













ENGINE OVERHAUL

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INTRODUCTION

This manual shows the overhaul procedures for the engine groups taking it that these groups have already been removed from the vehicle and set on a suitable stand.

The title-page of the manual lists the codes of the engine given in the text.

The specific manual for the vehicle in question, Volume I - Group 00 - Technical data - Identification of models, should be consulted to rapidly identify the engine belonging to the various models of vehicle.

This chapter also gives the technical data relative to the engine.

How to use this manual

The aim of this manual is to supply the Alfa Romeo Service Personnel with a tool enabling them to rapidly identify faults and to render the corrective interventions precise and efficient.

The manual illustrates the procedures relative to the dismantling operations and checks for the various engine groups. The procedures are illustrated in detail as is the use of the tools required. Appropriate symbols and explanations next to the main technical drawings facilitate a rapid and complete consultation of the manual.

The procedures illustrate complete disassembly procedures for the components which should only be carried out in their entirety when strictly necessary. The "refitting" procedures are normally obtained by reversing the operations followed for removal and only those assembly procedures which are significantly different are given in full.


























All the information given in this manual is accurate at the time of publication.

Alfa Romeo reserves the right to make any modifications to its products that it deems necessary without warning. However the technical information and updates to this manual will be supplied as soon as possible.

Symbology

A specific symbology has been used in this manual to permit a rapid identification of the main technical information supplied.

The list of symbols is given below.

	removal/disassembly			exhaust
	refitting/re-assembly			Lubricate only with engine oil
	tighten to the torque			left-hand thread
	caulk nut			torque for tightening in oil
	adjustment/regulation			engine r.p.m.
	visual check			ovalization
	lubricate			taper
	weight difference			eccentricity
	angular value			flatness
	pressure			diameter
	temperature			linear dimension
	brake system air purge			parallelism
	surfaces to be treated			service with grease
	interference			heating temperature
	play			seal
	intake			service with engine oil
				grease
				CAUTION!
				WARNING!

Warnings for the operator

All the operations must be carried out with the greatest care to prevent damage occurring to the vehicle or persons.

- The use of Alfa Romeo specific tools are indicated for some procedures. These tools must be used to ensure safety and to avoid damaging parts involved in the procedure.
- To free parts which are solidly stuck together, tap with an aluminium or lead mallet if the parts are of metal. Use a wooden or resin mallet for light alloy parts.
- When dismantling ensure parts are marked correctly if required.
- When refitting lubricate the parts, if necessary, to prevent seizing and binding during the initial period of operation.
- Using adhesive paper or clean rags cover those parts of the engine which, following disassembly, present openings which may allow dust or foreign material to enter.
- When refitting, the tightening torques and adjustment data must be respected.
- When substituting the main component(s) the seal rings, oil seals, flexible washers, safety plates, self-locking nuts and all worn parts must also be replaced.
- Avoid marking the internal coverings in the passenger compartment.

Substitution of groups or disconnected parts must be carried out using original spare parts only. Only in this way can the suitability and perfect operation of each organ be guaranteed.

- The words **CAUTION** and **WARNING** accompany those procedures where particular care should be taken to prevent damage occurring to people or vehicle parts.



CAUTION:
used when insufficient care could cause damage to people



WARNING:
used when insufficient care could cause damage to the vehicle or its component parts.

- The safety regulations applied to workshops should be respected. Where necessary the manual also lists the specific precautions to be taken to prevent dangerous situations from arising.



When using chemical products follow the safety indications given on the safety cards which the supplier is obliged to deliver to the user (in Italy in compliance with D.M. n.46/1992).

NOTE:

It is possible that for certain subjects were not completed in time for printing. However these subjects are given and highlighted in the indices of the single groups. It is the duty of the Technical Services to supply documentation regarding these subjects as soon as possible through updates or "Technical Bulletins".



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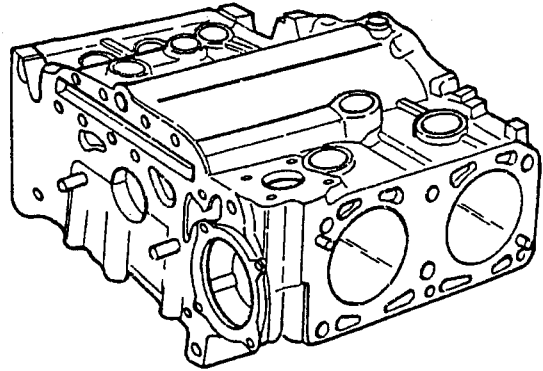
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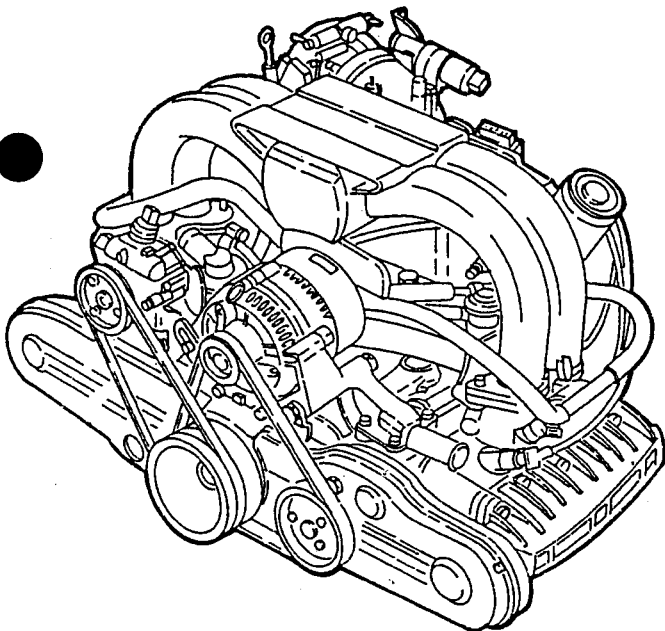
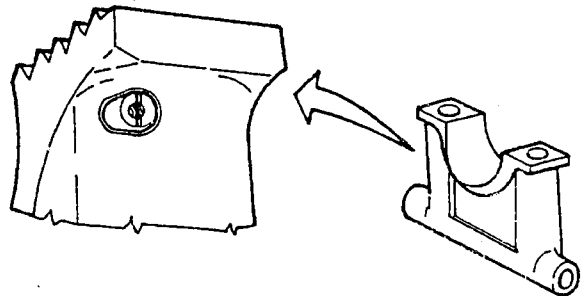
DESCRIPTION

The engine has 4 opposed cylinders, double camshaft for each cylinder head, two valves per cylinder controlled by hydraulic tappets and BOSCH MP3.1 multipoint electronic injection and static ignition for the 1.6 engine and IAW for the 1.3 engine. The clutch - gearbox - differential unit is connected behind the engine and forms an integral part of the power unit.

Special grooves machined in the crankcase walls allow the circulation of coolant fluid and lubricating oil.



Oil spray jets installed on the front and centre main bearing caps spray oil on the piston crowns to partially cool them.



The latter is front mounted and set longitudinally with a 3° inclination.

The power unit is fastened to the body by "suspension" type mounts through a support frame connected to the gearbox - differential unit. The various connections of the power unit to the support frame and to the rear support are made with appropriate flexible mounts to absorb engine vibrations.

The fuel supply system, with unleaded petrol, combined with the suitable antipollution systems described in the specific paragraphs, ensure low exhaust emission levels meeting "USA 83" regulations.

CYLINDER HEADS

This is one-piece, compact and chill-cast in aluminium and silicium alloy.

The camshaft bearings are fastened on the cylinder heads, these too, are made from aluminium and silicium alloy.

The camshafts, controlled through toothed belts, turn on three supports.

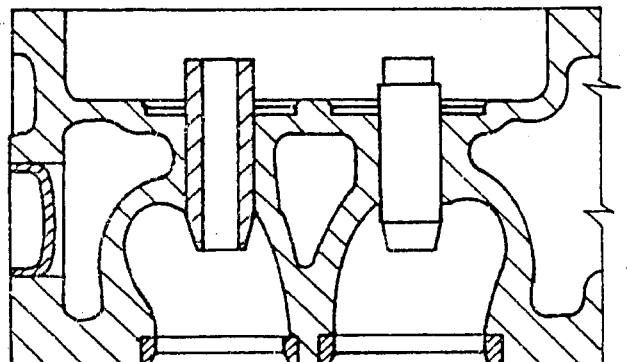
The valve guides are force-fitted in their housings on the cylinder heads by interference and the inside diameter is perfected after assembly using a specific reamer and checked using a pair of no-no go gauges. The seals between the cylinder heads and crankcase are of the ASTADUR type.

CRANKCASE

This is a single cast iron block with high mechanical strength.

The crankshaft is supported by 3 main bearings which house the same number of thin-walled half bearings.

The cylinders are machined directly in the crankcase and they are selected in five classes of dimensions. If cylinder wear exceeds the specified values, they must be bored to the specified diameters according to the oversizes of the pistons available from Spares (see CPT).





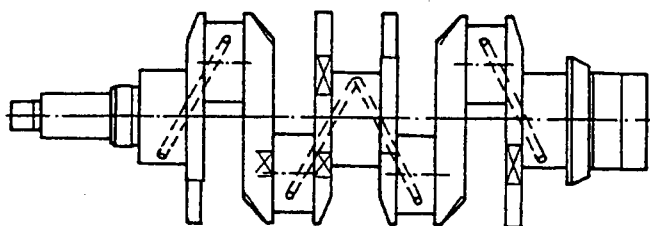
Due to the special material with which they are made, these seals are polymerized when the engine is running and harden considerably during use, therefore it is no longer necessary to tighten the cylinder heads at the first service coupon.

CRANKSHAFT

This is forged in high-strength, hardened and tempered steel. It rests on three main bearings and its end float is adjusted by two half rings housed in the rear main bearing.

Six counterweights accurately balance the rotating masses.

A set of grooves run inside the shaft to lubricate the main and connecting rod journals.



MAIN AND CONNECTING ROD HALF BEARINGS

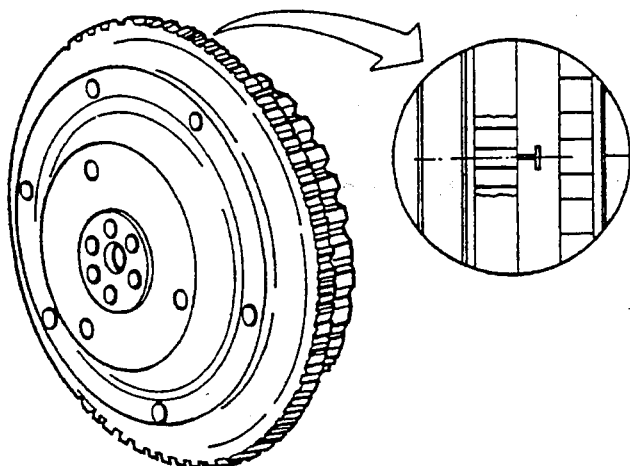
These are of the three-metal, thin shell type subdivided into two dimensional classes.

The main half bearings have a hole and groove for lubricating the rod journals.

FLYWHEEL

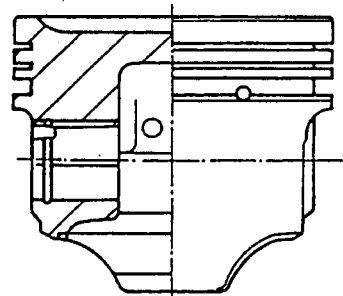
This is in cast iron, with two ring gears in hardened and tempered steel: one for connection with the starter motor and one for the rpm sensor facing it.

The "T" notch for checking engine timing is stamped on the flywheel.



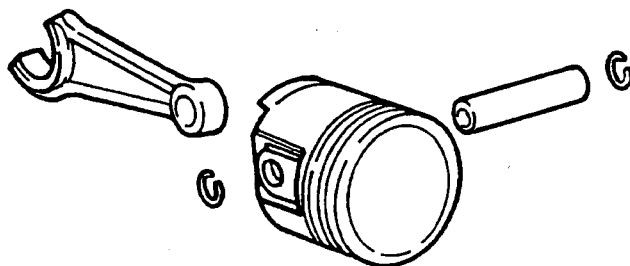
PISTONS AND CONNECTING RODS

The pistons in aluminium silicium alloy are subdivided into five dimensional classes and they are available as Spares in three other oversize classes.



The connecting rods are in hardened and tempered alloy steel, with a copper alloy bush for coupling with the piston gudgeon pin.

As the pins are floating on both the piston hubs and on the bush force-fitted in the connecting rod small end, their side stroke stop is made by two expanding circlips which are housed in special hollows machined on the actual hubs.



The right cylinder head pistons are positioned with the arrow stamped on the piston crown facing upwards and those of the left cylinder heads with the arrow pointing downwards.

TIMING

Direct drive by toothed belts, with overhead camshafts in case-hardened alloy steel. The hydraulic tappets in contact with the cams operate the valves directly.

This device, which has also been adopted in the 1712 16V, automatically eliminates "valve play" when the engine is running, thereby enormously reducing the need for periodic maintenance. The exhaust valve stem is chromium-plated and inside it has a hollow filled 50 + 60% with sodium which improves dispersion of the heat to which they are subjected.

The valve seats are sintered in material suitable for use with unleaded petrol.

LUBRICATION

Lubrication is forced by gear pump. The oil pump is fitted on the rear engine cover and it is operated by a shaft that receives motion from a gear installed behind on the crankshaft. The oil withdrawn from the sump through a suction device is filtered by the mesh filter on the actual suction device and then sent under pressure by the pump through a groove to the oil filter with full-flow cartridge fitted with a safety by-pass valve which ensures that the oil can still pass if the filter is clogged.

The maximum lubricating pressure is adjusted by a special limiting valve fitted on the pump. After being filtered, the oil flows through a transversal duct into the main longitudinal delivery duct machined in the crankcase. From here, it is ducted through three grooves to the lubricating grooves of the crankshaft main and rod bearings.

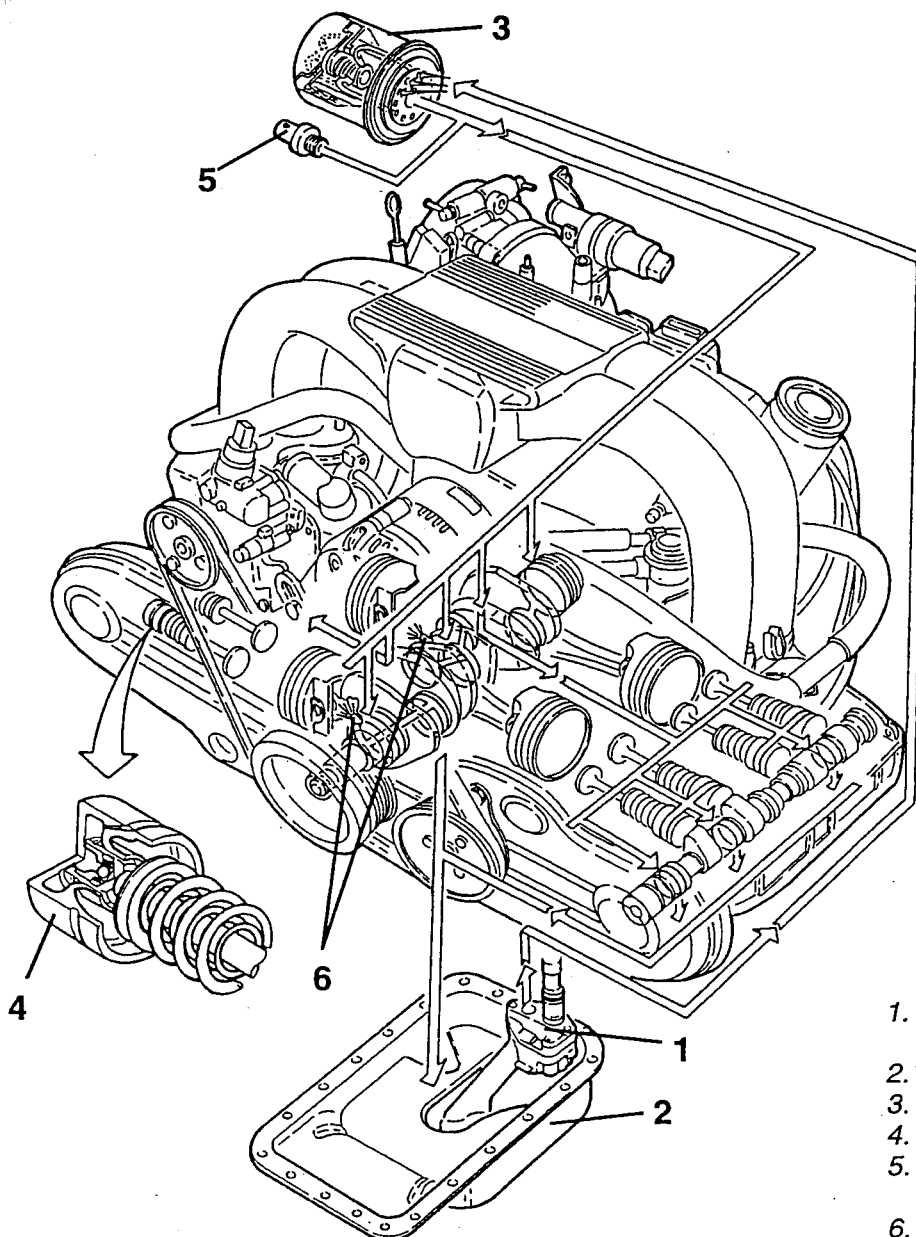
To improve cooling of the pistons on the right main bearing spray jets have been fitted on the front and centre main caps.

Through two transversal grooves and suitable branches machined in the crankcase and cylinder heads the oil reaches the camshaft bearings and allows the hydraulic tappets to work.

The cylinder head lubrication oil gathered in the trays of the camshaft bearings and the lubrication oil of the main and rod journals falls back into the sump.

The lubrication system is fitted with an oil vapour recirculation system which recovers the vapours coming from the sump.

Low oil pressure is signalled by a warning light on the dashboard connected to a sensor inserted on the rear engine cover.



1. Oil pump with pressure limiting valve
2. Oil sump
3. Oil filter with by-pass valve
4. Hydraulic tappet
5. Low oil pressure warning light sensor
6. Spray jets

INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhaul of the engine on the bench, after removing the power unit from the engine. The instructions are subdivided as follows:

- **Dis-assembly of the engine:**
removal of the engine accessories and components and dis-assembly into its main component parts.
- **Dis-assembly and checks of the crankcase:**
complete overhauling of the crank mechanisms.
- **Cautions for re-assembly:**
these include specific re-assembly operations where they differ substantially from the instructions for dis-assembly.
- **Checks and inspections of electrical components of the lubrication circuit.**

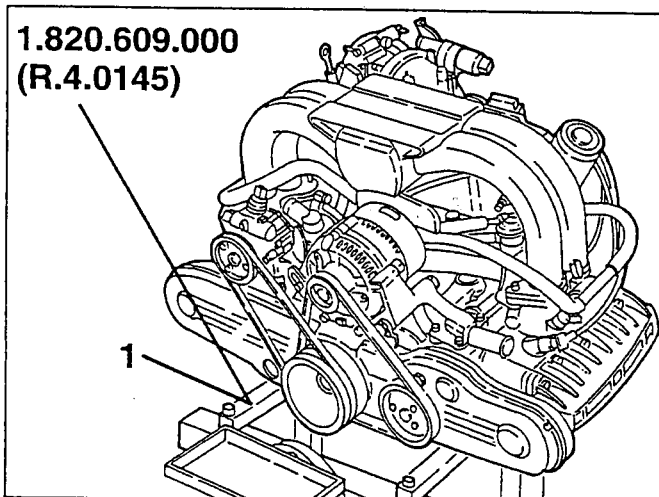
For re-assembly, the sequence for all the dis-assembly instructions described hereafter, should be reversed unless otherwise specified.

The following procedures refer to complete overhauling of the whole engine; it is however possible to use individual parts of these instructions when dealing with specific components.

ENGINE DIS-ASSEMBLY

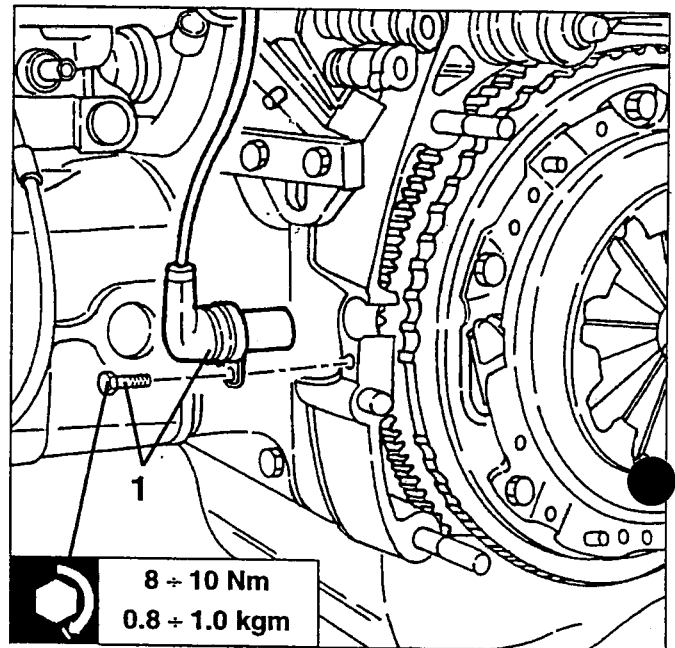
Preliminary operations

1. Set the engine on a special overhauling stand using supports N° 1.820.609.000 (R.4.0145).



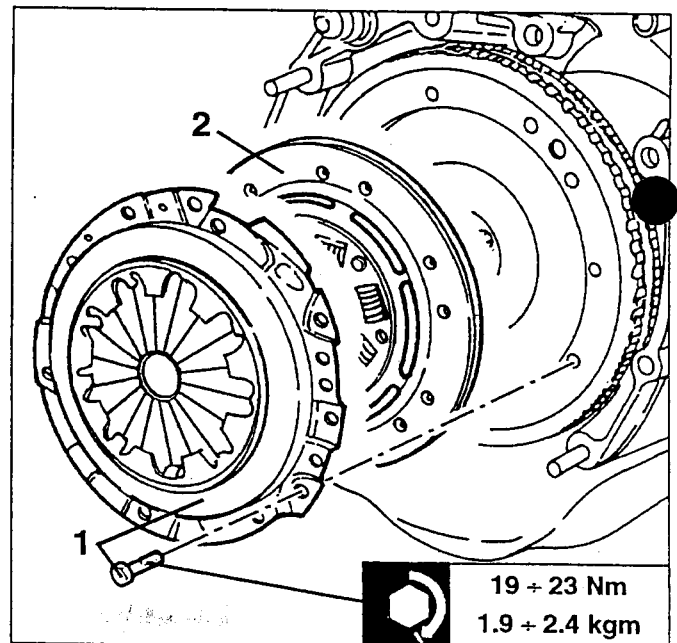
Removing the rpm sensor

1. Slacken the fastening screw and remove the sensor.



Removing the clutch plate

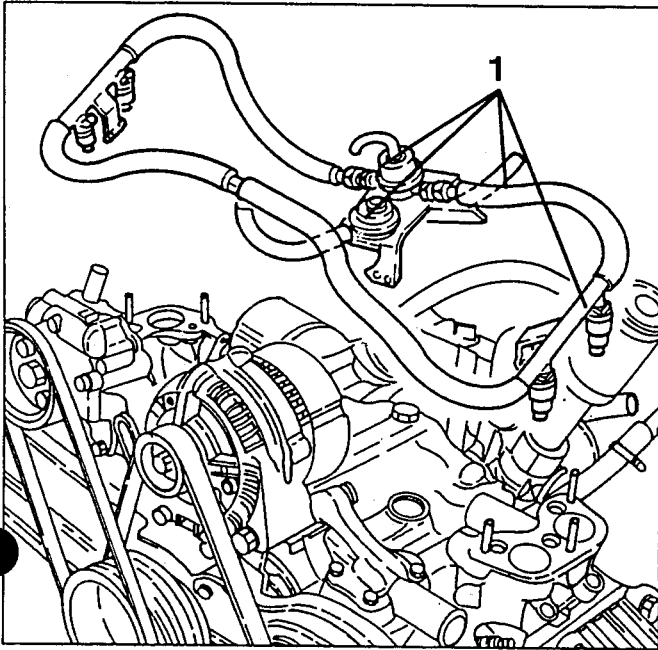
1. Slacken the fastening screws and remove the pressure plate.
2. Remove the clutch plate.



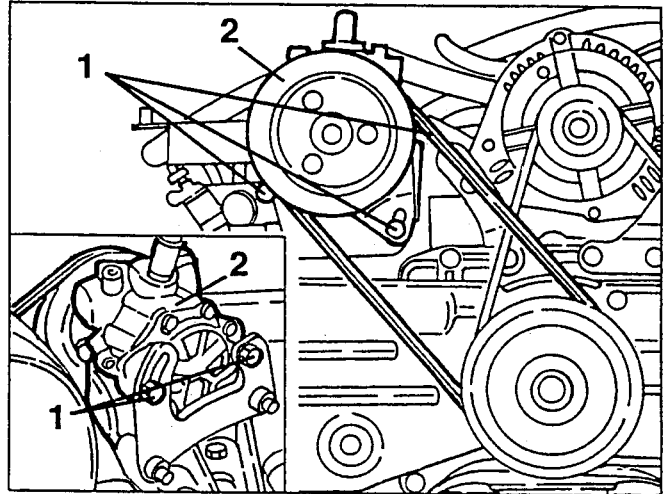
Removing the fuel distributor manifold

1. Slacken the fastening screws and remove the fuel distributor manifold complete with injectors, pulse

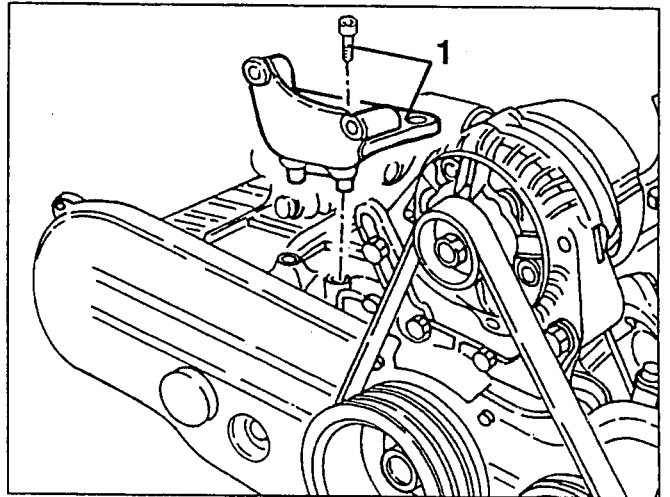
damper and pressure regulator.



2. Completely unscrew the screws slackened previously and remove the power steering pump.

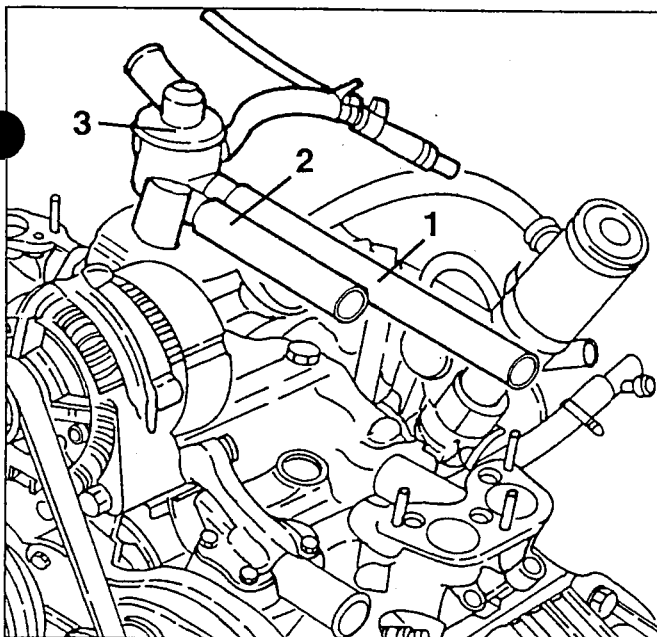


1. Slacken the two fastening screws and remove the power steering pump support bracket.



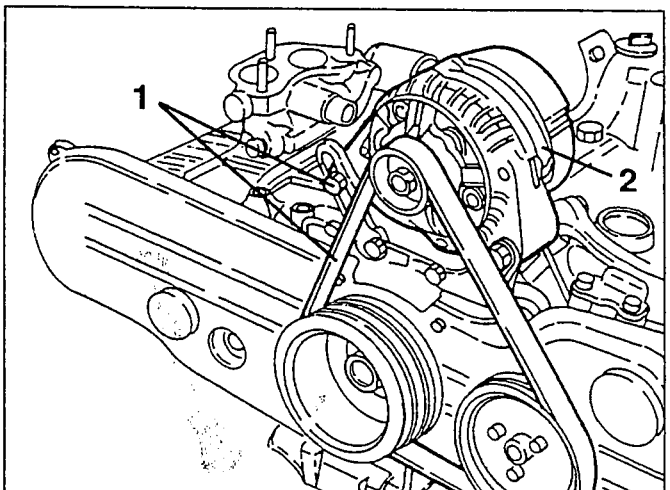
Removing the thermostat unit

1. Disconnect the coolant outlet pipes from the intake manifolds.
2. Disconnect the pump-thermostat connection pipe from the coolant inlet union.
3. Slacken the fastening screw and remove the thermostat unit complete with hoses.



Removing the alternator

1. Slacken the two alternator fastening bolts; prise and remove the drive belt.
2. Completely back off the two bolts slackened previously and remove the alternator.

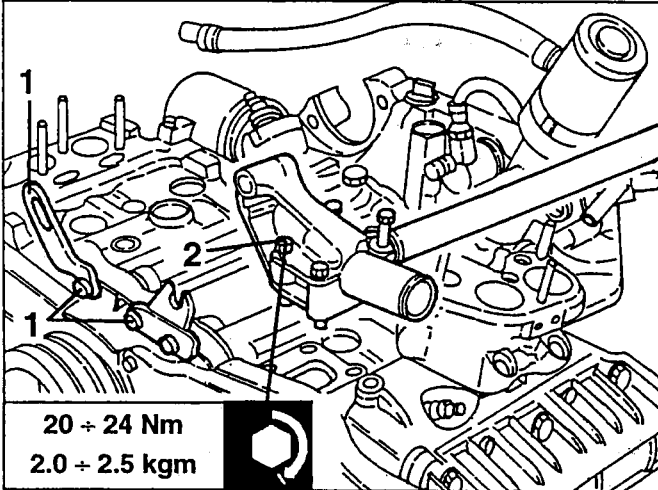


Removing the power steering pump

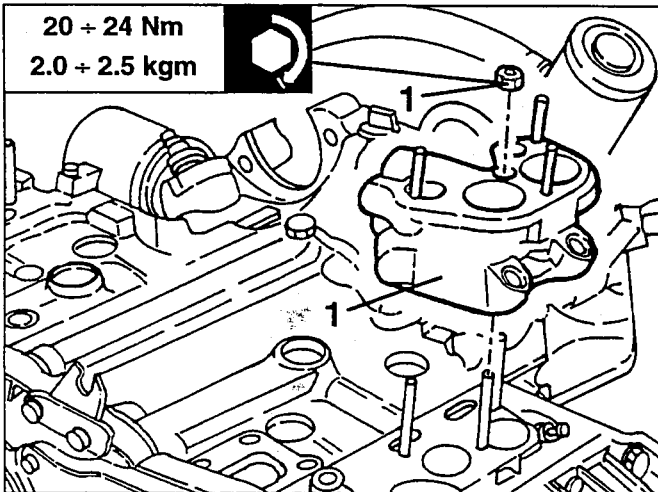
1. Slacken the power steering pump fastening screws; prise and remove the drive belt.

Removing the brackets

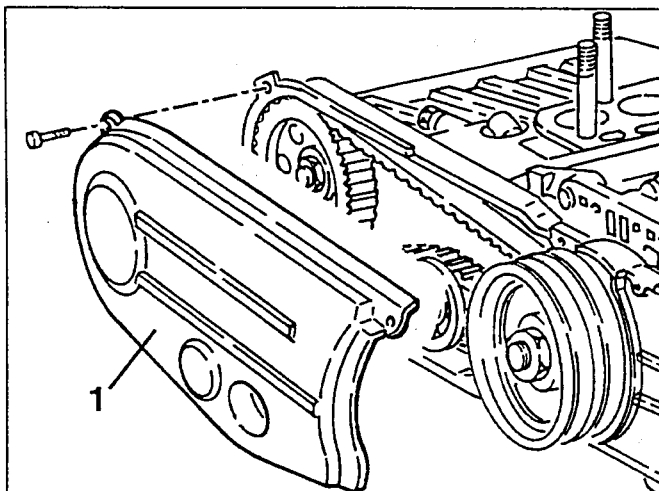
1. Slacken the fastening screws and remove the alternator support brackets.
2. Slacken the fastening screws and remove the water pump inlet union.

**Removing the intake manifolds**

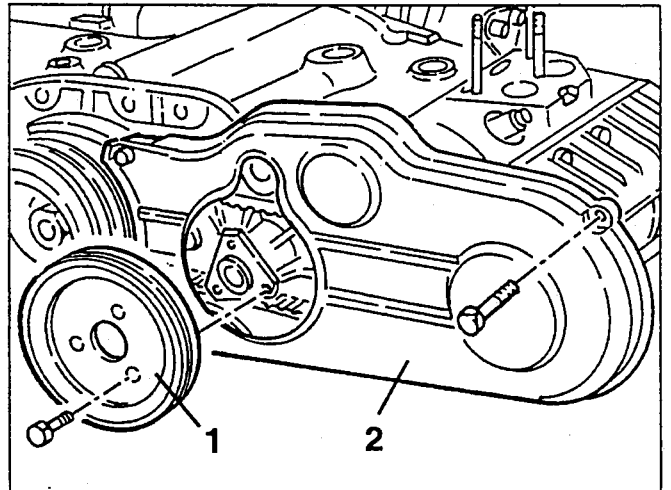
1. Slacken the fastening nuts and remove the manifolds.

**Removing the pulleys**

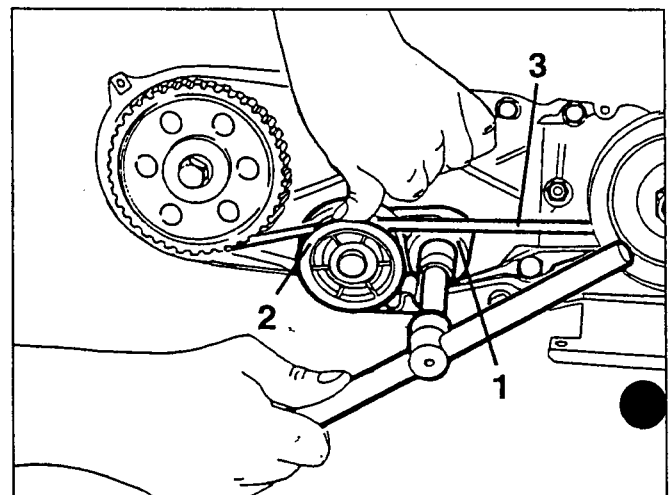
1. Slacken the fastening screws and remove the right timing belt front cover.



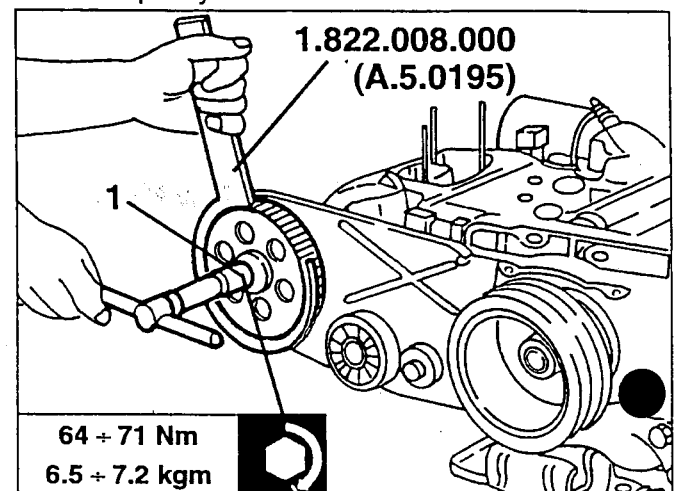
1. Remove the water pump pulley.
2. Remove the left front guard.



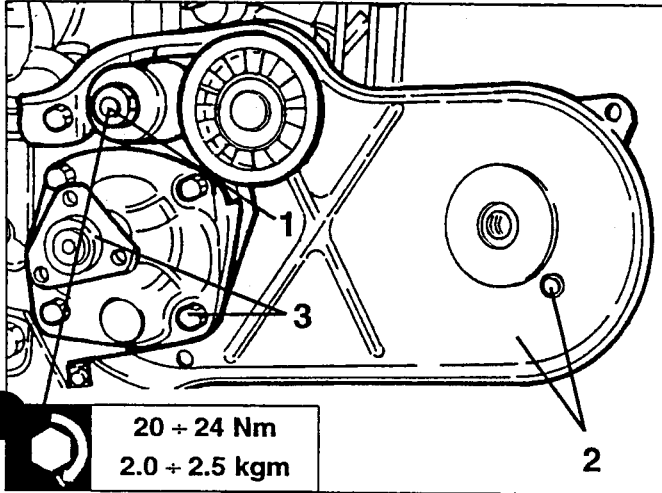
1. Slacken the belt tensioner fastening nut.
2. Press on the belt tensioner guide pulley to overcome the spring tension load and lock the fastening nut.
3. Remove the timing belt firstly from the camshaft pulley and then from the crankshaft pulley.



1. Using tool N° 1.822.008.000 (A.5.0195) as counter-torque, slacken the fastening screws and remove the camshaft pulleys.

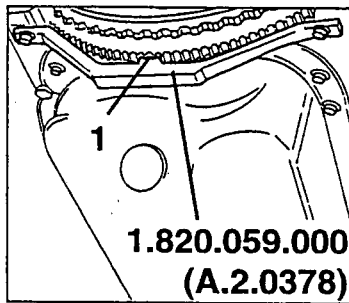


- Slacken the fastening nuts and remove the belt tensioners.
- Slacken the fastening screws and remove the timing belt rear guards.
- Slacken the fastening screws and remove the water pump with its seals.

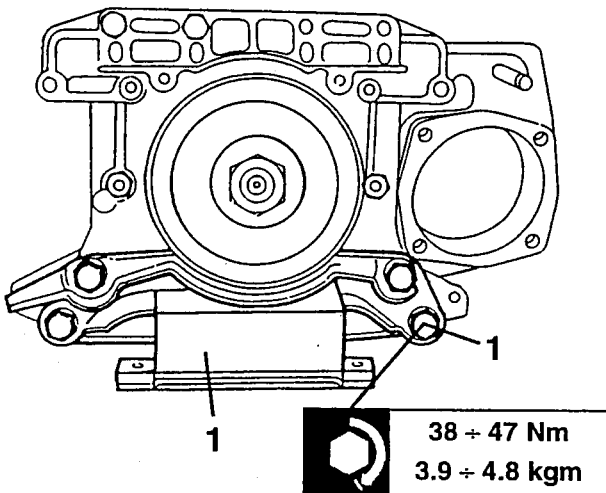


Removing the crankshaft pulleys

- Using tool N° 1.820.059.000 (A.2.0378) prevent the flywheel from turning.

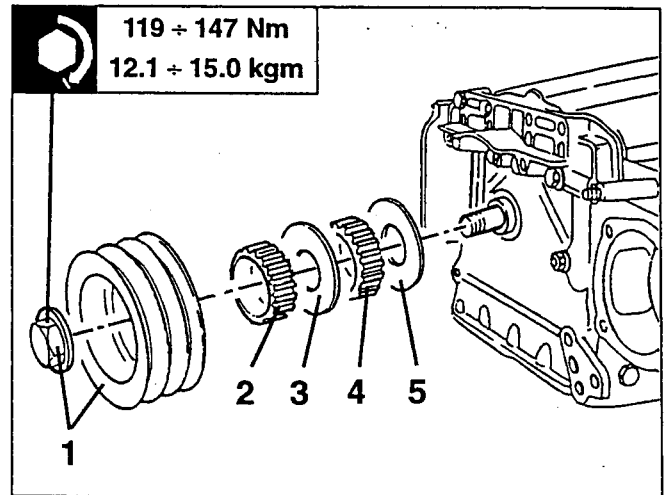


- Slacken the four fastening screws and remove the front flexible support.



- Slacken the fastening nut and remove the auxiliary drive pulley.
- Remove the right timing belt toothed pulley.
- Remove the spacer.
- Remove the left timing belt drive pulley.

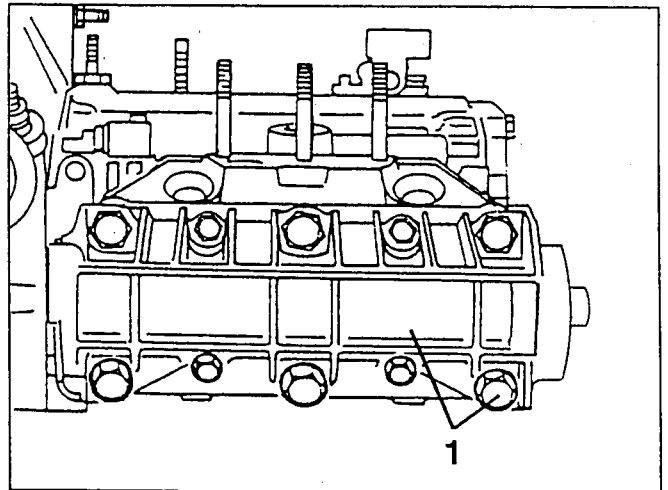
- Remove the belt contact washer.



- Remove tool N° 1.820.059.000 (A.2.0378) fitted previously to lock the flywheel.

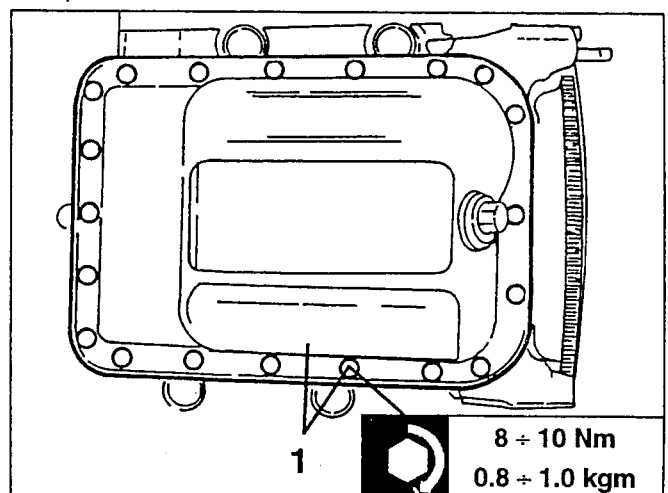
Removing the cylinder heads

- Slacken the fastening screws and remove the cylinder heads from the crankcase with their seals.



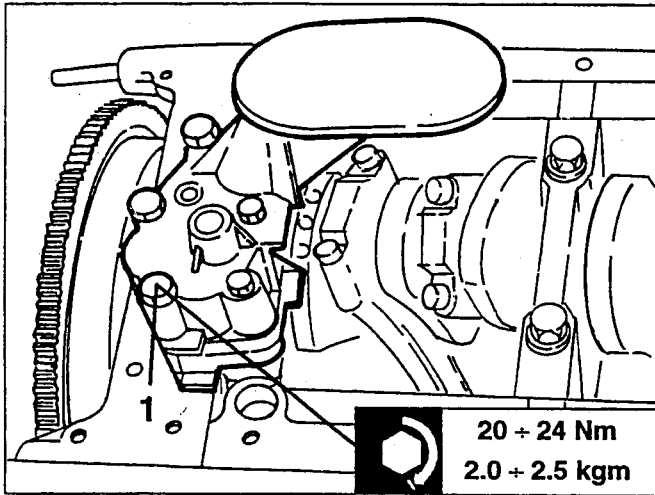
Removing the oil sump and pump

- Slacken the fastening screws and remove the oil sump with its seal.

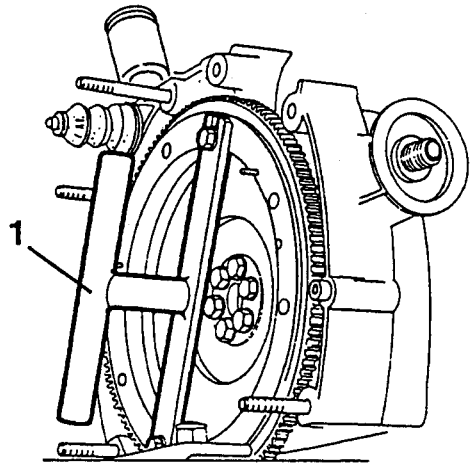




1. Slacken the screws fastening the oil pump to the crankcase rear cover and remove it.




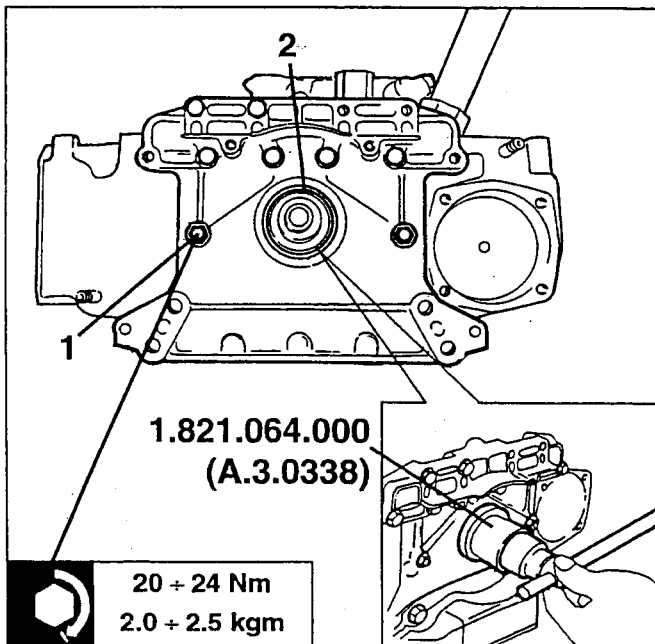
crankshaft to turn, then turn it to gain access to connecting rod cap fastening screws.



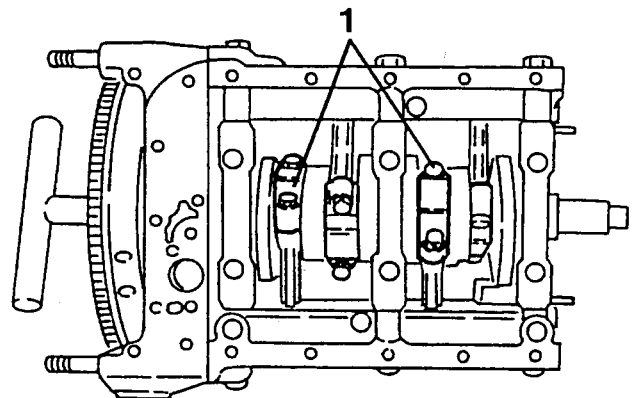
Removing the crankcase front cover

1. Slacken the fastening screws and nuts and remove the crankcase front cover with its seal.
2. Lever with a screwdriver to remove the oil guard from the front cover.

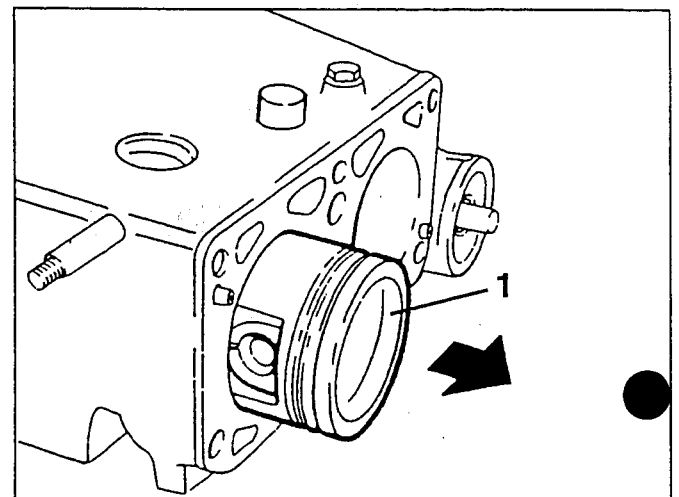
 When refitting insert the oil guard on the front cover using tool N° 1.821.064.000 (A.3.0338).



1. Slacken the fastening screws and remove the connecting rod caps with their half bearings.



1. Remove the pistons from the crankcase complete with connecting rods and half bearings.

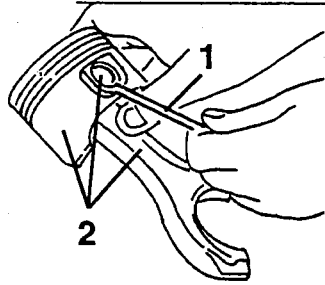


Removing the piston and connecting rods

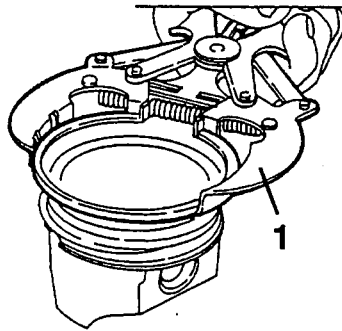
- Fit a suitable tool on the flywheel to allow the



1. Remove the two gudgeon pin circlips.
2. Remove the gudgeon pin and separate the connecting rod from the piston.



1. Using a suitable tool remove the seal rings and oil scraper ring from the piston.

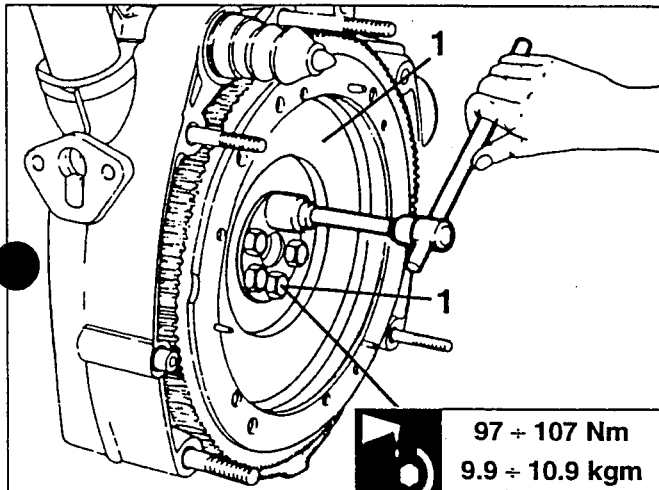


Work carefully to avoid breaking any rings that might be re-used.

Removing the flywheel

- Remove the tool for turning the crankshaft fitted previously and install tool N° 1.820.059.000 (A.2.0378) to prevent the flywheel from turning.

1. Slacken the fastening screws and remove the flywheel and safety plate.

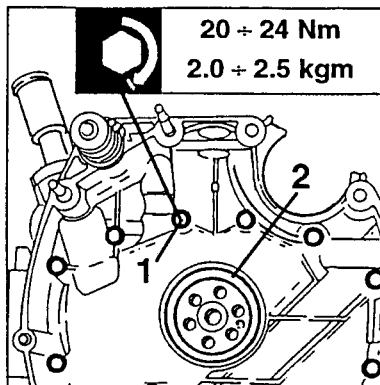


Removing the rear crankcase cover

1. Slacken the fastening screws and remove the rear crankcase cover and its seal.

2. Lever with a screwdriver to remove the oil guard from the rear cover.

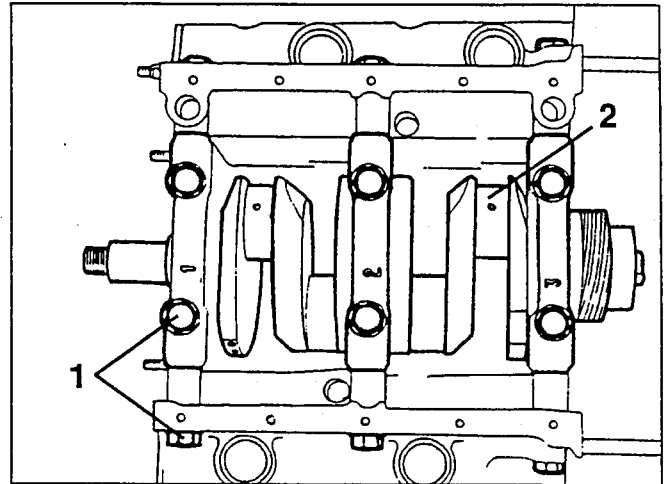
- Remove the seal ring from the main lubricating duct.



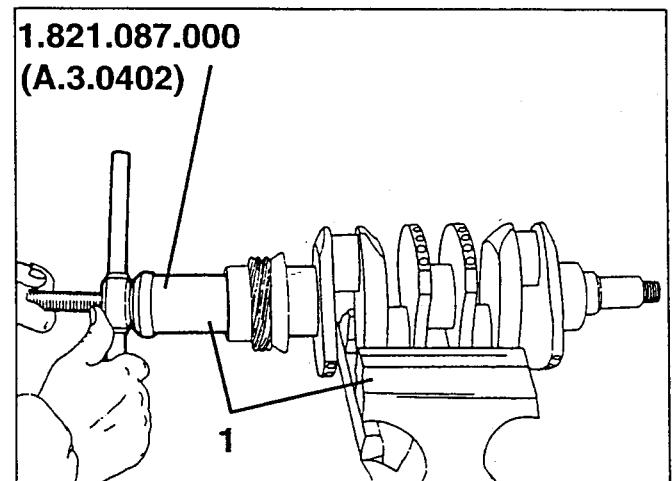
When refitting, use tool N° 1.821.063.000 (A.3.0337) to insert the oil seal ring on the rear cover.

Removing the crankshaft

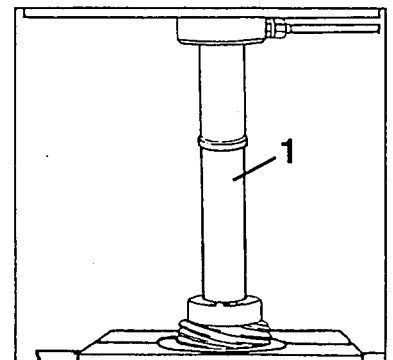
1. Slacken the fastening screws and remove the main bearing caps with the corresponding bearing halves.
2. Remove the crankshaft from the crankcase and retrieve the half bearings and half thrust rings.



1. Fasten the crankshaft in a vice with protective jaws and using puller tool N° 1.821.087.000 (A.3.0402), remove the rear guide bush from the drive shaft.



1. Working on the press using a suitable plate, remove the oil pump drive gear from the crankshaft.

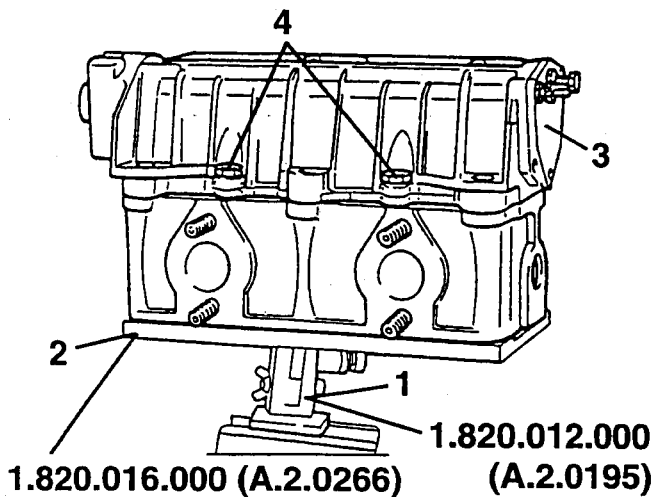




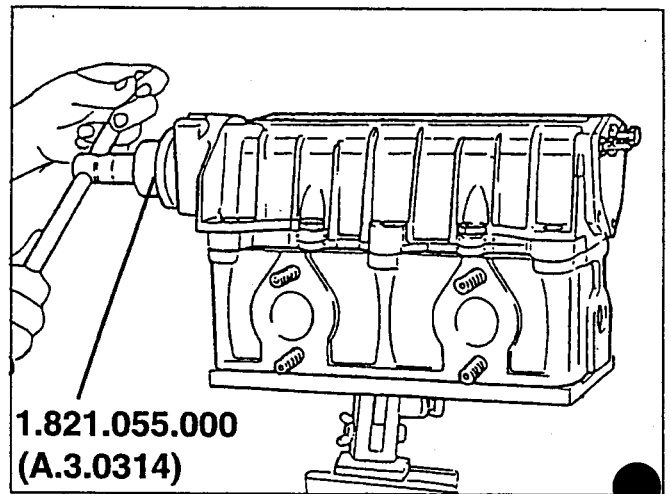
DIS-ASSEMBLY OF CYLINDER HEADS

Preliminary operations

1. Clamp the swivelling stand N° 1.820.012.000 (A.2.0195) in a vice.
2. Fasten tool N° 1.820.016.000 (A.2.0226) on the swivelling stand and fasten the cylinder head onto it.
3. Slacken the fastening screws and remove the camshaft rear cover and the corresponding seal.
4. Slacken the fastening screws and remove the camshaft bearing and seal taking care to recover the engine oil.

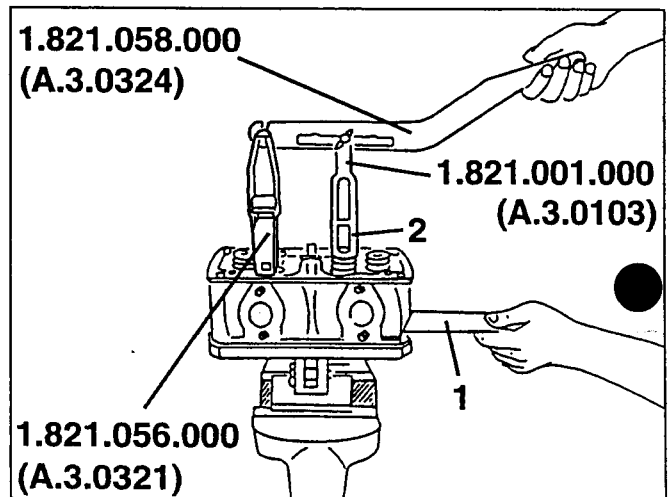


Remove the camshaft front oil seal ring working with the cylinder head assembled using tool N° 1.821.055.000 (A.3.0314).



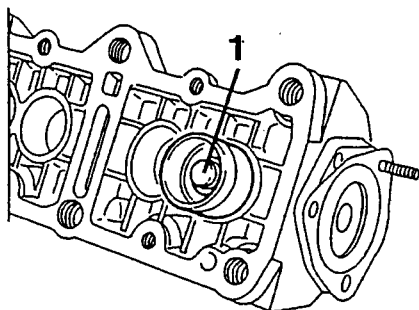
Dis-assembly of valves

1. Insert the valve seal plate in the head support tool.
2. Using tools N° 1.821.001.000 (A.3.0103), N° 1.821.058.000 (A.3.0324) and N° 1.821.056.000 (A.3.0321) remove the half tapers from the valve stem.



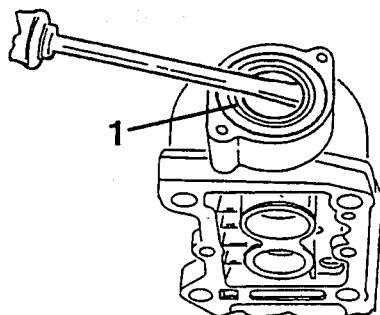
Removing the camshaft

1. Remove the cups from the housings on the camshaft bearing.



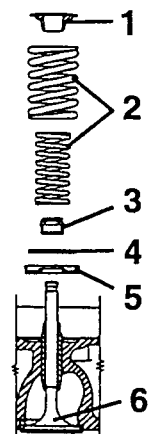
- Remove the camshaft pulling it out from the side.

1. Remove the front oil seal ring from its housing on the camshaft bearing.



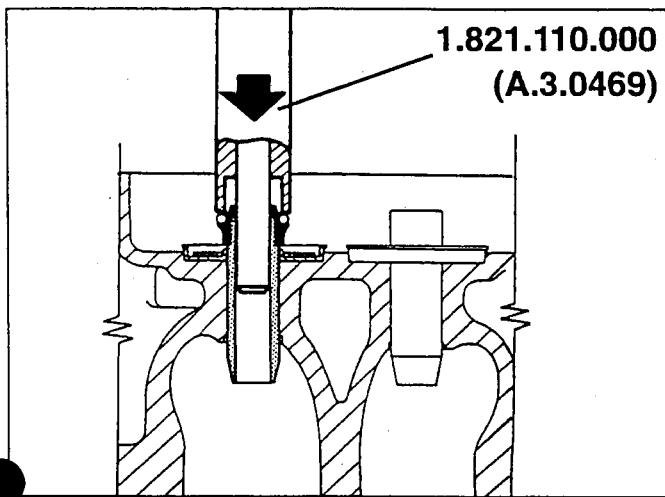
Remove:

1. Upper plate.
2. Inner and outer spring.
3. Oil seal cap.
4. Spring contact ring.
5. Lower plate.
6. Remove the plate from the head support tool and remove the valves from the lower side of the head.





When refitting use tool N° 1.821.110.000 (A.3.0469) to insert the oil seal cap.



CHECKS AND INSPECTIONS CYLINDER HEADS

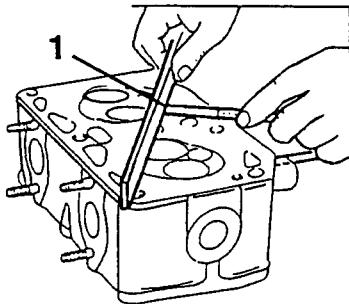
Checking the lower surface of cylinder heads

1. Check that the lower surface of the cylinder heads is level and check that it is within the specified limits.



Maximum head lower plane flatness

0.03 mm



- If the lower surface of the head is excessively distorted, both heads should be refaced without exceeding the minimum allowed value.



Minimum height of cylinder heads after refacing

77.676 ÷ 77.750 mm



CAUTION:
Exceeding the allowed height limit after refacing involves serious engine operating failures.

Checking the clearance between valve guides and valve stems

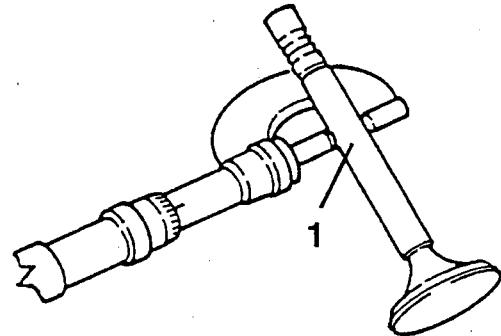
1. Measure the diameter of the valve stems and check that it is within the specified limits.



Diameter of valve stems

Intake 7.985 ÷ 8.000

Exhaust 7.968 ÷ 7.983

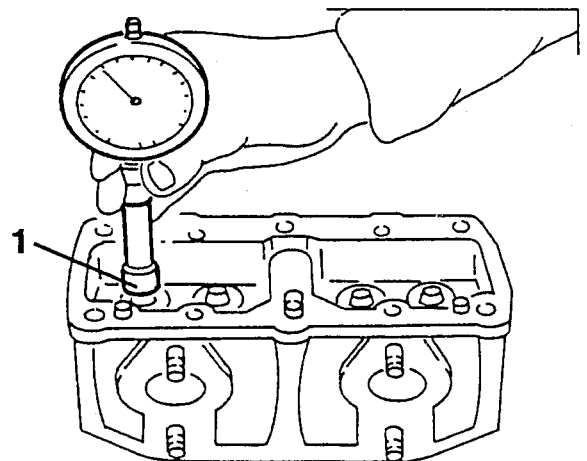


1. Measure the inside diameter of the valve guides and check that it is within the specified limits.



Inside diameter of valve guide

8.013 ÷ 8.031 mm



- Calculate the clearance between valve guides and stems and check that it is within the specified limit, if not, change any worn parts.



Radial clearance between valve guides and stems

Intake 0.013 ÷ 0.046

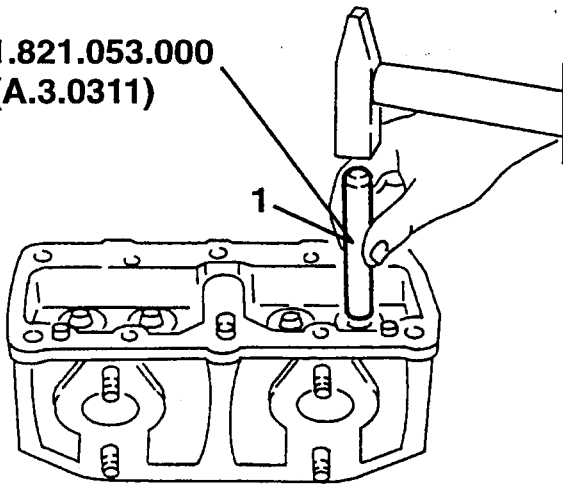
Exhaust 0.030 ÷ 0.063



Changing the valve guides

1. Using puller tool N° 1.821.053.000 (A.3.0311), remove the worn valve guides.

1.821.053.000
(A.3.0311)



- Check that the outside diameter of the valve guides and their seats on the head are within the specified limits and that their assembly interference is correct.



Outside diameter of valve guides

13.050 ÷ 13.068 mm



Diameter of valve guide seats

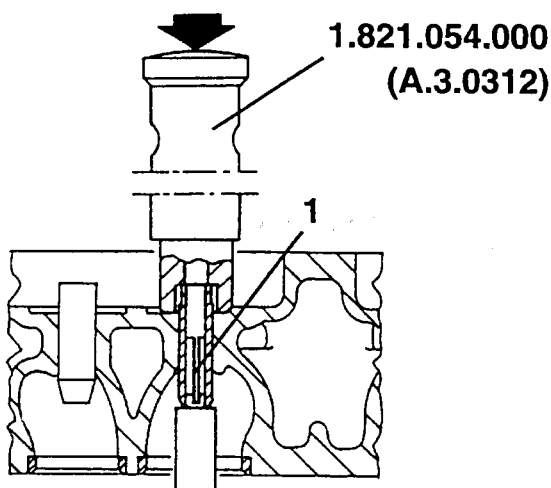
13.000 ÷ 13.018 mm



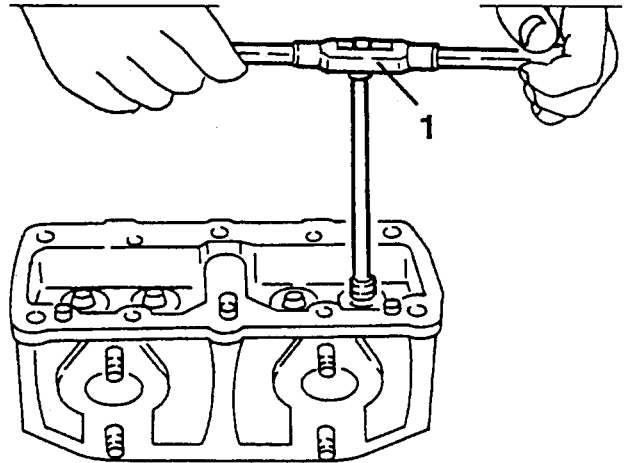
Interference between valve guides and seats

0.032 ÷ 0.068 mm

1. Insert the new valve guides using tool N° 1.821.054.000 (A.3.0312).



1. Bore the valve guide inside diameter using reamer to calibrate the holes to the specified diameter.



Inside diameter of valve guides

8.013 ÷ 8.031 mm

Checking the valve springs

- Check that the "free" length of the valve springs is within the specified limits.

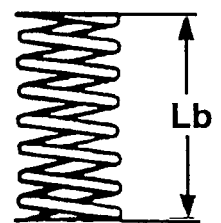
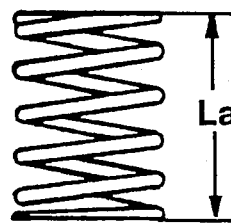
NOTE: The rest surfaces must be parallel with each other and perpendicular to the axis of the spring with a maximum error of 2°.



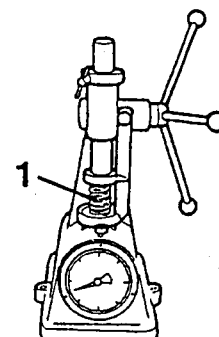
Length of valve springs

outer spring La ~ 45 mm

inner spring Lb ~ 44 mm



- Using a torque meter, check that the characteristic data of the springs are within the specified limits.

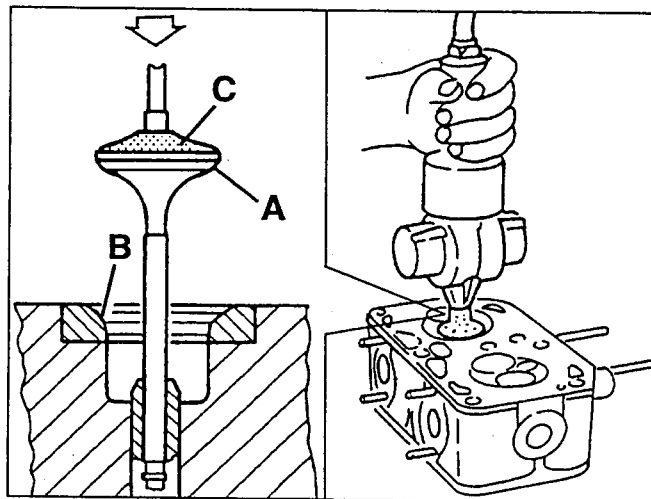


Outer spring length (mm)		Control load (kg)
Valve closed	32.2	23.0 ÷ 24.4
Valve open	23.2	43.3 ÷ 46.1

Length of inner spring (mm)		Control load (kg)
Valve closed	30.2	11.6 ÷ 12.4
Valve open	21.2	20.4 ÷ 21.8

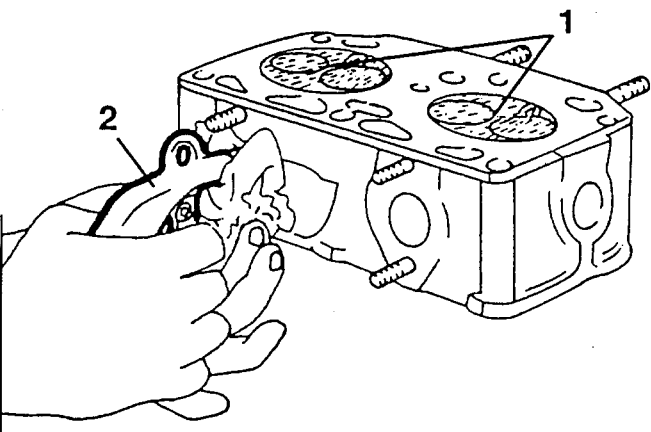
- After machining grind each valve in its housing as follows:

- coat the contact surfaces "A" and "B" of the valves and seats with abrasive paste (SIPAL AREXONS Carbosilicium for valves).
- lubricate the valve stem with engine oil.
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder.
- insert the valve in its guide and grind.
- after grinding, thoroughly clean the valve and the seat.



- When changing the valve guides, thus refacing and grinding the valve seats, it is advisable to check the valve tightness with the spark plugs in place, proceeding as follows:

1. Fill the hollow of the combustion chamber with petrol.
 2. Admit low pressure air to the intake manifolds and check that no air bubbles form in the petrol.
- Check the tightness of the exhaust valves in the same way, admitting air to the exhaust manifolds.
- If any leaks are noted, make sure that the valves are perfectly settled in their seats and repeat the check; if the result is negative, grinding must be repeated.



Turning the valve seats

1. Turn the valve seats using suitable tools with the cylinder heads cold



Taper of contact area with valve "β"	90° + 90°30'
Taper of upper valve seat area "α"	120°
Taper of lower valve seat area "γ"	Int. 70°
	Exh. 30°

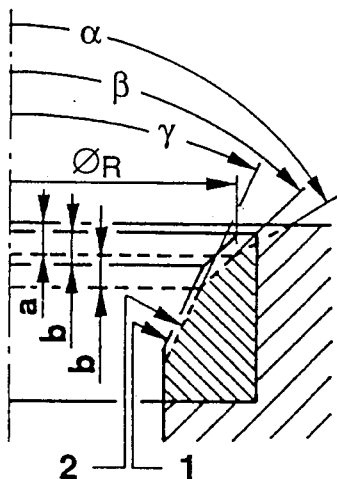


Dimension "a" at refacing limit	2.9 mm
Height "b" valve contact area	Int. 1.07 + 1.37 mm
	Exh. 1.26 + 1.56 mm



Reference diameter Ø _R	
Intake	39.0 mm
Exhaust	31.9 mm

1. Original profile
2. Profile after max. refacing

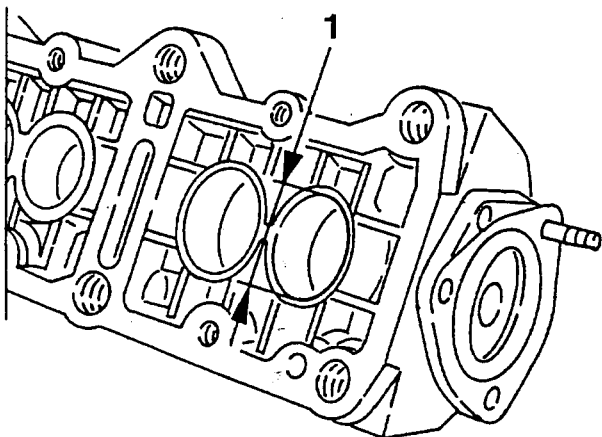




Checking the clearance between cups and seats

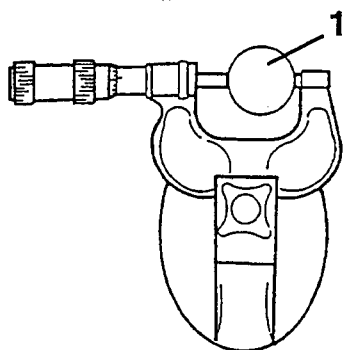
1. Check that the diameter of the seats is within the specified limits.

\varnothing	Diameter of valve cup seats
	35.000 + 35.025 mm



1. Check that the outside diameter of the cups is within the specified limits.

\varnothing	Diameter of valve cups
	34.959 + 34.975 mm



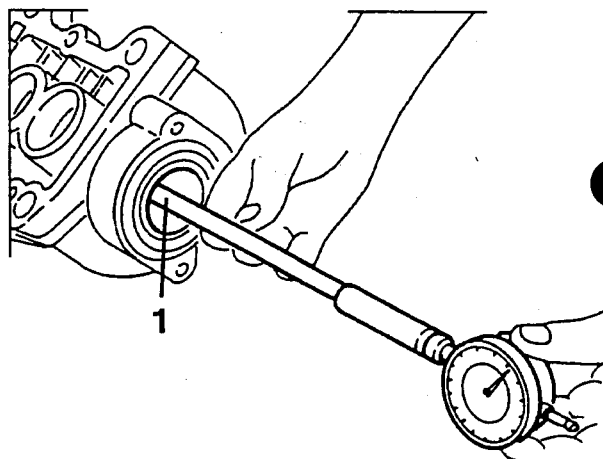
- Calculate the clearance between the cups and their seats and check that it is within the specified limit.

	Clearance between cups and seats
	0.025 + 0.066 mm

Camshafts and timing system bearings

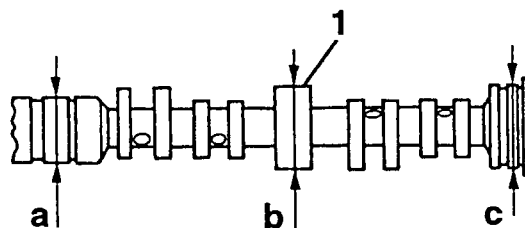
1. Check that the diameter of the camshaft supports is within the specified limits.

\varnothing	Diameter of camshaft supports	
	Front	35.015 + 35.040 mm
	Centre	48.000 + 48.025 mm
	Rear	49.200 + 49.225 mm



1. Check that the diameter of the camshaft journals is within the specified limits.

\varnothing	Diameter of camshaft journals	
	Front "a"	34.940 + 34.961 mm
	Centre "b"	47.940 + 47.956 mm
	Rear "c"	49.140 + 49.156 mm



- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limit.

	Clearance between camshafts and bearings	
	Front	0.054 + 0.100 mm
	Centre - Rear	0.044 + 0.085 mm

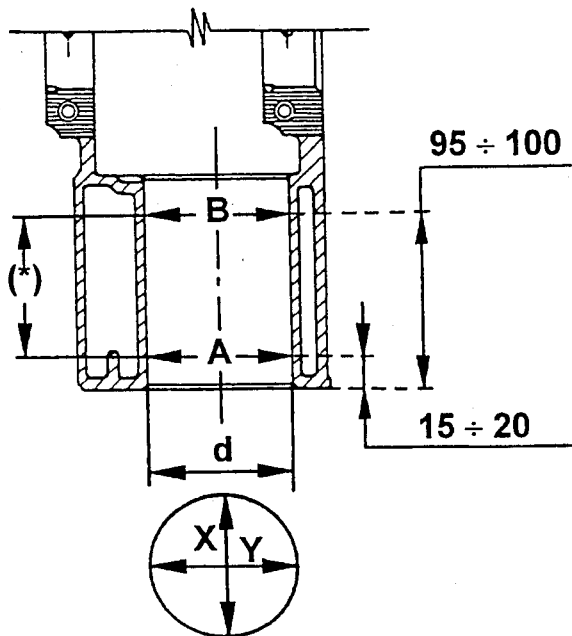
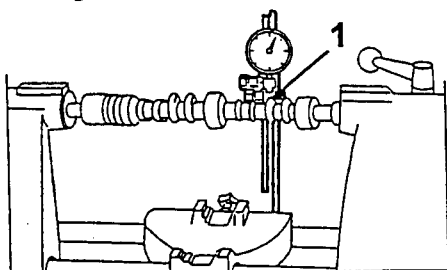


1. Check that the cam lifts exceed the minimum permissible limit.



Minimum cam lift	
Intake	9.8 mm (*)
Exhaust	9.0 mm

(*): 9.0 mm for 1351 c.c. engines after change and 1596 c.c. Rochester engine.



(*) Area for dimensional control

CHECKING AND INSPECTING THE CRANKCASE

- Visually inspect the crankcase for cracks and signs of excessive wear on the sliding surfaces; check that all the threads are intact.
- Remove the plugs of the lubrication and cooling ducts and clean the ducts with a suitable detergent, then dry them with a jet of air and refit new plugs.
- Accurately clean the crankcase surfaces of any fragments of seals or sealants.

Checking cylinders

- Using a bore gauge on a dial gauge, measure the inside diameter of the cylinders and check that it is within the specified limits.



Inside diameter "d" (mm)		
Engine	AR 33501	AR 33201
Class A	80.000 ÷ 80.010	84.000 ÷ 84.010
Class B	80.010 ÷ 80.020	84.010 ÷ 84.020
Class C	80.020 ÷ 80.030	84.020 ÷ 84.030
Class D	80.030 ÷ 80.040	84.030 ÷ 84.040
Class E	80.040 ÷ 80.050	84.040 ÷ 84.050



Maximum taper	
A - B = 0.02 mm	



Maximum ovalisation	
X - Y = 0.02 mm	

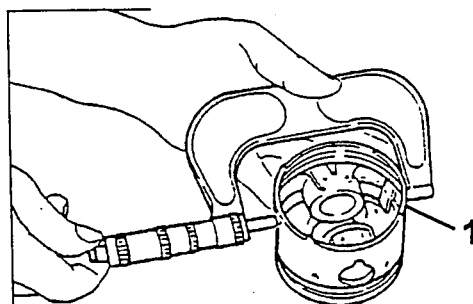
Checking pistons

1. Measure the outside diameter of the pistons and check that it is within the specified limits.



Piston outside diameter (mm) (1)		
Engine	AR 33501	AR 33201
Class A (Blue)	79.960 ÷ 79.970	83.950 ÷ 83.960
Class B (Pink)	79.970 ÷ 79.980	83.960 ÷ 83.970
Class C (Green)	79.980 ÷ 79.990	83.970 ÷ 83.980
Class D (Yellow)	79.990 ÷ 80.000	83.980 ÷ 83.990
Class E (White)	80.000 ÷ 80.010	83.990 ÷ 84.000

(1) To be measured at right angles to the gudgeon pin hole at a distance of 14 mm from the lower edge of the skirt for "Borgo" pistons and 11.5 mm from the gudgeon pin axis for "Mondial" pistons.





- Calculate the clearance between cylinder and piston and check that it is within the specified limits.



Clearance between cylinder - piston
0.03 ÷ 0.05 mm

- If dimensions are found to be out of tolerance, it is necessary to reface the cylinders bearing in mind that spare pistons have three oversizes; it is therefore necessary to make the diameter of the cylinders to the tolerances given in GROUP 00.

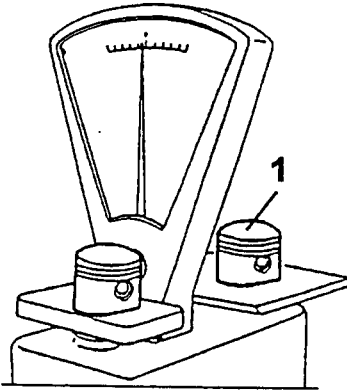
- Assemble the main bearing caps on the crankcase and tighten the fastening screws to the specified torque.

- Bore the cylinders to obtain the tolerances given in GROUP 00.



Facing should be carried out in such a way that the machining signs are crossed by an angle of 90° ÷ 120°.

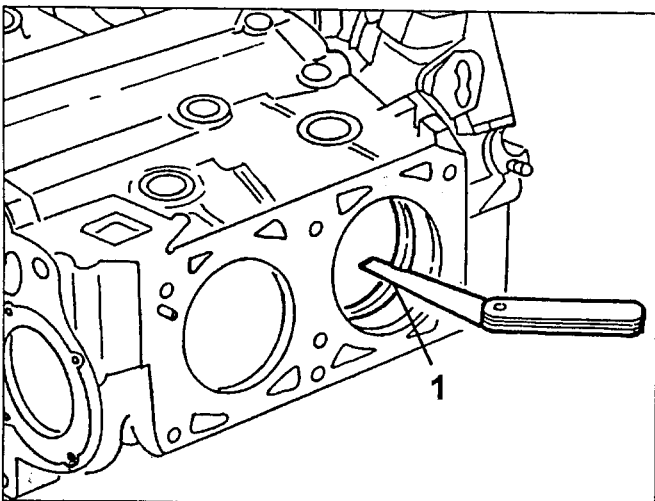
1. Check that the difference in weight between pistons complete with gudgeon pins and seal rings is within the specified limit.



Difference in weight between pistons
≤ 2 g

Checking seal ring gap

1. Insert the seal rings in the cylinder liner, check that they adhere to the whole circumference and check that the gap is within the specified limits.



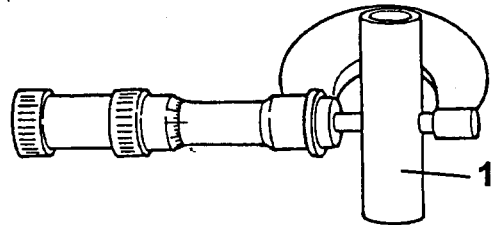
Ring gap (mm)		
Engine	AR 33501	AR 33201
First ring	0.30 ÷ 0.45	0.30 ÷ 0.50
Second ring	0.30 ÷ 0.45	0.30 ÷ 0.50
Oil scraper ring	0.25 ÷ 0.40	0.25 ÷ 0.40

Checking the clearance between gudgeon pins and seats on pistons

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



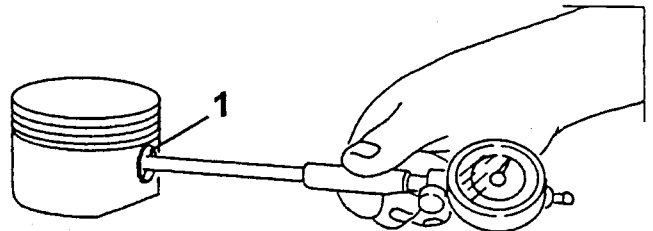
Gudgeon pin outside diameter
20.996 ÷ 21.000 mm



1. Measure the diameter of the hole on the piston corresponding to the gudgeon pins and check that it is within the specified limits.



Gudgeon pin hole diameter in pistons
21.004 ÷ 21.008 mm



- Calculate the clearance between the gudgeon pins and their seats on the pistons and check that it is within the specified limits.



Clearance between gudgeon pins and seats on pistons
0.004 ÷ 0.012 mm

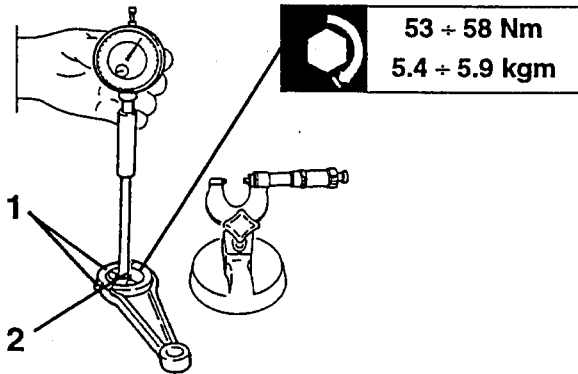


Checking the clearance between connecting rod journals and the corresponding half bearings

1. House the rod half bearings in the connecting rod big end and on the corresponding cap, then join them tightening them tightening the fastening screws to the specified torque.
2. Measure the diameter of the connecting rod big end and check that it is within the specified limits.



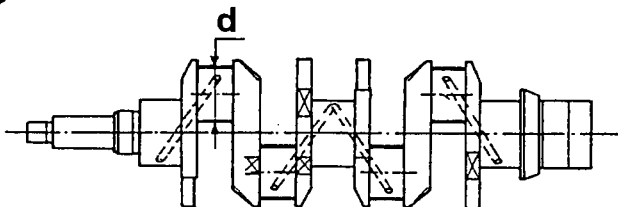
Inside diameter of connecting rod half bearings	
Class A - Blue	50.024 + 50.048 mm
Class B - Red	50.032 + 50.056 mm



1. Measure the diameter of the connecting rod journals and check that it is within the specified limits.



Diameter of connecting rod journals	
Class A - Red	49.992 + 50.000 mm
Class B - Blue	49.984 + 49.992 mm



Due to the nitriding treatment the crankshaft has been subjected to, no grinding operations are possible; therefore it must be changed in the event of excessive wear.

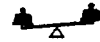
- Calculate the clearance between the rod journals and half bearings and check that it is within the specified limits.



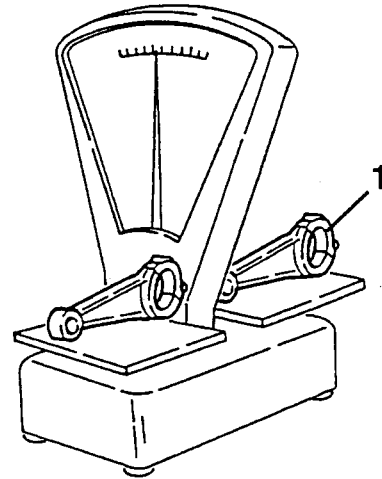
Clearance between rod journals and half bearings	
0.032 + 0.064 mm	

Checking the connecting rods

1. Check that the difference in weight between the rods complete with half bearings, caps and screws is within the specified limit.

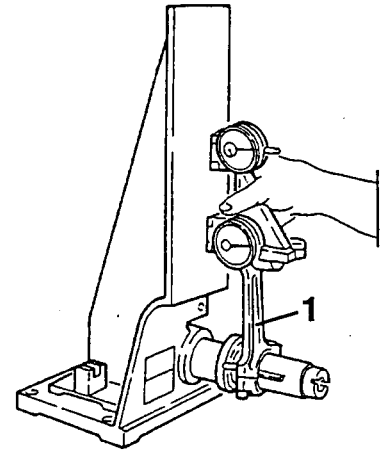


Difference in weight between connecting rods
≤ 2 g



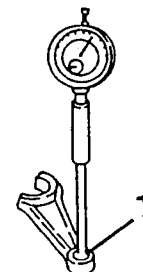
1. Check that the rods are perpendicular using a reference plane as illustrated.

If perpendicularity is not perfect, the connecting rod must be changed to avoid abnormal stresses when the engine is running, resulting in uneven wear of the piston and of the rod itself.



Checking the clearance between pins and small end bushings

1. Measure the inside diameter of the small end bushing and check that it is within the specified limits, if not, change the bushing.





Inside diameter of small end bushing

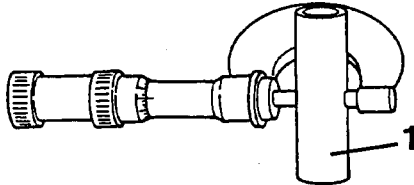
21.007 + 21.015 mm

1. Measure the outside diameter esterno of the pins and check that it is within the specified limits.



Outside diameter of pins

20.996 + 21.000 mm



- Calculate the clearance between the pins and the small end bushing and check that it is within the specified limits.



Clearance between pins and small end bushing

0.007 + 0.019 mm

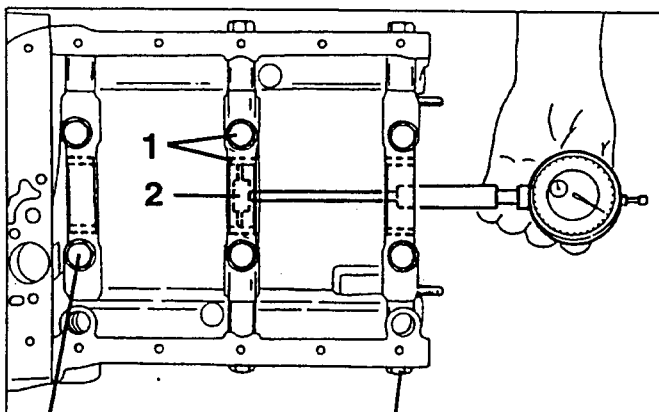
Checking the clearance between main bearing journals and half bearings

1. House the half bearings and fit the main bearing caps on the crankcase tightening the fastening screws to the specified torque.
2. Measure the diameter of the main bearings and check that it is within the specified limits.



Diameter of main bearings (mm)

Engine	AR 33501	AR 33201
Class A Red	63.610 + 63.635	63.618 + 63.640
Class B Blue		63.616 + 63.638



67 + 74 Nm
6.8 + 7.5 kgm

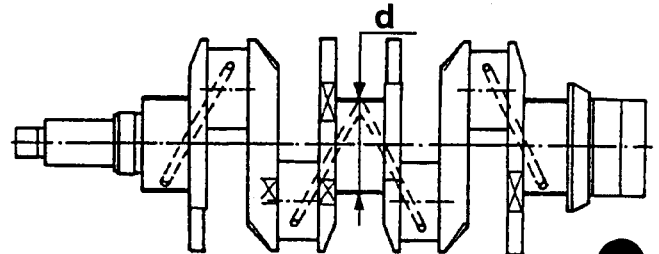
41 + 50 Nm
4.2 + 5.1 kgm

1. Measure the diameter of the main bearing journals and check that it is within the specified limits.



Diameter of main bearing journals (mm)

Engine	AR 33501	AR 33201
Class A Red	59.944 + 59.957	59.954 + 59.964
Class B Blue		59.944 + 59.954



- Calculate the clearance between the main bearing journals and half bearings and check that it is within the specified limits.



Working clearance between main bearing journals and half bearings

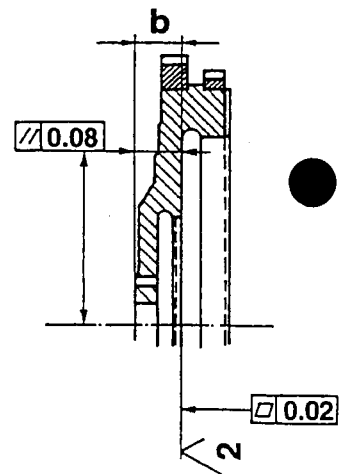
AR 33501	0.028 + 0.063 mm
AR 33201	0.023 + 0.057 mm

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, proceed as follows to change them:

- remove the old ring gears;
- accurately clean the contact surfaces of the new ring gears and of the flywheel;
- evenly heat the new ring gears to 120° + 140° C and fit them on the flywheel;
- leave to cool naturally, do not force cool.

- Check that the surface of the flywheel on which the clutch driven plate works has no nicks, material removal or signs of overheating. If not, check that dimension "B" shown in the diagram is above the specified limit and that the machining allowance enables refacing.



Refacing dimension

B ≥ 21.15



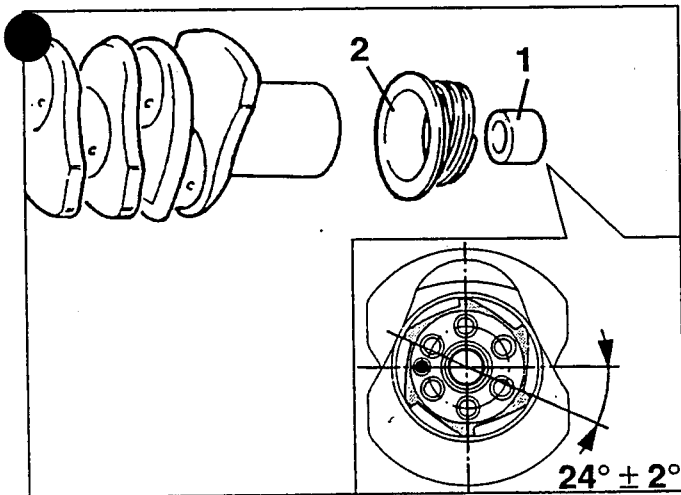
CAUTIONS FOR RE-ASSEMBLY

For re-assembly operations reverse the sequence of those described for dis-assembly unless otherwise indicated below.

- Check valve tightness when the cylinder heads are assembled.

Reassembling the crankshaft

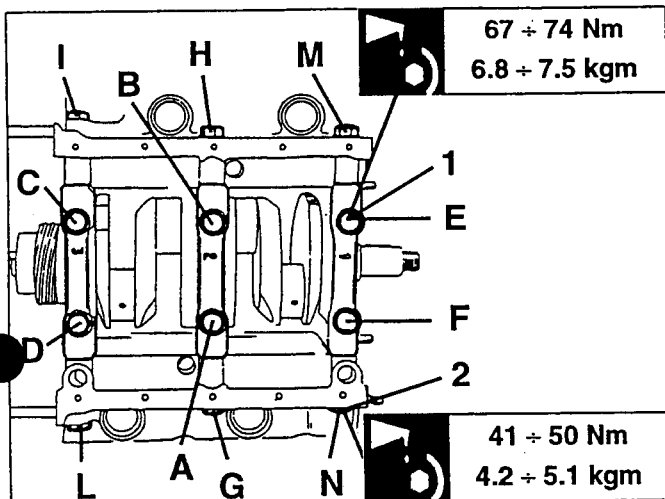
1. If removed previously, the crankshaft rear bushing should be refitted using tool n° 1.821.104.000 (A.3.0450).
2. Heat the oil pump drive gear to 150°C and shrink it onto the crankshaft directing it as illustrated.



Tightening the main bearing caps

Assemble the main bearing caps on the crankcase bearings in the correct position and tighten the fastening screws in oil without locking them.

1. Tighten the main bearing cap fastening screws to the respective crankcase bearings two or three times in the sequence shown from A to F.
2. Then in two or three operations, tighten the screws fastening the main bearing caps to the crankcase in the sequence shown from G to N.



- Turn the crankshaft by hand and check that it turns smoothly.

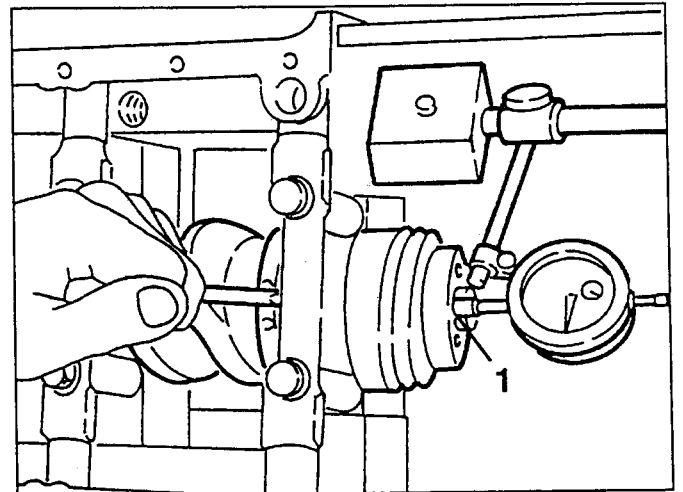
Checking the crankshaft end float

1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.



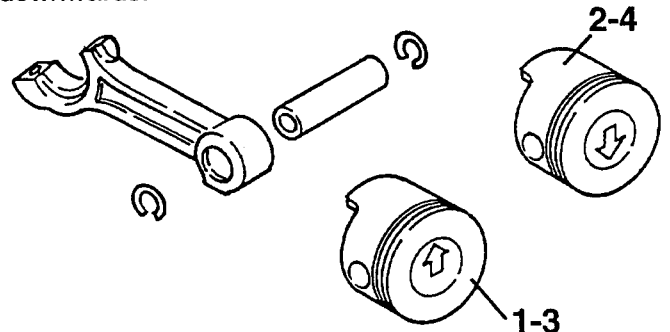
Crankshaft end float

0.06 ÷ 0.25 mm

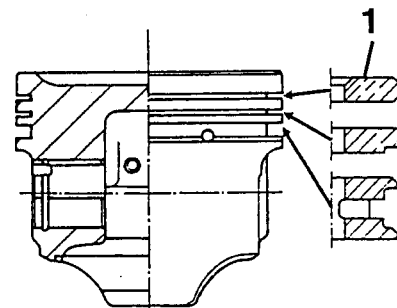


Refitting the pistons and connecting rods

1. Assemble the pistons and connecting rods so that the pistons of the right cylinder head 1-3 have the arrow stamped on the crown pointing upwards and the pistons of the left head 2-4 have the arrow pointing downwards.



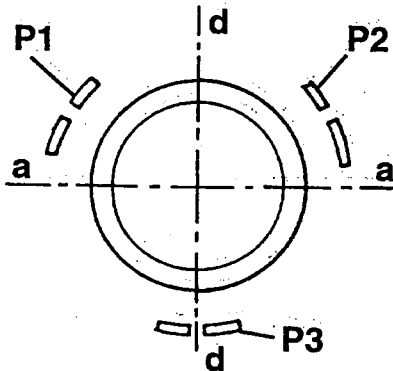
1. Insert the rings on the piston making sure that the wording on the flat surface faces upwards.



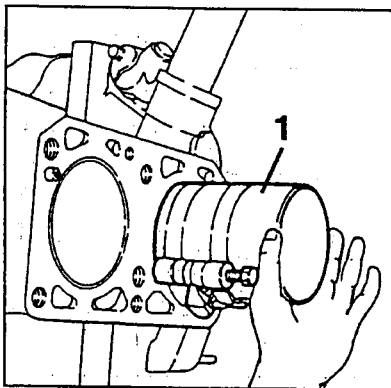


- Direct the rings on the pistons with the cuts offset by 120°.

P1. Position of upper ring;
P2. Position of lower ring;
P3. Position of oil scraper ring;
aa. Gudgeon pin axis;
dd. Direction of thrust;



1. Assemble the half bearings on the connecting rod big end and insert the piston-connecting rod assembly in the corresponding cylinders using the special tool.



When assembling direct the pistons with the arrow stamped on the crown pointing in the direction of rotation of the engine, i.e. upwards for the right head pistons and downwards for the left head pistons.

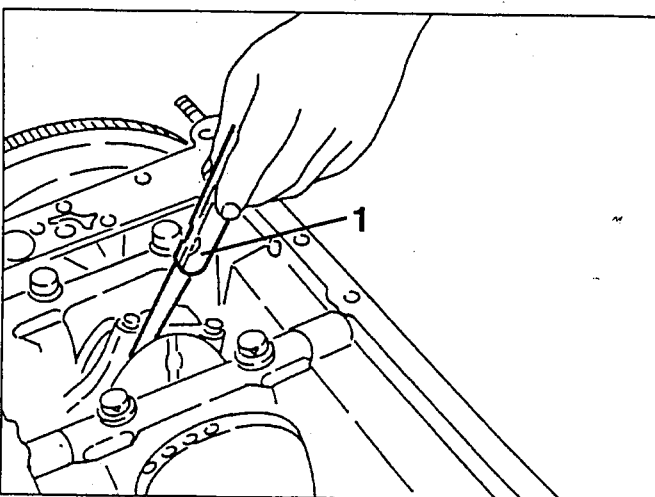
The position of the connecting rod big end must make it possible to read the identification number.

1. Position the connecting rod caps with the corresponding half bearings and check that there is the specified play between the crankshaft shoulder and the connecting rod-cap profile.

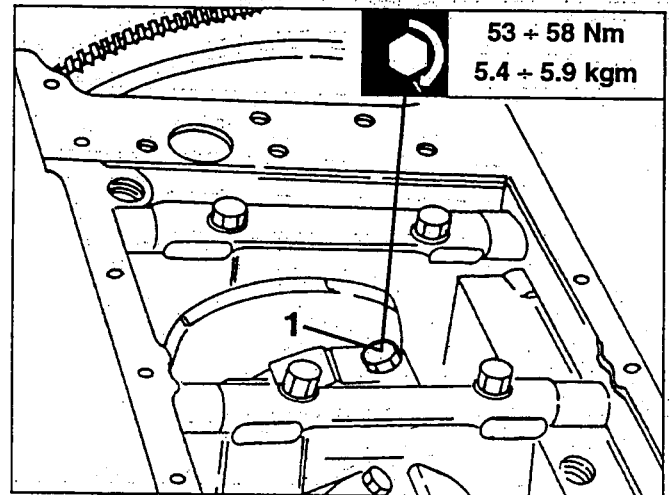


Clearance between crankshaft shoulder and connecting rod - cap profile

0.15 mm

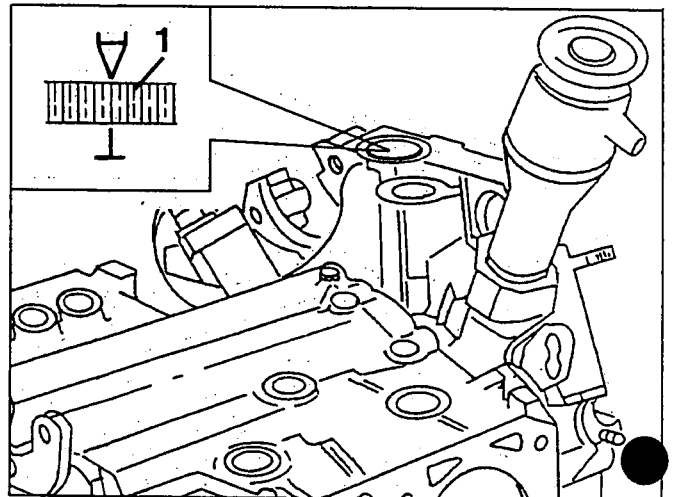


1. Suitably turn the crankshaft to tighten the connecting rod cap fastening screws.



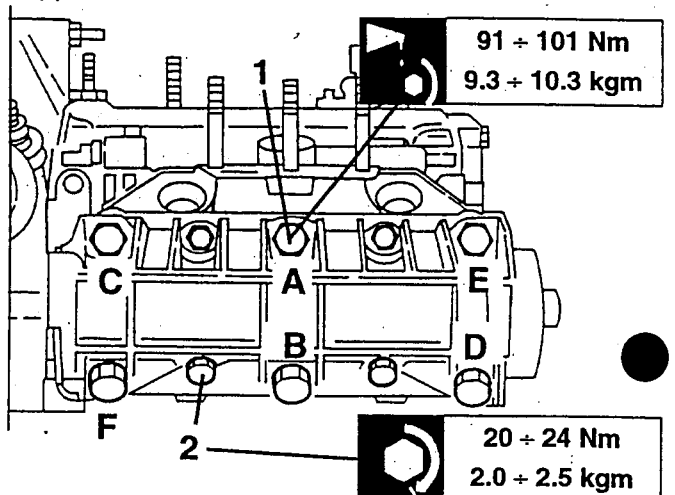
Refitting the cylinder heads

1. Turn the crankshaft to take piston no. 1 to the T.D.C. (bursting stroke); notch "T" on the flywheel coinciding with the impression on the cover.




1. Assemble the cylinder heads on the crankcase with the seals interposed and tighten the screws in to or three operations following the sequence illustrated (A - F).

2. Tighten the four screws fastening the camshaft support in crossed order.



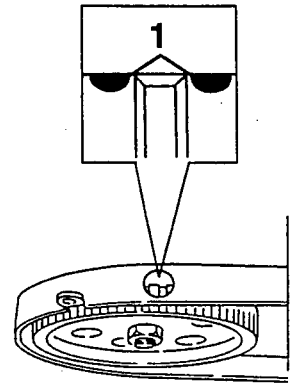


When working with the engine assembled on the car, use the extension wrench N° 1.822.010.000 (A.5.0198), the tightening torques become:

	for torque wrench with 300 mm arm	64 ÷ 71 Nm 6.5 ÷ 7.2 kgm
	for torque wrench with 400 mm arm	69 ÷ 77 Nm 7.0 ÷ 7.8 kgm

1. Turn the right camshaft so that the tooth and the two adjacent grooves milled on the timing pulley can be seen through the special holes on the rear guard.

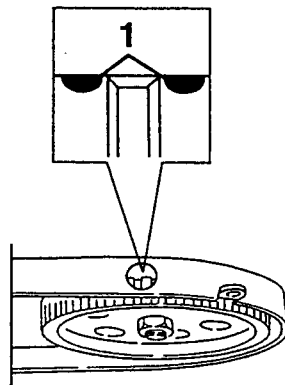
- Turn the crankshaft until the notch "T" on the flywheel is aligned with the fixed reference on the rear cover.



Assembling the timing belts

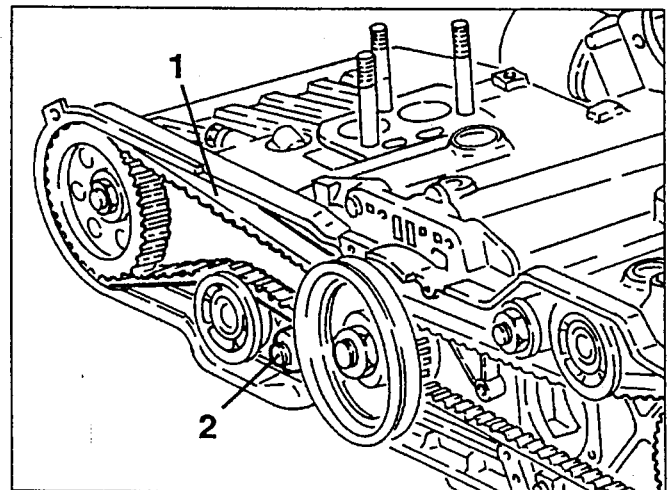
1. Turn the left camshaft so that the tooth and the two adjacent grooves milled on the timing pulley can be seen through the special holes on the rear guard.

- Turn the crankshaft until the notch "T" on the flywheel is aligned with the fixed reference on the rear cover.



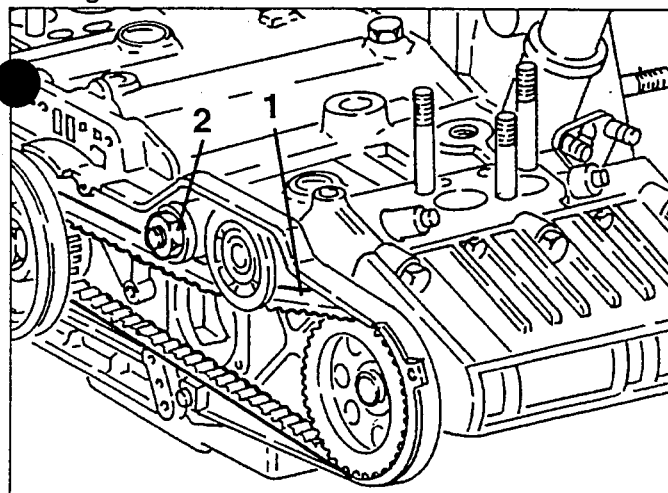
1. Fit the right timing belt.

2. Slacken the belt tensioner fastening nut so that it can exert the load impressed by the spring on the belt, then tighten the nut.



1. Fit the left timing belt.

2. Slacken the belt tensioner fastening nut so that it can exert the load impressed by the spring on the belt, then tighten the nut.

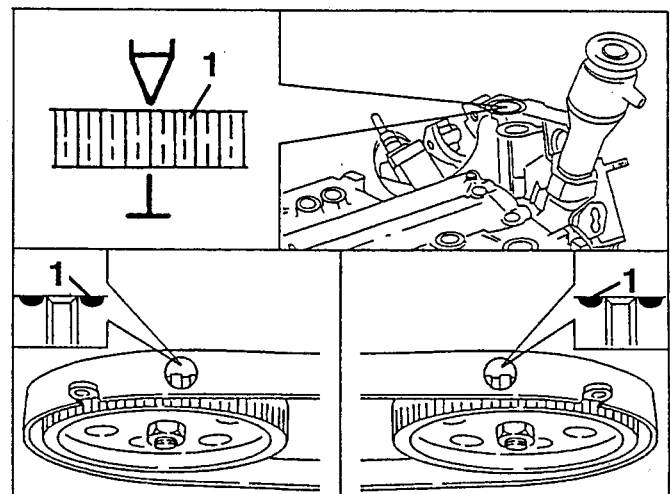


CAUTION:

Use special wrench N° 1.822.008.000 (A.5.0195) to prevent the pulley from turning.

- Turn the crankshaft a few times in its direction of rotation to allow the belts to take their final position.

1. Check the engine timing.



CAUTION:

The belt should be keyed with the belt pulling in each opposite the tensioners taut.

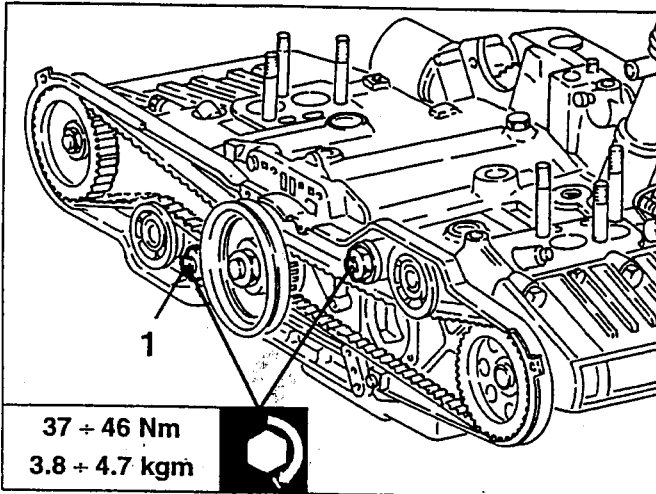


- Turn the crankshaft by 90° in its direction of rotation until the impression ● on the flywheel is aligned with the fixed reference.

1. Slacken the right belt tensioner nut, then tighten it to the specified torque.

- Turn the crankshaft by 360° in its direction of rotation until the impression ● on the flywheel is aligned with the fixed reference.

- Proceed in the same manner to tighten the left belt tensioner.

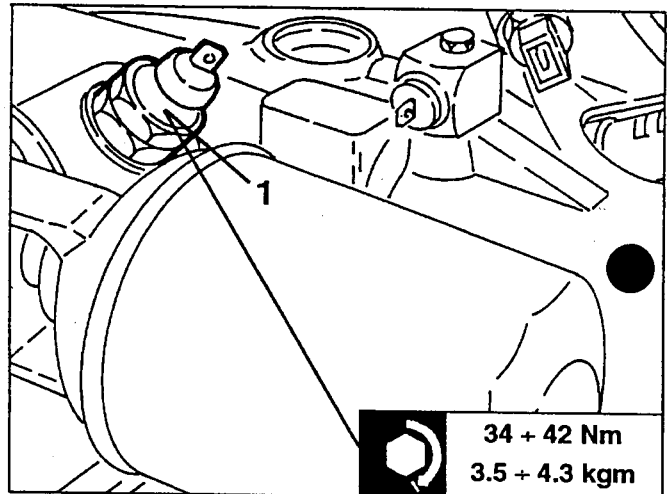


Upon completion of these operations check again that the timing references correspond.

CHECKING THE ELECTRICAL COMPONENTS OF THE LUBRICATION CIRCUIT

Minimum engine oil pressure warning light sensor

1. Check the setting of the minimum engine oil pressure warning light sensor. If the value fails to meet specifications, change the sensor.



Contact opening/closing pressure

0.2 + 0.5 bar

For the other sensors and electrical components located in the engine compartment, refer to the specific Groups in which an extensive description is given.



16V

BOXER ENGINE - AR33401

10

INDEX

GENERALITIES

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- Lubrication	3

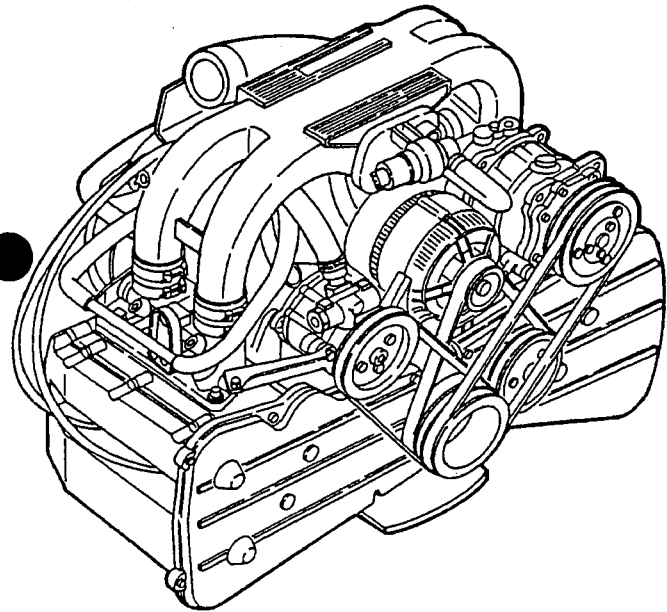
OVERHAULING

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- Engine dis - assembly	5
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DESCRIPTION

The engine has 4 opposed cylinders, double camshaft for each cylinder head, four valves per cylinder controlled by hydraulic tappets, BOSCH M2.10.3 multi-point electronic injection and static ignition controlled by a single control unit. The clutch - gearbox - differential unit is connected behind the engine and forms an integral part of the power unit.

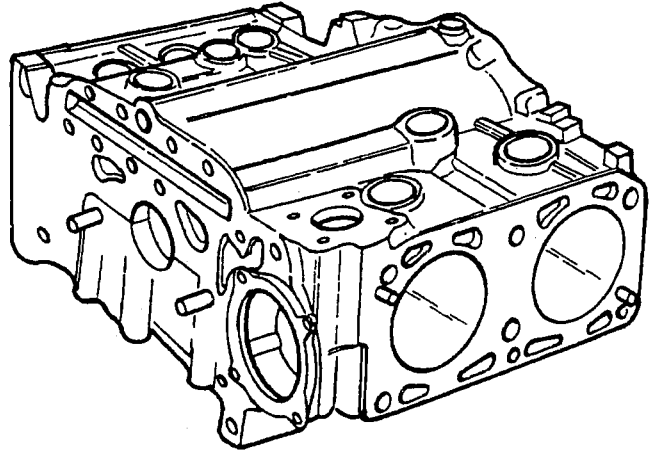


The latter is front mounted and set longitudinally with a 3° inclination. The power unit is fastened to the body by "suspension" type mounts through a support frame connected to the gearbox - differential unit. The various connections of the power unit to the support frame are made with appropriate flexible mounts to absorb engine vibrations. The fuel supply system, with unleaded petrol, combined with the suitable antipollution systems described in the specific paragraphs, ensure low exhaust emission levels meeting "USA 83" regulations.

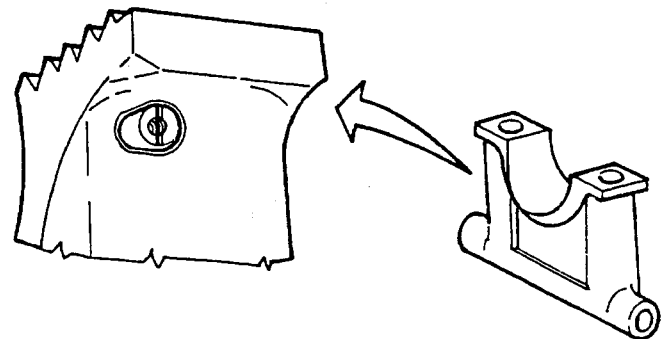
CRANKCASE

This is a single cast iron block with high mechanical strength. The crankshaft is supported by 3 main bearings which house the same number of thin-walled half bearings. The cylinders are machined directly in the crankcase and they are selected in five classes of dimensions. If cylinder wear exceeds the specified values, they must be bored to the specified diameters according to the oversizes of the pistons available from Spares (see CPT).

Special grooves machined in the crankcase walls allow the circulation of coolant fluid and lubricating oil.

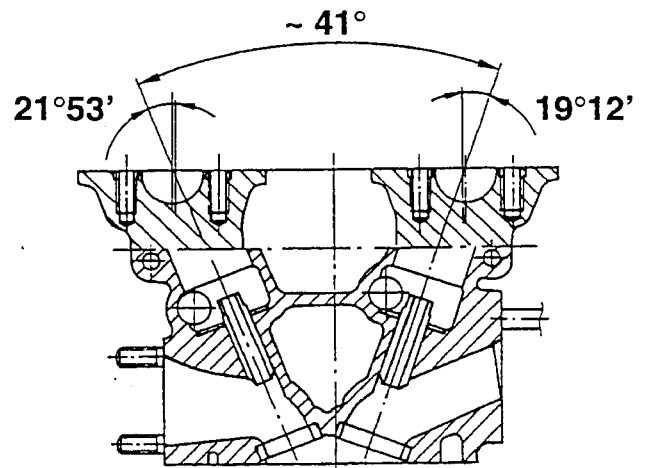


Oil spray jets installed on the front and centre main bearing caps spray oil on the piston crowns to partially cool them.



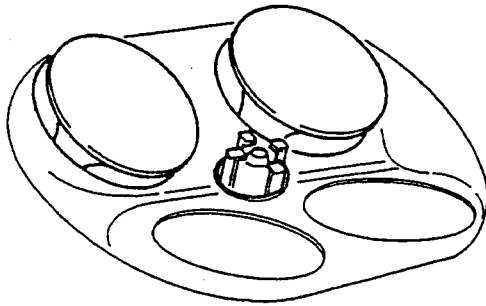
CYLINDER HEADS

This is one-piece, compact and chill-cast in aluminium and silicium alloy. The four valves per cylinder are fitted in their guides arranged in a "V" of ~ 41° and they are controlled by two camshafts through hydraulic tappets.



Due to the arrangement of the spaces, the combustion chamber accommodates the four mushrooms of the valves and the centre hole of the spark plug without weakening the structure of the head.

The solution with the spark plug in the centre of the four valves (two inlet valves and two smaller exhaust valves) enables even distribution of the mixture and optimum development of combustion with improved thermal yield of the engine and lower harmful emissions at the exhaust.

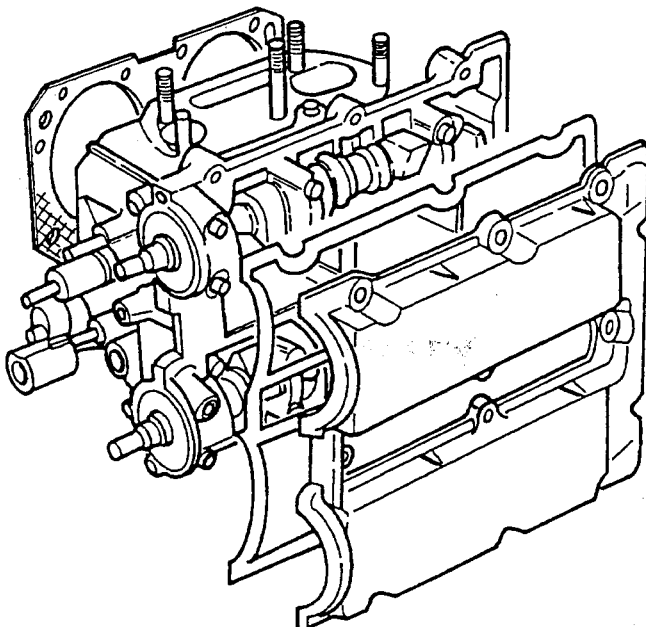


The camshafts turn on three supports and they are driven through toothed belts.

The valve seats are fitted on the cylinder heads after heating them to a temperature of $100^{\circ} + 120^{\circ}\text{C}$.

The valve guides are force-fitted in their housings on the cylinder heads with interference and the inside diameter is perfected after assembly using a specific reamer and checked using a pair of go-no go gauges. The seals between the cylinder heads and crankcase are of the ASTADUR type.

Due to the special material with which they are made, these seals are polymerized when the engine is running and harden considerably during use, therefore it is no longer necessary to tighten the cylinder heads at the first service coupon.



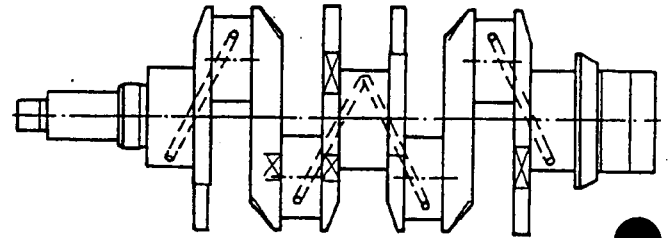
CRANKSHAFT

This is forged in high-strength, hardened and tempered steel.

It rests on three main bearings and its end float is adjusted by two half rings housed in the rear main bearing.

Six counterweights accurately balance the rotating masses.

A set of grooves run inside the shaft to lubricate the main and connecting rod journals.



MAIN AND CONNECTING ROD HALF BEARINGS

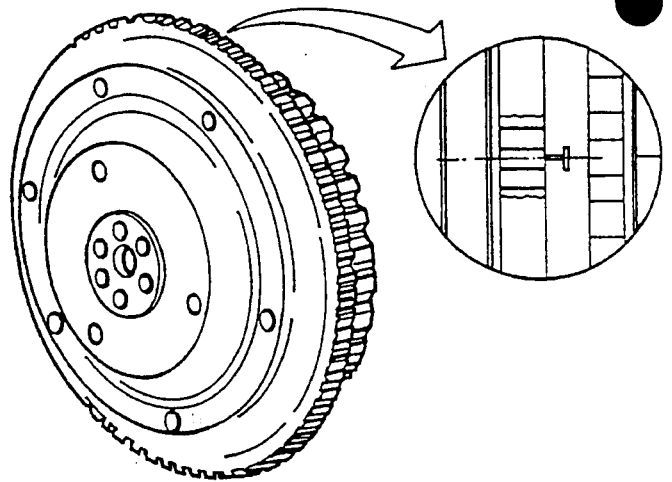
These are of the three-metal, thin shell type subdivided into two dimensional classes.

The main half bearings have a hole and groove for lubricating the rod journals.

FLYWHEEL

This is in cast iron, with two ring gears in hardened and tempered steel: one for connection with the starter motor and one for the rpm sensor facing it.

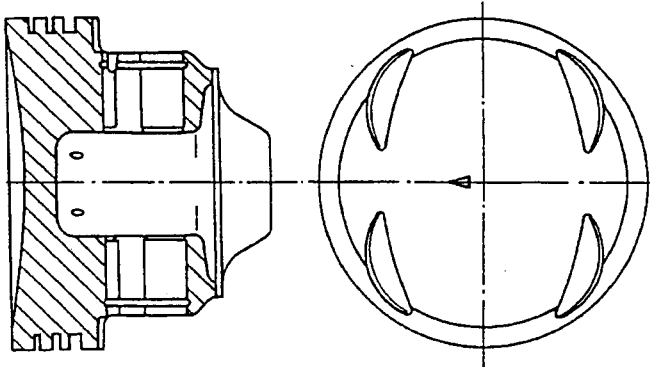
The "T" notch for checking engine timing is stamped on the flywheel.



PISTONS AND CONNECTING RODS

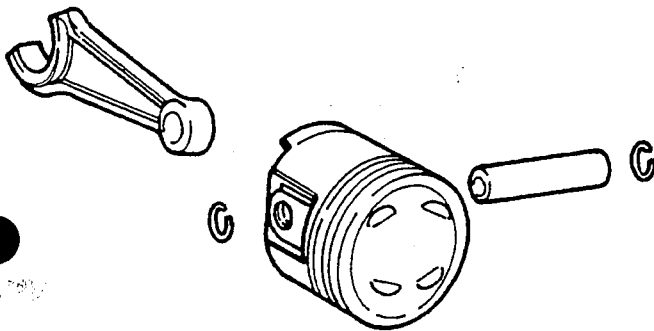
The pistons in aluminium silicium alloy are subdivided into five dimensional classes and they are available as Spares in three other oversize classes.

The piston crown is concave and has four notches to prevent interference with the valve mushrooms.



The connecting rods are in hardened and tempered alloy steel, with a copper alloy bush for coupling with the piston gudgeon pin.

As the pins are floating on both the piston hubs and on the bush force-fitted in the connecting rod small end, their side stroke stop is made by two expanding circlips which are housed in special hollows machined on the actual hubs.



The right cylinder head pistons are positioned with the arrow stamped on the piston crown facing upwards and those of the left cylinder heads with the arrow pointing downwards.

TIMING

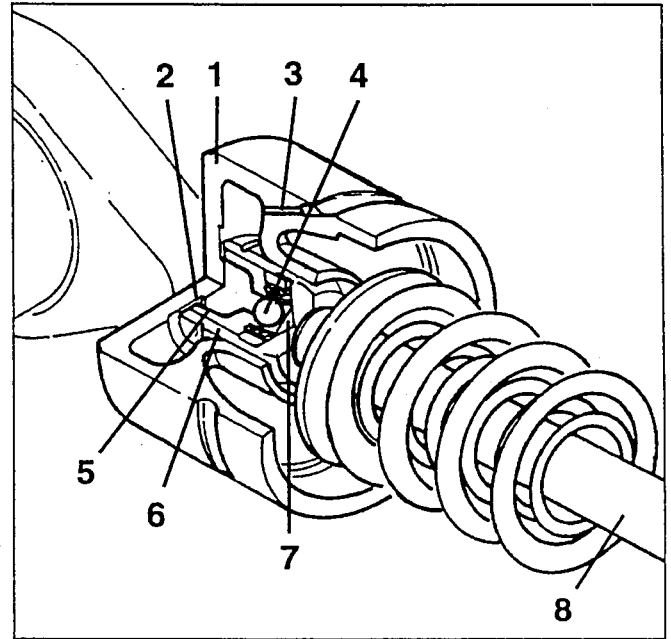
Direct drive by toothed belts, with overhead camshafts in case-hardened alloy steel.

The hydraulic tappets in contact with the cams operate the valves directly.

This device automatically eliminates "valve play" when the engine is running, thereby enormously reducing the need for periodic maintenance.

The exhaust valve stem is chromium-plated and inside it has a hollow filled 50 + 60% with sodium which improves dispersion of the heat to which they are subjected.

The valve seats are sintered in material suitable for use with unleaded petrol.



1. Cup
2. Oil circulation between inlet chambers
3. Oil inlet groove
4. Check valve
5. Piston
6. Cilinder
7. Pressure chamber
8. Valve stem

LUBRICATION

Lubrication is forced by gear pump. The oil pump is fitted on the rear engine cover and it is operated by a shaft that receives motion from a gear installed behind on the crankshaft. The oil withdrawn from the sump through a suction device is filtered by the mesh filter on the actual suction device and then sent under pressure by the pump through a groove to the oil filter with full-flow cartridge fitted with a safety by-pass valve which ensures that the oil can still pass if the filter is clogged.

The maximum lubricating pressure is adjusted by a special limiting valve fitted on the pump. After being filtered, the oil flows through a transversal duct into the main longitudinal delivery duct machined in the crankcase. From here, it is ducted through three grooves to the lubricating grooves of the crankshaft main and rod bearings.

To improve cooling of the pistons on the right main bearing spray jets have been fitted on the front and centre main journals.

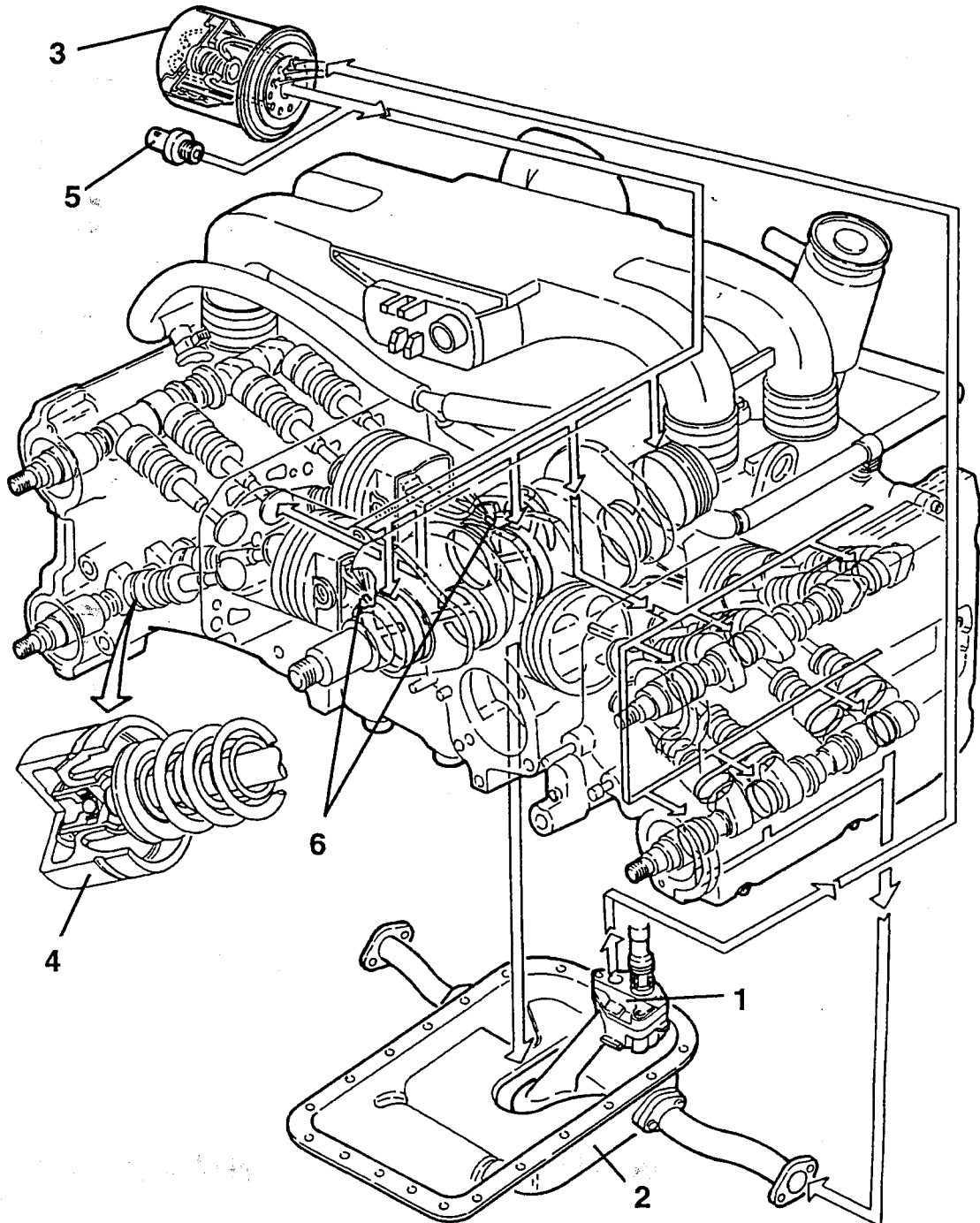
Through two transversal grooves and suitable branches machined in the crankcase and cylinder heads the oil reaches the camshaft bearings and allows the hydraulic tappets to work.

The lubrication oil of the main and rod journals falls back into the sump.

The cylinder head lubricating oil collected in the trays of the camshaft bearings returns to the sump through two special outside connection hoses.

The lubrication system is fitted with an oil vapour recirculation system which recovers the vapours from the sump.

A warning light on the instrument cluster connected to a sensor in the rear engine cover indicates low engine oil pressure.



1. Oil pump with pressure limiting valve
2. Oil sump
3. Oil filter with by-pass valve

4. Hydraulic tappet
5. Low oil pressure warning light sensor
6. Spray jets

INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhaul of the engine on the bench, after removing the power unit from the engine. The instructions are subdivided as follows:

- **Dis-assembly of the engine:**
removal of the engine accessories and components and dis- assembly into its main component parts.
- **Dis-assembly and checks of the crankcase:**
complete overhauling of the crank mechanisms.
- **Cautions for re-assembly:**
These include specific re-assembly operations where they differ substantially from the instructions for dis-assembly.
- **Checks and inspections of electrical components of the lubrication circuit.**

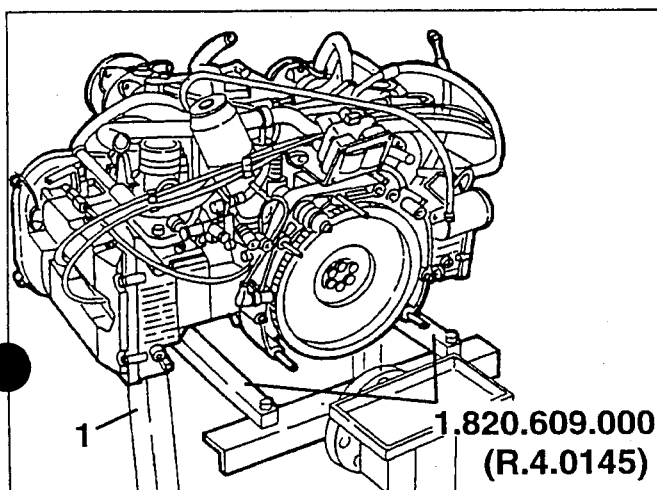
For re-assembly, the sequence for all the dis-assembly instructions described hereafter, should be reversed unless otherwise specified.

The following procedures refer to complete overhauling of the whole engine; it is however possible to use individual parts of these instructions when dealing with specific components.

ENGINE DIS-ASSEMBLY

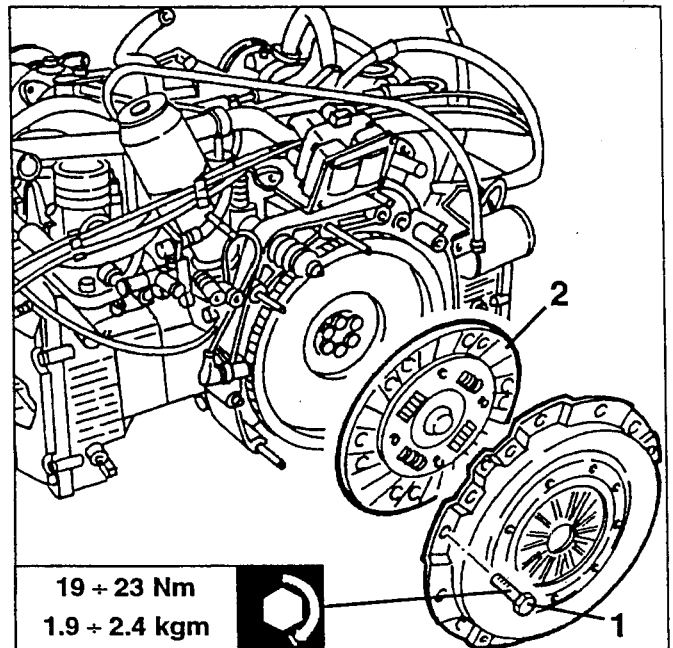
Preliminary operations

1. Set the assembly on a special overhauling stand using supports N° 1.820.609.000 (R.4.0145).



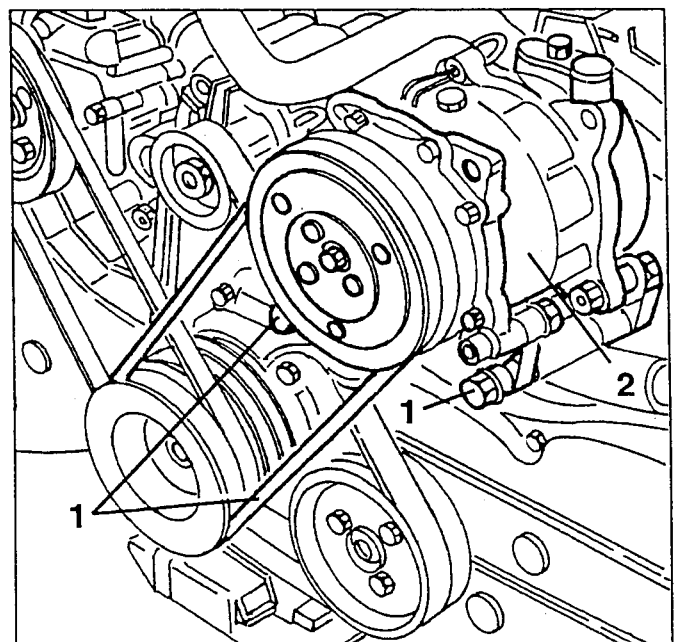
Removing the clutch plate

1. Slacken the fastening screws and remove the clutch pressure plate.
2. Remove the clutch plate.



Removing the conditioner compressor

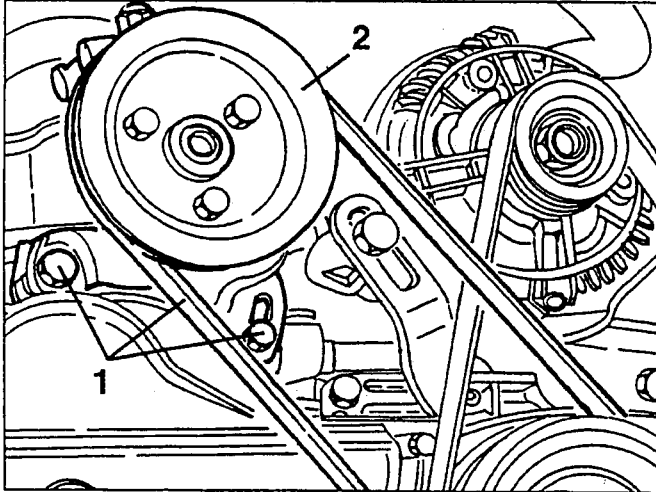
1. Slacken the compressor fastening bolt and screw; prise and remove the drive belt.
2. Completely unscrew the bolt and screw slackened previously and remove the compressor.



Removing the power steering pump

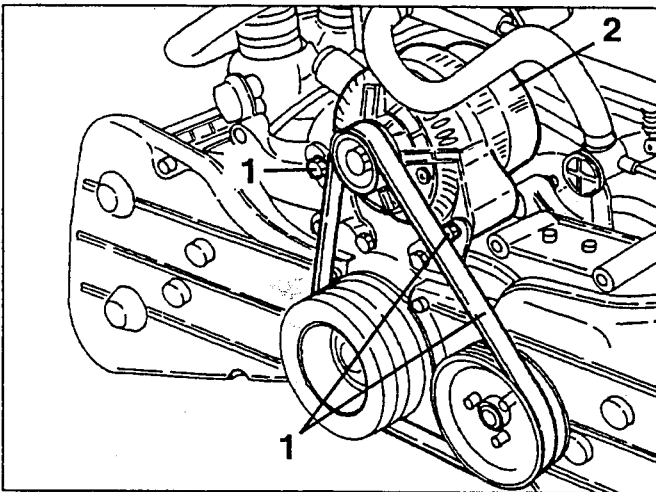
1. Slacken the two power steering pump fastening bolts; prise and remove the drive belt.

2. Completely unscrew the two bolts slackened previously and remove the power steering pump.



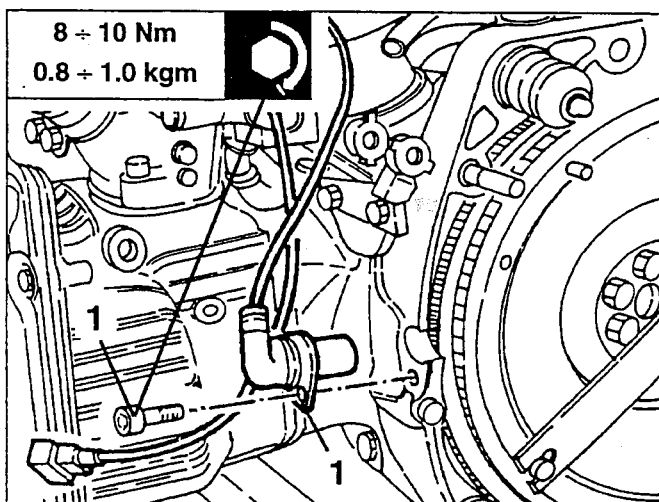
Removing the alternator

1. Slacken the two alternator fastening bolts; prise and remove the drive belt.
2. Completely unscrew the two bolts slackened previously and remove the alternator.

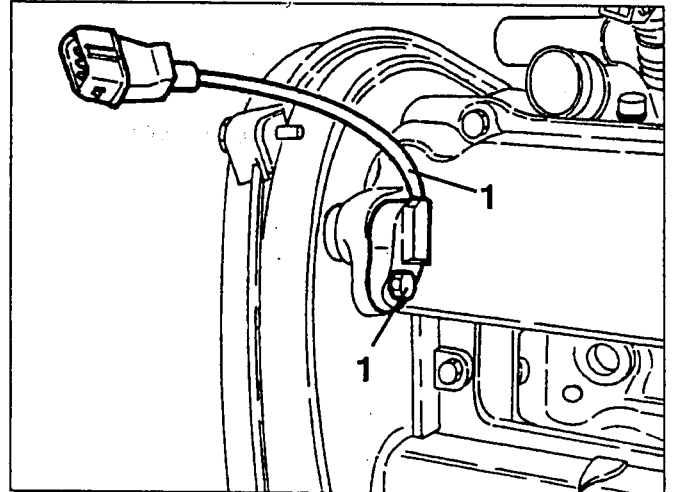


Removing the rpm and timing sensor

1. Slacken the fastening screw and remove the rpm sensor.

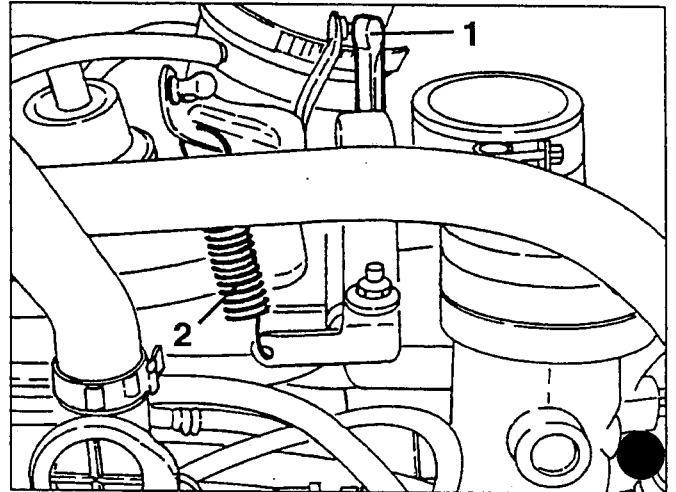


1. Slacken the fastening screw and remove the timing sensor.

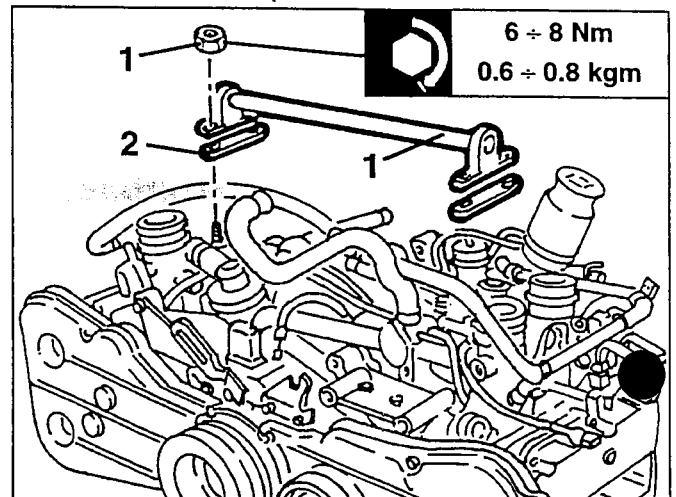


Removing the throttle control shaft

1. Disconnect the throttle valve control tie-rods.
2. Slacken the throttle control shaft return spring.

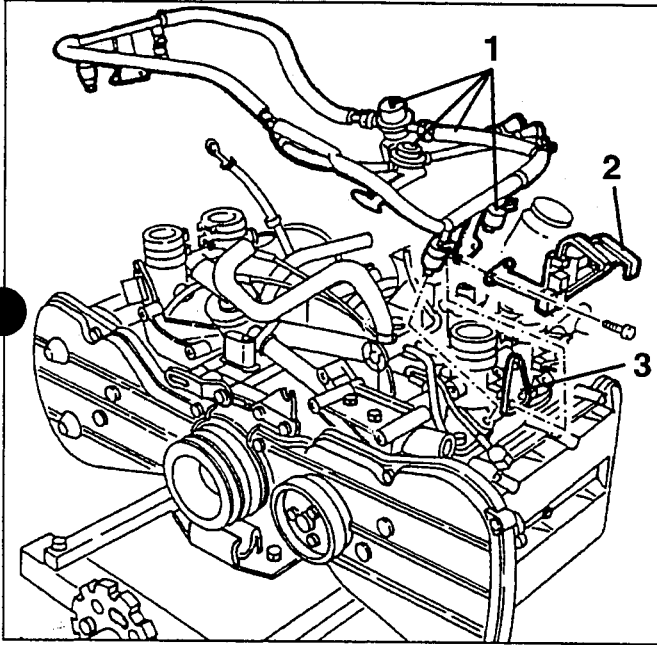


1. Slacken the fastening nuts and remove the throttle control shaft.
2. Retrieve the two spacers.



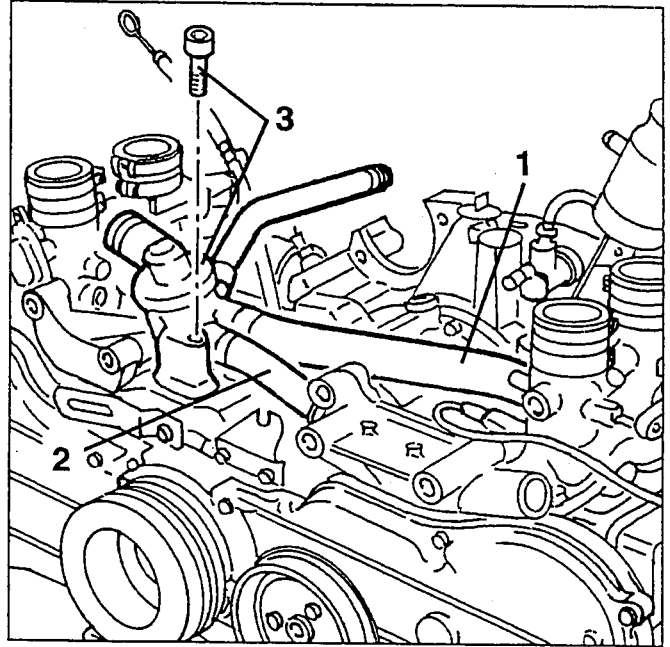
Removing the fuel distributor manifold

1. Slacken the screws fastening the fuel manifold support brackets and remove it complete with injectors, pulse damper and pressure regulator.
2. Retrieve the cable and hose support bracket.
3. Retrieve the engine lifting brackets.



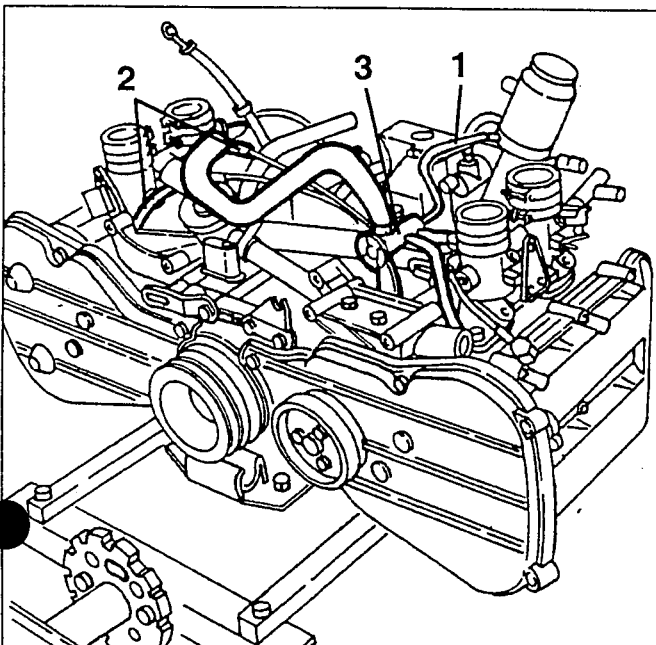
Removing the thermostat unit

1. Disconnect the coolant outlet hoses from the intakes.
2. Disconnect the thermostat unit connection pipe from the pump coolant inlet union.
3. Slacken the fastening screw and remove the thermostat unit complete with hoses.



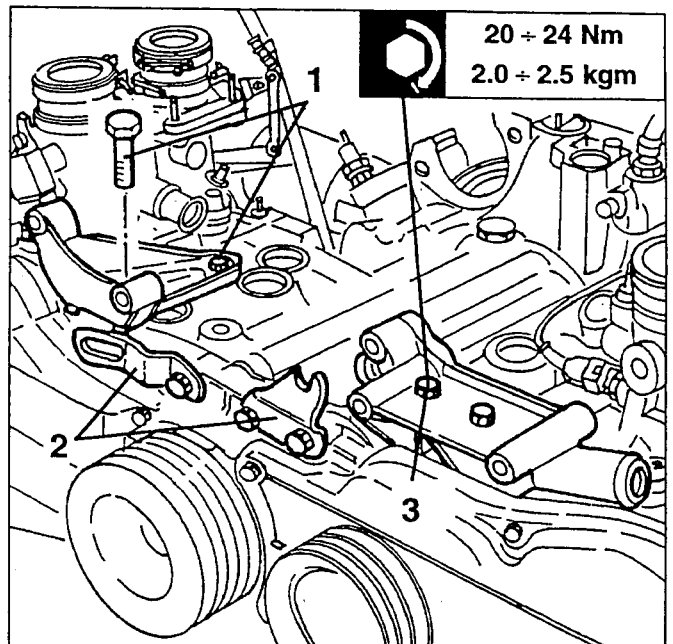
Removing the idle air distributor

1. Disconnect the oil vapour recirculation pipe from the separator.
2. Disconnect the additional air hoses for idle speed from the intakes.
3. Slacken the fastening screw and remove the idle air distributor complete with hoses.

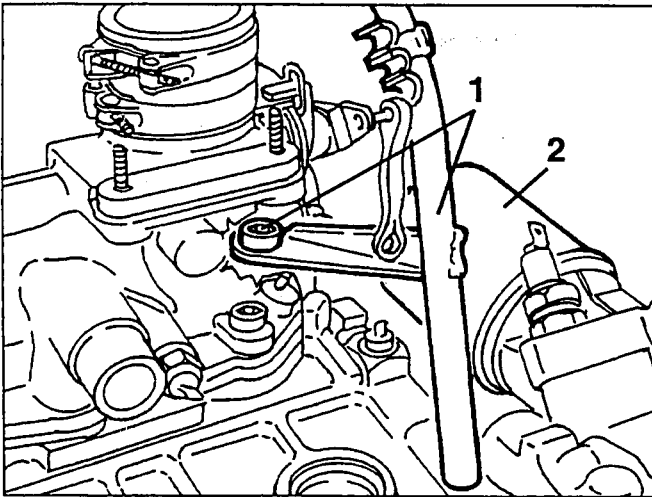


Removing the brackets

1. Slacken the fastening screws and remove the power steering pump support bracket.
2. Slacken the fastening screws and remove the alternator support bracket.
3. Slacken the fastening screws and remove the water pump inlet union and conditioner compressor support; retrieve the seal.

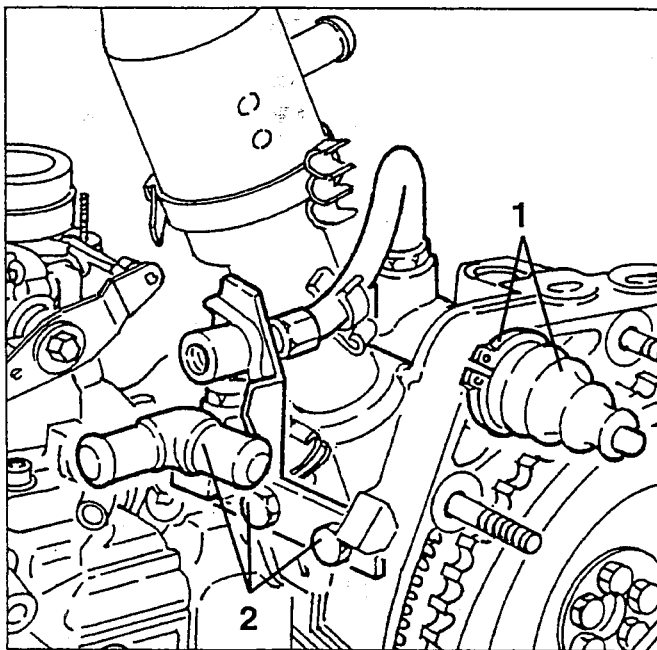


1. Slacken the fastening screw and remove the oil dipstick complete with guide.
2. Using a suitable tool, remove the engine oil filter.



Removing the clutch control cylinder

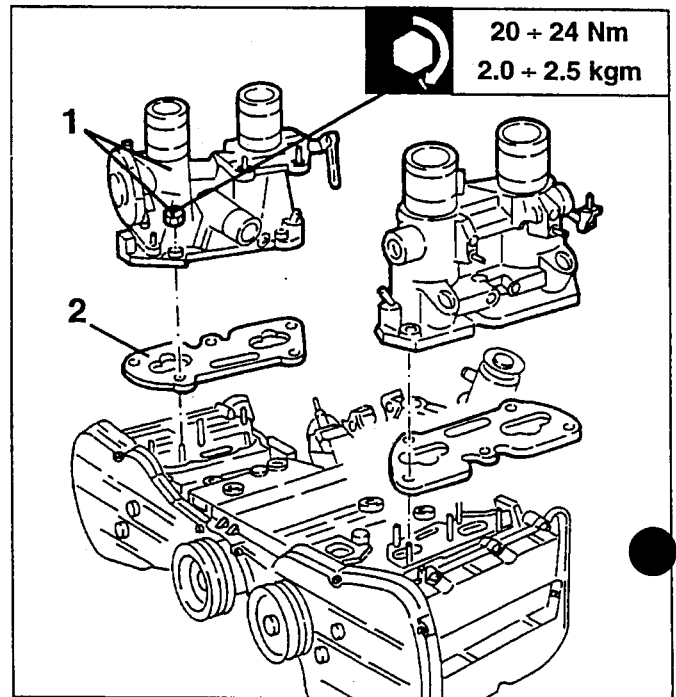
1. Remove the fastener ring and remove the clutch control cylinder complete with hose after disconnecting the latter from the support bracket.
2. Slacken the fastening screws and remove the engine cooling system three-way support bracket and the clutch control cylinder hose.



Removing the intake bodies

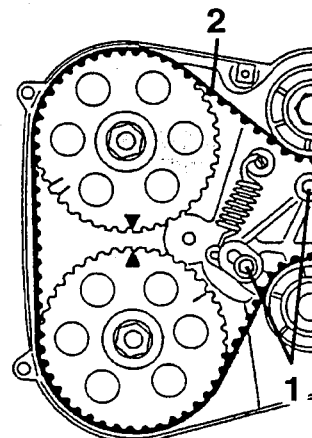
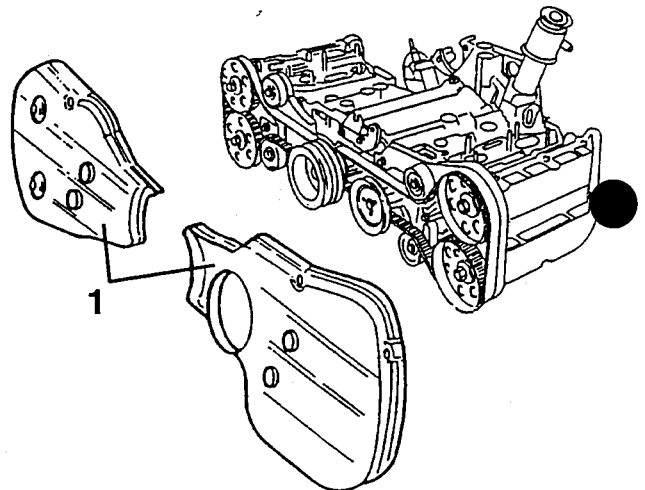
1. Slacken the fastening nuts and remove the intake bodies.

2. Retrieve the seals.



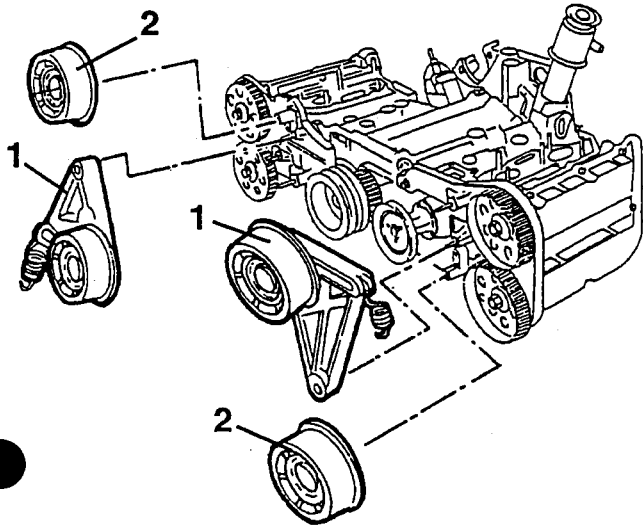
Removing the timing drive pulley

1. Slacken the fastening screws and remove the timing belt front guards.

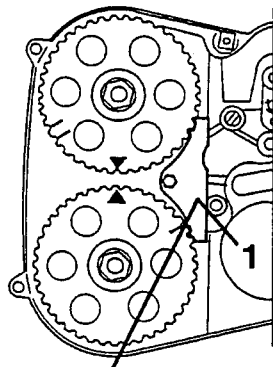


1. Release the two nuts fastening the right belt tensioner, then press on the pulley until overcoming the spring tension load and lock the belt tensioner in the slack position.
2. Prise and remove the right timing drive belt. Repeat the above-mentioned procedure to remove the left one.

1. Slacken the fastening nuts and remove the belt tensioner complete with springs.
2. Slacken the fastening screws and remove the pulleys.

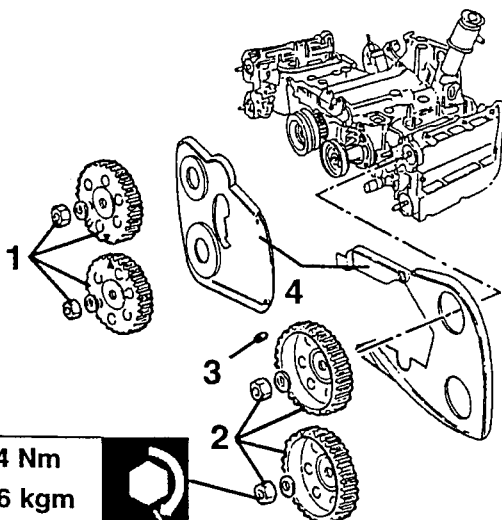


1. Fit the pulley locking tool N° 1.820.206.000.



1.820.206.000

1. Slacken the fastening screws and remove the right head pulleys.
2. Using tool N° 1.820.206.000, slacken the fastening nuts and remove the left head pulleys.
3. Retrieve the keys.
4. Slacken the fastening screws and remove the rear guards.

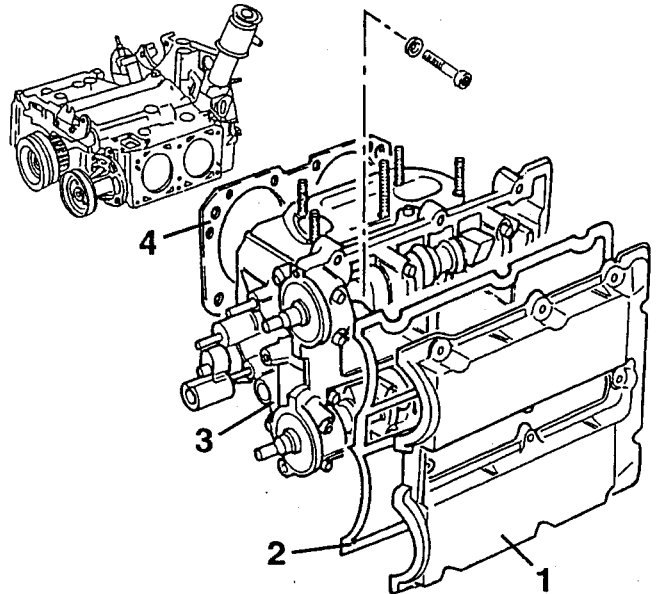


76 ÷ 84 Nm
7.7 ÷ 8.6 kgm



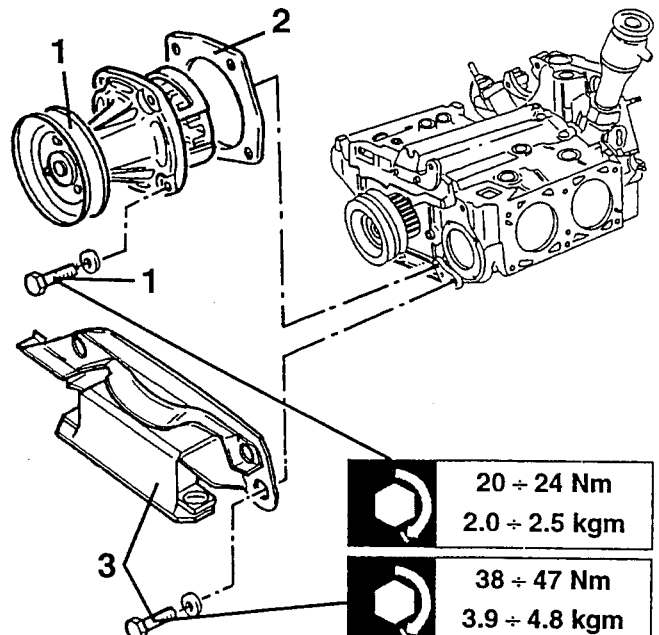
Removing the cylinder heads

1. Slacken the fastening screws and remove the head cover.
 2. Remove the seal.
 3. Slacken the six fastening screws and remove the cylinder head from the crankcase.
 4. Remove the cylinder head seal.
- Proceed in the same manner to remove the other cylinder head.



Removing the water pump

1. Slacken the four fastening screws and remove the water pump from the crankcase.
2. Remove the seal.
3. Slacken the four fastening screws and remove the front flexible mount.

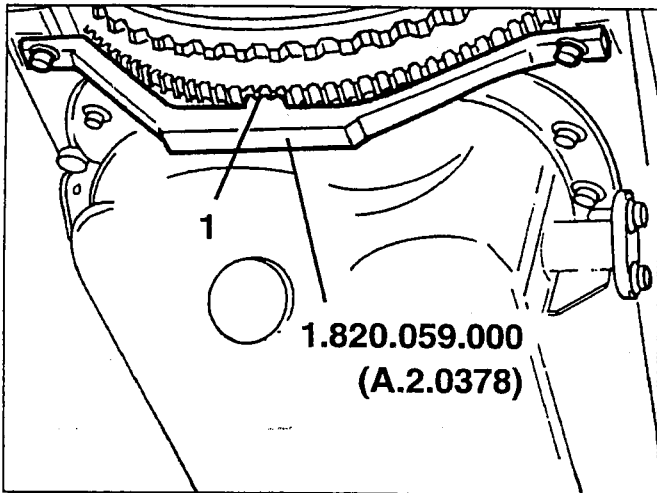


20 ÷ 24 Nm
2.0 ÷ 2.5 kgm

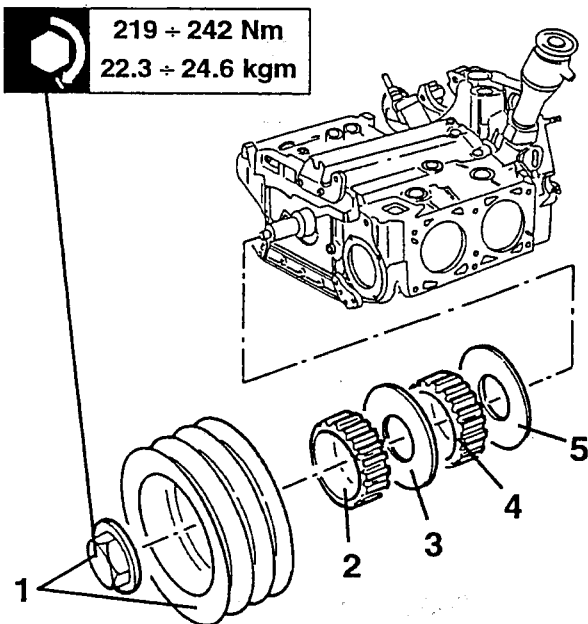
38 ÷ 47 Nm
3.9 ÷ 4.8 kgm

Removing the crankshaft pulley

1. Using tool N° 1.820.059.000 (A.2.0378), prevent the flywheel from turning.



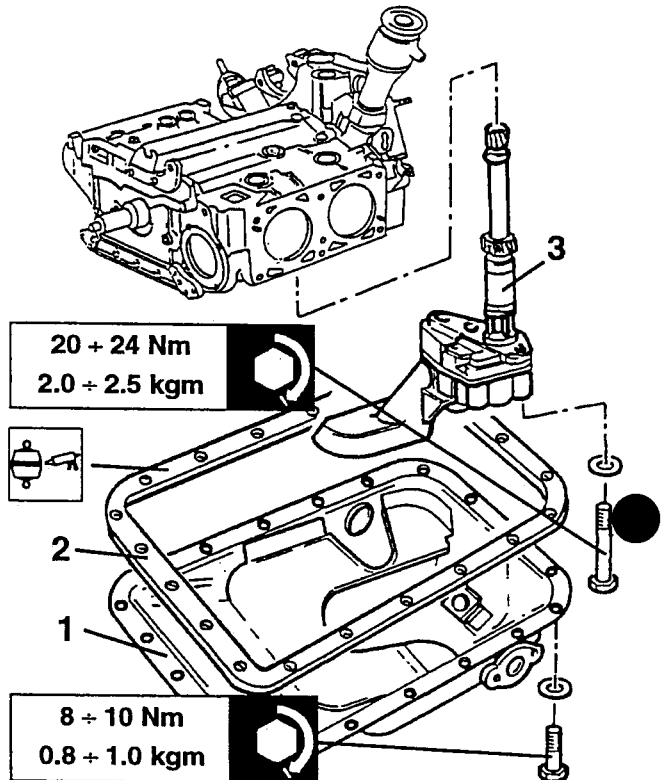
1. Slacken the fastening nut and remove the auxiliary drive pulley.
2. Remove the right timing belt toothed pulley.
3. Remove the spacer.
4. Remove the left timing belt toothed pulley.
5. Remove belt guide washer.



Removing the oil sump and pump

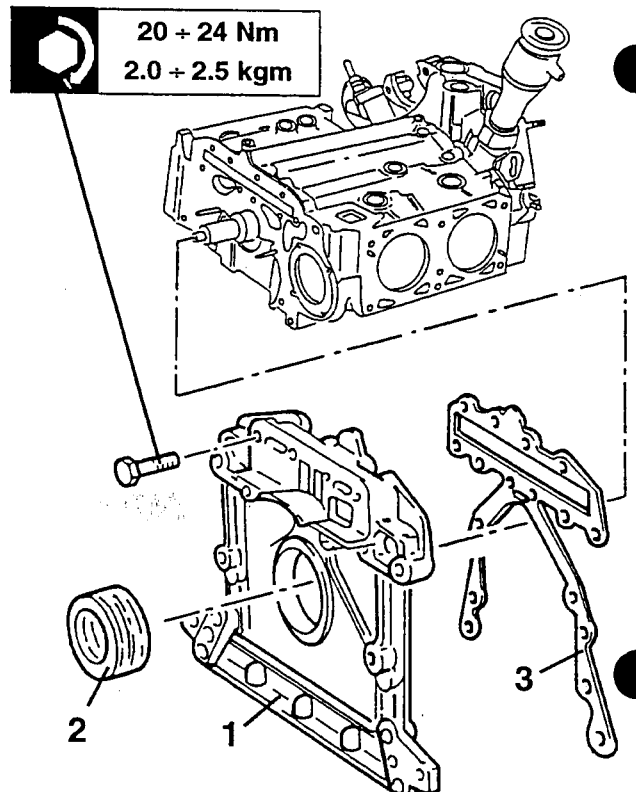
1. Slacken the fastening screws and remove the oil sump.
2. Remove the seal.

3. Slacken the fastening screws and remove the oil pump.



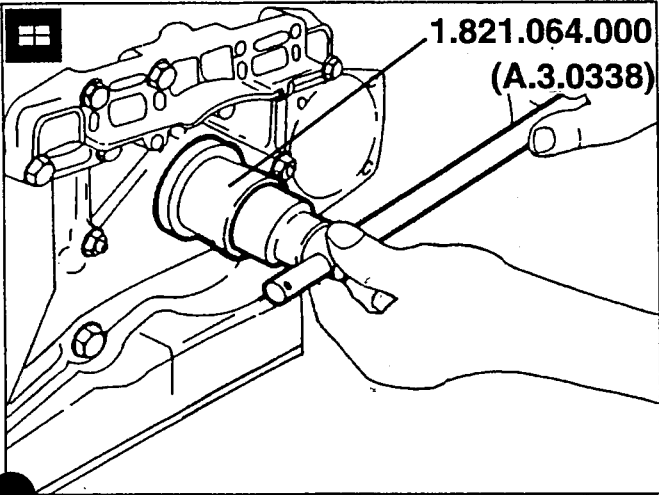
Removing the front crankcase cover

1. Slacken the fastening screws and nuts and remove the front crankcase cover.
2. Remove the oil seal from the front cover.
3. Remove the seal.



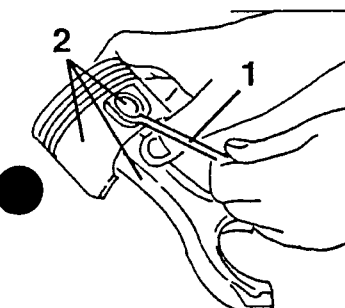
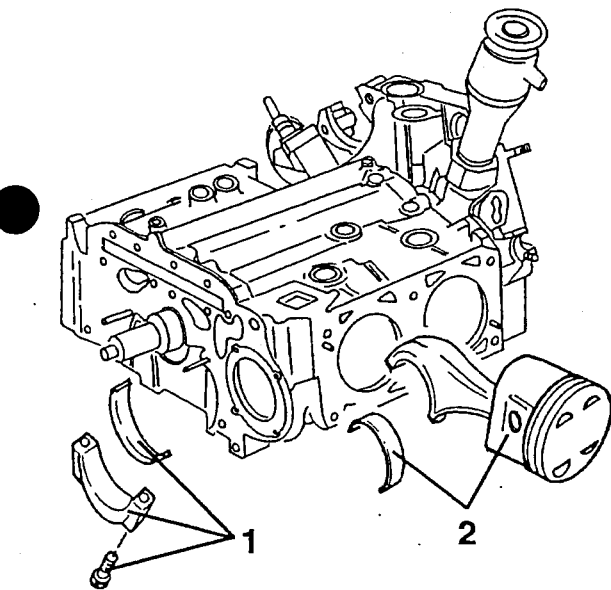


When refitting insert the oil seal on the front cover using tool N° 1.821.064.000 (A.3.0338).

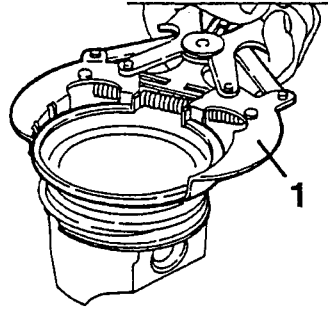


Removing the pistons and connecting rods

- Fit a suitable tool on the flywheel to allow the crankshaft to turn, then turn it to gain access to the connecting rod cap fastening screws.
- 1. Slacken the fastening screws and remove the connecting rod caps with their half bearings.
- 2. Remove the pistons complete with connecting rods and half bearings.



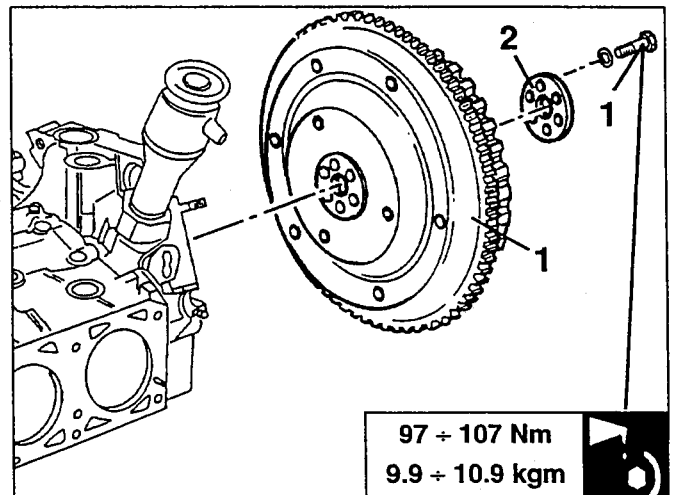
1. Remove the two gudgeon pin circlips.
2. Remove the gudgeon pin and separate the connecting rod from the piston.



1. Using a suitable tool remove the seal rings and oil scraper ring from the piston.
- Work carefully to avoid breaking any rings that might be re-used.

Removing the flywheel

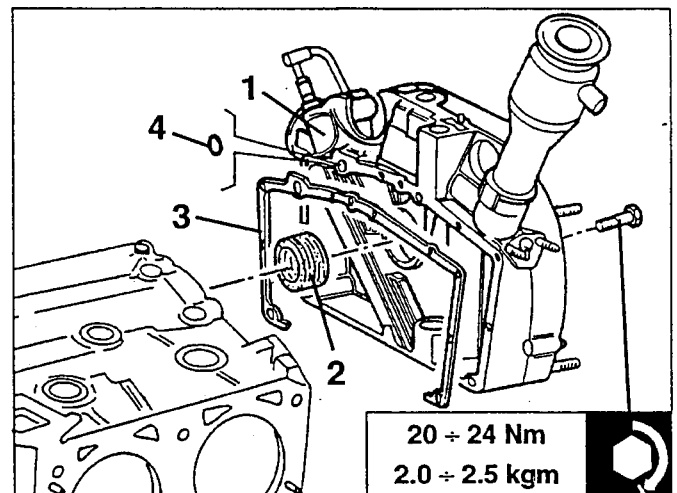
- Remove the tool for turning the crankshaft fitted previously and install tool N° 1.820.059.000 (A.2.0378).
- 1. Slacken the fastening screws and remove the flywheel.
- 2. Retrieve the safety plate.



97 ÷ 107 Nm
9.9 ÷ 10.9 kgm

Removing the rear crankcase cover

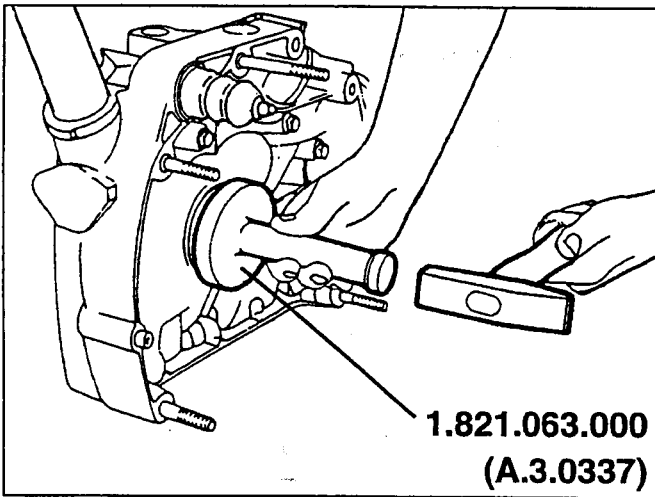
1. Slacken the fastening screws and remove the rear crankcase cover.
2. Remove the oil seal from the cover.
3. Remove the seal.
4. Remove the seal ring from the main lubricating duct.



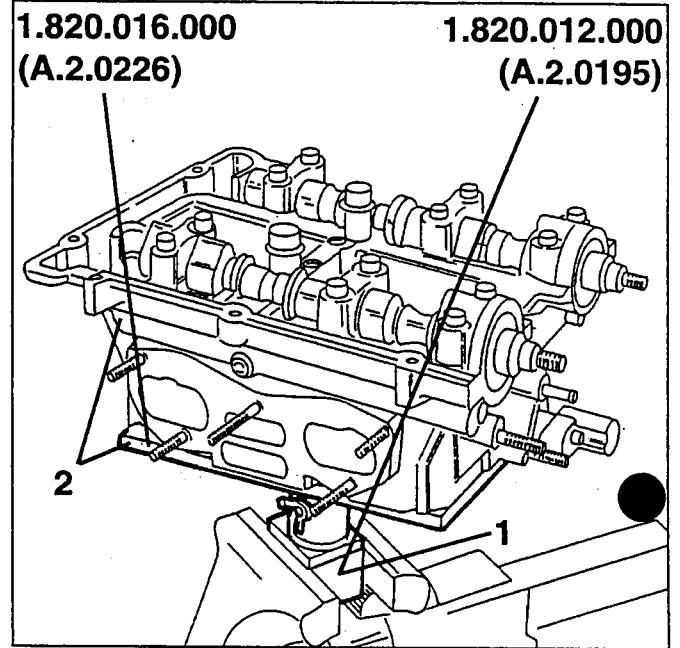
20 ÷ 24 Nm
2.0 ÷ 2.5 kgm



When refitting, use tool N° 1.821.063.000 (A.3.0337) to insert the oil seal on the rear cover.



2. Fasten tool N° 1.820.016.000 (A.2.0226) on swivelling stand and fasten the cylinder head on the latter.

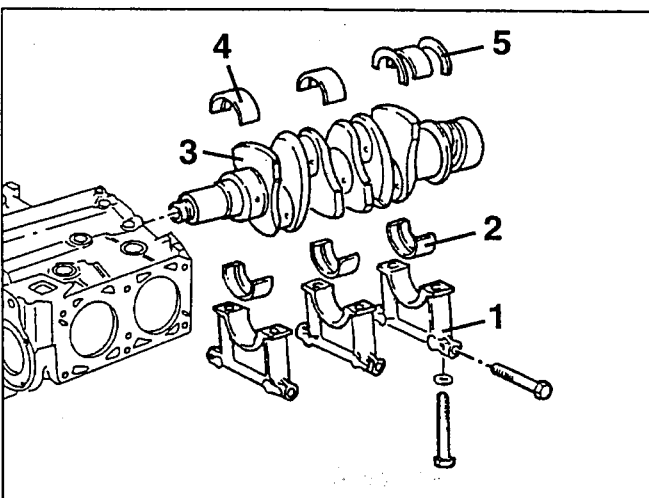


Removing the crankshaft

1. Slacken the fastening screws and remove the main bearing caps.
2. Retrieve the corresponding bearing halves.
3. Remove the crankshaft from the crankcase.
4. Retrieve the main bearing halves.
5. Retrieve the thrust half rings.



When refitting, install the two main bearing caps with oil spray jets with the jets pointing towards the right cylinder head.

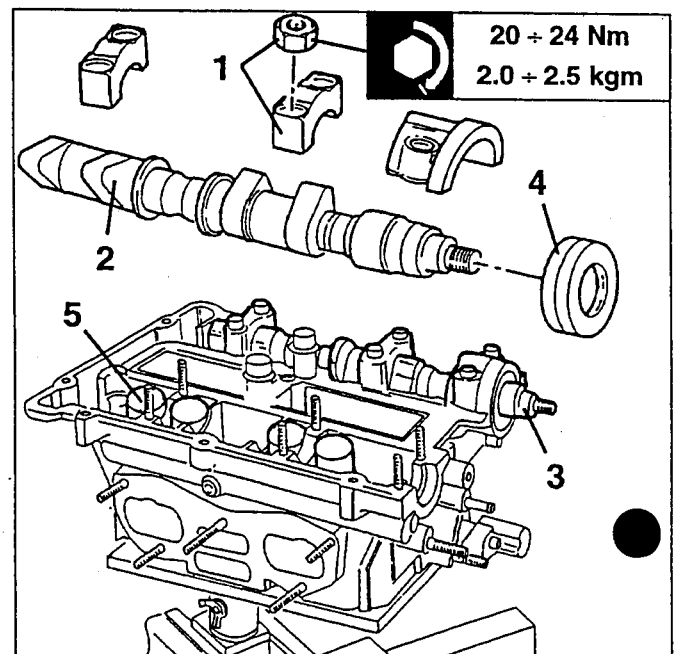


Removing the camshafts

1. Slacken the fastening nuts and remove the camshaft caps.
2. Remove the intake side camshaft.
3. Remove the exhaust side camshaft.
4. Remove the two oil rings.
5. Remove the cups and set them in order for re-assembly.



CAUTION:
The intake and exhaust camshafts are not interchangeable.



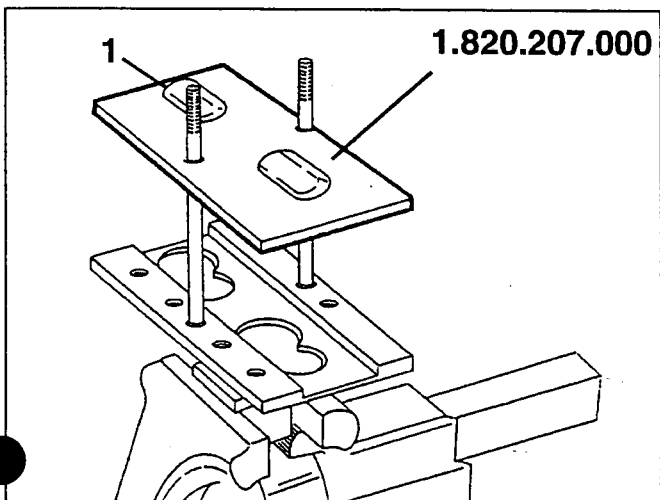
DIS-ASSEMBLY OF CYLINDER HEADS

Preliminary operations

1. Clamp the swivelling stand N° 1.820.012.000 (A.2.0195) in a vice.

Dis-assembly of valves

1. Interpose tool N° 1.820.207.000 between the cylinder head and the support stand.



1. Using tools N° 1.821.001.000 (A.3.0103), N° 1.821.058.000 (A.3.0324) and N° 1.821.205.000 remove the valve stem half cones.

2. Remove the upper plate.

3. Remove the outer spring.

4. Remove the inner spring.

5. Raise the head from tool N° 1.820.207.000 and retrieve the valve.

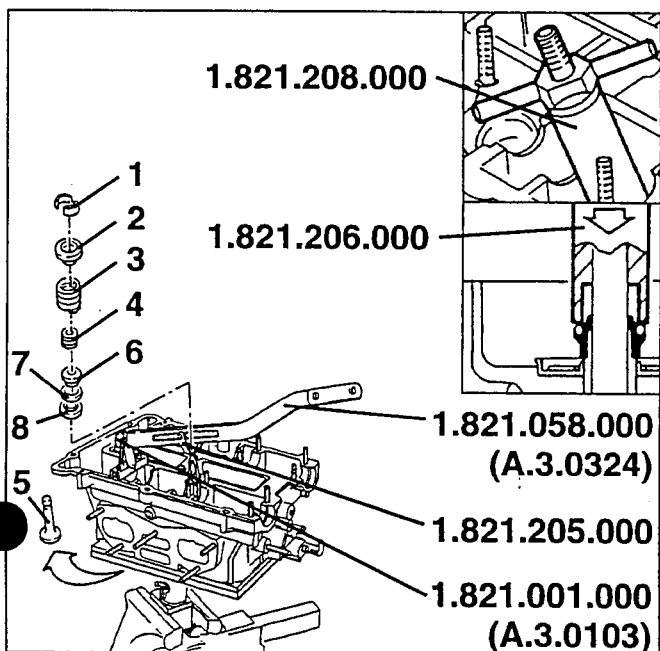
6. Using tool N° 1.821.208.000 remove the oil seal cap.



When refitting use tool N° 1.821.206.000 to insert the oil seal caps.

Remove the spring contact ring.

8. Remove the lower plate.



CHECKS AND INSPECTIONS FOR CYLINDER HEADS

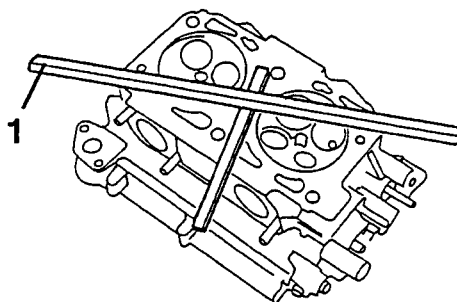
Checking the lower surface of cylinder heads

1. Check that the lower plane of the cylinder heads is level: if the lower plane is excessively worn, reface both heads.



Maximum head lower plane flatness error

0.03 mm



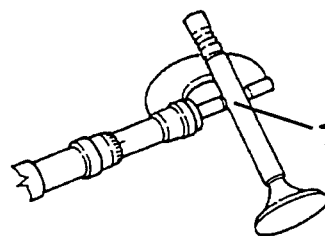
Checking the clearance between valve guides and stems

1. Measure the diameter of the valve stems and check that they are within the specified limits.



Diameter of valve stems

6.965 + 6.980 mm

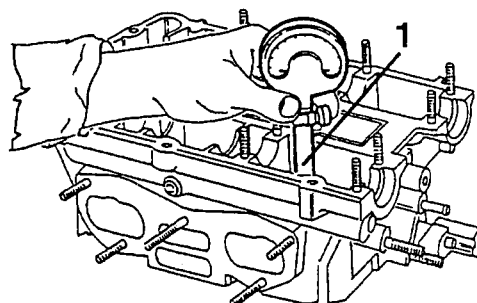


1. Measure the inside diameter of the valve guides and check that they are within the specified limits.



Inside diameter of valve guides

7.000 + 7.015 mm





- Calculate the clearance between valve guides and stems and check that they are within the specified limit, if not change any worn parts.

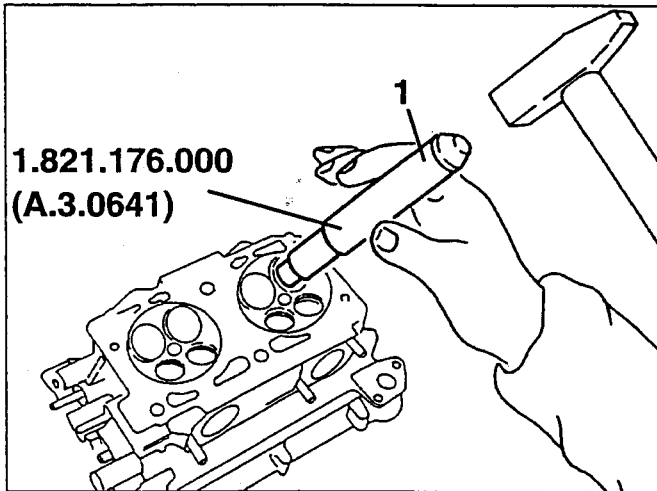


Radial clearance between valve guides and stems

0.02 + 0.05 mm

Changing the valve guides

1. Remove the worn valve guides using puller tool N° 1.821.176.000 (A.3.0641).



- Check that the outside diameter of the valve guides and of their seats on the head are within the specified limits and that interference is within the specified tolerance.



Valve guide outside diameter

Intake	12.040 + 12.051 mm
Exhaust	12.050 + 12.068 mm



Diameter of valve guide seats

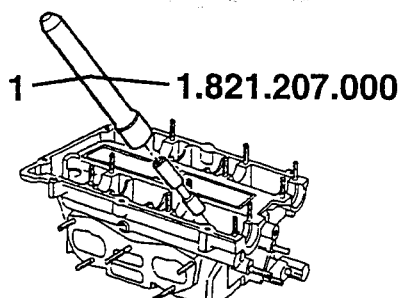
12.000 + 12.018 mm



Interference between seats and valve guides

Intake	0.022 + 0.051 mm
Exhaust	0.032 + 0.068 mm

1. Insert the new valve guides using tool N° 1.821.207.000.



NOTE: The guide valves are supplied also with a 0.2 mm oversize on the outside diameter.

- Ream the inside diameter of the valve guides to calibrate the holes to the specified diameter.



Inside diameter of valve guides "d"

7.000 + 7.015 mm

Checking the valve springs

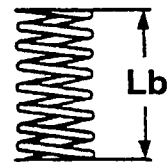
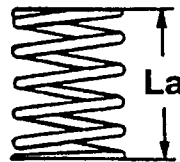
- Check that the "free" length of the valve springs is within the specified limits.

NOTE: The rest surfaces must be parallel with each other and perpendicular to the axis of the spring with a maximum error of

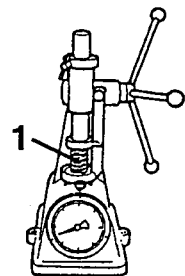


Length of valve springs

outer spring "La"	~ 51.8 mm
inner spring "Lb"	38 mm



1. Using a torque meter, check that the characteristic data of the springs are within the specified limits.



Outer spring

Spring length mm		Control load kg
Valve closed	32.5	21.4 + 22.6
Valve open	22.9	35.5 + 35.7

Inner spring

Spring length mm		Control load kg
Valve closed	30.5	13.6 + 14.4
Valve open	20.9	31.9 + 33.7

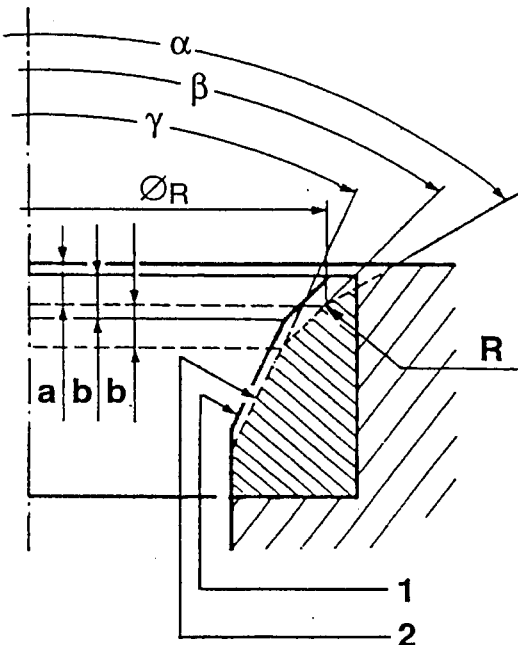
Turning the valve seats

1. Turn the valve seats using suitable tools with the cylinder heads cold.

	Taper "β" valve contact area	90° ± 20'
	Taper "α" upper valve seat area	Int. 150° Exh. 120°
	Taper "γ" lower valve seat area.	Int. 75° Exh. 60°

	Dimension "a" at refacing limit	Int. 0.4 mm Exh. 1.1 mm
	Height "b" valve contact area	Int. R = 0.9 mm Exh. b = 1.1 mm

	Reference diameter Ø_R	
	Intake	31.0 mm
	Exhaust	24.5 mm

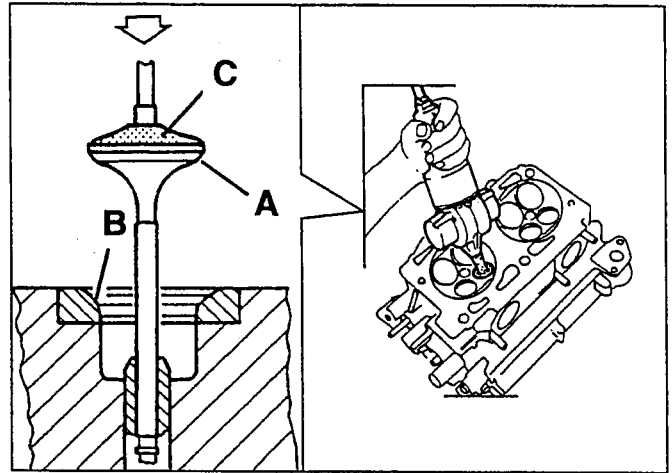


1. Original profile
2. Profile after max. refacing

- After machining grind each valve in its housing as follows:

- coat the contact surfaces "A" and "B" of the valves and seats with abrasive paste (SIPAL AREXONS carbosilicium for valves).
- lubricate the valve stem with engine oil.
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder.

- insert the valve in its guide and grind.
- after grinding, thoroughly clean the seat.

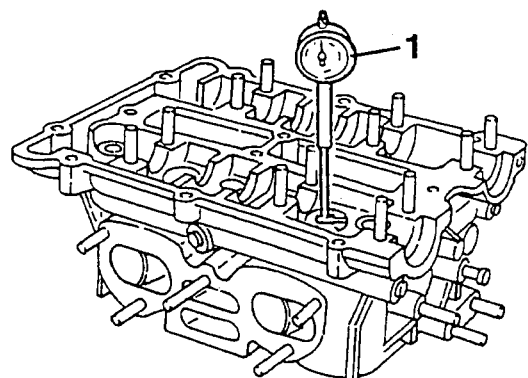


- When changing the valve guides, thus refacing and grinding the valve seats, it is advisable to check the valve tightness with the spark plugs in place, proceeding as follows:
- Fill the hollow of the combustion chamber with petrol.
- Admit low pressure air to the intake manifolds and check that no air bubbles form in the petrol.
- Check the tightness of the exhaust valves in the same way, admitting air to the exhaust manifolds.
- If any leaks are noted, make sure that the valves are perfectly settled in their seats and repeat the check; if the result is negative, grinding must be repeated.

Checking the clearance between cups and seats

1. Check that the diameter of the seats is within the specified limits.

	Diameter of valve cup seats
	33.000 ± 33.025 mm

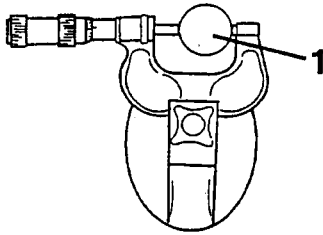




1. Check that the outside diameter of the cups is within the specified limits.



Diameter of valve cups
32.959 ÷ 32.975 mm



- Calculate the clearance between cups and seats, checking that it is within the specified limits.



Clearance between cups and seats
0.025 ÷ 0.066 mm

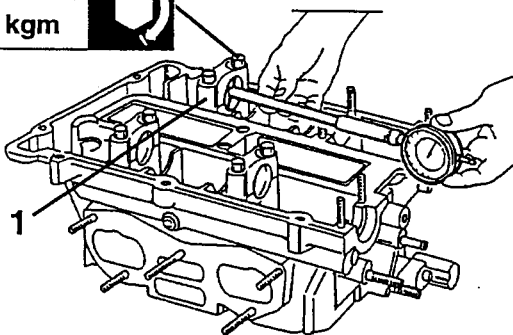
Camshafts and timing system bearings

1. Assemble the camshaft caps and tighten the screws to the specified torque, then check that the diameter of the bearings is within the specified limits.



Diameter of camshaft bearings
27.000 ÷ 27.033 mm

20 ÷ 24 Nm
2.0 ÷ 2.5 kgm



- Check that the diameter of the camshaft journals is within the specified limits.



Diameter of camshaft journals
26.959 ÷ 26.980 mm

- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limits.



Clearance between camshafts and bearings

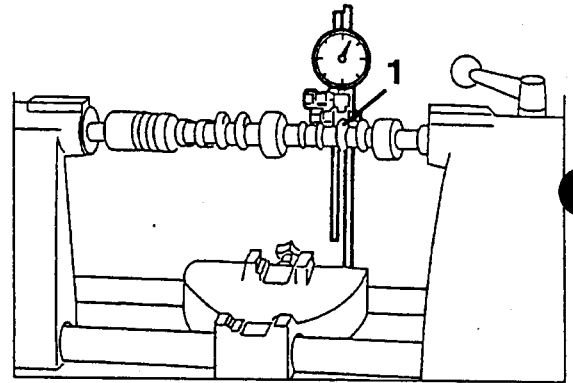
0.02 ÷ 0.074 mm

1. Check that the cam lifts are within the specified limits.



Minimum cam lift

Intake	9.5 mm
Exhaust	9.4 mm



CHECKS AND INSPECTIONS CRANKCASE

- Visibly check the crankcase for cracks and signs of excessive wear of the sliding surfaces; check that all the threads are intact.
- Remove the lubrication and cooling groove caps, and clean the ducts with a suitable detergent, then dry with a jet of air and fit new caps.
- Accurately remove any traces of seals or sealants from the crankcase surfaces.

Checking the cylinders

- Use a bore meter fitted on a dial gauge to measure the inside diameters of the cylinders and check that it is within the specified limits.



Inside diameter "d"

Class A	87.000 ÷ 87.010 mm
Class B	87.010 ÷ 87.020 mm
Class C	87.020 ÷ 87.030 mm
Class D	87.030 ÷ 87.040 mm
Class E	87.040 ÷ 87.050 mm

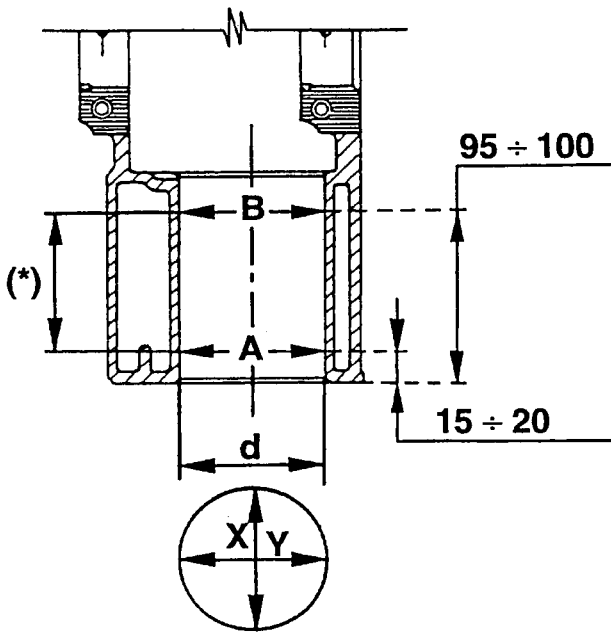


Maximum taper

A - B = 0.02 mm



Maximum ovalization
$X - Y = 0,02 \text{ mm}$



(*) Area for dimensional inspection

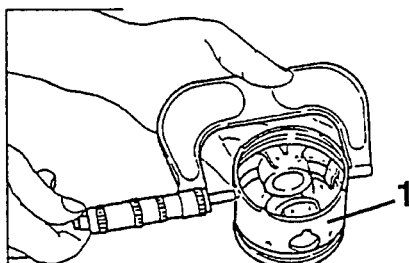
Checking the piston

1. Measure the outside diameter of the pistons and check that it is within the specified limits.



Outside diameter of pistons (mm) (1)	
Class A (Blue)	$86.950 \div 86.960$
Class B (Pink)	$86.960 \div 86.970$
Class C (Green)	$86.970 \div 86.980$
Class D (Yellow)	$86.980 \div 86.990$
Class E (White)	$86.990 \div 87.000$

(1) The outer diameter of the piston must be measured perpendicular to the gudgeon pin hole at a distance of 13.9 mm from the axis of the gudgeon pin.



- Calculate the clearance between the cylinder and piston and check that it is within the specified limits.



Clearance between cylinders - pistons
$0.04 \div 0.06 \text{ mm}$

- If the dimensions are not within tolerance, the liners should be refaced, bearing in mind that pistons in three oversizes are available as spares; therefore the diameter is to be made within the tolerances given in the "Technical Characteristics and Specifications" GROUP 00.

- Fit the main bearings caps on the crankcase and tighten the fastening screws to the specified torque.

- Then bore the cylinders to within the tolerances given in the "Technical Characteristics and Specifications" GROUP 00.

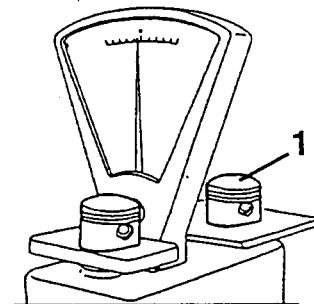


Grinding should be carried out so that the signs of machining are crossed with an angle of $90^\circ \div 120^\circ$.

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.

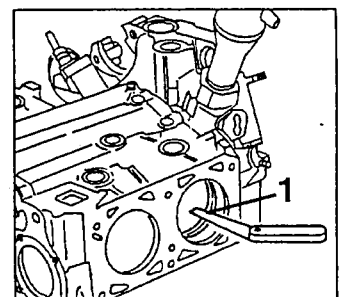


Difference in weight between pistons
$\leq 2 \text{ g}$



Checking the seal ring gap

1. Insert the rings in the cylinder liner, check that they adhere to the whole circumference and that the gap is within the specified limits.

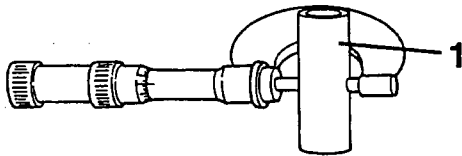


Ring gap	
First ring	$0.30 \div 0.50 \text{ mm}$
Second ring	$0.30 \div 0.50 \text{ mm}$
Oil scraper ring	$0.25 \div 0.50 \text{ mm}$

Checking the play between pins and seats on pistons

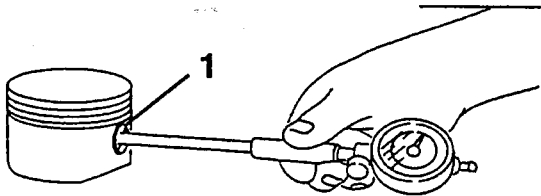
1. Measure the outside diameter of the pins and check that it is within the specified limits.

∅	Outside diameter of pins
	20.996 + 21.000 mm



1. Measure the diameter of the pin mating hole on the piston and check that it is within the specified limits.

∅	Diameter of pin hole on pistons
	21.004 + 21.008 mm



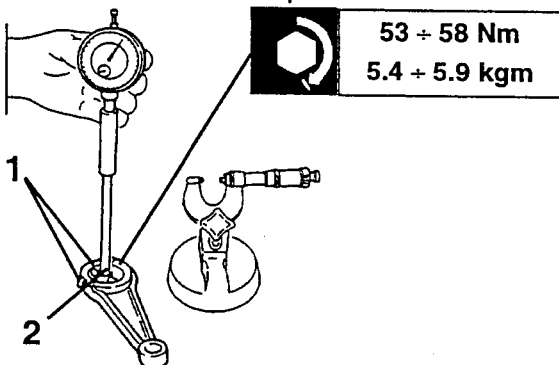
- Calculate the clearance between the pins and their seats on the pistons and check that it is within the specified limits.

↔	Clearance between pins and seats on pistons
	0.004 + 0.012 mm

Checking the clearance between connecting rod journals and the corresponding half bearings

1. House the rod half bearings in the connecting rod big end and on the corresponding cap, then join them tightening the fastening screws to the specified torque.

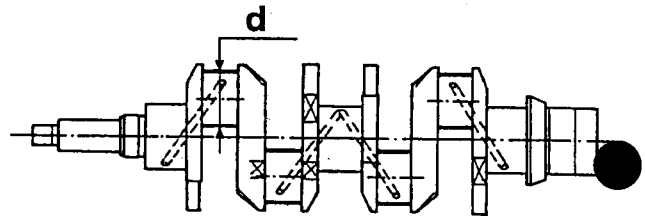
2. Measure the diameter of the connecting rod big end and check that it is within the specified limits.



∅	Inside diameter of connecting rod half bearings	
	Class A - Blue	50.032 + 50.056 mm
	Class B - Red	50.024 + 50.048 mm

1. Measure the diameter of the connecting rod journals and check that it is within the specified limits.

∅	Diameter of connecting rod journals	
	Class a - Blue	49.992 + 50.000 mm
	Class B - Red	49.984 + 49.992 mm



NOTE: Due to the nitriding treatment the crankshaft has undergone, no grinding operations are possible; therefore it must be changed in the event of excessive wear.

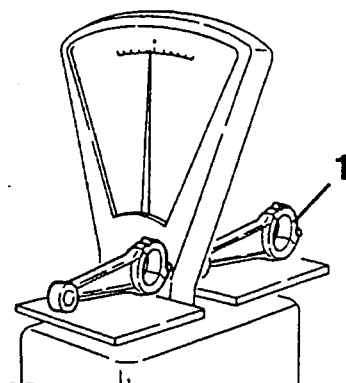
- Calculate the clearance between the rod journals and the corresponding half bearings and check that it is within the specified limits.

↔	Clearance between rod journals and half bearings
	0.032 + 0.064 mm

Checking the connecting rods

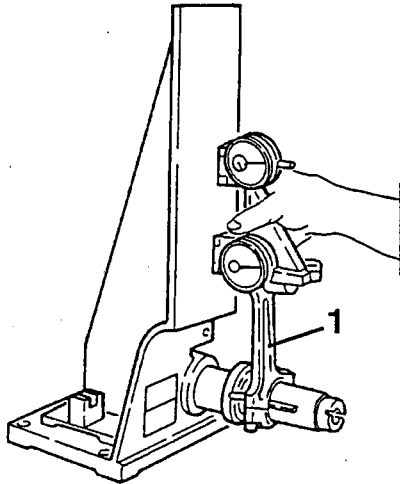
1. Check that the difference in weight between the rods complete with half bearings, caps and screws is within the specified limits.

⚖	Difference in weight between connecting rods
	≤ 2 g



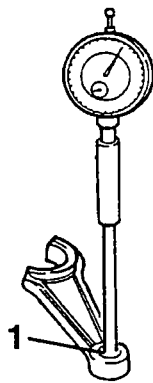
Check that the rods are perpendicular using a reference plane as illustrated.

NOTE: If perpendicularity is not perfect, the connecting rod must be changed to avoid abnormal stresses when the engine is running, resulting in uneven wear of the piston and of the rod itself.



Checking the clearance between pins and small end bushing

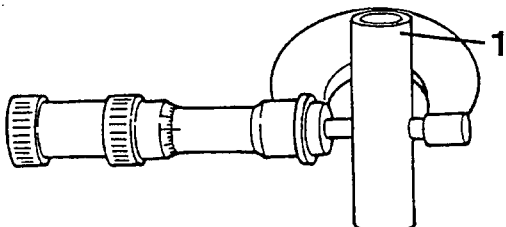
1. Measure the inside diameter of the small end bushing and check that it is within the specified limits, if not, change the bushing.



∅	Inside diameter of small end bushing
	21.007 ÷ 21.015 mm

1. Measure the outside diameter of the pins and check that it is within the specified limits.

∅	Outside diameter of pins
	20.996 ÷ 21.000 mm



- Calculate the clearance between the pins and the small end bushing and check that it is within the specified limits.



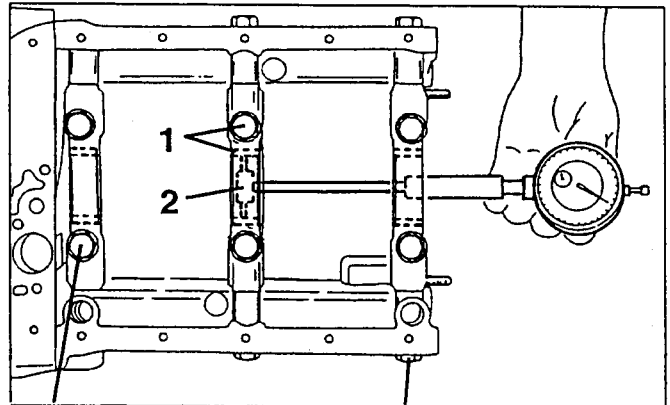
Clearance between pins and small end bushing
0.007 ÷ 0.019 mm

Checking the clearance between main bearing journals and the corresponding half bearings

1. House the half bearings and fit the main bearing caps on the crankcase tightening the fastening screws to the specified torque.
2. Measure the diameter of the main bearings and check that it is within the specified limits.



Diameter of main bearings	
Class A - Red	59.987 ÷ 60.009 mm
Class B - Blue	59.979 ÷ 60.001 mm

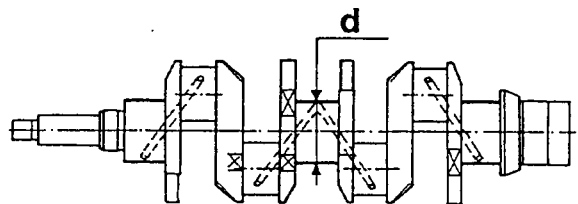


67 ÷ 74 Nm	41 ÷ 50 Nm
6.8 ÷ 7.5 kgm	4.2 ÷ 5.1 kgm

1. Measure the diameter of the main bearing journals and check that it is within the specified limits.



Diameter of main bearing journals	
Class A - Red	59.954 ÷ 59.964 mm
Class B - Blue	59.944 ÷ 59.954 mm



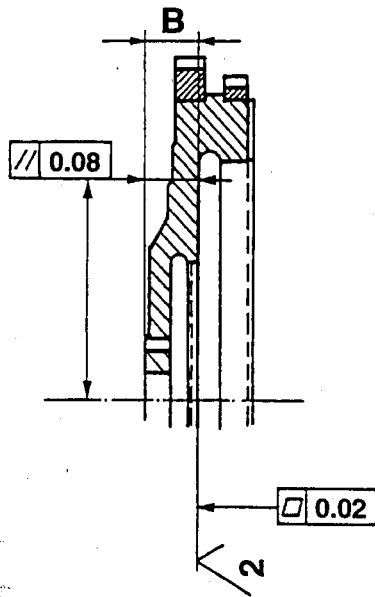
Clearance between main bearing journals/half bearings
0.023 ÷ 0.055 mm

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, proceed as follows to change them:

- remove the old ring gears;
- accurately clean the contact surfaces of the new ring gears and of the flywheel;
- evenly heat the new ring gears to 120° + 140° C and fit them on the flywheel;
- leave to cool naturally, do not force cool.

- Check that the surface of the flywheel on which the clutch driven plate works has no nicks, material removal or signs of overheating. If not, check that dimension "B" shown in the diagram is above the specified limit and that the machining allowance enables refacing.



	Refacing dimension
	$B \geq 21.15 \text{ mm}$

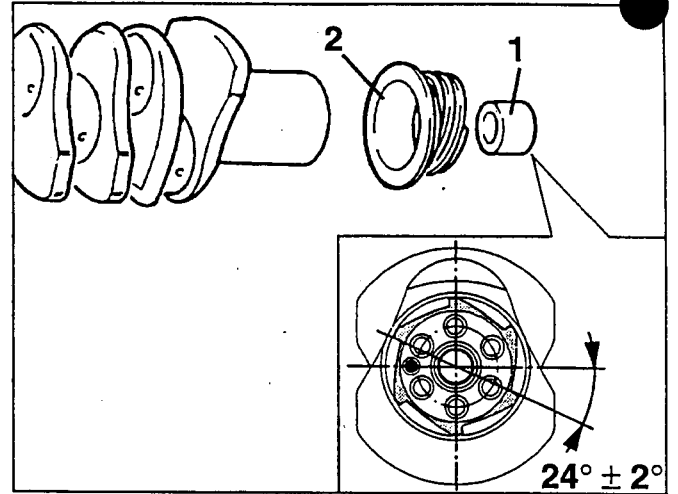
CAUTIONS FOR RE-ASSEMBLY

For re-assembly operations reverse the sequence of those described for dis-assembly unless otherwise indicated below.

- Check valve tightness when the cylinder heads are assembled.

Reassembling the crankshaft

1. If removed previously, the crankshaft rear bushing should be refitted using tool N° 1.821.104.000 (A.3.0450).
2. Heat the oil pump drive gear to 150°C and shrink it onto the crankshaft directing it as illustrated.



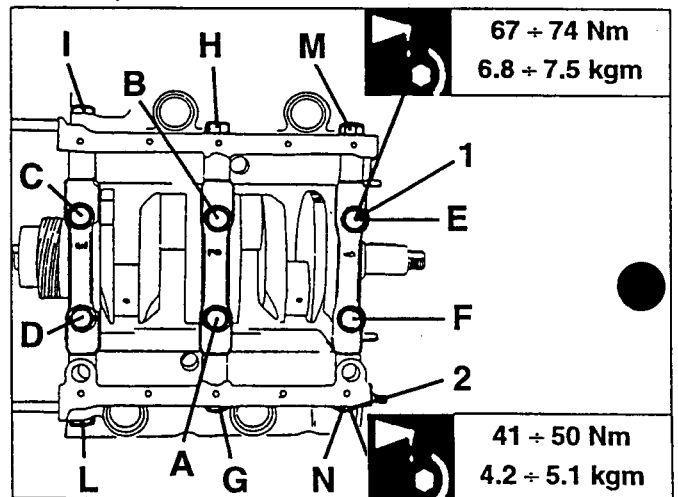
Tightening the main bearing caps

- Assemble the main bearing caps on the crank bearings in the correct position and tighten the fastening screws in oil without locking them.

1. Tighten the main bearing cap fastening screws to the respective crankcase bearings two or three times in the sequence shown (from A to F).

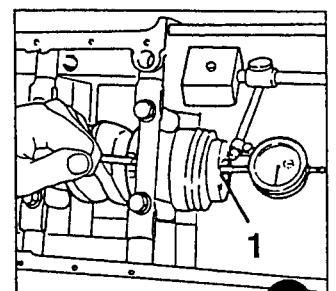
2. Then in two or three operations, tighten the screws fastening the main bearing caps to the crankcase in the sequence shown (from G to N).

- Turn the crankshaft by hand and check that it turns smoothly.



Checking the crankshaft end float

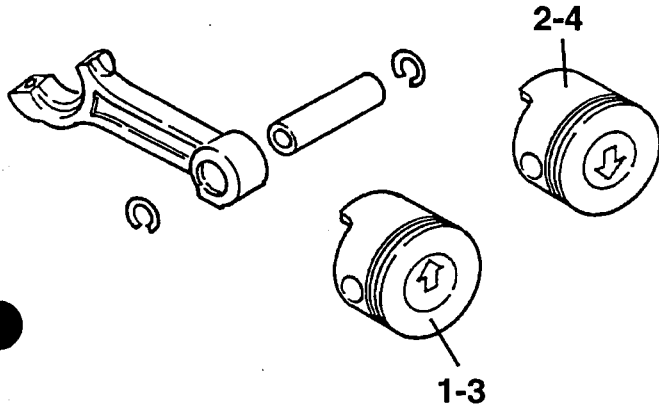
1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.



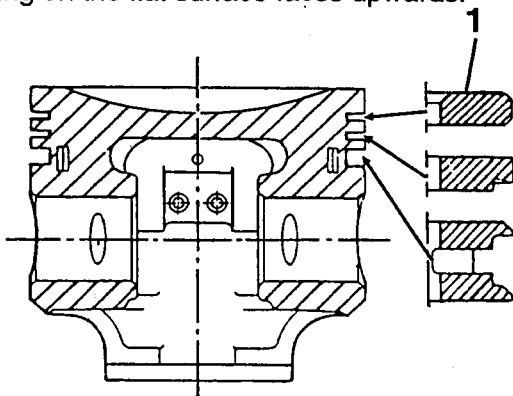
	Crankshaft end float
	0.35 mm

Reassembling the pistons and connecting rods

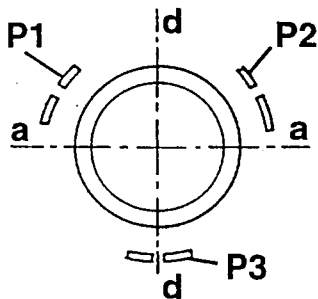
1. Assemble the pistons and connecting rods so that the pistons of the right cylinder head 1-3 have the arrow stamped on the crown pointing upwards and the pistons of the left head 2-4 have the arrow pointing downwards.



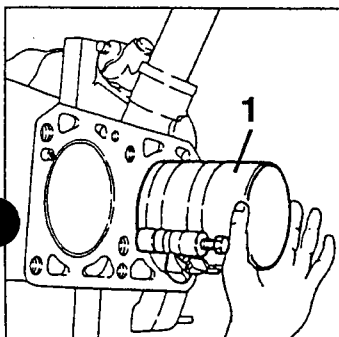
1. Insert the rings on the piston making sure that the wording on the flat surface faces upwards.



- Direct the rings on the pistons with the cuts offset by 120°.



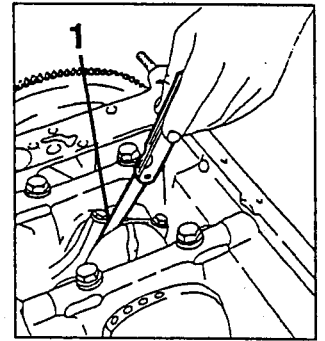
P1. Position of upper ring;
P2. Position of lower ring;
P3. Position of oil scraper ring;
aa. Gudgeon pin axis;
dd. Direction of thrust.



1. Assemble the half bearings on the connecting rod big end and insert the piston-connecting rod assembly in the corresponding cylinders using the special tool.

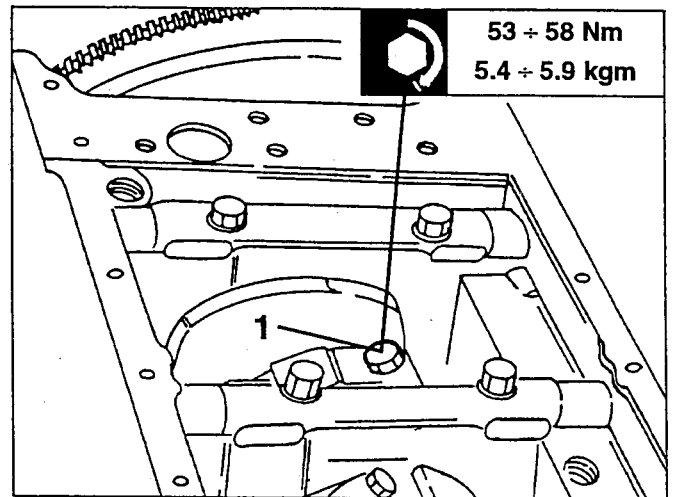
When assembling direct the pistons with the arrow stamped on the crown pointing in the direction of rotation of the engine, i.e. upwards for the right head pistons and downwards for the left head pistons.

The position of the connecting rod big end must make it possible to read the identification number.



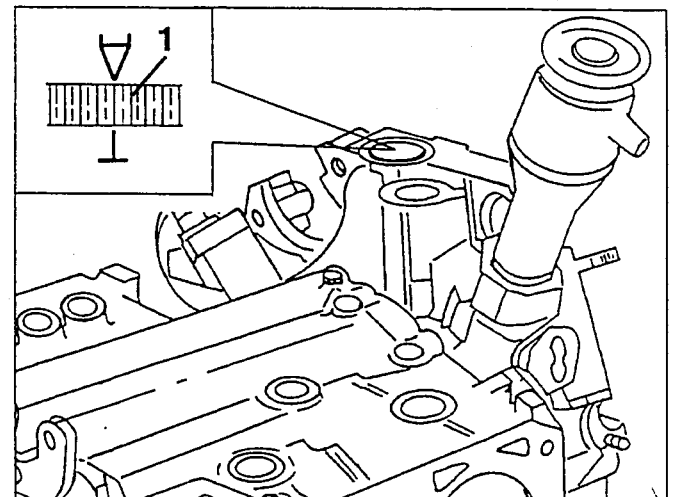
1. Position the connecting rod caps with the corresponding half bearings and check that there is the specified play between the crankshaft shoulder and the connecting rod-cap profile.

1. Suitably turn the crankshaft to gain access to the connecting rod cap fastening screws and tighten them to the specified torque.



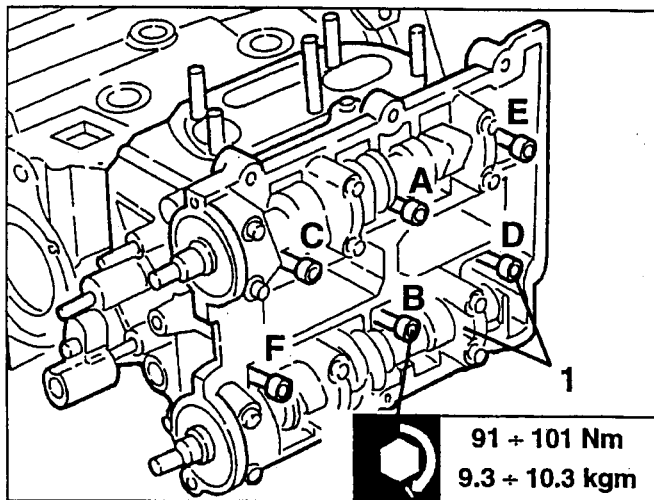
Reassembling the cylinder heads

1. Turn the crankshaft to take piston no. 1 to the T.D.C. (bursting stroke); making sure that the notch "T" on the flywheel coincides with the fixed reference of the rear cover.



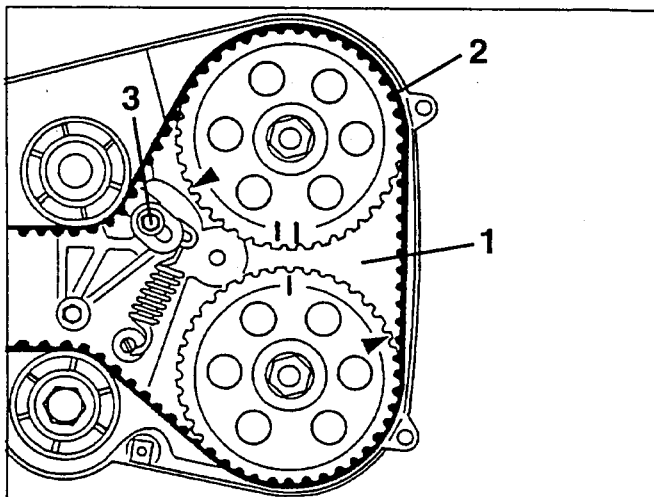
CAUTION:
Turn the camshafts to a neutral position.

1. Assemble the cylinder heads with the seals interposed on the crankcase and tighten the fastening screws in two or three operations to the specified torque following the sequence indicated (from A to F).



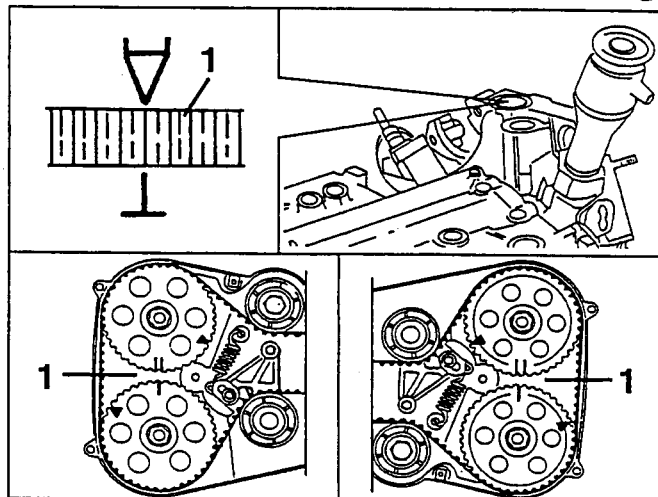
Assembling the timing belts

1. Turn the camshafts of the left head so that the area between the two notches of the intake pulley coincides with the notch of the exhaust pulley.
- Turn the crankshaft until the notch "T" on the flywheel is aligned with the fixed reference of the rear cover.
2. Fit the left timing belt.
3. Slacken the belt tensioner fastening nut so that it can exert the load impressed by the spring on the belt.

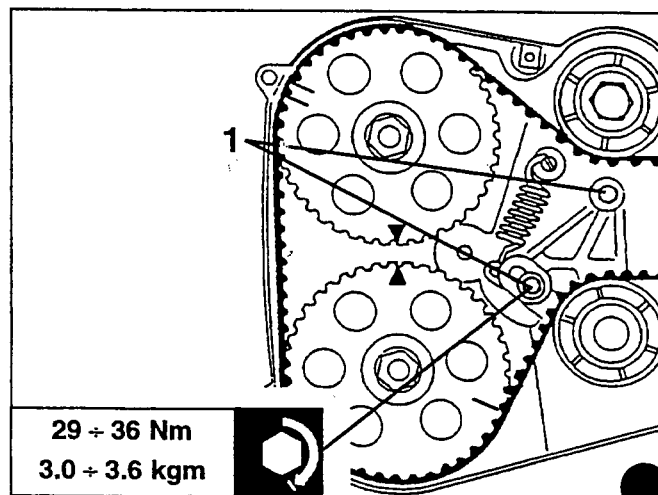


- Repeat the previous operations for assembly and timing of the right timing belt.
- Turn the crankshaft a few times in its direction of rotation to allow the belts to take their final position.

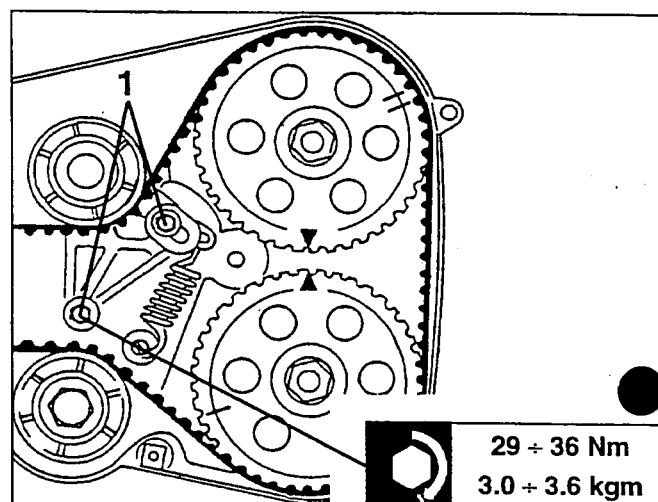
1. Check engine timing.



- Turn the crankshaft 90° to obtain: the impression on the flywheel aligned with the fixed index alignment of the notches ▲ on the pulleys.
1. Slacken the fastening nuts of the right belt tensioner to settle it then tighten them to the specified torque.



- Turn the crankshaft 360° to obtain: the impression on the flywheel aligned with the fixed index and alignment of the notches ▲ on the pulleys.
1. Slacken the fastening nuts of the left belt tensioner to settle it then tighten them to the specified torque.

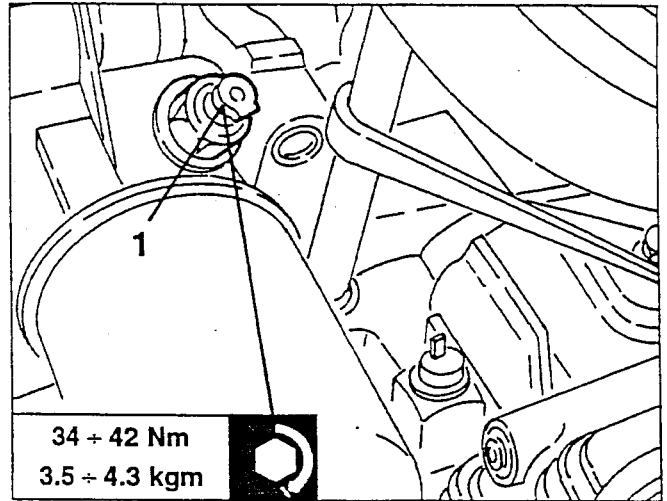


Turn the crankshaft a few turns and check again that the timing references correspond.

CHECKING THE ELECTRICAL COMPONENTS OF THE LUBRICATION CIRCUIT

Minimum engine oil pressure warning light sensor

1. Check the setting of the minimum engine oil pressure warning light sensor. If the value fails to meet specifications, change the sensor.



Contact opening/closing pressure	$0.2 \div 0.5 \text{ bar}$
---	----------------------------

For the other sensors and electrical components located in the engine compartment, refer to the specific Groups in which an extensive description is given.





INDEX

GENERALIES

- Description 1
- Lubrication 4

OVERHAULING

- Introduction 7
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- Engine block checks and inspections 23
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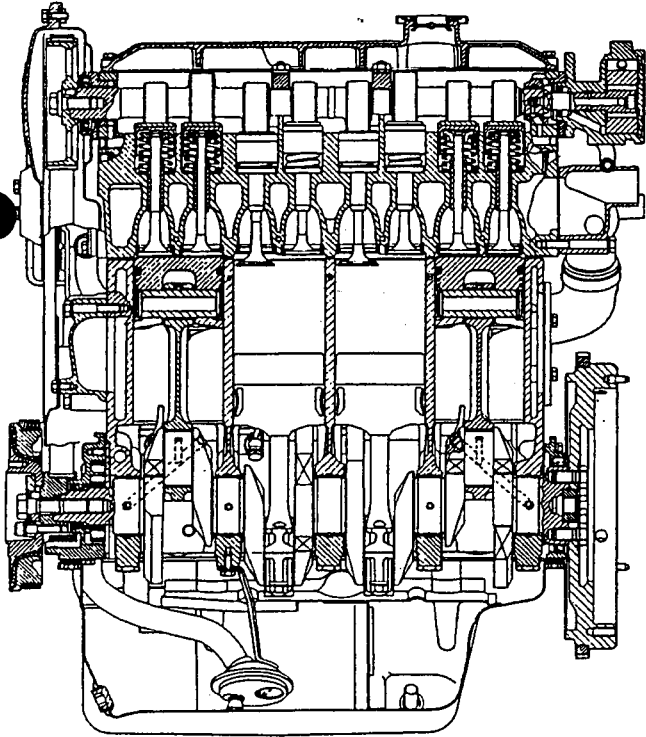


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DESCRIPTION

The engine is of the four cylinder in line type with overhead camshaft timing controlled by a drive belt, two valves per cylinder, turbine type air boosting system IHI, and indirect injection with low turbulence combustion prechamber.

The clutch - gearbox unit is connected behind the engine and forms an integral part of the engine unit. It is front mounted and set transversally at an inclination of $18^{\circ}30'$ forwards.



It is installed on the frame by suspension type mounts and fixed by two elastic damping supports at the front and by an elastic damping fork type support at the rear.

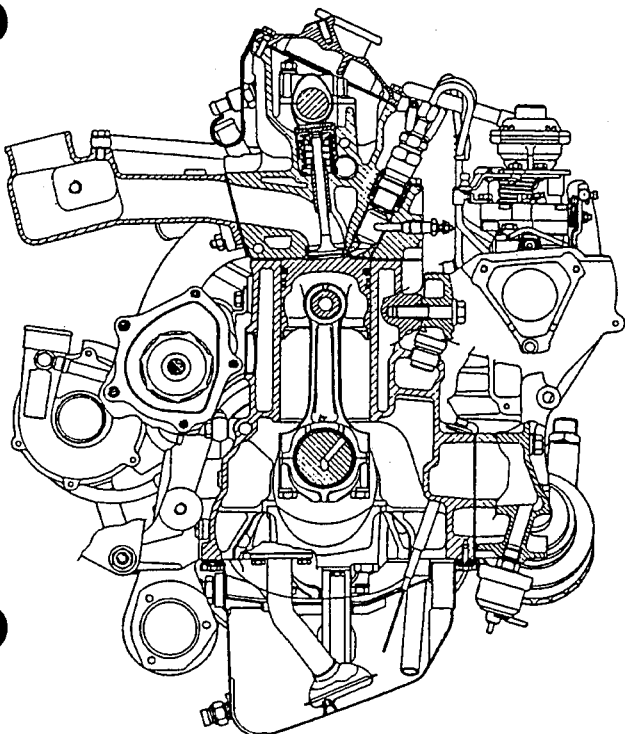
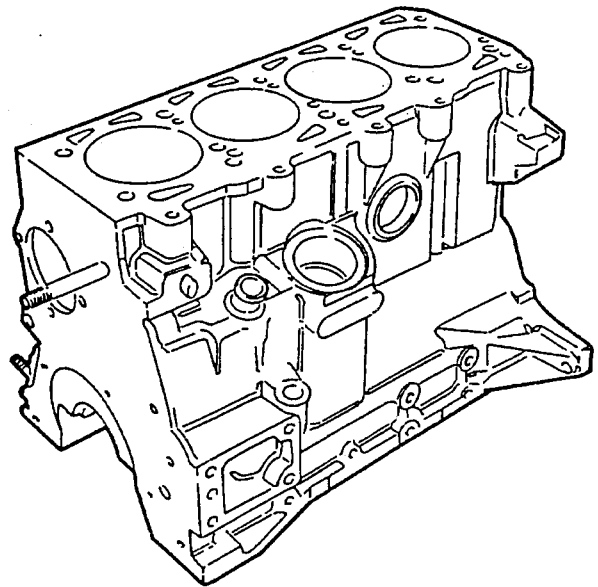
ENGINE BLOCK

This is a single block in iron with a high mechanical resistance.

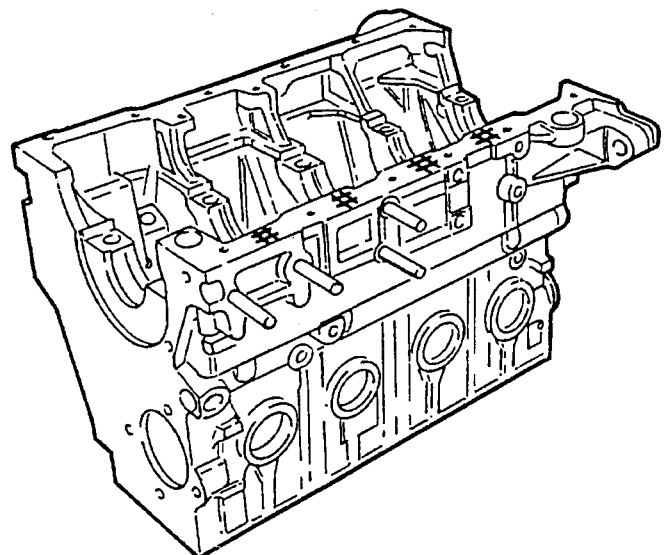
The crankshaft is supported by five main supports which also house the same number of bearing halves with thin shells.

The cylinder liners are the integral type.

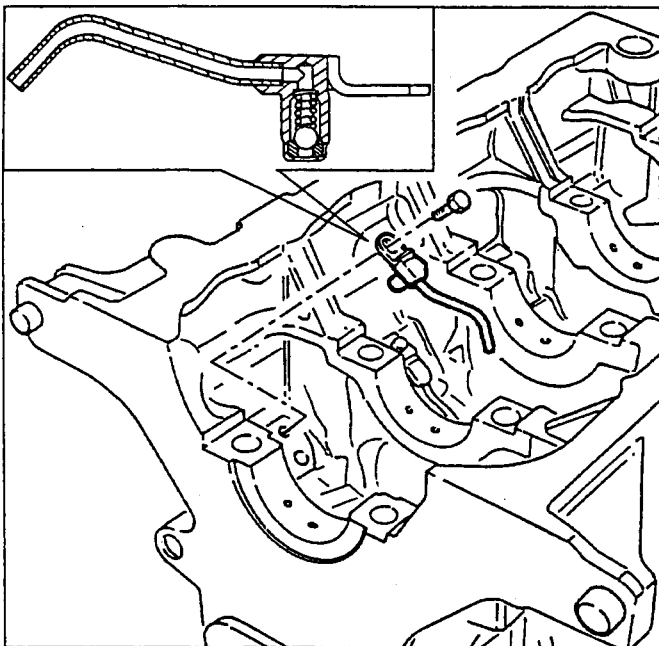
Grooving in the walls of the block allow circulation of engine coolant and lubricating oil.



The letters showing which class the cylinder liners belong to are printed on the block in the position shown in the figure below.

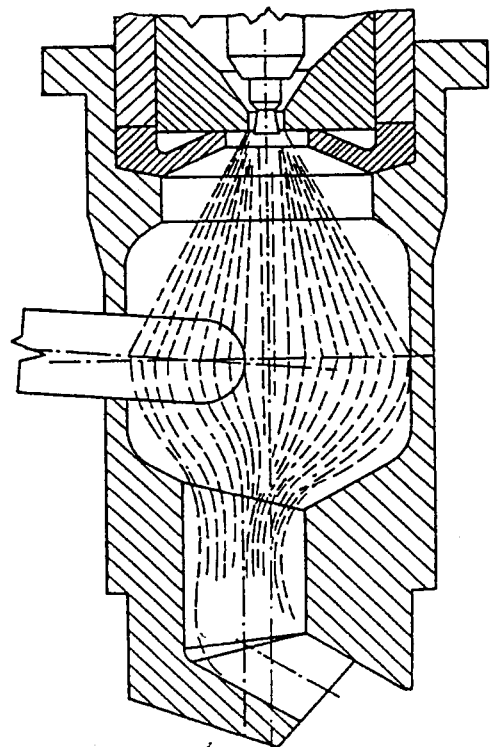


The lower part of the engine houses an oil spray jet which cools the piston skirt and lubricates the grudgeon pin.



The steel, low turbulence type precombustion chambers are positioned in suitable housings and fixed by a ring nut, within which the injector is then screwed. The seatings for the heater plugs are located in the lower part of the cylinder heads; the incandescence bulb is inserted into a suitable hole in the precombustion chamber and is consequently in direct contact with the injected fuel.

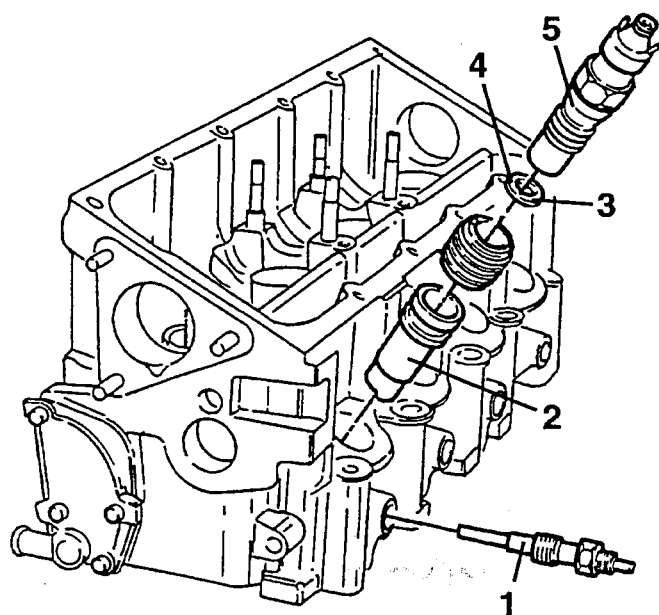
In the precombustion chamber, which is shaped like two offset cylinders, the compressed air from the piston hits the conic jet of fuel injected: the front of the flame uses up the whole amount of oxygen, and continues through the sump and flows into the cylinder. In this way, combustion is rather "slow", which is indispensable if the engine is to run softly and silently.



CYLINDER HEADS

They are the monolith type, compact and chill cast in an aluminium and silicon alloy.

The seatings housing the precombustion chambers and the injectors are found on the cylinder heads.



1. Heater plugs
2. Precombustion chamber with washer
3. Bushing securing precombustion chamber in cylinder head
4. Engine compression elastic sealing washer
5. Injector

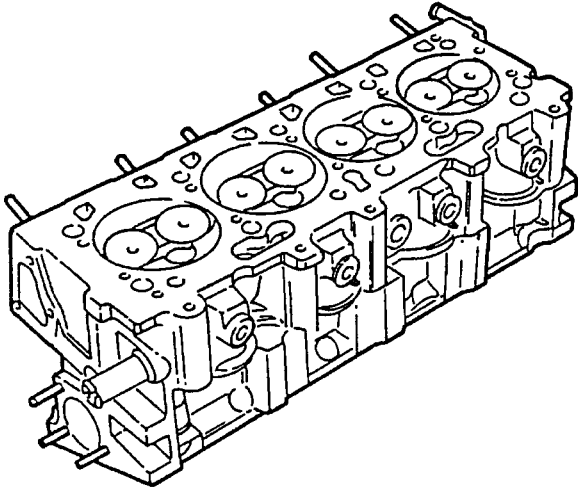
The cam shaft is supported by four supports; the front and rear ones are removable and the central ones are obtained from the cylinder heads.

The valve guides are fitted in the relative seatings of the cylinder heads with interference and the internal diameter is then perfected, after assembly, with a specific boring machine and checked by a pair of "fit-does not fit" gauges.

The seal between the cylinder heads and the engine block is the ASTADUR type.

This seal, due to the special material from which it is made, undergoes a polymerization process when the engine is running; and hardens significantly during use; adopting this type of seal, it is no longer necessary to tighten the cylinder head at the first service.

The cylinder head seal is supplied in three different thicknesses and the correct one is chosen on the basis of the average protrusion of the pistons from the upper surface of the engine block; this maintains the compression ratio within the prescribed limits.



After the interventions to grind down the main and rod journals, the crankshaft should be again subjected to the nitriding treatment, to reset its initial characteristics.

After this operation, the crankshaft should be checked to ensure that the deformation falls within prescribed limits, and that it can not be straightened; otherwise it must be replaced.

The crankshaft rests on five main supports and the radial clearance is regulated by two half rings housed on the rear main support.

Eight counterweights ensure that the rotating masses are equally balanced.

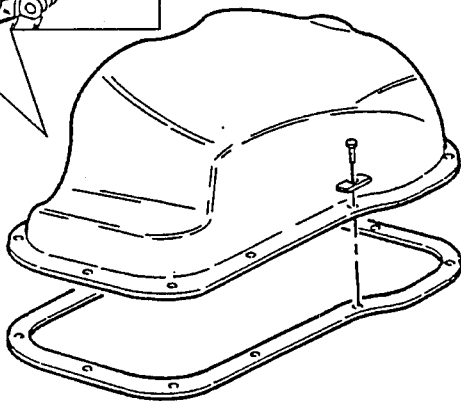
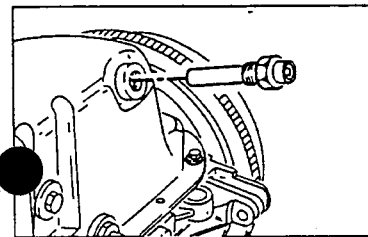
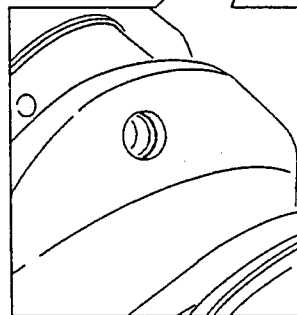
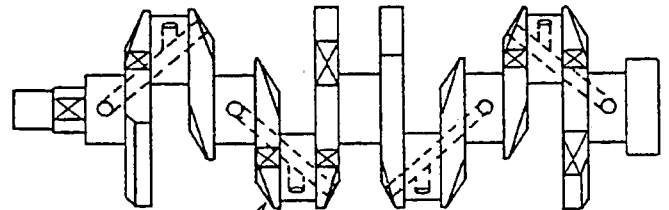
A channel runs inside the shaft to lubricate the main and rod journals. The machining holes on these channels are blocked with plugs; when the engine is overhauled they should be removed and cleaned thoroughly.

OIL SUMP

Made from stamped plate, it is also fitted with anti-splash walls.

The oil sump also contains the seating of the engine oil temperature sensor and the oil return from turbo-charger connection is also fitted here.

A suitably positioned gasket acts as seal between the sump and the engine block.



CRANKSHAFT

This is forged in a high resistance steel alloy and hardened and tempered.

In order to improve its mechanical resistance and wear characteristics, the crankshaft is subjected to a soft nitriding treatment.

MAIN AND ROD BEARING HALVES

They are the thin shell, three metal type and are divided into two dimensional classes, they are supplied to parts in another five decrease classes.

The main bearing halves have three holes to lubricate the main journals.

FLYWHEEL

Made from cast iron, with a ring gear in tempered steel, it is suitably balanced.

The flywheel has a precise position which must be respected during assembly: after the pistons of the first and fourth cylinders have been brought to T.D.C. the flywheel must be assembled making sure that the notch engraved on it faces upwards.

PISTONS AND RODS

The pistons are made from an aluminium-silicium alloy and are divided into five dimensional classes. The crown of the piston has a lift which connects with the combustion chamber of the cylinder heads.

The hole of the grudgeon pin is in axis with respect to the piston axis.

Close to the second and third seal ring housings, there are two grooves. The first is a labyrinth which reduces the passage of combustion gases in the sump, so as to reduce the formation of oil vapours; the second one serves to collect the oil "scraped" from the two rings to avoid it entering the combustion chamber.

The seating of the first seal ring is made on a molybdenum coating.

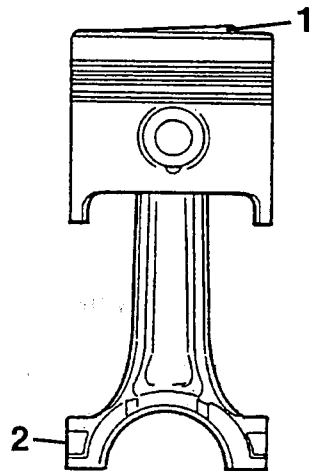
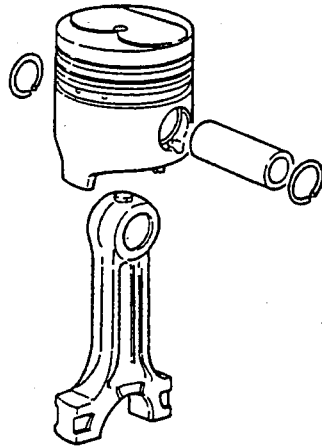
There are three seal rings: the first, seal type, is surface treated with a molybdenum coating, the second is the seal and oil scraper type, the third is the spring oil scraper type.

The visible scanso at the base of the piston skirt stops it from interfering with the oil sprayer in the engine block at B.D.C.

The rods are in tempered and hardened steel, with a copper alloy bushing fixed for connection to the piston grudgeon pin.

As the grudgeon pins are floating on both the piston hubs and the bushing fixed at the foot of the rod, they are stopped from moving laterally by two expanding elastic rings which are housed in the grooves on the hubs themselves.

The piston - rod connection must be made so that the lower part of the lift (1) on the piston is facing the same way as the number of the cylinder (2) to which the rod belongs stamped on it.

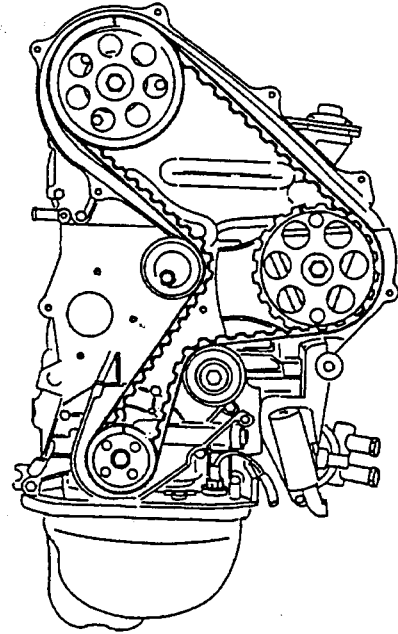


1. Lift on piston crown
2. Number of cylinder to which rod belongs.

The installation of the piston - rod assembly must be done in such a way that the numbers stamped on the rod face towards the intake-exhaust side.

TIMING

Direct drive by drive belt, with on head cam shaft in iron with induction hardening on the cams.



The mechanical tappets are made up of a cap in casehardened and phosphor-plated steel, in contact with the cam, used to regulate the valve clearance.

The command is transmitted from the cap to the cup in carbonitrided steel which directly controls the valve. The intake and exhaust valves are made in a steel alloy and the stem is chrome-plated.

The valve seatings and valve guides are in iron.

Small rubber plugs are mounted on the top of the valve guides to catch any oil between the stem and the valve guides.

LUBRICATION

The oil, taken from the sump using a suction device, is filtered by the net type filter which is part of the suction device itself and then reaches the oil pump. The oil pump which is the rotating lobe type is front mounted on the engine block and activated directly by the crankshaft through keying.

The oil sent under pressure by the pump, after having passed the pressure relief valve, reaches a thermostatic valve that:

- for temperatures lower than 75 °C, ensures that the oil passes directly into the cartridge filter and then to the engine;
- for temperatures greater than 90 °C, it opens allowing the oil to pass into the coolant radiator so that its temperature is lowered and a better lubrication is guaranteed.

The oil, after having been filtered by the cartridge filter (total flow with safety by-pass valve, which guarantees that the oil passes even if the cartridge becomes clogged up), makes its way towards the oil minimum pressure warning light sensor, and arrives at the main longitudinal pipe which runs around the engine block through a transversal channel.

The oil is then sent along secondary ducts to lubricate the main and rod journals.

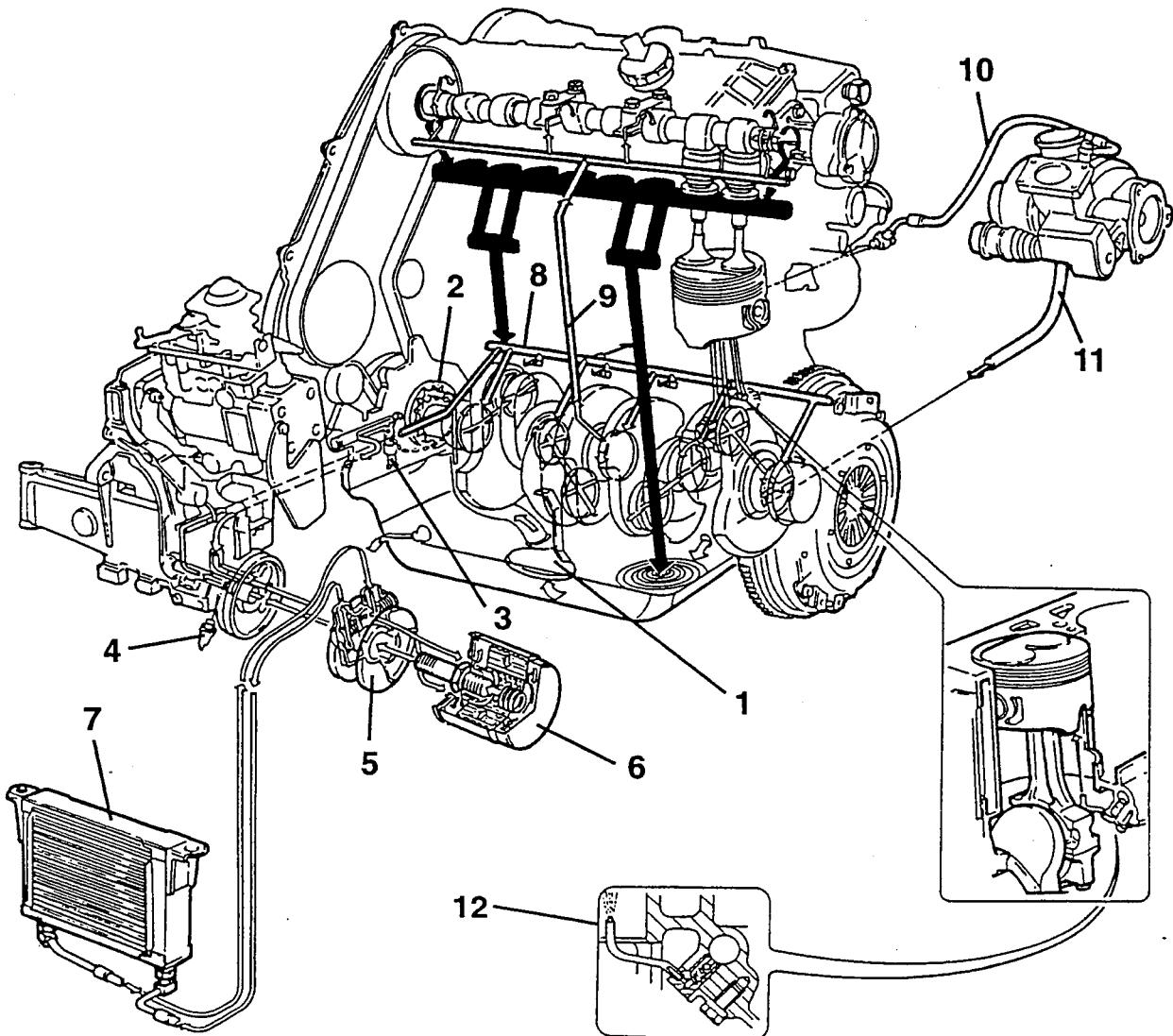
A vertical duct in the engine block and cylinder heads lubricates the cam shaft supports.

From the main duct the oil is sent to the turbo charger through an external tube to lubricate the control shaft and from here directly to the sump.

To improve the cooling of the piston skirts, sprayers with a small built in ball valve which opens when the pressure reaches 1.25 + 1.75 bar are located on the engine block; this guarantees that the main supports are sufficiently lubricated during engine start up and at idle speed.

The lubrication system is equipped with an oil vapour recirculation system which allows the vapours originating from the engine block to be recovered.

An oil temperature sensor is also fitted on the oil sump whilst the engine oil level sensor is positioned on the oil pump cover.



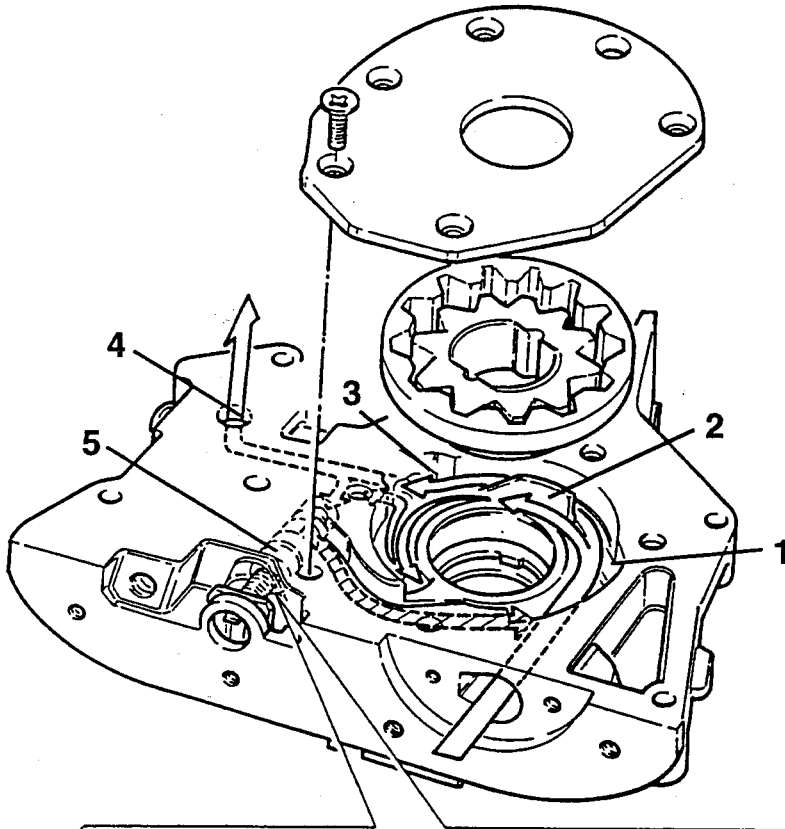
- 1. Suction device with wire gauze filter
- 2. Oil pump
- 3. Pressure relief valve
- 4. Minimum oil pressure warning light sensor
- 5. Oil filter support with thermostatic valve
- 6. Oil filter with safety by-pass valve

- 7. Engine oil cooling radiator
- 8. Oil delivery duct to various parts
- 9. Oil vertical delivery duct to cam shaft supports
- 10. Oil delivery tube to turbocharger
- 11. Oil return to sump from turbocharger tube
- 12. Sprayers

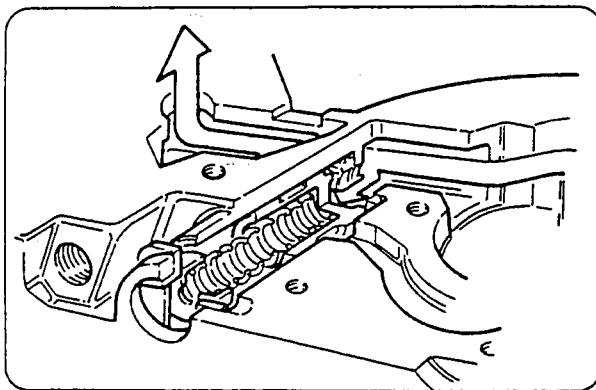
OIL PUMP

The oil is sucked from the sump through a vacuum created by the gears on the crankshaft rotating. The vacuum starts from the separating panel (2) of the gears upto the oil sump suction device.

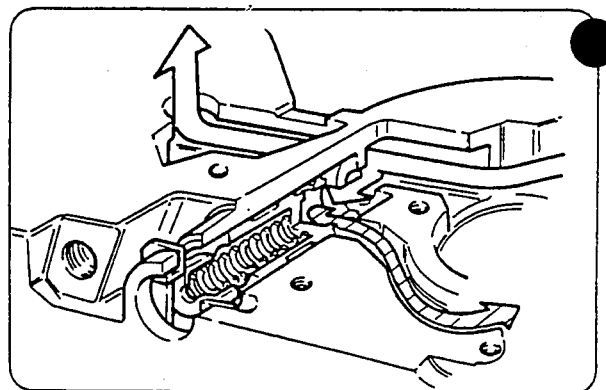
The pressure develops from the separating panel (2) in all the engine oil delivery ducts (4). When the pressure exceeds 5 bar, the thrust exercised on the relief valve (5) causes the spring positioned below to react and moves the valve enough to open the connection duct between the pressure chamber (3) and the low pressure chamber (1), limiting the maximum pressure in the circuit.



1. Low pressure chamber
2. Separating panel
3. Pressure chamber
4. Oil delivery duct
5. Pressure relief valve



Closing functioning position of the engine oil pressure relief valve.



Functioning position in short circuit of the relief valve.

INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhaul of the engine on a bench after removal from a vehicle.

The instructions are divided as follows:

- Disassembly and reassembly of engine:

removal of the engine accessories and components and dis- assembly into its main component parts.

- Disassembly and overhaul of cylinder heads:

complete overhaul of all the components of the cylinder heads.

- Engine block checks and inspections:

complete overhaul of the components of the crank mechanisms.

- Precautions for refitting:

comprising the refit operations where they significantly differ from the disassembly instructions.

All the disassembly procedures described in the part which follows, when carried out in the reverse order, are also valid for refitting purposes unless otherwise indicated.

- Checks and inspections of the lubrication system electrical components:

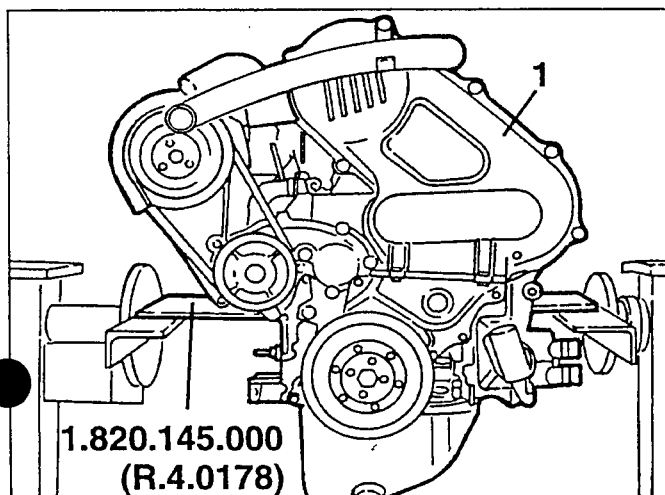
checks and controls of the electrical components relative to the engine lubrication system.

The procedures which follow refer to the complete overhaul of the whole engine unit; it is however possible to use individual parts of these instructions when dealing with specific components.

ENGINE DIS-ASSEMBLY

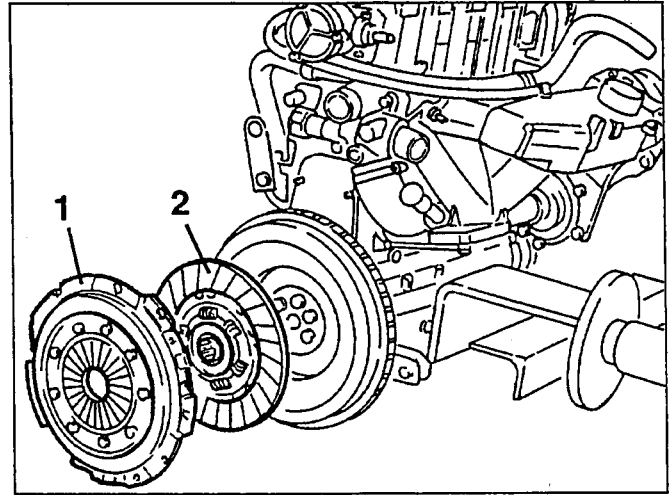
Preliminary operations

1. Set the assembly on a special overhauling stand using supports brackets N° 1.820.145.000 (R.4.0178).



Removal of clutch plate

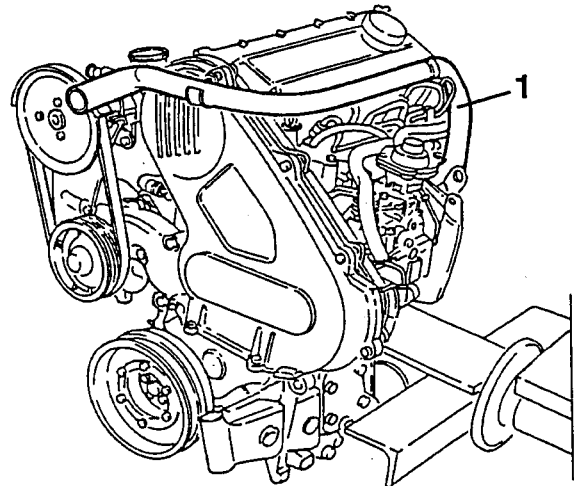
1. Remove the disk pressure plate body.
2. Remove the clutch disk.



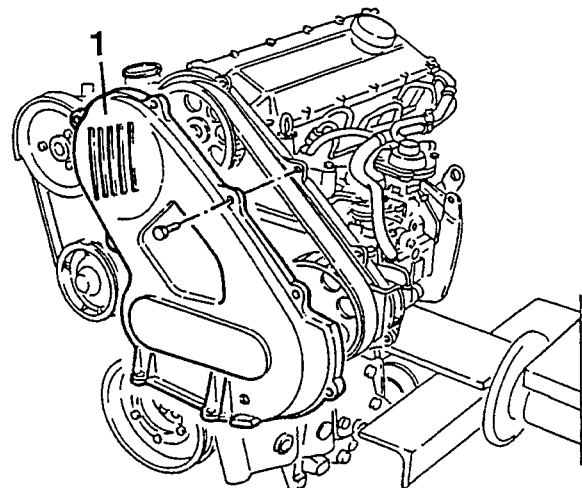
Removal of timing belt

- Install a suitable tool on the flywheel which will allow the crankshaft to rotate.

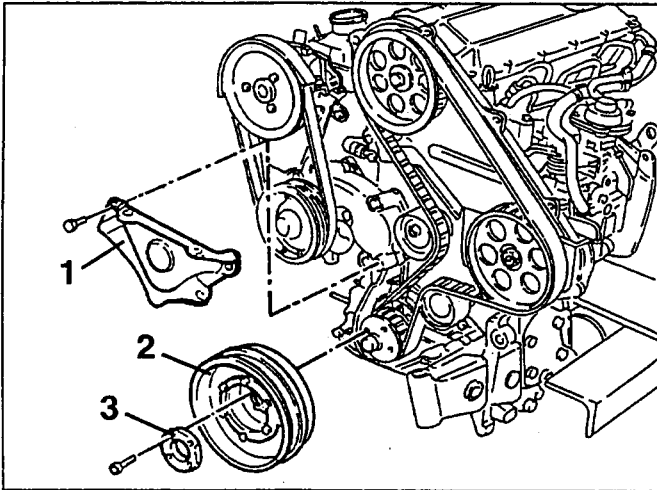
1. Remove the oil vapour recirculation sleeve.



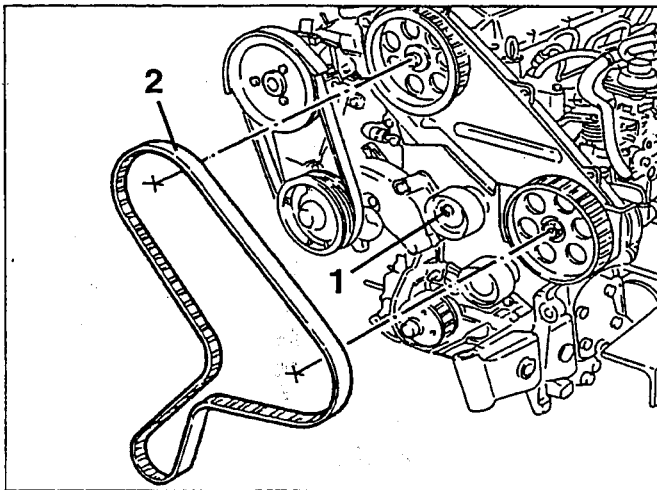
1. Remove the timing belt cover.



1. Remove the timing belt lower cover.
2. Remove the auxiliary parts belt control pulley.
3. Recover the spacer.

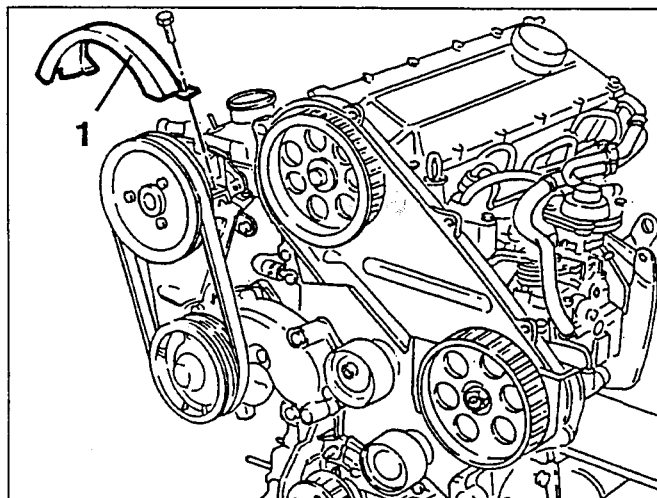


1. Loosen the fastening nut of the timing belt stretcher.
2. Remove the timing control belt.

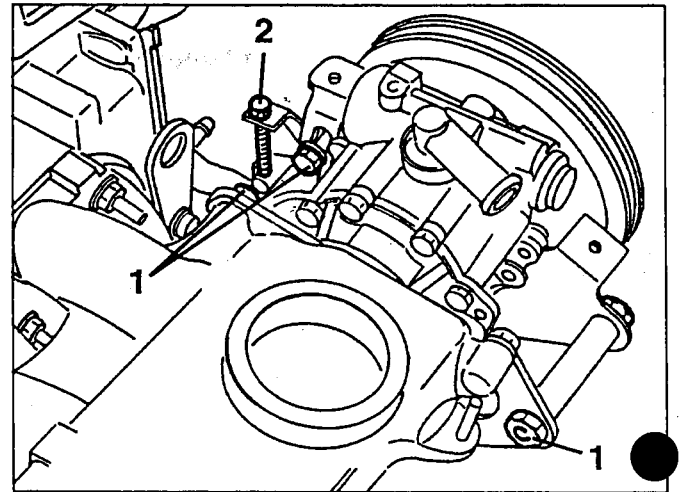


Removal of power steering pump

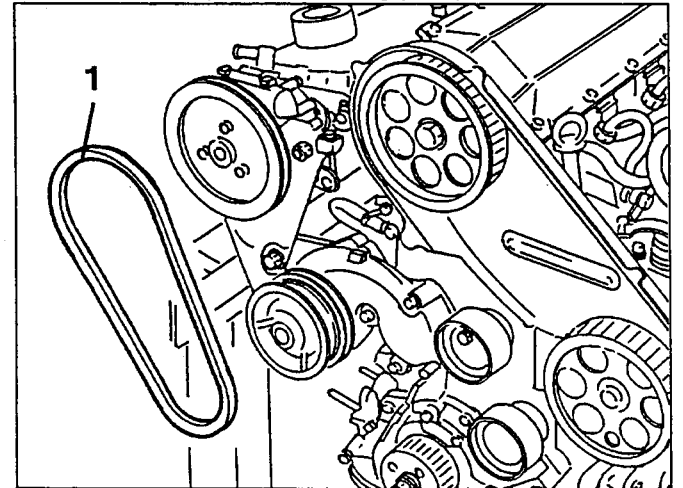
1. Remove the power steering pump belt guard.



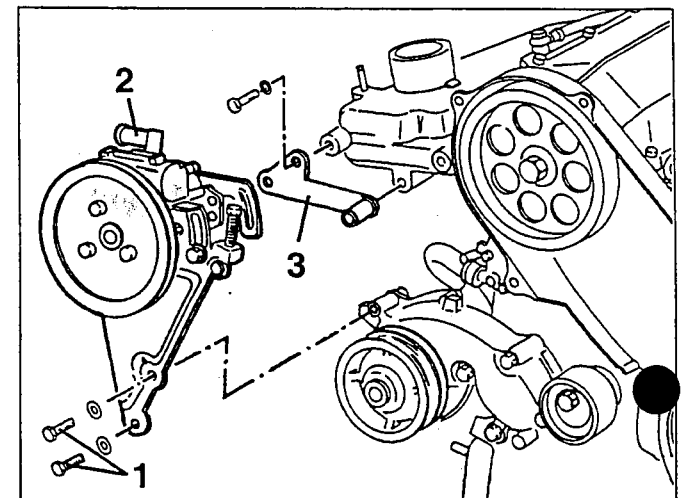
1. Loosen the fastening screws of the power steering pump indicated in the figure.
2. Decrease the tension of the power steering pump control belt by acting on the screws of the micrometric stretcher.



1. Remove the power steering pump control belt.

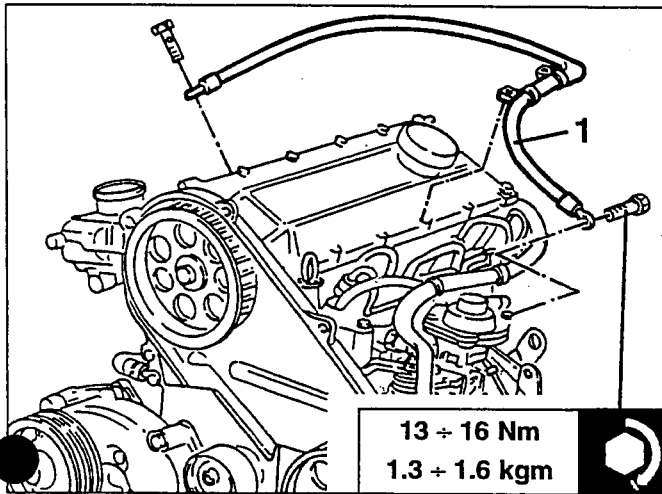


1. Unscrew completely the screws which have been loosened beforehand and the two screws indicated in the figure.
2. Remove the power steering pump complete with front bracket.
3. Remove the power steering pump front support bracket.

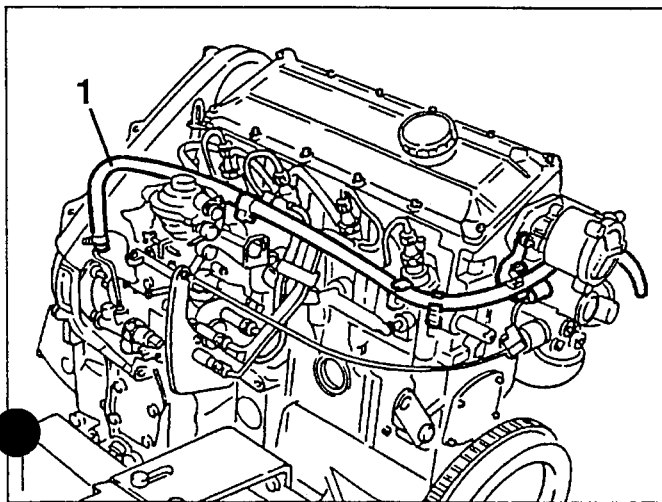


Removal of air intake box

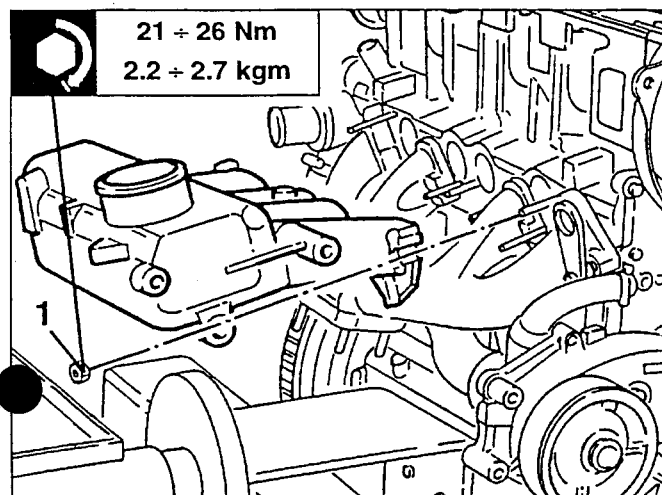
1. Remove the over pressure pipe for the flow limiter on the injection pump.



1. Remove the fuel arrival from filter to injection pump pipe.

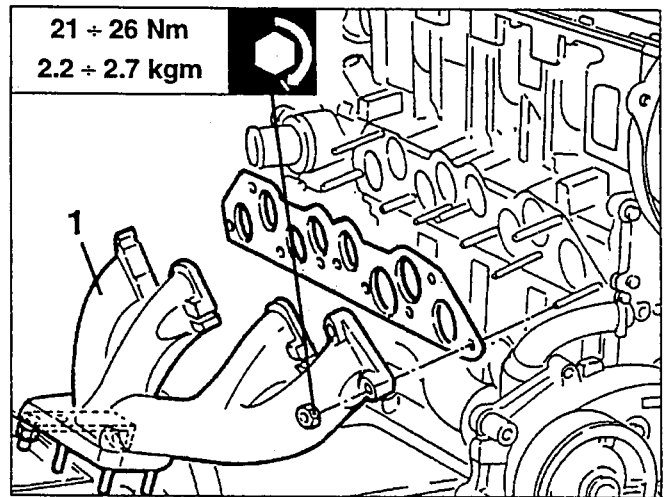


1. Unscrew the fastening screws and remove the air intake box.



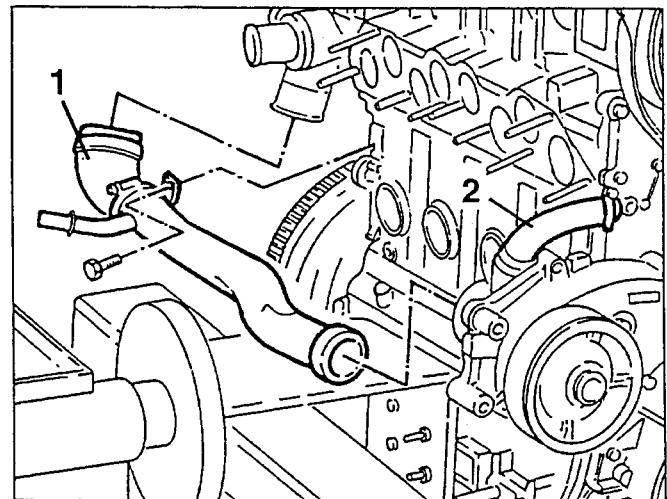
Removal of exhaust manifold

1. Unscrew the fastening screws and remove the exhaust manifold.

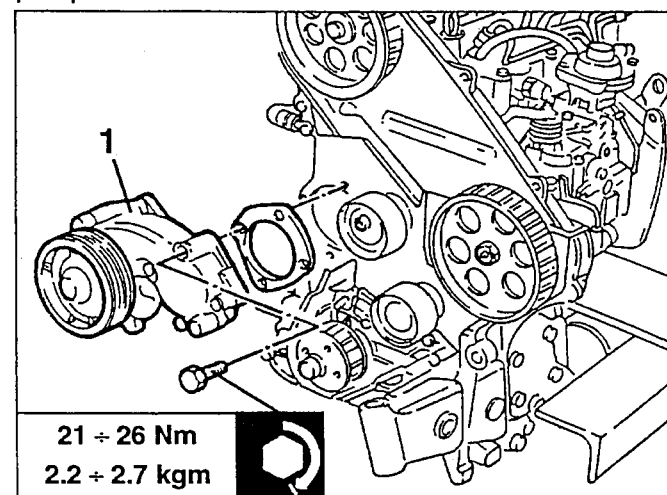


Removal of water pump

1. Remove the engine coolant to pump return manifold.
2. Disconnect the engine coolant to pump return pipe from the cylinder heads.

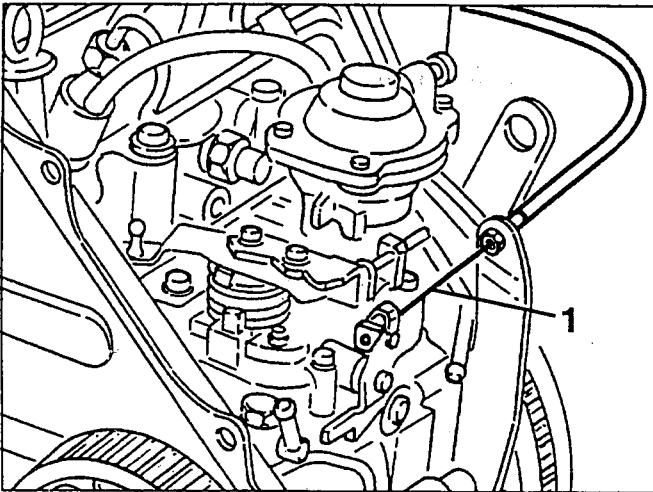


1. Unscrew fastening screws and remove water pump.

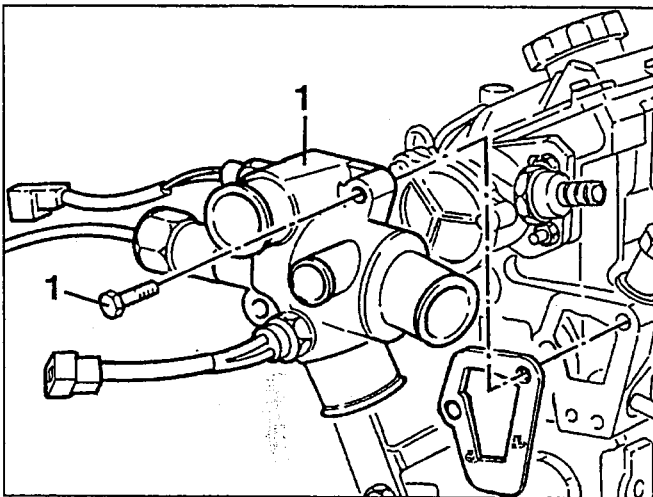


Removal of thermostatic cup

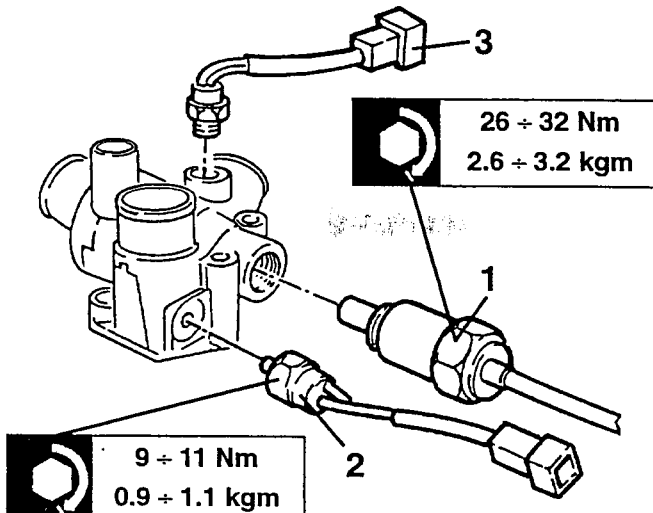
1. Disconnect the cable of the idle speed automatic control device.



1. Unscrew the screws and remove the complete thermostatic cup.



1. Remove the thermostatic sensor of the idle speed automatic device.
2. Remove the KSB consensus thermoswitch.
3. Remove the air conditioning compressor cut-off thermal contact.

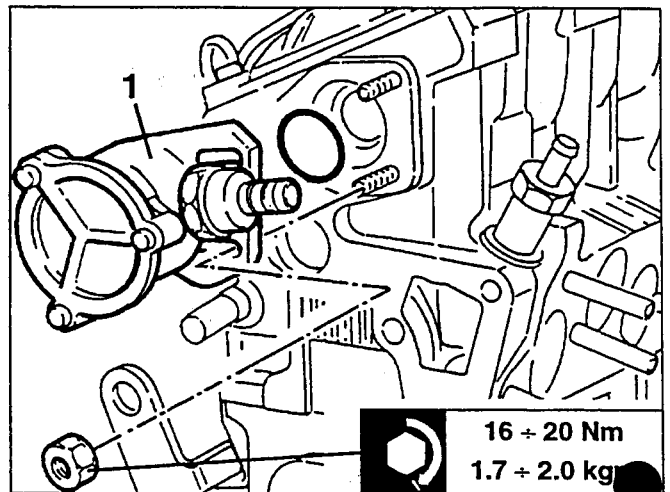


26 ÷ 32 Nm
2.6 ÷ 3.2 kgm

9 ÷ 11 Nm
0.9 ÷ 1.1 kgm

Removal of servobrake vacuum pump

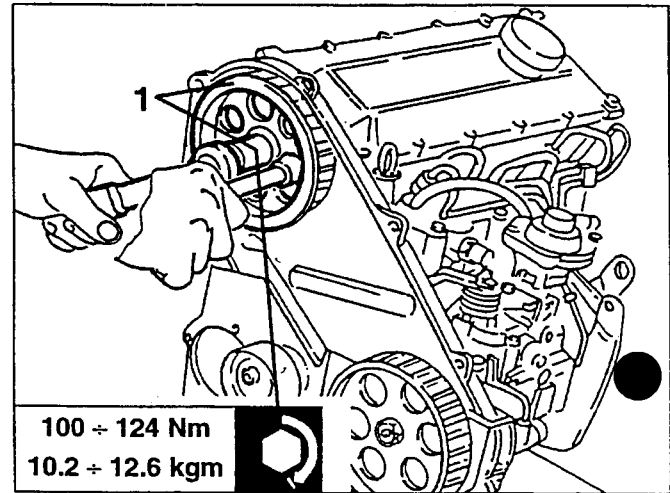
1. Unscrew the fastening screws and remove the vacuum pump for the servo brake.



16 ÷ 20 Nm
1.7 ÷ 2.0 kgm

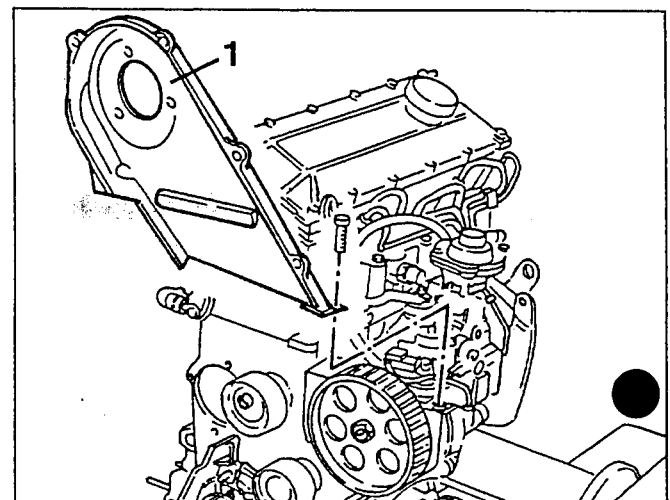
Removal of injection pump

1. Using a 13 mm spanner as a counter rotation tool loosen the screw and remove the timing command pulley.

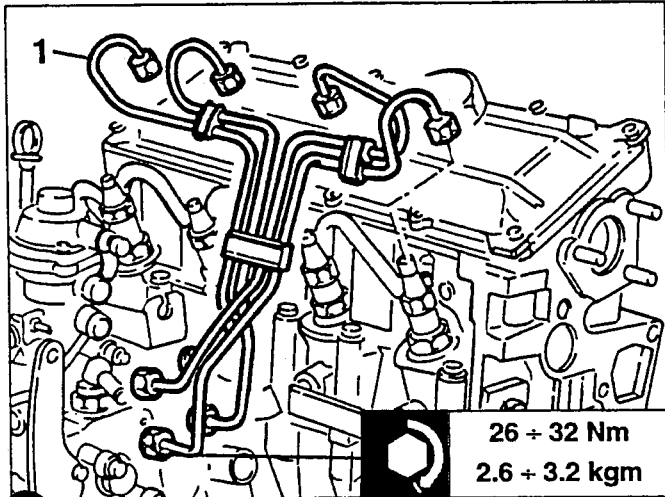


100 ÷ 124 Nm
10.2 ÷ 12.6 kgm

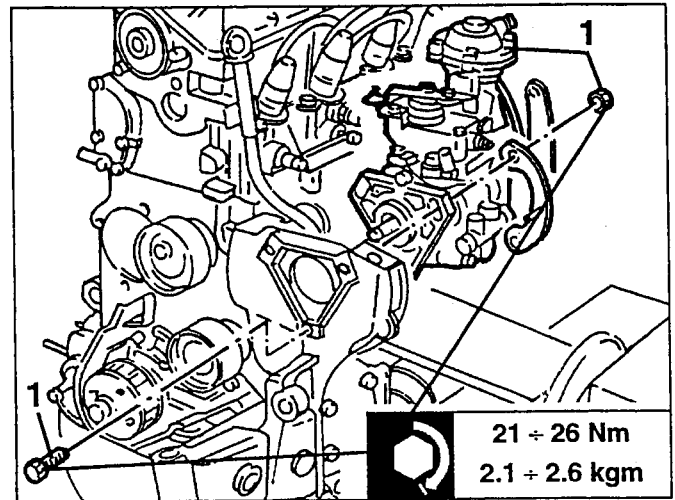
1. Remove the timing belt rear cover.



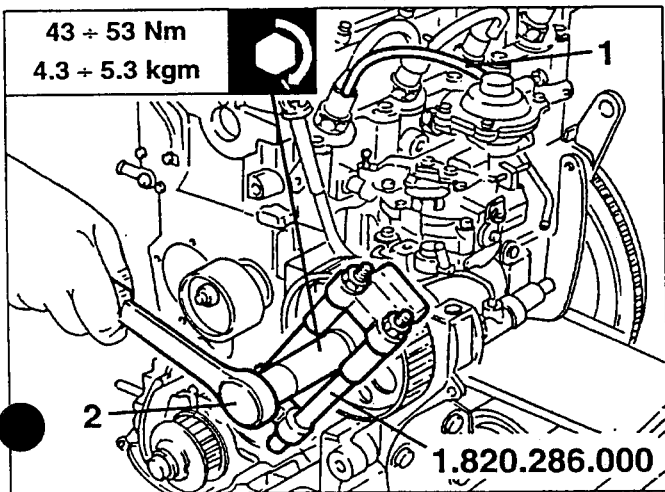
Remove the fuel from injection pump to electroinjectors delivery pipe.



1. Unscrew the fastening screws and nuts and remove the injection pump.

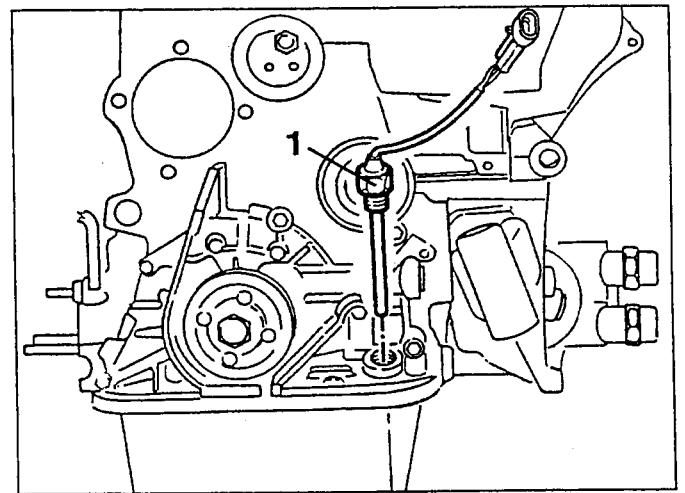


1. Disconnect the fuel to injection pump return pipe from injector.
2. Using tool N° 1.820.286.000 unscrew the fastening nut of the injection pump control pulley.

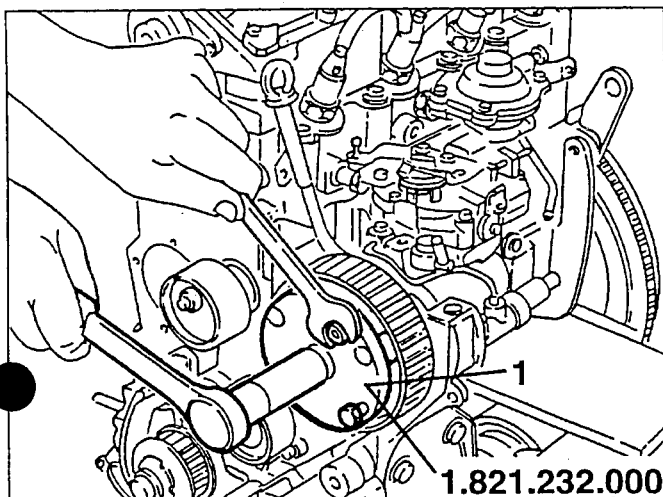


Removal of oil filter support bracket and injection pump

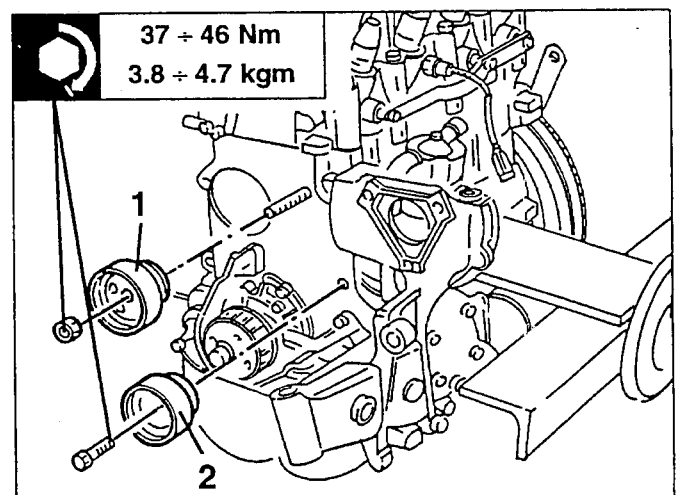
- Remove the guide and engine oil dipstick.
1. Remove engine oil level sensor.



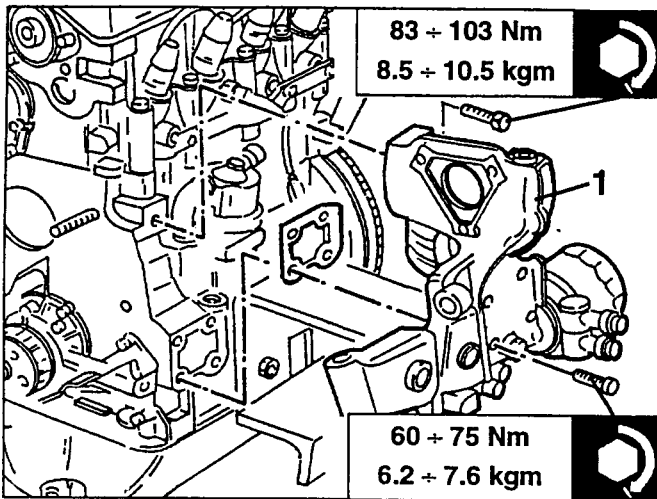
1. Using tool N° 1.821.232.000 remove the injection pump control pulley.



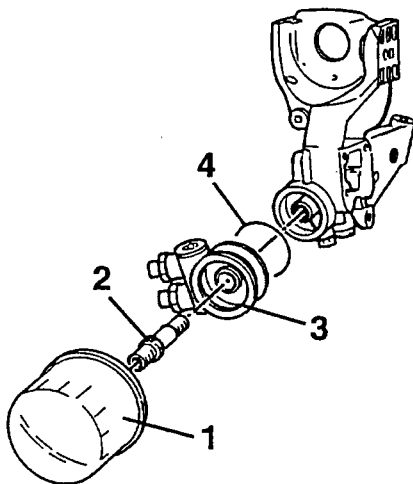
1. Remove the timing belt stretcher.
2. Remove the timing belt jockey pulley.



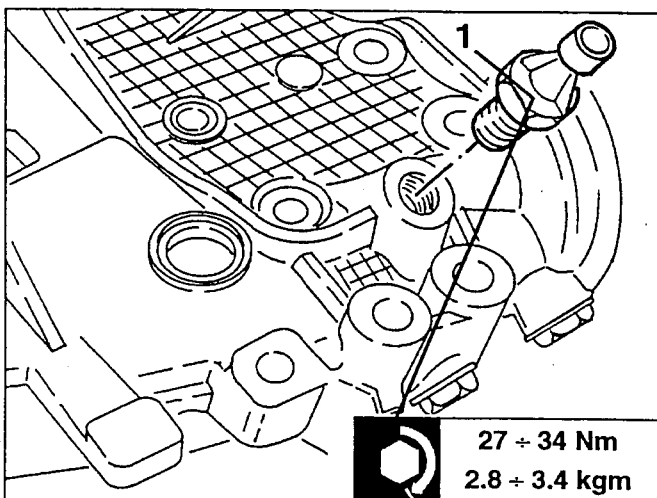
1. Unscrew the fastening screws and remove the oil filter support bracket and the injection pump.



1. At the bench remove the oil filter from the support bracket.
2. Remove fastening journal.
3. Remove oil filter support.
4. Remove O-Ring.

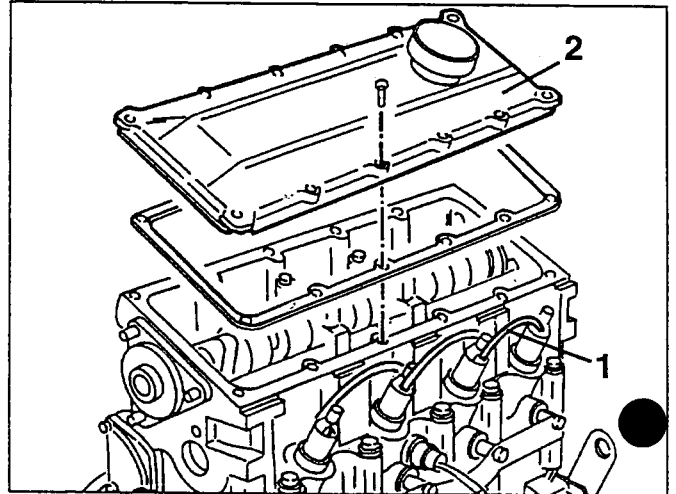


1. Remove the engine oil minimum pressure sensor from the bracket.

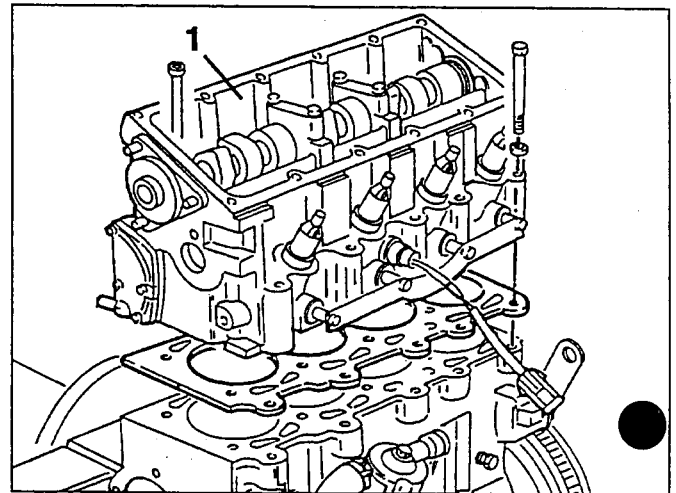


Removal of cylinder heads

1. Remove the fuel to injection pump return pipe from the injectors.
2. Unscrew the fastening screws and remove the timing cover.

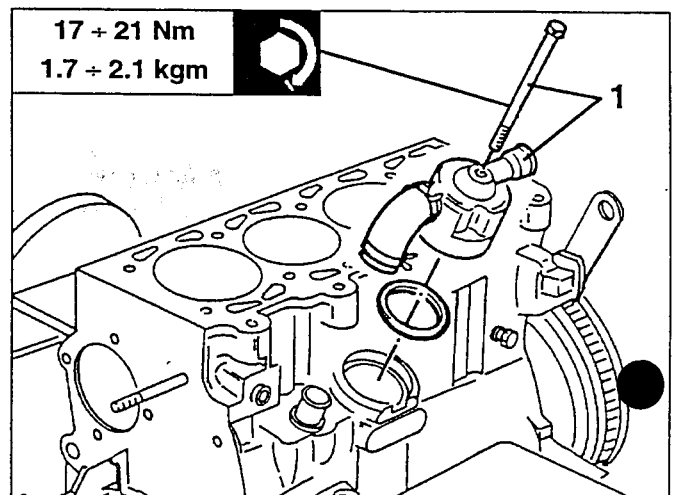


1. Unscrew the fastening screws and remove the cylinder heads.

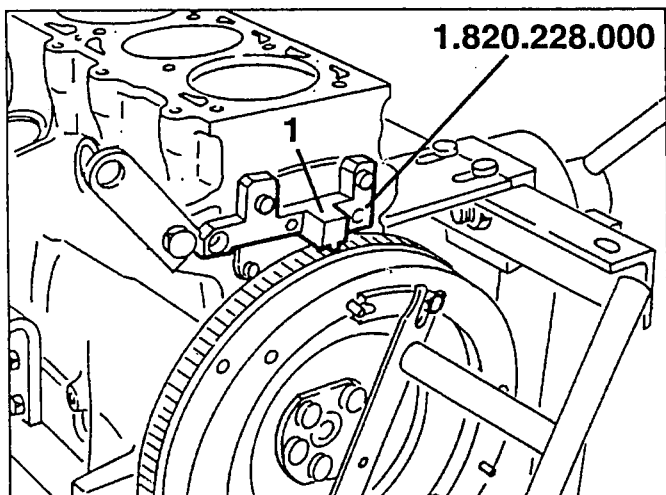


Removal of oil sump

1. Remove the oil vapour separator from engine block.

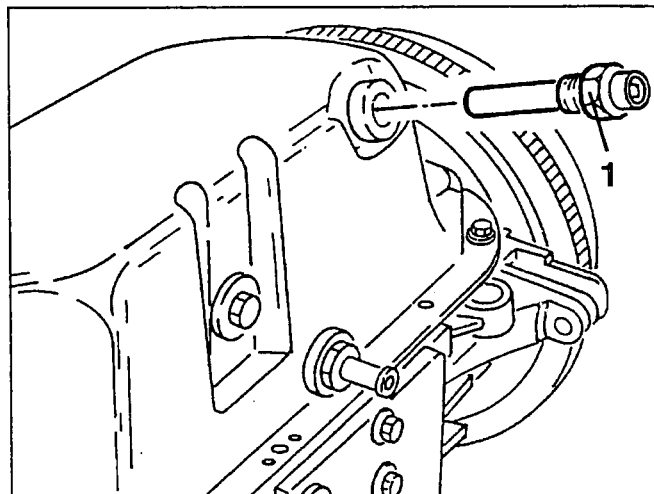


Install flywheel stop tool N° 1.820.228.000.

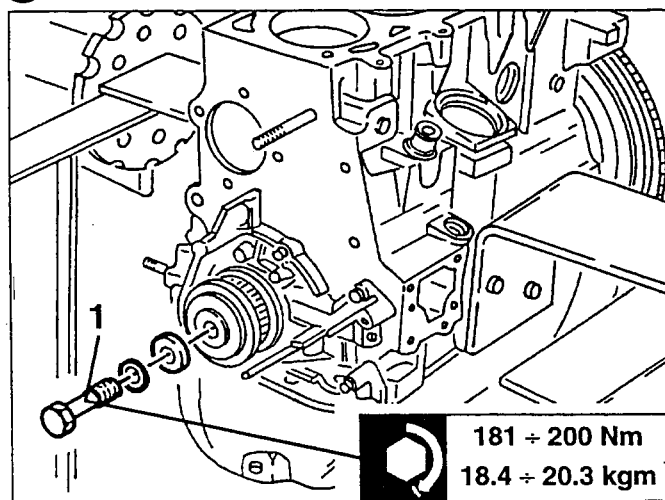


- Rotate the engine block 180° on the rotating over-haul stand.

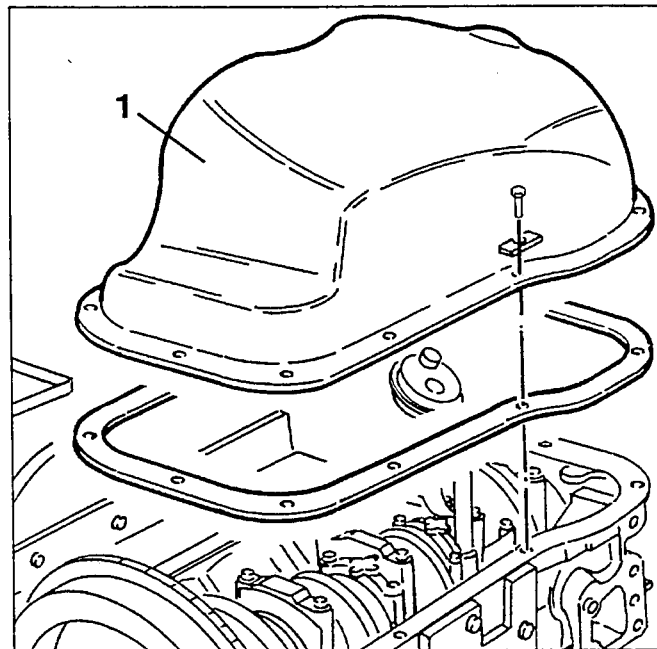
1. Remove the engine oil temperature sensor from the oil sump.



1. Unscrew the fastening screws of the timing control at pulley.

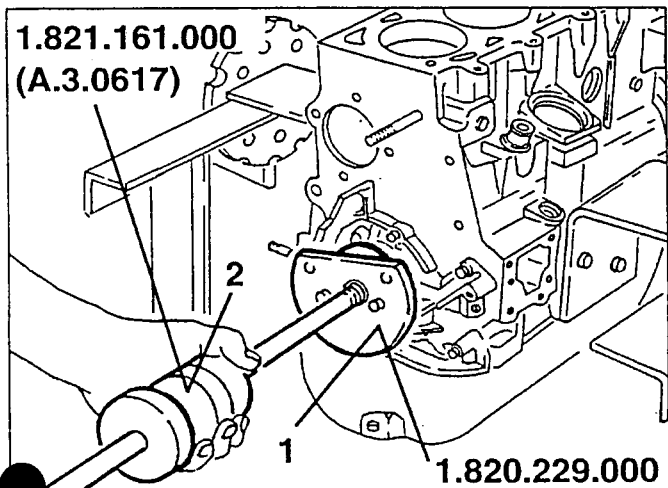


1. Unscrew the fastening screws and remove the oil sump.

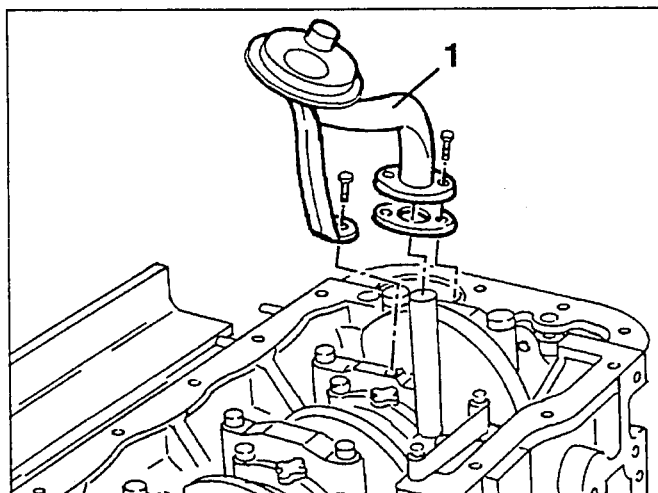


Install tool N° 1.820.229.000 on the timing control pulley.

2. Using ram N° 1.821.161.000 (A.3.0617), remove the timing control pulley.



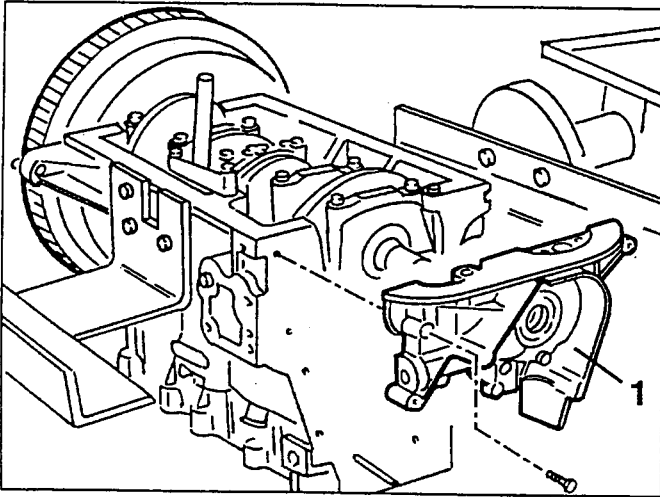
1. Remove the suction device for the engine oil pump.



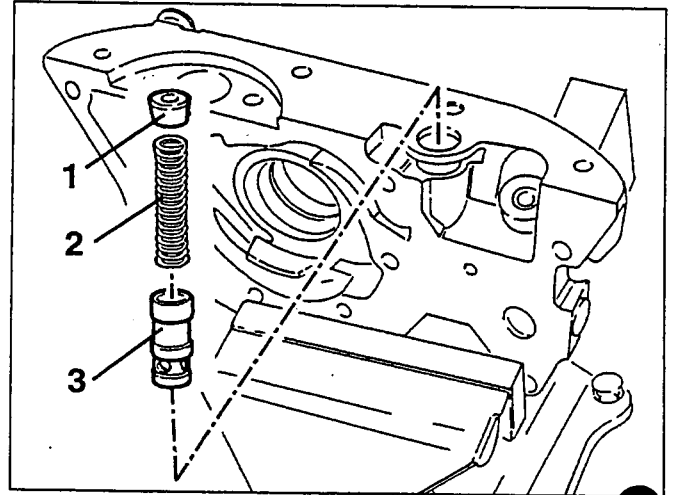
- Remove flywheel stop tool N° 1.820.228.000 installed previously.

Removal of engine block front cover

1. Remove the engine block front cover with built-in oil pump.

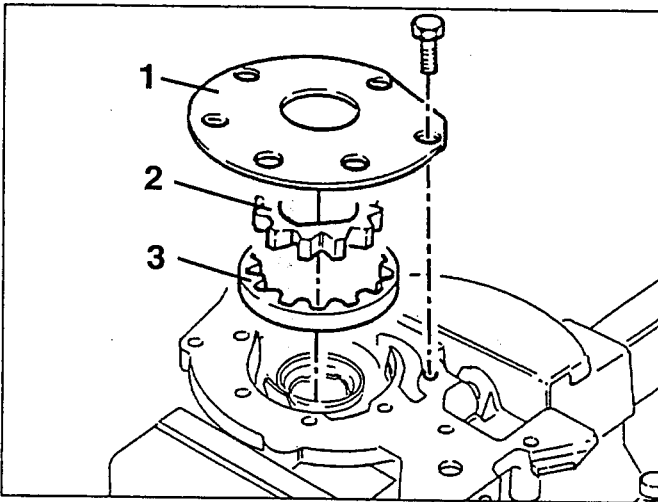


1. Remove the spring stop.
2. Remove the spring.
3. Remove the valve box.



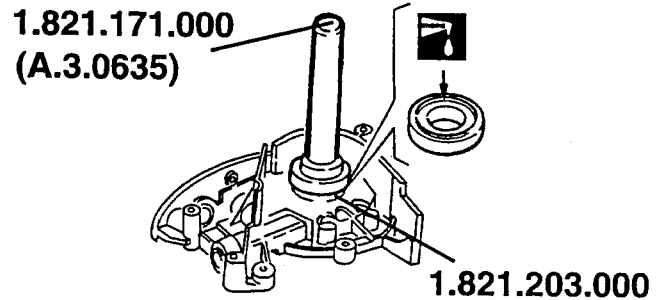
Disassembly of oil pump

1. Unscrew fastening screws and remove cover.
2. Remove driving gear.
3. Remove driven gear.

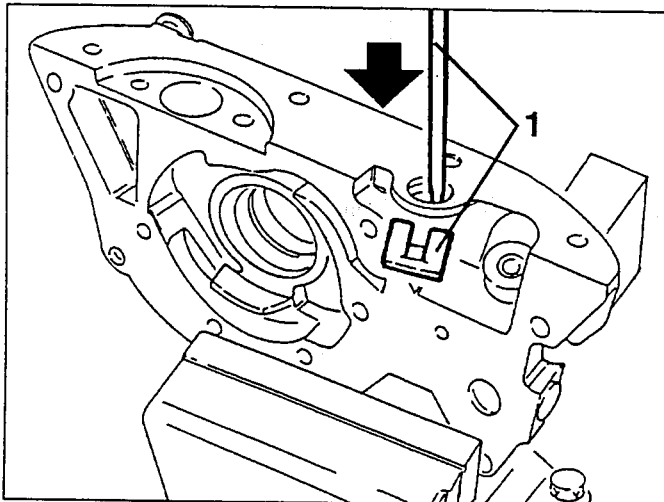


- Remove the oil seal ring from the engine block front cover.

During reassembly fit the oil seal ring on the engine block front cover using tools N° 1.821.171.000 (A.3.0635) and N° 1.821.203.000.

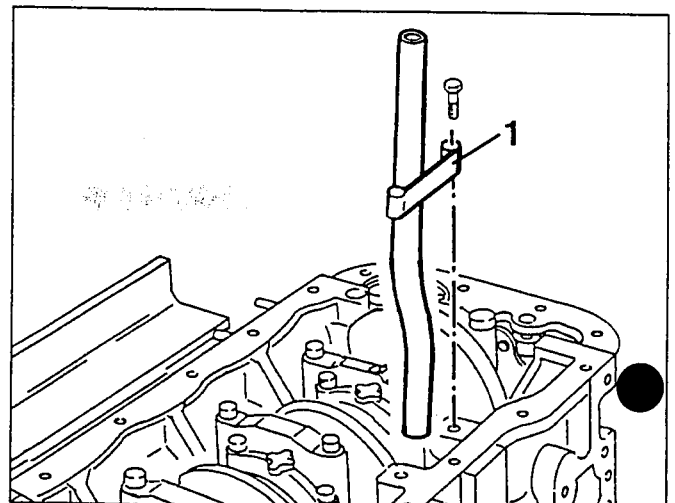


1. With a suitable punch press the oil pressure relief valve and extract the stop plate.



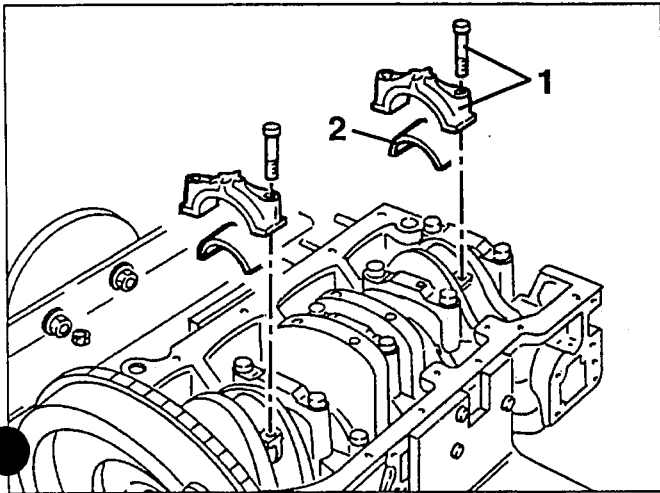
Removal of pistons and rods

- Remove the flywheel stop tool installed previously.
1. Remove the engine oil dipstick.



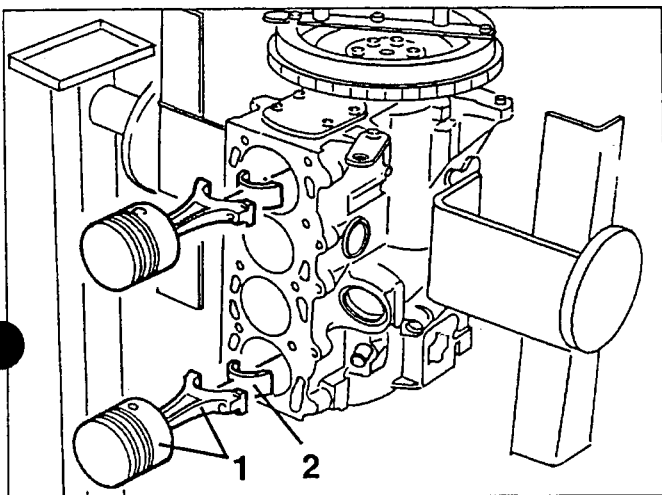
● Rotate the crankshaft so that the first and fourth piston is at B.D.C.

1. Unscrew the fastening screws and remove the first and fourth cylinder rod caps.
2. Recover the rod bearing halves.



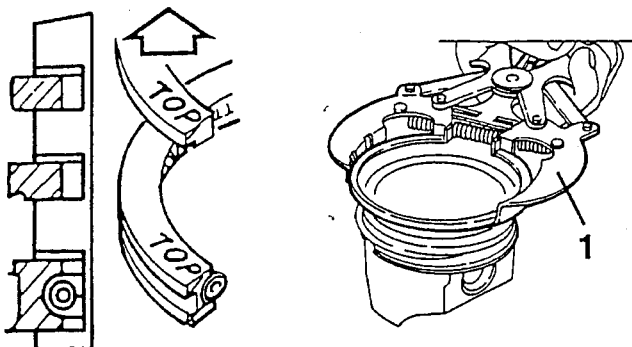
- Rotate the engine block by 90° on the overhauling stand.

1. Remove the piston-rod assembly of the first and fourth cylinders.
2. Recover the rod bearing halves.



- Rotate the engine block and repeat the procedure for the second and third cylinders.

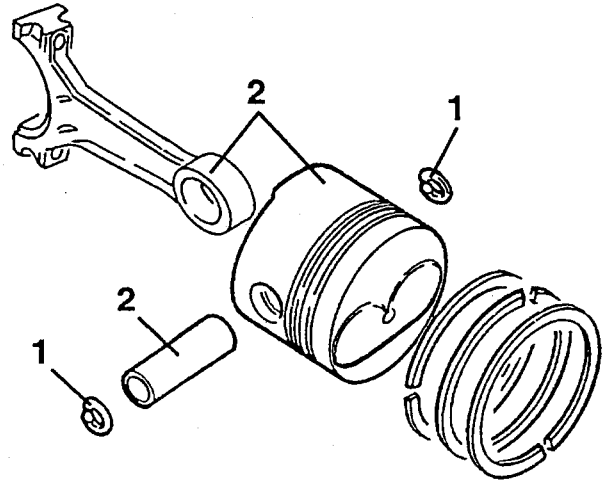
1. Using a suitable tool extract the seal rings and oil scraper ring from the piston.



During refitting rotate the seal rings so that the wording "TOP", stamped on the rings themselves, faces upwards.

1. Extract the two elastic rings which block the grudgeon pin.
2. Extract the grudgeon pin and separate the piston from the rod.

During refitting, follow the precautions contained in the relative paragraph.

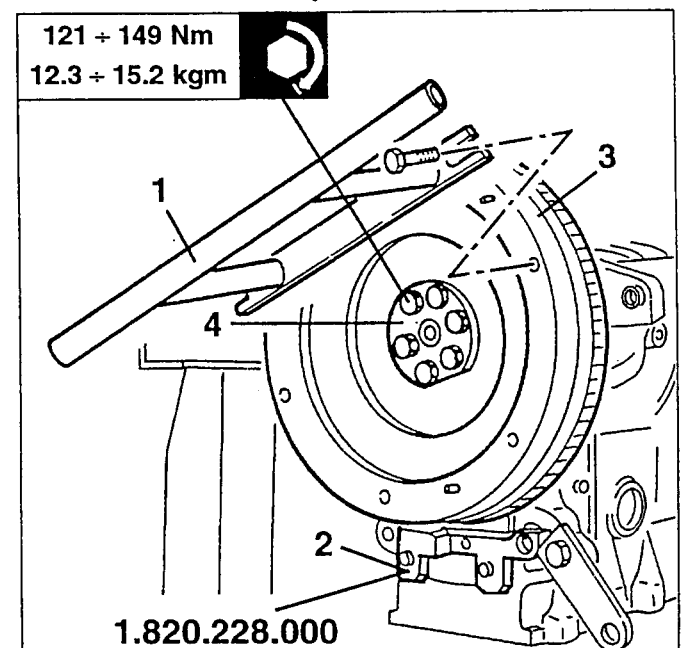


Removal of engine flywheel

1. Remove the tool used to rotate the crankshaft, installed previously, from the flywheel.
2. Install the flywheel stop tool N° 1.820.228.000.
3. Unscrew the fastening screws and remove the engine flywheel.
4. Recover the safety washer.

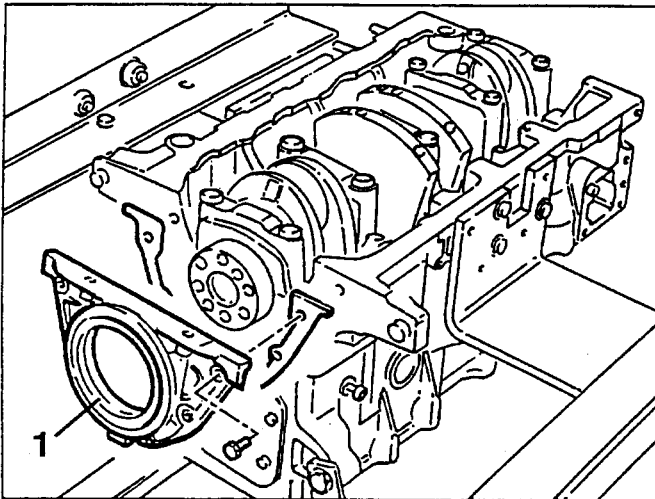
- Remove the flywheel stop tool.

During reassembly, bring the first and fourth cylinders to the T.D.C., install the flywheel ensuring that the notch faces upwards.



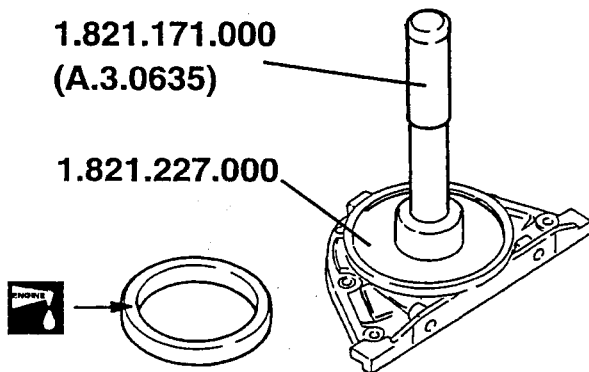
Removal of crankshaft

1. Remove the engine rear cover.

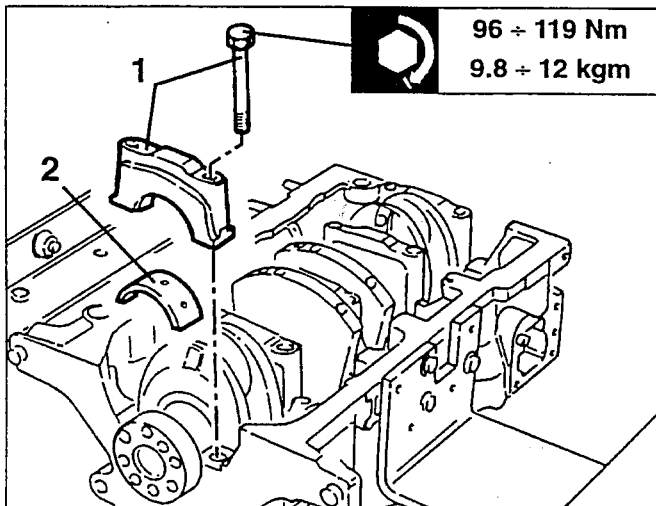


- Remove the oil seal ring from the engine rear cover.

During reassembly fit a new oil seal ring on the rear engine cover using tools N° 1.821.171.000 (A.3.0635) and N° 1.821.227.000.



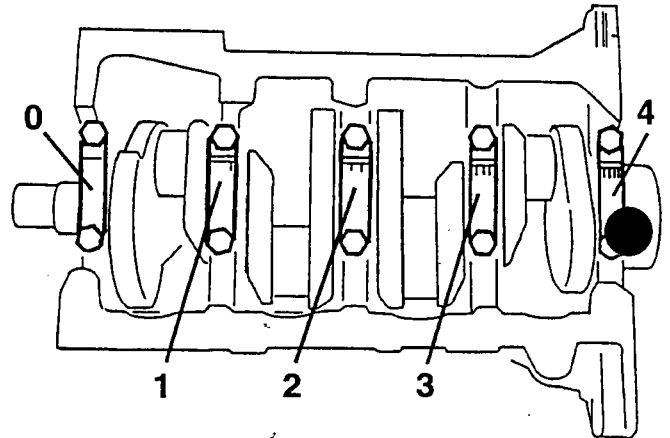
1. Unscrew the fastening screws and remove the main journals.
2. Remove the main bearing halves from the caps.



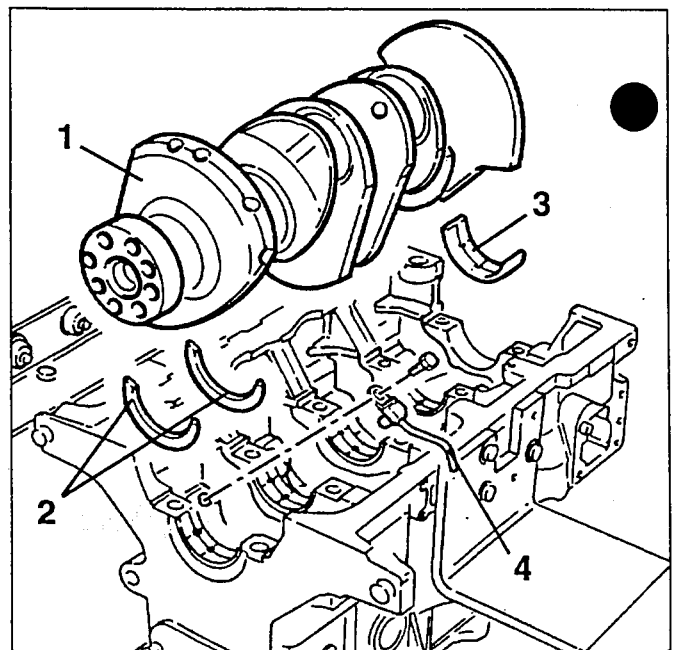
NOTE: Highlight the position of the various components should they be re-used during assembly.



CAUTION:
The position of each cap is dictated by a series of notches (from zero to four starting from the front side of the engine) engraved on the caps themselves.



1. Remove the crankshaft.
2. Recover the thrust half rings.
3. Recover the main bearing halves from the supports.
4. Remove the engine oil sprayers used to lubricate and cool the pistons from the engine block.

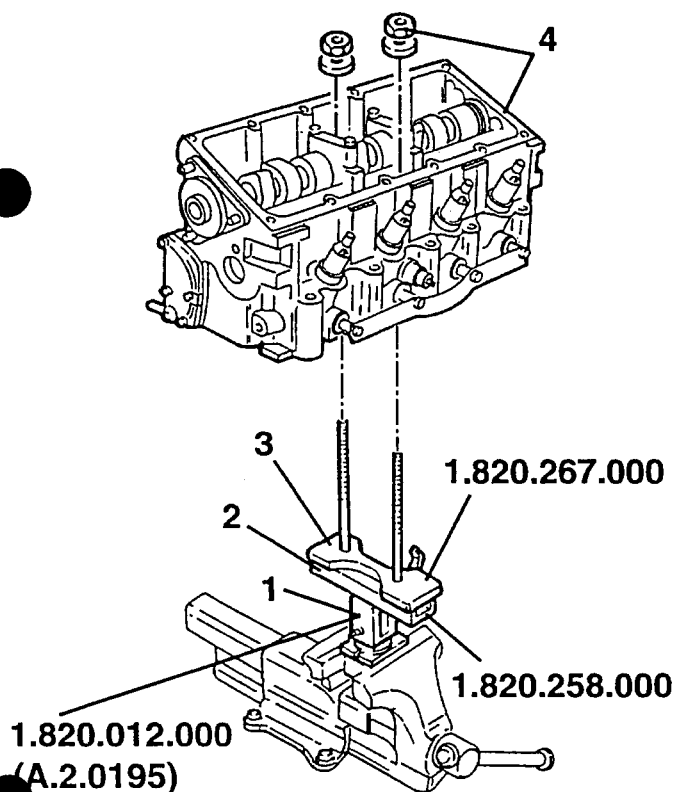


During crankshaft reassembly check that the axial play falls within prescribed limits (see "Precautions for reassembly").

DISASSEMBLY OF CYLINDER HEADS

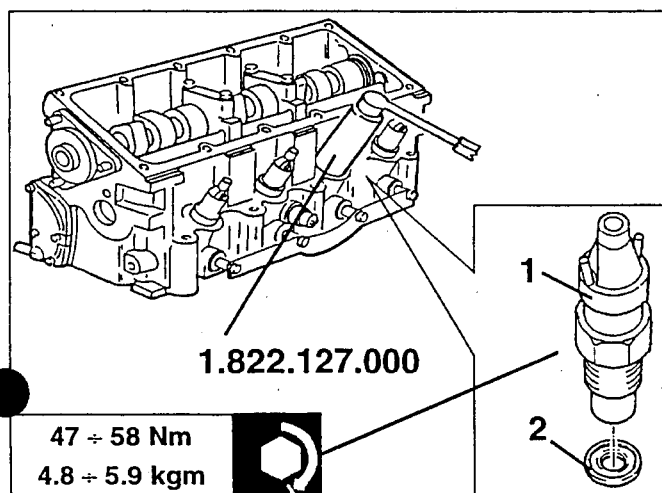
Preliminary operations

1. Clamp the moveable support N° 1.820.012.000 (A.2.0195) into a vice.
2. Install cylinder head support fork N° 1.820.258.000 and lock it to the support.
3. Insert tool N° 1.820.267.000 for the disassembly of the valves into the fork.
4. Insert the cylinder heads into the studs of the forks and lock them there.

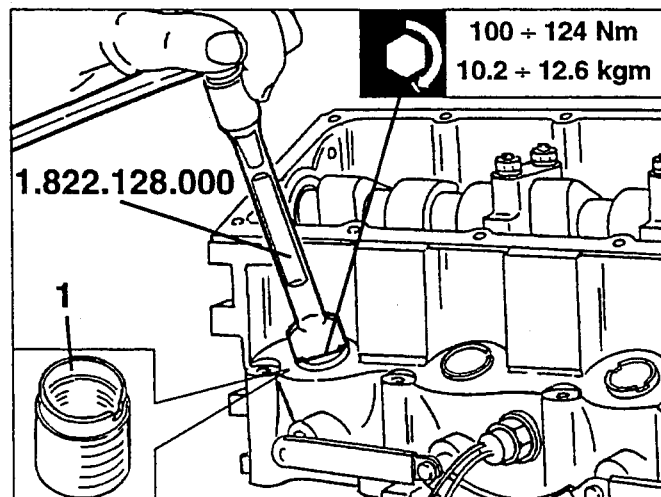


Removal of injectors

1. Using tool N° 1.822.127.000 remove the injectors.
2. Recover the engine compression seal elastic washer.

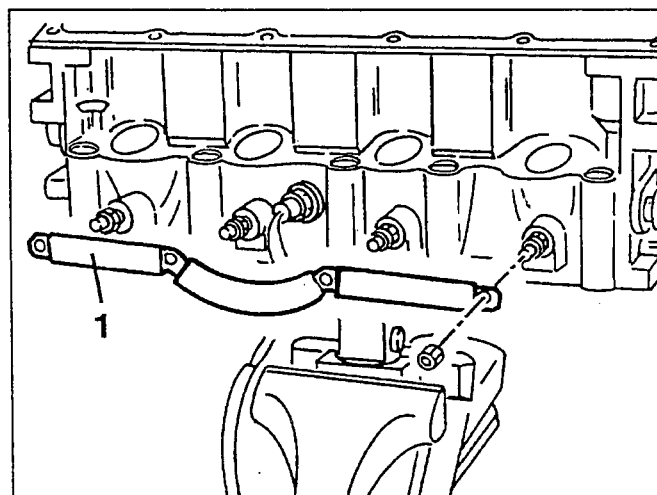


1. Using tool N° 1.822.128.000 remove the combustion prechamber fixing bushing.

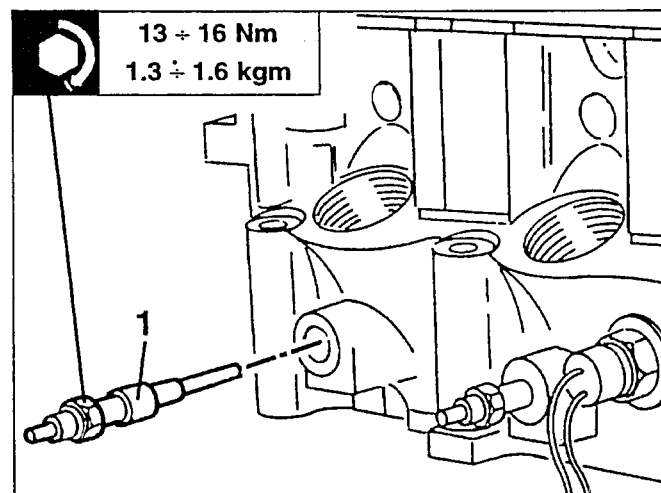


Removal of heater plugs

1. Remove the heater plugs supply connecting strip.

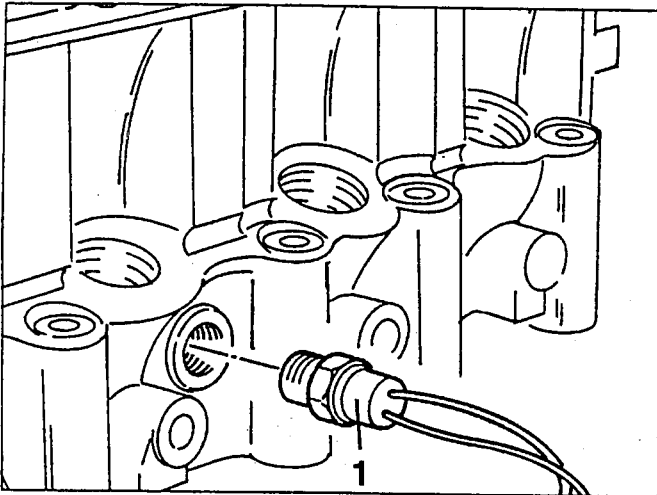


1. Remove the heater plugs.



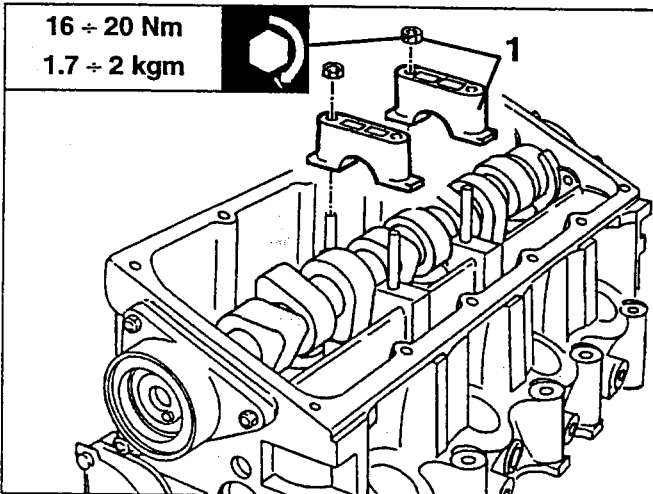
Removal of coolant temperature sensor

1. Remove the engine coolant temperature indicator transmitter and the max. temperature warning light contact.

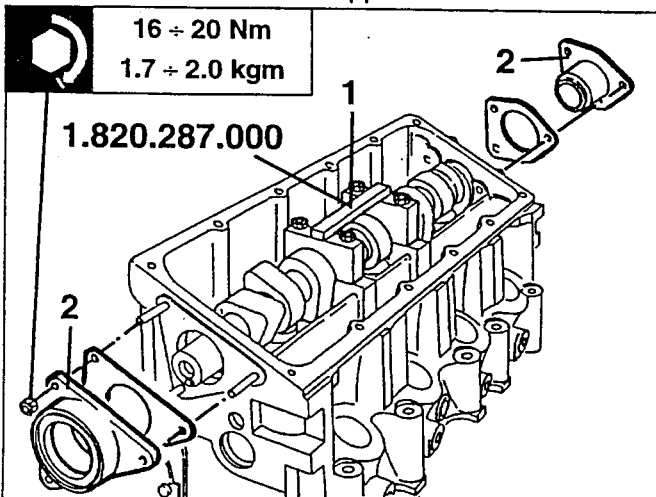


Removal of cam shaft

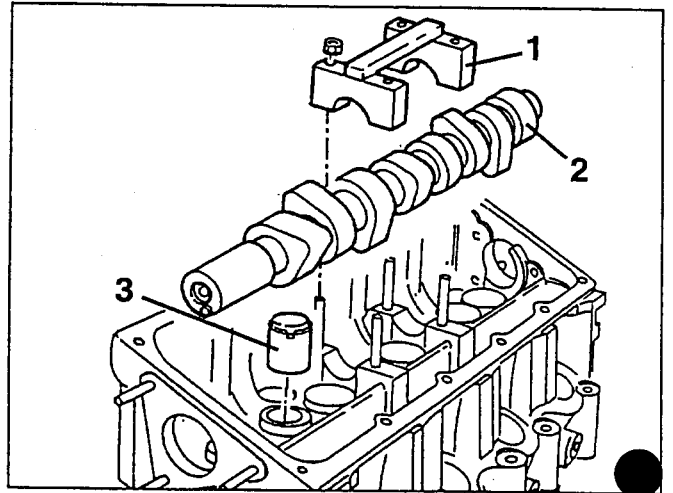
1. Unscrew the fastening nuts and remove the cam shaft caps.



1. Install tool N° 1.820.287.000.
2. Remove the camshaft support.

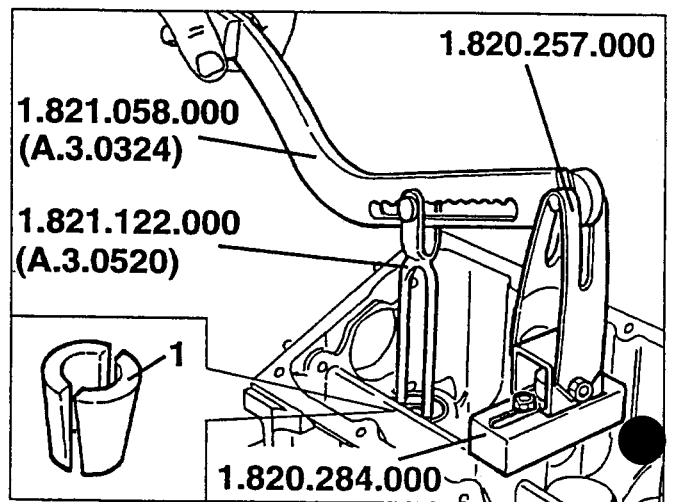


1. Remove tool installed previously.
2. Extract the camshaft.
3. Remove the valve cups complete with valve clearance adjusting plates.

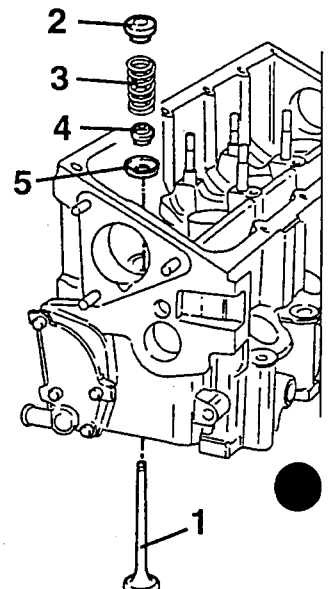


- Operate on each valve as follows.

1. Using the equipment indicated in figure, remove the cutters.

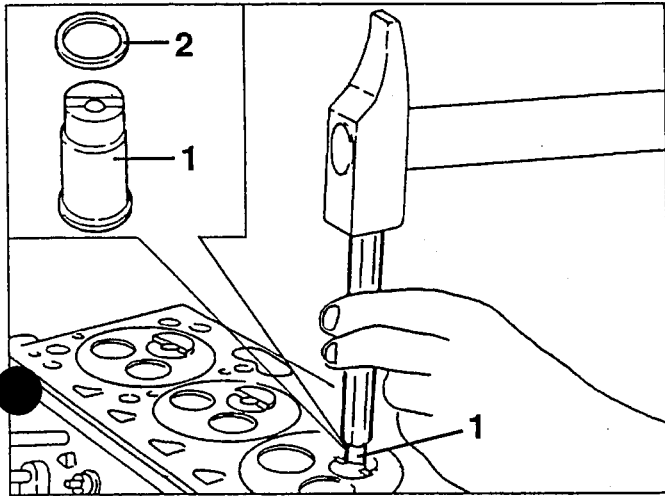


1. Extract the valve.
2. Remove the upper cap.
3. Recover the spring.
4. Using tool N° 1.821.208.000 remove the small rubber oil seal.
5. Remove the lower cap.



To reassemble the small rubber oil seal, use inserting tool N° 1.821.206.000.

- Remove the cylinder heads from the support tools.
- 1. Using a suitable punch, force the combustion pre-chamber from its seating.
- 2. Remove seal ring.



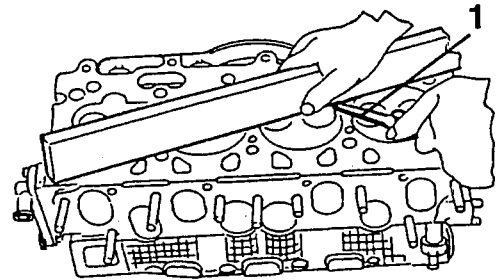
CYLINDER HEAD CHECKS AND INSPECTIONS

Checking lower plane of cylinder heads

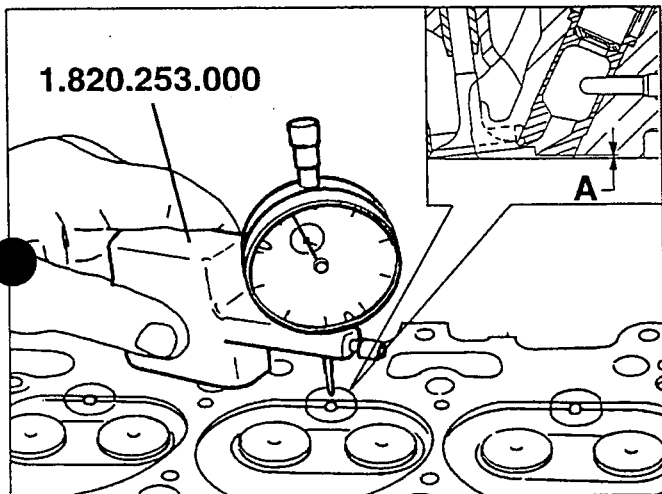
- 1. Check that the lower plane is level and, if necessary, reface.



Maximum head lower plane error
0.1 mm



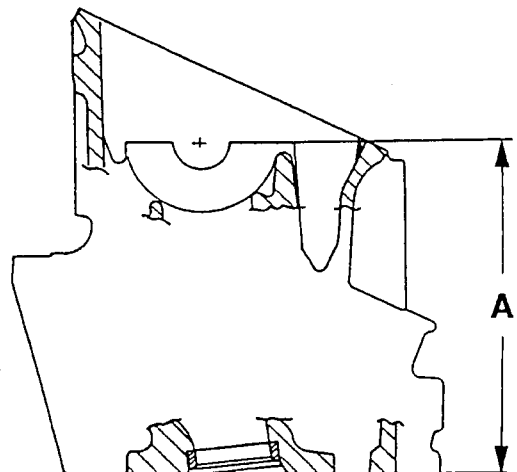
During reassembly of the combustion prechamber, check that it does not protrude from plane of the cylinder heads more than the prescribed limits using tool N° 1.820.253.000.



CAUTION:
do not exceed the minimum value as this could cause serious engine malfunction.



Minimum height "A" of head after facing
144.85 mm




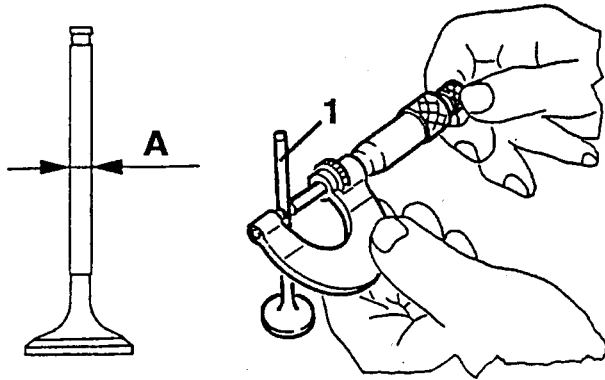
Distance "A" that precombustion chamber protrudes from plane of cylinder heads
- 0.765 + + 0.055

- Check that the surfacing of the lower plane of the head is of the required quality.


Clearance between valve guides and valve stems

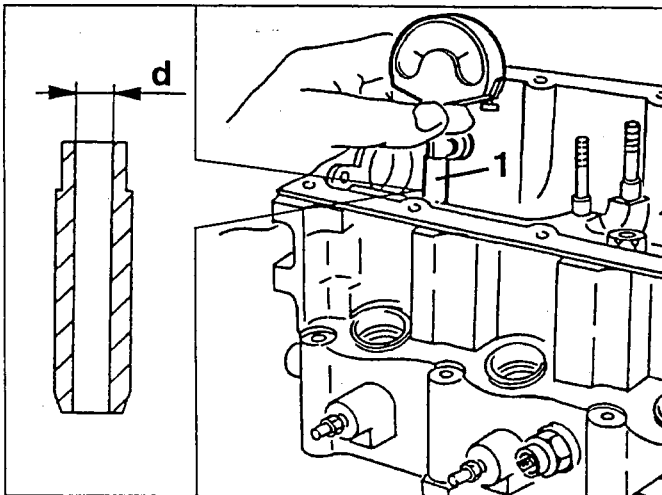
1. Measure the diameter of the valve stems and check that it falls within the prescribed limits:

	Diameter of valve stems "A"	
	intake and exhaust	7.974 ÷ 7.992 mm




1. Measure the inner diameter of the valve guides and check that it falls within prescribed limits.

	Inner diameter of valve guides "d"	
	intake and exhaust	8.022 ÷ 8.040 mm

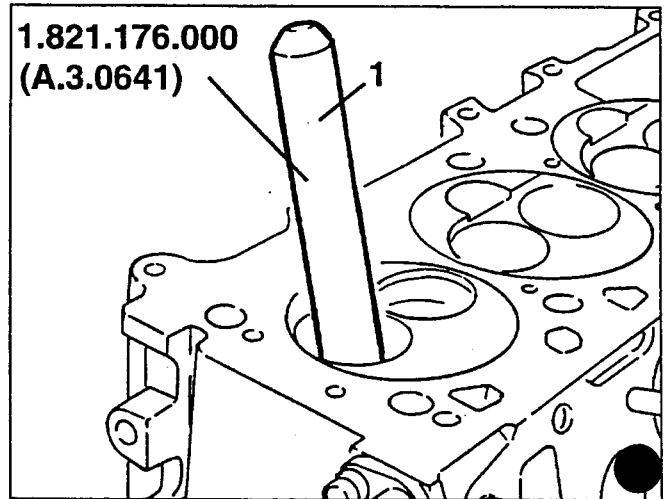


- Calculate the clearance between the guide valves and valve stems and check that it falls within the prescribed limits, if this is not the case replace the worn parts.

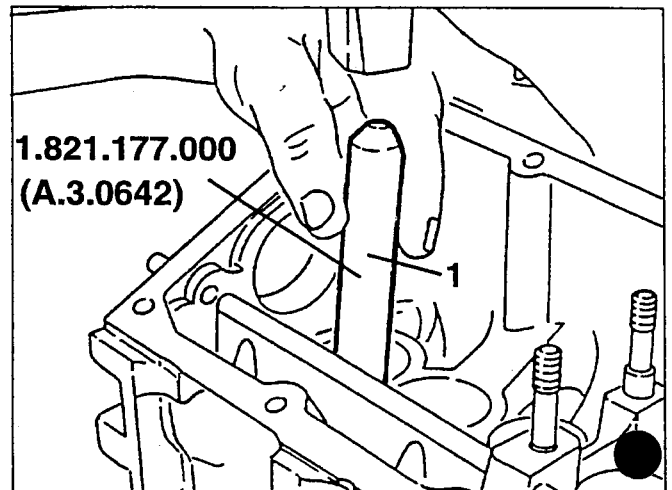
	Radial clearance between valve guides and valve stems	
	intake and exhaust	0.030 ÷ 0.066 mm

Replacement of valve guides


1. Extract the worn valve guides using extractor N° 1.821.176.000 (A.3.0641).

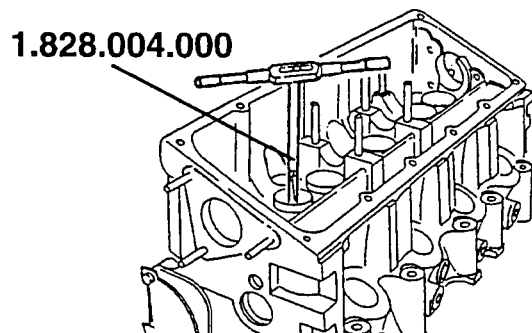


1. Insert the new valve guides using inserting tool N° 1.821.177.000 (A.3.0542).



1. Using tool N° 1.828.004.000, bore the valve guides to gauge the holes to the prescribed diameter.

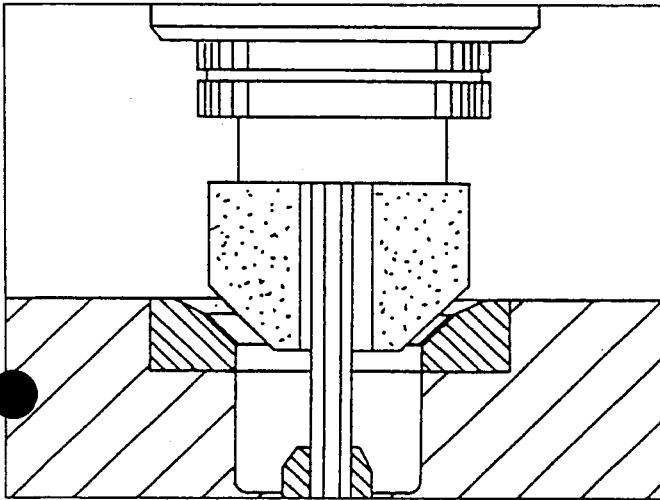
	Inner diameter of valve guides "d"	
	intake and exhaust	8.022 ÷ 8.040 mm



Turning of valve seatings

- If necessary, turn the valve seating using a suitable tool as follows:

- turn valve seatings with grinder at a $44^{\circ} 30'$.

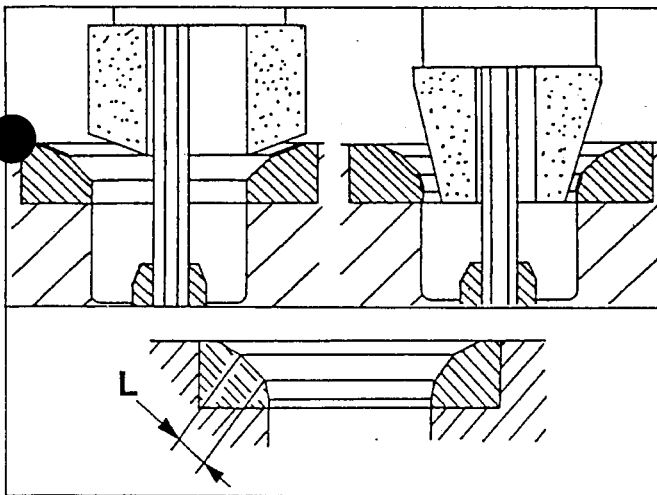


- turn valve seatings with grinder at 20° and at 75° as indicated in the figure until the prescribed value "L" is obtained.



Length "L" valve seating section with taper at 45°

~ 2.7 mm



- After turning, grind each valve in its seating as follows:

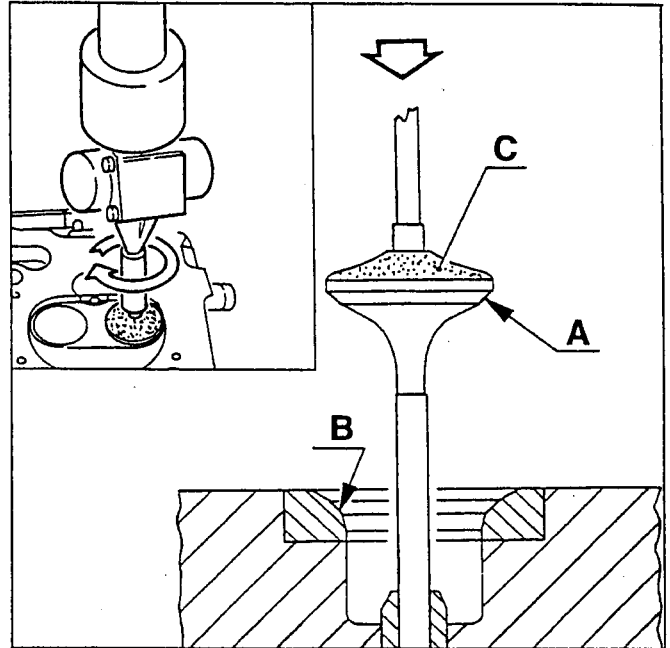
- spread the stop limit surfaces "A" and "B" of the valves and seatings with abrasive paste (SIPAL A-REXONS Carbosilicium for valve).

• lubricate the valve stem with engine oil.

• Fix the lower surface of the valve head to the suction cup "C" of a pneumatic lap.

- insert the valve into the respective guide and grind.

- after grinding, clean both the valves and their seatings thoroughly.



Valve springs

- Check that the "free" length of the valve springs falls within prescribed limits.

NOTE:

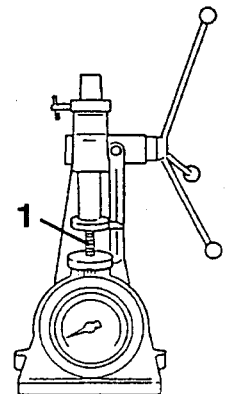
The planes must be parallel to each other and perpendicular to the axis of the spring with a maximum error of 2° .



Length of valve spring (L)

53.9 mm

1. Using a dynamometer, check that the spring's characteristics fall within prescribed limits.

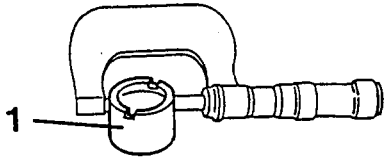


Length of spring mm		Control load daN (kg)
Valve closed	36	36.7 ÷ 39.6 (37.4 ÷ 40.4)
Valve open	26.5	55.9 ÷ 60.8 (57 ÷ 62)

Clearance between valve cups and relative seatings

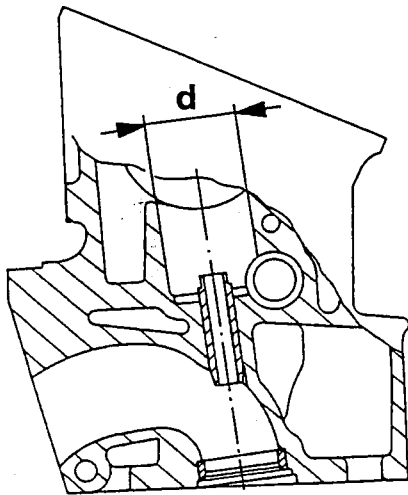
1. Measure the external diameter of the valve cups and check that it falls within the prescribed limits.

Diameter of valve cups	
intake and exhaust	36.975 + 36.995 mm



- Measure the diameter of the valve cup seatings on the cylinder heads and check that it falls within prescribed limits.

Diameter of valve cup seatings "d"	
intake and exhaust	37.000 + 37.025 mm



- Calculate the clearance between valve cups and relative seatings to check that it falls within prescribed limits, if not replace the worn parts.

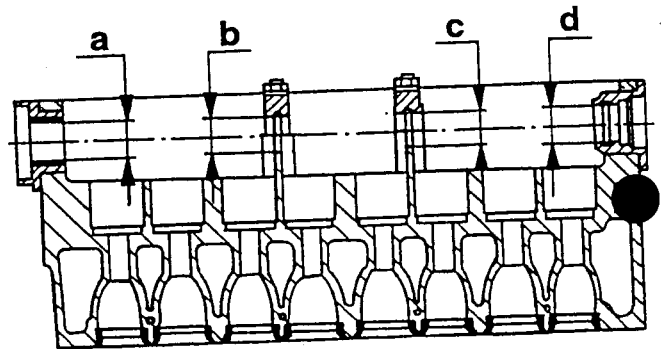
Clearance between cups and relative seatings	
0.005 + 0.050 mm	

Check camshaft radial clearance

- Install the lateral supports and camshaft central caps and tighten the relative nuts to the prescribed torque.
 - Measure the diameter of the camshaft supports and check that they fall within the prescribed values.



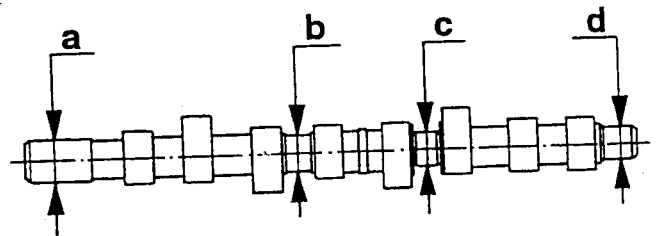
Diameter of camshaft supports	
First support (a)	29.990 + 30.015 mm
Second support (b)	25.545 + 25.570 mm
Third support (c)	24.045 + 24.070 mm
Fourth support (d)	23.990 + 24.015 mm



- Measure the diameter of the camshaft journals and check that they fall within the prescribed values.



Diameter of camshaft journals	
First journal (a)	29.945 + 29.960 mm
Second journal (b)	25.500 + 25.515 mm
Third journal (c)	24.000 + 24.015 mm
Fourth journal (d)	23.945 + 23.960 mm




- Calculate the radial clearance between the camshaft journals and the relative supports and check that they fall within the prescribed limits, if not replace the worn parts.

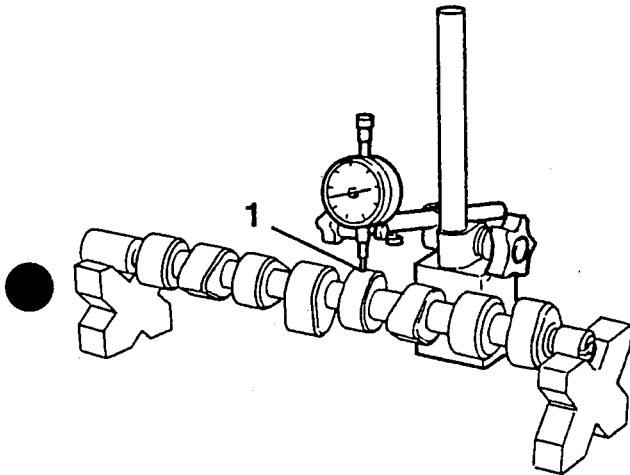


Camshaft radial clearance	
0.03 + 0.07 mm	

Check height of cams

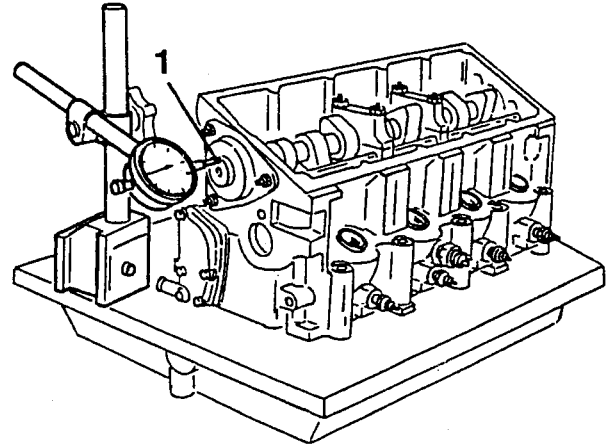
1. Measure the height of the camshaft cams and check that they fall within prescribed limits.

	Minimum cam height	
	intake and exhaust	8.5 mm



Camshaft axial clearance

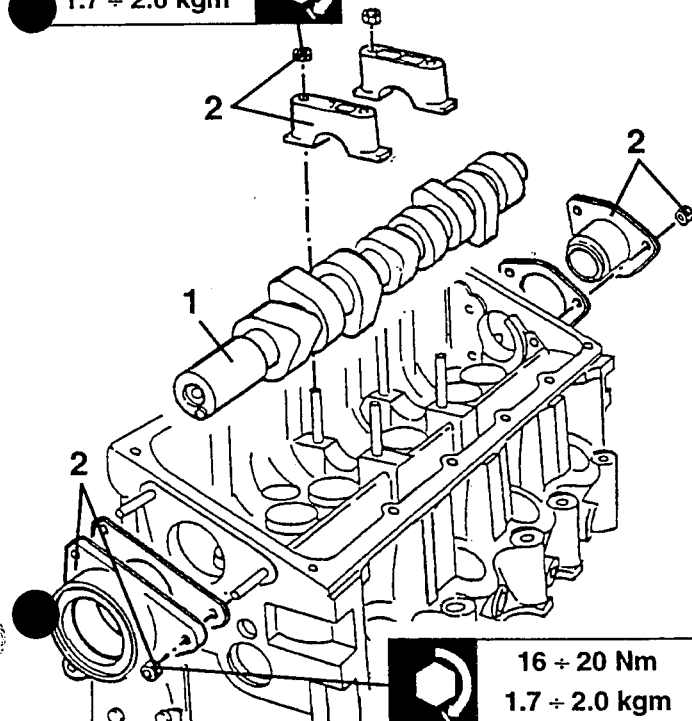
0.1 mm



Check camshaft axial clearance

1. Position the camshaft on the cylinder heads.
2. Install the central caps and the lateral supports and tighten the relative nuts to the prescribed torque.

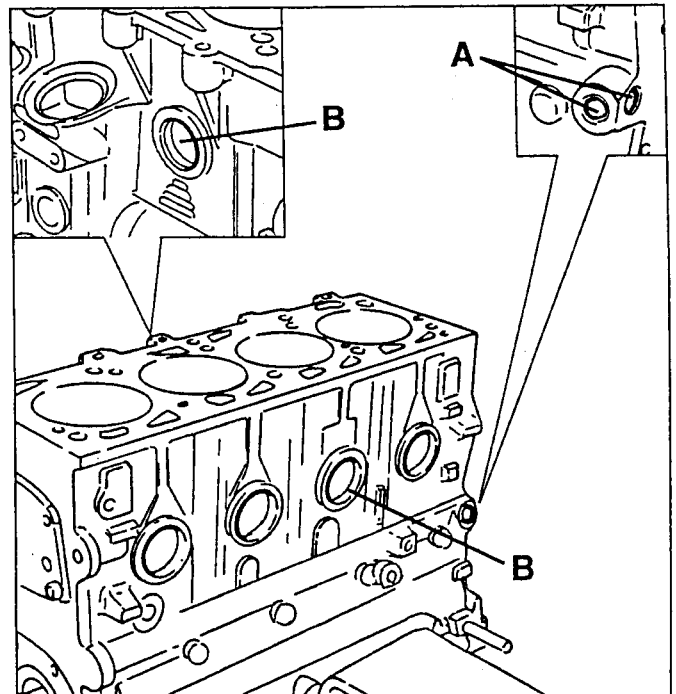
16 ÷ 20 Nm
1.7 ÷ 2.0 kgm



16 ÷ 20 Nm
1.7 ÷ 2.0 kgm

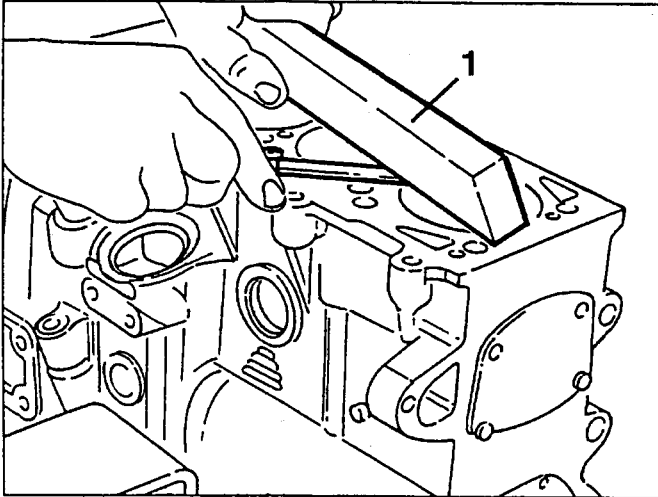
ENGINE BLOCK CHECKS AND INSPECTIONS

- Visibly check the engine block for cracks and signs of excessive wear; check the integrity of the threading.
- Remove the plugs from the lubricating and cooling ducts "A" and "B" and clean the ducts with a suitable detergent, then dry with a jet of air and replace the plugs.
- Thoroughly Clean off any fragments of gasket from the engine block plane.



1. Check the planarity of the cylinder head plane and check that it falls within prescribed values, and if necessary, reface.

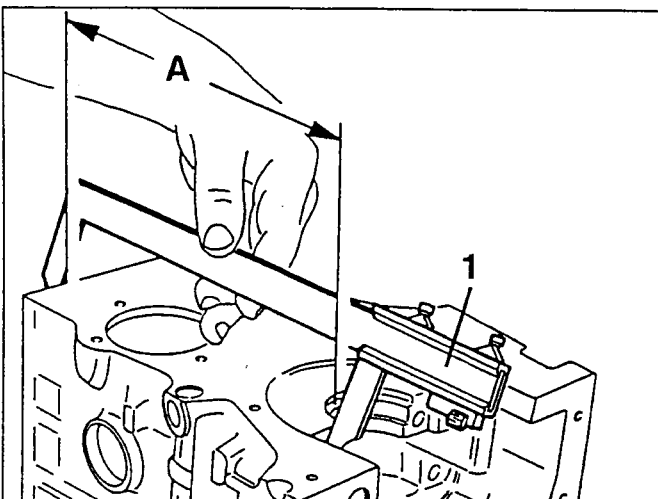
	Maximum planarity error of cylinder head plane
	0.1 mm



1. After refacing, check that the engine block height "A" exceeds the minimum value.

CAUTION:
do not exceed minimum value otherwise engine may seriously malfunction.

	Minimum height "A" of engine block after facing
	231.93 ÷ 232.07 mm

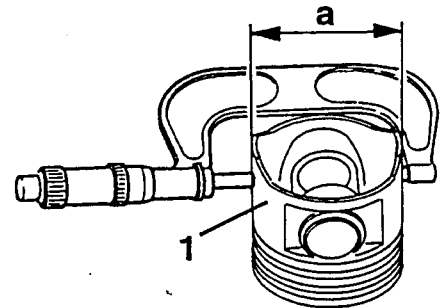


Check clearance between liners and pistons

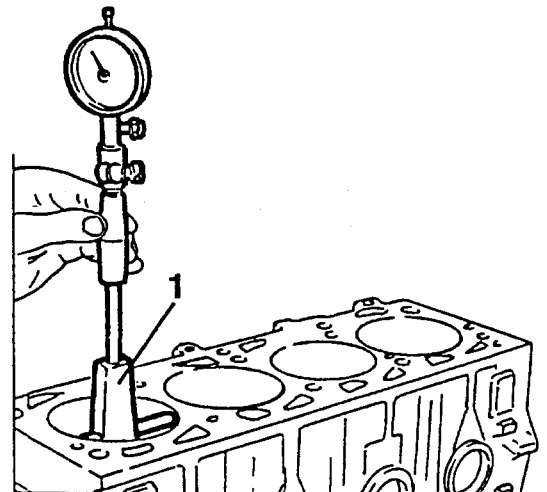
1. Measure the external diameter of the pistons and check that it falls within the prescribed values.

	External diameter "a" (1)
Class A	82.530 ÷ 82.540 mm
Class B	82.540 ÷ 82.550 mm
Class C	82.550 ÷ 82.560 mm
Class D	82.560 ÷ 82.570 mm
Class E	82.570 ÷ 82.580 mm

(1) The external diameter of the piston must be measured perpendicularly to the hole of the grudgeon pin and at a distance of 15mm from the lower edge of the skirt.



1. Measure the diameter of the cylinder liners and check that it falls within the prescribed values.

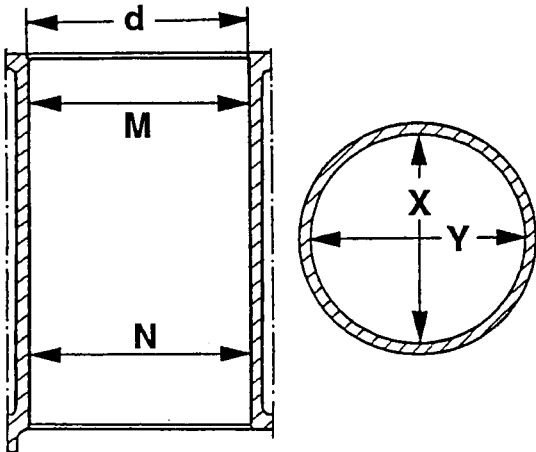


	Inner diameter "d"
Class A	82.600 ÷ 82.610 mm
Class B	82.610 ÷ 82.620 mm
Class C	82.620 ÷ 82.630 mm
Class D	82.630 ÷ 82.640 mm
Class E	82.640 ÷ 82.650 mm

● Check that the taper and the ovalization of the liners falls within the prescribed values.

△	Maximum taper
	$M - N = 0.005 \text{ mm}$

○	Maximum ovalization
	$X - Y = 0.05 \text{ mm}$

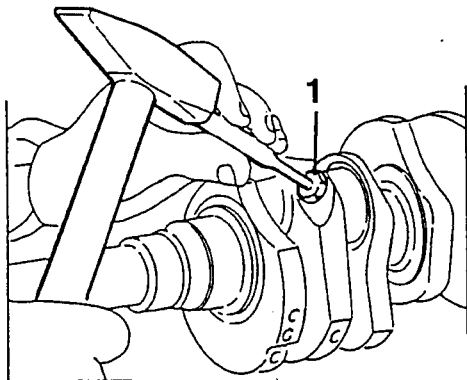


- Calculate the clearance between the liners and the pistons and check that it falls within prescribed limits.

↔	Clearance between liners and pistons
	$0.060 + 0.080 \text{ mm}$

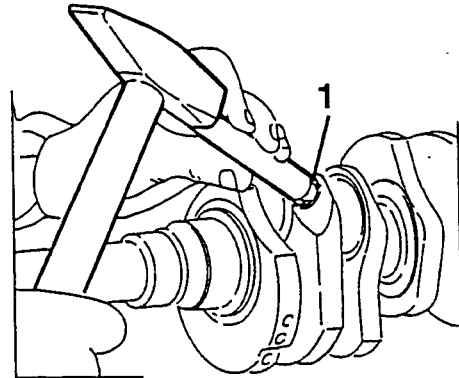
● **Cleaning of crankshaft lubrication ducts**

1. Punch a hole in the crankshaft lubrication duct plugs, then extract them and remove any shavings created by the calking operation.

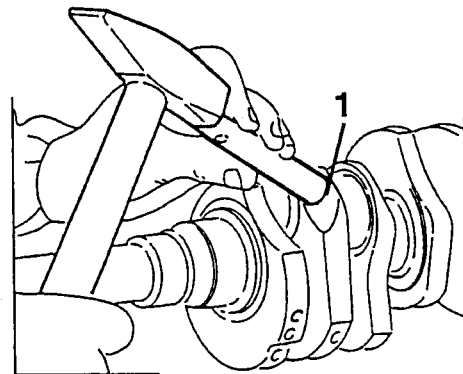


- Thoroughly clean the lubrication ducts using a suitable detergent, then dry with a jet of compressed air.

1. Apply the prescribed sealant on the new plugs and insert them, using a suitable tool, into the holes of the lubrication duct.



1. Calk the plugs using a suitable tool.

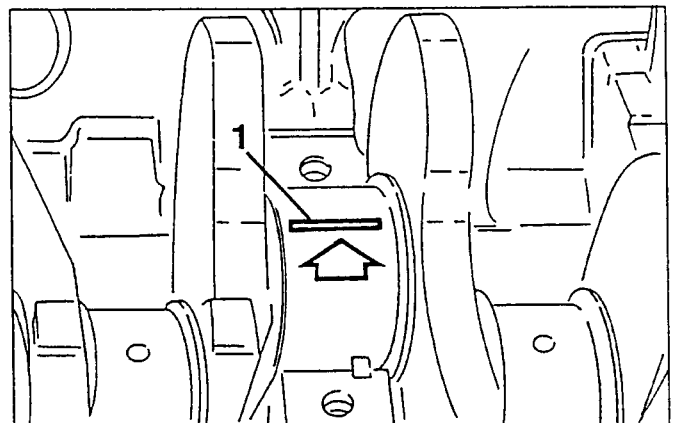


Measure the assembly clearance between the main journals and relative bearings halves using a gauged wire (plastigage)

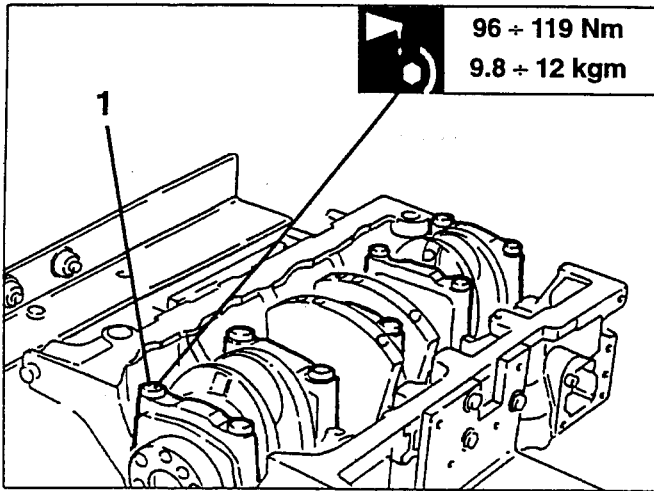
NOTE: Check each journal without removing the crankshaft during the checking operation.

The bearing halves must be housed in their respective seatings.

1. Rest a piece of calibrated wire across the whole width of the main journal being checked, paying particular attention that it does not correspond with the lubrication hole.



1. Tighten the lubricated main cap fastening screws to the prescribed torque.



1. Remove the main cap and compare the width of the gauged wire pressed with the scale indicated on the sachet.

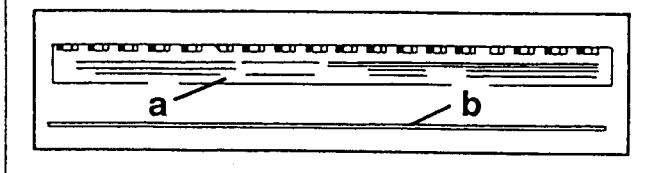
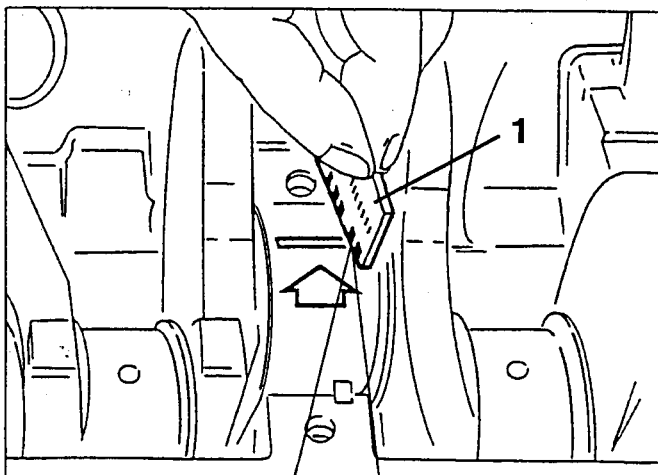
From the comparison between the width of the pressed wire and the scale, it is possible to determine the clearance between the journals and the relative bearing halves.

- Proceed in the same way for the other main journals.



Radial clearance between main journals and bearing halves

Class A (red)	0.027 ÷ 0.066 mm
Class B (blue)	0.024 ÷ 0.063 mm



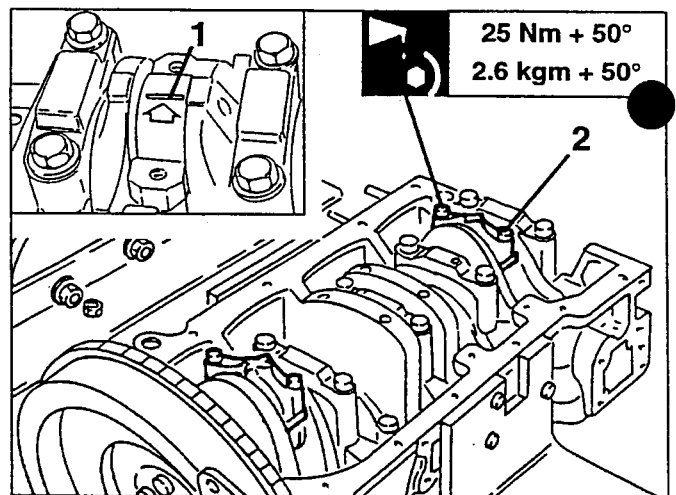
- a. Sachet with comparison scale
- b. Gauged wire

Measure assembly clearance between rod journals and relative bearing halves using a gauged wire (plastigage)

1. Rest a piece of gauged wire across the whole width of the rod journal paying particular attention that it does not correspond with the lubrication holes.

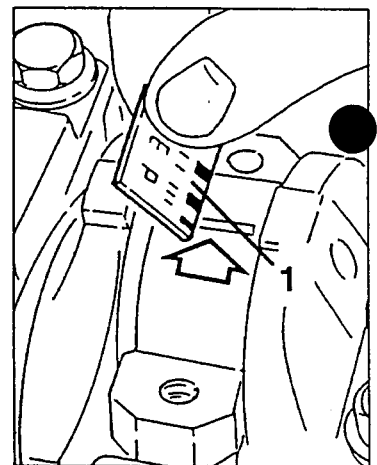
NOTE: The bearing halves must be housed in their respective seatings.

2. Tighten the lubricated rod cap fastening screws to the prescribed torque.



1. Remove the rod cap and compare the width of the pressed gauged wire with the scale indicated on the sachet.

- From the comparison between the width of the pressed wire and the scale, it is possible to determine the clearance between the bearings halves and the rod journals.



- Proceed in the same way for the other rod journals.




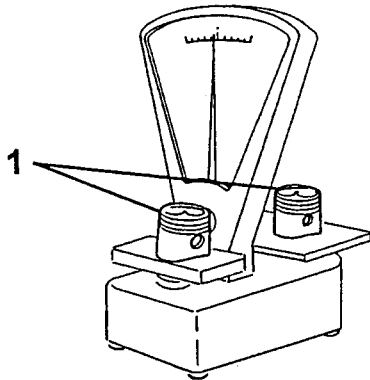
Radial clearance between the rod journals and bearing halves

Class A (red)	0.026 ÷ 0.063 mm
Class B (blue)	0.023 ÷ 0.060 mm


Checking and differences in weight between single pistons and single connecting rods

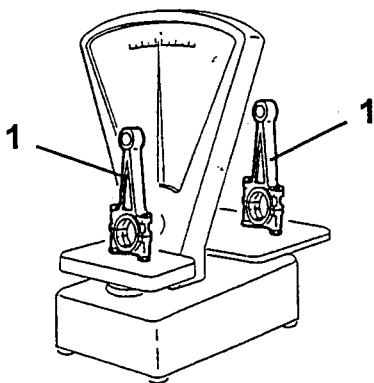
1. Weigh the pistons complete with seal rings, scraper ring, gudgeon pin and check that the difference in weight is within the specified limit.

	Difference in weight between pistons
	± 5 g



1. In the same way, check that the difference in weight between the connecting rods, complete with half bearings, caps and screws, is within the specified limit.

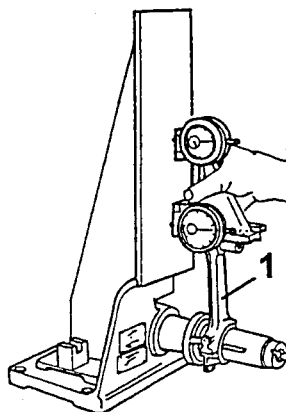
	Difference in weight between connecting rods
	± 2.5 g



Checking connecting rod squareness


1. Check the squareness of the connecting rods using a reference plane.

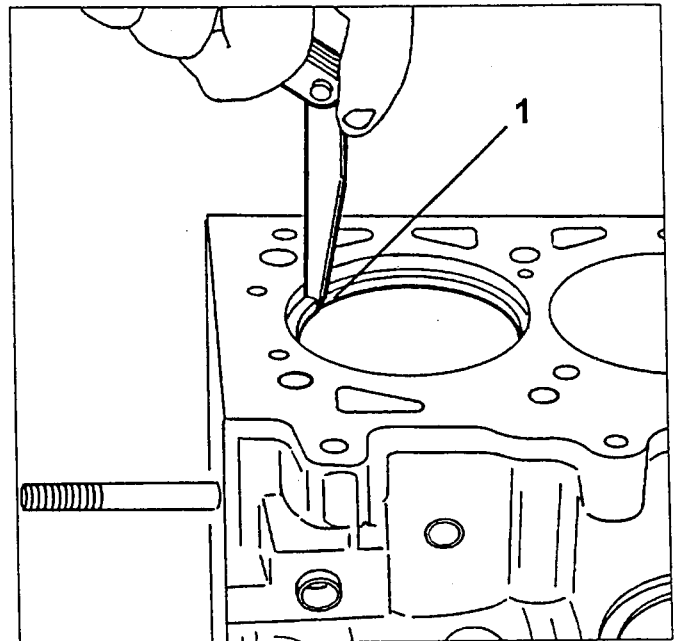
If imperfect squaring is noted, it is necessary to replace the connecting rod to avoid abnormal stresses, which would result in uneven wear of the piston and of the connecting rod itself.



Checking the seal ring gap


1. Insert the seal rings in the cylinder liner and use a thickness gauge to check that the gap is within the specified limits.

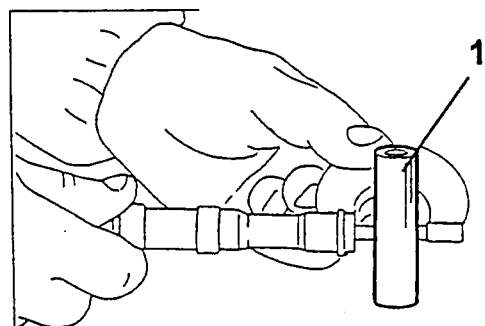
	Ring gap	
	First ring	0.20 ÷ 0.35 mm
	Second ring	0.30 ÷ 0.50 mm
	Oil scraper ring	0.25 ÷ 0.50 mm



Checking the clearance between gudgeon pin and seat on piston

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.

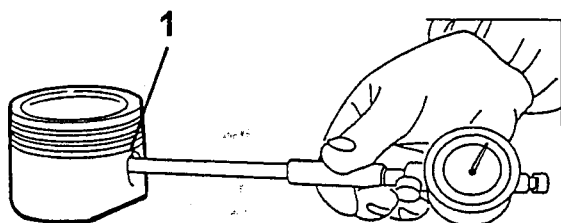
	Gudgeon pin outside diameter	
Version before change	Class 1	25.987 ÷ 25.990 mm
	Class 2	25.990 ÷ 25.993 mm
Version after change	25.987 ÷ 25.991 mm	



1. Measure the diameter of the hole on the piston paired with the gudgeon pins and check that it is within the specified limits.



Gudgeon pin hole diameter in pistons		
Version before change	Class 1	25.993 ÷ 25.996 mm
	Class 2	25.996 ÷ 25.999 mm
Version after change		25.994 ÷ 25.999 mm



- Calculate the clearance between the gudgeon pins and their seats on the pistons and check that it is within the specified limits.

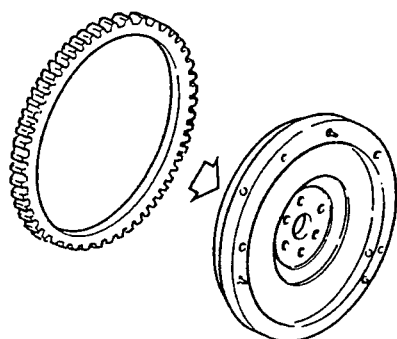


Clearance between gudgeon pins and seats on pistons	
Version before change	0.003 ÷ 0.009 mm
Version after change	0.003 ÷ 0.012 mm

Changing the flywheel ring gear

- Check that the flywheel ring gear is intact and, if necessary, replace it proceeding as follows:

- remove the old ring gear using a hydraulic press.
- carefully clean the contact surfaces of the new ring gear and of the flywheel.
- evenly heat the new ring gear to a temperature of 80 °C and fit it on the flywheel.
- allow to cool in a natural environment; do not force cool.

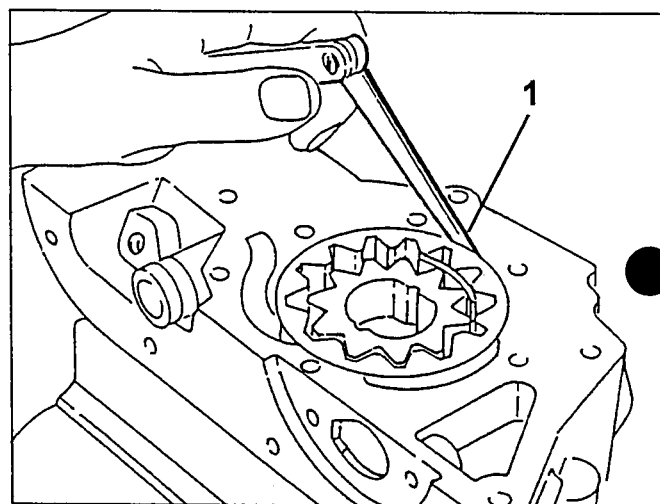


Inspecting and checking the oil pump

1. Check that the clearance between the pump casing housing and the driven gear is within the specified limit.



Clearance between pump casing housing and driven gear
0.080 ÷ 0.186 mm



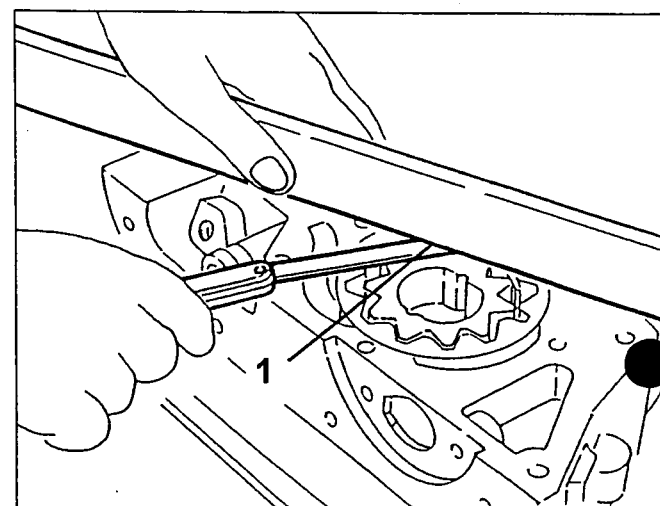
1. Check that the clearance between the resting surface of the pump cover and the upper side of the gears is within the specified limit.



WARNING:
If the clearances are not within the specified limits, change the front cover with incorporated oil pump.



Clearance between pump cover resting surface and upper side of gear
0.025 ÷ 0.056 mm



INSTRUCTIONS FOR REASSEMBLY

For reassembly operations, reverse the sequence followed for disassembly, unless otherwise specified below.

Checking and adjusting valve clearance

- After refitting the camshaft measure the valve clearance as follows:

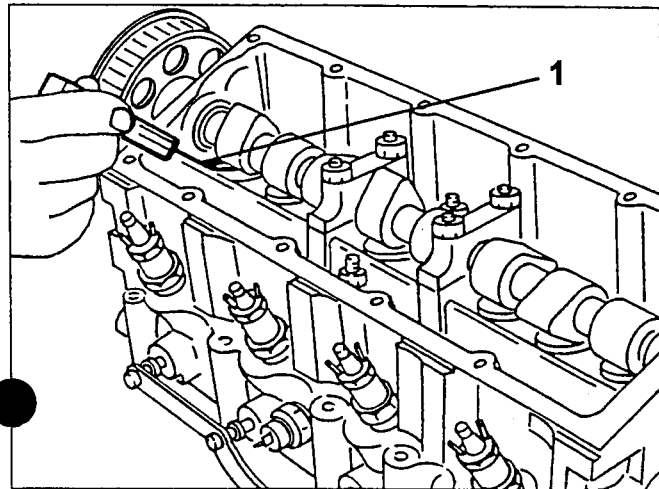
- Turn the camshaft to take the intake and exhaust valves to the closed position.

1. Check that the clearance between the lowered radius of the cam and the corresponding tappet is within the specified limits.



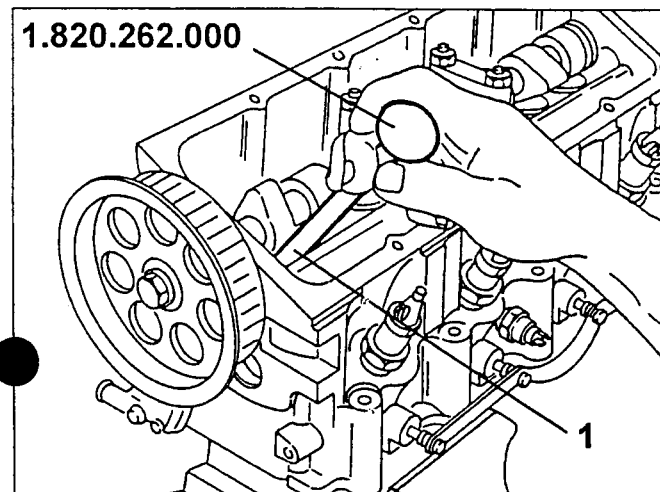
Valve operating clearance (with engine cold)

Intake	0.30 ± 0.05 mm
Exhaust	0.35 ± 0.05 mm

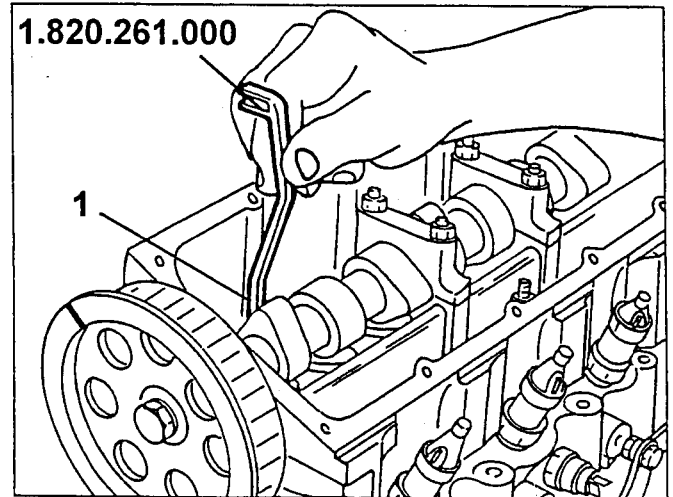


- If the clearance is not within the specified limits, proceed as follows:

1. Using the pressure lever no. 1.820.262.000 lower the tappet.

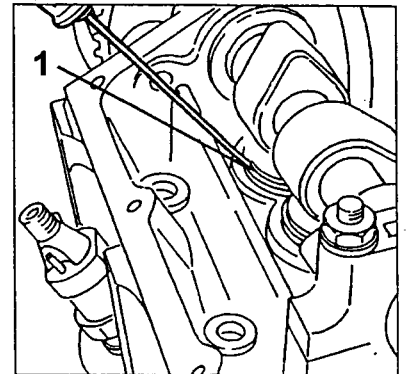


1. Position tool no. 1.820.261.000 directing the notches on the edge of the tappets to facilitate removal of the plate.



1. Prise and remove the tappet adjustment plate.

- Replace the removed plate by another one of suitable thickness to restore the correct valve clearance.



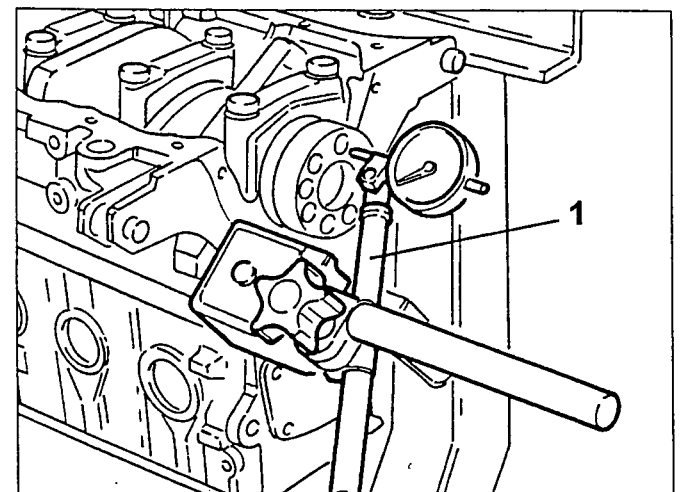
Checking the crankshaft end float

1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.



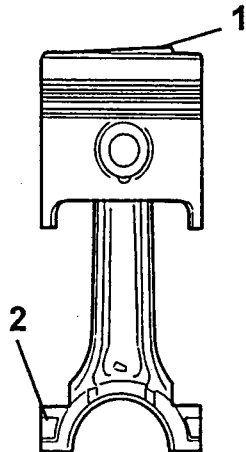
Crankshaft end float

$0.049 \div 0.211$ mm



Refitting pistons and connecting rods

- Turn the crankshaft until the connecting rod pins of the 1st and 4th cylinder reach the position corresponding to the B.D.C.
- Assemble the pistons - connecting rods in the sequence illustrated below.



1. Protrusion on piston crown
2. Number of cylinder to which connecting rod belongs

- House the corresponding half bearings on the connecting rod big ends.

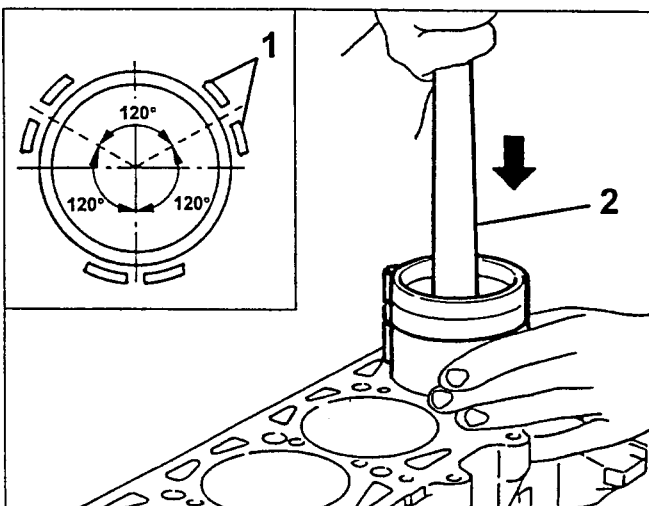


Carefully clean the outer surfaces of the half bearings and their seats.

1. Place the rings in the pistons with the notches offset by 120°.
2. Using a suitable tool, insert the pistons and connecting rods in the 1st and 4th cylinder.



Assemble the connecting rod-piston sets directing the number of the cilinder stamped on the connecting rod small end towards the intake - exhaust side.



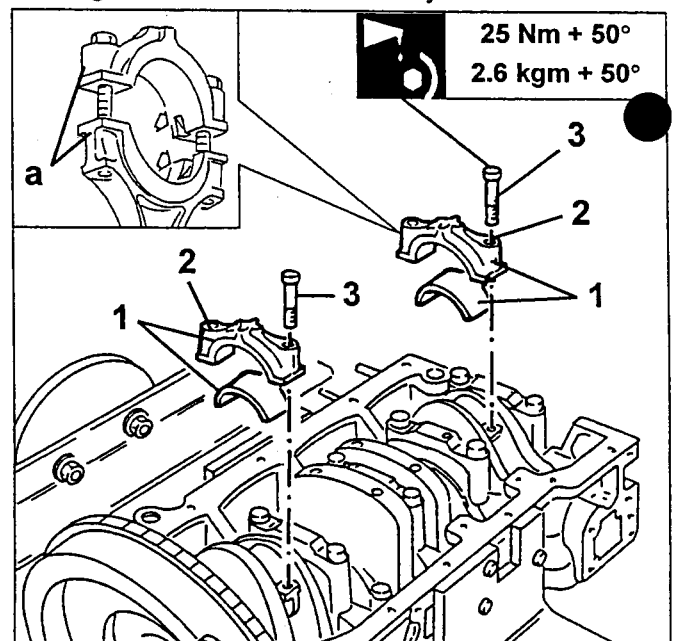
- Turn the crankcase 180°.
- 1. House the corresponding half bearings on the connecting rod caps.

2. Assemble the connecting rod caps of the first and fourth cylinder with the safety notch on the same side as the one on the connecting rod.



On the side, the connecting rod caps have the number of the cylinder to which they belong; during reassembly this number should be on the same side as the one stamped on the connecting rod big end.

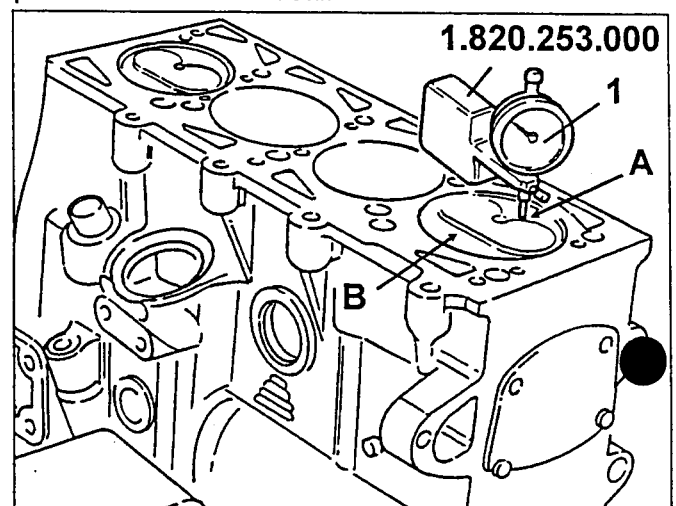
3. Tighten the connecting rod cap fastening screws to the specified torque in oil.
- In the same way reassemble the pistons and connecting rods of the 2nd and 3rd cylinder.



a. Stamped number of corresponding cylinder

Cylinder head refitting

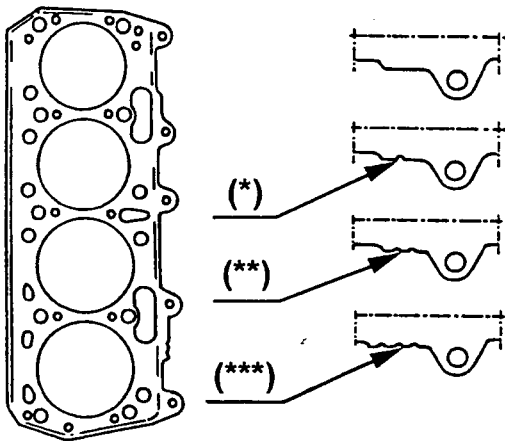
1. Using tool no. 1.820.253.000 fitted with dial gauge, find for each cylinder in points A and B the protrusion/recess of the piston; calculate the average of the values and consider the highest average among the pistons to define the seal.



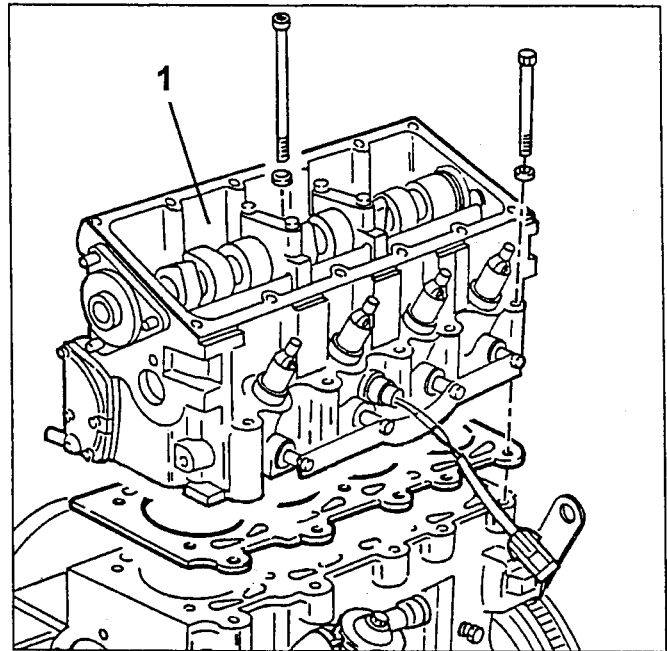
- Choose the cylinder head seal of suitable thickness according to the table given below.

Average piston protrusion		Thickness of cylinder head seal
up to engine no. 1762797	from engine no. 1762798	
< 0.7 mm	< 1.05 mm	1.67 mm
0.7 ÷ 0.8 mm	1.05 ÷ 1.15 mm	1.75 mm (*)
0.8 ÷ 0.9 mm	1.15 ÷ 1.25 mm	1.85 mm (**)
> 0.9 mm	> 1.25 mm	1.93 mm (***)

(*) marked by 1 notch on the outer edge
 (**) marked by 2 notches on the outer edge
 (***) marked by 3 notches on the outer edge

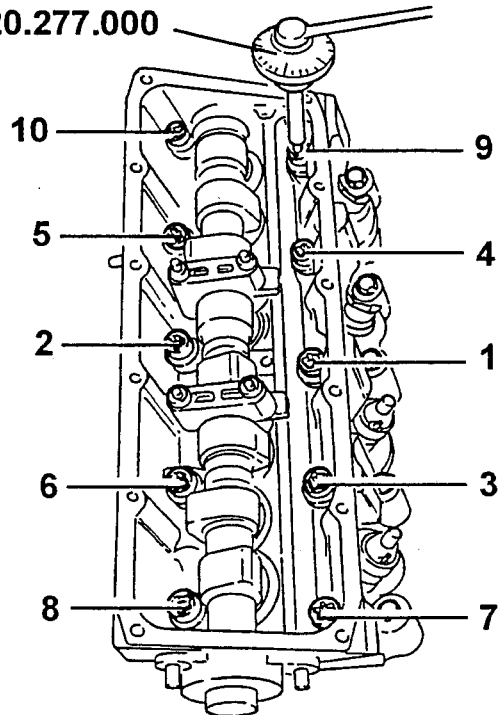


1. Assemble the cylinder head on the crankcase.



- Tighten the **inner screws** fastening the cylinder head as described below, bearing in mind that, for each step, the tightening sequence is the one shown below.
- Tighten the **inner screws** to a torque of 100 Nm (10.2 kgm).
- Angle tighten by 90° + 90° the **inner screws** using graduated disk no. 1.820.277.000.

1.820.277.000



- Tighten the **outer screws** fastening the cylinder head to the crankcase to a torque of 26 ÷ 32 Nm (2.6 ÷ 3.2 kgm).

The cylinder head seal is of the ASTADUR type. Due to the special material with which it is made, this seal polymerises when the engine is running therefore it hardens considerably.

CYLINDER HEAD SEAL ASSEMBLY

For the cylinder head seal to polymerise, it is necessary:

- to keep the seal in its original package;
- take the wrapper off shortly before assembly;
- not to lubricate or soil the seal with oil;
- during assembly, carefully clean the surfaces of the cylinder and crankcase.

NOTE: For tightening the cylinder head outer screws no particular sequence is required.



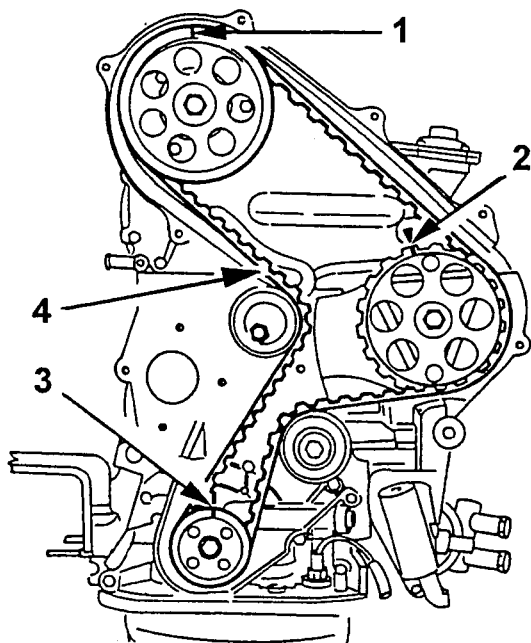
WARNING:
ASTADUR seals are paired with cylinder head fastening screws of the type with tightening to the yield point.
With the adoption of ASTADUR seals it is no longer necessary to tighten the cylinder head fastening screws at the first service coupon.

Camshaft drive belt assembly and checking valve gear timing

- Refit the camshaft toothed pulleys, the pulley guide and the belt tensioner.

1. Direct the camshaft drive pulley so that the notch on it corresponds with the hole on the camshaft belt rear cover.
2. Direct the injection pump drive pulley so that the notch on it corresponds with the relief on the camshaft belt rear cover.
3. Turn the crankshaft until the reference notch of the camshaft belt drive pulley is aligned with the relief on the engine front cover.
4. Assemble the toothed belt, checking correct mating of the teeth on all the toothed pulleys.

When assembling the toothed belt, to avoid damaging the structure of the fibres that form it, never cause sharp bends.

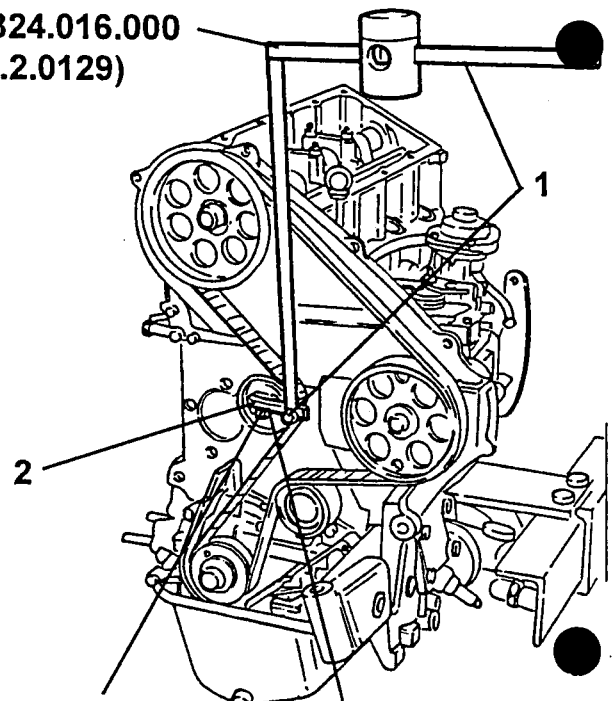


- On tool no. 1.824.016.000 (C.2.0129) assemble support no. 1.824.017.000 (C.2.0130), then position the weight, with the knurled piece, at a distance of 120 mm on the millimetre rod and lock it.

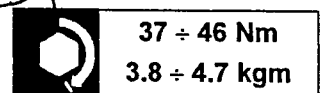
1. Apply the tool assembled in this way on the belt tensioner, as illustrated. Working on the joint, direct the millimetre rod so that it is horizontal.
- Settle the toothed belt turning the crankshaft twice in its normal direction of rotation.
2. Tighten the belt tensioner fastening nut to the specified torque.

During this phase, the millimetre rod may move from its horizontal position; in this case it is necessary to work on the belt tensioner again to restore the original position of the millimetre rod and repeat the operation.

1.824.016.000
(C.2.0129)

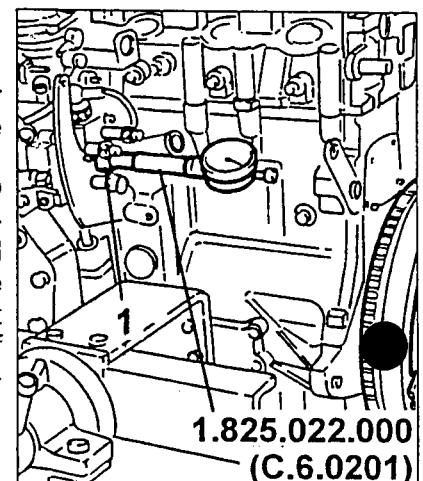


1.824.017.000
(C.2.0130)



Injection pump timing

1. Remove the plug on the pump cover and in its place screw on tool no. 1.825.022.000 (C.6.0201) complete with dial gauge with the feeler in contact with the crown of the distributor piston.

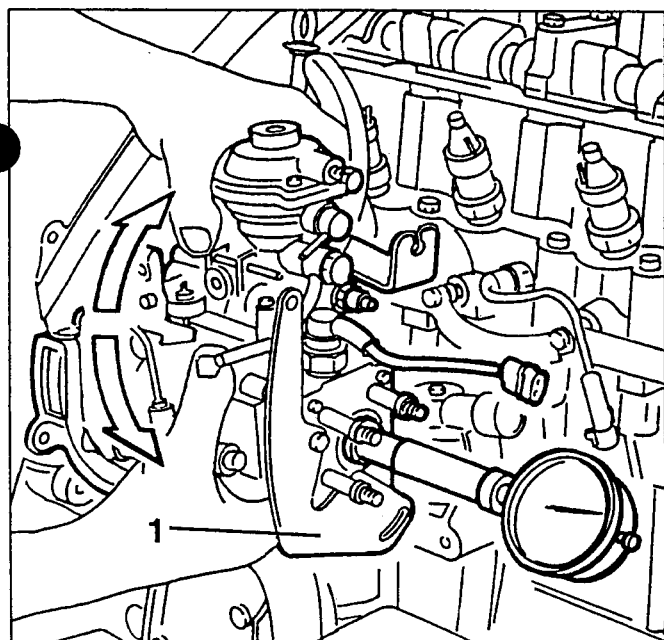


1.825.022.000
(C.6.0201)

Using a suitable tool, rotate the engine in the opposite direction to the normal rotating direction until the timing piston of the pump reaches the B.D.C. indicated by the comparator; when in this position set the latter to zero.

- Rotate the engine in the normal rotating direction until the piston of cylinder N° 1 is at the T.D.C. In this position the piston will have carried out a 0.8 mm stroke as indicated on the comparator.

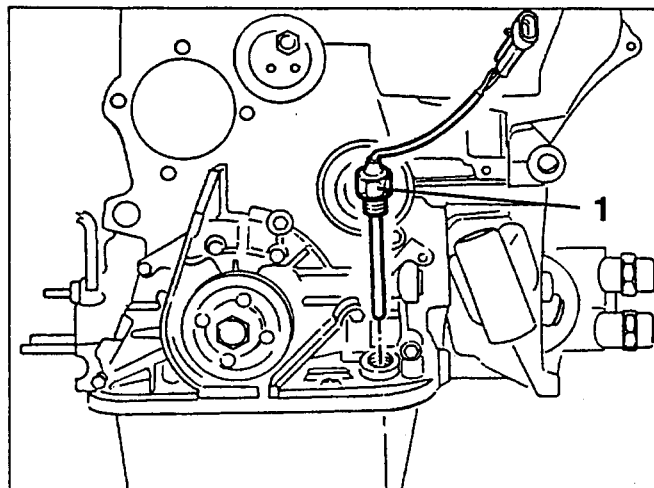
1. If this stroke is not indicated, the pump body must be rotated in its slot until the correct value, as indicated on the comparator, is obtained then tighten the screws fastening the pump to the support.



Engine oil level sensor

1. Check the setting of the engine oil level sensor; If the prescribed values are not found, replace the sensor.

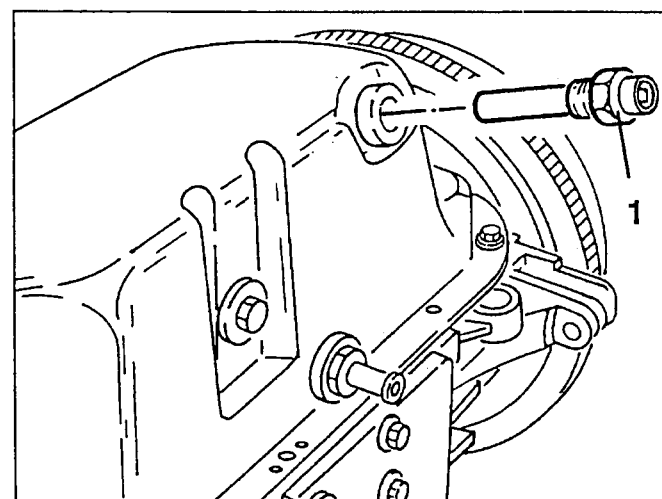
Circuit resistance	12Ω ± 5%
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Oil temperature sensor

1. Check the setting of the engine oil temperature sensor; If the prescribed values are not found, replace the sensor.

Temperature °C	Resistance Ω
60 ± 0.5	525 ÷ 605
90 ± 0.5	195 ÷ 215
120 ± 0.5	82 ÷ 94
140 ± 0.5	49 ÷ 55



 WHEN REASSEMBLY IS COMPLETED carry out all the checks and inspections required by ordinary maintenance (see GROUP 00) and the checks regarding the supply system (see GROUP 04) and the cooling system (see GROUP 07).

INSPECTION OF LUBRICATION CIRCUIT ELECTRICAL COMPONENTS

- Engine oil level sensor.
- Engine oil temperature sensor.
- Engine oil minimum pressure warning light.

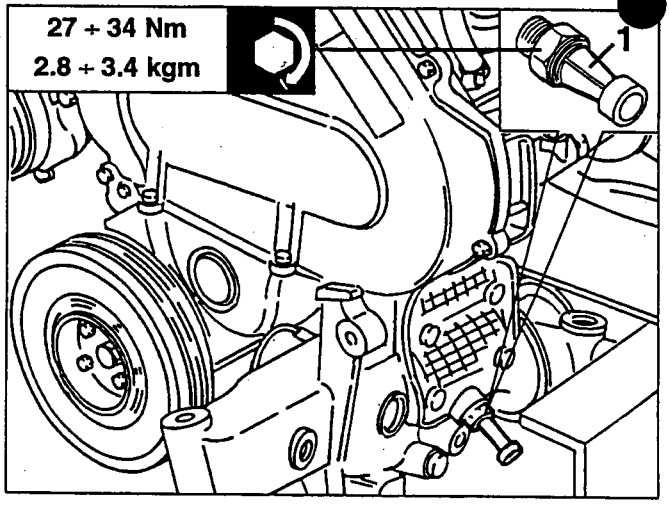
As regards the other sensors and electrical components located in the engine compartment, refer to the specific groups where they are described in detail.

Engine oil minimum pressure warning light sensor

1. Check the setting of the engine oil minimum pressure warning light sensor; if the prescribed value is not found, replace the sensor.



<p>Contact opening/closing pressure</p>	<p>0.2 + 0.5 bar</p>
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INDEX

GENERALITIES

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OVERHAULING

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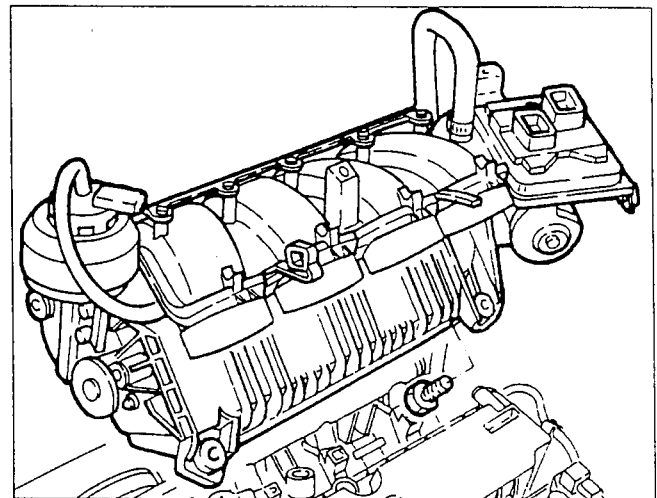
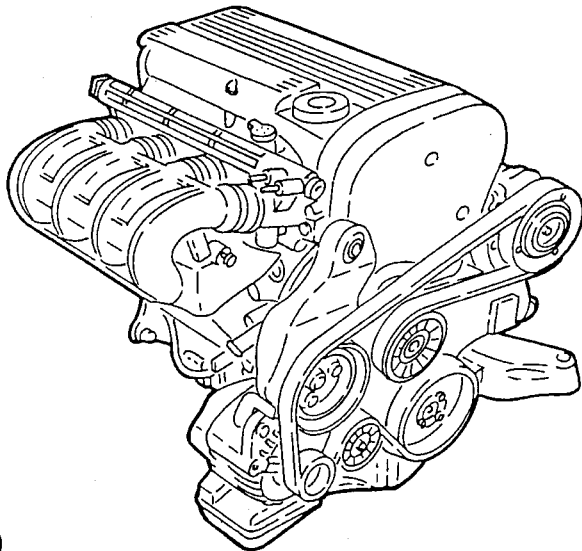
DESCRIPTION

Four cylinder in line engine with double camshaft in head, four valves per cylinder, phase variator, static injection and twin ignition controlled by a single ECU.

The rear engine is connected to the clutch-gearbox-differential unit which constitutes a sole assembly. The engine is installed frontally and transverse at a 18°30' slant. The engine is "suspended" by means of two damper mounts to the underbody and one scissors mount to the suspension crossmember. To contain vibrations, the engine top is connected to the underbody by means of a shock-proof connecting rod.

All belts are fitted with automatic take-up devices to ensure long belt working life.

The fuel feed system (unleaded petrol) is fitted with suitable pollution prevention devices which ensure low exhaust emissions as per "EEC PHASE 2" standards.



CRANKCASE

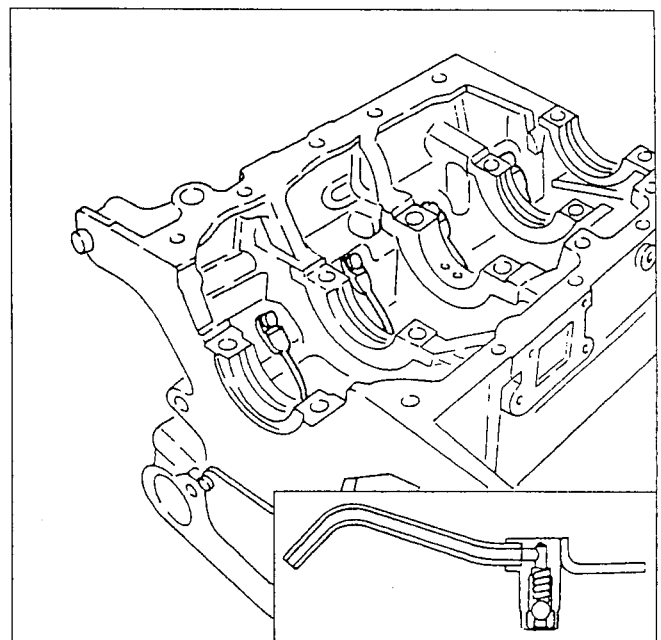
The engine block is made of high mechanical resistance cast iron.

The crankshaft is supported by means of five main journals which house five thin casing half-bearings. The cylinders are directly cut into the crankcase and are selected according to three size classes plus three oversized classes.

Two counter-rotating shafts, supported by means of a central bushing and ball bearings in the front and rear parts are housed in the crankcase.

Specific ducts in the crankcase walls ensure the passage of coolant and lubrication oil.

A nozzle, which sprays oils on the top of the piston thus ensuring partial cooling, is fitted in the lower part of each cylinder.



AR 32301 engines are fitted with a plastic intake manifold with variable geometry instead of an aluminium intake manifold.

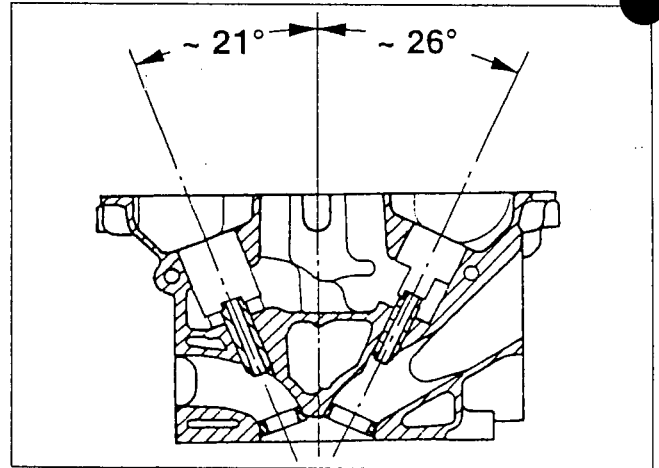
The fuel feed system is returnless, i.e. with a single feed pipe.



CYLINDER HEAD

Monolith, compact, mould-cast aluminium and silicon alloy.

The four valves per cylinder are fitted in their respective V guides at approximately 47° and are controlled by two camshafts by means of hydraulic tappets.

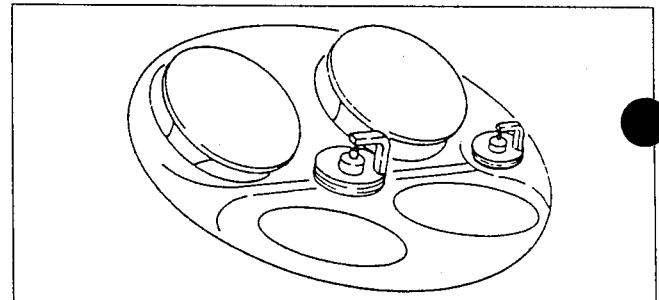


The space is organised so that the combustion chambers can house the four valve caps and the central and side spark plug holes without weakening the head structure.

The central spark plugs (larger) are tightened at a torque of 25 - 35 Nm, while the side (smaller) spark plugs are fastened at a torque of 10 - 12 Nm.

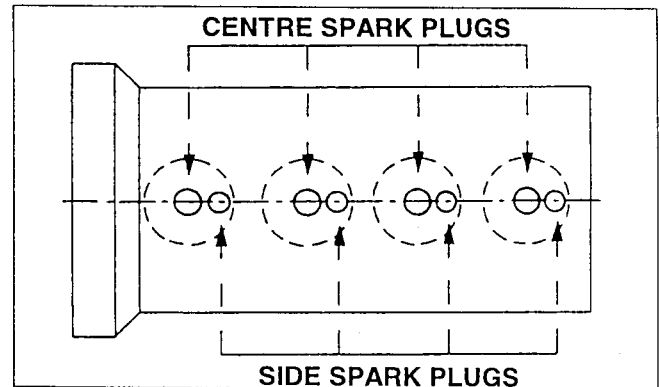
They should be replaced every 100,000 km.

The twin spark plugs positioned in this fashion, the two intake valves and the two exhaust valves ensure uniform distribution of the mixture and optimal combustion with improved engine thermal performance and reduced harmful emission in exhaust.



The camshaft on intake side turns on six journals. The camshaft on exhaust side turns on five journals. The shafts are controlled with a timing belt.

The valve seats are fitted in the cylinder head after it is heated to a temperature of 80°C. The seats are then cooled with liquid nitrogen. The valve guides are fitted in their seats in the cylinder head. Interference and internal diameter is perfected after assembly with a specific borer and controlled by means of a go-no-go set of gauges. The cylinder head and crankcase seal is made of aramide fibre. No head re-torque is required for the entire life of the engine.

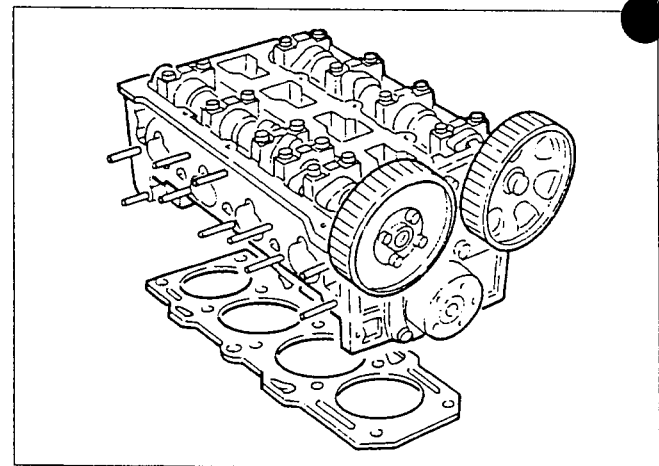


OIL SUMP

The oil sump is a structural part of the engine with mechanical functions.

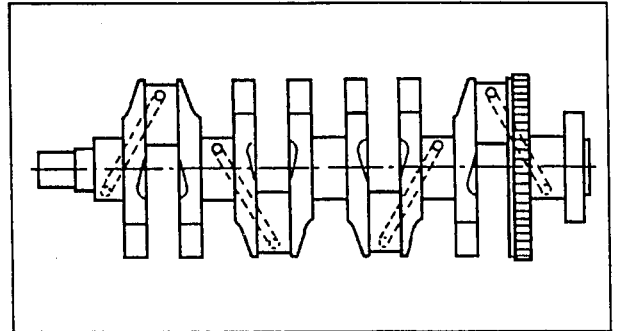
It contains the engine oil and is directly connected to the gearbox and to the rear engine mount. It is made of die-cast aluminium alloy and features internal shock-proof partitions.

It is fastened to the crankcase with a specific sealant.



CRANKSHAFT

This is forged in high strength alloy steel, induction tempered on the journals and rolled on the grooves. It rests on five main bearings and its end float is adjusted by two half rings housed in the centre main bearings. Eight counterweights accurately balance the rotating masses. A groove runs inside the shaft to lubricate the main and connecting rod journals. At the rear of the crankshaft there is the phonic wheel for detecting the rpm and timing sensor.



MAIN AND ROD BEARING HALVES

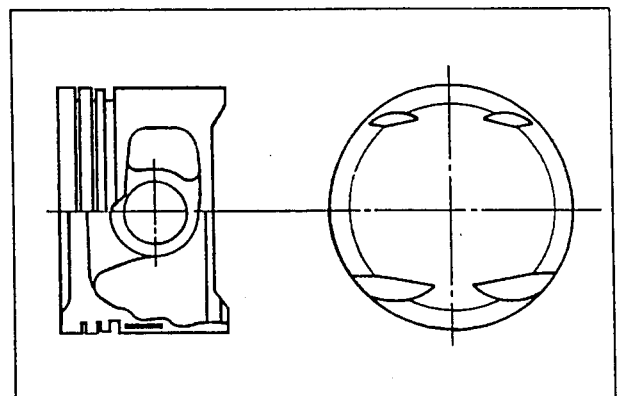
These are of the three-metal, thin shell type and they are divided into three dimensional classes.

FLYWHEEL

This is in cast iron with a hardened ring gear and suitably balanced.

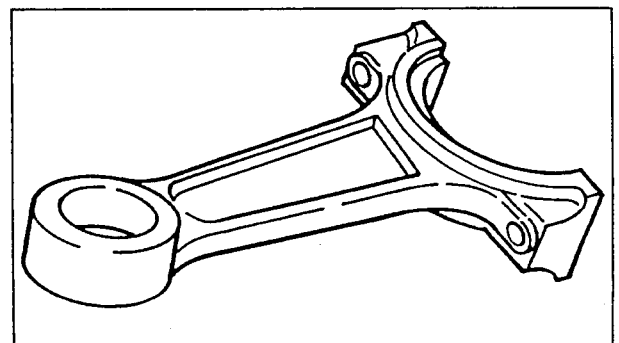
PISTONS AND CONNECTING RODS

The pistons are in aluminium-silicium alloy with self-heating inserts and are divided into three dimensional classes. To ensure correct assembly an arrow is stamped on the piston crown to indicate the direction of rotation of the engine. The piston crown is concave and has four notches to prevent interference with the valve mushrooms.



The connecting rods are in hardened and tempered alloy steel, with a bushing in copper alloy force-fitted for coupling with the piston gudgeon pin.

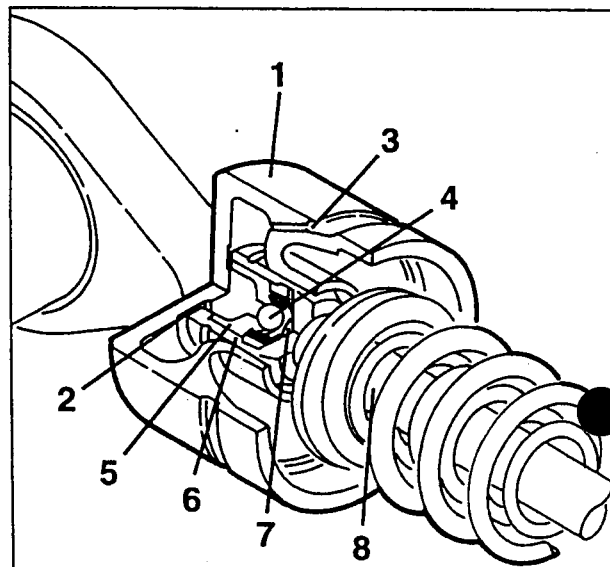
As the gudgeon pins are floating on the piston hubs and on the bushing force-fitted in the connecting rod small end, their side movement is stopped by two expanding circlips housed in the special hollows machined on the actual hubs.



VALVE GEAR TIMING

Direct drive by toothed belts with automatic tensioner and with overhead camshaft in cast iron with induction tempered cams and bearings. The hydraulic tappets, in contact with the cams, control the valves directly. This device automatically eliminates "valve play" when the engine is running thereby dramatically reducing the need for periodical maintenance.

1. Cup
2. Oil passage between chambers
3. Oil inlet groove
4. Check valve
5. Piston
6. Cylinder
7. Pressure chamber
8. Valve stem



The stem of the exhaust valves is chromium plated and has a cavity inside filled 50 + 60% with sodium to improve dispersion of the heat to which they are subjected.

The valve seats are sintered and made from material suitable for the use of unleaded petrol.

TIMING VARIATOR

This is of the simplified type which ensures considerable timing precision, rapid intervention and high mechanical reliability. It is coupled to the intake pulley and fitted with two half bearings which support it. The inner parts are nitrided and an O-Ring keeps the oil inside when the engine is not running. In order to reduce the size of engine, the actuation valve seat has been machined on the intake manifold with suitable grooves which also involve the cylinder head, to regulate the flow of oil to the variator.

- The purpose of this device is to change the intake valve timing according to the engine load and speed required; this parameter is received and processed by the control unit in the form of an electric signal sent by the air flow meter and rpm sensor and transmitted as a command to the electromagnet via a relay.

- When the closed phase is required (idling and full power area), the electromagnet (1) is de-energized, thus the valve distributor (2) pushed by the counter spring (3), stays up preventing the passage of the oil leading from groove (A) from reaching the variator.

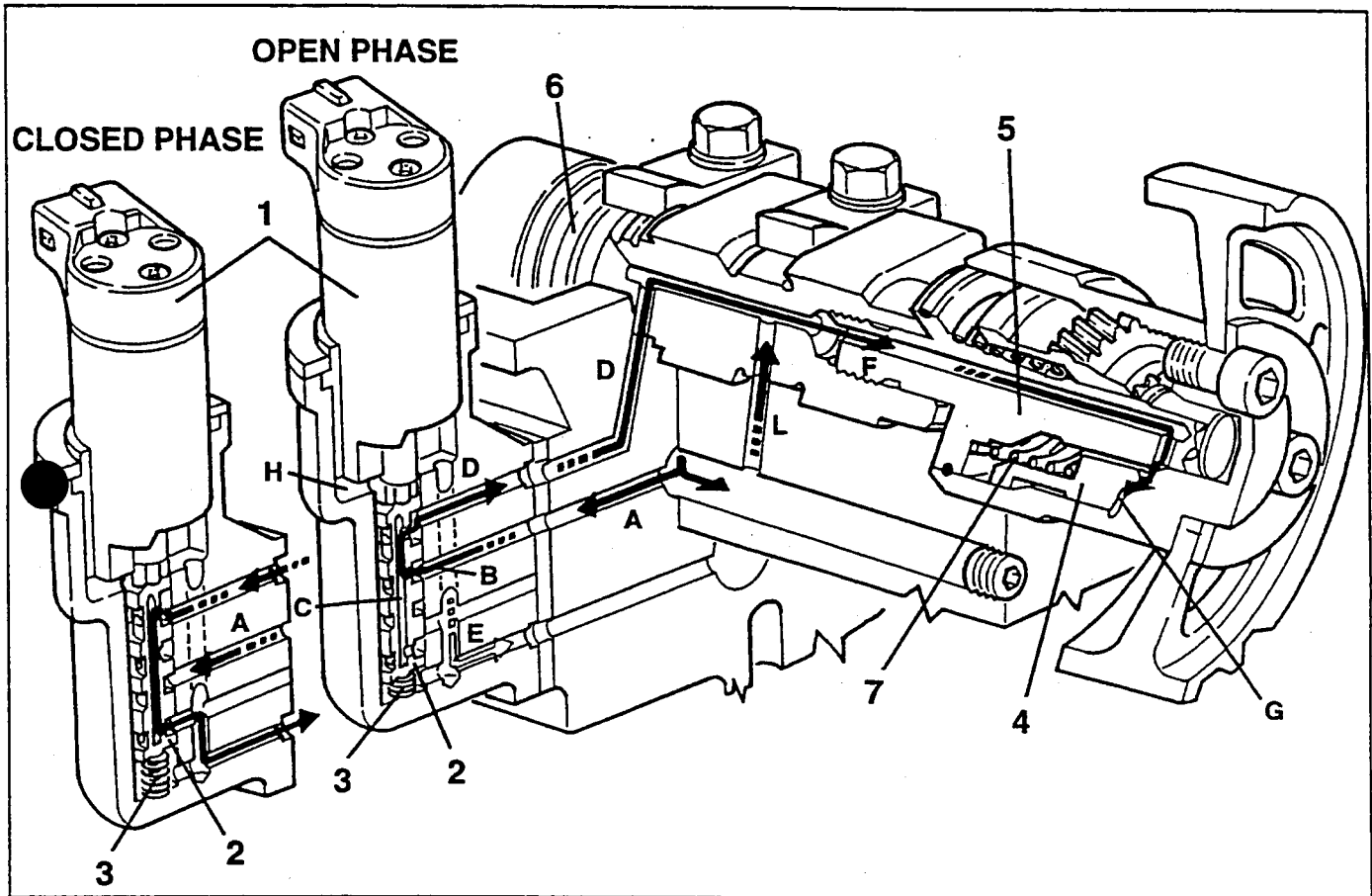
In this case the timing of the intake valves remains unchanged (closed).

- If the open phase is required (average speeds at high torque), the electromagnet (1) is energized, thus pushing the valve distributor (2) downwards. In this position the oil, leading from groove (A), enters chamber (B) of the piston, from where it passes through a special hole into groove (C) machined inside the latter.

The oil can only leave this groove through the upper hole (in communication with the oil delivery duct (D) to the variator) as the lower hole no longer leads to the exhaust duct (E) because the valve distributor (2) is lowered. The oil passes through duct (D) and (F) and reaches the chamber (G) moving piston (4) axially towards the engine. The outside of piston (4) is fitted with helical teeth and as a result of the above-mentioned axial movement it is forced to move clockwise (as seen from the timing side). The rotation is transmitted through a straight-toothed grooved profile to the pinion (5) which is screwed onto the threaded lug of the camshaft (6) and transmits the rotation to the shaft. This way the timing of the intake valves is changed by 25°.

When the electromagnet is de-energized, the valve distributor (2) returns to its initial position, shutting off the flow of pressurised oil to the piston (4), but allowing the oil to return to the exhaust due to the thrust of the counter spring (7).

- Duct (L) enables the camshaft journal to be lubricated under the various operating conditions.
- The oil which leaks into the electromagnet chamber (H) is discharged through the drainage hole (E).



Vibration damper device with counter-rotating shafts

In combustion engines, in addition to the forces acting on the piston crowns caused by the expanding gases, there is the action of the following:

- centrifugal forces of inertia, caused by the rotating masses;
- alternated forces of inertia of the 1st and 2nd order generated by the masses with reciprocating motion.

The purpose of the balancing of the engine is to eliminate the vibrations that these imbalances caused during operation.

The imbalances produced by the centrifugal forces and by the alternated forces of inertia of the 1st order are eliminated by suitably counter-weighting the crankshaft.

The imbalance caused by the alternated forces of inertia of the 2nd order is generally not eliminated in 4-cylinder in line engines, in which the task of partially absorbing it is left to the engine bearings.

In this engine though, a device has been adopted which is capable of nullifying the vibrations caused by the above-mentioned forces: it comprises 2 shafts, located in the crankcase, with eccentric masses, which counter rotate with respect to one another.

The counter-rotating shafts are pulled by a special double-toothed belt, a set of gears and an automatic tensioner which make it possible to obtain twice the speed of the crankshaft and perfect synchronism with it.

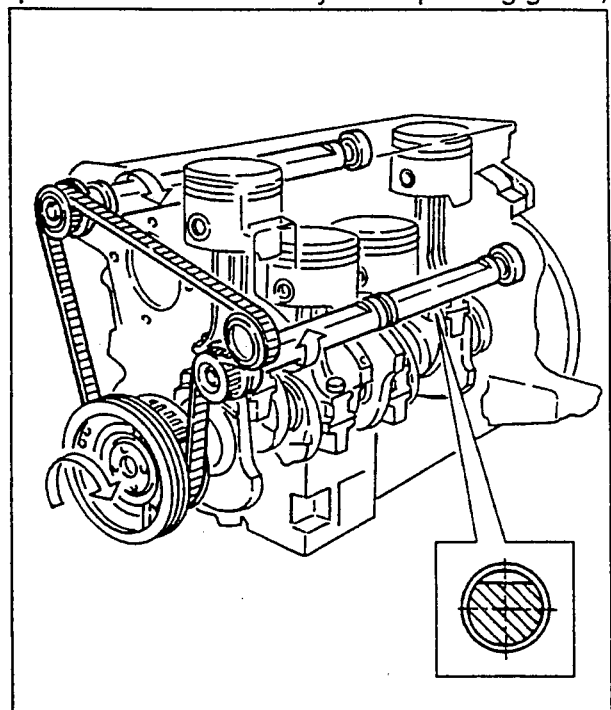
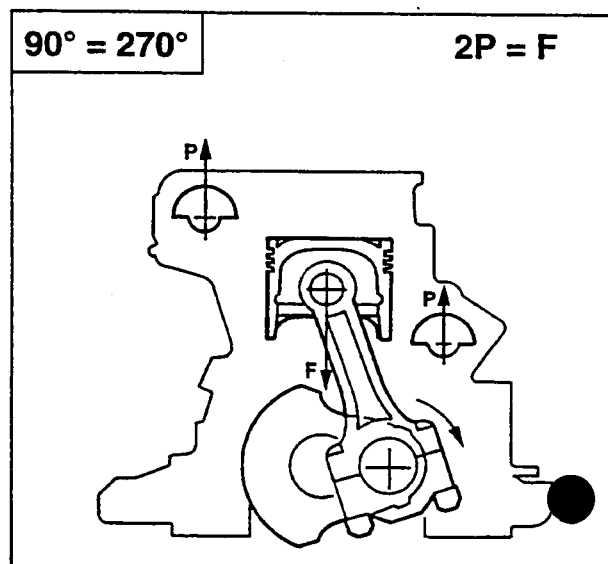
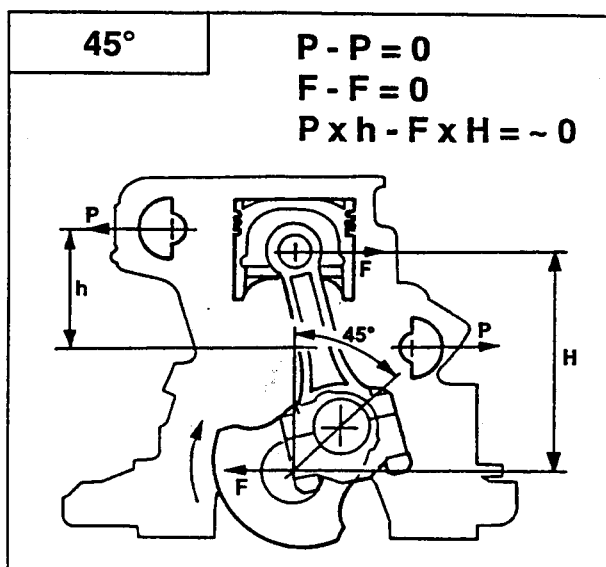
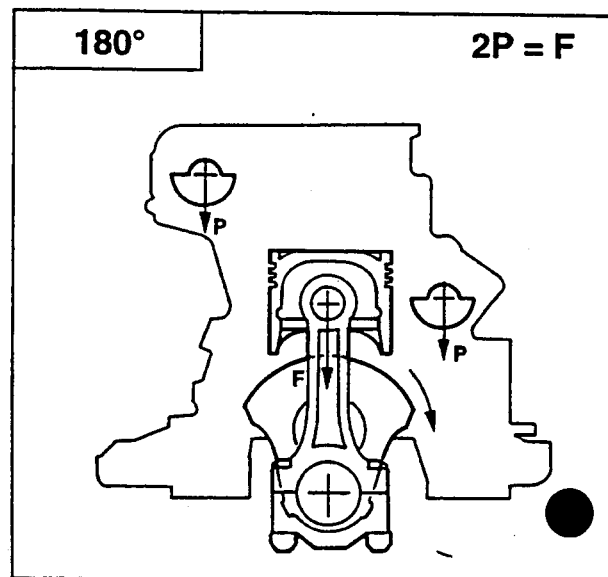
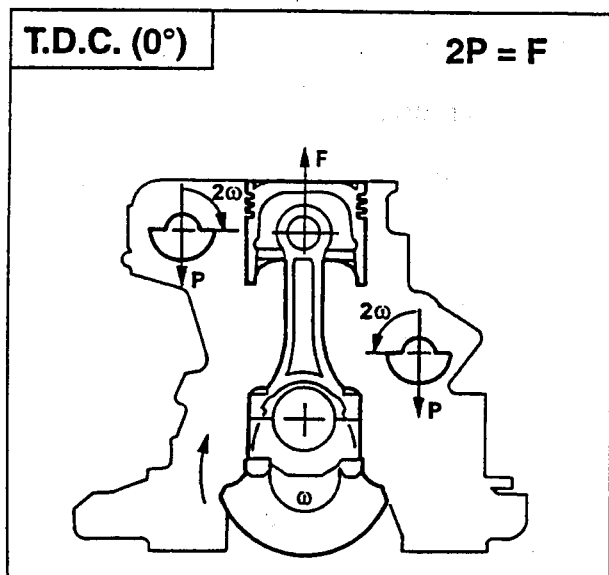


Illustration of the alternated forces of inertia of the 2nd order and of the balancing masses in the main operating positions.



LUBRICATION

The rotary lobe pump (3) fitted on the front of the crankcase is activated directly by the crankcase through keying. The oil withdrawn from the sump by a suction device (1) is filtered by the gauze filter on the suction device and then sent under pressure by the pump through a duct to the full-flow cartridge oil filter (6) fitted with a by-pass safety valve, which ensures that the oil passes even if the cartridge is clogged.

A water-oil heat exchanger (5) is installed on the filter support to keep the oil temperature within the optimum limits.

The maximum lubricating pressure is regulated by a special limiting valve (4) fitted on the pump.

After being filtered, the oil passes through a duct machined on the front engine cover and reaches the main longitudinal delivery duct in the crankcase.

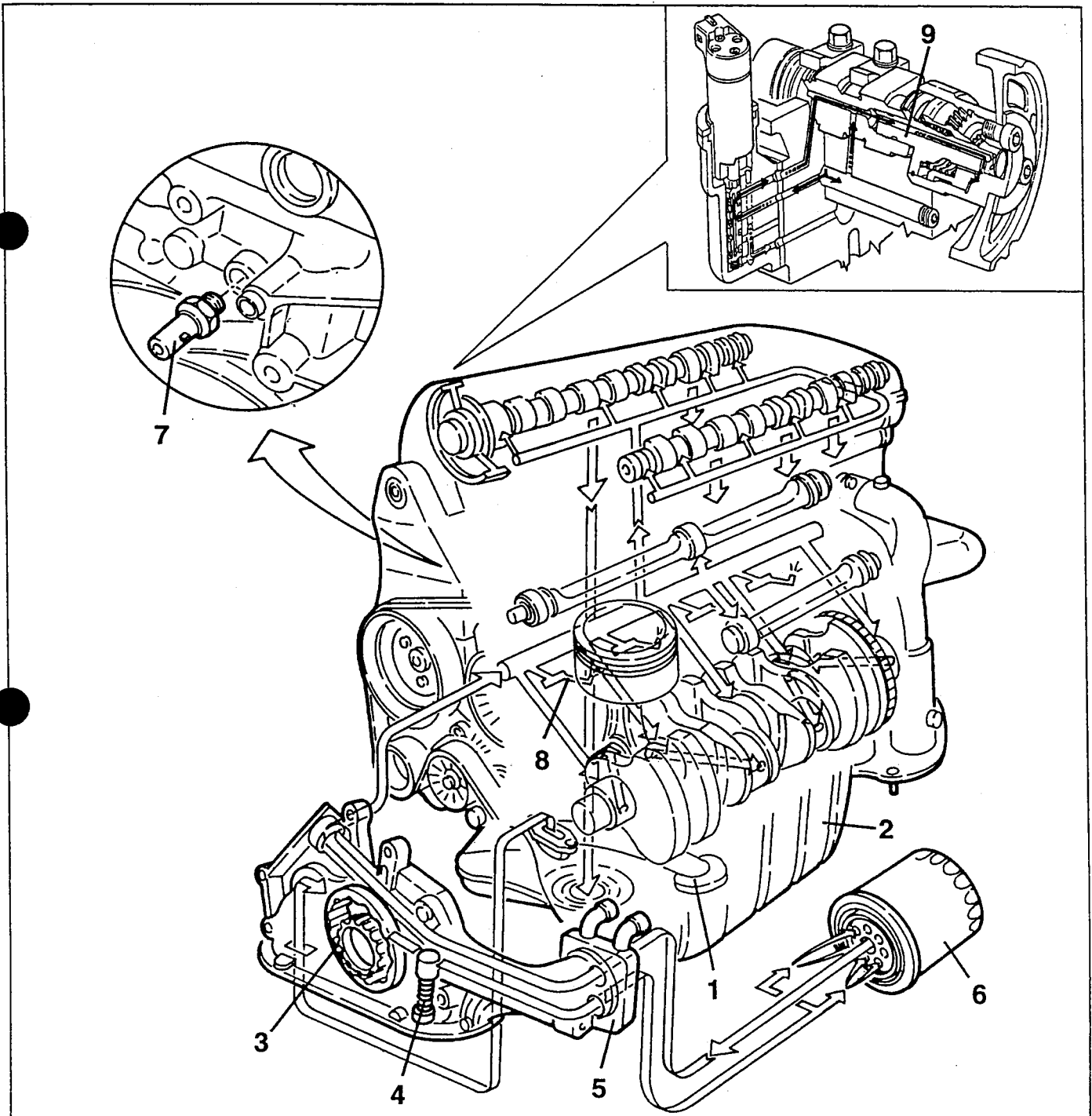
From here, it is then sent along five ducts to the grooves of the main bearings and from these to those of the connecting rod journals via special ducts machined in the crankshaft.

Another two vertical ducts machined in the crankcase lubricate the centre bearing of the counter-rotating shafts. To improve the cooling of the piston skirts the crankcase is fitted with spray jets (8) with built-in ball valve which opens at a pressure of 2.25 ÷ 2.75 bar.

From the main longitudinal duct in the crankcase, a vertical duct branches off which lubricates the camshaft bearings. On the intake side of the camshaft lubricating duct there are two special channels through which the oil for operating the timing variator passes. The recovery circuit is formed of a few ducts located in the cylinder head which collect the oil leading from the outlets and then drain it from the head from which it falls back into the sump.

The lubricating system is fitted with an oil vapour recirculation system which recovers the vapours leading from the sump and from the cylinder head.

The system is fitted with a minimum engine oil pressure sensor (7) which indicates insufficient lubricating pressure by turning on the warning light on the instrument cluster.



- 1. Suction device with gauze filter
- 2. Oil sump
- 3. Oil pump
- 4. Pressure limiting valve
- 5. Heat exchanger

- 6. Filter with safety by-pass valve
- 7. Engine oil minimum pressure warning light sensor
- 8. Spray jets
- 9. Timing variator

INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhauling of the engine on the bench, after having removed the power unit from the car. The instructions are subdivided as follows:

- Engine dis-assembly:

removal of the engine accessories and components and dis-assembly into the main units forming part of it.

- Dis-assembly and overhauling of the cylinder head:

complete overhauling of all the components of the head.

- Crankcase overhauling:

complete overhauling of the crank mechanism.

- Instructions for re-assembly:

these include the specific re-assembly operations which differ substantially from the dis-assembly instructions.

- Checking and inspecting electric components of the lubrication circuit.

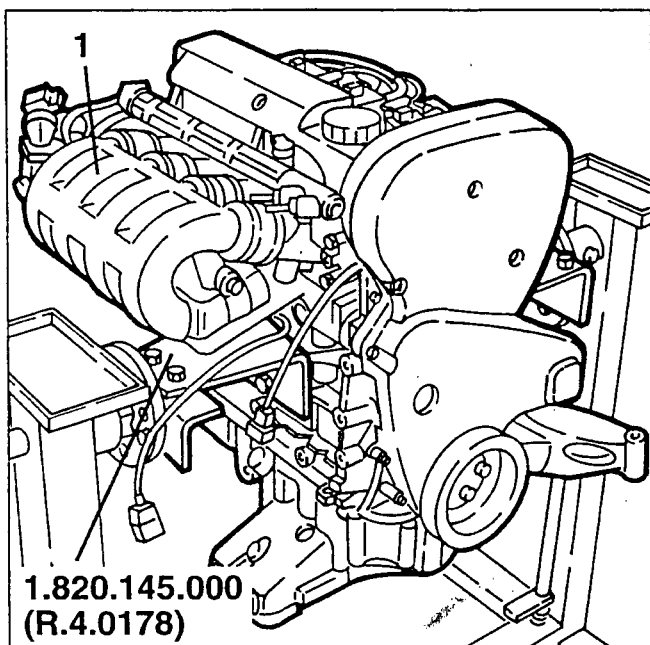
All the dis-assembly procedures described hereafter are also valid for re-assembly reversing the sequence described, unless otherwise specified.

The following procedures refer to the complete overhauling of the whole engine; it is however possible to use only certain parts of them separately, when necessary for dealing with specific components.

ENGINE DIS-ASSEMBLY

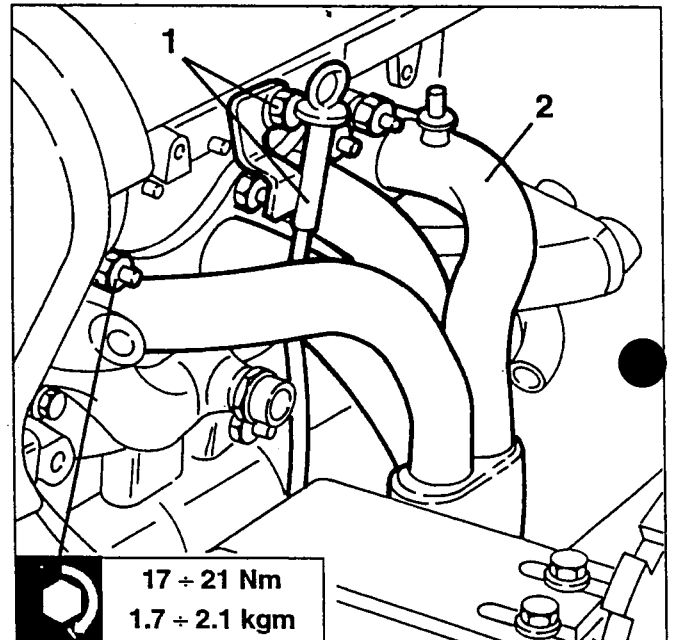
PRELIMINARY OPERATIONS

1. Set the engine on a special overhauling stand using supports no. 1.820.145.000 (R.4.0178).



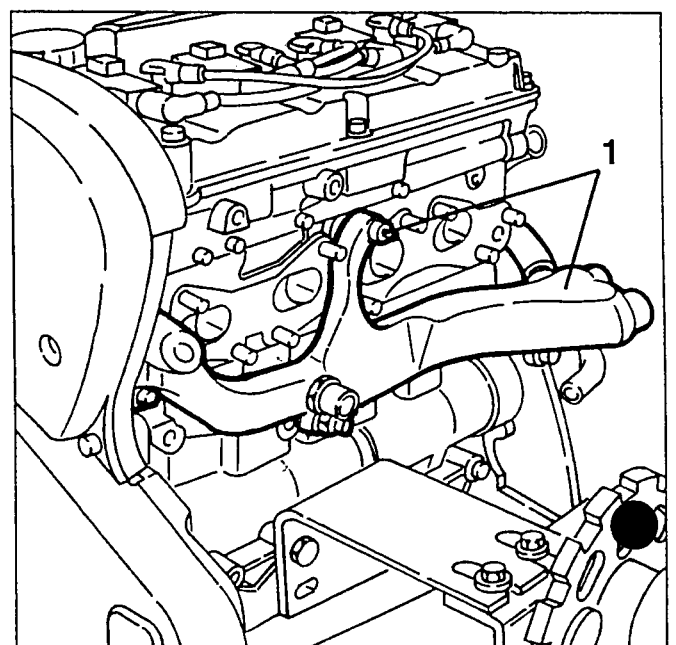
REMOVING THE EXHAUST MANIFOLD

1. Slacken the fastening screw and remove the complete engine oil dipstick.
2. Slacken the fastening nuts and remove the exhaust manifold.



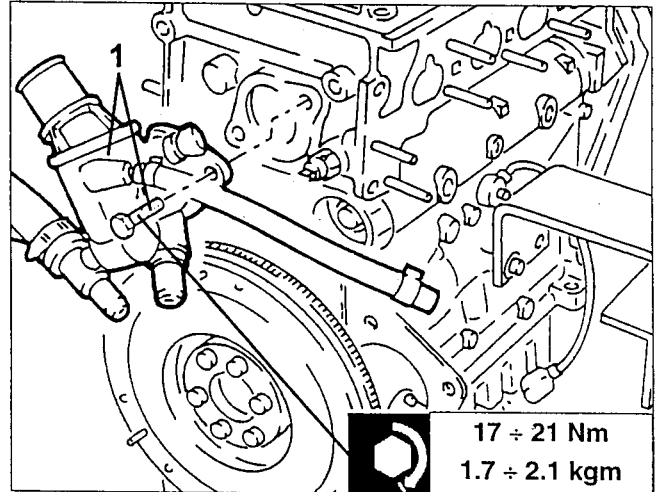
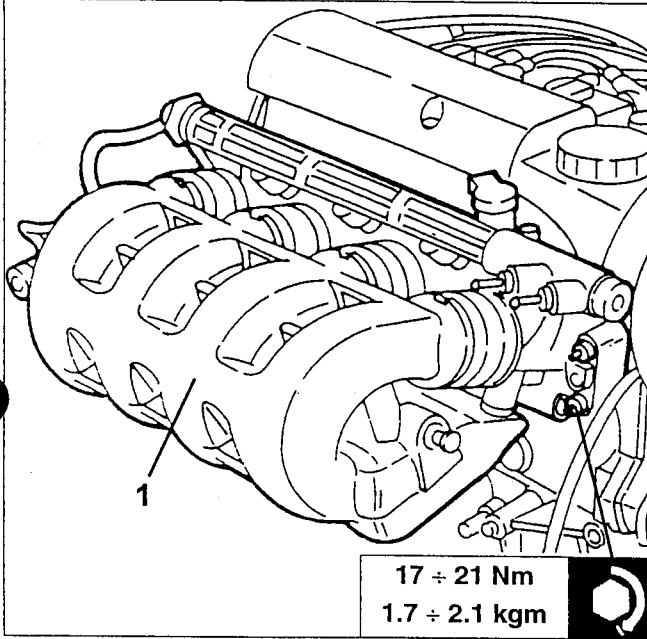
REMOVING THE ENGINE COOLANT FLUID MANIFOLD

1. Remove the coolant return manifold, after disconnecting the pipe connecting to the thermostatic and slackening the associated fastenings.
- Remove the exhaust manifold seal.



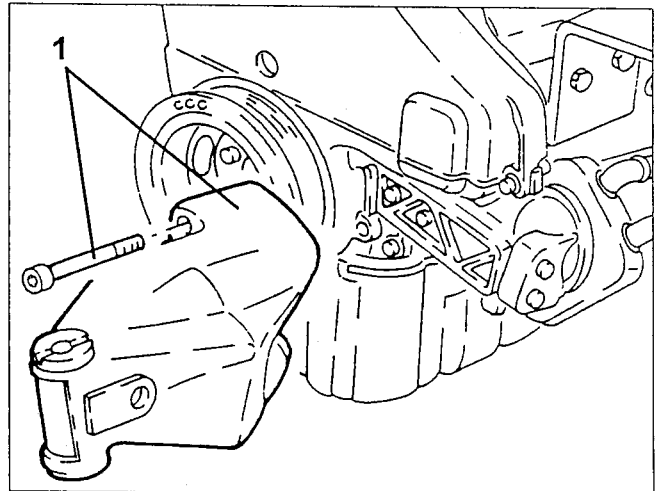
INTAKE MANIFOLD REMOVAL (pre-change versions)

1. Loosen the fastening nuts and remove the intake manifold.
- Remove the respective seal.



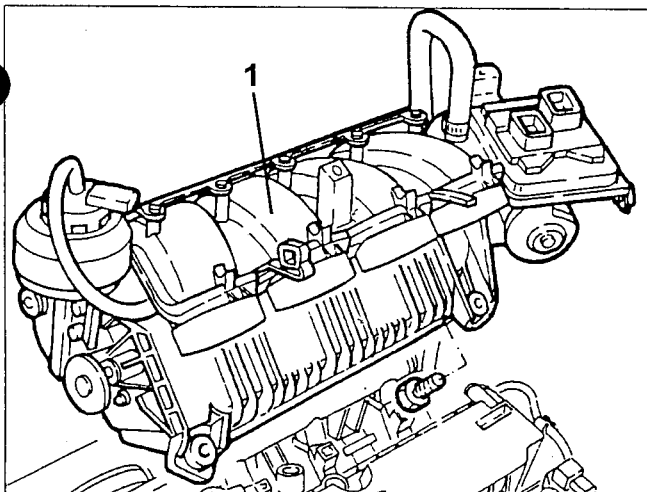
FRONT ENGINE REMOVAL JOURNAL

1. Loosen the three fastening screws and remove the front engine journal.



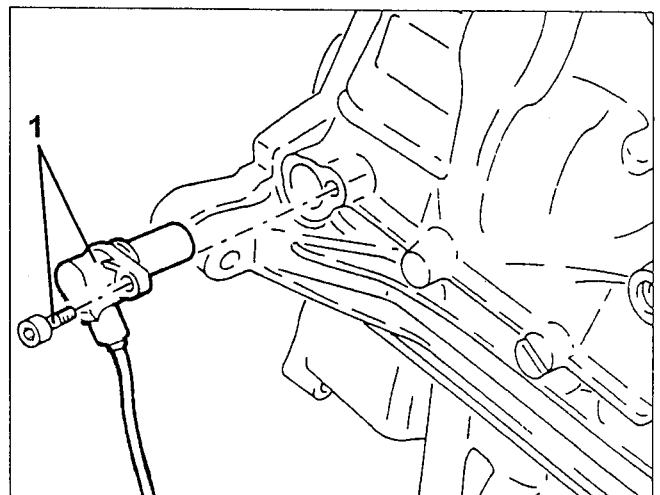
INTAKE MANIFOLD REMOVAL (post-change versions)

1. Loosen the fastening nuts and remove the intake manifold.
- Remove the respective seal.



RPM AND STROKE SENSOR REMOVAL

1. Loosen the fastening screw and remove the rpm and stroke sensor.

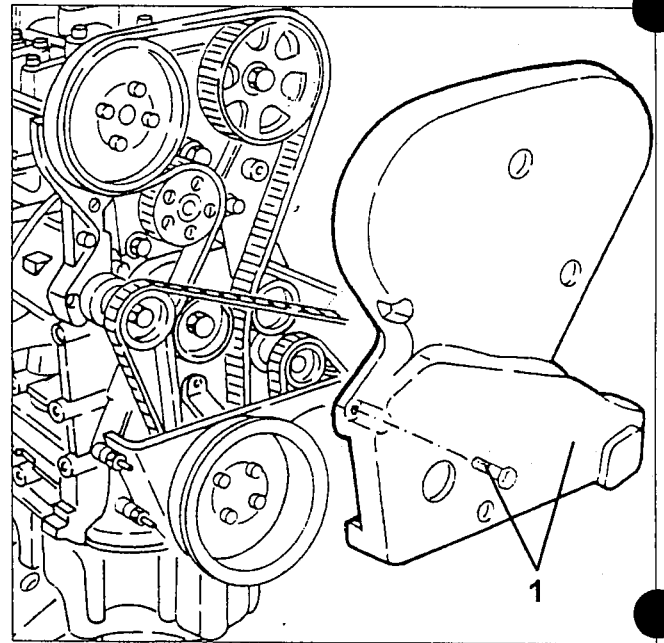
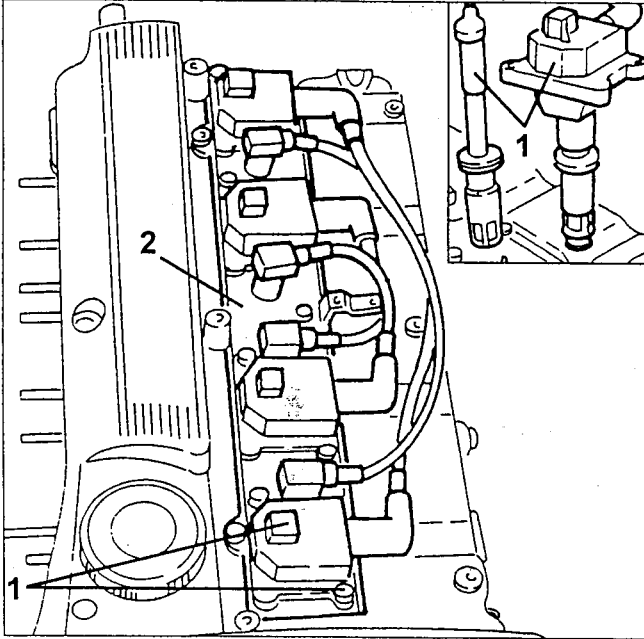


THERMOSTAT UNIT REMOVAL

1. Remove the two fastening screws and remove the thermostat unit with coolant temperature sensor (NTC) and pipes
- Remove the respective seal.

IGNITION COIL REMOVAL

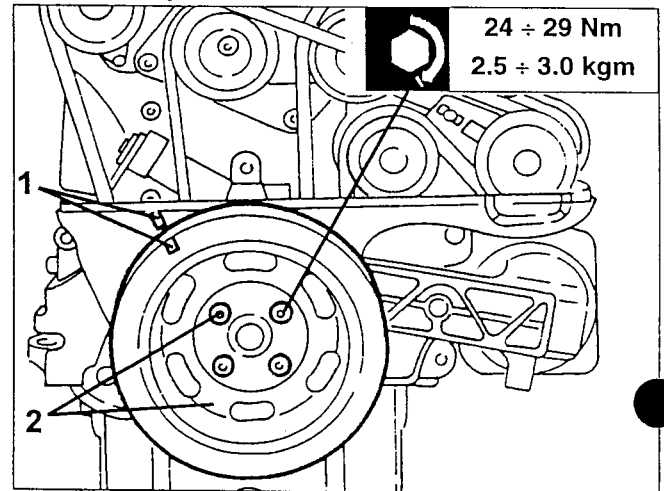
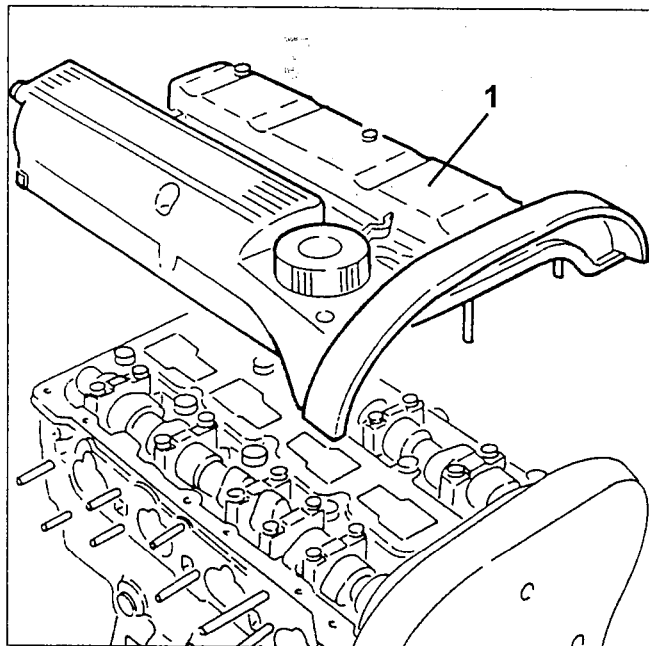
1. Loosen the fastening screws and remove the ignition coils and spark plug wires.
 2. Loosen the fastening screws and remove the ignition coil bracket.
- Remove the spark plugs.



1. Turn the crankshaft until the notch on the engine pulley corresponds to that on the lower belt cover (cylinder 1 at DTC, firing stroke).
2. Loosen the fastening screws and remove the engine pulley.

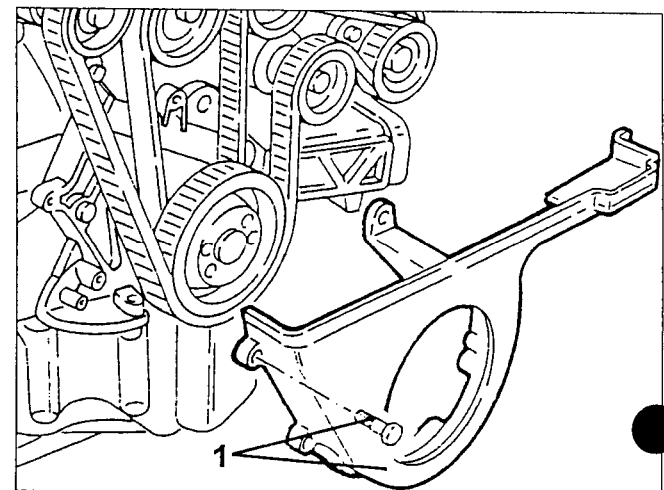
COUNTER-ROTATING SHAFT BELT AND TIMING BELT REMOVAL

1. Loosen the fastening screws and remove the hydraulic tappet cover and seal.

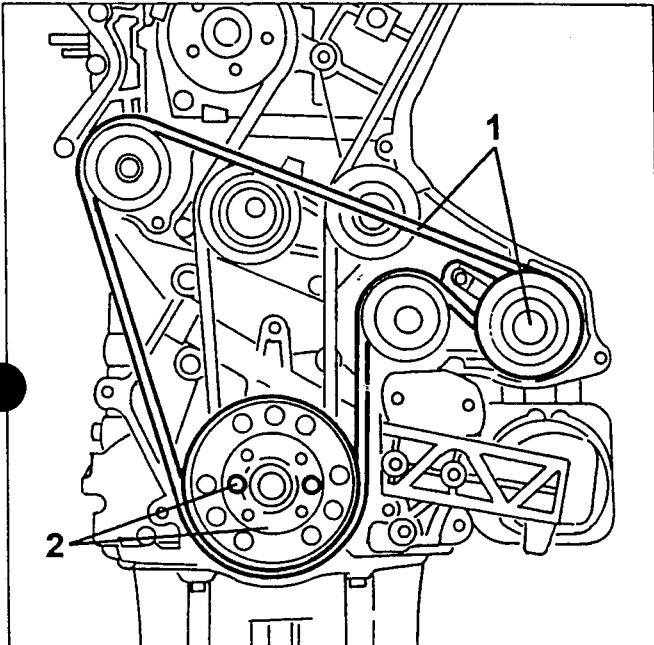


1. Loosen the three fastening screws and remove the lower belt cover.

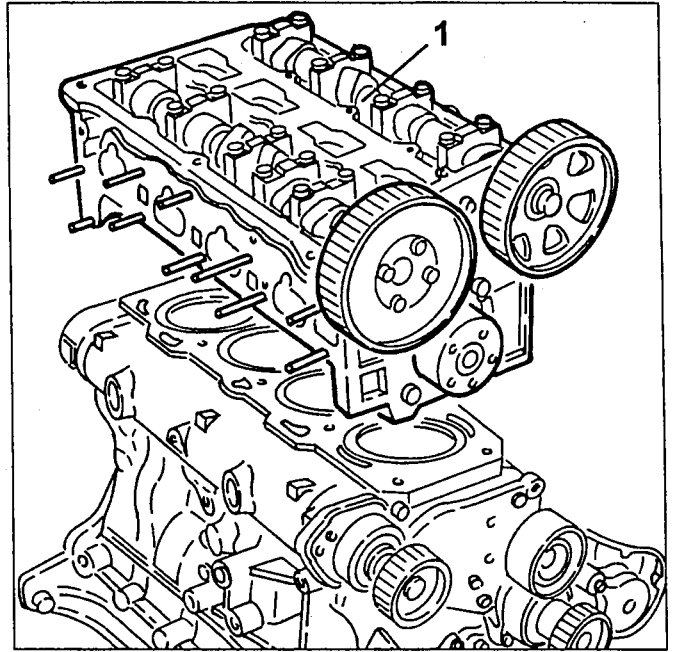
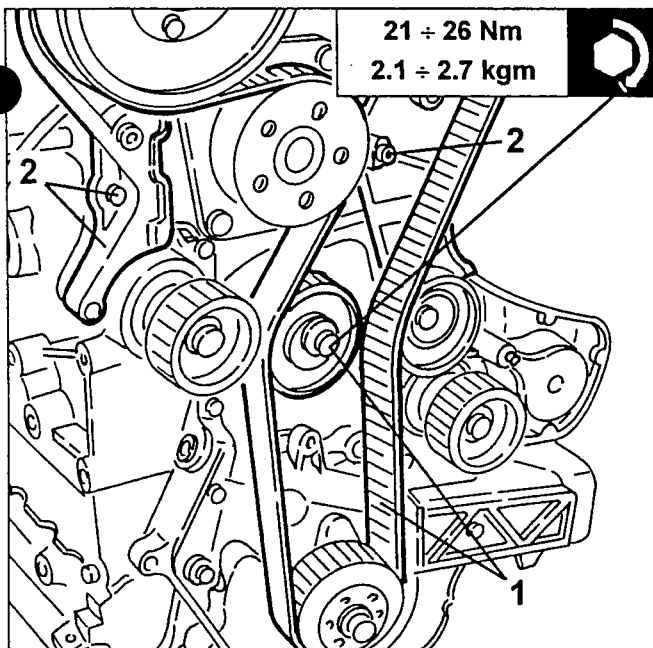
1. Loosen the fastening screws and remove the upper timing belt and counter-rotating shaft belt cover.



1. Slacken the counter-rotating shaft belt tensioner then prise and remove the belt.
- Completely unscrew the fastening nut and remove the counter-rotating shaft belt tensioner.
2. Slacken the two fastening screws and remove the counter-rotating shaft belt drive pulley.

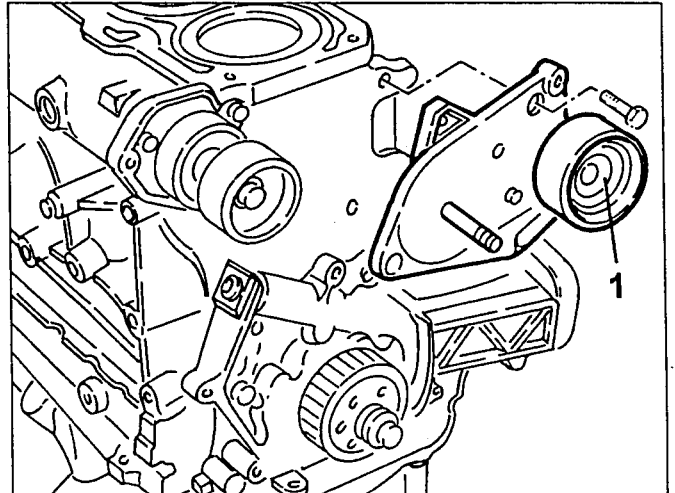


1. Slacken the camshaft belt tensioner, then prise and remove the belt.
- Completely unscrew the fastening nut and remove the camshaft belt tensioner.
2. Slacken the fastening screws and remove the side guards of the camshaft belt and counter-rotating shaft belt.

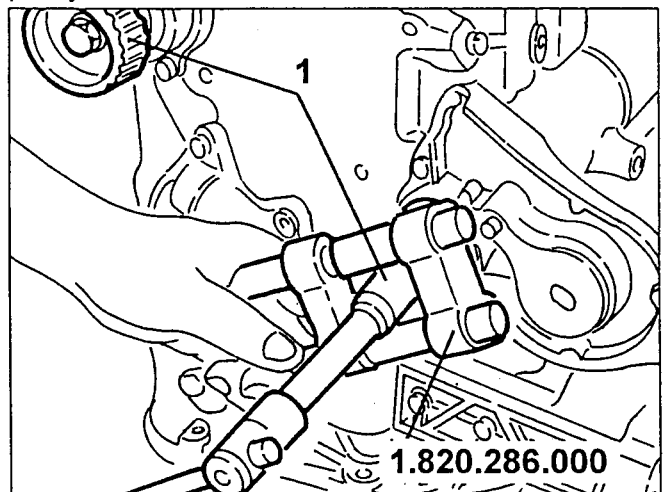


REMOVING THE COUNTER-ROTATING SHAFTS

1. Slacken the three fastening screws and remove the bracket complete with the camshaft tightening pulley.



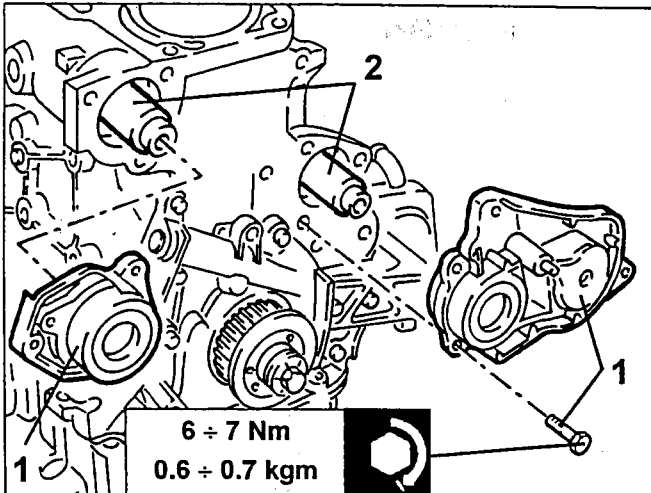
1. Using tool no. 1.820.286.000, slacken the fastening screws and remove the counter-rotating shaft drive pulleys.



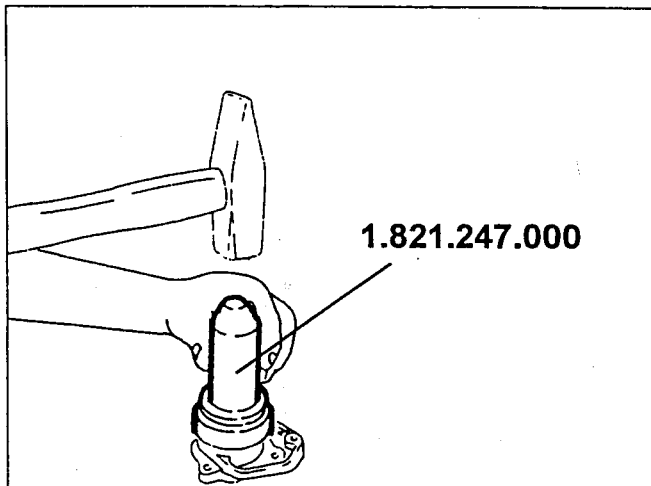
REMOVING THE CYLINDER HEAD

1. Slacken the fastening screws and remove the cylinder head.
- Remove the seal.

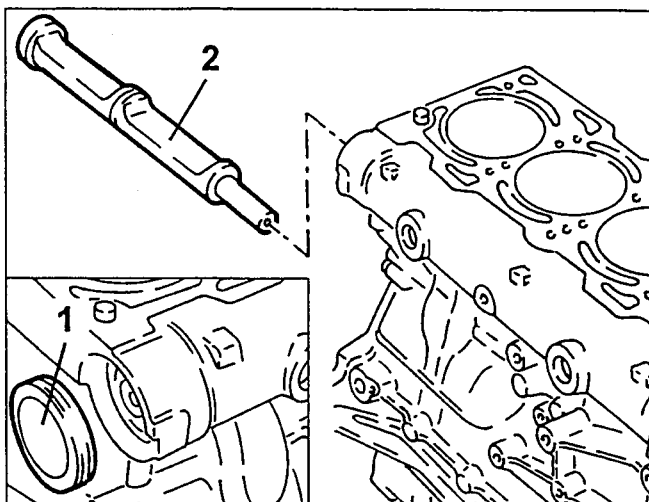
1. Slacken the fastening screws and remove the counter-rotating shaft front covers complete with oil seal rings.
2. Withdraw the two spacers from the counter-rotating shafts.



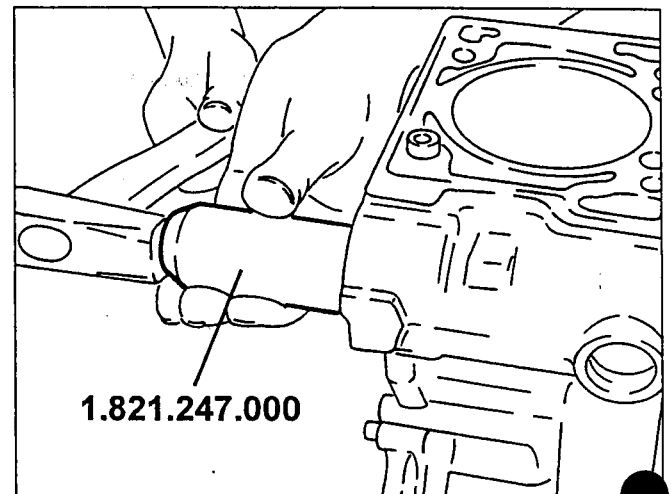
When refitting the oil seal rings, use tool no. 1.821.247.000.



1. Prise and remove the counter-rotating shaft rear plugs.
2. Using a plastic mallet remove the counter-rotating shafts from the rear of the engine.

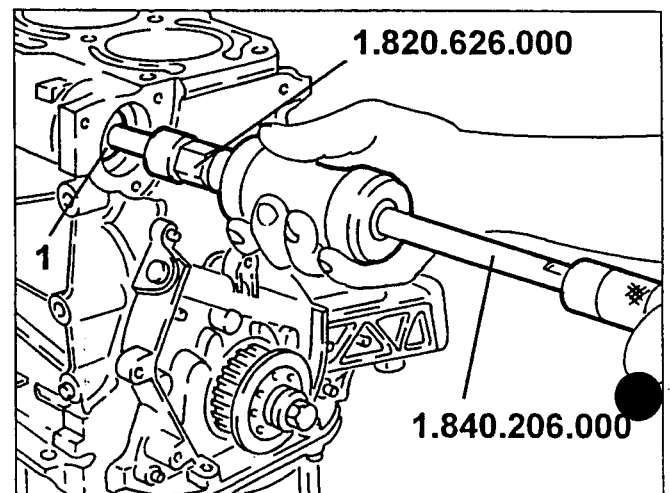


When refitting, insert the counter-rotating shafts complete with rear bearings using tool no. 1.821.247.000.

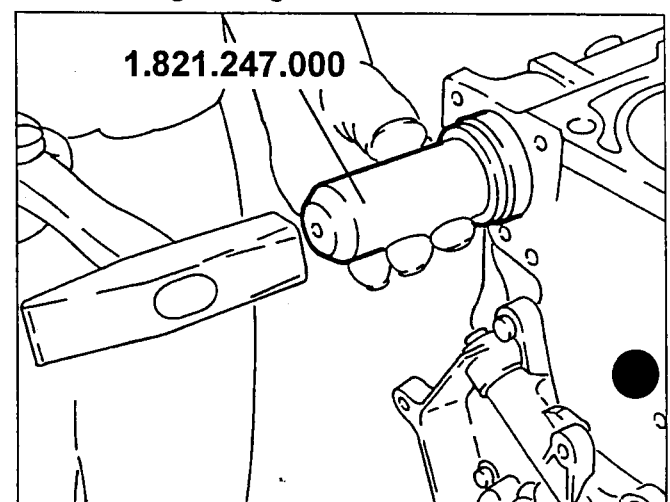


- Using a suitable puller tool remove the rear bearings from the counter-rotating shafts.

1. Using tools no. 1.820.626.000 and no. 1.840.206.000 remove the two front bearings from the counter-rotating shafts.

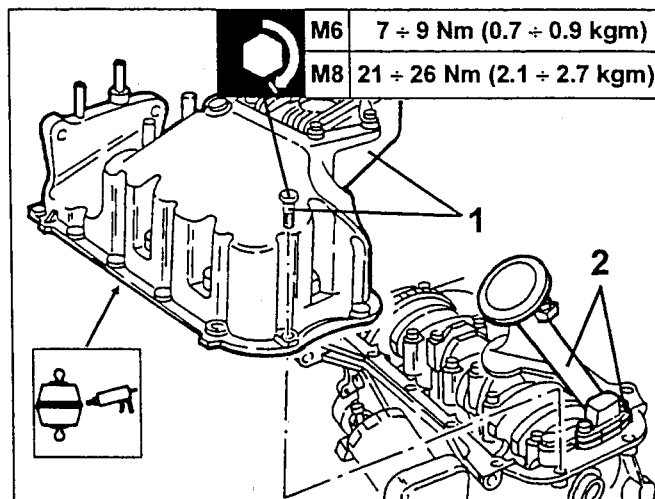
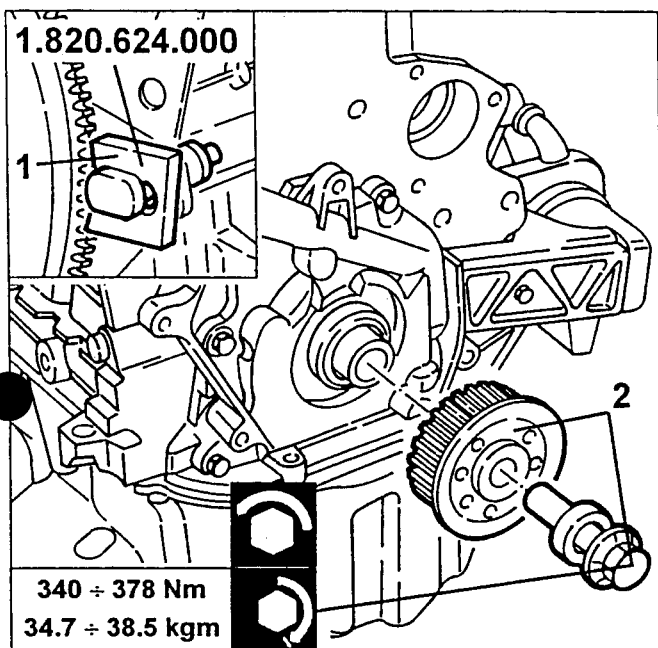


When refitting insert the counter-rotating shaft front bearings using tool no. 1.821.247.000.



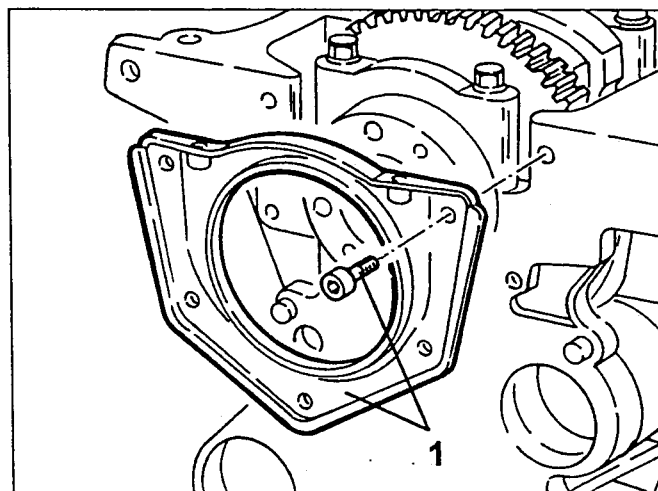
REMOVING THE CAMSHAFT DRIVE BELT PULLEY

1. Install flywheel stopper tool no. 1.820.624.000.
2. Slacken the left-handed screw and remove the camshaft drive belt pulley.



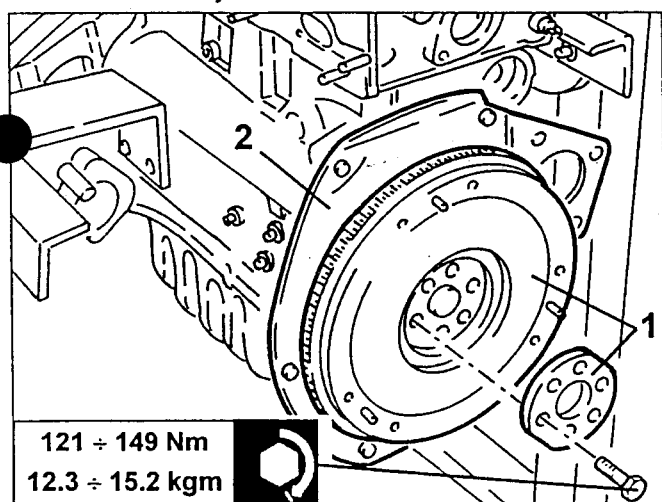
REMOVING THE CRANKCASE REAR COVER

1. Slacken the fastening screws and remove the crankcase rear cover with incorporated oil seal ring.



REMOVING THE FLYWHEEL

1. Slacken the fastening screws and remove the flywheel.
2. Retrieve the flywheel cover.



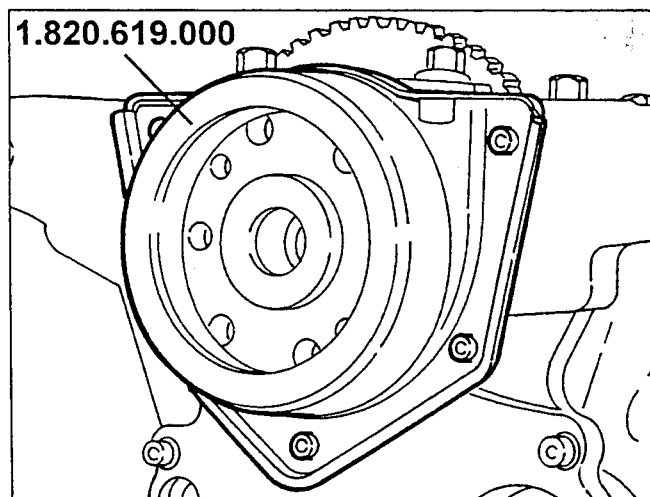
- Remove the flywheel stopper tool installed previously.

REMOVING THE OIL SUMP

1. Turn the engine on the overhauling stand, then slacken the fastening screws and remove the oil sump.
2. Slacken the two fastening screws and remove the oil suction device with its seal.

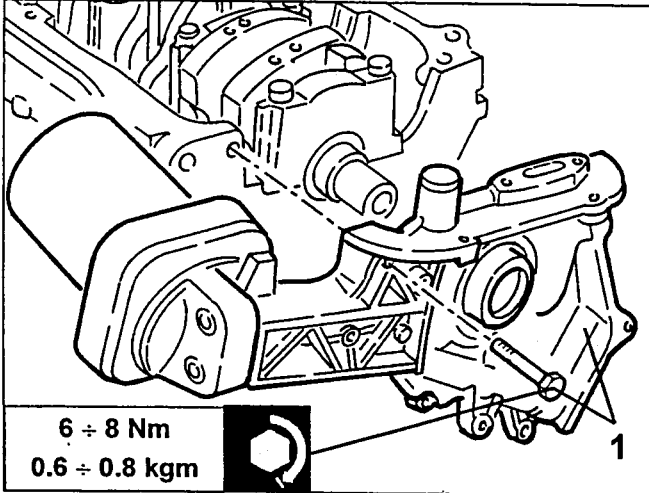
Refit the rear cover as follows:

- Fit tool no. 1.820.619.000 on the oil seal of the rear crankcase cover;
- fit the tool - rear cover together and tighten the screws fastening to the crankcase; the tool should be removed only after also tightening the screws fastening the rear cover to the oil sump.



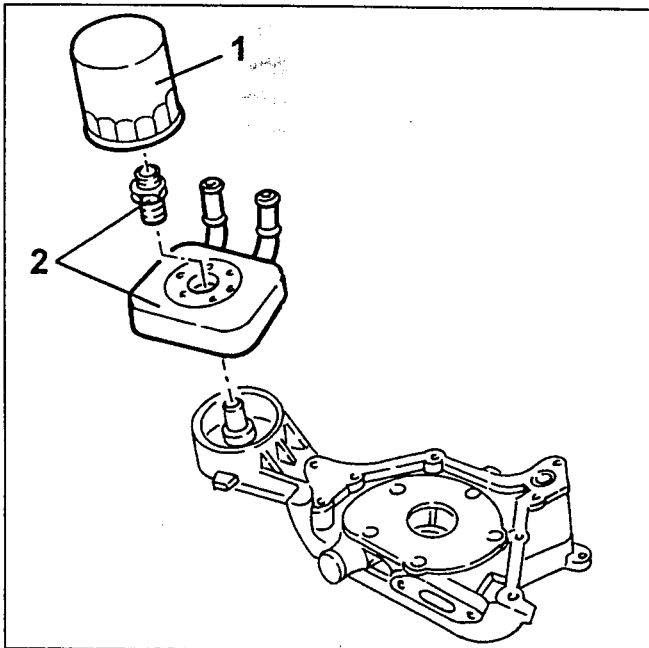
REMOVING THE ENGINE OIL PUMP ASSEMBLY

1. Slacken the fastening screws and remove the engine front cover with incorporated oil pump, filter and heat exchanger.

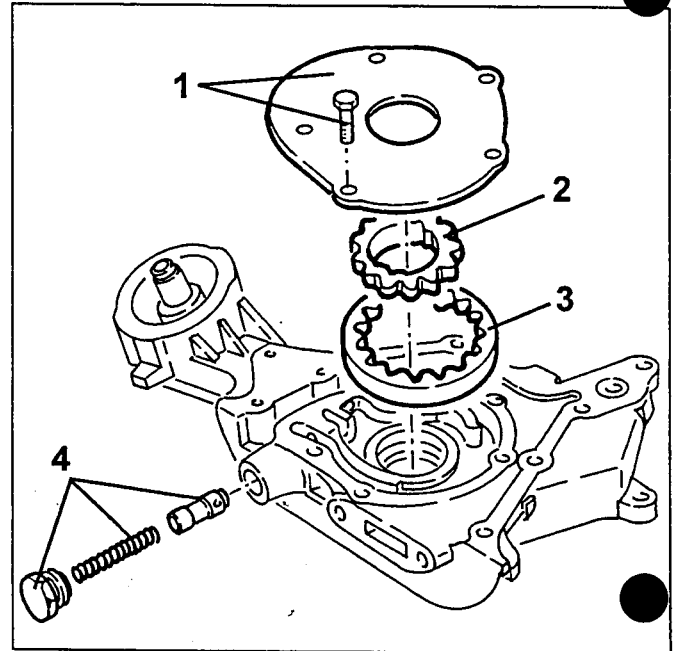


- Prise and remove the crankshaft front oil seal.
When refitting the crankshaft front oil seal, after fitting it on the oil pump assembly and assembling this on the crankcase, use tool no. 1.821.247.000.

1. On the bench, slacken and remove the oil filter.
2. Remove the fastening pin and remove the engine oil-coolant fluid heat exchanger complete with O-Ring.



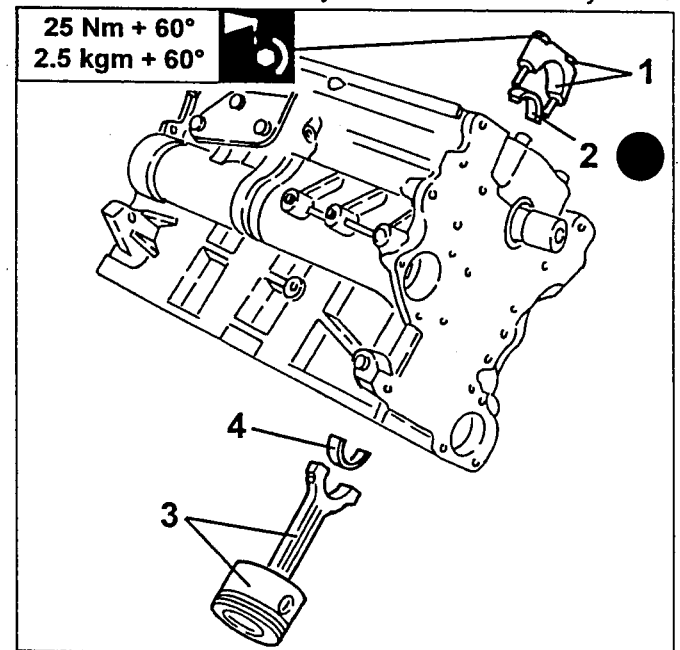
1. Slacken the fastening screws and remove the engine oil pump cover.
2. Remove the driving gear.
3. Remove the driven gear.
4. Slacken the fastening pin and remove the spring and the engine oil pump overpressure sliding valve.



REMOVING PISTONS AND CONNECTING RODS

- Turn the crankshaft so that the pistons of the 1st and 4th cylinder reach the T.D.C.

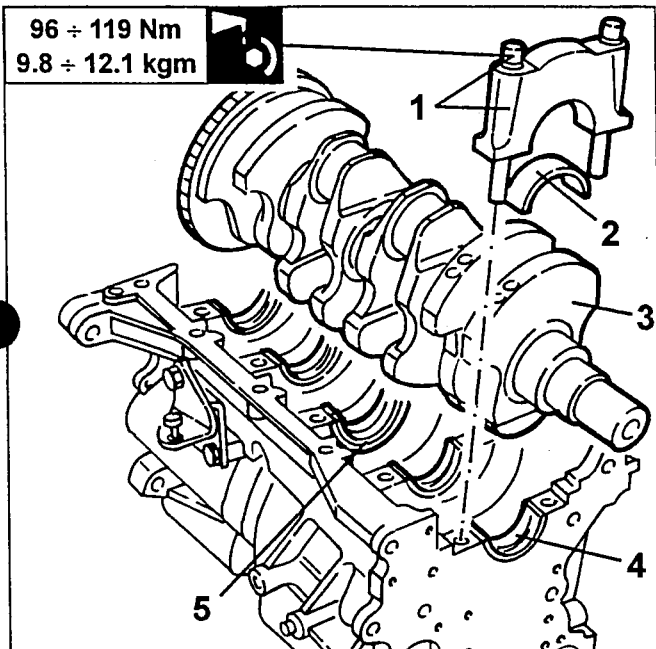
1. Slacken the fastening screws and remove the connecting rod caps of the 1st and 4th cylinder.
 2. Remove the corresponding connecting rod half bearings.
 3. Withdraw the pistons and connecting rods of the 1st and 4th cylinder.
 4. Remove the corresponding connecting rod half bearings.
- Proceed in the same way for the 2nd and 3rd cylinder.



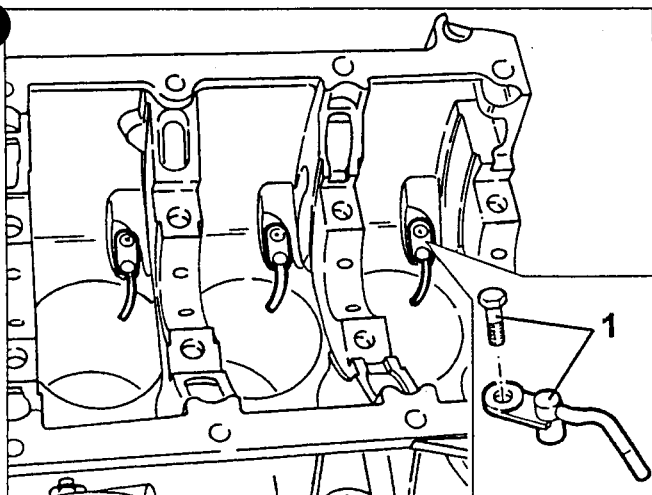
- Using a suitable tool, remove the seal rings and scraper ring from the piston.
WARNING: Proceed with care to avoid accidentally breaking any re-usable rings.
 - Remove the two gudgeon pin circlips.
 - Remove the gudgeon pin and separate the piston from the connecting rod.

REMOVING THE CRANKSHAFT

1. Slacken the fastening screws and remove the main bearing caps.
2. Remove the corresponding main half bearings.
3. Remove the crankshaft.
4. Remove the main half bearings from the supports.
5. Remove the two half thrust rings.



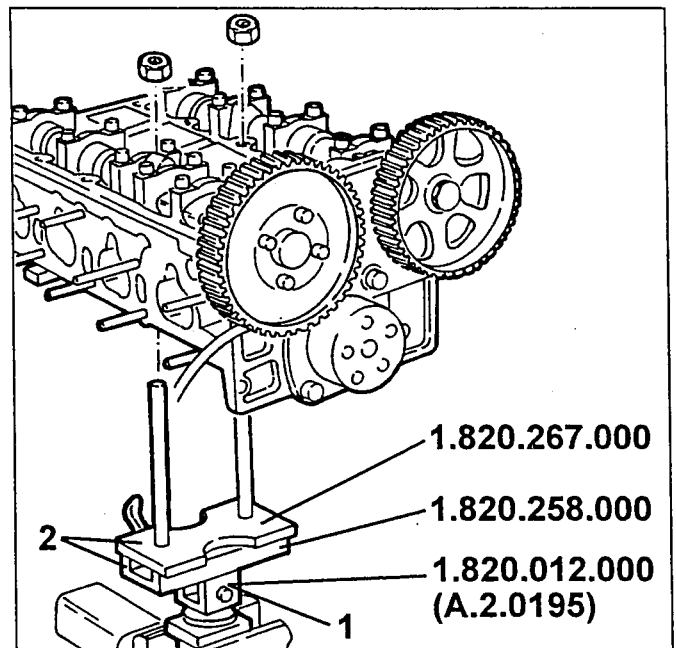
1. If necessary, slacken the fastening screw and remove the oil spray jets for lubricating and cooling the pistons from the crankcase.



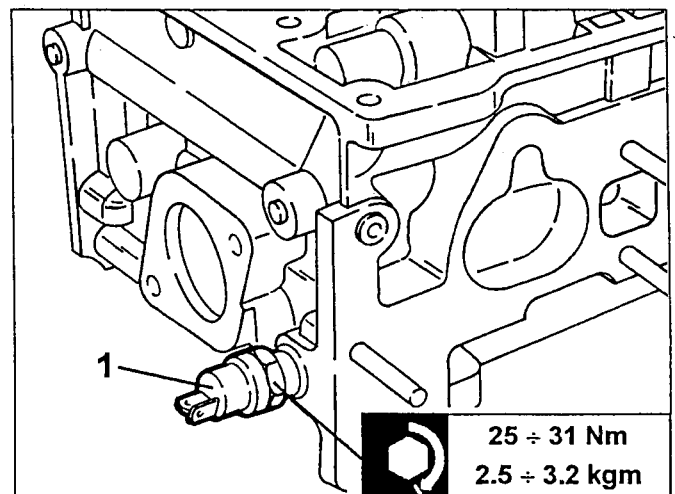
CYLINDER HEAD DISASSEMBLY

PRELIMINARY OPERATIONS

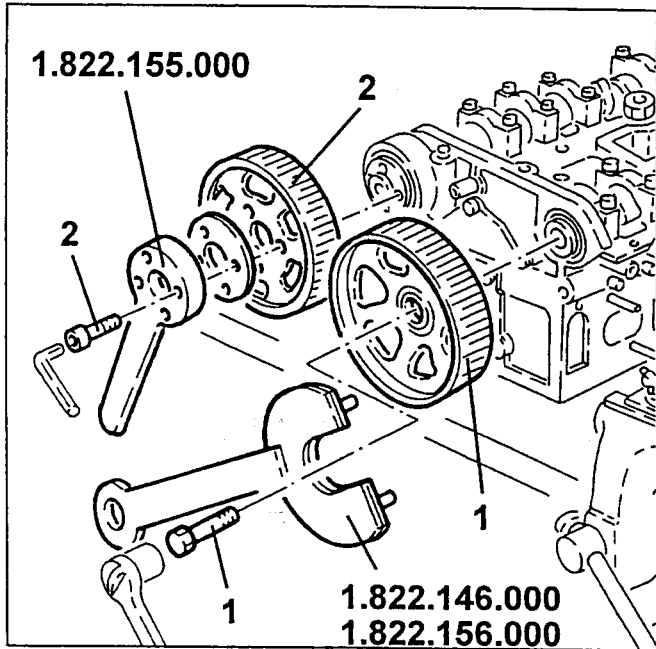
1. Fasten swivel support no. 1.820.012.000 (A.2.0195) in a vice.
2. Fasten tools no. 1.820.258.000 and no. 1.820.267.000 on the swivel support, then fasten the cylinder head on them.



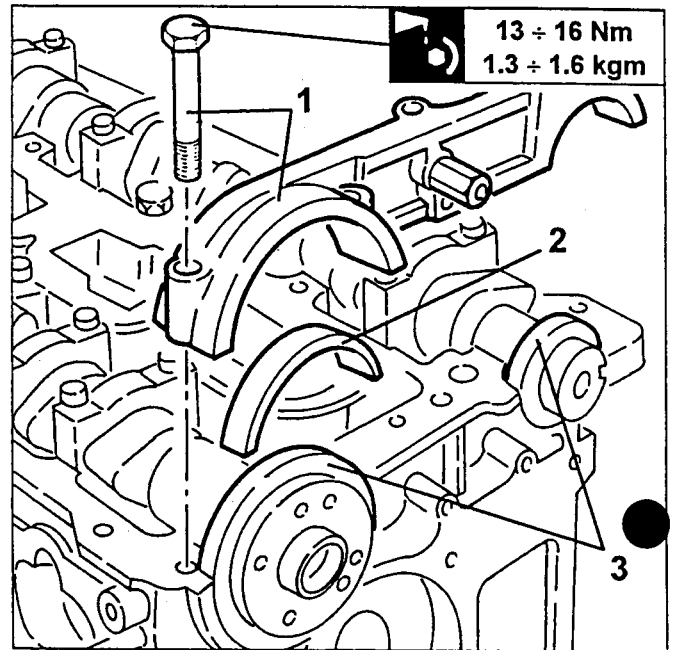
1. Remove the engine coolant temperature gauge transmitter and maximum temperature warning light contact from the cylinder head.



1. Slacken the fastening screw using tools no. 1.822.146.000 and no. 1.822.156.000 and remove the exhaust side camshaft drive pulley.
2. Slacken the fastening screws using tool no. 1.822.155.000 and remove the intake side camshaft drive pulley.

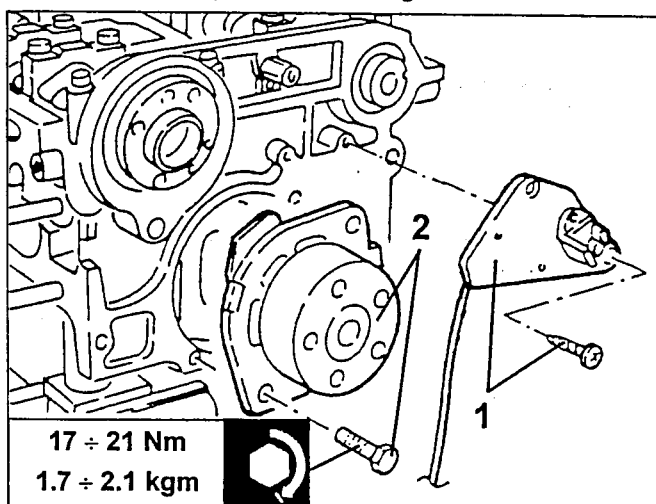


2. Remove the intake side half bearing.
3. Remove the oil seal rings from the camshafts.

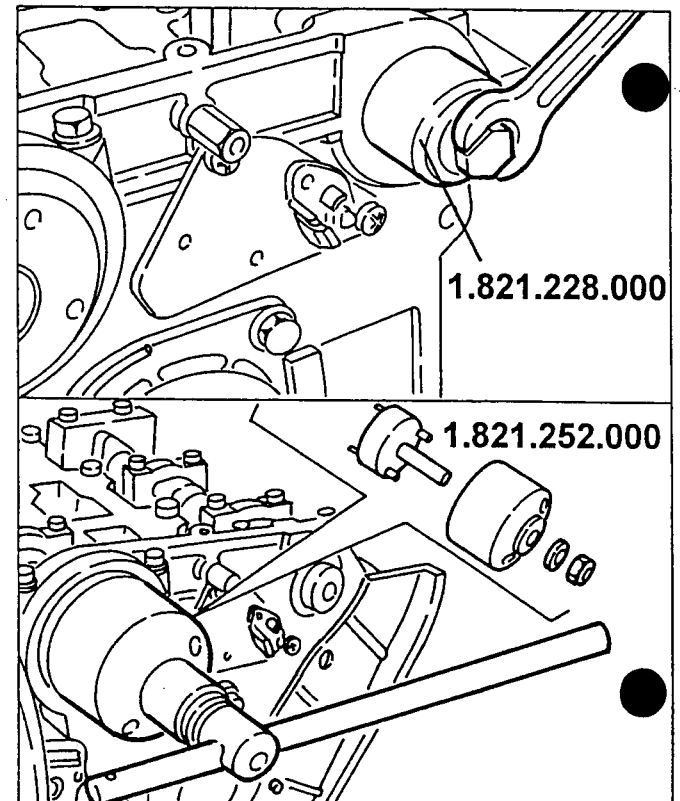


REMOVING THE WATER PUMP

1. Slacken the two fastening screws and remove the timing sensor complete with support.
2. Slacken the two fastening screws and remove the water pump complete with O-ring.



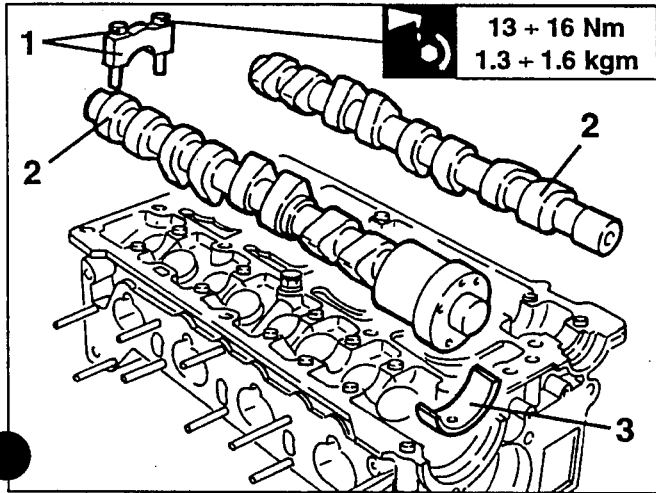
When refitting using tool no. 1.821.228.000 insert the exhaust side oil seal.
Using tool no. 1.821.252.000 insert the intake side oil seal.



REMOVING THE CAMSHAFTS

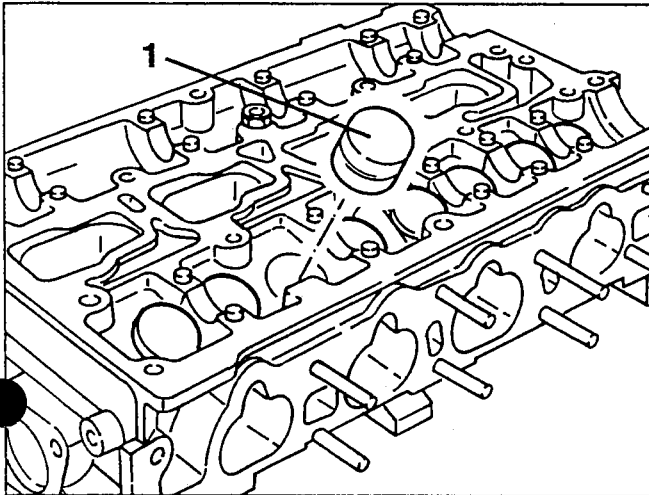
1. Slacken the four fastening screws and remove the camshaft front cap.

1. Slacken the fastening screws and remove the camshaft caps.
2. Remove the camshafts.
3. Remove the intake side half bearing.

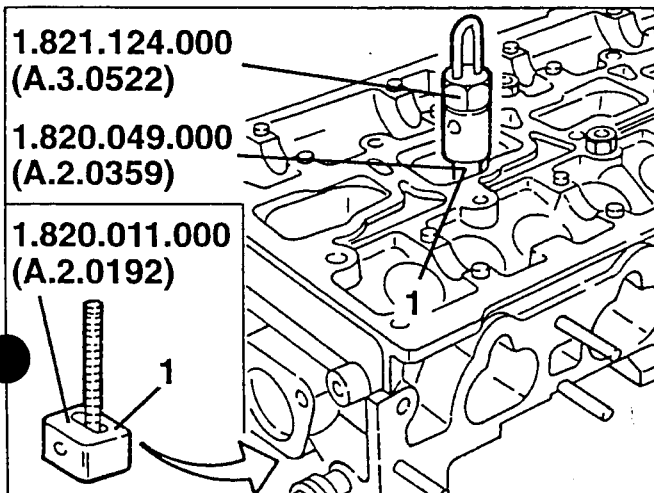


VALVES DIS-ASSEMBLY

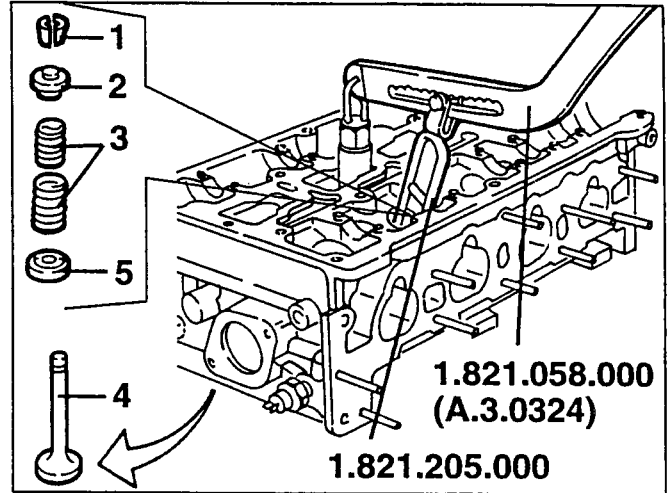
1. Withdraw the hydraulic tappets from their housings.



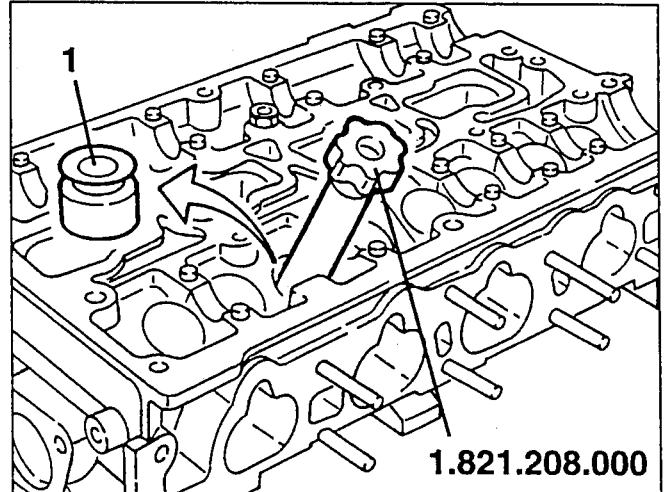
1. On the cylinder head assemble tools no. 1.820.011.000 (A.2.0192), no.1.820.049.000 (A.2.0359) and no. 1.821.124.000 (A.3.0522).



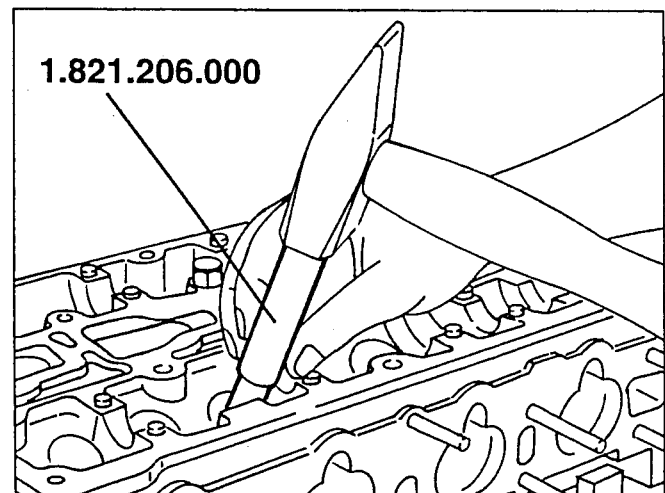
1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.205.000, remove the half cones from the valve stem.
2. Remove the upper plate.
3. Remove the outer and inner springs.
4. Remove the tools and retrieve the valve.
5. Remove the valve lower plate.



1. Using tool no. 1.821.208.000, remove the oil seal cap.



- When refitting the oil seal cap use tool no. 1.821.206.000.

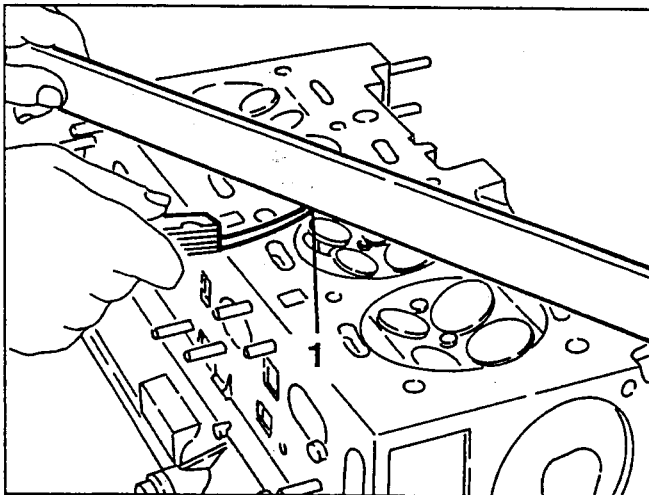


CHECKS AND INSPECTION CYLINDER HEAD

Checking the lower surface of the cylinder head

1. Check the flatness of the lower cylinder head surface; reface if it is excessively worn.

	Maximum flatness error of cylinder head lower surface
	0.1 mm

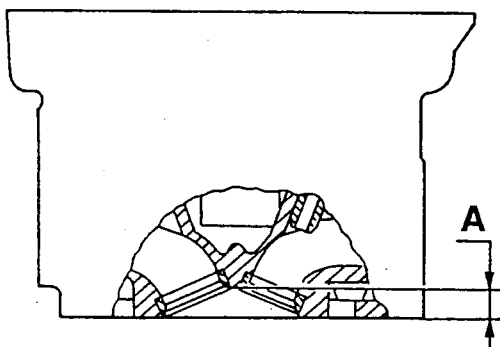


- After refacing, check that the depth of the combustion chamber, on the head, exceeds the minimum allowed limit.

WARNING:
Exceeding the minimum allowed limit involves serious engine operating failures.

	Minimum depth "A" of the combustion chamber in the head
	13 ± 0.2 mm

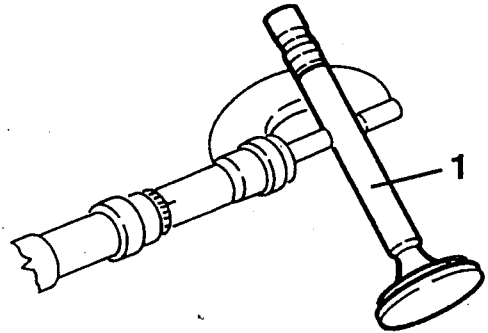
- Check that the finishing of the lower cylinder head surface is satisfactory.



Checking the clearance between valve guides and valve stems

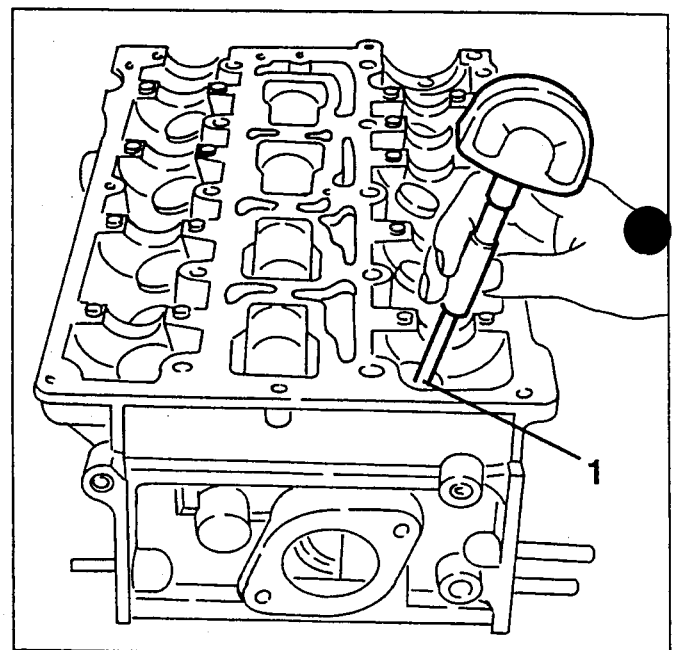
1. Measure the diameter of the valve stems and check that it is within the specified limits.

	Diameter of valve stems	
	Intake	6.975 + 6.990 mm
	Exhaust	6.960 + 6.975 mm



1. Measure the inside diameter of the valve guides and check that it is within the specified limits.

	Inside diameter of valve guides
	7.022 + 7.040 mm

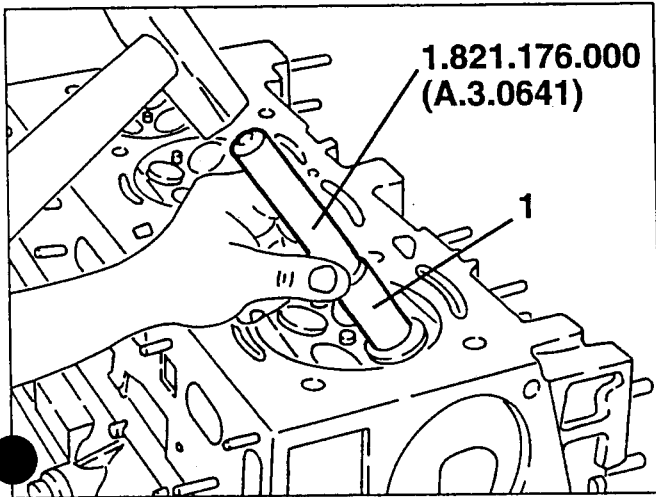


- Calculate the clearance between valve guides and stems and check that it is within the specified limits, if not, change any worn parts.

	Radial clearance between valve guides and stems	
	Intake	0.032 + 0.065 mm
	Exhaust	0.047 + 0.080 mm

Changing the valve guides

1. Using puller tool no. 1.821.176.000 (A.3.0641), remove the worn valve guides.



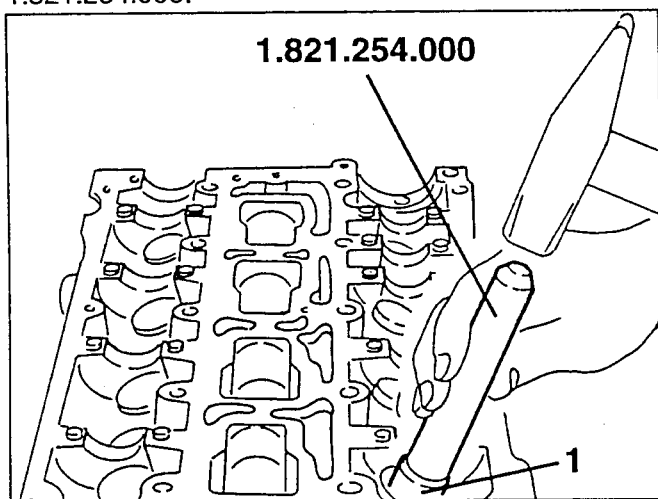
- Check that the outside diameter of the valve guides and their seats on the head are within the specified limits and that their assembly interference is correct.

\varnothing	Outside diameter of valve guides
	13.010 + 13.030 mm

\varnothing	Diameter of valve guide seats
	12.950 + 12.977 mm

	Interference between valve guides and seats
	0.033 + 0.080 mm

Insert the new valve guides using tool no. 1.821.254.000.



- Bore the valve guide inside diameter to calibrate the poles to the specified diameter.

\varnothing	Inside diameter of valve guides
	7.022 + 7.040 mm

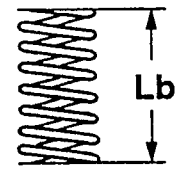
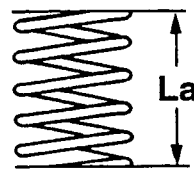
Checking the valve springs

- Check that the "free" length of the valve springs is within the specified limits.

NOTE: The rest surfaces must be parallel with each other and perpendicular to the axis of the spring with a maximum error of 2°.



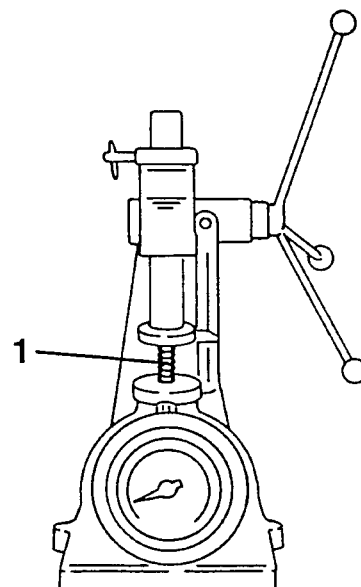
Free length of valve springs	
outer spring "La"	46 mm
inner spring "Lb"	39 mm



1. Using a torque meter, check that the characteristic data of the springs are within the specified limits.

Outer spring		
Length of spring mm		Control load N (Kg)
With valve closed	34	271 + 294 (27.6 + 30)
With valve open	24.5	485 + 524 (49.4 + 53.4)

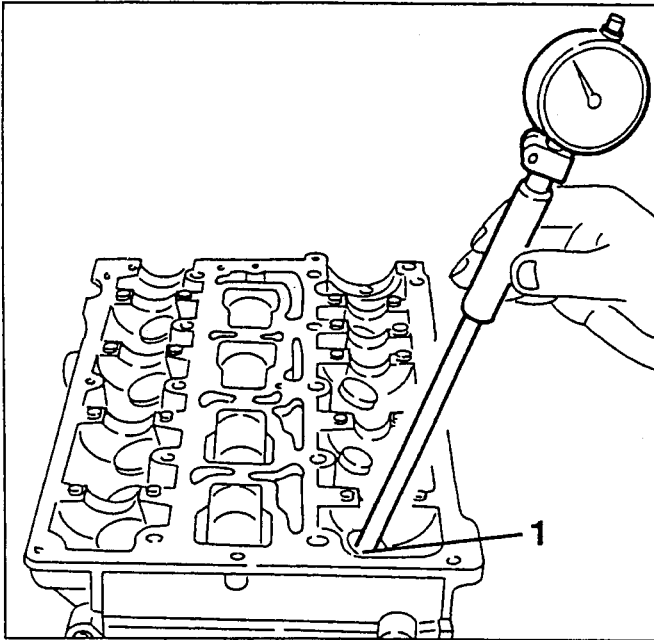
Inner spring		
Length of spring mm		Control load N (Kg)
With valve closed	29.5	96 + 106 (9.8 + 10.8)
With valve open	20	201 + 221 (20.5 + 22.5)



Checking the clearance between the cups and their seats

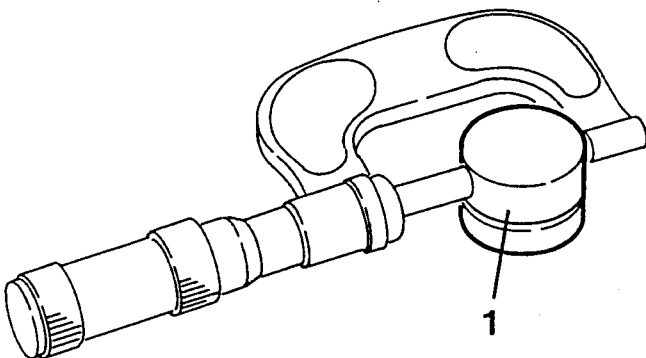
1. Check that the diameter of the cup seats is within the specified limits.

∅	Diameter of valve cup seats
	33.000 + 33.025 mm



1. Check that the outside diameter of the cups is within the specified limits.

∅	Diameter of valve cups
	32.959 + 32.975 mm



- Calculate the clearance between the cups and their seats checking that it is within the specified limits.

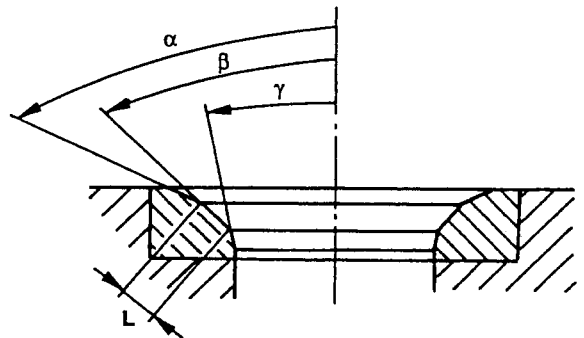
↕	Clearance between cups and seats
	0.025 + 0.066 mm

Turning the valve seats

- If necessary, turn the valve seats using suitable equipment within the following limits.

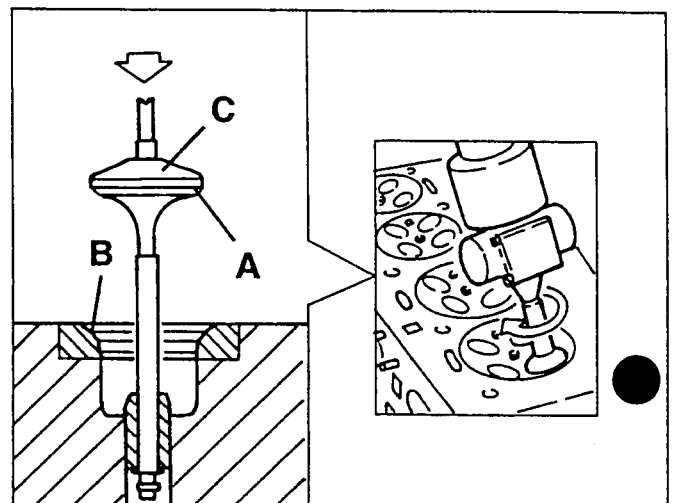
△	Taper of contact area with valve "β"	90° ± 10'
	Taper of upper valve seat area "α"	150°
	Taper of lower valve seat area "γ"	30°

	Dimension "L" contact area with valve	
	Intake	6.5 mm
	Exhaust	5.5 mm



- After machining, grind each valve in its seat as follows:

- coat the contact surfaces "A" and "B" of the valves and their seats with abrasive paste (SIPALAREXONS Carbosilicium for valves);
- lubricate the valve stem with engine oil;
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder;
- insert the valve in its guide and grind;
- after grinding, thoroughly clean the valve and the seat.



- When turning and grinding the valve seats it is advisable to check the valve tightness with the spark plugs in place, proceeding as follows:

- fill the hollow of the combustion chamber with petrol;
- admit low pressure air into the intake manifolds and check that no bubbles form in the petrol;
- check the tightness of the exhaust valves in the same way, admitting air to the exhaust manifolds;
- if any leaks are noted, make sure that the valves are perfectly settled in their seats and repeat the check; if the result is negative, grinding must be repeated.

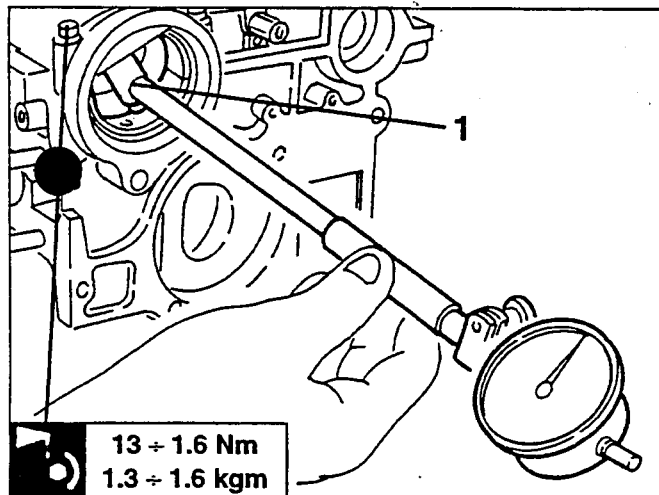
Camshafts and timing system bearings

1. Assemble the camshaft caps and tighten the fastening screws to the specified torque, then check that the diameter of the supports is within the specified limits.

NOTA: The half bearings should be assembled on the intake side front support.

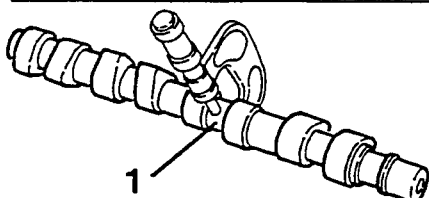
Diameter of camshaft supports	
	26.045 ÷ 26.070 mm
	50.034 ÷ 50.071 mm (*)

(*) Front intake side support with half bearings assembled (for timing variator)



1. Check that the diameter of the camshaft journals is within the specified limits.

Diameter of camshaft journals	
	26.000 ÷ 26.015 mm



- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limits.



Clearance between camshafts and bearings

0.03 ÷ 0.07 mm 0.034 ÷ 0.086 mm (*)

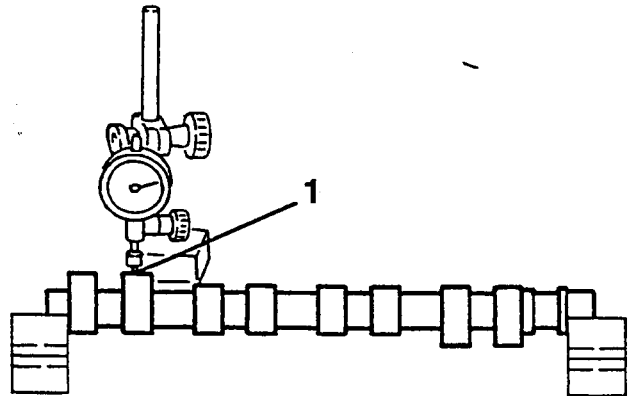
(*) Specific for timing variator

1. Check that the cam lifts are within the specified limits.



Cam nominal lift

Intake	9.50 mm
Exhaust	9.50 mm



Checking the camshaft end float

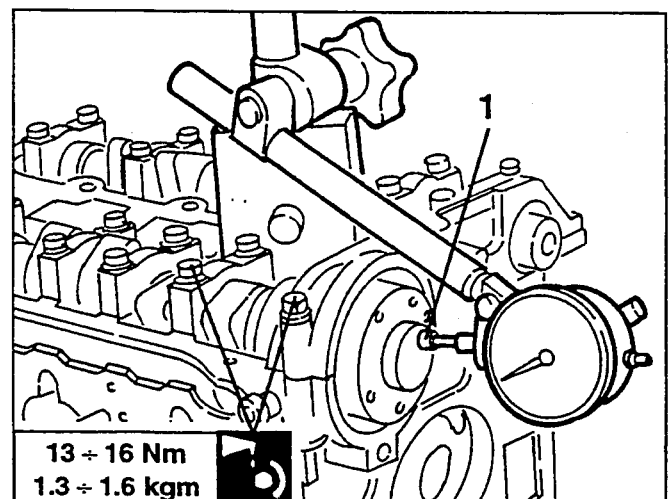
- Place the camshafts on the cylinder head, assemble the corresponding caps and tighten the fastening screws to the specified torque.

1. Install a centesimal dial gauge and measure the end float of the camshafts checking that it is within the specified limits.



Camshafts end float

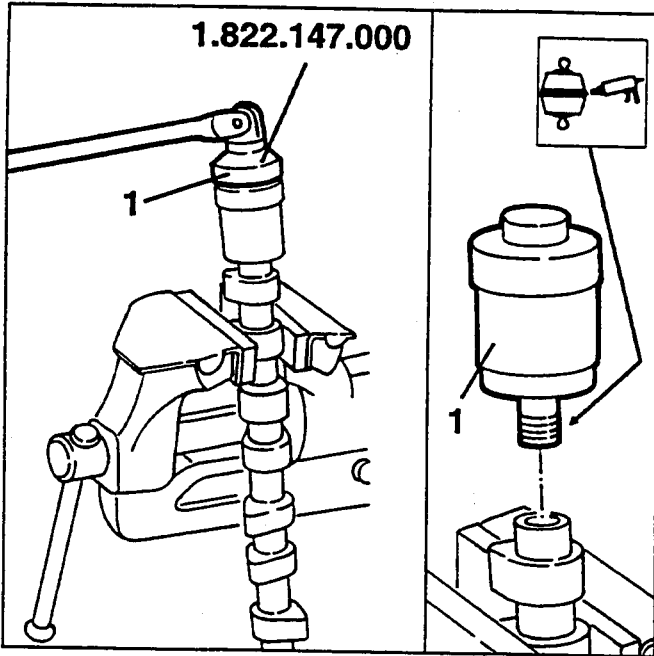
0.10 ÷ 0.23 mm



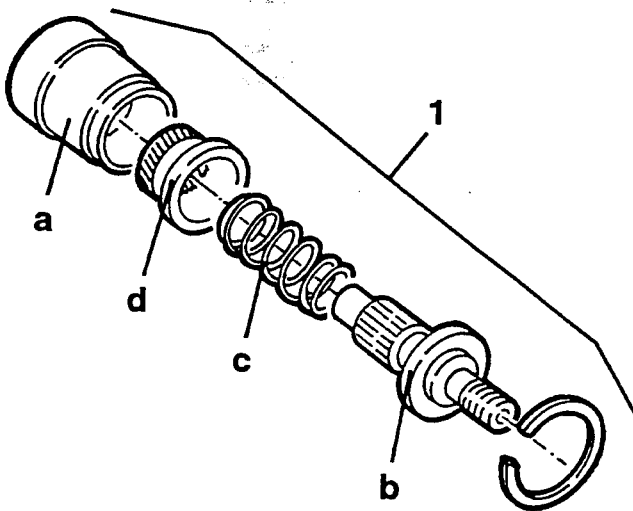
Removing the timing variator from the camshaft

- Position the camshaft intake side in a vice fitted with protective jaws.

- Using tool no. 1.822.147.000, slacken and remove the timing variator from the camshaft.



- Remove the stop ring and remove the outer body (a) of the variator pinion (b), spring (c) and the piston (d).



WARNING:

When refitting the timing variator, follow the instructions given below:

- Make sure that the mastic on the thread coupling the timing variator to the camshaft does not obstruct the oil ducts.
- Wait for about two hours before assembling the shaft on the cylinder head.

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CHECKS AND INSPECTION CRANKCASE

- Visibly check the crankcase for cracks and signs of excessive wear of the sliding surfaces; check that all the threads are intact.
- Remove the lubrication and cooling groove caps and clean the ducts with a suitable detergent, then dry with a jet of air and fit new caps.
- Accurately remove any traces of seals or sealants from the crankcase surfaces.

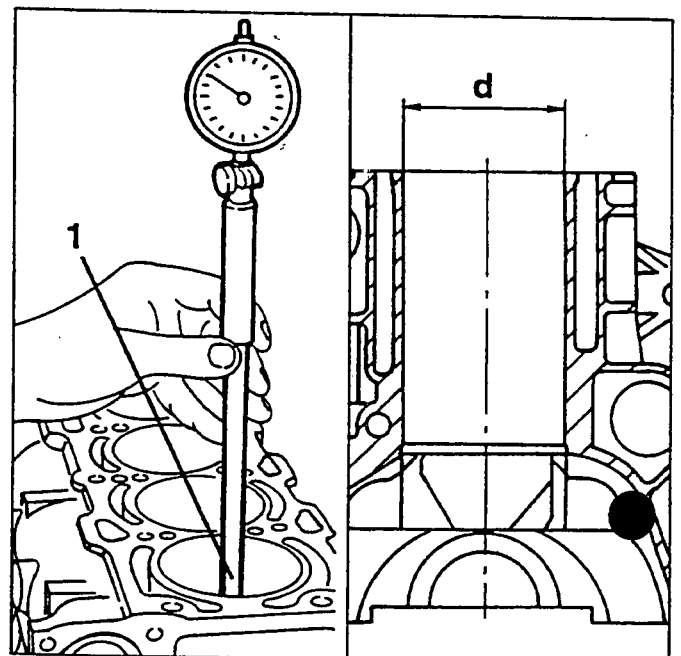
Checking the cylinders

- Using a bore gauge fitted on a dial gauge, measure the inside diameter of the cylinders and check that it is within the specified limits.

∅	Inside diameter "d"	
	Class A	83.000 ÷ 83.010 mm
Class B	83.010 ÷ 83.020 mm	
Class C	83.020 ÷ 83.030 mm	
Oversize of 0.1 mm		

△	Maximum cylinder taper	
	0.010 mm	

○	Maximum cylinder ovalization	
	0.005 mm	



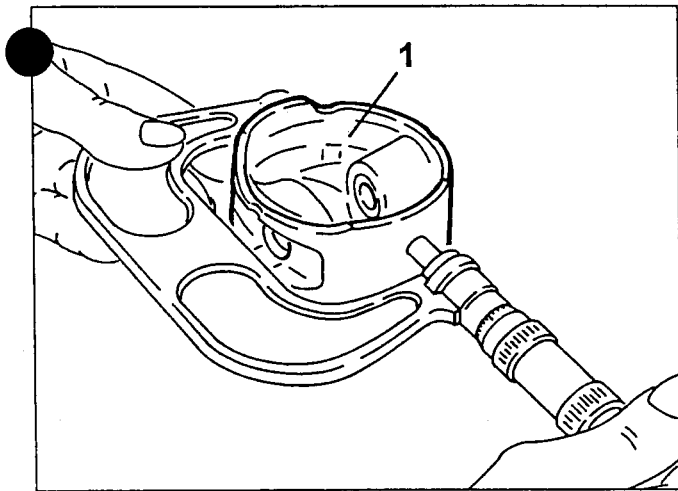
Checking the pistons

1. Measure the outside diameter of the pistons and check that it is within the specified limits.



Outside diameter of pistons (1)	
Class A (Blue)	82.952 ÷ 82.962 mm
Class B (Pink)	82.959 ÷ 82.971 mm
Class C (Green)	82.968 ÷ 82.978 mm
Oversize of 0.1 mm	

(1) To be measured at right angles to the gudgeon pin hole at a distance of 12.5 mm from the lower edge of the piston skirt.



- Calculate the clearance between the cylinder and the piston and check that it is within the specified limits.

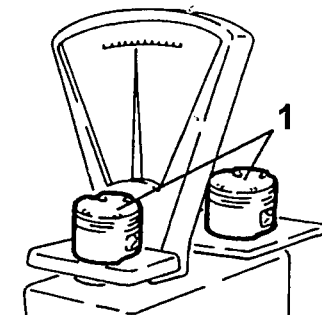


Clearance between piston and cylinder	
0.038 ÷ 0.062 mm	

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.



Difference in weight between pistons	
± 5 g	

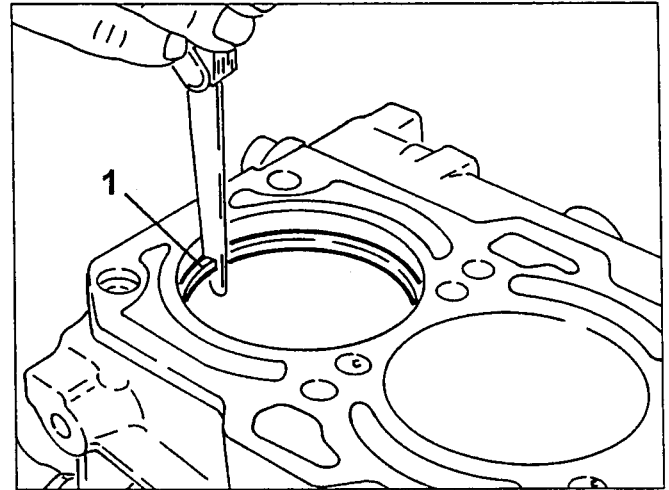


Checking the seal ring gap

1. Insert the seal rings in the cylinder, check that they adhere to the whole circumference and that the gap is within the specified limits.



Ring gap	
First ring	0.25 ÷ 0.50 mm
Second ring	0.30 ÷ 0.50 mm
Oil scraper ring	0.25 ÷ 0.45 mm

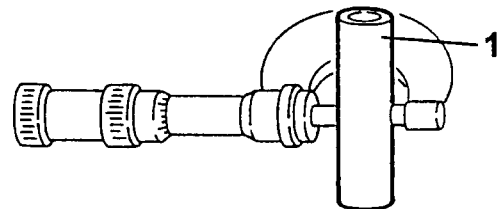


Checking the play between gudgeon pins and seats on pistons

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



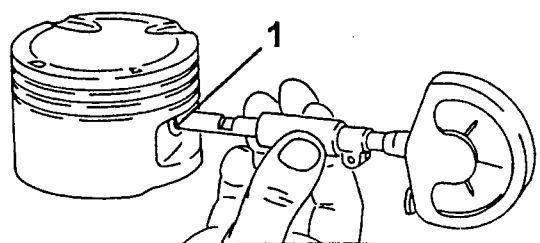
Outside diameter of gudgeon pins	
19.996 ÷ 20.000 mm	



1. Measure the diameter of the pin mating hole in the piston and check that it is within the specified limits.



Diameter of pin seat in pistons	
20.002 ÷ 20.007 mm	



- Calculate the clearance between the pins and their seats on the pistons and check that it is within the specified limits.



Clearance between pins and seats on pistons
0.002 ÷ 0.011 mm

- Calculate the clearance between the rod journals and the corresponding half bearings and check that it is within the specified limits.



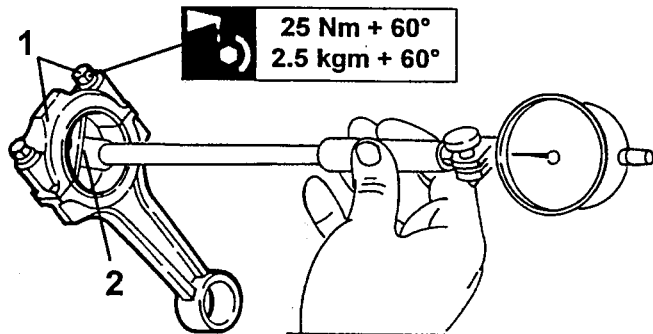
Clearance between rod journals and half bearings
0.03 ÷ 0.056 mm

Checking the clearance between connecting rod journals and the corresponding half bearings

1. House the rod half bearings in the connecting rod big end and on the corresponding cap, then join them tightening the fastening screws to the specified torque.
2. Measure the diameter of the connecting rod big end and check that it is within the specified limits.



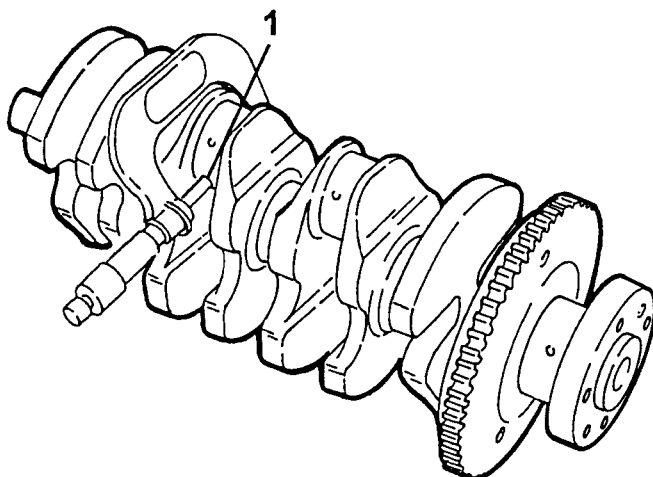
Inside diameter of connecting rod half bearings	
Class A	50.835 ÷ 50.855 mm
Class B	50.829 ÷ 50.849 mm
Class C	50.823 ÷ 50.843 mm



1. Measure the diameter of the connecting rod journals and check that it is within the specified limits.



Diameter of connecting rod journals	
Class A	50.799 ÷ 50.805 mm
Class B	50.793 ÷ 50.799 mm
Class C	50.787 ÷ 50.793 mm

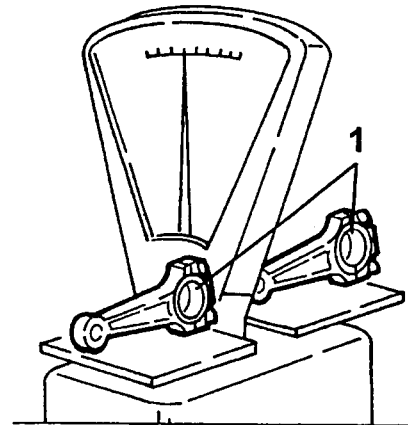


Checking the connecting rods

1. Check that the difference in weight between the connecting rods complete with half bearings, caps and screws is within the specified limits.

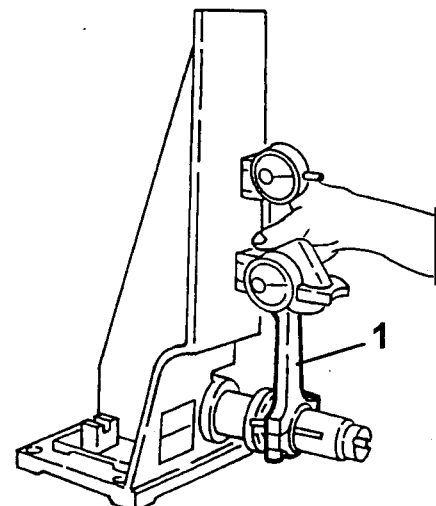


Difference in weight between connecting rods
≤ 5 g



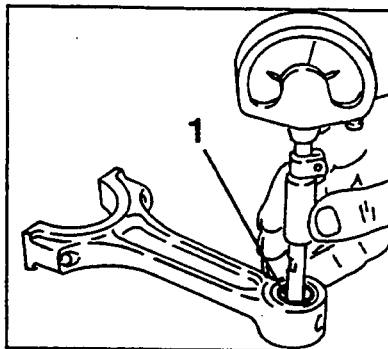
1. Check that the connecting rods are perpendicular using a reference plane as illustrated.

NOTE: If perpendicularity is not perfect, the connecting rod must be changed to avoid abnormal stresses when the engine is running, resulting in uneven wear of the piston and of the rod itself.



Checking the clearance between pins and small end bushings

1. Measure the inside diameter of the small end bushing and check that it is within the specified limits, if not, change the bushing.



Inside diameter of small end bushing

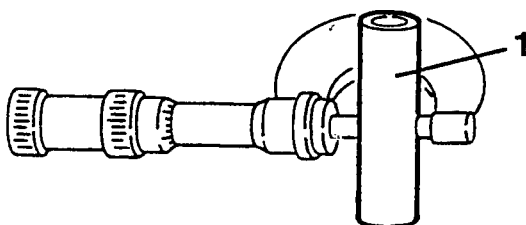
20.006 ÷ 20.012 mm

1. Measure the outside diameter of the pins and check that it is within the specified limits.



Outside diameter of pins

19.996 ÷ 20.000 mm



- Calculate the clearance between the pins and small end bushings and check that it is within the specified limits.



Clearance between pins and small end bushing

0.006 ÷ 0.016 mm

Checking the clearance between main bearing journals and half bearings

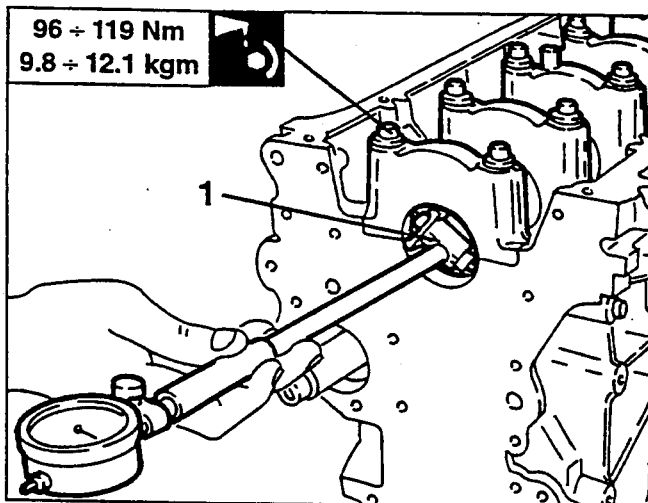
1. House the half bearings and fit the main bearings caps on the crankcase tightening the fastening screws to the specified torque.

2. Measure the diameter of the main bearings and check that it is within the specified limits.



Diameter of main bearings

Class A (Red)	53.025 ÷ 53.046 mm
Class B (Blue)	53.019 ÷ 53.040 mm
Class C (Yellow)	53.013 ÷ 53.034 mm

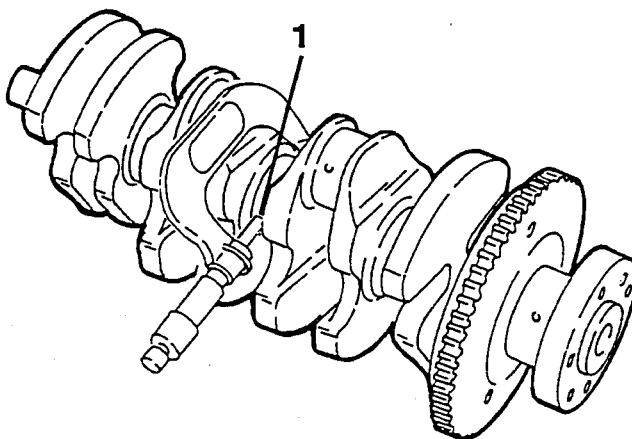


1. Measure the diameter of the main bearing journals and check that it is within the specified limits.



Diameter of main bearing journals

Class A	52.994 ÷ 53.000 mm
Class B	52.988 ÷ 52.994 mm
Class C	52.982 ÷ 52.988 mm



- Calculate the clearance between the main bearing journals and half bearings and check that it is within the specified limits.



Clearance between main bearing journals and half bearings

0.025 ÷ 0.052 mm

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, change the ring gear as described below:

- working under the press remove the old ring gear;
- accurately clean the contact surfaces of the new ring gear and of the flywheel;

• evenly heat the new ring gear to 80° + 100° C and fit it on the flywheel: leave to cool naturally, do not force cool.

- Using a torque meter check the characteristic values of the engine oil pressure limiting valve control spring.

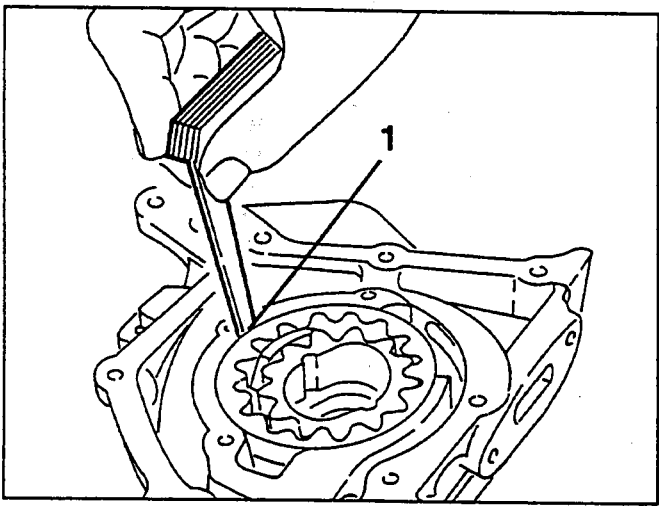
Checking the oil pump

1. Check that the clearance between the pump casing and the driven gear is within the specified limit.

Control load Kg	Spring length mm
6.8	36



Clearance between pump casing and driven gear
0.080 + 0.186 mm



1. Check that the clearance between the pump cover rest surface and the upper side of the gears is within the specified limit.

INSTRUCTIONS FOR RE-ASSEMBLY



For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

- Check valve tightness when the cylinder heads are assembled (see "Turning the valve seats").

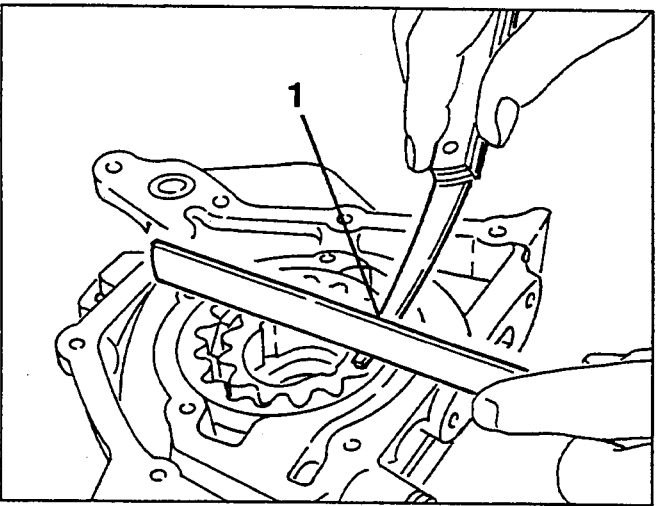
Reassembling the crankshaft

- Assemble the crankshaft on the crankcase complete with half bearings and half thrust rings.

Reassemble the half thrust rings with the grooved surfaces facing the crankshaft.

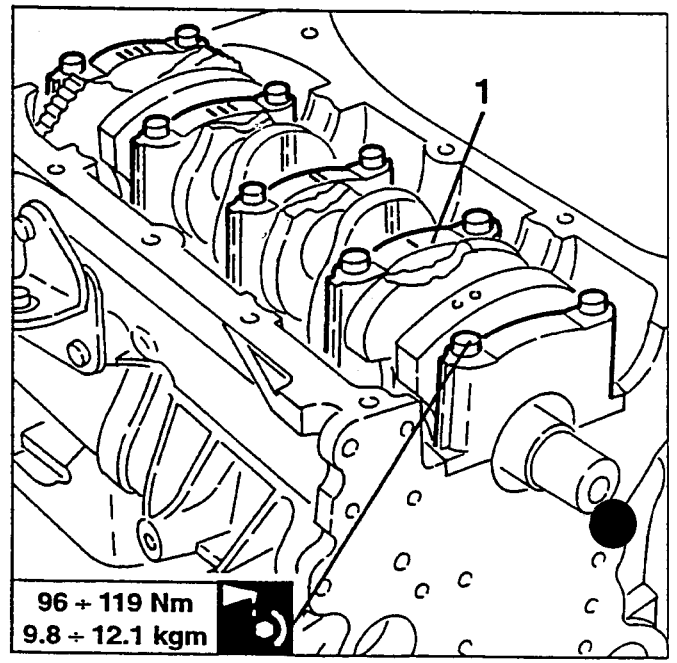


Clearance between pump cover rest surface and upper side of gears
0.025 + 0.070 mm



1. Assemble the main bearing caps complete with half bearings on the supports and tighten the fastening screws two or three times starting from the centre main bearing cap.

The position of each cap is given by a series of consecutive notches (from zero to four starting from the front of the engine) etched on the caps themselves.




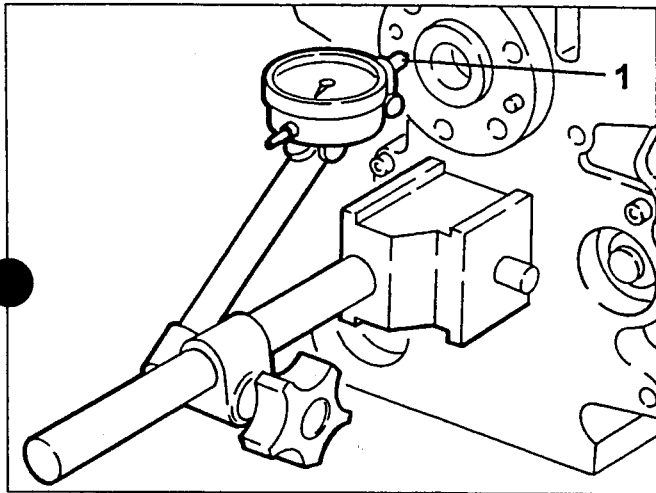
96 + 119 Nm
9.8 + 12.1 kgm

WARNING: If the clearances measured are not within the specified limits, change the front crankcase cover with oil pump incorporated.

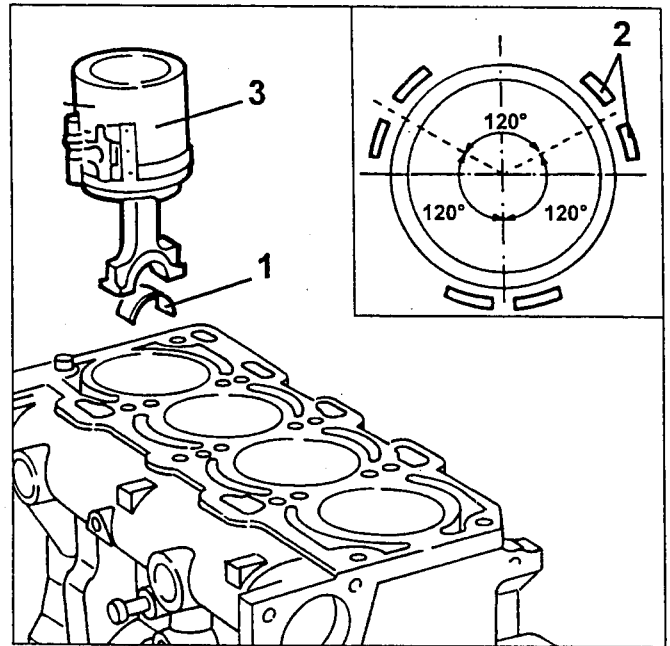
Checking the crankshaft end float

1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.

	Crankshaft end float
	0.059 ÷ 0.221 mm

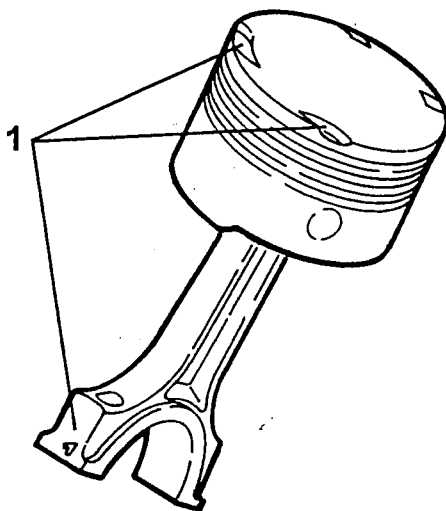


Assemble the connecting rod - piston unit in the crankcase directing the arrow stamped on the piston crown in the direction of rotation of the engine.



Refitting the pistons and connecting rods

1. Assemble the piston and connecting rod so that the number stamped on the connecting rod big end is on the same side as the large notches (for intake valves) on the piston crown.



- Turn the crankshaft until the connecting rod journals of the 1st and 4th cylinder are in the position corresponding to the B.D.C.

1. House the half bearings on the connecting rod big ends.

Insert the rings in the pistons with the cuts offset by 120° and the word TOP printed on them facing upwards.

3. Using a suitable tool, insert the pistons and connecting rods in the 1st and 4th cylinder.

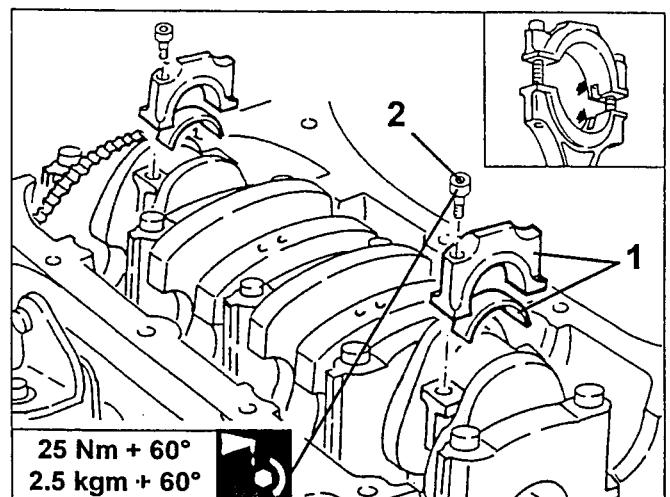
- Turn the crankcase 180°.

1. House the half bearings on the connecting rod caps, then assemble those of the 1st and 4th cylinder directing the safety notch towards the same side as the corresponding notch on the connecting rod big end.

On one side, the connecting rod caps have the number of the cylinder to which they belong; when refitting, this number must always be on the same side as the one stamped on the connecting rod big end.

2. Tighten the connecting rod cap fastening screws in oil to the specified torque.

- In the same way, reassemble the pistons and connecting rods of the 2nd and 3rd cylinder.

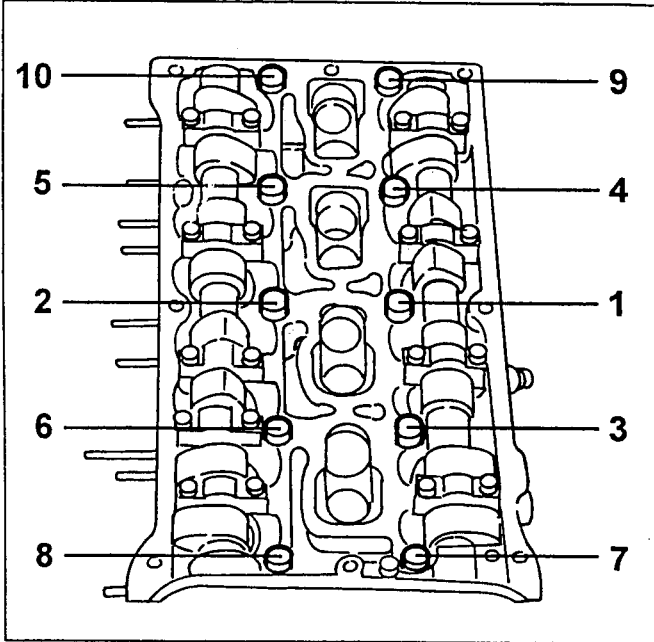


25 Nm + 60°
2.5 kgm + 60°



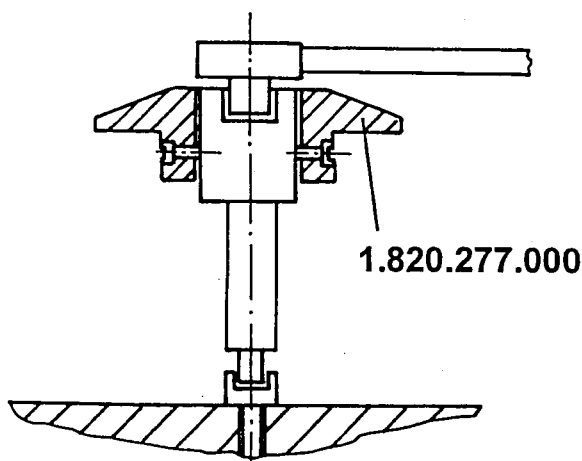
Reassembling the cylinder head

- Turn the crankshaft to take the pistons of the 1st and 4th cylinder to the T.D.C.
- Position the gasket on the crankcase, then the cylinder head.
- Tighten the cylinder head fastening screws as described below and bearing in mind that the tightening sequence is the one shown below for each phase.



Tightening procedure	
Set in all the screws to a torque of:	20 Nm (2.0 kgm)
Tighten the screws to the preliminary torque of:	40 Nm (4.1 kgm)
Turn all the screws with an angle of:	90° + 90° + 90°

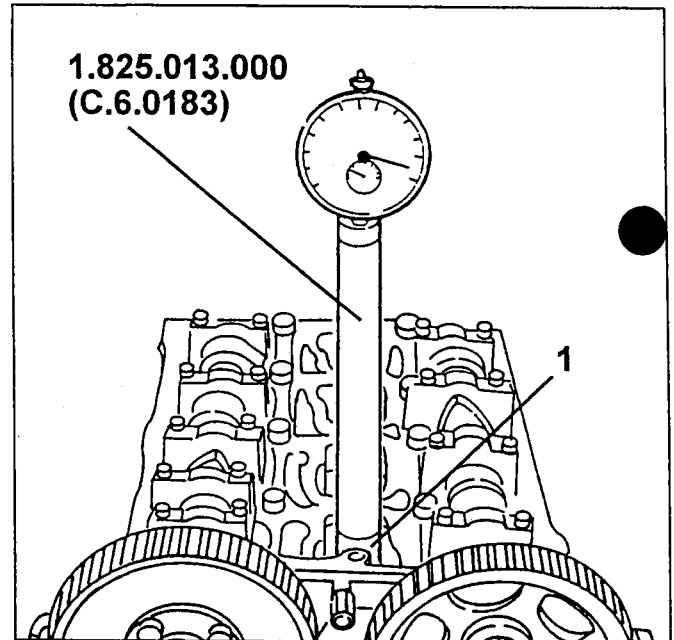
- For angle tightening use the graduated disk no. 1.820.277.000 as illustrated.



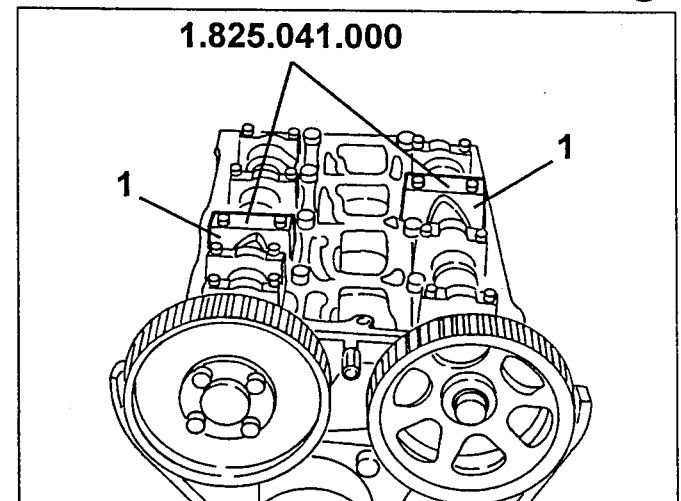
The gasket between the cylinder head and the crankcase is in aramidic fibre and cylinder head retightening is unnecessary throughout the life of the engine.

Assembling the timing gear drive belt and checking timing

- Assemble the camshaft toothed pulleys without tightening the fastening screws, the timing drive belt pulleys and the corresponding belt tensioners.
- 1. Install tool no. 1.825.013.000 (C.6.0183) fitted with a dial gauge in the seat of the centre spark plug of the 1st cylinder.
- Turn the crankshaft until the piston of the first cylinder reaches the T.D.C. in the bursting stroke.

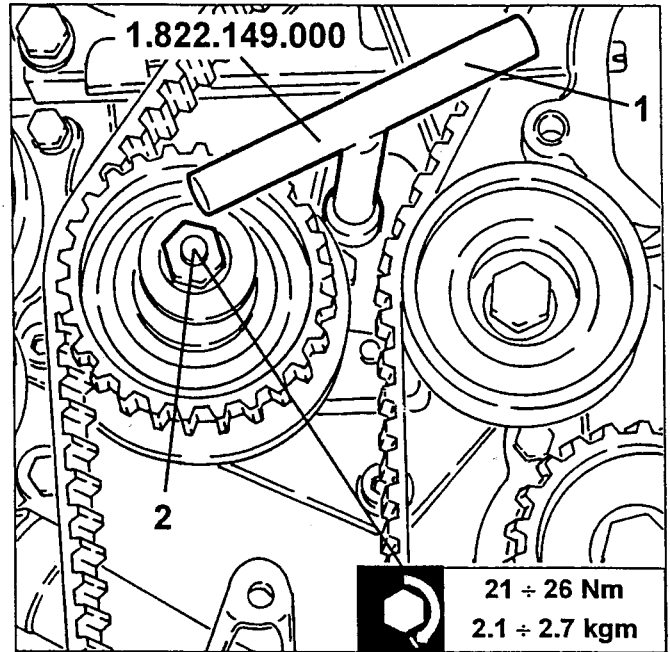



1. Remove the camshaft caps illustrated and in their place insert templates no. 1.825.041.000 tightening the fastening screws to a maximum torque of 10 Nm (1 Kg) and checking for correct coupling with the cams.

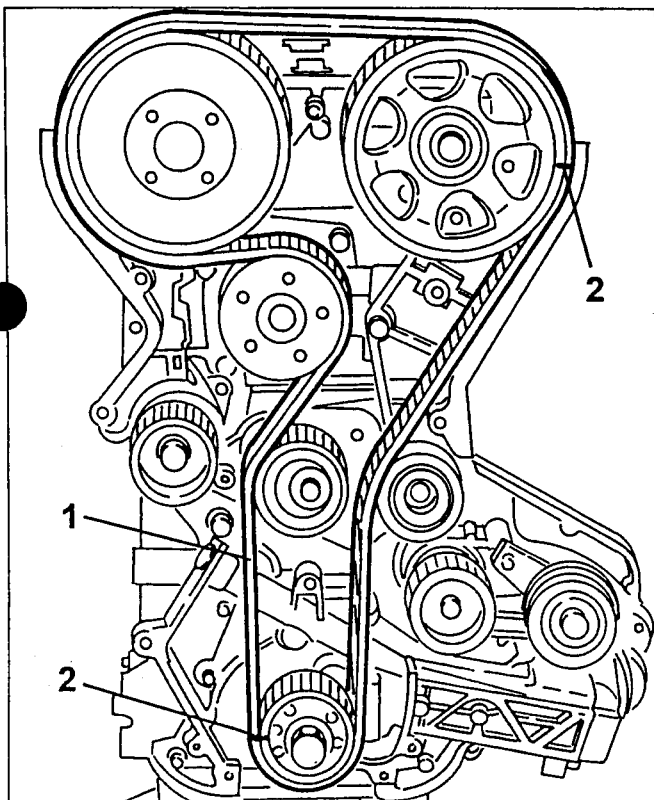


NOTE: For turning the camshafts, use tool no. 1.822.155.000 for the intake side and tools no. 1.822.146.000 and no. 1.822.156.000 for the exhaust side, to be applied on the corresponding pulleys.

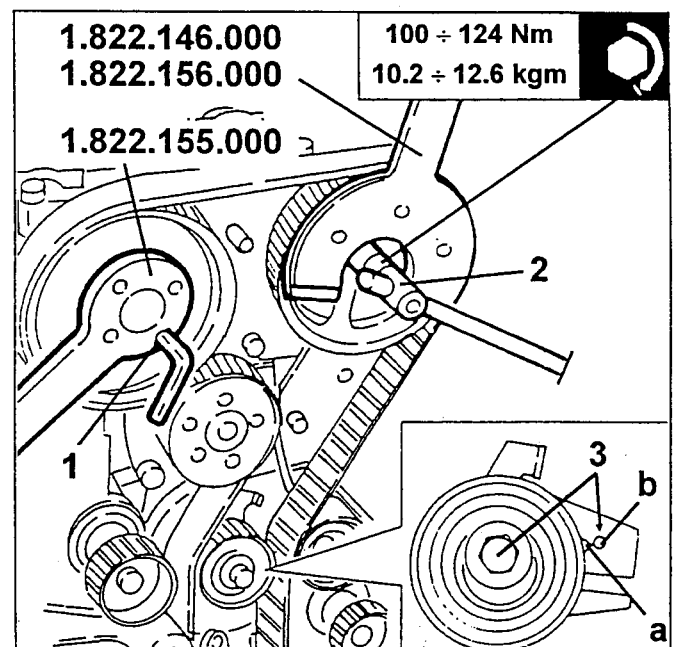
- Assemble the timing gear drive belt taking care to check correct coupling with the pulley teeth, installing it in the following sequence:
 - crankshaft pulley
 - fixed tightening pulley
 - exhaust side camshaft pulley
 - intake side camshaft pulley
 - automatic tensioner pulley
 - coolant fluid pump pulley
- The notches painted on the belt must coincide with the indexes made on the crankshaft pulley and on the exhaust side camshaft pulley.



WARNING:
 When assembling the toothed belt, to avoid damaging the structure of the fibres that form it, never cause sharp bends.
 For correct assembly the belt has an arrow on it which shows the direction of rotation of the engine.



- Using tool no. 1.822.155.000, tighten the screws fastening the intake side camshaft drive pulley.
- Using tool no. 1.822.146.000 complete with tool no. 1.822.156.000, tighten the screw fastening the exhaust side camshaft drive pulley.
 - Remove the two templates from the camshafts and turn the crankshaft twice in its direction of rotation until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke.
- Release the nut fastening the automatic tensioner, then using tool no. 1.822.149.000, move the mobile index (a) to coincide with the reference hole (b).
 - Tighten the automatic tensioner fastening nut to the specified torque.



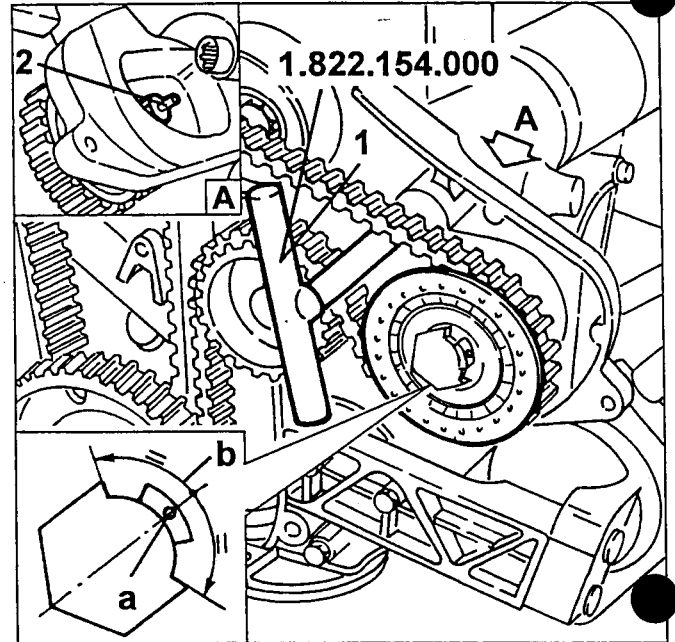
- Using tool no. 1.822.149.000 as illustrated, tension the belt to the maximum.
- Tighten the nut fastening the automatic camshaft belt tensioner.

Assembly of counter-rotating shaft drive belt and checking valve gear timing

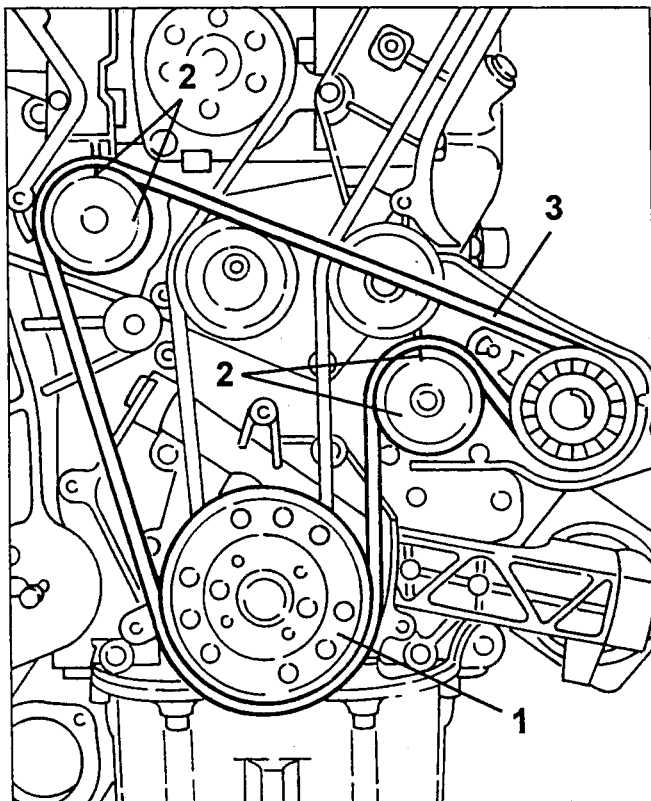
1. Move the piston of cylinder no. 1 to the T.D.C. in the bursting stroke, then assemble the counter-rotating shaft drive pulley.
2. Position the counter-rotating shaft pulleys so that the notches on them correspond with the reliefs on the rear covers (tooth at the side of the reference notch on the vertical).
3. Assemble the counter-rotating shaft drive belt checking correct mating of the teeth on all the toothed pulleys.



WARNING:
When assembling the toothed belt, to avoid damaging the structure of the fibres that form it, never cause sharp bends.



- Turn the crankshaft twice in its direction of rotation until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke and check that all the timing references correspond.



1. Using tool no. 1.822.154.000, as illustrated, tension the counter-rotating shaft drive belt until the reference hole (a) on the tensioner reaches the centre of the rotation sector (b).
2. Tighten the nut fastening the counter-rotating shaft automatic tensioner.

CHECKING LUBRICATION CIRCUIT ELECTRIC COMPONENTS

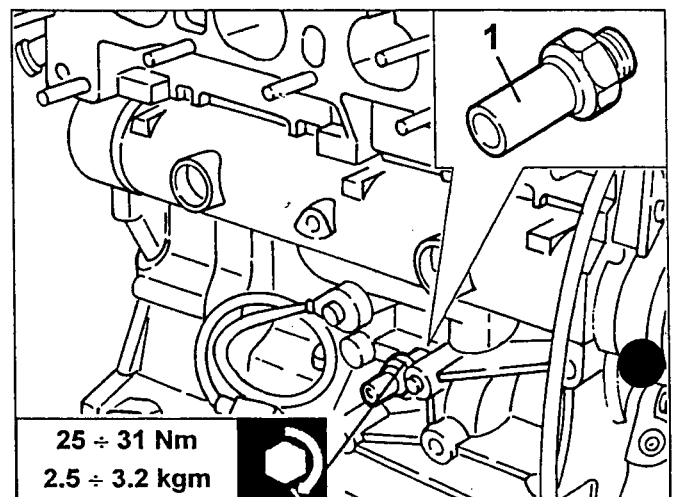
ENGINE OIL MINIMUM PRESSURE WARNING LIGHT SENSOR

1. Check the setting of the engine oil minimum pressure warning light sensor. If the ratings are not as specified, replace the sensor.



Contact opening/closing pressure

0.2 ÷ 0.5 bar





T. SPARK
16V



T. SPARK
16V



T. SPARK
16V

ENGINES AR33503 - AR67601 - AR67106 - AR32201

10

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GENERALITIES T. SPARK 16V

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(*): See  T. SPARK 16V

 T. SPARK 16V



DESCRIPTION

Four cylinder in line engine with double camshaft in head, four valves per cylinder, phase variator, static injection and twin ignition controlled by a single ECU.

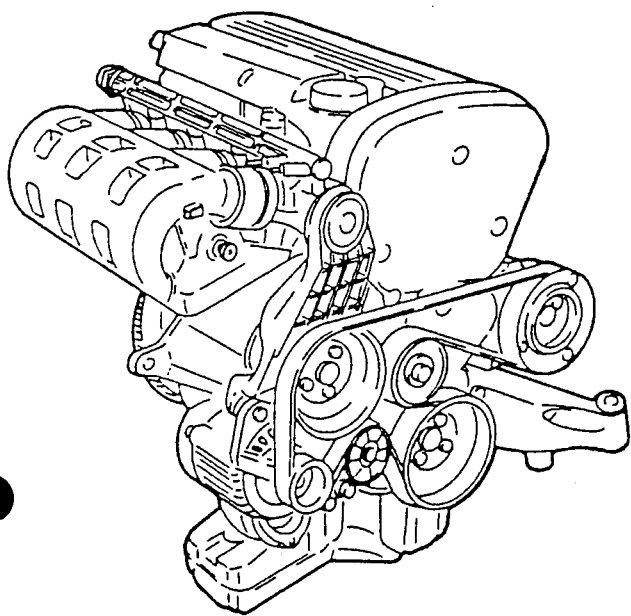
The rear engine is connected to the clutch-gearbox-differential unit which constitutes a sole assembly.

The engine is installed frontally and transverse at a 18°30 slant.

The engine is "suspended" by means of two damper mounts to the underbody and one scissors mount to the suspension crossmember. To contain vibrations, the engine top is connected to the underbody by means of a shock-proof connecting rod.

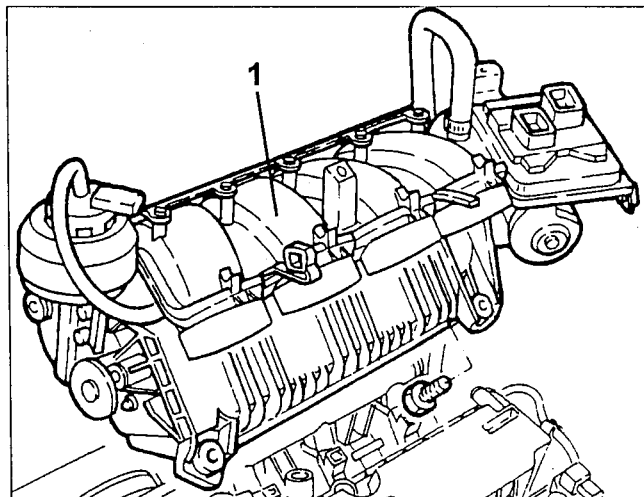
All belts are fitted with automatic take-up devices to ensure long belt working life.

The fuel feed system (unleaded petrol) is fitted with suitable pollution prevention devices which ensure low exhaust emissions as per "EEC PHASE 2" standards.



M1.5.5 injection-ignition engines are fitted with a plastic intake manifold (with variable geometry 1747 cc versions) instead of an aluminium intake manifold.

The fuel feed system is returnless, i.e. with a single feed pipe.



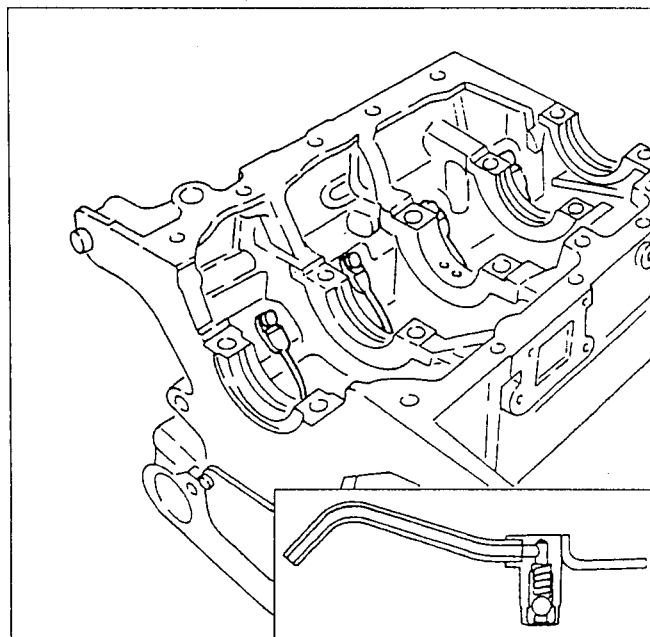
CRANKCASE

The engine block is made of high mechanical resistance cast iron.

The crankshaft is supported by means of five main journals which house five thin casing half-bearings. The cylinders are directly cut into the crankcase and are selected according to three size classes plus three oversized classes.

Specific ducts in the crankcase walls ensure the passage of coolant and lubrication oil.

A nozzle, which sprays oils on the top of the piston thus ensuring partial cooling, is fitted in the lower part of each cylinder.





CYLINDER HEAD

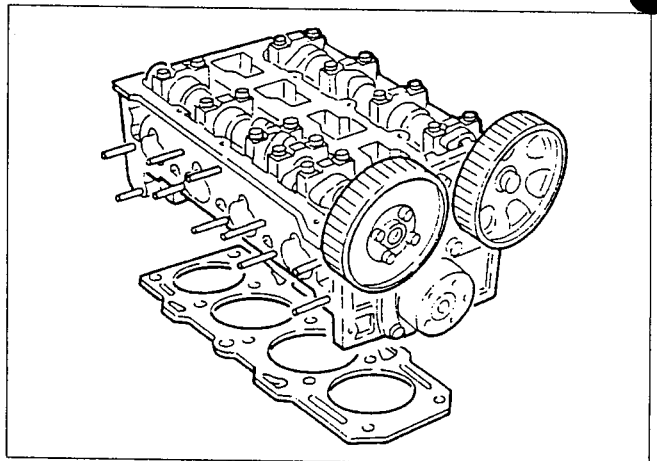
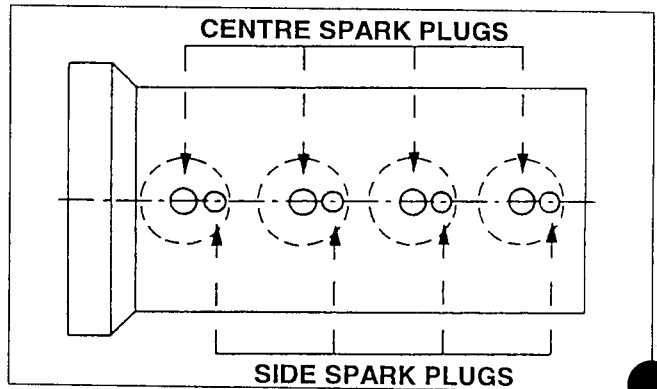
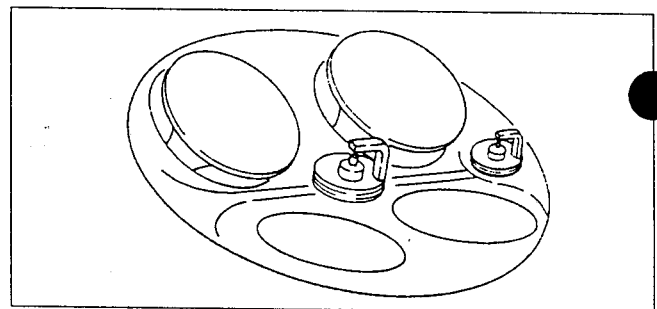
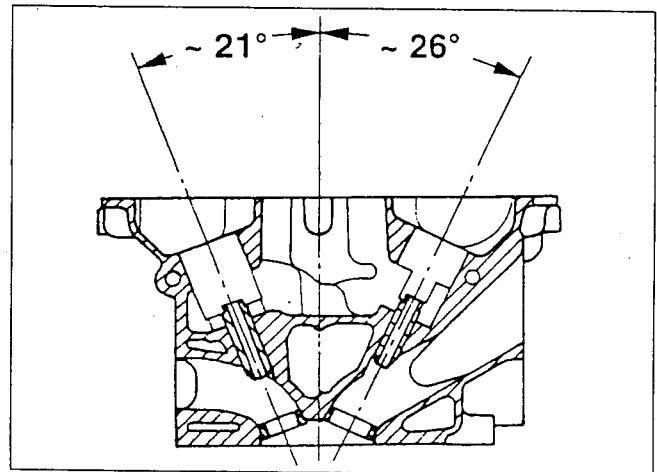
Monolith, compact, mould-cast aluminium and silicon alloy.
 The four valves per cylinder are fitted in their respective V guides at approximately 47° and are controlled by two camshafts by means of hydraulic tappets.

The space is organised so that the combustion chambers can house the four valve caps and the central and side spark plug holes without weakening the head structure.
 The central spark plugs (larger) at tightened at a torque of 25 - 35 Nm, while the side (smaller) spark plugs are fastened at a torque of 10 - 12 Nm.
 They should be replaced every 100,000 km.
 The twin spark plugs positioned in this fashion, the two intake valves and the two exhaust valves ensure uniform distribution of the mixture and optimal combustion with improved engine thermal performance and reduced harmful emission in exhaust.

The camshaft on intake side turns on six journals. The camshaft on exhaust side turns on five journals. The shafts are controlled with a timing belt.
 The valve seats are fitted in the cylinder head after it is heated to a temperature of 80°C. The seats are then cooled with liquid nitrogen. The valve guides are fitted in their seats in the cylinder head. Interference and internal diameter is perfected after assembly with a specific borer and controlled by means of a go-no-go set of gauges. The cylinder head and crankcase seal is made of aramide fibre. No head re-torque is required for the entire life of the engine.

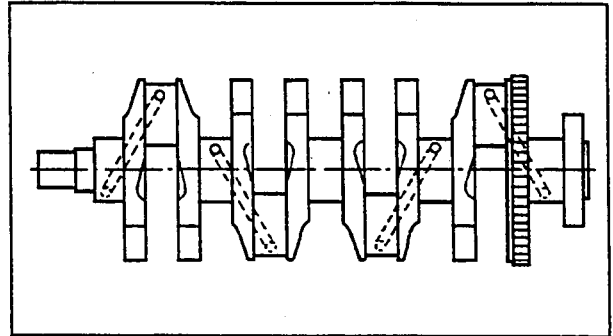
OIL SUMP

The oil sump is a structural part of the engine with mechanical functions.
 It contains the engine oil and is directly connected to the gearbox and to the rear engine mount.
 It is made of die-cast aluminium alloy and features internal shock-proof partitions.
 It is fastened to the crankcase with a specific sealant.



CRANKSHAFT

This is forged in high strength alloy steel, induction tempered on the journals and rolled on the grooves. It rests on five main bearings and its end float is adjusted by two half rings housed in the centre main bearings. Eight counterweights accurately balance the rotating masses. A groove runs inside the shaft to lubricate the main and connecting rod journals. At the rear of the crankshaft there is the phonic wheel for detecting the rpm and timing sensor.



MAIN AND ROD BEARING HALVES

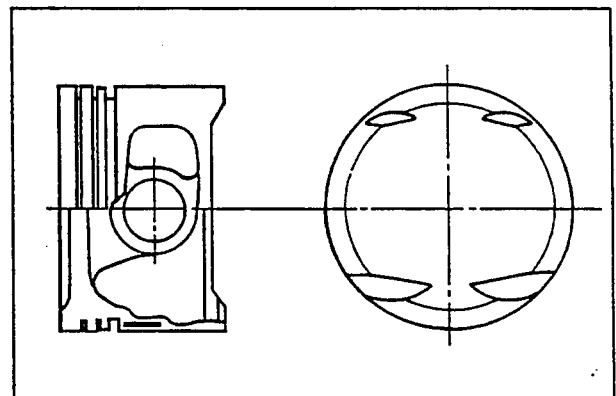
These are of the three-metal, thin shell type and they are divided into three dimensional classes.-

FLYWHEEL

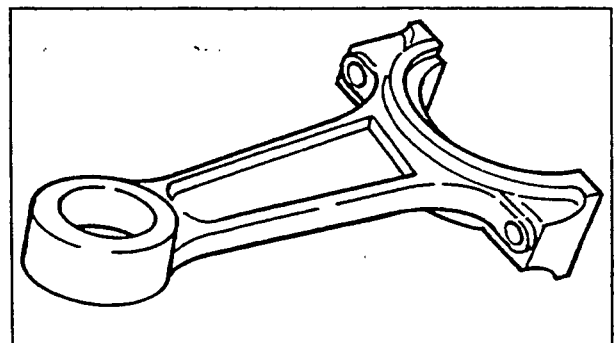
This is in cast iron with a hardened ring gear and suitably balanced.

PISTONS AND CONNECTING RODS

The pistons are in aluminium-silicium alloy with self-heating inserts and are divided into three dimensional classes. To ensure correct assembly an arrow is stamped on the piston crown to indicate the direction of rotation of the engine. The piston crown is concave and has four notches to prevent interference with the valve mushrooms.



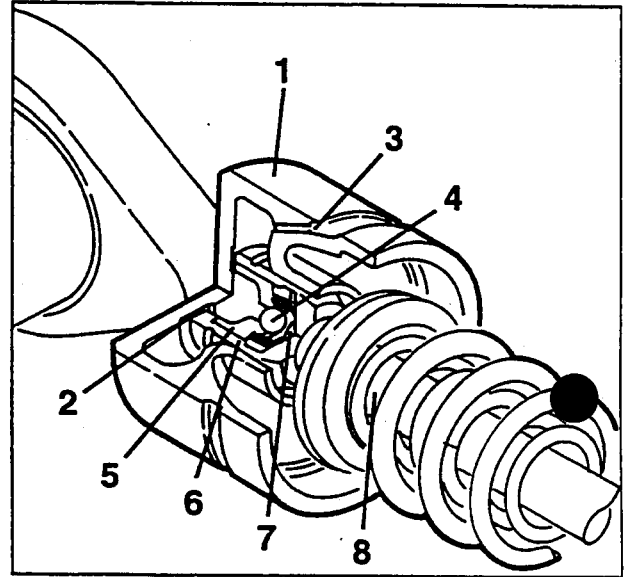
The connecting rods are in hardened and tempered alloy steel, with a bushing in copper alloy force-fitted for coupling with the piston gudgeon pin. As the gudgeon pins are floating on the piston hubs and on the main bearings force-fitted in the connecting rod small end, their side movement is stopped by two expanding circlips housed in the special hollows machined on the actual hubs.



VALVE GEAR TIMING

Direct drive by toothed belts with automatic tensioner and with overhead camshaft in cast iron with induction tempered cams and bearings. The hydraulic tappets, in contact with the cams, control the valves directly. This device automatically eliminates "valve play" when the engine is running thereby dramatically reducing the need for periodical maintenance.

1. Cup
2. Oil passage between chambers
3. Oil inlet groove
4. Check valve
5. Piston
6. Cylinder
7. Pressure chamber
8. Valve stem



The stem of the exhaust valves is chromium plated and has a cavity inside filled 50 ÷ 60% with sodium to improve dispersion of the heat to which they are subjected.

The valve seats are sintered and made from material suitable for the use of unleaded petrol.

TIMING VARIATOR

This is of the simplified type which ensures considerable timing precision, rapid intervention and high mechanical reliability. It is coupled to the intake pulley and fitted with two half bearings which support it. The inner part is nitrided and an O-Ring keeps the oil inside when the engine is not running. In order to reduce the size of the engine, the actuation valve seat has been machined on the intake manifold with suitable grooves which also involve the cylinder head, to regulate the flow of oil to the variator.

- The purpose of this device is to change the intake valve timing according to the engine load and speed required; this parameter is received and processed by the control unit in the form of an electric signal sent by the air flow meter and rpm sensor and transmitted as a command to the electromagnet via a relay.

- When the closed phase is required (idling and full power area), the electromagnet (1) is de-energized, thus the valve distributor (2) pushed by the counter spring (3), stays up preventing the passage of the oil leading from groove (A) from reaching the variator.

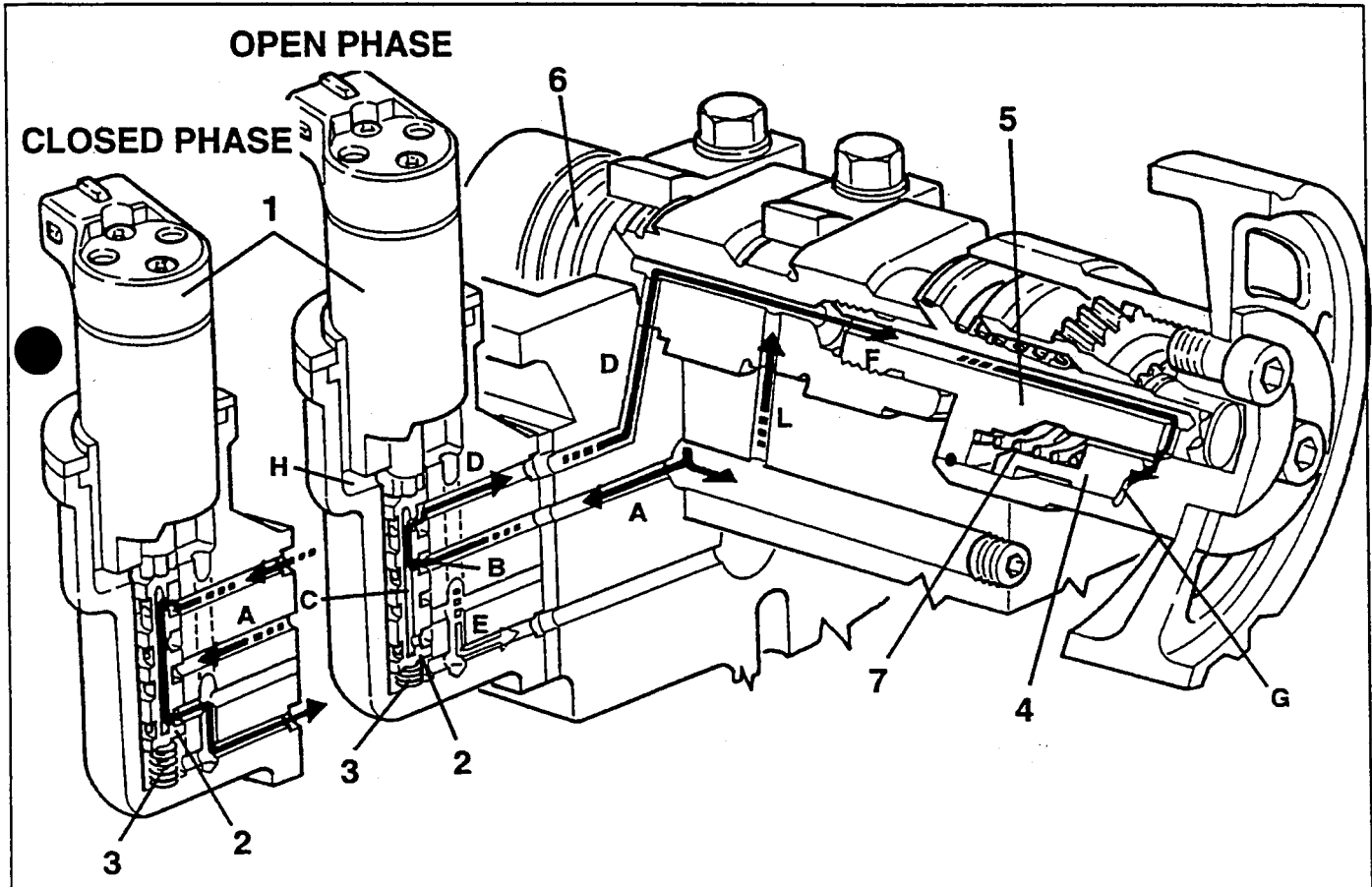
In this case the timing of the intake valves remains unchanged (closed).

- If the open phase is required (average speeds at high torque), the electromagnet (1) is energized, thus pushing the valve distributor (2) downwards. In this position the oil, leading from groove (A), enters chamber (B) of the piston, from where it passes through a special hole into groove (C) machined inside the latter.

The oil can only leave this groove through the upper hole (in communication with the oil delivery duct (D) to the variator) as the lower hole no longer leads to the exhaust duct (E) because the valve distributor (2) is lowered. The oil passes through duct (D) and (F) and reaches the chamber (G) moving piston (4) axially towards the engine. The outside of piston (4) is fitted with helical teeth and as a result of the above-mentioned axial movement it is forced to move clockwise (as seen from the timing side). The rotation is transmitted through a straight-toothed grooved profile to the pinion (5) which is screwed onto the threaded lug of the camshaft (6) and transmits the rotation to the shaft. This way the timing of the intake valves is changed by 25°.

When the electromagnet is de-energized, the valve distributor (2) returns to its initial position, shutting off the flow of pressurised oil to the piston (4), but allowing the oil to return to the exhaust due to the thrust of the counter spring (7).

- Duct (L) enables the camshaft journal to be lubricated under the various operating conditions.
- The oil which leaks into the electromagnet chamber (H) is discharged through the drainage hole (E).



LUBRICATION

The rotary lobe pump (3) fitted on the front of the crankcase is activated directly by the crankcase through keying. The oil withdrawn from the sump by a suction device (1) is filtered by the gauze filter on the suction device and then sent under pressure by the pump through a duct to the full-flow cartridge oil filter (6) fitted with a by-pass safety valve, which ensures that the oil passes even if the cartridge is clogged.

A water-oil heat exchanger (5) is installed on the filter support to keep the oil temperature within the optimum limits.

The maximum lubricating pressure is regulated by a special limiting valve (4) fitted on the pump.

After being filtered, the oil passes through a duct machined on the front engine cover and reaches the main longitudinal delivery duct in the crankcase.

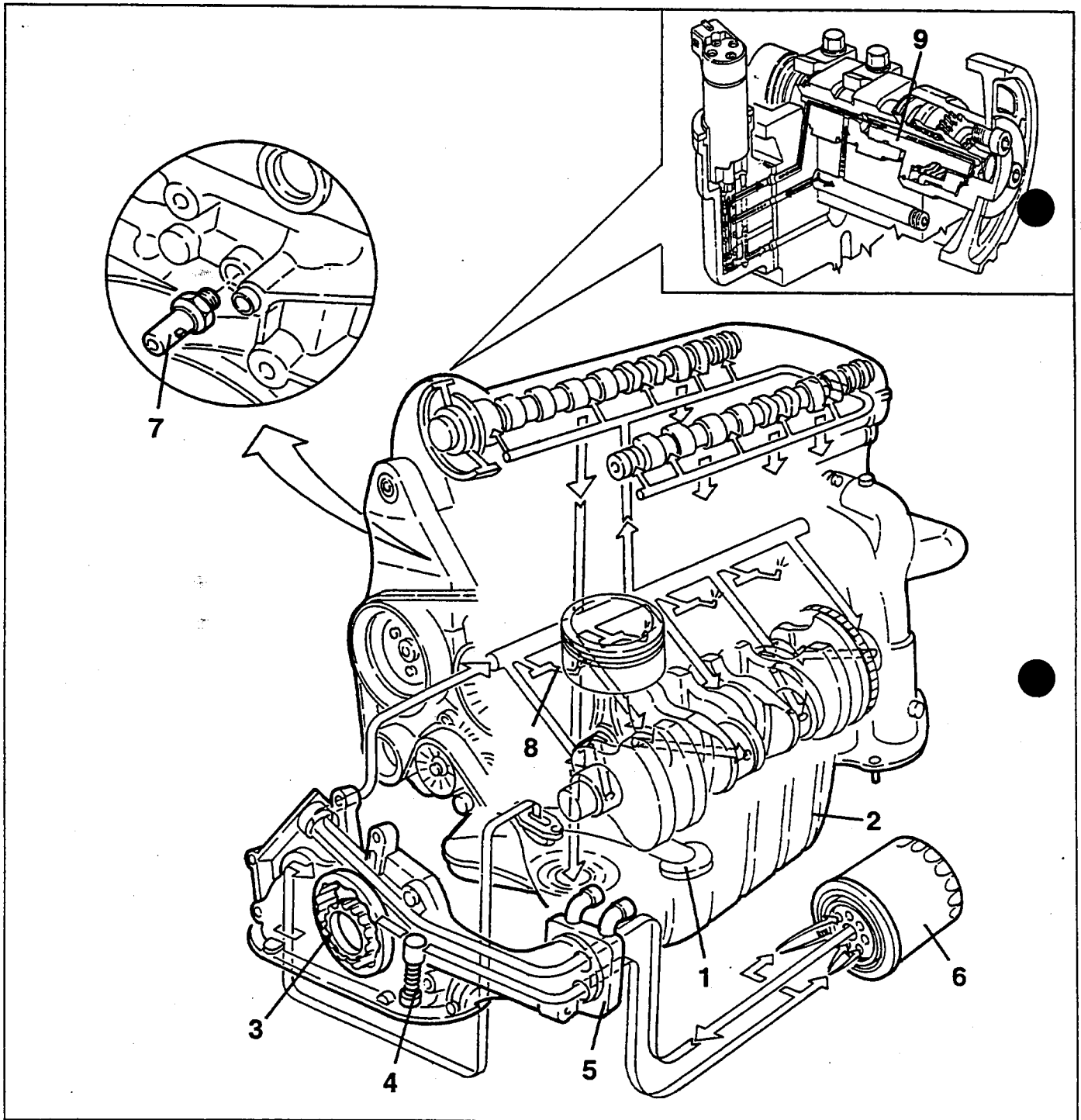
From here, it is then sent along five ducts to the grooves of the main bearings and from these to those of the connecting rod journals via special ducts machined in the crankshaft.

To improve the cooling of the piston skirts the crankcase is fitted with spray jets (8) with built-in ball valve which opens at a pressure of 2.25 ÷ 2.75 bar.

From the main longitudinal duct in the crankcase, a vertical duct branches off which lubricates the camshaft bearings. On the intake side of the camshaft lubricating duct there are two special channels through which the oil for operating the timing variator passes. The recovery circuit is formed of a few ducts located in the cylinder head which collect the oil leading from the outlets and then drain it from the head from which it falls back into the sump.

The lubricating system is fitted with an oil vapour recirculation system which recovers the vapours leading from the sump and from the cylinder head. The system is fitted with a minimum engine oil pressure sensor (7) which indicates insufficient lubricating pressure by turning on the warning light on the instrument cluster.

On some versions there is also the engine oil temperature sensor, minimum engine oil warning light sensor and the engine oil pressure sender (see the corresponding paragraph for further details).



- 1. Suction device with gauze filter
- 2. Oil sump
- 3. Oil pump
- 4. Pressure limiting valve
- 5. Heat exchanger.

- 6. Filter with safety by-pass valve
- 7. Engine oil minimum pressure warning light sensor
- 8. Spray jets
- 9. Timing variator

INTRODUCTION

The instructions contained in the following paragraphs refer to complete engine bench overhaul after removing the engine from the vehicle. The instructions are organised as follows:

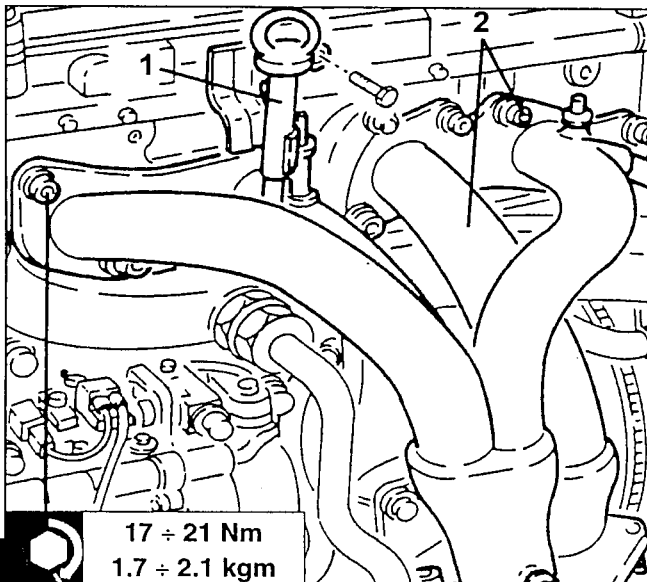
- **Engine removal:**
removal of engine accessories and components and disassembly of the main engine assemblies.
- **Cylinder head disassembly and overhauling:**
complete overhauling of component parts.
- **Crankcase overhauling:**
complete overhauling of component parts.
- **Refitting precautions:**
specific refitting operations which mainly differ from the removal instructions.
- **Lubrication electrical circuit checks.**

All the disassembly procedures described in the following paragraphs should be reversed for refitting, unless specifically indicated. The following procedures refer to complete engine overhauling. Some procedures, however, can be used separately for some parts only when required for specific components.

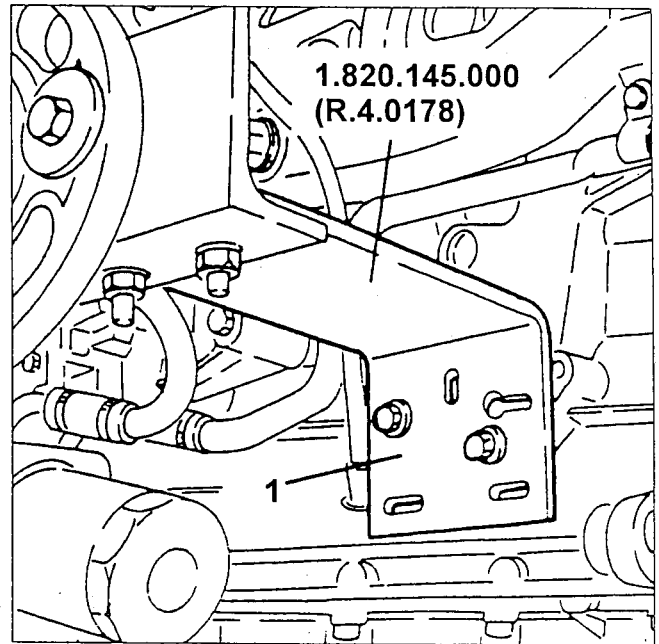
ENGINE REMOVAL

PRELIMINARY OPERATIONS

- Loosen the fastening nuts and remove the exhaust manifold guard.
- 1. Loosen the fastening screw and remove the oil dipstick.
- 2. Loosen the fastening nuts and remove the exhaust manifold.

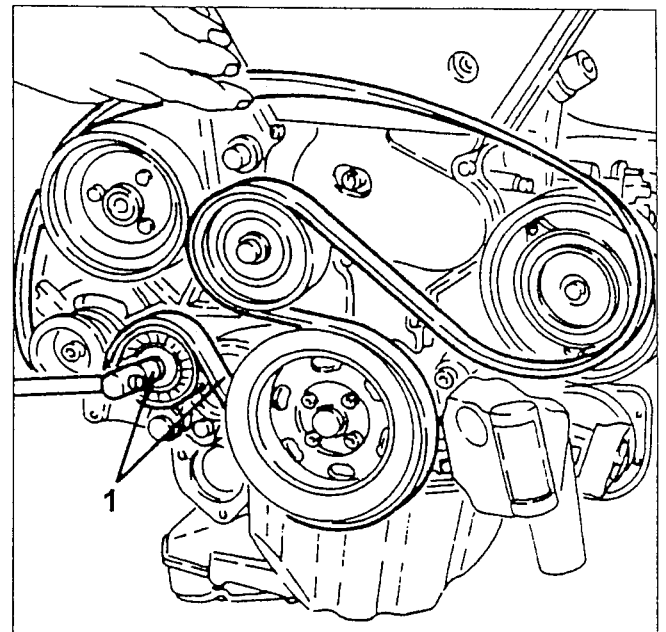


1. Position the engine on a specific overhaul stand with brackets no. 1.820.145.000 (R.4.0178).



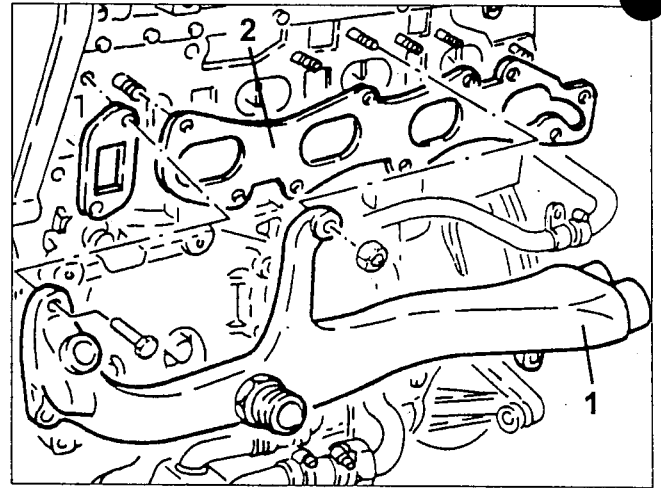
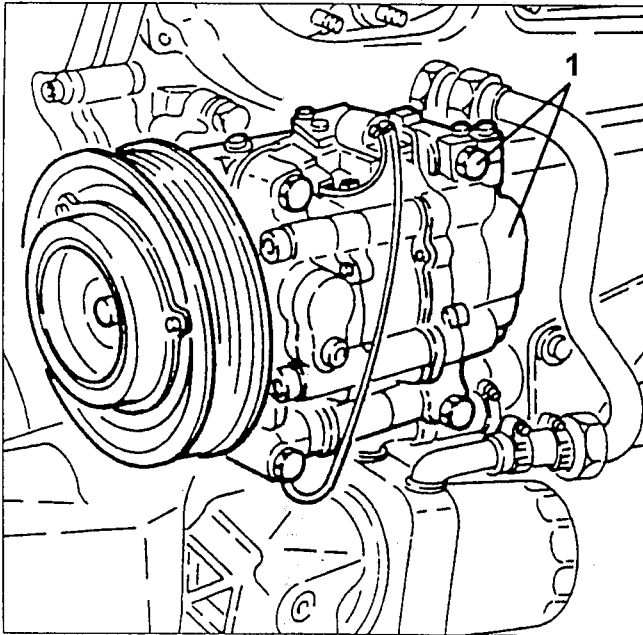
CLIMATE CONTROL COMPRESSOR REMOVAL

1. Loosen the belt-take up device as shown in the figure. Loosen the auxiliary unit drive belt and remove it.





1. Loosen the four fastening screws and remove the climate control compressor.

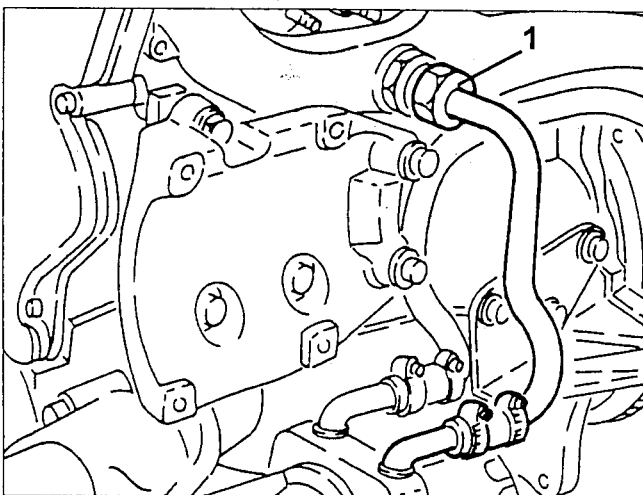


INTAKE MANIFOLD REMOVAL (pre-change versions)

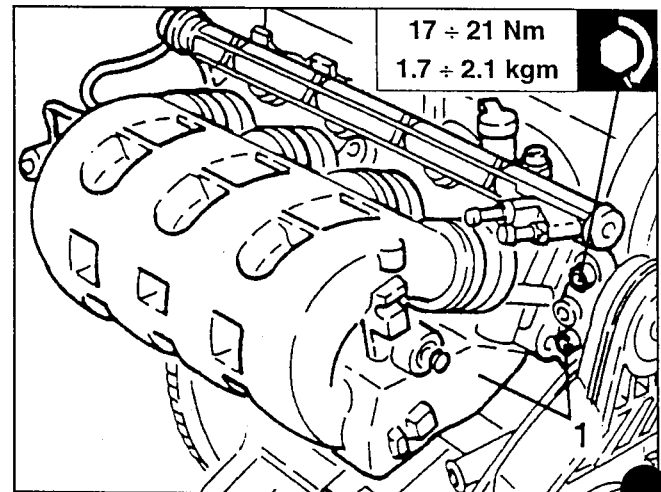
1. Loosen the fastening nuts and remove the intake manifold.
- Remove the respective seal.

ENGINE COOLANT MANIFOLD REMOVAL

1. Disconnect the engine oil heat exchanger outlet pipe from the pump coolant return manifold.

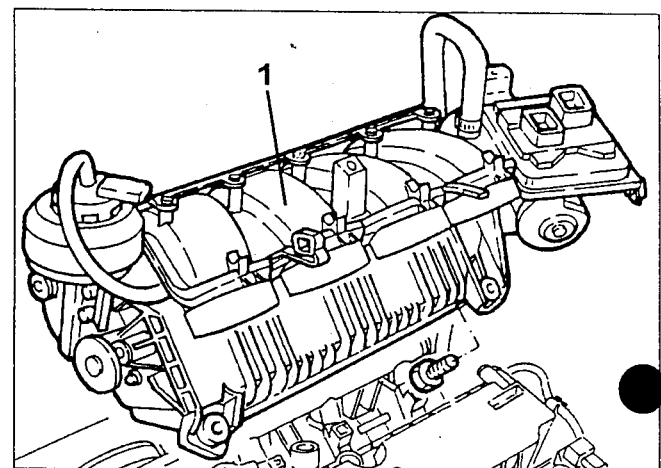


1. Loosen the fasteners and remove the pump coolant manifold and respective seal.
2. Remove the exhaust manifold seal.



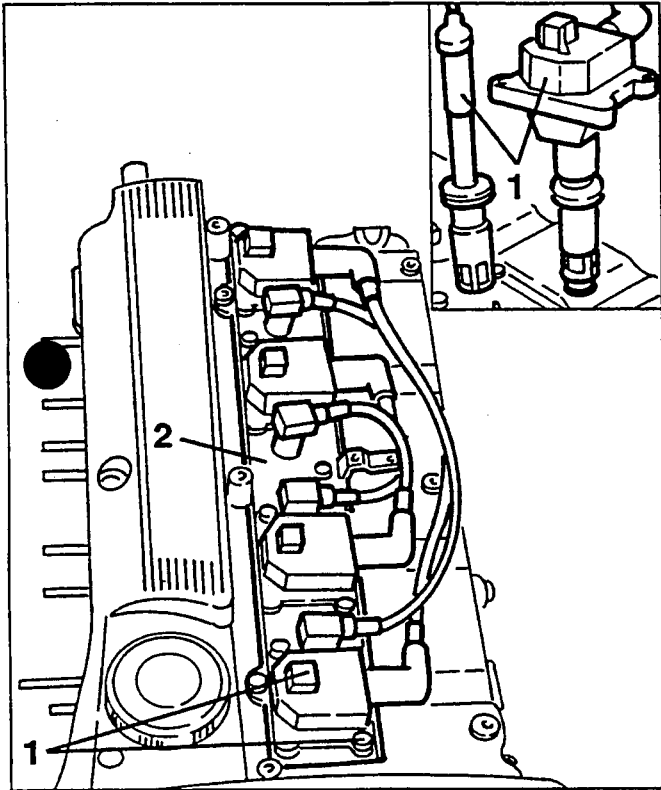
INTAKE MANIFOLD REMOVAL (post-change versions)

1. Loosen the fastening nuts and remove the intake manifold.
- Remove the respective seal.

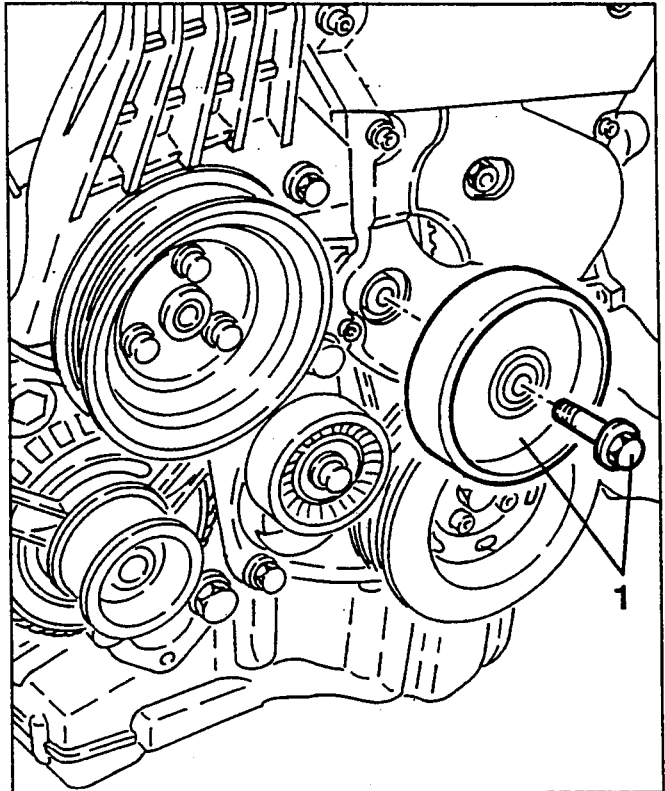


REMOVING THE IGNITION COILS

1. Slacken the fastening screws and remove the ignition coils complete with spark plug cables.
 2. Slacken the fastening screws and ignition coils support bracket.
- Remove the spark plugs.

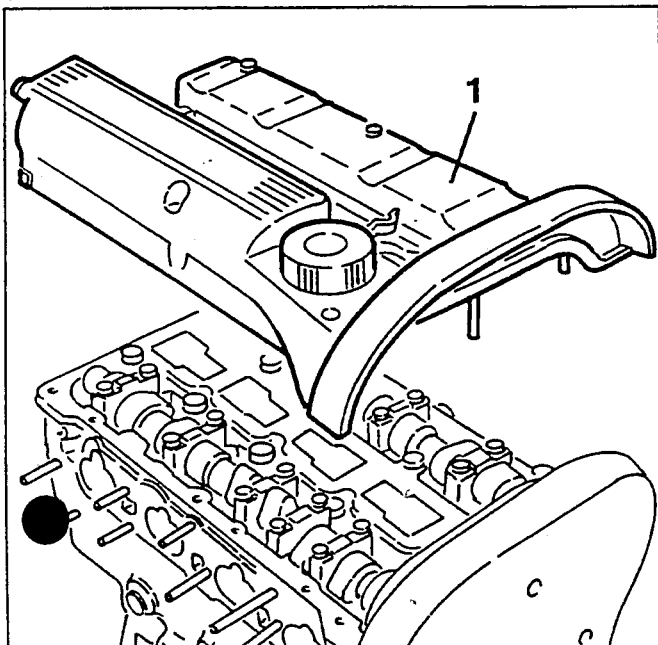


1. Slacken the fastening screw and remove the auxiliary components drive belt guide pulley.

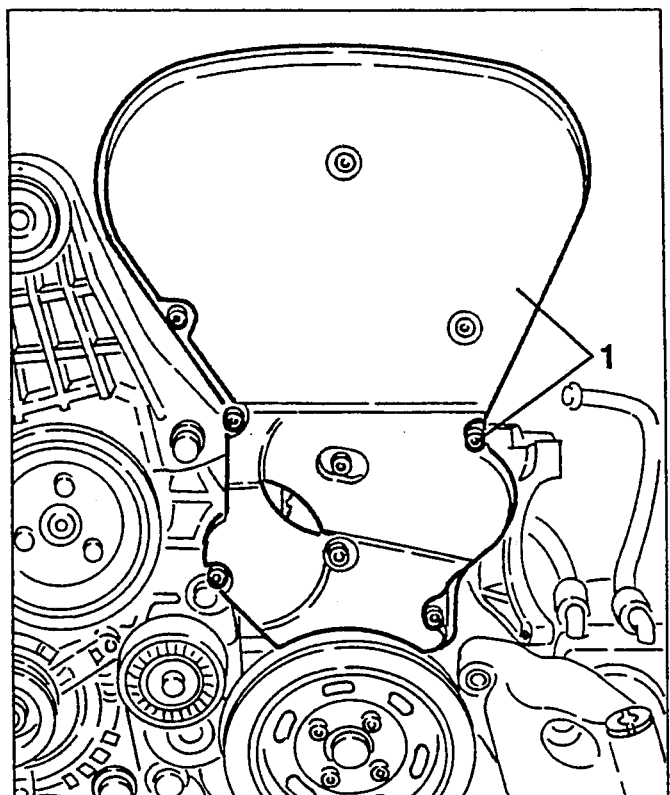


REMOVING THE TIMING GEAR DRIVE BELT

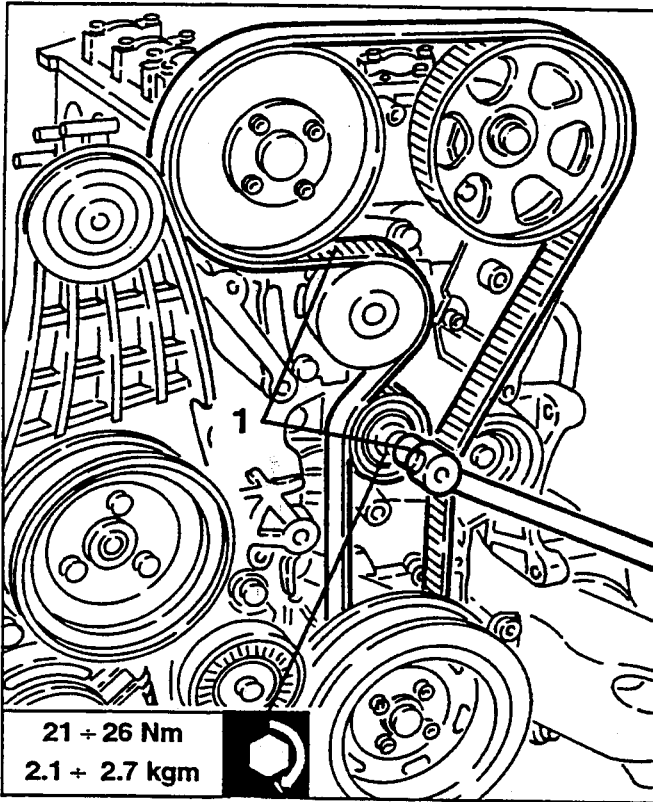
1. Slacken the fastening screws and remove the tappet cover complete with seal.



1. Slacken the fastening screws and remove the timing gear belt protective cover.

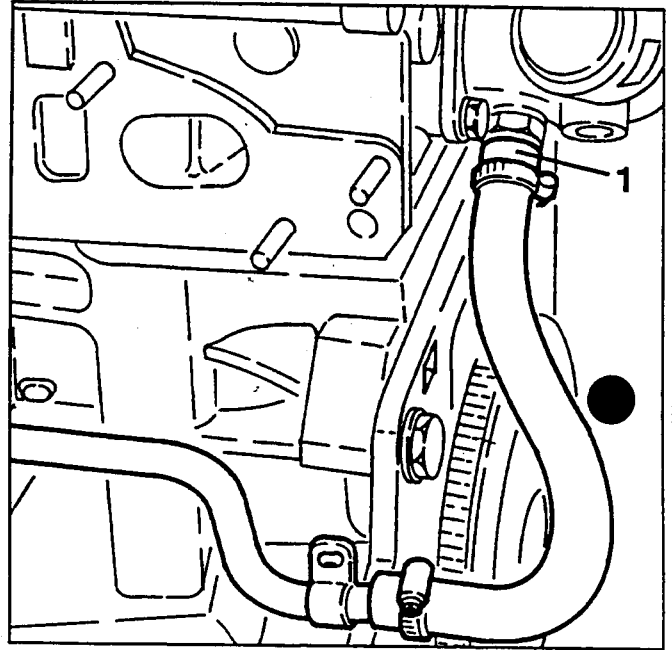


1. Slacken the timing gear belt tensioner, then remove the belt from the camshaft drive pulleys.

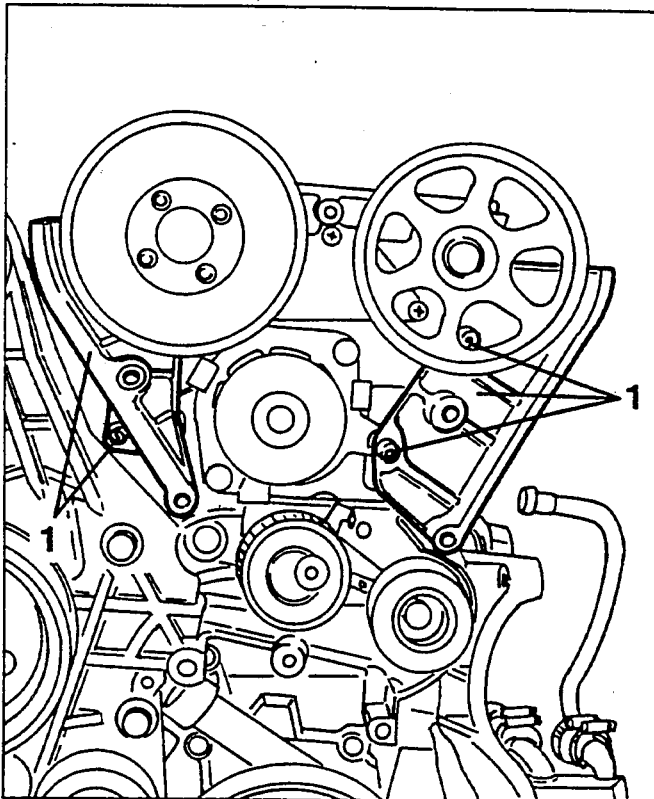


REMOVING THE CYLINDER HEAD

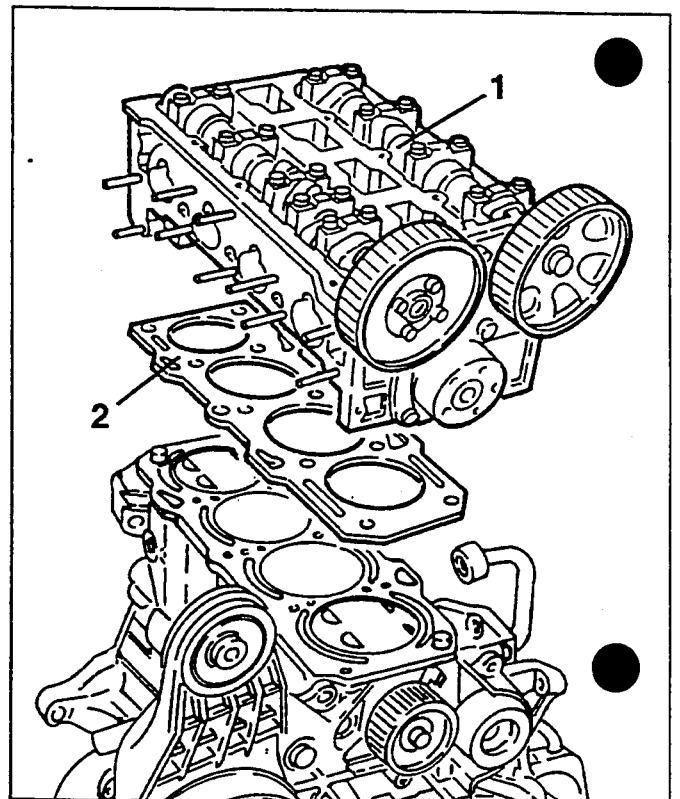
1. Disconnect the coolant fluid delivery pipe to the engine oil heat exchanger from the thermostatic cup.



1. Slacken the fastening screws and remove the timing gear belt side guards.

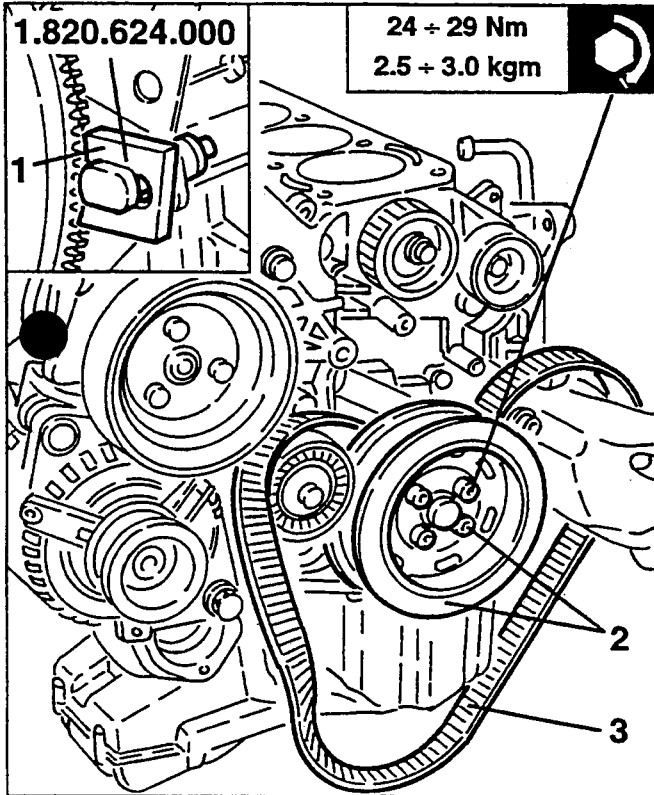


1. Slacken the fastening screws and remove the cylinder head.
2. Remove the associated seal.

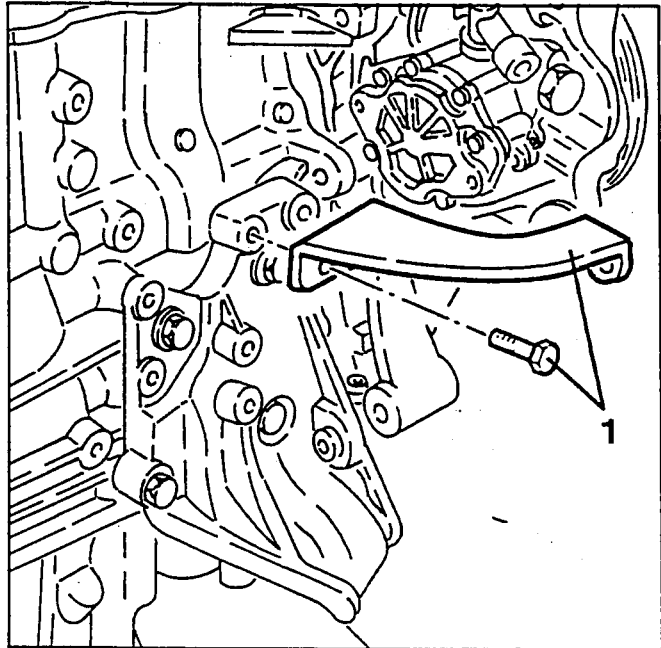


REMOVING THE AUXILIARY COMPONENTS BELT DRIVE PULLEY

1. Install the flywheel stopper tool, no. 1.820.624.000.
2. Slacken the four fastening screws and remove the auxiliary components drive belt pulley.
3. Withdraw and remove the timing gear drive belt.



1. Slacken the two fastening screws and remove the upper alternator support bracket.

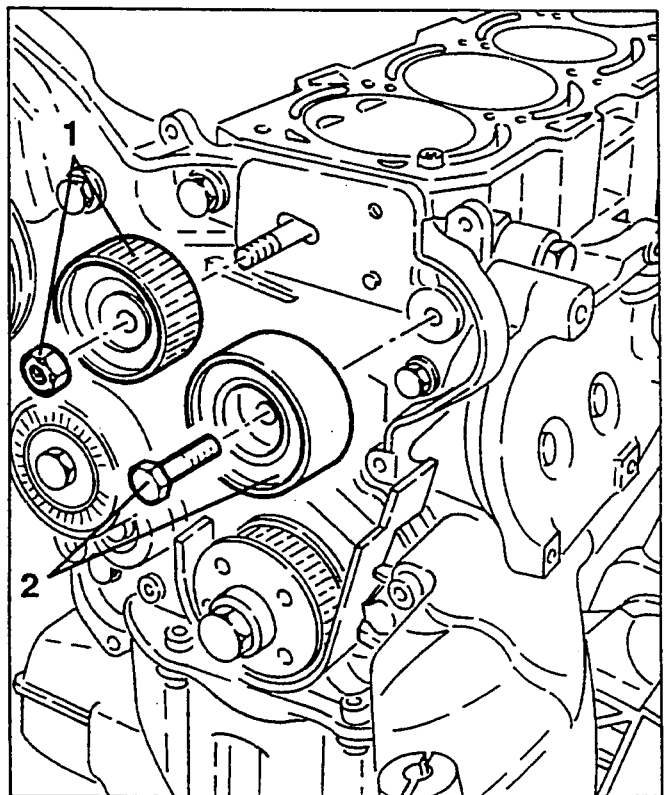
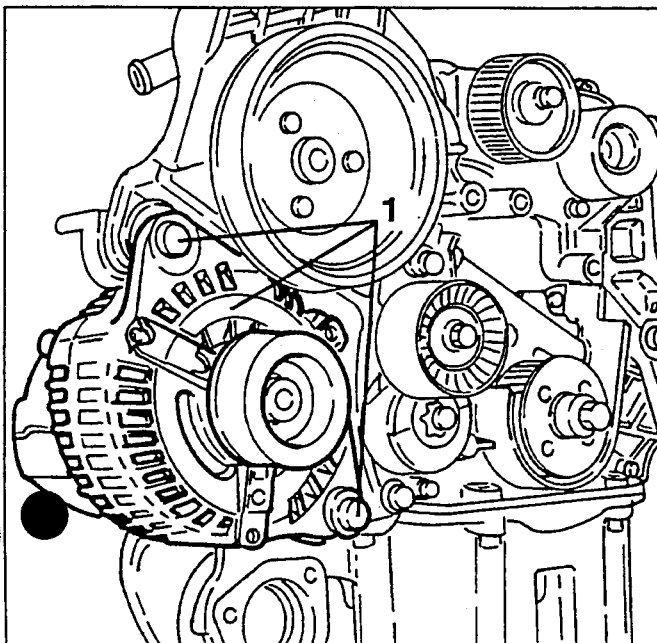


REMOVING THE ALTERNATOR AND POWER STEERING PUMP SUPPORT

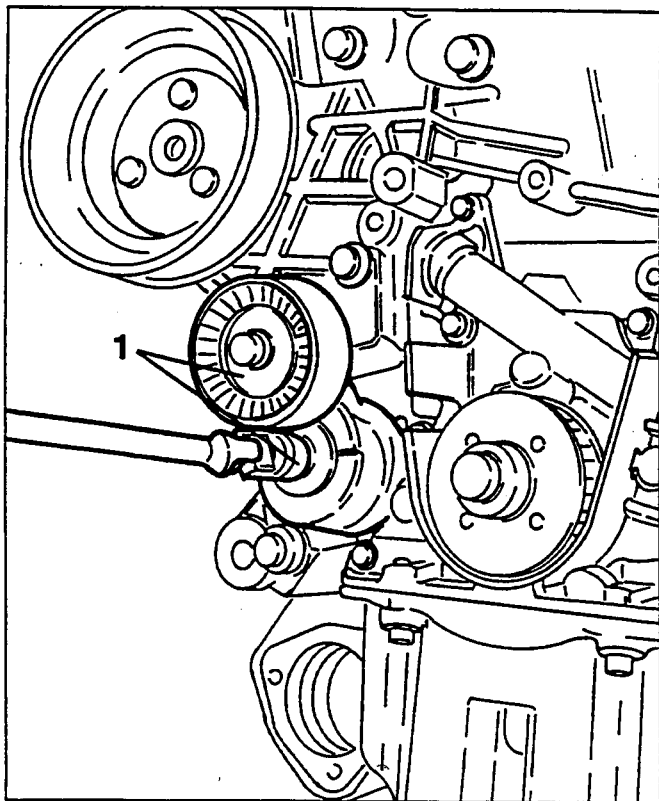
1. Slacken completely the nut loosened previously and remove the timing gear belt tensioner.
2. Slacken the fastening screw and remove the timing gear belt guide pulley.

REMOVING THE ALTERNATOR

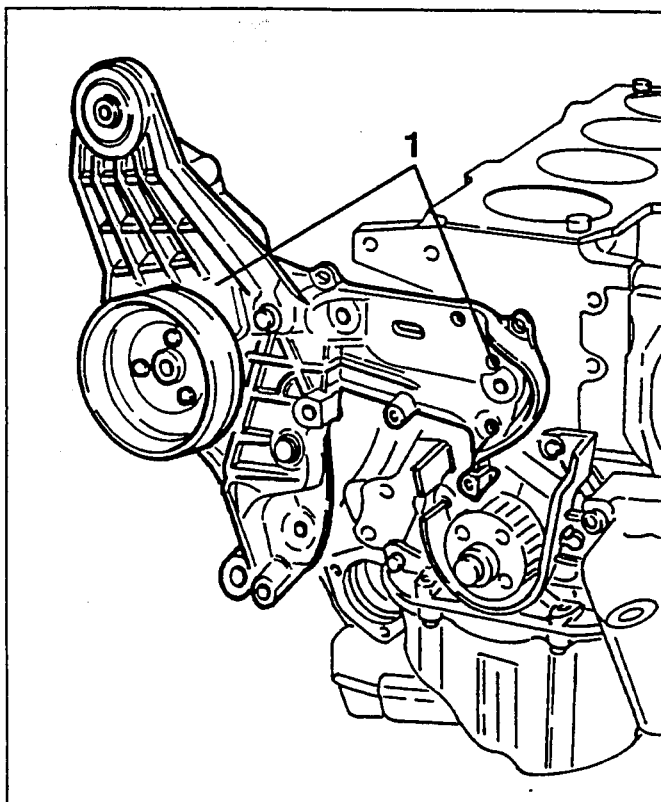
1. Slacken the two fastening bolts and remove the alternator.



1. Slacken the fastening screw and remove the auxiliary components drive belt tensioner.

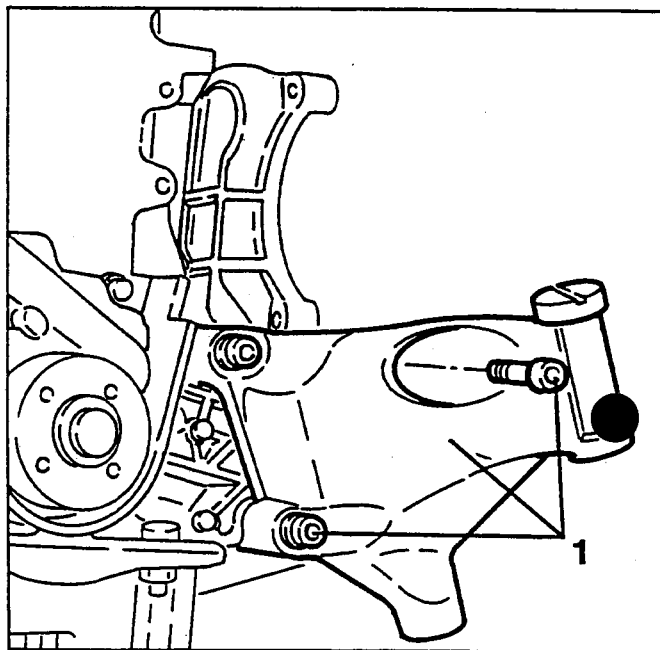


1. Slacken the fastening screws and remove the alternator and power steering pump support complete with the pump and, if necessary, separate them on the bench.



REMOVING THE POWER UNIT FRONT SUPPORT

1. Slacken the three fastening screws and remove the power unit front support.

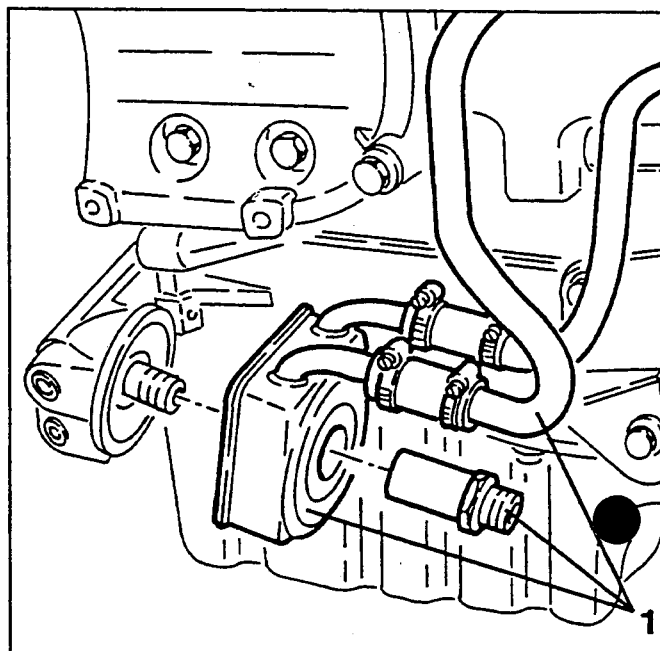


REMOVING THE ENGINE OIL COOLING FLUID HEAT EXCHANGER

- Remove the engine oil filter.

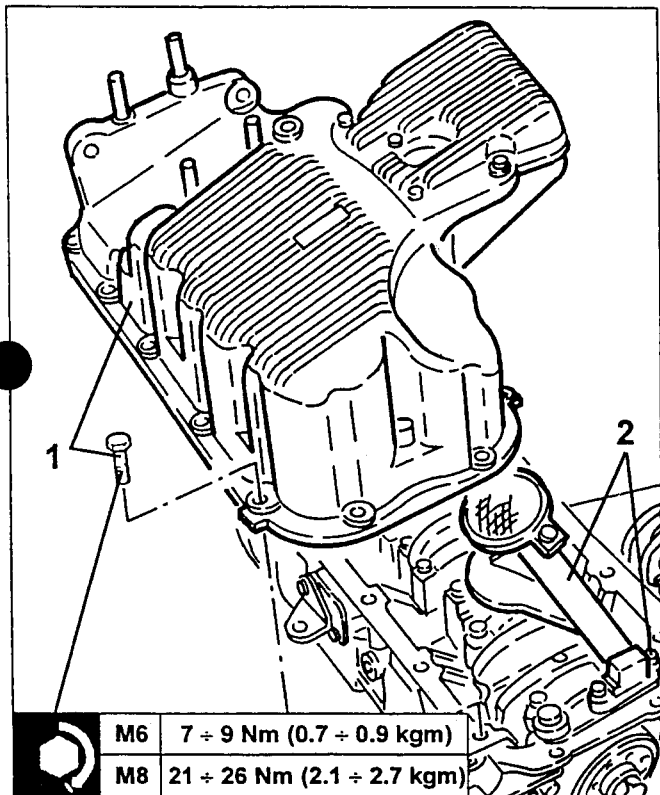
1. Slacken the fastening pin and remove the heat exchanger complete with coolant fluid inlet and outlet pipes.

- Remove the O-Ring.



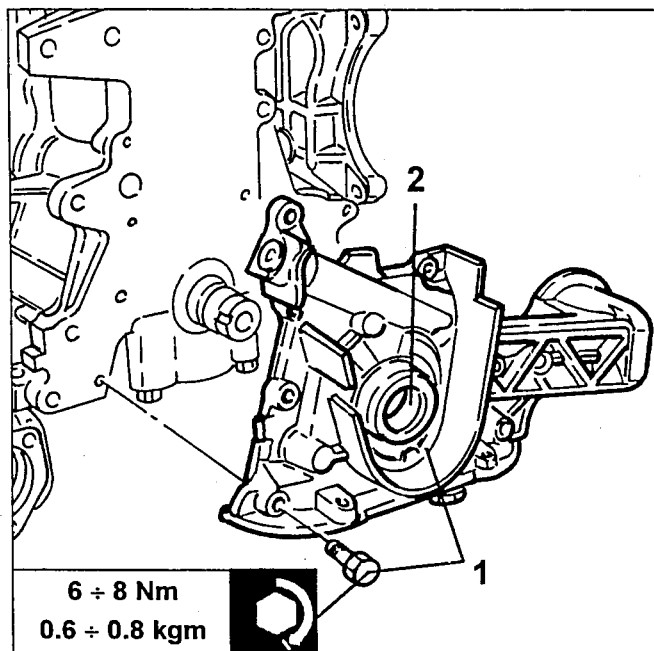
REMOVING THE OIL SUMP

1. Turn the engine on the overhauling stand, then slacken the fastening screws and remove the oil sump.
2. Slacken the two fastening screws and remove the suction device with its seal.



REMOVING THE ENGINE OIL PUMP

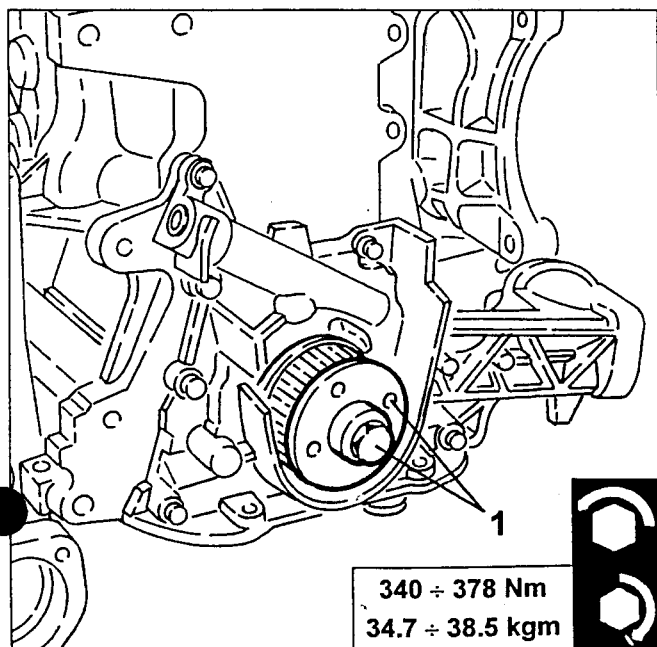
1. Slacken the fastening screws and remove the engine front cover with incorporated oil pump.
2. Prise and remove the crankshaft front oil seal.



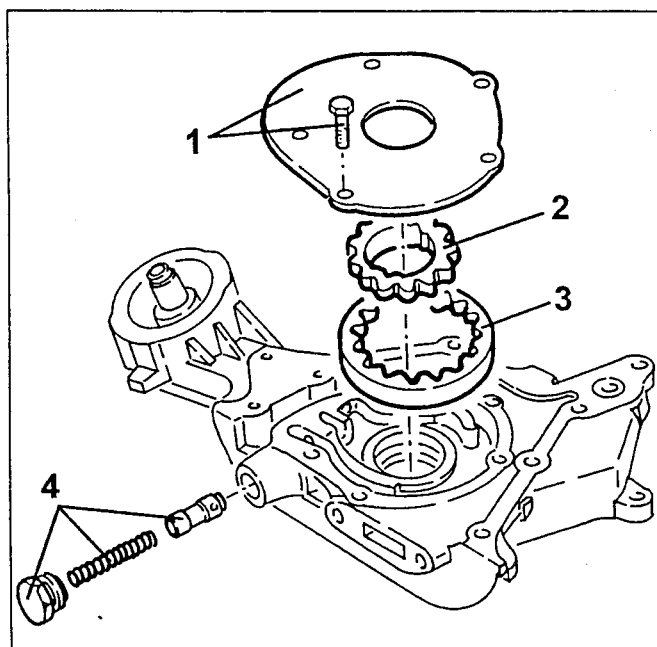
When refitting the crankshaft front oil seal, after fitting it on the oil pump assembly and assembling this on the crankcase, use tool no. 1.821.247.000.

REMOVING THE TIMING GEAR DRIVE BELT PULLEY

1. Slacken the left-handed screw and remove the camshaft drive belt pulley.

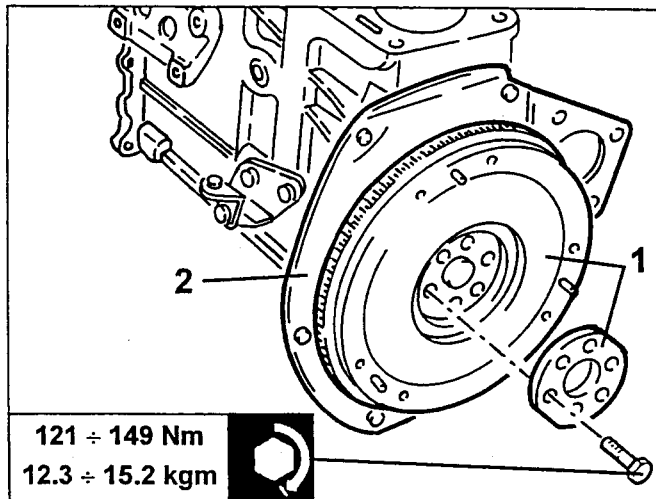


1. On the bench, slacken the fastening screws and remove the engine oil pump cover.
2. Remove the driving gear.
3. Remove the driven gear.
4. Slacken the fastening pin and remove the spring and the engine oil pump overpressure sliding valve.



REMOVING THE FLYWHEEL

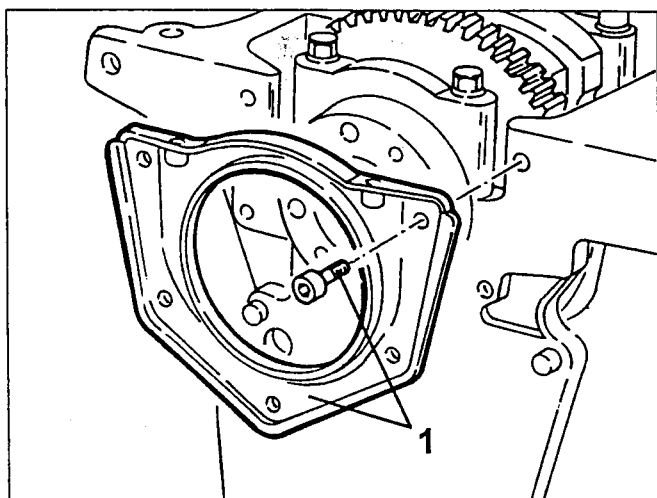
1. Slacken the fastening screws and remove the flywheel.
2. Retrieve the flywheel cover.



- Remove the flywheel stopper tool installed previously.

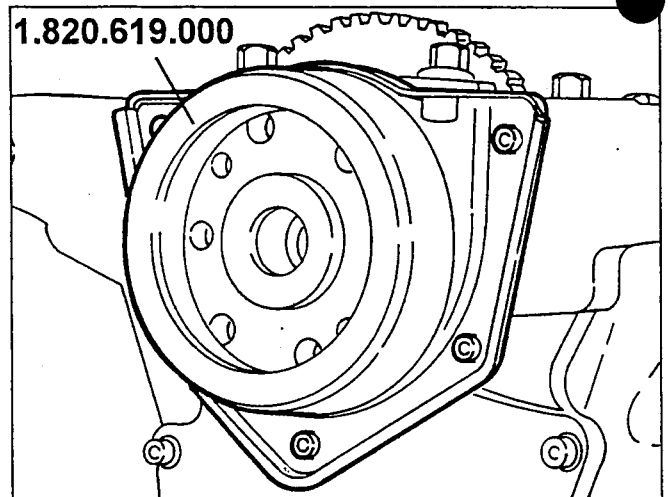
REMOVING THE CRANKCASE REAR COVER

1. Slacken the fastening screws and remove the crankcase rear cover with incorporated oil seal ring.



Refit the rear cover as follows:

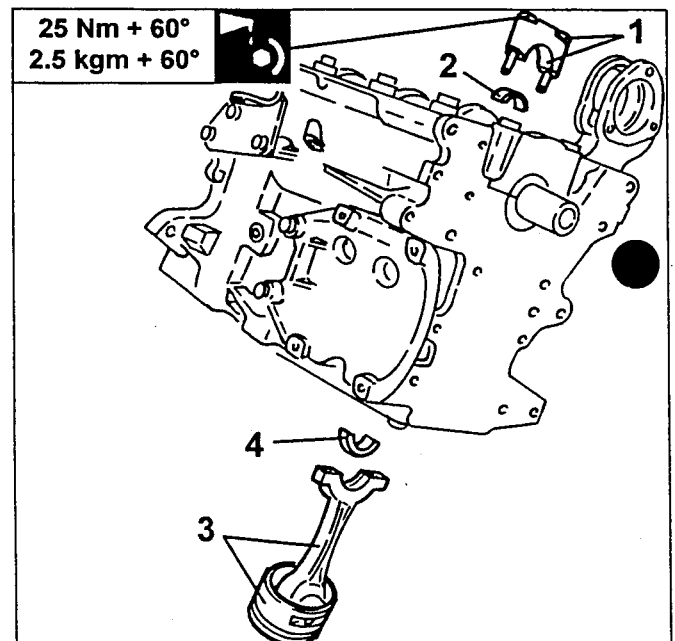
- fit tool no. 1.820.619.000 on the oil seal of the rear crankcase cover;
- fit the tool - rear cover together and tighten the screws fastening to the crankcase; the tool should be removed only after also tightening the screws fastening the rear cover to the oil sump.



REMOVING THE PISTONS AND CONNECTING RODS

- Turn the crankshaft so that the pistons of the 1st and 4th cylinder reach the T.D.C.

 1. Slacken the fastening screws and remove the connecting rod caps of the 1st and 4th cylinder.
 2. Remove the corresponding connecting rod half bearings.
 3. Withdraw the pistons and connecting rods of the 1st and 4th cylinder
 4. Remove the corresponding connecting rod half bearings.



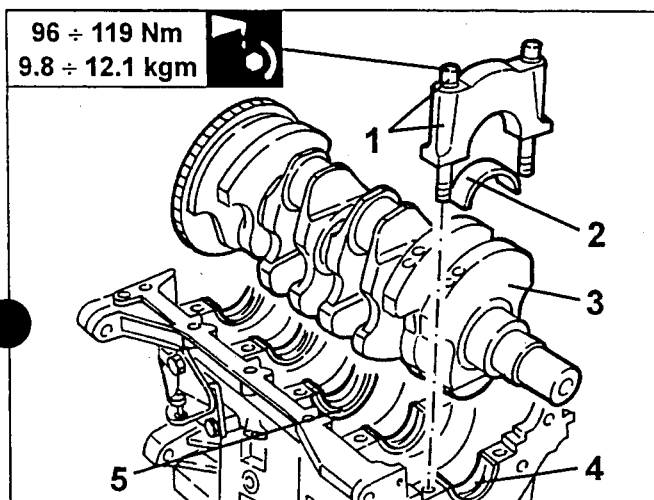
- Proceed in the same way for the 2nd and 3rd cylinder.
- Using a suitable tool, remove the seal rings and scraper ring from the piston.

WARNING: Proceed with care to avoid accidentally breaking any re-usable rings.

- Remove the two gudgeon pin circlips.
- Remove the gudgeon pin and separate the piston from the connecting rod.

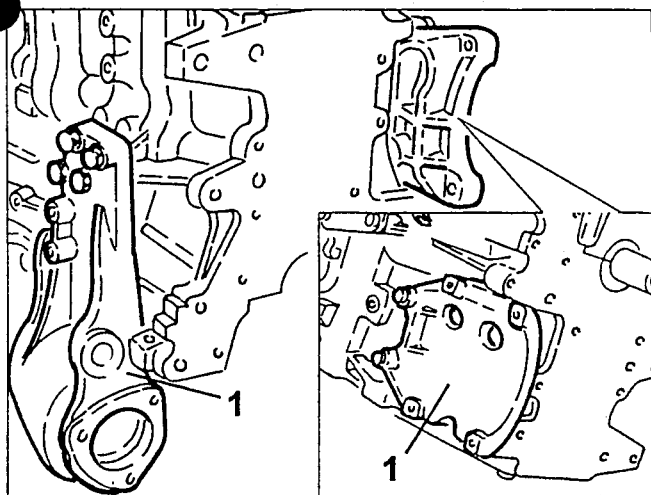
REMOVING THE CRANKSHAFT

1. Slacken the fastening screws and remove the main bearing caps.
2. Remove the corresponding main half bearings.
3. Remove the crankshaft.
4. Remove the main half bearings from the supports.
5. Remove the two half thrust rings.



- If necessary, slacken the fastening screw and remove the engine oil spray jets for lubricating and cooling the pistons from the crankcase.

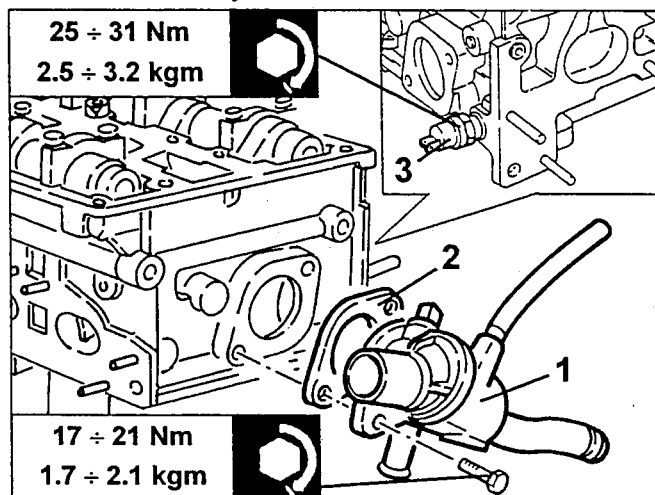
1. If necessary, slacken the fastening screws and remove the air conditioner compressor and layshaft support brackets from the crankcase.



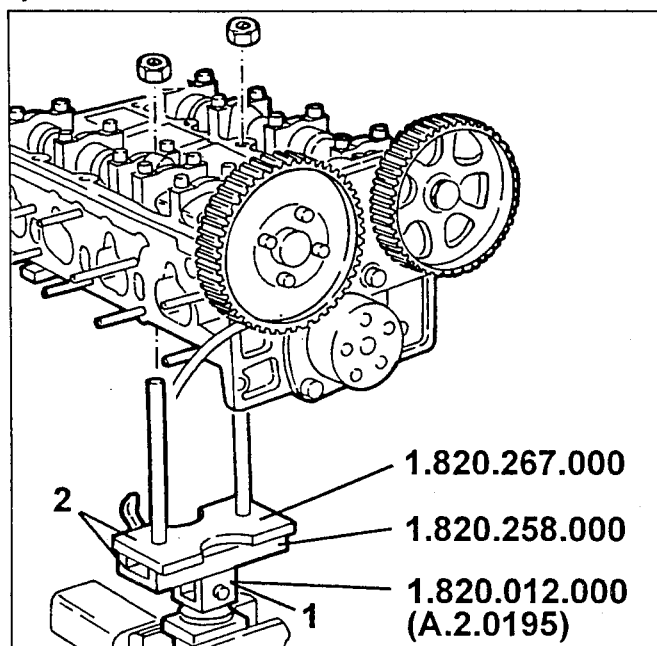
CYLINDER HEAD DISASSEMBLY

PRELIMINARY OPERATIONS

1. Slacken the fastening screws and remove the thermostatic cup complete with piping from the cylinder head.
2. Remove the corresponding seal.
3. Remove the engine coolant temperature gauge transmitter and maximum temperature warning light contact from the cylinder head.

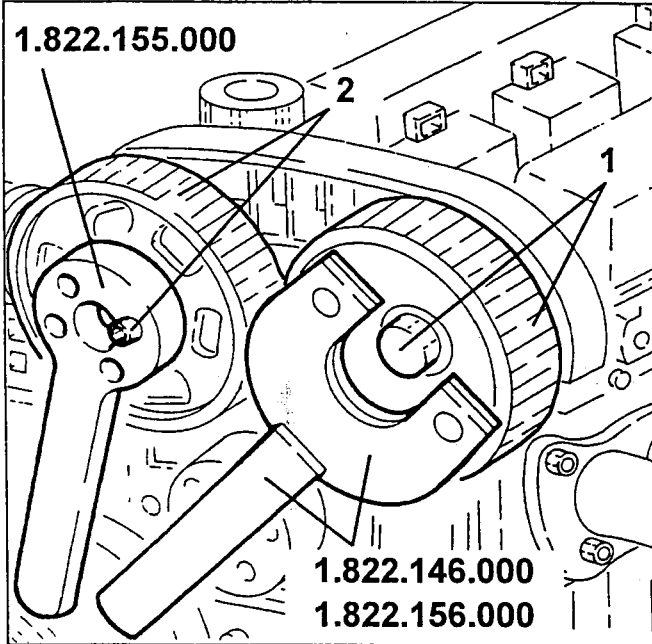


1. Fasten swivel support no. 1.820.012.000 (A.2.0195) in a vice.
2. Fasten tools no. 1.820.258.000 and no. 1.820.267.000 on the swivel support, then fasten the cylinder head on them.

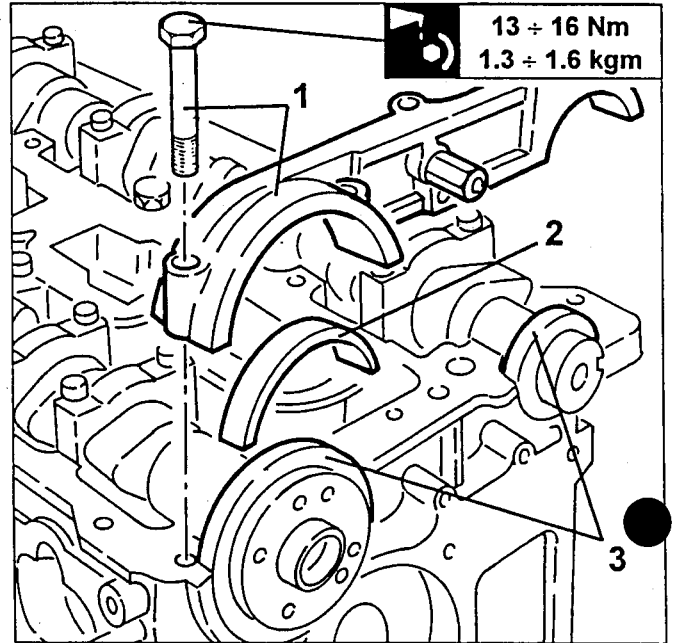




1. Slacken the fastening screw using tools no. 1.822.146.000 and no. 1.822.156.000 and remove the exhaust side camshaft drive pulley.
2. Slacken the fastening screws using tool no. 1.822.155.000 and remove the intake side camshaft drive pulley.

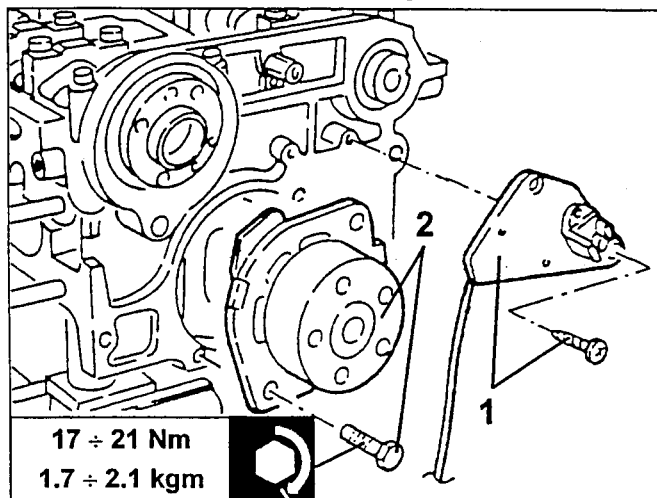


2. Remove the intake side half bearing.
3. Remove the oil seal rings from the camshafts.

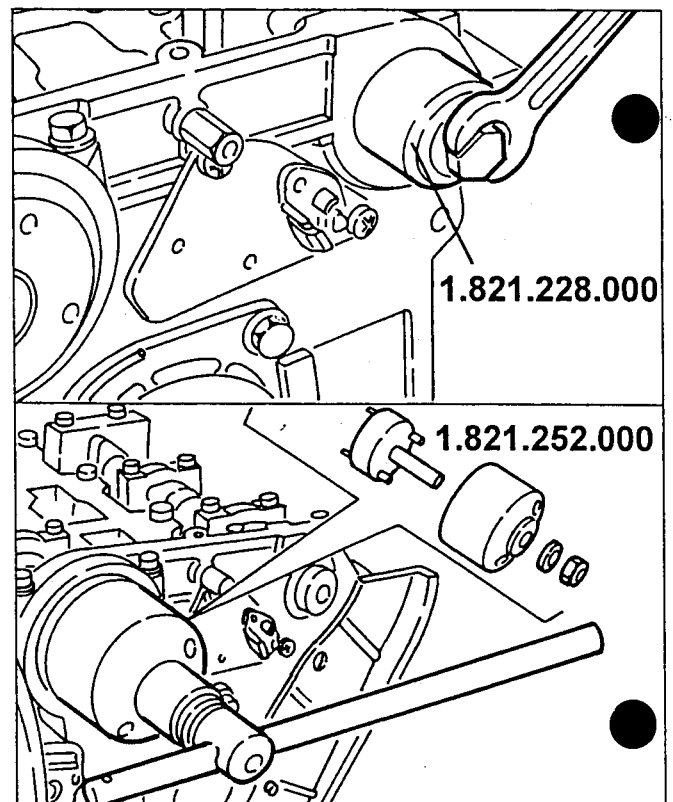


REMOVING THE WATER PUMP

1. Slacken the two fastening screws and remove the timing sensor complete with support.
2. Slacken the two fastening screws and remove the water pump complete with O-ring.



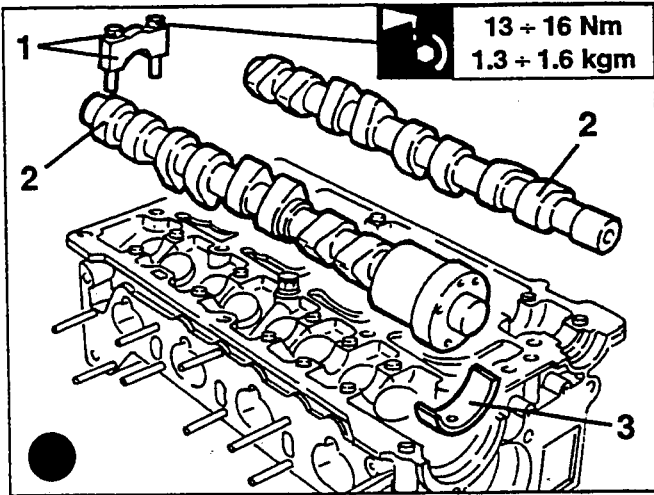
When refitting using tool no. 1.821.228.000 insert the exhaust side oil seal.
Using tool no. 1.821.252.000 insert the intake side oil seal.



REMOVING THE CAMSHAFTS

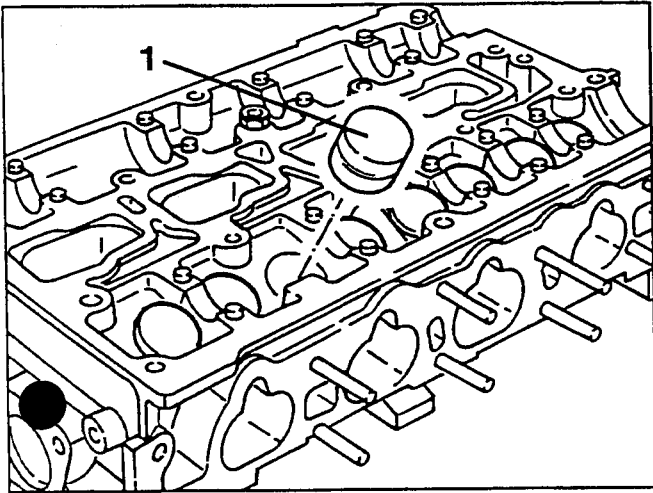
1. Slacken the four fastening screws and remove the camshaft front cap.

1. Slacken the fastening screws and remove the camshaft caps.
2. Remove the camshafts.
3. Remove the intake side half bearing.

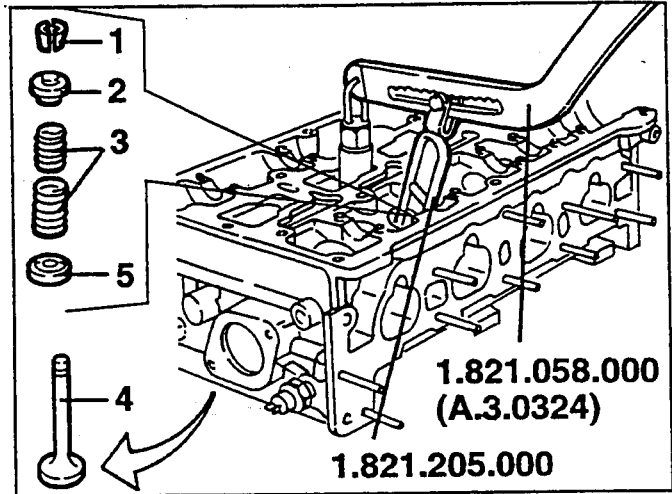


VALVES DIS-ASSEMBLY

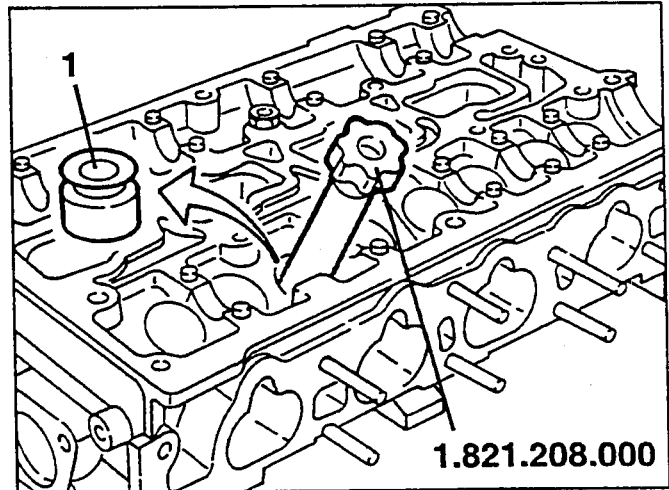
1. Withdraw the hydraulic tappets from their housings.



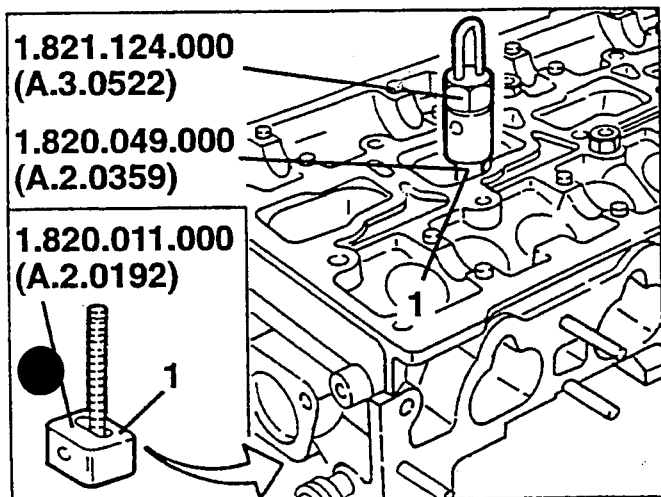
1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.205.000, remove the half cones from the valve stem.
2. Remove the upper plate.
3. Remove the outer and inner springs.
4. Remove the tools and retrieve the valve.
5. Remove the valve lower plate.



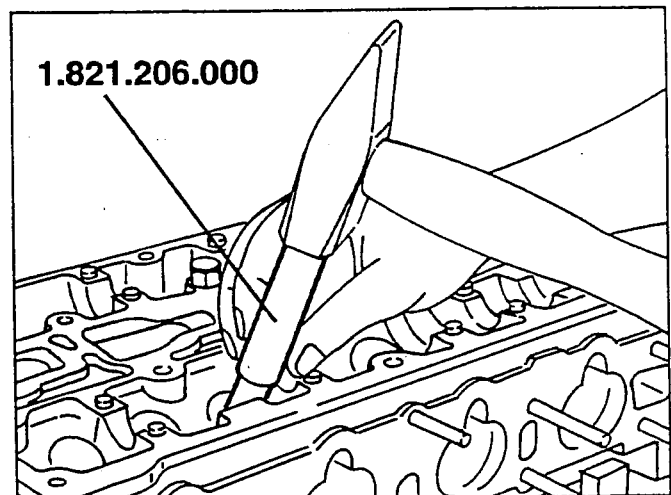
1. Using tool no. 1.821.208.000, remove the oil seal cap.



1. On the cylinder head assemble tools no. 1.820.011.000 (A.2.0192), no. 1.820.049.000 (A.2.0359) and no. 1.821.124.000 (A.3.0522).



- When refitting the oil seal cap use tool no. 1.821.206.000.



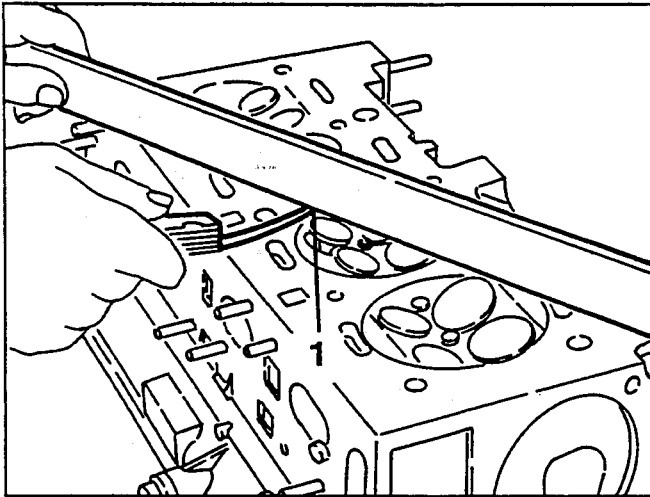


CHECKS AND INSPECTION CYLINDER HEAD

Checking the lower surface of the cylinder head

1. Check the flatness of the lower cylinder head surface; reface if it is excessively worn.

	Maximum flatness error of cylinder head lower surface
	0.1 mm



- After refacing, check that the depth of the combustion chamber, on the head, exceeds the minimum allowed limit.

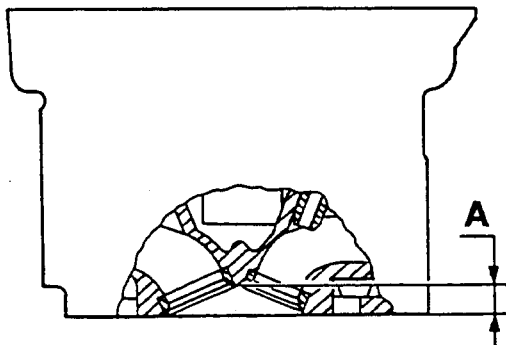


WARNING:
Exceeding the minimum allowed limit involves serious engine operating failures.



Minimum depth "A" of the combustion chamber in the head
13 ± 0.2 mm

- Check that the finishing of the lower cylinder head surface is satisfactory.

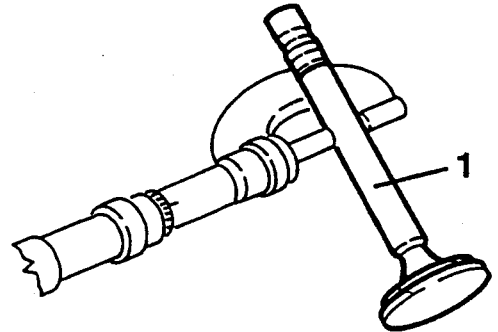


Checking the clearance between valve guides and valve stems

1. Measure the diameter of the valve stems and check that it is within the specified limits.



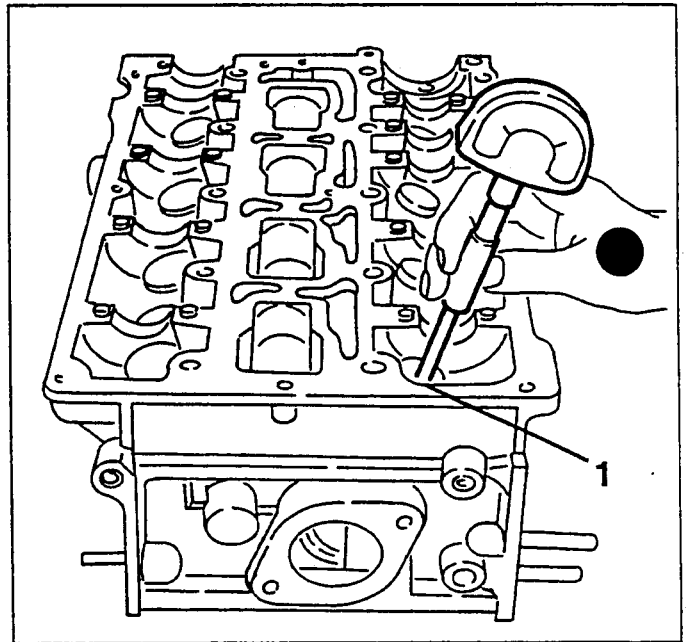
Diameter of valve stems	
Intake	6.975 + 6.990 mm
Exhaust	6.960 + 6.975 mm



1. Measure the inside diameter of the valve guides and check that it is within the specified limits.



Inside diameter of valve guides	
7.022 + 7.040 mm	



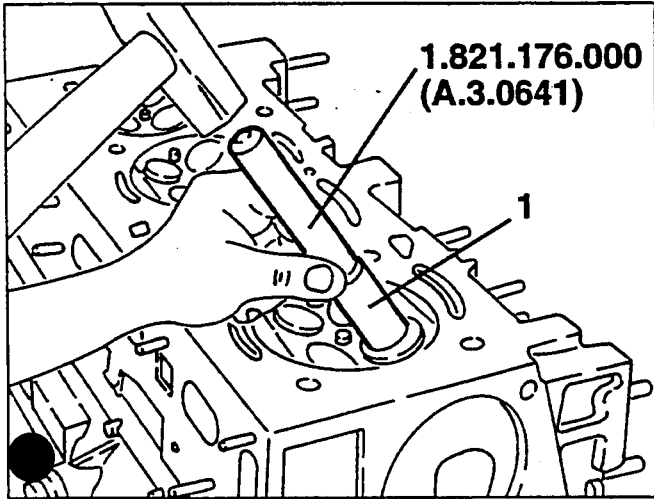
- Calculate the clearance between valve guides and stems and check that it is within the specified limits, if not, change any worn parts.



Radial clearance between valve guides and stems	
Intake	0.032 + 0.065 mm
Exhaust	0.047 + 0.080 mm

Changing the valve guides

1. Using puller tool no. 1.821.176.000 (A.3.0641), remove the worn valve guides.



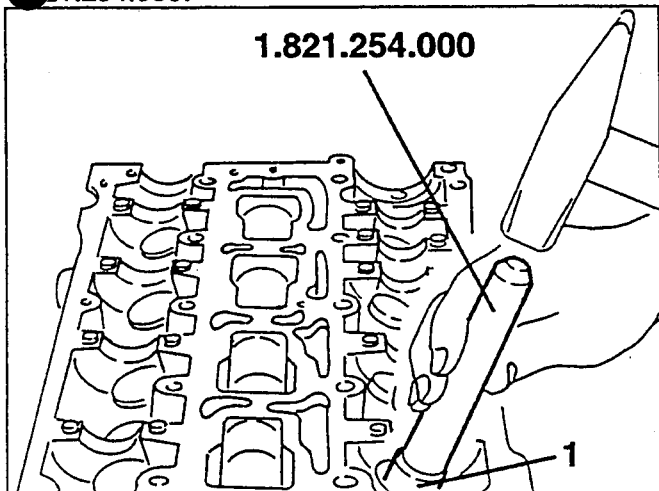
- Check that the outside diameter of the valve guides and their seats on the head are within the specified limits and that their assembly interference is correct.

∅	Outside diameter of valve guides
	13.010 ÷ 13.030 mm

∅	Diameter of valve guide seats
	12.950 ÷ 12.977 mm

↔	Interference between valve guides and seats
	0.033 ÷ 0.080 mm

1. Insert the new valve guides using tool no. 1.821.254.000.



- Bore the valve guide inside diameter to calibrate the holes to the specified diameter.

∅	Inside diameter of valve guides
	7.022 ÷ 7.040 mm

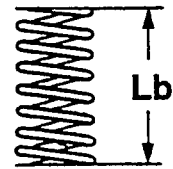
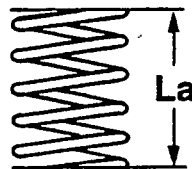
Checking the valve springs

- Check that the "free" length of the valve springs is within the specified limits.

NOTE: The rest surfaces must be parallel with each other and perpendicular to the axis of the spring with a maximum error of 2°.



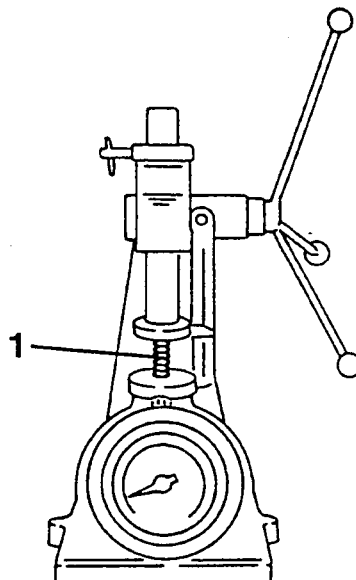
Free length of valve springs	
outer spring "La"	46 mm
inner spring "Lb"	39 mm



1. Using a torque meter, check that the characteristic data of the springs are within the specified limits.

Outer spring		
Length of spring mm		Control load N (Kg)
With valve closed	34	271 ÷ 294 (27.6 ÷ 30)
With valve open	24.5	485 ÷ 524 (49.4 ÷ 53.4)

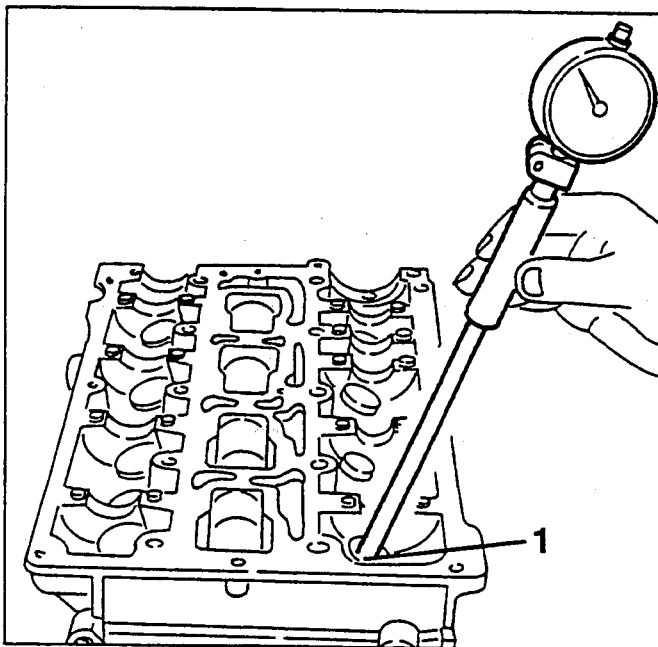
Inner spring		
Length of spring mm		Control load N (Kg)
With valve closed	29.5	96 ÷ 106 (9.8 ÷ 10.8)
With valve open	20	201 ÷ 221 (20.5 ÷ 22.5)



Checking the clearance between the cups and their seats

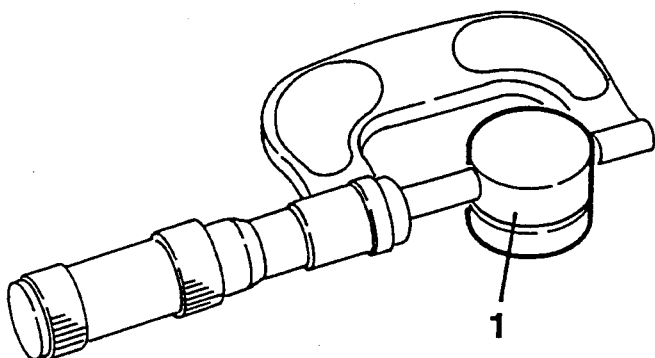
1. Check that the diameter of the cup seats is within the specified limits.

∅	Diameter of valve cup seats
	33.000 + 33.025 mm



1. Check that the outside diameter of the cups is within the specified limits.

∅	Diameter of valve cups
	32.959 + 32.975 mm



- Calculate the clearance between the cups and their seats checking that it is within the specified limits.

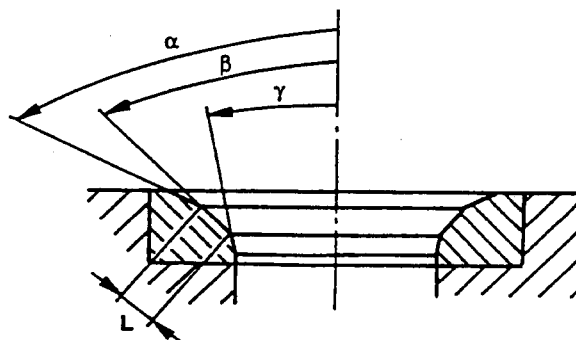
↔	Clearance between cups and seats
	0.025 + 0.066 mm

Turning the valve seats

- If necessary, turn the valve seats using suitable equipment within the following limits.

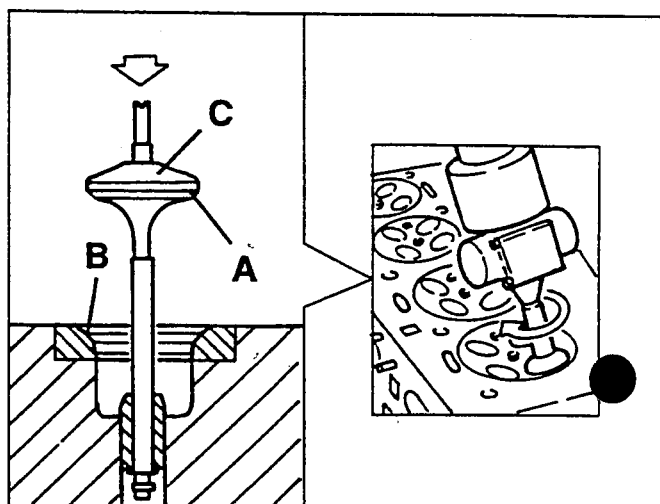
∠	Taper of contact area with valve "β"	90° ± 10'
	Taper of upper valve seat area "α"	150°
	Taper of lower valve seat area "γ"	30°

	Dimension "L" contact area with valve	
	Intake	6.5 mm
	Exhaust	5.5 mm



- After machining, grind each valve in its seat as follows:

- coat the contact surfaces "A" and "B" of the valves and their seats with abrasive paste (SIPALAREXONS Carbosilicium for valves);
- lubricate the valve stem with engine oil;
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder;
- insert the valve in its guide and grind;
- after grinding, thoroughly clean the valve and the seat.



If valve seat machining and grinding is required, perform a valve tightness test (with the spark plugs fitted) as follows:

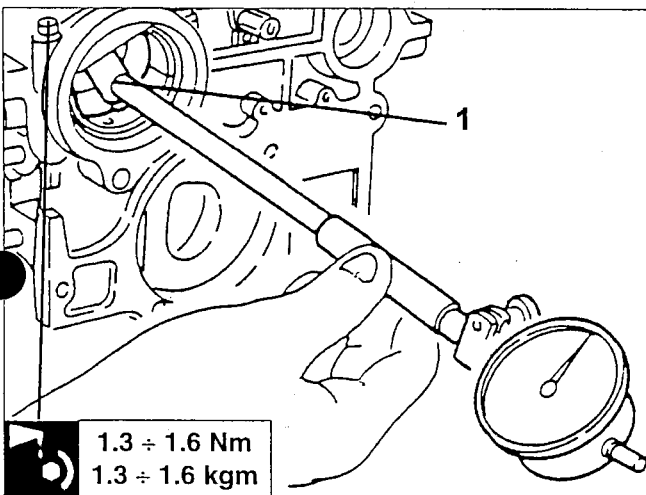
- fill the combustion chamber with petrol;
- let low pressure air into the intake manifolds and check no air bubbles form in the petrol;
- perform the same test on the exhaust valve by letting air into the exhaust manifolds;
- if leaks are found, make sure the valves are perfectly fitted in their seats. Repeat the tightness test. If the outcome is negative, repeat the grinding operation.

Camshaft and journals

1. Fit the camshaft bearings and fasten the respective screws at the prescribed torque. Then check whether the journal bearing diameter falls within prescribed values.

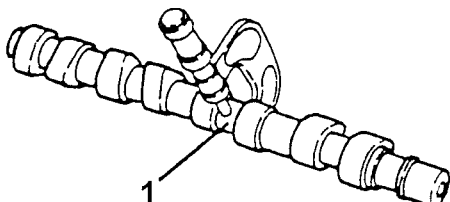
NOTE: Fit the respective half-bearings on the front journal, intake side.

∅	Camshaft journal bearing diameter	
	26.045 ÷ 26.070 mm	50.034 ÷ 50.071 mm (*)
	(*) Front journal, intake side, with half-bearings fitted (for phase variator)	



1. Check whether the camshaft journal fall within the prescribed values.

∅	Camshaft journal diameter	
	26.000 ÷ 26.015 mm	



- Calculate the play between the camshaft bearings and respective journals and check whether it falls within the prescribed values.



Play between camshaft and journal

0.03 ÷ 0.07 mm	0.034 ÷ 0.086 mm (*)
(*) Specific for phase variator	

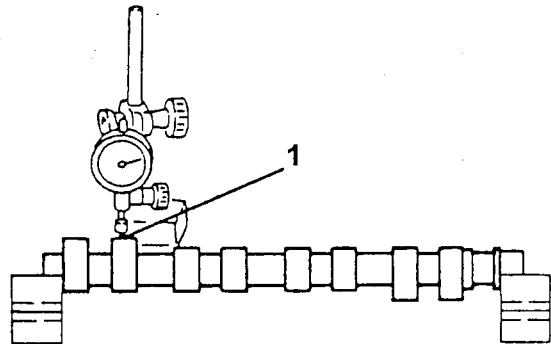
1. Check whether the cam rising falls within prescribed values.



Nominal cam raising

Intake	8.3 mm pre-change	9.5 mm (2)
	9.0 mm post-change (*) (1)	
Exhaust	7.5 mm (1)	9.5 mm (2)

(*): with M1.5.5 injection-ignition
(1): 1598 c.c. (2) 1747 c.c.



Crankshaft axial play

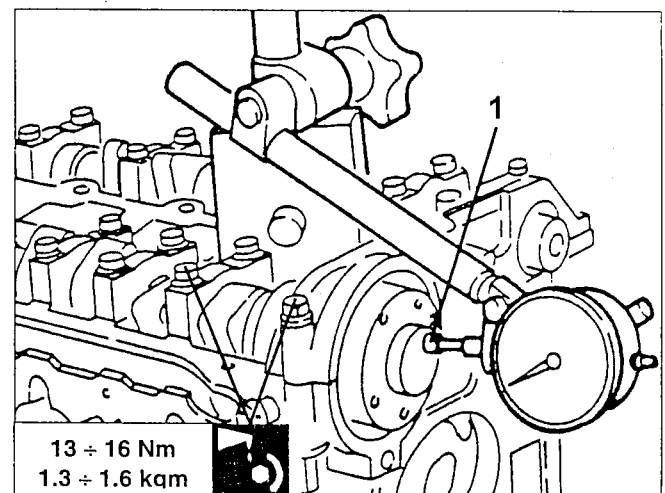
- Position the camshafts on the cylinder head, fit the respective bearings and fasten the screws as prescribed.

1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.



Crankshaft axial play

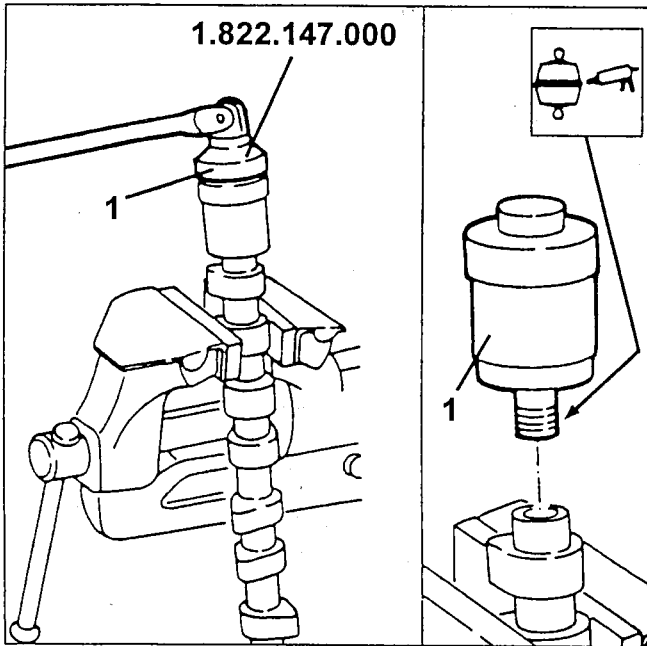
0.10 ÷ 0.23 mm



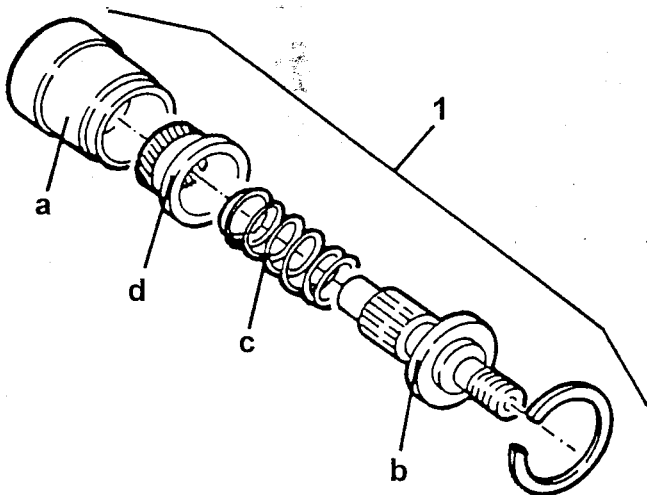
Camshaft phase variator disassembly

- Position the camshaft, intake side, in a vice with padded jaws.

1. Loosen and remove the phase variator from the camshaft with tool no. 1.822.147.000.



1. Remove the retainer ring and extract the pinion (b), the spring (c) and the piston (d) from the phase variator casing (a).



IMPORTANT:

Attain to the following instructions when refitting the phase variator:

- Make sure the glue on the camshaft phase variator coupling thread does not obstruct the oil ducts.
- Wait for approximately two hours before fitting the camshaft on the cylinder head.

CRANKCASE CHECKS AND TESTS

- Inspect the crankcase for cracks or signs of excessive wear on sliding surfaces. Check intactness of all threading.

- Remove the lubrication and cooling duct caps and clean the ducts with a suitable detergent. Dry with a jet of compressed air and fit new caps.

- Clean the crankcase surfaces from fragments of seals or sealant.

Cylinder checks

1. Measure the internal diameter of the cylinders with a gauge and check it falls within the prescribed values.



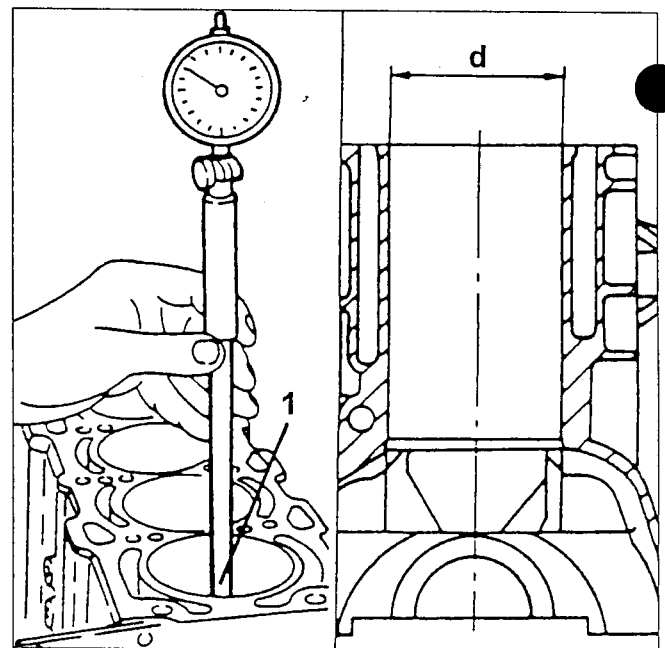
Internal diameter "d"	
Class A	82.000 ÷ 82.010 mm
Class B	82.010 ÷ 82.020 mm
Class C	82.020 ÷ 82.030 mm
0.1 mm oversize	



Maximum cylinder taper	
0.010 mm	



Maximum cylinder ovality	
0.005 mm	

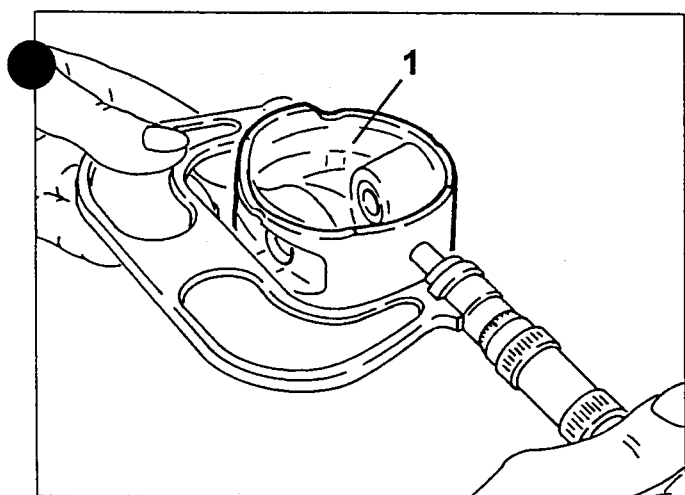


Checking the pistons

1. Measure the outside diameter of the pistons and check that it is within the specified limits.

Outside diameter of pistons (1)	
Class A (Blue)	81.952 ÷ 81.962 mm
Class B (Pink)	81.960 ÷ 81.970 mm
Class C (Green)	81.968 ÷ 81.978 mm
Oversize of 0.1 mm	

(1) To be measured at right angles to the gudgeon pin hole at a distance of 12.5 mm from the lower edge of the piston skirt.



- Calculate the clearance between the cylinder and the piston and check that it is within the specified limits.

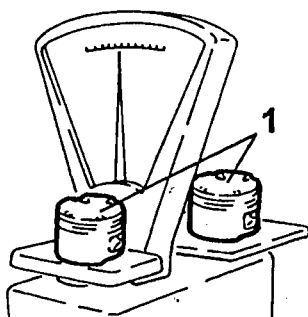


Clearance between piston and cylinder
0.038 ÷ 0.062 mm

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.



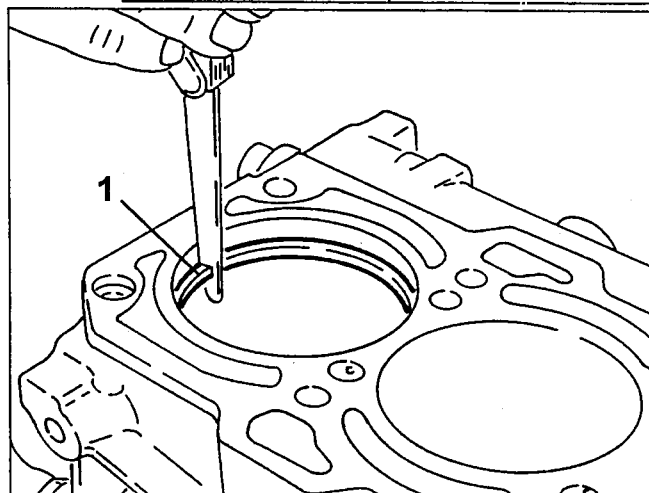
Difference in weight between pistons
± 5 g



Checking the seal ring gap

1. Insert the seal rings in the cylinder, check that they adhere to the whole circumference and that the gap is within the specified limits.

Ring gap	
First ring	0.25 ÷ 0.50 mm
Second ring	0.30 ÷ 0.50 mm
Oil scraper ring	0.25 ÷ 0.45 mm

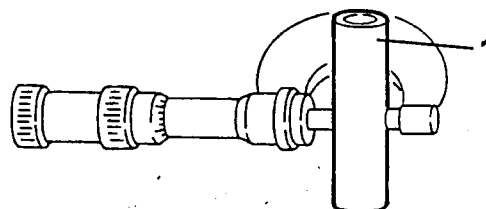


Checking the play between gudgeon pins and seats on pistons

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



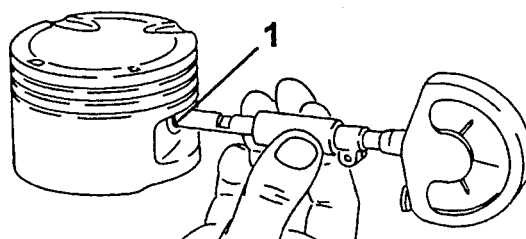
Outside diameter of gudgeon pins
19.996 ÷ 20.000 mm



1. Measure the diameter of the pin mating hole in the piston and check that it is within the specified limits.



Diameter of pin seat in pistons
20.002 ÷ 20.007 mm





- Calculate the clearance between the pins and their seats on the pistons and check that it is within the specified limits.



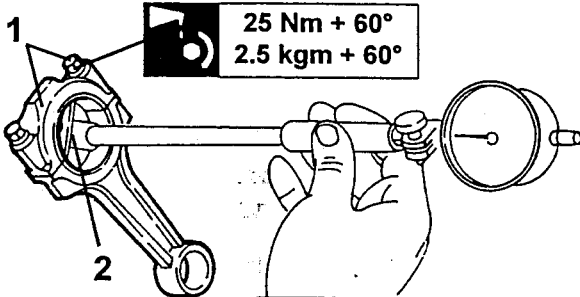
Clearance between pins and seats on pistons
0.002 ÷ 0.011 mm

Checking clearance between connecting rod journals and corresponding half bearings

1. House the rod half bearings in the connecting rod big end and on the corresponding cap, then join them tightening the fastening screws to the specified torque.
2. Measure the diameter of the connecting rod big end and check that it is within the specified limits.



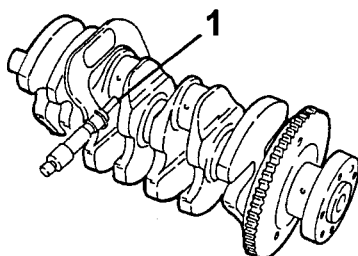
Inside diameter of connecting rod half bearings (mm)		
Class		
Class A (Red)	48.274 ÷ 48.294	50.835 ÷ 50.855
Class B (Bleu)	48.268 ÷ 48.288	50.827 ÷ 50.847
Class C (Yellow)	48.262 ÷ 48.282	50.819 ÷ 50.839



1. Measure the diameter of the connecting rod journals and check that it is within the specified limits.



Diameter of connecting rod journals (mm)		
Class		
Class A (Red)	48.238 ÷ 48.244	50.799 ÷ 50.805
Class B (Bleu)	48.232 ÷ 48.238	50.793 ÷ 50.799
Class C (Yellow)	48.226 ÷ 48.232	50.787 ÷ 50.793



- Calculate the clearance between the rod journals and the corresponding half bearings and check that it is within the specified limits.



Clearance between rod journals and half bearings
0.03 ÷ 0.056 mm (1)
0.026 ÷ 0.056 mm (2)

(1):

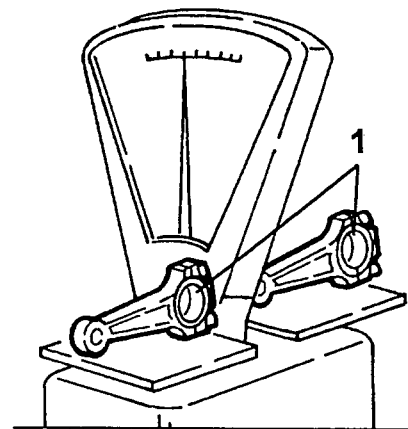
(2):

Checking the connecting rods

1. Check that the difference in weight between the connecting rods complete with half bearings, caps and screws is within the specified limits.

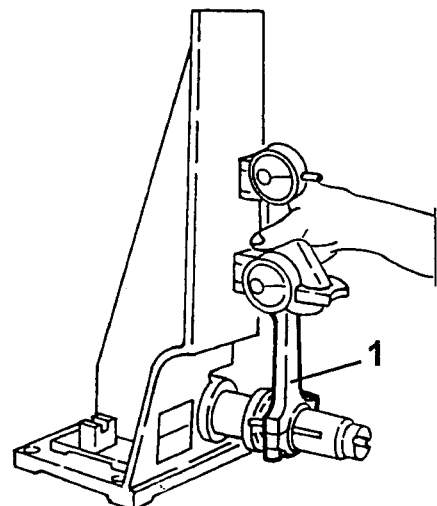


Difference in weight between connecting rods	≤ 5
---	-----



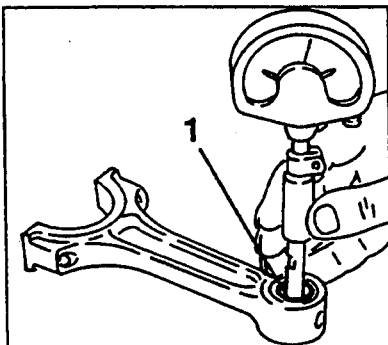
1. Check that the connecting rods are perpendicular using a reference plane as illustrated.

NOTE: If perpendicularity is not perfect, the connecting rod must be changed to avoid abnormal stresses when the engine is running, resulting in uneven wear of the piston and of the rod itself.



Checking the clearance between pins and small end bushings

1. Measure the inside diameter of the small end bushing and check that it is within the specified limits, if not, change the bushing.



Inside diameter of small end bushing

20.006 ÷ 20.012 mm

1. Measure the outside diameter of the pins and check that it is within the specified limits.



Outside diameter of pins

19.996 ÷ 20.000 mm

- Calculate the clearance between the pins and small end bushings and check that it is within the specified limits.



Clearance between pins and small end bushing

0.006 ÷ 0.016 mm

Checking the clearance between main bearing journals and half bearings

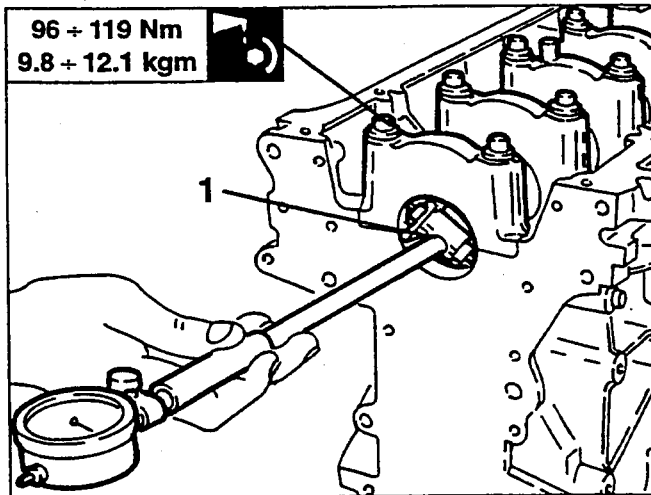
1. House the half bearings and fit the main bearings cap on the crankcase tightening the fastening screws to the specified torque.

2. Measure the diameter of the main bearings and check that it is within the specified limits.



Diameter of the main bearings (mm)

P o s.	Classe	T. SPARK 16V	
		1598	1747
Side	Class A (Red)	53.025 ÷ 53.046	53.031 ÷ 53.056
	Class B (Blue)	53.019 ÷ 53.040	53.017 ÷ 53.046
	Class C (Yellow)	53.013 ÷ 53.034	53.007 ÷ 53.032
Centre	Class A (Red)	53.035 ÷ 53.056	53.041 ÷ 53.066
	Class B (Blue)	53.029 ÷ 53.050	53.027 ÷ 53.056
	Class C (Yellow)	53.023 ÷ 53.044	53.017 ÷ 53.042

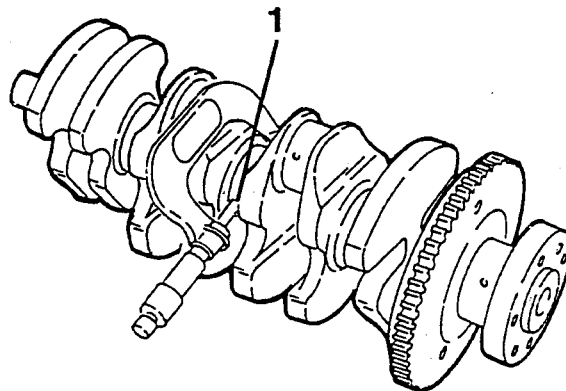


1. Measure the diameter of the main bearing journals and check that it is within the specified limits.



Diameter of main bearing journals

Class A (Red)	52.994 ÷ 53.000 mm
Class B (Bleu)	52.988 ÷ 52.994 mm
Class C (Yellow)	52.982 ÷ 52.988 mm



- Calculate the clearance between the main bearing journals and half bearings and check that it is within the specified limits.



Clearance between main bearing journals and half bearings (mm)

Pos.	1598	1747
Side	0.025 ÷ 0.052	0.019 ÷ 0.062
Centre	0.035 ÷ 0.062	0.029 ÷ 0.072

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, change the ring gear as described below:

- working under the press remove the old ring gear;
- accurately clean the contact surfaces of the new ring gear and of the flywheel;

- evenly heat the new ring gear to 80° + 100° C and fit it on the flywheel: leave to cool naturally, do not force cool.

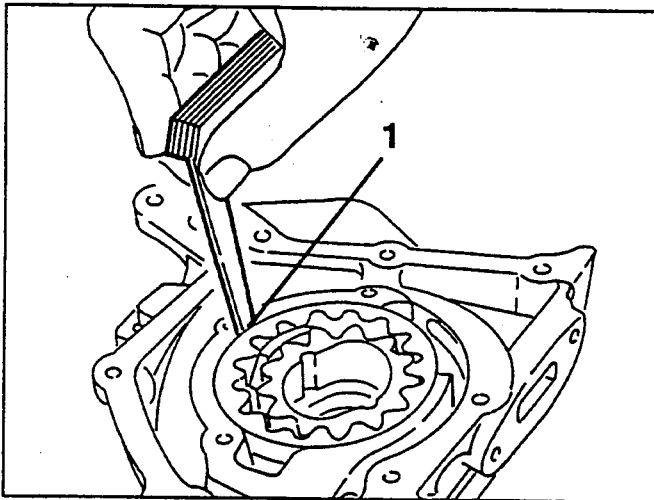
Checking the oil pump

1. Check that the clearance between the pump casing and the driven gear is within the specified limit.



Clearance between pump casing and driven gear

0.080 + 0.186 mm

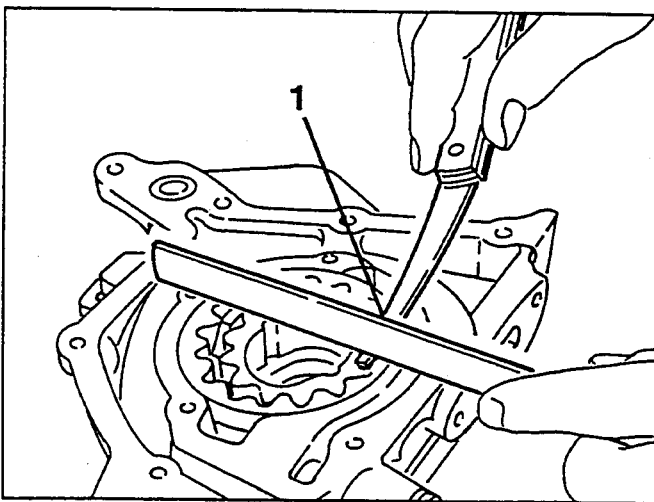


1. Check that the clearance between the pump cover rest surface and the upper side of the gears is within the specified limit.



Clearance between pump cover rest surface and upper side of gears

0.025 + 0.070 mm



WARNING: If the clearances measured are not within the specified limits, change the front crankcase cover with oil pump incorporated.

- Using a torque meter check the characteristic values of the engine oil pressure limiting valve control spring.

Control load Kg	Spring length mm
6.4 + 7.2	36

INSTRUCTIONS FOR RE-ASSEMBLY



For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

- Check valve tightness when the cylinder heads are assembled (see "Turning the valve seats").

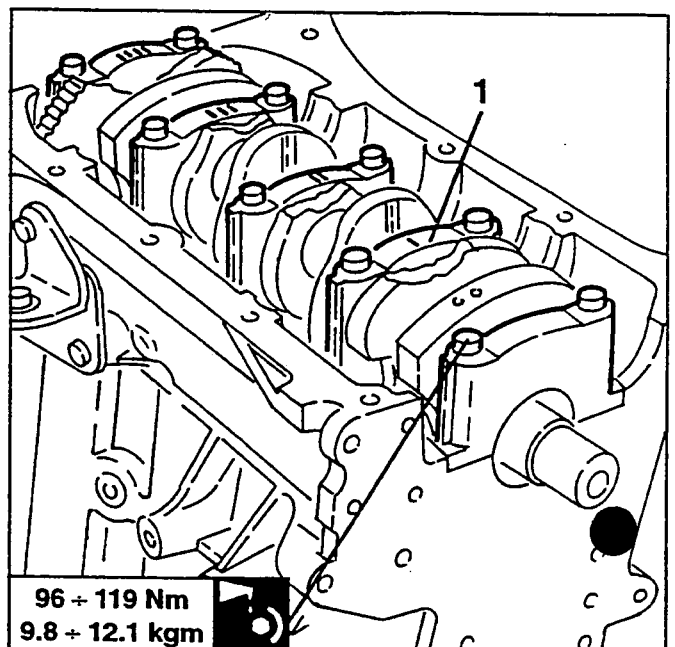
Reassembling the crankshaft

- Assemble the crankshaft on the crankcase complete with half bearings and half thrust rings.

Reassemble the half thrust rings with the grooved surfaces facing the crankshaft.

1. Assemble the main bearing caps complete with half bearings on the supports and tighten the fastening screws two or three times starting from the centre main bearing cap.

The position of each cap is given by a series of consecutive notches (from zero to four starting from the front of the engine) etched on the caps themselves.



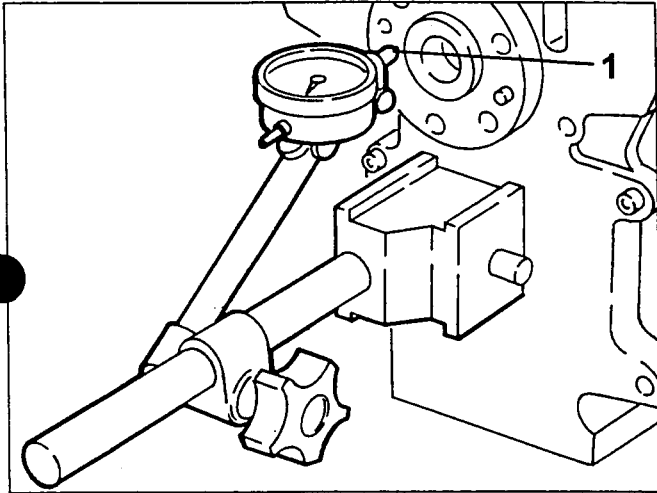
96 + 119 Nm
9.8 + 12.1 kgm

Checking the crankshaft end float

1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.

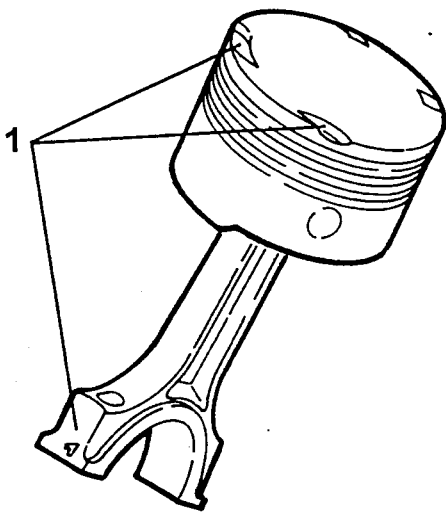


Crankshaft end float
0.059 ÷ 0.221 mm



Refitting the pistons and connecting rods

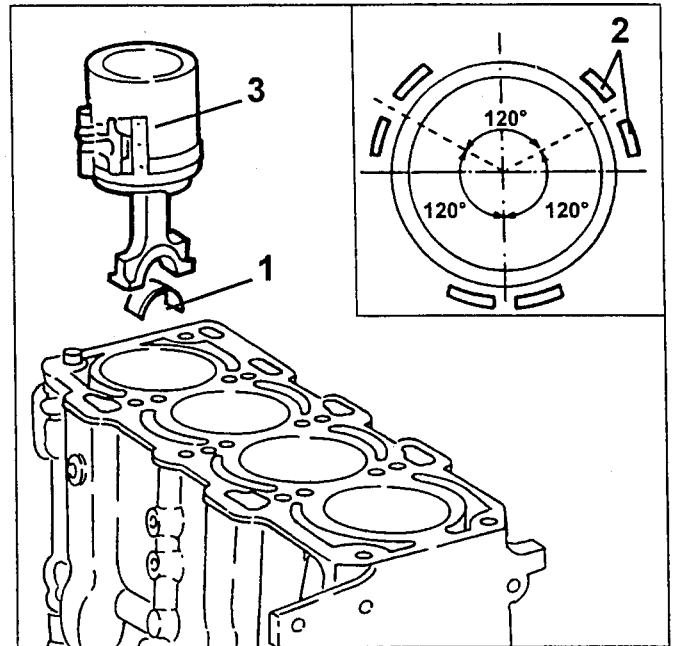
1. Assemble the piston and connecting rod so that the number stamped on the connecting rod big end is on the same side as the large notches (for intake valves) on the piston crown.



- Turn the crankshaft until the connecting rod journals of the 1st and 4th cylinder are in the position corresponding to the B.D.C.

1. House the half bearings on the connecting rod big ends.
2. Insert the rings in the pistons with the cuts offset by 20° and the word TOP printed on them facing upwards.
3. Using a suitable tool, insert the pistons and connecting rods in the 1st and 4th cylinder.

Assemble the connecting rod - piston unit in the crankcase directing the arrow stamped on the piston crown in the direction of rotation of the engine.



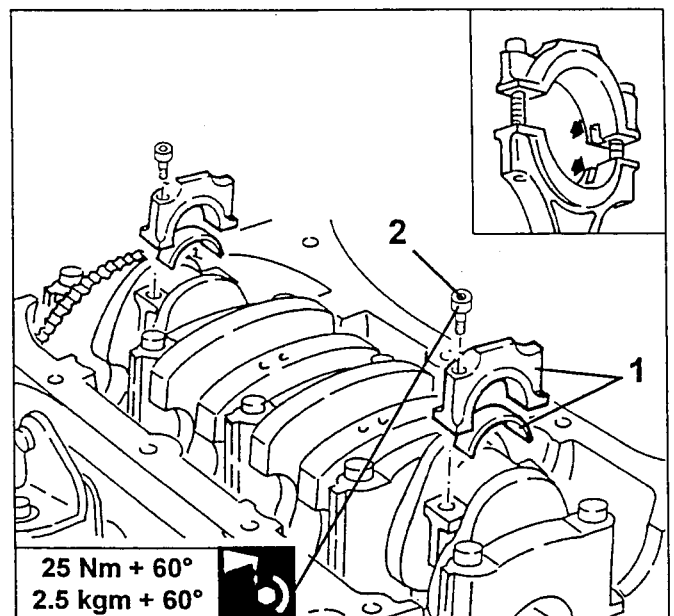
- Turn the crankcase 180°.

1. House the half bearings on the connecting rod caps, then assemble those of the 1st and 4th cylinder directing the safety notch towards the same side as the corresponding notch on the connecting rod big end.

On one side, the connecting rod caps have the number of the cylinder to which they belong; when refitting, this number must always be on the same side as the one stamped on the connecting rod big end.

2. Tighten the connecting rod cap fastening screws in oil to the specified torque.

- In the same way, reassemble the pistons and connecting rods of the 2nd and 3rd cylinder.

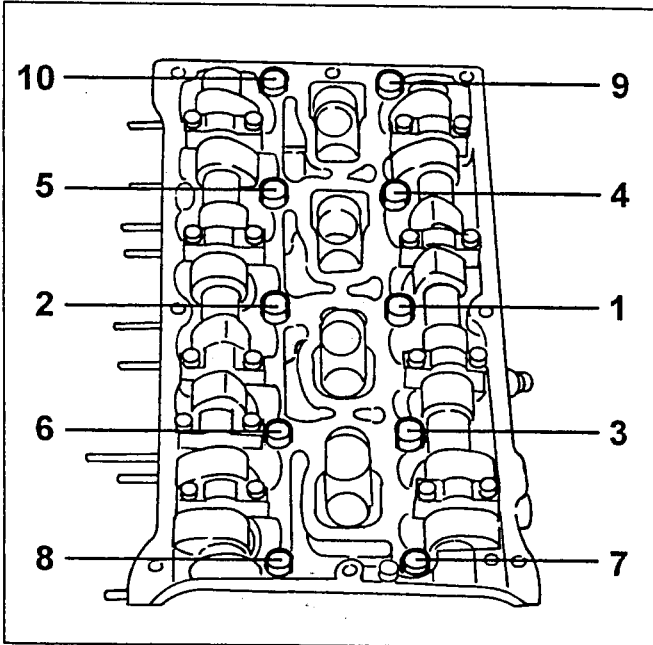


25 Nm + 60°
2.5 kgm + 60°



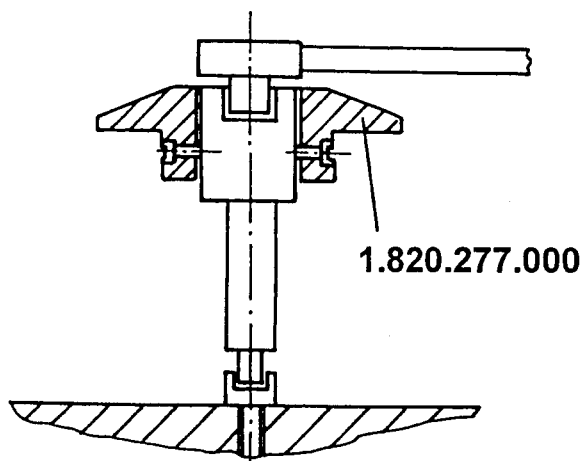
Reassembling the cylinder head

- Turn the crankshaft to take the pistons of the 1st and 4th cylinder to the T.D.C.
- Position the gasket on the crankcase, then the cylinder head.
- Tighten the cylinder head fastening screws as described below and bearing in mind that the tightening sequence is the one shown below for each phase.



Tightening procedure	
Set in all the screws to a torque of:	20 Nm (2.0 kgm)
Tighten the screws to the preliminary torque of:	40 Nm (4.1 kgm)
Turn all the screws with an angle of:	90° + 90° + 90°

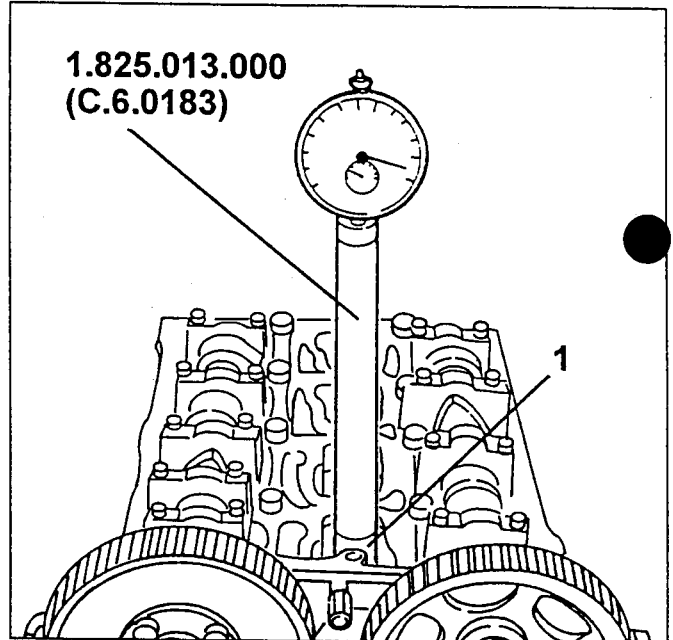
- For angle tightening use the graduated disk no. 1.820.277.000 as illustrated.



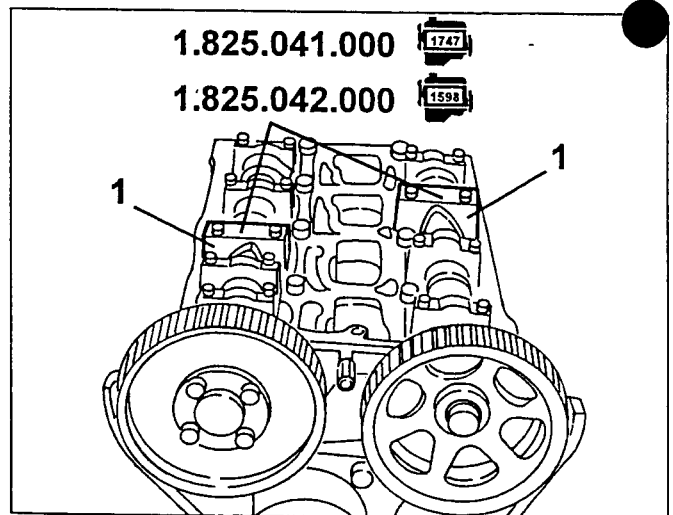
The gasket between the cylinder head and the crankcase is in aramidic fibre and cylinder head retightening is unnecessary throughout the life of the engine.

Assembling the timing gear drive belt and checking timing

- Assemble the camshaft toothed pulleys without tightening the fastening screws, the timing drive belt pulleys and the corresponding belt tensioners.
- 1. Install tool no. 1.825.013.000 (C.6.0183) fitted with a dial gauge in the seat of the centre spark plug of the 1st cylinder.
- Turn the crankshaft until the piston of the first cylinder reaches the T.D.C. in the bursting stroke.



- 1. Remove the camshaft caps illustrated and in their place insert templates, tightening the fastening screws to a maximum torque of 10 Nm (1 Kg) and checking for correct coupling with the cams.



NOTE: For turning the camshafts, use tool 1.822.155.000 for the intake side and tools no. 1.822.146.000 and no. 1.822.156.000 for the exhaust side, to be applied on the corresponding pulleys.

1. Assemble the timing gear drive belt taking care to check correct coupling with the pulley teeth, installing it in the following sequence:

- crankshaft pulley
- fixed tightening pulley
- exhaust side camshaft pulley
- intake side camshaft pulley
- automatic tensioner pulley
- coolant fluid pump pulley

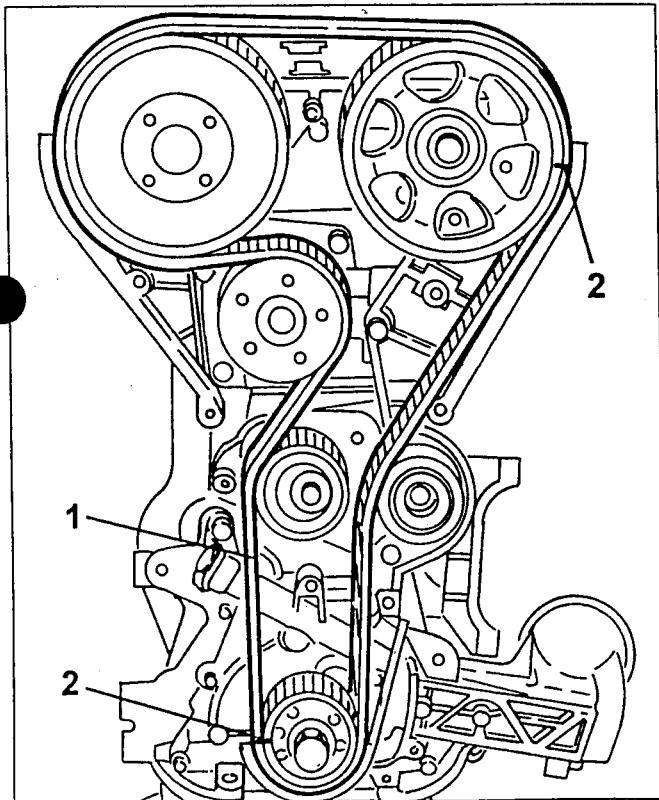
2. The notches painted on the belt must coincide with the indexes made on the crankshaft pulley and on the exhaust side camshaft pulley.



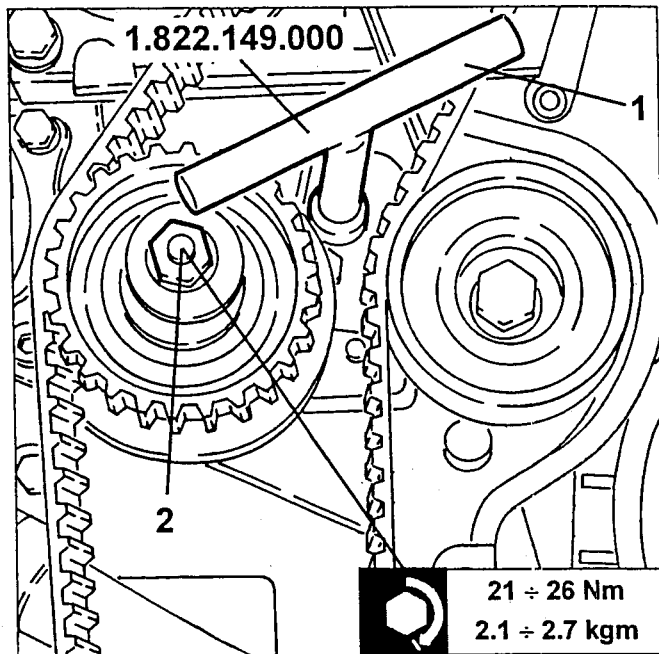
WARNING:

When assembling the toothed belt, to avoid damaging the structure of the fibres that form it, never cause sharp bends.

For correct assembly the belt has an arrow on it which shows the direction of rotation of the engine.



1. Using tool no. 1.822.149.000 as illustrated, tension the belt to the maximum.
2. Tighten the nut fastening the automatic camshaft belt tensioner.



1. Using tool no. 1.822.155.000, tighten the screws fastening the intake side camshaft drive pulley.

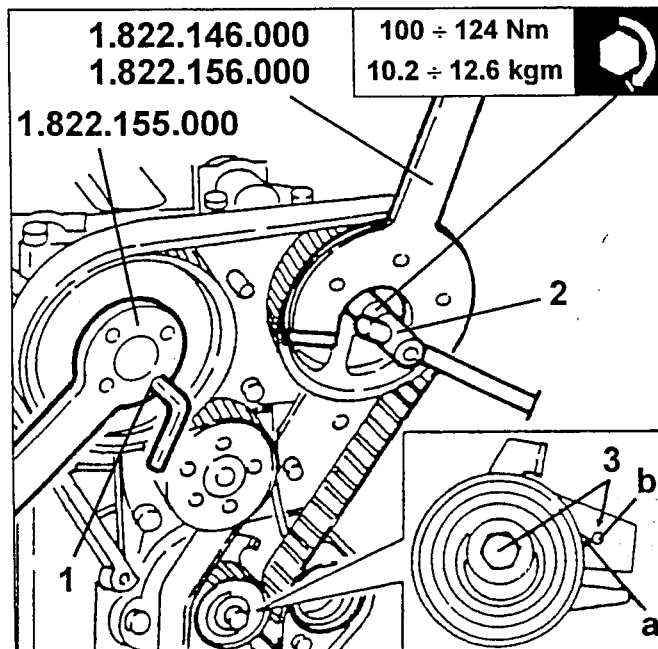
2. Using tool no. 1.822.146.000 complete with tool no. 1.822.156.000, tighten the screw fastening the exhaust side camshaft drive pulley.

- Remove the two templates from the camshafts and turn the crankshaft twice in its direction of rotation until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke.

3. Release the nut fastening the automatic tensioner, then using tool no. 1.822.149.000, move the mobile index (a) to coincide with the reference hole (b).

- Tighten the automatic tensioner fastening nut to the specified torque.

- Turn the crankshaft twice in its direction of rotation until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke and check that all the timing references coincide.





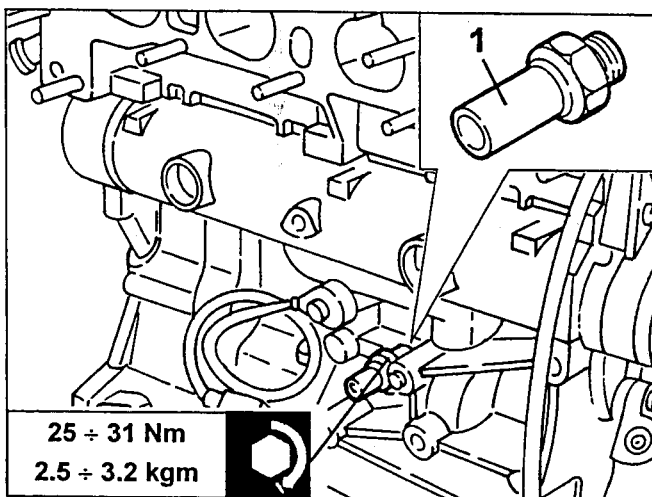
CHECKING LUBRICATION CIRCUIT ELECTRIC COMPONENTS

ENGINE OIL MINIMUM PRESSURE WARNING LIGHT SENSOR

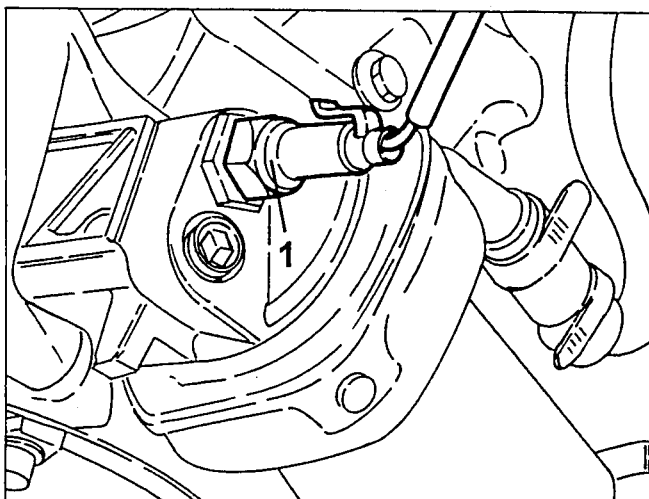
1. Check the setting of the engine oil minimum pressure warning light sensor. If the ratings are not as specified, replace the sensor.



Contact opening/closing pressure
0.2 ÷ 0.5 bar



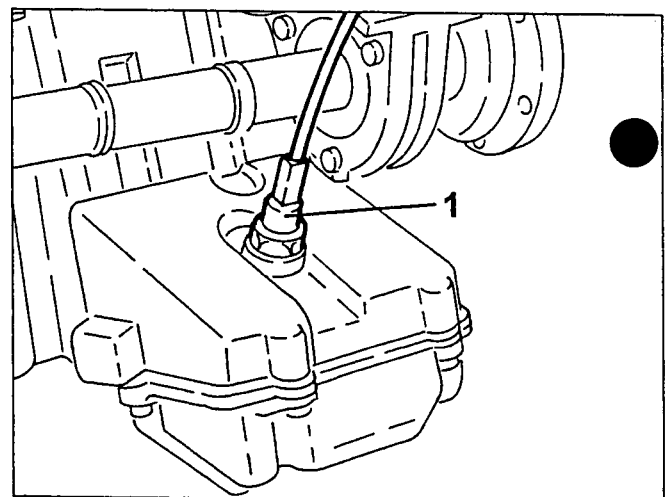
NOTE: In some versions the engine oil minimum pressure warning light sensor (1) is fitted on the oil filter support as illustrated below.



ENGINE OIL TEMPERATURE SENSOR

1. Check the setting of the engine oil temperature sensor. If the ratings are not as specified, replace the sensor.

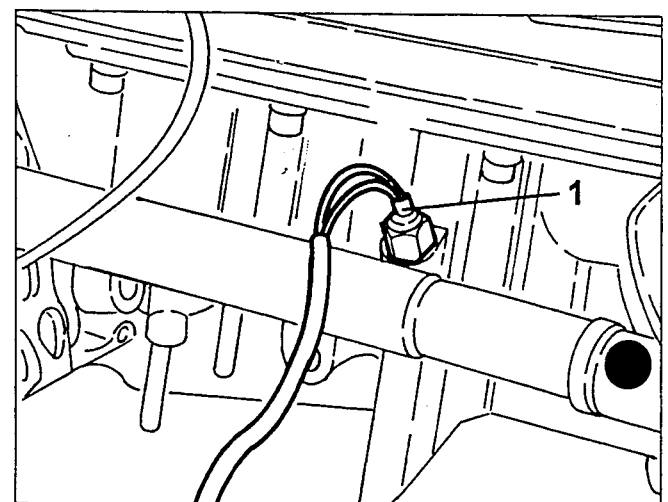
Temperature (°C)	Resistance (Ω)
50	800 ÷ 900
70	350 ÷ 450
90	180 ÷ 220



LOW ENGINE OIL LEVEL WARNING LIGHT SENSOR

1. Check the setting of the low engine oil level warning light sensor. If the ratings are not as specified, replace the sensor.

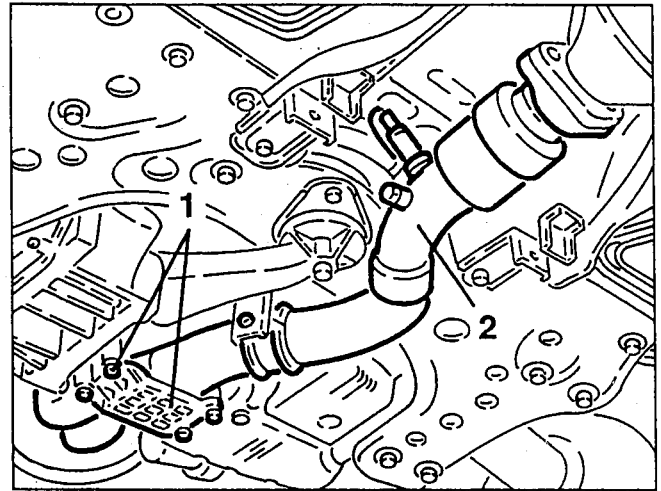
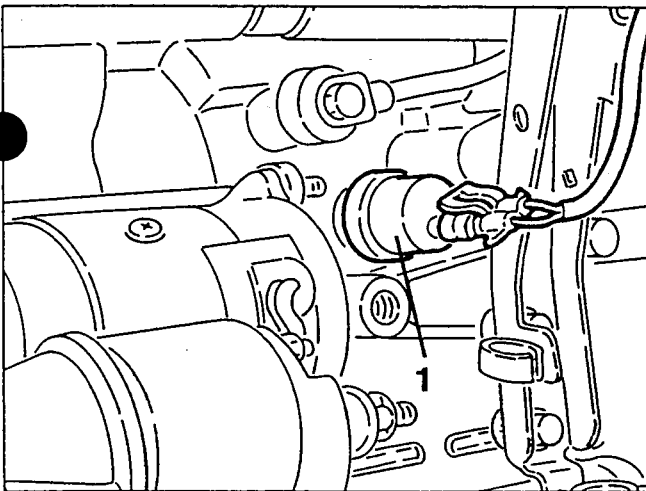
Circuit resistance	12 Ω ± 5%
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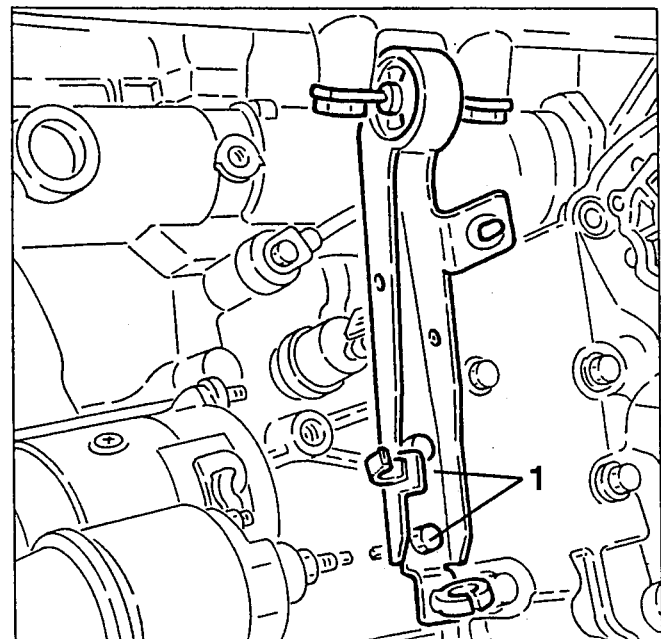
ENGINE OIL PRESSURE SENDER

1. Check the setting of the engine oil pressure sender. If the values are not within the specified limits, change the sensor.

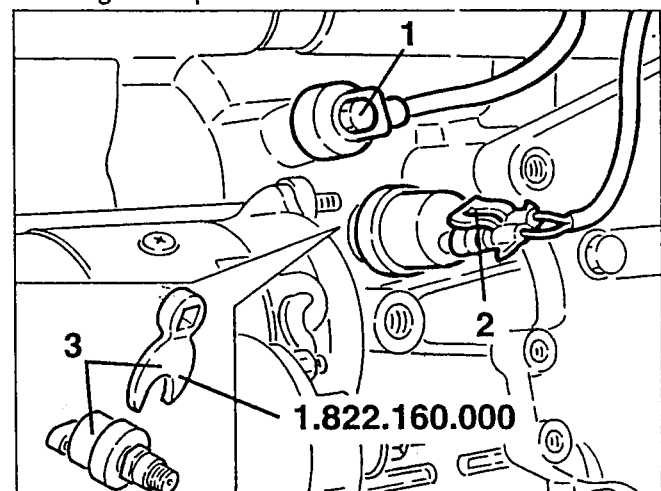
Pressure (bar)	Resistance (Ω)
0	305 ± 15
2	190 ± 15
4	118 ± 15
8	20 ± 20



1. Slacken the fastening screws and remove the intake box support bracket.

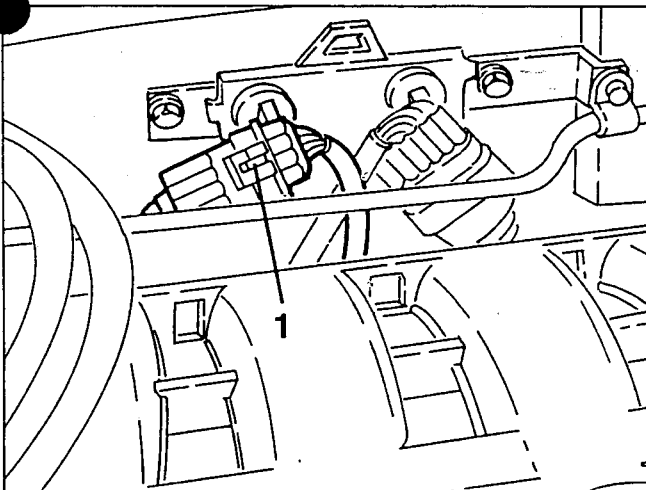


1. Slacken the fastening screw and move aside the pinging sensor.
 2. Disconnect the electrical connection from the engine oil pressure transmitter.
 3. Using tool no. 1.822.160.000 slacken and remove the engine oil pressure transmitter.



Removing/Refitting

- Set the car on a lift.
- Disconnect the battery (-) terminal.
- 1. Disconnect the electrical connection of the lambda probe.




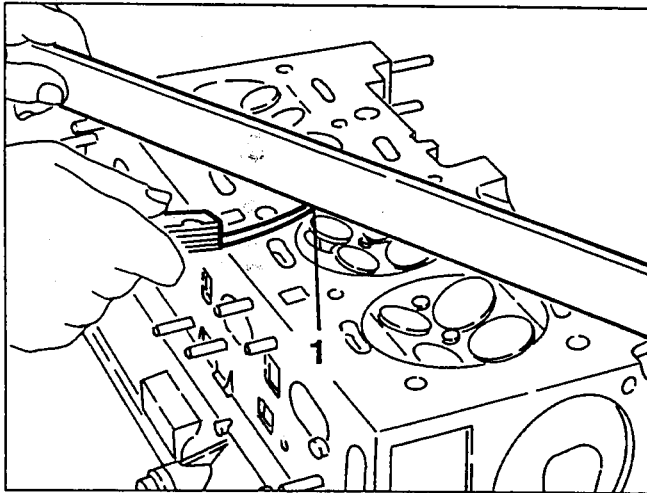
- Raise the car.
- 1. Slacken the fastening screws and remove reinforcement bracket.
- 2. Remove the front section of the exhaust pipe complete with lambda probe after slackening the fastenings concerned.

CHECKS AND INSPECTION CYLINDER HEAD

Checking the lower surface of the cylinder head

1. Check the flatness of the lower cylinder head surface; reface if it is excessively worn.

	Maximum flatness error of cylinder head lower surface
	0.1 mm



- After refacing, check that the depth of the combustion chamber, on the head, exceeds the minimum allowed limit.

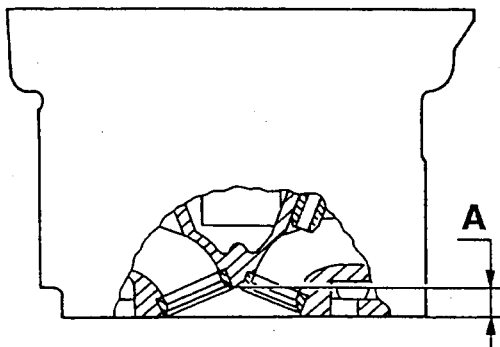


WARNING:
Exceeding the minimum allowed limit involves serious engine operating failures.



	Minimum depth "A" of the combustion chamber in the head
	13 ± 0.2 mm

- Check that the finishing of the lower cylinder head surface is satisfactory.

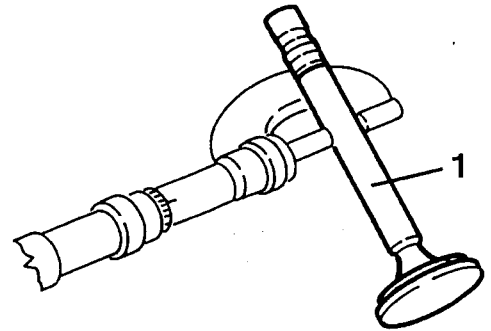


Checking the clearance between valve guides and valve stems

1. Measure the diameter of the valve stems and check that it is within the specified limits.



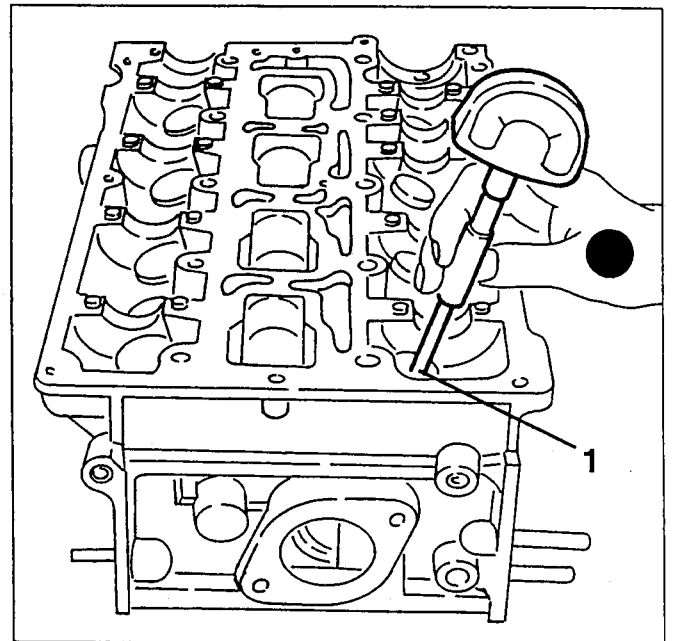
Diameter of valve stems	
Intake	6.975 + 6.990 mm
Exhaust	6.960 + 6.975 mm



1. Measure the inside diameter of the valve guides and check that it is within the specified limits.



Inside diameter of valve guides	
7.022 + 7.040 mm	



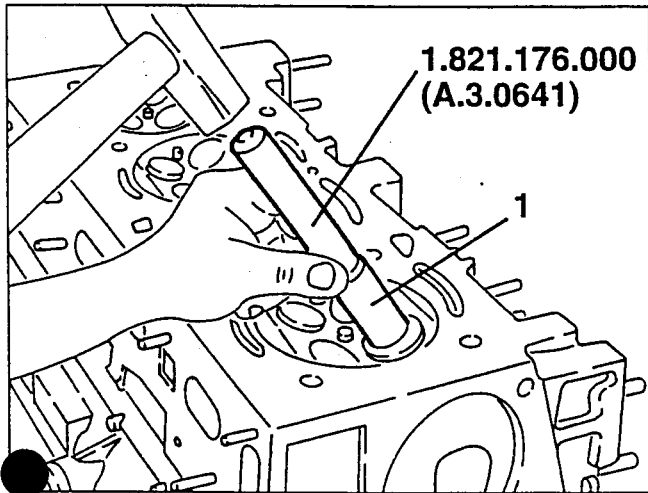
- Calculate the clearance between valve guides and stems and check that it is within the specified limits, if not, change any worn parts.



Radial clearance between valve guides and stems	
Intake	0.032 + 0.065 mm
Exhaust	0.047 + 0.080 mm

Changing the valve guides

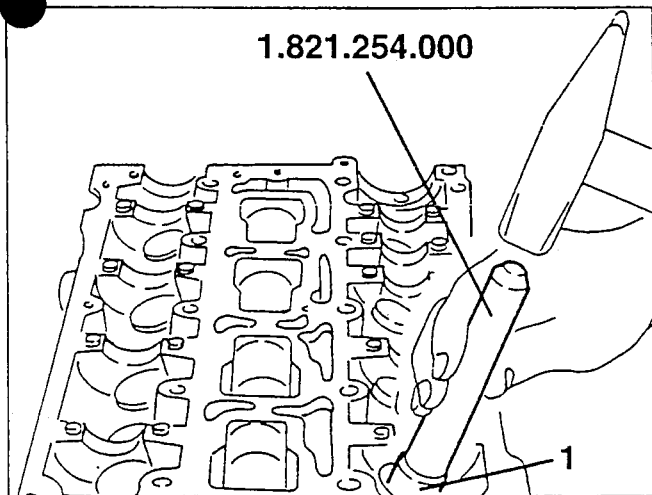
1. Using puller tool no. 1.821.176.000 (A.3.0641), remove the worn valve guides.



- Check that the outside diameter of the valve guides and their seats on the head are within the specified limits and that their assembly interference is correct.

	Outside diameter of valve guides
	13.010 ÷ 13.030 mm
	Diameter of valve guide seats
	12.950 ÷ 12.977 mm
	Interference between valve guides and seats
	0.033 ÷ 0.080 mm

1. Insert the new valve guides using tool no. 1.821.254.000.



- Bore the valve guide inside diameter to calibrate the holes to the specified diameter.

	Inside diameter of valve guides
	7.022 ÷ 7.040 mm

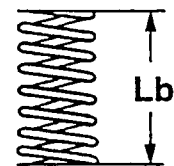
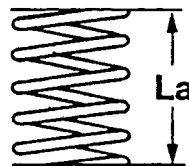
Checking the valve springs

- Check that the "free" length of the valve springs is within the specified limits.

NOTE: The rest surfaces must be parallel with each other and perpendicular to the axis of the spring with a maximum error of 2°.



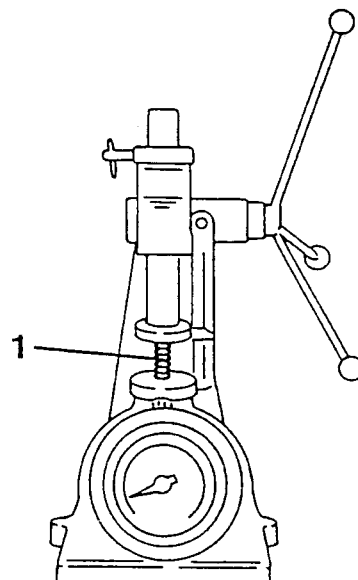
Free length of valve springs	
outer spring "La"	46 mm
inner spring "Lb"	39 mm



1. Using a torque meter, check that the characteristic data of the springs are within the specified limits.

Outer spring		
Length of spring mm		Control load N (Kg)
With valve closed	34.0	271 ÷ 294 (27.6 ÷ 30)
With valve open	24.5	485 ÷ 524 (49.4 ÷ 53.4)

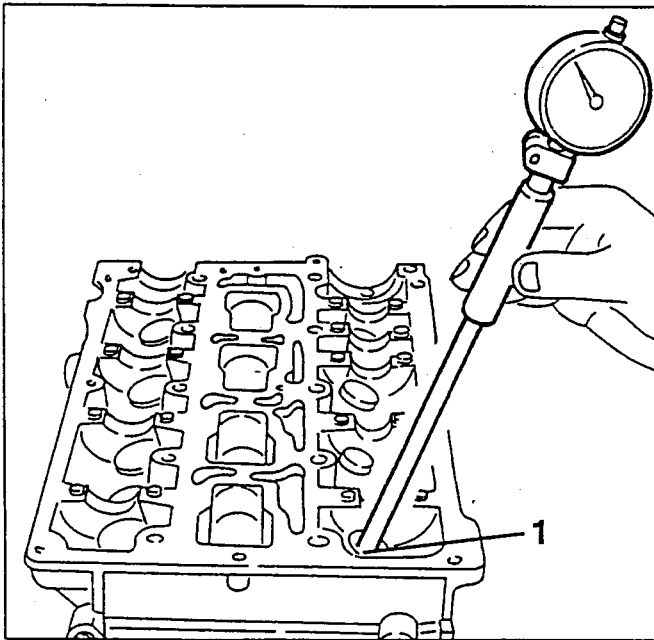
Inner spring		
Length of spring mm		Control load N (Kg)
With valve closed	29.5	96 ÷ 106 (9.8 ÷ 10.8)
With valve open	20.0	201 ÷ 221 (20.5 ÷ 22.5)



Checking the clearance between hydraulic tappets and their seats

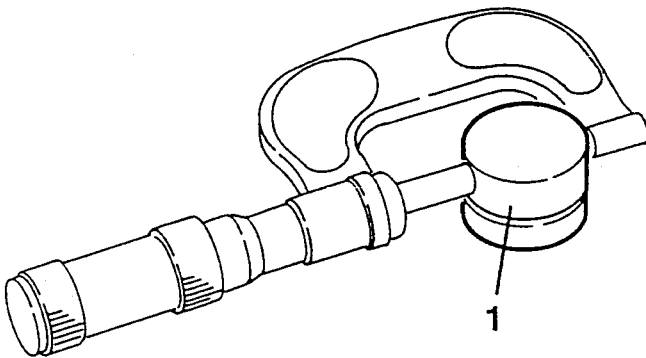
1. Check that the diameter of the hydraulic tappets seats is within the specified limits.

∅	Diameter of hydraulic tappets seats
	33.000 + 33.025 mm



1. Check that the outside diameter of the hydraulic tappets is within the specified limits.

∅	Diameter of hydraulic tappets
	32.959 + 32.975 mm



- Calculate the clearance between the hydraulic tappets and their seats checking that it is within the specified limits.

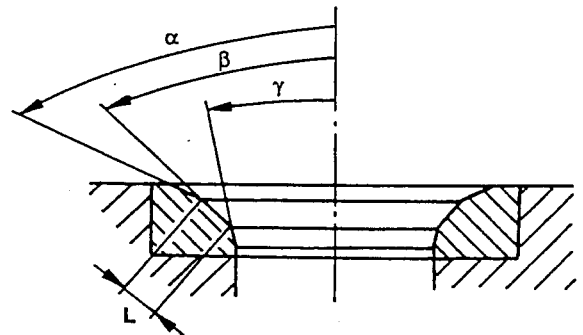
↔	Clearance between hydraulic tappets and seats
	0.025 + 0.066 mm

Turning the valve seats

- If necessary, turn the valve seats using suitable equipment within the following limits.

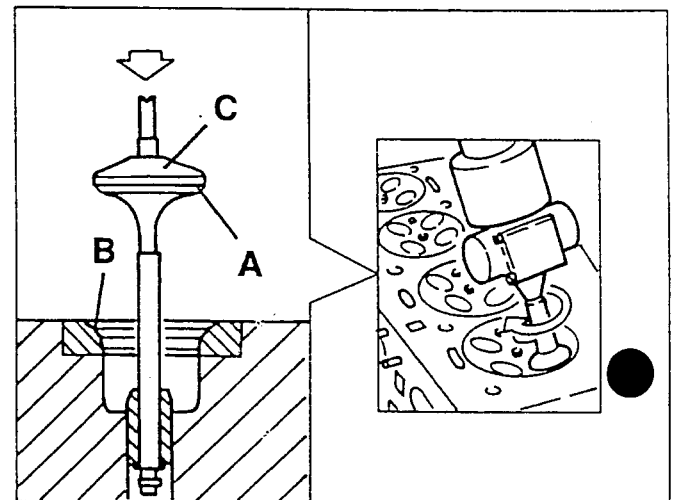
◁	Taper of contact area with valve "β"	90° ± 10'
	Taper of upper valve seat area "α"	150°
	Taper of lower valve seat area "γ"	30°

	Dimension "L" contact area with valve	
	Intake	0.8 mm
	Exhaust	1 mm



- After machining, grind each valve in its seat as follows:

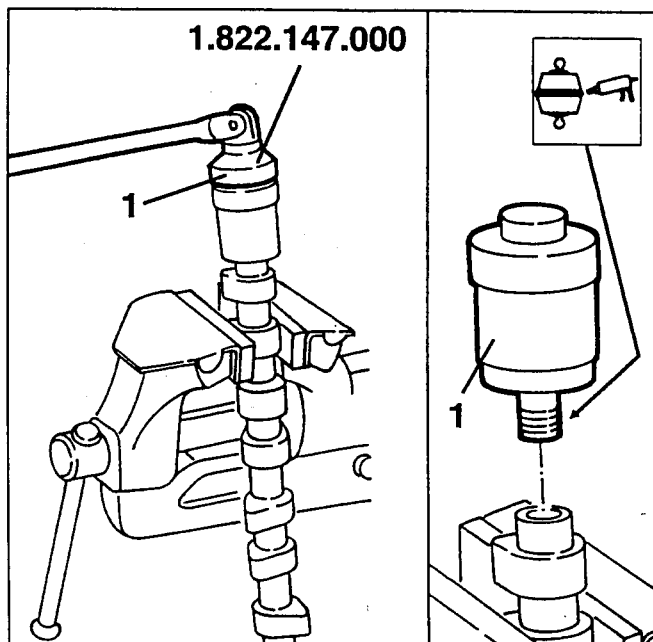
- coat the contact surfaces "A" and "B" of the valves and their seats with abrasive paste (SIPALAREXOS Carbo-silicium for valves);
- lubricate the valve stem with engine oil;
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder;
- insert the valve in its guide and grind;
- after grinding, thoroughly clean the valve and the seat.



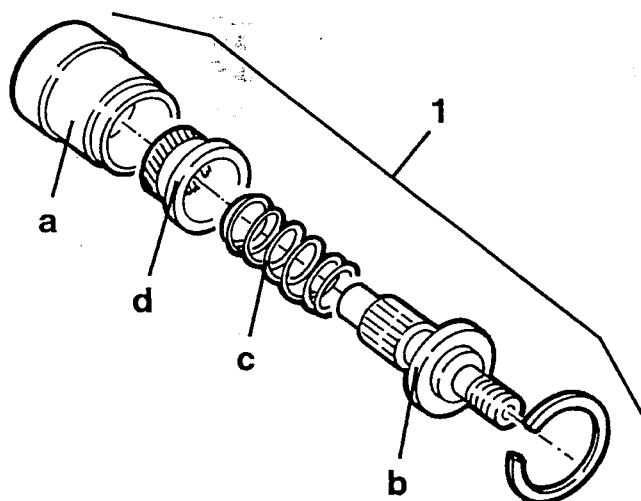
Removing the timing variator from the camshaft

- Position the camshaft intake side in a vice fitted with protective jaws.

1. Using tool no. 1.822.147.000, slacken and remove the timing variator from the camshaft.



1. Remove the stop ring and remove the outer body (a) of the variator pinion (b), spring (c) and the piston (d).



WARNING:

When refitting the timing variator, follow the instructions given below:

- Make sure that the mastic on the thread coupling the timing variator to the camshaft does not obstruct the oil ducts.
- Wait for about two hours before assembling the shaft on the cylinder head.

CHECKS AND INSPECTION CRANKCASE

- Visibly check the crankcase for cracks and signs of excessive wear of the sliding surfaces; check that all the threads are intact.

- Remove the lubrication and cooling groove caps and clean the ducts with a suitable detergent, then dry with a jet of air and fit new caps.

- Accurately remove any traces of seals or sealants from the crankcase surfaces.

Checking the cylinders

1. Using a bore gauge fitted on a dial gauge, measure the inside diameter of the cylinders and check that it is within the specified limits.



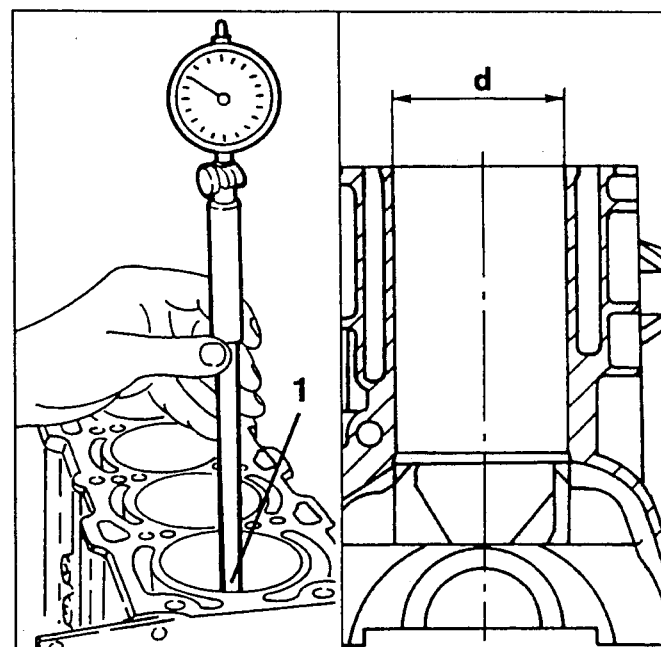
Inside diameter of the cylinders "d"	
Class A	83.000 + 83.010 mm
Class B	83.010 + 83.020 mm
Class C	83.020 + 83.030 mm
Oversize of 0.1 mm	



Maximum cylinder taper	
0.010 mm	



Maximum cylinder ovalization	
0.005 mm	



- When turning and grinding the valve seats it is advisable to check the valve tightness with the spark plugs in place, proceeding as follows:

- fill the hollow of the combustion chamber with petrol;
- admit low pressure air into the intake manifolds and check that no bubbles form in the petrol;
- check the tightness of the exhaust valves in the same way, admitting air to the exhaust manifolds;
- if any leaks are noted, make sure that the valves are perfectly settled in their seats and repeat the check; if the result is negative, grinding must be repeated.

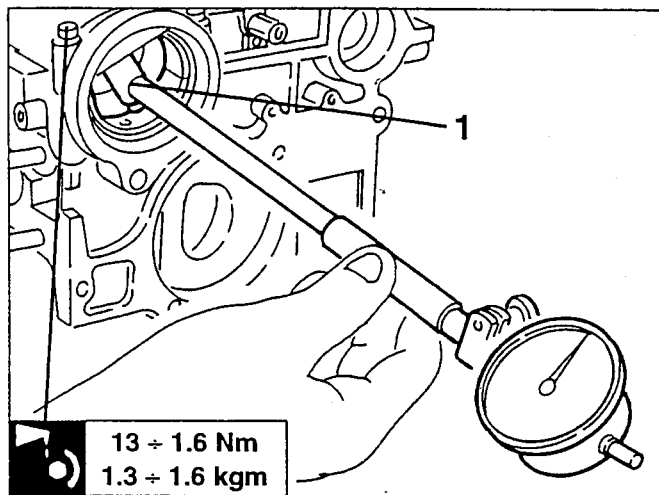
Camshafts and timing system bearings

1. Assemble the camshaft caps and tighten the fastening screws to the specified torque, then check that the diameter of the supports is within the specified limits.

NOTA: The half bearings should be assembled on the intake side front support.

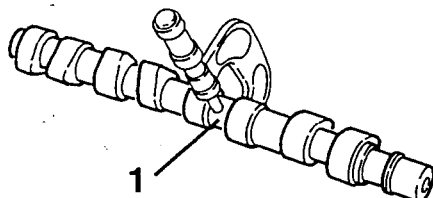
Diameter of camshaft supports	
	26.045 ÷ 26.070 mm
	50.034 ÷ 50.071 mm (*)

(*) Front intake side support with half bearings assembled (for timing variator)



1. Check that the diameter of the camshaft journals is within the specified limits.

Diameter of camshaft journals	
	26.000 ÷ 26.015 mm



- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limits.



Clearance between camshafts and bearings

0.03 ÷ 0.07 mm 0.034 ÷ 0.086 mm (*)

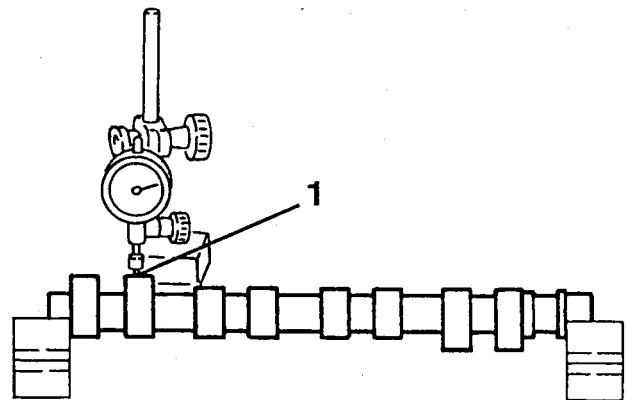
(*) Specific for timing variator

1. Check that the cam lifts are within the specified limits.



Cam nominal lift

Intake	8.3 mm
Exhaust	7.5 mm



Checking the camshaft end float

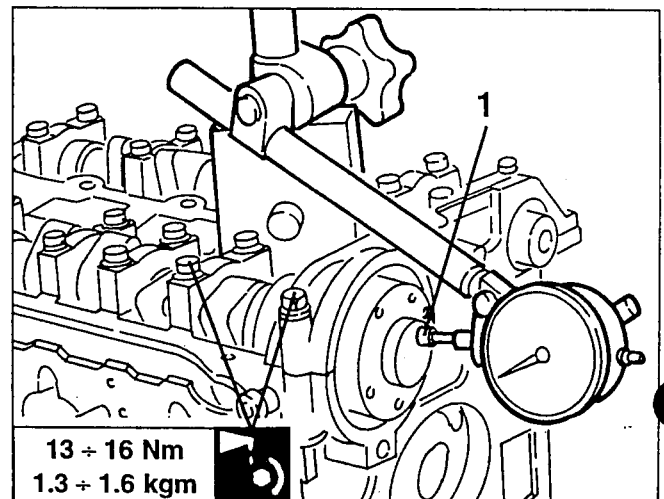
- Place the camshafts on the cylinder head, assemble the corresponding caps and tighten the fastening screws to the specified torque.

1. Install a centesimal dial gauge and measure the end float of the camshafts checking that it is within the specified limits.



Camshafts end float

0.10 ÷ 0.23 mm

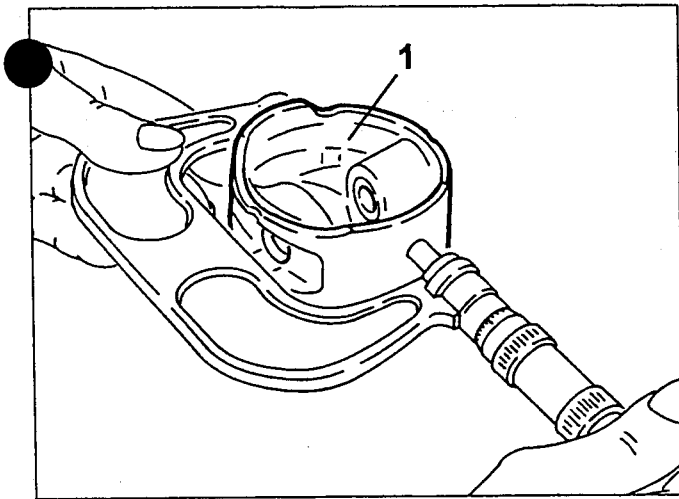


Checking the pistons

1. Measure the outside diameter of the pistons and check that it is within the specified limits.

Outside diameter of pistons (1)	
Class A - Blue	81.952 ÷ 81.962 mm
Class B - Pink	81.960 ÷ 81.970 mm
Class C - Green	81.968 ÷ 81.978 mm
Oversize of 0.1 mm	

(1) To be measured at right angles to the gudgeon pin hole at a distance of 12.5 mm from the lower edge of the piston skirt.



- Calculate the clearance between the cylinder and the piston and check that it is within the specified limits.

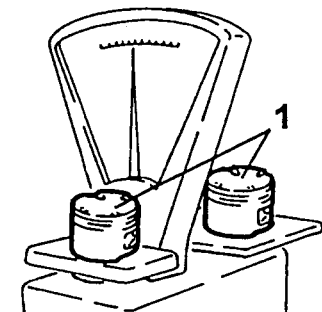


Clearance between piston and cylinder
0.040 ÷ 0.060 mm

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.



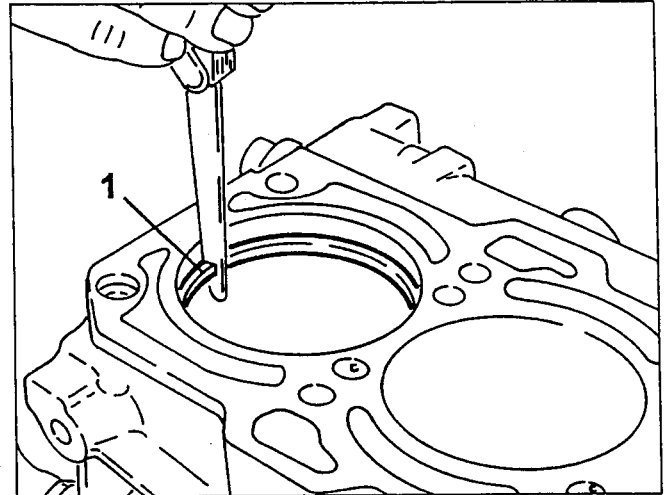
Difference in weight between pistons
± 5 g



Checking the seal ring gap

1. Insert the seal rings in the cylinder, check that they adhere to the whole circumference and that the gap is within the specified limits.

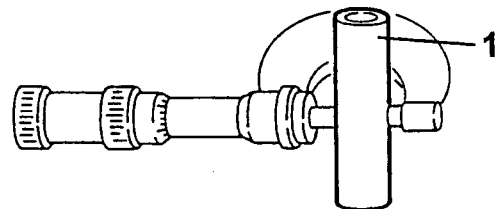
Ring gap	
First ring	0.25 ÷ 0.50 mm
Second ring	0.30 ÷ 0.50 mm
Oil scraper ring	0.25 ÷ 0.50 mm



Checking the play between gudgeon pins and seats on pistons

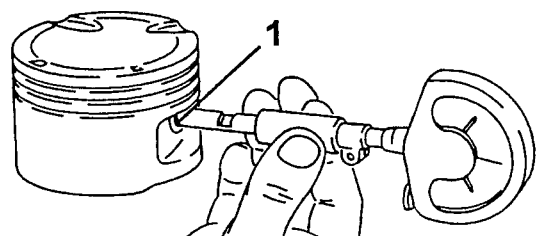
1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.

Outside diameter of gudgeon pins
19.996 ÷ 20.000 mm



1. Measure the diameter of the pin mating hole in the piston and check that it is within the specified limits.

Diameter of pin seat in pistons
20.002 ÷ 20.007 mm



- Calculate the clearance between the pins and their seats on the pistons and check that it is within the specified limits.



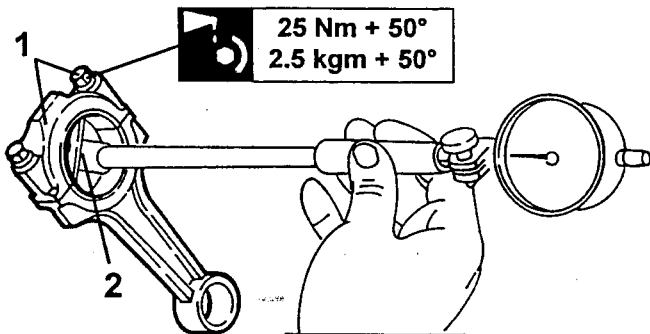
Clearance between pins and seats on pistons
0.002 ÷ 0.011 mm

Checking clearance between connecting rod journals and corresponding half bearings

1. House the rod half bearings in the connecting rod big end and on the corresponding cap, then join them tightening the fastening screws to the specified torque.
2. Measure the diameter of the connecting rod big end and check that it is within the specified limits.



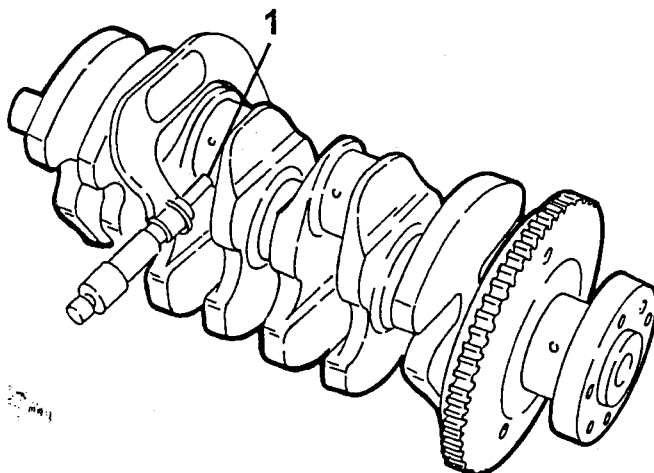
Inside diameter of connecting rod half bearings	
Class A - Red	40.920 ÷ 40.940 mm
Class B - Bleu	40.914 ÷ 40.934 mm
Class C - Yellow	40.908 ÷ 40.928 mm



1. Measure the diameter of the connecting rod journals and check that it is within the specified limits.



Diameter of connecting rod journals	
Class A - Red	40.884 ÷ 40.890 mm
Class B - Bleu	40.878 ÷ 40.884 mm
Class C - Yellow	40.872 ÷ 40.878 mm



- Calculate the clearance between the rod journals and the corresponding half bearings and check that it is within the specified limits.



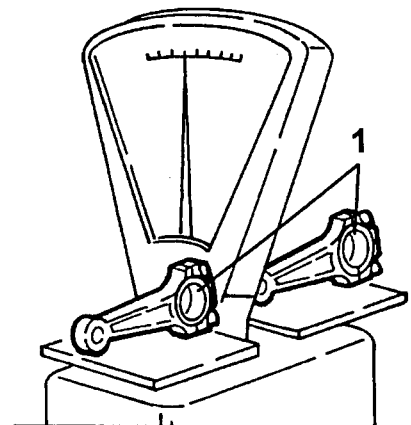
Clearance between rod journals and half bearings
0.030 ÷ 0.056 mm

Checking the connecting rods

1. Check that the difference in weight between the connecting rods complete with half bearings, caps and screws is within the specified limits.

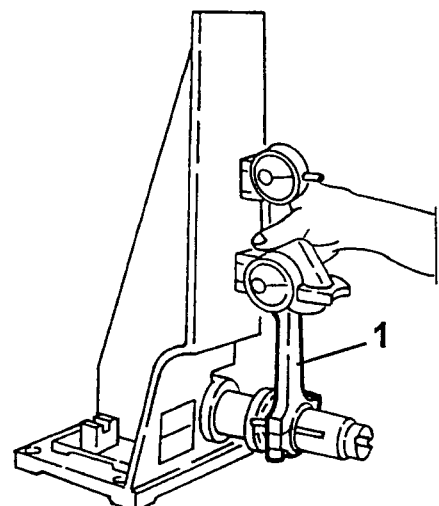


Difference in weight between connecting rods
≤ 5 g



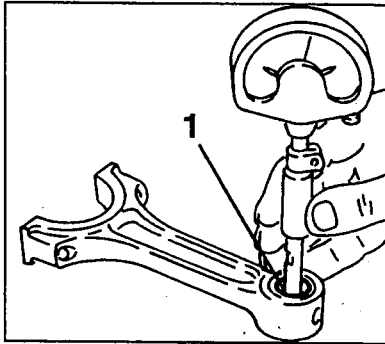
1. Check that the connecting rods are perpendicular using a reference plane as illustrated.

NOTE: If perpendicularity is not perfect, the connecting rod must be changed to avoid abnormal stresses when the engine is running, resulting in uneven wear of the piston and of the rod itself.



Checking the clearance between pins and small end bushings

1. Measure the inside diameter of the small end bushing and check that it is within the specified limits, if not, change the bushing.



∅	Inside diameter of small end bushing
	20.006 ÷ 20.012 mm

- Measure the outside diameter of the pins and check that it is within the specified limits.

∅	Outside diameter of pins
	19.996 ÷ 20.000 mm

- Calculate the clearance between the pins and small end bushings and check that it is within the specified limits.

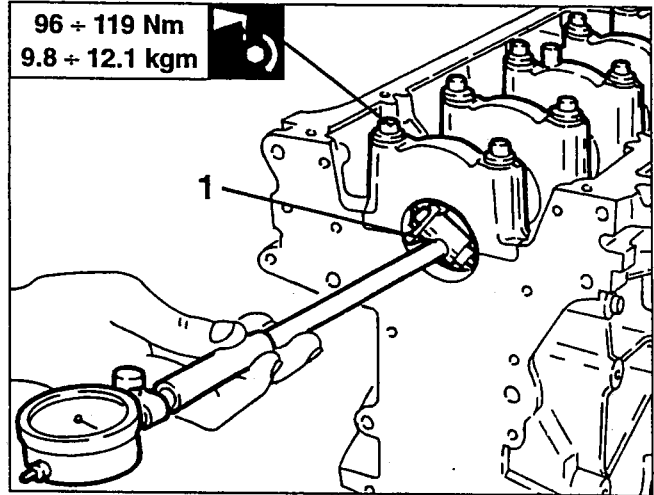
↔	Clearance between pins and small end bushing
	0.006 ÷ 0.016 mm

Checking the clearance between main bearing journals and half bearings

1. House the half bearings and fit the main bearings caps on the crankcase tightening the fastening screws to the specified torque.

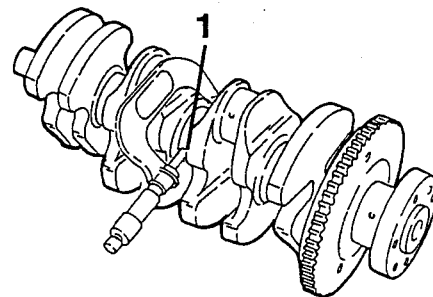
2. Measure the diameter of the main bearings and check that it is within the specified limits.

∅	Diameter of the main bearings
	Side
	Class A - Red 53.031 ÷ 53.056 mm
	Class B - Blue 53.017 ÷ 53.046 mm
	Class C - Yellow 53.007 ÷ 53.032 mm
	Centre
	Class A - Red 53.041 ÷ 53.066 mm
	Class B - Blue 53.027 ÷ 53.056 mm
	Class C - Yellow 53.017 ÷ 53.042 mm



1. Measure the diameter of the main bearing journals and check that it is within the specified limits.

∅	Diameter of main bearing journals
	Class A - Red 52.994 ÷ 53.000 mm
	Class B - Bleu 52.988 ÷ 52.994 mm
	Class C - Yellow 52.982 ÷ 52.988 mm



- Calculate the clearance between the main bearing journals and half bearings and check that it is within the specified limits.

↔	Clearance between main bearing journals and half bearings
	Side
	Class A - Red 0.031 ÷ 0.062 mm
	Class B - Blue 0.023 ÷ 0.058 mm
	Class C - Yellow 0.019 ÷ 0.050 mm
	Centre
	Class A - Red 0.041 ÷ 0.072 mm
	Class B - Blue 0.033 ÷ 0.068 mm
	Class C - Yellow 0.029 ÷ 0.060 mm

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, change the ring gear as described below:

- working under the press remove the old ring gear;



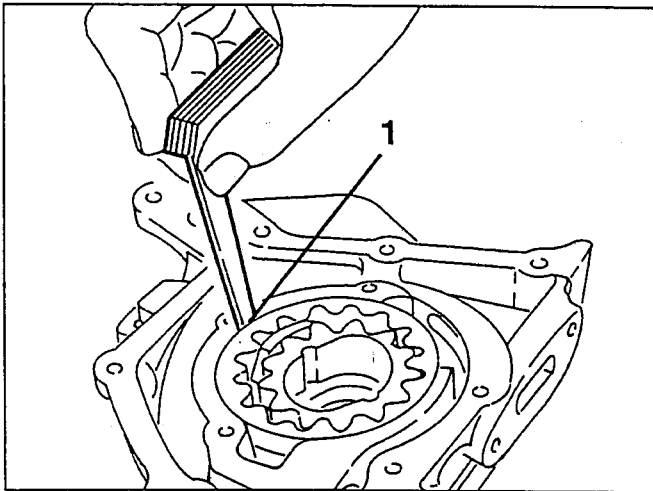
- accurately clean the contact surfaces of the new ring gear and of the flywheel;
- evenly heat the new ring gear to $80^{\circ} \pm 100^{\circ} \text{C}$ and fit it on the flywheel: leave to cool naturally, do not force cool.

Checking the oil pump

1. Check that the clearance between the pump casing and the driven gear is within the specified limit.



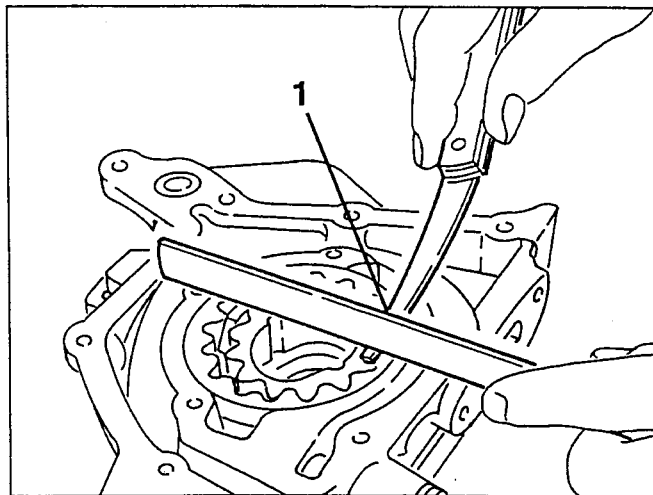
Clearance between pump casing and driven gear
$0.080 \pm 0.186 \text{ mm}$



1. Check that the clearance between the pump cover rest surface and the upper side of the gears is within the specified limit.



Clearance between pump cover rest surface and upper side of gears
$0.025 \pm 0.070 \text{ mm}$



WARNING: If the clearances measured are not within the specified limits, change the front crankcase cover with oil pump incorporated.

- Using a torque meter check the characteristic values of the engine oil pressure limiting valve control spring.

Control load Kg	Spring length mm
6.4 ± 7.2	36

INSTRUCTIONS FOR RE-ASSEMBLY



For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

- Check valve tightness when the cylinder head is assembled (see "Turning the valve seats").

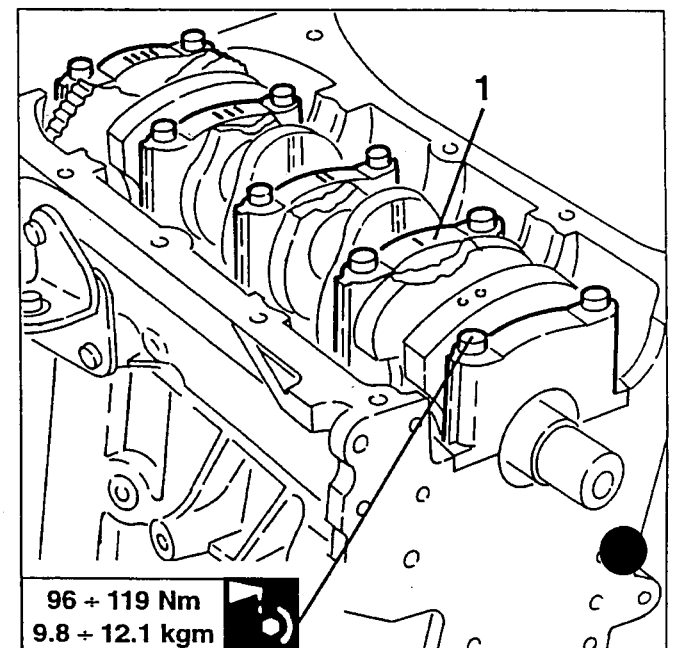
Reassembling the crankshaft

- Assemble the crankshaft on the crankcase complete with half bearings and half thrust rings.

Reassemble the half thrust rings with the grooved surfaces facing the crankshaft.

1. Assemble the main bearing caps complete with half bearings on the supports and tighten the fastening screws two or three times starting from the centre main bearing cap.

The position of each cap is given by a series of consecutive notches (from zero to four starting from the front of the engine) etched on the caps themselves.




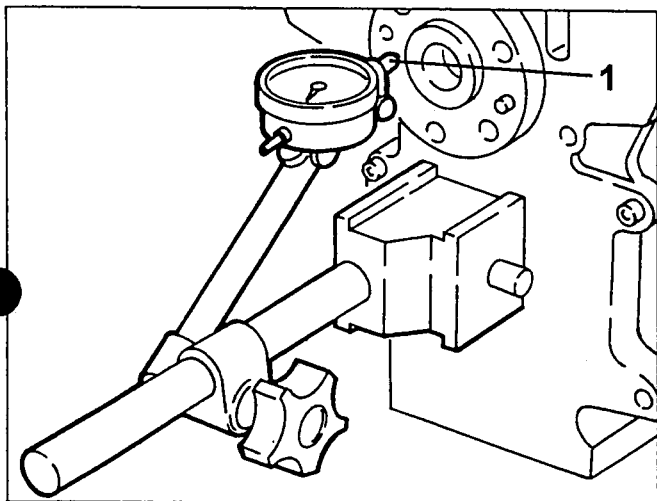
96 ± 119 Nm
9.8 ± 12.1 kgm



Checking crankshaft end float

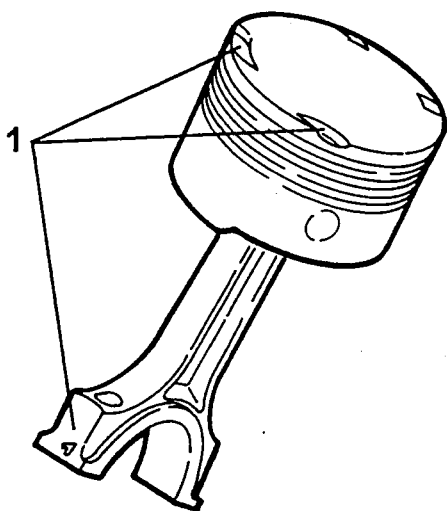
1. Using a dial gauge on a magnetic base, measure the crankshaft end float and check that it is within the specified limits.

	Crankshaft end float 0.059 ÷ 0.221 mm
--	---



Refitting pistons and connecting rods

1. Assemble the piston and connecting rod making sure that the number stamped on the big end is on the same side as the large notches (for intake valves) on the piston crown.



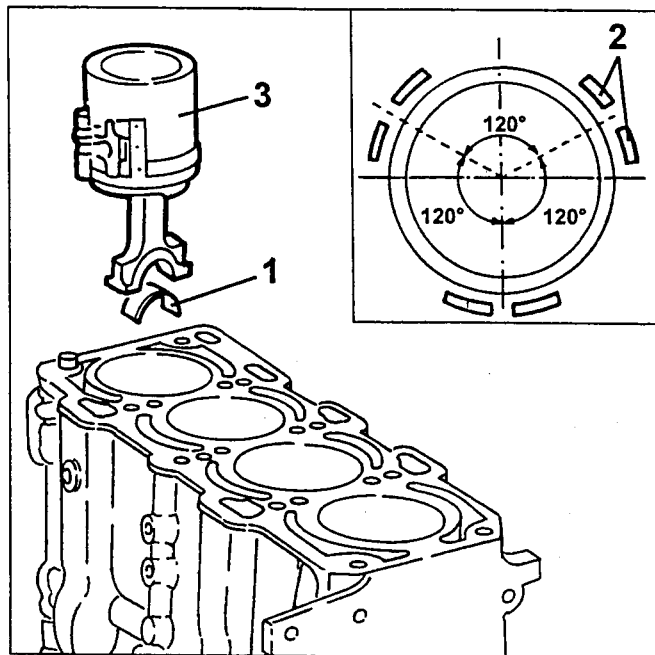
- Turn the crankshaft until the connecting rod pins of the 1st and 4th cylinder reach the position corresponding to the B.D.C.

1. House the corresponding half bearings on the connecting rod big ends.

2. Place the rings in the pistons with the notches offset by 120° and the word TOP stamped on them facing upwards.

3. Using a suitable tool, insert the pistons and connecting rods in the 1st and 4th cylinder.

Assemble the connecting rod - piston sets in the crankcase directing the arrow stamped on the piston crown in the direction of rotation of the engine.



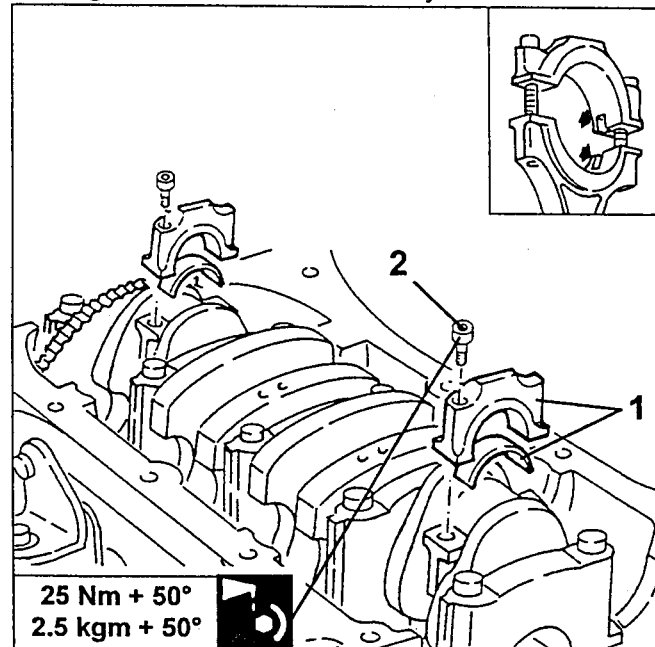
- Turn the crankcase 180°.

1. House the corresponding half bearings on the connecting rod caps, then assemble those of the 1st and 4th cylinder directing the safety notch towards the same side as the corresponding notch on the connecting rod big end.

On the side, the connecting rod caps have the number of the cylinder to which they belong; during reassembly this number should be on the same side as the one stamped on the connecting rod big end.

2. Tighten the connecting rod cap fastening screws to the specified torque in oil.

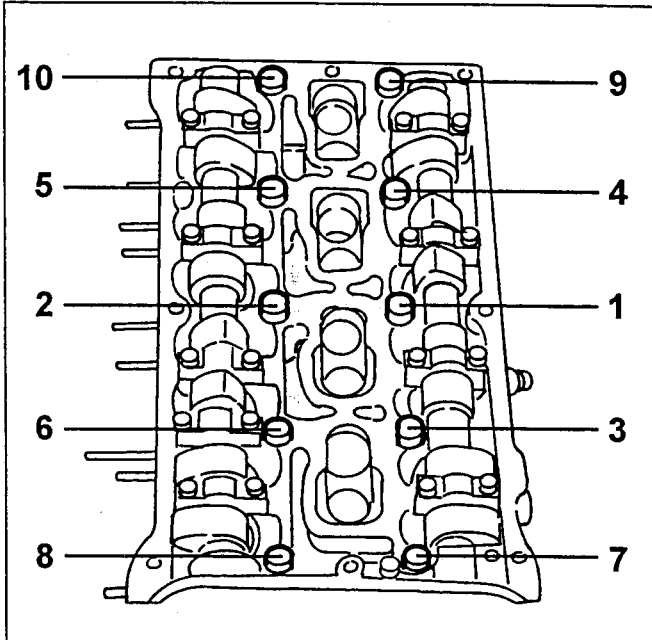
- In the same way reassemble the pistons and connecting rods of the 2nd and 3rd cylinder.



25 Nm + 50°
2.5 kgm + 50°

Cylinder head reassembly

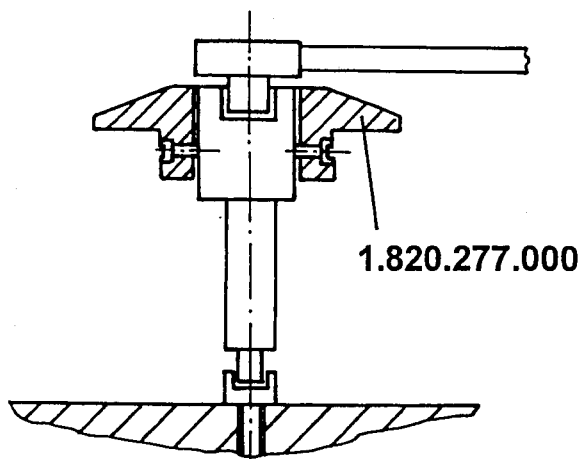
- Turn the crankshaft until the pistons of the 1st and 4th cylinder reach the T.D.C.
- Position the seal on the crankcase and then the cylinder head.
- Tighten the cylinder head fastening screws proceeding as described below and bearing in mind that, for each step the tightening sequence is the one shown below.



Tightening sequence

Approach all the screws to a torque of:	20 Nm (2.0 kgm)
Tighten the screws to a preliminary torque of:	40 Nm (4.1 kgm)
Turn the screws by an angle of:	90° + 90° + 90°

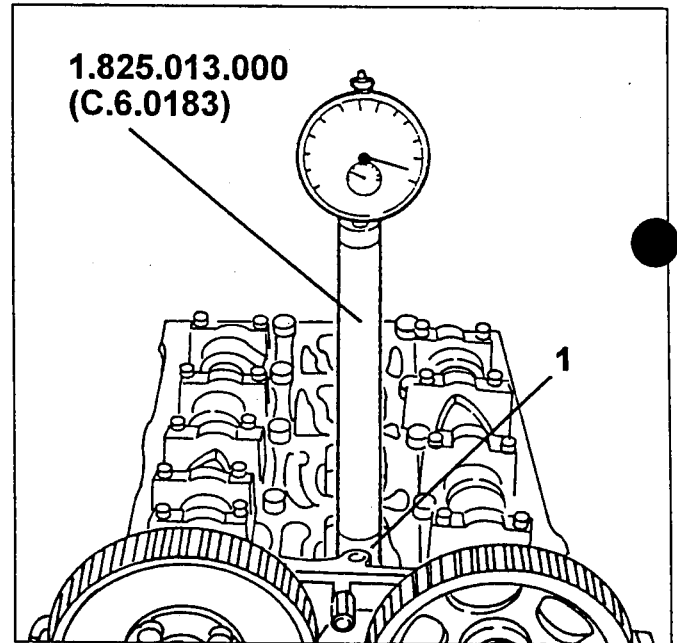
- For angle tightening use graduated disk no. 1.820.277.000 as illustrated.



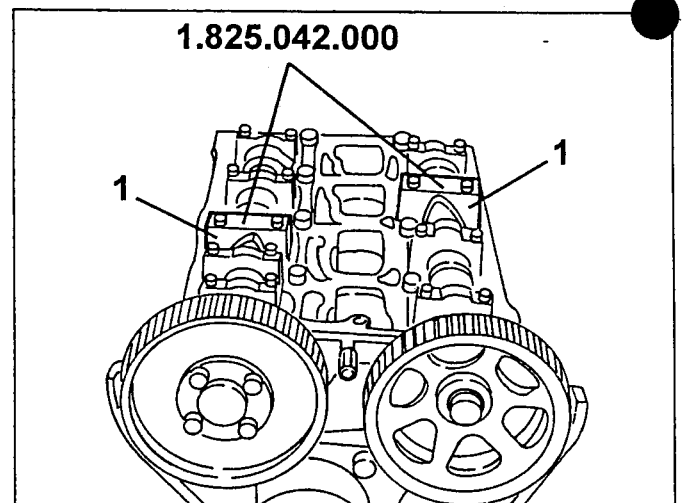
The seal between the cylinder head and crankcase is of the type in aramid fibre and no further head tightening is scheduled throughout the whole life of the engine.

Camshaft drive belt assembly and checking valve gear timing

- Assemble the camshaft toothed drive pulleys without tightening the fastening screws, the camshaft belt drive pulleys and the corresponding belt tensioner.
- 1. Assemble tool no. 1.825.013.000 (C.6.0183) fitted with dial gauge in the seat of the centre spark plug of the 1st cylinder.
- Turn the crankshaft until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke.



1. Remove the camshaft caps illustrated and in place of them, fit templates no. 1.825.042.000 tightening the fastening screws to a maximum torque of 10 Nm (1 Kg) and checking correct mating with the cams.

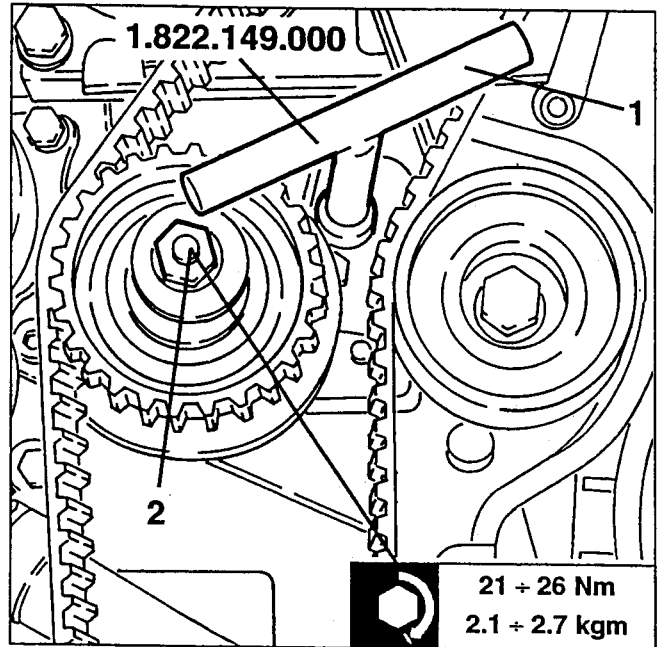


NOTE: For turning the camshafts, use tool 1.822.155.000 for the intake side and tools no. 1.822.146.000 and no. 1.822.156.000 for the exhaust side, to be applied to the corresponding pulleys.

Assemble the timing gear drive belt ensuring correct coupling with the teeth of the pulleys, fitting it in the following sequence:

- crankshaft pulley
- fixed pulley guide
- camshaft pulley on exhaust side
- camshaft pulley on intake side
- automatic tensioner guide
- coolant fluid pump guide pulley

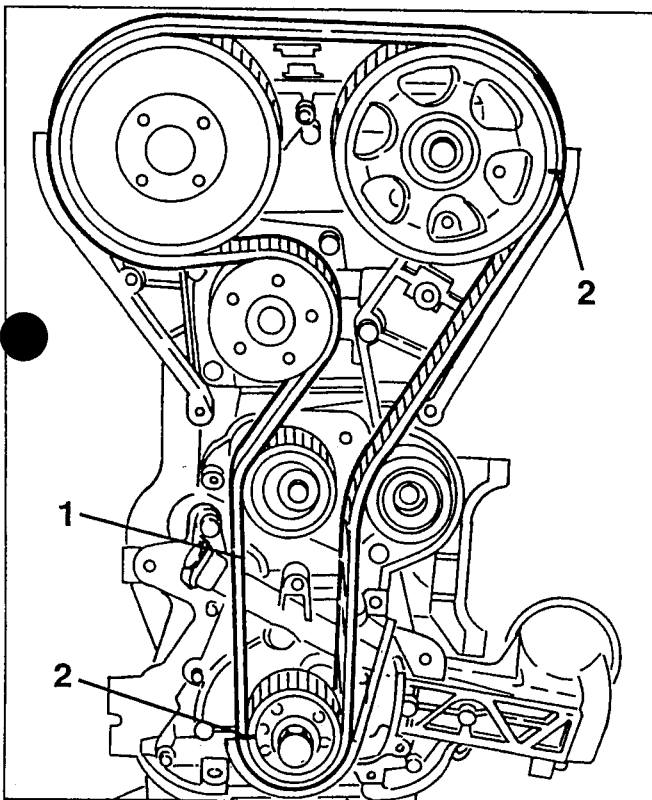
2. The notches painted on the belt must coincide with the indexes machined on the crankshaft pulley and on the camshaft pulley exhaust side.



WARNING:

When assembling the toothed belt, avoid bending it sharply as this can lead to damage of the structures forming the belt.

The arrow on the belt indicates the direction of rotation of the engine.



1. Tighten the screws fastening the intake side camshaft drive pulley.

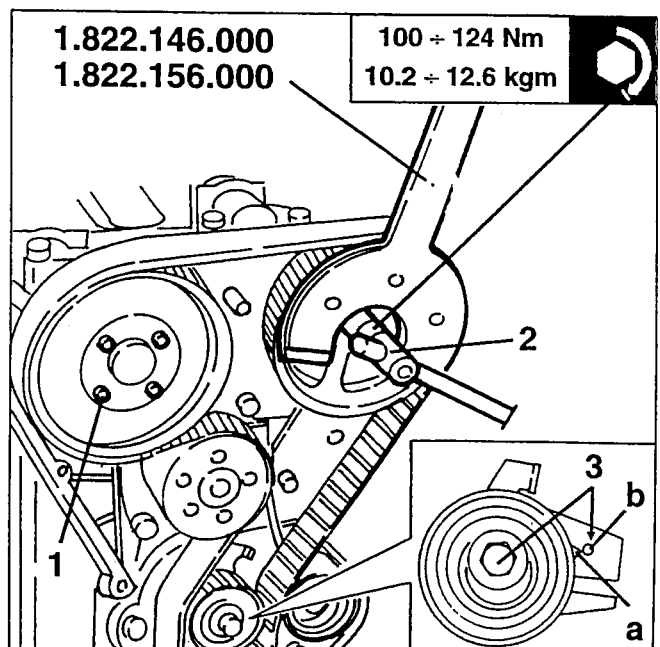
2. Using tool no. 1.822.146.000 complete with tool no. 1.822.156.000, tighten screw fastening the camshaft drive pulley on the exhaust side.

- Remove the two templates from the camshafts and turn the crankshaft twice in its direction of rotation to take the piston of the 1st cylinder to the T.D.C. in the bursting stroke.

3. Release the nut fastening the automatic tensioner, then using tool no. 1.822.149.000, move the mobile index (a) coinciding with the reference hole (b).

- Tighten the automatic tensioner fastening nut to the specified torque.

- Turn the crankshaft twice in its direction of rotation until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke and check that all the references coincide.



Using tool no. 1.822.149.000 as illustrated, apply the maximum tension on the belt.

2. Tighten the nut fastening the automatic timing gear belt tensioner.



CHECKING THE ELECTRIC COMPONENTS OF THE LUBRICATION CIRCUIT

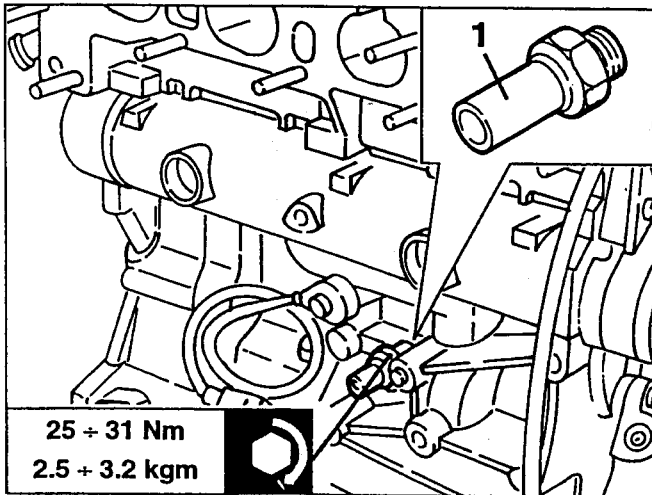
MINIMUM ENGINE OIL PRESSURE SENSOR

1. Check the setting of the minimum engine oil pressure sensor. If the value fails to meet specifications, change the sensor.



Contacts opening/closing pressure

0.2 + 0.5 bar





ENGINE AR 16101

10

INDEX

GENERALITIES

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- Lubrification4

OVERHAULING

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of the lubrication circuit.....39



DESCRIPTION

The engine is of the type with six 60° V mounted cylinders in light alloy with a total cylinder displacement of 2959 cm³ with injection and static ignition controlled by a single MOTRONIC M 3.7.1 control unit. The "V" arrangement and the 60° angle make the engine extremely compact and well balanced from the dynamic point of view.

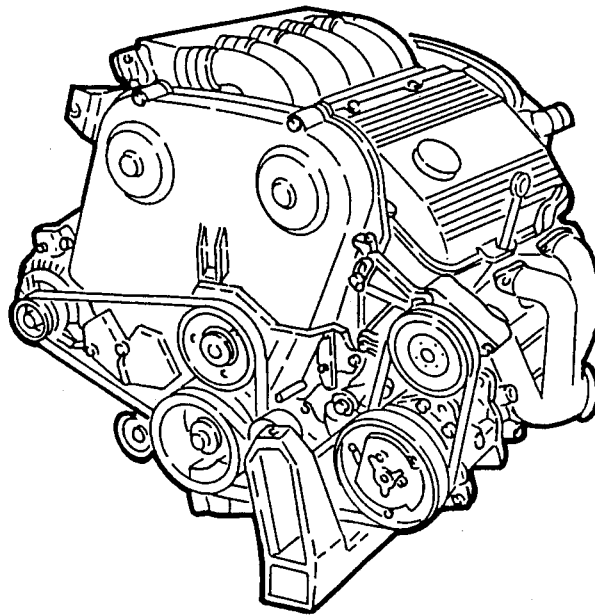
With a piston stroke of 72.6 mm and a bore of 93 mm, the engine is of the super square type (stroke and bore ratio below 1), which enables a better arrangement of the valves and optimal filling of the cylinders (high volumetric ratio).

The gearbox-clutch-differential unit is connected at the rear of the engine and is an integral part of the power unit.

The power unit is installed in the front of the vehicle arranged transversally with a 14° inclination forwards. It is fastened to the body by two "suspension" type flexible damping mounts and by a third to the suspension crossmember.

To reduce vibrations, a rod above the engine connected to the body prevents excessive shaking.

The fuel supply system, with unleaded petrol, combined with adequate anti-pollution systems described in the specific paragraphs, feature low exhaust emission levels meeting "EEC STAGE 2" regulations.



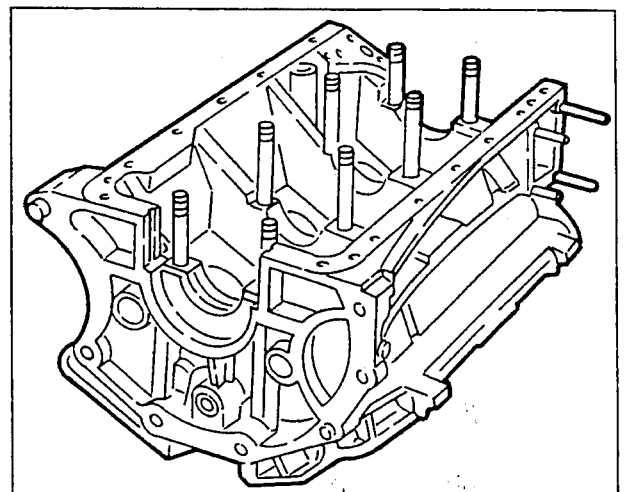
CRANKCASE

A single block in light aluminium and silicium alloy with high mechanical strength and thermal conductivity.

The crankshaft is supported by four main bearings which house the thin shell half bearings.

Special grooves, machined in the walls of the crankcase allow the passage of the engine coolant fluid and lubricating oil.

There are jets at the base of the cylinders from which oil is sprayed to cool the pistons.

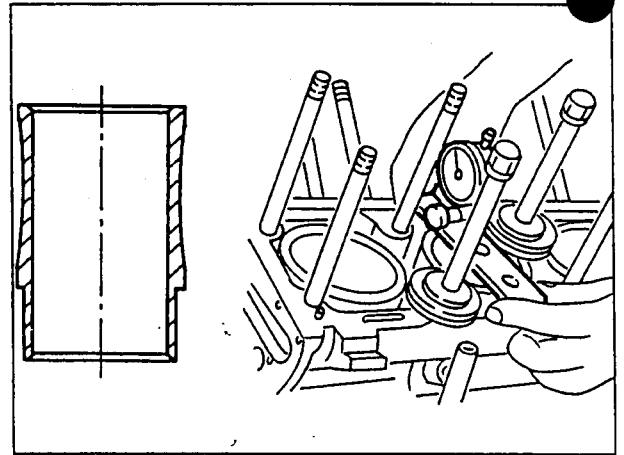


CYLINDER LINERS

These are of the low-slung type in cast iron and are directly reached from outside by the coolant for a more rational heat dissipation (humid).

The liner is sized so as to avoid distorsions and contain the gas.

When refitting the engine it is necessary to check that the protrusion of the cylinder liners from the crankcase is within the specified limits.



CYLINDER HEADS

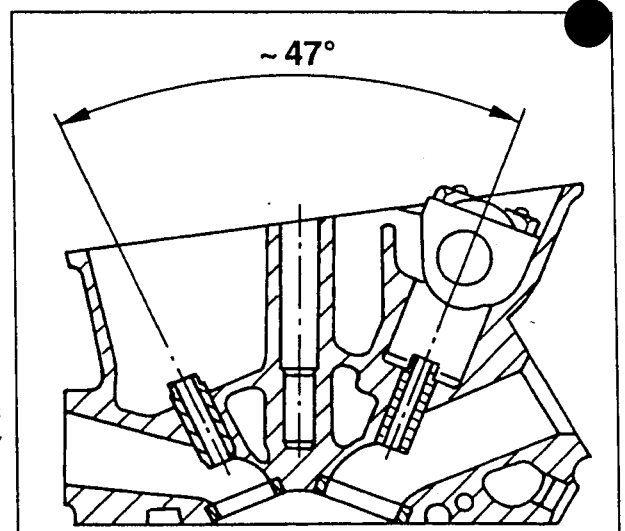
These are compact, single-piece, chill-cast in aluminium and silicium alloy.

The arrangement of the valves in a V of $\sim 47^\circ$ gives the combustion chamber an optimal shape.

Each cylinder head supports a camshaft for the intake valves and a rod and rocker system for controlling the exhaust valves. The camshafts turn on four bearings and are driven by a toothed belt.

The valve seats are fitted on the cylinder heads after heating them to a temperature of appr. 150°C .

The valve guides are force-fitted in their housings on the cylinder heads with interference and the inside diameter is perfected after assembly with a specific bore and checked by a pair of go-no-go gauges.



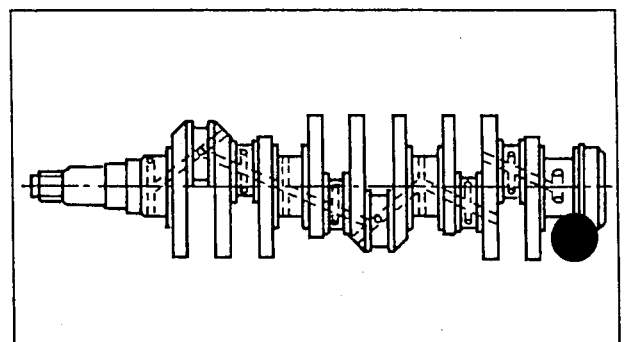
OIL SUMP

This is made of die-cast aluminium alloy with splash guards inside. It is fastened to the crankcase by the insertion of silicone rubber.

CRANKSHAFT

This is forged in high strength alloy steel and soft-nitrided; a treatment which increases resistance to wear and reliability (fatigue strength). It rests on four main bearings and it is shouldered on the rear main bearing. Nine counterweights accurately balance the rotating parts.

A groove runs along the inside of the crankshaft to lubricate the main and connecting rod journals. The machining holes of these grooves are closed with special plugs, which should be removed for accurate cleaning when the engine is overhauled.



MAIN AND ROD BEARING HALVES

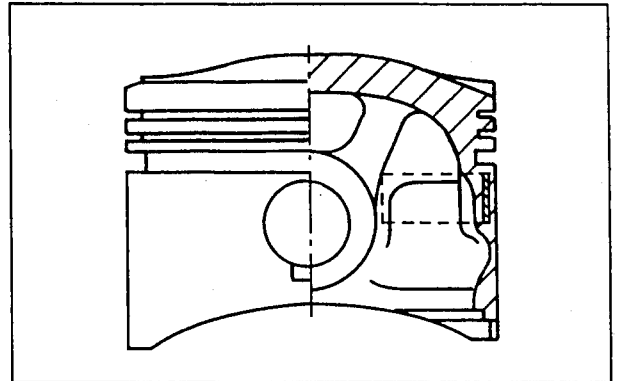
These are of the three-metal, thin shell type, divided into three dimensional classes, for the main bearing halves and two for the connecting rod bearing halves.

FLYWHEEL

This is in cast iron with a hardened ring gear and suitably balanced.

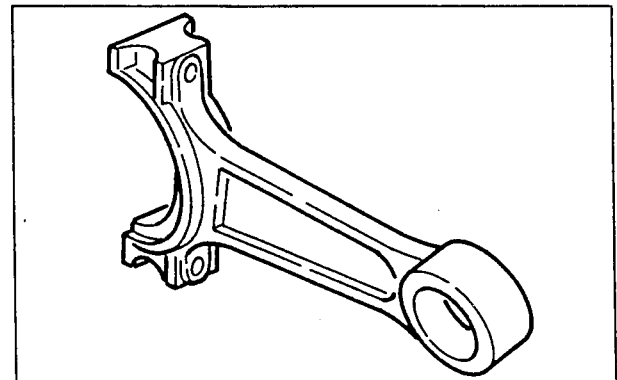
PISTONS - CONNECTING RODS

The pistons are in aluminium-silicium alloy with self-heating inserts and are divided into three dimensional classes. To ensure correct assembly an arrow is stamped on the piston crown to indicate the direction of rotation of the engine.

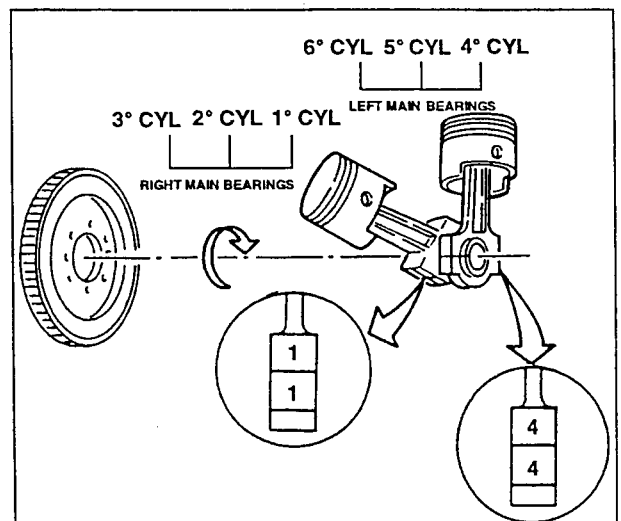


The connecting rods are in hardened and tempered alloy steel with a bushing in copper alloy force-fitted for coupling with the piston gudgeon pin.

As the gudgeon pins are floating on the piston hubs and on the connecting rod small end, their side movement is stopped by two expansion circlips housed in the special hollows machined on the actual hubs.



Each connecting rod is stamped with the number of the cylinder to which it refers; this number is towards the righthand side of the connecting rods of the right main bearings and on the lefthand side of the connecting rods of the left main bearings. Also the connecting rod caps have the number of the cylinder to which they refer on one side. When refitting this number should be on the same side as the one stamped on the connecting rod big end.



VALVE GEAR TIMING

This takes place through two camshafts in casehardened and tempered alloy steel, one for each row of cylinders.

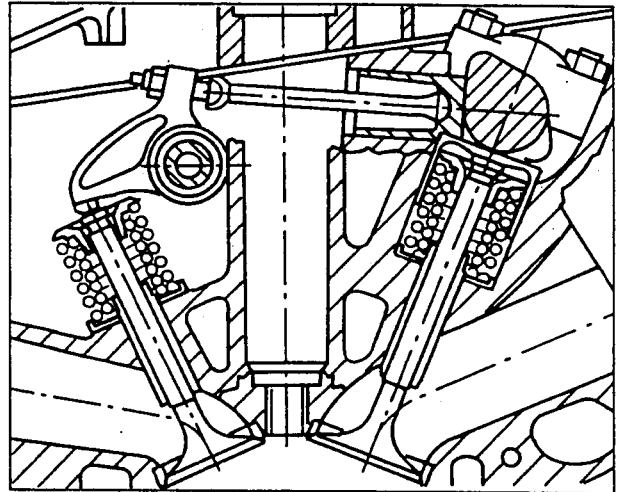
The camshafts are driven by a toothed belt with tensioner which automatically adjusts and maintains the belt tension.

The shaft acts directly on the intake valves by the cams and on the exhaust valves by rods and rockers.

On the intake the tappets are of the "light" mechanical type, made up of a hardened alloy steel cup in contact with the cam.

Valve cup control is transmitted to the valve through a cap in carbonitrided and tempered steel, used for valve play adjustment.

On the exhaust, timing takes place through a cast iron cup, which is in direct contact with the cam and transmits the movement to the valve through a rod and rocker system. The valve play is adjusted by the use of a special tool, through a screw which acts directly on the tappet rod.



LUBRICATION

The engine lubrication system is pressurised by a rotary lobe pump (3) fastened to the inner lower side of the crankcase.

The pump is driven by camshaft toothed timing belt through a pulley and a shaft.

A limiting valve (7) controls the pressure of the system.

During intake the oil is filtered through a gauze filter on the intake body and then through a replaceable filtering element on the supply line.

A longitudinal central oil hole in the crankcase makes it possible to lubricate the crankshaft, pistons and connecting rods.

Another two passages allow lubrication of the cylinder heads and of all the components of the engine timing system.

A recirculation system and vapour separator recover the oil vapours leading from the right cylinder head.

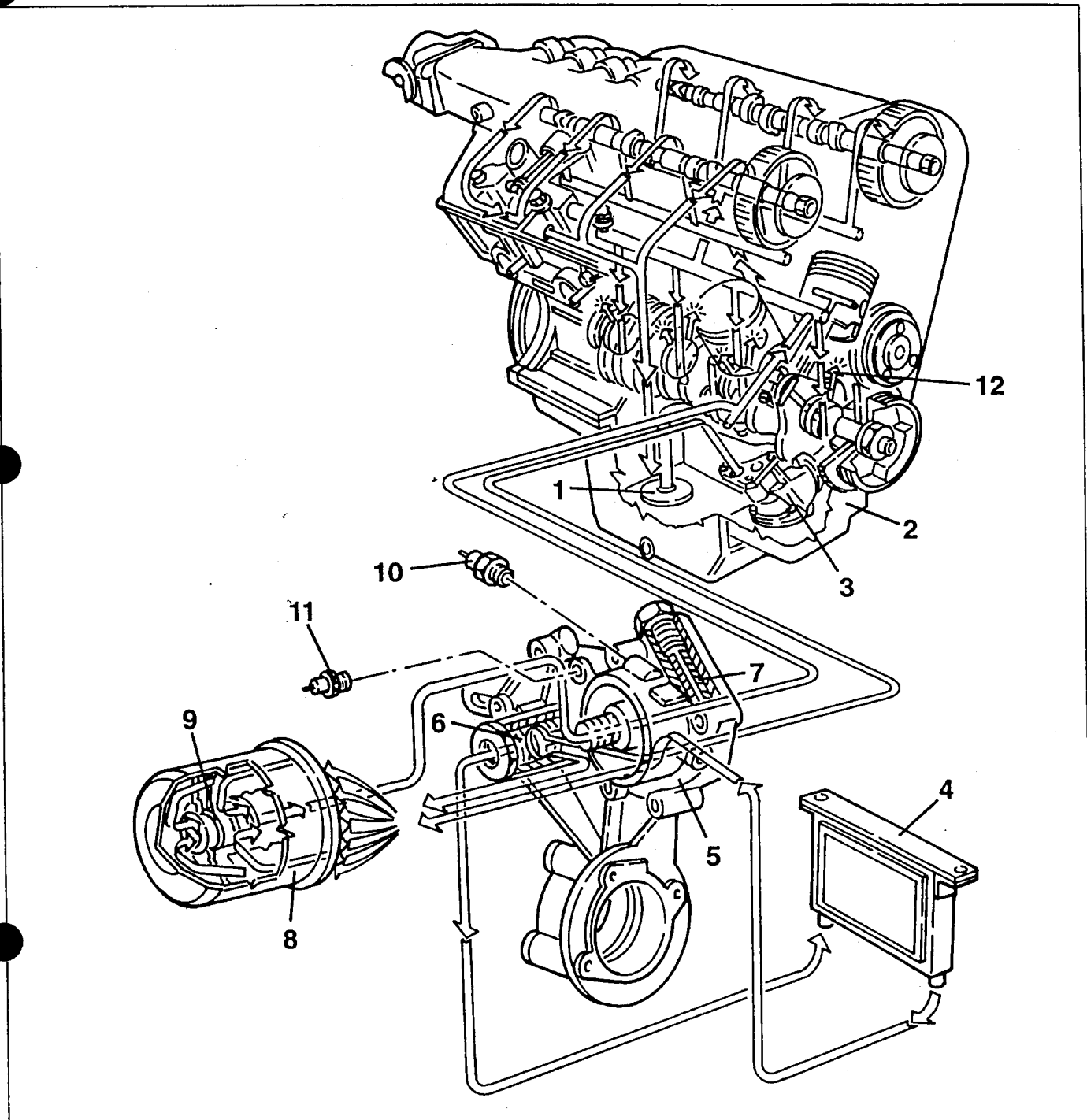
On the oil filter support (5) there is an engine oil minimum pressure sensor (11) connected to a warning light on the instrument cluster which alerts the driver if the oil pressure is too low.

The oil filler cap is located on the timing gear cover of the left cylinder head.

- The lubrication system includes an engine oil cooling radiator (4) and a thermostatic valve (6) located in the oil filter support.

When the temperature is below $82 \pm 2^\circ\text{C}$, the oil passes directly into the cartridge filter and returns to the engine, when the temperature is above this value the thermostatic valve is opened and allows the oil to flow into the cooling radiator and lower its temperature.

- To improve cooling of the piston skirts spray jets (12) are fitted in the crankcase with a built-in valve which opens at a pressure of $2.25 \div 2.75$ bar.



- 1. Suction device
- 2. Oil sump
- 3. Oil pump
- 4. Oil radiator
- 5. Oil filter support
- 6. Thermostatic valve

- 7. Oil pressure limiting valve
- 8. Oil filter
- 9. By-pass valve
- 10. Engine oil temperature transmitter
- 11. Low engine pressure warning light sensor
- 12. Spray jets

INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhauling of the engine on the bench, after having removed the power unit from the car. The instructions are subdivided as follows:

- Engine dis-assembly:

removal of the engine accessories and components and dis-assembly into the main units forming part of it.

- Dis-assembly and overhauling of the cylinder heads:

complete overhauling of all the components of the heads.

- Crankcase overhauling:

complete overhauling of the crank mechanism.

- Instructions for re-assembly:

these include the specific re-assembly operations which differ substantially from the dis-assembly instructions.

- Checking and inspecting electric components of the lubrication circuit.

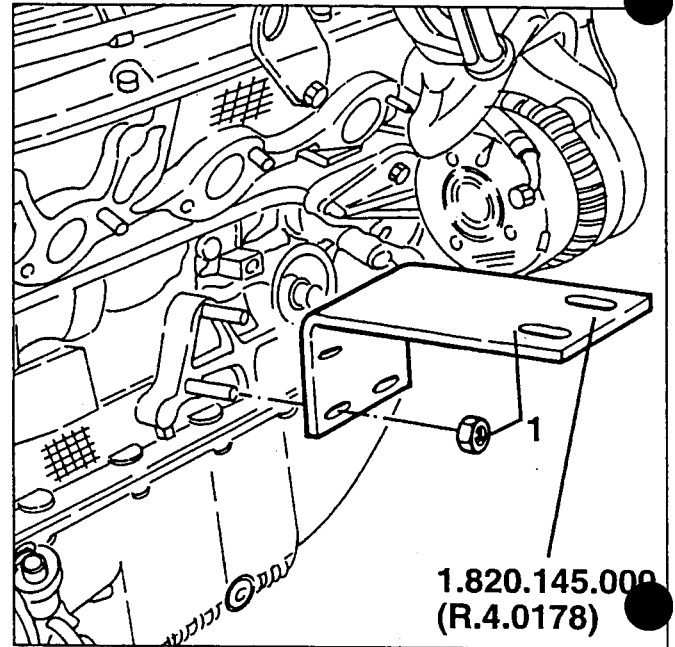
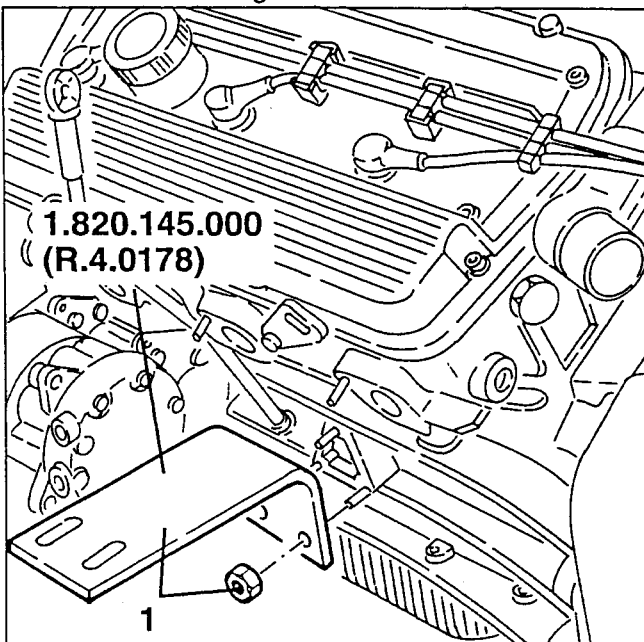
All the dis-assembly procedures described hereafter are also valid for re-assembly reversing the sequence described, unless otherwise specified.

The following procedures refer to the complete overhauling of the whole engine; it is however possible to use only certain parts of them separately, when necessary for dealing with specific components.

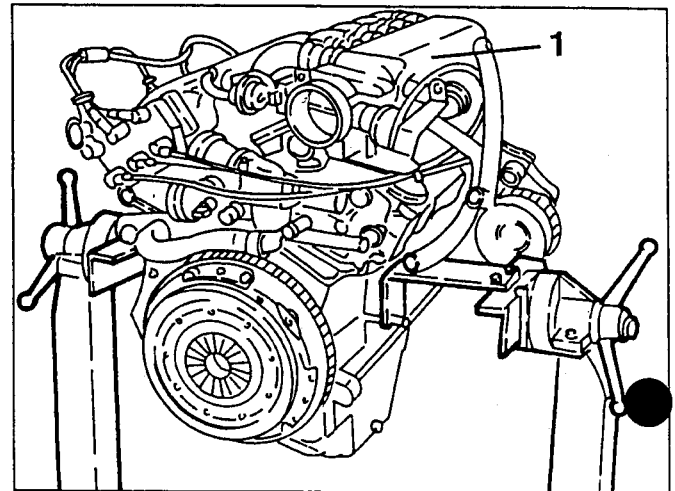
ENGINE DIS-ASSEMBLY

PRELIMINARY OPERATIONS

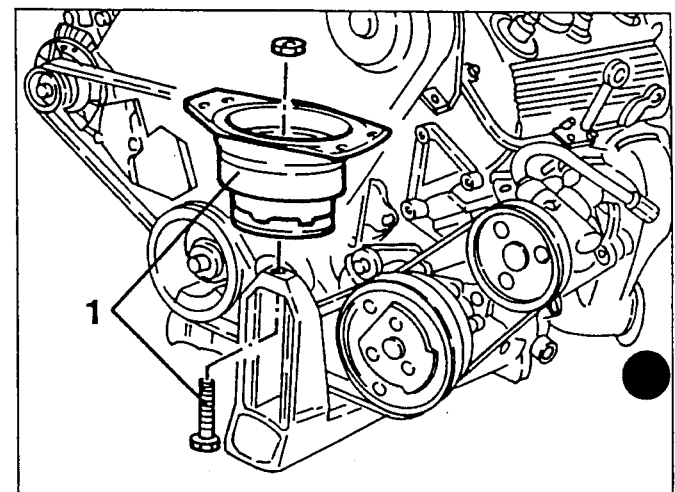
1. Install the two brackets no. 1.820.145.000 (R.4.0178) on the crankcase for positioning the engine on the overhauling stand.



1. Raise the engine with the hydraulic hoist and position it on the overhauling stand with support brackets no. 1.820.145.000 (R.4.0178).

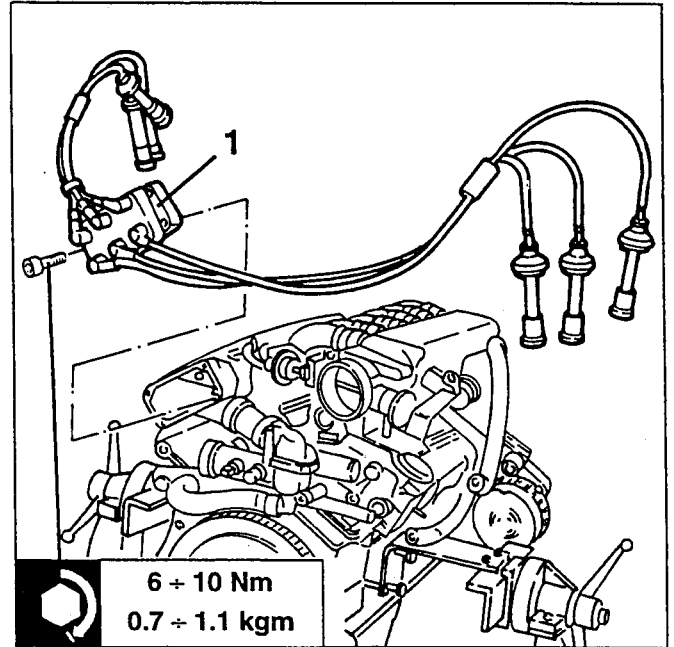
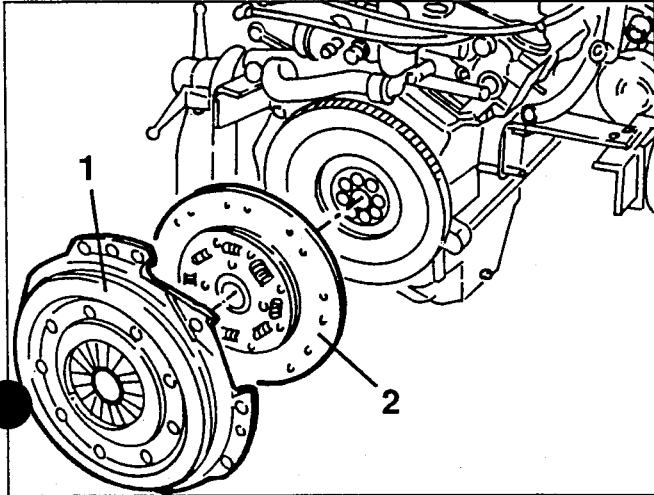


1. Slacken the fastening bolt and remove the timing gear side support.



REMOVING THE CLUTCH PLATE

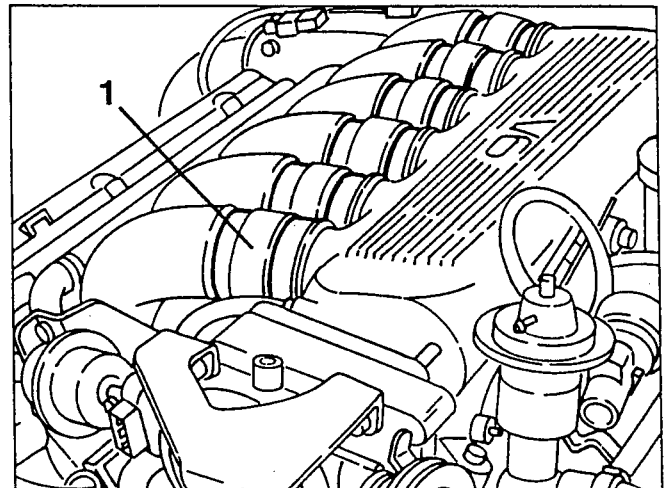
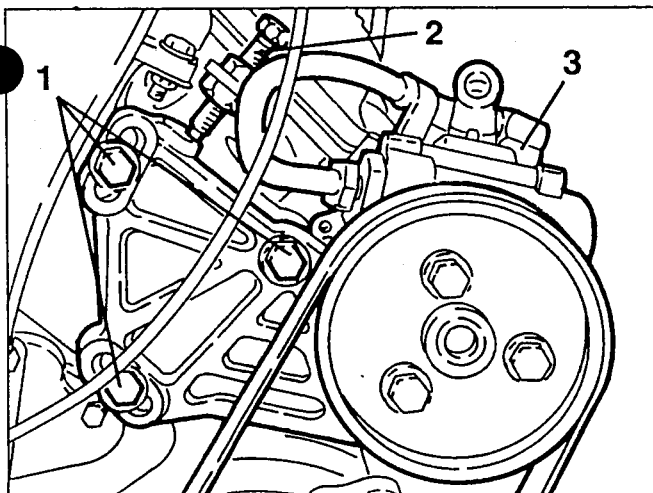
1. Slacken the fastening screws and remove the pressure plate body.
2. Remove the clutch plate.



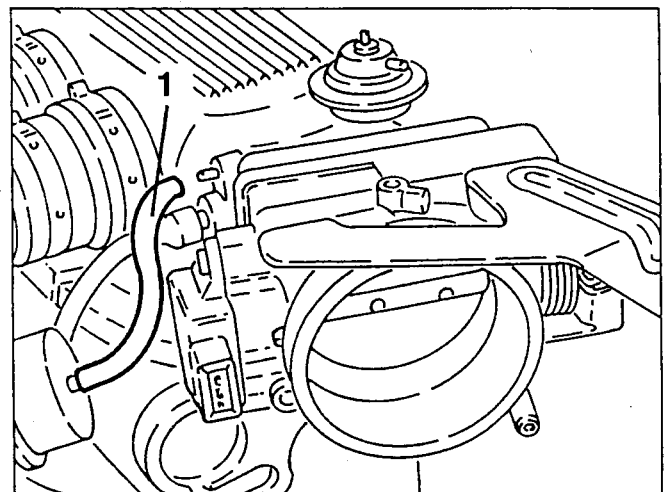
1. Slacken the clamps fastening the air intake ducts to the intake box.

REMOVING THE POWER STEERING PUMP

1. Slacken the three screws fastening the power steering pump support bracket.
2. Slacken the locknut, slacken the micrometric tensioner screw, then remove the power steering pump drive belt.
3. Back off the three screws slacked previously and remove the power steering pump complete with support bracket.



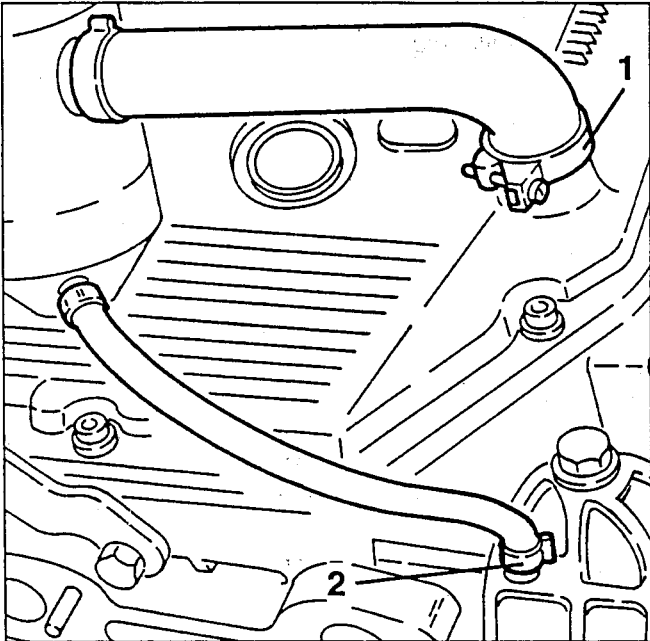
1. Disconnect the vacuum takeoff pipe for the fuel pressure regulator from the intake box.



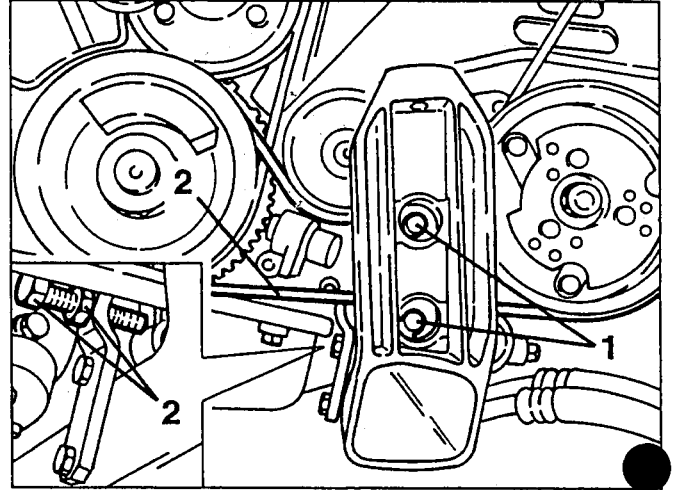
REMOVING THE AIR INTAKE BOX

1. Slacken the ignition coil fastening screws, then remove the coils complete with high voltage cables after disconnecting them from the spark plugs.

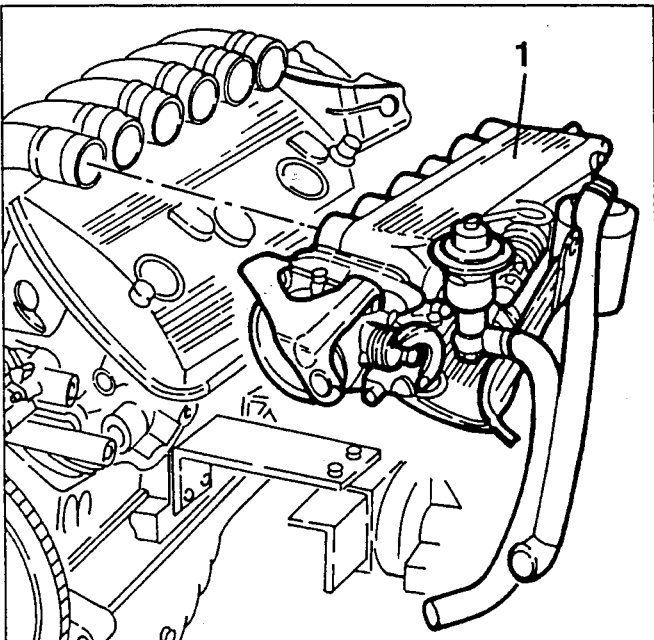
1. Disconnect the oil vapour recovery pipe from the cylinder head.
2. Disconnect the condensed oil recovery pipe from the upper alternator support.



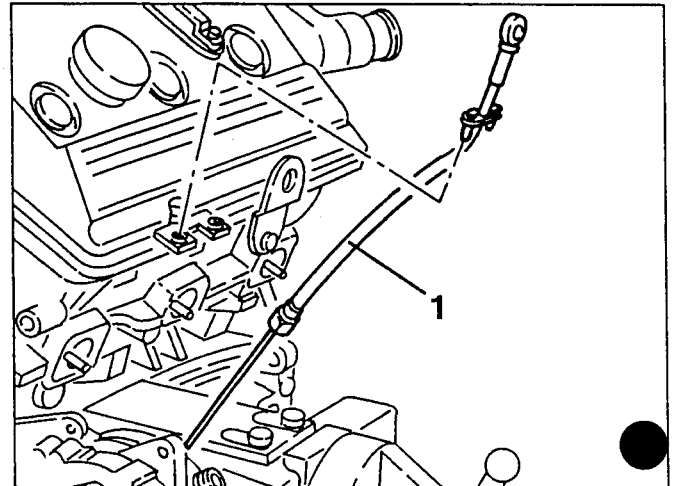
- Retrieve the power steering pump drive belt.
- Completely back off the two fastening screws and remove the conditioner compressor belt tensioner guide.



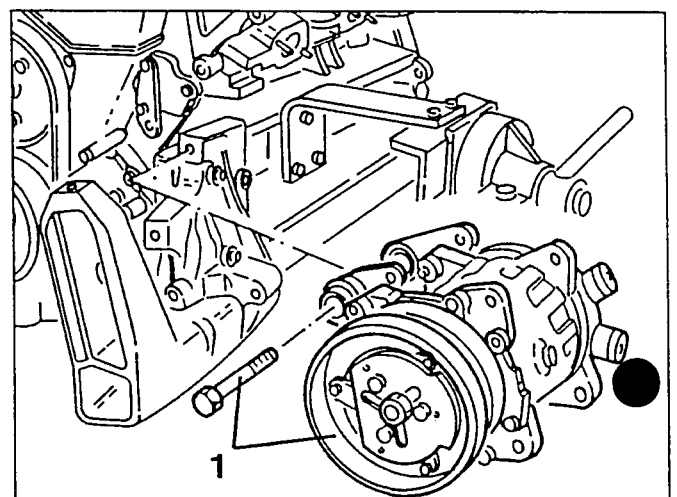
1. Remove the intake box complete with oil vapour separator, constant idle speed actuator, throttle body and E.G.R. valve.



1. Remove the engine oil dipstick complete with its guide.



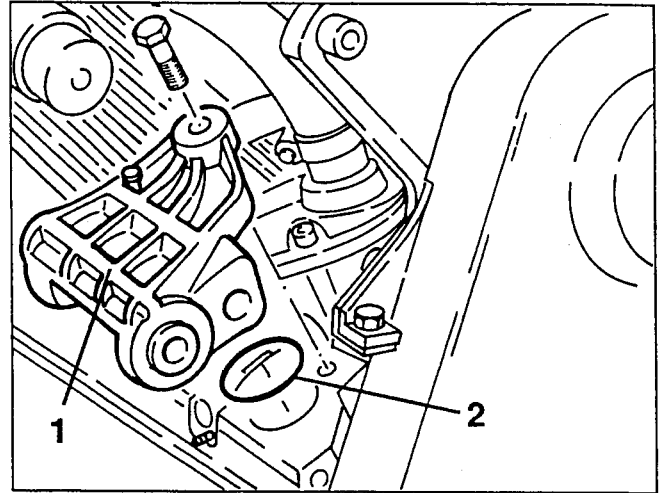
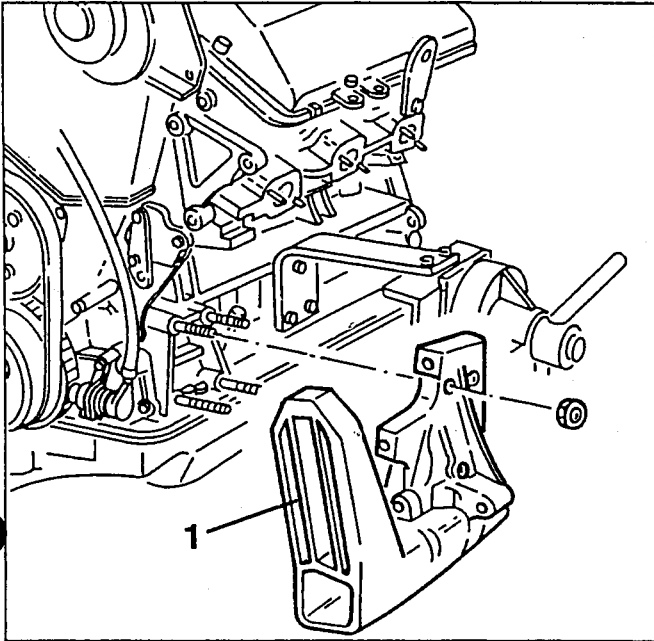
1. Slacken the fastening bolts and remove the conditioner compressor complete with support brackets.



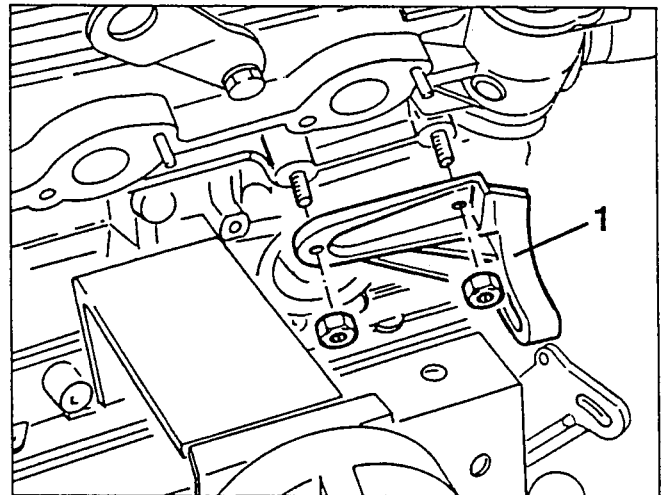
REMOVING THE CONDITIONER COMPRESSOR

1. Slacken the two screws fastening the conditioner compressor belt tensioner.
2. Slacken the locknut, back off the micrometric tensioner screw, then prise and remove the conditioner compressor drive belt.

1. Slacken the fastening nuts and remove the front engine support.

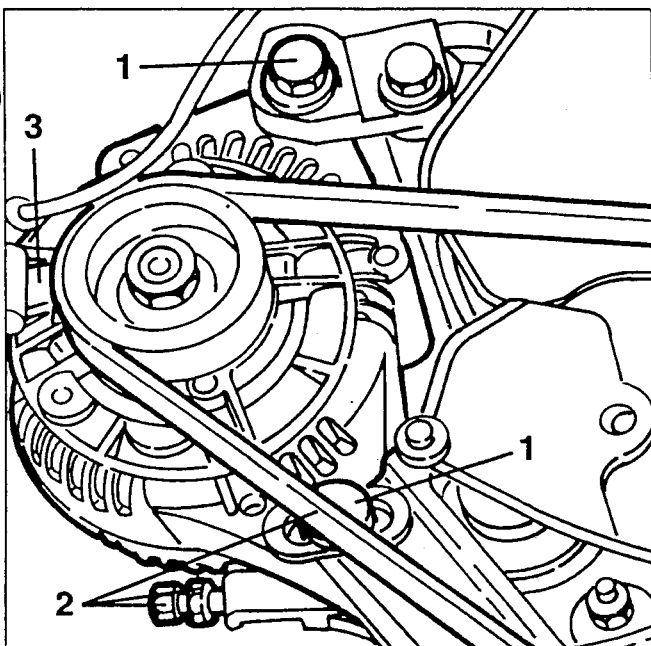


1. Slacken the fastening nuts and remove the rear lower alternator support bracket.

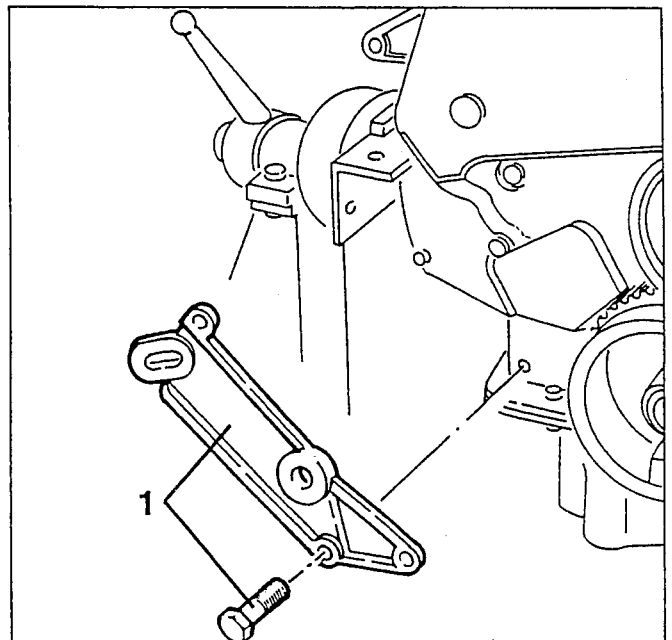


REMOVING THE ALTERNATOR

1. Slacken the two bolts fastening the alternator to the support brackets.
2. Loosen the locknut, slacken the micrometric tensioner screw, then prise and remove the alternator - water pump drive belt.
3. Completely back off the two bolts loosened previously and remove the alternator.

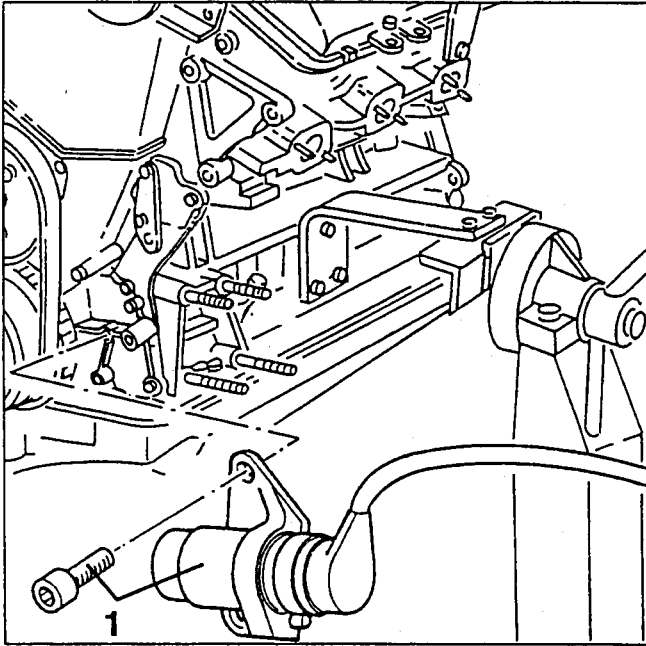


1. Slacken the fastening screws and remove the front lower alternator support bracket.

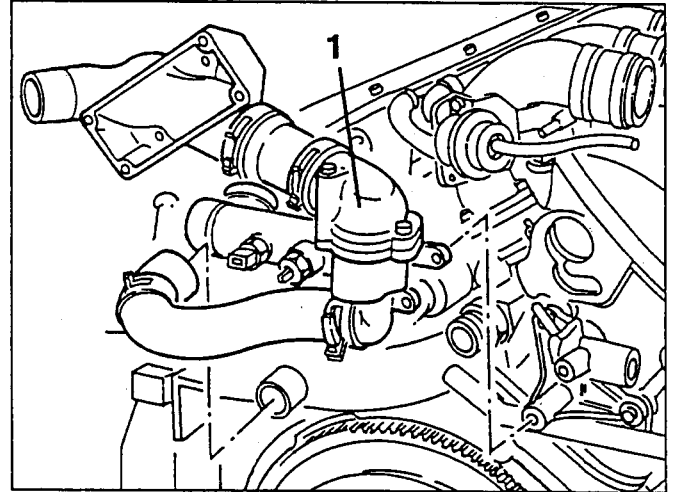


1. Remove the upper alternator support bracket.
2. Remove the O-Ring.

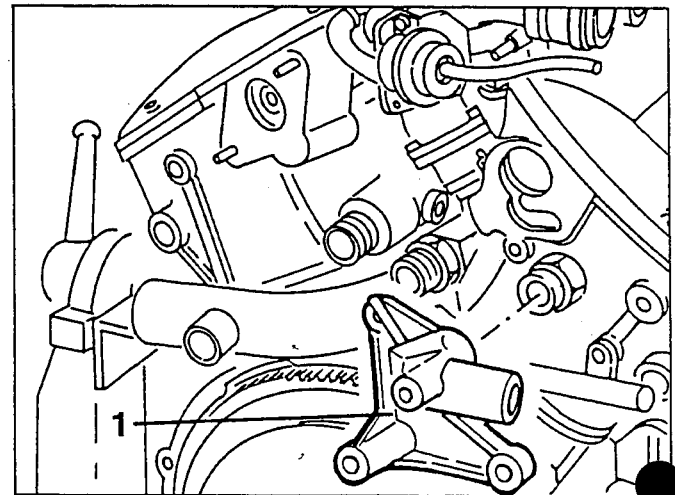
1. Slacken the fastening screws and remove the rpm and timing sensor complete with support bracket.



1. Remove the thermostat unit complete with ignition coil support and connection sleeves.

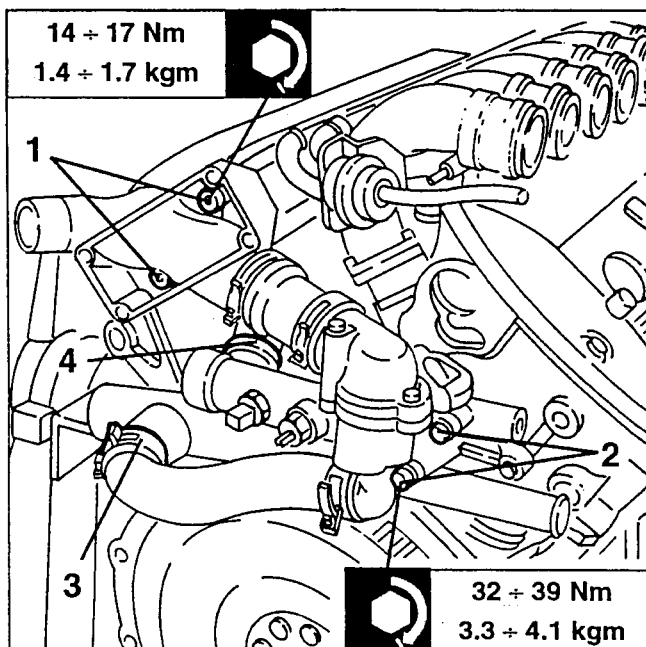


1. Slacken the fastening screws and remove the coolant fluid delivery union to the throttle body and climate control system heater.



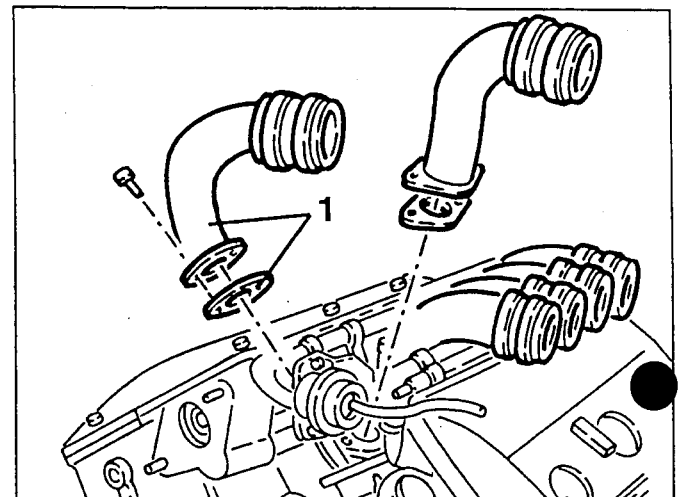
REMOVING THE THERMOSTAT UNIT

1. Slacken the two screws fastening the ignition coils support to the cylinder head.
2. Slacken the two screws fastening the thermostat unit.
3. Disconnect the thermostatic cup fluid outlet sleeve from the coolant return manifold.
4. Slacken the clamp fastening the left-hand cylinder head connection sleeve to the thermostat unit.

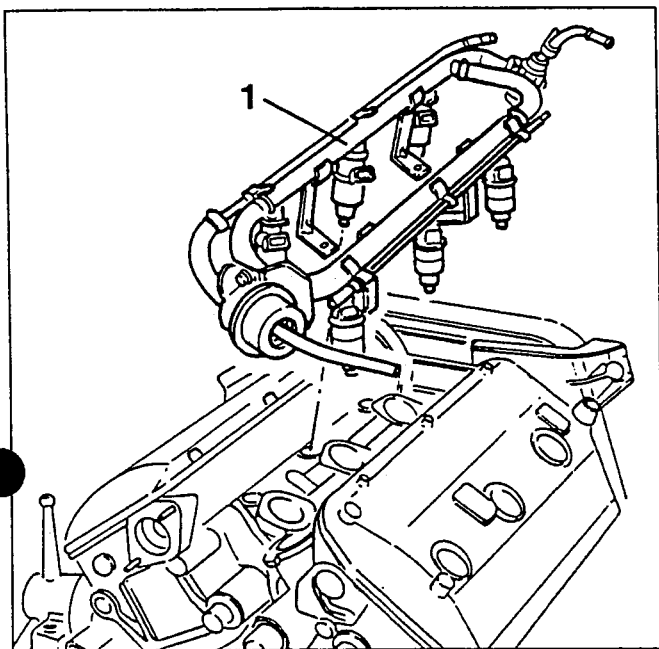


REMOVING THE FUEL DISTRIBUTOR MANIFOLD

1. Slacken the fastening screws and remove the air supply ducts complete with seals.

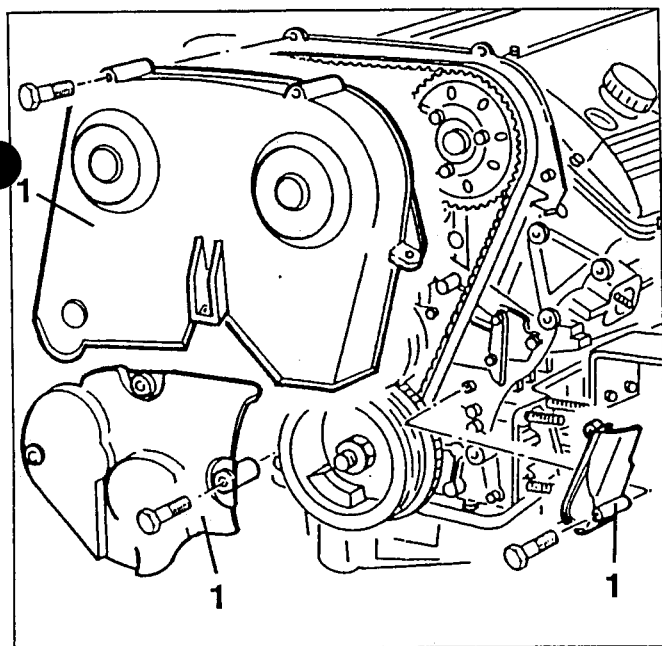


1. Slacken the fastening screws and remove the fuel distributor manifold complete with injectors, pressure regulator and pulse damper.

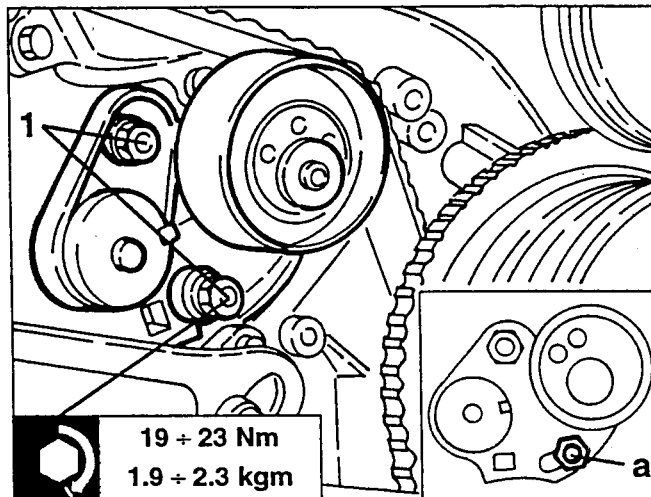


REMOVING THE TIMING GEAR BELT

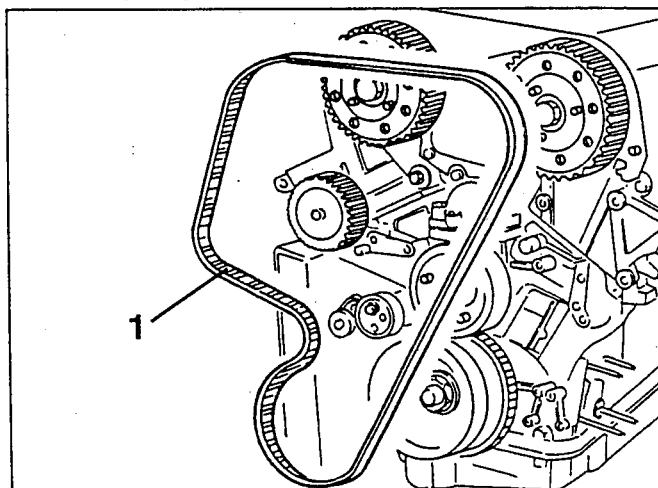
1. Slacken the fastening screws and remove the timing gear belt front covers.



1. Slacken the two nuts fastening the timing gear belt tensioner and position them so that stud "a" is as illustrated, then completely tighten the two fastening nuts locking them lightly.



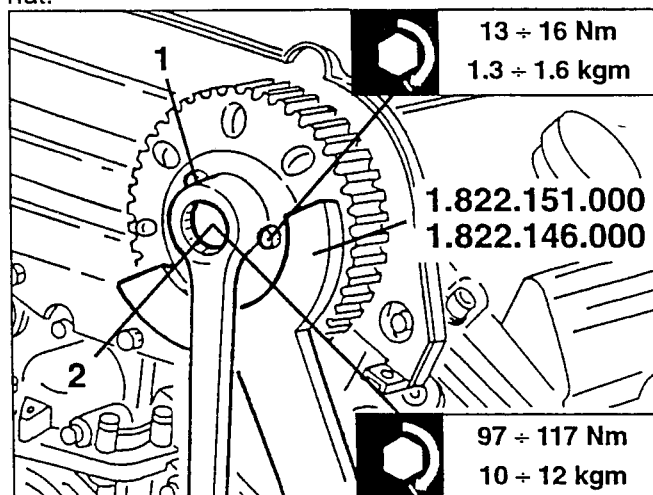
1. Remove the timing gear drive belt prising it off the camshaft toothed drive pulley and withdrawing it from the drive pulley.



- Completely slacken the two nuts fastening the timing gear belt tensioner and remove it.

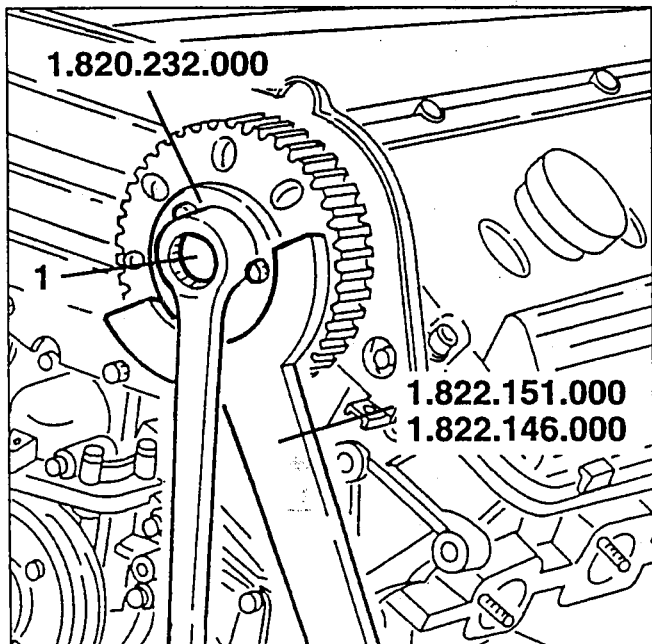
REMOVING THE TIMING GEAR PULLEYS

1. Slacken the screws fastening the timing gear drive pulley to the support hub.
2. Using tools no. 1.822.151.000 and no. 1.822.146.000 completely back off the hub fastening nut.

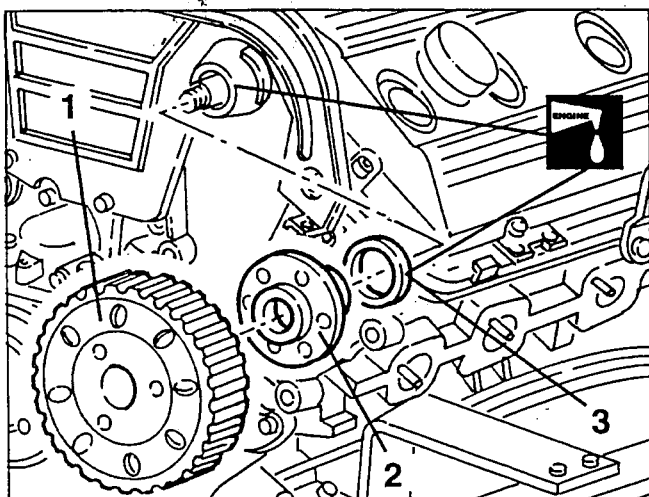


- Completely back off the screws slackened previously fastening the timing gear drive pulley to the support hub.

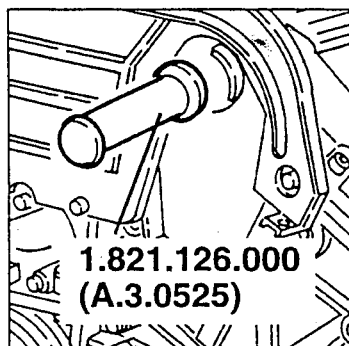
1. Install tool no. 1.820.232.000 on the timing gear pulley and tighten the nut of the tool levering with tools no. 1.822.151.000 and no. 1.822.146.000.



1. Remove the tools installed previously, then withdraw the timing gear pulley.
2. Remove the support hub.
3. Prise and remove the oil seal.

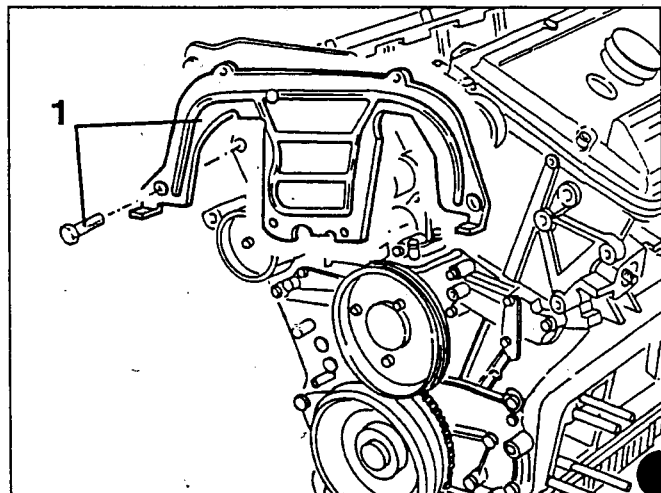


When refitting insert a new camshaft front oil seal using tool no. 1.821.126.000 (A.3.0525).

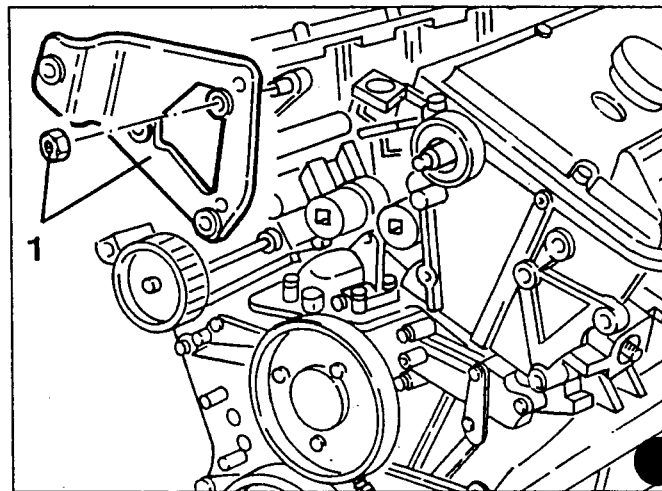


- Proceed in the same way to remove the right-hand cylinder head timing gear pulley.

1. Slacken the fastening screws and remove the timing gear belt rear cover.

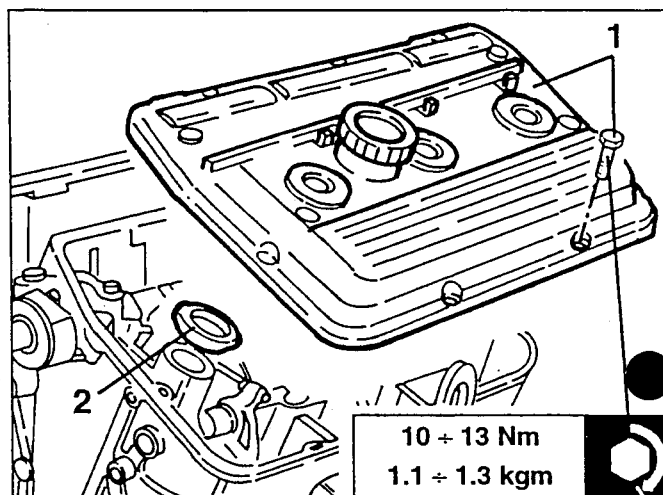


1. Slacken the fastening nuts and remove the engine stay rod connection bracket from the right-hand cylinder head.



REMOVING THE CYLINDER HEADS

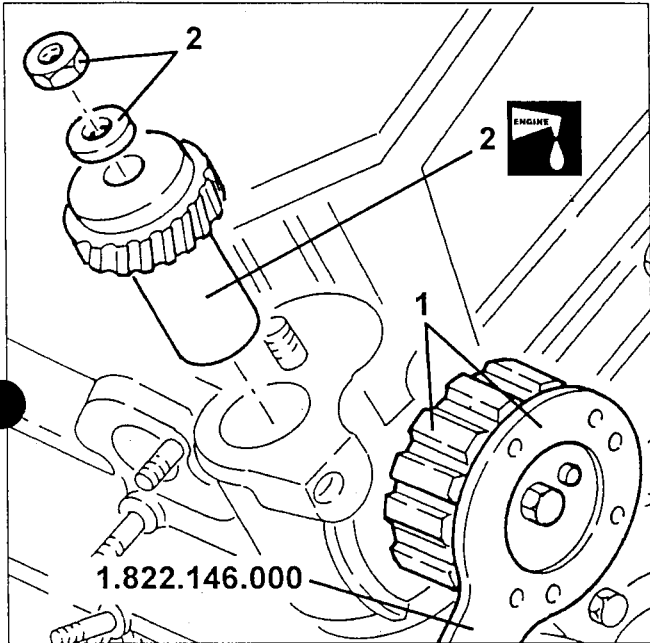
1. Slacken the fastening screws and remove the cylinder head covers.
2. Remove the seals from the spark plug pits.



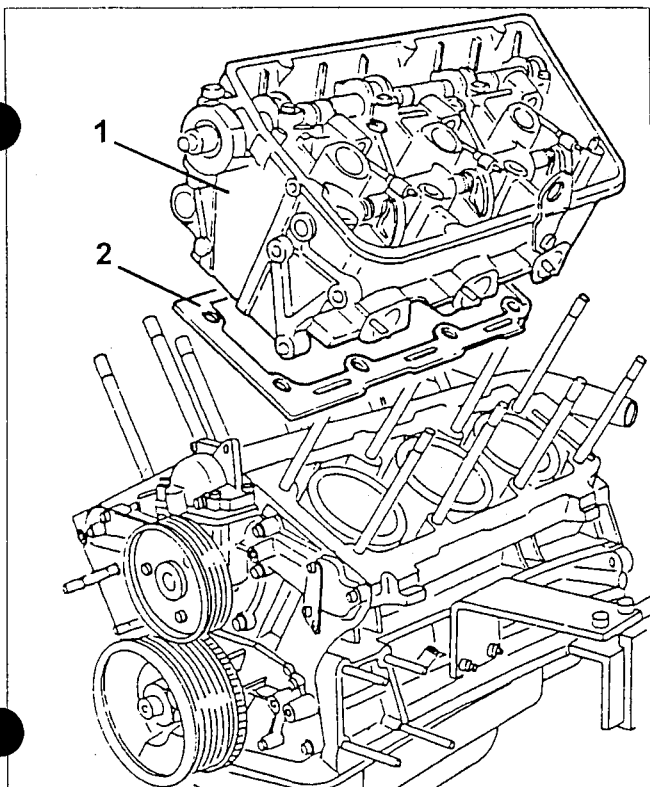
10 + 13 Nm
1.1 + 1.3 kgm

Proceed as follows (right-hand cylinder head only):

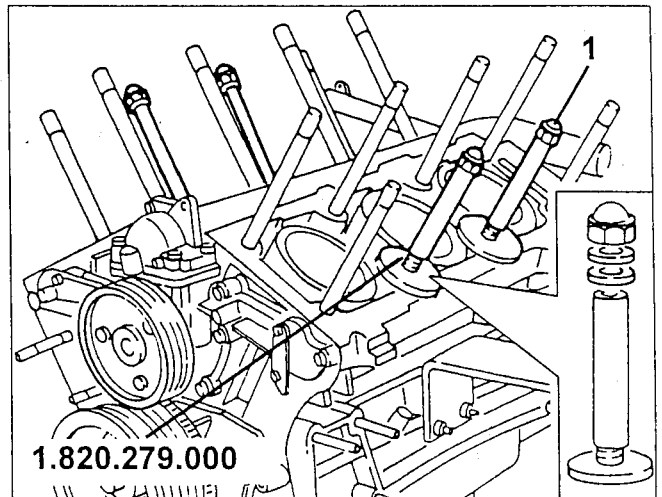
1. Lock engine oil pump drive pulley rotation with tool no. 1.822.146.000.
2. Loosen the fastening nut and remove the oil pump intermediate drive gear from its seat.



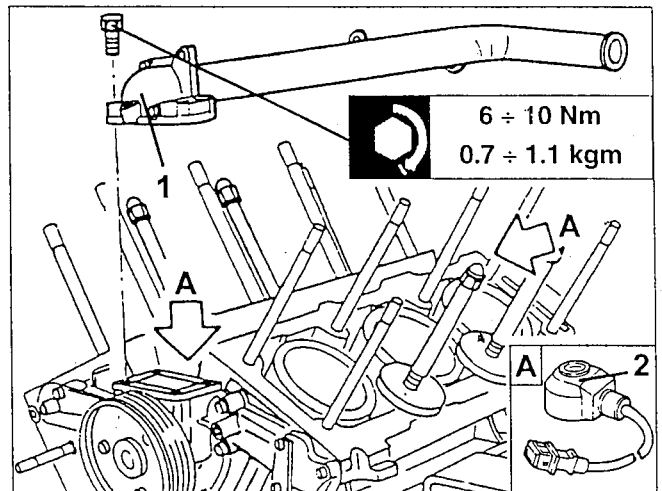
1. Loosen the fastening nuts and remove the engine crankcase cylinder head.
2. Remove the respective seals.



1. Fit liner retainer tools no. 1.820.279.000.



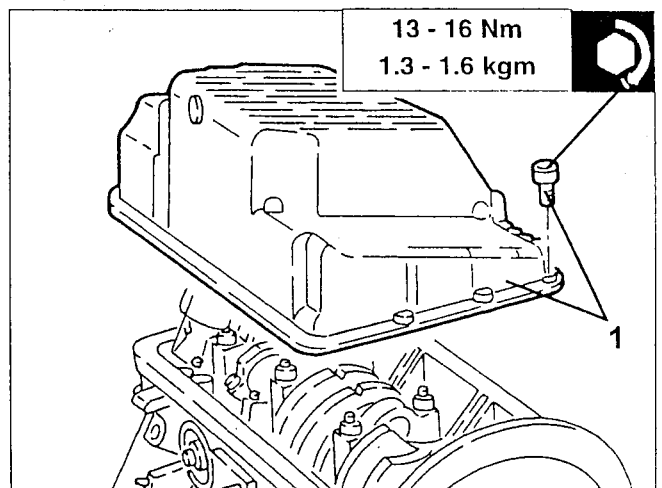
1. Loosen the fastening screws and remove the pump coolant return manifold.
2. Loosen the screws and remove the knock sensors.



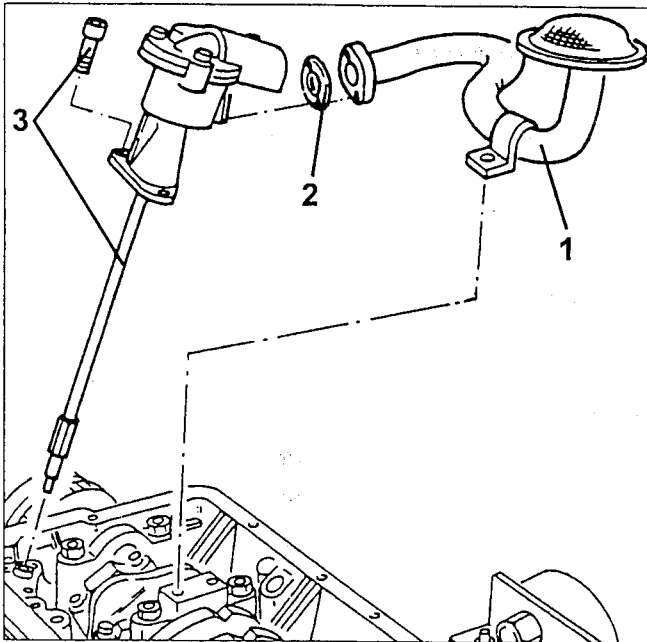
OIL PUMP REMOVAL

- Turn the engine on the overhaul bench.

1. Loosen the fastening screws and remove the oil sump.

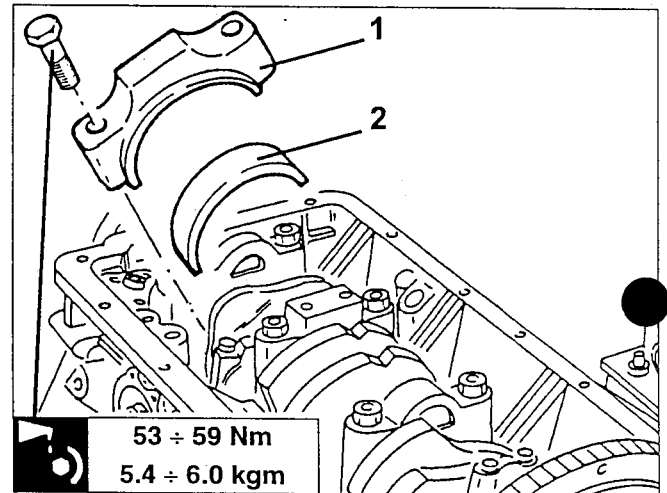


1. Loosen the fastening screws and remove the oil pump suction device.
2. Remove the respective seal.
3. Loosen the fastening screws and remove the complete oil pump.



CYLINDER LINER AND PISTON REMOVAL

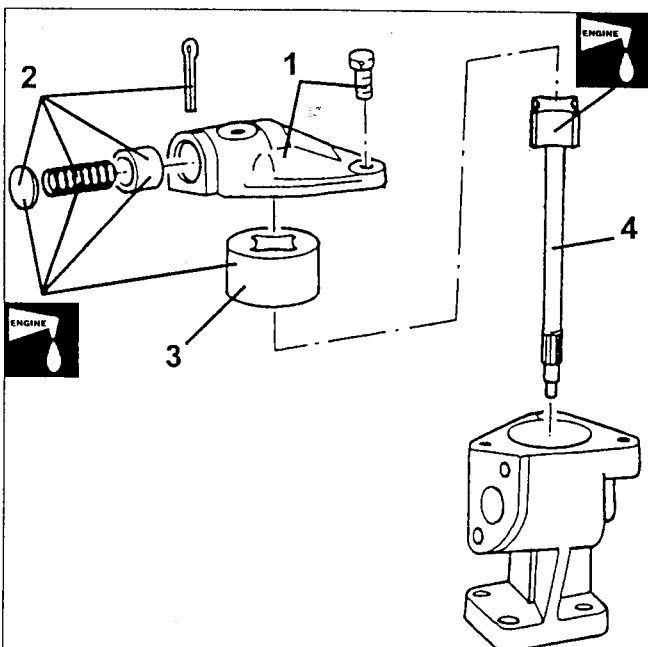
- Fit a suitable tool to rotate the crankshaft.
- Turn the crankshaft to access the right-hand bank connecting rod caps (cylinders 1, 2 and 3).
- 1. Loosen the fastening nuts and remove cylinder 1, 2 and 3 connecting rod caps.
- 2. Take the respective connecting rod half-bearings.



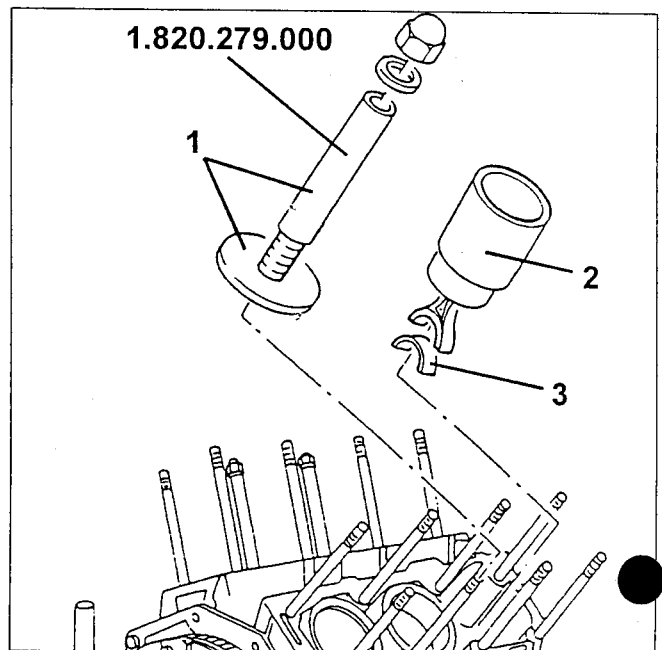
OIL PUMP DISASSEMBLY

1. Loosen the fastening screws and remove the oil pump cover.
2. Remove the split pin. Remove the cap, the spring and the engine oil pressure limiting valve casing from the cover.
3. Remove the driven rotor from the pump casing.
4. Remove the rotor and shaft from the pump casing.

NOTE: Never remove the rotor from the shaft.



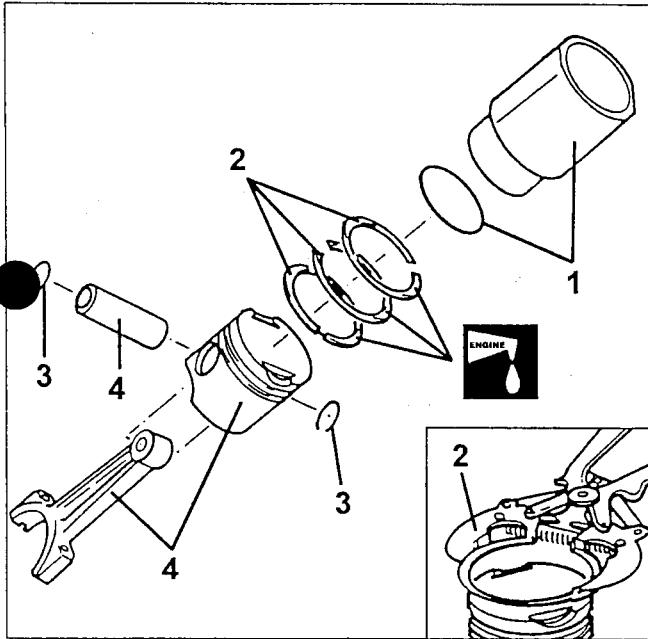
- Turn the engine on the overhaul stand.
- 1. Loosen the fastening nuts and remove the liner retainer tool no. 1.820.279.000 from the right-hand bench only.
- 2. Extract the connecting rod-piston assemblies from the crankcase. Remove the cylinder liners at the same time.
- 3. Take the respective connecting rod half-bearings.
- Turn the crankcase on the overhaul bench and perform the same operation on the left-hand bank (cylinders 4, 5 and 6).



1. Remove the cylinder liner and O-Ring.
2. Extract the gas rings and the oil scraper from the pistons with a suitable tool.

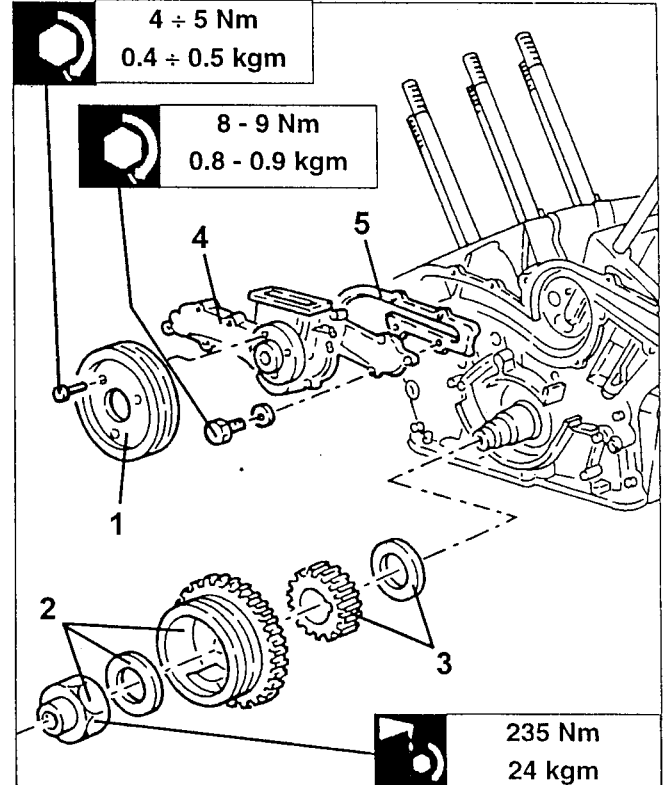
IMPORTANT: Be careful not to damage rings which could be re-used.

3. Extract the two pin snap rings.
4. Extract the pin and separate the piston from the connecting rod.



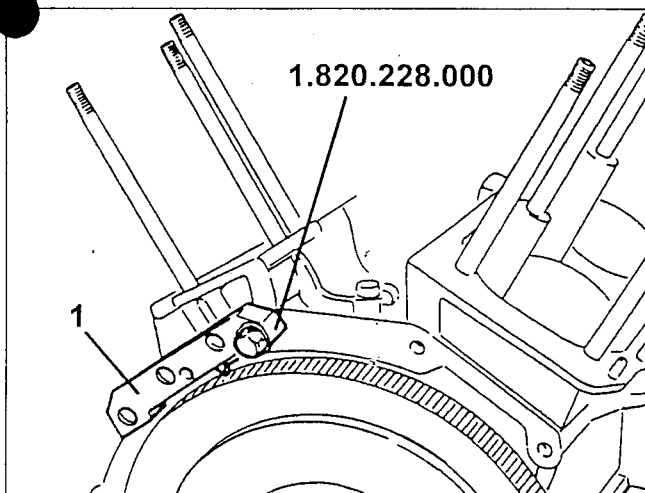
NOTE: When refitting, the thrust ring convex surface should face the front crankcase cover.

4. Loosen the fastening screws and remove the coolant pump.
5. Remove the respective seal.



COOLANT PUMP REMOVAL

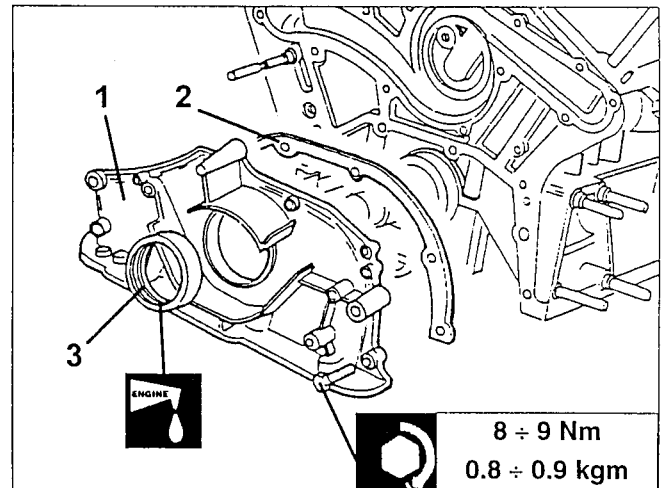
1. Remove the crankshaft rotation tool and fit the flywheel retainer no. 1.820.228.000.



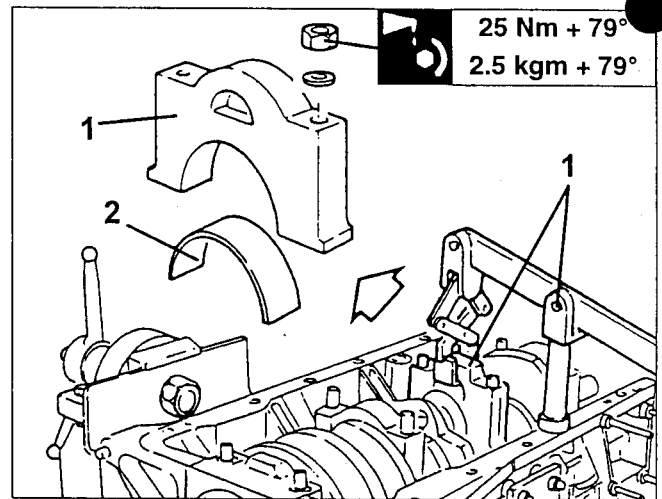
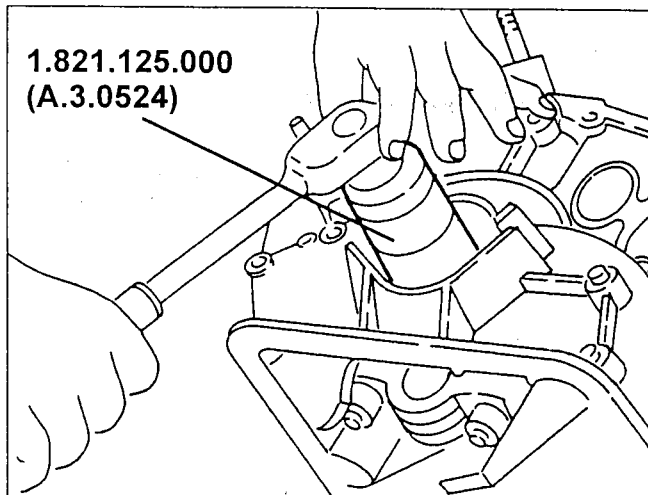
1. Loosen the fastening screws and remove the coolant pump.
2. Loosen the fastening nut and remove the auxiliary unit drive pulley.
3. Remove the timing belt pulley and thrust ring.

FRONT CRANKCASE COVER REMOVAL

1. Loosen the fastening screws and remove the front crankcase cover.
2. Remove the respective seal.
3. Remove the front crankcase cover oil seal.



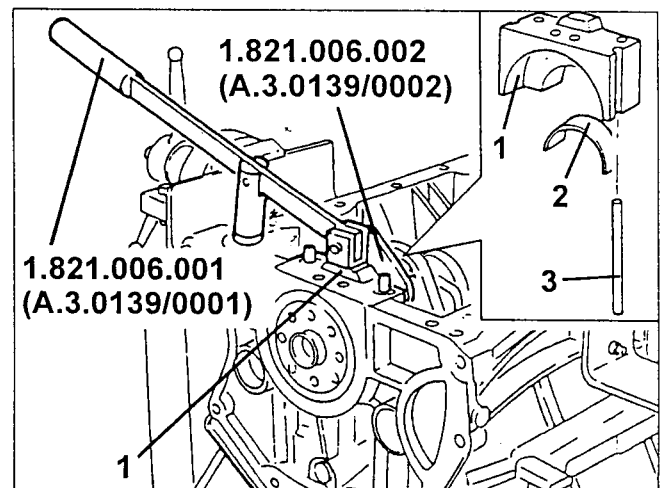
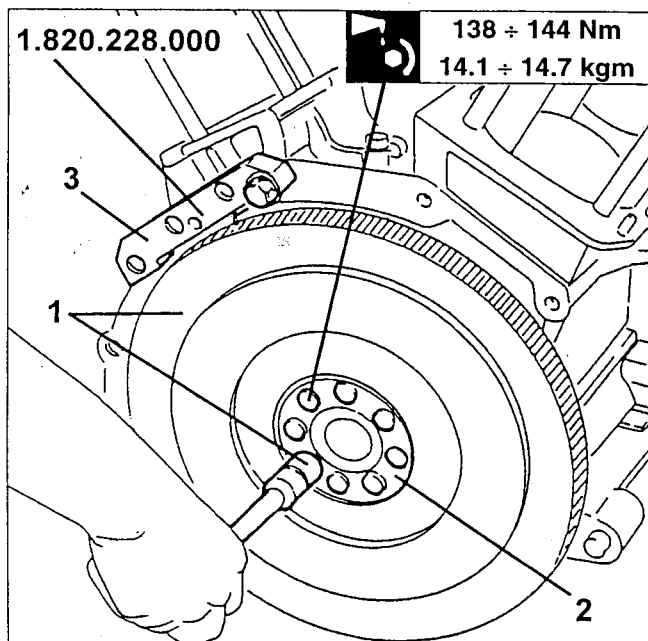
When refitting, fit a new front crankshaft oil seal on the crankcase with tool no. 1.821.125.000 (A.3.0524).



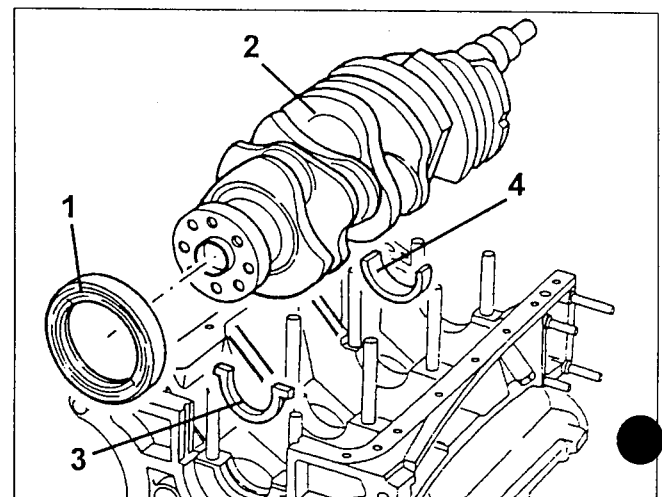
1. Remove the rear main bearing with lever no. 1.821.006.001 (A.3.0139/0001) and fork no. 1.821.006.002 (A.3.0139/0002).
2. Remove the respective main half-bearing.
3. Remove the seals.

FLYWHEEL REMOVAL

1. Loosen the fastening screws and remove the flywheel.
2. Take the lock washer.
3. Remove the previously fitted flywheel retainer no. 1.820.228.000.



1. Remove the crankshaft rear ring.
2. Remove the crankshaft.
3. Remove the thrust half-bearings.
4. Remove the main journal half-bearings.



CRANKSHAFT REMOVAL

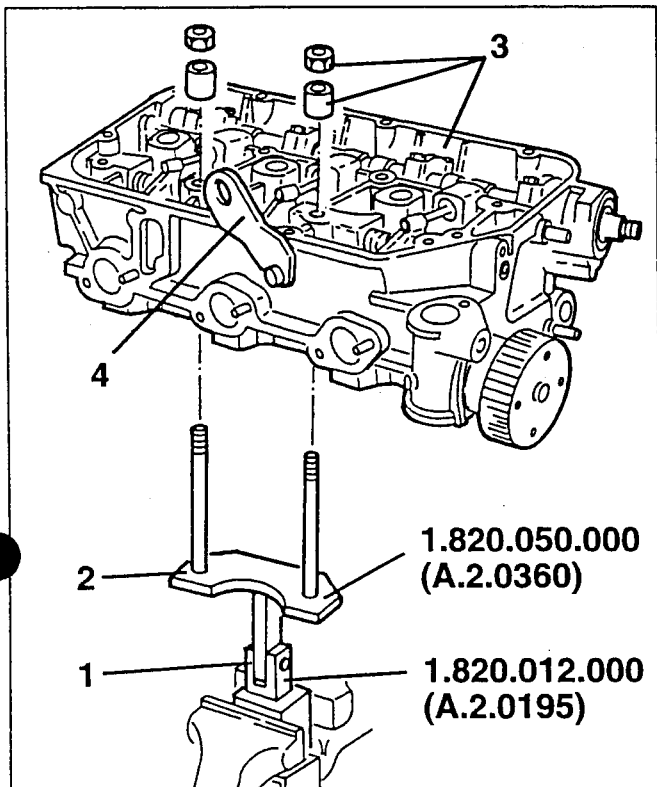
- Turn the engine on the overhaul stand.
1. Loosen the main bearing nuts and then remove the front and central main bearings with a suitable tool.
 2. Remove the respective main half-bearings.

DIS-ASSEMBLING THE CYLINDER HEADS

NOTE: The dis-assembly procedures described refer to the right-hand cylinder head. Proceed in the same way to dis-assemble the left-hand head.

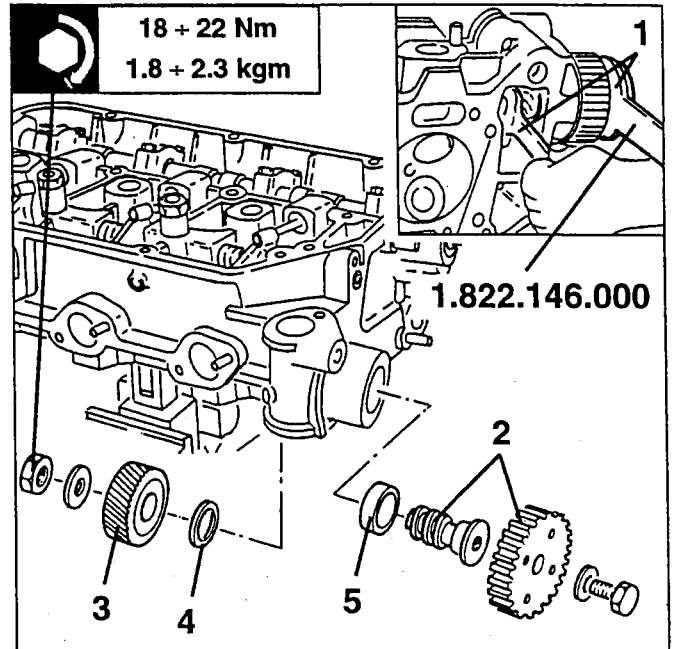
PRELIMINARY OPERATIONS

1. Clamp swivel support no. 1.820.012.000 (A.2.0195) in a vice.
2. Install fork no. 1.820.050.000 (A.2.0360) on the swivel support.
3. Fit the cylinder head on the fork studs and lock it in place using two suitable spacers and two nuts.
4. Slacken the fastening screw and remove the engine lifting bracket.

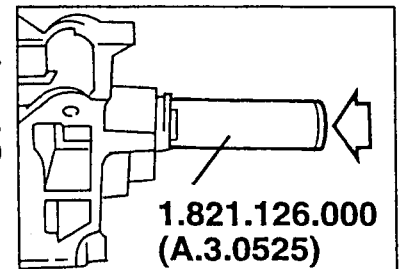


REMOVING THE OIL PUMP DRIVE PULLEY (Specific for the right-hand cylinder head)

1. Levering with tool no. 1.822. 146.000, slacken the oil pump drive pulley fastening bolt.
2. Withdraw the oil pump drive pulley and the corresponding shaft.
3. Retrieve the toothed gear.
4. Retrieve the spacer.
5. Prise and remove the oil ring.



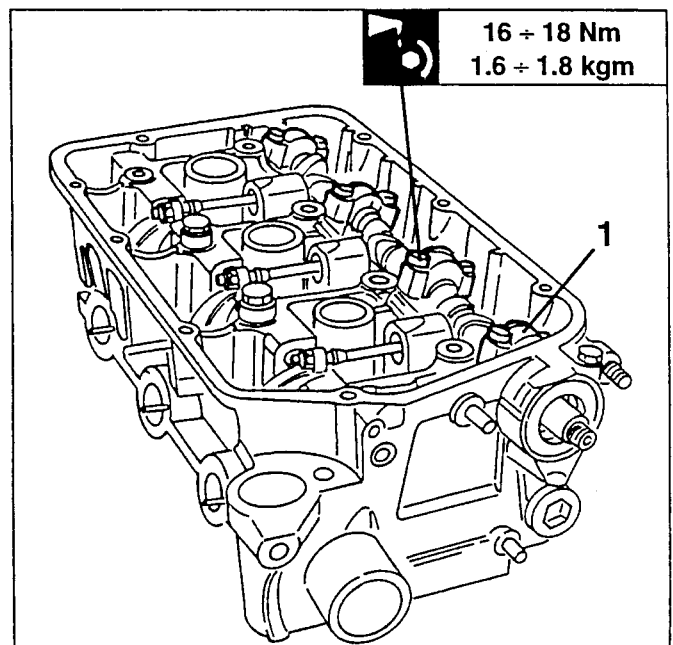
When refitting, insert a new oil ring using tool no. 1.821.126.000 (A.3.0525).



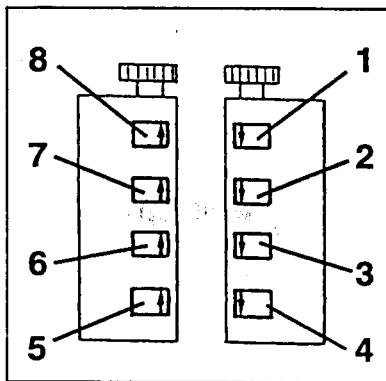
REMOVING

THE CAMSHAFT

1. Slacken the fastening nuts and remove the camshaft caps.



NOTE: The camshaft caps are numbered consecutively (1, 2, 3 and 4 for the right cylinder head; 5, 6, 7 and 8 for the left head) and they are to be placed in the same sequence when re-assembling.

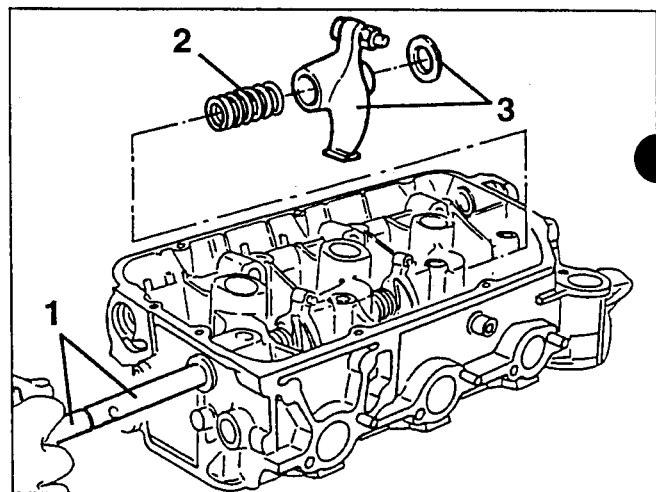


1. Remove the camshaft firstly raising it from the rear and withdrawing it as illustrated.

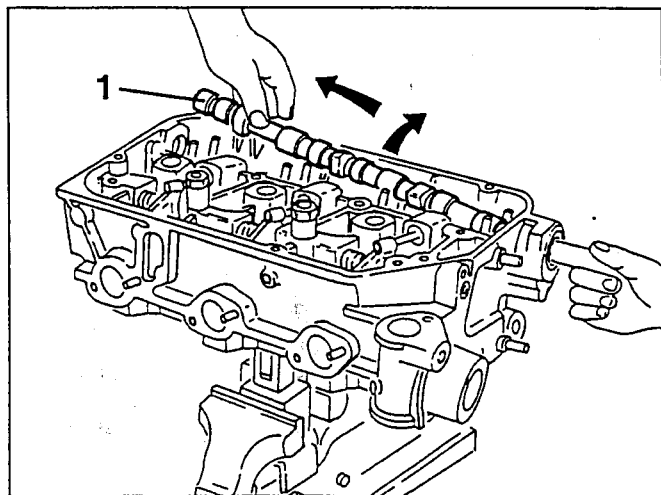
NOTE: Set the components in order in case they are re-used when refitting.

REMOVING THE ROCKERS

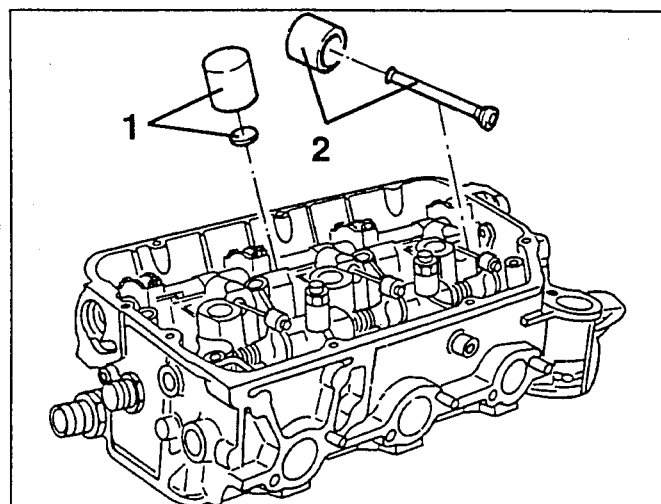
- Slacken and remove the rocker support shaft housing plug.
- 1. Screw a suitable tool on the threaded tang of the rocker support shaft and use the tool to gradually remove the shaft itself.
- 2. Retrieve the springs.
- 3. Retrieve the rockers and their washers.



WARNING: Work carefully: the cam and support contact surfaces can easily be damaged.

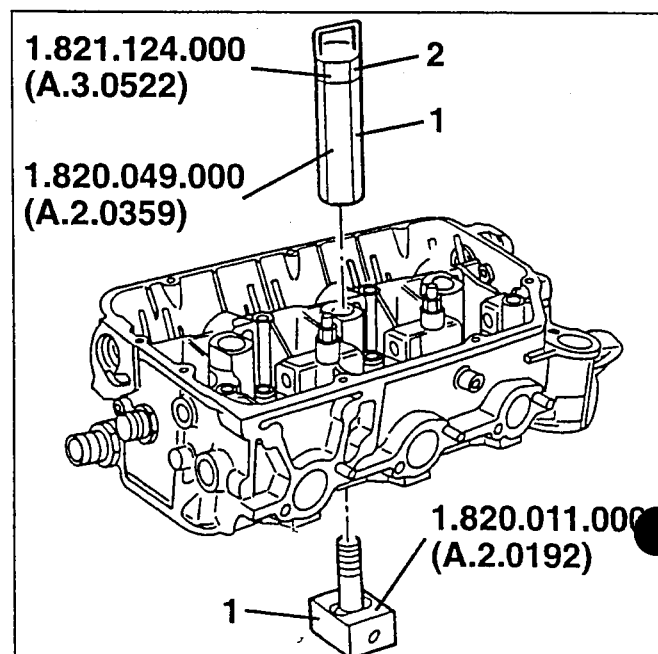


1. Remove the intake cups with the valve play adjustment caps.
2. Remove the exhaust cups with the rocker control rods.

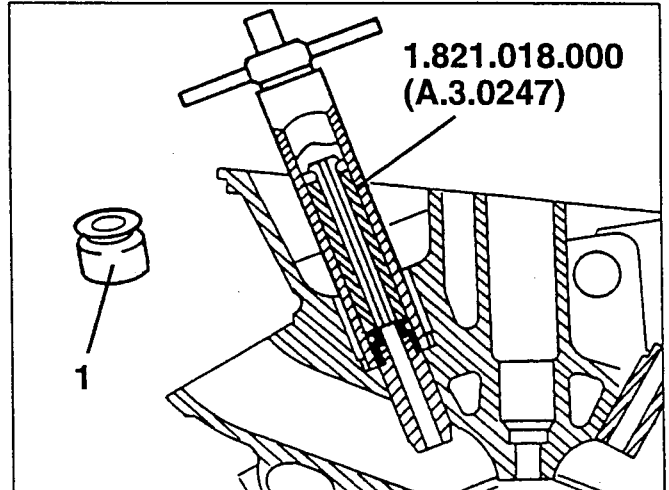
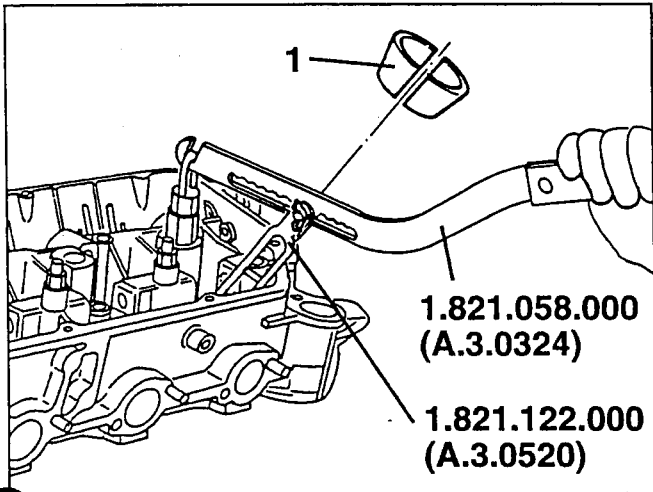


DISASSEMBLING THE VALVES

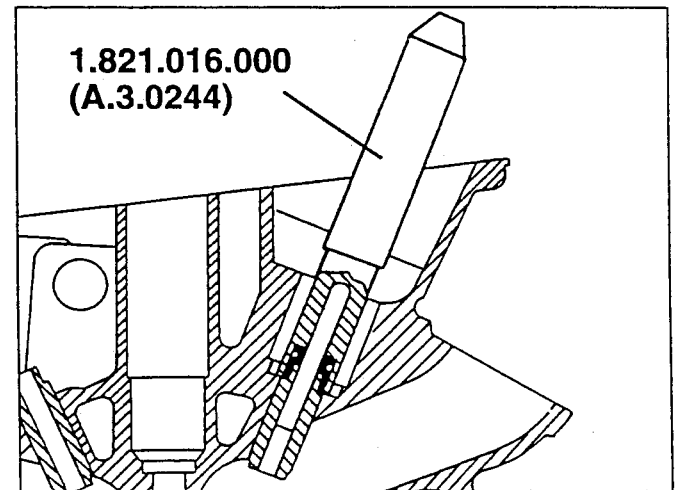
1. From the lower end of the spark plug hole insert valve support tool no. 1.820.011.000 (A.2.0192), and fasten it with the special nut no. 1.820.049.000 (A.2.0359).
2. Screw support no. 1.821.124.000 (A.3.0522) to the threaded tang of the special nut.



1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.122.000 (A.3.0520) remove the half cones.



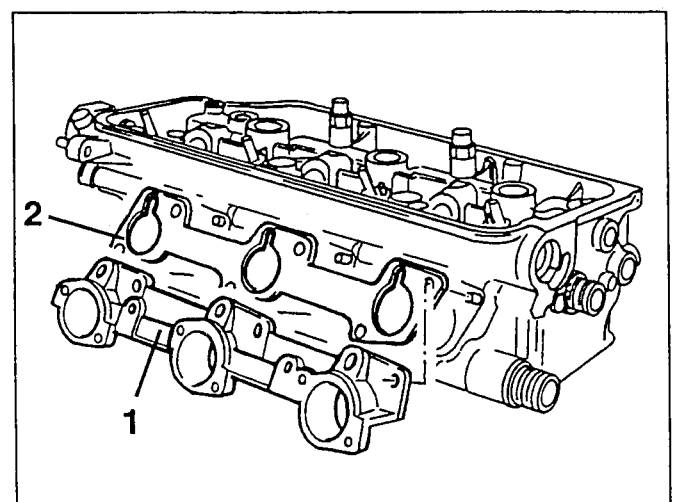
When refitting, insert new oil seal caps using tool no. 1.821.016.000 (A.3.0244).



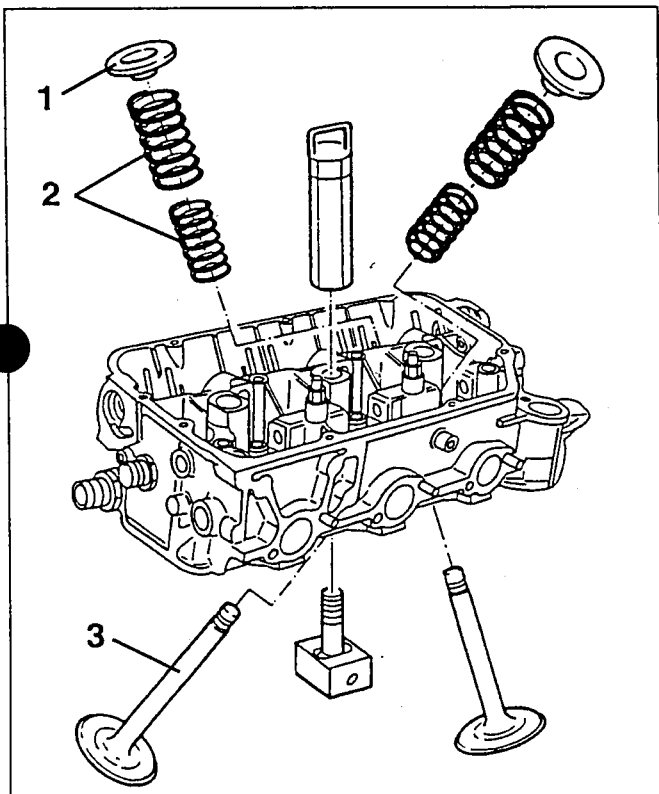
- Retrieve the valve lower plates.

REMOVING THE AIR INTAKE MANIFOLD

1. Slacken the fastening screws and remove the air intake manifold.
2. Remove the seal.



1. Remove the upper plates.
2. Remove the outer and inner springs.
3. Remove the tools used for removing the valves and remove the intake and exhaust valve pair.



Following the same procedure and using the same tools, remove the valves of the remaining cylinders.


1. Using puller tool no. 1.821.018.000 (A.3.0247), remove the oil seal caps.

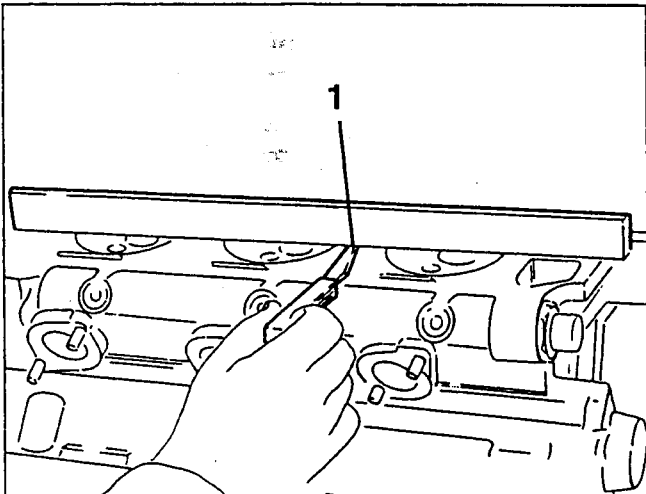
CHECKS AND INSPECTION CYLINDER HEADS

Checking the lower surface of the cylinder heads

1. Check the flatness of the lower cylinder head surface; reface if it is excessively worn.

NOTE: Refacing must be carried out on both cylinder heads.

	Maximum flatness error of cylinder head lower surface
	0.05 mm



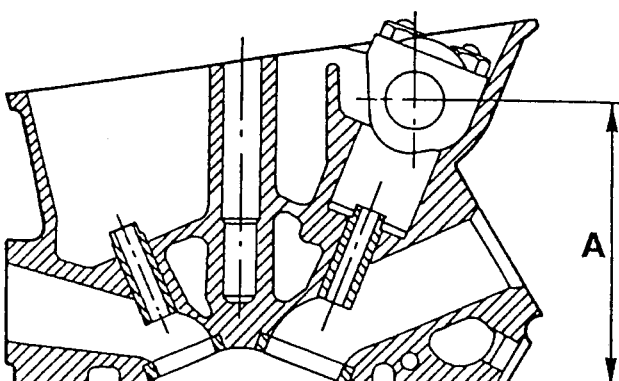
- After refacing, check that dimension "A" of the cylinder heads exceeds the minimum allowed limit.



WARNING:
Exceeding the minimum allowed limit involves serious engine operating failures.



	Minimum height "A" of the heads allowed after refacing
	124.85 ÷ 125.15 mm



Checking the cylinder head bushings

1. Measure the inside diameter of the bushings fitted on the cylinder heads and check that they are within the specified limits.

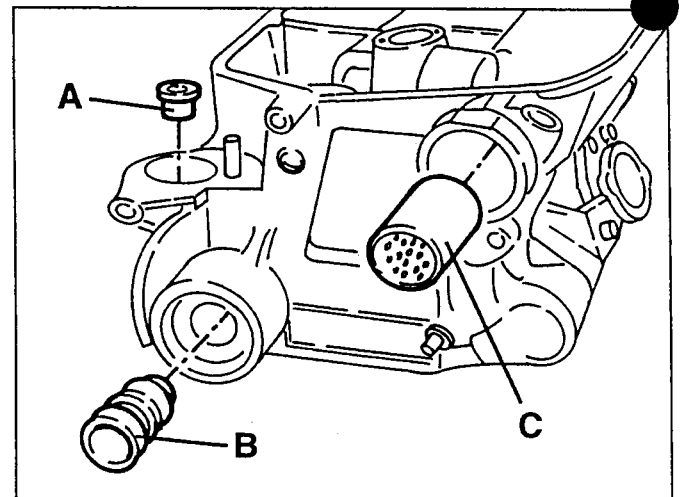


Inside diameter of bushings	
Bushing "A"	19.000 + 19.021 mm
Bushing "B"	19.000 + 19.021 mm
Bushing "C"	32.000 + 32.025 mm

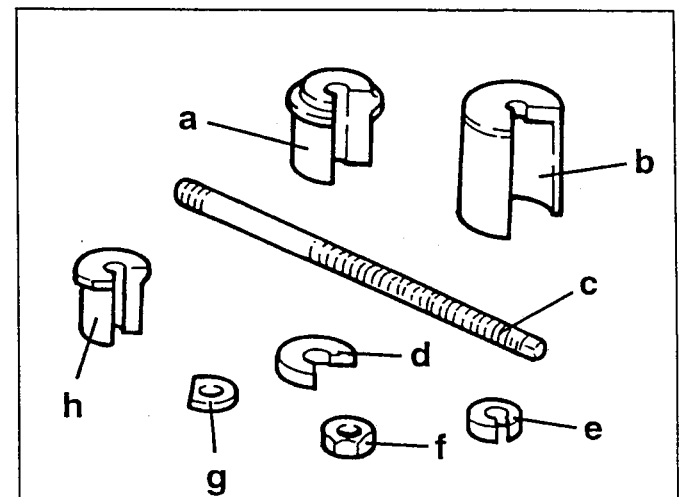
"A" : bushing for oil pump drive gear (specific for right-hand cylinder head)

"B" : bushing for oil pump toothed drive pulley shaft (specific for right-hand cylinder head)

"C" : bushing for camshaft toothed drive pulley hub



NOTE: If the values measured fail to be within the specified limits, change the bushings concerned using tool no. 1.821.129.000 (A.3.0528).

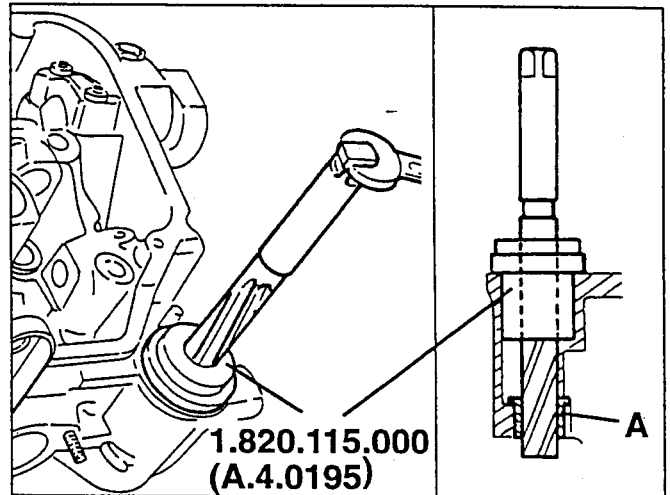
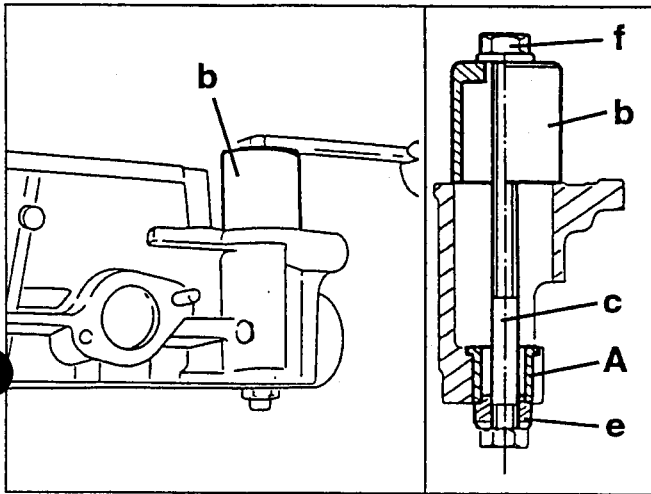


a. Coil
b. Cup
c. Tie-rod
d. Flange

e. Special washer
f. Hexagon nut
g. Shaped washer
h. Coil

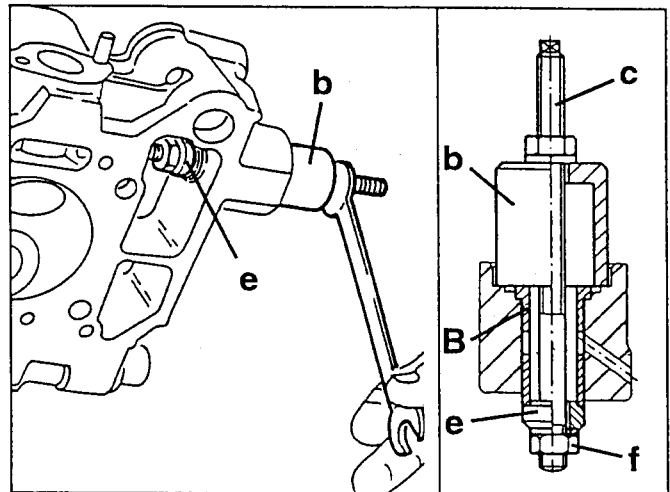
Changing the bushing for oil pump driving gear (specific for right-hand cylinder head)

- Remove bushing "A" for the oil pump driving gear, using tie-rod "c" complete with nut "f", the special washer "e" as puller tool and levering with the cup "b".

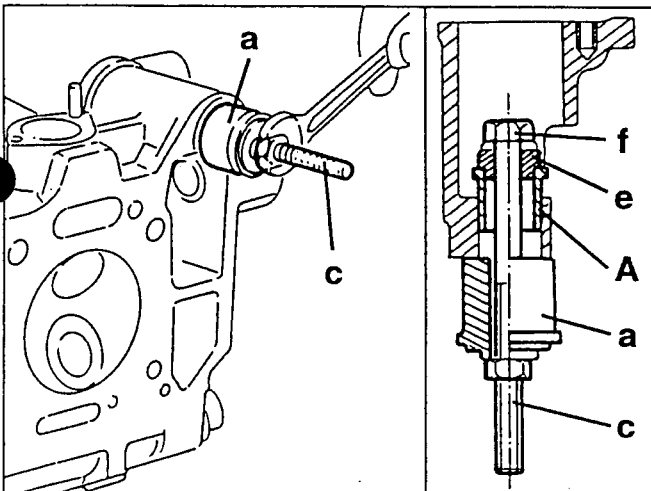


Changing the bushing for oil pump toothed driving pulley shaft (specific for right cylinder head)

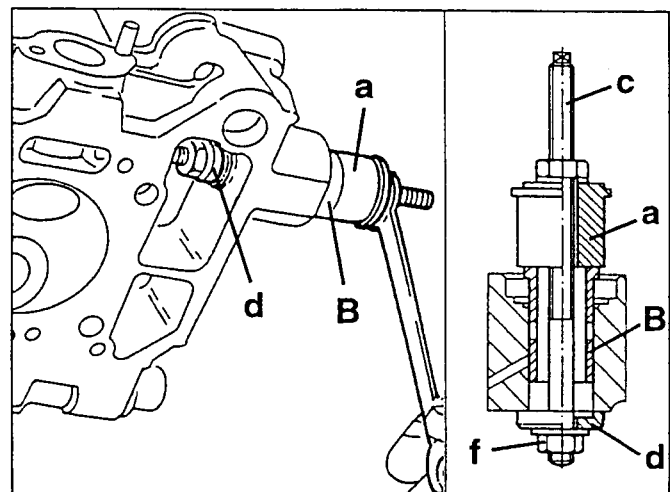
- Remove the bushing "B" for oil pump toothed driving pulley shaft, using tie-rod "c" complete with nut "f", the special washer "e" as puller tool and levering with the cup "b".



- Position a new bushing "A".
 - Insert tie-rod "c" complete with nut "f" and special washer "e" as installing tool.
 - From the opposite side to the tie-rod, insert the reaction coil "a" and complete insertion of the bushing "A".



- Insert a new bushing "B" using tie-rod "c" complete with nut "f" and the coil "a" as installing tool and levering with flange "d".



- After insertion, bushing "A" must be reamed to the specified dimension; for this purpose use guide tool no. 1.820.115.000 (A.4.0195) and a suitable reamer.

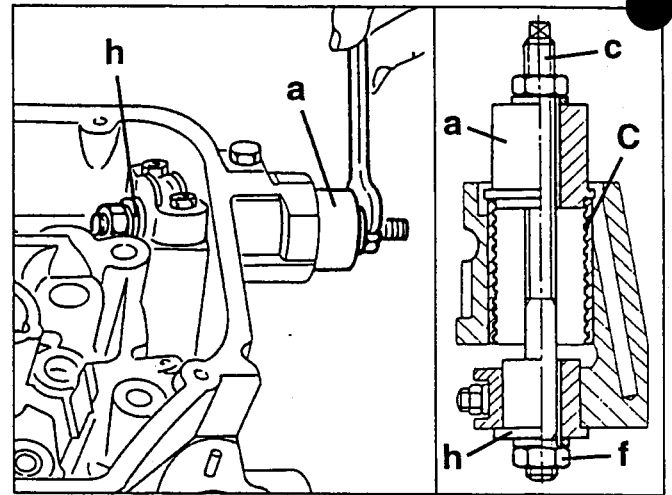
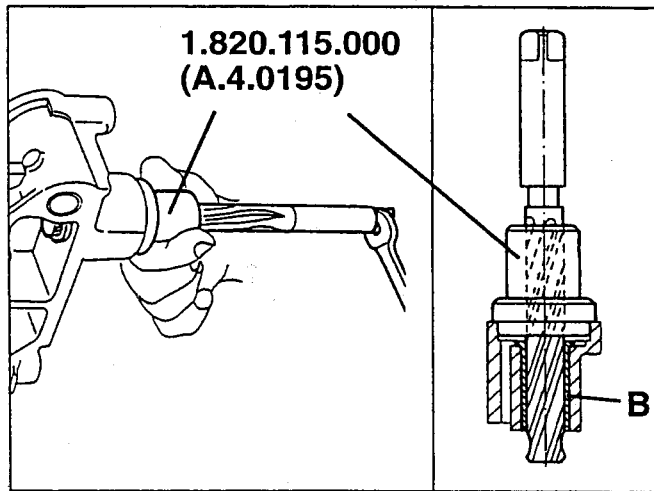


Inside diameter (bore) of bushing "A" for oil pump driving gear

19.000 ÷ 19.021 mm

- After insertion, bushing "B" must be reamed to the specified dimension; for this purpose use guide tool no. 1.820.115.000 (A.4.0195) and a suitable reamer.

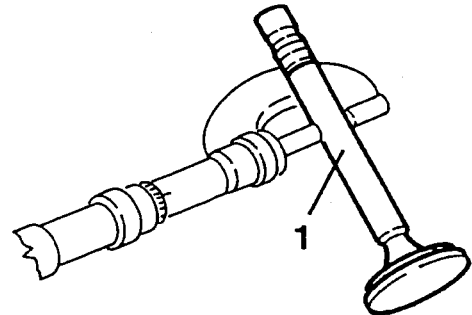
∅	Inside diameter (bore) of bushing "B" oil pump driving pulley shaft
	19.000 + 19.021 mm



Checking the clearance between valve guides and valve stems

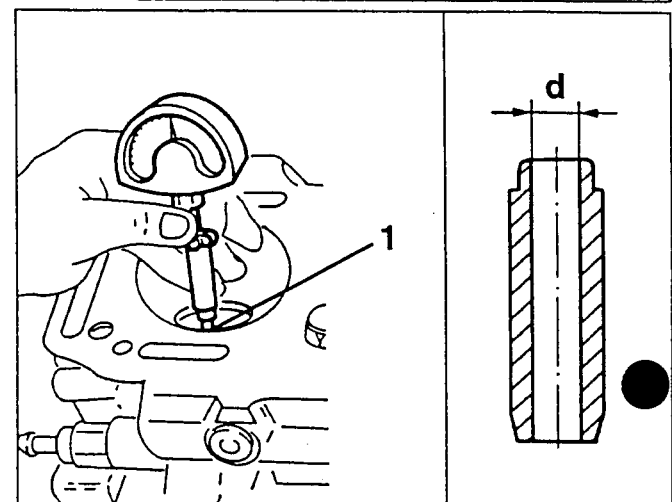
1. Measure the diameter of the valve stems and check that it is within the specified limits.

∅	Diameter of valve stems	
	Intake	8.925 + 8.960 mm
	Exhaust	8.972 + 8.987 mm



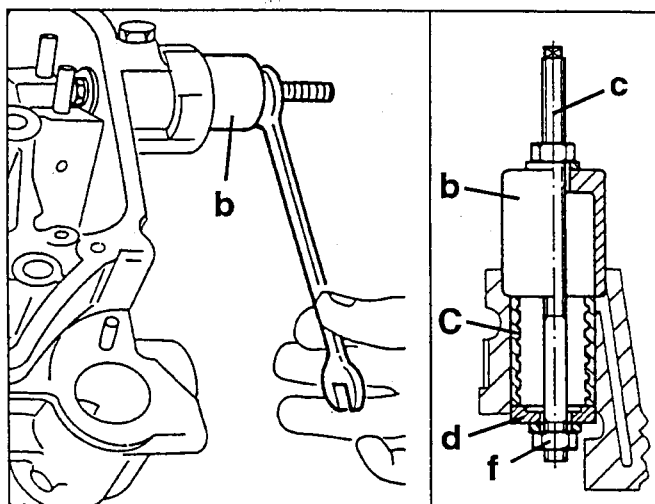
1. Measure the inside diameter of the valve guides and check that it is within the specified limits.

∅	Inside diameter of valve guide "d"
	9.000 + 9.015 mm



Changing the bushing for the camshaft driving pulley hub

- Remove the bushing "C" for the camshaft drive pulley hub, using tie-rod "c" complete with nut "f", and flange "d" as puller tool and levering with the cup "b".



- Fit the adjacent camshaft cap and fasten it with the corresponding nuts.
 - Position a new bushing "C" and insert it using tie-rod "c" complete with nut "f" and coil "a" as installing tool, levering with coil "h".

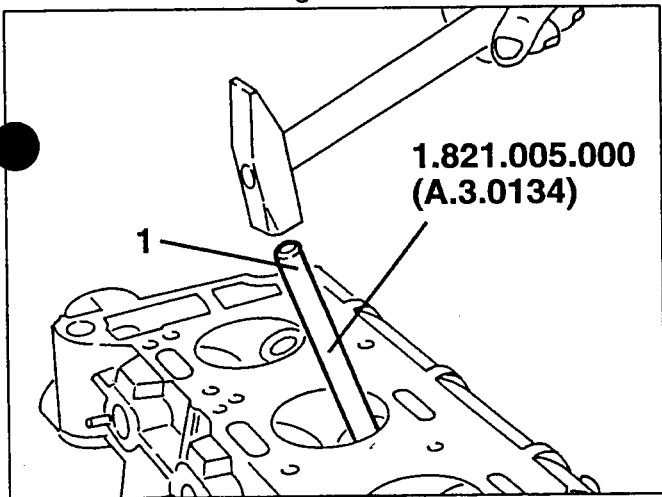
- Calculate the clearance between valve guides and valve stems and check that it is within the specified limits; if not, change any worn parts.



Radial clearance between valve guides and valve stems	
Intake	0.040 + 0.090 mm
Exhaust	0.013 + 0.043 mm

Changing the valve guides

1. Using puller tool no. 1.821.005.000 (A.3.0134), remove the worn valve guides.



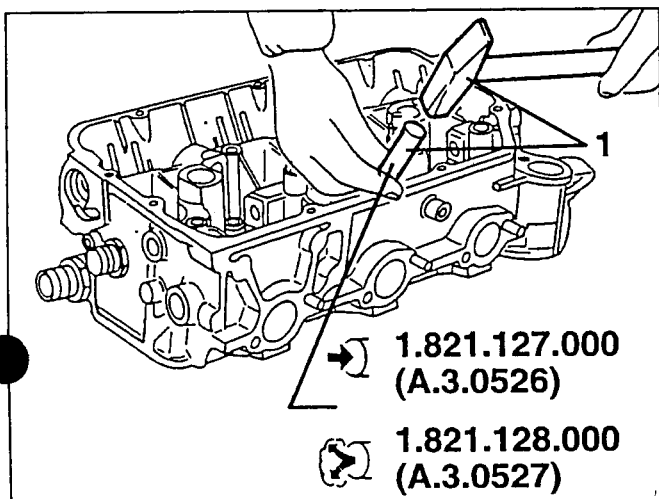
- Check that the outside diameters of the valve guides and their seats on the cylinder heads are within the specified limits and meet the assembly interference.



Outside diameter of valve guides	14.048 + 14.059 mm
Diameter of valve guide seats	13.990 + 14.018 mm
Seats - valve guide interference	0.030 + 0.069 mm



1. Insert the new valve guides in their seats using the tools illustrated.



- Ream the inside diameter of the valve guides to calibrate the holes to the specified diameter.



Inside diameter of valve guides
9.000 + 9.015 mm

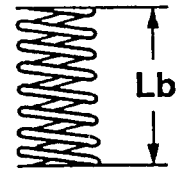
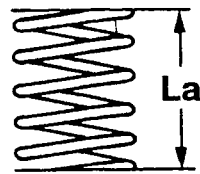
Checking the valve springs

- Check that the "free" length of the valve springs is within the specified limits.

NOTA: The resting planes must be parallel with one another and perpendicular to the axis of the spring with a maximum error of 2°.



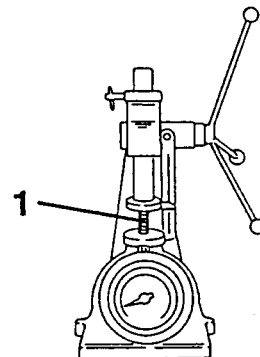
Free length of valve springs	
Outer spring "La"	44.6 mm
Inner spring "Lb"	44.1 mm



1. Using a torque meter, check that the characteristic data of the springs are within the specified limits.

Outer spring		
	Spring length mm	Control load N (kg)
With valve closed	32.5	243 + 252 (24.8 + 25.7)
With valve open	23.5	470 + 488 (47.9 + 49.7)

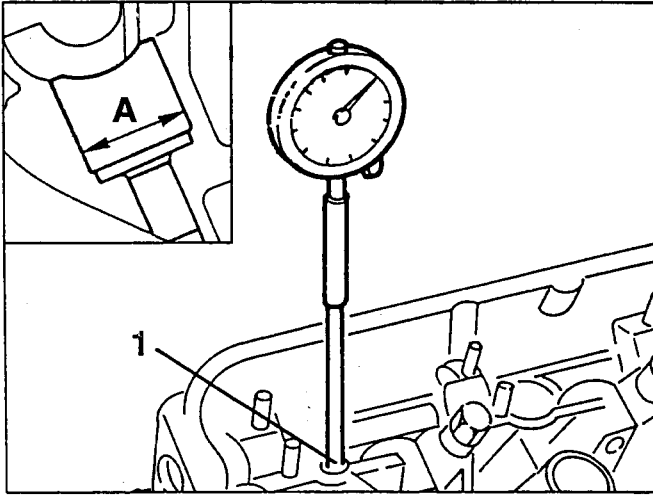
Inner spring		
	Spring length mm	Control load N (kg)
With valve closed	30.5	126 + 130 (12.8 + 13.3)
With valve open	21.5	222 + 231 (22.7 + 23.5)



Checking the clearance between the intake side cups and their seats

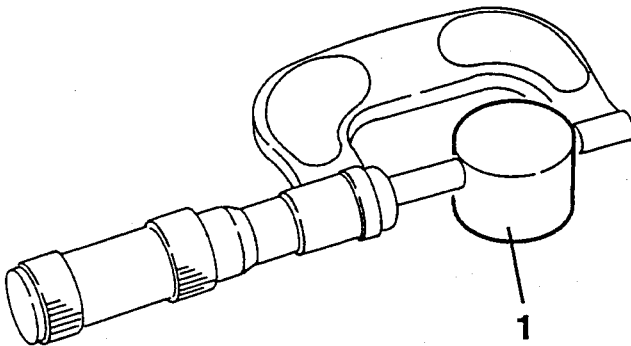
1. Check that the diameter of the intake side cup seats is within the specified limits.

∅	Diameter "A" of valve cup seats
	35.000 + 35.025 mm



1. Check that the outside diameter of the intake side cups is within the specified limits.

∅	Diameter of valve cups
	34.973 + 34.989 mm



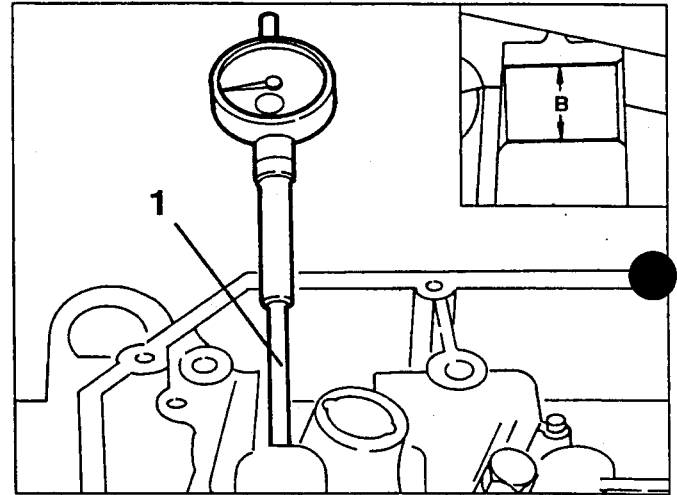
- Calculate the clearance between the intake side cups and their seats checking that it is within the specified limits.

	Clearance between intake side cups and seats
	0.011 + 0.052 mm

Checking the clearance between the exhaust side cups and their seats

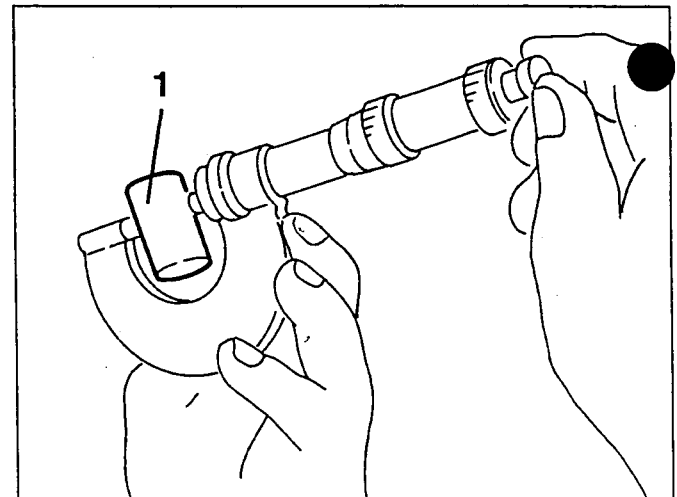
1. Check that the diameter of the exhaust side cup seats is within the specified limits.

∅	Diameter "B" of valve cup seats
	24.000 + 24.021 mm



1. Check that the outside diameter of the exhaust side cups is within the specified limits.

∅	Diameter of valve cups
	23.971 + 23.989 mm



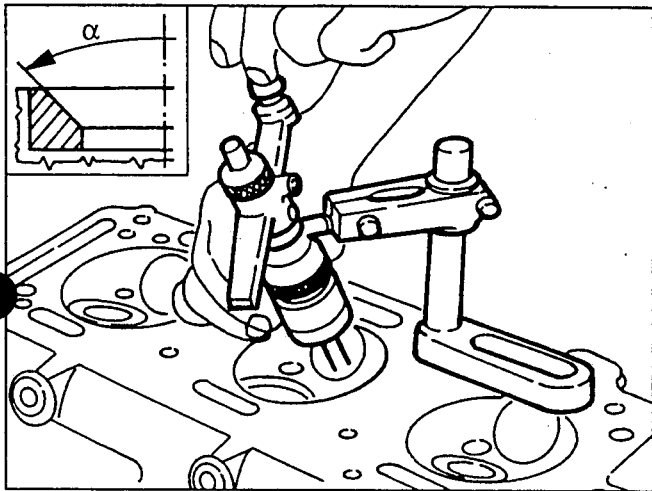
- Calculate the clearance between the exhaust side cups and their seats checking that it is within the specified limits.

	Clearance between exhaust side cups and seats
	0.011 + 0.050 mm

Turning the valve seats

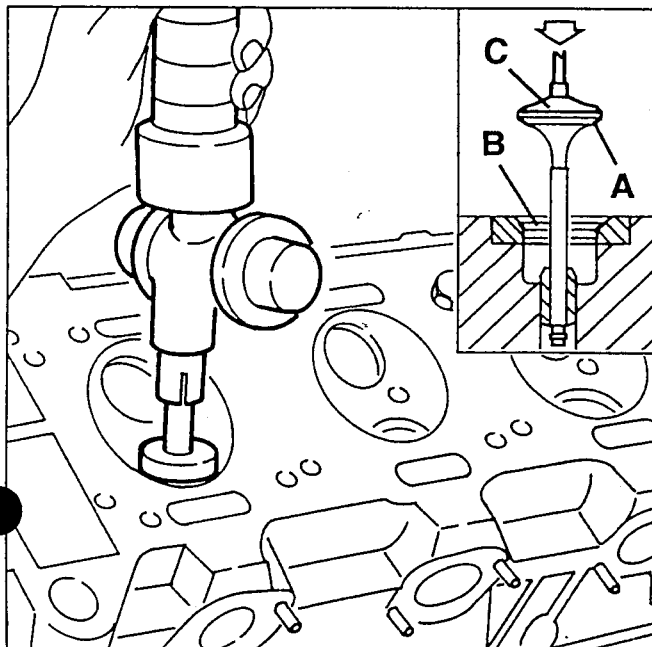
- If necessary, turn the valve seats using suitable equipment.

	Valve seat taper "α"
	$90^\circ \pm 20'$



- After machining, grind each valve in its seat as follows:

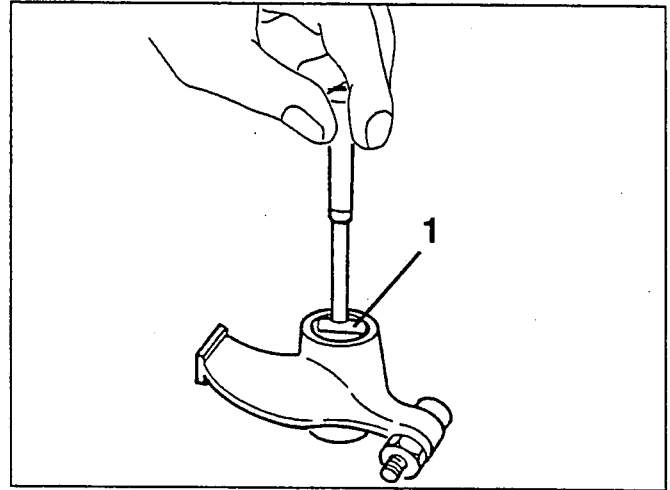
- coat the contact surfaces "A" and "B" of the valves and their seats with abrasive paste (SIPALAREXONS Carbosilicium for valves);
- lubricate the valve stem with engine oil;
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder;
- insert the valve in its guide and grind;
- after grinding, thoroughly clean the valve and the seat.



Checking the clearance between rockers and support shaft

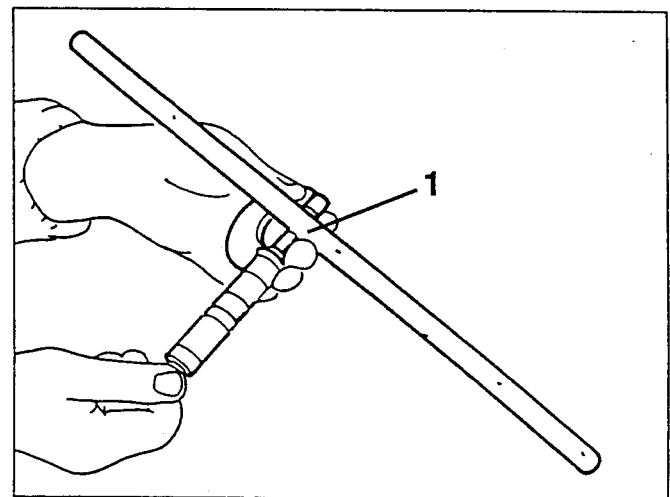
1. Check that the inside diameter of the rockers is within the specified limits.

	Inside diameter of rockers
	$16.010 \div 16.028$ mm



1. Check that the diameter of the rocker shaft is within the specified limits.

	Diameter of rocker support shaft
	$15.988 \div 16.000$ mm



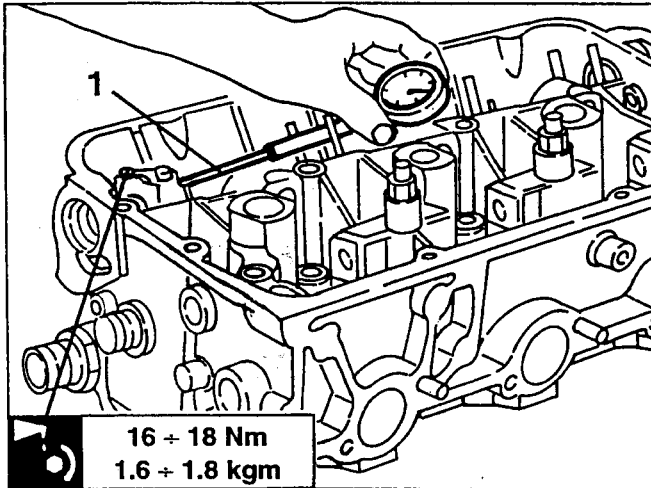
- Calculate the clearance between rockers and support shaft checking that it is within the specified limits.

	Clearance between rockers and support shaft
	$0.010 \div 0.040$ mm

Supports and camshafts

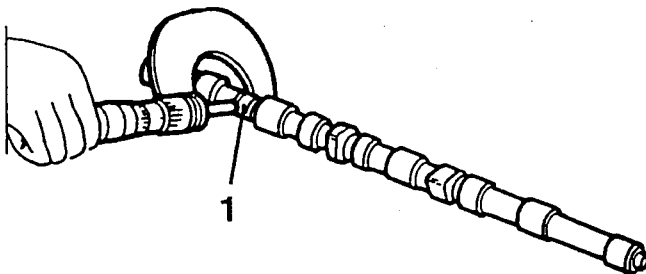
1. Assemble the camshaft caps and tighten the corresponding fastening screws to the specified torque, then check that the diameter of the supports is within the specified limits.

∅	Diameter of camshaft supports
	27.000 + 27.033 mm



1. Check that the diameter of the camshaft journals is within the specified limits.

∅	Diameter of camshaft journals
	26.949 + 26.970 mm

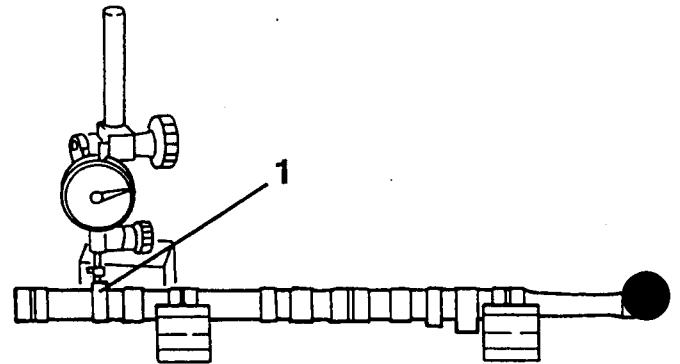


- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limits.

↕	Clearance between camshafts and bearings
	0.030 + 0.084 mm

1. Check that the nominal lifts of the camshaft cams is within the specified limits.

	Nominal cam lift	
	Intake	10.4 mm
	Exhaust	9 mm

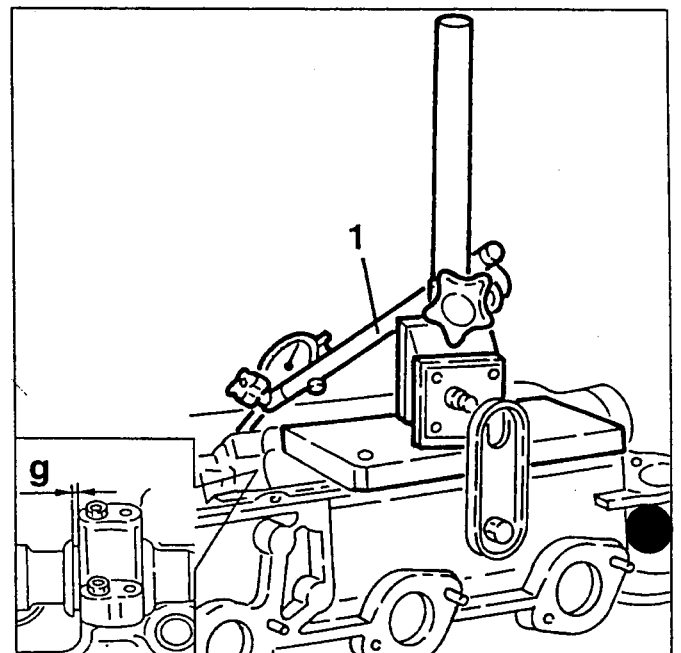


Checking the camshaft end float

- Place the camshafts on the cylinder head, assemble the corresponding caps and tighten the fastening screws to the specified torque.

1. Install a centesimal dial gauge and measure the end float of the camshafts checking that it is within the specified limits.

↔	Camshafts end float "g"
	0.060 + 0.201 mm



CHECKS AND INSPECTIONS CRANKCASE

- Visibly check the crankcase for cracks and signs of excessive wear of the sliding surfaces; check that all the threads are intact.
- Remove the plugs of the lubricating and cooling ducts and clean the duct using a suitable detergent, then dry them with a jet of air and refit new plugs.
- Remove any traces of seals and sealant from the crankcase surfaces.

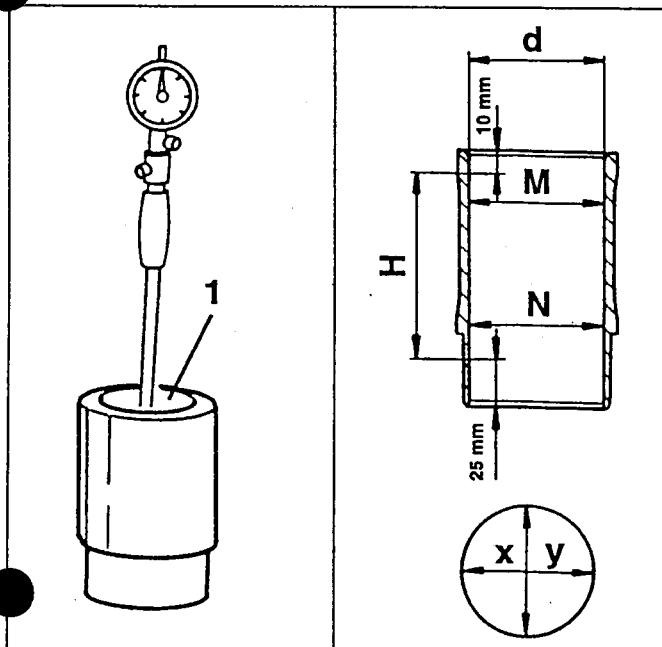
Checking the cylinder liners

Using a bore gauge fitted with dial gauge, measure the inside diameter of the cylinder liners and check that it is within the specified limits.

\varnothing	Inside diameter "d" of cylinder liners	
	Class A (Blue)	92.895 + 92.994 mm
	Class B (Pink)	92.995 + 93.004 mm
	Class C (Green)	93.005 + 93.014 mm

\triangle	Maximum cylinder taper
	0.01 mm

\circ	Maximum cylinder ovalization
	0.01 mm

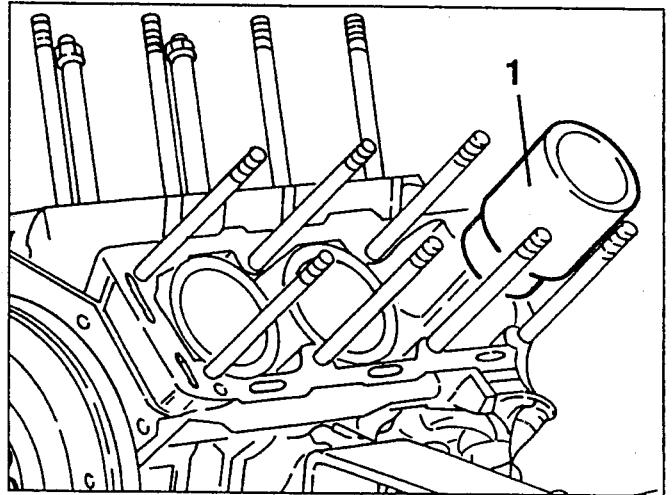


H : Area for dimensional inspection

Checking the cylinder liner protrusion (without seal rings)

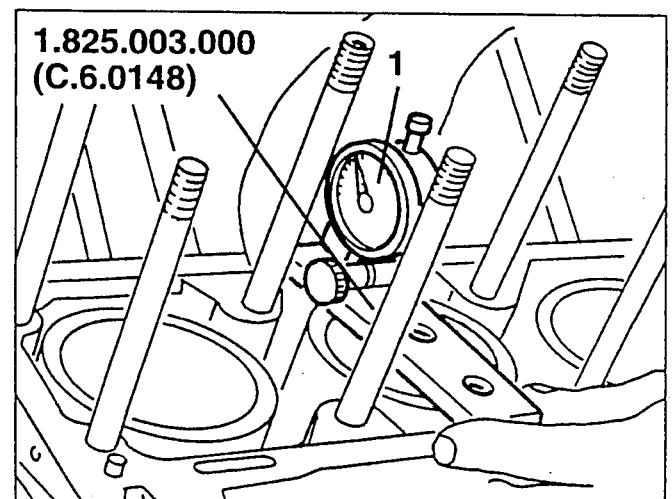
NOTE: This procedure, to be carried out as a preliminary control of the correct coupling between the cylinder liners and crankcase, should be carried out without the seal rings, therefore there is no need for the liner stopper tool, which if tightened to the specified torque would annul the thickness.

1. Insert the cylinder liners in the crankcase ensuring that they reach the stroke limit.



1. Assemble tool no. 1.825.003.000 (C.6.0148) complete with centesimal dial gauge suitably set to zero, on the crankcase first on one side and then on the other so that the feeler rests on the edges of the cylinder liner and check that the protrusion is within the specified tolerances.

\perp	Cylinder liner protrusion from crankcase
	0.01 ÷ 0.06 mm



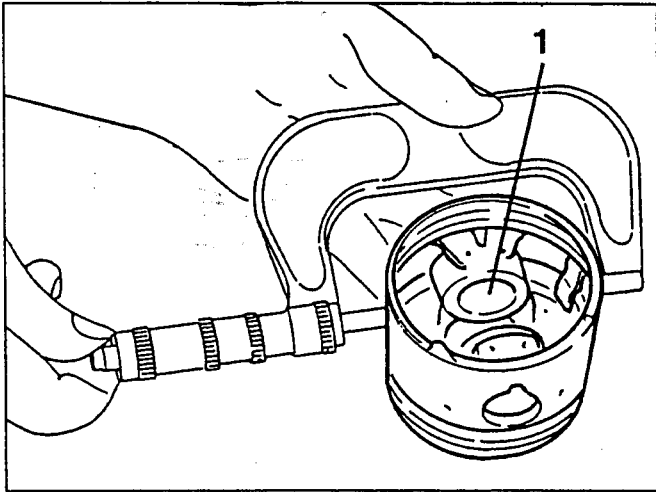
Checking the pistons

1. Measure the outside diameter of the pistons and check that it is within the specified limits.



Outside diameter of pistons (1)	
Class A (Blue)	92.925 + 92.935 mm
Class B (Pink)	92.935 + 92.945 mm
Class C (Green)	92.945 + 92.955 mm

(1) To be measured at right angles to the gudgeon pin hole at a distance of 14 mm from the lower edge of the piston skirt.



- Calculate the clearance between the cylinder liners and the pistons and check that it is within the specified limits.

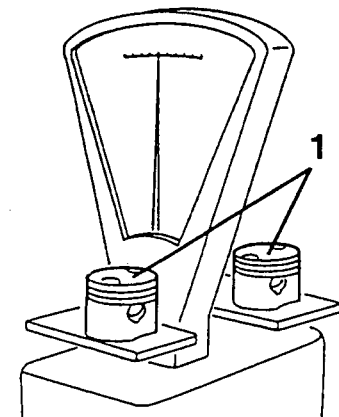


Clearance between piston and cylinder liners	
0.050 + 0.069 mm	

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.



Difference in weight between pistons	
≤ 4 g	

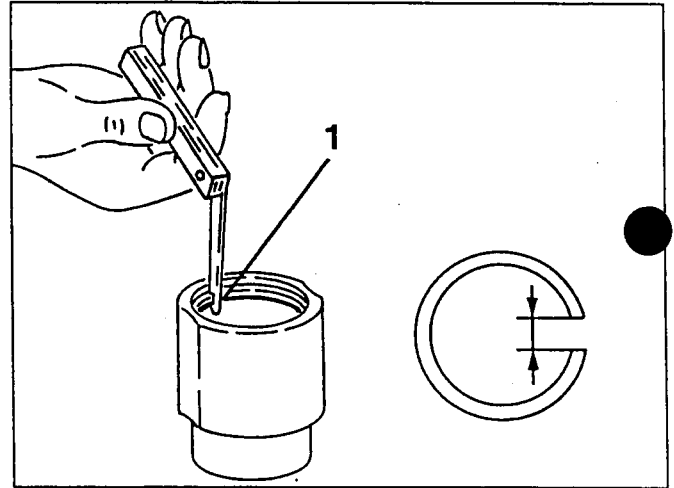


Checking the seal ring gap

1. Insert the seal rings in the cylinder liners, check that they adhere to the whole circumference and that the gap is within the specified limits.



Ring gap	
First ring	0.40 + 0.65 mm
Second ring	0.40 + 0.65 mm
Oil scraper ring	0.30 + 0.60 mm

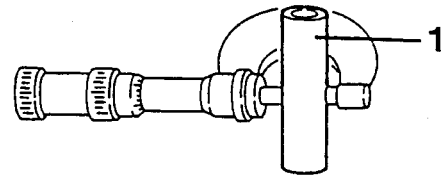


Checking the play between gudgeon pins and seats on pistons

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



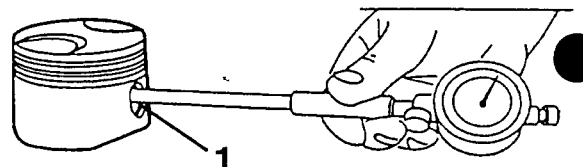
Outside diameter of gudgeon pins	
Black	21.994 + 21.997 mm
White	21.997 + 22.000 mm



1. Measure the diameter of the pin mating hole in the piston and check that it is within the specified limits.



Diameter of pin seat in pistons	
Black	22.003 + 22.006 mm
White	22.006 + 22.009 mm



- Calculate the play between pins and respective piston seats. Check whether the value falls within prescriptions.



Play between pins and piston seats

0.006 ÷ 0.012 mm

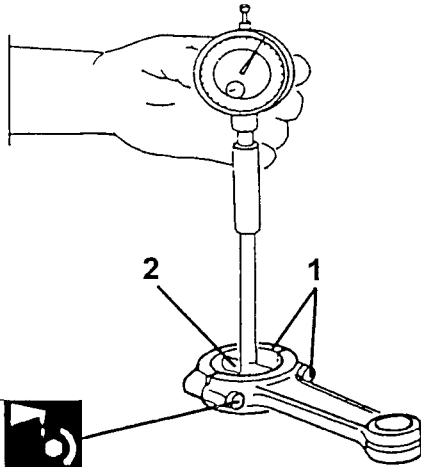
Play between connecting rod journal and respective half-bearings

1. Fit the connecting rod half-bearings in the connecting rod big end and on the respective cap. Then assemble, fastening the screws at the prescribed torque.
2. Measure the connecting rod big end internal diameter and check whether it falls within the prescribed values.



Connecting rod half-bearing internal diameter

Class A (Red)	52.021 ÷ 52.050 mm
Class B (Blue)	52.013 ÷ 52.042 mm



53 ÷ 59 Nm
5.4 ÷ 6.0 kgm

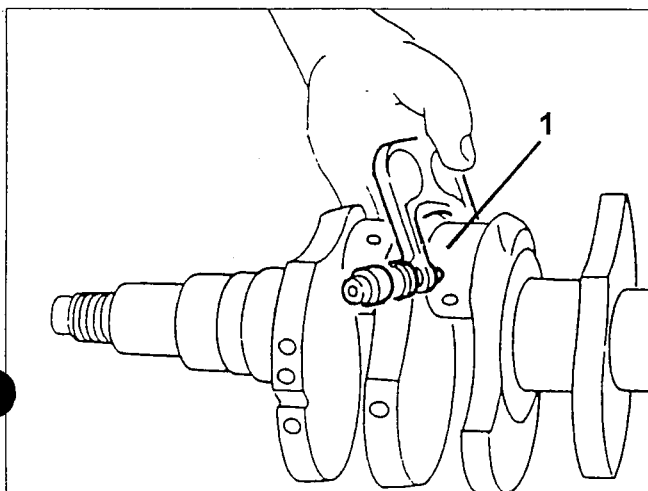


1. Measure the connecting rod journal diameter and check whether it falls within the prescribed values.



Connecting rod journal diameter

Class A (Red)	51.990 ÷ 52.000 mm
Class B (Blue)	51.980 ÷ 51.990 mm



NOTE: The crankshaft nitriding treatment does not allow re-facing. Consequently, it should be replaced if excessively worn.

- Calculate the play between connecting rod journals and the respective half-bearings. Check whether the value falls within prescriptions.



Connecting rod journals and respective half-bearing diameter

Class A (Red)	0.021 ÷ 0.060 mm
Class B (Blue)	0.023 ÷ 0.062 mm

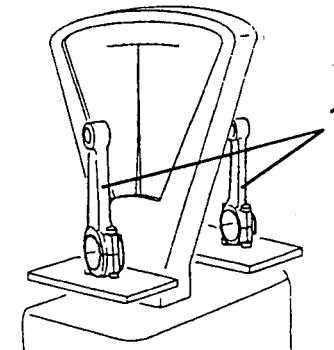
Connecting rod check

1. Check the difference in weight between connecting rods with half-bearings, caps and screws. Check whether the value falls within prescriptions.



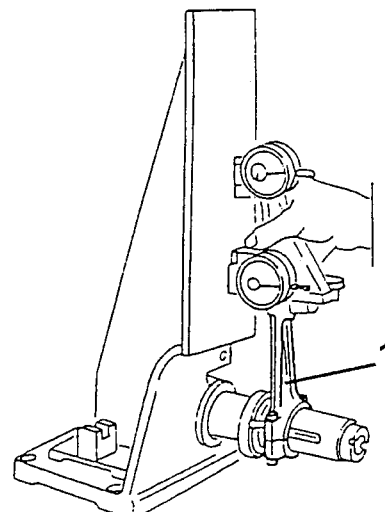
Connecting rod weight difference

± 4 g



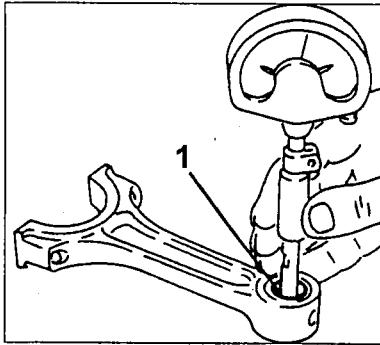
1. Check connecting rod squaring with a reference as shown in the figure.

NOTE: If squaring is not perfect, replace the connecting rod to avoid improper stress during engine operation with consequent irregular piston and connecting rod wear.



Play between connecting rod small end journal and bushing

1. Measure the connecting rod small end internal diameter. Check whether the value falls within prescriptions. If not, replace it.

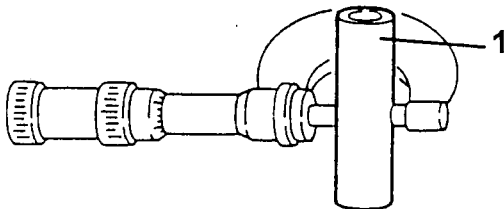


Connecting rod small end bushing internal diameter	
22.004 ÷ 22.014 mm	

1. Measure the journal external diameter and check whether the value falls within prescriptions.



Journal external diameter	
Black	21.994 ÷ 21.997 mm
White	21.997 ÷ 22.000 mm



- Calculate the play between journals and connecting rod small end bushing. Check whether the value falls within prescriptions.



Connecting rod small end journal and bushing play	
Black	0.007 ÷ 0.020 mm
White	0.004 ÷ 0.017 mm

Play between main journal and respective half-journals

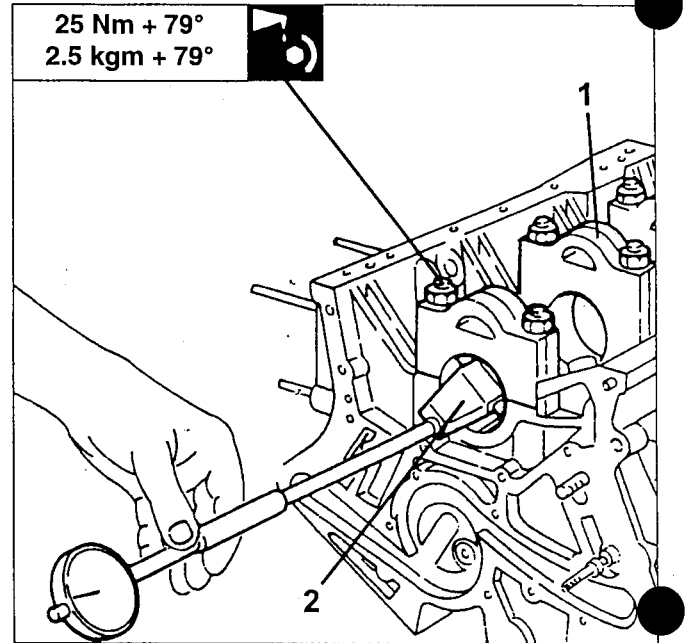
1. Fit the half-bearings and main bearings on the crankcase. Fasten the nuts at the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angular torque.

2. Measure the main journal internal diameter and check whether the value falls within prescriptions.



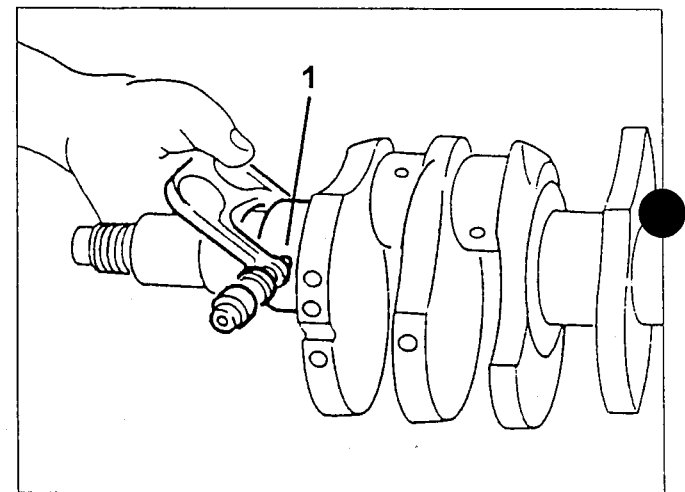
Main journal diameter	
Class A (Red)	59.979 ÷ 59.997 mm
Class B (Blue)	59.973 ÷ 59.991 mm
Class C (Green)	59.967 ÷ 59.985 mm



1. Measure the main journal diameter and check whether the value falls within prescriptions.



Main journal diameter	
Class A (Red)	59.973 ÷ 59.979 mm
Class B (Blue)	59.967 ÷ 59.973 mm
Class C (Green)	59.961 ÷ 59.967 mm



- Calculate the play between main journals and respective half-bearings and check whether the value falls within prescriptions.



Play between main journals and respective half-bearings	
0.000 ÷ 0.024 mm	

Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, change the ring gear as described below:

- working under the press remove the old ring gear;
- accurately clean the contact surfaces of the new ring gear and of the flywheel;
- evenly heat the new ring gear to $120^{\circ} + 140^{\circ}\text{C}$ and fit it on the flywheel: leave to cool naturally, do not force cool.

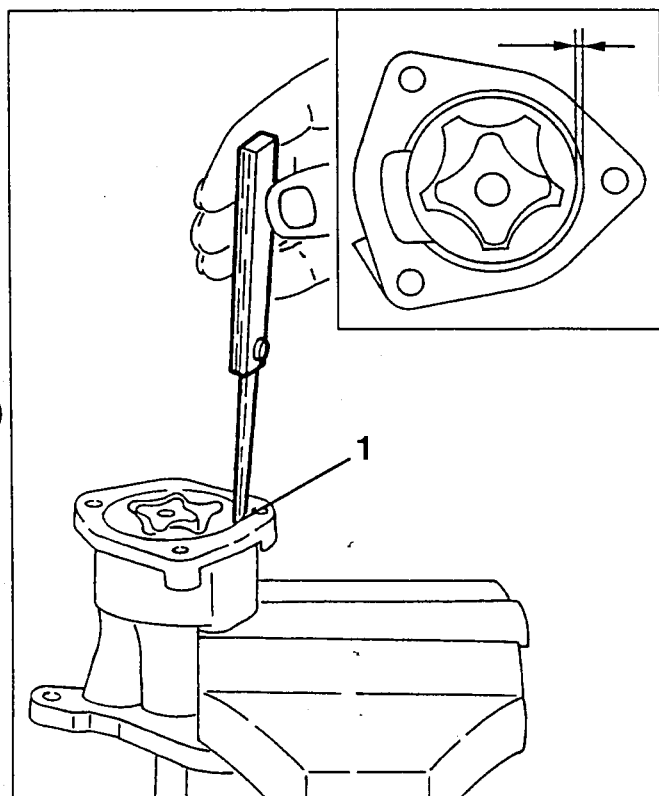
Checking the oil pump

1. Check that the clearance between the pump casing and the driven gear is within the specified limit.



Clearance between pump casing and driven gear

$0.170 \pm 0.275 \text{ mm}$

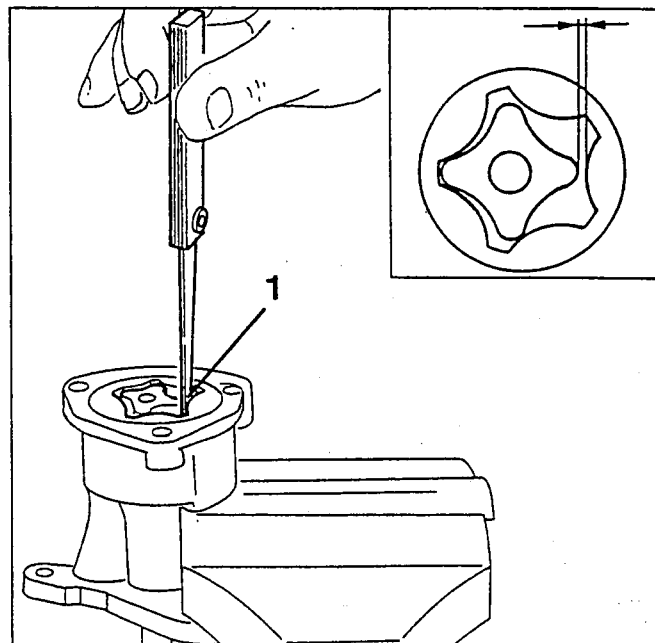


1. Check that the clearance between the lobe of the inner gear and that of the driven gear is within the specified limits.



Clearance between driven gear and inner gear

$0.040 \pm 0.290 \text{ mm}$

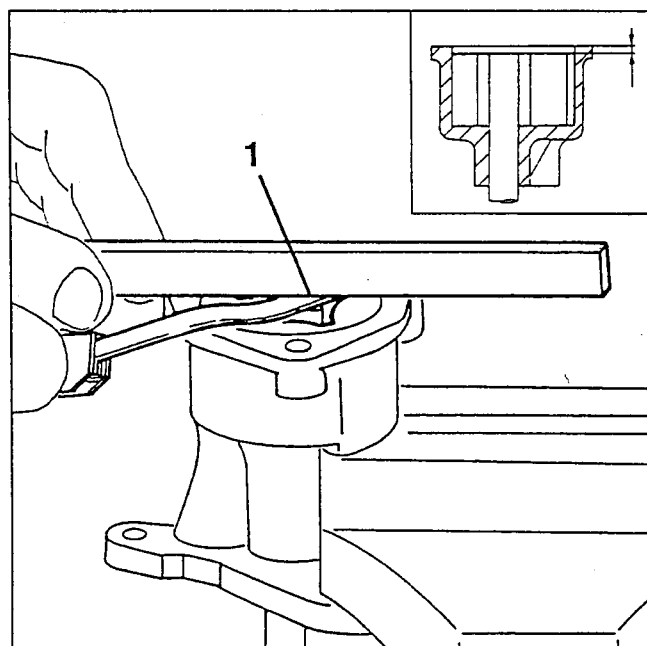


1. Check that the clearance between the rest surface of the pump casing and the upper side of the gears is within the specified limits.



Clearance between pump casing rest surface and upper side of gears

$0.025 \pm 0.075 \text{ mm}$



- Using a torque meter, check that the characteristic data of the engine oil pressure limiting valve control spring are within the specified limits.

Spring length	
With spring free	54 mm
With static load (14.6 kg)	36 mm
With dynamic load (21 kg)	28 mm

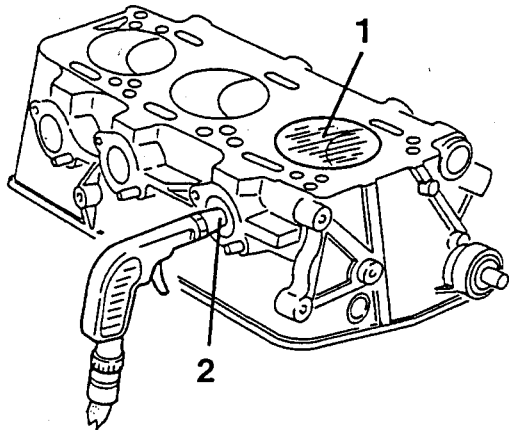
INSTRUCTIONS FOR RE-ASSEMBLY



For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

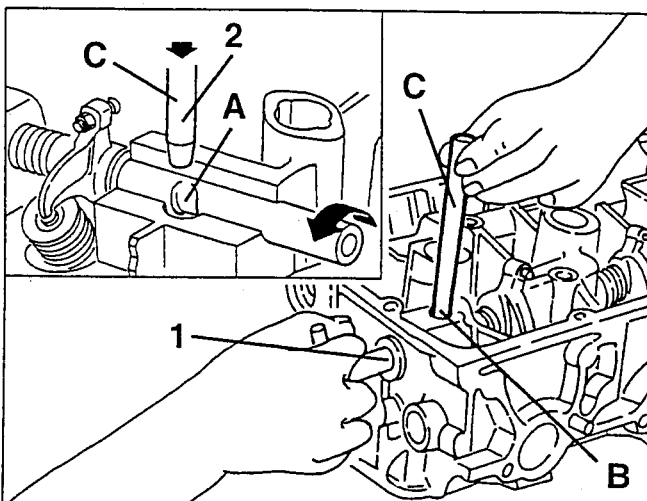
Checking valve tightness

- Install the spark plugs in their seats.
- 1. Pour just enough fuel into a combustion chamber to cover the valve mushrooms.
- 2. Admit low pressure air into the intake and exhaust manifolds and check that no bubbles form in the fuel, if they do, check the correct positioning and if necessary turn the valve seats (see specific paragraph).



Positioning the rocker support shaft

- 1. After fitting the washers, rockers and springs, turn the support shaft until notches "A" correspond with holes "B" to allow the passage of the cylinder head fastening studs.
- 2. To check this condition, use a 12 mm diameter pin "C".



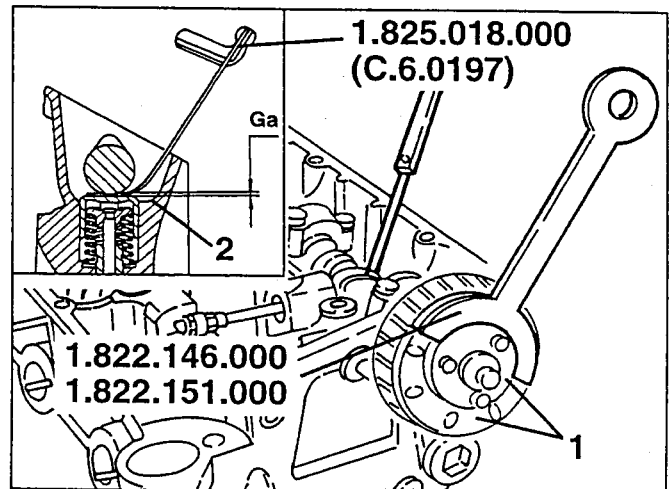
Checking and adjusting the valve clearance

Intake side valves

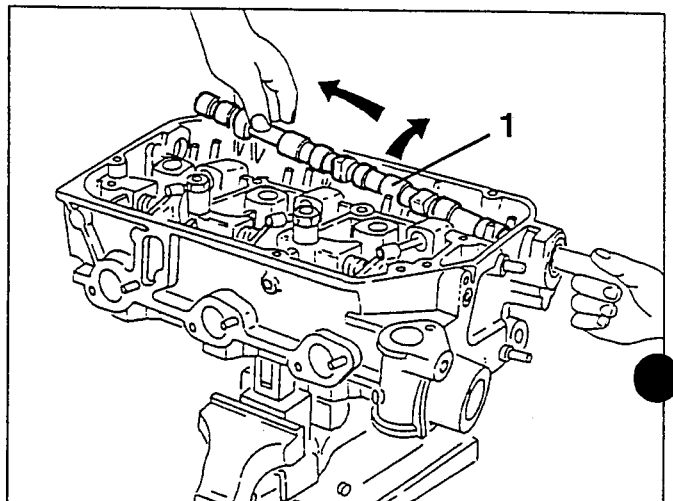
- After refitting the camshaft, measure the clearance of the intake valves as follows:
- 1. Temporarily install the hub and corresponding camshaft toothed driving pulley.
- 2. Using tools no. 1.822.146.000 and no. 1.822.151.000 for turning the camshaft, use thickness gauge no. 1.825.018.000 (C.6.0197) to check that the clearance "Ga" between the lowered radius of the cams and the corresponding cup is within the specified limits.



Intake valve clearance "Ga"
0.475 ± 0.500 mm



- Should the intake valve clearance fail to be as specified, adjust proceeding as follows:
- 1. Remove the caps and withdraw the camshaft.



Checking the engine flywheel

- Check that the ring gear teeth are not cracked or show signs of seizure; if they do, change the ring gear as described below:

- working under the press remove the old ring gear;
- accurately clean the contact surfaces of the new ring gear and of the flywheel;
- evenly heat the new ring gear to 120° + 140°C and fit it on the flywheel: leave to cool naturally, do not force cool.

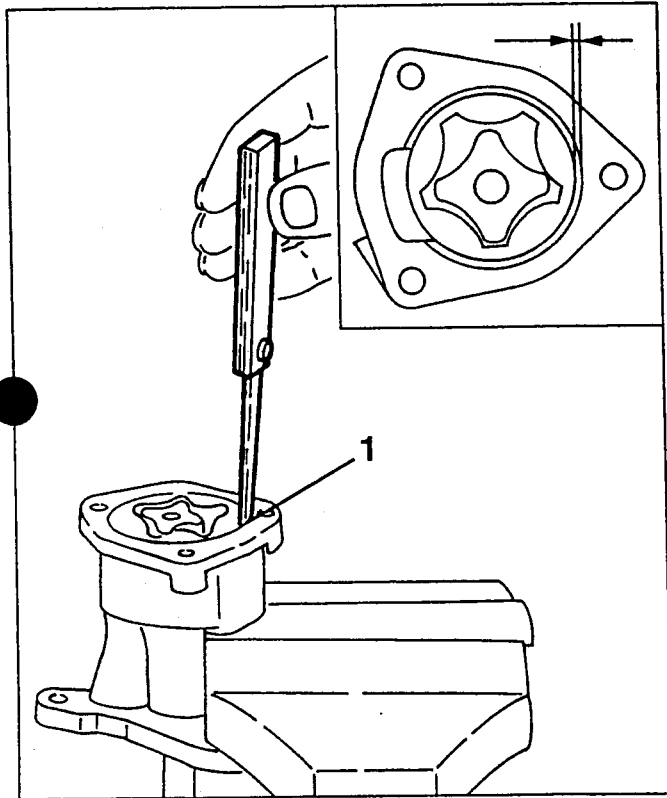
Checking the oil pump

Check that the clearance between the pump casing and the driven gear is within the specified limit.



Clearance between pump casing and driven gear

0.170 + 0.275 mm

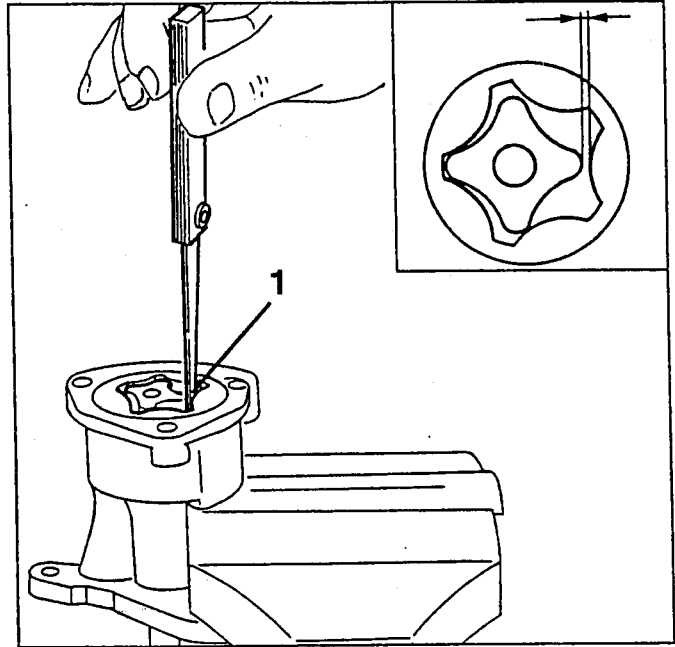


1. Check that the clearance between the lobe of the inner gear and that of the driven gear is within the specified limits.



Clearance between driven gear and inner gear

0.040 + 0.290 mm

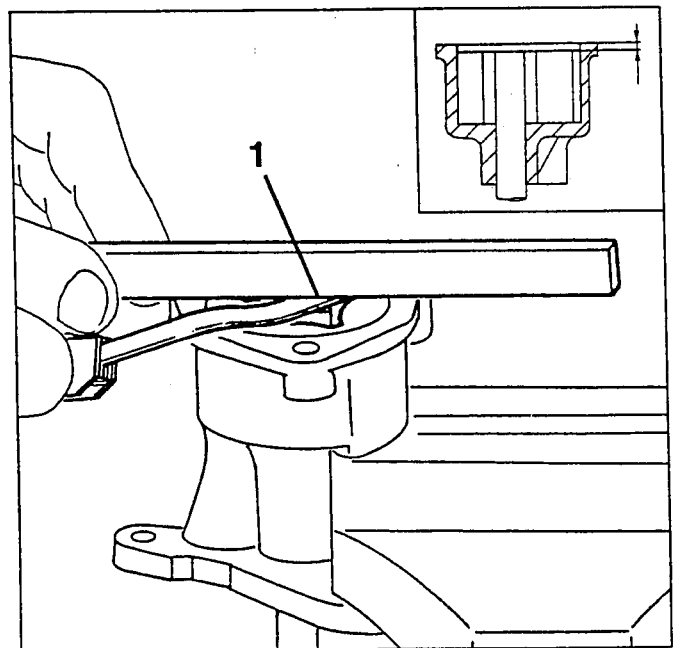


1. Check that the clearance between the rest surface of the pump casing and the upper side of the gears is within the specified limits.



Clearance between pump casing rest surface and upper side of gears

0.025 + 0.075 mm



- Using a torque meter, check that the characteristic data of the engine oil pressure limiting valve control spring are within the specified limits.

Spring length

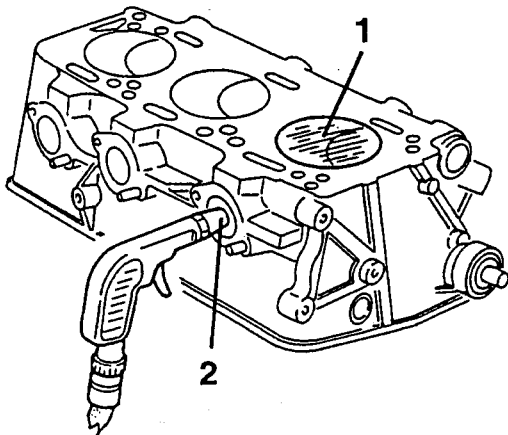
With spring free	54 mm
With static load (14.6 kg)	36 mm
With dynamic load (21 kg)	28 mm

INSTRUCTIONS FOR RE-ASSEMBLY

 For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

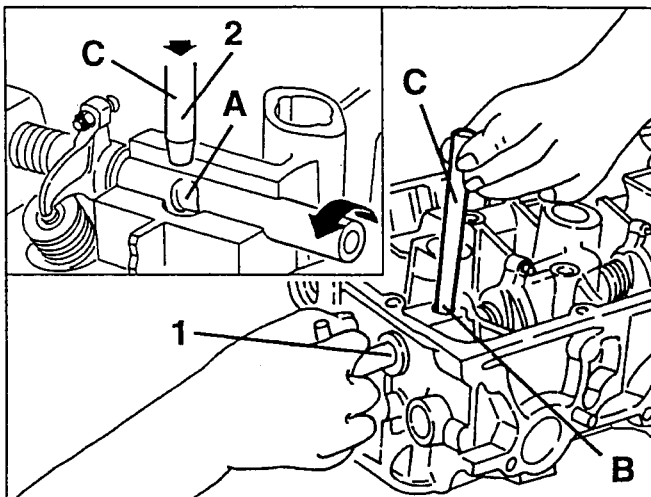
Checking valve tightness

- Install the spark plugs in their seats.
- 1. Pour just enough fuel into a combustion chamber to cover the valve mushrooms.
- 2. Admit low pressure air into the intake and exhaust manifolds and check that no bubbles form in the fuel, if they do, check the correct positioning and if necessary turn the valve seats (see specific paragraph).



Positioning the rocker support shaft

- 1. After fitting the washers, rockers and springs, turn the support shaft until notches "A" correspond with holes "B" to allow the passage of the cylinder head fastening studs.
- 2. To check this condition, use a 12 mm diameter pin "C".



Checking and adjusting the valve clearance

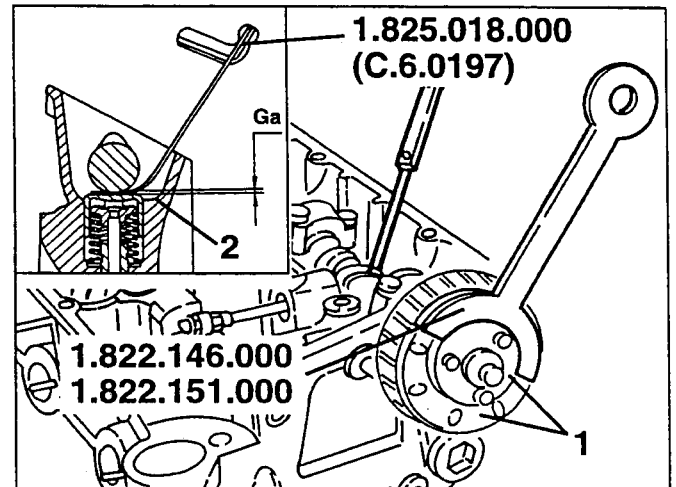
Intake side valves

- After refitting the camshaft, measure the clearance of the intake valves as follows:
- 1. Temporarily install the hub and corresponding camshaft toothed driving pulley.
- 2. Using tools no. 1.822.146.000 and no. 1.822.151.000 for turning the camshaft, use thickness gauge no. 1.825.018.000 (C.6.0197) to check that the clearance "Ga" between the lowered radius of the cams and the corresponding cup is within the specified limits.



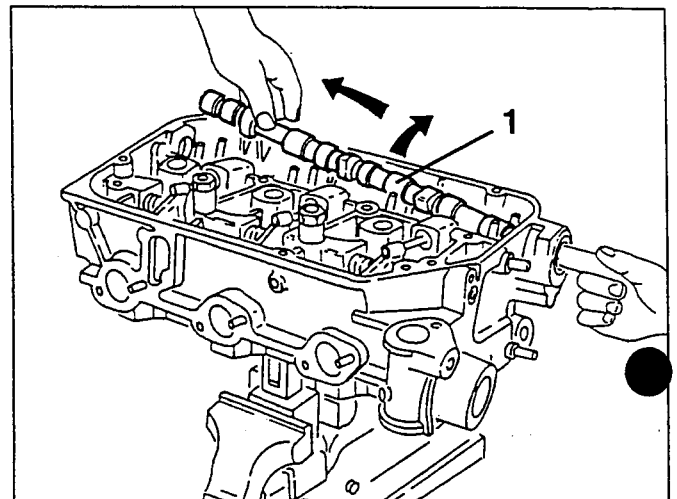
Intake valve clearance "Ga"

0.5 mm

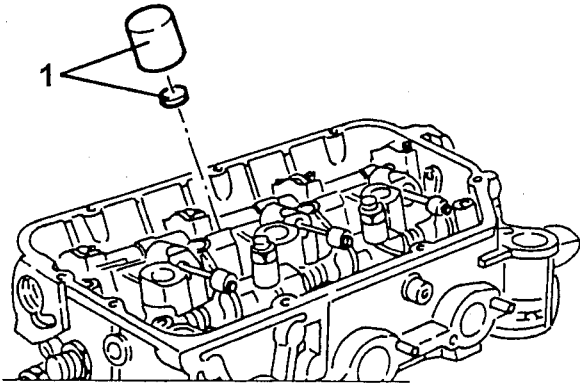


- Should the intake valve clearance fail to be as specified, adjust proceeding as follows:

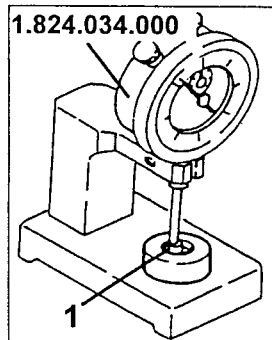
- 1. Remove the caps and withdraw the camshaft.



Remove the cups and remove the tappet clearance adjustment caps.



Measure cap thickness with gauge no. 1.824.034.000. Then choose from the no. 1.820.150.000 (R.9.0001) set the suitable tool to restore correct tappet clearance according to the measured values.

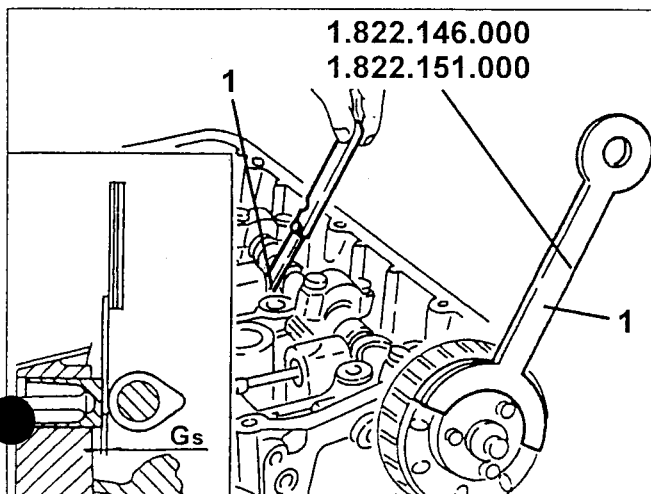


Refit the cups, the camshaft and the respective caps. Fasten the caps at the prescribed torque and check the intake tappet clearance.

Exhaust side tappets

Temporarily fit the hub and the camshaft drive pulley.

1. Turn the camshaft with tools no. 1.822.146.000 and no. 1.822.151.000. Then measure the clearance between lowered cam radius and corresponding cup. Check whether the value falls within prescriptions.

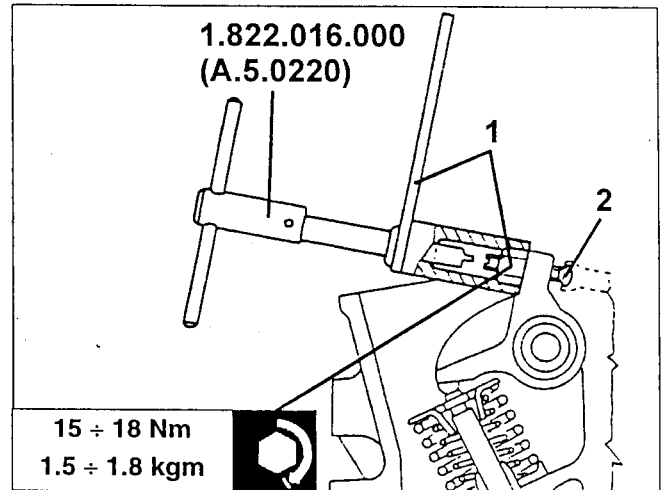


"Gs" exhaust tappet clearance

0.225 ± 0.250 mm

If the exhaust tappet clearance is not included within the prescribed values, adjust as follows:
 1. With tool no. 1.822.016.000 (A.5.0220) intermediate lever, loosen the adjustment screw lock nut.
 2. Turn the adjustment screw until the prescribed exhaust tappet clearance is reached with the same tool.

Torque the lock nut and check tappet clearance.



Crankshaft refitting

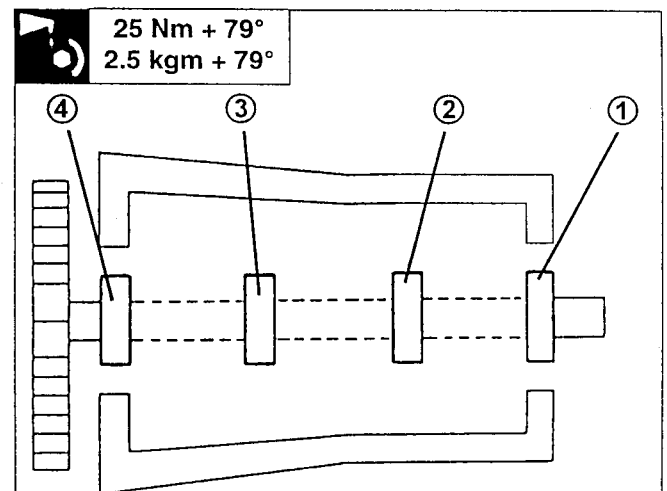
Fit the crankshaft with half-bearings and thrust rings on the crankcase.

NOTE: Refit the thrust half-rings with the grooved surface facing the crankshaft.

Fit the main bearings and half-bearings on the journals according to the numbers. Fasten to the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angle torque.

NOTE: The safety notches on the crankcase and on the main bearings should be on the same side.



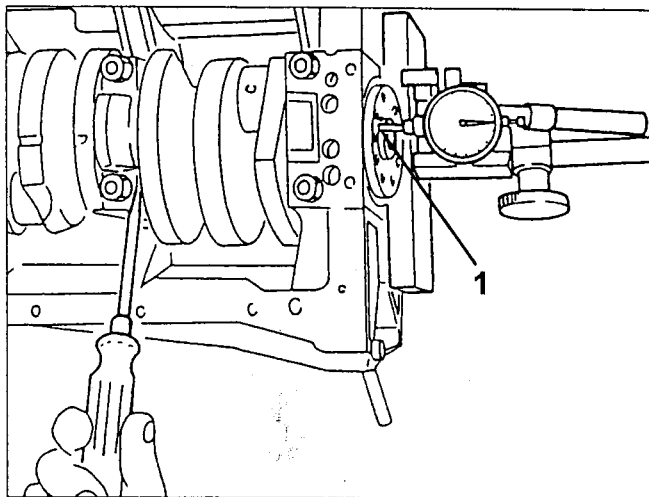
Crankshaft axial play

1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.

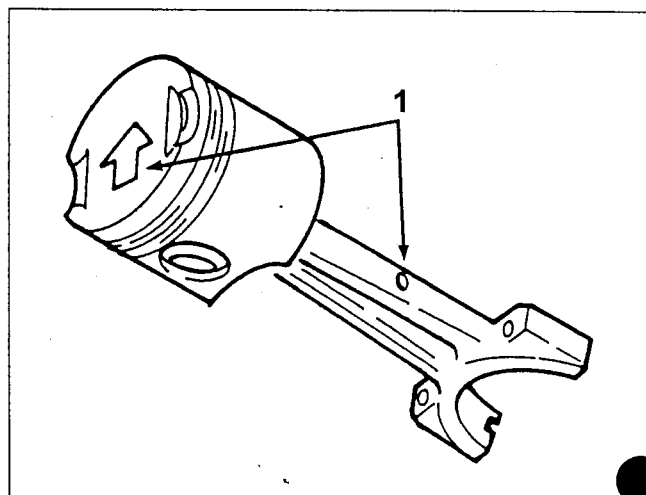


Crankshaft axial play

0.080 ÷ 0.265 mm



1. Couple the pistons and their respective connecting rods. Make sure the arrow printed on the top of the piston is facing the direction shown in the figure with respect to the lubrication hole on the side of the connecting rod.



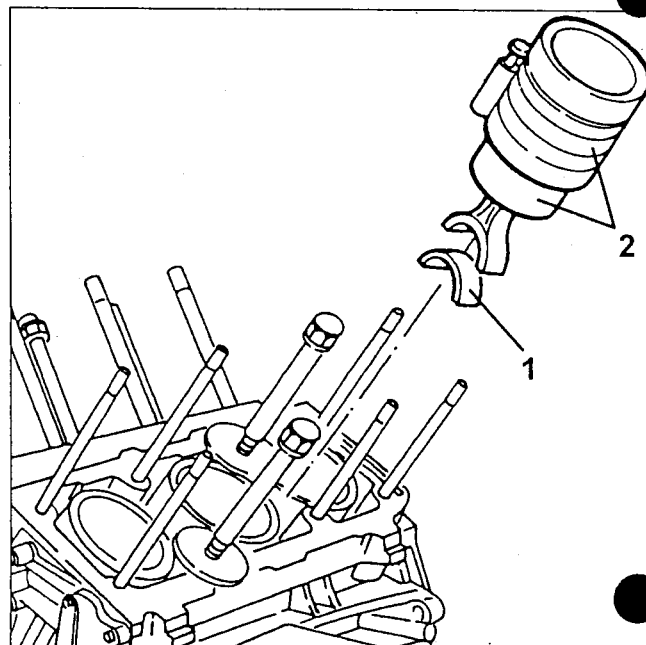
- Fit the gas rings and the oil scraper on the piston with a suitable tool.

NOTE: After refitting, address the gas ring cuts so that they do not coincide with the journal axis and at 120° one from the other.

1. Fit the respective half-bearings on the connecting rod big end.

2. Insert the connecting rod-piston assembly in the bank cylinder liner with a suitable tool.

NOTE: Fit the connecting rod-piston assembly so that the arrow printed on the top of piston is facing the front side of the motor and that the lubrication hole is facing towards the right-hand side of the crankcase.



Cylinder liner, piston and connecting rod refitting

- Clean the cylinder liners carefully, fit the seals and insert in the crankcase. Make sure they reach the end of the stroke.

1. Lock the cylinder liners in the crankcase with the liner retainer tools no. 1.820.279.000 and fasten the respective nuts at the prescribed torque.

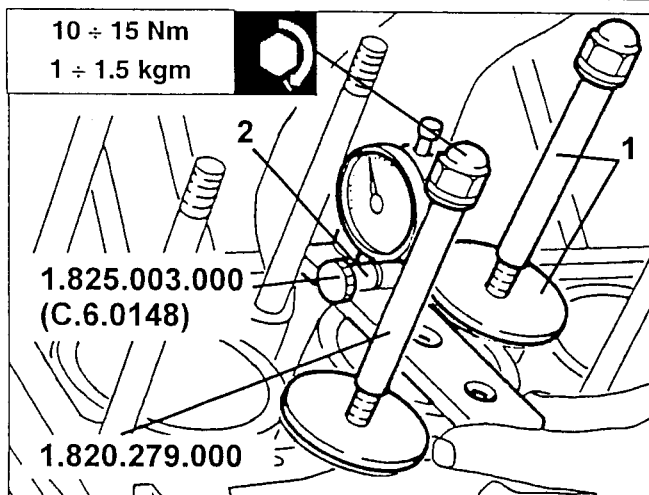
2. Fit tool no. 1.825.003.000 (C.6.0148) and the reset centesimal gauge on the crankcase. Position one side and then the other so that the feeler is in contact with the cylinder liner edges. Check the projection falls within the prescribed values.



Crankcase cylinder liner projection

0.01 ÷ 0.06 mm

10 ÷ 15 Nm
1 ÷ 1.5 kgm

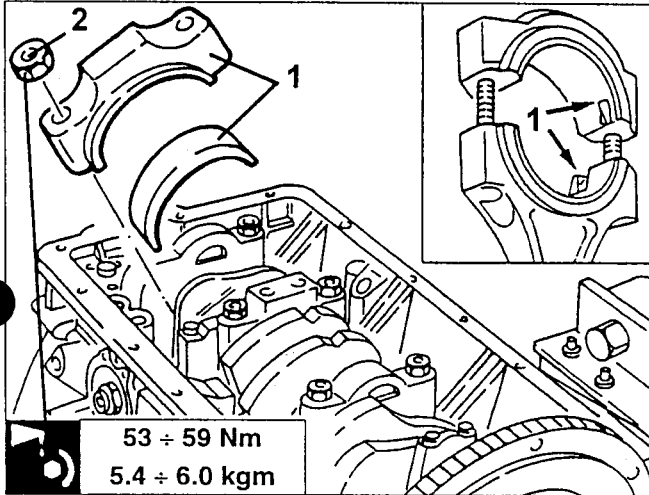


Turn the crankcase on the overhaul stand.

1. Fit the connecting rod caps and half-bearings on the bank. Address the safety notch towards the notch on the connecting rod cap.

NOTE: The cylinder number is shown on the side of each connecting rod cap. When refitting, this number should be on the same side as the number printed on the connecting rod.

2. Fasten the connecting rod cap screws at the prescribed torque.

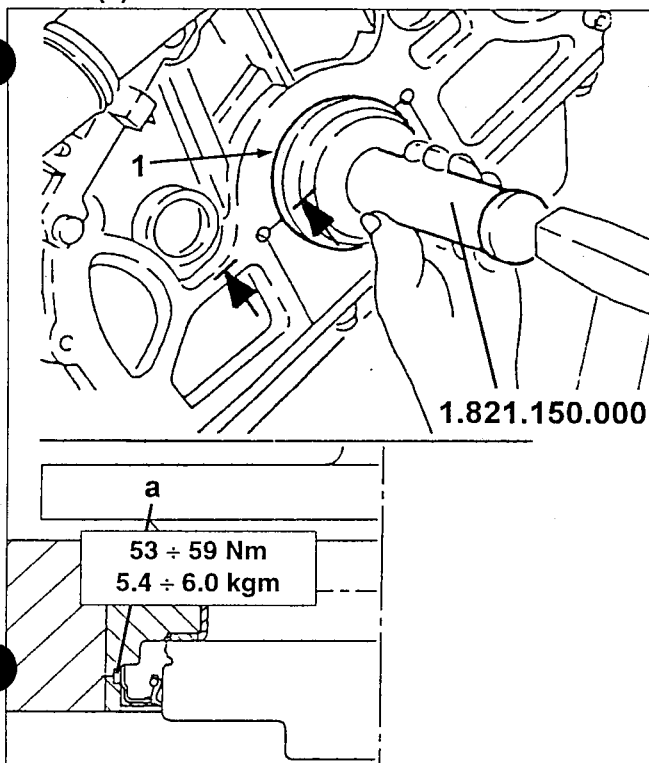


- Fit the pistons and the connecting rod of the other bank in the same way.

Oil sump refitting

1. Fit the rear crankshaft oil seal with tool no. 1.821.150.000.

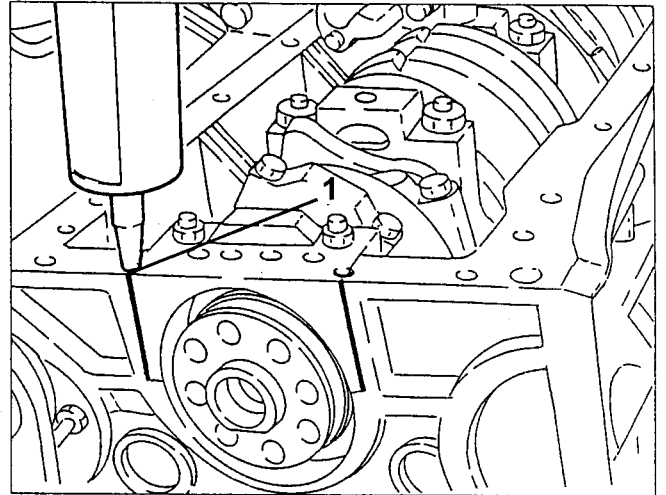
NOTE: Fit the oil seal in its seat so that the holes (a) are covered.



For pre-change versions (to engine no. 02054)

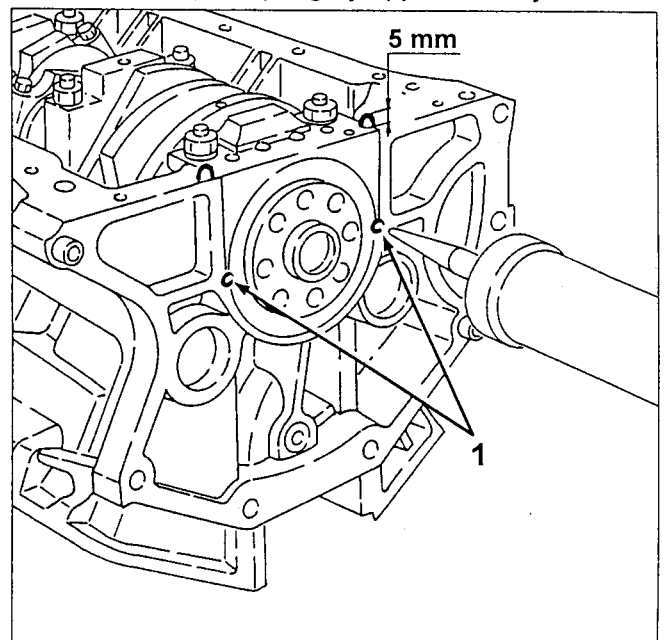
1. Apply "DOW CORNING 7091" silicon sealant with a mechanical gun through the holes shown in the figure.

NOTE: Check that the sealant seeps out from the rear crankcase-main cap coupling along the entire length.

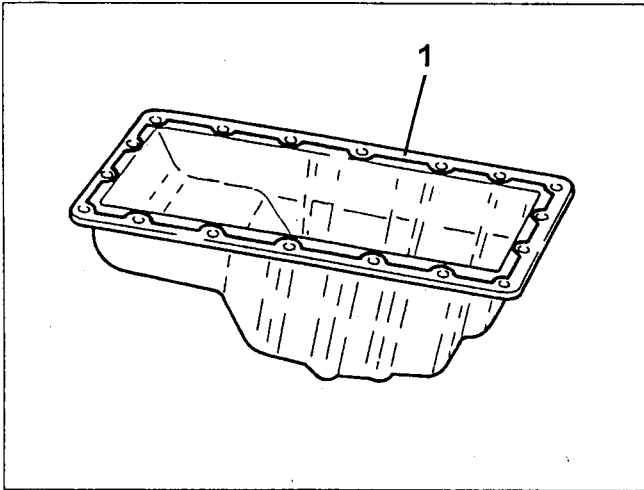


For pre-change versions (to engine no. 02055)

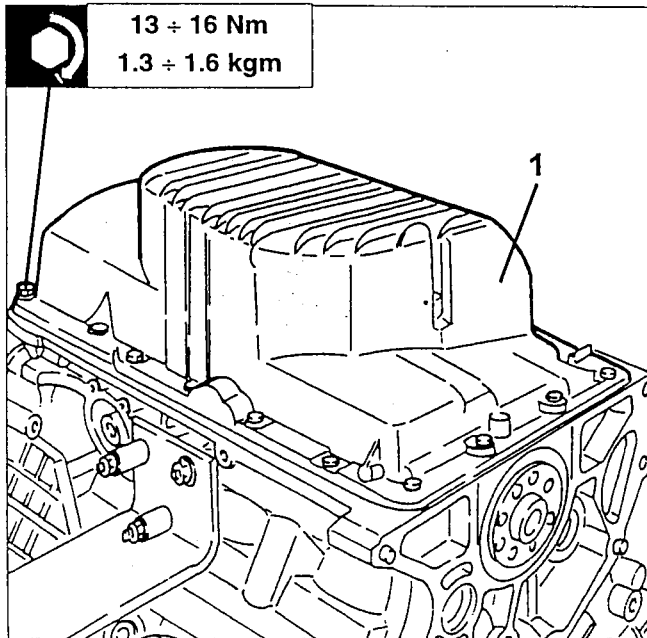
1. Apply "DOW CORNING 7091" silicon seals by means of a mechanical gun through the holes on the crankcase until the sealant seeps out from the engine oil sump coupling by approximately 5 mm.



1. Apply sealant to the oil sump. Make sure the strip of sealant (not wider than approximately 1.5 mm in diameter) is within the oil sump fastening holes (between reservoir and hole).



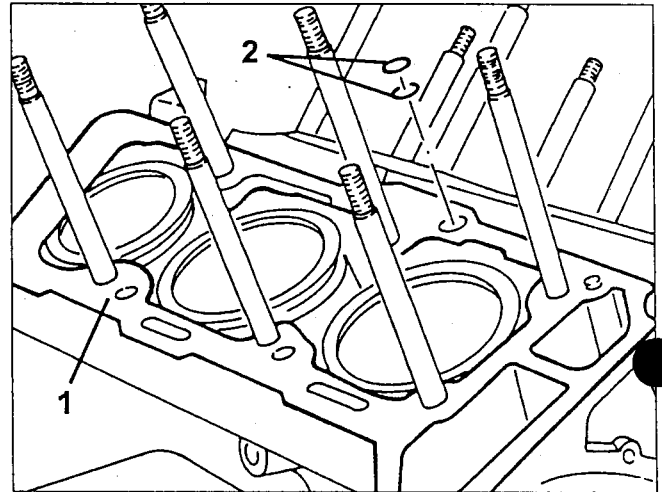
1. Position the oil sump avoiding considerable side movements which could remove the silicon sealant. Then fasten the oil sump screws at the prescribed torque.



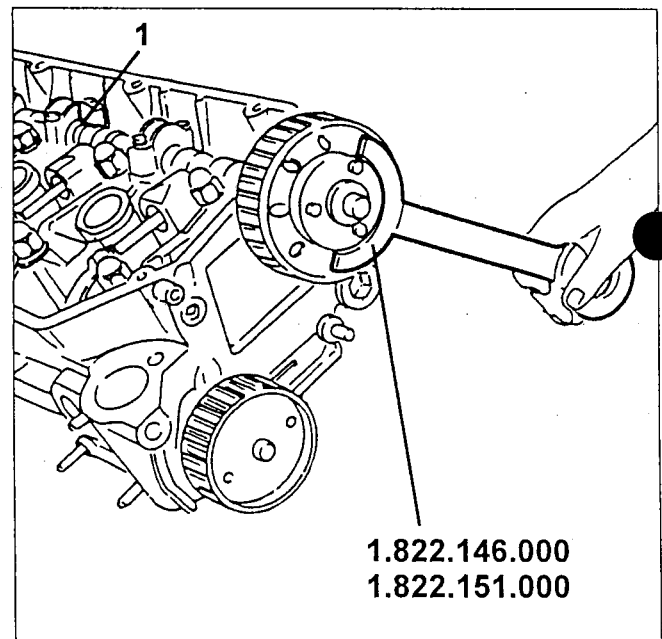
IMPORTANT: Fit the oil sump within 15 minutes from applying the sealant in the crankshaft rear seal holes.

Cylinder head refitting

- Turn the crankshaft to take cylinder 1 piston to TDC.
- Remove the previously fitted liner retainer tool no. 1.820.279.000.
- 1. Position the cylinder head seals.
- 2. Position the lubrication duct seals.

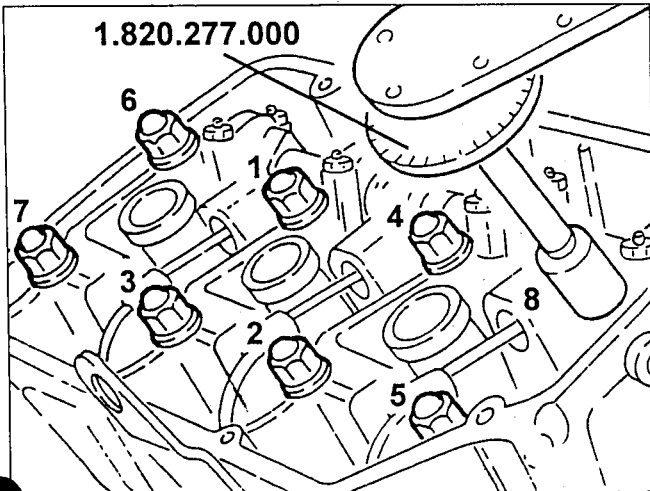


1. Turn the camshaft on each head to make the timing reference notches on the camshafts coincide with those on the respective notches using tool no. 1.822.146.000 and tool no. 1.822.151.000.



- Fit the cylinder heads on the crankcase.

Torque the cylinder head fastening screws as follows. The tighten torque order for each stroke is given in the figure.



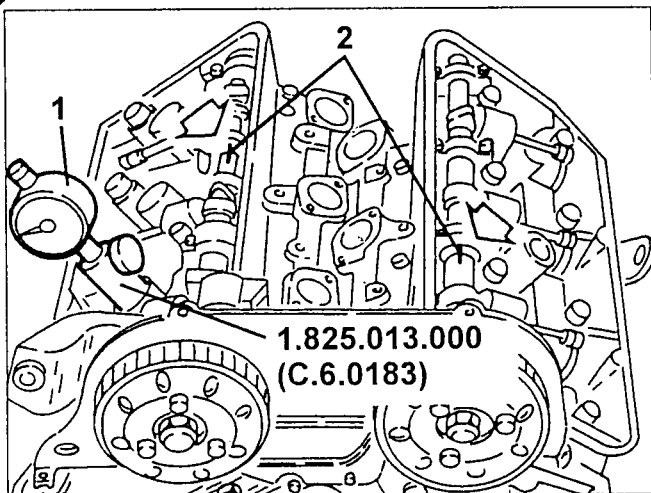
1.820.277.000

Tightening torque procedure

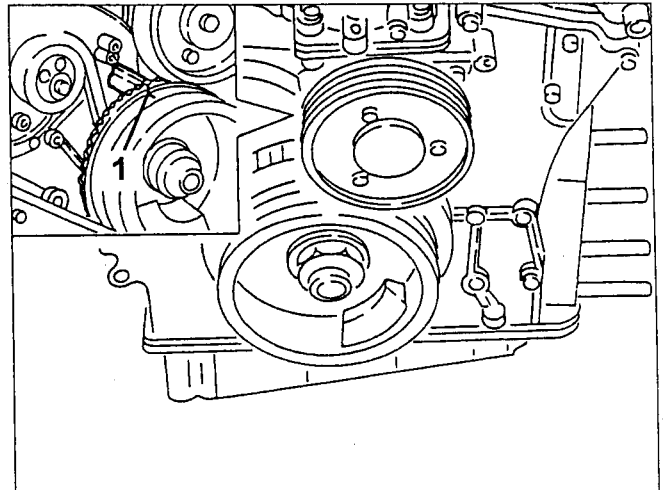
Fasten all screws at:	25 Nm
Complete torque by an additional angle of:	240° ± 1°30'

Refitting timing belt and checking timing

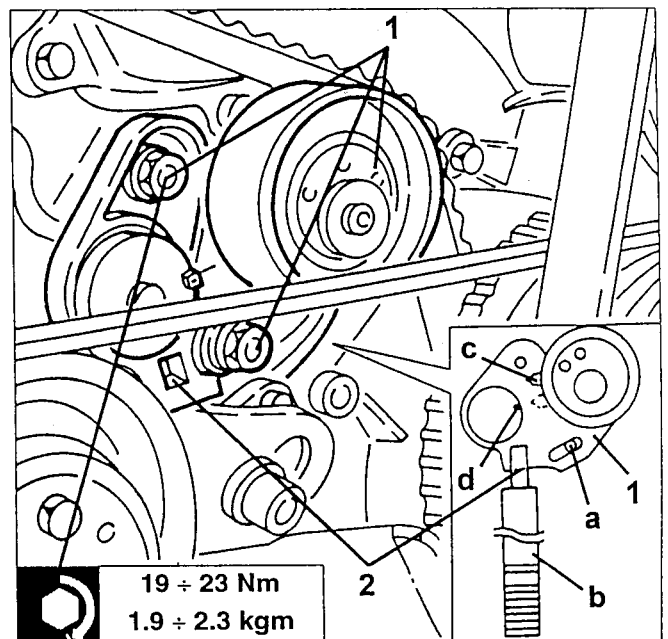
1. Turn the crankshaft to take cylinder 1 piston to TDC firing stroke with tool no. 1.825.013.000 (C.6.0183) and gauge.
2. Check alignment of the notches on the camshafts and those on the respective caps.



1.825.013.000 (C.6.0183)



1. Position the timing belt take-up device so that stud "a" is as shown in the figure. Then torque the two fastening nuts locking them slightly.
 - Fit the timing belt on the pulleys from the drive pulley anti-clockwise.
 - Loosen the two belt take-up device fastening nuts.
2. Insert a template 10 mm from tension lever "b" (3/82 ratchet) in the belt take-up device hole. Then turn it anti-clockwise so to advance hand "c" by 2 - 3 mm until they meet. Then fasten the two belt take-up device nuts without locking them.
 - Turn the crankshaft clockwise by two turns to take cylinder 1 piston to DTC.
 - Check whether hand "c" meets central notch "d" and torque the two belt take-up fastening nuts as prescribed.
 - Remove the belt take-up tension lever "b".



19 ÷ 23 Nm
1.9 ÷ 2.3 kgm

1. Furthermore, check alignment of the notch on the phonic wheel with the reference pin on the front crankcase cover.

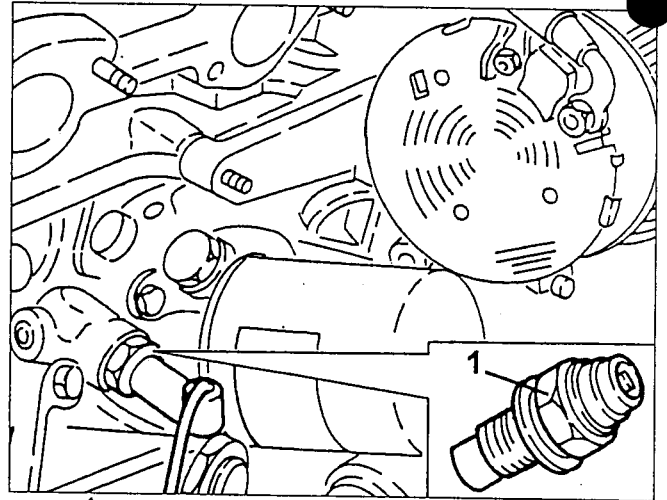
LUBRICATION CIRCUIT ELECTRICAL COMPONENT CHECKS

Minimum engine oil sensor warning light

1. Check the minimum engine oil pressure sensor calibration. If the values are not as prescribed, replace the sensor.



Contact open/close pressure
0.1 - 0.35 bar



For the other sensors and electrical components located in the engine compartment, refer to the specific assemblies where greater details are offered.



TB

ENGINE V6 TURBO - AR16202

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INDEX

OVERHAULING

- Introduction1
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SECRET

SECRET



INTRODUCTION

The instructions given in the following paragraphs refer to the complete overhauling of the engine on the bench, after removing the power unit from the vehicle.

The instructions are sub-divided as follows:

- **Engine dis-assembly:**
removing the engine accessories and components and dis-assembly into the main units forming it.
- **Cylinder head dis-assembly and overhauling:**
complete overhauling of all the components of the heads.
- **Crankcase overhauling:**
complete overhauling of the components of the cranking mechanisms.
- **Instructions for re-assembly:**
these comprise the specific re-assembly operations which differ substantially from the dis-assembly instructions.
- **Checking and inspecting the electric components of the lubricating circuit.**

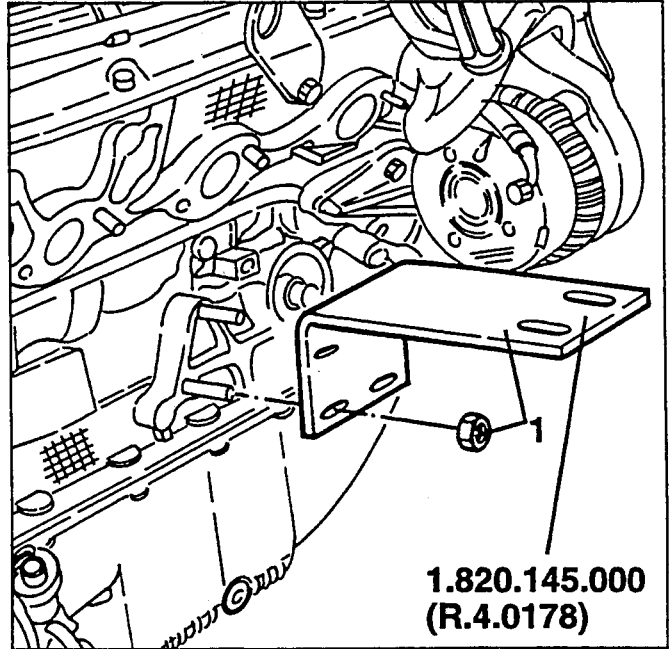
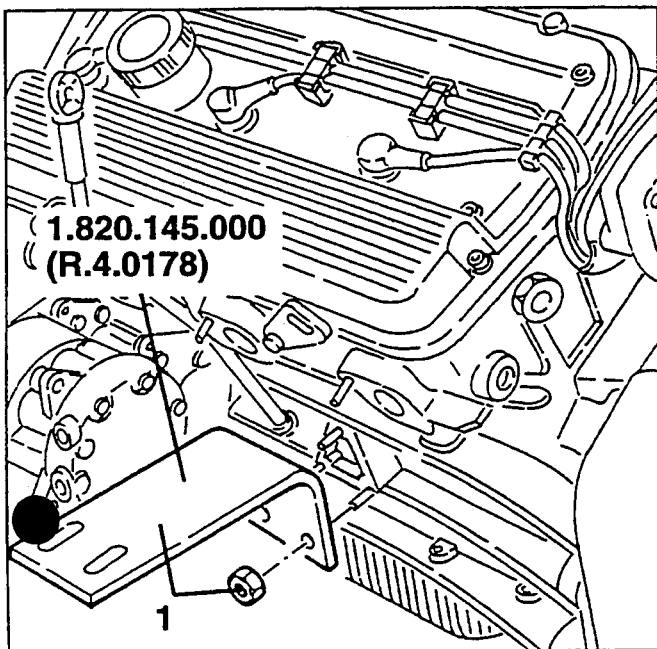
All the dis-assembly procedures described are valid in the reversed sequence for re-assembly, unless otherwise specified.

The following procedures refer to the complete overhauling of the whole engine, but it is possible to use them in part separately when required for specific components.

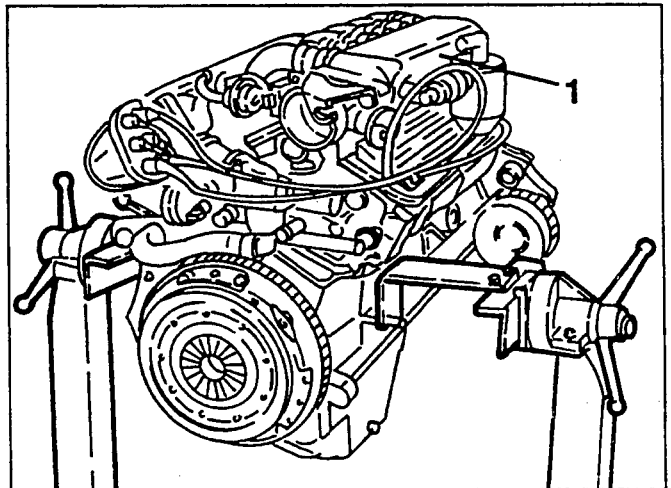
ENGINE DIS-ASSEMBLY

PRELIMINARY OPERATIONS

1. On the crankcase install the two brackets no. 1.820.145.000 (R.4.0178) for positioning the engine on the overhauling stand.

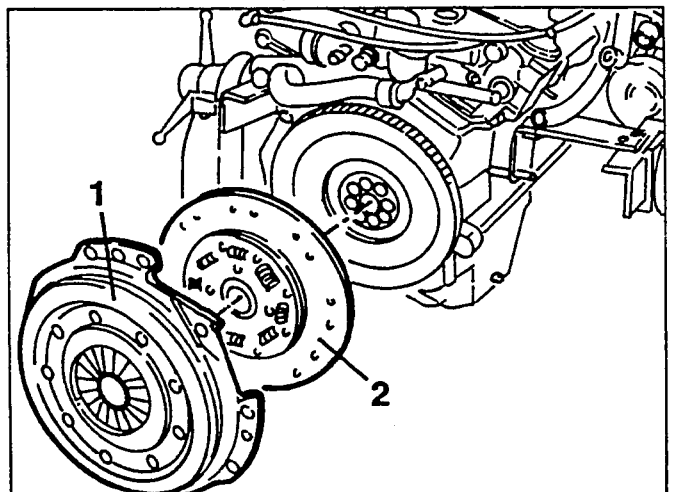


1. Raise the engine with the hydraulic lift and set it on the overhauling stand using support brackets no. 1.820.145.000 (R.4.0178).



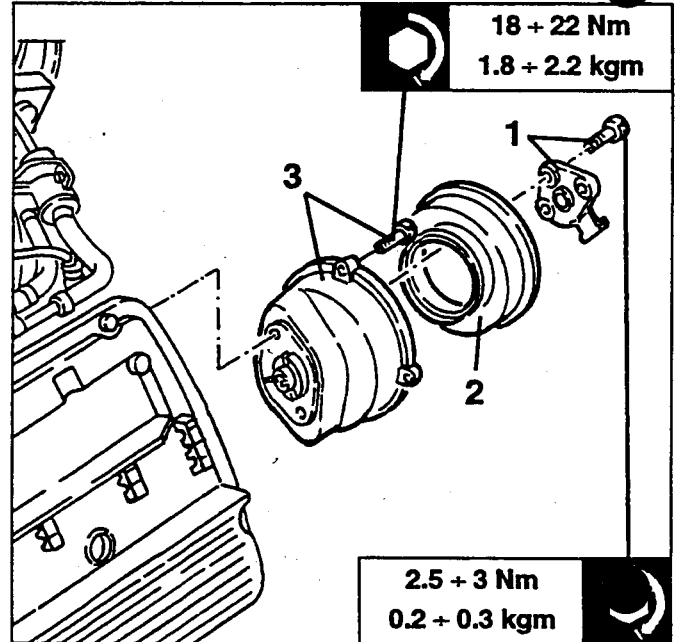
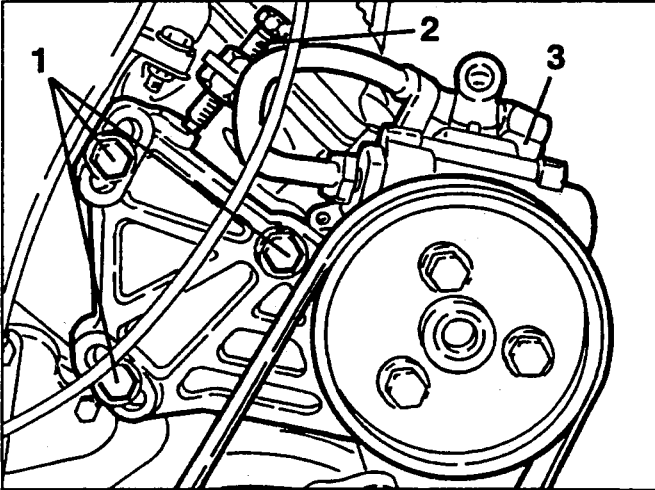
REMOVING THE CLUTCH PLATE

1. Slacken the fastening screws and remove the pressure plate body.
2. Remove the clutch plate.



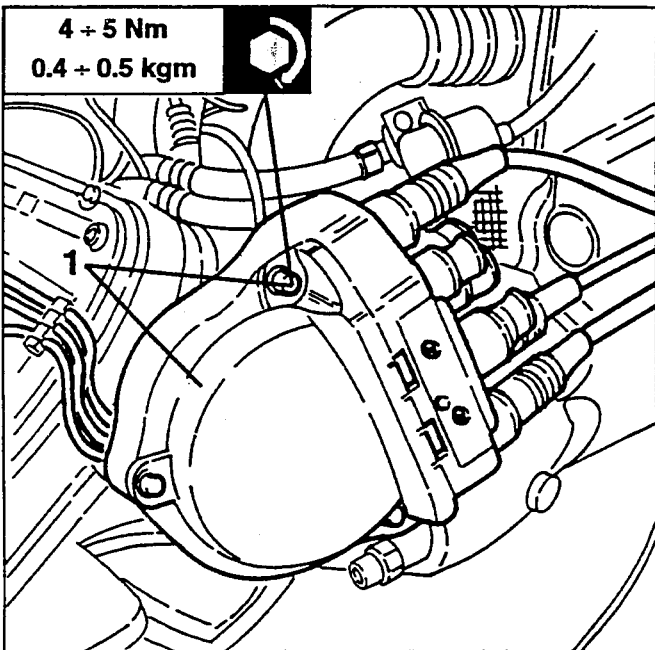
REMOVING THE POWER STEERING PUMP

1. Slacken the three screws fastening power steering pump support bracket.
2. Slacken the locknut, slacken the screw of the micrometric tensioner, then prise off the power steering pump drive belt.
3. Unscrew the three screws slackened previously and remove the power steering pump complete with support bracket.



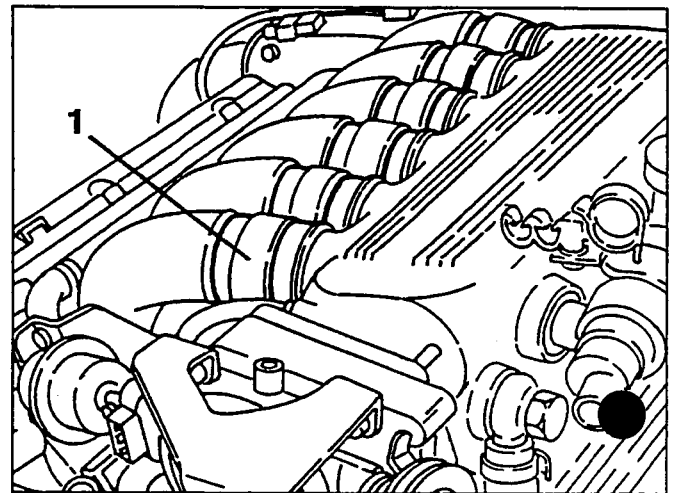
REMOVING THE AIR INTAKE BOX

1. Slacken the ignition distributor fastening screws then remove them complete with high voltage cables and 1st cylinder detection sensor.

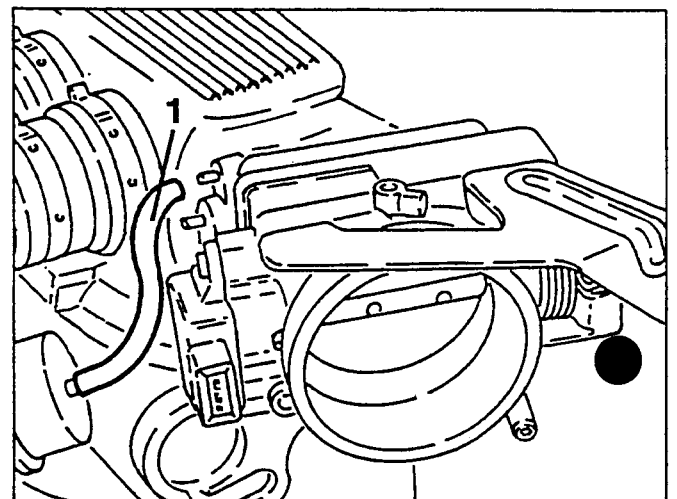


1. Slacken the three fastening screws and remove the rotary brush.
2. Retrieve the cover.
3. Slacken the two fastening nuts and remove the ignition distributor body.

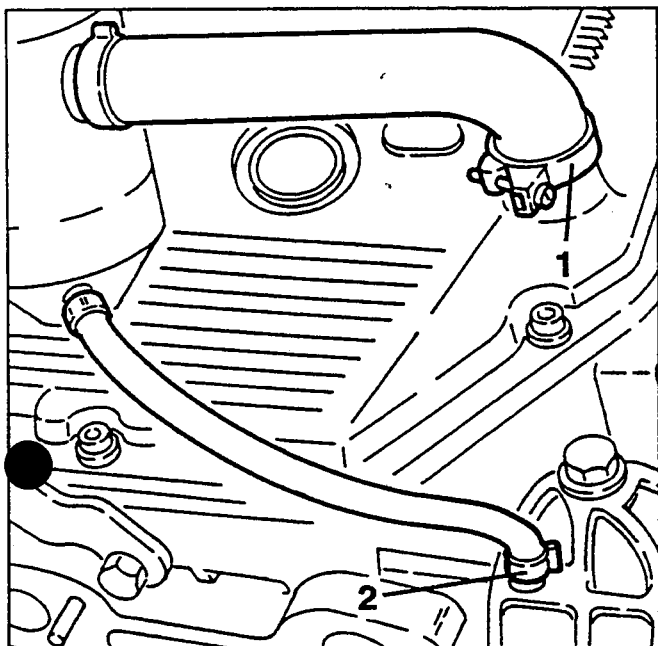
1. Slacken the fastening clamps of the air supply ducts to the intake box.



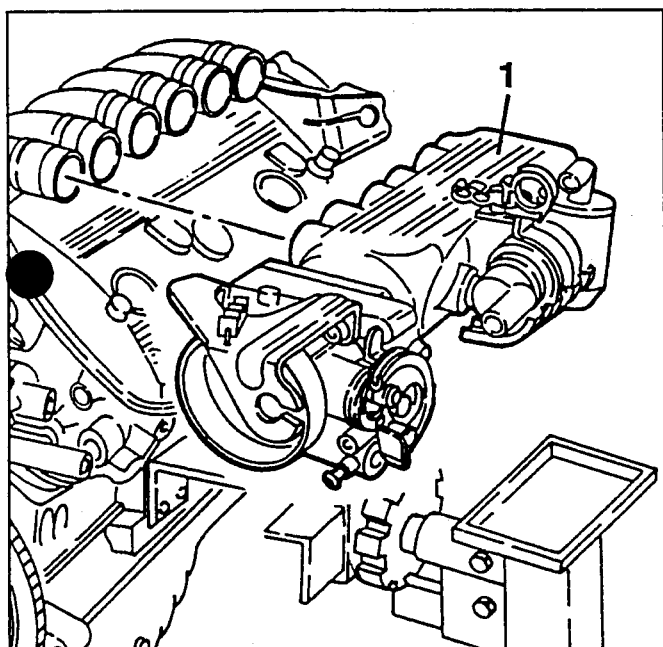
1. Disconnect the vacuum takeoff pipe for the fuel pressure regulator from the intake box.



1. Disconnect the oil vapour recovery pipe from the cylinder head.
2. Disconnect the condensed oil recovery pipe from the upper alternator support.



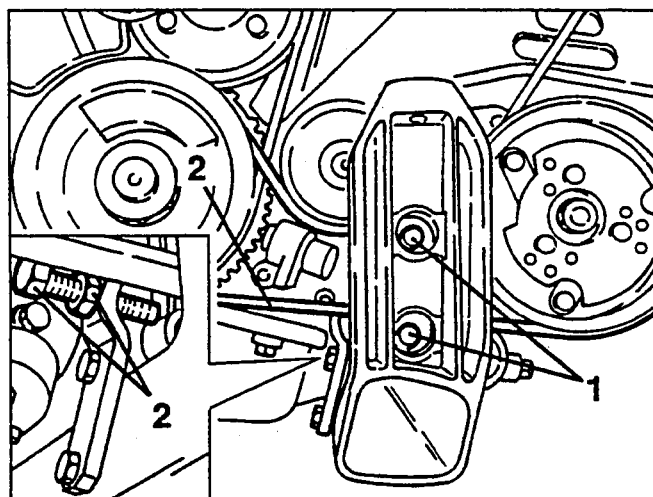
1. Remove the intake box complete with oil vapour separator, constant idle speed actuator and throttle body.



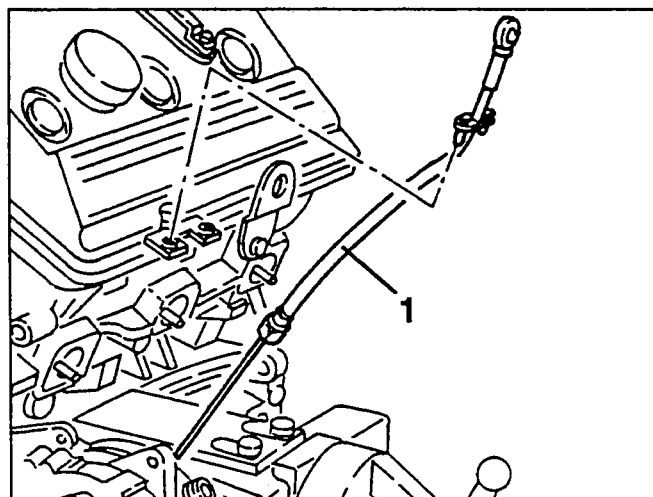
REMOVING THE CONDITIONER COMPRESSOR

1. Slacken the two screws fastening conditioner compressor belt tensioner.
2. Slacken the locknut, unscrew the screw of the micrometric tensioner, then prise and remove the conditioner compressor drive belt.

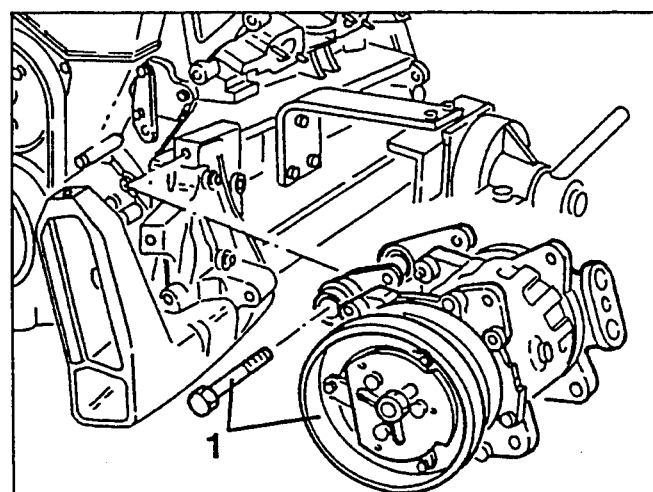
- Retrieve the power steering pump drive belt.
- Slacken the two fastening screws completely and remove the conditioner compressor belt tensioner guide.



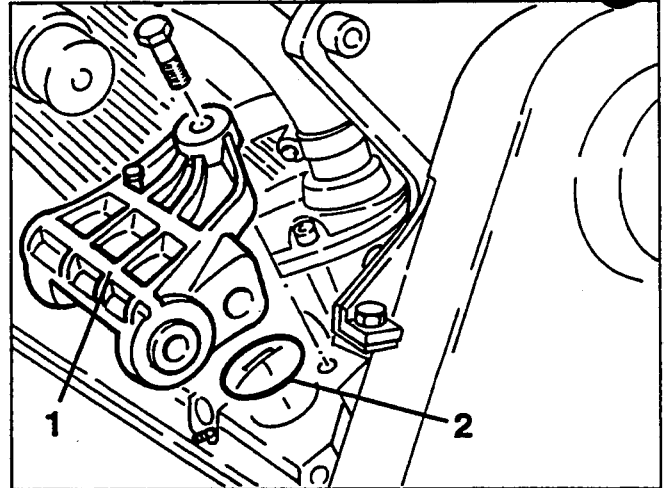
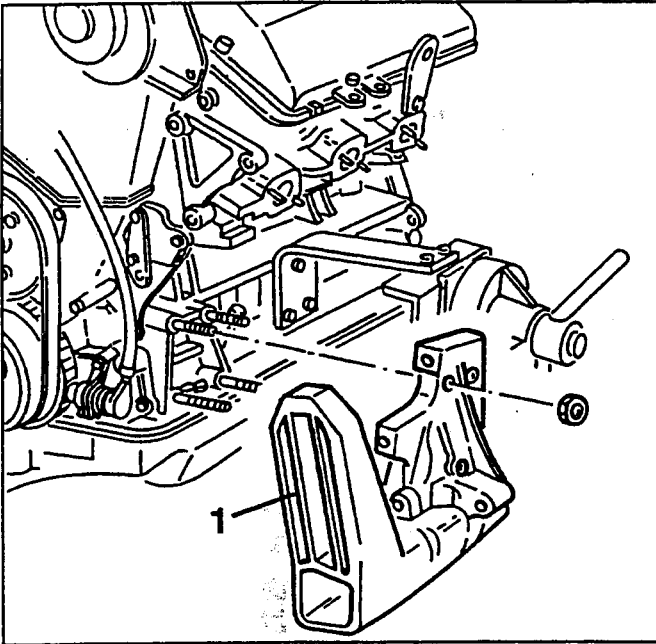
1. Remove the the engine oil dipstick complete with guide.



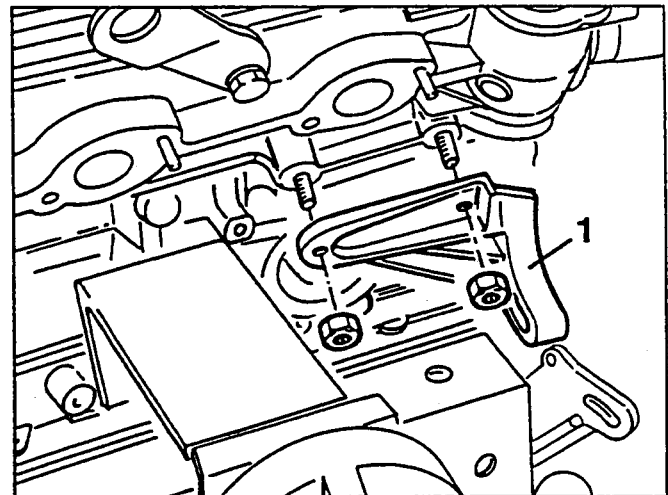
1. Slacken the fastening bolts and remove the conditioner compressor complete with support brackets.



1. Slacken the fastening nuts and remove the front engine support.

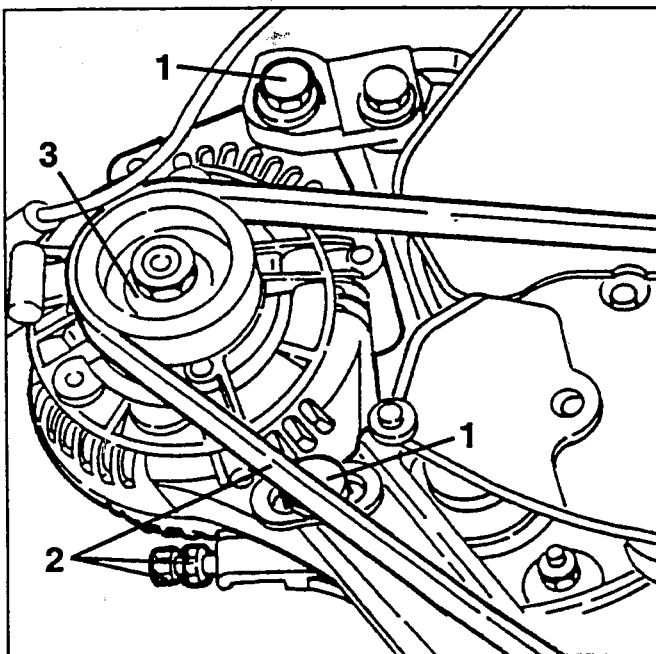


1. Slacken the fastening nuts and remove the lower rear alternator support bracket.



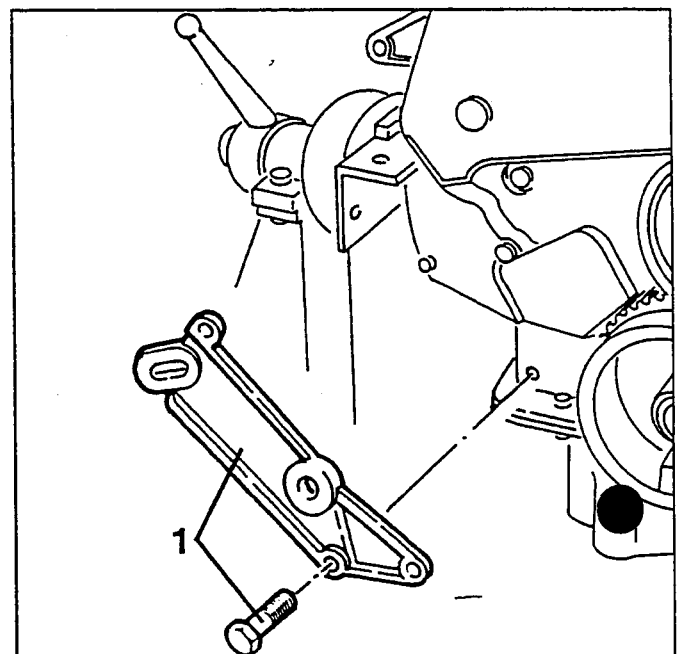
REMOVING THE ALTERNATOR

1. Slacken the two bolts fastening the alternator to the support brackets.
2. Slacken the locknut, slacken the screw of the micrometric tensioner, then prise and remove the alternator - water pump drive belt.
3. Completely unscrew the two bolts slackened previously and remove the alternator.

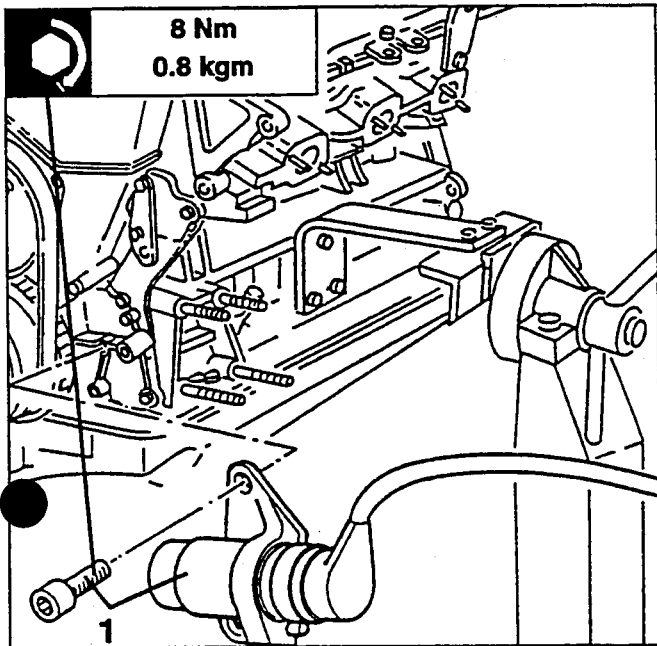


1. Remove the upper alternator support bracket.
2. Remove the O-Ring.

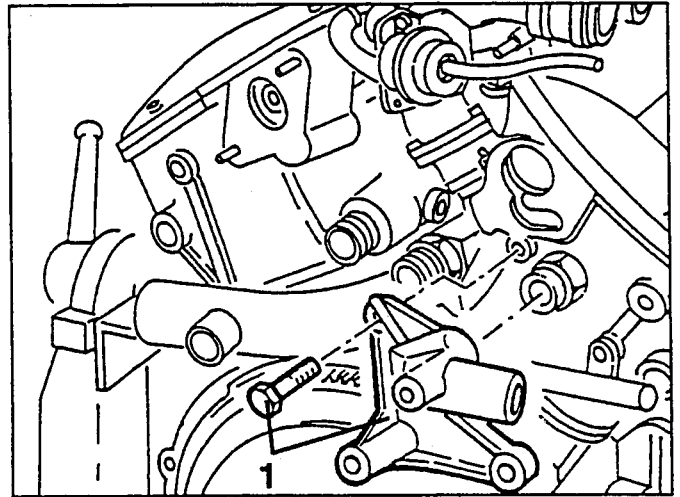
1. Slacken the fastening screws and remove the lower front alternator support bracket.



1. Slacken the fastening screws and remove the rpm and timing sensor complete with support bracket.

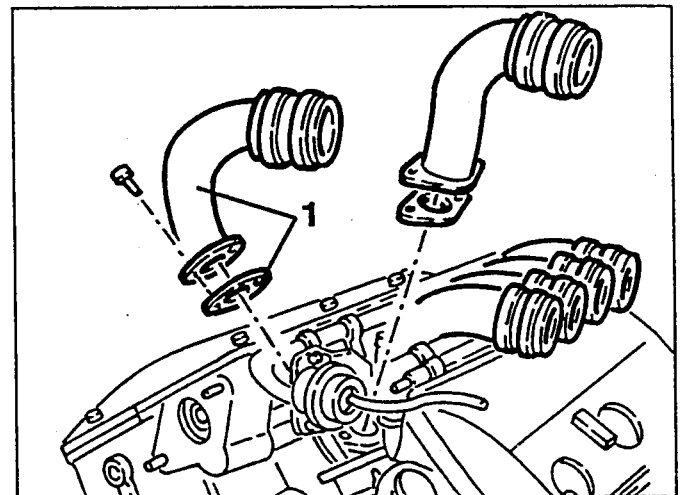


1. Slacken the fastening screws and remove the union for coolant delivery to the throttle body and to the heater of the climate control system.



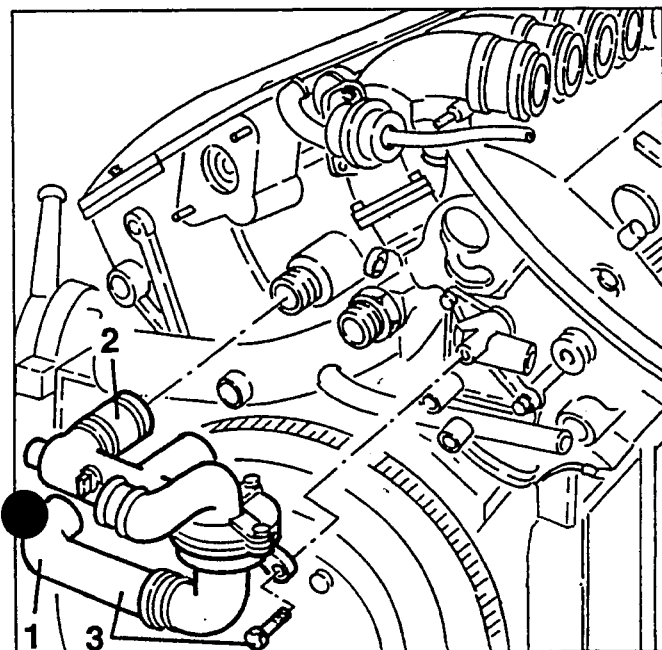
REMOVING THE FUEL DISTRIBUTOR MANIFOLD

1. Slacken the fastening screws and remove the air intake ducts complete with seals.

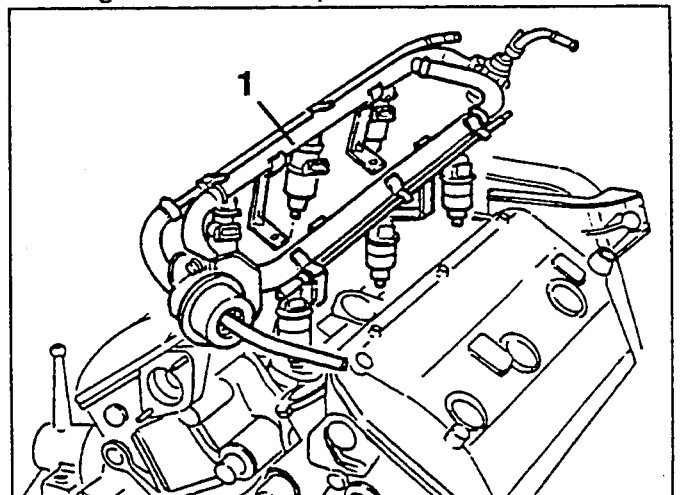


REMOVING THE THERMOSTAT UNIT

1. Disconnect the thermostatic cup fluid outlet sleeve from the coolant return manifold to the pump.
2. Slacken the clamp fastening the left-hand cylinder head coupling sleeve to the thermostat unit.
3. Slacken the two fastening screws and remove the complete thermostat unit.

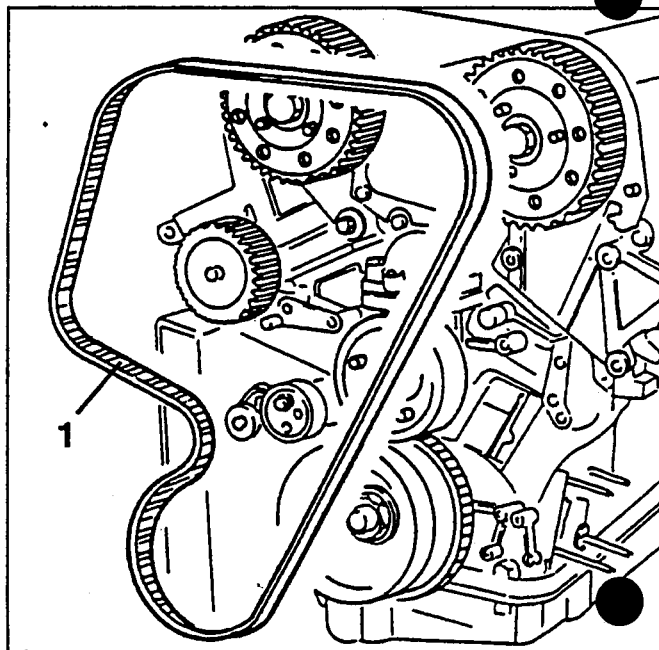
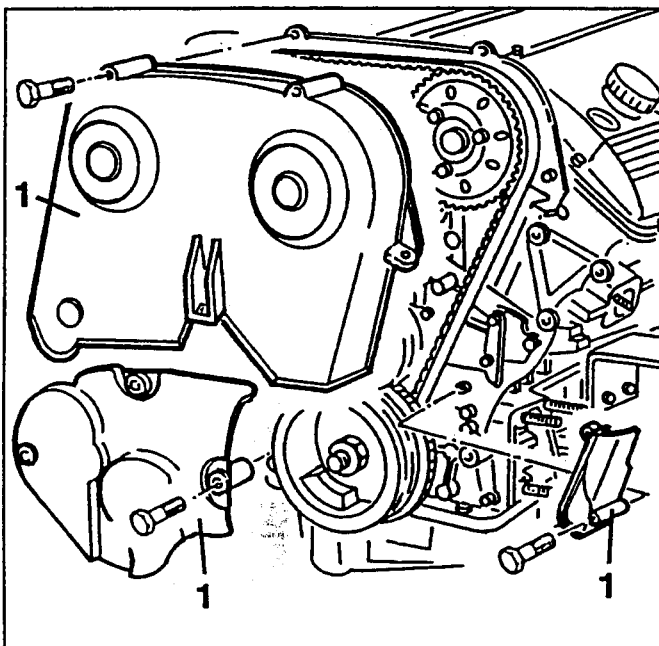


1. Slacken the fastening screws and remove the fuel distributor manifold complete with injectors, fuel pressure regulator and dash pot.



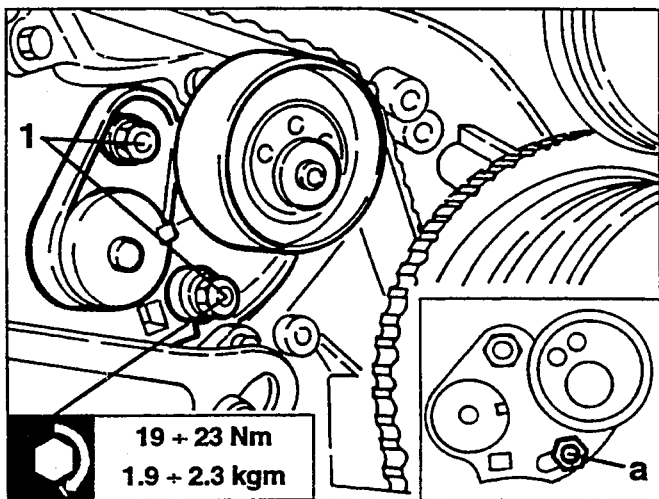
REMOVING THE VALVE GEAR TIMING BELT

1. Slacken the fastening screws and remove the front timing belt covers.



- Completely back off the two nuts fastening the timing belt tensioner and remove it.

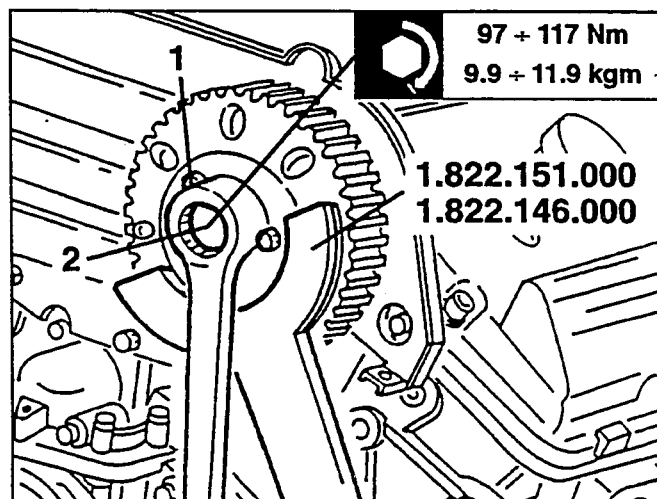
1. Slacken the two nuts fastening the timing belt tensioner and position it so that stud "a" is as illustrated, then completely tighten the two fastening nuts, locking them lightly.



1. Remove the valve gear timing belt prising it off the toothed camshaft drive pulleys and withdrawing it from the drive pulley.

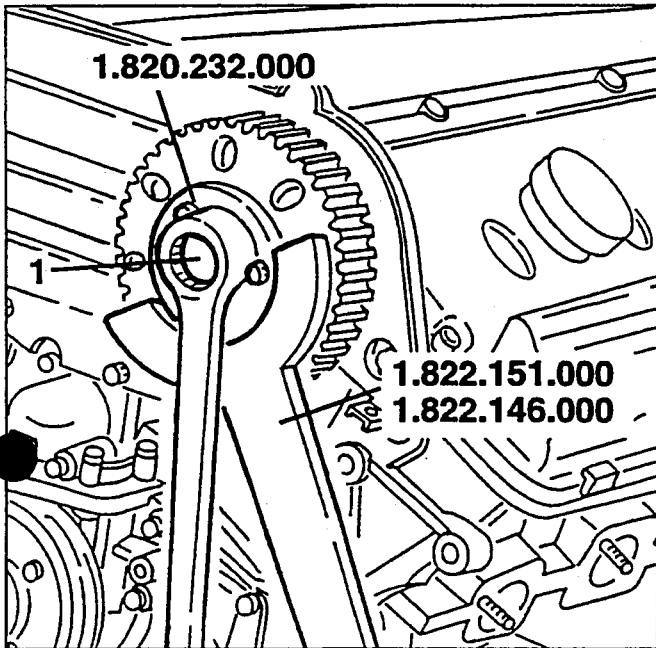
REMOVING THE TIMING GEAR PULLEYS

1. Slacken the screws fastening the timing gear pulley to the support hub.
2. Using tools no. 1.822.151.000 and no. 1.822.146.000 completely back off the hub fastening nut.

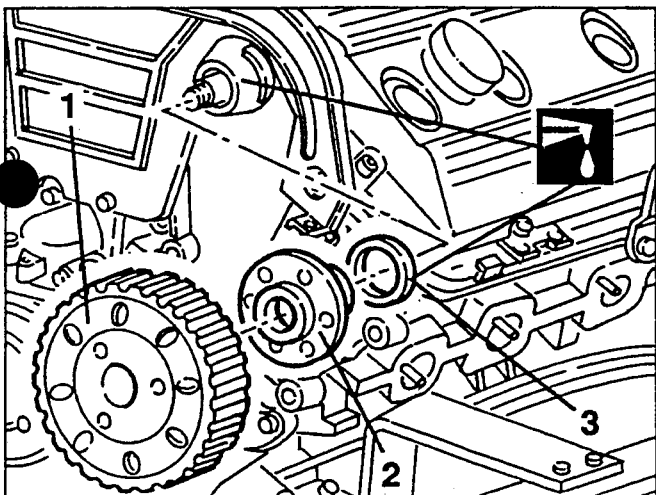


- Completely unscrew the screws slackened previously, fastening the timing gear pulley to the support hub.

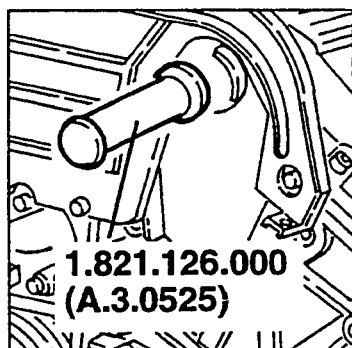
1. Install tool no. 1.820.232.000 on the timing gear pulley and tighten the nut of the tool itself levering with tools no. 1.822.151.000 and no. 1.822.146.000.



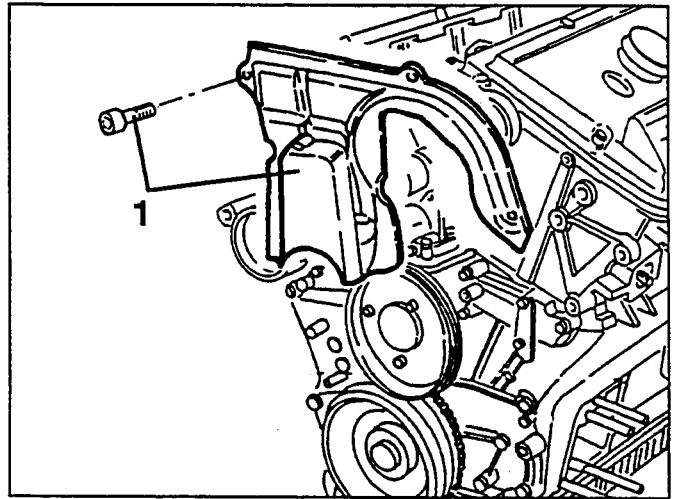
1. Remove the tools installed previously, then withdraw the timing gear pulley.
2. Withdraw the support hub.
3. Prise and remove the oil ring.



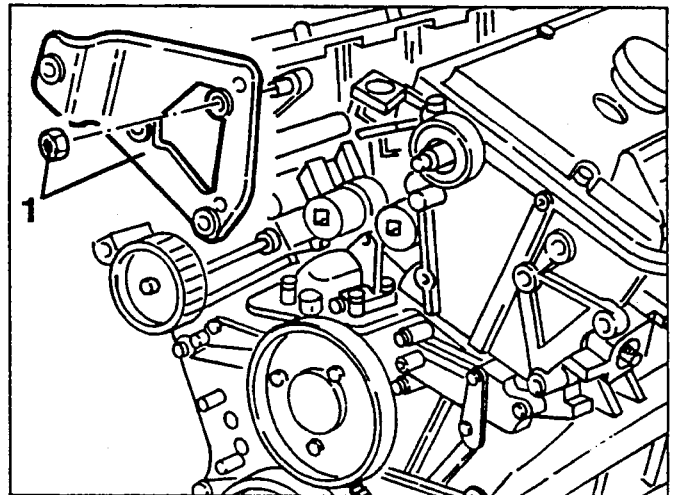
When refitting insert a new front camshaft oil ring using tool no. 1.821.126.000 (A.3.0525).



- Proceed in the same manner for removing the timing gear pulley of the right-hand cylinder head
1. Slacken the fastening screws and remove the timing gear belt rear cover.

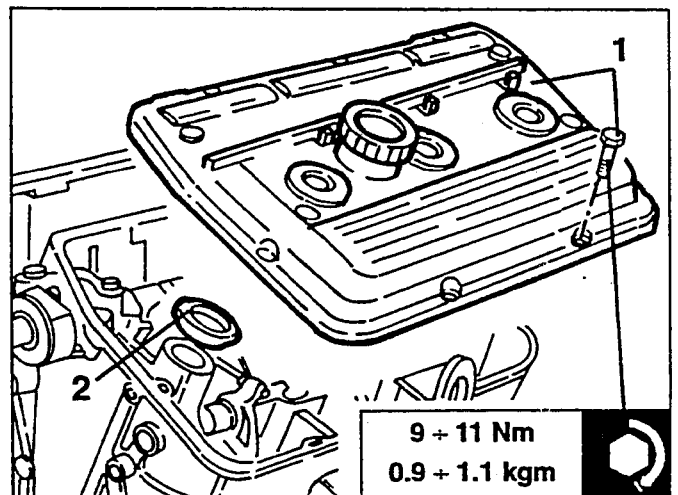


1. Slacken the fastening nuts and remove the engine stay rod connection bracket from the right-hand cylinder head.



REMOVING THE CYLINDER HEADS

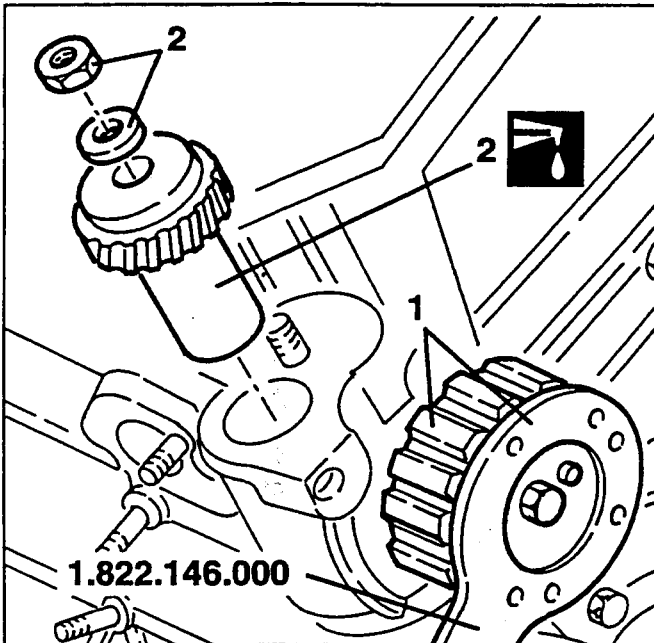
1. Slacken the fastening screws and remove the cylinder head covers.
2. Remove the seals from the spark plug wells.



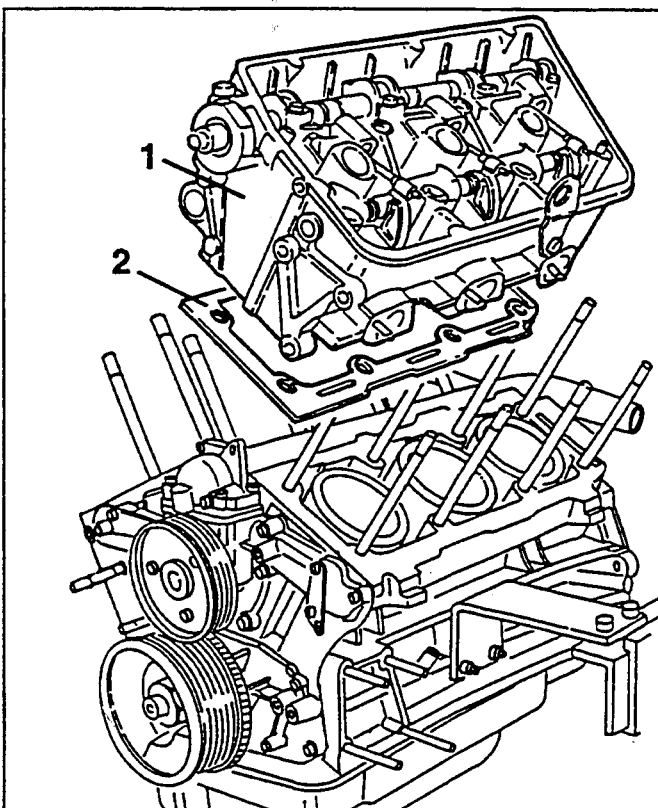
9 + 11 Nm
0.9 + 1.1 kgm

Proceed as follows, for the right-hand cylinder head only:

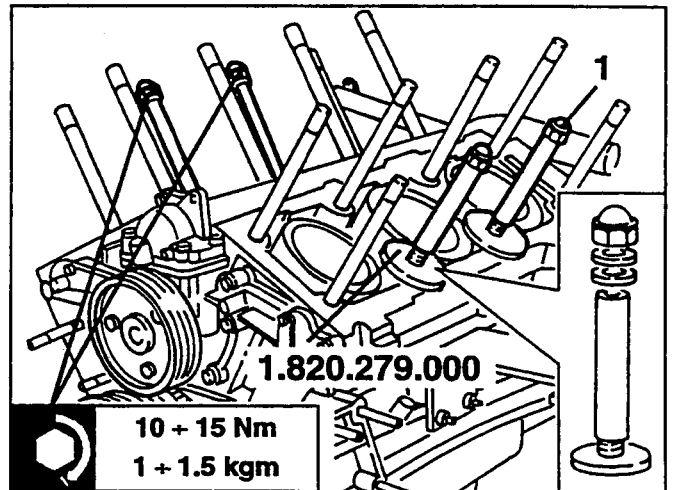
1. Using tool no. 1.822.146.000 prevent the engine oil pump drive pulley from turning.
2. Slacken the fastening nut and withdraw the oil pump intermediate driving gear from its housing.



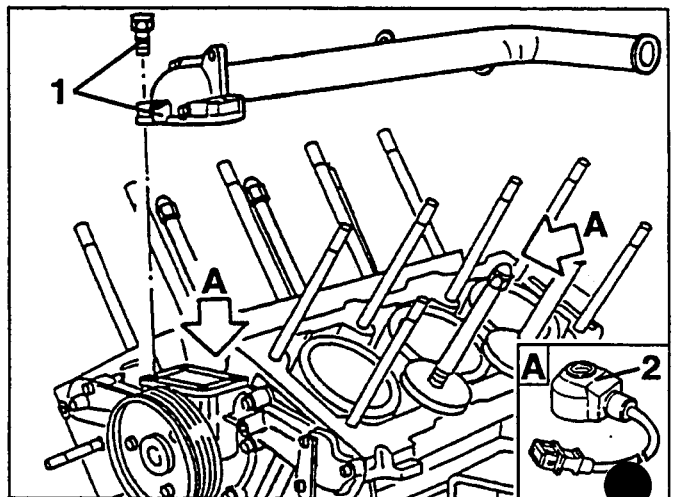
- Slacken the and remove the spark plugs.
1. Slacken the fastening nuts and remove the cylinder heads from the crankcase.
 2. Remove the seals.



1. Install the cylinder liner stopper tools no. 1.820.279.000.

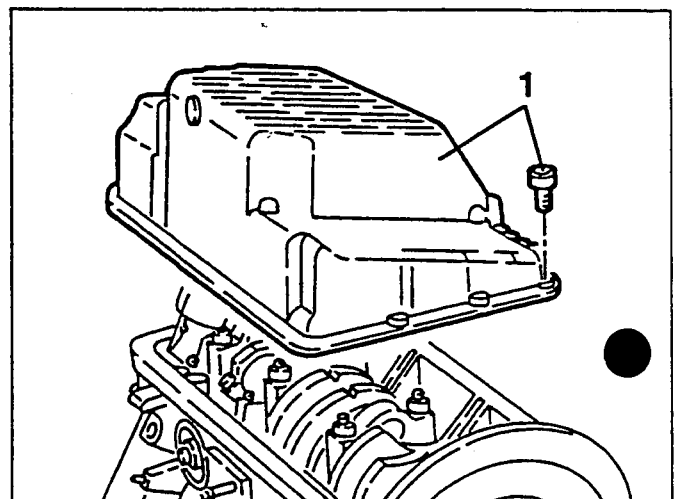


1. Slacken the fastening screws and remove the coolant return to the pump manifold.
2. Slacken the screws and remove the pinging sensors.

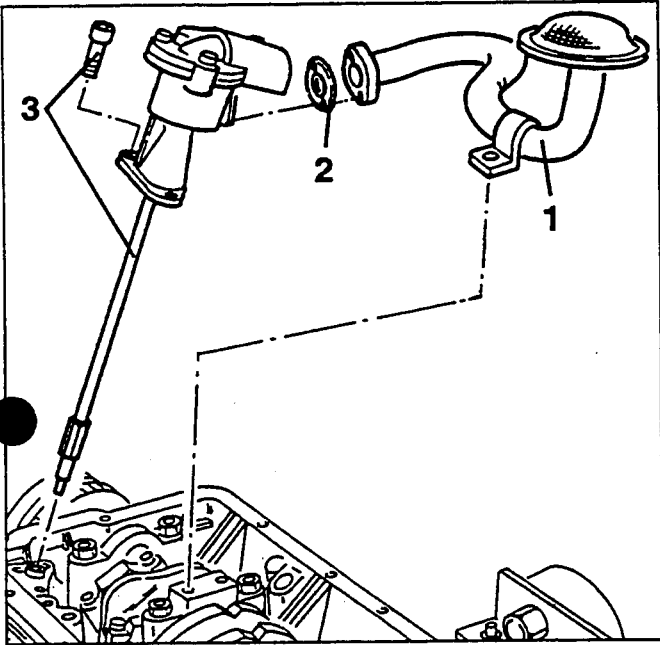


REMOVING THE OIL PUMP

- Turn the engine on the rotary overhauling stand.
1. Slacken the fastening screws and remove the oil sump.

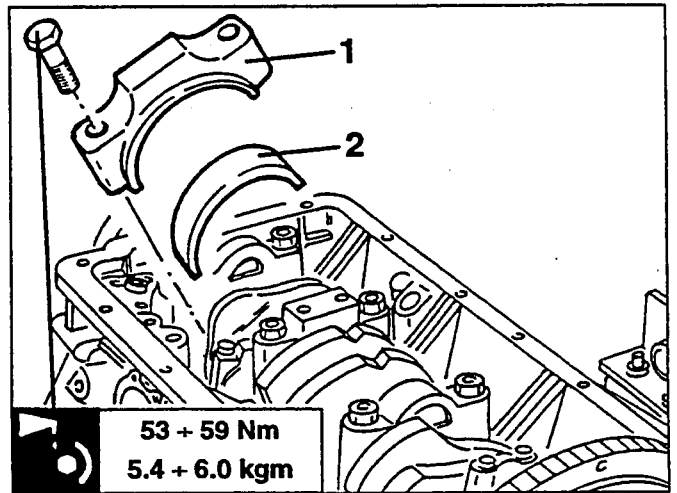


1. Slacken the fastening screws and remove the oil pump suction device.
2. Remove the seal.
3. Slacken the fastening screws and remove the oil pump complete.



REMOVING THE CYLINDER LINERS AND PISTONS

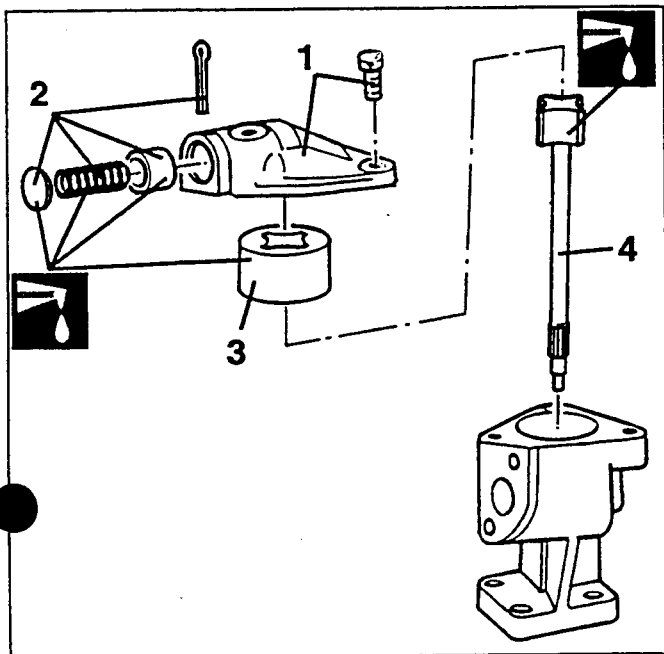
- Install a suitable tool to enable the rotation of the crankshaft.
 - Turn the crankshaft to gain access to the fastening screws from the connecting rod caps of the right main bearing (1st, 2nd and 3rd cylinder).
1. Slacken the fastening screws and remove the connecting rod caps of the 1st, 2nd and 3rd cylinder.
 2. Retrieve the corresponding connecting rod half bearings.



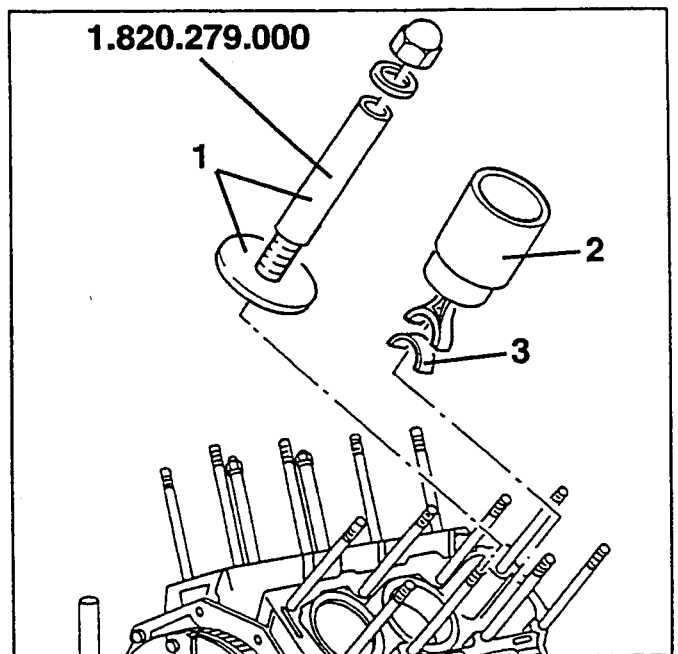
DIS-ASSEMBLING THE OIL PUMP

1. Slacken the fastening screws and remove the oil pump cover.
2. Remove the split pin and from the cover withdraw the plug, spring and engine oil pressure limiting valve.
3. Withdraw the driven rotor from the pump casing.
4. Withdraw the the shaft with driving rotor from the pump casing.

NOTE: The driving rotor must never be removed from the shaft.



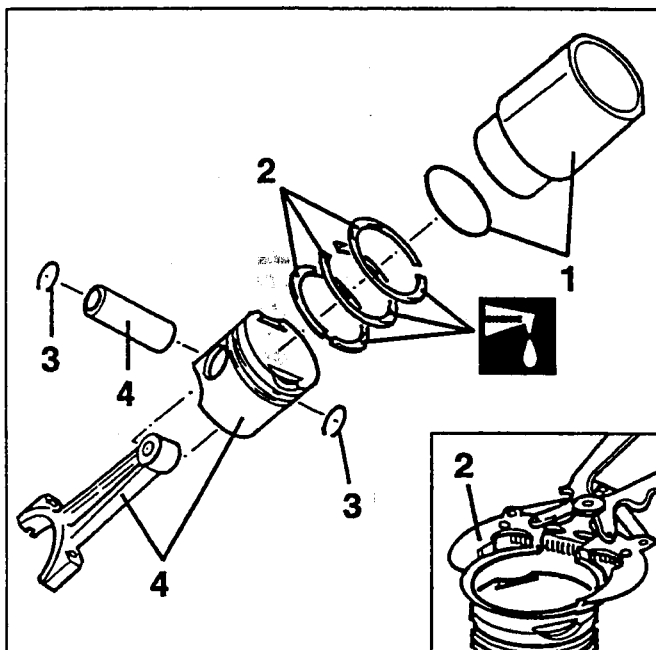
- Turn the engine on the rotary overhauling stand.
1. Slacken the fastening nuts and remove the cylinder liner stopper tools no. 1.820.279.000 only from the right-hand main bearing,
 2. From the crankcase withdraw the connecting rod-piston assemblies withdrawing them together with their cylinder liners.
 3. Retrieve the corresponding connecting rod half bearings.
- Turn the crankcase on the rotary overhauling stand and proceed as for the left-hand main bearing (4th, 5th and 6th cylinder).



1. Withdraw the cylinder liner complete with O-ring.
2. Using a suitable tool, remove the seal rings and oil scraper ring from the piston.

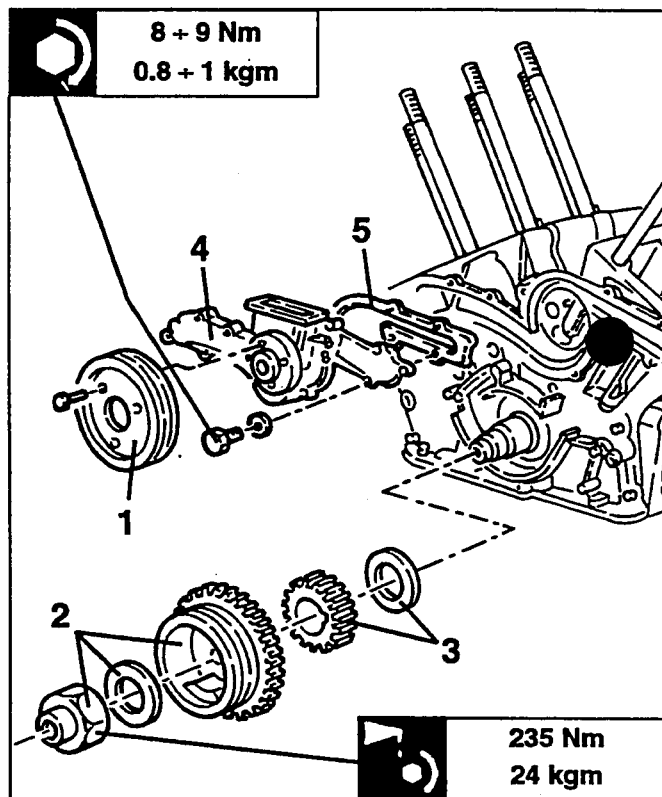
WARNING: Proceed with care to avoid breaking any re-usable rings.

3. Withdraw the two gudgeon pin seal rings.
4. Withdraw the gudgeon pin and separate the piston from the connecting rod.



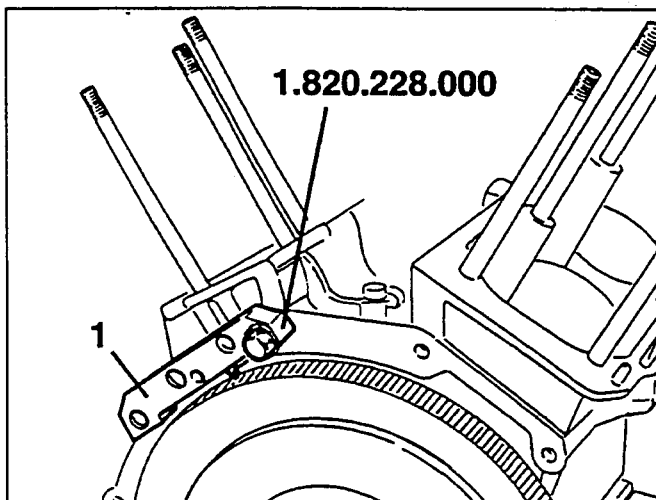
NOTE: When refitting the convex surface of the thrust ring must face the front crankcase cover.

4. Slacken the fastening screws and remove the water pump.
5. Remove the corresponding seal.



REMOVING THE WATER PUMP

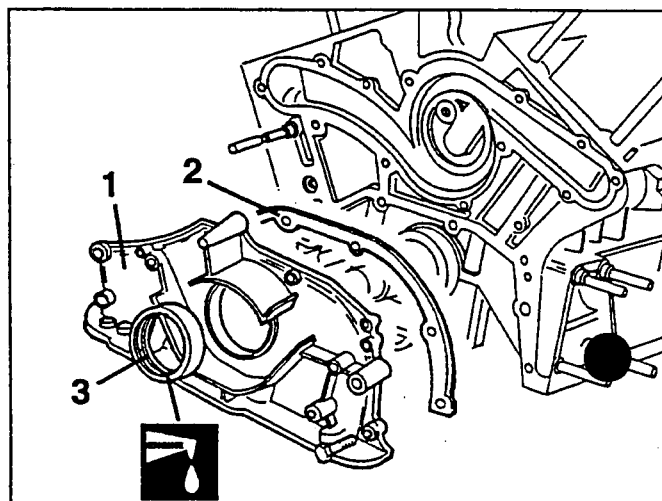
1. Remove the crankshaft turning tool and install the flywheel stopper tool no. 1.820.228.000.



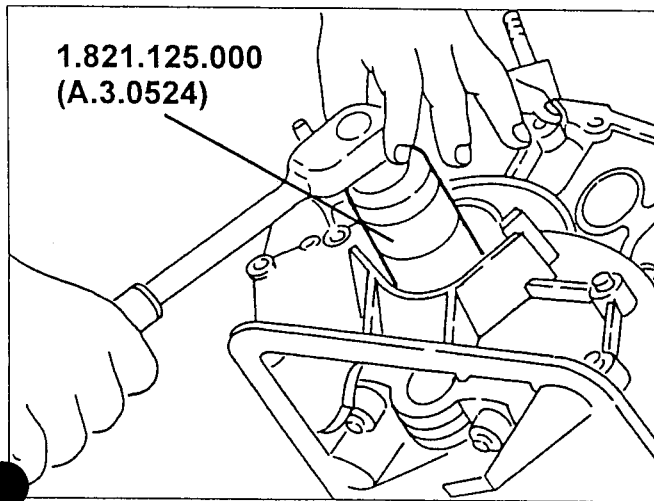
1. Slacken the fastening screws and remove the water pump pulley.
2. Slacken the fastening nut and remove the auxiliary components drive pulley.
3. Remove the toothed timing belt drive pulley complete with thrust ring.

REMOVING THE CRANKCASE FRONT COVER

1. Slacken the fastening screws and remove the crankcase front cover.
2. Remove the corresponding seal.
3. Remove the oil ring from the crankcase front cover.

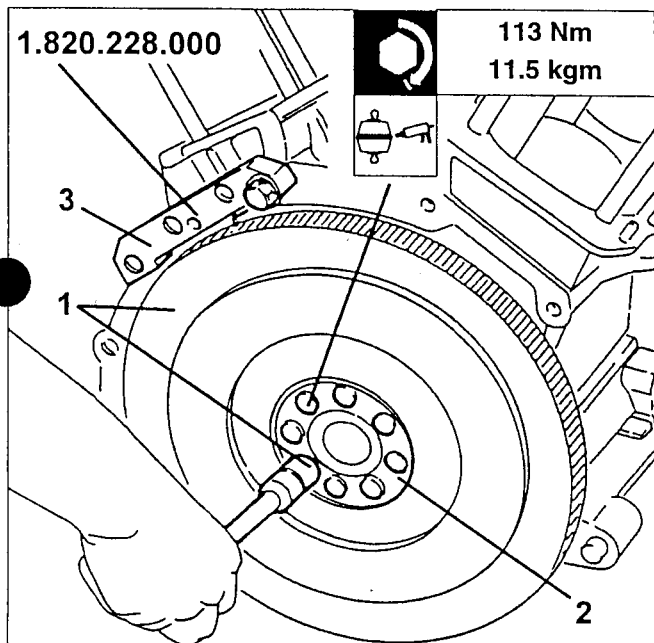


When refitting, introduce a new front crankshaft oil seal on the crankcase with tool no. 1.821.125.000 (A.3.0524).



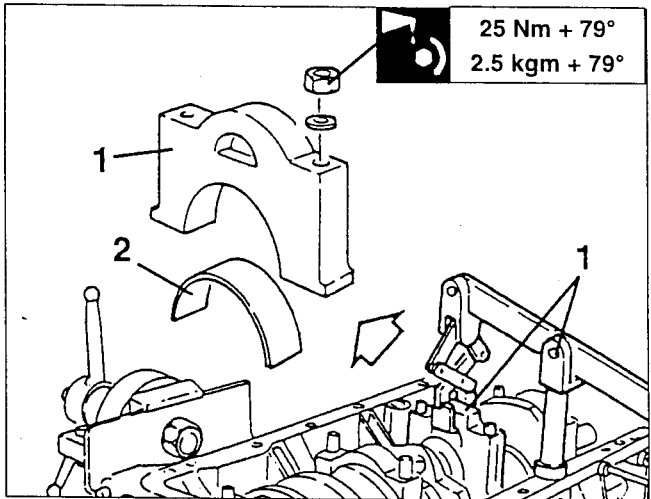
FLYWHEEL REMOVAL

1. Loosen the fastening screws and remove the flywheel.
2. Take the safety washer.
3. Remove the previously fitted flywheel retainer no. 1.820.228.000.

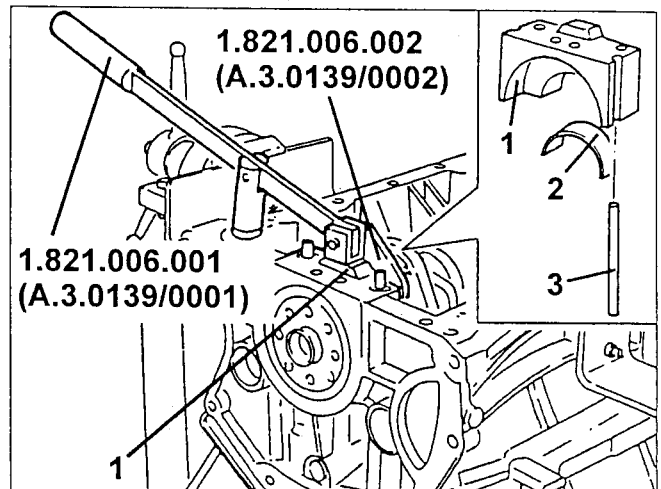


CRANKSHAFT REMOVAL

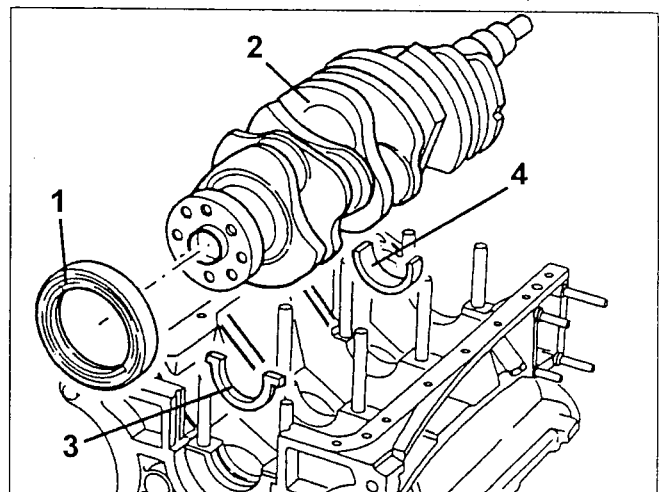
- Turn the engine on the tuning overhaul stand.
1. Loosen the lock nuts and the main bearing fastening nuts. Then use a suitable tool to remove the front and central main bearings.
 2. Remove the respective main half bearings.



1. Remove the rear main bearing with lever no. 1.821.008.001 (A.3.0139/0001) and fork no. 1.821.008.002 (A.3.0139/0002).
2. Remove the respective main half bearing.
3. Remove the seals.



1. Remove the rear crankshaft ring.
2. Remove the crankshaft.
3. Remove the thrust half bearings.
4. Remove the half bearings from the main journals.

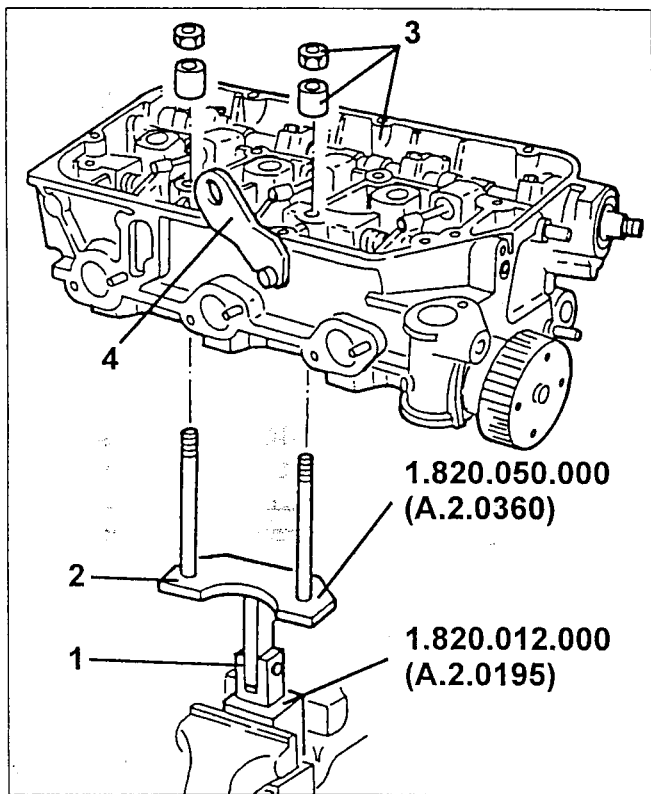


CYLINDER HEAD REMOVAL

NOTE: The following operations refer to the right-hand cylinder head. Proceed in the same way from the left-hand cylinder head.

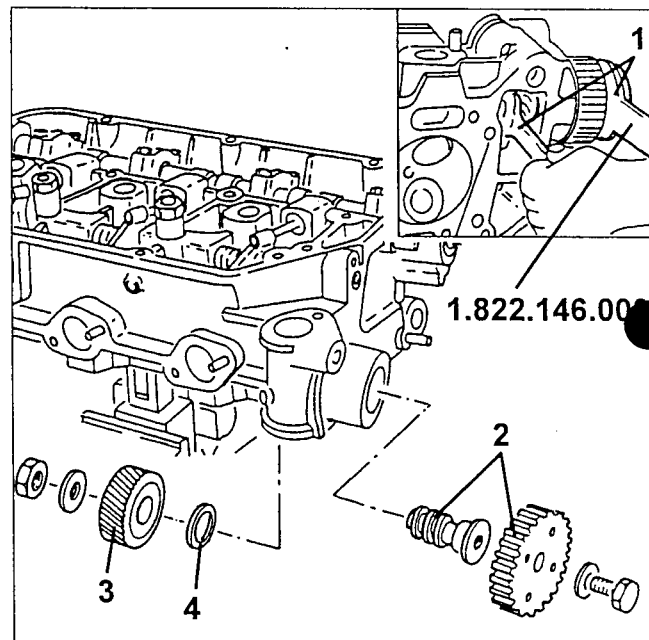
PRELIMINARY OPERATIONS

1. Fasten adjustable support no. 1.820.012.000 (A.2.0195) in a vice.
2. Fit fork no. 1.820.050.000 (A.2.0360) on the adjustable support.
3. Fit the cylinder head on the fork studs and lock it with two suitable shims and two nuts.
4. Loosen the fastening screw and remove the engine lifting rod.

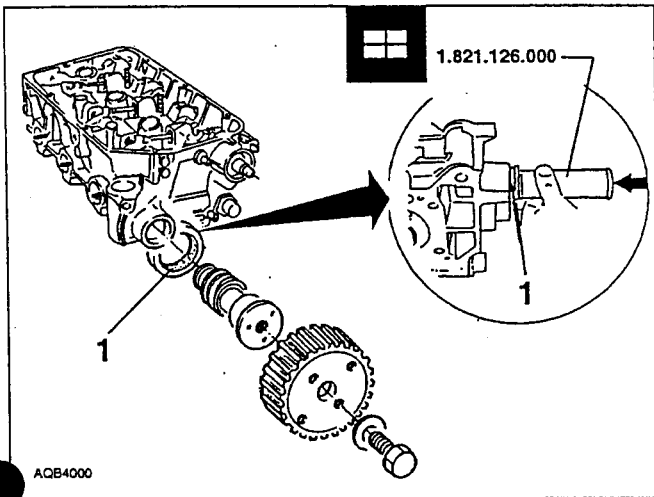


OIL PUMP PULLEY REMOVAL (Specific for right-hand cylinder head)

1. Use tool no. 1.822.148.000 to loosen the oil pump pulley fastening bolt.
2. Loosen the oil pump pulley and respective shaft.
2. Take the gear wheel.
4. Take the shim.



1. Remove the seal ring
(On assembling make use of inserter 1.821.126.000)



TIMING CAMSHAFT AND ROCKER ARM SUPPORTING SHAFT REMOVAL

1. Remove the timing camshaft caps

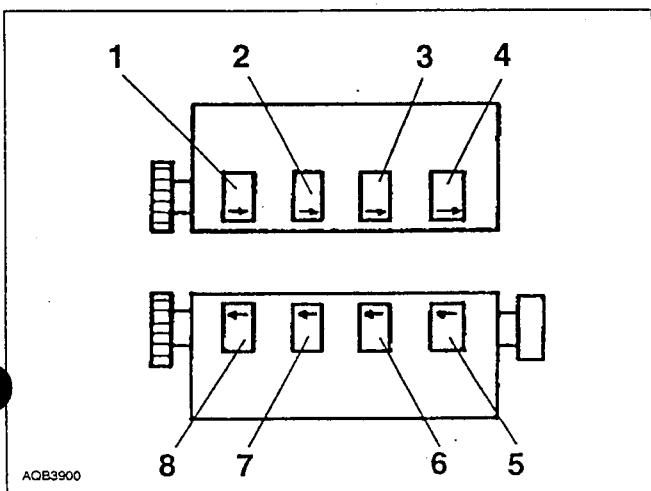


Caps are serially numbered (1, 2, 3 and 4 for the right cylinder head; 5, 6, 7 and 8 for the left cylinder head).
Observe the same order when assembling

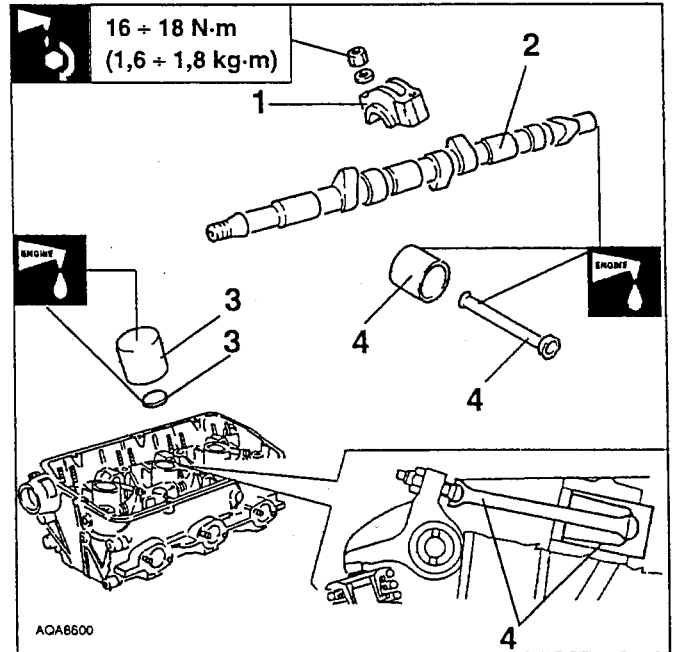
2. Remove the timing camshaft

NOTE: In case the camshaft had not been removed, remove the distributor to be able to proceed to the removal

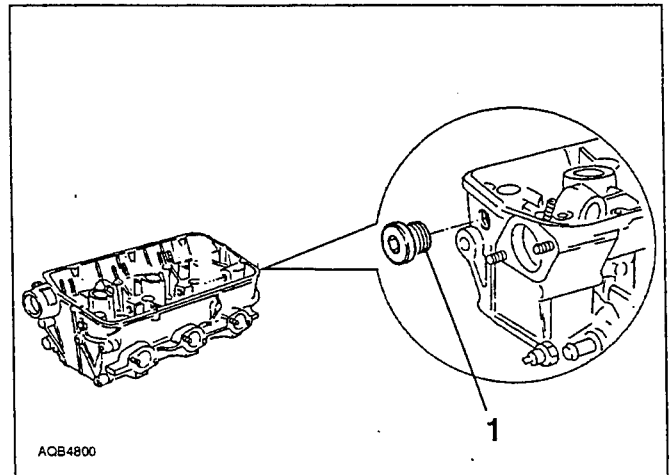
3. Withdraw the intake-side tappets with the relevant valve adjusting caps
4. Withdraw the exhaust-side tappets with the relevant rocker arm control rods



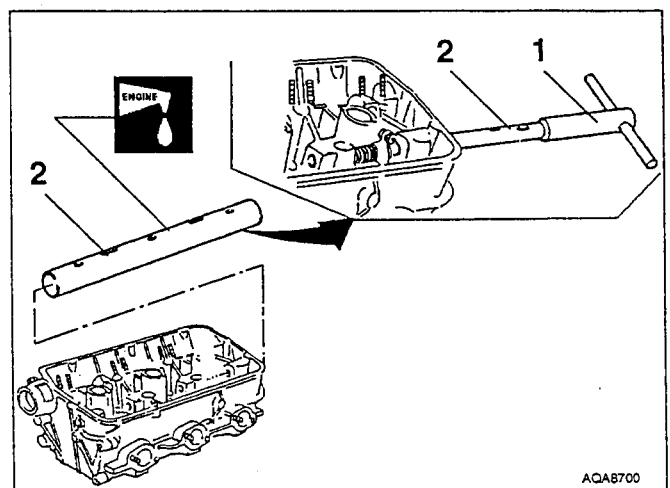
NOTE: Set the components in order, should they be re-used on assembly



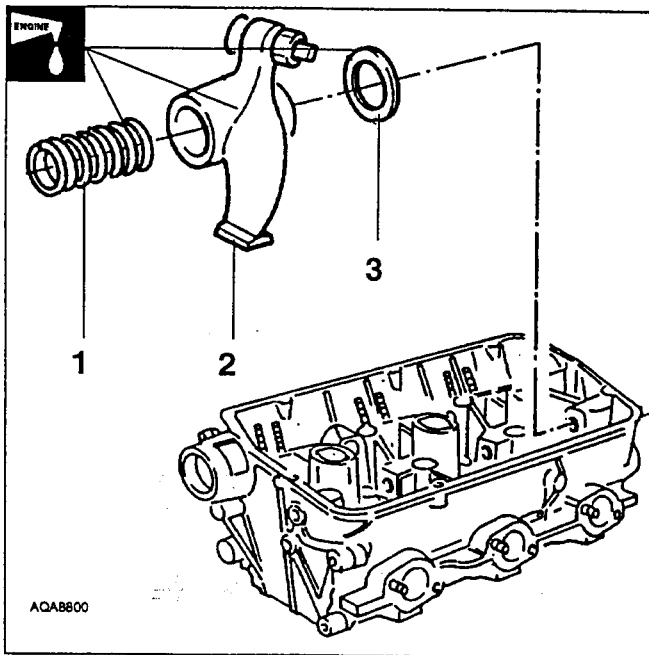
1. Remove the plug



1. Screw down a suitable tool on the threaded ending of the rocker arm supporting shaft
2. Gradually withdraw the rocker arm shaft

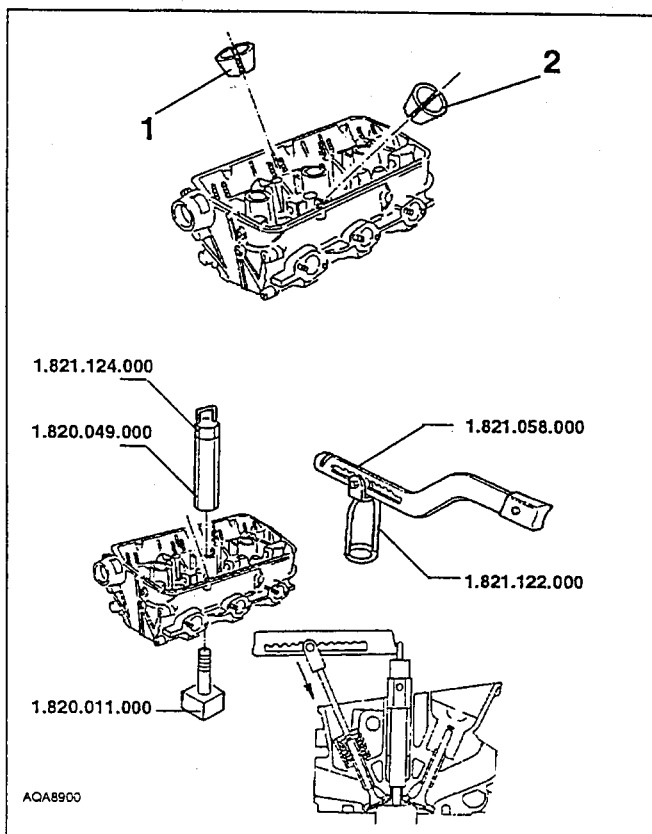


1. Remove the springs
2. Remove the rocker arms
3. Remove the washers

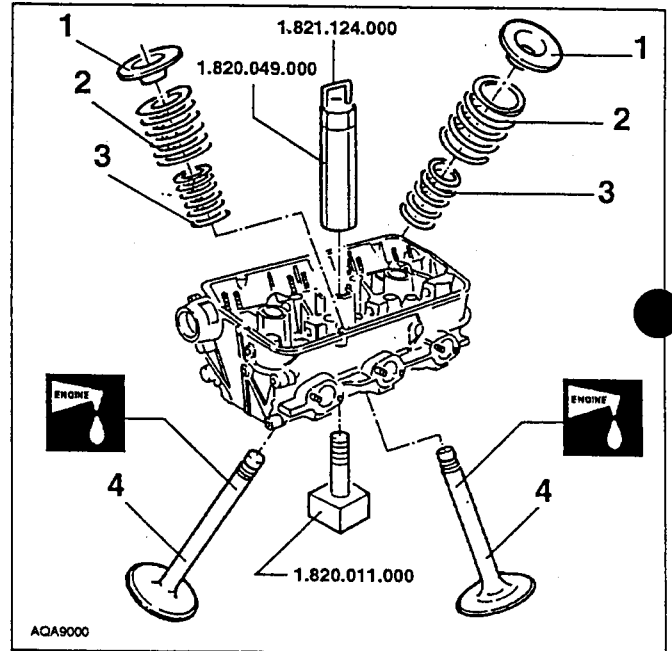


VALVE DISASSEMBLY

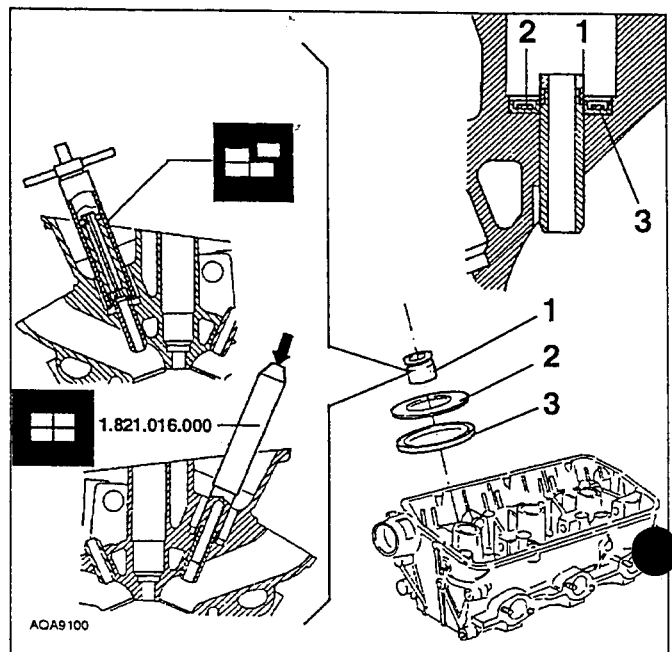
- Operate on one cylinder
1. By means of the equipment shown in the figure, remove the exhaust-side cotters
 2. Remove the intake-side cotters by acting in the same way



1. Remove the upper caps
2. Remove the outer springs
3. Remove the inner springs
— Remove tools 1.820.049.000 by means of 1.821.124.000 and 1.820.011.000
4. Withdraw the valve pair (intake and exhaust)
— By using the same tools and carrying out the same procedure, act on the other cylinders

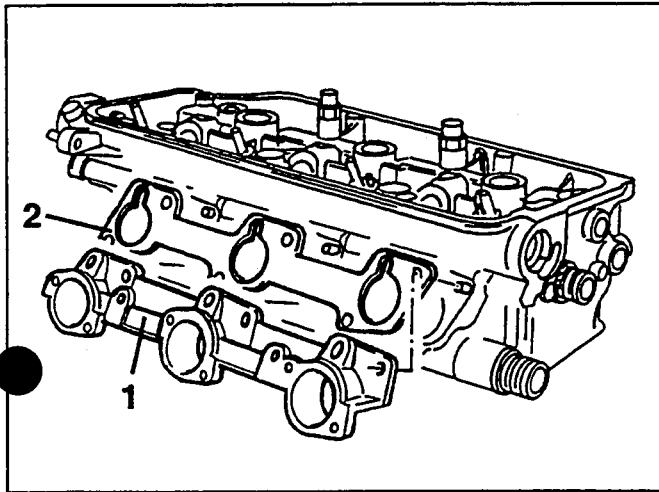


1. By means of extractor 1.821.018.000, remove the grommets
(On assembling, make use of inserter 1.821.016.000)
2. Remove the stop rings
3. Remove the lower caps



REMOVING THE AIR INTAKE MANIFOLD

1. Slacken the fastening screws and remove the air intake manifold.
2. Remove the corresponding seal.

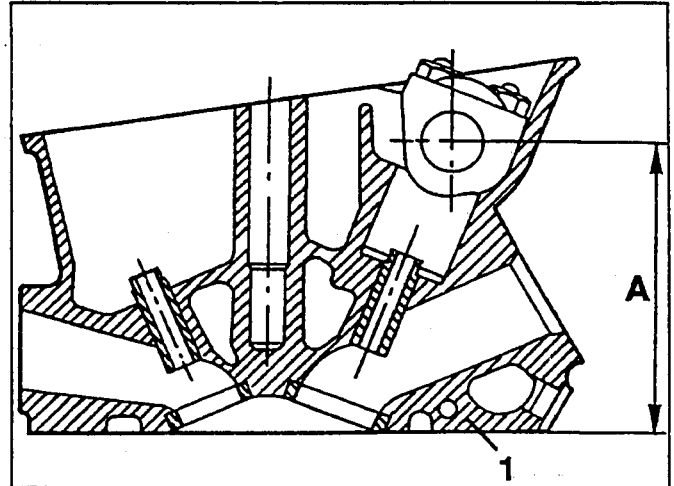


1. After refacing check that the height of the heads is within the minimum permissible limit.



Do not exceed the minimum permissible limit as serious engine failure may result.

- Check that the lower head surface is well finished.



Max. permissible height of heads after refacing

$$A = 124.85 + 125.15 \text{ mm}$$

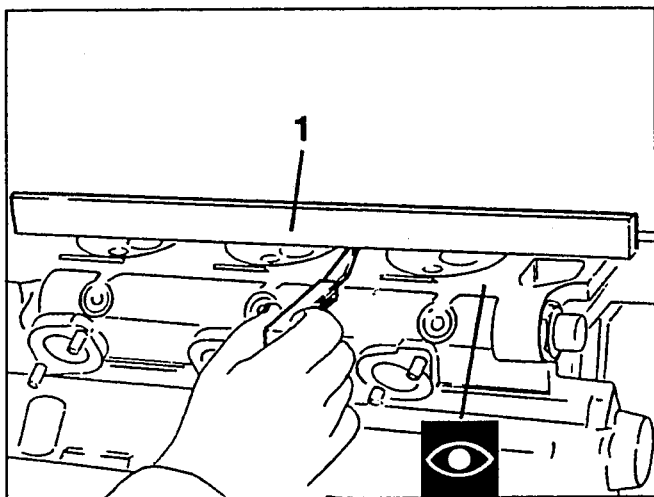
CHECKING AND INSPECTING THE CYLINDER HEADS

CHECKING THE LOWER SURFACE

1. Check the flatness of the lower surface and reface if necessary.



Refacing must be carried out on both heads.



Maximum error of flatness of head lower surface

0.05 mm

CHECKING THE CYLINDER HEAD BUSHES

- Measure the inside diameter "d" of the bushes fitted on the cylinder heads and check that it is within the specified limits.

«A» (only on right-hand cylinder head)

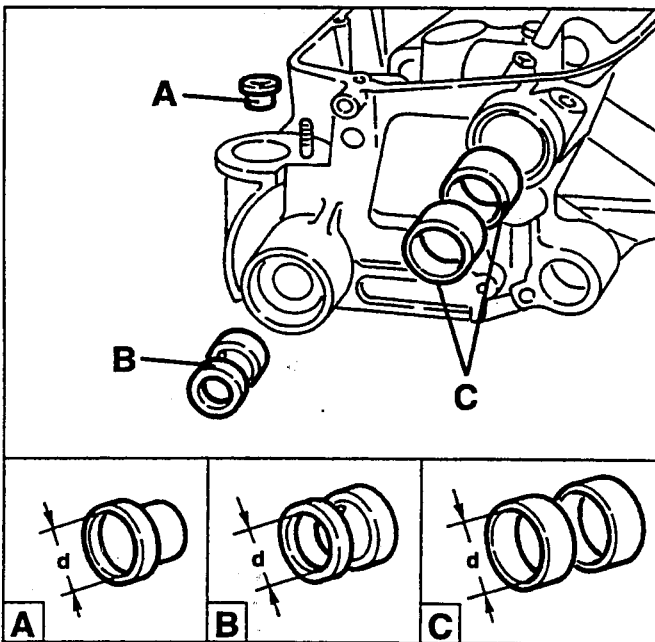
Bush for oil pump drive gear.

«B» (only on right-hand cylinder head)

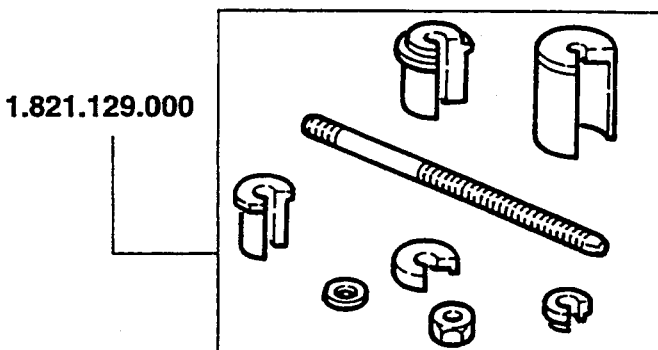
Bush for toothed oil pump drive pulley spindle.

«C» Bushes for toothed camshaft drive pulley hub.

- If the values measured are not within the specified limits replace the bushes concerned using tool no. 1.821.129.000 as described in the following steps.

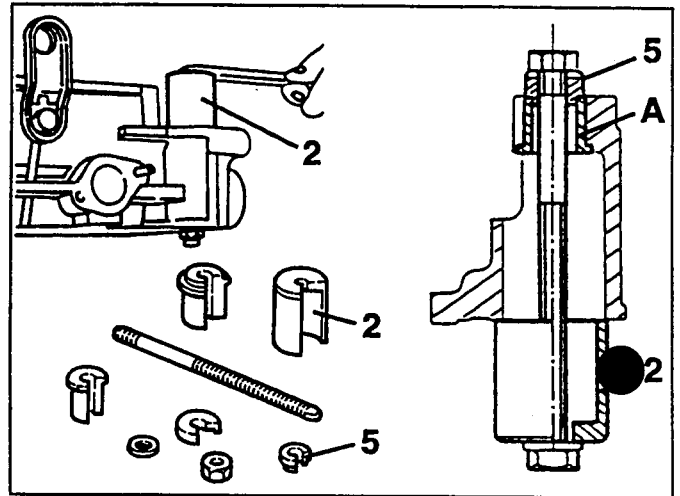


Inside diameter of bushes "d"	
"A"	19.000 + 19.021 mm
"B"	19.000 + 19.021 mm
"C"	32.000 + 32.025 mm



REMOVING BUSH «A» (For oil pump drive gear)

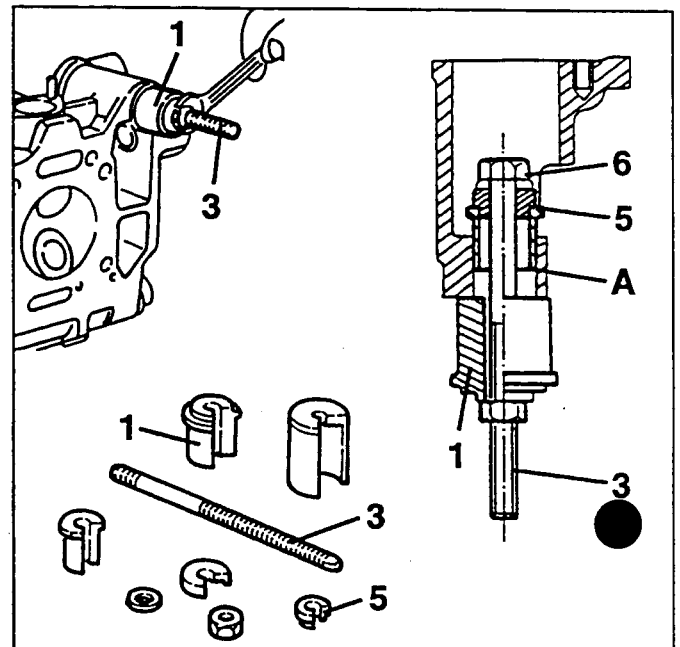
- Bush «A» of the oil pump drive gear must be removed using the special washer "5" as pusher and reacting with the cup "2".



INSERTING BUSH «A» (For oil pump drive gear)

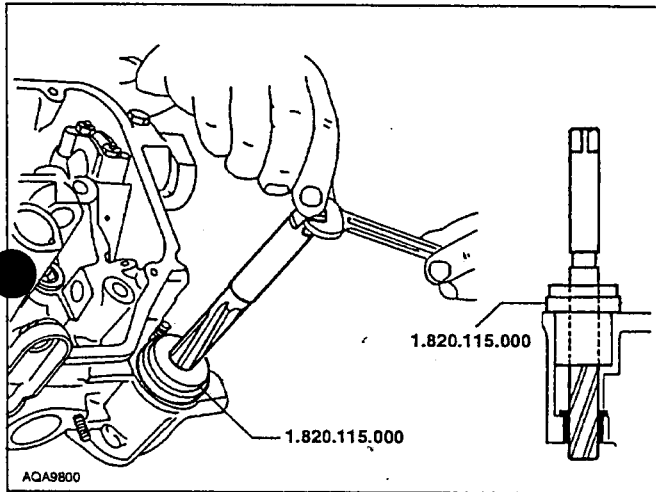
- Bush «A» of the oil pump drive gear must be inserted as follows:

- position the new bush.
- insert tie-rod "3" complete with nut "6" and special washer "5" (as pusher).
- from the side opposite the tie-rod, insert reaction coil "1" and complete inserting the bush.



CYLINDER HEADS OVERHAUL
BUSH «A» REAMING (For oil pump drive gear)

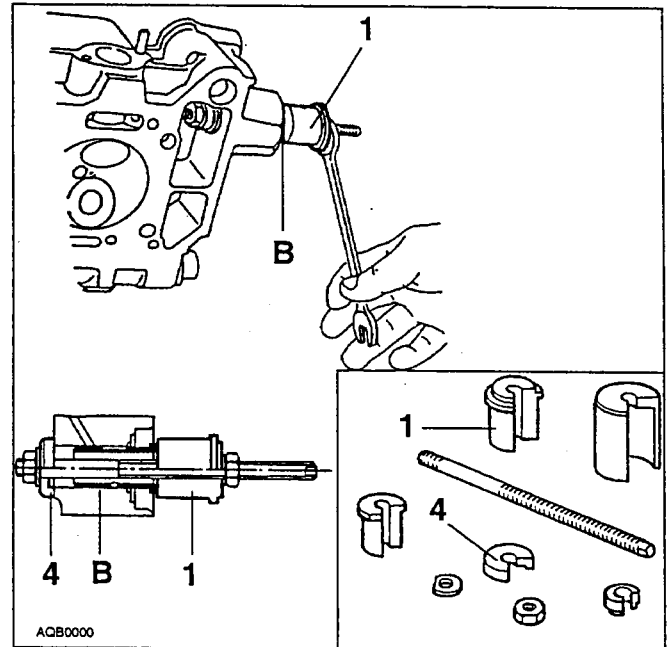
— After the installation, bush «A» must be reamed to the specified value; for this purpose, make use of tool 1.820.115.000 and a suitable reamer (19 mm H7)



	Bush inner diameter for oil pump drive gear hub (reaming)
	19,000 ÷ 19,021 mm

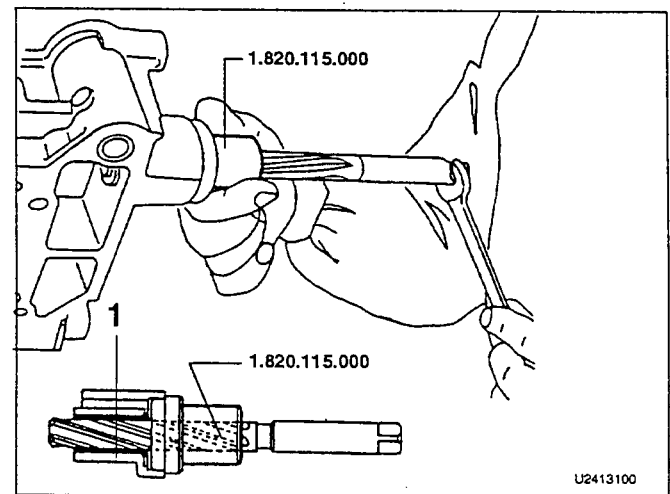
BUSH «B» INSTALLATION (For oil pump drive pulley shaft)

— Bush «B» for the oil pump drive pulley shaft must be installed by using the spool «1» as a pusher and blocking with the flange «4»



BUSH «B» REAMING (For oil pump drive pulley shaft)

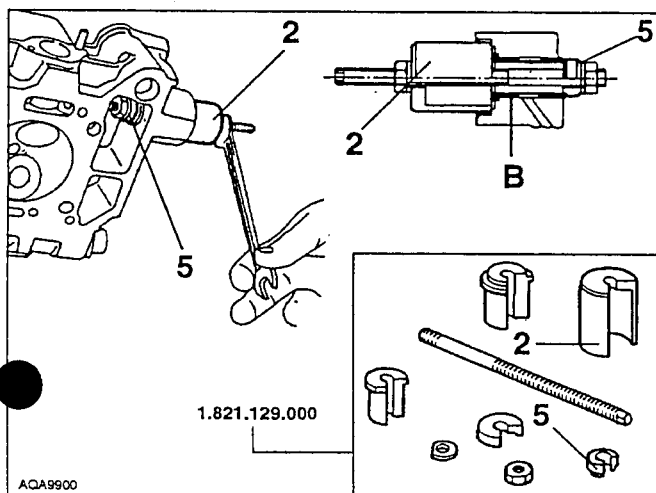
— After the installation, bush «B» must be reamed to the specified value; for this purpose, make use of tool 1.820.115.000 and a suitable reamer (19 mm H7)



	Bush inner diameter for oil pump drive pulley hub (reaming)
	19,000 ÷ 19,021 mm

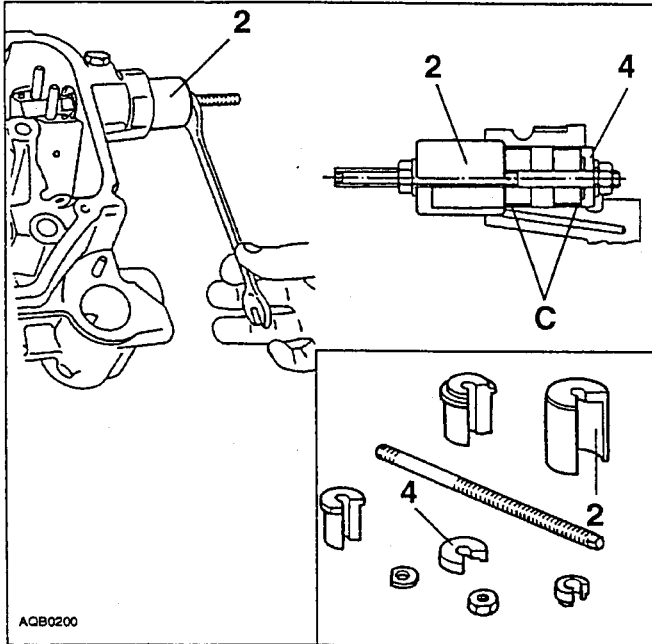
BUSH «B» REMOVAL (For oil pump drive pulley shaft)

— Bush «B» for the oil pump drive pulley shaft must be removed by means of the special washer «5» as a pusher and blocking by means of the bowl «2»



BUSH «C» REMOVAL (For timing camshaft drive pulley hub)

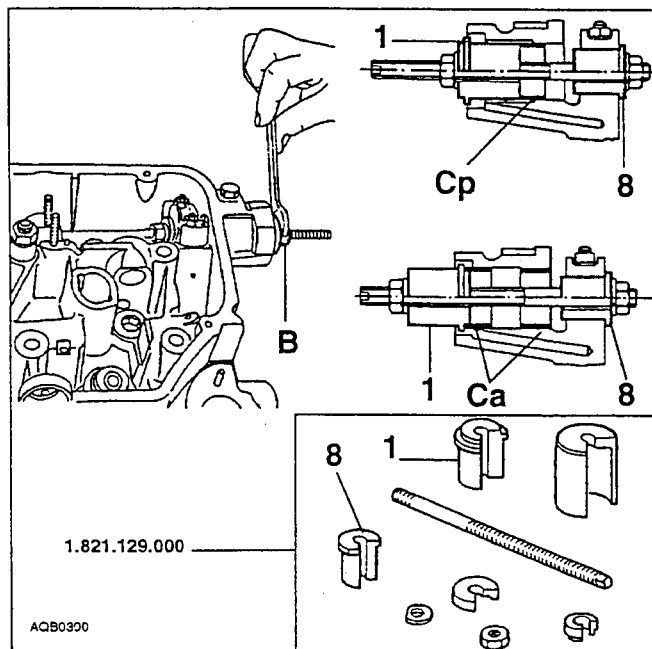
— Bushes «C» for the timing camshaft drive pulley hub must be removed by using the flange «4» as a pusher and blocking with the bowl «2»



AQB0200

BUSH «C» INSTALLATION (For timing camshaft drive pulley hub)

— Bushes «C» for timing camshaft drive pulley hub must be installed by acting as follows:

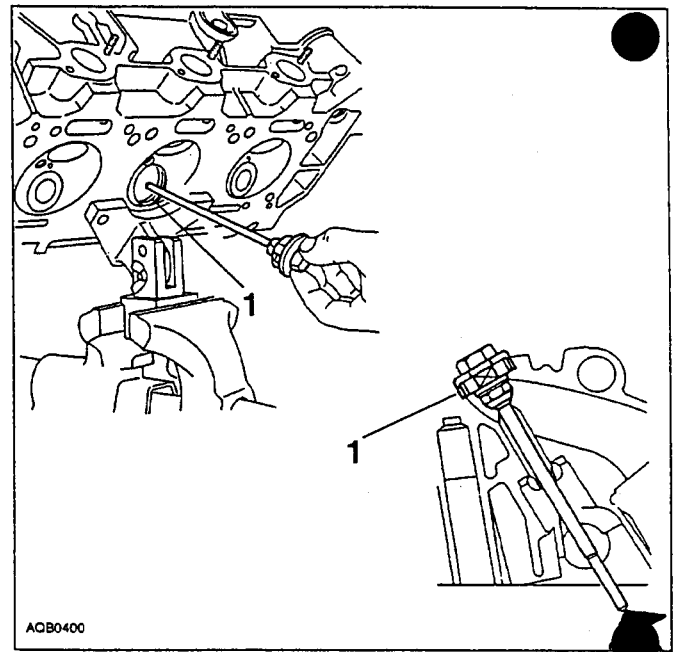


AQB0300

- install the adjacent cap of the timing camshaft and secure it by means of two nuts
- Fit the rear bush «C_p», (the thinner one) so as to center it in its seat
- install the bush «C_p» by using spool «1» as a pusher and spool «8»
- to install the front bush «C_f» act in the same way, but using the spool «1» in inverted position

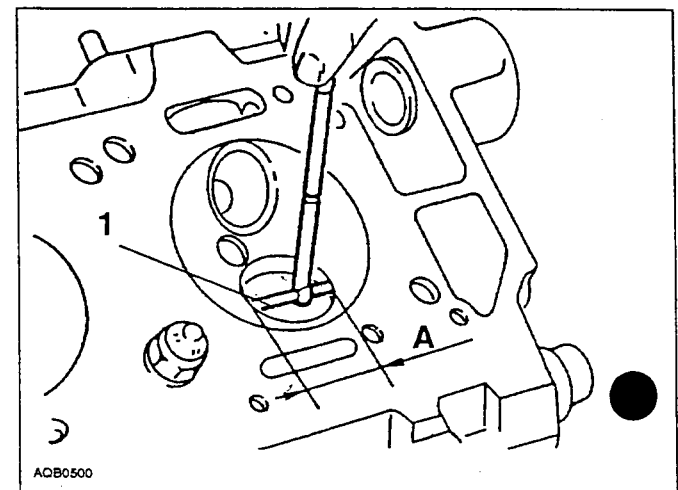
VALVE SEAT REPLACEMENT

1. Extract the worn valve seats by using a suitable equipment



AQB0400

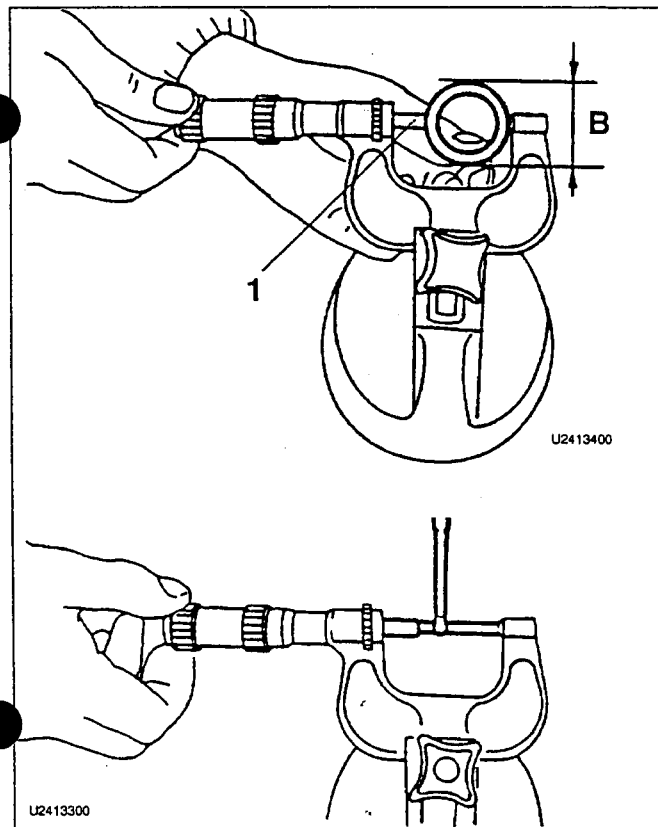
1. Check that the housing diameter of valve «A» seat ranges within the specified values



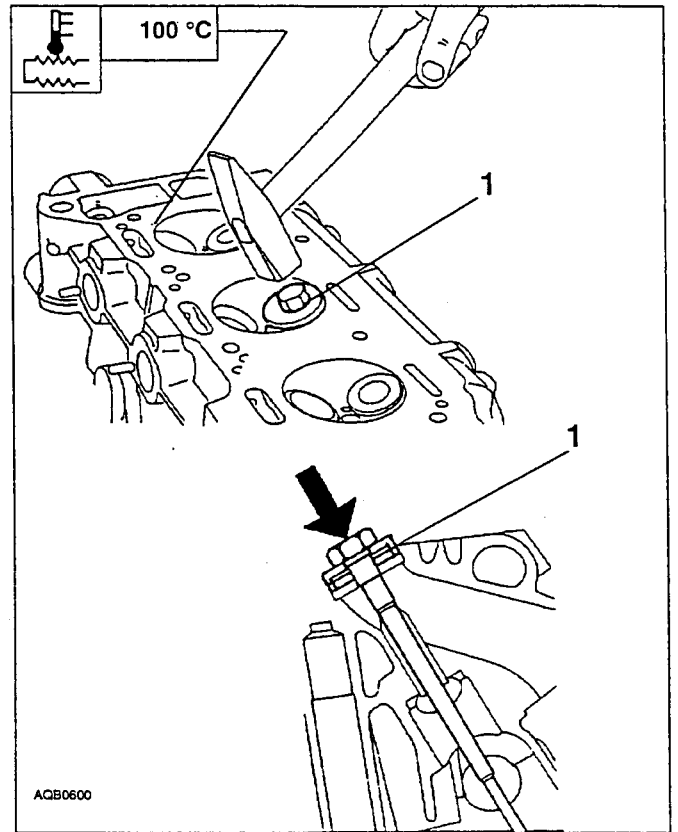
AQB0500

Outer diameter valve «A» seat		
Standard	intake	37,500 ÷ 37,525 mm
	exhaust	32,500 ÷ 32,525 mm
Spares	intake	37,800 ÷ 37,825 mm
	exhaust	32,800 ÷ 32,825 mm

1. Check that the outer diameter of valve «B» new seat ranges within the specified values



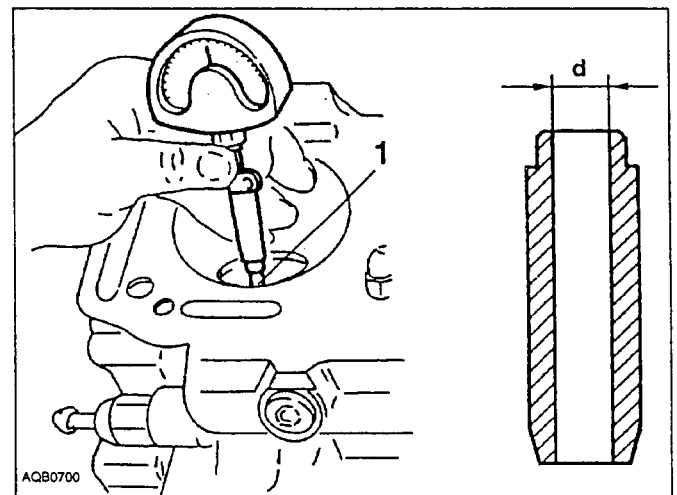
Outer diameter valve «B» seat		
Standard	intake	37,565 ÷ 37,600 mm
	exhaust	32,610 ÷ 32,626 mm
Spares	intake	37,865 ÷ 37,900 mm
	exhaust	32,910 ÷ 32,926 mm



CYLINDER HEADS OVERHAUL

VALVE GUIDE AND STEM CLEARANCE

1. Measure the inner diameter «d» of the valve guide and verify if it ranges within the specified values

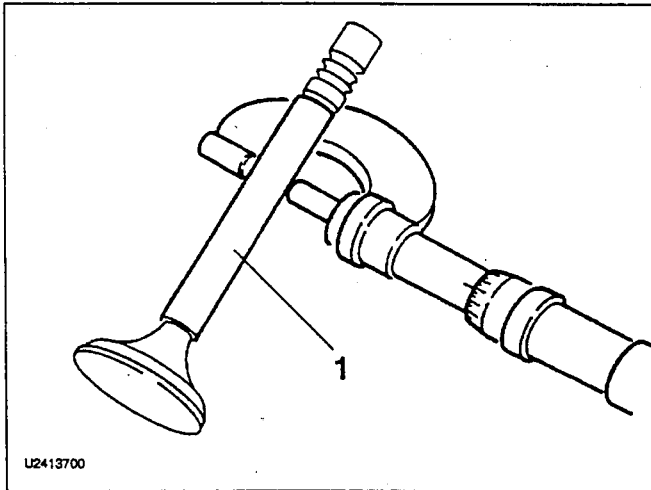


Valve guide inner diameter «d»	
intake and exhaust	9,000 ÷ 9,015 mm

Pre-heat the head to a temperature of 100 °C

1. Install the new valve seats by using the mandrel and the stop ring already used during removal operations

1. Measure the valve stem diameter in at least three points and in mutually orthogonal directions — Determine the clearance and verify if it ranges within the permissible tolerances; otherwise replace the worn parts



Valve stem and valve guide inner diameter radial clearance	
intake	0,013 ÷ 0,043 mm
exhaust	0,045 ÷ 0,075 mm



Valve guide seat diameter	
13,990 ÷ 14,018 mm	



Valve guide outer diameter	
intake	14,033 ÷ 14,044 mm 14,047 ÷ 14,058 mm *
exhaust	14,033 ÷ 14,059 mm 14,062 ÷ 14,073 mm *

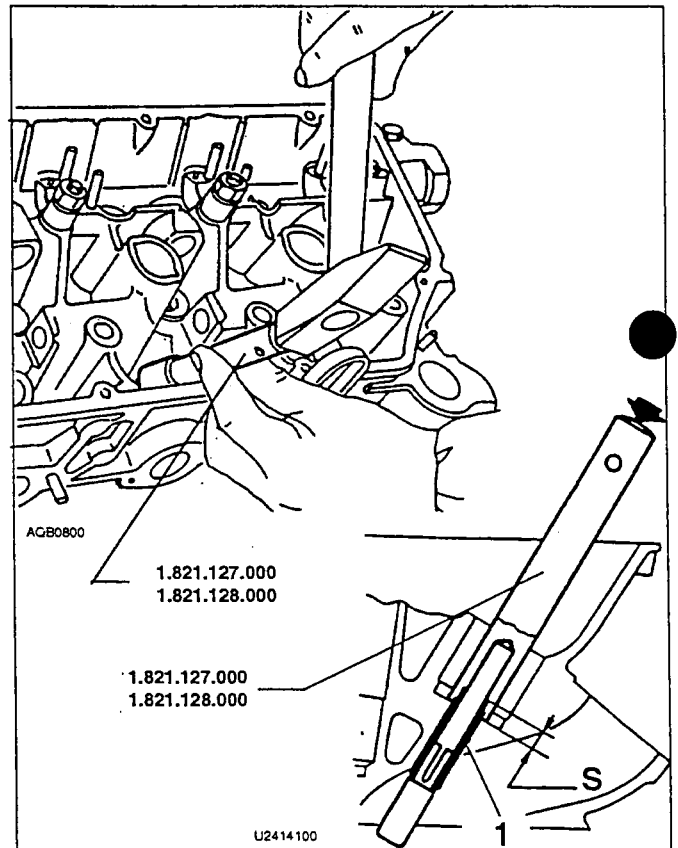
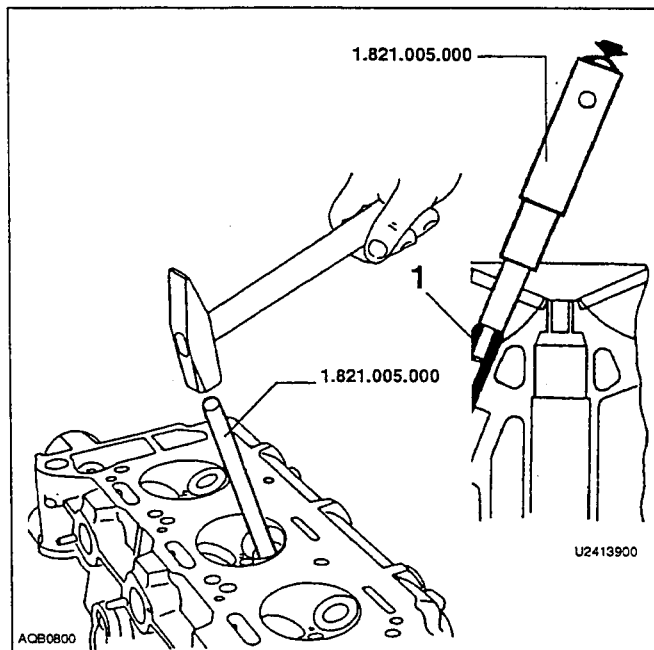
* Dimensions referred part supplied as spare

Interference between valve guide and valve guide seat	
intake	0,015 ÷ 0,054 mm
exhaust	0,030 ÷ 0,069 mm

1. Install the new valve guides by using the special inserters which also ensure the correct stand out values

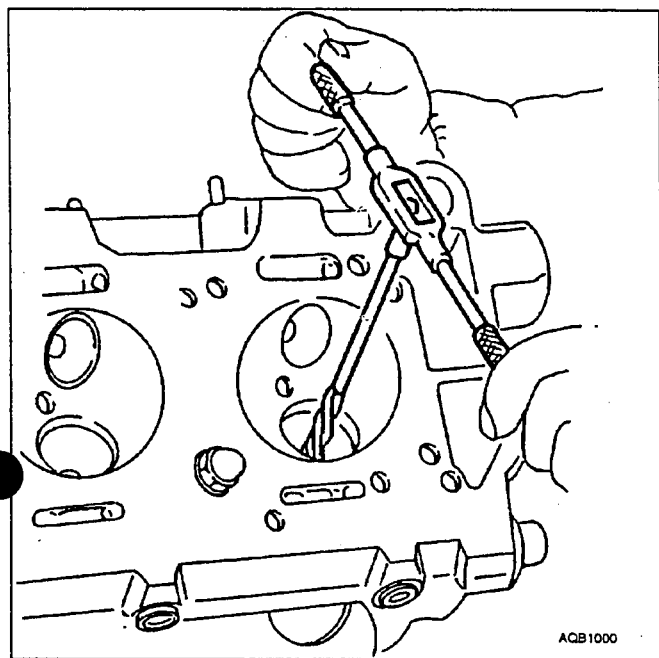
VALVE GUIDE REPLACEMENT

1. Extract the worn valve guides by means of extractor **1.821.005.000** — Measure the valve guide seat diameter and the new valve guide outer diameter: the assembly interference must be within the specified tolerances



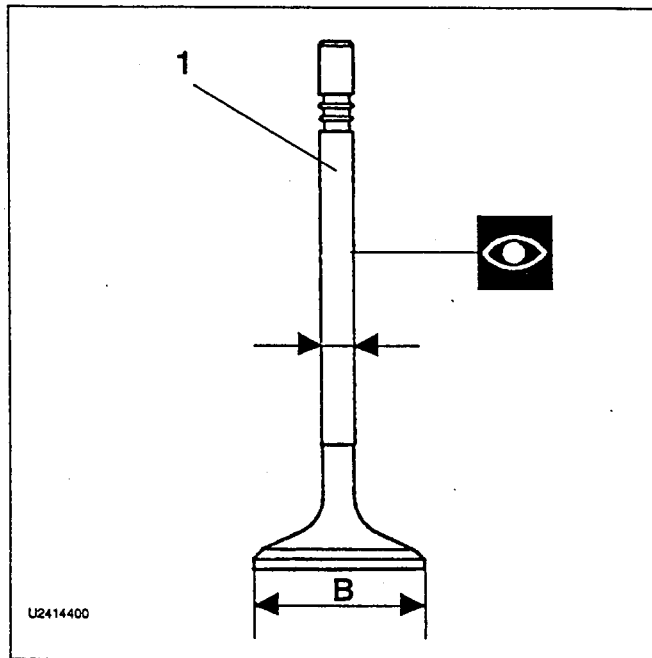
Valve guide stand-out "S"	
intake and exhaust	9,7 ÷ 10,1 mm

1. Ream the new valve guides (intake and exhaust) by means of a suitable reamer (diameter 9 mm H7) to calibrate the bores to the specified value



AQB1000

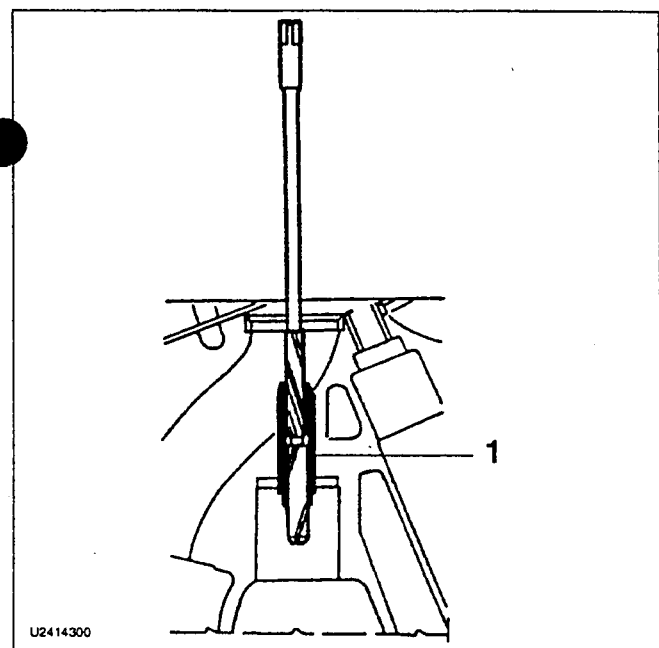
Valve guide inner diameter	
intake and exhaust	9,000 + 9,015 mm



U2414400

Valve «A» stem diameter	
intake	8,972 ÷ 8,987 mm
exhaust	8,940 ÷ 8,955 mm

Valve «B» head diameter	
intake	36,35 + 36,5 mm
exhaust	32,45 + 32,6 mm

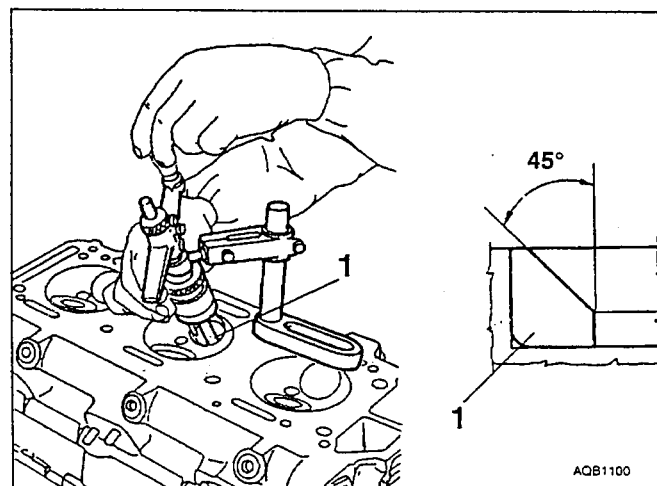


U2414300

VALVE SEAT TURNING

1. If necessary, carry out the valve seat turning by using suitable tools

NOTE: The taper «C» is obtained with the tool of the portable lathe at 45°



AQB1100

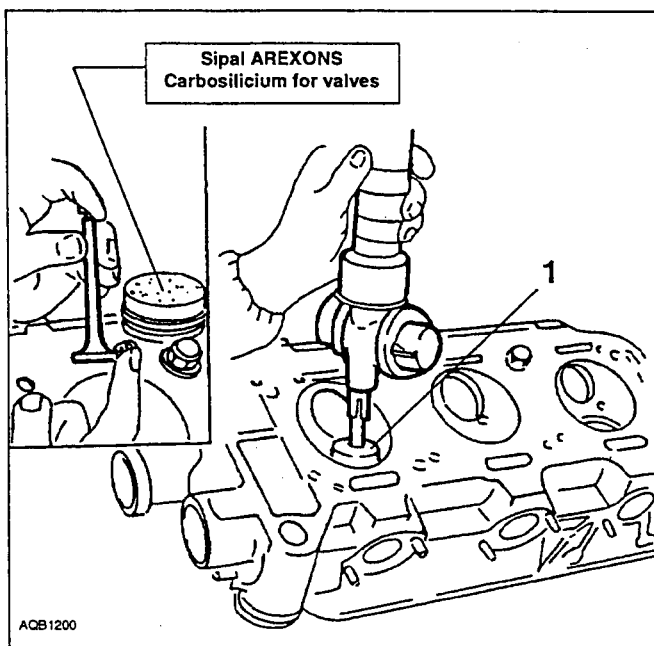
VALVES

1. Check that the valve stem and head diameters range within the specified values

Intake and exhaust valve seat taper
$"C" = 90^\circ \pm 20'$

1. After machining, grind each valve in its seat as follows:

- smear the valve contact surfaces and relevant seats with abrasive paste (**SIPAL AREXONS Carbosilicium for valves**)
- lubricate the valve stem with engine oil
- apply a pneumatic lap suction cup to the valve head lower surface
- insert the valve into its seat and carry out the grinding
- after grinding, carefully clean all valves and relevant seats



External spring		
Spring length	mm	Test load N (Kg)
Valve closed	32,5	243,20 + 251,60 (24,80 + 25,66)
Valve open	23,5	470,20 + 487,80 (47,95 + 49,75)

Internal spring		
Spring length	mm	Test load N (Kg)
Valve closed	30,5	125,70 + 130,20 (12,82 + 13,28)
Valve open	21,5	222,30 + 230,70 (22,67 + 23,53)

VALVE SPRINGS

— Check that the unloaded spring length is within the specified values

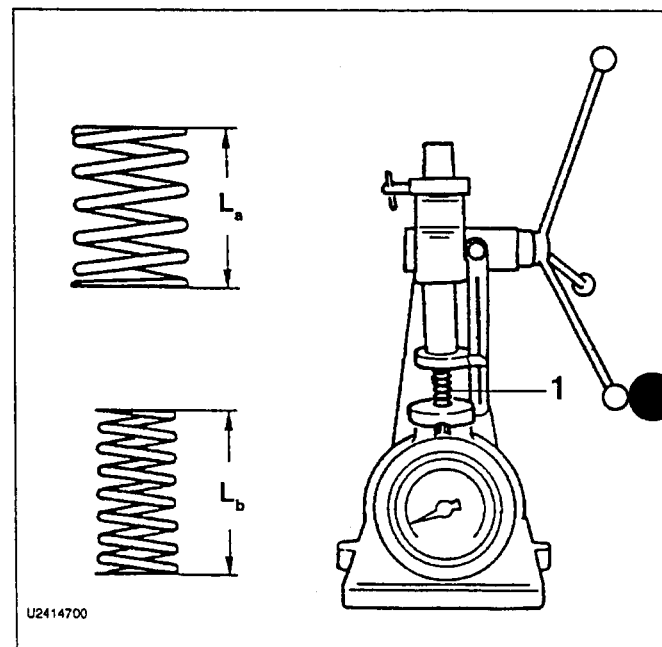


The terminal turns must be parallel and perpendicular to the axis of the spring, max. error 2°

1. Using a dynamometer, measure the flexibility values and check if ranging within specified values



Unloaded spring length		
external spring	L_a	44,6 mm
internal spring	L_b	44,1 mm

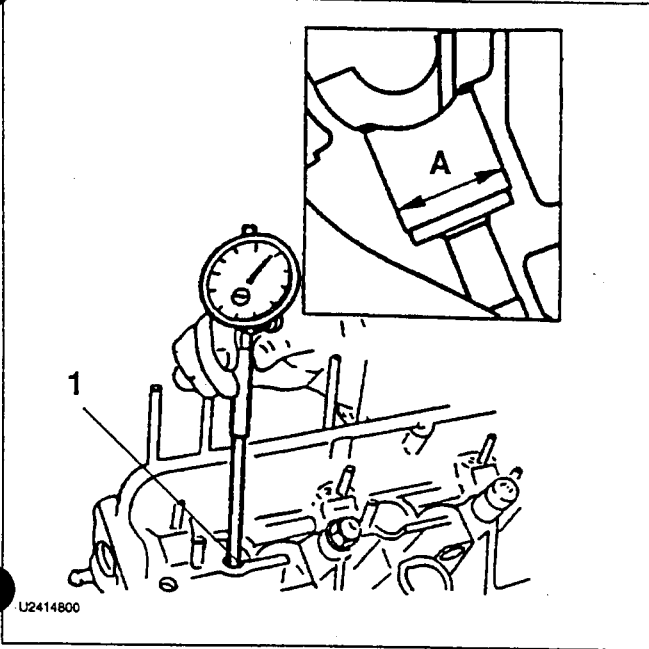


TAPPET SEATS AND INTAKE-SIDE TAPPETS

1. Check that the tappet seat diameter ranges within the specified values

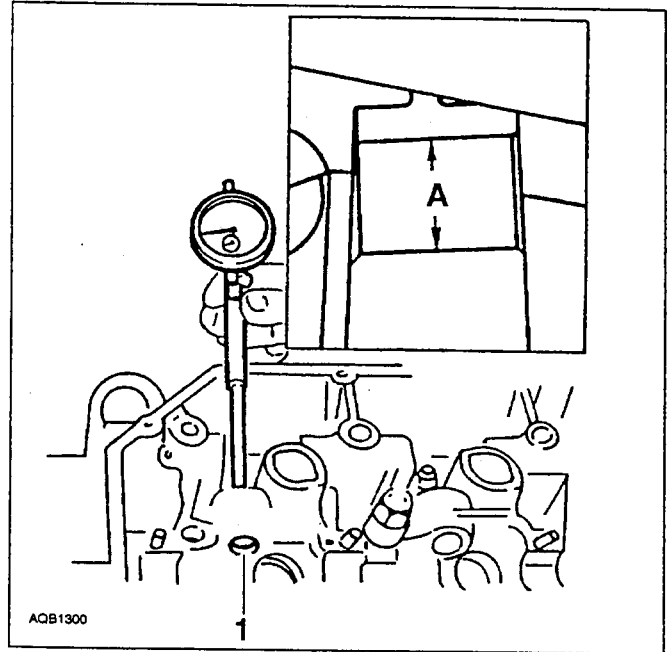


Tappet seat diameter of intake valve
$A = 35,000 \div 35,025$ mm



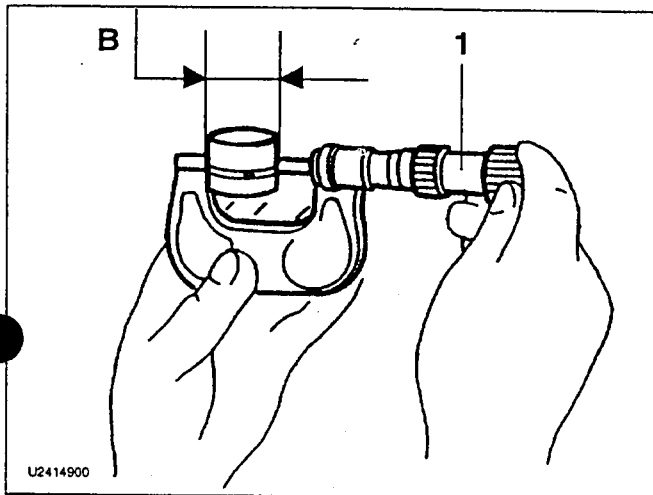
⊘ Tappet seat diameter of exhaust valve

$$C = 22,000 \div 22,021 \text{ mm}$$



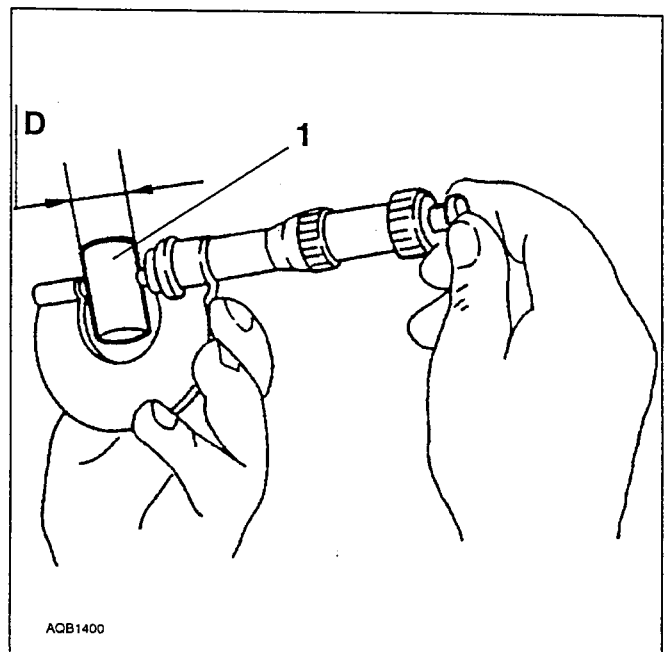
1. Check that the tappet outer diameter ranges within the specified values

1. Check that the tappet outer diameter ranges within the specified values



⊘ Tappet diameter of intake valve

$$B = 34,973 \div 34,989 \text{ mm}$$



⊘ Tappet diameter of exhaust valve

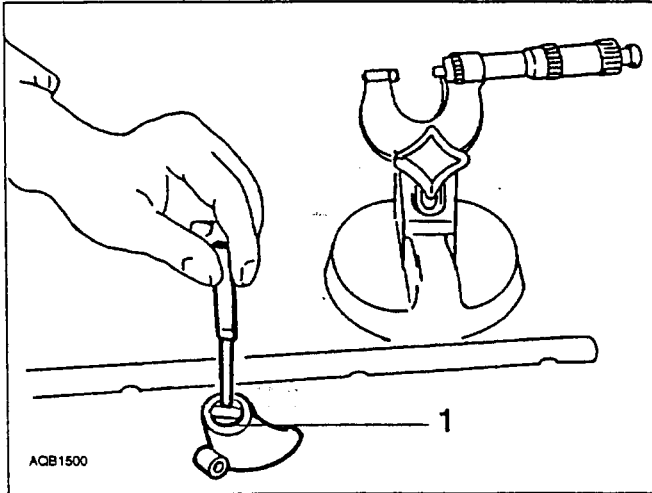
$$D = 21,971 \div 21,989 \text{ mm}$$

TAPPET SEATS AND EXHAUST-SIDE TAPPETS

1. Check that the tappet seat diameter ranges within the specified values

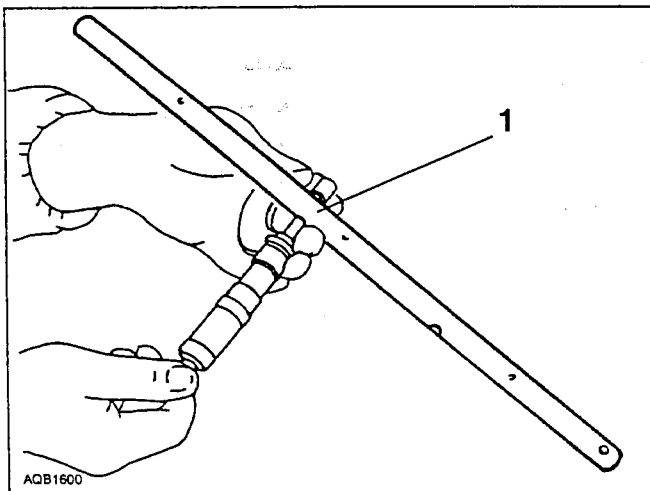
ROCKER ARMS AND ROCKER ARM SHAFT

1. Check that the rocker arm bore ranges within the specified values



∅	Rocker arm bore	16,016 ÷ 16,034 mm
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1. Check that the rocker arm shaft diameter ranges within the specified values

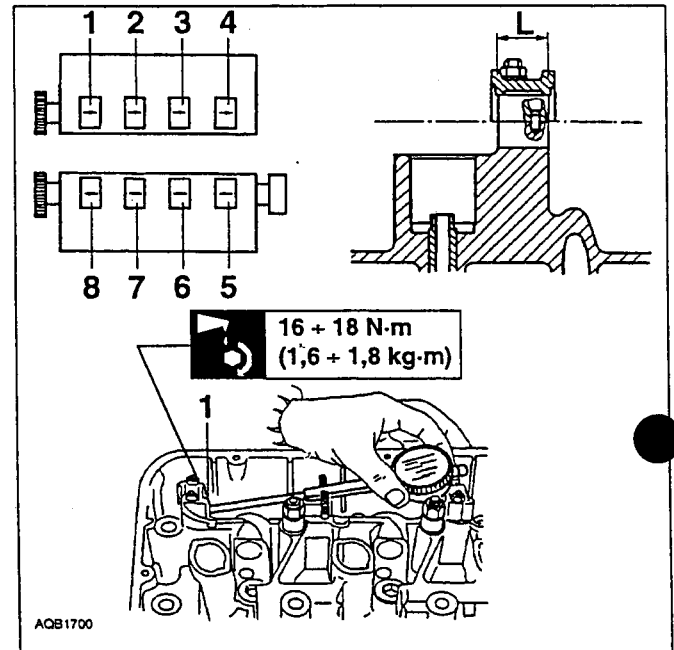


∅	Rocker arm shaft diameter	15,988 ÷ 16,000 mm
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CAMSHAFTS AND JOURNAL BEARINGS

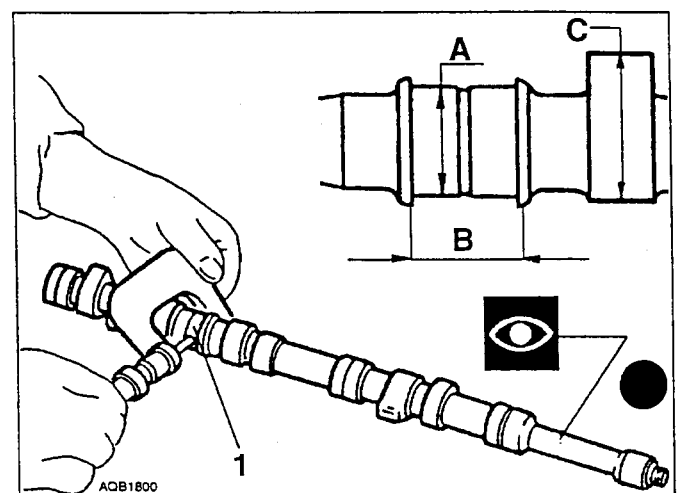
— Install the caps according to the numbering and arrows printed on them; tighten the lubricated nuts to the specified torque

1. Check that camshaft journal bearing diameter ranges within the specified values
 — Check that the maximum width “L” of the shoulder ranges within the specified values



∅	Camshaft journal bearing diameter	27,000 ÷ 27,033 mm
	Maximum width “L” of the shoulder	26,851 ÷ 26,940 mm

1. Check journals diameter “A” is within prescribed limits
 — Check cams height is above minimum allowable dimension
 — Check cam shoulder length “B” is within prescribed limits
 — Check maximum eccentricity between journals does not exceed prescribed limit





Camshaft journal diameter
A = 26,949 ÷ 26,970 mm



Cam height	
C = intake	35,511 ÷ 35,550 mm
C = exhaust	34,011 ÷ 34,050 mm



Shoulder length
B = 27,000 ÷ 27,052 mm

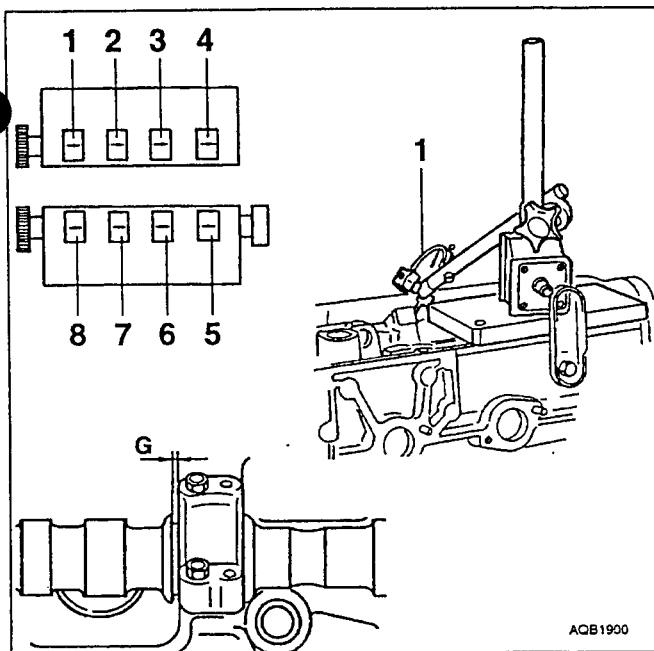
Maximum eccentricity between journals	0,03 mm
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CAMSHAFT END FLOAT CHECK

- Position the camshafts
- Install the caps according to the numbering and the arrows printed on them; tighten the lubricated nuts at the specified torque:

[16 ÷ 18 N·m (1.6 ÷ 1.8 kgm)]

1. Apply a centesimal comparator and measure the end float "G" of the camshafts; check that the value obtained ranges within the specified tolerances



Camshaft end float
G = 0,060 ÷ 0,201 mm

CYLINDER BLOCK CHECK AND INSPECTION

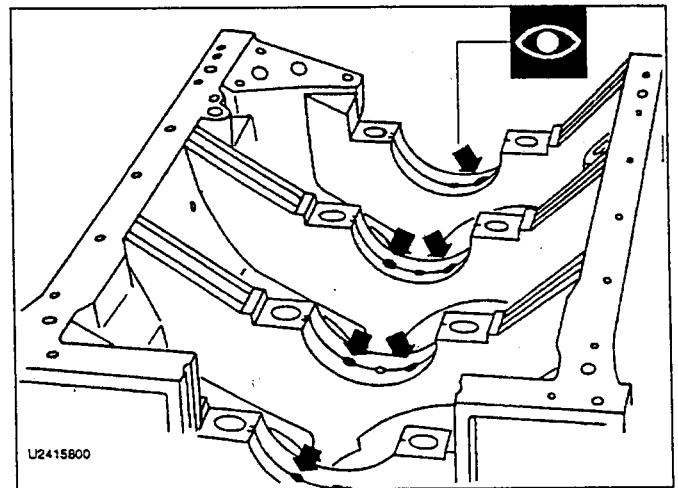
OIL JET VALVES FOR PISTON COOLING

— The cylinder block is equipped with six oil jet valves (See arrows in figure) supplied directly from main journals.

— These sprayers are meant for the cooling and lubricating of the pistons and the relevant piston pins

— Thoroughly clean the sprayers making sure they are neither damaged nor clogged

— Check with jet of compressed air that the lubrication valves open at the specified pressure



Opening pressure of lubrication valves
250 ± 25 kPa (2,5 ± 0,25 bar; 2,54 ± 0,254 Kg/cm ²)

MAIN AND CONNECTING ROD HALF BEARINGS - THRUST RINGS

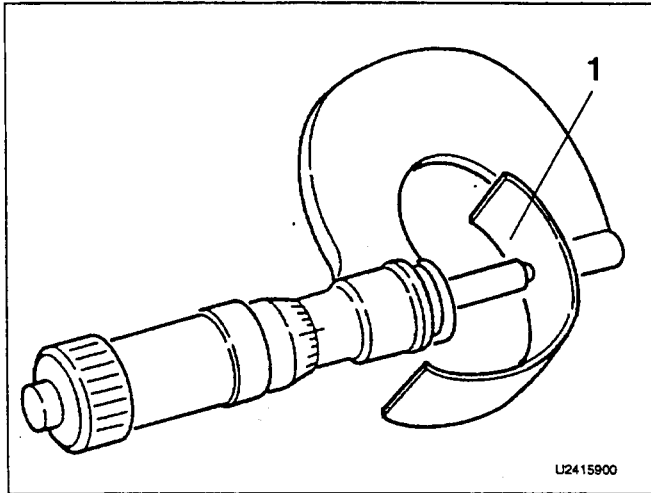


Class	Half bearing thickness main
Green	1,8450 ÷ 1,8510 mm
Blue	1,8390 ÷ 1,8450 mm
Red	1,8330 ÷ 1,8390 mm

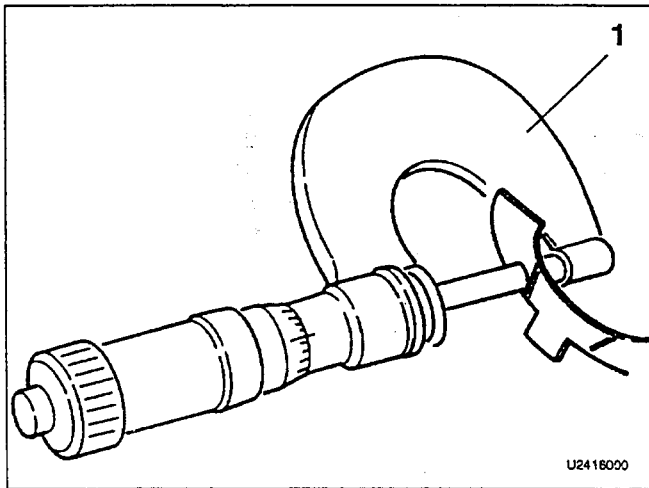
Class	Half bearing thickness big end
Red	1,7370 ÷ 1,745 mm
Blue	1,741 ÷ 1,749 mm

— The coupling between main and big end half bearings and crankshaft must be carried out by matching parts of the same class which are tagged on the half bearing side and on the relevant main journal with the same **RED** or **BLUE** coloured mark

1. Check that the half bearing thickness ranges within the specified values



1. Check that the half thrust ring thickness ranges within the specified values

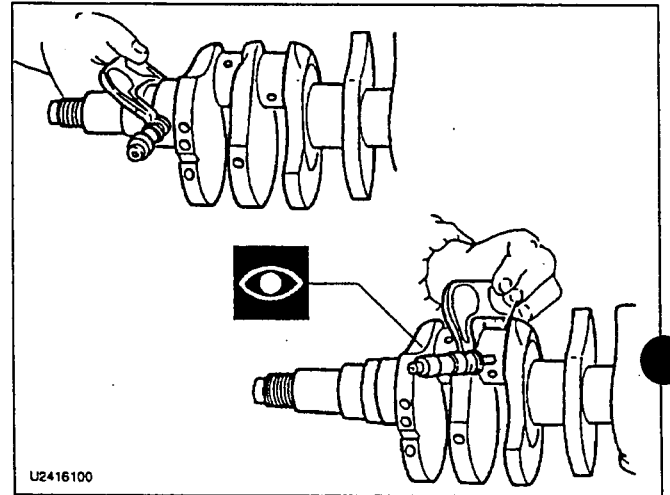


	Half thrust ring thickness
	2,310 ÷ 2,360 mm

**CRANKSHAFT
MAIN JOURNALS AND CRANK PINS**

NOTE: The nitriding treatment, which the crankshaft has undergone, does not allow any grinding operation; in case of excessive wear it is thus necessary to replace the crankshaft

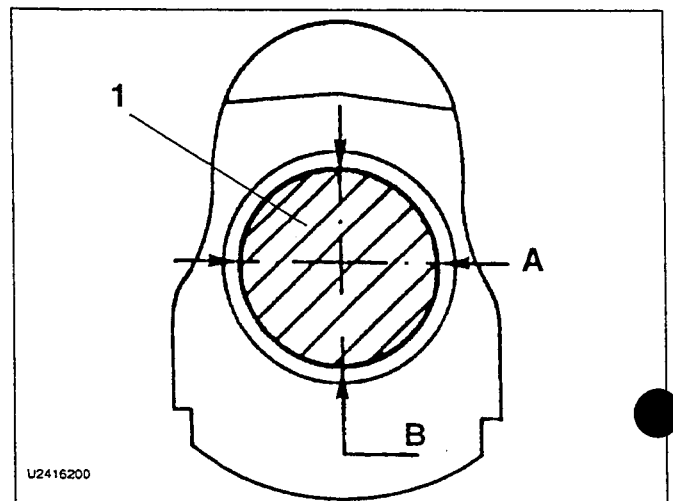
- The crankshaft journals are subdivided into classes and marked with a **RED** or **BLUE** dot for the connecting rod journals and 3 green, **BLUE** or **RED** stripes for the main journals according to machining tolerances
- Verify that the main journal and crank pin diameter ranges within the specified values



	Main journal diameter	
	Green	59,961 + 59,967 mm
	Blue	59,967 + 59,973 mm
	Red	59,973 + 59,979 mm

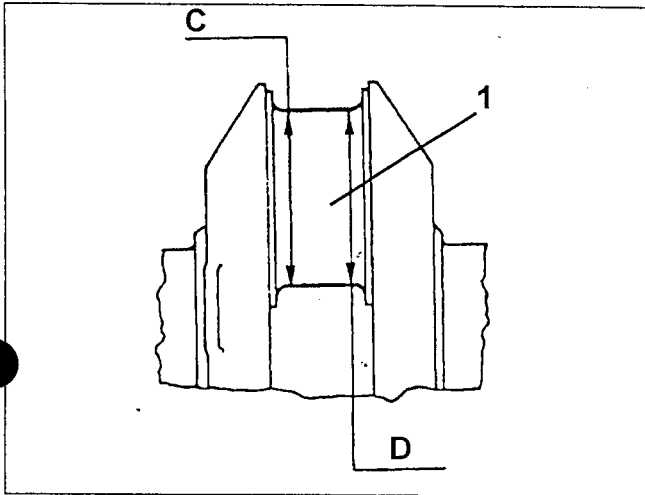
	Crank pin diameter	
	Red	51,990 + 52,000 mm
	Blue	51,980 + 51,990 mm

1. Check that the ovalization of the main journals and crank pins ranges within the specified values



Main and connecting rod bearing maximum ovalisation error	$A - B = 0.004 \text{ mm}$
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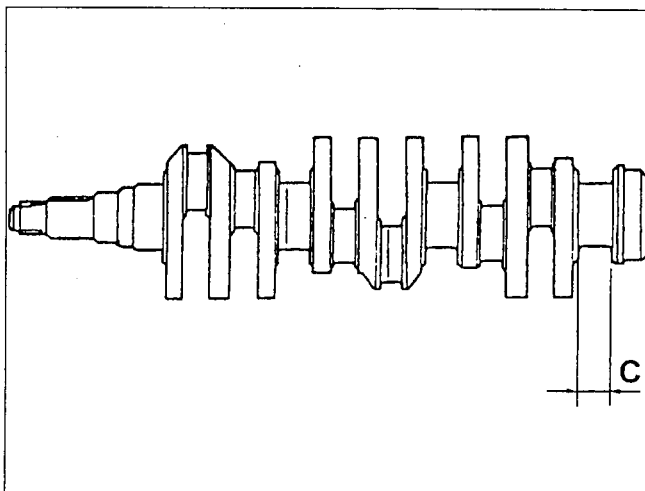
1. Check main and connecting rod bearing taper ratio falls within the prescribed values.



Main and connecting rod bearing maximum taper error	$C - D = 0.010 \text{ mm}$
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- Check:

- whether the central main journals and the front and rear main journals are concentric,
- whether the main and connecting rod journal generating lines are parallel,
- the length of rear main journal "C",
- whether the middle line shift with respect to main journal middle line falls into the prescribed value.



Main journal maximum eccentricity	0.004 mm
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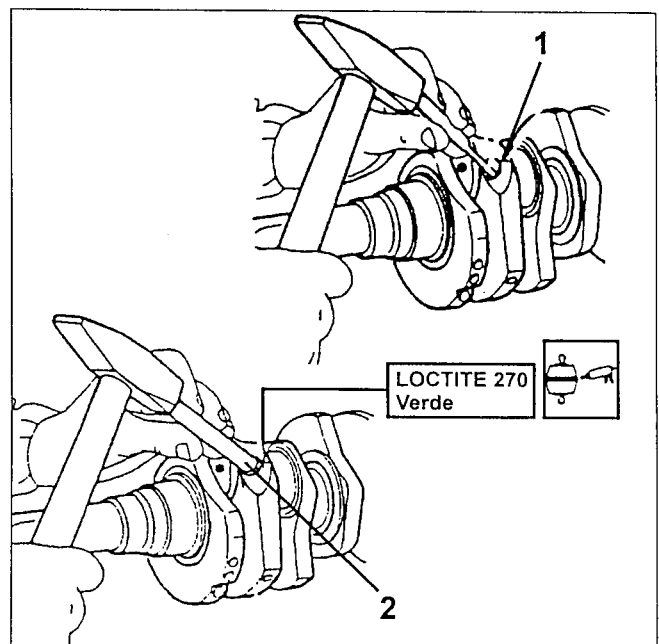
Main and connecting rod maximum parallel error	0.015 mm
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	Rear main journal length
	$C = 31.300 \div 31.335 \text{ mm}$

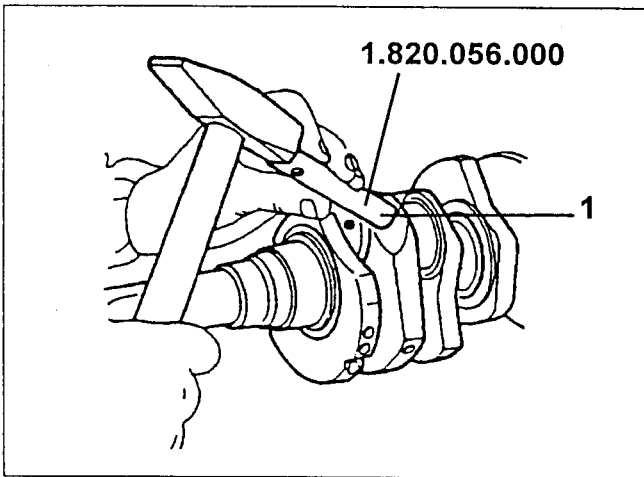
Maximum middle line shift with respect to main journal middle line	0.3 mm
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LUBRICATION DUCT CLEANING

1. Pierce the lubrication duct caps with a punch and eliminate burrs created by the previous caulking.
- Clean the lubrication ducts carefully with warm diesel fuel and dry with a jet of compressed air.
2. Apply the prescribed glue (**LOCTITE 270 Green**) on the new caps and insert them with a suitable tool in the lubrication duct holes.



1. Caulk the caps with tool no. 1.820.056.000.



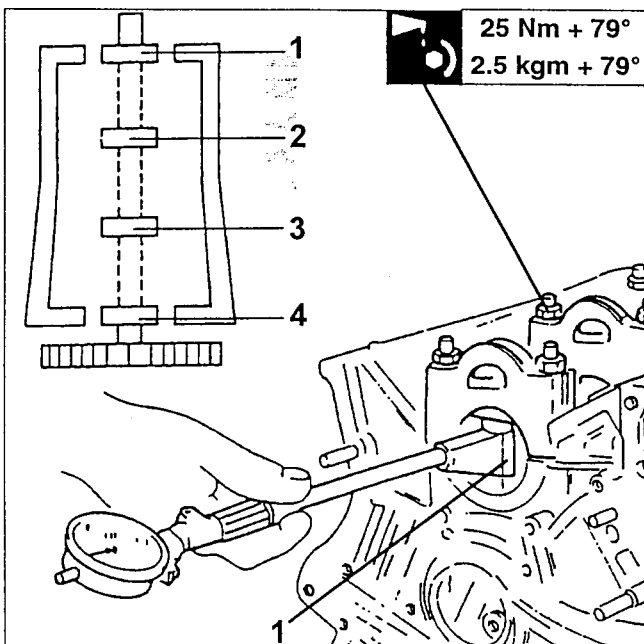
MAIN BEARINGS

- Fit the main bearings addressing them according to the indications given on the bearings.

1. Fasten the nuts to the prescribed torque in oil. Check whether the main journal diameter falls within prescribed values.

NOTE: Use goniometer no. 1.860.942.000 for angle torque.

- Check whether the rear main journal shoulder falls within the prescribed values.

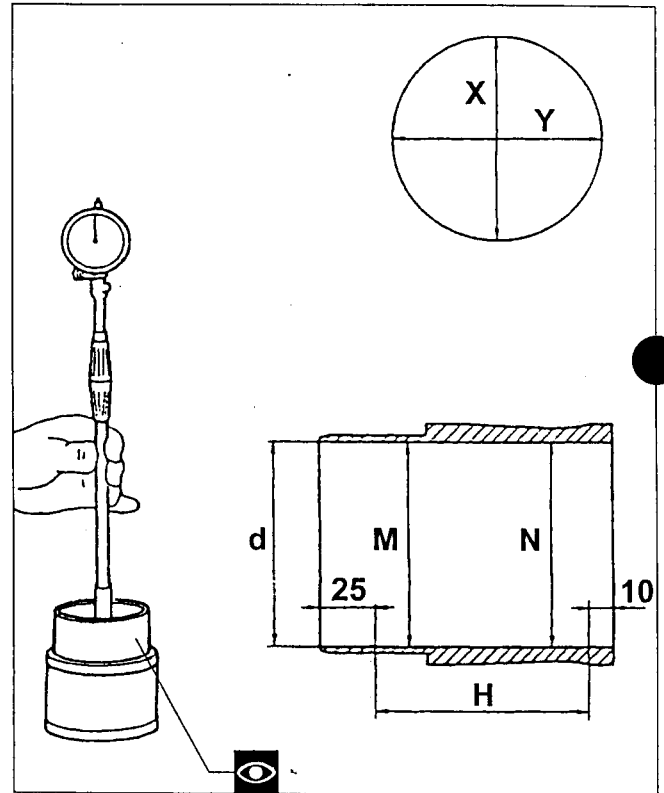


	Main journal diameter	63.657 ÷ 63.676 mm
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	Rear main Journal shoulder length	26.45 ÷ 26.50 mm
--	--	------------------

CYLINDER LINERS

- The cylinder liners are organised into three classes - **A, B** and **C** - according to their internal diameter. They can be distinguished by means of the **BLUE, PINK** or **GREEN** labels on the outside.
 - Check whether the internal diameter, taper ratio and ovality fall within prescribed values.



H = dimension check area

Diameter (d)	
Class A (Blue)	79.985 ÷ 79.994 mm
Class B (Pink)	79.995 ÷ 80.004 mm
Class C (Green)	80.005 ÷ 80.014 mm

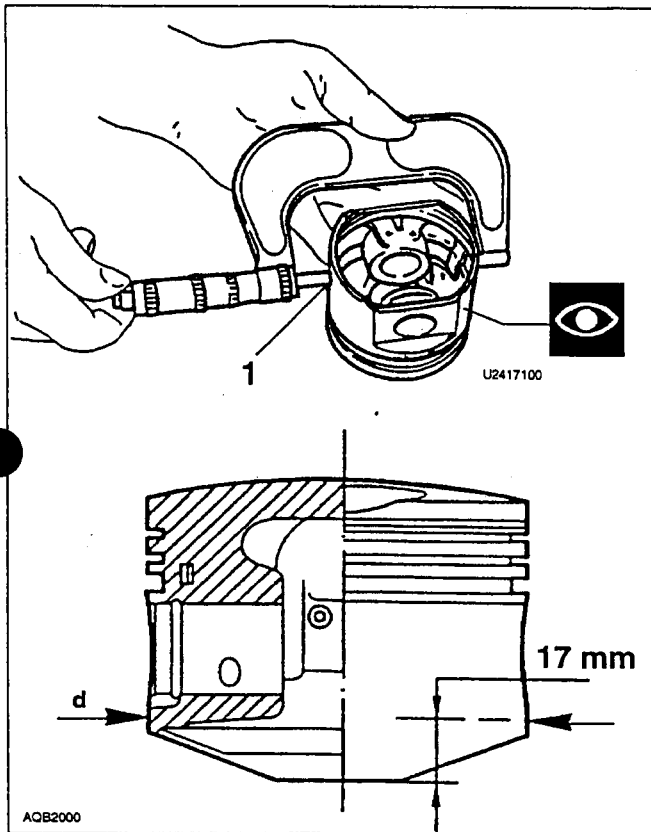
Maximum taper ratio (M-N)	0.01 mm
Maximum ovality (X-Y)	0.01 mm

PISTONS AND PINS

- The pistons - as the cylinder liners - are organised into three class according to their machining tolerance. The classes **A, B** and **C** can be distinguished by the **BLUE, PINK** or **GREEN** labels on the top of the piston.

1. Check whether the external diameter of the piston falls within the prescribed values.

NOTE: This diameter must be perpendicularly measured as to the piston pin hole and at 17 mm from the skirt lower edge

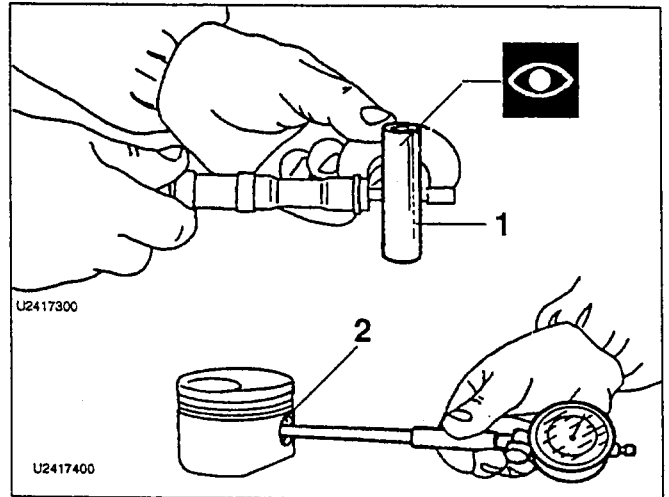


Outer diameter (d)	
Class A (Blue)	79,935 ÷ 79,945 mm
Class B (Pink)	79,945 ÷ 79,955 mm
Class C (Green)	79,955 ÷ 79,965 mm

— The piston pins and the piston coupling holes are subdivided into two classes according to the manufacturing tolerances. These classes are differentiated by marks in **BLACK** or **WHITE** painted on the piston pin inner surface and the outer surface of the piston hub

1. Check that the piston pin outer diameter ranges within the specified values
2. Check that the coupling hole diameter with the piston ranges within the specified values

Piston pin outer diameter	
Black	21,994 ÷ 21,997 mm
White	21,997 ÷ 22,000 mm

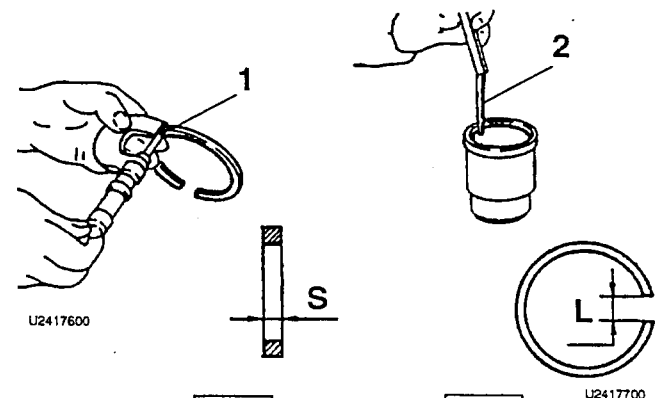


Piston pin outer diameter	
Black	21,994 ÷ 21,997 mm
White	21,997 ÷ 22,000 mm

Pin hole diameter in the piston	
Black	22,001 ÷ 22,003 mm
White	22,003 ÷ 22,005 mm

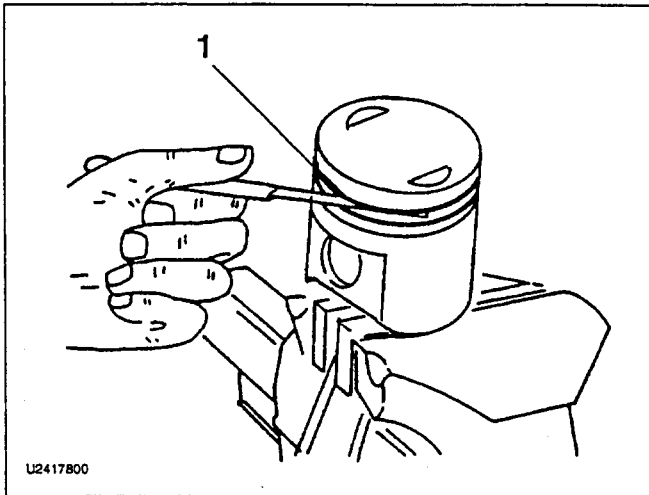
PISTON RING AND OIL SCRAPER RINGS

1. Check that thickness "S" value of the piston and oil scraper rings ranges within the specified values
2. Insert the rings into the cylinder liner and check that gap "L" ranges within the specified values



	Thickness «S»	Gap "L"
First ring	1,478 ÷ 1,490 mm	0,30 ÷ 0,50 mm
Second ring	1,478 ÷ 1,490 mm	0,30 ÷ 0,50 mm
Oil scraper ring	3,478 ÷ 3,490 mm	0,25 ÷ 0,50 mm

1. Check that the end float between the piston rings, the oil scraper rings and the piston seats ranges within the specified tolerances



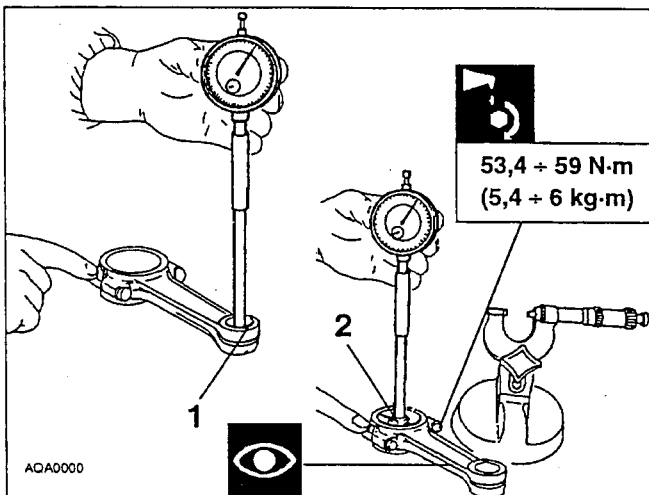
U2417800



End float between seats and piston rings

First ring	0,035 + 0,067 mm
Second ring	0,035 + 0,067 mm
Oil scraper ring	0,025 + 0,057 mm

1. Check that the bushing hole diameter of the small end ranges within the specified values
 2. Install the connecting rod caps and tighten the lubricated nuts to the specified torque.
- Check that the big end diameter ranges within the specified values



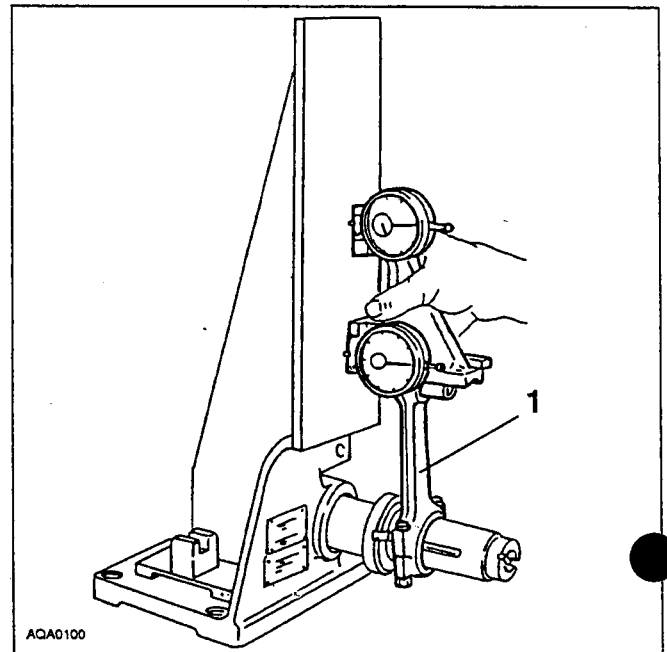
AQA0000



Small end bushing hole diameter

22,004 + 22,014 mm

1. Check the perpendicularity of the connecting rods



AQA0100

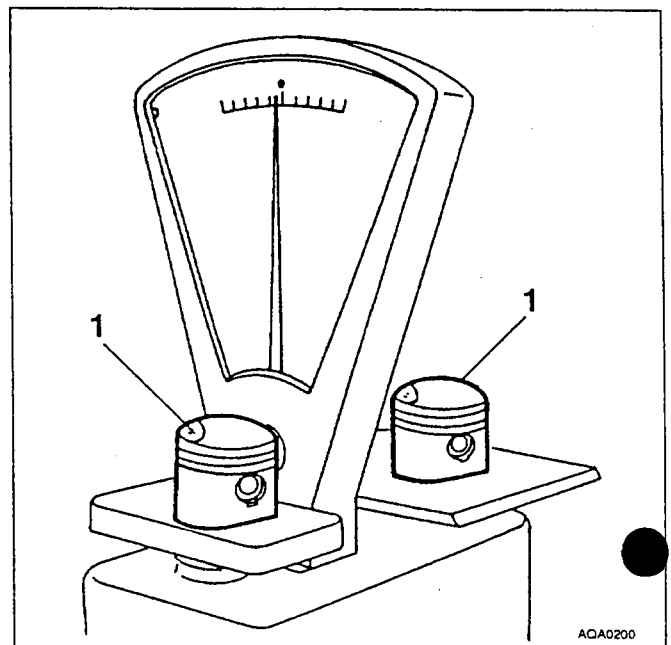


Big end inner diameter

55,511 + 55,524 mm

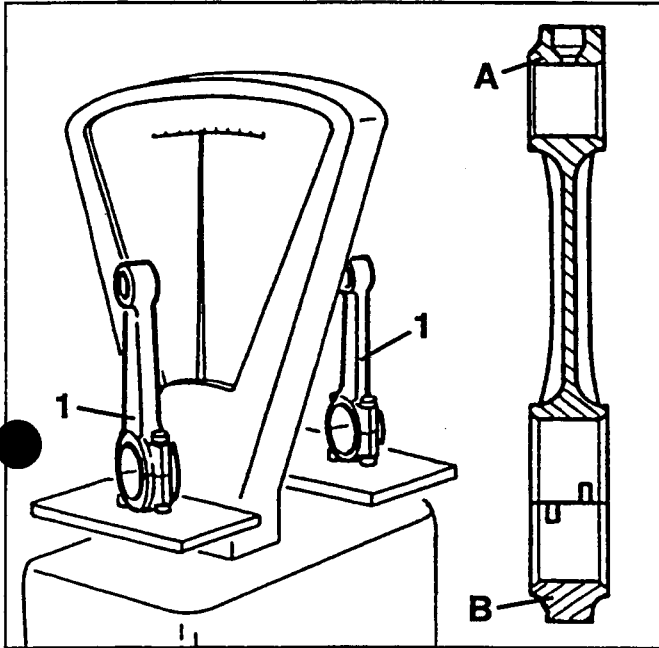
WEIGHT DIFFERENCE CHECK OF PISTON AND CONNECTING ROD PAIRS

1. Match piston pins and pistons according to the relevant dimension class (**BLACK** or **WHITE**). Insert the piston pins in the pistons and block them by means of spring rings; install the piston rings and the oil scraper ring. Check that the weight difference between piston pairs ranges within the specified values



AQA0200

Similarly, check that the difference in weight between the connecting rods, complete with half bearings, caps and bolts, is within the specified limit (if necessary remove the excess material from "A" and "B").

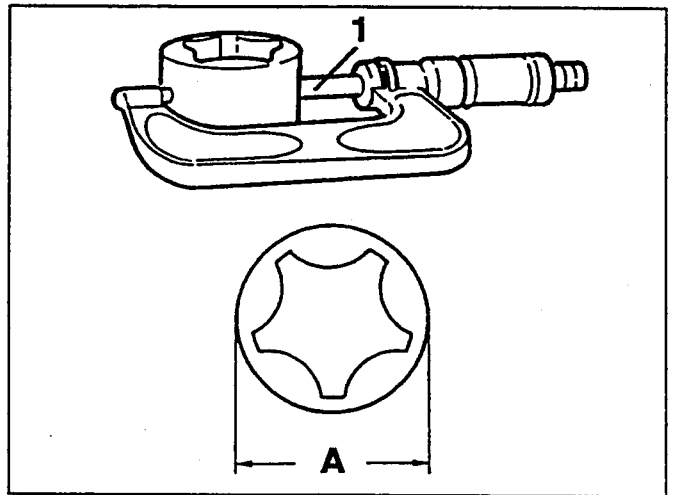


	Difference in weight between pistons
	≤ 4 g
	Difference in weight between connecting rods
	≤ 2 g

- remove the old ring gear using a hydraulic press.
- accurately clean the contact surfaces of the new ring gear and flywheel.
- evenly heat the new ring gear to a temperature of 120 + 140 °C and fit it on the flywheel.
- leave to cool at environment temperature: **do not force cool.**

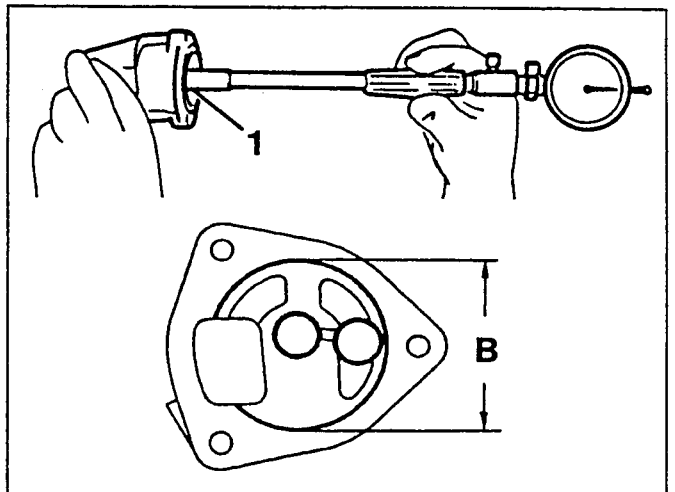
CHECKING AND INSPECTING THE OIL PUMP

1. Check that the outside diameter of the driven rotor is within the specified limits.



	Outside diameter of driven rotor
	A = 49.100 + 49.155 mm

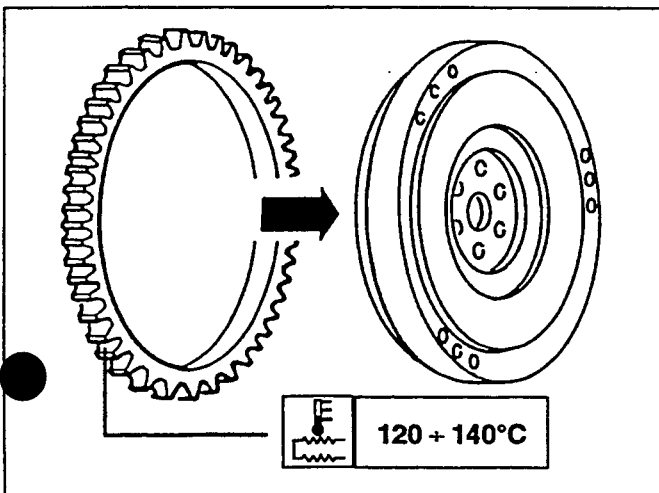
1. Check that the inside diameter of the pump casing is within the specified limits.



	Diameter of seat for rotor in pump casing
	B = 49.325 + 49.375 mm

CHANGING THE FLYWHEEL RING GEAR

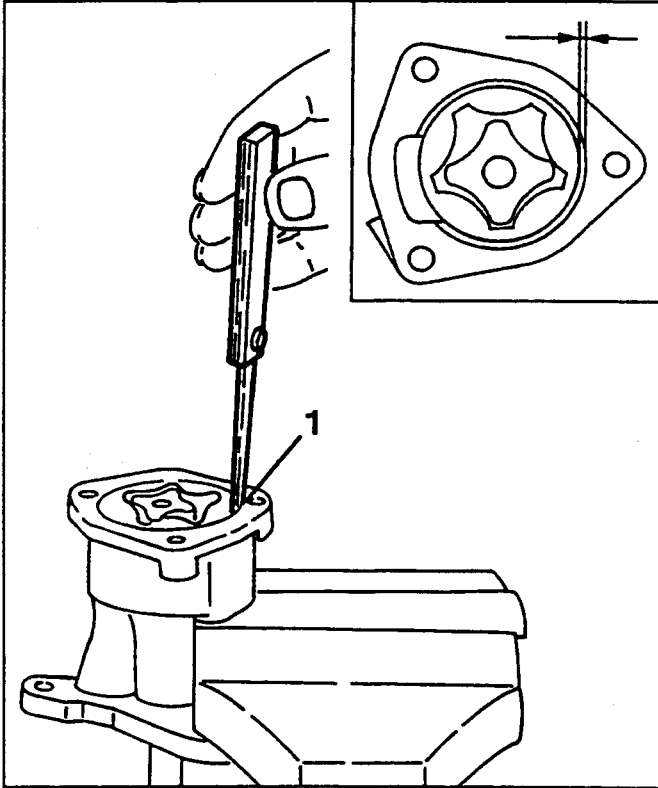
- When replacing the flywheel ring gear, proceed as follows:



1. Check that the clearance between the pump casing and driven gear is within the specified limit.



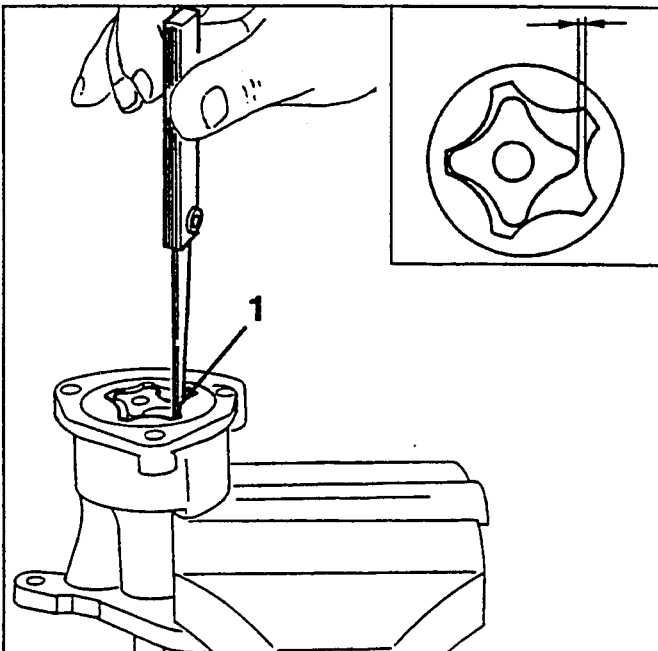
Clearance between pump casing and driven gear
 $0.170 + 0.275 \text{ mm}$



1. Check that the clearance between the lug of the inside gear and that of the driven gear is within the specified limits.



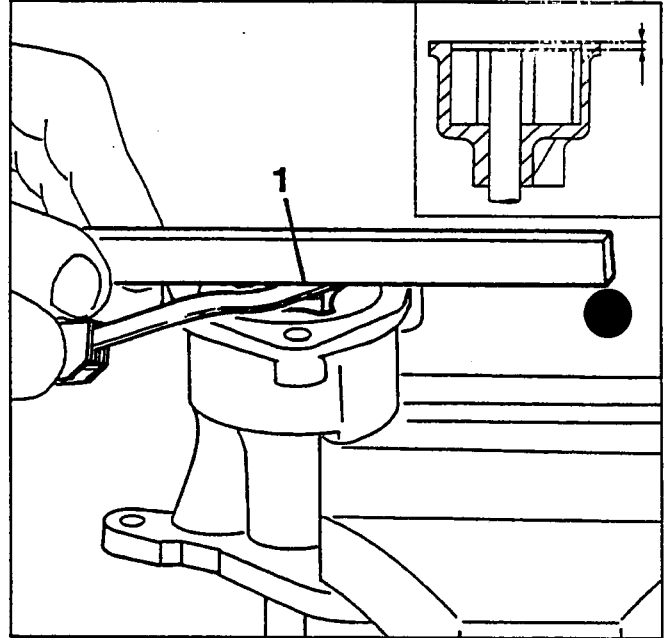
Clearance between driven gear and inside gear
 $0.040 + 0.290 \text{ mm}$



1. Check that the clearance between the pump casing rest surface and the upper surface of the gears is within the specified limits.

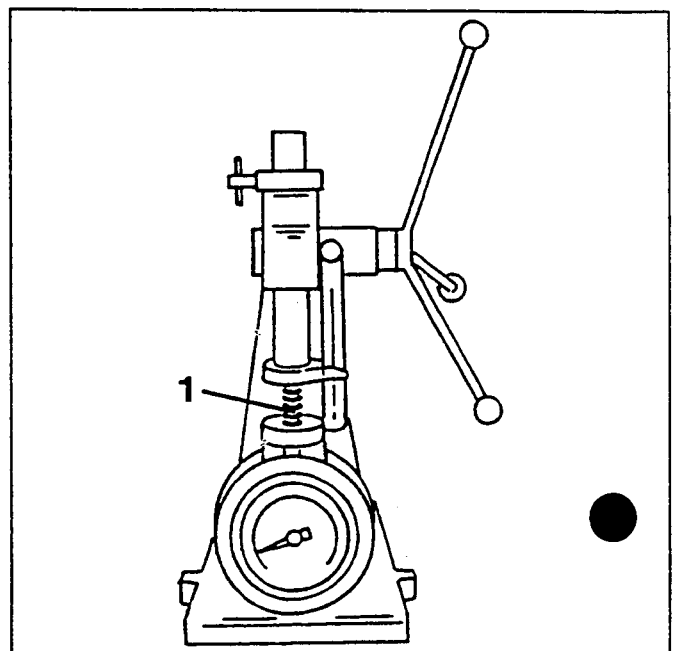


Clearance between pump casing rest surface and upper gear surface
 $0.025 + 0.075 \text{ mm}$



1. Check, using a torque meter, that the characteristic data of the engine oil pressure limiting valve control spring are within the specified limits.

Length of spring	
With spring free	54 mm
With static load (14.6 kg)	36 mm
With dynamic load (21 kg)	28 mm

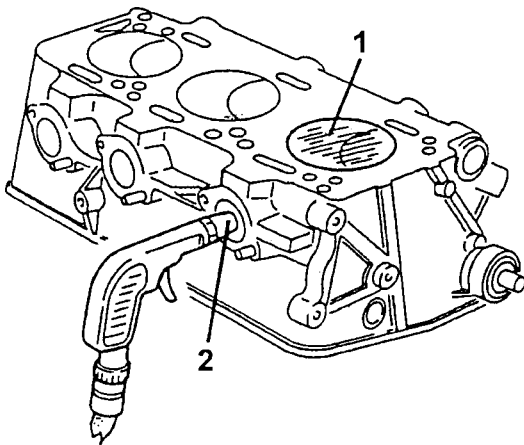


REFITTING PRECAUTIONS

 Reverse the removal sequence for refitting unless otherwise specified in the following instructions.

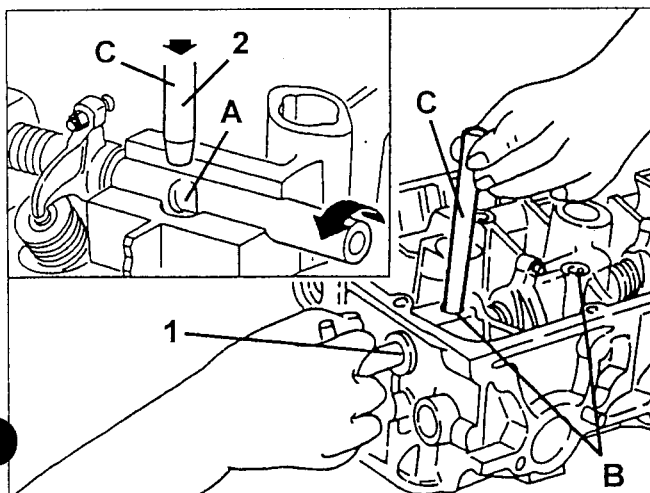
Valve tightness check

- Fit the spark plugs in their seats.
- 1. Pour some petrol in the combustion chamber so to just cover the valve caps.
- 2. Let low pressure air into the intake manifolds and into the exhaust manifolds. Check there are no air bubbles in the petrol. If there are bubbles, check correct position and if required machine the valve seats (see specific paragraph).



Rocker arm journal

- 1. Fit the washers, the rocker arms and the springs. Turn the shaft so that the notches "A" correspond to holes "B" to let the cylinder head fastening studs through.
- 2. Use pin "C" (diameter 12 mm) to make sure it is so.



Check and adjust tappet clearance

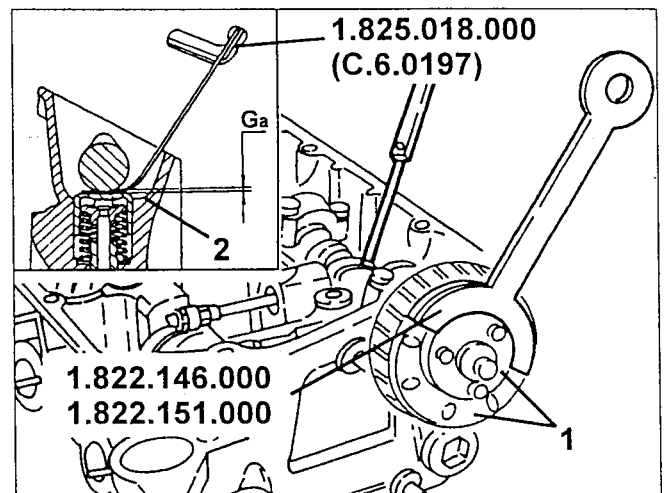
Intake side

- Refit the camshaft and measure intake valve clearance as follows:
 1. Temporarily fit the hub and respective camshaft drive pulley.
 2. Turn the camshaft with tools no. 1.822.146.000 and no. 1.822.151.000. Check whether clearance "Ga" between the cam lower radius and the corresponding cup falls into the prescribed values with thickness gauge no. 1.825.018.000 (C.6.0197).

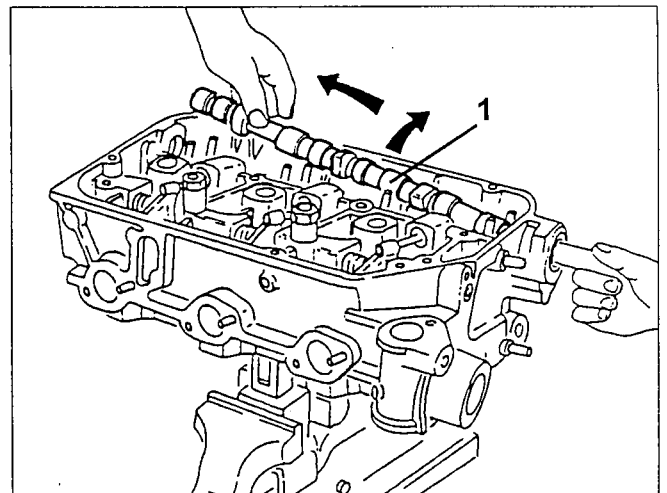


"Ga" intake valve clearance

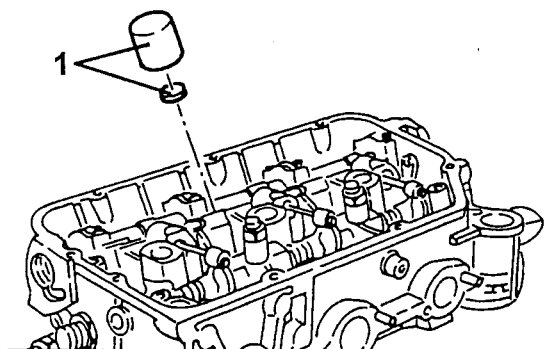
0.475 ÷ 0.500 mm



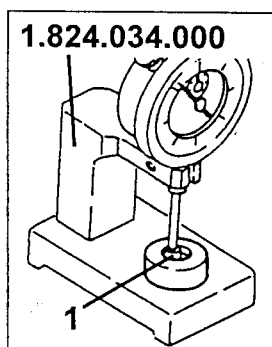
- If the intake valve clearance does not fall within the prescribed values, adjust as follows:
 1. Remove the bearings and remove the camshaft.



1. Remove the cups and remove the tappet clearance adjustment caps.



1. Measure cap thickness with tool no. 1.824.034.000 (and gauge). Then choose from set no. 1.820.150.000 (R.9.0001) those suitable to restore correct tappet clearance.

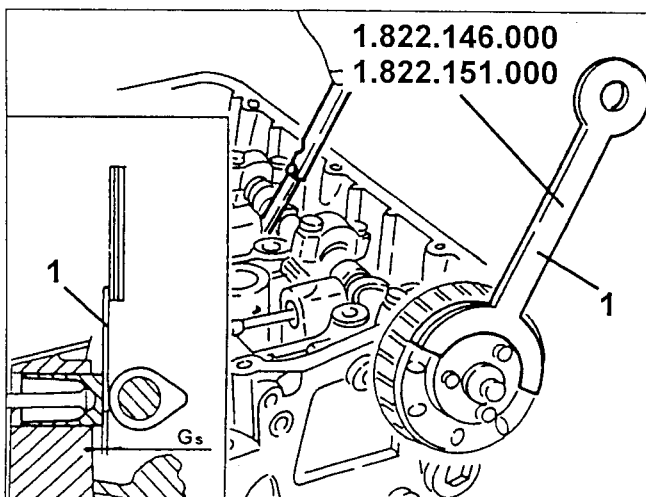


- Refit the caps, the camshaft and the respective bearings. Fasten the bearing nuts as prescribed and measure the intake valve clearance.

Exhaust side

- Refit the camshaft and measure intake valve clearance as follows:

1. Turn the camshaft with tools no. 1.822.146.000 and no. 1.822.151.000. Check whether clearance "Gs" between the cam lower radius and the corresponding cup falls into the prescribed values.

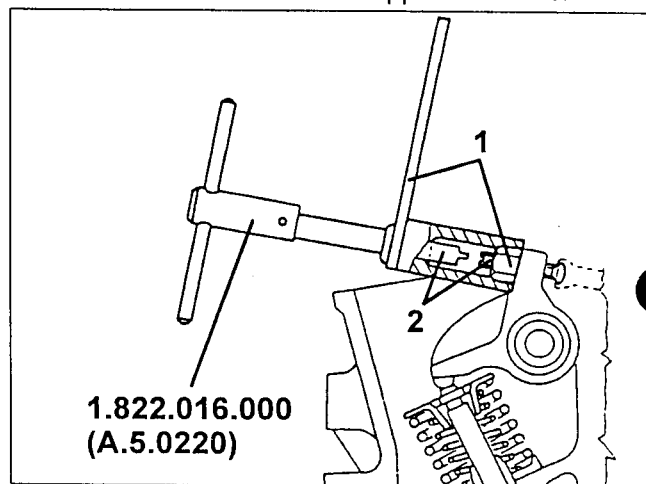


"Gs" exhaust valve clearance

0.275 ÷ 0.300 mm

- If the intake valve clearance does not fall within the prescribed values, adjust as follows:

1. Loosen the adjustment screw lock nut with tool no. 1.822.016.000 (A.5.0220) intermediate lever.
 2. Turn the adjustment screw with the tool to reach the prescribed exhaust valve clearance.
- Lock the lock nut and check tappet clearance.



Crankshaft refitting

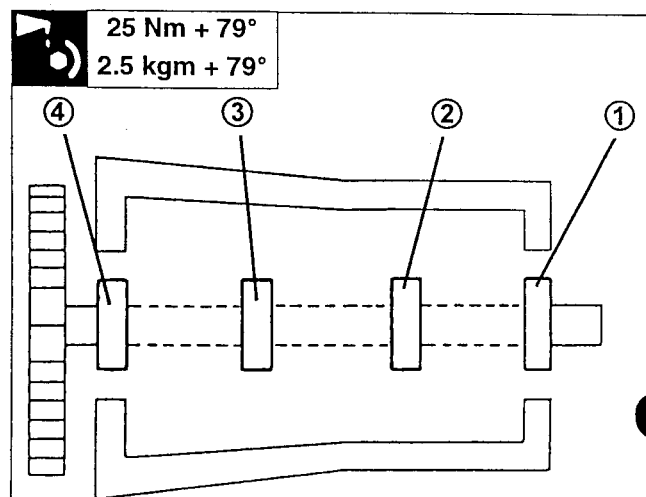
- Fit the crankshaft with half-bearings and thrust half-rings on the crankcase.

NOTE: Refit the half thrust rings with the grooved surfaces facing the crankshaft.

- Fit the main bearings and half-bearings on the journals according to the numbers. Fasten to the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angle torque.

NOTE: The safety notches on the crankcase and on the main bearings should be on the same side.

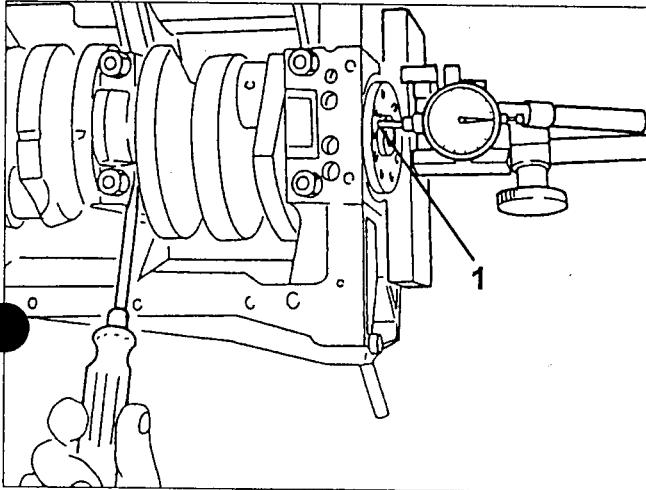


Crankshaft axial play

1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.



Crankshaft axial play
0.080 ÷ 0.265 mm



Cylinder liner, piston and connecting rod refitting

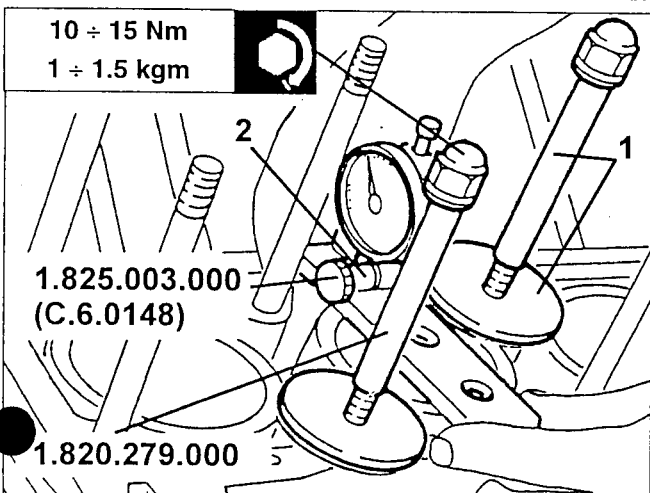
- Clean the cylinder liners carefully, fit the seals and insert in the crankcase. Make sure they reach the end of the stroke.

1. Lock the cylinder liners in the crankcase with the liner retainer tools no. 1.820.279.000 and fasten the respective nuts at the prescribed torque.

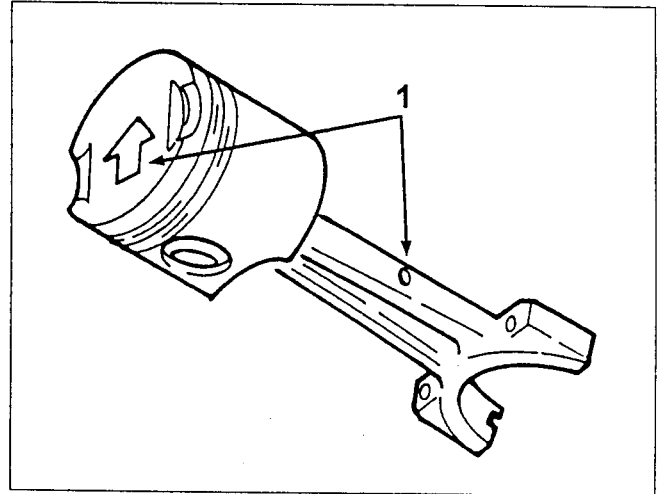
2. Fit tool no. 1.825.003.000 (C.6.0148) and the reset centesimal gauge on the crankcase. Position one side and then the other so that the feeler is in contact with the cylinder liner edges. Check the projection falls within the prescribed values.



Crankcase cylinder liner projection
0.01 ÷ 0.06 mm



1. Couple the pistons and their respective connecting rods. Make sure the arrow printed on the top of the piston is facing the direction shown in the figure with respect to the lubrication hole on the side of the connecting rod.



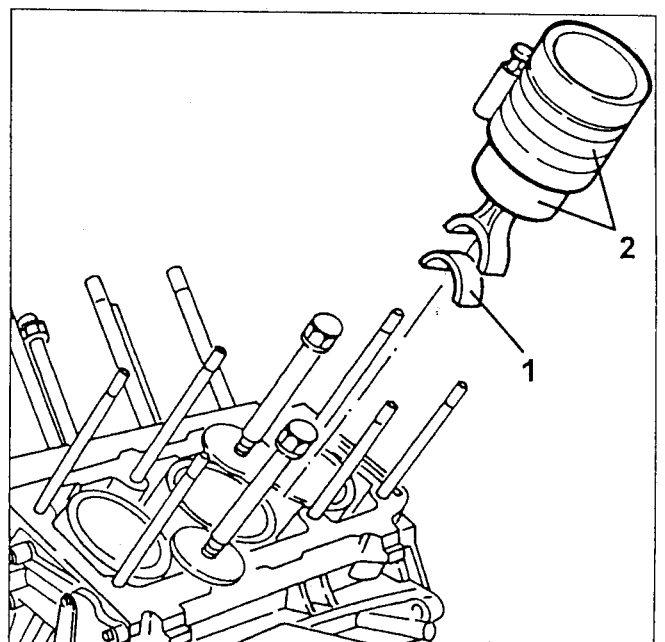
- Fit the gas rings and the oil scraper on the piston with a suitable tool.

NOTE: After refitting, address the gas ring cuts so that they do not coincide with the journal axis and at 120° one from the other.

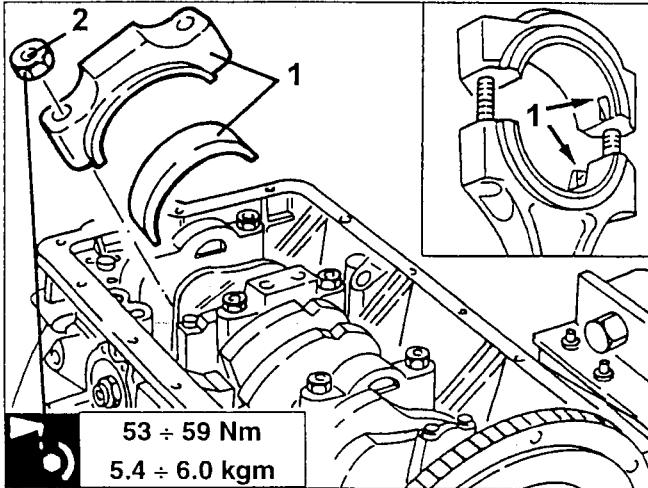
1. Fit the respective half-bearings on the connecting rod big end.

2. Insert the connecting rod-piston assembly in the bank cylinder liner with a suitable tool.

NOTE: Fit the connecting rod-piston assembly so that the arrow printed on the top of piston is facing the front side of the motor and that the lubrication hole is facing towards the right-hand side of the crankcase.



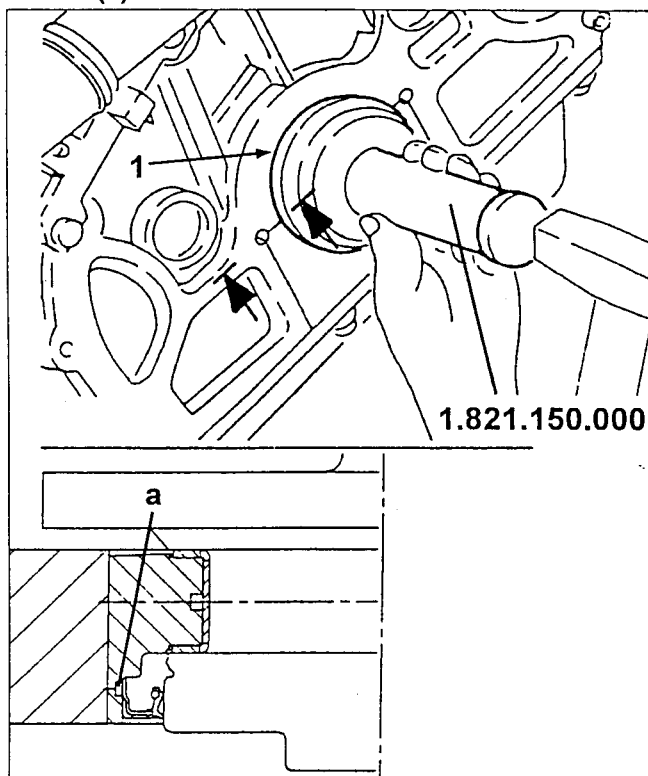
- Turn the crankcase on the overhaul stand.
- 1. Fit the connecting rod caps and half-bearings on the bank. Address the safety notch towards the notch on the connecting rod cap.
- NOTE:** The cylinder number is shown on the side of each connecting rod cap. When refitting, this number should be on the same side as the number printed on the connecting rod.
- 2. Fasten the connecting rod cap screws at the prescribed torque.



- Fit the pistons and the connecting rod of the other bank in the same way.

Oil sump refitting

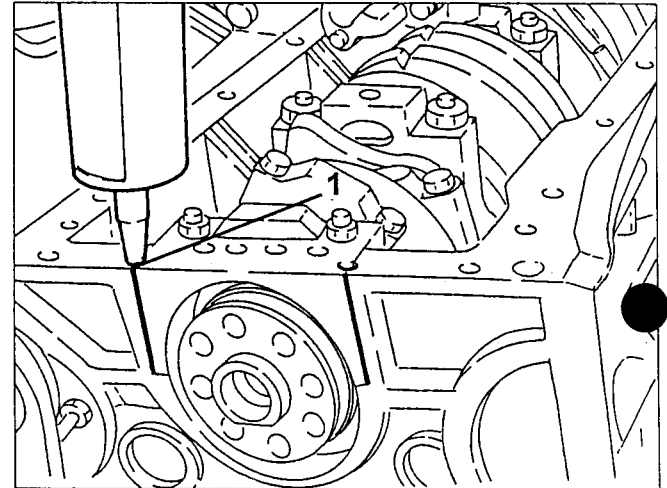
- 1. Fit the rear crankshaft oil seal with tool no. 1.821.150.000.
- NOTE:** Fit the oil seal in its seat so that the holes (a) are covered.



For pre-change versions (to engine no. 05697)

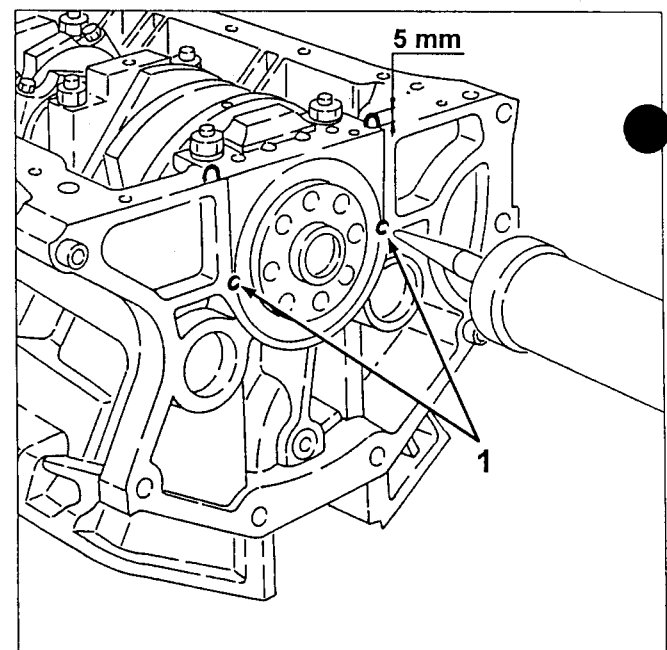
- 1. Apply "DOW CORNING 7091" silicon sealant with a mechanical gun through the holes shown in the figure.

NOTE: Check that the sealant seeps out from the rear crankcase-main bearing coupling along the entire length.

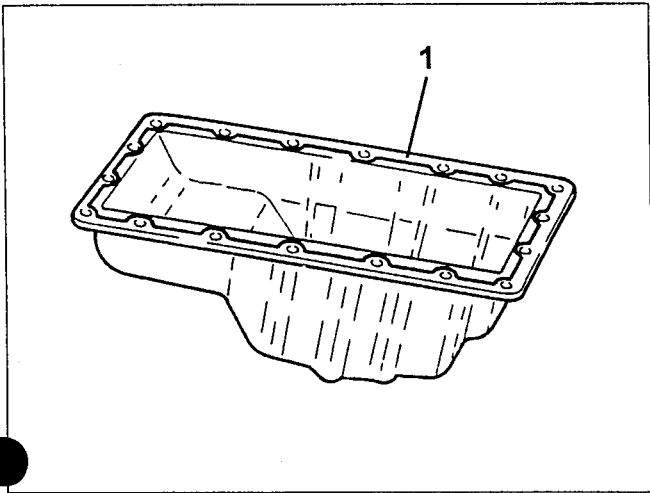


Post-change versions (from engine no. 05698)

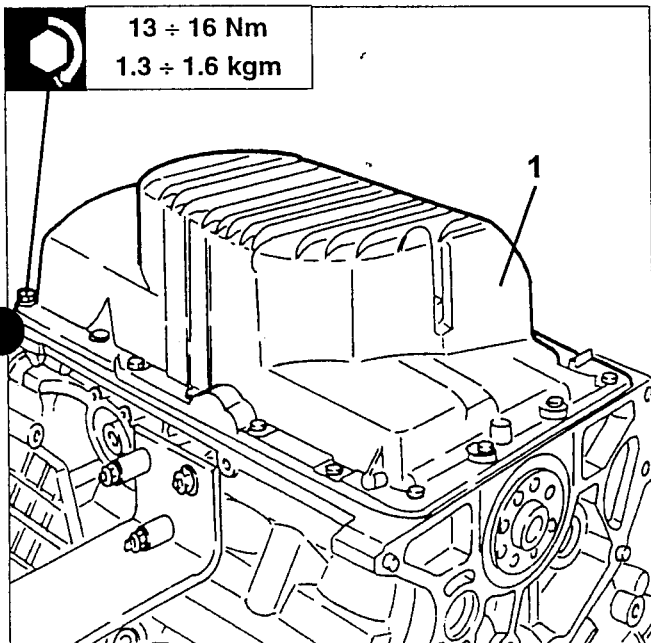
- 1. Apply "DOW CORNING 7091" silicon seals by means of a mechanical gun through the holes on the crankcase until the sealant seeps out from the engine oil sump coupling by approximately 5 mm.



1. Apply sealant to the oil sump. Make sure the strip of sealant (not wider than approximately 1.5 mm in diameter) is within the oil sump fastening holes (between reservoir and hole).



1. Position the oil sump avoiding considerable side movements which could remove the silicon sealant. Then fasten the oil sump screws at the prescribed torque.

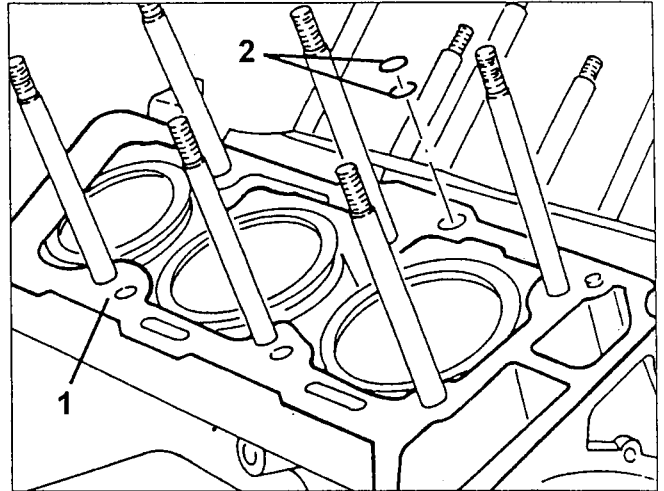


IMPORTANT: Fit the oil sump within 15 minutes from applying the sealant in the crankshaft rear seal holes.

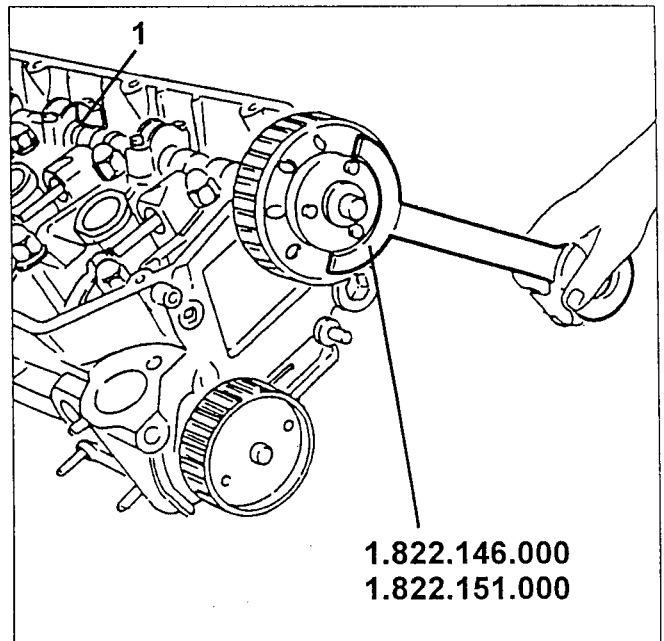
Cylinder head refitting

- Turn the crankshaft to take cylinder 1 piston to DTC.
 - Remove the previously fitted liner retainer tools no. 1.820.279.000.

1. Fit the cylinder head seals.
2. Fit the lubrication duct washer seals.

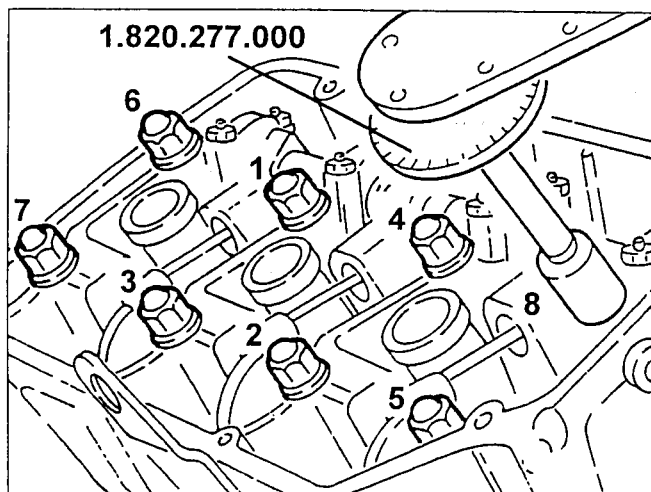


1. Turn the camshaft on each head with tool no. 1.822.146.000 and tool no. 1.822.151.000 until the timing reference notches on the camshafts correspond to those on the respective caps.



- Fit the cylinder heads on the crankcase.

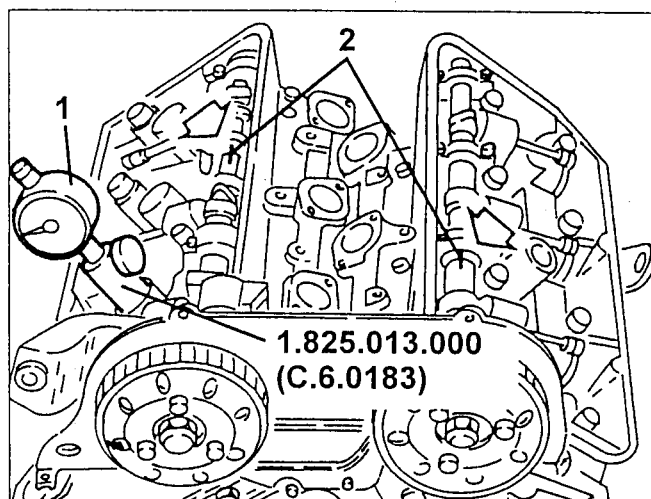
- Torque the cylinder head fastening screws as described below. The torque order is shown in the figure.



Tightening torque procedure	
Fasten all screws at:	25 Nm
Complete torque by an additional angle of:	240° ± 1°30'

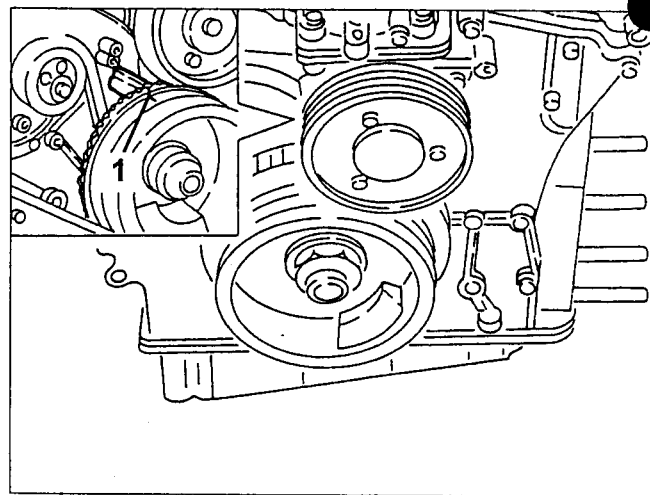
Refitting timing belt and checking timing

1. Turn the crankshaft to take cylinder 1 piston to TDC firing stroke with tool no. 1.825.013.000 (C.6.0183) and gauge.
2. Check alignment of the notches on the camshafts and those on the respective caps.

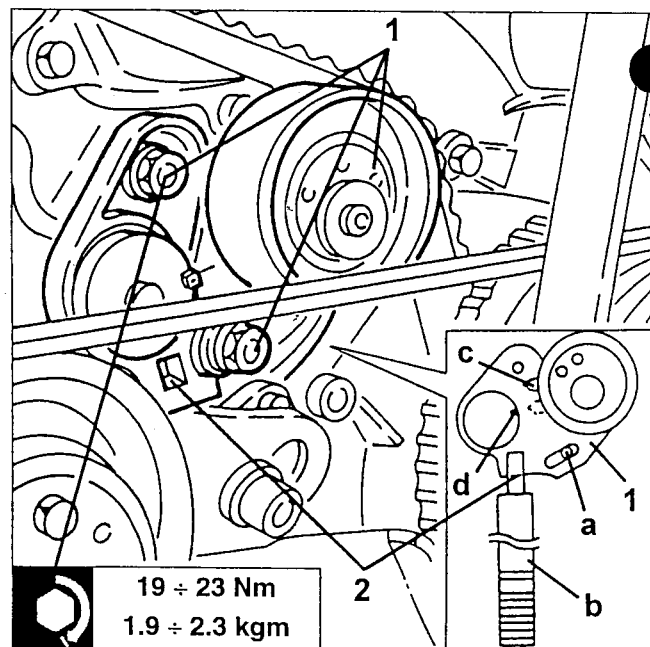


1. Furthermore, check alignment of the notch on the phonic wheel with the reference pin on the front crankcase cover.

PA493600000008



1. Position the timing belt take-up device so that stud "a" is as shown in the figure. Then torque the two fastening nuts locking them slightly.
 - Fit the timing belt on the pulleys from the drive pulley anti-clockwise.
 - Loosen the two belt take-up device fastening nuts.
2. Insert a template 10 mm from tension lever "b" (3/82 ratchet) in the belt take-up device hole. Then turn it anti-clockwise so to advance hand "c" by 2 - 3 mm until they meet. Then fasten the two belt take-up device nuts without locking them.
 - Turn the crankshaft clockwise by two turns to take cylinder 1 piston to DTC.
 - Check whether hand "c" meets central notch "d" and torque the two belt take-up fastening nuts as prescribed.
 - Remove the belt take-up tension lever "b".



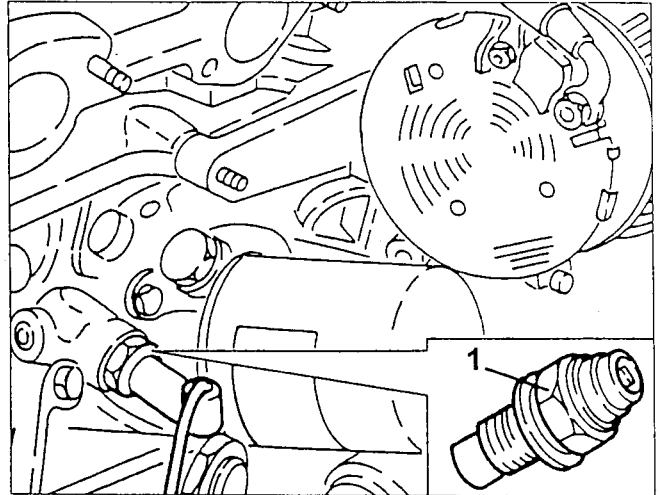
LUBRICATION CIRCUIT ELECTRICAL COMPONENT CHECKS

Minimum engine oil sensor warning light

1. Check the minimum engine oil pressure sensor calibration. If the values are not as prescribed, replace the sensor.



Contact open/close pressure
0.1 - 0.35 bar



For the other sensors and electrical components located in the engine compartment, refer to the specific assemblies where greater details are offered.



Vertical text or markings, possibly a page number or header, located in the left-center area of the page.

Horizontal text or markings, possibly a footer or page number, located at the bottom center of the page.



24V

ENGINE AR 16102

INDEX

GENERALITIES

- Description 1
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OVERHAULING

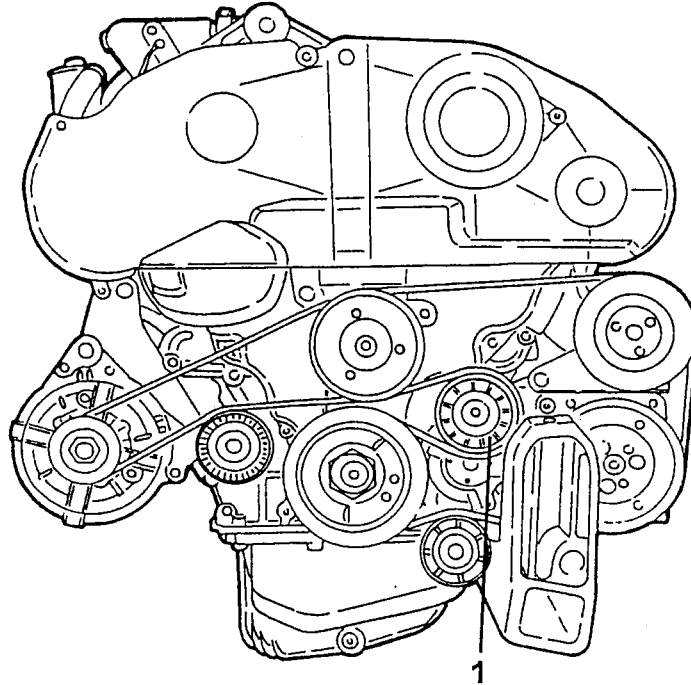
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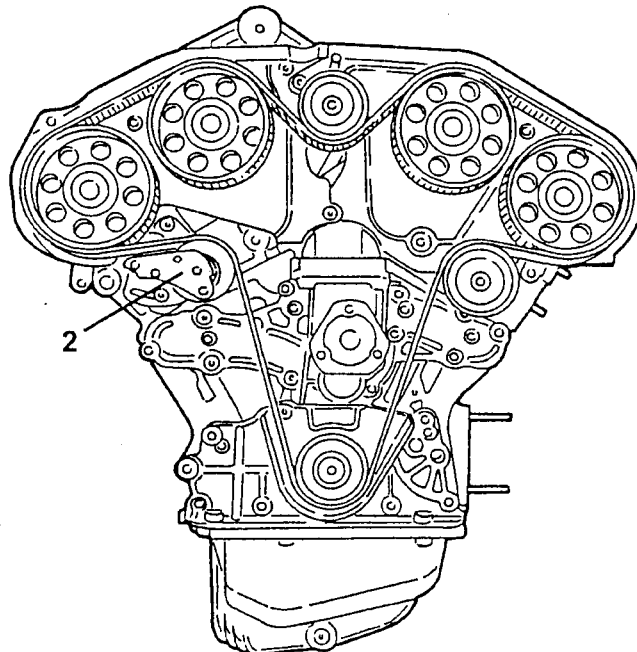
DESCRIPTION

Six cylinder, 60° V, compact, two camshaft timing for each bank and four valves per cylinder.
Static ignition, with one coil per spark plug.
Static injection and ignition are controlled by a single ECU.
The main variation of this engine with respect to the previous version are:

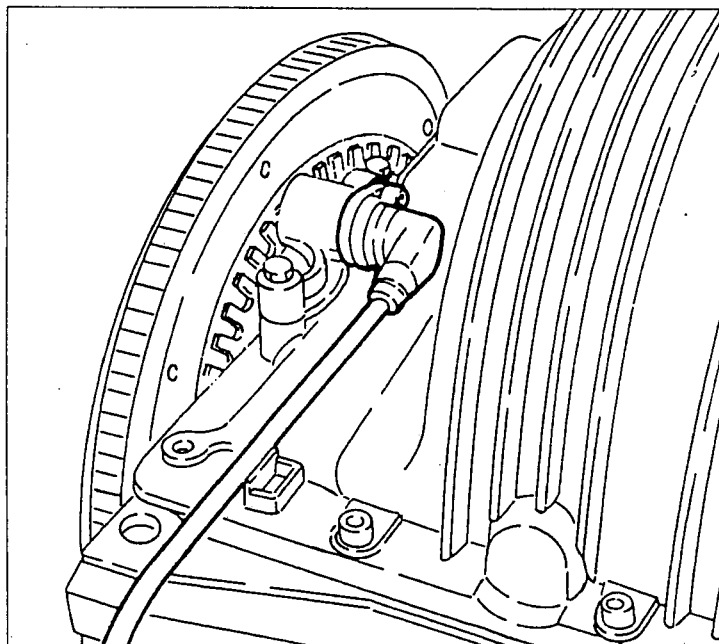
- "Compact" engine, thanks to the adoption of new accessory units (compressor, power steering, alternator) which reduce engine size.
- Adoption of a new automatic "Dayco" (1) auxiliary unit drive belt take-up device; this was a seven-rib Poly-V and is now a six-rib.



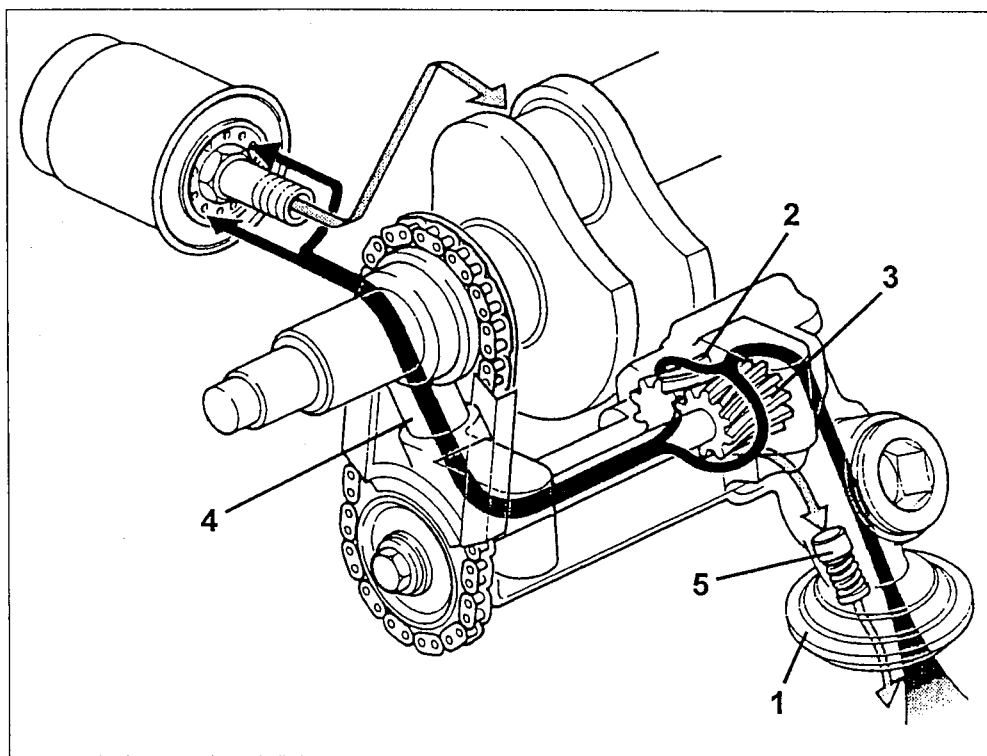
- Adoption of a new "litens" (2) timing belt drive take-up device.



- Positioning of an rpm and timing sensor phonic wheel on flywheel rather than on the auxiliary unit drive belt to eliminate the torsion oscillation effects and increases angle speed sensitivity. Consequently, it can more effectively identify misfiring.



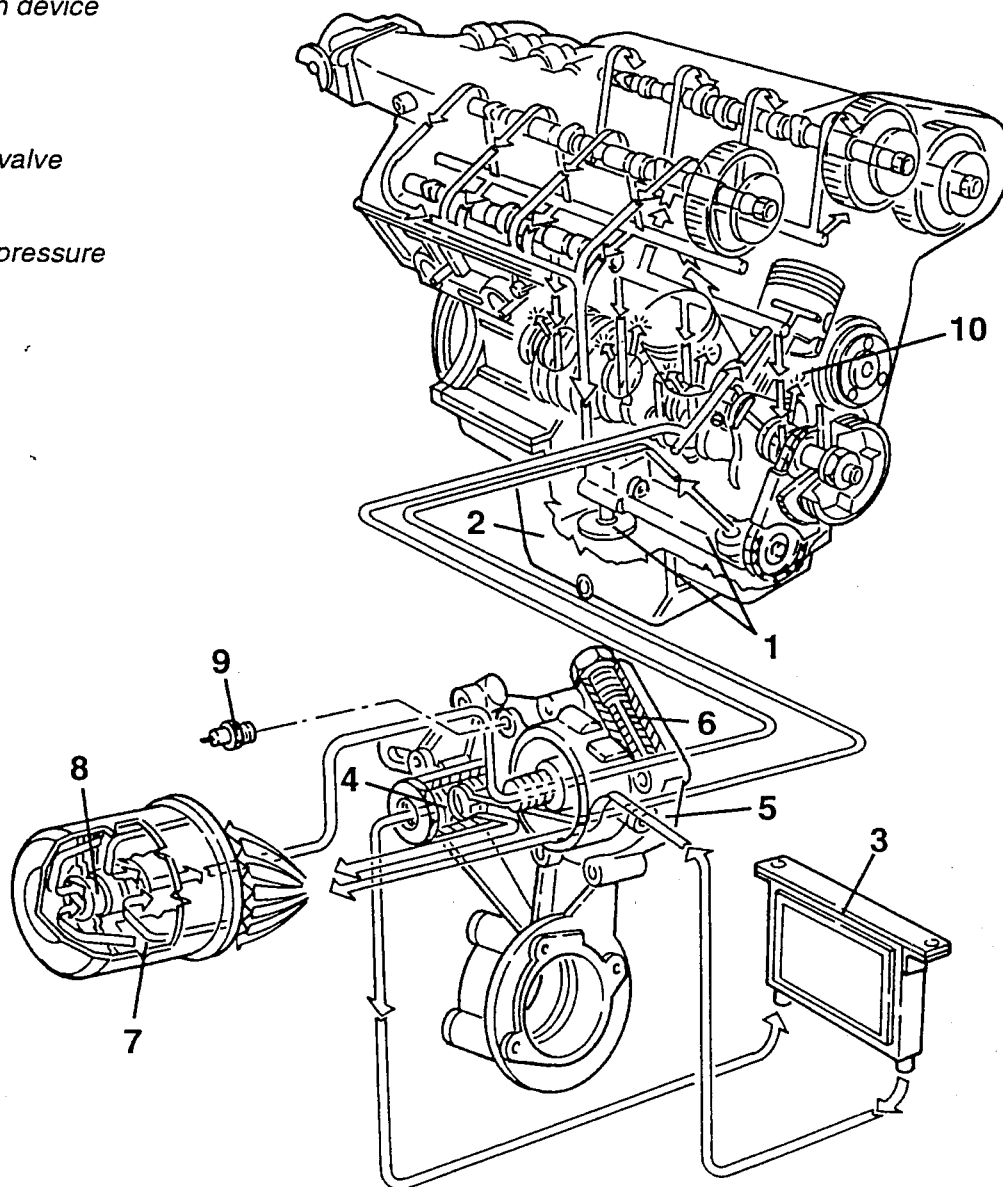
- Adoption of a "silent" oil pump chain (ex lobular, now geared) with increased performance, especially at low engine ratios.



1. Suction device
2. Drive gear
3. Drive gear
4. Oil supply manifold to filter
5. Oil pressure limiting valve

LUBRICATION SYSTEM

1. Oil pump with suction device
2. Oil sump
3. Oil radiator
4. Thermostatic valve
5. Oil filter support
6. Oil pressure limiting valve
7. Oil filter
8. By-pass valve
9. Engine oil minimum pressure warning light sensor
10. Spray jets



The engine lubrication system is pressurised through a rotary gear pump (1) complete with suction device fastened below the two main bearing caps.

The pump is operated through a "silent" chain drive which transmits motion from the crankshaft to the pump spindle.

A limiting valve (6) controls the system pressure. During intake, the oil is filtered through a net filtering element on the intake and then crosses a replaceable filtering element on the supply line.

A longitudinal oil groove in the crankcase allows lubrication of the crankshaft, pistons and connecting rods. Two other grooves allow lubrication of the cylinder heads and then all the components of the timing system including the hydraulic tappets. A recirculation system and a vapour separator recover the oil vapours leading from the right cylinder head.

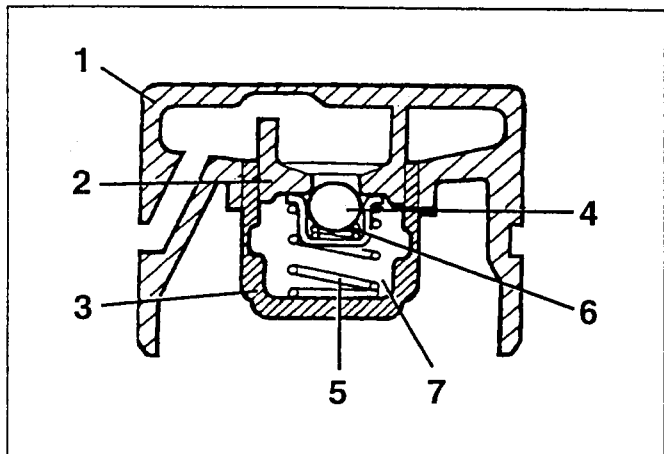
On the oil filter support (5) there is an engine oil minimum pressure sensor (9) which is connected to a warning light on the instrument cluster to alert the driver if the oil pressure is too low.

The oil filler plug is located on the timing gear cover of the left cylinder head.

The lubrication system includes an engine oil cooling radiator (3) and a thermostatic valve (4) located in the oil filter support. With temperatures below $82 \pm 2^\circ\text{C}$, the oil flows directly into the cartridge filter and returns to the engine, with temperature above this value, the thermostatic valve is open and allows the oil to flow into the cooling radiator to lower the temperature.

To improve cooling the piston skirts the crankcase has spray jets (10) with a small valve incorporated which opens at a pressure of 2.25 ± 2.75 bar.

DESCRIPTION OF THE HYDRAULIC TAPPETS AND HOW THEY WORK

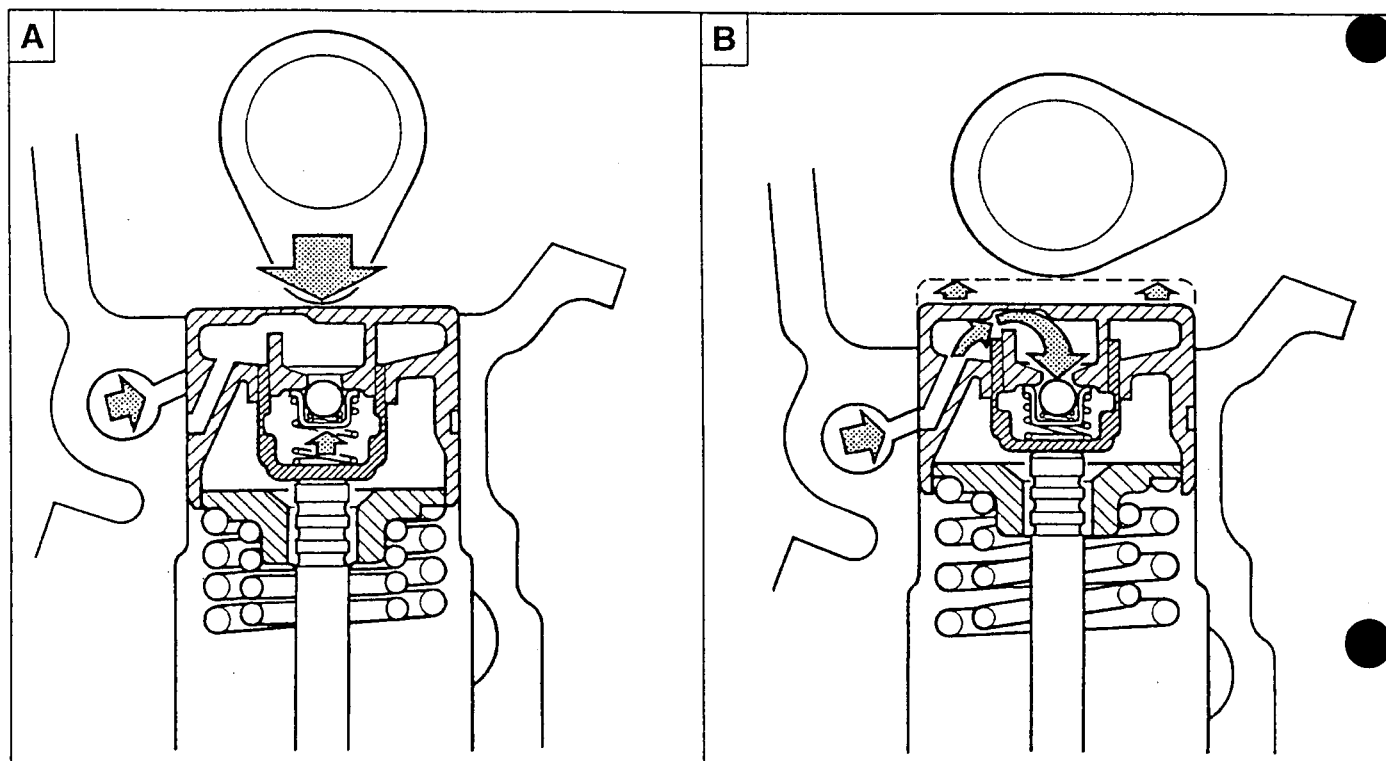


- 1. Body
- 2. Piston
- 3. Sleeve
- 4. Ball
- 5. Piston spring
- 6. Ball valve spring
- 7. Chamber

The hydraulic tappets automatically nullify the valve clearance when the engine is running. This makes it possible to obtain quieter running (especially for multivalve engines) along with the advantages deriving from the extremely simplified servicing operations. Elimination of the valve clearance ensures the start of the opening of each valve exactly in the instant programmed of each cycle.

The device works on the principle that lubricating oil is an incompressible fluid, therefore, when the camshaft cam acts on the cup (1) and consequently on the piston (2), the oil trapped in the chamber (7) (detail A), owing to the closing of the ball valve (4), transmits the motion of the piston (2) directly to the sleeve (3) and as a result to the valve. In this phase, due to the high pressure to which it is subjected, part of the oil in the chamber (7), leaks through the tiny gap between the piston (2) and the sleeve (3).

When the valve closes (detail B), to ensure that the tappet, pushed by the action of the spring (5) follows the profile of the cam, a vacuum is created inside the chamber (7) which causes the ball valve to open (4), allowing oil to be admitted. The oil admitted to the chamber (7) replaces that leaked out during the previous valve opening phase.



INTRODUCTION

The instructions given in the following paragraphs refer to complete overhauling of the engine on the bench after removing the power unit from the car.

The instructions are divided as follows:

- Engine disassembly:

removal of engine accessories and components and disassembly of the main units which form it.

- Disassembly and overhauling of cylinder heads: complete overhauling of all the head components.

- Crankcase overhauling:

complete overhauling of the crank components.

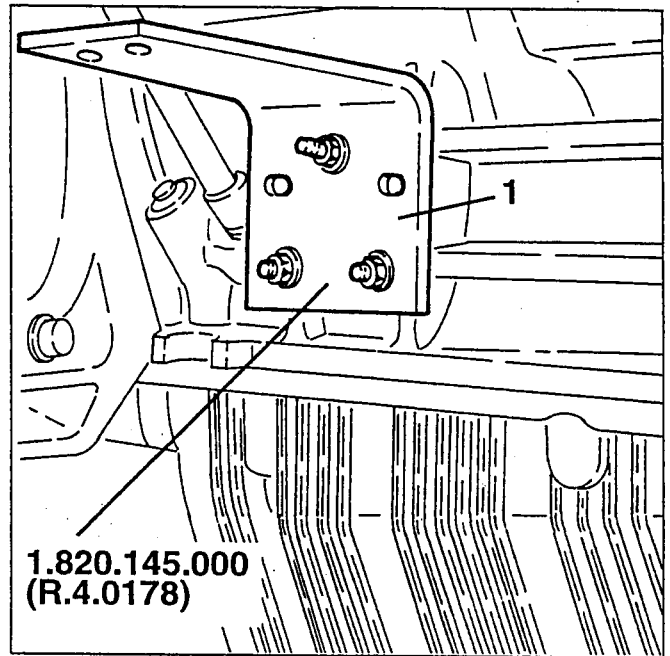
- Instructions for reassembly:

including specific reassembly operations which differ in good part from the disassembly instructions.

- Checking and inspecting electric components of the lubrication circuit.

All the disassembly procedures described in the part that follows, if reversed, are also valid for reassembly, except where otherwise stated.

The procedures that follow refer to complete overhauling of the whole engine; it is however possible to use certain parts separately when necessary for specific components.

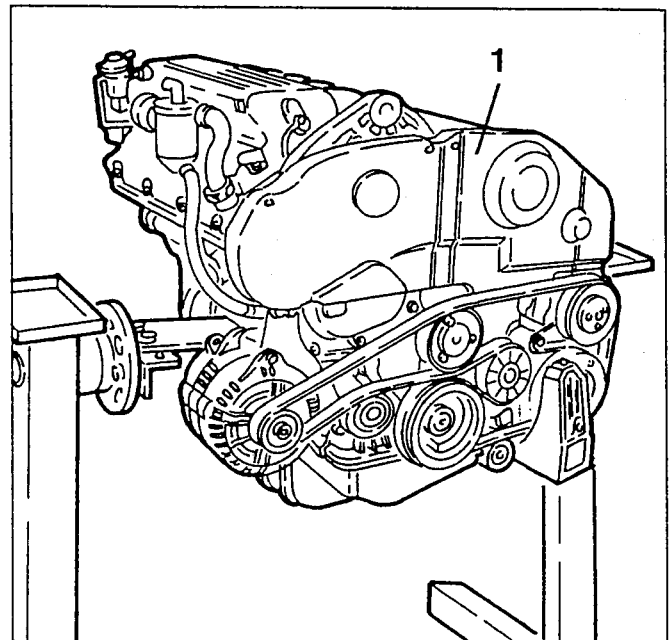
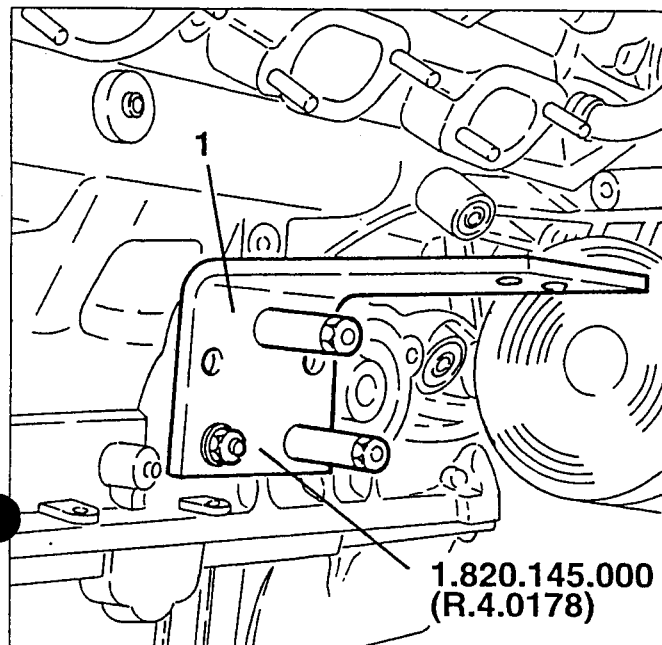


1. Raise the engine with the hydraulic jack and set it on the overhauling stand using the support brackets fitted previously.

ENGINE DISASSEMBLY

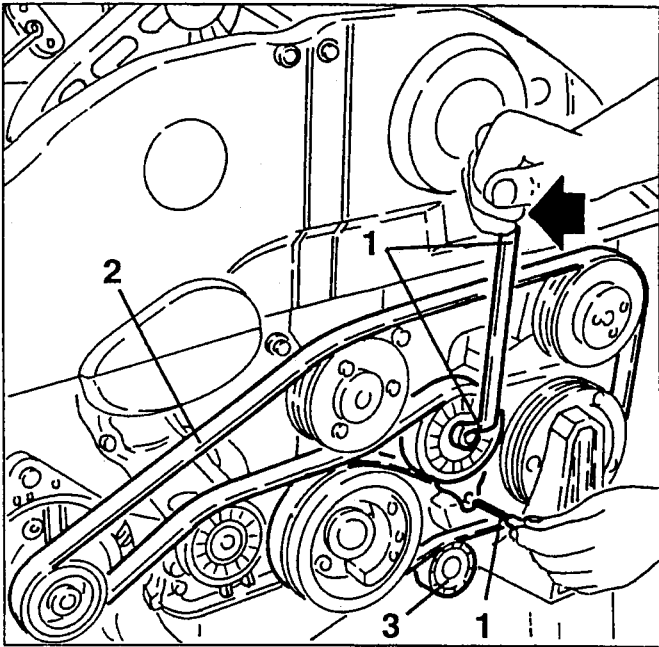
PRELIMINARY OPERATIONS

1. Install on the crankcase two brackets no. 1.820.145.000 (R.4.0178) for positioning the engine on the overhauling stand.

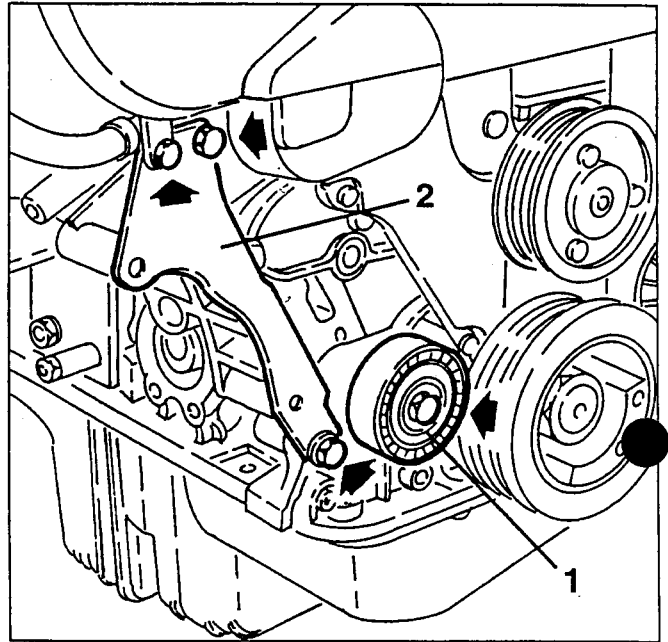


REMOVING THE ALTERNATOR

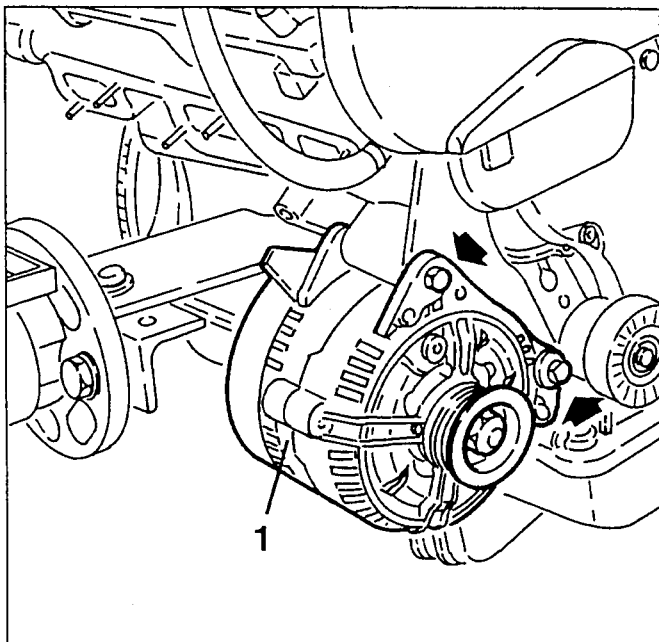
1. Slacken the tension on the auxiliary components drive belt as illustrated and lock the belt tensioner in this position using a special peg.
2. Prise and remove the auxiliary components drive belt.
3. Slacken the fastening screw and remove the lower guide pulley.



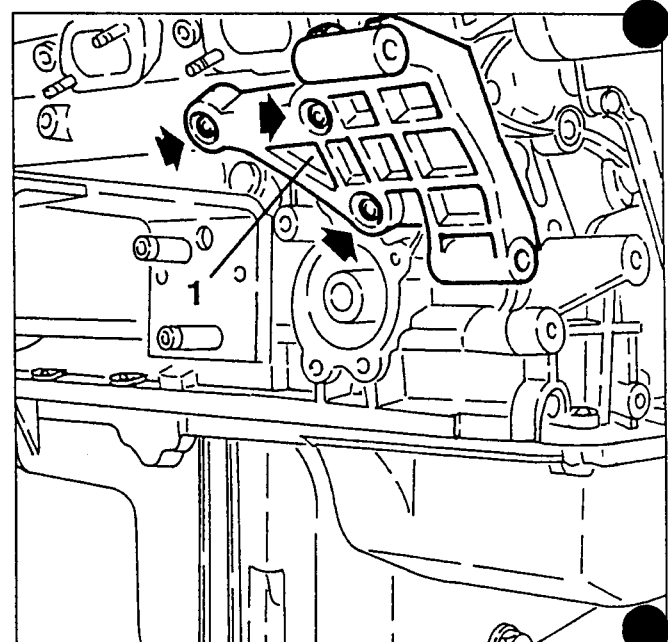
1. Slacken the fastening screw and remove the auxiliary components drive belt guide pulley.
2. Slacken the fastening screws and remove the spacer bracket.



1. Slacken the two fastening bolts and remove the alternator.

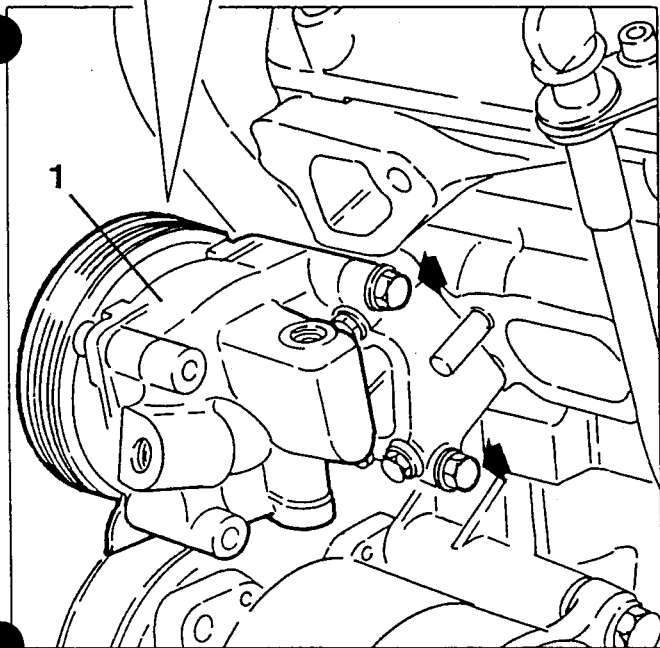
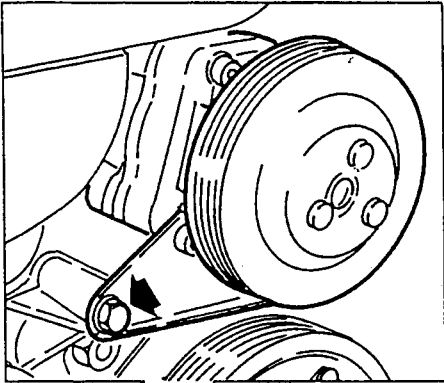


1. Slacken the fastening screw and remove the alternator support bracket.

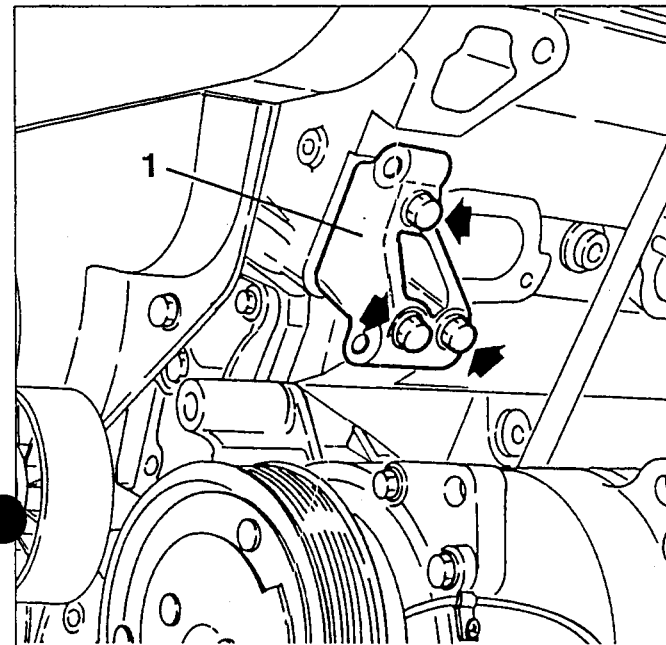


REMOVING THE POWER STEERING PUMP

1. Slacken the fastening screw and remove the power steering pump.

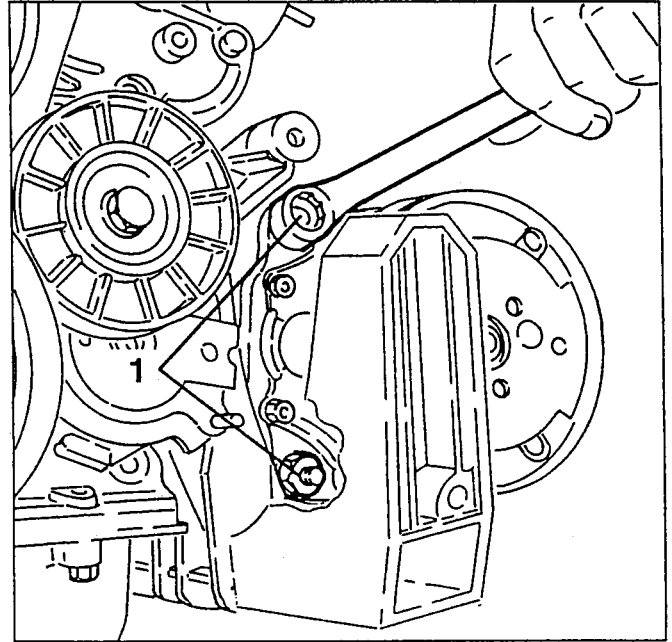


1. Slacken the fastening screw and remove the power steering pump support bracket.



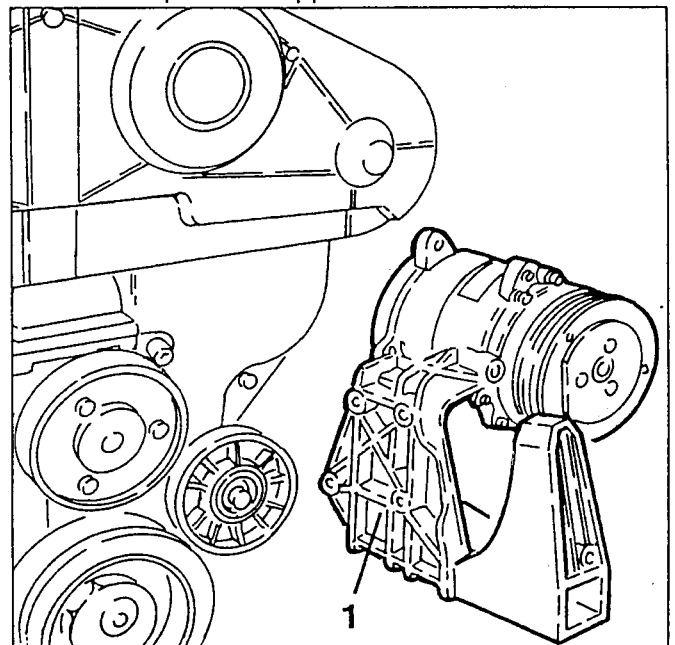
REMOVING THE AIR CONDITIONER COMPRESSOR

1. Slacken the bolts fastening the conditioner compressor and remove only the lower one.

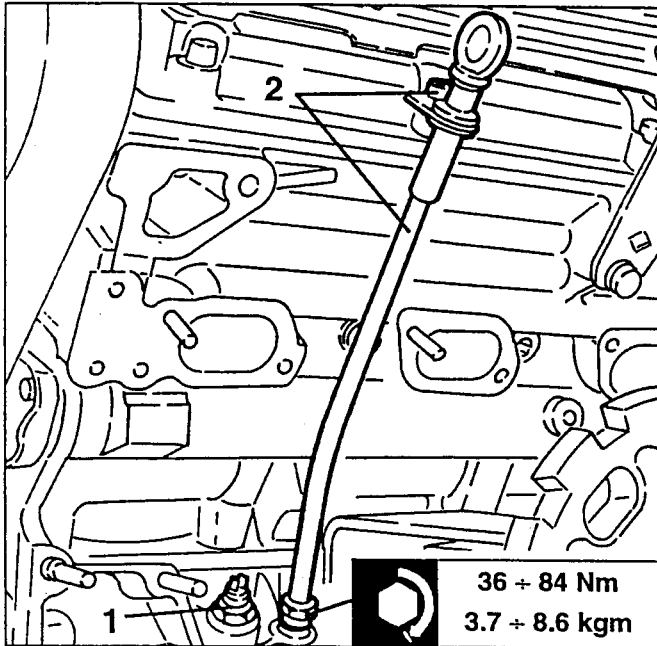


-Turn the conditioner compressor upwards pivoting on the upper fastening bolt and lock it in this position by tightening the bolt.

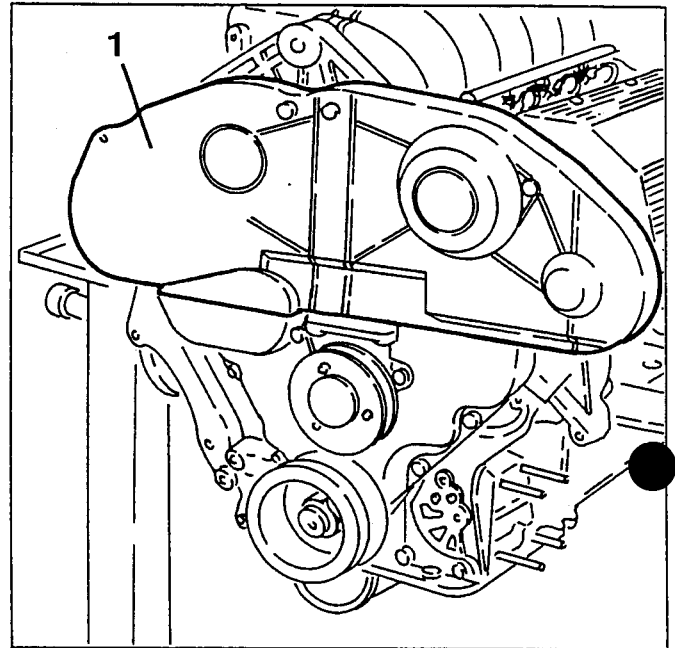
1. Slacken the four fastening nuts, which in this position are accessible and remove the complete air conditioner compressor support bracket.



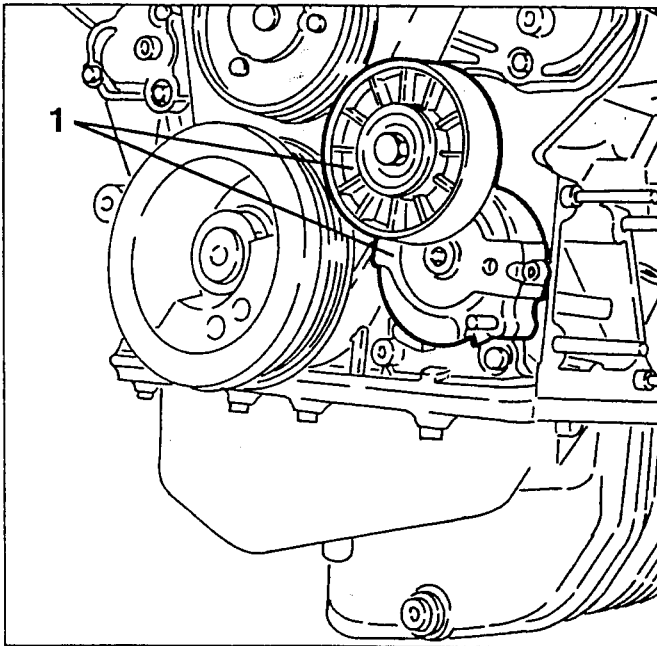
1. Slacken and remove the low engine oil level sensor from the crankcase.
2. Remove the engine oil dipstick complete with guide.



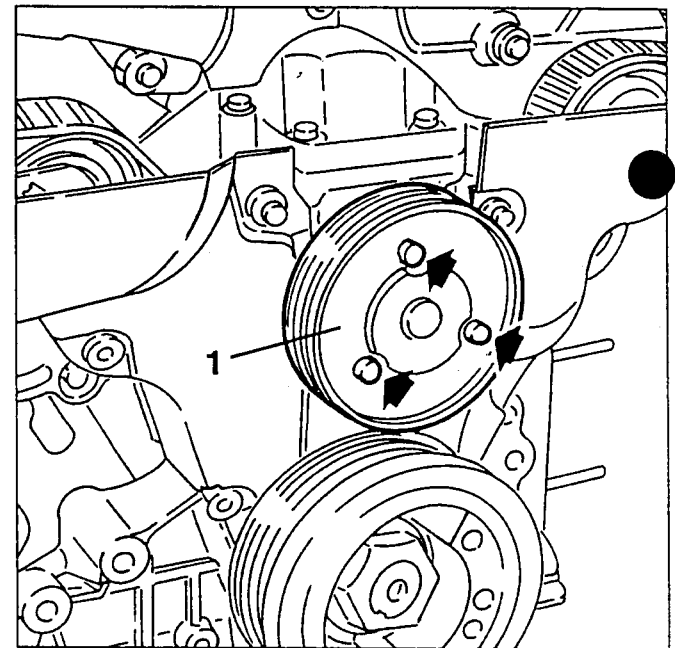
1. Slacken the fastening screw and remove the timing gear belt guard.



1. Slacken the fastening screw and remove the auxiliary components drive belt tensioner.

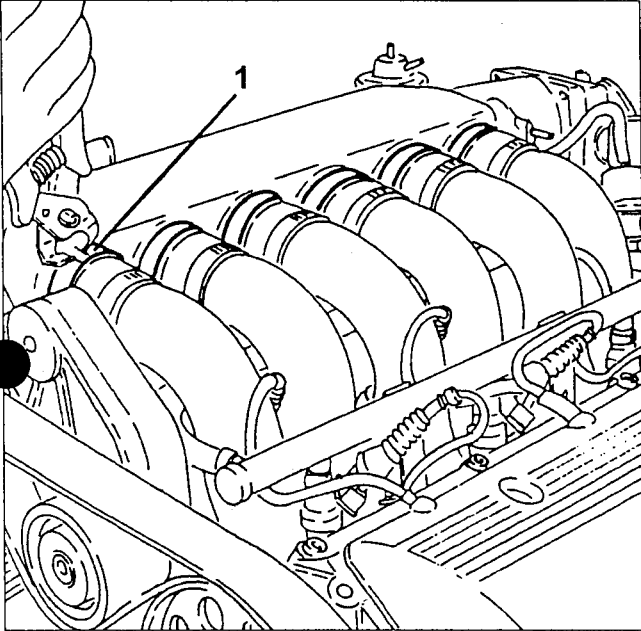


1. Slacken the fastening screw and remove the water pump pulley.

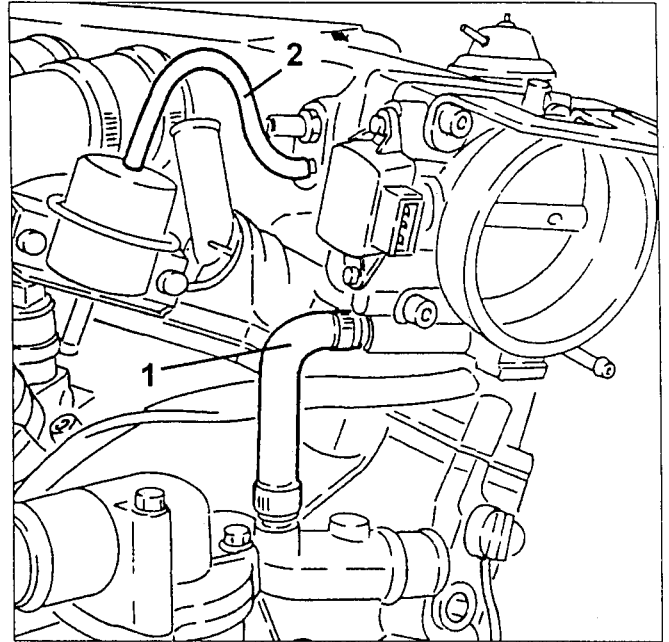


**INTAKE MANIFOLD REMOVAL
(pre-change version)**

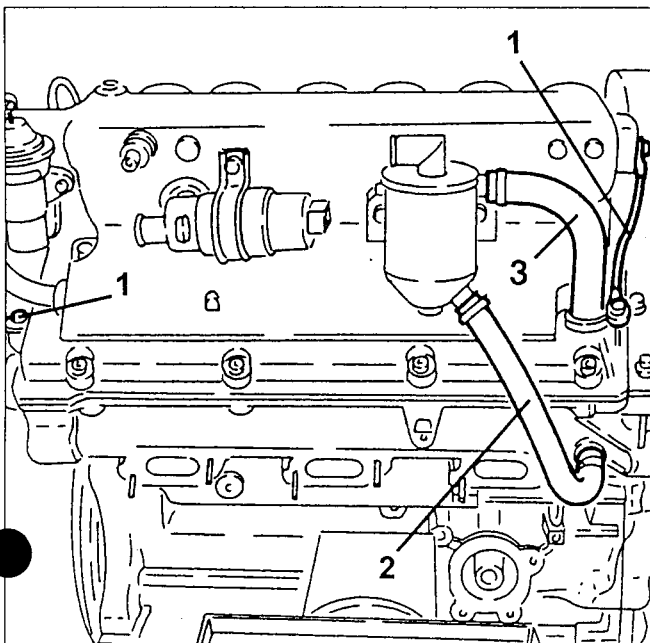
1. Loosen the clips fastening the air feed ducts to the intake manifold.
- Loosen the screws fastening the feed ducts to the cylinder heads.



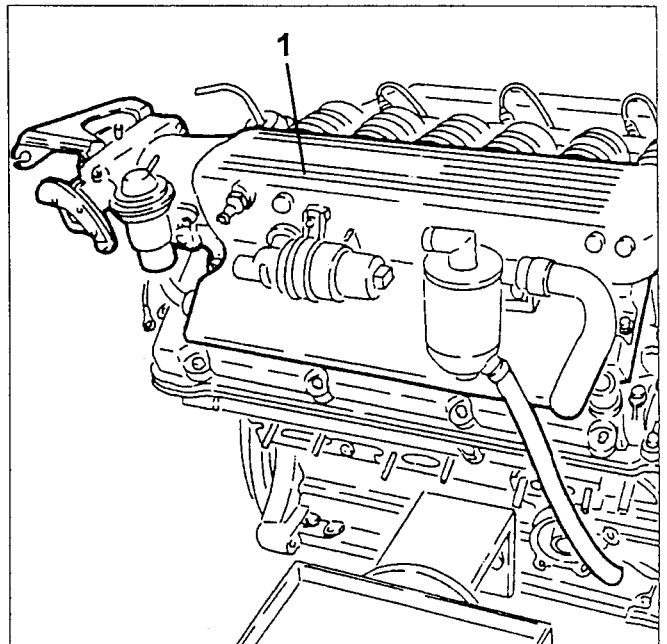
1. Disconnect the throttle casing coolant inlet pipe from the throttle casing.
2. Disconnect the fuel pressure regulator vacuum pipe from the intake manifold.



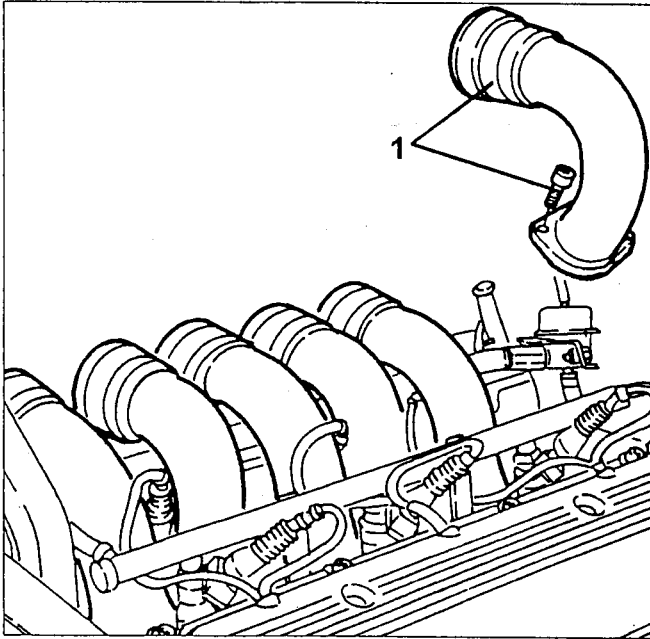
1. Disconnect the two earth wires between the intake manifold and the right-hand cylinder head.
2. Disconnect the condensed oil vapour recovery pipe from the separator.
3. Disconnect the oil vapour recovery pipe from the cylinder head.



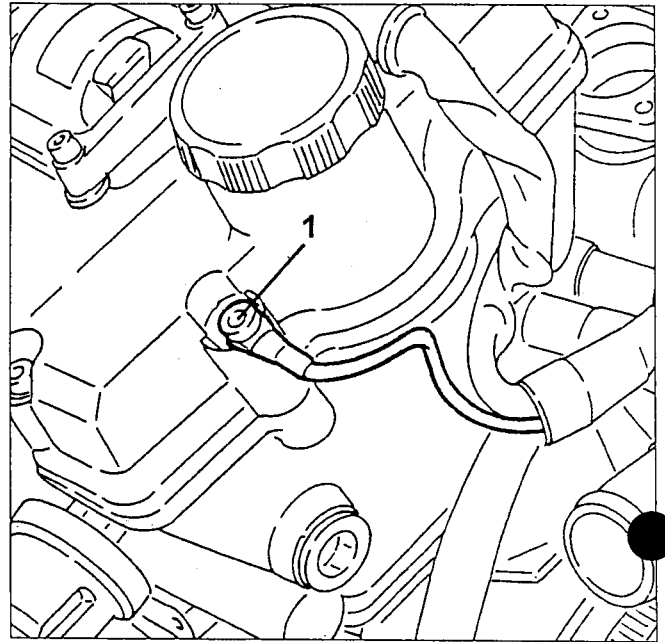
1. Loosen the fastening screws and remove the intake manifold/static ignition coil cover assembly from the right-hand cylinder head.



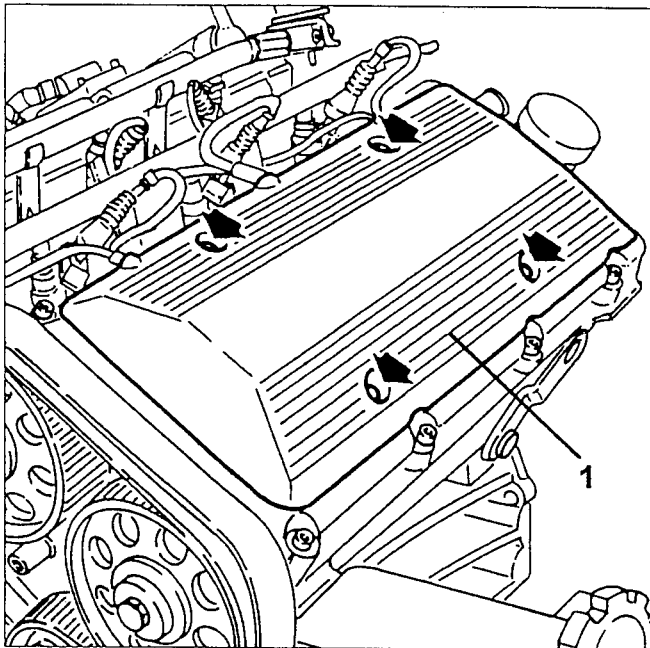
1. Completely remove the previously loosened fastening screws and remove the air feed ducts.
- Remove the respective seals.



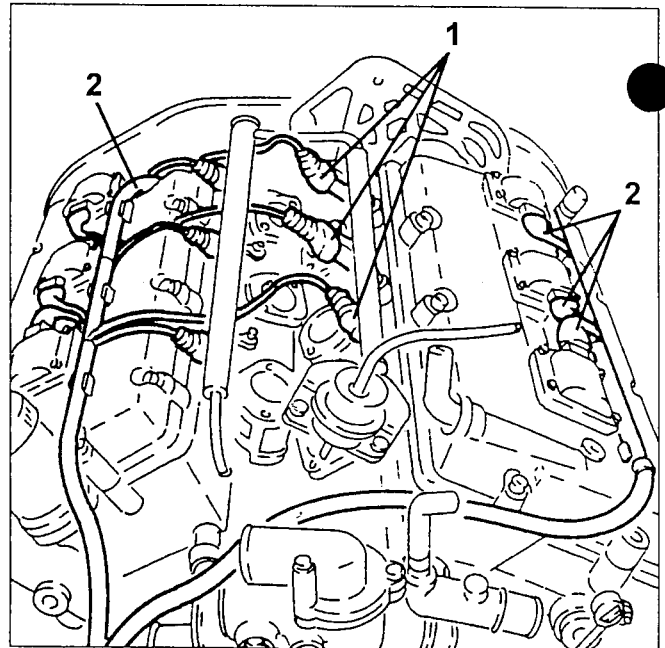
1. Disconnect the earth wire from the left-hand cylinder head.



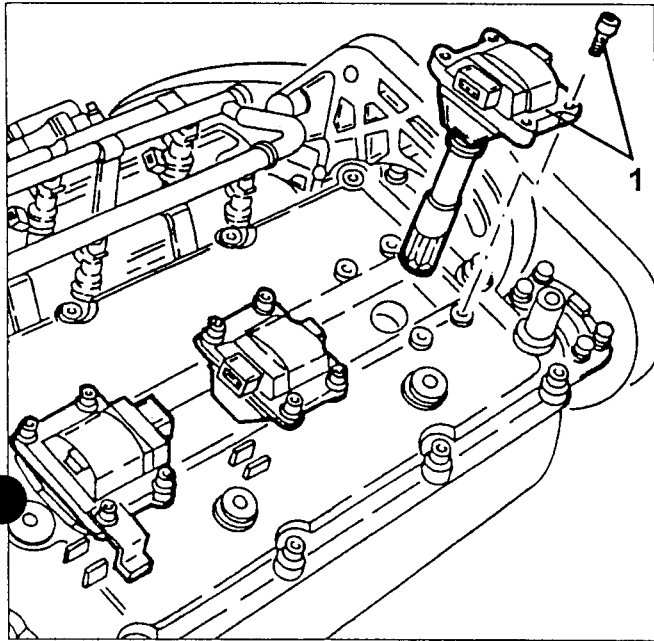
1. Loosen the fastening screws and remove the static ignition coil cover from the left-hand cylinder head.



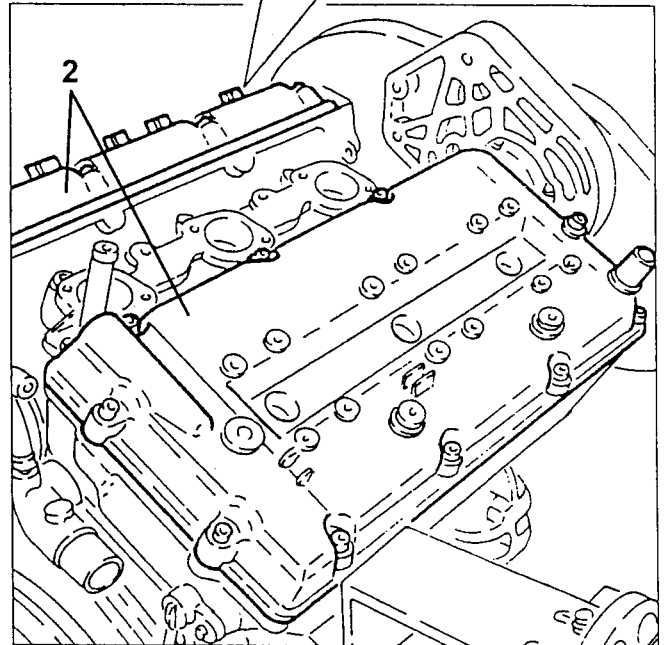
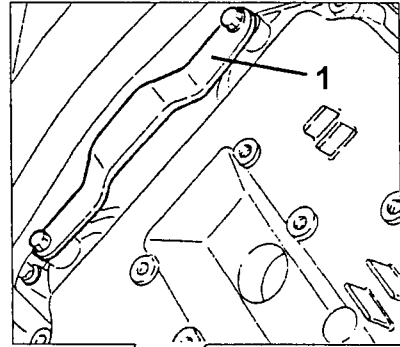
1. Disconnect the injector electrical connections.
2. Disconnect the static ignition coil electrical connections and then remove the electrical wiring by releasing the fastening clips.



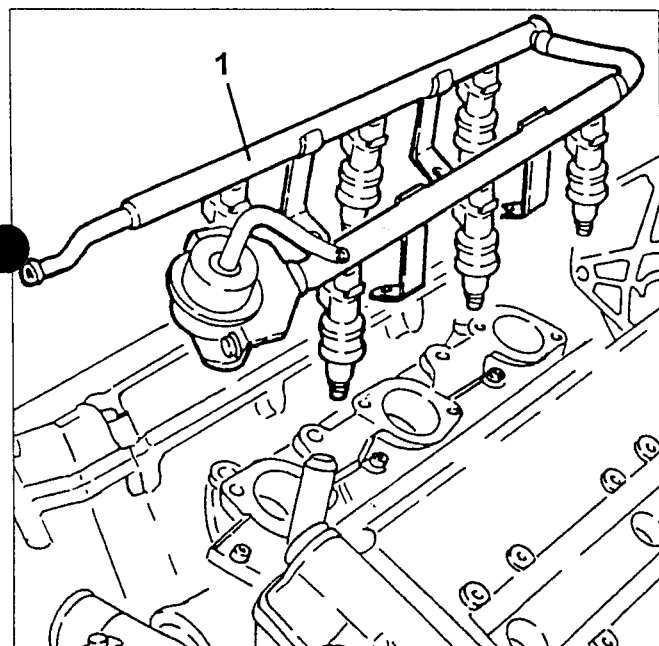
1. Loosen the fastening screws and remove the static ignition coils.
- Loosen and remove the spark plugs.



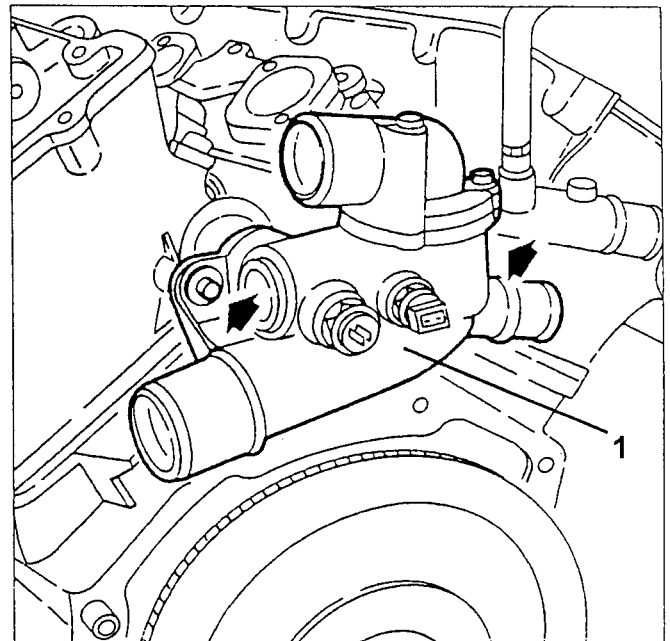
2. Loosen the fastening screws and remove the cylinder head covers.



1. Loosen the fastening screws and remove the fuel distribution manifold with the injectors.

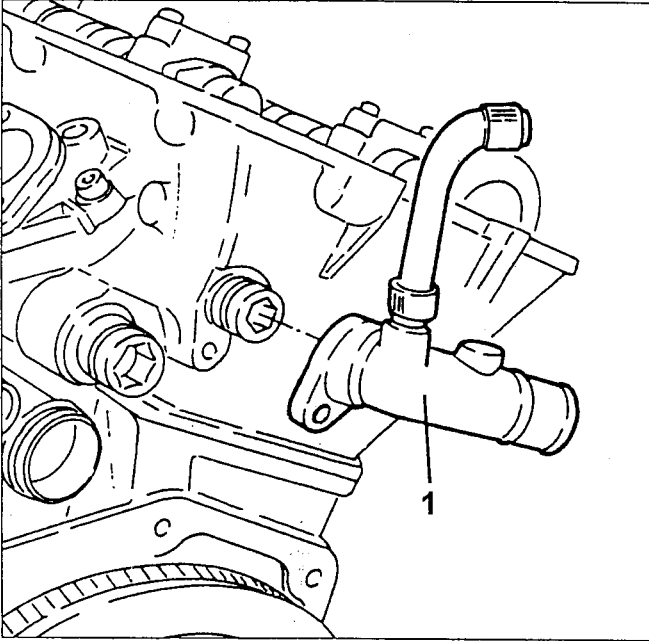


1. Loosen the fastening screws and remove the thermostat cup and sensors.

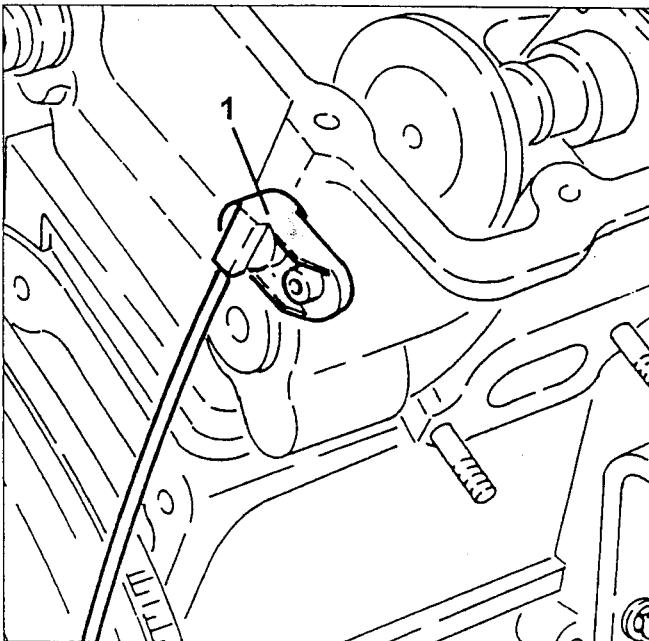


1. Remove the fastening screws and remove the rod and threaded nut to fasten the upper timing belt guard from the left-hand cylinder head.

1. Remove the throttle casing and climate control system heater coolant delivery duct.

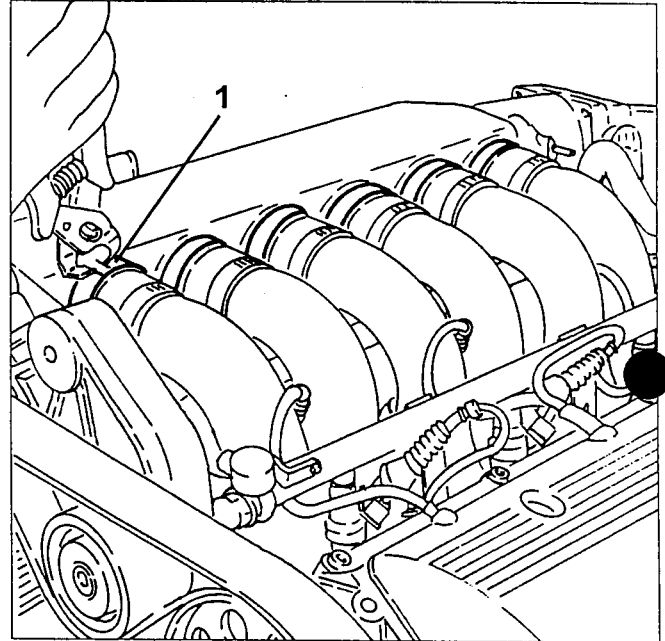


1. Loosen the fastening screw and remove the cam angle sensor.

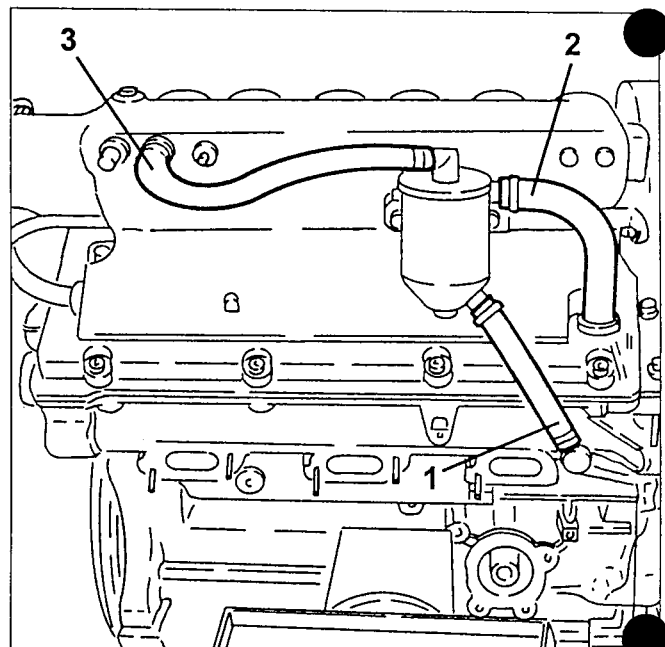


INTAKE MANIFOLD REMOVAL (post-change version)

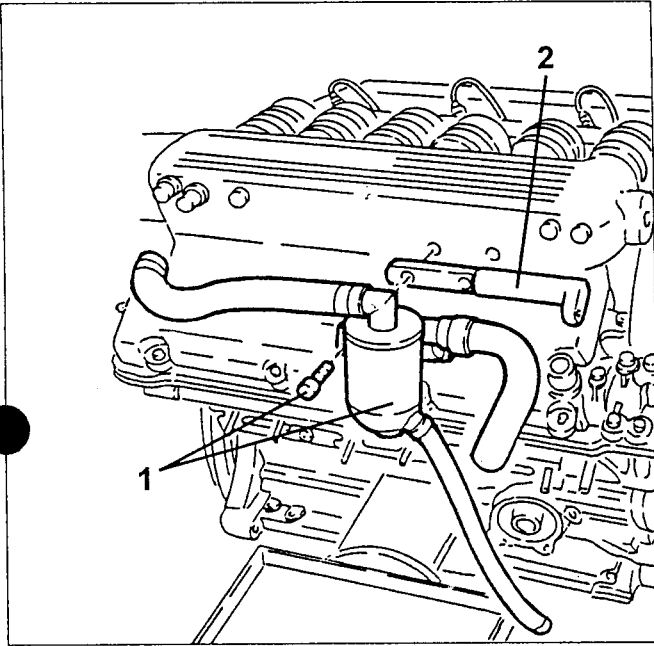
1. Loosen the clips fastening the air feed ducts to the intake manifold.
- Loosen the screws fastening the feed ducts to the cylinder heads.



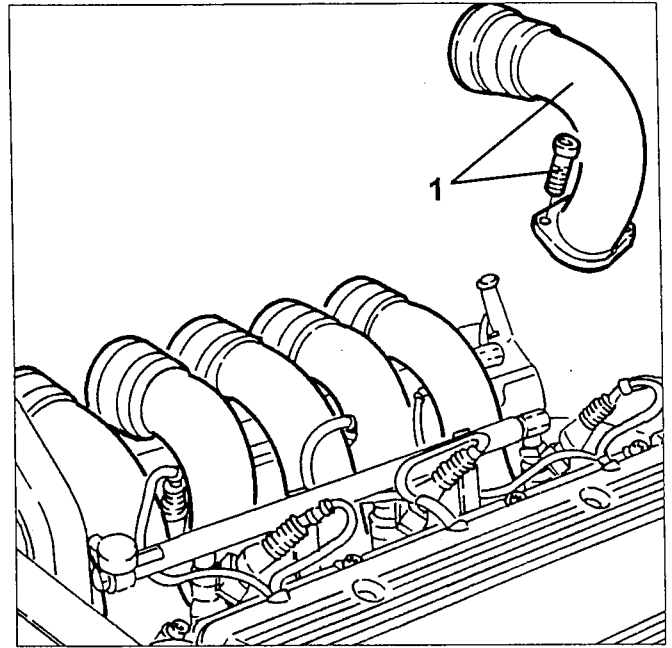
1. Disconnect the separator - condensed oil vapour recovery pipe from the cylinder head.
2. Disconnect the oil vapour recovery pipe from the cylinder head.
3. Disconnect the oil vapour recirculation pipe from the intake manifold.



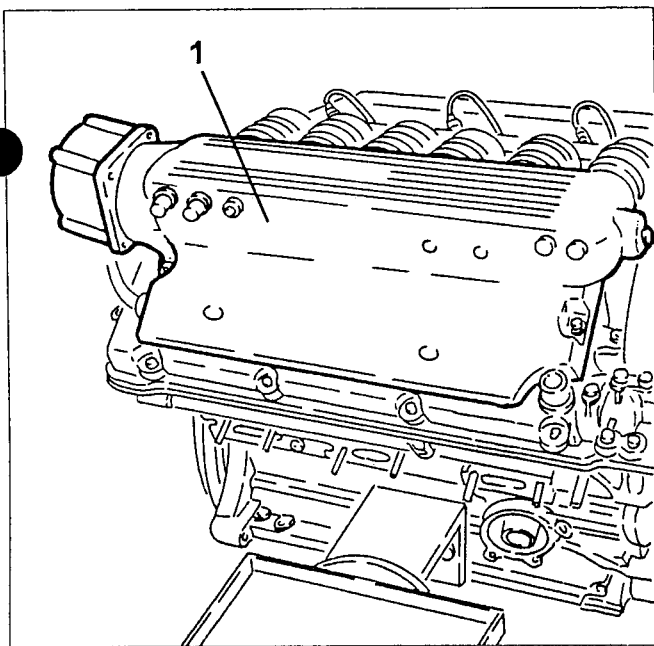
1. Loosen the fastening screws and remove the oil vapour separator.
2. Loosen the fastening screw and remove the intake manifold connection to the reaction tie-rod engine bracket.



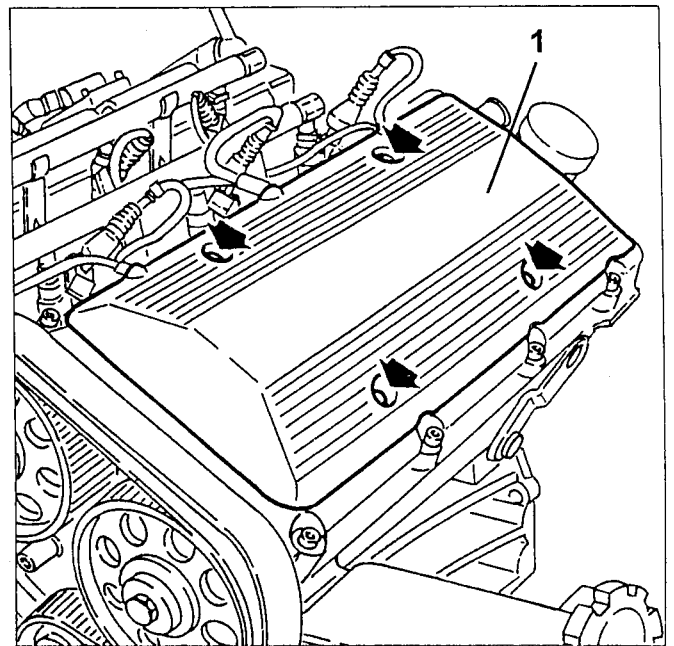
1. Completely remove the previously loosened fastening screws and remove the air feed ducts.
- Remove the respective seals.



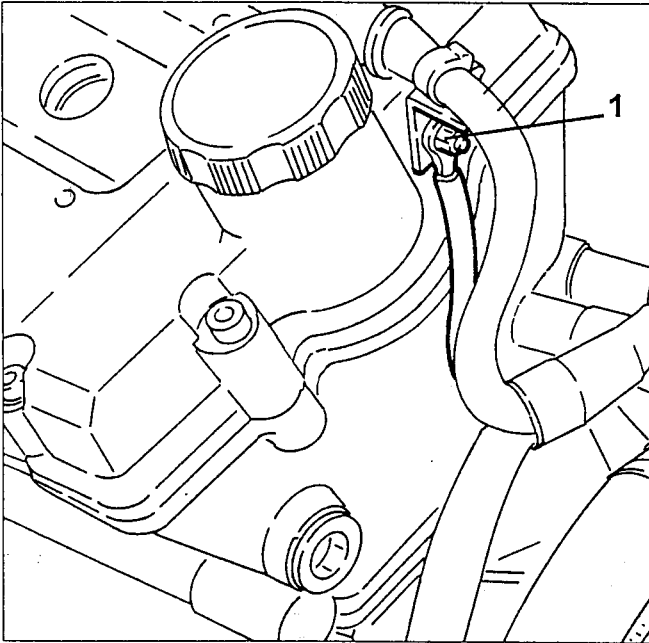
1. Remove the screws fastening the intake manifold/ignition coil cover assembly from the right-hand cylinder head.



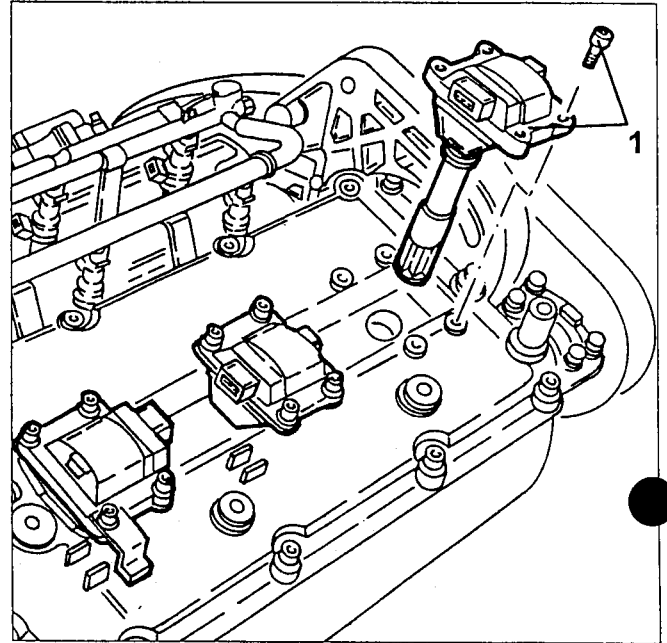
1. Loosen the fastening screws and remove the static ignition coil cover from the left-hand cylinder head.



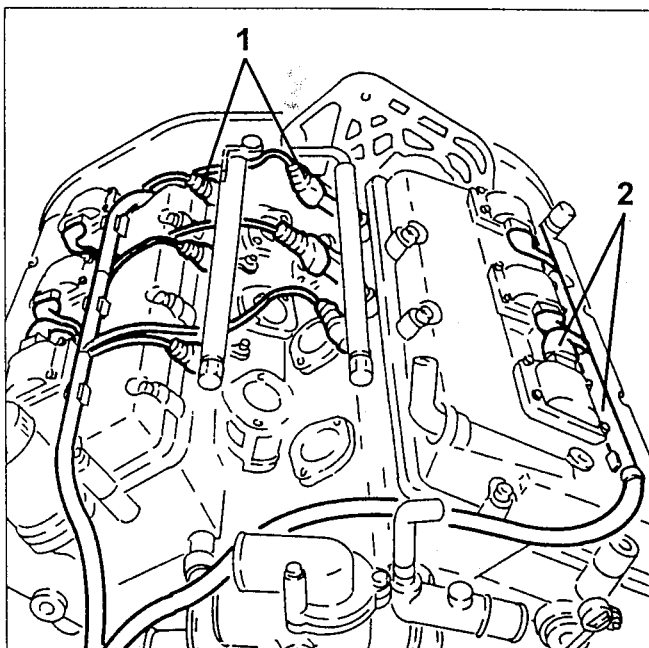
1. Disconnect the earth wire from the left-hand cylinder head.



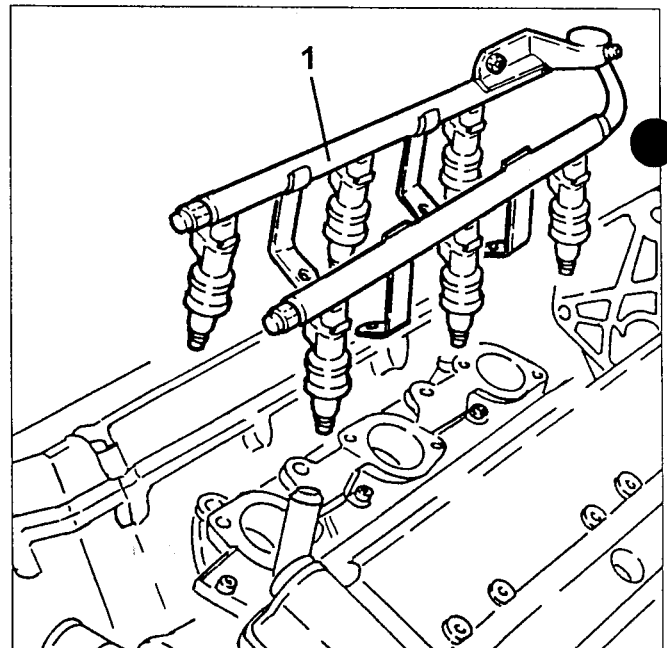
1. Loosen the fastening screws and remove the static ignition coils.
- Loosen and remove the spark plugs.



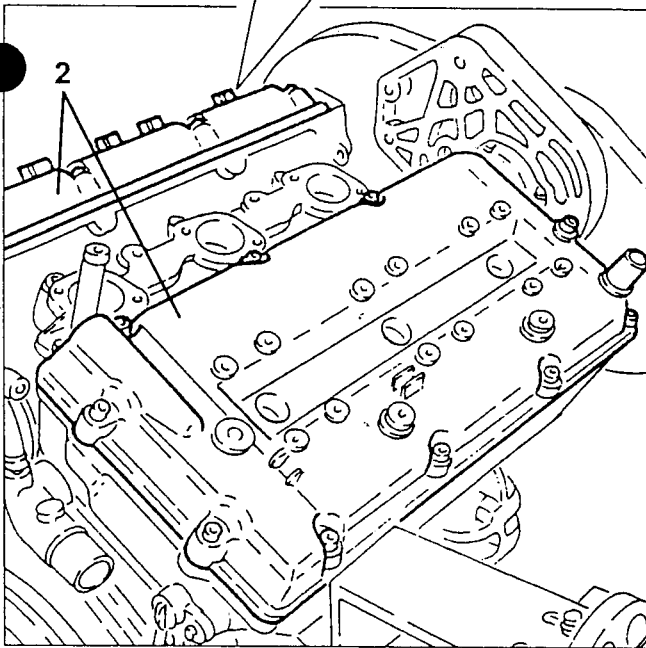
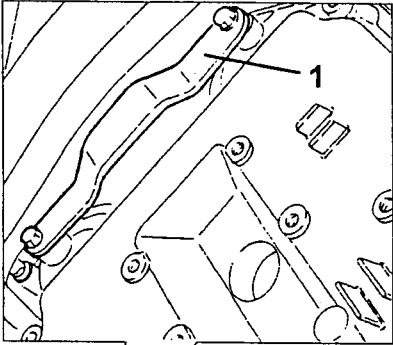
1. Disconnect the injector electrical connections.
2. Disconnect the static ignition coil electrical connections then remove the electrical wiring after releasing the fastening clips.



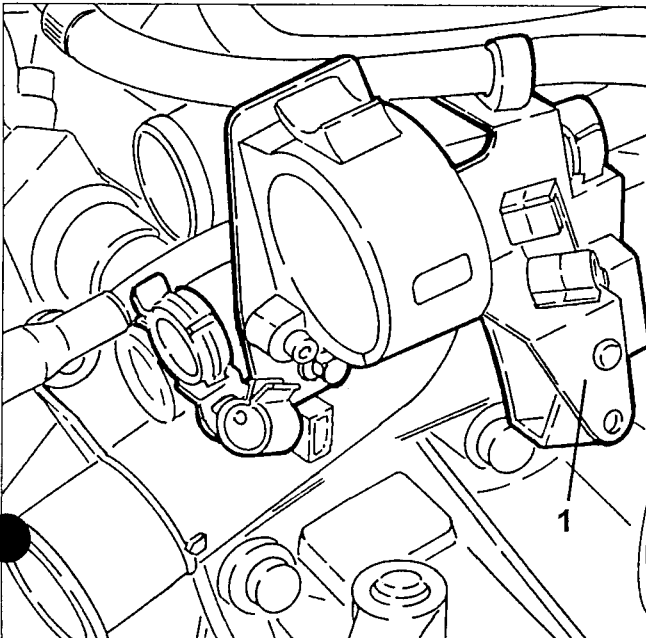
1. Loosen the fastening screws and remove the fuel distributor manifold and the injectors.



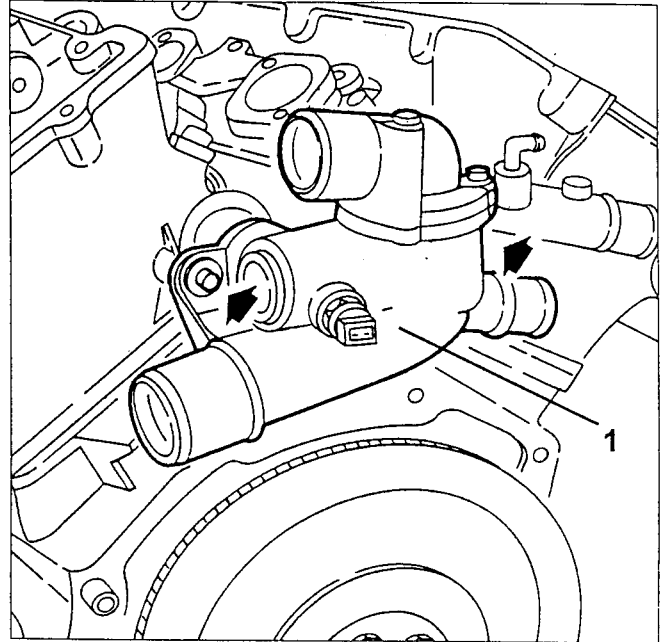
1. Remove the fastening screws and remove the rod and threaded nut to fasten the upper timing belt guard from the left-hand cylinder head.
2. Loosen the fastening screws and remove the cylinder head covers.



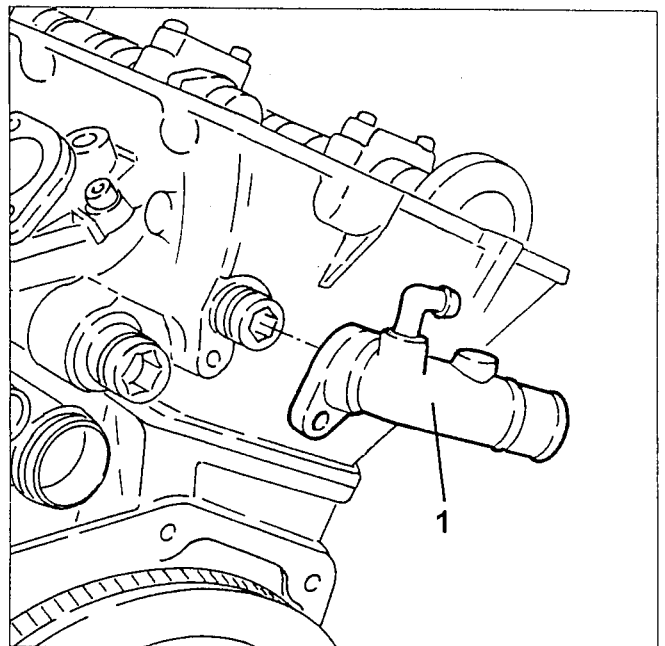
1. Loosen the fasteners and remove the injection wiring joint support bracket.



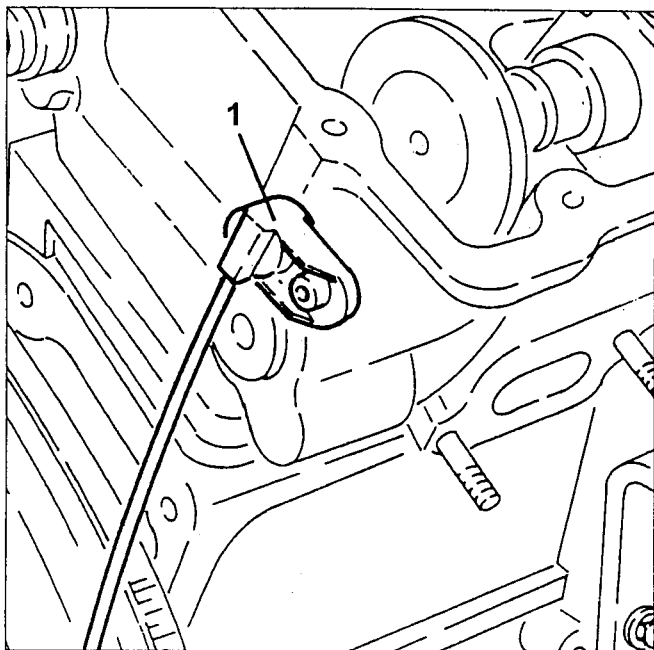
1. Loosen the fastening screws and remove the thermostat cup and coolant temperature sensor.



1. Remove the expansion reservoir and climate control heater coolant delivery duct.

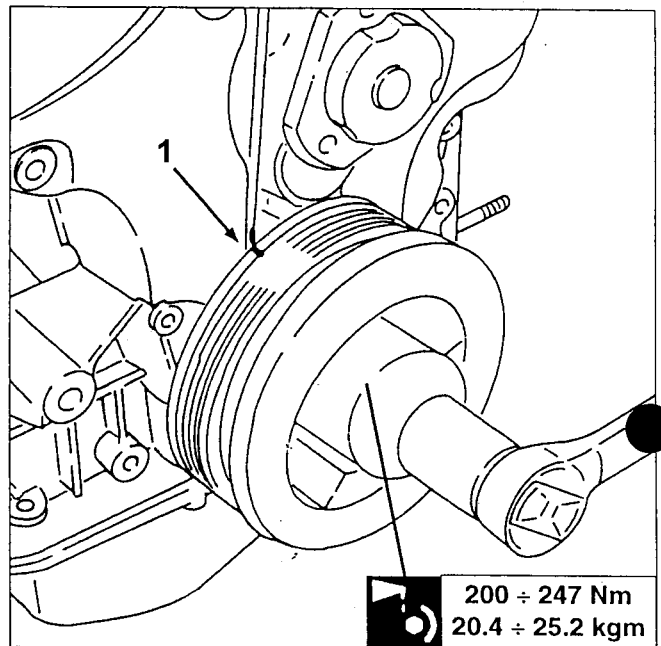


1. Loosen the fastening screw and remove the cam angle sensor.

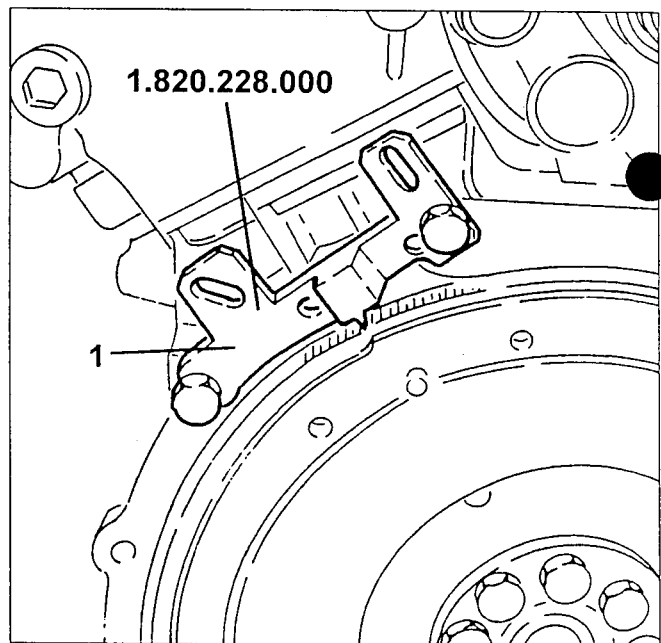


TIMING BELT REMOVAL

1. Move the auxiliary unit drive pulley as shown in the figure and take the engine to DTC first cylinder firing stroke: in this position the pulley notch is aligned with the fixed reference mark.

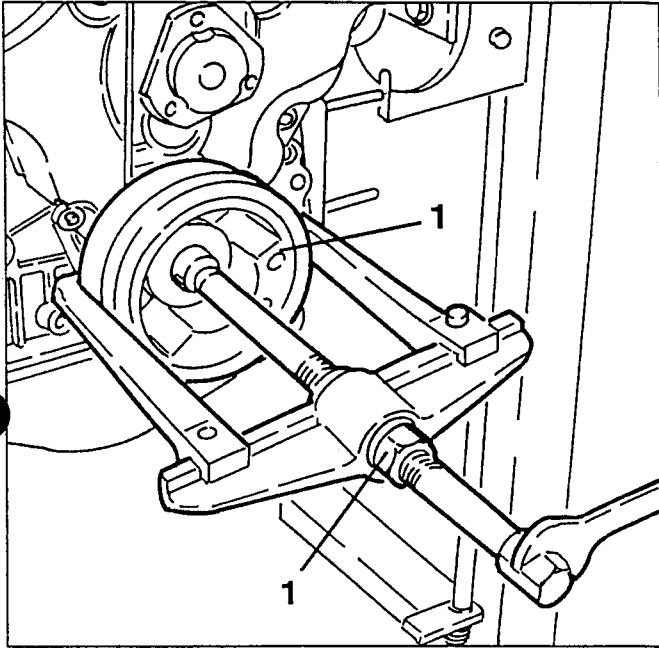


1. Fit the flywheel retainer tool no. 1.820.228.000 as shown in the figure.

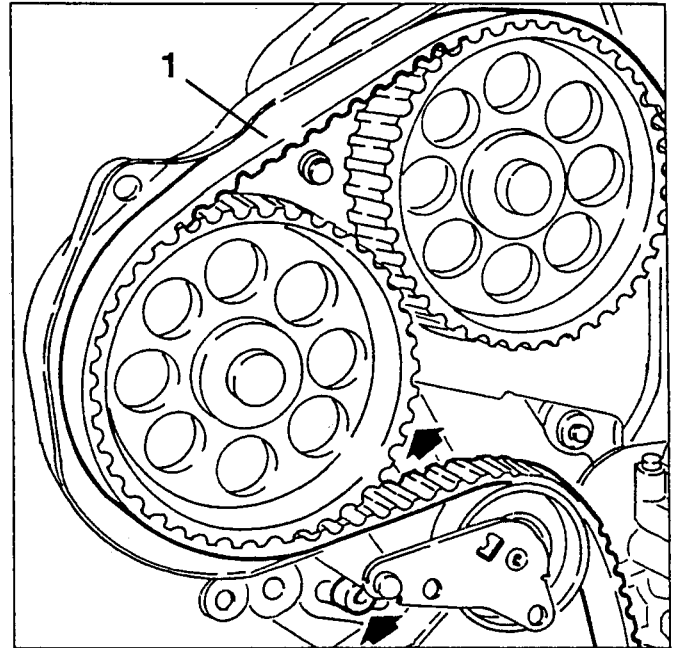


1. Slacken the fastening nuts and remove the auxiliary components drive pulley.

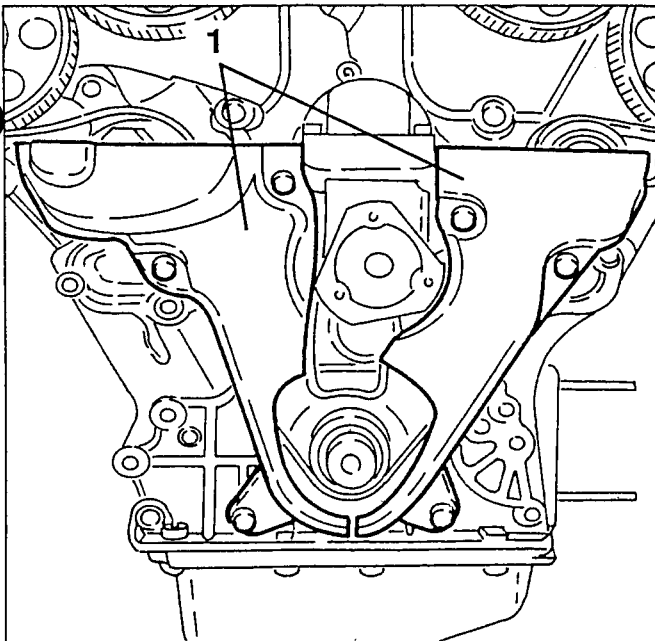
NOTE: If this operation proves to be difficult, use a universal puller tool.



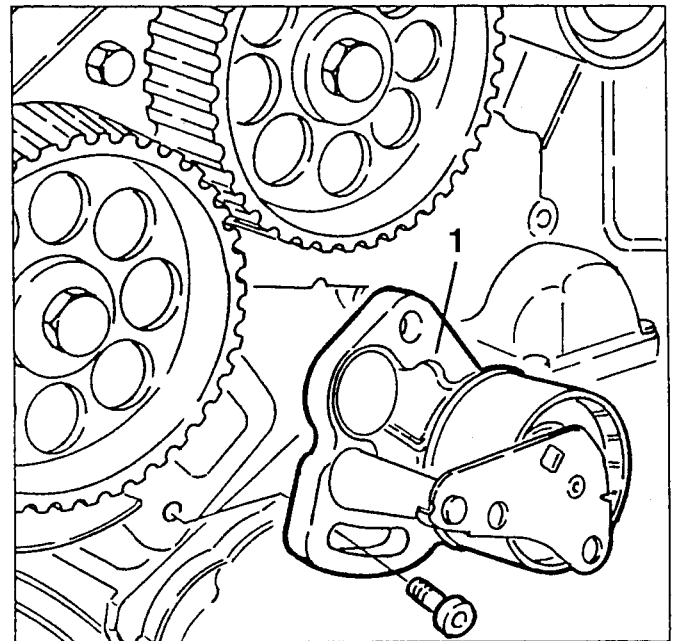
1. Slacken the belt tensioner fastening screws, then prise and remove the timing gear drive belt.



1. Slacken the fastening screws and remove the lower timing gear belt guards.

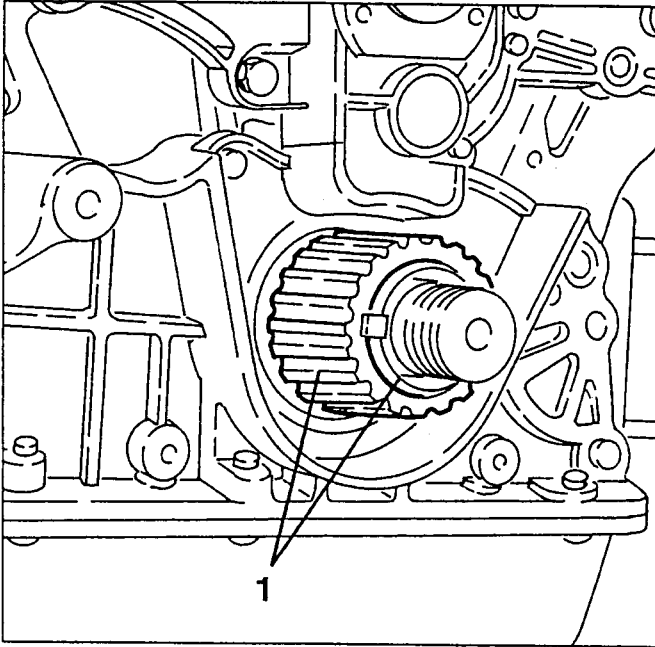


1. Slacken the fastening screws completely and remove the timing gear drive belt tensioner.



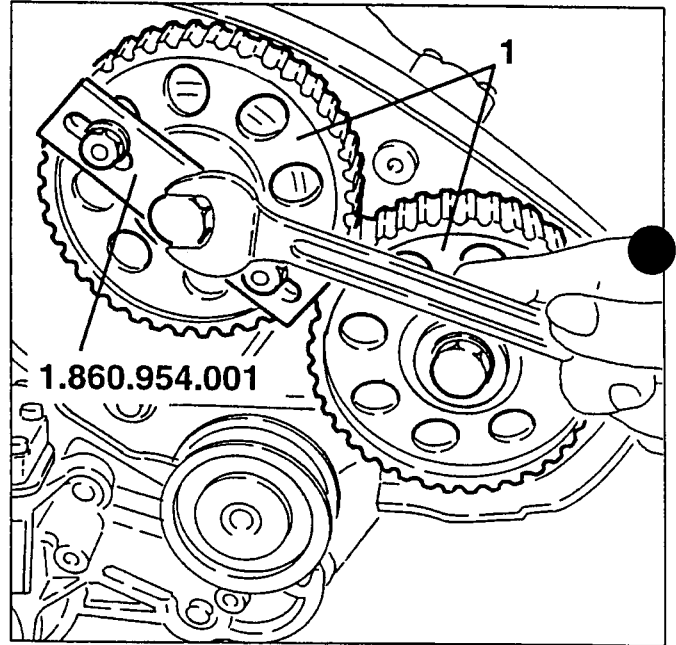
1. Withdraw the timing gear drive belt complete with thrust ring.

NOTE: When refitting, the convex surface of the thrust ring must be turned to the crankcase front cover.

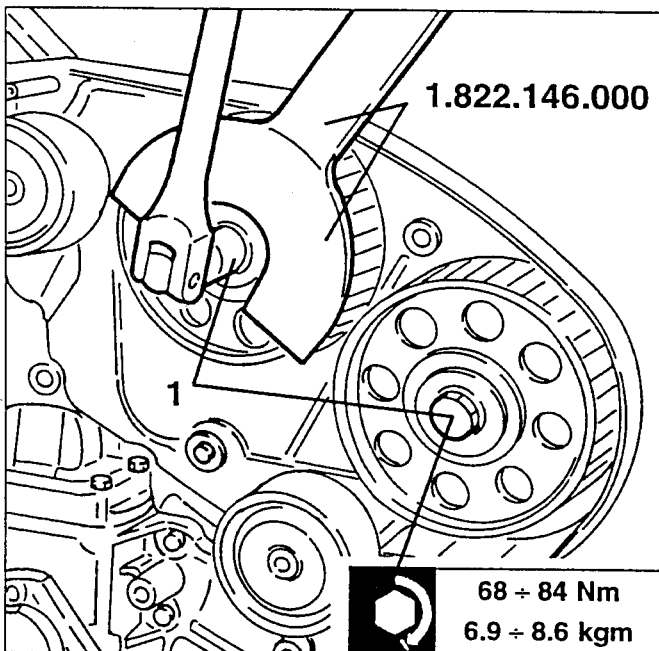


1. Remove the camshaft drive pulleys using puller tool no. 1.860.954.001.

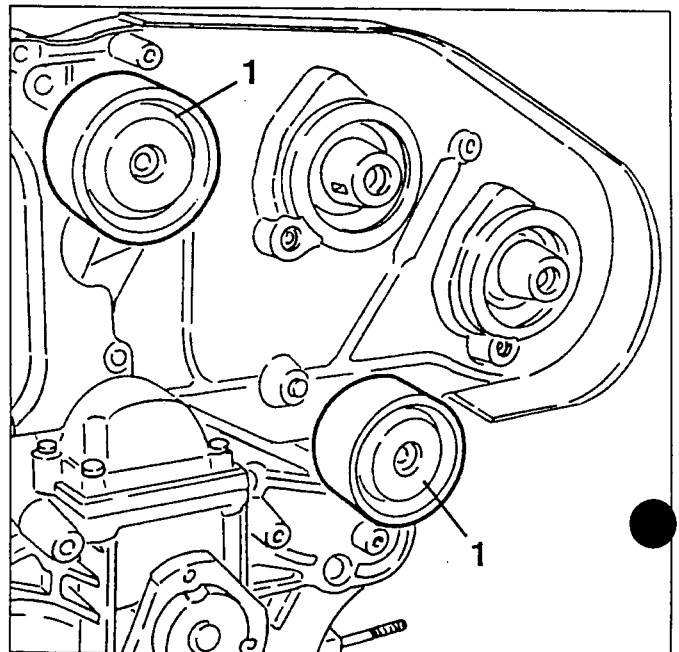
NOTE: The hooking ends of the tool have different profiles so that they can be used for the pulleys of both heads. Suitably turn the hooking ends to adapt them to the different profiles of the pulleys.



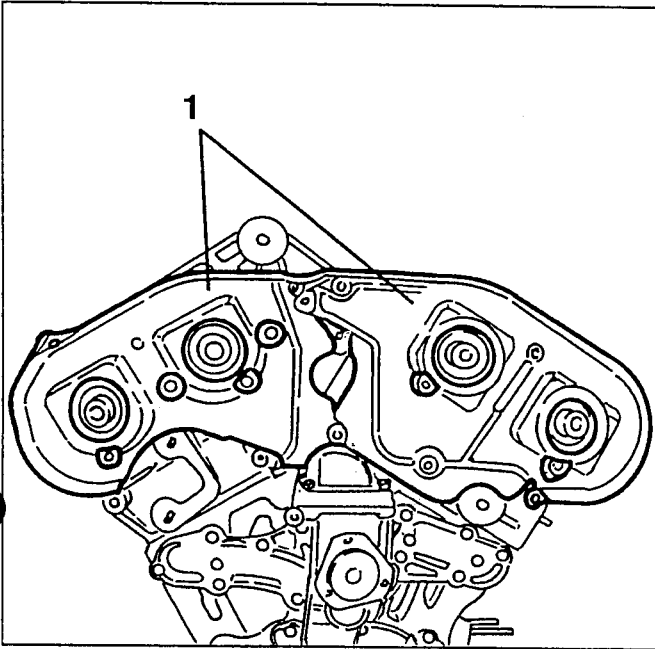
1. Slacken the fastening screws of the camshaft drive pulleys levering with tool no. 1.822.146.000.



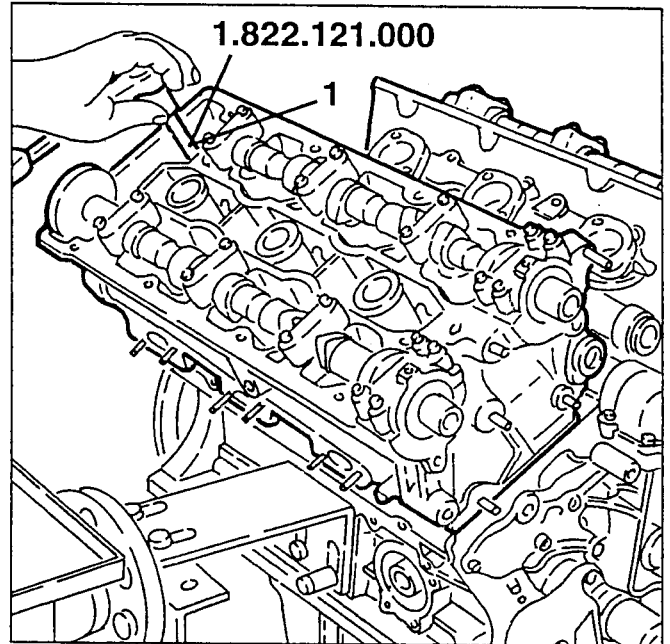
1. Slacken the fastening screws and remove the fixed guide pulleys of the timing gear drive belt.



1. Slacken the fastening screws and remove the timing gear belt inner protections.

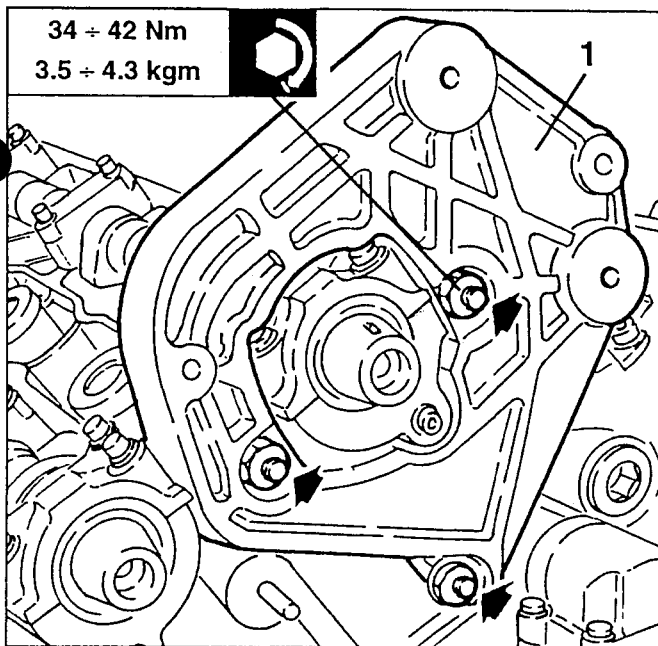


1. Using wrench no. 1.822.121.000 slacken the nuts fastening the cylinder heads and remove them.
- Remove the corresponding seals.

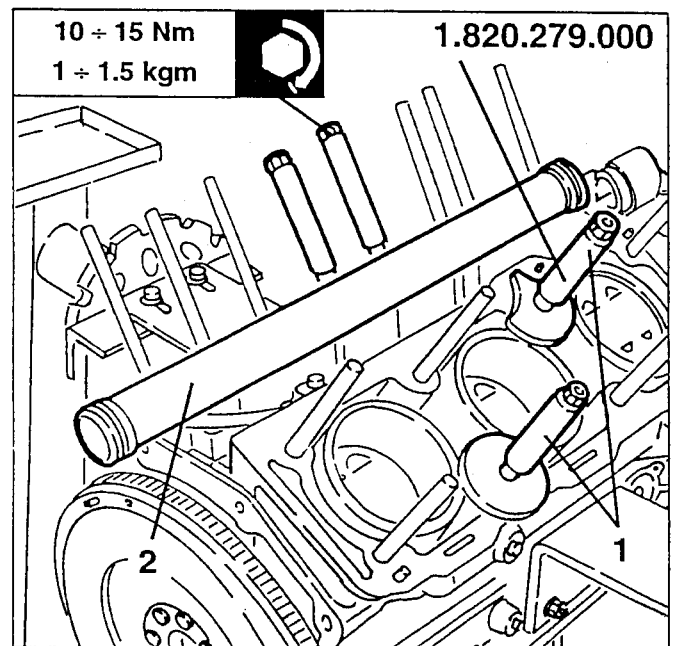


REMOVING THE CYLINDER HEADS

1. Slacken the fastening nuts and remove the engine stay rod support bracket.

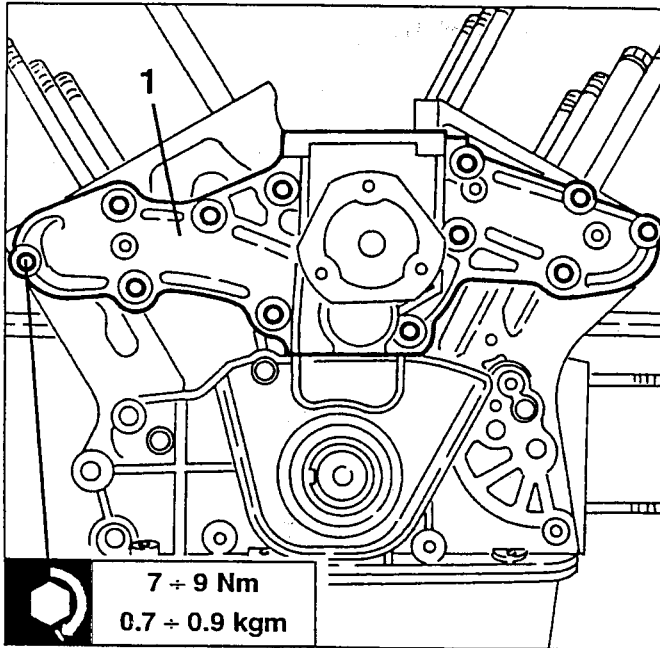


1. Install the liner stopper tools no. 1.820.279.000.
2. Withdraw the manifold for returning coolant fluid to the pump.



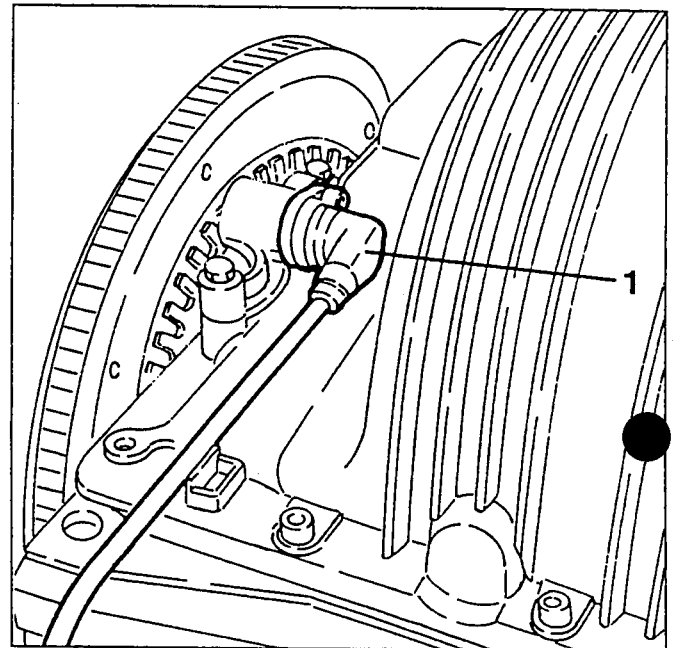
REMOVING THE WATER PUMP

1. Slacken the fastening screws and remove the water pump.
- Remove the corresponding seal.

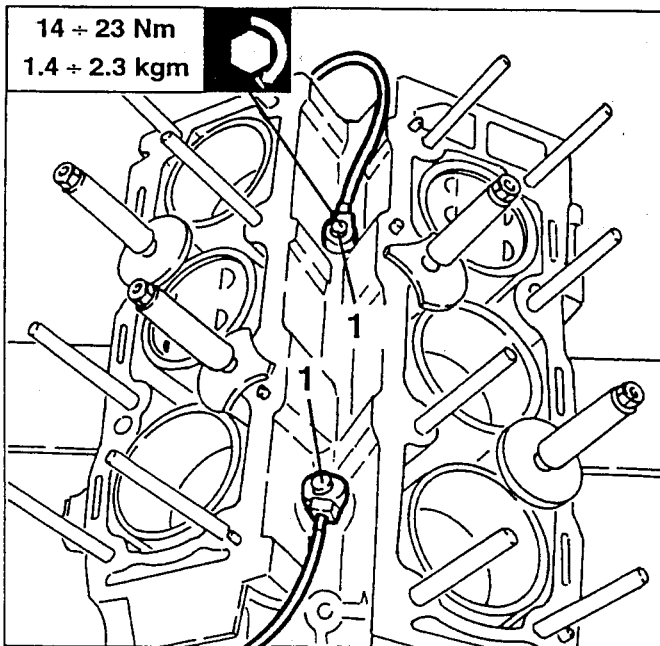


REMOVING THE OIL SUMP

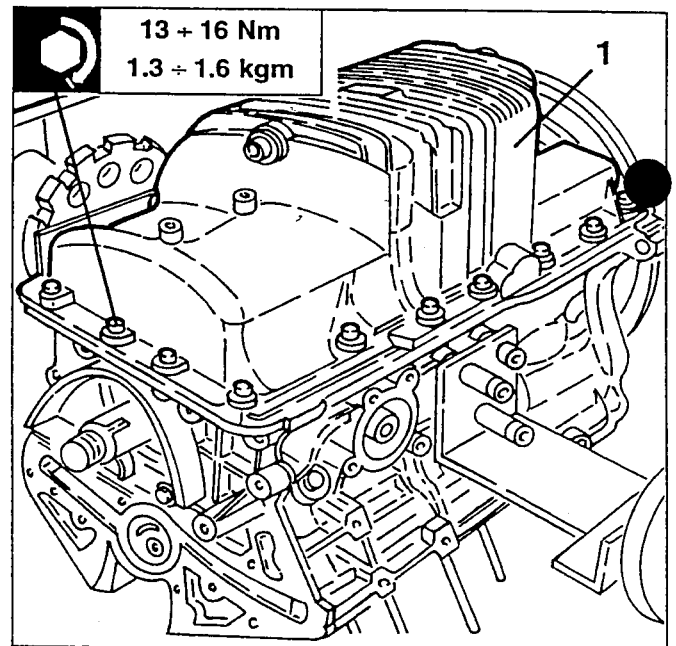
1. Turn the engine on the overhauling stand, slacken the fastening screw and remove the rpm and timing sensor.



1. Slacken the fastening screws and remove the two pinging sensors.

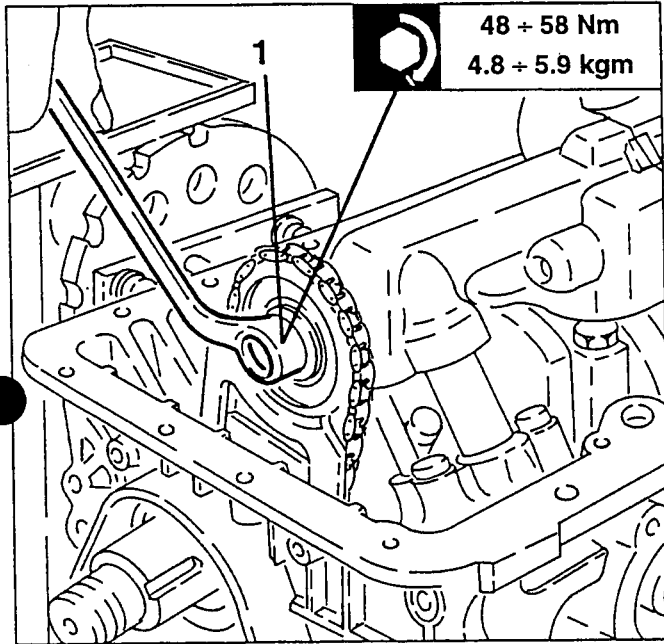


1. Slacken the fastening screws and remove the oil sump.

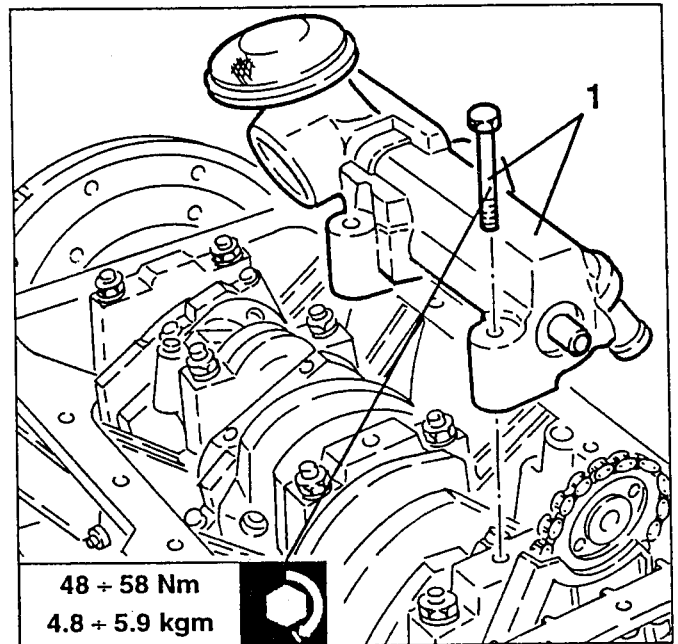


REMOVING THE OIL PUMP

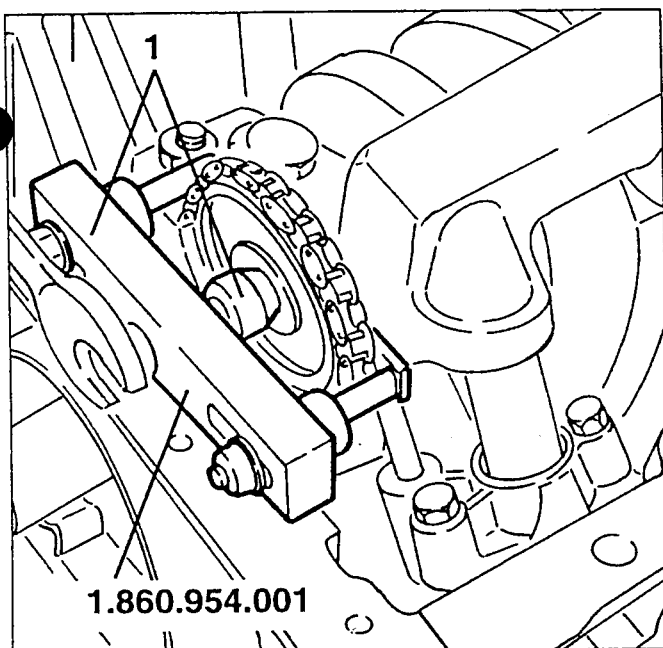
1. Using as stopper the flywheel stopper tool installed previously, slacken the screw fastening the oil pump drive gear.



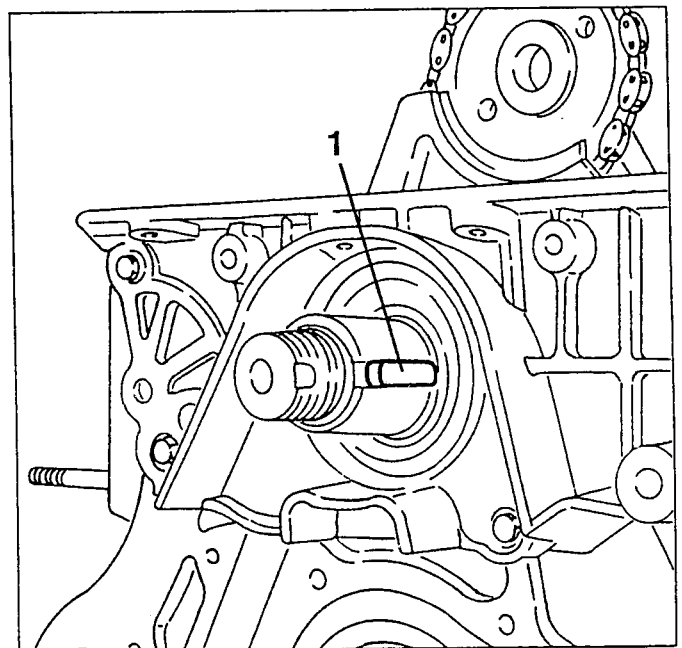
1. Slacken the fastening screws and remove the complete oil pump, freeing it from the drive gear.



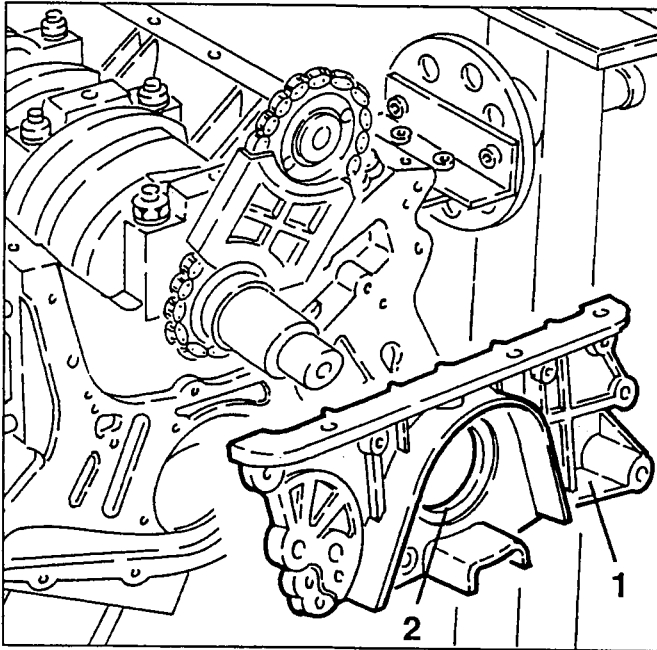
1. Using tool no. 1.860.954.001 remove the drive gear from the oil pump spindle.



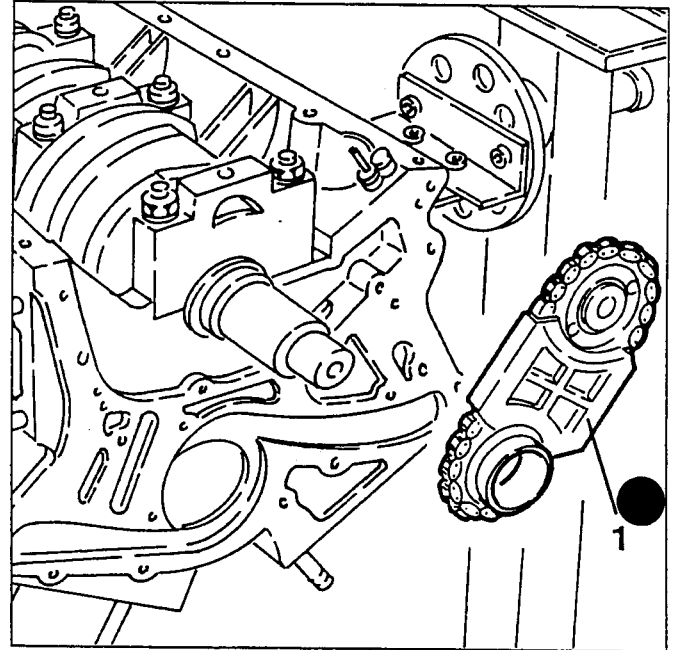
1. Remove the key for the timing gear belt drive pulley from the crankshaft using a flat punch.



1. Slacken the fastening screws and remove the crankcase front cover.
 - Remove the corresponding seal.
2. Remove the oil seal from the crankcase front cover.

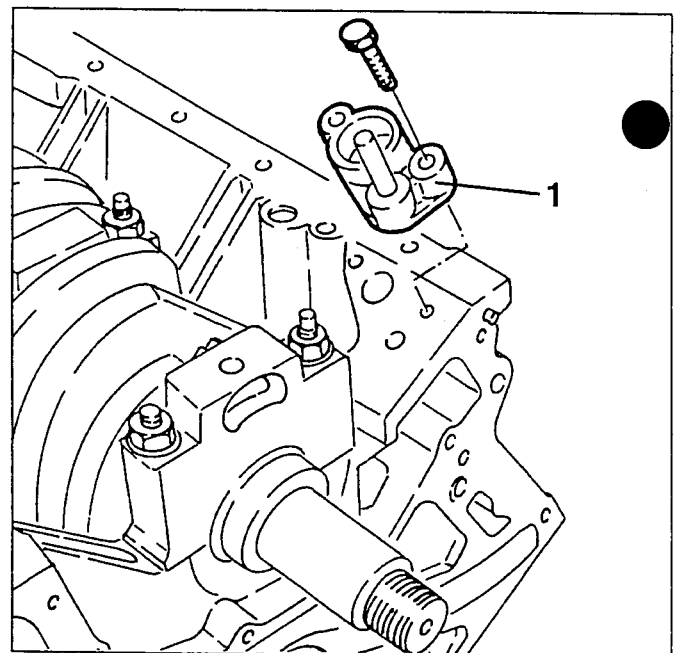
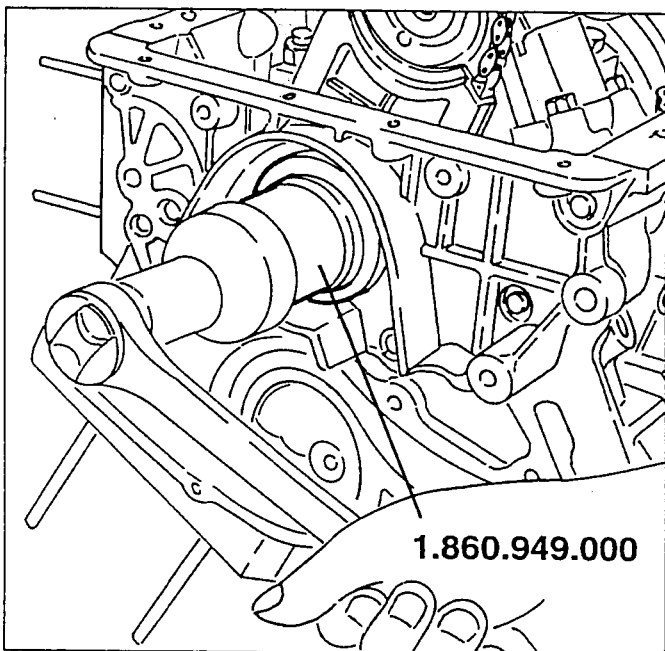


1. Withdraw and remove the oil pump drive chain/gears assembly.



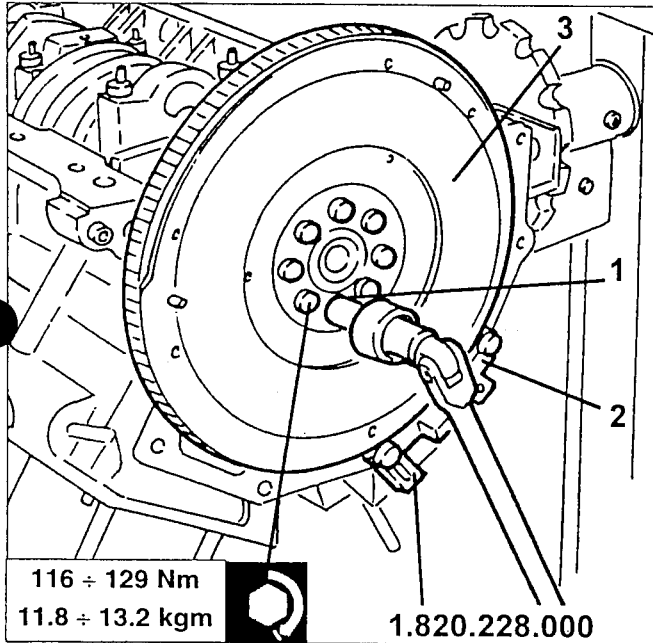
When refitting, insert a new front crankshaft oil seal, with the front cover fitted on the crankcase, using tool no. 1.860.949.000.

1. Slacken the fastening screws and remove the oil pump casing support from the crankcase.



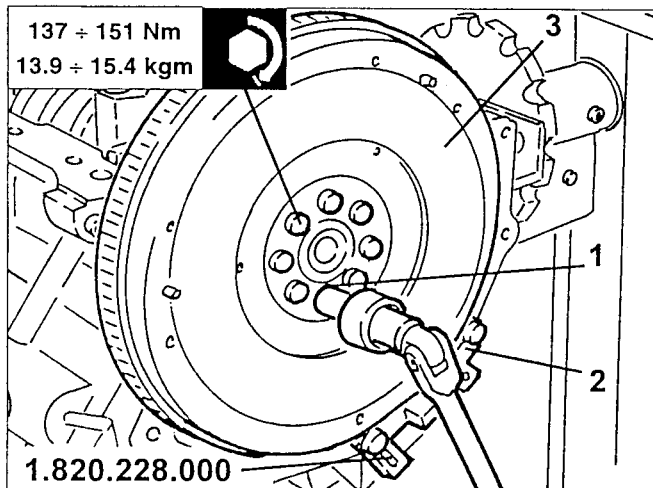
FLYWHEEL REMOVAL (pre-change solution)

1. Loosen the flywheel screws.
 2. Remove the previously fitted flywheel retainer tool 1.820.228.000.
 3. Remove the fastening screws and remove the flywheel.
- Take the lock washer.

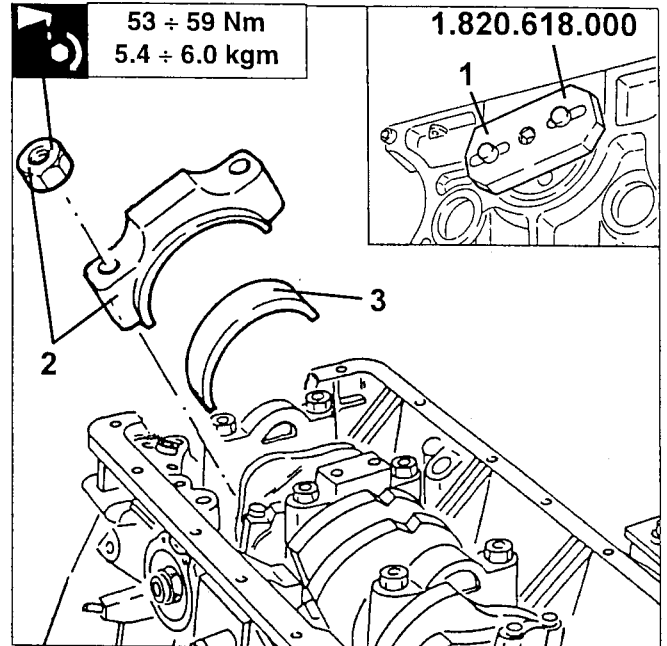


FLYWHEEL REMOVAL (post-change solution with ME2.1 injection)

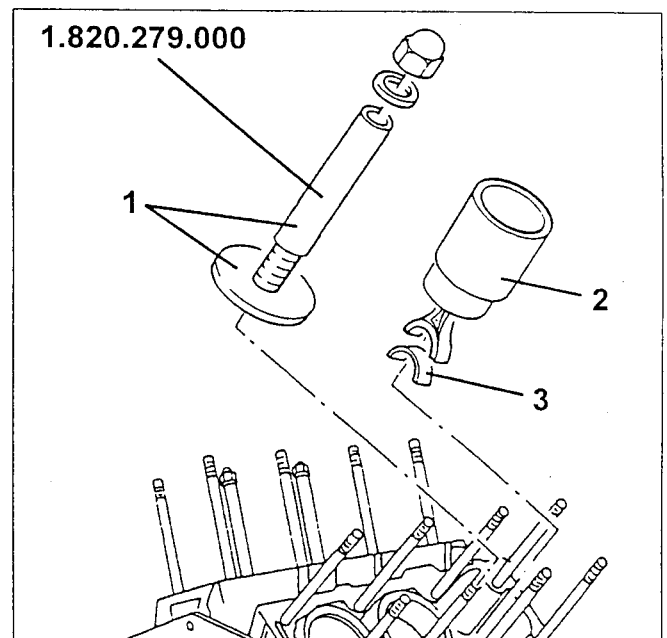
1. Loosen the flywheel screws.
 2. Remove the previously fitted flywheel retainer tool 1.820.228.000.
 3. Remove the fastening screws and remove the flywheel.
- Take the lock washer.



- Turn the crankshaft to access the right-hand bank connecting rod caps (cylinders 1, 2 and 3).
- 2. Loosen the fastening nuts and remove cylinder 1, 2 and 3 connecting rod caps.
- 3. Take the respective connecting rod half-bearings.



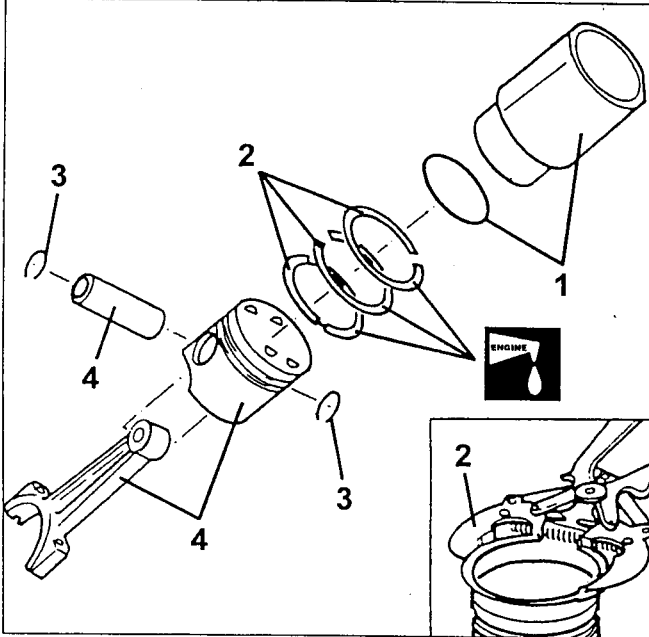
- Turn the engine on the overhaul stand.
 - 1. Loosen the fastening nuts and remove the liner retainer tool no. 1.820.279.000 from the right-hand bench only.
 - 2. Extract the connecting rod-piston assemblies from the crankcase. Remove the cylinder liners at the same time.
 - 3. Take the respective connecting rod half-bearings.
- Turn the crankcase on the overhaul bench and perform the same operation on the left-hand bank (cylinders 4, 5 and 6).



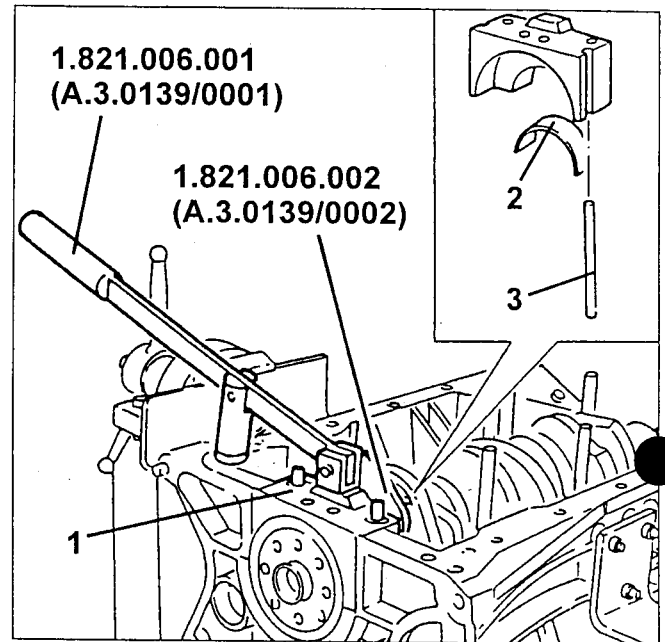
CYLINDER LINER AND PISTON REMOVAL

1. Fit tool no. 1.820.618.000 to rotate crankshaft.

1. Remove the cylinder liner and O-Ring.
 2. Extract the gas rings and the oil scraper from the pistons with a suitable tool.
- IMPORTANT: Be careful not to damage rings which could be re-used.**
3. Extract the two pin snap rings.
 4. Extract the pin and separate the piston from the connecting rod.

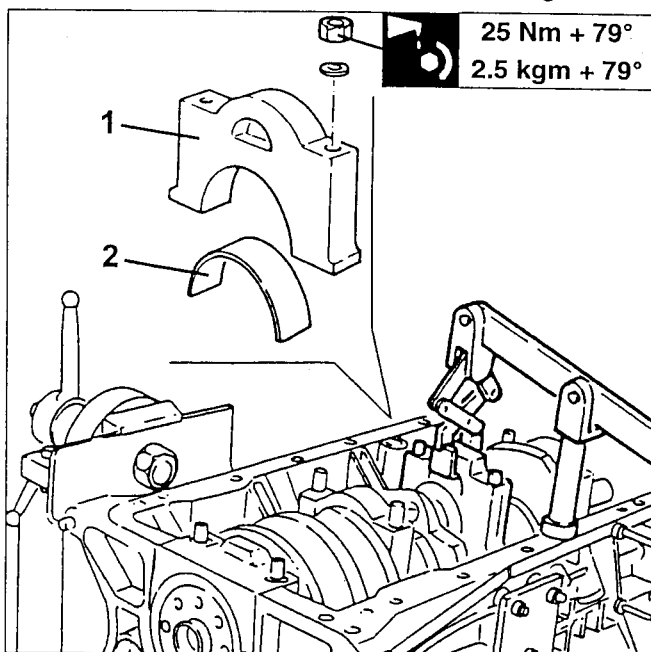


1. Remove the rear main bearing with lever no. 1.821.006.001 (A.3.0139/0001) and fork no. 1.821.006.002 (A.3.0139/0002).
2. Remove the respective main half-bearing.
3. Remove the seals.

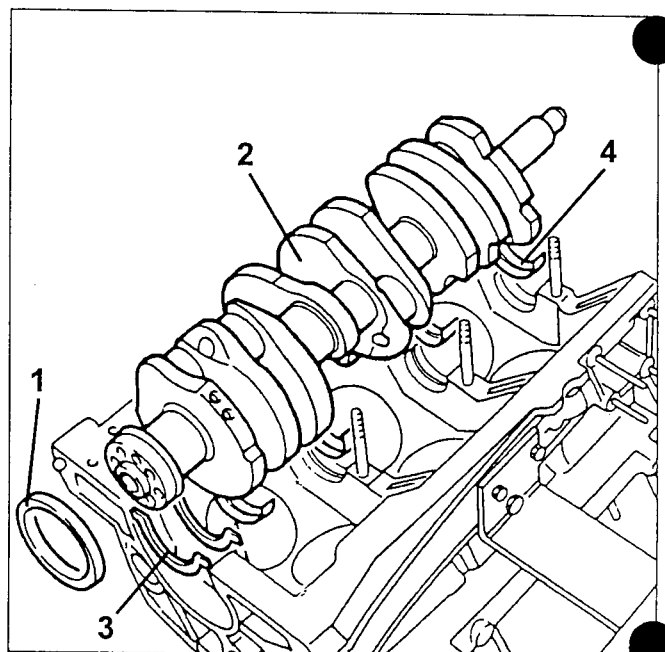


CRANKSHAFT REMOVAL

- Turn the engine on the overhaul stand.
1. Loosen the main bearing fastening nuts and remove the front and central main bearings with a suitable tool.
 2. Remove the respective main half-bearings.



1. Remove the crankshaft rear oil seal.
2. Remove the crankshaft.
3. Remove the thrust half-bearings.
4. Remove the main journal half-bearings.

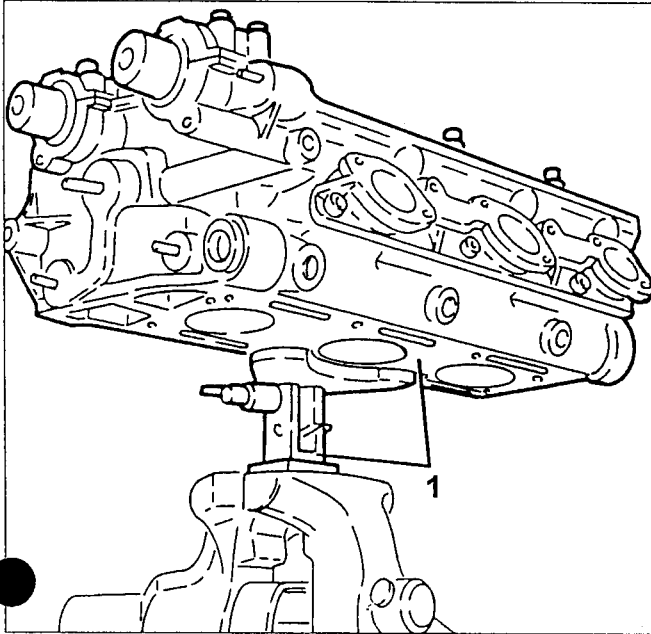


CYLINDER HEAD REMOVAL

NOTE: The following removal operations refer to the right-hand cylinder head. Proceed in the same way for the left-hand cylinder head.

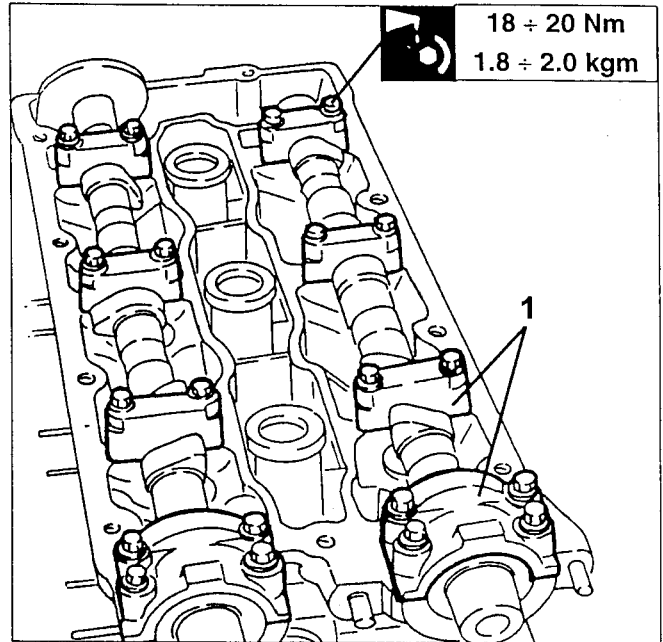
PRELIMINARY OPERATIONS

1. Position the cylinder head on the support tool formed by adjustable joint no. 1.820.012.000 (A.2.0195), fork no. 1.820.050.000 (A.2.0360) and jds no. 1.860.952.000.



CAMSHAFT REMOVAL

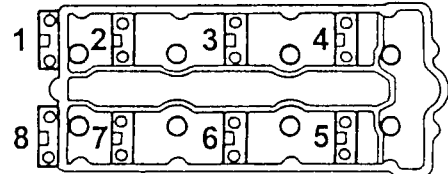
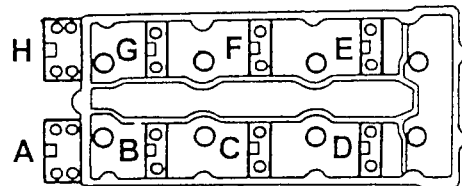
1. Remove the fastening screws and remove the camshaft caps.



NOTE: The camshaft caps are progressively numbered (A, B, C, D, E, F, G and H from the right-hand cylinder head; 1, 2, 3, 4, 5, 6, 7 and 8 for the left-hand cylinder head) as shown in the figure.

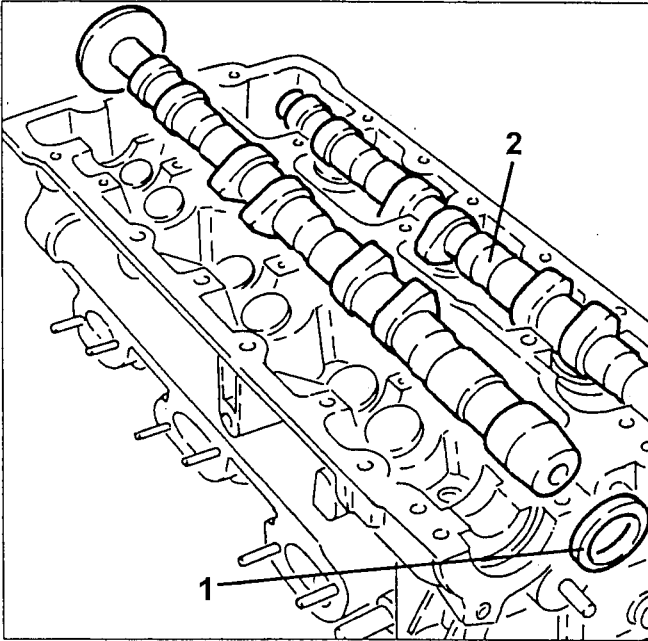
Refit in the same order with the number facing the pulleys.

RIGHT-HAND HEAD



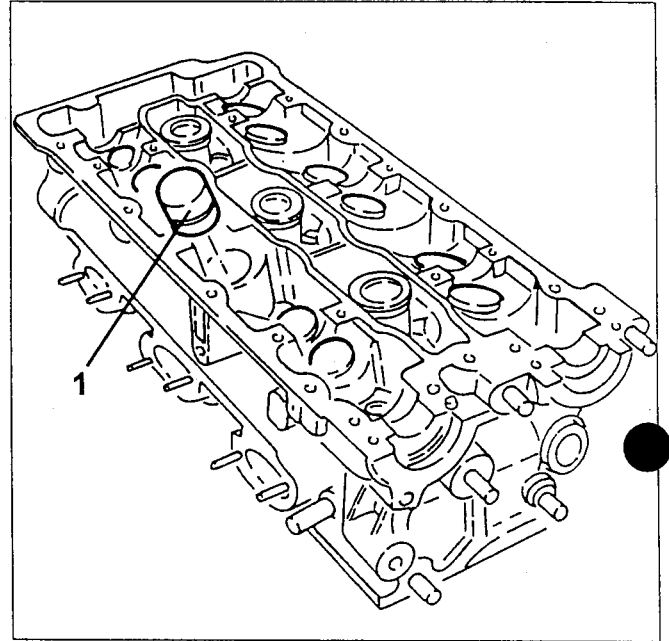
LEFT-HAND HEAD

1. Remove the camshaft oil seals.
2. Remove the camshafts.

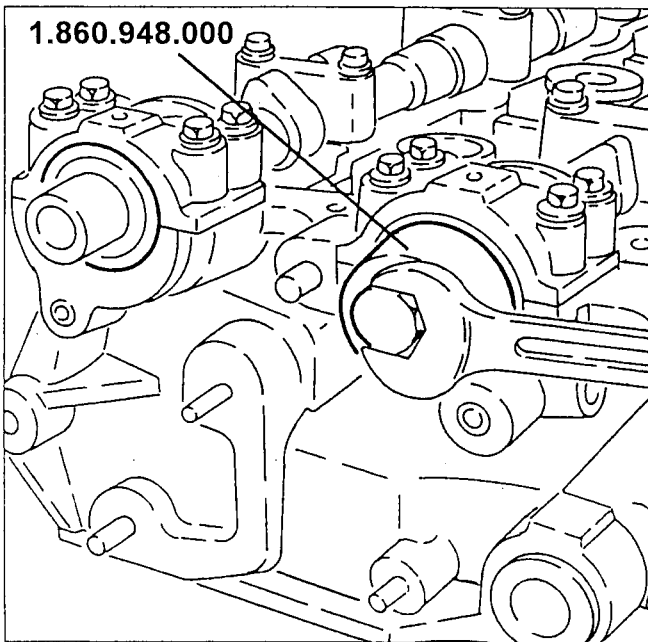


1. Remove the hydraulic tappets.

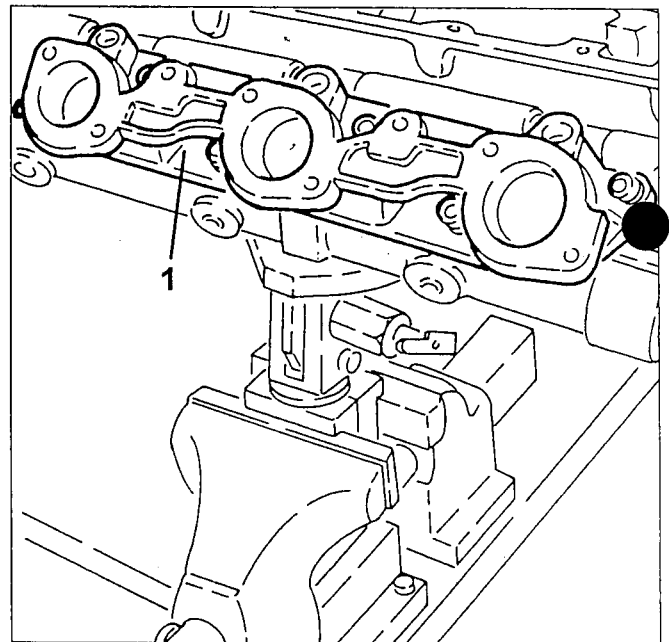
IMPORTANT: Place the tappets in a suitable container according to the removal sequence if they will be refitted.



When refitting, insert new camshaft oil seals with tool no. 1.860.948.000.



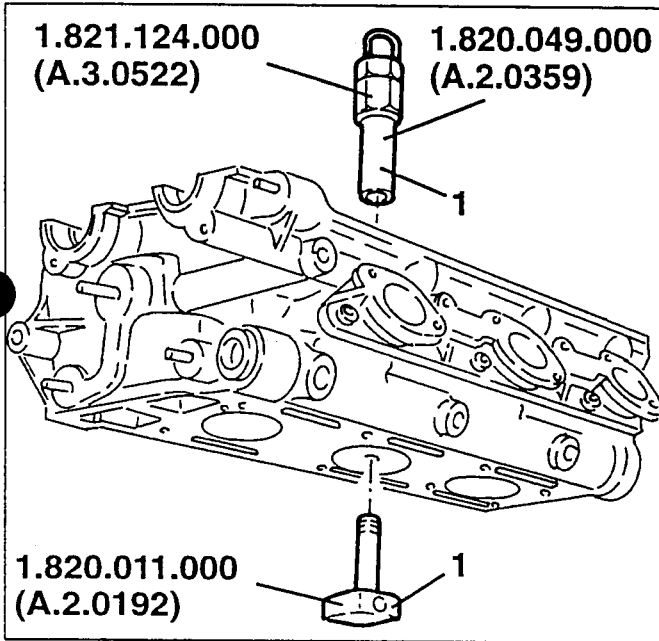
1. Remove the fastening screws and remove the air intake manifold.
- Remove the respective seal.



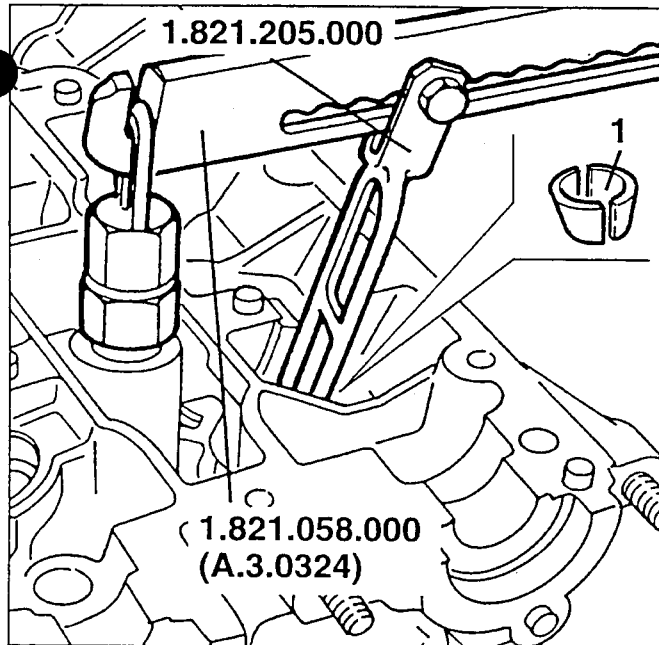
VALVE DISASSEMBLY

Work on the valves of each cylinder as described below.

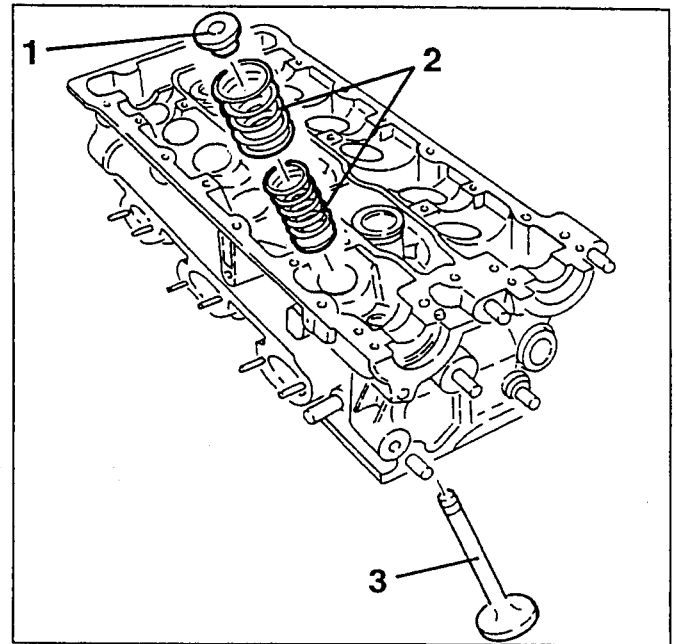
1. From the lower part of the spark plug hole insert tool no. 1.820.011.000 (A.2.0192) for supporting the valves and fasten it with the special nut no. 1.820.049.000 (A.2.0359) complete with support no. 1.821.124.000 (A.3.0522).



1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.205.000, remove the half cones.

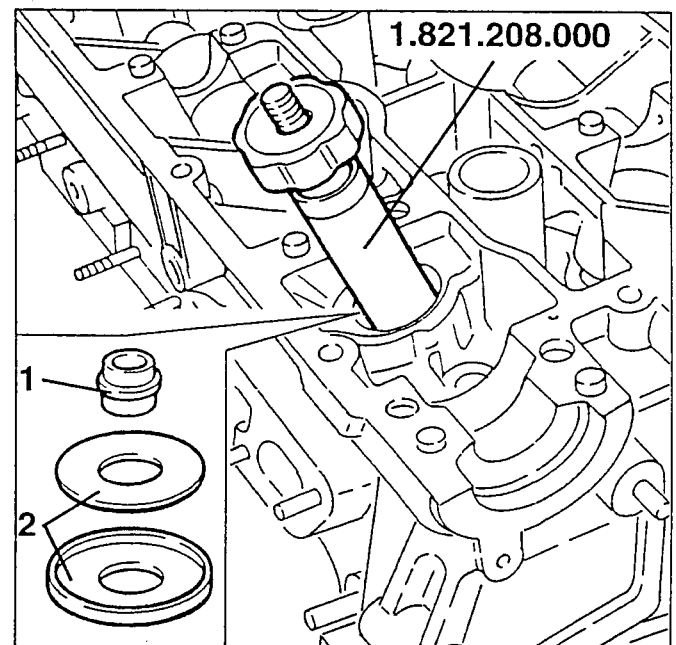


1. Remove the upper plates.
2. Remove the outer and inner springs.
3. Remove the tools used for removing the valves and withdraw the four valves.



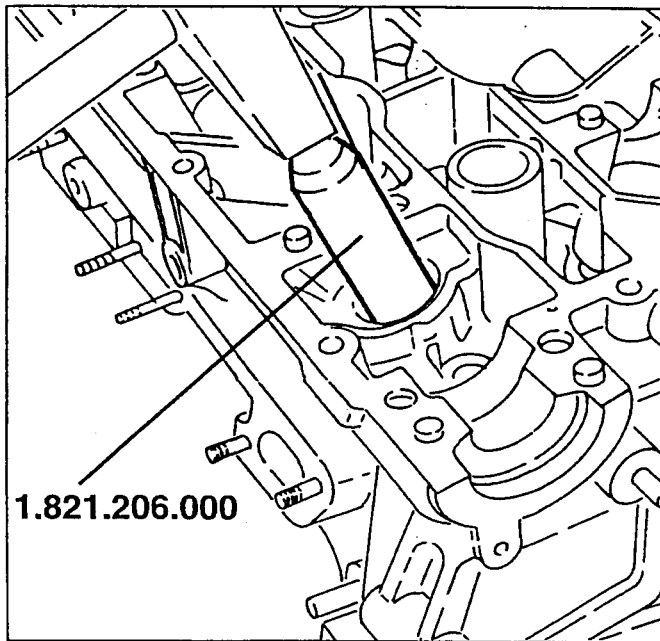
- Following the same procedure and using the usual tools, remove the valves of the remaining cylinders.

1. Using puller tool no. 1.821.208.000 remove the valve guide oil seal caps.
2. Withdraw the lower spring stop rings and the lower plates.





When reassembling insert new oil seal caps on the valve guides using tool no. 1.821.206.000.



CHECKING AND INSPECTING CYLINDER HEADS

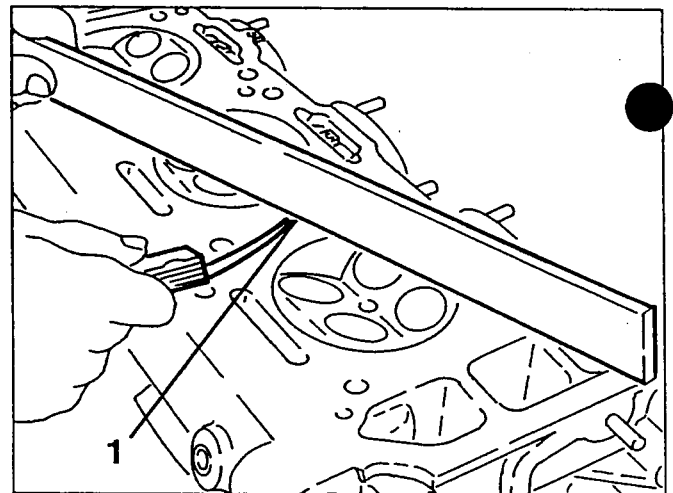
CHECKING THE LOWER SURFACE OF CYLINDER HEADS

1. Check the flatness of the lower surface of the cylinder heads after removing the remains of the old seal; if the lower surface of the heads is excessively worn reface it.



Maximum flatness error of cylinder head lower surface

0.05 mm



- After refacing check that the height "A" of the cylinder heads exceeds the minimum permissible value.



WARNING:

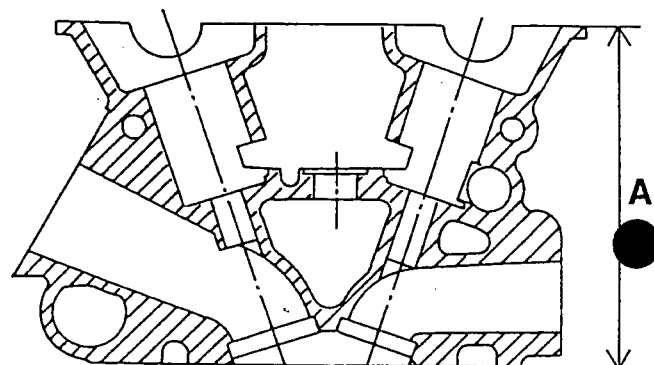
Refacing must be carried out on both cylinder heads.

Do not exceed the minimum permissible height limit of the heads as serious operating faults on the engine may result.



Minimum height "A" of heads after refacing

134.85 ÷ 135.15 mm

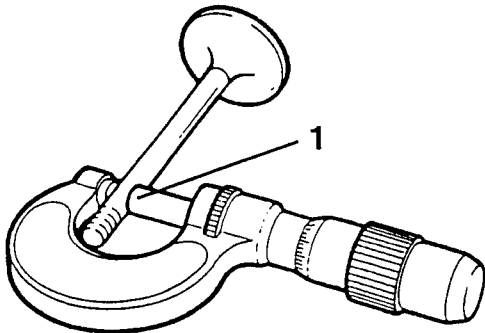


CHECKING THE CLEARANCE BETWEEN VALVE GUIDES AND STEMS

1. Measure the diameter of the valve stems and and check that it is within the specified limits.



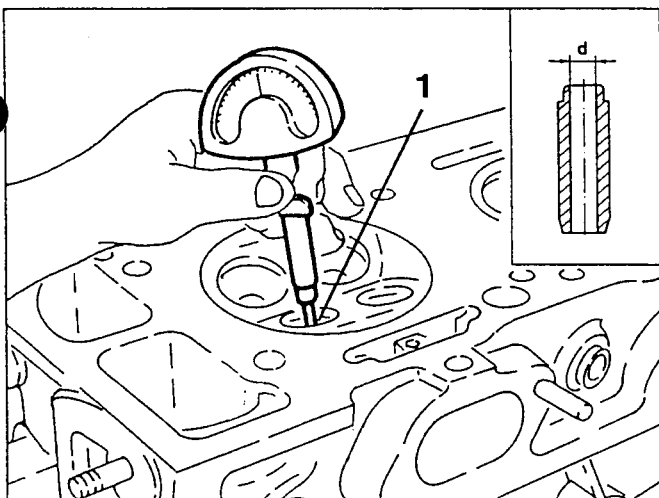
Valve stem diameter	
Intake	6.965 ÷ 6.980 mm
Exhaust	



1. Measure the inside diameter of the valve guides and check that it is within the specified limits.



Valve guide inside diameter "d"	
7.000 ÷ 7.015 mm	



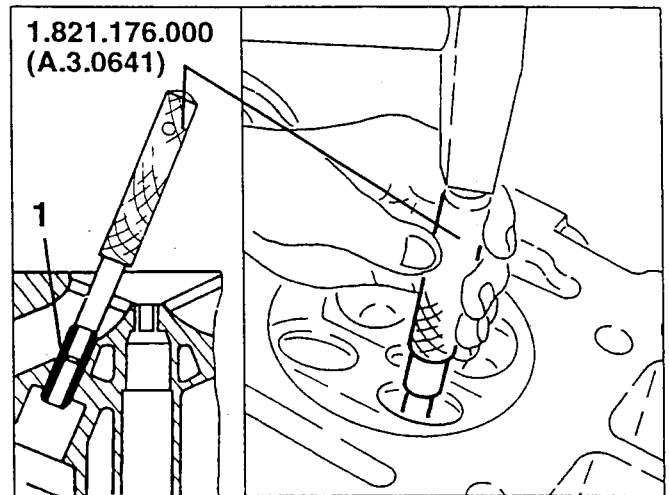
- Calculate the clearance between valve guide and stem and check that it is within the specified limits; if not replace the worn parts.



Radial clearance between valve guide and stem	
Intake	0.020 ÷ 0.050 mm
Exhaust	

CHANGING VALVE GUIDES

1. Using puller tool no. 1.821.176.000 (A.3.0641), remove the worn valve guides.



- Check that the valve guide outside diameter and the diameter of their housings on the cylinder heads are within the specified limits and that the assembly interference is correct.



Valve guide seat diameter	
12.000 ÷ 12.018 mm	

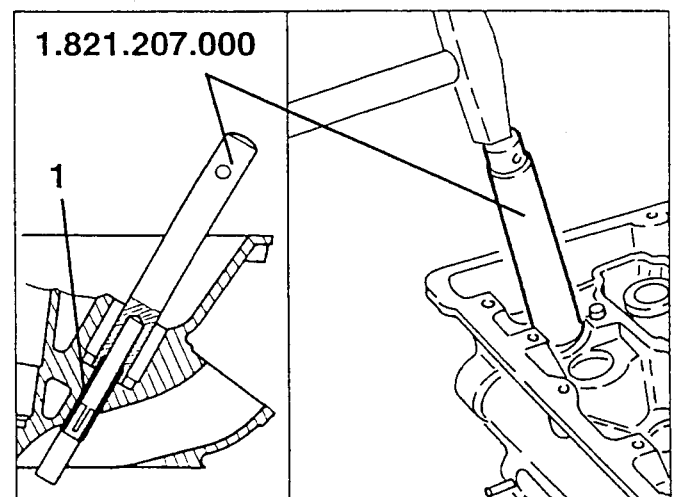


Valve guide outside diameter	
Intake	12.040 ÷ 12.051 mm
Exhaust	12.050 ÷ 12.068 mm



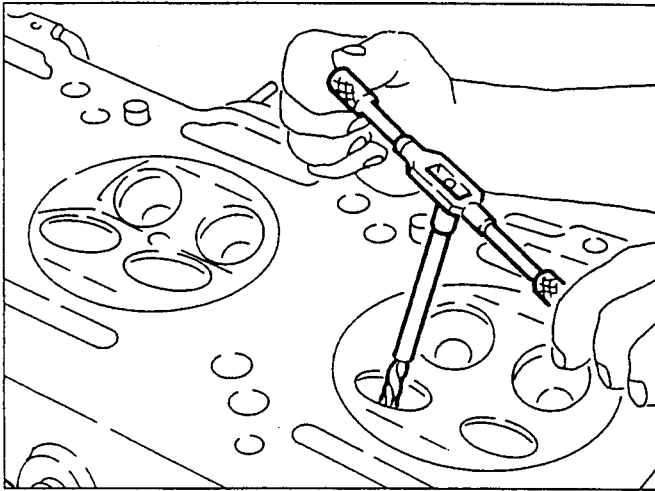
Seat-valve guide interference	
Intake	0.022 ÷ 0.051 mm
Exhaust	0.032 ÷ 0.068 mm

1. Heat the cylinder head to the specified value, then insert the new valve guides in their seats using installing tool no. 1.821.207.000 which also ensures the correct protrusion values.



- Bore the inside diameter of the valve guide to calibrate the holes to the specified diameter.

∅	Valve guide inside diameter	
	7.000 + 7.015 mm	



CHECKING VALVE SPRINGS

- Check that the "free" length of the valve springs is within the specified limits.

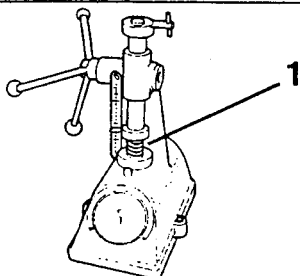
NOTE: The rest planes must be parallel with one another and at right angles to the axis of the spring with a maximum error of 2°.

H	Free length of valve springs	
	Outside spring	51.8 mm
	Inside spring	38.0 mm

1. Using a torque meter, check that the spring specifications are within the specified limits.

Outside spring			
Spring length	(mm)	Test load	N (Kg)
With valve closed	32.5	215 ÷ 221	(22 ÷ 22.6)
With valve open	22.9	339 ÷ 359	(34.6 ÷ 36.6)

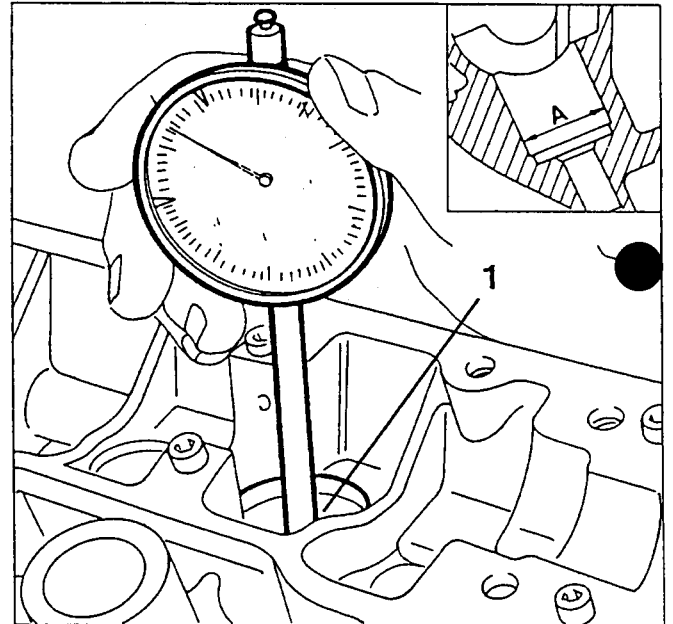
Inside spring			
Spring length	(mm)	Test load	N (Kg)
With valve closed	30.5	133 ÷ 141	(13.6 ÷ 14.4)
With valve open	20.9	313 ÷ 330	(31.9 ÷ 33.7)



CHECKING THE CLEARANCE BETWEEN HYDRAULIC TAPPETS AND THEIR SEATS

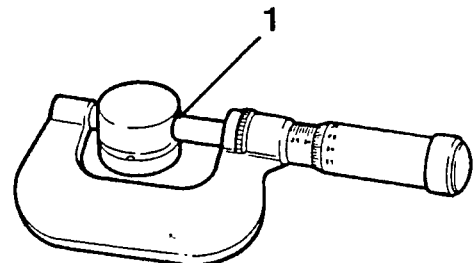
1. Check that the diameter of the hydraulic tappet seats is within the specified limits.

∅	Diameter "A" of hydraulic tappet seats	
	33.000 + 33.025 mm	



1. Check that the outside diameter of the hydraulic tappets is within the specified limits.

∅	Diameter of hydraulic tappets	
	32.959 + 32.979 mm	

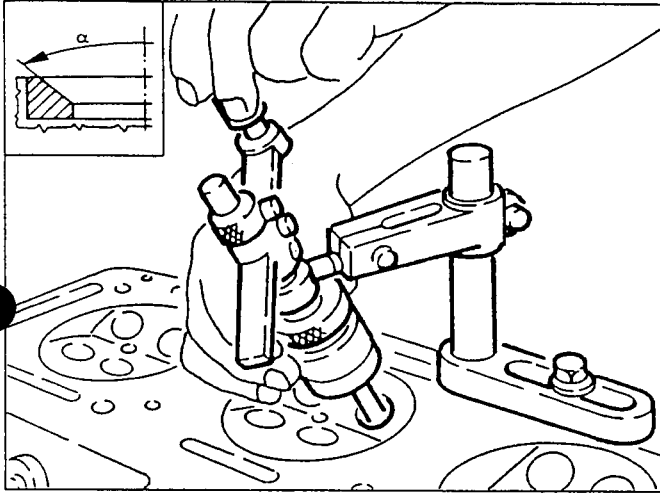
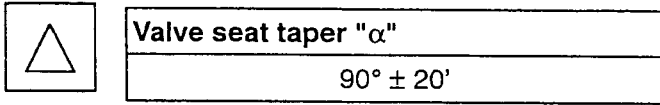


- Calculate the clearance between the hydraulic tappets and their seats checking that it is within the specified limits.

↔	Clearance between hydraulic tappets and their seats	
	0.025 + 0.066 mm	

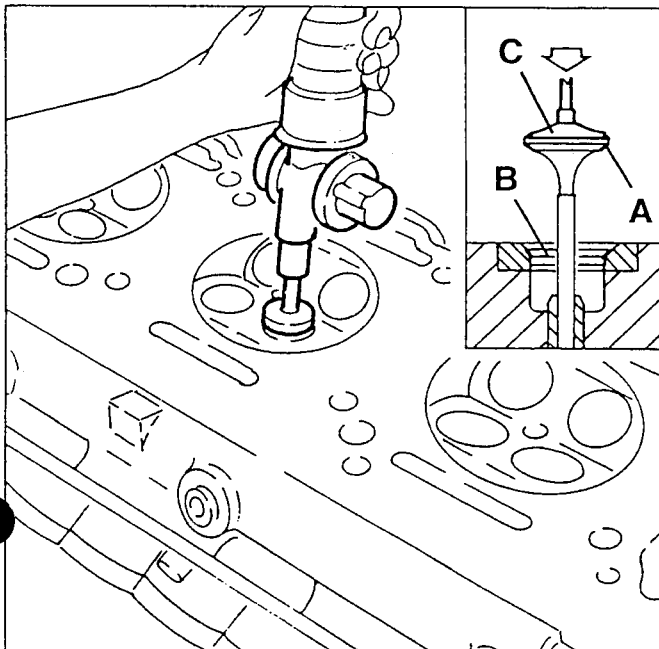
VALVE SEAT TURNING

- If necessary, turn the valve seats using suitable equipment.



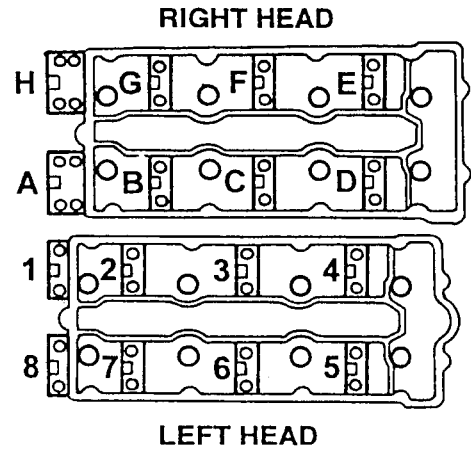
- After machining, grind each valve in its seat as follows:

- coat contact surfaces "A" and "B" of the valve and its housing with abrasive paste (SIPAL AREXONS Carbosilicium for valves or an equivalent product);
- lubricate the valve stem with engine oil;
- attach the lower surface of the valve mushroom to the suction grip of a pneumatic grinder;
- insert the valve in its valve guide and grind;
- after grinding, accurately clean both the valve and the seat.

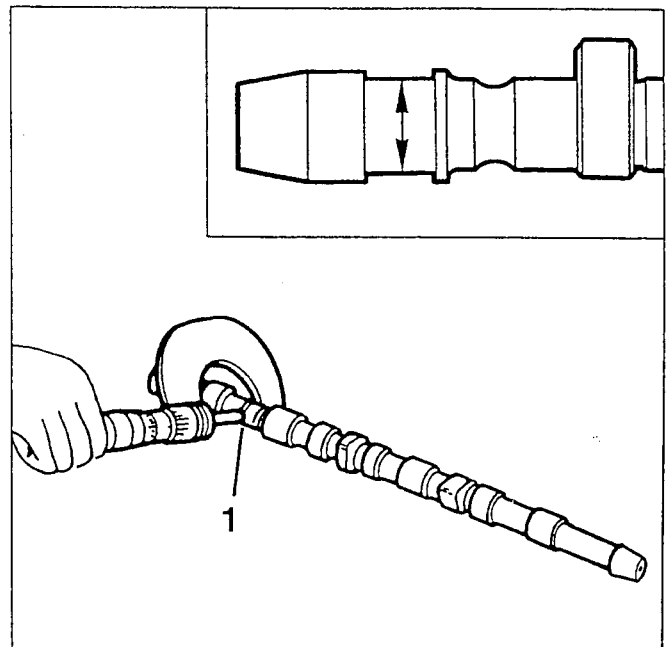
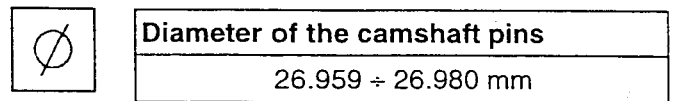


CAMSHAFTS AND BEARINGS

- Assemble the camshaft caps according to the numbers on them and tighten the fastening screws to the specified torque.

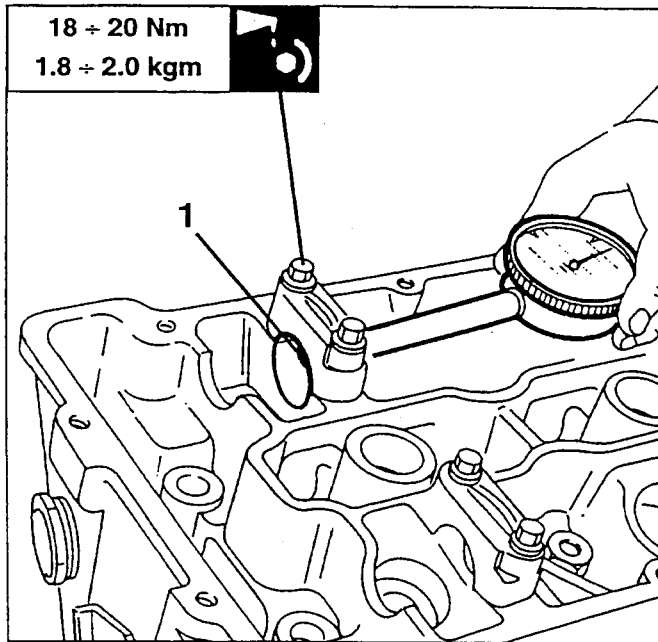


1. Check that the diameter of the camshaft pins is within the specified limits.



1. Check that the diameter of the camshaft supports is within the specified limits.

∅	Diameter of camshaft supports	
	27.000 ÷ 27.033 mm	

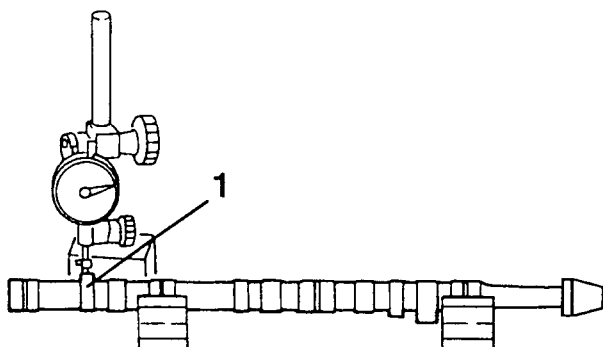


- Calculate the clearance between the camshaft pins and their supports checking that it is within the specified limits.

↔	Clearance between camshaft pins and their supports	
	0.030 ÷ 0.084 mm	

1. Check that the nominal lift of the camshaft cams is within the specified limits.

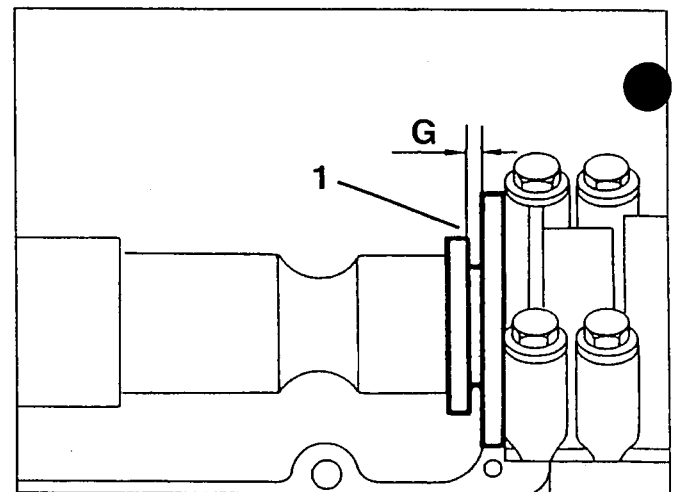
	Nominal cam lift	
	Intake	9.3 mm
	Exhaust	9.3 mm



CHECKING THE CAMSHAFT END FLOAT

- Position the camshafts on the cylinder heads, then fit the caps according to the previous numbering and tighten the fastening screws to the specified torque.
1. Install a centesimal dial gauge and measure the end float "G" of the camshafts checking that it is within the specified limits.

↔	Camshaft end float "G"	
	0.060 ÷ 0.201 mm	



CHECKING AND INSPECTING THE CRANKCASE

- Visually check the crankcase for cracks and signs of excessive wear of the sliding surfaces; check that all the threads are intact.
- Remove the lubricating and cooling duct plugs, then clean the ducts using a suitable detergent and dry them with a jet of air and install new plugs.
- Clean the crankcase surfaces of any fragments of seals and sealant.

CHECKING OIL JETS FOR PISTONS LUBRICATION/COOLING

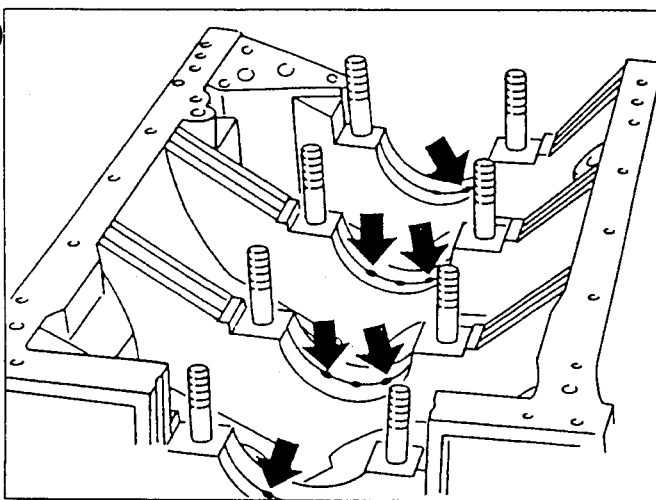
The crankcase has six oil jets, positioned as illustrated and supplied directly by the lubricating grooves of the main bearings.

The purpose of these jets is to cool and lubricate the pistons and their gudgeon pins.

- Accurately clean the oil jets checking that they are not damaged or clogged.
- Check with a jet of compressed air that the oil jets open at the specified pressure.



Oil jet opening pressure
2.5 ± 0.25 bar



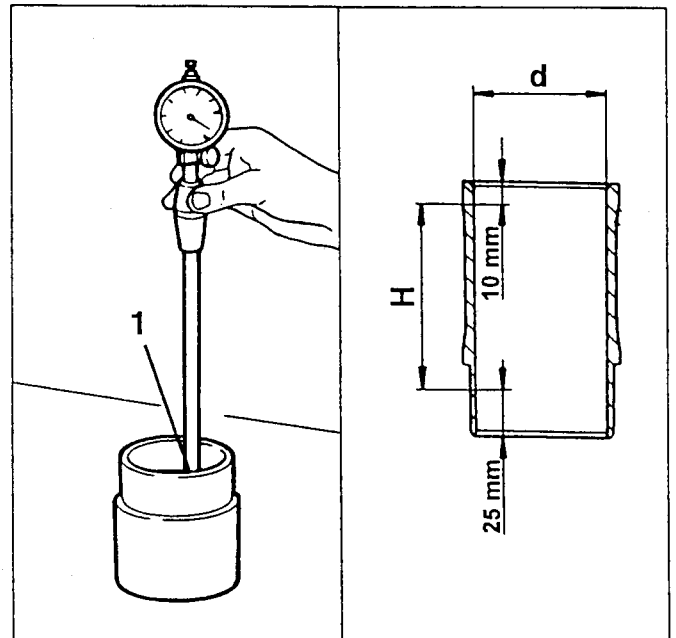
CHECKING THE CYLINDER LINERS

1. Measure the inside diameter of the cylinder liners and check that it is within the specified limits.



Inside diameter "d" of cylinder liners	
Class A (Blue)	92.985 ± 92.994 mm
Class B (Pink)	92.995 ± 93.004 mm
Class C (Green)	93.005 ± 93.014 mm

Maximum taper/ovalisation of cylinder liners
0.01 mm



H: Area for dimensional inspection

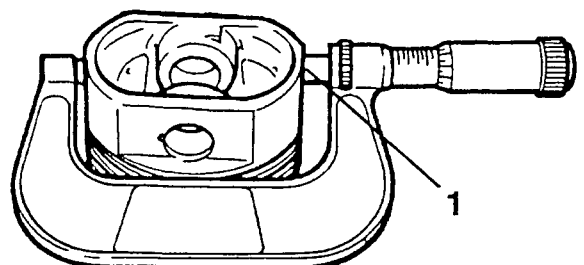
CHECKING PISTONS

1. Measure the outside diameter of the pistons and check that it is within the specified limits.



Piston outside diameter (1)	
Class A (Blue)	92.925 ± 92.935 mm
Class B (Pink)	92.935 ± 92.945 mm
Class C (Green)	92.945 ± 92.955 mm

1. This diameter should be measured at right angles to the gudgeon pin hole 17 mm from the lower edge of the skirt.

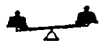


- Calculate the clearance between the pistons and liners and check that it is within the specified limits.

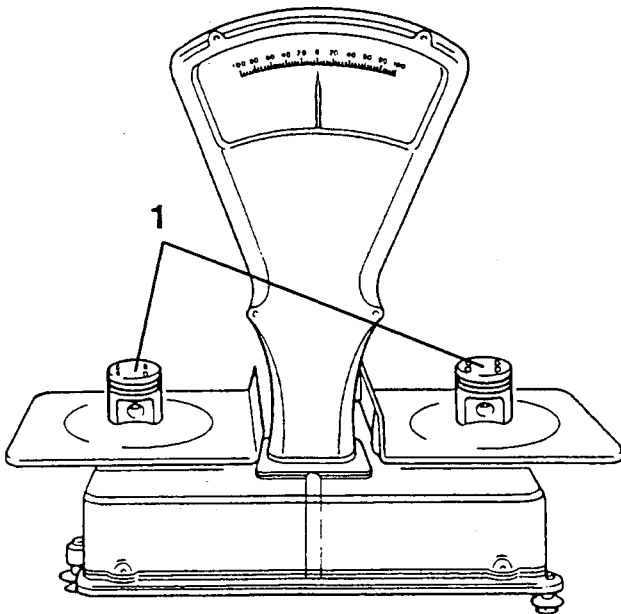


Piston - cylinder liner clearance	
0.059 ÷ 0.060 mm	

1. Check that the difference in weight between the pistons complete with gudgeon pins and seal rings is within the specified limits.



Difference in weight between pistons	
≤ 4 g	

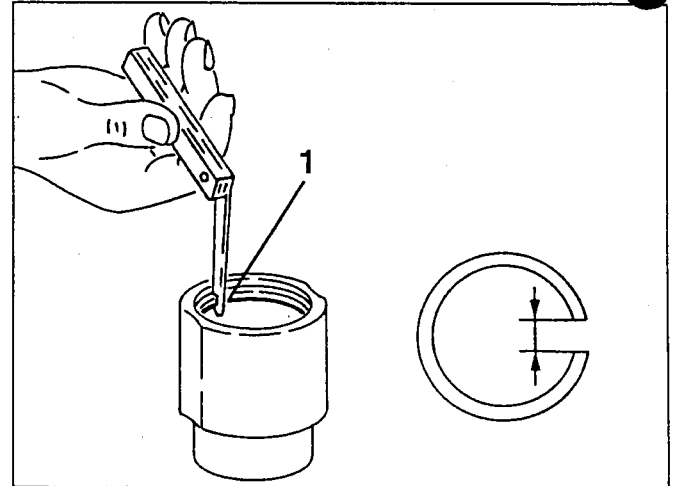


CHECKING THE SEAL RING GAP

1. Insert the seal rings in the cylinder liners, check that they adhere along the entire circumference and that the gap is within the specified limits.



Ring gap	
First ring	0.40 ÷ 0.65 mm
Second ring	0.40 ÷ 0.65 mm
Oil scraper ring	0.30 ÷ 0.60 mm

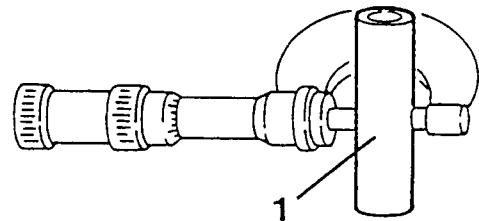


CHECKING THE CLEARANCE BETWEEN GUDGEON PINS AND SEATS ON PISTONS

1. Measure the outside diameter of the gudgeon pins and check that it is within the specified limits.



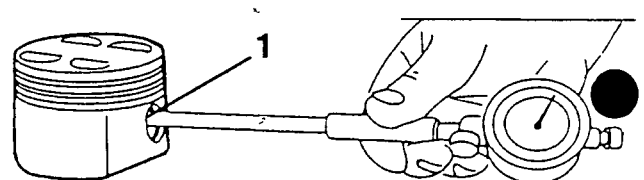
Outside diameter of gudgeon pins	
Class A (Black)	21.994 ÷ 21.997 mm
Class B (White)	21.997 ÷ 22.000 mm



1. Measure the diameter of the hole of the piston mating with the gudgeons and check that it is within the specified limits.



Diameter of gudgeon seats on pistons	
Class A (Black)	22.003 ÷ 22.006 mm
Class B (White)	22.006 ÷ 22.009 mm



Calculate the play between pins and respective piston seats. Check whether the value falls within prescriptions.



Play between pins and piston seats

0.006 ÷ 0.012 mm

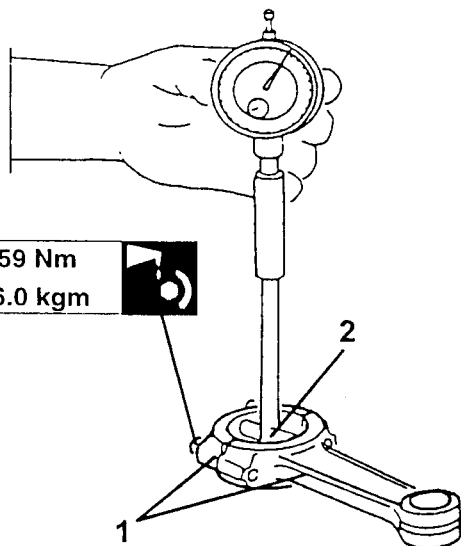
PLAY BETWEEN CONNECTING ROD JOURNAL AND RESPECTIVE HALF-BEARINGS

1. Fit the connecting rod half-bearings in the connecting rod big end and on the respective cap. Then assemble, fastening the screws at the prescribed torque.
2. Measure the connecting rod big end internal diameter and check whether it falls within the prescribed values.



Connecting rod half-bearing internal diameter

Class A (Red)	52.021 ÷ 52.050 mm
Class B (Blue)	52.013 ÷ 52.042 mm



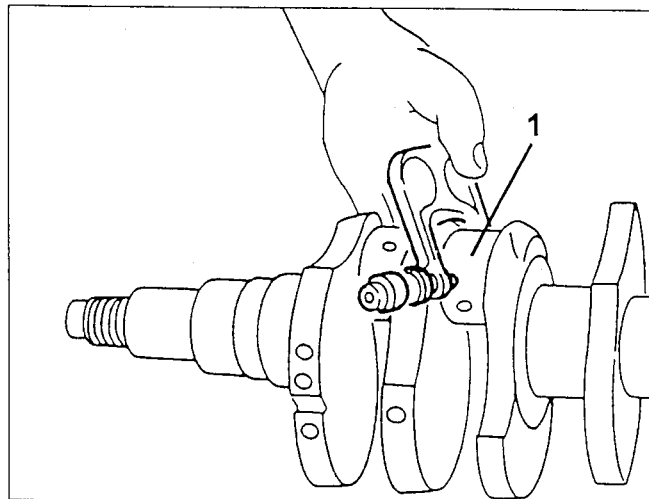
53 ÷ 59 Nm
5.4 ÷ 6.0 kgm

1. Measure the connecting rod journal diameter and check whether it falls within the prescribed values.



Connecting rod journal diameter

Class A (Red)	51.990 ÷ 52.000 mm
Class B (Blue)	51.980 ÷ 51.990 mm



NOTE: The crankshaft nitriding treatment does not allow re-facing. Consequently, it should be replaced if excessively worn.

- Calculate the play between connecting rod journals and the respective half-bearings. Check whether the value falls within prescriptions.



Connecting rod journals and respective half-bearing diameter

Class A (Red)	0.034 ÷ 0.060 mm
Class B (Blue)	0.036 ÷ 0.062 mm

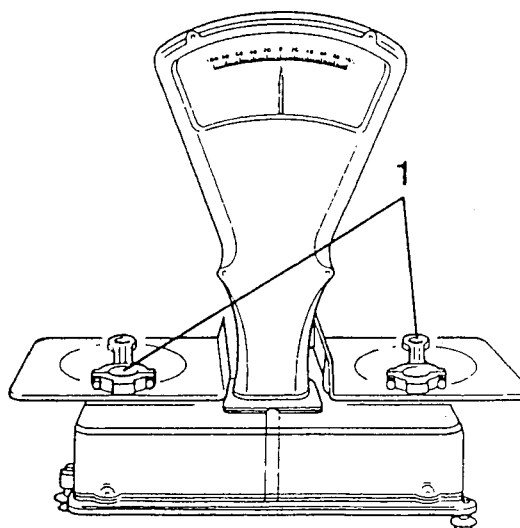
CONNECTING ROD CHECK

1. Check the difference in weight between connecting rods with half-bearings, caps and screws. Check whether the value falls within prescriptions.



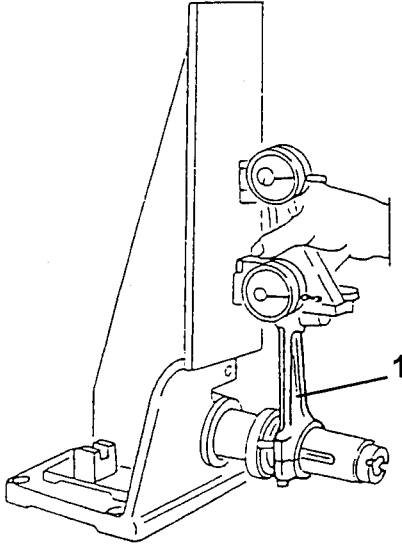
Connecting rod weight difference

≤ 2 g



1. Check connecting rod squaring with a reference as shown in the figure.

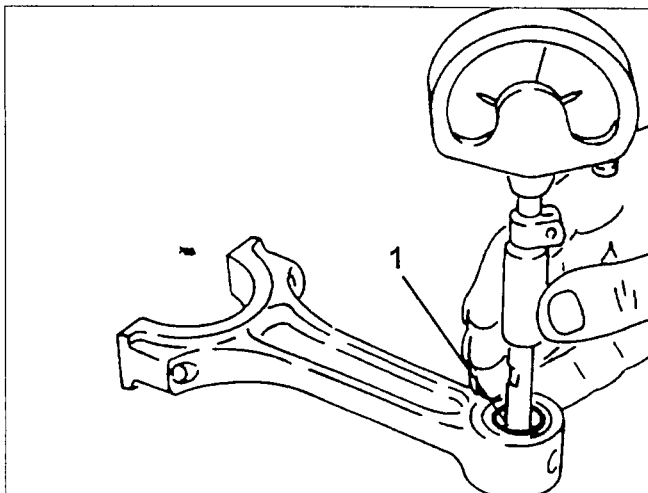
NOTE: If squaring is not perfect, replace the connecting rod to avoid improper stress during engine operation with consequent irregular piston and connecting rod wear.



PLAY BETWEEN CONNECTING ROD SMALL END JOURNAL AND BUSHING

1. Measure the connecting rod small end internal diameter. Check whether the value falls within prescriptions. If not, replace it.

∅	Connecting rod small end bushing internal diameter
	22.005 ÷ 22.015 mm



- Measure the journal external diameter and check whether the value falls within prescriptions.

∅	Journal external diameter	
	Class A (Black)	21.994 ÷ 21.997 mm
	Class B (White)	21.997 ÷ 22.000 mm

- Calculate the play between journals and connecting rod small end bushing. Check whether the value falls within prescriptions.

↔	Connecting rod small end journal and bushing play	
	Class A (Black)	0.008 ÷ 0.021 mm
	Class B (White)	0.005 ÷ 0.018 mm

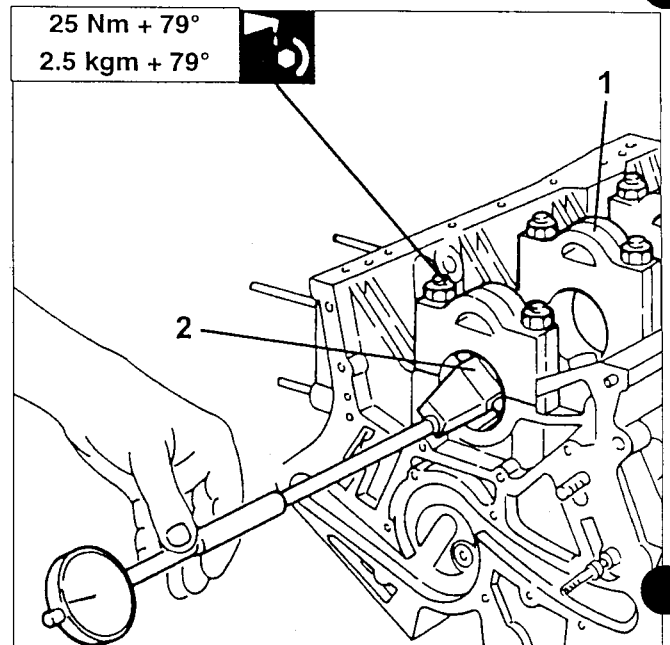
PLAY BETWEEN MAIN JOURNAL AND RESPECTIVE HALF-JOURNALS

1. Fit the half-bearings and main bearings on the crankcase. Fasten the nuts at the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angular torque.

2. Measure the main journal internal diameter and check whether the value falls within prescriptions.

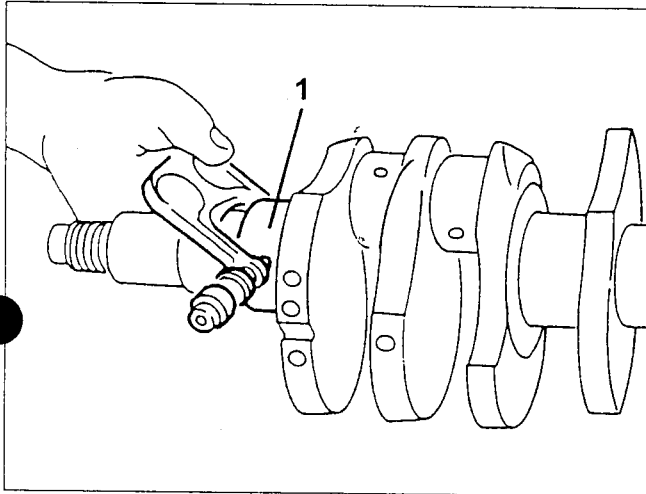
∅	Main journal diameter	
	Class A (Red)	59.979 ÷ 59.997 mm
	Class B (Blue)	59.973 ÷ 59.991 mm
	Class C (Green)	59.967 ÷ 59.985 mm



1. Measure the main journal diameter and check whether the value falls within prescriptions.



Main journal diameter	
Class A (Red)	59.973 ÷ 59.979 mm
Class B (Blue)	59.967 ÷ 59.973 mm
Class C (Green)	59.961 ÷ 59.967 mm

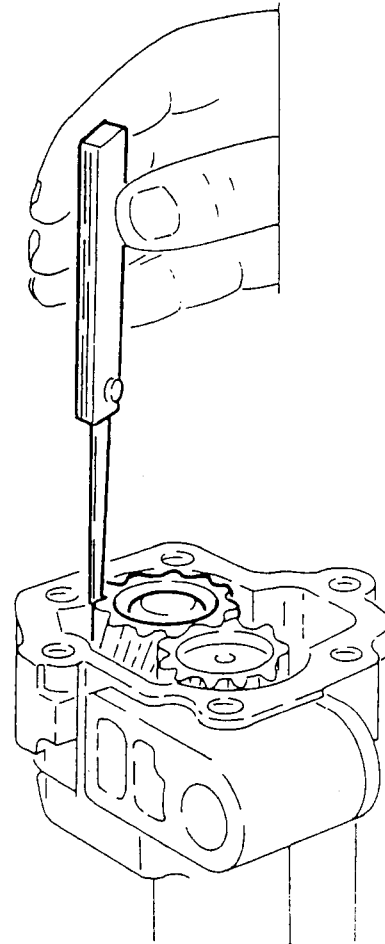


OIL PUMP CHECK

The oil pump is a complete spare part. Measure the play between the pump casing and the driven gear as shown in the figure after separating the suction device from the pump casing.



Play between pump casing and driven gear
0.025 ÷ 0.075 mm



- Calculate the play between main journals and respective half-bearings and check whether the value falls within prescriptions.



Play between main journals and respective half-bearings
0.000 ÷ 0.024 mm

FLYWHEEL CHECK

- Check whether the clutch plate surface is not scratched and that the crown teeth are neither cracked or seized. In this case, replace the crown wheel as follows:

- remove the old crown wheel with a press;
- clean the new crown wheel and flywheel contact surfaces carefully;
- heat the new crown wheel uniformly at 120 - 140°C and fit in to the flywheel. Leave to cool at ambient temperature. Do not forcefully cool.

REFITTING PRECAUTIONS



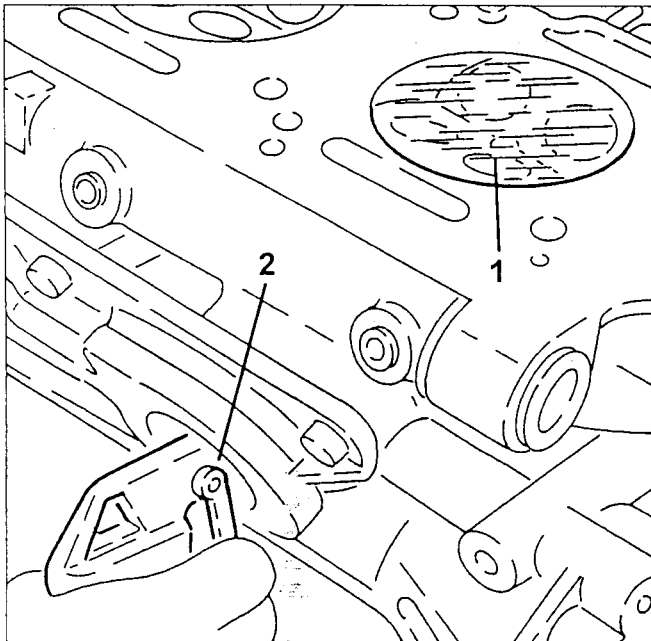
Reverse the removal sequence for refitting unless otherwise specified in the following instructions.

VALVE TIGHTNESS CHECK

- Fit the spark plugs in their seats.

1. Pour some petrol in the combustion chamber so to just cover the valve caps.

2. Let low pressure air into the intake manifolds and into the exhaust manifolds. Check there are no air bubbles in the petrol. If there are bubbles, check correct position and if required machine the valve seats (see specific paragraph).



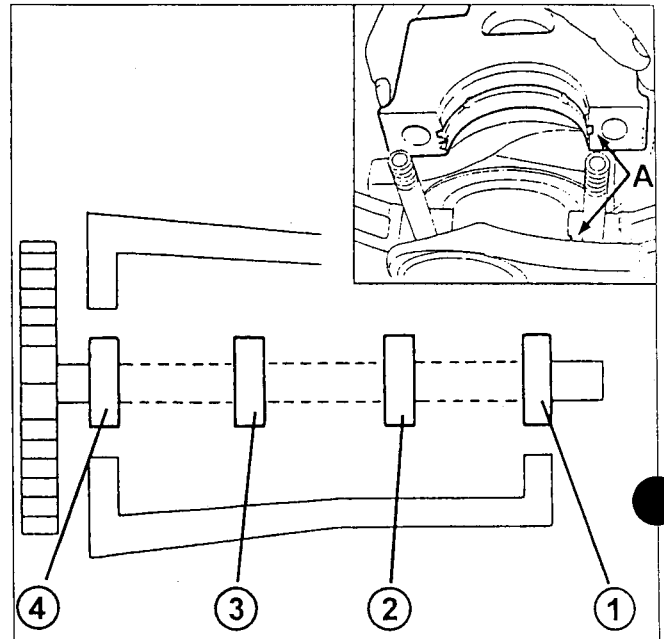
CRANKSHAFT REFITTING

- Fit the main half-bearings and the thrust half-rings on the crankcase and position the crankshaft.

NOTE: Make sure the lubrication ducts are facing the crankshaft shoulder when refitting the thrust half-rings.

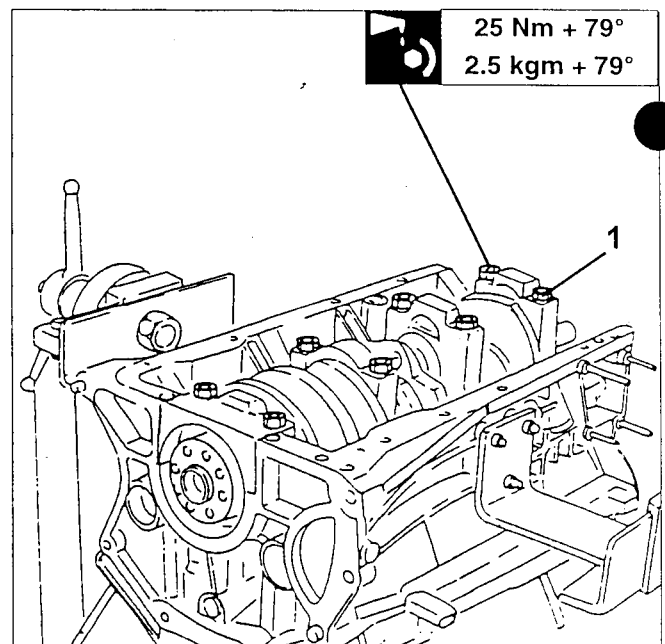
- Fit the main bearings and half-bearings on the journals according to the numbers.

NOTE: The safety notches "A" on the crankcase and on the main bearings should be on the same side.



1. Fasten the main bearing fastening nuts at the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angle torque.

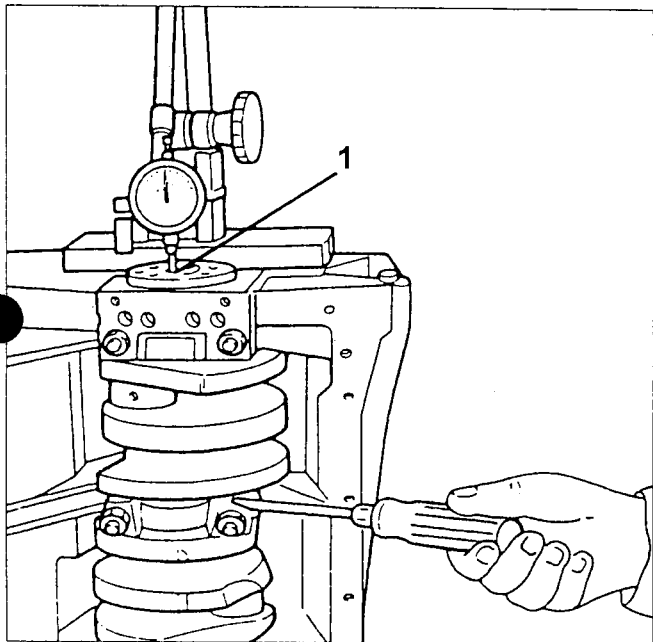


CRANKSHAFT AXIAL PLAY

1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.



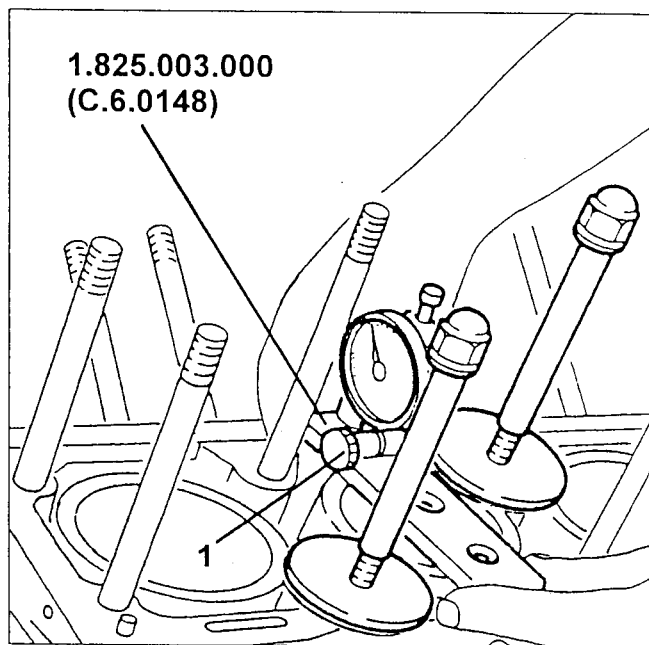
Crankshaft axial play
0.080 ÷ 0.265 mm



1. Fit tool no. 1.825.003.000 (C.6.0148) and the reset centesimal gauge on the crankcase. Position one side and then the other so that the feeler is in contact with the cylinder liner edges. Check the projection falls within the prescribed values.



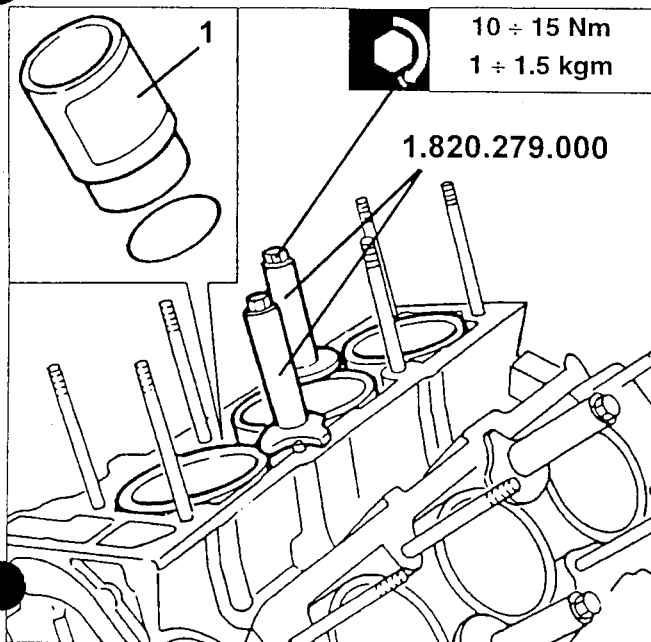
Crankcase cylinder liner projection
0.01 ÷ 0.06 mm



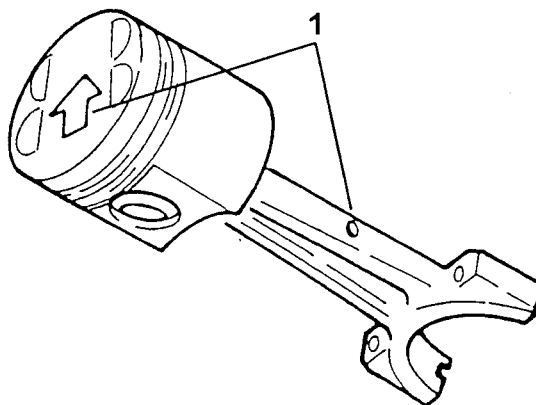
CYLINDER LINER, PISTON AND CONNECTING ROD REFITTING

- Clean the cylinder liners carefully, fit the seals and insert in the crankcase. Make sure they reach the end of the stroke.

1. Lock the cylinder liners in the crankcase with the liner retainer tools no. 1.820.279.000 and fasten the respective nuts at the prescribed torque.



1. Couple the pistons and their respective connecting rods. Make sure the arrow printed on the top of the piston is facing the direction shown in the figure with respect to the lubrication hole on the side of the connecting rod.

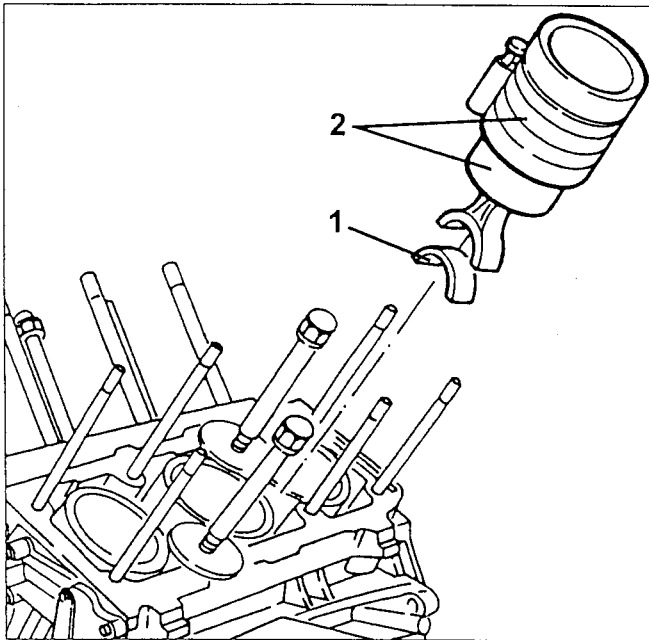


- Fit the gas rings and the oil scraper on the piston with a suitable tool.

NOTE: After refitting, address the gas ring cuts so that they do not coincide with the journal axis and at 120° one from the other.

1. Fit the respective half-bearings on the connecting rod big end.
2. Insert the connecting rod-piston assembly in the bank cylinder liner with a suitable tool.

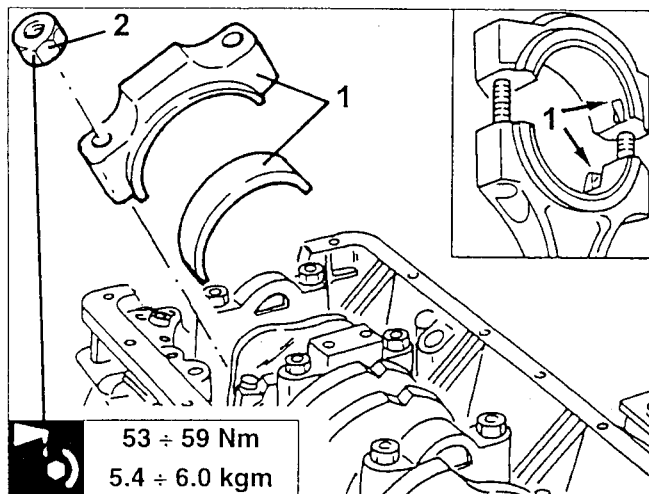
NOTA: Fit the connecting rod-piston assembly so that the arrow printed on the top of piston is facing the front side of the motor and that the lubrication hole is facing towards the right-hand side of the crankcase.



- Turn the crankcase on the overhaul stand.
1. Fit the connecting rod caps and half-bearings on the bank. Address the safety notch towards the notch on the connecting rod cap.

NOTE: The cylinder number is shown on the side of each connecting rod cap. When refitting, this number should be on the same side as the number printed on the connecting rod.

2. Fasten the connecting rod cap screws at the prescribed torque.

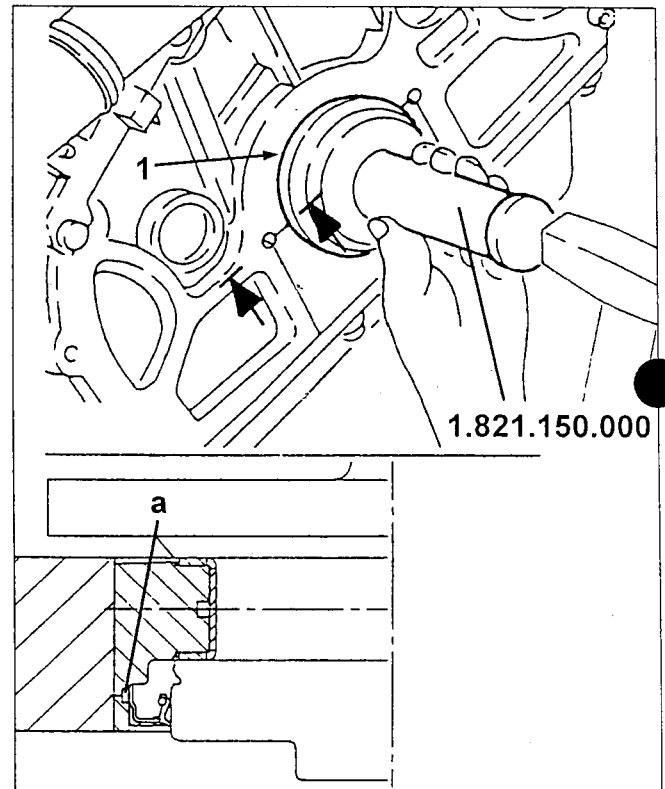


- Fit the pistons and the connecting rod of the other bank in the same way.

OIL SUMP REFITTING

1. Fit the rear crankshaft oil seal with tool no. 1.821.150.000.

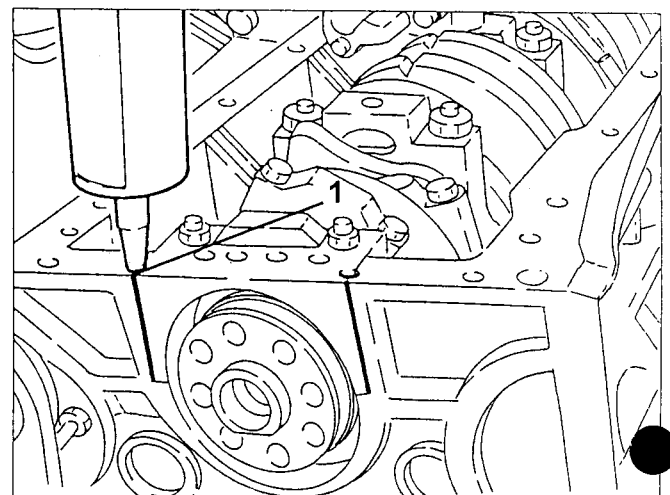
NOTE: Fit the oil seal in its seat so that the holes (a) are covered.



For pre-change versions (to engine no. 00708)

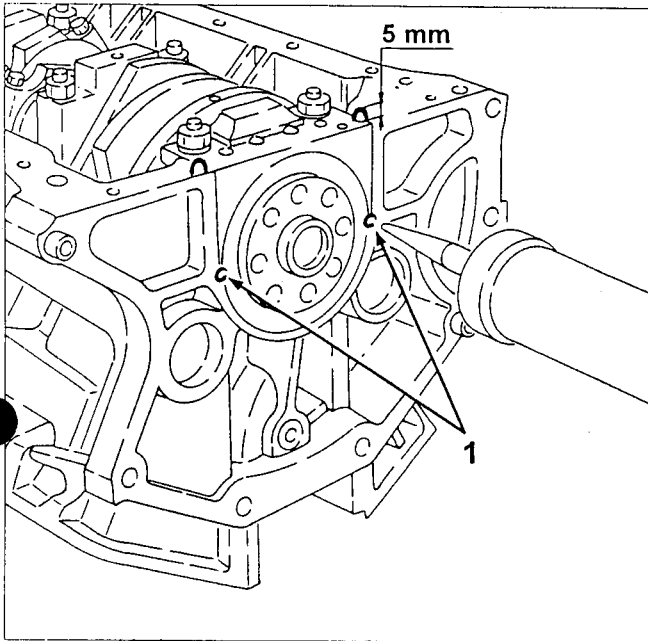
1. Apply "DOW CORNING 7091" silicon sealant with a mechanical gun through the holes shown in the figure.

NOTE: Check that the sealant seeps out from the rear crankcase-main bearing coupling along the entire length.

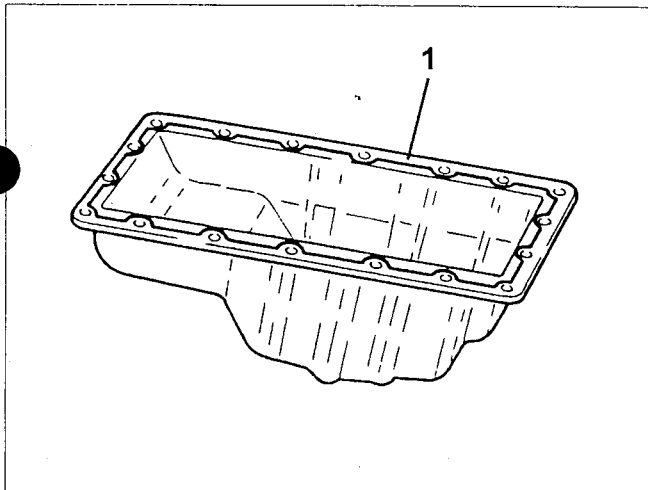


**Post-change versions
(from engine no. 00709)**

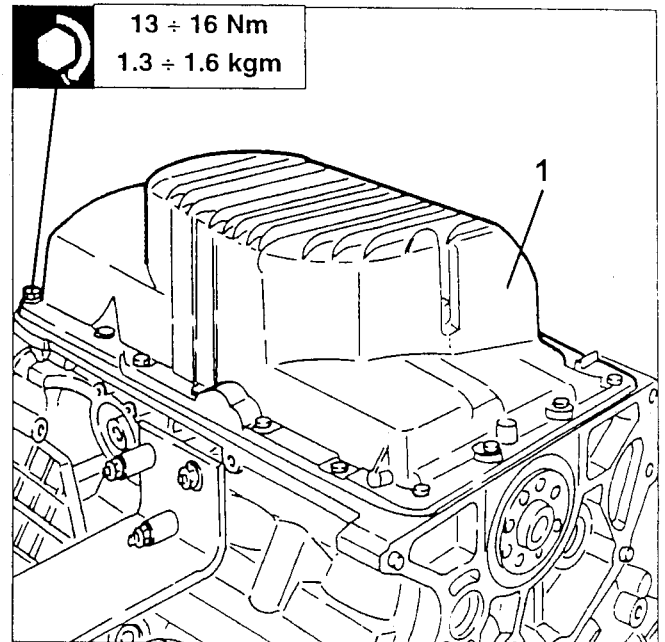
1. Apply "DOW CORNING 7091" silicon seals by means of a mechanical gun through the holes on the crankcase until the sealant seeps out from the engine oil sump coupling by approximately 5 mm.



1. Apply sealant to the oil sump. Make sure the strip of sealant (not wider than approximately 1.5 mm in diameter) is within the oil sump fastening holes (between reservoir and hole).



1. Position the oil sump avoiding considerable side movements which could remove the silicon sealant. Then fasten the oil sump screws at the prescribed torque.



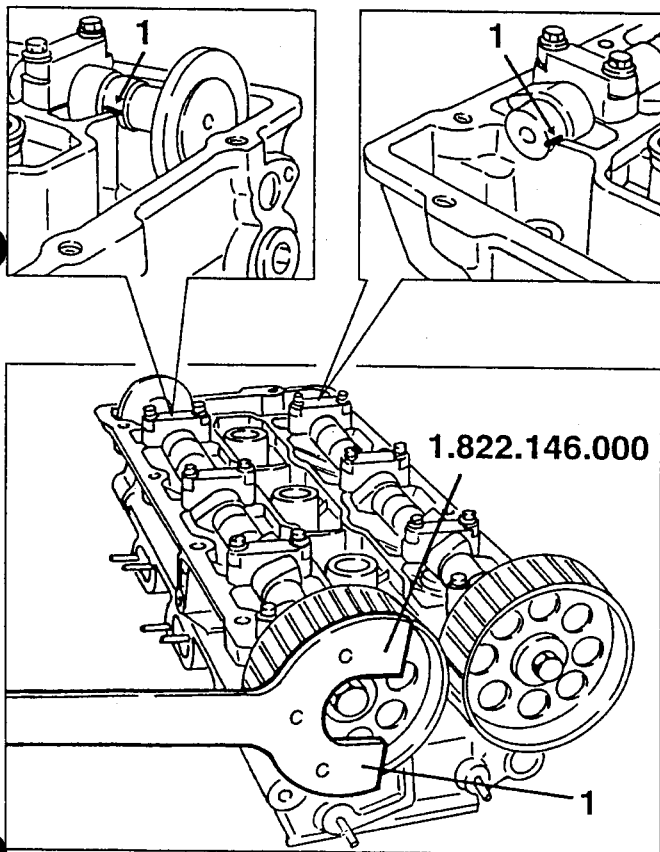
IMPORTANT: Fit the oil sump within 15 minutes from applying the sealant in the crankshaft rear seal holes.

WHITE

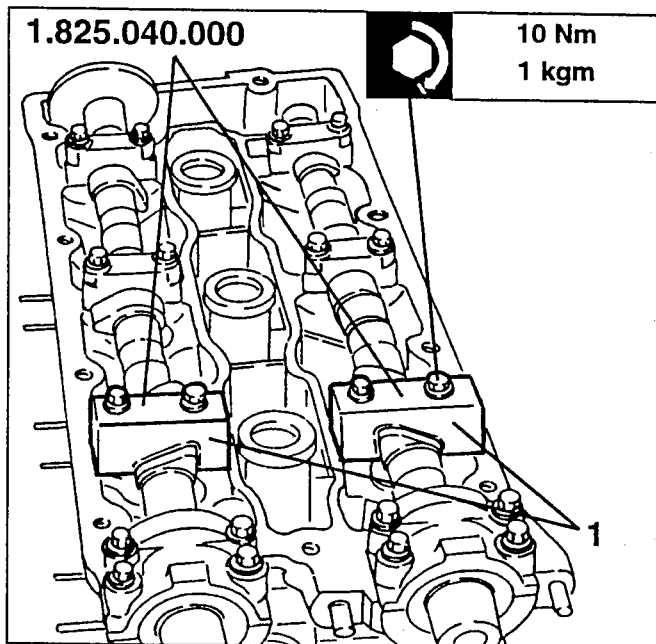
REFITTING THE CYLINDER HEADS

1. Temporarily assemble the camshaft drive pulleys and using tool no. 1.822.146.000, turn each camshaft until the reference notches on the shafts coincide with the upper surface of the cylinder head.

NOTE: The reference notches must face the centre of each head.

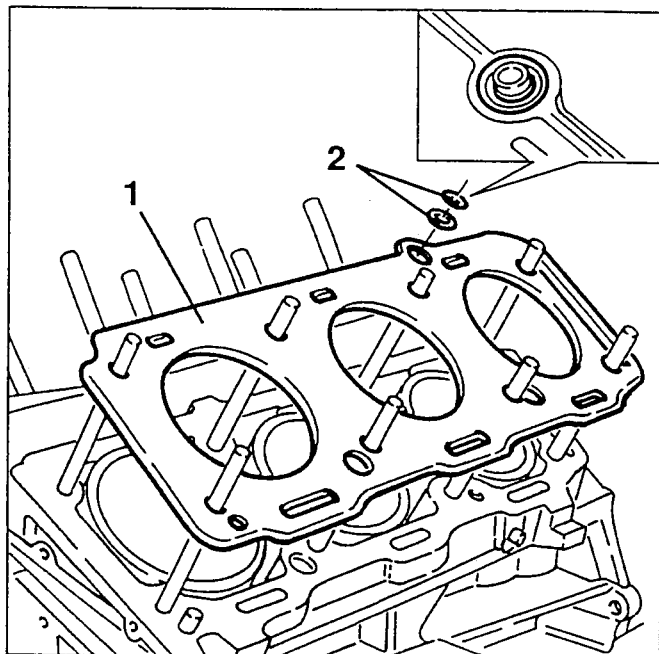
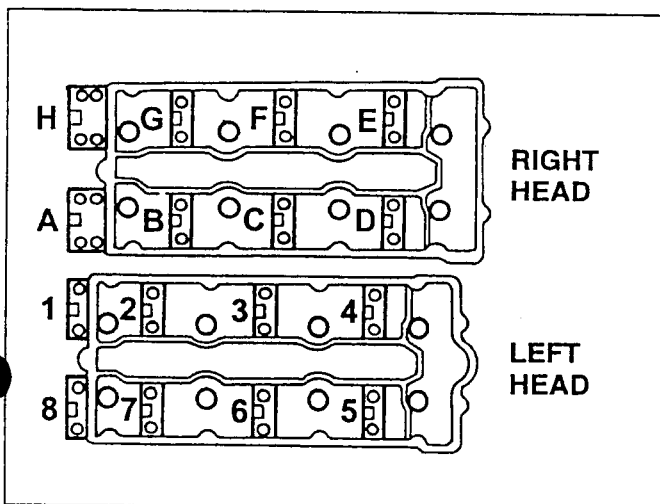


1. In place of the removed camshaft caps, install the templates no. 1.825.040.000 in the position shown by the stamping on them.



- Turn the crankshaft until the piston of the first cylinder reaches T.D.C.
- Remove the liner stopper tools installed previously.
- 1. Position the cylinder head seals on the crankcase.
- 2. Position lubricating duct seal rings (two for each side of the crankcase).

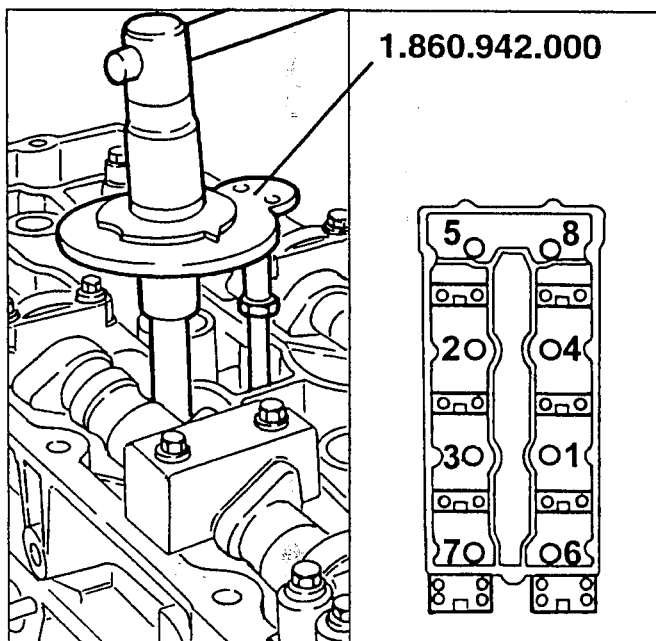
- Remove camshaft caps 4 and 7 for the left cylinder head and caps B and G for the right cylinder head.



- Assemble the cylinder heads on the crankcase.
- Lubricate the threads, nuts and washers with engine oil, then tighten the heads as described below, bearing in mind that, for each step, the tightening sequence is the one illustrated below.

NOTE: For angle tightening use the tool complete with graduated disk no. 1.860.942.000.

Tightening procedure	
Tighten all the nuts to a torque of:	24 ÷ 26 Nm 2.5 ÷ 2.7 kgm
Complete tightening with a further angle of:	240° ± 2°



The figure represents the right cylinder head; for the left cylinder head the tightening sequence is symmetrical.

NOTE: The cylinder head seals are ASTADUR. Because of the special material with which they are made, these seals undergo a polymerisation process when the engine is running, therefore they harden considerably during use.

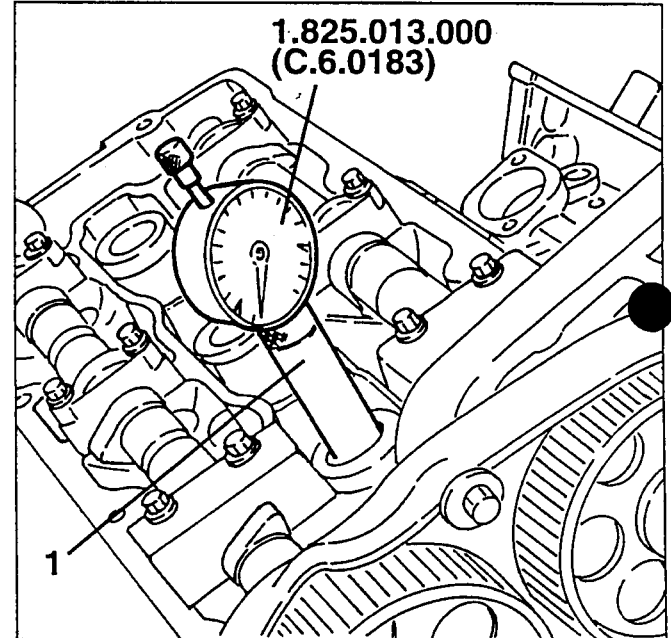
To ensure that the cylinder head seals polymerise, it is necessary to:

- keep the seals closed in their polythene bag;
- take them out of their wrapper a little before assembly;
- not to lubricate or soil the seals with oil, making sure that the cylinder head and crankcase surfaces are clean.

ASSEMBLING THE TIMING GEAR DRIVE BELT AND CHECKING TIMING

- Refit the camshaft belt pulleys and belt tensioner without tightening the fastening screws of the camshaft drive pulleys and the belt tensioner fastening screws.

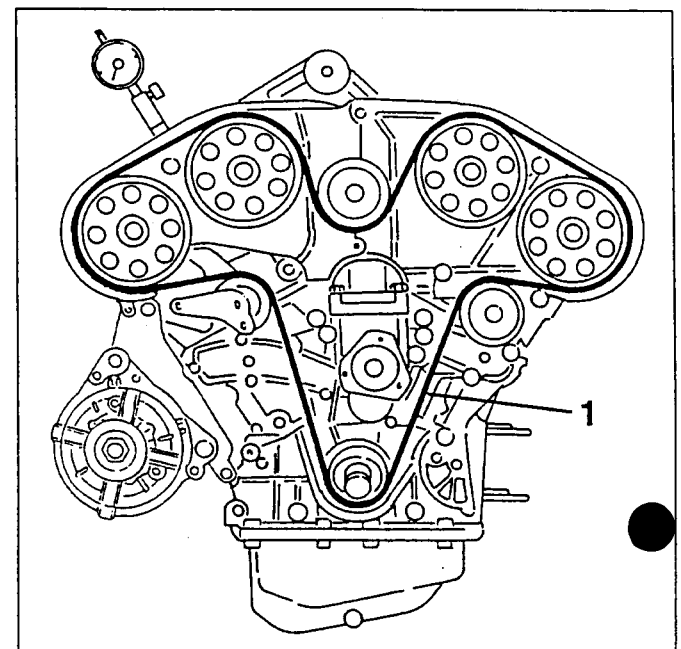
1. Install tool no. 1.825.013.000 (C.6.0183) in the seat of the first cylinder spark plug.



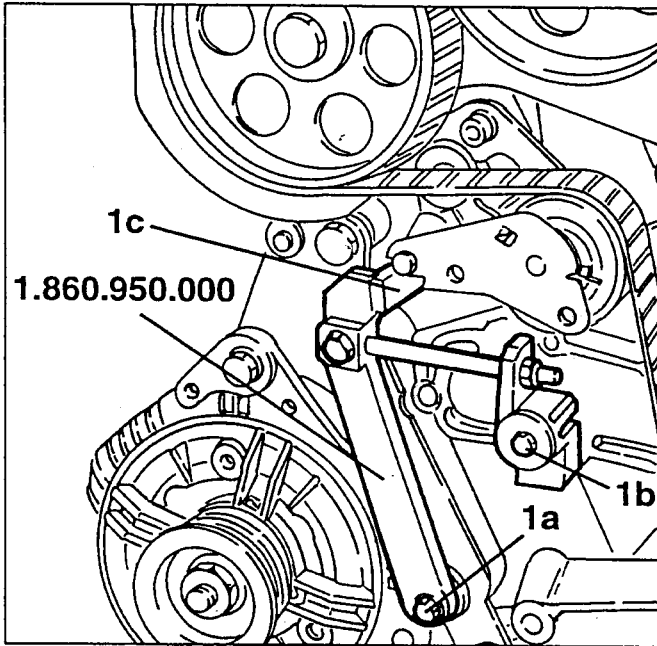
- Working on the fastening nut from the auxiliary components drive pulley, make the crankshaft turn a little (both ways) until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke.

NOTE: Make sure that the last turn of the crankshaft is in the operating direction.

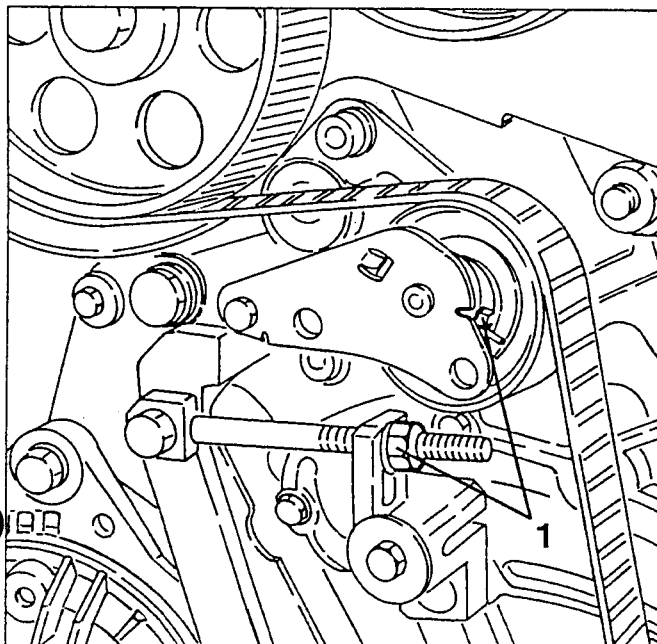
1. Fit the timing gear drive belt starting from the drive pulley and continuing anti-clockwise making sure that the driving branches are well taut.



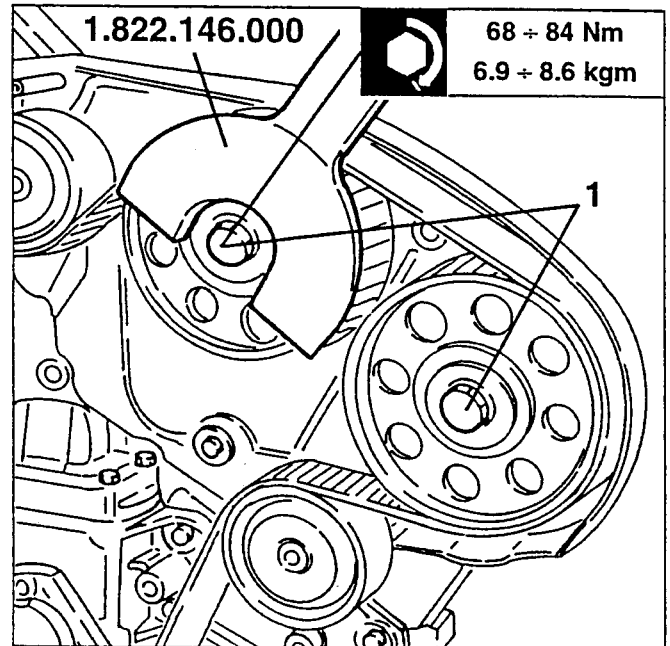
1. Position tool no. 1.860.950.000 for tensioning the timing gear drive belt fastening with the alternator screw (1a) and with the water pump screw (1b); the tooth (1c) of the tool must lever on the mobile part of the belt tensioner.



1. Working on the nut illustrated move the notch of the mobile index under the fixed notch of the tensioner.



1. Tighten the camshaft drive pulleys to the specified torque levering with tool no. 1.822.146.000.

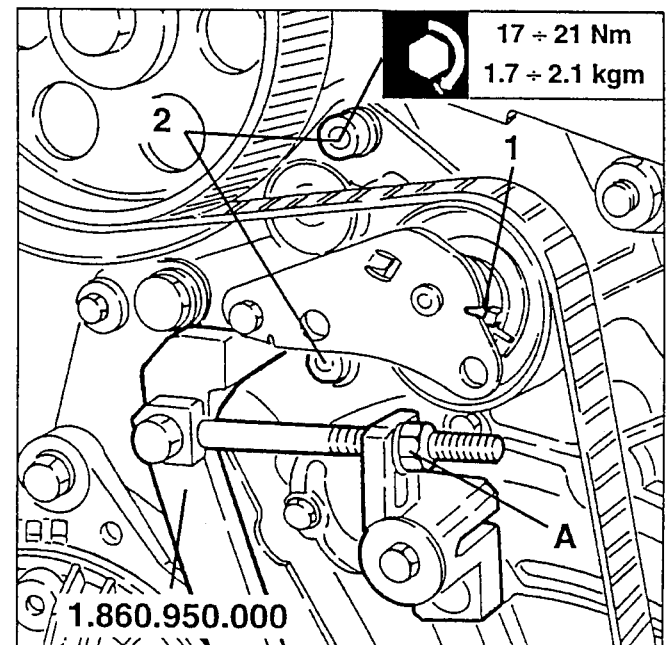


- Remove the templates no. 1.825.040.000 installed previously and in place of them fit the corresponding caps and tighten the fastening screws to the specified torque.

- Turn the crankshaft twice in its direction of rotation to allow the belt to settle.

1. Check that the tensioner fixed index coincides with the mobile index; if not slightly relieve the tension of the tensioner working on nut (A) until the indexes coincide.

2. Tighten the belt tensioner fastening screws to the specified torque and remove tool no. 1.860.950.000 used for tensioning.



- Complete reassembly of the engine reversing the sequence followed for disassembly.

CHECKING ELECTRIC COMPONENTS OF THE LUBRICATION CIRCUIT

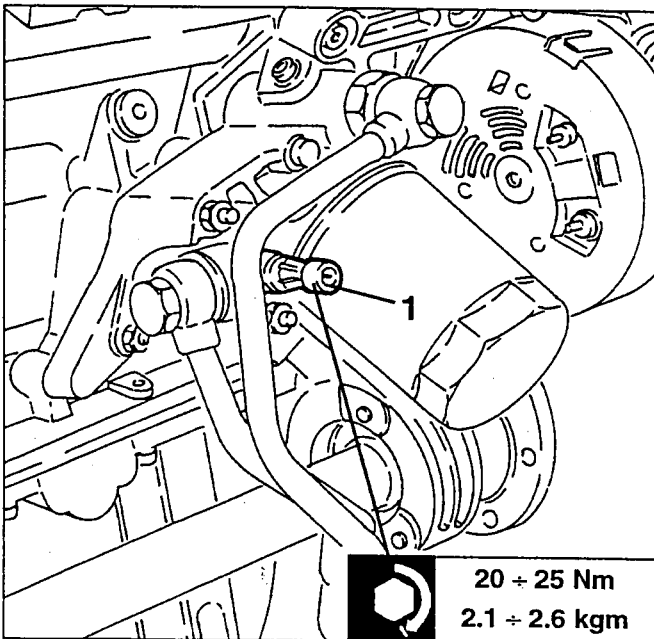
Low engine pressure warning sensor

1. Check the setting of the low engine pressure warning light sensor. Replace the sensor if the values are not within the specified limits.



Contact opening/closing pressure

0.15 ÷ 0.35 bar



For the other electric sensors and components located in the engine compartment, refer to the specific groups in which they are described in detail.



ENGINE AR 32302

INDEX

GENERALITIES

- Description 1
- Lubrication system 3

OVERHAULING

- Introduction 5
- Engine disassembly 5
- Cylinder head disassembly 12
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- Checking and inspecting the crankcase 18
- Reassembly instructions 22
- Checking lubrication circuit
electric components 26



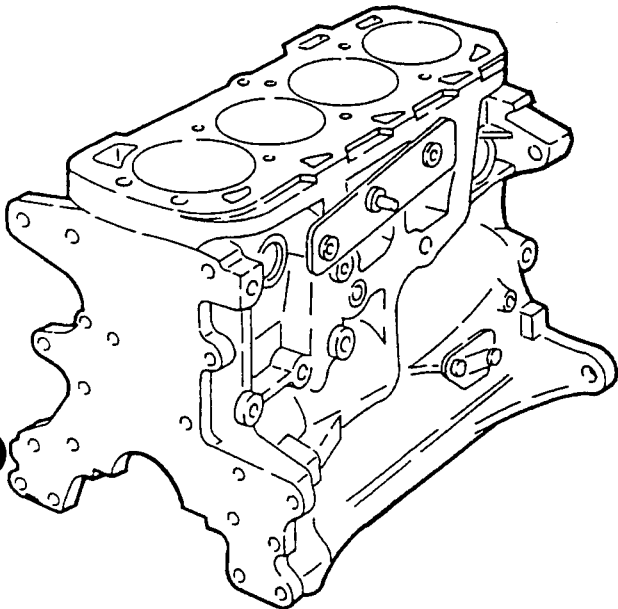
DESCRIPTION

Turbodiesel engine, direct injection without pre-combustion chamber, 4 cylinders in line, 1910 c.c., two valves per cylinder, one overhead camshaft, air supercharging by turbocharger and intercooler, Bosch Common Rail EDC-15C electronic injection system.

CRANKCASE

The crankcase is in spheroidal cast iron with integral cylinder liners of the closed-deck type.

The crankshaft is supported by five main bearings. Special grooves machined in the crankcase walls allow the flow of coolant fluid and lubricating oil. A jet is installed in the lower part which sprays oil to cool the piston skirts and lubricate the gudgeon pin.



CYLINDER HEAD

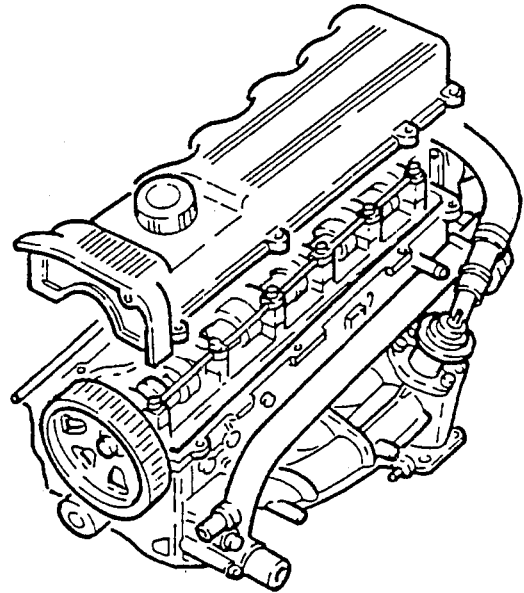
The cylinder head is in one piece and made from aluminium and silicon alloy.

The two parallel and vertical valves per cylinder are installed in their valve guides and controlled by a single overhead camshaft, the cams of which act on mechanical tappets.

The valve guides are force-fitted in their seats on the cylinder head by interference and the inside diameter is perfected after assembly using a special bore.

Unlike heads with pre-combustion chamber, the whole combustion process takes place in the combustion chamber machined in the piston.

The seal between the cylinder head and crankcase is made from aramidic fibre and there is no need to retighten the head throughout the whole life of the engine.



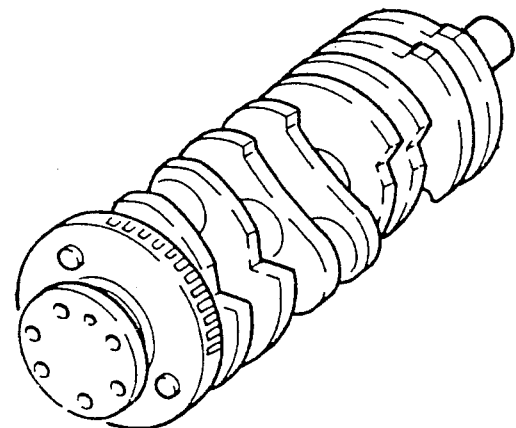
CRANKSHAFT

This is in cast iron and rests on five main bearings and its end float is adjusted by two half rings housed in the rear main bearing.

Eight counterweights accurately balance the rotating masses.

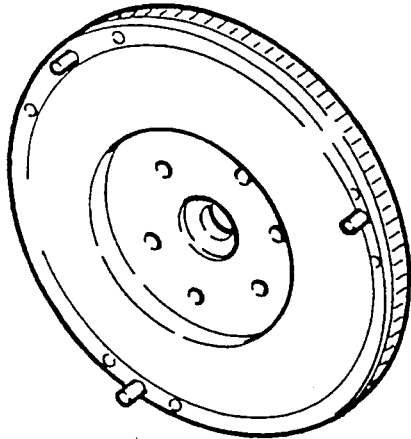
A groove runs inside the shaft to lubricate the main bearing and connecting rod journals.

The phonic wheel for the rpm sensor is installed at the rear.



FLYWHEEL

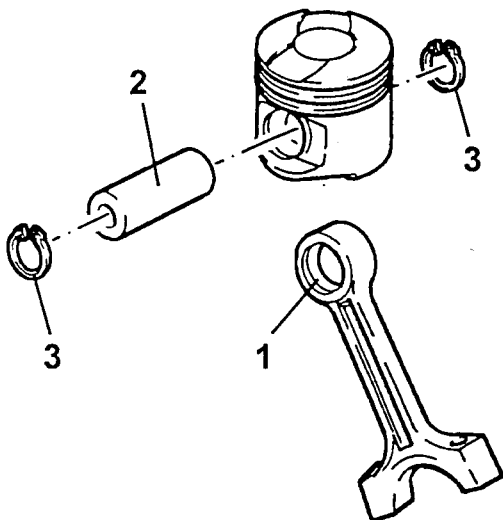
This is in cast iron, with inserted ring gear, in hardened and tempered steel, and suitably balanced.



PISTONS AND CONNECTING RODS

The connecting rods are in hardened and tempered steel, with force-fitted copper bush (1) for mating with the gudgeon pin (2) of the piston.

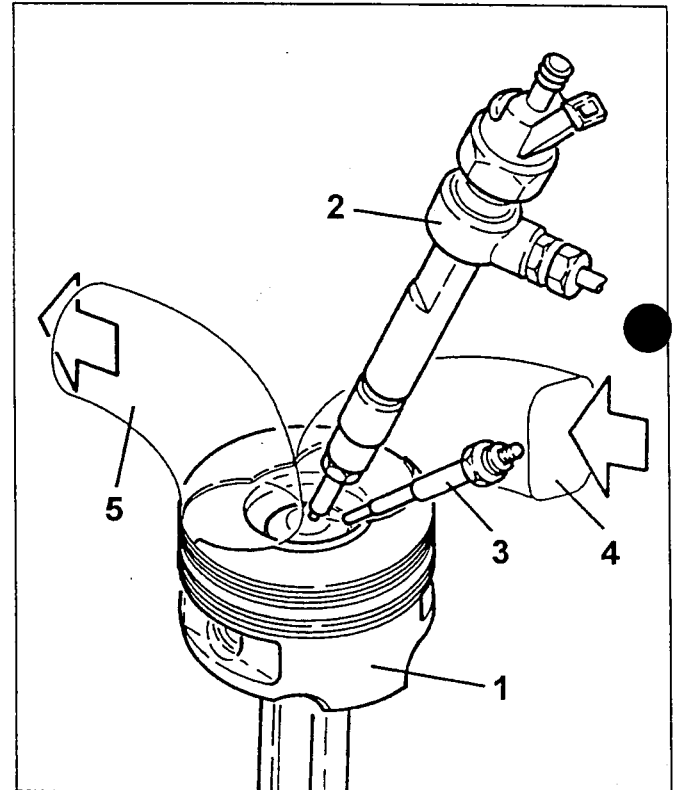
The floating type gudgeon pins are retained by two expansion circlips (3) which are housed in the special hollows machined on the piston hubs.



The pistons are in aluminium and silicon alloy with self-heating inserts and are subdivided into three dimensional classes.

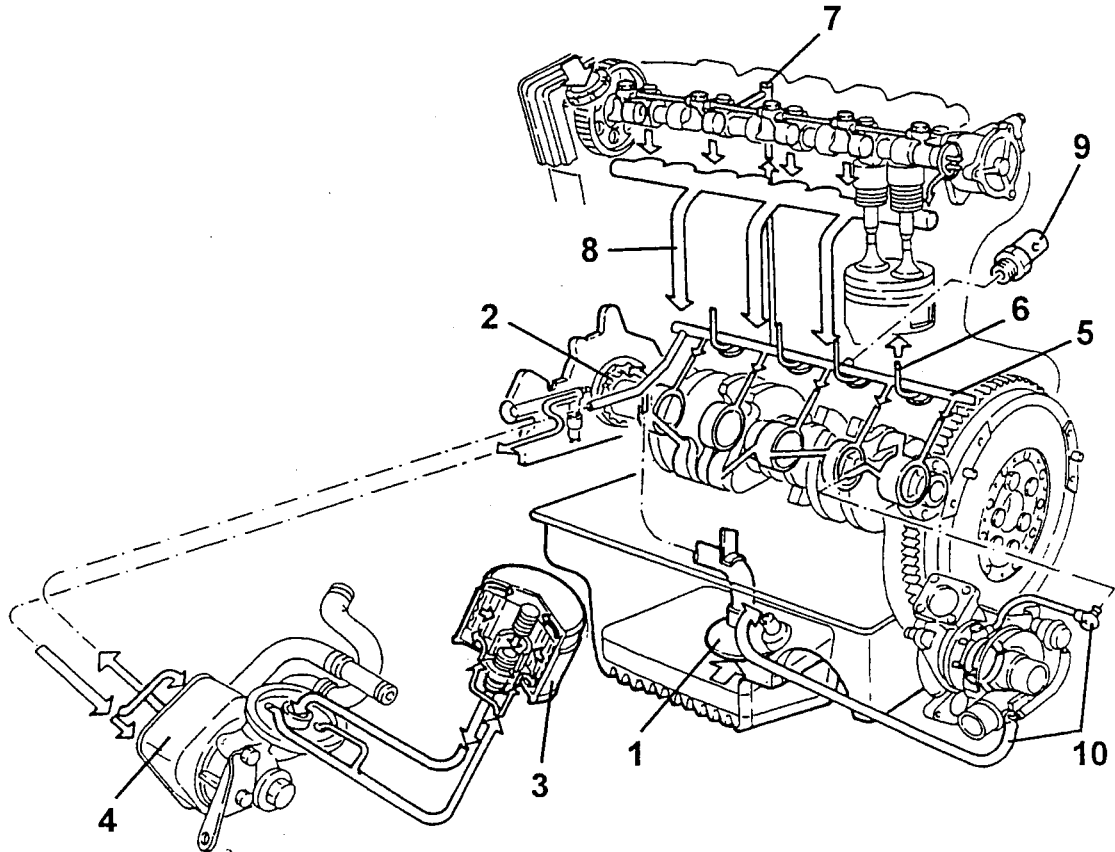
The "OMEGA" shaped combustion chamber, which improves combustion yield, is machined on the piston crown.

Mating with the gudgeon pin is through two copper alloy bushes.



- 1. Piston
- 2. Injector
- 3. Glow plug
- 4. Air inlet
- 5. Exhaust gas outlet

LUBRICATION SYSTEM



- 1. Suction device with filtering mesh
- 2. Oil pump
- 3. Oil filter cartridge
- 4. Heat exchanger (water/oil)
- 5. Main longitudinal groove

- 6. Spray jets (piston skirt cooling)
- 7. Vertical groove (lubricating camshaft bearings)
- 8. Oil return to sump
- 9. Switch for engine oil pressure warning light
- 10. Turbocharger lubrication pipes

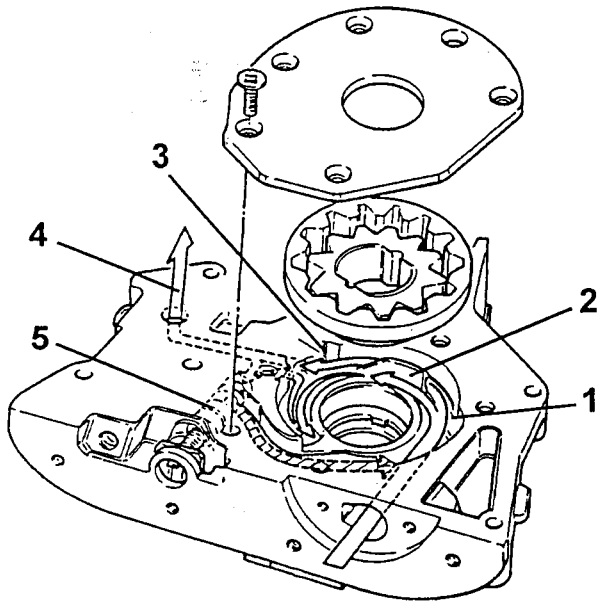
OIL PUMP

The engine oil is withdrawn from the sump by the vacuum created by the rotation of the gears shrunk onto the crankshaft.

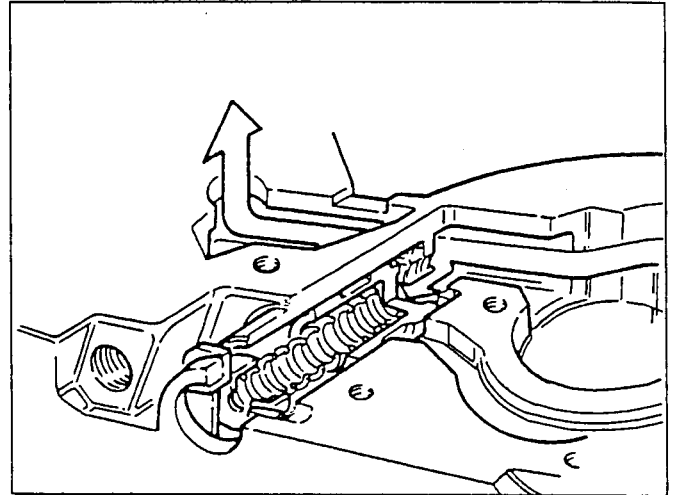
The vacuum is present starting from the separation partition (2) of the gears up to the oil sump suction device.

On the other hand, the pressure develops starting from the separation partition (2) in all the engine oil delivery ducts (4).

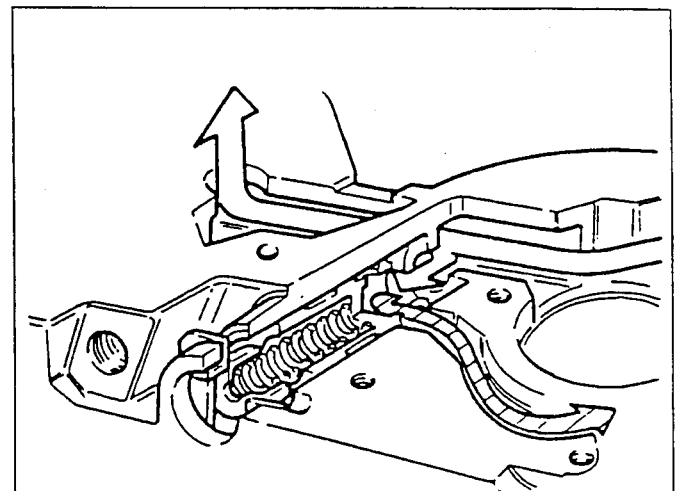
When the pressure exceeds 5 bar, the thrust exerted on the limiting valve (5) overcomes the reaction of the spring below and moves the valve until it opens the connection duct between the pressure chamber (3) and the low pressure chamber (1).



Closing operating position of the engine oil pressure limiting valve



Short circuit operating position of the limiting valve



INTRODUCTION

The instructions contained in the following paragraphs refer to complete engine bench overhaul after removing the engine from the vehicle. The instructions are organised as follows:

- **Engine removal:**
removal of engine accessories and components and disassembly of the main engine assemblies.
- **Cylinder head disassembly and overhauling:**
complete overhauling of component parts.
- **Crankcase overhauling:**
complete overhauling of component parts.
- **Refitting precautions:**
specific refitting operations which mainly differ from the removal instructions.
- Lubrication electrical circuit checks.

All the disassembly procedures described in the following paragraphs should be reversed for refitting, unless specifically indicated.

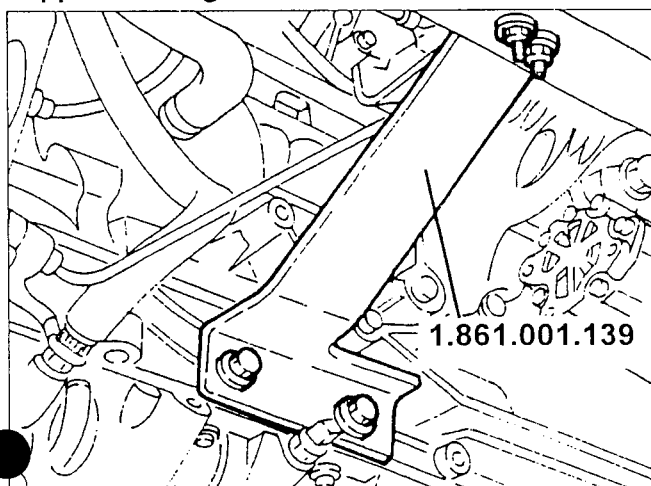
The following procedures refer to complete engine overhauling. Some procedures, however, can be used separately for some parts only when required for specific components.

ENGINE REMOVAL

PRELIMINARY OPERATIONS

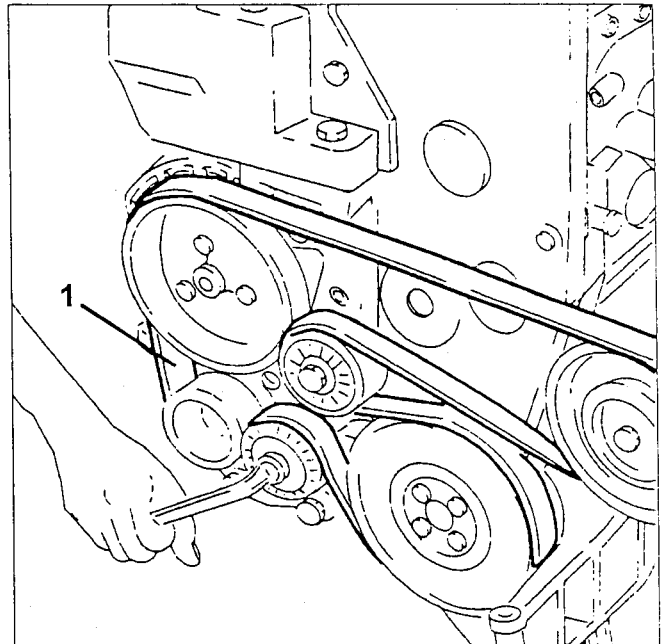
- Position the engine on a stand with common suitable tools.

NOTE: Tool no. 1.861.001.139 can be used to support the engine on the overhaul stand.

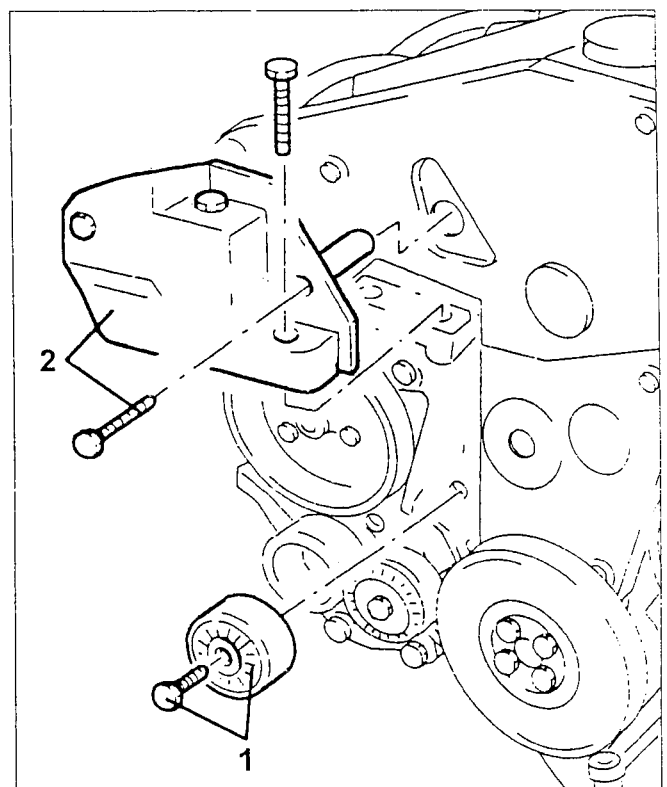


SINGLE ENGINE UNIT BELT REMOVAL

- Loosen the single engine unit belt by means of a wrench on the automatic belt take-up device.
- 1. Remove the single engine unit belt.

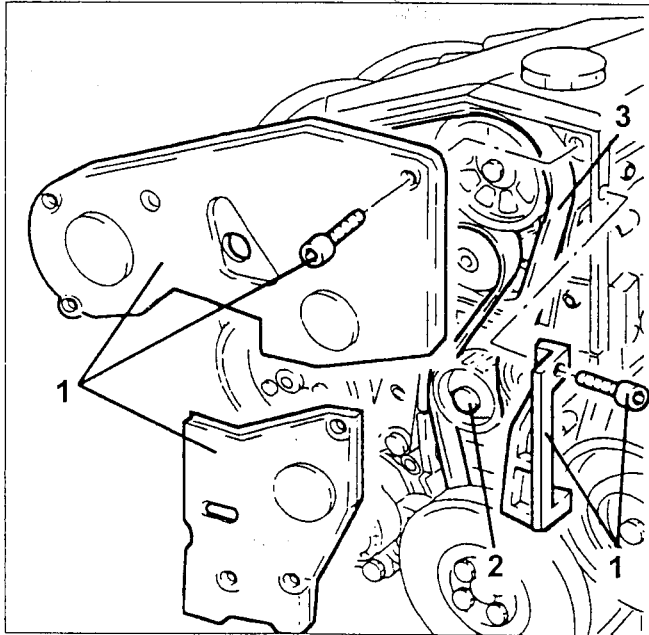


1. Loosen the fastening screw and remove the single engine unit belt runner.
2. Loosen the fastening screws and remove the engine tie-rod bracket.

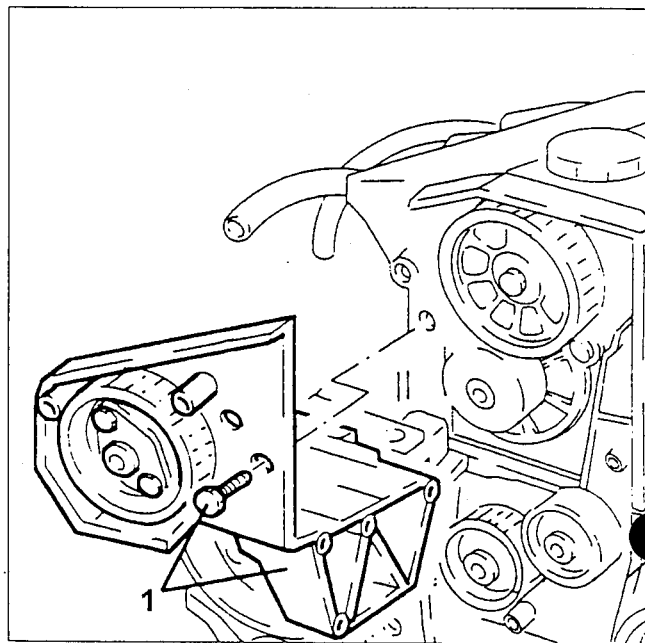


TIMING BELT REMOVAL

1. Loosen the screws and remove the timing belt guard.
2. Loosen the timing belt take-up device nut.
3. Remove the timing belt.

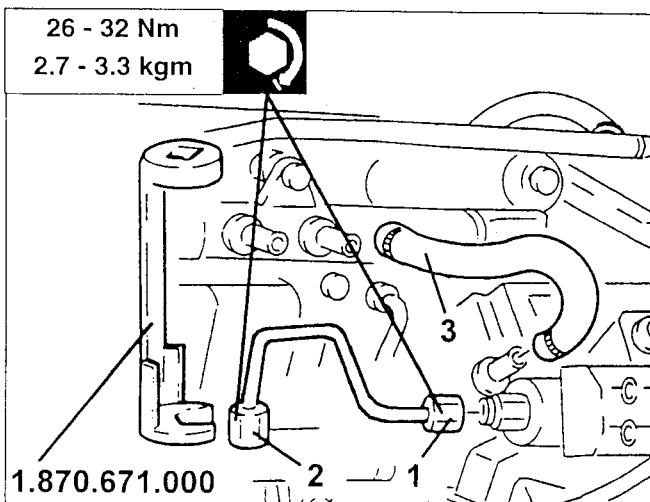


1. Loosen the remaining front screws and remove the pressure pump and bracket.



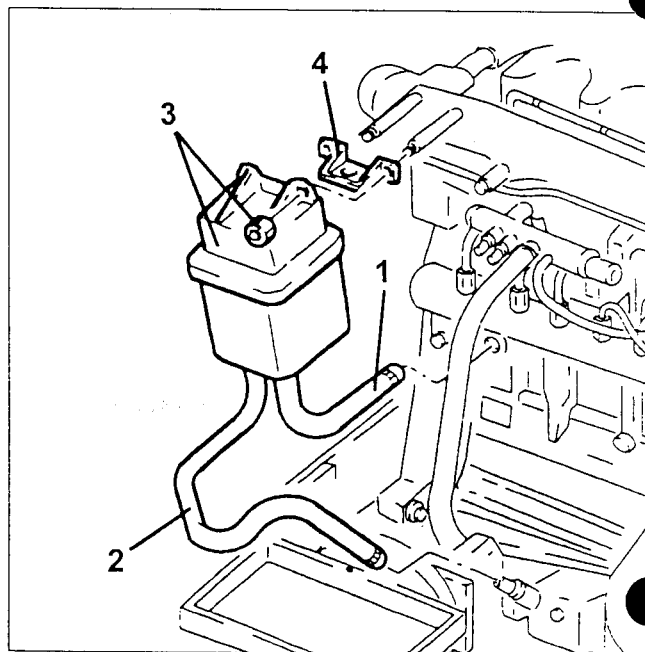
PRESSURE PUMP REMOVAL

- Loosen the screws and remove the engine oil level dipstick.
 - Loosen the pressure pump bracket side screws.
1. Disconnect the pressure pump-fuel manifold pipe pump side fitting with a suitable tool.
 2. Loosen the pressure pump-fuel manifold pipe manifold side fitting with tool no. 1.870.671.000.
 3. Disconnect the pressure pump-fuel return pipe on pipe side.

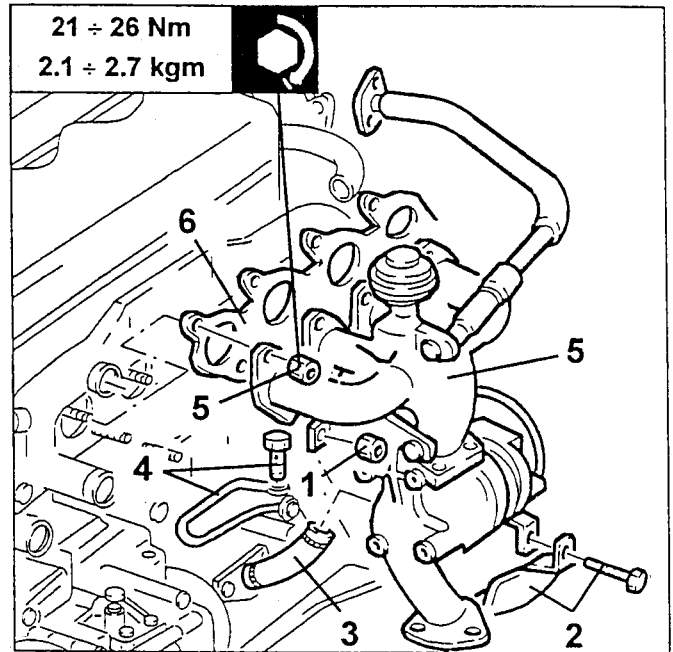
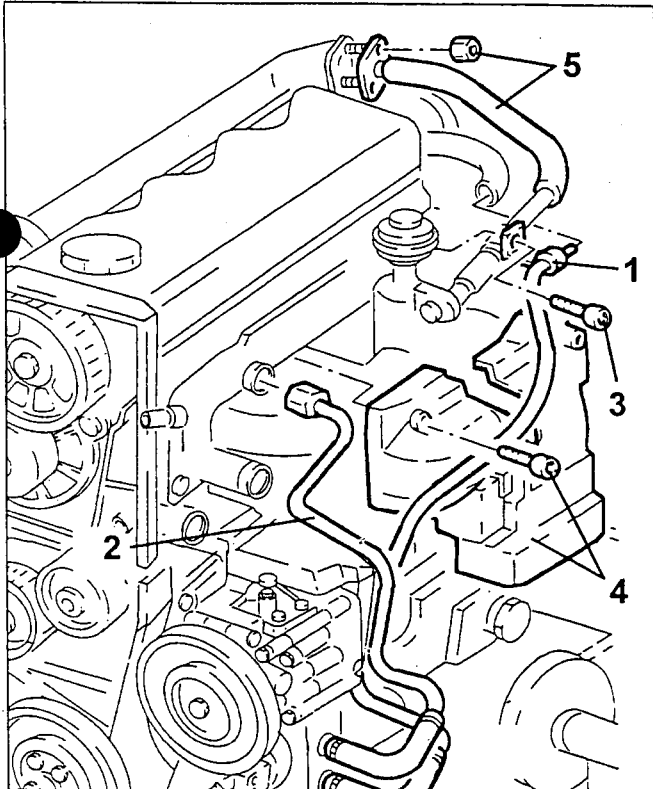


TURBO COMPRESSOR REMOVAL

1. Disconnect the crankcase oil vapour recovery pipe.
2. Disconnect the condense oil recovery pipe from the crankcase sump.
3. Loosen the nuts and remove the oil vapour separator.
4. Remove the bracket.

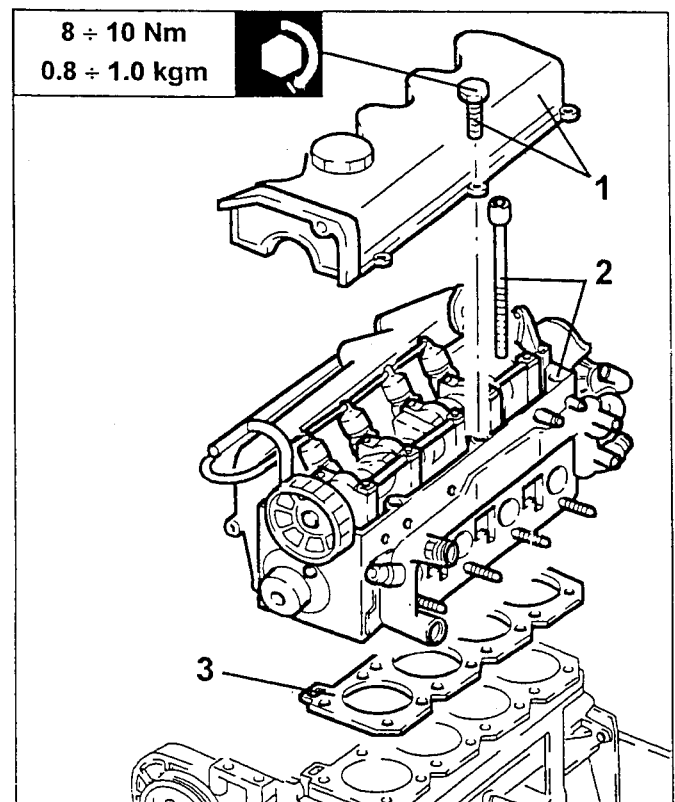


1. Disconnect the coolant delivery pipe to the water-oil heat exchanger from the thermostat.
 2. Disconnect from the water pump fluid inlet stiff pipe the outlet pipe from the water-oil heat exchanger.
 3. Slacken the screw fastening the water inlet pipe to the water-oil heat exchanger.
 4. Slacken the screws and remove the heat shield from the turbocharger.
 5. Slacken the nuts and disconnect the exhaust gas recirculation pipe from the intake box.
- Remove the seal.



REMOVING THE CYLINDER HEAD

1. Slacken the fastening screws and remove the tappet cover complete with seal.
2. Slacken the fastening screws and remove the cylinder head complete.
3. Remove the cylinder head seal.




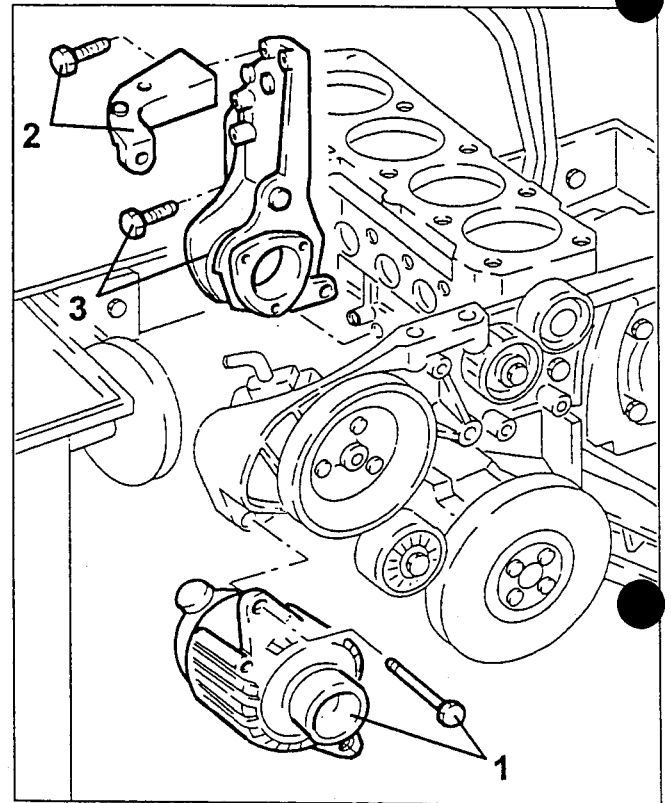
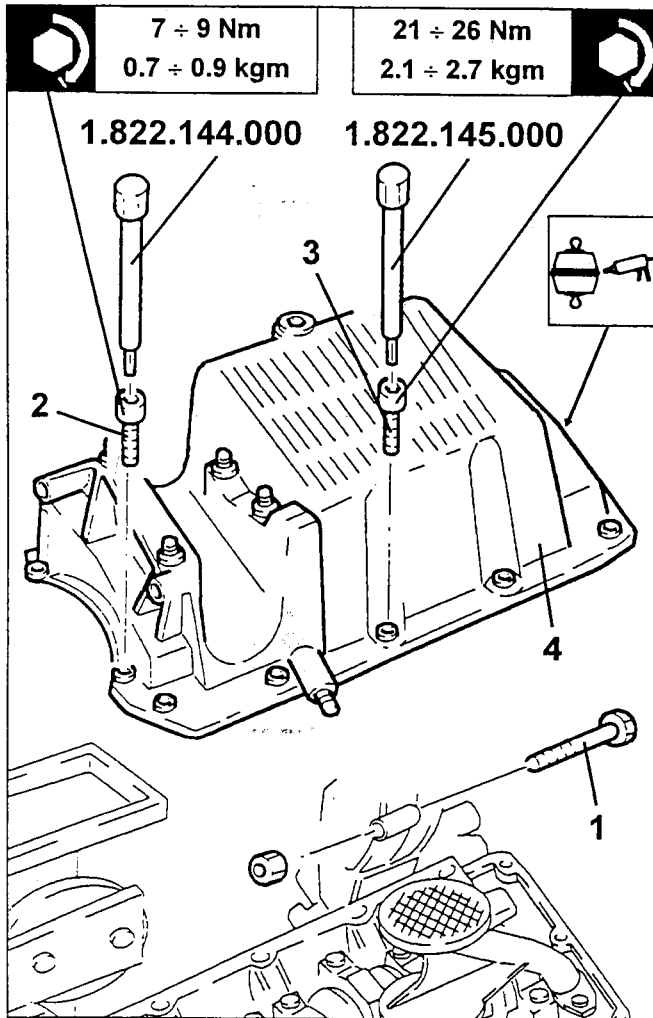
- Slacken the screw of the exhaust gas recirculation pipe support bracket.

1. Slacken the nut fastening the exhaust manifold bracket to the crankcase.
2. Slacken the screws and remove the cover of the oil return pipe to the sump from the turbocharger.
3. Disconnect the oil return pipe to the sump from the turbocharger.
4. Disconnect the oil inlet pipe from the turbocharger.
5. Slacken the fastening nuts and remove the exhaust manifold complete with turbocharger and E.G.R. valve.
6. Remove the seal.

REMOVING THE CRANKCASE SUMP

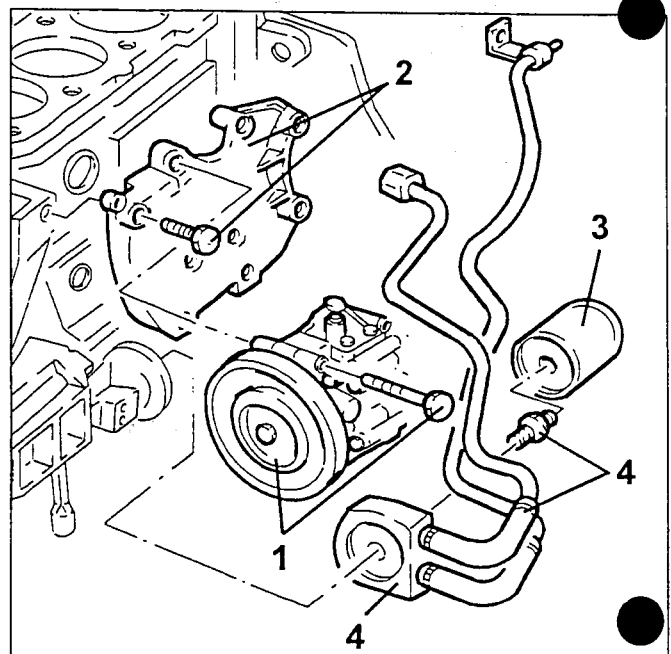
- Turn the engine by 180° on the overhauling stand.
- 1. Slacken the bolt connecting the crankcase sump to the layshaft support.
- 2. Slacken the front and rear screws of the crankcase sump using tool no. 1.822.144.000.
- 3. Slacken the side screws of the crankcase sump using tool no. 1.822.145.000.
- 4. Remove the crankcase sump.

 Coat silicone sealant around the whole perimeter of the sump.



REMOVING THE AIR CONDITIONER COMPRESSOR

- 1. Slacken the fastening screws and remove the air conditioner compressor.
- 2. Slacken the fastening screws and remove the air conditioner compressor support.
- 3. Remove the engine oil filter and cartridge.
- 4. Slacken the pin and remove the water-oil heat exchanger complete with pipes.

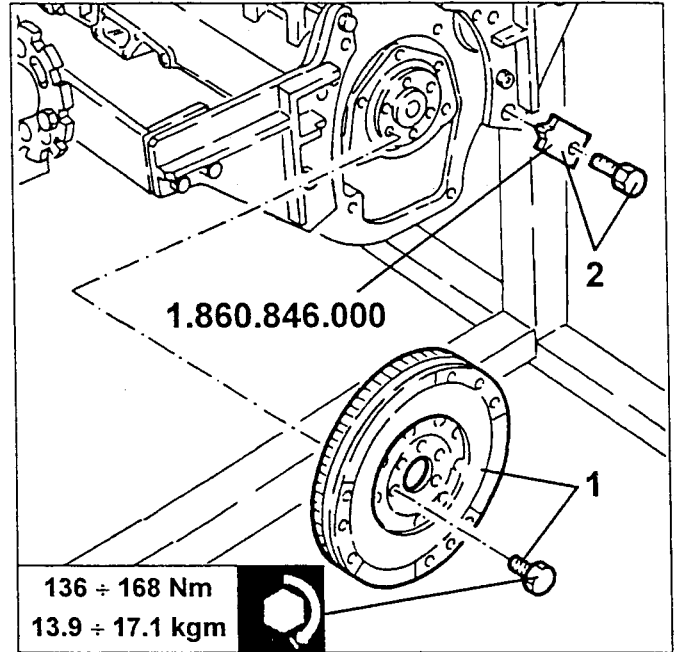
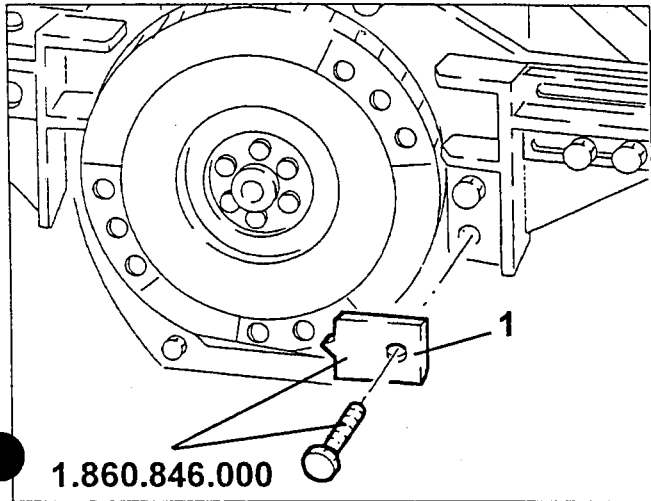


REMOVING THE ALTERNATOR

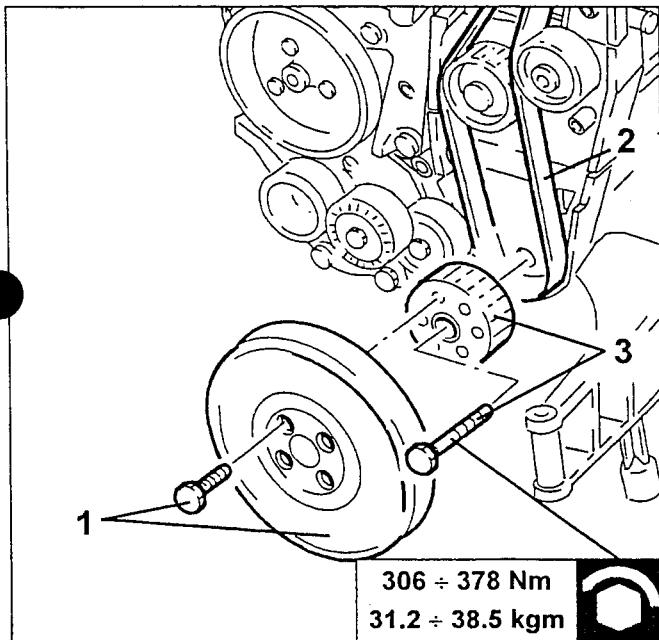
- Turn the crankcase 180° on the overhauling stand.
- 1. Slacken the fastening bolts and remove the alternator.
- 2. Slacken the fastening screws and remove the rear alternator support bracket.
- 3. Slacken the fastening screws and remove the layshaft support.

REMOVING THE FLYWHEEL

1. Assemble the flywheel stopper tool no. 1.860.846.000.



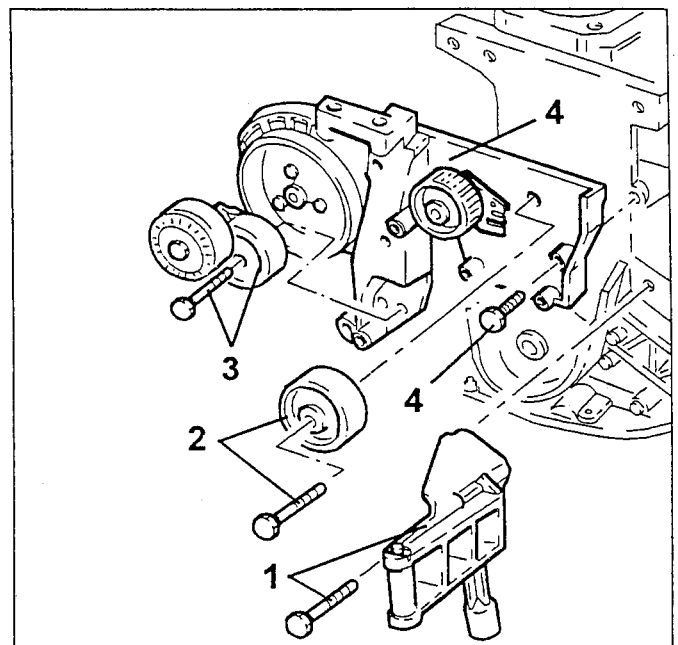
1. Slacken the fastening screws and remove the crankshaft pulley.
2. Remove the camshaft belt.
3. Slacken the screw (left-handed) and remove the driving toothed pulley.



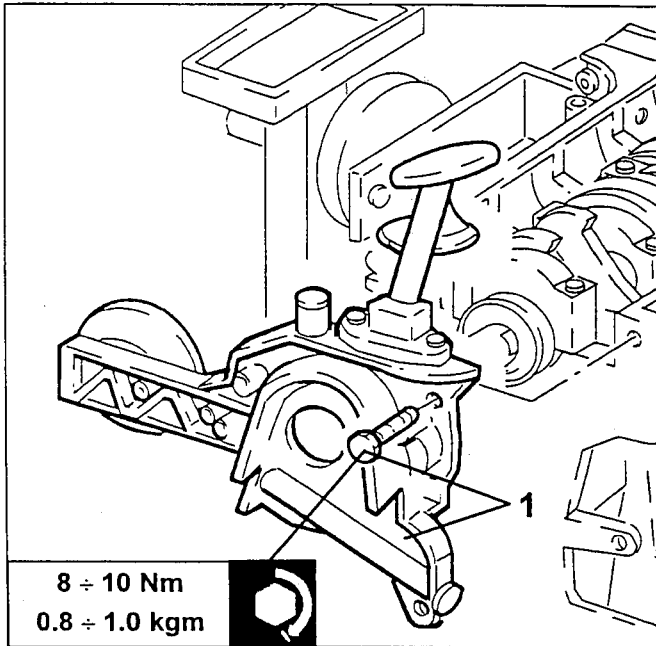
1. Slacken the fastening screws and remove the flywheel.
2. Remove the flywheel stopper tool no. 1.860.846.000.

REMOVING THE CRANKCASE FRONT COVER

1. Slacken the fastening screws and remove the power unit rigid support on the camshaft side.
2. Slacken the fastening screw and remove the camshaft drive fixed tensioner.
3. Slacken the fastening screw and remove the engine parts drive belt automatic tensioner.
4. Slacken the screws and remove the support complete with power steering pump and mobile camshaft drive tensioner.



1. Slacken the screws and remove the front crankcase cover with incorporated oil pump complete with intake horn.
- Remove the seal.



REMOVING THE PISTONS AND CONNECTING RODS

- Assemble tool no. 1.860.815.000 for turning the crankshaft.
- Turn the crankshaft 180° on the overhauling stand.
- Turn the crankshaft using the tool installed previously until the cylinder concerned reaches the B.D.C.
- 1. Slacken the fastening screws and remove the connecting rod cap.
- 2. Remove the lower connecting rod half bearing.
- 3. Remove the connecting rod-piston assembly.
- 4. Remove the upper connecting rod half bearing.
- Proceed in the same way for removing the pistons and connecting rods of the remaining cylinders.
- Remove the tool no. 1.860.815.000 used for turning the crankshaft.
- 5. Slacken the fastening screws and remove the crankcase rear cover with incorporated oil seal.
- Check that the crankshaft end float is within the specified limits using a magnetic base with dial gauge.

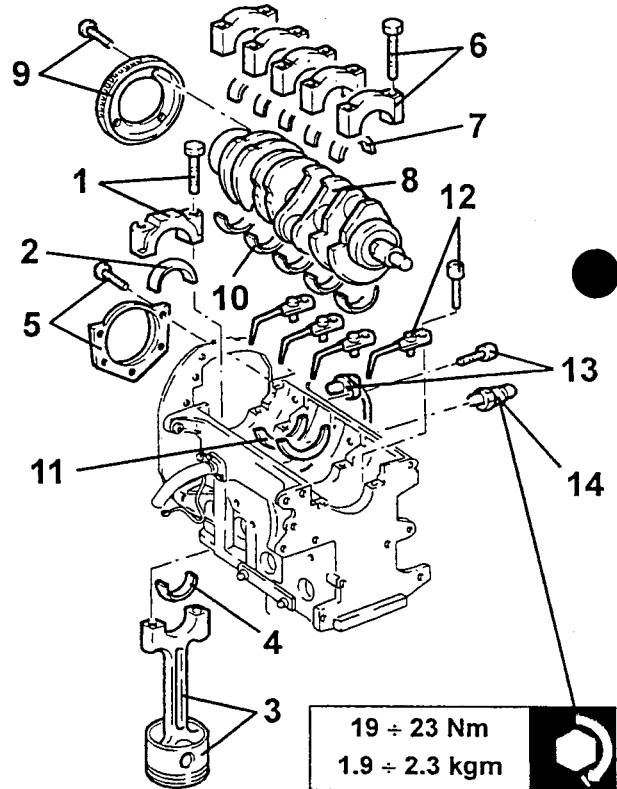


Crankshaft end float

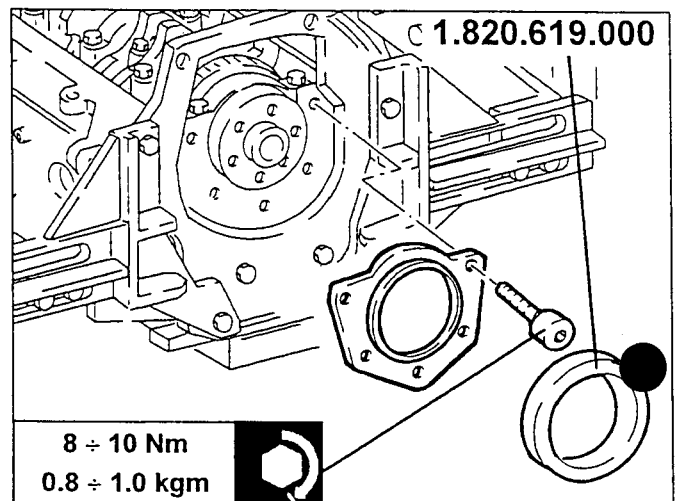
0.049 ÷ 0.211

- If the crankshaft end float is not within the specified limits, when reassembling grind the seat on the crankcase and use suitably oversized half thrust rings.
- 6. Slacken the fastening screws and remove the main bearing caps.
- 7. Remove the lower main half bearings.
- 8. Remove the crankshaft.

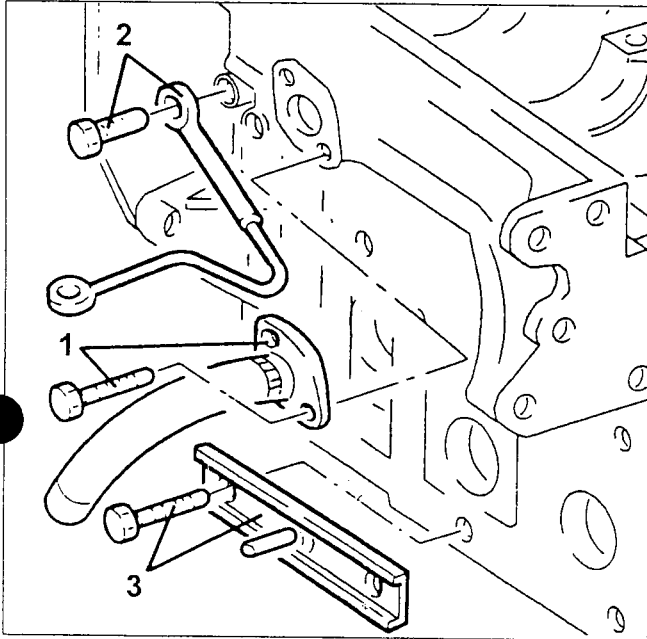
9. Slacken the fastening screws and remove the phonic wheel from the crankshaft.
10. Remove the upper main half bearings.
11. Remove the half thrust rings.
12. Slacken the fastening screws and remove the jets for cooling the pistons from the crankcase.
13. Slacken the fastening screw and remove the rpm and timing sensor.
14. Remove the minimum engine oil pressure warning light sensor.



When refitting the crankcase rear cover with incorporated oil seal ring use tool no. 1.820.619.000 for centering the oil seal.



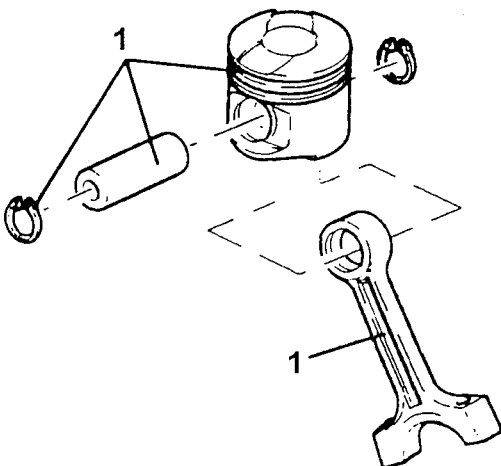
1. Loosen the fastening screw and remove the flange and turbo compressor oil return pipe.
2. Loosen the fitting and remove the turbo compressor oil delivery pipe.
3. Loosen the fastening screws and remove the turbo compressor bracket.



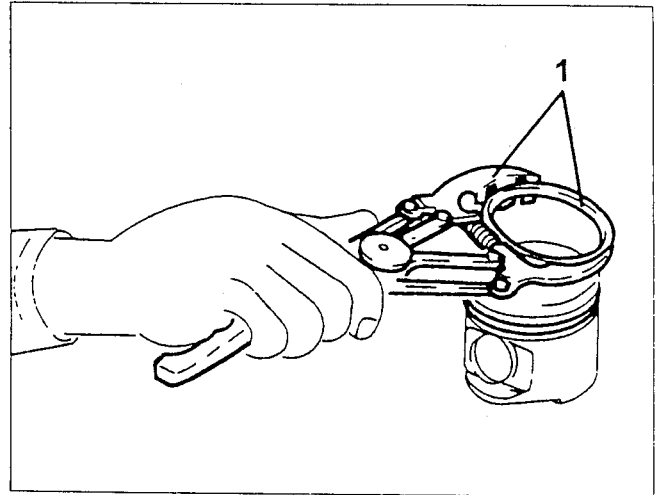
- Turn the crankcase by 90° on the overhaul stand.
- Loosen the screws and remove the crankcase from the bracket then place it on a specific stand.
- Loosen the fastening screws and remove the fly-wheel protection.

CONNECTING ROD - PISTON REMOVAL

1. Remove the washers, remove the pin and separate the connecting rod from the piston.



1. Remove the gas rings with a suitable tool.



OIL PUMP DISASSEMBLY

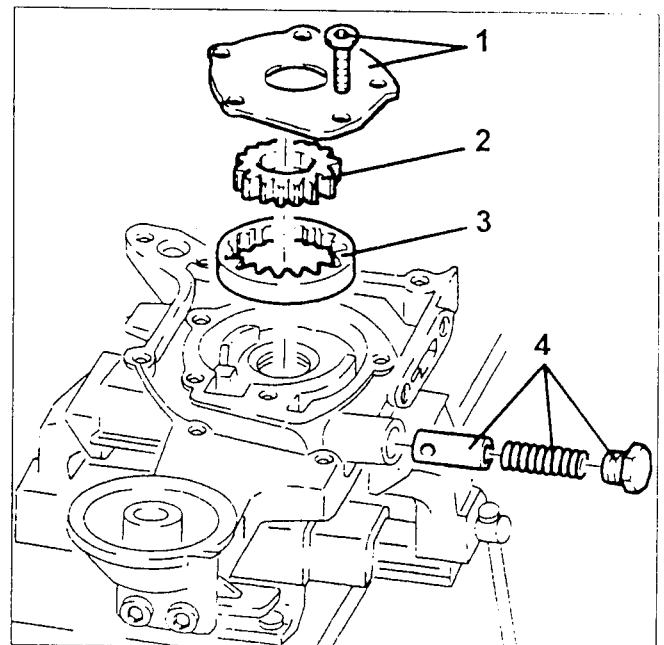
- Loosen the fastening screws and separate the suction device from the oil pump.

 1. Loosen the fastening screws and remove the oil pump cover.
 2. Remove the drive gear.
 3. Remove the driven gear.



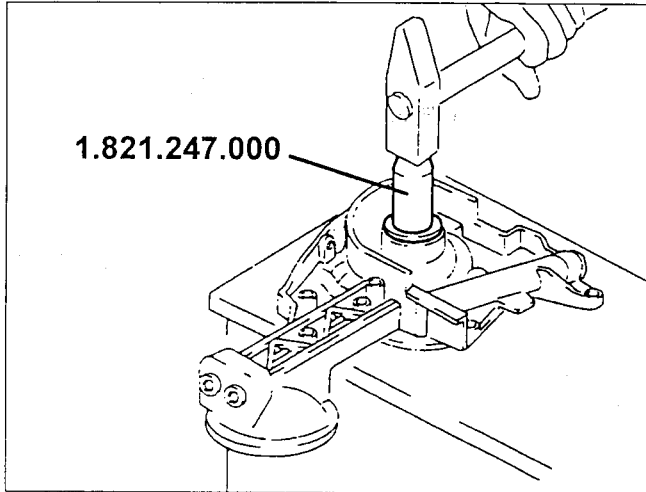
When refitting the oil pump, manually turn the gears to make sure they turn without seizing.

4. Remove the cap and remove the oil pressure limiting valve.
- Remove the crankshaft front oil seal.





When refitting, insert a new crankshaft front oil seal with tool no. 1.821.147.000.



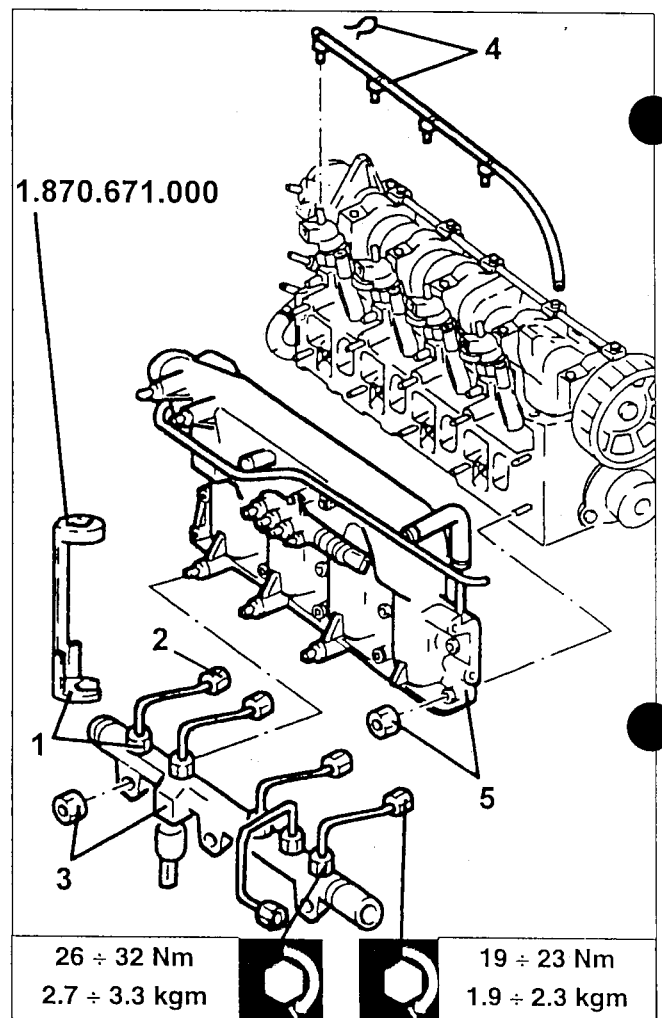
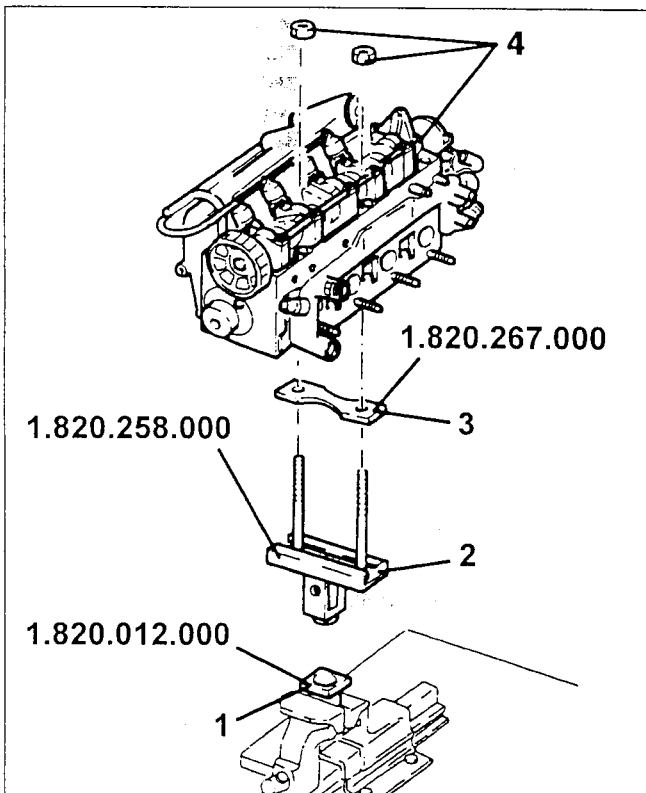
INTAKE MANIFOLD REMOVAL

1. Loosen the fuel manifold- injector fittings on manifold side with tool no. 1.870.671.000.
2. Loosen the fuel manifold-injector fitting on injector side with a suitable tool.
3. Loosen the nuts and remove the single fuel manifold with pipes and fuel pressure sensor.
4. Remove the retainers and remove the fuel return pipe for injector lubrication.
 - Loosen the nuts and disconnect the pre-heat glow plug power wiring.
 - Disconnect the expansion reservoir coolant return pipe from the thermostat.
5. Loosen the fastening nuts and remove the complete air intake manifold.

CYLINDER HEAD DISASSEMBLY

PRELIMINARY OPERATIONS

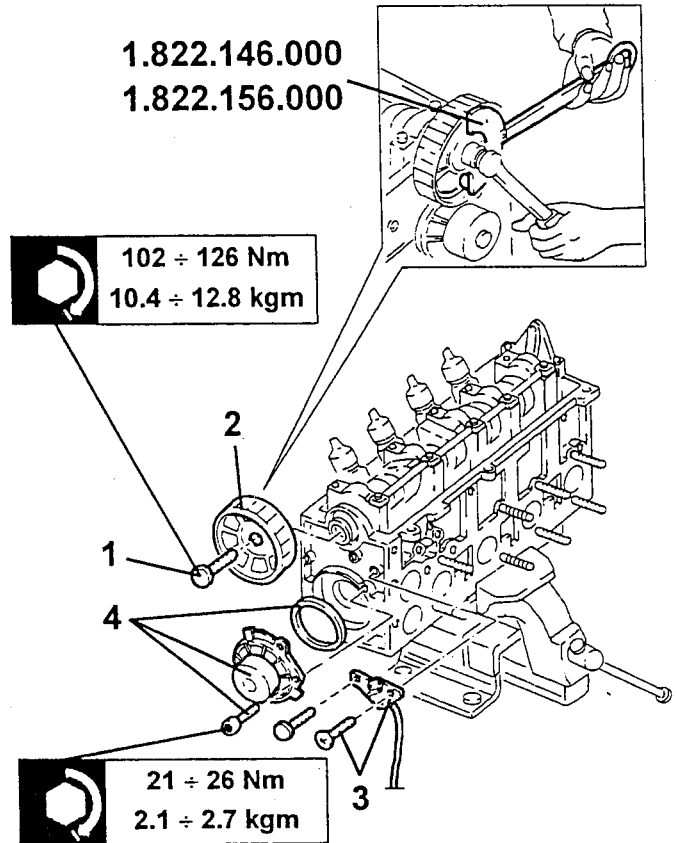
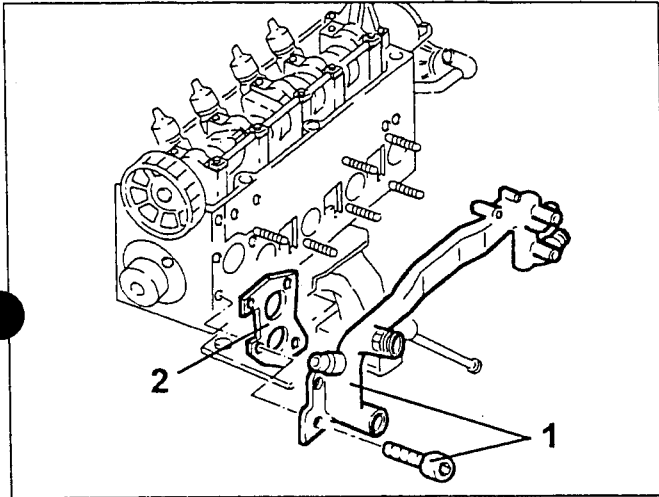
1. Position stand no. 1.820.012.000 in a vice.
2. Fit tool no. 1.820.258.000.
3. Fit shim no. 1.820.267.000.
4. Position the cylinder head on the bracket and fasten the respective nuts.



REMOVING THE STIFF WATER PUMP FLUID INLET PIPE

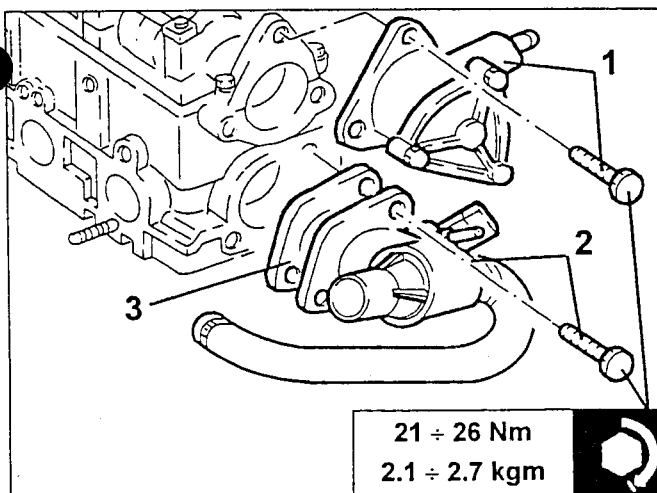
- Disconnect the delivery pipe to the pump stiff inlet pipe.

1. Slacken the fastening screws and remove the stiff water pump inlet pipe.
2. Remove the seal.



REMOVING THE WATER PUMP

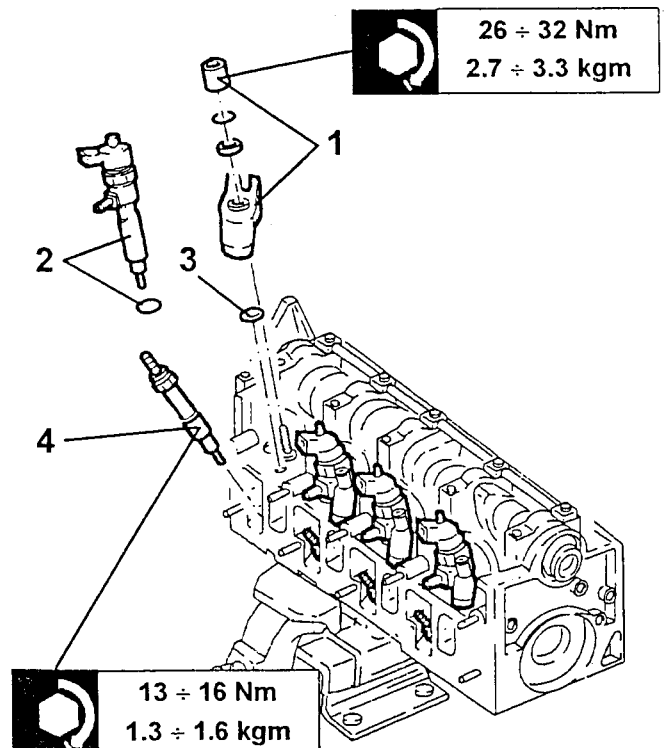
1. Slacken the fastening screws and remove the vacuum pump complete with O-Ring.
2. Slacken the fastening screws and remove the thermostat complete with pipe and sensors.
3. Remove the seal.



1. Slacken the screw of the driven toothed pulley using tools no. 1.822.146.000 and no. 1.822.156.000.
2. Remove the driven toothed pulley.
3. Slacken the fastening screws and remove the cam angle sensor.
4. Slacken the fastening screws and remove the water pump complete with O-Ring.

REMOVING THE INJECTORS

1. Slacken the fastening nuts and remove the injector brackets.
2. Remove the injectors complete with seal.
3. Remove the injector bracket support pads.
4. Remove the glow plugs.



REMOVING THE CAMSHAFT

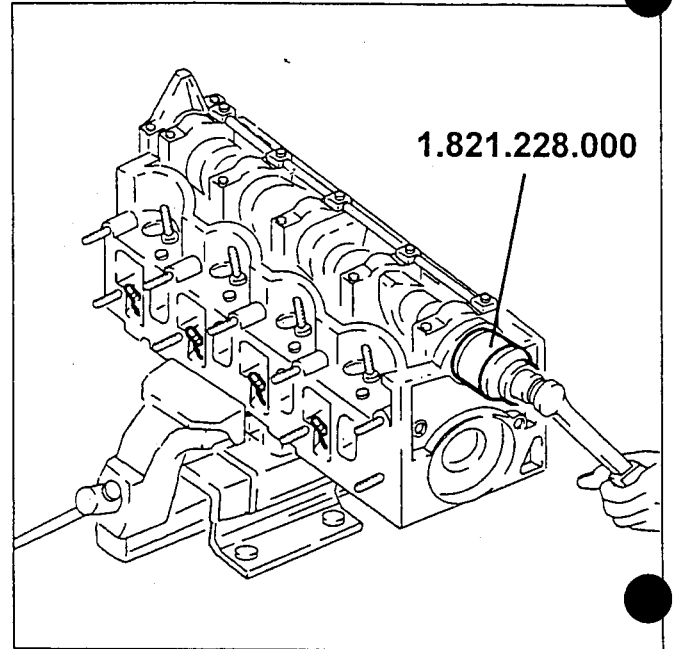
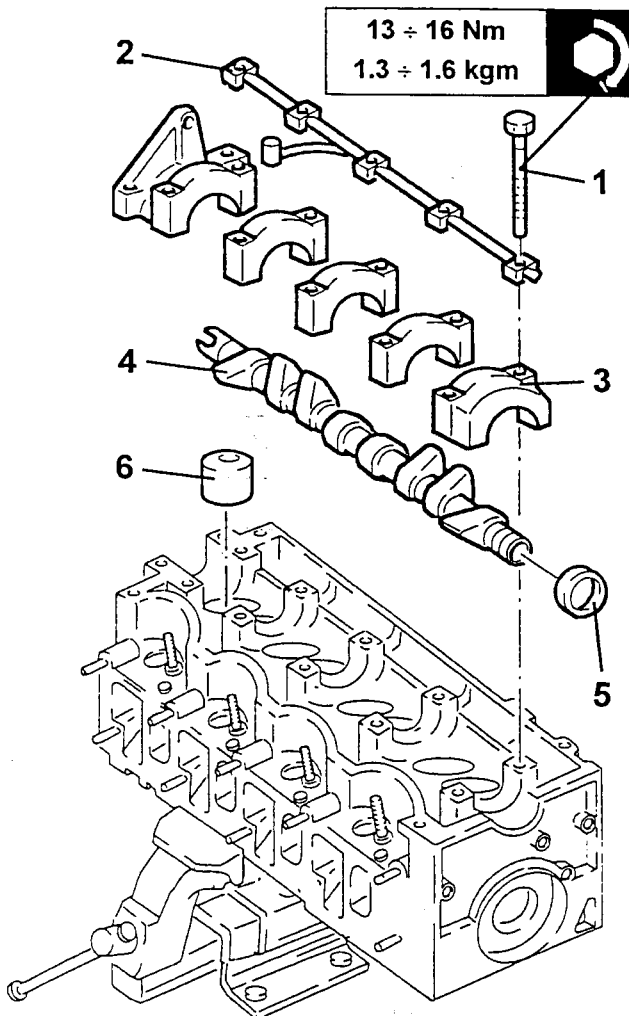
- Check that the camshaft end float is within the specified limits using a dial gauge.



Camshaft end float
0.100 ÷ 0.230 mm

- If the camshaft end float is not within the specified limits, when reassembling the cylinder head change the worn parts.

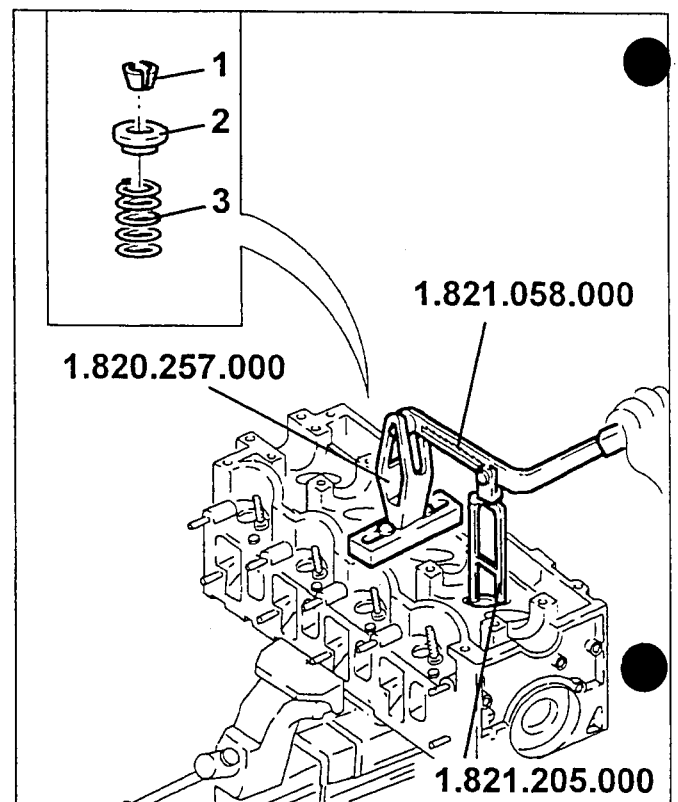
1. Slacken the camshaft cap screws.
2. Remove the camshaft support lubrication pipe.
3. Remove the camshaft caps.
4. Remove the camshaft.
5. Remove the camshaft front oil seal.
6. Remove the cups complete with valve clearance adjustment pads.



REMOVING THE VALVES

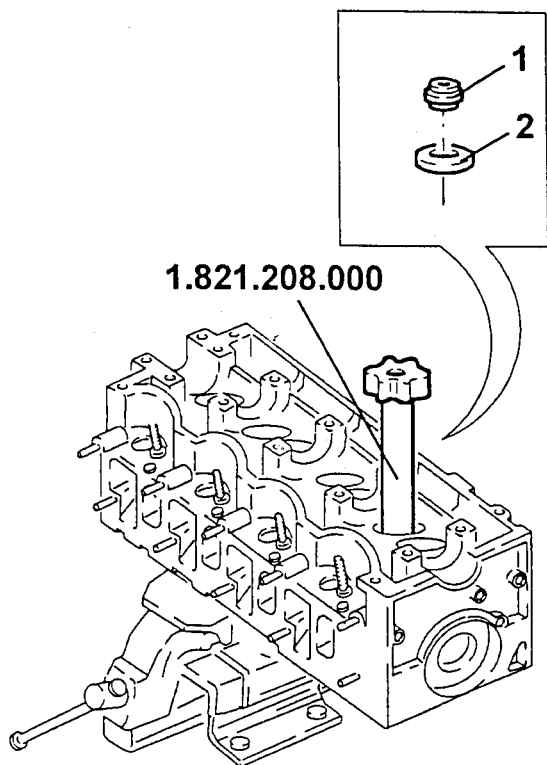
- Remove the cylinder head from the support tools.
- Place a suitable wooden board between the support tools and the cylinder head to support the valves.
- Refit the cylinder head on the support tools and fasten it with the nuts.

1. Remove the half tapers using support no. 1.820.257.000, lever no. 1.821.058.000 and cage no. 1.821.205.000.
2. Remove the valve upper plates.
3. Remove the valve springs.



When reassembling insert a new camshaft front seal, using tool no. 1.821.228.000.

1. Remove the valve guide oil seals using tool no. 1.821.208.000.
2. Remove the valve lower plates.

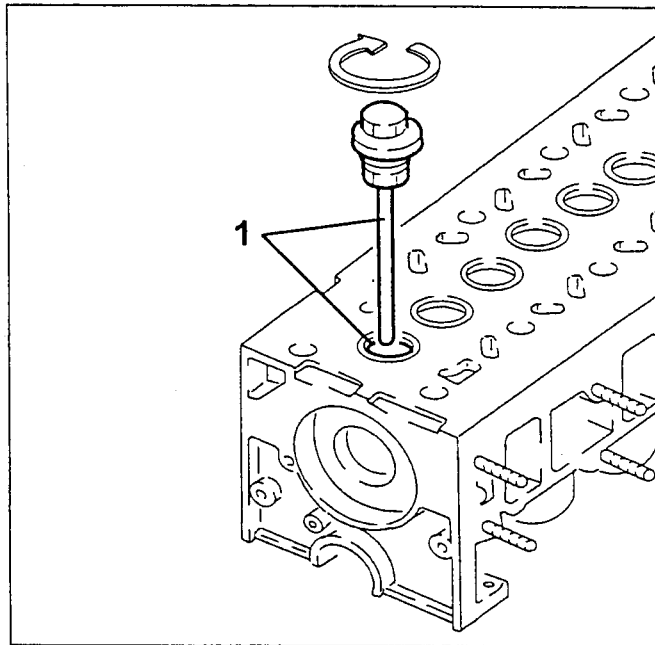


REPLACING VALVE SEATS AND VALVE GUIDES

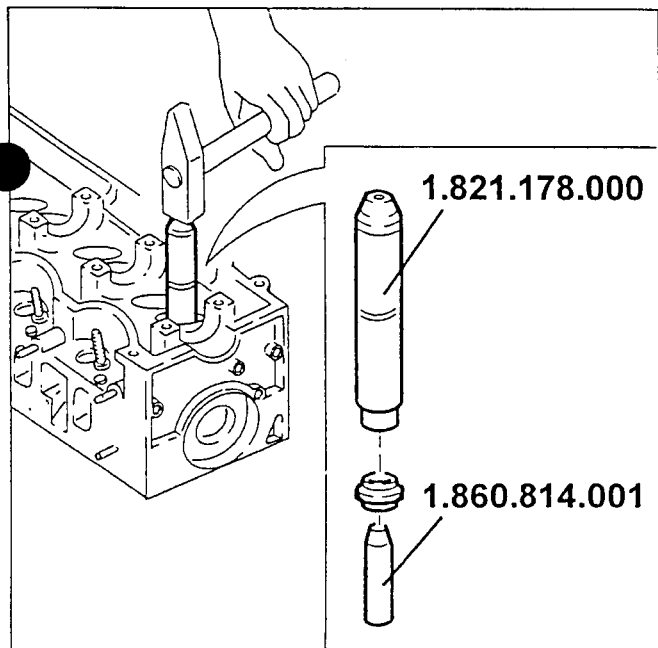
- Remove the cylinder head from the support tools and retrieve the valves.

- Place the cylinder head on the work bench.

1. Thread the special puller tool on the valve seat.



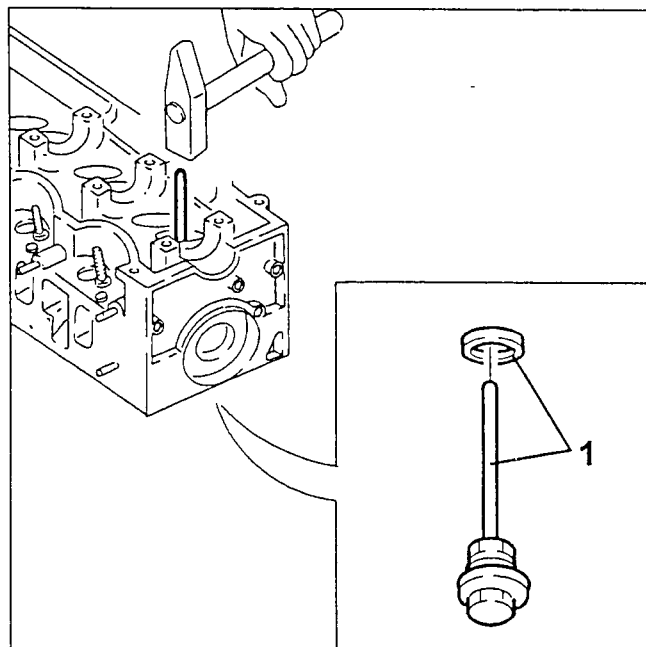
When reassembling insert new valve guide oil seals, using tools no. 1.860.814.001 and no. 1.821.178.000.



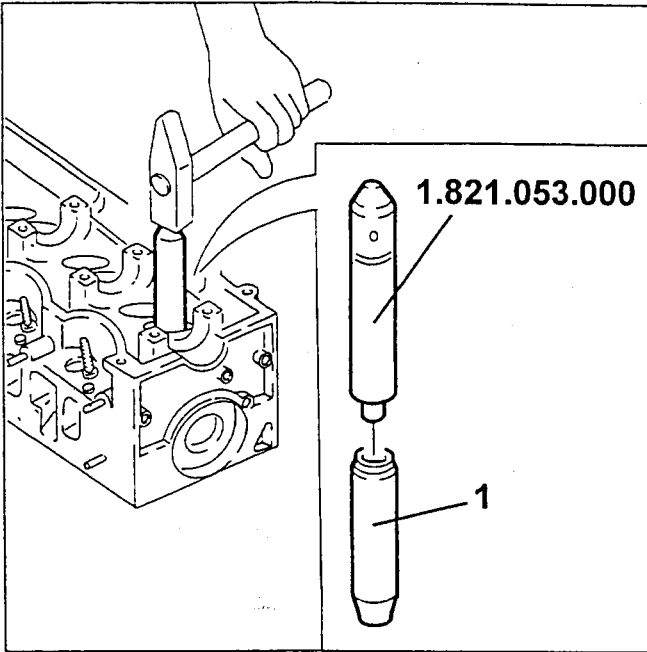
- Overturn the cylinder head on the work bench.

1. Remove the valve seat using the puller tool.

- Proceed in the same way on the remaining valve seats.



1. Remove the valve guides using tool no. 1.821.053.000.

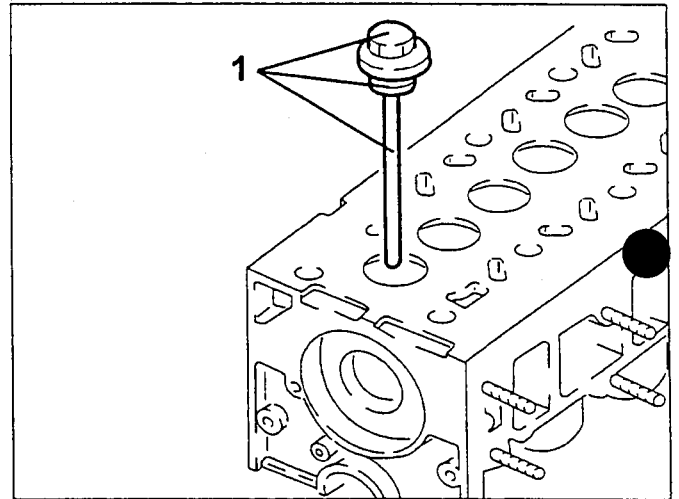


- Check that the outside diameter of the seats of the valves to be installed is within the specified limits.

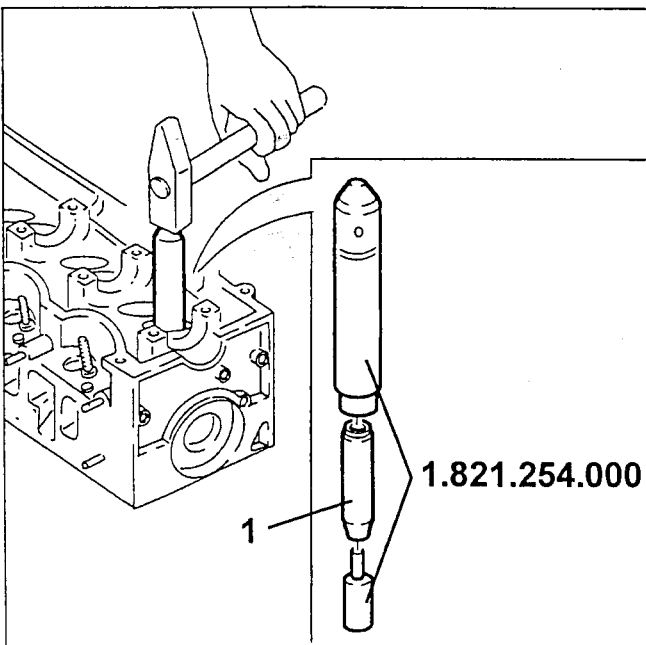


Valve seat outside diameter	
Intake	36.135 ÷ 36.150 mm
Exhaust	35.142 ÷ 35.157 mm

1. Install the valve seats using suitable equipment.



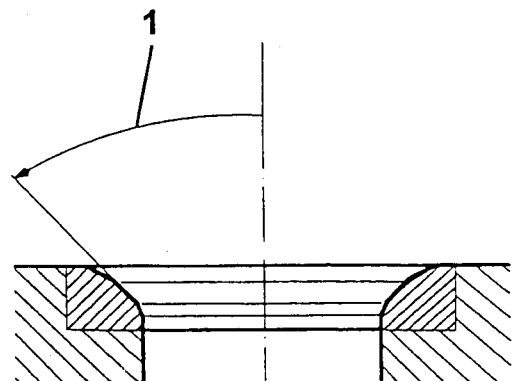
1. Install new valve guides using tool no. 1.821.254.000.



1. Grind the valve seats to the specified dimension.



Angle of contact band with valve	
	90° ± 20'




- Bore the inside diameter of the valve guides to the specified value.

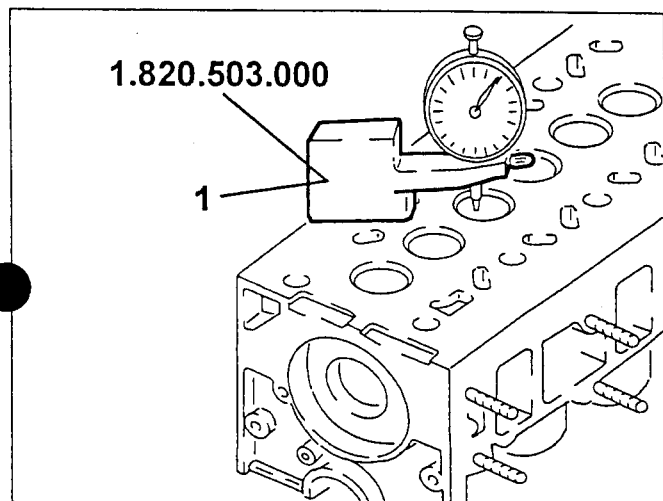


Valve guide inside diameter	
	8.022 ÷ 8.040 mm

- Grind the valve seats using suitable equipment.
- Assemble the valves temporarily.

1. Check that the embedding of the valves from the surface of the cylinder head is within the specified limits by measuring using tool no. 1.820.503.000 complete with dial gauge.

	Valve embedding from cylinder head surface
	0.1 ÷ 0.5 mm




If the embedding of the valves from the cylinder head surface is not within the specified limits, grind the valve seats again.


CHECKING AND INSPECTING CYLINDER HEAD

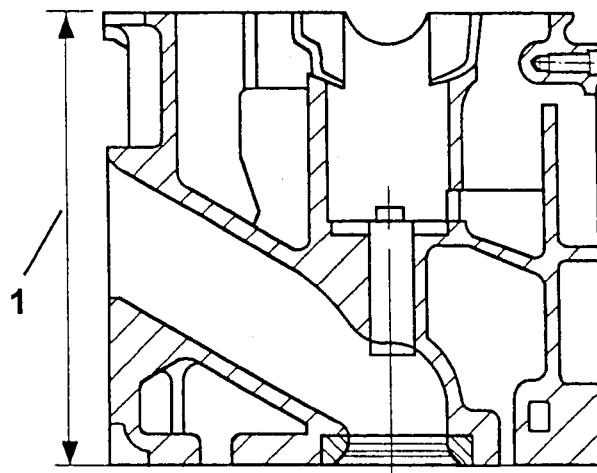
CHECKING THE CYLINDER HEAD LOWER SURFACE

- Remove all traces of the old seal from the lower surface of the cylinder head.
- Check that the flatness of the cylinder head lower surface is within the specified limits.

	Maximum error of flatness of cylinder head lower surface
	0.1 mm


1. If the flatness of the cylinder head lower surface is not within the specified limits, grind the cylinder head lower surface without exceeding the minimum permissible height.

	Minimum permissible height of cylinder head after refacing
	140.85 ÷ 141.15 mm




CHECKING THE VALVES

- Check that the valves have no signs of scoring or seizing.
- Check that the valve stem diameter is within the specified limits; if not, replace the worn valves.


	Valve stem diameter
	7.974 ÷ 7.992 mm

CHECKING THE CUPS

- Check that the outside diameter of the cups is within the specified limits; if not, replace the worn parts.


	Outside diameter of valve cups
	36.975 ÷ 36.995 mm

- Check that the diameter of the cup seats is within the specified limits; if not, replace the cylinder head.

	Diameter of valve cup seats
	37.000 ÷ 37.025 mm

CHECKING VALVE SPRINGS

- Check that the free length of the springs is within the specified limits.

	Valve spring free length
	53.9 mm

- Use a torque meter to check that the specifications of the valve springs are within the specified limits; if not, replace the strained parts.

Spring length (mm)		Check load N (kg)
With valve closed	36	367 ÷ 396 (37.4 ÷ 40.4)
With valve open	26.5	560 ÷ 610 (57.1 ÷ 62.2)

CHECKING THE CAMSHAFT

- Check that the diameter of the camshaft pins is within the specified limits; if not, replace the worn camshaft.

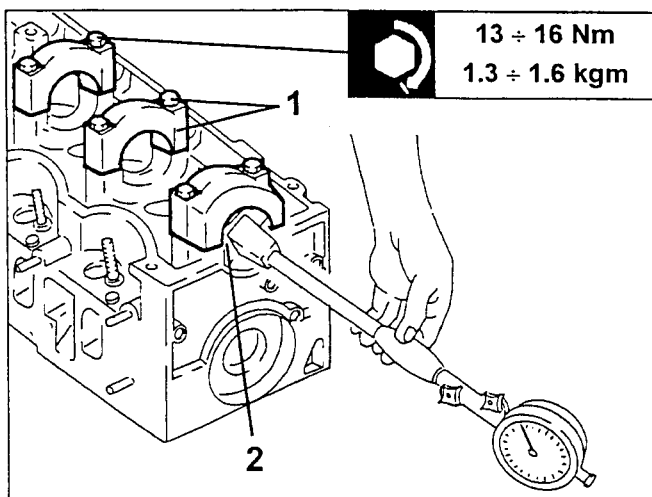
Ø	Diameter of camshaft pins
	26.000 ÷ 26.015 mm

- Check that the nominal lift of the camshaft cams is within the specified limits; if not, replace the worn camshaft.

— —	Nominal cam lift
	8.5 mm

1. Assemble the camshaft caps on the cylinder head and tighten the screws to the specified torque.
2. Check that the diameter of the camshaft supports is within the specified limits; if not, replace the cylinder head.

Ø	Diameter of camshaft supports
	26.045 ÷ 26.070 mm



CHECKING AND INSPECTING THE CRANKCASE

CHECKING THE SYLINDER HEAD RESTING SURFACE

- Check the cylinder head resting surface for cracks or surface scores.
- Check that the flatness of the cylinder head resting surface is within the specified limits; if not, grind the resting surface of the cylinder head.



Flatness of cylinder head resting surface

< 0.1 mm

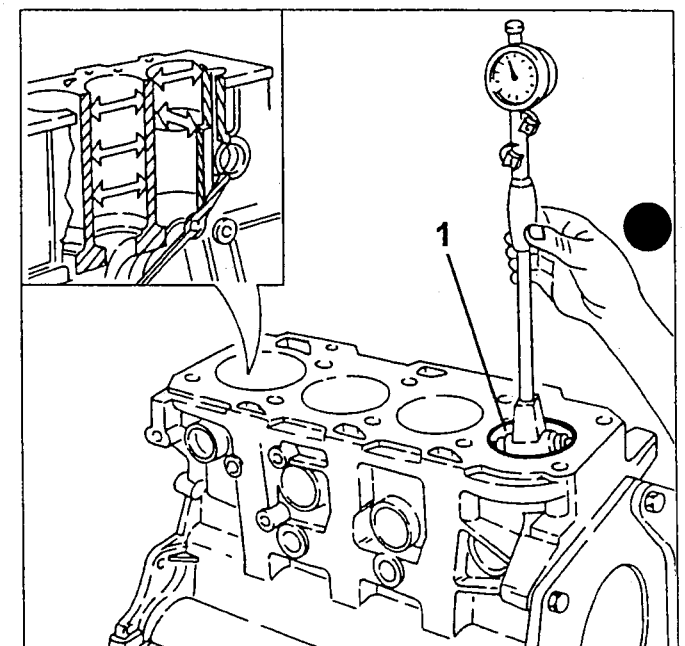
CHECKING THE CYLINDER LINERS

1. Measure the diameter of the cylinder liners as illustrated.



Cylinder liner inside diameter

Class A	82.000 ÷ 82.010 mm
Class B	82.010 ÷ 82.020 mm
Class C	82.020 ÷ 82.030 mm



- Check that the cylinder liner taper is within the specified limits.



Cylinder liner taper

< 0.005 mm

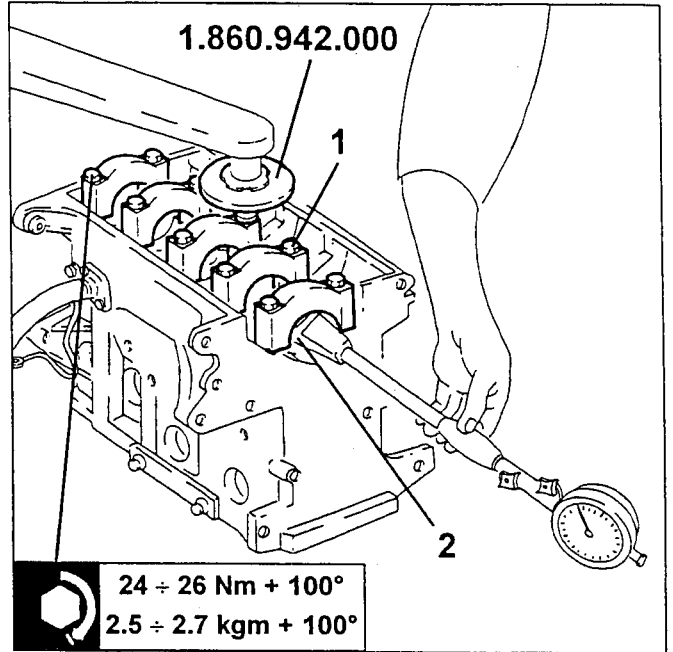
- Check that the cylinder liner ovalisation is within the specified limits.

0	Cylinder liner ovalisation
	< 0.05 mm

- If the cylinder liner diameter is not within the specified limits, bore the cylinder liners according to the specified oversizes.

NOTE: In the case of boring all the cylinder liners must have the same oversize.

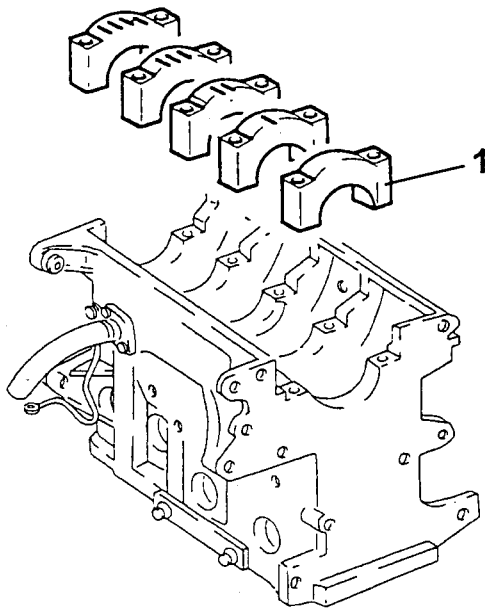
>	Cylinder liner oversize
	0.1 mm



CHECKING THE MAIN BEARING PINS

1. Assemble the main bearing caps.

NOTE: The main bearings are notched consecutively (from 0 to four starting from the engine front) to define their assembly position.



1. Tighten the main bearing cap screws to the specified torque using tool no. 1.860.942.000 for angle tightening.

2. Check that the diameter of the main bearing pin seats is within the specified limits.

∅	Main bearing pin seat diameter
	63.691 ÷ 63.732 mm

CHECKING THE CRANKSHAFT

- Check that the lubricating ducts of the crankshaft are not scaled or clogged.
- Check that the main bearing pin diameter is within the specified limits.

∅	Main bearing pin diameter	
	Class A	59.994 ÷ 60.000 mm
	Class B	59.988 ÷ 59.994 mm
	Class C	59.982 ÷ 59.988 mm

- If the main bearing pin diameter is not within the specified limits, grind them according to the specified undersize.

<	Main bearing pin undersizes
	0.127 mm

- Check that the connecting rod pin diameter is within the specified limits.

∅	Diameter of connecting rod pins	
	Class A	50.799 ÷ 50.805 mm
	Class B	50.793 ÷ 50.799 mm
	Class C	50.787 ÷ 50.793 mm

- If the connecting rod pin diameter is not within the specified limits, grind them according to the specified undersize.

<	Undersizes of connecting rod pins
	0.127 mm

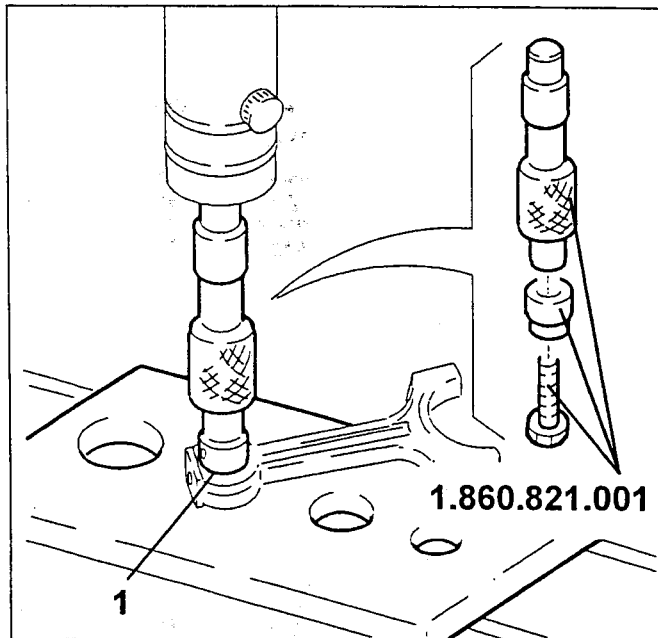
CHECKING AND IF NECESSARY REPLACING SMALL END BUSHES

- Check that the inside diameter of the small end bushes is within the specified limits.

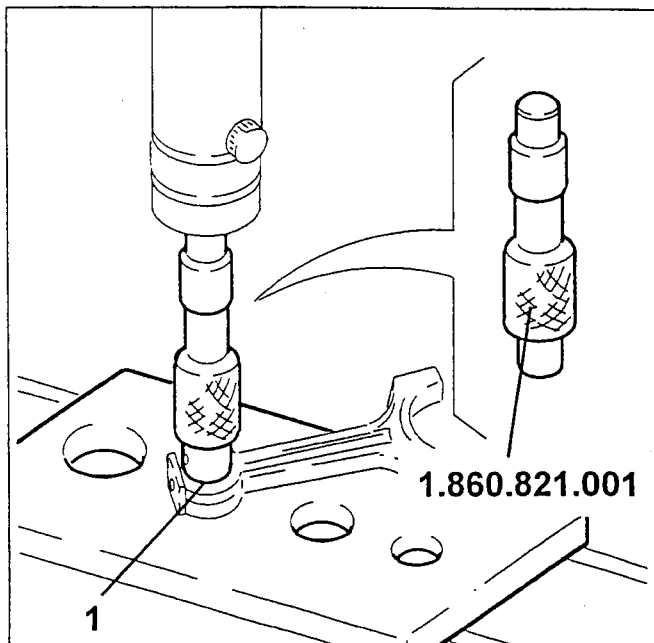
∅	Inside diameter of small end bush
	26.006 ÷ 26.012 mm

- If the diameter of the small end bushes is not within the specified limits, replace the worn bushes as described below.

1. Remove the small end bush under a hydraulic press and using puller tool no. 1.860.821.001.

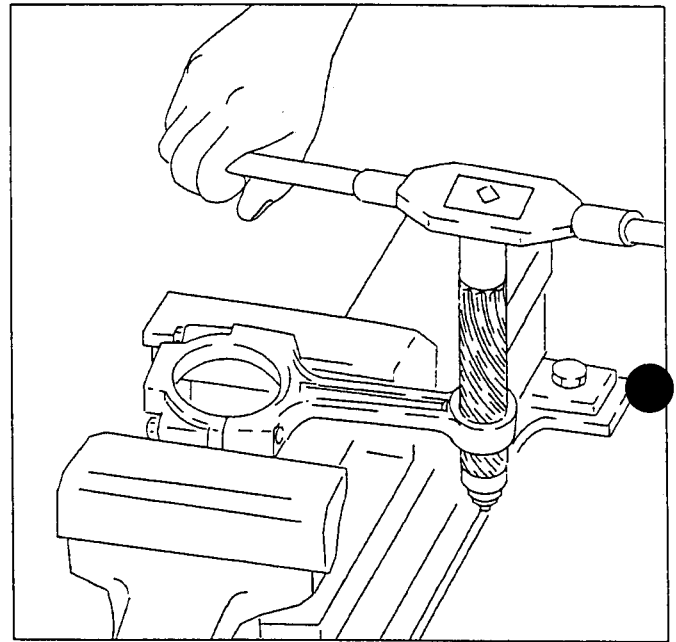


1. Install a new bush in the connecting rod small end under a hydraulic press and using installing tool no. 1.860.821.001 and a suitable reaction plate.



- Bore the inside diameter of the small end bush to the specified limits.

∅	Inside diameter of small end bush
	26.006 ÷ 26.012 mm



CHECKING THE PISTONS

- Check that the inside diameter of the piston bushes is within the specified limits; if not, replace the piston complete with seal rings, gudgeon pins and bushes.

∅	Inside diameter of bushes in pistons
	25.999 ÷ 26.004 mm

- Check that the outside diameter of the piston gudgeon pins is within the specified limits; if not, replace the worn gudgeon pins.

∅	Outside diameter of piston gudgeon pins
	25.982 ÷ 25.988 mm

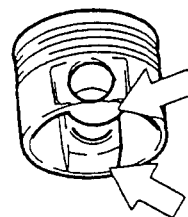
- Insert the seal rings in the cylinder liner and check that the gap between the ends is within the specified limits; if not, change the rings.

H	Seal ring gap	
	First ring	0.25 ÷ 0.40 mm
	Second ring	0.25 ÷ 0.50 mm
	Oil scraper ring	0.25 ÷ 0.50 mm

- Check that the outside diameter of the pistons is within the specified limits; if not, replace the piston complete with seal rings and gudgeon pin.



Outside diameter of pistons	
Class A	81.783 ÷ 81.797 mm
Class B	81.793 ÷ 81.807 mm
Class C	81.803 ÷ 81.817 mm

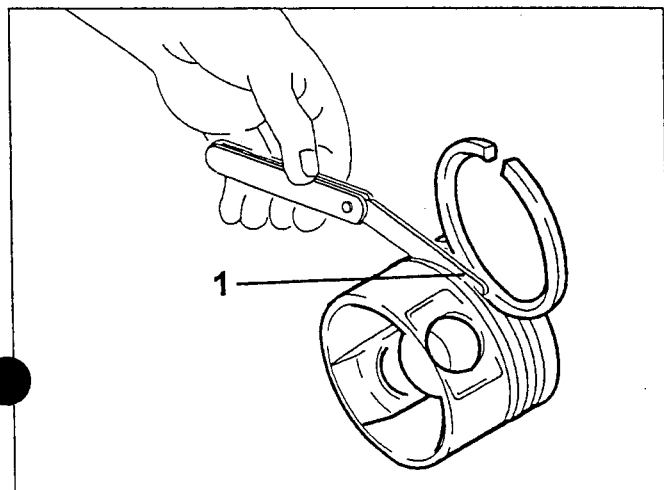


NOTE: The outside diameter of the piston should be measured at right angles to the gudgeon pin axis and 8 mm from the lower edge of the skirt.

1. Check that the end floats between the second ring/scrapper ring and their seats on the piston are within the specified limits.



Piston ring end float	
Second ring	0.020 ÷ 0.060 mm
Oil scraper ring	0.030 ÷ 0.065 mm



- Check that the difference in weight between the pistons is within the specified limits.



Difference in weight between pistons
± 5 g

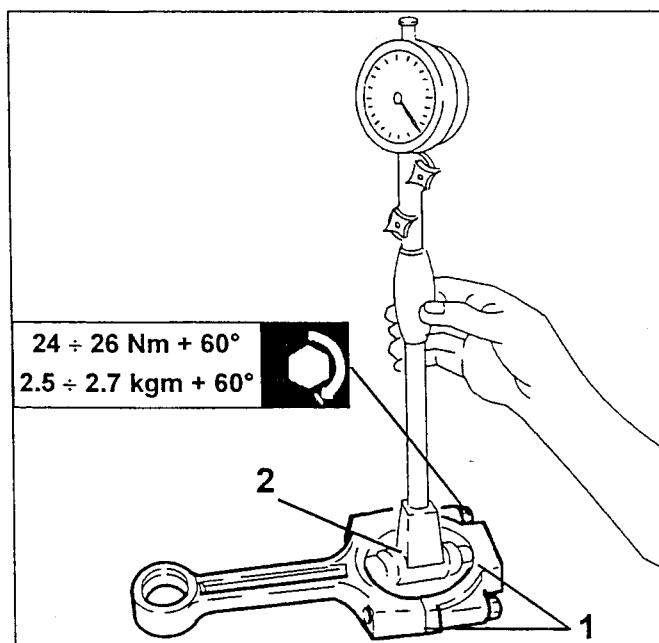
NOTE: The arrows indicate the areas from which it is possible to remove material to obtain an equal weight.

CHECKING THE CONNECTING RODS

1. Fit the caps on the connecting rods and fasten them with their screws to the specified torque.
2. Check that the diameter of the connecting rod big end is within the specified limits; if not, replace the connecting rods.



Inside diameter of big end
53.883 ÷ 53.923 mm



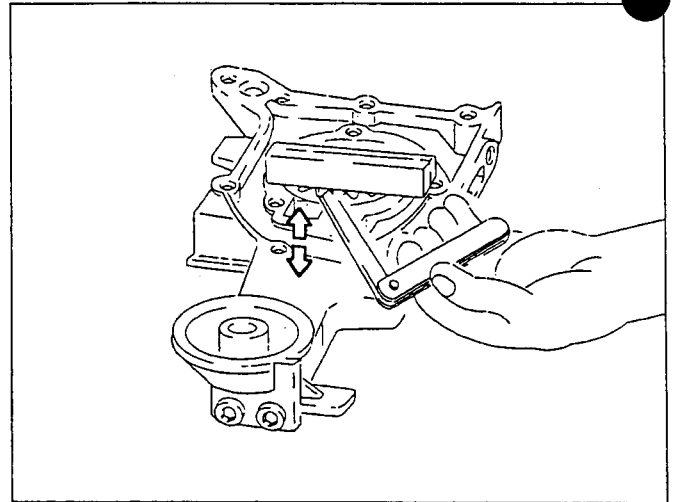
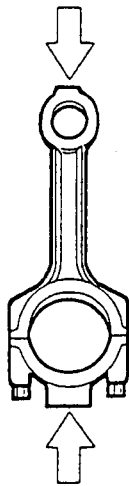
- Check the squaring of the connecting rods using suitable equipment; if squaring is less than perfect, replace the connecting rod.

- Check that the difference in weight between the connecting rods complete with half bearings, caps and screws is within the specified limits.



Difference in weight between connecting rods
± 2.5 g

NOTE: The arrows indicate the areas from which it is possible to remove material to obtain an equal weight.



- Check that the height of the spring for the oil pressure limiting valve is within the specified limits; if not, replace the spring.

Spring length (mm)	Check load N (kg)
35	117 ÷ 125 (11.9 ÷ 12.7)

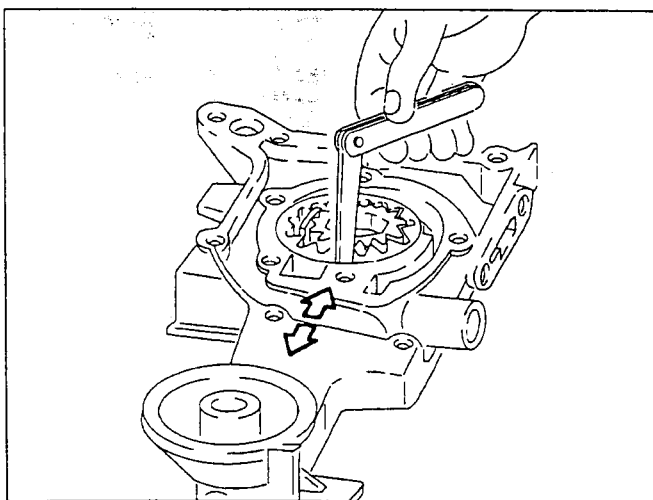
CHECKING AND INSPECTING THE OIL PUMP

- Check that the radial clearance between the pump casing and the driven gear is within the specified limits; if not, replace the oil pump complete.



Radial clearance between oil pump casing and driven gear

0.080 ÷ 0.186 mm



- Check that the end float between the pump cover resting surface and the gear upper side is within the specified limits; if not replace the complete oil pump.



End float between oil pump cover resting surface and gear upper side

0.025 ÷ 0.070 mm

REASSEMBLY INSTRUCTIONS

For reassembly operations, reverse the sequence of the operations followed for removal, unless otherwise specified in the instructions given below.

Checking and adjusting valve clearance

- Check that the valve clearance in the closed position, is within the specified limits.



Valve clearance (with valves in closed position)

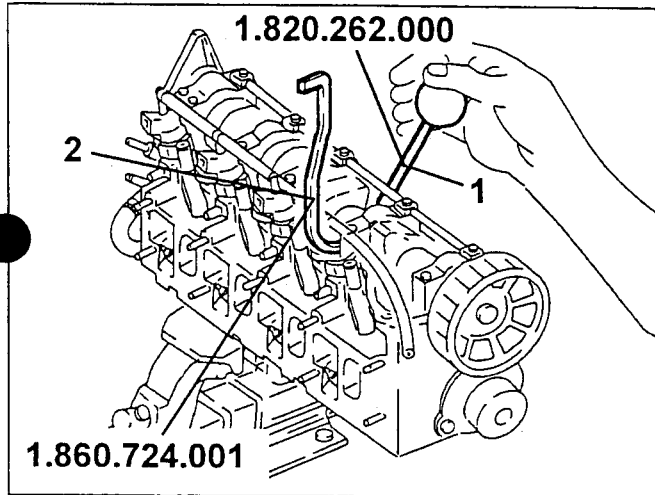
Intake	0.25 ÷ 0.35 mm
Exhaust	0.30 ÷ 0.40 mm

If the valve clearance is not within the specified limits, proceed as follows.

1. Lower the tappet in question using tool no. 1.820.262.000.
2. Assemble tool no. 1.860.724.001 to keep the tappets down.

NOTE: Direct the notches on the edge of the tappets to facilitate removal of the plate.

- Remove the valve clearance adjustment pad and replace it with another one of suitable thickness.
- Remove the tool used to keep the tappets lowered.

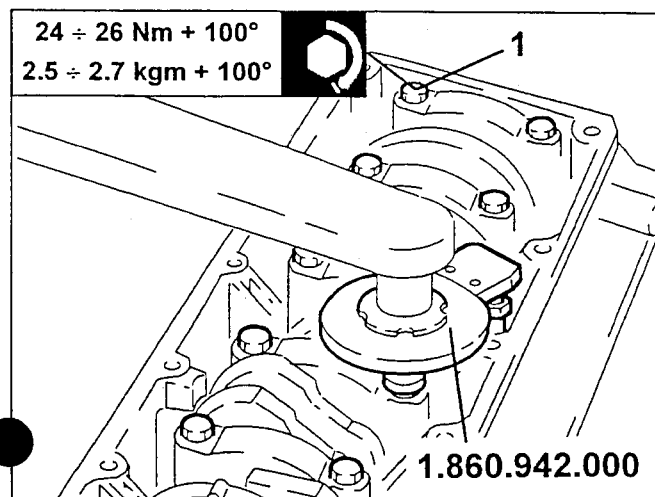


CRANKSHAFT REASSEMBLY

- After assembling the crankshaft, fit the main bearings caps complete with half bearings.

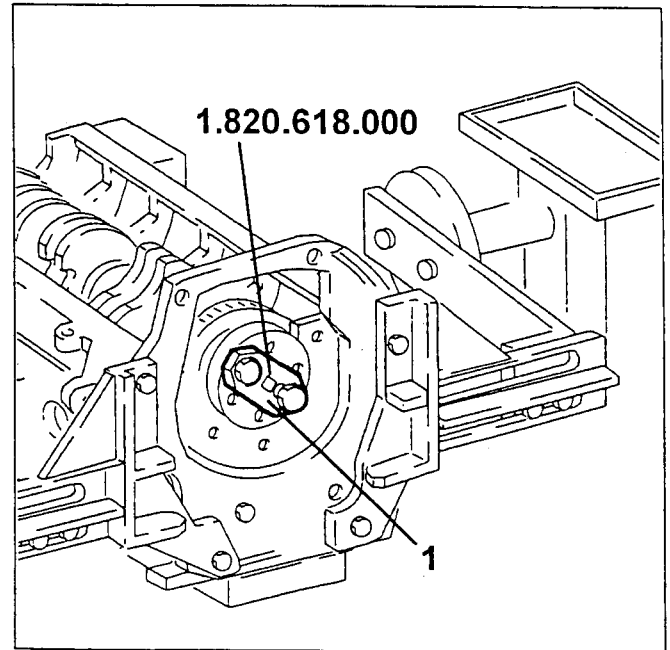
NOTE: The main bearing caps are notched consecutively (from 0 to four starting from the engine front) to define their assembly position.

1. Tighten the main bearing cap screws to the specified torque using tool no. 1.860.942.000 for angle tightening.

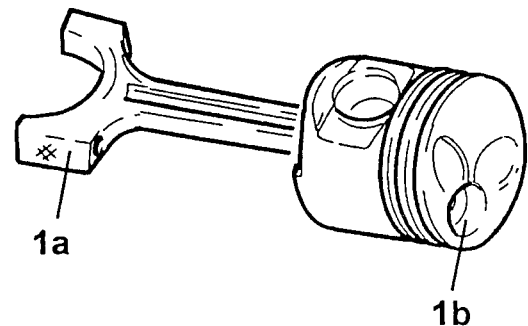


ASSEMBLING PISTONS AND CONNECTING RODS

1. Assemble tool no. 1.820.618.000 to make it possible to turn the crankshaft.



- Assemble the piston rings using a suitable tool.
- 1. Connect the connecting rods to the corresponding pistons so that the number stamped on the big end (1a) faces the combustion chamber (1b) machined on the piston.
- Assemble the gudgeon pins and fasten them with their circlips.



- Turn the crankshaft using the tool installed previously until the cylinder concerned reaches its B.D.C.

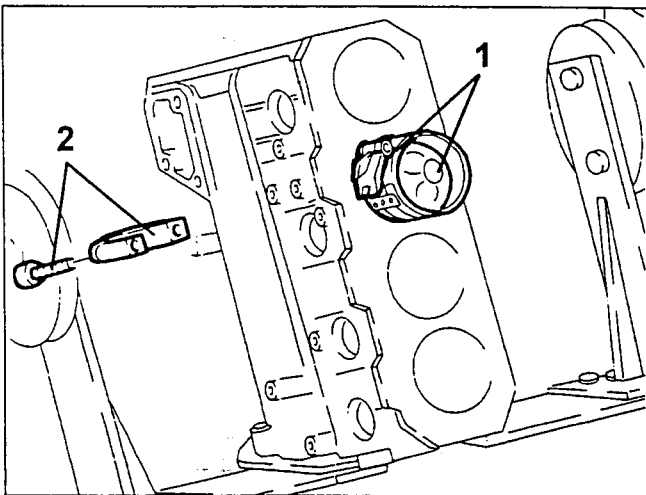
1. Assemble the connecting rod-piston set complete with half bearing using a suitable installing tool.

NOTE: The connecting rod-piston sets should be assembled in the crankcase with the combustion chamber on the piston facing towards the intake side.

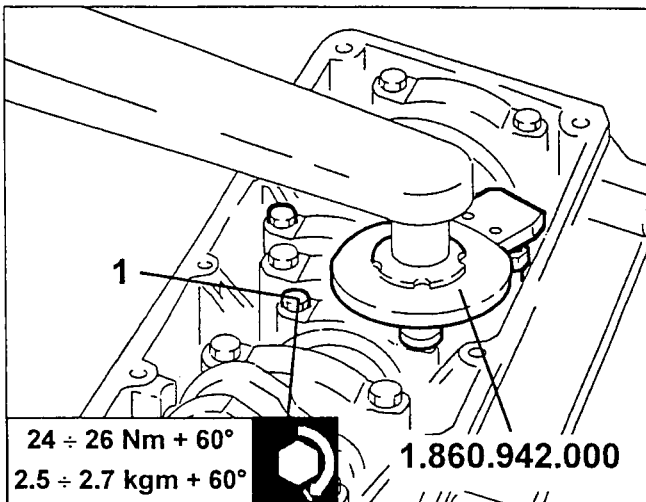
2. Assemble the connecting rod cap complete with half bearing and fasten it with its screws without locking them.

NOTE: The connecting rod caps should be assembled so that the number stamped on them points towards the same side as the one stamped on the connecting rod big end (intake side).

- Proceed in the same way to assemble the pistons and connecting rods of the remaining cylinders.

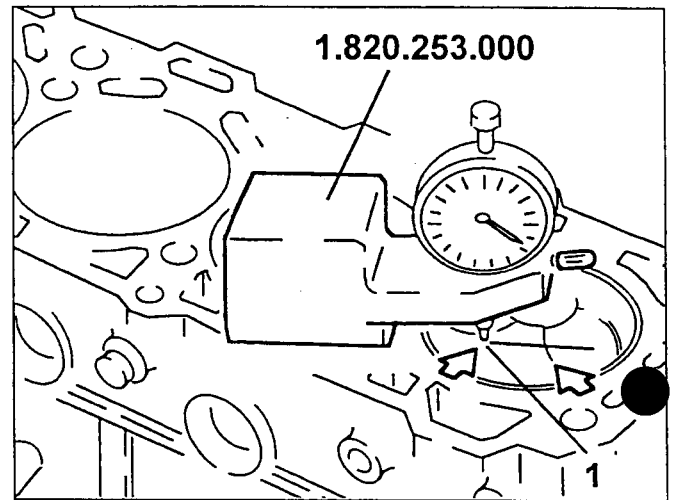


1. Tighten the connecting rod cap screws to the specified torque using tool no. 1.860.942.000 for angle tightening.



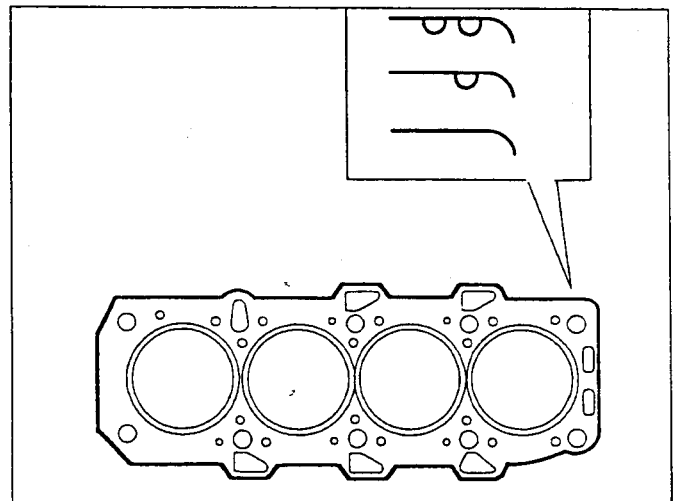
REFITTING THE CYLINDER HEAD

1. Measure the protrusion of the pistons on two points at 180°, on the gudgeon pin axis using tool no. 1.820.253.000 and calculate the average of the two values measured for each piston.



- Choose the thickness of the cylinder head seal to be used, according to the maximum value between the averages of the protrusion of each single piston.

Maximum average piston protrusion	Cylinder head seal thickness to be used
0.795 ÷ 0.881 mm	1.55 ÷ 1.65 mm (no notch)
0.881 ÷ 0.967 mm	1.65 ÷ 1.75 mm (one notch)
0.967 ÷ 1.055 mm	1.75 ÷ 1.85 mm (two notches)



- Position the cylinder head centering bushes on the crankcase.
- Assemble the cylinder head seal of the chosen thickness.

NOTE: The cylinder head seal is of the ASTADUR type.

The material with which it is made undergoes a polymerising process when the engine is running, therefore it hardens considerably during use.

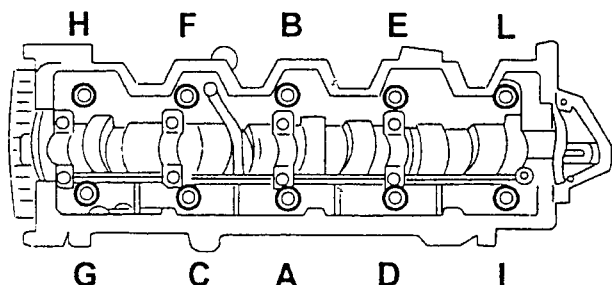
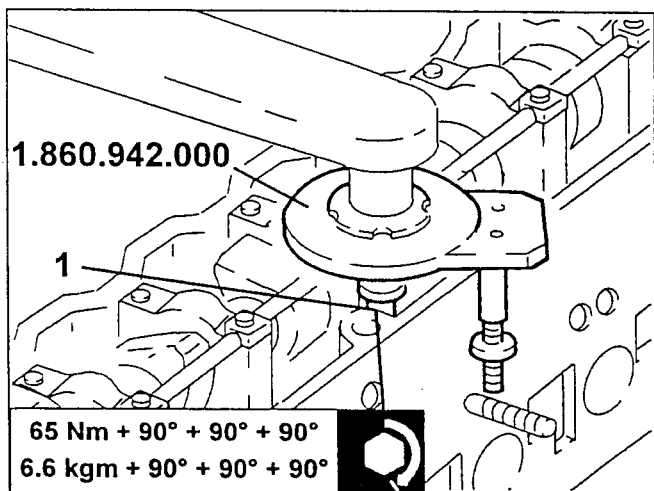
To ensure that the seal polymerises it is necessary to:

- keep the seal closed in its wrapper until assembly
- do not lubricate or soil the seal and contact surfaces with oil.

- Position the cylinder head on the crankcase.

1. Tighten the cylinder head screws to the specified torque using tool no. 1.860.942.000 for angle tightening.

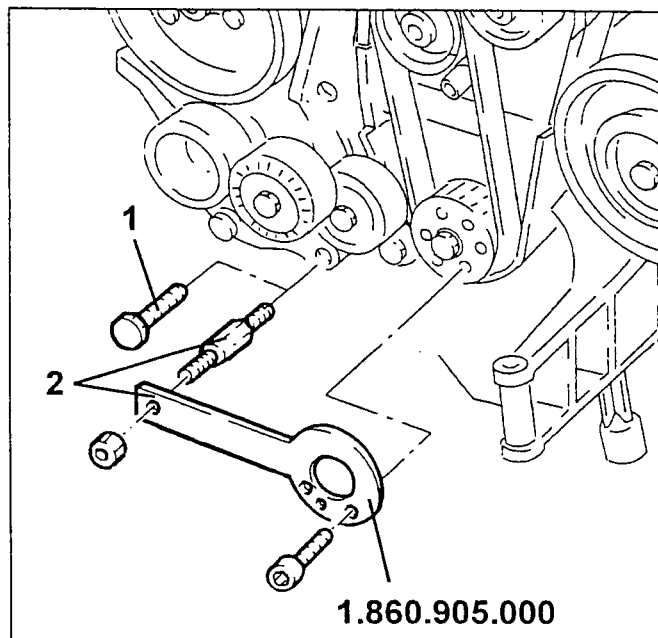
NOTE: For each tightening sequence, follow the order given below.



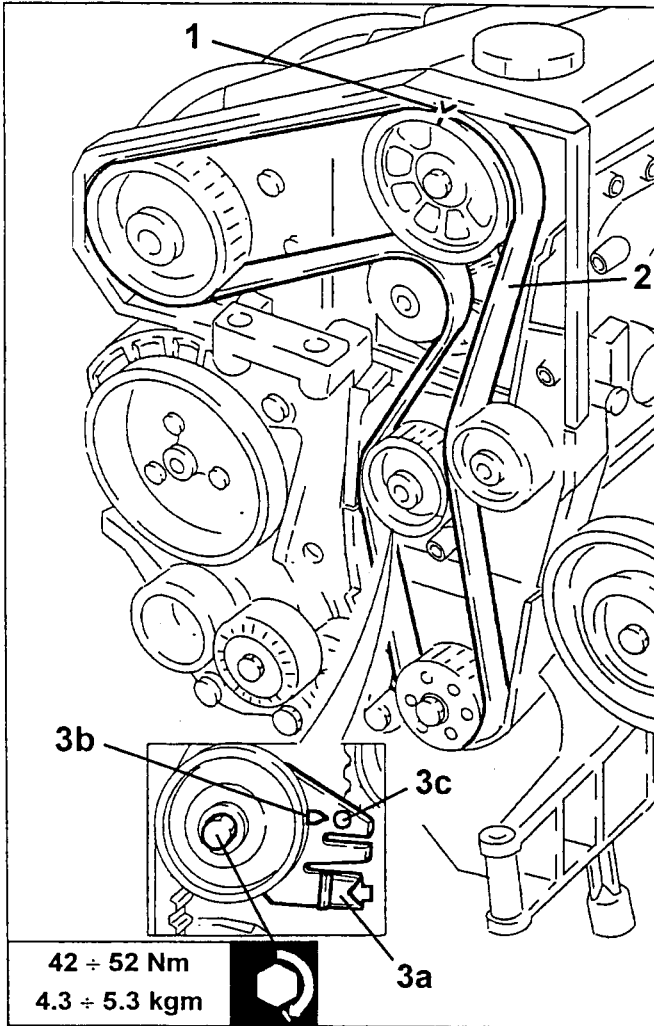
CAMSHAFT DRIVE BELT ASSEMBLY AND CHECKING VALVE GEAR TIMING

1. Remove the oil pump screw indicated.
- Temporarily assemble the camshaft toothed drive belt on the drive pulley.
2. Assemble tool no. 1.860.905.000.

NOTE: To make it possible to insert the dowel on the camshaft toothed belt drive pulley with the hole on the tool, turn the crankshaft with small movements.



1. Turn the driven toothed pulley until the timing notches coincide.
 2. Completely fit the camshaft toothed drive belt.
 3. Lever with a screwdriver in the hole (3a) until the index of the tensioner (3b) coincides with the reference hole (3c) and in this position, tighten the camshaft belt tensioner nut to the specified torque.
- Turn the crankshaft twice.
 - Check again that the timing references coincide and also the tensioning references on the camshaft belt tensioner.



CHECKING LUBRICATION CIRCUIT ELECTRIC COMPONENTS

- Engine oil minimum pressure warning light

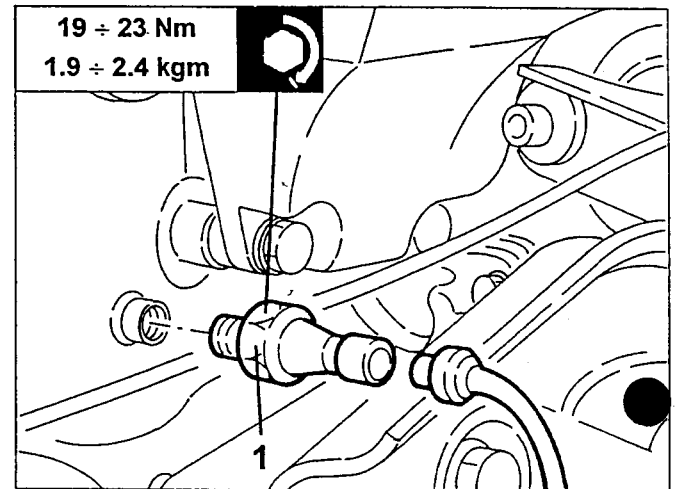
For all the other sensors and electric components located in the engine compartment, refer to the specific Groups in which they are described in detail.

ENGINE OIL MINIMUM PRESSURE WARNING LIGHT SENSOR

1. Check the setting of the engine oil minimum pressure warning light sensor. If the values are not as specified, replace the sensor.



Contact opening/closing pressure	0.2 ÷ 0.5 bar
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WHEN ENGINE REASSEMBLY HAS BEEN COMPLETED carry out all the checks and inspections of routine maintenance (see GROUP 00) and the checks concerning the fuel supply system and the cooling system (see GROUP 10).