

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).

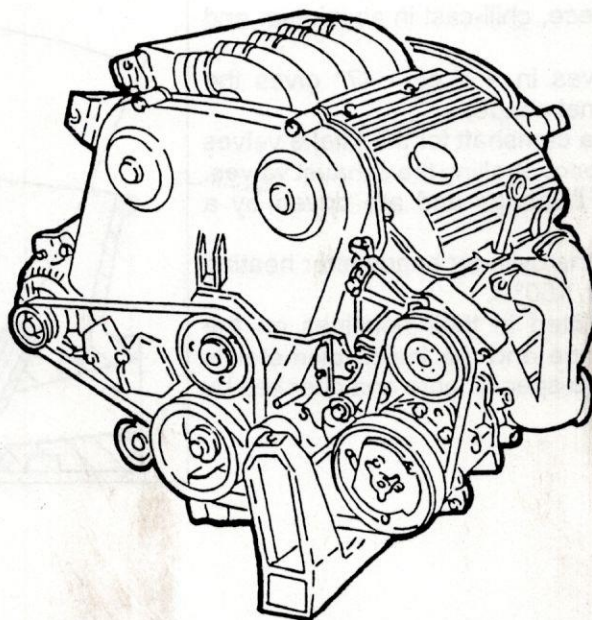
The gearbox-clutch-differential unit is connected at the rear of the engine and is an integral part of the power unit.

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.



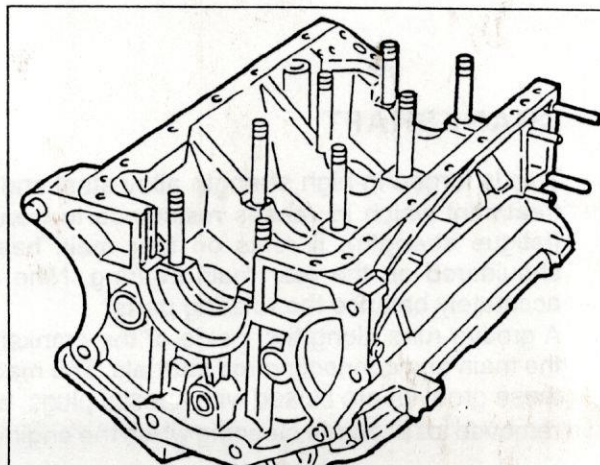
CRANKCASE

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.

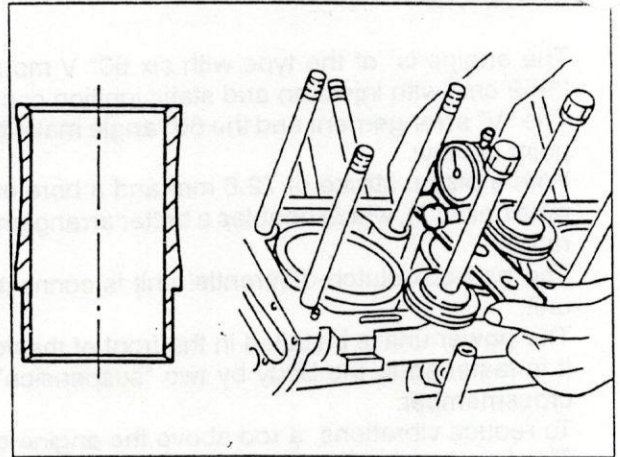


CYLINDER LINERS

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 distortions 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

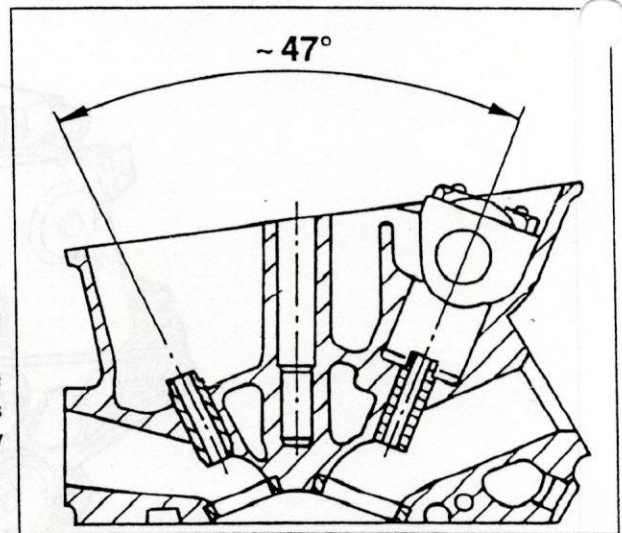
These are compact, single-piece, chill-cast in aluminium and silicium alloy.

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.



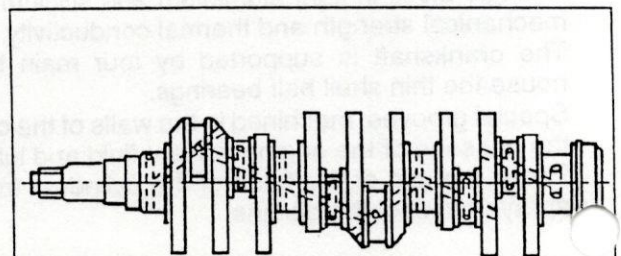
OIL SUMP

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

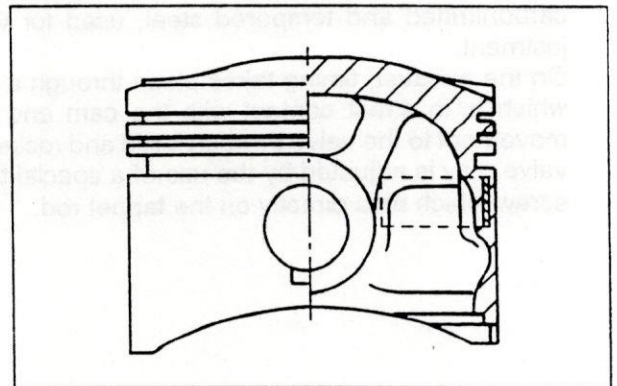
These are of the three-metal, thin shell type, divided into three dimensional classes, for the main bearing halves and two for the connecting rod bearing halves.

FLYWHEEL

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

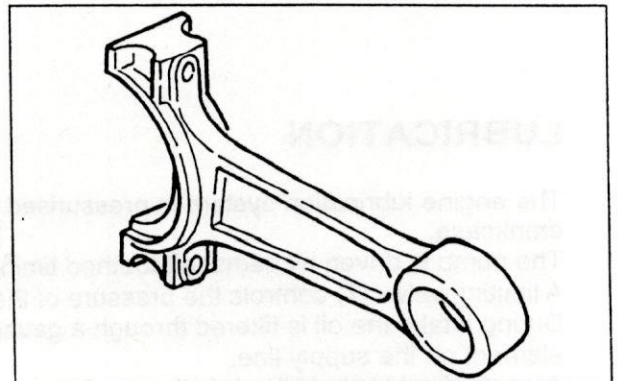
PISTONS - CONNECTING RODS

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.

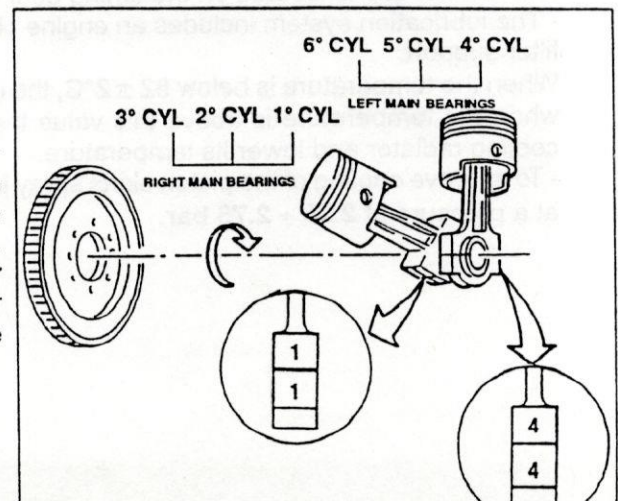


The connecting rods are in hardened and tempered alloy steel with a bushing in copper alloy force-fitted for coupling with the piston gudgeon pin.

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

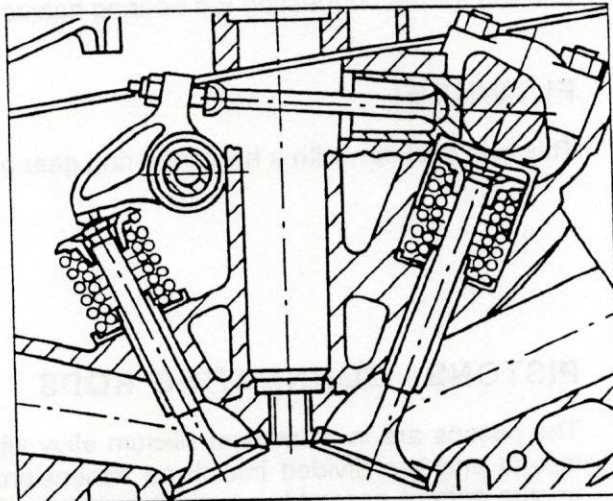
This takes place through two camshafts in casehardened and tempered alloy steel, one for each row of cylinders.

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.

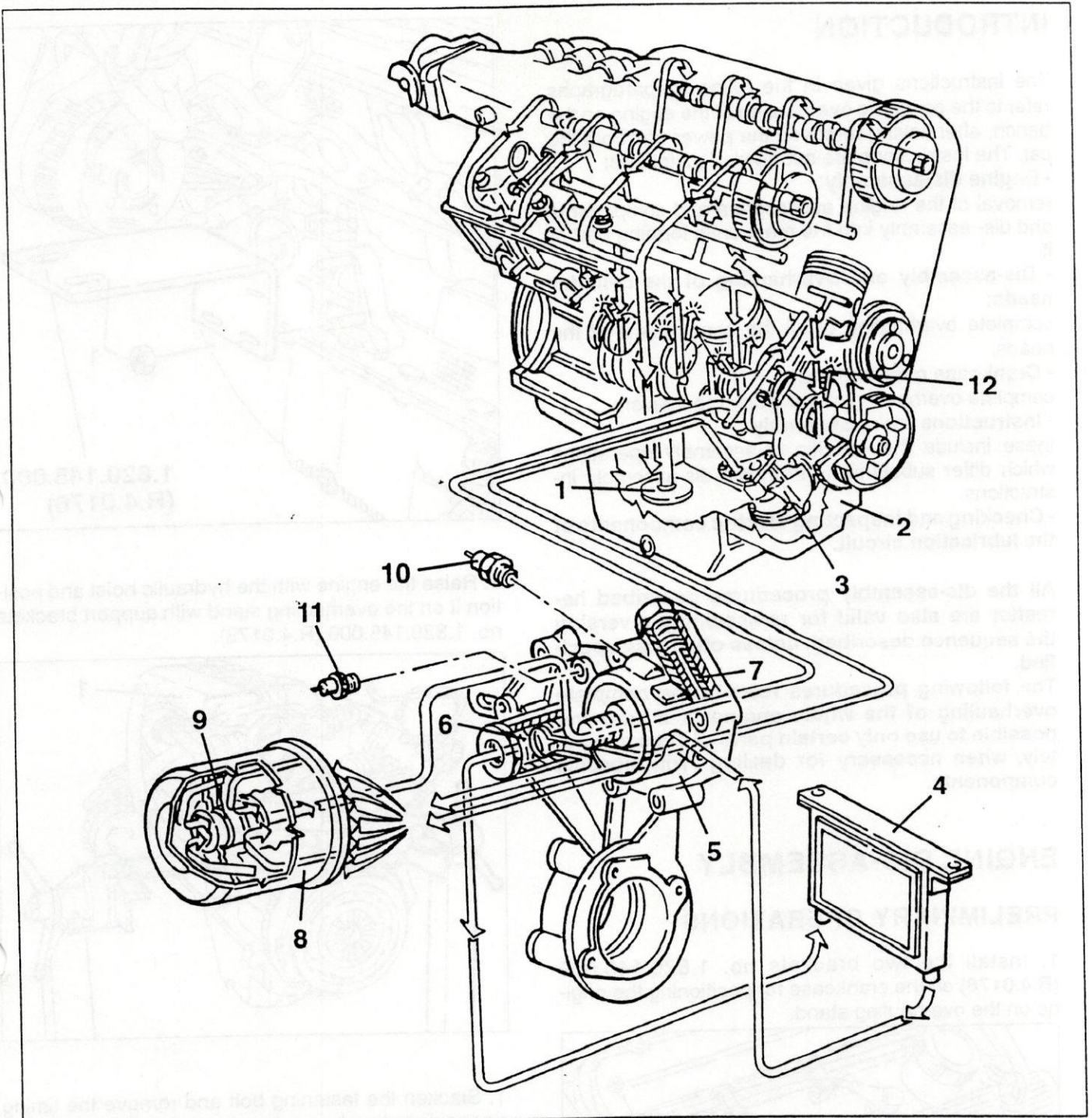
On the oil filter support (5) there is an engine oil minimum pressure sensor (11) connected to a warning light on the instrument cluster which alerts the driver if the oil pressure is too low.

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.

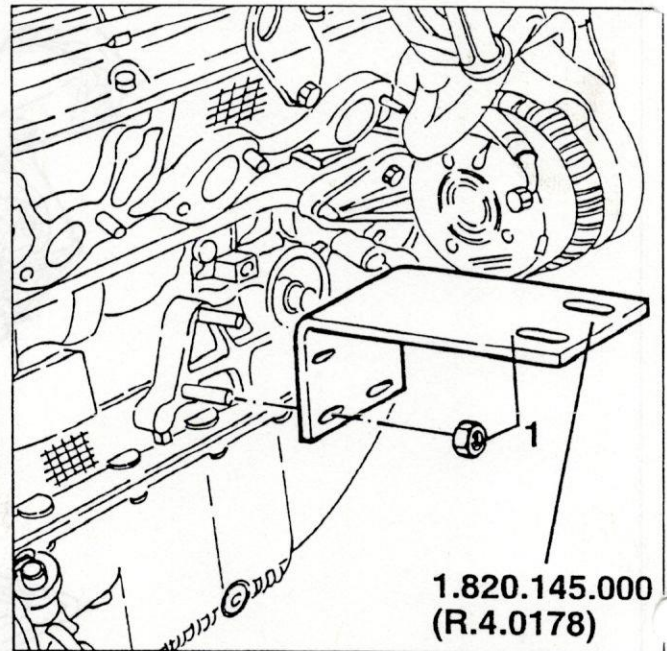
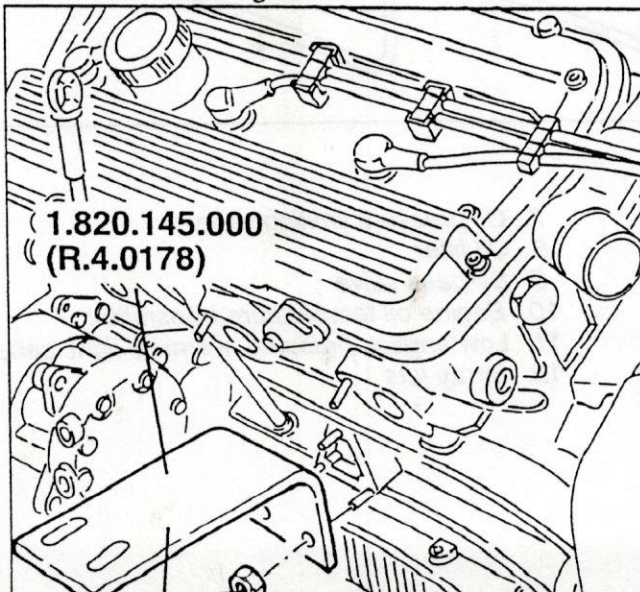
All the dis-assembly procedures described hereafter are also valid for re-assembly reversing the sequence described, unless otherwise specified.

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.

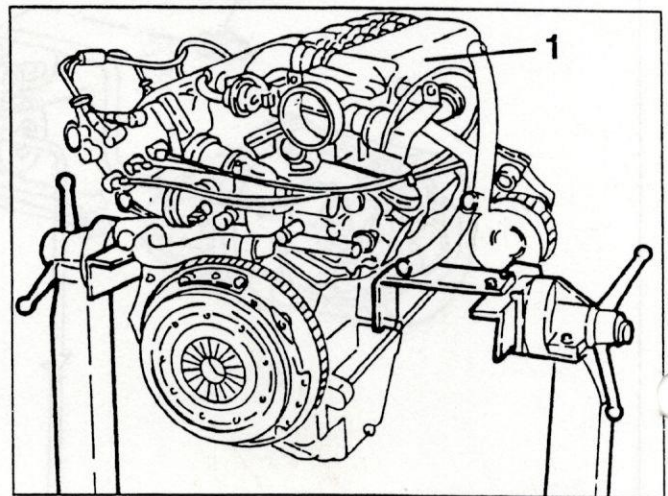
ENGINE DIS-ASSEMBLY

PRELIMINARY OPERATIONS

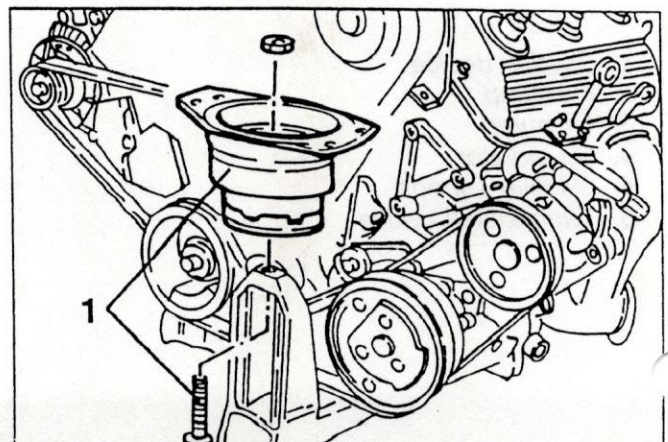
1. Install the two brackets no. 1.820.145.000 (R.4.0178) on the crankcase for positioning the engine on the overhauling stand.



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).

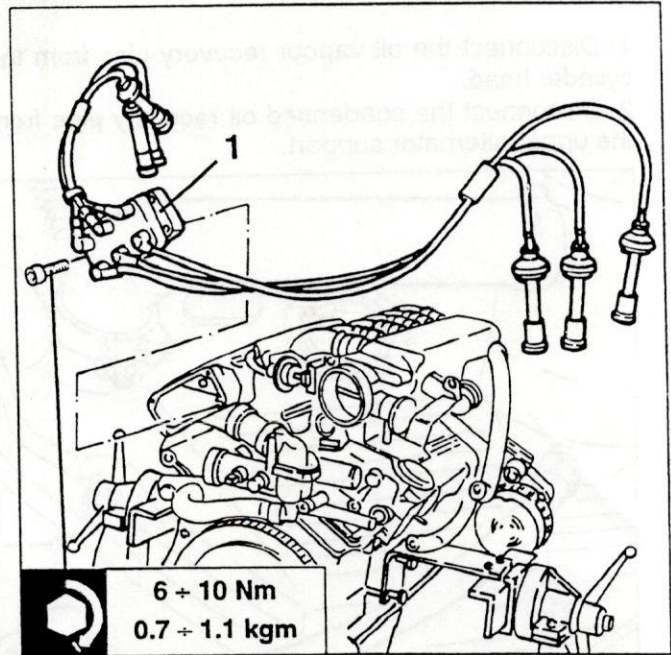
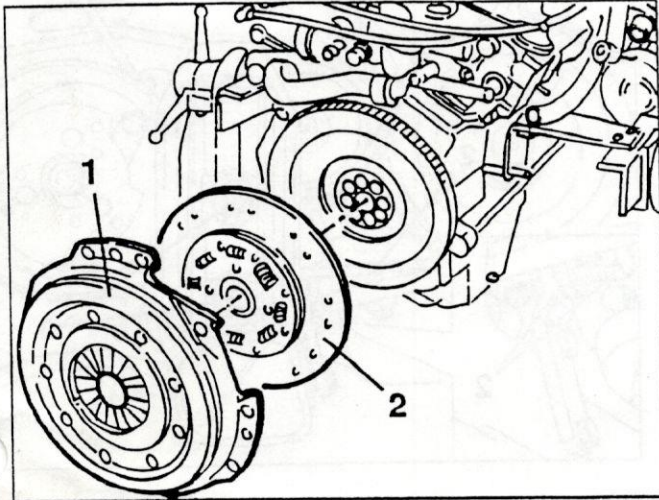


1. Slacken the fastening bolt and remove the timing gear side support.



REMOVING THE CLUTCH PLATE

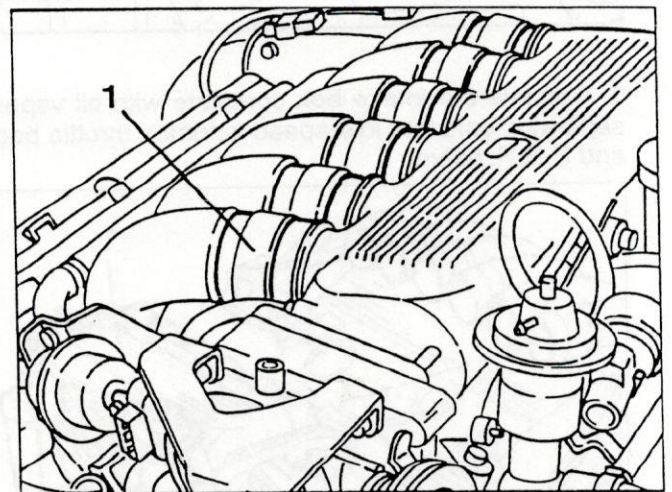
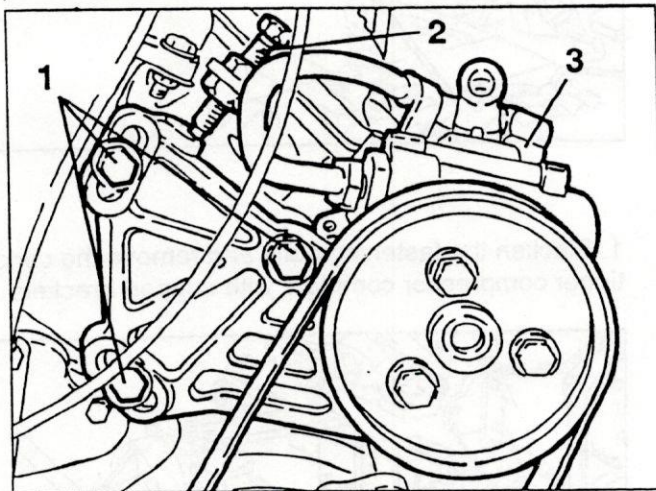
1. Slacken the fastening screws and remove the pressure plate body.
2. Remove the clutch plate.



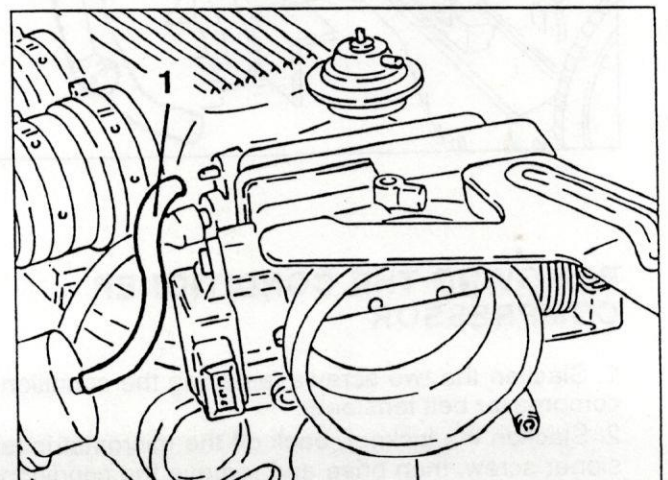
1. Slacken the clamps fastening the air intake ducts to the intake box.

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 slackened previously and remove the power steering pump complete with support bracket.



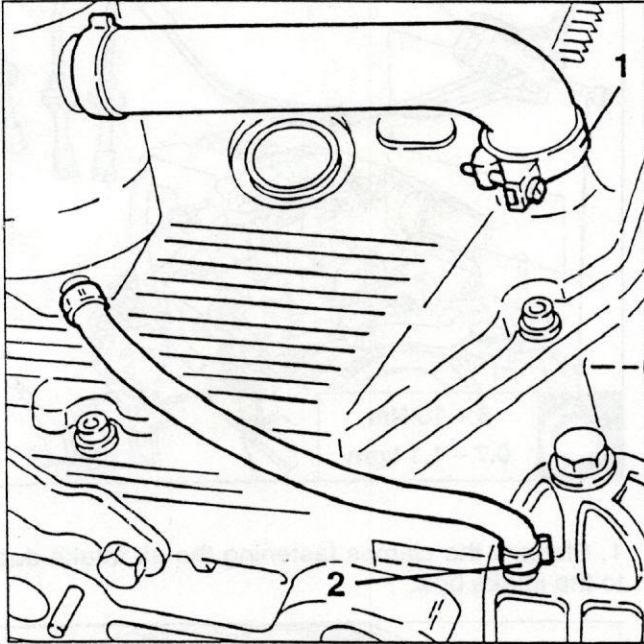
1. Disconnect the vacuum takeoff pipe for the fuel pressure regulator from the intake box.



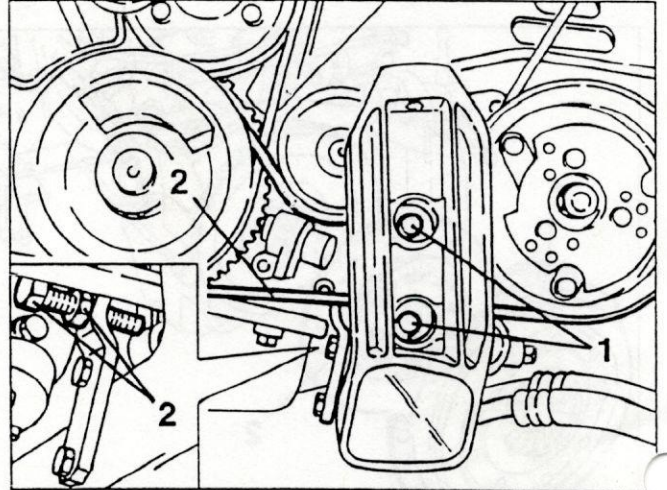
REMOVING THE AIR INTAKE BOX

1. Slacken the ignition coil fastening screws, then remove the coils complete with high voltage cables after disconnecting them from the spark plugs.

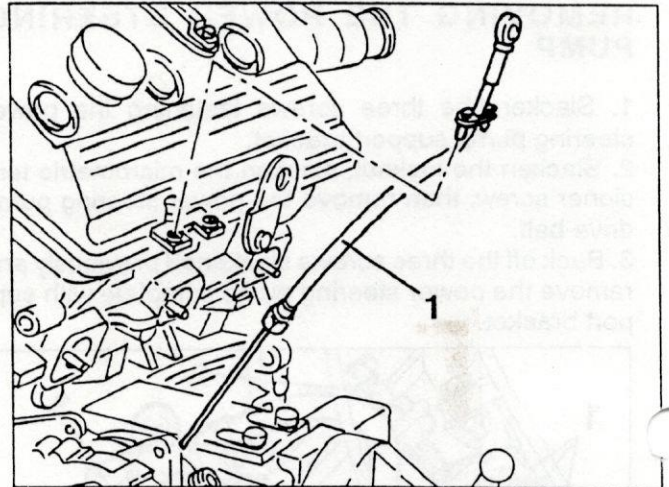
1. Disconnect the oil vapour recovery pipe from the cylinder head.
2. Disconnect the condensed oil recovery pipe from the upper alternator support.



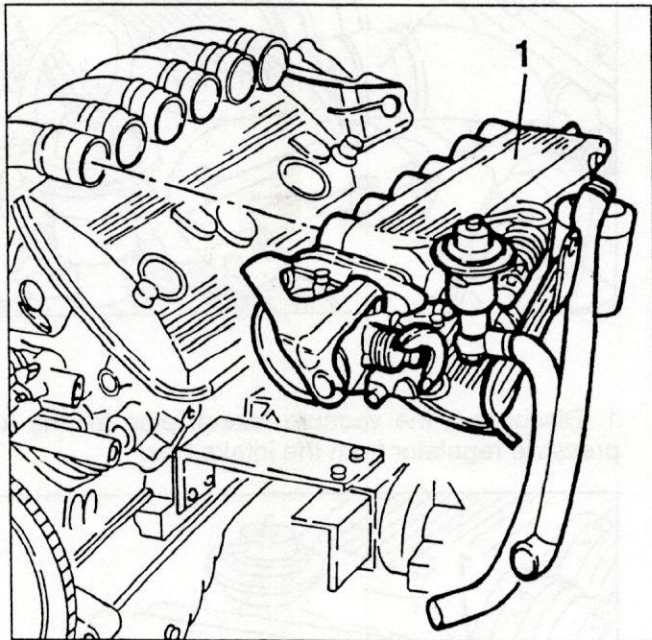
- Retrieve the power steering pump drive belt.
- Completely back off the two fastening screws and remove the conditioner compressor belt tensioner guide.



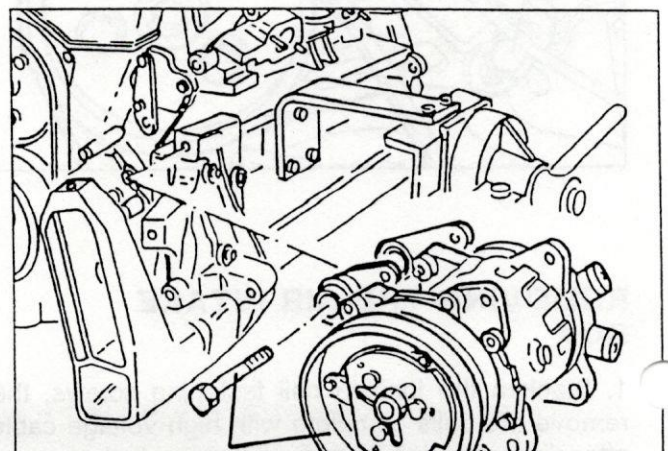
1. Remove the engine oil dipstick complete with its guide.



1. Remove the intake box complete with oil vapour separator, constant idle speed actuator, throttle body and E.G.R. valve.



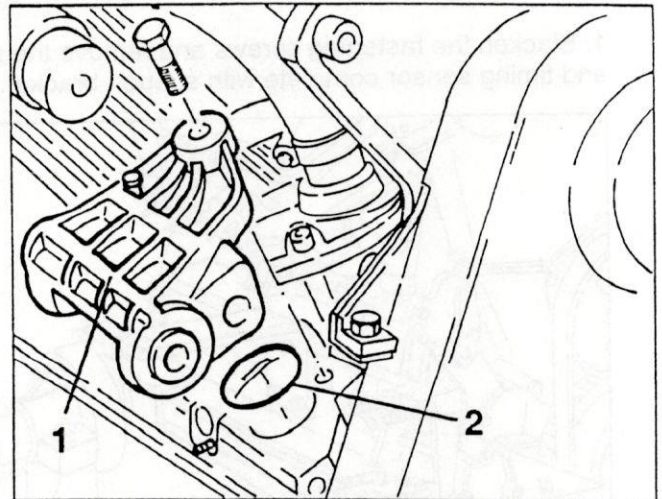
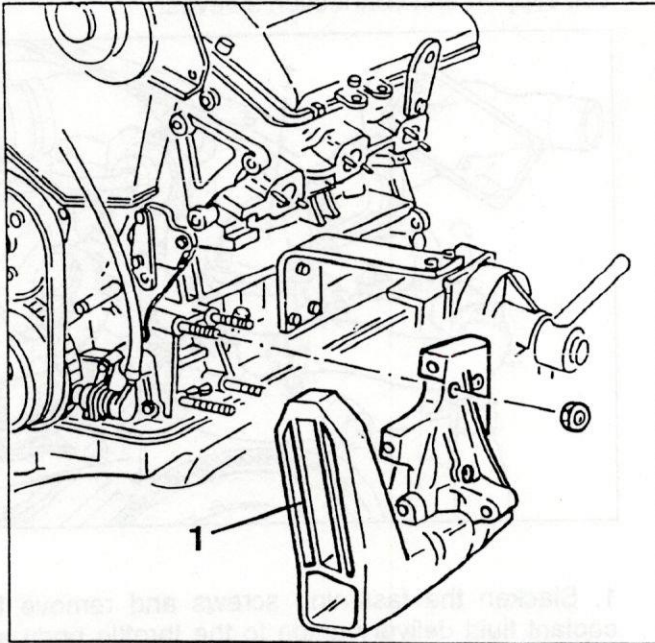
1. Slacken the fastening bolts and remove the conditioner compressor complete with support brackets.



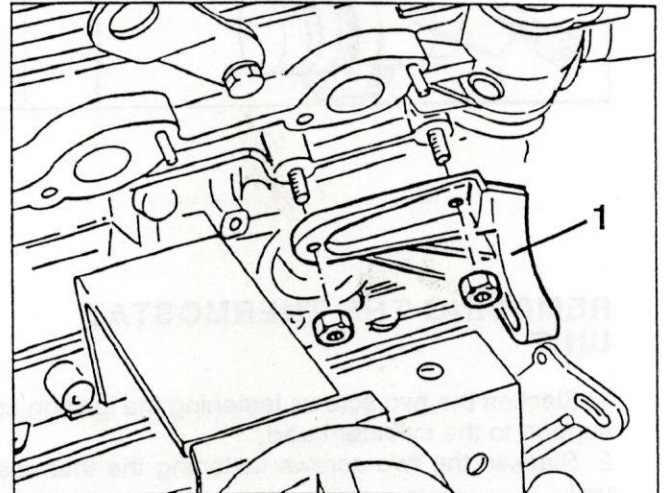
REMOVING THE CONDITIONER COMPRESSOR

1. Slacken the two screws fastening the conditioner compressor belt tensioner.
2. Slacken the locknut, back off the micrometric tensioner screw, then raise and remove the conditioner compressor.

1. Slacken the fastening nuts and remove the front engine support.

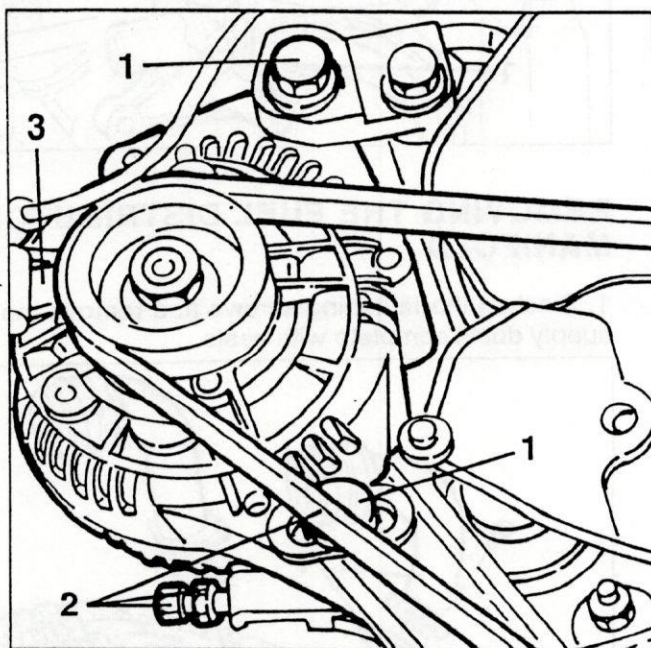


1. Slacken the fastening nuts and remove the rear lower alternator support bracket.



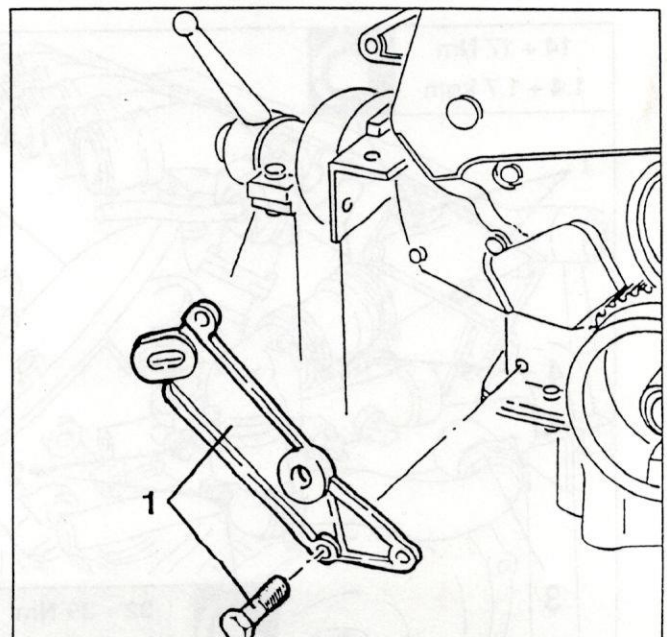
REMOVING THE ALTERNATOR

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.

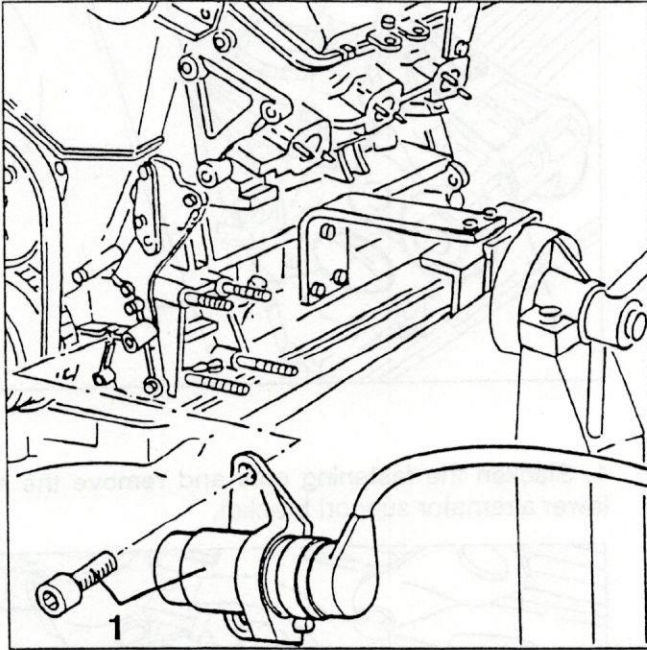


1. Remove the upper alternator support bracket.
2. Remove the O-Ring.

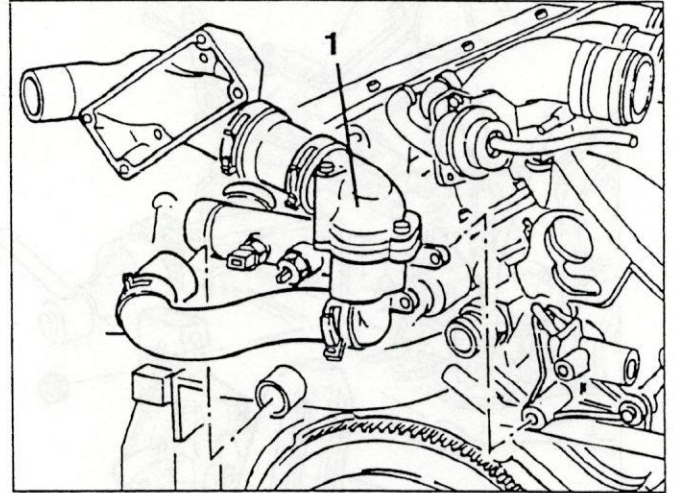
1. Slacken the fastening screws and remove the front lower alternator support bracket.



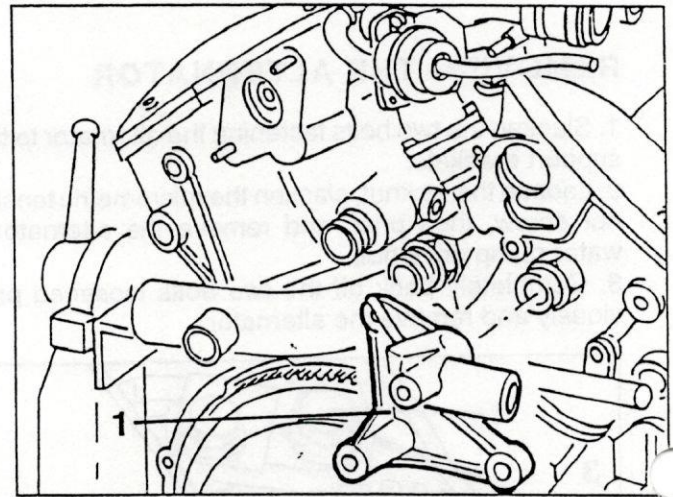
1. Slacken the fastening screws and remove the rpm and timing sensor complete with support bracket.



1. Remove the thermostat unit complete with ignition coil support and connection sleeves.

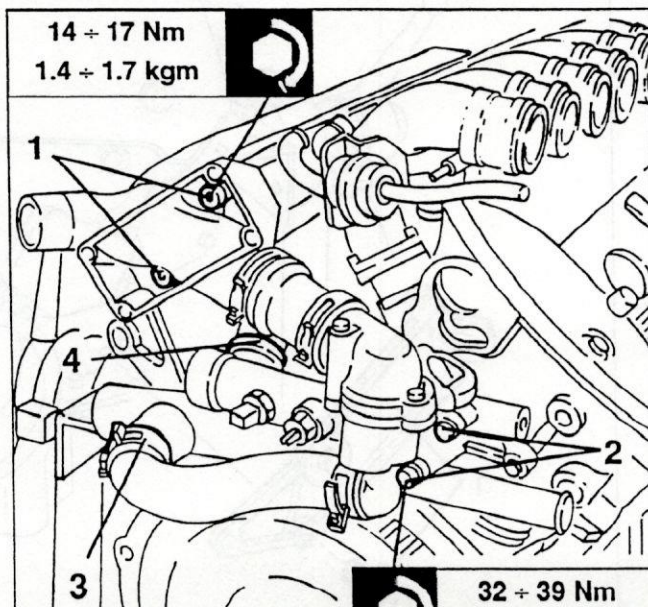


1. Slacken the fastening screws and remove the coolant fluid delivery union to the throttle body and climate control system heater.



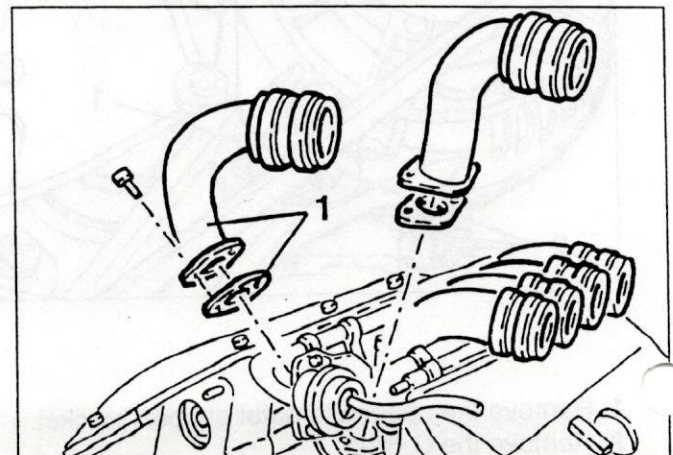
REMOVING THE THERMOSTAT UNIT

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.

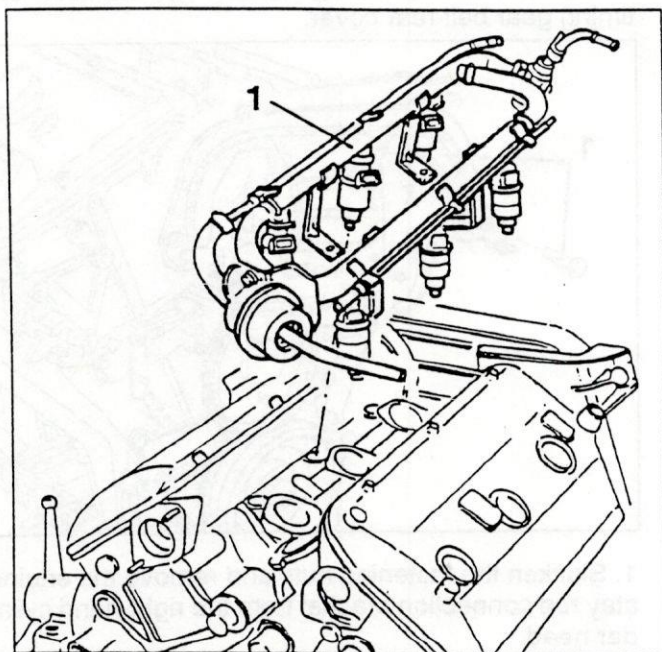


REMOVING THE FUEL DISTRIBUTOR MANIFOLD

1. Slacken the fastening screws and remove the air supply ducts complete with seals.

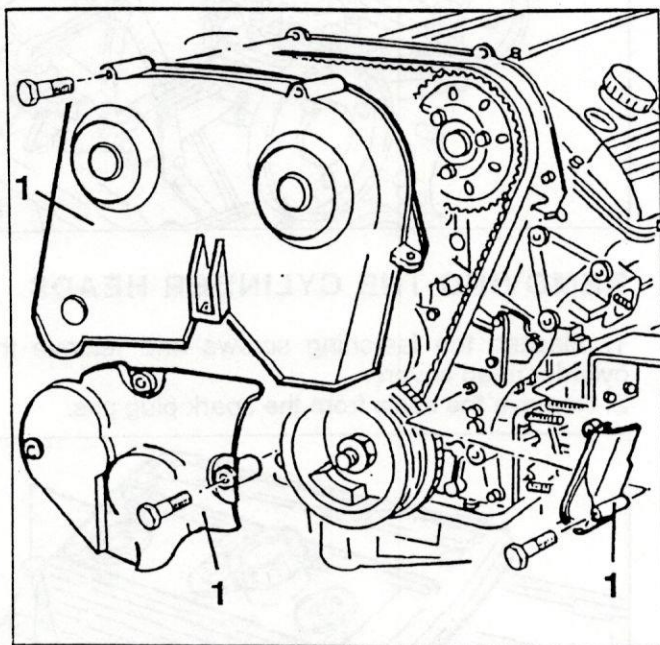


1. Slacken the fastening screws and remove the fuel distributor manifold complete with injectors, pressure regulator and pulse damper.

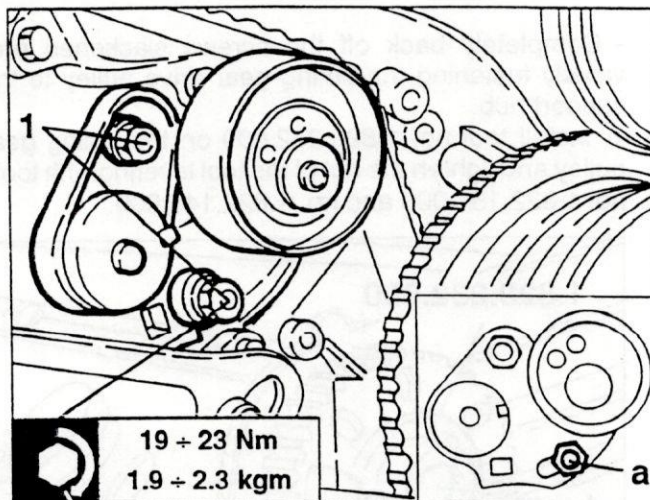


REMOVING THE TIMING GEAR BELT

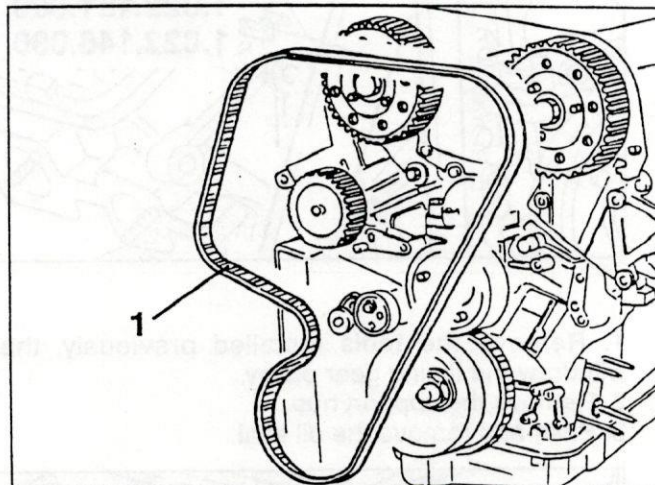
1. Slacken the fastening screws and remove the timing gear belt front covers.



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



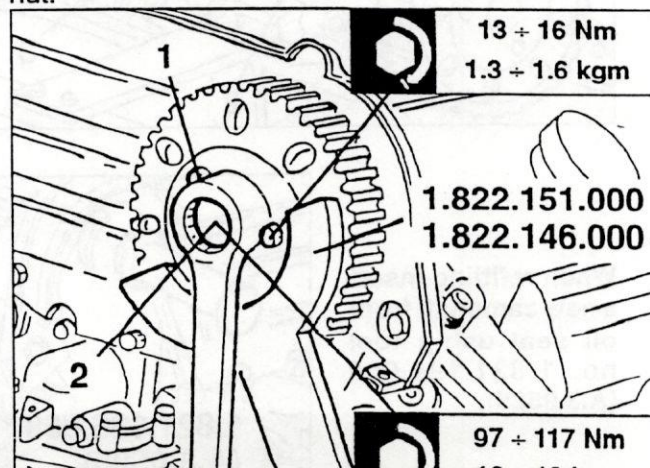
1. Remove the timing gear drive belt prising it off the camshaft toothed drive pulley and withdrawing it from the drive pulley.



- 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.



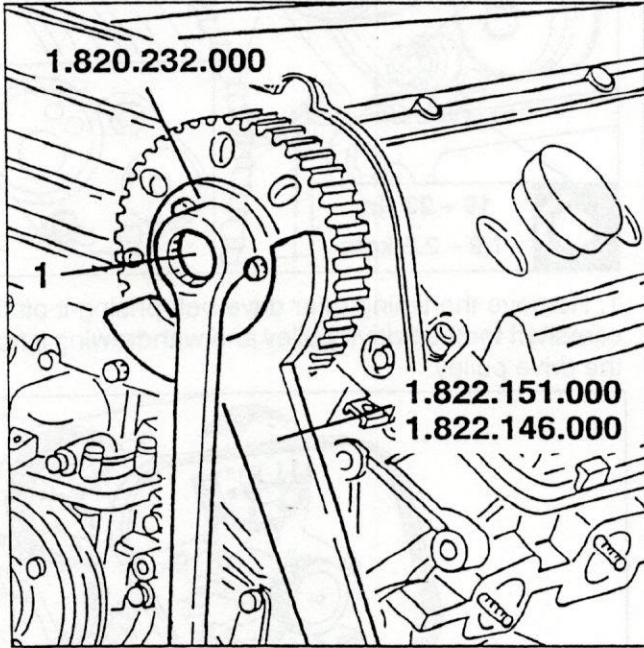
13 + 16 Nm
 1.3 + 1.6 kgm

1.822.151.000
 1.822.146.000

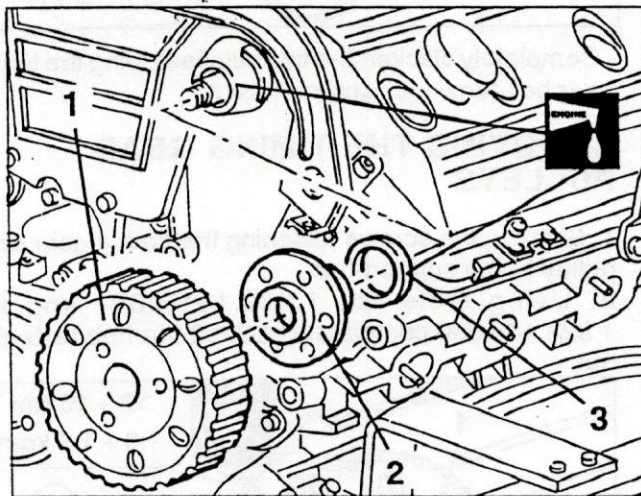
97 + 117 Nm

- Completely back off the screws slackened previously fastening the timing gear drive pulley to the support hub.

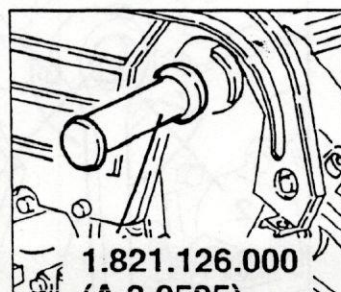
1. Install tool no. 1.820.232.000 on the timing gear pulley and tighten the nut of the tool levering with tools no. 1.822.151.000 and no. 1.822.146.000.



1. Remove the tools installed previously, then withdraw the timing gear pulley.
2. Remove the support hub.
3. Prise and remove the oil seal.

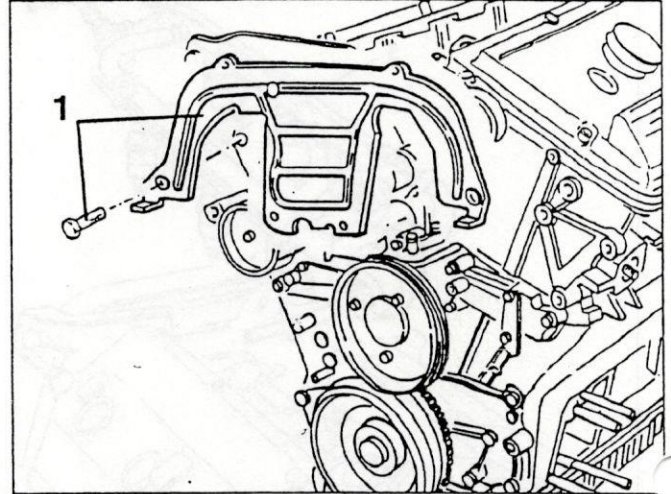


When refitting insert a new camshaft front oil seal using tool no. 1.821.126.000 (A.3.0525).

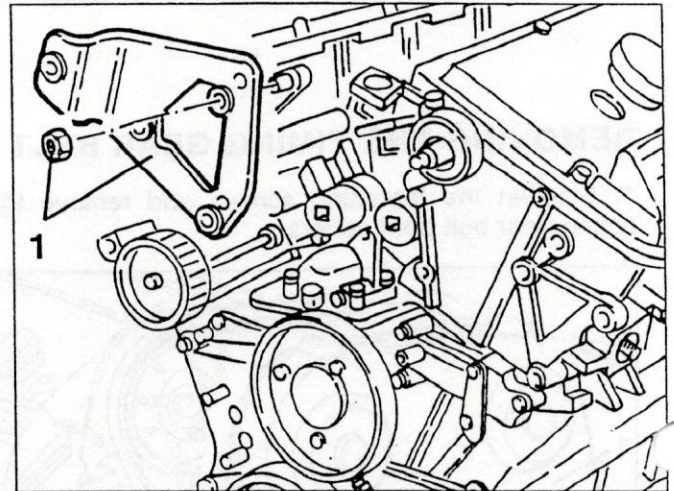


- Proceed in the same way to remove the right-hand cylinder head timing gear pulley.

1. Slacken the fastening screws and remove the timing gear belt rear cover.

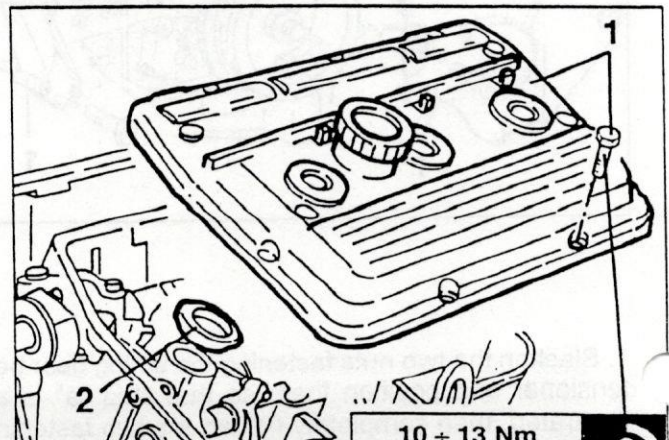


1. Slacken the fastening nuts and remove the engine stay rod connection bracket from the right-hand cylinder head.



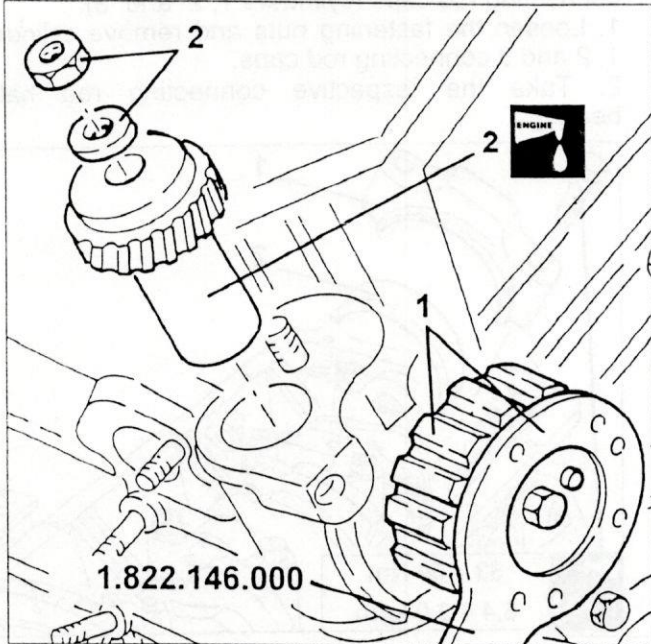
REMOVING THE CYLINDER HEADS

1. Slacken the fastening screws and remove the cylinder head covers.
2. Remove the seals from the spark plug pits.

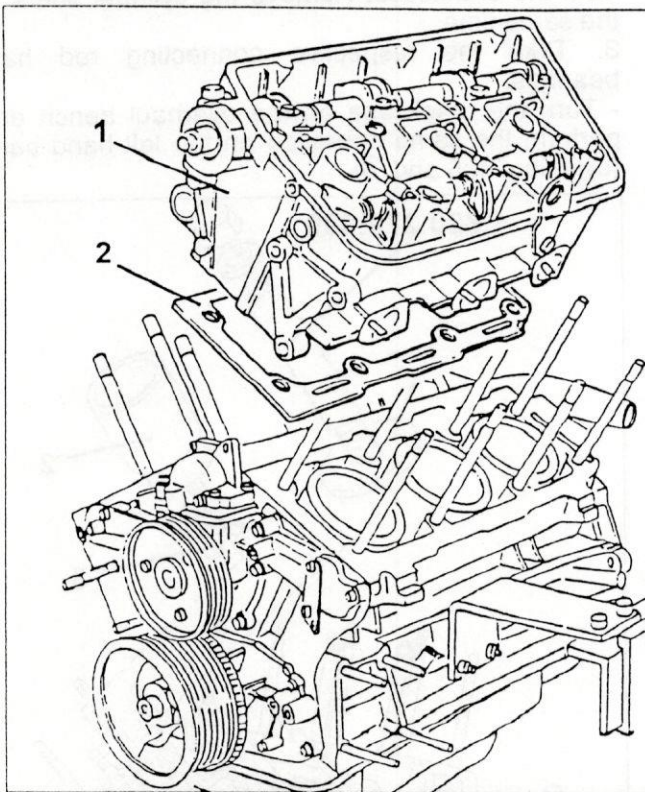


Proceed as follows (right-hand cylinder head only):

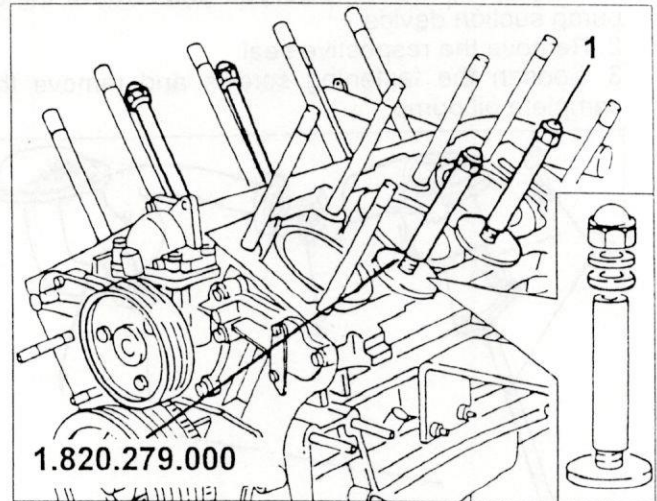
1. Lock engine oil pump drive pulley rotation with tool no. 1.822.146.000.
2. Loosen the fastening nut and remove the oil pump intermediate drive gear from its seat.



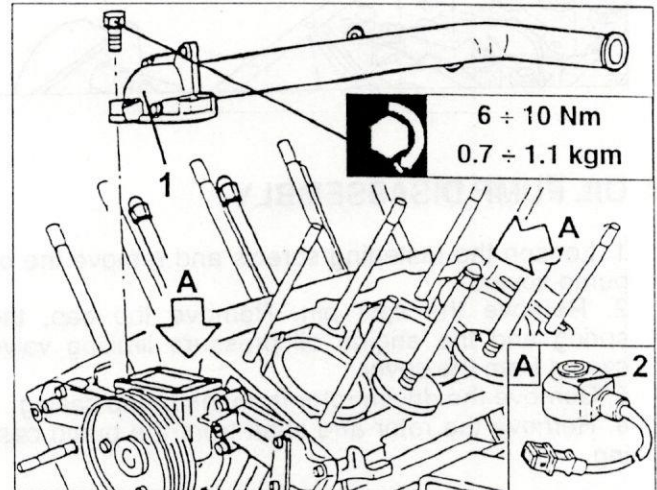
1. Loosen the fastening nuts and remove the engine crankcase cylinder head.
2. Remove the respective seals.



1. Fit liner retainer tools no. 1.820.279.000.



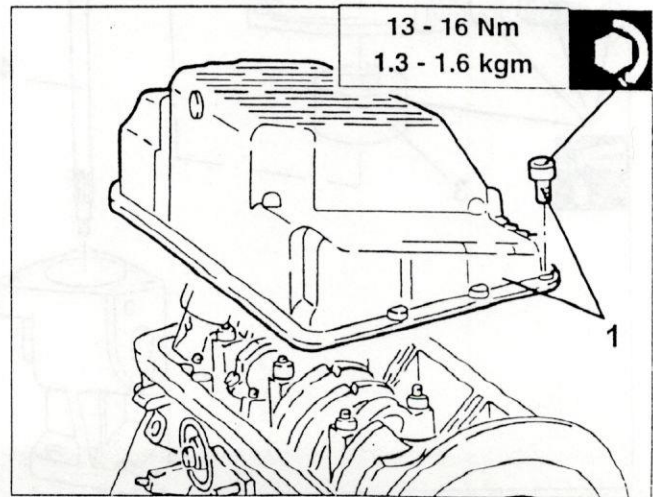
1. Loosen the fastening screws and remove the pump coolant return manifold.
2. Loosen the screws and remove the knock sensors.



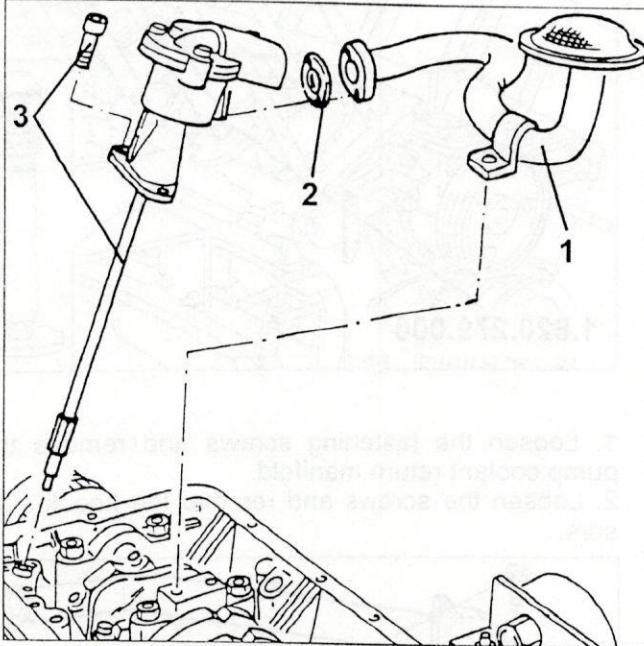
OIL PUMP REMOVAL

- Turn the engine on the overhaul bench.

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



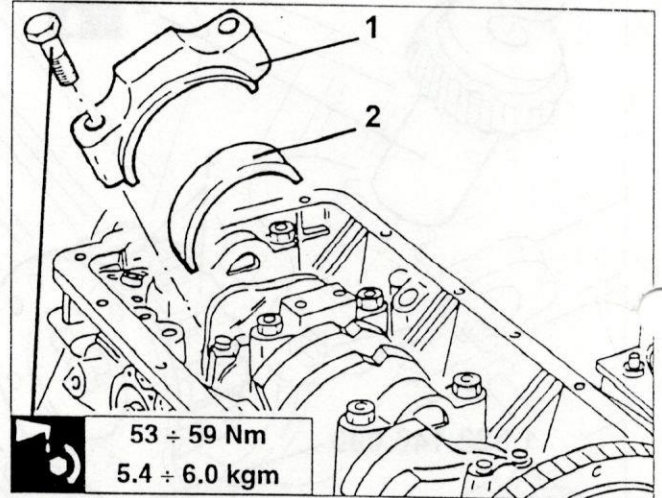
1. Loosen the fastening screws and remove the oil pump suction device.
2. Remove the respective seal.
3. Loosen the fastening screws and remove the complete oil pump.



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).

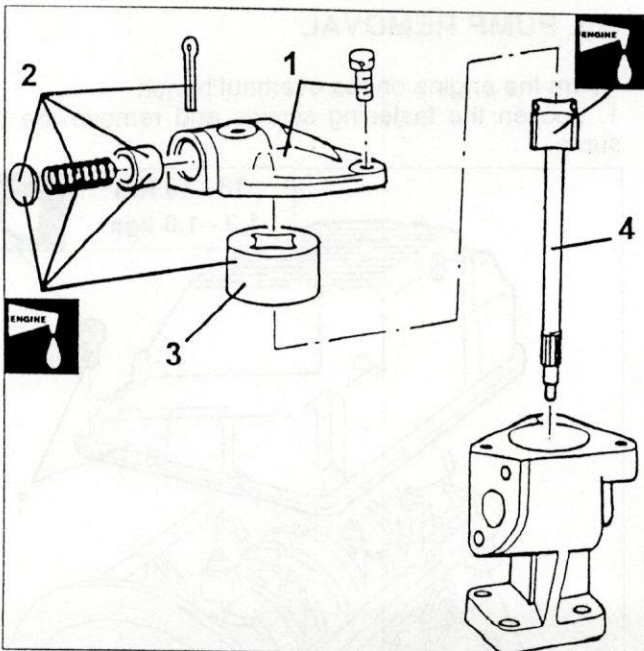
 1. Loosen the fastening nuts and remove cylinder 1, 2 and 3 connecting rod caps.
 2. Take the respective connecting rod half-bearings.



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.

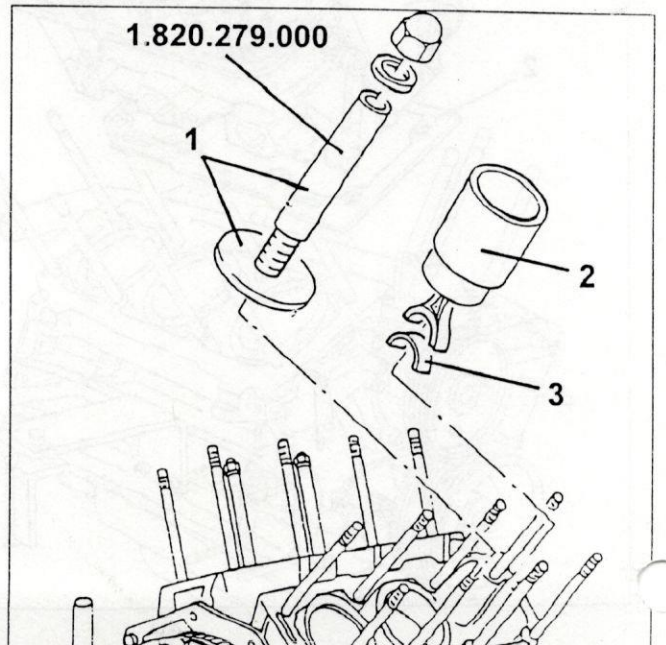
NOTE: Never remove the rotor from the shaft.



- 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.

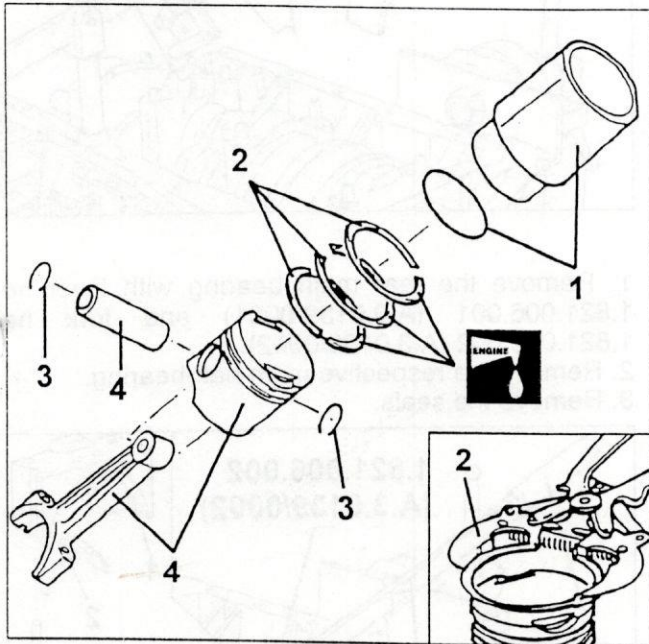
 - Turn the crankcase on the overhaul bench and perform the same operation on the left-hand bank (cylinders 4, 5 and 6).



1. Remove the cylinder liner and O-Ring.
2. Extract the gas rings and the oil scraper from the pistons with a suitable tool.

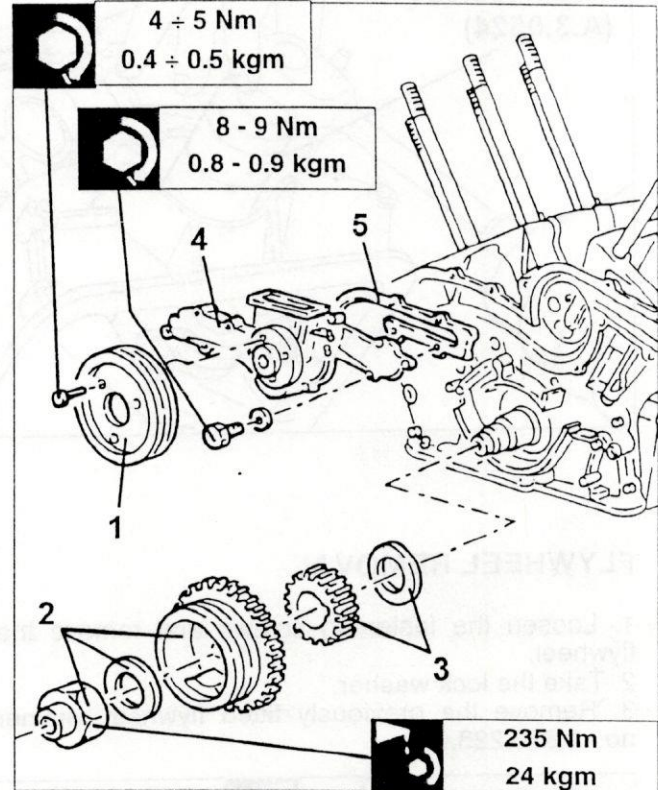
IMPORTANT: Be careful not to damage rings which could be re-used.

3. Extract the two pin snap rings.
4. Extract the pin and separate the piston from the connecting rod.



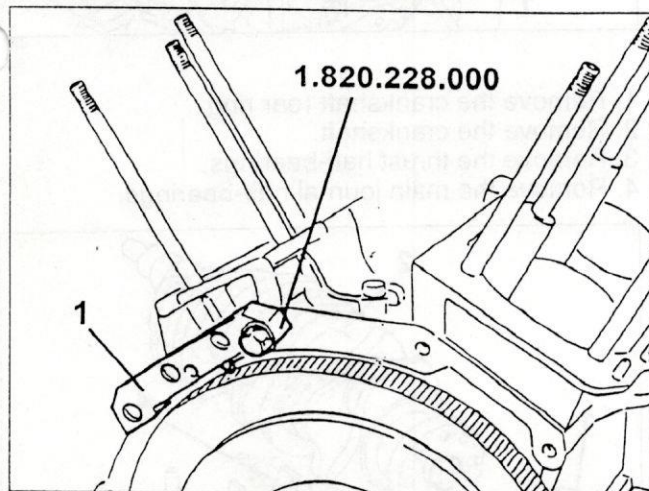
NOTE: When refitting, the thrust ring convex surface should face the front crankcase cover.

4. Loosen the fastening screws and remove the coolant pump.
5. Remove the respective seal.



COOLANT PUMP REMOVAL

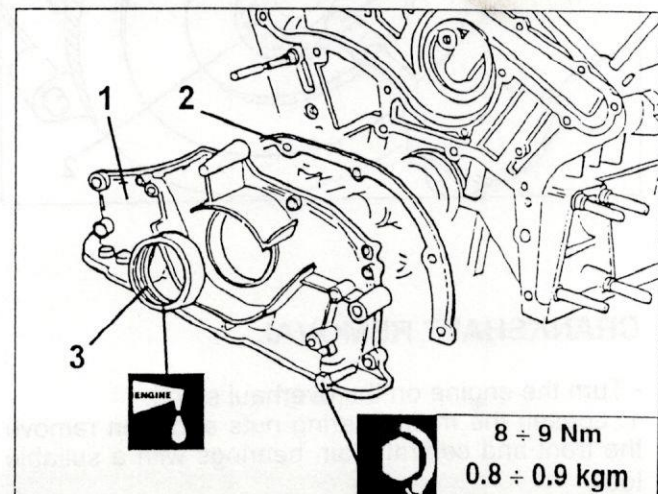
1. Remove the crankshaft rotation tool and fit the flywheel retainer no. 1.820.228.000.



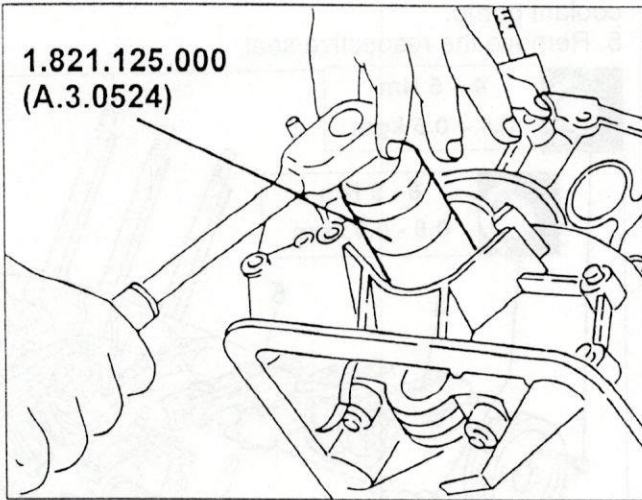
1. Loosen the fastening screws and remove the coolant pump.
2. Loosen the fastening nut and remove the auxiliary unit drive pulley.
3. Remove the timing belt pulley and thrust ring.

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.

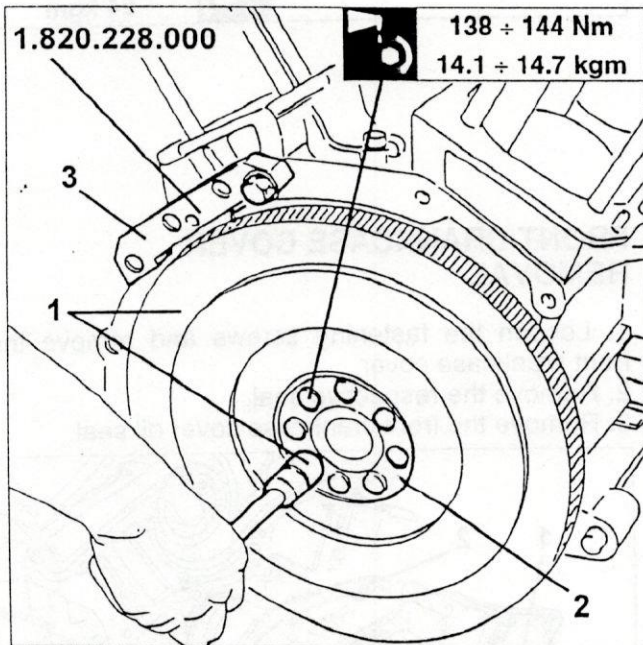


When refitting, fit a new front crankshaft oil seal on the crankcase with tool no. 1.821.125.000 (A.3.0524).



FLYWHEEL REMOVAL

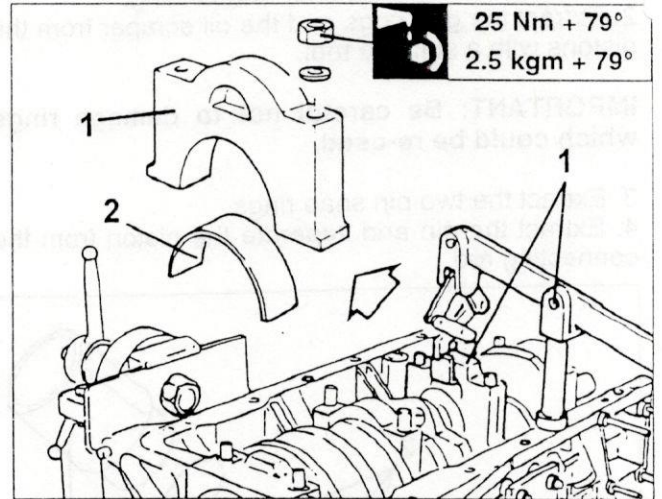
1. Loosen the fastening screws and remove the flywheel.
2. Take the lock washer.
3. Remove the previously fitted flywheel retainer no. 1.820.228.000.



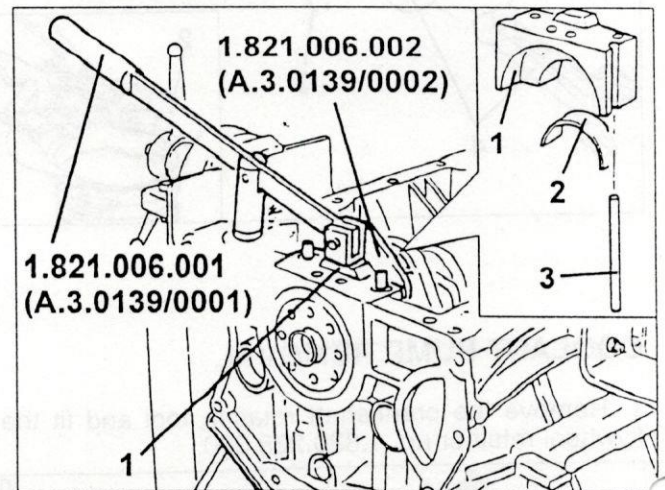
CRANKSHAFT REMOVAL

- Turn the engine on the overhaul stand.

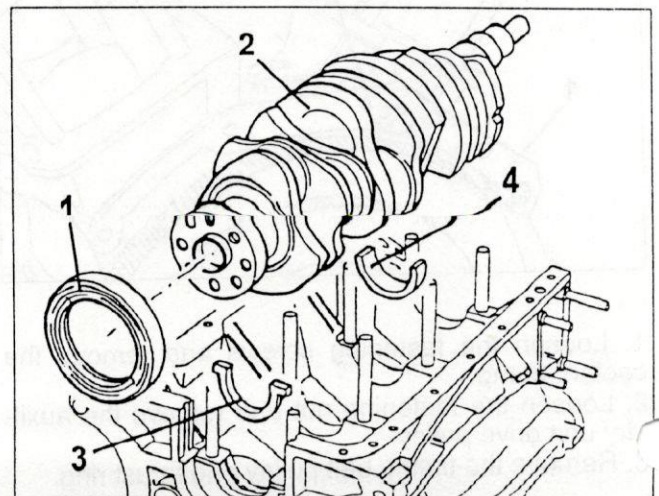
1. Loosen the main bearing nuts and then remove the front and central main bearings with a suitable tool.



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.



1. Remove the crankshaft rear ring.
2. Remove the crankshaft.
3. Remove the thrust half-bearings.
4. Remove the main journal half-bearings.

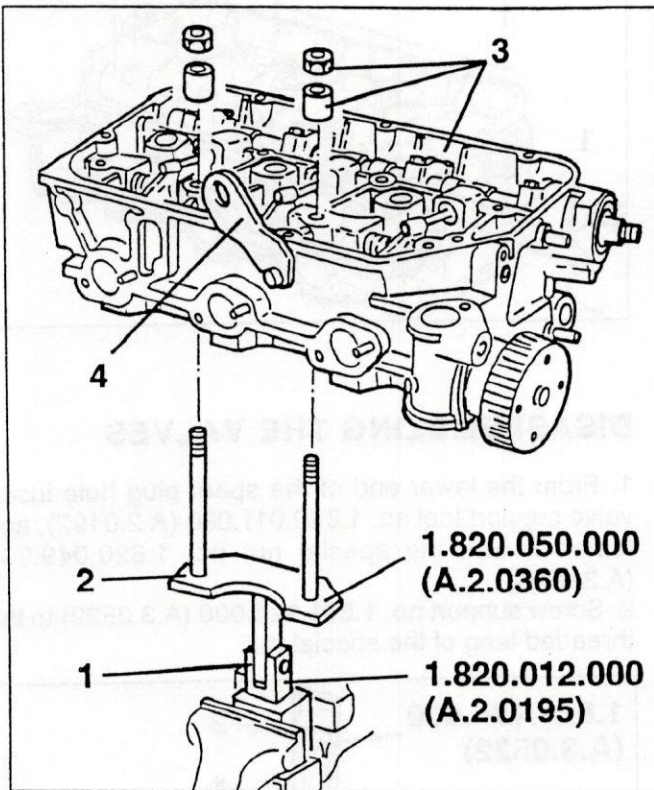


DIS-ASSEMBLING THE CYLINDER HEADS

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.

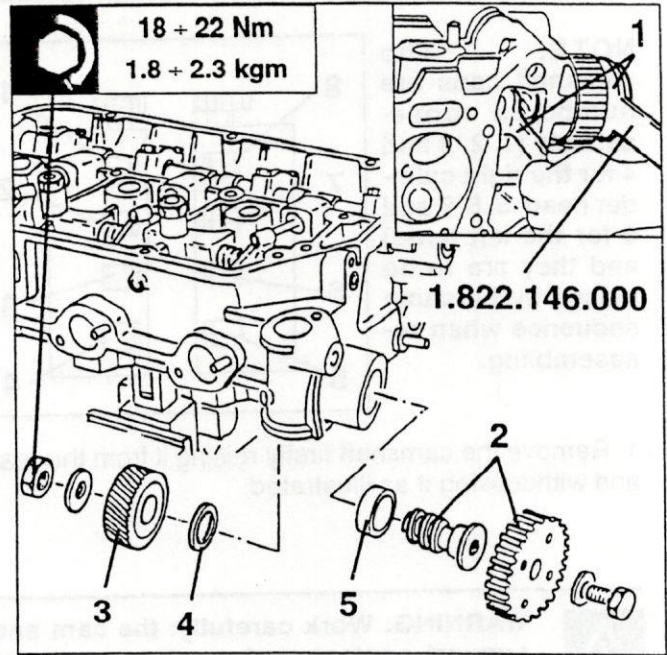
PRELIMINARY OPERATIONS

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.

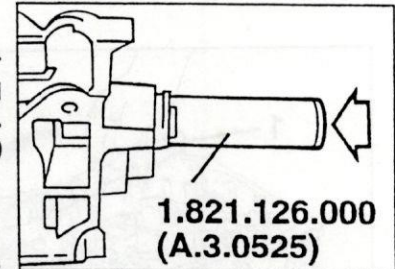


REMOVING THE OIL PUMP DRIVE PULLEY (Specific for the right-hand cylinder head)

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. Disassemble the remaining parts.



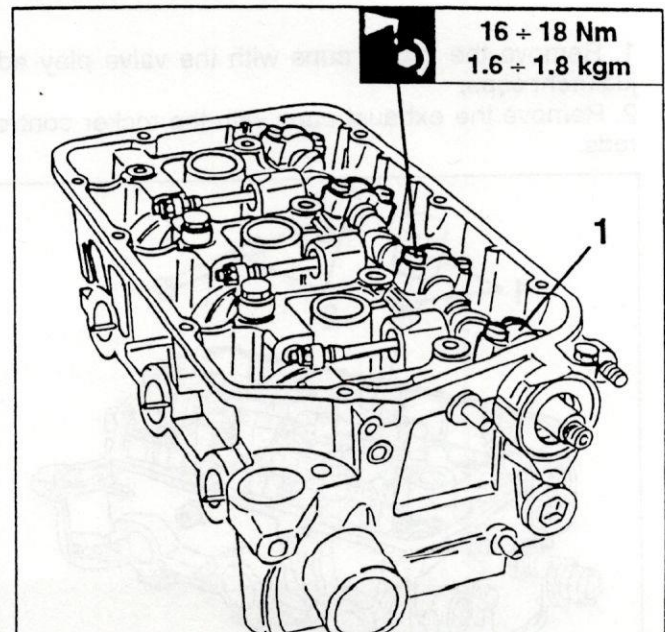
When refitting, insert a new oil ring using tool no. 1.821.126.000 (A.3.0525).



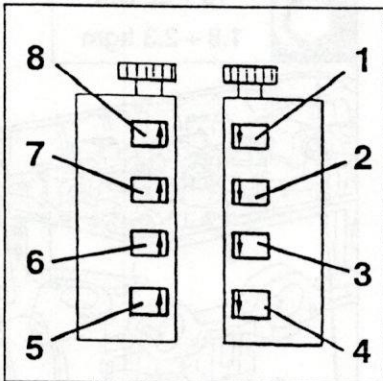
REMOVING

THE CAMSHAFT

1. Slacken the fastening nuts and remove the camshaft caps.



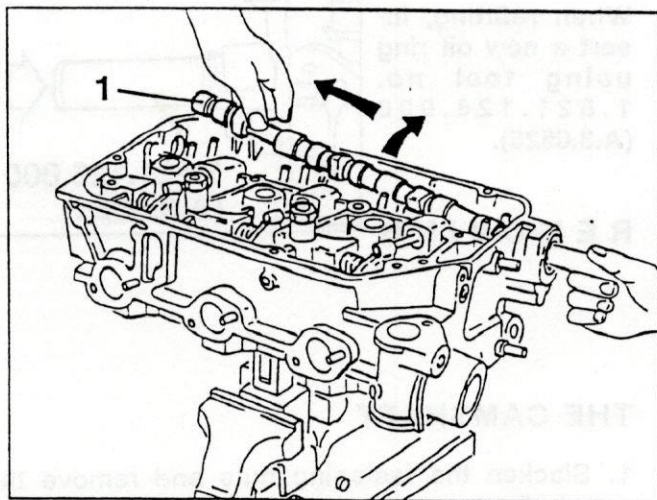
NOTE: The camshaft caps are numbered consecutively (1, 2, 3 and 4 for the right cylinder head; 5, 6, 7 and 8 for the left head) and they are to be placed in the same sequence when re-assembling.



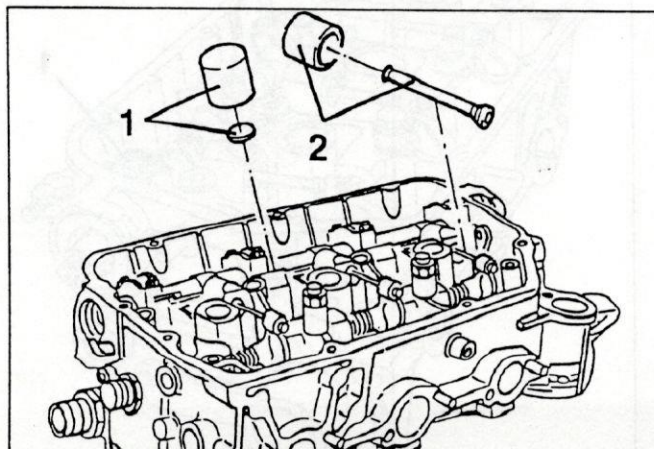
1. Remove the camshaft firstly raising it from the rear and withdrawing it as illustrated.



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.

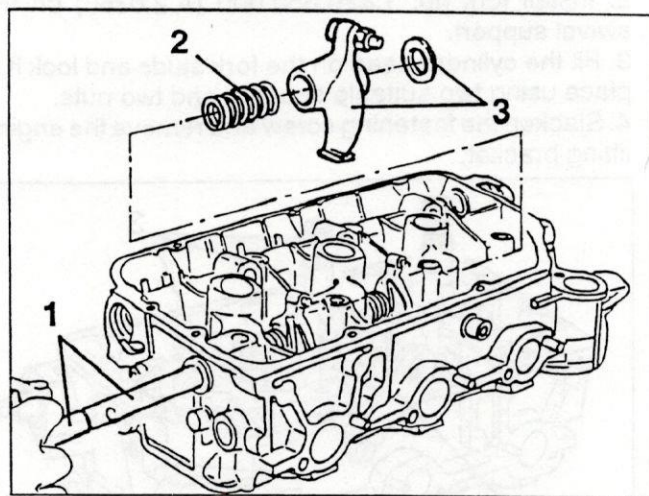


NOTE: Set the components in order in case they are re-used when refitting.

REMOVING THE ROCKERS

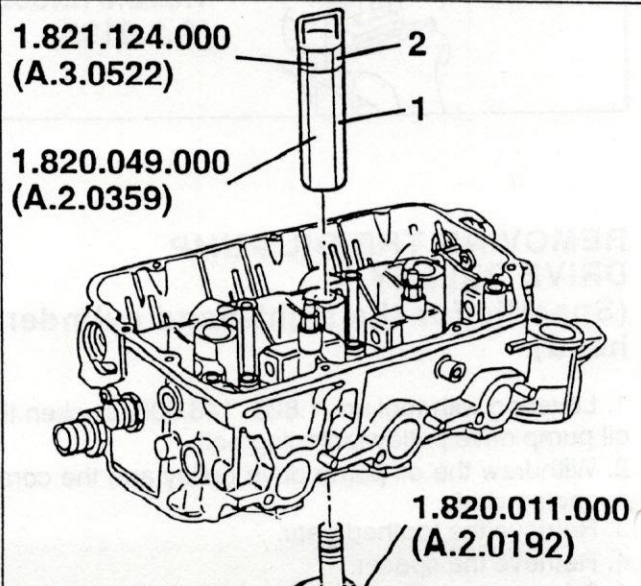
- Slacken and remove the rocker support shaft housing plug.

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.

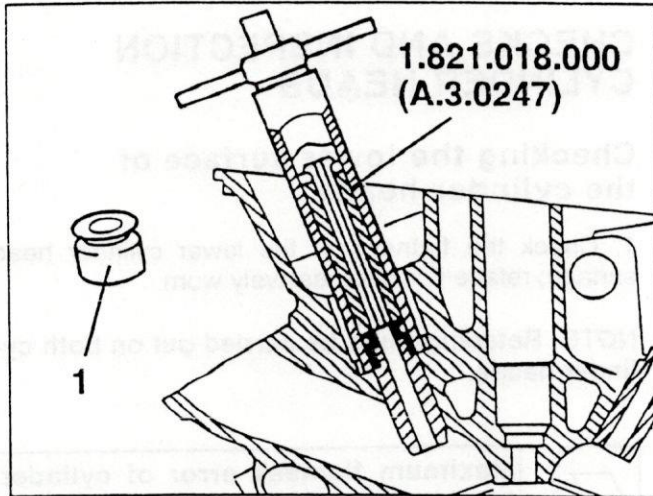
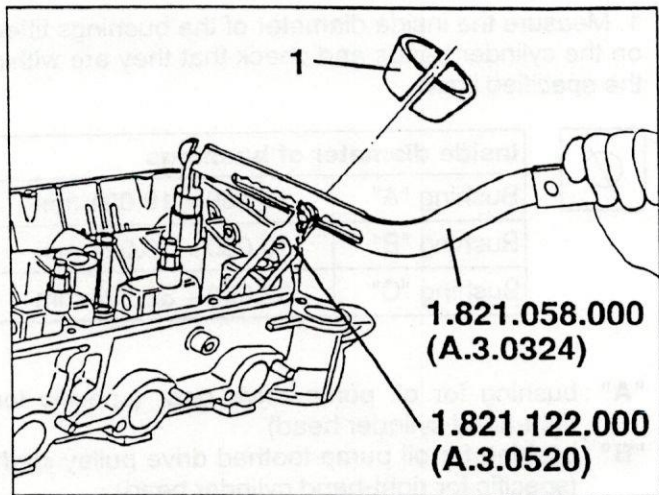


DISASSEMBLING THE VALVES

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.

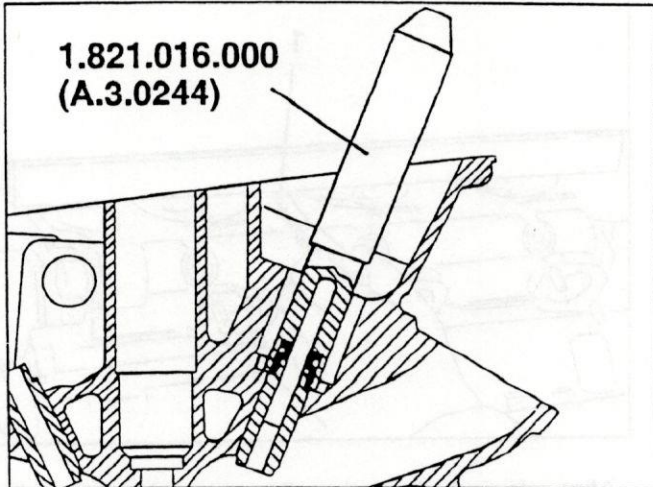
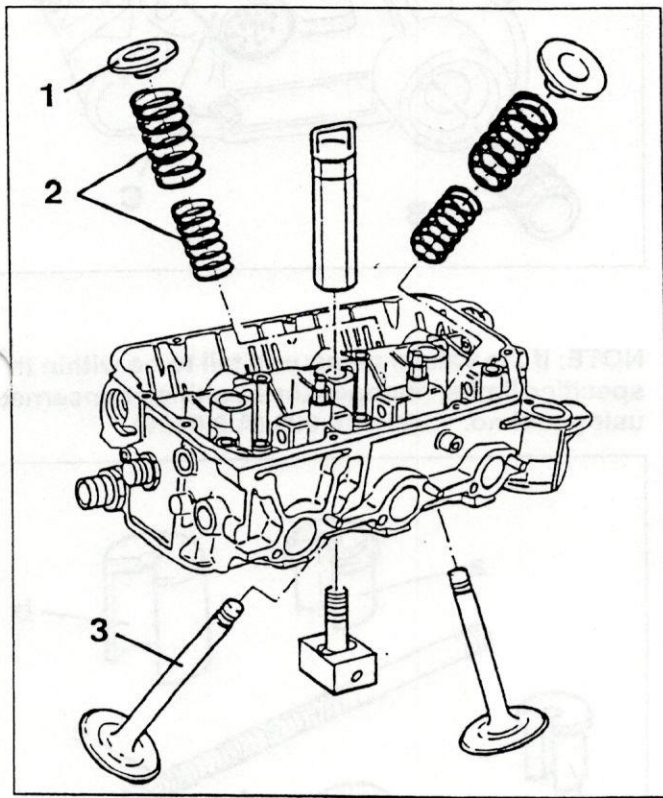


1. Using lever no. 1.821.058.000 (A.3.0324) and cage no. 1.821.122.000 (A.3.0520) remove the half cones.



When refitting, insert new oil seal caps using tool no. 1.821.016.000 (A.3.0244).

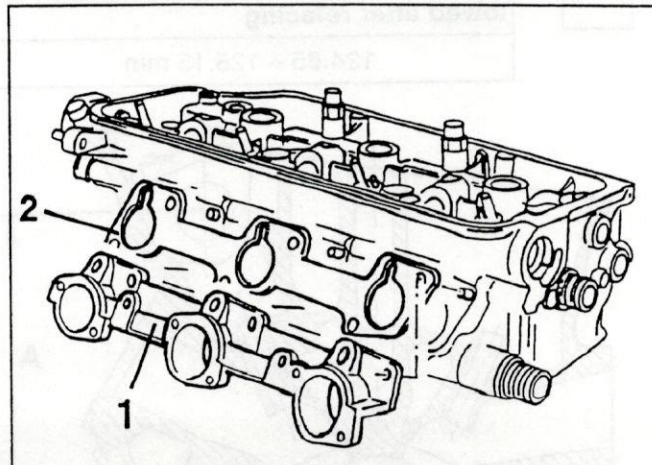
1. Remove the upper plates.
2. Remove the outer and inner springs.
3. Remove the tools used for removing the valves and remove the intake and exhaust valve pair.



- 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.



- 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),

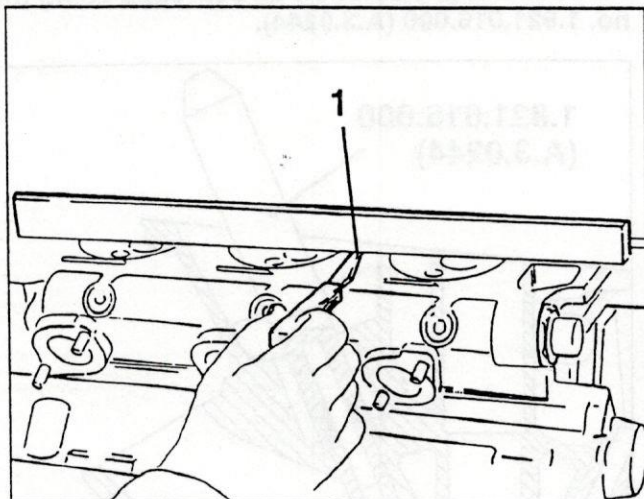
CHECKS AND INSPECTION CYLINDER HEADS

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.

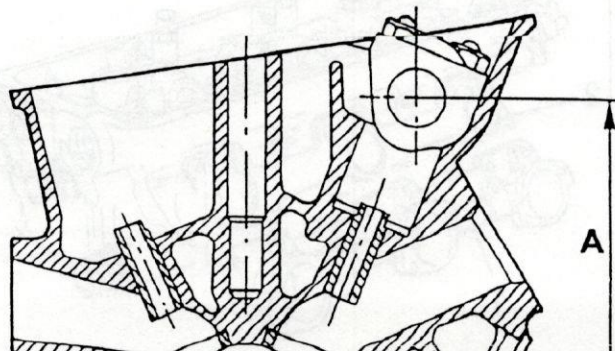
	Maximum flatness error of cylinder head lower surface
	0.05 mm



- 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

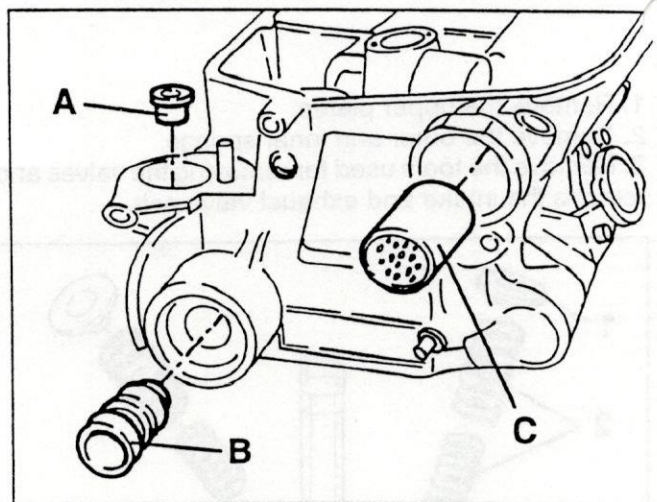


Checking the cylinder head bushings

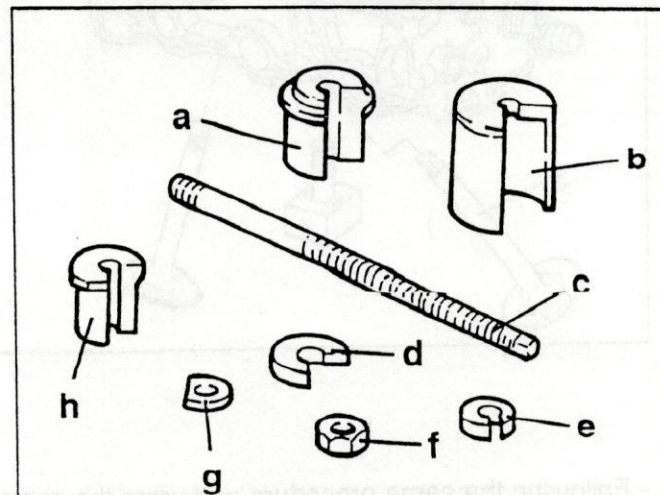
1. Measure the inside diameter of the bushings fitted on the cylinder heads and check that they are within the specified limits.

	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).

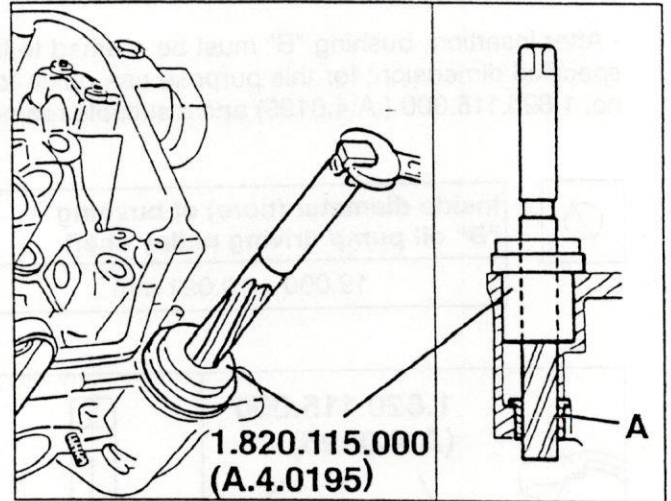
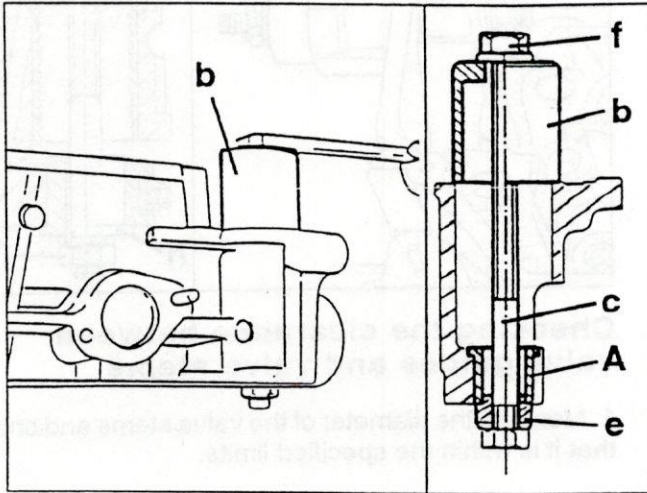


a. Coil
b. Cup

e. Special washer
f. Hexagon nut

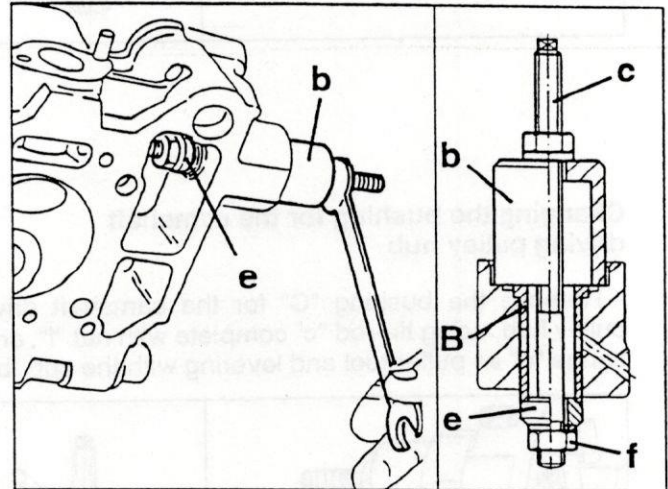
Changing the bushing for oil pump driving gear (specific for right-hand cylinder head)

- 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".

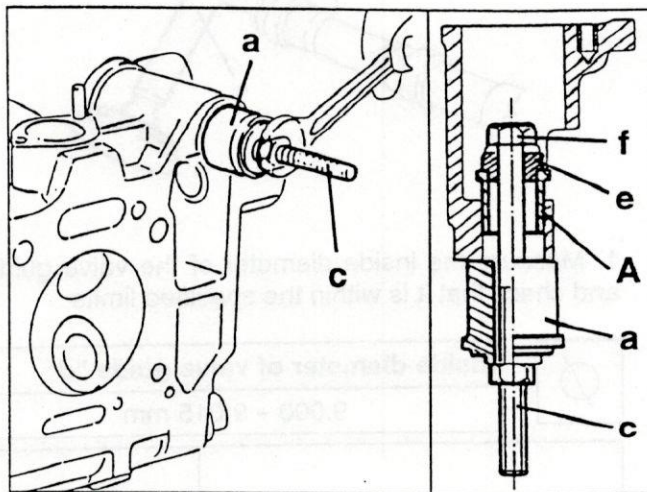


Changing the bushing for oil pump toothed driving pulley shaft (specific for right cylinder head)

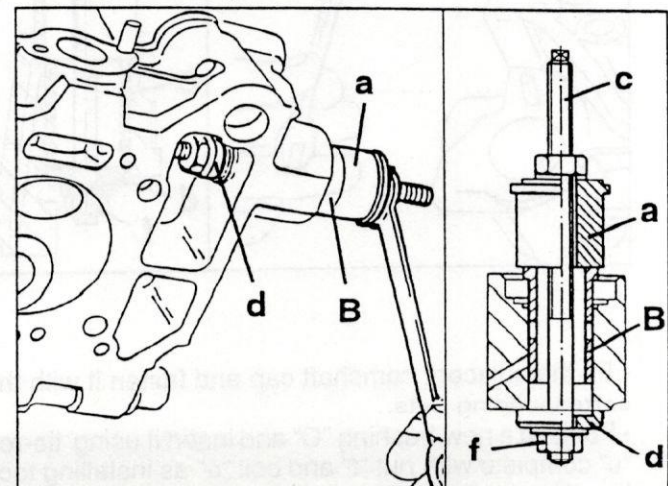
- Remove the bushing "B" for oil pump toothed driving pulley shaft, using tie-rod "c" complete with nut "f", the special washer "e" as puller tool and levering with the cup "b".



- 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.

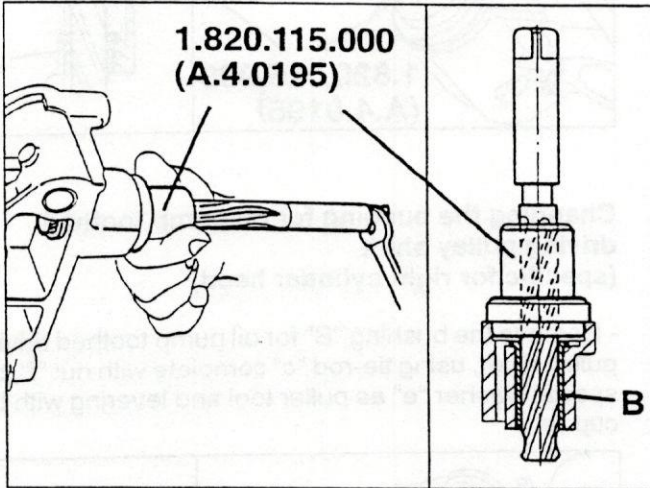


Inside diameter (bore) of bushing "A" for oil pump driving gear

19.000 ± 0.021 mm

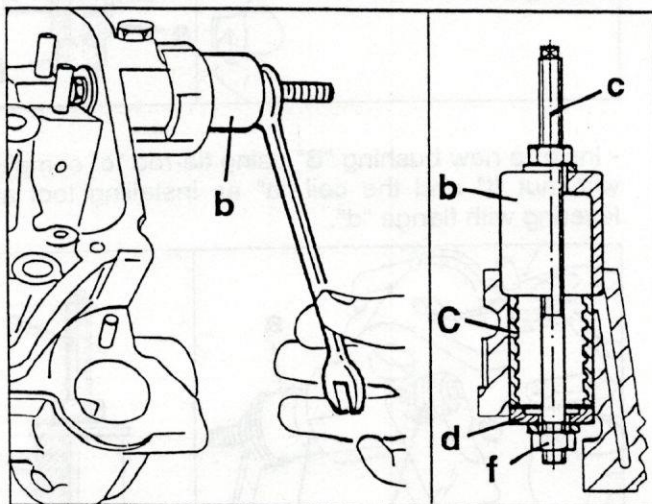
- After insertion, bushing "B" must be reamed to the specified dimension; for this purpose use guide tool no. 1.820.115.000 (A.4.0195) and a suitable reamer.

∅	Inside diameter (bore) of bushing "B" oil pump driving pulley shaft
	19.000 + 19.021 mm



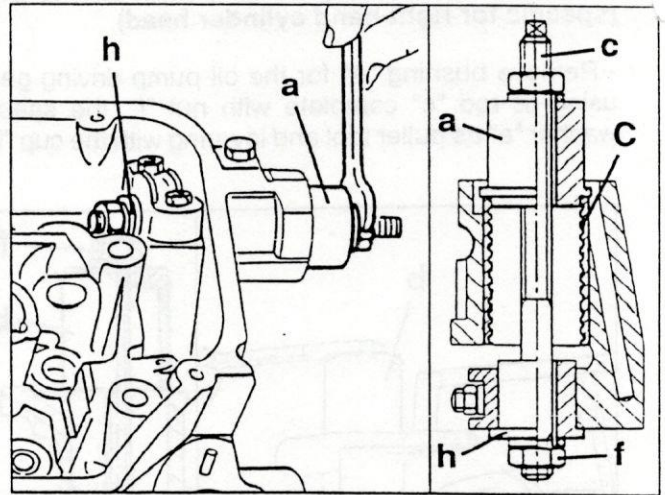
Changing the bushing for the camshaft driving pulley hub

- 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.

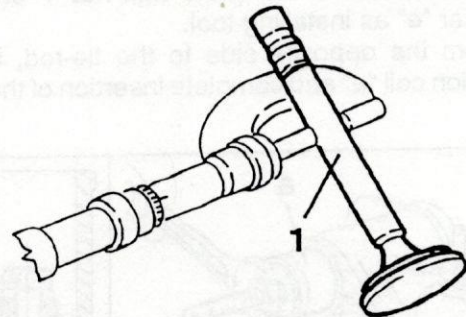
- Position a new bushing "C" and insert it using tie-rod "c" complete with nut "f" and coil "a" as installing tool



Checking the clearance between valve guides and valve stems

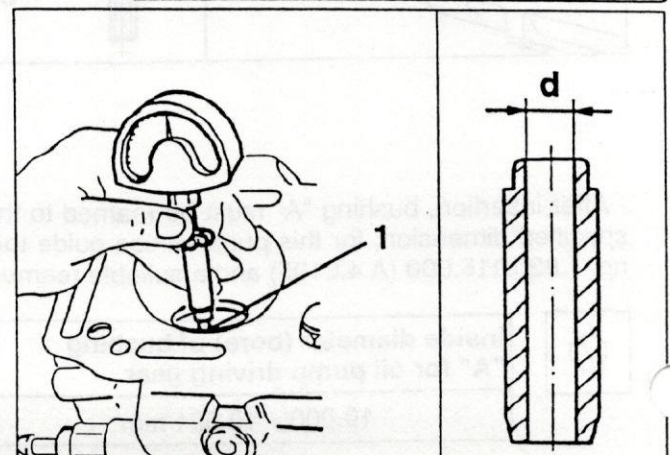
1. Measure the diameter of the valve stems and check that it is within the specified limits.

∅	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	



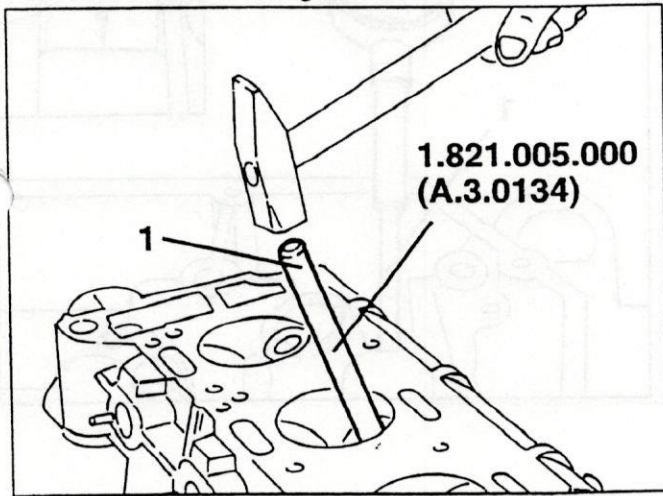
- Calculate the clearance between valve guides and valve stems and check that it is within the specified limits; if not, change any worn parts.



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.

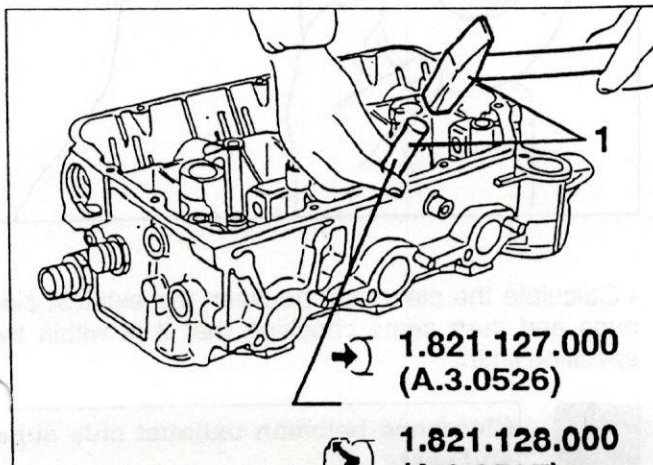


Outside diameter of valve guides	14.048 + 14.059 mm
Diameter of valve guide seats	13.990 + 14.018 mm



Seats - valve guide interference	0.030 + 0.069 mm
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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

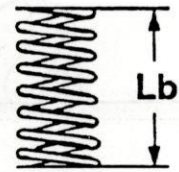
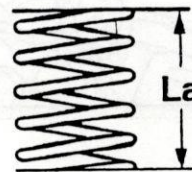
- Check that the "free" length of the valve springs is within the specified limits.

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

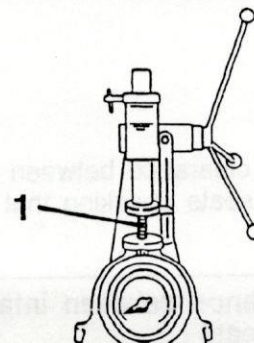
Outer spring "La"	44.6 mm
Inner spring "Lb"	44.1 mm



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)

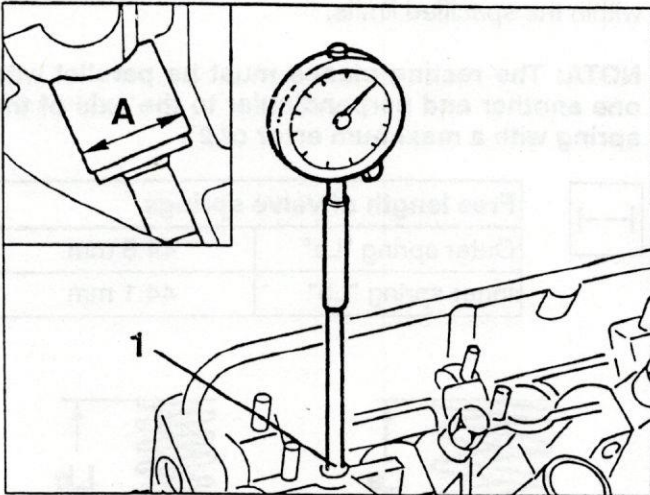




Checking the clearance between the intake side cups and their seats

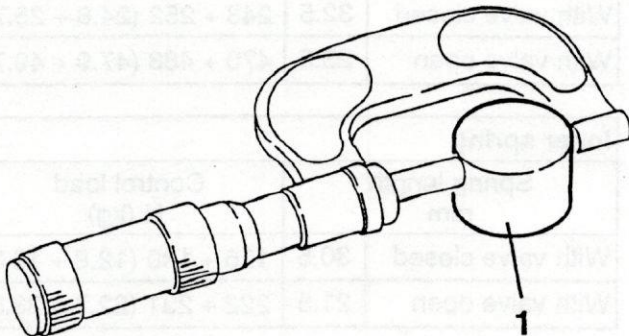
1. Check that the diameter of the intake side cup seats is within the specified limits.

∅	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



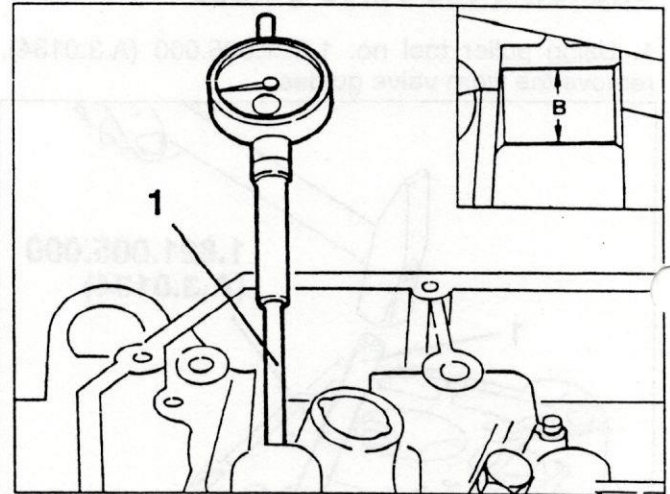
- Calculate the clearance between the intake side cups and their seats checking that it is within the specified limits.

	Clearance between intake side cups and seats
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Checking the clearance between the exhaust side cups and their seats

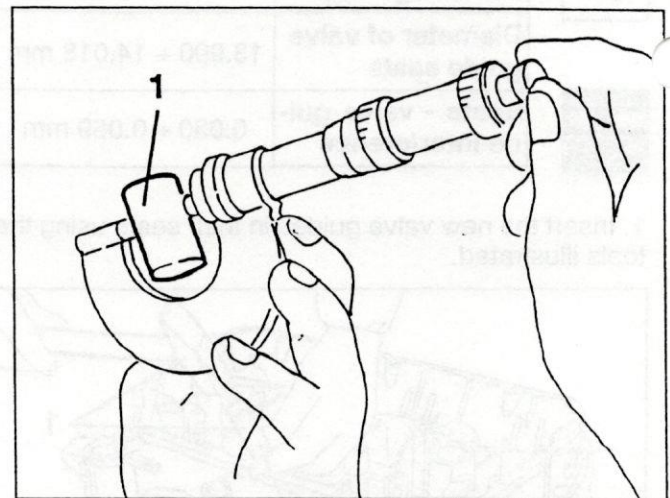
1. Check that the diameter of the exhaust side cup seats is within the specified limits.

∅	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



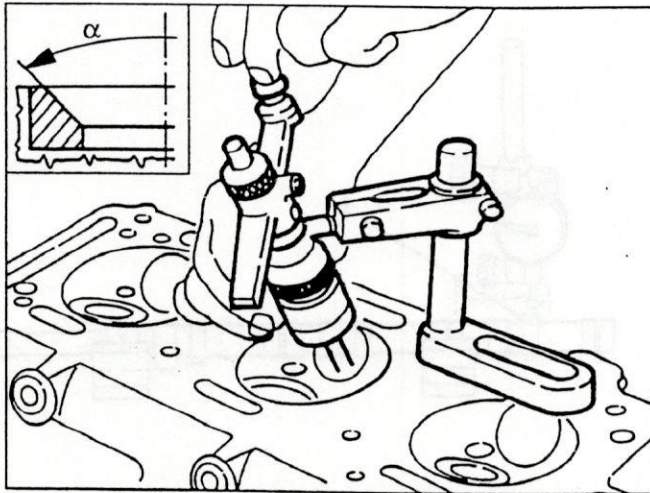
- Calculate the clearance between the exhaust side cups and their seats checking that it is within the specified limits.

	Clearance between exhaust side cups and seats
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Turning the valve seats

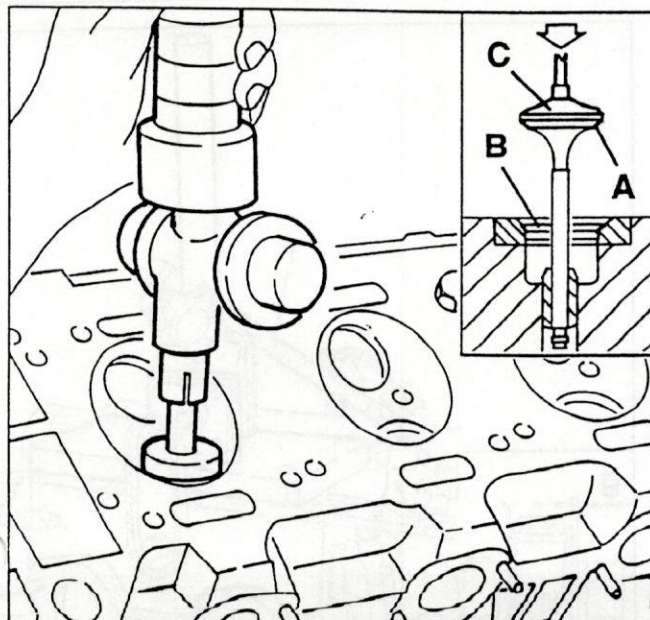
- If necessary, turn the valve seats using suitable equipment.

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



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

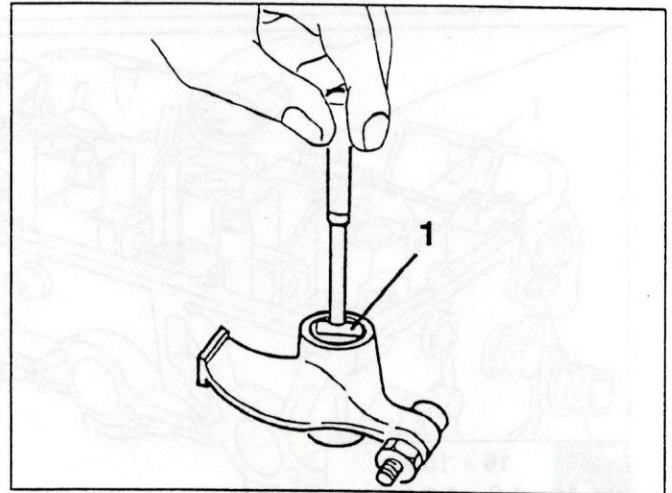
- coat the contact surfaces "A" and "B" of the valves and their seats with abrasive paste (SIPALAREXONS Carbosilicium for valves);
- lubricate the valve stem with engine oil;
- fit the lower surface of the valve mushroom to the suction cup "C" of a pneumatic grinder;
- insert the valve in its guide and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



Checking the clearance between rockers and support shaft

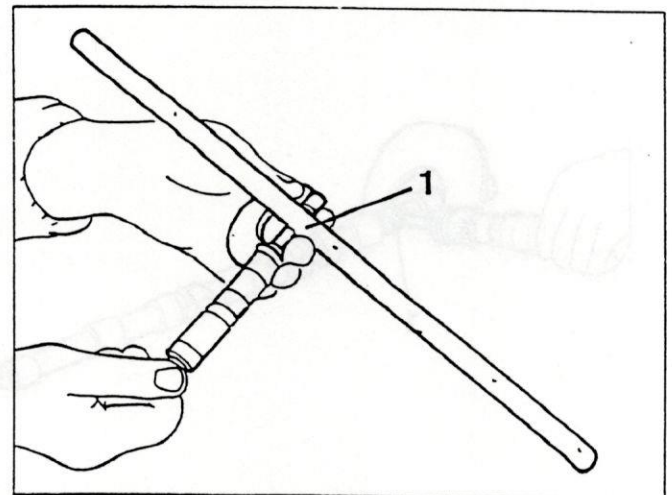
1. Check that the inside diameter of the rockers is within the specified limits.

	Inside diameter of rockers
	16.010 ± 16.028 mm



1. Check that the diameter of the rocker shaft is within the specified limits.

	Diameter of rocker support shaft
	15.988 ± 16.000 mm



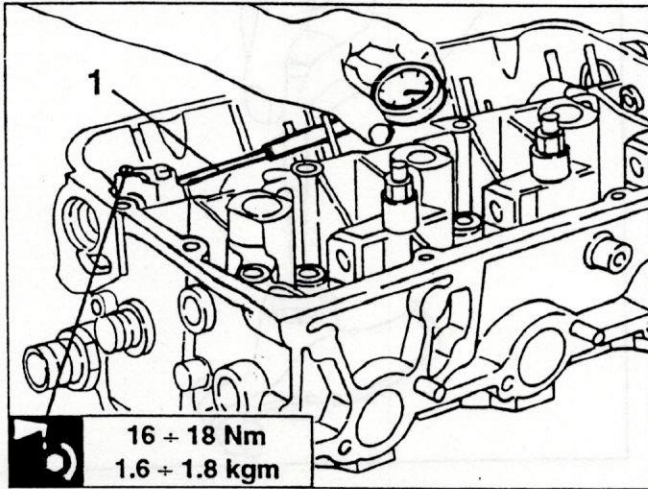
- Calculate the clearance between rockers and support shaft checking that it is within the specified limits.

	Clearance between rockers and support shaft
--	--

Supports and camshafts

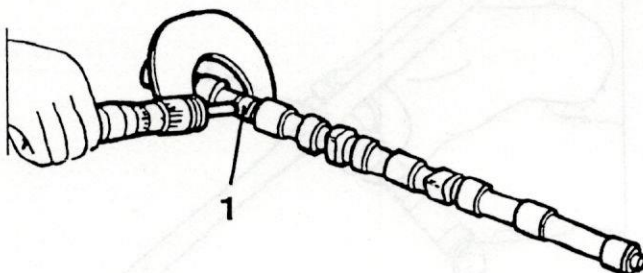
1. Assemble the camshaft caps and tighten the corresponding fastening screws to the specified torque, then check that the diameter of the supports is within the specified limits.

∅	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

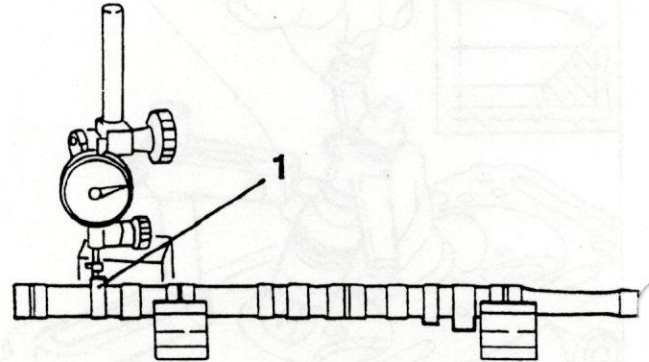


- Calculate the clearance between the camshaft journals and their bearings and check that it is within the specified limits.

↕	Clearance between camshafts and bearings

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

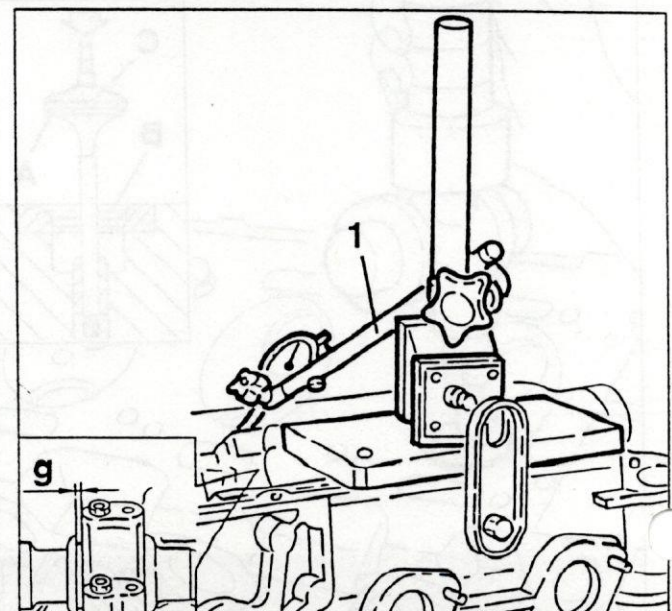


Checking the camshaft end float

- 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.

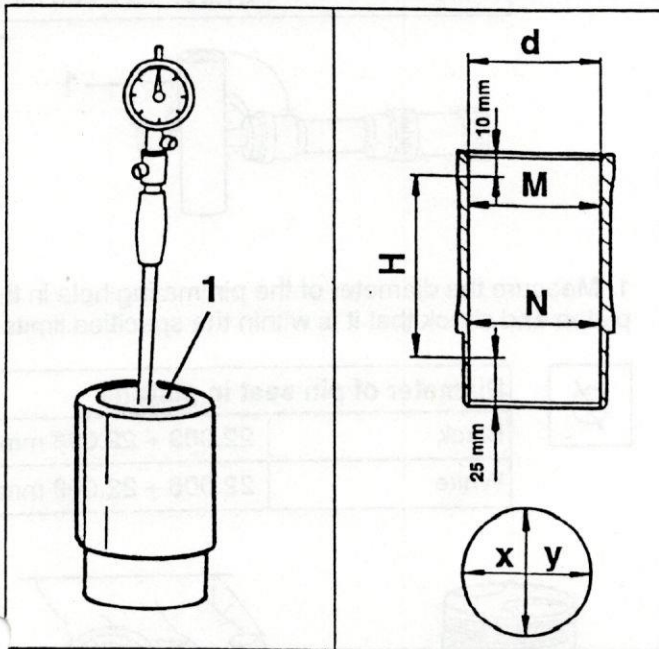
Checking the cylinder liners

1. 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

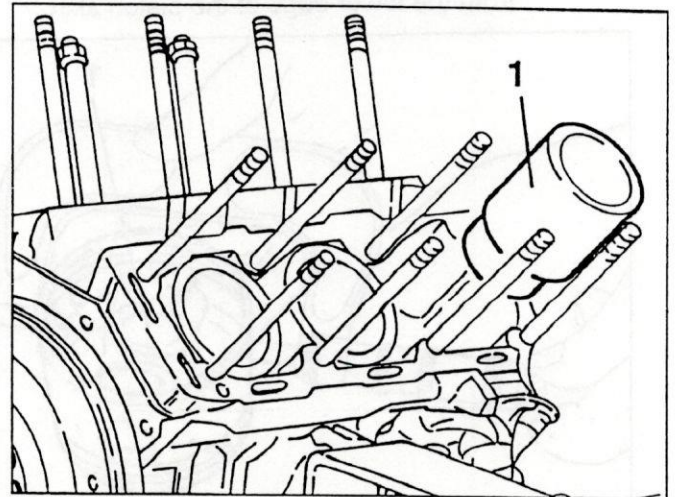


H : Area for dimensional inspection

Checking the cylinder liner protrusion (without seal rings)

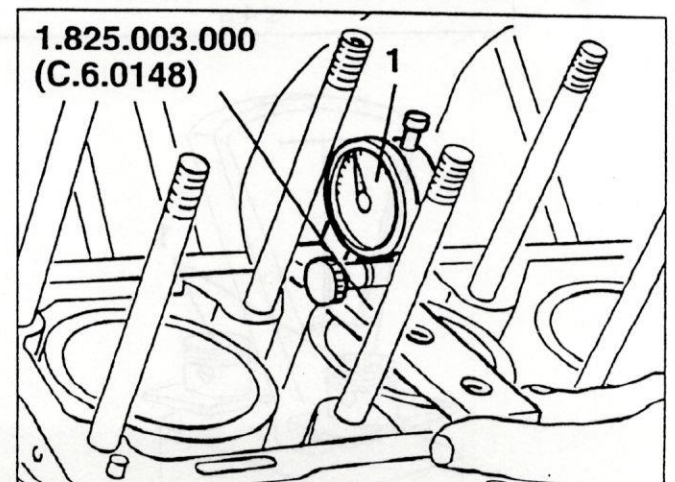
NOTE: This procedure, to be carried out as a preliminary control of the correct coupling between the cylinder liners and crankcase, should be carried out without the seal rings, therefore there is no need for the liner stopper tool, which if tightened to the specified torque would annul the thickness.

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.

\parallel	Cylinder liner protrusion from crankcase
	0.01 + 0.06 mm



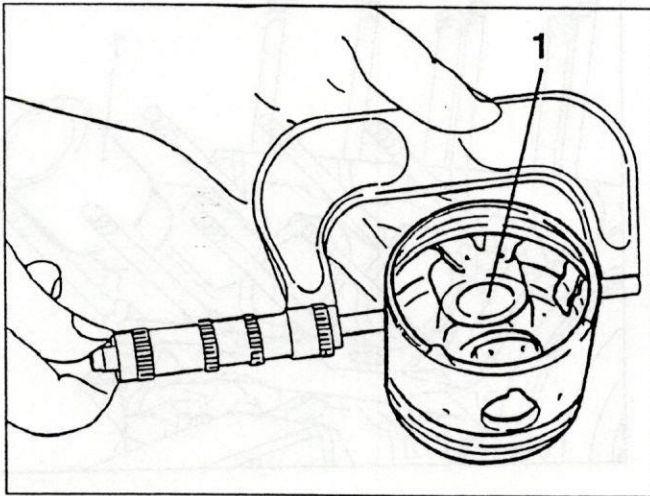
Checking the pistons

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.

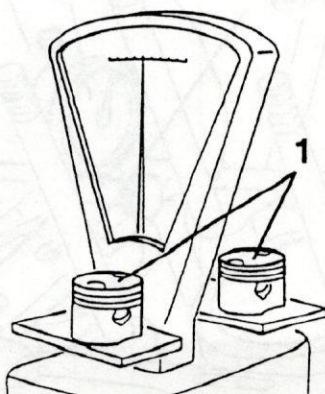


Clearance between piston and cylinder liners	
0.050 + 0.069 mm	

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	

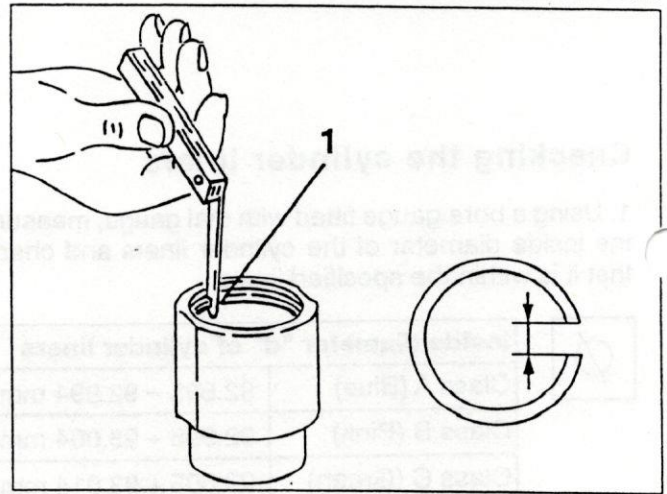


Checking the seal ring gap

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

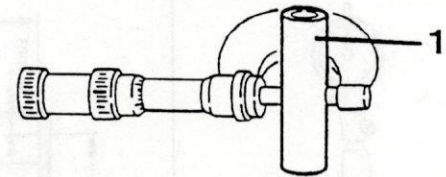


Checking the play between gudgeon pins and seats on pistons

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



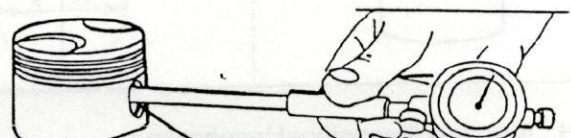
Outside diameter of gudgeon pins	
Black	21.994 + 21.997 mm
White	21.997 + 22.000 mm



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.



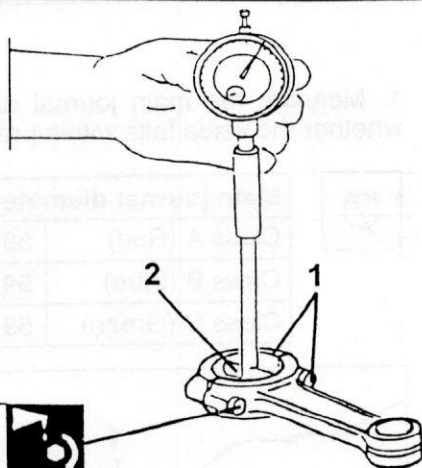
Play between pins and piston seats	
0.006 ÷ 0.012 mm	

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

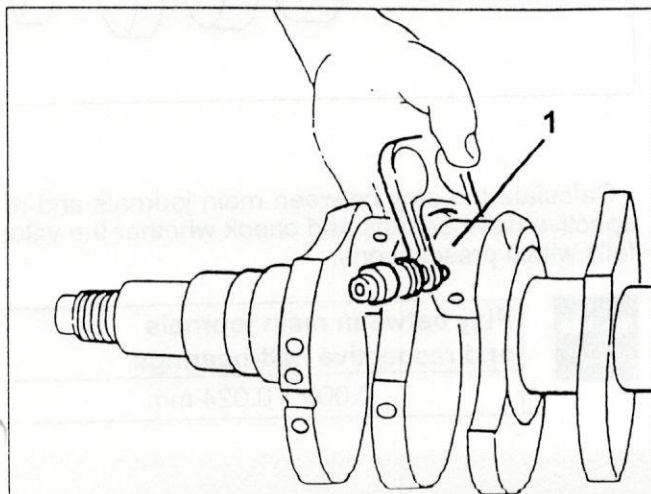


53 ÷ 59 Nm
5.4 ÷ 6.0 kgm

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.



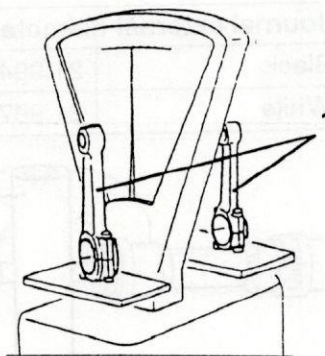
Connecting rod journals and respective half-bearing diameter	
Class A (Red)	0.021 ÷ 0.060 mm
Class B (Blue)	0.023 ÷ 0.062 mm

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.

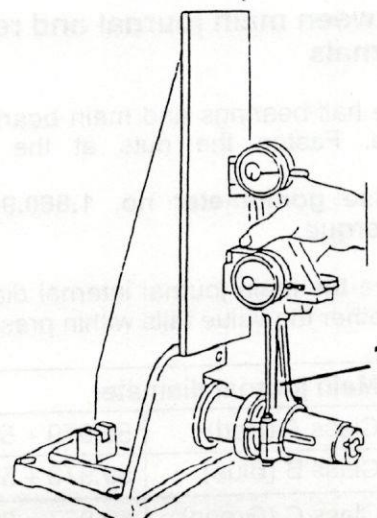


Connecting rod weight difference	
± 4 g	



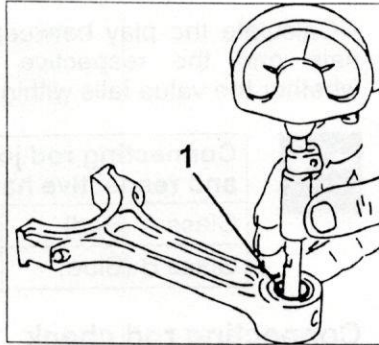
1. Check connecting rod squaring with a reference as shown in the figure.

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

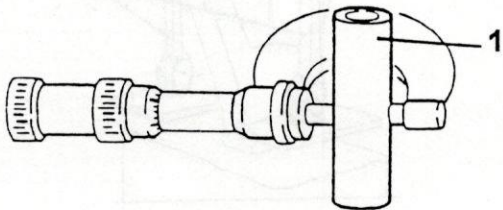
1. Measure the connecting rod small end internal diameter. Check whether the value falls within prescriptions. If not, replace it.



∅	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

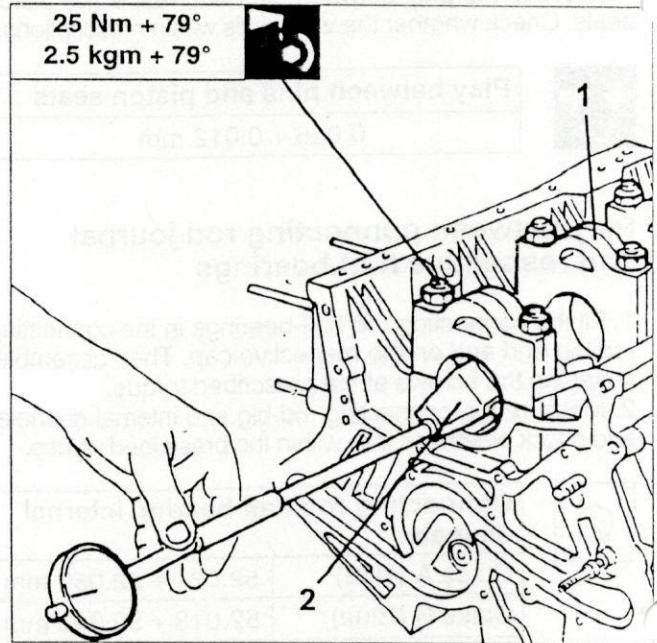
Play between main journal and respective half-journals

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.

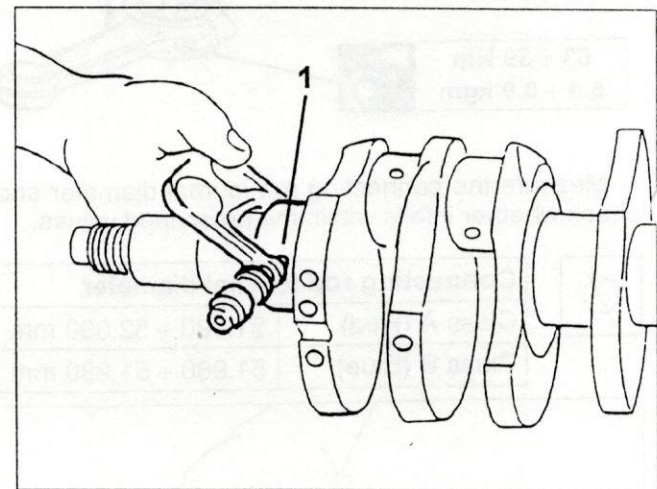
2. Measure the main journal internal diameter and check whether the value falls within prescriptions.

∅	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



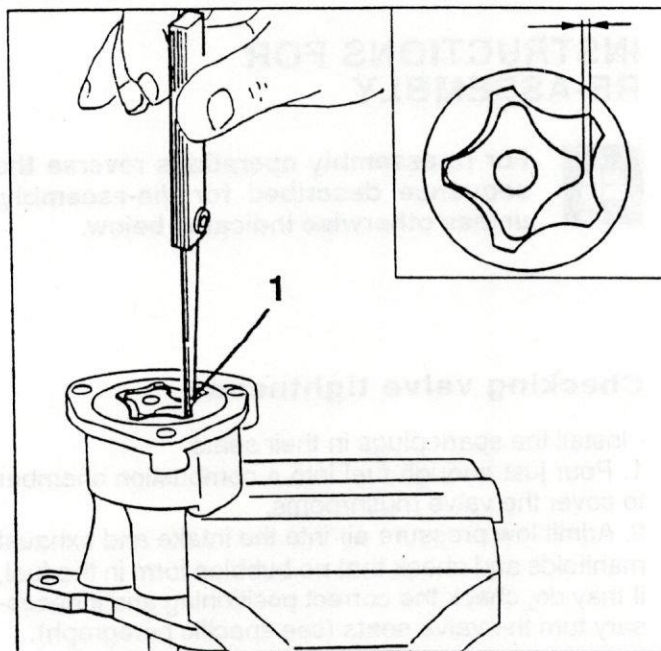
- Calculate the play between main journals and respective half-bearings and check whether the value falls within prescriptions.

↔	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.



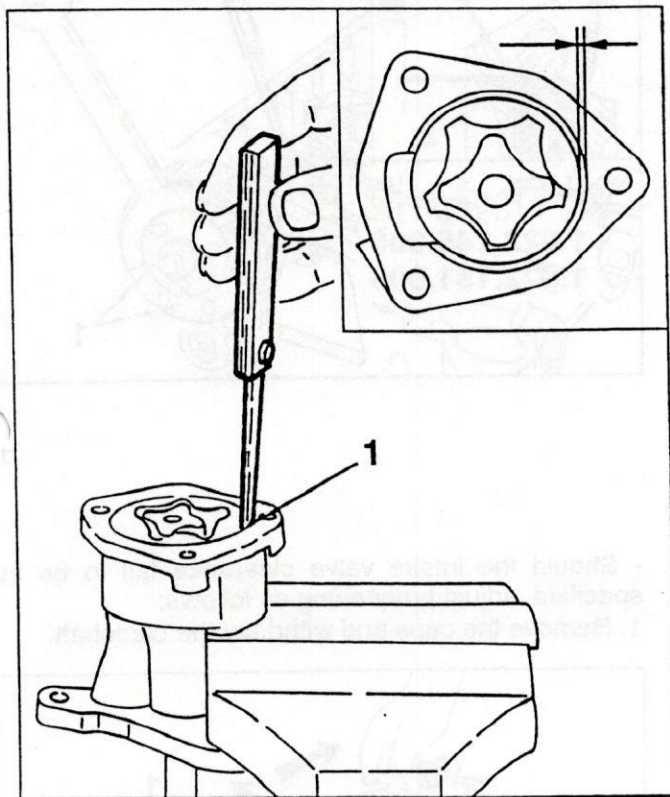
Checking the oil pump

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

$0.170 + 0.275 \text{ mm}$



1. Check that the clearance between the lobe of the inner gear and that of the driven gear is within the specified limits.

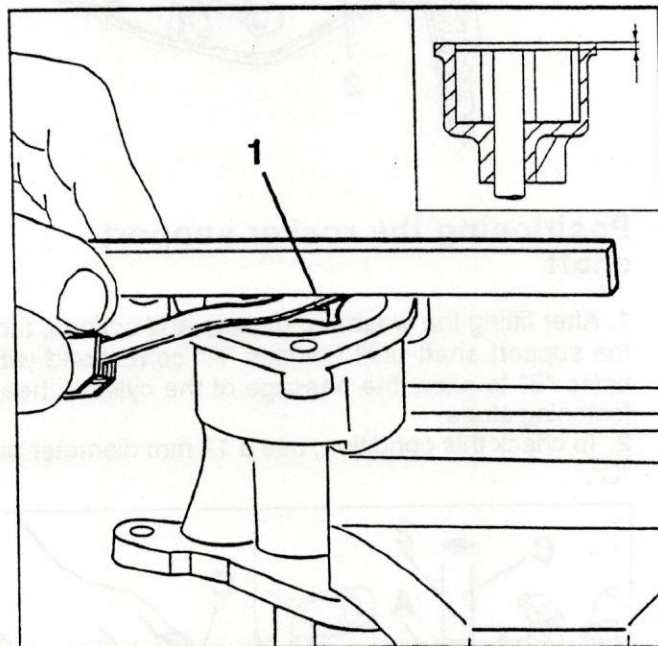


Clearance between driven gear and inner gear



Clearance between pump casing rest surface and upper side of gears

$0.025 + 0.075 \text{ mm}$



- 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

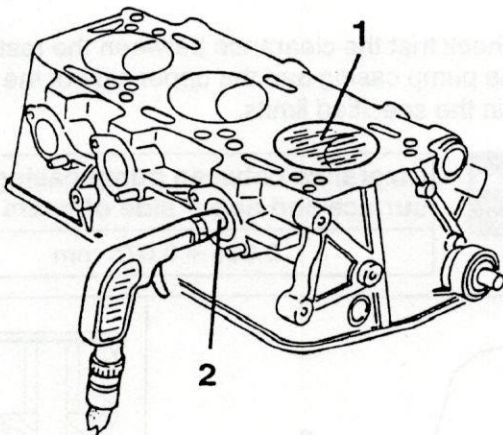


For re-assembly operations reverse the sequence described for dis-assembly, unless otherwise indicated below.

Checking valve tightness

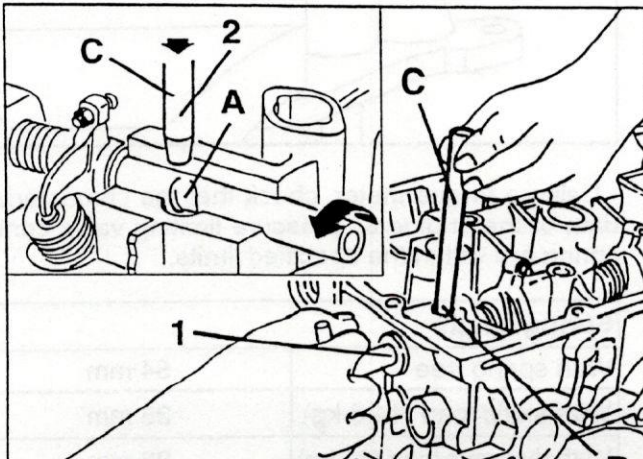
- Install the spark plugs in their seats.

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

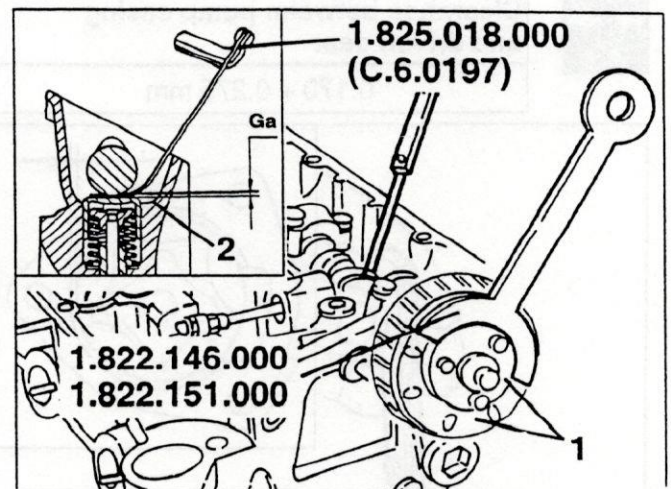
- After refitting the camshaft, measure the clearance of the intake valves as follows:

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.



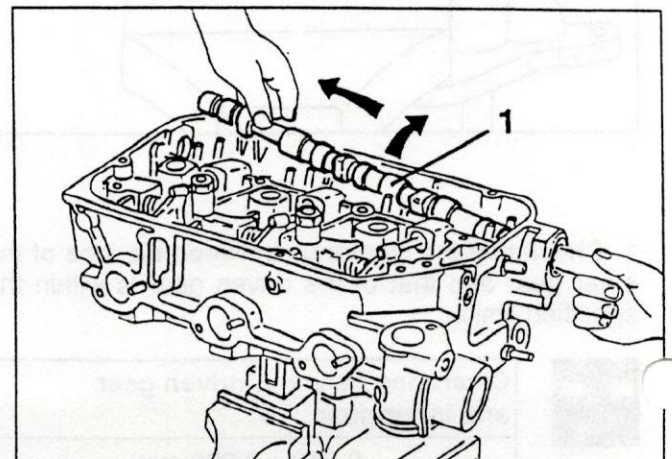
Intake valve clearance "Ga"

0.5 mm

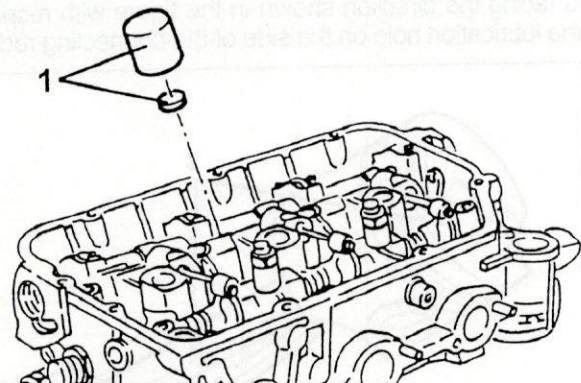


- Should the intake valve clearance fail to be as specified, adjust proceeding as follows:

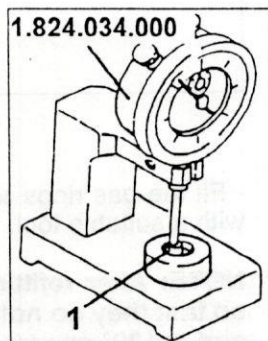
1. Remove the caps and withdraw the camshaft.



1. Remove the cups and remove the tappet clearance adjustment caps.



1. 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.

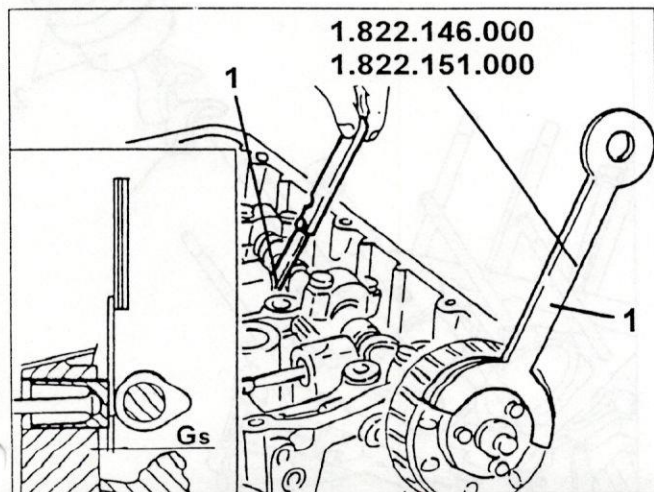


- Refit the cups, the camshaft and the respective caps. Fasten the caps at the prescribed torque and check the intake tappet clearance.

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.

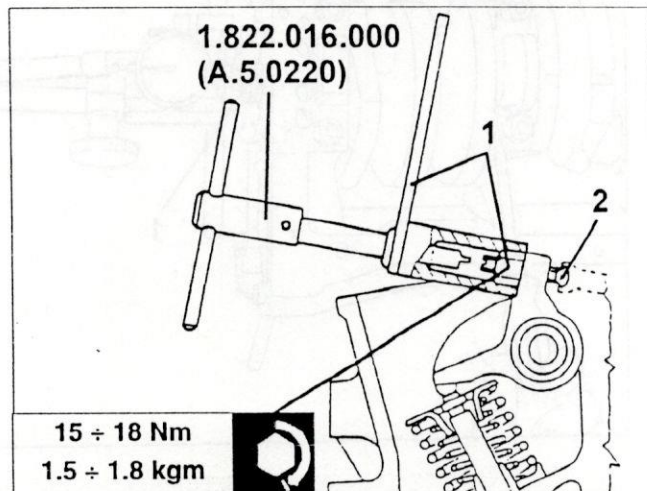


"Gs" exhaust tappet clearance

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

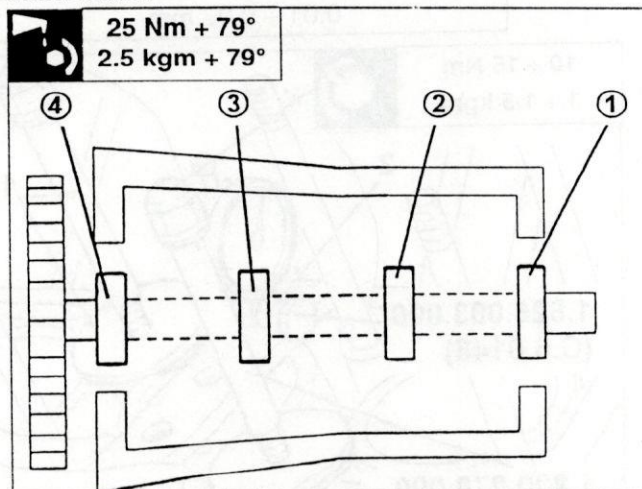
- Fit the crankshaft with half-bearings and thrust rings on the crankcase.

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.

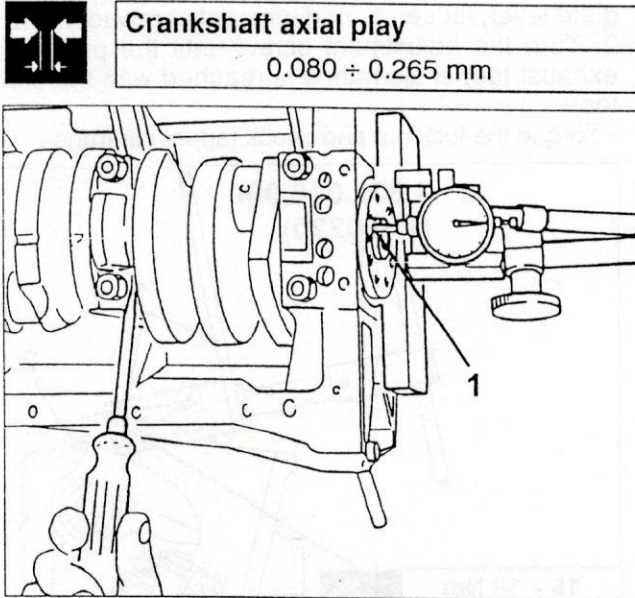
NOTE: Use goniometer no. 1.860.942.000 for angle torque.

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



Crankshaft axial play

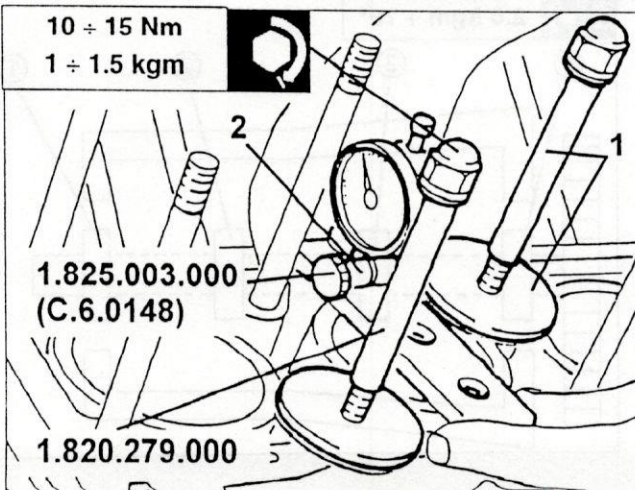
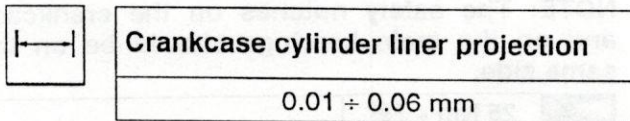
1. Check whether crankshaft axial play falls within prescribed values by means of a centesimal gauge applied with its magnetic base.



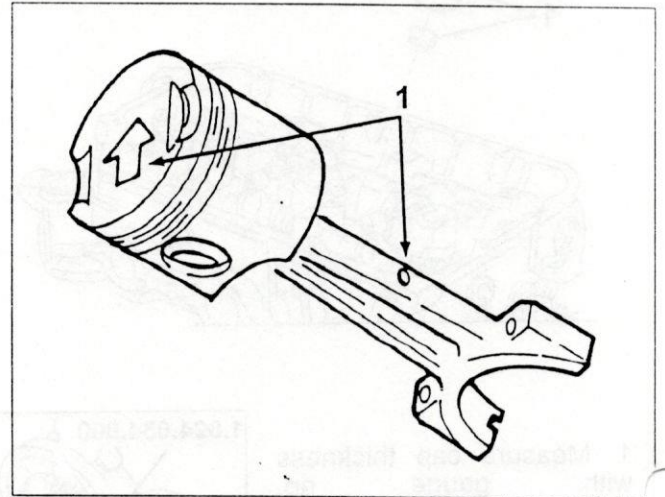
Cylinder liner, piston and connecting rod refitting

- 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.



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.

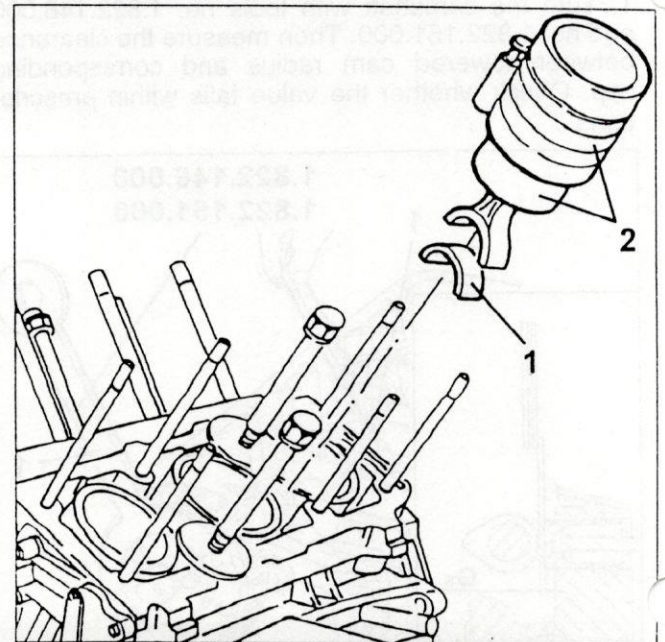


- Fit the gas rings and the oil scraper on the piston with a suitable tool.

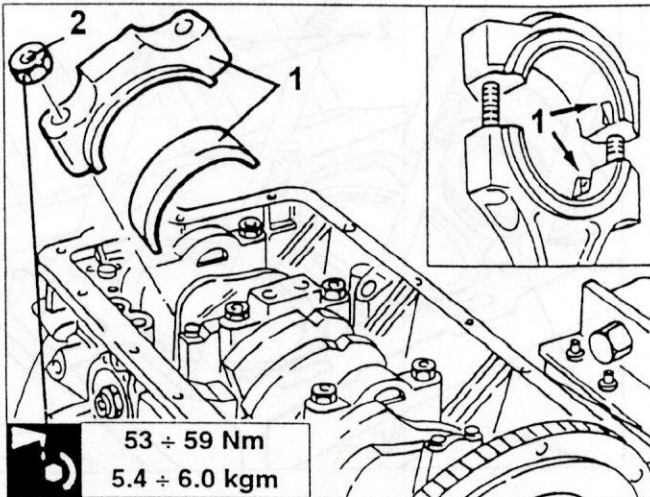
NOTE: After refitting, address the gas ring cuts so that they do not coincide with the journal axis and at 120° one from the other.

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.



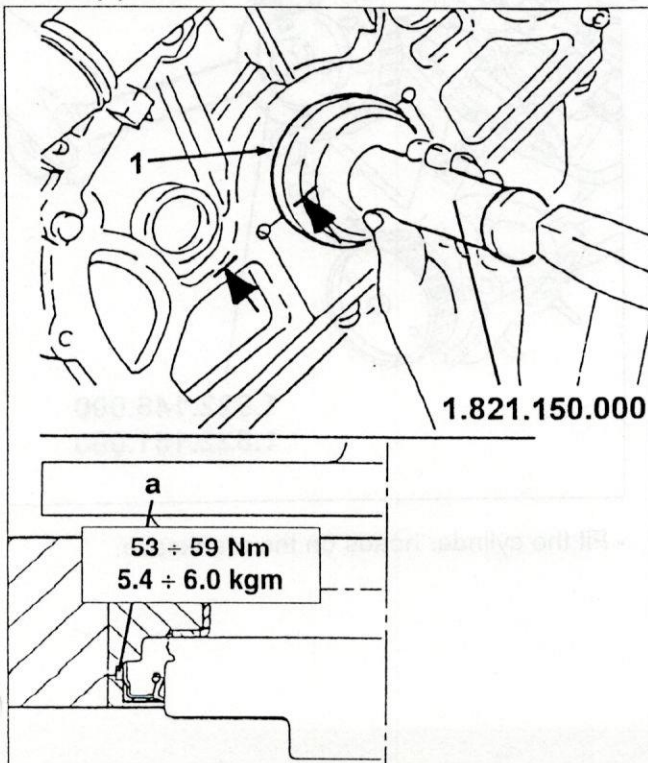
- Turn the crankcase on the overhaul stand.
 - 1. Fit the connecting rod caps and half-bearings on the bank. Address the safety notch towards the notch on the connecting rod cap.
- NOTE:** The cylinder number is shown on the side of each connecting rod cap. When refitting, this number should be on the 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

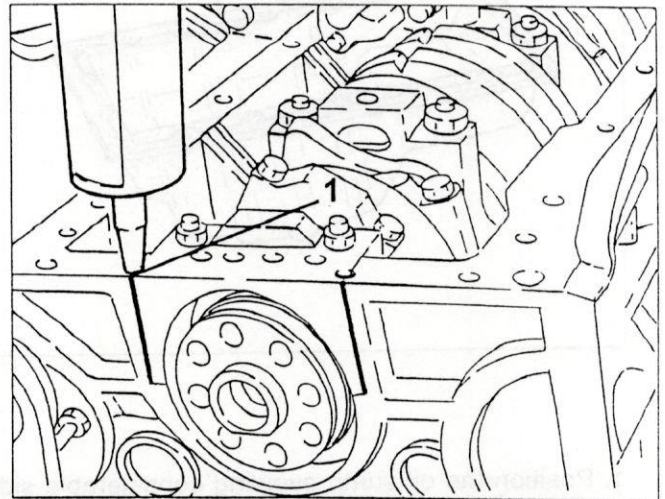
- 1. Fit the rear crankshaft oil seal with tool no. 1.821.150.000.
- NOTE:** Fit the oil seal in its seat so that the holes (a) are covered.



For pre-change versions (to engine no. 02054)

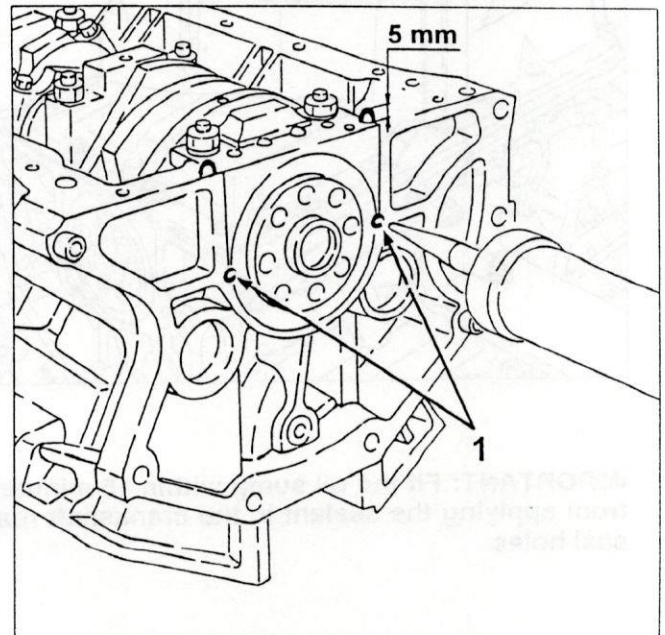
- 1. Apply "DOW CORNING 7091" silicon sealant with a mechanical gun through the holes shown in the figure.

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

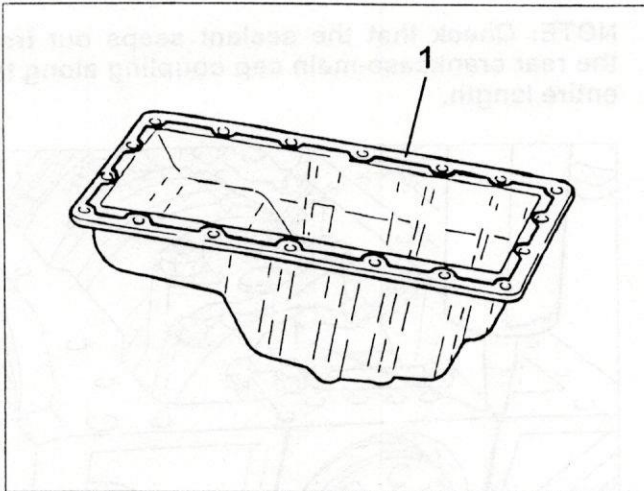


For pre-change versions (to engine no. 02055)

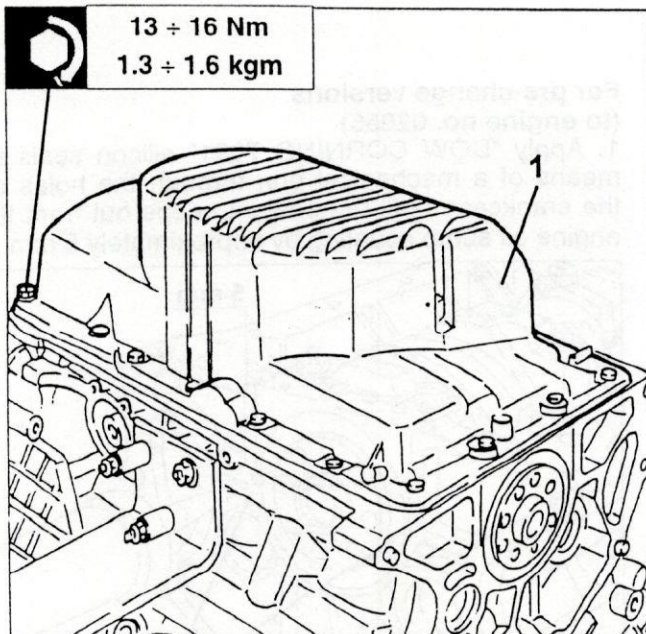
- 1. Apply "DOW CORNING 7091" silicon seals by means of a mechanical gun through the holes on the crankcase until the sealant seeps out from the engine oil sump coupling by approximately 5 mm.



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.



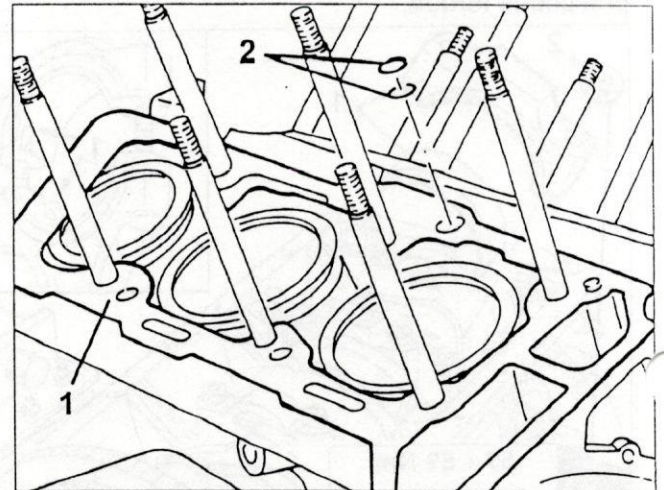
IMPORTANT: Fit the oil sump within 15 minutes from applying the sealant in the crankshaft rear seal holes.

Cylinder head refitting

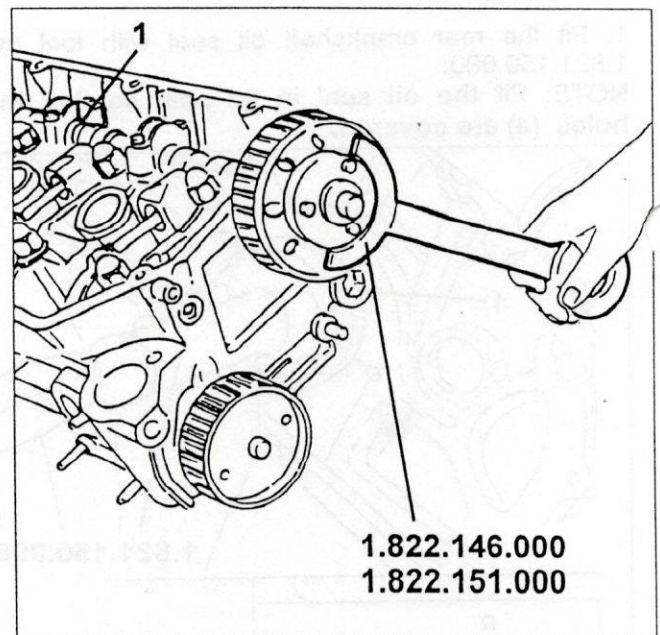
- Turn the crankshaft to take cylinder 1 piston to TDC.

- Remove the previously fitted liner retainer tool no. 1.820.279.000.

1. Position the cylinder head seals.
2. Position the lubrication duct seals.

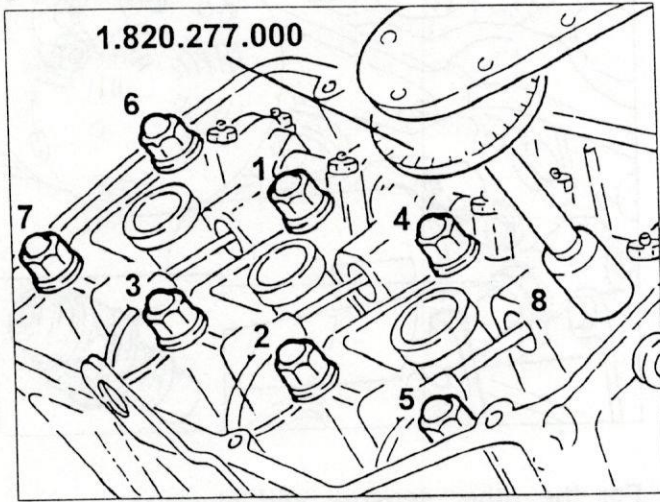


1. Turn the camshaft on each head to make the timing reference notches on the camshafts coincide with those on the respective notches using tool no. 1.822.146.000 and tool no. 1.822.151.000.



- 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.

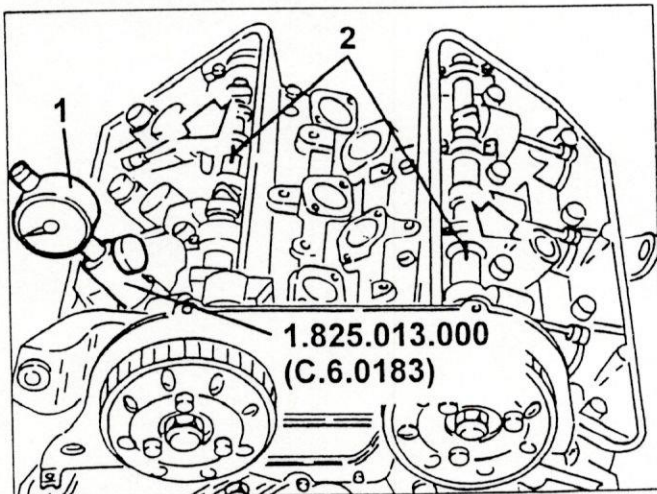


1.820.277.000

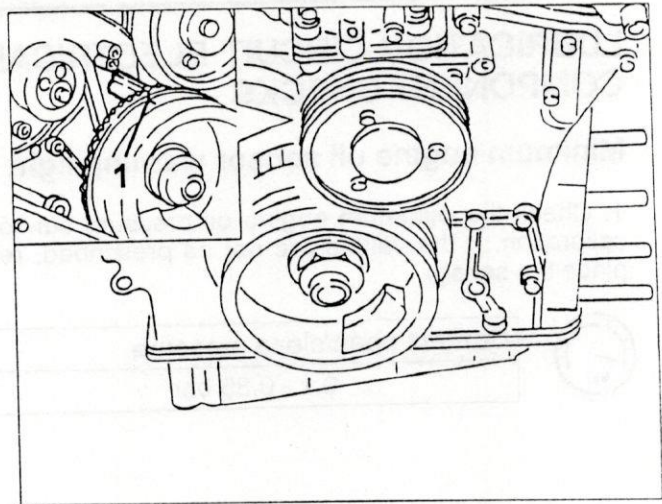
Tightening torque procedure	
Fasten all screws at:	25 Nm
Complete torque by an additional angle of:	240° ± 1°30'

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.

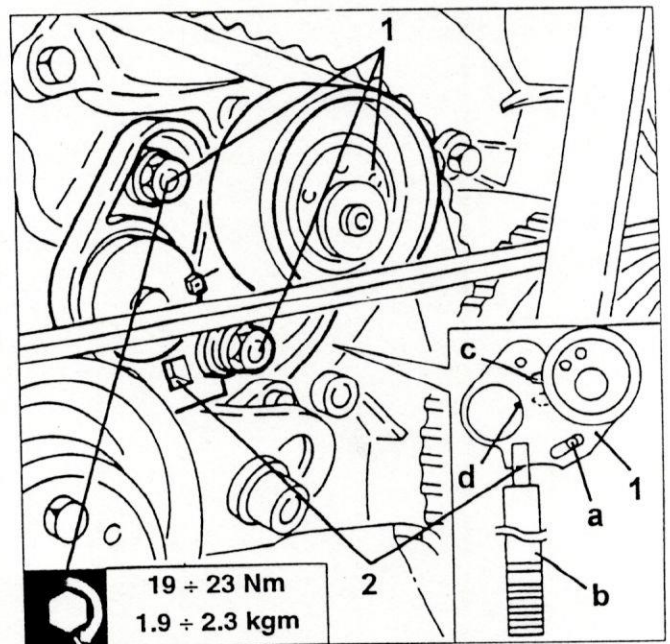
- Fit the timing belt on the pulleys from the drive pulley anti-clockwise.

- 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.

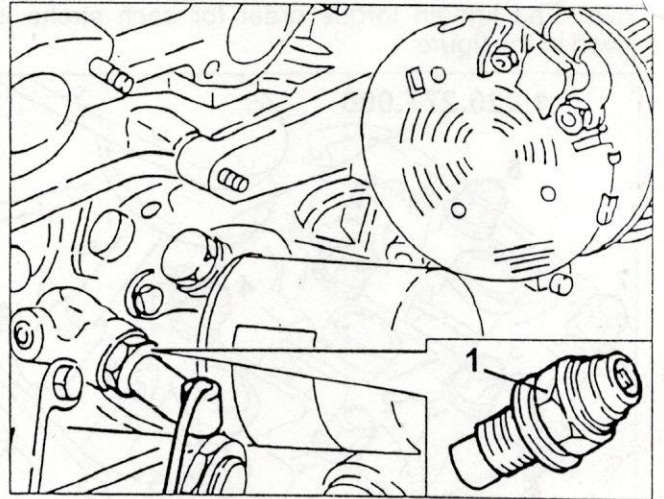
LUBRICATION CIRCUIT ELECTRICAL COMPONENT CHECKS

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.