



industrial engines

section 1

8141 series

workshop manual

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IVECO *aifo*

The data contained in this publication may not have been updated following modifications carried out by the manufacturer, at any time, for technical or commercial reasons and also to conform to the requirements of the law in the various countries.

This publication supplies features and data together with the suitable methods for repair operations to be carried out on each single component of the engine. Following the supplied instructions and using the inherent specific fixtures, a correct repair procedure will be obtained in due time, protecting the operators from all possible accidents. Before starting any repair, be sure that all accident prevention devices are available and efficient. Therefore check and wear what indicated by the safety provision: protective glasses, helmet, gloves, safety shoes. Before use, check all work, lifting and transport equipment

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ENGINE SPECIFICATIONS

Engine type. 8141I07
 4 - stroke Diesel with direct injection
 Cylinders, number and arrangement. 4, in line
 Bore x stroke. 93 X 92 mm
 Displacement. 2,5 l
 Compression ratio. 18,5:1
 Automotive rating * 55 kW (75 CV)
 At. 4000 rpm
 Intermittent rating. 50 kW (68 CV)
 At. 3800 rpm
 Continuous rating (10% overload allowed). 44 kW (60 CV)
 At. 3600 rpm
 Engine rotation:
 (see from flywheel) CCW

* Duty according to DIN 70020
 - Ambient reference conditions:
 760 mmHg; 20°C; 60% relative humidity

TIMING

Valve Timing:

- Intake:
 opens: before T.D.C 8°
 closes: after B.D.C 48°
 - Exhaust:
 opens: before B.D.C 48°
 closes: after T.D.C 8°

Clearance between cams and valves
 tappets for timing checks 0,5 ± 0,05 mm

Operating clearance between cam and valve tappets, cold engine:
 intake and exhaust 0,5 ± 0,05 mm

FUEL SYSTEM

Rotary injection pump type Bosch VE

Fixed injection pump delivery start advance 6° ± 30'
 Fuel injectors setting 240 + 8 bar
 Firing order 1-3-4-2

LUBRICATION

Maximum oil pressure:

- at full throttle 3,8 Kg/cm²
 - when idling 0,8 Kg/cm²

COOLING SYSTEM

Forced water circulation controlled by centrifugal pump.
 Water temperature controlled by thermostat.

STARTING

By starter motor.

ELECTRIC SYSTEM

- Voltage 12 V
 - Self-regulated alternator 14 V, 45 A
 - Starting motor power 2,5 kW
 - Battery (optional) 110 Ah

ENGINE SPECIFICATIONS

Engine type.8141SI27
 4 - stroke Diesel with direct injection
 Cylinders, number and arrangement.....4, in line
 Bore x stroke.....93 X 92 mm
 Displacement.....2,5 L
 Compression ratio.....18,5:1
 Automotive rating *77 kW(104 CV)
 At.....3800 rpm
 Intermittent rating.....72 kW 98 CV)
 At.....3800 rpm
 Continuous rating(10% overload allowed).....65 kW(88 CV)
 AT.....3600 rpm
 Engine rotation:
 (see from flywheel)CCW

* Duty according to DIN 70020

- Ambient reference conditions:
 760 mmHg; 20°C; 60% relative humidity

TIMING

Valve Timing:

- Intake:
 opens: before T.D.C8°
 closes: after B.D.C37°
- Exhaust:
 opens: before B.D.C48°
 closes: after T.D.C8°

Clearance between cam and valves

tappets for timing checks.....0,5 ± 0,05 mm
 Operating clearance between cam and valve tappets, cold engine:
 intake and exhaust.....0,5 ± 0,05 mm

FUEL SYSTEM

Rotary injection pump type Bosch VE

Fixed injection pump delivery start advance.....6° ± 30'
 Fuel injectors setting.....240 ± 8 bar
 Firing order.....1-3-4-2

TURBOCHARGING

The engine is supercharged by a turbocharger driven by the exhaust gases.
 Cooling intake air with air-water heat exchanger.
 The turbocharger is lubricated with the engine oil under pressure.

LUBRICATION

Minimum oil pressure:

- at full throttle...3,8 bar
- when idling.....0,8 bar

COOLING SYSTEM

Forced water circulation controlled by centrifugal pump.
 Water temperature controlled by thermostat.

STARTING

By starter motor.

ELECTRIC SYSTEM

- Voltage.....12 V
- Self-regulated alternator.....14 V, 45 A
- Starting motor power.....2,5 kW
- Battery (optional).....110 Ah

DATA/FITTING CLEARANCES

DESCRIPTION	mm						
CYLINDER BLOCK/CONNECTING RODS							
Internal diameter of cylinder liners (pressed-in and machined)	93 000–93 018						
External diameter of cylinder liners	95 970–96.000						
Diameter of cylinder liner housings in engine block	95 900–95 940						
Fit between cylinder liners and their housings in engine block (interference)	0 030–0 10						
Oversize on internal diameter of cylinder liners	0 2 – 0 4 – 0 6						
Oversize on external diameter of cylinder liners	0 2						
Main bearing bore diameter	80.587–80 607						
Width of rear main bearing between housing of thrust half-bearing	27 500–27 550						
Big end bore diameter	60 333–60 345						
After having fitted the connecting rod cap on successive occasions, the following values are permitted							
<input type="checkbox"/> Diameter of housing for big end bearing	<table border="0"> <tr> <td style="font-size: 2em; vertical-align: middle;">{</td> <td style="padding-left: 5px;">On vertical axis</td> <td style="padding-left: 20px;">60 340–60.36</td> </tr> <tr> <td></td> <td style="padding-left: 5px;">15° from horizontal axis</td> <td style="padding-left: 20px;">60 330–60 350</td> </tr> </table>	{	On vertical axis	60 340–60.36		15° from horizontal axis	60 330–60 350
{	On vertical axis	60 340–60.36					
	15° from horizontal axis	60 330–60 350					
Small end bush bore diameter	34 865–34 890						
Thickness of standard big end half-bearing							
<input type="checkbox"/> Connecting Rod Side	1 889–1.899						
<input type="checkbox"/> Cap Side	1 861–1 871						
Undersize of service big end half-bearings	0 254-0 508						
External diameter of small end bush	34 970–35 010						
Internal diameter of small end bush (to be measured when bush has been pressed in)	32 011–32 018						
Fit between bush and small end (interference)	0 080–0 145						
Fit between piston pin and small end bush (clearance)	0 015–0 028						
Fit between big end half-bearing and crankshaft journal (clearance)	0 028–0 075						
Tolerance on alignment between the two axes of the connecting rod measured at 125 mm from the vertical axis of the connecting rod	0.07						
PISTONS – PINS – RINGS							
Diameter of standard service pistons, measured perpendicular to pin axis and 12 mm from base of skirt							
<input type="checkbox"/> Borg	92 891–92 909						
<input type="checkbox"/> K S	92 913–92.927						
Fit between piston and cylinder liner measured along normal axis of pin and 12 mm from base of skirt (fitting clearance)							
<input type="checkbox"/> Borg	0 091–0 127						
<input type="checkbox"/> K S	0 073–0 105						
Oversize of Service Pistons	0 2/0 4/0 6						
Height of grooves for piston rings							
<input type="checkbox"/> 1st Trapezoidal Groove (measured on 90 mm diameter, Borg Piston)	2 685–2 715						
<input type="checkbox"/> 1st Trapezoidal Groove (measured on 90 mm diameter, K S Piston)	2 675–2 705						
<input type="checkbox"/> 2nd Groove	2.050–2 070						
<input type="checkbox"/> 3rd Groove	3 025–3 045						
Thickness of Piston Rings							
<input type="checkbox"/> 1st Trapezoidal Sealing Ring (measured on 90 mm diameter)	2 575–2 595						
<input type="checkbox"/> 2nd Oil Scraper Ring	1 978–1 990						
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	2 975–2 990						

DESCRIPTION	mm
Fit between rings and grooves on piston	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring (Borg Piston)	0 090-0 140
<input type="checkbox"/> 1st Trapezoidal Sealing Ring (K S Piston)	0 080-0 130
<input type="checkbox"/> 2nd Oil Scraper Ring	0 060-0.092
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	0 035-0 070
Gap between ends of rings fitted in cylinder liner (fitting clearance):	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring	0 25-0 50
<input type="checkbox"/> 2nd Oil Scraper Ring	0 30-0.55
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	0 30-0 60
Oversize of service rings	0 2/0 4/0 6
Diameter of piston pin bore	32 000-32 005
Diameter of standard piston pin	31 990-31 996
Fit between pin and piston bosses (fitting clearance)	0 004-0 015
CRANKSHAFT – BEARINGS	
Main journals standard diameter	76 187-76 200
Main bearing housing diameter	80 587-80 607
Thickness of main bearings	2 163-2 172
Fit between bearings and main journals, fitting clearance	0 043-0 094
Undersize for service main bearings	0 254-0.508
External width of shoulder journal bearing for crankshaft	31 780-31.955
Length of rear main journal between two shoulders	32 000-32 100
Crankshaft end float	0 045-0 320
Standard diameter of crank pins	56 520-56 535
Fit between big end bearings and crankshaft pins (clearance)	0 028-0 075
Maximum permitted tolerance on alignment of main journals (Total Indicator Reading)	0 05
CYLINDER HEAD	
Diameter of valve guide seats in cylinder head	12 955-12 980
External diameter of valve guide	13 012-13 025
Fit between valve guides and seat in head (Interference fit)	0 032-0 070
Oversize on service valve guide	0 05/0 10/0.25
Internal diameter of valve guide (after pressing into head)	8 023-8 038
Diameter of valve stem	7 985-8 000
Fit between valve stem and guide (Clearance fit)	0 023-0 053
Valve head diameter	
{ Inlet	40 800-41 000
{ Exhaust	34 300-34 500

DESCRIPTION	mm
Valve seat angle on valves { Inlet Exhaust	60°15'±7' 45°30'±7'
Valve seat angle in cylinder head { Inlet Exhaust	60° 45°
External diameter of valve seat housings { Inlet Exhaust	42 295–42 310 35 095–35 110
Internal diameter of valve seat housings in cylinder head { Inlet Exhaust	42 130–42 175 34 989–35.014
Fit between valve seats and housings in cylinder head (interference) { Inlet Exhaust	0 120–0 180 0 081–0.121
Maximum valve stem out of centre for one complete revolution, with indicator resting on centre of contact surface	0 03
Valve depth in relation to cylinder head face	1 4
Protrusion of injector nozzle beyond cylinder head	3 0–3 54
VALVE SPRINGS	
Height of Free Spring	approximately 50
Height of Spring under a load of { 54±2.7kg 104±5.2kg	39 29
VALVE GEAR	
Internal diameter of camshaft caps, fitted on cylinder head	33 989–34.014
Diameter of camshaft journals	33 934–33.950
Fitting clearance between caps and camshaft journals	0 039–0 080
Diameter of tappet seats in cylinder head	44 000–44 025
External diameter of tappet	43 950–43 970
Fitting clearance between tappets and seats	0 030–0 075
Thickness of valve clearance adjustment discs	3 25–3 30–3 35 3 40–3 45–3 50 3 55–3 60–3 65 3 70–3 75–3 80 3 85–3 90–3 95 4 00–4 05–4 10 4 15–4 20–4 25 4 30–4 35–4 40 4 45–4 60–4 65 4 70–4 75–4 80 4 85–4 90
Cam lift	10 5
OIL PUMP	
Clearance between top of gear and face of back cover	0 065–0 131
Lubrication pressure with oil at 100°C { at idling speed at rated speed	0 8 bar 3 8 bar
Spring for Regulating Valve	
<input type="checkbox"/> Height of Free Spring	56 9
<input type="checkbox"/> Height under a Load of { 12 6±0 4kg 16 3±0 6kg	39 34
<input type="checkbox"/> Opening Pressure	7 bar

DATA/FITTING CLEARANCES

DESCRIPTION	mm						
CYLINDER BLOCK/CONNECTING RODS							
Internal diameter of cylinder liners (pressed-in and machined)	93 000–93 018						
External diameter of cylinder liners	95 970–96 000						
Diameter of cylinder liner housings in engine block	95 900–95 940						
Fit between cylinder liners and their housings in engine block (interference)	0 03–0 10						
Oversize on internal diameter of cylinder liners	0 2/0 4/0 6						
Oversize on external diameter of cylinder liners	0 2						
Main bearing bore diameter	80 587–80 607						
Width of rear main bearing between housing of journal thrust half bearing	27 500–27 550						
Big end bore diameter	60 333–60 345						
After having fitted the connecting rod cap on successive occasions, the following values are permitted							
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Undersize of service big end half-bearings	0 254/0 508						
External diameter of small end bush	34 970–35 010						
Internal diameter of small end bush (to be measured when bush has been pressed in)	32 011–32 018						
Fit between bush and small end (interference)	0 080–0 145						
Fit between piston pin and small end bush (clearance)	0 015–0 028						
Fit between big end half-bearing and crankshaft journal (clearance)	0 028–0 075						
Tolerance on alignment between the two axes of the connecting rod measured at 125 mm from the vertical axis of the connecting rod	0 07						
PISTONS – PINS – RINGS							
Diameter of standard service pistons (Borg), measured perpendicular to pin axis and 12 mm from base of skirt	92 891–92 909						
Fit between piston (Borg) and cylinder liner measured along normal axis of pin and 17 mm from base of skirt (fitting clearance)	0 091–0 127						
Diameter of standard service pistons (KS), measured perpendicular to pin axis and 12 mm from base of skirt	92 913–92 927						
Fit between piston (KS) and cylinder liner measured along normal axis of pin and 17 mm from base of skirt (fitting clearance)	0 073–0 105						
Oversize of Service Pistons	0 2/0 4/0 6						
Height of grooves for piston rings (Borg)							
<input type="checkbox"/> 1st Trapezoidal Groove (measured on 90 mm diameter)	2 685–2 715						
<input type="checkbox"/> 2nd Groove	2 050–2 070						
<input type="checkbox"/> 3rd Groove	3 025–3 045						
Height of grooves for piston rings (KS)							
<input type="checkbox"/> 1st Trapezoidal Groove (measured on 90 mm diameter)	2 685–2 715						
<input type="checkbox"/> 2nd Groove	2 060–2 080						
<input type="checkbox"/> 3rd Groove	3 045–3 060						

DESCRIPTION	mm
Thickness of Piston Rings:	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring (measured on 90 mm diameter)	2 575–2 595
<input type="checkbox"/> 2nd Oil Scraper Ring	1 978–1 990
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	2 975–2 990
Fit between rings and grooves on piston (Borg)	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring	0 090–0 140
<input type="checkbox"/> 2nd Oil Scraper Ring	0 060–0 092
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	0 035–0 070
Fit between rings and grooves on piston (KS)	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring	0 090–0 140
<input type="checkbox"/> 2nd Oil Scraper Ring	0 070–0 102
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	0 055–0 085
Gap between ends of rings fitted in cylinder liner, fitting clearance	
<input type="checkbox"/> 1st Trapezoidal Sealing Ring	0 025–0 50
<input type="checkbox"/> 2nd Oil Scraper Ring	0 60–0 85
<input type="checkbox"/> 3rd Oil Scraper Ring milled with slots and internal spring	0 30–0 60
Oversize of service rings	0 2/0 4/0 6
Diameter of piston pin bore	
<input type="checkbox"/> Borg	32 000–32 005
<input type="checkbox"/> KS	32 007–32 012
Diameter of standard piston pin	31 990–31 996
Fit between pin and piston bosses, fitting clearance	
<input type="checkbox"/> Borg	0 004–0 015
<input type="checkbox"/> KS	0 011–0 022
CRANKSHAFT – BEARINGS	
Main journal standard diameter	76 187–76 200
Main bearing housing diameter	80 587–80 607
Thickness of main bearings	2 163–2 172
Fit between bearings and main journals, fitting clearance	0 043–0 094
Undersize for service main bearings	0 254/0 508
External width of journal thrust bearing for crankshaft	31 780–31 955
Length of rear main journal between two shoulders	32 000–32 100
Crankshaft end float	0 045–0 320
Standard diameter of crank pins	56 520–56 535
Fit between big end bearings and crankshaft pins (clearance)	0 028–0 075
Maximum permitted tolerance on alignment of main journals (Total Indicator Reading)	0 05
CYLINDER HEAD	
Diameter of valve guide seats in cylinder head	12 955–12 980
External diameter of valve guide	13 012–13 025
Fit between valve guides and seat on head (Interference Fit)	0 032–0 070
Oversize on service valve guide	0 05/0 10/0 25
Internal diameter of valve guide (after pressing into head)	8 023–8 038
Diameter of valve stem	7.985–8 000
Fit between valve stem and its guide (Clearance Fit)	0 023–0 053

DESCRIPTION	mm
Valve head diameter { Inlet Exhaust	40 750–41 000 34 300–34 500
Valve seat angle on valves { Inlet Exhaust	60°15'±7' 45°30'±7'
Valve seat angle in cylinder head { Inlet Exhaust	60° 45°
External diameter of valve seat housings { Inlet Exhaust	42 295–42 310 35 095–35 110
Internal diameter of valve seat housings in cylinder head { Inlet Exhaust	42 130–42 175 34 989–35 014
Fit between valve seats and housings in cylinder head (interference) { Inlet Exhaust	0 120–0 180 0 081–0 121
Maximum valve stem out of centre for one complete revolution, with indicator resting on centre of contact surface	0.03
Valve depth in relation to cylinder head face	1 4
Protrusion of injector nozzle beyond cylinder head	3 0–3 54
VALVE SPRINGS	
Height of Free Spring	approximately 50
Height of Spring under a load of { 54±2.7kg 104±5.2kg	39 29
VALVE GEAR	
Internal diameter of camshaft caps, fitted on cylinder head	33 989–34 014
Diameter of camshaft journals	33 934–33 950
Fitting clearance between caps and camshaft journals	0 039–0 080
Diameter of tappet seats in cylinder head	44 000–44 025
External diameter of tappet	43 950–43 970
Fitting clearance between tappets and seats	0 030–0 075
Thickness of valve clearance adjustment discs	3 25 – 3 30 – 3 35 – 3 40 – 3 45 – 3 50 – 3 55 – 3 60 – 3 65 – 3 70 – 3 75 – 3 80 – 3 85 – 3 90 – 3 95 – 4 00 – 4 05 – 4 10 – 4 15 – 4 20 – 4 25 – 4 30 – 4 35 – 4 40 – 4 45 – 4 50 – 4 55 – 4 60 – 4 65 – 4 70 – 4 75 – 4 80 – 4 85 – 4 90
Cam lift { Inlet Exhaust	9 5 10 5

DESCRIPTION	mm	
OIL PUMP		
Clearance between top of gear and face of back cover	0.065-0.131	
Lubrication pressure with oil at 100°C	$\left\{ \begin{array}{l} \text{at idling speed} \\ \text{at rated speed} \end{array} \right.$	$\left\{ \begin{array}{l} 0.8 \text{ bar} \\ 3.8 \text{ bar} \end{array} \right.$
Spring for Regulating Valve		
<input type="checkbox"/> Height of Free Spring		56.9
<input type="checkbox"/> Height under a Load of	$\left\{ \begin{array}{l} 12.6 \pm 0.4 \text{ kg} \\ 16.3 \pm 0.6 \text{ kg} \end{array} \right.$	$\left\{ \begin{array}{l} 39 \\ 34 \end{array} \right.$
<input type="checkbox"/> Opening Pressure		7 bar
Safety Valve		incorporated in heat exchanger
<input type="checkbox"/> Opening Pressure		0.82-1.03 bar

FAULT DIAGNOSIS

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine does not start	Battery charge low	Check and recharge battery. If necessary, replace battery.
	Connections to battery terminals corroded or loose	Clean, inspect and tighten battery terminals. Replace lead terminals and nuts if excessively corroded.
	Incorrect timing of injection pump	Check and adjust injection pump timing.
	Dirt or water in fuel pipes	Disconnect and clean pipes with compressed air. Dismantle and clean injection pump. Drain and clean fuel tank and refill.
	Insufficient fuel	Top up.
	No fuel supply	Overhaul or replace fuel pump or transfer pump.
	Air in fuel pipes or injection pump	Check pipes to ascertain cause of air, and check fuel pump, bleed air from inside injection pump by unscrewing plug and operating the fuel pump by hand.
	Faulty starter motor	Repair or replace starter motor.
Engine cuts out	Engine idle speed too slow	Adjust using adjustment screw.
	Irregular flow from injection pump	Regulate flow.
	Dirt or water in fuel pipes	Disconnect pipes and clean with compressed air. Dismantle and clean injection pump. Drain and clean fuel tank and refill.
	Fuel filter blocked	Remove and, if necessary, replace.
	Incorrect clearance between camshaft cams and tappets	Adjust clearance by replacing adjustment discs.
	Burnt, corroded or cracked valves	Replace valves.
	Air in fuel and injection systems	Check that pipes are not cracked or their connections have not worked loose. Replace worn parts then bleed air from pipes, injection pump and fuel pump by unscrewing the bleed plugs and operating the fuel pump by hand.
	Injection pump controls broken	Replace faulty parts and check pump timing.
Engine overheats	Water pump faulty	Replace pump.
	Thermostat damaged	Replace.
	Radiator partly blocked	Remove any scale by thoroughly flushing out, following the instructions given for the type of descaler used. Trace and repair any leaks from radiator hoses.
	Scale in water passages in cylinder head and cylinder block	Flush out thoroughly, following the instructions given for the type of descaler used.

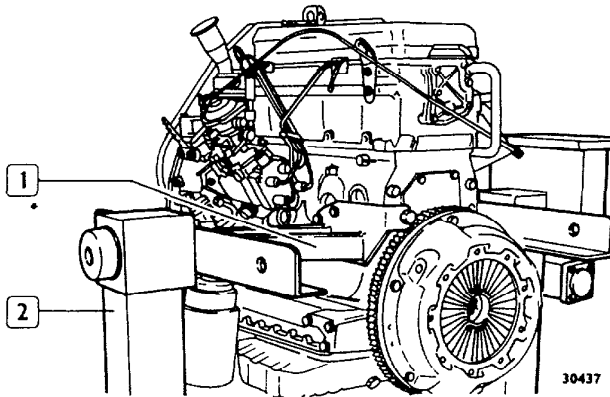
PROBLEM	POSSIBLE CAUSE	REMEDY
Engine overheats (Cont'd)	Water pump drive belt slack	Check and adjust belt tension
	Coolant level low	Top up radiator with coolant to specified level
	Incorrect engine timing	Check timing and adjust to specification
	Injection pump delivering either too much or too little fuel	Correct pump delivery on test bench so that injection occurs according to specified delivery
	Air filter blocked	Clean air filter and replace if necessary
Engine lacks power and runs irregularly	Incorrect timing of injection pump	Check timing and set pump to specification
	Automatic advance unit faulty	Check operation of injection pump on test bench, if test results are not to specification, replace internal spring of automatic advance unit
	Excessive plunger wear	Overhaul injection pump and replace any worn parts
	Speed governor incorrectly set	Check and set governor to specification
	Nozzles partly blocked or injectors faulty	Clean holes in nozzles with special tool kit and completely overhaul injectors
	Dirt or water in fuel or injection system	Clean thoroughly and fill with fresh fuel
	Incorrect clearance between cams on camshaft and tappets	Check clearance and adjust to specification
	Lack of compression	Using Tool 99395682, check that pressure at TDC is equal in all cylinders and check pressure value itself.
	Faulty turbocharger	Replace complete unit
	Blocked air filter	Clean air filter
	LDA Device	On the test bench, check device's efficiency. Check that there is sufficient air pressure in the induction manifold in relation to the engine's speed of rotation under full load
	HBA Device	On the test bench, check efficiency
	Incorrect adjustment of maximum stop screw	Adjust stop correctly.

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine knocks	Injectors not working properly	Check that pin is not jammed in nozzle body and that the setting is to specification
	Fuel pipes blocked	Remove and clean pipes and replace any that are badly kinked
	Incorrect injection pump setting	Correct pump setting so that injection occurs in accordance with the specified angles of advance
	Crankshaft knocks due to excessive play of one or more main or big end bearings or excessive end play	Grind crankshaft journals and fit undersize bearings Replace thrust bearing half-rings
	Crankshaft unbalanced	Check crankshaft alignment
	Flywheel bolts loose	Replace loosened bolts and tighten all bolts to specified torque
	Misalignment of connecting rods	Replace connecting rods
	Pistons knock due to piston slap	Rebore cylinder barrels and fit oversized pistons
	Noisy piston pins due to excessive clearance in piston bosses and connecting rod bush Bushes free in seat on connecting rod.	Replace piston pin Replace bushes with new ones
Clicking noise due to noisy timing system	Adjust clearance between camshaft cams and tappets and check that there are no broken springs or excessive clearance between stems and guides, and tappets and seats	
Abnormal smoke from engine: Black or dark grey smoke	Excessive maximum delivery of injection pump	Disconnect pump and adjust delivery according to Calibration Table
	Injection pump excessively retarded (or automatic advance faulty)	Correct setting and check automatic advance unit
	Injection pump excessively advanced	Adjust setting to specification
	All (or some) of holes in nozzles partly or completely blocked	Replace injectors with a new set or clean and recondition the original ones using the appropriate tool
	Air filter blocked or damaged	Clean or replace filter element
	Loss of engine compression due to <input type="checkbox"/> siezed piston rings, <input type="checkbox"/> worn cylinder barrels, <input type="checkbox"/> damaged or incorrectly-adjusted valves	Overhaul engine or restrict work to parts affected

PROBLEM	POSSIBLE CAUSE	REMEDY
Abnormal smoke from engine: (Cont'd) Black or dark grey smoke	Wrong type of injector or some injectors of different types, or badly adjusted	Replace or adjust injectors
	Injection pipes of wrong internal diameter, ends of pipes crushed due to repeated blockages	Check condition of ends and connections and if necessary, replace pipes
Blue, greyish-blue or greyish-white smoke	Excessive retard of injection or automatic advance unit damaged	Correct pump setting and check unit
	Injector needles blocked or faulty injectors	Check that needle does not stick or spring is not broken
	Oil leaking from piston rings due to jammed rings or worn barrel walls	Overhaul engine
	Engine oil flows through inlet valve guides, due to wear of guides or valve stems.	Recondition cylinder head
	Engine too cold (thermostat blocked or stuck)	Replace thermostat
Engine does not stop	Governor broken	Unscrew connection for fuel delivery pipe then carry out the necessary repair work
	Solenoid stop valve broken	Replace
	Governor components sticking.	Overhaul or replace
	Excessive clearance between various components of governor	Take up all clearances, allowing only minimum tolerances, if necessary replace excessively worn parts

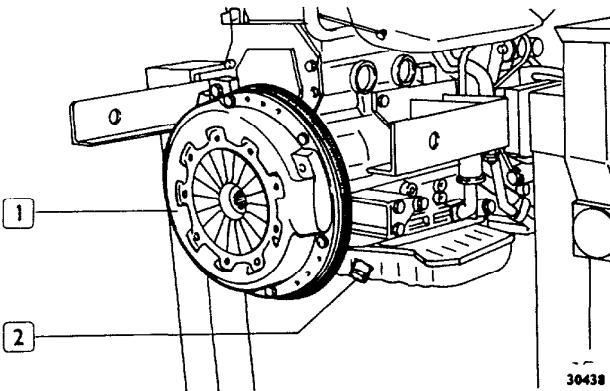
DISMANTLING THE ENGINE

FIGURE 31



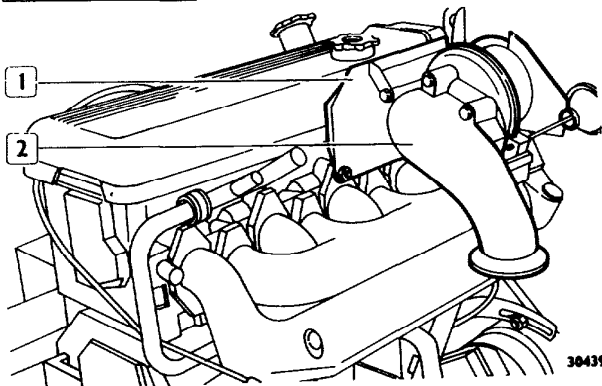
Remove oil breather, fit Brackets 99361029 (1) to engine and fix the latter to engine Stand 99322230 (2)

FIGURE 32



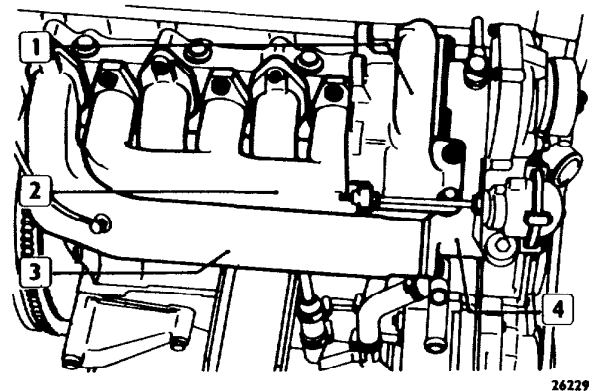
Unscrew plug (2) and drain oil from sump. Disconnect clutch (1)

FIGURE 33



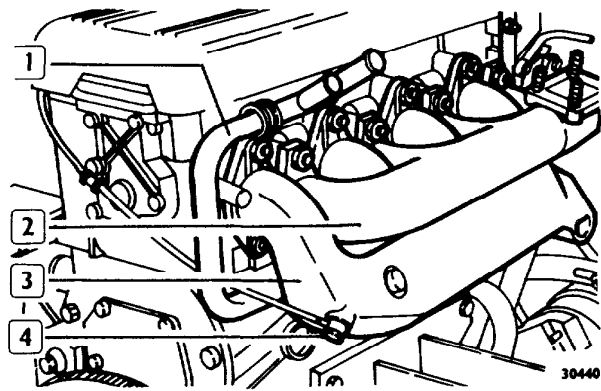
Disconnect exhaust pipe (2) from turbocharger (3) and remove heat shield (1)

FIGURE 34



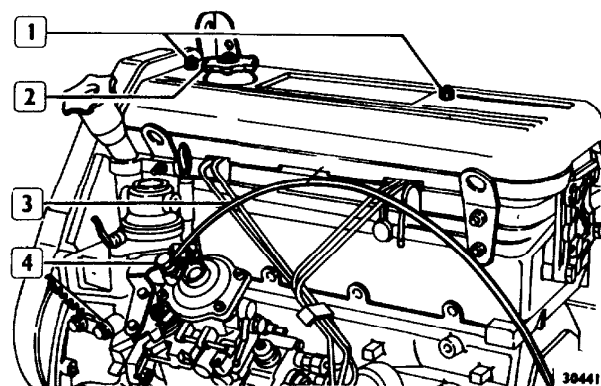
Disconnect air trunking (4) from inlet manifold (3). Disconnect turbocharger (1), together with oil inlet and outlet pipes, from exhaust manifold (2)

FIGURE 35



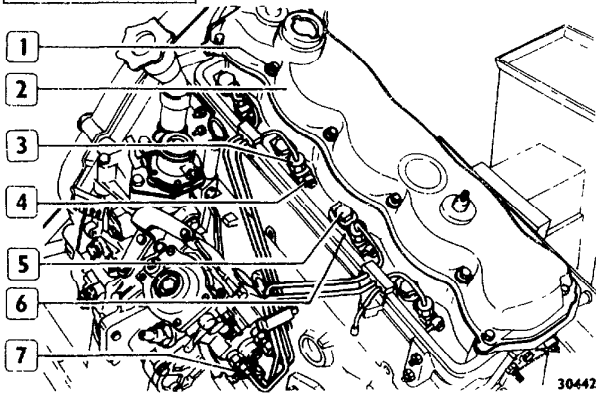
Remove connection (4) fixing LDA control air pipe from inlet manifold. Disconnect water pipe (1) and inlet (3) and exhaust (2) manifolds

FIGURE 36



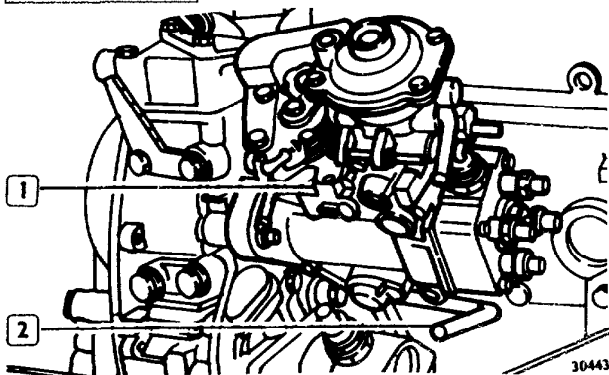
Unscrew connection (4) and disconnect LDA control air pipe (3). Remove cap (2), unscrew nuts (1) and lift off soundproof cover

FIGURE 37



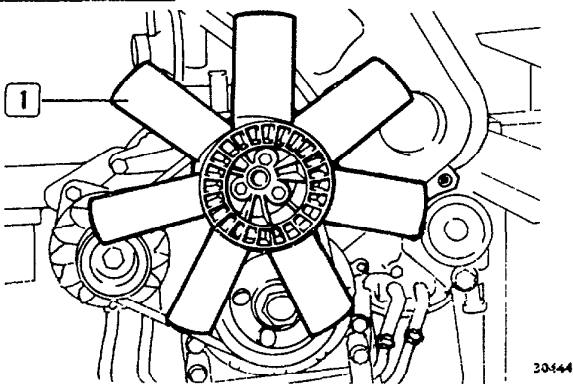
Undo connections (3, 4 and 7) and remove fuel delivery and return pipes. Unscrew bolts (5), remove brackets (6) and remove injectors. Unscrew nuts (1) and remove valve cover (2).

FIGURE 38



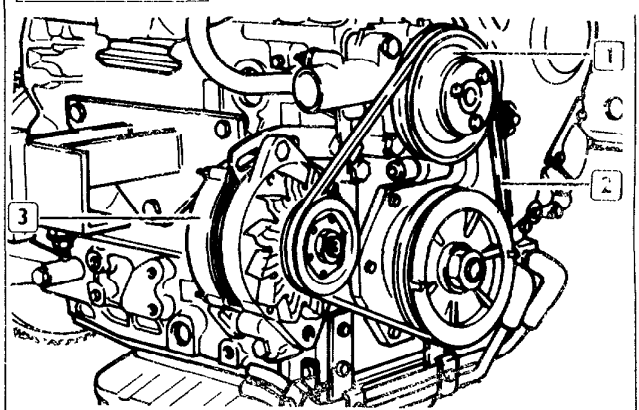
Remove injection pump (1) using Tool 99352114 (2) to undo bottom internal nut.

FIGURE 39



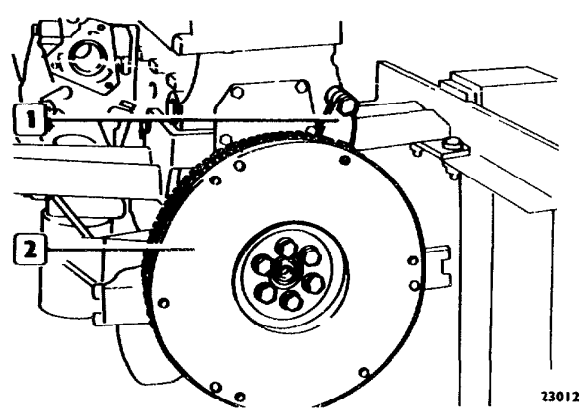
Remove cooling fan (1)

FIGURE 40



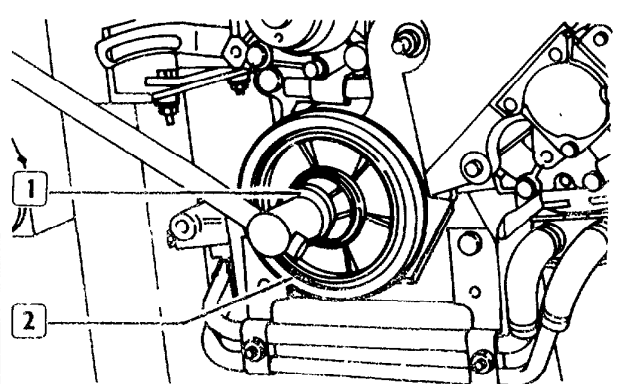
Disconnect alternator (3), remove drive belt (2) and water pump drive pulley (1)

FIGURE 41



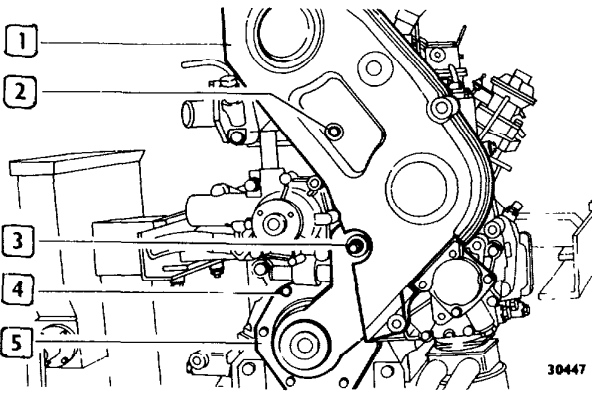
Prevent engine flywheel (2) from rotating by inserting Tool 99360306 (1) into hole for flywheel housing fixing bolt.

FIGURE 42



Using wrench (1), unscrew retaining bolt of crankshaft pulley (2) and remove the latter

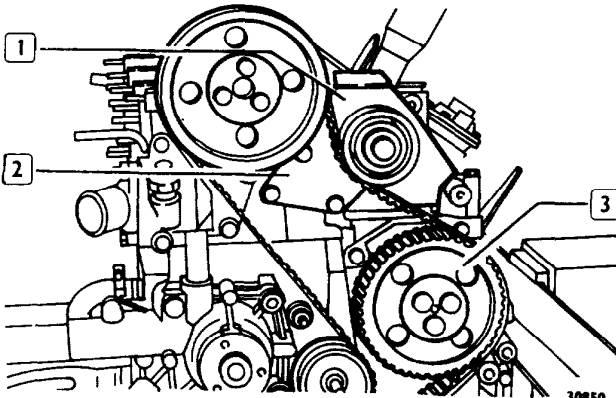
FIGURE 43



30447

Unscrew bolts (2) and remove belt cover (1) Unscrew nut (3) and bolts (4) and remove guard (5)

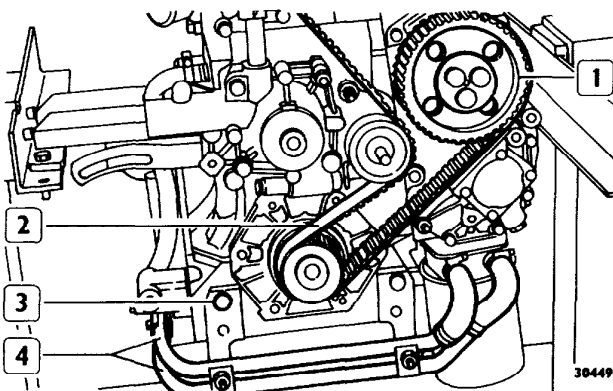
FIGURE 44



30850

Unscrew retaining bolts of ancillaries drive gear (3) Remove support (2) complete with fixed belt tensioner roller and guard (1)

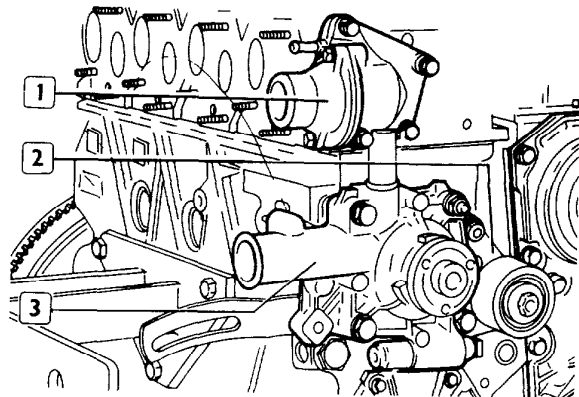
FIGURE 45



30449

Remove toothed belt (2) and ancillaries drive gear (1). Unscrew fixing bolts (3), disconnect and remove water pipes (4) of heat exchanger

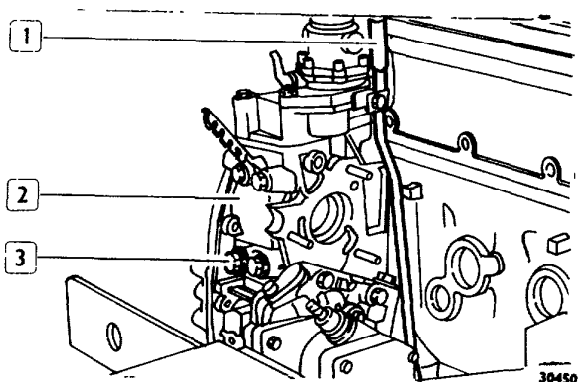
FIGURE 46



30794

Remove adjustable belt tensioner (2), after removing lock nut Take off thermostat (1) and water pump (3)

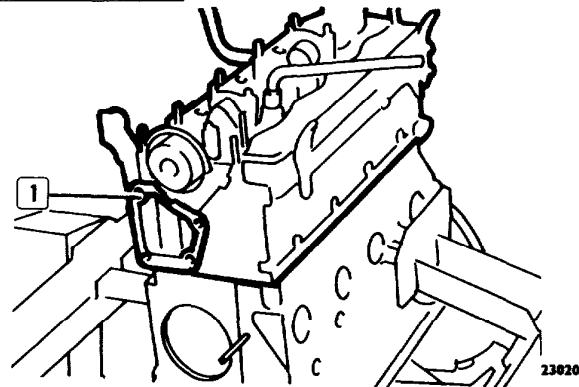
FIGURE 47



30450

Remove relative fixing brackets and take off oil filler pipe and dipstick pipe (1) Undo bolts (3) and remove ancillaries unit (2)

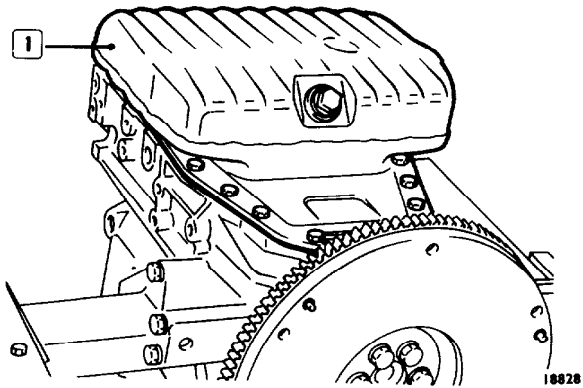
FIGURE 48



23020

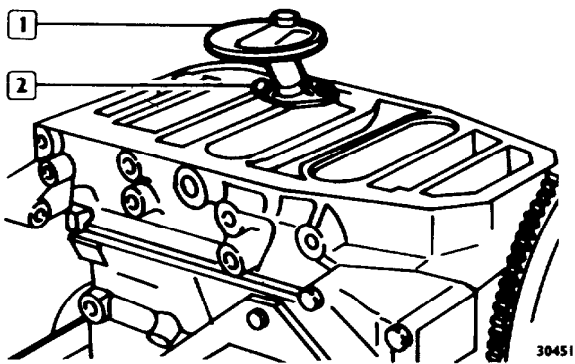
Remove cylinder head retaining bolts (1), remove cylinder head and gasket

FIGURE 49



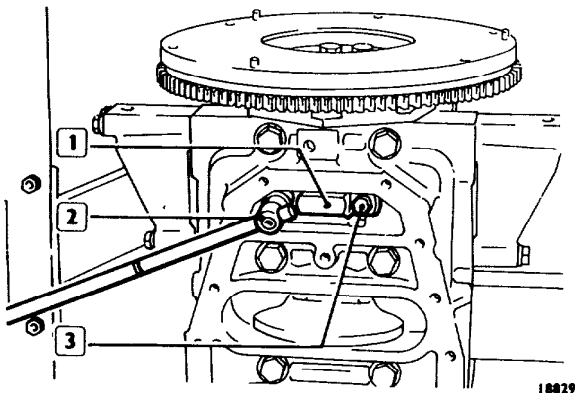
Rotate engine through 180° and remove sump (1)

FIGURE 50



Remove fixing bolts (2) and remove engine oil pick up pipe (1)

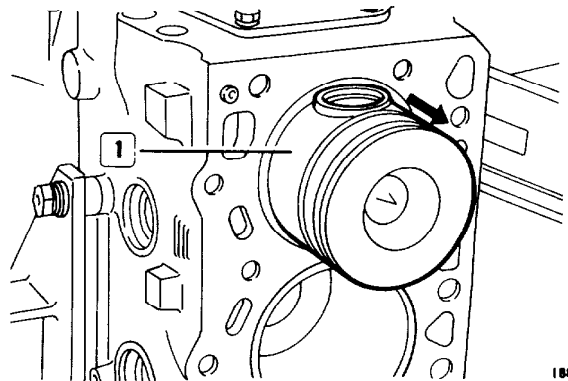
FIGURE 51



Remove Tool 99360306 for preventing flywheel from turning. Turn engine through 90°, undo bolts (3) of connecting rod caps (1) using wrench (2)

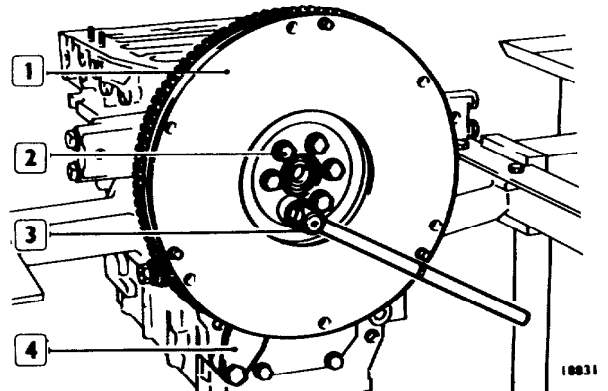
NOTE Position No. 4 piston at TDC so as to be able to pull connecting rod cap (1) out

FIGURE 52



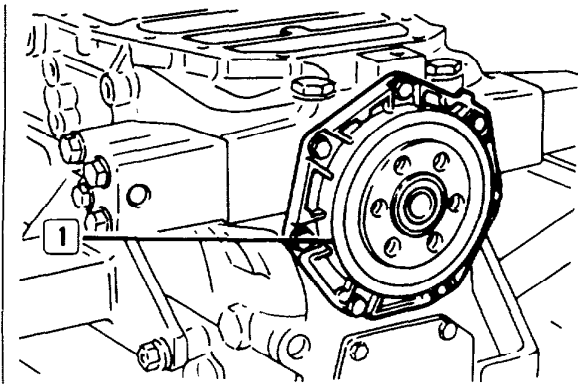
Remove connecting rod cap bolts, take off caps and pull out pistons (1) from top of block

FIGURE 53



Turn engine again, fit Tool 99360306 (4) and, using wrench (3), remove bolts (2) holding engine flywheel (1) and lift off flywheel

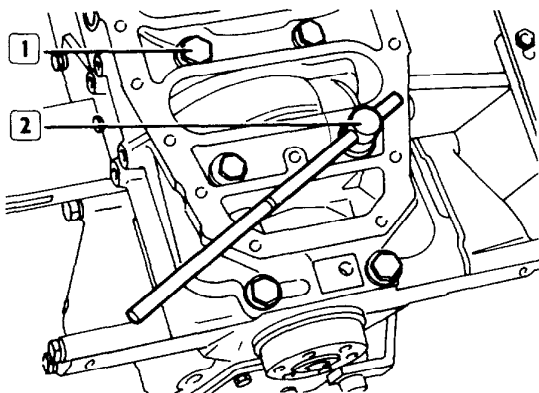
FIGURE 54



18832

Remove crankshaft rear housing (1) complete with oil seal

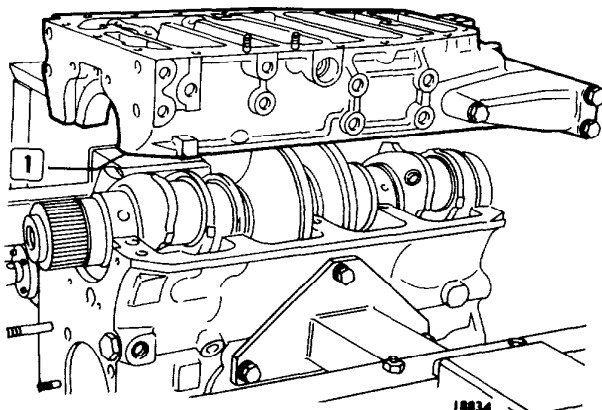
FIGURE 55



18833

Using wrench (2) unscrew bolts (1) securing bottom block to top block

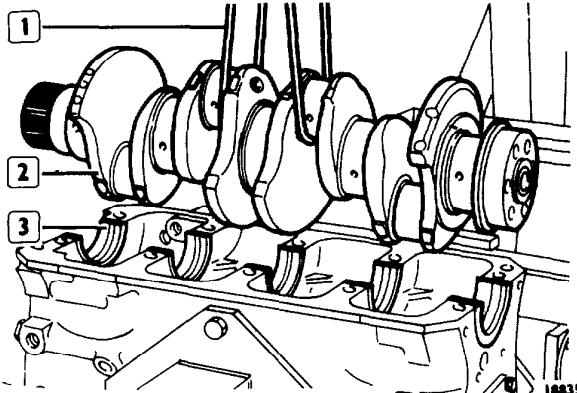
FIGURE 56



18834

Remove bottom block (1) together with gasket

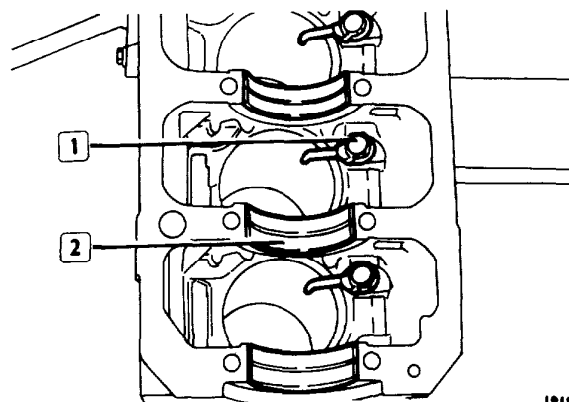
FIGURE 57



18835

Using a hoist and rope (1), remove crankshaft (2).

FIGURE 58



19183

Remove main bearings (2)
Remove piston cooling nozzles (1).

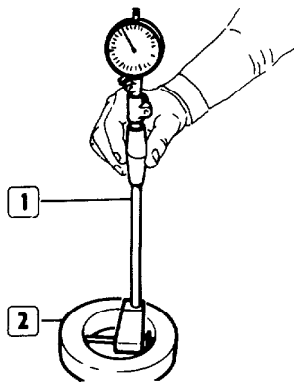
CYLINDER BLOCK

Having dismantled the engine, carefully clean cylinder and engine block

CHECKS AND MEASUREMENTS

Carefully check engine block for cracks
Check condition of core plugs, if rusty or there is the slightest doubt as to their sealing ability, replace them
Inspect surfaces of cylinder liners, they should show no signs of excessive seizing, scoring, ovality, taper or wear

FIGURE 59

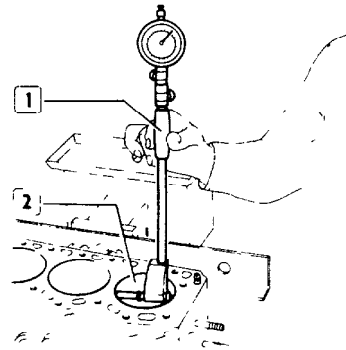


18834

Before checking cylinder bores, zero Gauge 99395687 (1) on Ring Gauge (2) (Diameter 93 mm)

NOTE. If a 93 mm diameter ring gauge is not available, use an external micrometer set at 93 mm.

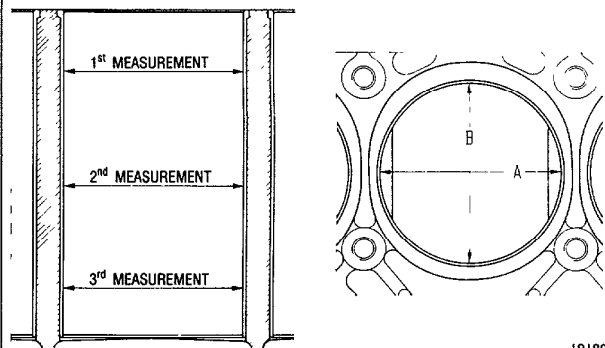
FIGURE 60



18837

Using Bore Gauge 99395687 (1), fitted with a dial gauge zeroed as previously described check cylinder bores (2), to determine the extent of ovality taper and wear

FIGURE 61



19180

Each cylinder must be measured at three different heights in the liner on two planes at right angles to each other one parallel to the longitudinal axis of the engine (A) and the other perpendicular (B), maximum wear is usually found on this last plane and near the first measurement

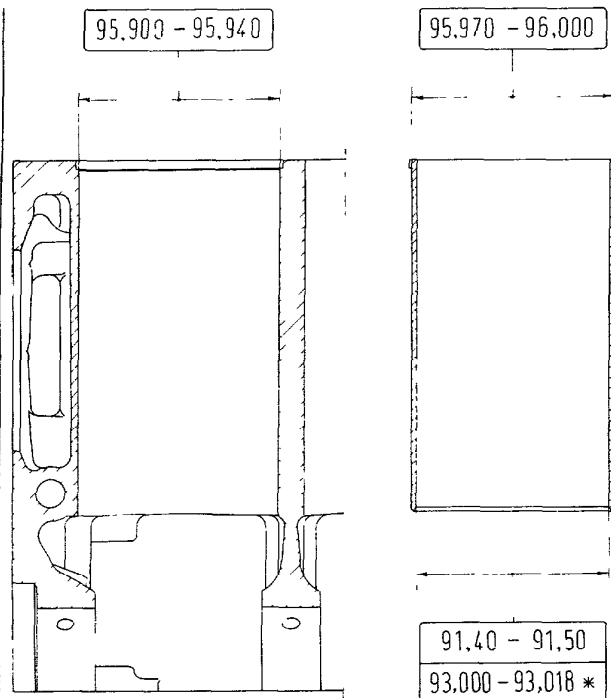
Any ovality, taper or wear can be rectified while repairs are being made by grinding the liners, in the case of slight wear and scoring, or by reboring with subsequent grinding, in the case of deep scoring or marked ovality

Liners must be ground to suit the diameter of the oversize pistons supplied in service (0.2, 0.4, 0.6 mm)

When overhauling, rebores the liners so that the specified fitting clearance is restored between the liners and the oversize pistons

NOTE Reboring reduces the thickness of the cylinder liner walls, so it may be repeated on the same liner until a total increase in the diameter of 0.6 mm is reached, after which the liners must be replaced

FIGURE 62



* Measurement to be obtained after driving liner into block

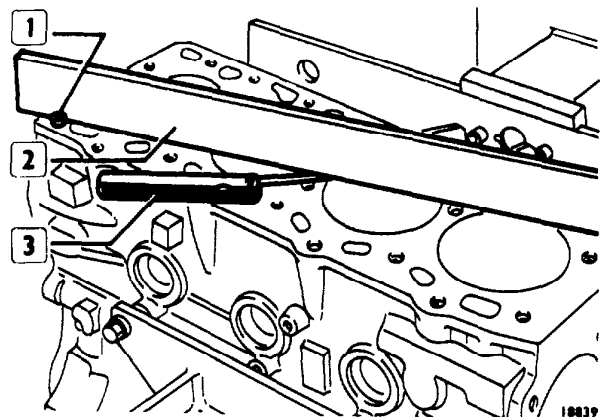
The liners are removed from and driven into the cylinder block using an hydraulic press and a special plate and following the instructions described below

- check that the external diameter of the cylinder liners is 95 970–96 000 mm and the internal diameter of the liner housings is 95 900–95 940 mm,
- never use oil or grease when driving in,
- fit liner into housing in block and check that at 80 mm down the load is ≥ 1300 daN,
- continue driving in and on completion check that the load is ≤ 5000 daN,
- check that edge of liner is perfectly flush in its housing in the block so as to avoid breakage
- Should the above fail to occur, the liner must be replaced

NOTE After driving in liners, skim over top of block and then rebores and grind liners, restore bevel on liners which must be 0.5 mm deep and have an inclination of 30°

Cylinder liners are also supplied in service with an oversize external diameter of 0.2 mm, should it be necessary to use them, the liner seats on the block must be rebored to a diameter of 96 100–96 140 mm

FIGURE 63



Check face of cylinder head for distortion. This may be done using a surface plate, spread with carbon black (after removing dowels (1)), or using a straight edge (2) and feeler gauge (3)

After determining where distortion occurs, grind the face flat, taking off the minimum amount of material possible. When flat, restore bevel on top edge of liner which should be 0.5 mm \times 30°

- Check main bearing housings as follows
- fit bottom block onto top one, without bearings and seals,
 - tighten up fixing bolts to specified torque,
 - with an inside gauge check diameter of housings which must be 80 587–80 607 mm, if it is not, having found distortion, replace block

CRANKSHAFT

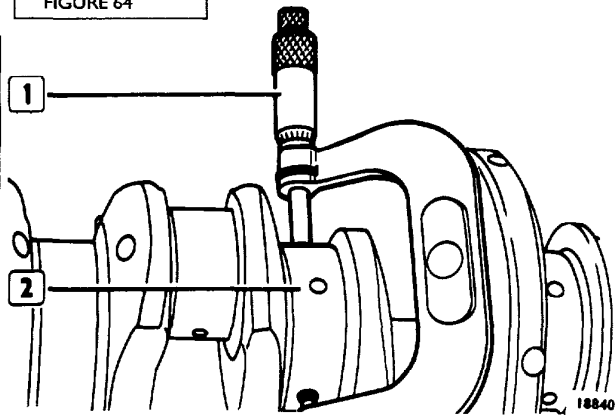
If main journals and crank pins show signs of seizing, scoring or excessive ovality, they must be dressed by grinding

NOTE Always grind main journals and crank pins to the same undersize

When grinding crankshaft journals, pay great attention to side groove measurements, which must be the same as those given in Fig 67

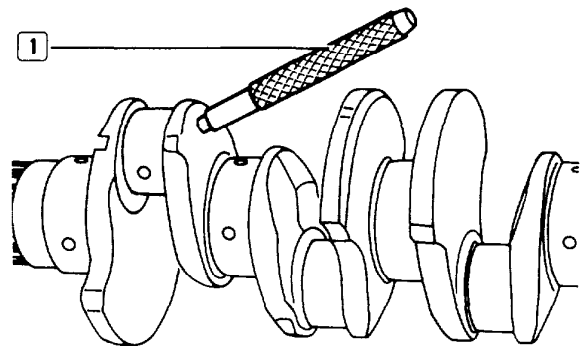
Remove crankshaft spigot bearing, using Slide Hammer 99340205 and Adaptor 99348004

FIGURE 64



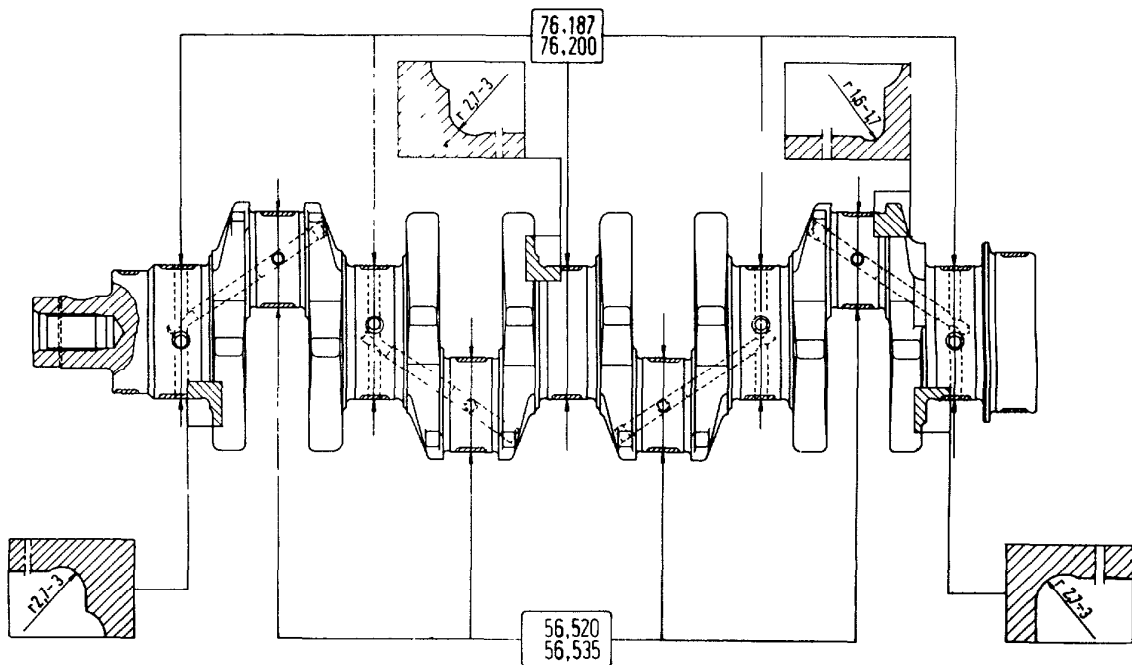
Before grinding, measure shaft journals (2) with a micrometer (1) to establish to which diameter the journals must be reduced on the basis of the bearing undersizes available

FIGURE 65



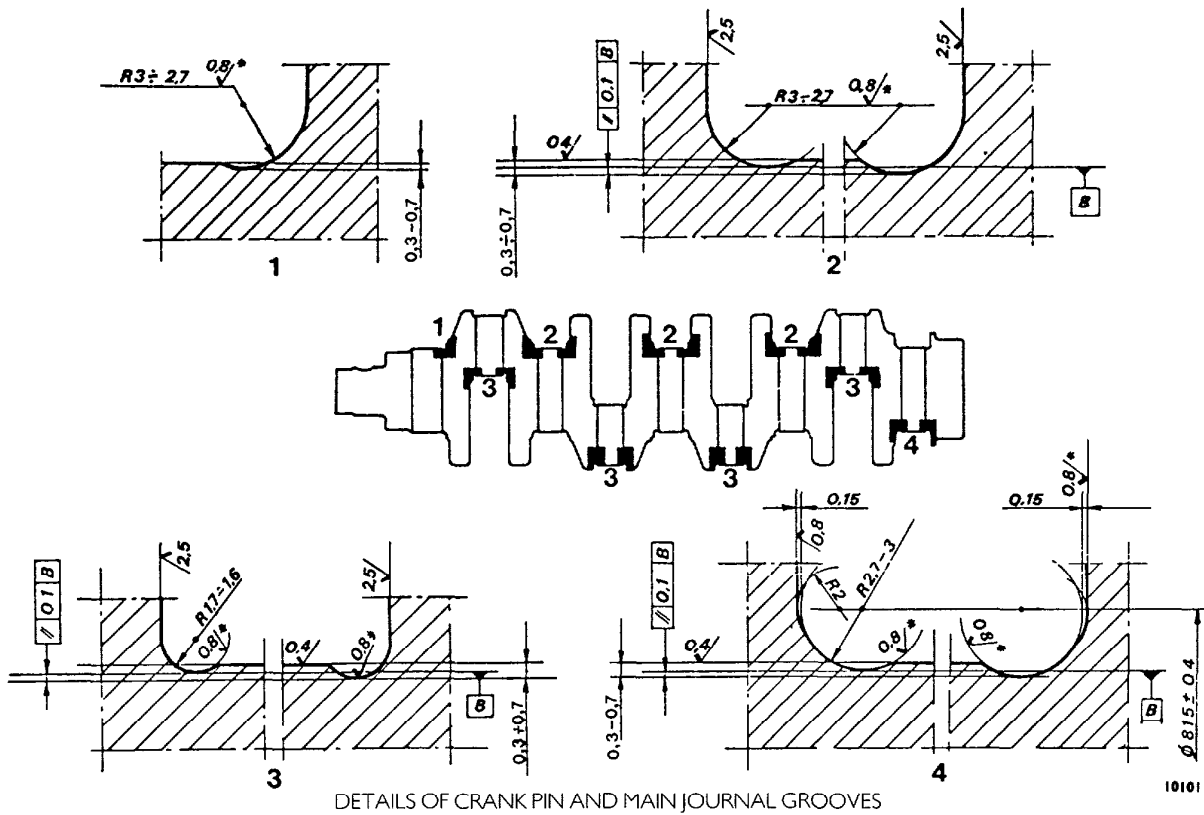
After grinding and before finally fitting the shaft, the countersunk edges of the main journal and crank pin lubrication holes must be chamfered
Check that the plugs of the lubrication circuit do not leak under an internal pressure of 15 bar, if they do replace them using a drift (1) to drive them in

FIGURE 66



MAIN DATA OF CRANKSHAFT MAIN JOURNALS AND CRANK PINS AND THE THRUST BEARING CONNECTION OF THE PINS

FIGURE 67



DETAILS OF CRANK PIN AND MAIN JOURNAL GROOVES

1 Main Journal, Timing Side – 2 Intermediate Main Journals – 3 Crank Pins – 4 Main Journal, Flywheel Side

NOTE: Since when reducing the diameter of the crank pins by 0.508 mm and that of the main journals by 0.254 or 0.508 mm, the rolled part of the side grooves on the pins or journals may be nicked, the grooves must be turned in accordance with the data in the Figure and rolled as follows

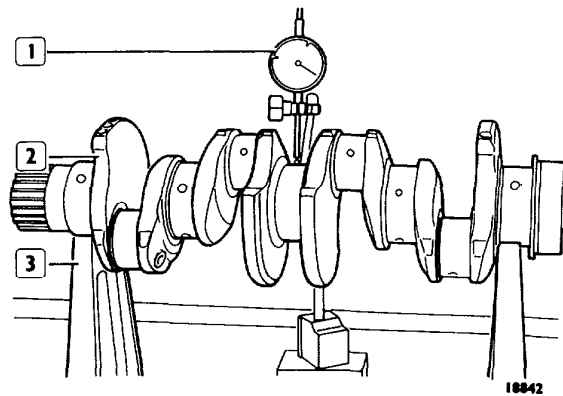
Rolling Pressure

- for crank pins 30 bar,
- for main journals 35 bar,
- for main journal, timing side 25 bar,
- reduction in depth of crank pin grooves after rolling 0.06–0.125 mm,
- reduction in depth of main journal grooves after rolling 0–0.03 mm

CHECKING ALIGNMENT OF MAIN JOURNALS AND CRANK PINS

This check must be performed after grinding the crank pins by placing the shaft (2) on two parallel V supports (3) and using a dial gauge (1).

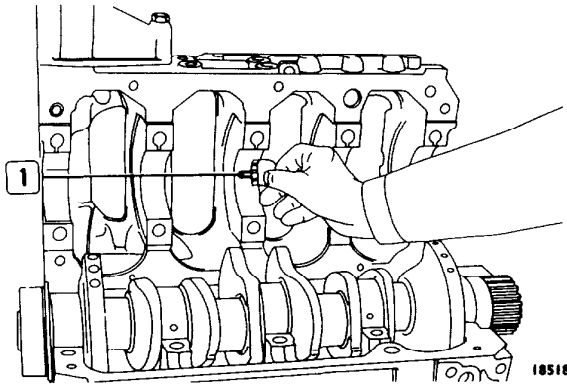
FIGURE 68



- alignment of main journals maximum tolerance ±0.05 mm,
- alignment of crank pins maximum tolerance ±0.07 mm,
- the axis of each pair of crank pins and that of the main journals must be on the same plane, the maximum permitted tolerance, perpendicular to this plane, is 0.25 mm,
- maximum ovality of main journals and crank pins after grinding 0.005 mm

CHECKING CLEARANCE BETWEEN CRANK PINS AND BEARINGS AND CHECKING END FLOAT

FIGURE 69



- Check using a calibrated wire as follows
- clean parts thoroughly and remove all trace of oil,
 - place half-bearing in housings on mountings,
 - fit crankshaft,
 - place a length of gauged wire along the crank pins parallel to their longitudinal axis,

FIGURE 70

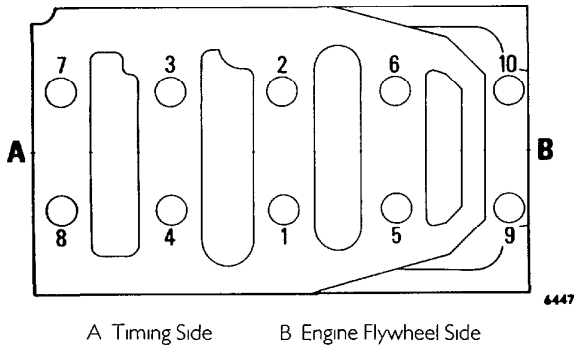
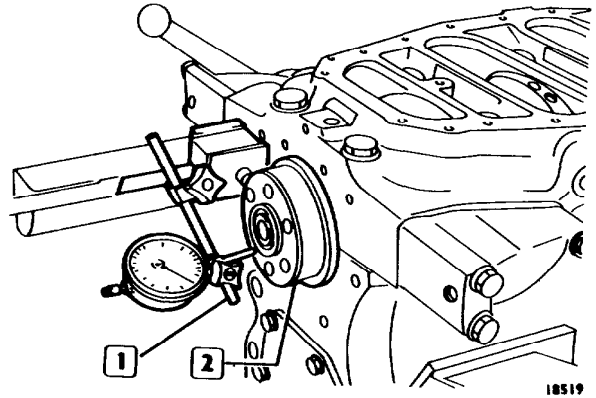


DIAGRAM SHOWING THE TIGHTENING SEQUENCE FOR BOLTS FIXING BOTTOM BLOCK TO TOP BLOCK

- fit bottom block complete with bearings, screw in fixing bolts, previously lubricated with oil, tighten them to a torque of 160 Nm (16.5 kgm), as shown in the diagram,
- remove bottom block and determine clearance between bearings and main journals of crankshaft, by comparing the width of the gauged wire where it is most deformed, with the scale on the packet that contained the wire

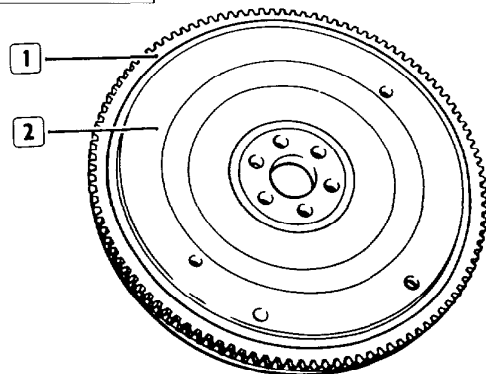
FIGURE 71



End float is checked by positioning a dial gauge (1) with a magnetic base as shown in the Figure, the standard fitting clearance is 0.045–0.320 mm. If clearance is greater, replace rear thrust main journal bearings.

REPLACING FLYWHEEL RING GEAR

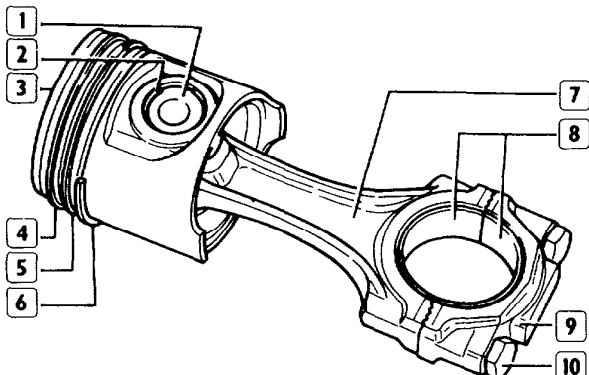
FIGURE 72



Check face of clutch disc, if scored turn it on the lathe. If teeth of gear (1) on flywheel (2) are badly damaged, replace gear. A hydraulic press must be used to remove and refit the gear onto the flywheel; before fitting, the gear must be heated to approximately 100°C and positioned with the bevel of the internal diameter facing the flywheel.

PISTON/CONNECTING ROD ASSEMBLY

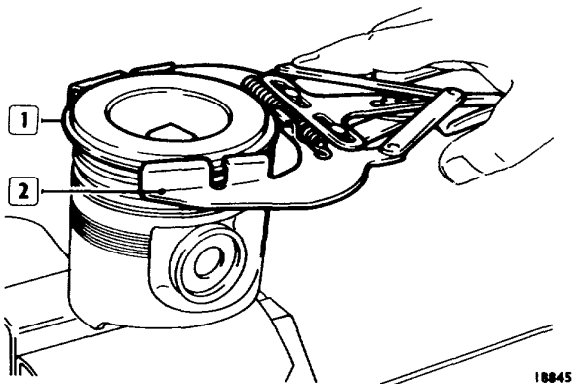
FIGURE 73



PISTON/CONNECTING ROD ASSEMBLY 18844

1 Pin – 2 Ring – 3 Piston – 4 Trapezoidal Sealing Ring – 5 Oil-scraper Ring – 6 Slotted, spring loaded oil scraper ring – 7 Connecting Rod Body – 8 Bearings – 9 Connecting Rod Cap – 10 Cap Bolt

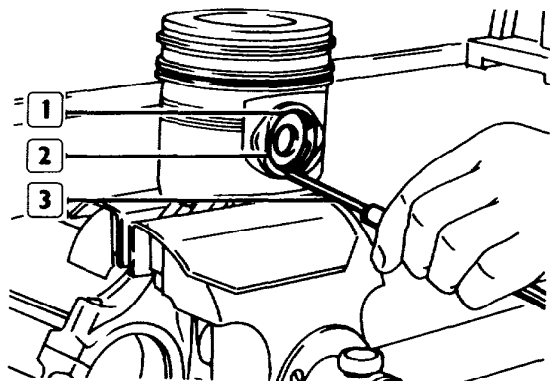
FIGURE 74



18845

The rings (1) are removed and fitted onto piston with Pliers 99360183 (2)

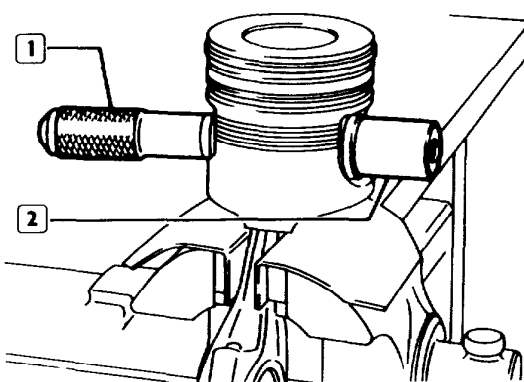
FIGURE 75



18846

The rings (1) holding piston pin (2) are removed with a scribe (3), as shown in the Figure

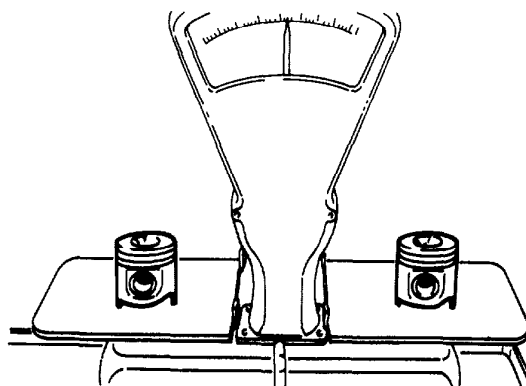
FIGURE 76



18847

Use drift (1) to remove piston pin (2)

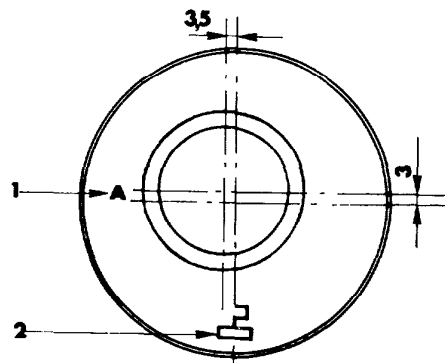
FIGURE 77



18848

Check that pistons weigh the same.

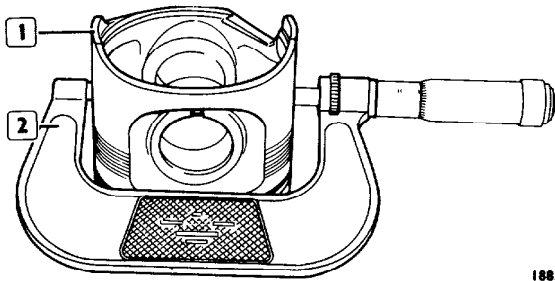
FIGURE 78



26934

The piston crowns have the following engraved on them a symbol (2) showing which way up the piston goes in the cylinder liner (symbol faces flywheel) The Letter A or B (1) shows the weight class

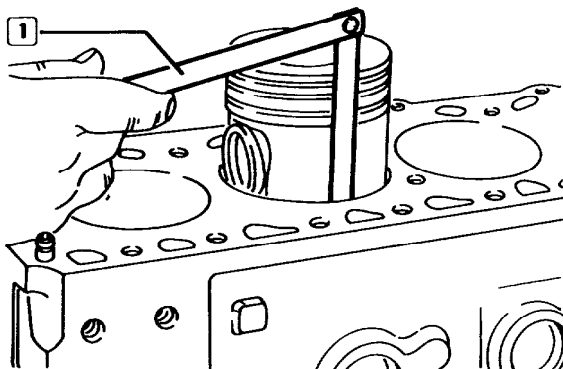
FIGURE 79



18854

Measuring piston diameter (1), using a micrometer (2), to determine fitting clearance. The diameter must be measured 12 mm from the base of the skirt in the case of a Borg piston and 17 mm in the case of a KS piston

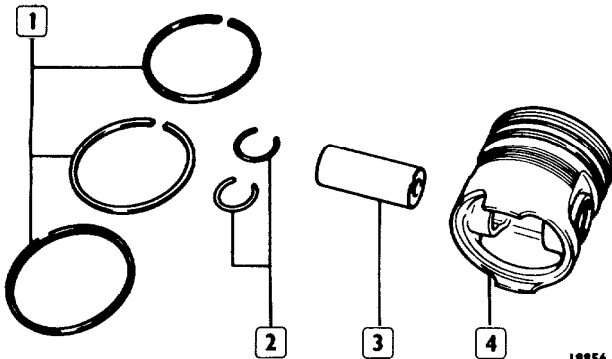
FIGURE 80



18855

As an alternative to measuring the piston diameters and liners, the clearance between the piston and cylinder liner may also be checked using a feeler gauge (1), as shown in the Figure

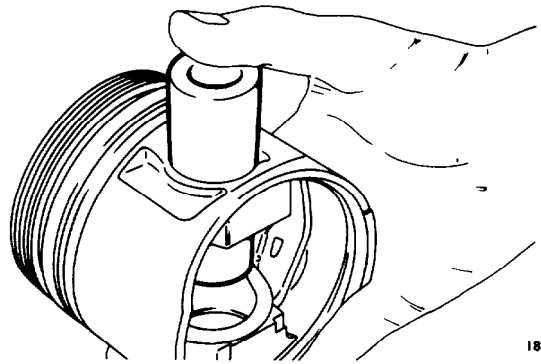
FIGURE 81



18856

Standard service pistons (4) are supplied complete with rings (1) pin (3) and snap rings (1) (2). They are also supplied oversized by 0.2, 0.4, and 0.6

FIGURE 82



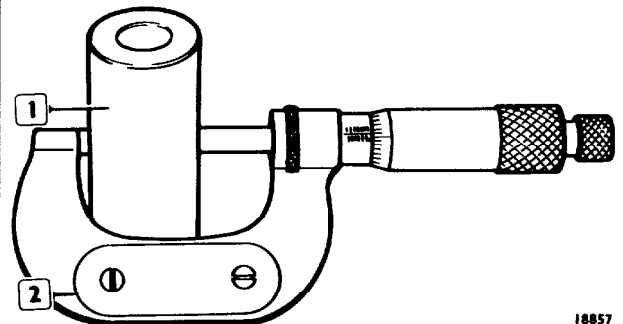
18525

CHECKING THAT FIT BETWEEN PIN AND PISTON IS CORRECT

Check for correct fit of piston pin in piston by carrying out the following test:

- lubricate pin and piston pin bores with engine oil,
- slide pin into bore,
- hold piston with pin in vertical position and check that pin slides in only by pressing with thumb, and not by falling under its own weight

FIGURE 83

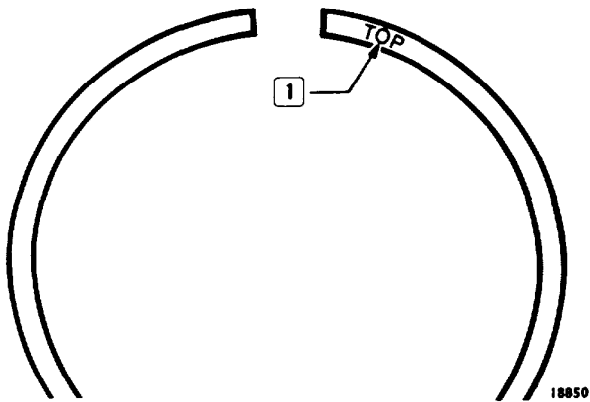


18857

If it does not, measure diameter of pin (1) with micrometer (2) to determine whether just the pin or the piston as well need to be replaced

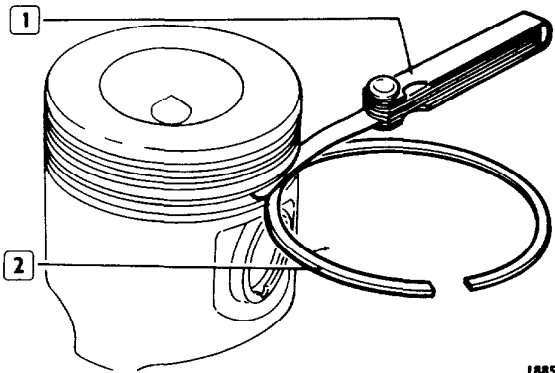
PISTON RINGS

FIGURE 84



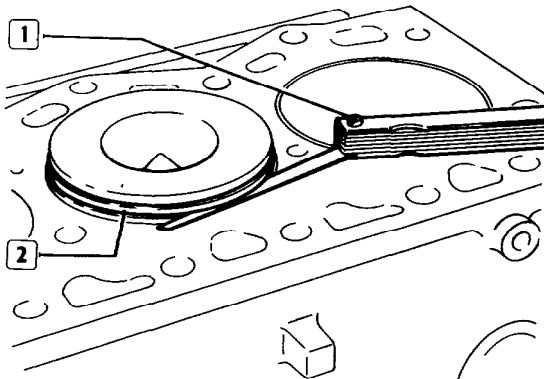
Trapezoidal sealing rings and oil-scraper rings (2nd groove) have the word TOP (1) engraved on them, so when fitting rings onto piston this word must face upwards

FIGURE 85



Checking clearance between rings (2) and their grooves with feeler gauge (1)

FIGURE 86



Checking clearance between trapezoidal ring (2) and its groove in piston with feeler gauge (1)

FIGURE 87

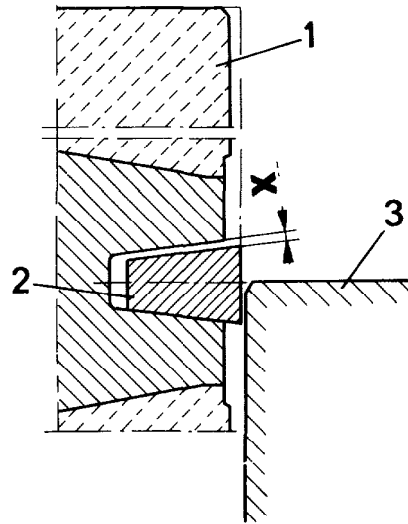
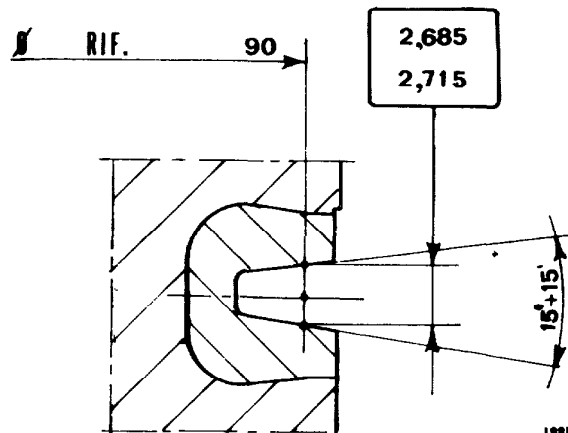


DIAGRAM FOR MEASURING CLEARANCE X BETWEEN FIRST PISTON GROOVE AND TRAPEZOIDAL RING

Due to the special shape of the first trapezoidal sealing ring, the clearance between the groove and ring must be measured as follows: bring piston (1) up beyond the block so that about half of the ring (2) in question protrudes beyond the cylinder liner (3). In this position, using a feeler gauge, check clearance (X) between ring and groove; this clearance should be 0.090–0.140 mm.

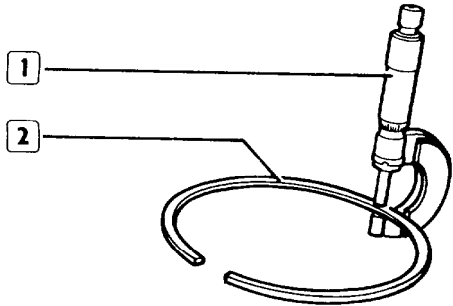
FIGURE 88



DETAIL OF FIRST GROOVE FOR A TRAPEZOIDAL SEALING RING

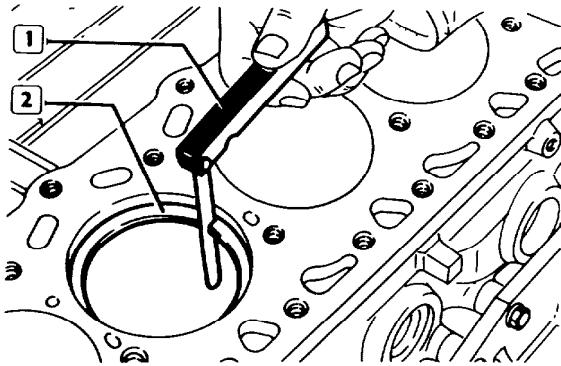
Groove height is measured on 90mm diameter

FIGURE 89



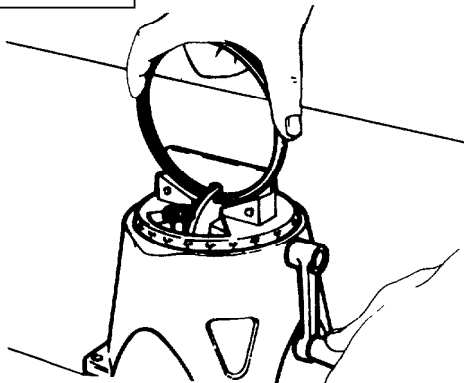
If the clearance measured exceeds the maximum specified value, measure thickness of rings (2) using micrometer (1) to determine whether clearance is due to wear of rings or wear of piston grooves, replace parts as necessary

FIGURE 90



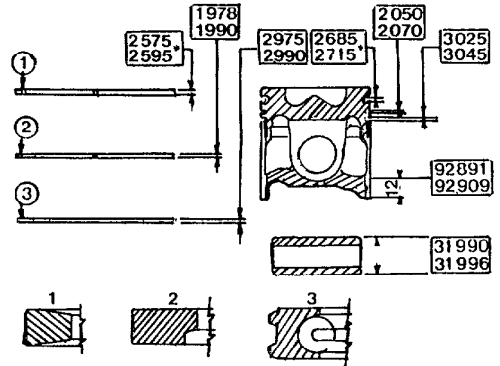
Checking gap between ends of rings (2) when fitted in cylinder barrel, using feeler gauge (1)

FIGURE 91



If gap between ends is less than that specified, replace rings

FIGURE 92

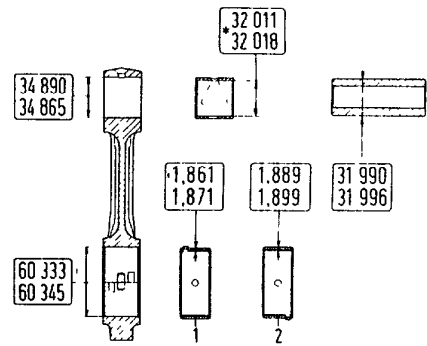


DETAILS OF PISTON (Borg), RINGS AND PIN

* Measurement made on 0/90 mm

CONNECTING RODS

FIGURE 93

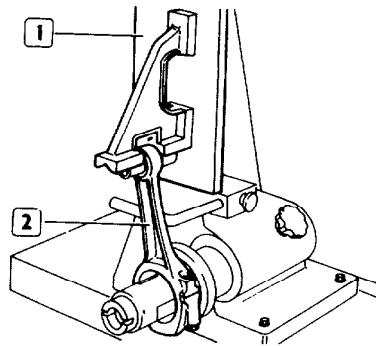


DETAILS OF CONNECTING ROD, BUSH, PISTON PIN, PISTON AND BEARINGS

1 Bearing, connecting rod cap side – 2 Bearing, connecting rod side

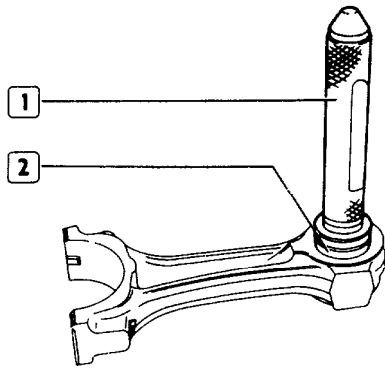
* Measurement to be taken after driving bush into small end

FIGURE 94



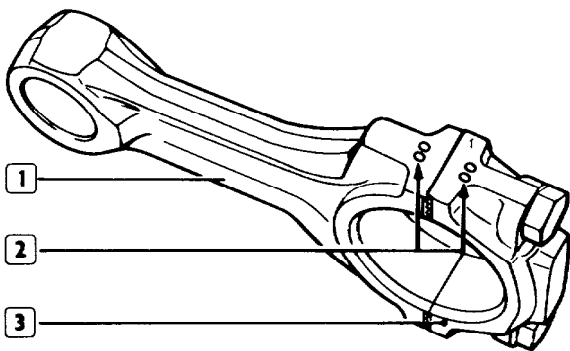
Check that axes of connecting rods (2) are parallel, using Tool 99395363 (1) Maximum permitted tolerance is 0.07 mm measured 125 mm from the longitudinal axis of the connecting rod. If connecting rod alignment exceeds the specified figure, replace the connecting rod

FIGURE 95



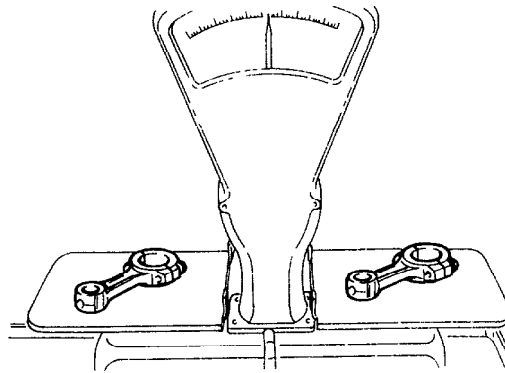
Check that bush (2) in small end is not loose and shows no signs of scoring or seizing up. If it has, replace it. It is removed and fitted using Drift 99360175 (1). When fitting, take great care to ensure that the oilway holes on the bush and small end coincide, grind bush to a diameter of 32.011–32.018 mm, using Tool 99301044.

FIGURE 96



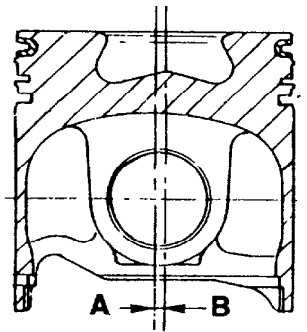
Each connecting rod is marked, on the body (1) and cap (3) with numbers (2) corresponding to the connecting rod body/cap fitting number.

FIGURE 97



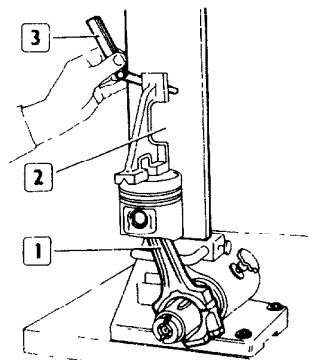
Check that all connecting rods weigh the same, permitted tolerance is $\pm 8g$. Connecting rods must be weighed complete with caps, bolts and bushes.

FIGURE 98



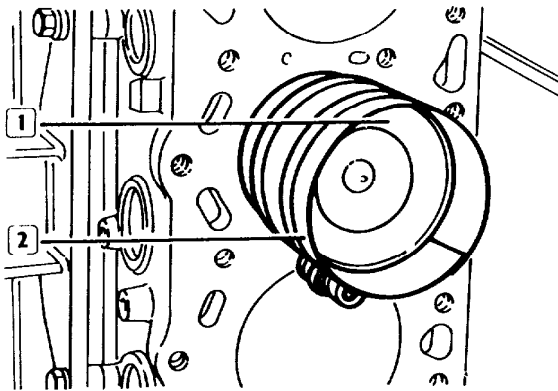
Vertical axis B of the pin hole is offset by 1 ± 0.1 mm in relation to vertical axis A of the piston (Borg).

FIGURE 99



NOTE Before fitting connecting rod and piston assembly in the engine, check that it is perpendicular, it should be perfect, if not establish the cause and replace parts as necessary.

FIGURE 100



Lubricate pistons well, including snap rings and inside cylinder liner interiors

Using installer 99360605 (2), fit connecting rod/piston assemblies (1) into cylinder liners, ensuring that

- the number on each connecting rod corresponds to the number of its appropriate cylinder,
- the gaps in the rings are offset by 120° in relation to each other,
- the pistons are all of the same weight class, A or B,

FIGURE 101

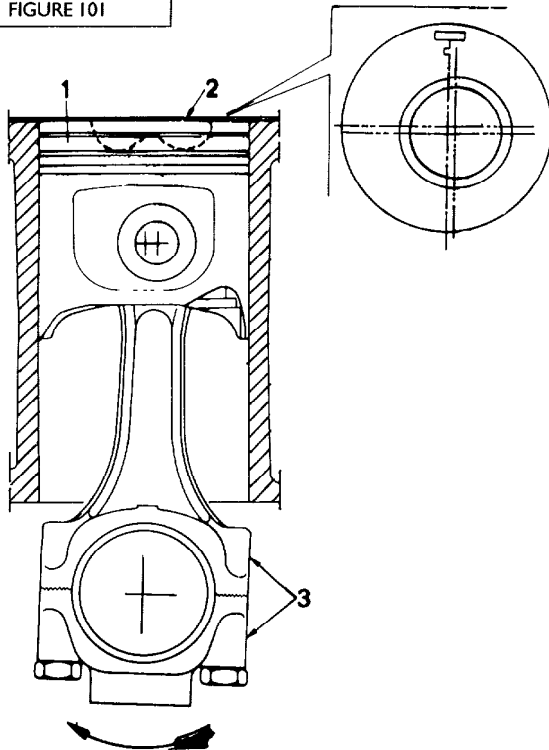
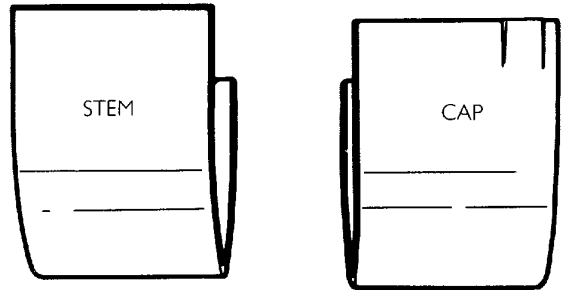


DIAGRAM FOR FITTING CONNECTING ROD/PISTON ASSEMBLY INTO THE CYLINDER

1 Piston – 2 Combustion Chamber – 3 Area where Numbers are Stamped

- that symbol, stamped on piston crown, is facing flywheel, or that hollow in piston skirt corresponds to position of piston cooling nozzles

FIGURE 102

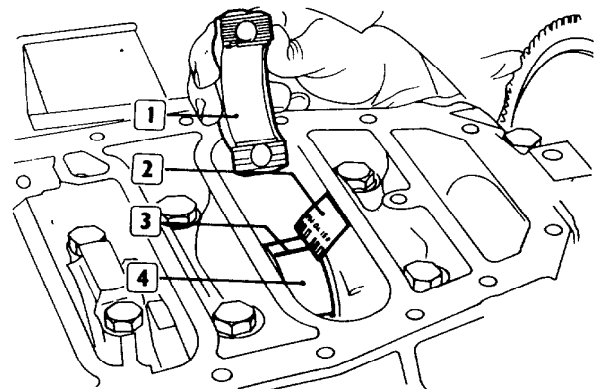


- that big end bearings are fitted in the correct housings, for this purpose the words STELO – CAPPELLO (STEM – CAP) are stamped on them

NOTE When fitting connecting rod/piston assembly into cylinder No 4, position the piston to TDC to enable connecting rod cap to be fitted

CHECKING CLEARANCE BETWEEN CRANK PINS AND BEARINGS

FIGURE 103

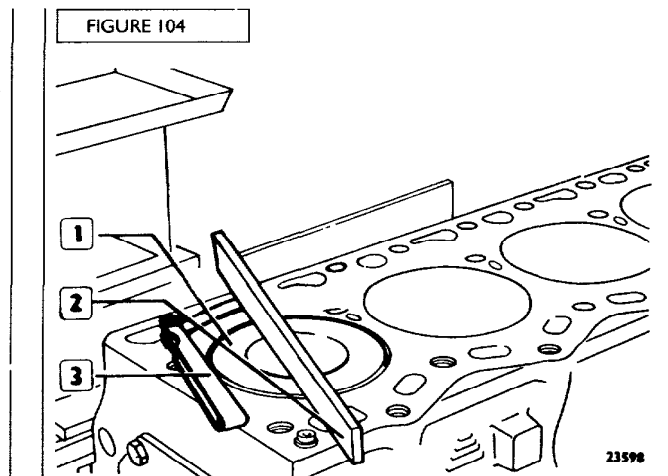


Measure the clearance as follows

- clean parts thoroughly and remove all traces of oil,
- place a length of calibrated wire (3) on crankshaft journals (4),
- fit connecting rod cap (1) and tighten bolts to a torque of 50 Nm (5kgm)+angle of 63° ±3°; lubricate bolts,
- remove cap and determine clearance by comparing width of calibrated wire with scale on packet (2)

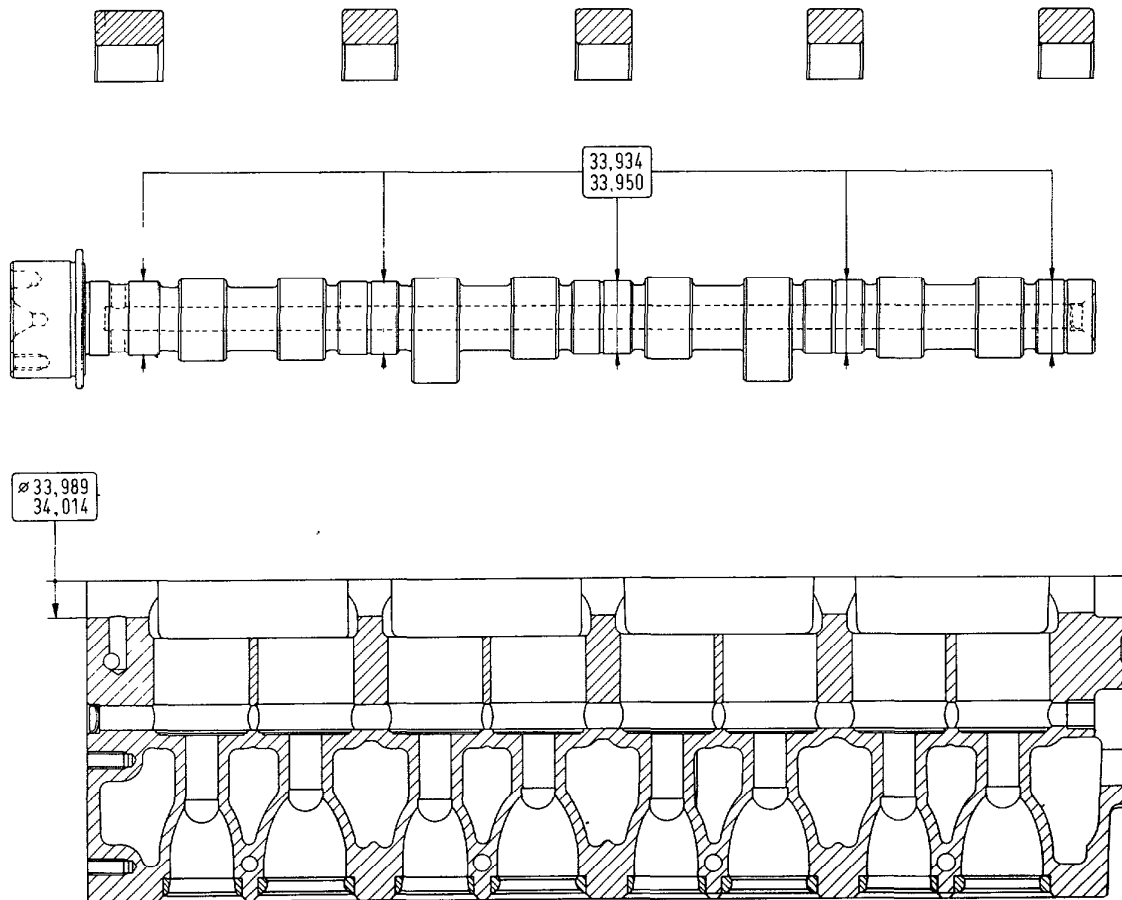
CHECKING PISTON PROTRUSION

Once connecting rod/piston assemblies have been fitted, check protrusion of pistons (1) at TDC in relation to top of block using a feeler gauge (3) and straight edge (2). Protrusion should be between 0.35 and 0.65 mm



CAMSHAFT

FIGURE 105

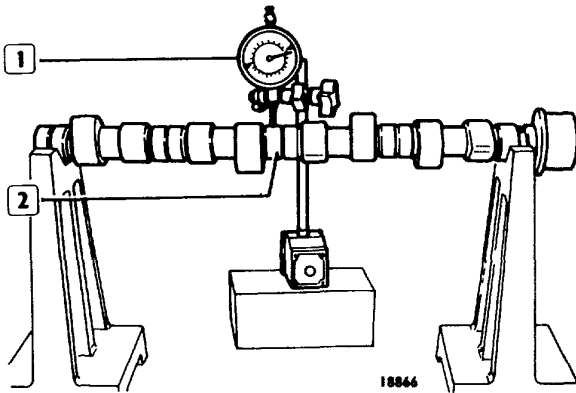


DETAILS OF CAMSHAFT AND ITS BEARINGS AND CAPS ON CYLINDER HEAD

The camshaft, in the cylinder head, is supported by 5 bearings with their caps and is driven by the crankshaft via a toothed belt

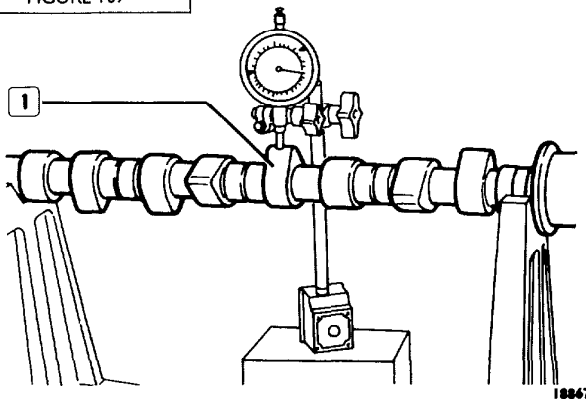
The surfaces of the shaft and cam journals must be very well ground, if they show signs of seizing up and scoring, the shaft should be replaced

FIGURE 106



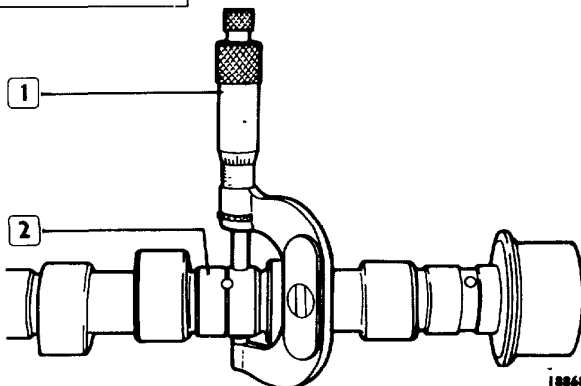
With camshaft on parallel stands and using a dial gauge (1) check run-out of journals (2), it should be no more than 0.04 mm. If run-out is not to specification, replace the camshaft.

FIGURE 107



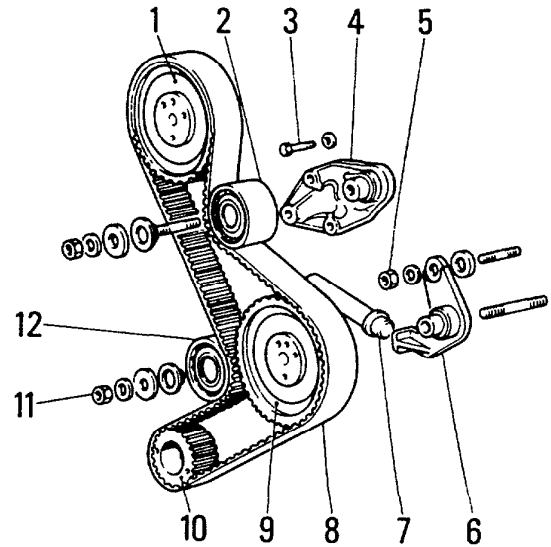
With camshaft still on parallel stands, check cam lift (1) which should be 10.5 mm for the exhaust and 9.5 mm for the inlet cams.

FIGURE 108



Using micrometer (1), measure camshaft journals (2) and, using an inside micrometer, measure the diameter of the camshaft bush bores relative to the appropriate journals. The difference between the two figures gives the actual clearance which should be 0.039–0.080 mm. If it is not, replace the parts concerned.

CAMSHAFT DRIVE

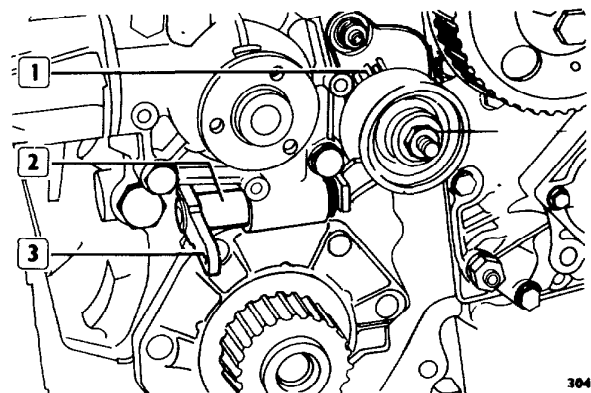


CAMSHAFT AND ANCILLARIES DRIVE COMPONENTS

- 1 Camshaft drive gear – 2 Fixed belt tensioner roller – 3 B.Jt fixing Fixed Belt tensioner Roller Support to Cylinder Head – 4 Fixed Belt tensioner Roller Support – 5 Nut fixing Belt tensioner Roller Support to Block – 6 Belt tensioner Roller Support – 7 Push Rod with Reaction Spring for Belt tensioner – 8 Toothed Belt – 9 Ancillaries Drive Gear – 10 Drive Gear splined onto Crankshaft – 11 Nut fixing Adjustable Belt tensioner Roller to Support – 12 Belt tensioner Roller

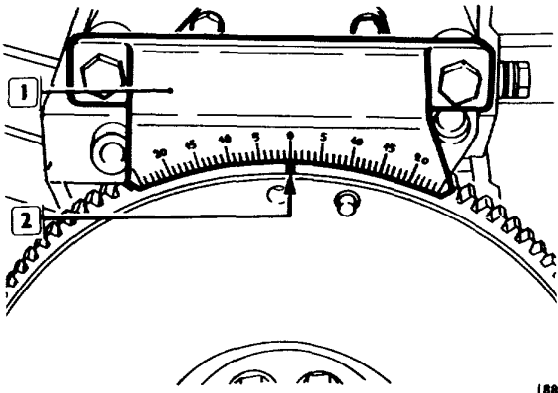
To fit camshaft toothed belt (8) proceed as follows

FIGURE 110



- apply Tool (3) to load reaction spring of belt tensioner push rod (2),
- fit adjustable belt tensioner (1),

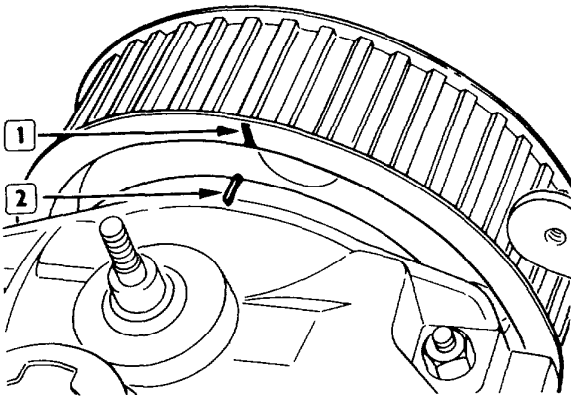
FIGURE 111



18870

- fit graduated quadrant 99395611 (1),
- align mark (2) engraved on flywheel with zero engraved on graduated quadrant,

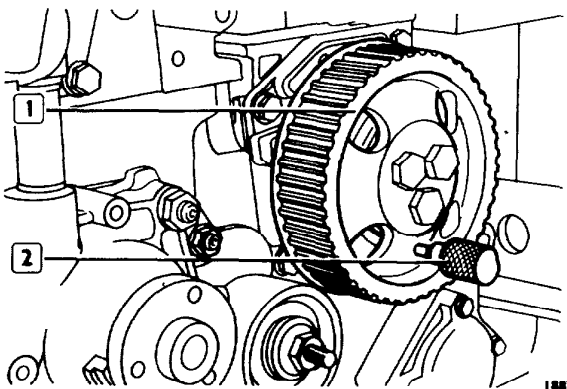
FIGURE 112



18871

- align mark (1) engraved on camshaft drive gear with that engraved on tappet cover (2),

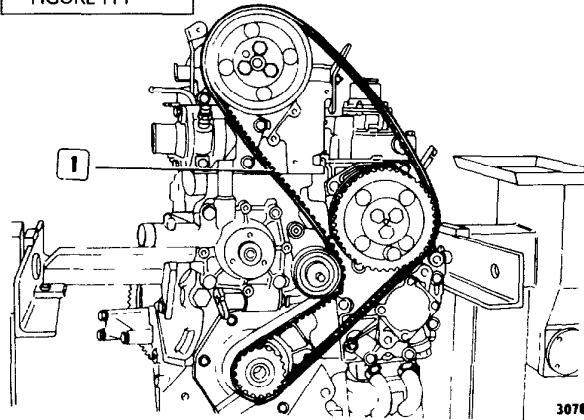
FIGURE 113



18872

- rotate ancillaries drive gear (1) so as to align hole in gear with that in support and prevent rotation by inserting special tool (2)

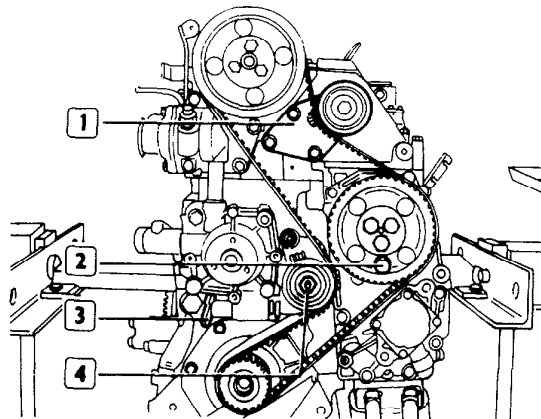
FIGURE 114



30780

- Fit toothed belt (1),

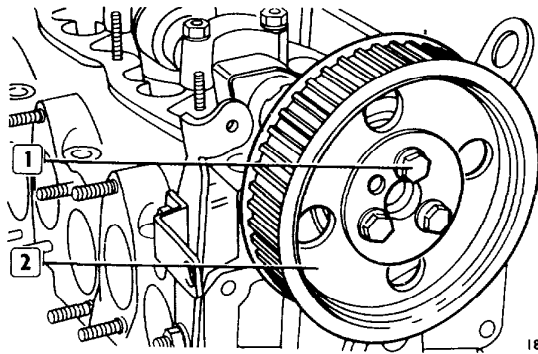
FIGURE 115



30781

- fit fixed belt tensioner (1) with guard,
- remove tool (3), enabling spring of adjustable belt tensioner push rod to take effect,
- pull out tool (2),
- turn engine over clockwise two complete revolutions and check that the marks and reference hole on the gears and flywheel match up, if they do not, remove toothed belt and repeat the operations described above,
- tighten nut (4) of adjustable belt tensioner

CYLINDER HEAD

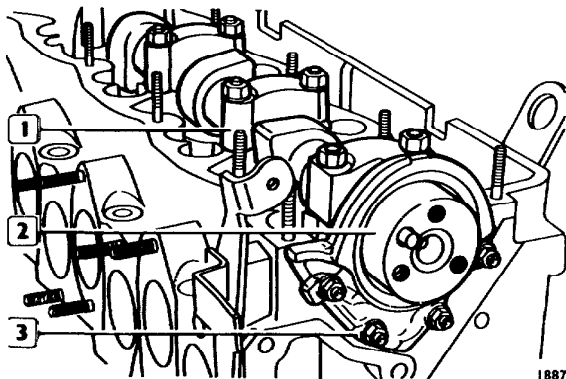


18875

The cylinder head is removed as follows

- unscrew retaining bolts (1) of gear (2) and slide gear off,

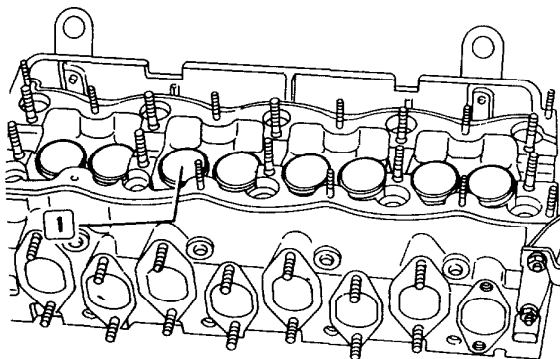
NOTE Removal and fitting of cylinder head is facilitated by using Tool 99361004



18876

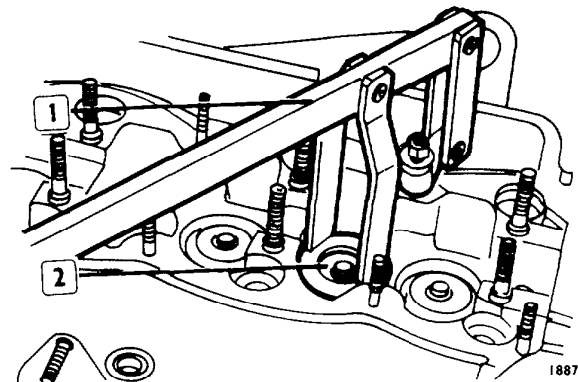
- remove cover (3), unscrew cap fixing nuts (1) of camshaft (2), remove caps and lift out shaft

NOTE. When fitting cover (3), apply LOCTITE 573 to sealing surface



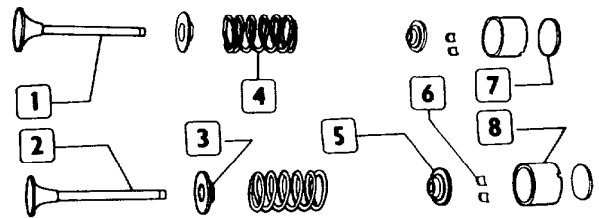
18877

Remove tappets (1) complete with adjustment discs, placing them in a container in their correct fitting order



18878

The valves are removed with Tool 99360355 (1) by exerting pressure on top cap (2) so as to remove collets. Remove top cap, springs and bottom cap, turn cylinder head over and remove valves

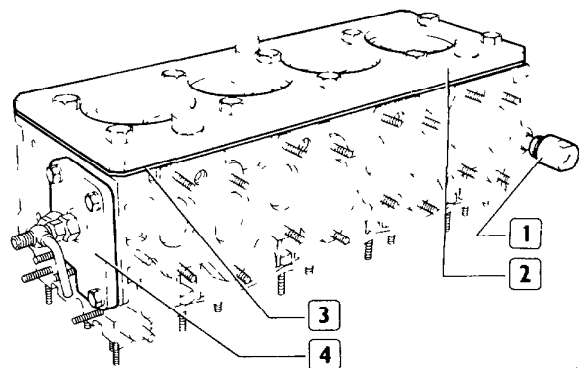


25225

VALVE ASSEMBLY COMPONENTS

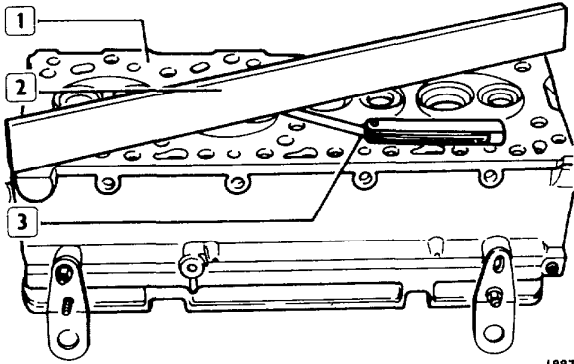
- 1 Inlet Valve – 2 Exhaust Valve – 3 Bottom Cap – 4 Spring – 5 Top Cap – 6 Collets – 7 Disc – 8 Tappet

NOTE To fit the valves, follow the operations described above in the reverse order



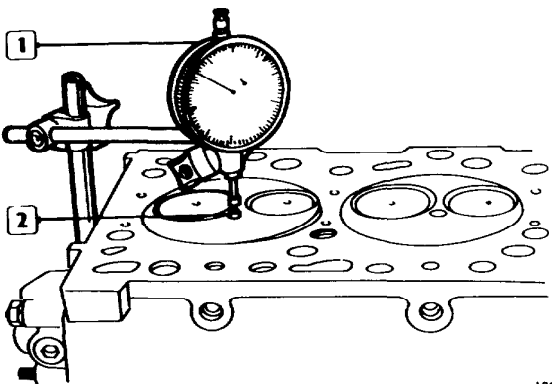
18542

Check watertightness using special tool (1, 2, 3 and 4) Pump in water heated to approximately 90°C at a pressure of 2–3 kg/cm² In these conditions no leaks should occur, if they do renew cylinder head



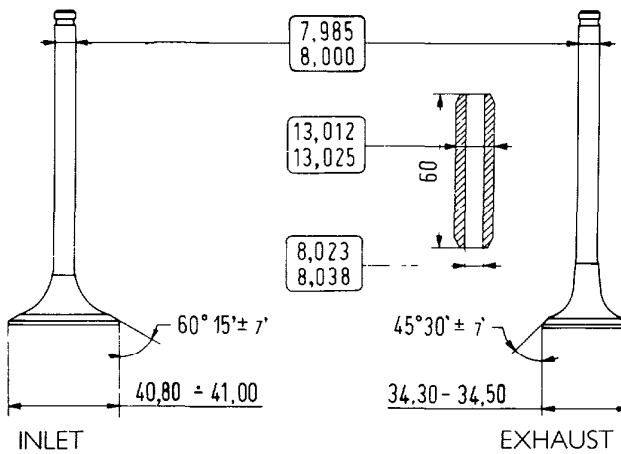
18879

The face of the head (1) on the cylinder block is checked for flatness with a straight edge (2) and feeler gauge (3), if distorted the cylinder head should be ground flat. No more than 0.4 mm of material may be removed. (Specified cylinder head height 150 ± 0.1 mm)

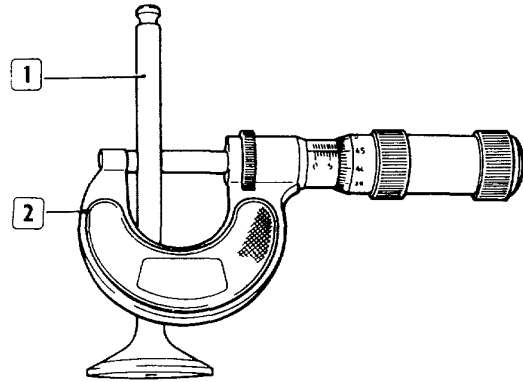


18880

After levelling off, fit injectors (2) and, using a dial gauge (1) check their protrusion which should be 3.0–3.54 mm, if it is not, insert a copper washer in the seal housing



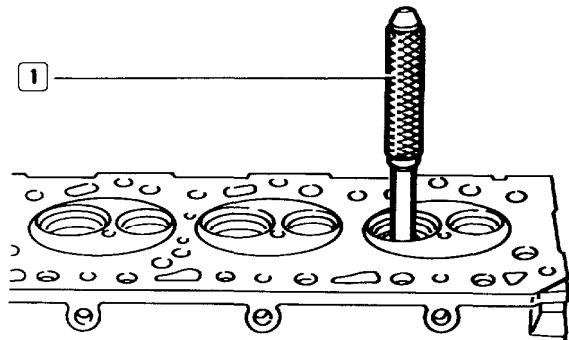
DETAILS OF INLET AND EXHAUST VALVES AND VALVE GUIDES



18882

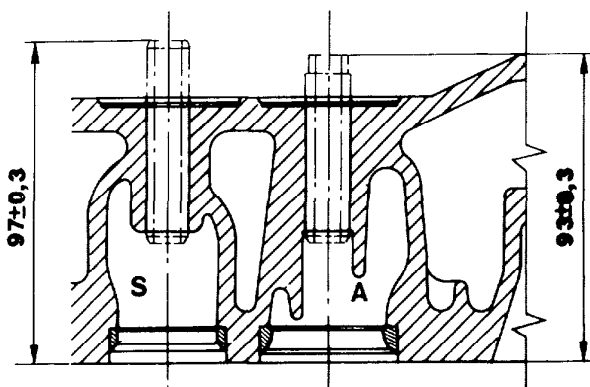
Using a micrometer (2), measure diameter of valve stem (1), it should be 7.985–8.000 mm

Using Bore Gauge 99395723 check diameter of valve guide hole, it should be 8.023–8.038 mm. Replace badly worn parts



18883

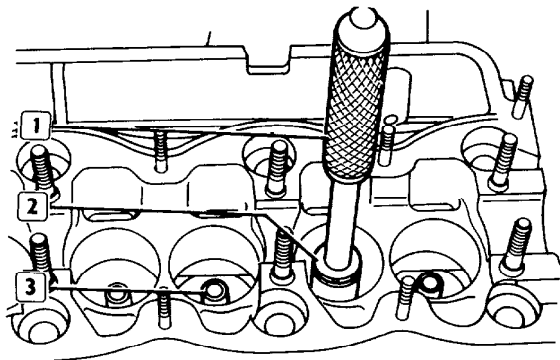
The valve guides are removed using Drift 99360288 (1)



30425

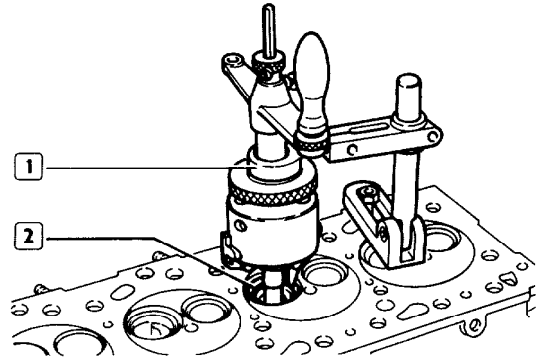
DIAGRAM SHOWING CORRECT FITTING OF INLET AND EXHAUST VALVE GUIDES

S = Exhaust, A = Inlet



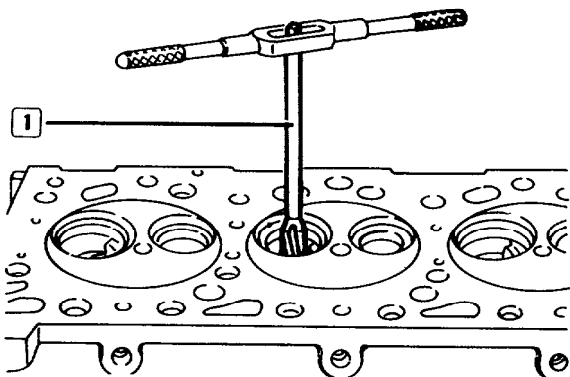
1885

Valve guides (3) are fitted using Drift 99360288 (1) with Adaptor 99360271 (2). Guides supplied in service are oversized on the external diameters by 0.05, 0.10 and 0.25 mm.



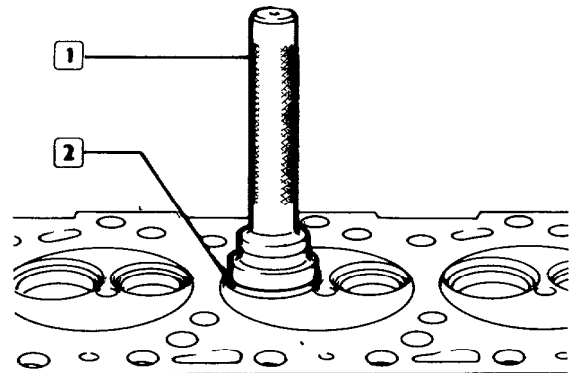
1887

Check valve seats (2), if slightly scored or burnt, grind them using HUNGER Tool 99360419 (1).

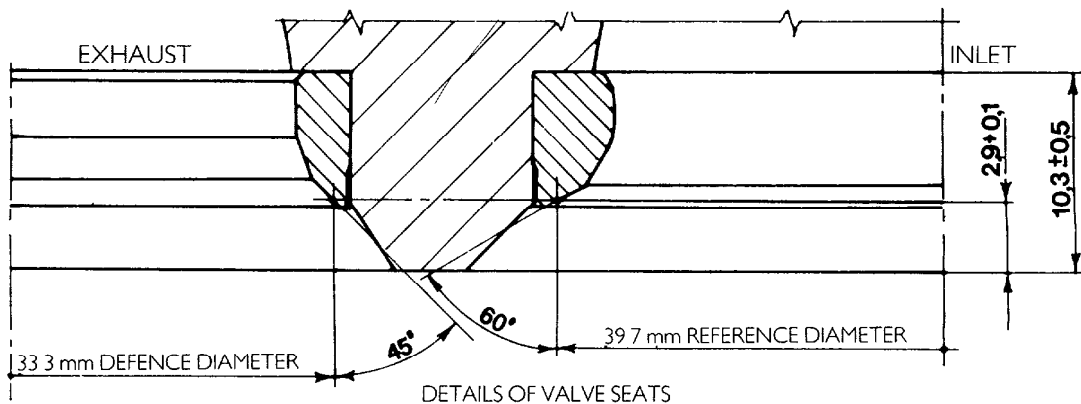


1886

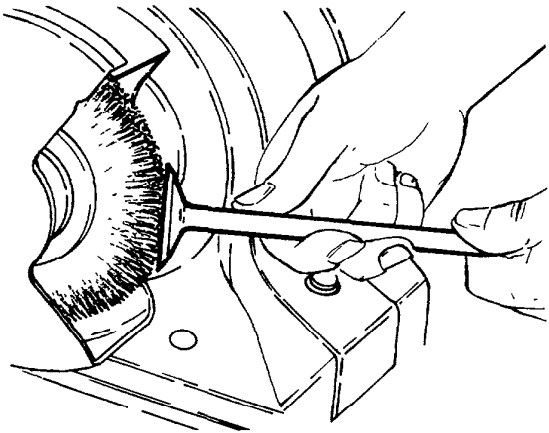
After fitting valve guides, ream with Tool 99390310 (1).



If after grinding seats their seal is poor, replace valve seats. Use drift (1) to fit valve seats (2).

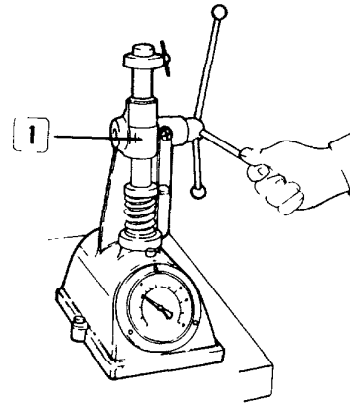


30426



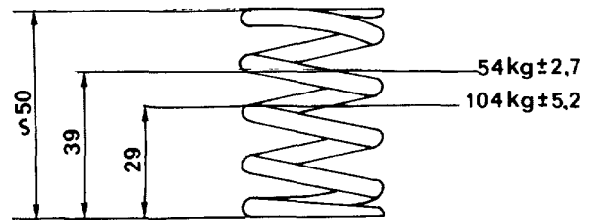
16825

Remove carbon deposits from valves using wire brush. Check that valves show no signs of seizure or cracks, if they do replace them. To grind valve head surfaces, place valve stem in self-centering chuck of Grinder 99301014 and adjust support so that grinding is at an angle of $60^{\circ}15' \pm 7'$ for inlet valves and $45^{\circ}30' \pm 7'$ for exhaust valves.



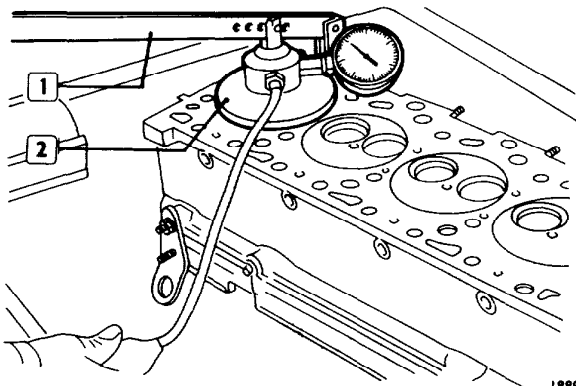
16587

Check that valve springs are not cracked, if so replace them. Using Tool 99305049 (1), also test flexibility of springs, checking that load and flexibility figures correspond to those shown in Fig 118.



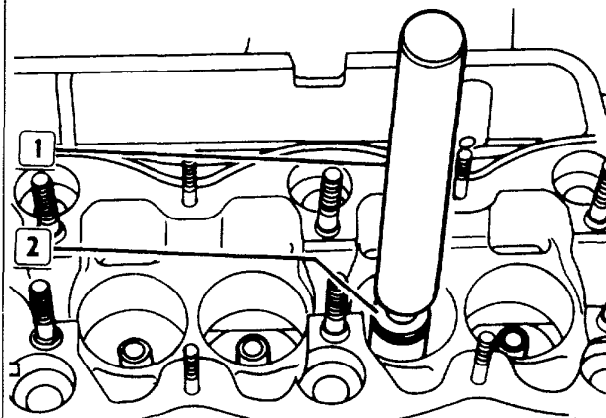
25226

DATA FOR CHECKING INLET AND EXHAUST VALVE SPRINGS



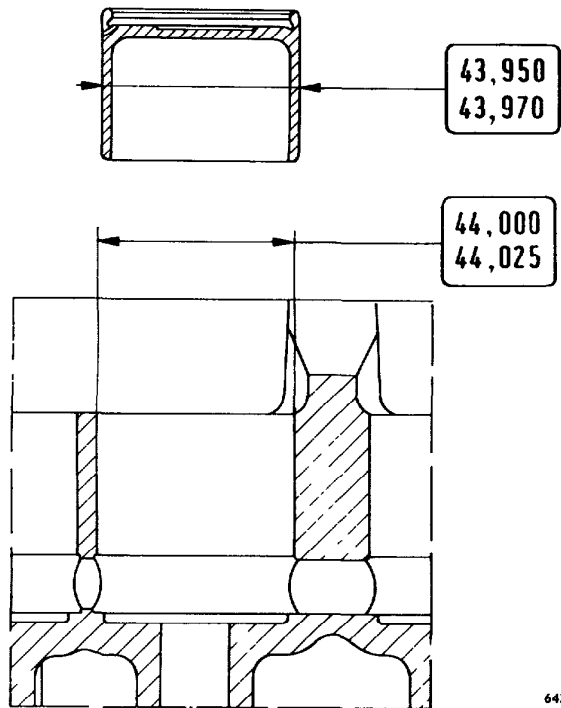
18890

Once valve seats have been ground, fit valves and injector and check valve seal using special tool (1 and 2). After grinding, when fitting check that valves are 1.0–1.4 mm from cylinder head face.

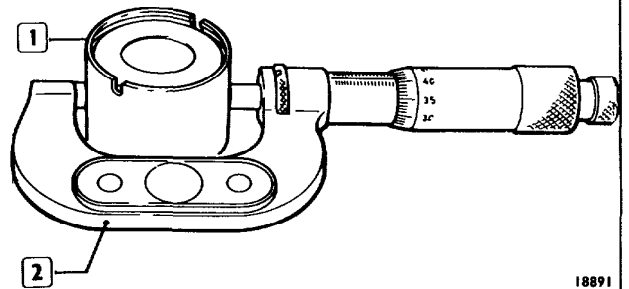


30427

Using Installer 99360292 (1) fit seals onto inlet valve guides.



DETAILS OF TAPPETS AND SEATS ON CYLINDER HEAD



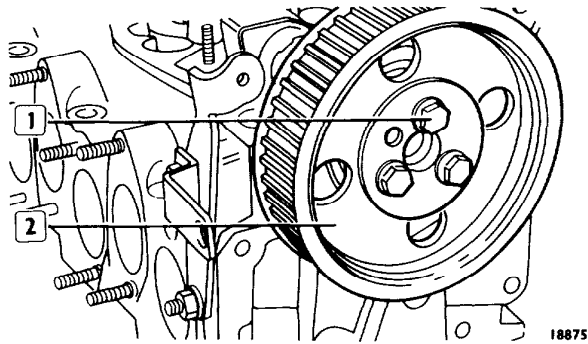
18891

Using a micrometer (2), check diameter of tappet (1) and with an inside micrometer check diameter of its seat on cylinder head, the figures should correspond to those shown in Fig. 120

The standard fitting clearance between the maximum diameter of the tappet and that of the seat is 0.030–0.075 mm. If clearance is excessive, replace tappets with new ones.

CYLINDER HEAD

FIGURE 116

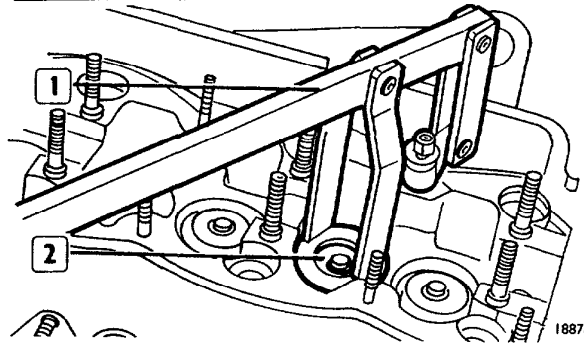


18875

The cylinder head is removed as follows
 □ unscrew retaining bolts (1) of gear (2) and slide gear off,

NOTE Removal and fitting of cylinder head is facilitated by using Tool 99361004

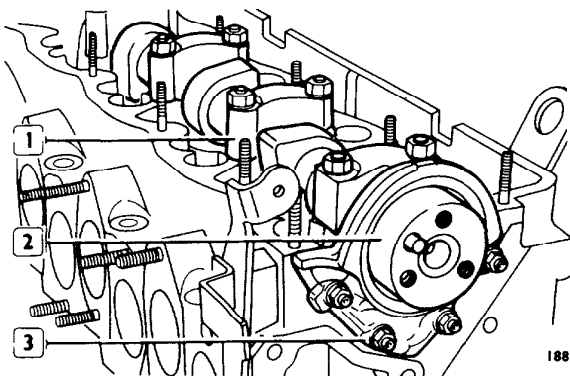
FIGURE 119



18878

The valves are removed with Tool 99360355 (1) by exerting pressure on top cap (2) so as to remove collets
 Remove top cap, springs and bottom cap, turn cylinder head over and remove valves

FIGURE 117

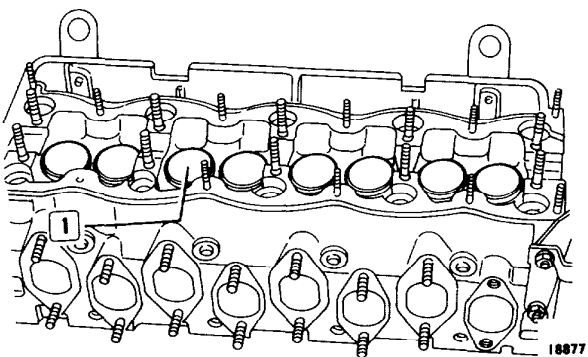


18876

□ remove cover (3), unscrew cap fixing nuts (1) of camshaft (2), remove caps and lift out shaft

NOTE - When fitting cover (3), apply LOCTITE 573 to sealing surface

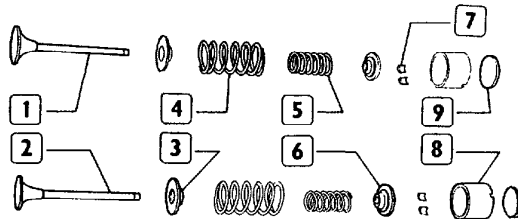
FIGURE 118



18877

Remove tappets (1) complete with adjustment discs, placing them in a container in their correct fitting order

FIGURE 120

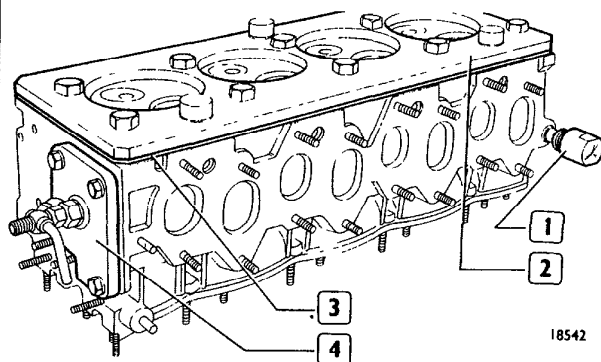


VALVE ASSEMBLIES AND COMPONENTS

1 Intake valve - 2 Exhaust valve - 3 Lower cap - 4 External spring - 5 Internal spring - 6 Upper cap - 7 Collets - 8 Tappet - 9 Adjusting washer

NOTE - To fit the valves, follow the operations described above in the reverse order.

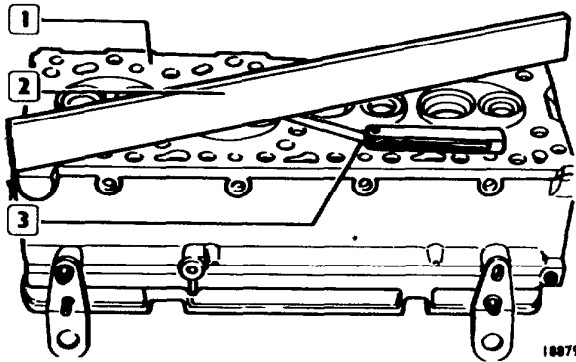
FIGURE 121



18542

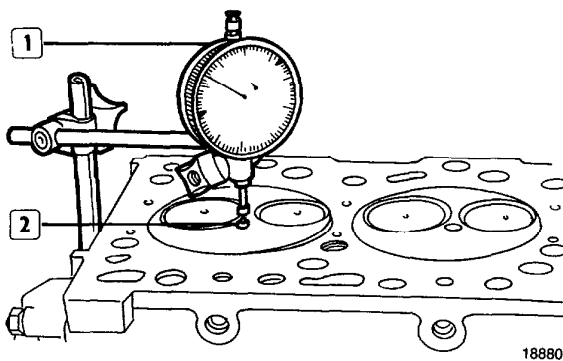
Check watertightness using special tool (1, 2, 3 and 4) Pump in water heated to approximately 90°C at a pressure of 2-3 kgm/cm²
 In these conditions no leaks should occur, if they do renew cylinder head

FIGURE 122



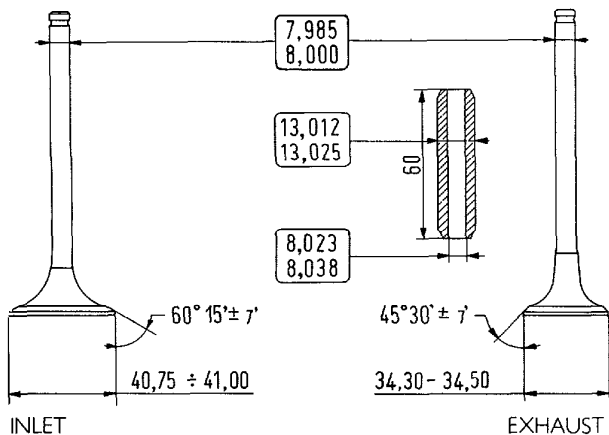
The face of the head (1) on the cylinder block is checked for flatness with a straight edge (2) and feeler gauge (3); if distorted the cylinder head should be ground flat. No more than 0.4 mm of material may be removed (Specified cylinder head height 150 ± 0.1 mm.)

FIGURE 123



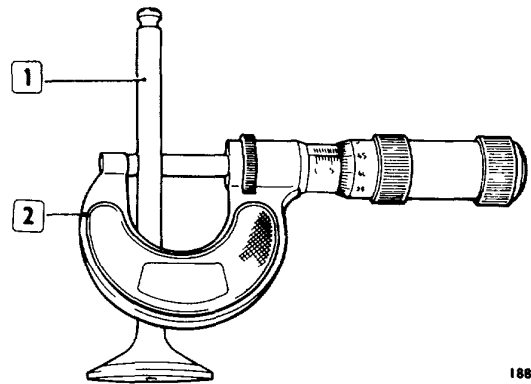
After levelling off, fit injectors (2) and, using a dial gauge (1) check their protrusion which should be 3.0–3.54 mm, if it is not, insert a copper washer in the seal housing.

FIGURE 124



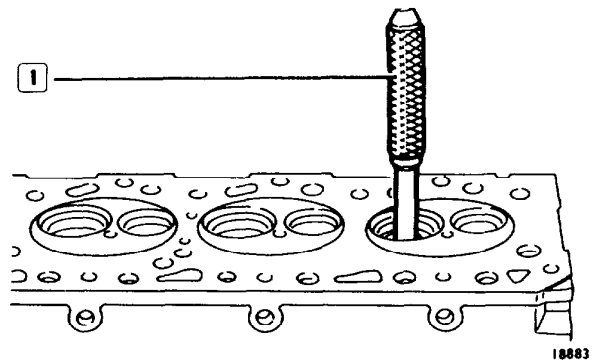
DETAILS OF INLET AND EXHAUST VALVES AND VALVE GUIDES

FIGURE 125



Using a micrometer (2), measure diameter of valve stem (1), it should be 7.985–8.000 mm. Using Bore Gauge 99395723 check diameter of valve guide hole, it should be 8.023–8.038 mm. Replace badly worn parts.

FIGURE 126



The valve guides are removed using Drift 99360288 (1).

FIGURE 127

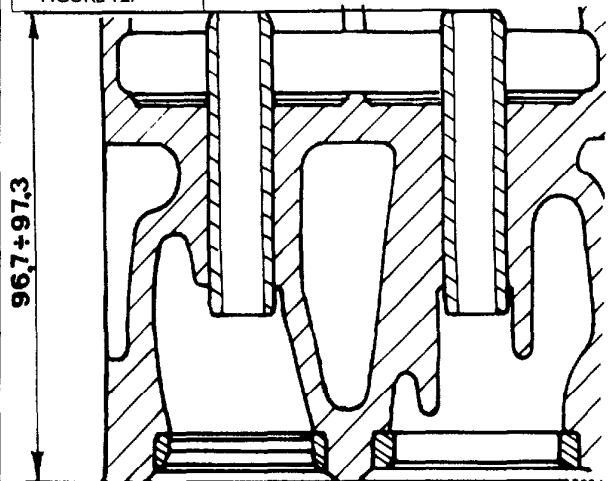
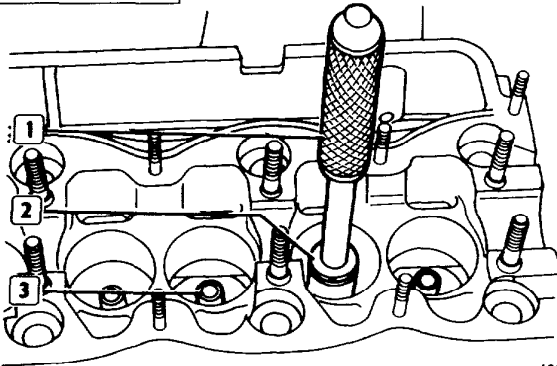


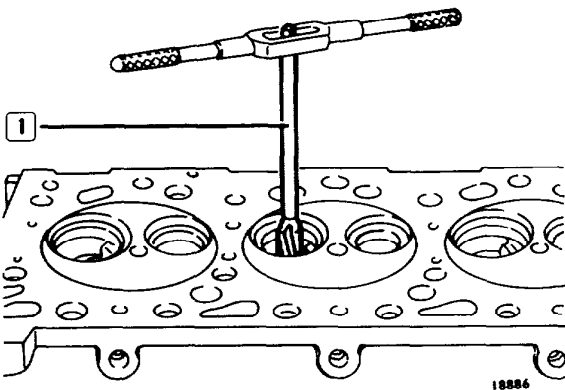
DIAGRAM SHOWING CORRECT FITTING OF INLET AND EXHAUST VALVE GUIDES

FIGURE 128



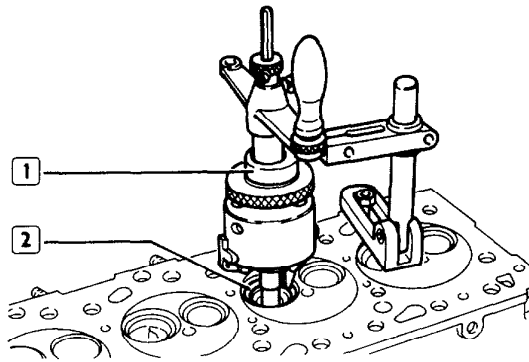
Valve guides (3) are fitted using Drift 99360288 (1) with Adaptor 99360271 (2) Guides supplied in service are oversized on the external diameters by 0.05, 0.10 and 0.25 mm

FIGURE 129



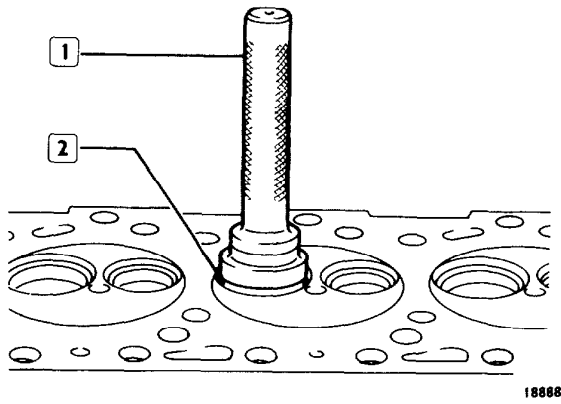
After fitting valve guides, ream with Tool 99390310 (1)

FIGURE 130



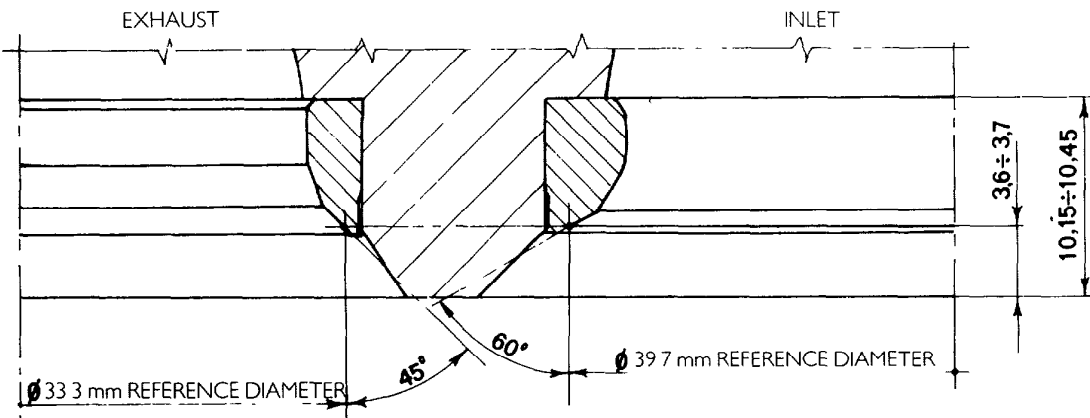
Check valve seats (2), if slightly scored or burnt, grind them using HUNGER Tool 99360419 (1)

FIGURE 131



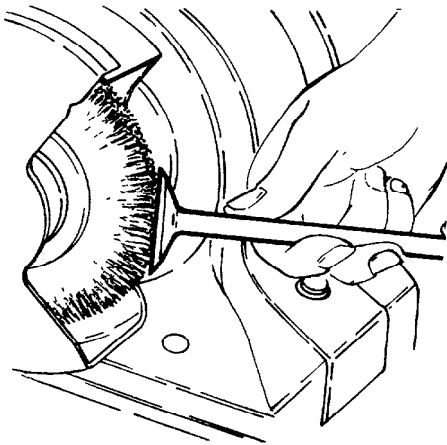
If after grinding seats their seal is poor, replace valve seats Use drift (1) to fit valve seats (2)

FIGURE 132



DETAILS OF VALVE SEATS

FIGURE 133

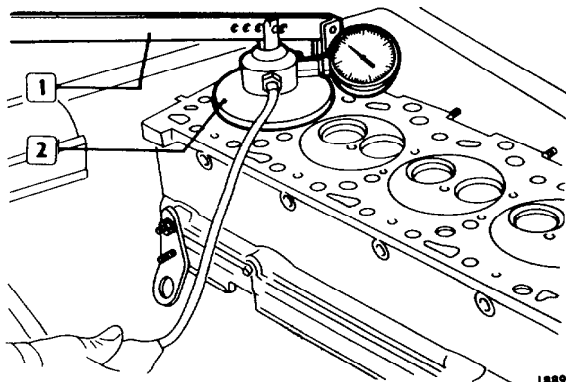


16825

Remove carbon deposits from valves using wire brush. Check that valves show no signs of seizure or cracks, if they do replace them.

To grind valve head surfaces, place valve stem in self-centering chuck of Grinder 99301014 and adjust support so that grinding is at an angle of $60^{\circ}15' \pm 7'$ for inlet valves and $45^{\circ}30' \pm 7'$ for exhaust valves.

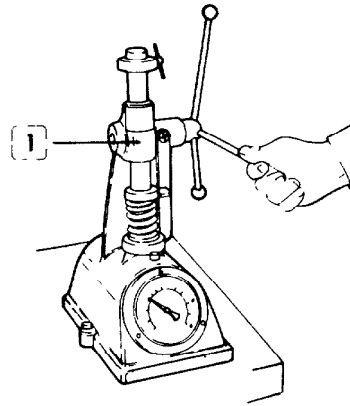
FIGURE 134



18890

Once valve seats have been ground, fit valves and injector and check valve seal using special tool (1 and 2). After grinding, when fitting check that valves are inset 1.0–1.4 mm from cylinder head face.

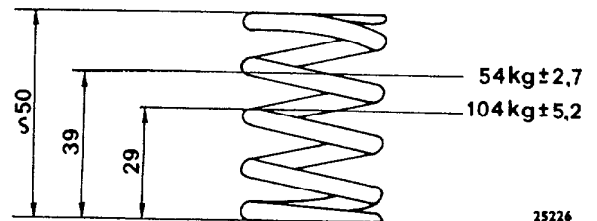
FIGURE 135



16587

Check that valve springs are not cracked, if so replace them. Using Tool 99305049 (1), also test flexibility of springs, checking that load and flexibility figures correspond to those shown in Fig 136.

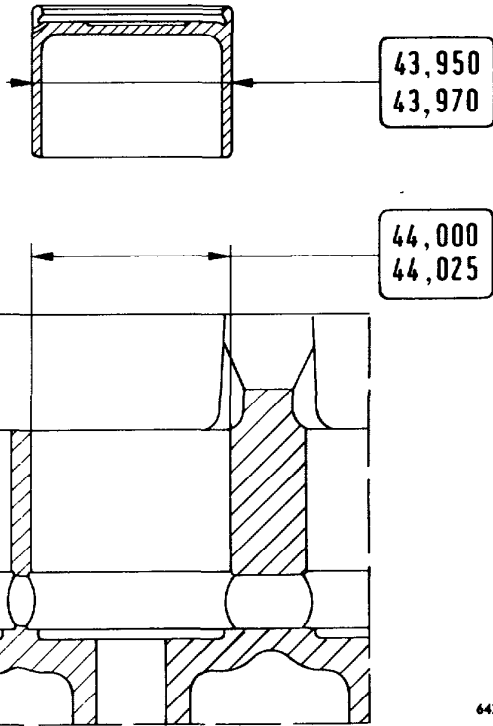
FIGURE 136



25226

DATA FOR CHECKING INLET AND EXHAUST VALVE SPRINGS

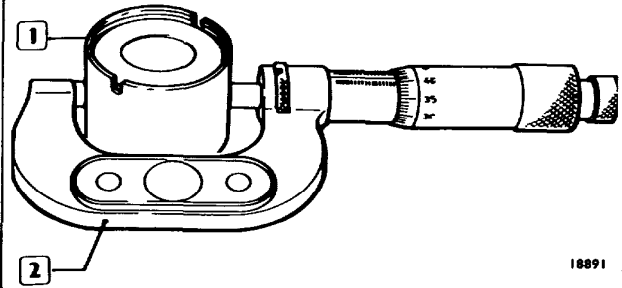
FIGURE 137



6431

DETAILS OF TAPPETS AND SEATS ON CYLINDER HEAD

FIGURE 138

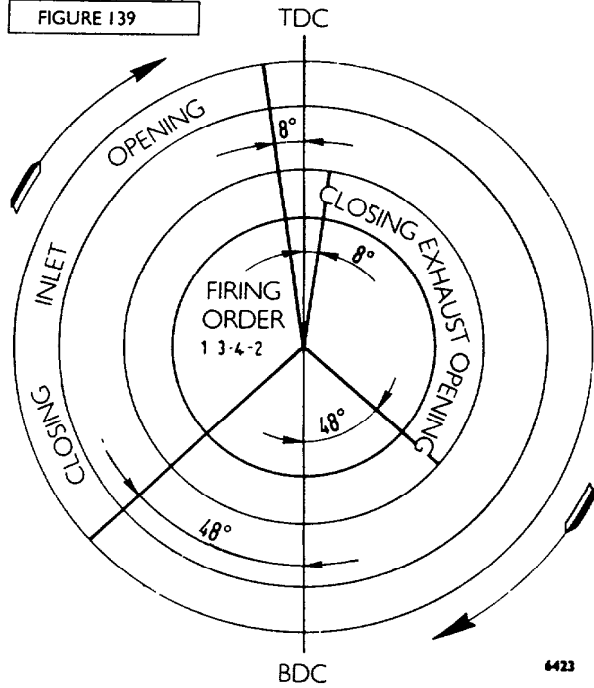


18891

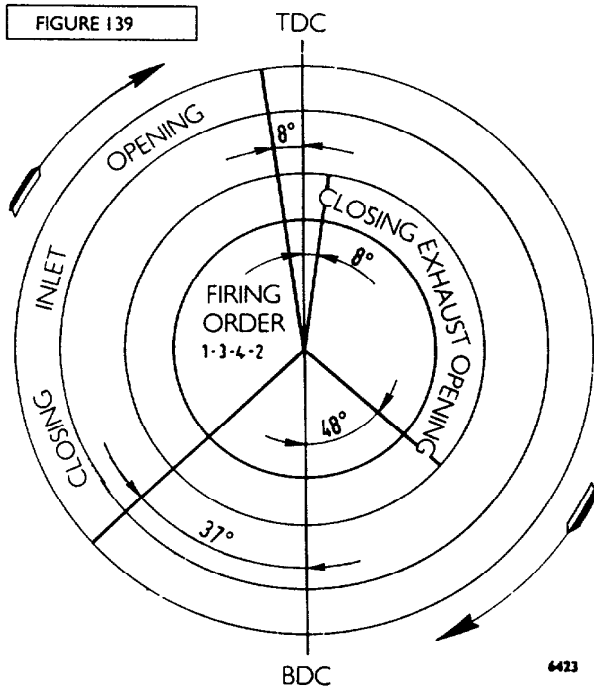
Using a micrometer (2), check diameter of tappet (1) and with an inside micrometer check diameter of its seat on cylinder head, the figures should correspond to those shown in Fig 137

The standard fitting clearance between the maximum diameter of the tappet and that of the seat is 0.030–0.075 mm. If clearance is excessive, replace tappets with new ones.

ADJUSTING TAPPET CLEARANCE WITH CYLINDER HEAD ON BENCH

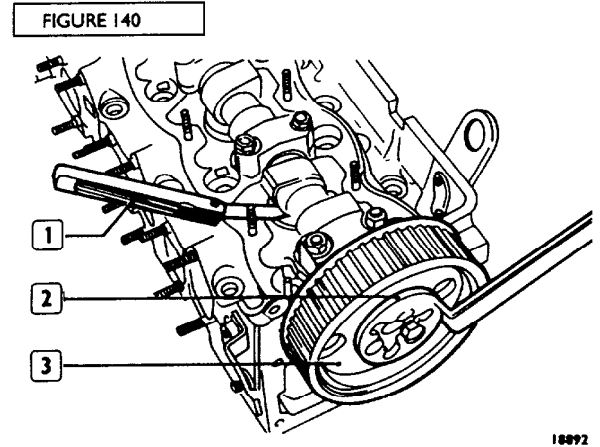


VALVE TIMING DIAGRAM (8141I07)

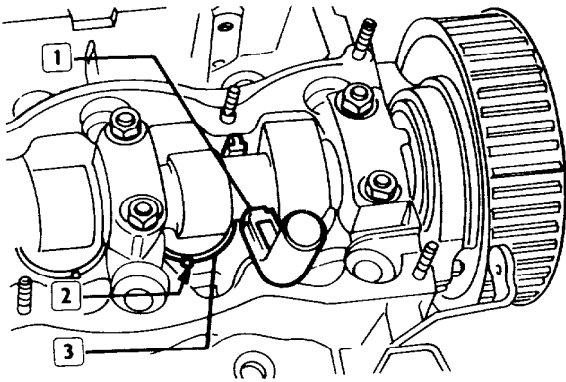


VALVE TIMING DIAGRAM (8141SI27)

So that the specified timing diagram is not changed, as it would be if clearance were greater or less than specified, tappet clearance must be adjusted very carefully. Excessive clearance causes noise, retards opening and advances closing of the valves, whereas insufficient clearance has the opposite effect, if there is absolutely no clearance, the valves are always slightly open, with very damaging consequences for the life of the valves and their seats.



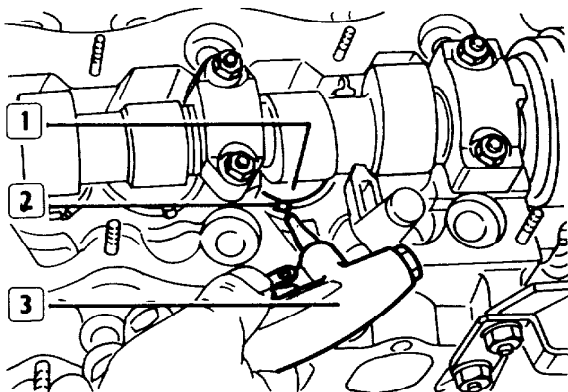
- Adjust tappet clearance as follows
- fit wrench 99350114 (2) onto fixing bolts of gear (3) and use it to turn camshaft and bring valves into closing position,
 - use feeler gauge 99395113 (1) to check that clearance between inlet and exhaust tappets and cams is 0.5 ± 0.05 mm



18893

Should it be necessary to replace the adjustment discs, to give the specified operating clearance, proceed as follows

- rotate tappets (3) so that milled grooves (2) round edge are facing towards inlet and exhaust pipes,
- place Tool 99360309 (1) between inlet and exhaust tappets and lever down until tappets are fully compressed.

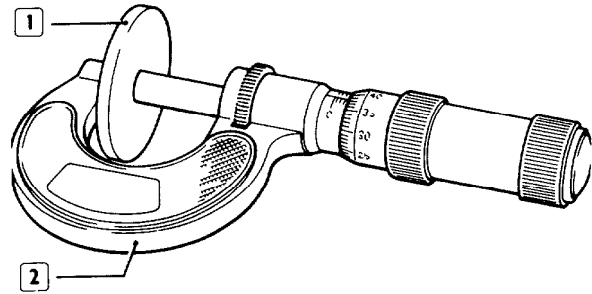


18894

- using gun (3) blow a jet of compressed air into milled grooves (2) lifting up the adjustment disc (1) to be replaced.

NOTE: Tappet clearance adjustment discs are supplied in service in the following thicknesses 3.25, 3.30, 3.35, 3.40, 3.45, 3.50, 3.55, 3.60, 3.65, 3.70, 3.75, 3.80, 3.85, 3.90, 3.95, 4.00, 4.05, 4.10, 4.15, 4.20, 4.25, 4.30, 4.35, 4.40, 4.45, 4.50, 4.55, 4.60, 4.65, 4.70, 4.75, 4.80, 4.85, 4.90

- remove adjustment disc,

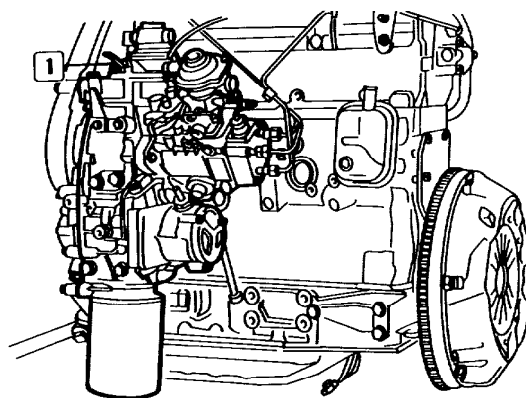


18895

The adjustment disc (1) thickness is stamped on one side, if illegible, measure thickness with a micrometer (2) When fitting the adjustment disc, the engraved figure must face towards the tappet

NOTE Should it be necessary to adjust tappet clearance with cylinder head in engine, rotate engine with special tool to bring inlet valve cam approximately facing upwards, in this position the piston will be 10–13 mm from TDC, thus preventing it from hitting the valves

ANCILLARIES UNIT



18896

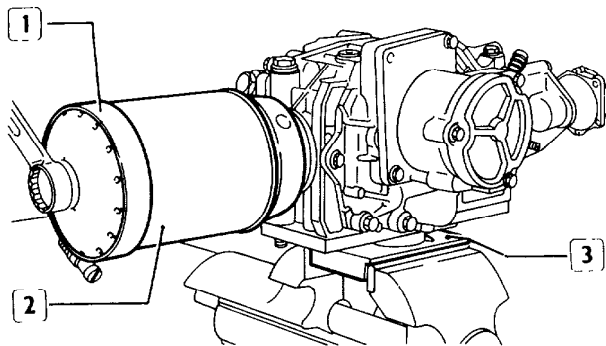
The ancillaries are grouped together on a single mounting (1) fixed on the side of the top engine block and driven by the toothed belt that drives the camshaft

The mounting has oilways for the circulation of lubricating oil for the various units

The following components are fitted to the mounting fuel pump, injection pump, oil pump and regulating valve, double-filtration oil filter, vacuum pump for servo brake, drive for power take-off (if any) and tachometer

DISMANTLING THE ANCILLARIES UNIT

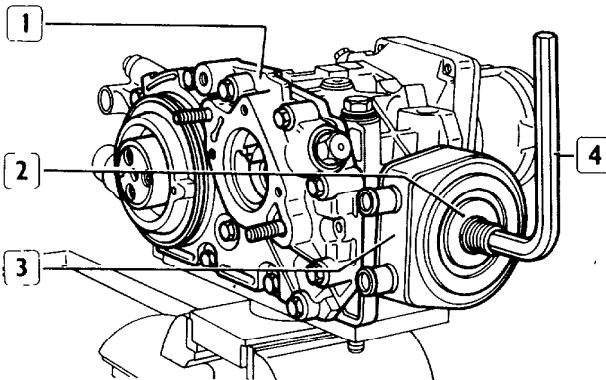
FIGURE 145



26241

Bolt ancillaries unit to Support 99360363 (3), previously clamped in vice
Unscrew oil filter (2) using Tool 99360314 (1).

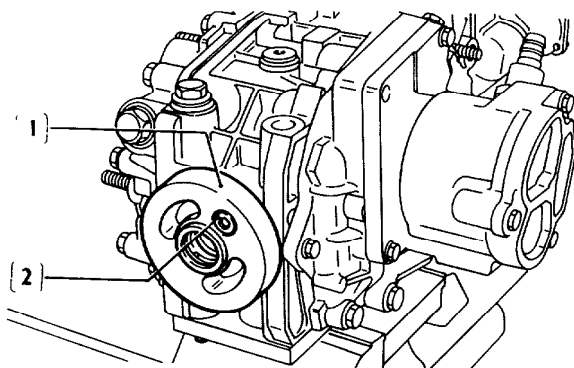
FIGURE 146



26242

Using allen key (4), unscrew connection (2) fixing heat exchanger (3) to ancillaries mounting (1) (ENGINE 8141S127)

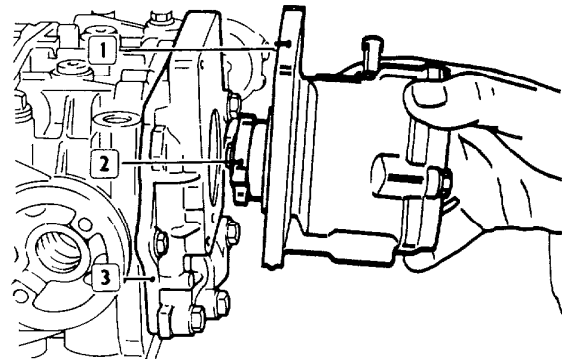
FIGURE 147



26243

Using allen key, remove bolt (2) and take off oil filter support (1) (ENGINE 8141S127)

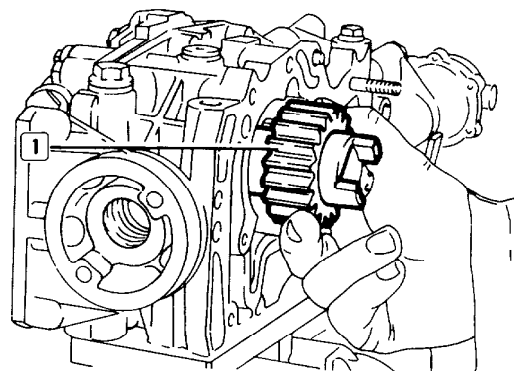
FIGURE 148



18899

Remove vacuum pump (1) complete with drive connection (2) and seal
Remove back cover (3) of oil pump, complete with pressure relief valves and tachometer drive shaft.

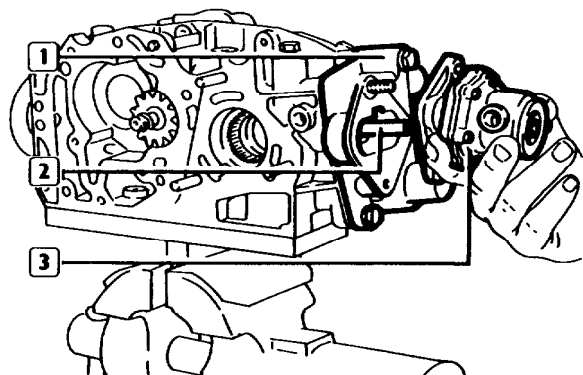
FIGURE 149



26245

Pull off oil pump driven gear (1)

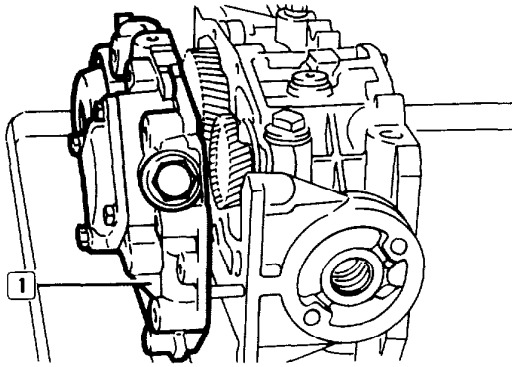
FIGURE 150



18991

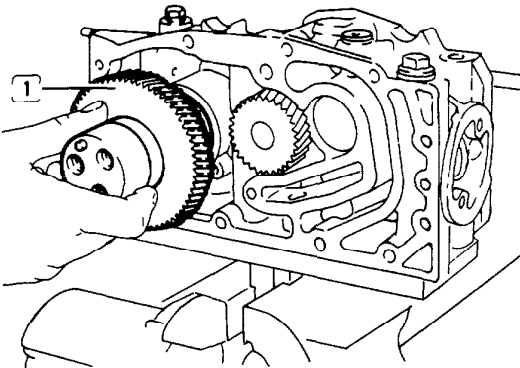
Remove complete fuel pump (3), pull out drive rod (2) and remove top cover (1).

FIGURE 151



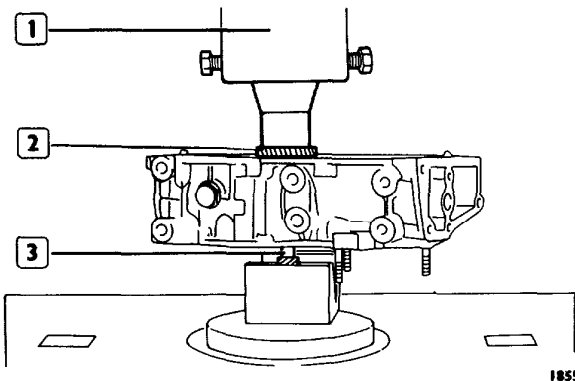
Unscrew bolts and remove front cover (1)

FIGURE 152



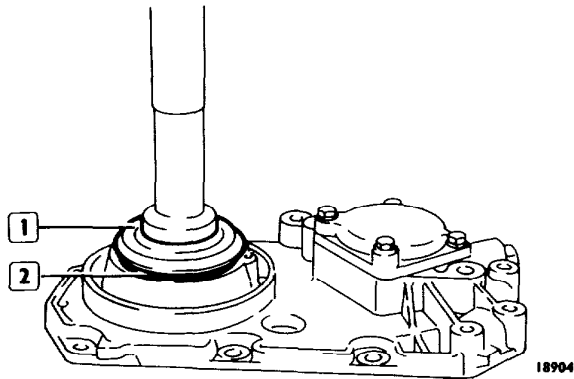
Pull off oil pump drive gear (1)

FIGURE 153



Remove driven gear (2) only if it and its complete drive shaft (3) show excessive wear, this operation must be performed using a hydraulic press (1)

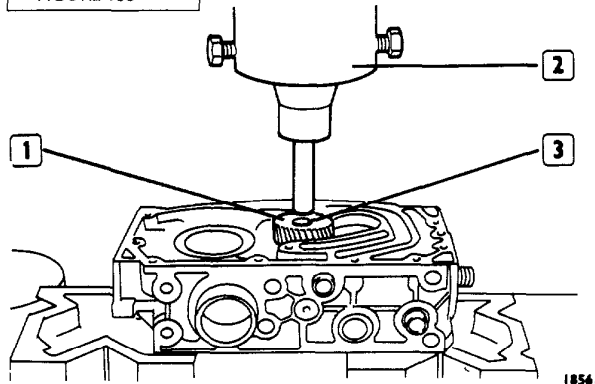
FIGURE 154



Use suitable drift (1) to replace seal (2) on front cover

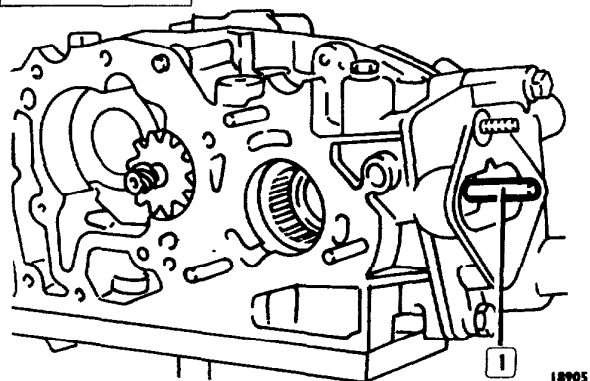
FITTING THE ANCILLARIES UNIT

FIGURE 155



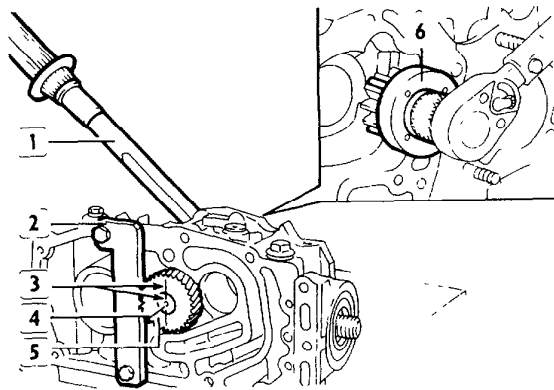
To fit ancillaries unit, carry out dismantling operations in reverse order, remembering that driven gear (1) must be fitted onto drive shaft (3) using a hydraulic press (2), heating the gear and cooling the shaft so that between the two parts there is a temperature difference of approximately 270°C After fitting, check that there is a gap of 88 mm ±0.2 mm between the external faces of the gears

FIGURE 156



When fitting fuel pump drive shaft (1), check its travel, which should be approximately 2.5 mm

FIGURE 157

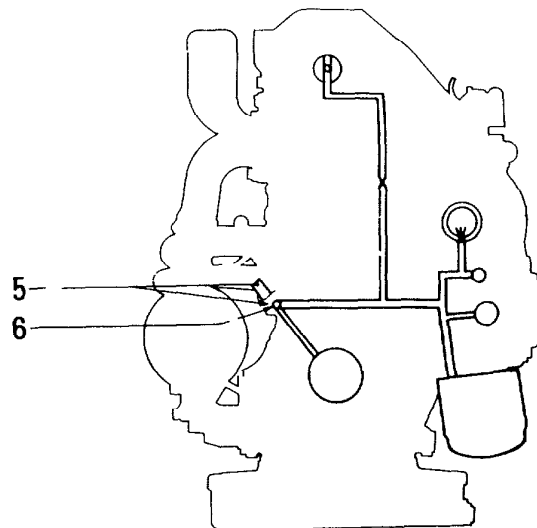
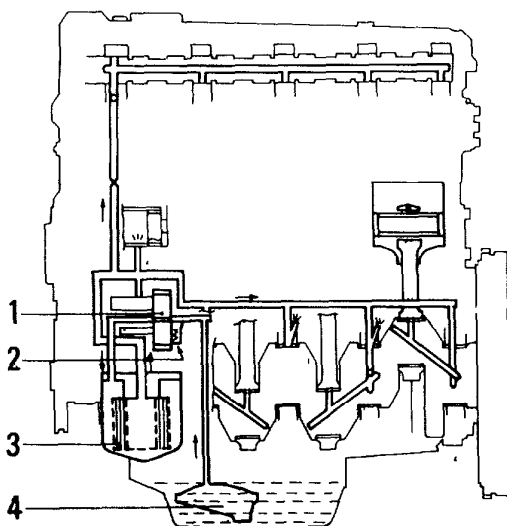


18906

- Also check resistance to rotation of gears (5) as follows
- apply Tool 99360607 (2), make two reference marks (3) on shaft (4) and gear (5),
 - work gear with torque wrench (1) set at 64 Nm (6.5 kgm) and Tool 99360607 (6),
 - check that marks are perfectly aligned

NOTE Before fitting back cover spread a thin layer of LOCTITE 245 over sealing surface

LUBRICATION SYSTEM

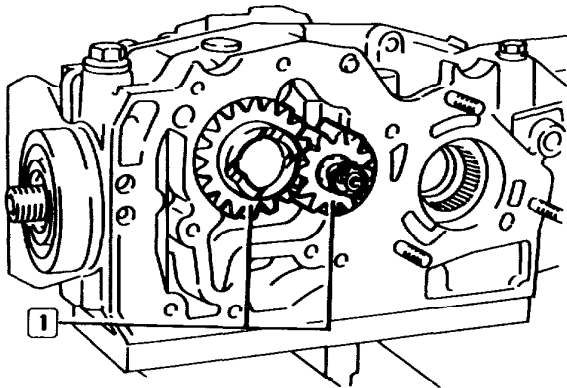


6439

ENGINE OIL CIRCULATION DIAGRAM

- 1 Oil Pump – 2 Oil Filter Cartridge – 3 Oil Pressure Regulating Valve – 4 Oil Pick Up Pipe – 5 Electrical Oil Pressure Sender – 6 Main Oilway

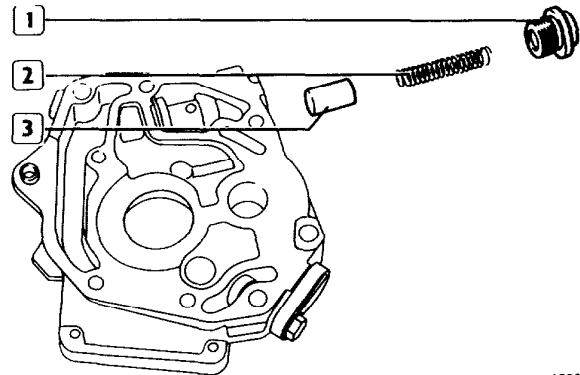
OIL PUMP



18907

Engine lubrication is by a gear pump (1)
There is a regulating valve on the oil pump cover.

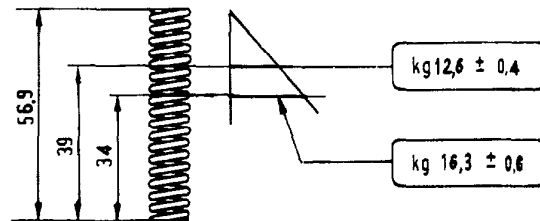
- at idling speed 0.8 bar
- at rated speed 3.8 bar



18909

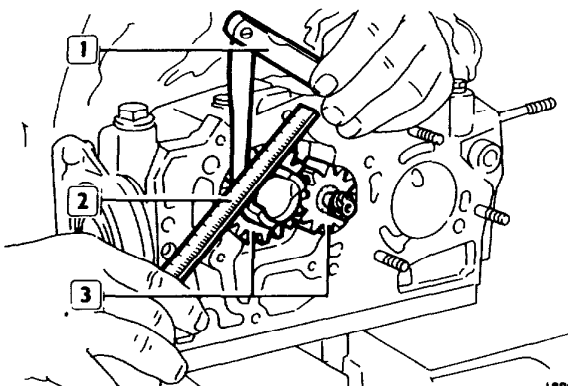
Unscrew plug (1), pull out spring (2) and regulating valve (3)

Check that valve (3) slides freely and has no score marks and that spring (2) is not broken



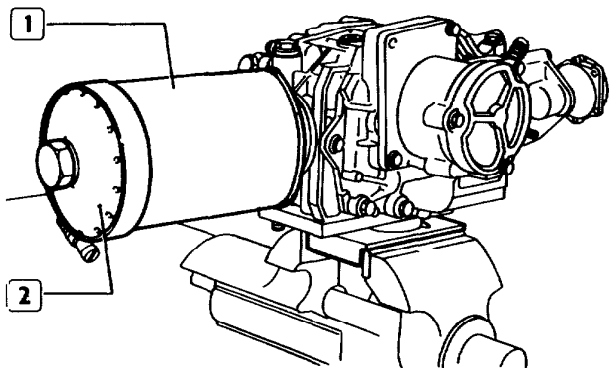
30776

Using Tool 99305049, check that settings for regulating valve spring correspond to those shown in the Figure



18908

Using a straight edge (2) and feeler gauge (1), check clearance between top of gears (3) and cover face, which should be 0.065–0.131 mm; if it is not, replace worn parts



30782

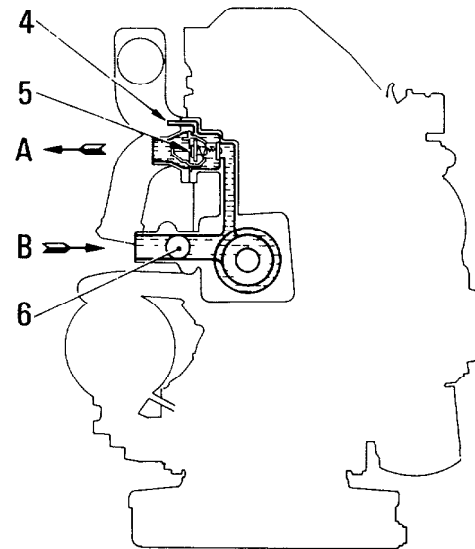
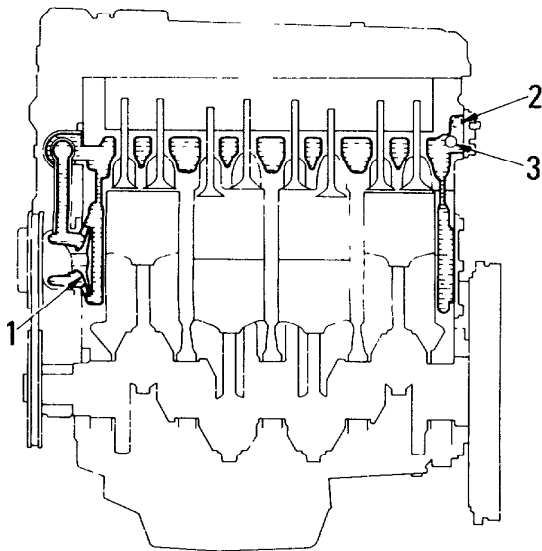
NOTE – When fitting oil filter (1), lubricate seal, screw in filter until it touches seal and tighten up with Tool 99360314 (2) for a further 3/4 of a turn

COOLING SYSTEM

A forced-circulation water cooling system is used and comprises

- centrifugal water pump, driven by V belt,
- thermostat which adjusts engine operating temperature;

- water cooling radiator positioned in front of engine,
- fan fitted on pulley of water pump

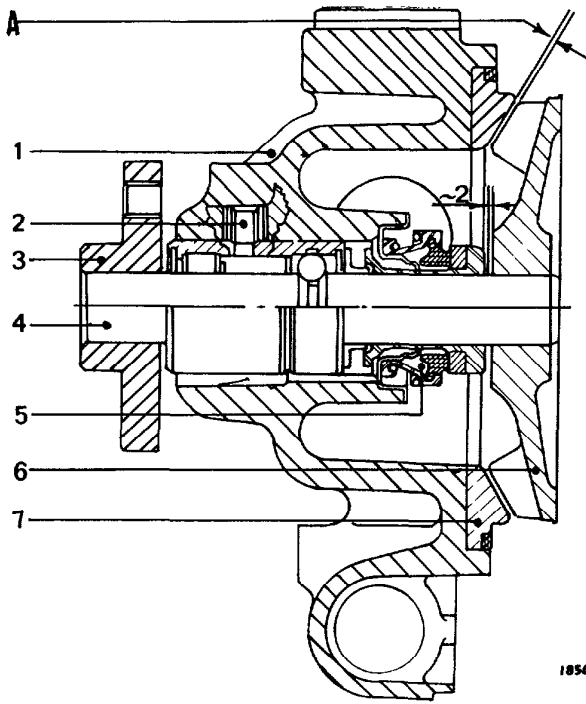


COOLING SYSTEM

6433

- 1 Water Pump – 2 Heater Water Outlet – 3 Temperature Sender Unit Outlet – 4 Steam Vent – 5 Thermostat – 6 Heater Water Return –
A Water Outlet – B Water Inlet

WATER PUMP

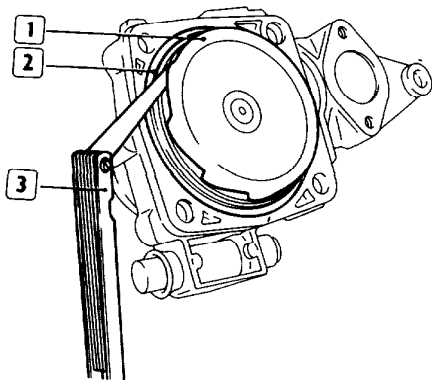


18561

LONGITUDINAL SECTION OF WATER PUMP

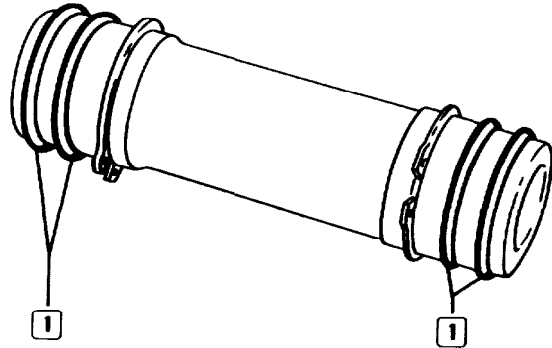
1 Pump Body – 2 Bearing Fixing Screw – 3 Flange – 4 Pump Drive Shaft complete with Bearing – 5 Seal – 6 Impeller – 7 Pump Body Seal

A = 0.56–1.08 mm Fitting clearance between impeller and pump body seal



18915

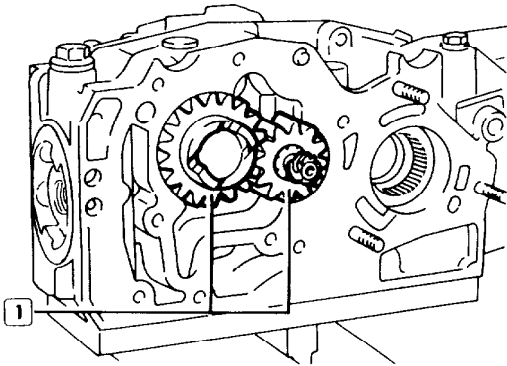
Using feeler gauge (3), check that distance between impeller (1) and seal (2) is 0.56–1.08 mm Also check pump body for cracks, if there are any, replace complete water pump



18917

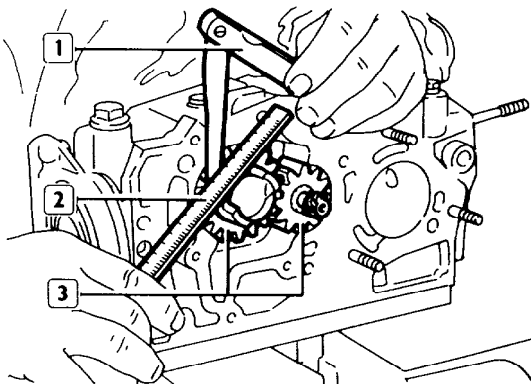
There are 4 sealing rings (1) on connecting pipe between thermostat and water pump body, replace them whenever pump is removed.

OIL PUMP



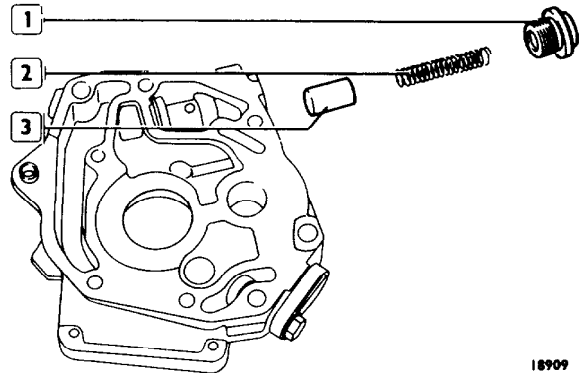
26249

Engine lubrication is by a gear pump (1)
 There is a regulating valve on the oil pump cover,
 lubrication pressure with oil at 100°C
 □ at idling speed 0.8 bar
 □ at rated speed 3.8 bar



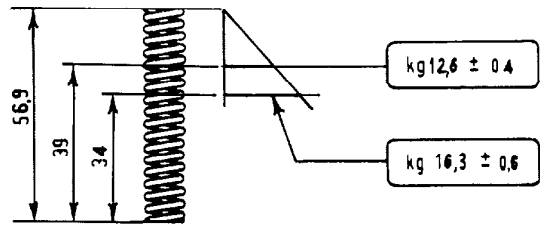
18908

Using straight edge (2) and feeler gauge (1), check clearance between top of gears (3) and cover face, which should be 0.065–0.131 mm, if it is not, replace worn parts



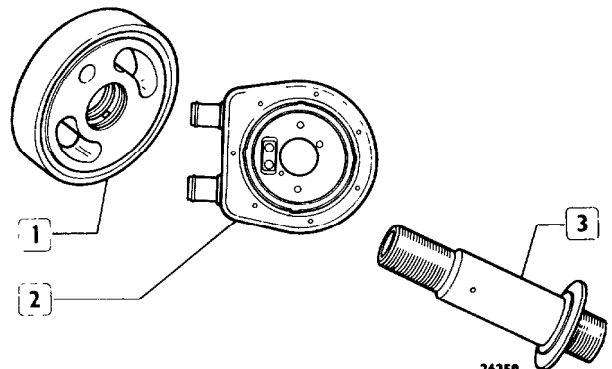
18909

Unscrew plug (1), pull out spring (2) and regulating valve (3)
 Check that valve (3) slides freely and has no score marks and that spring (2) is not broken



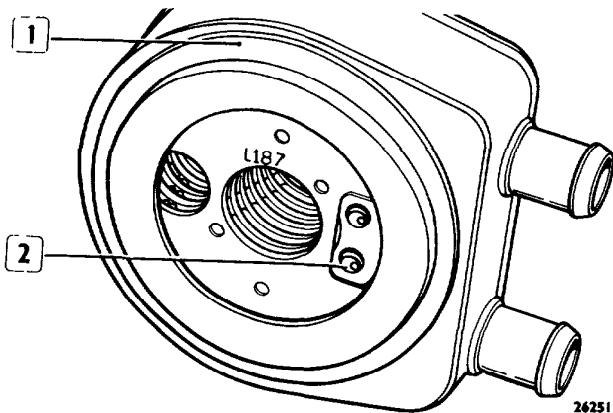
30776

Using Tool 99305049, check that settings for regulating valve spring correspond to those shown in the Figure



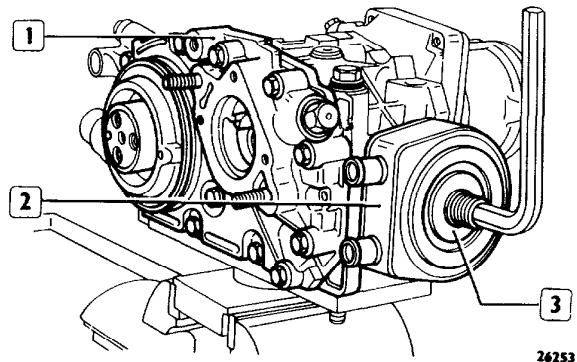
26250

Thoroughly clean support (1), heat exchanger (2) and connection (3), paying particular attention to oilways. Always replace sealing rings



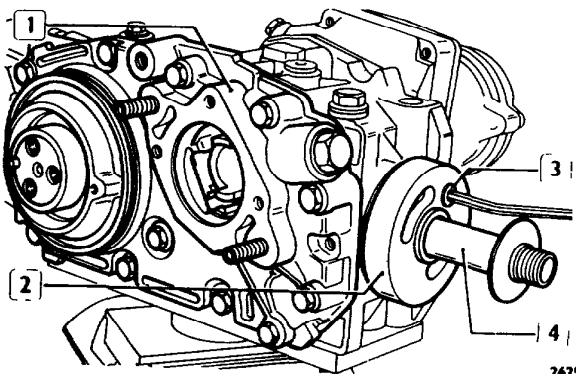
26251

Blow air at a pressure of 1 bar into heat exchanger (1), checking for leaks from both oil side and water side



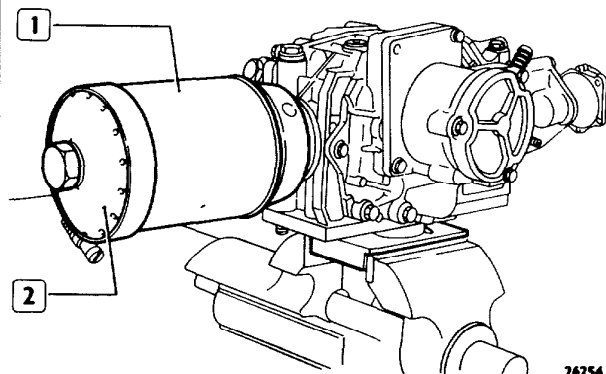
26253

Position heat exchanger (2) and fix to ancillaries mounting (1) with connection (3)



26252

Position support (2) on ancillaries mounting (1), temporarily screw up connection and tighten up support (2) with allen key (3) Remove connection (4)

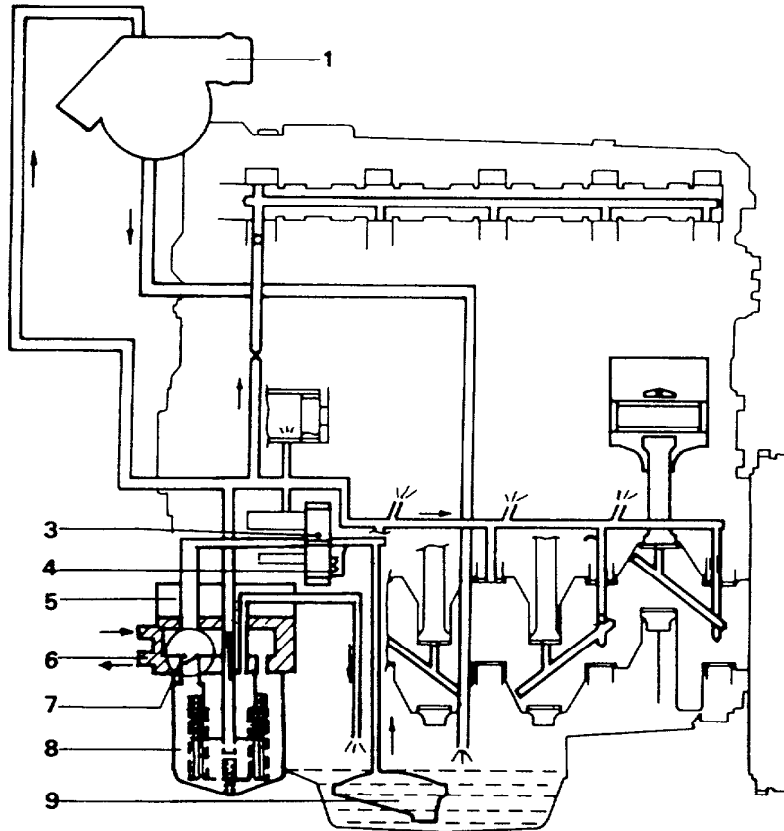


26254

Lubricate sealing rings with engine oil and place them on oil filter (1) Screw filter onto connection (4, Fig 135) and using Tool 99360314 (2) torque to 55 Nm (5.5 kgm)

LUBRICATION SYSTEM

FIGURE 158



ENGINE LUBRICATION DIAGRAM

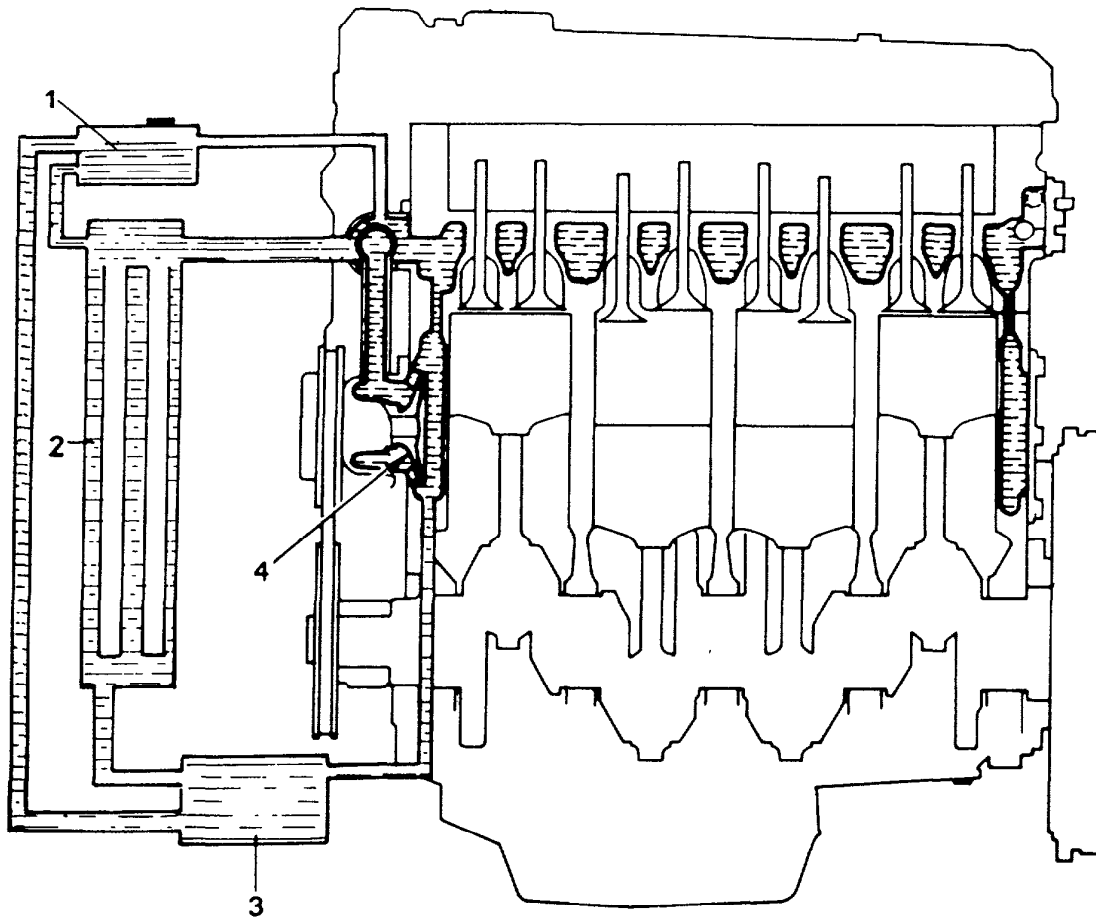
30851

- 1 Turbocharger – 3 Oil Pump – 4 Oil Pressure Regulating Valve – 5 Oil Filter Support – 6 Heat Exchanger – 7 Safety Valve –
8 Double-filtration Oil Filter with built-in Safety Valve – 9 Oil Pick Up Pipe

COOLING SYSTEM

A forced-circulation water cooling system is used and comprises a centrifugal pump, driven via a V belt by the crankshaft. Circulation of the coolant is regulated by a three-way thermostat.

FIGURE 168



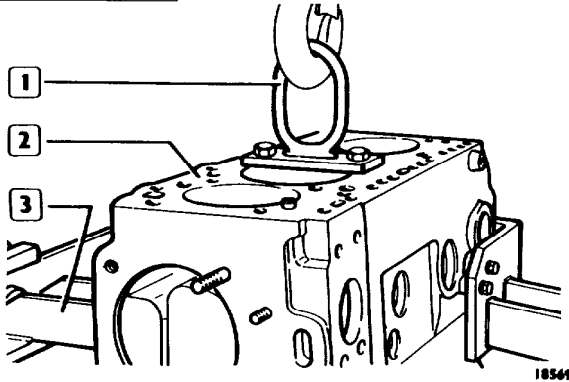
COOLING SYSTEM

1 Expansion Tank – 2 Radiator – 3 Heat Exchanger – 4 Water Pump

19534

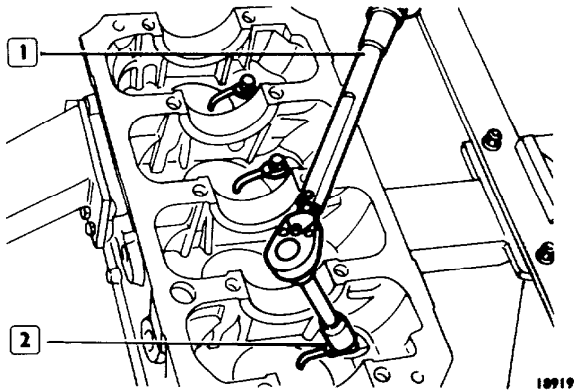
REASSEMBLING THE ENGINE

FIGURE 174



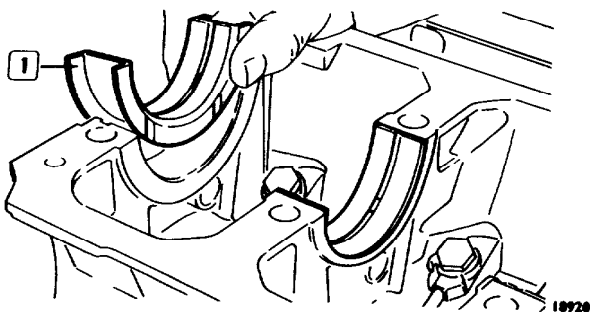
Using Hook 99360508 (1), lift engine block (2) and fix it on Rotary Stand 99322230 by means of Brackets 99361029 (3)

FIGURE 175



Rotate block, fit piston cooling nozzles (2) and tighten up bolts with a torque wrench (1) to 47 Nm (4.7 kgm)

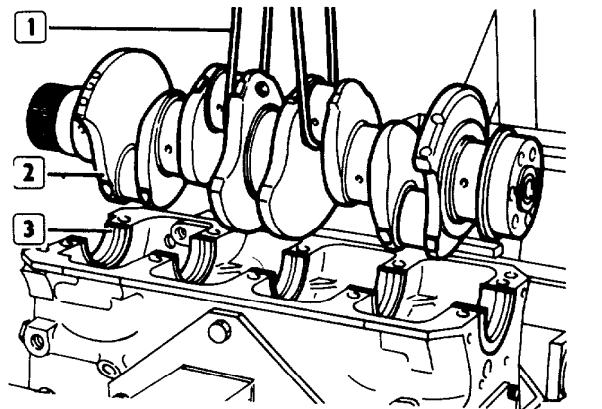
FIGURE 176



Place bearings (1) in their housings and lubricate them

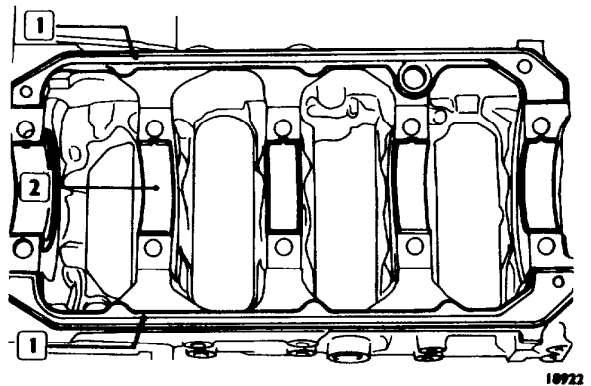
NOTE The main bearings, fitted in the top block housings, have an oilway, they must not, therefore, be fitted onto the bottom block housings

FIGURE 177



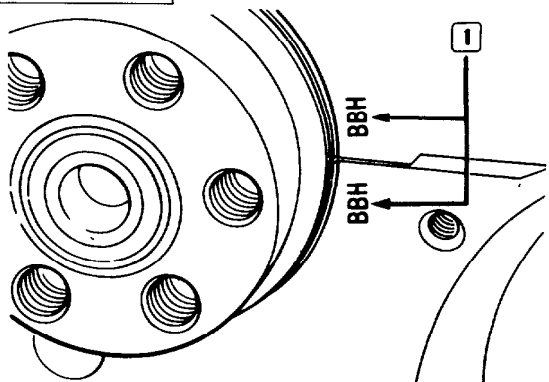
Fit crankshaft (2)

FIGURE 178



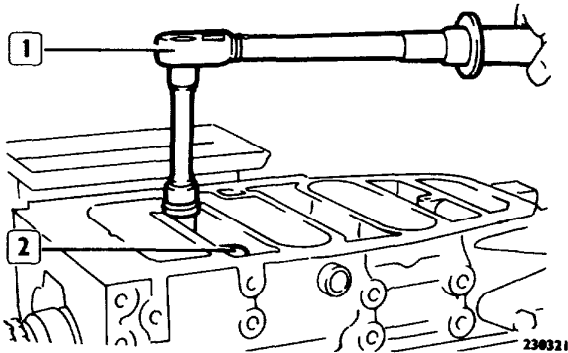
Fit rubber seals (1) and main bearings (2) onto bottom block

FIGURE 179



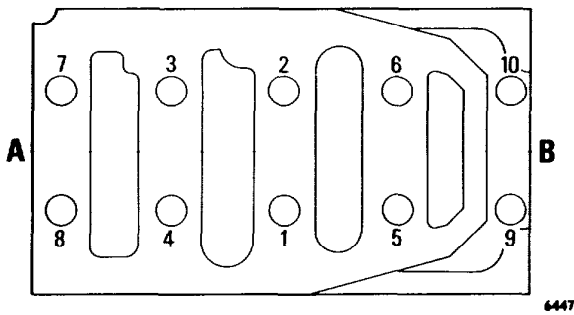
Fit bottom block onto top one checking that reference marks (1) match, since component parts of block are not interchangeable

FIGURE 180



Lubricate bolts (2) and tighten them up with torque wrench (1) in two successive stages to following torque settings 1st stage 80 Nm (8.2 kgm), 2nd stage 160 Nm (16.5 kgm), following the order shown in the following Figure

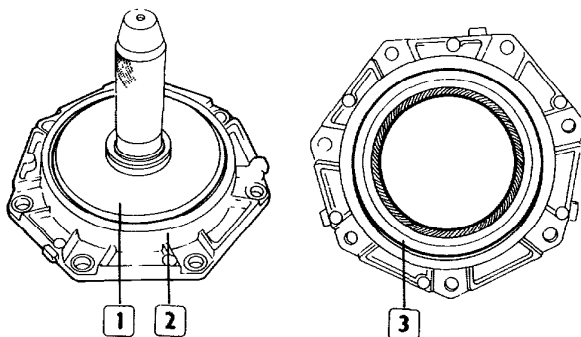
FIGURE 181



A Timing Side – B Flywheel Side

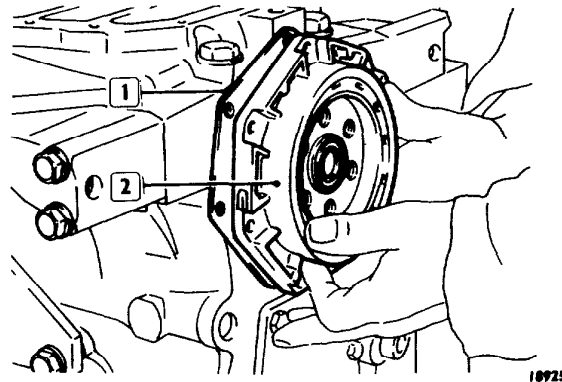
Diagram showing tightening sequence of bolts fixing bottom block to top block.

FIGURE 182



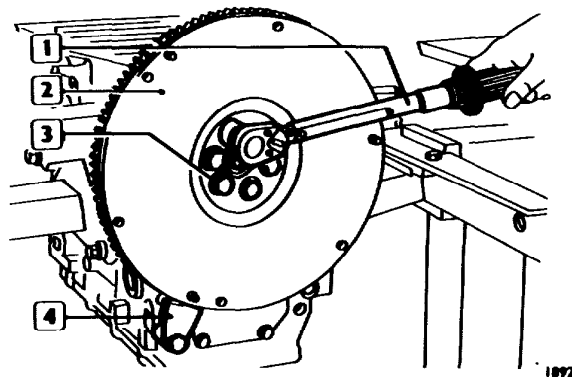
Fit sealing ring (3) onto rear cover (2) using installer 99374328 (1) complete with handle 99370006

FIGURE 183



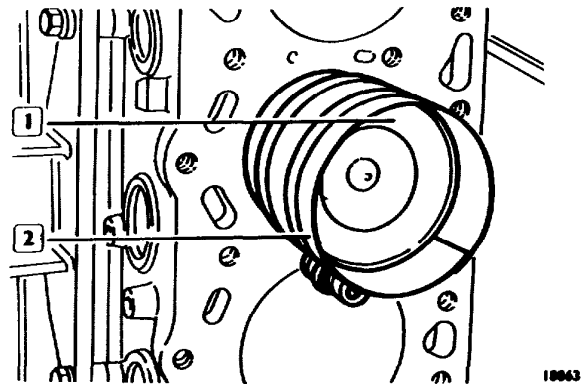
Position gasket (1), fit cover (2) and secure it to block with its bolts

FIGURE 184



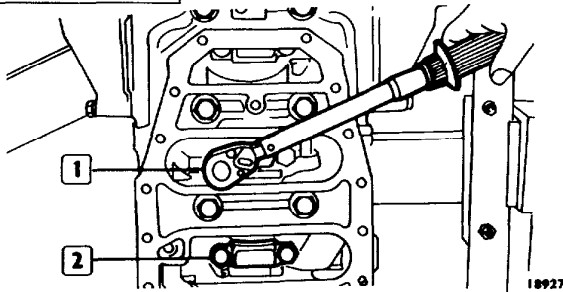
Fit flywheel (2), prevent it from turning by means of tool 99360306 (4) and tighten up bolts (3) using torque wrench (1) to 117 Nm (12 kgm) Remove tool 99360306 (4)

FIGURE 185



Place engine in vertical position and from top of block insert piston/connecting rod assemblies (1), using clamp 99360605 (2)

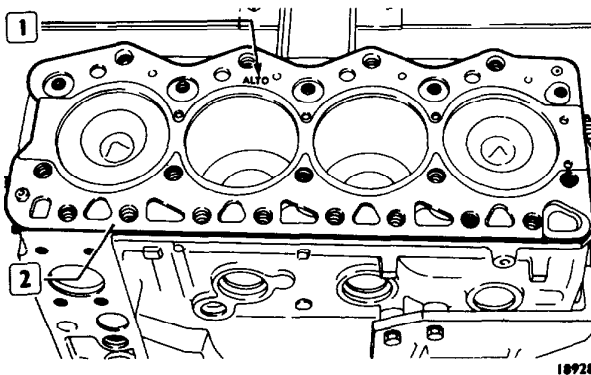
FIGURE 186



Fit connecting rod caps (2) with their bearings and tighten up bolts, previously lubricated with oil, using torque wrench (1), to 50 Nm (5 kgm) + Angle of $63^\circ \pm 3^\circ$

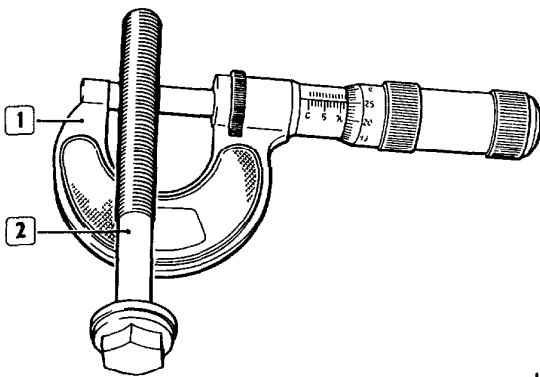
NOTE When fitting piston/connecting rod assembly in Cylinder No 4, position Piston No 4 to TDC so as to be able to fit its connecting rod cap.

FIGURE 187



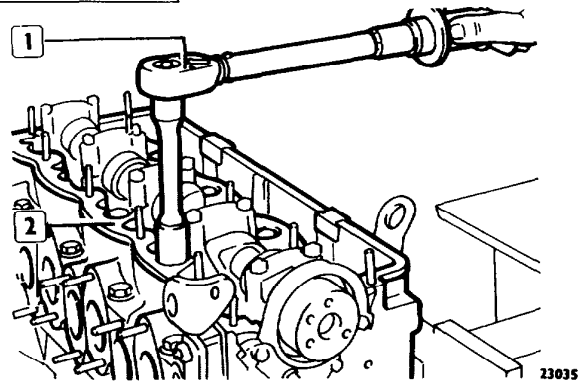
Rotate engine through 90° to a horizontal position, fit cylinder head gasket (2) with the word ALTO (TOP) (1) facing upwards

FIGURE 188



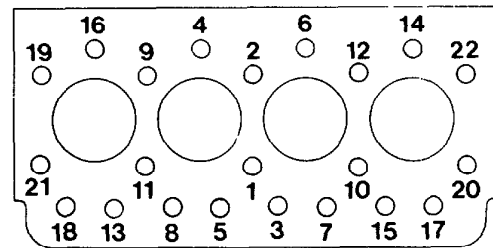
Before fitting the cylinder head bolts (2), measure them with a micrometer (1) to check that the bolt thread diameters are not less than 11.5 mm, at any point, if they are, they should be replaced.

FIGURE 189



Fit cylinder head (2), insert bolts, after lubricating with oil, tighten them with torque wrench (1) successive stages in the sequence described in the following Figures.

FIGURE 190

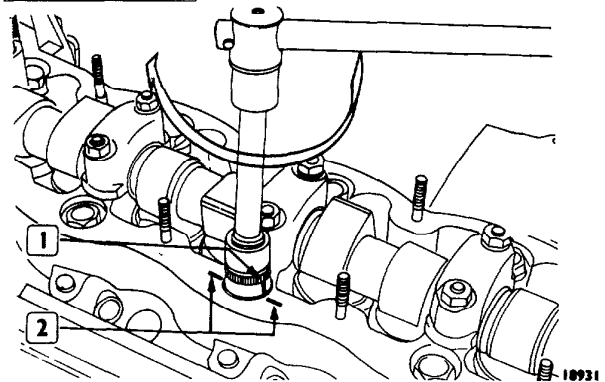


6448

Diagram showing Tightening sequence of Cylinder Head Bolts

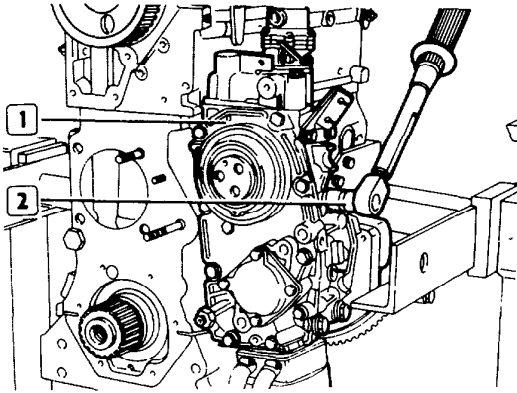
- 1st stage pre-tighten with torque wrench to 40 Nm (4 kgm).
- 2nd stage: final tighten through a further angle of 180° .

FIGURE 191



NOTE Before performing 2rd bolt-tightening stage, make two matching marks (2) on cylinder head and one on socket spanner (1) or on bolt head, then tighten bolts through a further 180° following the order shown in Figure 190

FIGURE 192

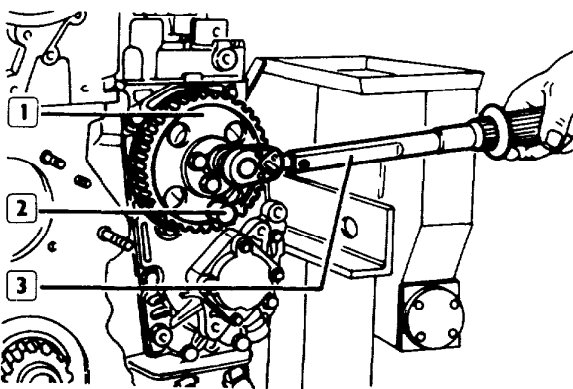


Fit ancillaries unit (1) and insert sealing rings, tighten bolts with torque wrench (2) to specified torque setting

NOTE Apply silicone to bolt threads top LH and bottom RH, ancillaries unit

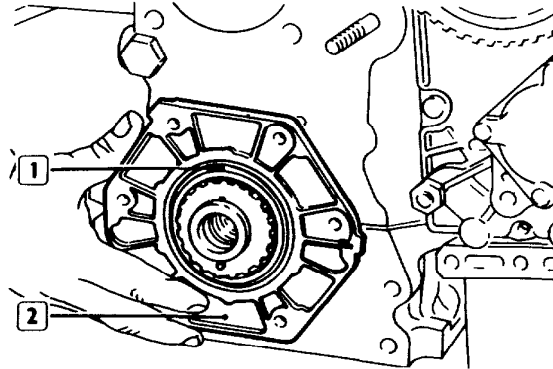
Fit dipstick pipe and oil filler pipe

FIGURE 193



Fit gear (1), secure to prevent rotation, and tighten bolts with torque wrench (3) to specified setting

FIGURE 194



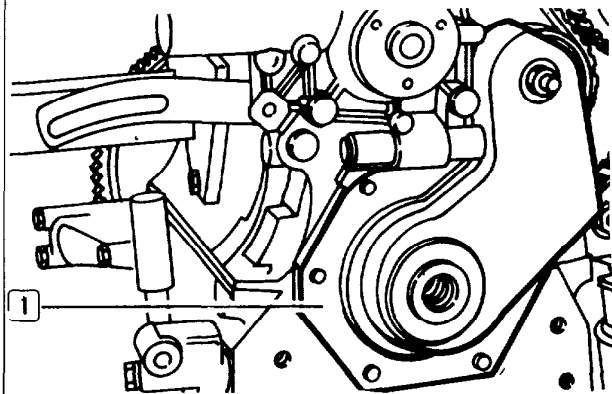
After fitting sealing ring (1) on front cover (2) insert gasket and fit cover onto block

Fit water pump, position connecting pipe with its sealing rings and fit thermostat

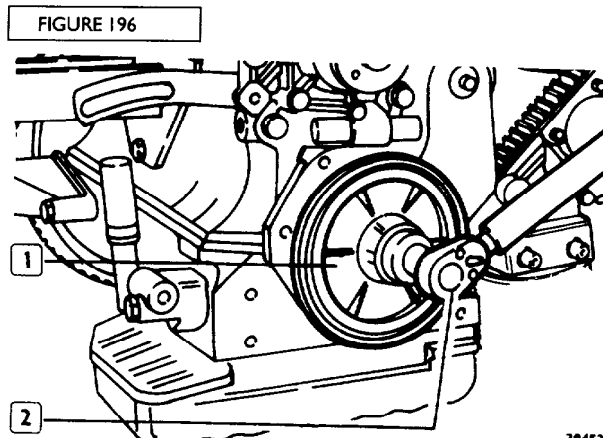
Fit adjustable belt-tensioner

Then fit camshaft drive toothed belt as described in the CAMSHAFT DRIVE Section on page 116

FIGURE 195



Fit toothed belt guard (1)



30453

Fit pulley (1); prevent flywheel from turning by means of Tool 99360306 and tighten bolt with torque wrench (2) to 201 Nm (20.3 kgm)

TIGHTENING TORQUES

PART		TORQUE Nm (kgm)
Cylinder head bolts	▲	40 (4)+180°
Bottom block to top block bolts	▲	160 (16.4)
Engine oil pipe plug		47 (4.7)
Sump to engine block bolts		13.5 (1.4)
Ancillaries support oil pipe plug		16.5 (1.7)
Ancillaries support	{ M12 M8	▲ 70 (7.0) 20 (2.0)
Ancillaries support front cover bolts		20 (2.0)
Ancillaries support bolts	▲	20 (2.0)
Ancillaries support front cover bolts		20 (2.0)
Ancillaries support rear cover bolts		20 (2.0)
Crankshaft oil seal rear cover bolts		20 (2.0)
Front cover of crankshaft bolts		8.2 (0.8)
Front cover of camshaft nuts		8.2 (0.8)
Cylinder block rear cover bolts		20 (2.0)
Cylinder head rear cover nuts		22.5 (2.3)
Engine lifting eye nuts		22.5 (2.3)
Induction manifold nuts		19 (2.0)
Exhaust manifold nuts	■	22.5 (2.3)
Connecting rod cap bolts	▲	50 (5.0)+63°±3°
Flywheel bolts	▲	117 (12.0)
Drive pulley to crankshaft bolts		20.1 (2.05)
Camshaft cap nuts		19 (2.0)
Camshaft drive gear bolt	▲	24.5 (2.5)
Toothed bush nut		59 (6.0)
Injection pump nuts		20 (2.0)
Injection pump drive gear bolt	▲	115 (11.5)

- ▲ Lubricate with UTDM Oil
- Lubricate with Graphite Oil
- Spread LOCTITE 222E on bolts

	TORQUE Nm (kgm)
Injector bracket bolt	39 (3.9)
Fuel pump support bolts	22.5 (2.3)
Fuel lift pump bolts	22.5 (2.3)
Fuel pump and fuel pump support bolts	22.5 (2.3)
Oil pick up pipe bolts	22.5 (2.3)
Oil pressure valve spring plug	75 (7.5)
Union for piston cooling nozzle	47 (4.7)
Water pump body bolts	46 (4.6)
Water pump body bolts	46 (4.6)
Cylinder head water outlet union bolt	22.5 (2.3)
Water pump manifold nuts	22.5 (2.3)
Water pump pulley bolts	22.5 (2.3)
Alternator support to bottom block bolts	55 (5.5)
Alternator bracket to water pump body nut	47 (4.7)
Alternator to support nut	85 (8.5)
Turbocharger to exhaust manifold nuts	22.5 (2.3)
Water outlet pipe bolts	20 (2.0)
Crankshaft front cover bolt	8.2 (0.8)
Plug on front cover of ancillaries unit	4.7 (4.7)
Tensioner bolt	4.3 (0.4)
Timing case to block nut (M8)	9.5 (0.9)
Timing case to block (M10)	20 (2.0)
Timing case to block nut (M12)	36 (3.6)

	TORQUE Nm (kgm)
Toothed bush nut	59 (6.0)
Injection pump nut	22.5 (2.3)
Injection pump drive bolt driven gear bolt ▲	94 (9.5)
Injector bracket bolts	34 (3.5)
Fuel pump support bolts	22.5 (2.3)
Fuel pump bolts	22.5 (2.3)
Fuel pump and fuel pump support bolts	22.5 (2.3)
Oil filter cartridge connection	75.5 (7.7)
Oil pick-up pipe bolts	22.5 (2.3)
Oil pressure valve spring plug	61 (6.3)
Union for piston cooling nozzle	32 (3.3)
Water pump body bolts	46 (4.6)
Water pump body nuts	46 (4.6)
Cylinder head water outlet union bolts	22.5 (2.3)
Water pump manifold nuts	22.5 (2.3)
Water pump pulley bolts	22.5 (2.3)
Alternator support to bottom block bolt	45.5 (4.6)
Alternator adjusting nut	45.5 (4.6)
Alternator to support nut	82.5 (8.5)
Front crossmember to engine block bolts	75 (7.6)
Engine insulator to front crossmember nut	19.8 (2.0)
Rear engine insulator to chassis bracket nut	47.1 (4.8)
Bolt for nut fixing rubber pad to chassis	19.8 (2.0)
Nut for bolt fixing side brackets for rear crossmember to chassis	47.1 (4.8)
Nut for bolt fixing rubber block to rear crossmember	24 (2.5)

▲ Lubricate with UTDM Oil

SPECIAL TOOLS

TOOL No.	DESCRIPTION
	ENGINE
99340035	Pulley boss and water pump impeller remover
99340205	Slide Hammer
99348004	Spigot bearing bush remover (use with 99340205)
99350114	Camshaft rotator wrench for adjusting engine valve clearance (bench operation)
99360183	Piston ring remover
99360288	Valve guide remover
99360309	Tappet retainer when replacing disc to adjust valve clearance
99360314	Cartridge filter remover
99360268	Valve remover/installer
99360363	Support for fixing injection pump drive and ancillaries while overhauling on the bench
99360423	Crankshaft front seal installer (use with 99370006)
99360486	Compression test adaptor (use with 99395682)
99360508	Cylinder block lifting eyes
99360549	Engine lifting bracket
99360605	Piston ring clamp
99360607	Parts for checking oil pump drive shaft fit
99361004	Bracket to support cylinder head while adjusting tappets
99361029	Brackets for fixing engine to Rotary Stand 99322230
99365160	Injector pipe wrench
99370006	Interchangeable drift handle
99374328	Crankshaft rear seal installer (use with 99370006)
99374336	Camshaft front oil seal installer (use with 99370006)
99387001	Pliers for retrieving valve clearance discs
99390310	Polisher for valve guides
99395611	Graduated quadrant for checking timing