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GENERALITIES

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OVERHAULING

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DESCRIPTION

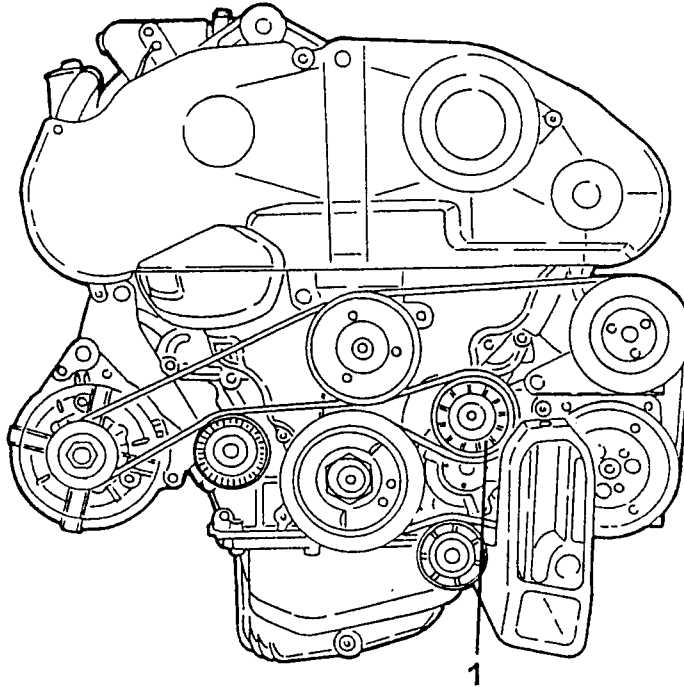
Six cylinder, 60° V, compact, two camshaft timing for each bank and four valves per cylinder.

Static ignition, with one coil per spark plug.

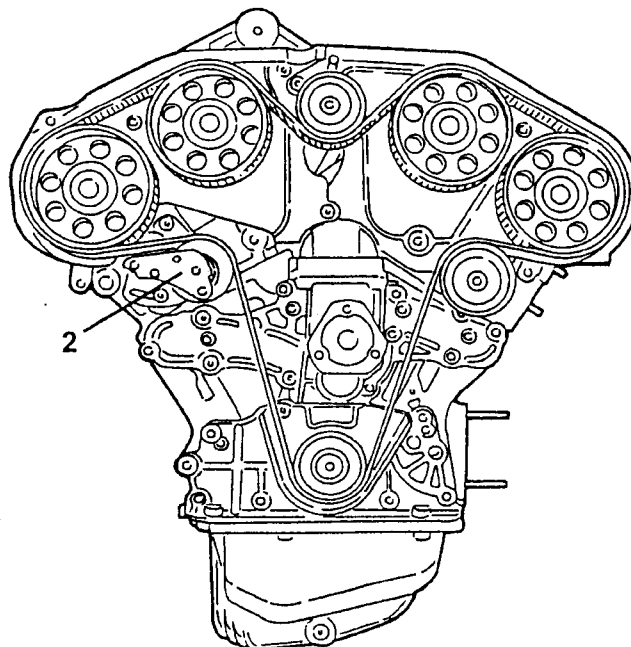
Static injection and ignition are controlled by a single ECU.

The main variation of this engine with respect to the previous version are:

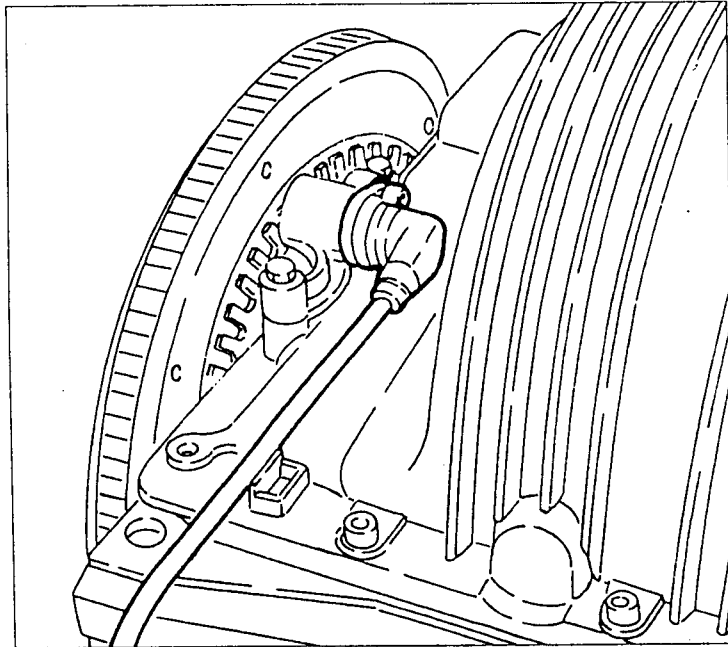
- "Compact" engine, thanks to the adoption of new accessory units (compressor, power steering, alternator) which reduce engine size.
- Adoption of a new automatic "Dayco" (1) auxiliary unit drive belt take-up device; this was a seven-rib Poly-V and is now a six-rib.



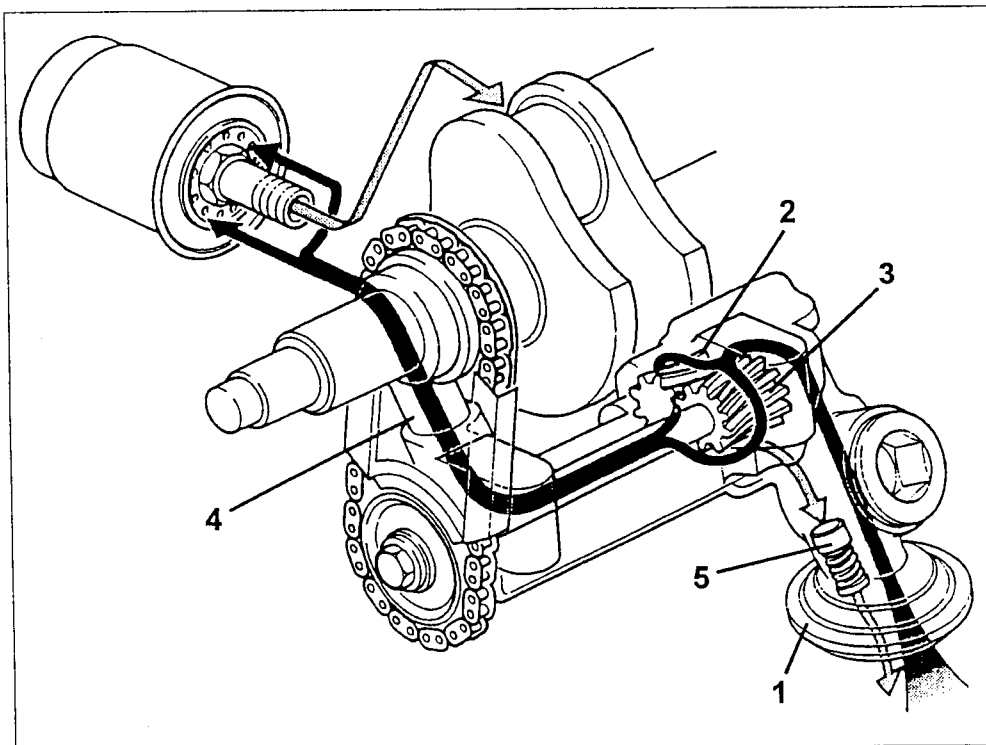
- Adoption of a new "litens" (2) timing belt drive take-up device.



- 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.



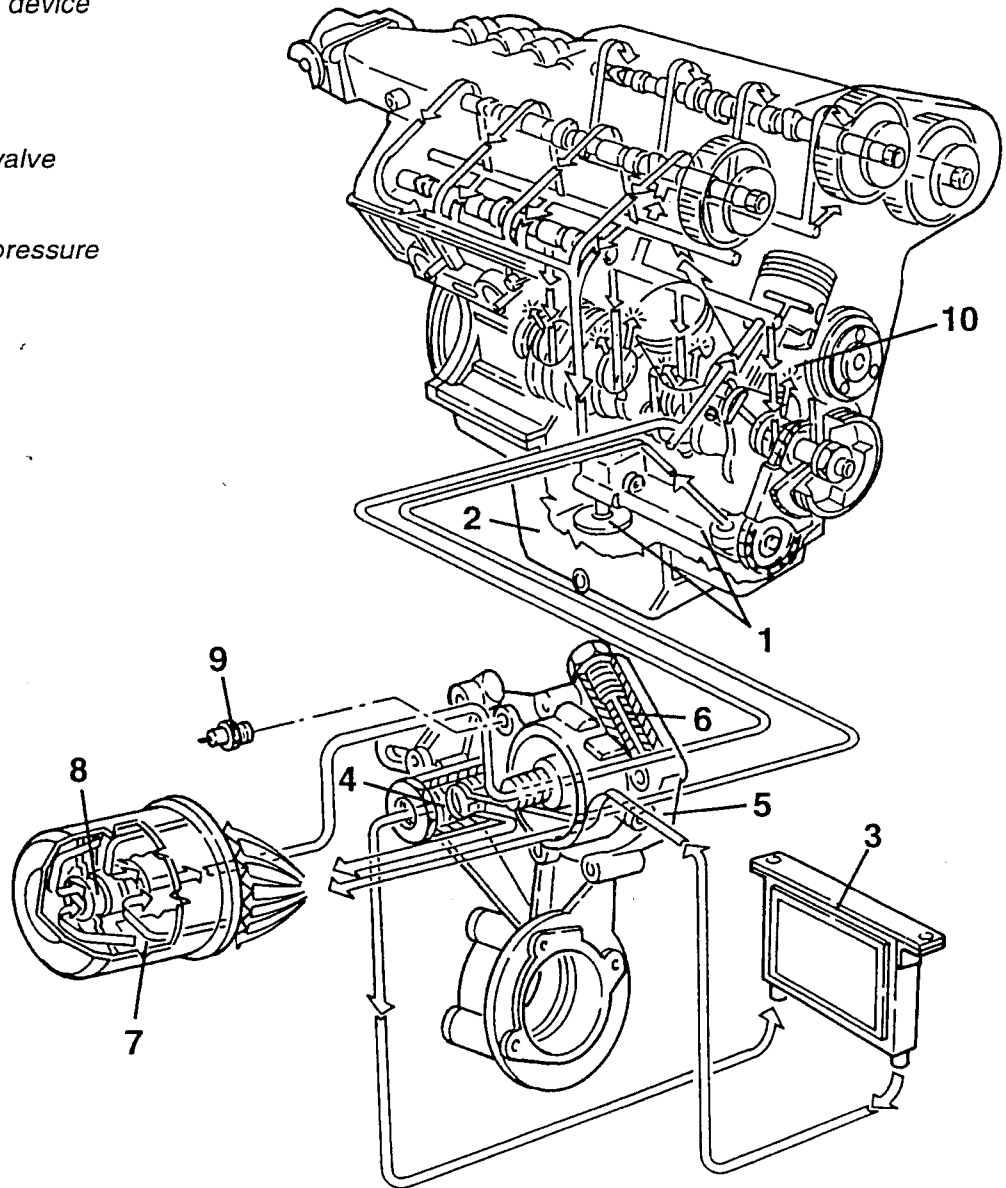
- Adoption of a "silent" oil pump chain (ex lobular, now geared) with increased performance, especially at low engine ratios.



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.

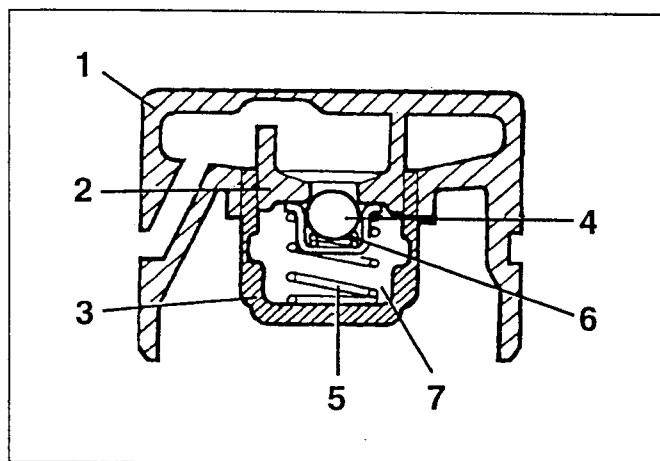
On the oil filter support (5) there is an engine oil minimum pressure sensor (9) which is connected to a warning light on the instrument cluster to alert the driver if the oil pressure is too low.

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 $2.25 \div 2.75$ bar.

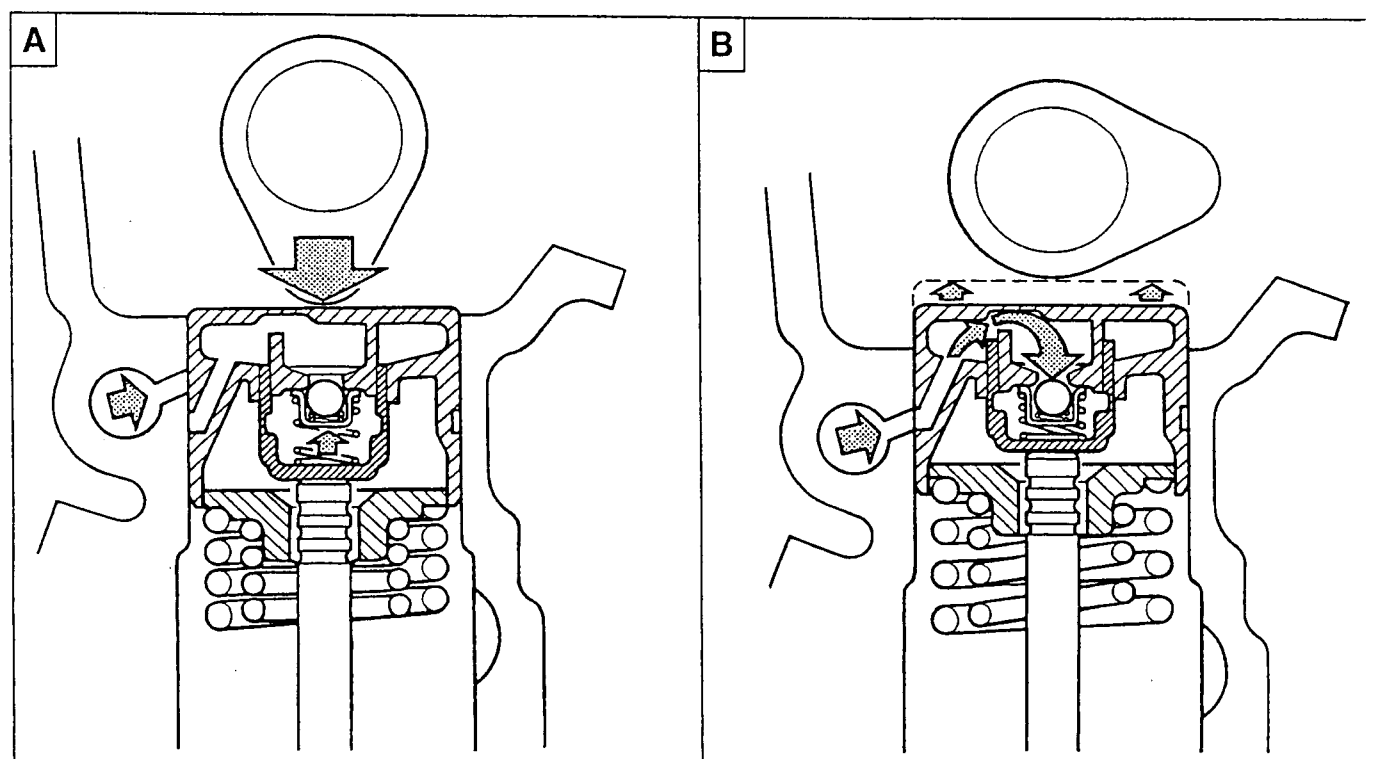
DESCRIPTION OF THE HYDRAULIC TAPPETS AND HOW THEY WORK



- | | |
|-----------|----------------------|
| 1. Body | 5. Piston spring |
| 2. Piston | 6. Ball valve spring |
| 3. Sleeve | 7. Chamber |
| 4. Ball | |

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.**

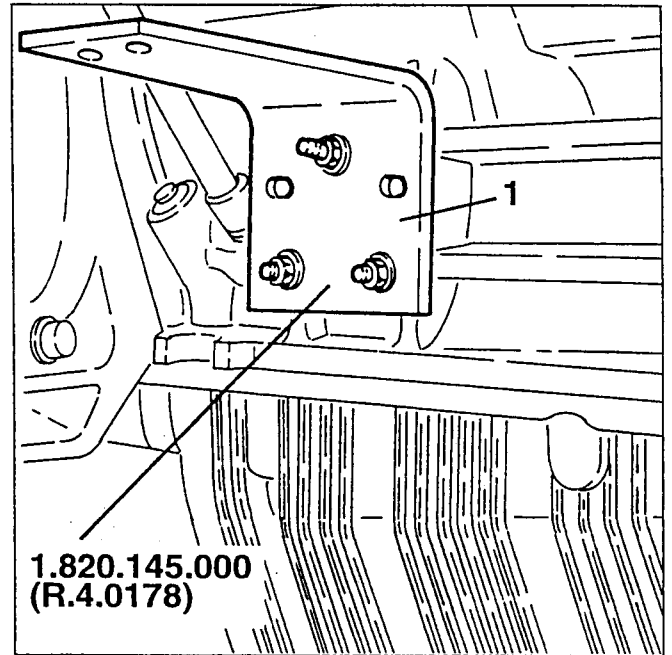
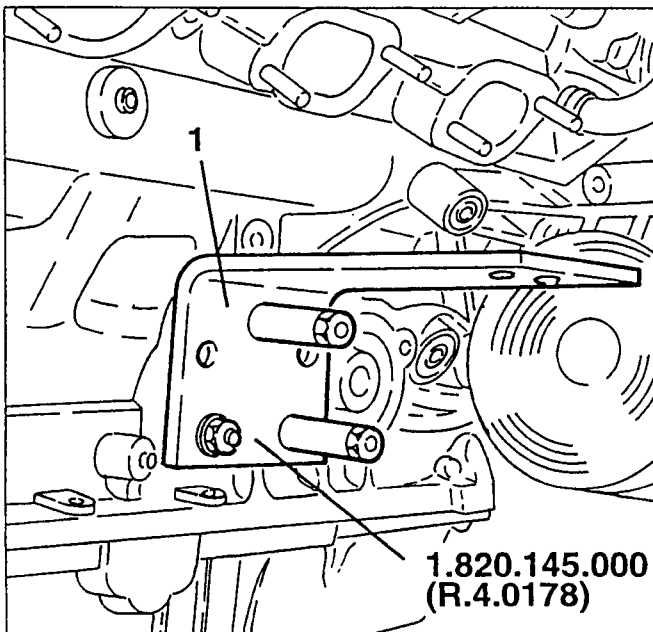
All the disassembly procedures described in the part that follows, if reversed, are also valid for reassembly, except where otherwise stated.

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.

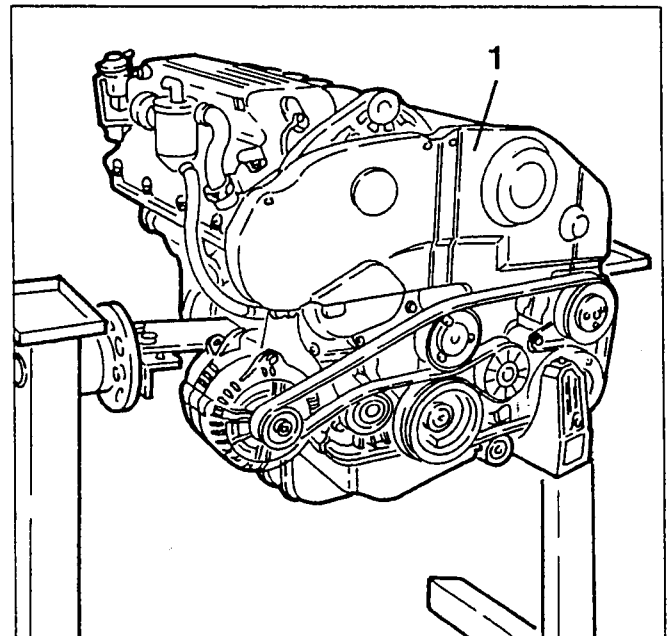
ENGINE DISASSEMBLY

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.

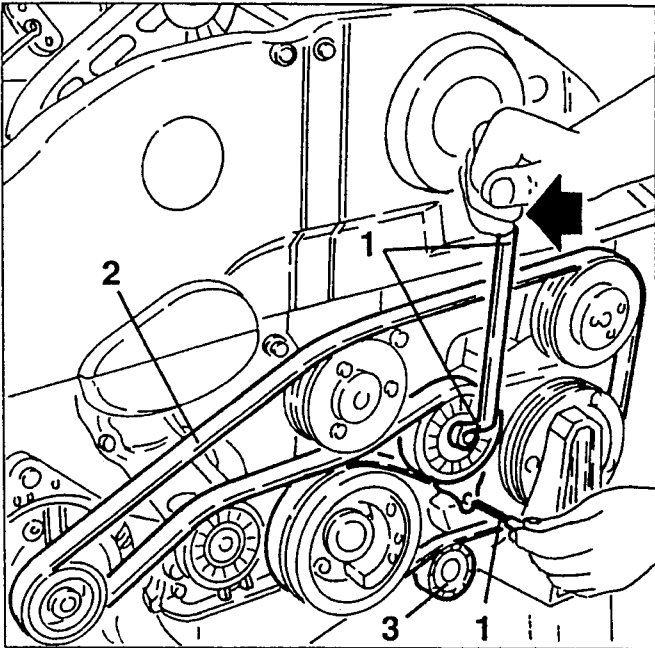


1. Raise the engine with the hydraulic jack and set it on the overhauling stand using the support brackets fitted previously.

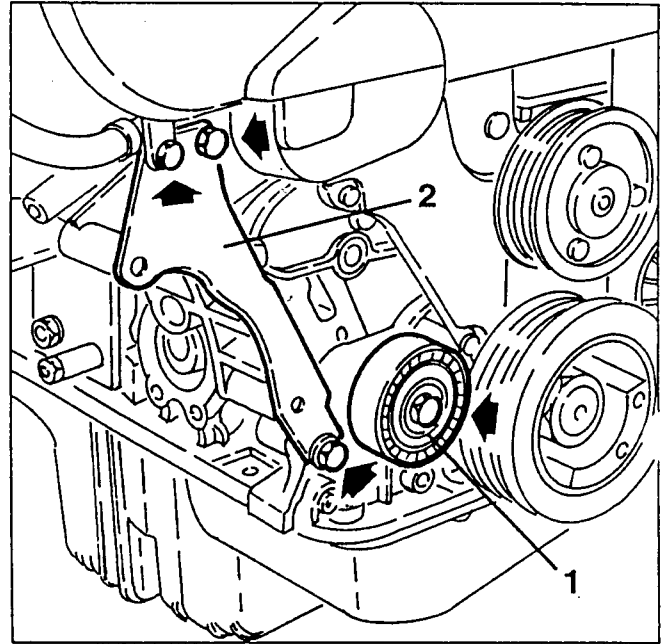


REMOVING THE ALTERNATOR

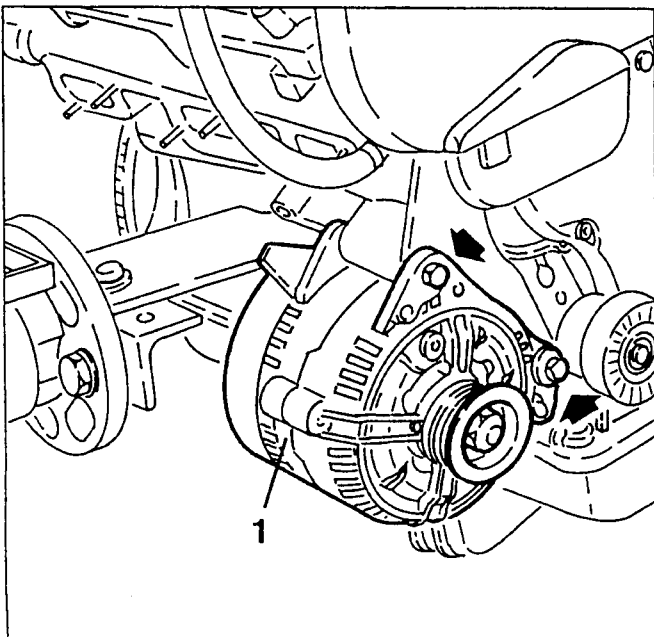
1. Slacken the tension on the auxiliary components drive belt as illustrated and lock the belt tensioner in this position using a special peg.
2. Prise and remove the auxiliary components drive belt.
3. Slacken the fastening screw and remove the lower guide pulley.



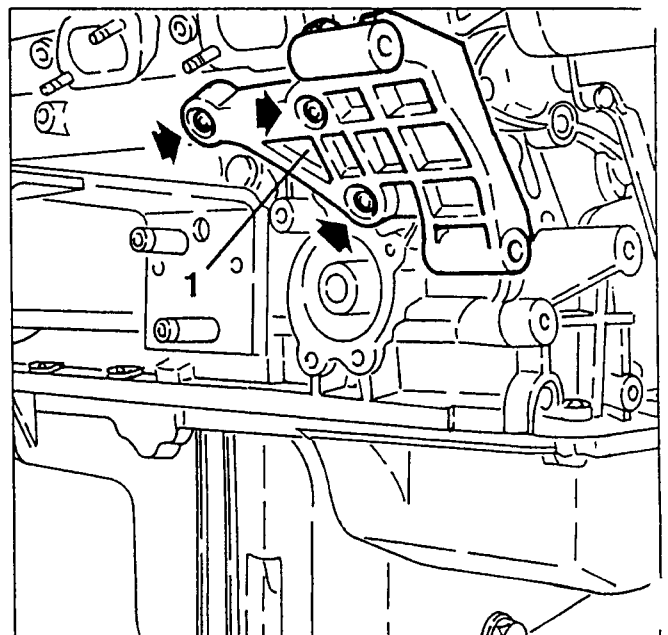
1. Slacken the fastening screw and remove the auxiliary components drive belt guide pulley.
2. Slacken the fastening screws and remove the spacer bracket.



1. Slacken the two fastening bolts and remove the alternator.

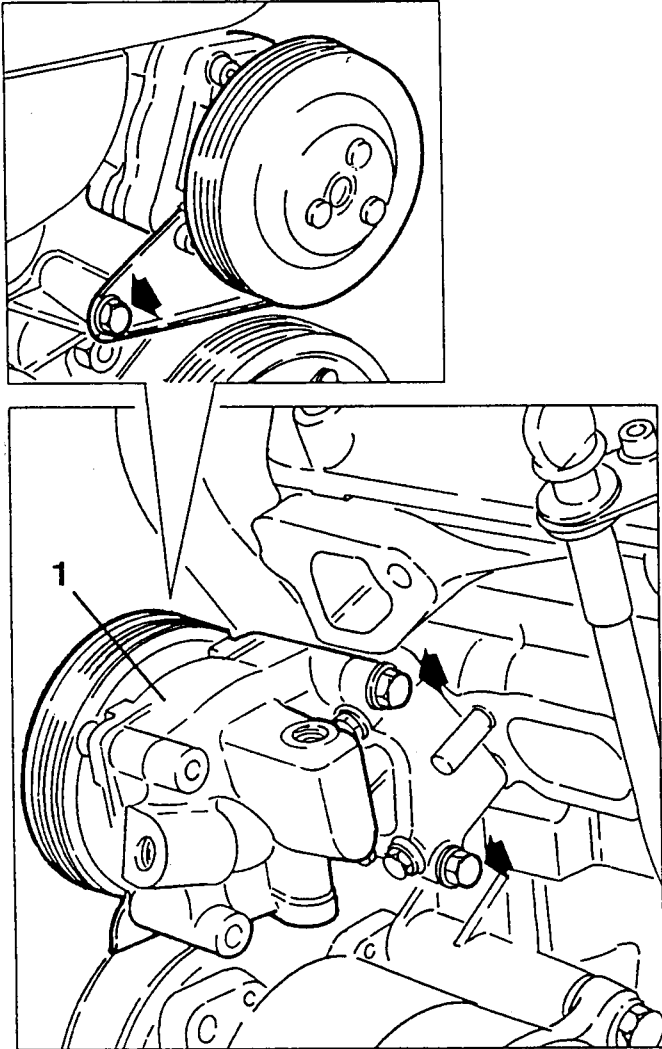


1. Slacken the fastening screw and remove the alternator support bracket.

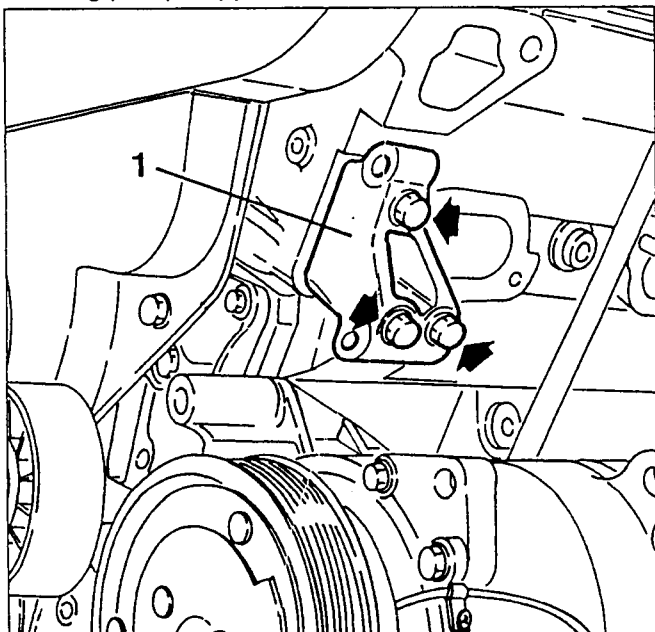


REMOVING THE POWER STEERING PUMP

1. Slacken the fastening screw and remove the power steering pump.

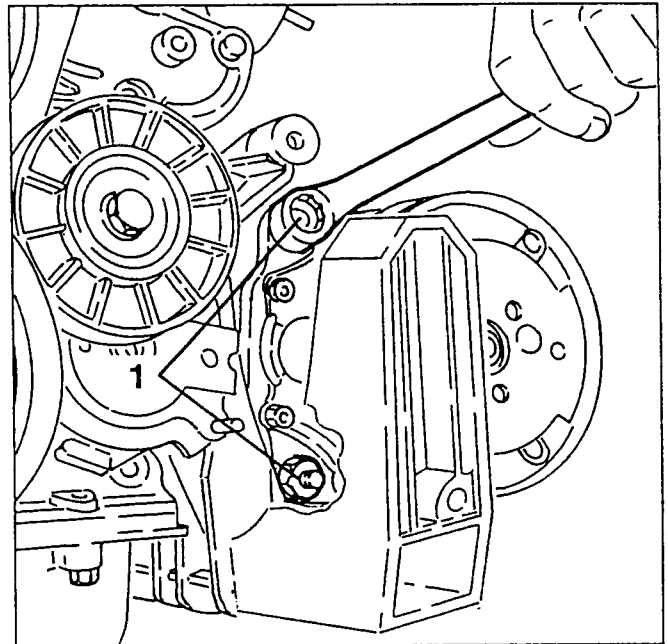


1. Slacken the fastening screw and remove the power steering pump support bracket.



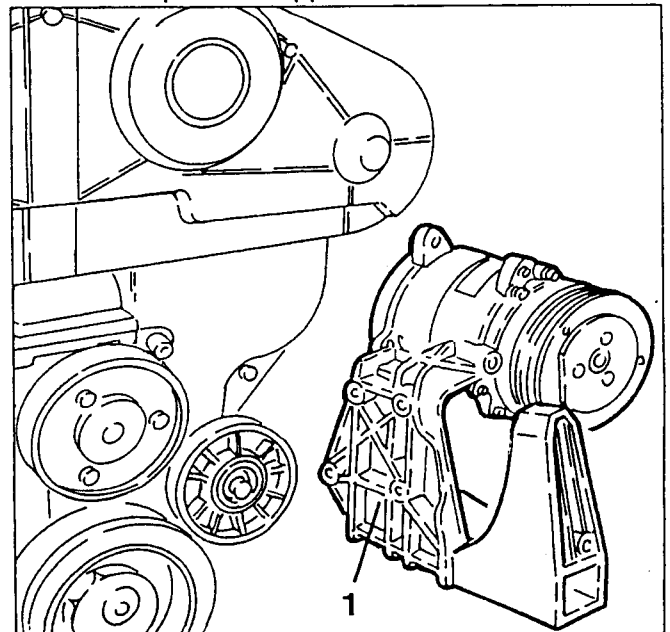
REMOVING THE AIR CONDITIONER COMPRESSOR

1. Slacken the bolts fastening the conditioner compressor and remove only the lower one.

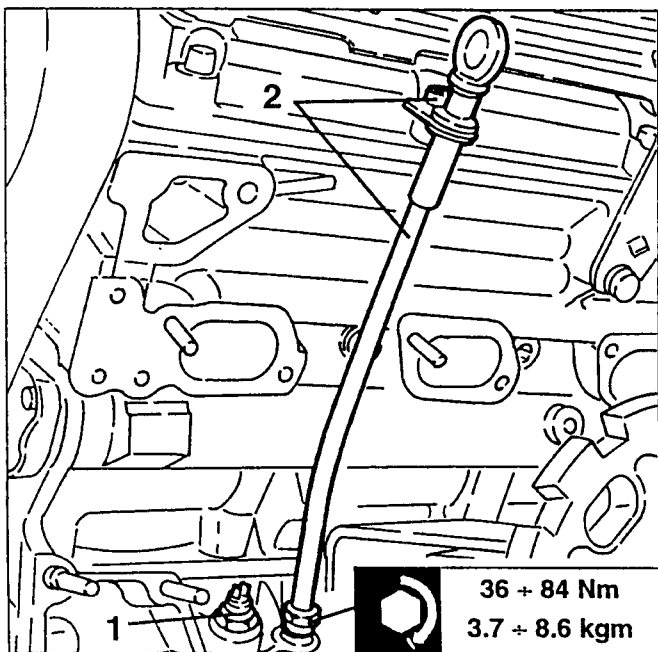


-Turn the conditioner compressor upwards pivoting on the upper fastening bolt and lock it in this position by tightening the bolt.

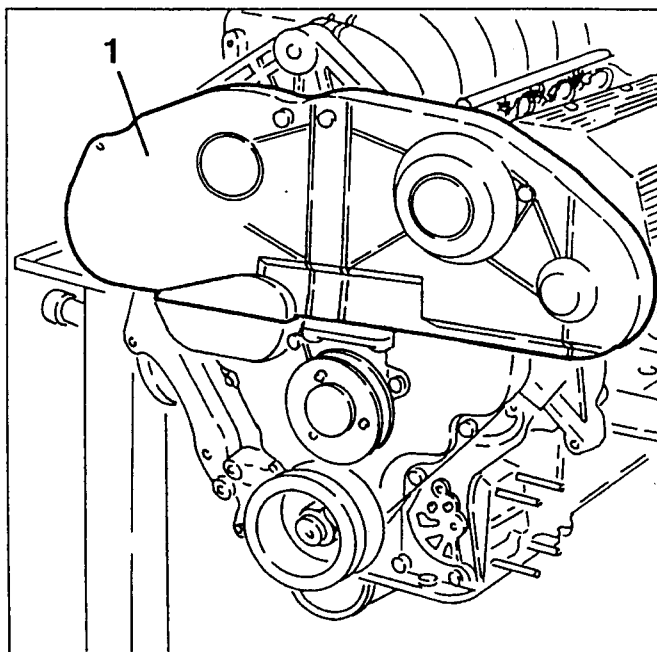
1. Slacken the four fastening nuts, which in this position are accessible and remove the complete air conditioner compressor support bracket.



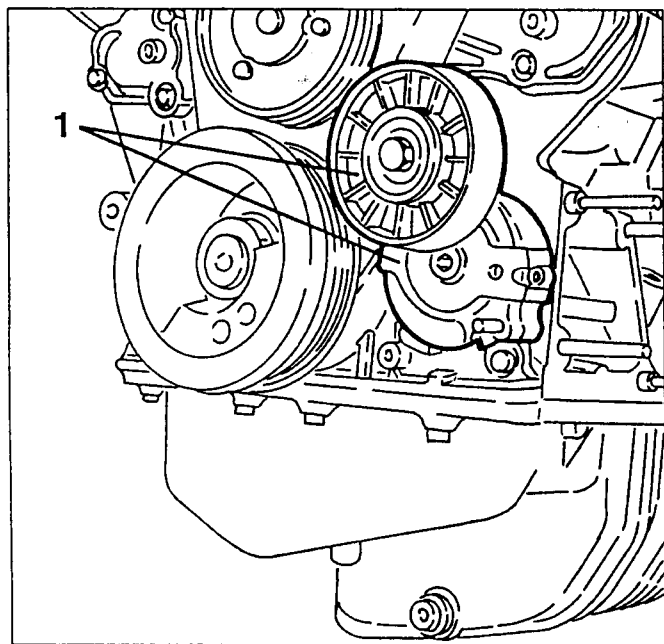
1. Slacken and remove the low engine oil level sensor from the crankcase.
2. Remove the engine oil dipstick complete with guide.



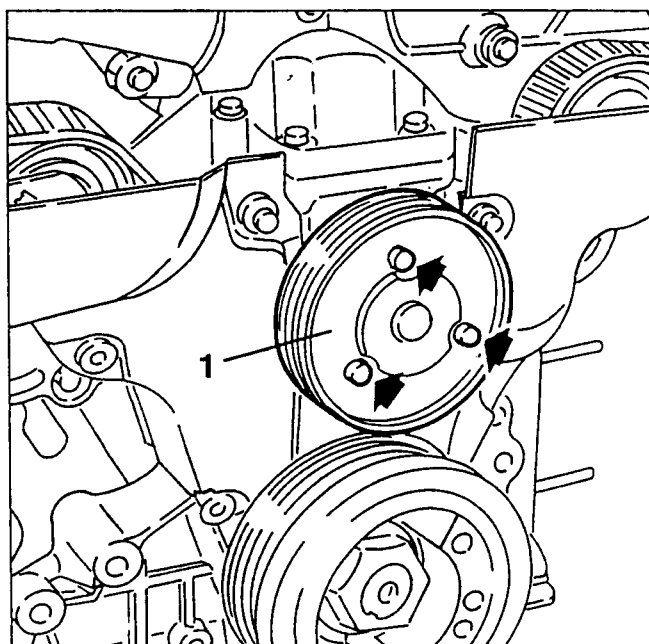
1. Slacken the fastening screw and remove the timing gear belt guard.



1. Slacken the fastening screw and remove the auxiliary components drive belt tensioner.

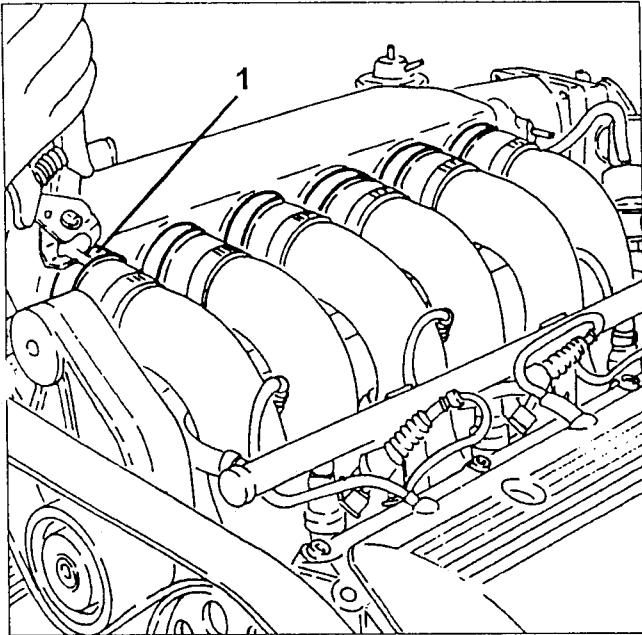


1. Slacken the fastening screw and remove the water pump pulley.

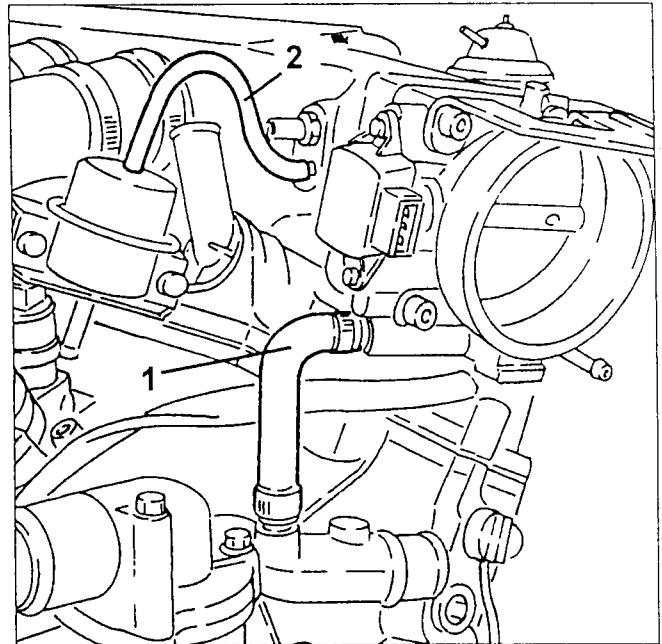


INTAKE MANIFOLD REMOVAL
(pre-change version)

1. Loosen the clips fastening the air feed ducts to the intake manifold.
- Loosen the screws fastening the feed ducts to the cylinder heads.

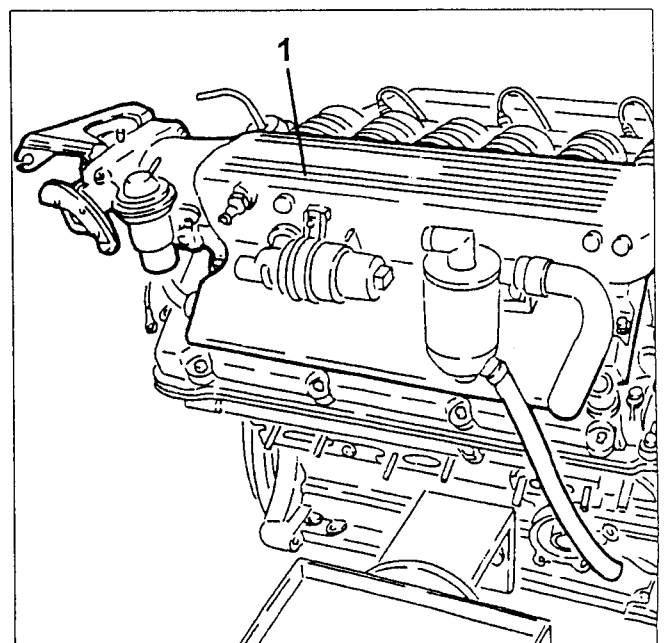
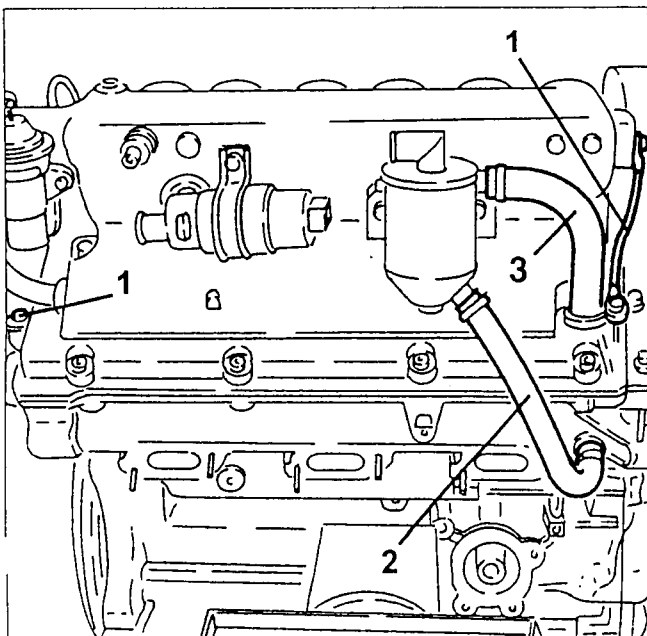


1. Disconnect the throttle casing coolant inlet pipe from the throttle casing.
2. Disconnect the fuel pressure regulator vacuum pipe from the intake manifold.

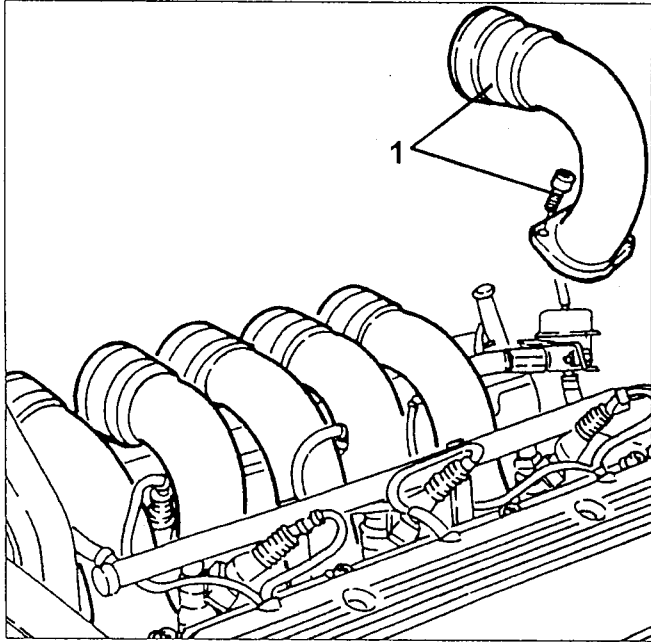


1. Disconnect the two earth wires between the intake manifold and the right-hand cylinder head.
2. Disconnect the condensed oil vapour recovery pipe from the separator.
3. Disconnect the oil vapour recovery pipe from the cylinder head.

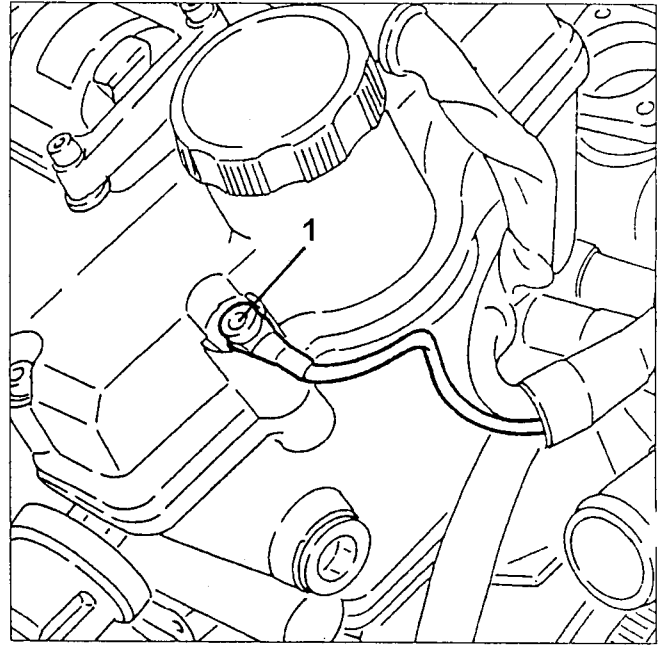
1. Loosen the fastening screws and remove the intake manifold/static ignition coil cover assembly from the right-hand cylinder head.



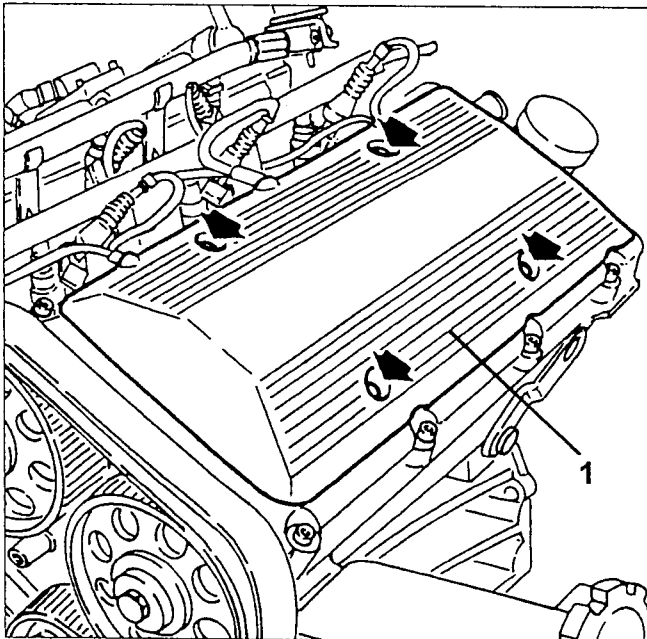
1. Completely remove the previously loosened fastening screws and remove the air feed ducts.
- Remove the respective seals.



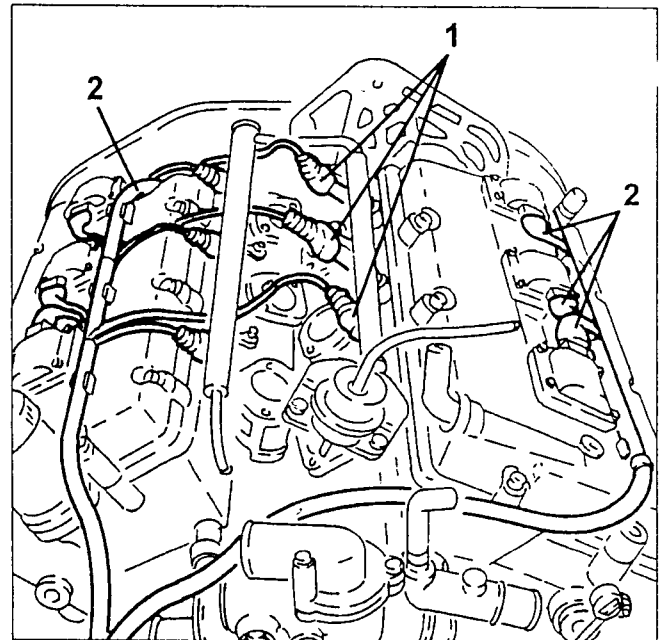
1. Disconnect the earth wire from the left-hand cylinder head.



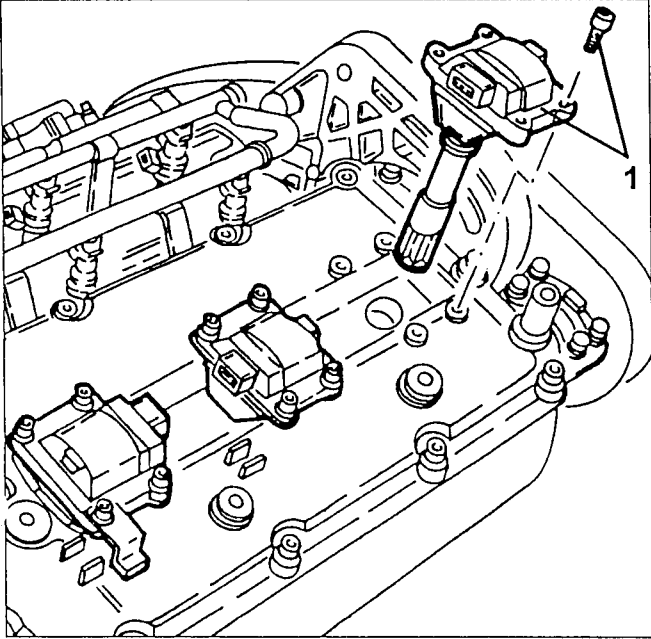
1. Loosen the fastening screws and remove the static ignition coil cover from the left-hand cylinder head.



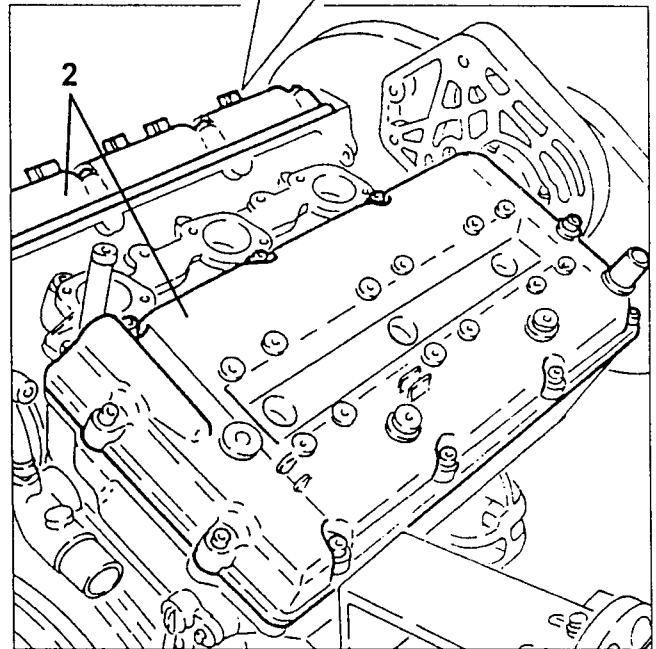
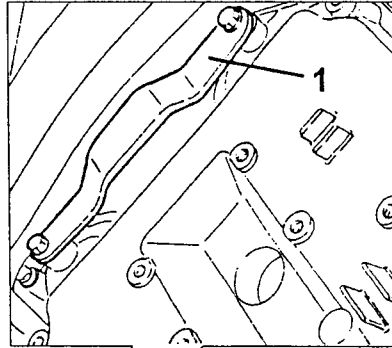
1. Disconnect the injector electrical connections.
2. Disconnect the static ignition coil electrical connections and then remove the electrical wiring by releasing the fastening clips.



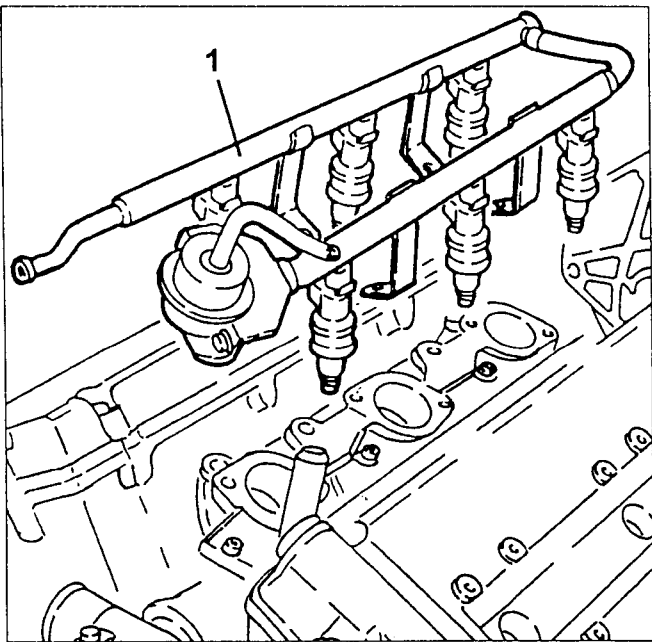
1. Loosen the fastening screws and remove the static ignition coils.
- Loosen and remove the spark plugs.



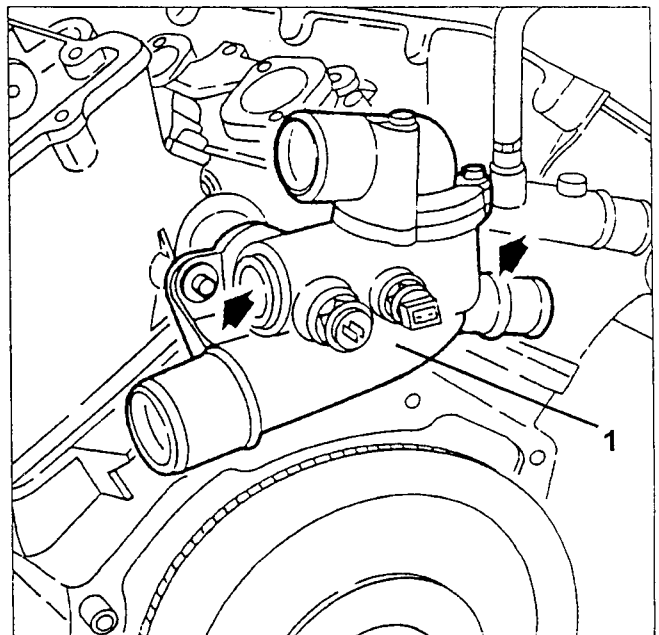
2. Loosen the fastening screws and remove the cylinder head covers.



1. Loosen the fastening screws and remove the fuel distribution manifold with the injectors.

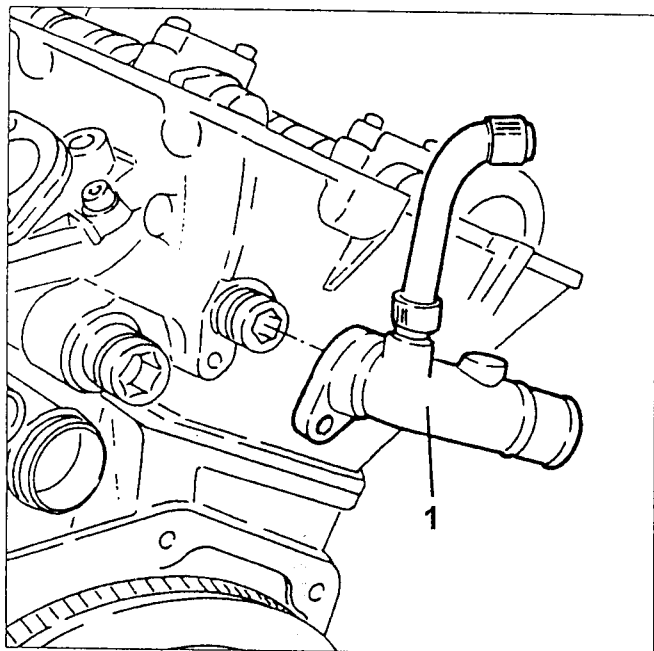


1. Loosen the fastening screws and remove the thermostat cup and sensors.

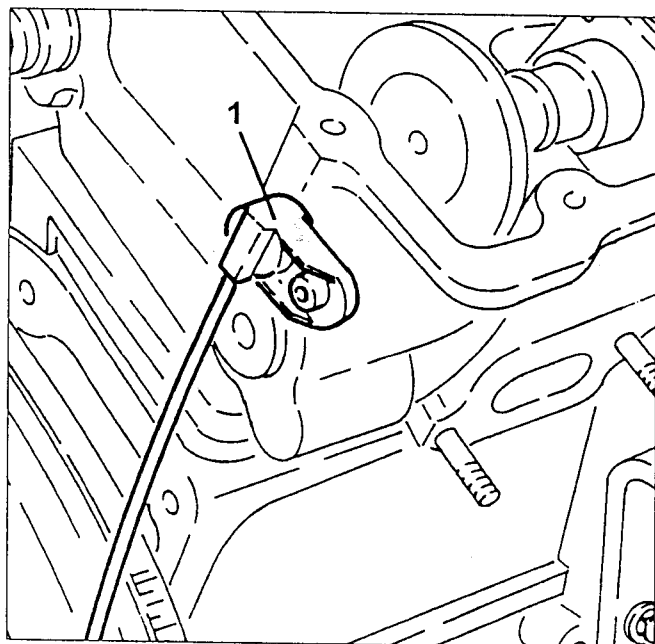


1. Remove the fastening screws and remove the rod and threaded nut to fasten the upper timing belt guard from the left-hand cylinder head.

1. Remove the throttle casing and climate control system heater coolant delivery duct.

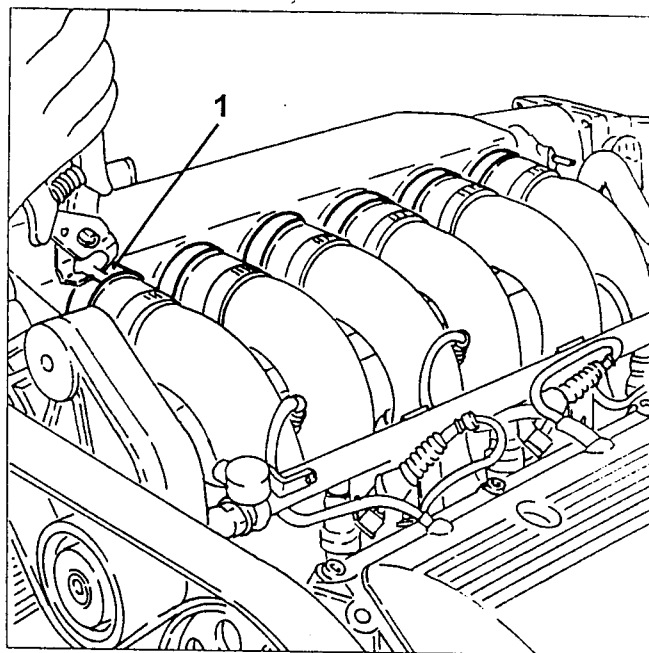


1. Loosen the fastening screw and remove the cam angle sensor.

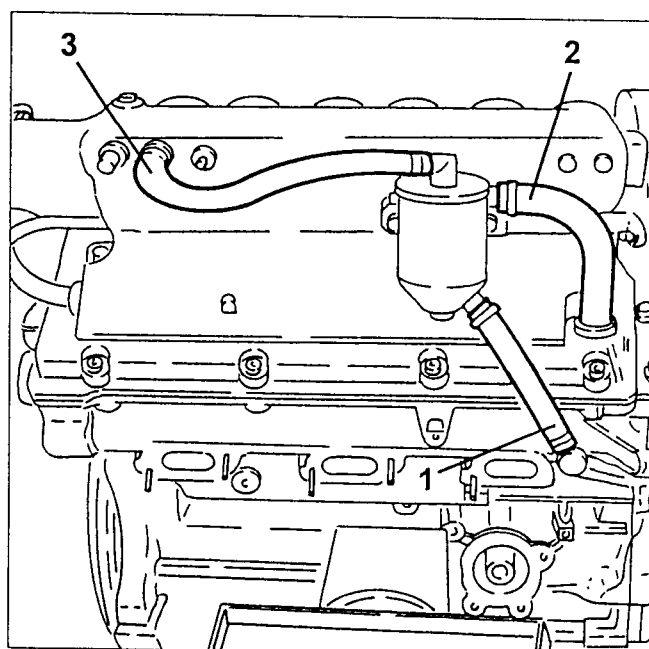


INTAKE MANIFOLD REMOVAL (post-change version)

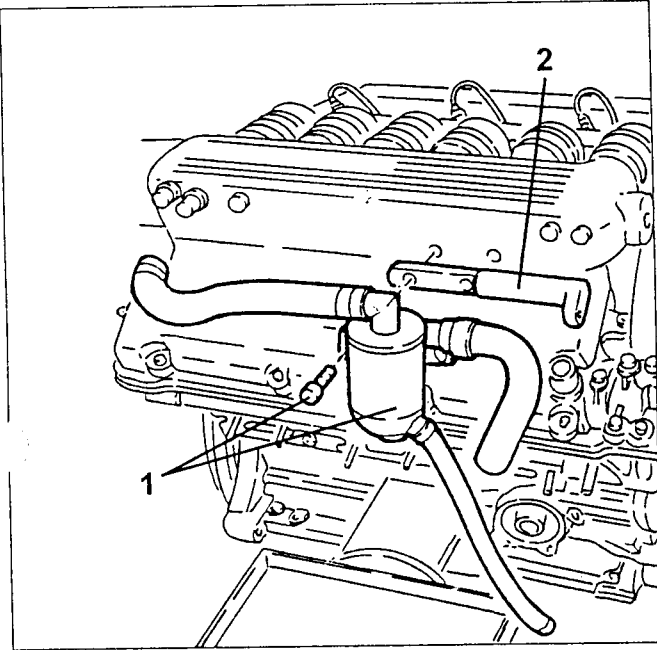
1. Loosen the clips fastening the air feed ducts to the intake manifold.
- Loosen the screws fastening the feed ducts to the cylinder heads.



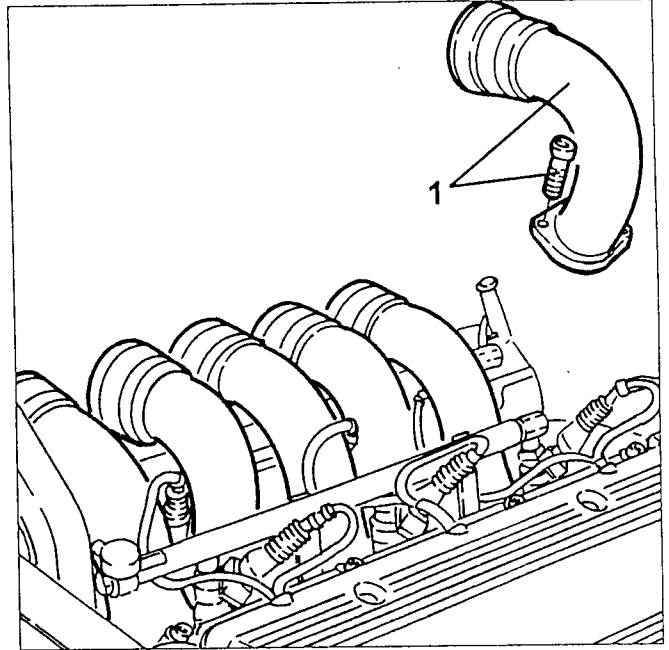
1. Disconnect the separator - condensed oil vapour recovery pipe from the cylinder head.
2. Disconnect the oil vapour recovery pipe from the cylinder head.
3. Disconnect the oil vapour recirculation pipe from the intake manifold.



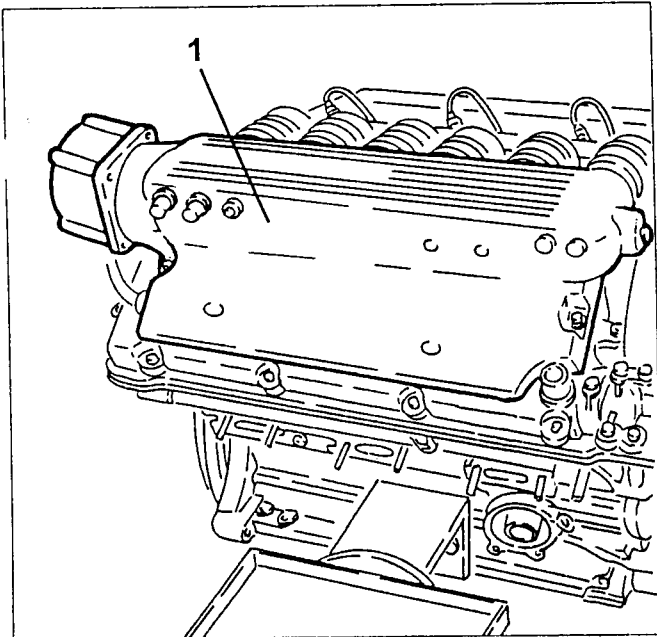
1. Loosen the fastening screws and remove the oil vapour separator.
2. Loosen the fastening screw and remove the intake manifold connection to the reaction tie-rod engine bracket.



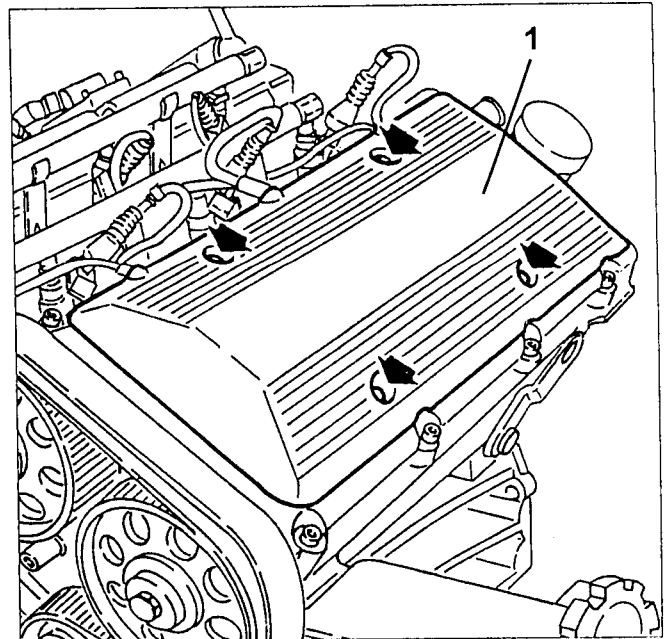
1. Completely remove the previously loosened fastening screws and remove the air feed ducts.
- Remove the respective seals.



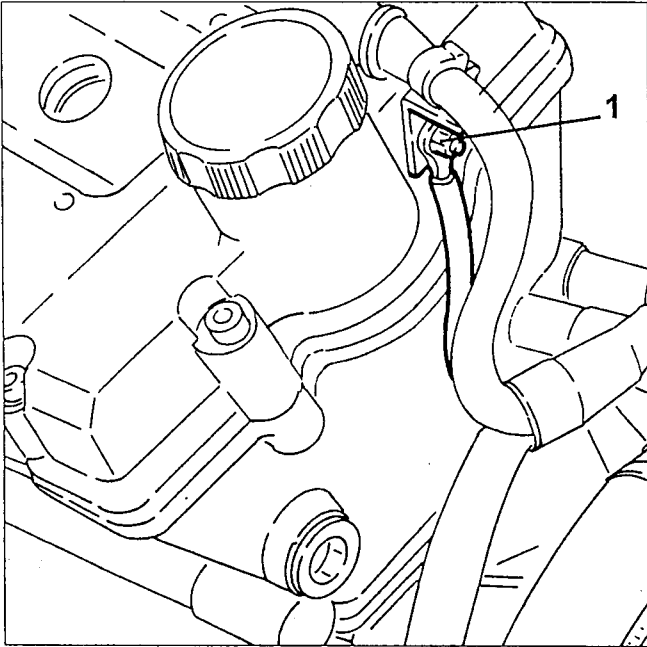
1. Remove the screws fastening the intake manifold/ignition coil cover assembly from the right-hand cylinder head.



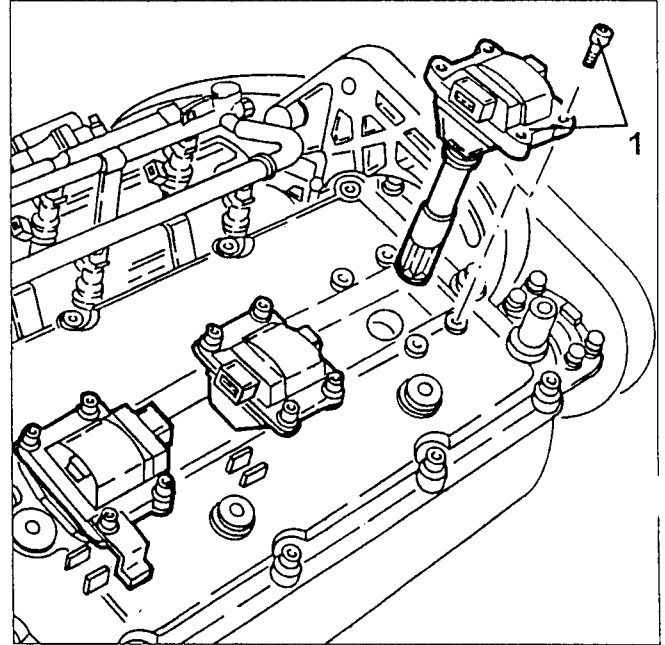
1. Loosen the fastening screws and remove the static ignition coil cover from the left-hand cylinder head.



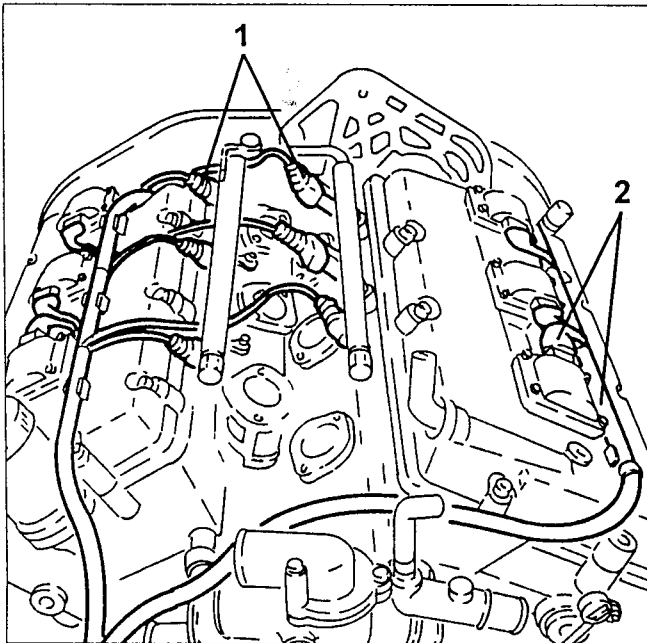
1. Disconnect the earth wire from the left-hand cylinder head.



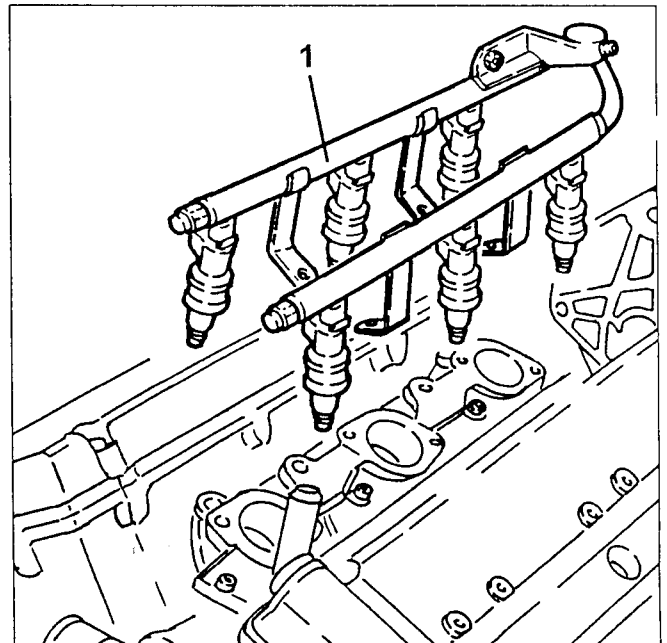
1. Loosen the fastening screws and remove the static ignition coils.
- Loosen and remove the spark plugs.



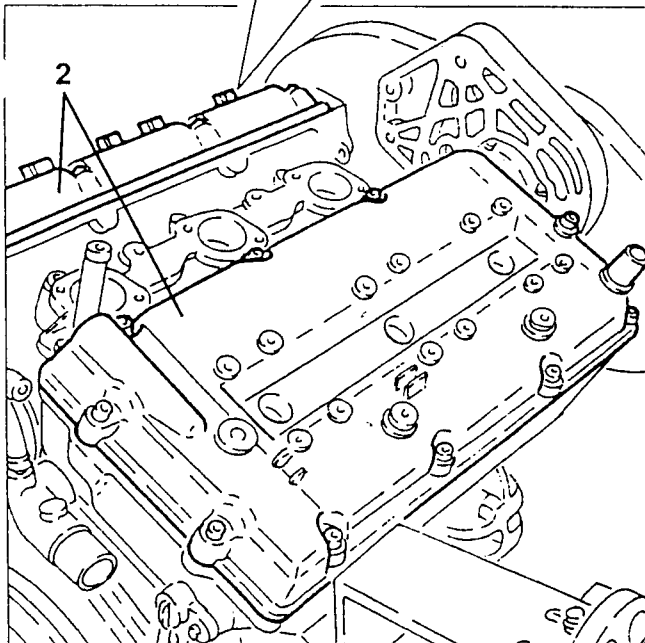
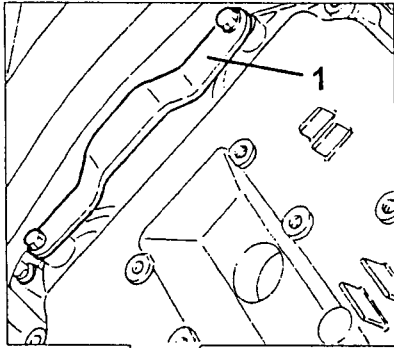
1. Disconnect the injector electrical connections.
2. Disconnect the static ignition coil electrical connections then remove the electrical wiring after releasing the fastening clips.



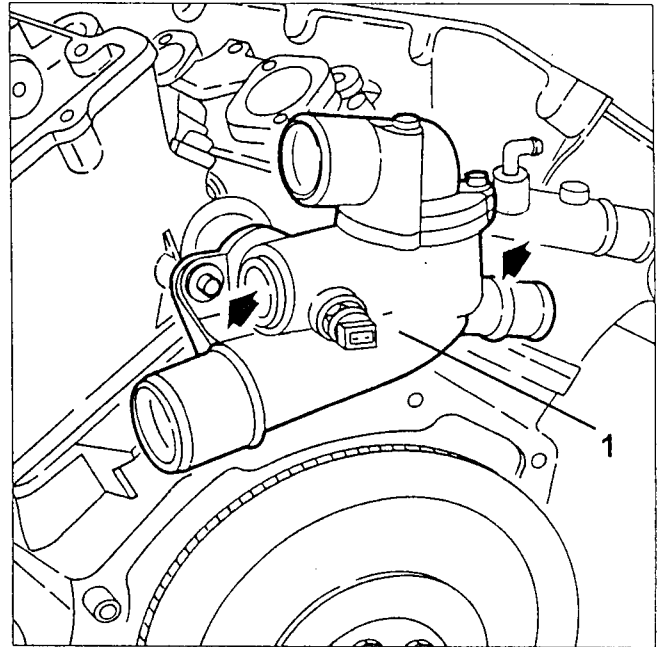
1. Loosen the fastening screws and remove the fuel distributor manifold and the injectors.



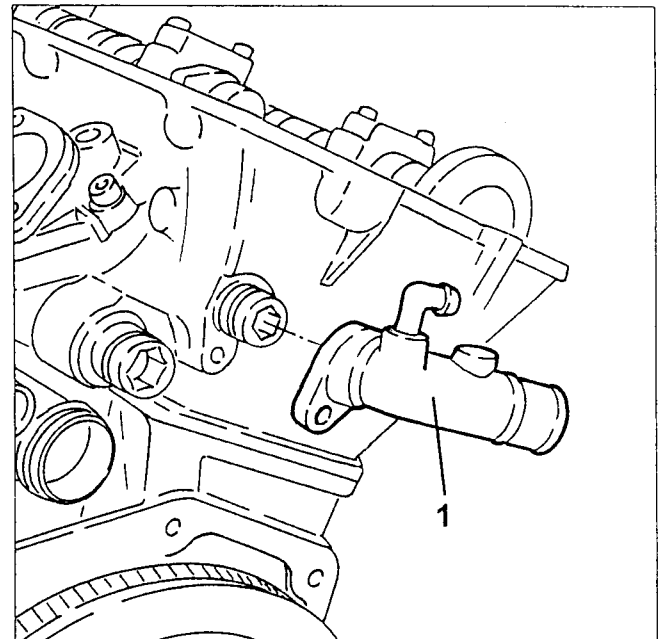
1. Remove the fastening screws and remove the rod and threaded nut to fasten the upper timing belt guard from the left-hand cylinder head.
2. Loosen the fastening screws and remove the cylinder head covers.



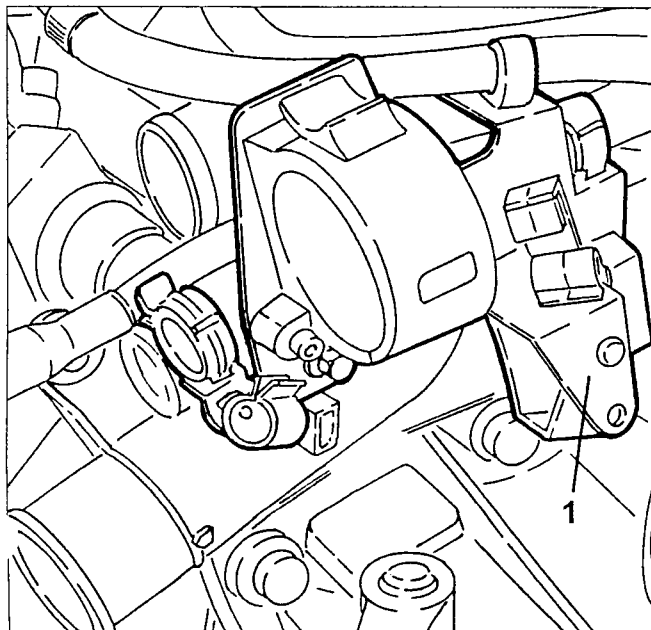
1. Loosen the fastening screws and remove the thermostat cup and coolant temperature sensor.



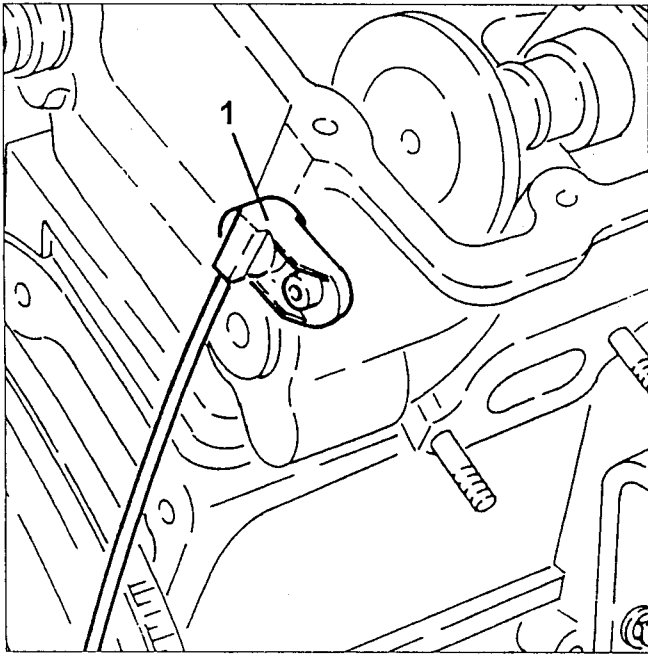
1. Remove the expansion reservoir and climate control heater coolant delivery duct.



1. Loosen the fasteners and remove the injection wiring joint support bracket.

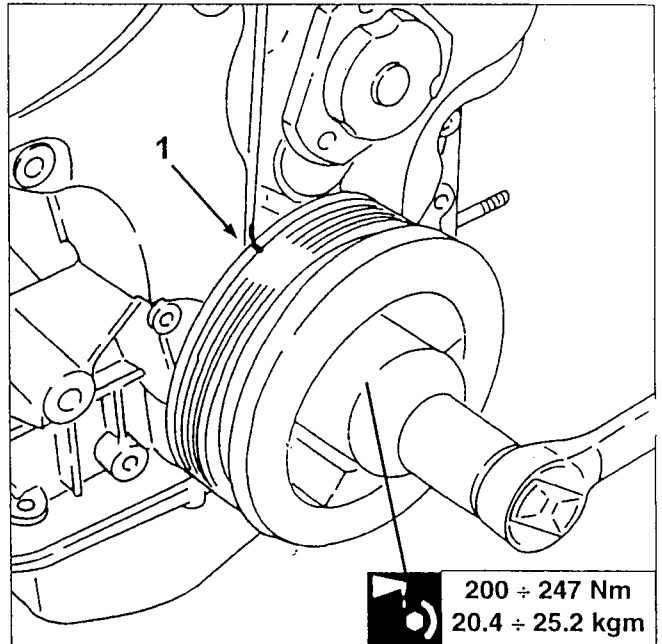


1. Loosen the fastening screw and remove the cam angle sensor.

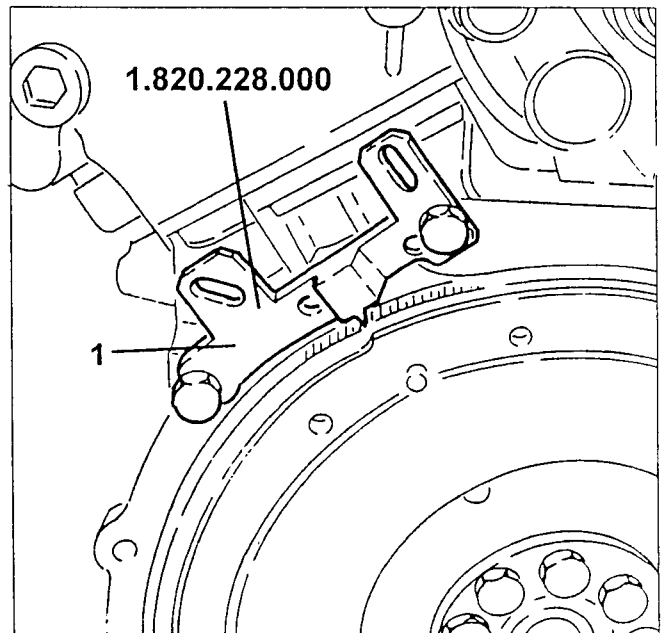


TIMING BELT REMOVAL

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.

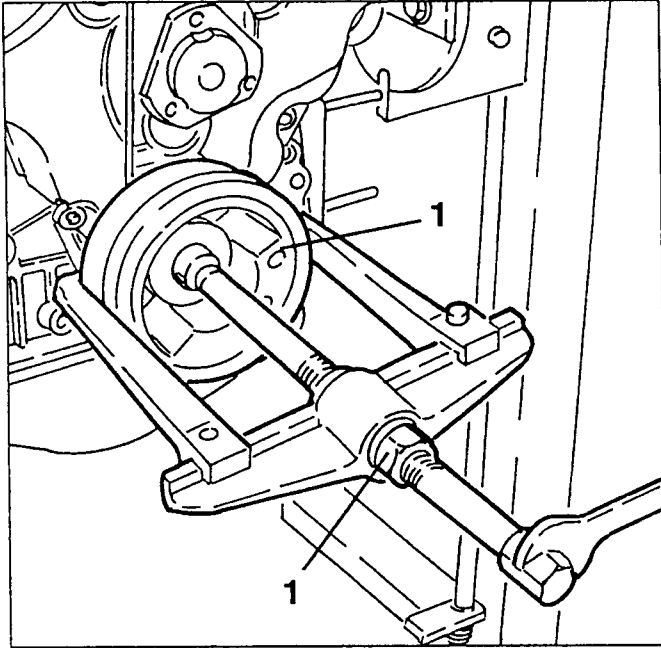


1. Fit the flywheel retainer tool no. 1.820.228.000 as shown in the figure.

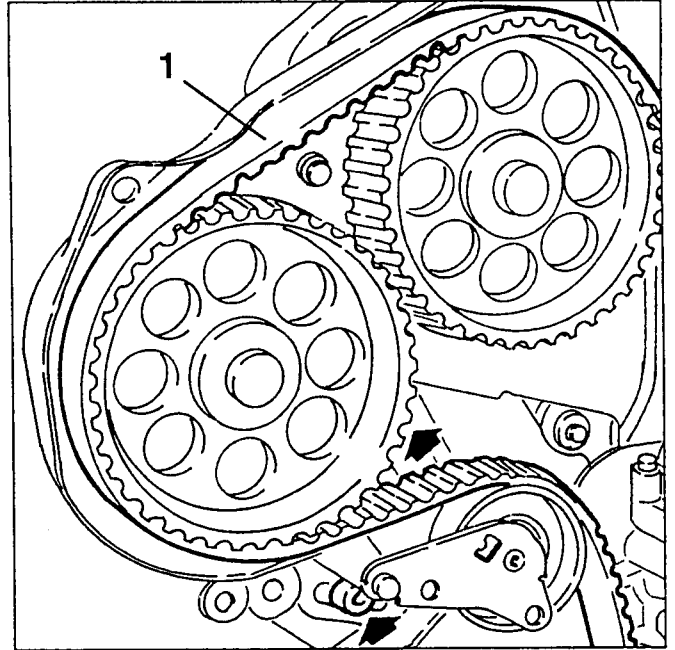


1. Slacken the fastening nuts and remove the auxiliary components drive pulley.

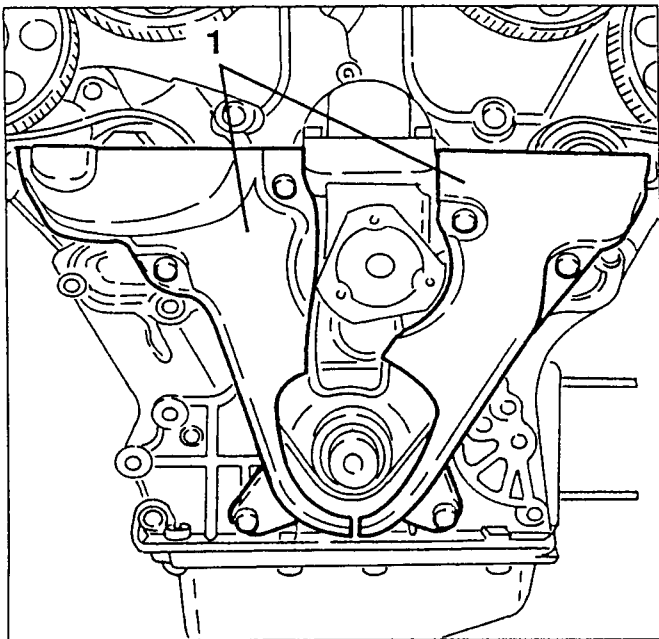
NOTE: If this operation proves to be difficult, use a universal puller tool.



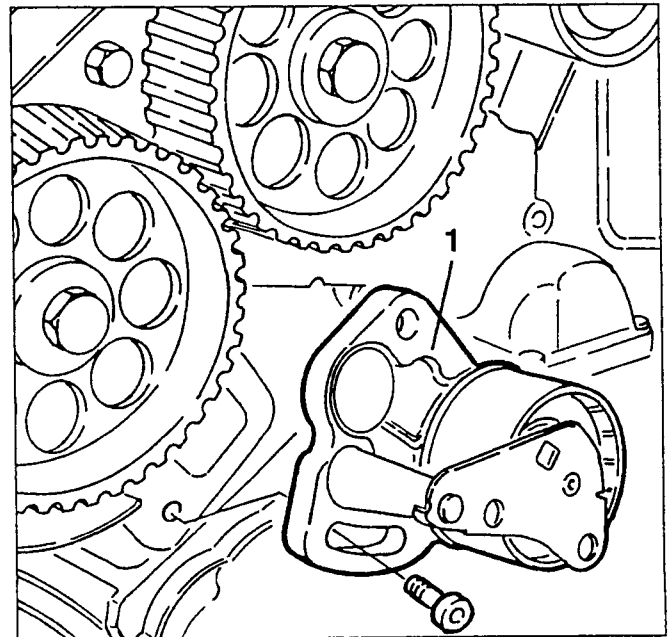
1. Slacken the belt tensioner fastening screws, then prise and remove the timing gear drive belt.



1. Slacken the fastening screws and remove the lower timing gear belt guards.

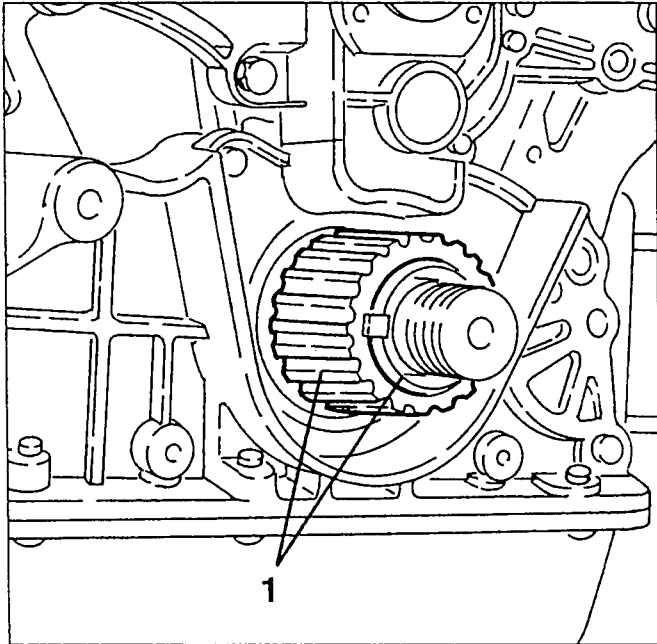


1. Slacken the fastening screws completely and remove the timing gear drive belt tensioner.



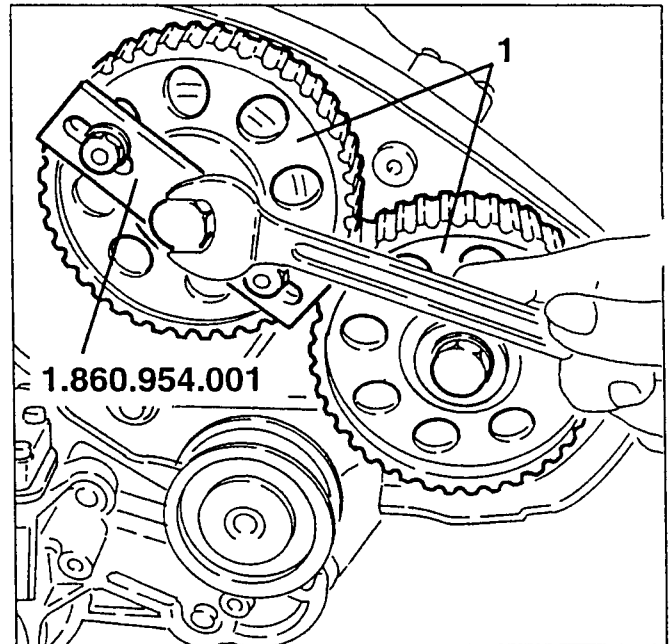
1. Withdraw the timing gear drive belt complete with thrust ring.

NOTE: When refitting, the convex surface of the thrust ring must be turned to the crankcase front cover.



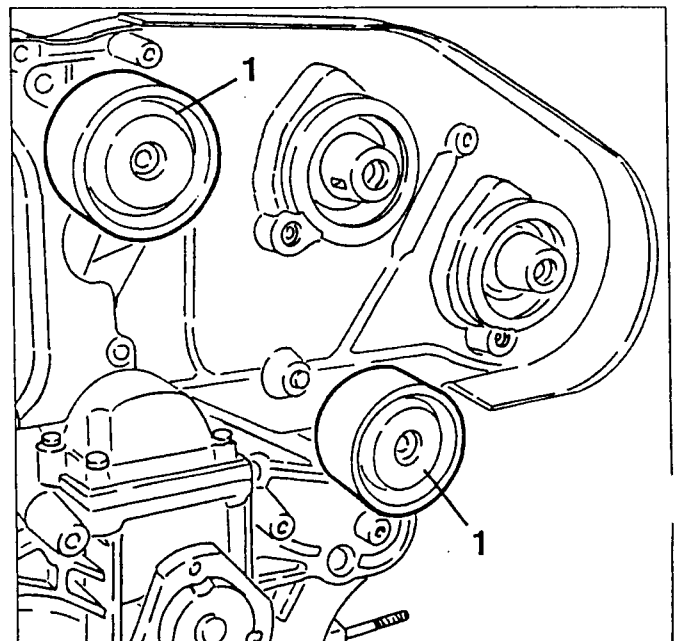
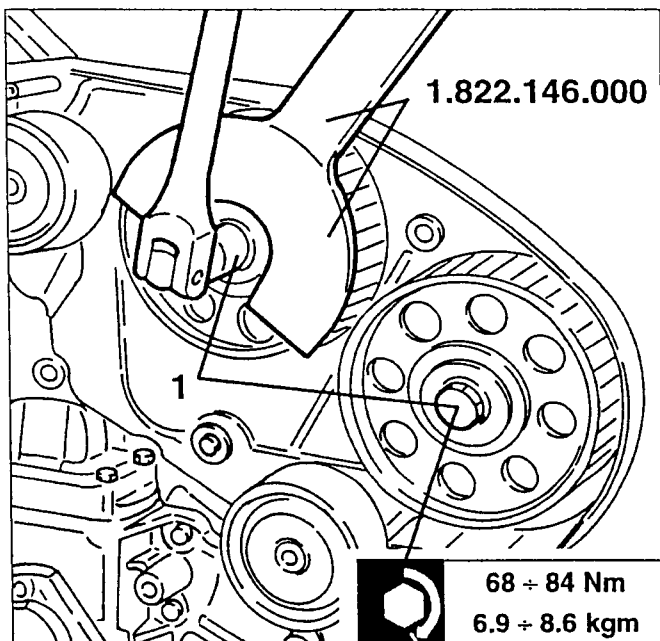
1. Remove the camshaft drive pulleys using puller tool no. 1.860.954.001.

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.

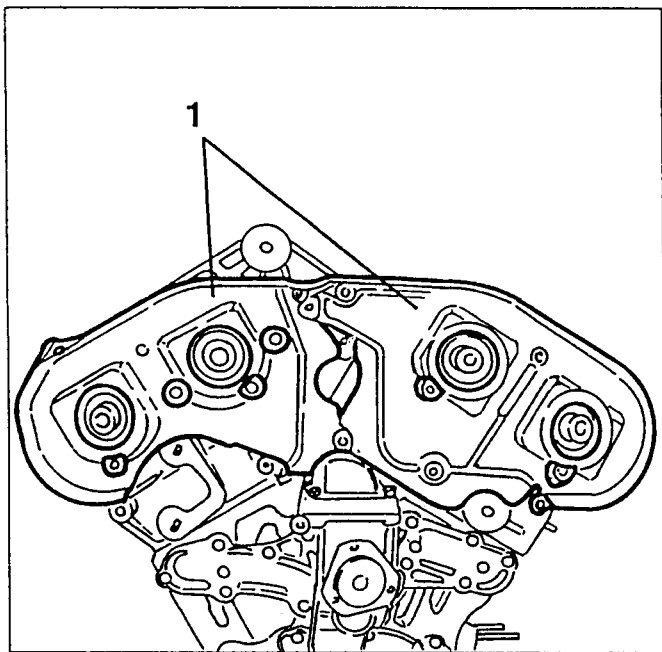


1. Slacken the fastening screws of the camshaft drive pulleys levering with tool no. 1.822.146.000.

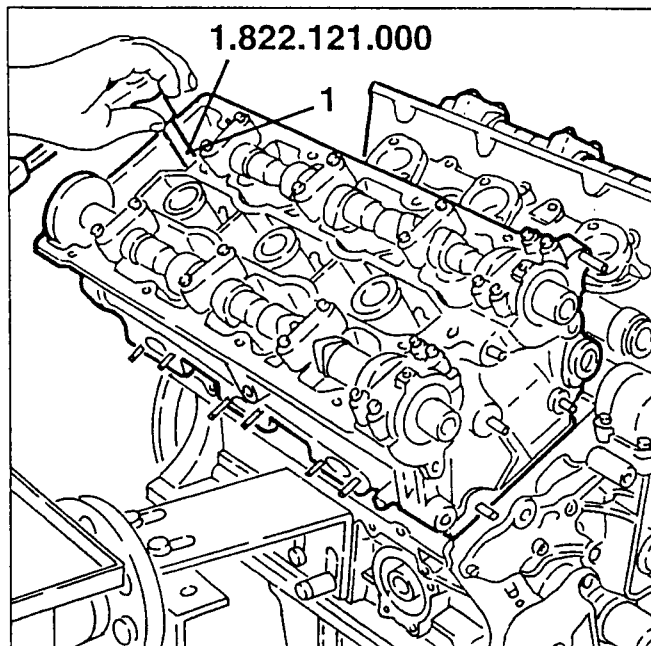
1. Slacken the fastening screws and remove the two fixed guide pulleys of the timing gear drive belt.



1. Slacken the fastening screws and remove the timing gear belt inner protections.

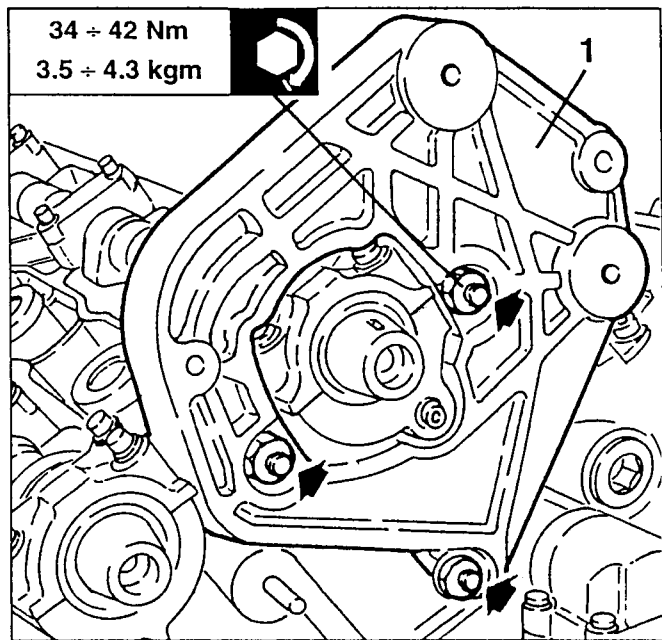


1. Using wrench no. 1.822.121.000 slacken the nuts fastening the cylinder heads and remove them.
- Remove the corresponding seals.

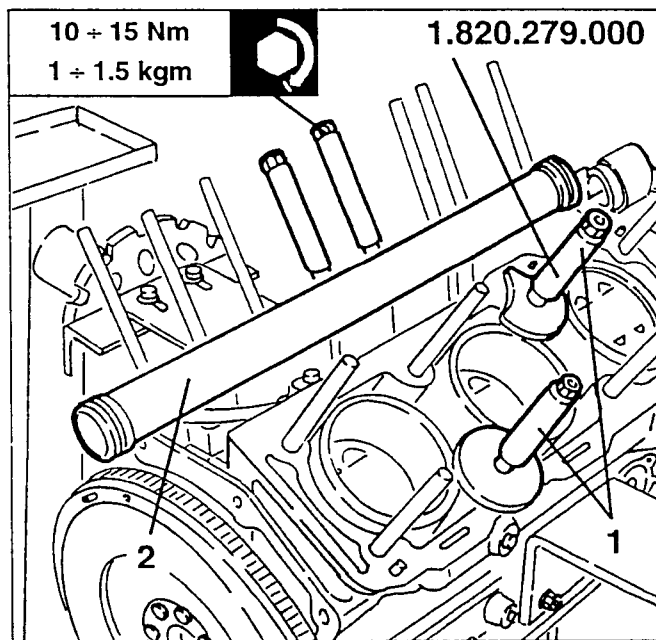


REMOVING THE CYLINDER HEADS

1. Slacken the fastening nuts and remove the engine stay rod support bracket.

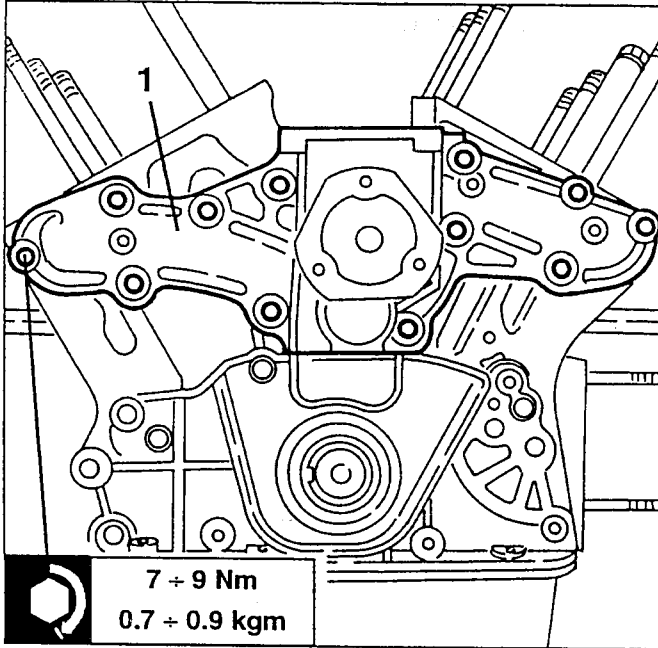


1. Install the liner stopper tools no. 1.820.279.000.
2. Withdraw the manifold for returning coolant fluid to the pump.



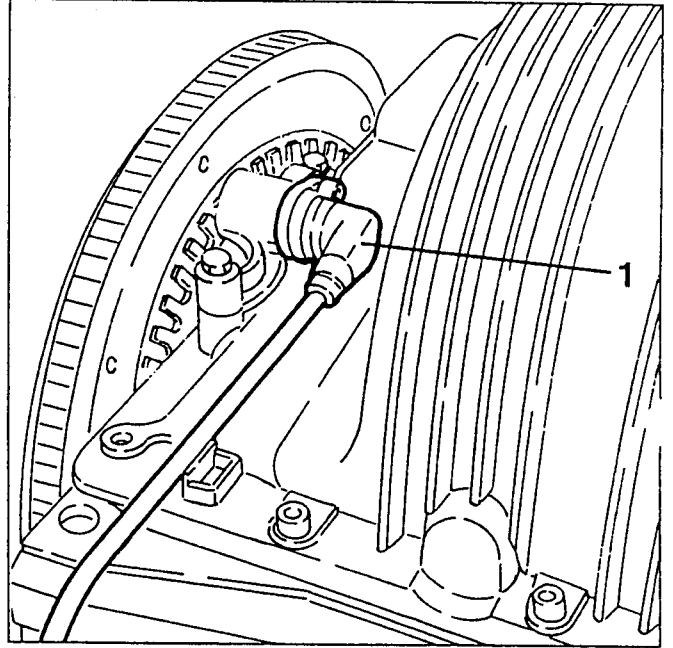
REMOVING THE WATER PUMP

1. Slacken the fastening screws and remove the water pump.
- Remove the corresponding seal.

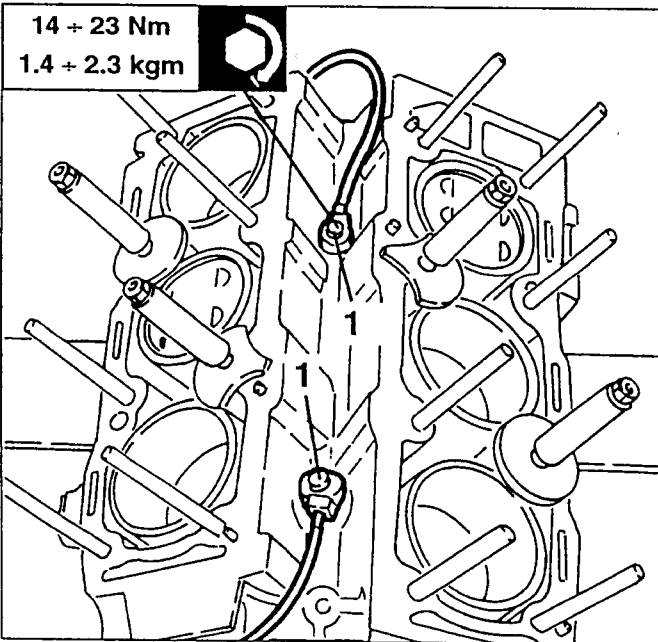


REMOVING THE OIL SUMP

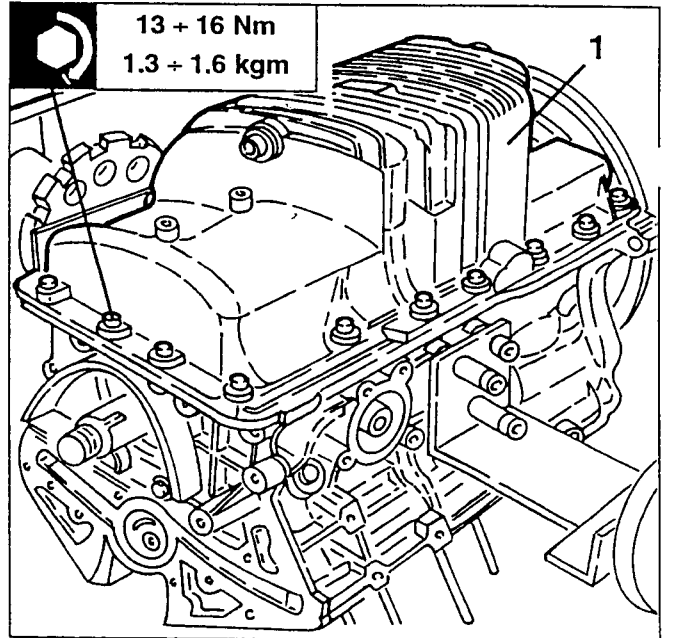
1. Turn the engine on the overhauling stand, slacken the fastening screw and remove the rpm and timing sensor.



1. Slacken the fastening screws and remove the two pinging sensors.

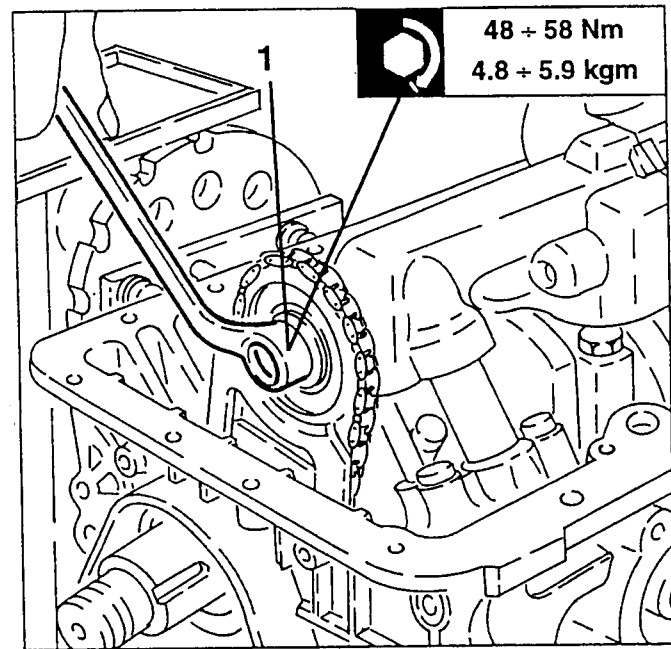


1. Slacken the fastening screws and remove the oil sump.

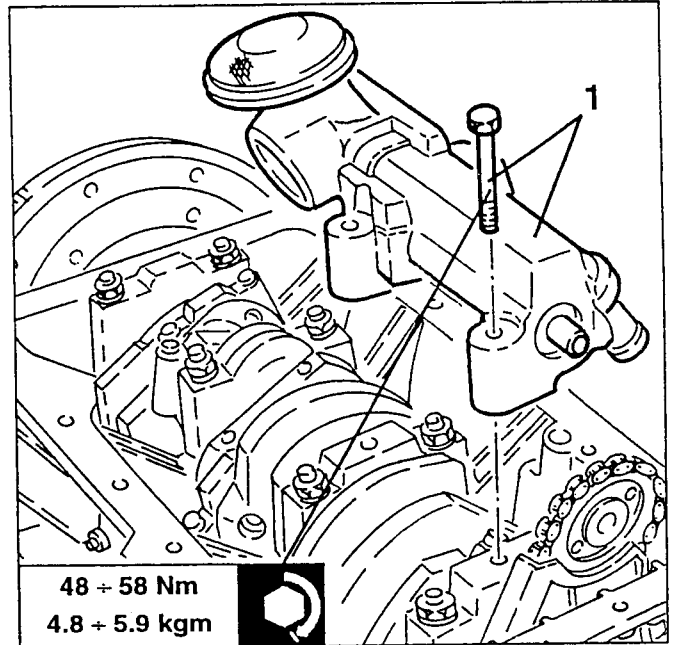


REMOVING THE OIL PUMP

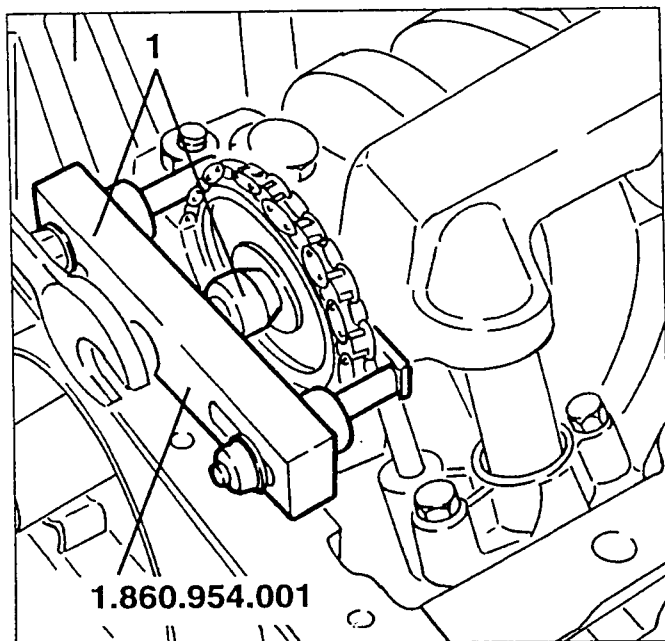
1. Using as stopper the flywheel stopper tool installed previously, slacken the screw fastening the oil pump drive gear.



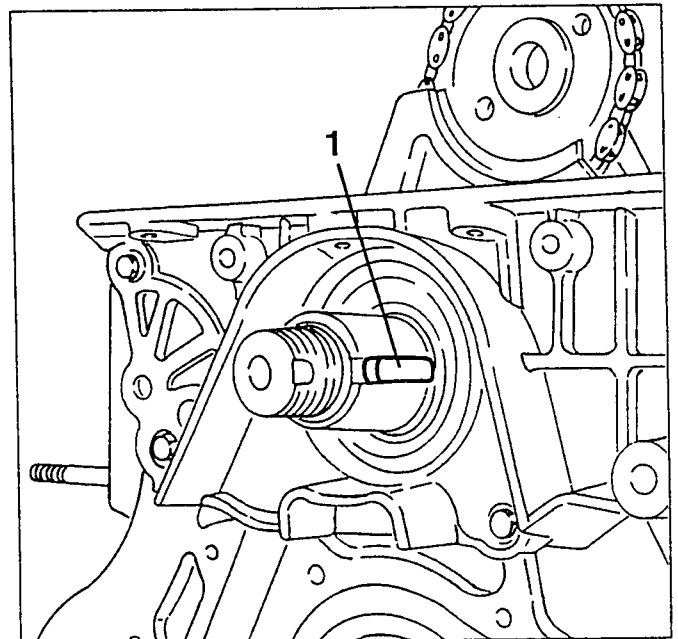
1. Slacken the fastening screws and remove the complete oil pump, freeing it from the drive gear.



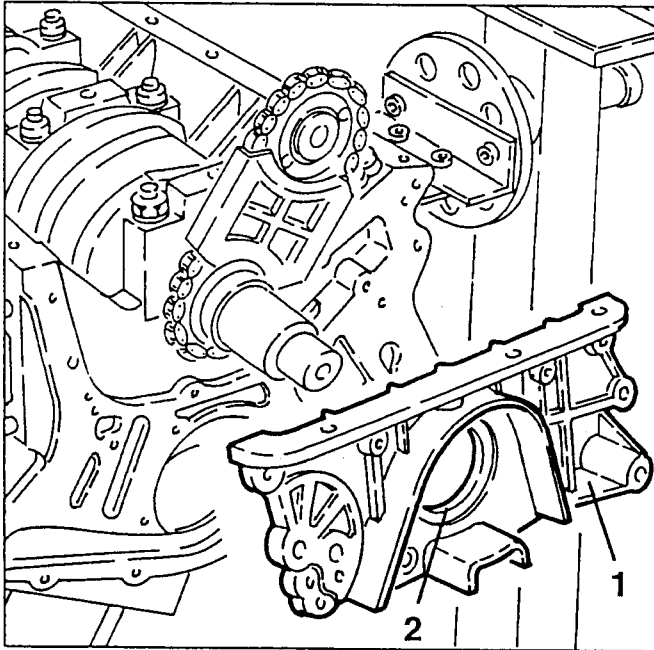
1. Using tool no. 1.860.954.001 remove the drive gear from the oil pump spindle.



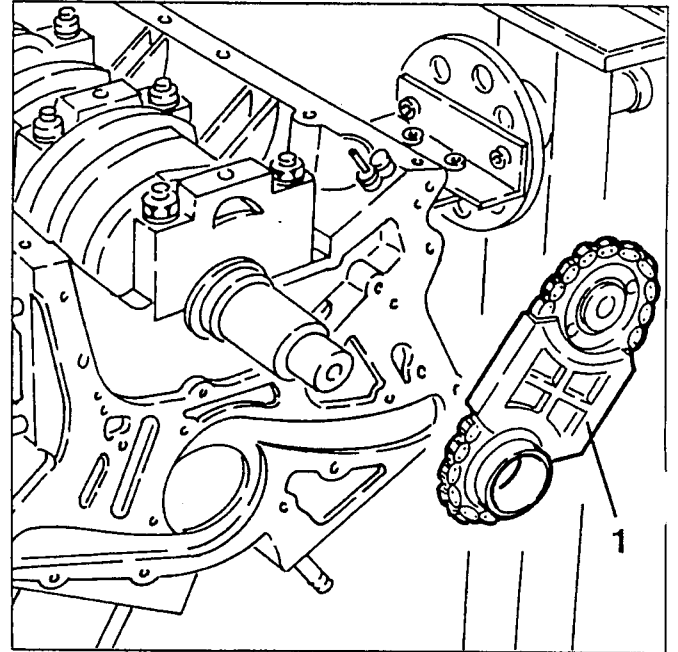
1. Remove the key for the timing gear belt drive pulley from the crankshaft using a flat punch.



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.

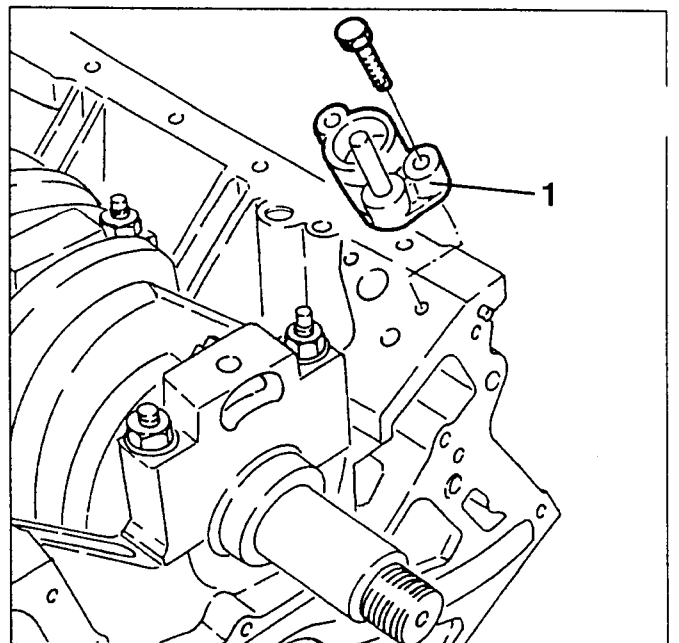
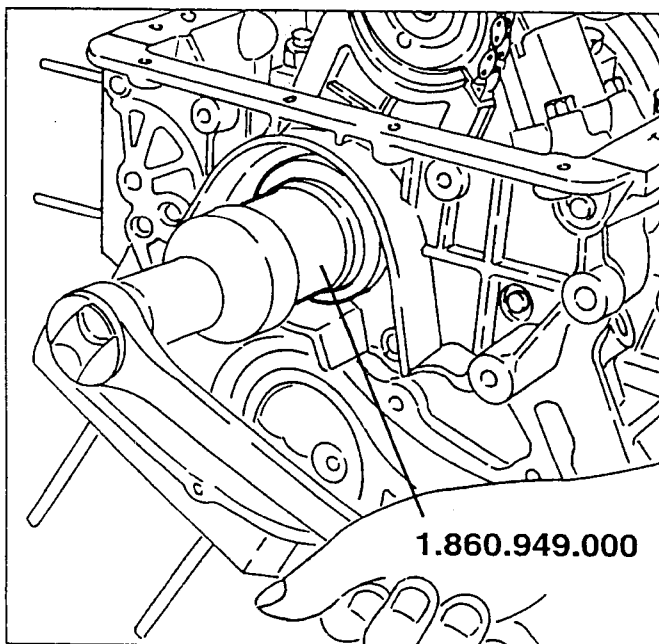


1. Withdraw and remove the oil pump drive chain/gears assembly.



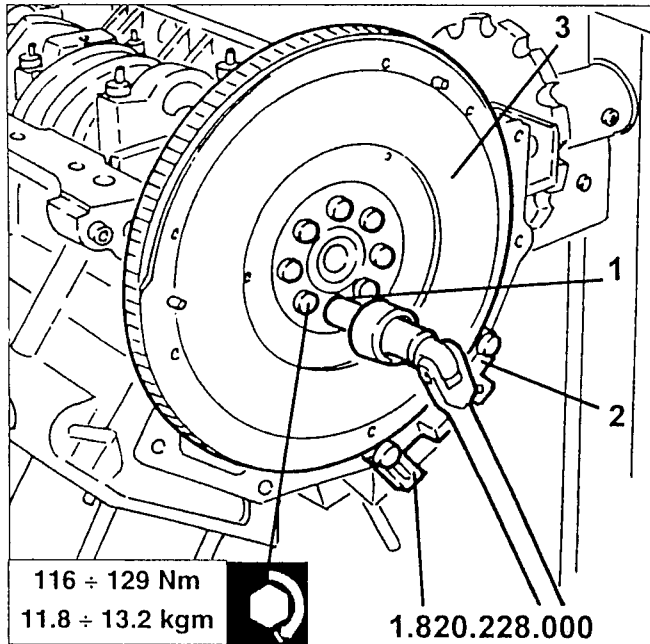
When refitting, insert a new front crankshaft oil seal, with the front cover fitted on the crankcase, using tool no. 1.860.949.000.

1. Slacken the fastening screws and remove the oil pump casing support from the crankcase.



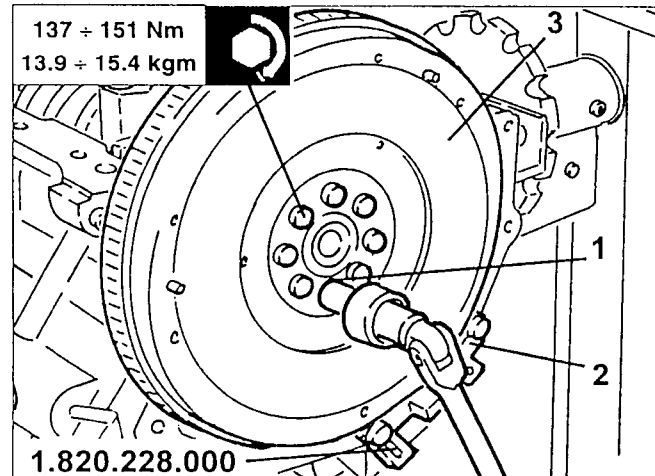
FLYWHEEL REMOVAL (pre-change solution)

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)

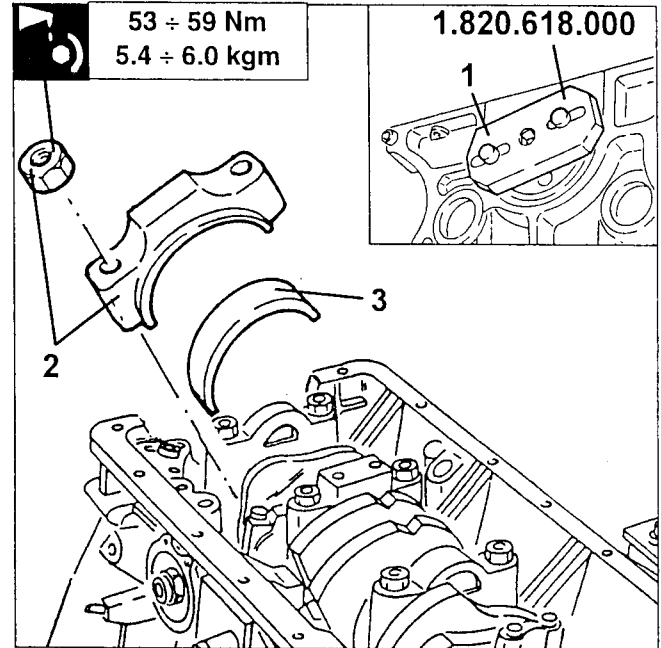
1. Loosen the flywheel screws.
 2. Remove the previously fitted flywheel retainer tool 1.820.228.000.
 3. Remove the fastening screws and remove the flywheel.
- Take the lock washer.



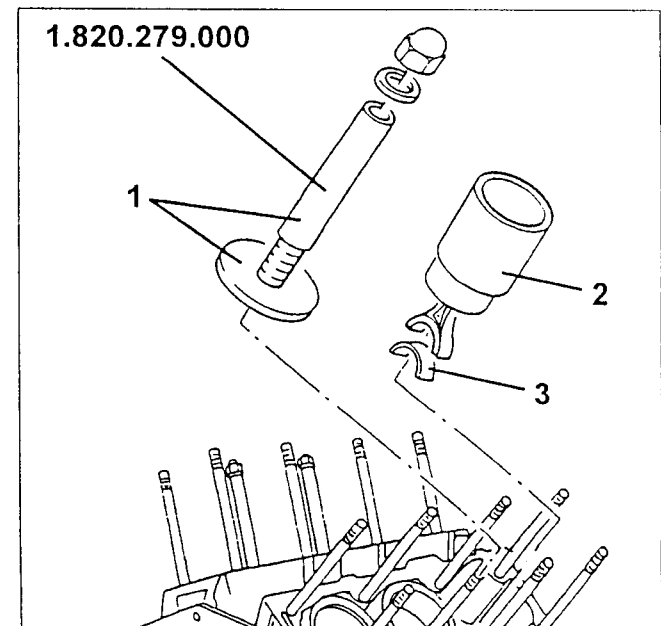
CYLINDER LINER AND PISTON REMOVAL

1. Fit tool no. 1.820.618.000 to rotate crankshaft.

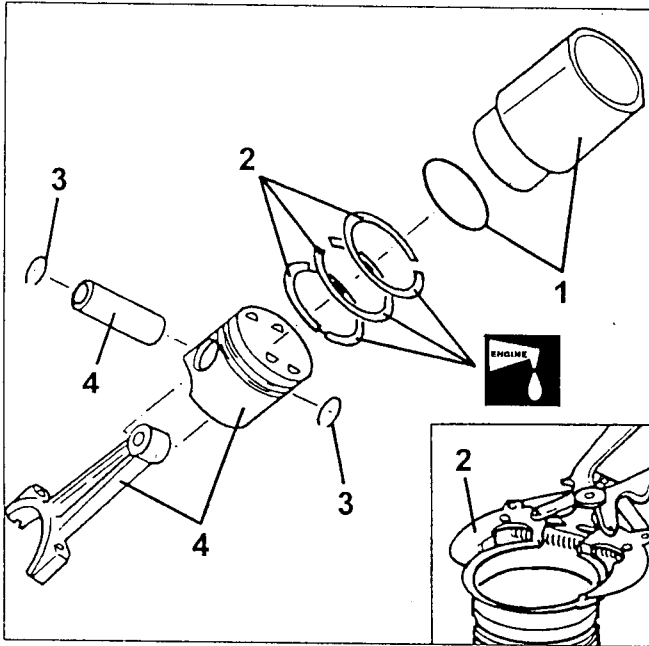
- Turn the crankshaft to access the right-hand bank connecting rod caps (cylinders 1, 2 and 3).
- 2. Loosen the fastening nuts and remove cylinder 1, 2 and 3 connecting rod caps.
- 3. Take the respective connecting rod half-bearings.



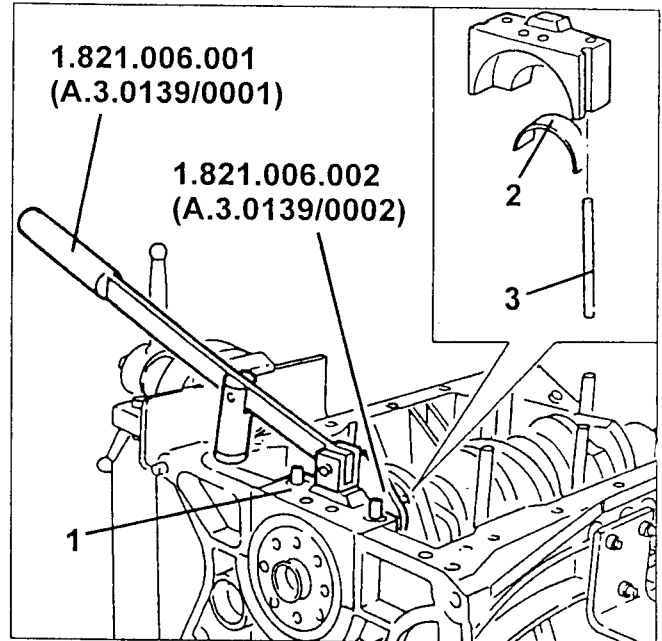
- Turn the engine on the overhaul stand.
 - 1. Loosen the fastening nuts and remove the liner retainer tool no. 1.820.279.000 from the right-hand bench only.
 - 2. Extract the connecting rod-piston assemblies from the crankcase. Remove the cylinder liners at the same time.
 - 3. Take the respective connecting 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).



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.

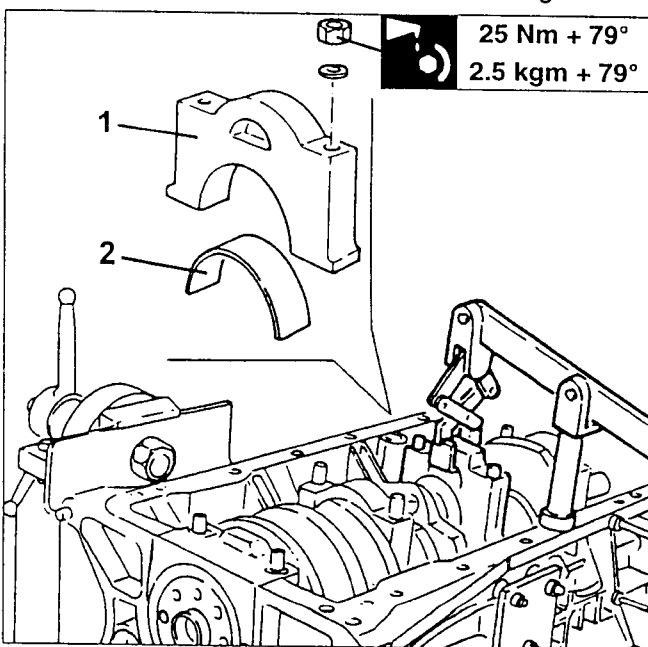


1. Remove the rear main bearing with lever no. 1.821.006.001 (A.3.0139/0001) and fork no. 1.821.006.002 (A.3.0139/0002).
2. Remove the respective main half-bearing.
3. Remove the seals.

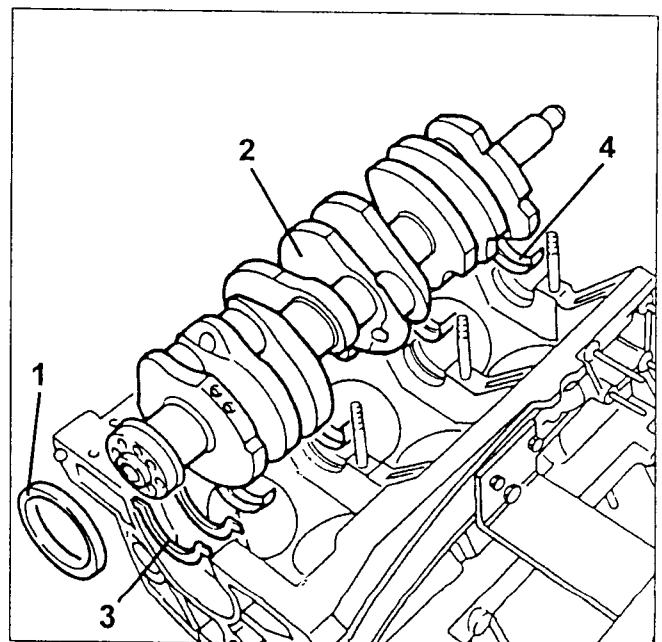


CRANKSHAFT REMOVAL

- 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

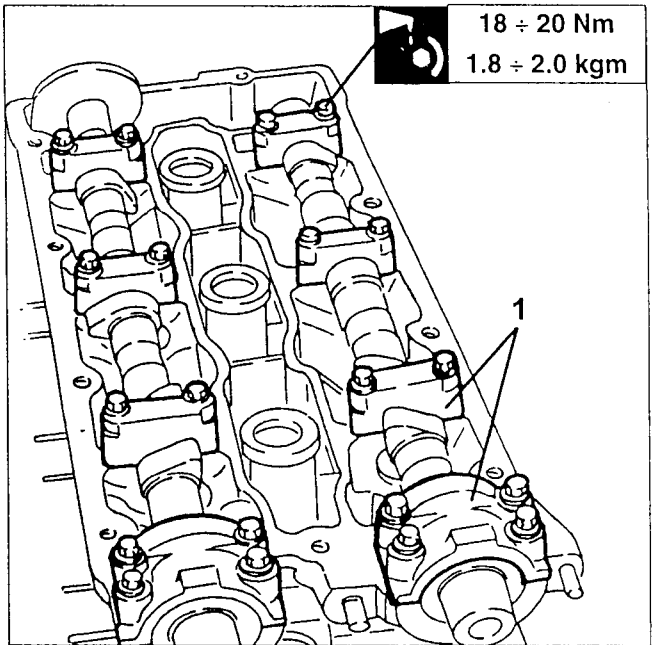
NOTE: The following removal operations refer to the right-hand cylinder head. Proceed in the same way for the left-hand cylinder head.

CAMSHAFT REMOVAL

1. Remove the fastening screws and remove the camshaft caps.

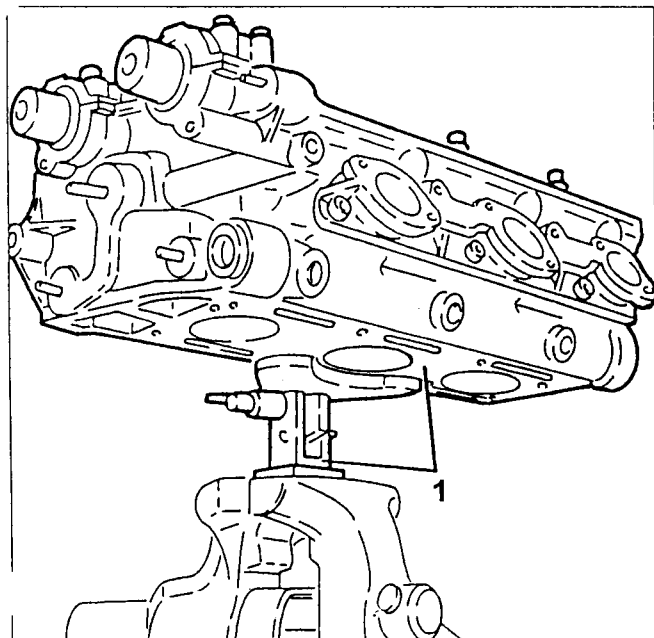
PRELIMINARY OPERATIONS

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 studs no. 1.860.952.000.

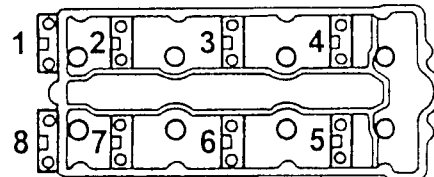
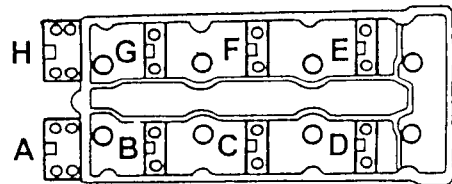


NOTE: The camshaft caps are progressively numbered (A, B, C, D, E, F, G and H from the right-hand cylinder head; 1, 2, 3, 4, 5, 6, 7 and 8 for the left-hand cylinder head) as shown in the figure.

Refit in the same order with the number facing the pulleys.

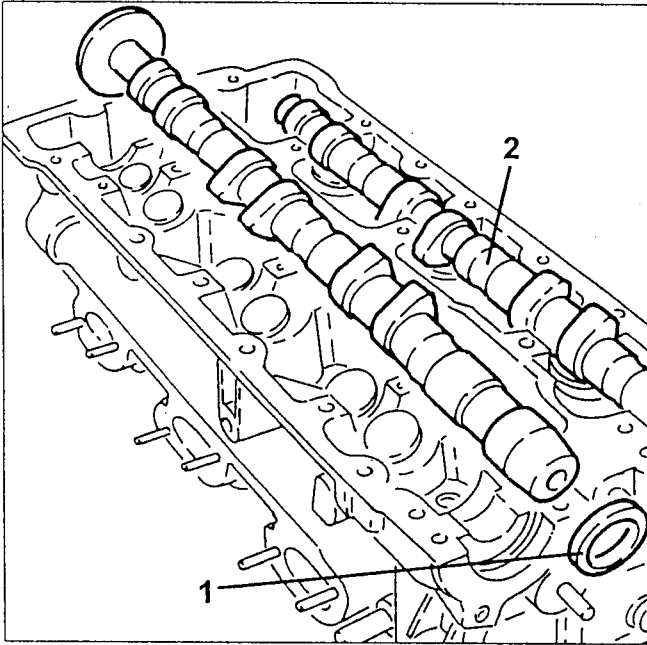


RIGHT-HAND HEAD



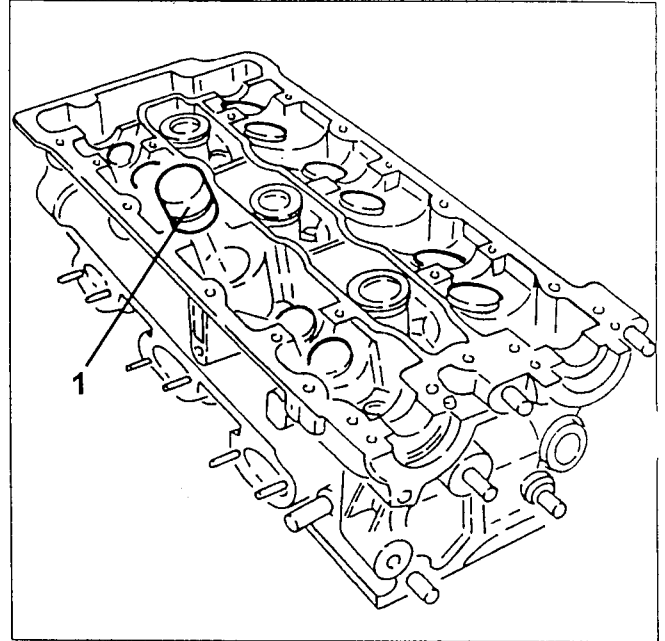
LEFT-HAND HEAD

1. Remove the camshaft oil seals.
2. Remove the camshafts.

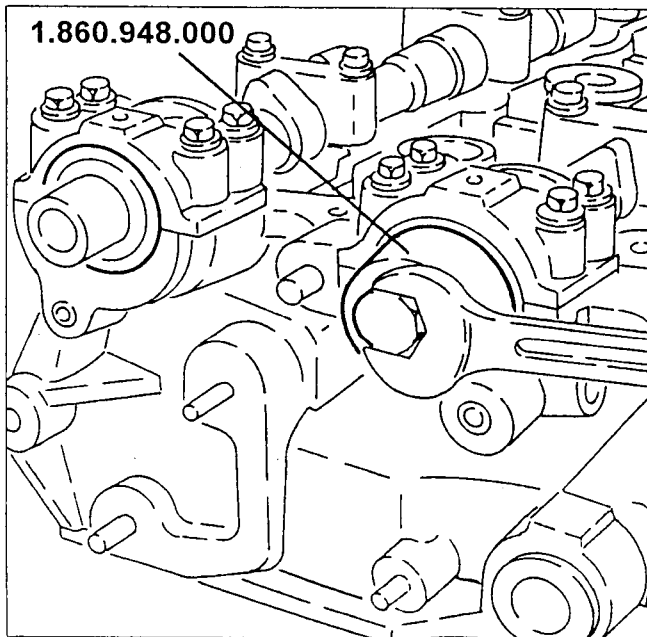


1. Remove the hydraulic tappets.

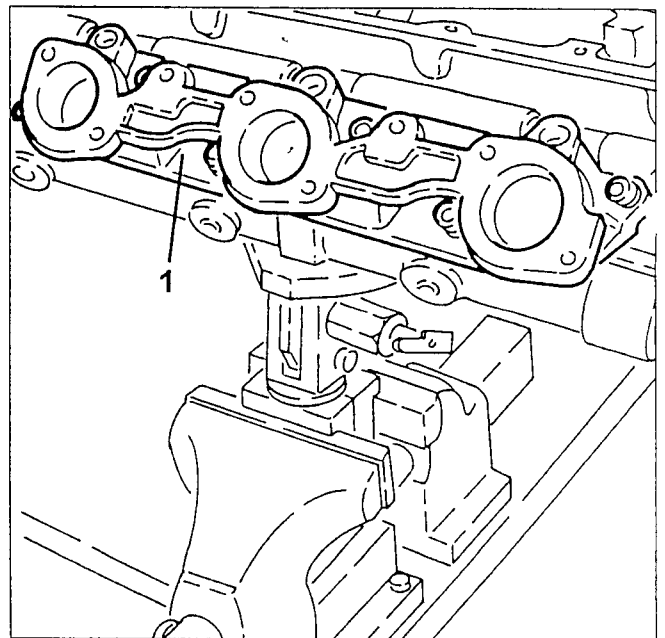
IMPORTANT: Place the tappets in a suitable container according to the removal sequence if they will be refitted.



When refitting, insert new camshaft oil seals with tool no. 1.860.948.000.



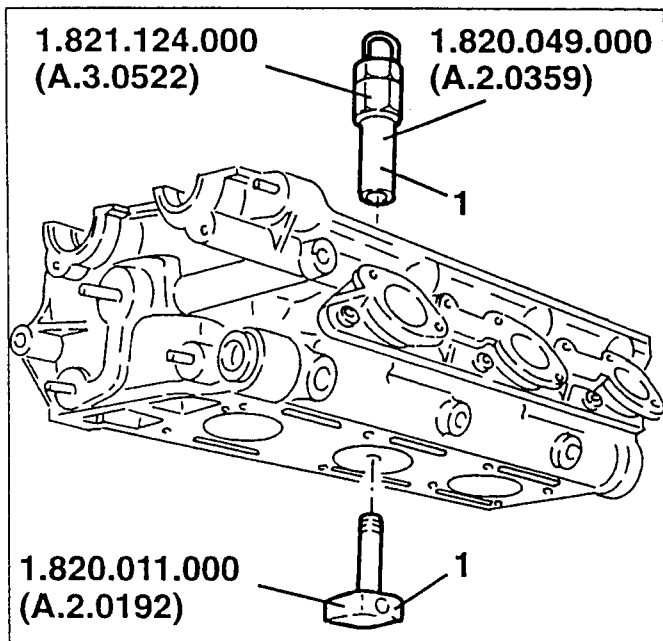
1. Remove the fastening screws and remove the air intake manifold.
- Remove the respective seal.



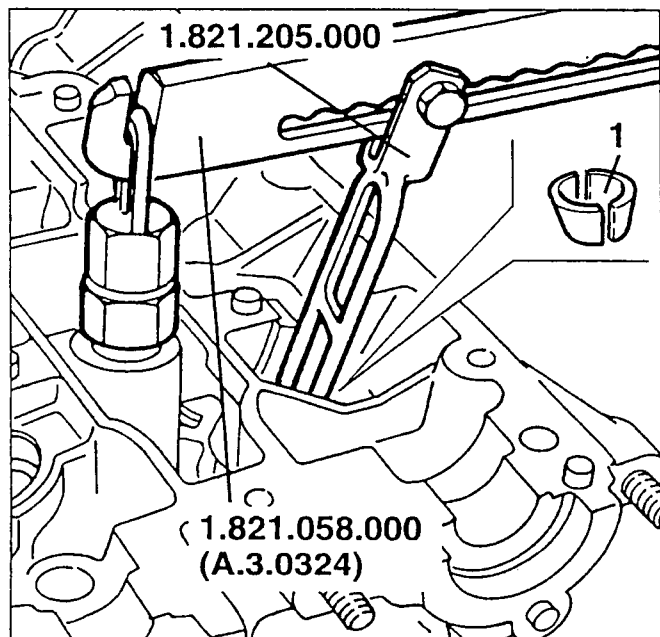
VALVE DISASSEMBLY

Work on the valves of each cylinder as described below.

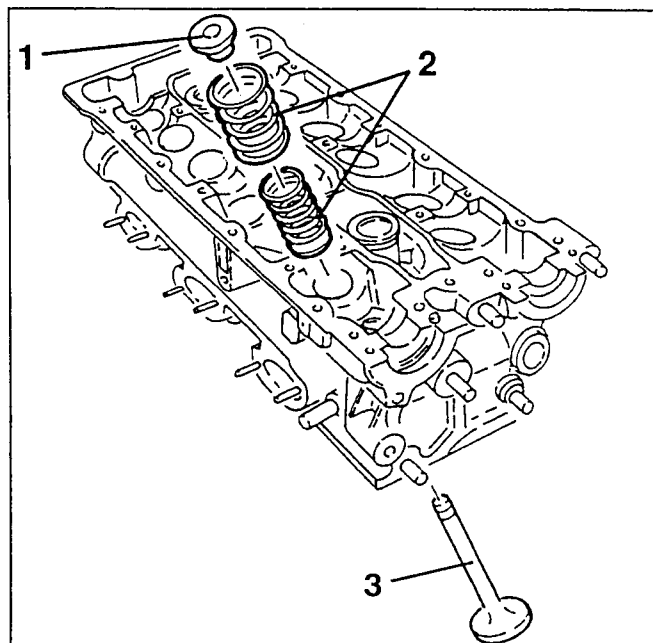
1. From the lower part of the spark plug hole insert tool no. 1.820.011.000 (A.2.0192) for supporting the valves and fasten it with the special nut no. 1.820.049.000 (A.2.0359) complete with support no. 1.821.124.000 (A.3.0522).



1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.205.000, remove the half cones.

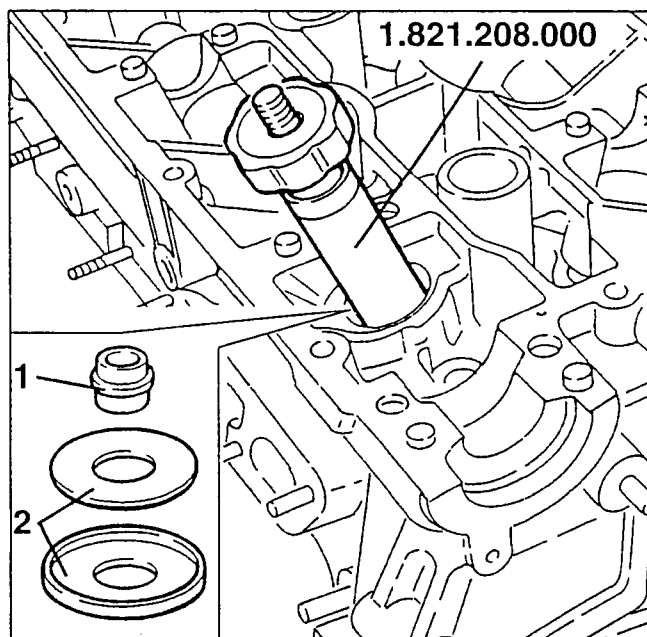


1. Remove the upper plates.
2. Remove the outer and inner springs.
3. Remove the tools used for removing the valves and withdraw the four valves.



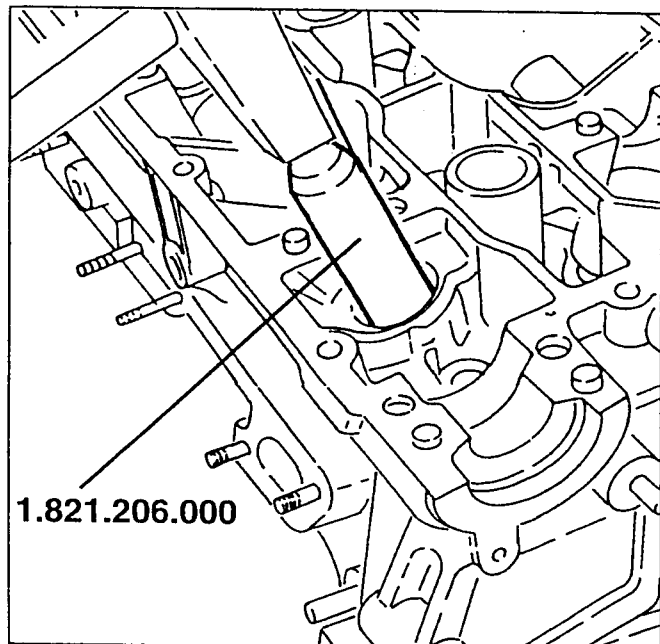
- Following the same procedure and using the usual tools, remove the valves of the remaining cylinders.

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

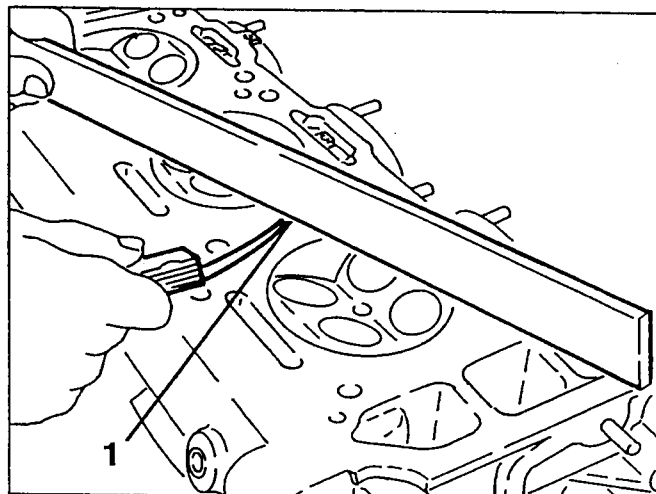
CHECKING THE LOWER SURFACE OF CYLINDER HEADS

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:

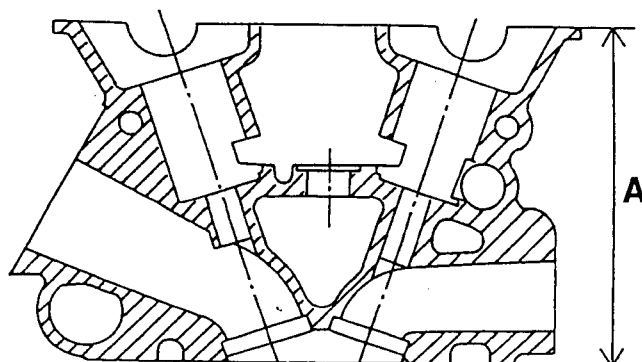
Refacing must be carried out on both cylinder heads.

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

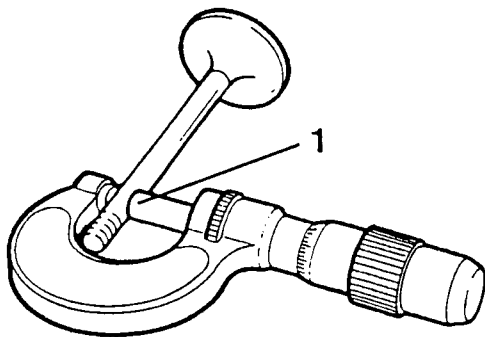
134.85 ÷ 135.15 mm



CHECKING THE CLEARANCE BETWEEN VALVE GUIDES AND STEMS

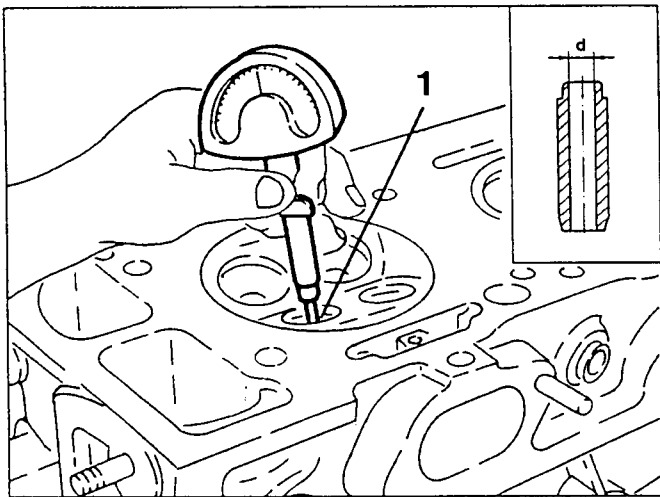
1. Measure the diameter of the valve stems and and check that it is within the specified limits.

| | | |
|---|----------------------------|------------------|
| ∅ | 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 | |

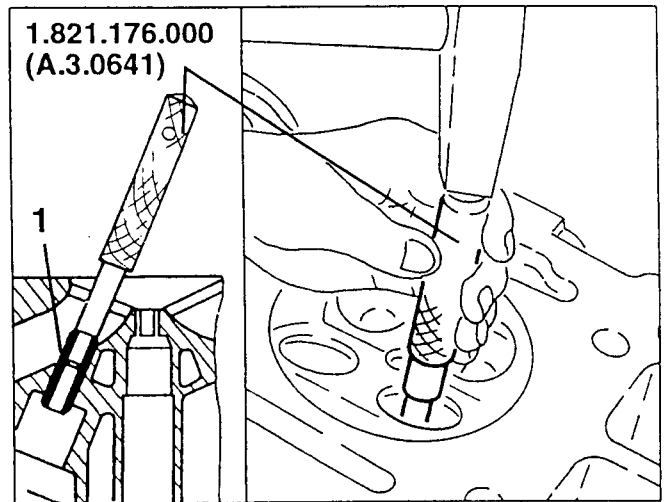


- Calculate the clearance between valve guide and stem and check that it is within the specified limits; if not replace the worn parts.

| | | |
|---|--|------------------|
| ↔ | 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.



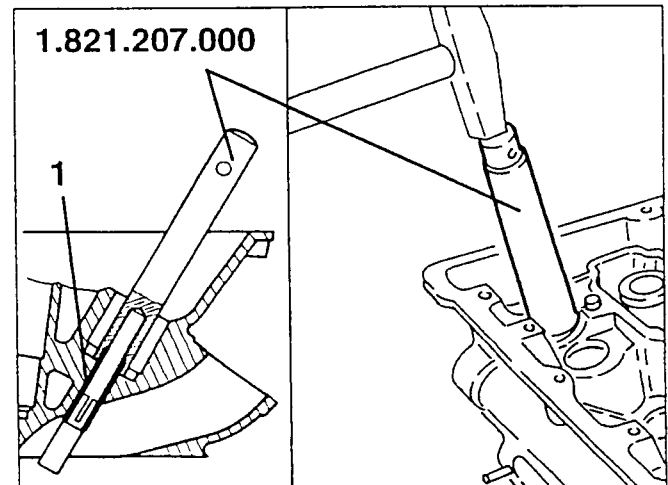
- Check that the valve guide outside diameter and the diameter of their housings on the cylinder heads are within the specified limits and that the assembly interference is correct.

| | | |
|---|----------------------------------|--|
| ∅ | 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 |

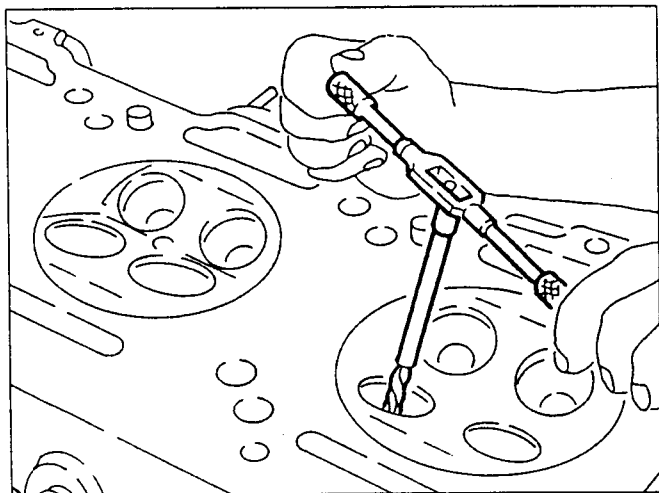
| | | |
|---|--------------------------------------|------------------|
| ← | Seat-valve guide interference | |
| | Intake | 0.022 ÷ 0.051 mm |
| | Exhaust | 0.032 ÷ 0.068 mm |

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.

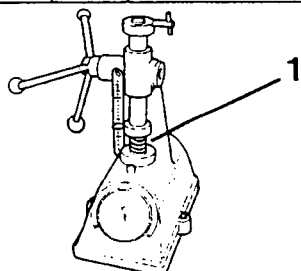
NOTE: The rest planes must be parallel with one another and at right angles to the axis of the spring with a maximum error of 2°.

| | | |
|--|-------------------------------------|---------|
| | 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) |

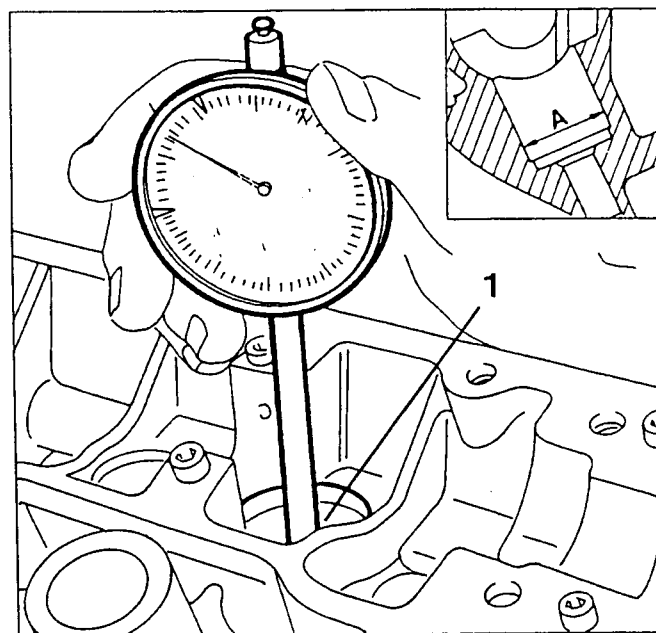
| Inside spring | | | |
|----------------------|------|-----------|---------------|
| Spring length | (mm) | Test load | N (Kg) |
| With valve closed | 30.5 | 133 ÷ 141 | (13.6 ÷ 14.4) |
| With valve open | 20.9 | 313 ÷ 330 | (31.9 ÷ 33.7) |



CHECKING THE CLEARANCE BETWEEN HYDRAULIC TAPPETS AND THEIR SEATS

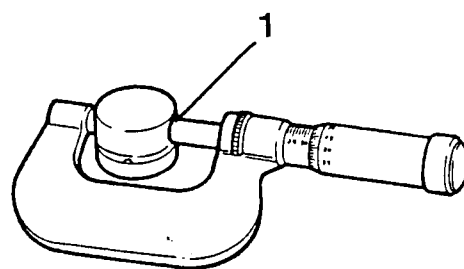
1. Check that the diameter of the hydraulic tappet seats is within the specified limits.

| | | |
|---|---|--|
| ∅ | 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 | |




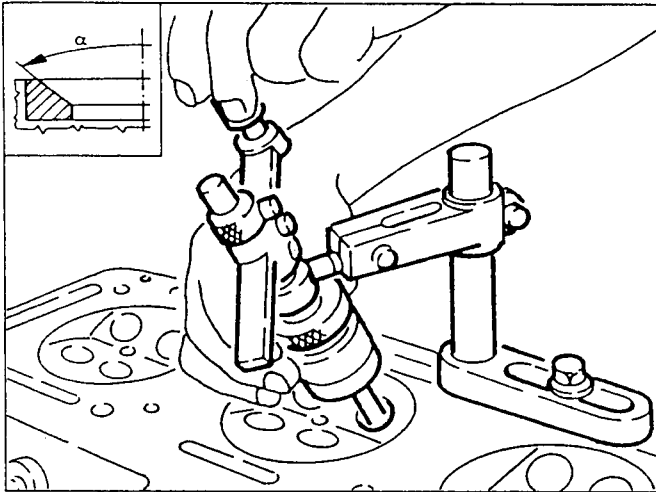
- Calculate the clearance between the hydraulic tappets and their seats checking that it is within the specified limits.

| | | |
|---|--|--|
| ↔ | Clearance between hydraulic tappets and their seats | |
| | 0.025 + 0.066 mm | |

VALVE SEAT TURNING

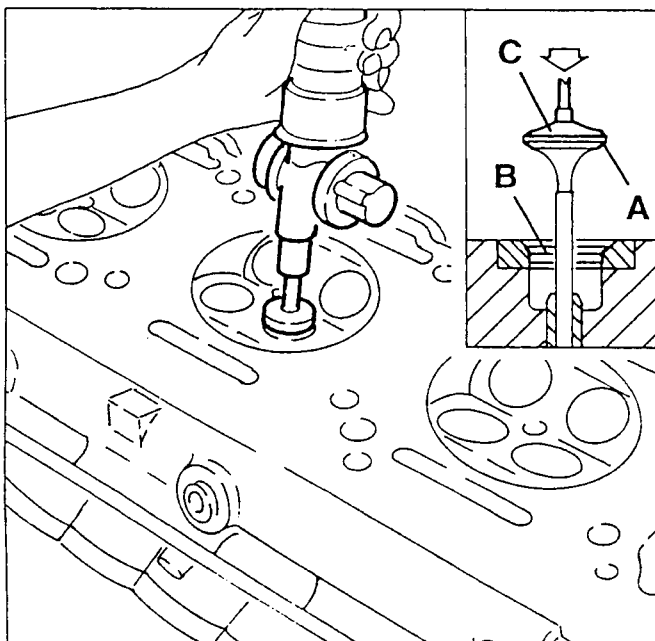
- If necessary, turn the valve seats using suitable equipment.

| | |
|---|-----------------------------|
|  | Valve seat taper "α" |
| | $90^\circ \pm 20'$ |



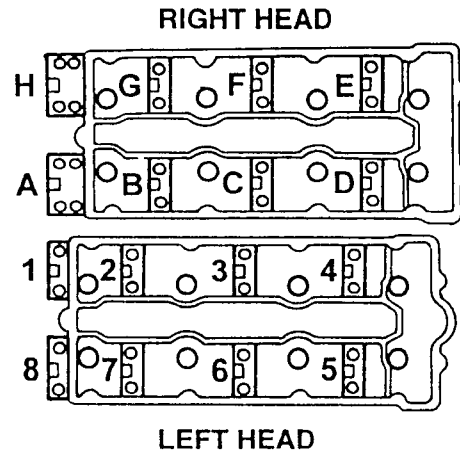
- After machining, grind each valve in its seat as follows:

- 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.




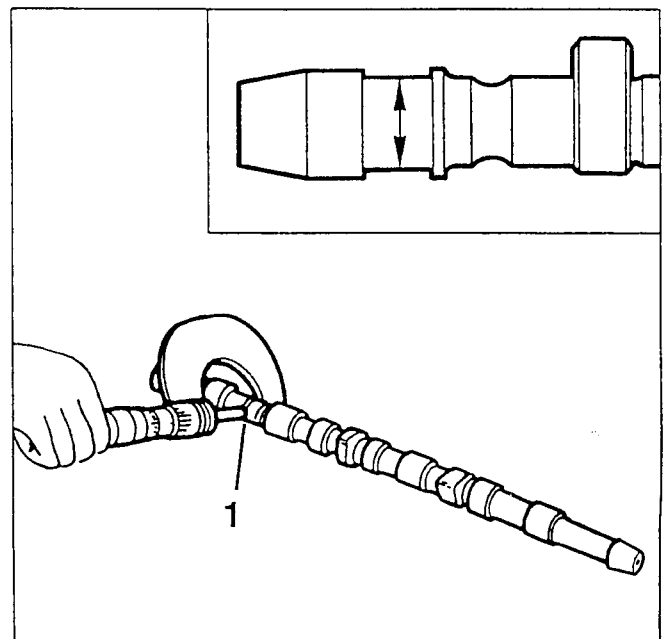
CAMSHAFTS AND BEARINGS

- Assemble the camshaft caps according to the numbers on them and tighten the fastening screws to the specified torque.



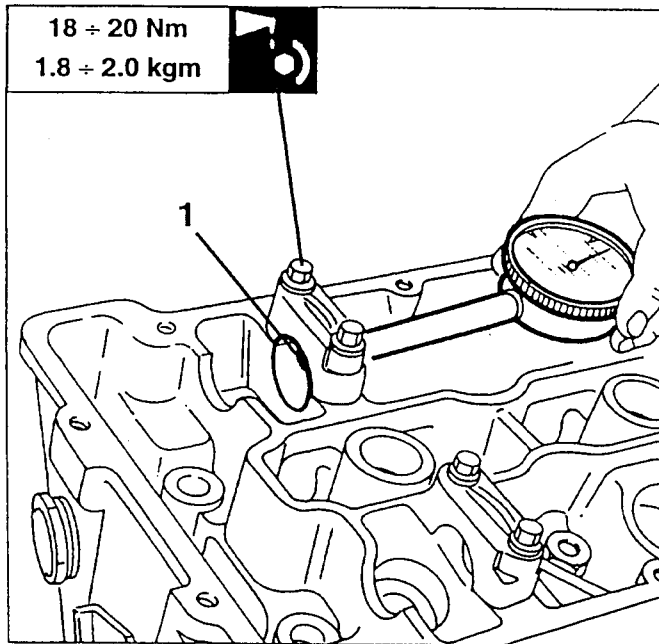
1. Check that the diameter of the camshaft pins is within the specified limits.

| | |
|---|--------------------------------------|
|  | Diameter of the camshaft pins |
| | $26.959 \div 26.980 \text{ mm}$ |



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

| | | |
|---|--------------------------------------|--|
| ∅ | Diameter of camshaft supports | |
| | 27.000 ÷ 27.033 mm | |

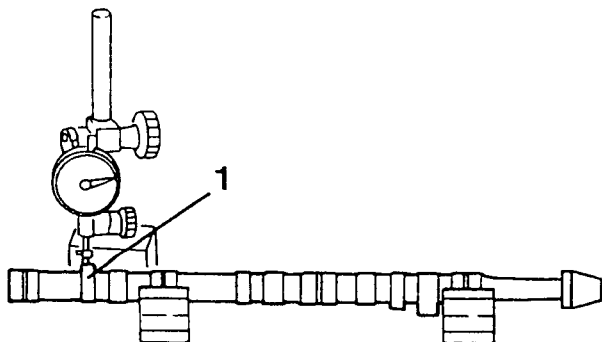


- Calculate the clearance between the camshaft pins and their supports checking that it is within the specified limits.

| | | |
|---|---|--|
| ↔ | 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 |

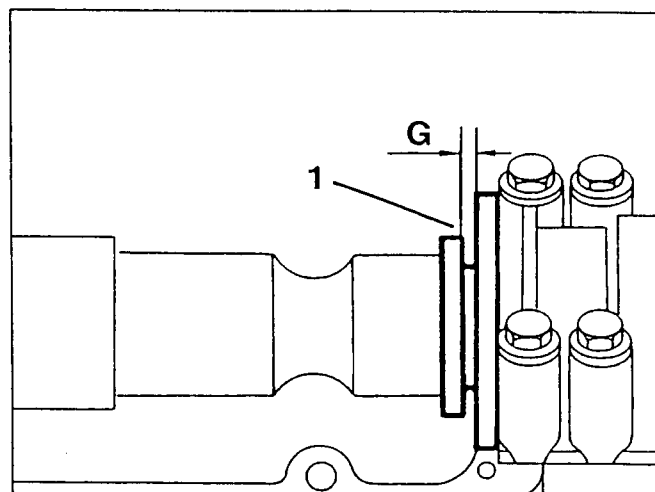


CHECKING THE CAMSHAFT END FLOAT

- 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

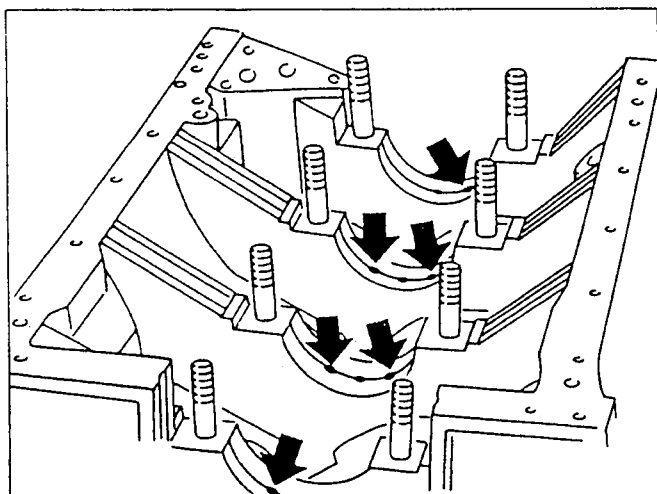
The crankcase has six oil jets, positioned as illustrated and supplied directly by the lubricating grooves of the main bearings.

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 |



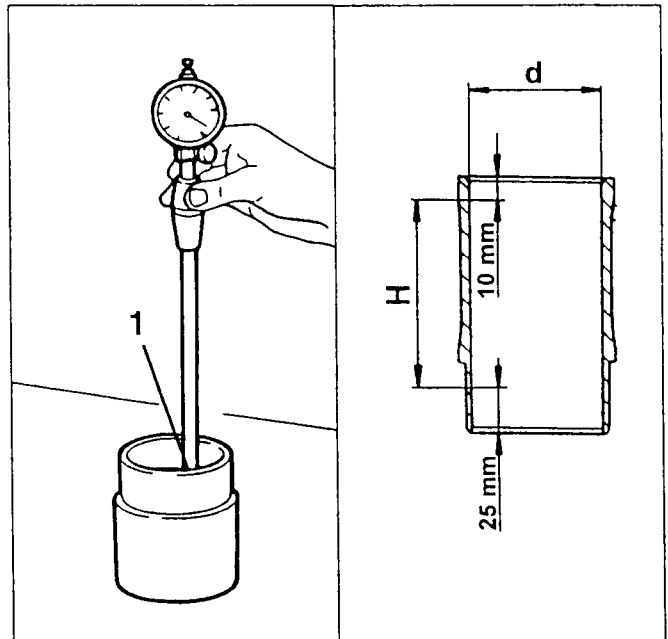
CHECKING THE CYLINDER LINERS

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

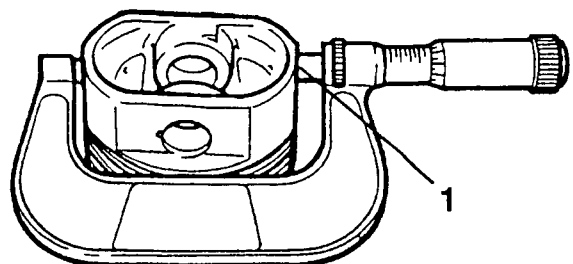
CHECKING PISTONS

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.

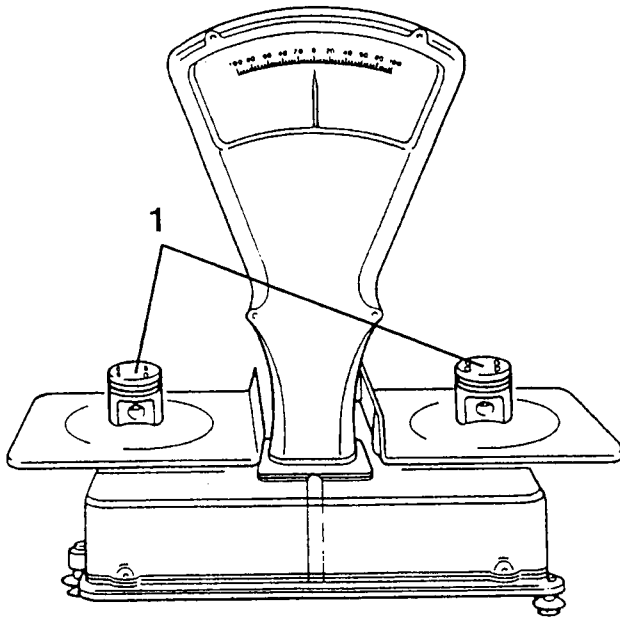


| | |
|--|--|
| Piston - cylinder liner clearance | |
| 0.059 ÷ 0.060 mm | |

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 | |

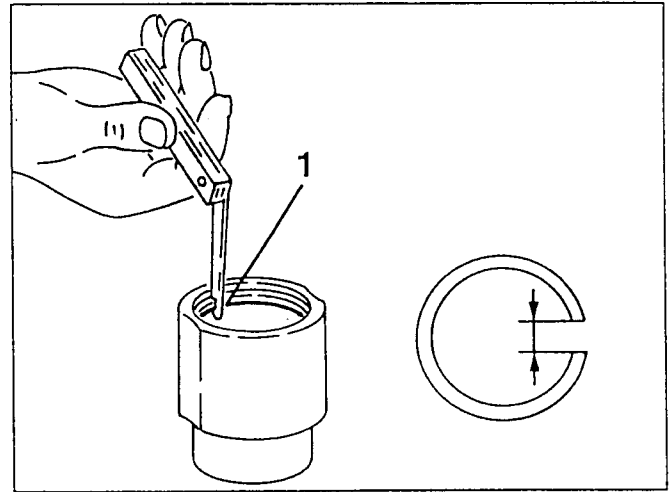


CHECKING THE SEAL RING GAP

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 |

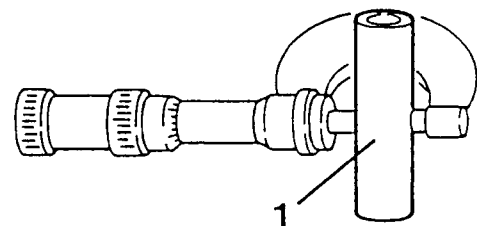


CHECKING THE CLEARANCE BETWEEN GUDGEON PINS AND SEATS ON PISTONS

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



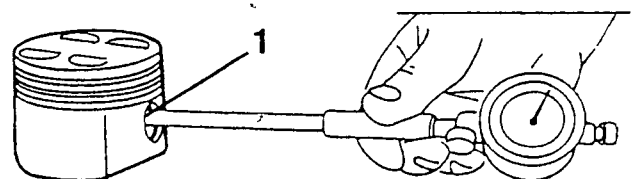
| | |
|---|--------------------|
| Outside diameter of gudgeon pins | |
| Class A (Black) | 21.994 ÷ 21.997 mm |
| Class B (White) | 21.997 ÷ 22.000 mm |



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.



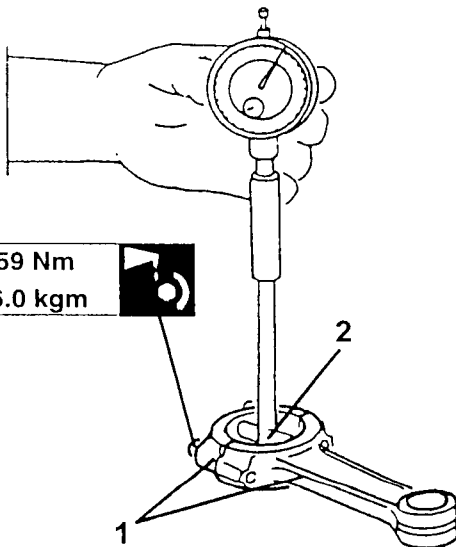
| | |
|---|--|
| Play between pins and piston seats | |
| 0.006 ÷ 0.012 mm | |

PLAY BETWEEN CONNECTING ROD JOURNAL AND RESPECTIVE HALF-BEARINGS

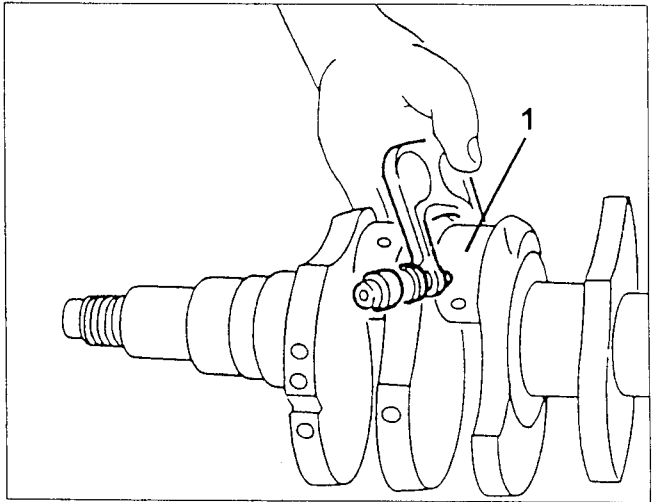
1. Fit the connecting rod half-bearings in the connecting rod big end and on the respective cap. Then assemble, fastening the screws at the prescribed torque.
2. Measure the connecting rod big end internal diameter and check whether it falls within the prescribed values.



| | |
|--|--------------------|
| 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



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.

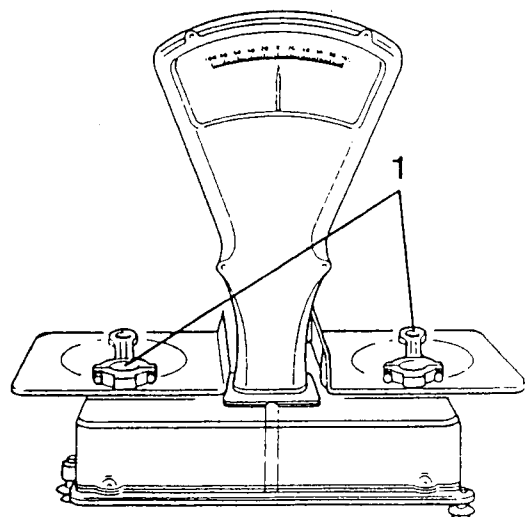


| | |
|---|--|
| Connecting rod weight difference | |
| ≤ 2 g | |

1. Measure the connecting rod journal diameter and check whether it falls within the prescribed values.

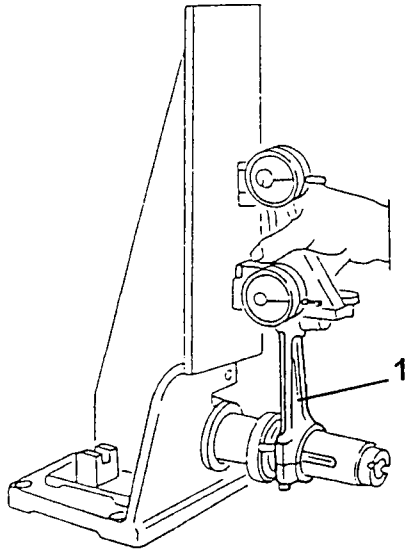


| | |
|--|--------------------|
| Connecting rod journal diameter | |
| Class A (Red) | 51.990 ÷ 52.000 mm |
| Class B (Blue) | 51.980 ÷ 51.990 mm |



1. Check connecting rod squaring with a reference as shown in the figure.

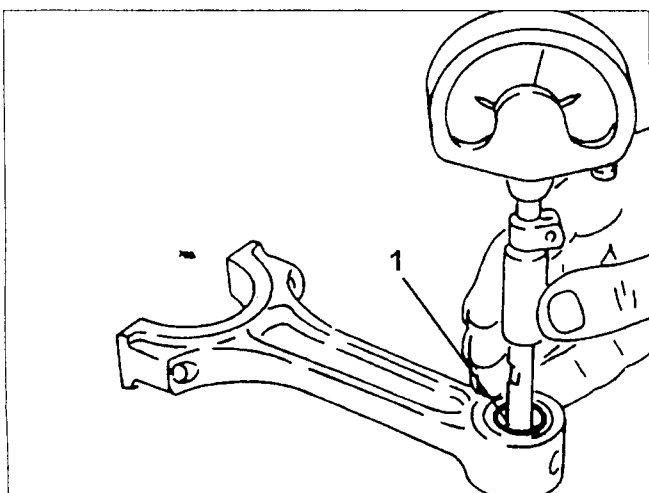
NOTE: If squaring is not perfect, replace the connecting rod to avoid improper stress during engine operation with consequent irregular piston and connecting rod wear.



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 |

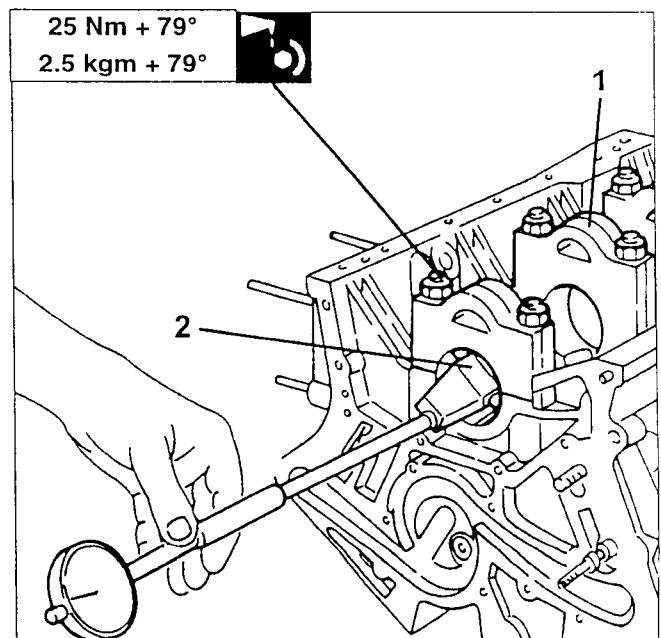
PLAY BETWEEN MAIN JOURNAL AND RESPECTIVE HALF-JOURNALS

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.

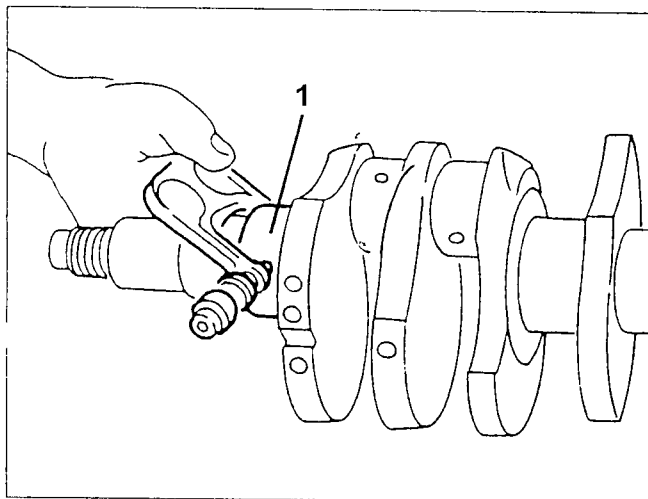
| | | |
|---|------------------------------|--------------------|
| ∅ | Main journal diameter | |
| | Class A (Red) | 59.979 ÷ 59.997 mm |
| | Class B (Blue) | 59.973 ÷ 59.991 mm |
| | Class C (Green) | 59.967 ÷ 59.985 mm |



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 |



- 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:

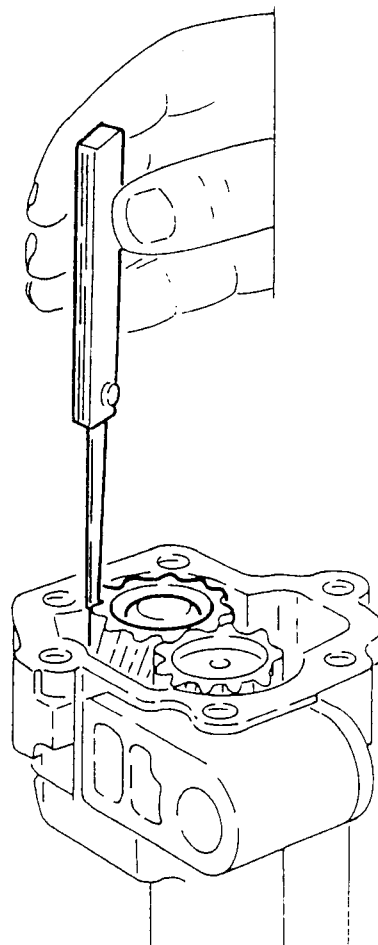
- remove the old crown wheel with a press;
- clean the new crown wheel and flywheel contact surfaces carefully;
- heat the new crown wheel uniformly at 120 - 140°C and fit in to the flywheel. Leave to cool at ambient temperature. Do not forcefully cool.

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 | |



REFITTING PRECAUTIONS

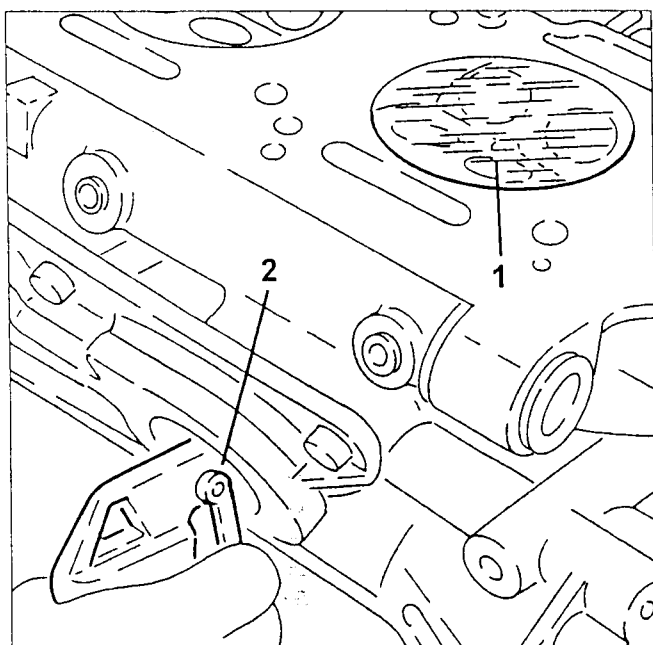


Reverse the removal sequence for refitting unless otherwise specified in the following instructions.

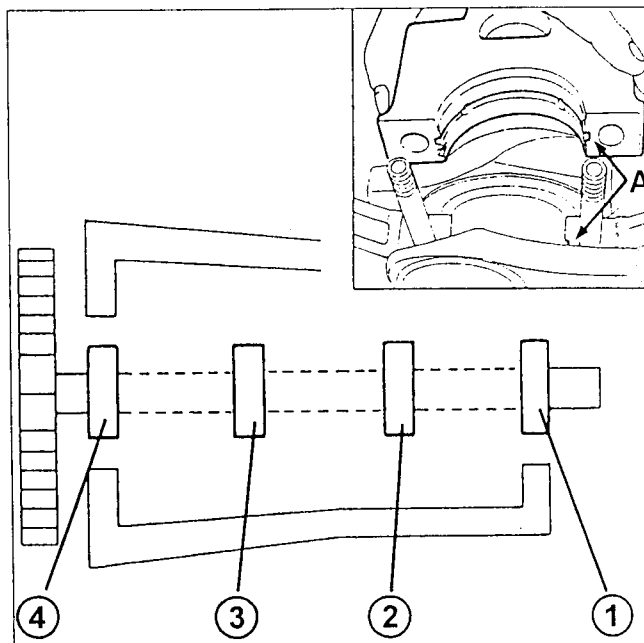
VALVE TIGHTNESS CHECK

- 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).

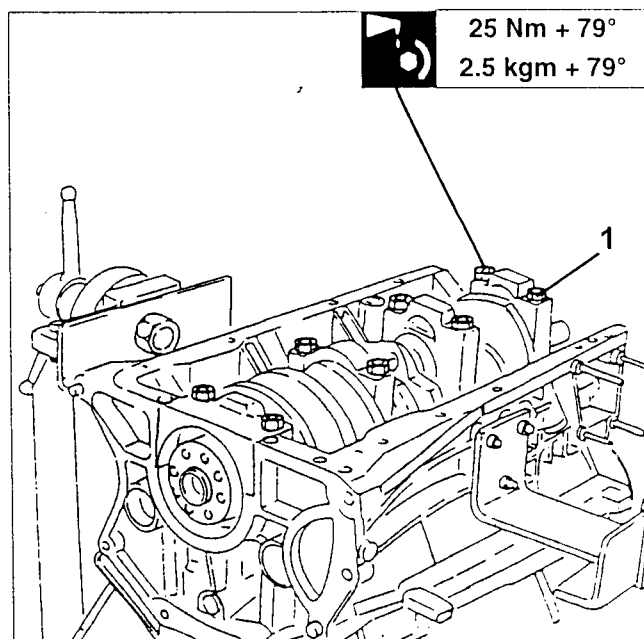


NOTE: The safety notches "A" on the crankcase and on the main bearings should be on the same side.



1. Fasten the main bearing fastening nuts at the prescribed torque.

NOTE: Use goniometer no. 1.860.942.000 for angle torque.



CRANKSHAFT 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.

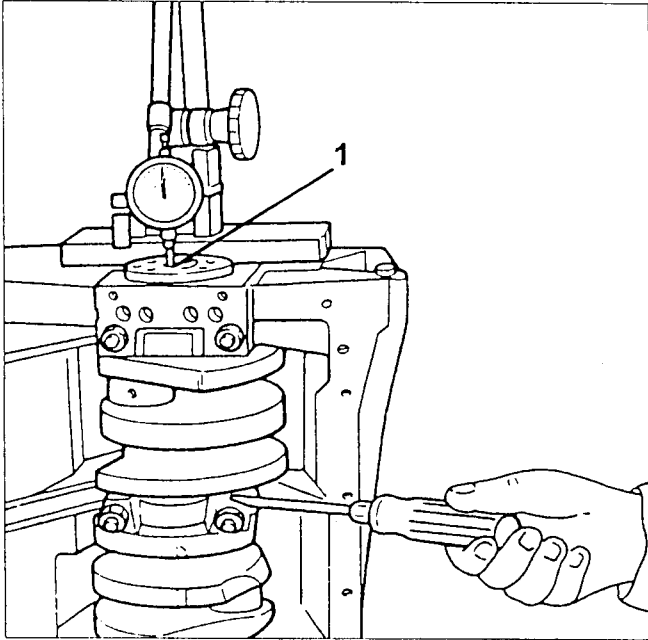
- Fit the main bearings and half-bearings on the journals according to the numbers.

CRANKSHAFT AXIAL PLAY

1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.



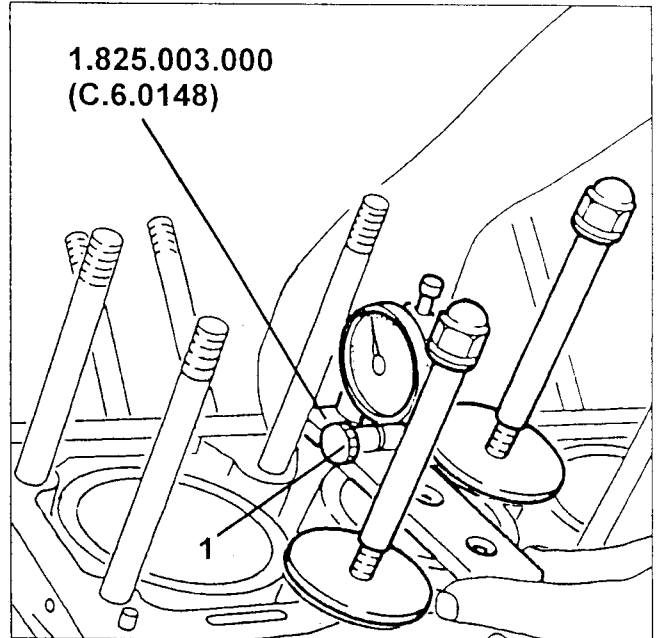
| |
|------------------------------|
| Crankshaft axial play |
| 0.080 ÷ 0.265 mm |



1. Fit tool no. 1.825.003.000 (C.6.0148) and the re-set 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.



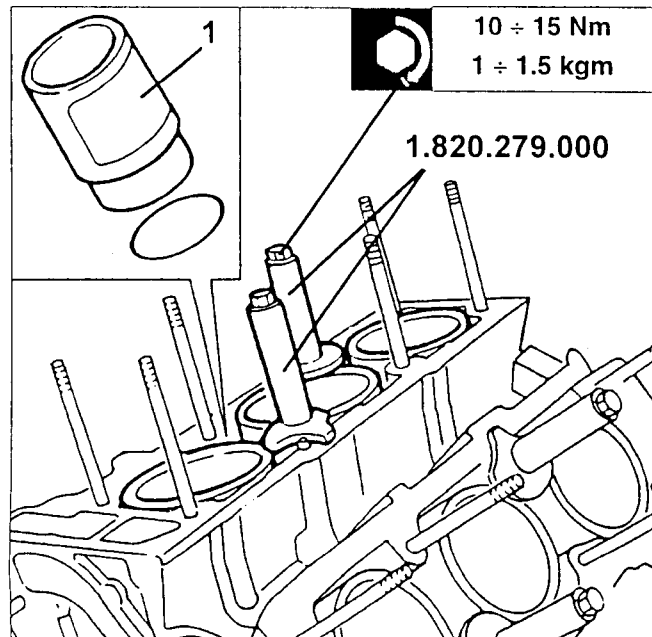
| |
|--|
| Crankcase cylinder liner projection |
| 0.01 ÷ 0.06 mm |



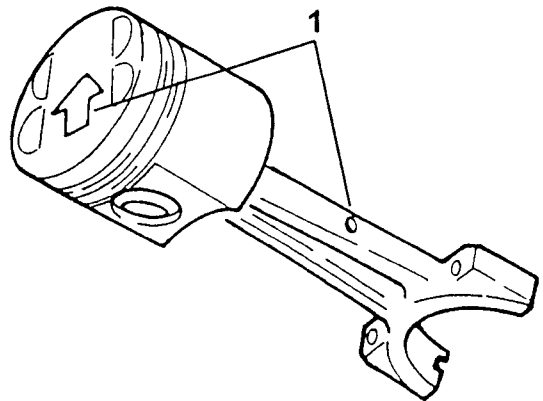
CYLINDER LINER, PISTON AND CONNECTING ROD REFITTING

- 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.



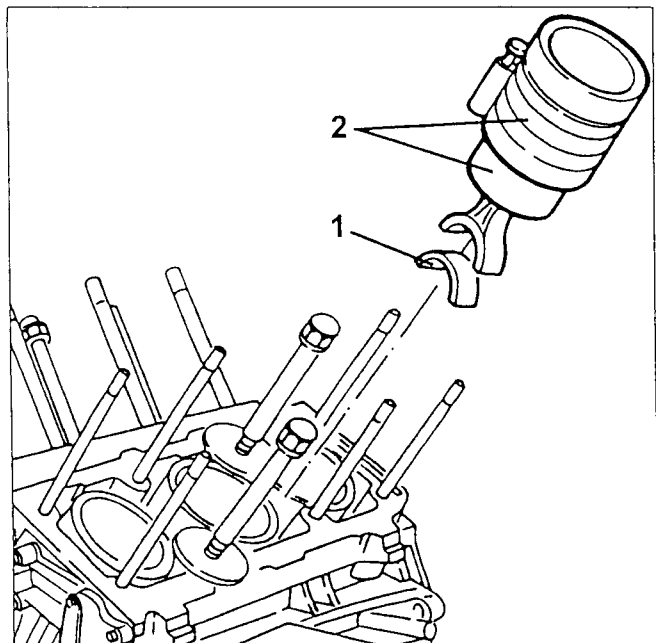
- Fit the gas rings and the oil scraper on the piston with a suitable tool.

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.

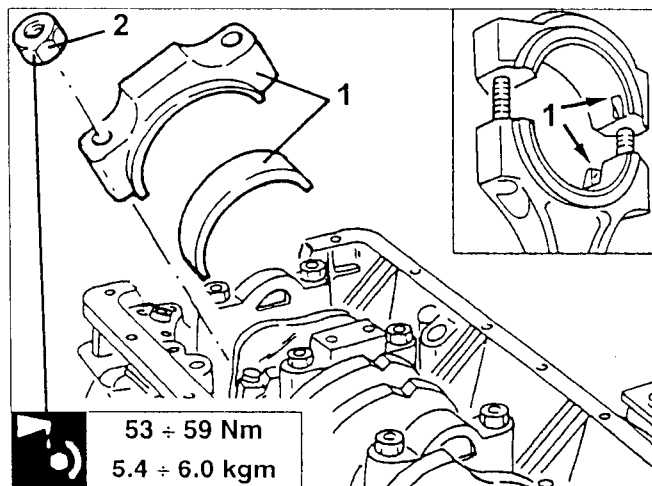


- Turn the crankcase on the overhaul stand.

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.

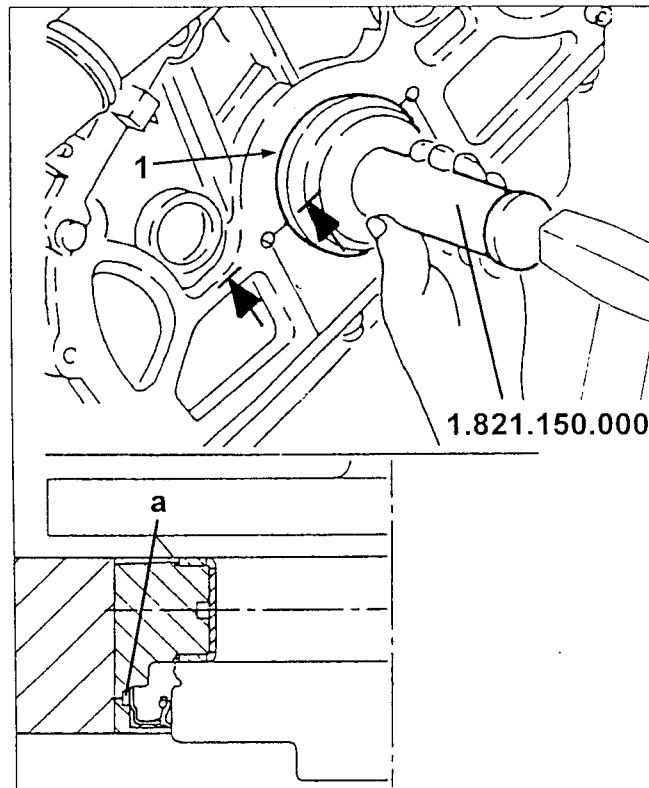


- Fit the pistons and the connecting rod of the other bank in the same way.

OIL SUMP REFITTING

1. Fit the rear crankshaft oil seal with tool no. 1.821.150.000.

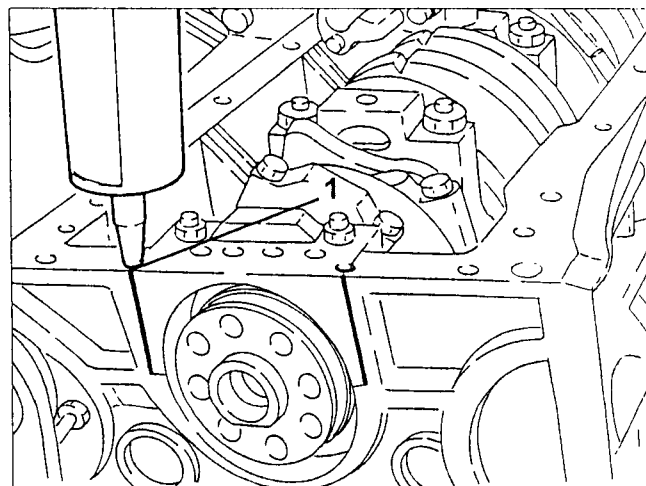
NOTE: Fit the oil seal in its seat so that the holes (a) are covered.



For pre-change versions (to engine no. 00708)

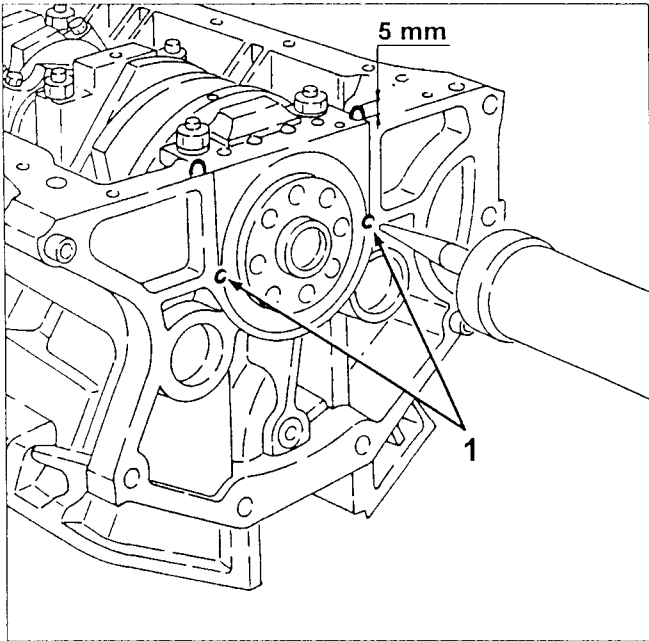
1. Apply "DOW CORNING 7091" silicon sealant with a mechanical gun through the holes shown in the figure.

NOTE: Check that the sealant seeps out from the rear crankcase-main bearing coupling along the entire length.

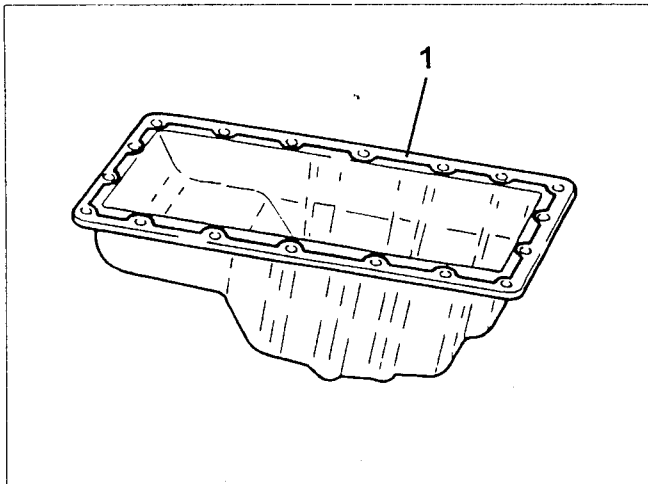


**Post-change versions
(from engine no. 00709)**

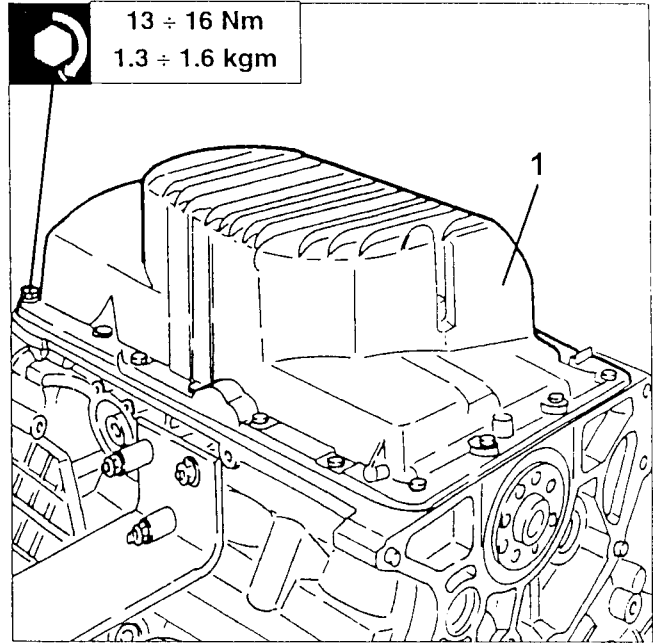
1. Apply "DOW CORNING 7091" silicon seals by means of a mechanical gun through the holes on the crankcase until the sealant seeps out from the engine oil sump coupling by approximately 5 mm.



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.



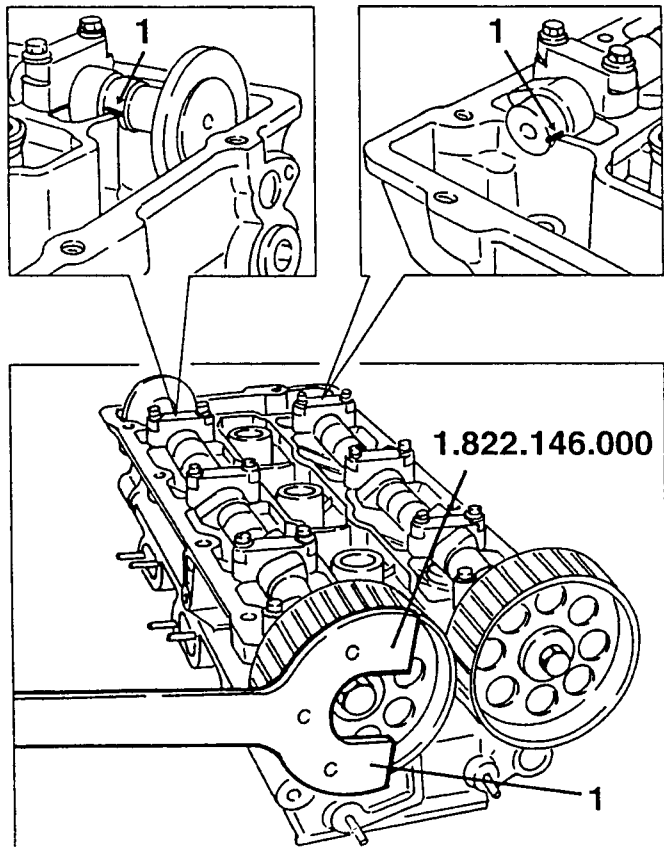
IMPORTANT: Fit the oil sump within 15 minutes from applying the sealant in the crankshaft rear seal holes.

WHITE

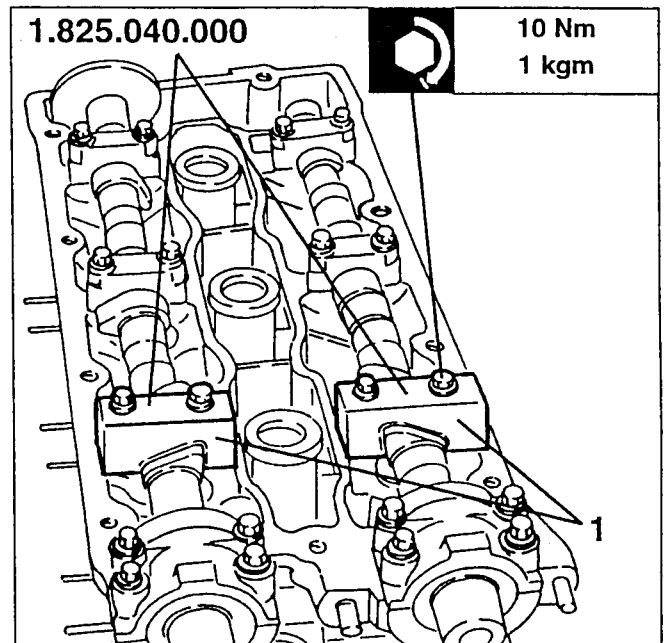
REFITTING THE CYLINDER HEADS

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.

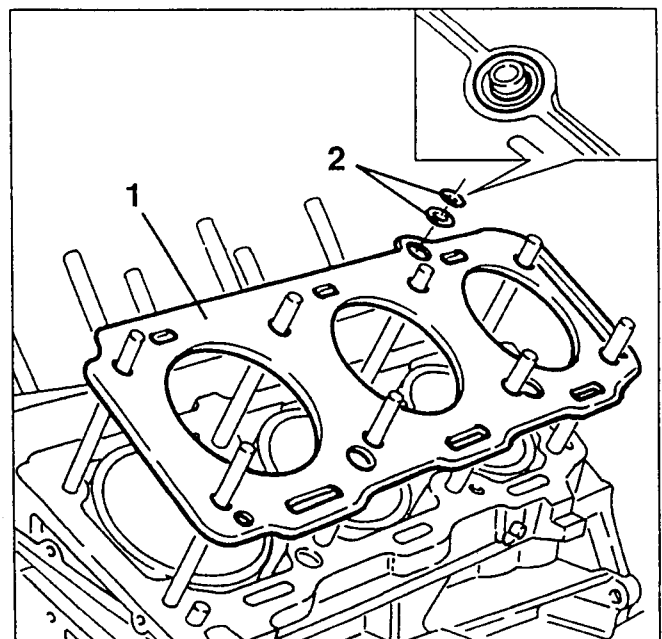
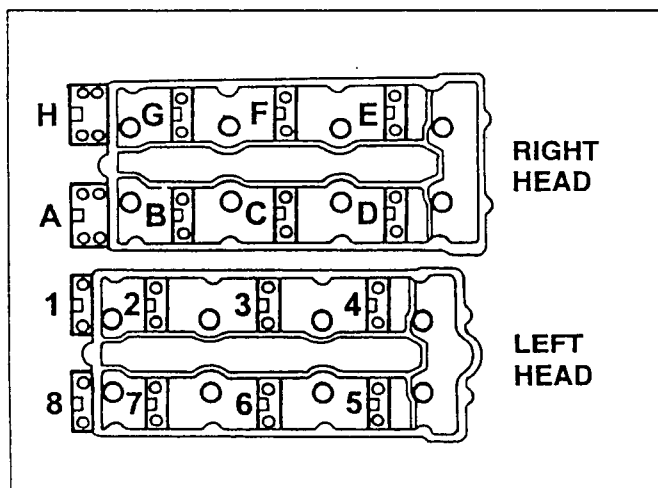


1. In place of the removed camshaft caps, install the templates no. 1.825.040.000 in the position shown by the stamping on them.



- 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).

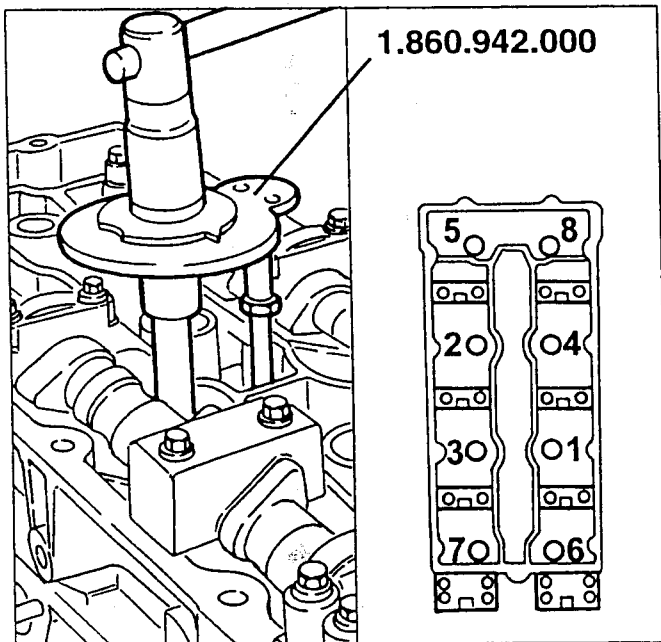
- Remove camshaft caps 4 and 7 for the left cylinder head and caps B and G for the right cylinder head.



- 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.

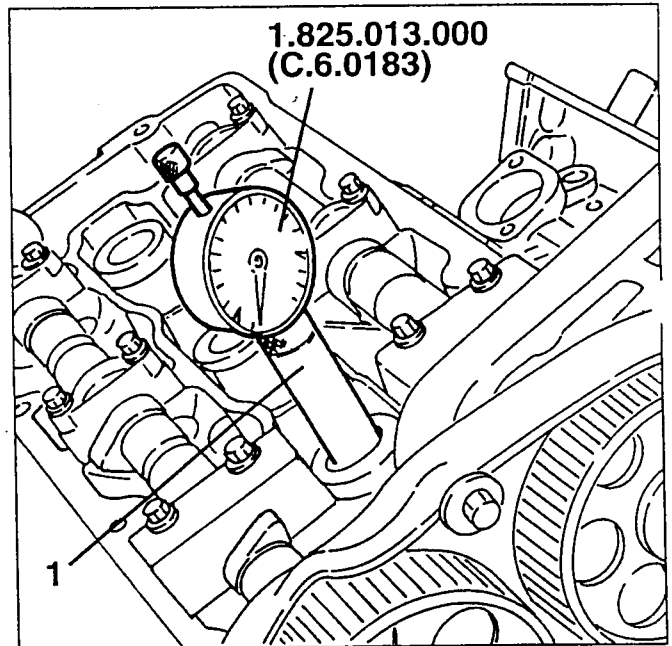
NOTE: The cylinder head seals are ASTADUR. Because of the special material with which they are made, these seals undergo a polymerisation process when the engine is running, therefore they harden considerably during use. To ensure that the cylinder head seals polymerise, it is necessary to:

- 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.

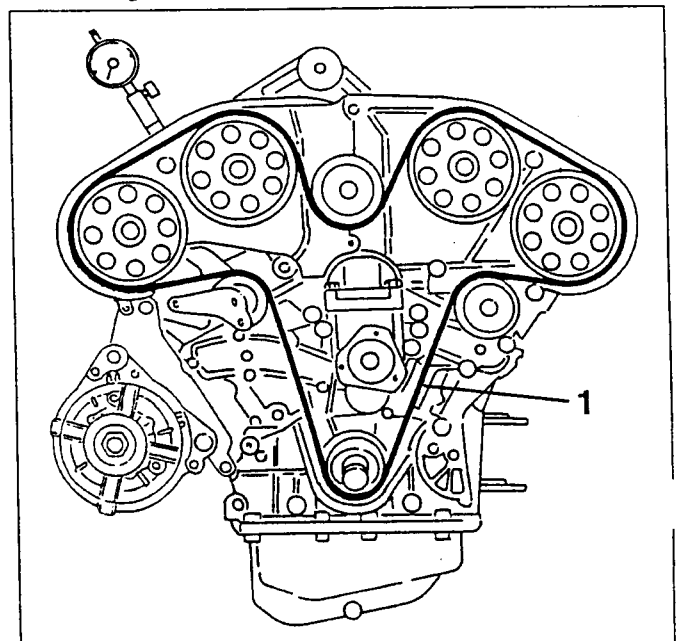
1. Install tool no. 1.825.013.000 (C.6.0183) in the seat of the first cylinder spark plug.



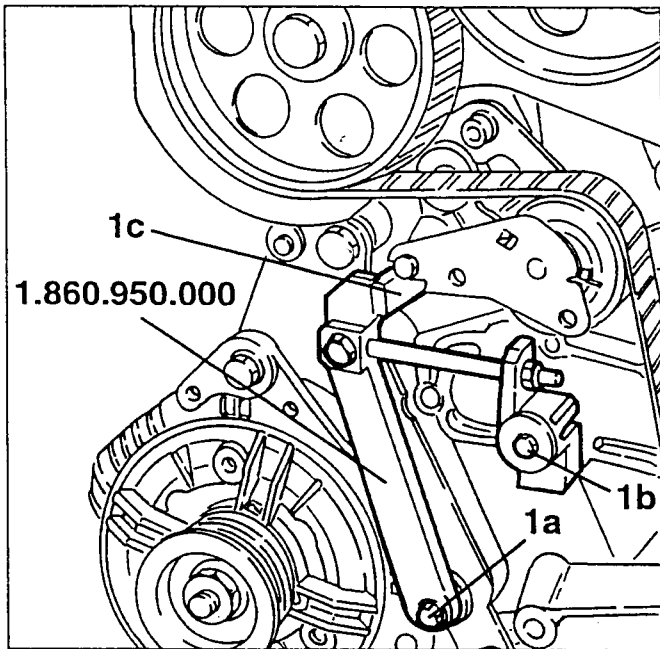
- Working on the fastening nut from the auxiliary components drive pulley, make the crankshaft turn a little (both ways) until the piston of the 1st cylinder reaches the T.D.C. in the bursting stroke.

NOTE: Make sure that the last turn of the crankshaft is in the operating direction.

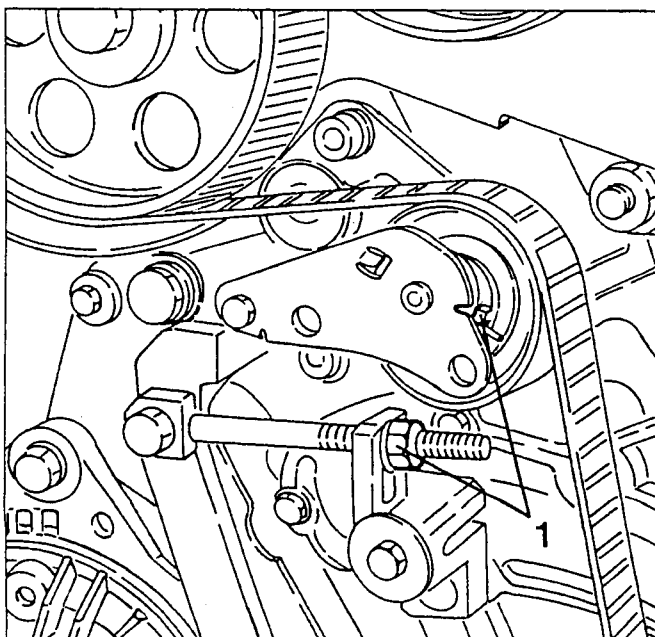
1. Fit the timing gear drive belt starting from the drive pulley and continuing anti-clockwise making sure that the driving branches are well taut.



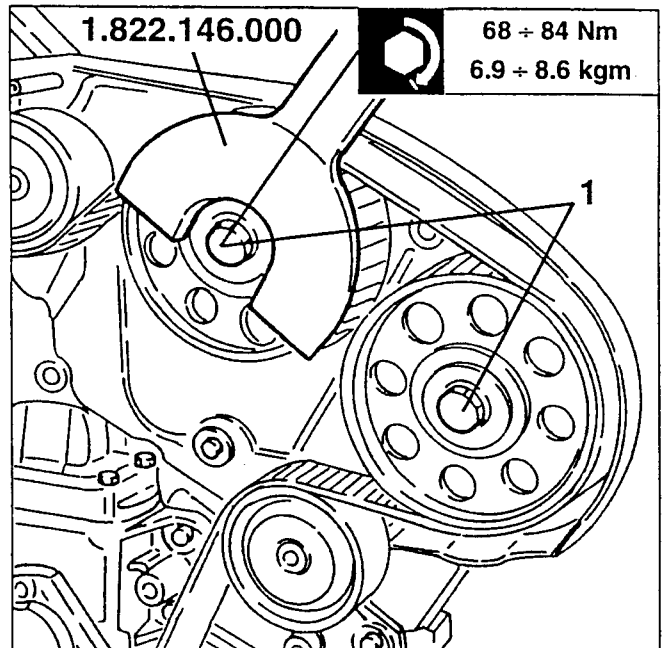
1. Position tool no. 1.860.950.000 for tensioning the timing gear drive belt fastening with the alternator screw (1a) and with the water pump screw (1b); the tooth (1c) of the tool must lever on the mobile part of the belt tensioner.



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.

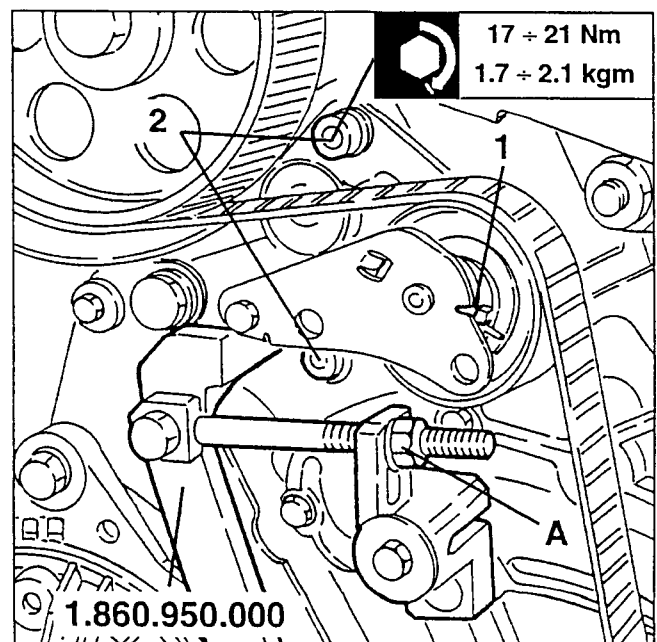


- Remove the templates no. 1.825.040.000 installed previously and in place of them fit the corresponding caps and tighten the fastening screws to the specified torque.

- 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.

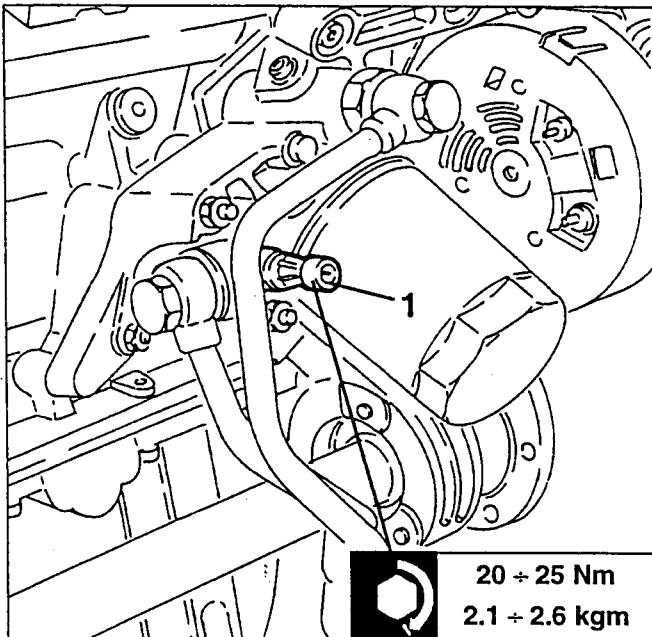
CHECKING ELECTRIC COMPONENTS OF THE LUBRICATION CIRCUIT

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.