marine engines

section 2

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 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

INDEX Page

8141 SM 12

INDEX Page

ENGINE SPECIFICATIONS

Engine type 8141 M08
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 ..... 22 · 1
Net power at flywheel (*) .
- Pleasure craft ..... 59 kW (80 CV)
At ..... 4200 rpm
- Light-duty commercial ..... 44kW (60 CV)
At ..... 3600 rpm
Engine rotation :
(see from flywheel) ..... CCW

(*) Net rating at flywheel according to ISO 3046-1
- Ambient reference conditions : 750 mmHg ; 25° C ;
30 % relative humidity.

TIMING

Valve Timing :
- Intake
opens : before T.D.C. ..... 8 °
closes : after B.D C. ..... 37 °
- Exhaust
opens : before B D.C. ..... 48°
closes : after T D.C. ..... 8 °
Clearance between cams and valve tappet for
timing checks ..... 0.5 ±0.05 mm
Operating clearance between cams and valve tappet,
cold engine :
- intake ..... 0.5 ±0.05 mm
- exhaust ..... 0.5 ±0.05 mm

FUEL SYSTEM

Rotary injection pump type "Bosch VE4"
Fixed injection pump delivery start advance ..... 0 ° ± 1°
Fuel injectors setting ..... 125 + 8 bar
Firing order ..... 1 - 3 - 4 - 2

LUBRICATION

Minimum oil pressure :
- at full throttle ..... 4 kg/cm^2
- when idling ..... 0.8 kg/cm^2

COOLING SYSTEM

Cooling by dual water circuit .
- Primary circuit (closed) by fresh water;
- Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.
Complete sea water circuit is protected from corrosion by replaceable sacrifical anodes.

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

MARINE GEAR

Available in different models for their overhauling see the specific manual of the manufacturer.

ENGINE SPECIFICATIONS

Engine type 8141 SM12
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 . 1
Net power at flywheel (*) :
- Pleasure craft ..... 88 kW (120 CV)
At ..... 3800 rpm
Engine rotation :
(see from flywheel) ..... CCW

(*) Net rating at flywheel according to ISO 3046-1
- Ambient reference conditions : 750 mmHg ; 25° C ;
30 % relative humidity.

TIMING

Valve Timing :
- Intake
opens : before T.D.C..... 8 °
closes · after B D C ..... 37 °
- Exhaust
opens : before B.D.C. ..... 48°
closes . after T.D.C. ..... 8 °
Clearance between cams and valve tappet for timing checks ..... 0.5 ±0.05 mm
Operating clearance between cams and valve tappet, cold engine :
- intake ..... 0.5 ±0.05 mm
- exhaust. ..... 0 5 ±0.05 mm

FUEL SYSTEM

Rotary injection pump type "Bosch VE4"
Fixed injection pump delivery start advance ..... 0 ° ± 1°
Fuel injectors setting..... 230 + 8 bar
Firing order..... 1 - 3 - 4 - 2

TURBOCHARGING

The engine is turbocharged by means of a turbocharger.

The turbocharger is provided with a Waste-gate valve in order to obtain a high torque value and better engine performance in all fields of use

The turbocharger is lubricated with the engine oil under pressure.

LUBRICATION

Minimum oil pressure .
- at full throttle ..... 4 kg/cm^2
- when idling ..... 0.8 kg/cm^2

COOLING SYSTEM

Cooling by dual water circuit :
- Primary circuit (closed) by fresh water;
- Secondary circuit (open) by sea water.

Water circulation is provided by a self priming pump featuring a neoprene impeller.

Complete sea water circuit is protected from corrosion by replaceable sacrifical anodes

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

MARINE GEAR

Available in different models for their overhauling see the specific manual of the manufacturer.

SEA WATER PUMP

GENERALITIES

The sea water circulation for cooling the fresh water and the marine gear oil is ensured by a self-priming pump type neoprene impeller

INSTRUCTIONS FOR USE

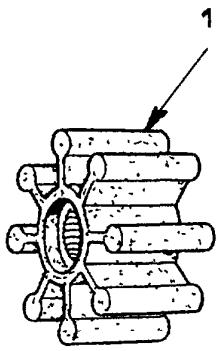
Each time the engine is started, check that the sea water intake valve is open.

Dry running of the pump would damage the impeller (- Fig. 1) in a very short time.

Under normal operating conditions of the engine check every 800 hours the state of the neoprene impeller after removing first the cover

Make sure that it is free from cracks or excessive wear of the lobes.

If not replace it.



FRESH WATER-SEA WATER HEAT EXCHANGER

GENERALITIES

When the fresh water circulating in the engine reaches temperature values in excess of.

- 74 ° C (8141 M 08) and
- 68 ° C (8141 SM 12)

is convoyed under thermostatic control to the fresh water-sea water heat exchanger,where it is cooled and returned to circulation

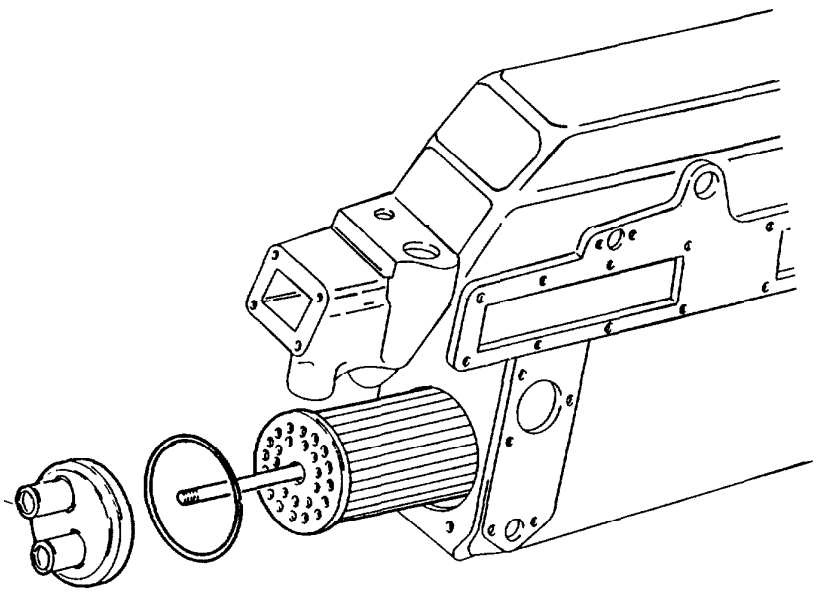
This heat exchanger consists essentially of a cast iron body with the fresh water circulation therein and a copper tube bundle containing the circulating sea water for cooling the fresh water.

MAINTENANCE

For ensuring the perfect efficiency of the fresh water-sea water heat exchanger it is necessary to clean periodically the tube bundle:

- Remove the tube bundle from the exchanger body and immerse it into a solution of water and anti-incrustator type "P3" or the like (*) which does not attack copper, brass, aluminium and tin.
- After the end of the reaction (indicated by effervescence) after about 15 to 20 minutes, rinse the tube bundle aboundingly with running water for completely eliminating any residue of the solution and re-assemble the bundle into the exchanger body.

(*) When using solvents observe the prescriptions of the makers.



DATA/FITTING CLEARANCES

CYLINDER BLOCK AND CONNECTING RODS

DESCRIPTION	mm
Cylinder sleeve bore diameter (fitted and machined)	93.000 to 93.018
Cylinder sleeve external diameter	96.020 to 96.050
Cylinder sleeve seat diameter on engine block	95.890 to 95.920
Interference fit between cylinder sleeves and seat diameter on engine block	0.100 to 0.160
Oversize on cylinder sleeve internal diameter	0.2 - 0.4 - 0.6
Oversize on cylinder sleeve external diameter	0.2
Diameter of crankshaft bearing seats	80.587 to 80.607
Width of rear main bearing between seat of shoulder half-bearing	27.500 to 27.550
Big end bore diameter	60.333 to 60.345
Small end bush bore diameter	34.865 to 34.890
Thickness of standard connecting rod half-bearing ☐ connecting rod side ☐ cap side	 1.889 to 1.889 1.861 to 1.871
Undersize of connecting rod spare half-bearings	0.254 - 0.508
External diameter of small end bush	34.970 to 35.010
Internal diameter of small end bush (with bush fitted)	32.011 to 32.018
Small end bush interference fit	0 080 to 0.145
Piston pin play in small end bush	0.015 to 0 028
Crankpin play in big end bearings	0.028 to 0.075
Tolerance on alignment between the two connecting rod axes measured 125 mm from vertical axis of the connecting rod	0.07

PISTONS - PINS - RINGS

DESCRIPTION	mm
Diameter of standard spare pistons (Mondial Piston type), measured perpendicular to the pin axis and 47 mm from base of skirt	92.875 to 92.861
Clearance between piston and cylinder sleeve for Mondial type piston (measured on normal pin axis 47 mm from base of skirt)	0.125 to 0.157
Diameter of Borg type piston, standard spare, measured perpendicular to pin axis and 47 mm from base of skirt	92.861 to 92.893
Clearance between piston and cylinder sleeve, Borg piston (measured on normal pin axis 47 mm from base of skirt)	0.107 to 0.157
Diameter of K S pistons, standard spares, measured perpendicular to pin axis and 48 mm from base of skirt	92.863 to 92.877
Clearance between piston and cylinder sleeve for K S piston (measured on normal pin axis, 48 mm from base of skirt)	0.123 to 0.155
Oversize on spare pistons	0.20 - 0.40 - 0.60
Height of grooves for piston rings: ☐ 1st groove ☐ 2nd groove ☐ 3rd groove	 3 080 to 3.100 2.050 to 2.070 3.025 to 3.045
Thickness of piston rings for pistons ☐ 1st chromium-plated compression ring ☐ 2nd oil scraper ring ☐ 3rd oil scraper ring, milled with slits and internal spring	 2.978 to 2.990 1.978 to 1.990 2.975 to 2 990
Fitting tolerance between rings and grooves on piston· ☐ 1st chromium plated compression ring ☐ 2nd oil scraper ring ☐ 3rd oil scraper ring, milled with slits and internal spring	 0,090 to 0,122 0,060 to 0,092 0,035 to 0,070
Gap between ends of rings fitted in cylinder sleeves, fit tolerance· ☐ 1st chromium-plated compression ring ☐ 2nd oil scraper ring ☐ 3rd oil scraper ring, milled with internal spring	 0,30 to 0 55 0.30 to 0.55 0 30 to 0.60

Oversize on spare piston rings	0 20 - 0 40 - 0.60
Piston pin hole diameter	31 998 to 32 003
Standard piston pin diameter	31 990 to 31 996
Tolerance between pin and boss	0.002 to 0.013

CRANKSHAFT AND BEARINGS

DESCRIPTION	mm
Main journal standard diameter	76,187 to 76,200
Main bearing housing diameter	80,587 to 80,607
Thickness of main half bearings	2,163 to 2,172
Fit tolerance for main journal half bearings	0,043 to 0,094
Undersize for spare main journal half bearings	0,254 - 0,508
External width of crank shaft shoulder bearing	31.780 to 31.995
Length of rear main journal between the two thrust shoulders	32.000 to 32.100
Crankshaft axial play	0,045 to 0.320
Standard diameter of crankpins	56.520 to 56.535
Play between connecting rod half-bearings and crankshaft pins	0.028 to 0.075
Maximum permitted tolerance on alignment of main journals (total comparator reading)	0.05

CYLINDER HEAD

DESCRIPTION		mm
Diameter of valve guide seats on cylinder head		12.965 to 12 980
External diameter of valve guide		13 012 to 13 025
Fit between valve guide and seat on cylinder head		0 032 to 0 060
Oversize on spare valve guide		0 05 - 0 10 - 0 25
Internal diameter of valve guide (after fitting on cylinder head)		8 023 to 8.038
Diameter of valve stem		7.985 to 8 000
Play between valve stem and its guide		0.023 to 0.053
Valve head diameter	intake exhaust	40 750 to 41 000 34 300 to 34 500
Angle of inclination of seats on valves	intake exhaust	60° 15′ ± 7′ 45° 30′ ± 7′
Angle of inclination of valve seats on cylinder head	intake exhaust	60° 45°
External diameter of valve seat	intake exhaust	42,295 to 42.310 35.095 to 35.110
Internal diameter of valve seat housing on cylinder head	intake exhaust	42.130 to 42.175 34 989 to 35.014
Interference fit between valve seat and housing on cylinder head	intake exhaust	0.120 to 0 180 0 081 to 0 121
Maximum valve stem out of centre for one complete revolution with gauge resting on centre of contact surface		0 03
Valve cavity depth in relation to cylinder head flat surface	intake exhaust	1 to 1 5 1 to 1 3
Precombustion chambers plug seats, internal diameter		30 320 to 30 370
Precombustion chambers plug seats, external diameter		30.380 to 30 400
Fit between precombustion chamber plugs and housings on cylinder head (interference)		0.010 to 0.080
Thickness of precombustion chamber plugs base ☐ Class A ☐ Class B ☐ Class C		 4.500 to 4.520 4 520 to 4 540 4.540 to 4 560
Height of housings for precombustion chamber plugs base ☐ Class A ☐ Class B ☐ Class C		 4 480 to 4 500 4 500 to 4.520 4 520 to 4 540
Projection of precombustion chamber plugs above cylinder head surface		o to 0 04

VALVE SPRINGS

DESCRIPTION		mm
Free spring height	External	~ 52
	Internal	~ 45 5
External spring height under a load of	kg 43 8 ± 2 5	38 5
	77 4 ± 4 kg	28 5
Internal spring height under a load of	16 4 ± 1 kg	33.5
	30 ± 1 5 kg	23.5

OIL PUMP

DESCRIPTION	mm
Play between gear top surface and rear cover bearing surface	0.065 to 0.131
Lubrication pressure with oil at temperature of 100° C — at idling speed	0.8 bar
Lubrication pressure with oil at temperature of 100° C — at maximum speed	4 bar
Regulating valve spring	
☐ free spring height	56.9
☐ spring height under load of 10 5 ± 0 4 kg	39
☐ spring height under load of 14 6 ± 0 6 kg	32
Spring for relief valve for oil circulation in heat exchanger	
☐ start opening	1.2 ± 0.1 bar
☐ end opening	1,7 bar
☐ free spring height	52.5
☐ spring height under a load of 0 86 ± 0 04 kg	38
☐ spring height under a load of 2 ± 0 1 kg	19

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	
☐ Diameter of housing for big end bearing — On vertical axis	60 340–60 360
☐ Diameter of housing for big end bearing — 15° from horizontal axis	60 330–60 350
Small end bush bore diameter	34 865–34 890
Thickness of standard big end half-bearing	
☐ Connecting Rod Side	1 889–1 899
☐ 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 (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)	
☐ 1st Trapezoidal Groove (measured on 90 mm diameter)	2 685–2 715
☐ 2nd Groove	2 050–2 070
☐ 3rd Groove	3.025–3 045
Height of grooves for piston rings (KS)	
☐ 1st Trapezoidal Groove (measured on 90 mm diameter)	2 685–2 715
☐ 2nd Groove	2 060–2 080
☐ 3rd Groove	3 045–3 060

DESCRIPTION	mm
Thickness of Piston Rings	
☐ 1st Trapezoidal Sealing Ring (measured on 90 mm diameter)	2 575–2 595
☐ 2nd Oil Scraper Ring	1 978–1 990
☐ 3rd Oil Scraper Ring milled with slots and internal spring	2 975–2 990
Fit between rings and grooves on piston (Borg)	
☐ 1st Trapezoidal Sealing Ring	0 090–0 140
☐ 2nd Oil Scraper Ring	0 060–0 092
☐ 3rd Oil Scraper Ring milled with slots and internal spring	0 035–0 070
Fit between rings and grooves on piston (KS)	
☐ 1st Trapedzoidal Sealing Ring	0 090–0 140
☐ 2nd Oil Scraper Ring	0 070–0 102
☐ 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	
☐ 1st Trapezoidal Sealing Ring	0 025–0 50
☐ 2nd Oil Scraper Ring	0 60–0 85
☐ 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	
☐ Borg	32 000–32 005
☐ KS	32 007–32 012
Diameter of standard piston pin	31 990–31 996
Fit between pin and piston bosses, fitting clearance	
☐ Borg	0 004–0 015
☐ 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	40 750–41 000
	Exhaust	34 300–34 500
Valve seat angle on valves	Inlet	60°15′±7′
	Exhaust	45°30′±7′
Valve seat angle in cylinder head	Inlet	60°
	Exhaust	45°
External diameter of valve seat housings	Inlet	42 295–42 310
	Exhaust	35 095–35 110
Internal diameter of valve seat housings in cylinder head	Inlet	42 130–42 175
	Exhaust	34 989–35 014
Fit between valve seats and housings in cylinder head (interference)	Inlet	0 120–0 180
	Exhaust	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 injecter 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	39
	104±5.2kg	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	9 5
	Exhaust	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	at idling speed	0 8 bar
	at rated speed	3 8 bar
Spring for Regulating Valve		
☐ Height of Free Spring		56.9
☐ Height under a Load of	12 6±0 4 kg	39
	16 3±0.6 kg	34
☐ Opening Pressure		7 bar
Safety Valve		incorporated in heat exchanger
☐ Opening Pressure		0 82–1 03 bar

FAULT-FINDING DIAGNOSIS

FAULT	POSSIBLE CAUSE	REMEDY
Engine does not start		
	Incorrect timing of injection pump	Check and adjust injection pump timing.
	Dirt or water in fuel pipes.	Remove pipes and clean out with jet of compressed air Strip out and clean injection pump. Wash out fuel tank and refill
	Insufficient fuel left in tank	Top up fuel
	No fuel supply.	Overhaul or replace fuel pump or transfer pump
	Air in fuel pipes or injection pump	Check pipes to ascertain cause of presence of a leak Also check fuel pump, bleed off air from inside injection pump by loosening bleed plug and work fuel pump by hand
	Faulty starter motor	Repair or replace starter motor
Engine cuts out	Idling speed too low	Adjust idling using adjustment screw
	Incorrect injection pump out-puts.	Adjust pump outputs
	Dirt or water in fuel pipes	Remove pipes and clean out with jet of compressed air Strip out and clean injection pump Wash out tank and refill it
	Fuel filter blocked	Strip out filter and if necessary change
	Incorrect gap between camshaft lobes and tappets	Adjust gap by changing adjusting washers
	Valves burnt, rusty or cracked	Change valves
	Air present in fuel and injection systems	Check if pipes are cracked or flawed or if pipe connections are loose Change worn parts, then bleed air from pipes and from injection pump and fuel filter by unscrewing the air bleed plugs provided and working the fuel pump by hand
	Broken injection pump drive components	Change faulty parts and check pump timing.
Engine overheating	Faulty water pump	Overhaul pump assembly and change seal
	Damaged thermostat	Change thermostat

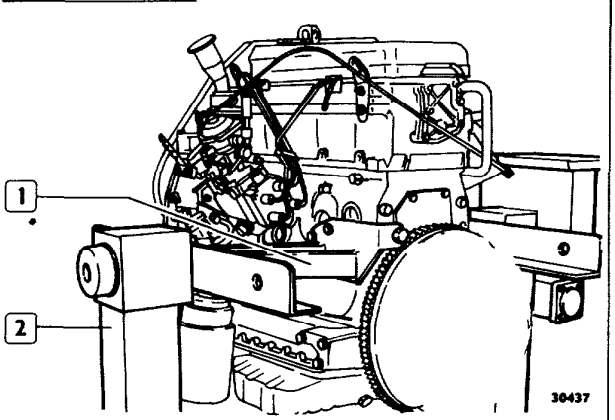
FAULT	POSSIBLE CAUSE	REMEDY
Engine overheating	Scale in water flow recesses in cylinder head and cylinder block	Wash out thoroughly according to usual descaling methods
	Pump drive belt too slack	Check and adjust belt tension
	Incorrect engine timing	Check timing and adjust accurately
	Injection pump delivering either too much or too little	Check pump output on test bench and correct to specified delivery
	Air filter blocked	Clean air filter and change if necessary
Engine lacking power and running irregularly	Incorrect timing of injection pump	Check timing and set pump accurately
	Faulty automatic advance unit	Check injection pump efficiency on bench if readings do not correspond to the specified figures, replace the automatic advance unit's internal spring
	Excessive plunger wear	Overhaul the injection pump and replace any parts found to be worn
	Incorrect setting of speed governor	Check governor and set it accurately
	Partial blocking of nozzles or injectors not working properly	Clean the atomizer holes using the appropriate equipment Carry out complete overhaul of injectors
	Impurities or water in fuel injection system	Thoroughly clean out fuel system and fill up with new fuel
	Inaccurate play between cam lobes and tappets	Check play and adjust as necessary
	Loss of compression	Using check that the pressure at T D C in all cylinders is the same, and check the pressure itself (16 kg/cm^2), if below that figure, an engine overhaul will be necessary
	Faulty turbocharger **(Engine 8141 S M12/)**	Replace the complete assembly
	Air filter blocked	Clean the air filter
	L D A unit faulty **(Engine 8141 S M12)**	Check that diaphragm is not perforated, that resistance spring is the correct one and that it is correctly loaded (check on test bench) Check that there is adequate air pressure inside the intake manifold relative to engine speed at full load
	Incorrect setting of maximum shut-off screw	Set shut-off screw correctly

FAULT	POSSIBLE CAUSE	REMEDY
Engine knocking	Injectors malfunctioning	Check that the needle is not jammed in the atomiser body and that injectors are set to the specified setting
	Fuel pipes blocked	Strip out fuel pipes, clean them, and replace any which are buckled
	Incorrect injection pump setting	Correct pump setting so that injection takes place at the specified advance angle
	Crankshaft knocking caused by excessive play on one or more main journals or crankshaft pins or too high crankshaft end float	Grind crankshaft pins and fit undersized bearings. Replace thrust bearing shells.
	Crankshaft unbalanced	Check crankshaft alignment.
	Flywheel fixing screws loose	Replace loose screws and tighten all screws to the specified torque
	Misalignment of connecting rods	Straighten the connecting rods under an hydraulic press and check that axes are parallel
	Piston knocking - piston slap	Ream out cylinder liners and fit oversize pistons
	Gudgeon pin noise due to excessive play in piston hubs and connecting rod bush Bushes loose in seat on connecting rod	Replace gudgeon pin with a new oversize pin and grind piston hubs and connecting rod bushes Replace bushes
	Ticking noise due to noisy timing gear	Adjust play between cam lobes and tappets and check that no springs are broken and there is no excessive play between the stems and guides or tappets and their seats
Abnormal smoke from engine: black or dark grey	Maximum pump delivery excessive	Remove the pump and check delivery with reference to data in setting table
	Injection pump excessively retarded (or the automatic advance unit is faulty)	Correct the setting, check the automatic advance unit
	Injection pump excessively advanced	Correct pump setting
	Atomiser holes (or some of them) partially or completely blocked	Replace the injectors with a set of new injectors or clean and recondition the original ones using suitable equipment
	Air filter blocked or damaged	Clean or replace filter element.
	Engine compression losses, due to.	Overhaul the engine or repair affected parts
	☐ piston rings jammed,	
	☐ wear on cylinder liners,	
	☐ valves deteriorated or incorrectly set.	

FAULT	POSSIBLE CAUSE	REMEDY
Black or dark grey fumes	Unsuitable type of injector, or various injectors mixed or not set correctly	Replace or reset the injectors
	Injection tubes of unsuitable internal diameter, tube ends distorted due to repeated blockages	Check state of tube joints, if necessary, replace the tubes
Blue, greyish-blue, or greyish white smoke	Excessive injection retard or automatic advance unit faulty	Correct pump setting and check automatic advance unit
	Injector needles jammed or injectors faulty	Check whether needle is jamming or spring broken
	Oil exuding from piston rings due to jammed rings or wear on cylinder liner walls	Overhaul the engine
	Engine oil flowing through intake valve guide, due to wear on the guides or on the valve stems	Recondition the cylinder head
	Engine too cold (thermostat seized or resistant)	Replace the thermostat
Engine will not stop	Governor broken	Unscrew fuel delivery pipe and repair as necessary
	Governor parts stiff	Overhaul or replace
	Excessive play between different parts of the governor	Eliminate all play, allowing only minimum tolerances replacing any parts which are worn

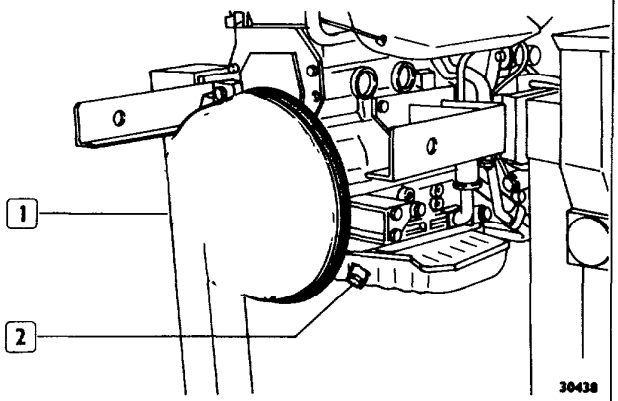
DISMANTLING THE ENGINE

FIGURE 31



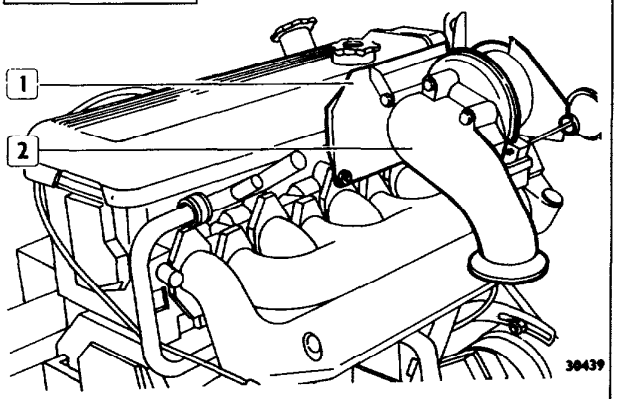
Remove oil breather, fit Brackets 99361029 (1) to engine and fix the latter to engine Stand 99322230 (2).

FIGURE 32



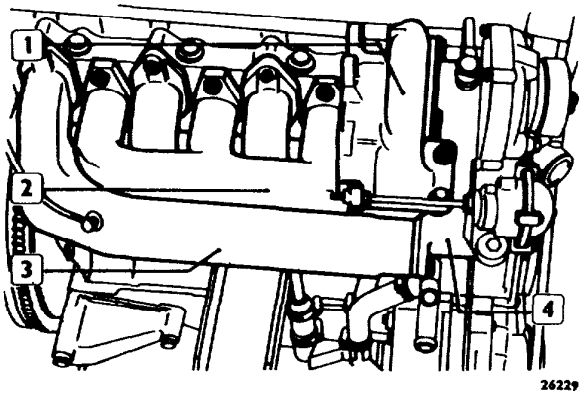
Unscrew plug (2) and drain oil from sump Disconnect clutch (1)

FIGURE 33



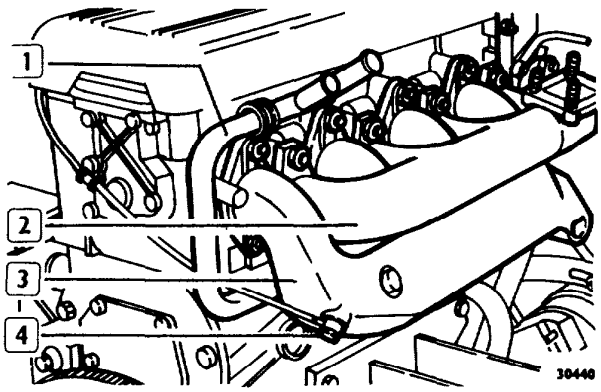
Disconnect exhaust pipe (2) from turbocharger (3) and remove heat shield (1)

FIGURE 34



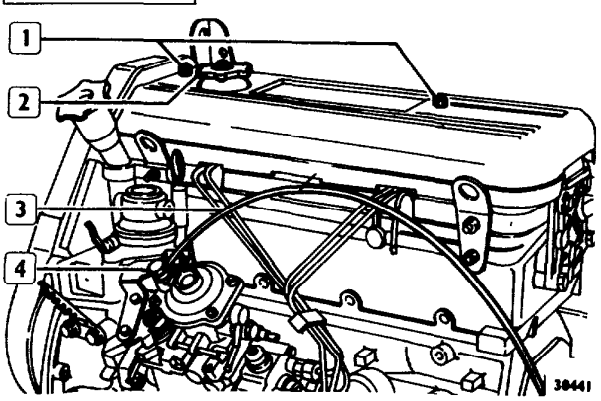
Disconnect air trunking (4) from inlet manifold (3) Disconnect turbocharger (1), together with oil inlet and outlet pipes, from exhaust manifold (2).

FIGURE 35



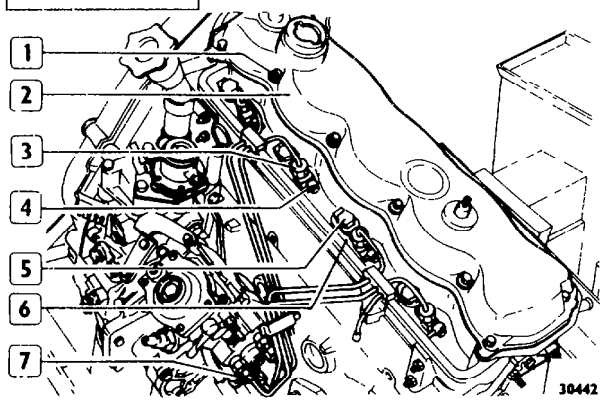
Remove connection (4) fixing LDA control air pipe from inlet manifold. Disconnect water pipe (1) and inlet (3) and exhaust (2) manifolds.

FIGURE 36



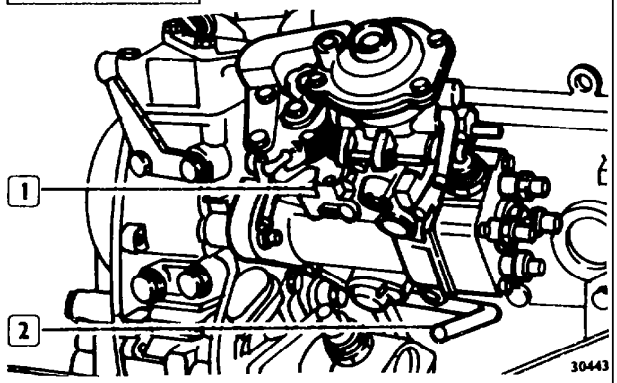
Unscrew connection (4) and disconnect LDA control air pipe (3) Remove cap (2), unscrew nuts (1) and lift off soundproof cover.

FIGURE 37



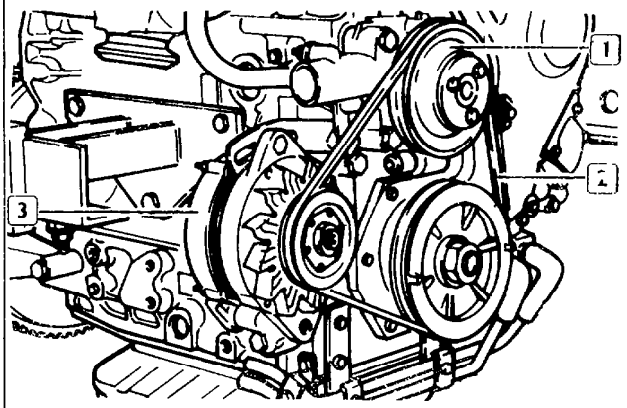
Undo connections (3, 4 and 7) and remove fuel delivery and return pipes Unscrew bolts (5), remove brackets (6) and remove injectors Unscrew nuts (1) and remove valve cover (2)

FIGURE 38



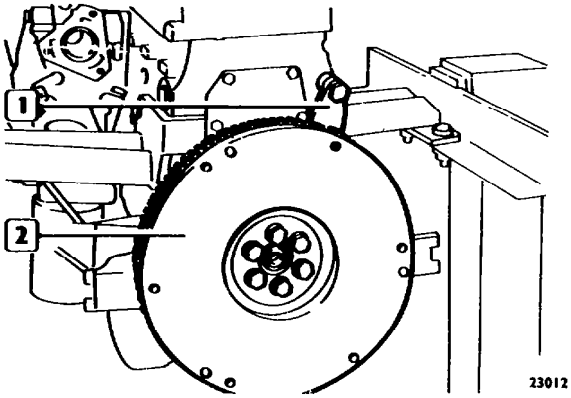
Remove injection pump (1) using Tool 99352114 (2) to undo bottom internal nut.

FIGURE 40



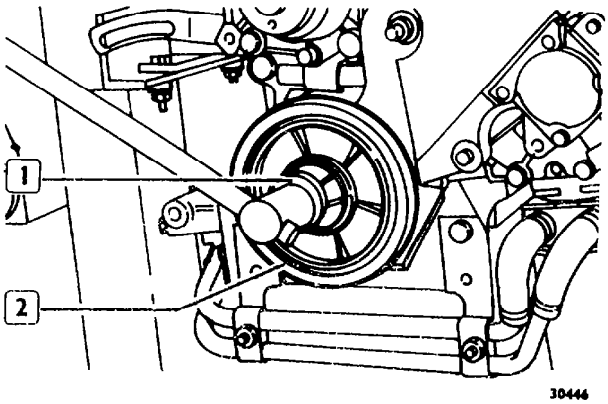
Disconnect alternator (3), remove drive belt (2) and water pump drive pulley (1)

FIGURE 41



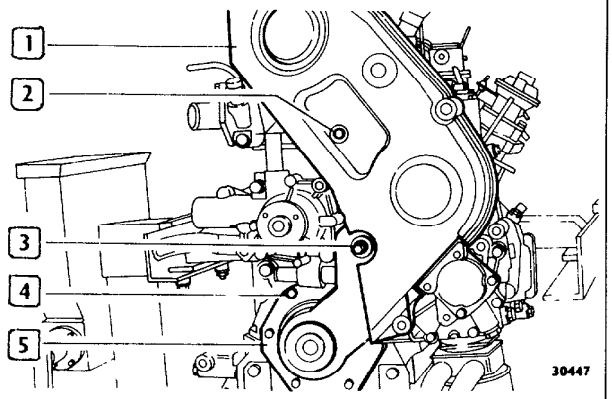
Prevent engine flywheel (2) from rotating by inserting Tool 99360306 (1) into hole for flywheel housing fixing bolt

FIGURE 42



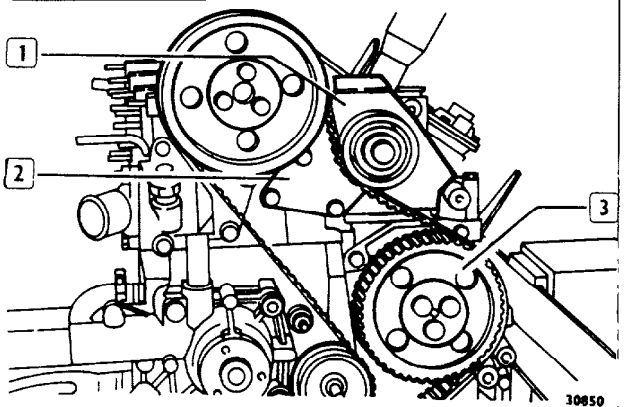
Using wrench (1), unscrew retaining bolt of crankshaft pulley (2) and remove the latter

FIGURE 43



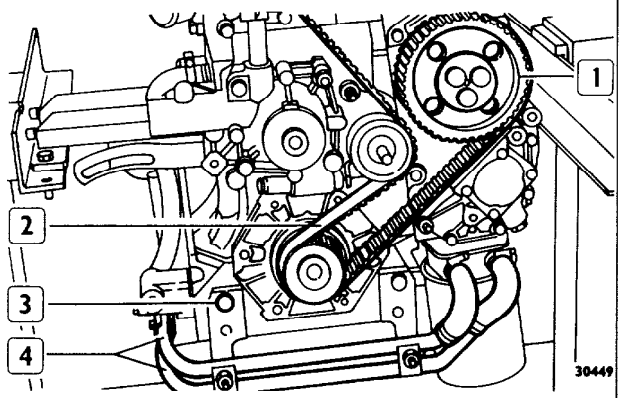
Unscrew bolts (2) and remove belt cover (1) Unscrew nut (3) and bolts (4) and remove guard (5)

FIGURE 44



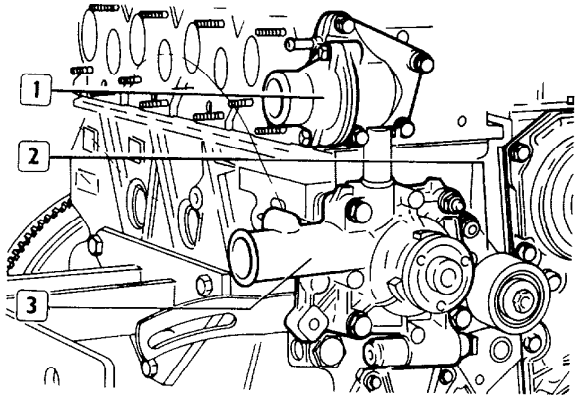
Unscrew retaining bolts of ancillaries drive gear (3) Remove support (2) complete with fixed belt tensioner roller and guard (1)

FIGURE 45



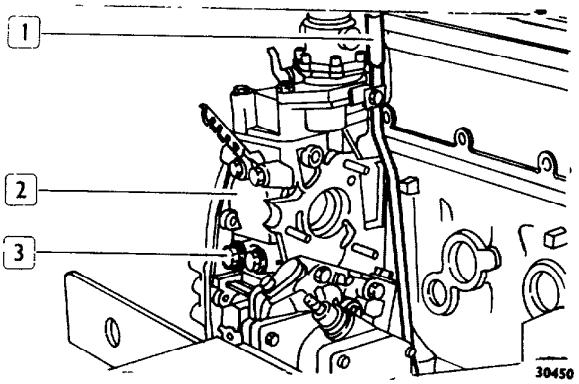
Remove toothed belt (2) and ancillaries drive gear (1) Unscrew fixing bolts (3), disconnect and remove water pipes (4) of heat exchanger

FIGURE 46



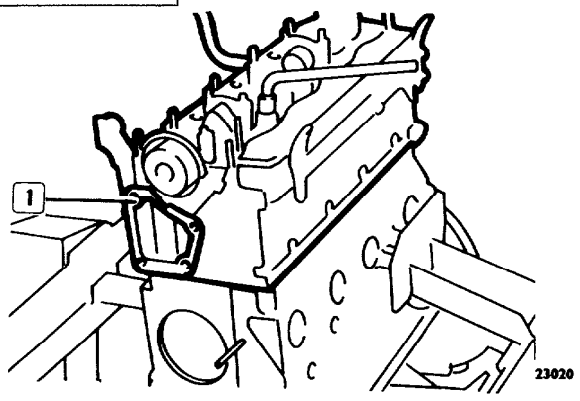
Remove adjustable belt tensioner (2), after removing lock nut Take off thermostat (1) and water pump (3)

FIGURE 47



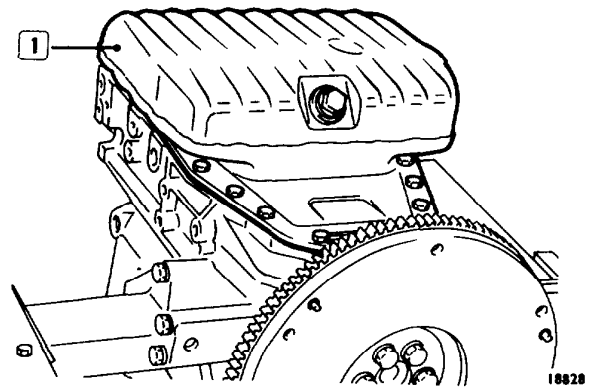
Remove relative fixing brackets and take off oil filler pipe and dipstick pipe (1). Undo bolts (3) and remove ancillaries unit (2)

FIGURE 48



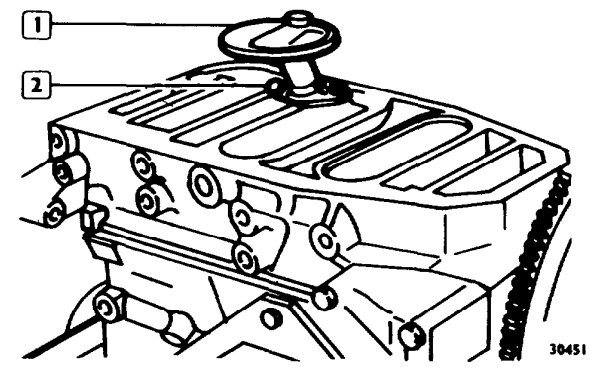
Remove cylinder head retaining bolts (1), remove cylinder head and gasket

FIGURE 49



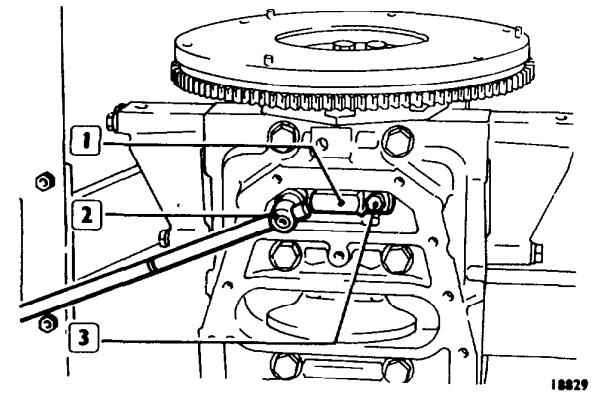
Rotate engine through 180° and remove sump (1)

FIGURE 50



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

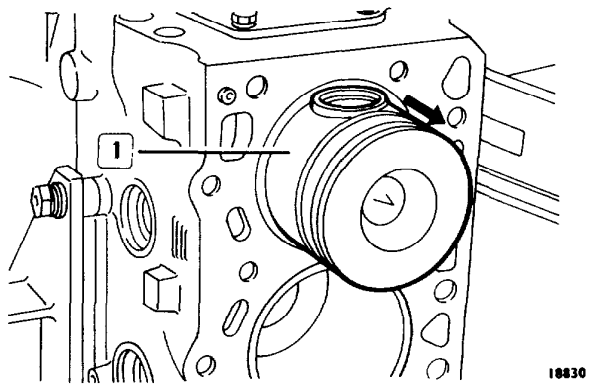
FIGURE 51



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

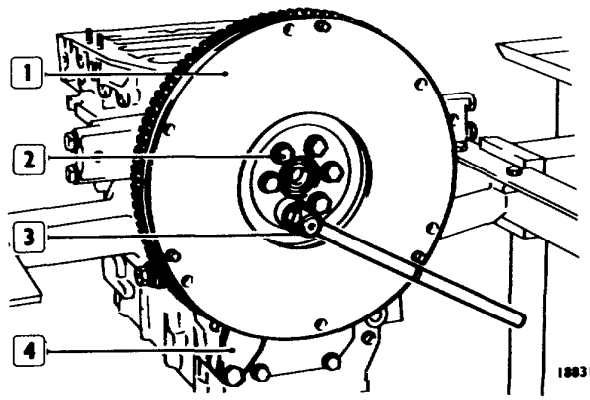
NOTE Position No. 4 piston at TDC so as to be able to pull connecting rod cap (1) out

FIGURE 52



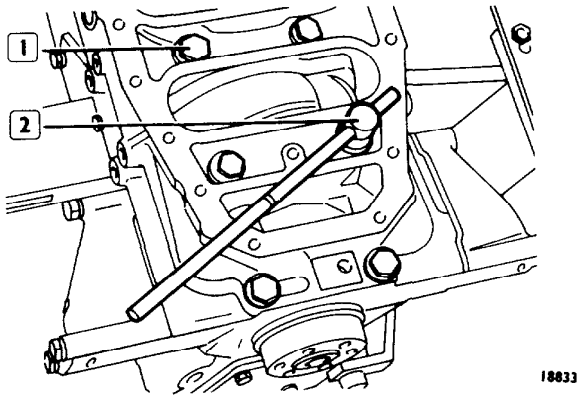
Remove connecting rod cap bolts, take off caps and pull out pistons (1) from top of block

FIGURE 53



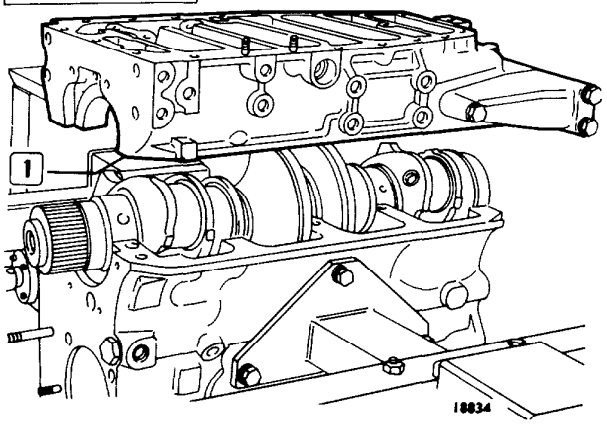
Turn engine again, fit Tool 99360306 (4) and, using wrench (3), remove bolts (2) holding engine flywheel (1) and lift off flywheel.

FIGURE 55



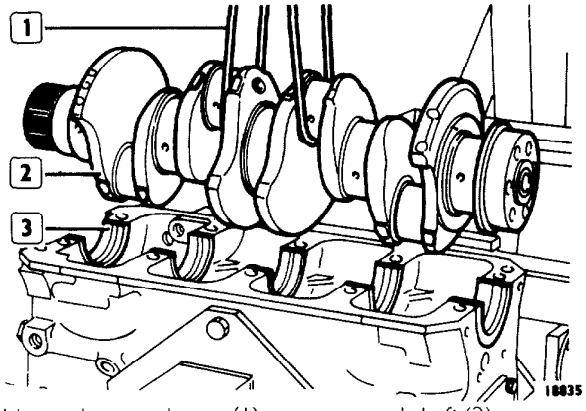
Using wrench (2) unscrew bolts (1) securing bottom block to top block

FIGURE 56



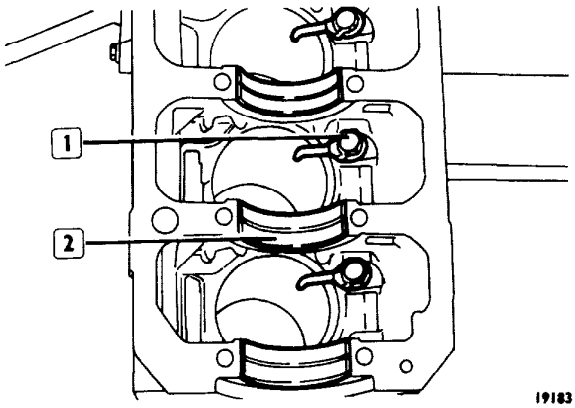
Remove bottom block (1) together with gasket

FIGURE 57



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

FIGURE 58



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

CYLINDER GROUP

After disassembling the engine, thoroughly clean the cylinder-engine block.

CHECKS AND MEASUREMENTS

Thoroughly check engine block for cracks.

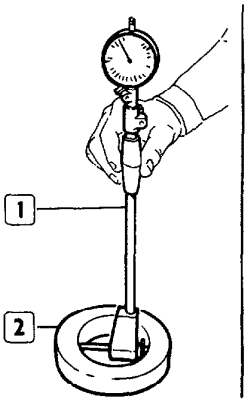
Check condition of machined plugs, if they are rusted or if there is the slightest doubt about them being watertight, replace them

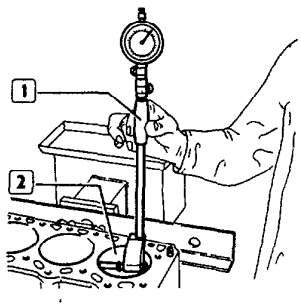
Examine surfaces of cylinder liners, these should show no signs of seizure, score marks, ovality, taper or excessive wear
Measure each cylinder at three different heights on the liner at two planes perpendicular to each other: one parallel to the longitudinal axis of the engine (A) and the other perpendicular to it (B), on this latter plane around the first measurement maximum wear is generally found. If ovality or taper or any wear whatsoever are found, take steps to eliminate them, as a repair, by grinding the linings in the case of slight wear and scoring, or by reboring and subsequent grinding when deep score marks or marked ovality are found.

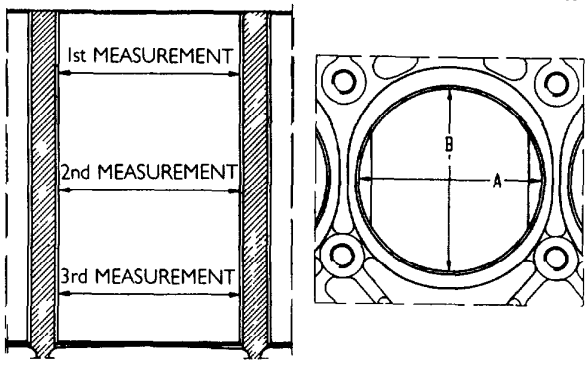
Linings should be dressed relative to the diameter of the oversize pistons supplied as spares (0.2, 0.4, 0 6 mm).

When overhauling them, rebore liners so that the specified fitting play is restored between the liners and the oversize pistons

NOTE: Reboring operations cause a reduction in thickness of the cylinder liner walls; this work can therefore be carried out on one liner until there is an overall increase in diameter of 0 6 mm, after which it will be necessary to replace the liner.



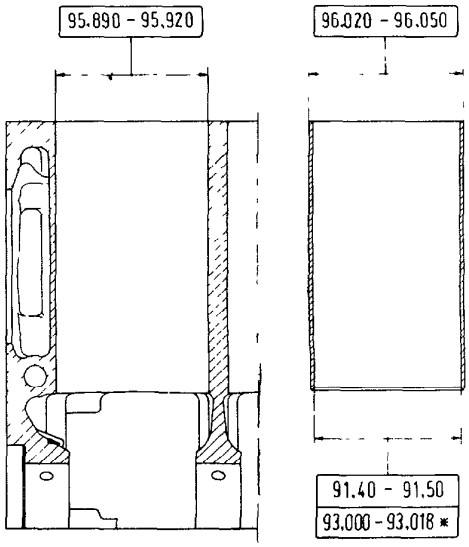




Method to follow for measuring the internal diameter of cylinder liners.
MEASUREMENT

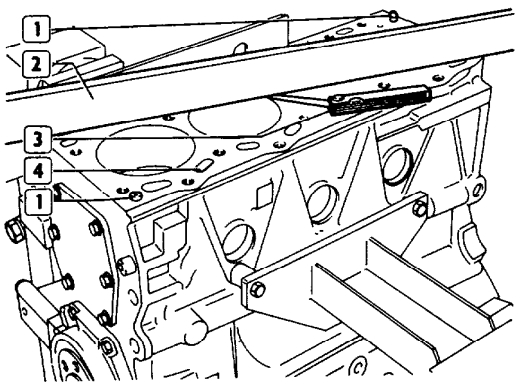
Cylinder sleeve bores should be checked to determine the degree of ovality, taper and wear, using ring gauge (1) (93 mm diameter) fitted on gauge (2), with dial preset at zero

Check seats of main journal bearings, as follows
Fit lower engine block onto upper section, without bearings and gaskets Tighten fixing screws to specified torque
With the appropriate comparator gauge for internal measurement, check diameter of the seats, which should be 80 587 - 80 607 mm, if this is not so, change the engine block, as it is warped



*Dimension which should be obtained after fitting cylinder sleeve in engine block

The cylinder sleeves are stripped out and fitted in the cylinder block with a hydraulic press After fitting, the sleeves must be reamed out and ground
The cylinder sleeves, however, are supplied as spares with the external diameter oversized by 0 2 mm, if spare sleeves have to be used, the cylinder sleeve seats on the block must be reamed out to a diameter of 96 090 - 96 120 mm



Check cylinder head mating surface for deformations.
This check can be carried out with a surface plate smeared with carbon black after removing the dowels (1) or with a straight ruler (2) and thickness gauge (3)
After ascertaining which areas are deformed, smooth the contact surface with a grinder, taking off the smallest possible amount of material
After completion of the levelling, remake the bevel on the top edge of the cylinder sleeve, which should be 0.8 mm - 1 x 26°

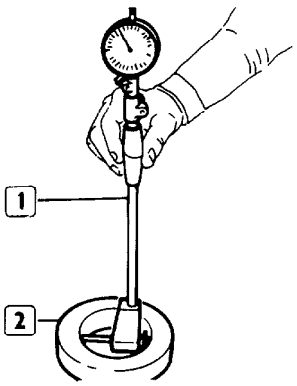
CYLINDER BLOCK

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

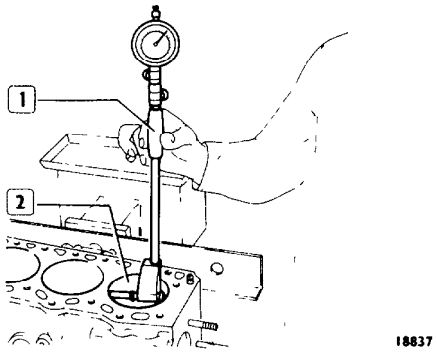
FIGURE 59



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

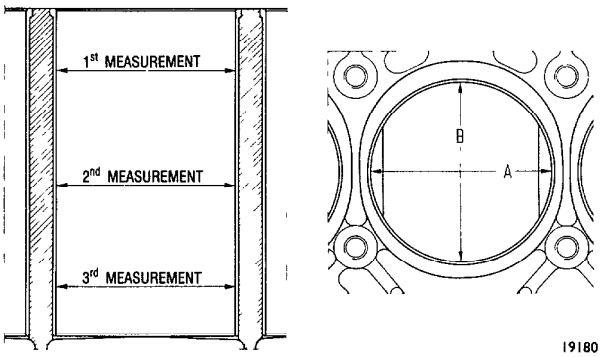
NOTE If a 93 mm diameter ring gauge is not available, use an external micrometer set at 93 mm

FIGURE 60



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

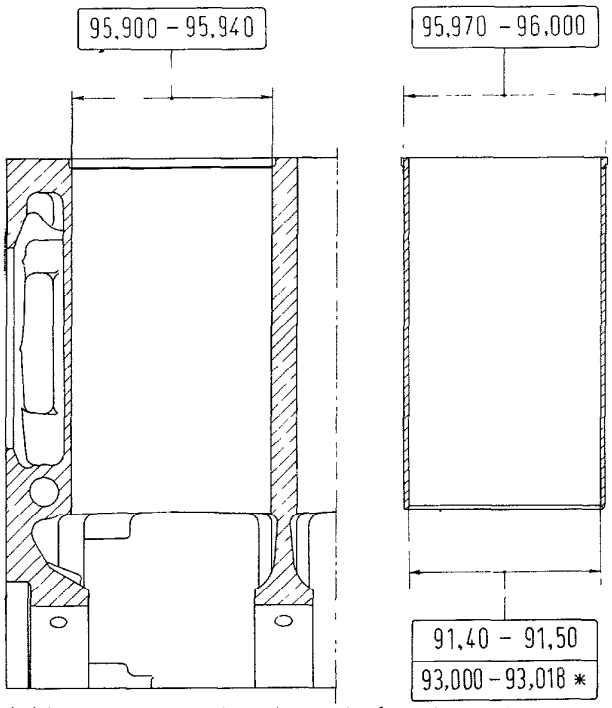
FIGURE 61



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, rebore 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

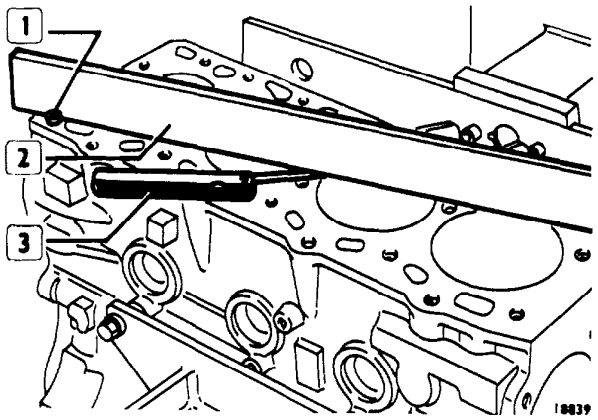
The liners are removed from and driven into the cylinder block using an hydraulic press and a special plate and following the instructions described below

- ☐ 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 rebore 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 × 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

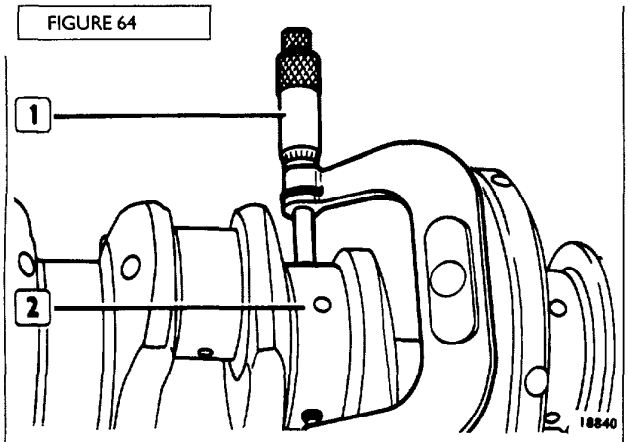
If main journals and crank pins show signs of seizing, scoring or excessive ovality, they must be dressed by grinding

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

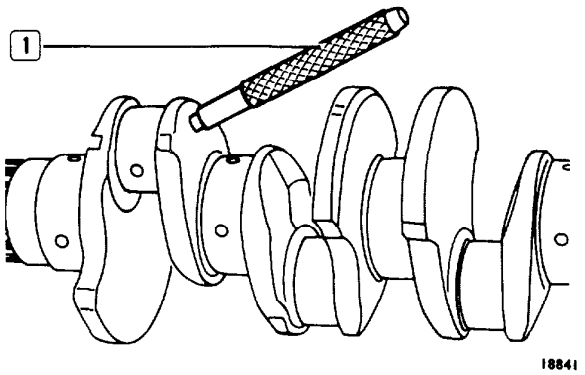
Remove crankshaft spigot bearing, using Slide Hammer 99340205 and Adaptor 99340213

FIGURE 64



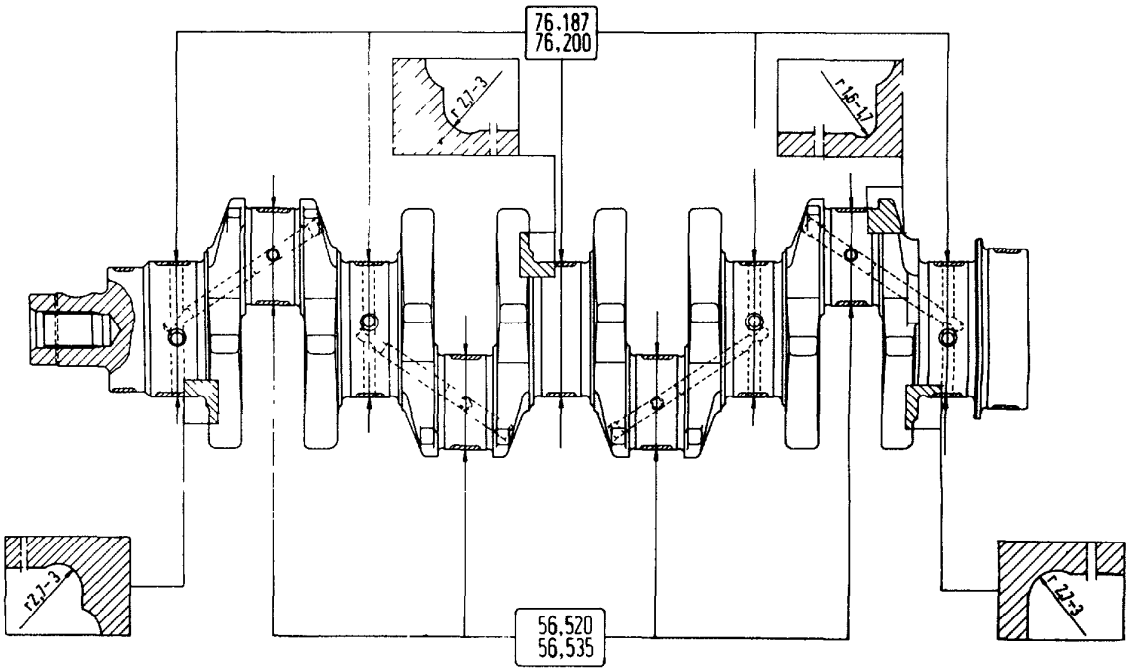
Before grinding, measure shaft journals (2) with a micrometer (1) to establish to which diameter the journals must be reduced on the basis of the bearing undersizes available

FIGURE 65



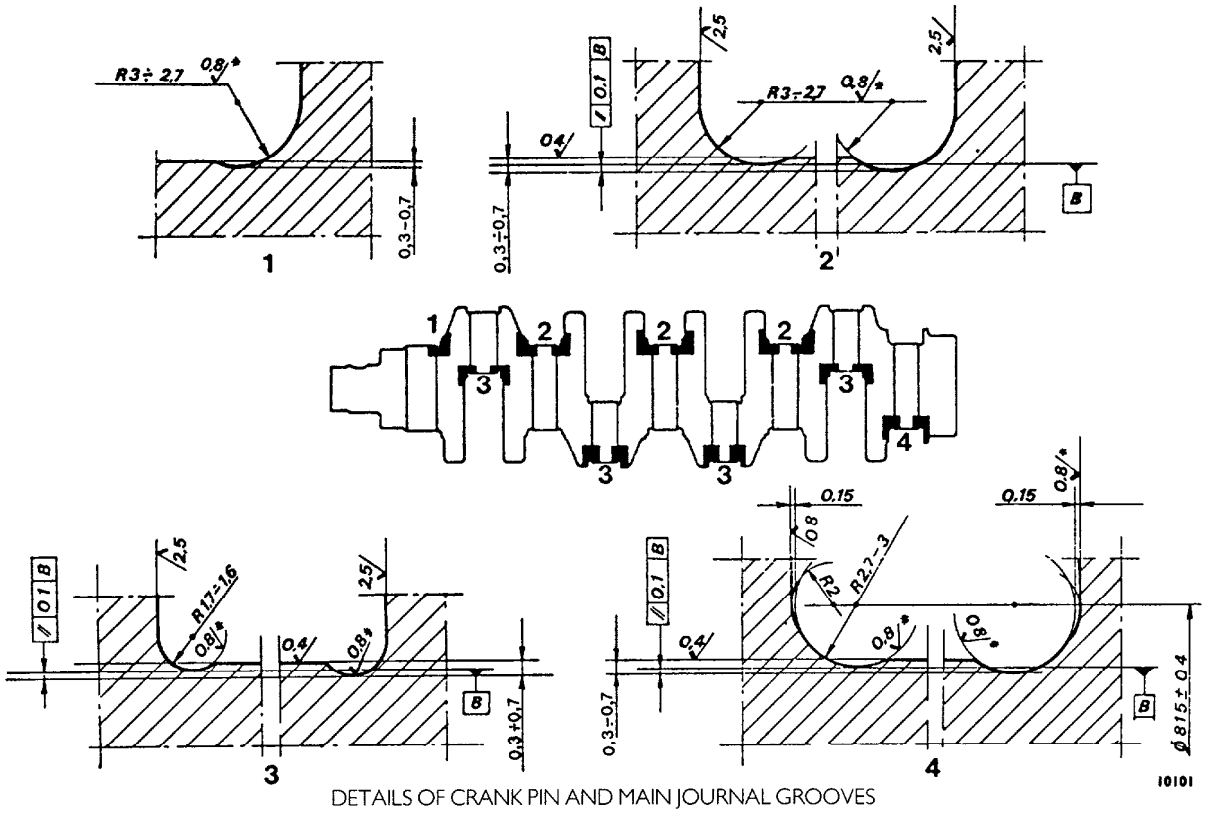
After grinding and before finally fitting the shaft, the countersunk edges of the main journal and crank pin lubrication holes must be chamfered
Check that the plugs of the lubrication circuit do not leak under an internal pressure of 15 bar, if they do replace them using a drift (1) to drive them in.

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

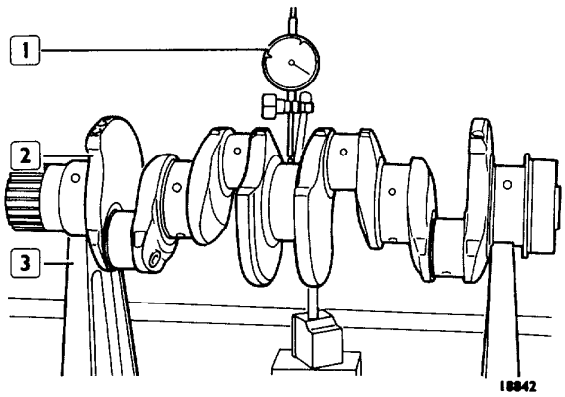
Rolling Pressure

- ☐ 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)

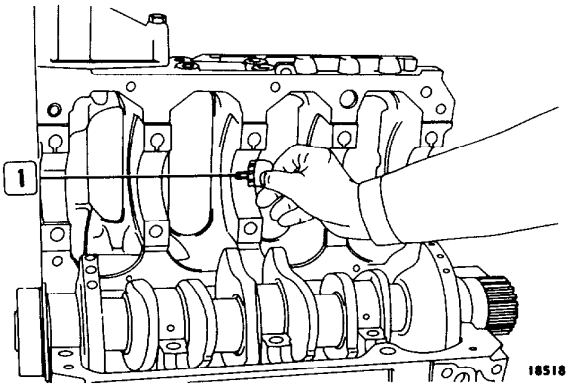
FIGURE 68



- ☐ 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

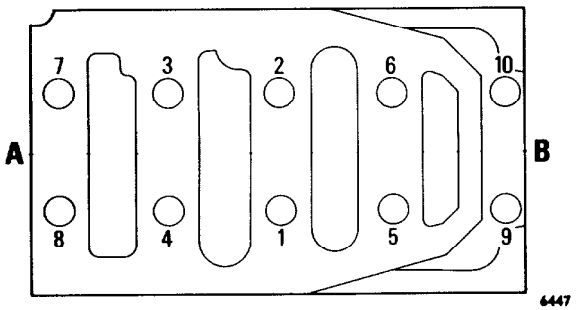
FIGURE 69



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

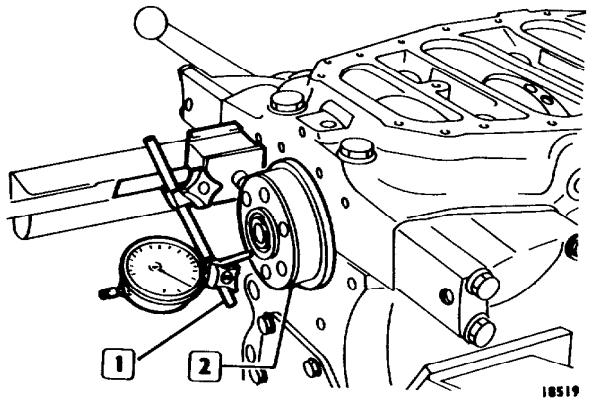


A Timing Side B Engine Flywheel Side

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

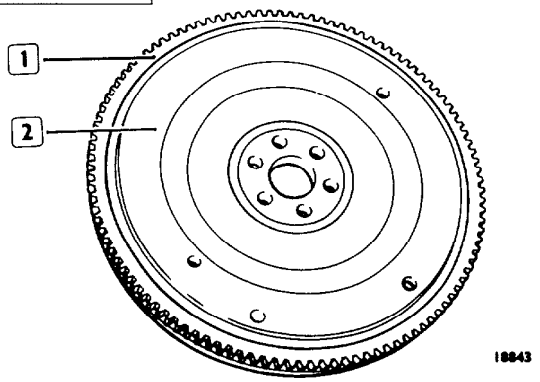


End float is checked by positioning a dial gauge (1) with a magnetic base as shown in the Figure, the standard fitting clearance is 0 045–0 320 mm

If clearance is greater, replace rear thrust main journal bearings

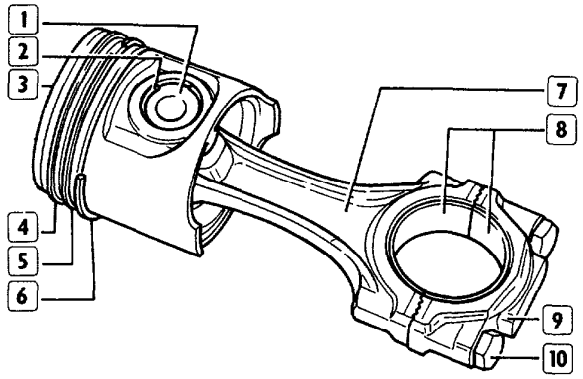
REPLACING FLYWHEEL RING GEAR

FIGURE 72



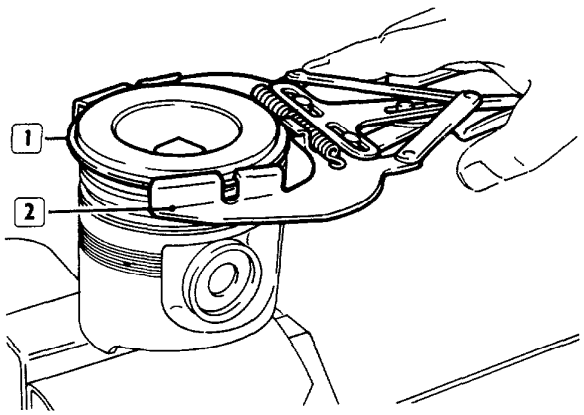
Check face of clutch disc, if scored turn it on the lathe If teeth of gear (1) on flywheel (2) are badly damaged, replace gear A hydraulic press must be used to remove and refit the gear onto the flywheel, before fitting, the gear must be heated to approximately 100°C and positioned with the bevel of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

PISTON AND CONNECTING ROD ASSEMBLY

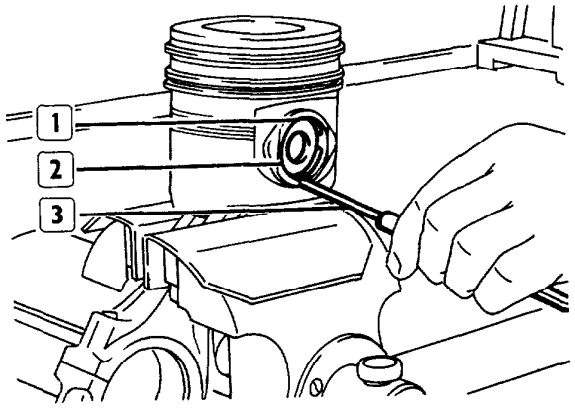


PISTON AND CONNECTING ROD ASSEMBLY

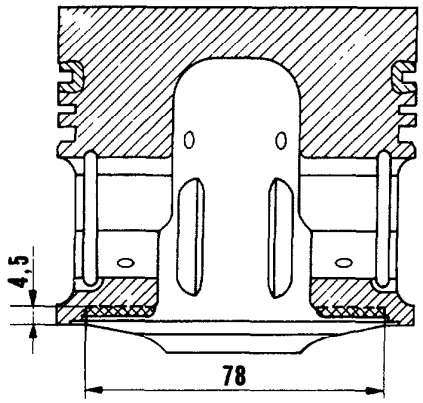
1 Pin 2 Piston ring 3 Piston 4 Trapezoidal retaining ring 5 Oil scraper ring 6 Oil scraper ring with slots and coil spring 7 Connecting rod body 8 Bearing halves 9 Connecting rod cap 10 Cap fixing screw



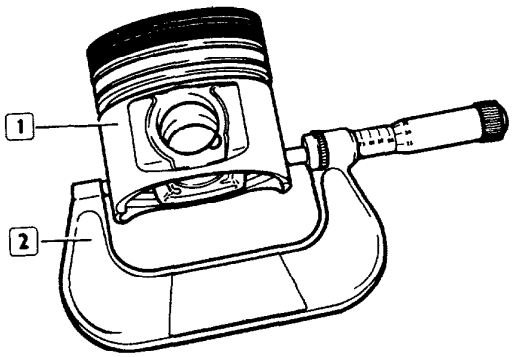
The rings (1) are removed from and fitted on the piston using pliers 99360183 (2)



Dismantling the circlips (1) retaining the gudgeon pin (2) is carried out using a pointed scribe (3), as shown in the diagram

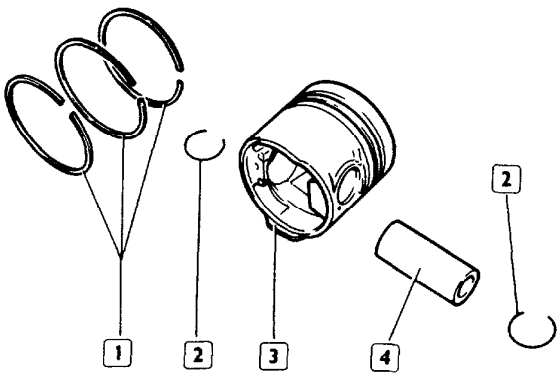


Check weight of pistons, which should be 786 to 793 g (class A) and 793-800 g (class B), if not to weight, remove material in area indicated

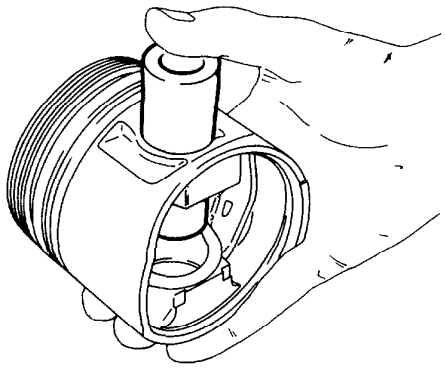


Measuring piston diameter (1) using a micrometer (2) to determine play

NOTE. When fitting pistons in engine, check that they are all of the same class



NOTE Standard replacement pistons (3) are supplied complete with flexible rings (1), pin (4) and safety rings (2) They are also supplied oversized by 0 2, 0 4, 0 6 mm

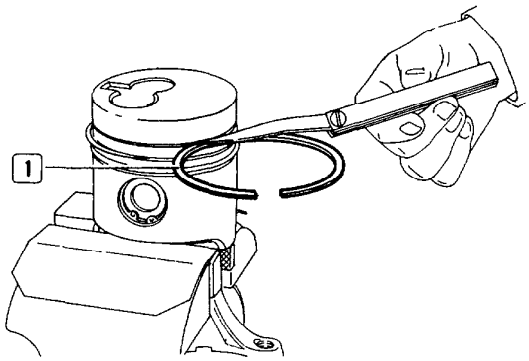


Check that fit between pin and piston is correct

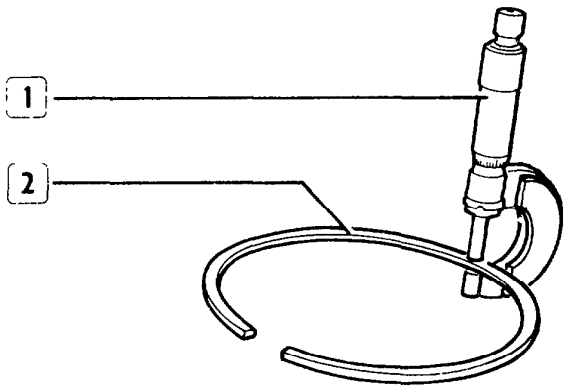
Check for correct fit in seat on piston as follows

- ☐ lubricate pin and its seat on the relative bosses on the piston with engine oil
- ☐ insert the pin in its seat

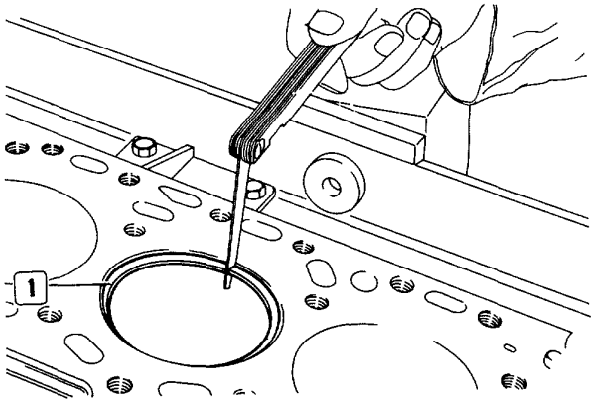
Place piston with pin in vertical position and check that the latter can be withdrawn with thumb pressure only and not on its own If not, change the pin and if necessary the piston also



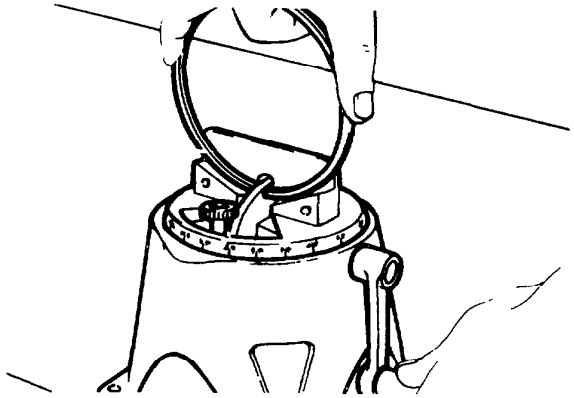
Check play between flexible rings (1) and their respective seats, using feeler



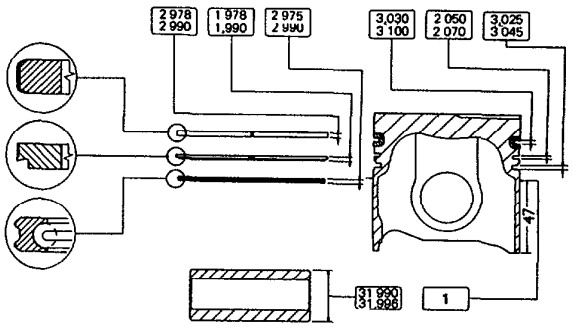
If the play found is in excess of the maximum, measure ring thickness (2) with a micrometer (1) and if the play can be put down to wear on the rings or their seats on the piston, replace the parts concerned



Checking gap between ends of the flexible rings (1) when fitted in the cylinder linings



If the gap between ring ends is less than that specified, dress snapring ends with if distance between ends is greater than specified, change the rings

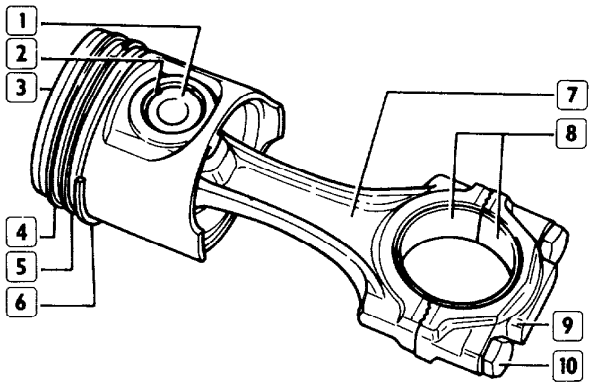


DETAILS OF PISTON RINGS AND PIN

1	Mondial Piston	92 875 - 92 861
	Borgo	92 893 - 92 861
	KS (48 mm)	98 863 - 92 877

PISTON/CONNECTING ROD ASSEMBLY

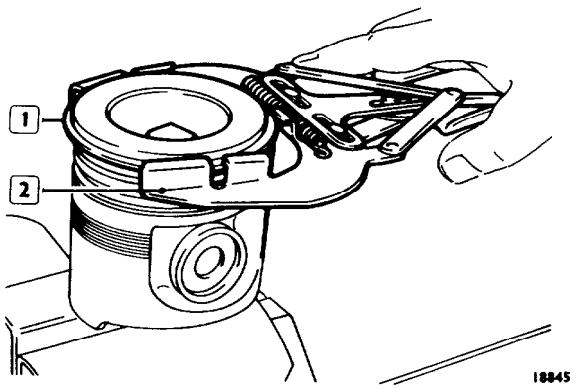
FIGURE 73



PISTON/CONNECTING ROD ASSEMBLY

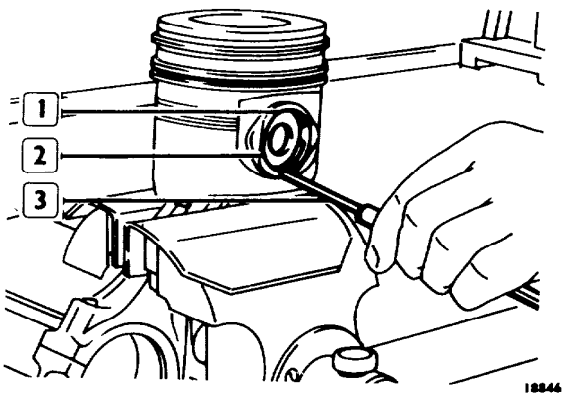
1 Pin – 2 Ring – 3 Piston – 4 Trapezoidal Sealing Ring – 5 Oil-scraper Ring – 6 Slotted, spring loaded oil scraper ring – 7 Connecting Rod Body – 8 Bearings – 9 Connecting Rod Cap – 10 Cap Bolt

FIGURE 74



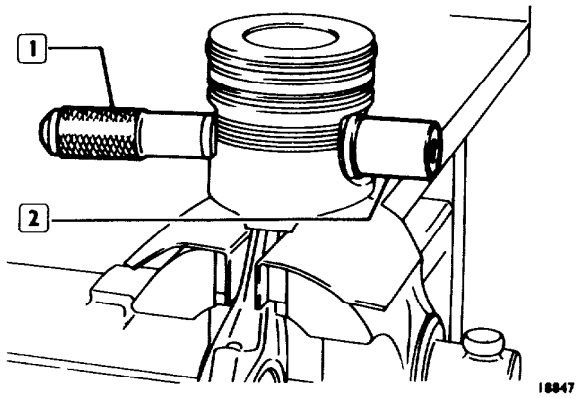
The rings (1) are removed and fitted onto piston with Pliers 99360183 (2).

FIGURE 75



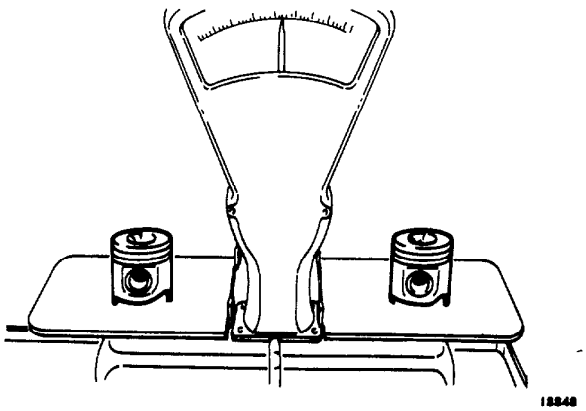
The rings (1) holding piston pin (2) are removed with a scriber (3), as shown in the Figure

FIGURE 76



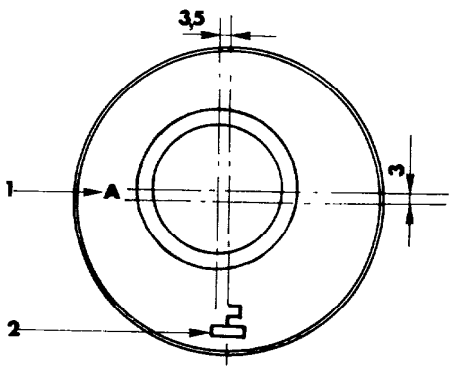
Use drift (1) to remove piston pin (2).

FIGURE 77



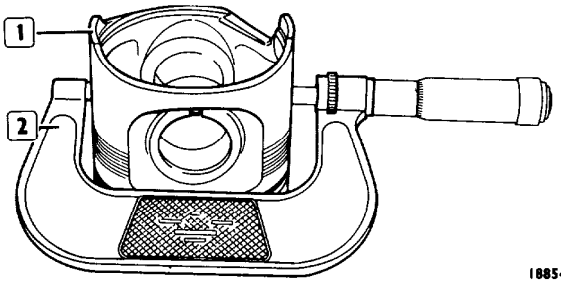
Check that pistons weigh the same

FIGURE 78



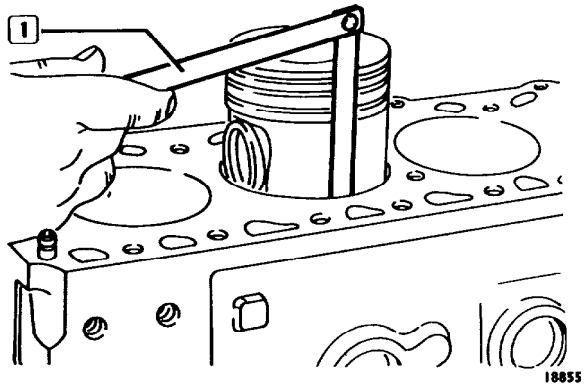
The piston crowns have the following engraved on them a symbol (2) showing which way up the piston goes in the cylinder liner (symbol faces flywheel) The Letter A or B (1) shows the weight class

FIGURE 79



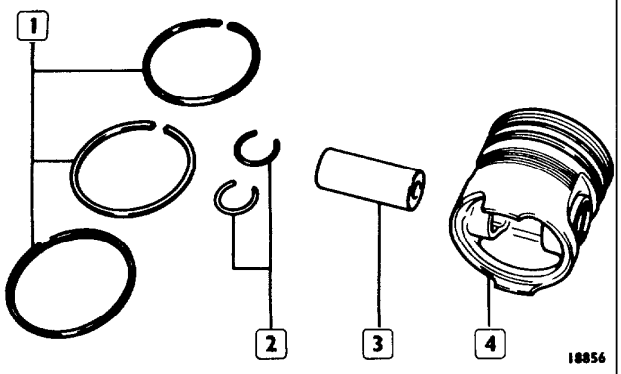
Measuring piston diameter (1), using a micrometer (2), to determine fitting clearance The diameter must be measured 12 mm from the base of the skirt in the case of a Borg piston and 17 mm in the case of a KS piston

FIGURE 80



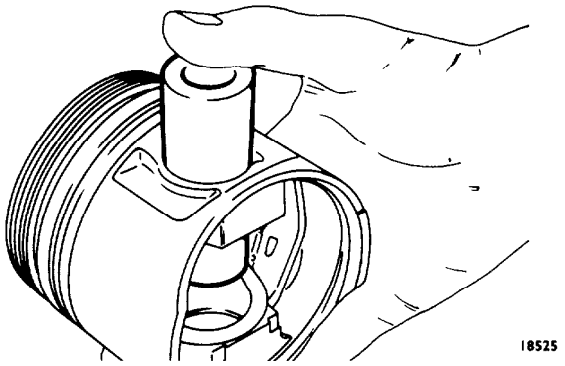
As an alternative to measuring the piston diameters and liners, the clearance between the piston and cylinder liner may also be checked using a feeler gauge (1), as shown in the Figure

FIGURE 81



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

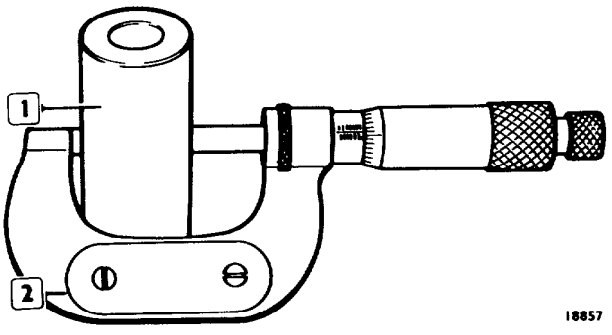


CHECKING THAT FIT BETWEEN PIN AND PISTON IS CORRECT

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

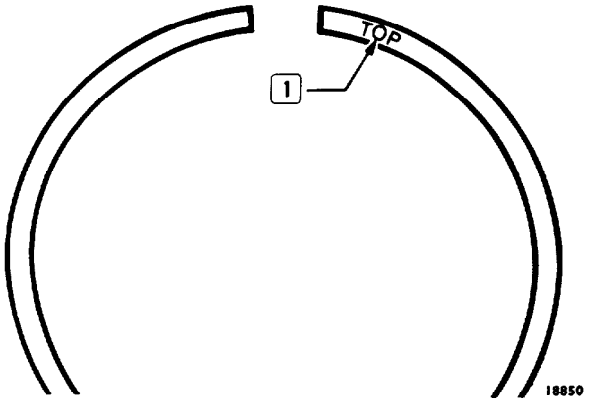
FIGURE 83



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.

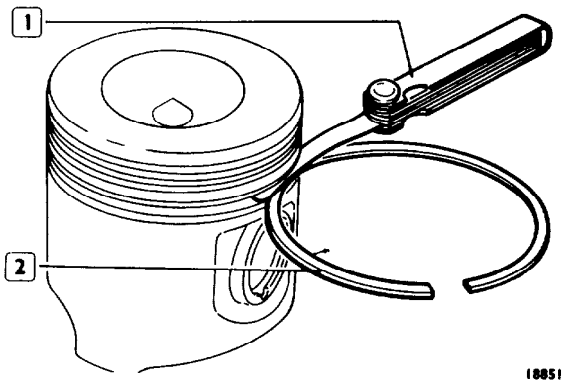
PISTON RINGS

FIGURE 84



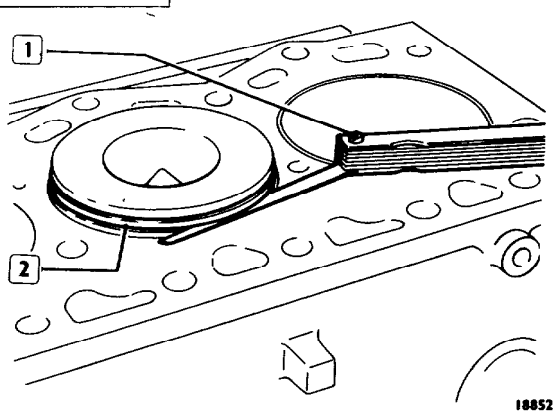
Trapezoidal sealing rings and oil-scraper rings (2nd groove) have the word TOP (1) engraved on them, so when fitting rings onto piston this word must face upwards

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

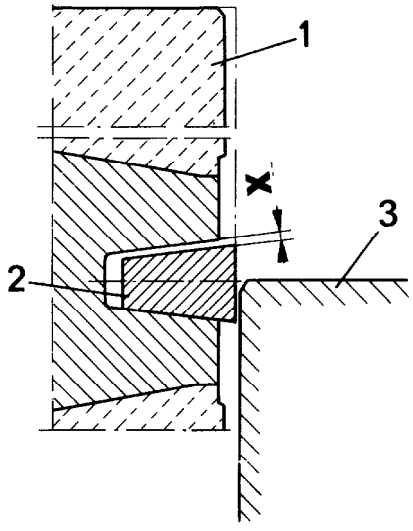
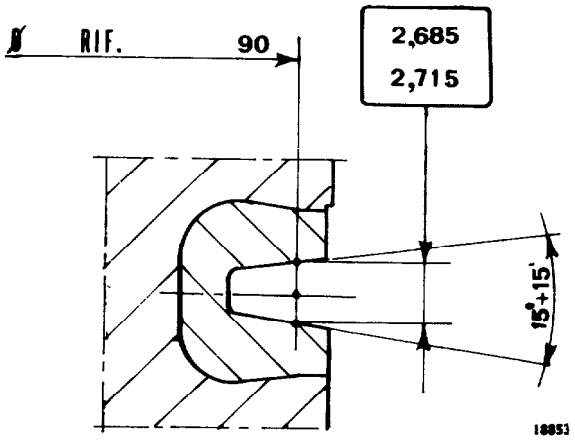


DIAGRAM FOR MEASURING CLEARANCE X BETWEEN FIRST PISTON GROOVE AND TRAPEZOIDAL RING

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

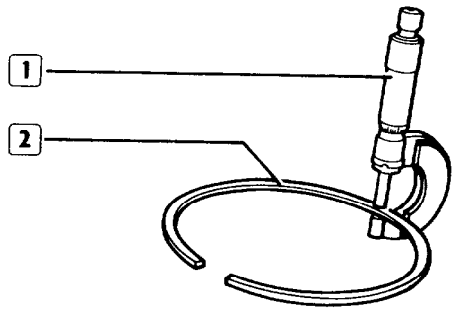
FIGURE 88



DETAIL OF FIRST GROOVE FOR A TRAPEZOIDAL SEALING RING

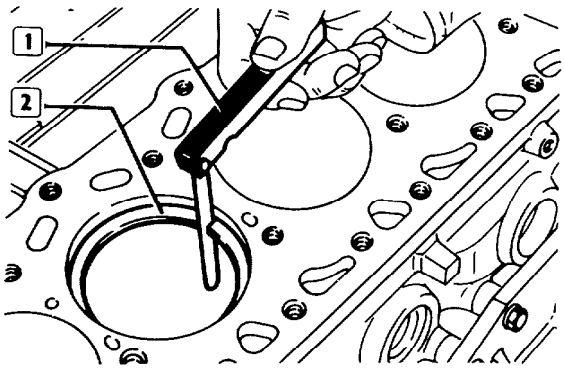
Groove height is measured on 90mm diameter

FIGURE 89



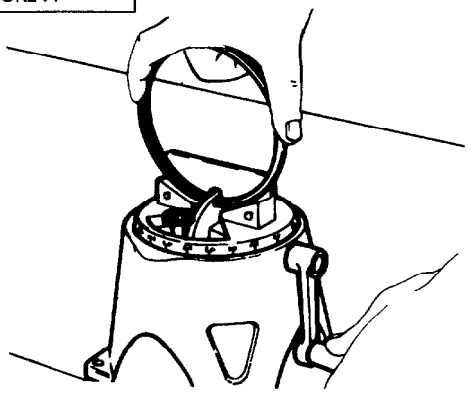
If the clearance measured exceeds the maximum specified value, measure thickness of rings (2) using micrometer (1) to determine whether clearance is due to wear of rings or wear of piston grooves; replace parts as necessary

FIGURE 90



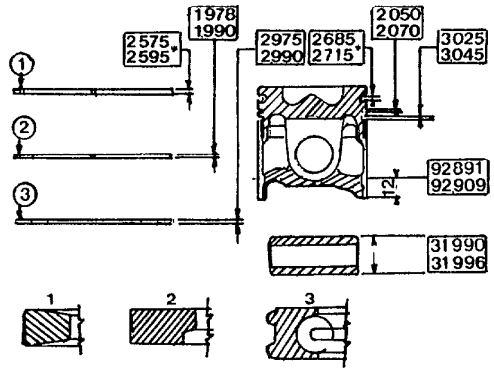
Checking gap between ends of rings (2) when fitted in cylinder barrel, using feeler gauge (1)

FIGURE 91



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

FIGURE 92

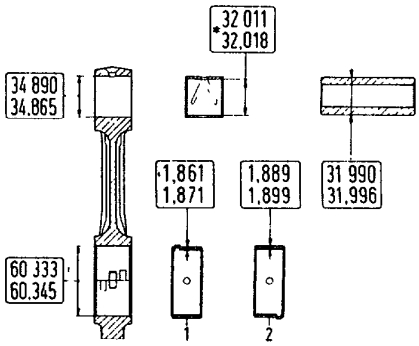


DETAILS OF PISTON (Borg), RINGS AND PIN

* Measurement made on 0/90 mm

CONNECTING RODS

FIGURE 93

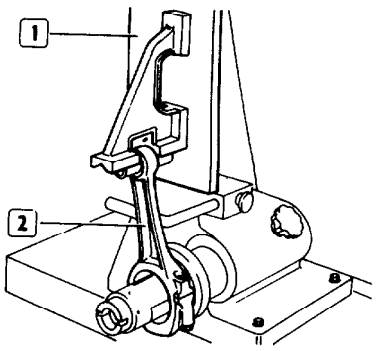


DETAILS OF CONNECTING ROD, BUSH, PISTON PIN, PISTON AND BEARINGS

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

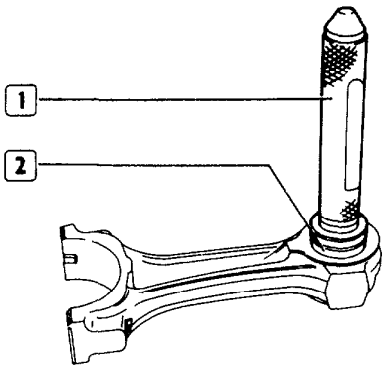
* Measurement to be taken after driving bush into small end

FIGURE 94



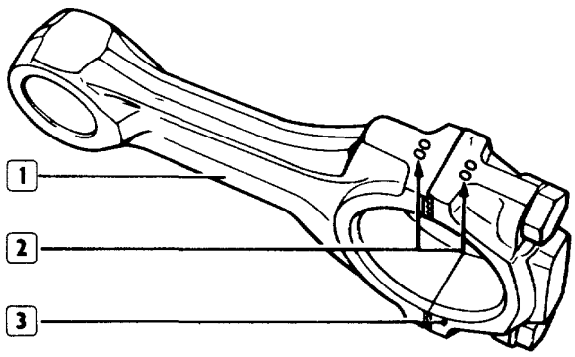
Check that axes of connecting rods (2) are parallel, using Tool 99395363 (1) Maximum permitted tolerance is 0 07 mm measured 125 mm from the longitudinal axis of the connecting rod If connecting rod alignment exceeds the specified figure, replace the connecting rod

FIGURE 95



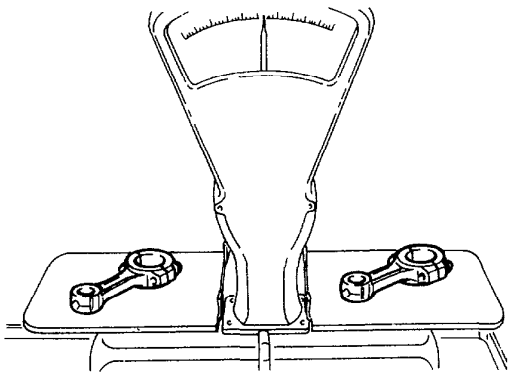
Check that bush (2) in small end is not loose and shows no signs of scoring or seizing up. If it has, replace it It is removed and fitted using Drift 99360175 (1) When fitting, take great care to ensure that the oilway holes on the bush and small end coincide, grind bush to a diameter of 32 011–32 018 mm, using Tool 99301044

FIGURE 96



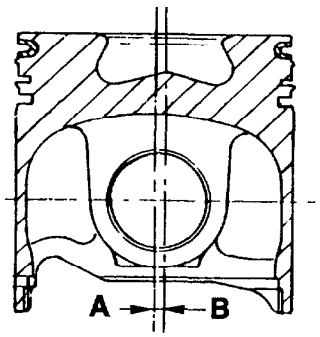
Each connecting rod is marked, on the body (1) and cap (3) with numbers (2) corresponding to the connecting rod body/cap fitting number

FIGURE 97



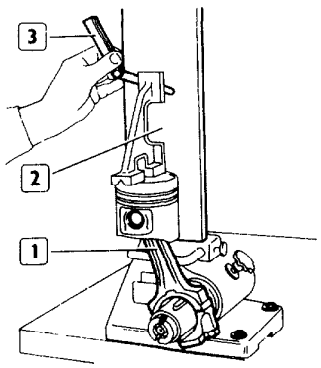
Check that all connecting rods weigh the same, permitted tolerance is ±8g Connecting rods must be weighed complete with caps, bolts and bushes

FIGURE 98



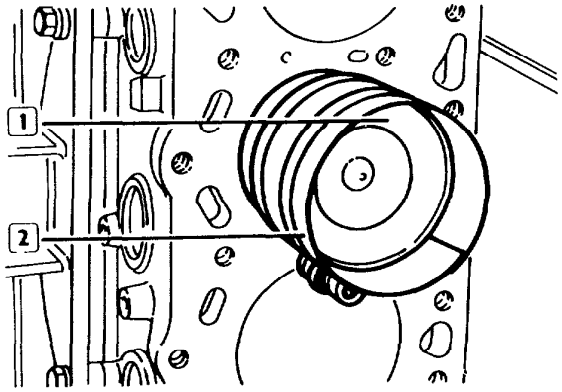
Vertical axis B of the pin hole is offset by 1±01 mm in relation to vertical axis A of the piston (Borg)

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

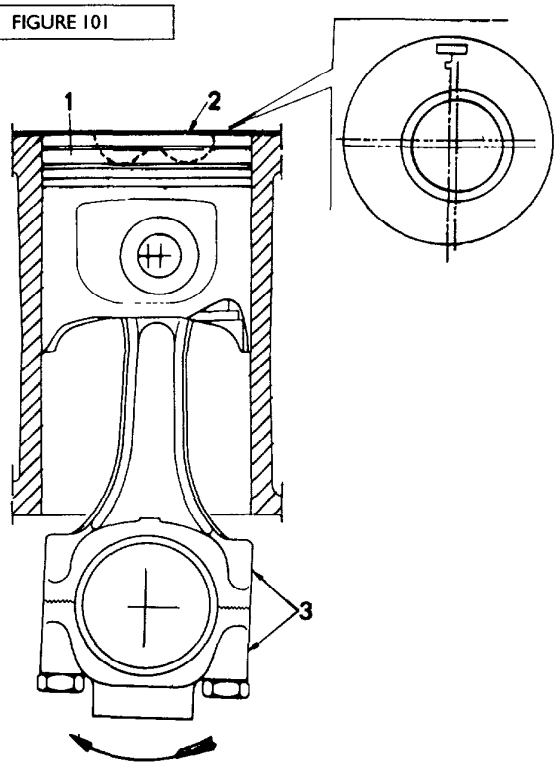
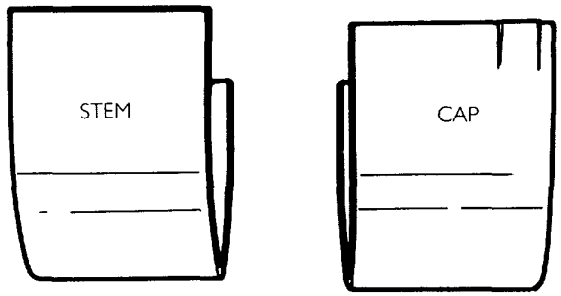


DIAGRAM FOR FITTING CONNECTING ROD/PISTON ASSEMBLY INTO THE CYLINDER

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

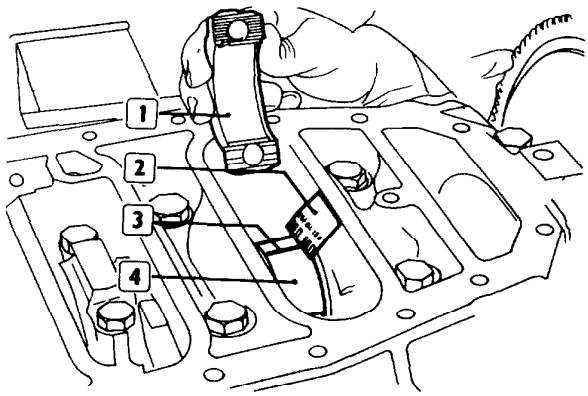


- ☐ that big end bearings are fitted in the correct housings, for this purpose the words STELO – CAPPELLO (STEM – CAP) are stamped on them.

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



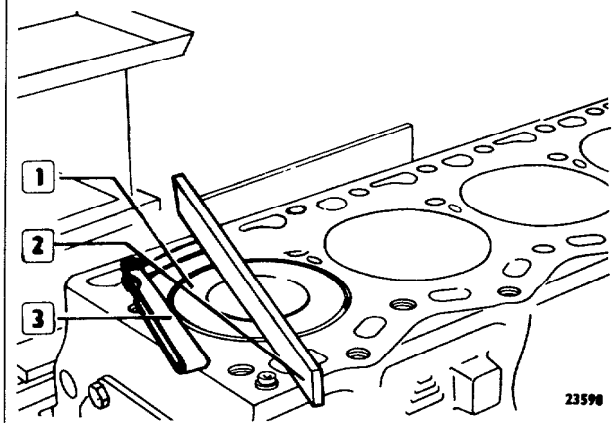
Measure the clearance as follows

- ☐ 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

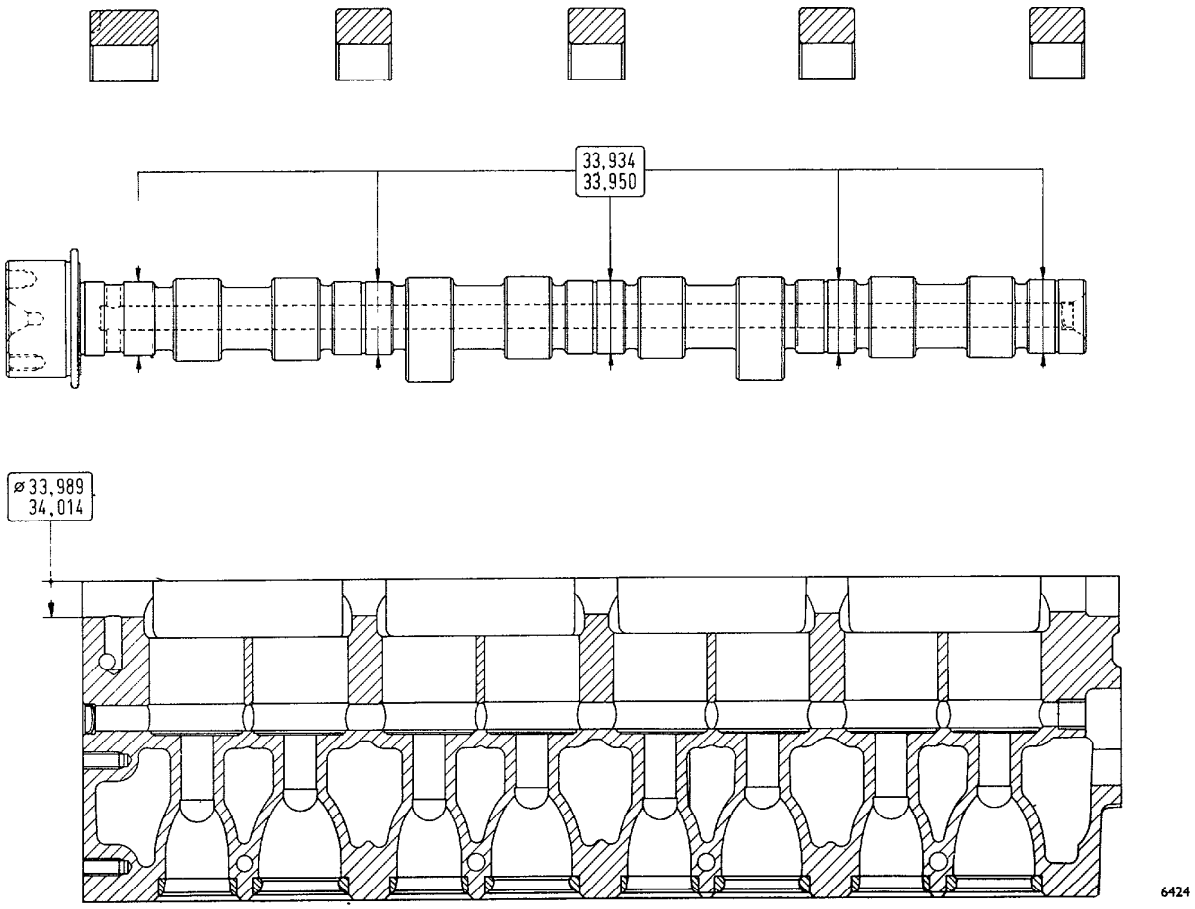
Once connecting rod/piston assemblies have been fitted, check protrusion of pistons (1) at TDC in relation to top of block using a feeler gauge (3) and straight edge (2) Protrusion should be between 0 35 and 0 65 mm

FIGURE 104



CAMSHAFT

FIGURE 105

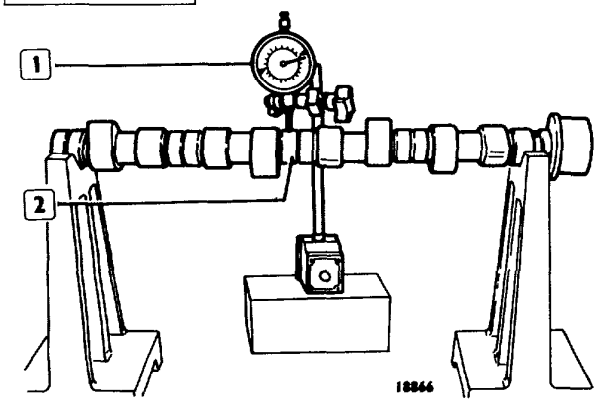


DETAILS OF CAMSHAFT AND ITS BEARINGS AND CAPS ON CYLINDER HEAD

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

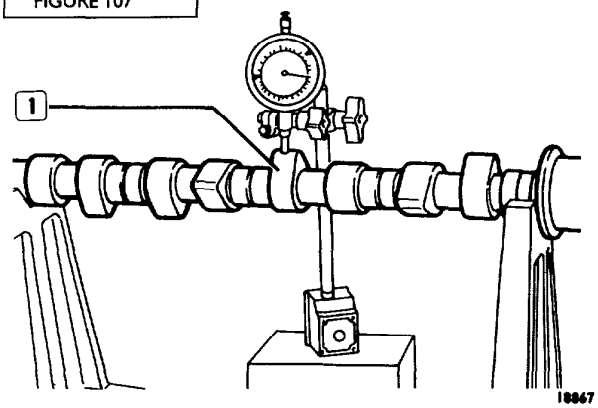
The surfaces of the shaft and cam journals must be very well ground, if they show signs of seizing up and scoring, the shaft should be replaced.

FIGURE 106



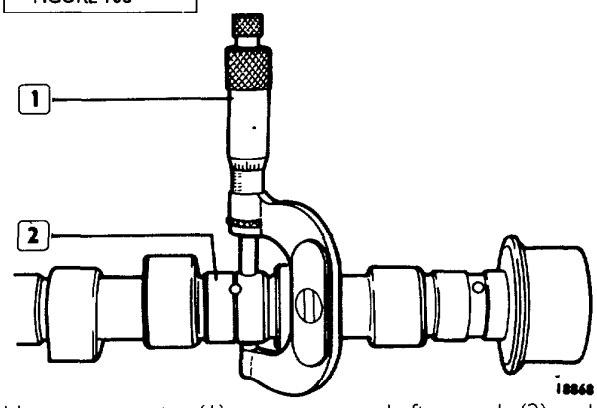
With camshaft on parallel stands and using a dial gauge (1) check run-out of journals (2), it should be no more than 0 04 mm If run-out is not to specification, replace the camshaft.

FIGURE 107



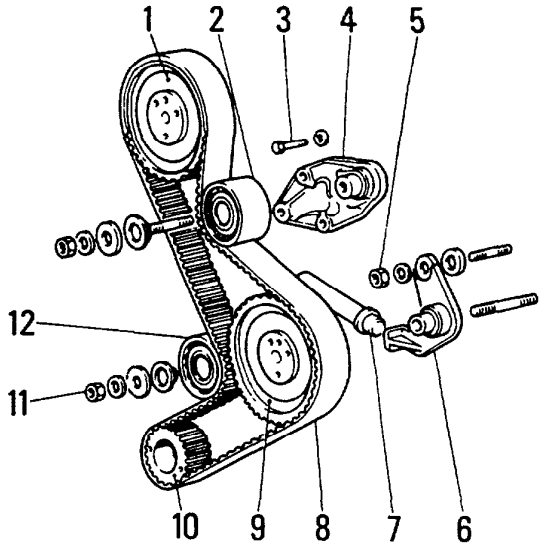
With camshaft still on parallel stands, check cam lift (1) which should be 10 5 mm for the exhaust and 9.5 mm for the inlet cams.

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

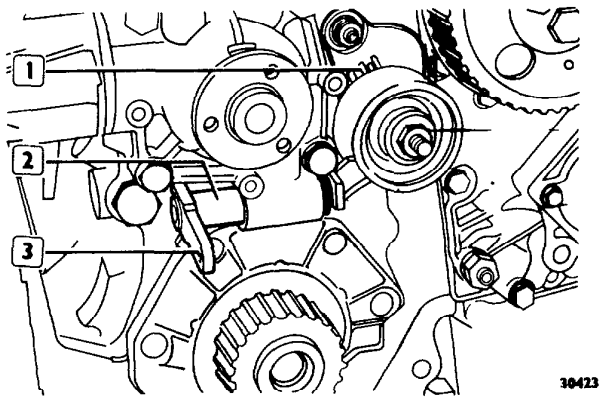


CAMSHAFT AND ANCILLARIES DRIVE COMPONENTS

1 Camshaft drive gear – 2 Fixed belt tensioner roller – 3 Bolt 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

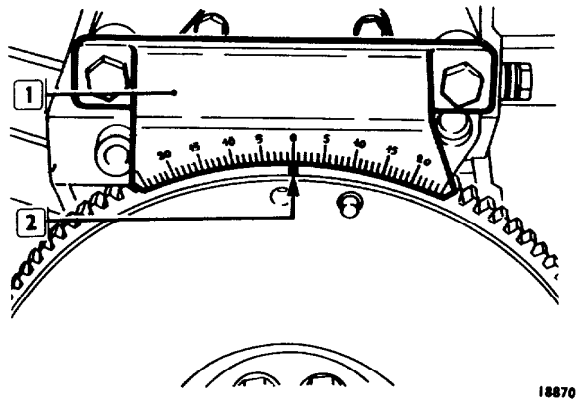
To fit camshaft toothed belt (8) proceed as follows

FIGURE 110



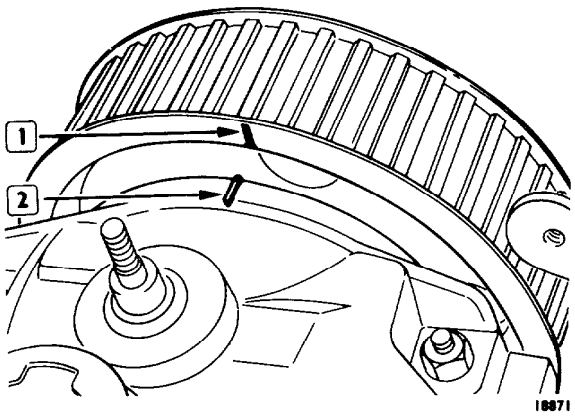
- ☐ apply Tool (3) to load reaction spring of belt tensioner push rod (2),
- ☐ fit adjustable belt tensioner (1),

FIGURE 111



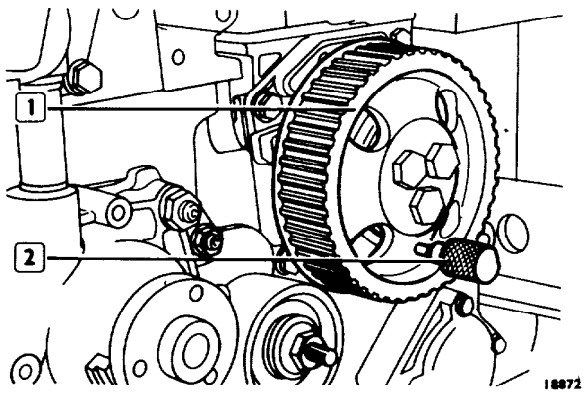
☐ fit graduated quadrant 99395611 (1),
☐ align mark (2) engraved on flywheel with zero engraved on graduated quadrant,

FIGURE 112



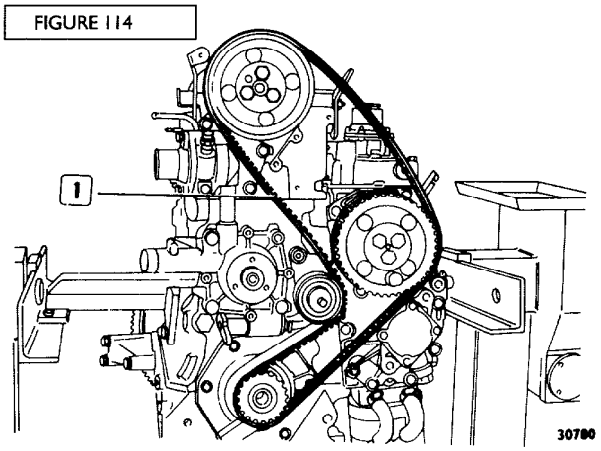
☐ align mark (1) engraved on camshaft drive gear with that engraved on tappet cover (2);

FIGURE 113



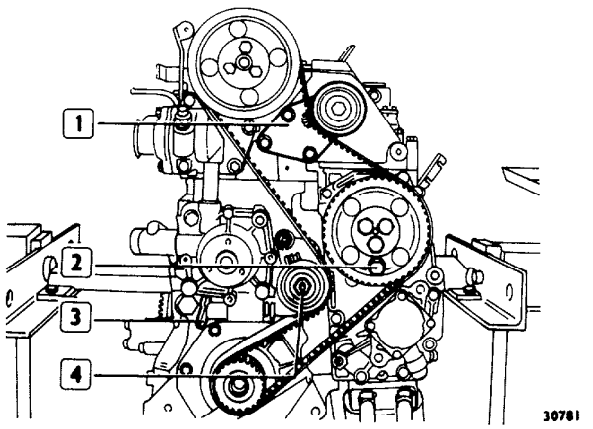
☐ rotate ancillaries drive gear (1) so as to align hole in gear with that in support and prevent rotation by inserting special tool (2).

FIGURE 114



☐ Fit toothed belt (1),

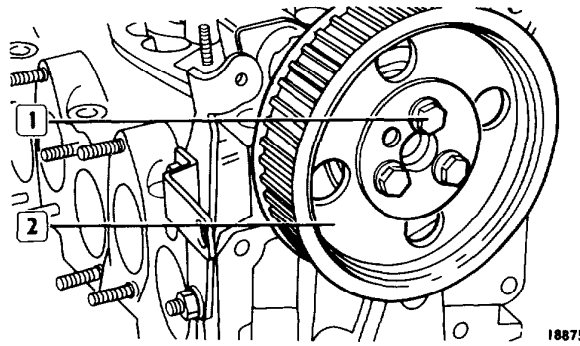
FIGURE 115



☐ 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

FIGURE 116

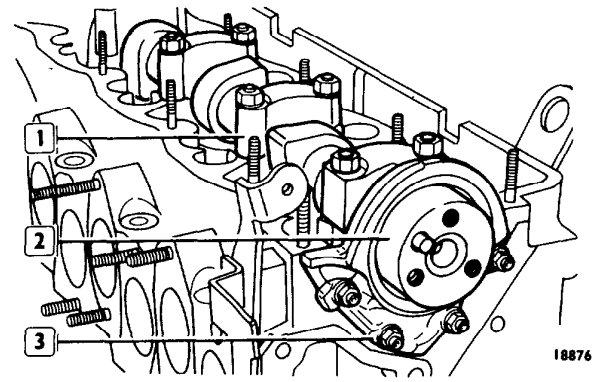


The cylinder head is removed as follows.

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

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

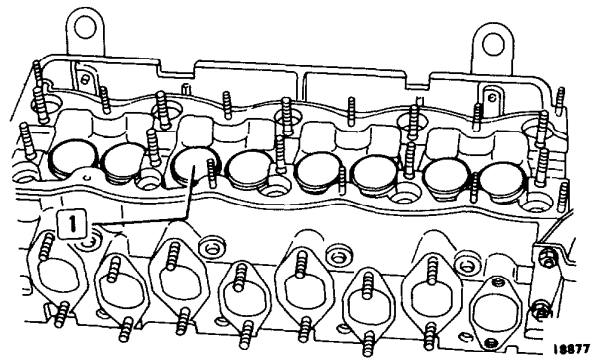
FIGURE 117



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

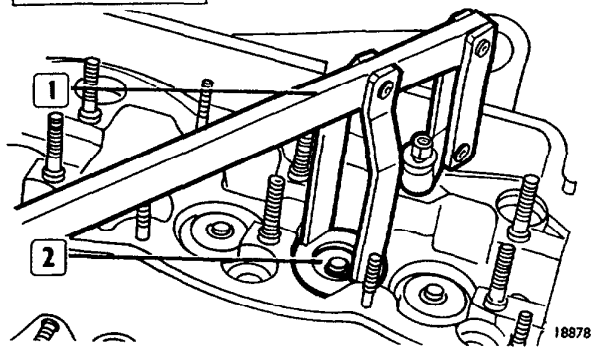
NOTE – When fitting cover (3), apply LOCTITE 573 to sealing surface.

FIGURE 118



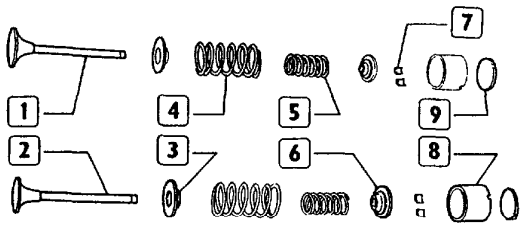
Remove tappets (1) complete with adjustment discs, placing them in a container in their correct fitting order.

FIGURE 119



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 120

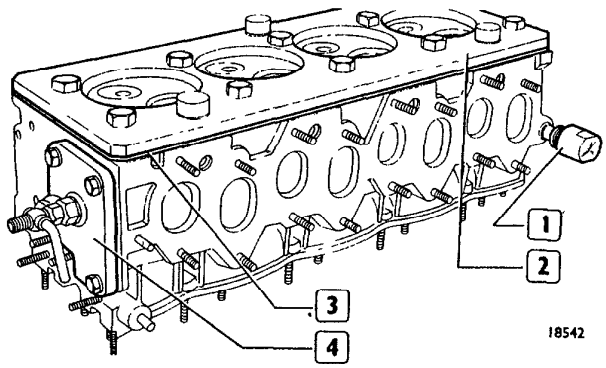


VALVE ASSEMBLIES AND COMPONENTS

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

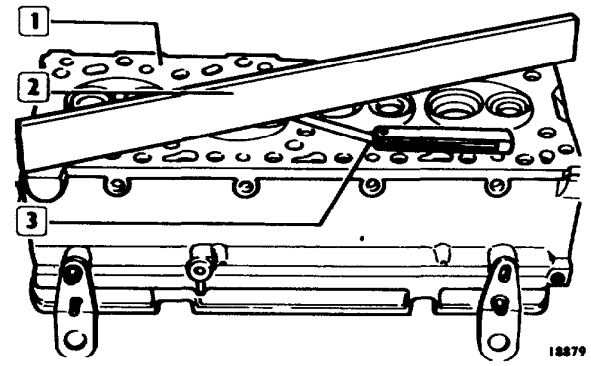
NOTE – To fit the valves, follow the operations described above in the reverse order

FIGURE 121



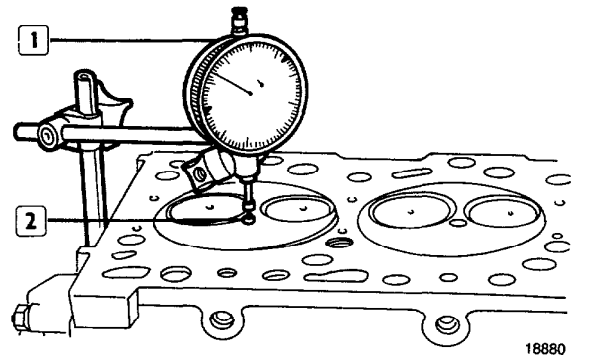
Check watertightness using special tool (1, 2, 3 and 4)
Pump in water heated to approximately 90°C at a pressure of 2–3 kgm/cm^2
In these conditions no leaks should occur, if they do renew cylinder head.

FIGURE 122



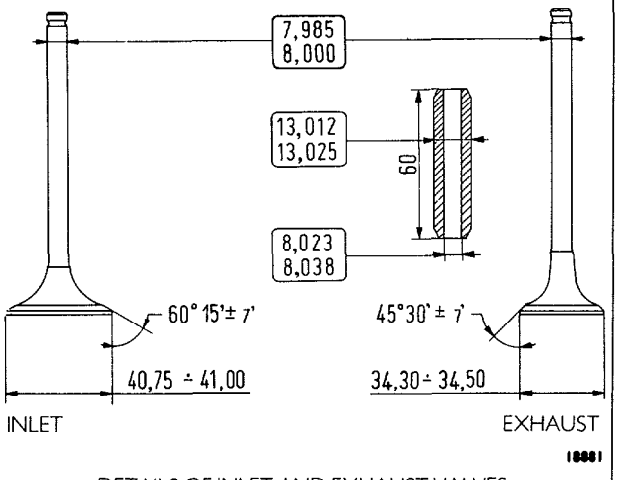
The face of the head (1) on the cylinder block is checked for flatness with a straight edge (2) and feeler gauge (3), if distorted the cylinder head should be ground flat No more than 0 4 mm of material may be removed (Specified cylinder head height 150±0 1 mm)

FIGURE 123



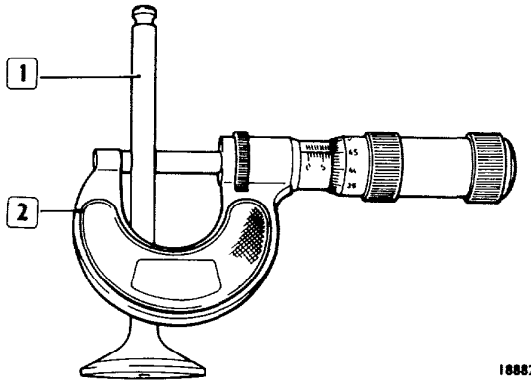
After levelling off, fit injectors (2) and, using a dial gauge (1) check their protrusion which should be 3 0–3 54 mm, if it is not, insert a copper washer in the seal housing

FIGURE 124



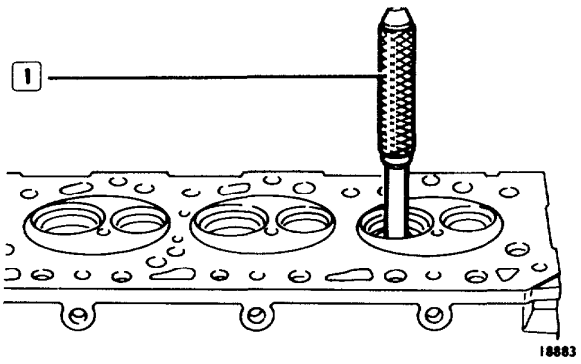
DETAILS OF INLET AND EXHAUST VALVES AND VALVE GUIDES

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

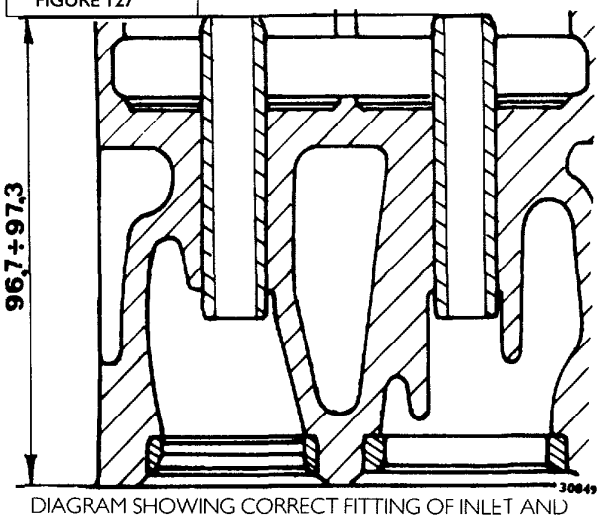
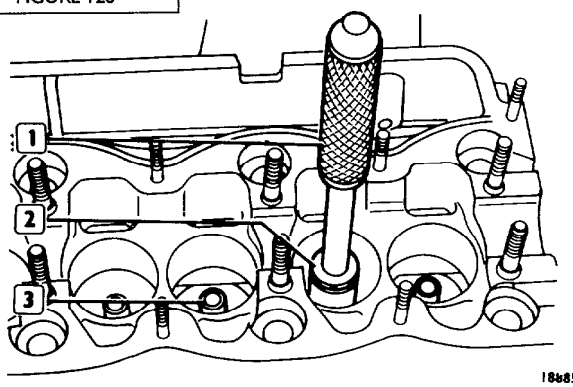


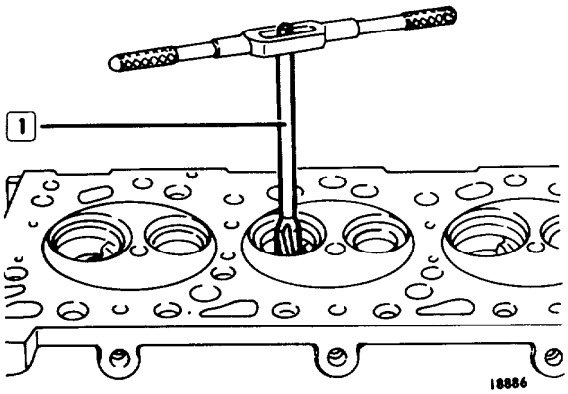
DIAGRAM SHOWING CORRECT FITTING OF INLET AND EXHAUST VALVE GUIDES

FIGURE 128



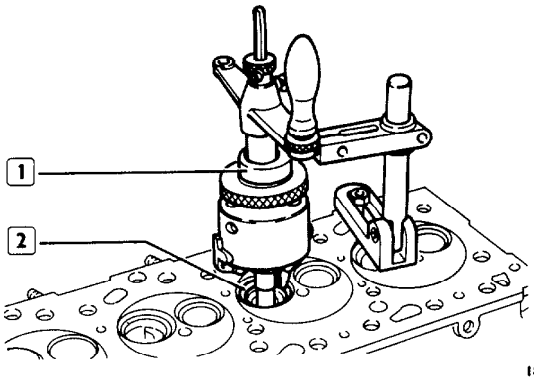
Valve guides (3) are fitted using Drift 99360288 (1) with Adaptor 99360271 (2) Guides supplied in service are oversized on the external diameters by 0 05, 0 10 and 0.25 mm

FIGURE 129



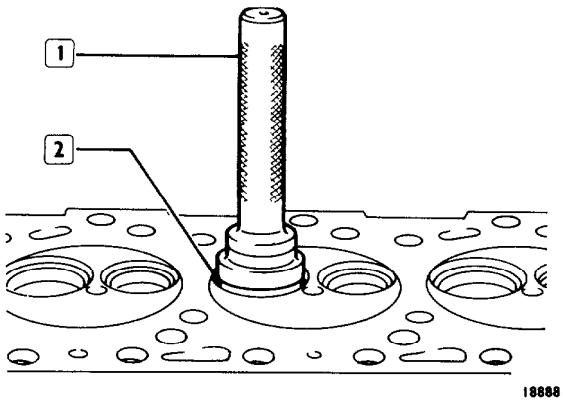
After fitting valve guides, ream with Tool 99390310 (1)

FIGURE 130



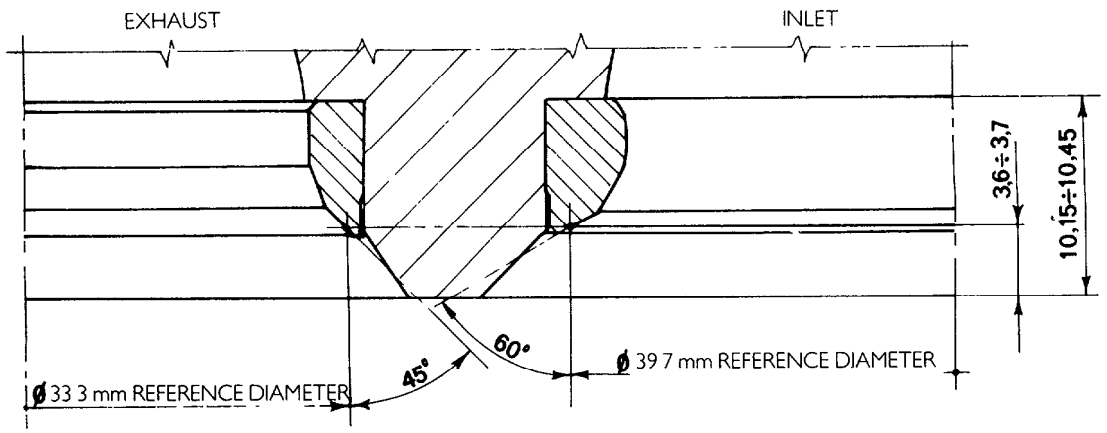
Check valve seats (2), if slightly scored or burnt, grind them using HUNGER Tool 99360419 (1).

FIGURE 131



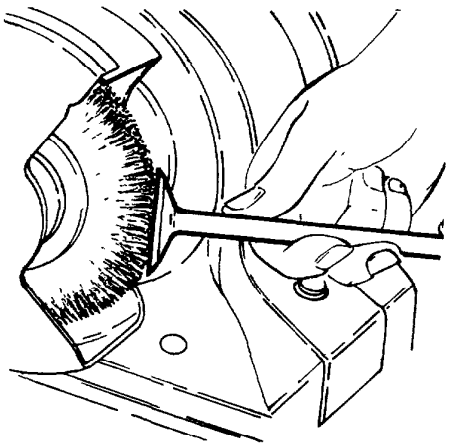
If after grinding seats their seal is poor, replace valve seats Use drift (1) to fit valve seats (2)

FIGURE 132



DETAILS OF VALVE SEATS

FIGURE 133

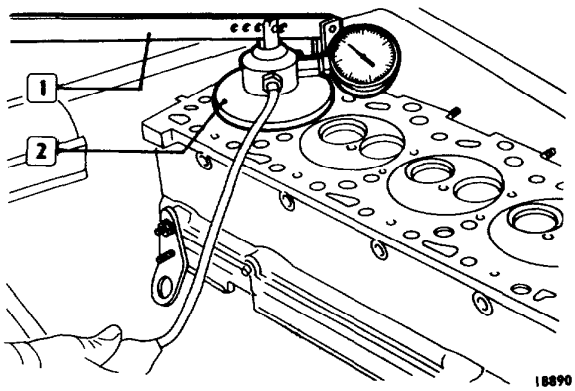


16825

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°15'±7' for inlet valves and 45°30'±7' for exhaust valves

FIGURE 134

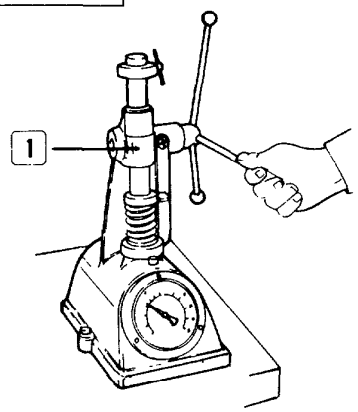


18890

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

NOTE: If a valve spring is found to be inefficient, always replace both springs

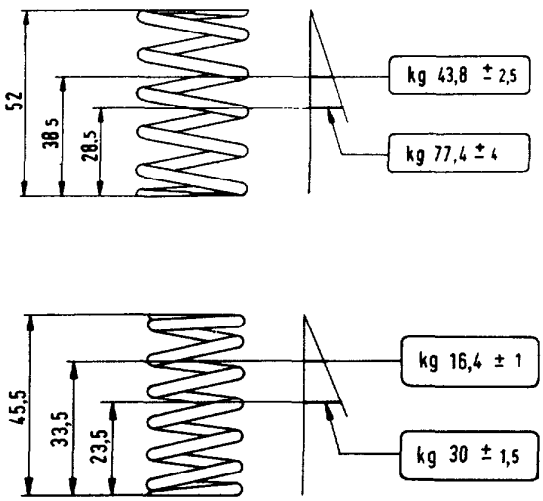
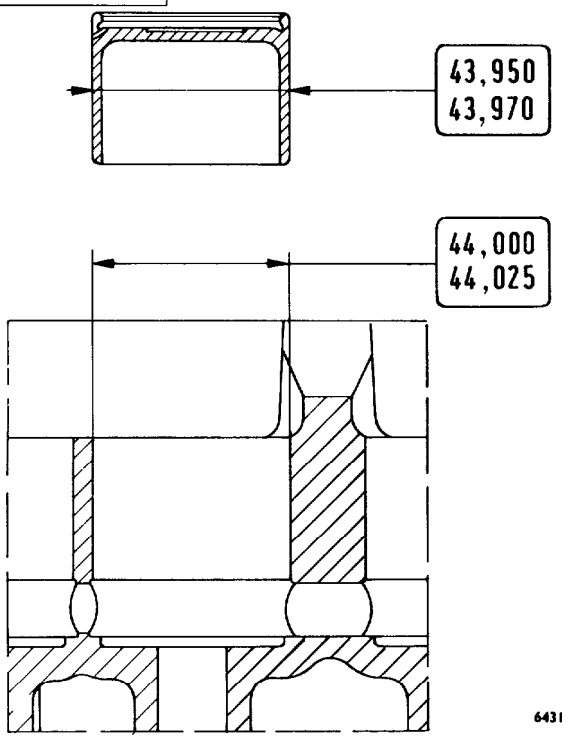
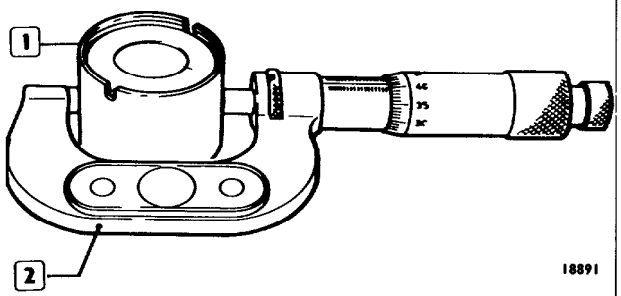


FIGURE 137



DETAILS OF TAPPETS AND SEATS ON CYLINDER HEAD

FIGURE 138

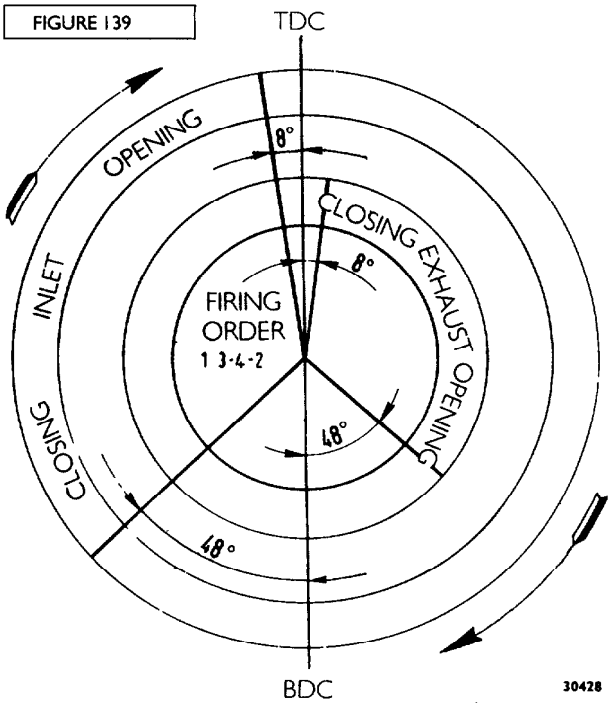


Using a micrometer (2), check diameter of tappet (1) and with an inside micrometer check diameter of its seat on cylinder head, the figures should correspond to those shown in Fig. 137

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

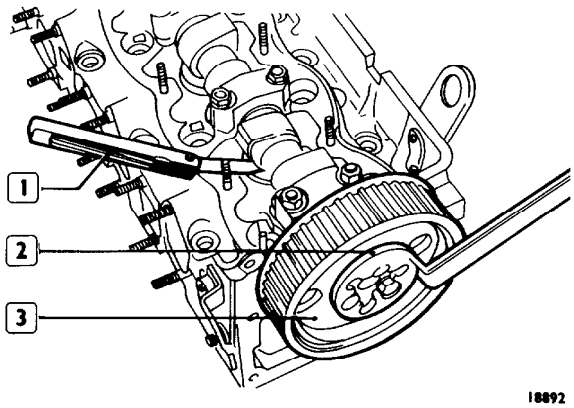
ADJUSTING TAPPET CLEARANCE WITH CYLINDER HEAD ON BENCH

FIGURE 139



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

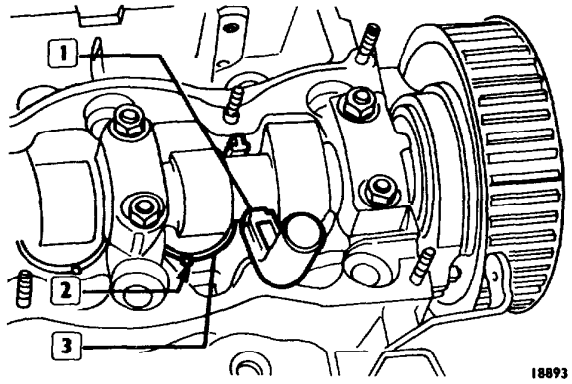
FIGURE 140



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

FIGURE 141

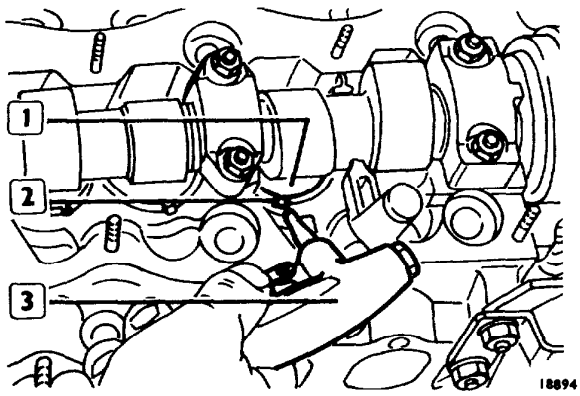


Should it be necessary to replace the adjustment discs, to give the specified operating clearance, proceed as follows

☐ 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,

FIGURE 142

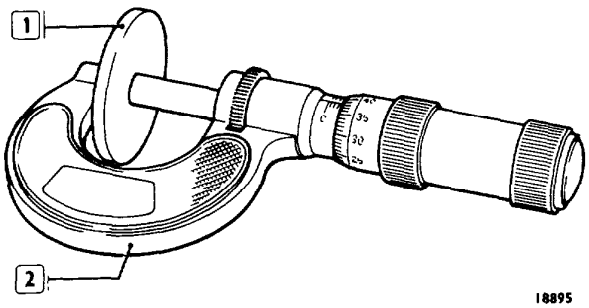


☐ using gun (3) blow a jet of compressed air into milled grooves (2) lifting up the adjustment disc (1) to be replaced,

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,

FIGURE 143

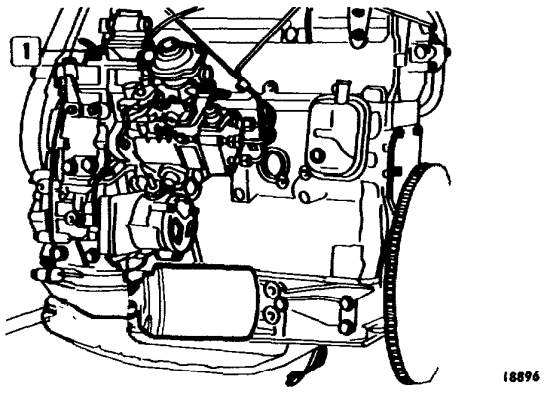


The adjustment disc (1) thickness is stamped on one side, if illegible, measure thickness with a micrometer (2) When fitting the adjustment disc, the engraved figure must face towards the tappet

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

FIGURE 144



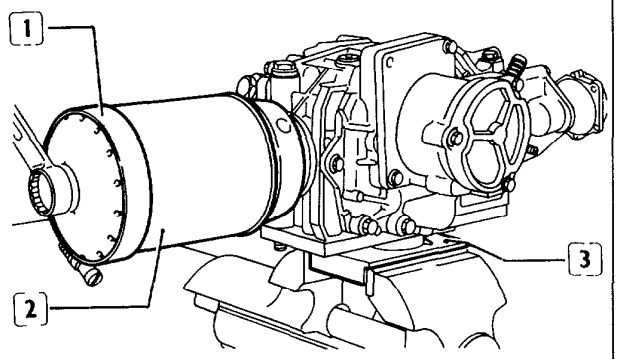
The ancillaries are grouped together on a single mounting (1) fixed on the side of the top engine block and driven by the toothed belt that drives the camshaft

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 for tachometer and heat exchanger.

DISMANTLING THE ANCILLARIES UNIT

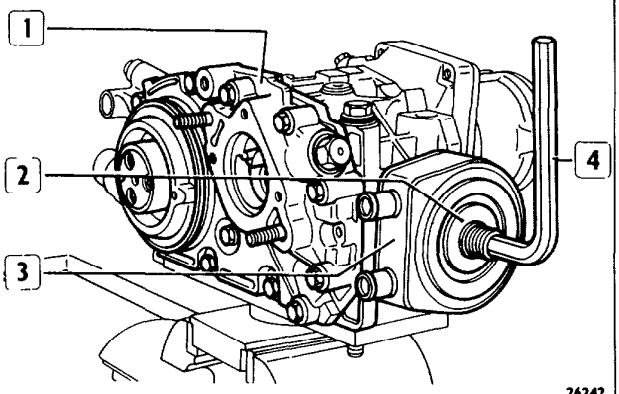
FIGURE 145



26241

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

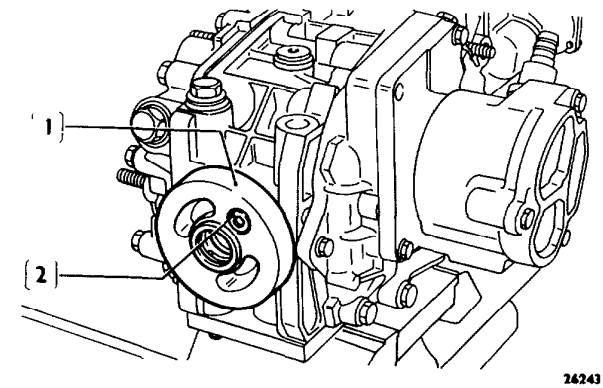
FIGURE 146



26242

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

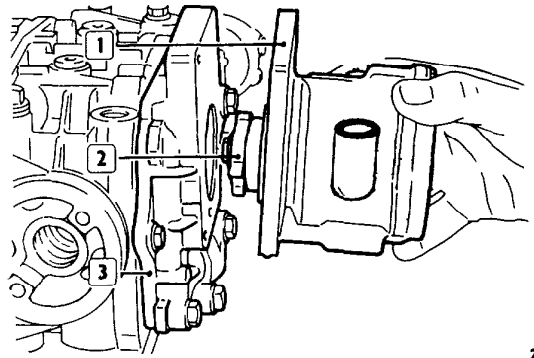
FIGURE 147



26243

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

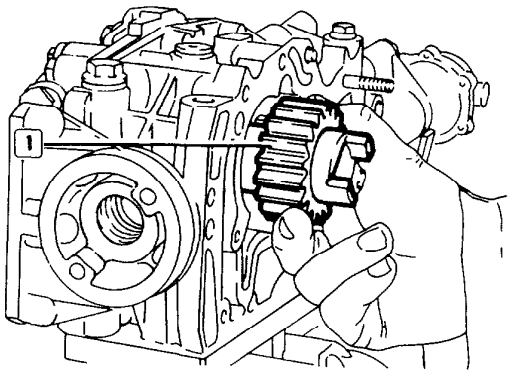
FIGURE 148



26244

Remove 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

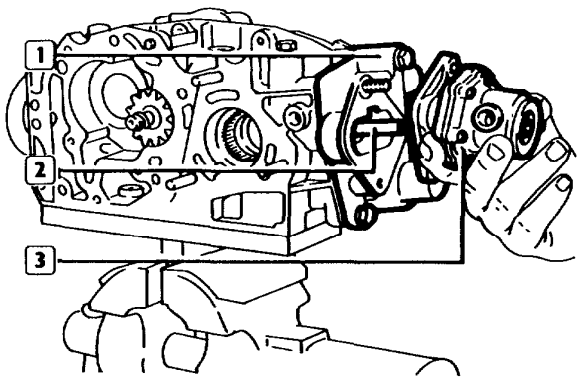
FIGURE 149



26245

Pull off oil pump driven gear (1)

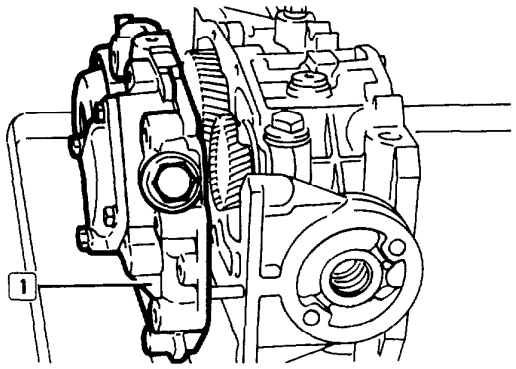
FIGURE 150



18901

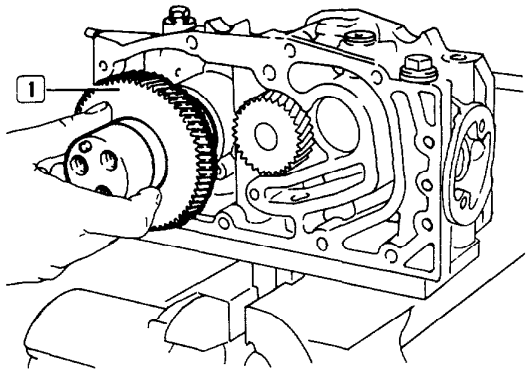
Remove complete fuel pump (3), pull out drive rod (2) and remove top cover (1)

FIGURE 151



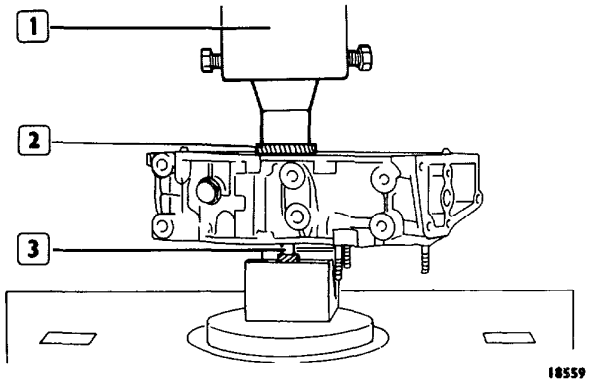
Unscrew bolts and remove front cover (1).

FIGURE 152



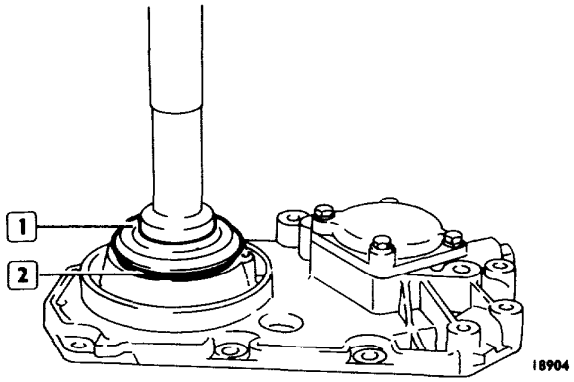
Pull off oil pump drive gear (1).

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).

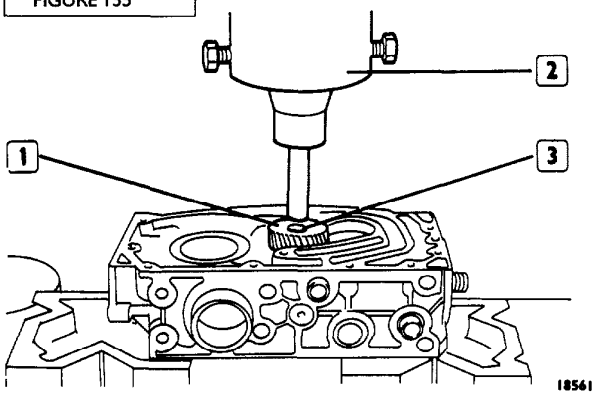
FIGURE 154



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

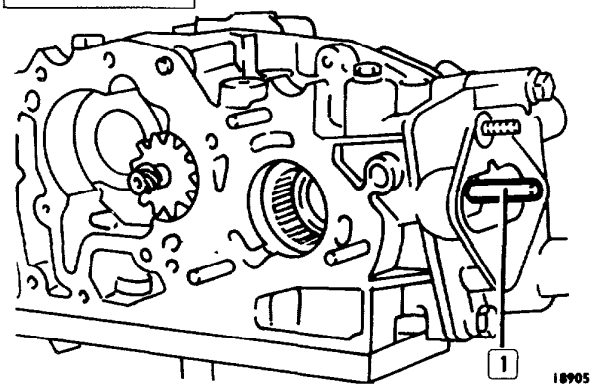
FITTING THE ANCILLARIES UNIT

FIGURE 155



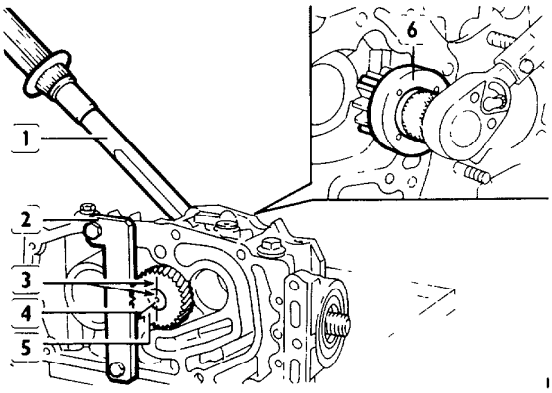
To fit ancillaries unit, carry out dismantling operations in reverse order, remembering that driven gear (1) must be fitted onto drive shaft (3) using a hydraulic press (2), heating the gear and cooling the shaft so that between the two parts there is a temperature difference of approximately 270°C.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

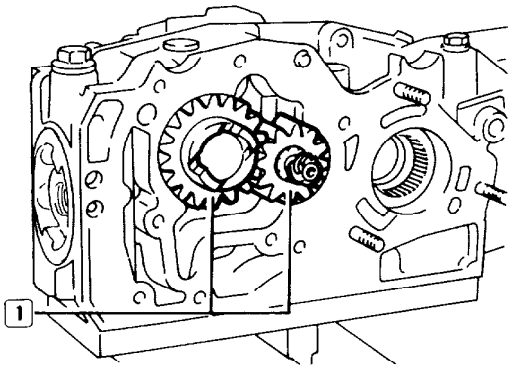
FIGURE 157



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.

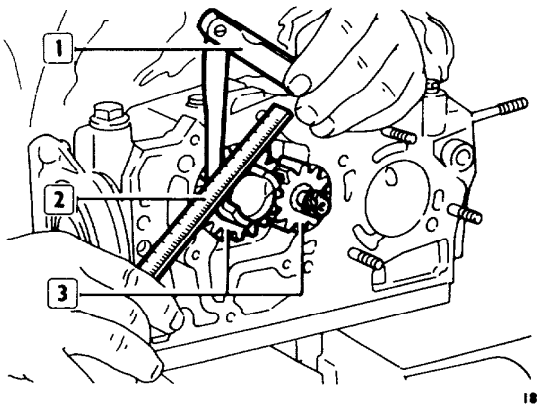
NOTE Before fitting back cover spread a thin layer of LOCTITE 245 over sealing surface.

OIL PUMP



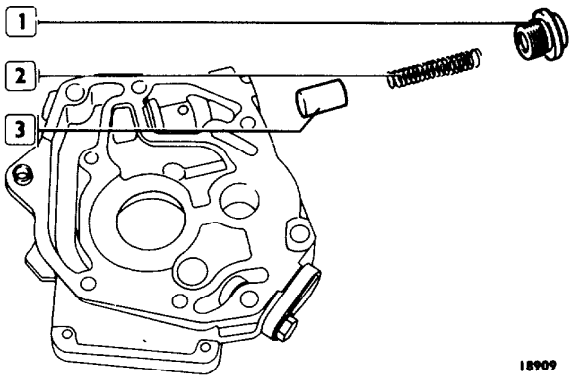
Engine lubrication is by a gear pump (1)
There is a regulating valve on the oil pump cover, lubrication pressure with oil at 100°C
☐ at idling speed 0 8 bar
☐ at rated speed 3 8 bar

FIGURE 160



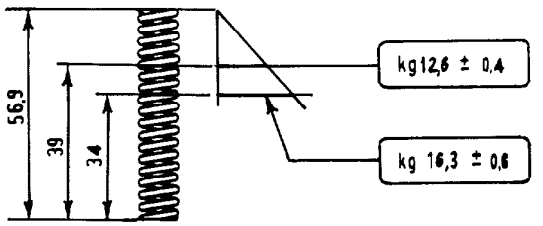
Using straight edge (2) and feeler gauge (1), check clearance between top of gears (3) and cover face, which should be 0 065–0.131 mm, if it is not, replace worn parts

FIGURE 161



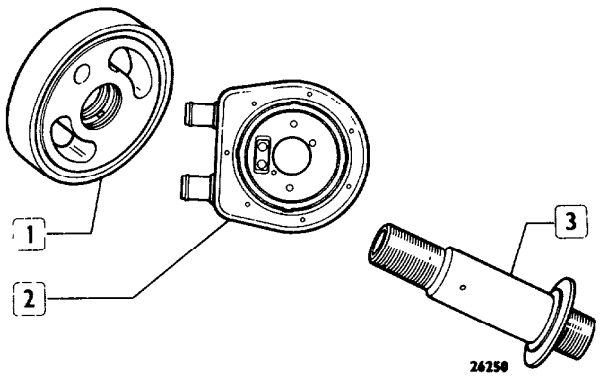
Unscrew plug (1), pull out spring (2) and regulating valve (3)
Check that valve (3) slides freely and has no score marks and that spring (2) is not broken.

FIGURE 162



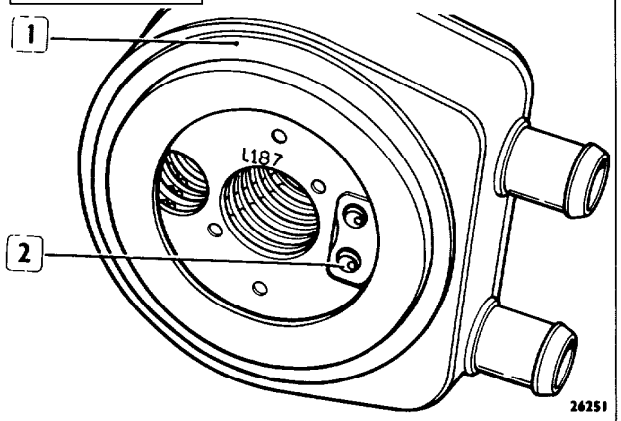
Using Tool 99305049, check that settings for regulating valve spring correspond to those shown in the Figure

FIGURE 163



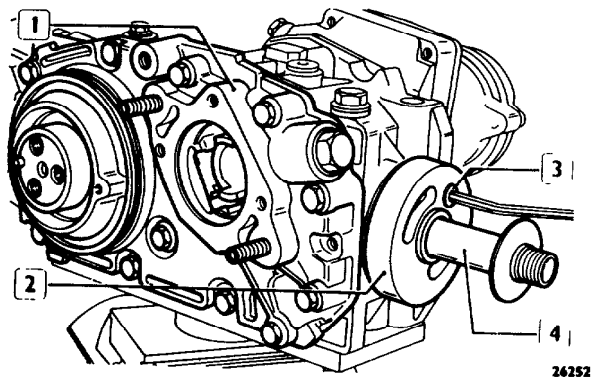
Thoroughly clean support (1), heat exchanger (2) and connection (3), paying particular attention to oilways Always replace sealing rings

FIGURE 164



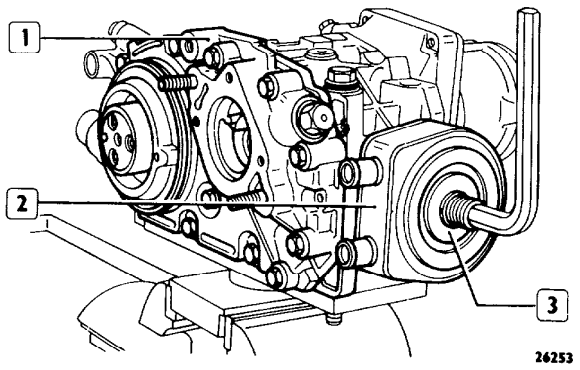
Blow air at a pressure of 1 bar into heat exchanger (1), checking for leaks from both oil side and water side.

FIGURE 165



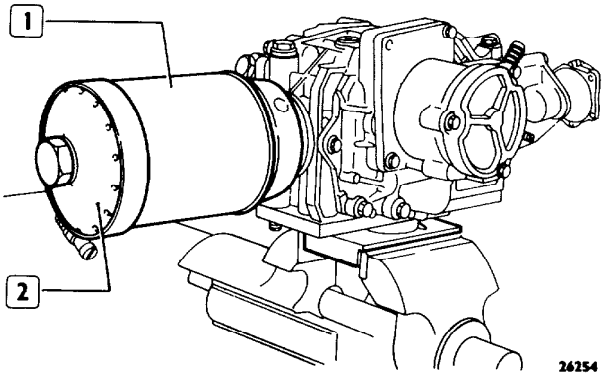
Position support (2) on ancillaries mounting (1), temporarily screw up connection and tighten up support (2) with allen key (3). Remove connection (4)

FIGURE 166



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

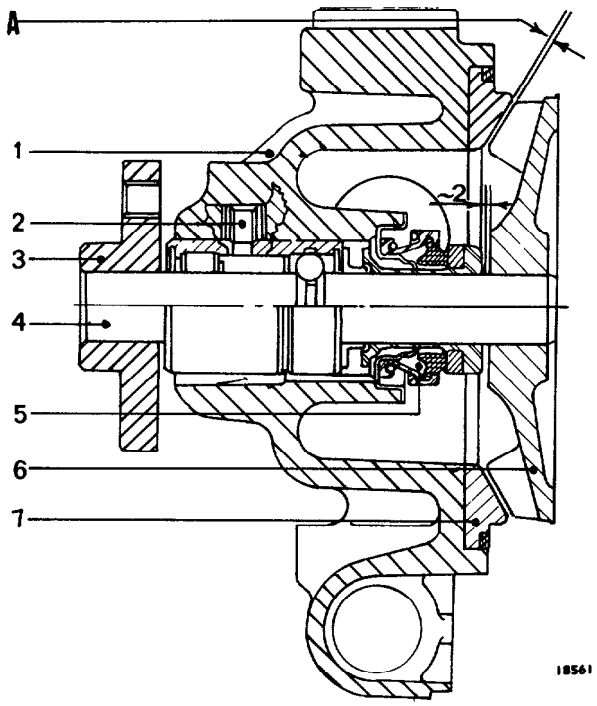
FIGURE 167



Lubricate sealing rings with engine oil and place them on oil filter (1) Screw filter onto connection (4, Fig 135) and using Tool 9936031 4 (2) torque to 55 Nm (5 5 kgm)

WATER PUMP

FIGURE 169

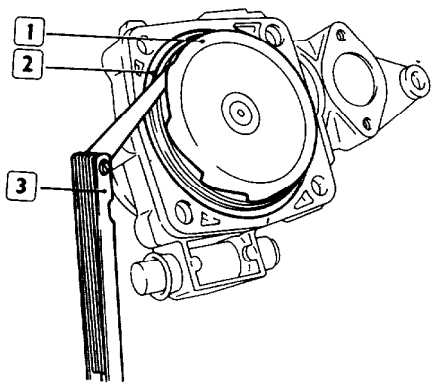


LONGITUDINAL SECTION OF WATER PUMP

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

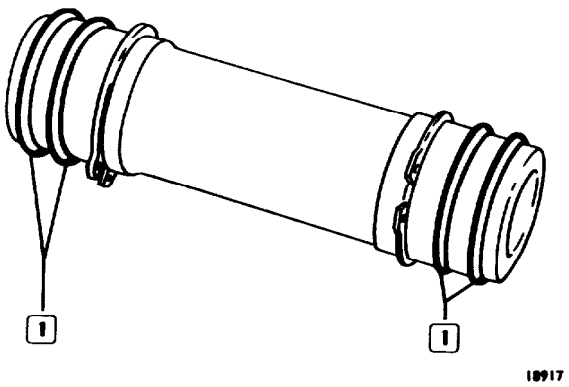
A = 0 56–1 08 mm Fitting clearance between impeller and pump body seal

FIGURE 170



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

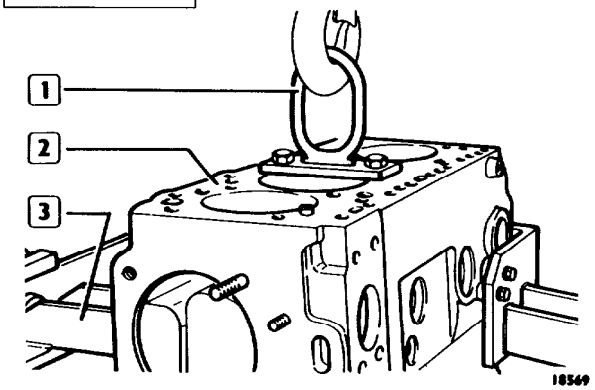
FIGURE 172



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

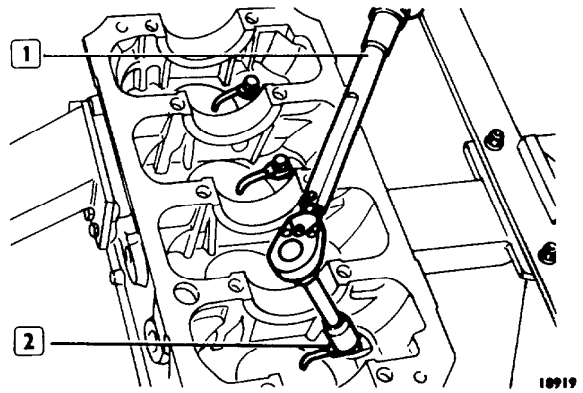
REASSEMBLING THE ENGINE

FIGURE 174



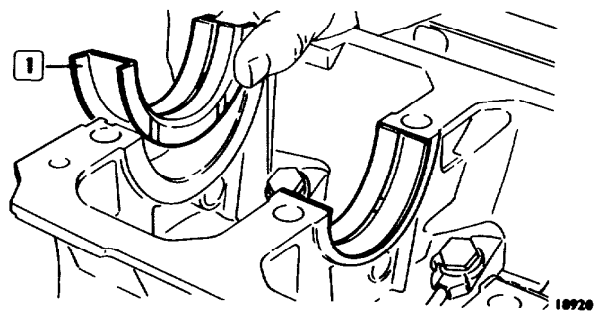
Using Hook 99360508 (1), lift engine block (2) and fix it on Rotary Stand 99322230 by means of Brackets 99361029 (3).

FIGURE 175



Rotate block, fit piston cooling nozzles (2) and tighten up bolts with a torque wrench (1) to 47 Nm (4 7 kgm)

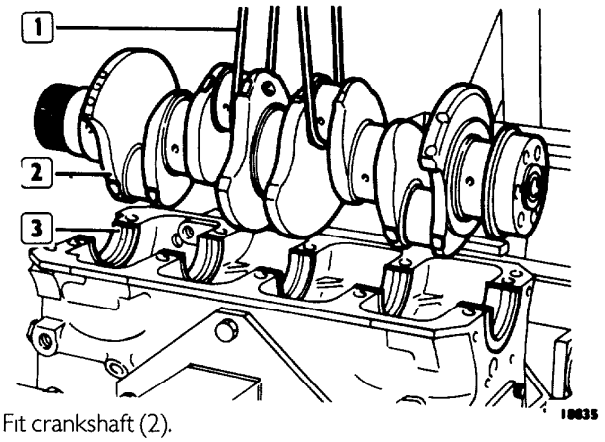
FIGURE 176



Place bearings (1) in their housings and lubricate them.

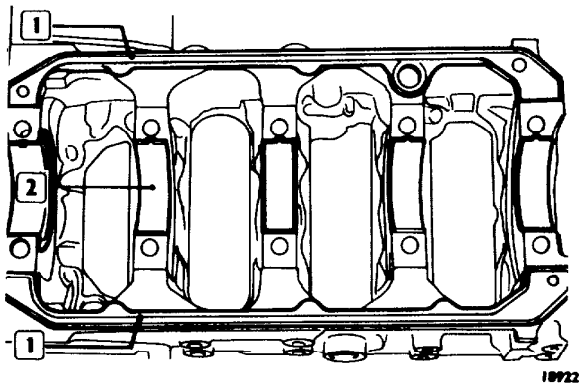
NOTE. The main bearings, fitted in the top block housings, have an oilway, they must not, therefore, be fitted onto the bottom block housings.

FIGURE 177



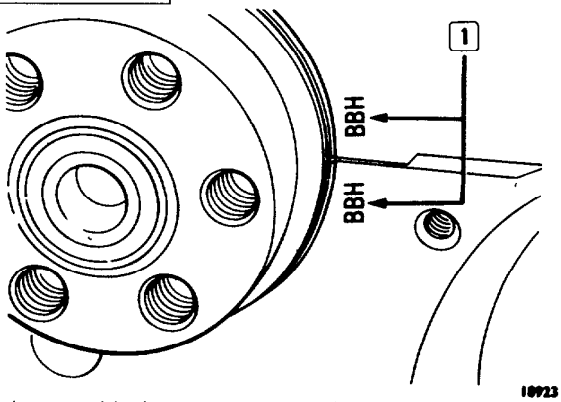
Fit crankshaft (2).

FIGURE 178



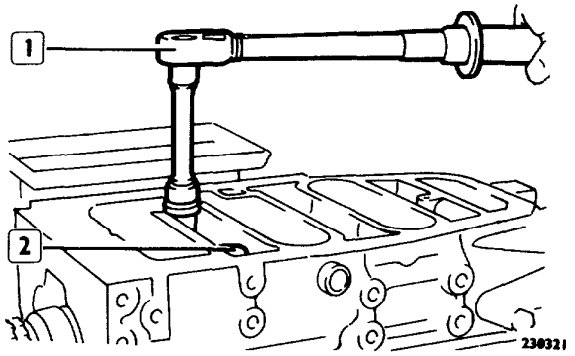
Fit rubber seals (1) and main bearings (2) onto bottom block.

FIGURE 179



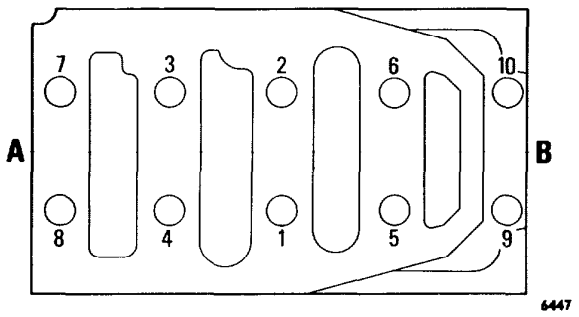
Fit bottom block onto top one checking that reference marks (1) match, since component parts of block are not interchangeable

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

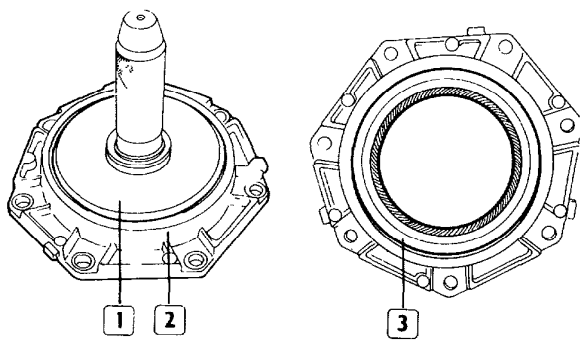
FIGURE 181



A Timing Side – B Flywheel Side

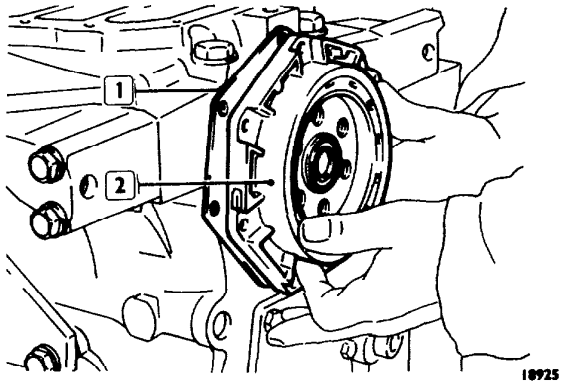
Diagram showing tightening sequence of bolts fixing bottom block to top block

FIGURE 182



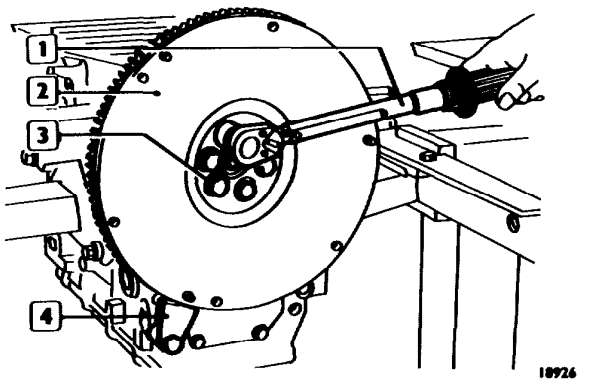
Fit sealing ring (3) onto rear cover (2) using installer 99374328 (1) complete with handle 99370006

FIGURE 183



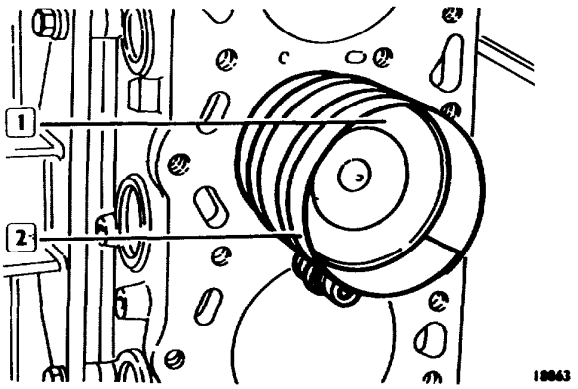
Position gasket (1), fit cover (2) and secure it to block with its bolts.

FIGURE 184



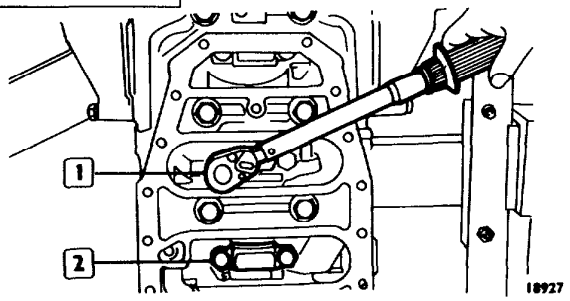
Fit flywheel (2), prevent it from turning by means of tool 99360306 (4) and tighten up bolts (3) using torque wrench (1) to 117 Nm (12 kgm) Remove tool 99360306 (4)

FIGURE 185



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

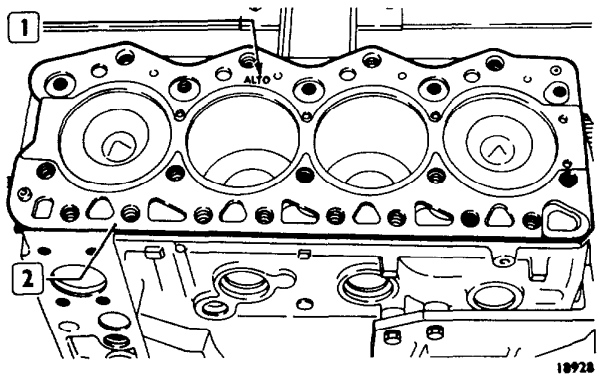
FIGURE 186



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° ±3°

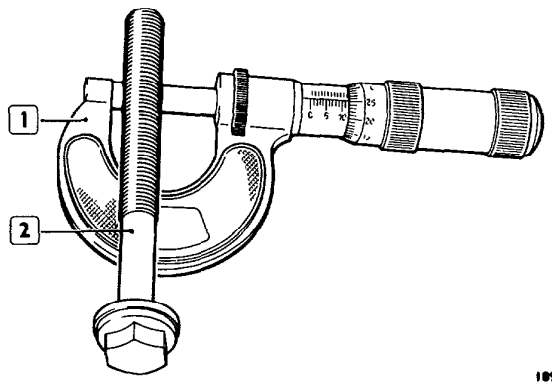
NOTE: When fitting piston/connecting rod assembly in Cylinder No. 4, position Piston No 4 to TDC so as to be able to fit its connecting rod cap.

FIGURE 187



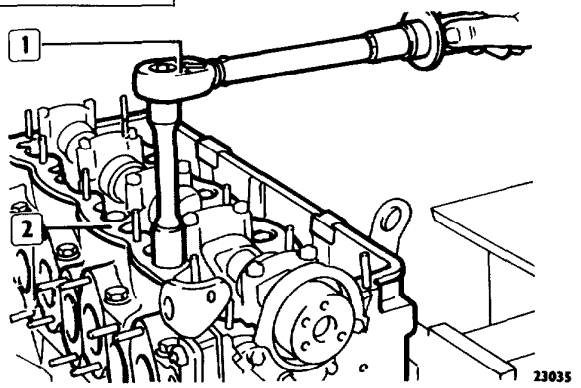
Rotate engine through 90° to a horizontal position, fit cylinder head gasket (2) with the word ALTO (TOP) (1) facing upwards.

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

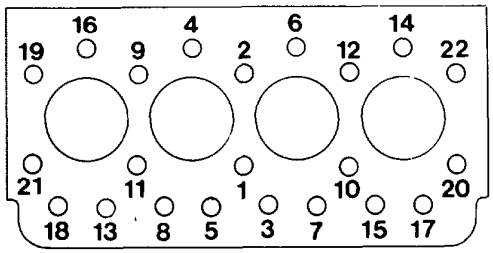


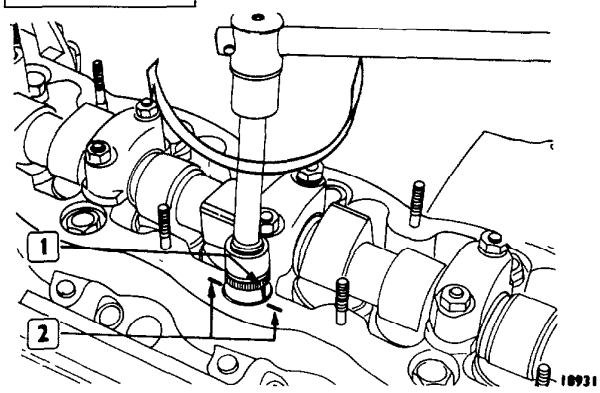
Diagram showing Tightening sequence of Cylinder Head Bolts

☐ 1st stage pre-tighten with torque wrench to 40 Nm (4 kgm), *

☐ 2rd stage final tighten through a further angle of 180°

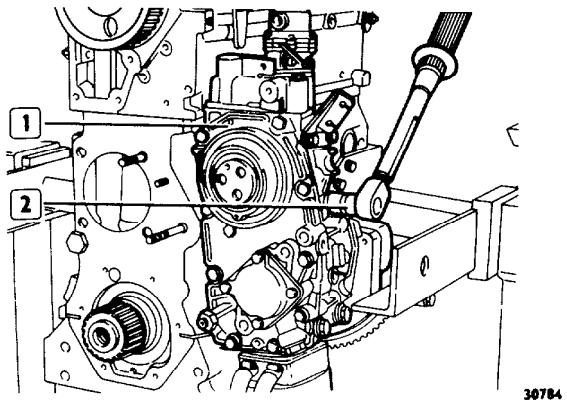
* From serial number 499114 (up to serial number 499113 : 88 Nm) .

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

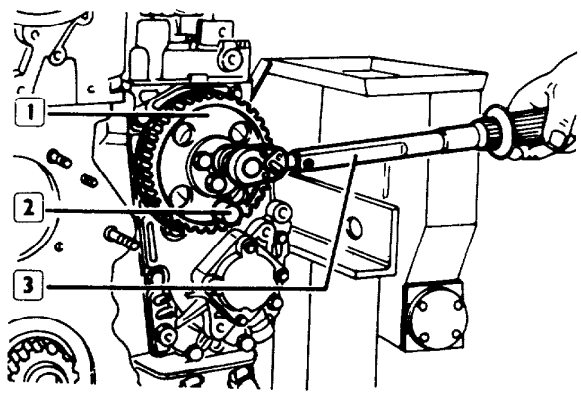


Fit ancillaries unit (1) and insert sealing rings, tighten bolts with torque wrench (2) to specified torque setting

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

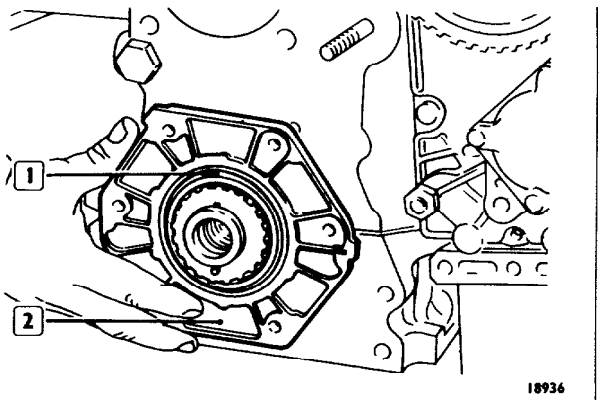
Fit dipstick pipe and oil filler pipe

FIGURE 193



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

FIGURE 194



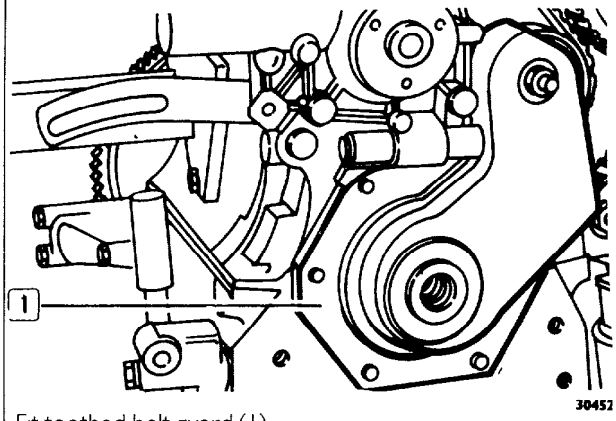
After fitting sealing ring (1) on front cover (2) insert gasket and fit cover onto block

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

Fit adjustable belt-tensioner

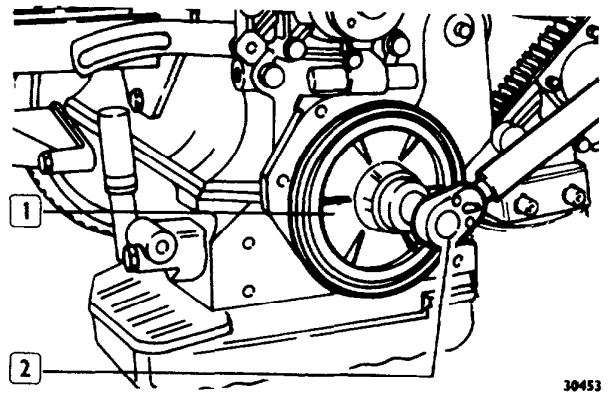
Then fit camshaft drive toothed belt as described in the CAMSHAFT DRIVE Section on page 116

FIGURE 195



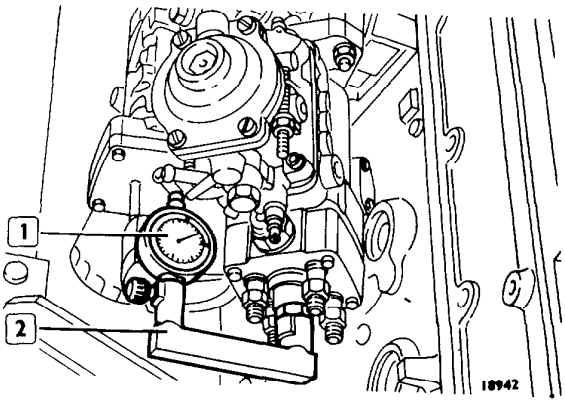
Fit toothed belt guard (1)

FIGURE 196



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)

FIGURE 198



- ☐ remove cap on pump fixing bolt and screw in Tool 99395099 (2), with rod in contact with crown of distributor plunger;
- ☐ preload dial gauge 99395603 (1) by 3 mm,
- ☐ turn engine in opposite way to its normal direction of rotation until distributor plunger on pump reaches BDC, as shown on the dial gauge,
- ☐ set dial gauge to zero,

TIGHTENING TORQUES

PART		TORQUE Nm (kgm)
Clinder 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	▲	70 (7 0)
Ancillaries support { M8		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		201 (20.5)
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
* From serial number 499114 (up to serial number 499113 : 88 Nm) .

	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	47 (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
99340213	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
99360355	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