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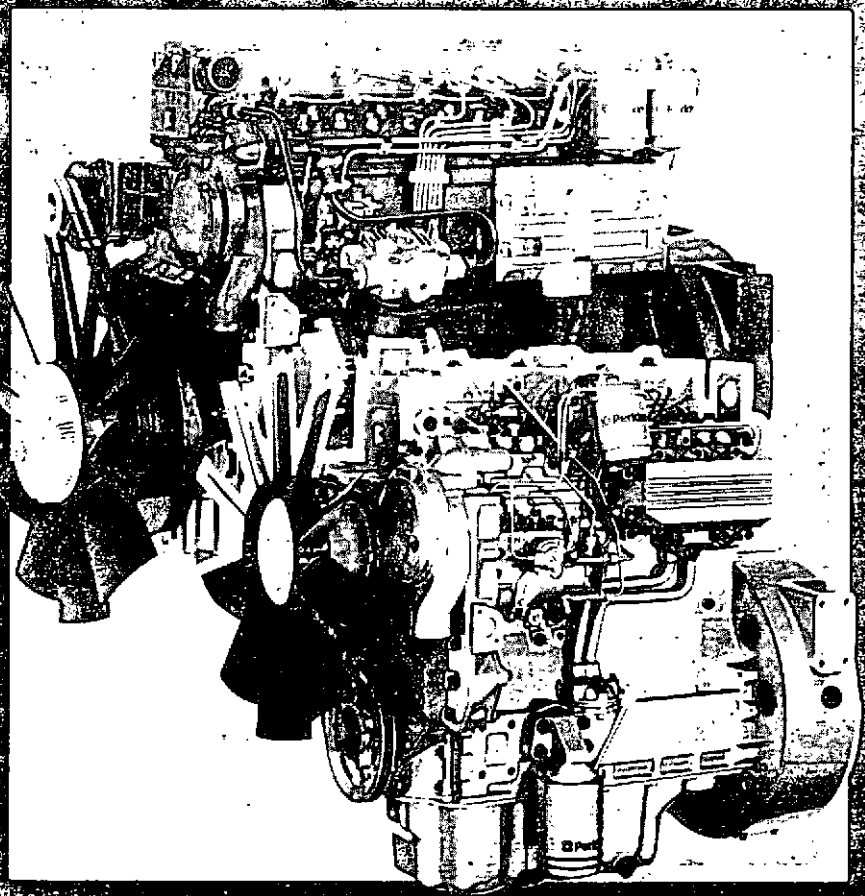

Phaser 1000 Series

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WORKSHOP MANUAL

Phaser	4 and 6 cylinder diesel engines for vehicle and truck applications
1000 Series	4 and 6 cylinder diesel engines for agricultural and industrial applications

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Contents

General information 10

Introduction

This workshop manual has been designed to provide assistance in the service and overhaul of Perkins Phaser and 1000 Series engines.

Most of the general information which is included in the relevant User's Handbook (sections 1 to 9) 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 pump type can be found by reference to the manufacturer's identification plate on the pump but, generally, the type of pump fitted is as shown below.

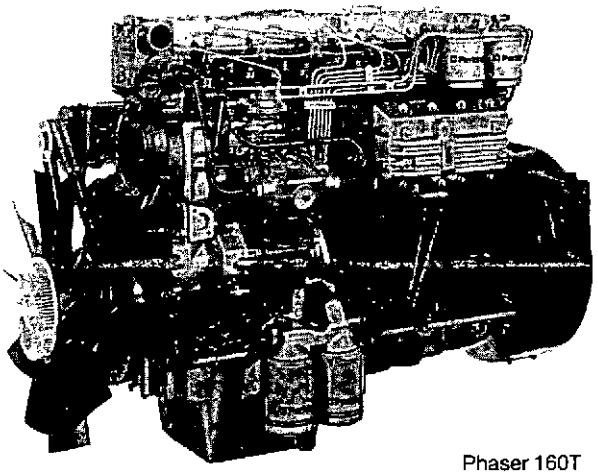
Bosch EPVE	Vehicle and truck applications
CAV DPA	Naturally aspirated engines in industrial and agricultural applications
CAV DPS	Turbocharged engines in industrial and agricultural applications

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

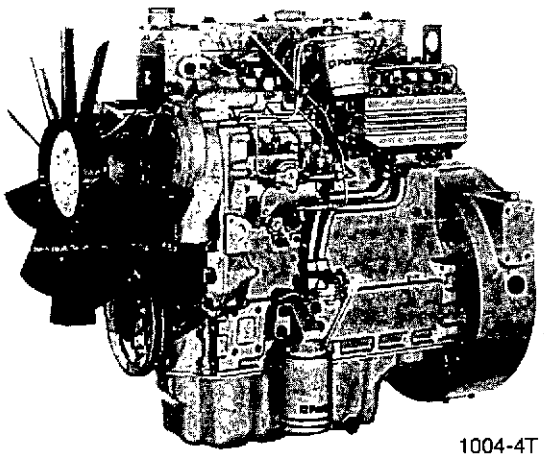
Special tools have been made available and a list of these is given in section 25. Reference to the relevant special tools is also made at the beginning of each operation.

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

A hazard symbol in the text indicates that there is a danger of personal injury if certain operations are not done correctly.



Phaser 160T



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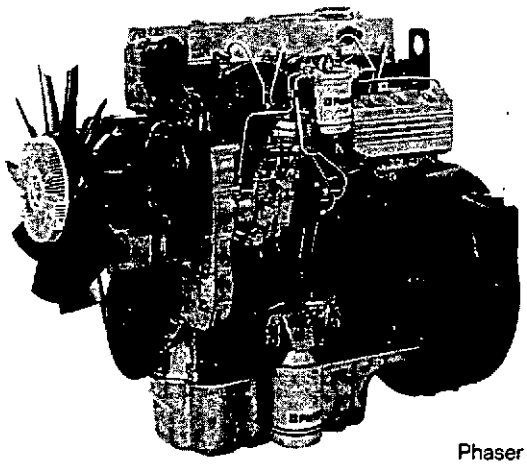
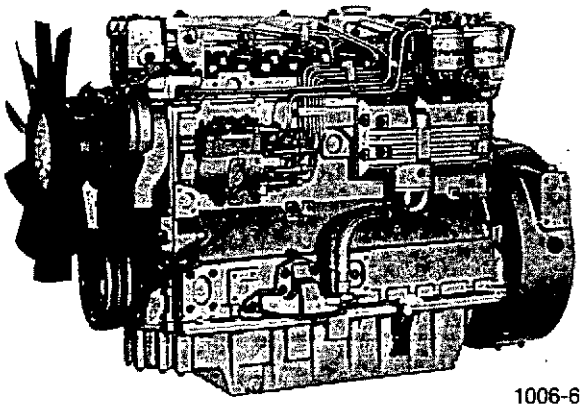


Phaser 110T



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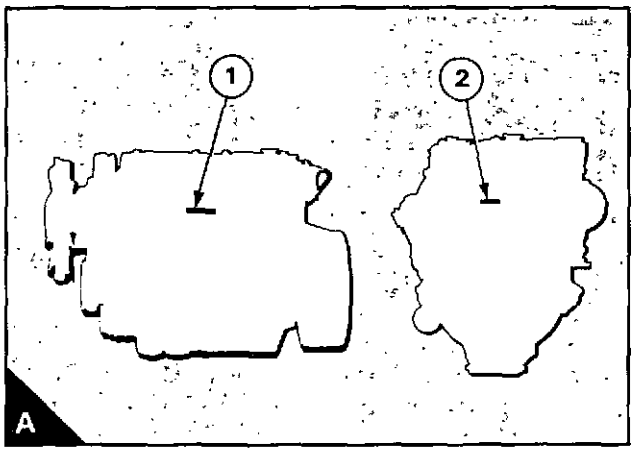
Engine identification



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

Phaser for vehicle and truck 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 90 - four cylinder engine rated at 87 bhp

Phaser 180Ti - six cylinder engine rated at 180 bhp

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

1006-6TW - six cylinder engine of six litres

Further information about the engine number system can be found in the relevant user's handbook.

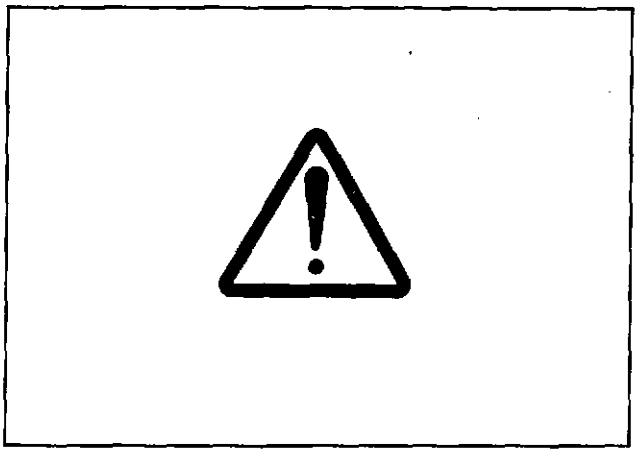
In this workshop manual, the different engine types are indicated by their code letters. These are the first two letters of the engine number as indicated below:

Code letters	Engine type
AA	Four cylinder, naturally aspirated
AB	Four cylinder, turbocharged
AC	Four cylinder, compensated
AD	Four cylinder, turbocharged/intercooled.
YA	Six cylinder, naturally aspirated
YB	Six cylinder, turbocharged
YC	Six cylinder, compensated
YD	Six cylinder, turbocharged/intercooled.

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.

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

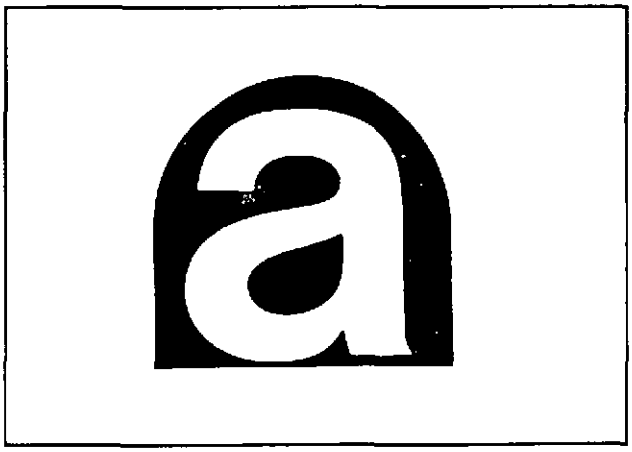
Safety precautions



These safety precautions are important. You must refer also to the local regulations in the country of use.

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine or equipment is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. **Attention:** The fan 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 operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not move mobile equipment if the brakes are not in good condition.
- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Read and use the instructions relevant to asbestos joints which are given on the next page.
- Fit only genuine Perkins parts.

Asbestos joints



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

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

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

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

Basic engine data 11A

Basic engine data

Number of cylinders:	
- AA, AB, AC, AD	4
- YA, YB, YC, YD	6
Cylinder arrangement	In-line
Cycle	Four stroke
Induction system:	
- AA, YA	Naturally aspirated
- AB, YB	Turbocharged
- AC, YC	Altitude compensated
- AD, YD	Turbocharged/intercooled
Combustion system	Direct injection
Nominal bore	100 mm (3.937 in)
Stroke	127 mm (5.000 in)
Compression ratio:	
- AA, AC, YA, YC	16.5:1
- AB, AD, YB, YD	16.0:1
Cubic capacity:	
- AA, AB, AC, AD	4 litres (243 in^3)
- YA, YB, YC, YD	6 litres (365 in^3)
Firing order	
- AA, AB, AC, AD	1, 3, 4, 2
- YA, YB, YC, YD	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):	
- AA, AC, YA, YC	207kN/m^2 (30lbf/in^2) 2,1kgf/cm^2
- AB, AD, YB, YD	280kN/m^2 (40lbf/in^2) 2,8kgf/cm^2
Direction of rotation	Clockwise from the front

Recommended torque tensions 11B

Recommended torque tensions

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 section 12		
Fasteners, rocker shaft brackets:				
- Aluminium bracket	M12	40	30	4,1
- Cast iron bracket	M12	75	55	7,6
Cap nuts, rocker cover	M12	20	15	2,1
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	27	20	2,8
Crankshaft assembly				
Setscrews, main bearings	5/8 UNF	265	196	27,0
Setscrews, crankshaft pulley	7/16 UNF	115	85	11,8
Cap screws, damper to crankshaft pulley	M8	35	26	3,6
Setscrews, rear oil seal housing to cylinder block	M8	22	16	2,2
Cap screws, 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	M10	30	22	3,1
Setscrews, oil pump to balancer frame	M8	22	16	2,2
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
	M10	44	33	4,5
Setscrews, hub of idler gear	M10	44	33	4,5
Setscrew, camshaft gear	M12	78	58	8,0
Setscrews, timing case cover to timing case	M8	22	16	2,2
Nuts, timing case cover to timing case	M8	22	16	2,2
Aspiration system				
Nuts, turbocharger to manifold	M10	44	33	4,5
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
Fuel system				
Nuts, high-pressure fuel pipes	M12	18	14	1,9
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
Nuts for flange of fuel injection pump	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	M8	22	16	2,2
	M10	44	33	4,5

Description	Thread size	Torque		
		Nm	lbf ft	kgf m
Flywheel and housing				
Setscrews, flywheel to crankshaft	1/2 UNF	105	77	10,7
Setscrews, flywheel housing to cylinder block	M10	44	33	4,5
	M12	75	55	7,6
Electrical equipment				
Nut, alternator pulley:				
- CAV AC5RA and AC5RS	5/8 UNF	55	40	5,6
- Lucas A127	M17	60	45	6,3
Fuelled start aid to induction manifold	7/8 UNF	31	23	3,1
Auxiliary equipment				
Nut, compressor drive gear:				
- 6,4 mm (0.25 in) thick nut	3/4 UNF	80	59	8,2
- 10 mm (0.4 in) thick nut	3/4 UNF	130	95	13,3
Nuts for gears of auxiliary drive assembly:				
- 6,4 mm (0.25 in) thick nut	3/4 UNF	80	59	8,2
- 10 mm (0.4 in) thick nut	3/4 UNF	130	95	13,3
	M20	130	95	13,3

Data and dimensions 11C

Introduction

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 assembly

Cylinder head

Angle of valve seat	46° (88° 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/in²) 2,04 kgf/cm²
Head thickness	102,79/103,59 mm (4.047/4.078 in)
Minimum permissible thickness after head face has been machined in service	102,48 mm (4.035 in)

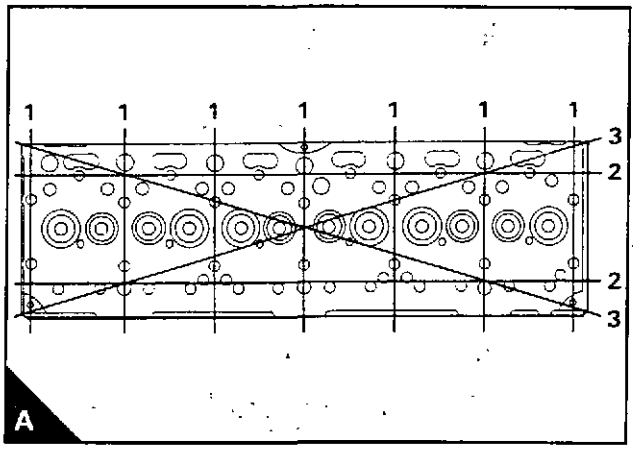
Maximum permissible distortion of cylinder head (A):

- AA,AB,AC,AD:

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

- YA,YB,YC,YD:

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



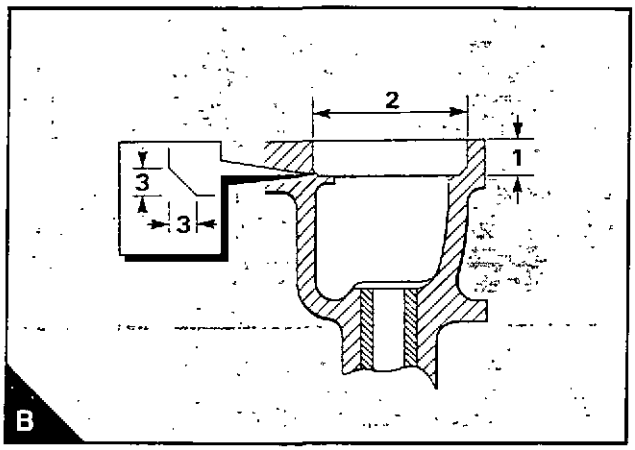
Dimensions of recesses for valve seat inserts (B):

- Inlet:

B1 7,19/7,32 mm (0.283/0.288 in)
B2 51,22/51,24 mm (2.0165/2.0175 in)
B3 Radius 0,38 mm (0.015 in) maximum

- Exhaust:

B1 9,52/9,65 mm (0.375/0.380 in)
B2 42,62/42,65 mm (1.6780/1.6790in)
B3 Radius 0,38 mm (0.015 in) Maximum



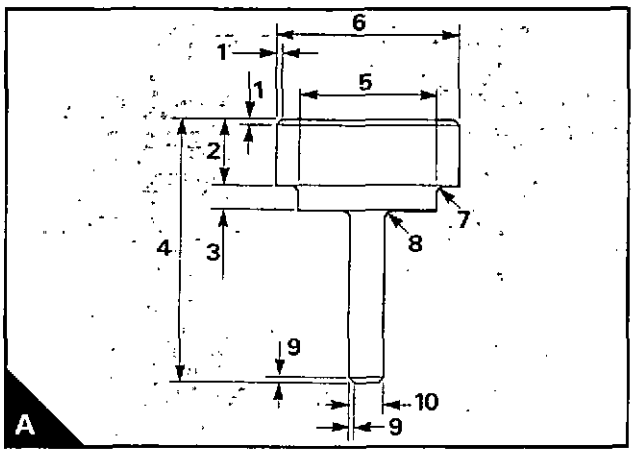
Valve seat insert tool (A):

- Inlet:

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)

- Exhaust:

A1 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

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)
Overall 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)

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 (0.0008/0.00039 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°
Depth of valve head below face of cylinder head:	
- Production limit	1,27/1,60 mm (0.050/0.063 in)
- Service limit	1,85 mm (0.073 in)
Overall length	122,66/123,07 mm (4.829/4.845 in)
Seal arrangement	Rubber seal fitted to valve guide

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°
Depth of valve head below face of cylinder head:	
- Production limit	1,28/1,83 mm (0.050/0.072 in)
- Service limit	2,08 mm (0.082 in)
Overall length	123,07/123,57 mm (4.845/4.865 in)
Seal arrangement	Rubber seal fitted to valve guide

Double valve springs - outer

Fitted length	35,8 mm (1.41 in)
Load at fitted length	176/195N (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	35,8 mm (1.41 in)
Load at fitted length	89/104N (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	312/344N (70.1/77.3 lbf) 31,8/35,1 lbf
Number of active coils	4.5
Number of damper coils	0
Direction of coils	Left hand

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 clearance between rocker lever and rocker shaft	0,13 mm (0.005 in)

Pistons and connecting rods

Pistons - AA, AC, YA, YC

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 - AB, AD, YB, YD

Type	"Quadram" combustion bowl, controlled expansion, inserted top ring groove, reduced diameter top land, anodised area on top face
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)

Piston rings - AA, AC, YA, YC

Top compression ring	Barrel face, molybdenum insert, with a 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	0,30/0,76 mm (0.012/0.030 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)

Piston rings - AB, AD, YB, YD

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	0,35/0,75 (0.014/0.030 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)

Connecting rods - AA, AC, YA, YC

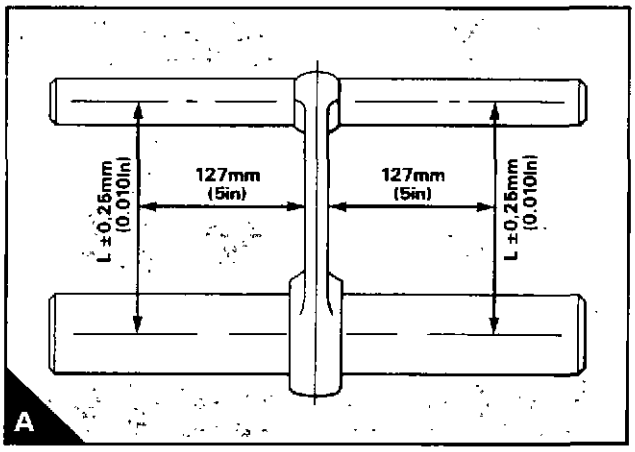
Type	"H" section, square shape small end
Location of cap to connecting rod	Serrations
Diameter of parent bore for big end	67,21/67,22 mm (2.6460/2.6465 in)
Diameter of parent bore for small end	38,89/38,92 mm (1.531/1.532 in)
Length between centres	219,05/219,10 mm (8.624/8.626 in)

Connecting rods - AB, AD, YB, YD

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	42,07/42,09 mm (1.656/1.657 in)
Length between centres	219,05/219,10 mm (8.624/8.626 in)

Connecting rod alignment (A)

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).



Gudgeon pins - AA, AC, YA, YC

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 - AB, AD, YB, YD

Type	Fully floating
Outside diameter	38,095/38,100 mm (1.4998/1.5000 in)
Clearance fit in piston boss	0,003/0,014 mm (0.0001/0.0006 in)

Small end bushes - AA, AC, YA, YC

Type	Steel back, lead bronze 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 - AB, AD, YB, YD

Type	Steel back, lead bronze bearing material
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)
Clearance between bush in small end and gudgeon pin	0,020/0,043 mm (0.0008/0.0017 in)

Connecting rod bearings

Type:	
- AA, AC, YA, YC	Steel back, aluminium-tin bearing material
- AB, AD, YB, YD	Steel back, lead bronze bearing material with lead finish
Width:	
- AA, AC, YA, YC	31,62/31,88 mm (1.245/1.255 in)
- AB, AD, YB, YD	31,55/31,88 mm (1.240/1.255 in)
Thickness	1,835/1,842 mm (0.0723/0.0725 in)
Inside diameter	63,525/63,548 mm (2.5010/2.5019 in)
Bearing clearance	0,025/0,076 mm (0.001/0.003 in)
Available undersize bearings	-0,25 mm (-0.010 in); -0,51 mm (-0.020 in); -0,76 mm (-0.030 in)

Piston cooling jets - AB, AD, YB, YD:

Valve open pressure	178/250 kPa (26/36 lbf/in$_2$) 1,8/2,6 kgf/cm$_2$

Crankshaft assembly

Crankshaft

Diameter of main journals	76,16/76,18 mm (2.998/2.999 in)
Maximum wear and ovality on journals and crank pins	0,04 mm (0.0016)
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:	
- AA, AB, AC, AD	20,22/20,98 mm (0.796/0.826 in)
- YA, YB, YC, YD	14,72/15,48 mm (0.579/0.609 in)
Bore of recess for spigot bearing:	
- AA, AB, AC, AD	46,96/46,99 mm (1.849/1.850 in)
- YA, YB, YC, YD	51,97/51,99 mm (2.046/2.047 in)
Crankshaft end-float	0,05/0,38 mm (0.002/0.015 in)
Maximum 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 and 3131H024
- Nitrocarburised	Part numbers 31315661, 31315991 and 3131H022

Crankshaft overhaul

Induction hardened crankshafts 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.

Check the crankshaft for cracks before and after it is ground. Demagnetise the crankshaft after it has been checked for cracks.

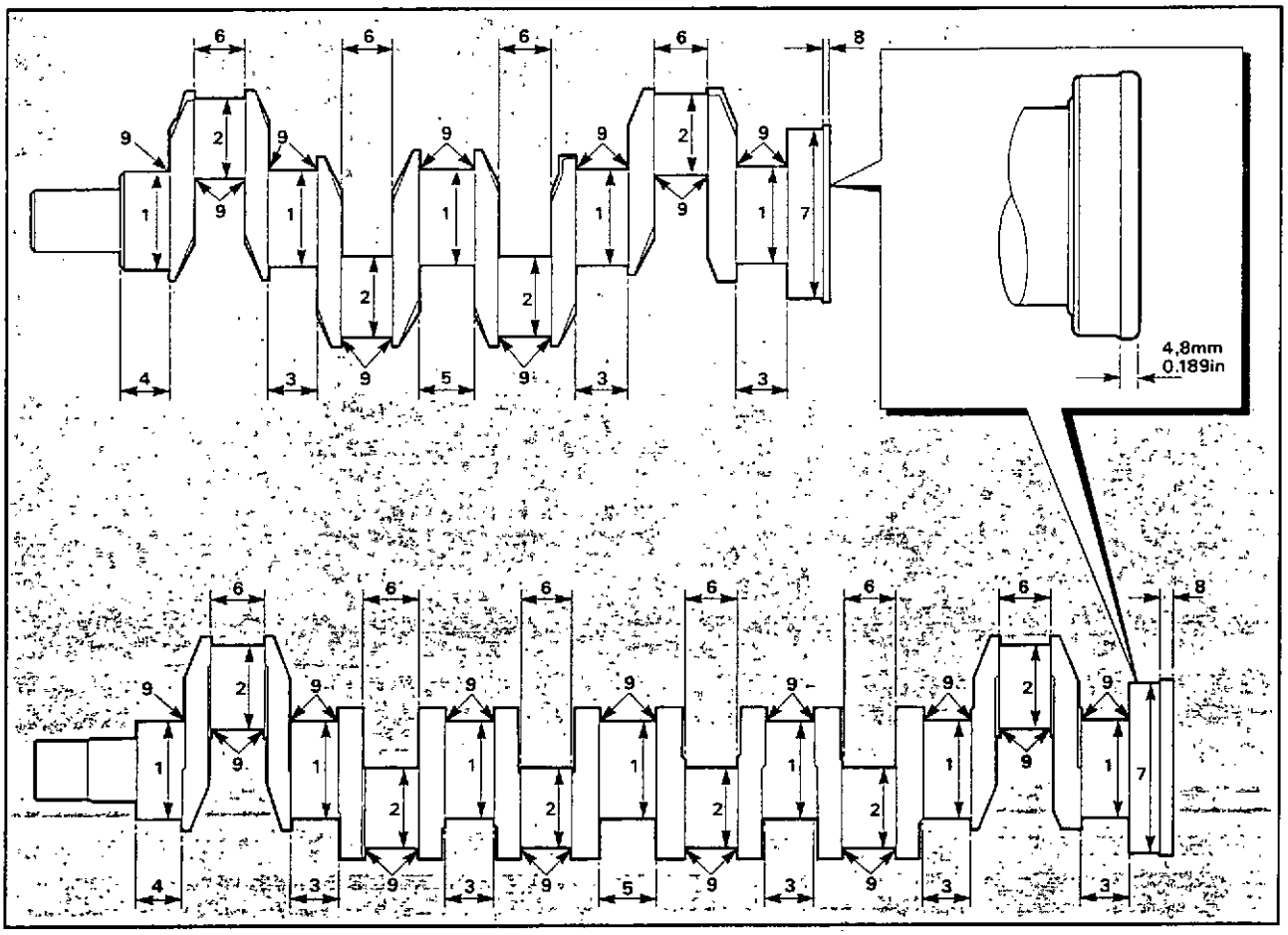
After the crankshaft has been machined remove any sharp corners from the lubricating oil holes.

Surface finish and fillet radii must be maintained.

The finished sizes for crankshafts which have been ground undersize are given below.

Item	Undersize		
	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 (1.759 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 and crankpins must be 0,4 microns (16 micro inches).
Surface finish for radii must be 1,3 microns (51 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 engines
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.

Main bearings

Type:
- AA, AB, AC, AD:
All bearings ... Steel back, 20% tin-aluminium bearing material

- YA, YB, YC, YD:
Centre bearing ... Steel back, lead bronze bearing material with lead finish

All other bearings ... Steel back, 20% tin-aluminium bearing material

Bearing width:
- AA, AB, AC, AD:
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)

- YA, YB, YC, YD:
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:
- AA,AB,AC,AD:
All bearings ... 2,083/2,089 mm (0.0820/0.0823 in)

- YA,YB,YC,YD:
Centre bearing ... 2,087/2,096 mm (0.0822/0.0825 in)

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

Inside diameter ... 76,23/76,27 mm (3.0010/3.0025 in)

Bearing clearance ... 0,046/0,107 mm (0.0018/0.0042 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)
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:	
- AA, AB, AC, AD	49,95/49,98 mm (1.9665/1.9675 in)
- YA, YB, YC, YD	50,20/50,23 mm (1.9765/1.9775 in)
Diameter of number 4 journal:	
- YA, YB, YC, YD	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 ovality and wear on journals	0,05 mm (0.021 in)
End-float:	
- Production limit	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°
Clearance fit of thrust washer in recess in cylinder block	5,41/5,49 mm (0.213/0.216 in)
Thickness of thrust washer	5,49/5,54 mm (0.216/0.218 in)
Protrusion of thrust washer beyond the front face of cylinder block	0,00/0,13 mm (0.000/0.005 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	Tapered

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 (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)
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)	50,80/50,82 mm (1.9998/2.0007 in)
Outside diameter of hub	50,70/50,74 mm (1.9960/1.9975 in)
Clearance of bushes on hub	0,058/0,119 mm (0.0023/0.0047 in)
End float of gear:	
- Production limit	0,10/0,20 (0.004/0.008 in)
- Service limit	0,38 mm (0.015 in)
Backlash for all gears	0,08 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:	
- AA, AB, AC, AD:	
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)
- YA, YB, YC, YD:	
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
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)	100,04/100,06 mm (3.9385/3.9395 in)
Maximum 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

Aspiration system

Turbocharger

Make and type of turbocharger fitted:	
- AB	Airsearch T31 or Schwitzer S2A
- AC	Airesearch T25
- AD	Schwitzer S2A
- YB	Airesearch T04B
- YD	Schwitzer S76

Lubrication system

Lubricating oil pump - AA, AB, AC, AD

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 - YA, YB, YC, YD

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 YB, YD:	
- Inner rotor	0,043/0,118 mm (0.0017/0.0046 in)
- Outer rotor	0,031/0,106 mm (0.0012/0.0042 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):	
- AA, AB, AC, AD	59,8 mm (2.4 in)
- YA, YB, YC, YD	55,6 mm (2.2 in)
Load on spring (fitted):	
- AA, AB, AC, AD	18,9/20,1 N (4.3/4.5 lbf) 1,9/2,1 kgf
- YA, YB, YC, YD	15,2/16,2 N (3.4/3.6 lbf) 1,6/1,7 kgf
Pressure to open valve:	
- AA, AC	360/415 kPa (52/60 lbf/in²) 3,7/4,2 kgf/cm²
- AB, AD	435/490 kPa (63/71 lbf/in²) 4,4/5,0 kgf/cm²
- YA, YB, YC, YD	345/414 kPa (50/60 lbf/in²) 3,5/4,2 kgf/cm²

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):	
- AA, AC	25/29 N (5.6/6.5 lbf) 2,6/2,9 kgf
- AB, AD	34/38 N (7.6/8.5 lbf) 3,5/3,9 kgf
Pressure to open valve:	
- AA, AA	414 kPa (60 lbf/in²) 4,2 kgf/cm²
- AB, AD	523 kPa (76 lbf/in²) 5,3 kgf/cm²

Oil filter

Type	Full flow, screw-on type canister
Pressure to open by-pass valve in filter	55/83 kPa (8/12 lbf/in²) 0,6/0,8 kgf/cm²
Pressure to open by-pass valve in oil cooler	172 kPa (25 lbf/in²) 1,8 kgf/cm²

Fuel system

Bosch fuel injection pump

Type ... ... EPVE

Direction of rotation from drive end ... ... Clockwise

Outlet for number 1 cylinder ... ... "C"

Static timing:

The engine check angle must be used with special tool MS678 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 data plate which is fastened to the fuel injection pump. 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 degrees before TDC	Piston displacement	
				mm	in
BK	308	314	12	1,78	0.070
CK	308	314	12	1,78	0.070
DK	307	313	12	1,78	0.070
EK	308 1/2	315 1/2	14	2,42	0.095
FM	288 3/4	295	12 1/2	1,93	0.076

CAV 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 MS67B and with the engine set with number 1 piston at top dead centre (TDC) on 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. 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	324 1/2	336
AM	282 1/4	292
BM	282 1/4	290 1/2
CM	282 1/4	290
DM	282 1/4	290 1/2

Atomisers

Code	Holder	Nozzle	Set and reset pressure		
			atm	(lbf/in²)	MPa
HV	LRB67014	JB6801052	250	3675	25,3
HZ	LRB67014	JB6801029	220	3234	22,3
JB	LRB67014	JB6801058	250	3675	25,3
JE	LRB67014	JB6801058	220	3234	22,3
JF	LRB67032	JB6801052	250	3675	25,3
JG	LRB67032	JB6801058	230	3381	23,3
RD	KBEL66S45	DLLA140S1039	250	3675	25,3
RE	KBEL66S47	DLLA150S1055	250	3675	25,3
RF	KBEL66S47	DLLA150S1072	250	3675	25,3
RH	KBEL66S47	DLLA150S1087	250	3675	25,3

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

Fuel lift pump - AA, AB, AC, AD

Type	A.C.Delco, type XD
Method of drive	Eccentric on camshaft
Static pressure (no delivery)	42/70 kPa (6/10 lbf/in²) 0,4/0,7 kgf/cm²

Fuel lift pump - YA, YB, YC, YD

Type	A.C.Delco, type LU
Method of drive	Eccentric on camshaft
Static pressure (no delivery)	34,5/55,2 kPa (5/8 lbf/in²) 0,35/0,56 kgf/cm²
Test pressure (75% of minimum static pressure)	26 kPa (3.75 lbf/in²) 0,26 kgf/cm²

Fuel filter

Type	Twin parallel flow or single element

Cooling system

Water pump

Type	Centrifugal, gear driven
Outside diameter of shaft	15,91/15,92 mm (0.6262/0.6257 in)
Diameter of bore of drive gear	15,88/15,89 mm (0.6253/0.6257 in)
Interference fit of drive gear on shaft	0,02/0,04 mm (0.0008/0.0014 in)
Diameter of bore of impeller	15,87/15,89 mm (0.6249/0.6257 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)	8,1/8,5 mm (0.319./0.335 in)
Dimension of gear from rear face of pump body (fitted)	0,6/2,6 mm (0.024/0.102 in)

Thermostat

Type:	
- AA, AB, AC, AD	Single, wax pellet, by-pass blanking
- YA, YB, YC, YD	Twin, wax pellet, by-pass blanking
"Start to open" temperature	77°/85°C (170°/185°F)
"Fully open" temperature	92°/98°C (198°/208°F)
Valve lift, fully open	9,1 mm (0.358 in)

Fan drive housing

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 mmm (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)

Flywheel and 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
Up to 362	Up to 14.25	0,15	0.006
362 to 511	14.25 to 20.125	0,20	0.008
511 to 648	20.125 to 25.50	0,25	0.010
Over 648	Over 25.50	0,30	0.012

Electrical equipment

The information which follows is general and can change with individual applications.

Alternators

Make and type	CAV AC5RA, CAV AC5RS or Lucas A127
Rating:	
- AC5RA and AC5RS	12V/60A or 24V/40A
- A127	12V/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 20°C (68°F):	
- 12V	0.0017 ohms
- 24V	0.0034 ohms

Starting aid

Type	Fuel fed, electrically operated heater
Voltage	12V (dropping resistor used on 24V system)
Flow rate of fuel through starting aid	3,5/5,9 ml/min

Auxiliary equipment

Compressor drive assembly

Number of teeth on idler gears	27
Number of teeth on compressor drive gear	26
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 (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 (0.0007/0.0022in)
Inside diameter of rear bush	15,875/15,900 mm (0.625/0.626 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)
Inside diameter of drive gear	23,750/23,775 mm (0.9350/0.9360 in)
Outside diameter of compressor drive shaft	23,753/23,765 mm (0.9352/0.9356 in)
Transition fit of gear on shaft	−0,015/+0,022 mm (−0.0006/+0.0009 in)
Bore for bush	19,000/19,030 mm (0.7480/0.7492 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)

Cylinder head assembly 12

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.

The valves move in phosphated guides which can be renewed. The exhaust valve guide has a counter bore 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.

Engine types AB, AD, YB and YD have valve seat inserts fitted in the cylinder head for both inlet and exhaust valves. Engine types AA, AC, YA and YC do not have valve seat inserts, but they can be fitted in service.

Rocker cover

To remove and to fit 12A-01

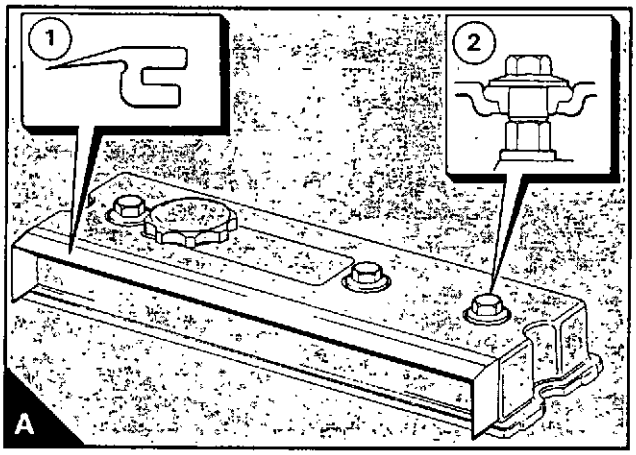
To remove

1 Disconnect the breather pipe.

2 Remove the cap nuts and the sealing washers from the top of the rocker cover.

3 Lift off the rocker cover and the joint together with the rocker cover seal, which is fitted between the rocker cover and the induction manifold.

4 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 and these nuts should be checked for tightness every time the cover is removed.



To fit

1 Check the condition of the rocker cover joint and the sealing washers and clean the joint face of the cylinder head. If necessary, the joint can be removed and a new joint fitted with a suitable adhesive.

2 Fit the rocker cover together with the seal (A1) which is fitted between the rocker cover and the induction manifold. Fit the seals and the cap nuts (A2). Tighten the cap nuts to 20 Nm (15 lbf ft) 2,1 kgf m. If the cap nuts are tightened too much the cap nuts can fasten on the nuts for the rocker shaft brackets.

Rocker assembly

To remove and to fit 12A-02

To remove

1 Remove the rocker cover, operation 12A-01.

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.

3 Remove the rubber oil seal (B) from the oil supply connection or 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.

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 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. Ensure that all the fasteners are tightened evenly to the correct torque, see section 11B.

To dismantle and to assemble 12A-03

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 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 for the oil supply connection is fitted correctly in the rocker shaft. Fit the clips to the ends of the rocker shaft.

To inspect and to correct 12A-04

To inspect

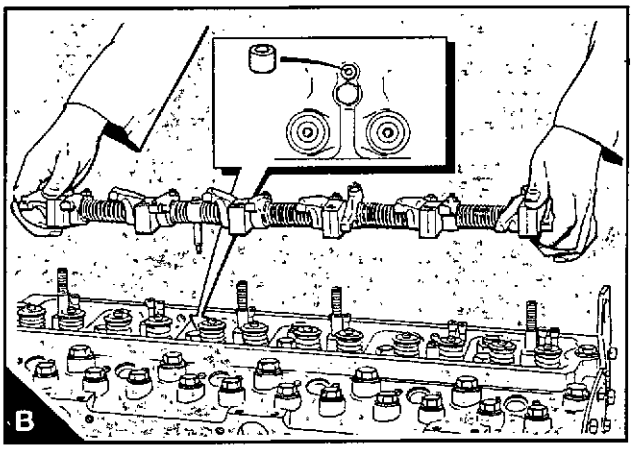
1 Clean and inspect all the components for wear and any other damage. Check the clearance of the rocker levers on the rocker shaft. If the clearance is larger than 0,13 mm (0.005 in), renew the rocker lever bush and/or the rocker shaft.

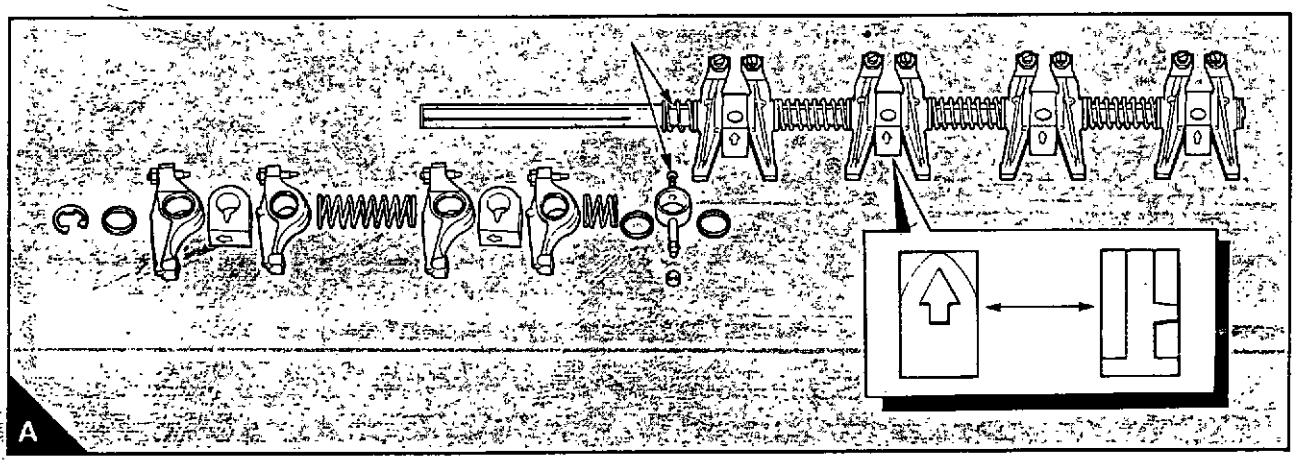
To correct

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

2 Press in the new bush with the lubrication hole in the bush on the same side as that in the rocker lever and aligned with it.

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).





Valve tip clearances

To check and to adjust **12A-05**

The valve tip clearance is measured between the top of the valve stem and the rocker lever (A). With the engine 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. See B for the position of the valves.

Attention: Number 1 cylinder is at the front of the engine.

Four cylinder engines

1 Turn the crankshaft in the normal direction of rotation until the inlet valve of number 4 cylinder has just opened and the exhaust valve of the same cyliner has not fully closed. Check the clearances of the valves of number 1 cylinder and adjust them, if necessary.

2 With the valves of number 2 cylinder set as indicated above for number 4 cylinder, check/adjust the clearances of the valves of number 3 cylinder.

3 With the valves of number 1 cylinder set, check/adjust the clearance of the valves of number 4 cylinder.

4 With the valves of number 3 cylinder set, check/adjust the clearances of the valves of number 2 cylinder.

Six cylinder engines

1 Turn the crankshaft in the normal direction of rotation until the inlet valve of number 6 cylinder has just opened and the exhaust valve of the same cylinder has not fully closed. Check the clearances of the valves of number 1 cylinder and adjust them, if necessary.

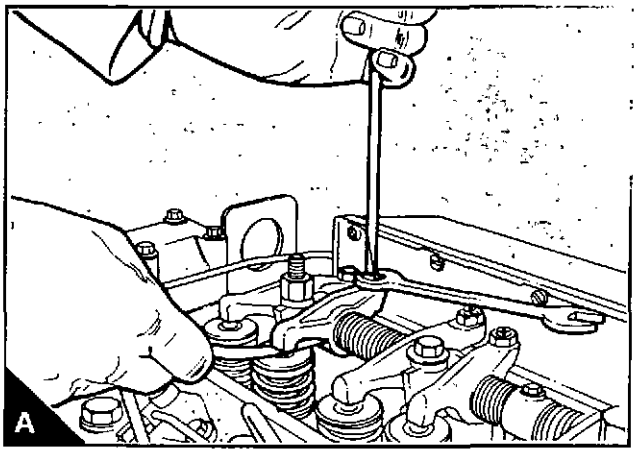
2 With the valves of number 2 cylinder set as indicated above for number 6 cylinder, check/adjust the clearances of the valves of number 5 cylinder.

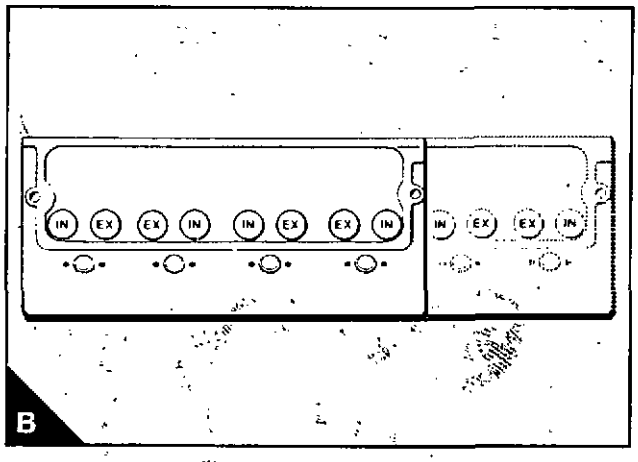
3 With the valves of number 4 cylinder set, check/adjust the clearances of the valves of number 3 cylinder.

4 With the valves of number 1 cylinder set, check/adjust the clearances of the valves of number 6 cylinder.

5 With the valves of number 5 cylinder set, check/adjust the clearances of the valves of number 2 cylinder.

6 With the valves of number 3 cylinder set, check/adjust the clearances of the valves of number 4 cylinder.





Valve springs

To change the valve springs (with cylinder head fitted) 12A-06

Special tools:
Valve spring compressor, PD.6118B
Stud adaptor for use with PD.6118B, PD.6118-7
Setscrew adaptor for use with PD.6118B, PD.6118-8

Paragraphs 1 to 12 refer to a change of valve springs for a single cylinder.

1 Remove the rocker cover, operation 12A-01.

2 Turn 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, operation 12A-02.

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.

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

Attention: Do not turn the crankshaft while the valve springs are removed.

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 (12A.10/A).

8 Fit the valve spring caps.

9 Fit the valve spring compressor, compress the valve springs and fit the collets. Ensure that the valve springs are compressed squarely or damage can occur to the valve stem. Remove the valve spring compressor.

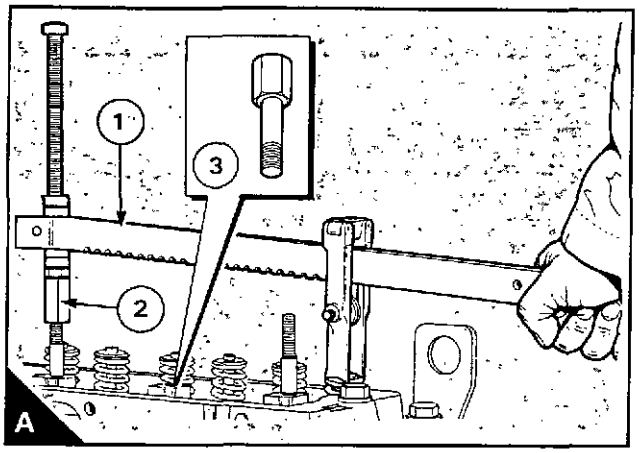
10 Fit the rocker assembly, operation 12A-02.

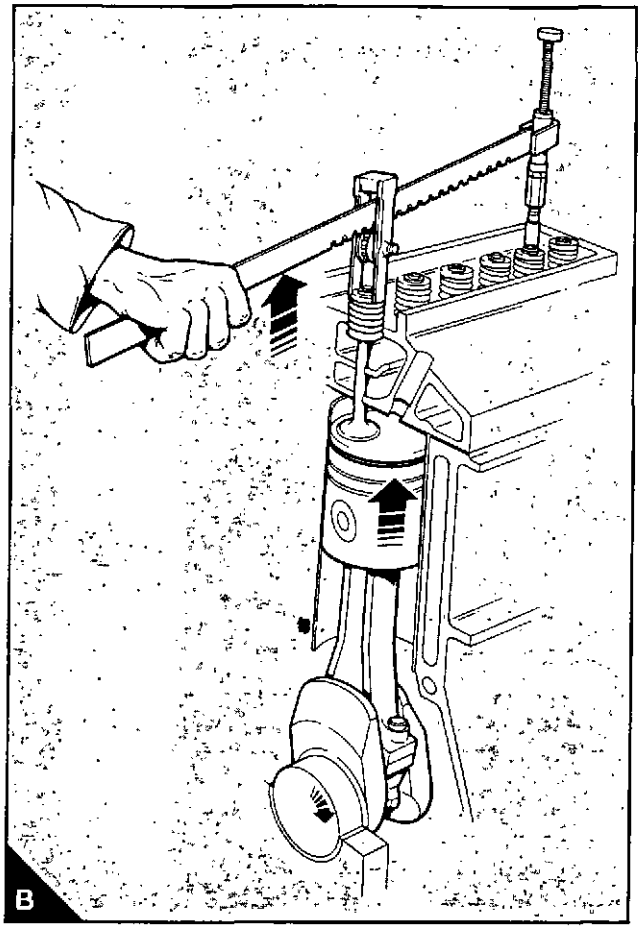
11 Check the valve tip clearances, operation 12A-05.

12 Fit the rocker cover, operation 12A-01.

If other or all of the valve springs are to be changed, they can be changed two cylinders at a time. The pairs of cylinders are: engine types AA, AB, AC and AD - 1 and 4, 2 and 3; engine types YA, YB, YC and YD - 1 and 6, 2 and 5, 3 and 4.

If the rocker assembly has been removed, piston TDC can be found as follows: Fit the valve spring compressor and compress the valve springs to open the valve. Turn the crankshaft, by hand, in the normal direction of rotation until the piston touches the valve. Continue to turn 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 and to fit — 12A-07

To remove

1 Drain the cooling system.

2 Disconnect the battery terminals.

3 Engine types AA and YA: Remove the air filter/cleaner hose at the induction manifold.

Engine types AB, AC, AD, YB, YC and YD: Remove the air filter/cleaner hose at the compressor inlet of the turbocharger.

4 Remove the pipe which is fitted between the cold start device in the induction manifold and the fuel filter. Disconnect the electrical connection.

5 Engine types AB, AD, YB and YD: Remove the boost control pipe which is fitted between the front of the induction manifold and the fuel injection pump.

6 Remove the induction manifold.

7 Engine types AB, AC, AD, YB, YC and YD: Disconnect all connections to the turbocharger and remove the turbocharger, operation 18A-01.

8 Remove the exhaust manifold.

9 Remove the low pressure fuel pipes which are fitted between the fuel injection pump and the fuel filter. Where a Bosch fuel injection pump is fitted, keep the fuel outlet banjo bolt with the fuel injection pump. Remove the fuel pipe fitted between the fuel lift pump and the fuel filter. Remove the fuel filter bracket together with the fuel filter.

10 Remove the high pressure fuel pipes. Where a Bosch fuel injection pump is fitted, 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.

11 Remove the atomiser leak-off pipe.

12 Remove the atomisers, operation 20A-02. Fit suitable covers to the nozzles and the open connections.

13 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.

14 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.

15 Disconnect the coolant temperature sender unit.

16 Engine types AB, AD and certain AA: Remove the oil cooler, operation 21A-07A.

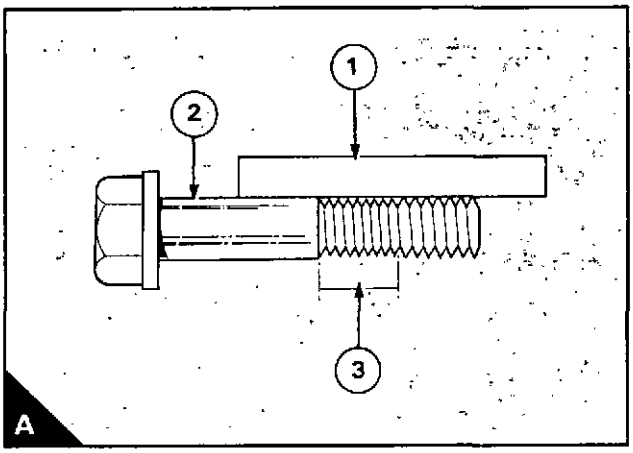
17 Remove the rocker cover, operation 12A-01.

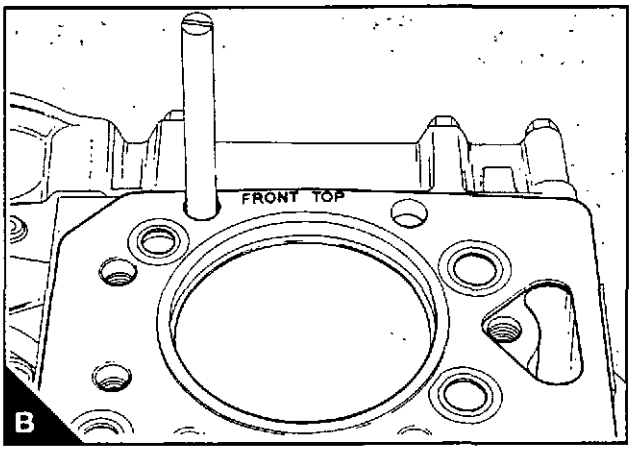
18 Remove the rocker assembly, operation 12A-02.

19 Remove the push rods.

20 Release the cylinder head setscrews evenly and gradually in the reverse sequence to that shown in 12A.08/A or B. Check the setscrews for distortion with a straight edge (A1) held along the setscrew (A2). If there is a visual reduction in the diameter of the thread that has not been in engagement with the cylinder block (A3), the setscrew must be discarded.

21 Remove the cylinder head and put it on a surface that will not damage the face of the cylinder head. Do not use a lever to separate the cylinder head from the cylinder block.





To fit

Special tools:

Angle gauge, to tighten cylinder head setscrews, MS.1531

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.

2 Put the cylinder head gasket in position; the cylinder head gasket must be fitted without jointing compound. It is stamped "FRONT TOP" for correct assembly (12A.07/B).

3 To hold the gasket in the correct position when the cylinder head is fitted, fit two suitable 1/2 UNF studs (C) in positions 15 and 20 (B) or positions 25 and 30 (A). Put the cylinder head in position.

4 Lightly lubricate the setscrew threads and the thrust faces of the setscrew heads. Engage some of the setscrews in their correct positions (A or B) 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 in the sequence shown in A or B.

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

7 Tighten the setscrews, in the correct sequence, a further part of a turn according to the length of the setscrews, see A or 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 (D) can be used for this operation. Fit the tool between the socket and the handle. Position the stop (D1) against a suitable protrusion on the cylinder head to prevent movement of the degree dial in a clockwise direction. Turn the pointer to align with the zero mark on the degree dial. Tighten the setscrew until the pointer on the tool is at the correct angle for the length of setscrew.

If no tool is available, make a suitable mark on the cylinder head in line with a corner of each setscrew, see 12A.09/A. 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.

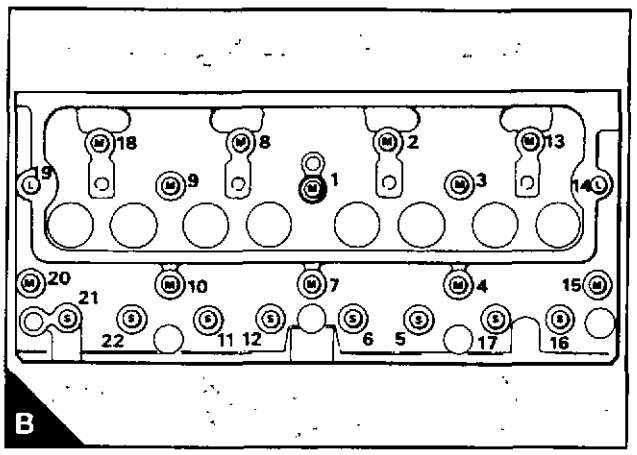
Tighten each setscrew in the correct sequence until the marks on the flange are next to, and in line with, the marks on the cylinder head.

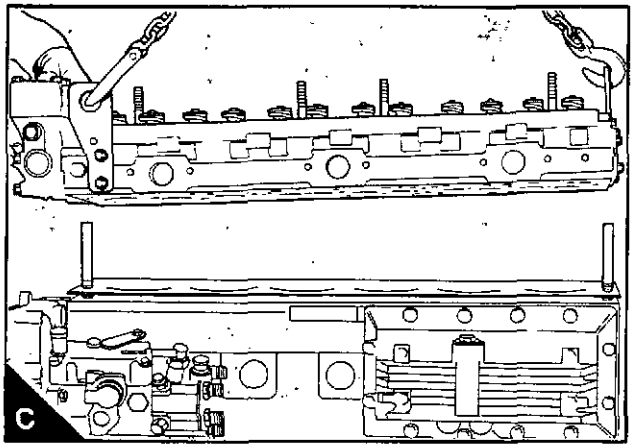
8 Put the push rods in position. Ensure that the end of each push rod fits correctly in the tappet socket.

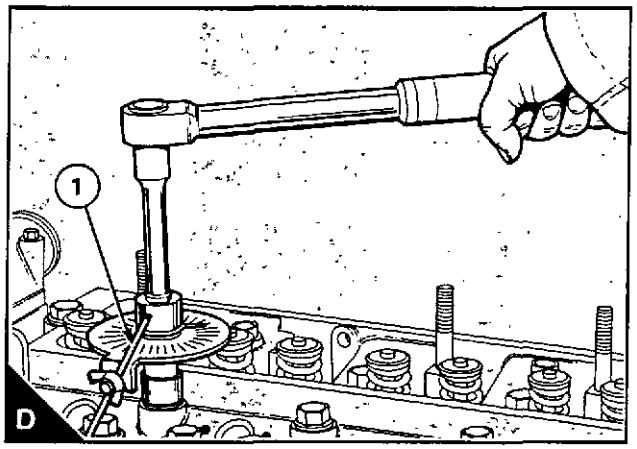
9 Fit the rocker assembly, operation 12A-01.

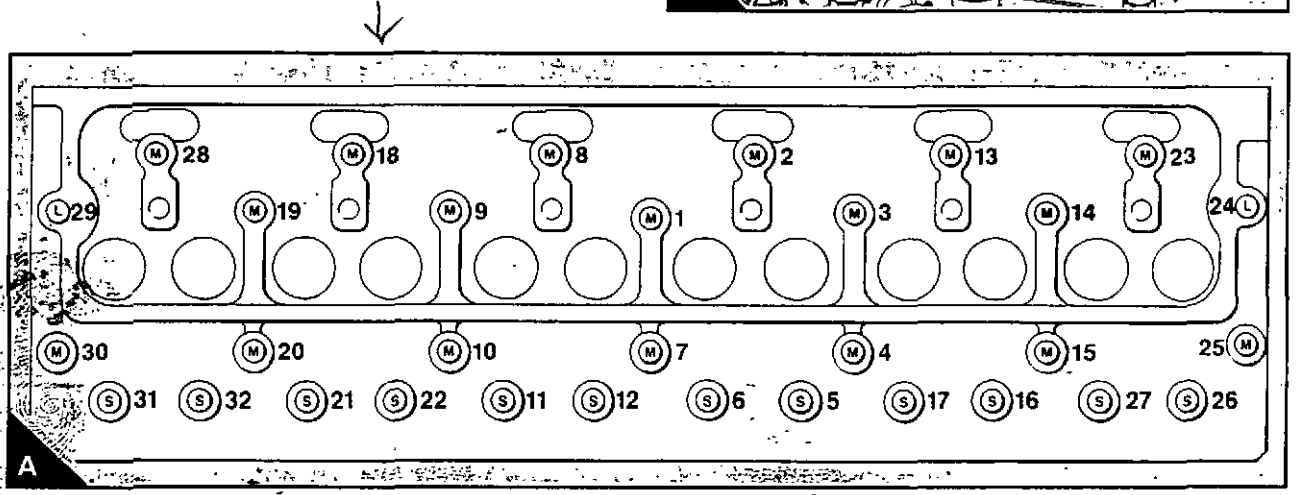
10 Set the valve tip clearances, operation 12A-05.

11 Fit the atomisers, operation 20A-02.









12 Fit the high-pressure fuel pipes; tighten the connection nuts to 18 Nm (14 lbf ft) 1,9 kgfm. Where a Bosch fuel injection pump is fitted, ensure that a separate spanner is used to prevent movement of the fuel injection pump outlets.

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 Engine types AB, AD and certain AA: Fit the oil cooler, operation 21A-07A.

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

18 Engine types AB, AC, AD, YB, YC and YD: Fit the turbocharger, operation 18A-01.

19 Engine types AA, AB, AC and AD: 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 (B). The manifold joint for the centre position can be fitted either way. Fit the joints without jointing compound.

Engine types YA, YB, YC and YD: Fit the induction manifold. Ensure that the joints are fitted with the notch at the top and the straight edge towards the centre (C). Fit the joints without jointing compound.

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 cold start device in the induction manifold. Connect the electrical connection to the cold start device.

22 Engine types AB, AD, YB and YD: Fit the boost control pipe between the front of the induction manifold and 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.

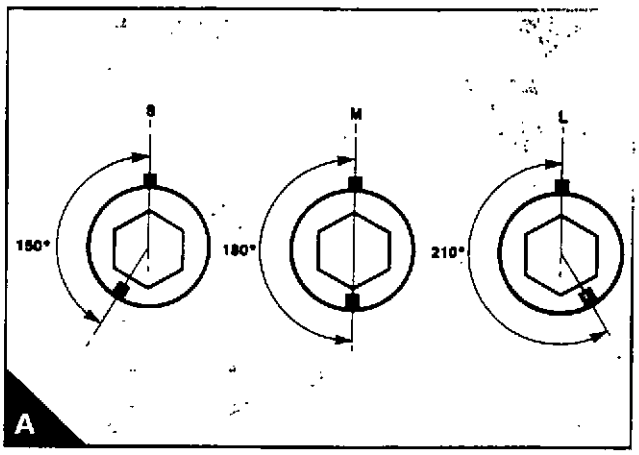
26 Connect the air filter/cleaner.

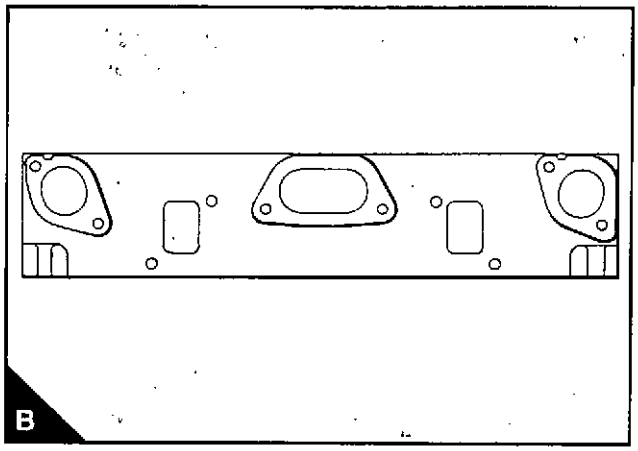
27 Connect the battery.

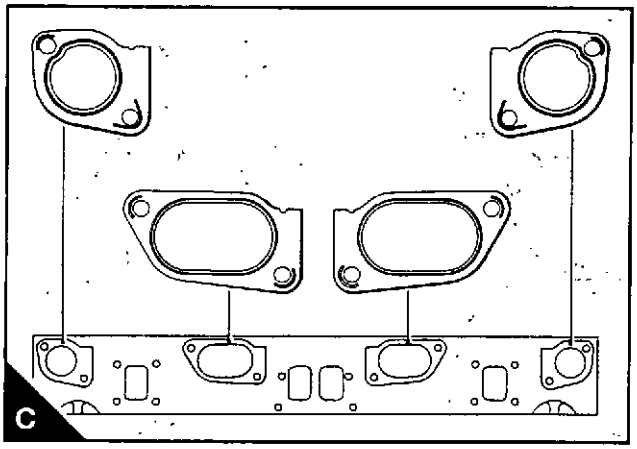
28 Eliminate air from the fuel system, operation 20A-08A or 20A-08B.

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, operation 12A-01.

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 and to fit — 12A-08

Special tools:

Valve spring compressor, PD.6118B
Stud adaptor, PD.6118-7
Setscrew adaptor, PD.6118-8

To remove

1 Remove the cylinder head, operation 12A-07.

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 12A-09.

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.

4 Use the valve spring compressor and the relevant adaptor to compress the valve spring(s) and remove the collets. Ensure that the valve springs are compressed squarely or damage can occur to the valve stem.

5 Release the valve spring compressor and remove the valve spring cap, valve spring(s), valve stem seal and the valve seat washer.

6 Repeat items 4 and 5 for the other valves.

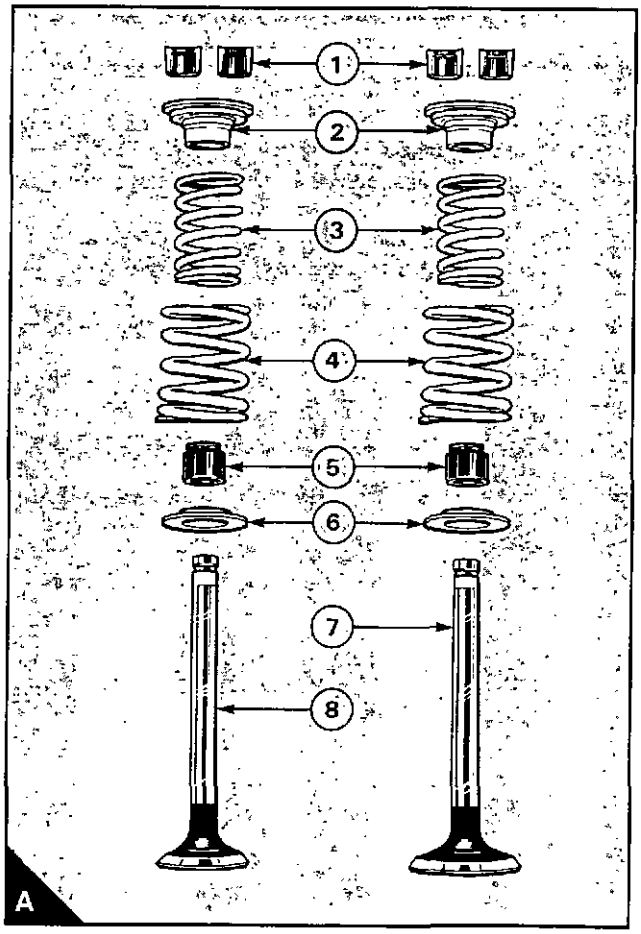
To fit

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

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

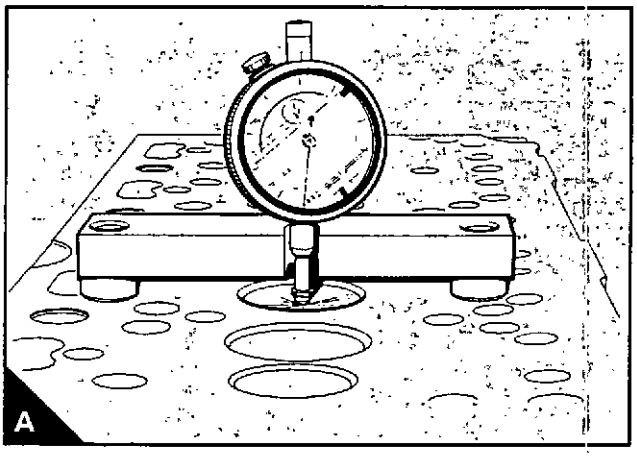
2 Fit the spring seat washers (A6). Fit new valve stem seals (A5) on the valve guides. If double valve springs are used, fit the inner and outer valve springs (A3 and A4) on the spring seat washers with their damper coils toward the cylinder head. If single valve springs are used, the spring does not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

3 Use the valve spring compressor and the relevant adaptor to compress the valve spring(s) and fit the collets (A1). Ensure that the valve springs are compressed squarely or damage can occur to the valve stem.



To inspect and to correct 12A-09

Special tool:
Gauge, valve depth, PD.41D
Dial gauge for use with PD.41D, PD.208



1 Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Ensure that the heads of the valves and the bottom face of the cylinder head are clean. Put the valve depth tool on the face of the cylinder head and zero the dial gauge. Carefully put the valve depth tool in position over the head of each valve (A) and make a note of the measurement. In service the maximum depth for the inlet valve is 1,85 mm (0.073 in) and for the exhaust valve it is 2,08 mm (0.082 in). 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. 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, operation 12A-14.

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

3 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 little damage can be lapped to their valve seats. When new valves are fitted, the valve depths must be checked, see paragraph 1.

4 Check that the load on the valve springs is correct at their fitted length, see section 11C.

– Fit new valve springs at every complete engine overhaul.

Valve guides

To inspect — 12A-10

Check the valve guides for wear. The maximum clearance 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 must be fitted.

To remove and to fit — 12A-11

Special tools:
Remover/replacer for valve guides (main tool), PD.1D
Adaptor for use with PD.1D, PD.1D-1A
Adaptor for use with PD.1D and PD.1D-1A, PD.1C-6

To remove

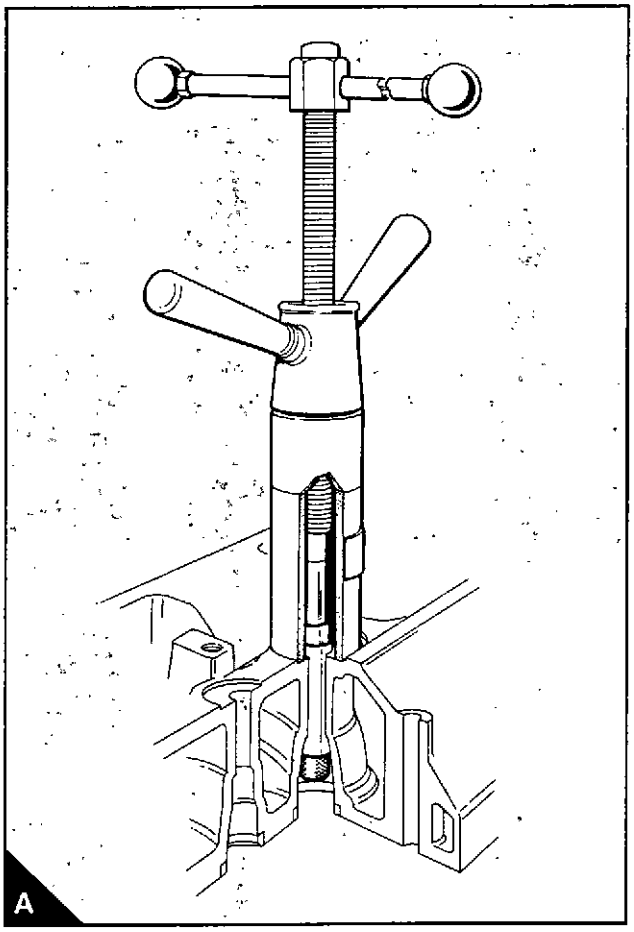
Fit the removal and replacement tool and the adaptor and pull the valve guide out of the cylinder head (A).

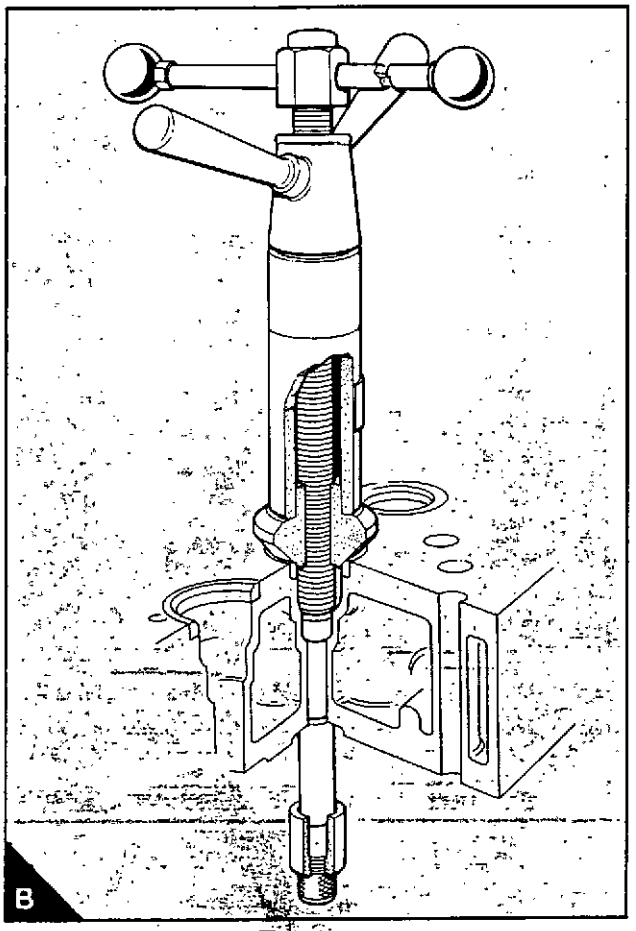
To fit

1 Clean the parent bore for the valve guide.

2 Lubricate the outer surface of the new guide with clean engine lubricating oil.

3 Fit the valve guide with the reduced diameter for the valve stem seal at the top. Use the tool, adaptor and distance piece to pull the valve guide into the cylinder head (B). When 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 — 12A-12

1 Remove the cylinder head assembly, operation 12A-07.

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, operation 12A-08.

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 section 11C.

7 When the cylinder head is thoroughly clean, check it for cracks. Examine 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 paragraph 9; there are deep scratches; or, for engines types AA, AC, YA, and YC, 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 section 11C. If the distortion is more than the limit given in section 11C, the bottom face can be machined. Remove only the minimum material and ensure that the thickness of the cylinder head will not be less than 120,48 mm (4.035 in) after the cylinder head has been machined.

Attention: After the cylinder head has been machined the valve seats must be corrected to give the correct valve head depth. It is advisable to 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, ensure that there is no wear on the valve guides, see section 11C. If the valve guide wear is more than the limit, then the valve guide must be renewed, operation 12A-11.

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, operation 12A-13, or new inserts can be fitted, operation 12A-14.

To correct a valve seat with a valve seat cutter — 12A-13

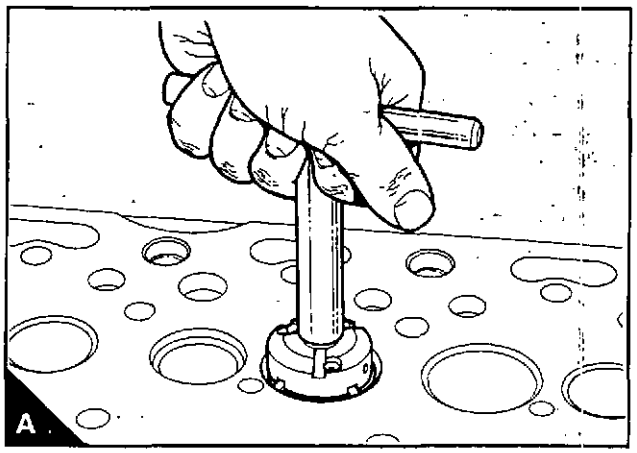
Special tools:

Cutter for inlet valve seats, MS.281*
Cutter for exhaust valve seats, MS.275*
Pilot for use with valve seat cutters, MS.150-9.5*
Handle set for use with valve seat cutters, MS.67B*
* Included in set of adjustable cutters for valve seats, MS.73A

1 If the valve guide is worn, renew it, operation 12A-11.

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

3 Select the relevant cutter. Set 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, see section 11C.

If a valve seat has become too damaged or too worn, a valve seat insert can be fitted to engines types AA, AC, YA and YC. Engines types AB, AD, YB and YD have valve seat inserts fitted as standard and these inserts can be renewed.

To fit valve seat inserts — 12A-14

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

2 Fit new valve guides, operation 12A-11.

3 With the bore of the new valve guide used as a pilot, machine the recess in the cylinder head to the dimensions shown in section 11C, 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 tool shown in section 11C. 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° operation 12A-09, and lightly lap the valve and the valve seat. Ensure that the depth of the valve head below the face of the cylinder head is within the production limits, see section 11C. Work as near as possible to the minimum figure to allow for future wear on the valve seat.

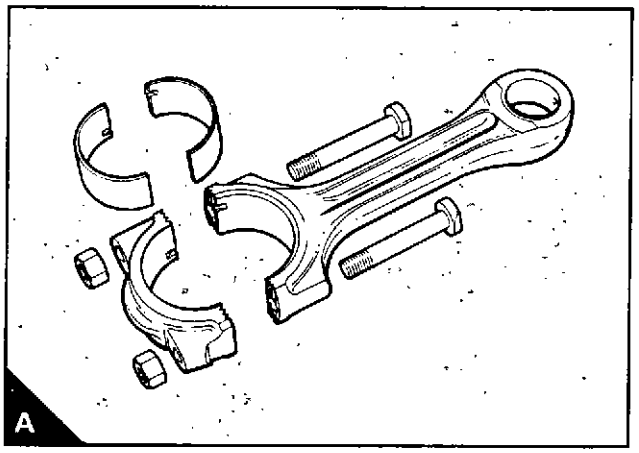
Piston and connecting rod assemblies 13

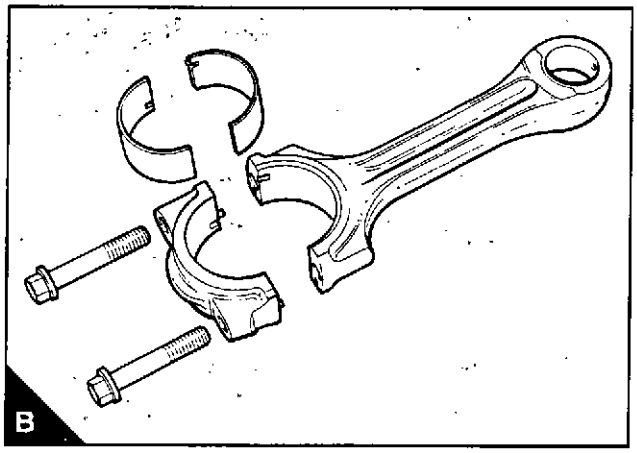
General description

The "Quadram" combustion chamber in the top of the piston is specially designed to give an efficient mix of fuel and air.

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. There is a steel insert in the piston skirt to control piston expansion. Engine types AB, AD, YB and YD have pistons with a reduced diameter above the groove for the top ring and an "anodised" area on the top face of the piston. These engine types also have cooling jets fitted in the cylinder block to spray lubricating oil onto the inner surface of the piston.

The connecting rods are machined from "H"section forgings of molybdenum steel. Generally, the location of the bearing caps to the connecting rods is made by serrations and the cap is retained by two nuts and bolts (A). For engines types AB, AD, YB and YD used in vehicle applications the location of the bearing cap to the connecting rod is made by dowels fitted in the bearing cap (B). The faces of these connecting rods and caps are flat and the caps are retained by two setscrews.





Big end bearing

To remove and to fit 13A-01

To remove

1 Drain the engine lubricating oil.

2 Remove the lubricating oil sump, operation 19A-03.

3 Remove the lubricating oil strainer and suction pipe, operation 19A-04 or remove the balancer unit, operation 14A-10.

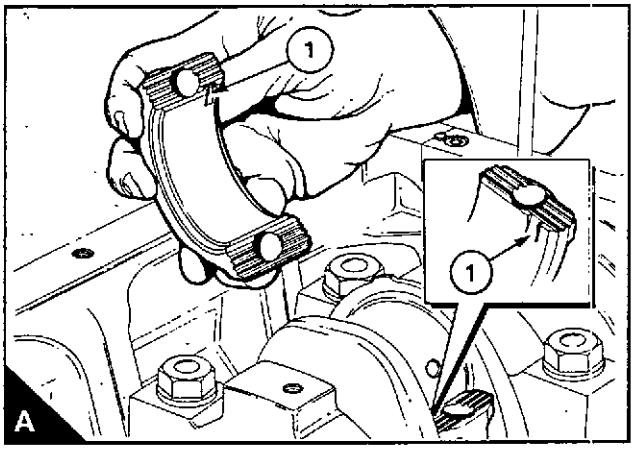
4 Turn the crankshaft until the relevant connecting rod is at its lowest position.

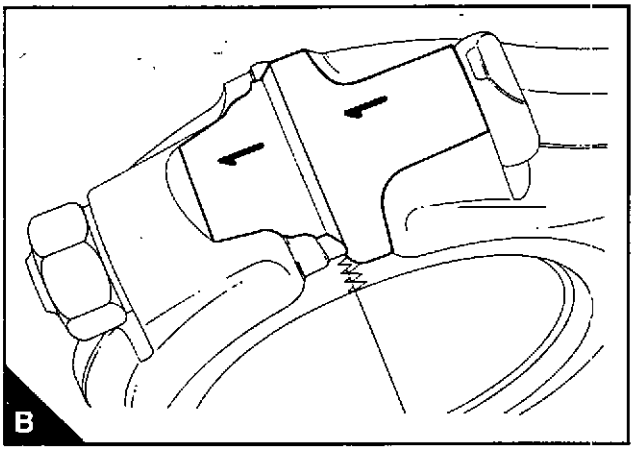
5 Release the nuts and remove the bearing cap. Remove the bolts from the connecting rod. For engines types AB, AD, YB and YD used in vehicle applications: Release the setscrews approximately 4 turns. Then lightly hit the heads of the setscrews with a soft face hammer to separate the connecting rod from the bearing cap. Remove the setscrews and the bearing cap.

6 Remove the lower half 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 bearing. Remove the bearing from the connecting rod. Keep the bearings from the connecting rod and cap together.

Attention: Do not allow the connecting rod to hit the piston cooling jet, if fitted.





To fit

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

2 Clean the complete bearing and lubricate the bearing surface and the crank pin with clean engine lubricating oil. Fit the upper half bearing to the connecting rod; ensure that the location tag is fitted correctly in its recess (A1). Fit the connecting rod to the crankpin; 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 bearing 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 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).

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 turns freely.

6 Fit the lubricating oil strainer and suction pipe, operation 19A-04 or fit the balancer unit, operation 14A-10.

7 Fit the lubricating oil sump, operation 19A-03 and fill the sump to the correct level with lubricating oil of an approved grade.

To inspect 13A-02

Check the bearings and the crank pin for wear or other damage.

Piston and connecting rod assembly

To remove and to fit **13A-03**

To remove

1 Drain the lubricating oil and the cooling system.

2 Remove the cylinder head assembly, operation 12A-07.

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

4 Remove the lubricating oil sump, operation 19A-03.

5 Remove the lubricating oil strainer and suction pipe, operation 19A-04, or remove the balancer unit, operation 14A-10.

6 Remove the big end caps and the big end bearings from the connecting rods, operation 13A-01.

7 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.

Attention: Do not allow the connecting rods to hit the piston cooling jets, if fitted. If a cooling jet is hit, check its alignment, operation 13A-10, and renew it, if necessary.

8 Inspect the crank pins for damage.

To fit

Special tools:

Piston replacer tool, PD.206
Piston height tool, PD.41D
Dial gauge for use with PD.41D, PD.208

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.

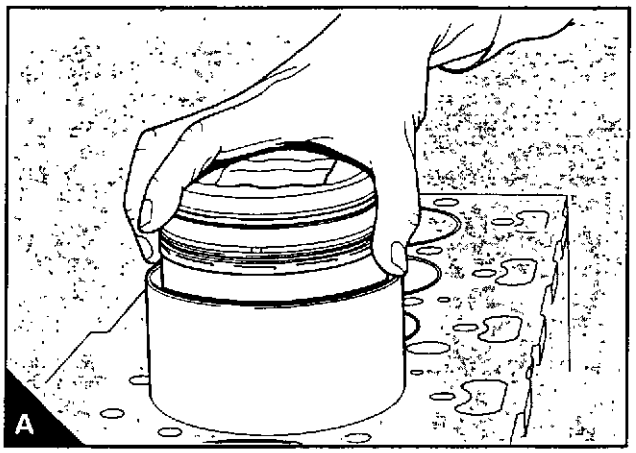
2 Turn the crankshaft until the relevant crank pin is at its lowest position. Lubricate the crank pin with clean engine lubricating oil.

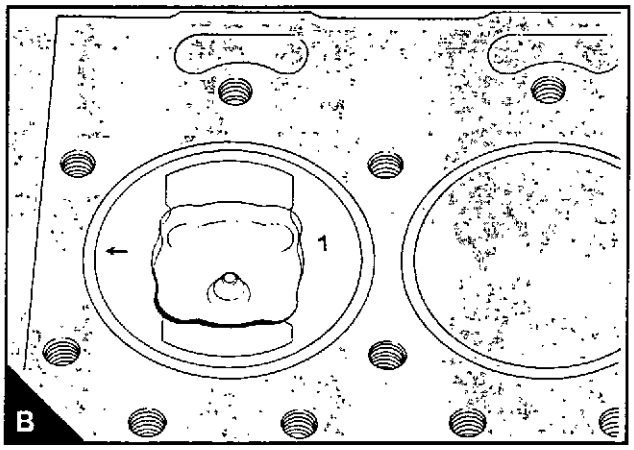
3 Fit the upper half bearing to the connecting rod. Ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil.

4 Put the piston replacement 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 replacing 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 replacing tool (A) and onto the crank pin. If piston cooling jets are fitted, the piston and connecting rod assembly must be turned 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, turn the connecting rod until the arrow or "FRONT" mark on top of the piston is towards the front of the engine (B).

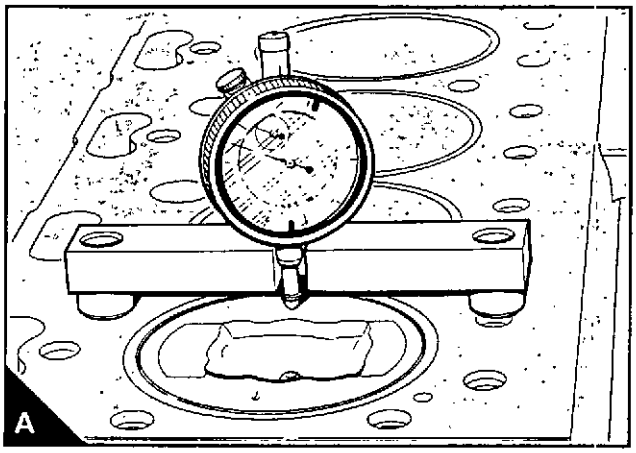




7 Clean the connecting rod cap and the lower half bearing. Fit the bearing to the cap; ensure that the location tag is fitted correctly in its recess. Lubricate the bearing with clean engine lubricating oil. Fit the cap and ensure that the assembly number is the same as that on the connecting rod and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

8 Check that the crankshaft will turn freely.

9 Check the piston height above the top face of the cylinder block with the piston height tool. Put the tool on the face of the cylinder block and turn the gauge dial to the zero position. Turn 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). Turn the crankshaft to bring the piston to its highest position and make a note of the gauge indication. The piston height above the face of the cylinder block should be 0,14/0,36 mm (0.005/0.014 in). Two 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 must not be machined.



10 Fit the lubricating oil strainer and suction pipe, operation 19A-04 or fit the balancer unit, operation 14A-10.

11 Fit the lubricating oil sump, operation 19A-03.

12 Fit the cylinder head assembly, operation 12A-07.

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

14 Fill the cooling system.

Piston rings

To remove and to fit **13A-04**

To remove

Remove the piston rings with a suitable ring expander. Only increase the ring gaps enough to ensure that the ends of the rings do not damage the piston. Keep the rings with their relevant piston.

To fit

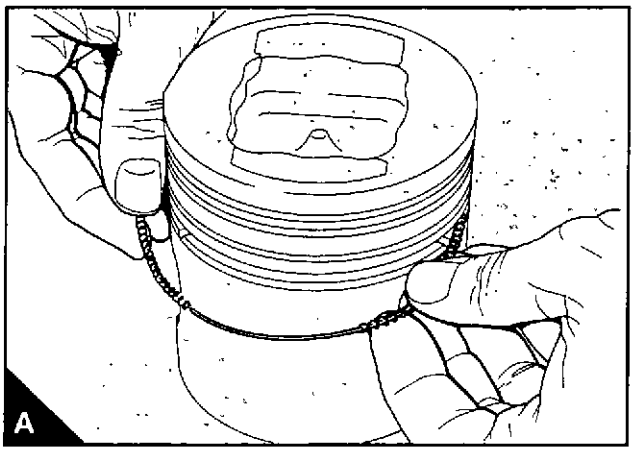
Use a suitable ring expander to fit the piston rings. Only increase the ring gaps enough to ensure that the ends of the rings do not damage the piston.

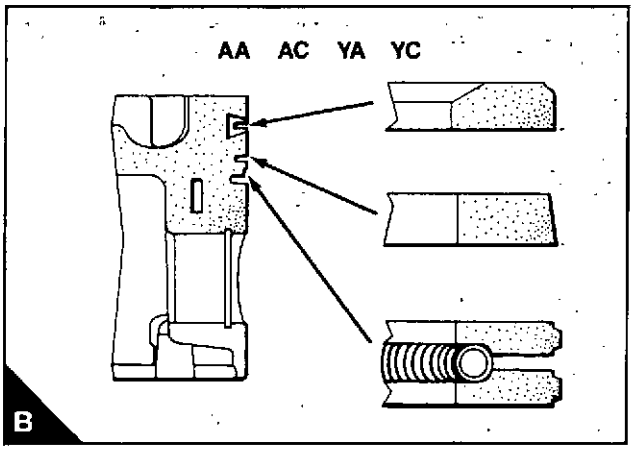
1 Fit the spring of the oil control ring in the bottom groove with the latch pin inside both ends of the spring (A). Fit the oil control ring over the spring (B or C). Ensure that the ring gap is at 180° to the latch pin.

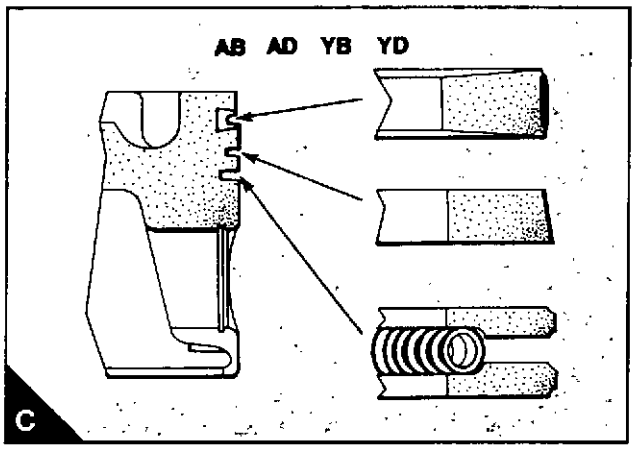
2 Fit the cast iron ring with the tapered face into the second groove with the word "TOP", or the manufacturer's symbol, towards the top of the piston. New piston rings have a green identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

3 Fit the barrel face ring with the molybdenum insert into the top groove. Engine types AB, AD, YB and YD have a wedge shaped top ring. On engine types AA, AC, YA and YC, the latest top ring has a chamfer on the inner top face. A few earlier rings did not have a chamfer. The word "TOP", or the manufacturer's symbol, must be towards the top of the piston. New piston rings have a red identification mark which must be on the left of the ring gap when the ring is fitted and the piston is upright.

4 Ensure that the ring gaps are 120° apart.







Piston and connecting rods

To dismantle and to assemble 13A-05

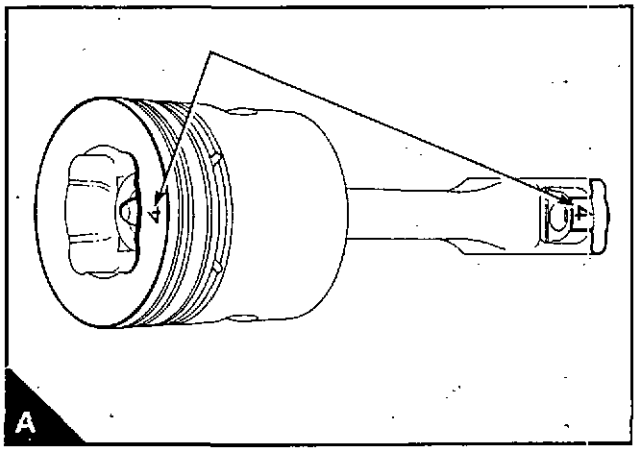
To dismantle

1 Remove the piston rings, operation 13A-04.

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).

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.

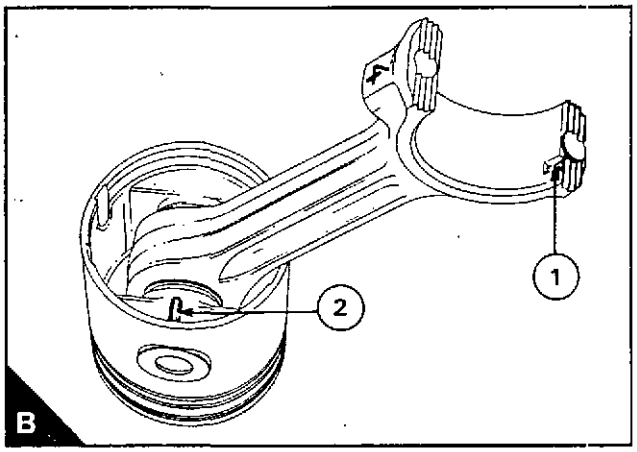
2 Fit a new circlip in the circlip groove of one of the gudgeon pin bosses. Ensure that it fits correctly in the groove.

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.

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 is fits correctly in the groove.

6 Fit the piston rings, operation 13A-04.



Piston and rings

To inspect **13A-06**

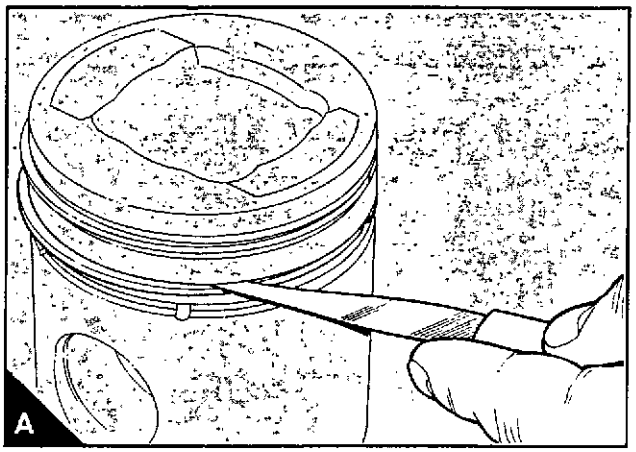
1 Check the piston for wear and other damage.

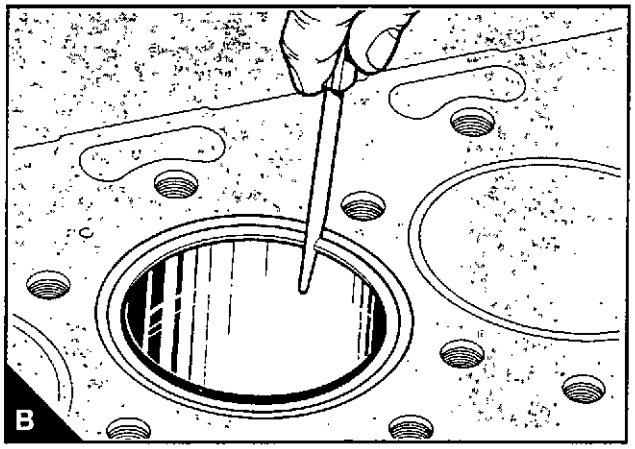
2 Check that the piston rings are free to move in their grooves and that the the rings are not broken.

3 Remove the piston rings, operation 13A-04, and clean the piston ring grooves and the piston rings.

4 Fit new rings in the grooves and check for wear of the ring grooves with feeler gauges (A). Compare the piston ring clearance in the groove to that given for new components in section 11C and renew the piston, if necessary. The tapered top groove of pistons used on engine types AB, AD, YB and YD 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 ring is measured. The ring gaps for new components are given in section 11C.





Connecting rod

To inspect **13A-07**

1 Check the connecting rod for distortion, see section 11C.

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, see section 11C.

Small end bush

To remove and to fit — 13A-08

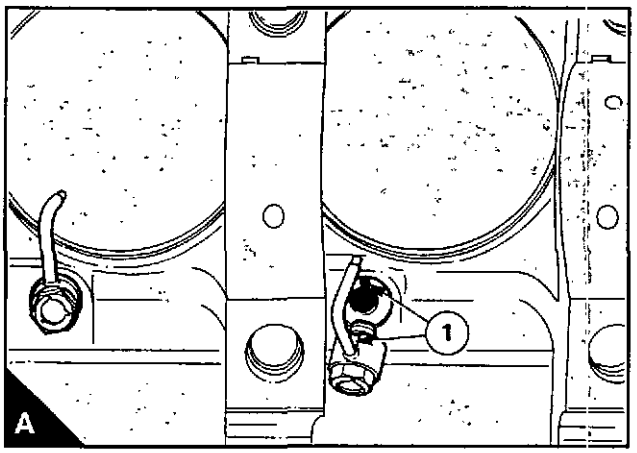
1 Press out the old bush with a suitable adaptor.

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, see section 11C.

For engine types AB, AD, YB and YD, 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

Piston cooling jets are fitted to engine types AB, AD, YB and YD.

To remove and to fit — 13A-09

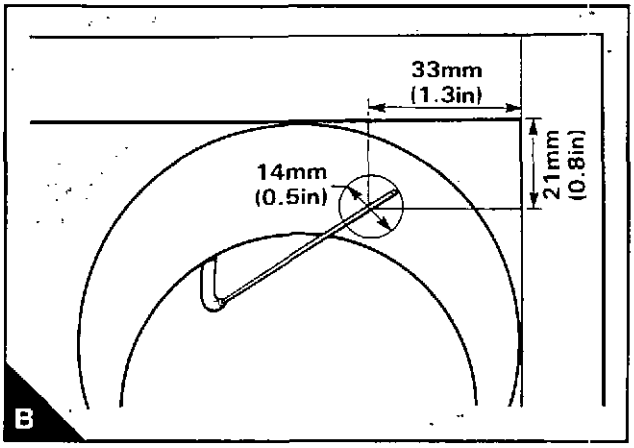
To remove

Release the valve assembly and remove the piston cooling jet assembly (A). (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 27 Nm (20 lbf ft) 2,8 kgf m.



To check the jet alignment — 13A-10

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

Crankshaft assembly 14

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.

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 tin aluminium 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 cast iron or spheroidal graphite (SG) iron.

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.

The nose of the crankshaft of four cylinder engines is serrated for location of the front pulley. The location of the front pulley of six cylinder engines is by a key in the crankshaft nose.

The crankshaft pulley of four cylinder engines is held in position by a plain thrust block and three setscrews.The crankshaft pulley of six cylinder engines is held in position by a "Ringfeder" arrangement (14A.03/B).

A separate damper is fastened to the rear face of the crankshaft pulley of six cylinder vehicle engines. An integral damper is built into the pulley of the remainder of six cylinder engines and some four cylinder engines.

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 a satisfactory condition.

Crankshaft pulley

To remove and to fit - engine types AA, AB, AC and AD — 14A-01A

1 Remove the drive belt(s), operation 23A-04.

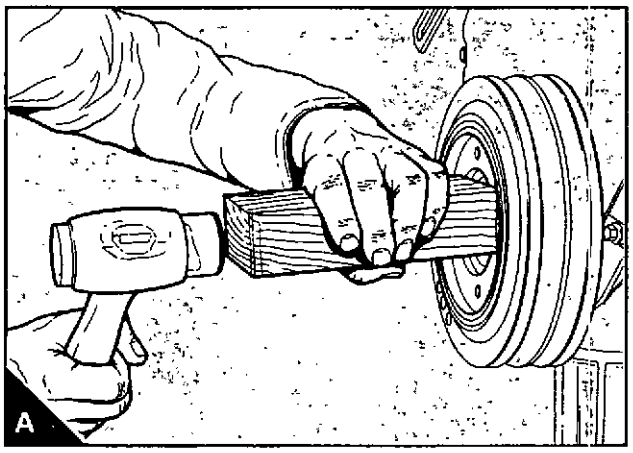
2 Release the three setscrews which hold the pulley and remove the setscrews, the thrust block and the pulley.

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

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

5 Check each setscrew again to ensure that they are still to the correct torque.

6 Fit the drive belt(s), operation 23A-04.



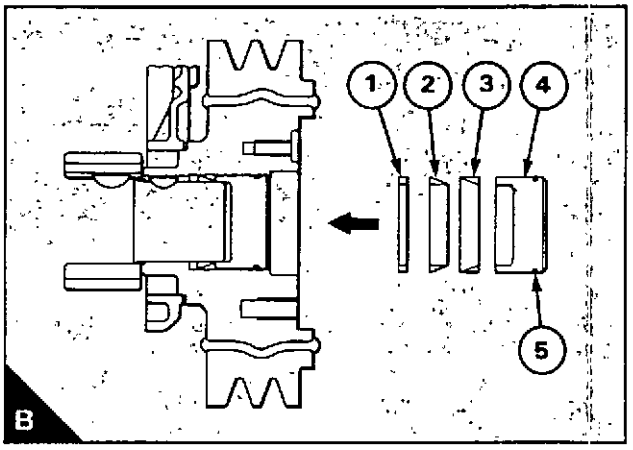
To remove and to fit - engine types YA, YB, YC and YD — 14A-01B

To remove

1 Remove the drive belts, operation 23A-04.

2 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 (A) to loosen the tapered rings.

3 If necessary, release the cap screws which fasten the separate damper to the pulley and remove the damper.



To fit

1 If necessary,put the separate damper in position with its inner flange against the rear face of the pulley. Fit the clamp ring or washers and the cap screws and tighten the cap screws gradually and evenly to 35Nm (26 lbf ft) 3,6 kgf m.

2 Clean thoroughly the nose of the crankshaft, the bore of the pulley and the "Ringfeder" components. Do not use a degreasing solution. Do not open out 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.

Attention: Extreme difficulty in pulley removal can occur 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.

7 Fit the drive belt(s), operation 23A-04.

Rear oil seal assembly

To remove and to fit — 14A-02

Special tools:
Replacer tool for rear oil seal, PD.145D

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

2 Remove the flywheel and the flywheel housing, see section 22.

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.

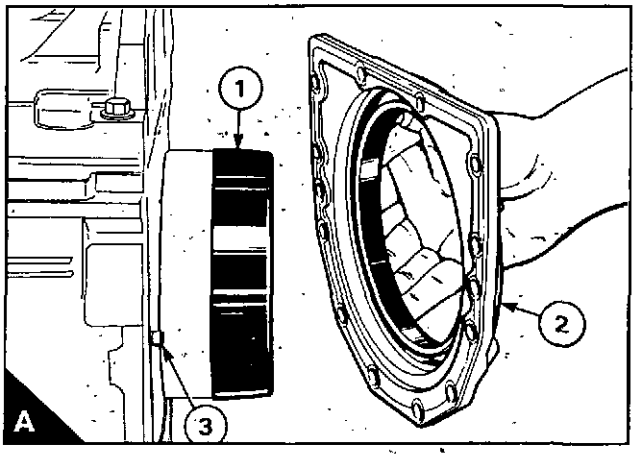
5 Clean the faces of the cylinder block, the oil seal housing and the crankshaft flange.

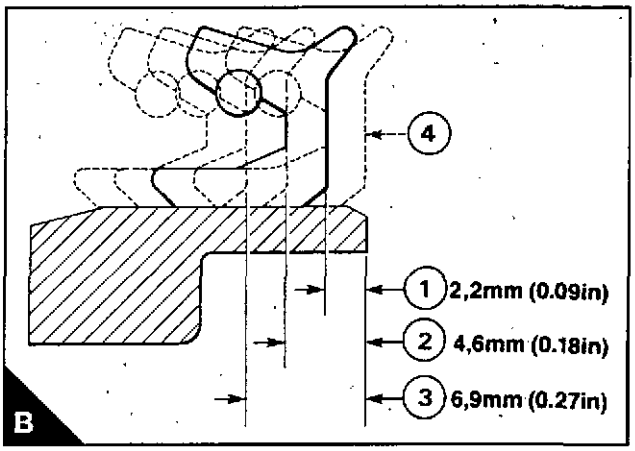
6 Check that the seal and the outer circumference of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position in the housing.

7 Ensure that the two dowels are fitted in the cylinder block. Put a new joint in position on the dowels, no jointing compound is necessary.

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

9 Put the seal and housing (A2) on the seal guide (A1) and carefully push the assembly into position on the crankshaft flange and onto the dowels (A3). Remove the seal guide, fit the setscrews and the cap screws. Tighten the setscrews to 22 Nm (16 lbf ft) 2,2 kgf m and tighten the cap screws to 18 Nm (13 lbf ft) 1,9 kgf m.





To renew the rear oil seal — 14A-03

Special tools:
Replacer tool for rear oil seal, PD.145D

There are four positions in which the seal can be fitted in the housing (B).

Position "1" is used in the factory or if a new seal is fitted on a new or reground crankshaft in service.

Position "2" is used when a new seal is fitted in service and the crankshaft flange is worn in position "1".

Position "3" is used when a new seal is fitted in service and the crankshaft flange is worn in positions "1" and "2".

Position "4" can also be used with a new seal in service, if a wet clutch is not used.

If all positions have been used it is permissible to grind the crankshaft flange, see section 11C.

1 Remove the seal and housing assembly, operation 14A-02.

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.

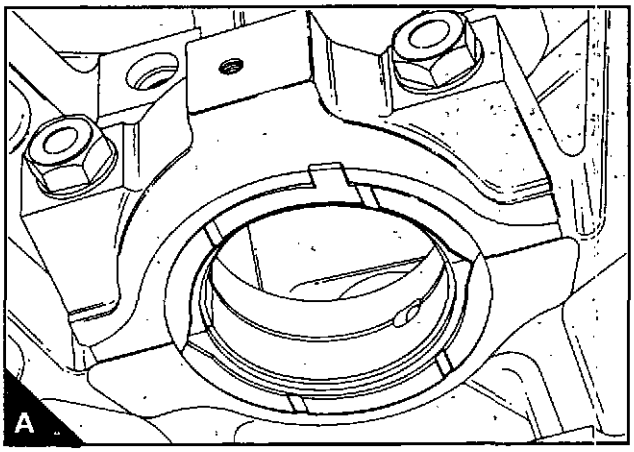
4 Put the engine side of the housing on a suitable support and put the seal into position on the flywheel end of the bore with the spring of the seal towards the housing.

5 Press the seal into the housing to the correct position with the relevant side of the tool.

Thrust washers

To check crankshaft end-float 14A-04

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 section 11C, thrust washers which are 0,019 mm (0.0075 in) oversize can be fitted to one or to both sides of the main bearing, instead of the standard size washer, to reduce the end-float to the factory tolerances.



To remove and to fit 14A-05

To remove

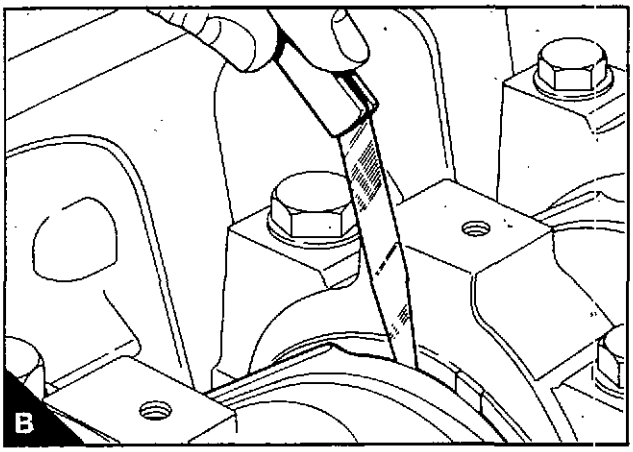
1 Drain the lubricating oil and remove the lubricating oil sump, operation 19A-03.

2 Where necessary, remove the balancer unit, operation 14A-10.

3 Where necessary, remove the lubricating oil strainer and suction pipe, operation 19A-04.

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, to slide the washer from its recess (D). 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.

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 the bearing and the crankshaft journal are clean. Lubricate the bearing with clean engine lubricating oil.

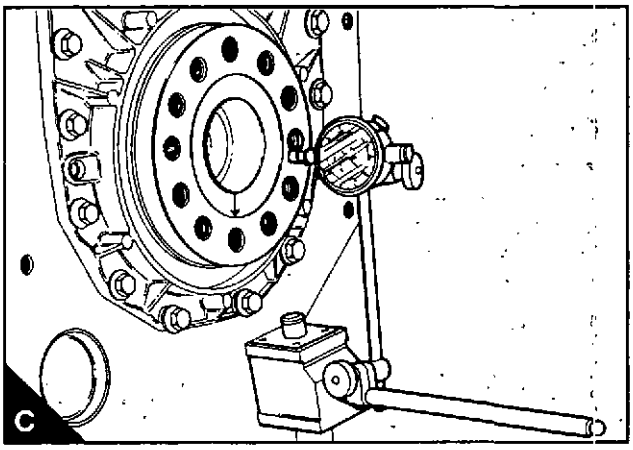
6 Fit the cap with the location tags of both half bearings to the same side (14A.06/A1). Tighten the main bearing setscrews gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

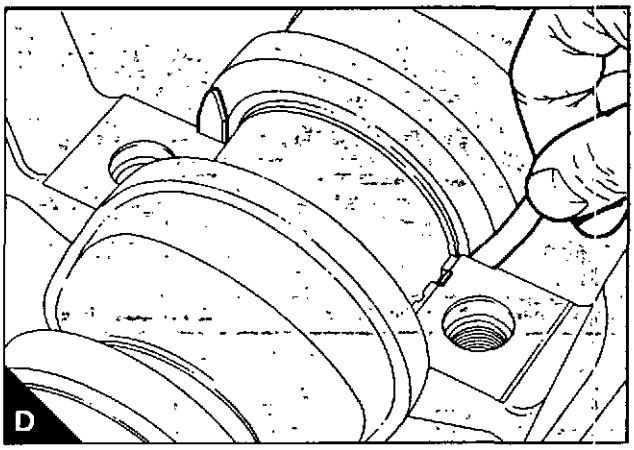
7 Check the crankshaft end-float, operation 14A-04.

8 If necessary, fit the balancer unit, operation 14A-10.

9 If necessary, fit the lubricating oil strainer and the suction pipe, operation 19A-04.

10 Fit the lubricating oil sump, operation 19A-03, and fill it to the correct level with an approved lubricating oil.





Main bearing

To remove and to fit (with the crankshaft in position) 14A-06

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.

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 and the delivery pipe and the relief valve will have to be removed.

To remove

1 Drain the lubricating oil and remove the sump, operation 19A-03.

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 bearing from the cap.

4 With a suitable tool, push the upper half 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

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

Attention: Only the upper half bearing has lubrication holes and must be fitted to the cylinder block side.

2 Fit the plain end of the upper half 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 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.

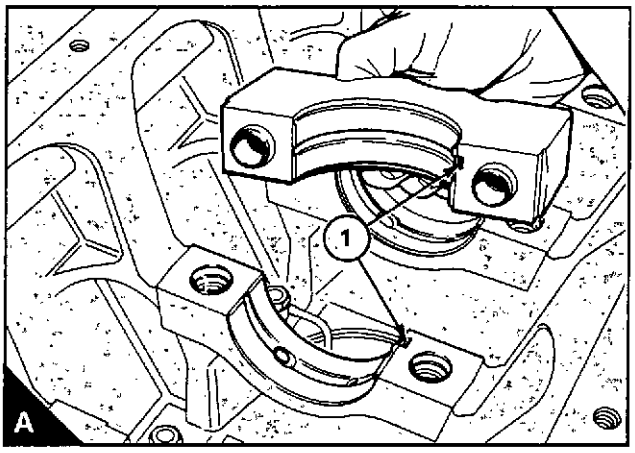
5 Ensure that the location thimbles are fitted correctly to the cap or to the cylinder block. Fit the bearing cap with the location tags of both bearings on the same side (A1).

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.

7 Ensure that the crankshaft turns freely. If the thrust washers have been removed and fitted, check the crankshaft end-float, operation 14A-03.

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

9 Fit the lubricating oil sump, operation 19A-03 and fill it to the correct level with an approved lubricating oil.



To inspect 14A-07

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

Crankshaft

To remove and to fit **14A-08**

To remove

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

2 Remove the lubricatig oil sump, operation 19A-03.

3 Remove the fan, the drive belts, the fan drive pulley and housing and the coolant pump, see section 21.

4 Remove the crankshaft pulley, operation 14A-01.

5 Remove the alternator and its mounting bracket, see section 23.

6 Remove the compressor and its drive assembly or remove the exhauster, see section 24.

7 Remove the timing case cover, operation 15A-01.

8 Remove the fuel injection pump, see section 20.

9 Remove the timing gears and the timing case, see section 15.

10 Remove the flywheel and the flywheel housing, see section 22.

11 Remove the rear oil seal housing, operation 14A-02.

12 If a balancer unit is fitted, remove it, operation 14A-10. 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 section 19.

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 into 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 bearings and the upper and lower thrust washers. Keep the bearings with their relevant caps.

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

To fit

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

2 Clean the main bearing housings and the upper half bearings. Fit the 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 half 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 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 washers to the main bearing caps and tighten them gradually and evenly to 265 Nm (196 lbf ft) 27,0 kgf m.

9 Clean the bridge piece and the location areas for the bridge piece in the cylinder block. Apply a narrow strip of POWERPART Hylosil sealant 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. Later engines may not have been fitted with rubber seals and the grooves in the bridge piece should be filled with POWERPART Hylosil sealant. Use a straight edge to ensure that the bridge piece is in line with the rear face of the cylinder block (B). Tighten the bridge piece capscrews.

10 Fit the connecting rod caps, operation 13A-01. Turn the crankshaft two complete revolutions to ensure free movement.

11 If necessary, fit the balancer unit, operation 14A-10. 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 section 19.

12 Fit the rear oil seal housing, operation 14A-02.

13 Fit the flywheel housing and the flywheel, see section 22.

14 Fit the timing case and the timing gears, see section 15.

15 Fit the fuel injection pump, see section 20.

16 Fit the timing case cover, operation 15A-01.

17 Fit the compressor and its drive assembly or fit the exhauster, see section 24.

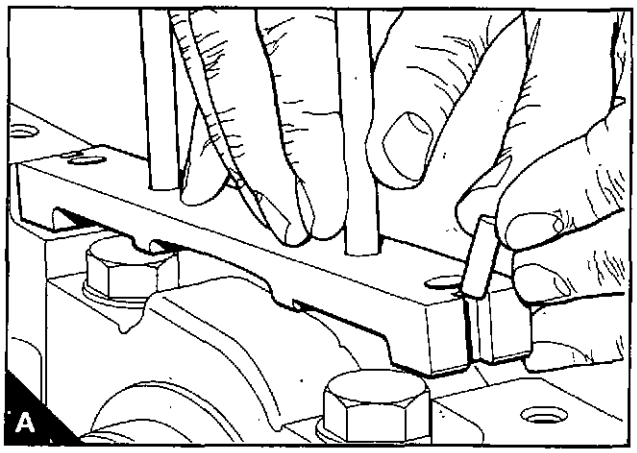
18 Fit the alternator and its mounting bracket, see section 23.

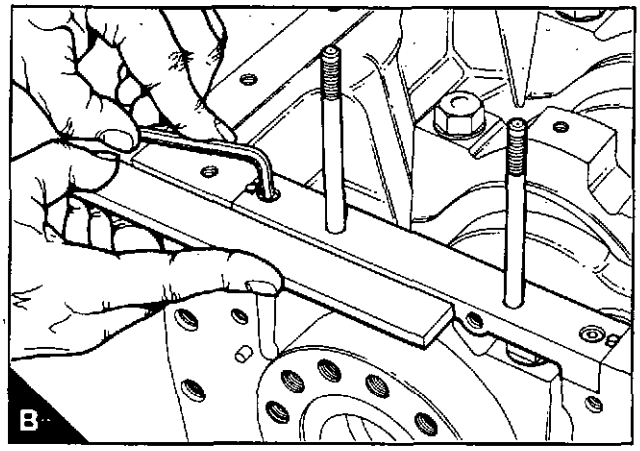
19 Fit the crankshaft pulley, operation 14A-01.

20 Fit the coolant pump, the fan drive pulley and housing, the drive belts and the fan , see section 21.

21 Fit the lubricating oil sump, operation 19A-03.

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 14A-09

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).

The main journals and the crankpins of standard size crankshafts 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 section 11C. Special undersize bearings are available.

The seal location area of the rear flange can be machined to remove the wear marks, if the seal has been used in all positions, see section 11C.

Balancer unit

To remove and to fit 14A-10

To remove

1 Drain the lubricating oil from the sump and remove the sump, operation 19A-03.

2 Provide a support for the balancer unit.

Attention: A support must be provided for the balancer unit because the weight of the unit is approximately 25 kg (55 lb).

3 Release the setscrews and lower carefully the balancer unit. Make a note of the positions of the setscrews of different lengths.

To fit

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, operation 17A-01.

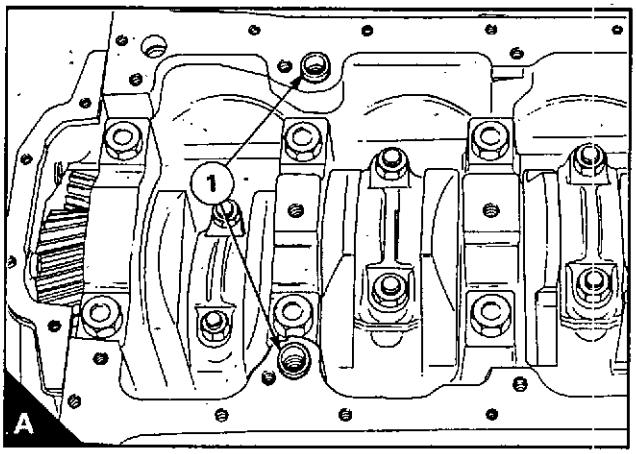
3 Ensure that the timing of the balance weights to the drive shaft is correct (14A.11/B).

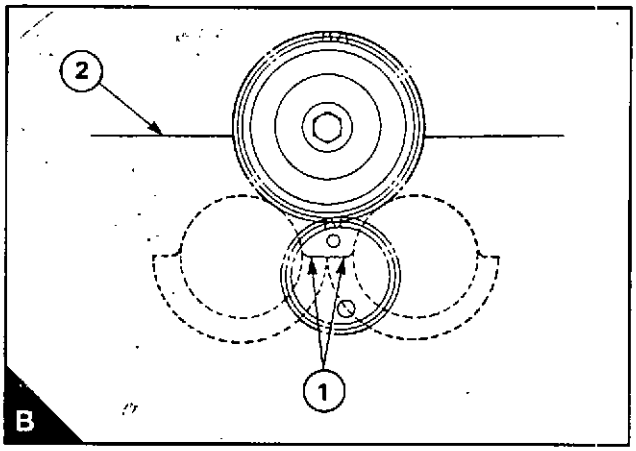
4 Before the balancer unit is fitted, ensure that the flat faces of the balance weights are level with each other (B1) and the weights hang down away from the cylinder block (B2).

5 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.

6 Turn the crankshaft through two revolutions to ensure that it is free to rotate.

7 Fit the lubricating oil sump, operation 19A-03 and fill the sump to the correct level with an approved oil.





To dismantle and to assemble 14A-11

To dismantle

1 Remove the balance weight cover (A8).

2 Release the setscrew and remove the idler gear assembly (A1). Keep the components together as an assembly to protect the needle roller bearing.

3 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. Ensure that the needle roller bearings are not damaged when the drive shaft is removed.

4 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.

5 Release the setscrews and remove the transfer plate for the lubricating oil (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 (14A.12/A or B) to ensure that it can be assembled correctly.

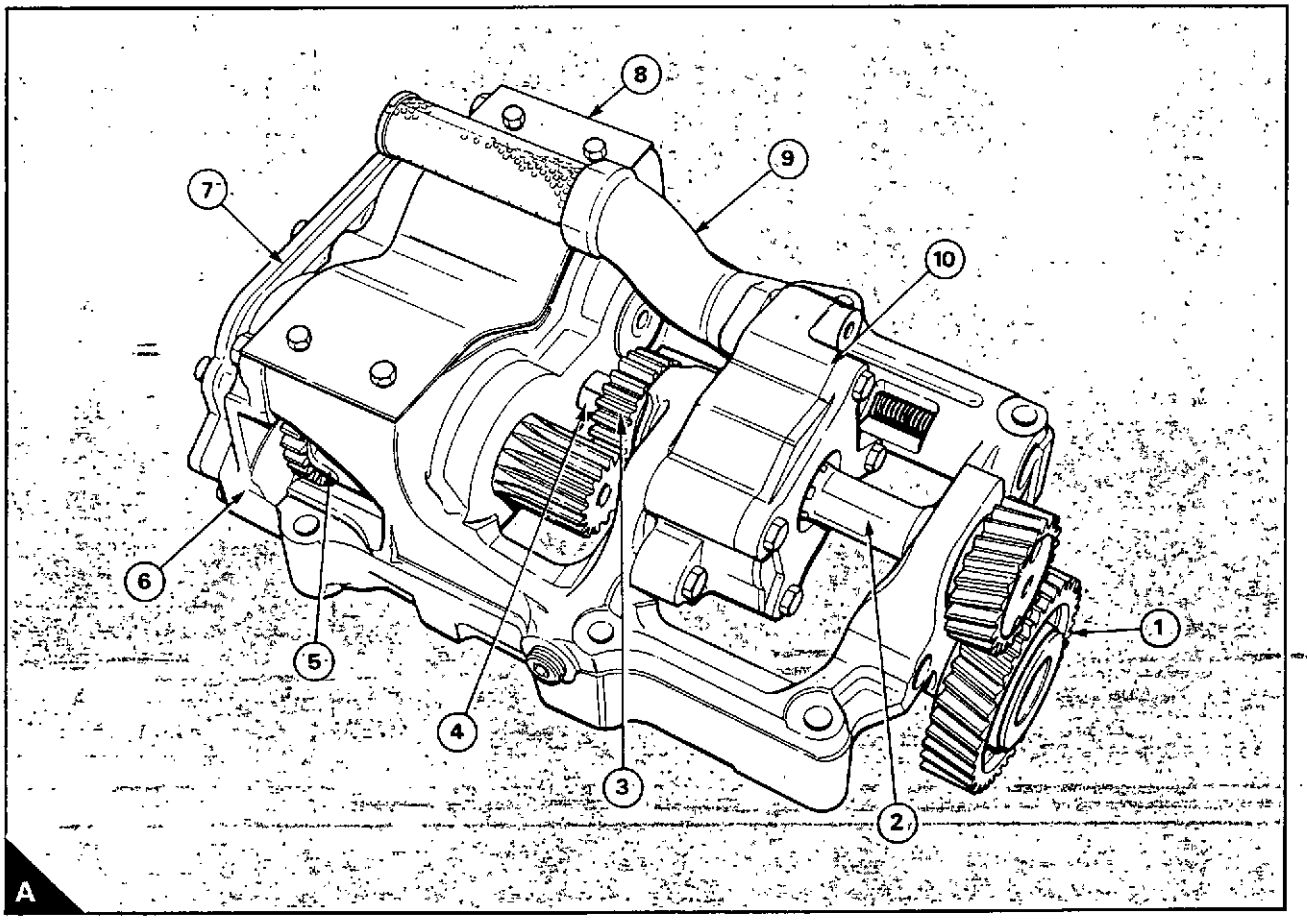
6 Release the setscrews and remove the rear cover of the balancer frame (A6). A hammer and a suitable drift will be necessary to remove the rear cover from the dowels.

7 Remove the balance weights (A5). Ensure that the gear of the driven weight does not damage the bush in the balancer frame.

8 Dismantle the lubricating oil relief valve, operation 19A-09.

9 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 (14A.12/A). 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 (14A.12/B). Removal of these plugs can cause damage to the threads in the balancer frame and a new balancer frame would then be necessary. 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.

10 Clean the lubricating oil passages with kerosene and dry them with low pressure compressed air.



To assemble

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 22 Nm (16 lbf ft) 2,2 kgf m.

2 Assemble the lubricating oil relief valve, operation 19A-09.

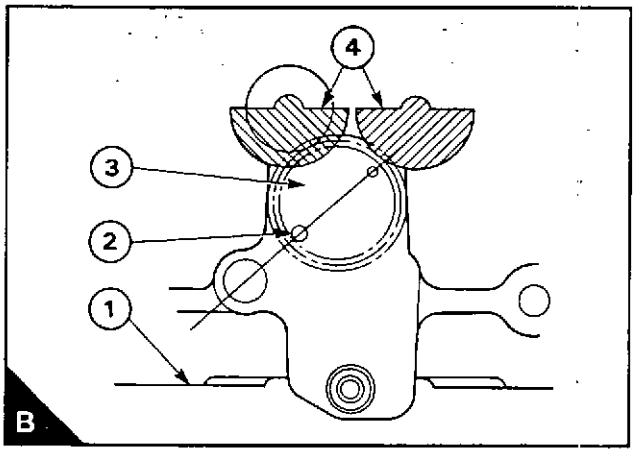
3 Lubricate the needle roller bearings (A7 and A10) with clean engine lubricating oil. Fit the drive shaft (A9) and engage the splines for the lubricating oil pump with the pump rotor. Ensure that the needle roller bearing at the front of the balancer frame is not damaged by the splines on the drive shaft.

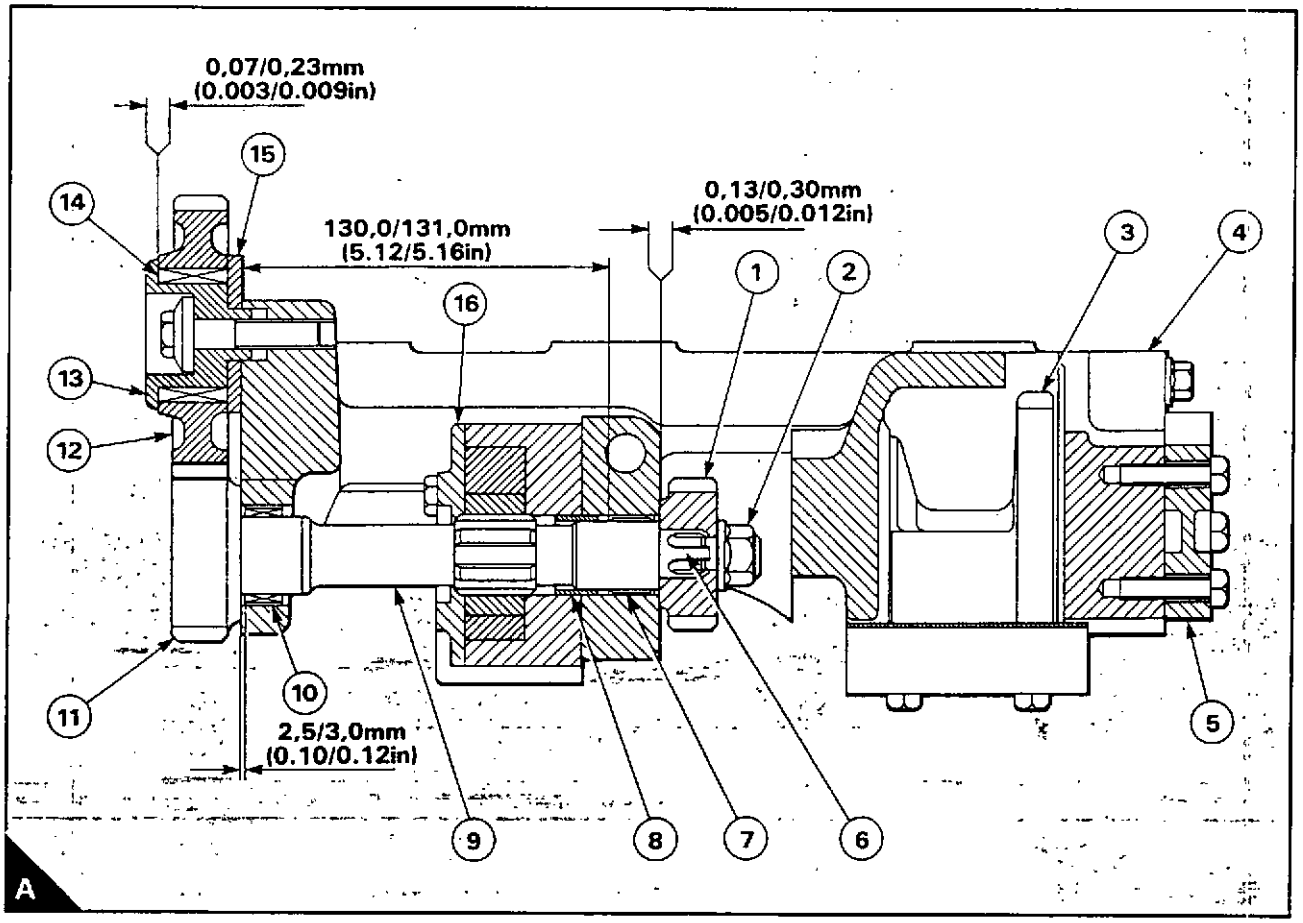
4 Clean and dry the splines (A6) and the thread on the end of the drive shaft. Apply a small amount of Loctite 'Nutlock' to the splines and to the thread. Fit the drive gear of the balance weights (A1) with the flat face of the gear towards the rear of the balancer unit. Fit and tighten the nut (A2) to 85 Nm (63 lbf ft) 8,7 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 With 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 figure 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 figure 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 (A4) 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 (14A.13/B). The correct end-float is given in section 11C. 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 section 11C.



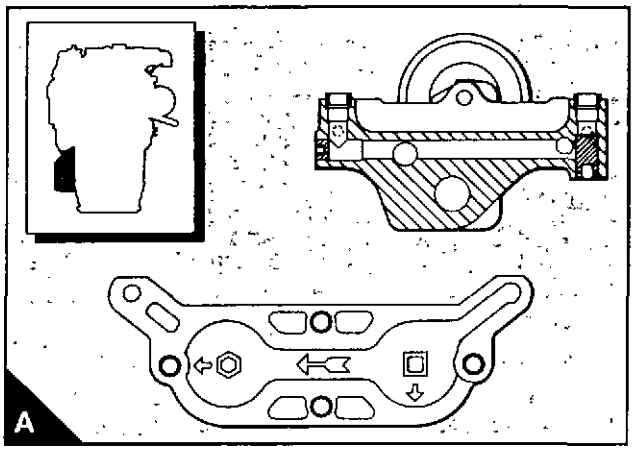


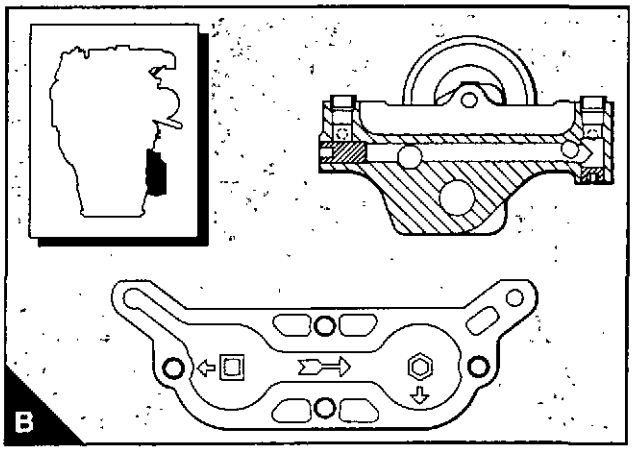
8 Fit the oil transfer plate and the joint to the rear of the rear cover and tighten the setscrews to 30 Nm (22 lbf ft) 3,1 kgf m. Ensure that the plate is fitted correctly for the oil filter position. The direction arrow (A or B) indicates the direction of lubricating oil flow for left side (A) and right side (B) oil filter positions. The symbols and arrows (A or B) 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.

9 If necessary, press a new bearing (14A.11/A14) into the idler gear (14A.11/A12). Lubricate the bearing with clean engine lubricating oil. Fit the hub (14A.11/A13) into the bearing and fit the thrust washer (14A.11/A15) 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 'Loctite 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 (14A.11/A11). Tighten the setscrew to 95 Nm (70 lbf ft) 9,6 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 (A). Check the backlash between the idler gear and the drive shaft gear. The correct backlash is given in section 11C.

10 Fit the balance weight cover and tighten the setscrews.

11 Fit the suction tube and the joint and tighten the setscrews.





To inspect 14A-12

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, operation 14A-13, if necessary.

7 Check the bushes for the balance weights for wear or other damage. Renew the bushes operation 14A-14, if necessary.

8 To inspect the lubricating oil pump, see operation 19A-07.

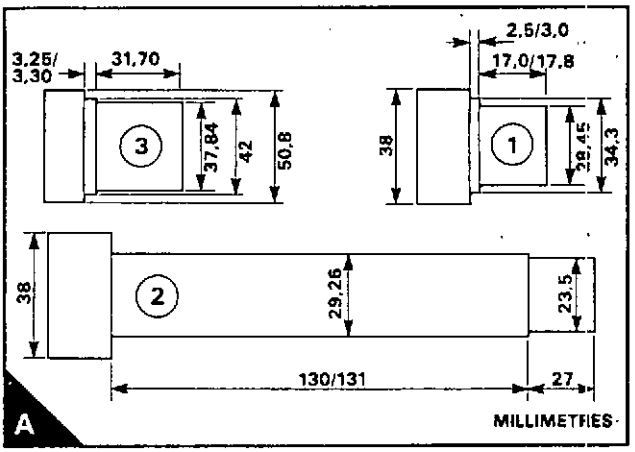
To remove and to fit the needle roller bearings for the drive shaft 14A-13

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 (14A.11/A7) 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 (14A.11/A).

4 Make a suitable adaptor to the dimensions given in (A1). Fit the front bearing (14A.11/A10) 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 (14A.11/A).



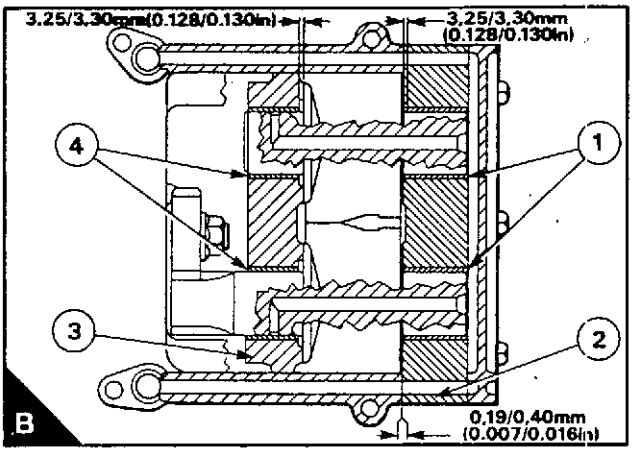
To remove and to fit the bushes for the balance weights 14A-14

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.



Timing case and drive assembly 15

General description

The timing case is made of cast aluminium or cast iron. The helical timing gears are made of steel, except for the camshaft gear of some low rated engines which is made of cast iron. 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.

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 of the water 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. The cover has a noise shield fitted to its front face.

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 and to fit — 15A-01

To remove

1 Remove the fan, operation 21A-04.

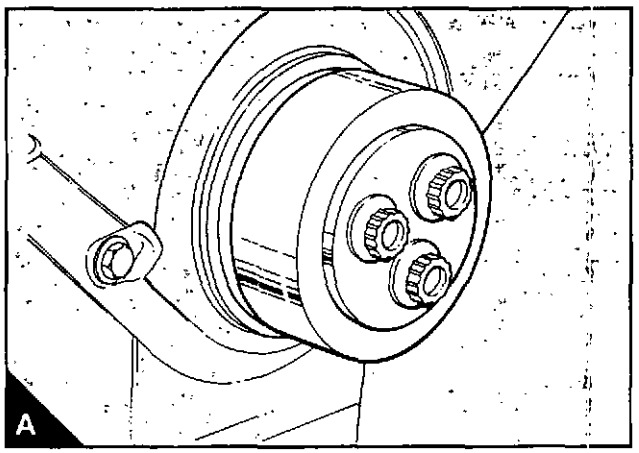
2 Remove the drive belts 23A-03.

3 Remove the crankshaft pulley, operation 14A-01.

4 If necessary, remove the fan drive pulley, operation 21A-05.

5 Drain the coolant and remove the water pump, operation 21A-02.

6 Release the setscrews and nuts of the cover and remove the cover. There is no need to remove the noise shield from the cover.



To fit

Special tools:
Centralising tool, PD.163A

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 opposite setscrews to hold the cover in place. 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.

3 Fit the water pump, operation 21A-02.

4 Fit the crankshaft pulley, operation 14A-01.

5 Where necessary, fit the fan drive pulley, operation 21A-05.

6 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

7 Fit the fan, operation 21A-04.

8 Fill the cooling system.

Front oil seal

To remove and to fit 15A-02

To remove

1 Remove the fan operation 21A-04 and the drive belts operation 23A-03.

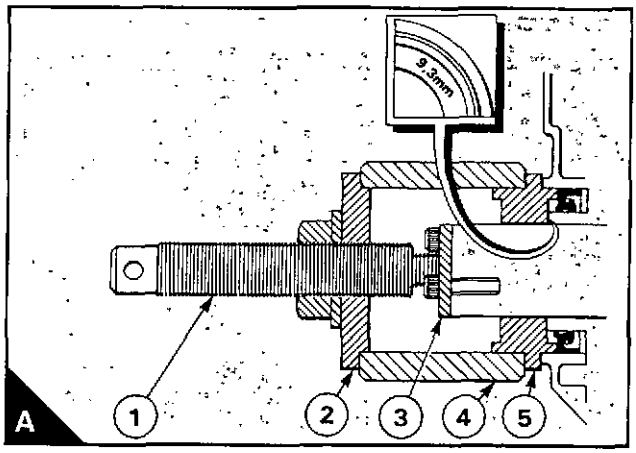
2 Remove the crankshaft pulley, operation 14A-01.

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

Special tools:

Replacer tool for front oil seal (main tool), PD170
Pressure plate for use with PD.170, PD170-1
Fastener plate for use with PD.170, PD170-2
Sleeve for use with PD.170, PD170-3
Seal adaptor for use with PD.170, PD170-4



The oil 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).

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.

3 Assemble the oil seal replacing tool (A). Fasten PD.170-2 (A3) to the front of the crankshaft. Hold PD.170-4 (A5) against the seal with the side stamped 9,3 mm towards the seal, put PD.170-3 (A4) and PD170-1 (A2) in position and fasten PD.170 (A1)to the stud of PD.170-2. Fit a rod through the hole in the end of the tool so that the tool will not turn. Turn the nut with a suitable spanner and the oil seal will be pushed into the housing. Push the seal in to the correct depth. If the seal is to be pushed in to the service position, turn the nut until the face of PD170-4 is against the face of the oil seal housing.

4 Remove the replacing tool and lightly lubricate the seal location area of the crankshaft pulley with clean engine lubricating oil. Fit the crankshaft pulley, operation 14A-01.

5 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

6 Fit the fan, operation 21A-04.

Idler gear and hub

To remove and to fit **15A-03**

To remove

1 Remove the fan, operation 21A-04.

2 Remove the drive belts, operation 23A-03.

3 Remove the crankshaft pulley, operation 14A-01.

4 If necessary, remove the fan drive pulley, operation 21A-05.

5 Drain the coolant and remove the water pump, operation 21A-02.

6 Remove the timing case cover, operation 15A-01.

7 Turn 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 Release the three setscrews, remove the plate of the idler gear and remove the gear. The drive gear of the fuel injection pump may turn counter-clockwise when the idler gear is removed.

9 Remove the idler hub.

Attention: Do not turn the crankshaft with the idler gear removed.

10 Inspect the gear and the bushes for wear and other damage and renew as necessary. The gear and bushes are available as an assembly or separate bushes are available.

11 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, see section 11C.

To fit

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, turn 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). 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 Check the idler gear end-float (B) and the timing gear backlash (C).

4 Fit the timing case cover, operation 15A-01.

5 Fit the water pump, operation 21A-02.

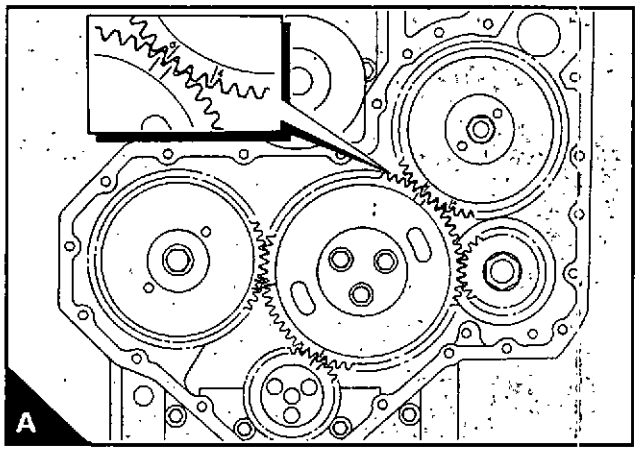
6 Fit the crankshaft pulley, operation 14A-01.

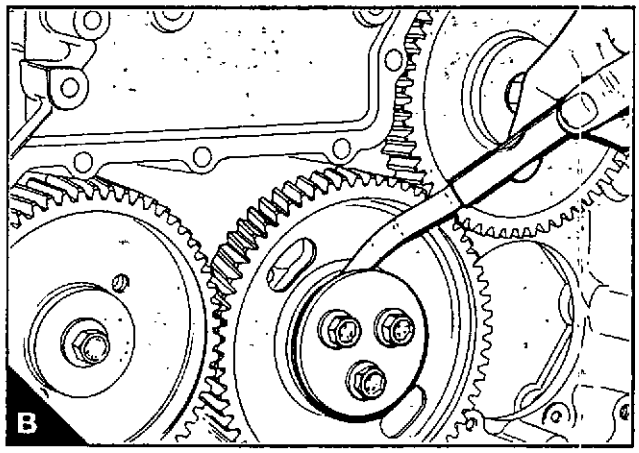
7 Where necessary, fit the fan drive pulley, operation 21A-05.

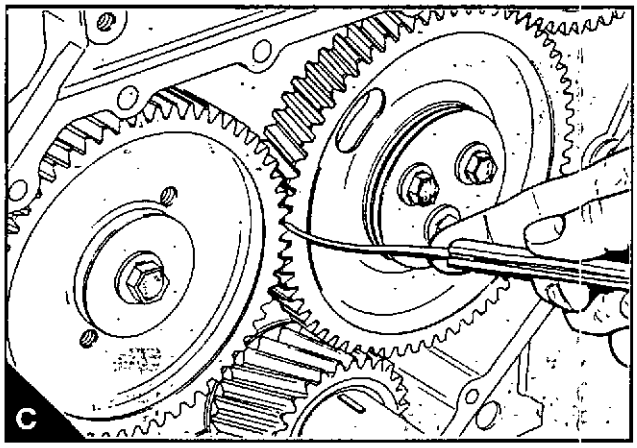
8 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

9 Fit the fan, operation 21A-04.

10 Fill the cooling system.







Fuel pump gear

To remove and to fit **15A-04**

To remove

Special tools:
Gear puller, PD.155B
Adaptors for use with PD.155B, PD.155B-5

1 *Remove the fan, operation 21A-04.*

2 Remove the drive belts, operation 23A-03.

3 Remove the crankshaft pulley, operation 14A-01.

4 If necessary, remove the fan drive pulley, operation 21A-05.

5 Drain the coolant and remove the water pump, operation 21A-02.

6 Remove the timing case cover, operation 15A-01.

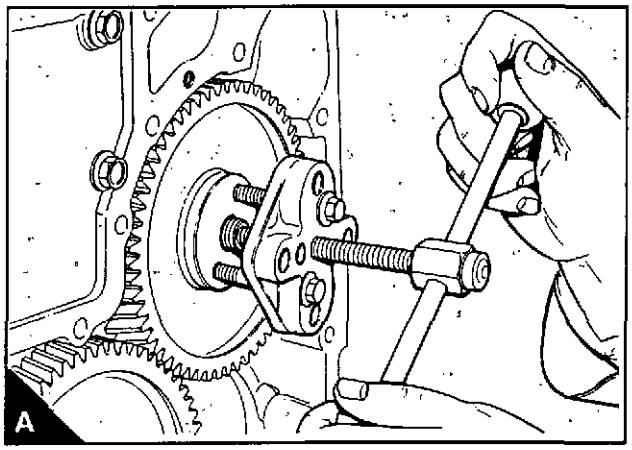
7 Turn the crankshaft until the marked teeth of the crankshaft gear, the camshaft gear and the fuel pump gear are all in mesh with the idler gear. The marked teeth of the idler gear will not necessarily be in mesh with the marked teeth of the other gears because of the different speed of rotation of the idler gear.

8 Remove the nut and the spring washer from the fuel pump gear.

9 Remove the idler gear, operation 15A-03.

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

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.

2 Turn the fuel pump gear 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 (15A.05/A). Fit the idler gear, operation 15A-03.

3 Tighten the nut of the fuel pump gear to 80 Nm (59 lbf ft) 8,2 kgf m.

4 If a new gear has been fitted, check the backlash.

5 Fit the timing case cover, operation 15A-01.

6 Fit the water pump, operation 21A-02.

7 Fit the crankshaft pulley, operation 14A-01.

8 If necessary, fit the fan drive pulley, operation 21A-05.

9 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

10 Fit the fan, operation 21A-04.

11 Fill the cooling system.

Camshaft gear

To remove and to fit 15A-05

To remove

Special tools:
Gear puller, PD.155B
Adaptors for use with PD.155B, PD.155B-5

1 Remove the fan, operation 21A-04.

2 Remove the drive belts 23A-03.

3 Remove the crankshaft pulley, operation 14A-01.

4 If necessary, remove the fan drive pulley, operation 21A-05.

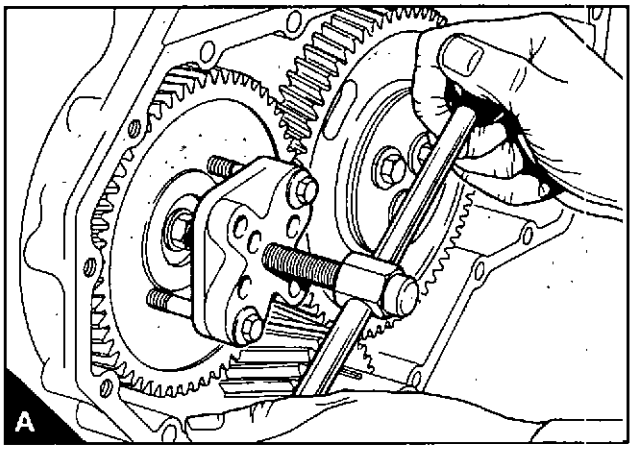
5 Drain the coolant and remove the water pump, operation 21A-02.

6 Remove the timing case cover, operation 15A-01.

7 Turn 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 setscrew and washer of the camshaft gear 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

1 Ensure that the key in the camshaft is fitted correctly.

2 Remove the idler gear, operation 15A-03.

3 Fit the camshaft gear to the camshaft with the marked teeth towards the front and the keyway correctly aligned with the key. If necessary, lightly hit the gear with a soft face hammer to engage the key into the keyway.

4 Fit the idler gear with the marked teeth in correct mesh, operation 15A-03. 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, operation 15A-01.

7 Fit the water pump, operation 21A-02.

8 Fit the crankshaft pulley, operation 14A-01.

9 Where necessary, fit the fan drive pulley, operation 21A-05.

10 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

11 Fit the fan, operation 21A-04.

12 Fill the cooling system.

Crankshaft gear

To remove and to fit **15A-06**

To remove

1 Remove the fan, operation 21A-04.

2 Remove the drive belts, operation 23A-03.

3 Remove the crankshaft pulley, operation 14-01.

4 If necessary, remove the fan drive pulley, operation 21A-05.

5 Drain the coolant and remove the water pump, operation 21A-02.

6 Remove the timing case cover, operation 15A-01.

7 Turn 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 idler gear, operation 15A-03.

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, operation 14A-08, 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 that 180°C (226°F). If an oven is not available, heat it in water 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, operation 15A-03 and ensure that all the timing marks are correctly aligned.

3 Fit the timing case cover, operation 15A-01

4 Fit the water pump, operation 21A-02.

5 Fit the crankshaft pulley, operation 14A-01.

6 Where necessary, fit the fan drive pulley, operation 21A-05.

7 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

8 Fit the fan, operation 21A-04.

9 Fill the cooling system.

Timing case

To remove and to fit — 15A-07

To remove

1 Remove the fan, operation 21A-04.

2 Remove the drive belts, operation 23A-03.

3 *Remove the crankshaft pulley, operation* 14A-01.

4 If necessary, remove the fan drive assembly, operation 21A-05.

5 Drain the coolant and remove the water pump, operation 21A-02.

6 Remove the alternator together with its mounting bracket and *front support plate.*

7 Remove the compressor and drive assembly, operation 24A-01, if fitted.

8 Remove the timing case cover, operation 15A-01.

9 Turn 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.

10 Remove the fuel injection pump, operation 20A-06.

11 *Remove the idler gear, operation* 15A-03 *and the camshaft* gear, operation 15A-05.

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

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 a 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 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.

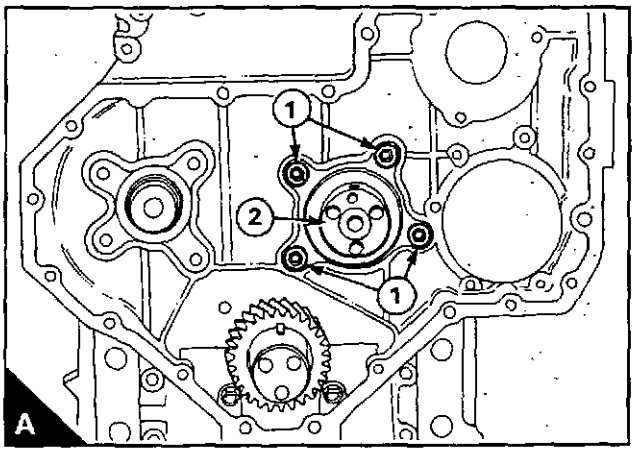
3 Ensure that the thrust washer for the camshaft is in position.

4 *Fit a new joint for the timing case to the cylinder block. Cut the bottom ends of the joint to fit correctly. Apply a suitable 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 paragraph 2. Fit the four setscrews (A1) around the idler gear hub (A2) and tighten them. 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 a suitable* sealant 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, operation 19A-03, and fill it to the correct level with an approved oil.

7 *Fit the camshaft gear,operation 15A-05 and the idler gear,* operation 15A-03. Ensure that all the timing marks are correctly *aligned.*



8 If a new timing case has been fitted, put a timing mark for the fuel injection pump on the rear face of the timing case, operation 17A-05 or 17B-05. Fit the fuel injection pump and the drive gear, operation 20A-06. Eliminate air from the fuel system, operation 20A-08.

9 Fit the compressor and its drive assembly, operation 24A-01.

10 Fit the timing case cover, operation 15A-01

11 Fit the water pump, operation 21A-02.

12 Fit the crankshaft pulley, operation 14A-01.

13 Where necessary, fit the fan drive pulley, operation 21A-05.

14 Fit the alternator, operation 23A-04 and the alternator front bracket.

15 Fit the drive belts, operation 23A-03 and adjust the belt tension, operation 23A-02.

16 Fit the fan, operation 21A-04.

17 Fill the cooling system.

Camshaft and tappets

To remove and to fit **15A-08**

To remove

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

2 Remove the fan, operation 21A-04.

3 Remove the drive belts, operation 23A-03.

4 Remove the crankshaft pulley, operation 14A-01.

5 If necessary, remove the fan drive assembly, operation 21A-05.

6 Drain the coolant and remove the water pump, operation 21A-02.

7 Remove the alternator together with its mounting bracket and front support plate.

8 Remove the compressor and its drive assembly or remove the exhauster, see section 24.

9 Remove the timing case cover, operation 15A-01.

10 Remove the timing gears, operations 15A-03,15A-04 and 15A-05.

11 Remove the fuel injection pump, operation 20A-06.

12 Remove the timing case, operation 15A-07.

13 Remove the rocker cover, the rocker assembly and the push rods, see section 12.

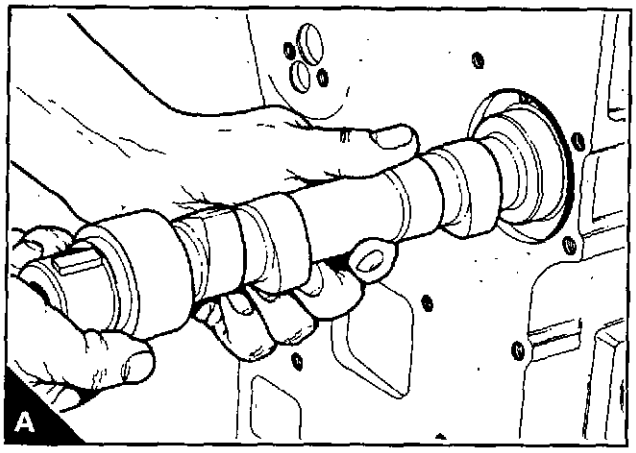
14 Remove the fuel lift pump, operation 20A-03.

15 Turn the engine upside down and remove the lubricating oil sump, operation 19A-03.

16 Remove the camshaft thrust washer (15A.11/A) and carefully remove the camshaft (A).

17 Remove the tappets.

18 Inspect the camshaft and the tappets for wear and other damage, also inspect the camshaft bush. Renew the components as necessary.



To fit

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.

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, operation 15A-07.

6 Check that the camshaft end-float is within the limits shown in section 11C.

7 Turn the camshaft until the cam for the fuel lift pump is at the minimum lift position and fit the fuel lift pump, operation 20A-03.

8 Turn the engine to an upright position. Turn the crankshaft until the keyway in the crankshaft is at the top. Fit the timing gears, operations 15A-03, 15A-04 and 15A-05, and ensure that all the timing marks are correctly aligned.

9 Fit the fuel injection pump, operation 20A-06.

10 Fit the push rods and the rocker assembly, see section 12.

11 Set the valve tip clearances, operation 12A-05.

12 Fit the timing case cover, operation 15A-01 and the lubricating oil sump, operation 19A-03.

13 Fit the water pump, operation 21A-02.

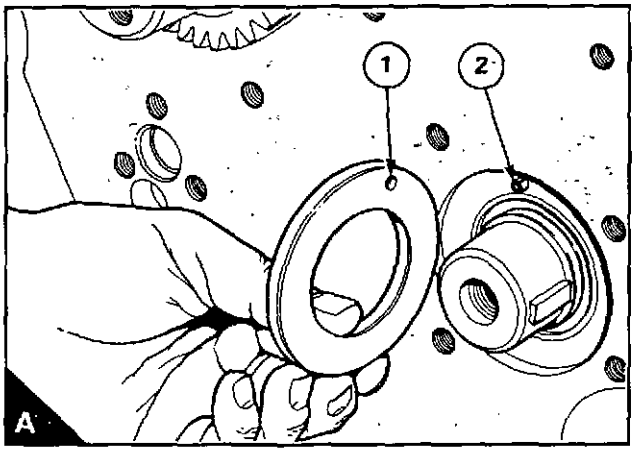
14 Fit the crankshaft pulley, operation 14A-01.

15 Where necessary, fit the alternator and its mounting brackets and the fan drive pulley, operation 21A-05.

16 Fit the drive belts, operation 23A-03, and adjust the belt tension, operation 23A-02.

17 Fit the fan, operation 21A-04.

18 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, operation 20A-08.



Cylinder block assembly 16

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 specially controlled finish to ensure long life and low oil consumption. 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 and to assemble — 16A-01

To dismantle

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 section 23.

4 Remove the fan, the fan drive and the water pump, see section 21.

5 Remove the compressor or the exhauster, where fitted, see section 24.

6 Remove the fuel filter, the atomisers and the fuel injection pump, see section 20.

7 Remove the lubricating oil cooler, where fitted, operation 21A-07.

8 Remove the lubricating oil filter assembly and the lubricating oil *sump, see section 19.*

9 If necessary, remove the turbocharger, operation 18A-01.

10 Remove the fuel lift pump, operation 20A-03.

11 Remove the starter motor, operation 23B-01.

12 Remove the cylinder head assembly, operation 12A-07.

13 Remove the timing case and the timing gears, see section 15.

14 Remove the lubricating oil pump and the pressure relief valve, *see section 19, or remove the balancer unit, operation 14A-10.*

15 Remove the piston and connecting rod assemblies, operation 13A-04.

16 Remove the camshaft and the tappets, operation 15A-09.

17 Remove the flywheel and the flywheel housing, see section 22.

18 Remove the rear oil seal assembly and the crankshaft, see section 14.

19 Remove the piston cooling jets, operation 13A-09, or remove the plugs if jets are not fitted.

To assemble

1 *Clean thoroughly the new cylinder block. Ensure that all the oil* passages are clean and free from debris.

2 Remove the screw plugs from the old cylinder block and clean the threads. Seal the threads with POWERPART Threadseal, or a *similar sealant, and fit the screw plugs into the new cylinder block.*

3 Fit the piston cooling jets, or the plugs where jets are not fitted, operation 13A-09.

4 Fit the crankshaft and the rear oil seal assembly, see section 14.

5 Fit the flywheel housing and the flywheel, see section 22.

6 Fit the tappets and the camshaft, operation 15A-08.

7 Fit the lubricating oil pump and the pressure relief valve, see section 19, or fit the balancer unit, operation 14A-10.

8 *Fit the timing case and the timing gears, see section 15.*

9 Fit the cylinder head assembly, operation 12A-07.

10 Fit the starter motor, operation 23B-01.

11 Fit the fuel lift pump, operation 20A-03.

12 If necessary, fit the turbocharger, operation 18A-01.

13 Fit the lubricating oil filter assembly and the lubricating oil sump, see section 19.

14 *If necessary, fit the lubricating oil cooler, operation 21A-07.*

15 Fit the fuel filter, the atomisers and the fuel injection pump, section 20.

16 If necessary, fit the compressor or the exhauster, see section 24.

17 Fit the fan, the fan drive and the water pump, see section 21.

18 Fit the alternator and its mounting brackets and the alternator *drive belts, see section 23.*

19 Install the engine into the vehicle or machine.

20 *Fill the cooling system.*

21 Fill the lubricating oil sump to the correct level with an approved lubricating oil.

22 Eliminate air from the fuel system, operation 20A-08.

To inspect — 16A-02

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.

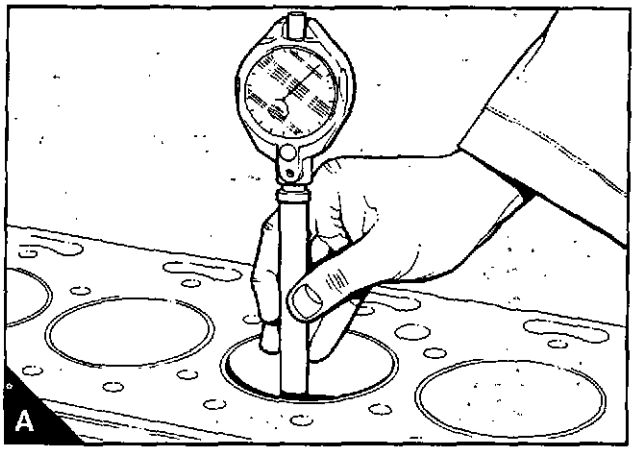
4 Check the camshaft bush for wear. If the bush is to be renewed, use a suitable adaptor to press it out of the bore. Ensure that the lubricating oil hole in the new bush will be towards the front of the engine, when fitted. Press in the bush with the oil hole on the same side and aligned with the oil hole in the block until the front end of the bush is aligned with the face of the recess.

Cylinder liner

To inspect — 16A-03

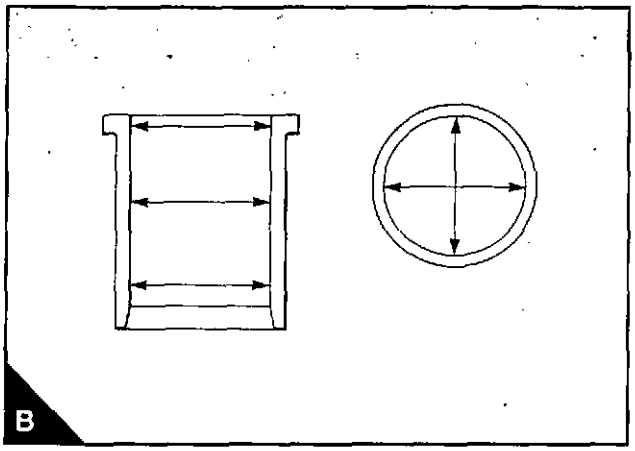
Check the liners for damage and wear. To check the wear of the liner bore see A and B. The maximum permissible wear is 0,25 mm (0.010 in).

An engine can have high oil consumption with very little wear of the liner bores, if the surfaces of the liners are glazed.



To remove glaze from the bore — 16A-04

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.



1 Grade 80SC 'Flex-Hone' is to be used. A 4 in or 4 1/8 in 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 sections of this workshop manual.

Attention: 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 and to fit 16A-05

Special tools:

Remover/replacer for cylinder liner (main tool), PD.150B
Adaptors for use with PD.150B, PD.150B-17
Depth gauge liner flange, PD.41D
Dial gauge for use with PD.41D, PD.208

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.

To remove

1 *Drain the lubricating oil and remove the lubricating oil sump,* operation 19A-03.

2 Remove the cylinder head assembly, operation 12A-07.

3 Remove the piston and connecting rod assembly, see operation 13A-03.

4 Carefully remove the piston cooling jet, where fitted, operation 13A-09.

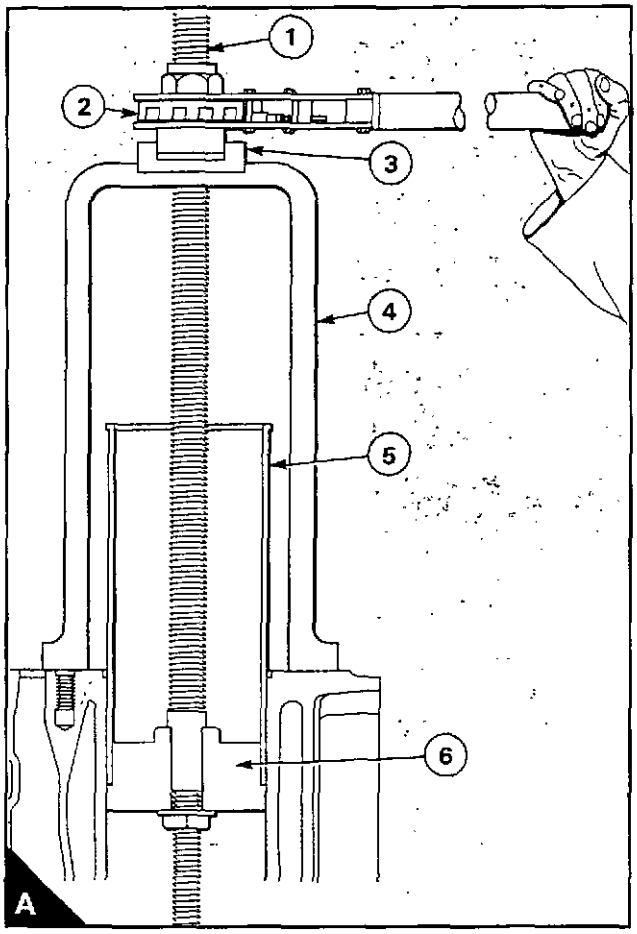
5 Turn the crankshaft to give access to the cylinder liner and protect the crank pin.

6 Put the tool (A4) on the top face of the cylinder block and over the centre of the liner. 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.

8 Fit the threaded rod (A1) through the bearing and the top of the tool until the handle (A2) 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 PD.150B-17/1 (A6) 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

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 PD150B can be used. 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 Loctite Safety Solvent or a similar product; use it in accordance with the manufacturer's instructions.

2 Clean thoroughly the outer surface of the liner with Loctite Safety Solvent.

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 PD.150B-17/2 (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.

5 Fit the threaded rod (A1) 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 PD150B/6 (A6) 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 Loctite Safety Solvent. Apply Loctite 602 to the top 25 mm (1.0 in) of the outer surface of the liner and under the flange; also apply Loctite 602 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 Loctite from the top of the cylinder block.

9 Allow 15 minutes to elapse before the liner bore dimension is checked. The Loctite will reach full strength after 3 hours.

10 With tool PD41D, 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 (B).

11 Fit new piston rings, operation 13A-04.

12 Fit the piston and connecting rod assembly, operation 13A-03.

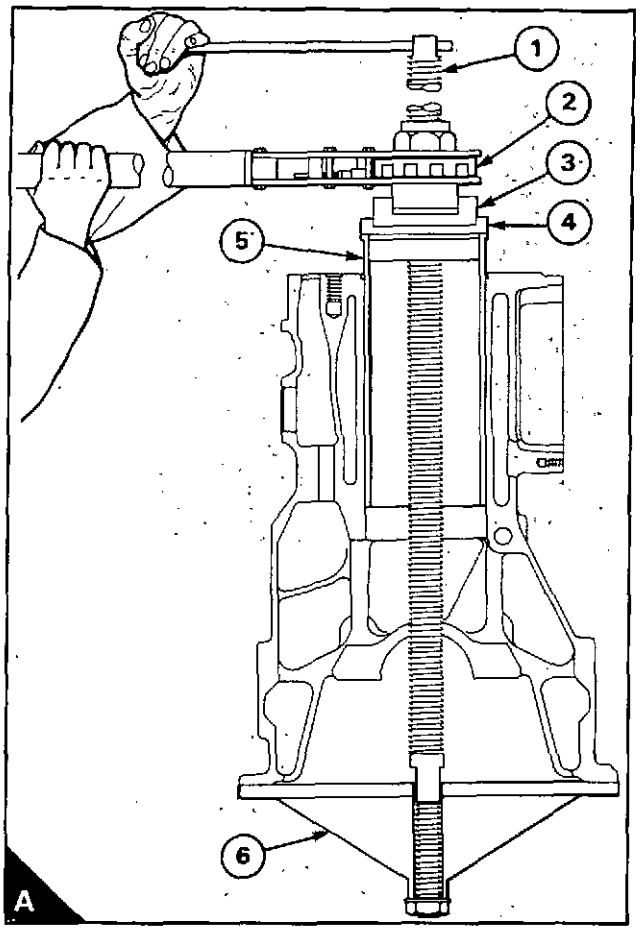
13 If necessary, fit the piston cooling jet, operation 13A-09.

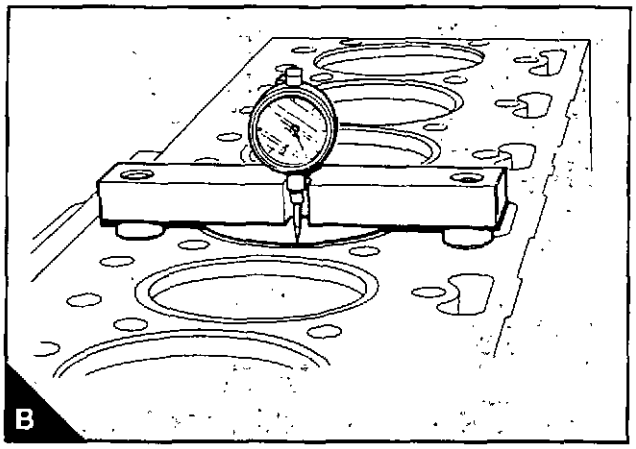
14 Fit the cylinder head assembly, operation 12A-07.

15 Fit the lubricating oil sump, operation 19A-03, and fill it to the correct level with an approved lubricating oil.

Attention: 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 extended periods.





Engine timing

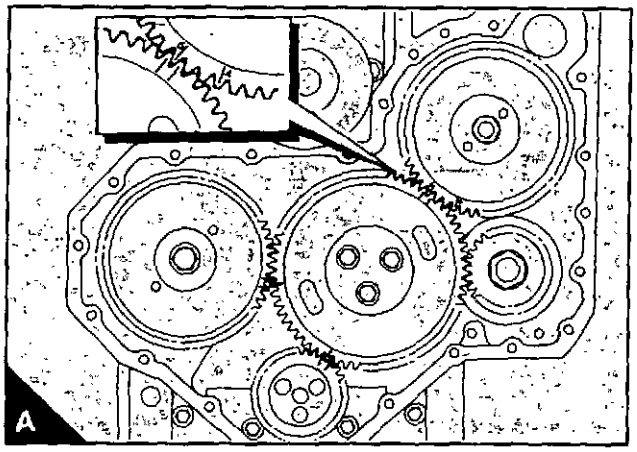
17

Engines fitted with Bosch fuel injection pumps 17A

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, due to 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.



To set number 1 piston to TDC on the compression stroke — 17A-01

Special tools:

Valve spring compressor, PD.6118B
Stud adaptor for use with PD.6118B, PD.6118B-7
Setscrew adaptor for use with PD.6118B, PD.6118B-8

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, operation 12A-01.

3 Turn the crankshaft, clockwise from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

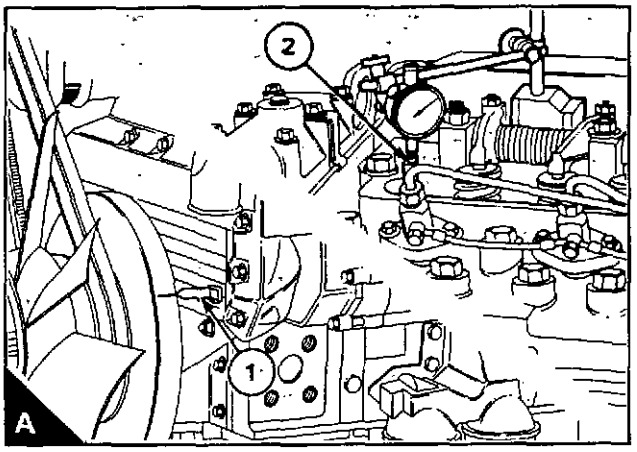
4 Remove the spring clip and the spacer from the front of the rocker shaft. Release the fasteners of the front two pedestals of the rocker shaft and remove the front rocker lever; tighten the fasteners of the rocker shaft pedestals.

5 Remove the valve springs from the front valve with the valve spring compressor 6118B and the adaptor PD6118-7, for pedestal studs, or the adaptor PD.6118-8, for pedestal setscrews.

6 Allow the valve to be held by the top of the piston. Fit a suitable collar near the top of the valve to hold the valve if the crankshaft is turned too far.

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. Turn 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 turn 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 Turn 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.



To check the valve timing 17A-02

1 Set the piston of number 1 cylinder to TDC on the compression stroke, operation 17A-01.

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 Turn 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 Turn 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 pointer.

2 1/2° is 4,5 mm (0.18 in) at the circumference of the standard pulley, which has a diameter of 203 mm (8 in), or 7,0 mm (0.28 in) at the circumference of the large damper, which has a diameter of 310,0 mm (12.0 in).

6 If the timing is more than 2 1/2° out of position, the timing gears are probably not in correct mesh.

Attention: One tooth on the camshaft gear is equivalent to 23,0 mm (0.90 in) of pulley circumference or 35,0 mm (1.40 in) of damper circumference.

7 Turn 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, operation 12A-01.

9 Remove the temporary pointer from the timing case and the timing mark from the pulley or damper.

To check the timing of the fuel injection pump — 17A-03

Special tools:

Timing gauge adaptor, MS.107
Spanner for flange nuts of fuel injection pump, PD.199

1 Set the piston of number 1 cylinder to TDC on the compression stroke, operation 17A-01. It is not necessary to fit a temporary pointer (17A-01/paragraph 1). Instead, the dial of the dial test indicator (A1) should be set at zero when the clockwise movement of the pointer stops (17A-01/paragraph 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 MS107, and a suitable dial gauge (A2). Set the dial gauge to indicate approximately 3,0 mm.

4 Slowly turn 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.

5 Slowly turn the crankshaft clockwise until the dial gauge on the valve stem indicates the correct position of the piston before TDC, see section 11C. The timing of the fuel injection pump is correct if the dial gauge on the pump plunger indicates 1,0 mm (0.039 in).

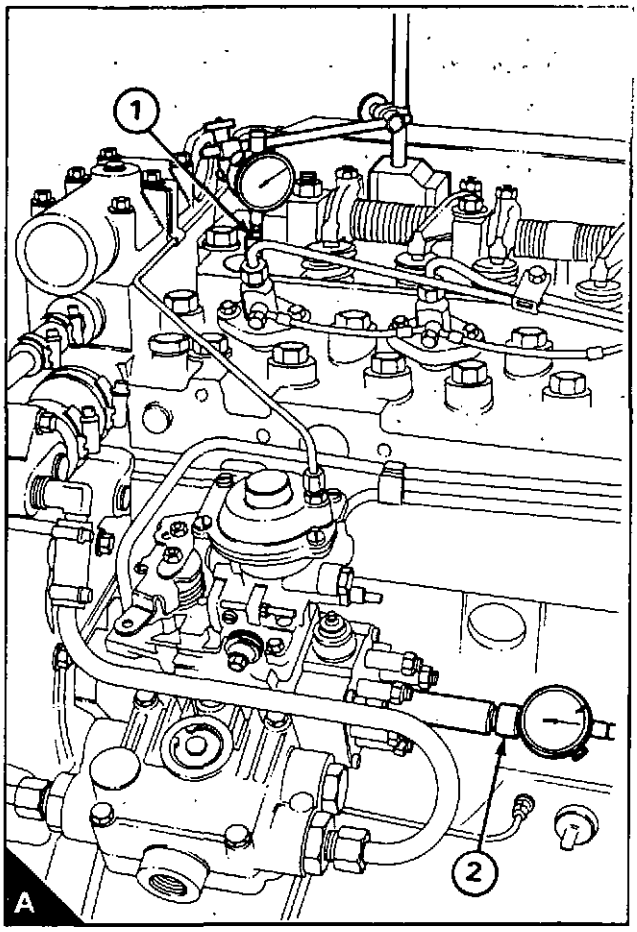
6 If the timing is not correct, disconnect the remainder of the pipes of the fuel injection pump and loosen the setscrew of support bracket for the pump.

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 PD199 to release the flange nuts. If the gauge on the pump plunger indicates more than 1,0 mm (0.039 in), turn 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), turn 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 Turn the crankshaft counter-clockwise approximately 45°, then slowly clockwise to check the timing again. Continue to turn 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.

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). Fit the rocker cover, operation 12A-01.

10 Eliminate the air from the fuel system, operation 20A-08A.



To check the timing mark of the fuel injection pump — 17A-04

Special tools:
Pump timing gauge, MS.107
Universal timing gauge, MS.67B
Gear adaptor for use with MS.67B, PD.67-3

1 Remove the fuel injection pump, operation 20A-06A.

2 Fit the adaptor PD67-3 to the drive shaft of the fuel pump (A) and fasten it with the nut of the fuel pump gear.

3 Release the screw (B1), set the timing tool to the correct angle, see section 11C, and tighten the screw.

4 Fit the timing tool to the splined adaptor on the fuel pump drive. Release the screw (B2), slide the pointer (B3) forward until it is over the centre of the fuel pump flange and tighten the screw. Turn 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 MS.107. Fit a dial gauge to the adaptor and set the gauge to indicate approximately 2,0 mm (0.080 in).

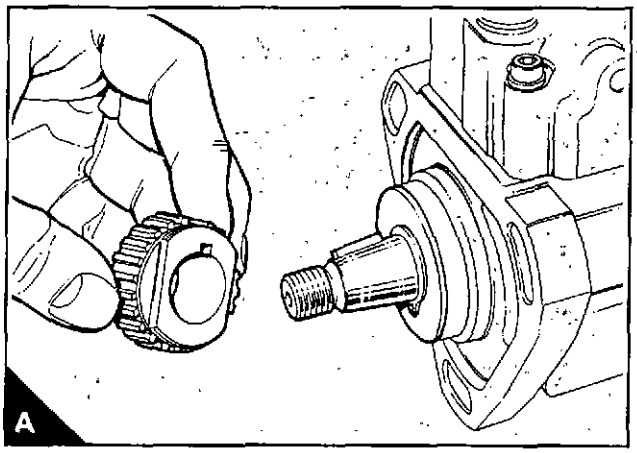
6 With the fuel injection pump held securely, turn the tool and the drive shaft counter-clockwise, from the drive end, and set the dial gauge to zero when the pump plunger is at its lowest position. Keep the fuel pump secure and turn the drive shaft clockwise until the gauge indicates 1,0 mm (0.039 in) 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.

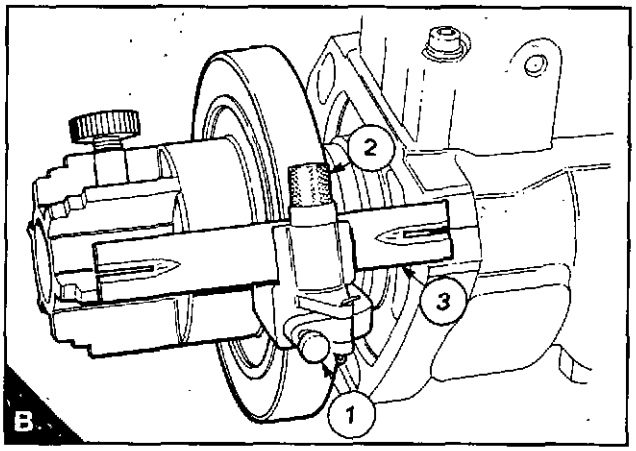
8 If the mark is not correct, remove the timing tool and eliminate the mark on the flange. Fit the timing tool and repeat the above operation to obtain 1,0 mm (0.039 in) plunger lift. With the fuel injection pump and timing tool held securely in the correct position, make a new mark on the flange of 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.

9 Remove the timing tool, splined adaptor and the adaptor and dial gauge. Fit the washer and plug to the rear of the fuel pump.

10 Fit the fuel injection pump, operation 20A-06A.

11 Eliminate air from the fuel system, operation 20A-08A.





To check the engine timing mark — 17A-05

Special tools:

Universal timing tool, MS.67B
Drive adaptor for use with MS.67B, PD.67-2
Pointer for use with MS.67B, PD.67-4
Distance piece for use with MS.67B, PD.67-5

1 Set the piston of number 1 cylinder to TDC on the compression stroke, operation 17A-01.

2 Remove the fuel injection pump and its joint, operation 20A-06A.

3 Fit the distance piece PD67-5 (A1) to the timing tool adaptor PD67-2. 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 (B1) on the timing tool MS.67B. Set the timing tool to the correct engine check angle, see section 11C, and tighten the screw. Loosen the screw (B2) and fit the splined shaft (B5) into the timing tool (B). Loosen the screw (B4). Fit the 90° pointer PD.67-4 (B3) 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 (B2).

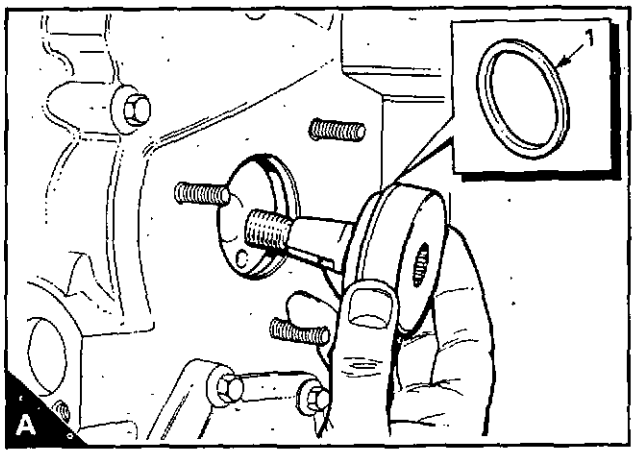
6 Loosen the screw (B4). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B3). If the mark is not correct, remove the timing tool and eliminate 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.

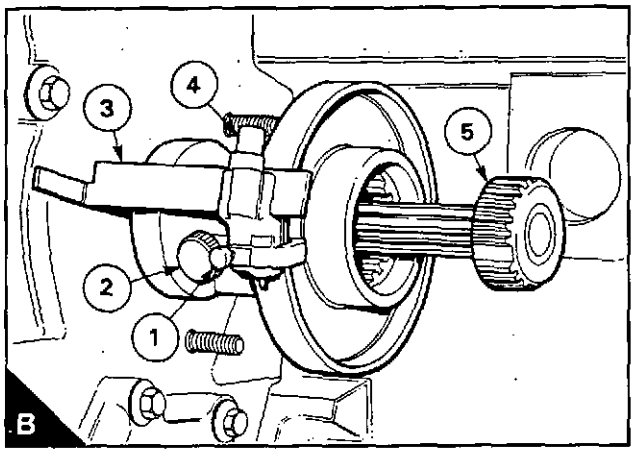
7 Remove the timing tool and the adaptor.

8 Fit the fuel pump together with a new joint, operation 20A-06A.

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). Fit the rocker cover, operation 12A-01.

10 Eliminate air from the fuel system, operation 20A-08A.



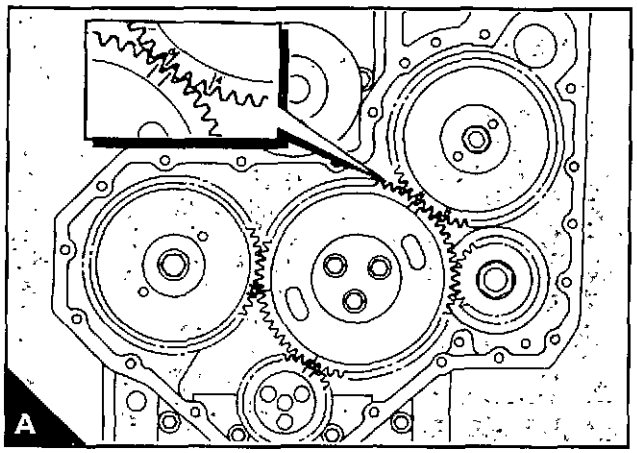


Engines fitted with CAV fuel injection pumps 17B

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, due to 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 CAV 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.



To set number 1 piston to TDC on the compression stroke — 17B-01

Special tools:

Valve spring compressor, PD.6118B
Stud adaptor for use with PD.6118B, PD.6118B-7
Setscrew adaptor for use with PD.6118B, PD.6118B-8

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, operation* 12A-01.

3 Turn the crankshaft, clockwise from the front, until the push rod for the inlet valve of the rear cylinder just tightens.

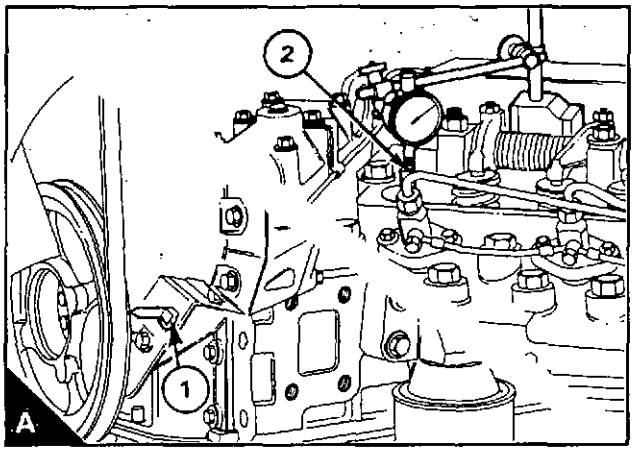
4 Remove the spring clip and the spacer from the front of the rocker shaft. Release the fasteners of the front two pedestals of the rocker shaft and remove the front rocker lever; tighten the fasteners of the rocker shaft pedestals.

5 Remove the valve springs from the front valve with the valve spring compressor 6118B and the adaptor PD6118-7, for pedestal studs, or the adaptor PD.6118-8, for pedestal setscrews.

6 Allow the valve to be held by the top of the piston. Fit a suitable collar near the top of the valve to hold the valve if the crankshaft is turned too far.

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. Turn the crankshaft slowly, clockwise from the front, until the clockwise movement of the dial gauge pointer just stops. Make a suitable mark on the crankshaft pulley to align with the temporary pointer. Continue to turn 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 to align with the pointer. Mark the centre point between the two marks on the pulley and remove the other two marks.

8 Turn the crankshaft approximately 45° counter-clockwise from the front and then clockwise until the mark on the pulley is aligned with the pointer. Number 1 piston is now at TDC on the compression stroke.



To check the valve timing 17B-02

1 Set the piston of number 1 cylinder to TDC compression stroke, operation 17B-01.

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 Turn 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 Turn 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 is within 2 1/2° of the pointer.
2 1/2° is 4,5 mm (0.18 in) at the circumference of the standard pulley, which has a diameter of 203 mm (8 in).

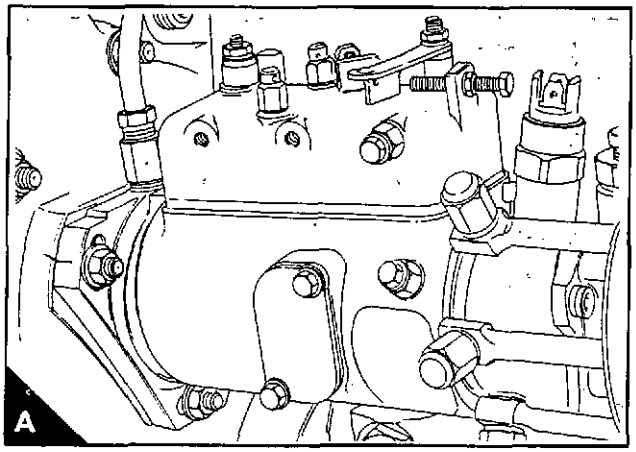
6 If the timing is more than 2 1/2° out of position, the timing gears are probably not in correct mesh.

Attention: One tooth on the camshaft gear is equivalent to 23,0 mm (0.90 in) of pulley circumference.

7 Turn 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, operation 12A-01.

9 Remove the temporary pointer from the timing case and the timing mark from the pulley.



To check the timing of the fuel injection pump 17B-03

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, operations 17B-04 and 17B-05.

To check the timing mark of the fuel injection pump — 17B-04

Special tools:
Universal timing tool, MS.67B
Gear adaptor for use with MS.67B, PD.67-3

1 Remove the fuel injection pump, operation 20A-06B.

2 Fit the adaptor PD.67-3 (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 - 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.in²) 31 kgf/cm² is indicated on the gauge.

5 *Loosen the screw (B1) on the timing tool MS.67B and set the* timing tool to the correct angle, see section 11C. Tighten the screw.

6 Fit the timing tool to the adaptor on the fuel pump drive shaft. *Turn 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 (B2). Slide the pointer (B3) 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.

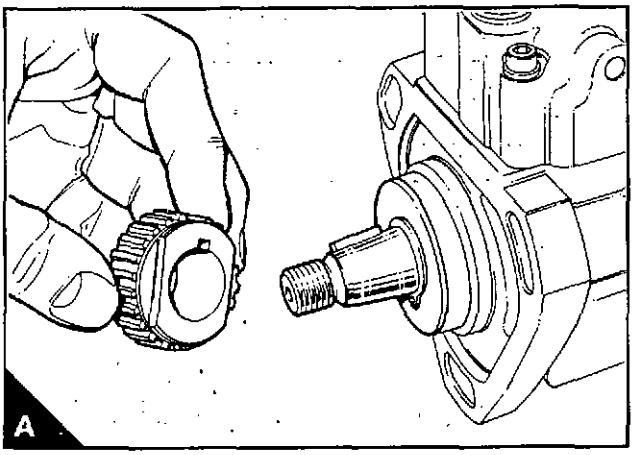
8 If the mark is not correct, remove the timing tool and eliminate *the mark. Fit the timing tool and ensure that the fuel pump is at the* start of injection for number 1 cylinder. Loosen the screw (B2). Slide the pointer forward to the complete width of the flange and tighten the screw. Make a new mark on the flange of the pump through the slot in the pointer.

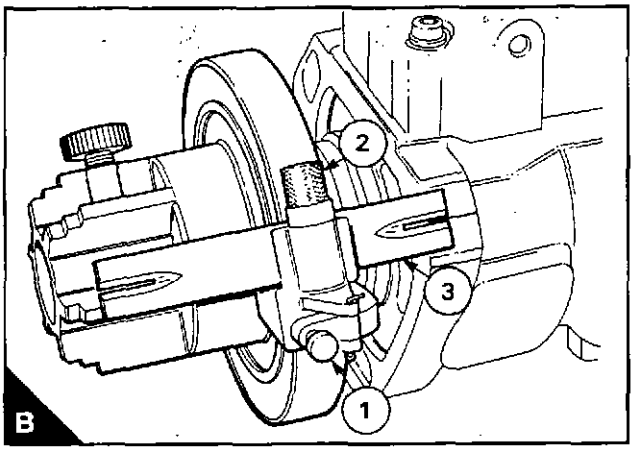
9 Remove the timing tool and the adaptor.

10 Disconnect the atomiser tester and fit the original banjo bolt to number 1 high pressure outlet.

11 *Fit the fuel injection pump, operation 20A-06B.*

12 Eliminate air from the fuel system, operation 20A-08B.





To check the engine timing mark — 17B-05

Special tools:

Universal timing tool, MS.67B
Adaptor for use with MS.67B, PD.67-2
Pointer for use with MS.67B, PD.67-4
Distance piece for use with MS.67B, PD.67-5

1 Set the piston of number 1 cylinder to TDC on the compression stroke, operation 17B-01.

2 Remove the fuel injection pump and its joint, operation 20A-06B.

3 Align the key in the adaptor PD.67-2 (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 (B1) on the timing tool MS67B. Set the timing tool to the correct engine check angle, see section 11C, and tighten the screw. Loosen the screw (B2) and fit the splined shaft (B5) into the timing tool (B). Loosen the screw (B4). Fit the 90° pointer PD67-4 (B3) 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 (B2).

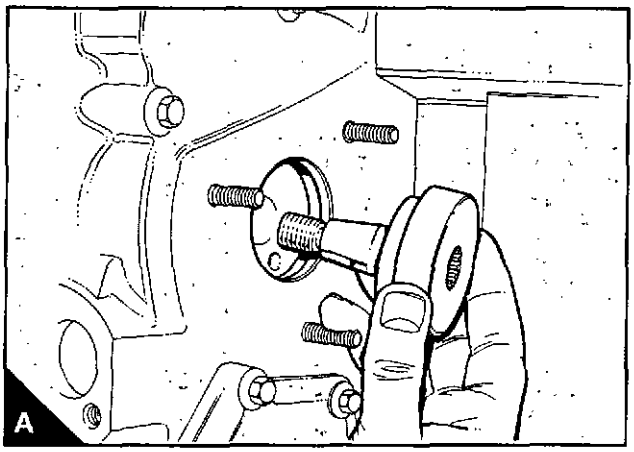
6 Loosen the lock screw (B4). Slide the pointer forward until the flat face is against the rear face of the timing case and tighten the screw. If the mark on the timing case is correct, the mark will align with the top edge of the pointer (B3). If the mark is not correct, remove the timing tool and eliminate 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.

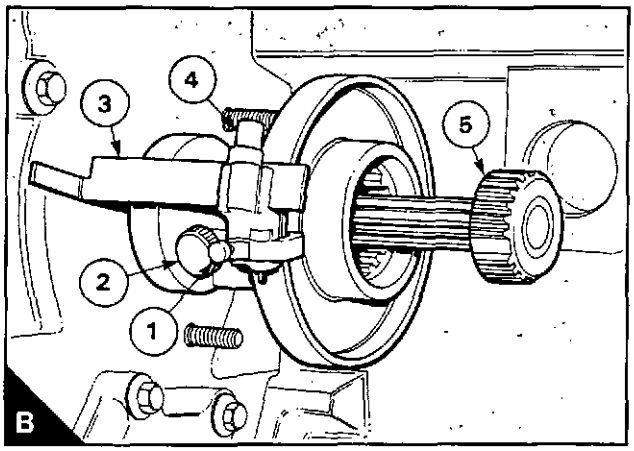
7 Remove the timing tool and the adaptor.

8 Fit the fuel injection pump and a new joint, operation 20A-06B.

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). Fit the rocker cover, operation 12A-01.

10 Eliminate air from the fuel system, operation 20A-08B.





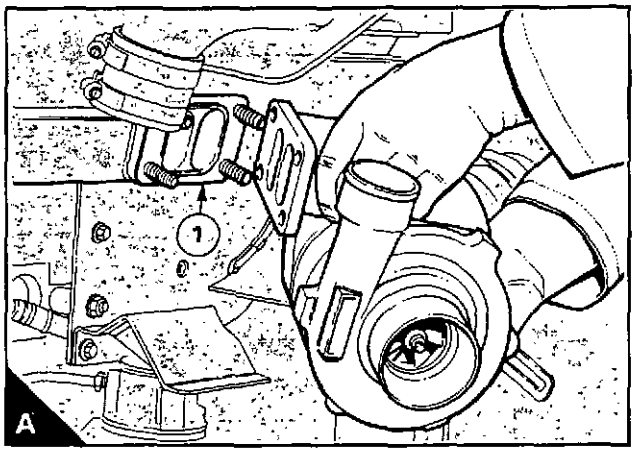
Aspiration system 18

General description

The turbocharger, which is fitted between the exhaust and induction manifolds, is driven by exhaust gases and supplies air to the engine at more than atmospheric pressure. It is lubricated by oil from the main pressure rail. The oil passes through the bearing housing of the turbocharger and returns to the lubricating oil sump.

Turbocharger

To remove and to fit — 18A-01



To remove

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. Release the nuts and remove the exhaust elbow and its gasket 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 of the turbocharger. Lift off the pipe and remove 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.

7 *Release the nuts at the turbocharger to exhaust manifold* flange and remove the turbocharger and the gasket. Cover the openings in the manifolds 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

1 *Remove the covers from the pipes and manifolds.*

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 openings 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.

5 Fit the oil drain pipe together with a new joint and tighten the flange setscrews, but do not connect the hose.

6 *If the original nuts are to be used, clean the threads of the studs* of the turbocharger to exhaust pipe flange and apply a suitable compound to prevent seizure. The threads of new nuts are *phosphated to prevent seizure. Put a new gasket in position over* the studs. Fit the exhaust elbow to the turbocharger and fit and tighten the nuts. Fit or connect the support bracket for the turbocharger. If necessary, fit the heat shield for the fuel lift pump.

7 Slide the hose on the induction manifold elbow onto the compressor outlet and tighten the hose clips.

8 Check that there is no restriction in the air filter to turbocharger hose. Fit the hose and tighten the clip.

9 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

Generally, it is not necessary to remove the turbocharger to remove the compressor casing, except for engine types AB and AD used in vehicle applications. On these engines, the compressor casing is held by a circlip and access to the circlip is not always possible.

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 the bearing housing to ensure correct location later. Release the setscrews and lock plates. For engine types AB and AD used in vehicle applications: Remove the turbocharger, make reference marks as above and release the circlip.
Remove carefully the compressor casing from the turbocharger (A). If the casing is tight, lightly hit it with a soft faced hammer. Be careful not to damage the impeller blades. If the impeller is damaged, the turbocharger must be renewed.

3 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.

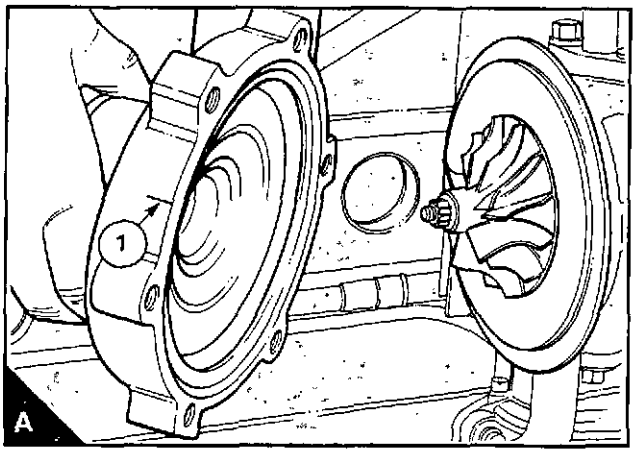
4 Clean the impeller with a soft brush.

5 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.

6 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.
For engine types AB and AD used in vehicle applications: If the circlip has been removed, fit it loosely on the bearing housing. Ensure that the chamfered face of the circlip is towards the exhaust end of the turbocharger. Carefully fit the turbocharger assembly into the compressor casing. Align the two location marks and fit the circlip in the groove.

7 Fit the hoses to the compressor inlet and outlet and tighten the clips.

8 If necessary, fit the turbocharger to the engine, operation 18A-01.



Lubrication system 19

General description

For four cylinder engines the lubrication system is as follows:

Pressure lubrication is supplied by a rotor type pump. The pump is driven through an idler gear from the crankshaft gear. If a balancer unit is fitted, the pump is fitted to the balancer frame and is driven by the balancer drive shaft. The lubricating oil from the oil pump passes through a full flow filter to the pressure rail. The filter has a by-pass valve which lets oil pass directly to the pressure rail, if the filter becomes restricted. 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 for the camshaft journals is supplied from the main bearings and a reduced supply is sent from the centre camshaft journal, through passages in the cylinder block and the cylinder head, to the rocker assembly. Lubricating oil passes through the rocker shaft to the bearings of the rocker levers. The valve stems and valve springs are lubricated by splash and oil mist.

The hub of the idler gear is supplied with lubricating oil from the pressure rail and the timing gears are splash lubricated.

The maximum pressure in the system is controlled by a relief valve. This valve controls the pressure of the oil immediately after it has left the oil pump. If a balancer unit is fitted, the valve is fitted in the frame of the balancer.

On turbocharged engines and certain naturally aspirated engines the lubricating oil passes through an oil cooler before it passes to the oil filter. When cold oil increases the restriction in the cooler, a by-pass valve lets the lubricating oil pass directly to the oil filter.

The turbocharger is lubricated by oil from the pressure rail. The lubricating oil is sent through a passage across the cylinder block to an adaptor fitted to the right side of the engine and then by pipe to the turbocharger. The lubricating oil returns from the turbocharger to the sump.

These engines have piston cooling jets fitted. These jets are connected to the pressure rail and spray lubricating oil inside the piston to keep them cool.

The lubrication circuit of 6 cylinder engines is basically the same as that for 4 cylinder engines except for these differences:

1 All turbocharged engines and the majority of naturally aspirated engines have an oil cooler.

2 When an oil cooler is fitted, the relief valve is in the circuit between the oil cooler and the oil filter.

3 The oil supply for the rocker assembly is from number 2 camshaft journal.

For both 4 and 6 cylinder engines the supply of lubricating oil to the compressor or exhauster is by a pipe connected to the pressure rail.

Filter canister

To renew — 19A-01

The filter can have one or two canisters fitted. When two canisters are fitted, both must be renewed at the same time.

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. Ensure that the adaptor (A1) is secure in the filter head and then discard the canister.

3 Clean the filter head.

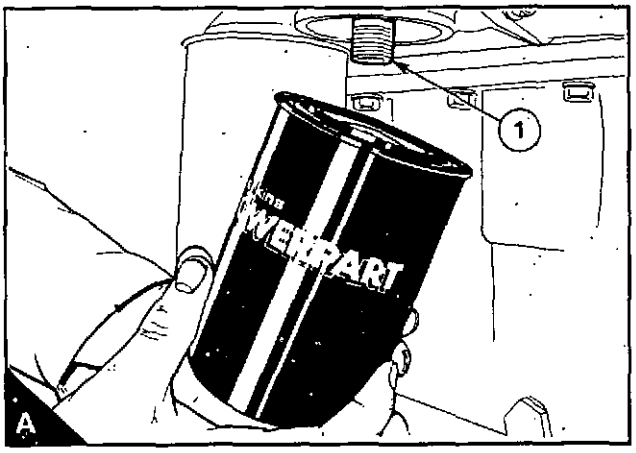
4 Add clean engine lubricating oil to the new canister. Give the oil time to fill the canister through the filter element.

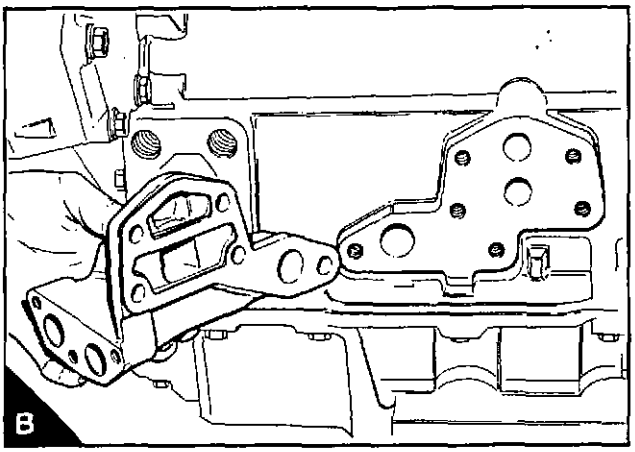
5 Lubricate the top of the canister seal with clean engine lubricating oil.

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.

Attention: 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 — 19A-02

1 Put a tray under the filter head to contain spilt lubricating oil.

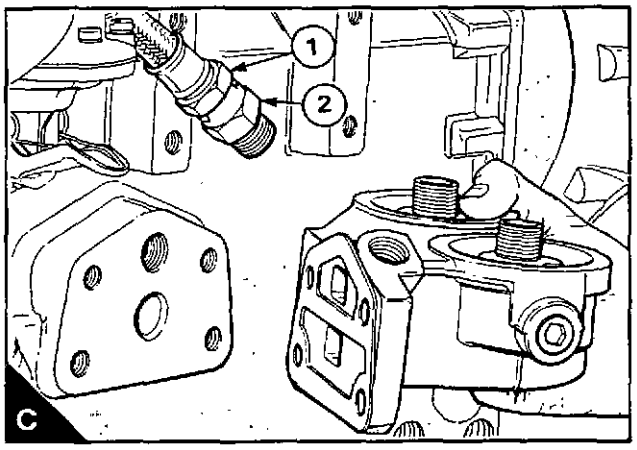
2 Remove the filter canister(s), operation 19A-01.

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 (C1) to hold the pipe* while the connection (C2) is released.

4 Release the setscrews or nuts and remove the filter head from the cylinder block (B or C). Discard the joint.

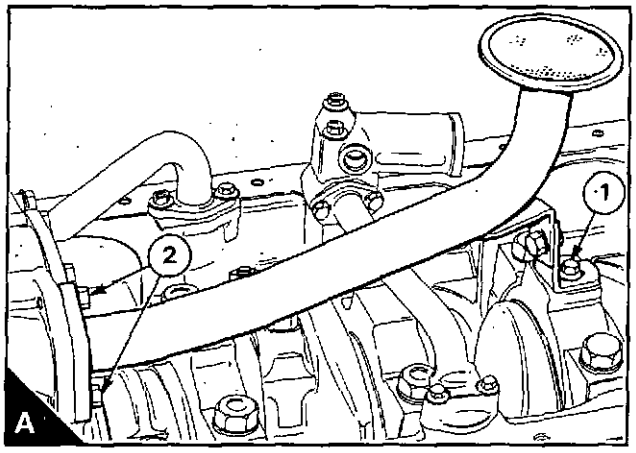
5 Clean the joint face of the filter head and, if fitted, the flange of the oil cooler pipes. Fit the filter head and a new joint. Tighten the setscrews or nuts. Where necessary, fit the pipes of the oil cooler and a new joint. Tighten the setscrews. Where necessary, connect the oil supply pipe of the turbocharger. Use a spanner on the hexagonal end of the flexible pipe to hold the pipe while the connection is tightened.

6 Fit new filter canister(s), operation 19A-01.



Sump

To remove and to fit 19A-03



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 clean kerosene, ensure all the kerosene is removed. Clean the flange face of the sump and of the cylinder block.

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. 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 19A-04

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.

1 Remove the sump, operation 19A-03.

2 Release the setscrew which holds the bracket to the main bearing cap (A1).

3 Release the setscrews from the flange of the suction pipe (A2). Remove the suction pipe and strainer. Remove the old joint. Clean the flange face of the oil pump and of the suction pipe.

4 Loosely assemble the bracket of the suction pipe to the correct main bearing cap. Fit the suction pipe to the oil pump together with a new joint. Tighten the setscrews. Tighten the setscrew of the suction pipe bracket. If the clamp type bracket, used on some four cylinder engines, has been removed, ensure that the clamp, bracket and pipe are correctly aligned before the setscrews are tightened. Ensure that there is no stress on the suction pipe.

5 Fit the sump, operation 19A-03, and fill it with an approved oil to the "MAX" level on the dipstick.

To inspect and to correct 19A-05

1 Wash the assembly in kerosene 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.

Lubricating oil pump

To remove and to fit 19A-06

Engine types AA, AB, AC and AD: If a balancer unit is fitted, the oil pump is integral with the balancer unit, see section 14 for removal instructions etc.

To remove

1 Drain the lubricating oil and remove the lubricating oil sump, operation 19A-03.

2 Remove the suction pipe and strainer, operation 19A-04.

3 Engine types AA, AB, AC and AD: Remove the oil pressure relief valve, operation 19A-09, and the delivery pipe. Engine types YA, YB, YC and YD: 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, operation 15A-08.

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

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.

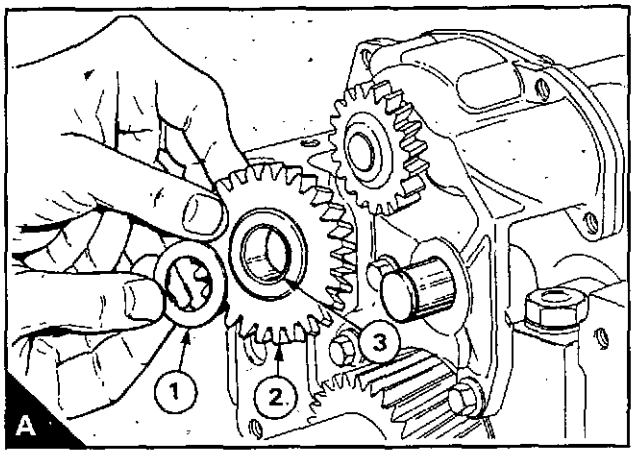
2 Check the idler gear and the bush for wear and other damage. If the gear and/or bush are damaged, they can be renewed as an assembly or the bush can be renewed as a single item. Lubricate the bush (A3) with clean engine lubricating oil and fit the idler gear (A2), the washer (A1) and the circlip. Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump gear and the idler gear (C).

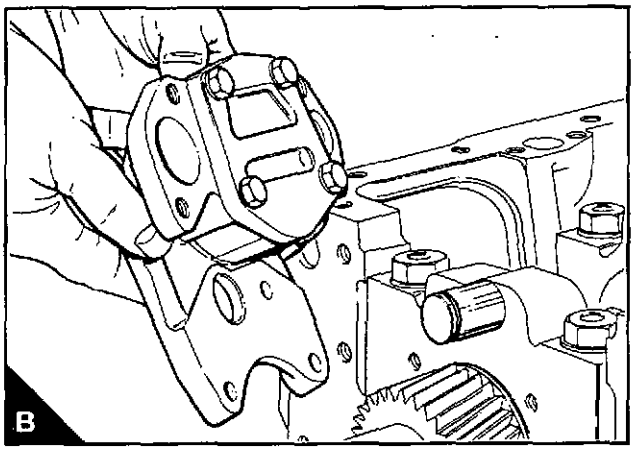
3 If number 1 main bearing cap was removed, lubricate the bearing with clean engine lubricating oil and fit the bearing cap. Tighten the setscrews to 265 Nm (196 lbf ft) 27,0 kgf m. If the timing case was removed, fit the timing case, operation 15A-08. Check that there is a minimum of 0,076 mm (0.003 in) backlash between the oil pump idler gear and the crankshaft gear.

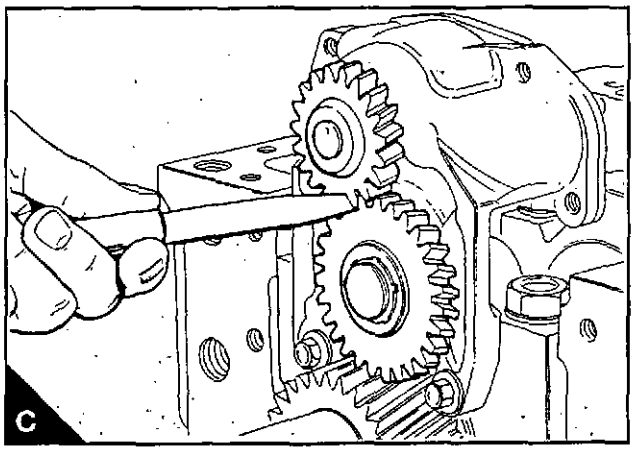
4 Fit the suction pipe and strainer, operation 19A-04.

5 Engine types AA, AB, AC and AD: Fit the delivery pipe and oil pressure relief valve, operation 19A-09. Engine types YA, YB, YC and YD: Fit the delivery pipe and tighten the setscrews. Use new joints.

6 Fit the lubricating oil sump, operation 19A-03. Fill the sump to the "MAX" mark on the dipstick with an approved lubricating oil.







To inspect 19A-07

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.

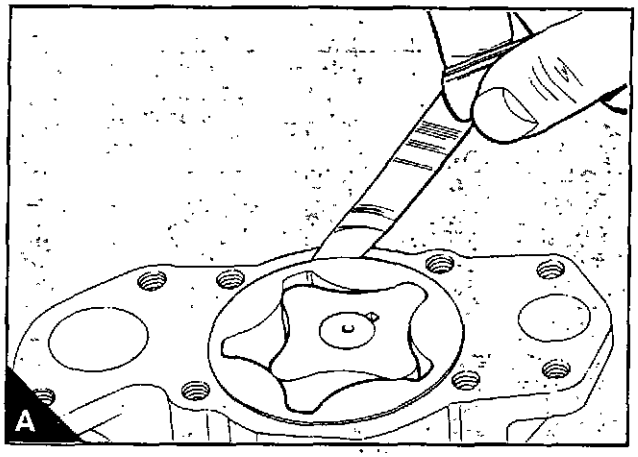
2 Remove the outer rotor and clean thoroughly all the parts. Check for cracks and any other damage.

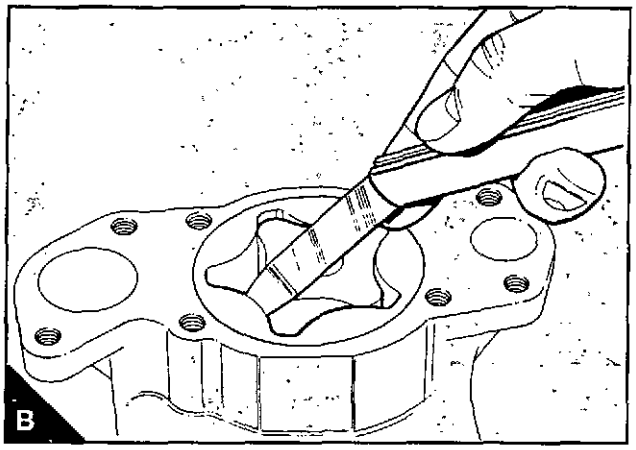
3 Fit the outer rotor and check the outer rotor to body clearance (A).

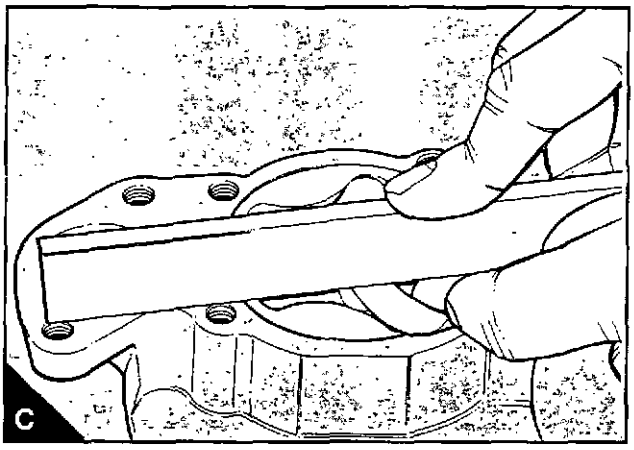
4 Check the inner rotor to outer rotor clearance (B).

5 Check the rotor end-float with a straight edge and a feeler gauge (C). For all the above clearances, see section 11C.

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.







Relief valve

To remove and to fit — 19A-08

Engine types AA, AB, AC, and AD which have a balancer unit fitted: The relief valve is fitted inside the balancer frame and cannot be removed as an assembly.

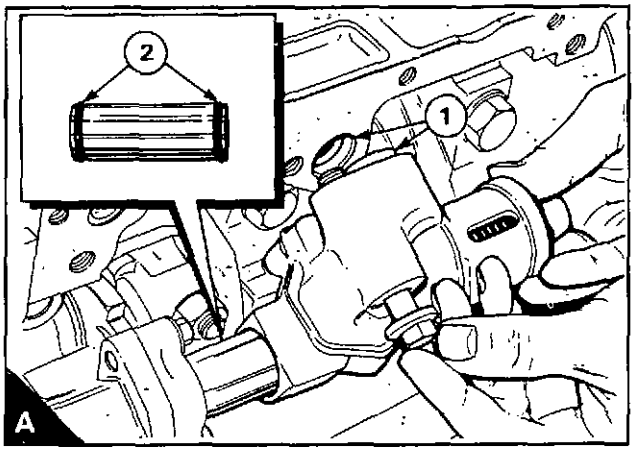
1 Drain the lubricating oil and remove the sump, operation 19A-03.

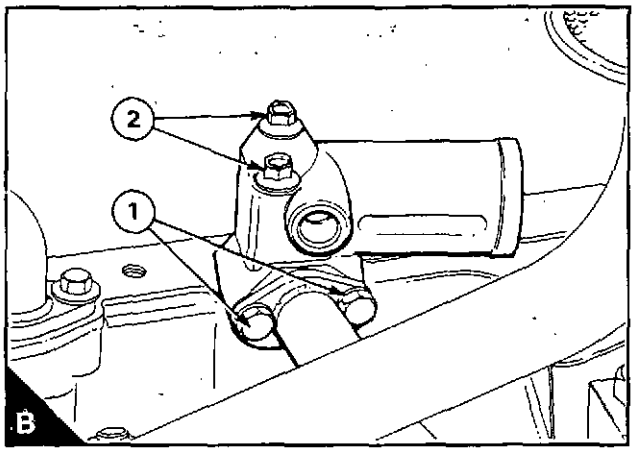
2 Engine types AA, AB, AD and AD: Release the setscrew and turn the relief valve to withdraw the thimble from the cylinder block (A1). Pull the relief valve from the delivery pipe and pull the delivery pipe from the oil pump.

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.

3 Engine types YA, YB, YC and YD: Remove the setscrews which fasten the cross flow pipe to the relief valve (B1). Remove the flange joint. Release the two setscrews (B2) 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.





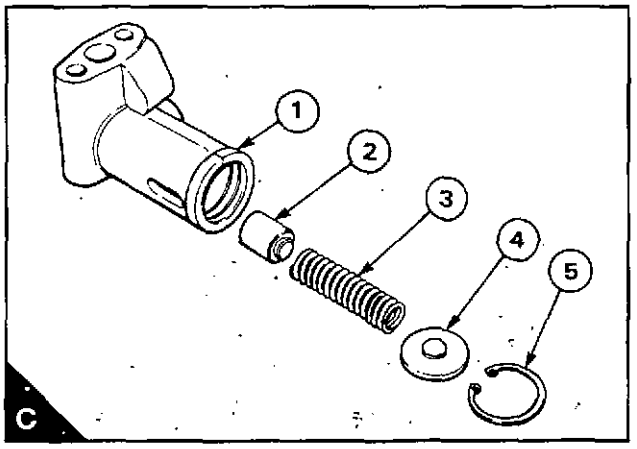
To dismantle and to assemble — 19A-09

If necessary, the relief valve can be dismantled and assembled while it is fitted to the engine.

1 Apply pressure to the end plate (C4 or D4) of the spring assembly; release the circlip (C5) or remove the pin (D5) and carefully release the pressure to remove the end plate and the spring (C3 or D3) from the valve body. Remove the plunger (C2 or D2) from the bore of the body (C1 or D1).

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 — 19A-10

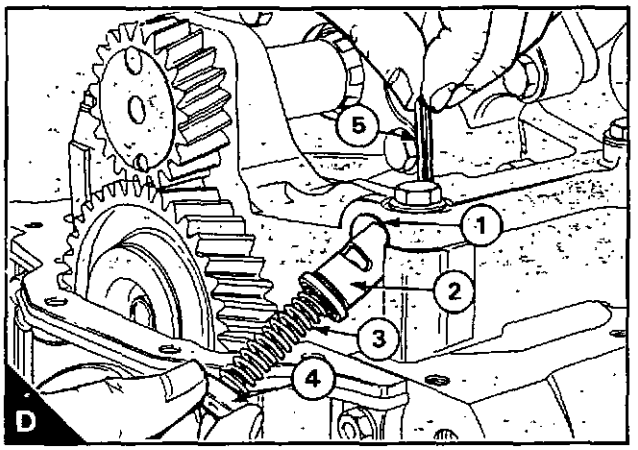
Do not try to change the operation pressure of the relief valve by a method other than the installation of new components.

1 Check the spring for wear and other damage and, if possible, check the load necessary to compress the spring to its fitted length, see section 11C.

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.



Fuel system 20

General description

Engines used for vehicle applications have Bosch fuel injection pumps (A or B). The pumps which are fitted to engine types AB, AD, YB and YD have a boost control (B1).

Engines used for agricultural and industrial applications have CAV fuel injection pumps. Engine types AA, AC, YA and YC have CAV DPA fuel pumps fitted (C). Engine types AB, AD, YB and YD have CAV DPS fuel pumps fitted (D) and these pumps have a boost control (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.

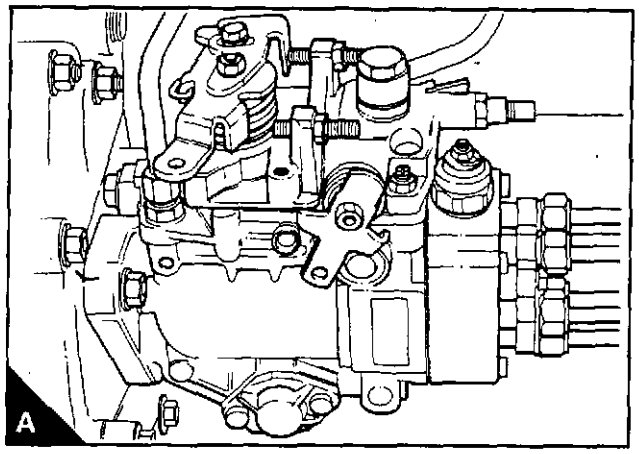
Both the Bosch and CAV fuel injection pumps have mechanical governors to control the engine speed.

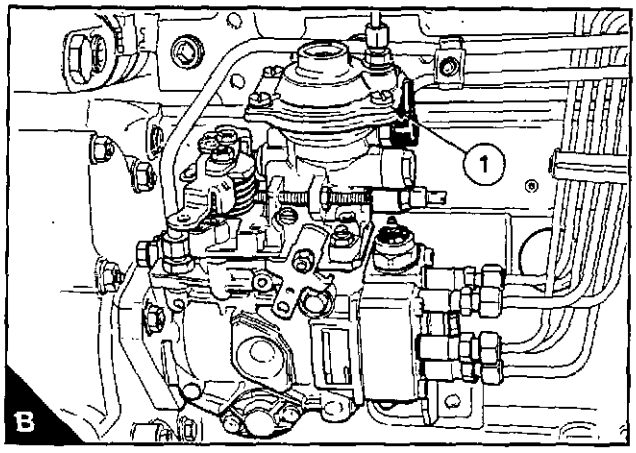
The "low spring" atomisers receive high pressure fuel from the fuel injection pump and inject this fuel into the combustion chamber of the pistons as a very fine spray. The atomisers are set in the factory, but must be checked in accordance with the preventive maintenance schedules. The pressure at which atomisers operate can be adjusted by a change of shims fitted above the spring.

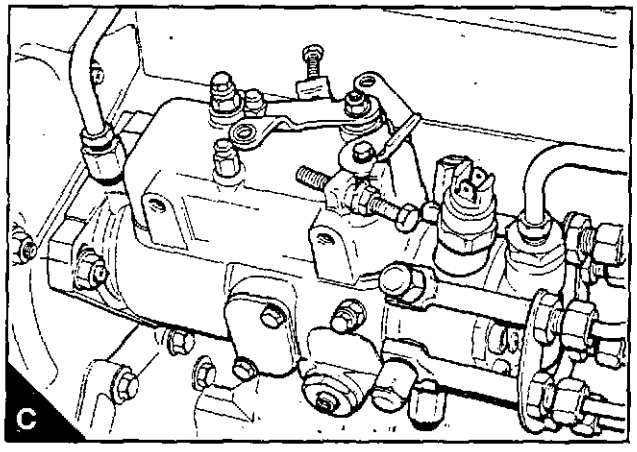
The fuel injection equipment must only be checked and adjusted by personnel who have had the correct training.

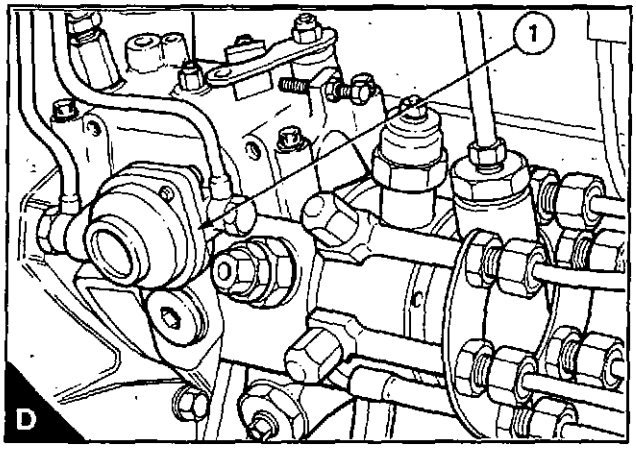
The fuel lift pump is of the diaphragm type and is mechanically driven. It is fitted on the right side of the cylinder block and is driven by an eccentric on the camshaft. The pump is fitted with a priming lever.

Attention: 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 a component has been disconnected, fit a suitable cover to all open connections.









Fuel filter

To remove and to fit — 20A-01

The filter can have one or two elements. 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 is fitted to the filter bowl, drain the fuel from the filter (A).

2 Hold the bottom cover of the filter element and release the setscrew which is fitted through the filter head above the centre of each element.

3 Lower the bottom cover of the filter (B).

4 Remove the element and discard it.

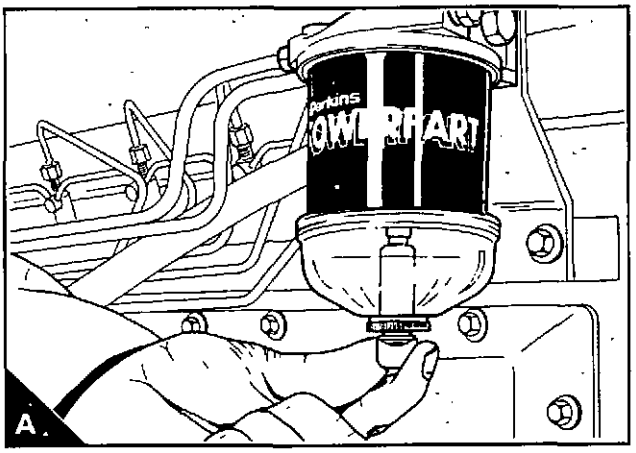
5 Clean the inside surfaces of the top and bottom filter covers.

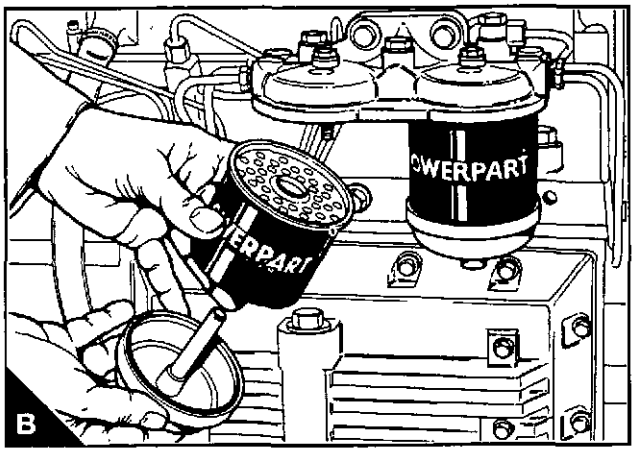
6 Fit the new sealing rings.

7 Put the bottom cover on the bottom of the new element 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, operation 20A-08A or 20A-08B.





Atomisers

Atomiser fault

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.

Do not let the fuel spray on to your skin!

To remove and to fit — 20A-02

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.

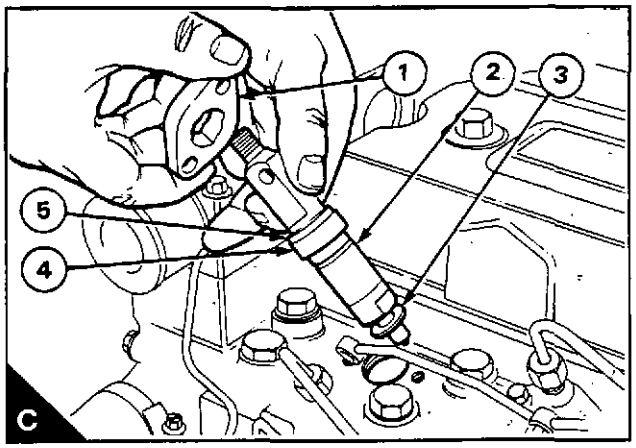
3 Release the setscrews of the atomiser flange and remove the flange (C1), the atomiser (C2) and its seat washer (C3). Remove the dust seal (C4) and the spacer (C5) and fit the spacer and a new dust seal to the new atomiser.

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 — 20A-03

1 If a heat shield is fitted, remove it. Disconnect the fuel pipes from the fuel lift pump.

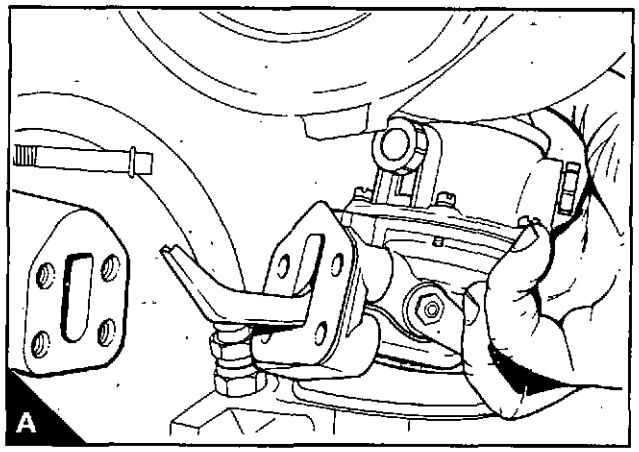
2 Release the setscrews, remove the lockplates and remove the fuel lift pump (A). The lift pump may be difficult to remove from the engine. If this occurs the crankshaft must be rotated until the camshaft eccentric, that operates the lift pump, is in a position which will free the rocker lever of the 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 lockplates 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 and to assemble — 20A-04

To dismantle

1 Clean the outside surfaces of the fuel lift pump.

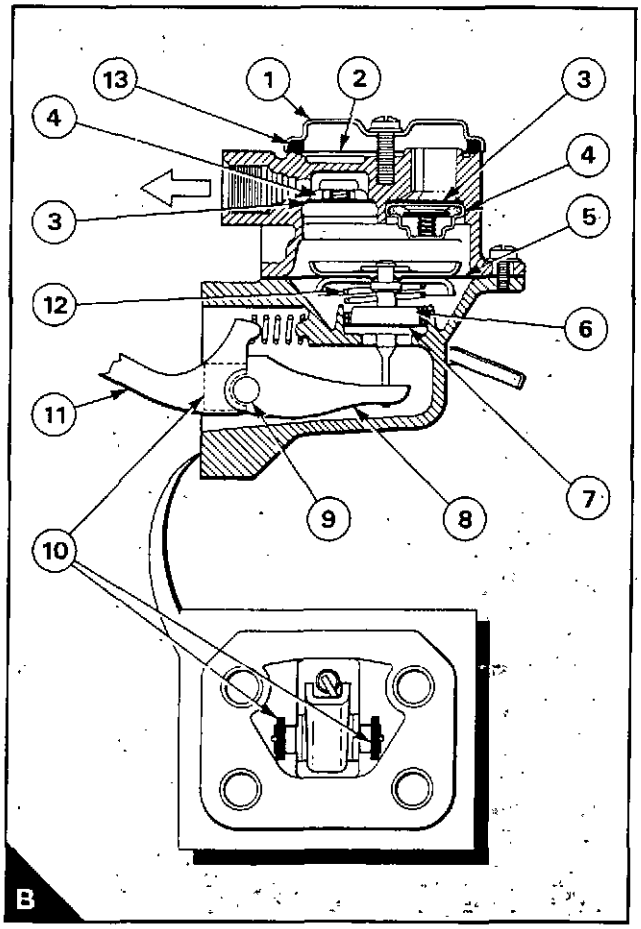
2 Make a mark across the flanges of the two halves of the pump to ensure correct relationship when the pump is assembled.

3 Remove the cover (B1) and the gauze (B2). Release the setscrews and separate the two halves of the pump.

4 Turn the diaphragm assembly (B5) 90° to release the pull rod from the link arm (B8) and remove the diaphragm assembly. Remove the stem seal (B6), the spring seat washer (B7) and the spring (B12) 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 (B4) 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 (B11) in a vice and hit the body of the lift pump with a soft face hammer to release the two retainers (B10). Be careful not to damage the joint face of the pump body. Remove the rocker lever, the pin (B9), the link arm and the return spring. Check the components for wear and other damage.



To assemble

1 Thoroughly clean the valve housings. Fit new seat washers (B3) and push the new valves (B4) 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 B. 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 (B11), pin (B9) and link arm assembly (B8) 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 (B10) 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 (20A.04/B12) into its location under the diaphragm (20A.04/B5) and put the spring seat washer (20A.04/B7) and a new stem seal (20A.04/B6) 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 arm 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 arm; fit the spring washers and the screws and tighten them evenly.

7 Fit the gauze filter (20A.04/B2) and the cover (20A.04/B1), ensure that the rubber seal (20A.04/B13) is fitted correctly and tighten the screw.

To test **20A-05**

1 Disconnect the fuel outlet pipe from the fuel lift pump. Fit a 0-70 kPa (0-10 lbf/in²) 0-0,7 kgf/cm² 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 and note the maximum pressure indicated on the gauge. If the pressure indicated is less than the test pressure shown in section 11C, 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.

3 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.

Fuel injection pump

To remove and to fit - Bosch pump 20A-06A

To remove

Special tools:
Gear puller, PD.155B
Adaptors for use with PD.155B, PD.155B-5
Spanner for flange nuts of fuel injection pump, PD.199

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 Turn 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 PD.199 to release the flange nuts.

5 Loosen the drive gear of the fuel injection pump with the puller PD.155B and adaptors PD155B-5 (B).

6 Remove the fuel pump; ensure that the key does not fall from the drive shaft.

To fit

1 Turn 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 (C1). 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.

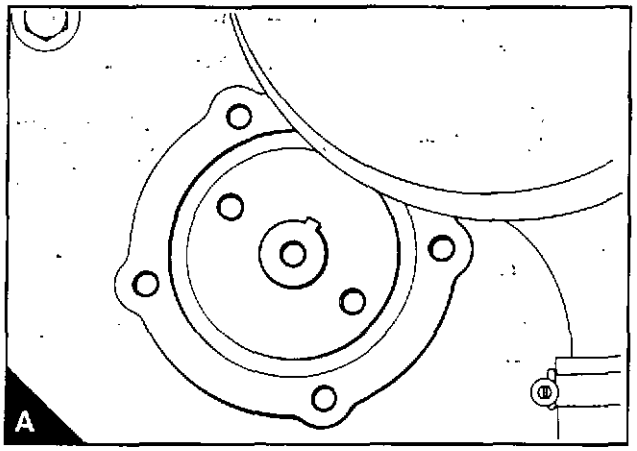
3 Fit the spring washer and nut to the drive shaft of the fuel pump and tighten the nut to 80 Nm (59 lbf ft) 8,2 kgf m. Fit the gear cover to the cover of the timing case. Fit a new joint, if necessary.

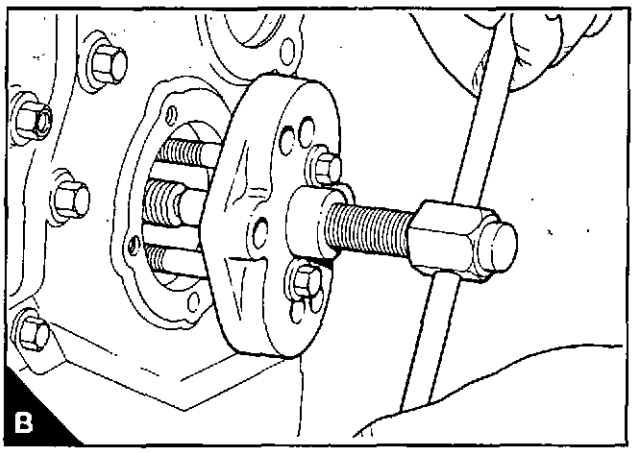
4 Fit all the pipes, connect the stop control and the control rod of the fuel injection pump. Ensure that a spanner is used to prevent movement of the pump outlets when the high-pressure pipes are fitted.

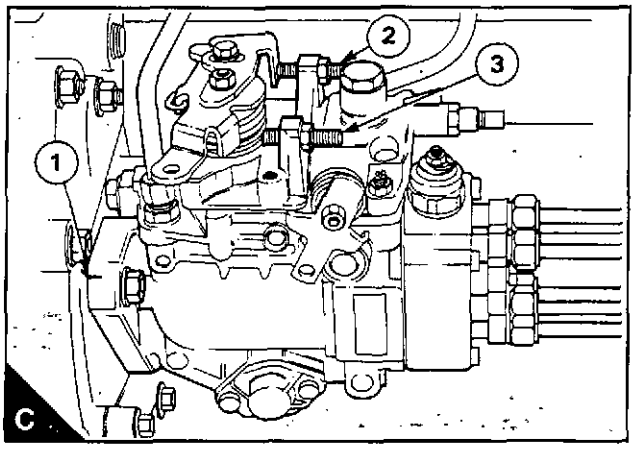
5 Eliminate air from the fuel system, operation 20A-08A.

6 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, operation 20A-07A.

7 If a new fuel injection pump has been fitted, check the maximum no load speed, operation 20A-07A.







To remove and to fit - CAV pump 20A-06B

To remove

Special tools:

Gear puller, PD.155B
Adaptors for use with PD.155B, PD.155B-5
Spanner for flange nuts of fuel injection pump, PD.199

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 Turn 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 PD.199 to release the flange nuts.

5 Loosen the drive gear of the fuel injection pump with the puller PD.155B and the adaptors PD.155B-5 (20A.06/B).

6 Remove the fuel pump; ensure that the key does not fall from the drive shaft.

To fit

1 Turn 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.

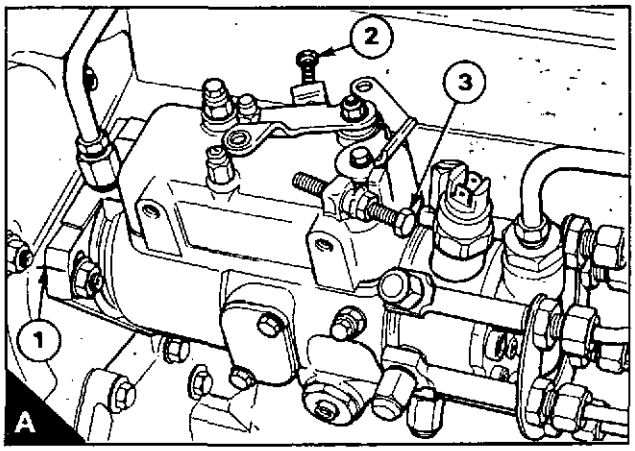
5 Eliminate air from the fuel system. operation 20A-08B.

6 Operate the engine and check for leakage. With the engine at the normal temperature of operation, check that the idle speed is correct, operation 20A-07B.

7 If a new fuel pump has been fitted, check the maximum no load speed, operation 20A-07B.

To adjust - Bosch pump 20A-07A

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 (20A.06/C2). Release the locknut and turn the screw clockwise to increase the speed, or counter-clockwise to decrease the speed. When the speed is correct, tighten the locknut. 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 Services Department, Perkins Engines, Peterborough, England.



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 on the side of the fuel pump. A typical setting code is 2643J000CK/1/2960. In this example, the maximum no load speed is 2960 rev/min. If necessary, this speed can be adjusted by the outer adjustment screw (20A.06/C3). Release the locknut and turn the screw counter-clockwise to increase the speed or clockwise to decrease the speed. When the speed is correct, tighten the locknut 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.

To adjust - CAV pump 20A-07B

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 (A2). Release the locknut and turn the screw clockwise to increase the speed or counter-clockwise to decrease the speed. When the speed is correct, tighten the locknut. 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 Services Department, Perkins Engines, Peterborough, England.

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 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 outer adjustment screw (A3). Release the locknut and turn the screw counter-clockwise to increase, or clockwise to decrease, the speed. When the speed is correct, tighten the locknut 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.

To eliminate air from the fuel system - Bosch pump **20A-08A**

If air enters the fuel system, it must be eliminated 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:

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).

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. 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 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.

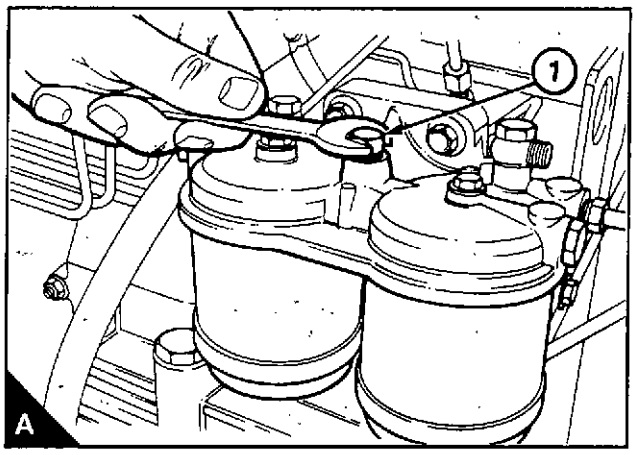
4 Loosen the union nut of the fuel inlet pipe (D1). Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the loose connection. Tighten the union nut.

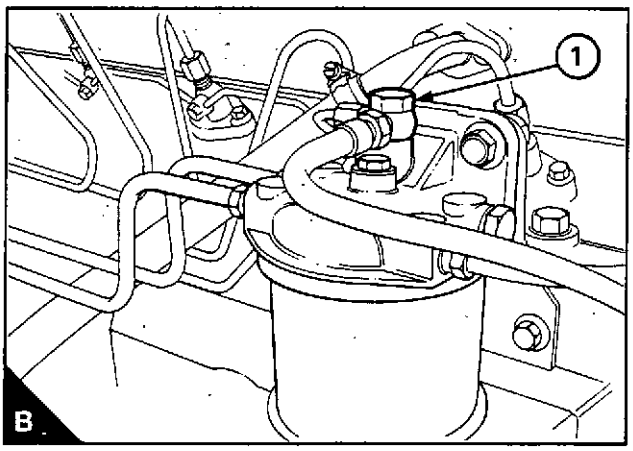
5 Loosen the union nut (20A.09/A1) at the fuelled starting aid, if one is fitted, and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

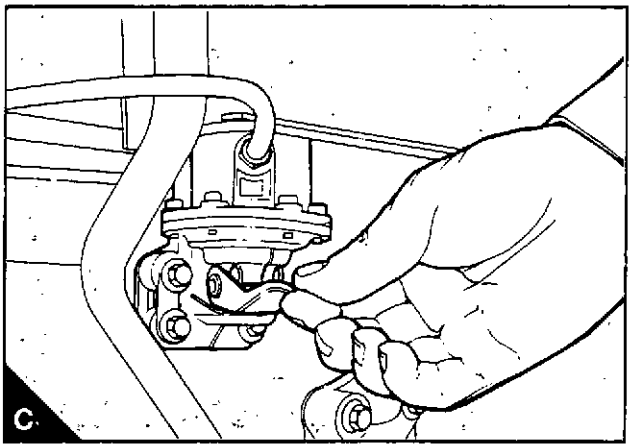
6 Loosen the high-pressure pipe connections (20A.09/B1) at two of the atomisers.

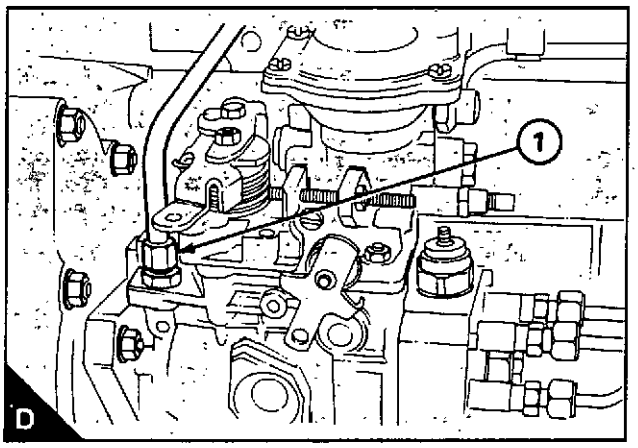
7 Ensure that the manual stop control, if one is fitted, is in the 'run' position. Operate the starter motor until fuel, free from air, comes from the pipe connections.

8 The engine is now ready to start.
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.









To eliminate air from the fuel system - CAV pump **20A-08B**

If air enters the fuel system, it must be eliminated 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:

1 Loosen the vent plug on top of the twin element fuel filter (20A.08/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 (20A.08/B1).

2 Operate the priming lever on the fuel lift pump (20A.08/C) until fuel, free of air, comes from the filter vent point. Tighten the vent plug or the banjo connection bolt. 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 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.

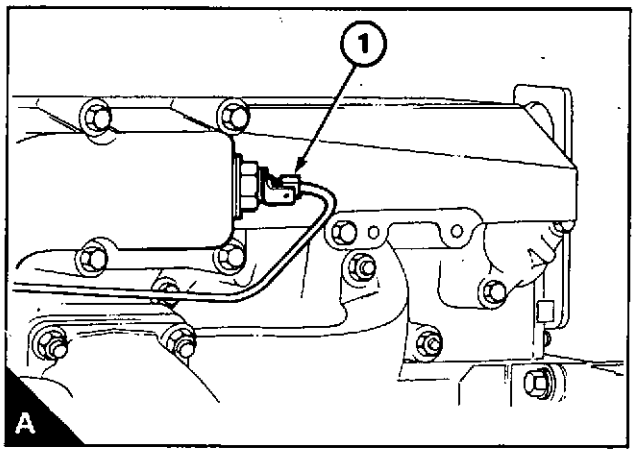
4 CAV DPA fuel injection pump: Loosen the vent screw (C1) on the lock screw of the hydraulic head and loosen the vent screw (C2) on the top of the governor housing.
Operate the priming lever of the fuel lift pump until fuel, free of air, comes from the vent point in the lock screw of the hydraulic head. 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: 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.

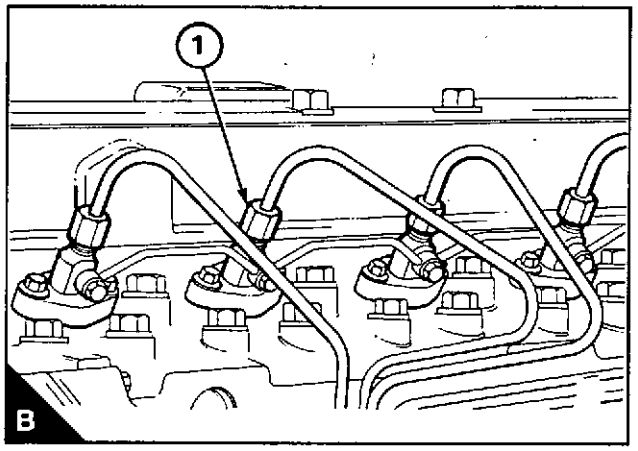
5 Loosen the union nut (A1) at the fuelled starting aid, if one if fitted, and operate the priming lever of the fuel lift pump until fuel, free of air, comes from the connection. Tighten the union nut at the starting aid.

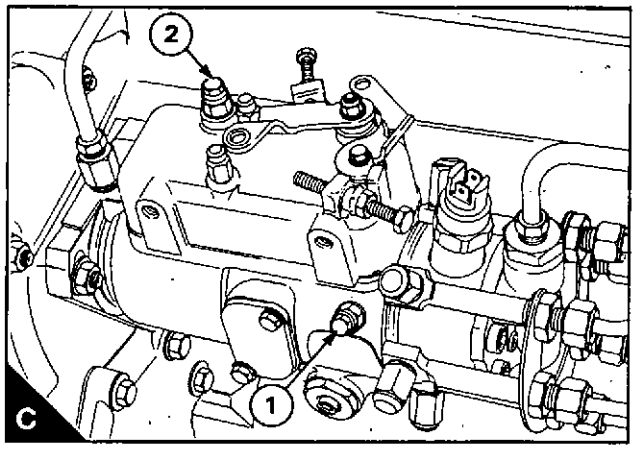
6 Loosen the high-pressure pipe connections (B1) at two of the atomisers.

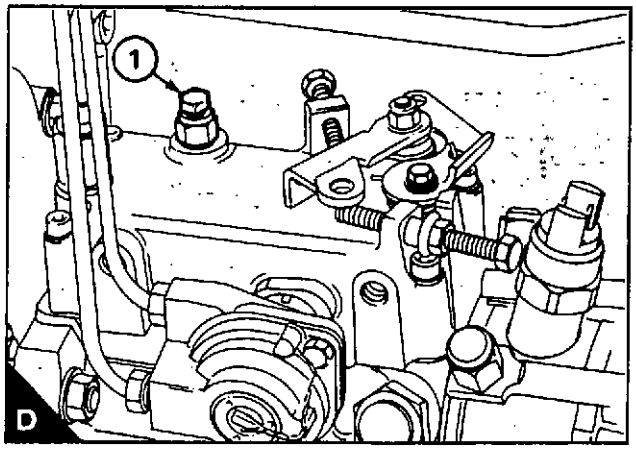
7 Ensure that the manual stop control, if one is fitted, is in the "run" position. Operate the starter motor until fuel, free from air, comes from the pipe connections.

8 The engine is now ready to start.
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.









Cooling system 21

General description

Coolant from the bottom of the radiator passes through the centrifugal water pump which is fitted on the front of the timing case. The pump is gear driven from the gear of the fuel injection pump and assists the flow of the coolant through the system. From the pump, the coolant passes through a passage in the timing case 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. Where 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. 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 water 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 water pump. If the thermostats are open, the coolant passes to the top of the radiator.

Thermostats

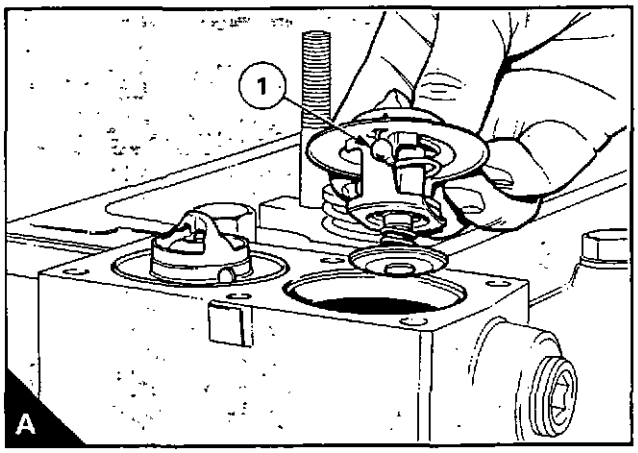
To remove and to fit — 21A-01

To remove

1 Drain the cooling system so that the coolant level is below the thermostat position and disconnect the top hose from the water outlet connection.

2 Release the setscrews and remove the water outlet connection.

3 Remove the thermostat(s) (A).



To fit

1 Ensure that the joint faces of the housing and the outlet are clean and that the jiggle pin(s) (A1) in the thermostat(s) is/are free to move.

2 Put the new thermostat(s) in position in the housing.

3 Fit a new joint and the water outlet connection. Tighten the setscrews.

4 Connect the top hose and fill the cooling system.

To test

1 Hang the thermostat in a suitable container filled with water.

2 Heat the water gradually. Use a thermometer to check the temperature at which the valve starts to open and at which it is fully open. The correct temperatures are given in section 11C.

3 If the thermostat does not operate correctly, it must be renewed. Do not try to adjust the settings.

Water pump

To remove and to fit — 21A-02

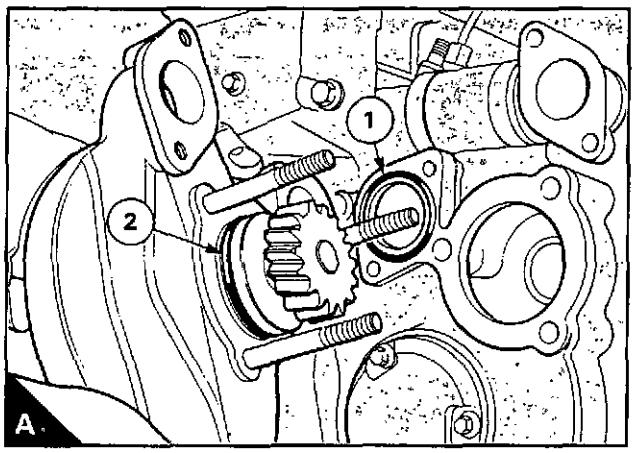
To remove

1 Drain the cooling system and disconnect the hose at the inlet connection of the water pump.

2 Release the setscrews from the flange of the coolant by-pass.

3 Release the three setscrews which retain the water 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 water pump (A). Ensure that the "O" ring (A1) on the cover of the timing case is not lost.



To fit

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.

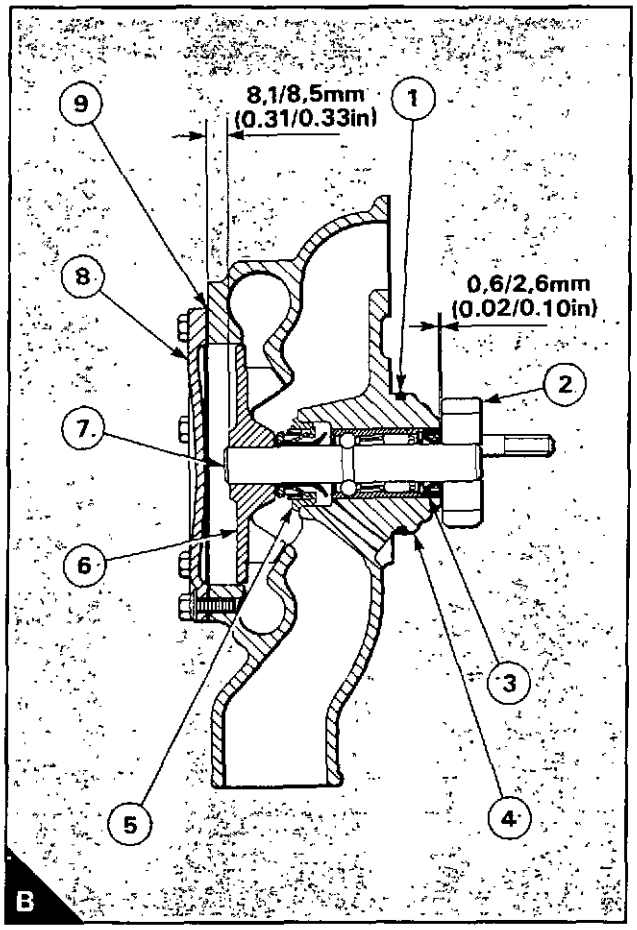
2 Check the drive gear of the water pump for wear or other damage. If the gear is damaged, it must be renewed.

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.

4 Fit and tighten the three setscrews which retain the pump to 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 by-pass. Fit the by-pass and tighten the setscrews.

6 Connect the hose to the inlet connection of the water pump and fill the cooling system. Operate the engine and check for leakage.



To dismantle and to assemble — 21A-03

To dismantle

Special tool:
Gear puller, MS.99

1 Remove the three long studs and the "O" ring (B1) from the pump body (B4).

2 Remove the front cover (B8) and the joint (B9).

3 Remove the gear (B2) with puller.

4 Use a suitable lever to remove the oil seal (B3) 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 (B7), together with the impeller (B6) and the water seal (B5).

6 With a suitable support under the impeller, press the shaft out of the impeller. Remove the water seal and discard it.

To assemble

1 Clean thoroughly the inside of the pump body especially the bearing bore and the counterbore for the water seal. Both of these bores and their chamfers must be clean and free of corrosion.

2 Apply a thin layer of Loctite 35 to the outer surface of the bearing, but keep the Loctite 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 (21A.04/B7) 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 water seal. Remove the adaptor and remove all Loctite from the end of the bearing.

3 Do not lubricate the water seal (21A.04/B5). 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. With the widest end of the water 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.

4 Hold the pump with the gear end of the shaft on a suitable support and, with the use of a suitable distance piece and a flat bar, press the impeller (21A.04/B6) onto the shaft to the dimension indicated in 21A.04/B. Remove the tool and ensure that the shaft is free to rotate. If the original impeller is to be used again, Loctite 35 must be applied to the bore of the impeller and any excess Loctite removed after the impeller has been fitted.

5 Turn the pump over and provide a suitable support for the pump body; remove the studs, if necessary. Lightly lubricate the oil seal (21A.04/B3) 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.

6 Hold the pump with the impeller end of the shaft on a suitable support. Press the gear (21A.04/B2) onto the shaft to the dimension shown in 21A.04/B. If the original gear is used, Loctite 35 must be applied to the bore of the gear and all excess Loctite removed after the gear has been fitted.

7 Fit a new joint (21A.04/B9) and the cover (21A.04/B8) and tighten the fasteners.

Fan

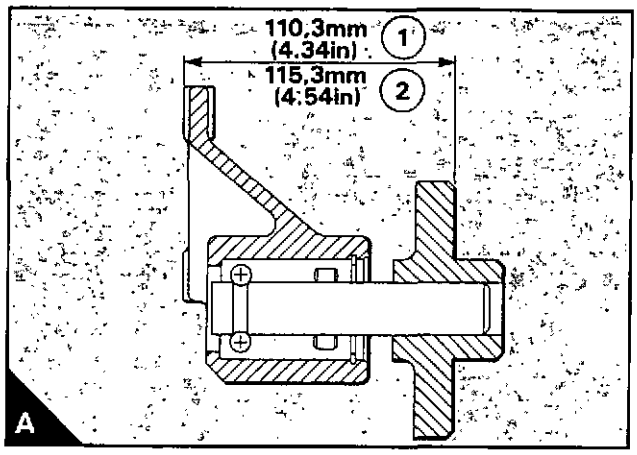
To remove and to fit 21A-04

To remove

Release the setscrews and remove the fan. If necessary, fit the setscrews to retain the fan extension and the pulley to the hub.

To fit

If necessary, release the setscrews from the hub of the fan drive. Fit the fan and the setscrews and tighten the setscrews to the torque recommended in section 11C.



Fan drive

To remove and to fit 21A-05

To remove

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, operation 21A-04.

3 Fit the belt(s) and adjust the tension, operation 23A-02.

To dismantle and to assemble 21A-06

To dismantle

1 Use a suitable puller to remove the hub from the drive shaft.

2 Remove the circlip which retains the bearing.

3 Provide a suitable support for the front of the bearing housing. Put a suitable adaptor on the rear of the bearing and press the bearing and shaft assembly out through the front of the bearing housing. Do not apply force to the shaft.

To assemble

1 Put the bearing housing on a suitable support with the largest opening towards the top.

2 Put the bearing on the housing with the shortest end of the shaft towards the housing. Put a suitable adaptor on the bearing and press the bearing and shaft assembly into the housing. Do not apply force to the shaft.

3 Fit the circlip in its groove in the bearing housing.

4 With the rear end of the shaft on a suitable support, press on the hub to the relevant dimension shown in A: dimension A1 is for six cylinder engines in vehicle applications; dimension A2 is for all other engines. Ensure that the chamfered edge of the hub flange is towards the front.

Lubricating oil cooler

To remove and to fit - engine types AB and AD — 21A-07A

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 (A4) 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.

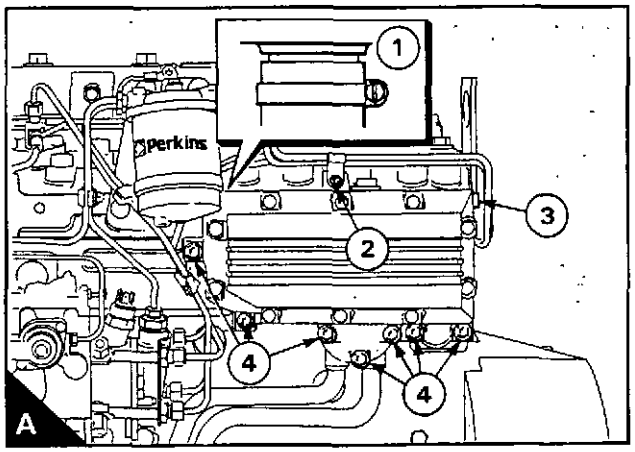
4 Fit the cooler to the engine with the vent (B1) fitted correctly in its connection. Tighten the setscrews and the hose clip of the vent connection.

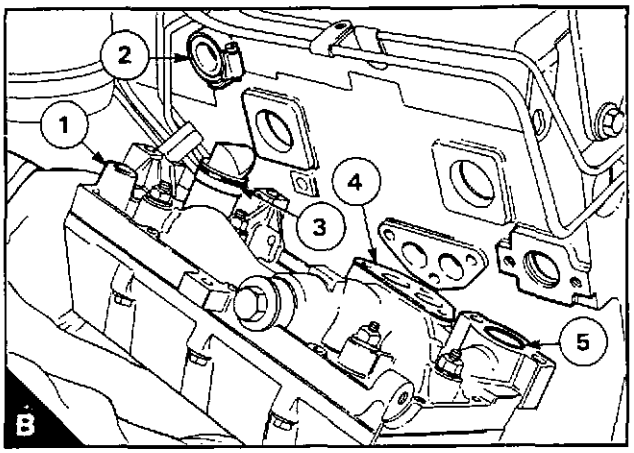
5 Fit and tighten the setscrew of the support bracket.

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 - engine types YA, YB, YC and YD — 21A-07B

To remove

1 Drain the cooling system.

2 Disconnect the lubricating oil pipes at the flange on the cooler cover.

3 Release the setscrews and nuts of the cover of the oil cooler and remove the cover together with the element (C).

To fit

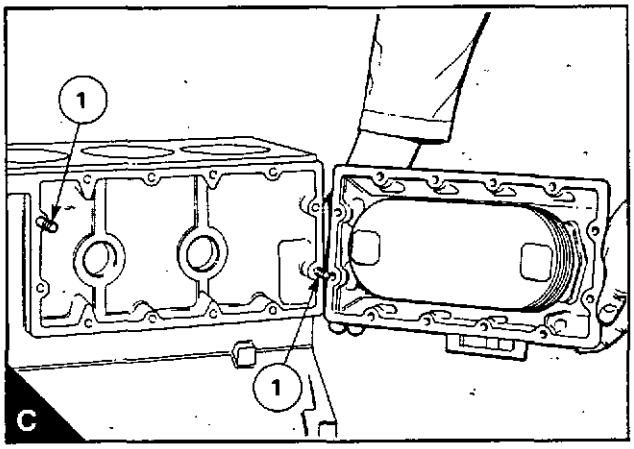
1 If the studs (C1) have been removed and are to fitted again, clean the threads in the cylinder block and on the studs. Apply a suitable sealant before the studs are fitted to the cylinder block.

2 Fit the oil cooler and a new joint to the cylinder block and 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 and tighten the setscrews.

4 Fill the cooling system.

5 Operate the engine and check for oil or coolant leakage.



To dismantle and to assemble - engine types AB and AD 21A-08A

To dismantle

1 Remove the oil cooler from the cylinder block, operation 21A-07A.

2 Release the setscrews and remove the cover.

3 Release the self-locking nuts at the back of the oil cooler and remove the cooler element.

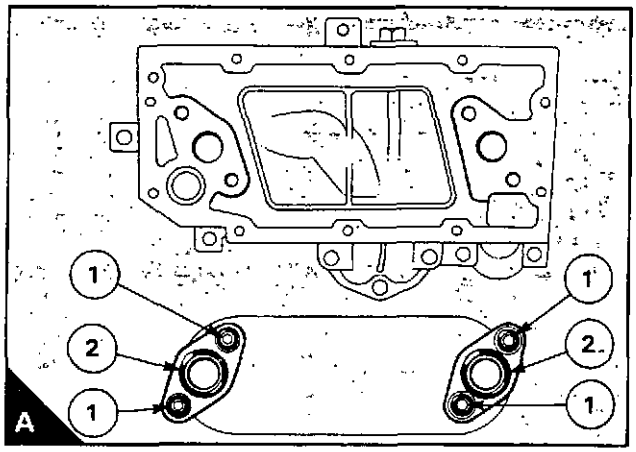
4 Clean the element and check for cracks. If a solution is used to clean the outside of the element, ensure that this does not enter the element. Check that there is nothing to restrict the flow of lubricating oil through the element of the oil cooler. If the inside of the element needs to be cleaned, use a solvent which is suitable for copper. Dry the element with low pressure air and then flush it with clean engine lubricating oil.

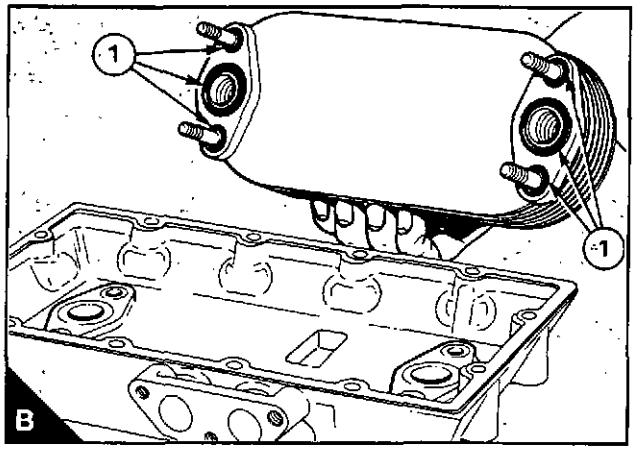
To assemble

1 Renew the "O" rings (A1 and A2) on the flanges of the element and the self-locking nuts for the studs.

2 Fit the element to the backplate and tighten the self-locking nuts to 22 Nm (16 lbf ft) 2,2 kgf m.

3 Fit the cover and a new joint to the cooler backplate and tighten the setscrews to 11 Nm (8 lbf ft) 1,1 kgf m.





To dismantle and to assemble - engine types YA, YB, YC and YD 21A-08B

To dismantle

1 Remove the oil cooler, operation 21A-07B.

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.

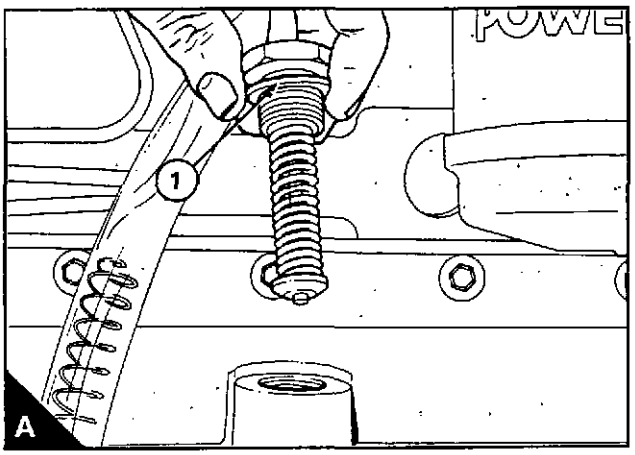
Cooler by-pass valve

To remove and to fit **21A-09**

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.



Flywheel and flywheel housing 22

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 22A-01

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.*

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.

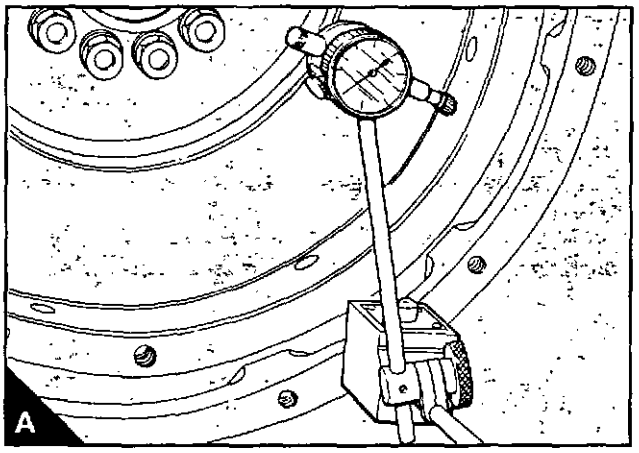
To fit

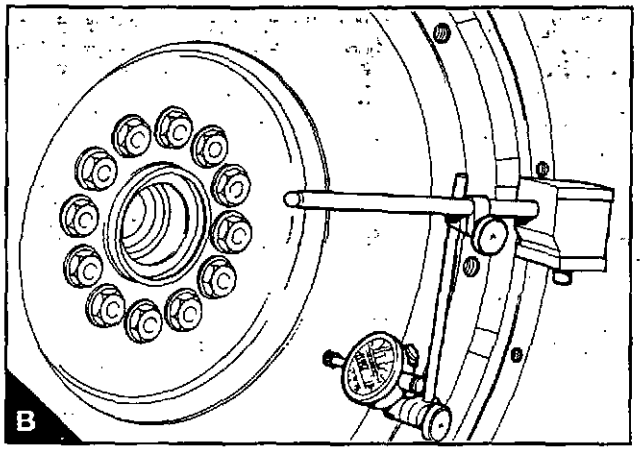
1 Ensure that the location faces of the crankshaft and the flywheel are clean and free from damage.

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). This must be not* more than the tolerance of 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 22A-02

To remove

For this operation eye protection must be used.

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 25°C (48°F). Ensure that the chamfer on the teeth of the gear is in the correct direction.

Flywheel housing

To remove and to fit — 22A-03

To remove

1 Remove the starter, operation 23B-01, and the flywheel, operation 22A-01.

2 Release the housing setscrews and with a soft face hammer, hit carefully the housing to remove it from the dowels.

To fit

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.

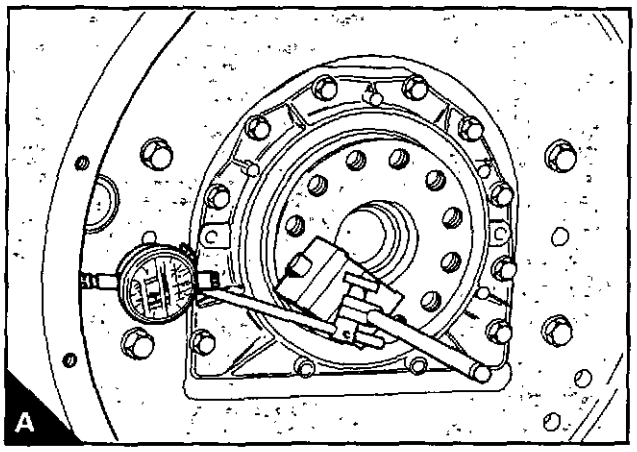
2 Fit the housing onto the dowels and tighten lightly the setscrews.

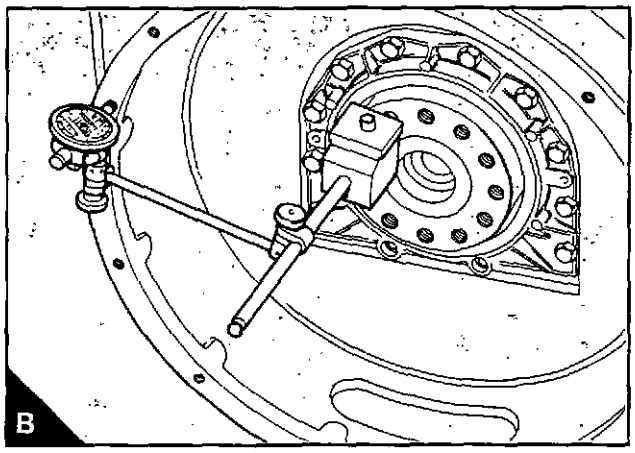
3 Check the housing concentricity with a dial test indicator (A). The maximum tolerance is given in section 11C. If any adjustment is necessary, it must be made on the housing and the concentricity checked again.

4 Tighten the setscrews to the torque recommended in section 11B.

5 Check the housing alignment (B). The maximum tolerance is given in section 11C. Any necessary adjustment must be made on the housing and not on the cylinder block.

6 Fit the flywheel, operation 22A-01 and the starter motor, operation 23B-01.





Electrical equipment 23

Alternators 23A

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.

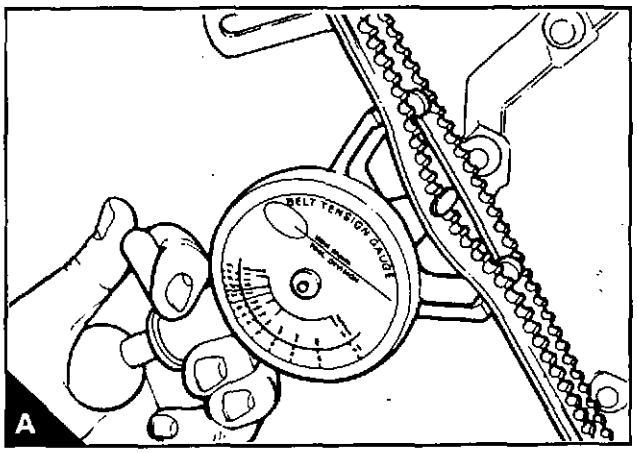
- Do not disconnect the battery while the engine is in operation. This will cause a voltage surge in the alternator charge system which will immediately cause damage to the diodes or to the transistors.
- Do not disconnect an electrical wire before the engine is stopped and all electrical switches are in the "off" position.
- Do not cause a short circuit by the connection of electrical wires to the wrong terminals. The correct identification of the electrical wire to the correct terminal must be made. 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.

Drive belts

To check 23A-01

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 tensioner gauge is used. Fit the gauge (A) at the centre of the longest free length and check the tension. If a "Burroughs" gauge is used, the correct tension is 355N (80 lbf) 36 kgf. If the tension is as low as 220N (50 lbf) 22 kgf, adjust it to 355N (80 lbf) 36 kgf, operation 23A-02.
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, 45N (10 lbf) 4,5 kgf, the correct belt deflection is 10 mm (3/8 in).

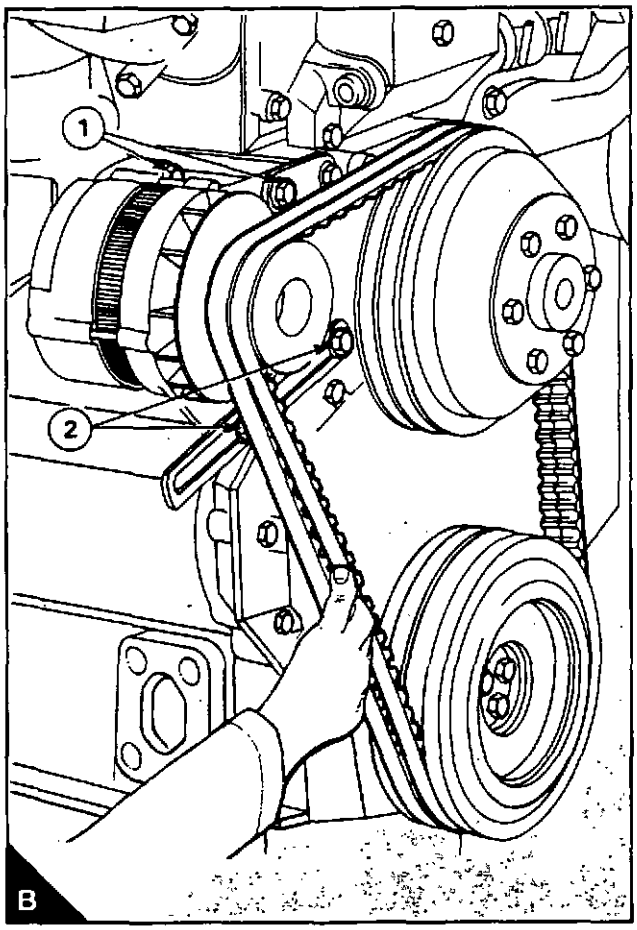


To adjust tension 23A-02

1 Loosen the pivot fasteners (B1) of the alternator and the fasteners of the adjustment link (B2).

2 Change the position of the alternator to give the correct tension. Tighten the pivot fasteners of the alternator and the fasteners of the adjustment link.

3 *Check the belt tension again to ensure that it is still correct.*



To remove and to fit 23A-03

Where twin belts are fitted, they are supplied as a set and must be *renewed as a set.*

1 Loosen the pivot fasteners (B1) of the alternator and the adjustment link fasteners (B2).

2 Release all of the tension from the belt(s) and remove the belt(s).

3 Fit the new belt(s) and adjust the tension, operation 23A-02. *The belt tension must be checked again after the first* 1000 km (600 miles) or 20 hours of operation.

Alternator

To remove and to fit 23A-04

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, operation, 23A-02. Tighten the fasteners and check the tension again.

3 Connect the electrical connection.

To maintain

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.

Fault diagnosis

The alternator is so designed that a flow of current indicated by no light at the warning light or a reading shown on an ammeter is enough indication 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 in a fully charged condition.

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) when 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 when 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 60 amperes (AC5RA or RS) or 55 amperes (A127) for a 12 volt system or 40 amperes (AC5RA or RS) for a 24 volt system.

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 ia 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 23B

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 cylinder 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.

Starter motor

To remove and to fit 23B-01

To remove

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.
3 Connect the battery.

To maintain the brush gear and the commutator 23B-02

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 so worn that 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 exact 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 of dirt and oil. Any sign of 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 23B-03

Ensure that the battery is in a fully charged condition.

Turn on 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.

Difficulty 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 specially for the purpose, and apply a small quantity of Aero Shell 6B or its equal.

Starting aid 23C

General description

The fuelled starting aid is a device which is operated electrically and ignites a controlled amount of diesel fuel in the induction manifold to heat the induction air. A heater coil in the body expands a valve holder to allow fuel to flow into the device where it is ignited by an ignition coil when the engine is turned and air is drawn into the manifold.

Starting aid

To remove and to fit — 23C-01

1 Disconnect the fuel and the electrical connections.

2 Remove the starting aid.

3 Ensure that the contact faces of the manifold and the starting aid are clean and fit the starting aid. Tighten the starting aid to 31 Nm (23 lbf ft) 3,2 kgf m.

4 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 paragraph 5 of operation 20A-08A or 20A-08B.

5 Connect the electrical connection.

Auxiliary equipment 24

Compressors 24A

General description

The Clayton Dewandre 159 or 229 compressor 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 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 an external 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.

Compressor

To remove and to fit compressor and drive housing 24A-01

To remove

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 B2) are still in position.

To fit

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(s) (A3 or B2) are 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 compessor when the support bracket is fitted.

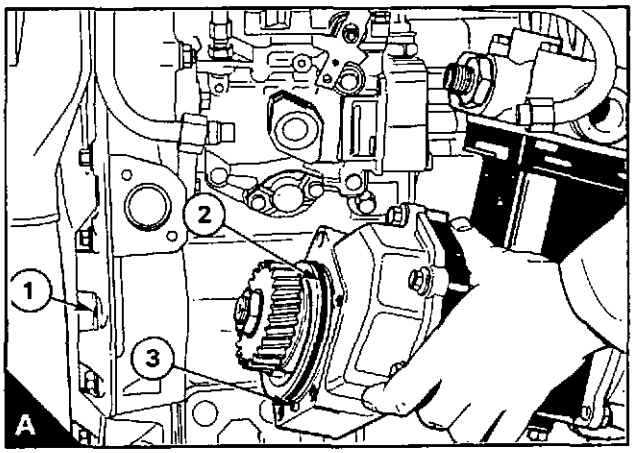
4 If necessary, fit the power steering pump to the rear of the compressor.

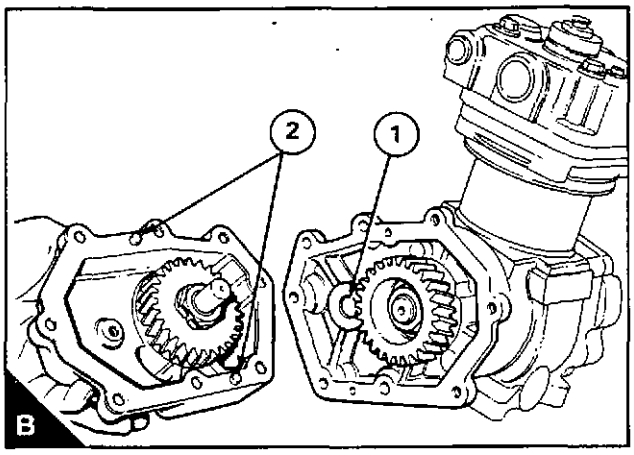
5 Fit the oil pipe between the compressor and the cylinder block of the engine.

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.





Compressor drive

To remove and to fit 24A-02

To remove

1 Remove the compressor and the drive housing assembly from the engine, operation 24A-01.

2 Release the setscrews and separate carefully the drive housing from the compressor (B).

To fit

1 Check the drive gears, and the bearing for wear or for damage. Renew components if necessary.

2 Check for wear the bush (B1) which is fitted in the compressor casing and renew it, if necessary. Ensure that the dowels (B2) 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, operation 24A-01.

To dismantle and to assemble 24A-03

To dismantle

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.

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.

6 Remove the gear (A11) from the housing.

7 Remove the keys (A6) and the spacer (A10) - 159 compressor only - from the shaft. 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

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.

5 Fit the circlip (A4) correctly in its groove.

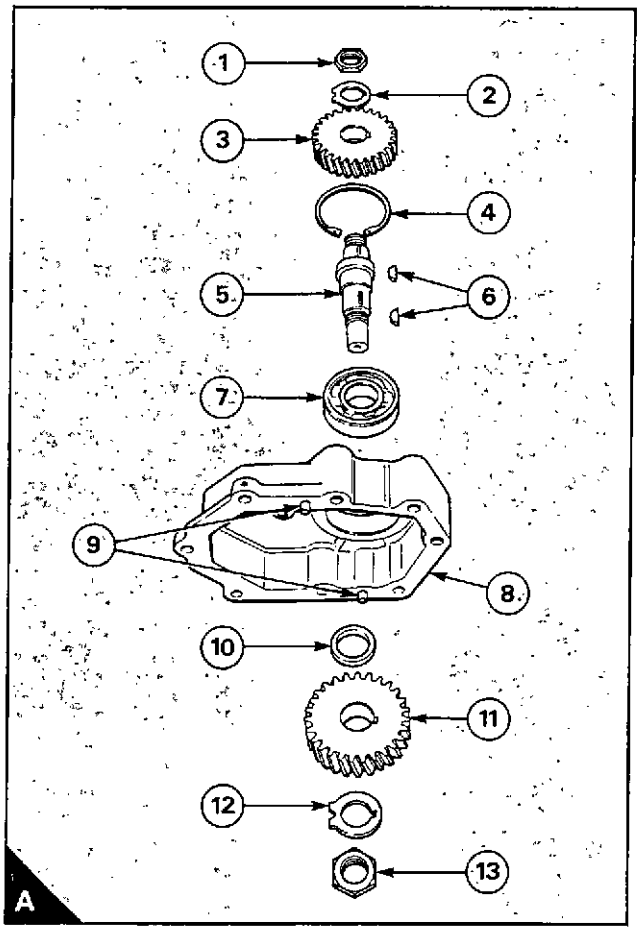
6 Put the spacer (A10) - Clayton Dewandre 159 compressors only - on the bearing (A7) and fit the keys (A6) in the keyways on the shaft.

7 Ensure that the keys are aligned correctly with the keyways in the gears (A3 and A11) and put the gears in position on the shaft. The gear (A11) which is used with Clayton Dewandre 229 compressors has a boss which must be towards the bearing when the gear is fitted.

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 (A2 and A12), ensure that the peg on the tab washers is located correctly in the keyway of the gears. Fit and tighten the nuts (A1 and A13) to the torque recommended in section 11B. Bend the tab washers to prevent the release of the nuts.

10 Fit the dowels into the compressor flange of the housing.



Power steering pump 24B

Power steering pump

Power steering pump

To remove and to fit **24B-01**

To remove

1 Disconnect the connections at the power steering pump and fit covers to the openings.

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 turn 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 openings and connect the connections.

Exhauster

24C

Exhauster

Exhauster

To remove and to fit **24C-01**

To remove

1 Disconnect the lubricating oil and vacuum pipes from the exhauster and fit covers to the openings.

2 Release the setscrews and remove the exhauster.

To fit

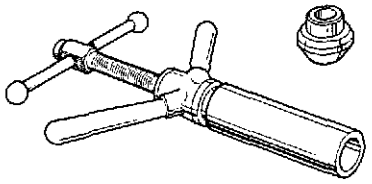
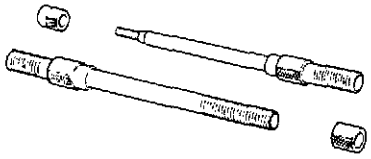
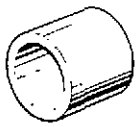
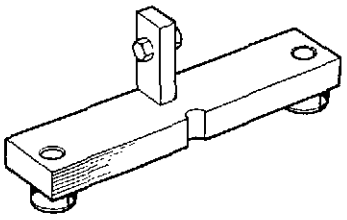
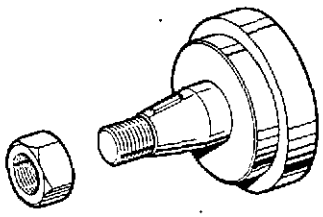
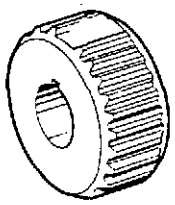
1 Ensure that the joint faces of the exhauster and the timing case are clean and renew the joint. Fit the exhauster to the timing case and tighten the setscrews.

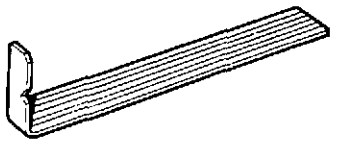
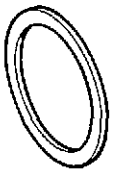
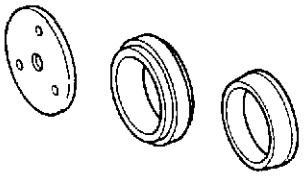
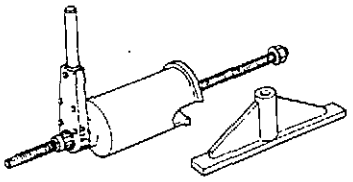
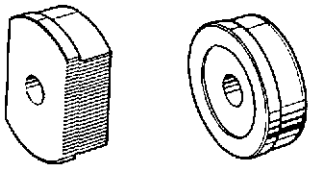
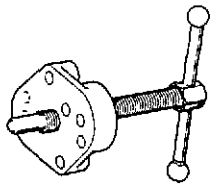
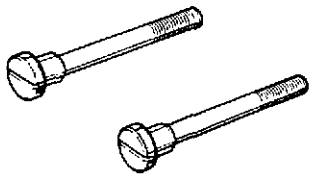
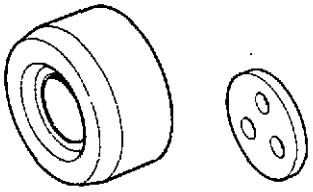
2 Remove the covers from the openings and connect the oil pipe and the vacuum pipe to the exhauster.

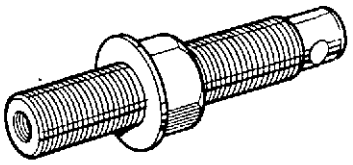
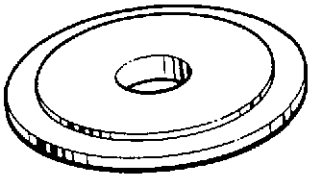
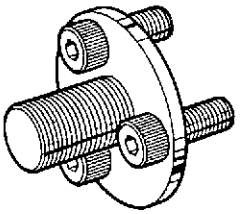
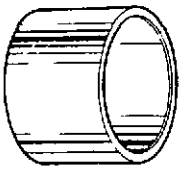
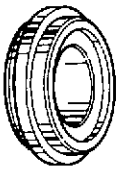
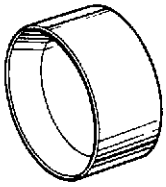
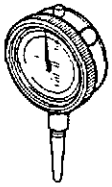
List of special tools 25

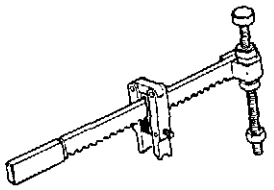
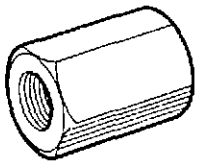
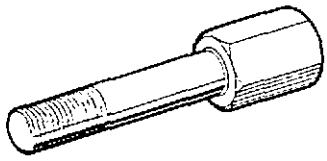
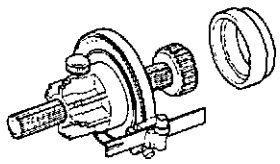
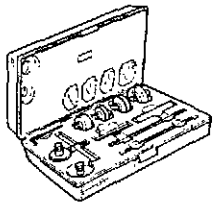
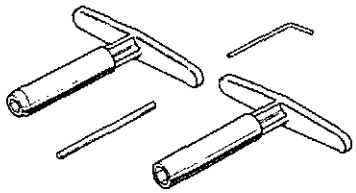
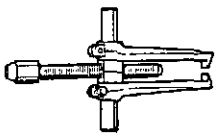
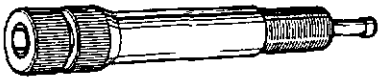
List of special tools

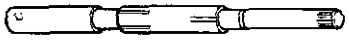
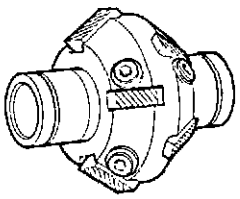
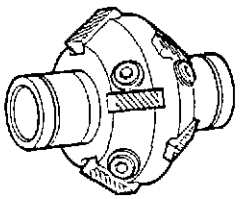
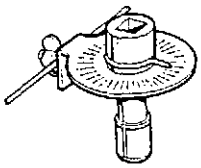
These tools are available from V.L. Churchill Limited, P.O. Box 3, London Road, Daventry, Northamptonshire, England NN11 4NF.

Number	Description	Illustration
PD.1D	Remover/replacer for valve guides (main tool).	
PD.1D-1A	Adaptor for use with PD.1D.	
PD.1C-6	Adaptor for use with PD.1D and PD.1D-1A.	
PD.41D	Gauge for piston height, valve depth and cylinder liner flange; for use with PD.208.	
PD.67-2	Drive adaptor for use with MS.67B.	
PD.67-3	Gear adaptor for use with MS.67B.	

Number	Description	Illustration
PD.67-4	Pointer for use with MS.67B.	
PD.67-5	Distance piece for Bosch pumps; use with MS.67B.	
PD.145D	Replacer tool for crankshaft rear seal.	
PD.150B	Remover/replacer for cylinder liner (main tool).	
PD.150B-17	Adaptors for use with PD.150B.	
PD.155B	Basic puller for camshaft and fuel pump gears.	
PD.155B-5	Adaptors for use with PD.155B.	
PD.163A	Centralising tool for timing case cover.	

Number	Description	Illustration
PD.170	Replacer tool for seal of timing case cover (main tool).	
PD.170-1	Pressure plate for use with PD.170.	
PD.170-2	Fastener plate for use with PD.170.	
PD.170-3	Sleeve for use with PD.170.	
PD.170-4	Seal adaptor for use with PD.170.	
PD.199	Spanner for flange nuts of fuel injection pump.	
PD.206	Replacer tool for pistons.	
PD.208	Dial gauge for use with PD.41D.	

Number	Description	Illustration
PD.6118B	Valve spring compressor.	
PD.6118-7	Stud adaptor for use with PD.6118B.	
PD.6118-8	Setscrew adaptor for use with PD.6118B.	
MS.67B	Timing gauge.	
MS.73A	Set of adjustable cutters for valve seats.	
MS.76B	Handle set for valve seat cutters (also included in MS.73A).	
MS.99	Gear puller for water pump.	
MS.107	Timing gauge for Bosch fuel injection pump.	

Number	Description	Illustration
MS.150-9.5	Adjustable pilot for valve seat cutters (also included in MS.73A).	
MS.275	Cutter for exhaust valve seats (also included in MS.73A).	
MS.281	Cutter for inlet valve seats (also included in MS.73A).	
MS.1531	Angle gauge to tighten cylinder head setscrews.	

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All information in this publication is substantially correct at the time of printing but may be changed subsequently by the Company without notice.

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