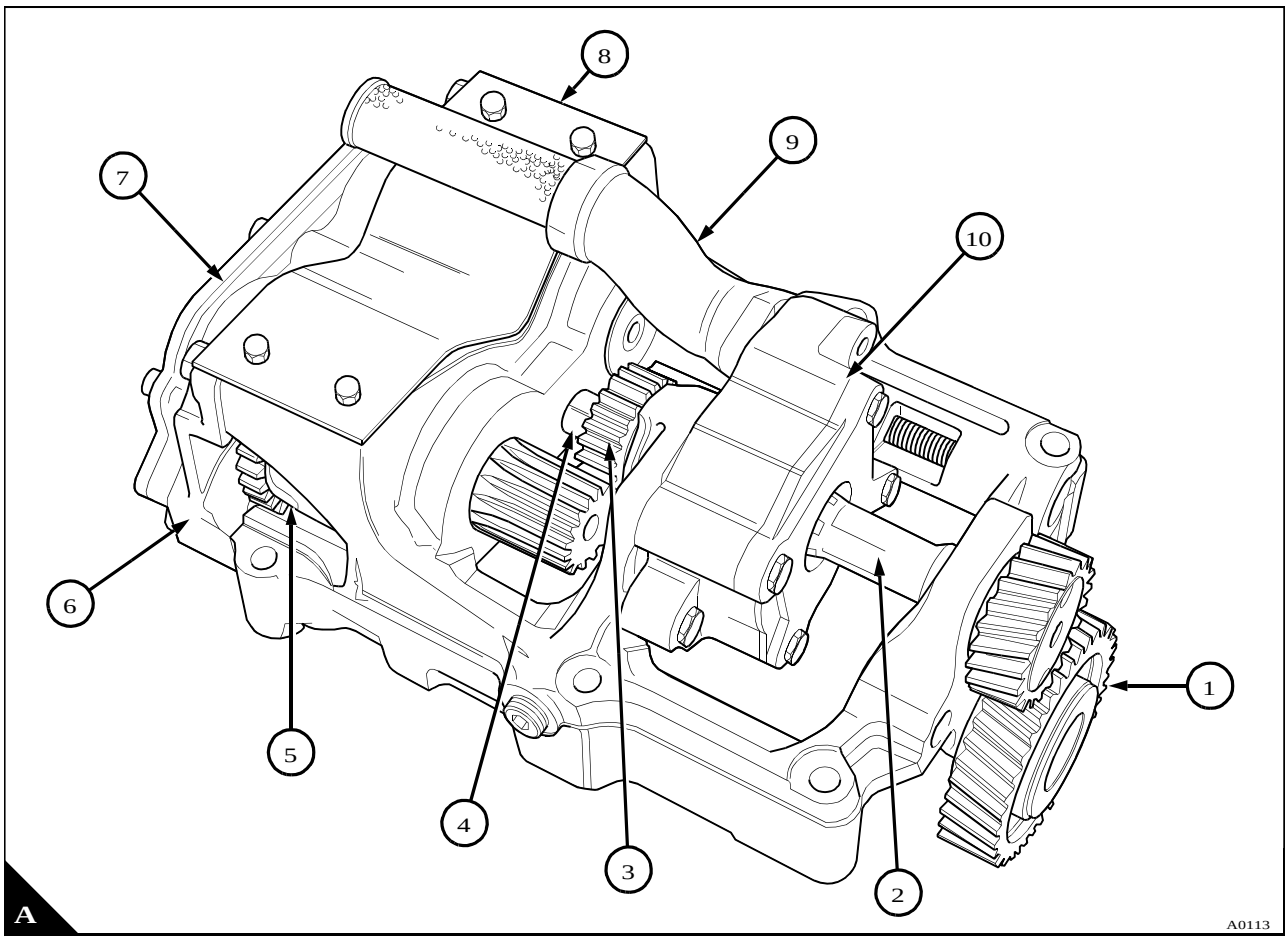
3 Release the setscrew and remove the idler gear assembly (A1). Keep the components together as an assembly to protect the needle roller bearing.

4 Prevent movement of the drive shaft (A2) and loosen the nut (A4) of the drive gear for the balance weights (A3). Put a suitable flat distance piece in position between the nut and the balancer frame. Turn the nut until it is against the face of the distance piece. Continue to turn the nut with a suitable spanner until the Loctite seal on the splines of the drive shaft is broken and the gear is loose on the shaft. Remove the nut and the drive gear and remove the drive shaft.

Caution: *Ensure that the needle roller bearings are not damaged when the drive shaft is removed.*

5 Release the setscrews which hold the lubricating oil pump and the suction pipe (A10 and A9) to the balancer frame and remove the lubricating oil pump and the suction pipe.

6 Release the setscrews and remove the oil transfer plate and joint (A7) from the rear of the balancer unit. Make a note of the position of the direction arrows on the outside of the transfer plate, see step 8 of Operation 5-24, to ensure that it can be assembled correctly.



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Notes:

- The latest oil transfer plate is fitted without a joint or sealant; always give the correct engine number when parts are needed.
- There are two plugs in the balancer frame, a short tapered plug with a hexagonal socket head and a long plug with a square socket head. These plugs control the flow of oil through the balancer frame. The position of the plugs is decided by which side of the engine the filter is fitted. When the filter is fitted on the left side, the short plug is fitted in the side of the balancer and the long plug is fitted in the bottom (Operation 5-24/C). When the filter is fitted on the right side of the engine, the short plug is fitted in the bottom of the balancer and the long plug is fitted in the side (Operation 5-24/D).

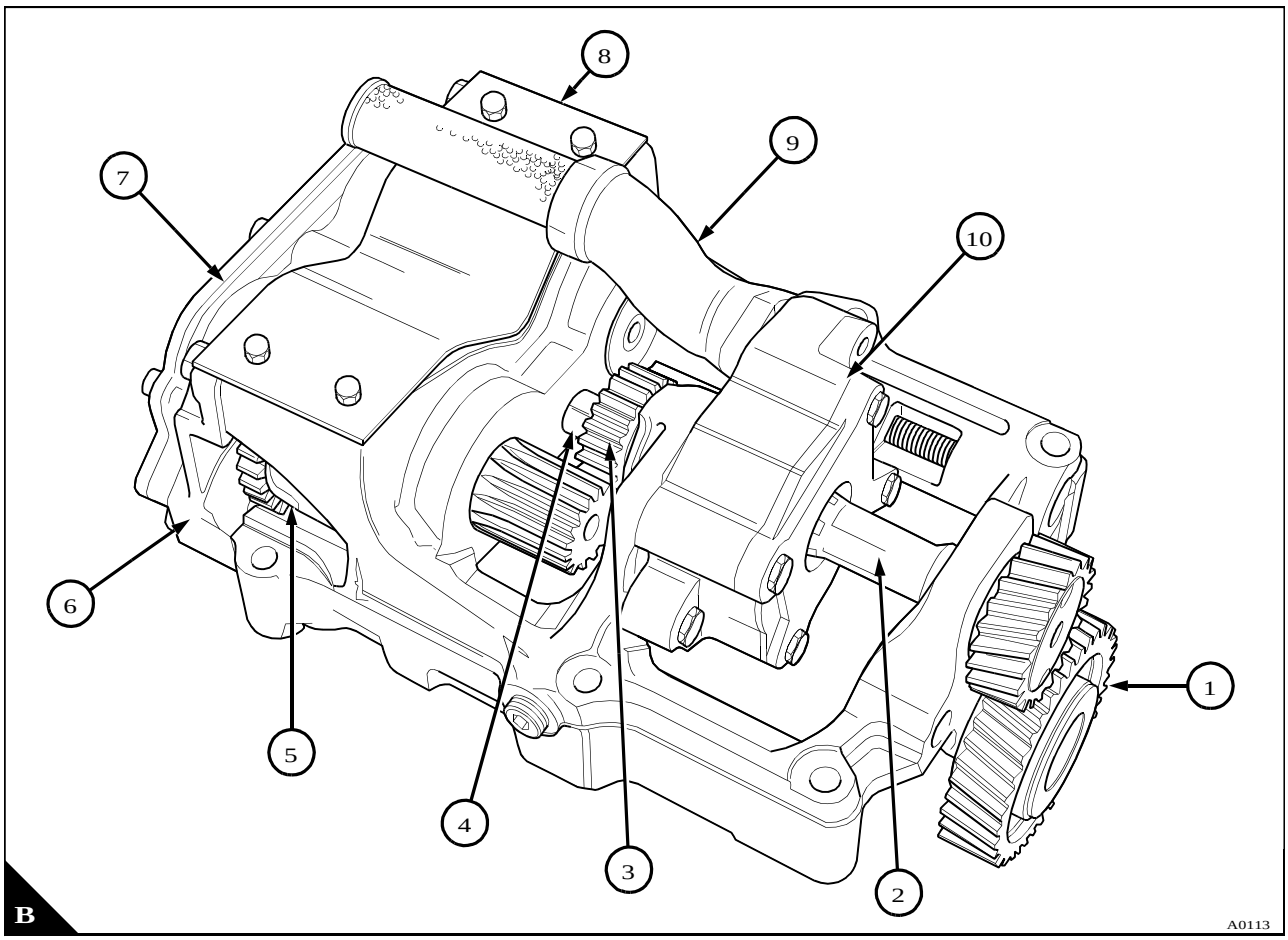
Caution: *Removal of these plugs can cause damage to the threads in the balancer frame and a new balancer frame will be needed. When a balancer unit is to be fitted, ensure that the lubricating oil flow through the balancer frame is correct for the position of the lubricating oil filter.*

7 Release the setscrews and remove the rear cover of the balancer frame (B6). A hammer and a suitable drift will be necessary to remove the rear cover from the dowels.

8 Remove the balance weights (B5). Ensure that the gear of the driven weight does not damage the bush in the balancer frame.

9 Dismantle the lubricating oil relief valve, see Operation 10-14.

10 Clean the lubricating oil passages with an approved kerosene cleaning solution and dry them with low pressure compressed air.



To assemble **Operation 5-24**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820177 or 21820118

1 Ensure that the location thimble (A8) in the rear of the lubricating oil pump is 5,6/6,4 mm (0.220/0.252 in) above the rear face of the pump. Clean the contact faces of the lubricating oil pump and the balancer frame. Fit the lubricating oil pump (A16) to the balancer frame and tighten the setscrews to 27 Nm (20 lbf ft) 2,8 kgf m.

Note: The latest balancers do not have a thimble for the oil pump location. The location of the latest oil pump is by a spigot on the rear face of the pump.

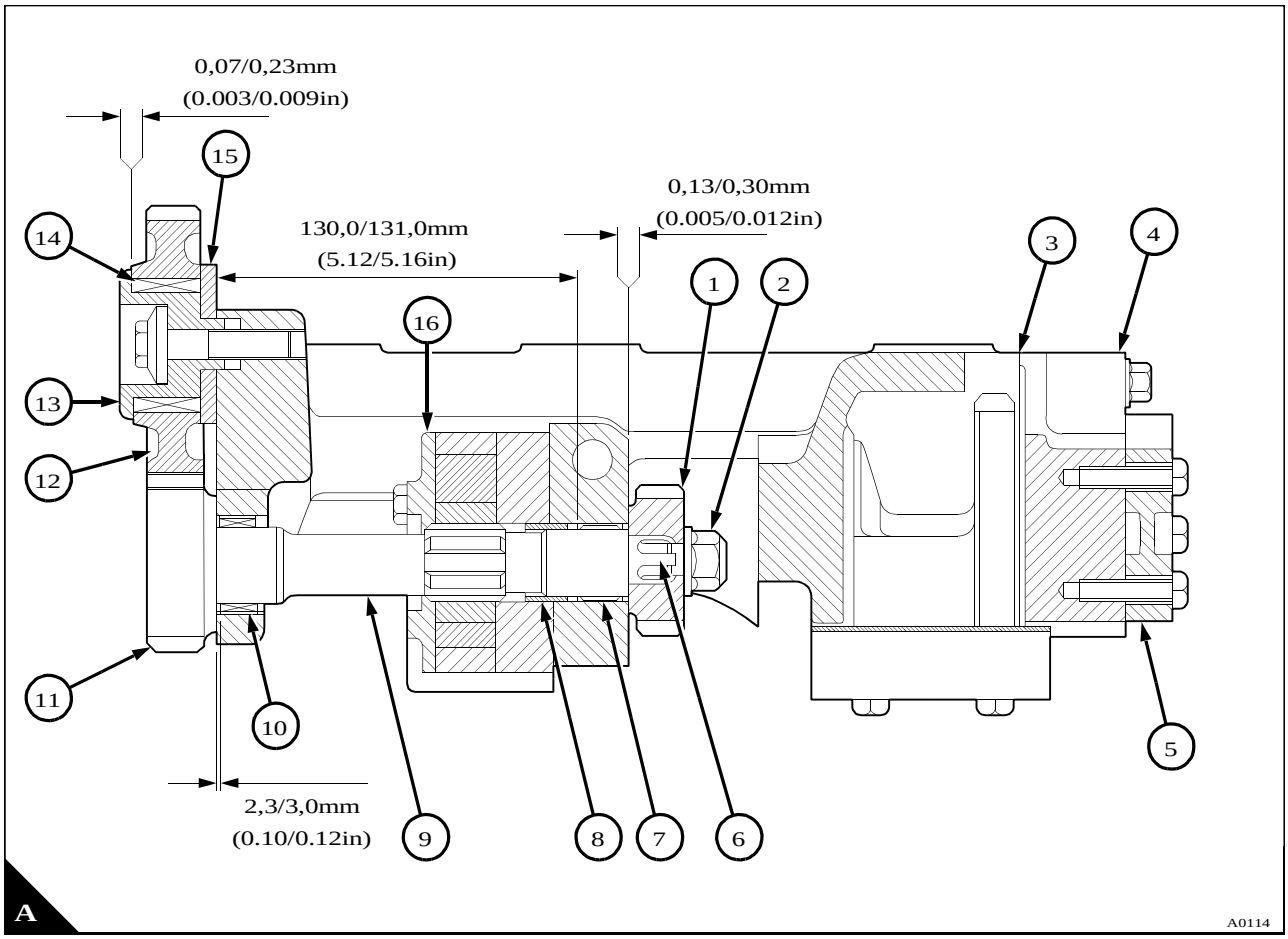
2 Assemble the lubricating oil relief valve, see Operation 10-14.

3 Lubricate the needle roller bearings (A7 and A10) with clean engine lubricating oil. Fit the drive shaft (A9) and engage the splines for the lubricating oil pump with the pump rotor. Ensure that the needle roller bearing at the front of the balancer frame is not damaged by the splines on the drive shaft.

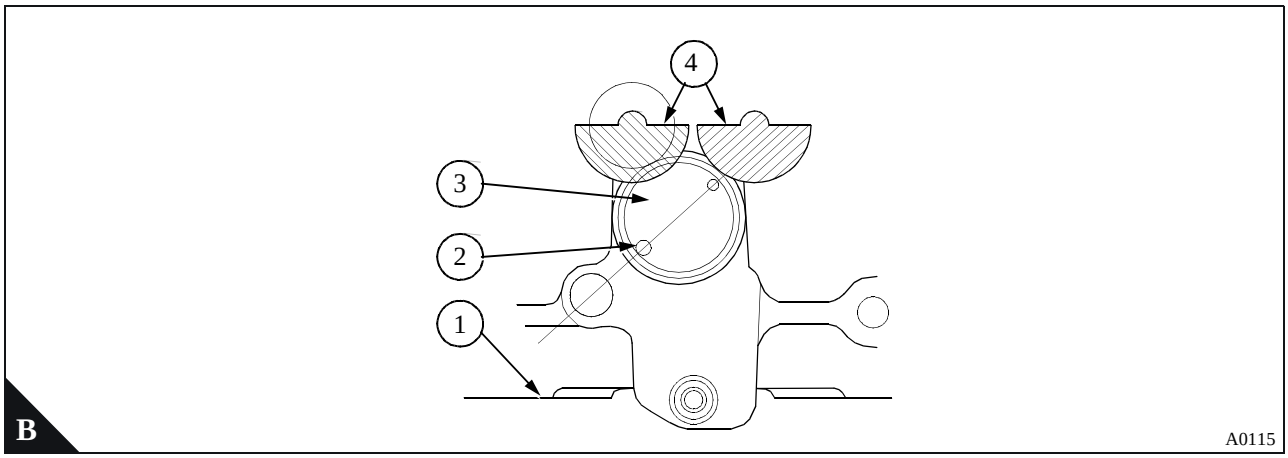
4 Clean and dry the splines (A6) and the thread on the end of the drive shaft. Apply a small amount of POWERPART Threadlock and nutlock to the splines and to the thread. Fit the drive gear of the balance weights (A1) with the flat face of the gear towards the rear of the balancer unit. Fit and tighten the nut (A2) to 82 Nm (60 lbf ft) 8,4 kgf m.

To tighten the nut, a peg spanner must be made to fit into the two holes in the front of the drive shaft and be suitable for use with a torque wrench. Fit the peg spanner to the front of the drive shaft. Hold the nut with a suitable spanner and apply the torque to the peg spanner.

5 Ensure that the drive shaft turns freely. Check the end-float of the drive shaft with feeler gauges between the front face of the drive gear for the balance weights and the frame (A).



6 Put the balancer frame upside down on the bench (B1). Turn the gear of the drive shaft (B3) until the larger of the two outer holes (B2) - in the front face of the drive gear - is in the position shown in (B). Ensure that the drive shaft will not move from this position. Lubricate the bushes in the rear of the balancer frame with clean engine lubricating oil and fit the balance weights in the position shown in (B). Ensure that the flats on the balance weights are level with each other (B4). With the balance weights in the correct position, check that the drive shaft is still in the correct position.

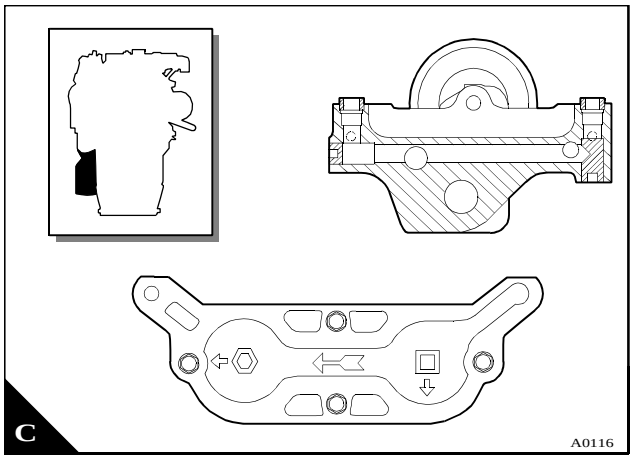


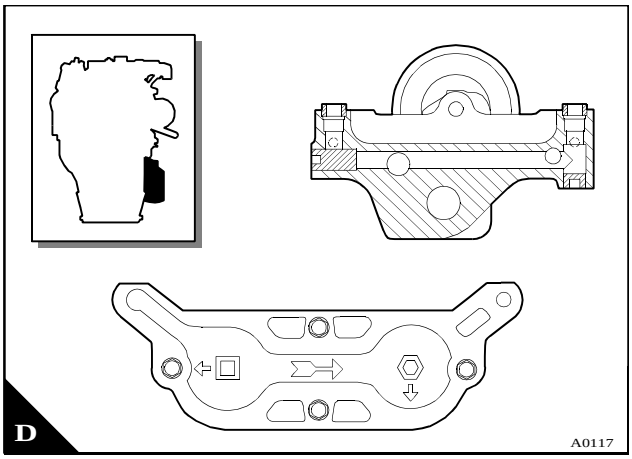
7 Fit the two dowels to the rear face of the balancer frame. Lubricate the bushes in the rear cover of the balance frame with clean engine lubricating oil. Put the rear cover in position with the rear spigots of the balance weights in the bushes of the cover. Hit lightly the rear cover with a soft face hammer to fit the cover onto the dowels. Fit the cover setscrews and tighten them to 54 Nm (40 lbf ft) 5,5 kgf m.

Check the end-float of the balance weights with feeler gauges between the rear face of the balance weights and the front face of the rear cover (Operation 5-27/B). The correct end-float is given in the relevant Data and dimensions for the "Balancer unit" on page 40.

Check the backlash between the drive gear of the balance weights and the driven gear on the balance weight. The correct backlash is given in the relevant Data and dimensions for the "Balancer unit" on page 40.

8 Fit the oil transfer plate and the joint, if fitted, to the rear of the rear cover and tighten the setscrews to 30 Nm (22 lbf ft) 3,1 kgf m. Ensure that the plate is fitted correctly for the oil filter position. The direction arrow (C or D) indicates the direction of lubricating oil flow for left side (C) and right side (D) oil filter positions. The symbols and arrows (C or D) indicate the position of the plugs in the balancer frame and the shape of their socket heads. Ensure that the plug on the bottom face of the frame is just below the face. If a new frame and plugs are used, ensure that the plugs are fitted correctly for the oil filter position and the symbols on the oil transfer plate.





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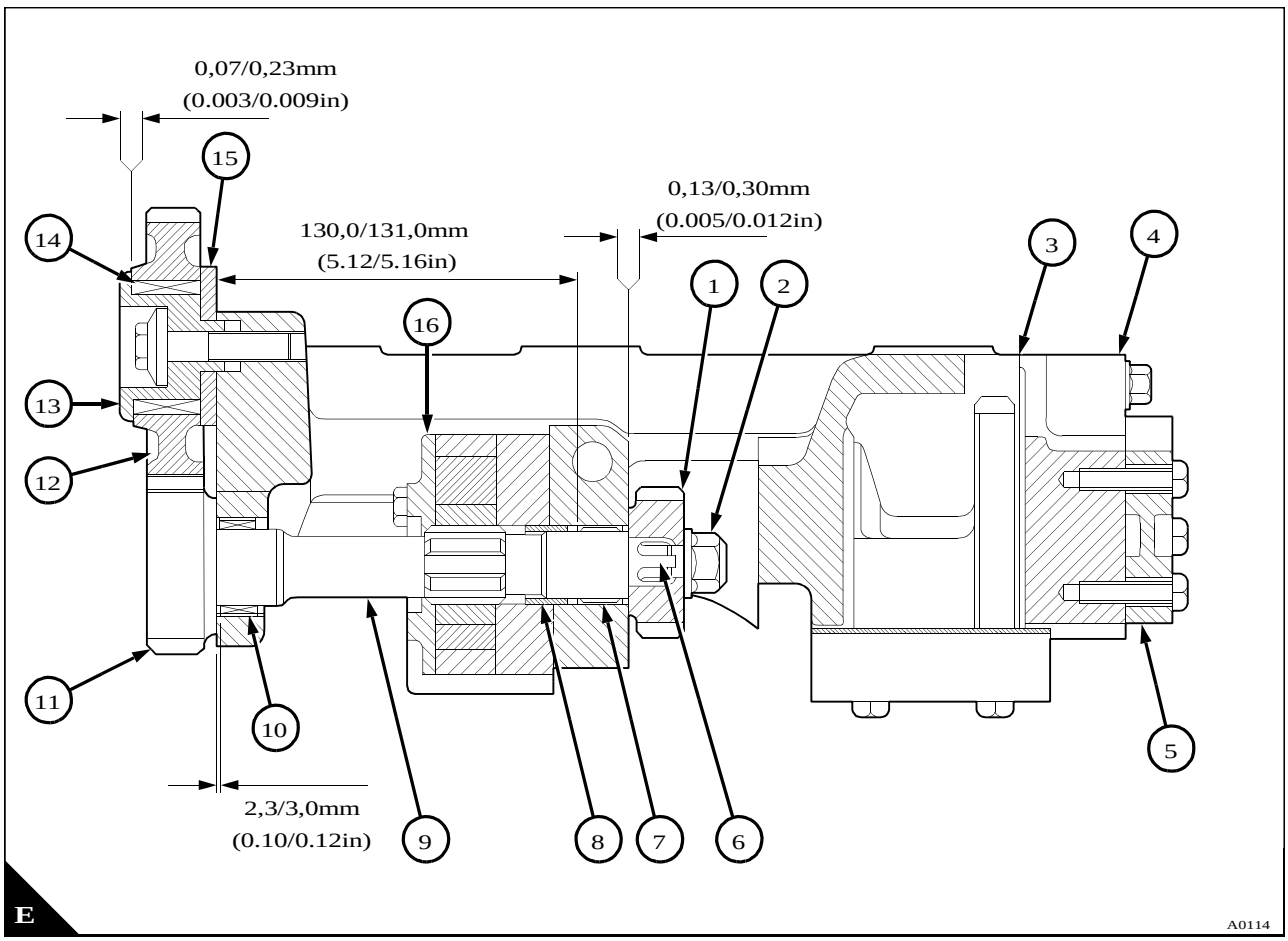
9 If necessary, press a new bearing (E14) into the idler gear (E12). Lubricate the bearing with clean engine lubricating oil. Fit the hub (E13) into the bearing and fit the thrust washer (E15) onto the rear of the hub. Ensure that the threads of the setscrew are clean and dry. Fit the setscrew through the assembly and apply a small amount of POWERPART Threadlock and nutlock to the thread. Fit the assembly to the front of the balancer unit with the idler gear in mesh with the gear of the drive shaft (E11). Tighten the setscrew to 93 Nm (68 lbf ft) 9,5 kgf m.

Check the end-float of the idler gear with a feeler gauge between the front face of the idler gear and the hub. Check the backlash between the idler gear and the drive shaft gear. The correct backlash is given in the relevant Data and dimensions for the "Balancer unit" on page 40.

10 Fit the balance weight cover and tighten the setscrews.

11 Fit the suction tube and the joint and tighten the setscrews.



To inspect **Operation 5-25**

1 Clean all the components before inspection.

2 Check the gear teeth and the splines of the drive shaft for wear or other damage. Renew the drive shaft if necessary.

3 Check the idler gear, needle roller bearing, hub and thrust washer for wear or other damage. Renew the components if necessary.

4 Check the drive gear for the balance weights for wear or other damage. Renew the gear if necessary.

5 Check the balance weights for wear or other damage. If either balance weight is worn or damaged, both balance weights must be renewed.

6 Check the needle roller bearings for the drive shaft for wear or other damage. Renew the bearings, see Operation 5-26, if necessary.

7 Check the bushes for the balance weights for wear or other damage. Renew the bushes, if necessary, see Operation 5-27.

8 To inspect the lubricating oil pump, see Operation 10-8.

To remove and to fit the needle roller bearings **Operation 5-26**

1 Press out the bearings with a suitable adaptor.

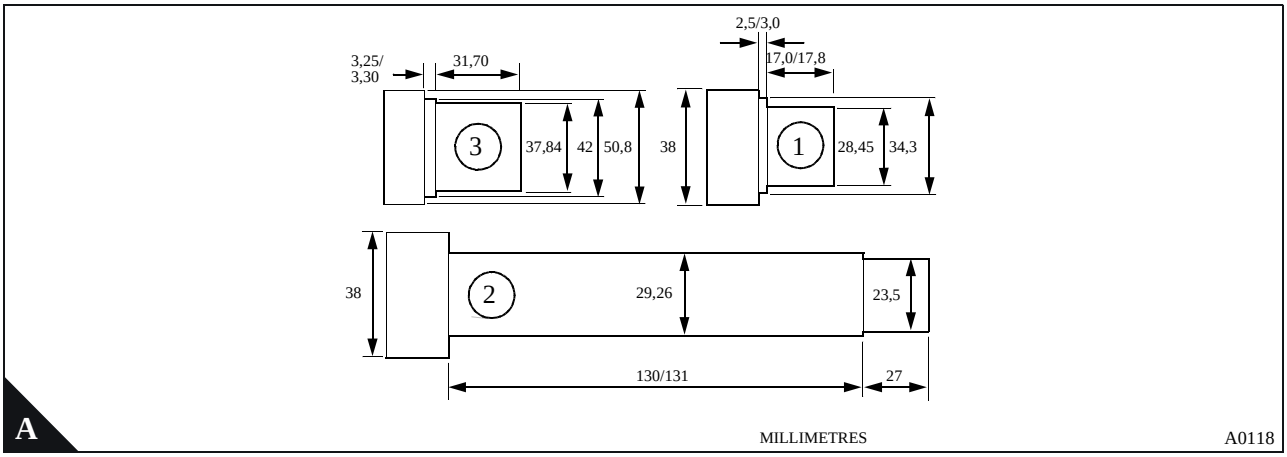
2 Clean the parent bores and lubricate them with clean engine lubricating oil.

3 Make a suitable adaptor to the dimensions given in (A2). Fit the rear bearing onto the adaptor with the stamped face of the bearing towards the shoulder of the adaptor. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame.

In this position the front face of the bearing should be 130,0/131,0 mm (5.12/5.16 in) from the front face of the balancer frame, see Operation 5-24 (A).

4 Make a suitable adaptor to the dimensions given in (A1). Fit the front bearing onto the adaptor with the stamped face of the bearing toward the shoulder. Press the bearing into the parent bore in a continuous movement until the shoulder of the adaptor is against the front face of the balancer frame.

In this position the front face of the bearing should be 2,5/3,0 mm (0.01/0.12 in) from the front face of the balancer frame, see Operation 5-24 (A).



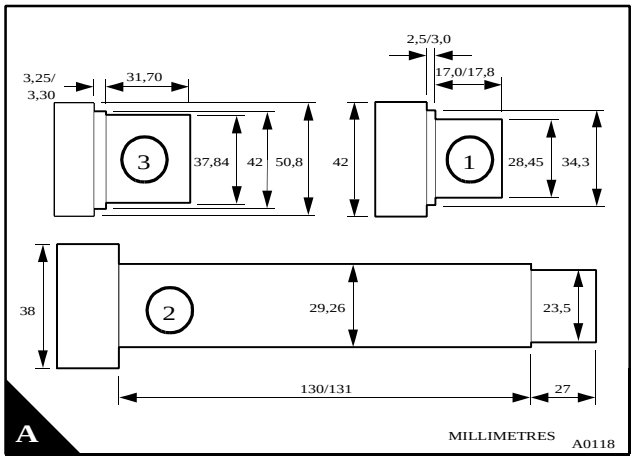
To remove and to fit the bushes for the balance weights **Operation 5-27**

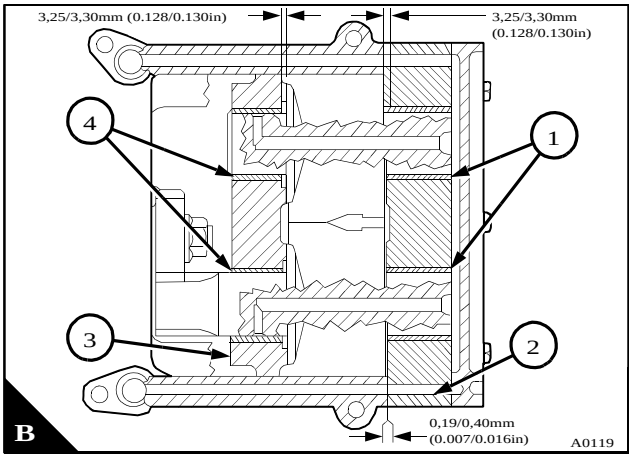
1 Press the bushes out of the balancer frame and the rear cover with a suitable adaptor.

2 Clean the parent bores and lubricate them with clean engine lubricating oil.

3 Make a suitable adaptor to the dimensions given in (A3). Fit a bush onto the adaptor. Press the bush (B4) into the parent bore in the rear of the balancer frame (B3), in a continuous movement, until the shoulder of the adaptor is against the rear face of the balancer frame. In this position the rear face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the rear face of the balancer frame (B). Repeat this operation for the other bush.

4 Fit a bush (B1) onto the adaptor and put it into position at the front end of one of the parent bores in the rear cover (B2). Press in the bush, in a continuous movement, until the shoulder of the adaptor is against the front face of the rear cover. In this position the front face of the bush should be 3,25/3,30 mm (0.128/0.130 in) from the front face of the rear cover (B). Repeat this operation for the other bush.





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6

Timing case and drive assembly

General description

The timing case (A) is for engines fitted with a gear driven coolant pump. The timing case (B) is for engines fitted with a belt driven coolant pump. The timing case is made of either aluminium or cast iron.

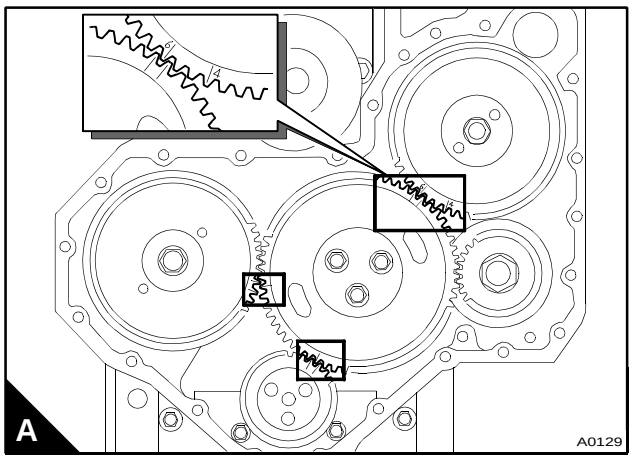
The timing gears on most engines are made of steel, but cast iron gears are used on certain low rated engines. A power take-off is available on the left side of the aluminium timing case or from both sides of the timing case made of cast iron. Some applications that need a power take-off from both sides of the timing case can have an idler gear assembly that uses needle roller bearings.

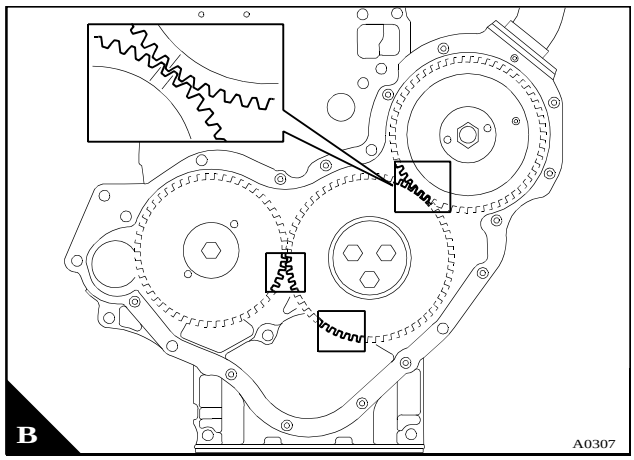
The drive from the crankshaft gear passes through an idler gear to the camshaft gear and to the gear of the fuel injection pump. The drive from the crankshaft gear also passes through a lower idler gear to the gear of the lubricating oil pump or, on some four cylinder engines, to the gear of the balancer unit. The gear driven coolant pump is driven by the gear of the fuel injection pump. The camshaft and the fuel injection pump run at half the speed of the crankshaft.

The aluminium cover of the timing case contains the front oil seal; this is made of viton and has a dust lip in front of the main lip. On most engines the cover has a noise shield fitted to its front face.

Warning! *Read the safety precautions for "Viton seals" on page 7.*

The camshaft is made of cast iron. The cam lobes and the eccentric for the fuel lift pump are chill hardened.





Timing case cover

To remove — Operation 6-1

1 Remove the fan, see Operation 12-18.

2 Remove the alternator, see Operation 14-4.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

5 Release the setscrews and nuts of the cover and remove the cover.

Notes:

- There is no need to remove the noise shield from the cover.
- If only the timing case cover is to be removed on belt driven coolant pump, there is no need to drain or remove the belt driven coolant pump.

To fit Operation 6-2

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Centralising tool (4 cylinder engines)	21825936	Centralising tool (6 cylinder engines)	21825574

1 Clean the faces of the timing case cover.

2 Put the cover and a new joint in position on the timing case. Loosely fit two setscrews which are in opposite locations to hold the cover in position. Fit the centralising tool in the oil seal housing (A) and use the special washer and the crankshaft pulley setscrews to put the cover in its correct position. Do not overtighten the setscrews. Fit the remainder of the setscrews and nuts and tighten all of the cover fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the centralising tool.

Caution: *It is important that the cover of the timing case is centred correctly. If the cover is not centred, the backlash between the fuel pump gear and coolant pump gear could be affected. This could cause the seizure of the fuel injection pump.*

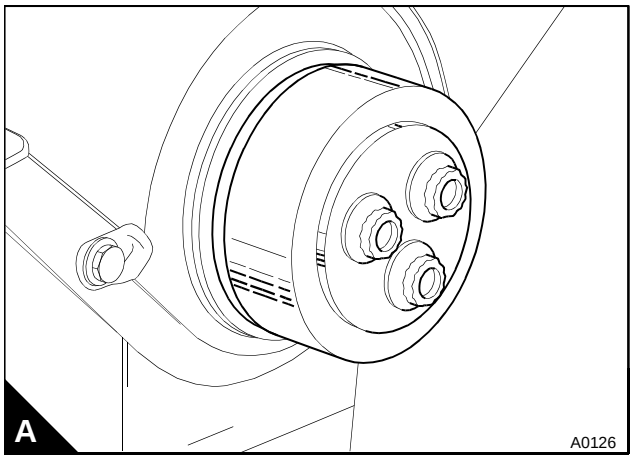
3 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

4 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

5 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

6 Fit the fan, see Operation 12-18.

7 Fill the cooling system.



Front oil seal

To remove **Operation 6-3**

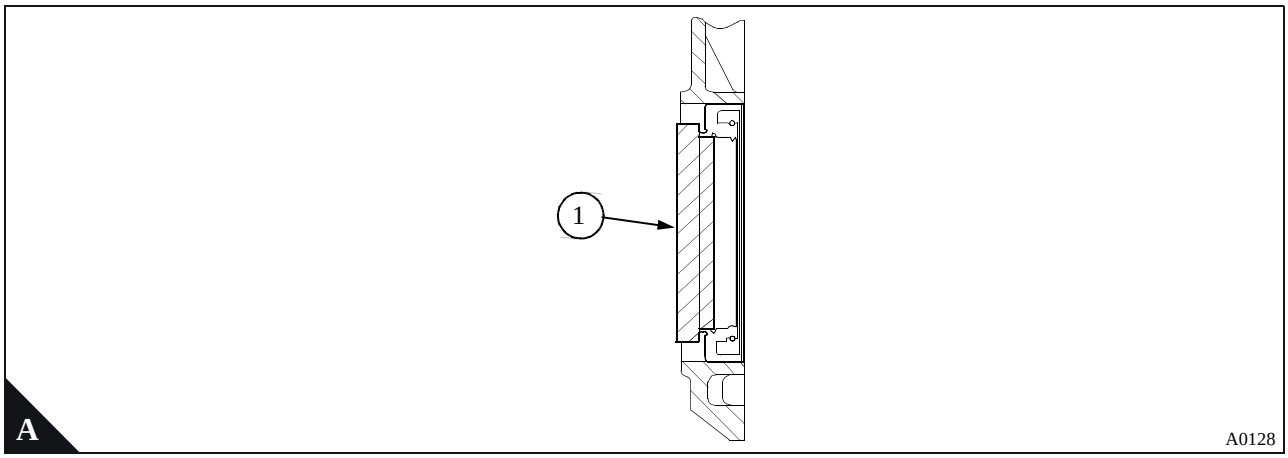
A special front oil seal is used in engines where immersion of the seal in water is possible. The water immersion seal has a flexible front lip that protrudes onto the boss of the front pulley. This front lip prevents the leakage of water past the oil seal.

As the front lip on this type of oil seal is very flexible, the oil seal must be kept on the plastic mandrel (A1) supplied with it until the pulley is to be fitted. The plastic mandrel must be fitted to the seal immediately the crankshaft pulley is removed. This will ensure that the front lip of the seal will keep its correct shape.

1 Remove the fan, see Operation 12-18, and the drive belts, see Operation 14-3.

2 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

3 Remove the oil seal with a suitable lever behind the main lip of the oil seal. Do not damage the edge of the oil seal housing.



To fit — Operation 6-4

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Replacer tool for front oil seal	21825577	Fastener plate for use with 21825577	21825580
Pressure plate for use with 21825577	21825578	Adaptor for standard seal for use with 21825577	21825581
Sleeve for use with 21825577	21825579	Adaptor for water immersion seal for use with 21825577	21825946

The standard seal is fitted to a depth of 6,75/7,25 mm (0.266/0.285 in) from the front face of the oil seal housing to the flat front face of the oil seal. If, in service, there is wear in the seal location area of the crankshaft pulley, the oil seal can be fitted to a depth of 9,3 mm (0.366 in).

The water immersion seal is fitted to a depth of 8,85/9,35 mm (0.348/0.368 in) and there is no service position.

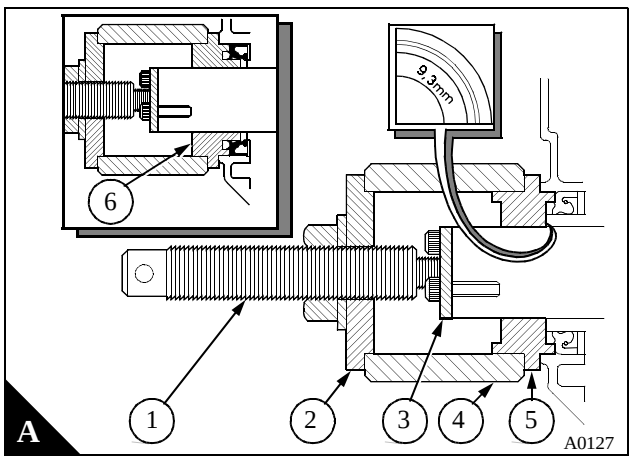
1 Clean the oil seal housing. Inspect the new seal for damage. If a scratch can be seen across the lip of the seal, do not fit the seal.

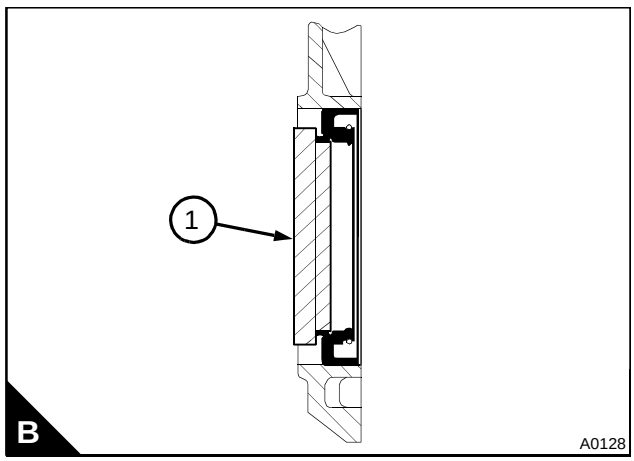
2 Lubricate the outer circumference of the oil seal with clean engine lubricating oil and enter the seal into the housing. Ensure that the spring loaded lip of the oil seal is towards the inside of the timing case cover and that the oil seal is square to the bore of the seal housing. When a water immersion seal is to be fitted, keep the plastic mandrel (B1) in position until it is time to fit the adaptor 21825946.

3 Assemble the oil seal replacer tool (A). Fit the fastener plate, 21825580, (A3) to the front of the crankshaft. For the standard seal, put the adaptor, 21825581, (A5) on the nose of the crankshaft and against the seal. Ensure that the adaptor has the side stamped 9,3 mm towards the seal. When a water immersion seal is to be fitted, remove the plastic mandrel from the seal and fit the adaptor 21825946, (A6). When the adaptor is fitted, ensure that the front lip of the seal is fully onto the taper of the adaptor.

Note: The other side of adaptor 21825946 can also be used to fit the standard seal.

4 Assemble the pressure plate, 21825578, (A2) together with the sleeve, 21825579, (A4) onto the threaded rod, 21825577, (A1). Put the tool assembly in position on the adaptor, 21825581 or 21825946, and tighten the threaded rod onto the stud of 21825580 (A3).





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5 Fit a rod through the hole in the end of the threaded bar to prevent movement of the bar when the nut is tightened. Tighten the nut to push the seal into the housing to the correct depth. If the standard seal is to be pushed in to the service position, turn the nut until the face of 21825581 is against the face of the seal housing. If a water immersion seal is to be fitted, the adaptor, 21825946, should also be pushed fully onto the face of the seal housing.

6 Remove the replacer tool and lightly lubricate the seal location area of the crankshaft pulley with clean engine lubricating oil. Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3. If a water immersion seal has been fitted, either leave the adaptor in position or fit the plastic mandrel until the crankshaft pulley can be fitted.

7 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

8 Fit the fan, see Operation 12-18.

To remove and to fit a wear sleeve **Operation 6-5**

To repair a worn crankshaft pulley, a wear sleeve (B) is fitted over the spigot (A1).

To remove

1 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

2 With a sharp tool mark a deep line along the length of the sleeve.

3 Insert a suitable thin blade between the pulley spigot and the sleeve next to the marked line, the wear sleeve will separate along the marked line.

4 Remove the wear sleeve. Use a suitable cleaner to remove any sealant from the pulley spigot.

To fit

1 Ensure that the pulley spigot is dry and free from oil, dirt and sealant.

2 Remove any rough spots from the pulley spigot surface.

3 Apply a small continuous bead of sealant (B2) that does not harden (Loctite 518) to the inner surface of the wear sleeve 5,0 mm (0.197 in) from the flange end of the sleeve (B1).

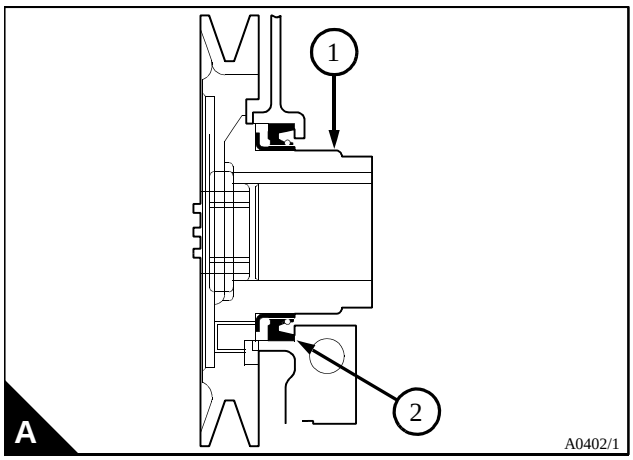
Caution: *The wear sleeve must be fitted within five minutes of applying the sealant.*

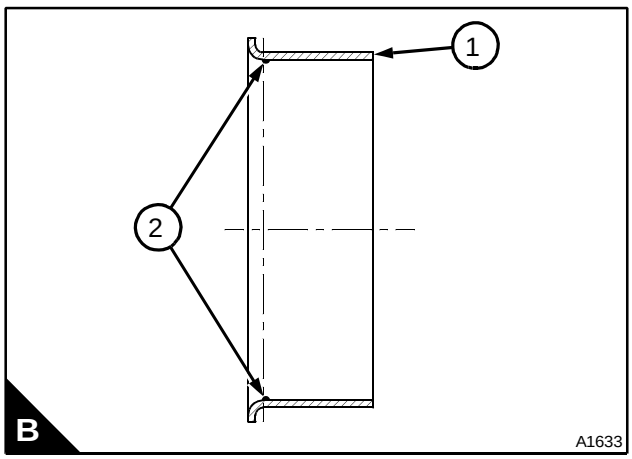
4 Place the wear sleeve on to the pulley spigot, use the tool that is supplied with the new wear sleeve and a suitable hammer, to force the wear sleeve (B) over the pulley spigot.

A new front oil seal (A2) must be used when a wear sleeve is fitted.

The dimension, to press the new oil seal into the timing case, with or without a wear sleeve fitted, is 9,3 mm (0.366 in), from the front face of the timing case.

5 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.





Idler gear and hub

To remove **Operation 6-6**

1 Remove the timing case cover, see Operation 6-1.

2 Rotate the crankshaft until the marked teeth of the crankshaft gear and the camshaft gear and the fuel pump gear are all aligned with the marked teeth of the idler gear (A).

Note: The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

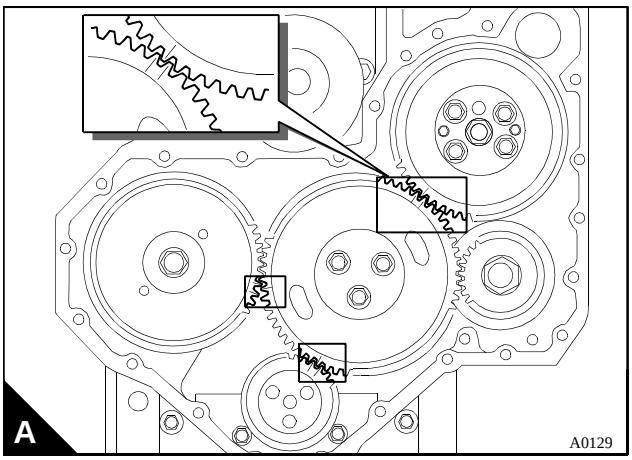
3 Release the three setscrews (B8), remove the plate (B1) of the idler gear and remove the gear (B3) from the idler gear hub (B5). The drive gear of the fuel injection pump may rotate counter clockwise when the idler gear is removed.

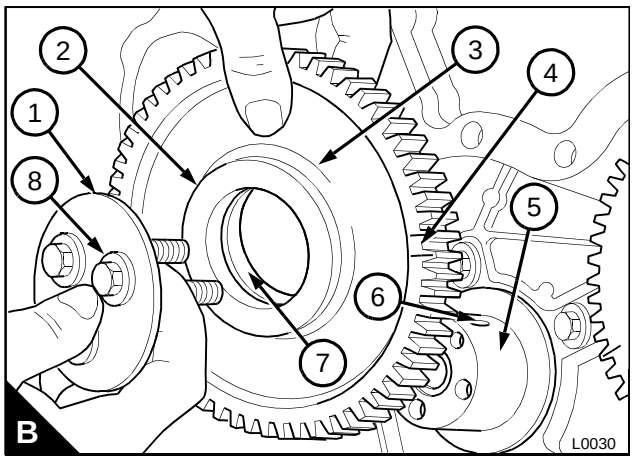
4 Remove the idler gear hub, note the position of the oil hole (B6).

Caution: *The valve timing and fuel injection pump timing will be lost if the crankshaft is rotated when the idler gear is removed.*

5 Inspect the gear and the bushes (B2) and (B7) for wear and other damage and renew as necessary. The gear and bushes are available as an assembly or separate bushes are available.

6 If the bushes are to be changed, remove them with a suitable puller. If a puller is not available, machine off the face of one of the bushes and press them out. Press in new bushes, machine the bores to get the correct clearance on the hub and machine the faces to get the correct end clearance, refer to the Data and dimensions for "Idler gear and hub" on page 41.





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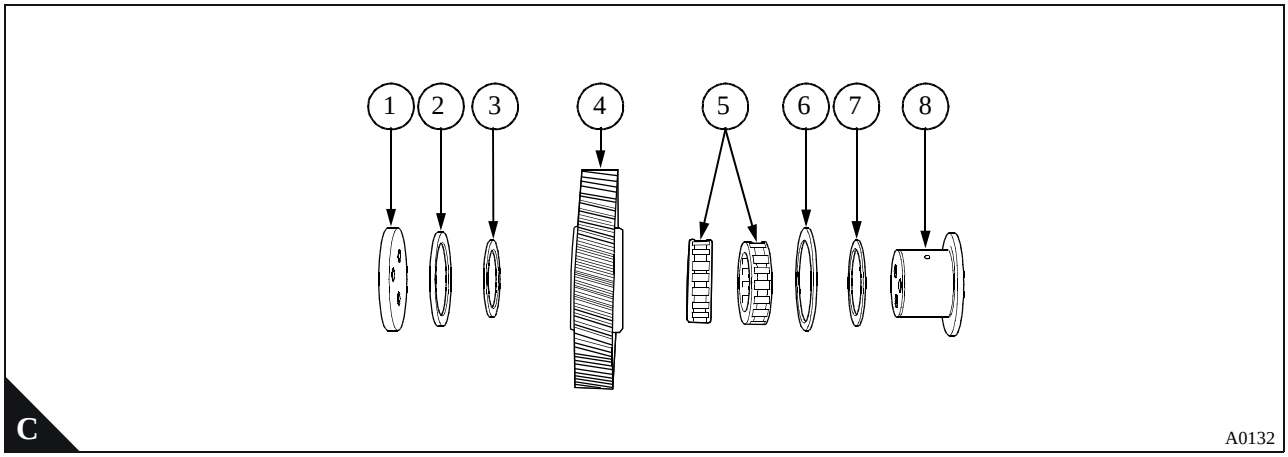
7 For engines that use the idler gear assembly with needle roller bearings - Release the three setscrews, remove the plate of the idler gear (C1). Remove the front thrust washer (C2), the front spacer (C3) and the gear (C4). Remove the two needle roller bearings (C5), if these are to be used again, they should be fitted in their original positions. Remove the rear thrust washer (C6) and the rear spacer (C7). Remove the hub (C8).

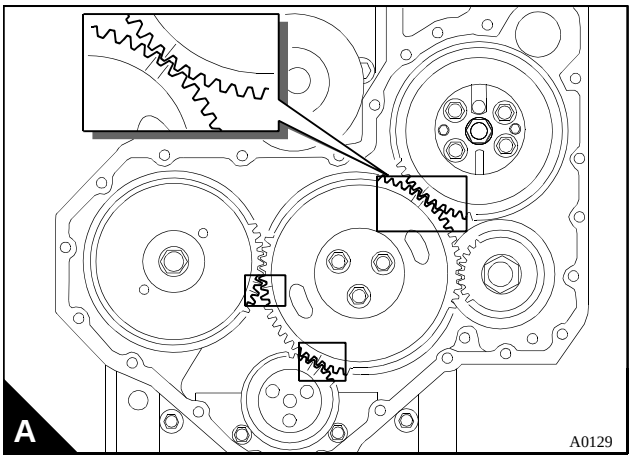


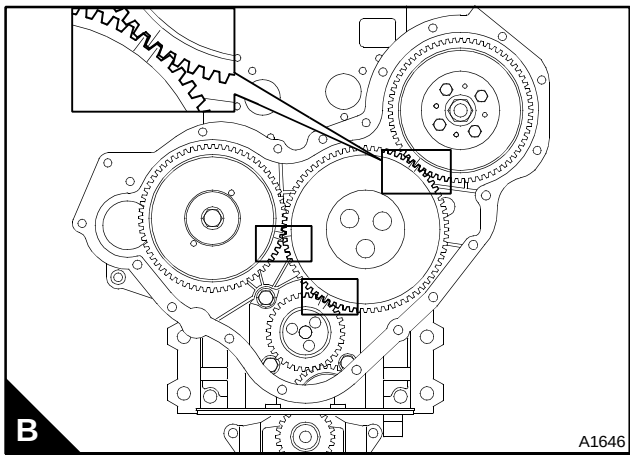
To fit **Operation 6-7**

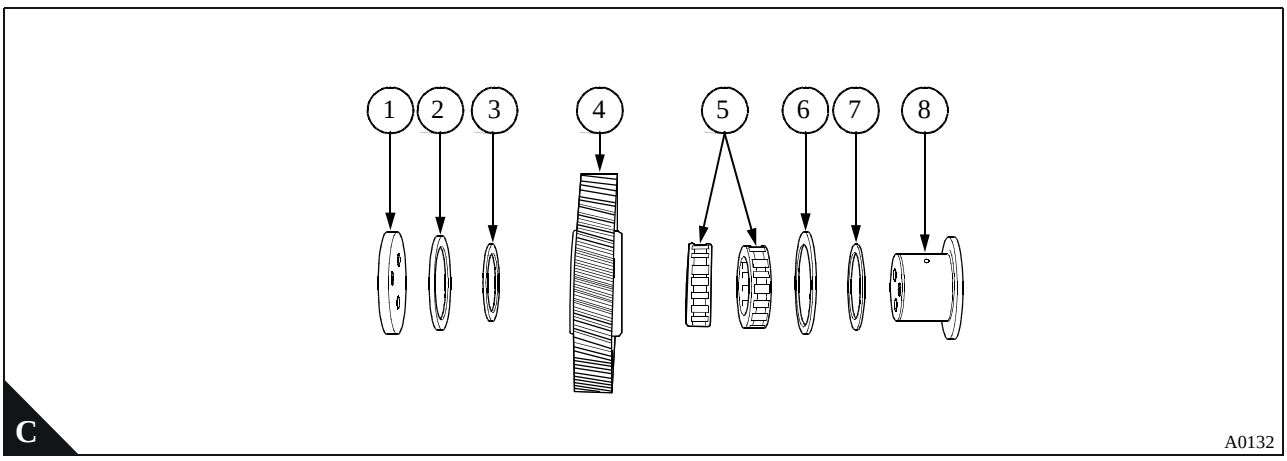
1 Use the three idler gear setscrews to ensure the correct position of the idler gear hub with the lubrication hole at the top. Push the hub into position and remove the setscrews.

2 Lubricate the idler gear bushes with clean engine lubricating oil. Align the timing marks on the idler gear with the marks on the crankshaft and camshaft gears. If necessary, rotate the gear of the fuel injection pump clockwise to align the relevant timing mark with the marks on the idler gear and slide the idler gear into position. Check that all the timing marks are in correct mesh (A), or (B) for engines fitted with a belt driven coolant pump. Fit the plate and the setscrews to the idler gear hub and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

3 For engines that use the idler gear assembly with needle roller bearings - Inspect the components for wear and other damage and renew them as necessary. Lightly lubricate the components with clean lubricating oil before assembly onto the hub. Fit the hub (C8) as described in step 1. Put the rear spacer (C7) in position on the hub. Put the rear thrust washer (C6) in position on the rear spacer. Put the bearings (C5) in position on the hub in the same position as they were before they were removed. Lightly lubricate the bore and thrust washer faces of the gear (C4) with clean lubricating oil and put the gear in position on the bearings. Put the front spacer (C3) in position on the hub then put the front thrust washer (C2) in position on the spacer. Put the plate (C1) in position. The plate has TOP stamped on the front face as the holes in the plate are not equally spaced. Fit the setscrews and tighten them to 44 Nm (33 lbf ft) 4,5 kgf m).







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4 Check the idler gear end-float (D) and the timing gear backlash (E). Refer to the Data and dimensions for "Idler gear and hub" on page 41.

5 Fit the timing case cover, see Operation 6-2.

6 Fit the coolant pump. Gear driven coolant pumps only, see Operation 12-4 or Operation 12-5.

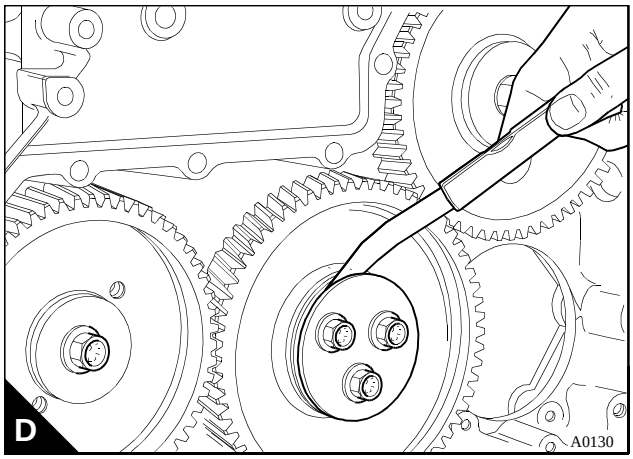
7 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

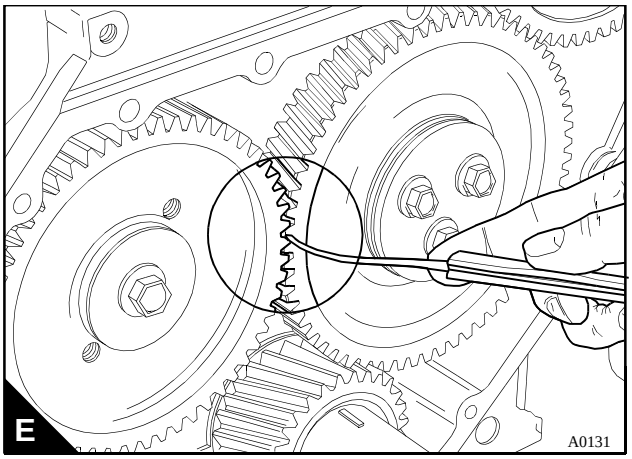
8 Where necessary, fit the fan drive pulley, see Operation 12-18.

9 Fit the drive belts, see Operation 14-3 and adjust the belt tension, see Operation 14-2.

10 Fit the fan, see Operation 12-18.

11 Fill the cooling system.





Idler gear and hub for the Bendix or Knorr-Bremse compressor

The compressors are driven directly from the engine timing case and does not have an auxiliary drive assembly. The engine idler gear (A12) drives the compressor gear (A4) through a separate idler gear (A11/ B5) fitted onto a hub (A9). The hub is fastened to the back of the timing case (A5) by a bracket (A3).

The idler gear is fitted on a needle roller bearing (A7) which is fitted onto the hub. The hub has an "O" ring (A1) to prevent oil leakage from the rear of the timing case. The roller bearing and the idler gear are retained on the hub by a plate (A10) which is fastened to the idler hub.

To remove **Operation 6-8**

1 Remove the fan, see Operation 12-18.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive pulley, see Operation 12-19.

5 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

6 Remove the timing case cover (A6), see Operation 6-1.

7 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

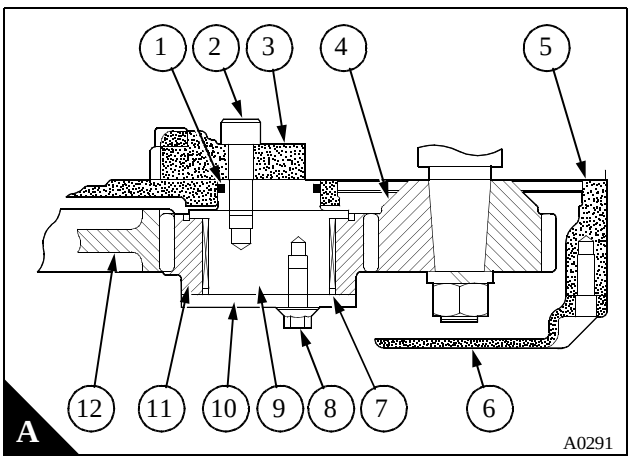
Caution: *Do not rotate the engine crankshaft or the compressor crankshaft if the idler gear is removed. If either of the crankshafts are moved, the compressor must be timed to the engine.*

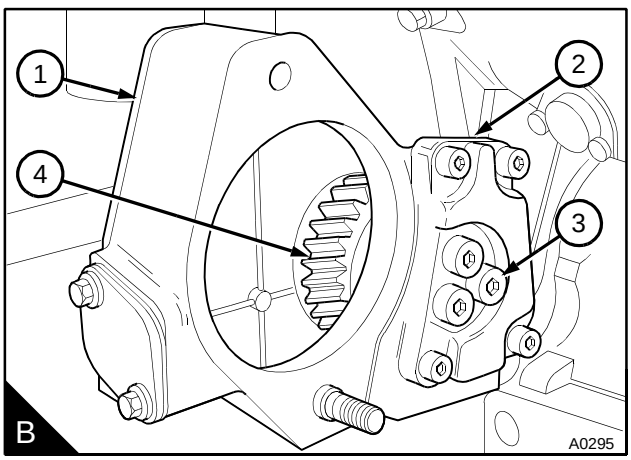
8 Release the three setscrews (A8). Remove the plate (A10) which retains the idler gear (A11). Remove the gear and the needle roller bearing (A7) from the idler hub (A9).

9 Remove the three cap screws (B3) which fasten the idler hub to the bracket (B2) at the rear of the timing case (B1). Remove the idler gear hub.

10 Remove and discard the "O" ring (A1).

11 Inspect the idler gear, needle roller bearing and idler gear hub for wear and other damage and, if necessary, renew them.





To fit **Operation 6-9**

1 Renew the "O" ring (A1). Lightly lubricate the components with clean lubricating oil before they are assembled onto the hub.

Check that the four cap screws (B4) which secure the idler hub bracket (B2) to the timing case are tightened to the correct torque 35 Nm (26 lbf ft) 3,5 kgf m.

Fit the hub (A9) with the "O" ring towards timing case. Fit the three M10 cap screws (B3) and tighten them to 60 Nm (44 lbf ft) 6 kgf m). Put the needle roller bearing (A7) into position on the hub.

Caution: *Do not rotate the engine crankshaft or the compressor crankshaft if the idler gear (B5) is removed. If either of the crankshafts are moved, the compressor must be timed to the engine.*

2 Lightly lubricate the bore of the gear (A11) with clean lubricating oil and put the gear in position on the bearing. Put the plate (A10) in position. Fit the setscrews (A8) and tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Use the method shown in Operation 6-6 (D) to check the compressor idler gear end-float and in Operation 6-6 (E) to check the timing gear backlash.

Refer to the relevant Data and dimensions for the "Timing case and drive assembly" on page 40 for the compressor idler gear end-float and backlash dimensions.

4 Fit the timing case cover, see Operation 6-2.

5 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

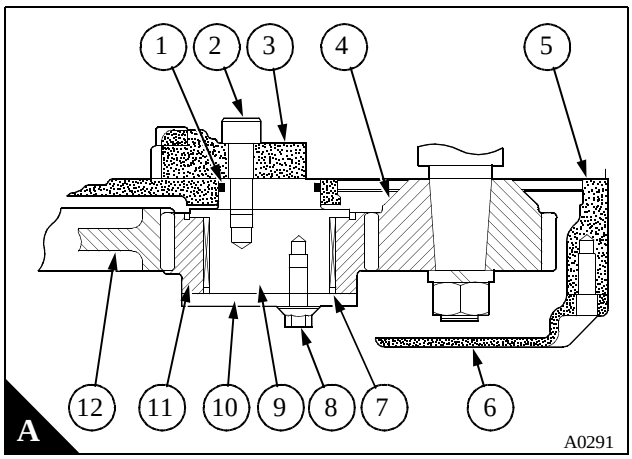
6 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

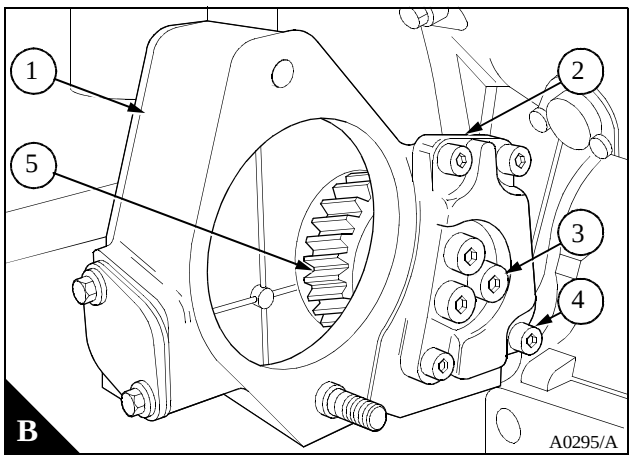
7 Where necessary, fit the fan drive pulley, see Operation 12-19.

8 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

9 Fit the fan, see Operation 12-18.

10 Fill the cooling system.





Fuel pump gear

To remove **Operation 6-10**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Adaptors for use with 21825565	21825568

1 Remove the fan, see Operation 12-18.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive pulley, see Operation 12-19.

5 For gear driven coolant pumps, drain the coolant and remove the coolant pump, see Operation 12-4.

Note: It is not necessary to remove the coolant pump, when the pump is belt driven.

6 Remove the timing case cover, see Operation 6-1.

Caution: *For fuel injection pumps fitted with a locking screw. Check that the shaft of the fuel injection pump is not locked, see Bosch EPVE pumps or, see Lucas/Delphi DP 200 pumps.*

7 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

8 Remove the nut and the spring washer from the fuel pump gear.

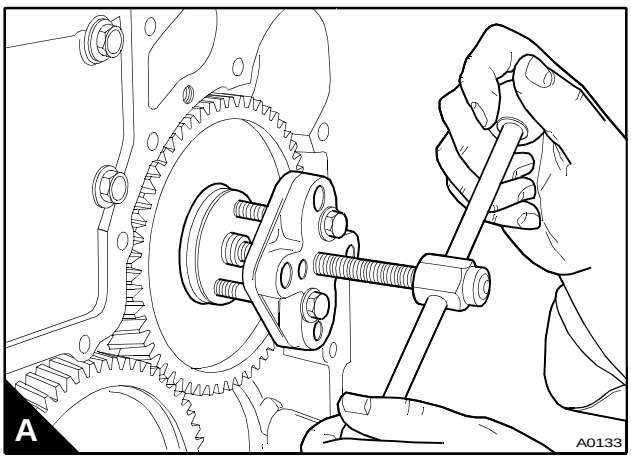
Notes:

- Early Phaser 210 Ti engines have a spacer between the gear and the spring washer.
- On certain engine types where the gear is retained by a plate and four cap screws, release the four cap screws and remove the plate and then the gear. Ensure that the plate does not fall when the cap screws are removed.

9 Remove the idler gear, see Operation 6-6.

10 Remove the fuel pump gear with the puller and the adaptors (A). Ensure that the key in the fuel pump shaft is not lost.

11 Inspect the gear for wear and other damage and renew it, if necessary.



To fit **Operation 6-11**

1 Ensure that the key is fitted correctly in the fuel pump shaft. Fit the gear and the spring washer and loosely fit the nut.

Note: Early Phaser 210Ti engines have a spacer between the gear and the spring washer.

2 Rotate the fuel pump gear (A2) to ensure that the relevant marked tooth of the fuel pump gear ("4" for four cylinder engines or "6" for six cylinder engines) will align with the marked teeth of the idler gear (A). Fit the idler gear, see Operation 6-7.

3 Tighten the nut of the fuel pump gear to 80 Nm (59 lbf ft) 8,2 kgf m. The teeth of the drive gear and the idler gear should be fully in mesh when the fuel pump gear is tightened onto the hub of the fuel injection pump.

Note: On engines fitted with an Bosch MW in-line fuel injection pump, the pump must be put in the static timing position, see "Engine timing (Bosch in-line fuel injection pump)" on page 44, before the gear is fitted. **For early engines:** When the gear is fitted, ensure that the B marked on the gear is to the front. **For the latest engines:** Ensure that the letter C (A1) and the last four digits of the part number marked on the gear are to the front.

Notes:

- On engines fitted with an Bosch MW in-line fuel injection pump, the pump must be put in the static timing position, see "Engine timing (Bosch in-line fuel injection pump)" on page 44, before the gear is fitted. **For early engines:** When the gear is fitted, ensure that the B marked on the gear is to the front. **For the latest engines:** Ensure that the letter C (A1) and the last four digits of the part number marked on the gear are to the front.
- Early Phaser 210 Ti engines have a spacer between the gear and the spring washer.
- On certain engine types where the gear is retained by a plate and four cap screws, release the four cap screws and remove the plate and then the gear. Ensure that the plate does not fall when the cap screws are removed.

4 If a new gear has been fitted, check the backlash.

5 Fit the timing case cover, see Operation 6-2.

6 For gear driven coolant pumps, fit the coolant pump, see Operation 12-5.

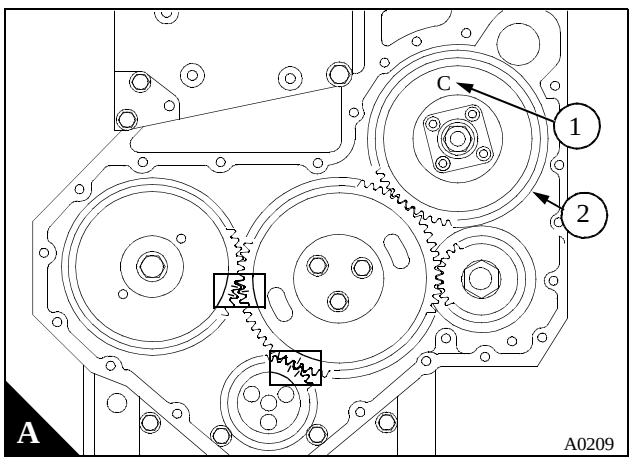
7 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

8 If necessary, fit the fan drive pulley, see Operation 12-19.

9 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

10 Fit the fan, see Operation 12-18.

11 Fill the cooling system.



Camshaft gear

To remove **Operation 6-12**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Adaptors for use with 21825565	21825568

1 Remove the fan, see Operation 12-18.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive pulley, see Operation 12-19.

5 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

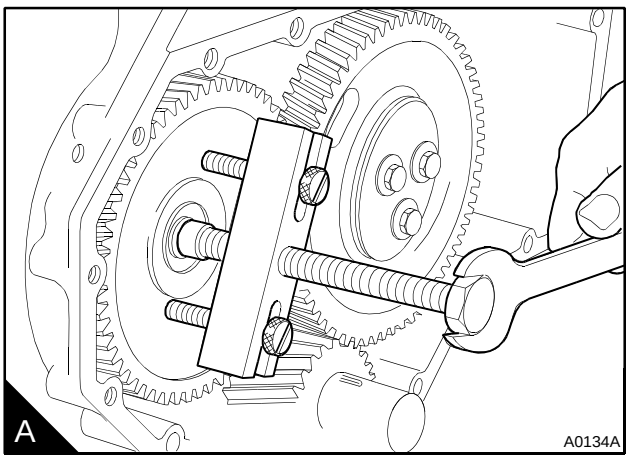
6 Remove the timing case cover, see Operation 6-1.

7 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

Note: The fuel pump gear used on engine types AE and YE does not have marked teeth.

8 Remove the setscrew and washer of the camshaft gear. Put a suitable adaptor onto the end of the camshaft and remove the gear with the puller and adaptor (A). Ensure that the key in the camshaft is not lost.

9 Inspect the gear for wear and any other damage and renew it, if necessary.



To fit — Operation 6-13

1 Ensure that the key in the camshaft is fitted correctly.

2 Remove the idler gear, see Operation 6-6.

3 Fit the camshaft gear to the camshaft with the marked teeth towards the front and the keyway correctly aligned with the key.

4 Fit the idler gear with the marked teeth in correct mesh, see Operation 6-7. If the camshaft has to be turned and a valve hits a piston, disengage the rocker assembly.

5 Fit the washer and the setscrew for the camshaft gear and tighten the setscrew to press the camshaft gear into position. Tighten the setscrew to 78 Nm (58 lbf ft) 8,0 kgf m. If a new camshaft gear has been fitted, check the backlash.

6 Fit the timing case cover, see Operation 6-2.

7 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

8 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

9 If necessary, fit the fan drive pulley, see Operation 12-19.

10 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

11 Fit the fan, see Operation 12-18.

12 Fill the cooling system.

Crankshaft gear

To remove and to fit — Operation 6-14

To remove

1 Remove the fan, see Operation 12-18.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive pulley, see Operation 12-19.

5 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

6 Remove the timing case cover, see Operation 6-1.

7 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

Note: The fuel pump gear used on engine types AE and YE does not have marked teeth.

8 Remove the idler gear, see Operation 6-6.

9 The crankshaft gear is a transition fit on the crankshaft. It may slide off easily or, if it is a tight fit and the gear is to be renewed, it may be necessary to remove the crankshaft, see Operation 5-18, to remove the gear safely.

To fit

1 The gear can fit easily, or it may be necessary to heat the gear before it will fit onto the crankshaft. If the gear is to be heated, heat it in an oven to not more than 180 °C (226 °F). If an oven is not available, heat it in coolant which is at its boiling point. Do not use a flame as this can cause local damage. Fit the gear with the timing marks to the front.

2 Fit the idler gear, see Operation 6-7, and ensure that all the timing marks are correctly aligned.

3 Fit the timing case cover, see Operation 6-2.

4 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

5 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

6 Where necessary, fit the fan drive pulley, see Operation 12-19.

7 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

8 Fit the fan, see Operation 12-18.

9 Fill the cooling system.

Timing case

To remove — Operation 6-15

1 Remove the fan, see Operation 12-18.

2 Remove the drive belts, see Operation 14-3.

3 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

4 If necessary, remove the fan drive pulley, see Operation 12-19.

5 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

6 Remove the alternator together with its mounting bracket and front support plate, see Operation 14-4.

7 Remove the compressor and drive assembly, if fitted, see Operation 15-1.

8 Remove the timing case cover, see Operation 6-1.

9 Rotate the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

Note: The fuel pump gear used on engine types AE and YE does not have marked teeth.

10 Remove the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-14 or Operation 11-16.
- Bosch MW fuel injection pumps, see Operation 11-26.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-31.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-38.
- Stanadyne fuel injection pumps, Operation 11-47.

11 Remove the idler gear, see Operation 6-6, and the camshaft gear, see Operation 6-12.

12 Remove the setscrews which hold the timing case to the cylinder block and the setscrews which hold the sump to the bottom of the timing case.

13 Remove the timing case and the joint, do not allow the idler gear hub to fall. Ensure that the camshaft thrust washer is not lost.

To fit **Operation 6-16**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Universal jointing compound	1861117	POWERPART Threadlock and nutlock	21820117 or 21820118

1 Ensure that the sump joint is not damaged. If the joint is damaged, remove the sump and fit it with a new joint after the timing case has been fitted. The front section of the joint can be cut away and the front section of a new joint fitted, without the removal of the sump, but extreme care must be used to prevent possible leaks.

2 If the sump has been removed, fit the idler gear hub (A2) or (B2) to the front of the cylinder block; use the three setscrews of the idler gear to hold the hub in position. Ensure that the oil hole is at the top.

3 Ensure that the thrust washer for the camshaft is in position.

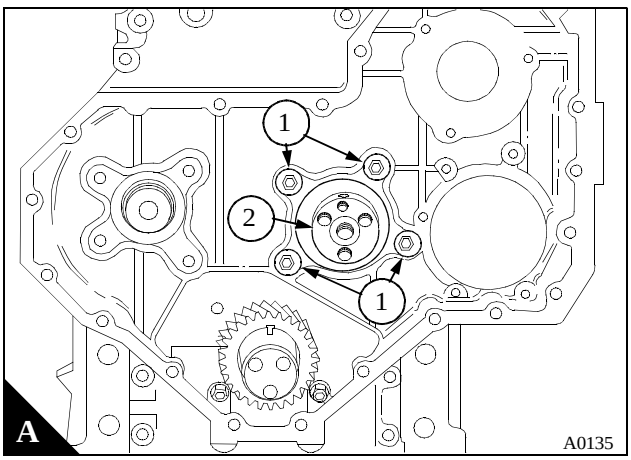
4 Fit a new joint for the timing case to the cylinder block. Cut the bottom ends of the joint to fit correctly. Apply POWERPART Universal jointing compound to the bottom ends of the joint.

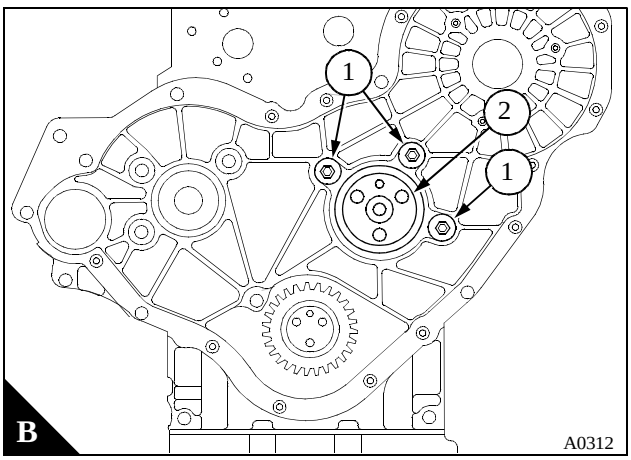
5 Put the timing case in position. If the sump has not been removed, fit the idler gear hub, see step 2. Fit the four setscrews (A1), or three setscrews (B1) for engines fitted with a belt driven coolant pump, around the idler gear hub. Ensure that the bottom of the timing case is correctly aligned with the bottom of the cylinder block before the setscrews are tightened.

Put the fan drive assembly and/or the alternator and its front support plate in position and fit and tighten the remainder of the setscrews of the timing case. If the front support plate has been separated from the alternator bracket, ensure that the right side of the plate is level with the machined face on the cylinder block where the alternator bracket is fitted. If a new timing case is fitted, remove the two studs from the timing case and clean the threads which fit into the timing case.

Seal the threads with POWERPART Threadlock and nutlock and fit the studs into the new timing case. Remove the setscrews from the idler gear hub.

6 If necessary, fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved oil.





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7 Fit the camshaft gear, see Operation 6-13, and the idler gear, see Operation 6-7. Ensure that all the timing marks are correctly aligned.

8 If the timing case is new and the old timing case had a timing mark, put a timing mark on the new timing case, see Operation 8-6 or Operation 8-12.

9 Fit the fuel injection pump and the drive gear:

- Bosch EPVE fuel injection pumps, see Operation 11-15 or Operation 11-17.
- Bosch MW fuel injection pumps, see Operation 11-27.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-32.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-39.
- Stanadyne fuel injection pumps, Operation 11-48.

10 Eliminate air from the fuel system:

- Bosch EPVE fuel injection pumps, see Operation 11-25.
- Bosch MW fuel injection pumps, see Operation 11-30.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46.
- Stanadyne fuel injection pumps, Operation 11-54.

Note: It is not necessary to mark the timing case if a DP200 Series or Bosch fuel injection pump is fitted which has a lock screw to fasten the drive shaft.

11 Fit the compressor and its drive assembly, see Operation 15-2, Operation 15-3 or Operation 15-4.

12 Fit the timing case cover, see Operation 6-2.

13 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

14 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

15 If necessary, fit the fan drive pulley, see Operation 12-19.

16 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

17 Fit the fan, see Operation 12-18.

18 Fill the cooling system.

Camshaft and tappets

To remove **Operation 6-17**

1 Before the engine is removed from the vehicle or the machine, drain the lubricating oil and the coolant.

2 Remove the fan, see Operation 12-18.

3 Remove the drive belts, see Operation 14-3.

4 Remove the crankshaft pulley, see Operation 5-1 or Operation 5-2.

5 If necessary, remove the fan drive pulley, see Operation 12-19.

6 Drain the coolant and remove the coolant pump, see Operation 12-4 or Operation 12-11.

7 Remove the alternator together with its mounting bracket and front support plate, Operation 14-4.

8 Remove the compressor and its drive assembly or remove the exhauster, see Chapter 15, Auxiliary equipment.

9 Remove the timing case cover, see Operation 6-1.

10 Remove the timing gears, see Operation 6-6, Operation 6-8, Operation 6-10 and Operation 6-12.

11 Remove the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-14 or Operation 11-16.
- Bosch MW fuel injection pumps, see Operation 11-26.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-31.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-38.
- Stanadyne fuel injection pumps, Operation 11-47.

12 Remove the timing case, see Operation 6-1.

13 Remove the rocker cover, see Operation 3-1, and the rocker assembly and push rods, see Operation 3-3.

14 Remove the fuel lift pump, see Operation 11-8.

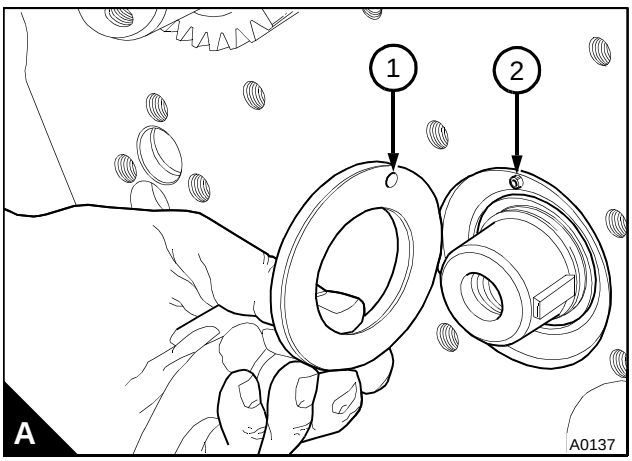
Note: On some AE and YE engines the fuel lift pump is fitted to the fuel injection pump and not to the cylinder block. Where the fuel lift pump is fitted to the cylinder block on these engines, an adaptor is fitted between the lift pump and the cylinder block. The adaptor and lift pump must be removed before the camshaft is removed.

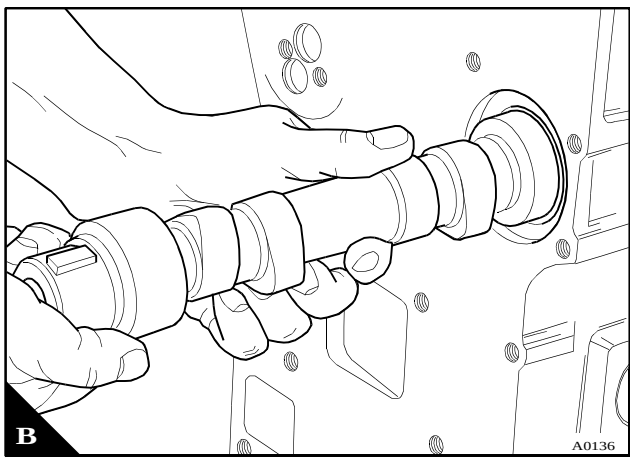
15 Turn the engine upside down and remove the lubricating oil sump, see Operation 10-3.

16 Remove the camshaft thrust washer (A) and carefully remove the camshaft (B).

17 Remove the tappets, retain in the correct sequence for assembly.

18 Inspect the camshaft and the tappets for wear and other damage, also inspect the camshaft bush. Renew the components as necessary.





To fit — Operation 6-18

1 Ensure that all components are clean and are lubricated with clean engine lubricating oil.

2 Fit the tappets in position.

3 Carefully fit the camshaft (B).

Note: On engines A------U747463B to A------U758106B the recess for the camshaft thrust washers was machined too deep, these engines have the letter “R” stamped on the engine number plate.
This has been corrected by the use of thicker thrust washer which is 6,15/6,20 mm (0.242/0.244 ins) instead of the standard thrust washer which is 5,49/5,54 mm (0.216/0.218 ins).

Caution: *Ensure that the correct thrust washers are used in accordance with the depth of the recess in the cylinder block.*

4 Fit the camshaft thrust washer (A1). Ensure that it is fitted correctly on the hollow dowel (A2).

5 Fit the timing case together with a new joint, see Operation 6-2.

6 Fit the lubricating oil sump, see Operation 10-3

7 Check that the camshaft end-float is within the limits shown in relevant Data and dimensions for the "Camshaft" on page 40.

8 Rotate the camshaft until the cam for the fuel lift pump is at the minimum lift position and fit the fuel lift pump, see Operation 11-8.

Note: On some engines fitted with a Bosch in-line fuel injection pump the fuel lift pump is fitted to the fuel injection pump body and not to the cylinder block. Where the fuel lift pump is fitted to the cylinder block on these engines, an adaptor is fitted between the lift pump and the cylinder block. The adaptor and lift pump must be removed before the camshaft is fitted.

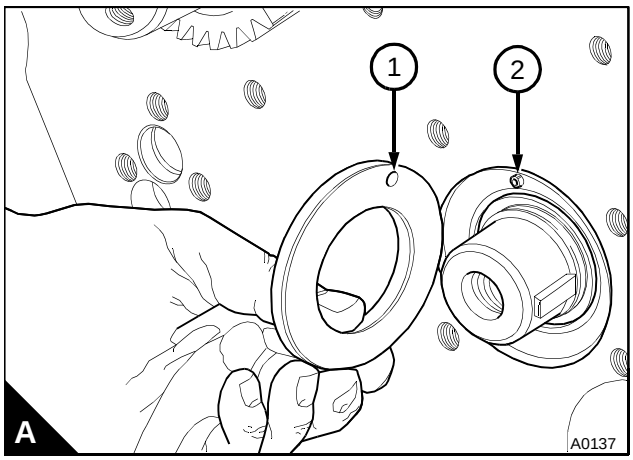
9 Turn the engine to an upright position. Rotate the crankshaft until the keyway in the crankshaft is at the top. Fit the timing gears, see Operation 6-7, Operation 6-9, Operation 6-11 and Operation 6-13, and ensure that all the timing marks are correctly aligned.

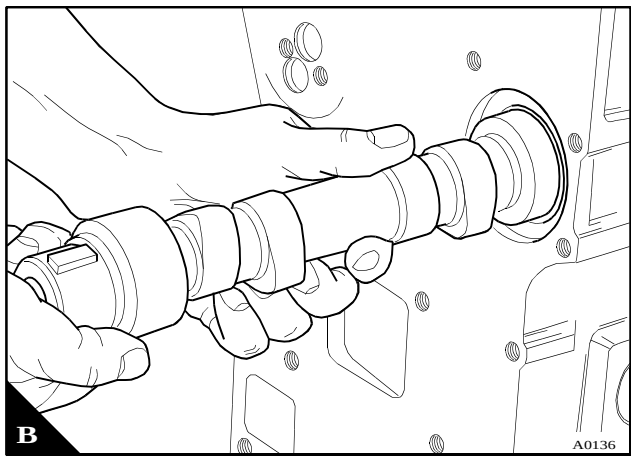
10 Fit the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-15 or Operation 11-17.
- Bosch MW fuel injection pumps, see Operation 11-27.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-32.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-39.
- Stanadyne fuel injection pumps, Operation 11-48.

11 Fit the push rods and the rocker assembly, see Operation 3-3.

12 Set the valve tip clearances, see Operation 3-6 for four cylinder engines or Operation 3-7 for six cylinder engines.





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13 Fit the timing case cover, see Operation 6-2.

14 Fit the coolant pump, see Operation 12-5 or Operation 12-12.

15 Fit the crankshaft pulley, see Operation 5-1 or Operation 5-3.

16 If necessary, fit the alternator and its mounting brackets, see Operation 14-4, and the fan drive pulley, see Operation 12-19.

17 Fit the drive belts, see Operation 14-3, and adjust the belt tension, see Operation 14-2.

18 Fit the fan, see Operation 12-18.

19 After the engine has been installed:

Fill the cooling system.

Fill the lubricating oil sump to the correct level with an approved lubricating oil.

Eliminate air from the fuel system:

- Bosch EPVE fuel injection pumps, see Operation 11-25.
- Bosch MW fuel injection pumps, see Operation 11-30.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46.
- Stanadyne fuel injection pumps, Operation 11-54.

7

Cylinder block assembly

General description

The cylinder block is made of cast iron and provides a full length support for the dry liners which are also made of cast iron. Production liners are a press fit in the block and service liners are a transition fit. Both types of liners are honed with silicon carbide tools to a controlled finish to ensure long life and low oil consumption. The cylinder liners fitted to some engines have a flame ring above the flange. A bush is fitted in the cylinder block for the front camshaft journal and the other camshaft journals run directly in the block.

Cylinder block

To dismantle — Operation 7-1

1 Drain the cooling system and the lubricating oil.

2 Remove the engine from the vehicle or machine.

3 Remove the alternator drive belts and the alternator and its mounting brackets, see Operation 14-4.

4 Remove the fan, see Operation 12-18, the fan drive, see Operation 12-19, and the coolant pump, see Operation 12-4 or Operation 12-11.

5 Remove the compressor or the exhauster, where fitted, see Chapter 15, Auxiliary equipment.

6 Remove the fuel filter, see Operation 11-2, Operation 11-3 or Operation 11-4.

7 Remove the atomisers, see Operation 11-7.

8 Remove the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-14 or Operation 11-16.
- Bosch MW fuel injection pumps, see Operation 11-26.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-31.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-38.
- Stanadyne fuel injection pumps, Operation 11-47.

9 Remove the lubricating oil cooler, where fitted, see Operation 12-21, Operation 12-22 or Operation 12-27.

10 Remove the lubricating oil filter assembly, see Operation 10-2, and the lubricating oil sump, see Operation 10-3.

11 If necessary, remove the turbocharger, see Operation 9-1.

12 Remove the fuel lift pump, see Operation 11-8 or Operation 11-12.

13 Remove the starter motor, see Operation 14-6.

14 Remove the cylinder head assembly, see Operation 3-9.

15 Remove the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

16 Remove the lubricating oil pump, see Operation 10-6, and the pressure relief valve, see Operation 10-13, or remove the balancer unit, see Operation 5-21.

17 Remove the piston and connecting rod assemblies, see Operation 4-4.

18 Remove the camshaft and the tappets, see Operation 6-17.

19 Remove the flywheel, see Operation 13-1, and the flywheel housing, see Operation 13-3.

20 Remove the rear oil seal assembly and the crankshaft, see Chapter 5, Crankshaft assembly.

21 Remove the piston cooling jets, see Operation 4-13, or remove the setscrews and spacers if jets are not fitted.

22 Inspect the cylinder block, see Operation 7-3.

To assemble Operation 7-2

Special requirements

Consumable products	
Description	**Part number**
POWERPART Threadlock and nutlock	21820117 or 21820118

1 Clean thoroughly the new cylinder block. Ensure that all the oil passages are clean and free from debris.

2 Remove the threaded plugs from the old cylinder block and clean the threads. Seal the threads with POWERPART Threadlock and nutlock, or a similar sealant, and fit the threaded plugs into the new cylinder block.

3 Fit the piston cooling jets, or the spacers and setscrews where jets are not fitted, see Operation 4-13.

4 Fit the crankshaft and the rear oil seal assembly, see Chapter 5, Crankshaft assembly.

5 Fit the piston and connecting rod assembly, see Operation 4-5.

6 Fit the flywheel housing, see Operation 13-3, and the flywheel, see Operation 13-3.

7 Fit the tappets and the camshaft, see Operation 6-18.

8 Fit the lubricating oil pump, see Operation 10-7, and the pressure relief valve, see Operation 10-13, or fit the balancer unit, see Operation 5-22.

9 Fit the timing case and the timing gears, see Chapter 6, Timing case and drive assembly.

10 Fit the cylinder head assembly, see Operation 3-10.

11 Fit the starter motor, see Operation 14-6.

12 Fit the fuel lift pump, see Operation 11-8 or Operation 11-12.

13 If necessary, fit the turbocharger, see Operation 9-2.

14 Fit the lubricating oil filter assembly, see Operation 10-2, and the lubricating oil sump, see Operation 10-3.

15 If necessary, fit the lubricating oil cooler, see Operation 12-21, Operation 12-22 or Operation 12-27.

16 Fit the fuel filter, see Operation 11-2, Operation 11-3 or Operation 11-4.

17 Fit the atomisers, Operation 11-7.

18 Fit the fuel injection pump:

- Bosch EPVE fuel injection pumps, see Operation 11-15 or Operation 11-17.
- Bosch MW fuel injection pumps, see Operation 11-27.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-32.
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-39.
- Stanadyne fuel injection pumps, Operation 11-48.

19 If necessary, fit the compressor or the exhauster, see Chapter 15, Auxiliary equipment.

20 Fit the fan drive, see Operation 12-19, the fan, see Operation 12-18, and the coolant pump, see Operation 12-5 or Operation 12-12.

21 Fit the alternator and its mounting brackets and the alternator drive belts, see Operation 14-4.

Continued

22 Install the engine into the vehicle or machine.

23 Fill the cooling system.

24 Fill the lubricating oil sump to the correct level with an approved lubricating oil.

25 Eliminate air from the fuel system:

- Bosch EPVE fuel injection pumps, see Operation 11-25.
- Bosch MW fuel injection pumps, see Operation 11-30.
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46.
- Stanadyne fuel injection pumps, Operation 11-54.

To inspect — Operation 7-3

1 Clean the passages for the coolant and for the oil.

2 Check the cylinder block for cracks and for other damage.

3 The top face of the cylinder block must not be machined as this will affect the liner flange depth and the piston height above the top face of the cylinder block.

4 Check the camshaft bush for wear. If the bush is to be renewed, use a suitable adaptor to press it out of the bore. Ensure that the lubricating oil hole in the new bush will be towards the front of the engine, when fitted. Press in the bush with the oil hole on the same side and aligned with the oil hole in the block until the front end of the bush is aligned with the face of the recess.

To remove and to fit a new type ‘D’ plug to the tappet chamber **Operation 7-4**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant	21820122

The new ‘D’ plug (A) has baffle plates (A1) attached to the rear of the ‘D’ plug. When fitted to the engine the push rods fit inside the baffle plates.

To identify if the engine has the new ‘D’ plug, the part number 3774A004 has been stamped on its outer face.

Paint, dirt and debris may have to be removed from the ‘D’ plug to enable it to be identified.

***Cautions*:**

- *Care must be taken when a new type ‘D’ plug is removed. Damage may occur to the push rods or the ‘D’ plug bore if it is not removed correctly.*
- *The new type ‘D’ plug must be fitted to a depth of 3,0 mm (0.12 in), this will provide clearance for the push rods.*

To remove a new type ‘D’ plug

1 Remove the rocker cover, see Operation 3-1.

2 Loosen only the tappet adjustment screws for the ‘D’ plug that is to be removed and remove the push rods.

3 Use a suitable tool to remove the ‘D’ plug and remove any remaining sealant.

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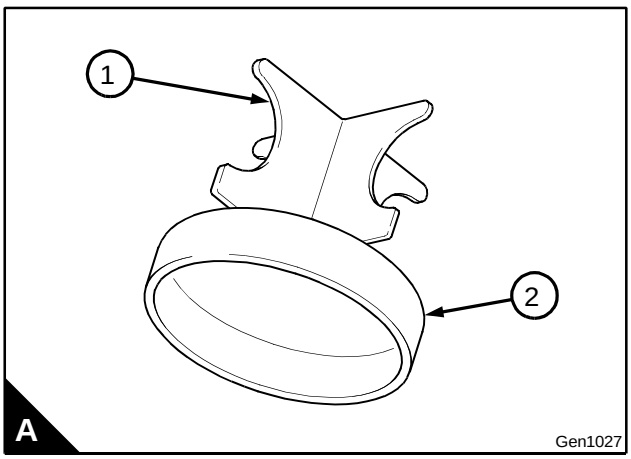


To fit a new type ‘D’ plug

Caution: *The baffle plates on the new type ‘D’ plug must be fitted horizontally and vertically to within ± 5°. This will ensure the maximum performance of the baffle plates.*

1 Ensure that the recess in the cylinder block is clean and free from damage.

2 Apply POWERPART Pipe sealant to the outer edge of the ‘D’ plug (B2).

3 Place the ‘D’ plug into its recess. The ‘D’ plug must be fitted with the baffle plates within ± 5° of the horizontal and vertical lines (C).

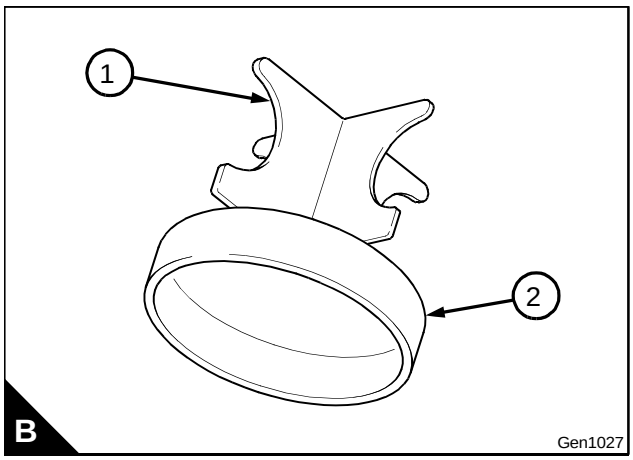
4 Use the tool (D) to fit the ‘D’ plug into the recess in the cylinder block until it is recessed (D1) to a depth of 3,0 mm (0.12 in). All measurements for the tool are in millimetres.

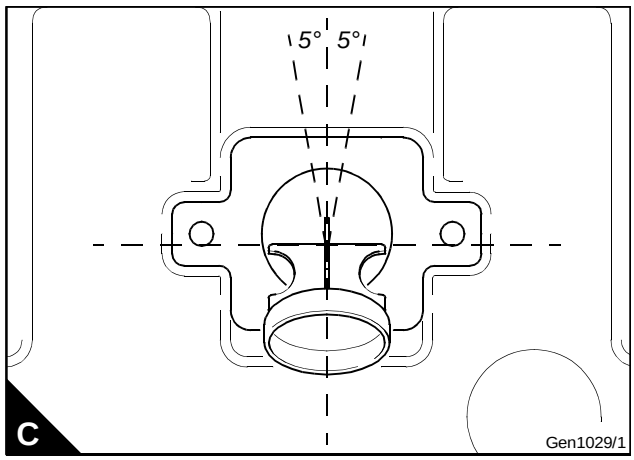
5 Remove any excess sealant.

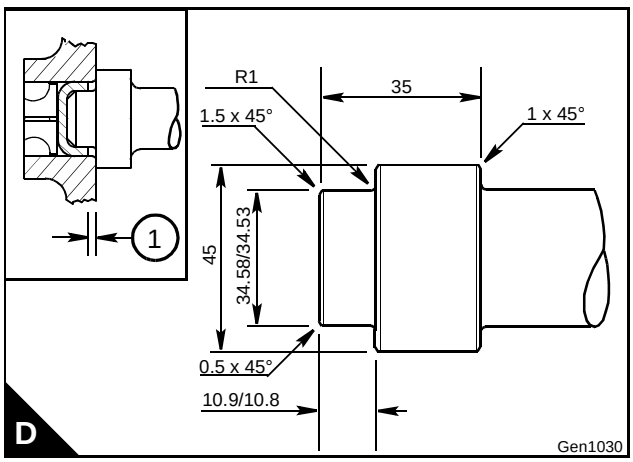
6 Fit the push rods and locate under the adjustment screws. From the top of the engine look down into the tappet chamber to ensure that there is clearance between the push rods and the baffle plates on the ‘D’ plug.

7 Adjust the tappets, see Operation 3-6 or Operation 3-7.

8 Fit the rocker cover, see Operation 3-2.







Cylinder liner

To inspect **Operation 7-5**

To ensure the best performance during the life of the engine it is important that worn or damaged cylinder liners are renewed. If a change of liner becomes necessary in service, a service liner is available.

The condition of a cylinder liner is decided by:

- The amount and location of any polished areas
- Wear
- Damage to the liner wall.

It will not be necessary to renew the liners if:

- The honed finish can still be clearly seen
- The engine performance and oil consumption is acceptable.

To check the condition of a cylinder liner

1 Inspect the liner surface for cracks and deep scratches.

2 Check the liner wall for areas where the honed finish has been polished away. Check especially the area around the top of the liner bore just below the carbon ring. In this area, thrust from the top piston ring is at its maximum.

***Cautions*:**

- *Damaged or worn liners must be discarded.*
- *New piston rings must be fitted when the cylinder liner is renewed.*
- *An engine can have high oil consumption with very little wear of the liner bores, if the surfaces of the liners are glazed.*

To recover a glazed liner **Operation 7-6**

A tool, known as a "Flex-Hone", is available to correct the liner surface. This tool can be used with an electric hand drill at low speed. The pistons and connecting rods must be removed and the piston cooling jets, where fitted, must also be removed. Use covers to protect all engine components from the debris which is caused during the process.

Caution: *To ensure that the engine confirms to the emissions legislation you must not use a "Flex-hone" on emission compliant engines.*

1 Grade 80SC Flex-Hone is to be used. A 4 inch or 4 $^{1}/_{8}$ inch size Flex-Hone can be used according to how badly the bore is glazed.

2 New Flex-Hones must be operated in an old liner before use on an engine to remove all loose material and sharp edges.

3 Lubricate lightly the liner and the Flex-Hone with clean engine lubricating oil.

4 Put the tool in position on top of the liner, but do not press the tool into the liner until the tool is operated.

5 Operate the tool and move it up and down the liner bore once a second for 30-50 seconds. Remove the tool while it rotates.

6 Clean thoroughly the liner bore to remove all dirt from the operation, use a hard brush and kerosene.

7 Dry the liners and remove carefully all the covers used to protect the components. Clean thoroughly all the engine components which have been affected by debris.

8 Fit the piston cooling jets or the plugs. Ensure that new piston rings are fitted when the engine is assembled in accordance with the relevant procedures in this Workshop Manual.

***Cautions*:**

- *After a glazed bore has been corrected, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*
- *Do not operate the engine at full load.*
- *Do not operate the engine at high speed.*
- *Do not allow the engine to run at low idle speed for extended periods.*

To remove **Operation 7-7**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner	21825543	Adaptors for use with 21825543	21825563

Where several liners are to be removed or a very tight production liner is fitted, a press should be used. Where a single liner is to be removed or the crankshaft is to remain in position, a tool for hand operation is available.

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 Remove the cylinder head assembly, see Operation 3-9.

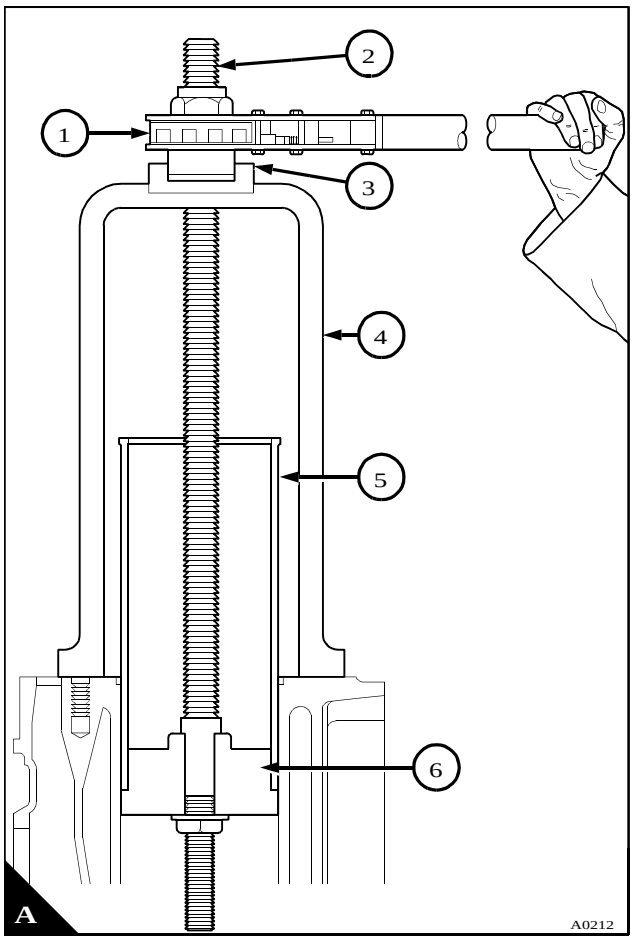
3 Remove the piston and connecting rod assembly, see Operation 4-4.

4 Carefully remove the piston cooling jet, where fitted, see Operation 4-13.

5 Rotate the crankshaft to give access to the cylinder liner. Protect the crank pin.

6 Put the tool (A4) on the top face of the cylinder block and over the centre of the liner (A5). Ensure that the base of the tool is not on top of the liner flange of the next cylinder.

7 Put the bearing (A3) in the recess in the top of the tool with the flat face of the bearing to the bottom of the recess.



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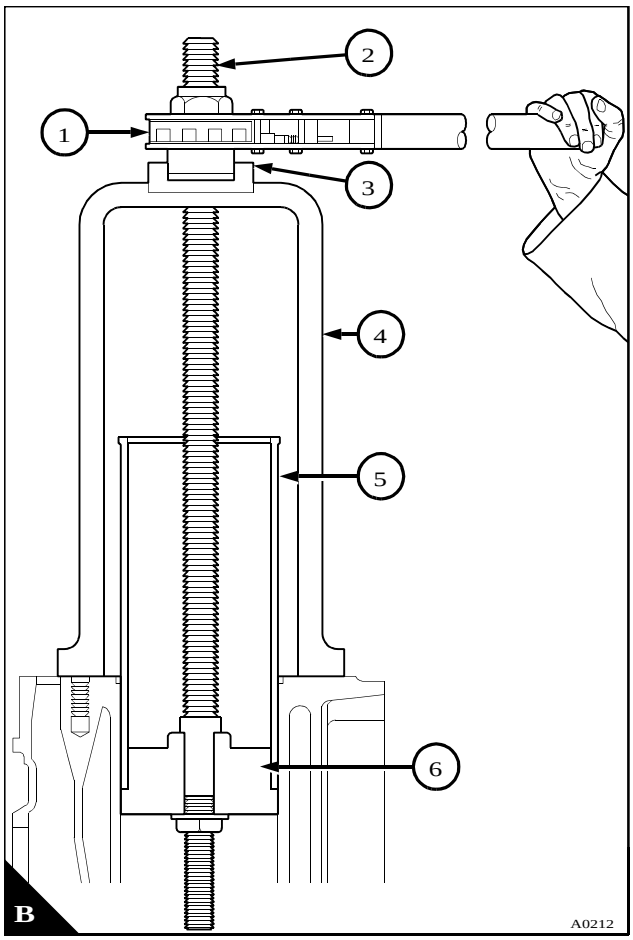
8 Fit the threaded rod (B2) through the bearing and the top of the tool until the handle (B1) is in the recess in the top of the bearing. In this position adjust the threaded rod until the end is below the bottom of the cylinder liner.

Fit the adaptor 21825563/1 (B6) onto the threaded rod and against the bottom of the cylinder liner. Ensure that the two lugs on the top of the adaptor engage with the flats on the threaded rod.

Fit the washer and nut and tighten the nut onto the adaptor.

9 Lubricate the ratchet of the handle and the threaded rod with Shell Spirax oil or an equivalent oil. Operate the handle and pull the cylinder liner out of the top of the cylinder block.



To fit a service liner — Operation 7-8

Special requirements

Special tools		Consumable products	
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner	21825543	POWERPART Retainer (oil tolerant)	21820603
Adaptors for use with 21825543	21825563		
Depth gauge, liner flange	21825496	POWERPART Safety cleaner	21820128
Dial gauge for use with 21825496	21825617		

Note: A service liner is a transition fit of +/- 0,03 mm (+/- 0.001 in) in the parent bore. A special tool will not be necessary to fit some liners, but where a liner is a tight fit, tool 21825543 can be used.

Caution: *Do not hit a liner with a hammer.*

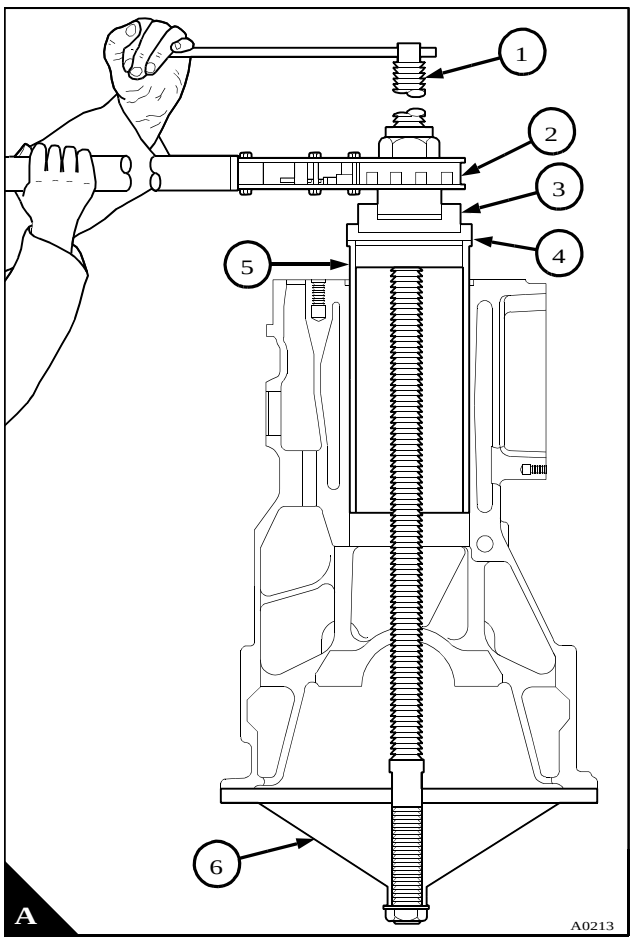
1 Clean thoroughly the parent bore. Clean the top 50 mm (2.0 in) and the recess for the liner flange with POWERPART Safety cleaner, use it in accordance with the instructions.

2 Clean thoroughly the outer surface of the liner with POWERPART Safety cleaner.

3 Lubricate lightly the parent bore with clean engine lubricating oil, except for the top 50 mm (2.0 in).

4 Engage the cylinder liner (A5) into the parent bore; ensure that the liner is vertical.

Put the adaptor 21825563/2 (A4) onto the top of the liner with the shoulder of the adaptor on the liner flange. Put the bearing (A3) into position in the recess in the top of the adaptor with the flat face of the bearing to the bottom of the recess.



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5 Fit the threaded rod (B1) through the bearing, the adaptor and the liner until the handle is against the recess in the bearing. In this position adjust the threaded rod until the end is below the bottom face of the cylinder block.

6 Fit the adaptor 21825543/6 (B6) onto the threaded rod; ensure that the flat face of the adaptor is against the bottom face of the cylinder block. Fit the washer and the nut; ensure that the threaded rod is in the centre of the liner and tighten the nut onto the adaptor.

7 Lubricate the ratchet of the handle and the threaded rod with Shell Spirax oil or an equivalent oil. Operate the handle and press the liner into the parent bore to within 50 mm (2.0 in) of the fitted position.

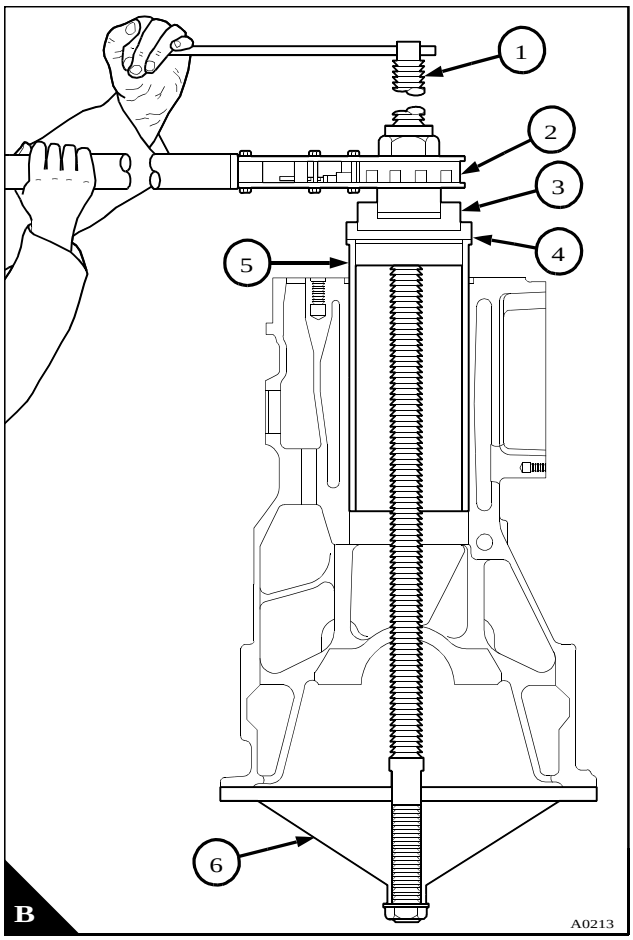
Clean the area below the flange of the liner with POWERPART Safety cleaner. Apply POWERPART Retainer (oil tolerant) to the top 25 mm (1.0 in) of the outer surface of the liner and under the flange; also apply POWERPART Retainer (oil tolerant) to the bottom of the flange recess in the parent bore.

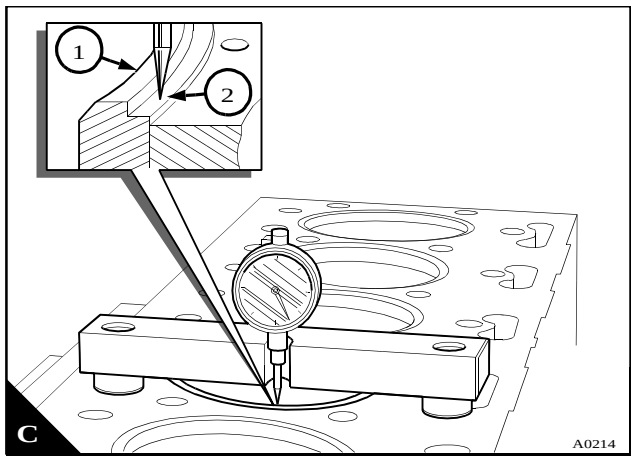
8 Press the liner in to the fully fitted position. Remove the tool and clean the retainer from the top of the cylinder block.

9 Allow 15 minutes to elapse before the liner bore dimension is checked. The retainer will reach full strength after 6 hours.

The inside diameter of a service liner, when fitted, should be 100,00/100,06 mm (3.937/3.939 in)

10 Use tool 21825496 to check that the liner flange is between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block (C).





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11 Fit new piston rings, see Operation 4-8.

12 Fit the piston and connecting rod assembly, see Operation 4-5.

13 If necessary, fit the piston cooling jet, see Operation 4-13.

14 Fit the cylinder head assembly, see Operation 3-10.

15 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.

***Cautions*:**

- *After a new service liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*
- *Do not operate the engine at full load.*
- *Do not operate the engine at high speed.*
- *Do not allow the engine to run at low idle speed for long periods.*

To fit a partially finished liner **Operation 7-9**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Remover/replacer for cylinder liner	21825543	Depth gauge, liner flange	21825496
Adaptors for use with 21825543	21825563	Dial gauge for use with 21825496	21825617

Note: The liner is an interference fit in the parent bore. A special tool will be necessary to fit the liners, tool 21825543 can be used. If a liner is a very tight fit it may be necessary to use a hydraulic press.

Caution: *Do not hit a liner with a hammer.*

1 Clean thoroughly the parent bore of the cylinder block with an approved degreasing fluid.

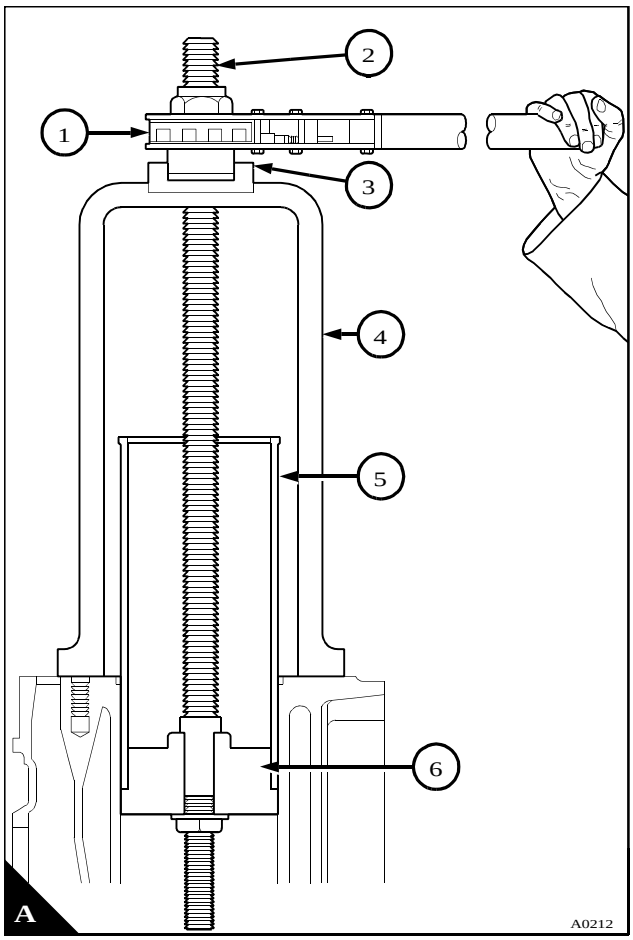
2 Inspect the parent bore for damage and corrosion. Damaged cylinder blocks should be discarded.

3 Clean thoroughly the outer surface of the liner with an approved degreasing fluid.

4 Apply a small amount of engine oil around the top of the parent bore to assist the entry of the liner.

5 Engage the cylinder liner (A5) into the parent bore; ensure that the liner is vertical.

Put the adaptor 21825563/2 (A4) onto the top of the liner with the shoulder of the adaptor on the flame ring of the liner. Put the bearing (A3) into position in the recess in the top of the adaptor with the flat face of the bearing to the bottom of the recess.



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6 Fit the threaded rod (B2) through the bearing, the adaptor and the liner until the handle (B1) is against the recess in the bearing. In this position adjust the threaded rod until the end is below the bottom face of the cylinder block.

7 Fit the adaptor 21825543/6 (B6) onto the threaded rod; ensure that the flat face of the adaptor is against the bottom face of the cylinder block as shown. Fit the washer and the nut; ensure that the threaded rod is in the centre of the liner and tighten the nut onto the adaptor.

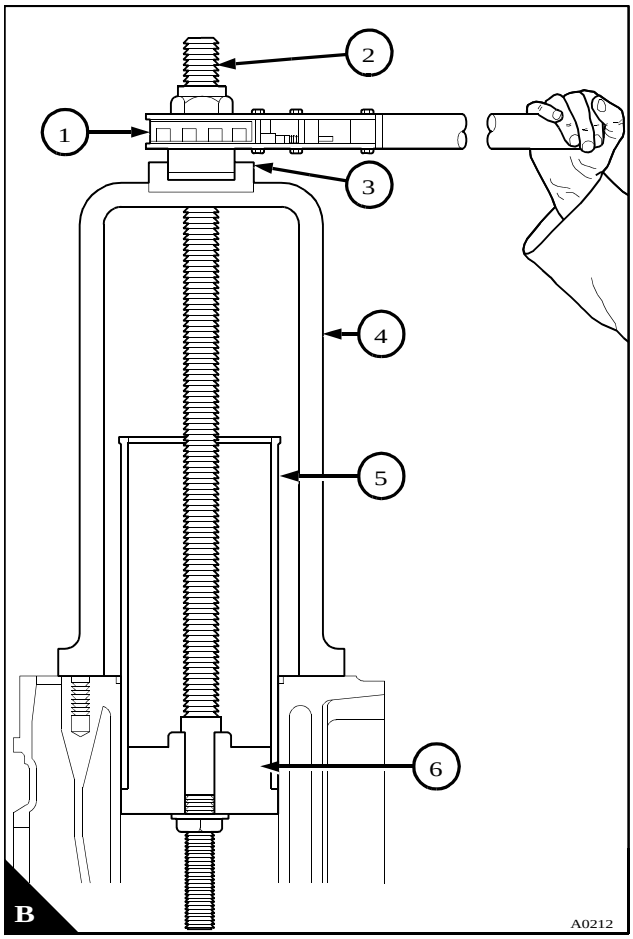
8 Lubricate the ratchet of the handle and the threaded rod with Shell Spirax oil or an equivalent oil. Operate the handle and press the liner into the fully fitted position.

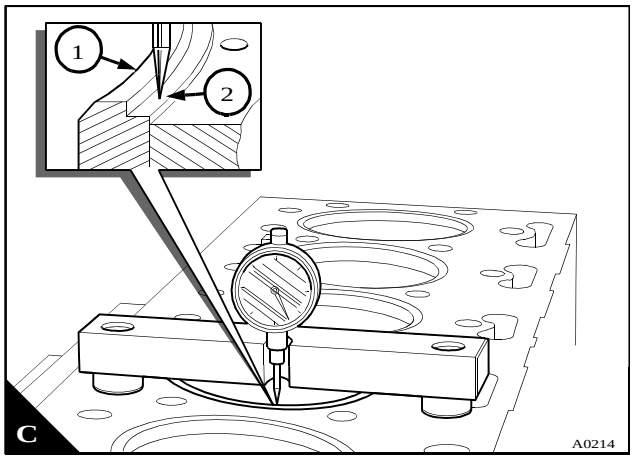
9 Remove the tool 21825543 and thoroughly clean the top of the cylinder block.

10 Use tool 21825496 to check that the flange of the cylinder liner is between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block (C).

Notes:

- This measurement must be from the flange (C2) of the cylinder liner, not the top of the flame ring (C1).
- Partially finished cylinder liners must be bored and then diamond honed and silicon carbide honed to the finished size to conform to the dimensions given in the relevant Data and dimensions for the "Cylinder block assembly" on page 42.





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11 Fit new piston rings, see Operation 4-8.

12 Fit the piston and connecting rod assembly, see Operation 4-5.

13 If necessary, fit the piston cooling jet, see Operation 4-13.

14 Fit the cylinder head assembly, see Operation 3-10.

15 Fit the lubricating oil sump, see Operation 10-3, and fill it to the correct level with an approved lubricating oil.

***Cautions*:**

- *After a new cylinder liner has been fitted, these recommendations are advised for the first 240 km (150 miles) or 5 hours of operation:*
- *Do not operate the engine at full load.*
- *Do not operate the engine at high speed.*
- *Do not allow the engine to run at low idle speed for long periods.*

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8

Engine timing

Standard operations

To set number 1 piston to TDC on the compression stroke — Operation 8-1

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Valve spring compressor	21825666	Setscrew adaptor for use with 21825666	21825932
Stud adaptor for use with 21825666	21825931		

1 Fasten a temporary pointer to the timing case cover with its tip near to the outer edge of the crankshaft pulley or damper (A1).

2 Remove the rocker cover, see Operation 3-1.

3 Rotate the crankshaft, clockwise from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

4 Remove the spring clip and the spacer from the front of the rocker shaft. Release the fasteners of the front two pedestals of the rocker shaft and remove the front rocker lever; tighten the fasteners of the rocker shaft pedestals.

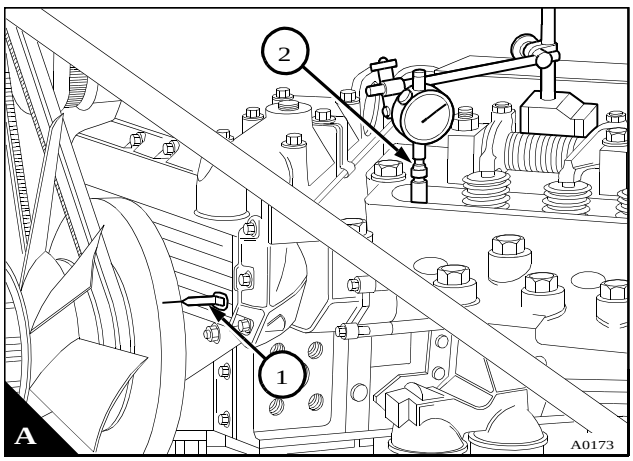
5 Remove the valve springs from the front valve with the valve spring compressor 21825666 and the adaptor 21825672, for pedestal studs, or the adaptor 21825673, for pedestal setscrews.

Caution: *Fit a suitable collar near the top of the valve to hold the valve if the crankshaft is rotated too far.*

6 Allow the valve to be held by the top of the piston.

7 Fasten a dial test indicator with its plunger in contact with the top of the valve stem (A2) and with a reading shown on the gauge. Rotate slowly the crankshaft, clockwise from the front, until the clockwise movement of the dial gauge pointer just stops. Make a suitable mark on the crankshaft pulley or damper to align with the temporary pointer. Continue to rotate the crankshaft, in the same direction, until the gauge pointer just begins to move in a counter-clockwise direction. Make another mark on the pulley or damper to align with the pointer. Mark the centre point between the two marks on the pulley or damper and remove the other two marks.

8 Rotate the crankshaft approximately 45° counter-clockwise from the front and then clockwise until the mark on the pulley or damper is aligned with the pointer. Number 1 piston is now at TDC on the compression stroke.



Another method to set number 1 piston to TDC **Operation 8-2**

1 Fasten a temporary pointer to the timing case cover (or other suitable position) with its tip near to the outer edge of the crankshaft damper or pulley.

2 Loosen the setscrews that retain the atomisers.

3 Remove the rocker cover.

4 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

5 Rotate the crankshaft a further $^{1}/_{8}$ of a turn clockwise. Insert a suitable lever between the rocker lever and the valve spring cap of number 1 inlet valve. Open the inlet valve and put a spacer approximately 5,0 mm (0.2 in) thick between the valve tip and the rocker lever.

6 Slowly rotate the crankshaft counter-clockwise until the piston makes contact with the open valve. Make a temporary mark on the damper or pulley to align accurately with the tip of the pointer.

7 Rotate the crankshaft clockwise one or two degrees and remove the spacer between the valve and the rocker lever. Rotate the crankshaft $^{1}/_{4}$ of a turn counter-clockwise. Put the spacer between the valve tip and the rocker lever.

8 Slowly rotate the crankshaft clockwise until the piston makes contact with the open valve. Make another temporary mark on the damper or pulley to align accurately with the tip of the pointer.

9 Make a temporary mark at the centre point between the two marks on the damper or pulley and remove the other two marks. Rotate the crankshaft counter-clockwise 1/8 of a rotate and remove the spacer between the valve and the rocker lever. Slowly rotate the crankshaft clockwise until the mark on the damper or pulley aligns accurately with the tip of the pointer. Number 1 piston is now at TDC on the compression stroke.

To check the valve timing **Operation 8-3**

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1.

2 Remove the dial test indicator from number 1 inlet valve and fit the valve springs and the rocker lever. Ensure that the fasteners for the rocker shaft pedestals are to the correct torque.

3 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open.

4 Set the valve tip clearance of number 1 cylinder inlet valve to 1,5 mm (0.059 in).

5 Rotate the crankshaft, clockwise from the front, until the push rod of number 1 cylinder inlet valve just tightens. In this position, check if the mark on the crankshaft pulley or damper is within +/- 2 $^{1}/_{2}$° of the temporary pointer. Use the formula below to find the measurement which is equal to 2 $^{1}/_{2}$° on the pulley or damper.

$$\frac{\mathbf{C \times P}}{\mathbf{360}}$$

C = Circumference of pulley or damper

P = 2.5 degrees

6 If the timing is more than 2 $^{1}/_{2}$° out of position, the timing gears are probably not in correct mesh.

Note: One tooth on the camshaft gear is equivalent to 23 mm (0.9 in) at the circumference of a pulley of 203 mm (8 in) diameter. If a large damper is fitted, one tooth on the camshaft gear is equivalent to 35 mm (1.4 in) at the circumference of a damper of 310 mm (12.2 in) diameter, or 37 mm (1.5 in) at the circumference of a damper of 327 mm (12.8 in) diameter.

7 Rotate the crankshaft, clockwise from the front, until the inlet valve of the rear cylinder is fully open. Set the valve tip clearance of the inlet valve of number 1 cylinder to 0,20 mm (0.008 in).

8 Fit the rocker cover, see Operation 3-2.

9 Remove the temporary pointer from the timing case and the timing mark from the pulley or damper.

Engines fitted with Bosch EPVE fuel injection pumps

General description

The timing gears are stamped with timing marks to ensure that they are assembled correctly (A). The stamped teeth of the crankshaft, the camshaft and the fuel pump gears will be in mesh with the idler gear when number 1 piston is at top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh in this position, because of the different speeds at which the gears rotate.

The fuel pump gear has timing marks for four and six cylinder engines. Also the gear is stamped with the letter "B" where a Bosch fuel pump is fitted. The letter "M" is stamped on the fuel pump gear to indicate that the threads for the gear puller are metric. A data plate is fitted to the pump. An example of the information shown on the plate (B) is:

- Perkins part number (1)
- Fuel pump code (2)
- Maximum engine no load speed (3)
- High idle reset speed (4)

Notes:

- The maximum no load speed (B3) set by Perkins may be reset by the equipment manufacturer. If the speed is changed the new speed is shown in the high idle reset position (B4). The original maximum no load speed should be removed from the label.
- The adjustment screw for the maximum no load speed, is sealed by the manufacturer. The setting must not be changed, unless approved, as it could affect the warranty of the engine.

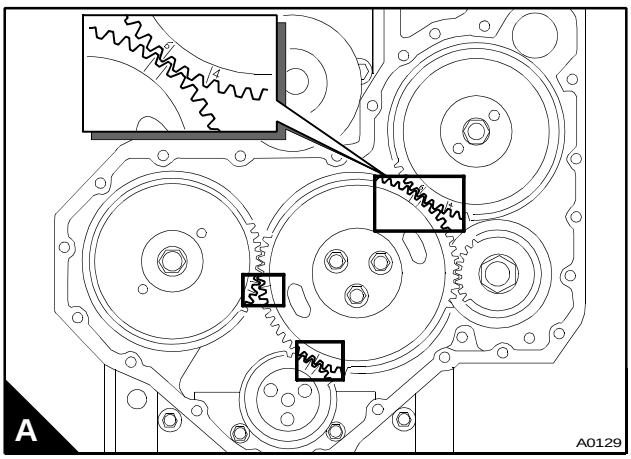
For details of the fuel pump code for the engine, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43.

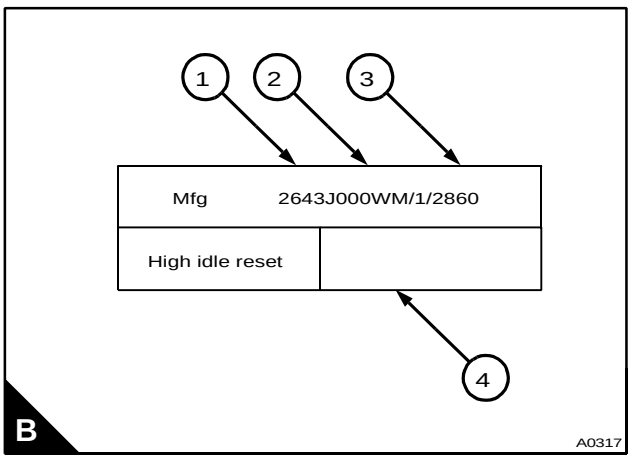
For details of the later model Bosch EPVE fuel injection pumps fitted with a locking screw, see "Bosch EPVE fuel injection pump (with a locking screw)" on page 278.

Standard operations

To set number 1 piston to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

To check the valve timing, see Operation 8-3.





To check the timing of the fuel injection pump (10° or more, static) **Operation 8-4**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing gauge adaptor	21825626	Spanner for flange nuts of fuel injection pump	21825964

Note: The procedure given below is suitable for engines fitted with a Bosch EPVE fuel injection pump and which have a static timing of 10° or more. Where static timing is 9° or less refer to Operation 8-5.

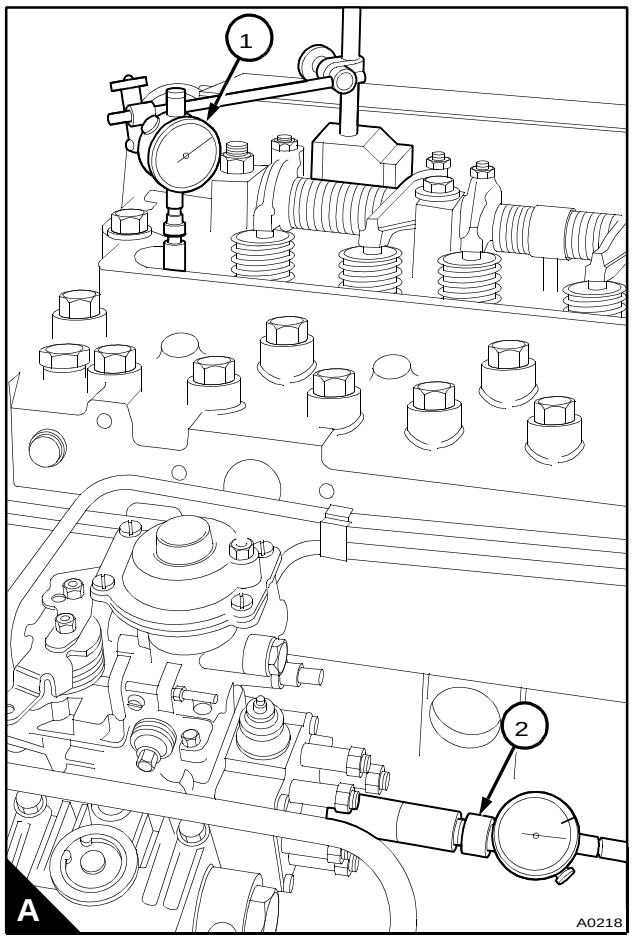
1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1. It is not necessary to fit a temporary pointer, see Operation 8-1, step 1.

Instead, the dial of the dial test indicator (A1) should be set at zero when the clockwise movement of the pointer stops, see Operation 8-1, step 7.

2 Remove the high-pressure pipes from the fuel injection pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are removed or fitted.

3 Remove the plug and washer from the rear of the fuel pump and fit the adaptor, number 21825626, and a suitable dial gauge (A2). Set the dial gauge to indicate approximately 3,0 mm.

4 Slowly rotate the crankshaft, counter-clockwise from the front of the engine, until the dial gauge indicates that the plunger of the fuel injection pump is at the bottom of its stroke. Set the dial to zero.



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5 Slowly rotate the crankshaft clockwise until the dial gauge on the valve stem indicates the correct position of the piston before TDC, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43. The timing of the fuel injection pump is correct if the dial gauge on the pump plunger indicates 1,0 mm (0.039 in).

6 If the timing is not correct, disconnect the remainder of the pipes of the fuel injection pump and loosen the setscrew of support bracket for the pump.

7 To correct the timing, hold the fuel injection pump and release the flange nuts; if a compressor is fitted, it will be necessary to use tool number 21825964 to release the flange nuts nearest the cylinder block.

If the gauge on the pump plunger indicates more than 1,0 mm (0.039 in), rotate the fuel pump counter-clockwise, from the rear of the fuel pump, until the gauge indication is 1,0 mm (0.039 in).

If the gauge indication is less than 1,0 mm (0.039 in), rotate the fuel pump clockwise until the gauge indication is 1,0 mm (0.039 in).

Tighten the flange nuts and the setscrew of the support bracket for the pump

8 Rotate the crankshaft counter-clockwise approximately 45°, then slowly clockwise to check the timing again. Continue to rotate the crankshaft clockwise and check the TDC position. If the timing and the TDC are correct, remove the dial gauge and the adaptor from the fuel injection pump and fit the washer and the plug. Tighten the plug to 10 Nm 7 lbf ft (1,0 kgf m).

9 Fit all the pipes to the fuel injection pump. Remove the dial test indicator from the cylinder head and fit the valve springs and the rocker lever. Set the valve tip clearance to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-2.

11 Eliminate the air from the fuel system, see Operation 11-25.

To check the timing of the fuel injection pump (9° or less, static) **Operation 8-5**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing gauge adaptor	21825626	Spanner for flange nuts of fuel injection pump	21825964

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-2.

2 Measure accurately clockwise around the outside surface of the damper/pulley from the TDC mark and make a temporary mark to indicate the static timing angle, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43.

Note: 1° is 1,8 mm (0.07 in) at the circumference of a pulley of 203 mm (8 in) diameter. If a large damper is fitted, 1° is 2,7 mm (0.106 in) at the circumference of a damper of 310 mm (12.2 in) diameter or 2,9 mm (0.114 in) for a damper of 327 mm (12.9 in) diameter.

If a pulley of a different size is fitted use the formulae below to find the measurement for the temporary mark for the static timing:

$$\frac{\mathbf{C \times P}}{\mathbf{360}}$$

C = Circumference of pulley or damper.

P = Static timing angle, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43.

3 Remove the high-pressure pipes from the fuel injection pump and fit the adaptor and dial gauge to the rear of the pump, see steps 2, 3 and 4 of Operation 8-4.

4 Rotate the crankshaft counter-clockwise for $^1/_8$ of a turn. Slowly rotate the crankshaft clockwise until the timing mark on the damper/pulley aligns accurately with the tip of the pointer. With the crankshaft in this position, the timing is correct if the dial gauge on the pump plunger indicates 1,0 mm (0.039 in).

5 If the timing is not correct see steps 6 and 7 of Operation 8-4.

6 Rotate the crankshaft $^1/_8$ of a turn counter-clockwise, then slowly clockwise to align the timing mark with the tip of the pointer and check the timing again. If the timing is correct, remove the dial gauge and the adaptor from the rear of the pump. Fit a new washer and the plug and tighten the plug to 10 Nm (7 lbf ft) 1,0 kgf m.

7 Fit the fuel pipes to the fuel pump. Remove the temporary marks from the damper/pulley. Remove the temporary pointer from the timing case.

8 Fit the rocker cover, see Operation 3-2.

9 Eliminate the air from the fuel system, see Operation 11-25.

To check the timing mark of the fuel injection pump — Operation 8-6

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Pump timing gauge	21825626	Gear adaptor for use with 21825610	21825513
Universal timing gauge	21825610		

Note: Only early Bosch EPVE pumps have a mark on the flange. The mark was removed when the locking screw was introduced.

1 Remove the fuel injection pump, see Operation 11-14.

2 Fit the adaptor 21825513 to the drive shaft of the fuel pump (A) and fasten it with the nut of the fuel pump gear.

3 Release the screw (B3), set the timing tool to the correct angle, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43, and tighten the screw.

4 Fit the timing tool to the splined adaptor on the fuel pump drive. Release the screw (B1), slide the pointer (B2) forward until it is over the centre of the fuel pump flange and tighten the screw. Rotate the timing tool and the pump shaft to align the master spline with the number 1 outlet of the pump (outlet "C").

5 Remove the plug and the washer from the centre of the rear of the fuel pump and fit the adaptor 21825626. Fit a dial gauge to the adaptor and set the gauge to indicate approximately 2,0 mm (0.080 in).

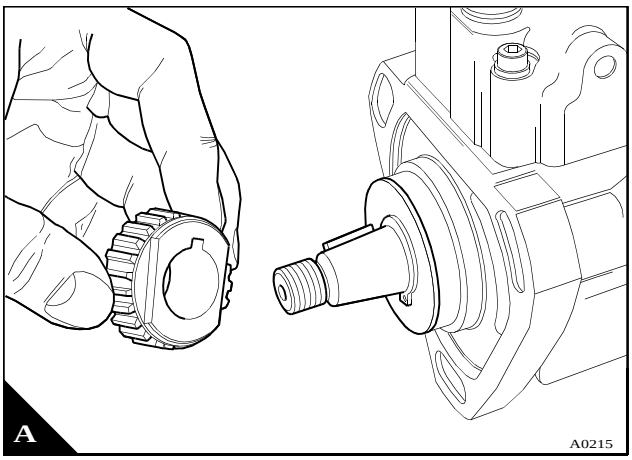
6 With the fuel injection pump held securely, rotate the tool and the drive shaft counter-clockwise, from the drive end, and set the dial gauge to zero when the pump plunger is at its lowest position. Keep the fuel pump secure and rotate the drive shaft clockwise until the gauge indicates 1,0 mm (0.039 in) plunger lift. At this position the slot in the pointer of the timing tool must align with the mark on the flange of the fuel pump.

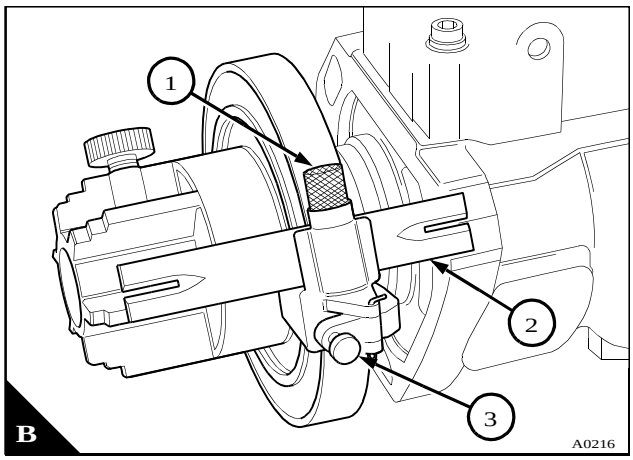
7 If the mark is not correct, remove the timing tool and eliminate the mark on the flange. Fit the timing tool and repeat the above operation to obtain 1,0 mm (0.039 in) plunger lift. With the fuel injection pump and timing tool held securely in the correct position, make a new mark on the flange of the fuel pump, within the slot of the pointer. Release the timing tool and repeat the operation to check that the new mark is correct.

8 Remove the timing tool, splined adaptor and the adaptor and dial gauge. Fit the washer and plug to the rear of the fuel pump.

9 Fit the fuel injection pump, see Operation 11-15.

10 Eliminate air from the fuel system, see Operation 11-25.





To check the engine timing mark **Operation 8-7**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Pointer for use with 21825610	21825514
Drive adaptor for use with 21825610	21825512	Distance piece for use with 21825610	21825515

Note: The mark was removed from the timing case when the Bosch EPVE pump with a locking screw was introduced.

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1.

2 Remove the fuel injection pump and its joint, see Operation 11-14.

3 Fit the distance piece 21825515 (A1) to the timing tool adaptor 21825512. Align the key in the adaptor with the keyway in the gear of the fuel pump and fit the adaptor to the gear (A). Ensure that the distance piece is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the screw (B4) on the timing tool 21825610. Set the timing tool to the correct engine check angle, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43, and tighten the screw. Loosen the screw (B5) and fit the splined shaft (B3) into the timing tool (B). Loosen the screw (B2). Fit the 90° pointer 21825514 (B1) and tighten the screw.

5 Fit the splined shaft of the timing tool to the adaptor. Slide the timing tool along the splined shaft until it is against the adaptor and tighten the screw (B5).

6 Loosen the screw (B2). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B1). If the mark is not correct, remove the timing tool and eliminate the mark on the timing case. Fit the timing tool. Ensure that the pointer is against the timing case and make a new mark on the timing case along the top straight edge of the pointer.

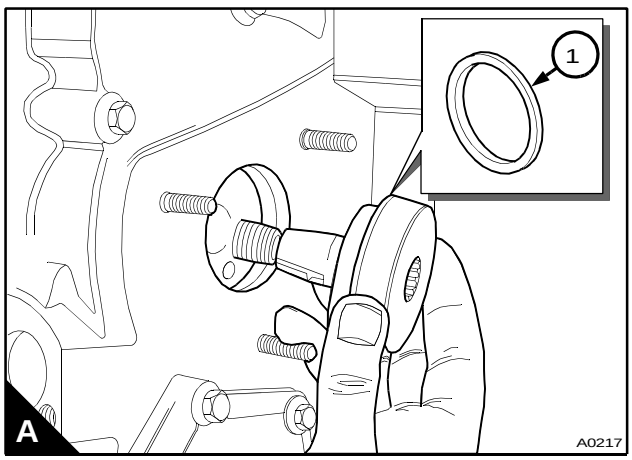
7 Remove the timing tool and the adaptor.

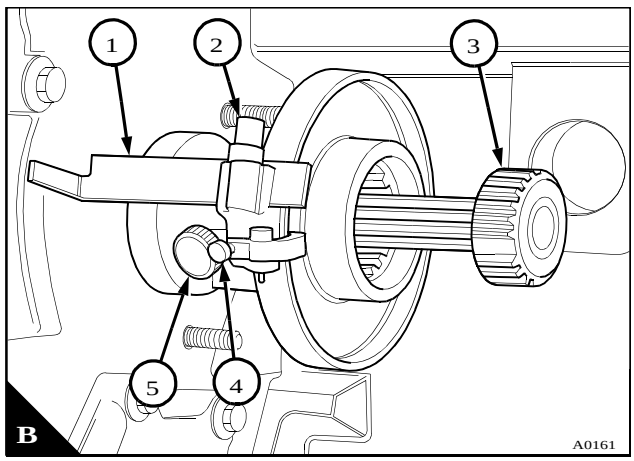
8 Fit the fuel pump together with a new joint, see Operation 11-15.

9 Remove the dial test indicator from the cylinder head and fit the valve springs and the rocker lever. Set the valve tip clearance of number 1 cylinder inlet valve to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-2.

11 Eliminate air from the fuel system, see Operation 11-25.





To check the timing of the pin timed fuel injection pump **Operation 8-8**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Bosch fuel injection pumps	27610032	Timing pin Lucas/Delphi and Stanadyne fuel injection pumps	27610033

Caution: *Do not remove the nut (A2) which retains the hub (A4) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment available to Perkins distributors.*

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump:

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.

3 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

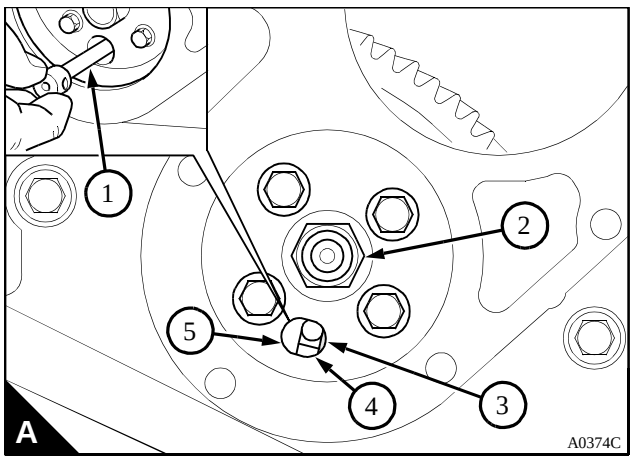
Note: The position for the timing pin for Lucas/Delphi and Stanadyne fuel injection pumps is (A1). The position for the timing pin for Bosch EPVE fuel injection pumps is (B1).

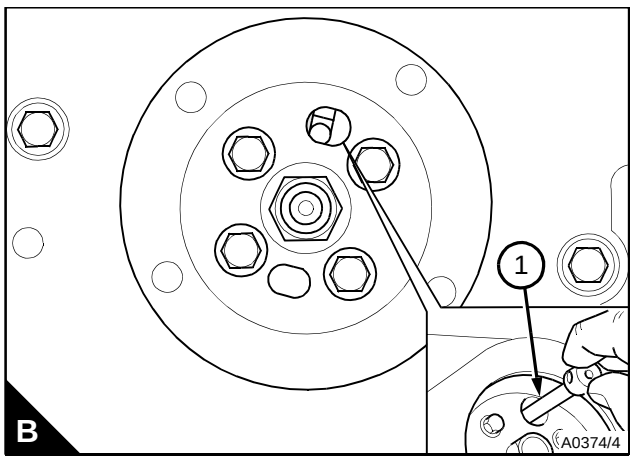
4 Remove the timing pin.

5 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1 or Operation 8-2.

If the engine is set correctly at TDC on the number 1 cylinder compression stroke, but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.

6 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump:





Engines fitted with Bosch MW in-line fuel injection pumps

General description

The timing gears are stamped with timing marks to ensure that they are assembled correctly (A). The stamped teeth of the crankshaft and camshaft gears will be in mesh with the idler gear when number 1 piston is at top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh, in this position, because of the different speeds at which the gears rotate.

There are no timing marks on the fuel pump gear of engine types AE and YE. The gear, which is fastened to a hub on the drive shaft of the fuel injection pump, has slots to allow adjustment to the timing.

A data plate is fitted to the pump. An example of the information shown on the plate (B) is:

- Perkins part number (1)
- Fuel pump code (2)
- Maximum engine no load speed (3)
- High idle reset speed (4)

Notes:

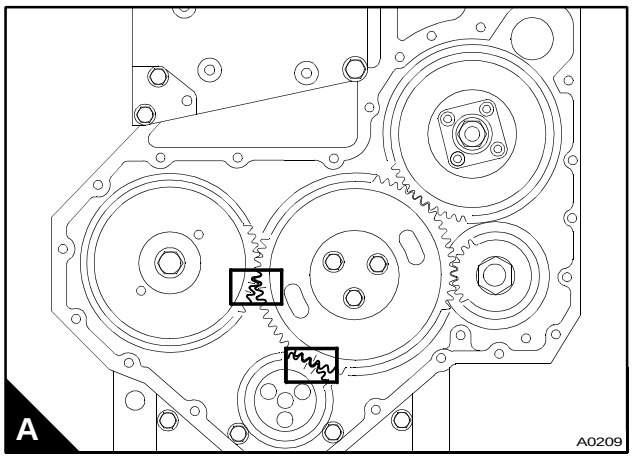
- The maximum no load speed (B3) set by Perkins may be reset by the equipment manufacturer. If the speed is changed the new speed is shown in the high idle reset position (B4). The original maximum no load speed should be remove from the label.
- The adjustment screw for the maximum no load speed, is sealed by the manufacturer. The setting must not be changed, unless approved, as it could affect the warranty of the engine.

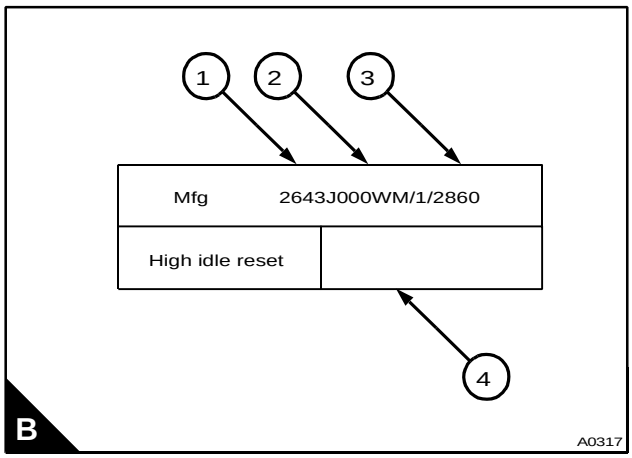
For details of the fuel pump code for the engine, see "Engine timing (Bosch EPVE fuel injection pump)" on page 43.

Standard operations

To set number 1 piston to TDC on the compression stroke, see Operation 8-1.

To check the valve timing, see Operation 8-3.





To check the timing of the fuel injection pump **Operation 8-9**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Piston replacer tool	21825615	Timing light	KJ37007

1 Remove the rocker cover, see Operation 3-1.

2 Loosen the setscrews which retain the atomisers.

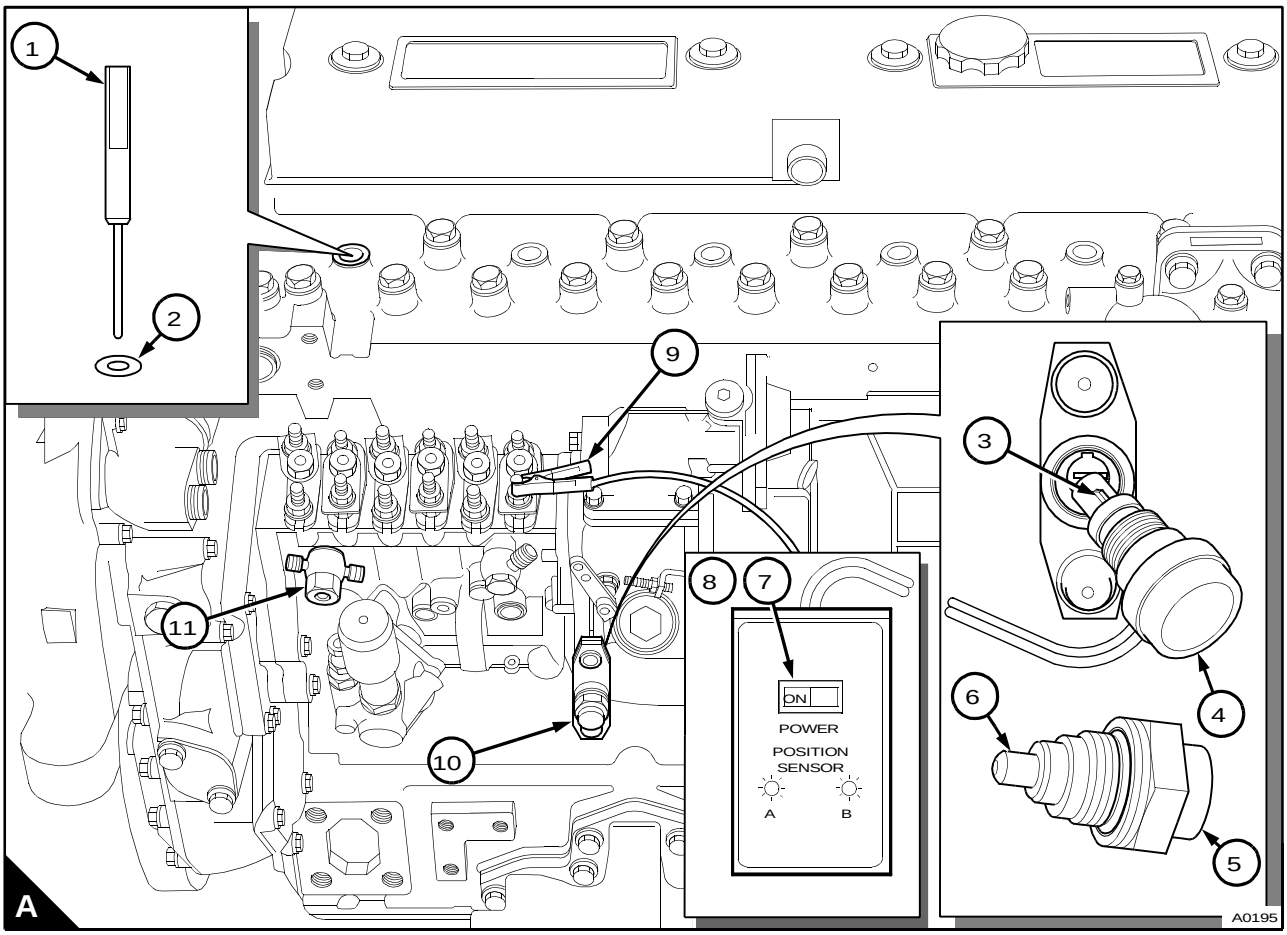
3 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of number 1 cylinder just releases.

Note: A locally made washer (A2) must be fitted onto the piston position probe (A1) when the engine check angle is less than 100° BTDC. See "Engine timing (Bosch in-line fuel injection pump)" on page 44 for details.

4 Remove the atomiser from number 1 cylinder together with its seat washer and put the piston position probe, 21825630 or 21825947, (A1) in its place. Fit the atomiser clamp to the probe and tighten the setscrews gradually and evenly.

5 Remove the cap (A5) and its washer from the timing attachment (A10) on the governor housing. Ensure that the plastic pin (A6) in the cap is not lost. Put the probe (A4) of the timing light, KJ37007, (A8) into the timing attachment. Ensure that the spline (A3) on the probe is at the top and enters the slot in the timing attachment.

Tighten the outer body of the probe. Connect the earth cable (A9) to the engine in a place where there will be a good earth connection. Press the switch (A7) on the timing light to the "ON" position.



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Caution: *Ensure that the piston comes lightly into contact with the piston position probe, or both the piston and the probe could be damaged.*

6 Very carefully rotate the crankshaft clockwise until the piston just comes into contact with the piston position probe.

7 The timing is correct when the two lamps on the timing light are illuminated.

If both of the lamps are not illuminated, release the setscrews and remove the gear cover from the timing case cover. Loosen the cap screws which retain the fuel pump gear. Adjust the position of the fuel injection pump hub until both lamps are illuminated. Tighten the cap screws to 35 Nm (26 lbf ft) 3,6 kgf m.

8 To check the timing is correct, rotate the crankshaft counter-clockwise, from the front of the engine to move the piston away from the probe and repeat steps six and seven above.

9 Press the switch on the timing light to the "OFF" position. Disconnect the earth cable from the engine. Release the outer body of the probe and remove the probe from the timing attachment and remove the timing light.

10 Check that the brass end of the plastic pin can be seen in the cap for the timing attachment. Fit the cap together with a new washer.

Caution: *If the plastic pin is not put into the cap correctly, damage could occur to the fuel injection pump.*

11 Release the setscrews and remove the piston position probe from number 1 cylinder. Fit the atomiser together with a new seat washer. Tighten the setscrews for all of the atomisers gradually and evenly to 12 Nm (9 lbf ft) 1,2 kgf m.

12 Fit the gear cover together with a new joint to the timing case cover. Clean the threads of the setscrews for the gear cover and apply a sealant to the threads. Fit the setscrews and tighten them.

13 Fit the rocker cover, see Operation 3-2.

Engines fitted with Lucas/Delphi DPA and DPS fuel injection pumps

General description

The timing gears are stamped with timing marks to ensure that they are assembled correctly (A). The stamped teeth of the crankshaft, camshaft and fuel pump gears will be in mesh with the idler gear when number 1 piston is at top dead centre (TDC) on the compression stroke. The marked teeth of the idler gear may not necessarily be in mesh in this position, because of the different speeds at which the gears rotate.

The fuel pump gear has timing marks for four and six cylinder engines. Also the gear is stamped with the letter "C" where a Lucas/Delphi fuel pump is fitted. The letter "M" is stamped on the fuel pump gear to indicate that the threads for the screws of the gear puller are metric.

A data plate is fitted to the side of the pump. An example of the information shown on the plate (B) is:

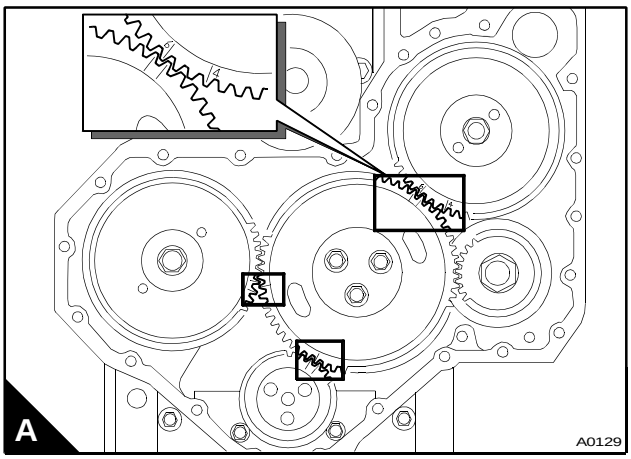
- Manufacturers model number (1)
- Manufacturers description number (2)
- Maximum engine no load speed (3)
- Fuel pump code letters (4)
- Perkins part number (5)
- Fuel pump serial number (6)

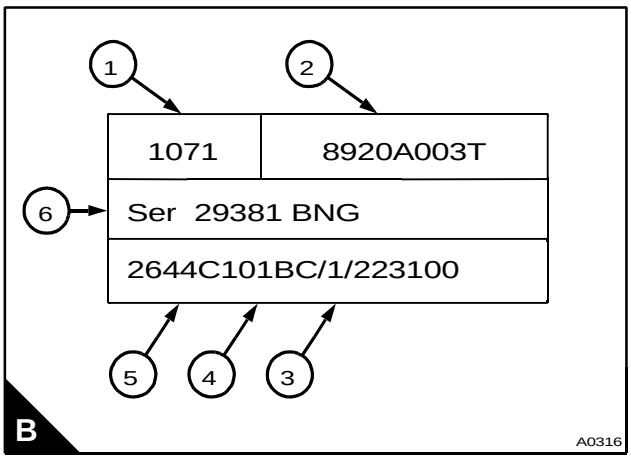
For details of the fuel pump code letters for the engine, see "Engine timing (Lucas CAV/Delphi DPA and DPS) fuel injection pump" on page 45.

Standard operations

To set number 1 piston to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

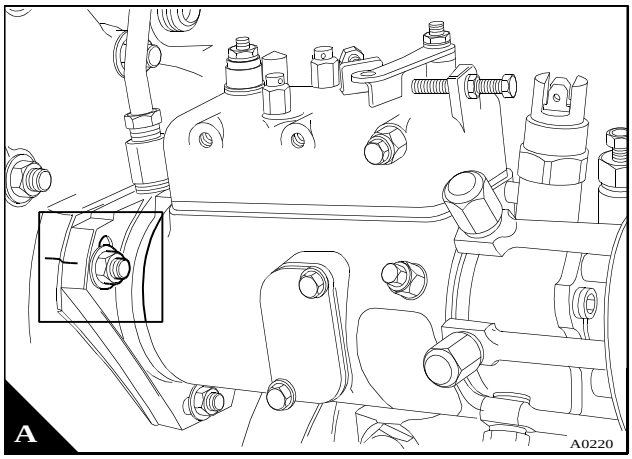
To check the valve timing, see Operation 8-3.





To check the timing of the fuel injection pump **Operation 8-10**

If the mark on the flange of the fuel injection pump is in line with the mark on the timing case (A), the timing of the fuel injection pump should be correct. If the timing marks are in line and the engine performance indicates that the timing is not correct, check that the marks on the flange and on the timing case are in their correct positions, see Operation 8-11 and Operation 8-12.



To check the timing mark of the fuel injection pump **Operation 8-11**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Gear adaptor for use with 21825610	21825513

1 Remove the fuel injection pump, see Operation 11-31.

2 Fit the adaptor 21825513 (A) to the drive shaft of the fuel pump and fasten it with the nut of the fuel pump gear.

3 Remove the banjo bolt from number 1 high-pressure outlet "W" for four cylinder engines, outlet "Y" for six cylinder engines - and fit a banjo bolt which does not contain a pressure valve.

4 Connect number 1 outlet to an atomiser tester. Operate the hand pump until a pressure of 30 atm (440 lbf in^2) 31 kgf/cm^2 is indicated on the gauge.

5 Loosen the screw (B3) on the timing tool 21825610 and set the timing tool to the correct angle, see "Engine timing (Lucas CAV/Delphi DPA and DPS) fuel injection pump" on page 45. Tighten the screw.

6 Fit the timing tool to the adaptor on the fuel pump drive shaft. Rotate the drive shaft of the fuel pump by hand in the normal direction of rotation -see arrow on pump data plate - until the fuel pressure prevents movement. In this position, the fuel pump is set at the start of injection from number 1 outlet.

7 Loosen the screw (B1). Slide the pointer (B2) forward until it is over the centre of the pump flange and check that the mark on the flange is in the centre of the slot in the pointer.

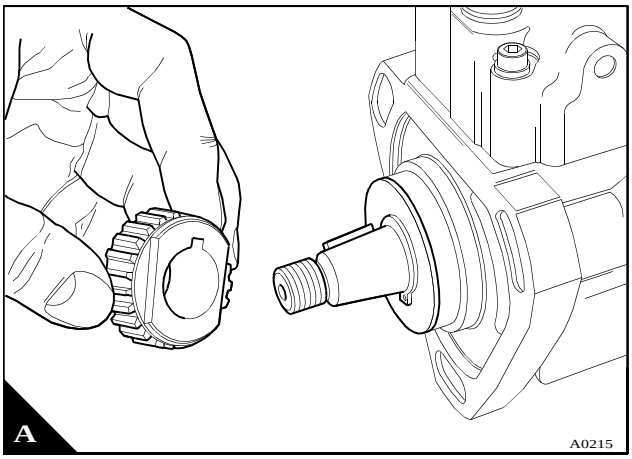
8 If the mark is not correct, remove the timing tool and eliminate the mark. Fit the timing tool and ensure that the fuel pump is at the start of injection for number 1 cylinder. Loosen the screw (B1). Slide the pointer forward to the complete width of the flange and tighten the screw. Make a new mark on the flange of the pump through the slot in the pointer.

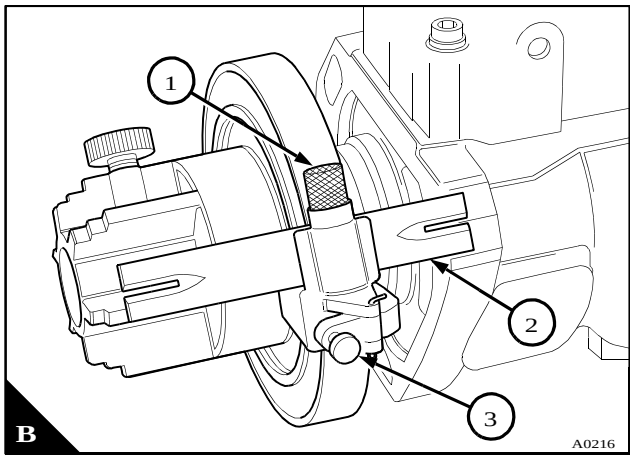
9 Remove the timing tool and the adaptor.

10 Disconnect the atomiser tester and fit the original banjo bolt to number 1 high-pressure outlet.

11 Fit the fuel injection pump, see Operation 11-32.

12 Eliminate air from the fuel system, see Operation 11-35.





To check the engine timing mark **Operation 8-12**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Pointer for use with 21825610	21825514
Adaptor for use with 21825610	21825512		

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the fuel injection pump and its joint, see Operation 11-31.

3 Align the key in the adaptor 21825512 (A) with the keyway in the gear of the fuel injection pump and fit the adaptor to the gear. Ensure that the adaptor is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the screw (B4) on the timing tool 21825610. Set the timing tool to the correct engine check angle, see "Engine timing (Lucas CAV/Delphi DPA and DPS) fuel injection pump" on page 45, and tighten the screw. Loosen the screw (B5) and fit the splined shaft (B3) into the timing tool (B). Loosen the screw (B2). Fit the 90° pointer 21825514 (B1) and tighten the screw.

5 Fit the splined shaft of the timing tool to the adaptor. Slide the timing tool along the splined shaft until it is against the adaptor and tighten the screw (B5).

6 Loosen the lock screw (B2). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B1). If the mark is not correct, remove the timing tool and eliminate the mark on the timing case. Fit the timing tool. Ensure that the pointer is against the timing case and make a new mark on the timing case along the top straight edge of the pointer.

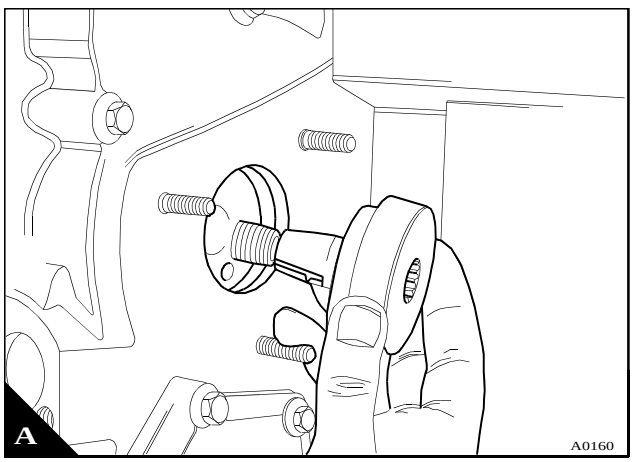
7 Remove the timing tool and the adaptor.

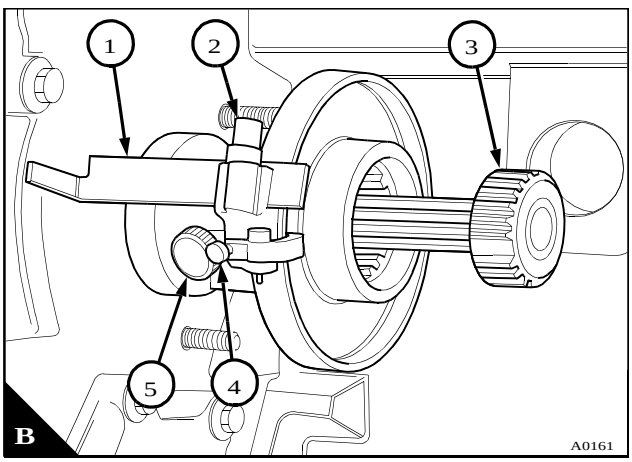
8 Fit the fuel injection pump and a new joint, see Operation 11-32.

9 Remove the dial gauge from number 1 cylinder inlet valve and fit the valve springs and the rocker lever. Set the valve tip clearance of number 1 cylinder inlet valve to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-2.

11 Eliminate air from the fuel system, see Operation 11-35.





To check the timing of the pin timed fuel injection pump **Operation 8-13**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Bosch fuel injection pumps	27610032	Timing pin Lucas/Delphi and Stanadyne fuel injection pumps	27610033

Caution: *Do not remove the nut (A2) which retains the hub (A4) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment available to Perkins distributors.*

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump:

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.

3 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

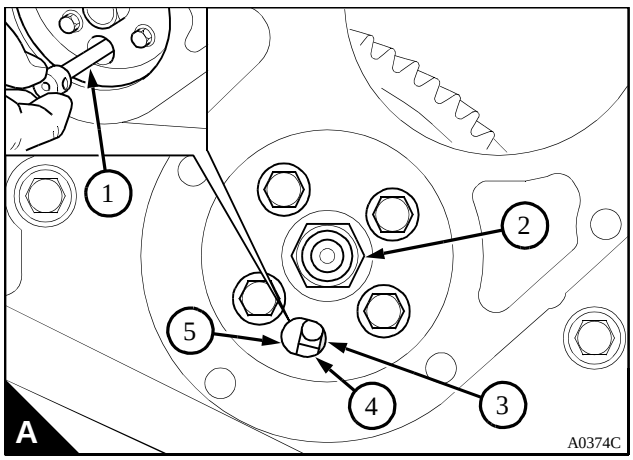
Note: The position for the timing pin for Lucas/Delphi and Stanadyne fuel injection pumps is (A1). The position for the timing pin for Bosch EPVE fuel injection pumps is (B1).

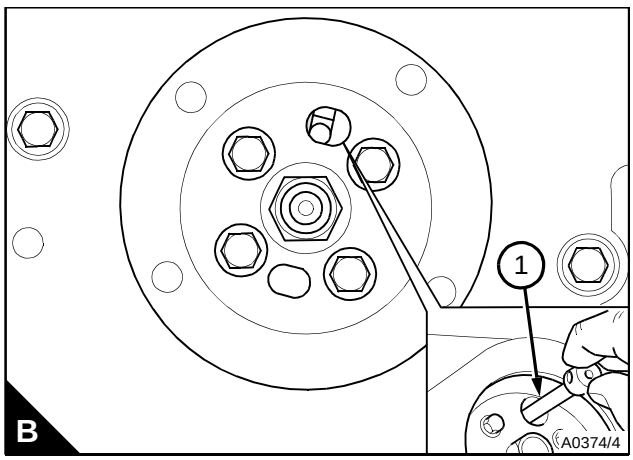
4 Remove the timing pin.

5 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1 or Operation 8-2.

If the engine is set correctly at TDC on the number 1 cylinder compression stroke, but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.

6 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump:





Engines fitted with a Lucas/Delphi DP200 Series fuel injection pump

General description

Lucas/Delphi DP200 Series fuel injection pumps have a locking screw (A3) and a spacer (A2). The locking screw prevents rotation of the drive shaft of the fuel pump when the pump is removed from the engine. An "O" ring (A1) is fitted in a groove in front of the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case. Engines which have the Lucas/Delphi DP200 Series fuel injection pumps operate at a static timing very close to TDC.

When the piston is close to TDC there is a relatively large movement of the crankshaft for only a small movement of the piston. For this reason the earlier methods of timing, where piston movement is measured, is not accurate enough.

When the piston is further down the cylinder, there is a relatively small movement of the crankshaft for a large movement of the piston. Therefore greater accuracy is possible. For this reason the crankshaft is set at 100° BTDC.

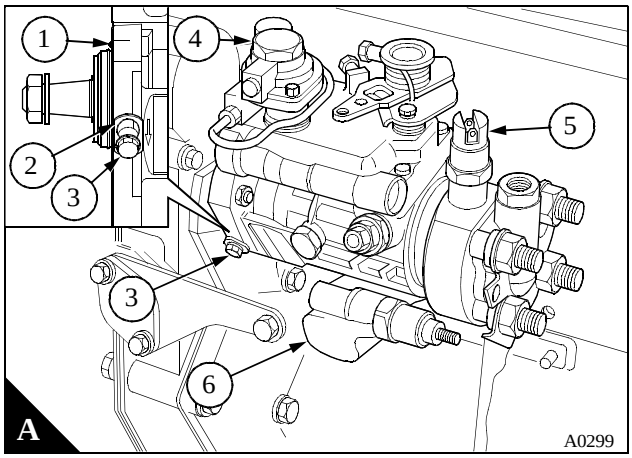
Caution: *The drive shaft of the pump must not be rotated without the spacer in position under the locking screw or the pump drive shaft will be damaged.*

Engines with these pumps do not have timing marks put on in the factory, but there is a timing mark on the pump flange.

A new pump will be received with the locking screw fitted and the spacer fastened to the engine speed control by a piece of wire.

Other features which may be fitted to the Lucas/Delphi DP200 Series fuel injection pumps are:

- A boost control device (A4)
- A stop solenoid (A5)
- A cold start advance unit (A6) which is electrically operated.



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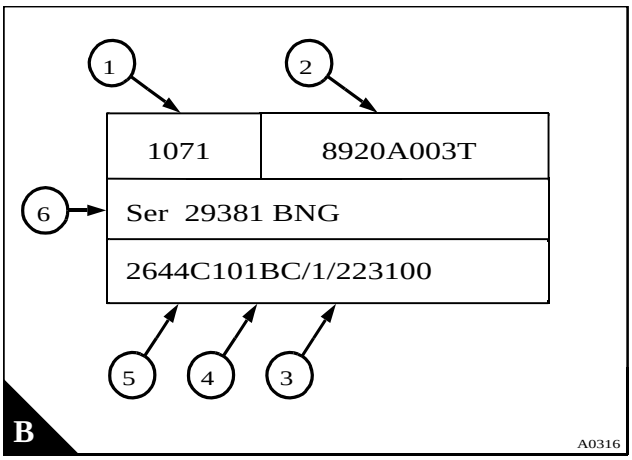
A data plate is fitted to the side of the pump. An example of the information shown on the plate (B) is:

- Manufacturers model number (1)
- Manufacturers description number (2)
- Maximum engine no load speed (3)
- Fuel pump code letters (4)
- Perkins part number (5)
- Fuel pump serial number (6).

For details of the fuel pump code for the engine, see Operation 8-14.

Standard operations

To check the valve timing, see Operation 8-3.



To check the timing of the fuel injection pump **Operation 8-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Gear adaptor for use with 21825610	21825513

Caution: *This procedure must be followed carefully if:*

- The engine performance is not correct.
- The locking screw is released after the fuel injection pump is removed from the engine.

1 Remove the fuel injection pump, see Operation 11-38.

Caution: *When the pump is held in a vice, do not apply pressure to the alloy components.*

2 Hold the pump securely. Fit adaptor, 21825513, (A) for the timing tool, 21825610, to the drive shaft of the pump. Use the nut for the drive gear, tightened finger tight only, to retain the adaptor.

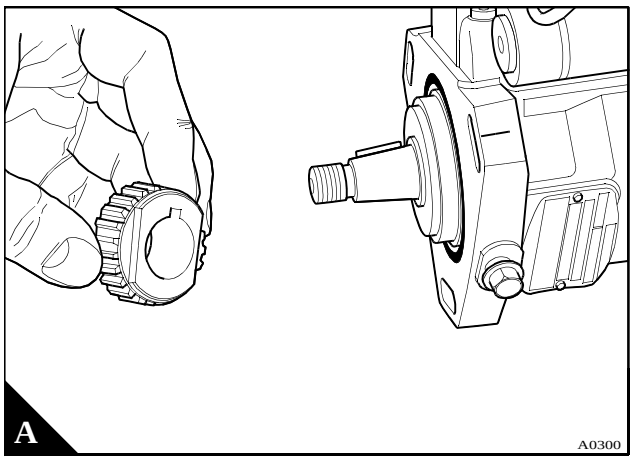
3 Loosen the screw (B2) on the timing tool and set the timing tool to the correct angle, see the table below for the correct angle. Tighten the screw.

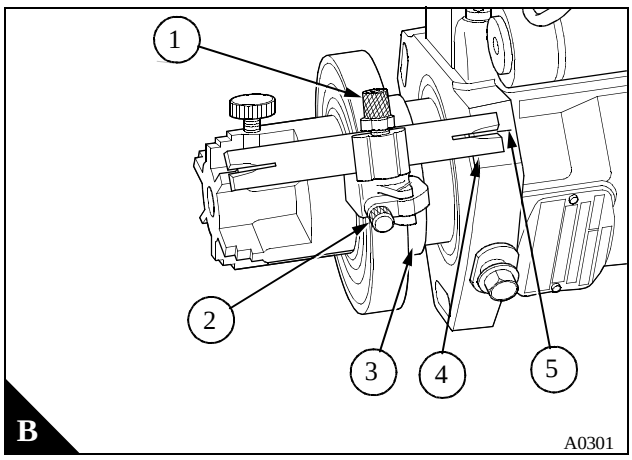
This angle is relative to the start of injection with the piston set at 100° BTDC. Fit the timing tool, 67B, together with the spacer (B3), to the adaptor on the pump.

Code letters for fuel pumps	Locking angle (degrees)
BC	336.5
CC	338.5
DC	337.5
EC	337.5
FC	335.5
GC	337
PC	339
RC	339
SC	341
XL	22

4 Release the screw (B1) and slide the pointer (B4) forward until it is over the centre of the pump flange and tighten the screw.

Note: If the mark (B5) on the fuel pump flange is not accurately aligned with the slot in the pointer of the timing tool the timing of the pump must be checked by the nearest Perkins Distributor.





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5 Remove the timing tool, the spacer, PD 67-3. Remove the nut and the adaptor from the shaft of the pump.

6 Fit the fuel injection pump to the engine, see Operation 11-39.

Note: If the fuel pump was removed because the engine performance was not correct, operate the engine and check if the performance has improved. If the performance is not correct, remove the fuel pump to the nearest Perkins Distributor.

To check the timing of the pin timed fuel injection pump **Operation 8-15**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Bosch fuel injection pumps	27610032	Timing pin Lucas/Delphi and Stanadyne fuel injection pumps	27610033

Caution: *Do not remove the nut (A2) which retains the hub (A4) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment available to Perkins distributors.*

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump:

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.

3 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

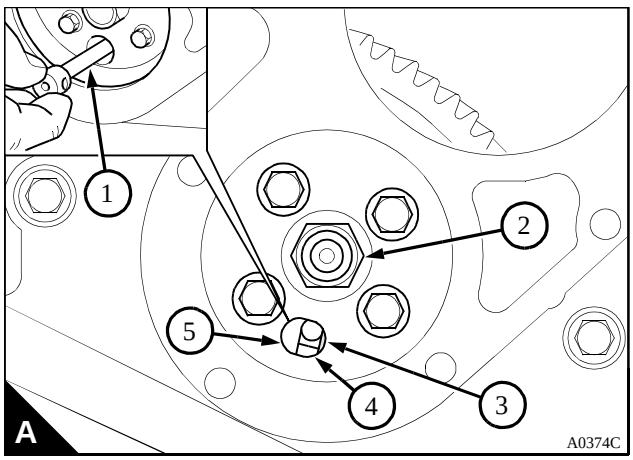
Note: The position for the timing pin for Lucas/Delphi and Stanadyne fuel injection pumps is (A1). The position for the timing pin for Bosch EPVE fuel injection pumps is (B1).

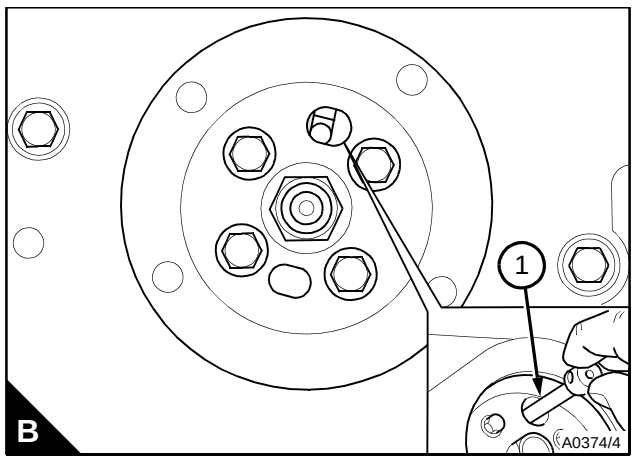
4 Remove the timing pin.

5 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1 or Operation 8-2.

If the engine is set correctly at TDC on the number 1 cylinder compression stroke, but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.

6 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump.





Engines fitted with Stanadyne fuel injection pumps

General description

The electrical stop solenoid on these fuel pumps is fitted inside the governor housing. The earth connection (A1) and the electrical connection (A2) are on top of the governor housing.

A data plate (A3) is fitted to the side of the pump.

An example of the information shown on the plate (B) is:

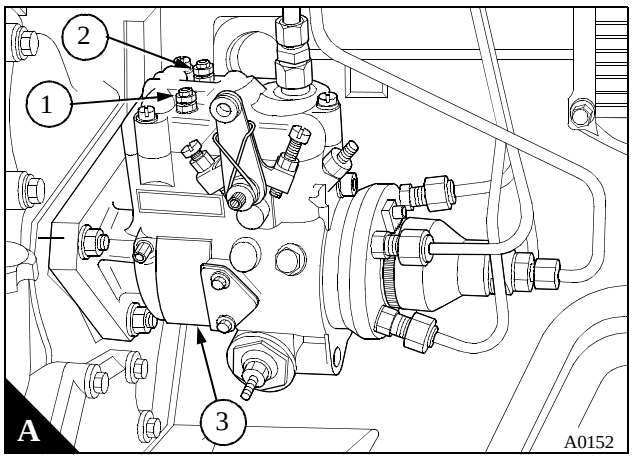
- Maximum engine no load speed (1)
- Fuel pump code (2)
- Perkins part number (3)
- Fuel pump serial number (4)
- Manufacturers model number (5)

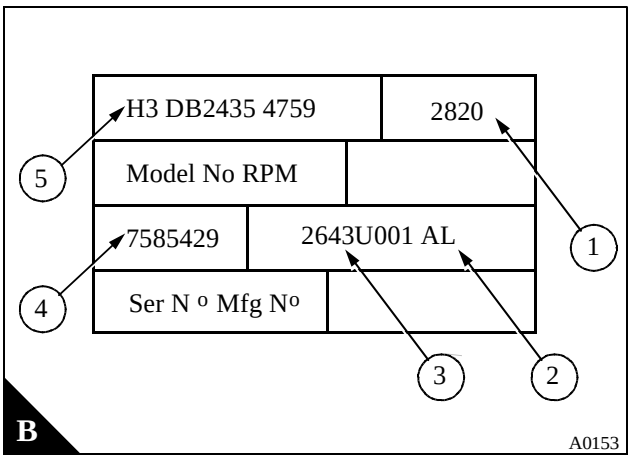
For details of the fuel pump code for the engine, see "Engine timing (Stanadyne fuel injection pump)" on page 46.

Standard operations

To set number 1 piston to TDC on the compression stroke, see Operation 8-1.

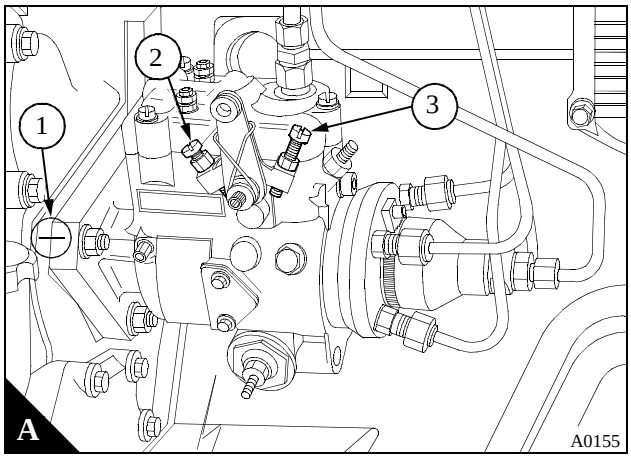
To check the valve timing, see Operation 8-3.





To check the timing of the fuel injection pump **Operation 8-16**

If the mark on the flange of the fuel injection pump is in line with the mark on the timing case (A1), the timing of the fuel injection pump should be correct. If the timing marks are in line and engine performance indicates that the timing is not correct, check that the marks on the flange and on the timing case are in their correct positions, see Operation 8-17.



To check the timing mark of the fuel injection pump **Operation 8-17**

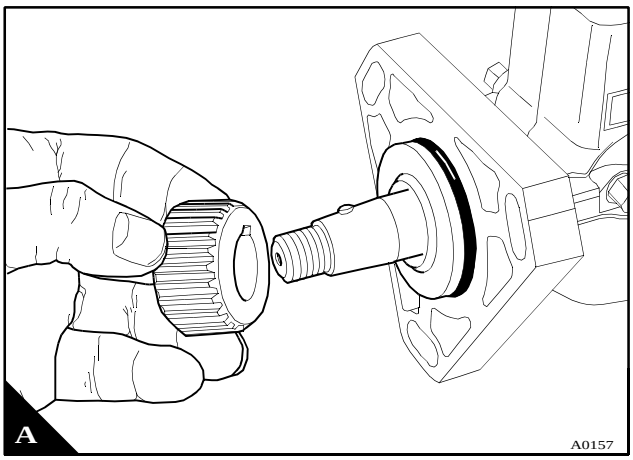
Special requirements

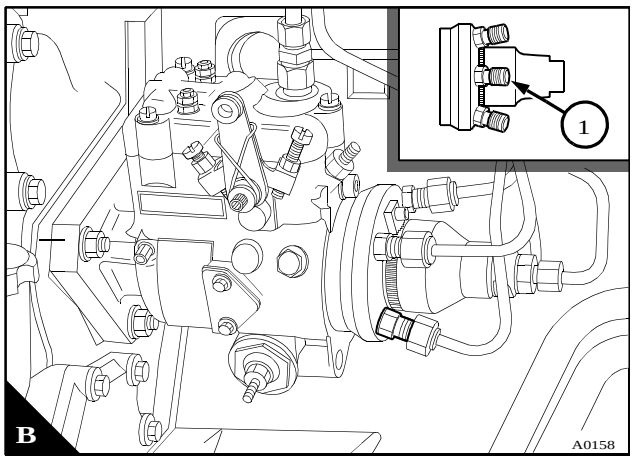
Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Gear adaptor for use with 21825610	21825513

1 Remove the fuel injection pump from the engine, see Operation 11-47.

2 Fit the adaptor 21825513 (A) to the drive shaft of the fuel pump and fasten it with the nut of the fuel pump gear.

3 Connect number 1 outlet (B1) to an atomiser tester. Operate the hand pump until a pressure of not more than 50 atm (735 lbf in^2) 52 kgf/cm^2 is indicated on the gauge.

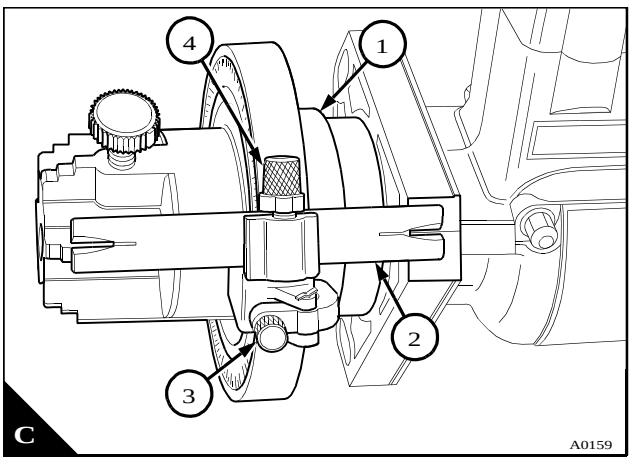




4 Rotate the drive shaft of the fuel pump clockwise from the drive end of the pump until the pin in the shaft aligns with number 1 outlet. Loosen the screw (C3) on the timing tool 21825610 and set the timing tool to the correct pump mark angle, see "Engine timing (Stanadyne fuel injection pump)" on page 46. Tighten the screw.

5 Put the sleeve (C1) for the timing tool in position on the fuel pump. Fit the timing tool to the adaptor on the fuel pump drive shaft. Rotate the shaft backwards and forwards until the fuel pressure prevents movement of the shaft.

This is necessary as fuel must pass the delivery valve in the fuel pump before the fuel pressure will prevent movement of the shaft. In this position, the fuel pump is set at the start of injection from number 1 outlet.



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6 Loosen the screw (D4). Slide the pointer (D2) forward until it is over the centre of the pump flange and check that the mark on the flange is in the centre of the slot in the pointer.

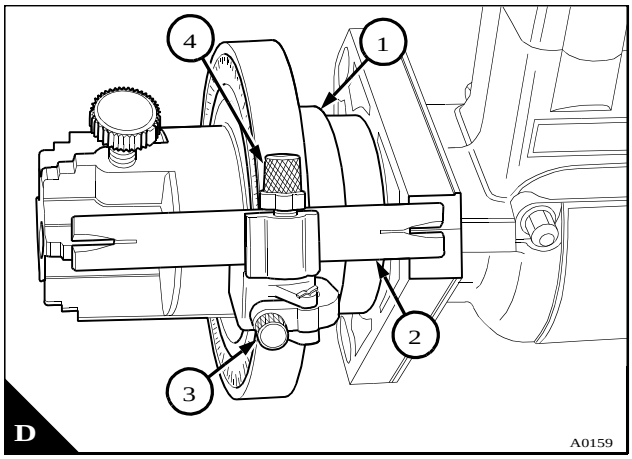
7 If the mark on the flange is not correct, remove the timing tool and eliminate the mark. Fit the timing tool and ensure that the fuel pump is at the start of injection for number 1 cylinder. Loosen the screw (D4). Slide the pointer forward to the complete width of the flange and tighten the screw. Make a new mark on the flange of the pump through the slot in the pointer.

8 Remove the timing tool, the sleeve and the adaptor.

9 Disconnect the atomiser tester from number 1 high-pressure outlet.

10 Fit the fuel injection pump, see Operation 11-48.

11 Eliminate air from the fuel system, see Operation 11-54.



To check the engine timing mark **Operation 8-18**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing tool	21825610	Pointer for use with 21825610	21825514
Adaptor for use with 21825610	21825512		

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1.

2 Remove the fuel injection pump and its joint from the pump flange, see Operation 11-47.

3 Align the key in the adaptor 21825512 (A) with the keyway in the gear of the fuel injection pump and fit the adaptor to the gear. Ensure that the adaptor is against the rear face of the timing case. Secure the adaptor to the gear with the nut supplied with the adaptor.

4 Loosen the screw (B4) on the timing tool 21825610. Set the timing tool to the correct engine check angle, see "Engine timing (Stanadyne fuel injection pump)" on page 46, and tighten the screw. Loosen the screw (B5) and fit the splined shaft (B3) into the timing tool (B). Loosen the screw (B2). Fit the 90° pointer 21825514 (B3) and tighten the screw.

5 Fit the splined shaft (B3) of the timing tool to the adaptor. Slide the timing tool along the splined shaft until it is against the adaptor and tighten the screw (B5).

6 Loosen the lock screw (B2). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. Rotate the timing tool clockwise, as seen from the rear of the engine, to remove the backlash. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B1). If the mark is not correct, remove the timing tool and eliminate the mark on the timing case. Fit the timing tool. Ensure that the pointer is against the timing case and make a new mark on the timing case along the top straight edge of the pointer.

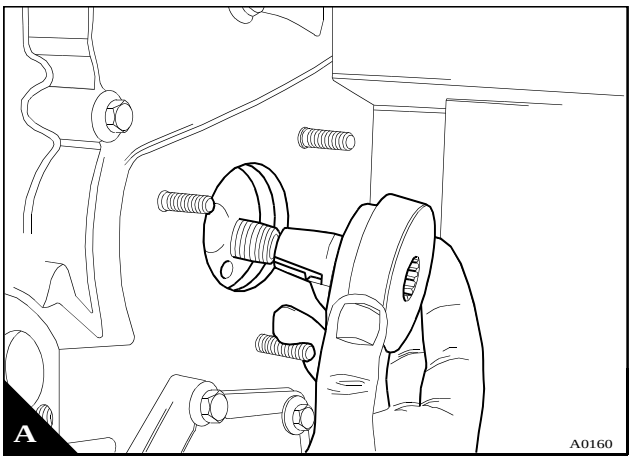
7 Remove the timing tool and the adaptor.

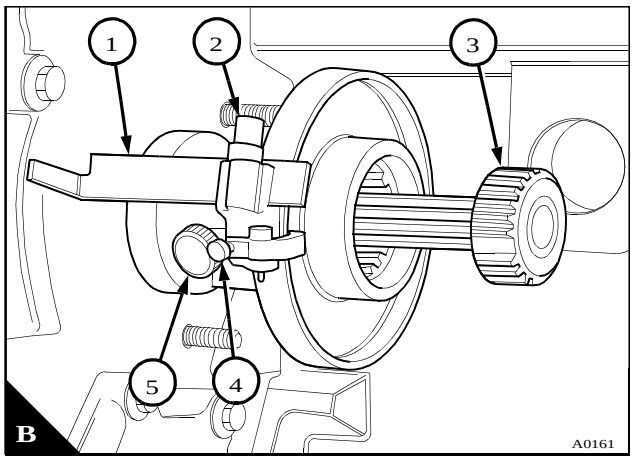
8 Fit a new joint to the fuel injection pump flange and fit the pump, see Operation 11-48.

9 Remove the dial gauge from the inlet valve of the number 1 cylinder and fit the valve springs and the rocker lever. Set the valve tip clearance of number 1 cylinder inlet valve to 0,20 mm (0.008 in).

10 Fit the rocker cover, see Operation 3-2.

11 Eliminate air from the fuel system, see Operation 11-54.





To check the timing of the pin timed fuel injection pump **Operation 8-19**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Timing pin Bosch fuel injection pumps	27610032	Timing pin Lucas/Delphi and Stanadyne fuel injection pumps	27610033

Caution: *Do not remove the nut (A2) which retains the hub (A4) to the shaft of the fuel injection pump. The hub is fitted permanently to the shaft. If the hub is moved, it will be necessary for a fuel injection pump specialist to correctly position the hub on the shaft with special test equipment available to Perkins distributors.*

1 Set the piston of number 1 cylinder to TDC on the compression stroke, see Operation 8-1 or Operation 8-2.

2 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump.

Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.

3 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

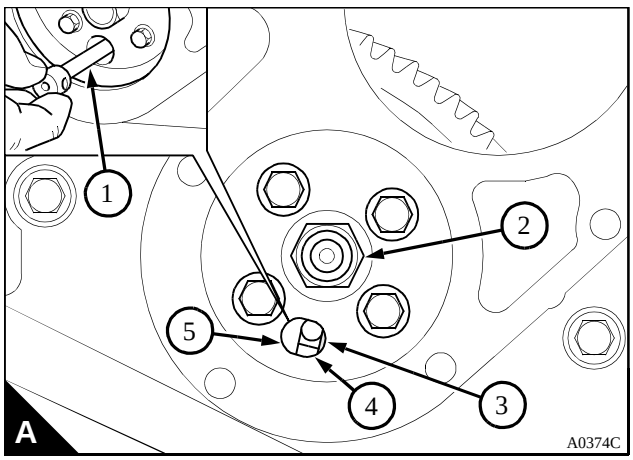
Note: The position for the timing pin for Lucas/Delphi and Stanadyne fuel injection pumps is (A1). The position for the timing pin for Bosch EPVE fuel injection pumps is (B1).

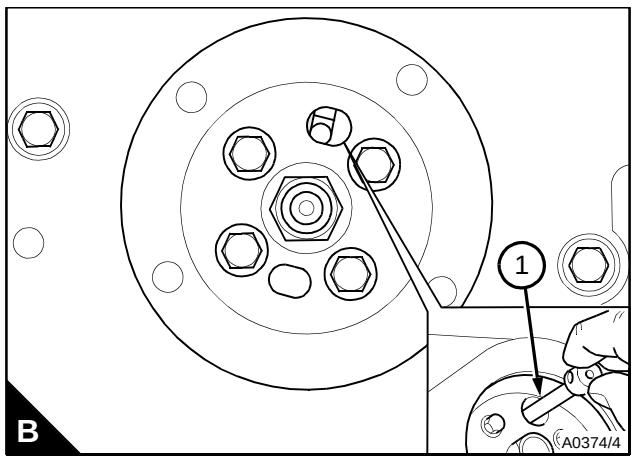
4 Remove the timing pin.

5 If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder compression stroke, see Operation 8-1 or Operation 8-2.

If the engine is set correctly at TDC on the number 1 cylinder compression stroke, but the pin does not fit into the hole, the fuel pump must be removed and set by a specialist.

6 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump.





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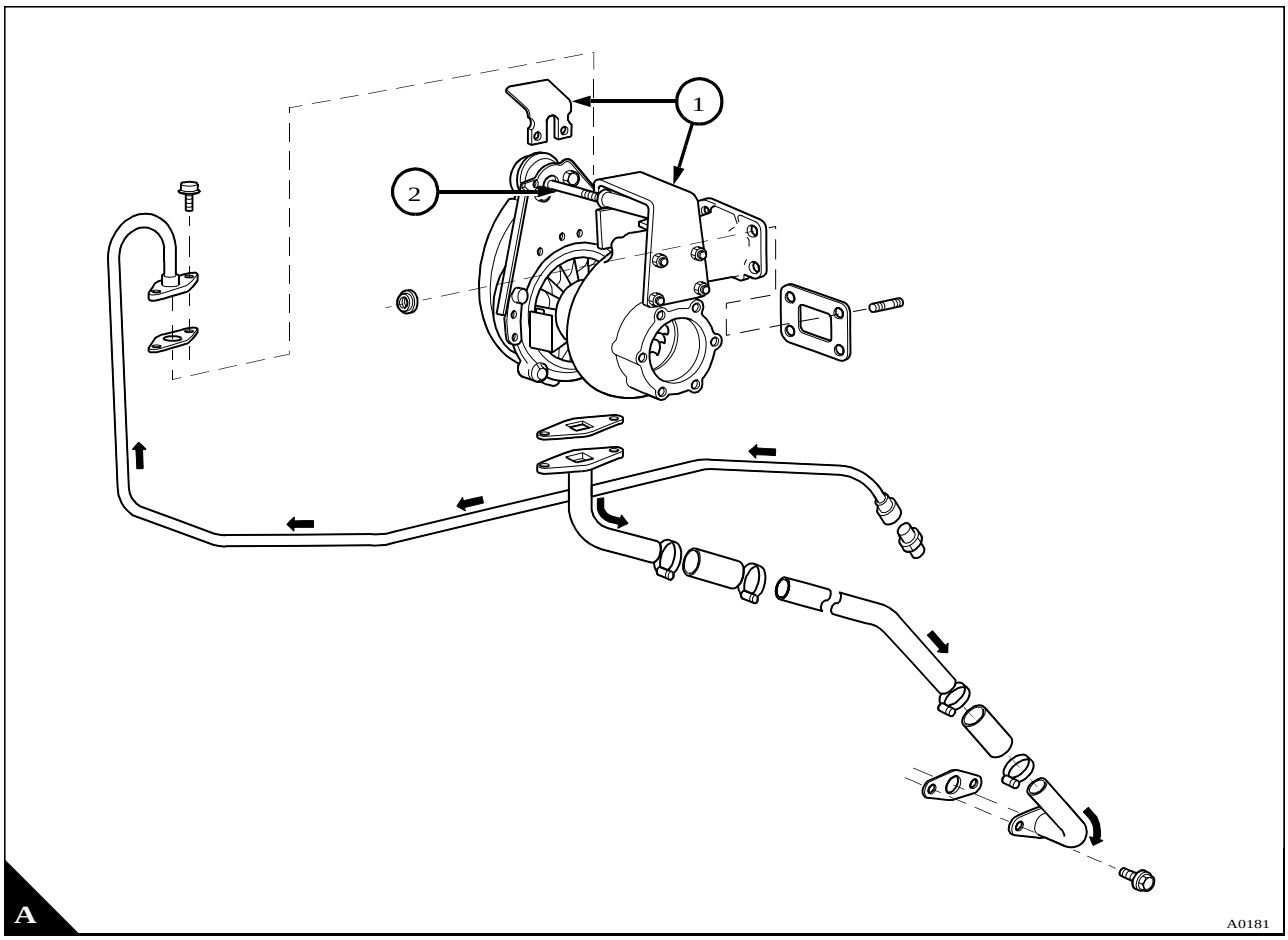
9

Aspiration system

General description

Warning! *Turbochargers operate at high speed and at high temperatures. Keep fingers, tools and debris away from the inlet and outlet ports of the turbocharger and prevent contact with hot surfaces.*

A turbocharger (A), is fitted between the exhaust and induction manifolds. The turbocharger is driven by exhaust gases and passes air to the engine at more than atmospheric pressure. It is lubricated by oil from the main gallery. The oil passes through the bearing housing of the turbocharger and returns to the lubricating oil sump; arrows are included on the illustration to indicate the typical oil flow.



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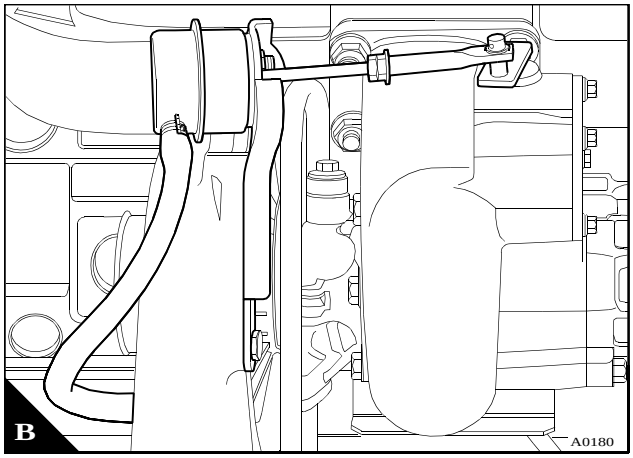
Some turbochargers are fitted with a waste-gate unit (B). This unit, which is controlled by boost pressure, allows some of the exhaust gases to bypass the turbine rotor at higher engine speeds. With this arrangement, the turbocharger can be designed to be more effective at lower engine speeds.

A waste-gate guard (A1) is fitted to protect the actuator rod (A2) of some engines.

Always use the manufacturers instructions and specialist assistance to fit the service kit for the turbocharger.



Turbocharger

To remove — Operation 9-1

1 Thoroughly clean the turbocharger.

2 Remove the air cleaner hose at the compressor inlet.

3 Remove or disconnect the support bracket for the turbocharger. If necessary, remove the heat shield for the fuel lift pump. Remove the exhaust elbow from the turbocharger. Where the elbow has a gasket, release the nuts and remove the elbow and the gasket. Where the elbow has a sleeve, pull the elbow together with the sleeve away from the turbocharger.

4 Release the hose clips and push the hose of the compressor outlet up the elbow of the induction manifold.

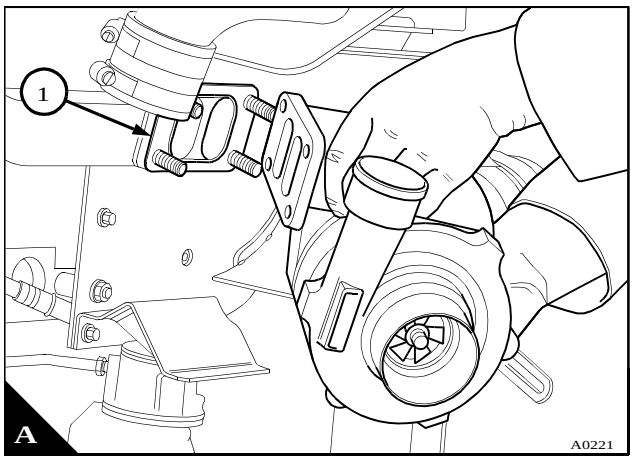
5 Release the setscrews from the flange of the oil supply pipe at the top of the bearing housing and the union nut/connection at the other end of the pipe. If the lower section of the oil supply pipe is flexible, use a spanner to hold the flats on the pipe while the union connection is removed from the oil filter head/adaptor plate. This will prevent damage to the flexible section of the pipe. If an adaptor is used in the oil filter head/adaptor plate, use a spanner to hold the adaptor when the union nut is released. Remove the pipe and the flange joint.

6 Release the setscrews from the flange of the oil drain pipe at the bottom of the bearing housing. If necessary, release the hose clip(s) from the oil drain pipe and push the hose down. Remove the oil drain pipe and the joint from the flange.

Caution: *If the turbocharger has a waste-gate ensure that the actuator rod of the waste-gate is not used to lift or move the turbocharger. This could damage the waste-gate and affect the calibration.*

7 Release the nuts at the turbocharger to exhaust manifold flange and remove the turbocharger and the gasket. Cover the open ports in the manifolds, the turbocharger and the pipes to ensure that dirt, etc. will not enter.

8 Check the air hoses and the oil drain hose for cracks or other damage and renew them, if necessary.



To fit **Operation 9-2**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant and sealant primer	21820122

1 Remove the covers from the pipes, manifolds and the turbocharger.

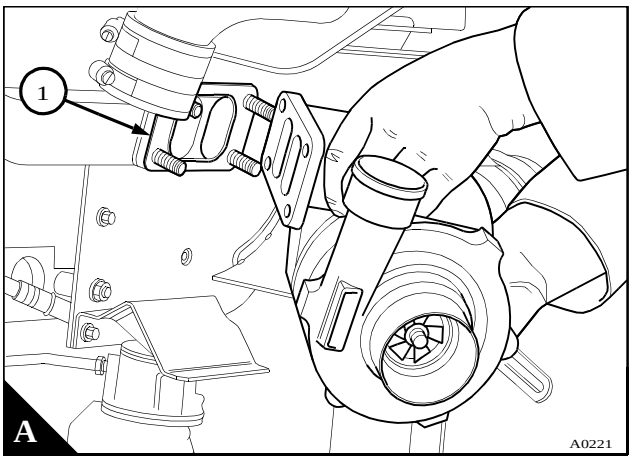
2 Check that the turbocharger inlets and outlets are clean and free from restriction and that the turbocharger shaft rotates freely. Also check that the open ports in the manifolds and the exhaust pipe are clean and free from restriction.

3 Fit a new gasket to the exhaust manifold to turbocharger flange (A1). If the original nuts are to be used, ensure that the threads of the studs are clean and apply a suitable compound to the studs to prevent seizure. The threads of new nuts are phosphated to prevent seizure. Fit the turbocharger. Fit the nuts and tighten them to 44 Nm (33 lbf ft) 4,5 kgf m.

4 Lubricate the bearing housing of the turbocharger with clean engine lubricating oil. Fit the oil supply pipe together with a new joint and tighten the flange setscrews. If the lower section of the pipe is flexible, clean the thread of the union connection and apply POWERPART Pipe sealant and sealant primer. Ensure that dirt does not enter the oil filter head/adaptor plate. Use a spanner to hold the flats on the pipe while the union connection is fitted to the oil filter head/adaptor plate. If an adaptor is used in the oil filter head/adaptor plate, use a spanner to hold the adaptor when the union nut is tightened.

5 Fit the oil drain pipe together with a new joint and tighten the flange setscrews, but do not connect the hose.

6 Where the exhaust elbow has a flange, clean the threads of the studs in the flange of the turbocharger. Apply a suitable compound to the studs to prevent seizure of the nuts. Put a new gasket in position on the flange and fit the elbow. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m (plated) or 25 Nm (18 lbf ft) 2,5 kgf m (non-plated). Fit or connect the support bracket between the elbow and the cylinder block. Ensure that there is no stress on the exhaust elbow. If necessary fit the heat shield for the fuel lift pump.



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7 Where the exhaust elbow (B2) has a sleeve (B1), check that the sleeve protrusion from the end of the elbow is 23 mm (0.90 in) (B9).

8 Fit the elbow in the correct position to the support bracket (B5) and tighten the setscrews (B4) finger tight. Some engines have an aluminium heat shield (B3) between the elbow and the bracket.

9 Fit the sleeve together with the elbow and bracket into the turbocharger outlet. Fit the setscrews (B6 and B7) which hold the bracket to the cylinder block, finger tight. Ensure that the setscrew (B6) has a thick washer fitted between the setscrew and the bracket.

10 Where the elbow is fitted vertically, check that the top face of the elbow flange is at 90° to the outer face of the inlet manifold (B10).

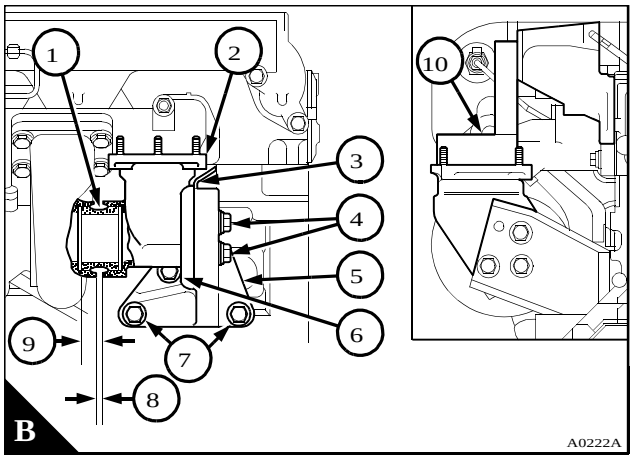
11 Fully tighten the setscrews that hold the bracket to the elbow. Check that there is a gap of 6,5 mm (0.25 in) (B8) between the turbocharger outlet and the end of the elbow. This gap should be equal all around the elbow. Fully tighten the setscrews that hold the bracket to the cylinder block.

12 Where the elbow is fitted vertically, check again that the top face of the elbow flange is at 90° to the outer face of the inlet manifold.

13 Slide the hose on the induction manifold elbow onto the compressor outlet and tighten the hose clips.

14 Check that there is no restriction in the air filter to turbocharger hose. Fit the hose and tighten the clip.

15 Operate the stop control or, where fitted, disconnect the electrical stop control. Operate the starter motor until there is a flow of lubricating oil from the oil drain pipe of the turbocharger. Connect the oil drain pipe. Where fitted, connect the electrical stop control.



To clean the impeller and the compressor casing **Operation 9-3**

Generally, it is not necessary to remove the turbocharger to remove the compressor casing, except on some engines where the compressor casing is held by a circlip and access to the circlip is not always possible. This type of turbocharger is usually fitted to engines used in vehicle applications.

1 Release the clip and remove the hose from the compressor inlet. Release the clips and push the hose on the compressor outlet up the elbow of the induction manifold.

2 Make a reference mark on the compressor casing (A1) and on the bearing housing to ensure correct assembly later.

3 Release the setscrews and remove the lock plates. If the compressor casing is retained by a circlip, remove the circlip. It may be necessary to remove the turbocharger if access to the circlip is not possible. If the turbocharger has a waste-gate unit, remove the actuator and bracket assembly, see Operation 9-4.

Caution: *Be careful not to damage the impeller blades. If the impeller is damaged, the turbocharger must be renewed.*

4 Remove carefully the compressor casing from the turbocharger (A). If the casing is tight, lightly hit it with a soft faced hammer.

5 Put the compressor casing in a suitable container that contains a non-caustic solution. Allow the dirt to become soft and then clean the casing with a hard brush and/or a soft scraper. Dry the casing with clean, compressed air at low pressure.

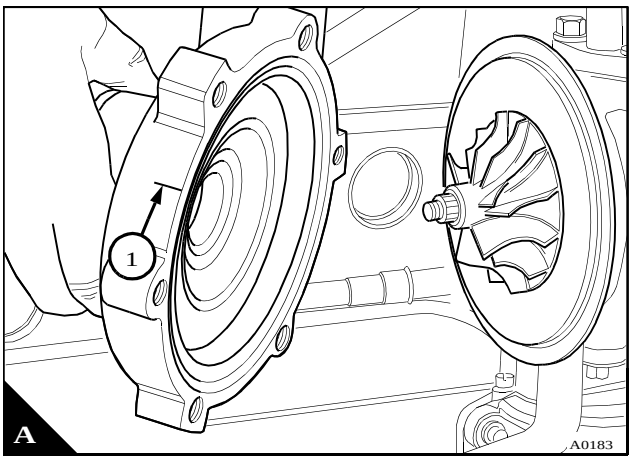
6 Clean the impeller with a soft brush.

7 Push carefully the compressor impeller towards the bearing housing and turn the impeller by hand. Check that there is no restriction of movement and that there is no noise which can indicate a fault. If there is a fault, remove the turbocharger for inspection by a specialist.

8 Fit the casing to the turbocharger and align the mark on the casing with the mark on the bearing housing. Fit the lock plates and the setscrews and tighten the setscrews.If the compressor casing of the turbocharger is retained by a circlip, fit the circlip loosely to the bearing housing. Ensure that the flat face of the circlip is toward the compressor casing. Fit the casing to the turbocharger and align the marks on the casing and on the bearing housing. Fit the circlip in its groove. If the turbocharger has a waste-gate unit, fit the actuator and bracket assembly, see Operation 9-4.

9 Fit the hoses to the compressor inlet and outlet and tighten the clips.

10 If necessary, fit the turbocharger to the engine, see Operation 9-2.



To remove and to fit the actuator assembly of the waste-gate unit **Operation 9-4**

It is important that the waste-gate actuator setting is not altered. Do not remove the actuator or mounting bracket unless it is necessary to renew the actuator assembly.

If a waste-gate actuator or mounting bracket assembly is removed from a turbine or compressor housing it is important that the bracket is fitted into the correct position on the housing.

To remove

1 Disconnect the boost sensor pipe (A1) at the actuator (A2).

2 Remove the clip (A4) which retains the actuator rod (A3) and lift the end of the actuator rod off the pin (A5) of the waste-gate valve.

3 Release the setscrews which retain the actuator bracket to the turbocharger and remove the actuator and bracket assembly.

To fit

1 Put the actuator and bracket assembly in position on the turbocharger and tighten the setscrews.

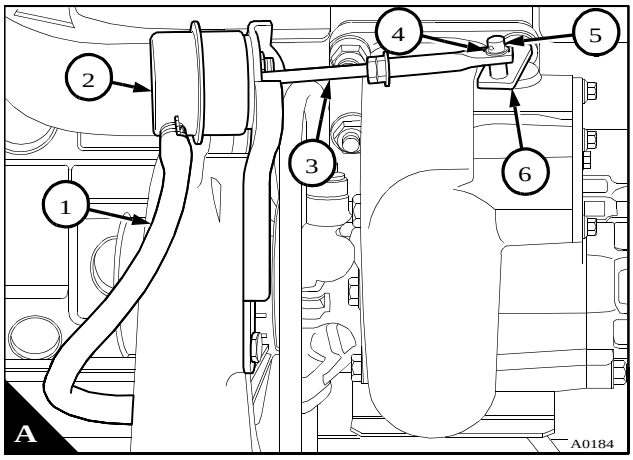
2 Connect to the actuator (A2) an air supply which can be adjusted accurately and is fitted with an accurate gauge.

3 Operate the arm (A6) of the waste-gate valve by hand to check that the valve is free to move.

4 Push the arm of the waste-gate valve as far as possible toward the actuator and hold the arm in this position. Slowly apply air pressure to the actuator until the end of the actuator rod (A3) will fit easily onto the pin (A5) of the waste-gate valve. Fit the clip (A4). Release the air pressure.

Caution: *Do not apply an air pressure of more than 205 kPa (30 lbf/in^2) 2,1 kgf/cm^2 to the actuator. Greater pressures may damage the actuator.*

5 Check the operation of the waste-gate unit, see Operation 9-5.



To check and adjust the operation of the waste-gate **Operation 9-5**

If the waste-gate valve does not operate at the correct pressure, it can affect the engine performance.

If the valve opens at a low pressure, this can cause black exhaust smoke and loss of power at lower engine speeds.

Caution: *A high pressure setting can cause high cylinder pressures. This can cause failure of the cylinder head gasket and damage to the bearings and pistons.*

1 Disconnect the boost sensor pipe (A6) at the actuator. Connect to the actuator an air supply which can be adjusted accurately and is fitted with an accurate gauge.

2 Fasten a dial test indicator (A1) to the turbocharger with its plunger in contact with the end of the actuator rod (A4) to measure the axial movement of the rod.

3 Slowly apply air pressure. Check that the pressure necessary to move the rod 1,00 mm (0.039 in), is within the limits shown in the relevant Data and dimensions for the "Turbocharger" on page 47. Ensure that the pointer returns to zero when the pressure is released. Repeat the test several times to ensure that an accurate reading is obtained. It may be necessary to lightly hit the turbine housing with a soft hammer during the test operation.

4 If the operation of the waste-gate is not correct, the actuator rod can be adjusted.

5 Remove the dial gauge from the end of the actuator rod.

6 With the air pressure still applied, release the lock nut (A5) on the actuator arm. Remove the clip (A2) and remove the actuator rod from the pin (A3) on the arm of the waste-gate valve.

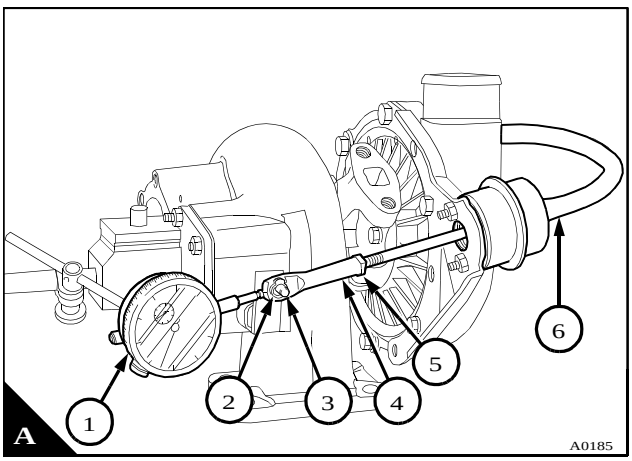
7 If the air pressure is too low, rotate the end of the actuator rod to reduce the length of the actuator rod. If the air pressure is too high, rotate the end of the actuator rod to increase the length of the actuator rod. Rotate the end of the actuator rod in half turn increments.

Caution: *Use only the end of the threaded rod to make adjustments. To pull or push the actuator rod could change the calibration of the actuator. The result could be damage to the engine because of too much boost.*

8 Put the actuator rod in position on the pin of the waste-gate arm. Fit the clip. Tighten the lock nut. Release the air pressure.

9 Put the dial gauge in position on the end of the actuator rod. Apply air pressure to move the actuator rod 1,00 mm (0.039 in) and check if the air pressure is correct. If the air pressure is not correct, repeat from step 6 of the operation until the correct pressure is obtained.

10 If the air pressure is correct, release the air pressure, remove the test equipment and connect the boost sensor pipe.



Turbocharger faults

The chart below is given to assist in the correct diagnosis of turbocharger faults.

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid, if there is one fitted, see Operation 14-9 and Operation 14-10.

Problems	Possible causes code numbers
Not enough power	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Black smoke	1, 4, 5, 6, 7, 8, 9, 10, 11, 18, 20, 21, 22, 25, 26, 27, 28, 34, 35, 36
Blue smoke	1, 2, 4, 6, 8, 9, 17, 19, 20, 21, 22, 30, 31, 32, 34
High lubricating oil consumption	2, 8, 15, 17, 19, 20, 28, 29, 31, 32, 34
Too much lubricating oil at turbine end	2, 7, 8, 17, 19, 20, 22, 28, 30, 31, 32
Too much lubricating oil at compressor end	1, 2, 4, 5, 6, 8, 19, 20, 21, 28, 31, 32
Not enough lubrication	8, 12, 14, 15, 16, 23, 24, 29, 32, 33, 37, 38
Lubricating oil in the exhaust manifold	2, 7, 17, 18, 19, 20, 22, 28, 31, 32
Inside of the induction manifold wet	1, 2, 3, 4, 5, 6, 8, 10, 11, 17, 18, 19, 20, 21, 28, 32, 34, 39, 40
Damaged compressor impeller	3, 4, 6, 8, 12, 15, 16, 20, 21, 23, 24, 29, 32, 33, 37, 38
Damaged turbine rotor	7, 8, 12, 13, 14, 15, 16, 18, 20, 22, 23, 24, 25, 27, 29, 32, 33, 37, 38
Rotating assembly does not turn freely	3, 6, 7, 8, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 29, 32, 33, 37, 38
Worn bearings, bearing bores, journals	6, 7, 8, 12, 13, 14, 15, 16, 23, 24, 29, 33, 37, 38
Noise from turbocharger	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 29, 32, 33, 34, 37, 38
Sludge or carbon deposit in bearing housing	2, 11, 13, 14, 15, 17, 18, 24, 29, 33, 37, 38

Possible causes

1 Element of the air filter dirty
2 Restricted crankcase breather
3 Element of the air filter not fitted, or not sealing correctly. Loose connection to turbocharger.
4 Internal distortion or restriction in pipe from air filter to turbocharger.
5 Damaged/restricted crossover pipe, turbocharger to induction manifold.
6 Restriction between air filter and turbocharger.
7 Restriction in exhaust system.
8 Turbocharger loose or clamps/setscrews loose.
9 Induction manifold has cracks, is loose, or has flange distortion.
10 Exhaust manifold has cracks, is loose, or has flange distortion.
11 Restricted exhaust system.
12 Delay of lubricating oil to turbocharger at engine start.
13 Insufficient lubrication.
14 Dirty lubricating oil.
15 Incorrect lubricating oil.
16 Restricted lubricating oil supply pipe.
17 Restricted lubricating oil drain pipe.
18 Turbine housing damaged or restricted.
19 Leakage from turbocharger seals.
20 Worn turbocharger bearings.
21 Excessive dirt in compressor housing.
22 Excessive carbon behind turbine rotor.
23 Engine speed raised too rapidly at initial start.
24 Insufficient engine idle period.
25 Faulty fuel injection pump.
26 Worn or damaged atomisers.
27 Valves burned.
28 Worn piston rings.
29 Lubricating oil leakage from supply pipe.
30 Excessive preservation fluid (on initial engine start).
31 Excessive engine idle period.
32 Restriction in turbocharger bearing housing.
33 Restriction in lubricating oil filter.
34 Wet type air cleaner: restricted, dirty element, viscosity of oil to low/high.
35 Waste-gate actuator faulty or damaged.
36 Waste-gate valve not free.
37 Engine stopped too soon from high load.
38 Insufficient lubricating oil.
39 Fuel leakage from fuelled starting aid.
40 Crack in backplate of compressor.

Open engine breather

Early open breathers fitted to some 1000 Series engines have a pipe connected to the rocker cover which passes crankcase emissions directly to atmosphere.
Some of the later Phaser and 1000 Series engines are fitted with a plastic or steel gauze filter which separates oil particles from the crankcase emissions.
Some of the latest Phaser and 1000 Series engines are fitted with an oil separator that is not serviceable and must be renewed.The latest oil separator has the part number marked on the top of the cover.

To remove, to fit and to clean (early type) **Operation 9-6**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone RTV sealing and jointing compound	1861108

To remove

1 Release the clip, disconnect and remove the pipe from the breather cover. Release the two setscrews (A1). Remove the setscrews and their sealing washers (A2). Remove carefully the cover (A3) with a suitable lever to break the seal between the cover and the body of the breather. Ensure that the lever does not damage the cover. Ensure that the sealing washer under the head of each setscrew is not lost.

2 Use a suitable lever to remove carefully the gauze (A4). Do not damage the gauze.

To clean

1 Wash the gauze, the cover, and the breather pipe in an approved cleaning fluid and dry them with compressed air at low pressure.

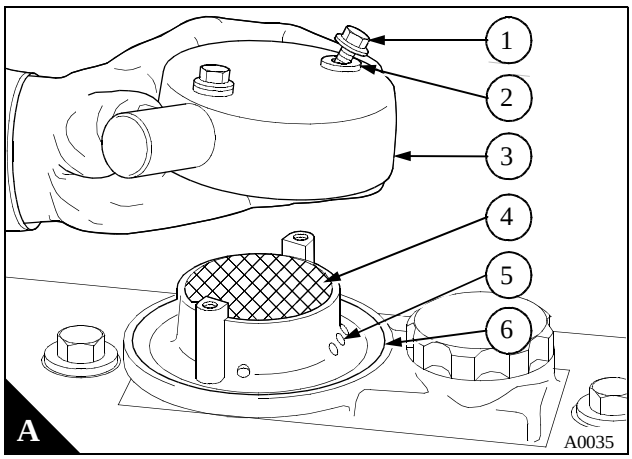
2 Remove the old sealant from the groove (A6) in the body of the breather. Ensure that the old sealant does not enter the engine. Ensure that the holes (A5) in the breather body are not restricted and, if necessary, clean the holes.

To fit

1 Put the gauze carefully into position in the body of the breather. Apply a bead of POWERPART Silicone RTV sealing and jointing compound to fill the groove in the body of the breather.

2 Put the cover in the correct position on the body of the breather. Inspect the sealing washers and, if necessary, renew them. Fit the sealing washers to the setscrews. Fit the setscrews and tighten them to 9 Nm (7 lbf ft) 0,9 kgf m. Clean off excess sealant from around the cover.

3 Check that there is no restriction in the breather pipe. Fit the breather pipe to the cover and tighten the clip.



Continued

To clean and to renew (Later type) **Operation 9-7**

Note: It is not necessary to remove the body of the oil separator from the rocker cover to obtain access to the gauze.

1 Release the hose clip (B1) and remove the hose from the breather cover (A1). Release the breather cover from the body of the breather (A4). The cover is a press fit onto the body.

2 Remove and discard the plastic or steel gauze (A2).

3 Clean the body of the oil separator with clean kerosene. Ensure that all of the kerosene is removed from the oil separator after cleaning.

4 If necessary, renew the "O" ring seal (A3).

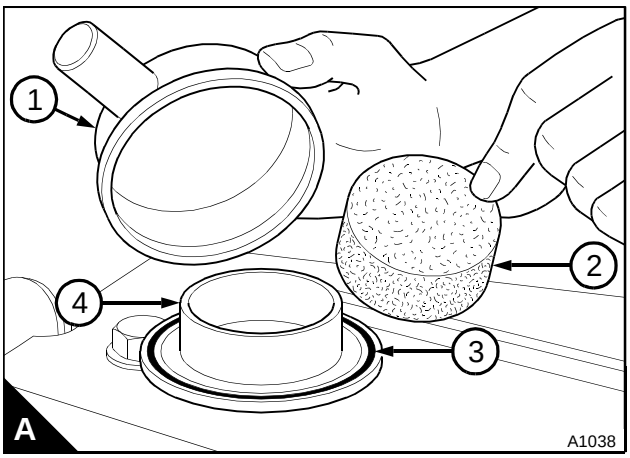
5 Check that the inside of the breather hose is clean. If the hose is not clean, release the hose clip and remove the hose. Wash the hose with kerosene and dry it with low-pressure air.

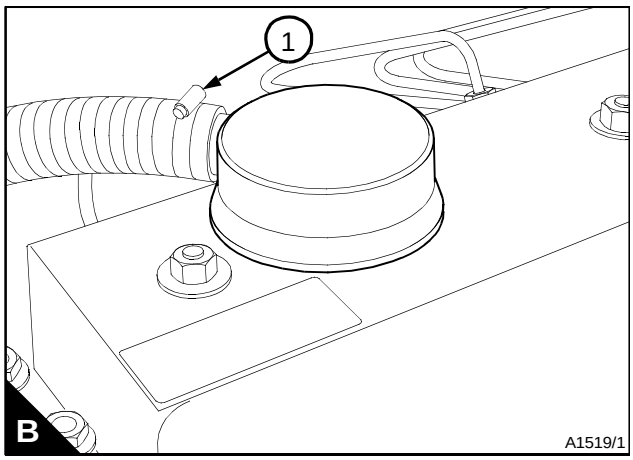
Note: If plastic gauze was fitted replace with steel gauze.

6 Renew the steel gauze.

7 Fit the cover to the breather body, ensure that it is securely fitted.

8 Fit the hose and tighten the hose clip (B1).





To renew (Latest type) **Operation 9-8**

Note: To remove the oil separator from the rocker cover, it will be necessary to make a tool (B) from 3,1 mm (0.125 in) mild steel plate, all dimensions are in millimetres.

Caution: *Do not attempt to remove the cover of the oil separator, this will damage the oil separator.*

1 Release the hose clip (A1) and remove the hose from the oil separator.

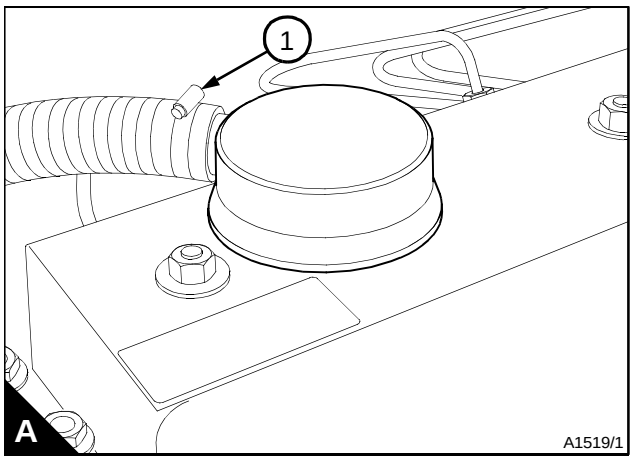
2 Use the pegs (C4) on the tool (C2) to contact the lugs (C5) of the oil separator. Rotate the tool counter-clockwise to release the oil separator.

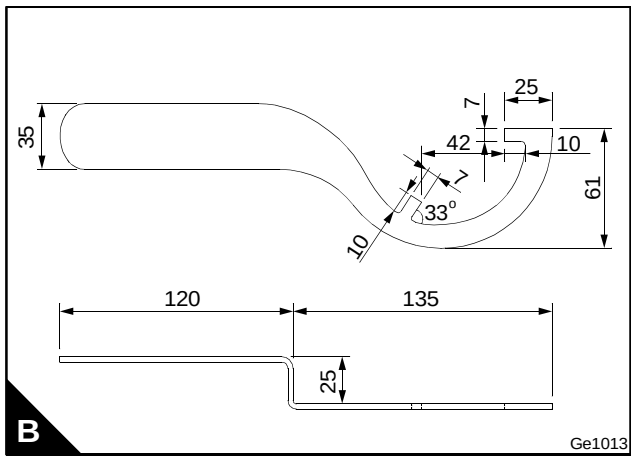
3 Ensure that the 'O' ring (C3), supplied with the new assembly, is fitted correctly to the new oil separator.

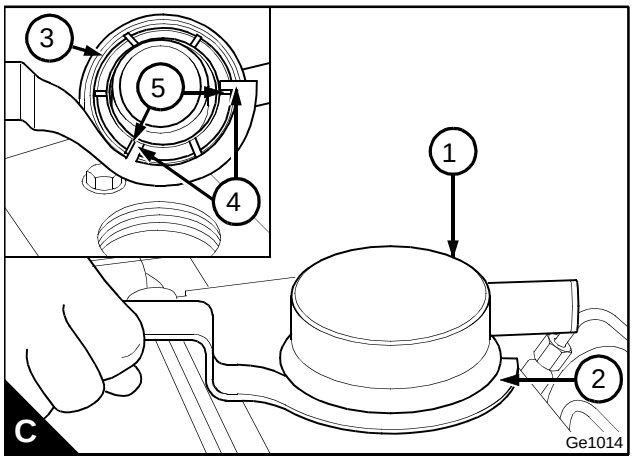
4 Lubricate the threads of the oil separator with clean engine lubricating oil.

5 Fit the new oil separator into the rocker cover until it is finger tight. Tighten the oil separator a further 90° with the tool.

6 Fit the hose and tighten the S clip (A1).







To Inspect **Operation 9-9**

If excessive crankshaft pressure is suspected the following procedure must be used.

Note: This procedure only refers to engines fitted with plastic rocker covers.

1 Remove the rocker cover and check if the end of the shroud (A4) has a skin of plastic.

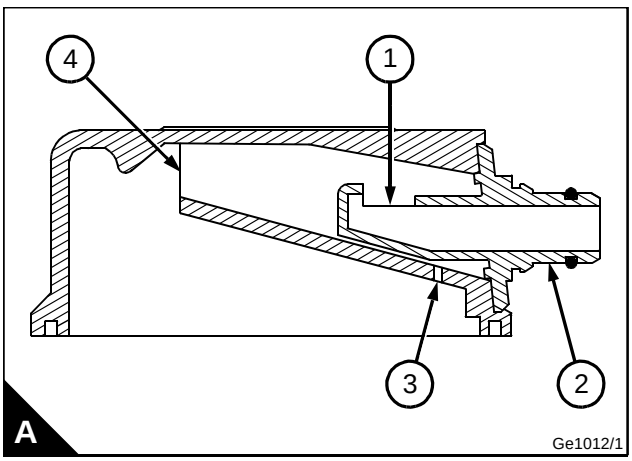
2 Remove the plastic skin and ensure all debris is removed.

3 Ensure hole (A3) in the shroud is not blocked, remove any blockage.

4 If breather connection (A2) is made of plastic, use low pressure compressed air in the end of the connection to check if there is any blockage, this can also have a plastic skin at the entry point (A1).

Notes:

- If the a plastic skin if found at (A1) the rocker cover assembly must be renewed.
- Do not try to remove the connector as this will result in a broken rocker cover.



Closed breather system

The early closed breather system is fitted to some naturally aspirated 1000 Series engines. The closed breather system has an oil separator which is fastened to the crankcase and a breather valve is fitted between the oil separator and the induction manifold. Crankcase gases pass through the oil separator where oil from the gases is returned to the sump. The crankcase gases then pass through the breather valve to the induction manifold.

The latest closed breather system is fitted to some naturally aspirated 1000 Series engines. The breather removes the combustion gases from the engine crankcase to the induction system.
An internal port in the rocker cover allows the gases to pass into the breather body through a gauze filter, then through 4 baffles (4 cylinder) and 5 baffles (6 cylinder). Oil particles removed from the gases, drain into the rocker cover through holes at the bottom of the chamber for the baffles. A valve controls the flow of the gases which pass from the breather, through the plastic outlet elbow, to the induction manifold. The rocker cover and breather assembly are made of a composite material and should be removed and fitted with care

It is very important that closed engine breather systems are fitted correctly to the engine. Below is a list of safety precautions that must be applied at all times.

***Cautions*:**

- *Do not exceed the correct level of lubricating oil in the sump. If there is too much lubricating oil, the excess must be drained to the correct level. An excess of lubricating oil could enter the breather valve. This could cause the engine speed to increase rapidly without control.*
- *Do not operate the engine if any of the breather valve or the induction hoses are loose or disconnected as this could allow dirt into the engine and damage to the engine could occur.*
- *Do not operate the engine if there is a blockage in the air filter or the induction hose. This can cause lubricating oil to enter the cylinders through the breather valve.*
- *Do not operate the engine if any of the breather valve or the induction hoses are bent such as to cause a restriction to the gases that flow through them. This can cause lubricating oil to enter the cylinders through the breather valve.*
- *Do not operate the engine at an angle of tilt greater than the limit approved for the engine. If there is doubt, contact the Perkins Service Department. If the approved angle is exceeded, an excess of lubricating oil could enter the breather valve. This could cause the engine speed to increase rapidly without control.*
- *Ensure that the breather valve or the induction hoses are cleaned and maintained in accordance with the maintenance schedules in the User's Handbook or the handbook of the manufacturer of the machine.*
- *Ensure that the breather valve assembly is renewed in accordance with the maintenance schedules in the User's Handbook or the handbook of the manufacturer of the machine.*

Continued

To clean the early closed breather system **Operation 9-10**

1 Release the hose clips and remove the breather valve (A2).

2 Release the short setscrew (A3) and the long setscrew (A5) and remove the oil separator (A4).

3 Wash the oil separator with approved cleaning fluid and dry it with low pressure air.

Caution: *Do not put the breather valve completely into the cleaning fluid.*

Warning! *Do not direct compressed air at your skin, if compressed air enters your skin obtain medical help immediately.*

4 The breather valve does not normally need to be cleaned. If the inside of the breather valve is to be cleaned, insert an approved cleaning fluid into the valve through the pipe at the bottom. Drain the fluid from the breather valve. Dry the breather valve with low pressure air.

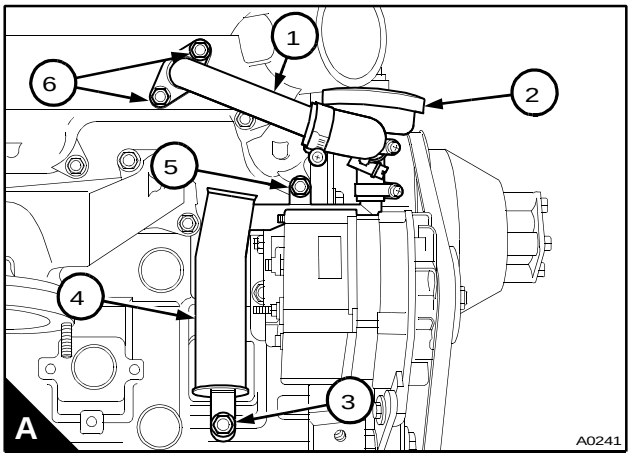
5 Check that the inside of the upper pipe (A1) is clean. If the pipe is not clean, release the flange setscrews (A6) and remove the pipe. Wash the pipe with kerosene and dry it with low pressure air.

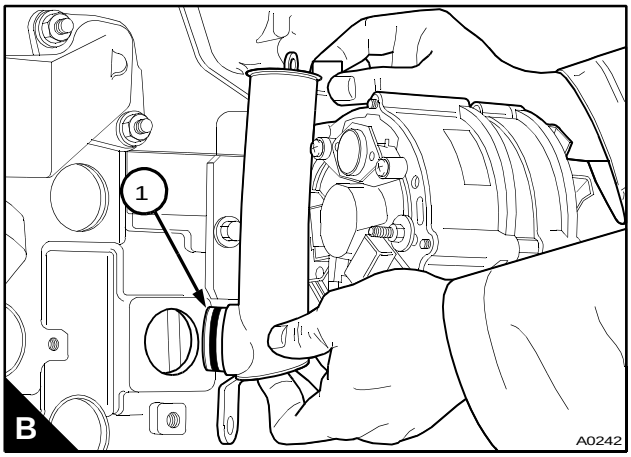
6 Ensure that the contact faces of the upper pipe flange and the induction manifold are clean.

7 Fit the upper pipe complete with a new joint and tighten the flange setscrews.

8 Renew the "O" ring (B1) at the bottom of the oil separator. Clean the bore in the cylinder block for the "O" ring of the oil separator. Lightly lubricate the "O" ring and fit the oil separator to the cylinder block. Fit the setscrews for the oil separator in their correct positions and tighten them.

9 Fit the breather valve and tighten the hose clips.





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To renew latest closed breather system **Operation 9-11**

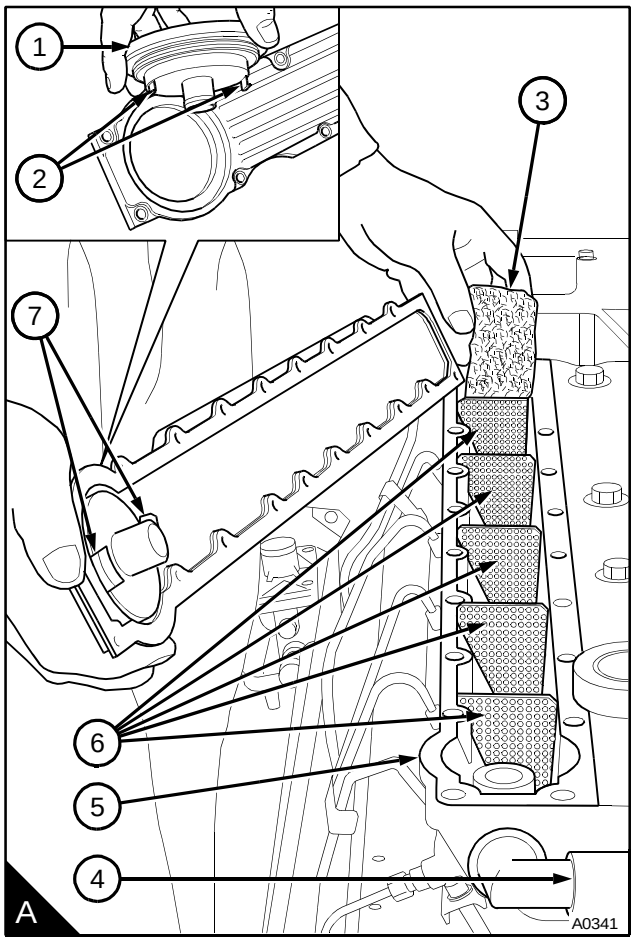
Caution: *Do not use excessive force to remove to remove the hose from the breather outlet elbow. If the elbow breaks away from the breather body, follow the procedure to repair the connection, see Operation 9-12.*

1 Release the hose clips and carefully remove the hose from the breather elbow (A4).

2 Remove the rocker cover, see Operation 3-1.

Caution: *Ensure the lever does not damage the cover.*

3 Release the fasteners and carefully remove the breather cover from the breather body. A suitable lever may be necessary to release the cover from the body of the breather. Ensure that the lever does not damage the cover. Discard the joint (A5).



Notes:

- The breather valve (A1) and the gauze (A3) must be renewed at the interval that follows:
- Breather valve - every 4000 hours of operation
- Gauze filter - every 2000 hours of operation.

Continued

4 Remove and discard gauze

Warning! *Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.*

***Cautions*:**

- *To prevent damage to the breather valve, remove the valve before the cover is washed.*
- *Ensure that all of the cleaning fluid is removed before the breather is assembled.*

5 Wash the body of the breather, the cover, the baffle plates (A6) and the breather elbow, every 2000 hours of operation. Use an approved kerosene cleaning fluid and dry them thoroughly with compressed air at low pressure.

6 Ensure that all the holes in the bottom of the chamber for the baffle plates are not restricted. If necessary, clean the holes.

7 Fit the baffle plates into grooves in the breather body.

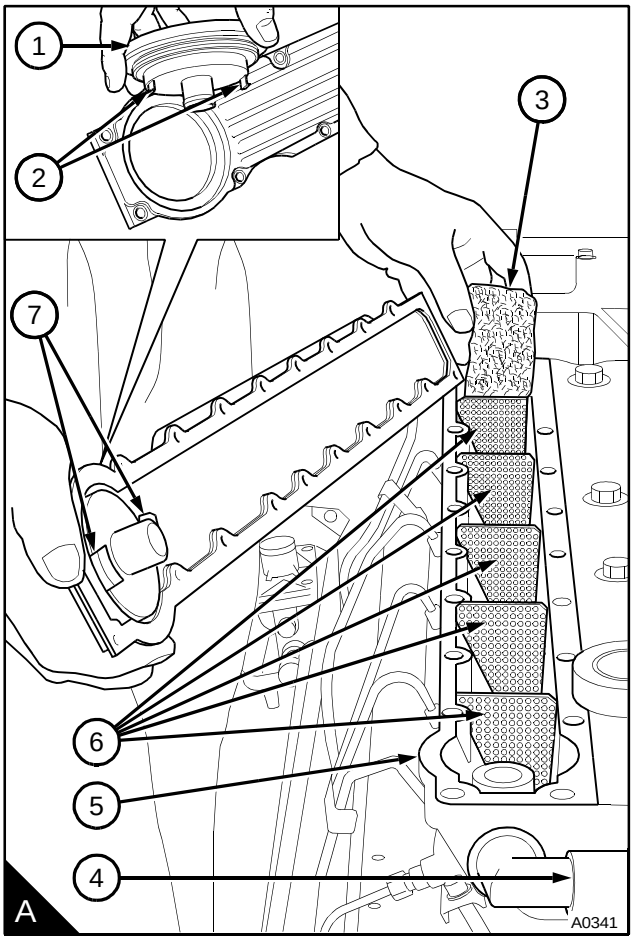
8 Fit a new gauze filter into the breather body.

9 Fit a new valve into the breather cover. Ensure that the clips are engaged correctly.

10 Renew the joint, which is fitted dry. Put the cover and valve assembly into the correct position on the breather body. Loosely fit the fasteners, the tighten gradually and evenly to 3 Nm (2.2 lbf ft) 0.3 kgf m.

Caution: *Do not use excessive force to fit the hose to the breather outlet elbow.*

11 Check that there is no restriction in the breather elbow or the breather hose. Carefully fit the breather hose to the elbow and tighten the clip.



To repair the connection for the latest breather outlet elbow **Operation 9-12**

Special requirements

Consumable products	
Description	**Part number**
Permabond E3524	

Caution: *Clean thoroughly the inside of the breather body after it has been drilled.*

1 Ensure that the breather body is secure and use a 22,5 mm (0.89 in) drill to a depth of 10 mm (0.39 in) to remove the broken connection of the outlet elbow. Clean thoroughly the inside of the breather body.

2 Thoroughly clean the contact faces of the elbow and the breather cover.

3 Renew the breather elbow. Ensure that the contact surface of the elbow connection has a rough finish. Put the elbow into position onto the breather body.

Warning! *Read the manufacturers safety instructions before the use of "Permabond E3524" adhesive.*

4 Apply "Permabond E3524" adhesive, to secure the elbow to the breather body.

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Lubrication system

General description (four cylinder engine lubrication system)

Pressure lubrication is supplied by a rotor type pump which is driven through an idler gear from the crankshaft gear. The pump has an inner rotor and an outer rotor which are off-centre to each other. There is a key between the inner rotor and the drive shaft. The inner rotor has six lobes which mesh with the seven lobes of the outer rotor. When the pump rotates, the space between the lobes of the outer rotor which are in mesh increases to cause a suction or decreases to cause a pressure increase. If a balancer unit (page 240/A) is fitted, the oil pump is fitted to the balancer frame and is driven by the balancer drive shaft.

Lubricating oil see page 239/A1 from the sump passes through a strainer and pipe to the suction side of the pump.

The lubricating oil, see page 239/A2 passes from the outlet side of the pump through a pipe to a relief valve, which is fitted to the bottom of the left side of the cylinder block. If a balancer unit is fitted, the relief valve is fitted in the frame of the balancer. The relief valves opens if the oil pressure is too high; this allows some of the lubricating oil to return to the sump.

From the relief valve, lubricating oil passes to a plate type oil cooler (some naturally aspirated engines do not have an oil cooler). The oil cooler is either fitted to the left side of the cylinder block and has seven plates, or it is fitted between the oil filter head and the filter canister and has ten plates. Some oil coolers are fitted with a by-pass valve. If cold oil increases the restriction in the cooler, the by-pass valve opens and the oil passes directly from the inlet side to the outlet side of the cooler.

Lubricating oil from the oil cooler, passes to an oil filter. The oil filter can be fitted to the left or right side of the engine. If the filter is fitted to the right side, see page 240/A of the engine, the oil passes through a pipe connected between the relief valve and the right side of the cylinder block. The oil passes from the pipe through a passage in the right side of the cylinder block to an oil cooler and then to the oil filter. When the oil filter is on the right side of the engine, and an oil cooler is fitted, the oil cooler will be between the oil filter head and the oil filter canister.

The lubricating oil passes from the filter to the pressure rail which is drilled the complete length of the left side of the cylinder block. If the oil filter is on the right side of the engine, the oil passes through a passage drilled across the cylinder block to the pressure rail.

From the pressure rail, lubricating oil passes to the main bearings of the crankshaft and through passages in the crankshaft to the big end bearings. The pistons and the cylinder bores are lubricated by splash and oil mist.

Lubricating oil, see page 239/A3 passes from the main bearings through passages in the cylinder block to the journals of the camshaft. Lubricating oil passes from the centre journal of the camshaft through a passage in the cylinder block and cylinder head to a restriction in the pedestal of the rocker shaft, at a reduced pressure, see page 239/A4, to the rocker bushes. The oil passes through a passage in the rocker shaft to the bearings of the rocker levers. The valve stems, valve springs and the tappets are lubricated by splash and oil mist.

The hub of the idler gear is lubricated by oil from the pressure rail and the timing gears are splash lubricated.

The turbocharger is lubricated by oil after the filter. Oil is supplied from a connection on the right side of the cylinder block through a pipe to the turbocharger. The oil passes through the turbocharger and returns through a pipe to the sump.

Turbocharged engines have piston cooling jets fitted. These jets are connected to the oil pressure rail and spray lubricating oil inside the pistons to keep them cool.

General description (six cylinder engine lubrication system)

The oil pump is similar to that used on four cylinder engines and is also driven through an idler gear from the crankshaft gear. The inner rotor has four lobes and the outer rotor has five lobes.

Lubricating oil from the sump passes through a strainer and pipe to the suction side of the pump.

The oil passes from the outlet side of the pump, through a pipe and a passage in the cylinder block to the oil filter head. The oil then passes through a passage in the filter head and a pipe to a plate type oil cooler, see the off set (page 239/A), which is an integral part on the left of the cylinder block. On naturally aspirated engines the oil cooler has four plates and on turbocharged engines the cooler has eight plates. The oil cooler is fitted with a by-pass valve. If cold oil increases the restriction in the cooler, the by-pass valve opens and the oil passes directly from the inlet side to the outlet side of the cooler. If the engine is not fitted with an oil cooler, the oil passes from the oil pump to the relief valve.

From the oil cooler, the oil returns through a pipe to the filter head where the oil divides to the relief valve and to the oil filter. The oil filter can be fitted on the left or right side of the engine. If the filter is fitted on the right side of the engine, the oil passes through a pipe connected between the relief valve and the right side of the cylinder block to the oil filter.

The lubricating oil passes from the filter to the pressure rail which is drilled the full length of the left side of the cylinder block. If the oil filter is on the right side of the engine, the oil passes through a passage drilled across the cylinder block to the pressure rail.

From the pressure rail, lubricating oil passes to the main bearings of the crankshaft and through passages in the crankshaft to the big end bearings. The pistons and the cylinder bores are lubricated by splash and oil mist.

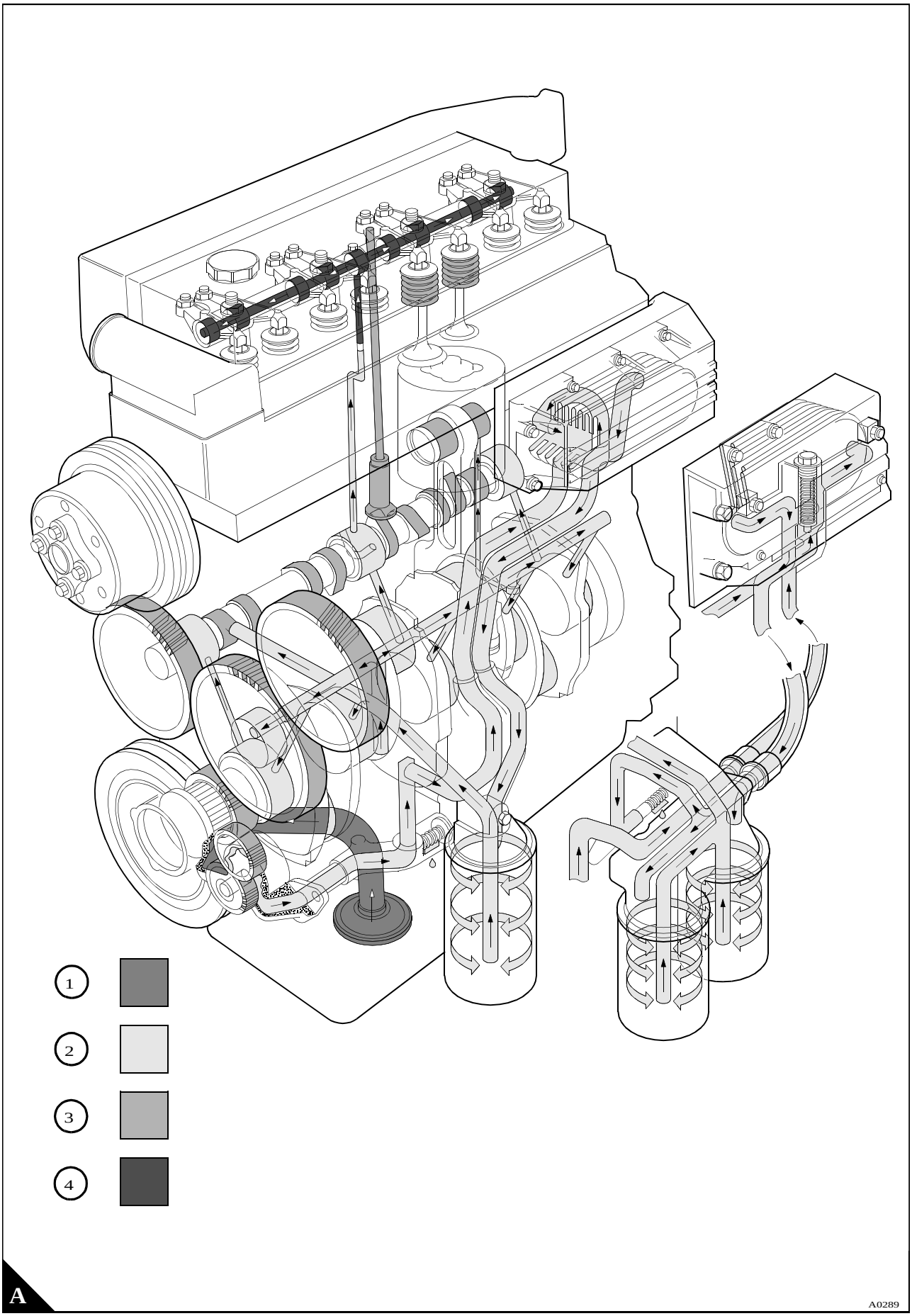
Lubricating oil passes from the main bearings through passages in the cylinder block to the journals of the camshaft. Lubricating oil passes, at a reduced pressure, from the second journal of the camshaft through a passage in the cylinder block and cylinder head to the rocker shaft. The oil passes through a passage in the rocker shaft to the bearings of the rocker levers. The valve stems, valve springs and the tappets are lubricated by splash and oil mist.

The hub of the idler gear is lubricated by oil from the pressure rail and the timing gears are splash lubricated.

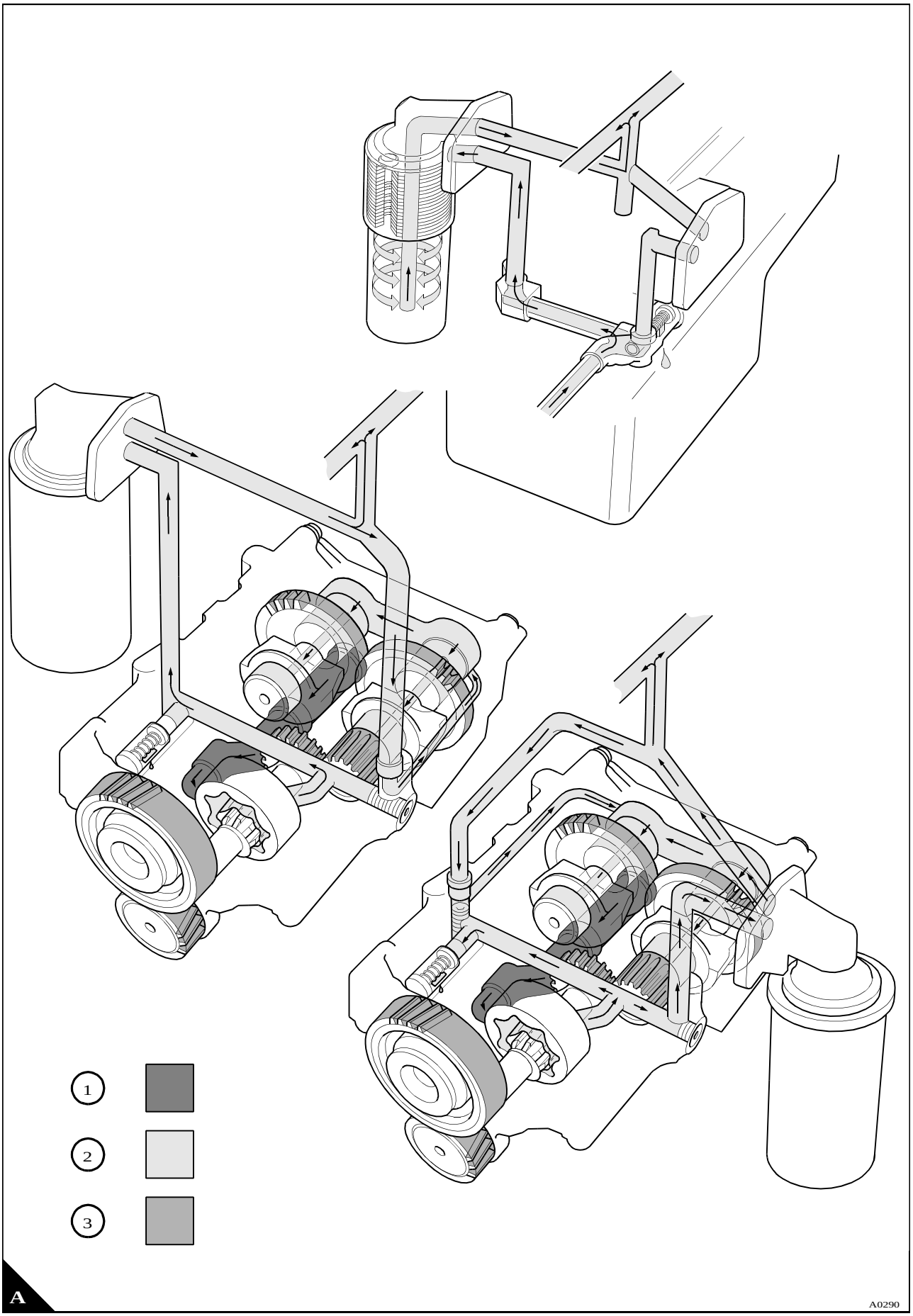
The turbocharger is lubricated by oil after the filter. Oil is supplied from a connection on the right side of the cylinder block through a pipe to the turbocharger. The oil passes through the turbocharger and returns through a pipe to the sump.

Turbocharged engines have piston cooling jets fitted. These jets are connected to the oil pressure rail and spray lubricating oil inside the pistons to keep them cool.

Lubrication system flow diagram



Lubrication system flow diagram for the relief valve and balancer



Filter canister

To renew **Operation 10-1**

The filter can have one or two canisters fitted. When two canisters are fitted, both must be renewed at the same time. On some engines an oil cooler (B) is fitted between the filter head and the filter canister. This arrangement is fitted on the left side or the right side of the engine.

On some four and six cylinder engines the adaptor (A1) or (B1) is sealed into the filter head. A new filter head is supplied without the adaptor fitted; if either the adaptor or the filter head is to be renewed, both parts will be necessary.

1 Put a tray under the filter to contain spilt lubricating oil.

2 Remove the filter canister with a strap wrench or a similar tool and then discard the canister.

Note: If the adaptor is to be renewed the thread sealant which is applied to one end during manufacture must be inserted into the filter head.

3 Clean the seal face of the filter head, or the bottom face of the oil cooler.

Caution: *Ensure that the adaptor (A1) or (B1) is secure in the filter head.*

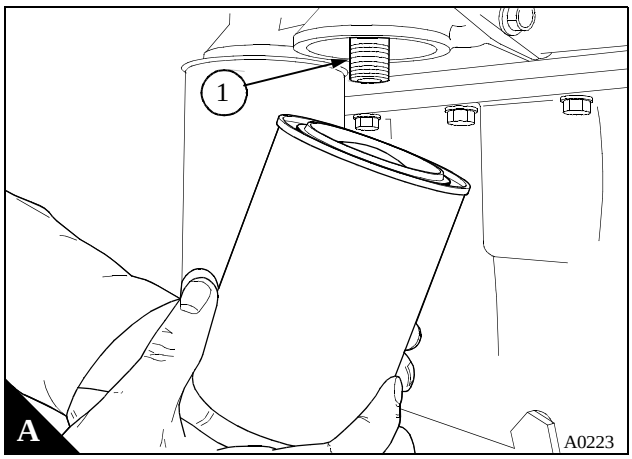
4 Add clean engine lubricating oil to the new canister. Give the oil time to fill the canister through the filter element.

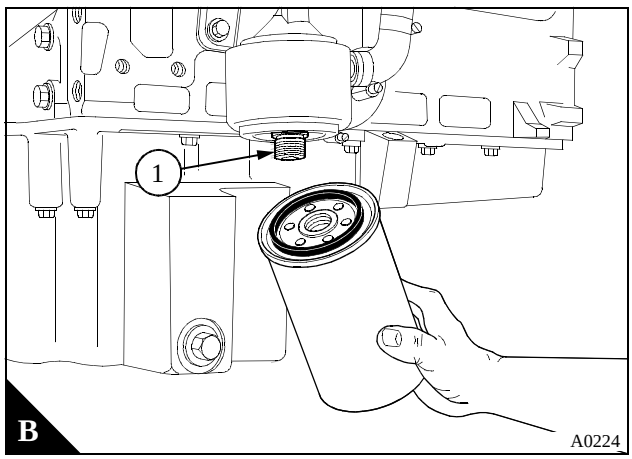
5 Lubricate the top of the canister seal with clean engine lubricating oil.

6 Install the new canister and tighten it by hand only. Do not use a strap wrench.

7 After the lubricating oil has been added to the sump, operate the engine and check for leakage from the filter. When the engine has cooled, check the oil level on the dipstick and add oil to the sump, as necessary.

Caution: *The canister contains a valve and special tube which ensure that lubricating oil does not drain from the filter. Therefore, ensure that the correct Perkins POWERPART canister is used.*





Filter head

To remove and to fit — Operation 10-2

1 Put a tray under the filter head to contain spilt lubricating oil.

2 Remove the filter canister(s), see Operation 10-1.

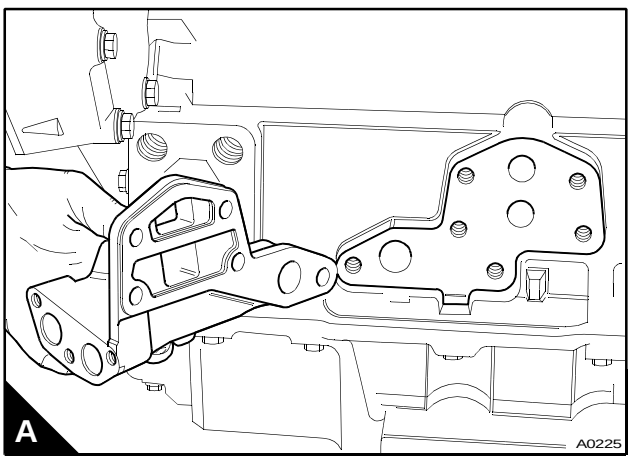
3 If a lubricating oil cooler is fitted, release the setscrews and remove the oil cooler pipes from the filter head. Discard the joint. If the filter head is fitted to the right side of a turbocharged engine, disconnect the oil supply pipe of the turbocharger. Use a spanner on the hexagonal end of the flexible pipe (B1) to hold the pipe while the connection (B2) is released. If an adaptor is used in the filter head, use a spanner to hold the adaptor while the union nut is released.

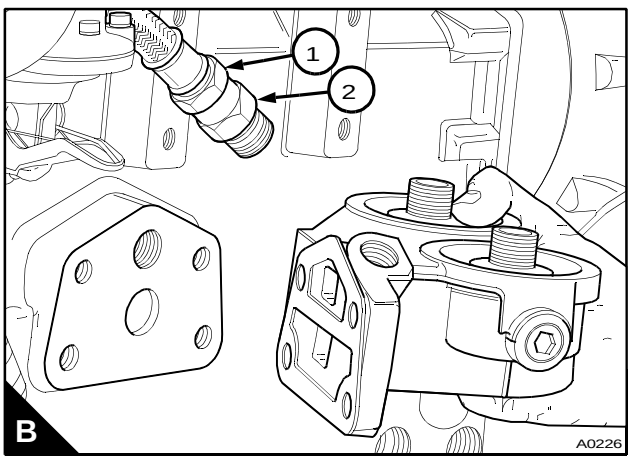
Note: On some engines an oil cooler is fitted between the filter head and the filter canister. To remove the oil cooler, see Operation 12-27.

4 Release the setscrews or nuts and remove the filter head from the cylinder block (A or B). Discard the joint.

5 Clean the joint face of the filter head and, if fitted, the flange of the oil cooler pipes. Fit the filter head and a new joint. Tighten the setscrews or nuts. If necessary, fit the pipes of the oil cooler and a new joint, see Operation 10-17. Tighten the setscrews. Where necessary, connect the oil supply pipe of the turbocharger. If the union connection on the flexible pipe fits into the filter head, clean the thread of the connection and apply a thread sealant. Ensure that dirt does not enter the filter head. Use a spanner to hold the flats on the pipe while the connection is fitted to the oil filter head. If an adaptor is used in the filter head, use a spanner to hold the adaptor when the union nut is tightened.

6 Fit new filter canister(s), see Operation 10-1.





Sump

To remove and to fit — Operation 10-3

1 Operate the engine until it is warm.

2 Stop the engine, remove the sump drain plug and its "O" ring and drain the oil. Where necessary, remove the dipstick and the dipstick tube.

3 Provide a support for the sump and remove the setscrews and the two nuts which fasten the sump to the cylinder block and to the timing case. Lower the sump and remove the joint.

4 Wash the sump with an approved cleaning fluid, ensure all the cleaning fluid is removed. Clean the flange face of the sump and of the cylinder block. If necessary, renew the felt dust seal which is fitted to the rear of the sump flange on some engines.

5 Fit the sump together with a new joint and ensure the correct location with a setscrew on each side. Fit the remainder of the setscrews and the nuts and tighten all the fasteners to 22 Nm (16 lbf ft) 2,2 kgf m. Fit the drain plug together with a new "O" ring and tighten the plug to 34 Nm (25 lbf ft) 3,5 kgf m. Where necessary, fit the dipstick tube and the dipstick.

6 Fill the sump to the "MAX" level on the dipstick with an approved lubricating oil.

Oil strainer and suction pipe

To remove and to fit — Operation 10-4

The oil strainer is an integral part of the suction pipe. No regular service is necessary but wash the strainer when it is removed. On four cylinder engines which have a balancer fitted, the suction pipe is normally a short pipe which is fastened to the balancer frame and a pipe bracket is not fitted.

Some four cylinder engines have an oil strainer and suction pipe which are made of a composite material. This arrangement has an "O" ring seal on the flange face of the oil pump instead of a joint.

To remove 6 cylinder engines

1 Remove the sump, see Operation 10-3.

2 Release the setscrew which holds the bracket to the main bearing cap (A2).

3 Release the setscrews from the flange of the suction pipe (A1). Remove the suction pipe and strainer. Remove and the old joint. Clean the flange face of the oil pump and of the suction pipe.

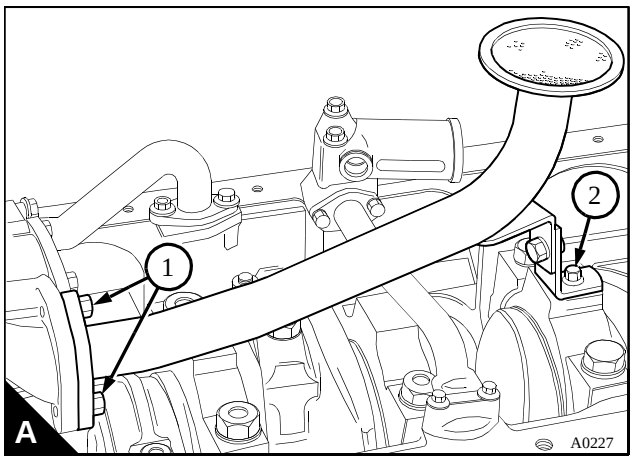
To fit 6 cylinder engines

1 Loosely assemble the bracket of the suction pipe to the correct main bearing cap (A2).

2 Fit the suction pipe to the oil pump together with a new joint (A1). Tighten the setscrews.

3 Tighten the setscrew of the suction pipe bracket. Ensure that there is no stress on the suction pipe.

4 Fit the sump, see Operation 10-3.



Continued

To remove 4 cylinder engines

1 Remove the sump, see Operation 10-3.

2 Release the setscrew which holds the bracket to the main bearing cap (B3).

3 Release the setscrews from the flange of the suction pipe (B1). Remove the suction pipe, strainer and bracket. Remove the old joint or “O” ring. Clean the flange face of the oil pump and of the suction pipe.

To fit 4 cylinder engines

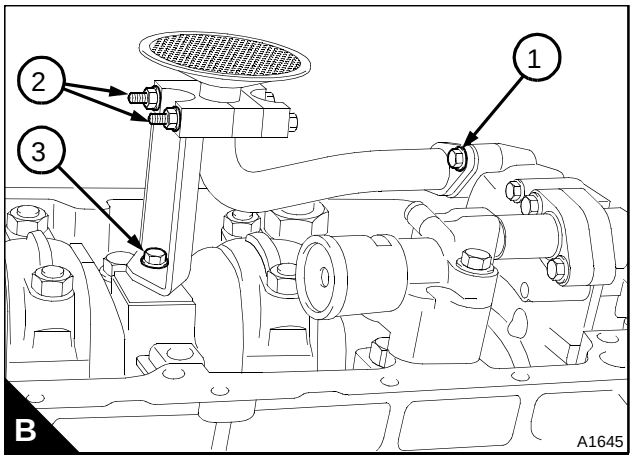
1 Loosely fit the bracket (B3) of the suction pipe (if fitted) to the correct main bearing cap.

2 Fit the suction pipe to the oil pump together with a new joint or “O” ring (B1). Tighten the setscrews.

3 Tighten the setscrew of the suction pipe bracket. Ensure that there is no stress on the suction pipe.

4 If the nuts and bolts (B2) for the clamp type bracket (B), used on some four cylinder engines, have been loosened or removed, assemble all parts loosely to the engine. Ensure that the clamp, the bracket and the pipe are correctly aligned before the nuts and bolts are tightened. Tighten the setscrews (B1) to the oil pump, then the setscrew (B3) and the nuts and bolts (B2) last. Ensure that there is no stress on the suction pipe.

5 Fit the sump, see Operation 10-3.



To inspect and to correct **Operation 10-5**

1 Wash the assembly in an approved cleaning fluid and dry it thoroughly.

2 Check the pipe, the strainer and the welded joints for cracks and other damage. Check that the mounting bracket is secure.

3 If the damaged component cannot be welded correctly, renew the assembly.

4 Composite material parts must be renewed if they have cracks or damage.

Lubricating oil pump

To remove **Operation 10-6**

For four cylinder engines fitted with a balancer unit, the oil pump is integral with the balancer unit, see Operation 5-21 and Operation 5-23.

The latest engines have a new lubricating oil pump which has a channel (B1) in the body of the pump. Lubricating oil from the front main bearing passes down the channel in the body of the pump to an oil hole in the idler shaft. The lubricating oil then passes through the hole in the idler shaft to the bush in the idler gear.

1 Drain the lubricating oil and remove the lubricating oil sump, see Operation 10-3.

2 Remove the suction pipe and strainer, see Operation 10-4.

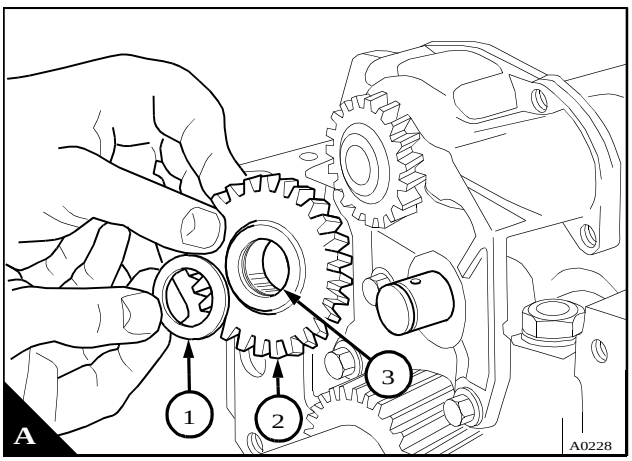
3 For four cylinder engines: Remove the oil pressure relief valve, see Operation 10-13, and the delivery pipe.

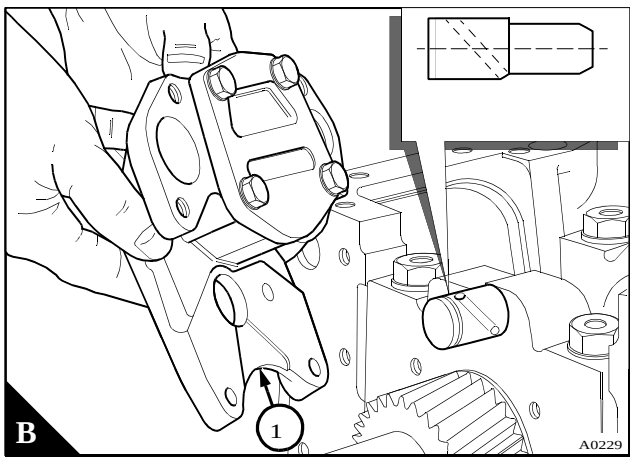
For six cylinder engines: Remove the delivery pipe of the oil pump.

4 The oil pump is fitted to number 1 main bearing cap. The oil pump can be removed with the main bearing cap, if a suitable spanner is available that will enable the torque to be applied correctly to the setscrews of the main bearing cap when it is fitted. If a suitable spanner is not available, the timing case must be removed, see Operation 6-1.

5 Release the circlip which retains the idler gear of the oil pump and remove the washer (A1) and the idler gear (A2).

6 Release the setscrews and remove the oil pump (B).





To fit **Operation 10-7**

1 Fill the oil pump with clean engine lubricating oil. Fit the oil pump to the main bearing cap and tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

2 Check the idler gear and the bush for wear and other damage. If the gear and/or bush are damaged, they can be renewed as an assembly or the bush can be renewed as a single item. Check the shaft of the idler gear for wear or other damage. If the shaft is worn or damaged, renew the shaft, see "Lubricating oil pump idler gear shaft" on page 249.

Lubricate the bush (A3) with clean engine lubricating oil and fit the idler gear (A2), the washer (A1) and the circlip. Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump gear and the idler gear (B).

3 If number 1 main bearing cap was removed, lubricate the bearing with clean engine lubricating oil and fit the bearing cap. Tighten the setscrews to 265 Nm (196 lbf ft) 27,0 kgf m. If the timing case was removed, fit the timing case, see Operation 6-2.

4 Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump idler gear and the crankshaft gear. If the latest lubricating oil pump with the oil supply channel is fitted, see Operation 10-9, the end-float for the idler gear is as follows:

- Four cylinder engines: 0,012/0,643 mm (0.0005/0.0253 in)
- Six cylinder engines: 0,020/0,650 mm (0.0008/0.0256 in)

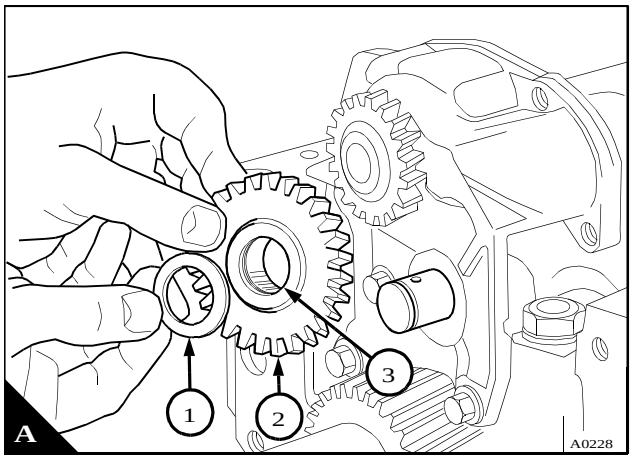
5 Fit the suction pipe and strainer, see Operation 10-4.

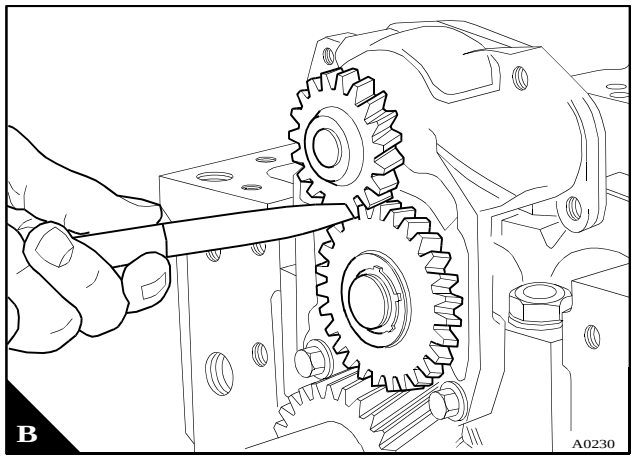
6 For four cylinder engines: Fit the delivery pipe and oil pressure relief valve, see Operation 10-13.

For six cylinder engines: Fit the delivery pipe and tighten the setscrews. Use new joints.

Note: An improved delivery pipe has been fitted to six cylinder engines from engine number Y-----U503656S. The new pipe, has an elbow and a 12,5 mm (0.5 in) thick flange instead of the two 6 mm (0.24 in) flanges of the earlier pipe. Joints are not used with the new pipe.

7 Fit the lubricating oil sump, see Operation 10-3. Fill the sump to the "MAX" mark on the dipstick with an approved lubricating oil.





To inspect **Operation 10-8**

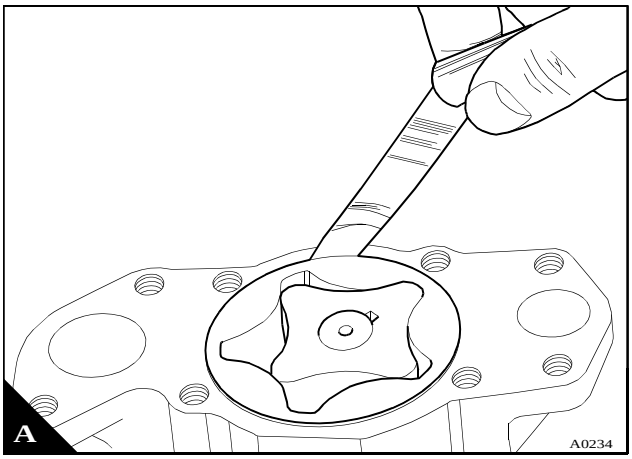
If any part is worn enough to have an effect on the performance of the oil pump, the complete oil pump must be renewed.

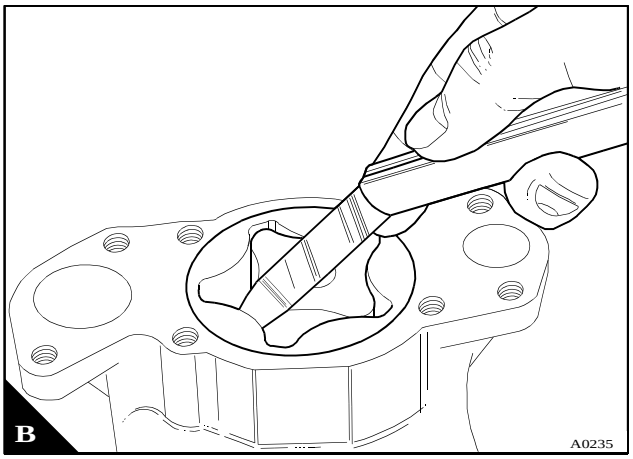
1 Release the setscrews and remove the cover of the oil pump. For pumps which are fitted to a balancer unit, remove the single setscrew and the cover.

2 Remove the outer rotor and clean thoroughly all the parts. Check for cracks and any other damage.

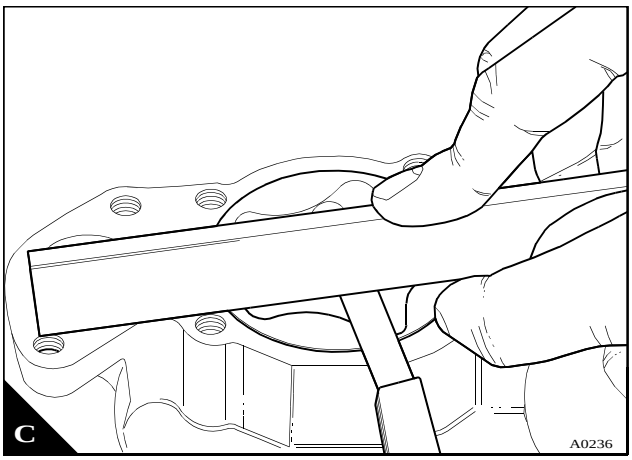
3 Fit the outer rotor and check the outer rotor to body clearance (A).

4 Check the inner rotor to outer rotor clearance (B).





5 Check the rotor end-float with a straight edge and a feeler gauge (C). For all the above clearances, refer to the relevant Data and dimensions for the "Lubrication system" on page 48.



6 Clean the top face of the oil pump and the bottom face of the cover and fit the cover. Tighten the setscrews to 28 Nm (21 lbf ft) 2,9 kgf m. For pumps which are fitted to a balancer unit, put the cover in position and tighten the single setscrew to 22 Nm (16 lbf ft) 2,2 kgf m.

Lubricating oil pump idler gear shaft

The idler shaft for the lubricating oil pump fitted in the front main bearing cap of six cylinder engines is now retained by a pin and POWERPART Retainer (oil tolerant). If it is necessary to renew the idler shaft on these engines, follow the procedure given below. The idler shaft used on earlier six cylinder engines is retained by the interference fit of the idler shaft in the bearing cap.

The latest engines have a new idler shaft (A3) which has an oil hole (A2) to provide more lubrication to the bush for the idler gear. Also a new lubricating oil pump has been introduced which has a channel (A4) in the body of the pump. Lubricating oil from the front main bearing passes down the channel in the body of the pump to the oil hole in the idler shaft. The lubricating oil then passes through the hole in the idler shaft to the bush in the idler gear.

To remove the idler shaft **Operation 10-9**

Caution: *The pin is very hard; if the tap is broken or the pin cannot be removed, see Operation 10-10.*

1 Carefully use an M5 X 0,8 mm taper tap to put a chamfer in the end of the pin (B1). Remove the tap.

2 Carefully use an M5 X 0,8 mm plug tap to cut not less than three complete threads in the end of the pin. Remove the tap.

3 Obtain the parts listed below:

- An M5 X 0,8 mm setscrew or a setscrew which has a thread which is at least 15 mm long.
- An M5 X 0,8 mm nut.
- A spacer with a 15,88 mm or 19,05 mm outside diameter and an internal diameter of 8,73 mm which is 9,53 mm long.

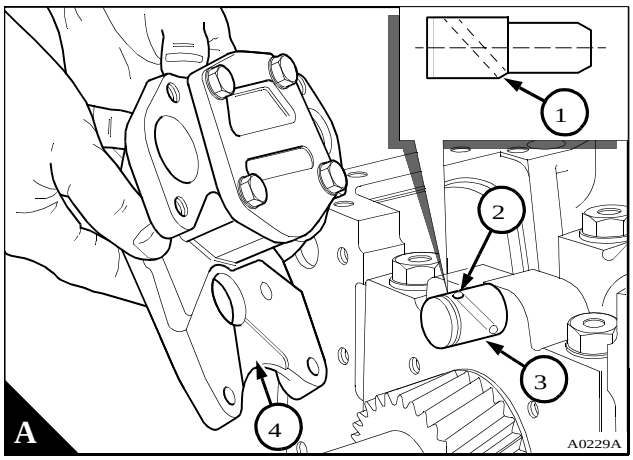
4 Fit the nut fully onto the threads of the setscrew and put the spacer onto the nut.

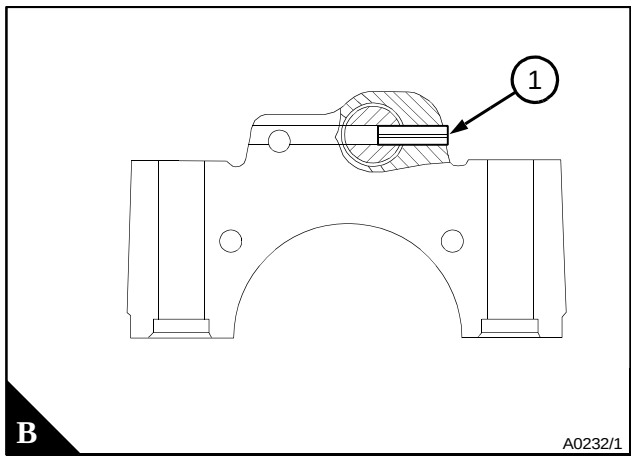
Caution: *Do not use excessive torque.*

5 Hold the spacer in position and engage the setscrew fully into the threads in the pin.

6 Put the spacer into position centrally over the pin and tighten the nut onto the spacer. Continue to tighten the nut and pull the pin through the spacer. Withdraw the pin enough to pull the pin out of the bearing cap with pliers.

7 Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.





Alternative method to remove the idler shaft **Operation 10-10**

Note: This method to remove the pin from the idler shaft must only be used if the pin cannot be removed by the earlier method.

1 Make a drill guide (A) to the dimensions given in the table below.

2 Put the drill guide (B1) into position in the setscrew hole on the opposite side of the bearing cap to the pin (B2). Ensure that the countersink in the guide faces to the outside and that the edge of the guide is aligned with the front edge of the bearing cap. Use a $^{5}/_{16}$ UNF setscrew (B3) and a plain washer (B4) to retain the guide in position.

3 Drill a 6,35 mm (0.25 in) diameter hole in the bearing cap 47,0 mm (1.85 in) deep.

4 Remove the drill and the drill guide.

5 Insert suitable drift into the hole in the bearing cap and drive out the pin.

6 Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.

A1 8,3 mm (0.327 in)

A2 20,0 mm (0.984 in)

A3 1,0 mm (0.039 in)

A4 16,1/16,4 mm (0.633/0.646 in)

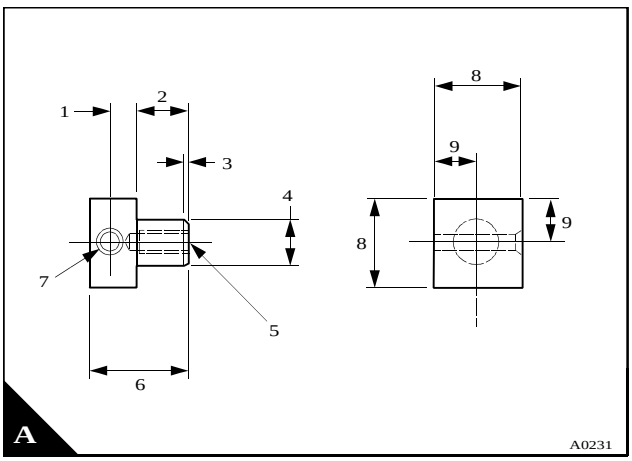
A5 6,9 x 22 mm (0.272 x 0.866 in) diameter hole for 5/16-24 UNF x 18 mm thread

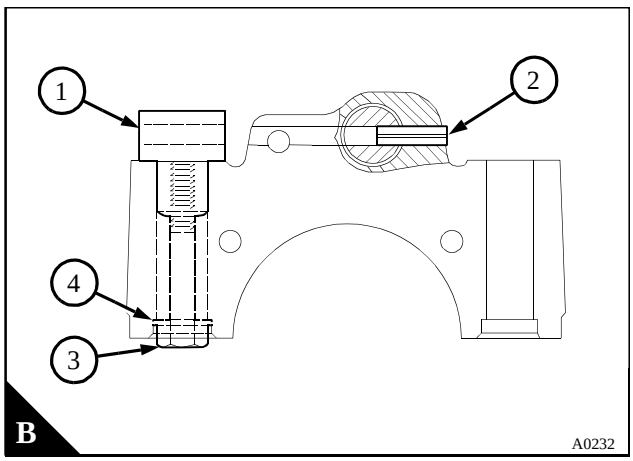
A6 36,0 mm (1.42 in)

A7 6,5/6,6 mm (0.256/0.260 in) diameter hole, countersink 9,0 mm x 900 included

A8 31,75 mm (1.250 in)

A9 15,9 mm (0.626 in)





To fit the idler shaft (Six cylinder engines) **Operation 10-11**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Check that the new idler shaft and the hole for the idler shaft in the bearing cap are clean and free from oil or grease. Remove any rough edges from the hole of the bearing cap.

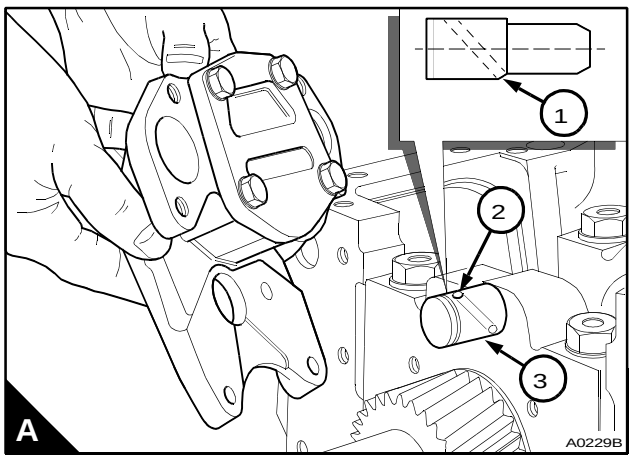
2 Support the rear of the bearing cap and ensure that the cap will not move when the idler shaft is pressed in. Apply only enough POWERPART Retainer (oil tolerant) around the chamfer of the shaft to fully cover the surface of the hole when the shaft is pressed into position. Enter the chamfer of the idler shaft into the hole.

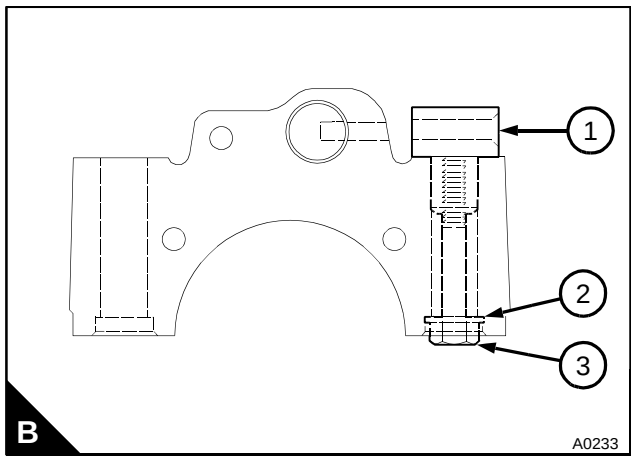
If the idler shaft (A3) has an oil hole ensure that the hole (A2) in the idler shaft is at the top and that the flat (A1) is at the bottom before the shaft is pressed into the bearing cap.

Ensure that the idler shaft is square to the bearing cap and press the shaft in onto its shoulder. Remove the surplus POWERPART Retainer from the idler shaft, the oil hole and the bearing cap before the oil pump is fitted.

3 Use the original hole for the pin in the bearing cap as a guide and drill a 6,35 mm (0.25 in) diameter hole in the idler shaft 9,5 mm (0.37 in) deep.

4 Fit a new pin, into the bearing cap and idler shaft.





To fit the idler shaft (where a pin was not fitted)

1 Follow the procedure to fit the idler shaft, steps 1 and 2 of Operation 10-11.

2 Put the drill guide (B1) into position in the right hand (seen from the front face of the bearing cap) setscrew hole of the bearing cap. Ensure that the countersink in the guide faces to the outside and that the edge of the guide is aligned with the front edge of the bearing cap. Use a $^{5}/_{16}$ UNF setscrew (A3) and a plain washer (B2) to retain the guide in position.

3 Drill a 6,35 mm (0.25 in) diameter hole in the bearing cap 25,4 mm (1.0 in) deep.

4 Remove the drill and the drill guide.

5 Fit a pin, part number 2116087, into the bearing cap and idler shaft.

To remove and to fit the idler shaft (four cylinder engines) **Operation 10-12**

Special requirements

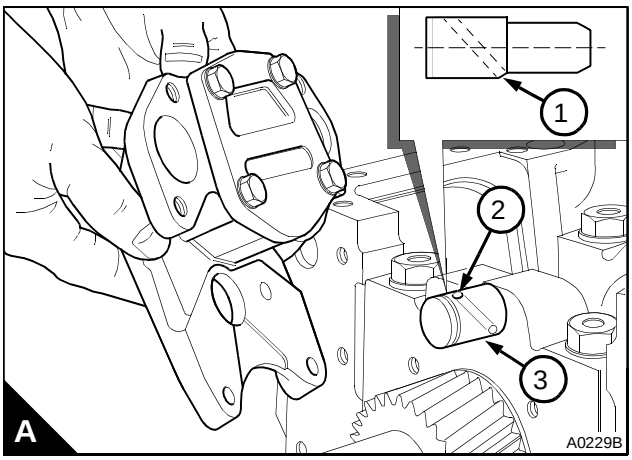
Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Support the front of the bearing cap. Put a suitable adaptor on the small diameter of the idler shaft and press the idler shaft out of the bearing cap.

2 Ensure that the idler shaft and the hole in the bearing cap are clean. Support the rear of the bearing cap and ensure that the cap will not move when the idler shaft is pressed in. Apply POWERPART Retainer (oil tolerant) to the small diameter of the idler shaft. The idler shaft for four cylinder engines is not retained by a pin.

If the idler shaft (A3) has an oil hole ensure that the hole (A2) in the idler shaft is at the top and that the flat (A1) is at the bottom before the shaft is pressed into the bearing cap.

Enter the chamfer of the idler shaft into the hole. Ensure that the idler shaft is square to the bearing cap and press in the shaft onto its shoulder. Remove the surplus POWERPART Retainer (oil tolerant), ensure that the oil hole is clear of the retainer.



Relief valve

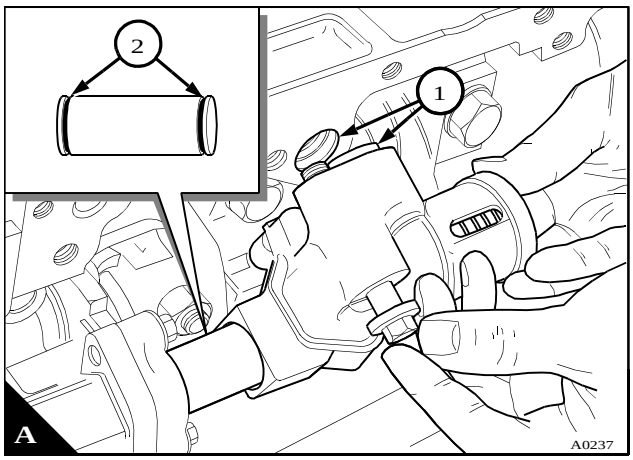
To remove and to fit **Operation 10-13**

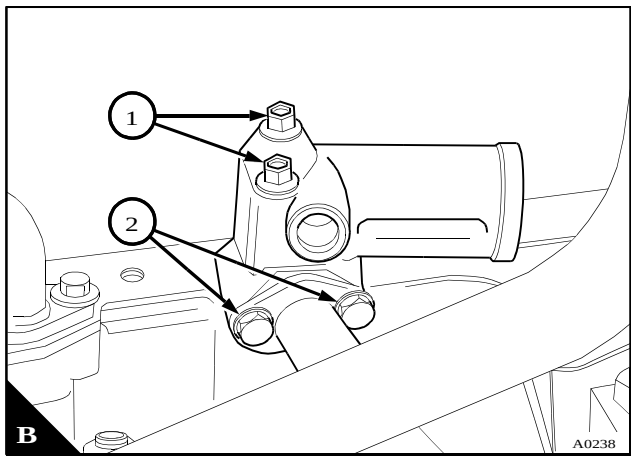
Note: For four cylinder engines which have a balancer unit have a relief valve fitted inside the balancer frame. The relief valve of these engines cannot be removed as an assembly.

1 Drain the lubricating oil and remove the sump, see Operation 10-3.

2 For four cylinder engines: Release the setscrew and rotate the relief valve to withdraw the thimble from the cylinder block (A1). Pull the relief valve from the delivery pipe and pull the delivery pipe from the oil pump. Renew the "O" rings (A2). Lightly lubricate the "O" rings with clean engine lubricating oil and push the delivery pipe into the oil pump. Push the relief valve onto the delivery pipe and fit the relief valve to the cylinder block; ensure that the thimble is correctly fitted and tighten the setscrew.

For six cylinder engines: Remove the setscrews which fasten the cross flow pipe to the relief valve (B2). The cross flow pipe is only fitted to engines which have the oil filter on the right side of the engine. Remove the flange joint. Release the two setscrews (B1) which fasten the relief valve to the cylinder block and remove the valve. Ensure that the faces of the cross flow pipe and the relief valve are clean. Put the valve in position, complete with a new flange joint. Engage the four setscrews and tighten the flange setscrews and then the valve setscrews.





To dismantle and to assemble — Operation 10-14

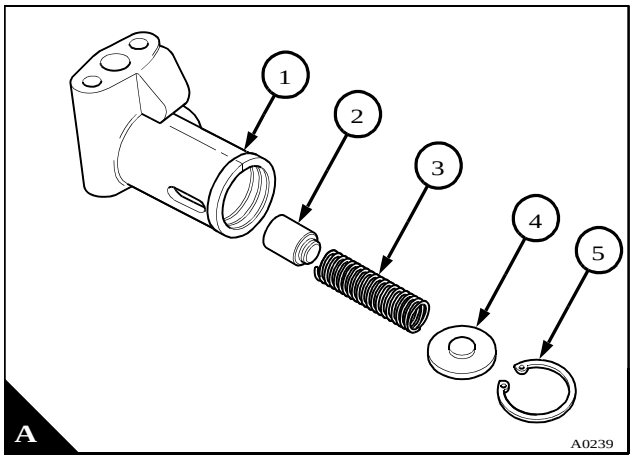
Warning! *Wear eye protection during this operation.*

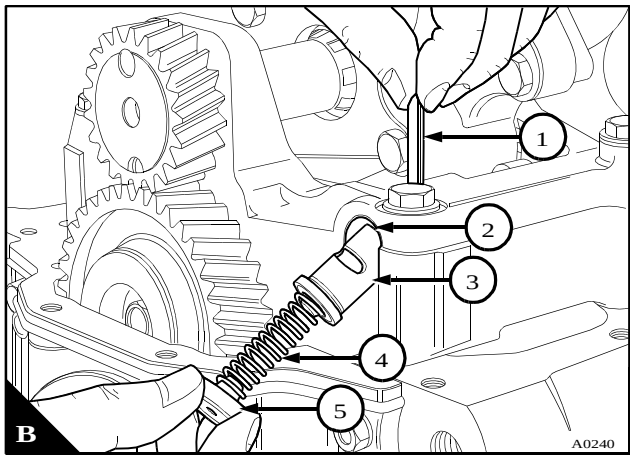
If necessary, the relief valve can be dismantled and assembled while it is fitted to the engine.

1 Apply pressure to the end plate (A4 or B5) of the spring assembly; release the circlip (A5) or remove the pin (B1) and carefully release the pressure to remove the end plate and the spring (A3 or B4) from the valve body. Remove the plunger (A2 or B3) from the bore of the body (A1 or B2).

2 Ensure that all the components are cleaned and then lubricated lightly with clean engine lubricating oil.

3 Fit the plunger into the bore with its hollow end to the inside. Fit the spring and the end cap into the bore with the ends of the spring fitted around the bosses of the plunger and the end plate. Apply pressure to the end plate and fit the circlip into its groove or fit the pin into the holes in the balancer frame.





To inspect — Operation 10-15

Caution: *Do not try to change the operation pressure of the relief valve by a method other than the installation of new components.*

1 Check the spring for wear and other damage and, if possible, check the load necessary to compress the spring to its fitted length. Refer to the relevant Data and dimensions for the "Lubrication system" on page 48.

2 Check the plunger for wear and other damage and ensure that it slides easily in the bore of the relief valve.

3 Check the body and the end plate for wear and other damage.

4 Renew worn or damaged components.

Flexible oil pipes

To remove **Operation 10-16**

The oil cooler pipes fitted to 6 cylinder New 1000 Series engines do not have metal braid and are separate pipes. The part number of the pipes is stamped on a clip which is fastened to one end of each pipe. The pipes are not interchangeable and it is important that the correct pipes are fitted to the engine.

There are three arrangements for the pipes which are used in accordance with the application and the type of oil cooler fitted to the engine:

Warning! *The engine oil may be hot, allow the engine temperature to cool before the oil pipes are released.*

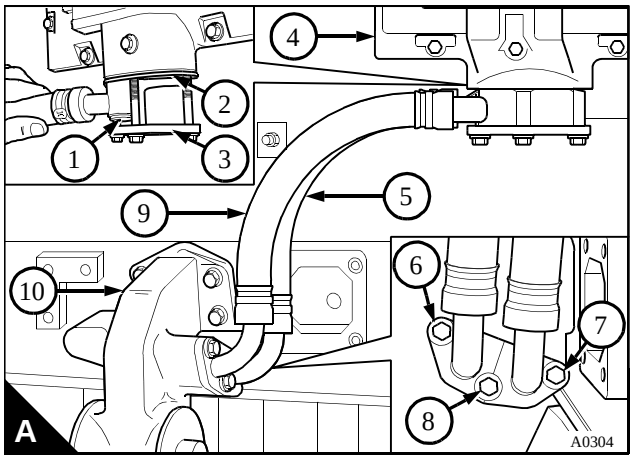
Caution: *For oil coolers that have a pressed steel cover. Do not remove both of the oil pipes together.*

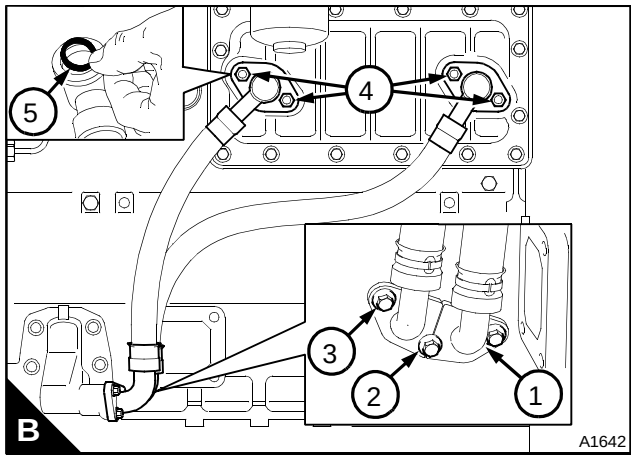
1 Allow the engine temperature to cool down and put a suitable container under the filter head.

2 Remove the three setscrews which retain the oil pipes to the filter head (A). Release the oil pipes and allow the oil to drain into the drip tray. Discard the joint.

3 Remove the three setscrews which retain the oil pipes to the oil cooler (A). Discard the joint.

4 For oil coolers that have a pressed steel cover: Remove one of the pipes from the oil cooler, then fit the flanges and nuts (B4) onto the studs again, before the other pipe is removed. This will ensure that the element remains fastened to the cover. Discard the “O” rings (B5).





Continued

To fit **Operation 10-17**

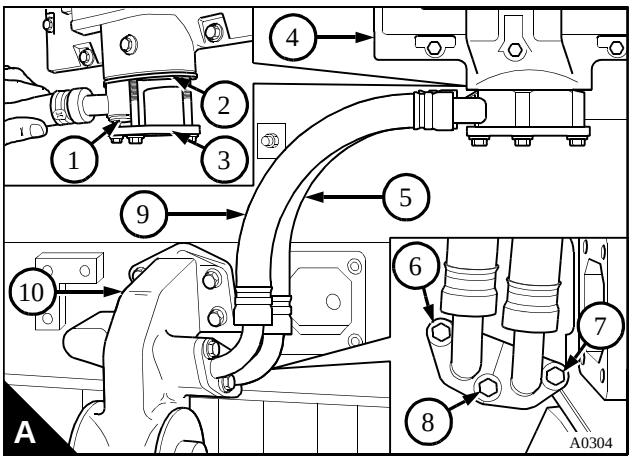
Arrangement 1 (A)

1 Put the three setscrews into position in the flange (A3) of the inner pipe (A5). Put a new joint (A2) in position on the setscrews.

2 Engage the setscrews by three or four threads in the flange of the oil cooler (A4). Engage the spigot (A1) of the outer pipe (A9), in the hole in the flange (A3) of the first pipe, ensure that it fits squarely in the flange.

3 Support the pipes by hand and tighten the centre setscrew finger tight. Tighten the other setscrews until they are finger tight. Ensure that the pipes are as close together as possible, then tighten the setscrews gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

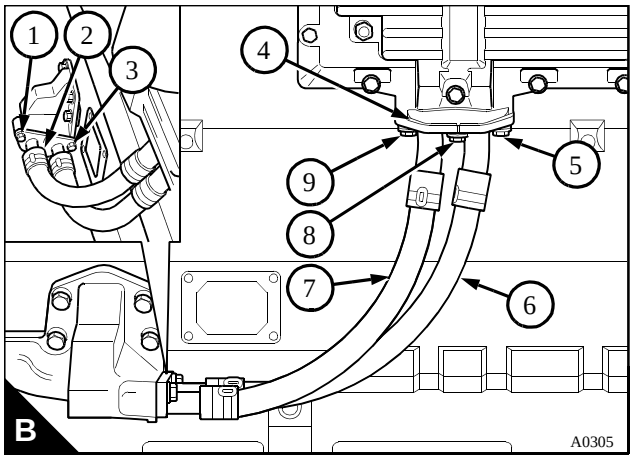
4 Put a setscrew (A7) in position in the flange of the inner pipe (A5) for the oil filter head (A10). Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (A8). Tighten the setscrews finger tight. Put the flange of the outer pipe (A9) in position and fit the third setscrew (A6), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.



Continued

Arrangement 2 (B)

1 Put a setscrew (B5) in position in the flange of the inner oil cooler pipe (B6). Put a new joint (B4) in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (B8). Tighten the setscrews finger tight.



2 Put the outer pipe (B7), in position on the flange of the oil cooler and fit the third setscrew (B9) finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

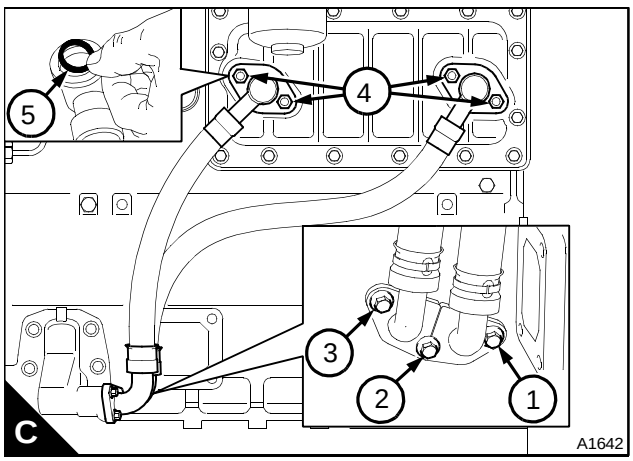
3 Put a setscrew (B3) in position in the flange of the inner pipe for the oil filter head. Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (B2). Tighten the setscrew finger tight.

4 Put the flange of the outer pipe in position and fit the third setscrew (B1), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

Arrangement 3 (C)

Caution: *Do not remove both sets of nuts and flanges at the same time.*

1 Put a setscrew (C1) in position in the flange of the inner pipe for the oil filter head. Put a new joint in position on the setscrew. Hold the flange and the joint in position and fit the centre setscrew (C2). Tighten the setscrew finger tight.



2 Put the flange of the outer pipe in position and fit the third setscrew (C3), tighten it finger tight. Beginning with the centre setscrew, tighten the three setscrews to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Fit new “O” rings to the recess in the oil pipes at the oil cooler end (C5).

4 Remove the nuts (C4) and flanges from one set of studs and fit the oil pipe. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m. Remove the nuts and flanges from the second set of studs and fit the remaining oil pipe. Tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

To Inspect **Operation 10-18**

1 Remove any old pieces of the joint and clean the flange faces of the oil pipes.

2 Thoroughly clean the oil pipes in an approved detergent cleaning solution.

3 Check the outer cover of the pipes for signs of leakage, cracks or splits. If the outer cover or the flanges are damaged the pipe must be renewed.

11

Fuel system

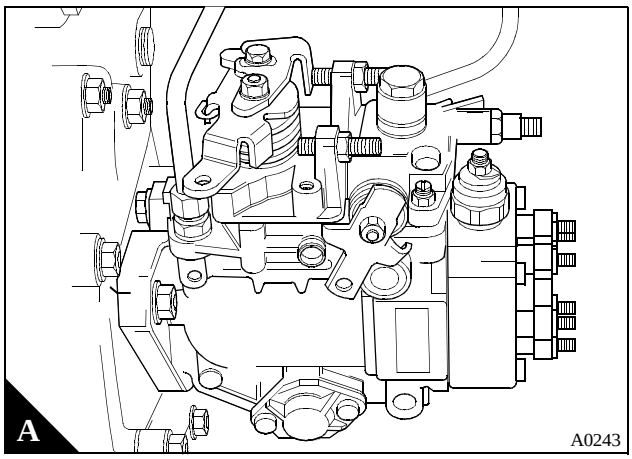
General description

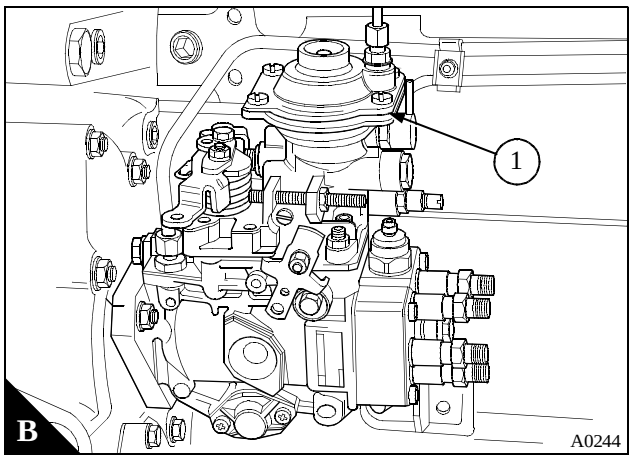
Caution: *It is very important that dirt does not enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After the component has been disconnected, fit a suitable cover to all open connections.*

Phaser/1000 Series engines are used for vehicle, agricultural and industrial applications and may have different fuel injection pumps. They use Bosch, Lucas/Delphi or Stanadyne pumps.

Turbocharged engines have pumps with a boost control (A1). Some of the later fuel pumps have a locking screw to fasten the drive shaft of the pump when the pump is removed from the engine.

Some of the latest fuel injection pumps are pin timed, see Operation 11-22, Operation 11-42 or Operation 11-51.

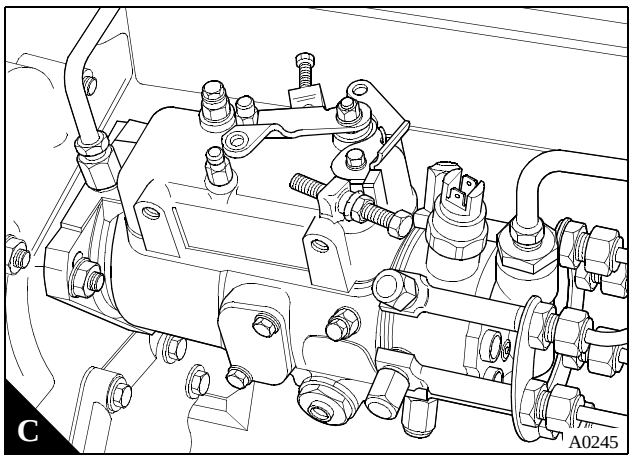


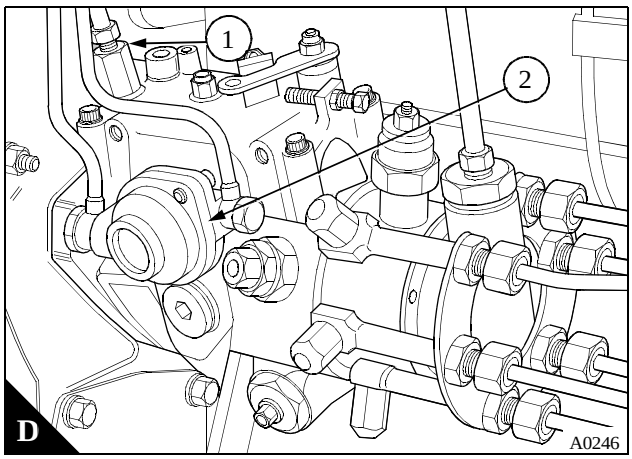


Lucas/Delphi DPA fuel injection pumps (B) are fitted to naturally aspirated engines. Turbocharged engines have Lucas/Delphi DPA or DPS fuel pumps (B). The DPS fuel pumps have a boost control (D2). Some of these pumps are fitted with a self-vent feature (D1).

The boost control is a device which is affected by boost pressure (from the turbocharger) and reduces the maximum fuel delivery at lower engine speeds to match the reduced air supply to the cylinders.

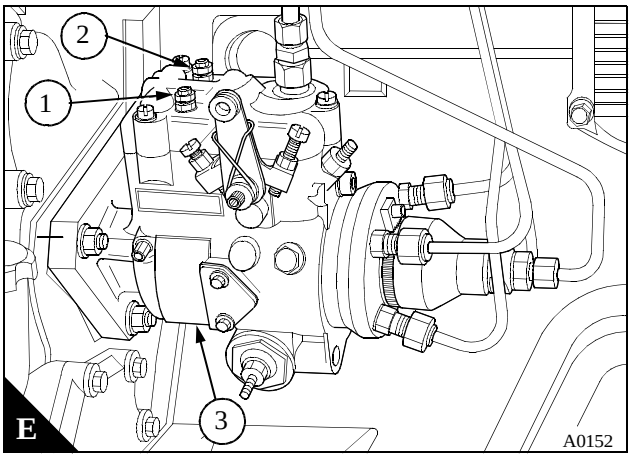
Both the Bosch and CAV fuel injection pumps have mechanical governors to control the engine speed.

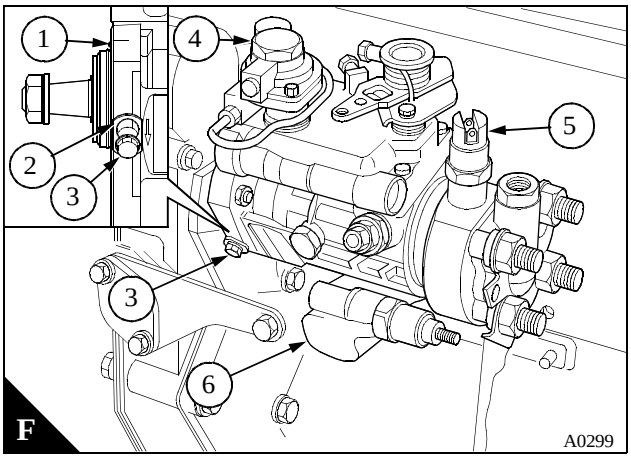




Some naturally aspirated engines have a Stanadyne fuel injection pump (A) fitted. The electrical stop solenoid on these fuel pumps is fitted inside the governor housing. The earth connection (A1) and the electrical supply connection (A2) are on top of the governor housing.

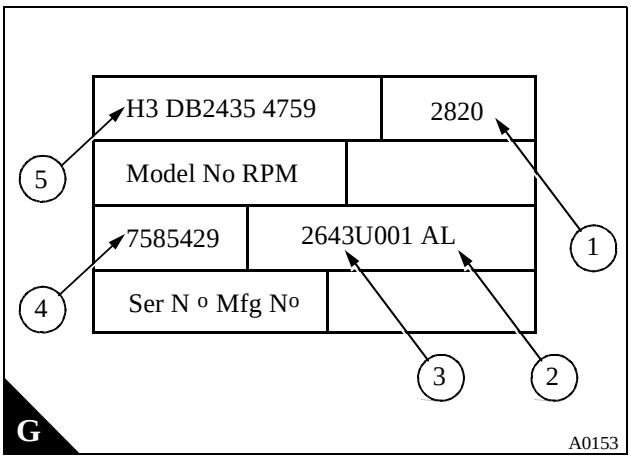
The latest engine types have a Lucas/Delphi DP200 fuel injection pump (B) with a locking screw (B1). Some of these pumps have an electrically operated cold start device (B4) which retards the timing for normal operation. Other features of this pump include a boost control (B2) and a stop solenoid (B3). These pumps are fitted with a self-vent feature.





A data plate is fitted to the side of the pump. A typical data plate (C) and an example of the information shown on the plate is:

- Maximum engine no load speed (1)
- Fuel pump code (2)
- Perkins part number (3)
- Fuel pump serial number (4)
- Manufacturers model number (5).



Continued

For details of the fuel pump code for the engine refer to the relevant engine timing data in Chapter 2, Specifications.

The "low spring" atomisers receive high pressure fuel from the fuel injection pump and inject this fuel into the combustion chamber of the pistons as a very fine spray. The atomisers are set in the factory, but they must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a change of shims fitted above the spring.

For details of the atomiser service setting pressures for the engine, see "Atomiser service settings" on page 51.

The fuel injection equipment must only be checked and adjusted by personnel who have had the correct training.

The fuel lift pump is of the diaphragm type and is mechanically driven. It is fitted on the right side of the cylinder block and is driven by an eccentric on the camshaft. The pump is fitted with a priming lever.

Cold start advance unit

Some Lucas/Delphi, Bosch and Stanadyne rotary fuel injection pumps have a cold start advance unit that holds the timing of the pump in an advanced position when the engine is cold.

Caution: *It is important that the electrical connections to the sender unit are connected correctly. Failure of the starting aid to operate correctly could result in damage to the engine as the timing will be fully advanced for normal operation.*

The sender unit, for engines fitted with belt driven coolant pumps, is on the top of the thermostat housing. The sender unit, for engines fitted with gear driven coolant pumps, is on the rear of the timing case on the left side of the engine.

As the engine warms, the sender unit energises to retard the pump timing to the correct timing for normal operation of the Lucas/Delphi and Bosch fuel injection pumps. The sender unit for the Stanadyne cold start unit de-energises to retard the pump timing to the correct timing for normal operation.

Note: The wiring diagrams on the following page show the sender unit (component 3) position when the engine is cold.

To ensure that the engine conforms to the emissions legislation, it is important that the electrical connections of the engine cold start advance unit are fitted correctly before the engine is operated.

Caution: *Damage to the engine will occur if the engine is load tested at more than 80% of full load with the cold start device disconnected.*

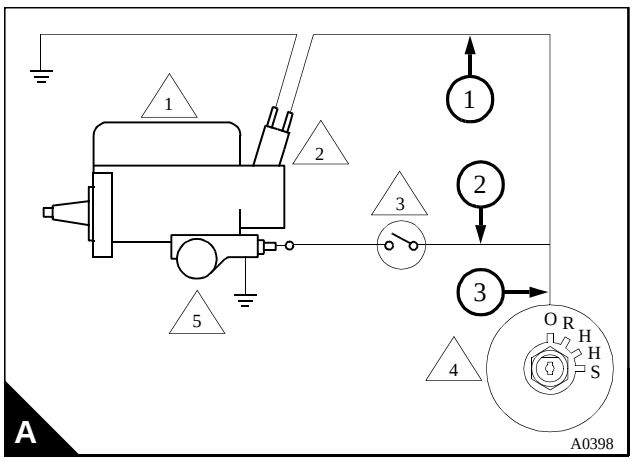
Continued

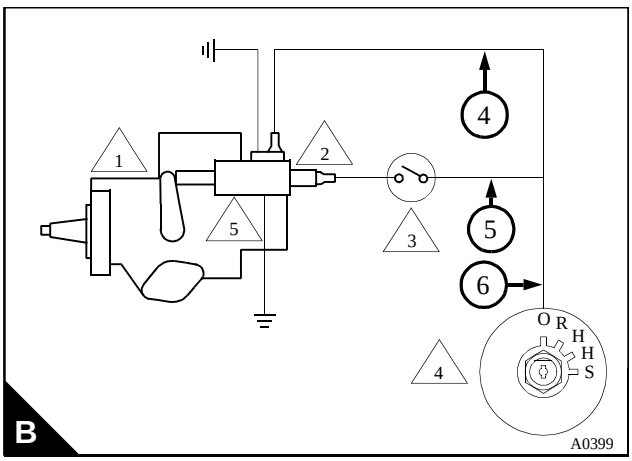
Wiring diagrams for the cold start advance unit fitted to some Lucas/Delphi DP200 Series, Bosch and Stanadyne fuel injection pumps are shown in the illustrations (A), (B) and (C) respectively. For easy identification the cables are shown in circles on the illustrations.

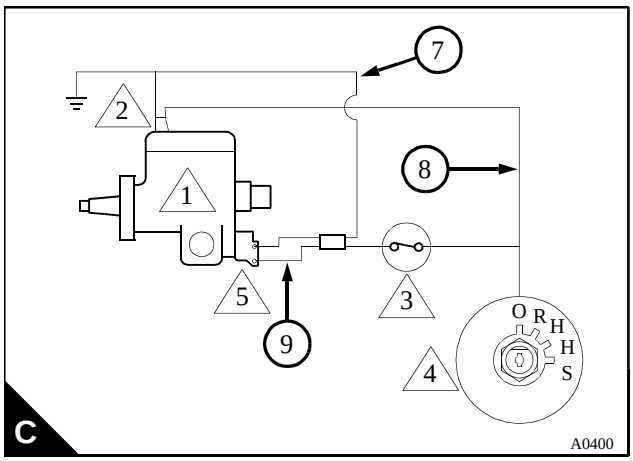
The amperage of each of the cables is listed in the cable identification table below. The identification numbers for the electrical components on the wiring diagram are shown in triangles.

Cable identification (1)		**Component identification (2)**	
Cable (Number)	**Current (Amperes)**	**Component**	**Description**
1	3	1	Fuel injection pump
2	3	2	Engine stop solenoid
3	6	3	Sender unit
4	3	4	Start switch
5	3	5	Cold start advance unit
6	6		
7	3		
8	6		
9	3		

(1) For numbers shown in circles
(2) For numbers shown in triangles





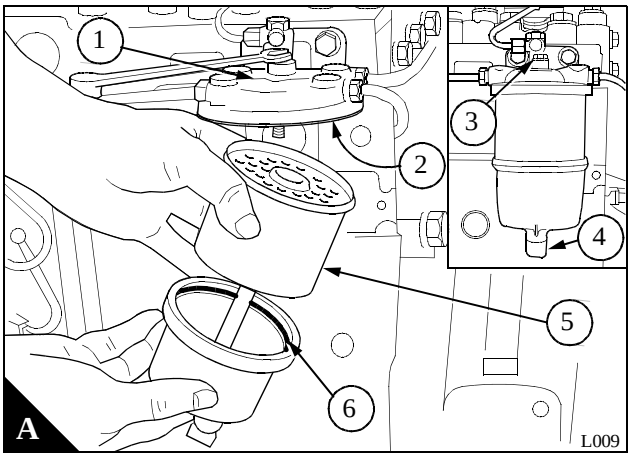


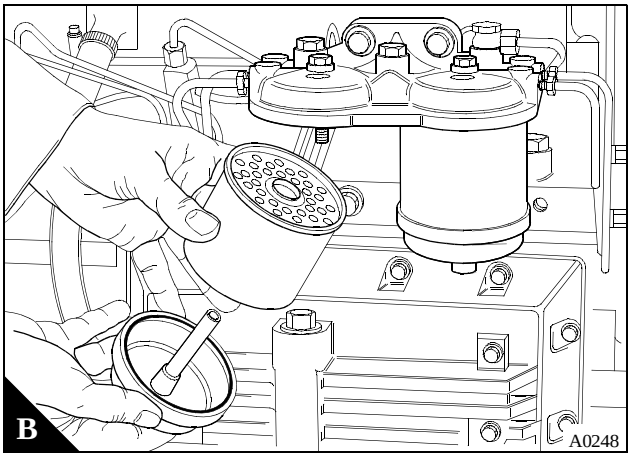
Fuel filter elements

Fuel filter element types — Operation 11-1

There are three types of fuel filter element in use:

The separate element type (A) or (B) where the filter element is held between the filter head and the bottom cover.

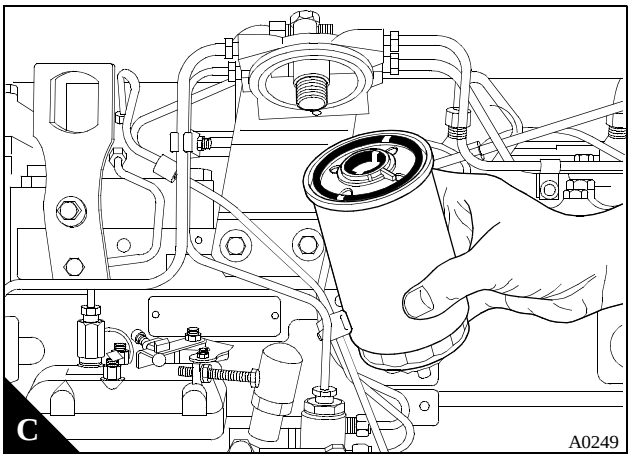


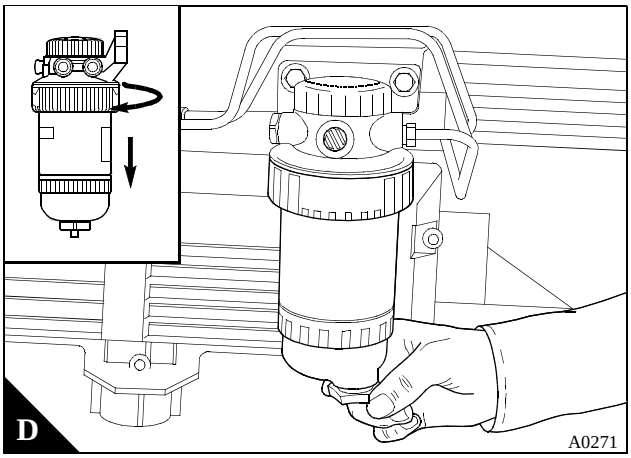


The canister type (C) where the filter element has an internal thread at the top and is fastened to a threaded adaptor in the filter head.

A fuel filter with a quick release canister (D), a quick release clamp ring at the top which is fastened to a thread on the filter head. Some engines are fitted with a pre-filter of the same type. This filter is fitted next to the main filter, but connected in the fuel system before the fuel lift pump.

Some of the latest engines have a clean side return system. Spill fuel from the fuel injection pump and atomisers is returned directly to the inlet side of the fuel injection pump instead of the fuel filter inlet.





To renew the filter element of the separate element type **Operation 11-2**

Warning! *Discard the used canister and fuel oil in a safe place and in accordance with local regulations.*

***Cautions*:**

- *It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

The filter can have one or two elements (A) or (B). When twin elements are fitted, both of the elements must be renewed at the same time.

1 Clean the outside surfaces of the fuel filter assembly. If a drain tap (A4) or (B1) is fitted to the bottom cover of the filter, drain the fuel from the filter.

2 Hold the bottom cover of the filter element and release the setscrew (A3) which is fitted through the filter head above the centre of each element.

3 Lower the bottom cover of the filter.

4 Remove the element (A5) and discard it.

5 Clean the inside surfaces of the filter head (A1) and bottom filter cover.

6 Fit the new sealing rings (A6) and (A2).

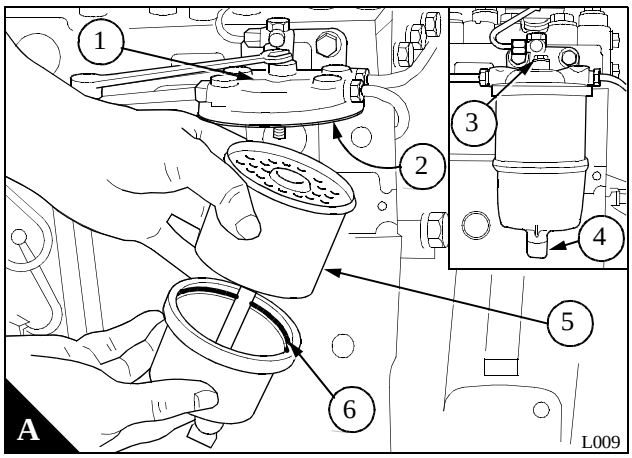
Note: Replace “O” ring on centre mounting stub if fitted.

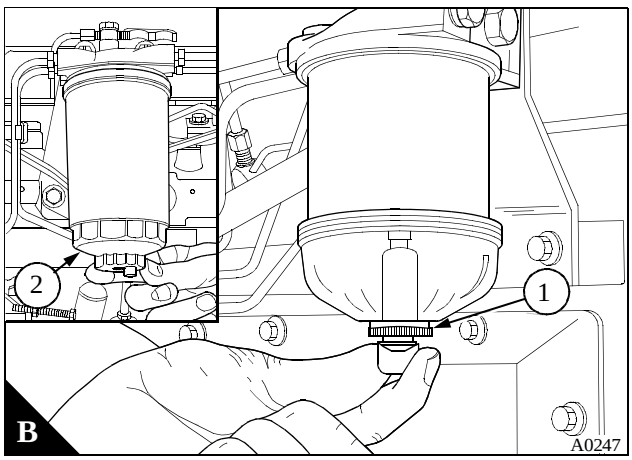
7 Put the bottom cover on the bottom of the new element (A5) and assemble it squarely to the filter head to ensure that the element is fitted in the centre against the joint in the filter head.

8 Hold the assembly in this position and engage and tighten the setscrew.

9 Eliminate all air from the fuel system:

- Bosch EPVE fuel injection pumps, see Operation 11-25
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46
- Stanadyne fuel injection pumps, Operation 11-54.





To renew the filter element of the canister type **Operation 11-3**

Warning! *Discard the used canister and fuel oil in a safe place and in accordance with local regulations.*

***Cautions*:**

- *It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

1 Thoroughly clean the outside surfaces of the fuel filter assembly.

2 Loosen the drain device (A2) at the bottom of the canister and allow the water/fuel to drain into a suitable container.

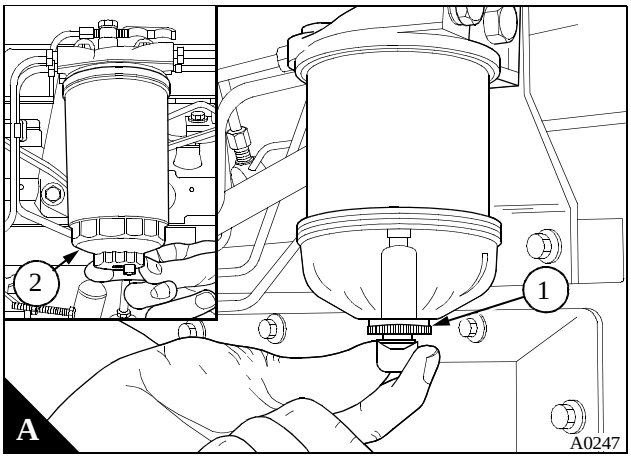
3 Use a strap wrench or similar tool to loosen the filter canister and remove the canister.

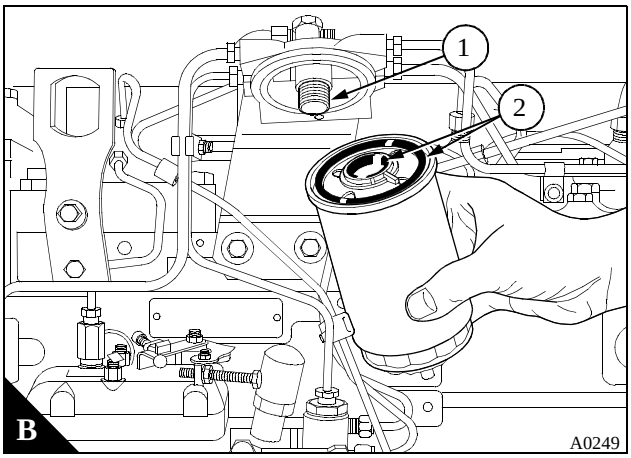
4 Ensure that the threaded adaptor (B1) is secure in the filter head and that the inside of the head is clean.

5 Lubricate lightly the seals (B2) on the top of the new canister with clean fuel. Fit the new canister to the filter head and tighten by hand only.

6 Eliminate the air from the fuel filter:

- Bosch EPVE fuel injection pumps, see Operation 11-25
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46
- Stanadyne fuel injection pumps, Operation 11-54.





To renew the filter element of the quick release canister type **Operation 11-4**

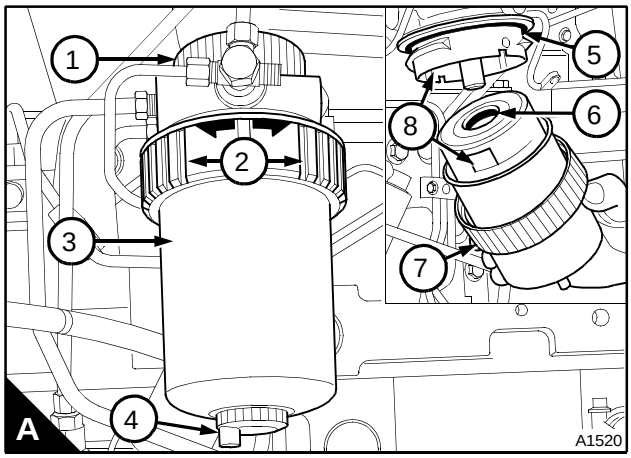
Warning! *Discard the used canister and fuel oil in a safe place and in accordance with local regulations.*

***Cautions*:**

- *It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

1 Thoroughly clean the outside surfaces of the filter assembly.

2 Loosen the drain device (A4), if one is fitted, at the bottom of the canister and allow the water/fuel to drain into a suitable container.



Note: If the filter does not have a drain device fitted release the cap (A1) on top of the filter head. Remove the nylon insert to lower the level of the fuel in the filter canister. This will prevent fuel spill when the clamp ring is released.

3 Unscrew the sediment bowl at the bottom of the canister, if one is fitted.

4 Support the filter canister and rotate the clamp ring (A2) to the left, see the direction arrow, and remove the clamp ring.

5 Remove the canister from the filter head by a direct pull downwards, and discard the old canister (A3). Retain the clamp ring.

6 Ensure the filter head is clean and that the seals (A5) and (A6) are in good condition or renew them. Align the spline (A8) with the groove in the filter head and push the new canister fully into the filter head.

7 Support the canister, fit the clamp ring (A7) and rotate it to the right, see the direction arrow, to fasten the canister to the filter head.

8 If a sediment bowl is fitted, remove the bowl and thoroughly clean the cover of the bowl.

9 Check the two 'O' ring seals of the sediment bowl for damage and renew if necessary.

10 Clean the threads of the sediment bowl and fit the bowl to the canister and tighten by hand only.

11 If it was removed, fit the nylon insert used to lower the level of the fuel in the filter canister and fasten the cap.

12 Eliminate the air from the fuel filter:

- Bosch EPVE fuel injection pumps, see Operation 11-25
- Lucas/Delphi DPA and DPS fuel injection pumps, see Operation 11-35
- Lucas/Delphi DP 200 fuel injection pumps, see Operation 11-46
- Stanadyne fuel injection pumps, Operation 11-54.

Fuel filter canister (Bosch MW fuel injection pump)

To renew **Operation 11-5**

Warning! *Discard the used canister and fuel oil in a safe place and in accordance with local regulations.*

***Cautions*:**

- *It is important that only the genuine Perkins parts are used. The use of a wrong canister or element can damage the fuel injection pump.*
- *Do not allow dirt to enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After a component has been disconnected, fit a suitable cover to all open connections.*

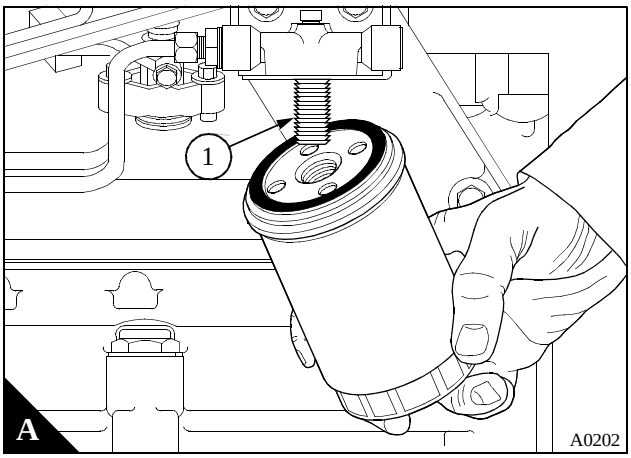
1 Thoroughly clean the outside surfaces of the fuel filter assembly.

2 Use a strap wrench or similar tool to loosen the filter canister and remove the canister.

3 Ensure that the threaded adaptor (A1) is secure in the filter head and that the inside of the head is clean.

4 Lightly lubricate the seal of the new canister with clean fuel. Fit the new canister to the filter head and tighten by hand only.

5 Eliminate the air from the fuel filter, see Operation 11-30.



Atomisers

Atomiser fault — Operation 11-6

An atomiser fault can be shown by an engine misfire. In order to find which atomiser is defective, operate the engine at a fast idle speed. Loosen and tighten the union nut of the high pressure fuel pipe at each atomiser. When the union nut of the defective atomiser is loosened, it will have little or no effect on the engine speed.

Warning! *Do not let the fuel spray on to your skin!*

To remove and to fit — Operation 11-7

1 Remove the fuel leak-off pipe.

2 Release the union nuts of the high-pressure pipes from the atomisers and from the fuel injection pump. Hold the pump outlet with a spanner to prevent movement while the union nut of the high-pressure pipe is released at the pump. Do not bend the pipe. If necessary, remove the pipe clamps.

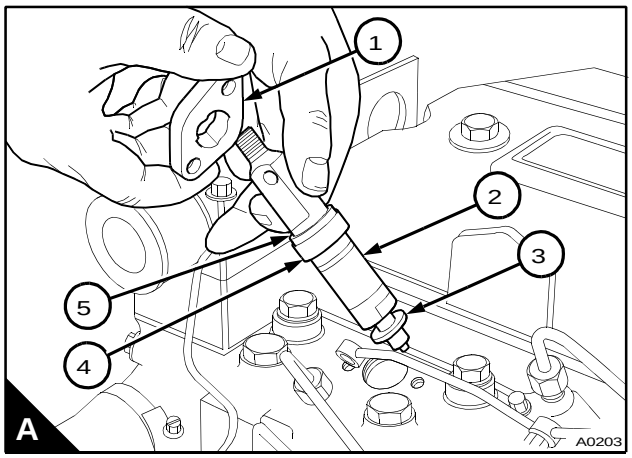
3 Release the setscrews of the atomiser flange and remove the flange (A1), the atomiser (A2) and its seat washer (A3). Remove the dust seal (A4) and the spacer (A5) and fit the spacer and a new dust seal to the new atomiser.

4 Put the new atomiser in position with its spacer, new dust seal and a new seat washer. Fit the flange and engage the flange setscrews. Ensure that the atomiser is not tilted and tighten the setscrews gradually and evenly to 12 Nm (9 lbf ft) 1,2 kgf m.

5 Fit the high-pressure pipes and tighten the union nuts to 18 Nm (13 lbf ft) 1,9 kgf m. Hold the pump outlet with a spanner to prevent movement while the pipe nut is tightened at the pump. If necessary, fit the pipe clamps.

6 Renew the seal washers and fit the leak-off pipe.

7 Operate the engine and check for fuel leakage.



Fuel lift pump

To remove and to fit **Operation 11-8**

Notes:

- A new fuel lift pump (B) is fitted to the latest four cylinder engines. The new fuel lift pump is a one-piece assembly and should not be dismantled. A strainer is fitted inside the fuel inlet connection (B1). The strainer is serviced at the same interval as the early fuel lift pump, refer to the user's handbook for servicing details. The procedure to remove and to fit this fuel lift pump is as the earlier fuel lift pump.
- Reflective heat shields if fitted to the fuel lift pump must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the fuel lift pump protected by the heat shield could be damaged.

1 If a heat shield is fitted, remove it. Disconnect the fuel pipes from the fuel lift pump.

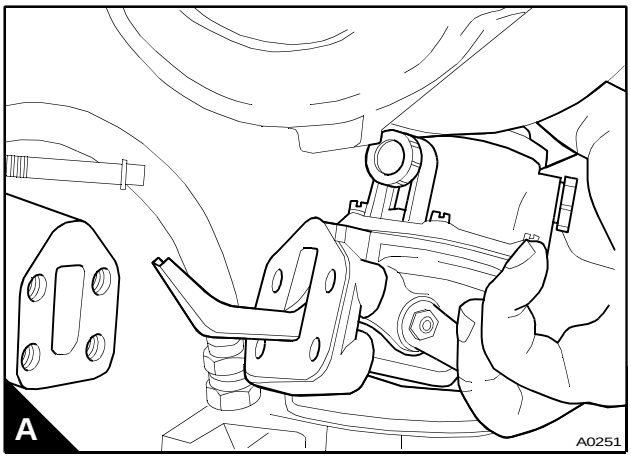
2 Release the setscrews, remove the lock plates and remove the fuel lift pump (A). The lift pump may be difficult to remove from the engine. If this occurs the crankshaft must be rotated until the camshaft eccentric, that operates the lift pump, is in a position which will free the rocker lever of the lift pump.

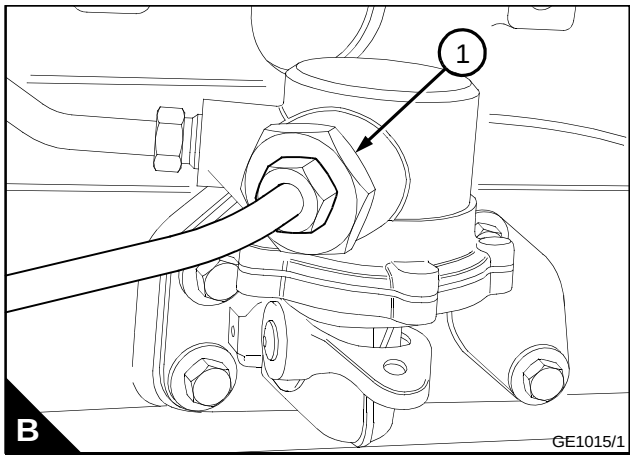
3 Ensure that the camshaft eccentric is in the minimum lift position before the lift pump is fitted. Clean the joint face of the lift pump and the cylinder block and fit the lift pump together with a new joint. Fit the lock plates and the setscrews and tighten them gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

4 Connect the fuel pipes and, if necessary, fit the heat shield.

5 Release the vent screw on the fuel filter head and operate the priming lever of the fuel lift pump to eliminate any air between the lift pump and the fuel filter. Operate the lift pump until fuel, free of air, comes from the vent screw. Tighten the vent screw.

6 Operate the engine and check for any fuel or air leakage.





To dismantle **Operation 11-9**

1 Clean the outside surfaces of the fuel lift pump.

2 Make a mark across the flanges of the two halves of the pump to ensure correct relationship when the pump is assembled.

3 Remove the cover (A1) and the gauze (A2). Release the setscrews and separate the two halves of the pump.

4 Turn the diaphragm assembly (A5) 90° to release the pull rod from the link arm (A8) and remove the diaphragm assembly. Remove the stem seal (A6), the spring seat washer (A7) and the spring (A12) from the pull rod. The diaphragm and pull rod assembly is renewed as an assembly and no service is possible on the diaphragm.

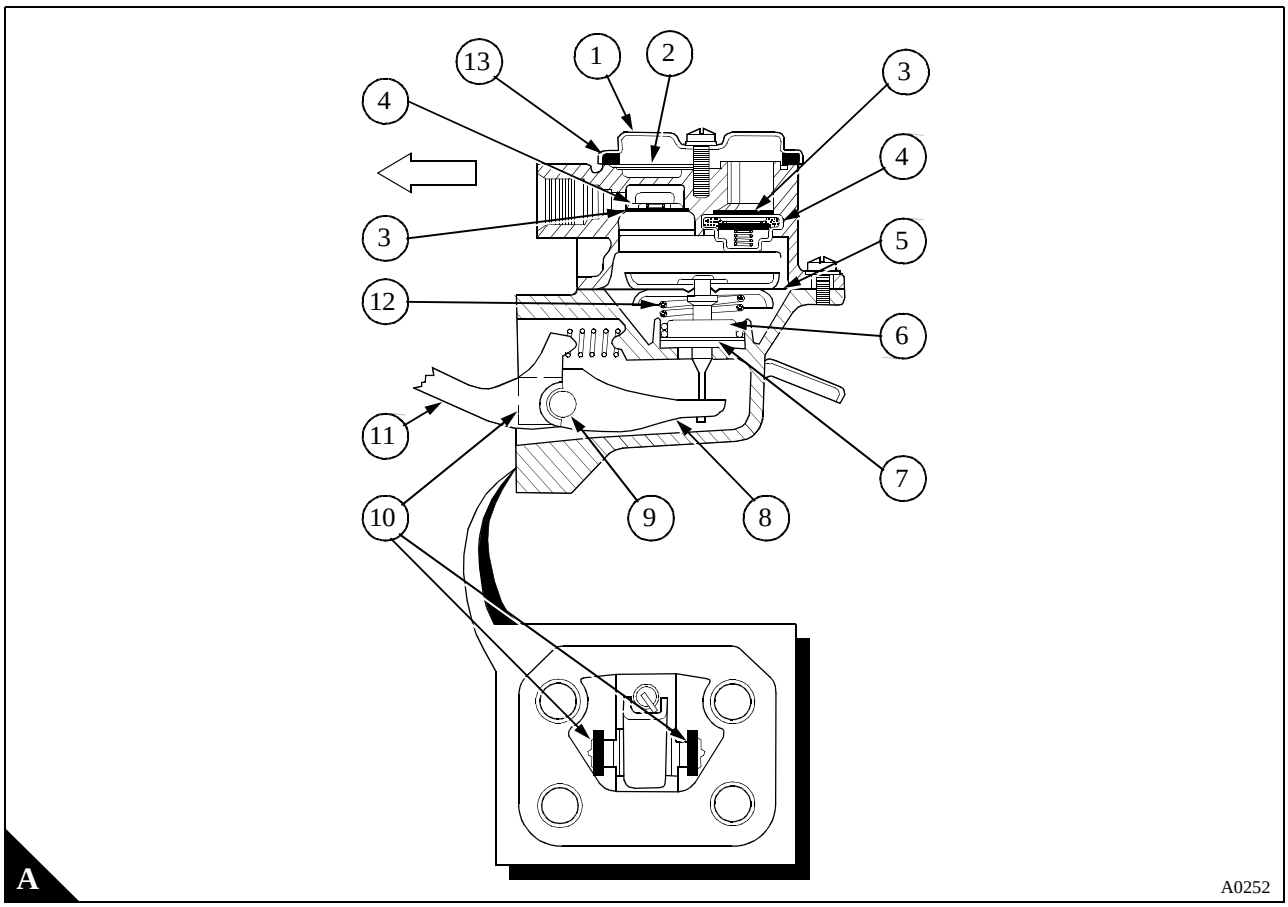
5 The valves (A4) are peened in and can be removed with a suitable lever. Some of the peened metal will have to be removed before the valves can be removed.

6 To remove the link arm:

Hold the rocker lever (A11) in a vice and hit the body of the lift pump with a soft face hammer to release the two retainers (A10). Be careful not to damage the joint face of the pump body.

Remove the rocker lever, the pin (A9), the link arm and the return spring.

Check the components for wear and other damage.



To assemble **Operation 11-10**

1 Thoroughly clean the valve housings. Fit new seat washers (A3) and push the new valves (A4) into position. As the valves are the same, but one valve is fitted in reverse of the other, it is possible to fit the valves upside down. To ensure that the valves are fitted correctly, fit them as shown in (A). When the valves are correctly fitted, peen the edge of the valve housings in six places, evenly divided, to keep the valves in position.

2 Fit the rocker lever (A11), pin (A9) and link arm assembly (A8) into the bottom half of the lift pump. Fit the return spring; ensure that the ends of the spring are in their correct location.

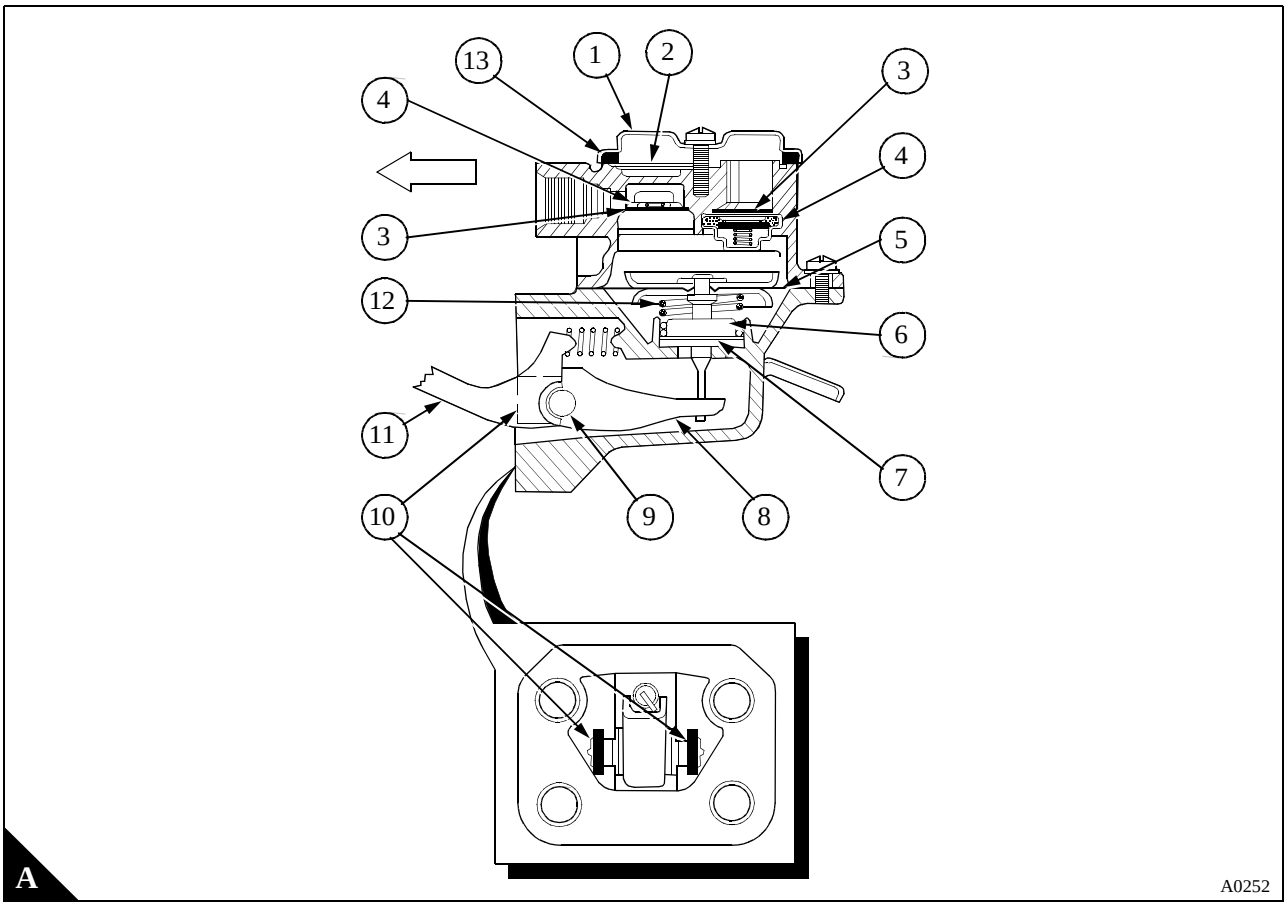
3 With a light hammer and a suitable adaptor, fit two new retainers (A10) in their grooves in the casing until they fasten the pin. Peen the open ends of the grooves to fasten the retainers in position.

4 Fit the diaphragm spring (A12) into its location under the diaphragm (A5) and put the spring seat washer (A7) and a new stem seal (A6) into position on the pull rod. Ensure that the small diameter at the top of the seal is on the round section of the pull rod.

5 Put the diaphragm assembly in position over the lower half of the body with the blade of the pull rod aligned with the slot in the link arm. Press lightly down on the diaphragm until the notch in the pull rod is in the slot in the link arm and turn the diaphragm 90° in either direction. This action will engage and retain the pull rod in the slot of the link arm.

6 Push the rocker lever towards the pump body until the diaphragm is level with the body flange and fit the top half of the body in position with the marks on the flanges aligned. Keep the pressure on the rocker lever, fit the spring washers and the screws and tighten them evenly.

7 Fit the gauze filter (A2) and the cover (A1), ensure that the rubber seal (A13) is fitted correctly and tighten the screw.



To test **Operation 11-11**

1 Disconnect the fuel outlet pipe from the fuel lift pump. Fit a 0-70 kPa (0-10 lbf/in^2) 0-0,7 kgf/cm^2 pressure gauge to the outlet of the lift pump. Release the connection at the gauge and operate the priming lever of the lift pump to eliminate air from the pipe. When fuel, free of air, flows from the pipe tighten the connection. Ensure that there are no leaks at the connections between the pump and the gauge.

2 Operate the starter motor for 10 seconds with the engine stop control in the stop position or with the stop solenoid disconnected.

3 Note the maximum pressure indicated on the gauge. If the pressure indicated is less than the test pressure shown in the relevant Data and dimensions for the "Fuel system" on page 50, repair or renew the pump. Also check the rate at which the pressure reduces to half the maximum pressure obtained. If this is less than 30 seconds, repair or renew the pump.

4 Remove the gauge and connect the outlet pipe to the lift pump. Release the vent screw on the fuel filter head and operate the priming lever until fuel, free of air, flows from the vent screw. Tighten the vent screw.

5 Connect the engine stop solenoid.

Fuel lift pump (Bosch MW fuel injection pump)

To remove and to fit **Operation 11-12**

1 Disconnect the fuel pipes from the fuel lift pump.

2 If the fuel lift pump is fitted to the side of the fuel injection pump, release the nuts and remove the fuel lift pump (A). If the fuel lift pump is fitted to the cylinder block (B), remove the setscrews and remove the lift pump (B3) from the adaptor (B5). To remove the fuel pump and adaptor assembly, release the nuts and remove the assembly from the side of the cylinder block.

To fit the lift pump to the fuel injection pump

3 Clean the joint face of the fuel lift pump and of the fuel injection pump. Ensure that the eccentric on the camshaft of the fuel injection pump is in the minimum lift position. Fit a new joint (A2) to the lift pump. Check that the push rod (A1) is in position and fit the lift pump the fuel injection pump. Tighten the nuts gradually and evenly to 6 Nm (4 lbf ft) 0,6 kgf m.

To fit the adaptor or the adaptor and lift pump assembly

4 Clean the joint face of the adaptor and of the cylinder block. Ensure that the eccentric on the engine camshaft is in the minimum lift position. Fit a new joint (B6) to the adaptor. Check that the push rod (B1) is in position. Ensure that the lubrication hole (B2) is at the top and fit the adaptor to the cylinder block. Tighten the nuts gradually and evenly to 22 Nm (16 lbf ft) 2,2 kgf m.

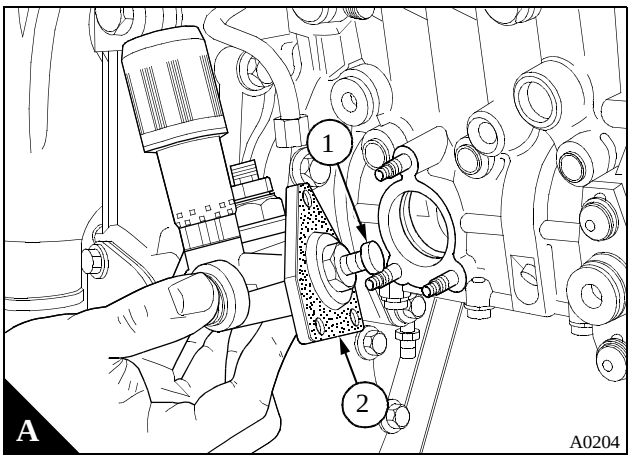
To fit the lift pump to the adaptor

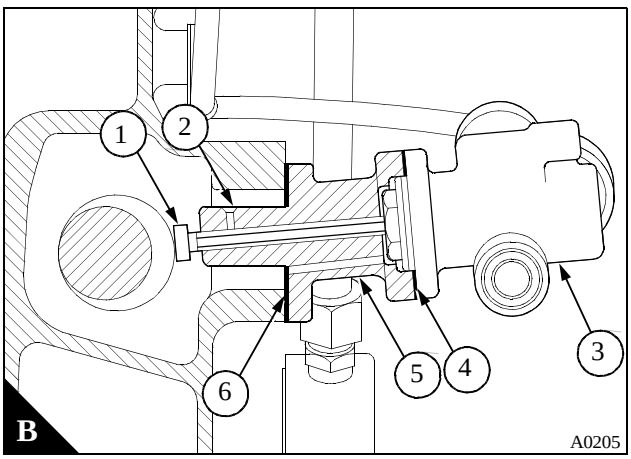
5 Clean the joint face of the lift pump and of the adaptor. Ensure that the eccentric on the engine camshaft is in the minimum lift position. Fit a new joint (B4) to the lift pump. Fit the lift pump to the adaptor and tighten the setscrews gradually and evenly to 6 Nm (4 lbf ft) 0,6 kgf m.

6 Connect the fuel pipes to the lift pump.

7 Release the vent plug on the fuel filter. Operate the priming pump on the fuel lift pump until fuel, free of air, comes from the vent plug. Tighten the vent plug.

8 Operate the engine and check for leakage of fuel or air.





To dismantle and assemble **Operation 11-13**

To dismantle

1 Clean the outside surfaces of the fuel lift pump.

2 Remove the push rod (A1).

3 Release the end nut (A2). Remove the plunger (A3) the suction valve (A4) the spring seat washer (A13) the spring (A5) and the second spring seat washer (A13) from the pump body (A6).

4 Remove the priming pump (A8), if fitted, and the copper washer (A7).

5 Release the delivery valve holder (A9). Remove the delivery valve (A11) and the "O" ring (A12) from the body.

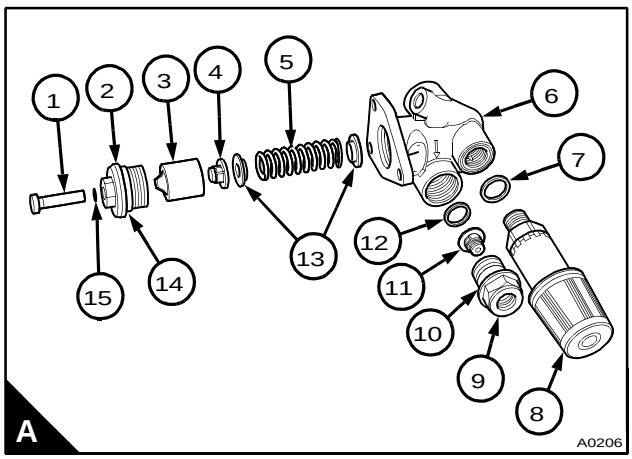
To assemble

1 Thoroughly clean inside the body of the lift pump and ensure that the passages in the body are not restricted. Carefully clean the valves in clean diesel fuel. Inspect each valve for damage to the valve spring and the valve plate. If there is damage, renew the valve.

2 Put a spring seat washer (A13) in position in the pump body. Ensure that the flat face of the washer is toward the bottom of the body. Put the spring (A5) on the spring seat washer and the other spring seat washer (A13) on the spring. Put the suction valve (A4) in position on top of the valve seat washer. Ensure that the large diameter of the valve is toward the spring seat washer. Put the plunger (A3) in position in the pump body over the valve and spring. Renew the "O" ring (A15) which fits inside the end nut and the "O" ring (A14) on the outside of the end nut. Support the pump body, put the end nut in position on the plunger, compress the spring and engage the threads of the end nut with the threads in the pump body. Tighten the end nut to 42 Nm (31 lbf ft) 4,3 kgf m. Put the push rod in position in the end nut.

3 Put a new "O" ring (A12) in position in the pump body. Put the delivery valve (A11) in position on the "O" ring. Ensure that the large diameter of the valve is toward the "O" ring. Renew the "O" ring (A10) on the delivery valve holder (A9). Fit the delivery valve holder and tighten to 42 Nm (31 lbf ft) 4,3 kgf m.

4 Renew the copper washer (A7) and fit the priming pump (A8). Tighten the priming pump to 47 Nm (34 lbf ft) 4,8 kgf m.



Bosch EPVE fuel injection pump (without a locking screw)

To remove **Operation 11-14**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Spanner for flange nuts of fuel injection pump	21825964
Adaptors for use with 21825565	21825568		

1 Remove all the pipes, disconnect the stop control and the control rod of the fuel injection pump. Ensure that a spanner is used to prevent movement of the fuel pump outlets when the nuts of the high-pressure pipes are released.

2 Remove the gear cover from the cover of the timing case. Remove the gear nut and the spring washer.

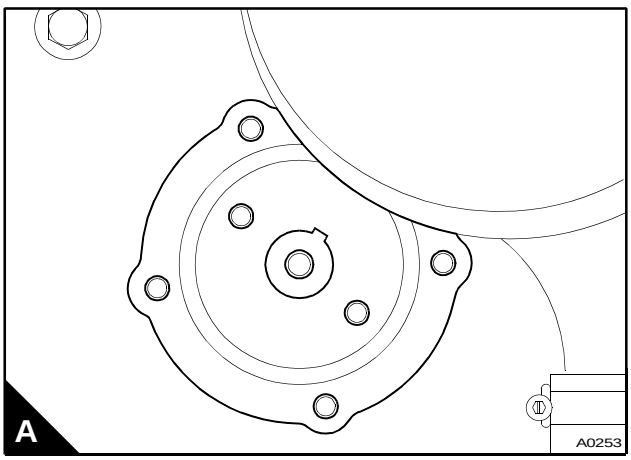
3 Rotate the crankshaft until the keyway in the gear of the fuel pump is in the 1 o'clock position (A).

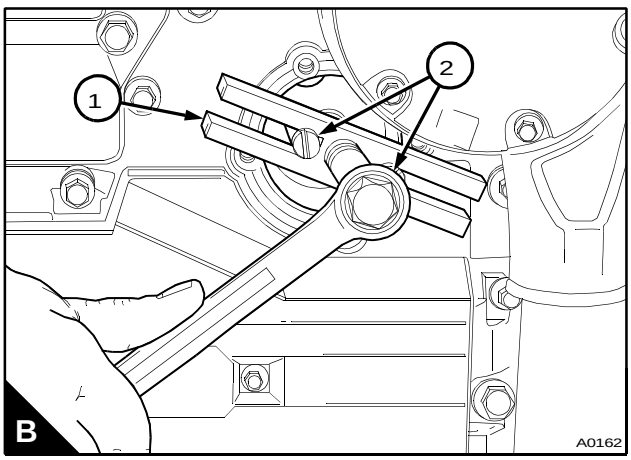
4 Remove the setscrew and the nut of the support bracket below the fuel pump. Release the flange nuts of the fuel pump. If access to the flange nuts of the fuel pump is restricted by, for example, a compressor, use tool 21825964 to release the flange nuts.

5 Loosen the drive gear of the fuel injection pump with the puller 21825565 (B1) and adaptors 21825568 (B2).

Caution: *The crankshaft must not be moved when the pump is not on the engine. Movement of the crankshaft may result in damage to the timing case and make it necessary to time the engine before the pump can be fitted.*

6 Remove the fuel pump; ensure that the key does not fall from the drive shaft.





To fit **Operation 11-15**

Special requirements

Special tools	
Description	**Part number**
Spanner for flange nuts of fuel injection pump	21825964

Caution: *The crankshaft must not be moved when the pump is not on the engine. Movement of the crankshaft may result in damage to the timing case and make it necessary to time the engine before the pump can be fitted.*

1 Rotate the drive shaft of the fuel injection pump clockwise to align the key with the 1 o'clock position of the keyway in the drive gear. In this position there will be no spring pressure on the drive shaft. Ensure that the key is correctly fitted and fit the fuel pump to the gear.

2 Align the mark on the flange of the fuel pump with the mark on the rear face of the timing case (A1). Fit the flange nuts of the fuel pump and the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

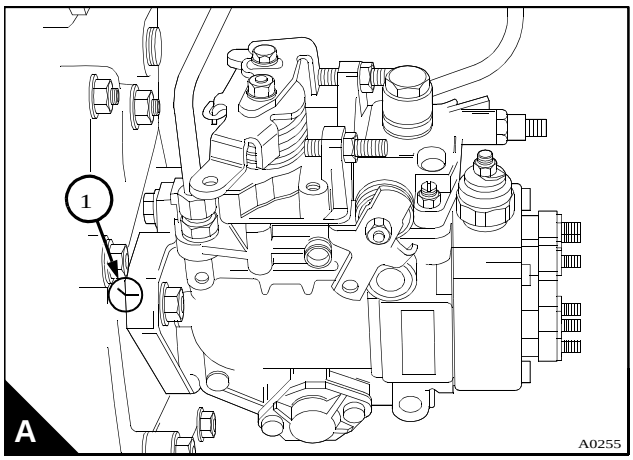
3 Fit the spring washer and nut to the drive shaft of the fuel pump and tighten the nut to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover to the cover of the timing case. Fit a new joint, if necessary.

4 Fit all the pipes, connect the stop control and the control rod of the fuel injection pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted.

5 Eliminate air from the fuel system, see Operation 11-25.

6 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-20.

7 If a new fuel injection pump has been fitted, check the maximum no load speed, see Operation 11-20.



Bosch EPVE fuel injection pump (with a locking screw)

General description

Some Bosch EPVE fuel injection pumps have a locking screw (A2) and a spacer (A3) fitted. The purpose of the locking screw is to fasten the drive shaft of the pump when the pump is removed from the engine.

Caution: *The drive shaft of the pump must not be turned without the spacer in position under the locking screw.*

A new pump will be received with the locking screw fitted and the spacer fastened to the speed control lever by a piece of wire. The new pump is not set to fit immediately onto the engine, but must be set before it is fitted, see Operation 11-18.

Engines which have the latest fuel injection pump operate at a static timing very close to TDC.

When the piston is close to TDC there is a relatively large movement of the crankshaft for only a small movement of the piston. For this reason the earlier method of timing, where piston movement is measured, is not accurate enough.

When the piston is further down the cylinder, there is a relatively small movement of the crankshaft for a large movement of the piston. Therefore greater accuracy is possible. For this reason the crankshaft is set at 100° BTDC.

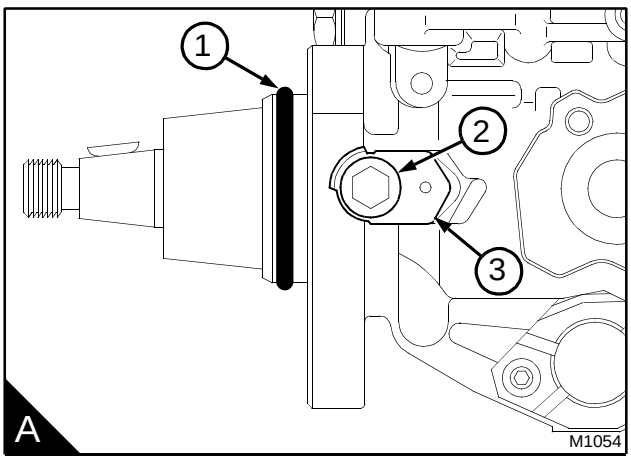
The timing is set on number 2 cylinder as this will put the key in the drive shaft of the pump at the top.

The pump is then set to a suitable angle to allow for the crankshaft angle and the static timing angle.

If the locking screw is used, it is not necessary to set the pump each time it is removed.

There is a timing mark on the pump flange, but not on the timing case.

Some fuel pumps have an "O" ring (A1) fitted in a groove in front of the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case.



To remove **Operation 11-16**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Piston position probe	21825947

Caution: *Disconnect the battery before the fuel injection pump is removed from the engine.*

1 Remove the rocker cover, see Operation 3-1.

2 Remove the atomisers together with their seat washers, see Operation 11-7.

3 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of number 2 cylinder just releases.

Caution: *Do not rotate the crankshaft, except in accordance with step five, when the piston position probe is fitted to the engine.*

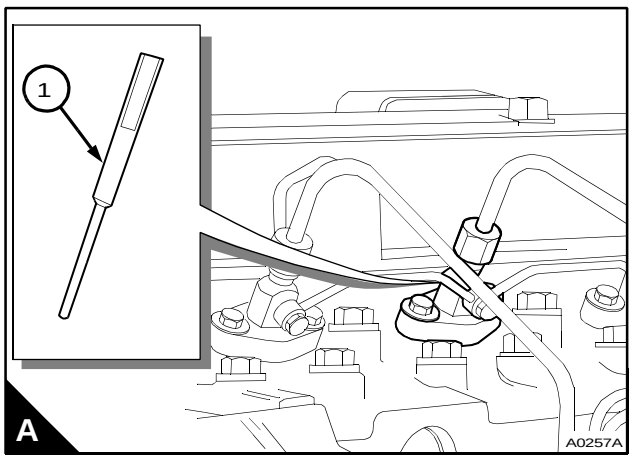
4 Ensure the seat washer from number 2 cylinder has been removed and put the piston position probe, 21825630 or 21825947 (A1) into the position for the number 2 cylinder. Fit the atomiser clamp to the probe and tighten the setscrews gradually and evenly. The piston position probe is used to set the crankshaft to 100° BTDC.

5 Slowly rotate the crankshaft clockwise, from the front, until the piston just contacts the piston position probe. The piston will now be set at 100° BTDC on the compression stroke of number 2 cylinder.

Caution: *Ensure that the piston comes lightly into contact with the piston position probe, or both the piston and the probe could be damaged.*

6 Loosen the locking screw and pull out the spacer between the locking screw and the pump body. Tighten the locking screw to 27 Nm (20 lbf ft) 2,8 kgf m. Ensure that the spacer is not lost. It is recommended that the spacer is fitted to the pump body by locking wire.

Caution: *Do not release the clamp of the KSB cold start device, if one is fitted.*



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7 Remove the low pressure pipes and cables from the fuel pump.

8 Remove the setscrew and the nut of the support bracket below the fuel pump.

9 Release the setscrews and remove the gear cover from the timing case cover. It may be necessary to carefully hit the cover with a soft faced hammer to release it.

Release the flange nuts of the pump three or four turns.

Remove the nut, washer and the spacer (early Phaser 210Ti engines only) from the drive gear for the pump.

Fit the gear puller 21825565 and loosen the gear on the drive shaft of the pump. If the holes for the puller adaptors in the fuel pump gear are not in the correct position to fit the puller it may be necessary to remove the coolant pump, see Operation 12-4 or Operation 12-11.

Caution: *The crankshaft must not be moved when the pump is not on the engine. Movement of the crankshaft may result in damage to the timing case and make it necessary to time the engine before the pump can be fitted.*

10 Remove the pump from the engine.

Caution: *The fuel injection pump must be set in accordance with the procedure in Operation 11-18 if:*

- The pump is to be renewed.
- The pump performance is not correct.
- The locking screw is released after the pump is removed from the engine.

To fit **Operation 11-17**

***Cautions*:**

- *Do not rotate the crankshaft when the piston position probe is fitted to the engine.*
- *Ensure that the spacer, fitted to early 210Ti engines, is in position or the nut will not tighten the gear correctly.*

1 Fit a new joint or the "O" ring (A1) and put the pump into position on the timing case. Ensure that the key is engaged correctly in the keyway of the drive gear.

2 Fit the spacer (early Phaser 210Ti engines only), spring washer and the nut to retain the drive gear. Tighten the nut to approximately 15 Nm (11 lbf ft) 1,5 kgf m.

3 Hold the top of the pump toward the engine to remove the backlash and fit the nuts to the pump flange. Tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

4 Fit the fastener for the pump bracket, ensure that there is no tension on the pump and tighten the fastener.

5 Release the locking screw (2) and fit the spacer (3), tighten the locking screw to 12 Nm (9 lbf ft) 1,2 kgf m.

6 Remove the piston position probe from the engine and fit the atomiser together with a new seat washer. Fit the remainder of the atomisers. Tighten the setscrews for all of the atomisers.

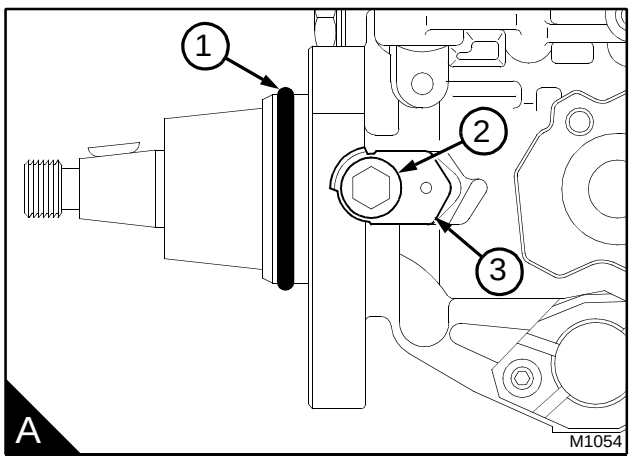
7 Fully tighten the nut for the drive gear to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover.

8 Fit the pipes and cables to the pump.

9 Eliminate air from the fuel system, see Operation 11-25.

10 Fit the rocker cover, see Operation 3-2.

11 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no load speed is correct, see Operation 11-20.



To set **Operation 11-18**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Universal timing gauge	21825610	Gear adaptor for use with 21825610	21825513
Adaptor for use with 21825610	21825511	Pump timing gauge	21825626

Caution: *This procedure must be followed carefully if:*

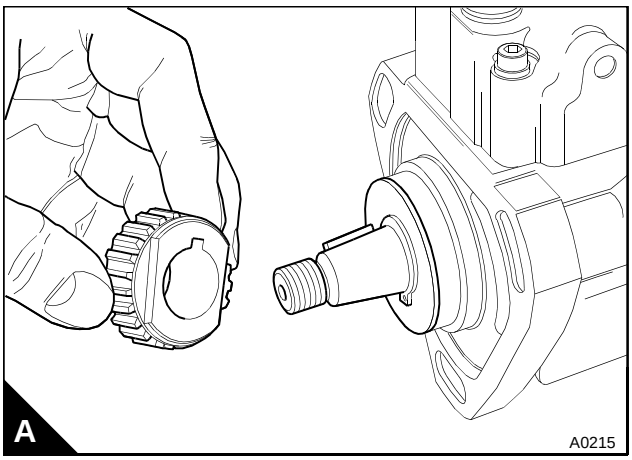
- The fuel injection pump is new.
- The pump performance is not correct.
- The locking screw is released after the pump is removed from the engine.

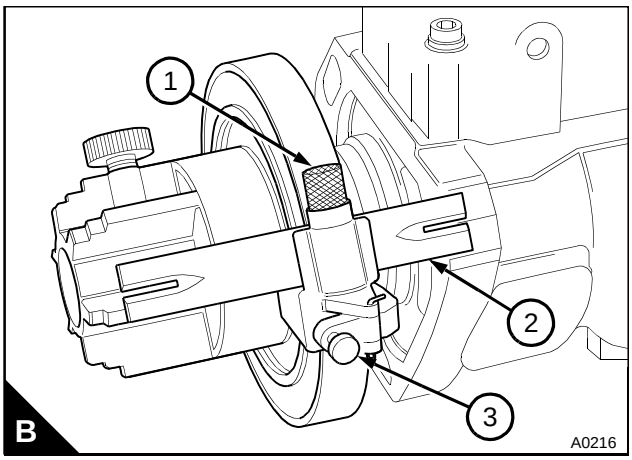
1 Hold the pump securely in a vice by the support bracket.

2 Release the pump locking screw. Remove the plug and washer from the rear of the pump and fit the adaptor, 21825626, and a suitable dial gauge. Set the dial gauge to indicate approximately 3,0 mm (0.12 in).

3 Fit adaptor, 21825513 (A), for the timing tool, 21825610, to the drive shaft of the pump. Use the nut for the drive gear, tightened finger tight only, to retain the adaptor.

4 Fit the timing tool, 21825610 (B) to the adaptor and fit adaptor PD.67B-1 to the timing tool. 21825511 is used to rotate the timing tool and the shaft of the pump. To rotate the adaptor, it will be necessary to make a suitable bar which uses the three setscrews in the adaptor.





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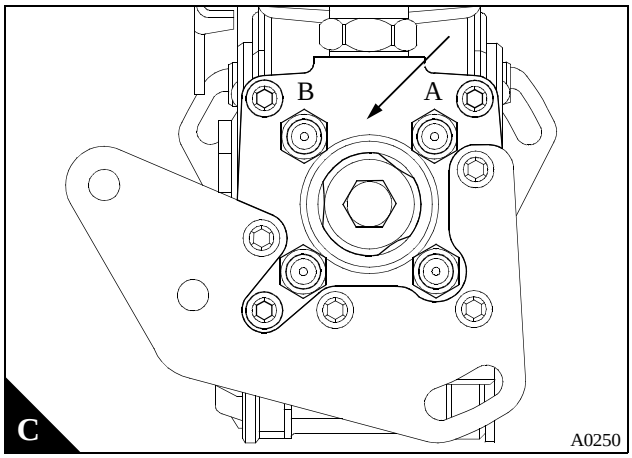
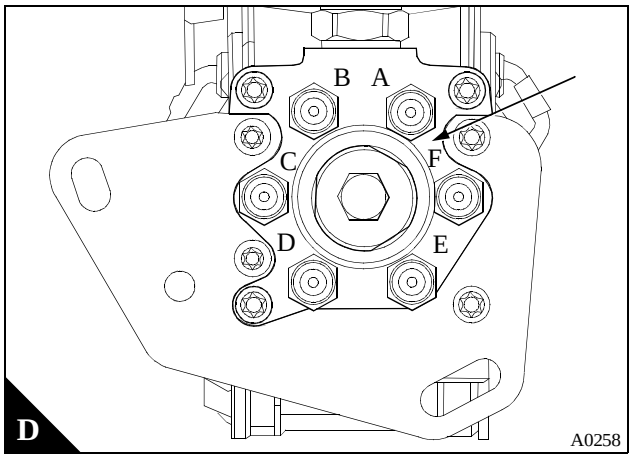
5 Set the injection advance device, if one is fitted, see Operation 11-19.

6 Ensure that the keyway in the drive shaft is between outlet A and B for four cylinder engines (C) or outlet A and F for six cylinder engines (D).



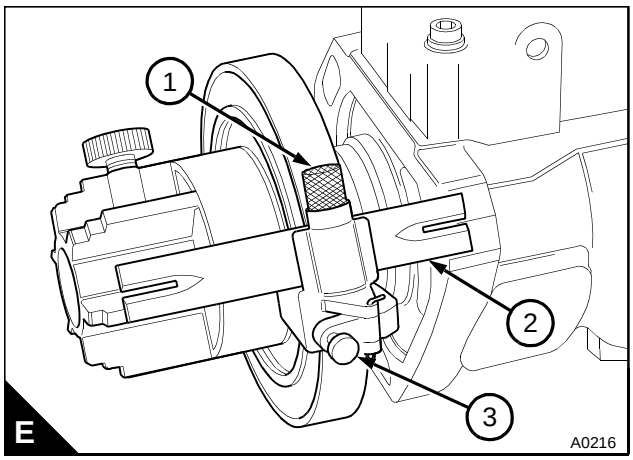


7 Check that the pump plunger is at its lowest position and set the dial of the gauge to zero. There will be no tension on the bar used to turn the pump in this position.

8 Rotate the pump shaft slowly clockwise, from the drive end, until the pointer on the dial gauge indicates 1,0 mm (0.039 in) plunger lift. For engines fitted with fuel pump code TL the plunger lift is 1,25 mm. Hold the shaft in this position and tighten the pump locking screw.

9 Release the locking screw (E3) of the timing tool and move the setting block until the pointer aligns approximately with the centre of the top outer slot in the pump flange. Tighten the screw.

10 Release the locking screw (E1) for the pointer (E2) and slide the pointer forward until the slot in the pointer covers the flange. Tighten the screw.



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11 Hold the timing tool against the direction of pump rotation to remove backlash. Mark the pump flange with a scriber along the slot in the pointer.

12 Release the locking screw for the pointer and slide the pointer backwards to cover half of the flange. Tighten the screw.

13 Remove the timing tool and note the angle indicated on the tool. Increase this angle by the amount shown in the table below at the end of this procedure.

14 Release the locking screw on the pump and allow the pump plunger to return to its lowest position. The dial should return to zero.

15 Fit the timing tool to the pump drive.

16 Rotate the timing tool against the direction of pump rotation until the slot in the pointer is aligned with the mark on the pump flange. Tighten the pump locking screw. Check that the key of the pump shaft is aligned with the keyway in the gear.

17 Disconnect the KSB, if one is fitted.

18 Remove the timing tool and adaptor 21825511S.

19 Remove the nut and adaptor from the shaft of the pump.

20 Remove the adaptor and dial gauge.

21 Fit the washer and plug to the rear of the pump and tighten the plug to 10 Nm (7 lbf ft) 1,0 kgf m.

22 Fit the pump to the engine, see Operation 11-15.

Setting code letter	Angle added to timing tool (degrees)	Setting code letter	Angle added to timing tool (degrees)
BK, CK, DK, EM	44	KL (3)	50
EK (1)	43	ML (3) (4)	50
EL	41	PM	44
EL	45.5	RL (3) (5)	50
FF(4) (6)	50	SK	45
FM	44	TL (4)(5)	50
JC (3)	50	VL	50
JM	46	VM	51
JM (2)	49	WL (7)	50
KC (3)	50		

(1) Engines to build lists YA80433 and YA50360 with the data plate of the pump stamped J609.
(2) Engines to build lists AD70229 and AD70230.
(3) The cold start device (KSB) must be energised before the timing is set, see Operation 11-19.
(4) The plunger lift is 1,25 mm, see step 8 of Operation 11-18.
(5) The plunger lift is 1,35 mm, see step 8 of Operation 11-18 for engines to build list YA50499.
(6) Engines to build list YD81235.
(7) Engines to build list YB50528.

To set the injection advance device (KSB) **Operation 11-19**

Some Bosch EPVE rotary fuel injection pumps have a starting aid (KSB) which advances the injection timing. The device (A) is operated electrically and is connected by a wire to the advance lever (A5) of the fuel injection pump.

When the engine reaches the normal temperature of operation a sender unit in the cooling system energises, to apply 24V to the wax filled element (A3) which operates to retard the timing.

The advance lever of the fuel injection pump is set in the factory to advance the injection timing when the engine is cold. Therefore it will be necessary to energise the KSB if the static timing of the fuel injection pump is to be set:

Caution: *Do not release the clamp (A6) from the KSB wire; this will result in the loss of adjustment set in the factory.*

1 With the fuel injection pump removed from the engine connect a cable from the positive terminal of the battery (A8) to the injection advance device (A2).

2 Connect a cable from the earth terminal of the battery to the fuel injection pump body (A4).

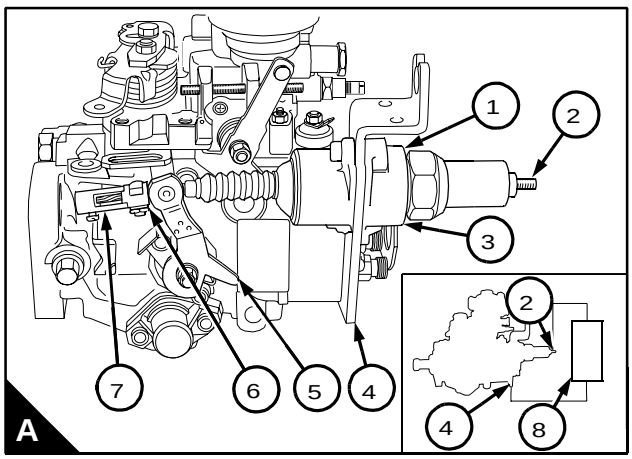
Warning! *Do not touch the body of the hot KSB during the pump setting operation.*

3 Allow a minimum of five minutes for the wax in the wax filled element to expand before the static timing is set.

4 Turn the pump shaft in the direction of rotation to move the lever of the advance mechanism, fully towards the clamp (A6), into the fully retarded position. Ensure that there is no tension in the cable of the KSB before the pump is set.

Notes:

- New pumps may be supplied with a special tool fitted to the end of the wire for factory adjustment (A7). This tool must be removed by the release of the screw and discarded to prevent damage to the wire when the engine is operated. Cut off excess wire which extends from the end of the clamp and seal the end of the wire.
- If the pump performance is correct and static timing adjustment is not necessary, the pump can be removed and fitted without the requirement to energise the KSB.



To adjust **Operation 11-20**

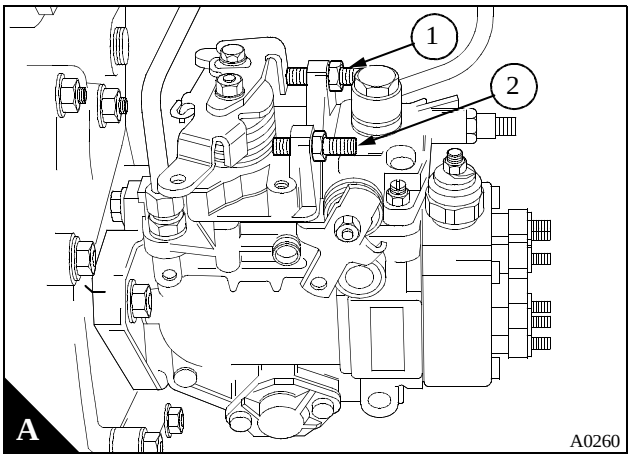
1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Service Department of Perkins Engines Company Limited, Peterborough, England, PE1 5NA.

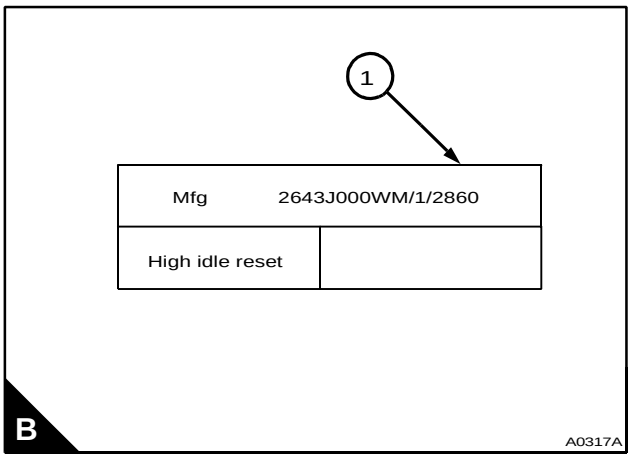
Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed. The maximum no load speed is indicated by the last section of the setting code for the fuel injection pump. The setting code can be found on the data plate (B1) on the side of the fuel pump. A typical setting code is 2643J000CK/1/2860. In this example, the maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed.

3 When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.

The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





General description for pin timed fuel injection pump **Operation 11-21**

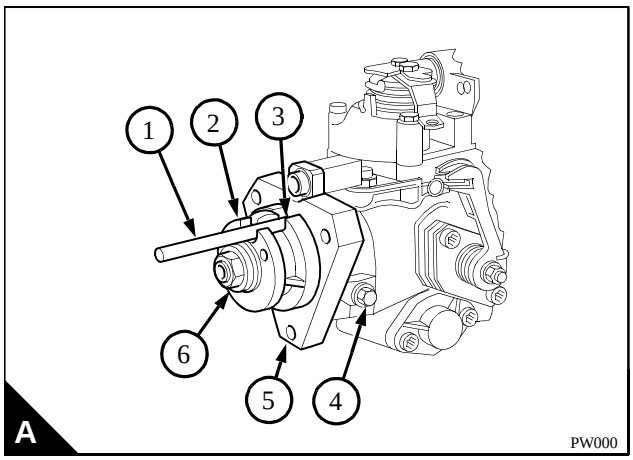
Caution: *Do not release the nut (A6) from the fuel injection pump. Illustration (B) shows the nut (B2) in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*

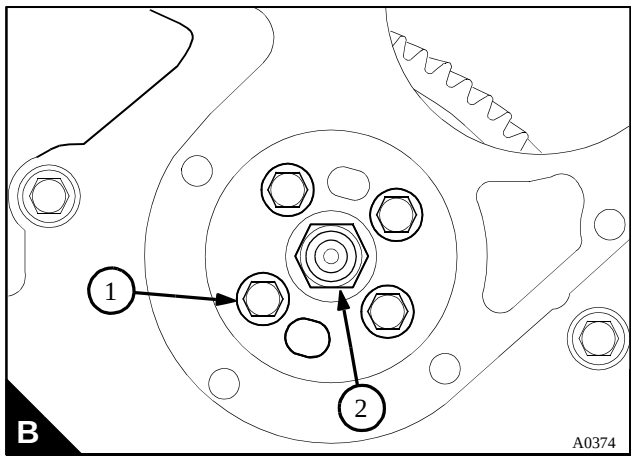
The manufacturer fits the hub (A2) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

To prevent incorrect adjustments to the engine timing by rotation of the fuel pump, the mounting flange (A5) has holes instead of slots.

Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub (A2), with a hole in the body (A3) of the fuel pump. The gear is passed over the pin and fastened to the hub with four flanged setscrews (B1).

Note: On the latest engines, four tamper proof flanged setscrews retain the fuel pump gear. Special tools and personnel with the correct training are necessary to remove these fasteners, refer to your nearest Perkins distributor.





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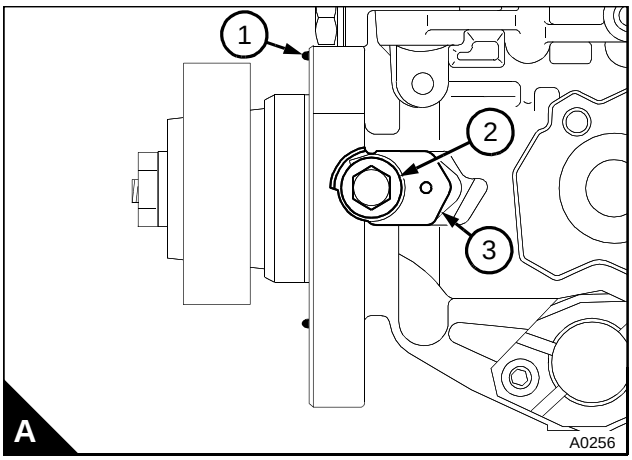
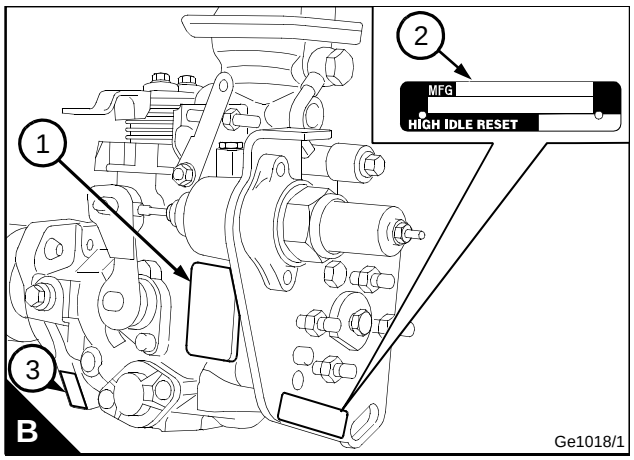
Caution: *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A3) in position under the locking screw (A2)*

The fuel injection pump has a locking screw (C2) and a spacer (C3). The locking screw prevents the rotation of the drive shaft.

An "O" ring (A1) is fitted into a groove in the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case.

Note: Later Bosch fuel injection pumps may be fitted with an additional data plate (B), the additional data plate is fitted in one of two places; either on the flange (B3) or on the rear mounting bracket (B2). The additional data plates are used by Perkins to identify fuel injection pumps after a minor modification to alter the pump and/or the engine performance. Information on the additional data plate will supersede the information found in the original Bosch data on the fuel injection pump body (B1).





To remove pin timed fuel injection pump **Operation 11-22**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Spanner for flange nut of the Bosch fuel injection pump	21825964	Timing pin	27610032

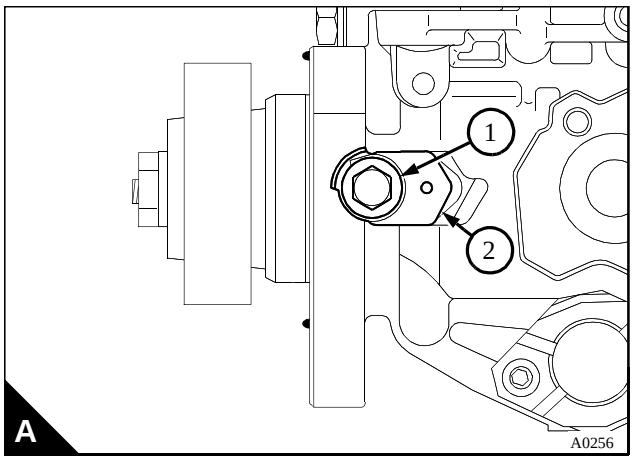
Caution: *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (A2) in position under the locking screw (A1). Before the crankshaft is turned or the pump is fitted, put the spacer into position under the locking screw to ensure that the pump drive shaft is released.*

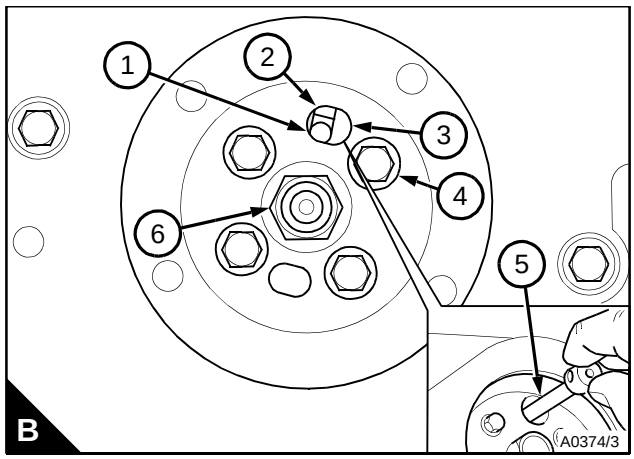
1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump.

4 Insert the timing pin (B5) through the hole (B3) in the fuel pump gear and the slot of the hub (B2). Push the pin fully into the hole (B1) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.





Caution: *Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is released.*

5 Remove the pipes. Remove the cables and the connections for the cold start device and the electrical stop solenoid from the fuel pump.

***Cautions*:**

- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw (A1) must be released and a spacer (A2) fitted.*
- *Do not release the nut (B6) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is moved, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Remove the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

7 Remove the four flanged setscrews (B4) and release the fuel pump gear from the hub of the fuel injection pump.

8 Remove the nuts from the flange of the fuel pump and remove the pump. If access to the nuts is restricted by, for example, a compressor, use tool 21825964 to release the nuts.

To fit pin timed fuel injection pump **Operation 11-23**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Spanner for flange nut of the Bosch fuel injection pump	21825964	Timing pin	27610032

***Cautions*:**

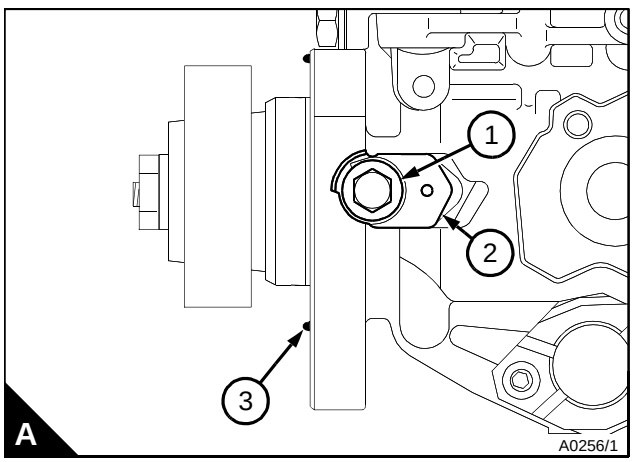
- *The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.*
- *The drive shaft of the pump must not be rotated without the spacer (A1) in position under the locking screw (A2). If the drive shaft is rotated with the locking screw tightened on to the shaft, the drive shaft will be damaged.*

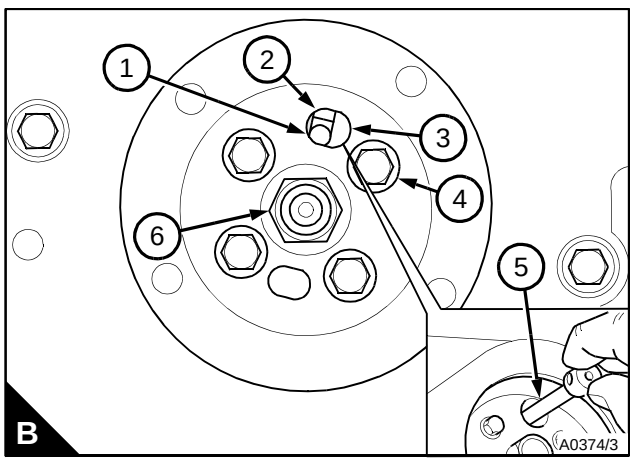
1 Inspect the "O" ring (A3) in the pump flange and, if necessary, fit a new "O" ring.

2 Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case.

3 Put the fuel pump into position on the three studs and fit the flange nuts.

4 Fit the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.





5 Tighten the flange nuts of the fuel pump to 28 Nm (20 lbf ft) 2,8 kgf m.

Caution: *Do not release the nut (B6) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is moved, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Put the fuel pump gear onto the hub of the fuel pump. The flanged setscrews (B4) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the flanged setscrews finger tight.

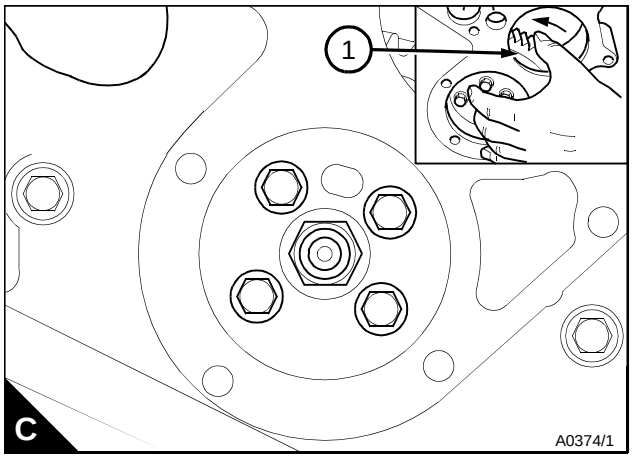
Note: The fuel pump gear will only fit in one position. The gear is fitted with the letters C and M at the front.

7 Insert the timing pin (B5) through the hole (B3) of the fuel pump gear and the slot of the hub (B1) until it can be pushed fully into the hole (B2) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.

Continued

Caution: *The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

8 Carefully turn the gear counter-clockwise, by hand (C1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the flanged setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.



9 Remove the timing pin.

10 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump.

Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.*

11 Fit all the pipes. Connect the stop control and the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

12 Eliminate air from the fuel system, see Operation 11-25.

13 Fit the cylinder head rocker cover.

14 Connect the battery.

15 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-24.

To adjust pin timed fuel injection pump **Operation 11-24**

The engine conforms with USA (EPA/CARB) stage 1 and EEC stage 1 emissions legislation for agricultural and industrial applications.

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission.

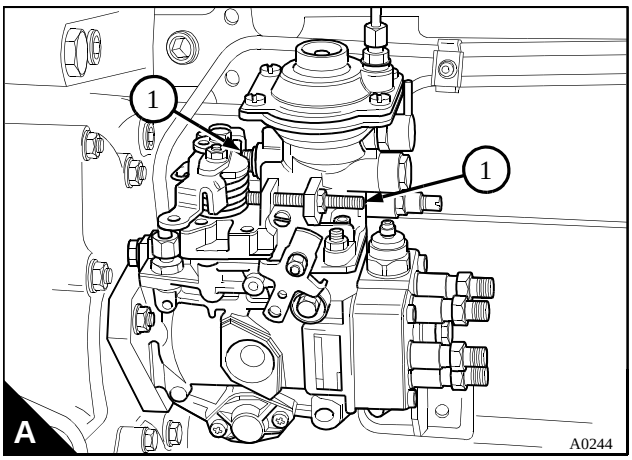
Specialist equipment, which is available at your Perkins distributor, is needed to adjust the idle or maximum speed settings. The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.



To eliminate air from the fuel system **Operation 11-25**

Warnings!

- *If your skin comes into contact with high pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

If air enters the fuel system, it must be removed from the system before the engine can be started.

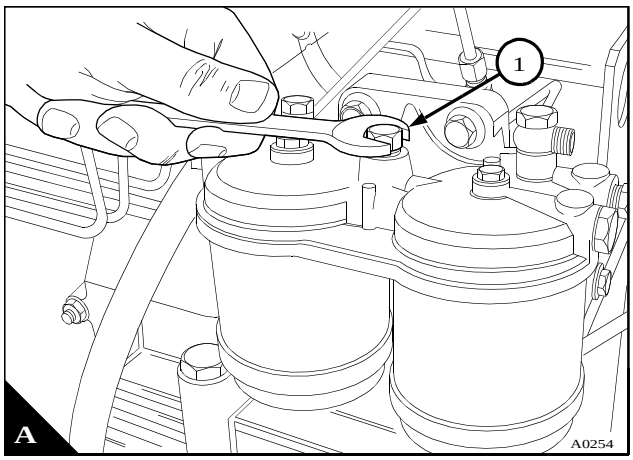
Air can enter the system if:

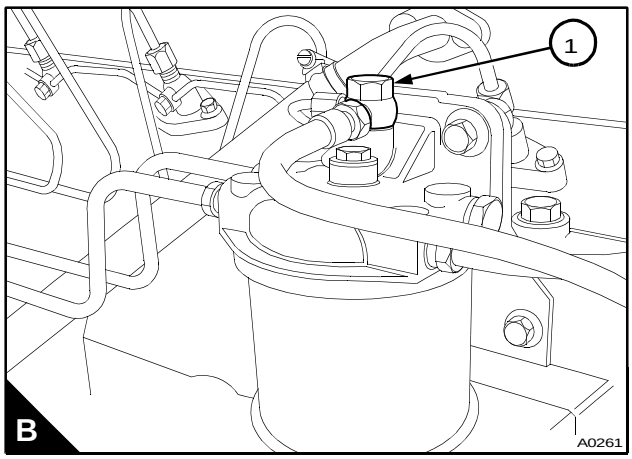
- The fuel tank is drained during normal operation
- The low-pressure fuel pipes are disconnected
- A part of the low-pressure fuel system leaks during engine operation

In order to remove air from the fuel system, proceed as follows:

Caution: *If the fuel system is empty or if the canister of the fuel filter has been removed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.*

1 Loosen the vent plug (A1) on top of the twin element fuel filter (A) by two or three turns. If a single element filter is used, loosen the banjo connection bolt (B1) which is fitted on the top of the filter (B).





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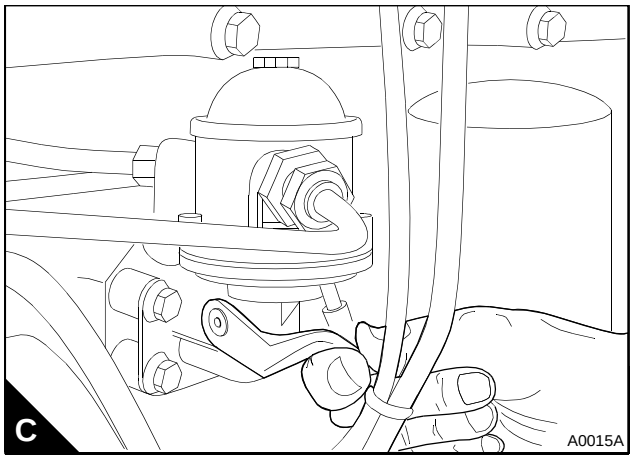
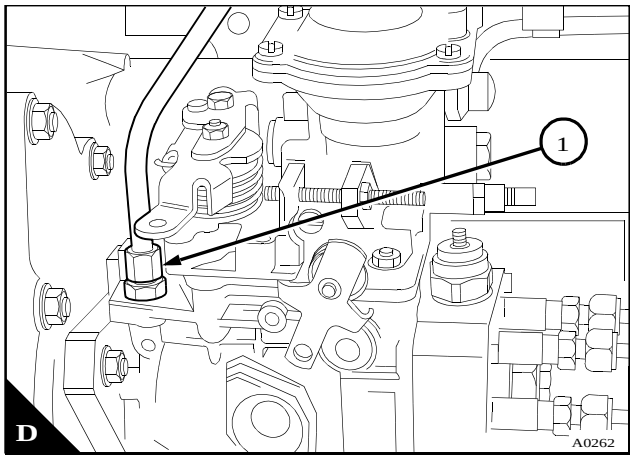
2 Operate the priming lever on the fuel lift pump (C) until fuel, free of air, comes from the filter vent point. Tighten the vent plug or the banjo connection bolt.

Note: If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

3 Ensure that the manual stop is in the "run" position. If an electrical stop control is used, turn the key of the start switch to the "R" position.

4 Loosen the union nut of the fuel inlet pipe (D1). Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the loose connection. Tighten the union nut.





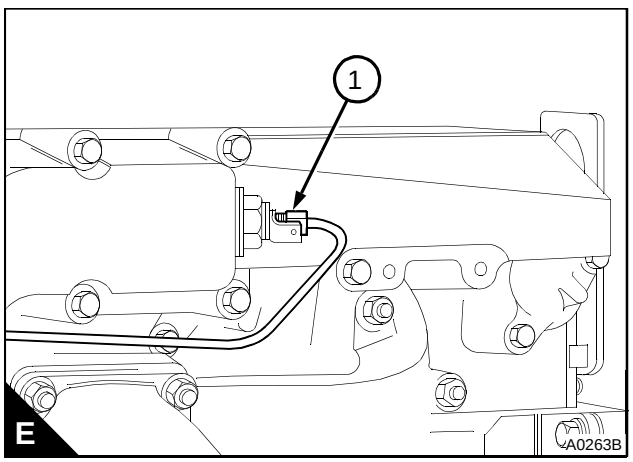
Caution: *spanner to prevent movement of the fuelled starting aid (E1) when the union nut is loosened or tightened.*

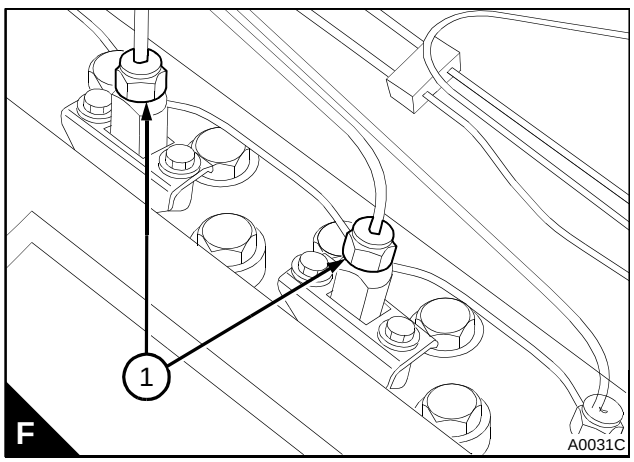
5 Loosen the union nut (E1) at the fuelled starting aid, if one is fitted, and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

6 Loosen the high-pressure pipe connections (F1) at two of the atomisers.

Warning! *When the starter motor is operated to eliminate air from the high pressure pipes, the engine may run.*

Caution: *Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.*





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7 Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free from air, comes from the pipe connections.

8 The engine is now ready to start.

Caution: *Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure 5hat the pump is free of air and prevent any damage to the fuel injection pumps internal parts by metal to metal contact.*

Note: If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the suction or low-pressure system.

Bosch MW in-line fuel injection pump

General description

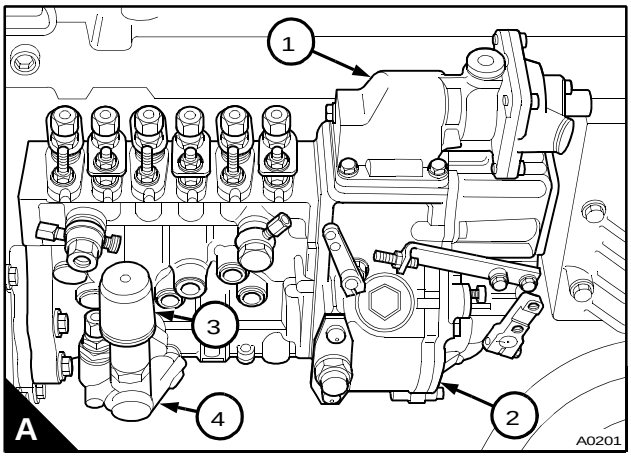
Caution: *It is very important that dirt does not enter the fuel system. Before a connection is disconnected, clean thoroughly the area around the connection. After the component has been disconnected, fit a suitable cover to all open connections.*

The Bosch MW in-line fuel injection pump has a mechanical governor (A2) fitted to the rear of the pump to control engine speed. On top of the governor housing is a boost control (A1). The boost control is a device which is affected by boost pressure (from the turbocharger) and reduces the maximum fuel delivery at lower engine speeds to match the reduced air supply to the cylinders.

The "low spring" atomisers receive high-pressure fuel from the fuel injection pump and inject this fuel into the combustion chamber of the piston as a very fine spray. The atomisers are set in the factory, but must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a shim fitted above the spring.

The fuel injection equipment must be checked and adjusted by personnel who have had the correct training.

The plunger type fuel lift pump (A4) can either be on the side of the fuel injection pump, or on the right side of the cylinder block. When the lift pump is fitted to the cylinder block, an adaptor is fitted between the pump and the cylinder block. The fuel lift pump is driven by an eccentric on the camshaft of the fuel injection pump, or by an eccentric on the engine camshaft. The fuel lift pump is fitted with a priming pump (A3).



To remove **Operation 11-26**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Puller	21825565	Piston position probe	21825947
Adaptor for use with 21825565	21825930		

1 Remove the rocker cover, see Operation 3-1.

2 Loosen the setscrews which retain the atomisers.

3 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of number 1 cylinder just releases.

Note: A locally made washer (A2) must be fitted onto the piston position probe (A1) when the engine check angle is less than 100° BTDC, see "Engine timing (Bosch in-line fuel injection pump)" on page 44.

4 Remove the atomiser from number 1 cylinder together with its seat washer and put the piston position probe, 21825630 or 21825947, (A1) in its place. Fit the atomiser clamp to the probe and tighten the setscrews gradually and evenly.

Caution: *Ensure that the piston comes lightly into contact with the piston position probe, or the piston could be damaged. Also the probe could become bent and this could cause the piston position to be incorrect.*

5 Very carefully turn the crankshaft clockwise until the piston just comes into contact with the piston position probe.

6 Release the setscrews and remove the gear cover from the cover of the timing case.

7 Release the cap screws which retain the fuel pump gear. Remove the cap screws and the plate (B1). Ensure that when the cap screws are removed, and the plate does not fall into the timing case.

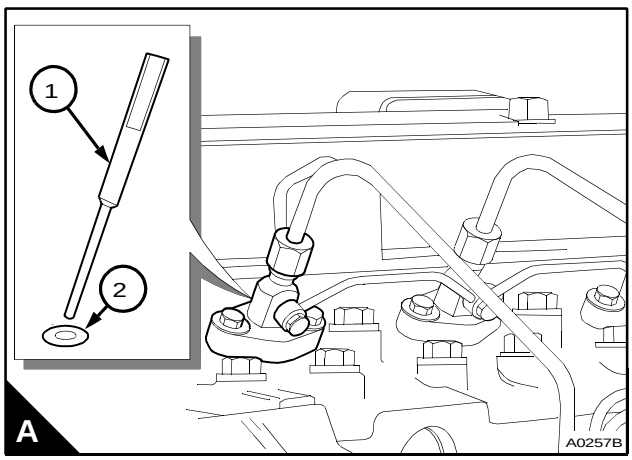
8 Remove the high-pressure pipes and the low pressure pipes from the fuel pump. Remove the lubricating oil pipe and the boost control pipe from the fuel pump.

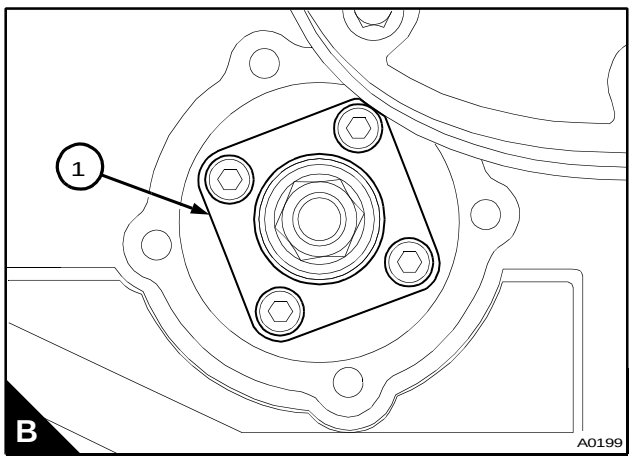
9 Disconnect the stop control/electrical cable and the engine speed control.

10 Four cylinder engines: Loosen the setscrews that retain the pump support bracket to the cylinder block. Remove the nut and bolt from the bracket and remove the spacer between the brackets.

Six cylinder engines: Loosen the setscrews that retain the pump support bracket to the cylinder block. Remove the setscrew that holds the support bracket for the pump body to the pump support bracket.

Caution: *The crankshaft must not be rotated when the pump is not on the engine.*





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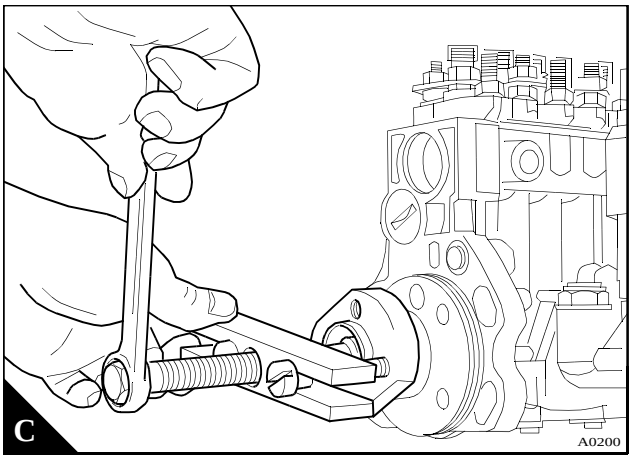
11 Release the fasteners which retain the fuel pump and remove the pump together with the hub.

12 If a new fuel pump is to be fitted, the hub must be removed from the old pump and fitted onto the new pump.

13 To remove the hub:

Release the hub nut. To prevent movement of the hub, hold the hub with a suitable spanner on the flats which are on the flange of the hub.

Remove the nut and the hardened washer. Loosen the hub with the puller 21825565 and the adaptors 21825930 (C). Remove the puller and the hub. Ensure that the key in the shaft is not lost.



To fit **Operation 11-27**

Special requirements

Special tools	
Description	**Part number**
Timing light	KJ37007

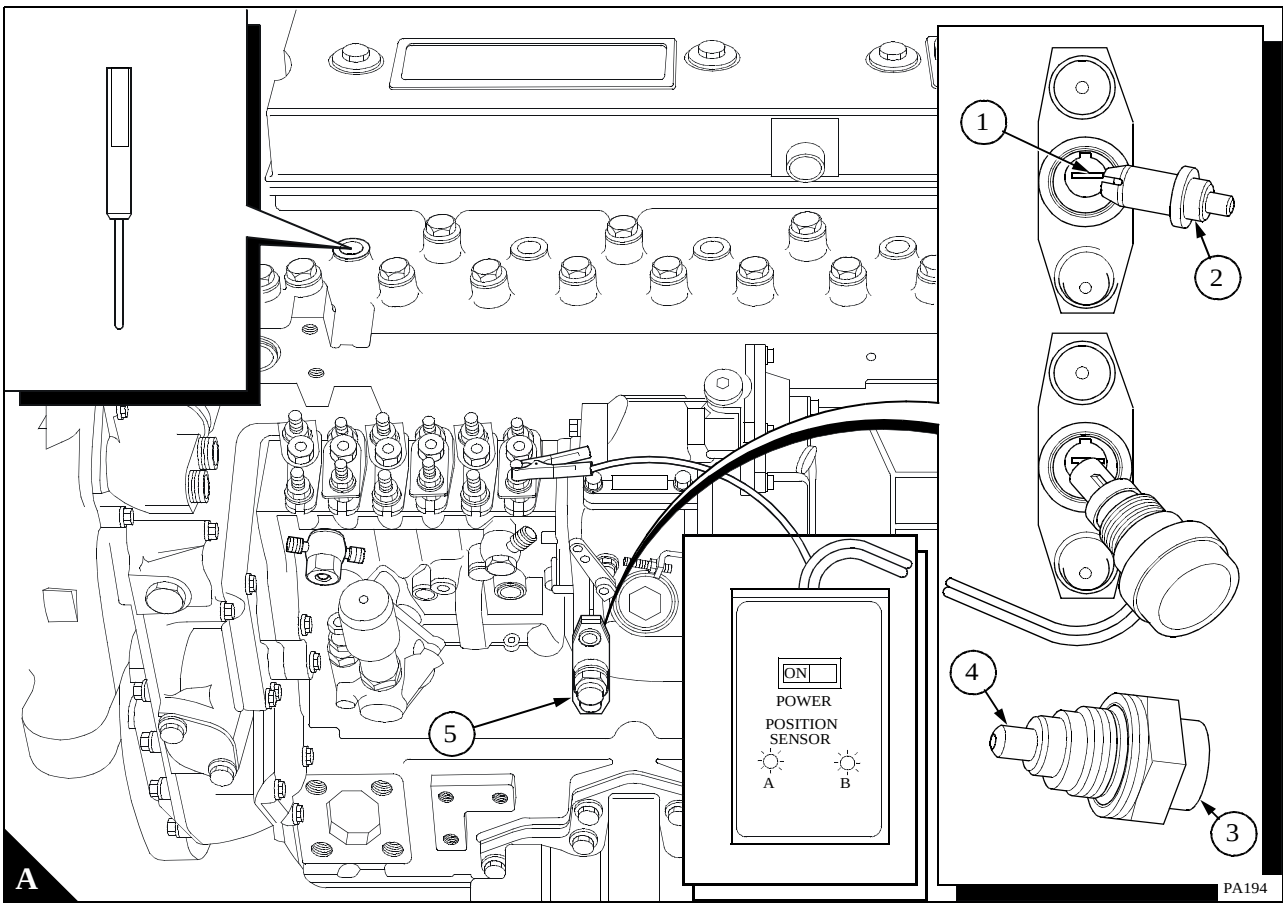
1 To fit the hub:

Ensure that the key is correctly fitted in the shaft and put the hub in position on the shaft with the keyway engaged on the key. Put the hardened washer in position in the hub and fit the nut.

To prevent movement of the hub, hold the hub with a suitable spanner on the flats on the flange of the hub. Tighten the hub nut to 135 Nm (100 lbf ft) 13,8 kgf m.

2 New fuel pumps and pumps that have had the lubricating oil drained should have clean engine lubricating oil added through the hole in the timing attachment (A5). To add the oil, remove the cap (A3) together with the plastic pin (A4) from the timing attachment. Ensure that the tag (A1) cannot be seen in the governor housing. Add oil through the hole in the timing attachment. For four cylinder engines add 600 ml (1 pint) $^{1}/_{2}$ US quart and for six cylinder engines add 700 ml (1 $^{1}/_{4}$ pints) $^{3}/_{4}$ US quart.

3 Remove the cap and its copper washer from the timing attachment on the governor housing and remove the plastic pin from the cap. Rotate the shaft of the fuel pump until the tag in the governor housing can be seen in the centre of the hole in the timing attachment. Put the plastic pin (A2), with the slot in a horizontal position and toward the pump, into the hole and engage the pin with the tag in the governor housing. Very carefully move the shaft of the pump to ensure that the pin is correctly engaged.



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Caution: *Ensure that the drive shaft of the pump is not rotated while the pin is engaged with the tag in the governor housing. If the shaft is rotated, damage could occur to the tag in the governor housing.*

4 Lightly lubricate the "O" ring (B2) on the flange of the pump with clean lubricating oil. Also ensure that the small "O" ring (B1) on the flat front face of the pump is in place.

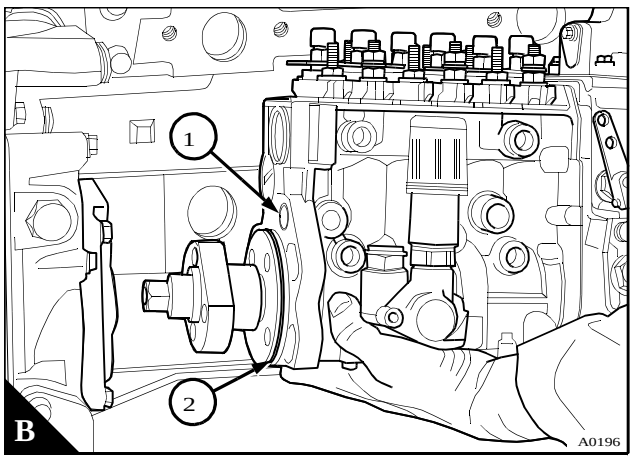
Note: The small "O" ring was only used on early engines. On these engines the oil supply to the pump was connected to the adaptor plate on the timing case. Later engines have the oil supply connected to the side of the fuel pump and the small "O" ring is removed.

5 Fit the fuel pump to the adaptor plate on the timing case, ensure that the "O" ring on the flange of the pump is not damaged. Fit the setscrews of the fuel pump. Ensure that the fasteners are in the centre of the slots in the pump flange and tighten the fasteners.

6 Four cylinder engines: Fit the spacer between the two pump support brackets, put the bolt in position and loosely fit the nut. Adjust the brackets to ensure that there is no tension on the fuel pump. Tighten the setscrews that retain the bracket to the cylinder block. Support the fuel pump and tighten the nut and bolt.

Six cylinder engines: Loosely fit the setscrew that holds the two brackets. Tighten the setscrews that retain the bracket to the cylinder block. Support the pump and tighten the setscrew that holds the two brackets, ensure that there is no tension on the fuel pump.

7 Put the drive gear in position on the hub of the fuel pump, see Operation 6-7. Ensure that the gear is fully in position on the hub. Fit the plate to the gear, ensure that the plate does not fall into the timing case. Fit the cap screws and tighten them enough to allow movement between the hub and the gear.



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8 Remove the plastic pin from the timing attachment. Put the probe (C4) of the timing light, KJ37007, (C9) into the timing attachment. Ensure that the spline (C7) on the probe is at the top and enters the slot in the timing attachment. Tighten the body of the probe. Connect the earth cable (C10) to the engine in a place where there will be a good earth connection.

9 Press the switch (C8) on the timing light to the "ON" position. Rotate the hub of the fuel pump clockwise, from the front, until the cap screws come to the end of the slots in the gear. Rotate the hub of the fuel pump counter-clockwise until the two lamps on the timing light are illuminated. Hold the hub in this position and tighten the cap screws enough to ensure that the hub will not move when the hub is released.

10 Rotate the crankshaft counter-clockwise, from the front of the engine, $^{1}/_{4}$ of a turn.

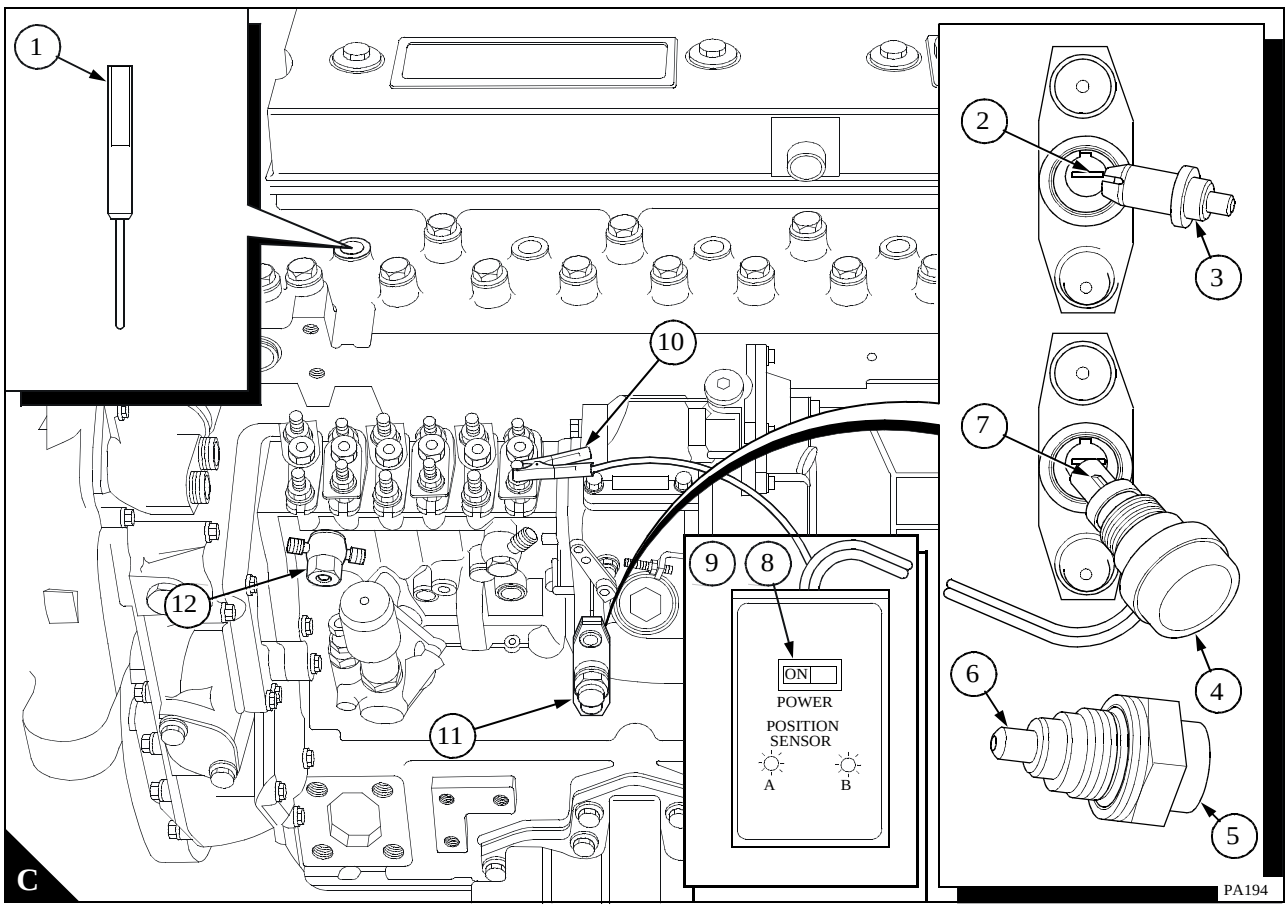
Caution: *Ensure that the piston comes lightly into contact with the piston position probe, or both the piston and the probe could be damaged.*

11 Very carefully rotate the crankshaft clockwise until the piston just comes into contact with the piston position probe.

12 Check that the two lamps on the timing light are illuminated and fully tighten the cap screws to 35 Nm (26 lbf ft) 3,6 kgf m.

13 If both of the lamps are not illuminated, hold the hub and release the cap screws. Adjust the position of the hub to illuminate both of the lamps and tighten the cap screws. To check the timing is correct, repeat steps 10, 11 and 12.

14 Fit the gear cover together with a new joint to the cover of the timing case. Clean the threads of the setscrews for the gear cover and apply a sealant to the threads. Tighten the setscrews to 9 Nm (6.5 lbf ft) 0,9 kgf m.



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15 Press the switch on the timing light to the "OFF" position. Disconnect the earth lead, remove the probe of the timing light from the timing attachment and remove the timing light.

16 Put the plastic pin into the cap (C5) for the timing attachment. Ensure that when the pin is in the cap, the brass end of the pin (C6) can be seen. Put the cap and its copper washer in position on the timing attachment and tighten the cap.

Caution: *If the plastic pin is not put into the cap correctly, damage could occur to the fuel injection pump.*

17 Release the setscrews and remove the piston position probe from number 1 cylinder and the special washer, if one is fitted. Fit the atomiser together with a new seat washer. Tighten the setscrews of all the atomisers gradually and evenly to 12 Nm (9 lbf ft) 1,2 kgf m.

18 Fit the high-pressure pipes. The relevant cylinder outlets of the pump are in the sequence 1,2,3,4 or 1,2,3,4,5,6 with the number 1 cylinder outlet at the drive end of the pump. Fit the low-pressure pipes. Ensure that the banjo connection bolt (C12) with the spring loaded valve is fitted to the low-pressure connection at the drive end of the fuel pump.

Note: This banjo connection bolt is usually identified by a ball bearing in the head.

19 Connect the lubricating oil pipe to the fuel pump. Connect the stop control/electrical cable and the engine speed control.

20 Fit the rocker cover, see Operation 3-1.

21 Eliminate the air from the fuel system, see Operation 11-30.

22 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-28.

23 If a new fuel injection pump has been fitted, check the maximum no-load speed, see Operation 11-28.

To adjust the fuel injection pump **Operation 11-28**

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (A7). Release the lock nut (A6) and rotate the adjustment screw clockwise, from the rear, to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given apply to your nearest Perkins distributor. If further assistance is necessary, apply to the Technical Service Department of Perkins Engines Company Limited, Peterborough, England, PE1 5NA.

2 With the engine at its normal temperature of operation, check the maximum no load speed. If necessary, adjustment can be made by the adjustment screw (A5).

For early engines, remove the lead seal (A4) for access to the lower screw (A3). Release the lower screw and remove the cover (A2).

On the latest engines the lead seal, screw and cover have been removed and locking wire fitted to prevent movement of the adjustment screw for the maximum no-load speed. Cut the locking wire and discard the lead seal.

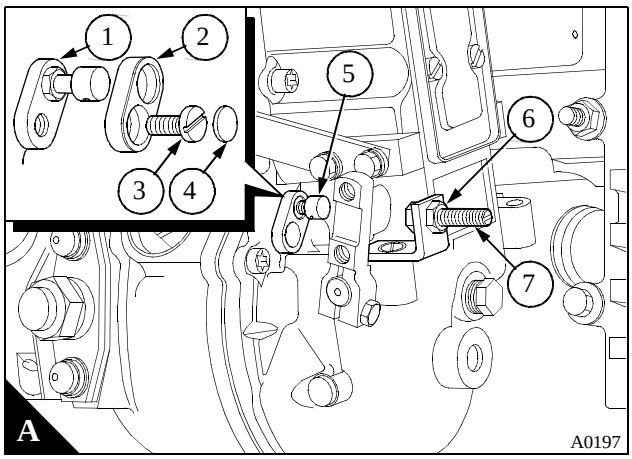
Release the lock nut (A1) and rotate the adjustment screw clockwise, from the rear, to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut.

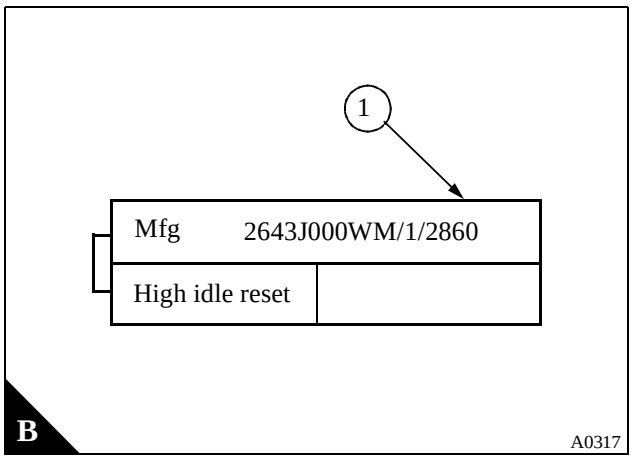
For early engines, fit the cover, fit and tighten the lower screw. Fit a new lead seal to seal the lower screw. For the latest engines, renew the locking wire and fit a new lead seal.

Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

With the engine at its normal temperature of operation, check the maximum no load speed. The maximum no load speed is indicated by the last section of the setting code for the fuel injection pump. The setting code can be found on the data plate (B1) on the side of the fuel pump. A typical setting code is 2643J000WM/1/2860. In this example, the maximum no load speed is 2860 rev/min.

The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially. The adjustment screw on the original fuel pump is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





To remove and fit the adaptor plate for the fuel injection pump **Operation 11-29**

1 Remove the fuel injection pump, see Operation 11-26.

Note: The latest engines do not have an "O" ring (A1) or a lubricating oil pipe fitted.

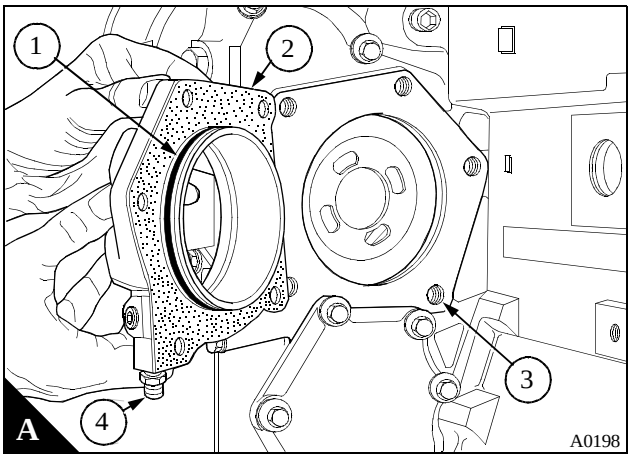
2 Disconnect the lubricating oil pipe, if one is fitted, from the adaptor plate connection (A4).

3 Release the five setscrews and remove the adaptor plate.

4 Renew the joint (A2) and the "O" ring (A1), if one is fitted. Lightly lubricate the "O" ring with lubricating oil and put the adaptor plate in position on the timing case.

5 Clean the threads of the setscrews and the threads in the timing case and apply a sealant to the threads. Fit the setscrews, ensure that the longest setscrew is fitted in the inner bottom position (A3). Tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

6 Connect the lubricating oil pipe (if one is fitted) to the adaptor plate.



To eliminate air from the fuel system **Operation 11-30**

If air enters the fuel system, it must be removed before the engine can be started.

Air can enter the system if:

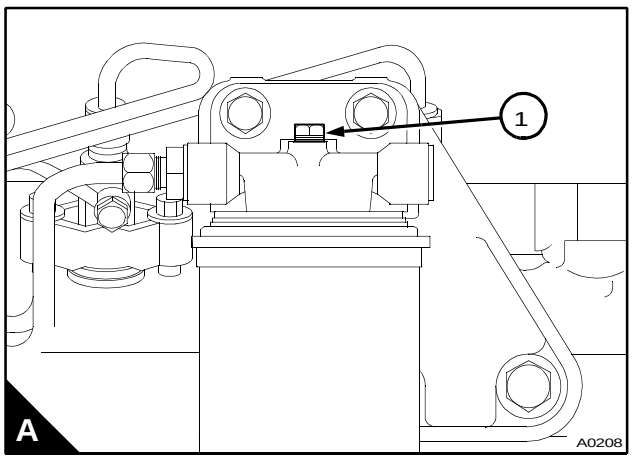
- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

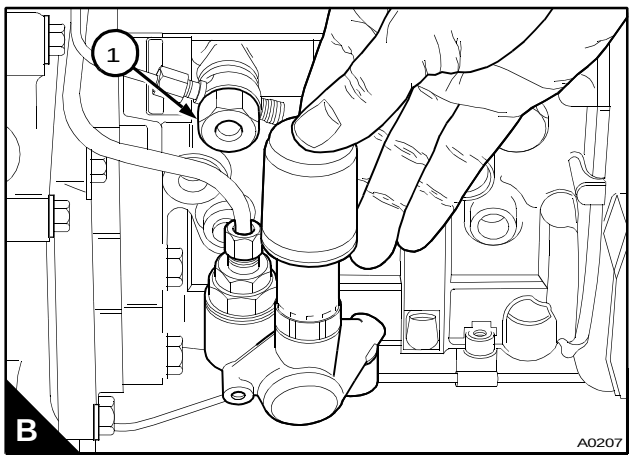
In order to eliminate air from the fuel system, proceed as follows:

1 Loosen the vent plug (A1) on top of the fuel filter by two or three turns. Operate the priming pump (B) of the fuel lift pump until fuel, free of air, comes from the filter vent point. Tighten the vent plug.

2 Loosen the banjo connection bolt (B1) at the drive end of the fuel pump. Operate the priming pump of the fuel lift pump until fuel, free of air, comes from the loosened connection. Tighten the banjo connection bolt.

3 Ensure that the stop control is in the run position and the speed control is in the maximum speed position. Operate the starter motor. When the engine starts, reduce the engine speed. If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the low pressure system.





Lucas/Delphi DPA and DPS fuel injection pumps

To remove **Operation 11-31**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Spanner for flange nuts of fuel injection pump	21825608
Adaptors for use with 21825565	21825568		

1 Remove all the pipes, disconnect the stop control and the control rod of the fuel injection pump.

2 Remove the gear cover from the cover of the timing case. Remove the gear nut and the spring washer.

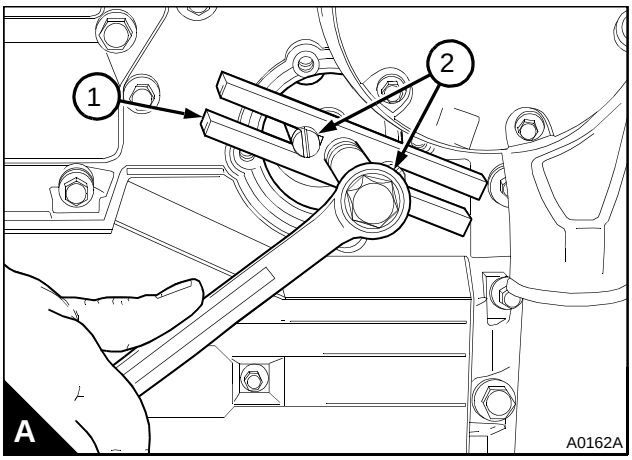
3 Rotate the crankshaft to ensure that the keyway in the drive gear of the fuel pump is at or is near to the top.

4 Remove the setscrew and the nut of the support bracket below the fuel pump. Release the flange nuts of the fuel pump. If access to the flange nuts of the fuel pump is restricted by, for example, a compressor, use tool 21825608 to release the flange nuts.

5 Loosen the drive gear of the fuel injection pump with the puller 21825565 and the adaptors 21825568 (A).

Caution: *The crankshaft must not be moved when the pump is not on the engine. Movement of the crankshaft may result in damage to the timing case and make it necessary to time the engine before the pump can be fitted.*

6 Remove the fuel pump. Ensure that the key does not fall from the drive shaft.



To fit **Operation 11-32**

Special requirements

Special tools	
Description	**Part number**
Spanner for flange nuts of fuel injection pump	21825608

Caution: *The crankshaft must not be moved when the pump is not on the engine. Movement of the crankshaft may result in damage to the timing case and make it necessary to time the engine before the pump can be fitted.*

1 Rotate the drive shaft of the fuel injection pump to align the key with the keyway in the drive gear. Ensure that the key is correctly fitted and fit the fuel pump to the gear.

2 Align the mark on the flange of the fuel pump with the mark on the rear face of the timing case (A1). Fit the flange nuts of the fuel pump and the setscrew and the nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

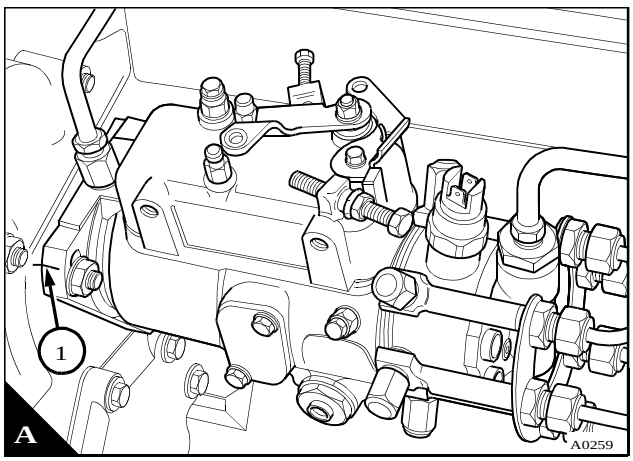
3 Fit the spring washer and the nut to the drive shaft of the fuel pump and tighten the nut to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover to the cover of the timing case together with a new joint.

4 Fit all the pipes. Connect the stop control and the control rod of the fuel pump.

5 Eliminate air from the fuel system, see Operation 11-35.

6 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-33.

7 If a new fuel pump has been fitted, check the maximum no load speed, see Operation 11-33.



To adjust **Operation 11-33**

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Service Department of Perkins Engines Company Limited, Peterborough, England, PE1 5NA.

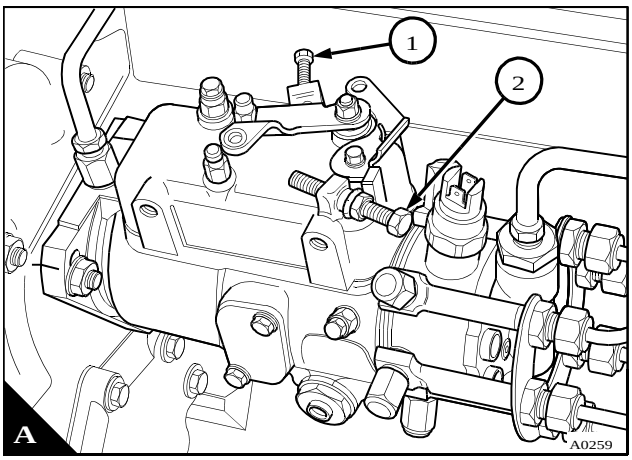
Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

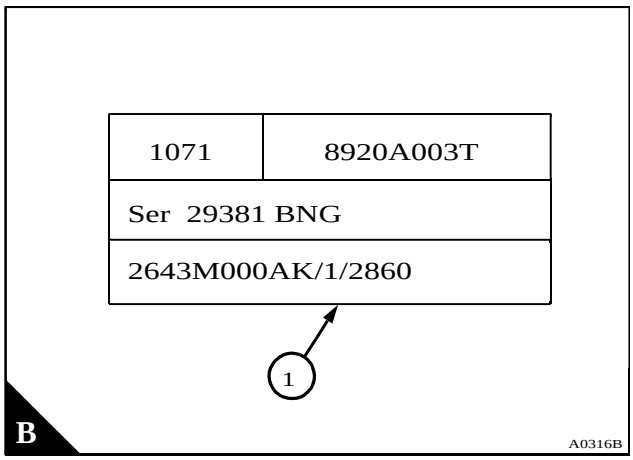
Note: The data on the fuel injection pump is now etched instead of stamped on the data plate. If it is necessary to remove paint from on the data plate, use a suitable solvent which is not corrosive. Do not use a scraper or other sharp tools to scratch off the paint, as the data on the plate could be removed.

2 With the engine at its normal temperature of operation, check the maximum no load speed. The maximum no load speed is indicated by the last part of the setting code for the fuel injection pump. The setting code can be found on the data plate (B1) on the side of the fuel pump. A typical setting code is 2643C618DM/1/2420. In this example, the maximum no load speed is 2420 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (A2).

Release the lock nut and rotate the adjustment screw counter-clockwise to increase, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.

The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





Electrical shut off solenoid (ESOS) **Operation 11-34**

General description

A new Junior Power Timer (JPT) ESOS was introduced to all new engines fitted with Lucas/Delphi fuel injection pumps. A conversion kit is available to enable the new (JPT) ESOS male connector (A1) to be connected to the Twin Lucar terminals (A4) on the wiring loom. The parts kit consists of a female adaptor (A2) with two male Lucar terminals (A3).

To fit the conversion kit

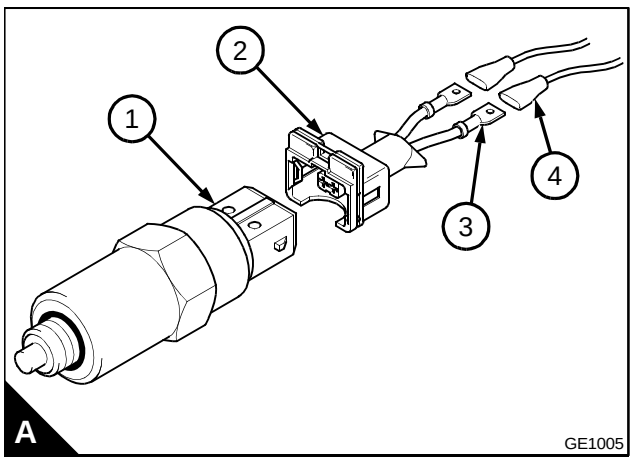
1 Align and fit the female adaptor (A2) on the male connector (A1). Ensure that the two components are fully engaged.

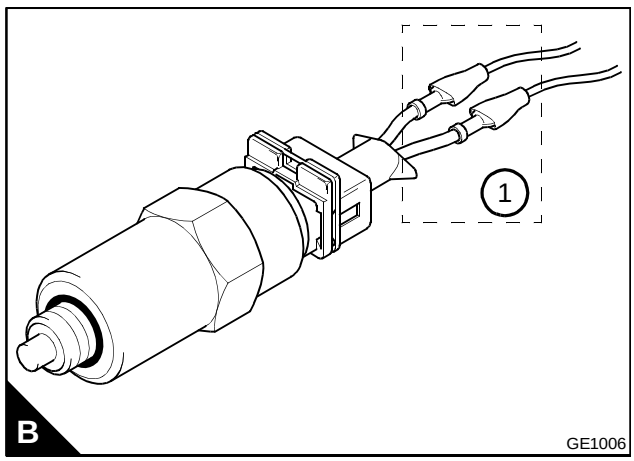
2 Insert the male Lucar terminals (A3) on the adaptor into the insulated female Lucar terminals (A4) on the wiring loom. Ensure that both components are fully engaged.

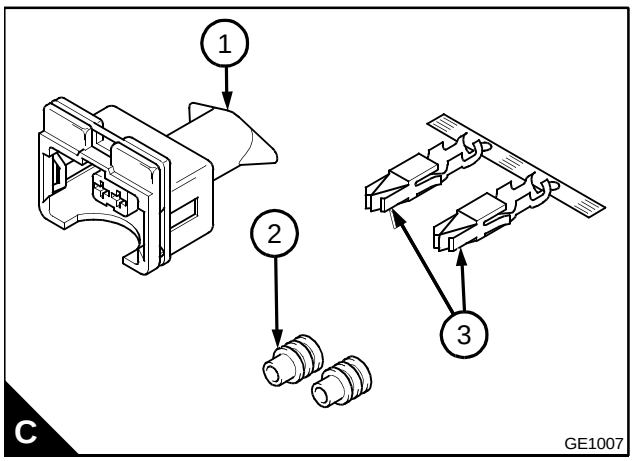
Caution: *This connection (B1) is compatible with IP67 waterproofing standards.*

Wiring loom modification

To ensure that the connection from the new ESOS to the wiring loom is compatible with IP67 water proofing standards, the twin Lucar terminals must be removed and a JPT adaptor kit fitted. The adaptor kit consists of a female JPT adaptor (C1), two cable seals (C2) and two metal terminals (C3).







To fit the adaptor kit

1 With a suitable tool, cut the cables near to the Lucar terminals and remove them from the wiring loom.

2 Remove 4,0 mm (0.17 in) of insulation from the ends of the two cables (A2) and put the cable seals (A4) on to each cable, the narrow end (A3) towards the 4 mm strip.

3 Insert the first cable into the terminal so that the bare wire (A2) is within the clamp (A1).

4 With a suitable tool, close the clamps (A1) until the bare wire is secure. Heat the terminal with a soldering iron and apply solder to the joint (B1). When the joint is cool, push the cable seal (B2) until the narrow end of the cable seal (B3) is within the clamp (B4). With a suitable tool close the clamp until the cable seal is secure.

5 Repeat sequence 3 and 4 for the second cable.

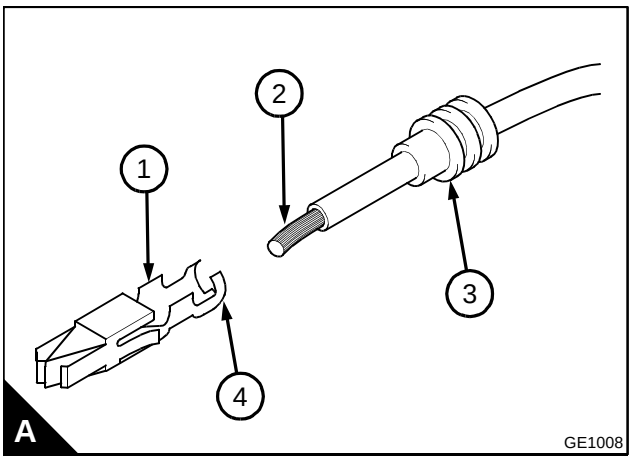
6 Put the adaptor (C2) on a flat surface with the spring clip (C1) at the top. Rotate the terminal, cable and cable seal so that the location tags (C4) on the terminal are at the top and the bottom.

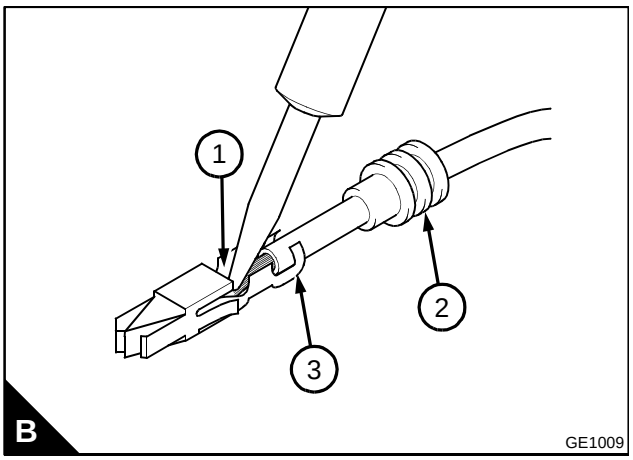
7 Insert the cable assembly into the adaptor and press it in until the cable seal is fully located and level with the end of the adaptor (C3).

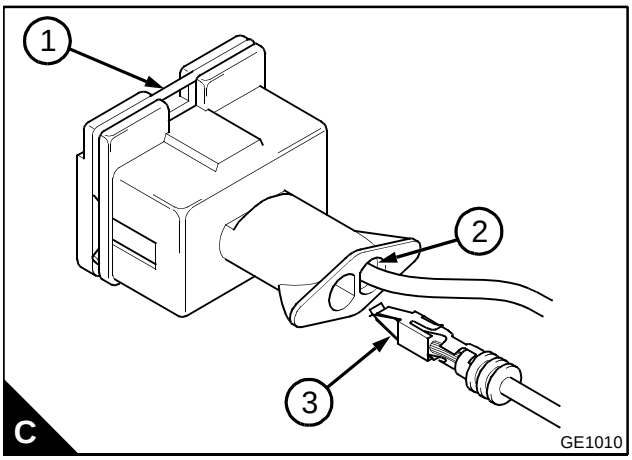
8 Repeat the process for the second cable.

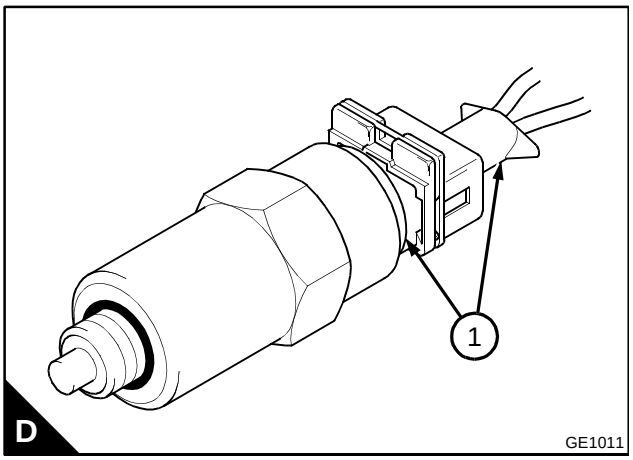
Notes:

- The modified wiring loom used with the (JPT) ESOS (D1) is compatible with IP67 Waterproofing Standards.
- If your current 24V wiring system uses a 12V (JPT) ESOS and an in-line ballast resistor, it is recommended that a 16 Ohm 50W ballast resistor is fitted.









To eliminate air from the fuel system **Operation 11-35**

There are two methods to eliminate air from the fuel system according to the type of pump fitted:

Warnings!

- *If your skin comes into contact with high pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

Standard method

This is used where the fuel injection pump has vent screws (A1, A2), see Operation 11-36.

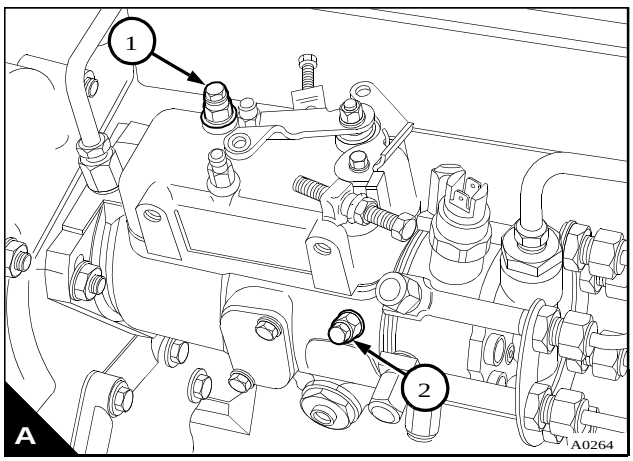
Self-vent method

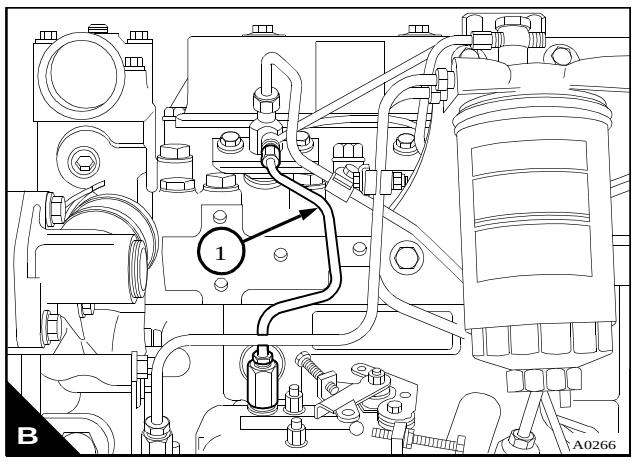
This is used where the fuel injection pump has a self-vent feature, see Operation 11-37.

These pumps have a vent pipe (B1) fitted between a connection in the top of the pump and the atomiser leak-off pipe. Vent screws are not fitted to these pumps. No connections or plugs need be released to eliminate air from the fuel system.

If air enters the fuel system, it must be removed from the system before the engine can be started. Air can enter the system if:

- The fuel tank is drained during normal operation
- The low-pressure fuel pipes are disconnected
- A part of the low-pressure fuel system leaks during engine operation.





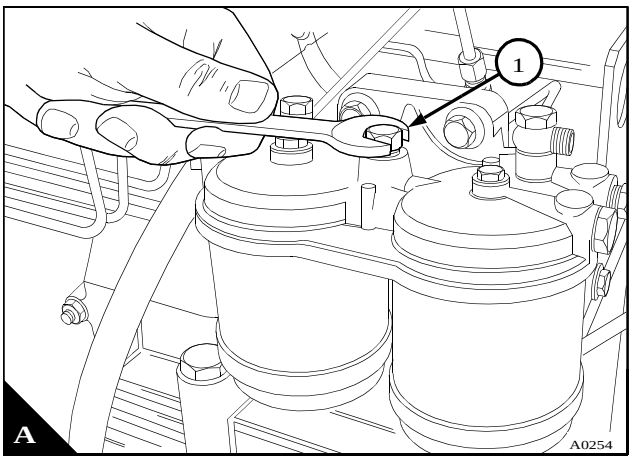
Standard method **Operation 11-36**

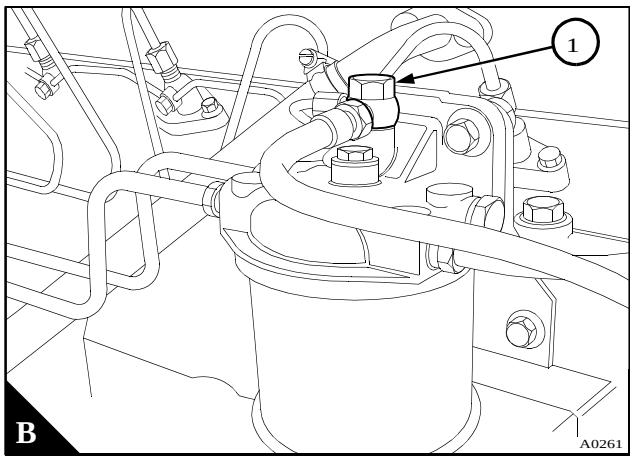
Caution: *If the fuel system is empty or if the canister of the fuel filter has been removed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.*

1 Loosen the vent plug on top of the twin element fuel filter (A1) by two or three turns. If a single element filter is used, loosen the banjo connection bolt which is fitted on the top of the filter (B1).

2 Operate the priming lever on the fuel lift pump until fuel, free of air, comes from the filter vent point. Tighten the vent plug or the banjo connection bolt.

Note: If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.

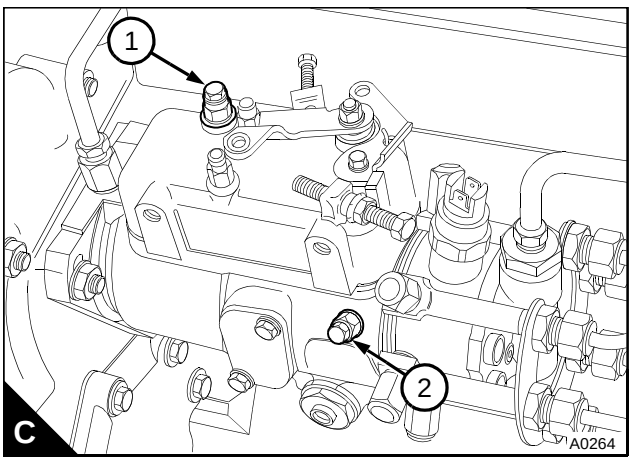


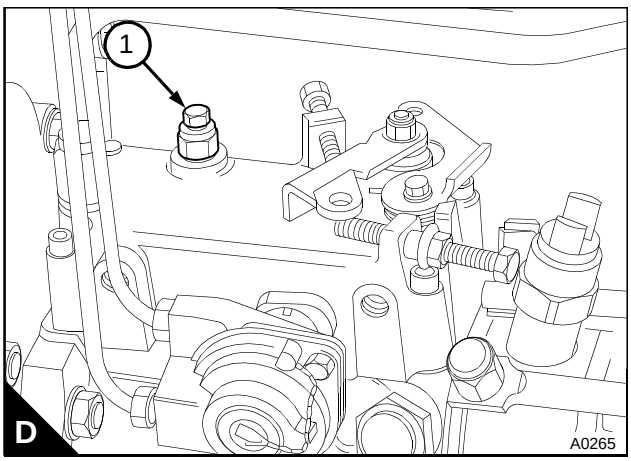


3 Ensure that the manual stop is in the "run" position. If an electrical stop control is used, turn the key of the start switch to the "R" position.

CAV DPA fuel injection pump:

4 Loosen the vent screw (C1) on the lock screw of the hydraulic head and loosen the vent screw (C2) on the top of the governor housing. Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the vent point in the lock screw of the hydraulic head. Tighten the vent screw. Continue to operate the priming lever on the fuel lift pump until fuel, free of air, comes from the vent point on the governor housing. Tighten the vent screw.





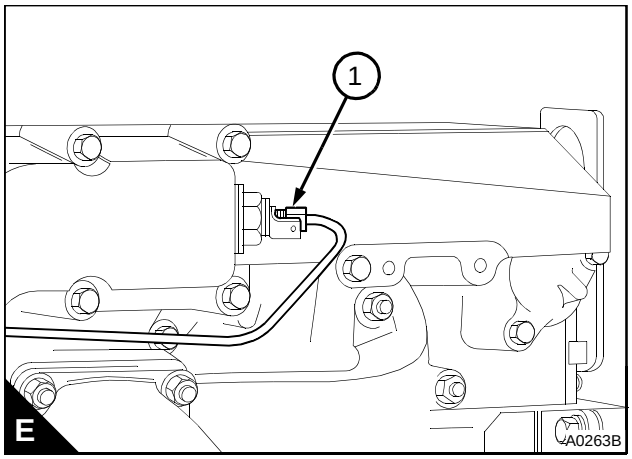
CAV DPS fuel injection pump:

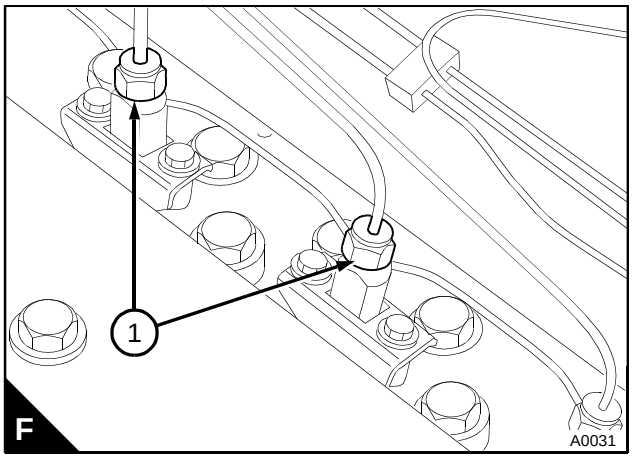
5 Loosen the vent screw (D1) on the top of the governor housing. Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the vent point. Tighten the vent screw.

Continued

Caution: *spanner to prevent movement of the fuelled starting aid (E1) when the union nut is loosened or tightened.*

6 Loosen the union nut (E1) at the fuelled starting aid, if one if fitted, and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.





7 Loosen the high-pressure pipe connections (F1) at two of the atomisers.

Warning! *When the starter motor is operated to eliminate air from the high pressure pipes, the engine may run.*

Caution: *Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.*

8 Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free from air, comes from the pipe connections.

9 The engine is now ready to start.

Caution: *Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure 5hat the pump is free of air and prevent any damage to the fuel injection pumps internal parts by metal to metal contact.*

Note: If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probable a leakage in the suction or low-pressure system.

Self-vent method **Operation 11-37**

If the engine has been stopped by air in the fuel system:

Ensure that fuel has been added to the tank or that the leakage has been corrected.

1 If a manual stop control is fitted, ensure that it is in the "run" position.

2 Operate the starter motor until the engine starts.

If the system or a component in the system has been drained:

1 Turn the start key to the 'R' position. If a manual stop control is fitted, ensure that it is in the "run" position.

2 Operate the lever of the fuel lift pump slowly for approximately two minutes. If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be turned one revolution.

3 Operate the starter motor until the engine starts. If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably a leakage in the low pressure system.

Lucas/Delphi DP 200 Series fuel injection pump

General description

These pumps have a locking screw (A3) and a spacer (A2). The locking screw prevents the rotation of the drive shaft when the pump is removed from the engine.

An "O" ring (A1) is fitted in a groove in the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case.

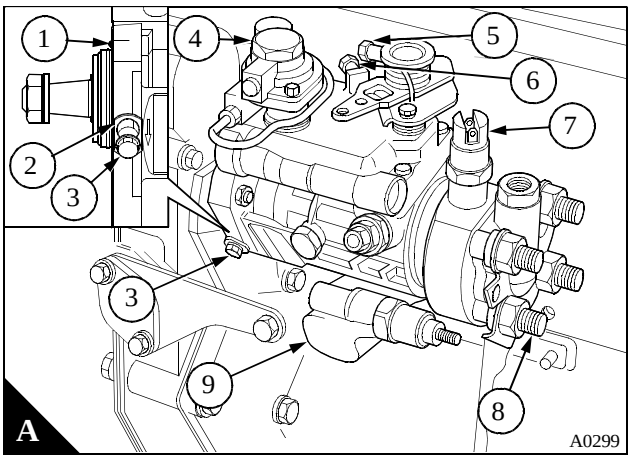
Caution: *The drive shaft of the pump must not be rotated without the spacer in position under the locking screw. If the drive shaft is rotated, the drive shaft will be damaged.*

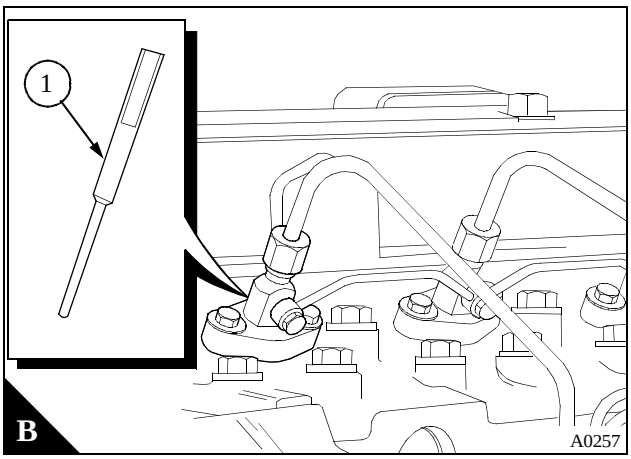
Engines with these pumps have a timing mark on the pump flange but not on the timing case.

For four cylinder engines the high-pressure outlet for number 1 cylinder is shown at (A8).

A new pump will be received locked at the correct angle for the engine. It is important that the engine number is given to the distributor when a new pump is needed.

These engines operate with the timing of the fuel injection retarded, therefore the accuracy necessary to position the piston for timing is difficult to obtain. Greater accuracy is possible if the piston is further down the cylinder bore. A piston position probe (B1), tool 21825630 or 21825947, is used to set accurately the piston at 100° BTDC.





To remove **Operation 11-38**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Piston position probe	21825630 or 21825947	Gear puller	21825565

1 Remove the rocker cover.

2 Loosen the setscrews which retain the atomisers.

3 Rotate the crankshaft clockwise, from the front, until the push rod for the inlet valve of number 1 cylinder just releases.

4 Remove the atomiser together with its seat washer from number 1 cylinder and fit the piston position probe, 21825630 or 21825947 (A1) instead. Fit the atomiser clamp to the probe and tighten the setscrews gradually and evenly to 12 Nm (9 lbf ft) 1,2 kgf m.

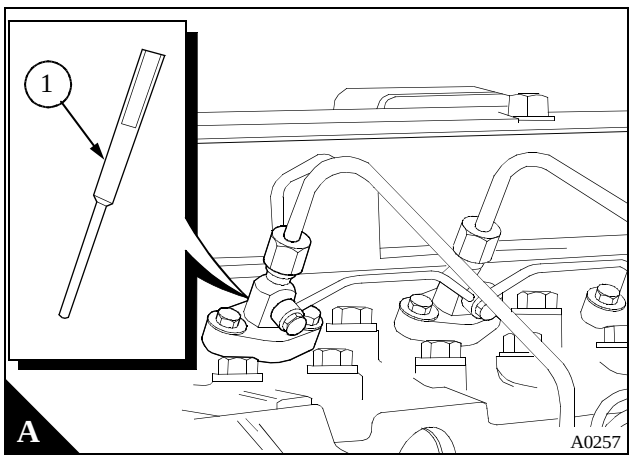
Caution: *Ensure that the piston comes lightly into contact with the piston position probe, or both the piston and the probe could be damaged.*

5 Slowly rotate the crankshaft clockwise, from the front, until the piston just comes into contact with the piston position probe. The piston will now be set at 100° BTDC on the compression stroke of number 1 cylinder.

Caution: *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw must be released.*

Notes:

- The fuel pump can be removed from the engine and fitted again if:
- The crankshaft is not rotated
- The drive shaft of the fuel pump is not rotated



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Caution: *If the crankshaft or the pump shaft is rotated when the pump is off the engine. Or if the engine timing is not correct the timing of the fuel injection pump must be checked, see Operation 8-14.*

6 Release the locking screw and adjust the spacer (B1) to enable the locking screw (B2) to be tightened on the drive shaft of the fuel pump. Tighten the locking screw to 12 Nm (9 lbf ft) 1,2 kgf m. Check that the spacer is free to move. The drive shaft of the fuel pump is now fastened.

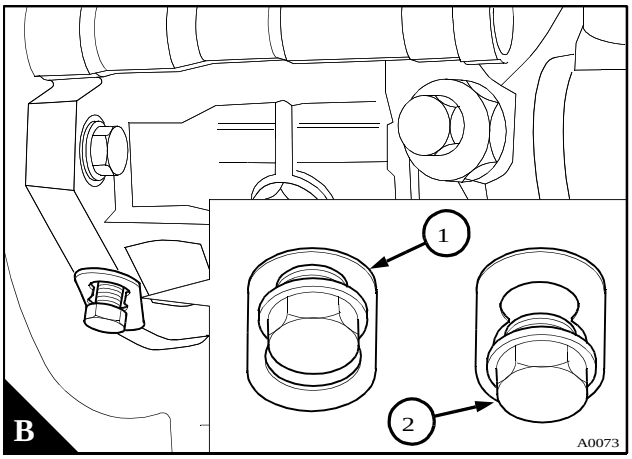
Caution: *Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is released.*

7 Remove the pipes, the cables and the connections for the cold start device and the electrical stop solenoid from the fuel pump. Loosen the nuts on the pump flange.

8 Release the setscrews and remove the gear cover from the timing case cover. Release the nut which retains the drive gear of the pump one to two turns.

9 Fit the gear puller 21825565 and loosen the gear on the drive shaft of the pump. Remove the puller, nut and spring washer.

10 Remove the nuts from the flange of the fuel pump and remove the pump.



To fit **Operation 11-39**

1 Inspect the "O" ring and, if necessary, fit a new "O" ring.

2 Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case. Ensure that the key is engaged correctly in the keyway of the drive gear.

3 Fit the spring washer and the nut to retain the drive gear. Tighten the nut to approximately 15 Nm (11 lbf ft) 1,5 kgf m.

4 Hold the top of the pump toward the engine to remove the backlash and fit the nuts to the pump flange. Tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

5 Release the locking screw on the pump and adjust the spacer (A1) to prevent the locking screw (A2) from locking the pump shaft, tighten the locking screw to 12 Nm (9 lbf ft) 1,2 kgf m. Check that the spacer cannot move. The drive shaft of the fuel pump is now free to move.

6 Fully tighten the nut for the drive gear to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover.

Caution: *Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is tightened.*

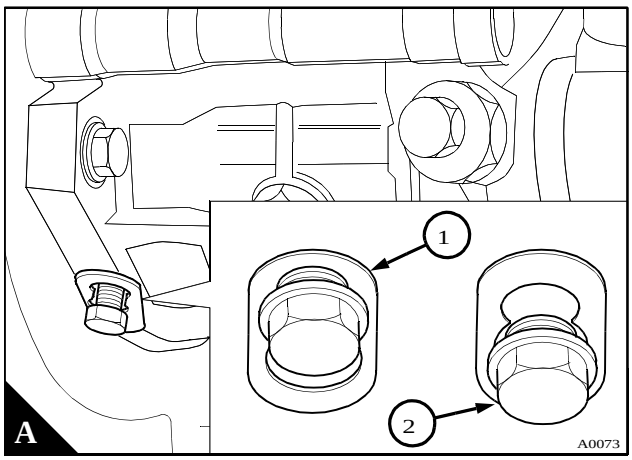
7 Remove the piston position probe and fit the atomiser together with a new seat washer. Tighten the setscrews of all of the atomisers gradually and evenly to 12 Nm (9 lbf ft) 1,2 kgf m.

8 Fit the pipes, cables and connection for the cold start device and electrical stop solenoid to the pump.

9 Eliminate air from the fuel system, see Operation 11-46.

10 Fit the cylinder head rocker cover, see Operation 3-2.

11 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no load speed are correct, see Operation 11-40.



To adjust **Operation 11-40**

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications.

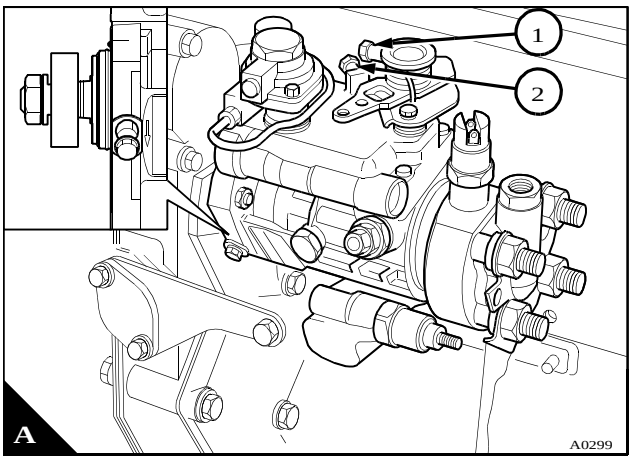
The correct speed will normally be given in the manufacturers handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Service Department of Perkins Engines Company Limited, Peterborough, England, PE1 5NA.

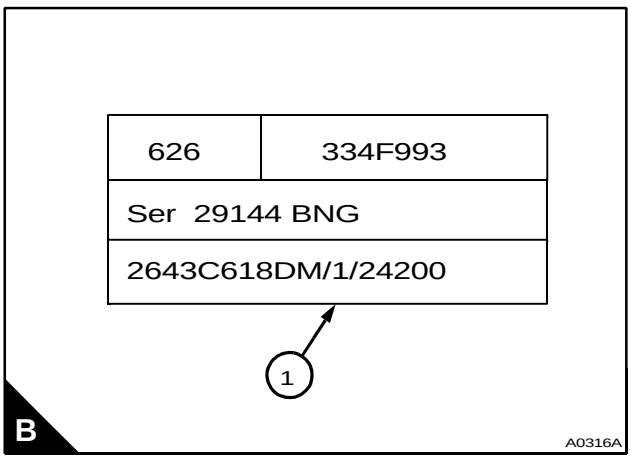
Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

Note: The data on the fuel injection pump is now etched instead of stamped on the data plate. If it is necessary to remove paint from on the data plate, use a suitable solvent which is not corrosive. Do not use a scraper or other sharp tools to scratch off the paint, as the data on the plate could be removed.

2 With the engine at its normal temperature of operation, check the maximum no load speed. The maximum no load speed is indicated by the last part of the setting code for the fuel injection pump. The setting code can be found on the data plate (B1) on the side of the fuel pump. A typical setting code is 2643M000AK/1/2860. In this example, the maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw counter-clockwise to increase, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.

The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





General description for pin timed fuel injection pump **Operation 11-41**

Caution: *Do not release the nut (A2) from the fuel injection pump. Illustration (A) shows the nut in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*

The manufacturer fits the hub (B2) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

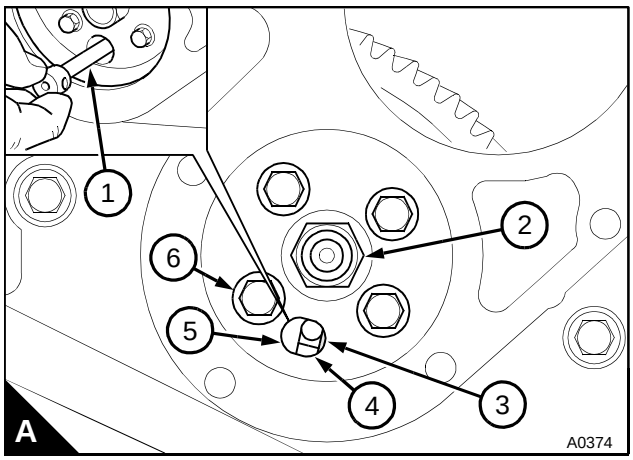
The hub is permanently mounted onto the drive shaft by the pump manufacturer to allow the pump timing to be set accurately when the engine is in service.

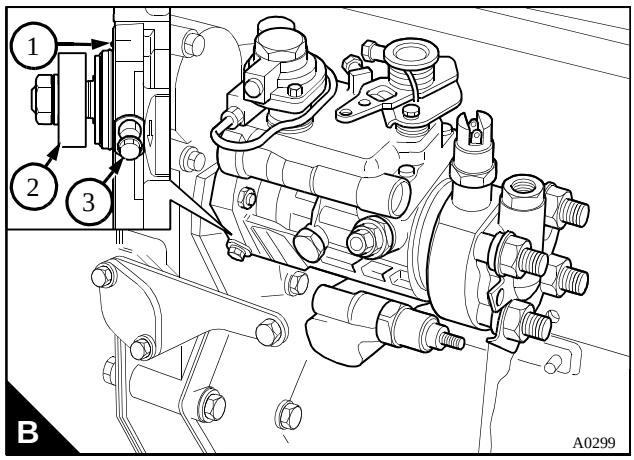
To prevent incorrect adjustments to the engine timing by rotation of the fuel pump, the mounting flange (C1) has holes instead of slots.

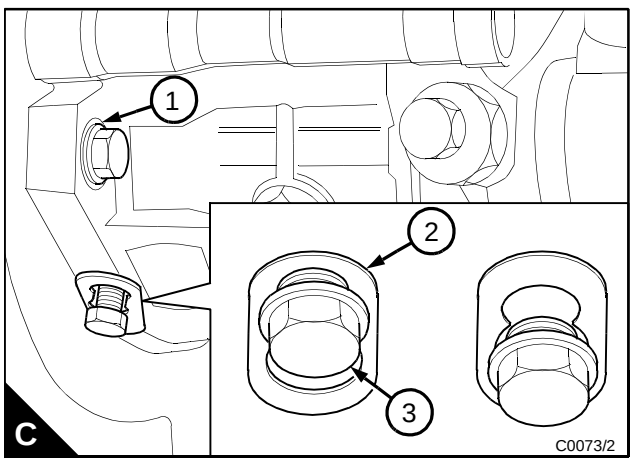
Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub (A4), with a hole in the body (A3) of the fuel pump. The gear is passed over the pin and fastened to the hub with four flanged setscrews (A6).

Note: On the latest engines, four tamper proof flanged setscrews retain the fuel pump gear. Special tools to remove these fasteners are available at your Perkins distributor.

Caution: *A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of the pump must not be turned without the spacer (C2) in position under the locking screw (C3).*







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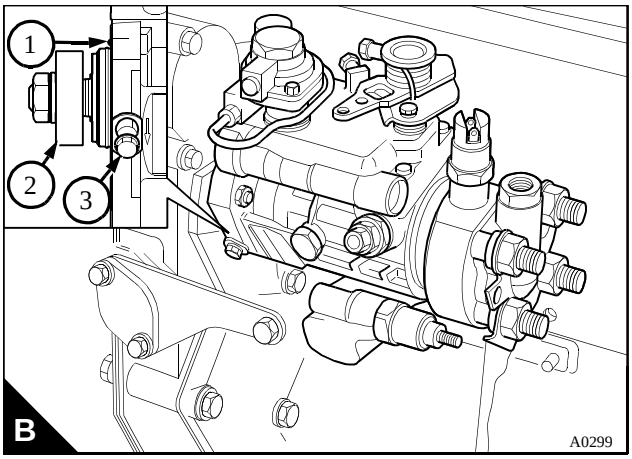
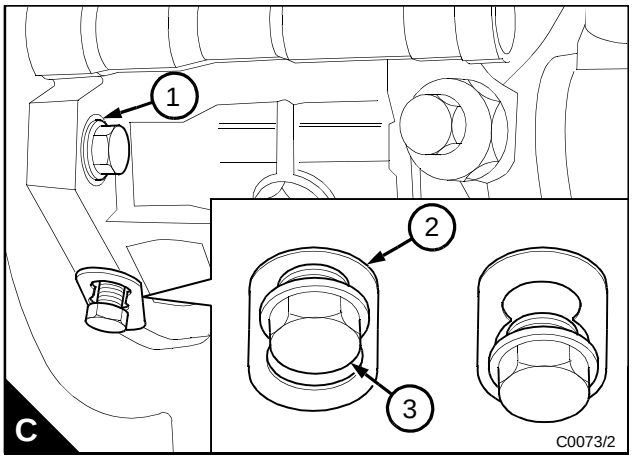




The fuel injection pump has a locking screw (B3) and (C3) and a spacer (C2). The locking screw prevents the rotation of the drive shaft.

An "O" ring (C1) is fitted into a groove in the pump flange. This "O" ring is fitted instead of a joint between the pump flange and the timing case.

To remove pin timed fuel injection pump **Operation 11-42**

Special requirements

Special tools	
Description	**Part number**
Timing pin Lucas/Delphi fuel injection pumps	27610033

Before the crankshaft is turned or the pump is fitted, put the spacer (A1) into position under the locking screw (A2) to ensure that the pump drive shaft is released.

1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps: Remove the coolant pump.

4 Insert the timing pin (B1) through the hole (B5) in the fuel pump gear and the slot of the hub (B4). Push the pin fully into the hole (B3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

Caution: *Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is released.*

5 Remove the pipes, the cables and the connections for the cold start device and the electrical stop solenoid from the fuel pump.

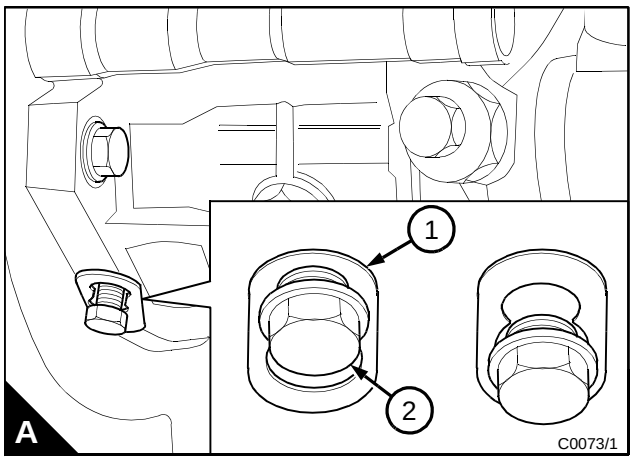
***Cautions*:**

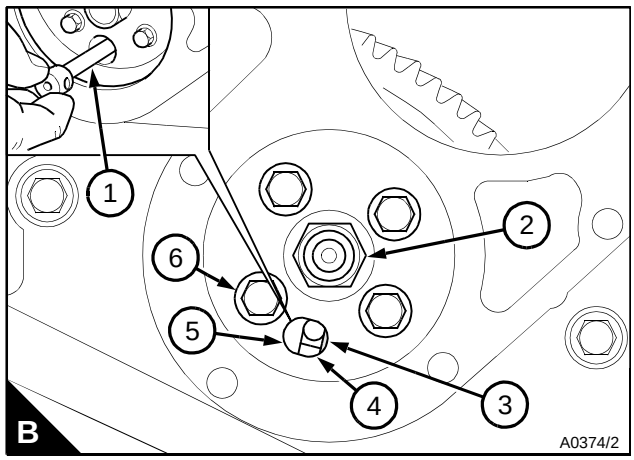
- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft, the locking screw (A2) must be released and a spacer (A1) fitted.*
- *Do not release the nut (B2) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Remove the setscrew and nut of the support bracket, if fitted. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

7 Remove the four flanged setscrews (B6) and release the fuel pump gear from the hub of the fuel injection pump.

8 Remove the nuts from the flange of the fuel pump and remove the pump.





To fit pin timed fuel injection pump **Operation 11-43**

Special requirements

Special tools	
Description	**Part number**
Timing pin Lucas/Delphi fuel injection pumps	27610033

***Cautions*:**

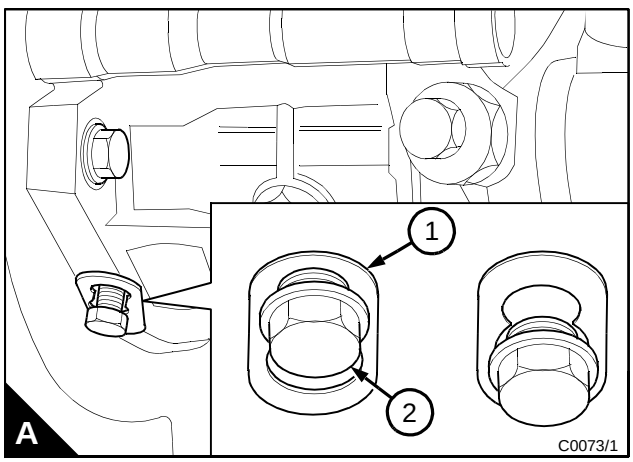
- *The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.*
- *The drive shaft of the pump must not be rotated without the spacer (A1) in position under the locking screw (A2). If the drive shaft is rotated with the locking screw tightened on to the shaft, the drive shaft will be damaged.*

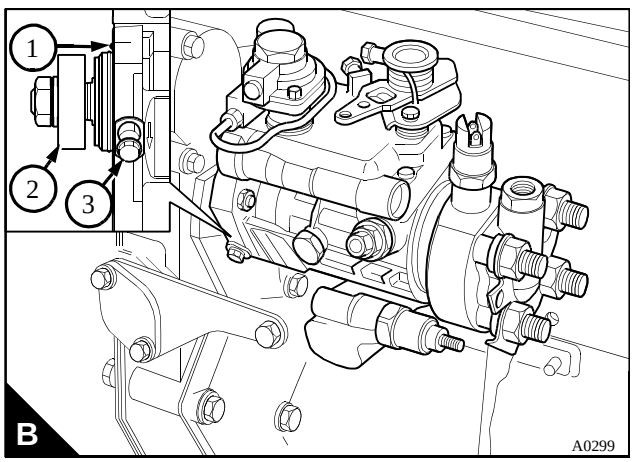
1 Inspect the “O” ring (B1) in the pump flange and, if necessary, fit a new "O" ring.

2 Lightly lubricate the “O” ring with clean engine lubricating oil and put the pump into position on the timing case.

3 Put the fuel pump in position on the three studs and fit the flange nuts.

4 Fit the setscrew and nut of the support bracket. Ensure that force is not applied to the fuel pump when the support bracket is fitted.





Continued

5 Tighten the flange nuts of the fuel pump to 28 Nm (20 lbf ft) 2,8 kgf m.

Caution: *Do not remove the nut (C2) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, it will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Put the fuel pump gear onto the hub of the fuel pump. The flanged setscrews (C6) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the flanged setscrews finger tight.

Note: The fuel pump gear will only fit in one position. The gear is fitted with the letters C and M at the front.

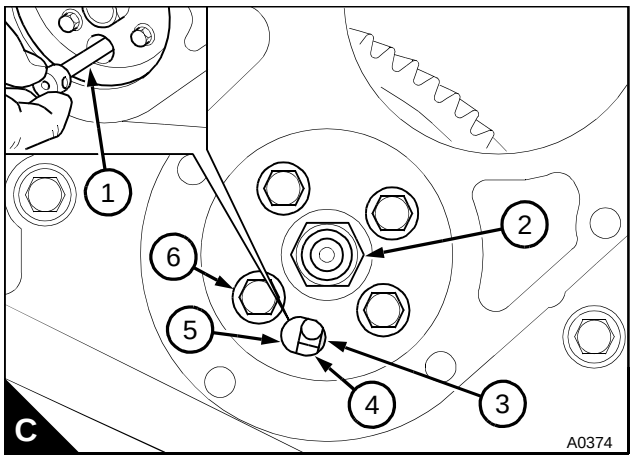
7 Insert the timing pin (C1) through the hole (C5) of the fuel pump gear and the slot of the hub (C4) until it can be pushed fully into the hole (C3) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.

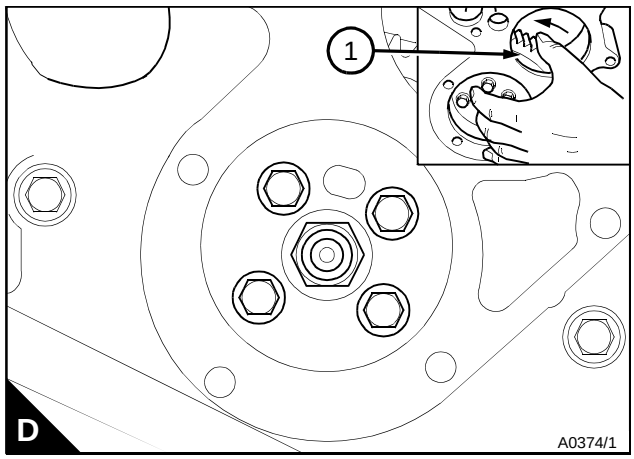
Caution: *The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

8 Carefully turn the gear counter-clockwise, by hand (D1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the flanged setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.

9 Remove the timing pin.

10 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump.





Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.*

11 Fit all the pipes. Connect the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

12 Eliminate air from the fuel system, see Operation 11-46.

13 Fit the cylinder head rocker cover.

14 Connect the battery.

15 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-44.

To adjust pin timed fuel injection pump **Operation 11-44**

The engine conforms with USA (EPA/CARB) stage 1 and EEC stage 1 emissions legislation for agricultural and industrial applications.

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission.

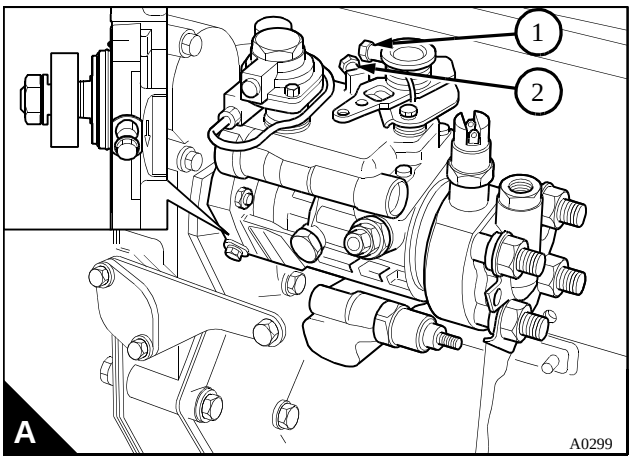
Specialist equipment, which is available at your Perkins Distributor, is needed to adjust the idle or maximum speed settings. The warranty of the engine can be affected if the seals on the fuel injection pump are broken during the warranty period by a person who is not approved by Perkins.

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the outer adjustment screw (A2). Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut. The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by the inner adjustment screw (A1). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.



Electrical shut off solenoid (ESOS) **Operation 11-45**

General description

A new Junior Power Timer (JPT) ESOS was introduced to all new engines fitted with Lucas/Delphi fuel injection pumps. A conversion kit is available to enable the new (JPT) ESOS male connector (A1) to be connected to the Twin Lucar terminals (A4) on the wiring loom. The parts kit consists of a female adaptor (A2) with two male Lucar terminals (A3).

To fit the conversion kit

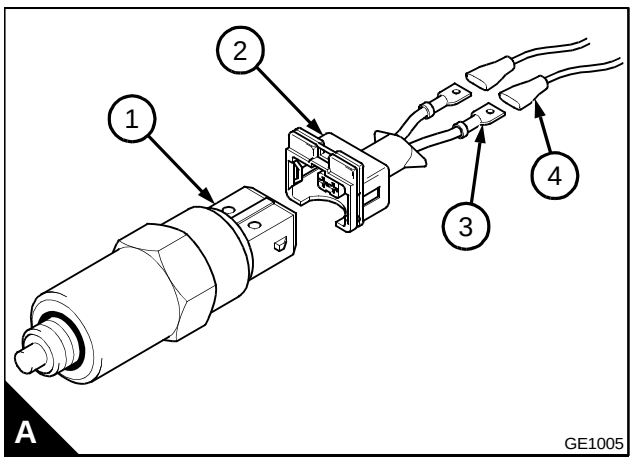
1 Align and fit the female adaptor (A2) on the male connector (A1). Ensure that the two components are fully engaged.

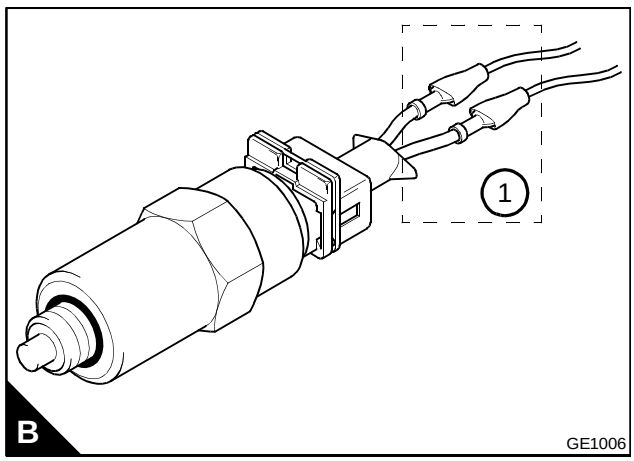
2 Insert the male Lucar terminals (A3) on the adaptor into the insulated female Lucar terminals (A4) on the wiring loom. Ensure that both components are fully engaged.

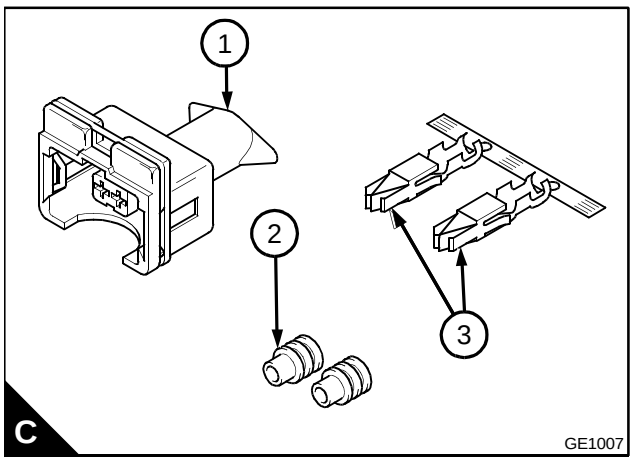
Caution: *This connection (B1) is compatible with IP67 waterproofing standards.*

Wiring loom modification

To ensure that the connection from the new ESOS to the wiring loom is compatible with IP67 water proofing standards, the twin Lucar terminals must be removed and a JPT adaptor kit fitted. The adaptor kit consists of a female JPT adaptor (C1), two cable seals (C2) and two metal terminals (C3).







To fit the adaptor kit

1 With a suitable tool, cut the cables near to the Lucar terminals and remove them from the wiring loom.

2 Remove 4,0 mm (0.17 in) of insulation from the ends of the two cables (A2) and put the cable seals (A4) on to each cable, the narrow end (A3) towards the 4 mm strip.

3 Insert the first cable into the terminal so that the bare wire (A2) is within the clamp (A1).

4 With a suitable tool, close the clamps (A1) until the bare wire is secure. Heat the terminal with a soldering iron and apply solder to the joint (B1). When the joint is cool, push the cable seal (B2) until the narrow end of the cable seal (B3) is within the clamp (B4). With a suitable tool close the clamp until the cable seal is secure.

5 Repeat sequence 3 and 4 for the second cable.

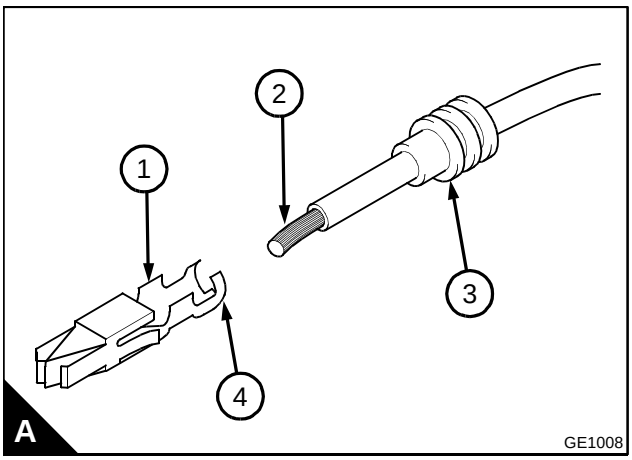
6 Put the adaptor (C2) on a flat surface with the spring clip (C1) at the top. Rotate the terminal, cable and cable seal so that the location tags (C4) on the terminal are at the top and the bottom.

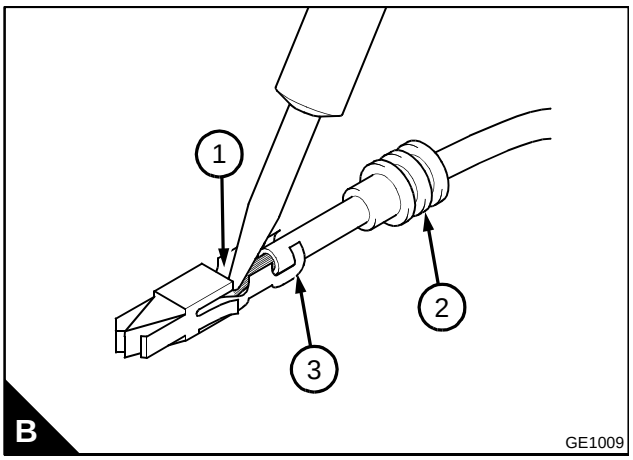
7 Insert the cable assembly into the adaptor and press it in until the cable seal is fully located and level with the end of the adaptor (C3).

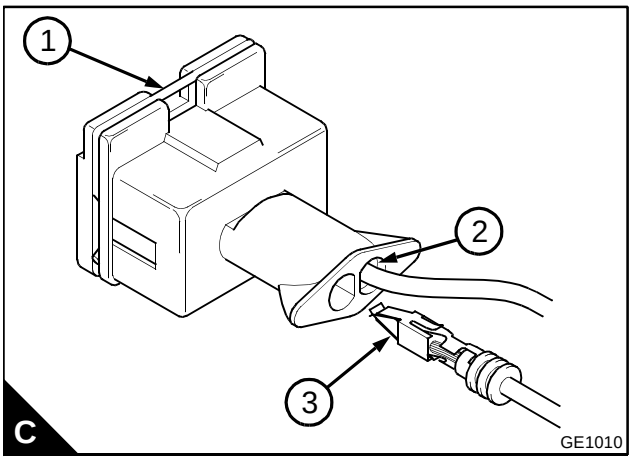
8 Repeat the process for the second cable.

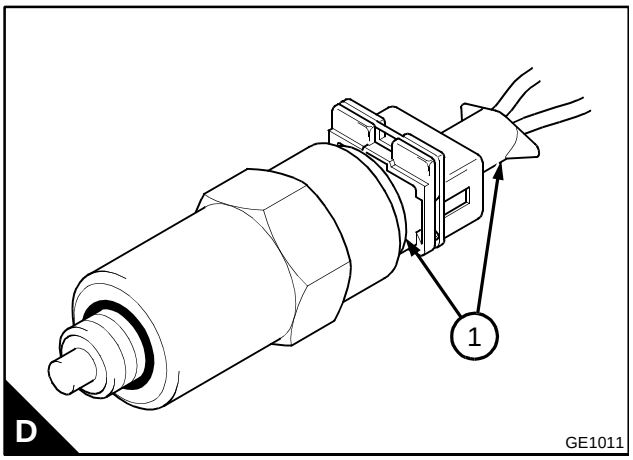
Notes:

- The modified wiring loom used with the (JPT) ESOS (D1) is compatible with IP67 Waterproofing Standards.
- If your current 24V wiring system uses a 12V (JPT) ESOS and an in-line ballast resistor, it is recommended that a 16 Ohm 50W ballast resistor is fitted.









To eliminate air from the fuel system **Operation 11-46**

Warnings!

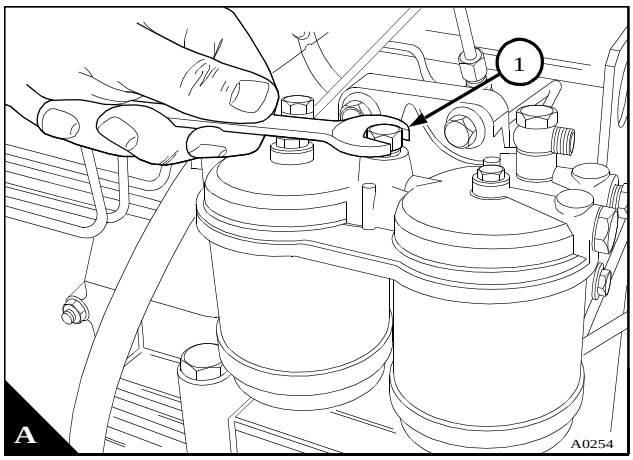
- *If your skin comes into contact with high pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

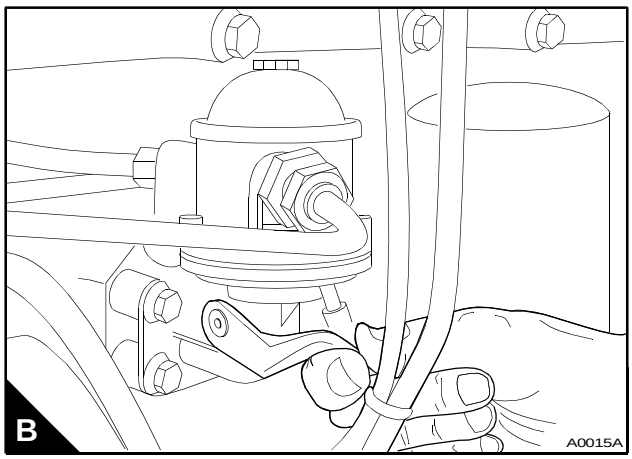
Caution: *If the fuel system is empty or if the canister of the fuel filter has been removed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.*

1 Release the vent plug on the fuel filter head (A).

2 Operate the priming lever of the fuel lift pump (B) until fuel, free of air, comes from the vent plug. Tighten the vent plug.

Note: If the drive cam of the fuel lift pump is at the point of maximum lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.





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Caution: *spanner to prevent movement of the fuelled starting aid (C1) when the union nut is loosened or tightened.*

3 Loosen the union nut (C1) at the fuelled starting aid, if one if fitted, and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

4 Loosen the high-pressure connections at two of the atomisers (D1).

5 Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free of air, comes from the pipe connections. Tighten the connections to 22 Nm (16 lbf ft) 2,3 kgf m.

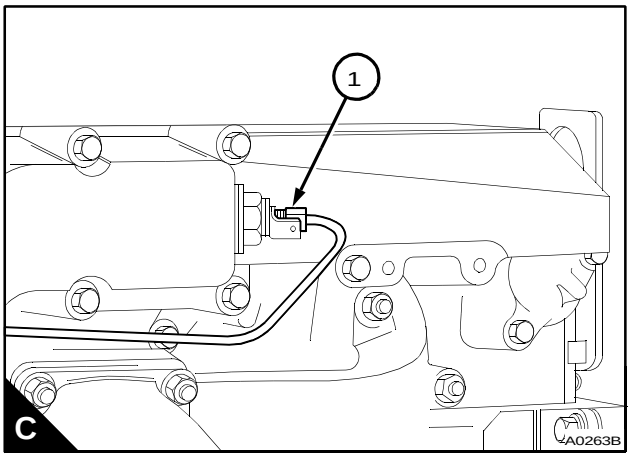
Warning! *When the starter motor is operated to eliminate air from the high pressure pipes, the engine may run.*

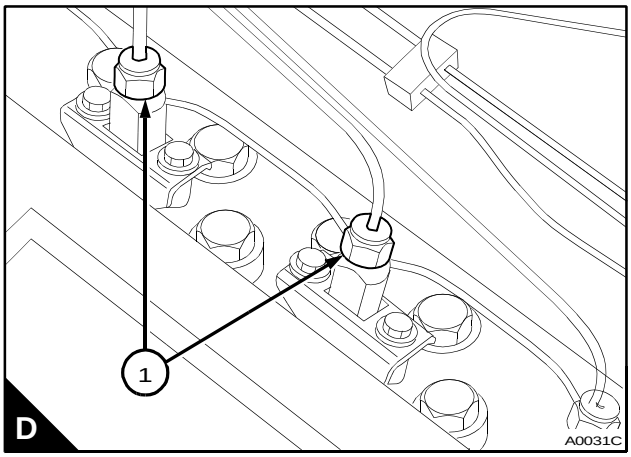
Caution: *Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.*

6 The engine is now ready to start.

Caution: *Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure 5hat the pump is free of air and prevent any damage to the fuel injection pumps internal parts by metal to metal contact.*

Note: If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probable a leakage in the suction or low-pressure system.





Stanadyne fuel injection pump

Stanadyne Data plates

In order to match engine performance to a wide range of applications, two extra data plates (A1) and (B1) have been fitted onto the pump housing flange of Stanadyne fuel injection pumps. The data plates are used to identify pumps after a minor modification to alter the pump and/or the engine performance.

Note: Stanadyne and Perkins must give authority for all modifications.

Information added to the data plates will supersede the information found on the standard Stanadyne pump data plate (A2). It is important that details added to these plates are correct in order to provide accurate calibration and service in the future.

Permitted modifications and the correct use of the two types of data plates is as follows:

Engine speed modifications to range pumps (without component changes)

"Range Pumps" is a name that Perkins uses for pumps that can be fitted to those applications which are specifically designed to operate at various high idle speeds. Modifications to these pumps are limited to high idle speed adjustments, and do not include governor spring or other component changes. The high idle speeds are listed in the "Special Notes" section of the Stanadyne specification sheet. Stanadyne will normally calibrate these pumps at the highest optional speed.

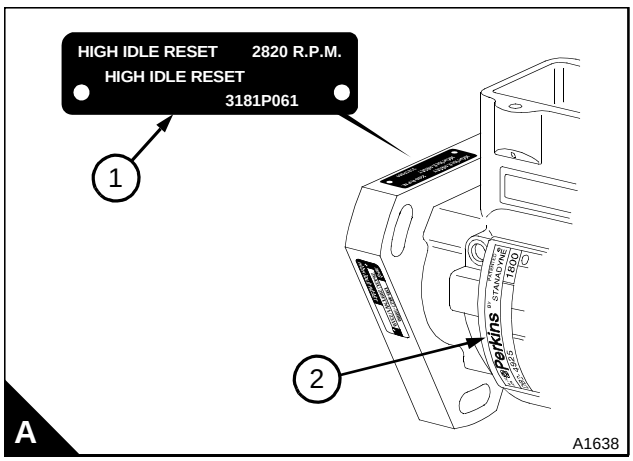
Perkins fastens a data plate (A1) to all “Range Pump” models, even if no change has been made to the original Stanadyne calibration, since the engines on which they are installed do not have a single specific speed rating.

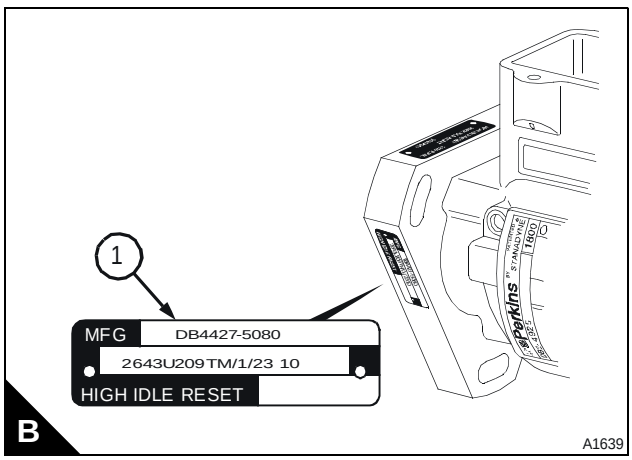
If Perkins changes the high idle speed of an application, the new high idle speed will be added to the modification data plate (A1). The data plate also has space to record one "In Service" high idle reset by a Perkins approved distributor or O.E.M. customer. Since this is an acceptable modification in accordance with the Stanadyne specification sheet, there will be no change to either the Perkins customer part number or the Stanadyne pump model number.

If it is necessary for Perkins to change the high idle speed on an application, but it is not an acceptable modification in accordance with the Stanadyne specification sheet, the change must be approved by Stanadyne and Perkins. If the new high idle speed rating is approved, it will be etched on the modification data plate and the information will be added to the "Special notes" section of the Stanadyne specification sheet.

Engine speed modifications to range pumps (with component changes)

Some engine speed changes need a different governor spring. This occurs when a reduction in the engine high idle speed does not allow the governor to operate correctly with the original governor spring. This change does not need a new Stanadyne model number, but will need a new Perkins customer part number. The new part number will be etched onto the data plate (B1) that Perkins will fasten to the side of the pump mounting flange. The new Perkins customer part number and the conversion information (spring part number) will be listed in the "Special notes" section of the Stanadyne specification sheet.





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Pump conversions

Pump conversions that change a pump from one Stanadyne number to another will need both a new Stanadyne number and a new Perkins customer part number. These conversions need major pump component changes or calibration changes and should only be done when a Stanadyne specification suitable for conversion is available.

When the conversions of this type are made in the Perkins factory the original Stanadyne data plate will remain in position. A modification data plate (B1), etched with the new Perkins customer part number, the new Stanadyne model number, and the high idle speed will be fitted.

If an approved Stanadyne service distributor make this type of conversion, they will fit a new Stanadyne data plate. The new data plate will show a new Stanadyne model number, a new Perkins customer part number and the original pump serial number and data code. When this occurs, modification data plates fitted by Perkins should be removed.

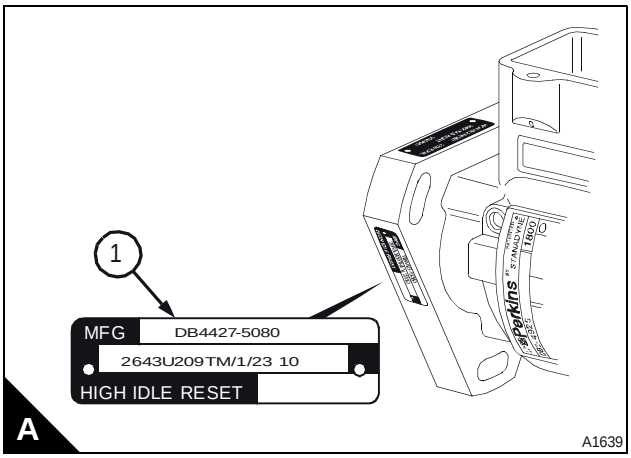
Warranty

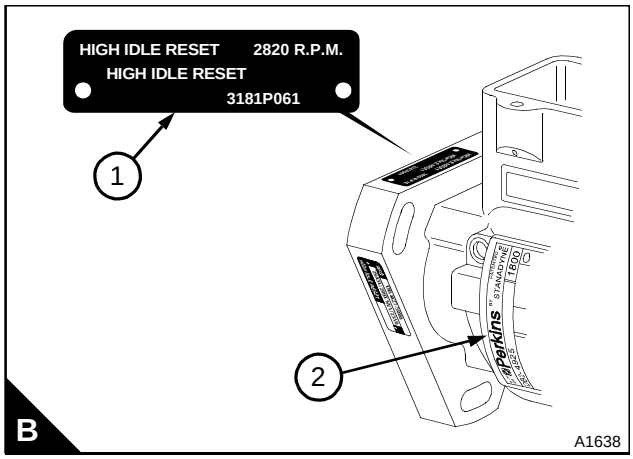
Pump modifications or conversions done by Perkins and “Range Pumps” which have their high idle reset by approved Perkins distributors or O.E.M. customers are protected by Stanadyne’s warranty in accordance with the Stanadyne Service Policies and Procedures Manual. Any failures which occur as a direct result of the Perkins conversion is not protected by the Stanadyne warranty, for example: pump modifications and conversions.

Electric shut off solenoid (E.S.O.S) changes

Perkins has the option to change the electric shut off solenoid to conform with the voltage or shut off requirements of an application.

Perkins can change the voltage of operation from 12V to 24V or from 24V to 12V DC or from “Energised - Run” (ETR) to “Energised - Shut off” (ETOS). A new Perkins customer part number for the pump must be etched on the modification data plate shown in (B1). An E.S.O.S change will not normally need a new Stanadyne model number, therefore the new Perkins customer part number will be added to the “Special notes”, section of the Stanadyne pump specification together with the identification of the new solenoid.





To remove **Operation 11-47**

Special requirements

Special tools			
Description	**Part number**	**Description**	**Part number**
Gear puller	21825565	Adaptors for use with 21825565	21825568

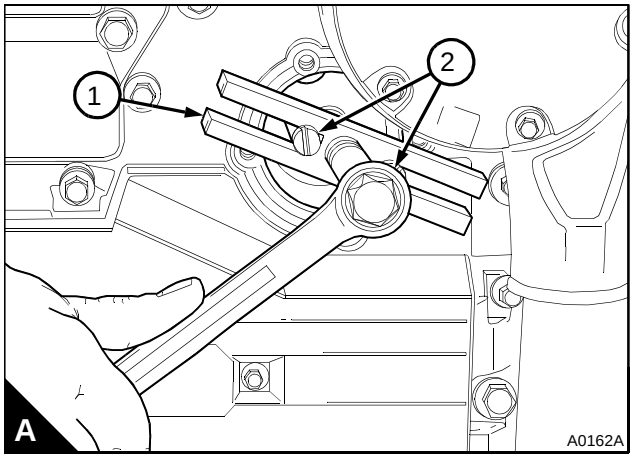
1 Remove the fuel pipes, disconnect the electrical stop control and the control rod of the fuel injection pump.

2 Remove the gear cover from the cover of the timing case. Remove the gear nut and the spring washer.

3 Release the flange nuts of the fuel pump.

4 Loosen the drive gear of the fuel injection pump with the puller 21825565 (A1) and the adaptors 21825568 (A2).

5 Remove the fuel injection pump.



To fit **Operation 11-48**

1 Fit a new joint (A1) to the timing case. Fit a new "O" ring (A3) to the fuel pump. DB4 fuel pumps are fitted with a rubber seal which has a square shape instead of an "O" ring. When a rubber seal is fitted it is not necessary to fit a joint.

2 Rotate the drive shaft of the fuel pump to align the pin (A2) or key with the keyway in the drive gear. Ensure that the pin or key is correctly fitted and fit the fuel pump to the gear. Fit the spring washer and the nut to retain the drive gear and tighten the nut lightly.

3 Align the mark on the flange of the fuel pump with the mark on the rear face of the timing case (B1). Fit the flange nuts of the fuel pump. Tighten them to 22 Nm (16 lbf ft) 2,2 kgf m.

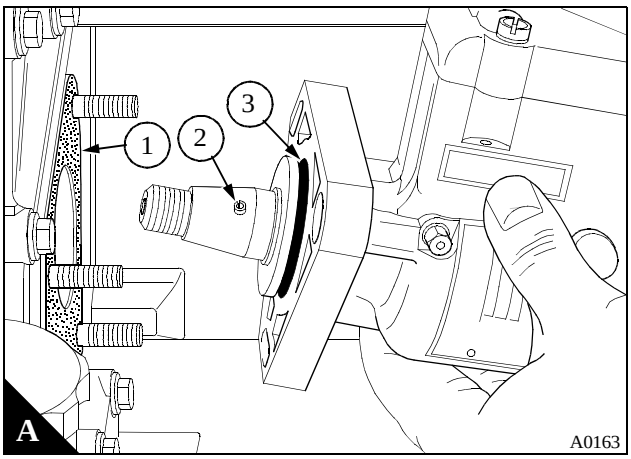
4 Fully tighten the nut for the drive gear to 80 Nm (59 lbf ft) 8,2 kgf m. Fit a new joint for the gear cover and fit the gear cover.

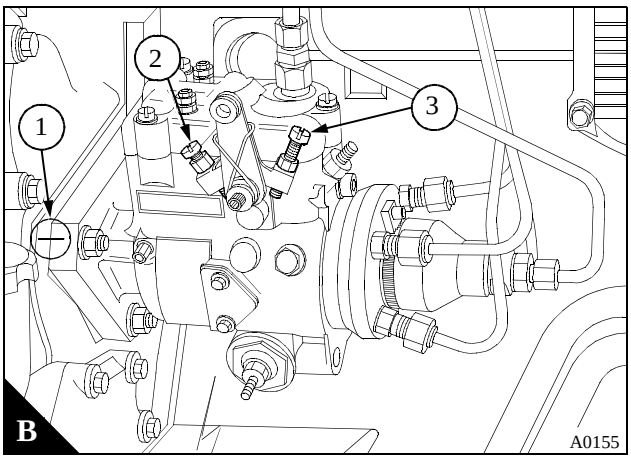
5 Fit the fuel pipes. Connect the electrical stop control and the control rod of the fuel pump.

6 Eliminate air from the fuel system, see Operation 11-54.

7 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, see Operation 11-49.

8 If a new fuel pump has been fitted, check the maximum no load speed, see Operation 11-49.





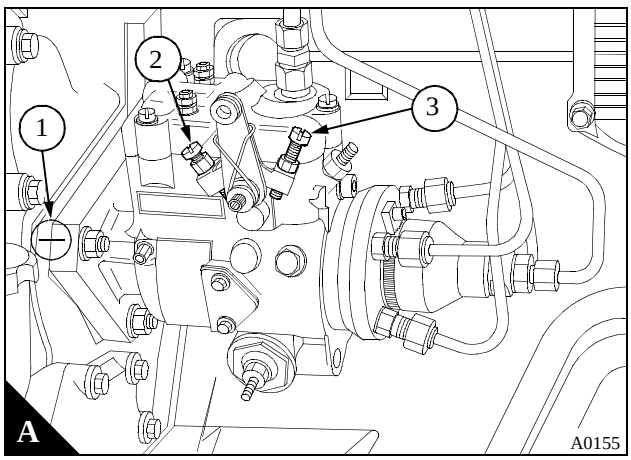
To adjust **Operation 11-49**

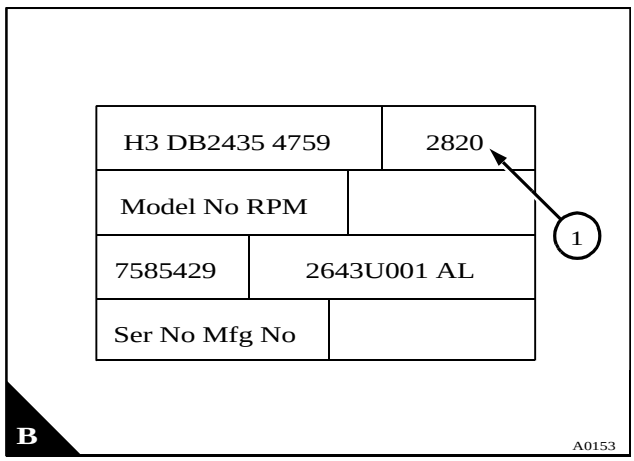
1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (A2). Release the lock nut and rotate the adjustment screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut.

The correct speed will normally be given in the manufacturer's handbook for the application. If it is not given, apply to your nearest Perkins distributor or to Technical Service Department of Perkins Engines Company Limited, Peterborough, England, PE1 5NA.

Caution: *The setting for the maximum no load speed can change for different applications. Always check the fuel injection pump data plate (B) fitted to a specific engine, before any adjustment to the maximum no load speed.*

2 With the engine at its normal temperature of operation, check the maximum no load speed on the fuel pump data plate. An example is given at (B1); if necessary, this speed can be adjusted by the adjustment screw (A3). Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed, or clockwise to decrease, the speed. When the speed is correct, tighten the lock nut and seal the screw. The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially. The adjustment screw on original fuel pumps is set and sealed by the manufacturer. The setting must not be changed as this could affect the engine warranty.





General description for pin timed fuel injection pump **Operation 11-50**

Caution: *Do not release the nut (A2) from the fuel injection pump. Illustration (A) shows the nut in position when the fuel pump is fitted to the engine. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the nut is removed and the hub moves, the hub will need to be accurately fitted to the pump by use of specialist equipment before the pump can be fitted to the engine.*

The manufacturer fits the hub (B3) to the pump to ensure very accurate timing. Engines that have this arrangement have the drive gear fastened to the hub instead of to the shaft of the pump.

The hub (B3) is permanently mounted onto drive shaft by the pump manufacturer to allow the pump timing to be set accurately when the engine is in service.

To prevent incorrect adjustments to the engine timing by rotation of the fuel pump, the mounting flange has holes instead of slots.

Accurate timing of the pump to the engine is by a pin (A1) used to align the fuel pump gear and the hub (A4), with a hole in the body (A3) of the fuel pump. The gear is passed over the pin and fastened to the hub with four flanged setscrews (A6).

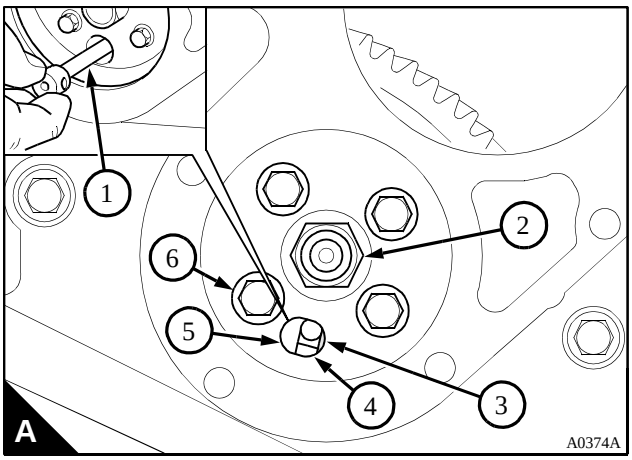
Note: On the latest engines with belt driven coolant pumps, four tamper proof fasteners retain the fuel pump gear. Special tools to remove these fasteners are available at your Perkins distributor.

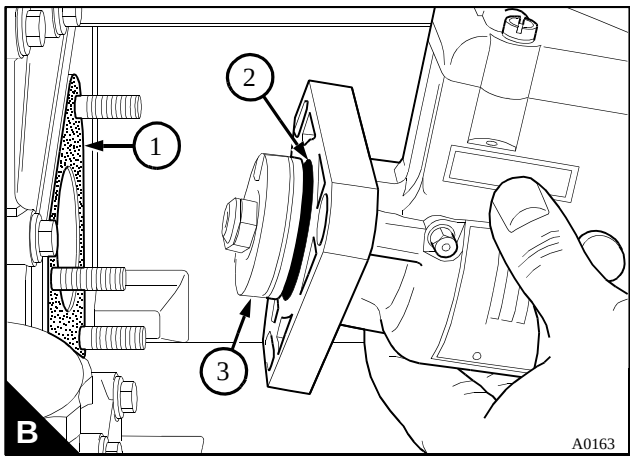
The fuel injection pump is sealed to the timing case by a joint (B1) and an “O” ring (B2) that is fitted to the fuel pump housing.

Note: DB4 fuel pumps are fitted with a rubber seal which has a square shape instead of an "O" ring. When a rubber seal is fitted it is not necessary to fit a joint.

A requirement of emissions legislation is that access to adjustments that affect the engine’s exhaust emissions is limited to personnel approved by Perkins. The adjustment screw for the high idle speed, is sealed by the manufacturer. The setting must not be changed, unless approved, as it could affect the warranty of the engine.

Note: The person who adjusts the pump must ensure that the adjustment screw is suitably sealed against interference after the adjustment.





To remove pin timed fuel injection pump **Operation 11-51**

Special requirements

Special tools	
Description	**Part number**
Timing pin Stanadyne fuel injection pumps	27610033

1 Disconnect the battery before the fuel injection pump is removed from the engine.

2 Set the engine to TDC on the number 1 cylinder on the compression stroke, see Operation 8-1 or Operation 8-2.

3 Remove the gear cover from the cover of the timing case. For gear driven coolant pumps. Remove the coolant pump.

4 Insert the timing pin (A1) through the hole (A5) in the fuel pump gear and the slot of the hub (A4). Push the pin fully into the hole (A3) in the body of the fuel pump. If the pin can be fully inserted then the pump timing is correct. There should be no resistance when the pin is inserted.

Caution: *Use a second spanner to prevent movement of the high-pressure outlet when the union nut for each high-pressure pipe is released.*

5 Remove the pipes, the cables and the connections for the cold start device (B2) and the electrical stop solenoid (B1) from the fuel pump.

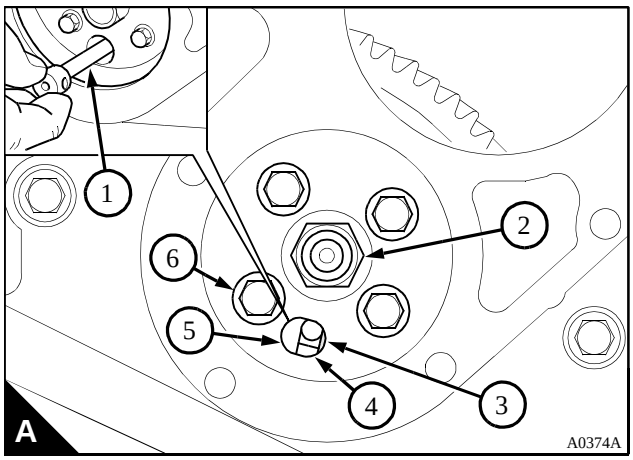
***Cautions*:**

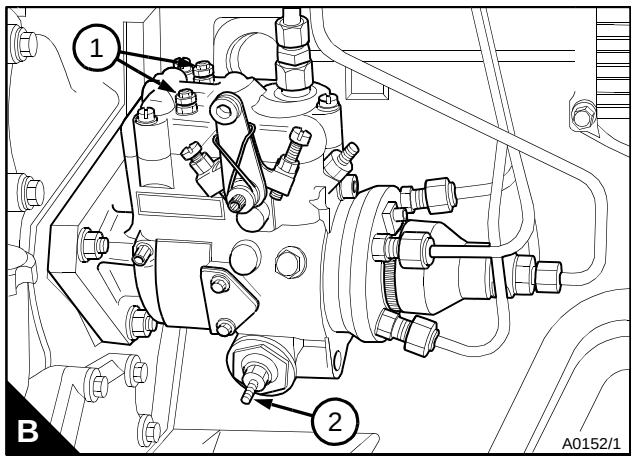
- *Do not rotate the crankshaft when the pump is not on the engine; the loose fuel pump gear may damage the timing case. If it is necessary to rotate the crankshaft, fit the fuel pump temporarily to ensure that the gear is in the correct position. If the fuel pump is fitted temporarily in order to rotate the crankshaft.*
- *Do not release the nut (A2) from the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

6 Remove the setscrew and nut of the support bracket, if fitted. Ensure that force is not applied to the fuel pump when the support bracket is fitted.

7 Remove the four flanged setscrews (A6) and release the fuel pump gear from the hub of the fuel injection pump.

8 Remove the nuts from the flange of the fuel pump and remove the pump.





To fit pin timed fuel injection pump — Operation 11-52

Special requirements

Special tools	
Description	**Part number**
Timing pin Stanadyne fuel injection pumps	27610033

Caution: *The engine must be set to TDC number 1 cylinder, compression stroke before the pump is fitted. If the crankshaft needs to be rotated, the pump must be fitted temporarily, or the loose gear could damage the timing case.*

1 Fit a new joint (A1) to the timing case. Fit a new "O" ring (A2) to the fuel pump. DB4 fuel pumps are fitted with a rubber seal which has a square shape instead of an "O" ring. When a rubber seal is fitted it is not necessary to fit a joint.

2 Lightly lubricate the "O" ring with clean engine lubricating oil and put the pump into position on the timing case.

3 Put the fuel pump in to position on the three studs and fit the flange nuts.

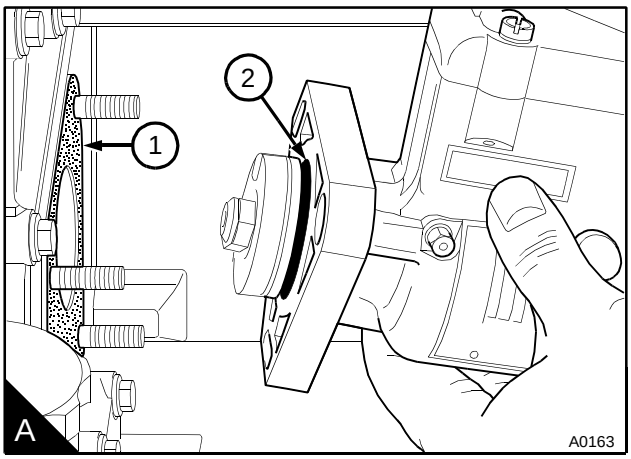
4 Tighten the flange nuts of the fuel pump to 28 Nm (20 lbf ft) 2,8 kgf m.

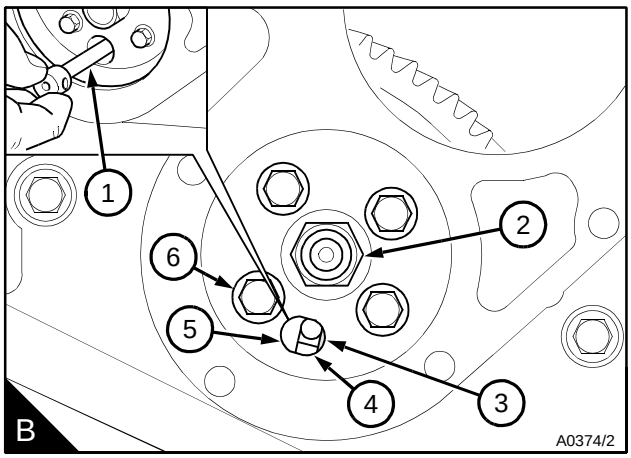
Caution: *Do not remove the nut (B2) from the shaft of the fuel injection pump. The fuel pump hub is fitted to the shaft in the factory to ensure that the fuel pump is in the correct position for timing. If the hub is removed, the hub will need to be accurately fitted to the pump by use of special equipment available to Perkins distributors.*

5 Put the fuel pump gear onto the hub of the fuel pump. The flanged setscrews (B6) for the fuel pump gear should be in the centre of the slots to allow for the removal of the backlash. Tighten the flanged setscrews finger tight.

Note: The fuel pump gear will only fit in one position. The gear is fitted with the letters C and M at the front.

6 Insert the timing pin (B1) through the hole (B5) of the fuel pump gear and the slot of the hub (B4) until it can be pushed fully into the hole (B3) in the body of the fuel pump. If the timing pin cannot be pushed into the pump body, check that the engine is correctly set at TDC on the number 1 cylinder, see Operation 8-1 or Operation 8-2.





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Caution: *The fuel pump gear must be fitted to the engine before the crankshaft is rotated.*

7 Carefully turn the gear counter-clockwise, by hand (C1), to remove the backlash between the idler gear and the fuel pump gear. Do not rotate the crankshaft or the fuel pump shaft. Tighten the flanged setscrews for the fuel pump gear to 28 Nm (20 lbf ft) 2,8 kgf m.

8 Remove the timing pin.

9 Fit the gear cover to the cover of the timing case. For gear driven coolant pumps. Fit the coolant pump.

Caution: *Do not tighten the union nuts of the high-pressure pipes more than the recommended torque tension. If there is a leakage from the union nut, ensure that the pipe is correctly aligned with the atomiser inlet. Do not tighten the atomiser union nut more, as this can cause a restriction at the end of the pipe. This can affect the fuel delivery.*

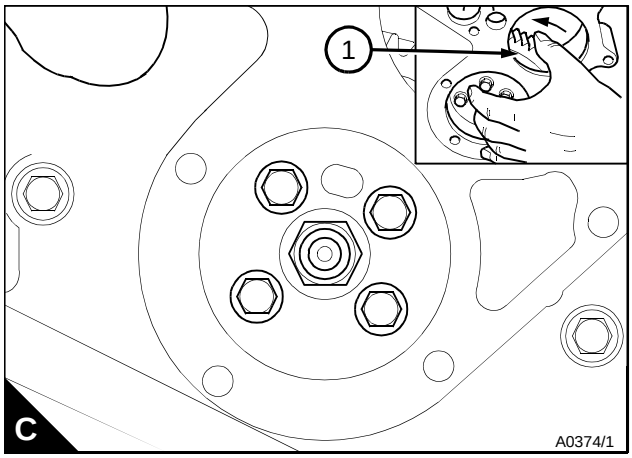
10 Fit all the pipes. Connect the control rod of the fuel injection pump. Fit the cables and connection for the cold start device and electrical stop solenoid to the pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted and tighten the union nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

11 Eliminate air from the fuel system, see Operation 11-54.

12 Fit the cylinder head rocker cover.

13 Connect the battery.

14 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed and the maximum no-load speed are correct, see Operation 11-53.



To adjust pin timed fuel injection pump **Operation 11-53**

Special requirements

Special tools	
Description	**Part number**
Idle adjustment locknut wrench	27610145
Torque screw locknut wrench	27610144

The engine conforms with USA (EPA/CARB) stage 1 and EEC stage 1 emissions legislation for agricultural and industrial applications.

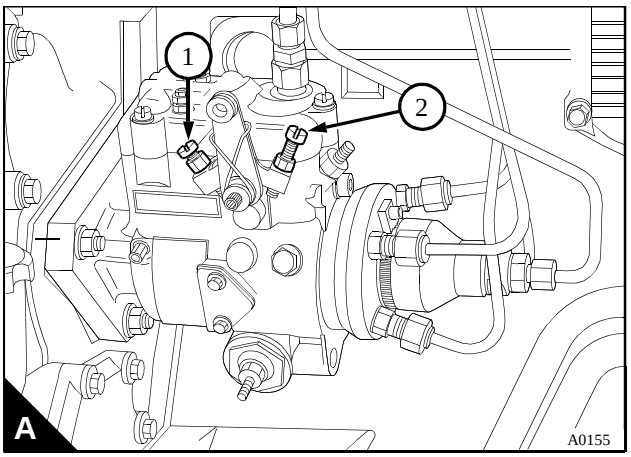
A requirement of emissions legislation is that access to adjustments that affect the engine's exhaust emissions is limited to personnel approved by Perkins. On early engines the adjustment screw for the high idle speed, is sealed by the manufacturer. The setting must not be changed, unless approved, as it could affect the warranty of the engine.

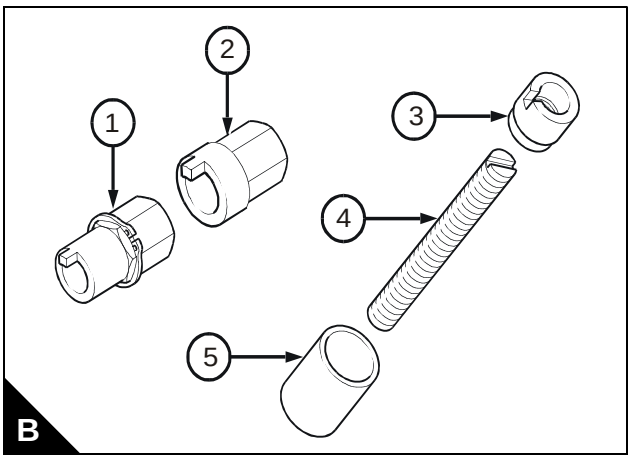
Note: The person who adjusts the pump must ensure that the adjustment screw is suitably sealed against interference after the adjustment.

The idle or maximum speed settings must not be changed by the engine operator, because this can damage the engine or the transmission. The warranty of the engine can be affected if the seal on the fuel injection pump is broken during the warranty period, or the fuel injection pump is adjusted by a person who is not approved by Perkins.

Fuel injection pumps (Type A) will have the adjustment screws sealed with lockwire and a seal (A).
Fuel injection pumps (Type B) have a mechanism (B) that consists of a sleeve (B5), an adjustment screw (B4) and a locknut (B3), these are for the adjustment of the idle speed and the maximum no-load speed.

Special tools (B1) and (B2) available at your Perkins distributor, are needed to adjust the idle or maximum speed settings on later engines.





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To adjust (type A fuel injection pump)

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by adjustment screw (C1).

2 Release the lock nut and rotate the adjustment screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the lock nut.

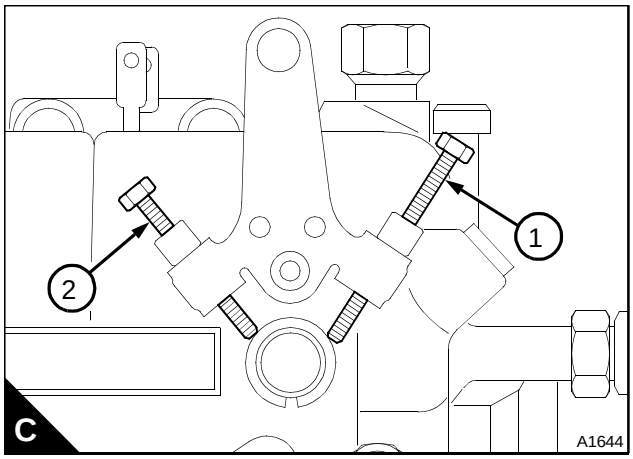
The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

3 With the engine at its normal temperature of operation, check the maximum no load speed. A typical maximum no load speed is 2860 rev/min. If necessary, this speed can be adjusted by adjustment screw (C2).

4 Release the lock nut and rotate the adjustment screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the lock nut and seal the screw.

The person who fits the pump must ensure that the adjustment screw is suitably sealed against interference after it has been set initially.



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To adjust (type B fuel injection pump)

1 Operate the engine until it reaches its normal temperature of operation and check the idle speed. If necessary, adjustment can be made by the adjustment screw (E1).

2 Fit the tool (D2) part number 27610145 into the sleeve on the pump (D5) so that it engages in the slot in the locknut (D3).

3 Put a screwdriver into the tool so that it engages in the slot in the adjustment screw (E). Put a spanner onto the hexagon of the tool.

4 Hold the adjustment screw (D4) with the screwdriver and use the spanner to loosen the locknut.

5 Use the screwdriver to rotate the adjustment screw until the engine runs at the correct speed.

6 Hold the adjustment screw with the screwdriver and use the spanner to tighten the locknut.

7 Remove the screwdriver, the spanner and the tool.

The setting of the idle speed can change for different applications. Normally the correct speed will be given in the manufacturer's handbook for the application. If it is not given, refer to your nearest Perkins distributor.

Caution: *The setting for the maximum no load speed can change for different applications. For the correct maximum no-load speed, check the emissions data plate fitted to the left side of the cylinder block before any adjustment is made to the maximum no load speed.*

8 With the engine at its normal temperature of operation, check the maximum no-load speed. A typical maximum no-load speed is 2860 rev/min. If necessary, this speed can be adjusted by the adjustment screw (E2).

9 Fit the tool (D1) part number 27610144 into the sleeve on the pump (D5) so that it engages in the slot in the locknut (D3).

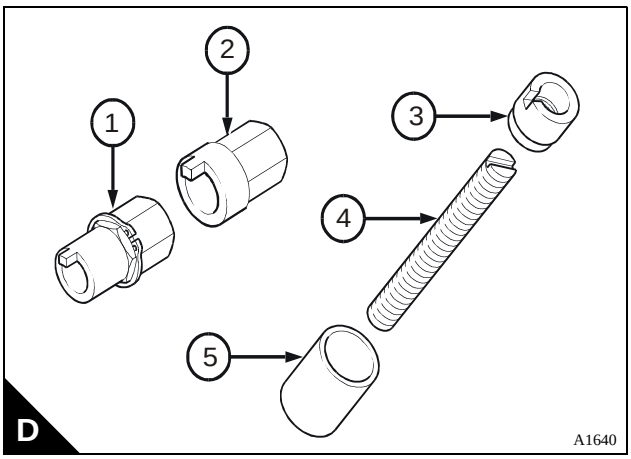
10 Put a screwdriver into the tool so that it engages in the slot in the adjustment screw (E). Put a spanner onto the hexagon of the tool.

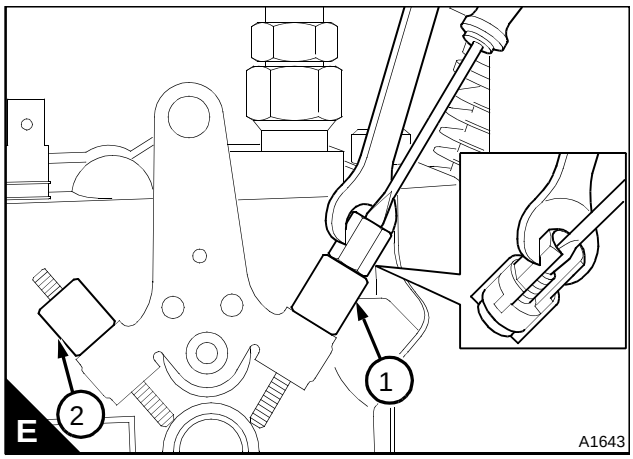
11 Hold the adjustment screw (D4) with the screwdriver and use the spanner to loosen the locknut.

12 Use the screwdriver to rotate the adjustment screw until the engine runs at the correct speed.

13 Hold the adjustment screw with the screwdriver and use the spanner to tighten the locknut.

14 Remove the screwdriver, the spanner and the tool.





To eliminate air from the fuel system **Operation 11-54**

Warnings!

- *If your skin comes into contact with high pressure fuel, obtain medical assistance immediately.*
- *Keep away from moving parts during engine operation. Some moving parts cannot be seen clearly while the engine runs.*

Caution: *If the fuel system is empty or if the canister of the fuel filter has been removed, it will be necessary to eliminate air from the fuel system, especially the fuel injection pump.*

If air enters the fuel system, it must be removed before the engine can be started.

Air can enter the system if:

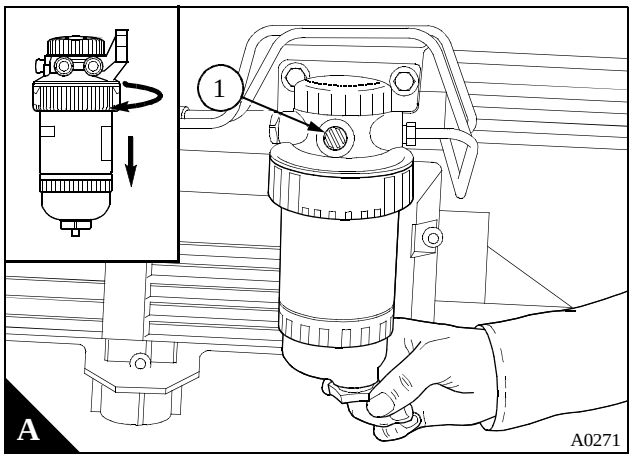
- The fuel tank is drained during normal operation.
- The low-pressure fuel pipes are disconnected.
- A part of the low-pressure fuel system leaks during engine operation.

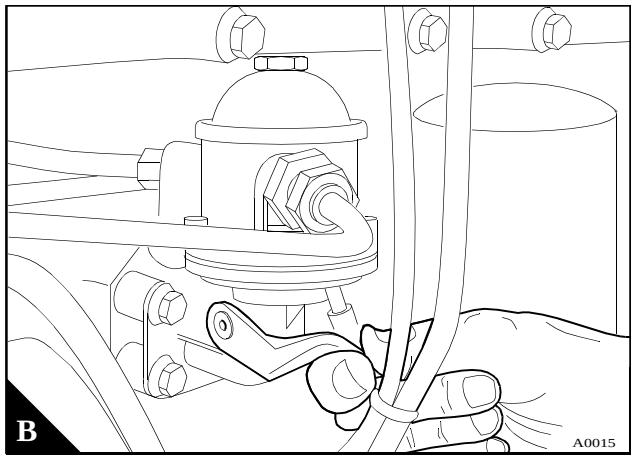
In order to eliminate air from the fuel system, proceed as follows:

1 Loosen the vent plug (A1) on the top of the filter head.

2 Operate the priming lever on the fuel lift pump (B) until fuel, free from air, comes from the filter vent point. Tighten the vent plug.

Note: If the drive cam of the fuel lift pump is at the point of maximum cam lift, it will not be possible to operate the priming lever. In this situation, the crankshaft must be rotated one revolution.





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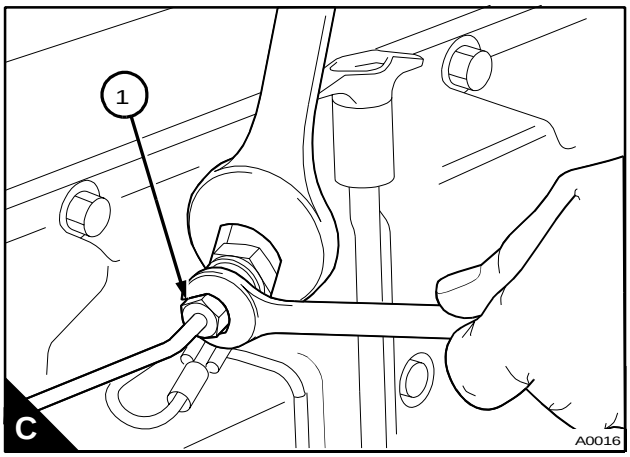
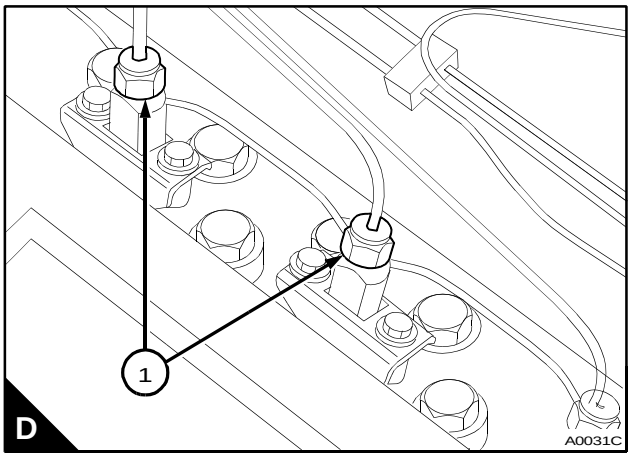
Caution: *spanner to prevent movement of the fuelled starting aid (E1) when the union nut is loosened or tightened.*

3 If the pipe to the fuelled starting aid has been drained, loosen the union nut (C1) at the fuelled starting aid and operate the lift pump until fuel, free from air, comes from the connection. Tighten the union nut at the starting aid. Use a spanner on the flats of the fuelled starting aid to prevent its movement when the union nut is loosened and tightened.

4 Loosen the union nuts (D1) of the high-pressure pipes at two of the atomisers.





Warning! *When the starter motor is operated to eliminate air from the high pressure pipes, the engine may run.*

Caution: *Damage to the fuel injection pump, battery and starter motor can occur if the starter motor is used excessively to eliminate air from the fuel system.*

5 Put the electrical system switch to the "ON" position. Operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the high-pressure pipe connections to 22 Nm (16 lbf ft) 2,2 kgf m. Return the switch to the "OFF" position.

6 The engine is now ready to start.

Caution: *Operate the engine at low idle speed for a minimum of five minutes immediately after air has been removed from the fuel system. This will ensure that the pump is free of air and prevent any damage to the fuel injection pumps internal parts by metal to metal contact.*

Note: If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probable a leakage in the suction or low-pressure system.

12

Cooling system

General description

Coolant from the bottom of the radiator passes through the centrifugal coolant pump, which is fitted onto the front of the timing case to assist the flow of the coolant through the system.

The pump is normally gear driven from the gear of the fuel injection pump.

On certain applications the pump is driven by a "V" belt from the crankshaft pulley.

From the pump, the coolant passes through a passage in the timing case.

Coolant pumps driven by a "V" belt pass the coolant through the pump body to the front of the cylinder block.

On four cylinder engines the coolant passes through a passage in the left side of the cylinder block to the rear of the cylinder block.

If a lubricating oil cooler is fitted, some of the coolant passes around the element of the cooler and then to the rear of the cylinder block.

If the oil cooler is fitted on the left side of the engine, coolant from the by-pass connection at the rear of the coolant pump passes through a pipe to the oil cooler.

If the oil cooler is fitted to the right side of the engine, a pipe is connected between the thermostat housing and the oil cooler. The coolant passes around the plates of the cooler and passes through a pipe to the cylinder block.

Some four cylinder engines have a plate type oil cooler fitted between the oil filter canister and the oil filter head.

The coolant then passes around the cylinders and up into the cylinder head. The coolant leaves the cylinder head at the front and passes into the thermostat housing.

If the thermostat is closed, the coolant goes directly through a by-pass to the inlet side of the coolant pump. If the thermostat is open, the thermostat closes the by-pass and the coolant passes to the top of the radiator.

On six cylinder engines the coolant divides as it enters the cylinder block. Most of the coolant passes along the right hand side of the cylinder block and around the outside of the cylinders to the rear of the cylinder block.

The remainder of the coolant passes along a passage on the left hand side of the cylinder block to the lubricating oil cooler.

The coolant flows around the element of the lubricating oil cooler to the rear of the cylinder block. The coolant then passes to the rear of the cylinder head.

Coolant passes forward through the cylinder head and into the thermostat housing. These engines have two thermostats. If the thermostats are closed, the coolant goes, through a by-pass, directly to the inlet side of the coolant pump. If the thermostats are open, the coolant passes to the top of the radiator.

Thermostats

To remove — Operation 12-1

Most engines are fitted with a single thermostat (A), some engines have twin thermostats fitted (B) Identification of the thermostat is by the nominal temperature which is stamped on the by-pass valve (A6) of the thermostat.

1 Drain the coolant in the cooling system to a level below the thermostat position and disconnect the top hose from the coolant outlet connection.

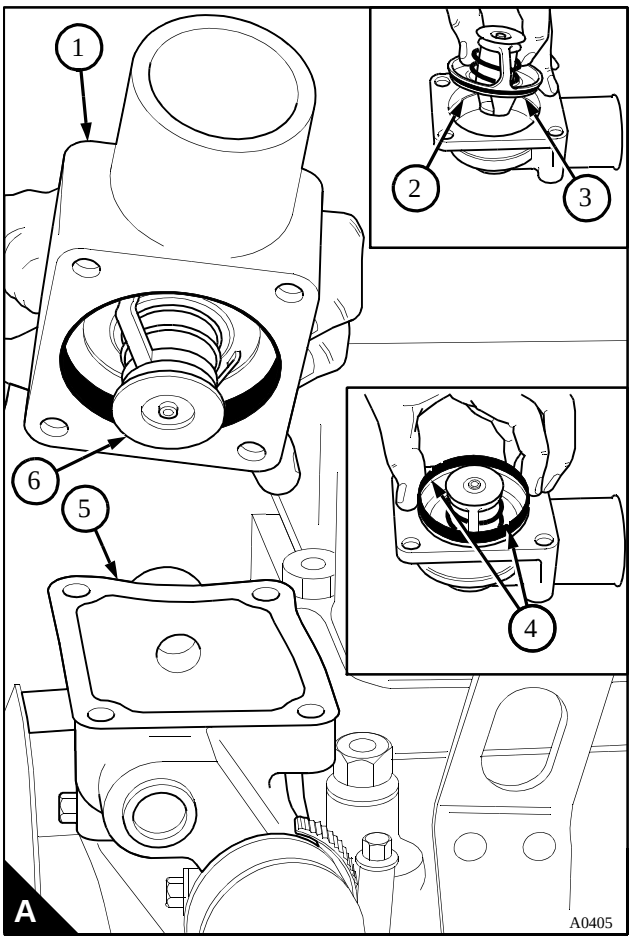
2 Release the four setscrews and remove the thermostat housing (A1) from the lower body. Discard the joint (A5).

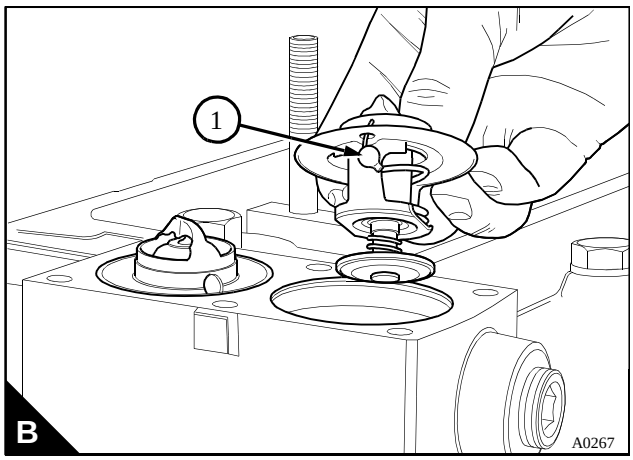
Note: Engines with a plastic thermostat housing have an “O” ring fitted to the flange face of the housing instead of a joint.

3 Press the retainer clips (A4) away from the groove in the thermostat body, and lift the plastic collar from the thermostat housing. If the retainer clips are damaged or the collar is loose discard and renew the plastic collar.

Caution: *It is important that the correct collar is fitted.*

4 Remove the thermostat and "O" ring assembly (A3) from the thermostat housing. Discard the "O" ring.





To fit **Operation 12-2**

1 Clean the thermostat housing, ensure that the groove (A2) for the clip retainers and the seat for the "O" ring are free of debris.

2 Ensure that the joint faces of the thermostat housing and the lower body are clean and that the jiggle pin (B1) in the thermostat is free to move.

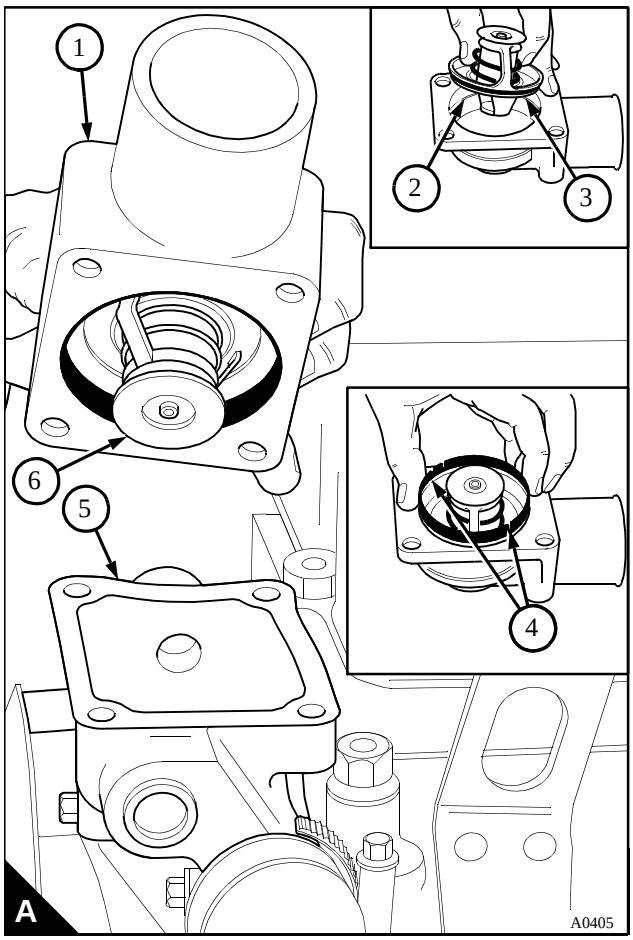
3 Renew the "O" ring and put the thermostat in position in the housing.

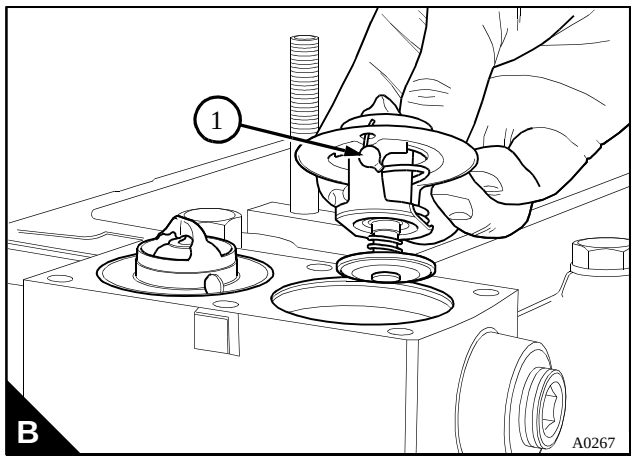
Caution: *If the clips on the plastic collar are not fitted correctly into the groove, the collar will not be secure and the thermostat will move out of position when the engine is in operation.*

4 Press the retainer clips, and push the plastic collar into the thermostat housing until the clip retainers engage the groove. Check that the plastic collar is a tight fit in the thermostat housing. If the collar is loose it must be renewed.

5 Fit a new joint, the joint is fitted dry. Fit and tighten the setscrews.

6 Connect the top hose and fill the cooling system.





To test **Operation 12-3**

1 Hang the thermostat in a suitable container filled with coolant.

2 Heat the coolant gradually. Use a thermometer to check the temperature at which the valve starts to open and at which it is fully open. For the correct operating temperatures, refer to the Data and dimensions for "Thermostat" on page 54.

Caution: *If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.*

Coolant pump (gear driven)

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.
Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

Identification of the coolant pump is by the last four digits of the part number stamped on the front of the pump body.

The coolant pump fitted to the latest engines has a larger bearing assembly which has an integral oil seal. Identification of the new coolant pump is by the last four digits of the part numbers, (4131E008) (4131E011), (4131E014) or (4131E113), stamped on the front of the coolant pump body and by the bearing which extends approximately 5 mm (0.2 in) past the end of the pump body. The gear for coolant pumps part number (4131E014) and (4131E113) has a recess machined into the hub. To dismantle and assemble the pumps fitted to the latest engines, see Operation 12-8 and Operation 12-9.

To remove **Operation 12-4**

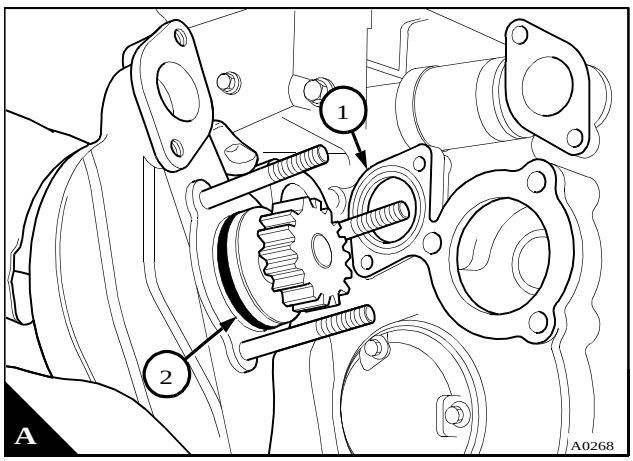
1 Drain the cooling system and disconnect the hose at the inlet connection of the coolant pump.

2 Release the setscrews from the flange of the coolant by-pass.

3 Release the three setscrews which retain the coolant pump to the cover of the timing case - two from the front and one from the rear.

4 Release the nuts from the rear face of the timing case, which fasten the pump to the timing case, and remove the coolant pump (A). Ensure that the "O" ring (A1) on the cover of the timing case is not lost.

Note: Most of the latest coolant pumps use setscrews instead of studs.



To fit **Operation 12-5**

1 Check the "O" rings on the pump body (A2) and on the cover of the timing case (A1) for damage. If either of the "O" rings are damaged, they must be renewed. Ensure that all joint faces are clean.

2 Check the drive gear of the coolant pump for wear or other damage. If the gear is damaged, it must be renewed.

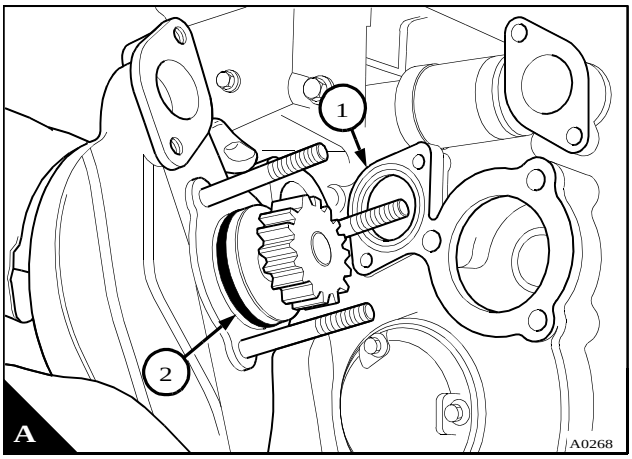
3 Lightly lubricate the "O" ring on the pump body with clean engine lubricating oil. Fit the pump to the timing case cover with its gear in mesh with the gear of the fuel injection pump. The pump is a tight fit in the cover, but can be pulled into position if the nuts for the pump studs are gradually and evenly tightened. Ensure that the "O" ring in the cover remains in position while the pump is fitted.

Note: Most of the latest coolant pumps use setscrews instead of studs. The setscrews have a sealant applied to the threads by the manufacturer. If the original setscrews are to be used again, the threads of the setscrews and the threads in which they will be engaged must be cleaned. A suitable sealant must then be applied to the threads of the setscrews.

4 Fit and tighten the three setscrews which retain the pump to the cover of the timing case - two from the front and one from the rear.

5 Fit a new joint to the flange of the coolant bypass. Fit the by-pass and tighten the setscrews.

6 Connect the hose to the inlet connection of the coolant pump and fill the cooling system. Operate the engine and check for leakage.



To dismantle (early engines) **Operation 12-6**

Special requirements

Special tools	
Description	**Part number**
Gear puller	21825625

1 Remove the three long studs and the "O" ring (A1) from the pump body (A5).

2 Remove the front cover (A9) and the joint (A10).

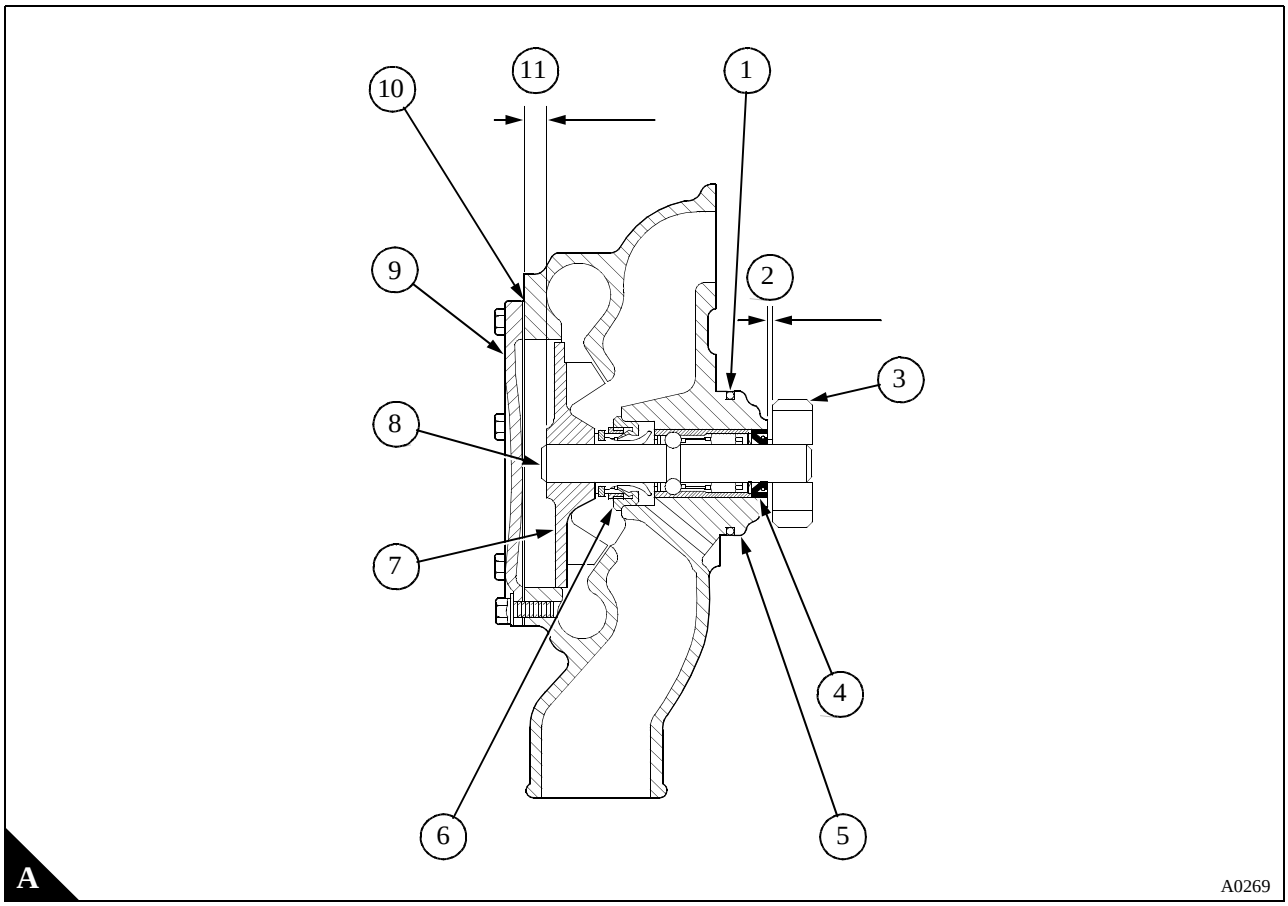
3 Remove the gear (A3) with the puller.

4 Use a suitable lever to remove the oil seal (A4) and discard the seal.

5 If necessary, remove the studs from the pump body. With a suitable support under the impeller end of the body, use a suitable adaptor to press out the shaft and bearing assembly (A8), together with the impeller (A7) and the coolant seal (A6).

6 With a suitable support under the impeller, press the shaft out of the impeller. Discard the impeller, the shaft, the bearing and the coolant seal.

Caution: *When a coolant pump repair kit is used, It is important that all of the components in the pump kit are changed. Coolant pump kits include the latest components which may be of a different design to the original components fitted to the engine.*



To assemble (early engines) **Operation 12-7**

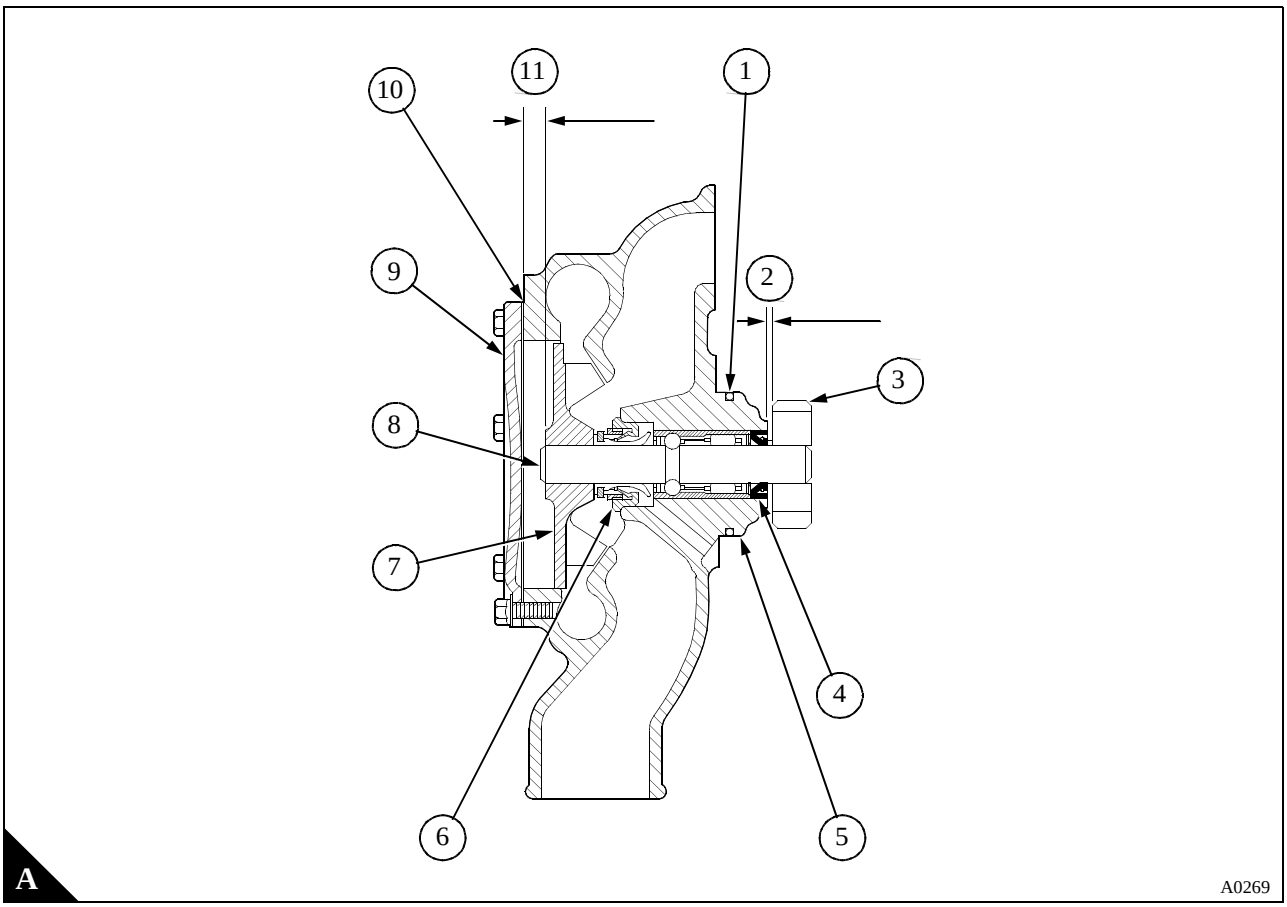
Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (high strength)	21820638

1 Clean thoroughly the inside of the pump body especially the bearing bore and the counterbore for the coolant seal. Both of these bores and their chamfers must be clean and free of corrosion.

2 Apply a thin layer of POWERPART Retainer (high strength) to the outer surface of the bearing, but keep the retainer away from the ends of the bearing. Provide a suitable support under the gear end of the pump body. Put the bearing and shaft assembly (A8) in position with the bearing square to the pump body and the shortest end of the shaft in the pump body. Use a press and a suitable adaptor, which will apply the force to the bearing and not to the shaft, to press in the bearing and shaft assembly. Press in the bearing until the end of the bearing is level with the bottom of the counterbore for the coolant seal. Remove the adaptor and remove all retainer from the end of the bearing.

Caution: *Do not lubricate the coolant seal (A6). It is important that it is not contaminated with oil or grease and, if it is held in the hand, it should be held by the edge of the outside flange.*



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3 With the widest end of the coolant seal towards the bearing, push the seal onto the shaft until it is against the chamfer of the counterbore. Ensure that the seal is square with the bore and press the seal into the counterbore, with a suitable adaptor, until the outer flange is in contact with the pump body. The adaptor must apply force only to the outer flange of the seal. With the seal in position, continue to apply force for approximately ten seconds to ensure that the seal remains in position.

A new coolant seal is fitted to the latest coolant pumps. The seal has a brass body and is interchangeable with the earlier seal. A small number of coolant pumps part number 4131E103, used on early six cylinder engines, have a coolant seal part number 2418M003 with a diameter of 38 mm (1.5 in). These seals are not interchangeable with other coolant seals.

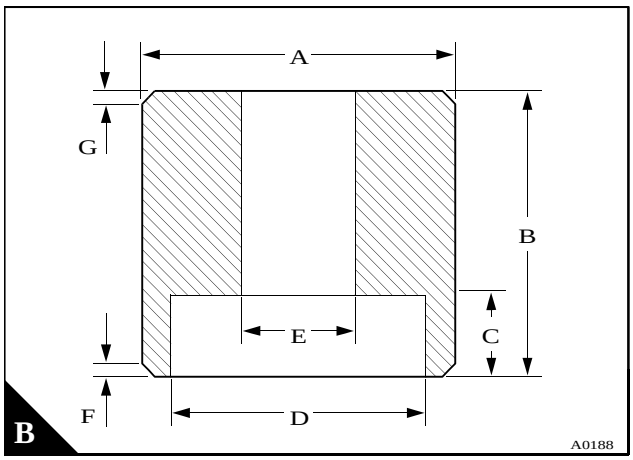
Note: It is important that the new seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange.

4 A tool (B) can be made to press the new seal into position. The tool should be made of a suitable material to the dimensions shown below:

A	44,0 mm (1.73 in)	**C**	11,6 mm (0.46 in)	**E**	16,1 mm (0.63 in)	**G**	2,00 mm (0.08 in) at 45°
B	40,0 mm (1.57 in)	**D**	35,8 mm (1.41 in)	**F**	1,00 mm (0.04 in) at 45°		

The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

The tool cannot be used for the 38 mm (1.5 in) seal. Ensure that the hole in the tool is aligned with the shaft as the seal is fitted. With the ring of sealant towards the bearing, use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body.



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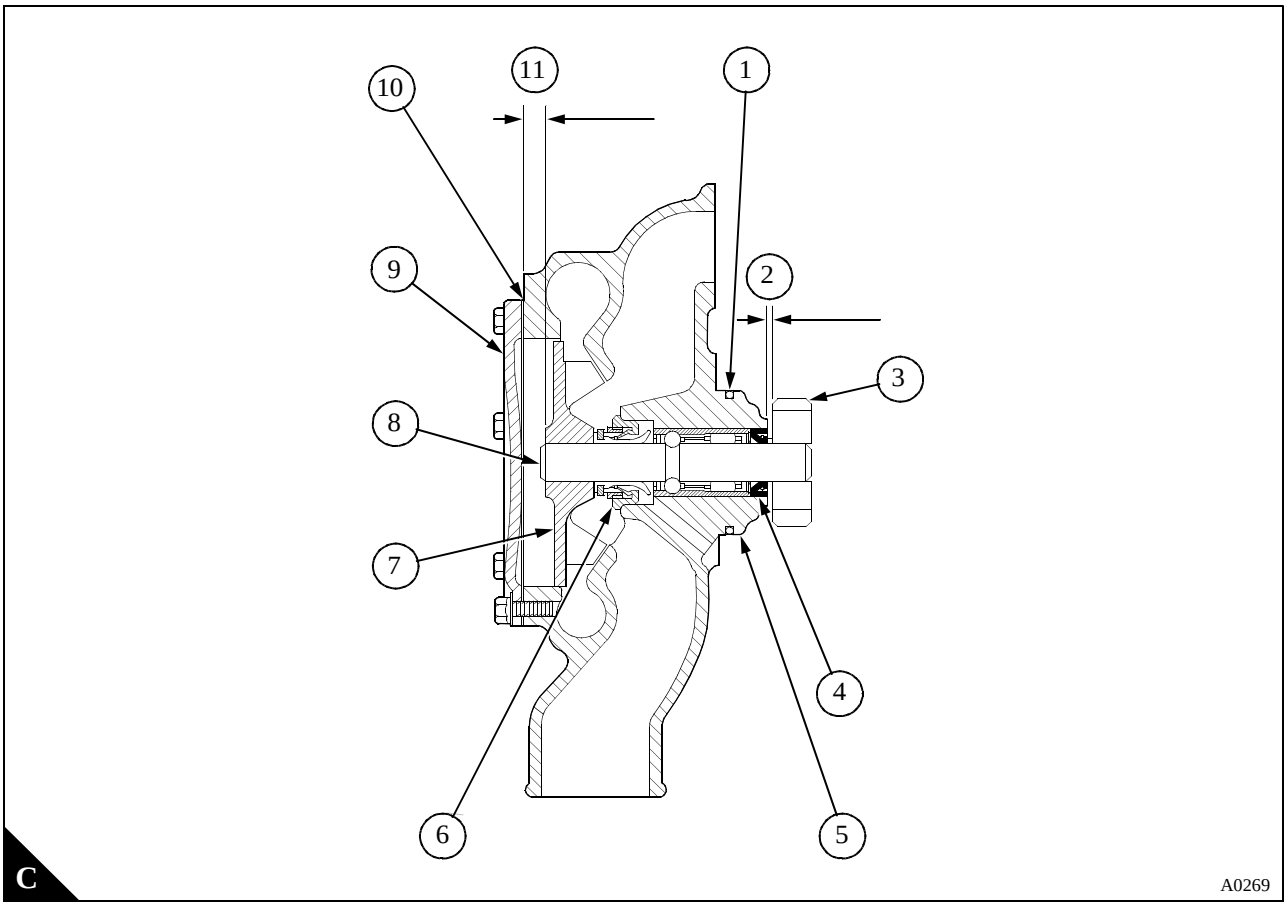
5 Hold the pump with the gear end of the shaft on a suitable support and, with a suitable distance piece and a flat bar, press the impeller (C7) on to the shaft to the dimension (C11) 7,1/7,5 mm (0.28/0.30 in) for coolant pump part number 4131E012 or 6,7/7,0 mm (0.26/0.28 in) for coolant pumps part number 4131E015 and 4131E016. Remove the tool and ensure that the shaft is free to rotate. Remove any excess retainer after the impeller has been fitted.

6 Turn the pump over and provide a suitable support for the pump body, remove the studs, if necessary. Lightly lubricate the oil seal (C4) with clean engine lubricating oil. Put the oil seal into position in the pump body with the flat face of the seal towards the bearing. With a suitable adaptor, press the oil seal into the body until the rear of the seal is level with the end of the pump. When the seal is in position, continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

7 Hold the pump with the impeller end of the shaft on a suitable support. If the original gear is used, POWERPART Retainer (high strength) must be applied to the bore of the gear. Press the gear (C3) onto the shaft to the dimension shown at (C2) 0,6/2,6 mm (0.024/0.102 in) for coolant pumps, part number 4131E012, 4131E015 and 4131E016. Remove all excess retainer after the gear has been fitted.

8 Clean the threads in the front face of the pump body for the setscrews that retain the cover. Fit a new joint (C10) and the cover (C9). Fit the setscrews and tighten them to 9 Nm (6 lbf ft) 0,9 kgf m. If the setscrews are new, a sealant will have been applied to the threads by the manufacturer. If the original setscrews are to be used again, the threads should be cleaned and a suitable sealant applied.

9 Fit a new "O" ring (C1) to the body of the pump.



To dismantle (later engines) **Operation 12-8**

Special requirements

Special tools	
Description	**Part number**
Gear puller	21825625

The later coolant pump has a larger bearing assembly which has an integral oil seal. Identification of the new coolant pump is by the last four digits of the part numbers, (4131E008) (4131E011), (4131E014) or (4131E113), stamped on the front of the coolant pump body and by the bearing which extends approximately 5 mm (0.2 in) past the end of the pump body. The gear for coolant pumps part number (4131E014) and (4131E113) has a recess machined into the hub.

1 Remove the "O" ring (A2) from the pump body (A4).

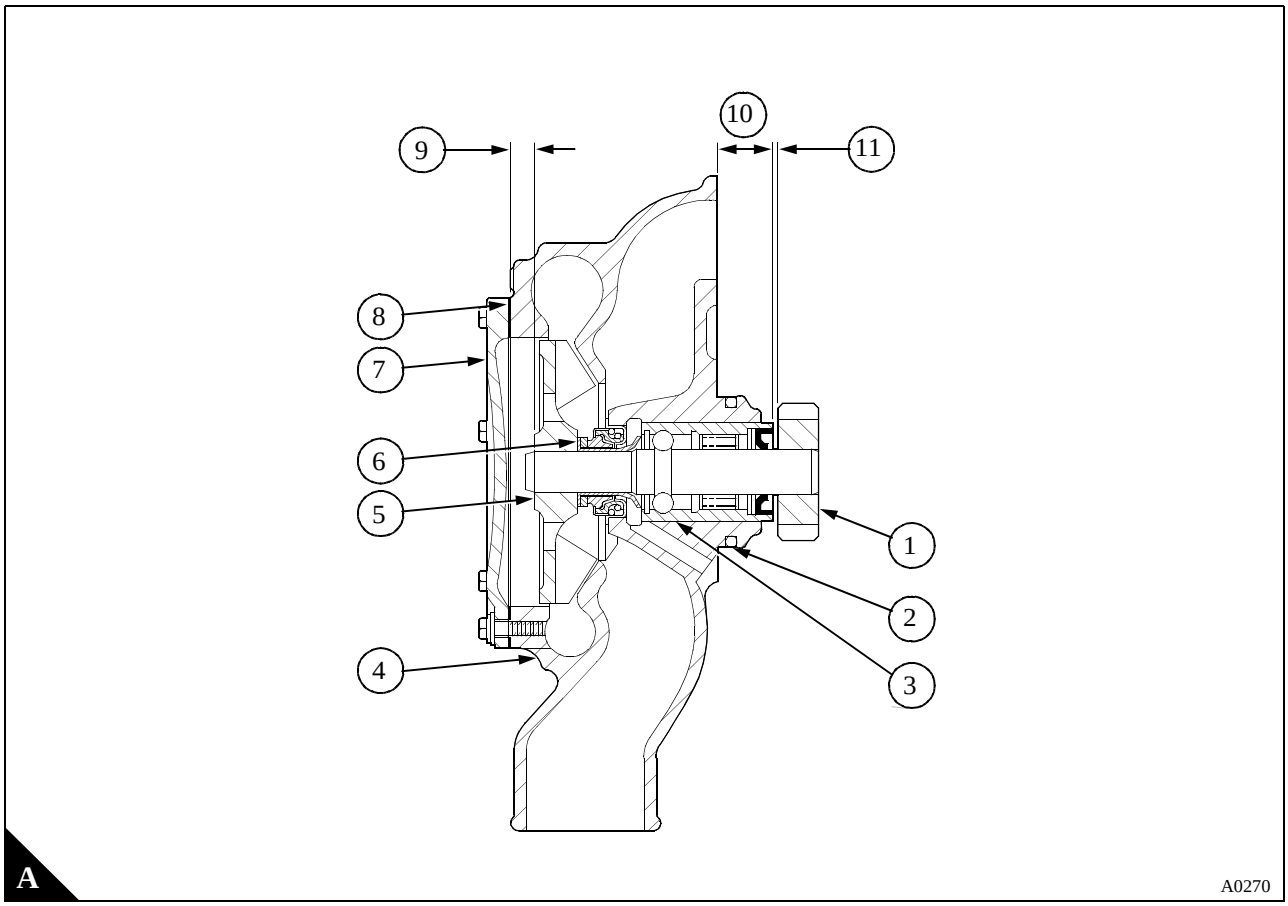
2 Remove the front cover (A7) and the joint (A8).

3 Remove the gear (A1) with the puller 21825625.

4 With a support under the drive end of the pump, use a suitable adaptor to press out the shaft and bearing assembly (A3) and discard it. Remove and discard the impeller (A5) from the body.

5 With a suitable support under the impeller end of the pump, press out the coolant seal and discard it.

Caution: *When a coolant pump repair kit is used, It is important that all of the components in the pump kit are changed. Coolant pump kits include the latest components which may be of a different design to the original components fitted to the engine.*



To assemble (later engines) **Operation 12-9**

Special requirements

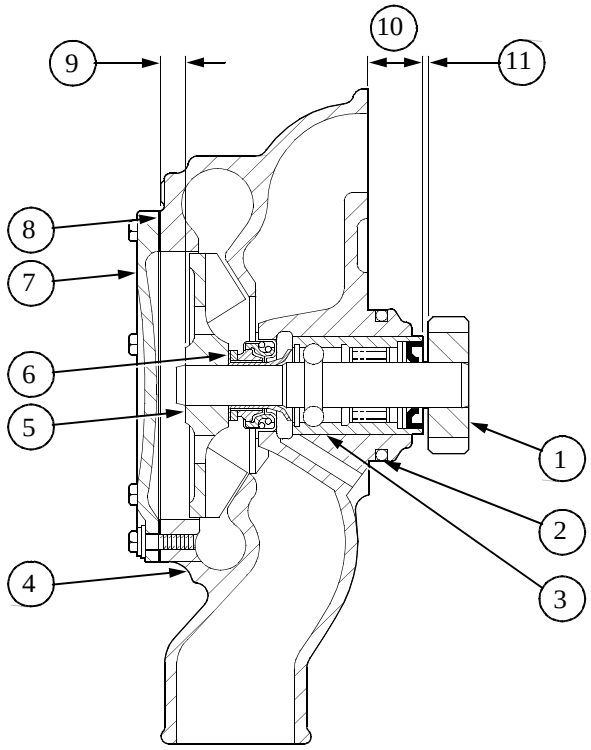
Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Retainer (high strength)	21820638	POWERPART Threadlock and nutlock	21820117 or 21820118

1 Clean thoroughly the inside of the pump body (A4). Ensure that the bore for the bearing and the chamfer at the coolant seal end of the bore are clean and free from corrosion.

2 Make a suitable adaptor which will apply force to the outer edge of the bearing and not to the shaft. Apply a thin layer of POWERPART Retainer (high strength) to the outer surface of the bearing (A3), but keep the retainer away from the ends of the bearing.

3 Provide a suitable support under the impeller end of the pump body. Put the bearing and shaft assembly in position with the bearing square to the pump body and the longest end of the shaft in the pump body. Use the adaptor to press in the bearing and shaft assembly. Press in the bearing until the rear face of the bearing is 21,0/21,5 mm (0.83/0.85 in) (A10) above the rear face of the pump body.

4 If the original gear is used, POWERPART Retainer (high strength) must be applied to the bore of the gear. Press the gear (A1) onto the shaft until the clearance between the front face of the gear and the rear face of the bearing (A11) is 0,47/1,53 mm (0.018/0.060 in) for coolant pumps part numbers, (4131E008) and (4131E011) or 1,07/3,43 mm (0.042/0.14 in) for coolant pumps part numbers, (4131E014) and (4131E113). Remove all excess retainer after the gear has been fitted.



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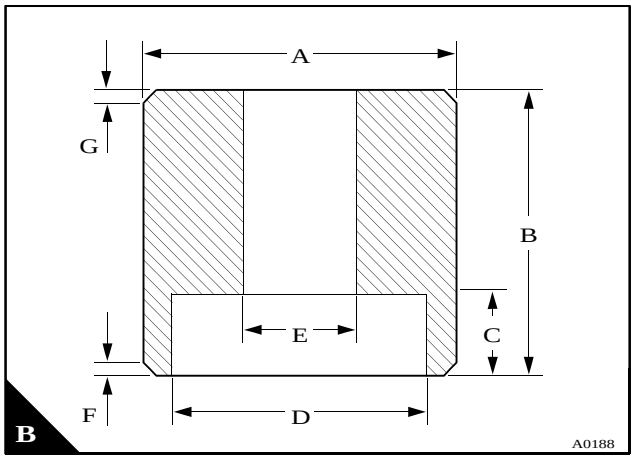
5 A tool (B) can be made to press the coolant seal into position. The tool should be made of a suitable material to the dimensions listed below:

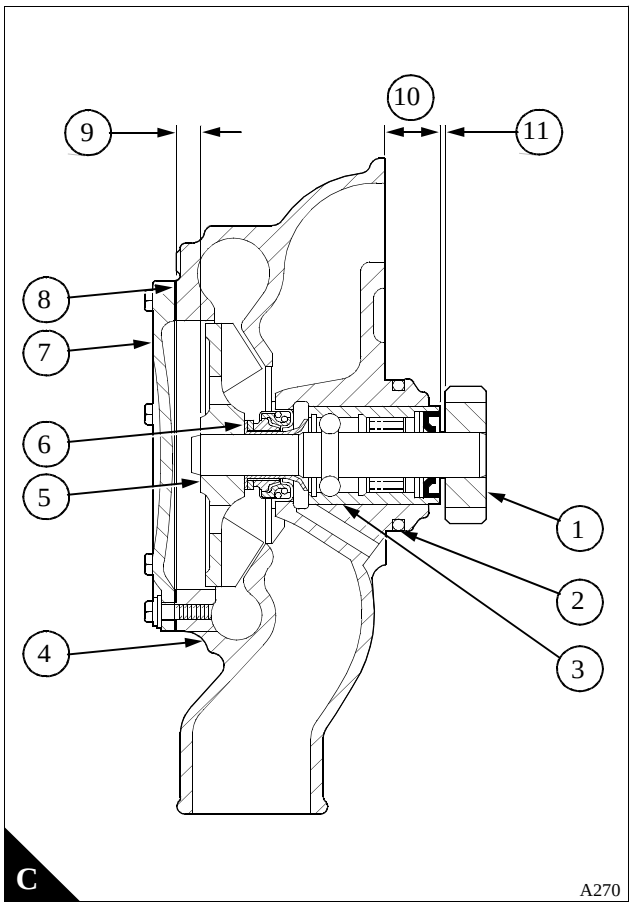
A	44,0 mm (1.73 in)	**C**	11,6 mm (0.46 in)	**E**	16,1 mm (0.63 in)	**G**	2,00 mm (0.08 in) at 45°
B	40,0 mm (1.57 in)	**D**	35,8 mm (1.41 in)	**F**	1,00 mm (0.04 in) at 45°		

The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Turn the pump over and support the drive end of the body. Do not lubricate the coolant seal (C6). It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange. Put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearing. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body.

6 Hold the pump with the drive end of the shaft on a suitable support. With the use of a suitable distance piece and a flat bar, press the new impeller (C5) onto the shaft until the front face of the impeller is 7,1/7,5 mm (0.28/0.30 in) for coolant pump part number (4131E008) and 6,7/7,0 mm (0.26/0.28 in) for coolant pumps part number (4131E011), (4131E014) and (4131E113) below the front face of the pump body (C9). Remove the flat bar and distance piece and ensure that the shaft is free to rotate.





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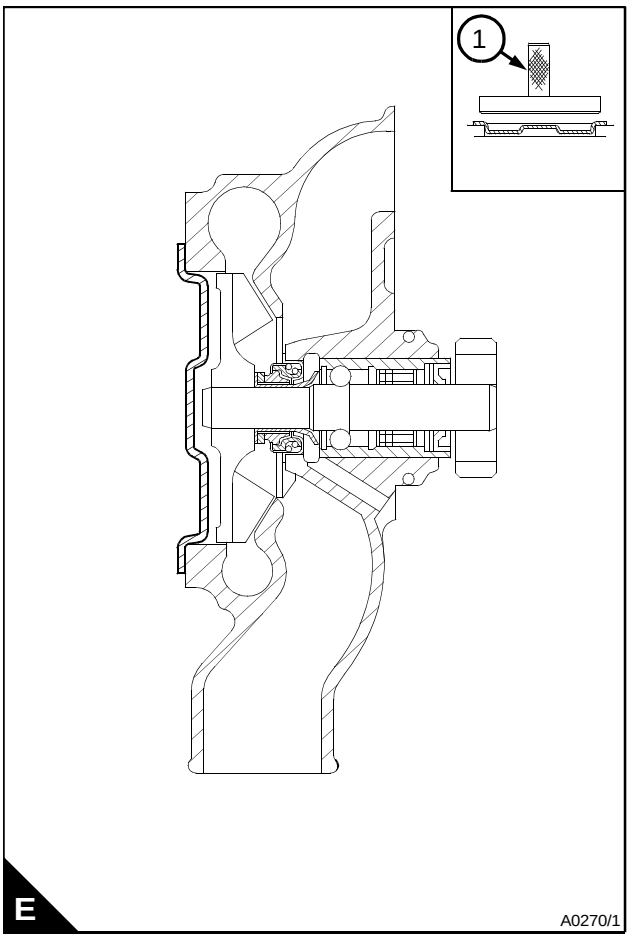
Note: If the latest pressed steel cover coolant pump is supplied, it is important that impeller clearance is set to the correct depth.The clearance is set by depth (E2) of the impeller from the front face of the pump body to the front face of the impeller hub. The correct depth for coolant pumps, part numbers 4131E018, 4131E019, 4131E021 and 4131E022 is 16,7/17,0 mm (0.657/0.669in) and the correct depth for part number 4131E025 is 17,1/17,5 mm (0.673/0.689 in)



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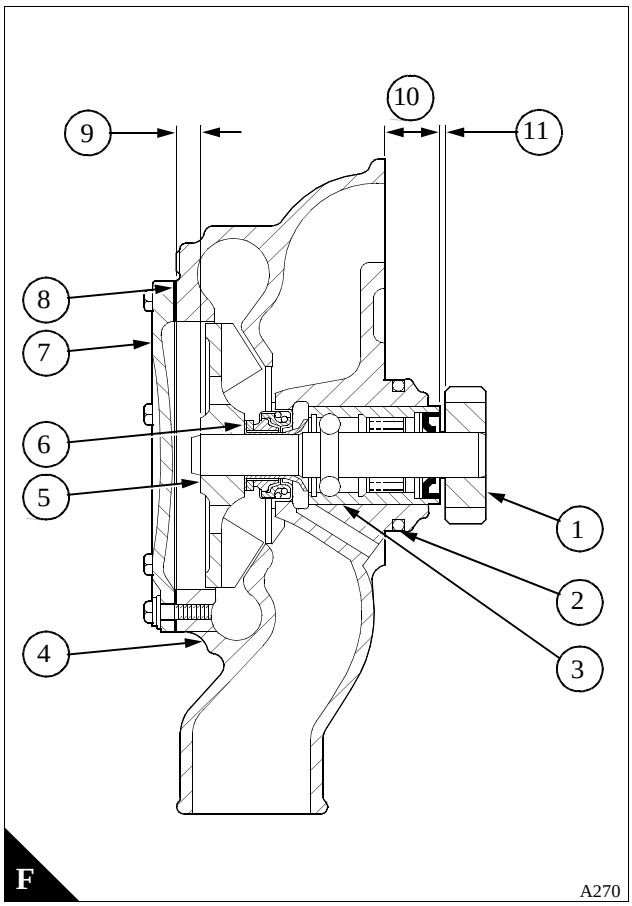
7 Clean the threads in the front face of the pump body. Fit a new joint (F8) and the cover (F7). Fit the setscrews and tighten them to 9 Nm (6 lbf ft) 0,9 kgf m. If the setscrews are new, a sealant will have been applied to the threads by the manufacturer. If the original setscrews are to be used again, the threads should be cleaned and a POWERPART Threadlock and nutlock applied.

8 Fit a new "O" ring (F2) to the body of the pump.



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To remove and fit pressed steel covers (latest engines) **Operation 12-10**

Special requirements

Consumable products	
Description	**Part number**
Powerpart gasket and flange sealant	21820518

The latest coolant pumps have an improved cover (A1) made of pressed steel.

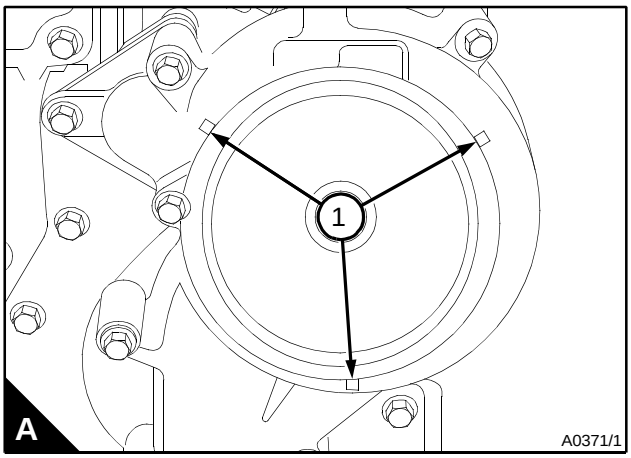
To fit

Caution: *Do not remove the pressed steel cover when the coolant is to be removed or fitted. It is only necessary to remove the cover when the pump is to be dismantled.*

1 Use a suitable lever in the recesses (A1) to obtain access to the edge of the pressed steel cover. Operate the lever in each of the recesses to remove the cover. Discard the cover.

Caution: *Do not damage the surface of the bore for the cover during the cleaning operation.*

2 Clean the old sealant and any corrosion from the surface of the bore to a depth of 7 mm (0.28 in).



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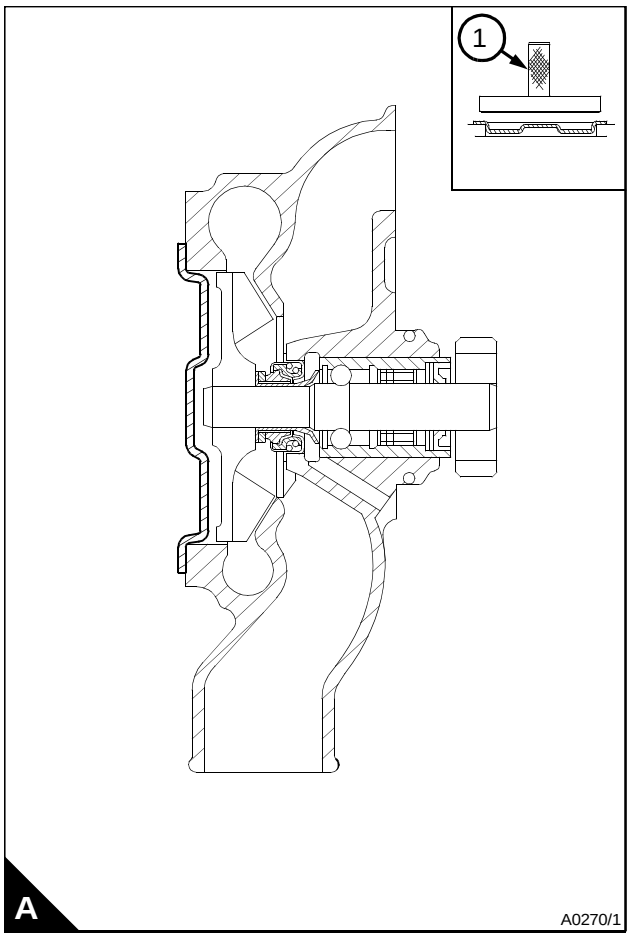
To fit

1 Put a bead of POWERPART Gasket and flange sealant on the contact surface of the pressed steel cover.

2 Support the body of the pump on the mounting flange.

3 Ensure that the new cover is square with the body of the pump and use a press with a suitable adaptor (A1) to press the cover fully into the body of the pump.

Note: To dismantle and to assemble see Operation 12-8 and Operation 12-9



Coolant pump (belt driven)

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.
Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

To remove **Operation 12-11**

Special requirements

Special tools	
Description	**Part number**
Gear puller	21825565

1 Remove the fan, see Operation 12-18.

2 Remove the fan belt, see Operation 14-3.

3 Disconnect the hose connections to the coolant pump.

4 Remove the nut, spring washer and plain washer from the pump pulley. It may be necessary to use extractor PD. 155C to remove the pulley from the pump shaft (A).

5 If the pump is to be dismantled remove the key from the keyway of the pump shaft.

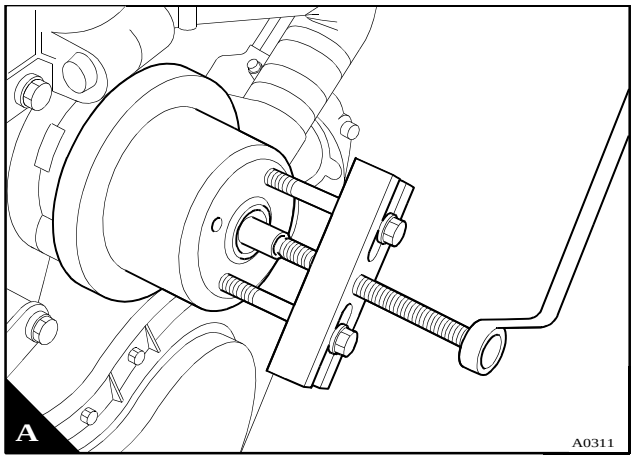
6 Remove the four setscrews which secure the coolant pump to the rear body of the pump (B) and remove the pump from the engine.

7 Remove the coolant pump and discard the joint.

8 If it is necessary to remove the rear body (B1) of the pump from the cylinder block:

Remove the setscrew for the alternator adjustment linkage and the spacer.

Remove the four other setscrews and remove the rear body from the cylinder block. Discard the joint (B2).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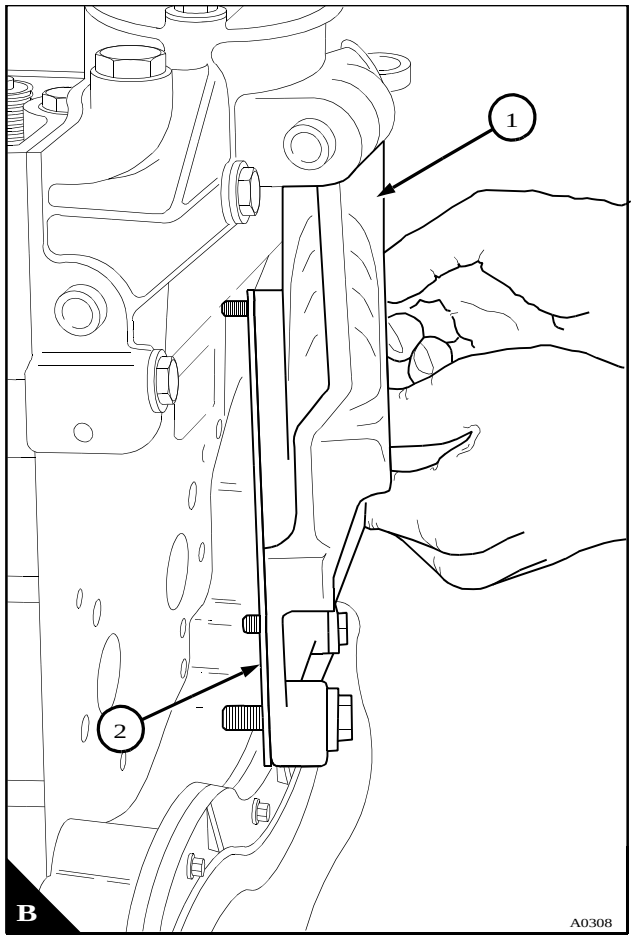
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To fit **Operation 12-12**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

Note: The joints are fitted without jointing compound.

1 If the rear body of the pump (A1) was removed from the cylinder block, thoroughly clean the joint faces of the cylinder block and pump rear body. Fit a new joint (A2) between the rear body of the pump and the cylinder block.

2 Fit the rear body of the pump and the joint to the cylinder block. Fit the spacer and adjustment linkage for the alternator and tighten the M10 setscrews to 44 Nm (33 lbf ft) 4,5 kgf m and the M12 setscrews to 75 Nm (55 lbf ft) 7,6 kgf m.

3 Thoroughly clean the joint faces of the pump rear body and coolant pump (B2). Fit a new joint (B4) to the coolant the pump.

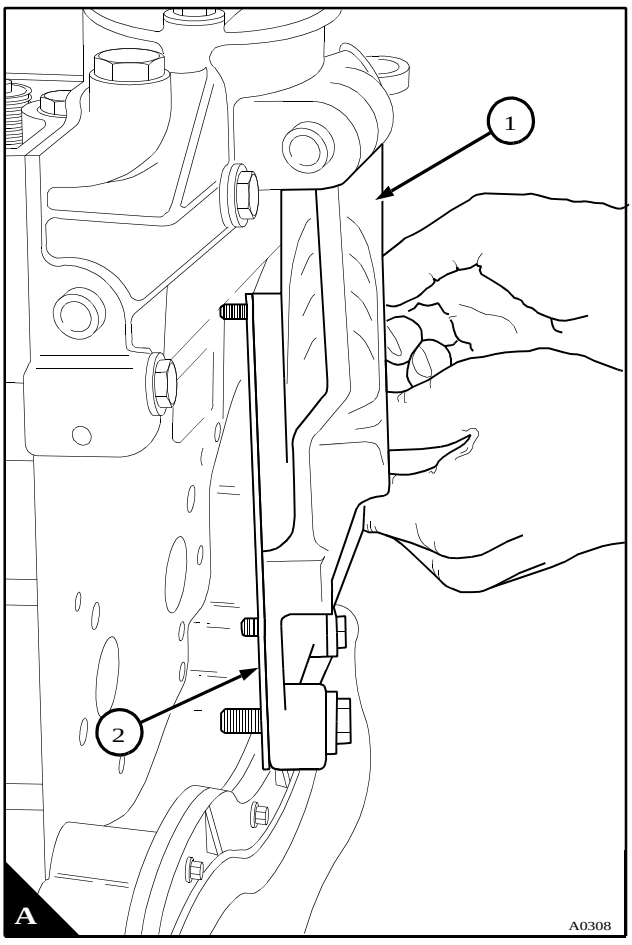
4 Fit the coolant pump and joint to the rear pump body and tighten the four M10 setscrews (B3) to 44 Nm (33 lbf ft) 4,5 kgf m.

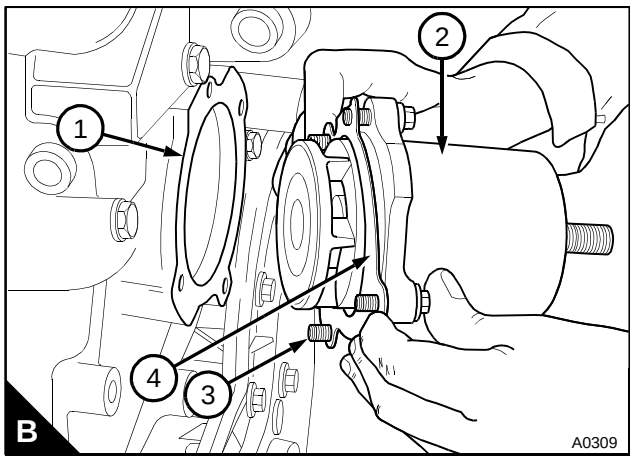
5 Fit the key to the keyway and put the pulley onto the pump shaft. Put the plain washer and the spring washer in position onto the pulley. Fit the nut and tighten it to 82 Nm (60 lbf ft) 8,2 kgf m.

6 Connect the hoses to the coolant pump and tighten the clips.

7 Fit the fan belt, see Operation 14-3.

8 Fit the fan, see Operation 12-18.





To dismantle **Operation 12-13**

Special requirements

Special tools	
Description	**Part number**
Standard bench press	-

1 Remove the coolant pump (A) from the engine, see Operation 12-11.

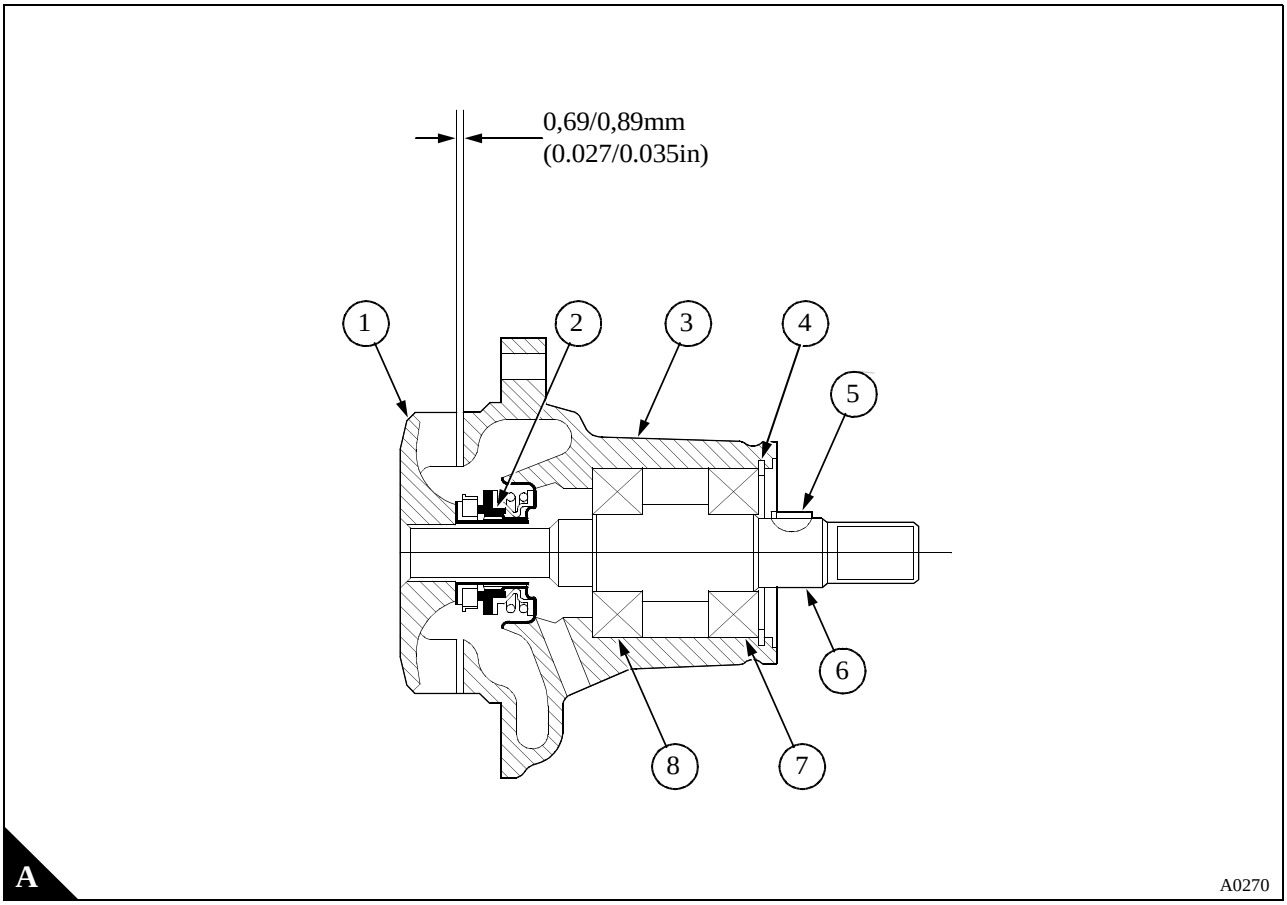
2 Remove the circlip (A4) for the bearing housing.

3 Support the pulley end of the pump and press the shaft (A6) through the impeller (A1) and coolant seal (A2). This will remove the bearing (A7).

4 Remove the impeller. Discard the coolant seal.

5 Support the pulley end of the pump and press out the bearing (A8). Discard the bearings.

6 Clean the body of the pump in a suitable safe cleaning fluid. Inspect the pump body for cracks.



To assemble **Operation 12-14**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

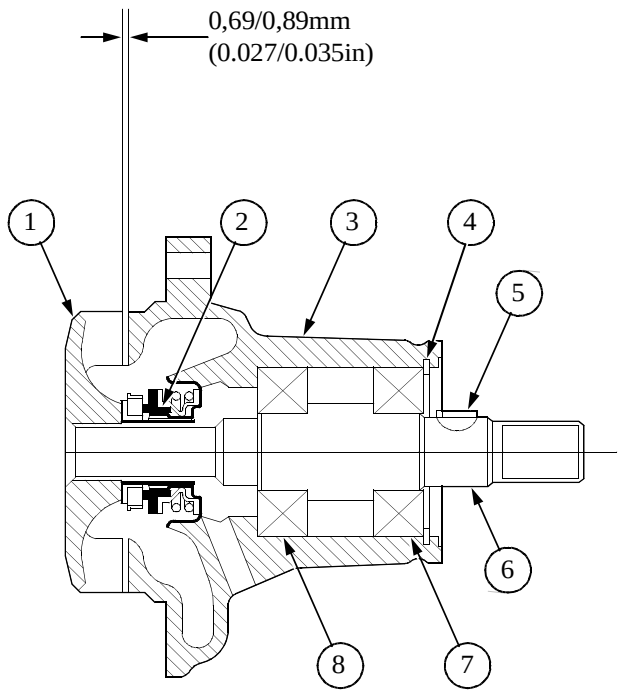
The service kit for the pump contains two bearings, the shaft, a circlip and a coolant seal.

Each bearing is filled with grease and sealed by the bearing manufacturer. The bearings will not need attention during service.

1 Support the impeller end of the pump body. Apply a narrow ring of POWERPART Retainer (oil tolerant) to the face of the outer race of each bearing race. Put the bearing (A8) into position on the pump housing. Use a suitable adaptor on the outer race and press the bearing fully into the back of the bearing housing.

2 Support the inner race of the bearing just fitted from the impeller end of the pump body. Use a suitable adaptor which will allow the shaft (A6) to pass through it. Press the new shaft into the bearing until shoulder of the shaft is fully against the inner race of the bearing. Put the bearing (A7) into position on the pump housing and shaft. Use a suitable adaptor on the inner and outer race to ensure the pressure is applied evenly. Press the bearing onto the shaft and housing until the inner race of the bearing is against the shoulder of the shaft. Remove excess retainer and fit the new circlip (A4).

3 Fit a new coolant seal (A2) as follows:



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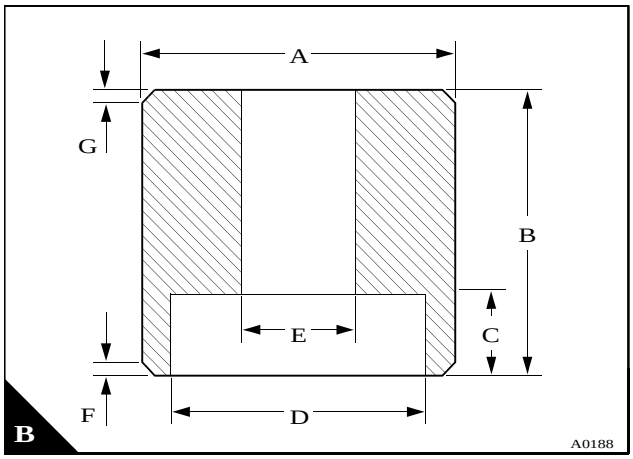
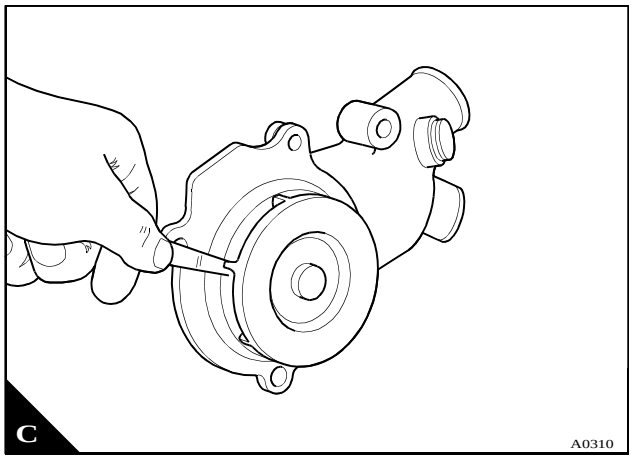
Caution: *It is important that only the tool, shown in (B), is used to fit the new coolant seal.*

4 The coolant seal is an interference fit on the shaft and a tool will be necessary to fit the seal correctly. The tool should be made of mild steel bar to the dimensions shown in (B), listed as follows:

A	44,0 mm (1.73 in)	**C**	10,7 mm (0.41 in)	**E**	16,1 mm (0.63 in)	**G**	2,00 mm (0.08 in) at 45°
B	40,0 mm (1.57 in)	**D**	35,8 mm (1.41 in)	**F**	1,00 mm (0.04 in) at 45°		





The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Do not lubricate the seal. It is important that the seal is not contaminated by oil or grease and if it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange of the seal.

Support the pulley end of the shaft, ensure that there are no sharp edges on the edge of the shaft and put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearings. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

5 Support the pulley end of the shaft and press the new impeller (A1) onto the shaft until the clearance (A) between the impeller blades and the pump body is 0,69/0,89 mm (0.027/0.035 in). The clearance can be checked with a feeler gauge (C). The minimum clearance with end float is 0,19 mm (0.007 in).

Rotate the shaft to ensure that the impeller is free.

6 Fit the coolant pump to the engine, see Operation 12-12.

Coolant pump (auxiliary)

An auxiliary coolant pump (A) is used on some high rated engines which have a water-to-air intercooler. The pump which is belt driven from the crankshaft pulley, circulates coolant through the intercooler. The pump is fitted to a mounting bracket on the right side of the engine.

Note: A small amount of leakage of coolant across the surface of the face seal in the coolant pump is normal. It's purpose is to provide lubrication for the seal. There is a hole in the coolant pump body to allow coolant to drain. Small amounts of coolant might be seen to leak intermittently from the drain hole during the engine operation cycle.
Signs of a small leakage through the drain hole are not an indication that the pump is faulty. Coolant stains or intermittent drops of coolant from the hole, indicate normal operation of the pump.

To remove and to fit **Operation 12-15**

To remove

1 Drain the cooling system.

2 Release the hose clips and disconnect the hoses from the inlet (A1) and outlet (A3) of the coolant pump.

3 Loosen the two nuts (A5 and A6) at the rear of the pump which secure the coolant pump to the mounting bracket (A4).

4 Push the pump towards the cylinder block and remove the belt (A2) from the pump pulley. Support the pump, remove the two nuts for the mounting bracket and remove the pump from the engine.

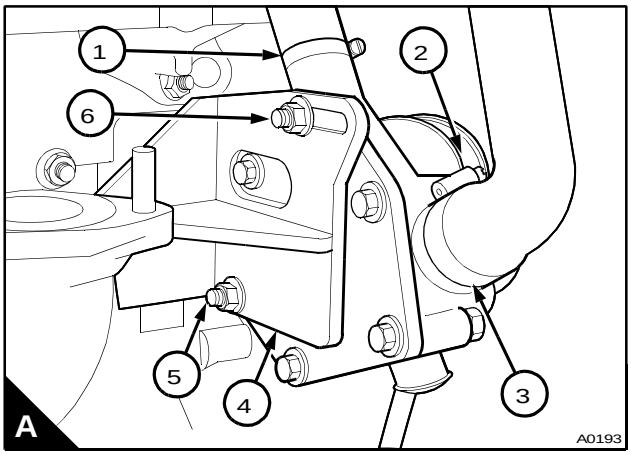
To fit

1 Fit the pump to the mounting bracket and fit loosely the two nuts. Fit the belt to the pump pulley.

2 Check and adjust the belt tension, see Operation 14-2, and fully tighten the two nuts (A5 and A6).

3 Connect the hoses to the inlet and outlet of the coolant pump and tighten the hose clips.

4 Fill the cooling system, start the engine and check for leakage.



To dismantle **Operation 12-16**

1 Mark the relative position of the blanking plate (A7) to the pump body before the plate is removed. This will ensure correct assembly.

2 Remove the four setscrews, nuts and washers which retain the blanking plate to the body of the coolant pump and discard the joint (A9).

3 Remove the nut (A1) and washers (A14) and (A2) which secure the coolant pump pulley (A5) to the shaft (A13).

4 Use a suitable puller (B) and remove the pulley from the shaft.

5 Support the impeller end of the pump and press the shaft, together with the coolant seal (A10) and the impeller (A6) out of the body of the pump.

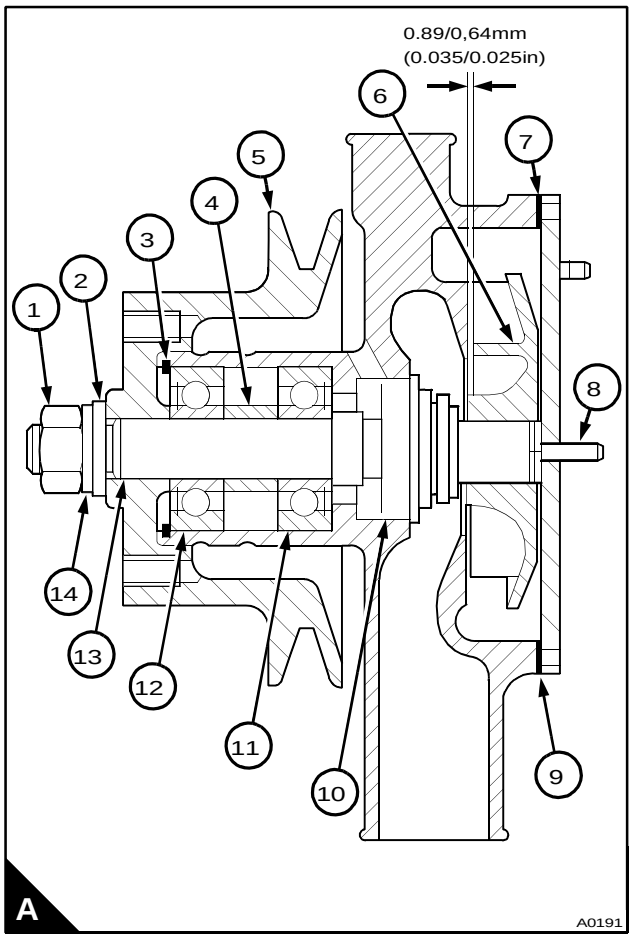
6 Remove the circlip (A3) for the bearing housing.

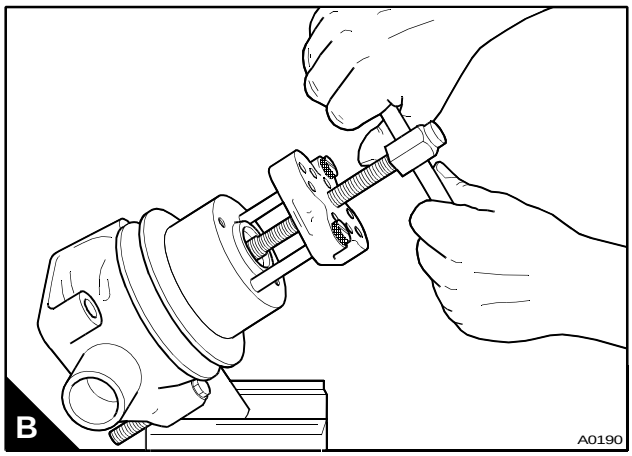
7 Support the pulley end of the pump and press the bearings (A11 and A12) and distance piece (A4) from the pump body. Discard the bearings.

8 Support the impeller and press the shaft from the impeller. Remove and discard the coolant seal.

9 Clean the components of the pump in a suitable safe cleaning fluid and inspect the components as follows:

- Check the coolant pump shaft for wear. If the shaft is worn it must be renewed.
- Check the impeller for cracks and broken blades.
- Inspect the pump body for cracks.





To assemble **Operation 12-17**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

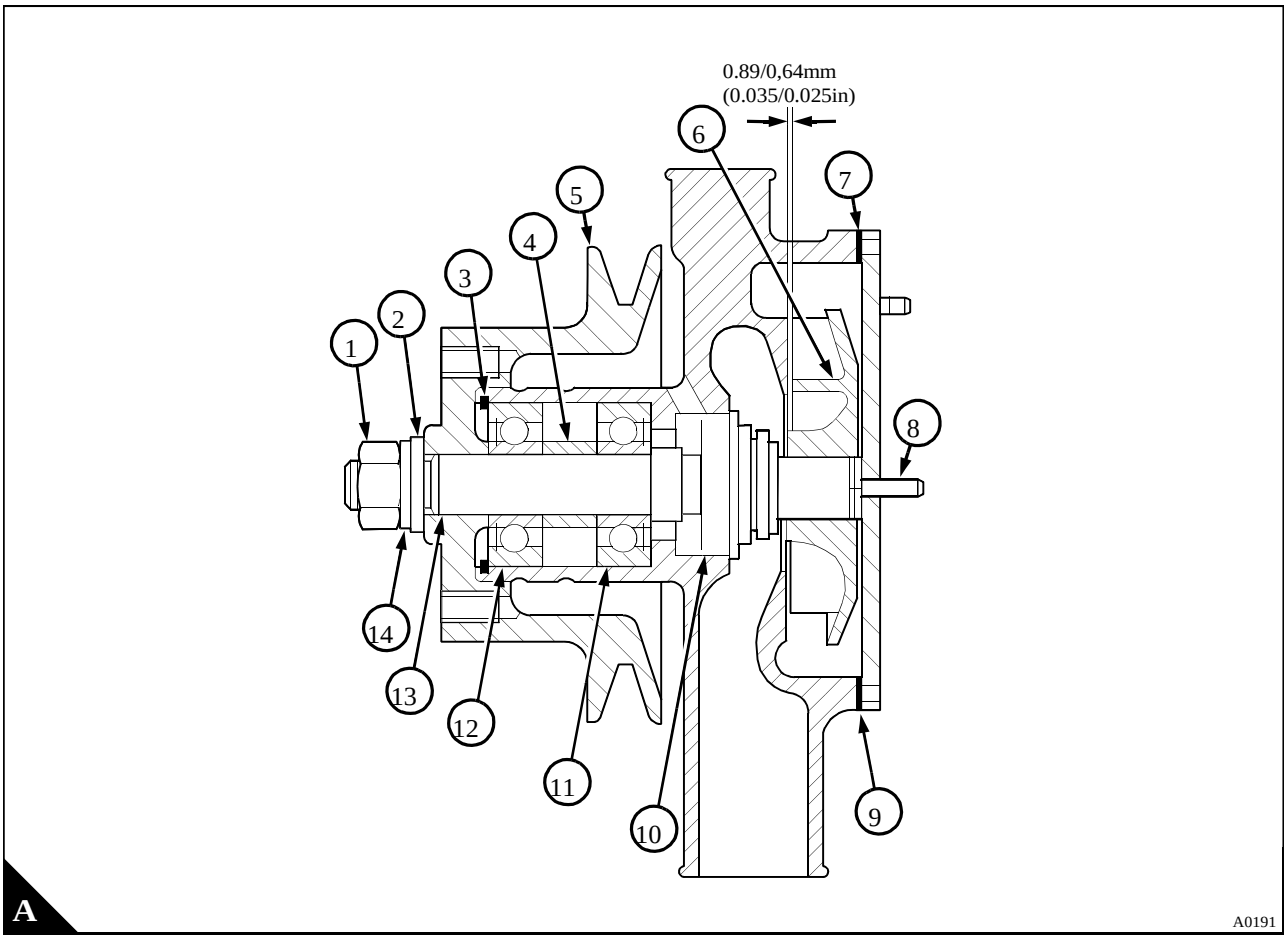
Note: Renew the bearings. Each bearing has a single grease seal.

1 Support the impeller end of the pump body. Apply a narrow ring of POWERPART Retainer (oil tolerant) to the face of the outer bearing. Put a new bearing (A11) in position with its grease seal toward the pump body. Press the bearing into the pump body until the bearing is fully onto the shoulder of the pump body. Ensure the pressure is applied evenly to the inner and outer race. Remove excess retainer and apply high melting point grease to the bearing.

2 Put the spacer (A4) in position. Half fill the bearing housing with high melting point grease.

3 Apply high melting point grease to the other new bearing (A12). Apply a narrow ring of POWERPART Retainer (oil tolerant) to the face of the outer bearing race in the position shown by the arrow head (A12). Put the bearing in position with the grease seal away from the pump body. Apply pressure evenly across the inner and outer races of the bearing and press the bearing into the pump body and onto the spacer. Remove excess retainer and fit the circlip (A3).

4 Support the inner and outer race of the bearing (A12). If the original shaft is used, apply a narrow ring of POWERPART Retainer (oil tolerant) to the inner race of the bearings. Put the shaft (A13) in position with the thread toward the bearings. Press the shaft into the bearings until the shoulder of the shaft is fully onto the bearing.



Continued

5 Fit the setscrews, which will be restricted by the pulley, to the pump flange. Support the impeller end of the shaft and press the pulley onto the shaft.

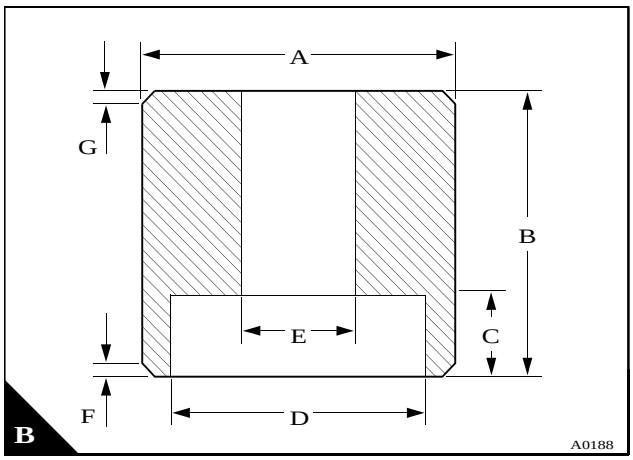
6 Fit a new coolant seal as follows:

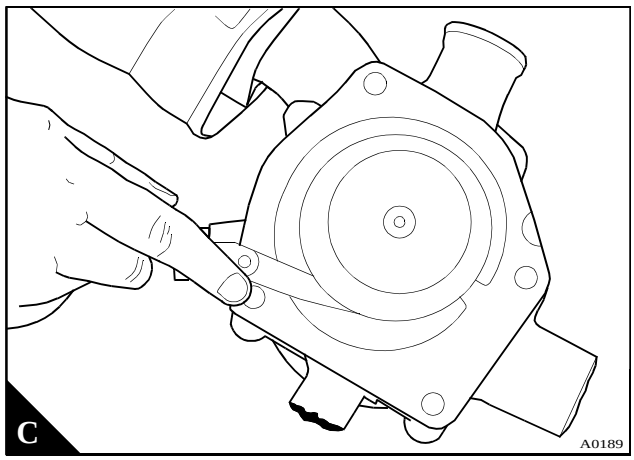
Caution: *It is important that only the tool, shown in (B), is used to fit the new coolant seal.*

Note: The coolant seal is an interference fit on the shaft and a tool will be necessary to fit the seal correctly.

The tool should be made of mild steel bar to the dimensions shown in (B), listed as follows:

A	44,0 mm (1.73 in)	**C**	10,7 mm (0.41 in)	**E**	16,1 mm (0.63 in)	**G**	2,00 mm (0.08 in) at 45°
B	40,0 mm (1.57 in)	**D**	35,8 mm (1.41 in)	**F**	1,00 mm (0.04 in) at 45°		





The dimensions of the tool to fit the coolant seal, will ensure that the seal is the correct length after it is installed. It will also prevent axial distortion of the seal when it is pressed onto the shaft.

Do not lubricate the seal. It is important that the seal is not contaminated by oil or grease. If it is held in the hand, it should be held by the edge of the flange. Do not damage the ring of green sealant applied to the body of the coolant seal just behind the flange of the seal.

Support the pulley end of the shaft, put the seal into position on the end of the shaft. Ensure that the ring of sealant is towards the bearings. Use the tool to press the seal onto the shaft until the bottom of the seal flange is in complete contact with the pump body. Continue to apply force for approximately ten seconds to ensure that the seal remains in position when the force is released.

7 Support the pulley end of the shaft and press the impeller onto the shaft until the clearance (A) between the impeller blades and the pump body is 0,64/0,89 mm (0.025/0.035 in). The clearance can be checked with a feeler gauge (C) Rotate the shaft to ensure that the impeller is free.

8 Put the plain washer (A2) and the spring washer (A14) in position onto the pulley. Fit the nut and tighten it to 82 Nm (60 lbf ft) 8,3kgf m.

9 Renew the joint for the blanking plate and fit the blanking plate to the pump body. Ensure that the mark on the pump body is aligned with the line on the blanking plate and that the two studs (A8) for the adjustment bracket are at the rear of the plate.

Fan

To remove and to fit — Operation 12-18

To remove

1 Release the setscrews and remove the fan.

2 If necessary, fit the setscrews to retain the fan extension and the pulley to the hub.

To fit

1 Clean thoroughly the rear of the fan where it fits onto the fan extension. Also ensure that all paint is removed from this area.

2 Put the pulley into position on the hub and the fan extension onto the pulley. Clean the front face of the fan extension.

3 Fit the fan and tighten the setscrews to the torque given in "Recommended torque settings" on page 58.

Fan drive

To remove and to fit the early pulley — Operation 12-19

To remove

Note: The early fan drive pulley is made from cast iron and is not interchangeable with the latest steel fan drive pulley.

1 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link. Remove the drive belt(s).

2 Release the setscrews and remove the fan. Remove the fan extension, if fitted, and the pulley.

3 Check the end-float of the drive shaft. If it is more than 0,25 mm (0.010 in), the assembly must be renewed.

4 Release the setscrews and remove the fan drive.

To fit

1 Fit the fan drive and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

2 Fit the fan, see Operation 12-18.

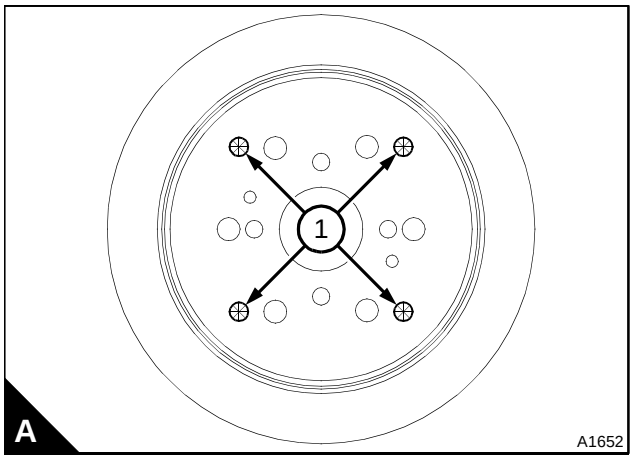
3 Fit the belt(s) and adjust the tension, see Operation 14-2.

Continued

To remove and to fit the latest pulley **Operation 12-20**

To remove

Note: The latest fan drive pulley is made from steel (identified by four spot weld positions) (A1) and is not interchangeable with the early cast iron fan drive pulley.



1 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link. Remove the drive belt(s).

2 Release the setscrews and remove the fan. Remove the fan extension, if fitted, and the pulley.

3 Check the end-float of the drive shaft. If it is more than 0,25 mm (0.010 in), the assembly must be renewed.

4 Release the setscrews and remove the fan drive.

To fit

1 Fit the fan drive and tighten the setscrews to 44 Nm (33 lbf ft) 4,5 kgf m.

2 Fit the fan, see Operation 12-18.

3 Fit the belt(s) and adjust the tension, see Operation 14-2.

Lubricating oil cooler

To remove and to fit (four cylinder turbocharged engines) **Operation 12-21**

To remove

1 Drain the cooling system.

2 Release the support bracket at the cooler (A3).

3 Release the setscrew and nut (A2) which fasten the low-pressure fuel pipes to the top of the cooler.

4 Release the hose clip at the top rear of the cooler (A1).

5 Release the six setscrews (A4) which are fitted below the cover and the setscrew (A4) to the left of the cover. Remove the cooler.

To fit

1 Renew the "O" rings on the inlet connection for the coolant (B3) and the outlet flange for the coolant (B5). Ensure that the joint faces are clean. Renew the joint (B4) for the oil pipe flange.

2 Lightly lubricate the bore of the vent connection (B2) and the "O" ring on the coolant inlet connection with engine lubricating oil.

3 Loosely fit the hose clip to the vent connection.

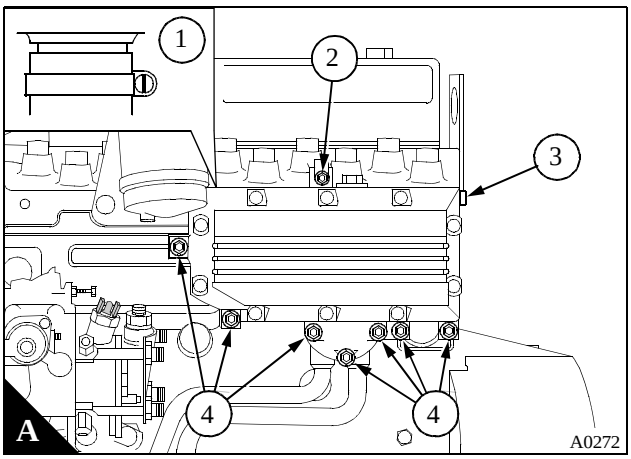
4 Fit the cooler to the engine with the vent (B1) fitted correctly in its connection. Tighten the setscrews and the hose clip of the vent connection.

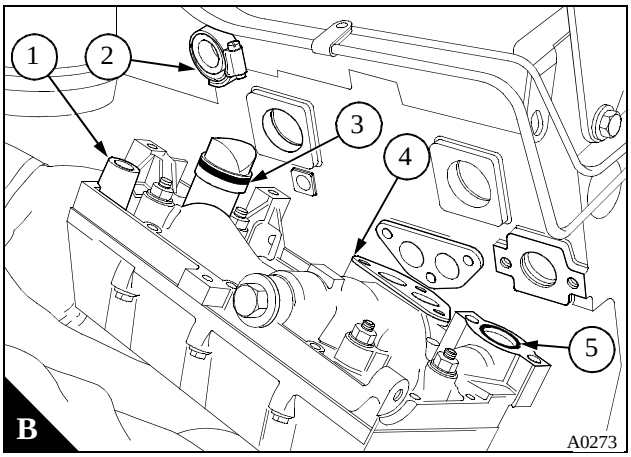
5 Fit and tighten the setscrew of the support bracket.

6 Fit the setscrew and nut which fasten the low-pressure fuel pipes to the top of the oil cooler.

7 Fill the coolant system.

8 Operate the engine and check for leakage of coolant or oil.





To remove and to fit (six cylinder engines) **Operation 12-22**

Some oil coolers fitted to six cylinder engines have a coolant flow baffle fitted (A3). The baffle must always be fitted towards the front of the engine (A1).

To remove

1 Drain the cooling system.

2 Disconnect the lubricating oil pipes at the flange on the cooler cover, see Operation 10-16.

3 Release the setscrews and nuts of the cover of the oil cooler and remove the cover together with the element (A2). Thoroughly clean the flange face of the cover and the cylinder block.

To fit

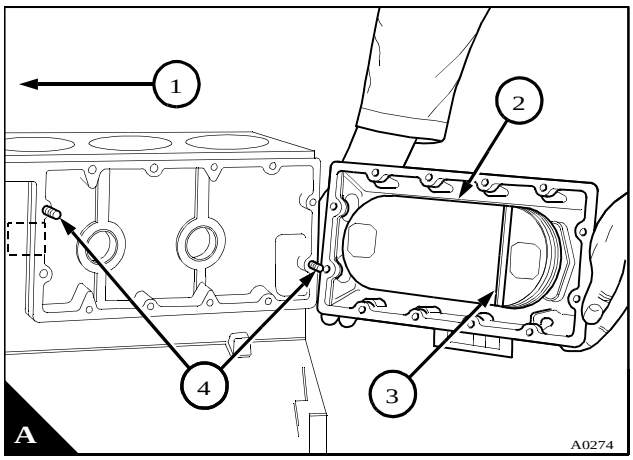
1 If the studs (A4) have been removed and are to be fitted again, clean the threads in the cylinder block and on the studs. Apply a suitable sealant before the studs are fitted to the cylinder block.

2 Apply Loctite 5204 sealant to the flange face of the oil cooler and fit the oil cooler and a new joint to the cylinder block. Tighten the setscrews and nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Fit a new joint and connect the lubricating oil pipes to the flange on the cover, see Operation 10-16.

4 Fill the cooling system.

5 Operate the engine and check for oil or coolant leakage.



To remove (six cylinder turbocharged engines) **Operation 12-23**

Early lubricating oil coolers fitted to six cylinder engines have an aluminium cover, the cooler element may have a baffle (A3) to control coolant flow. The cooler element must be fitted with the baffle toward the front of the engine (A1).

Later lubricating oil coolers fitted to six cylinder engines have a pressed steel cover. The cooler element does not have a baffle.

To remove an early type lubricating oil cooler

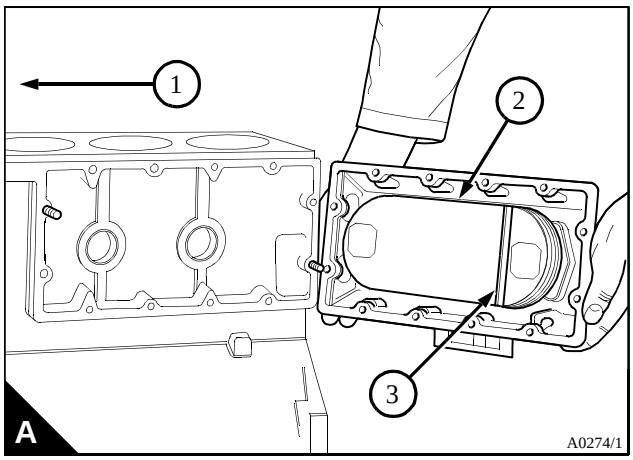
1 Drain the cooling system, refer to the User's Handbook.

Warning! *The engine oil may be hot, allow the engine temperature to cool down before the oil pipes are released.*

2 Put a suitable container under the oil cooler and remove the lubricating oil pipes from the oil cooler, see Operation 10-14.

3 Release the setscrews and nuts of the cover of the oil cooler and remove the cover together with the element (A2). Thoroughly clean the flange face of the cover and the cylinder block.

4 If an overhaul of the oil cooler is necessary, see Operation 12-25.



Continued

To remove a later type lubricating oil cooler

1 Drain the cooling system, refer to the User's Handbook.

Warning! *The engine oil may be hot, allow the engine temperature to cool down before the oil pipes are released.*

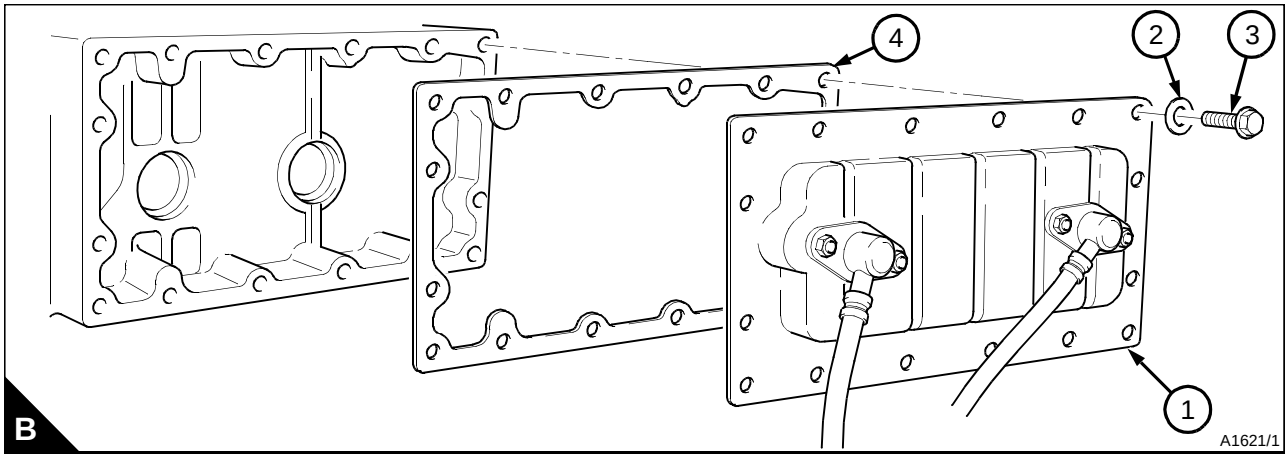
Caution: *Do not remove both of the oil pipes at the same time.*

2 Put a suitable container under the oil cooler and remove the lubricating oil pipes from the oil cooler, see Operation 10-14.

3 Release the setscrews and nuts (A3) of the cover of the oil cooler and remove the cover (A1) together with the element. Thoroughly clean the flange face of the cover and the cylinder block.

Note: A liquid joint may have been used in the factory, this must be removed and a new joint fitted in its place.

4 If an overhaul of the oil cooler is necessary, see Operation 12-25.



To fit (six cylinder turbocharged engines) **Operation 12-24**

To fit an early type lubricating oil cooler or blanking plate

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone rubber sealant	1861108

Early lubricating oil coolers fitted to six cylinder engines have an aluminium cover, the cooler element may have a baffle (A3) to control coolant flow. The cooler element must be fitted with the baffle toward the front of the engine (A1).

1 Thoroughly clean the joint faces of the lubricating oil cooler housing and the cylinder block.

2 Fit a new joint (C2) to the cylinder block (sealant must not be used on the joint).

3 Fit the lubricating oil cooler (C1) to the cylinder block.

4 Tighten the setscrews or nuts in sequence (B) to 28 Nm (20 lbf ft) 2.8 kgf m.

Note: Do not fit sealing washers to the setscrews.

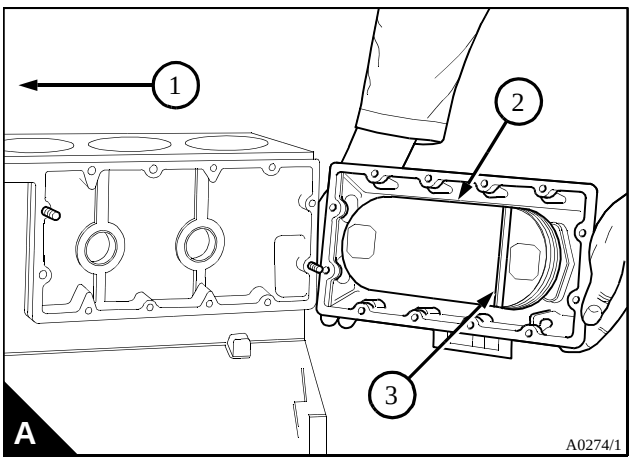
5 Fit the lubricating oil pipes to the cover, see Operation 10-17.

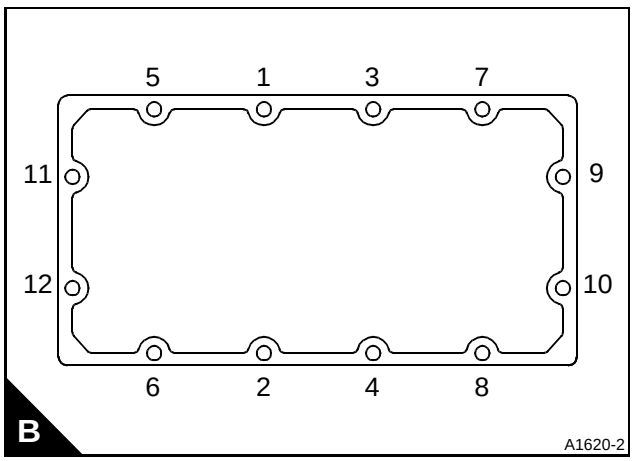
6 Fill the cooling system.

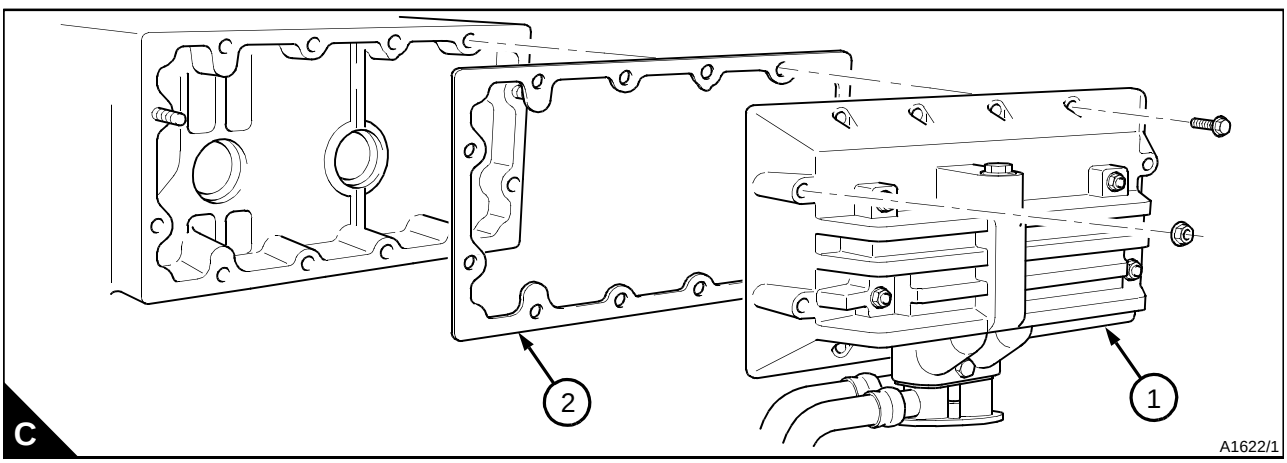
7 Operate the engine and check for oil or coolant leakage.

To fit an aluminium blanking plate

To fit an aluminium blanking plate use the same procedure as above.







To fit a later type lubricating oil cooler or blanking plate

Later lubricating oil coolers fitted to six cylinder engines have a pressed steel cover. The cooler element does not have a baffle.

1 Thoroughly clean the joint faces of the lubricating oil cooler housing and the cylinder block. Thoroughly clean the seating area around the holes for the setscrews on the front face of the lubricating oil cooler.

Note: If damage is found on the seating area around the holes for the setscrews on the front face of the lubricating oil cooler housing, the lubricating oil cooler housing must be renewed.

2 Thoroughly clean the seating face of the heads on all setscrews.

3 Remove any studs from positions 10,11 and 16 on the tightening sequence (D). MEAS coated setscrews must be fitted in these positions to ensure that coolant does not leak. If the setscrews are to be re-used the male and female threads must be cleaned and POWERPART Silicone rubber sealant applied to the first 13 mm (0.5 in) of the setscrews before they are fitted.

4 Fit a new joint (E4) to the cylinder block (sealant must not be used on the joint).

5 Fit the lubricating oil cooler (E1) to the cylinder block, ensure that sealing washers (E2) part number 2415D022 are used on all setscrews (E3).

Note: Sealing washers must not be fitted on any additional studs or spacers.

6 Tighten the setscrews in sequence (D) to 28 Nm (20 lbf ft) 2.8 kgf m.

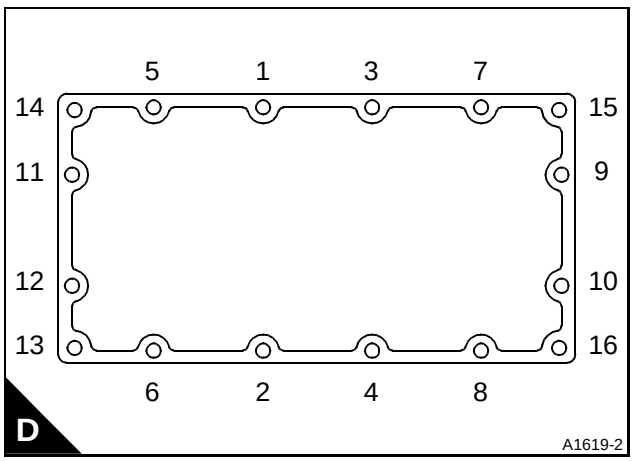
7 Fit the lubricating oil pipes to the cover, see Operation 10-17.

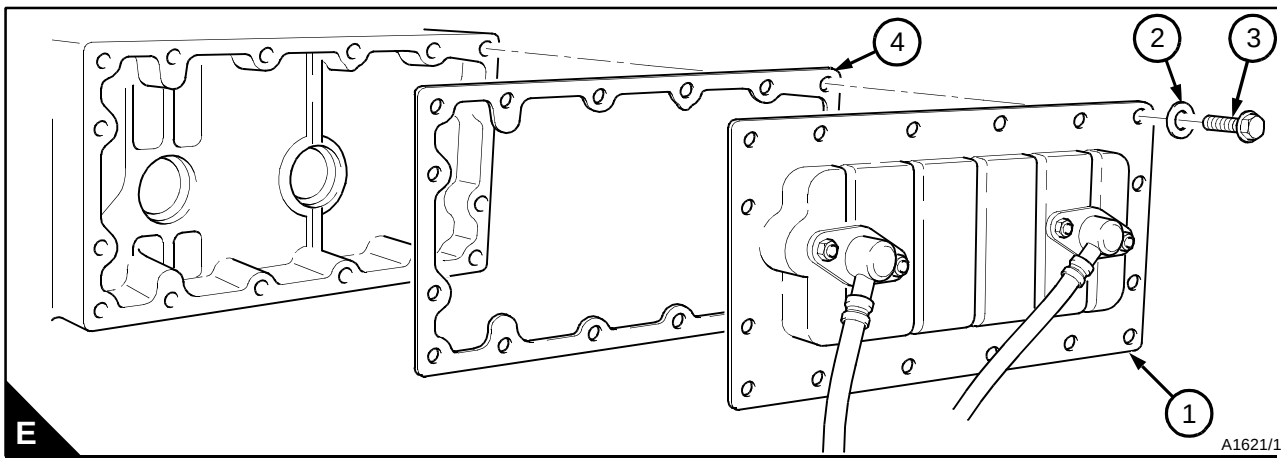
8 Fill the cooling system.

9 Operate the engine and check for oil or coolant leakage.

To fit a steel blanking plate

To fit a steel blanking plate use the same procedure as above.





To dismantle and to assemble - six cylinder engines **Operation 12-25**

To dismantle an early type lubricating oil cooler

1 Remove the lubricating oil cooler, see Operation 12-23.

2 Release the nuts on the front of the cover and remove the element of the oil cooler (A).

Warning! *Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.*

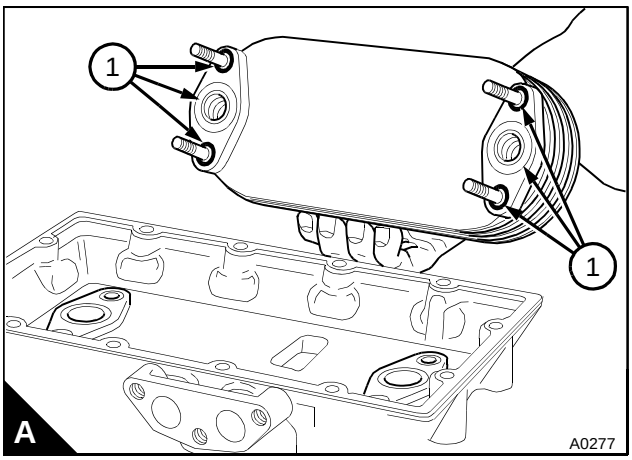
3 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, use a solvent which is suitable for copper. Dry the element with low pressure air and then flush it with clean engine lubricating oil.

To assemble an early type lubricating oil cooler

1 Renew the "O" rings (A1) on the flanges of the element.

Caution: *Some oil coolers fitted to six cylinder engines have a baffle to control coolant flow. The cooler element must be fitted with the baffle towards the front of the engine.*

2 Fit the element of the oil cooler to the cover and tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.



To dismantle a later type lubricating oil cooler

1 Remove the oil cooler from the cylinder block, see Operation 12-24.

2 Put the oil cooler assembly on a clean work surface. Release the four nuts that retain the flanges for the lubricating oil pipes. The pipe flanges are in two pieces.

3 Remove the cover (B1) from the four studs (B2) of the oil cooler element (B3).

Warning! *Do not allow compressed air to contact your skin. If compressed air enters your skin, obtain medical help immediately.*

4 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, use a solvent which is suitable for copper. Dry the element with low pressure air and then flush it with clean engine lubricating oil.

To assemble a later type lubricating oil cooler

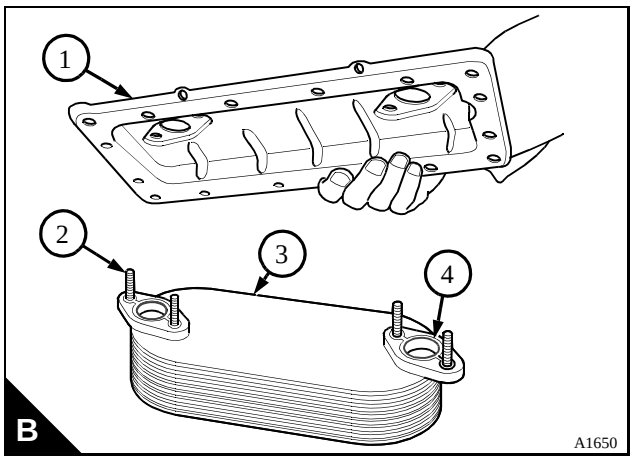
Clean the flange face and the seats for the three-piece “O” rings.

1 Fit new "O" rings (B4).

2 Fit the cover of the oil cooler to the element (B1).

3 Fit the two-piece flanges onto the studs (B2). Tighten the nuts to retain the element when the oil cooler assembly is fitted to the engine.

4 Fit the oil cooler to the cylinder block, see Operation 12-24.



To dismantle and to assemble (six cylinder turbocharged engines) **Operation 12-26**

Some oil coolers fitted to six cylinder engines have a coolant flow baffle fitted (A2). The baffle must always be fitted towards the front of the engine (A1).

To dismantle

1 Remove the oil cooler, see Operation 12-22.

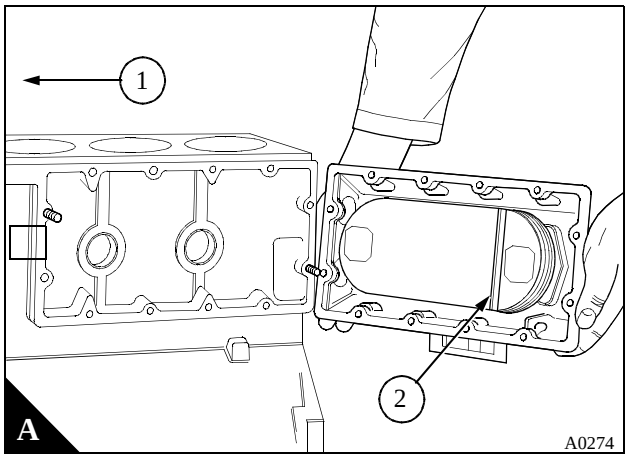
2 Release the nuts on the front of the cover and remove the element of the oil cooler (B).

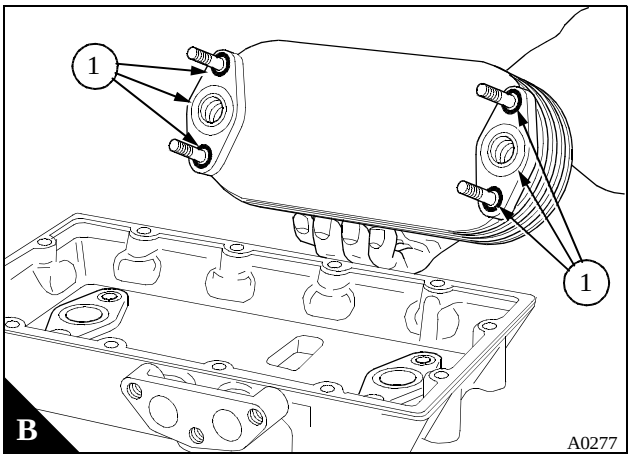
3 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, use a solvent which is suitable for copper. Dry the element with low pressure air and then flush it with clean engine lubricating oil.

To assemble

1 Renew the "O" rings (B1) on the flanges of the element.

2 Fit the element of the oil cooler to the cover and tighten the nuts to 22 Nm (16 lbf ft) 2,2 kgf m.





To remove and to fit vertical canister type — **Operation 12-27**

To remove

1 Remove the canister of the lubricating oil filter.

2 Drain the cooling system.

3 Release the hose clips of the coolant pipes at the oil cooler. Release the threaded adaptor (A4) from the lubricating oil cooler and pull the oil cooler (A3) from the hose connections.

To fit

1 Clean the filter head.

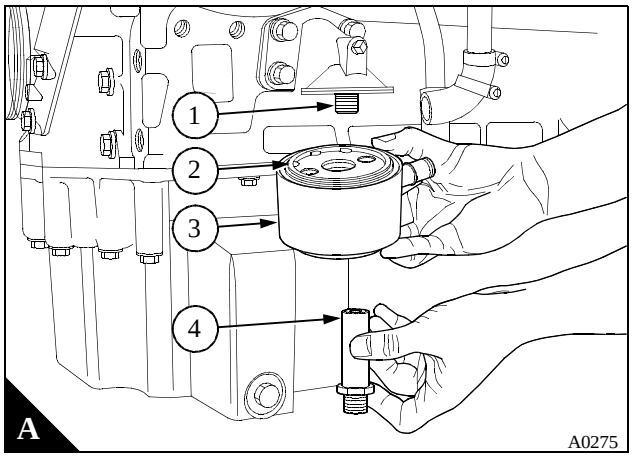
2 Ensure that the adaptor (A1) is secure in the filter head.

3 Check the seal (A2) on top of the oil cooler for damage and renew the seal if necessary. Lightly lubricate the seal with clean lubricating oil.

4 Push the hose connections for the coolant pipes onto the lubricating oil cooler. Hold the oil cooler (A3) in position against the filter head and fit the threaded adaptor (A4). Tighten the threaded adaptor to 37 Nm (27 lbf ft) 3,8 kgf m. Ensure that the hose connections are fitted correctly and tighten the hose clips.

5 Clean the bottom face of the oil cooler. Fit a new oil filter canister, see Operation 10-1.

6 Fill the cooling system.



To remove and to fit horizontal canister type **Operation 12-28**

To remove

1 Drain the cooling system.

2 Release the hose clips of the coolant pipes at the oil cooler (A3). Release the threaded adaptor (A5) from the lubricating oil cooler and pull the oil cooler (A6) from the hose connections and the filter head (A1).

To fit

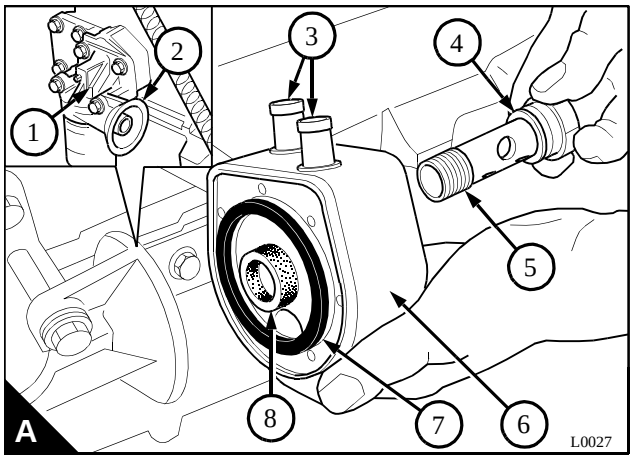
1 Clean the joint face of the filter head (A2).

2 Check the washer (A4) and the seals (A7 and A8) for damage. Renew the washer and the seals if they are damaged or worn. Lightly lubricate the seals with clean lubricating oil.

3 Push the hose connections for the coolant pipes onto the lubricating oil cooler. Hold the oil cooler in position against the filter head and fit the threaded adaptor. Tighten the threaded adaptor to 57 Nm (42 lbf ft) 5,8 kgf m. Ensure that the hose connections are fitted correctly and tighten the hose clips.

4 Fill the cooling system.

5 Operate the engine and check for leakage of coolant or oil.



Cooler by-pass valve

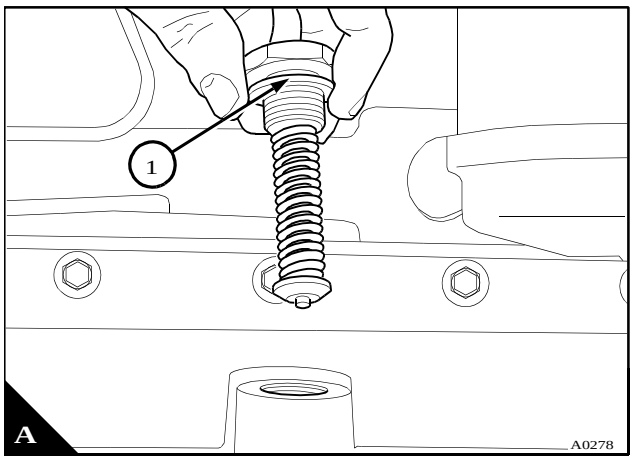
To remove and to fit **Operation 12-29**

1 Release the hexagonal cap and remove the by-pass valve (A).

2 Check the valve spring and the seat for damage and renew the complete assembly, as necessary.

3 Renew the aluminium washer (A1). Fit the by-pass valve into the oil cooler and tighten the cap to 50 Nm (37 lbf ft) 5,1 kgf m.

Note: The by-pass valve is not fitted to the latest oil cooler fitted to most four cylinder engines.



Intercooler

A water-to-air intercooler assembly (A1) is fitted to the induction manifold of some four and six cylinder engines to cool the air between the turbocharger and the combustion chamber. Hot air from the turbocharger passes through the casing of the intercooler and over the fins on the integral tube stack before it enters the combustion chamber. The air is cooled by the coolant which passes through the tubes of the tube stack. The coolant is circulated from the front of cylinder head, through the tube stack to the rear of the cylinder block by the coolant pump for the engine.

In addition to the engine coolant pump, certain engines have an auxiliary coolant pump mounted onto the right hand side of the cylinder block. The auxiliary pump circulates coolant directly from the radiator to the tube stack of the intercooler (A1). The coolant leaves the intercooler and is returned to the radiator.

The intercooler cannot be dismantled.

To remove **Operation 12-30**

Caution: *Do not damage the fins of the tube stack.*

To remove

1 Release the hose clips (A9) and (A10) which fasten the air hose from the turbocharger to the intercooler and slide the hose up the intercooler pipe.

2 Release the hose clips which fasten the hoses to the coolant inlet (A6) and the outlet (A5) connections of the tube stack and remove the hoses.

3 Remove the two setscrews (A4) which secure the flange (A3) and the "O" ring (A2) to the outlet of the tube stack. Remove the flange and discard the "O" ring.

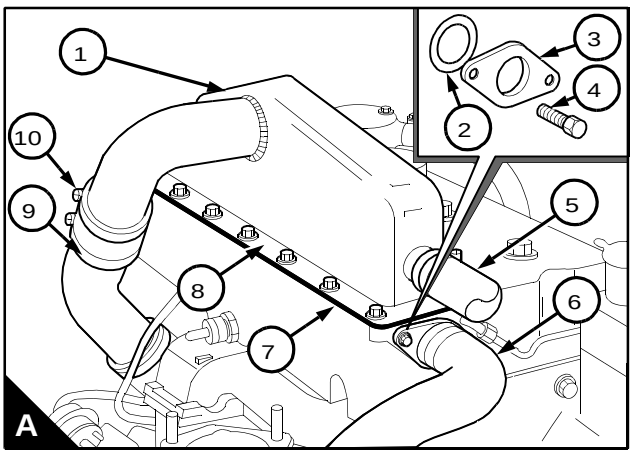
Caution: *Do not use a lever between the face of the flange (A8) to separate the intercooler assembly from the induction manifold.*

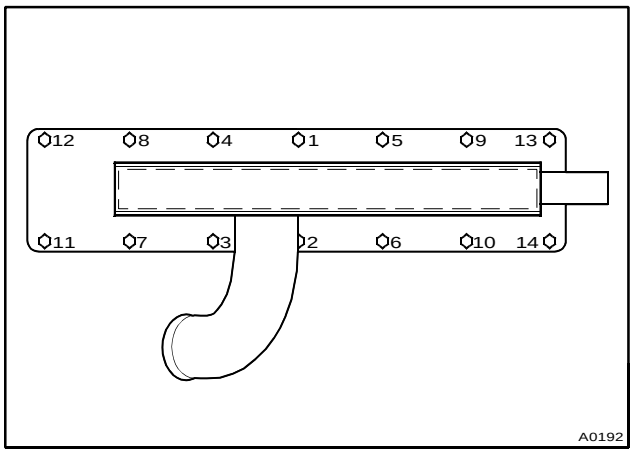
4 Release the 14 setscrews which secure the intercooler assembly to the induction manifold, in the reverse sequence to that shown in (A).

Caution: *Do not use force to remove the outlet pipe of the tube stack from the induction manifold.*

5 Carefully lift the intercooler assembly enough to allow movement of the intercooler toward the rear of the engine. This will allow clearance of the pipe connection (A6) from the induction manifold. When the pipe is free of the manifold remove the intercooler assembly and discard the joint (A7).

6 Clean and inspect the intercooler assembly, see Operation 12-32.





To fit **Operation 12-31**

1 Renew the joint (A7) between the flange face of the intercooler and the induction manifold. The joint is fitted dry.

Caution: *Do not use force to fit the outlet pipe of the tube stack into the induction manifold.*

2 Carefully lift the intercooler into the induction manifold. Do not damage the inlet pipe of the tube stack which must be put into position carefully to allow entry into the manifold.

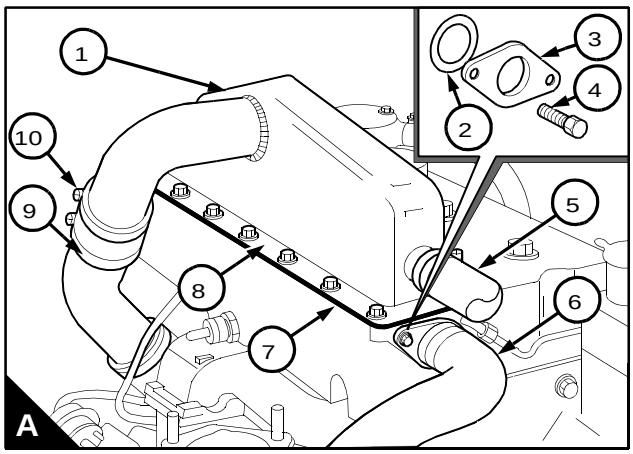
3 Fit the 14 setscrews which secure the intercooler assembly to the induction manifold and apply a torque tension of 22 Nm (16 lb ft) 2,2 kgf m to the fasteners in the sequence shown in (A).

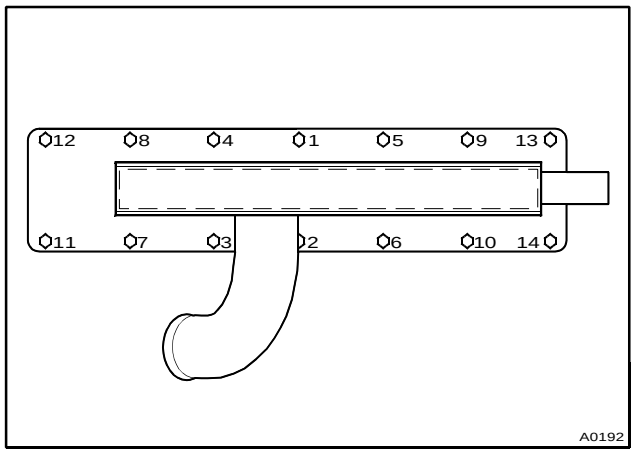
4 Fit a new "O" ring (A2) into the flange. Fit the flange (A3) with the two setscrews (A4) onto the outlet pipe (A6) of the tube stack. Tighten the flange to the manifold and apply a torque tension of 7 Nm (5 lbf ft) 0,7 kgf m.

5 Fit the inlet and the outlet hoses for the tube stack and fasten the hose clips.

6 Fit the air hose from the turbocharger to the intercooler assembly and tighten the hose clips (A9) and (A10).

7 Operate the engine and check for coolant and air leaks.





To clean

Caution: *Do not clean the tube stack in a caustic cleaning solution.*

1 Thoroughly clean the intercooler body its flange and the flange of the induction manifold with an approved detergent solution.

Warning! *Do not allow compressed air to contact your skin, if compressed air enters your skin obtain medical help immediately.*

2 Soak the fins of the tube stack in an approved detergent degreasing fluid. Allow the excess fluid to drain off and dry the fins with low pressure compressed air.

3 Flush the tube stack with clean coolant through the outlet connection, in the opposite direction of flow.

To inspect

1 Inspect the casing of the intercooler for cracks or distortion, especially the flange faces which must be flat to prevent leakage of air.

2 Inspect the tube stack for signs of coolant leakage. Also inspect the tube stack for damage to the fins, the hose connections, and for cracks. If the tube stack is damaged or restricted it must be renewed.

13

Flywheel and housing

General description

The steel flywheel is fitted with a hardened starter ring. Generally the starter rings have 126 teeth, but certain starter rings have 132 teeth.

The flywheel housing is normally made of cast iron, but certain flywheel housings are made of aluminium alloy.

Flywheel

To remove and to fit **Operation 13-1**

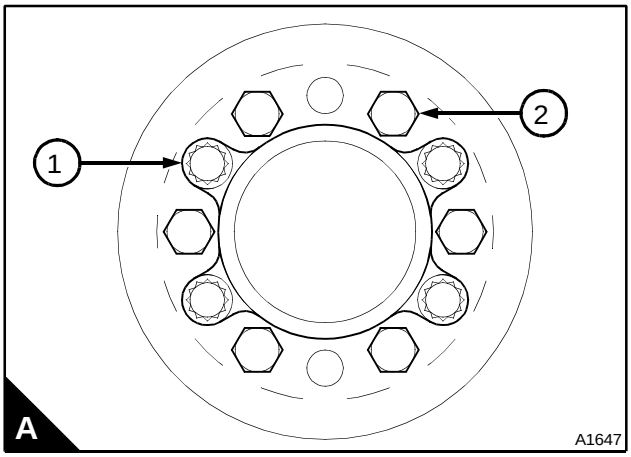
Warning! *The flywheel is heavy, use lift equipment or get help to assist with the lift operation before removal of the flywheel fasteners.*

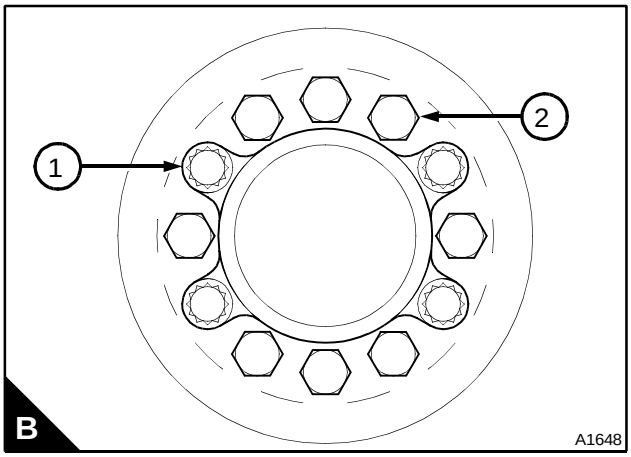
To remove

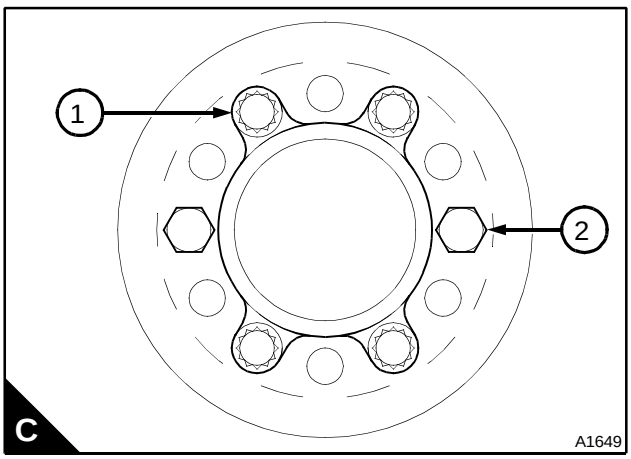
1 Remove two opposite setscrews from the flywheel and fit temporarily two guide studs to ensure safety when the flywheel is removed and fitted.

Notes:

- From engine number A.....U774811B (four cylinder engines) for automotive applications and generator sets have the fly wheel fastened to the crankshaft by ten setscrews. The setscrews must be fitted as shown in (A2). Other applications will have the flywheel fastened by six setscrews (C2). If a housing is used for a pilot bearing, the housing should be fitted as shown in (A1) if ten setscrews are used to retain the flywheel, or as shown in (C1) if six setscrews are used to retain the flywheel.
- From engine number Y.....U634271B (six cylinder engines), the flywheel is fastened to the crankshaft by either 12 setscrews (B2), ten setsrews (A2), or six setscrews (C2) in accordance with the power rating. If a housing is used for a pilot bearing, the housing should be fitted as shown in (B1) if 12 or ten setscrews are used to retain the flywheel, or as shown in (C1) if six setscrews are used to retain the flywheel.







2 Remove the remainder of the setscrews and washers and remove the flywheel.

3 Check the flywheel and ring gear for damage and renew, if necessary.

Continued

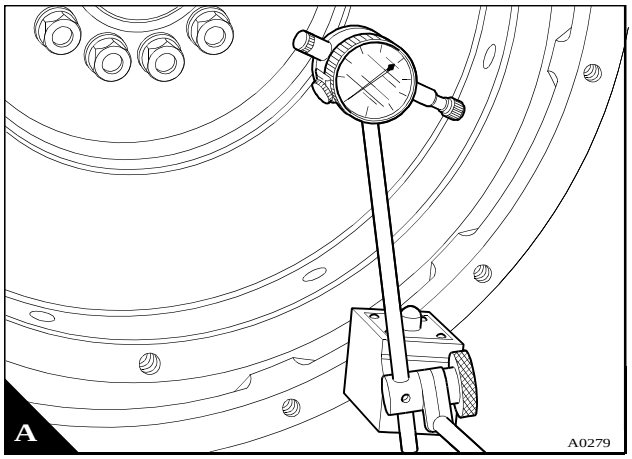
To fit

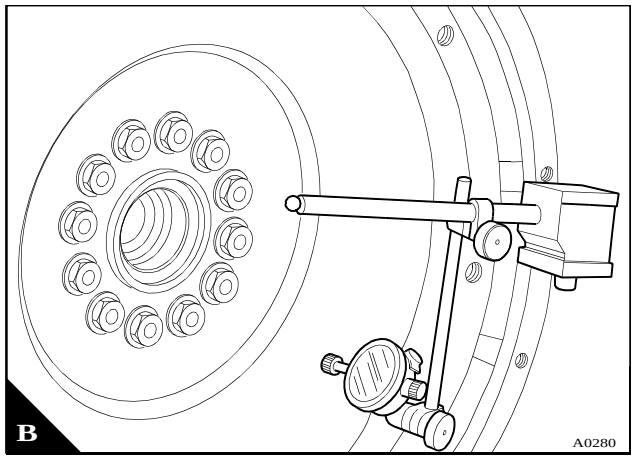
1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.

2 Fit the flywheel over the guide studs. Fit four setscrews and their washers. Remove the guide studs and fit the remainder of the setscrews and the washers. Tighten the setscrews to 105 Nm (77 lbf ft) 10,7 kgf m.

3 Check the flywheel run-out with a dial test indicator (A). This must be less than 0,30 mm (0.012 in) total indicator reading.

4 Check the alignment of the flywheel face (B). The error in alignment must not be more than 0,03 mm (0.001 in) total indicator reading for every 25 mm (1.0 in) of the flywheel radius from the crankshaft axis to the indicator plunger. During this check, keep the crankshaft pressed toward the front to remove the effect of crankshaft end-float.





Ring gear

To remove and to fit **Operation 13-2**

To remove

Warning! *Wear eye protection during this operation.*

Before the ring gear is removed, check the position of the chamfer on the teeth.To remove the ring gear use a hammer and a chisel to break the ring. Ensure that the flywheel is not damaged during this operation.

To fit

The ring gear is heated onto the flywheel. When a new gear is to be fitted, ensure that it is not heated to more than 250 °C (480 °F). Ensure that the chamfer on the teeth of the gear is in the correct direction.

Flywheel housing

To remove and to fit **Operation 13-3**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant and pipe sealant primer	21820122

Warning! *The flywheel housing is heavy, use lift equipment or get help to assist with the lift operation before removal of the flywheel housing fasteners.*

To remove

1 Remove the starter motor, see Operation 14-6, and the flywheel, see Operation 13-1.

2 Release the housing setscrews and with a soft face hammer, hit carefully the housing to remove it from the dowels.

To fit

Note: On oil filled flywheel housing the setscrews have a sealant applied by the manufacturer to the first 13,0mm (0.50 in) of the threads. If the setscrews are removed, sealant must be removed from the male and female threads and new sealant POWERPART Pipe sealant and pipe sealant primer, must be applied to the new setscrews before they are fitted.

1 Ensure that the rear face of the cylinder block and the faces of the housing are clean and free from damage. Ensure that the location dowels are fitted correctly. If a felt seal is fitted to the rear flange of the sump, renew the seal.

2 Fit the housing onto the dowels and tighten lightly the setscrews.

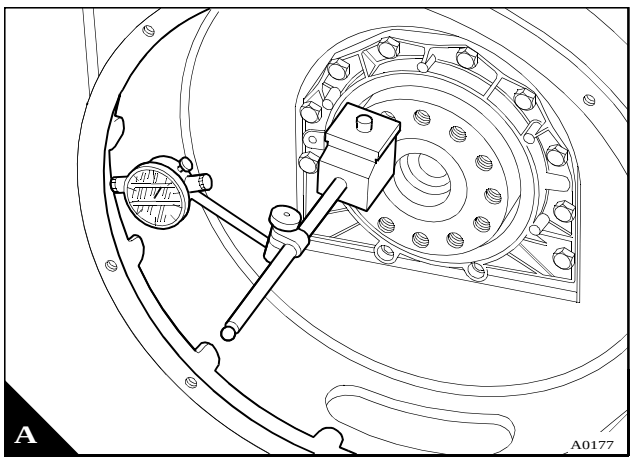
3 Check the housing concentricity with a dial test indicator (A). The run-out limit is given in the relevant Data and dimensions for the "Flywheel and flywheel housing" on page 54. If any adjustment is necessary, it must be made on the housing and the concentricity checked again.

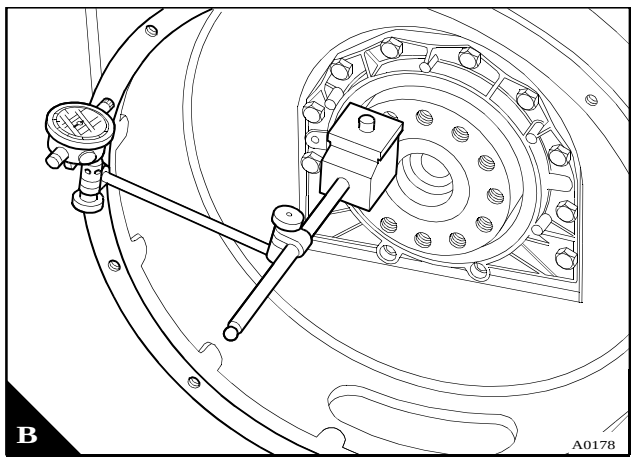
4 Tighten the setscrews to the torque recommended given in "Recommended torque settings" on page 58.

5 Check the housing alignment (B). The maximum tolerance is given in the relevant Data and dimensions for the "Flywheel and flywheel housing" on page 54.

Note: Any necessary adjustment must be made on the housing and not on the cylinder block.

6 Fit the flywheel, see Operation 13-1, and the starter motor, see Operation 14-6.





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14

Electrical equipment

Alternators

General description

The alternator is driven from the crankshaft pulley by single or double belt(s).

The CAV AC5RA or AC5RS and the Lucas A127 alternators have solid state regulators fitted at the rear. The regulator of the Lucas A127 alternator includes the brush box as a part of the unit. The regulators of both alternators are sealed and repair is not possible.

Precautions

To prevent damage to the diodes and to the resistors, the precautions given below must be followed:

- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.
- Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.
- Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct electrical wire must be connected to the correct terminal. A short circuit or wrong connection which gives reverse polarity will immediately cause permanent damage to the diodes and to the transistors.
- Do not connect a battery into the system until it has been checked for correct polarity and voltage.
- Do not check for current flow with a spark contact as damage can be caused to the transistors.

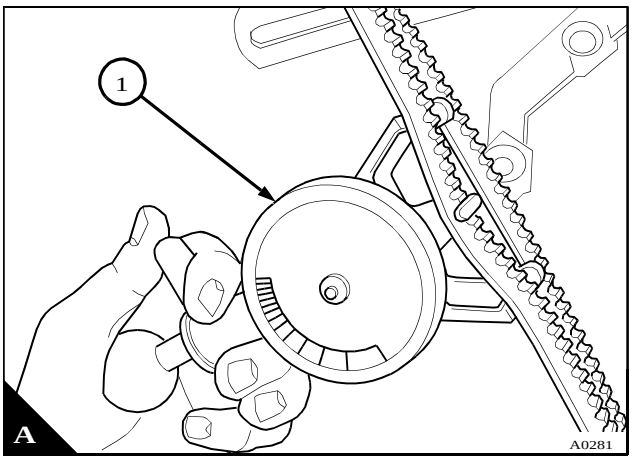
To check the drive belts **Operation 14-1**

1 Check the belt(s) for wear and damage and renew the belt(s), if necessary. If twin belts are fitted, they should both be renewed.

2 Check the belt tension. If twin belts are fitted, check/adjust the tension on the tighter belt. To ensure maximum belt life, it is recommended that a belt tension gauge is used.

3 Fit the gauge (A1) at the centre of the longest free length and check the tension. If a Burroughs gauge is used, the correct tension is 355 N (80 lbf) 36 kgf. If the tension is equal to or less than 220 N (50 lbf) 22 kgf, adjust it to 355 N (80 lbf) 36 kgf, see Operation 14-2.

If no gauge is available, press down the belt with the thumb at the centre of the longest free length and check the deflection (B). With moderate thumb pressure, 45 N (10 lbf) 4,5 kgf, the correct belt deflection is 10 mm ($^3/_8$ in).

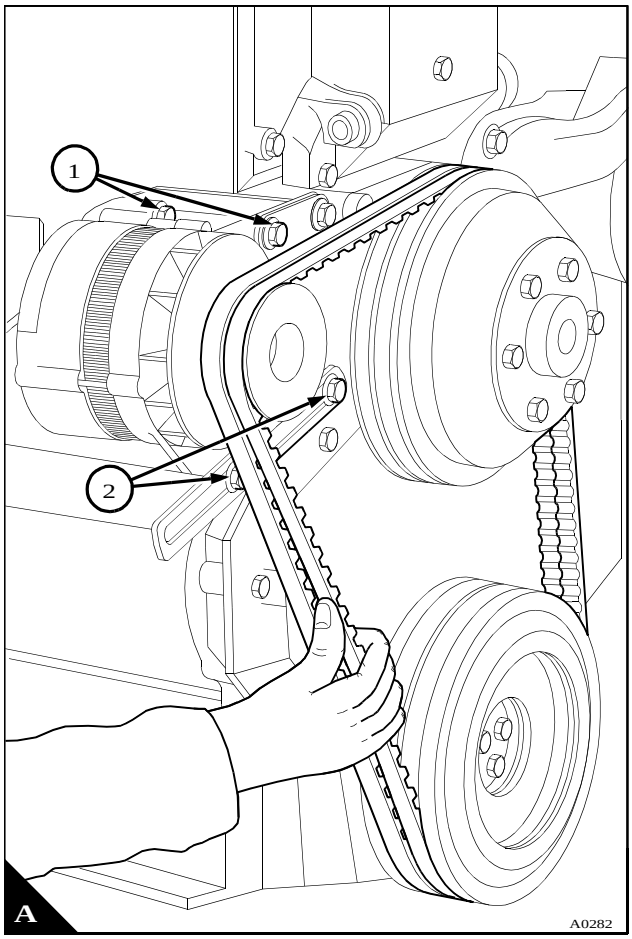


To adjust belt tension **Operation 14-2**

1 Loosen the pivot fasteners (A1) of the alternator and the fasteners of the adjustment link (A2).

2 Change the position of the alternator to give the correct tension, see Operation 14-2. Tighten the adjustment link fasteners and then the pivot link fasteners. If there are two pivot fasteners, tighten the front fastener and then the rear fastener.

3 Check the belt tension again to ensure that it is still correct.



To remove and to fit the drive belts **Operation 14-3**

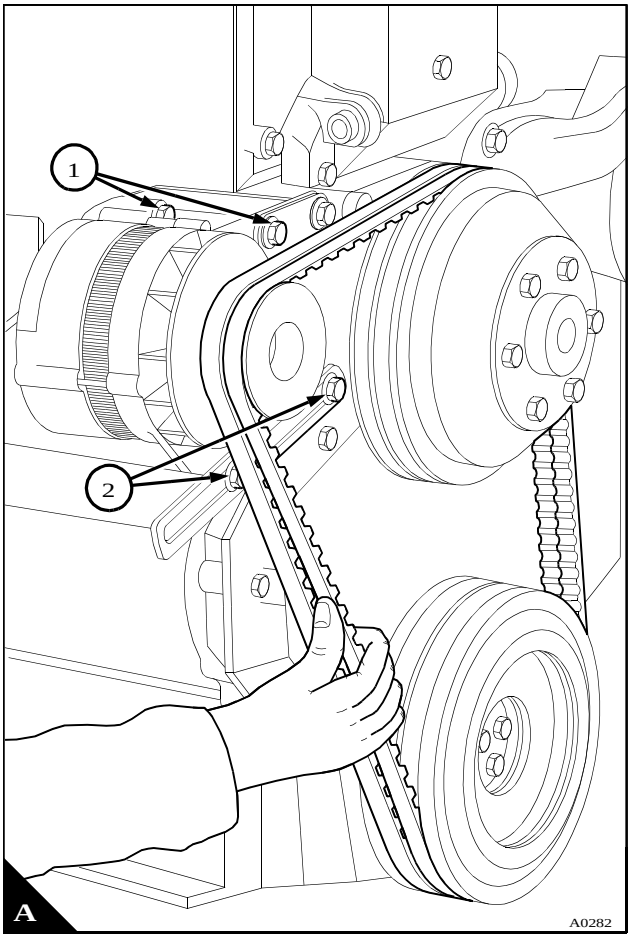
1 Where twin belts are fitted, they are supplied as a set and must be renewed as a set.

2 Loosen the pivot fasteners (A1) of the alternator and the adjustment link fasteners (A2).

3 Release all of the tension from the belt(s) and remove the belt(s).

4 Fit the new belt(s) and adjust the tension, see Operation 14-3 and Operation 14-2.

Note: The belt tension must be checked again after the first 1000 km (600 miles) or 20 hours of operation.



To remove and to fit the alternator **Operation 14-4**

To remove

1 Disconnect the electrical connection.

2 Loosen the pivot fasteners of the alternator and the fasteners of the adjustment link.

3 Release all the belt tension and remove the belt(s).

4 Remove the adjustment link from the alternator and remove the pivot bolt(s). Make a note of the position of the washers and distance pieces to ensure that they are fitted correctly. Remove the alternator.

To fit

1 Put the alternator in position and assemble loosely the pivot fasteners and the adjustment link and its fasteners. Ensure that the washers and the distance pieces are fitted in their correct positions and that the alternator pulley is aligned to the crankshaft pulley within +/- 2,4 mm ($^{3}/_{32}$ in).

2 Fit the drive belt(s) and adjust the drive belt tension, see Operation 14-3 and Operation 14-2. Tighten the fasteners and check the tension again.

3 Connect the electrical connection.

To maintain the alternator **Operation 14-5**

1 Ensure that the drive belts are not worn and that the belt tension is correct.

2 Keep the alternator clean. To clean the alternator, use a material which is damp with kerosene or a special fluid used for this purpose. Ensure that the fluid does not enter the cover of the alternator.

3 Ensure that air can pass easily over the casing to keep it cool.

Alternator fault diagnosis

The alternator is designed in such a way that a flow of current (indicated by no light at the warning light or a reading shown on an ammeter) shows that the system is in correct operation. If the system is in correct operation, no open circuit, voltage or current output checks need to be done on the installation unless:

- The warning light does not show when the alternator is stationary and the switch is in the "on" position or it shows a light when the alternator is in operation.
- No charge current is shown on the ammeter.
- The battery is discharged.
- The battery is hotter than normal which is an indication of loss of voltage control.

If one or more of the above symptoms occur, the procedure indicated below should be applied.

1 Ensure that the battery is fully charged.

2 Connect a moving-coil voltmeter of good quality, with a range of 0-50 volts, across the positive and negative terminals of the alternator. If an ammeter is not fitted in the electrical circuit, fit a moving-coil ammeter of good quality, with a range of 0-100 ampere, in the wire between the alternator and the positive terminal of the battery.

3 Turn the warning light switch to the "on" position (main switch on instrument panel); the warning light should be illuminated.

4 Switch on a 10-15 ampere load, for example, lights, fans, etc.

5 Start the engine and operate it at a fast idle speed; either the warning light should be extinguished or the ammeter indicates a small change in the current in relationship to the engine speed.

6 Increase the engine speed for a moment to near maximum speed, when the charge current should be approximately equal to the rating for the alternator, as shown in the relevant Data and dimensions for "Alternators" on page 55.

7 Operate the alternator at approximately half speed (engine speed approximately 1500 rev/min) and remove the electrical load. The voltage should go up to 14 volts for a 12 volt system or 28 volts for a 24 volt system and then remain constant. At the same time the current reading should show a reduction.

Any change in the above data can indicate a fault and the procedure that follows should be used before any components are disconnected. This procedure is not suitable for A127 alternators and, if a fault is found, the alternator should be removed for test by a specialist.

The regulator is a sealed unit and a repair is not possible. If there is a regulator fault, the regulator must be renewed.

If the warning light is not illuminated when the switch is in the "on" position:

Check the bulb. If no fault:

Check all the connections at the regulator, at the alternator and at the battery.

If no fault:

Turn the switch to the "off" position. Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position.

If the warning light shows, the fault is in the regulator.

If the warning light does not show, the fault is in the alternator.

If the warning light continues to show and the ammeter shows no output when the alternator is in operation:

Check all the connections at the regulator, alternator and battery.

If no fault:

Turn the switch to the "off" position. Disconnect the wire from the "F" terminal on the alternator and connect a wire between the "F" terminal and the negative terminal on the alternator. Turn the switch to the "on" position and operate the engine at fast idle.

If there is no output, there is a fault in the alternator.

If there is an output, there is a fault in the regulator.

If the warning light continues to show when the alternator is in operation and the ammeter shows a reduced output with maximum output only at maximum engine speed or, if the warning light does not show, but there is a reduced output from the alternator with maximum output only at maximum engine speed:

There is a fault in the alternator.

If there is an intermittent light from the warning light and the ammeter needle is not stationary when the battery is charged fully and no load is applied:

Check for a higher than normal resistance in the negative control wire of the regulator.

If the resistance is normal, there is a fault in the regulator.

If the battery charge is too high and the ammeter indicates high or maximum output at all times:

Check the positive control wire and its connection at the regulator.

If the wire and its connection are correct, there is a fault in the regulator.

Starter motors

General description

The Lucas M127 starter motor is operated by a solenoid and has a five roller clutch. The solenoid engages the starter drive in two operations to ensure that the motor gets its maximum torque only when the starter motor is engaged fully with the flywheel. The clutch prevents rotation of the armature at high speed if the starter is held in the engaged position.

The CAV CA45 or S115 starter motor has a smooth surface with no protrusions. This is because the solenoid and the main switch assemblies are inside the drive end cover around (co-axially with) the armature shaft. The main feature of the co-axial starter is that only the pinion assembly moves axially to engage the engine flywheel. There is no axial movement of the whole armature as with the axial type motor. To ensure smooth engagement of the pinion, full load is not applied until the pinion is completely engaged with the flywheel.

To remove and to fit **Operation 14-6**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Silicone RTV sealing and jointing compound	1861108

To remove

If the engine has a flywheel housing which is oil filled, drain the flywheel housing before the starter motor is removed.

1 Disconnect the battery.

2 Disconnect the starter motor cables.

3 Release the fasteners and remove the starter motor and, if necessary, the distance piece.

To fit

1 If necessary, put the distance piece in position with its location lip to the flywheel housing. Fit the starter motor and tighten the fasteners.

2 Connect the starter motor cables. If the engine has a flywheel housing which is oil filled, the starter motor must be sealed before it is fitted. Clean the flange face of the starter motor and the face of the flywheel housing. Apply a 2,0 mm (0.080 in) continuous bead of POWERPART Silicone RTV sealing and jointing compound to the flange face of the starter motor near to the spigot.

3 Connect the battery.

To maintain the brush gear and the commutator **Operation 14-7**

CA45G or S115 starter motors

Inspect the brushes at intervals to ensure that they are free in their guides and that the wire connections are free to move. To check this, lift the spring from the brush and pull carefully on the flexible connections. If the brush does not move freely, remove it from its holder and clean the sides with a material which is damp with gasolene.

Ensure that the brushes are fitted in their original positions to keep the original wear seat. The brushes must have good seats which conform to the shape of the commutator. If the brush seat is not correct, put a piece of very fine carborundum paper or similar material tight around the commutator with the rough face to the outside. With the brush in position, turn the armature by hand, in the normal direction of rotation, until the brush has the correct shape. If the brushes are worn and the springs do not give enough pressure, they must be renewed. Check the spring pressure with the hook of a spring balance under the spring lip. The correct tension is 8,34/ 11,00 N (30/40 ozf) 0,85/1,13 kgf.

The new brushes must be the same grade as the original brushes. To ensure that correct brushes are fitted, use only parts from the approved manufacturer. To remove the brushes, remove the four setscrews that hold the brushes, one for each brush. When the new brushes are assembled, connect carefully the field coil and connector wires, held by two of the setscrews. Before the brushes are inserted in their holders, it is advised that the holders are cleaned with compressed air or with a material which is damp with gasolene.

The commutator must be completely clean; dirt or oil must be removed by a piece of clean dry material (with no loose fibres) pressed against it, while the armature is turned by hand.If the commutator is dirty and has a colour other than its natural colour, lift the brushes and put a strip of fine carborundum paper or similar material around the commutator, with the rough surface to the inside. Turn the armature by hand until the surface has returned to its natural colour. Clean the commutator with a material which is damp with gasolene.

If a repair is necessary to the commutator or switch gear, etc. the starter must be removed for specialist repair.

M127 Starter motor

Repair of this starter motor is more difficult. If necessary, remove the starter motor for specialist repair.

To test on the engine **Operation 14-8**

Ensure that the battery is fully charged.

Turn on the lights and operate the starter switch. If no lights are fitted to the machine, connect a voltmeter across the battery terminals and operate the starter switch.

If the starter does not operate but the lights keep their power or there is no voltage drop across the battery, check the switch and all the connections and wires. Slow action of the starter can be caused by faulty connections.

Failure to engage smoothly between the starter and the flywheel can be caused, on some types of starter motor, by dirt on the helical grooves of the starter motor drive, which can prevent free pinion movement. Clean the shaft thoroughly with gasolene, or a fluid made especially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.

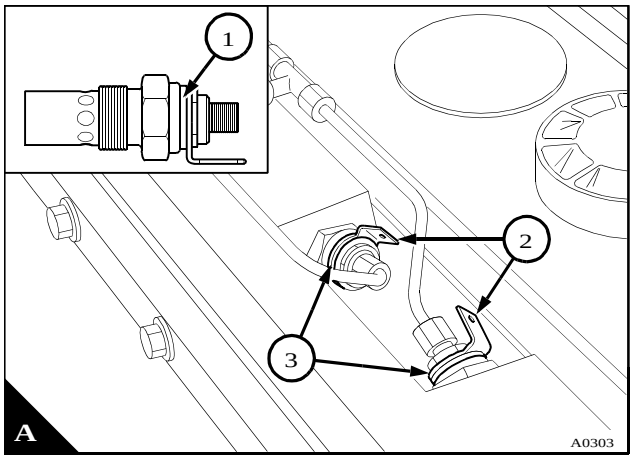
Starting aid

General description

There are two types of electrical starting aid in use - the fuelled starting aid and the port heater.

The fuelled starting aid (A1) is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device. The fuel is ignited by the hot coil and the heated air enters the induction manifold when the starter motor is operated.

The port heater has an electrically heated coil that heats the air as it enters the induction manifold. Port heaters are used in a group of two or three.



To remove and to fit a fuelled starting aid **Operation 14-9**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant and sealant primer	21820122

To remove

1 Disconnect the fuel pipe (A1) and the electrical connection (A2).

2 Remove the starting aid.

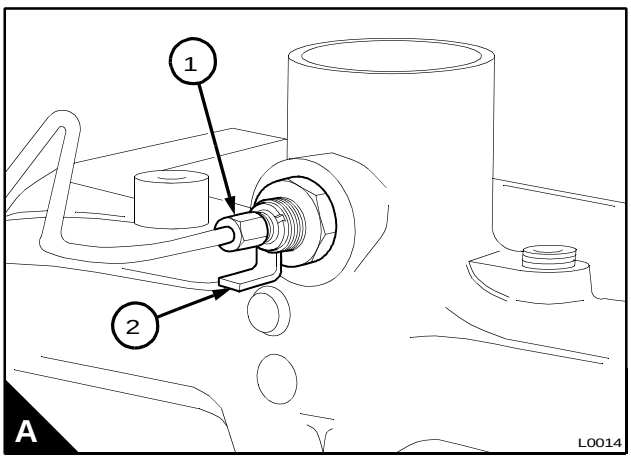
To fit

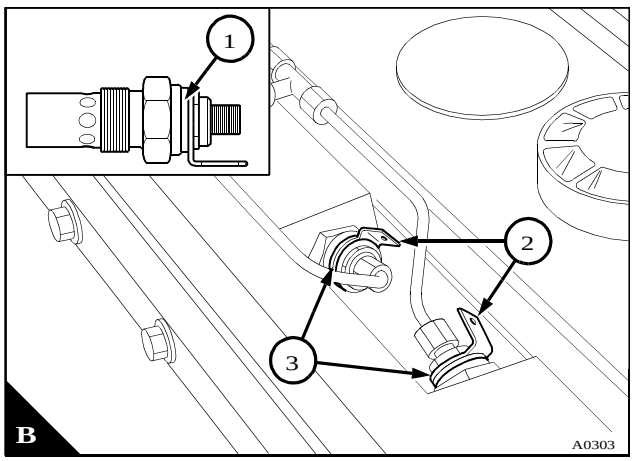
1 Ensure that the contact faces of the manifold and the starting aid are clean. Put the sealing washer into position and fit the starting aid. Tighten the starting aid to 31 Nm (23 lbf ft) 3,2 kgf m.

2 Check the fuel pipe and, if it is still full of fuel, connect it to the starting aid. If the fuel has drained from the pipe, eliminate the air from the pipe as shown in step 5 of Operation 11-25.

3 Connect the electrical connection (A2).

Some engines which have water-to-air intercoolers are fitted with twin fuelled starting aids (B3). These starting aids are in a recess on top of the induction manifold. In this situation, access to the electrical terminals (B2) can be restricted if the starting aids are not fitted correctly, see Operation 14-10.





To remove and to fit a twin fuelled starting **Operation 14-10**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Pipe sealant and sealant primer	21820603

To remove

1 Disconnect the fuel connections and the electrical connections.

2 Remove the starting aids.

To fit

Note: The Instructions that follow include the use of POWERPART Pipe sealant and sealant primer.

1 Ensure that the seat faces of the manifold and the fuelled starting aids are free of dirt and of old threadlock. It is not necessary to remove the old threadlock from the threads of the manifold or of the starting aids.

Warning! *Read the manufacturer's safety instructions before you apply* POWERPART Pipe sealant and sealant primer.

2 Apply POWERPART Pipe sealant and sealant primer onto the threads in the manifold. The POWERPART Pipe sealant and sealant primer will need five minutes to dry. During this period apply POWERPART Pipe sealant and sealant primer to the threads of the fuelled starting aids.

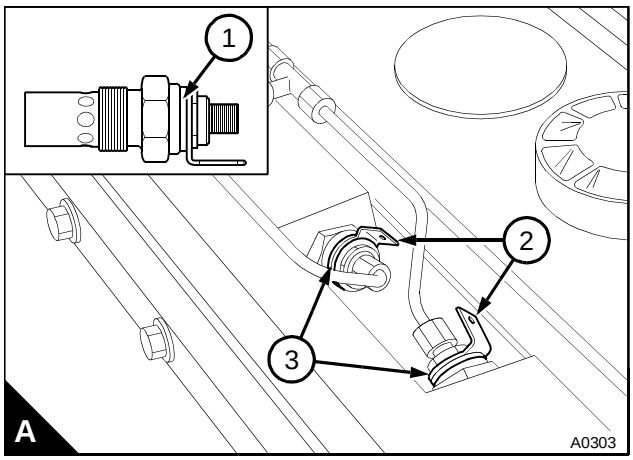
3 Fit the fuelled starting aids fully into the manifold. Rotate them back, not more than one complete turn, until the electrical terminals face away from the casing. Clean off the excess POWERPART Pipe sealant and sealant primer.

Caution: *After the fuelled starting aids are in position do not move them. If the fuelled starting aids are moved and the seal provided by the* POWERPART Pipe sealant and sealant primer *is broken, this procedure must be repeated. The* Pipe sealant and sealant primer *will be dry after 15 minutes.*

4 Check the fuel pipes and if they are still full of fuel, connect them to the starting aids. If the fuel has drained from the pipes, eliminate the air from the pipes as shown in the workshop manual.

5 Connect the electrical connections.

The latest engines have a nylon spacer (A3) fitted over the threads of the starting aid to ensure that the electrical connector (A2) is in the correct position. When the nylon spacer is fitted it is not necessary to use POWERPART Pipe sealant and sealant primer.



How to check the fuelled starting aid **Operation 14-11**

If the inside of the induction manifold is wet, check that there is not a fuel leak from the fuelled starting aid.

1 Disconnect the fuel pipe and the electrical connection at the starting aid. Remove the starting aid from the manifold and fit a suitable plug in the manifold.

2 Connect the fuel pipe to the starting aid, but leave the connection loose. Do not fit the electrical connection, but ensure that the connector has a suitable insulator fitted. Operate the priming lever of the fuel lift pump until fuel free of air comes from the connection. Tighten the connection.

3 Start the engine and operate it at low speed. Check that there is no fuel leakage from the valve of the starting aid.

4 If there is no leakage, remove the plug from the induction manifold and fit the starting aid. Connect the fuel pipe to the starting aid and remove the air from the pipe. Connect the electrical connection.

5 If there is a leak from the valve of the starting aid, fit a new starting aid.

To remove and to fit a port heater **Operation 14-12**

1 Disconnect the electrical connection.

2 Remove the port heater from the induction manifold or from the elbow.

3 Fit the port heater and tighten it to 60 Nm (44 lbf ft) 6,1 kgf m.

4 Connect the electrical connection.

15

Auxiliary equipment

Compressors

The earliest engines have a Wabco 159 or 229 compressor (A) is fitted to a drive assembly which is fitted to the rear face of the timing case on the left side of the engine. The drive assembly has two gears of equal size on a common shaft. The forward gear is driven by the engine idler gear and the gear at the rear of the drive assembly drives the compressor gear.

The early engines have a Wabco 159 and 229 compressors were introduced, together with a new compressor drive assembly which will enable the timing of the new compressor to the engine. This reduced the noise from the compressor and gears. The later compressors can be used with the earlier compressor drive if the earlier compressor drive gear is used, but the compressor timing cannot be matched to the engine.

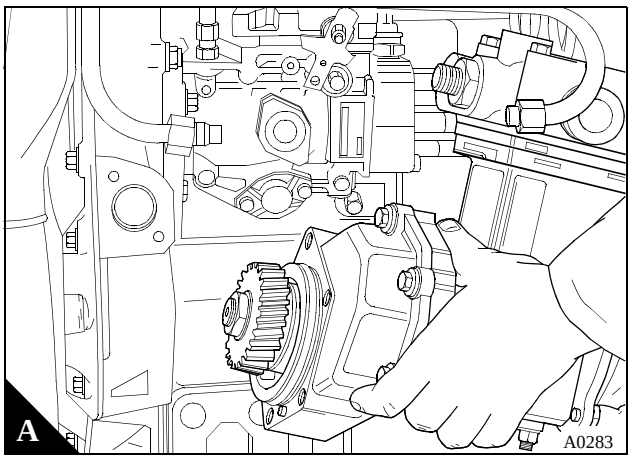
Later engines, are fitted with a compressor, have either a Bendix 1W150R or 1W250R (B). The Bendix compressor is fitted on the left side of the engine directly onto the rear face of the timing case. The compressor is driven from the main idler gear through an idler gear for the compressor.

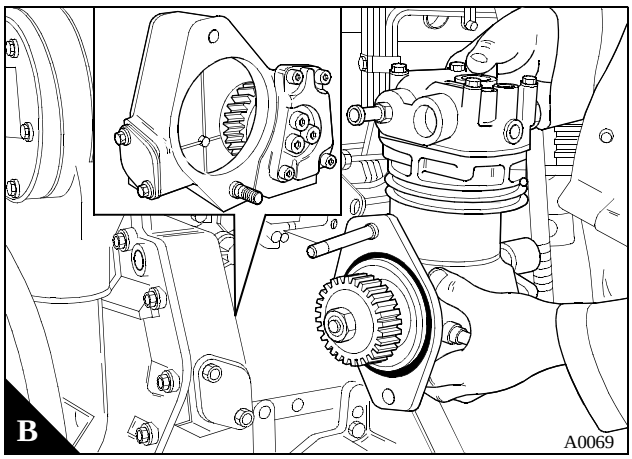
The latest engines are fitted with a compessor supplied by Knorr-Bremse.The compressor is fitted to the left side of the engine onto the rear face of the timing case and is driven by the main idler gear via a secondary idler gear.

The cylinder head of the single cylinder compressor is cooled by coolant from the engine. The compressor is lubricated from the lubrication system of the engine. Oil passes through a pipe from the engine pressure rail to the compressor crankcase. The oil passes to the main bearings and the big end bearings of the compressor and also to the rear bush for the drive shaft. Oil which drains from the compressor crankcase into the drive housing, lubricates the drive gears and the bearing. The oil returns to the engine sump through the timing case.

Operation

As the piston moves down the cylinder, air pressure above the piston is reduced. The reduction in air pressure opens the inlet valve and allows air to enter the cylinder above the piston. As the piston moves up the cylinder, air pressure under the valve and the action of the valve spring, closes the valve. The increase in air pressure under the delivery valve, opens the valve and air is discharged to the reservoir. Air pressure in the reservoir is controlled by an unloader valve which, at a certain pressure, holds the inlet valve of the compressor open until air pressure in the reservoir is reduced.





Wabco compressors

To remove the earliest compressor and drive assembly **Operation 15-1**

The compressor and its drive housing can be removed from the engine as an assembly or the compressor only can be removed.

1 Drain the engine cooling system.

2 Release the air pressure in the air system and disconnect all the pipe connections to and from the cylinder head of the compressor.

3 Remove the lubricating oil pipe which is fitted between the compressor and the engine cylinder block.

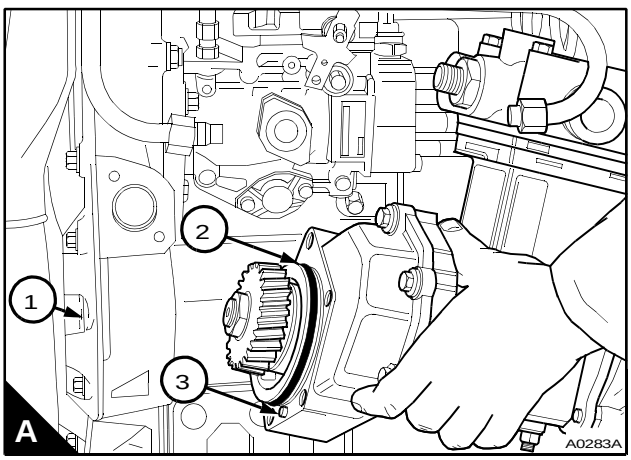
4 If necessary, remove the power steering pump from the rear of the compressor.

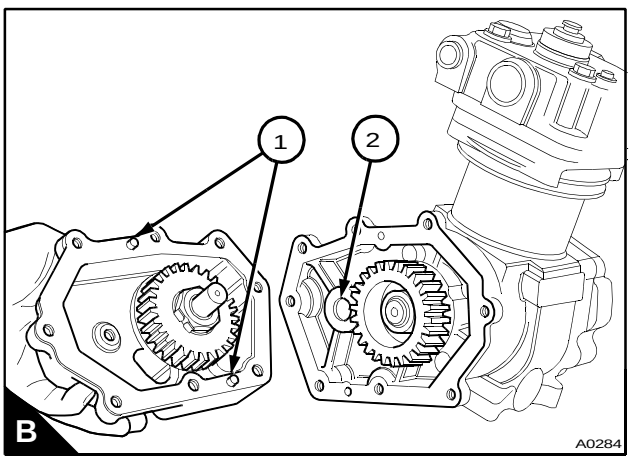
5 Remove the support bracket which is fitted between the bottom of the compressor and the cylinder block.

6 If the drive housing is to be removed, release the setscrew that passes through the timing case from the front (A1) and release the five setscrews which are fitted through the compressor flange into the timing case from the rear. If only the compressor is to be removed, release the five setscrews which are fitted through the compressor flange from the rear and release the three setscrews which are fitted through the drive housing flange from the front.

7 Remove the compressor or the compressor and its drive housing (A). Ensure that the dowel(s) (A3 or B1) are still in position.

Note: The latest engines have a stud in place of the setscrew (A1). Most of the latest engines have five studs in place of the five setscrews used to fasten the compressor assembly to the timing case. The dowel (A3) is not used on the latest engines. Correct location of the drive assembly is now controlled by a close tolerance hole for the stud at the bottom centre position of the drive housing.





To fit the earliest compressor and drive assembly **Operation 15-2**

Special requirements

Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Retainer (oil tolerant)	21820603	POWERPART Threadlock and nutlock	21820117 or 21820118

1 If the compressor drive housing has been removed, fit a new "O" ring (A2) in its recess and lubricate it with clean engine lubricating oil.

2 Ensure that the dowel (A3) is correctly fitted. Fit the compressor or the compressor and drive housing assembly and tighten the setscrews.

3 Fit the compressor support bracket, ensure that force is not applied to the compressor when the support bracket is fitted.

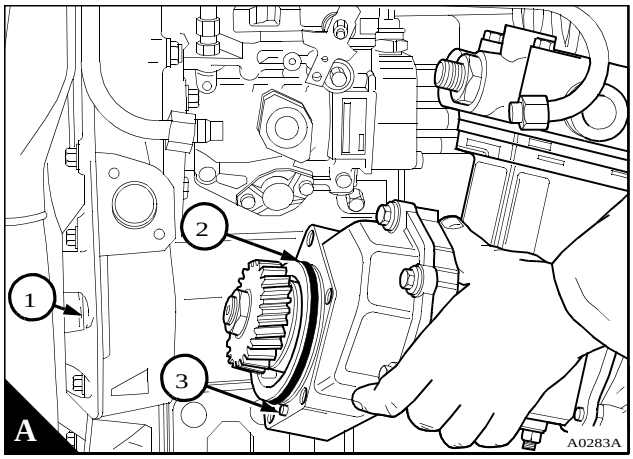
4 If necessary, fit the power steering pump to the rear of the compressor.

5 Fit the oil pipe between the compressor and the cylinder block of the engine.

6 Connect all the pipe connections to the cylinder head of the compressor.

7 Fill the engine cooling system.

8 Operate the engine and check for any leakage of oil or coolant.



To fit the early compressor and drive assembly **Operation 15-3**

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

2 Fit a new "O" ring in its recess in the drive housing and lubricate it with clean engine lubricating oil.

3 Rotate the crankshaft of the compressor until the mark (A1) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

4 Put the compressor and drive assembly in position on the studs of the timing case. Slide the assembly forward until the front idler gear of the compressor drive is against the engine idler gear. Slowly rotate the crankshaft of the compressor clockwise (from the rear) until the front idler gear will mesh with the engine idler gear.

5 Carefully push the compressor assembly forward until the spigot on the drive assembly is fully fitted in the timing case. In this position, the mark on the rear of the crankshaft should align with the dark area marked 6 (six cylinder engines) or 4 (four cylinder engines) on the timing label (A).

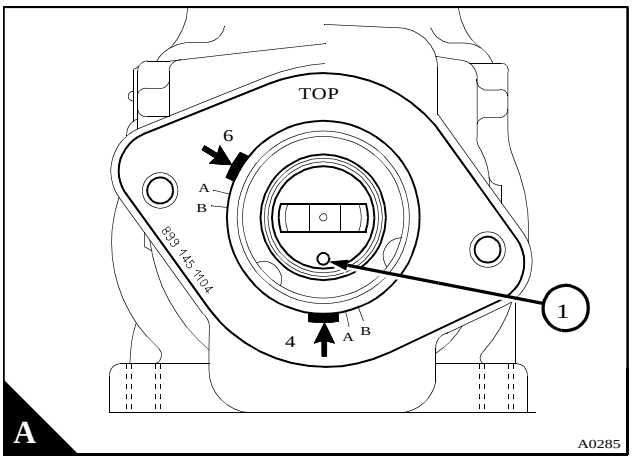
6 If it does not, pull the assembly out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor assembly into position again and check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts to the studs and tighten them. Fit the nut to the stud that passes through the timing case and tighten it.

7 For six cylinder engines: Fit the support bracket to the compressor and tighten the setscrews. Put the mounting bracket in position between the cylinder block and the support bracket and loosely fit the fasteners. Adjust the mounting bracket to ensure that there will be no tension on the compressor. Tighten the setscrews and then the nuts and bolts.

For four cylinder engines: Fit the support bracket to the bottom of the compressor and tighten the setscrews. Check that the nuts for the oil filter head are correctly tightened and put the two washers into position on the studs. Put the mounting bracket in position between the oil filter head and the support bracket and loosely fit the fasteners. Adjust the mounting bracket to ensure that there will be no tension on the compressor. Tighten the nuts and then tighten the setscrews.

8 Check that the "O" ring in the cover for the rear of the compressor is not damaged. Fit the cover and tighten the setscrews.

9 Ensure that there is no restriction in the oil pipe between the engine and the compressor. Before the oil pipe is connected to the compressor, ensure that the engine stop solenoid is disconnected or that the engine stop control is in the 'stop' position. Operate the starter motor until a free flow of oil comes from the oil pipe. Connect the engine stop solenoid.



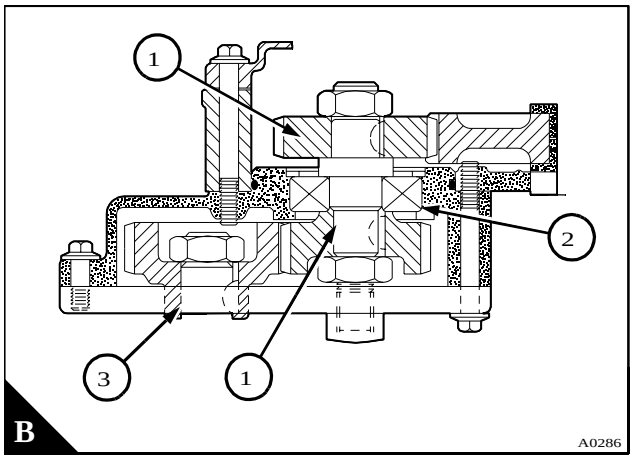
Continued

10 Connect the oil pipe, the compressor coolant pipes and the air pipes to the compressor.

11 Fill the engine cooling system. Operate the engine and check for leakage of oil, coolant and air from the compressor.

Notes:

- It is not possible to match the timing of the early the compressor to the engine. Also it is not possible to match the timing of the latest compressor to the engine if the early drive assembly is used.
- If the latest compressor is to be used with the early drive assembly, ensure that the drive gear (26 teeth) from the earlier compressor is fitted.
- Also ensure that the new M20 nut (part number 3331E003) is used. When this nut is to be used discard the tab washer and apply a narrow ring of POWERPART Retainer (oil tolerant) to the bore of the drive gear in the position shown in (B3). Also apply POWERPART Threadlock and nutlock to the thread of the compressor crankshaft. Fit the nut and tighten to 130 Nm (96 lbf ft) 13,3 kgf m. Clean off excess retainer (oil tolerant).



To fit the early compressor only **Operation 15-4**

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1.

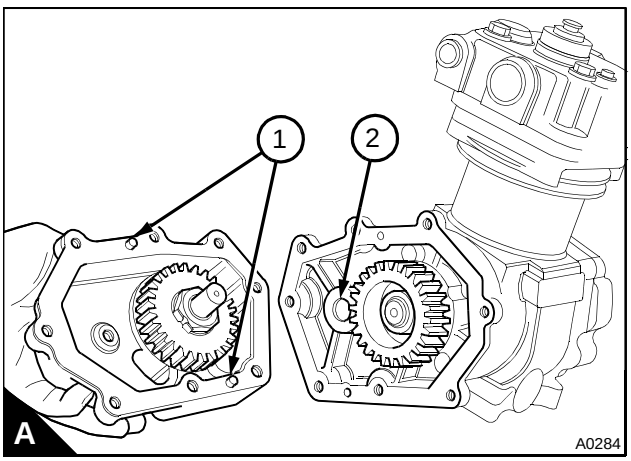
2 Ensure that the dowels (A1) are fitted correctly in the flange of the drive housing and fit a new joint to the flange.

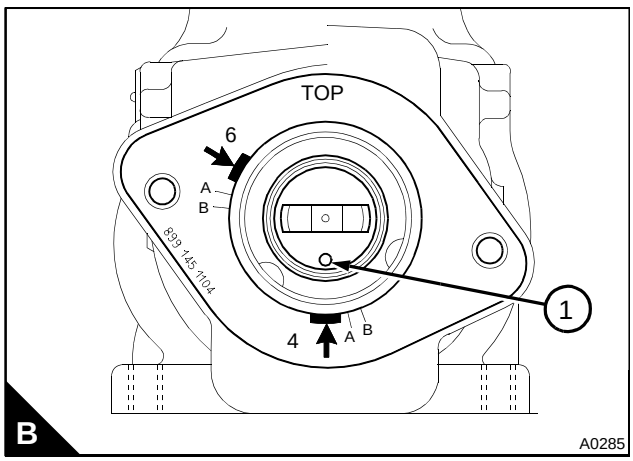
3 Rotate the crankshaft of the compressor until the mark (B1) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

4 Lubricate lightly the bush in the compressor casing with clean engine lubricating oil. Put the compressor in position on the studs of the timing case. Slide the compressor forward until the compressor gear is against the rear idler gear of the drive assembly. Slowly turn the crankshaft of the compressor clockwise (from the rear) until the compressor gear will mesh with the rear idler gear.

5 Carefully push the compressor forward until the gears are fully in mesh. In this position the mark on the rear of the crankshaft should align with the dark area marked 6 (six cylinder engines) or 4 (four cylinder engines) on the timing label (B).

6 If it does not, pull the compressor out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor into position again and check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts and the setscrews which fasten the compressor to the drive assembly and tighten them.





Compressor drive for Wabco compressors

To remove and to fit **Operation 15-5**

To remove

1 Remove the compressor and the drive housing assembly from the engine, see Operation 15-1.

2 Release the setscrews and separate carefully the drive housing from the compressor (A).

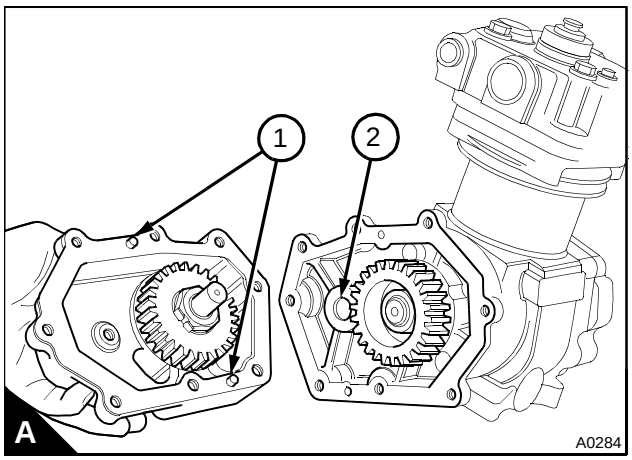
To fit

1 Check the drive gears, and the bearing for wear or for damage. Renew components if necessary.

2 Check the bush (A2), which is fitted in the compressor casing, for wear. If necessary, renew the bush. Ensure that the dowels (A1) are fitted correctly and that the joint faces are clean.

3 Lubricate lightly, with clean engine lubricating oil, the bush in the compressor casing. Put a new joint in position, fit the drive housing to the compressor and tighten the setscrews.

4 Fit the compressor and drive assembly to the engine, see Operation 15-1, Operation 15-2 or Operation 15-3.



To dismantle **Operation 15-6**

Notes:

- The gears, the drive shaft, the nuts of the drive shaft and the housing of the drive assembly have been changed.
- The number of teeth on the gears have been changed to enable the compressor timing to be matched to the engine. The front idler gear has 26 teeth, the rear idler gear has 39 teeth and the compressor drive gear has 42 teeth. The drive housing has been changed to increase the interference between the housing and the bearing. The tab washers have been removed. The spacer between the rear idler gear and the bearing (only used in the drive assembly for the Wabco 159 compressor) has also been removed. There is now a boss on the rear idler gear instead of the spacer. The new and the old components are not interchangeable.
- The components of the new drive assembly will now be the same when used with either the Wabco 159 or 229 compressor.
- There have also been changes to the Wabco 159 and 229 compressors. The thread on the front of the compressor crankshaft has been changed from $^{3}/_{4}$ UNF to M20 x 1,5 mm. A label which has timing marks has been fastened with adhesive to the rear face of the compressor.

Continued

1 Release the tab washer (A2) from the nut (A1) which is outside the housing (A8). Prevent movement of the shaft (A5) and remove the nut. Discard the tab washer. The latest drive assembly does not use tab washers.

2 With a suitable puller, remove the gear (A3).

3 Release the circlip (A4) which retains the bearing (A7).

4 Turn the housing upside down and release the tab washer (A12) from the nut (A13) inside the housing. Prevent movement of the shaft and remove the nut. Discard the tab washer.

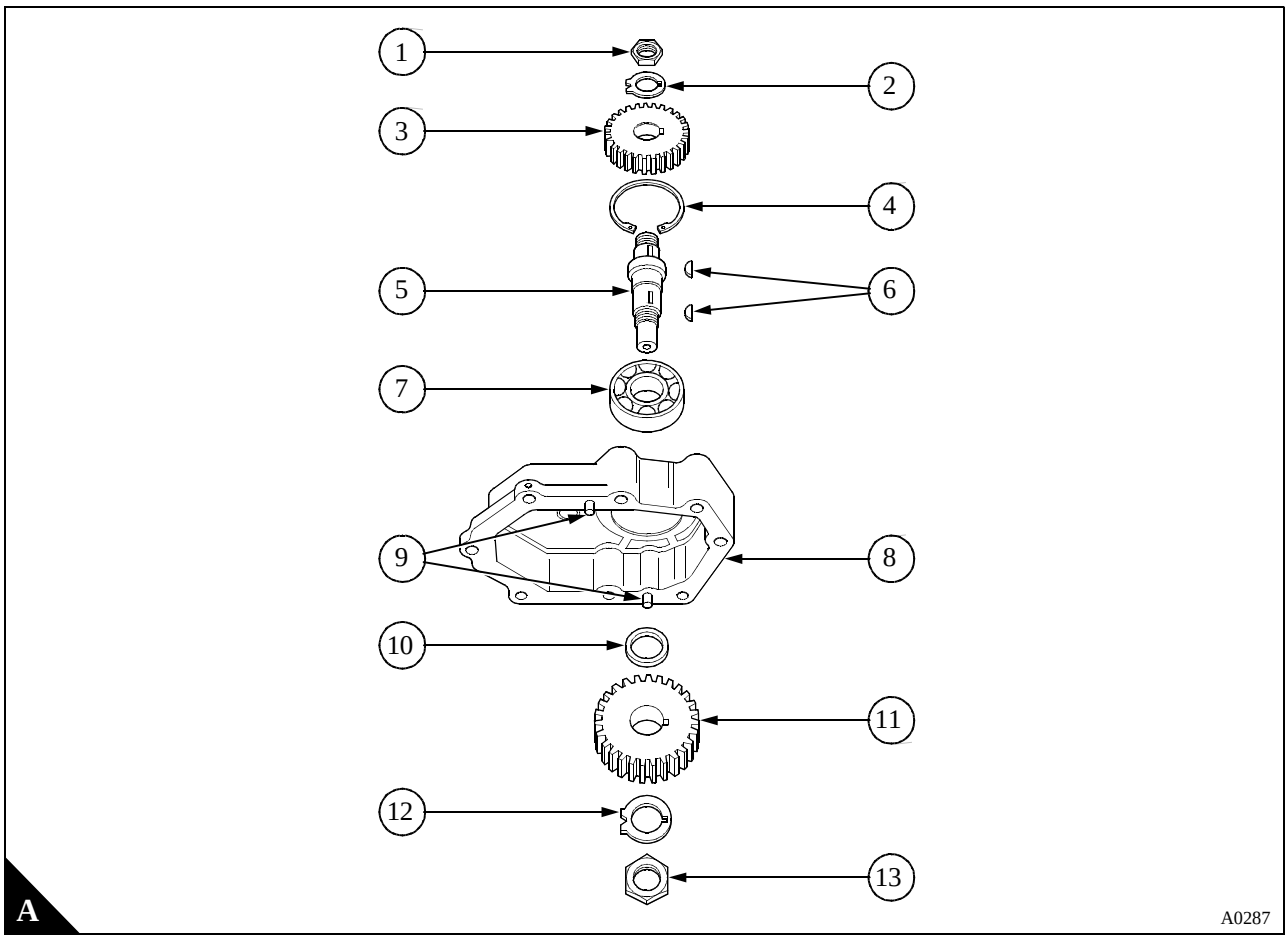
5 Provide a suitable support for the timing case side of the housing. Protect the compressor end of the shaft and press the shaft and bearing assembly out through the timing case side of the housing.

To remove the bearing and shaft assembly from the latest drive housing

Provide a suitable support for the timing case side of the housing. Heat the housing to a temperature of 130°/140 °C (266°/284 °F); ensure that the housing is heated evenly. Protect the compressor end of the shaft and press the shaft and bearing assembly out through the timing case side of the housing.

6 Remove the gear (A11) from the housing.

7 Remove the keys (A6) and the spacer (A10) -159 compressor only - from the shaft. A spacer is not used in the latest drive assembly. With the collar of the shaft towards the bottom, provide a suitable support for the inner ball guide of the bearing. Protect the end of the shaft and press the shaft out of the bearing.



To assemble **Operation 15-7**

Special requirements

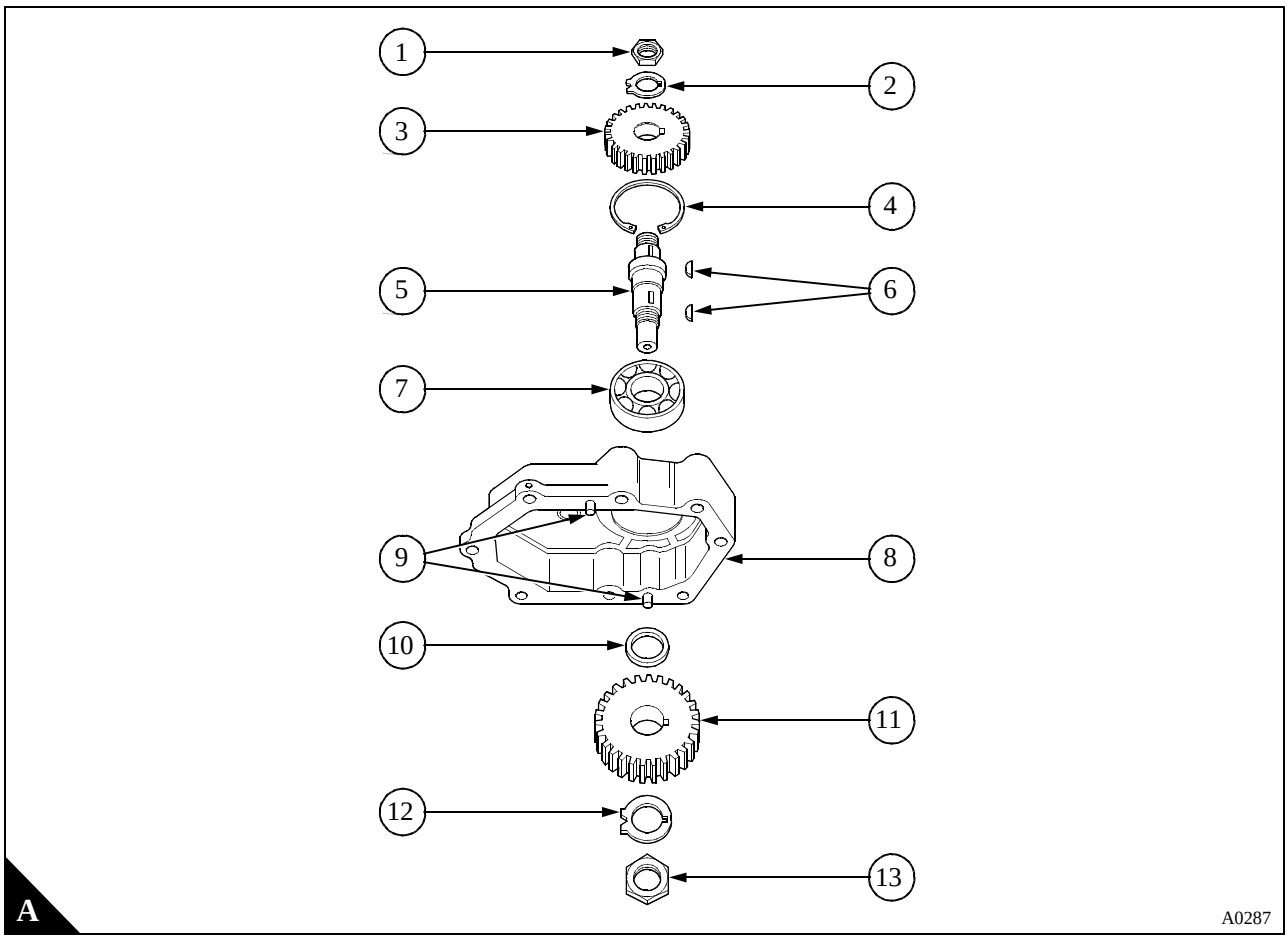
Consumable products			
Description	**Part number**	**Description**	**Part number**
POWERPART Retainer (oil tolerant)	21820603	POWERPART Threadlock and nutlock	21820117 or 21820118

1 Clean the components and check them for wear or for damage, renew the components as necessary.

2 Provide a suitable support for the inner ball guide of the bearing (A7). Put a suitable adaptor on to the collar of the shaft (A5) and press the shaft into the bearing.

3 If necessary, remove the dowels (A9) from the compressor flange of the housing (A8). Put the housing with its compressor flange on a suitable support that will allow enough space below the housing for the shaft protrusion.

4 Lubricate lightly the bearing location in the housing with clean engine lubricating oil. Put the bearing on the bearing housing with the threaded end of the shaft at the top. Put a suitable adaptor on the outer ball guide of the bearing and press the bearing into position on the shoulder of the bearing housing.



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To fit the bearing and shaft assembly into the latest drive housing

Clean the outer face of the bearing and apply a narrow ring of POWERPART Retainer (oil tolerant) to the bearing in the position shown in (B2). Heat the housing until the bearing and shaft assembly can be fully fitted by hand, 130°/140 °C (266°/284 °F); ensure that the housing is heated evenly. Fit the bearing and shaft assembly into the housing with the threaded end of the shaft at the top. The assembly must be fitted in one movement in less than three seconds or the retainer will harden at this temperature. Clean excess retainer off the bearing.

5 Fit the circlip (C4) correctly in its groove.

6 Put the spacer (C10) - Wabco 159 compressors only - on the bearing (C7) and fit the keys (C6) in the keyways on the shaft. A spacer is not used in the latest drive assembly.

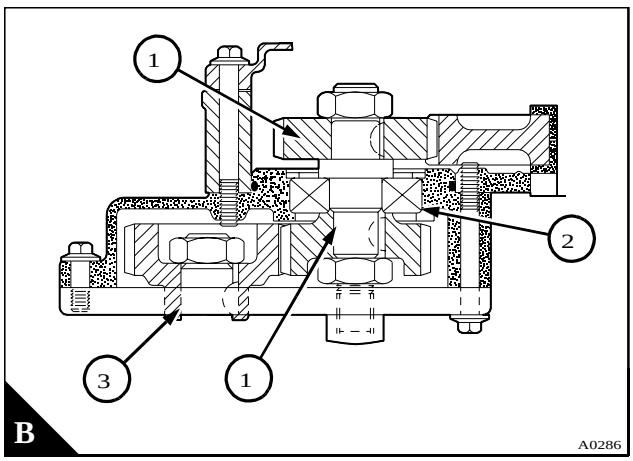
Note: The latest rear idler gear has a boss in place of the spacer.

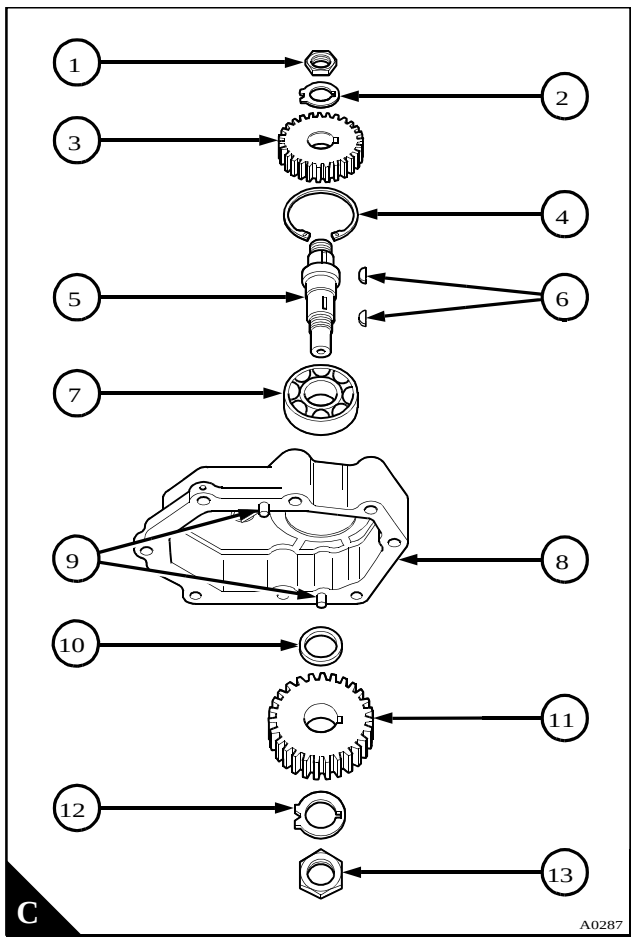
7 Ensure that the keys are aligned correctly with the keyways in the gears (C3 and C11) and put the gears in position on the shaft. The gear (C11) which is used with Wabco 229 compressors has a boss which must be towards the bearing when the gear is fitted. When the latest gears are to be fitted on the shaft, apply a narrow ring of POWERPART Retainer (oil tolerant) to the bore of the gears in the position shown in (B1). Ensure that the boss of the rear idler gear is toward the bearing when the gear is fitted. Clean off excess retainer.

8 Turn the housing upside down and support the outer gear. Apply pressure to the gear inside the housing and press both of the gears into position on the shaft.

9 Fit new tab washers (C2 and C12), ensure that the peg on the tab washers is fitted correctly in the keyway of the gears. Fit and tighten the nuts (C1 and C13) to the torque specified in "Recommended torque settings" on page 58. Bend the tab washers to prevent the release of the nuts. Tab washers are not used in the latest drive assembly. When the nuts at each end of the drive shaft are to be fitted, ensure that the threads at each end of the shaft are clean and apply POWERPART Threadlock and nutlock to the threads. Fit the nuts and tighten them to 130 Nm (96 lbf ft) 13,3 kgf m. Ensure that there is no retainer on the end of the shaft which fits into the bush.

10 Fit the dowels into the compressor flange of the housing.





Bendix compressors

To remove **Operation 15-8**

1 Drain the engine cooling system.

2 Release the air pressure in the air system.

3 Disconnect the air pipes and the coolant pipes (A1) to and from the cylinder head of the compressor.

4 Remove the lubricating oil pipe (A6) which is fitted between the compressor and the engine cylinder block.

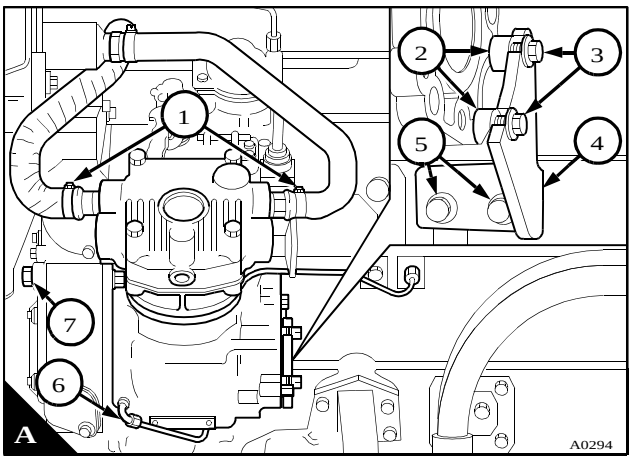
5 If necessary, remove the steering pump from the rear of the compressor.

6 Loosen the two setscrews (A3) of the support bracket (A4) at the rear end of the compressor. Remove the two fasteners (A5) which fasten the support bracket to the cylinder block or filter head and remove the bracket.

Note: Spacers (A2) are used between the bracket of the 1W150R compressor and the compressor body.

7 Remove the nut from the stud at the bottom of the compressor flange. Remove the nut (A7) from the stud at the front of the timing case and remove the compressor from the engine.

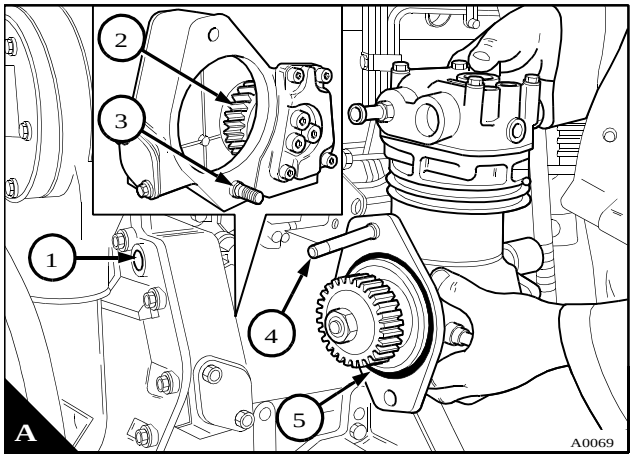
If it is necessary to remove the idler gear of the compressor, see Operation 6-8.



To fit **Operation 15-9**

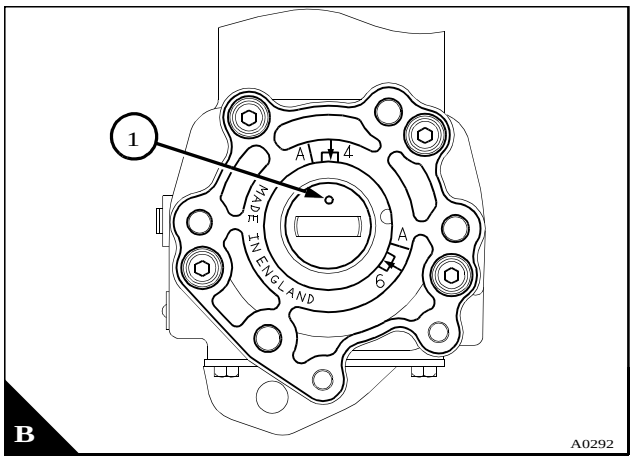
1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

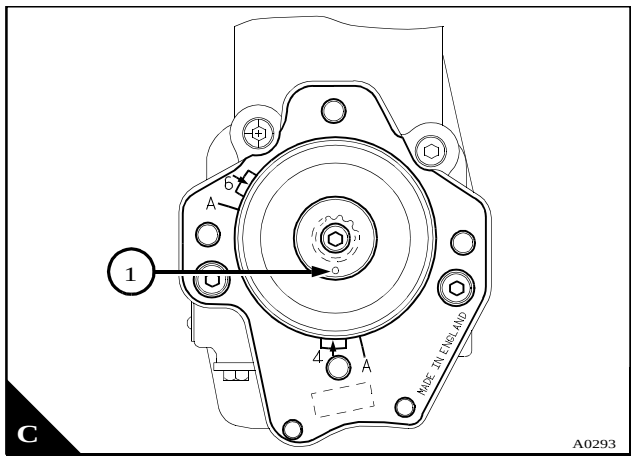
2 Fit a new "O" ring (A5) in its recess in the drive housing. Lubricate the "O" ring with clean engine lubricating oil.



3 Rotate the crankshaft of the compressor until the mark (B1) or (C1) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

4 Push the shortest thread of the stud (A4) through the hole at the top of the compressor flange and fit the nut fully onto the thread. Engage the stud in the hole (A1) in the timing case. Slide the compressor onto the stud (A3) for the bottom of the flange.





5 Slide the compressor forward until the teeth of the drive gear are against the teeth of the idler gear (A2). Slowly rotate the crankshaft of the compressor clockwise (from the rear) until the drive gear and the idler gear are in mesh.

6 Carefully push the compressor forward until the spigot on the compressor is fully fitted in the timing case. In this position, the mark on the rear of the crankshaft should align with the dark area on the timing label marked 6 (six cylinder engines) or 4 (four cylinder engines).

Continued

7 If the alignment is not correct, pull the compressor out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor assembly into position. Check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts to the stud (A4) which passes through the timing case (D1) and to the stud at the bottom of the flange. Tighten the two nuts to 75 Nm (55 lbf ft) 7,6 kgf m.

Caution: *If the support bracket is mounted on the oil filter head. Check that the nuts for the filter head are tightened correctly before the compressor support bracket is fitted.*

8 Put the support bracket (E4) in position between the cylinder block or the filter head and the compressor. Loosely fit the fasteners (E5) the spacer (E2), if fitted, and the setscrews (E3). Adjust the support bracket to ensure that there will be no tension on the compressor. Tighten the two setscrews to 22 Nm (16 lbf ft) 2,2 kgf m for the setscrews (E3) and 44 Nm (33 lbf ft) 4,5 kgf m for the fasteners (E5).

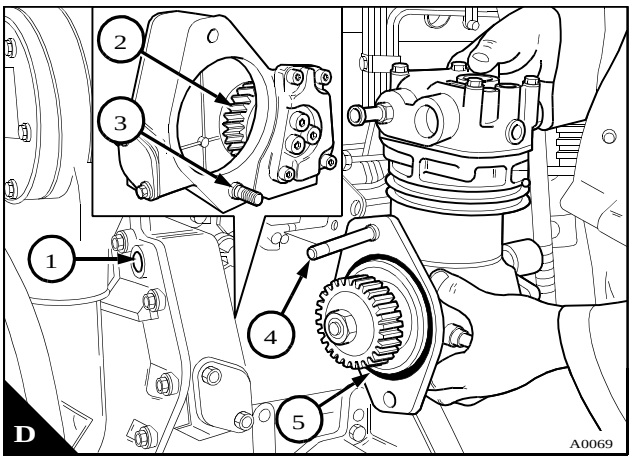
Note: Spacers (E2) are used between the bracket and the body of the 1W150R compressor.

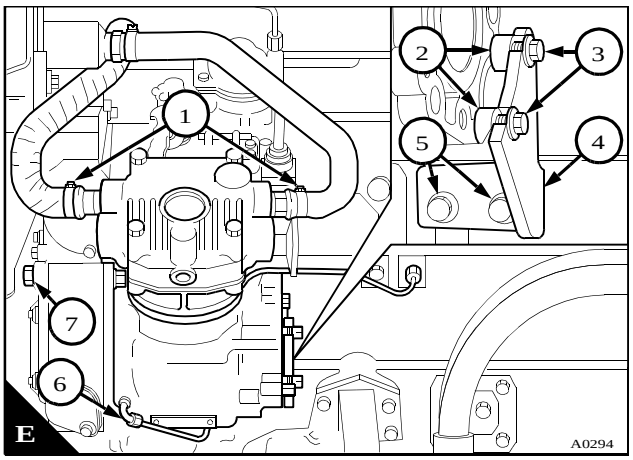
9 Check that the "O" ring in the cover for the rear of the compressor is not damaged. Fit the cover and tighten the setscrews.

10 Ensure that there is no restriction in the oil pipe (E6) between the engine and the compressor. Before the oil pipe is connected to the compressor, ensure that the engine stop solenoid is disconnected or that the engine stop control is in the 'stop' position. Operate the starter motor until a free flow of oil comes from the oil pipe. Connect the oil pipe. Connect the engine stop solenoid.

11 Connect the compressor coolant pipes (E1) and the air pipes to the compressor.

12 Fill the engine cooling system. Operate the engine and check for leakage of oil, coolant and air from the compressor.





Continued

Knorr-Bremse compressors

To remove **Operation 15-10**

Note: Illustration (A) shows a compressor with top unloader valve, and DIN drive. Illustration (B) shows a compressor that has a line unloader valve (line unloader valve not illustrated) and SAE drive.

1 Drain the engine cooling system.

2 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur.*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

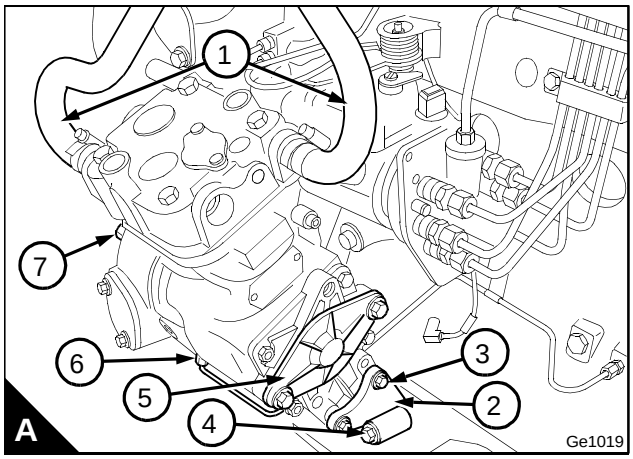
3 Disconnect the air pipes and the coolant pipes (A1/B1) to and from the cylinder head of the compressor.

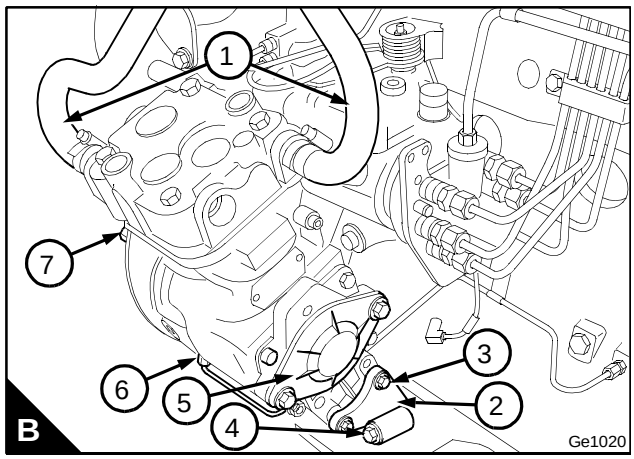
4 Remove the lubricating oil pipe (A6/B6) which is fitted between the compressor and the engine cylinder block.

5 If fitted, remove the hydraulic pump from the rear of the compressor.

6 Remove the two setscrews (A3/B3) at the rear end of the compressor. Remove the two setscrew (s) (A4/B4) which fasten the support bracket (A2/B2) to the cylinder block or filter head and remove the bracket.

7 Remove the nut from the stud at the bottom of the compressor to the timing case flange. Remove the nut (A7/B7) from the stud at the front of the timing case and remove the compressor from the engine. it may be necessary to support the compessor during this operation.

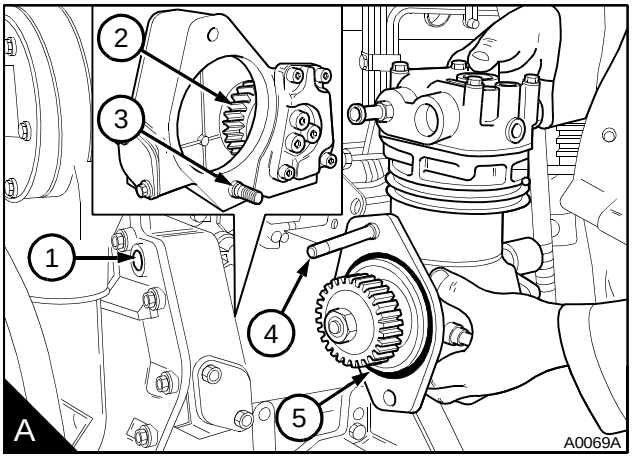


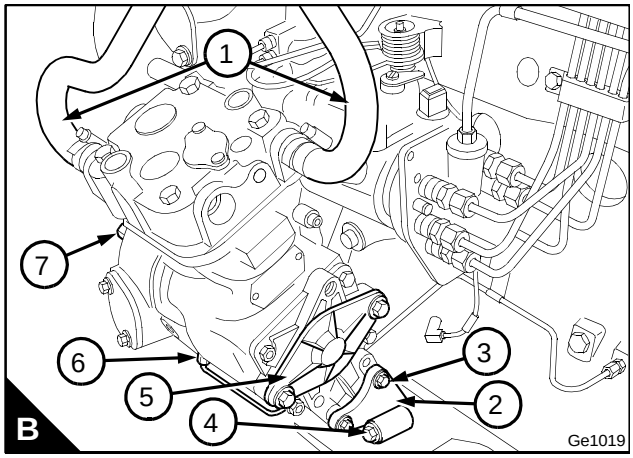


To fit **Operation 15-11**

1 Set the piston of number 1 cylinder to TDC, see Operation 8-1 or Operation 8-2.

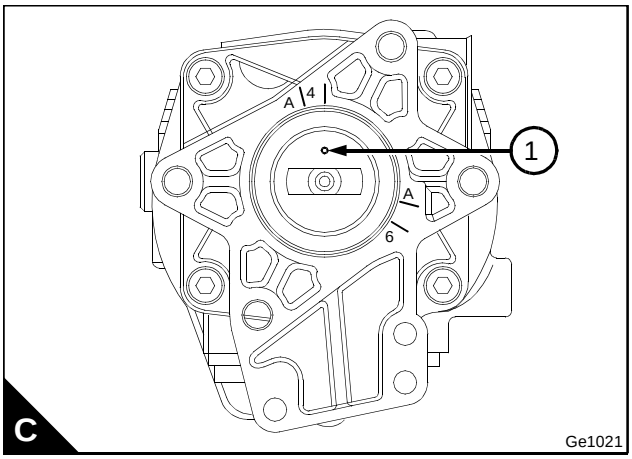
2 Fit a new "O" ring (A5) in its recess in the drive housing. Lubricate the "O" ring with clean engine lubricating oil.

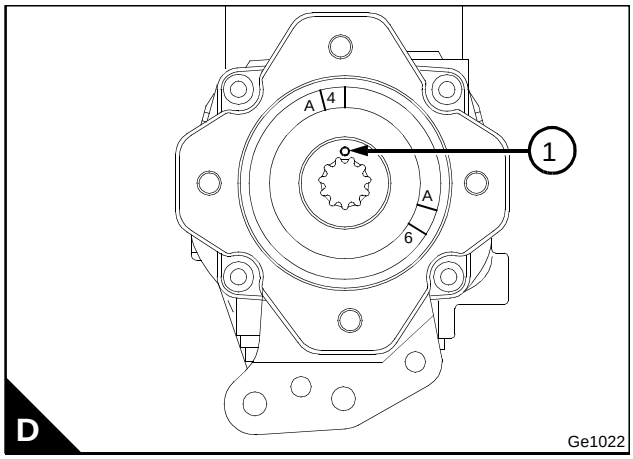




3 With the rear cover plate (B5) (or the hydraulic pump removed), rotate the crankshaft of the compressor until the mark (C1 - DIN crankshafts) or (D1 - SAE crankshafts) on the rear face of the crankshaft aligns with the 6A line (six cylinder engines) or the 4A line (four cylinder engines) on the label on the rear face of the compressor.

4 Push the shortest thread of the stud (A4) through the hole at the top of the compressor flange and fit the nut fully onto the thread. Engage the stud in the hole (A1) in the timing case. Slide the compressor onto the stud (A3) for the bottom of the flange.





5 Slide the compressor forward until the teeth of the drive gear are against the teeth of the idler gear (A2). Slowly rotate the crankshaft of the compressor clockwise (from the rear) until the drive gear and the idler gear are in mesh.

6 Carefully push the compressor forward until the spigot on the compressor is fully fitted in the timing case. In this position, the mark on the rear of the crankshaft should align with the area on the timing label marked 6 (six cylinder engines) or 4 (four cylinder engines) (C/D).

7 If the alignment is not correct, pull the compressor out of engagement and move the crankshaft of the compressor in the relevant direction to mesh with the next gear tooth. Carefully push the compressor assembly into position. Check that the mark on the rear of the crankshaft is in the correct position. Fit the nuts to the stud (A4) which passes through the timing case and to the stud (A3) at the bottom of the flange. Tighten the two nuts to 75 Nm (55 lbf ft) 7,6 kgf m.

Continued

8 Fit the rear cover plate (E5) (or the hydraulic pump) with a new ‘O’ ring seal lightly lubricated with clean engine lubricating oil. Fit and tighten the setscrews.

9 Fit the support bracket (E2) to the engine side / oil filter head with the setscrew(s) (B4) but do not tighten.

10 Fit the support bracket (E2) to the compressor with the two setscrews (E3).

11 Tighten the setscrews (E3) and (E4) evenly.

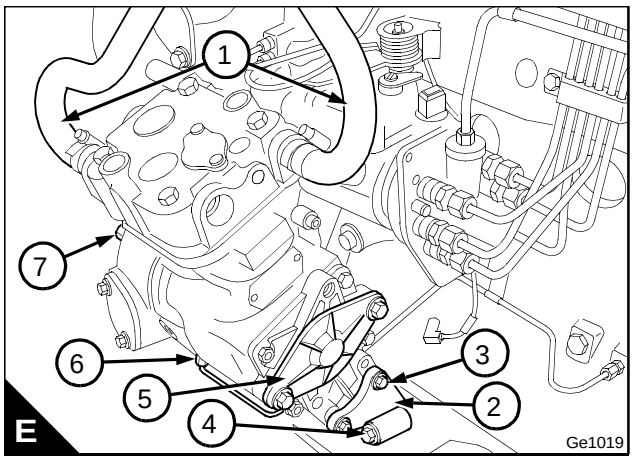
12 Disconnect the engine stop solenoid, or ensure the engine stop control is in the ‘stop’ position. Operate the starter motor until oil flows from the lubricating oil pipe (E6). Connect the lubricating oil pipe (E6) to the compressor. Connect the engine stop solenoid.

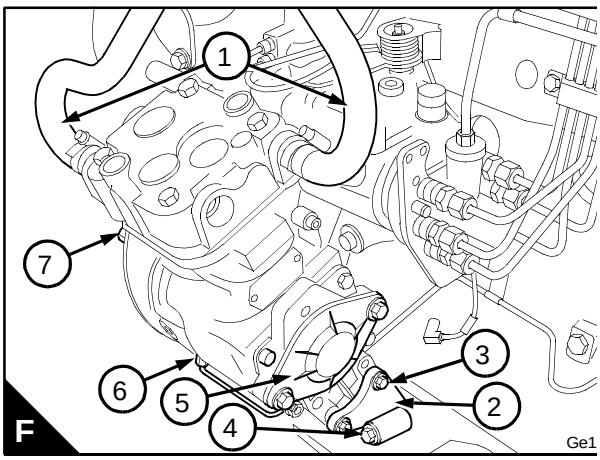
Note: Illustration (E) shows a compressor with top unloader valve, and DIN drive. Illustration (F) shows a compressor that has a line unloader valve (line unloader valve not illustrated) and SAE drive.

13 Connect the air pipes to the compressor cylinder head.

14 Connect the engine coolant pipes (E1) to the compressor cylinder head.

15 Fill the engine cooling system. Operate the engine and check for leakage of oil, coolant and air from the compressor.





To remove the reed valves **Operation 15-12**

Notes:

- To renew compressor cylinder head related components it may not be necessary to remove the compressor from the engine.
- Before attempting to renew any cylinder head component, the engine cooling system must first be drained, and the air pressure system must be released.

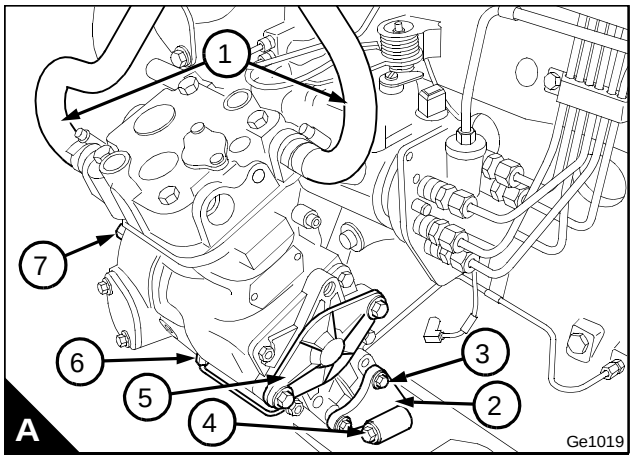
1 Drain the engine cooling system.

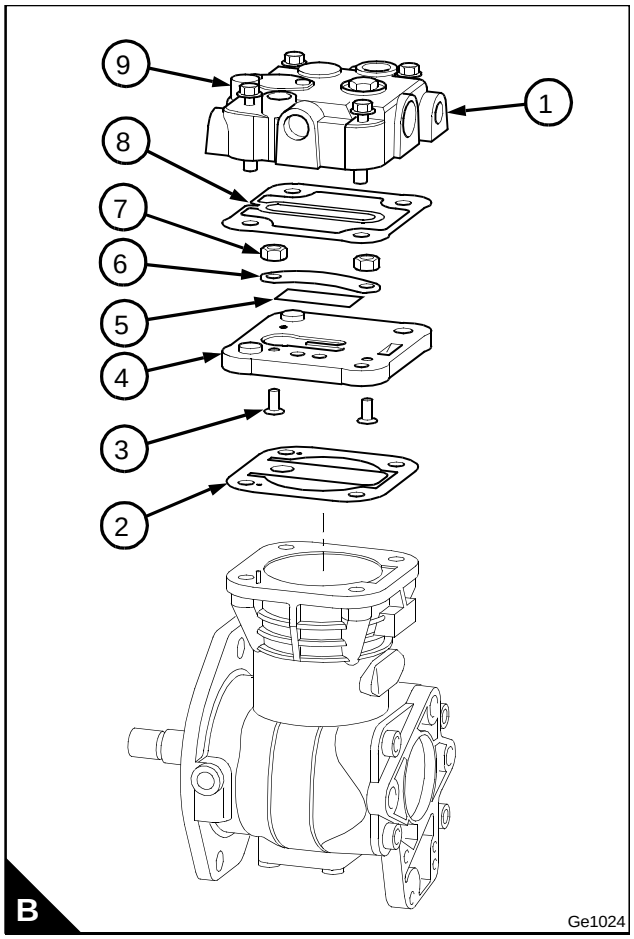
2 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur.*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

3 Disconnect the air pipes and the coolant pipes (A1) from the compressor cylinder head.





4 Remove the four cylinder head setscrews (B1), and remove the cylinder head (B9).

5 Remove the gasket (B8).

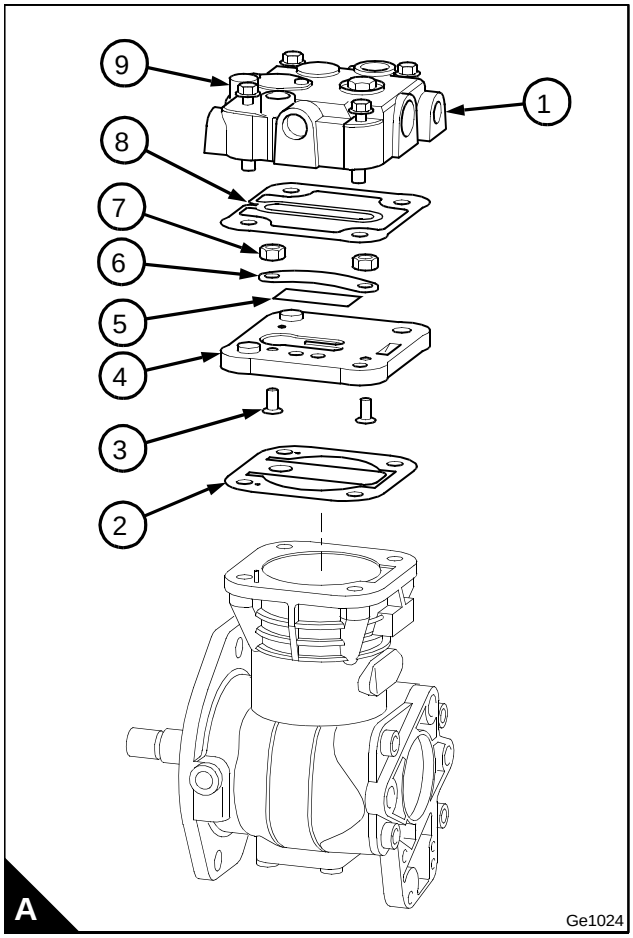
6 Remove the delivery reed plate (B4) and the inlet reed (B2).

7 Remove the delivery reed nuts (B7) and the setscrews (B3), remove the delivery bridge (B5) and remove the delivery reed (B5).

To fit the reed valves **Operation 15-13**

1 Ensure all contact surfaces are clean.

2 Fit and align the new delivery reed (A5) to the delivery reed plate (A4), and secure with the delivery bridge (A6), setscrews (A3) and nuts (A7) tighten to 8,25 Nm (6.08 lbf ft) 8,41 kgf m.



3 Fit and align a new inlet reed (A2).

4 Fit and align the delivery reed plate (A4).

5 Fit and align a new cylinder head gasket (A8).

6 Fit and align the cylinder head (A9) and secure with the setscrews (A1) and tighten to 27,50 Nm, (20.28 lbf ft) 28,04 kgf m.

7 Connect the air pipes to the compressor cylinder head.

8 Connect the engine coolant pipes to the compressor cylinder head.

9 Fill the engine cooling system. Operate the engine and check for leakage of oil, coolant and air from the compressor.

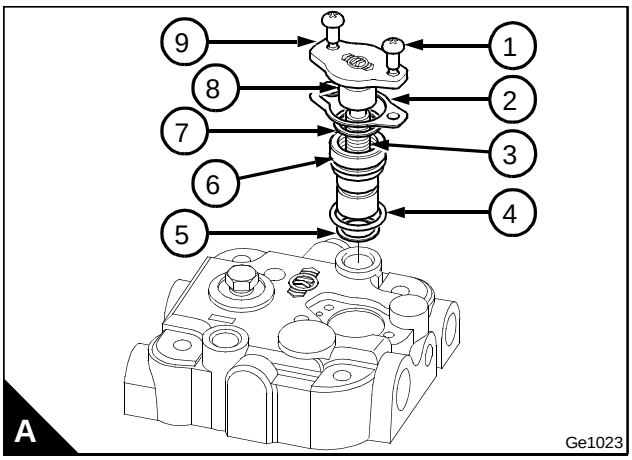
To remove the top unloader valve — Operation 15-14

1 Release the air pressure in the air system.

Warnings!

- *Never apply compressed air to any part of the body or clothing, severe injury can occur.*
- *Wear safety goggles/mask, and use correct shielding to protect others.*

2 Remove the unloader valve setscrews (A1).



3 Remove the unloader valve cap (A9).
4 Remove the joint (A2).
5 Remove the 'O' ring (A7).
6 Remove the piston (A8).
7 Remove the spring (A3).
8 Remove the balance piston (A6).
9 Remove the 'O' ring (A4) from the balance piston (A6).
10 Remove the 'O' ring (A5) from the balance piston (A6).

To fit the top unloader valve — Operation 15-15

Note: Ensure all components are clean.

1 Fit a new 'O' ring (A4) to the balance piston (A6).
2 Fit a new 'O' ring (A5) to the balance piston (A6).
3 Fit the balance piston (A6) to the cylinder head.
4 Fit the spring (A3).
5 Fit a new 'O' ring (A7).
6 Fit the piston (A8).
7 Fit a new joint (A2).
8 Fit the cap (A9) and secure with the screws (A1) and tighten to 7,0 Nm (5.16 lbf ft) 7,14 kgf m.

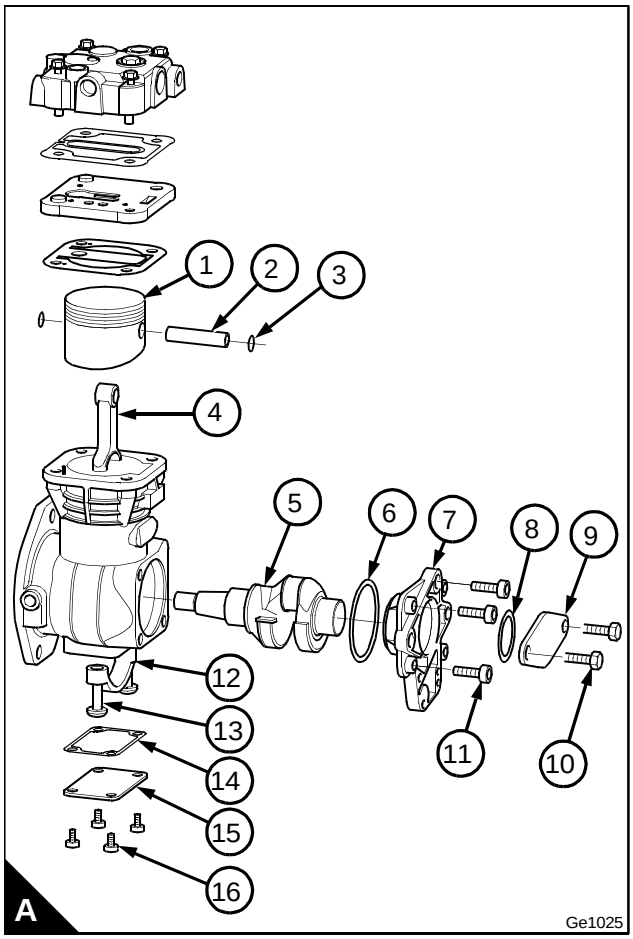
To remove the crankshaft / connecting rod / piston / piston rings **Operation 15-16**

1 Remove the compressor from the engine, see Operation 15-10.

2 Remove the compressor drive gear and drive key.

3 Remove the cylinder head, the cylinder head gasket, delivery reed plate, and the inlet reed.

4 Remove the setscrews (A16) and remove the sump plate (A15) together with the sump joint (A14).



5 Remove the connecting rod setscrews (A13) and remove the connecting rod bearing cap (A12).

6 The piston and connecting rod assembly can now be pushed up the cylinder and out through the top of the compressor.

7 Remove the circlips (A3) from the piston (A1) and push out the gudgeon pin (A2) to remove the piston from the connecting rod (A4).

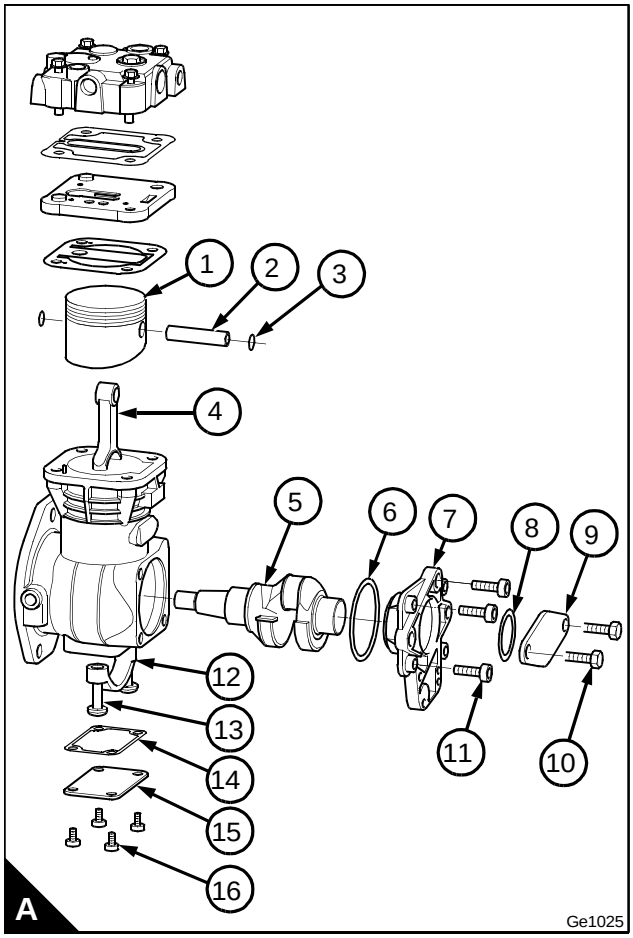
8 Remove the setscrews (A10), the cover plate (A9) and the 'O' ring (A8).

9 Remove the setscrews (A11) and remove the end plate (A7) and the 'O' ring (A6).

10 Remove the crankshaft (A5) through the compressor rear opening.

To fit the crankshaft / connecting rod / piston / piston rings **Operation 15-17**

1 Fit a new crankshaft (A5) into the compressor through the rear opening.



2 Ensure all components are clean. Fit a new 'O' ring (A6) in its recess in the end plate (A7). Lubricate the 'O' ring with clean engine lubricating oil.

3 Fit and secure the end plate (A7) with the setscrews (A11), and ensure that the crankshaft rotates freely.

4 Fit the piston (A1) to the connecting rod (A4) with the gudgeon pin (A2) and secure with the circlips (A3).

5 Fit the new piston / connecting rod assembly (without the connecting rod bearing cap) down through the compressor cylinder.

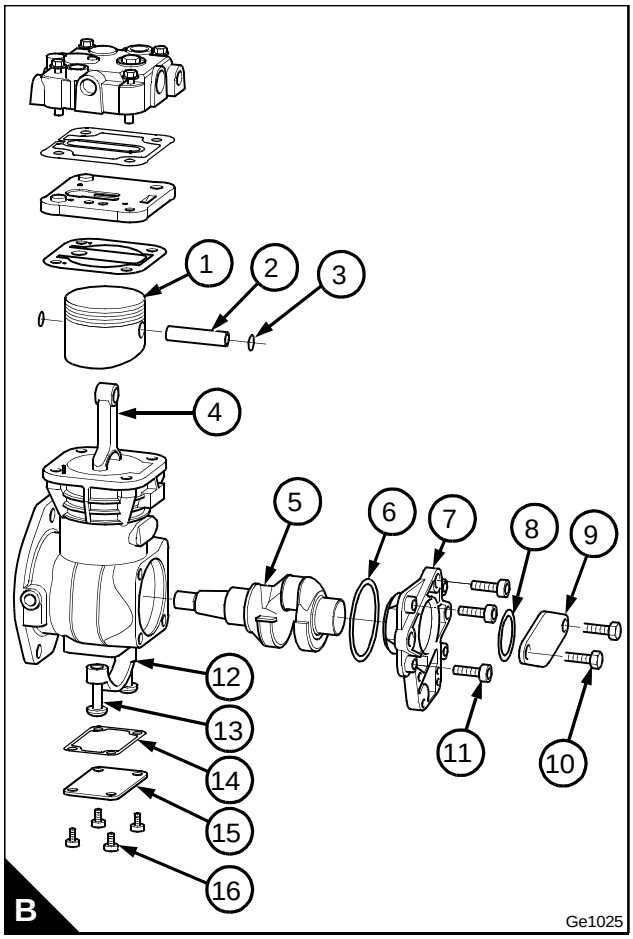
Caution: *Using a suitable piston ring compressor, ensure the piston rings are compressed into the piston grooves.*

6 Lubricate the connecting rod bearing surface and the crank pin with clean engine lubricating oil.

Continued

7 Fit the connecting rod to the crankpin.

8 Lubricate the bearing cap (B12) with clean engine lubricating oil and fit and hold the bearing cap in position to the connecting rod.



9 Fit the two bearing cap retaining setscrews (B13) by hand. If they do not fit freely by hand, fit new setscrews. If the new setscrews do not fit freely by hand, fit a new connecting rod.

10 Tighten the setscrews gradually and evenly to 14,5 Nm (10.69 lbf ft) 14,78 kgf m.

11 Ensure that the crankshaft rotates freely.

12 Fit a new sump joint (B14) and the sump plate (B15) and secure with the setscrews (B16) and tighten to 9 Nm (6.64 lbf ft) 9,17 kgf m.

13 Fit the inlet reed, the delivery reed plate, the cylinder head gasket and the cylinder head and tighten the cylinder head setscrews to 27,5 Nm
(20.28 lbf ft) 28,04 kgf m.

14 Fit the drive key and drive gear.

15 Fit the compressor to the engine, see Operation 15-11.

Power steering pump

To remove and to fit **Operation 15-18**

To remove

1 Disconnect the pipe connections at the power steering pump and fit covers to the open ends of the pipes.

2 Release the setscrews and remove the pump. If the pump is fitted to the rear of the compressor, ensure that the drive coupling is not lost.

To fit

1 Renew the "O" ring and lubricate it with clean engine lubricating oil.

2 Check the drive coupling or the gear for wear or for damage. Renew it, if necessary.

3 If necessary, fit the drive coupling to the end of the compressor shaft and rotate the pump shaft to align the drive with the coupling. Fit the pump to the compressor and tighten the setscrews.

4 Remove the covers from the open ends of the pipes and connect the connections.

Adaptor for a hydraulic pump or a steering pump with a splined drive

To remove and to fit **Operation 15-19**

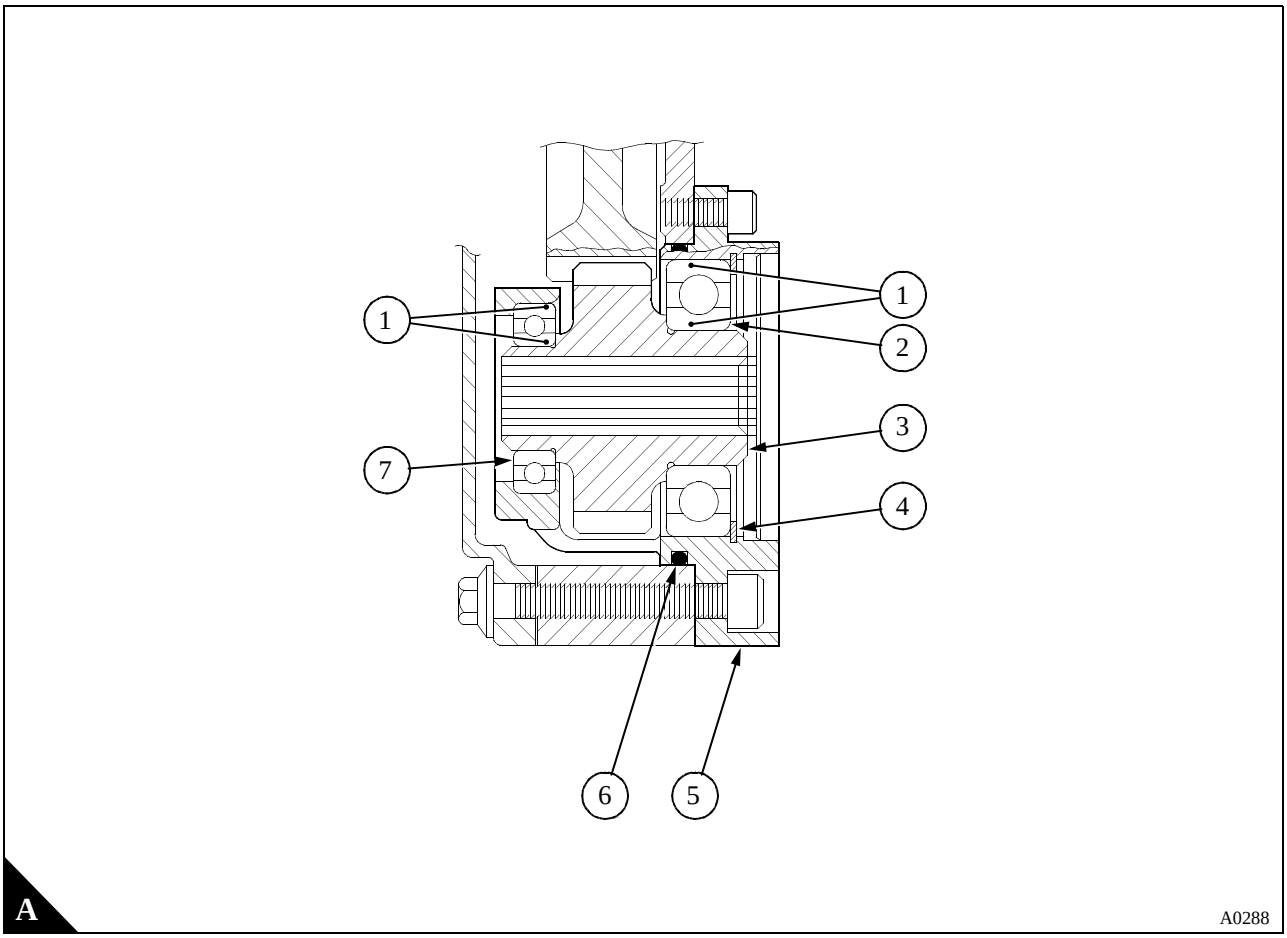
To remove

1 Release the cap screws and remove the adaptor assembly from the rear of the timing case.

2 Check the gear, the spline and the bearings for wear and other damage and renew the components as necessary.

To fit

1 Fit a new "O" ring (A6) in its recess in the housing (A5) and lightly lubricate it with clean engine lubricating oil. Lubricate the bearings (A2) and (A7) with clean engine lubricating oil. Fit the adaptor assembly to the timing case and tighten the cap screws.



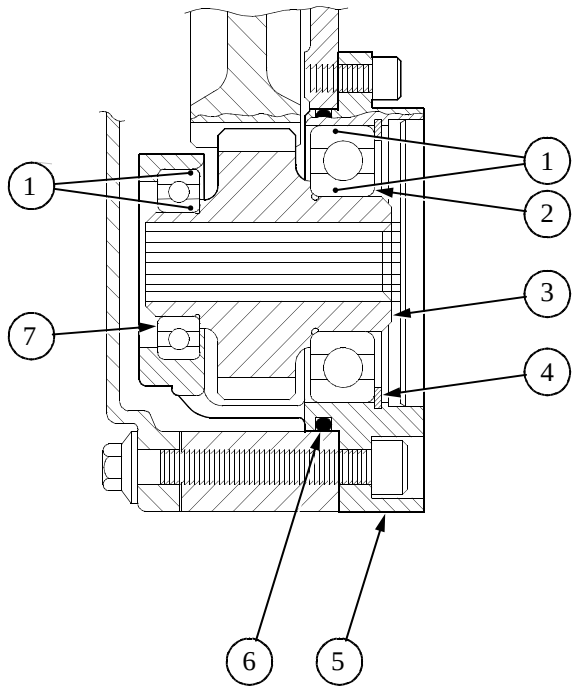
To dismantle **Operation 15-20**

1 Remove the hydraulic pump or steering pump.

2 Remove the adaptor assembly, see Operation 15-19.

3 Remove the circlip (A4). Provide a support for the flange face of the housing (A5). Use a suitable adaptor on the front bearing (A7) to press the gear and bearings out of the housing.

4 Remove the bearings from the gear (A3) with a suitable gear puller.



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A0288

To assemble **Operation 15-21**

Special requirements

Consumable products	
Description	**Part number**
POWERPART Retainer (oil tolerant)	21820603

1 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face of the front bearing (A7) in the position shown (A1). Provide a support for the front face of the housing. Use a suitable adaptor on the outer ball guide of the bearing to press the front bearing onto the shoulder in the housing. Remove excess retainer (oil tolerant).

2 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the inner face of the front bearing in the position shown (A1). Provide a support for the bearing. With the small diameter of the gear toward the bearing, press the gear into the bearing until the gear is onto its shoulder.

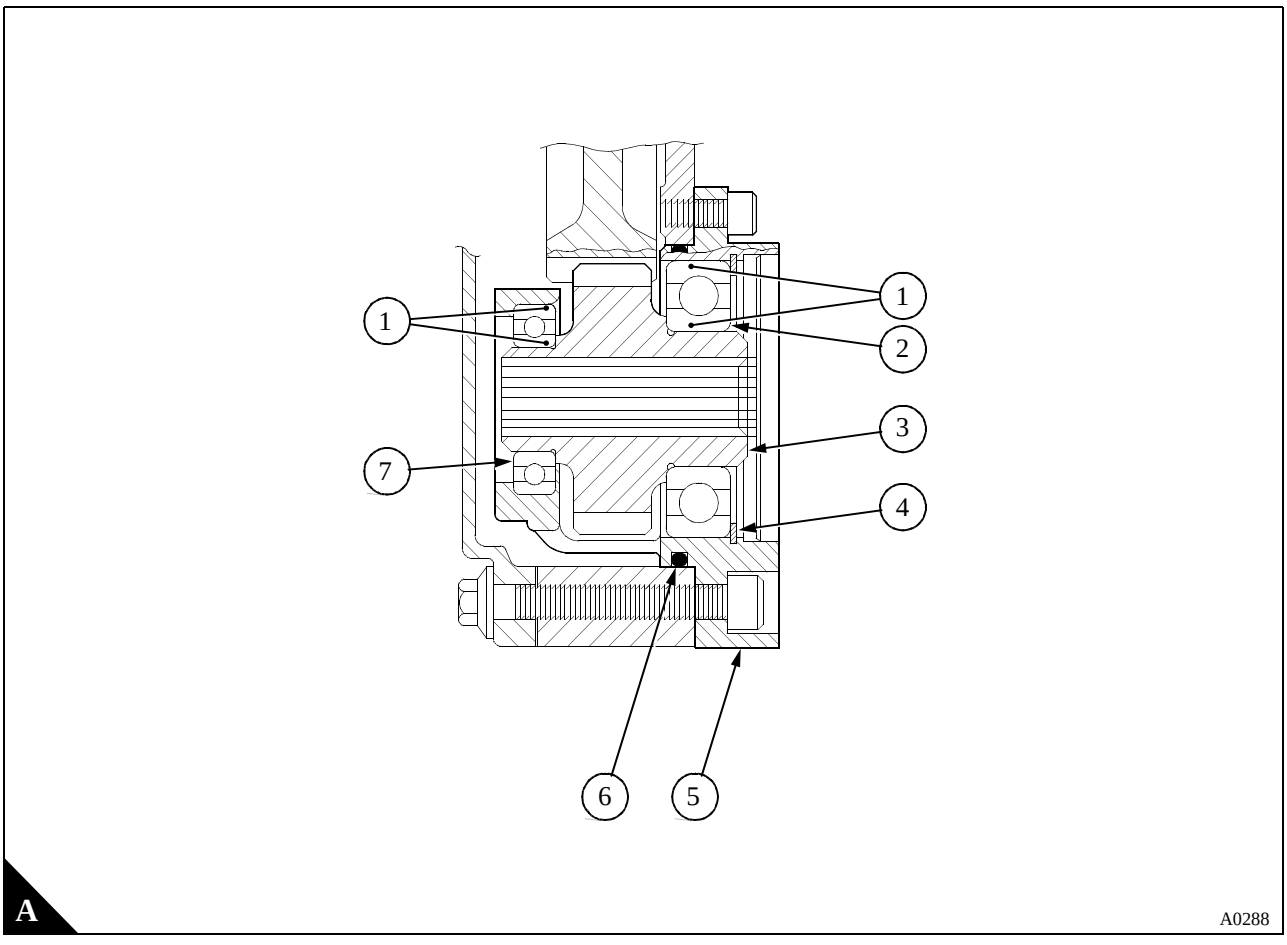
3 Apply a narrow ring of POWERPART Retainer (oil tolerant) to the outer face and to the inner face of the rear bearing (A2) in the positions shown (A1). Ensure that the support is under the front bearing. Use a suitable adaptor on the outer ball guide of the bearing to press the bearing into the housing and onto the shoulder on the gear. Remove excess retainer. Fit the circlip into its groove in the housing.

4 Check the backlash between the power take-off gear and the idler gear.

Power take-off gears are identified by the part number stamped on the gear face.

The backlash for gears with part numbers 3117C111, 3117C112 or 3117C113, is 0,08 mm (0.003 in) minimum.

The backlash for gears with part numbers 3117C114, 3117C115 and 3117C116 is 0,18/0,25 mm (0.007/0.010 in) minimum.



Exhauster

To remove and to fit — Operation 15-22

To remove

1 Disconnect the lubricating oil and vacuum pipes from the exhauster and fit covers to the open ends of the pipes.

2 Release the setscrews and remove the exhauster.

To fit

1 Ensure that the joint faces of the exhauster and the timing case are clean and renew the joint. Fit the exhauster to the timing case and tighten the setscrews.

2 Remove the covers from the open ends of the pipes and connect the oil pipe and the vacuum pipe to the exhauster.

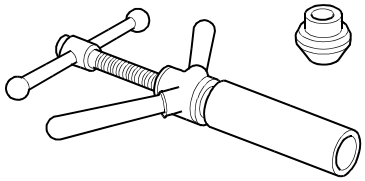
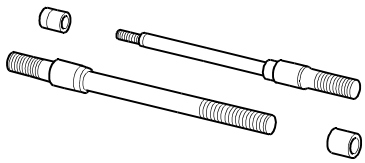
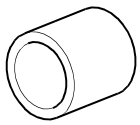
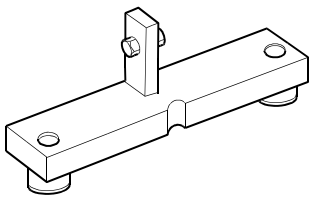
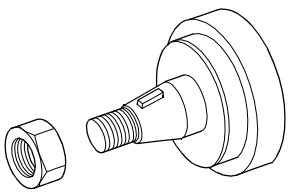
16

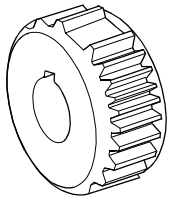
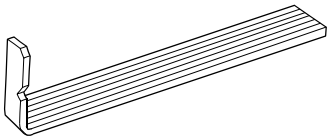
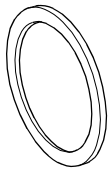
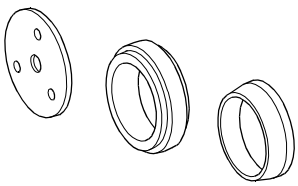
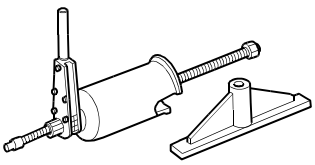
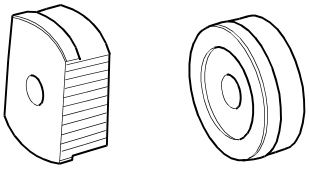
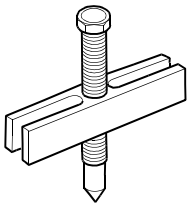
Special tools

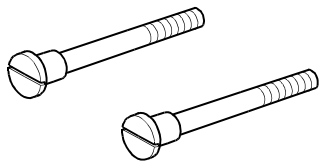
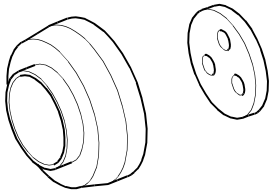
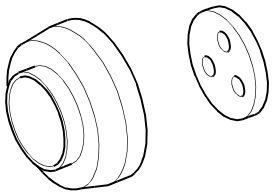
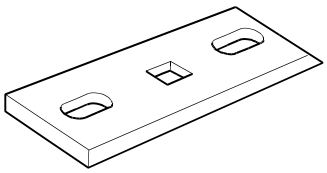
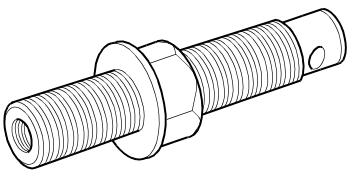
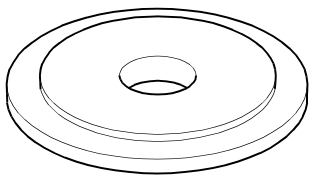
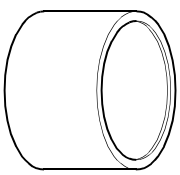
These tools are available through your local Perkins Distributor. If you cannot obtain the correct tool locally contact:

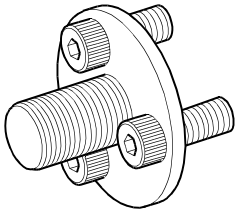
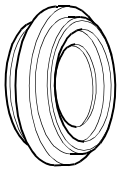
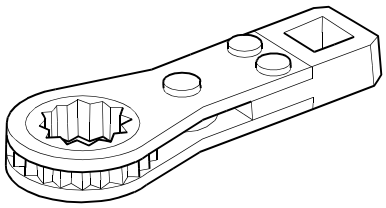
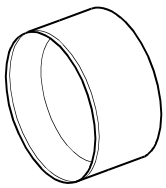
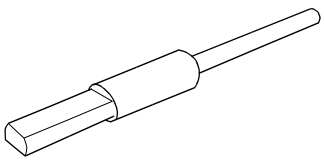
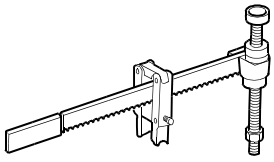
The Perkins Service Department, Peterborough, PE1 5NA, England, UK. Tel 01733 583000, Fax 01733 582240, Telex 32501 PERKEN G.

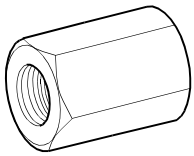
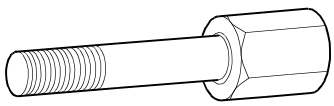
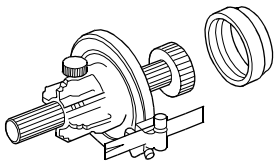
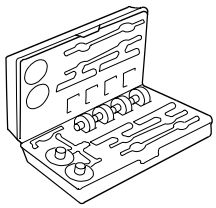
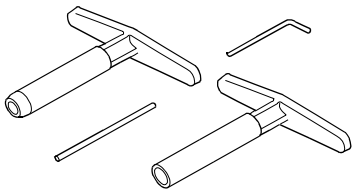
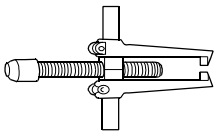
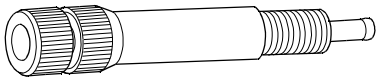
List of special tools

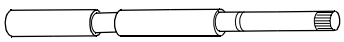
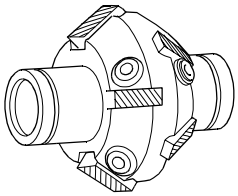
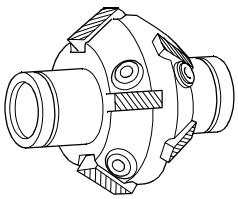
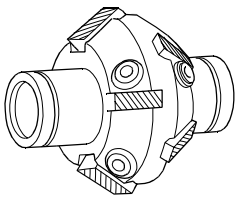
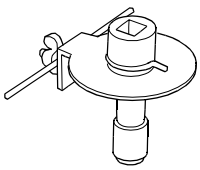
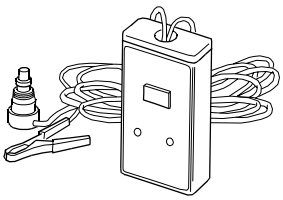
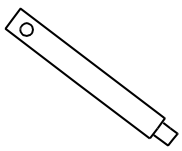
Part number	Description	Illustration
21825478	Remover/replacer for valve guides (main tool) Reference number PD.1D.	
21825479	Adaptor for use with 21825478 Reference number PD.1D-1A.	
21825482	Adaptor for use with 21825478 and 21825479 Reference number PD.1C-6.	
21825496	Gauge for piston height, valve depth and cylinder liner flange; for use with 21825617 Reference number PD.41D.	
21825512	Drive adaptor for use with 21825610 Reference number PD.67-2.	

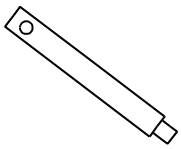
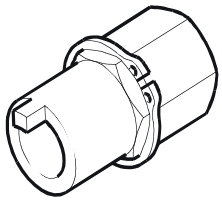
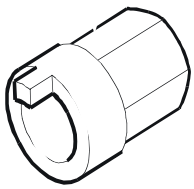
Part number	Description	Illustration
21825513	Gear adaptor for use with 21825610 Reference number PD.67-3.	
21825514	Pointer for use with 21825610 Reference number PD.67-4.	
21825515	Distance piece for Bosch pumps; use with 21825610 Reference number PD.67-5.	
21825540	Replacer tool for crankshaft rear seal Reference number PD.145D.	
21825543	Remover/replacer for cylinder liner (main tool) Reference number PD.150B.	
21825563	Adaptors for use with 21825543 Reference number PD.150B-17.	
21825565	Basic puller for camshaft and fuel pump gears Reference number PD.155C.	

Part number	Description	Illustration
21825568	Adaptors for use with 21825565 Reference number PD.155B-5.	
21825574	Centralising tool for timing case cover (Six cylinder engines) Reference number PD.162A.	
218255936	Centralising tool for timing case cover (Four cylinder engines). Reference number PD.162B.	
21825576	Crankshaft rotation adaptor for use with a 12,7 mm (0.5 in) square drive Reference number PD.165B.	
21825577	Replacer tool for seal of timing case cover (main tool) Reference number PD.170.	
21825578	Pressure plate for use with 21825577 Reference number PD.170-1.	
21825579	Sleeve for use with 21825577 Reference number PD.170-2.	

Part number	Description	Illustration
21825580	Fastener plate for use with 21825577 Reference number PD.170-3.	
21825581 **21825946**	Adaptor for standard seal for use with 21825577 Adaptor for water immersion seal for use with 21825577 Reference number PD.170-4 (21825581). Reference number PD.170-8 (21825946).	
21825964	Spanner for flange nuts of fuel injection pump Reference number PD.239.	
21825615	Replacer tool for pistons Reference number PD.206.	
21825617	Dial gauge for use with 21825496 Reference number PD.208.	
21825630 **21825947**	Piston position probe Reference number PD.221A. (now available with a whistle PD. 221A) Reference number PD.221A.	
21825666	Valve spring compressor Reference number PD.6118B.	

Part number	Description	Illustration
21825672	Stud adaptor for use with 21825666 Reference number PD.6118-7.	
21825673	Setscrew adaptor for use with 21825666 Reference number PD.6118-8.	
21825610	Universal timing gauge Reference number MS.67B.	
21825518	Set of adjustable cutters for valve seats Reference number MS.73.	
21825619	Handle set for valve seat cutters (also included in 21825618) Reference number MS.73B.	
21825625	Gear puller for coolant pump Reference number MS.99.	
21825626	Timing gauge for Bosch fuel injection pump Reference number MS.107.	

Part number	Description	Illustration
21825555	Adjustable pilot for valve seat cutters (also included in 21825518) Reference number MS.150-9.5.	
21825631	Cutter for exhaust valve seats (also included in 21825518) Reference number MS.275.	
21825632	Cutter for inlet valve seats (also included in 21825518) Reference number MS.281.	
21825642	Cutter for 31° valve seats Reference number MS.642.	
21825607	Angle gauge to tighten cylinder head setscrews Reference number PD198 (MS.1531).	
KJ37007	Timing light only for use with engines fitted with Bosch in-line fuel injection pumps	
27610032	Timing pin for Bosch fuel injection pumps. Reference number PD.245.	

Part number	Description	Illustration
27610033	Timing pin for Lucas/Delphi and Stanadyne fuel injection pumps. Reference number PD.246.	
27610144	Torque screw locknut wrench.	
27610145	Idle adjustment locknut wrench.	

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