Engine

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GROUP 01

ENGINE

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GROUP 01

ENGINE

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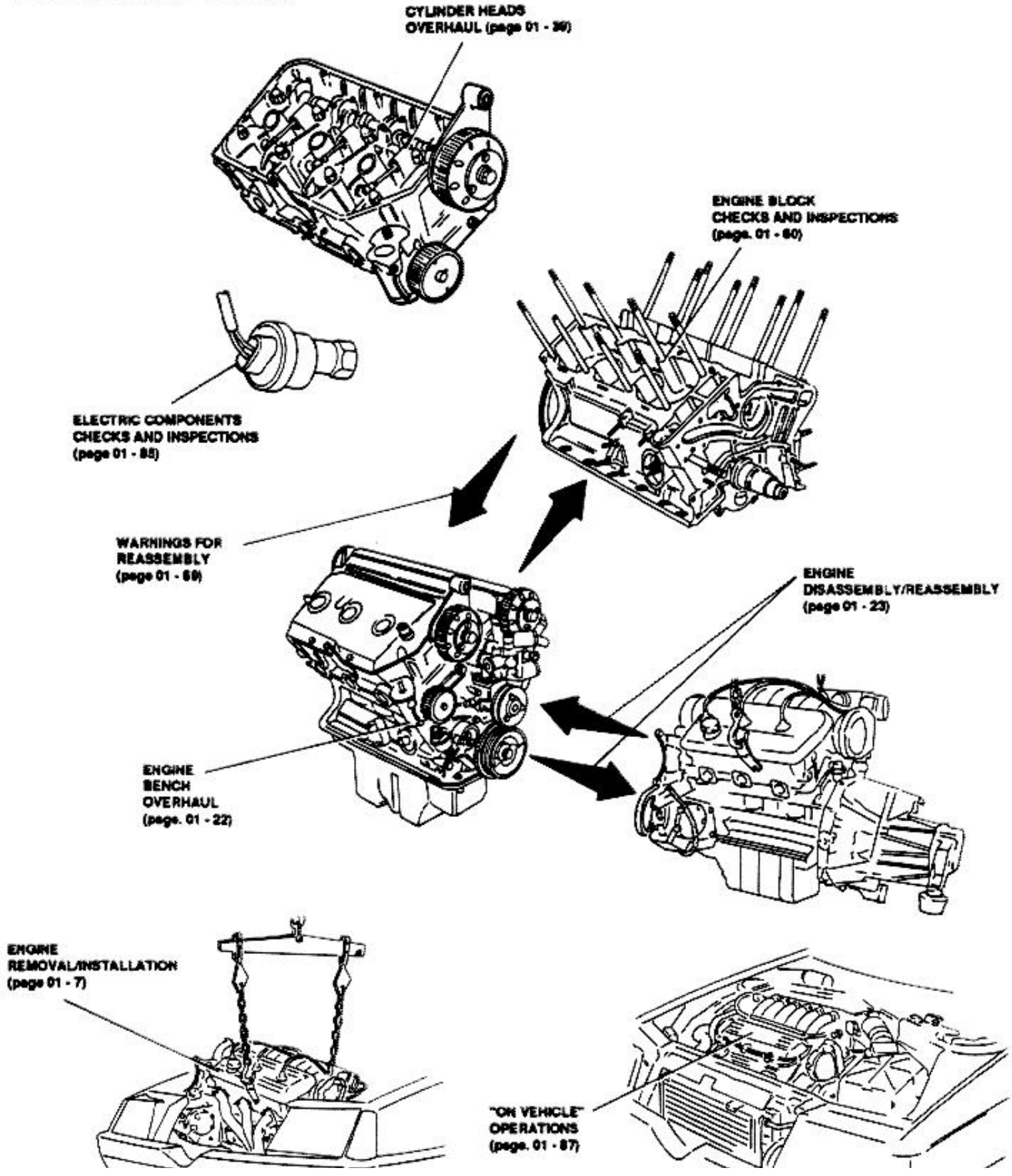
ILLUSTRATED INDEX



ENGINE

ATTACHMENTS

The engine is installed on a support frame by means of three mounts.
Two mounts are of the hydraulic dampening type, the third mount is of the torque rod link type.
The upper part of the engine is attached to the car body by means of a link rod.

DISPLACEMENT

The engine has six 60° V mounted cylinders and a total displacement of 2.959 liters (183 cu. in).
The "V" arrangement and angle of 60° make the engine an extremely compact and well balanced unit from the dynamic point of view.
With a piston stroke of 72.6 mm (2.85 in) and bore of 93 mm (3.66 in) (unit displacement 493 cu. cm/30 cu. in), the engine is of the super square type (stroke and bore ratio lower than 1), and therefore allows a better arrangement of the valves and optimum filling of the cylinders (high volumetric ratio).

ENGINE CRANKSHAFT

The engine crankshaft, short and well balanced, is also provided with counter weights on the flywheel and on the driven pulley, thus obtaining optimum balancing.

ENGINE BLOCK AND CYLINDER HEADS

The engine block, with "wet" inserted cylinder liners, and the cylinder heads, are fully made of aluminum and silicor. light alloy: this reduces the engine weight and allows an improved dissipation of engine heat.

TIMING

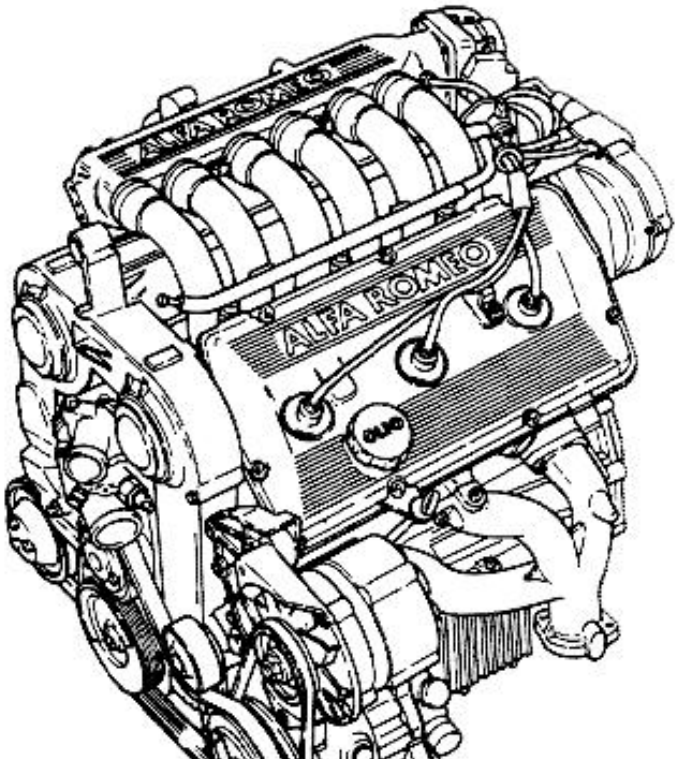
Engine timing is performed by means of two camshafts, one for each row of cylinders.
The camshafts are driven by a toothed belt with hydraulic tightener which automatically adjusts and maintains the belt tension.
The camshaft acts directly on the intake valves by means of the cams, and on the exhaust valves by means of short rods and rocker arms.

FUEL INJECTION AND IGNITION

Fuel injection and ignition are controlled in an integrated mode by the Bosch Motronic ML 4.1 system (refer to **Group 04**).

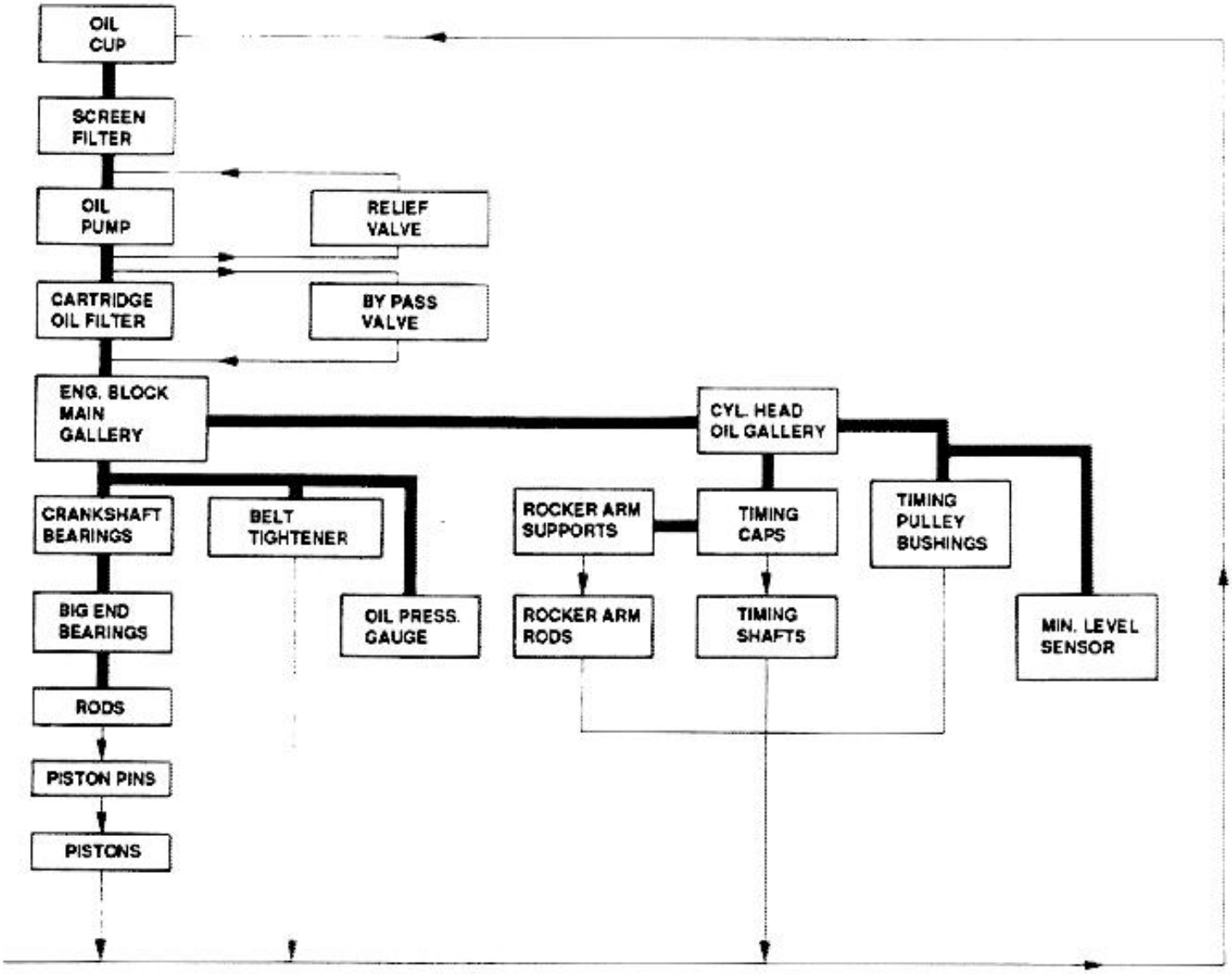
LUBRICATION

Engine oil flow is obtained by means of a rotating lobe type pump, attached to the lower inner side of engine block.
The oil pump is driven by the timing toothed belt through a pulley and a shaft.

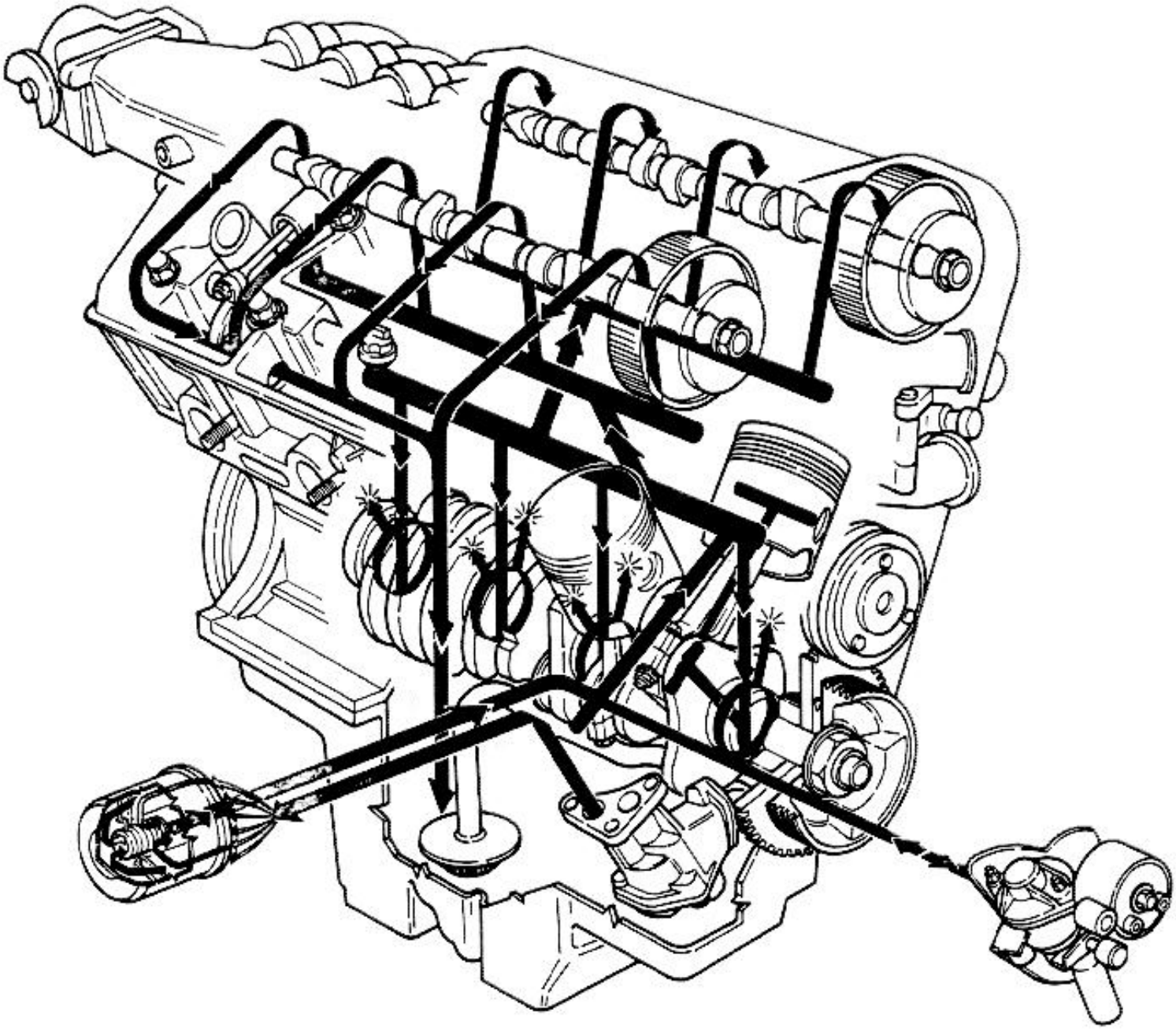


LUBRICATION

Engine lubrication is pressurized by a rotating lobe type pump fixed to the lower inner side of engine block. The pump is driven by the timing toothed belt through a pulley and a shaft. A relief valve controls the system pressure. The oil is filtered during suction by a screen filter on the suction body, and is subsequently filtered by a replaceable element filter on the supply line. The oil filter is provided with a by-pass valve that allows the oil to by-pass the filter when obstructed. A longitudinal central oil hole in the engine block allows to lubricate the crankshaft, the pistons and the connecting rods. Other two passages allow to lubricate the cylinder heads, and therefore all the components of engine timing system. Furthermore, the oil lubricates the timing toothed belt hydraulic tightener. A recirculation system and vapor separator allows recovering of oil vapors from the right cylinder head. The lubricating pressure is indicated by a pressure gauge on instrument panel, and a warning lamp alerts the driver when the oil pressure is too low. Pressure signals are supplied by a pressure switch and sensor located to the end of engine block longitudinal oil hole. An oil level sensor, located aside of the oil dipstick, provides input signal for the illumination of a low oil level warning lamp on the instrument panel. The oil filler cap is located on top of the front head.



LUBRICATING SYSTEM



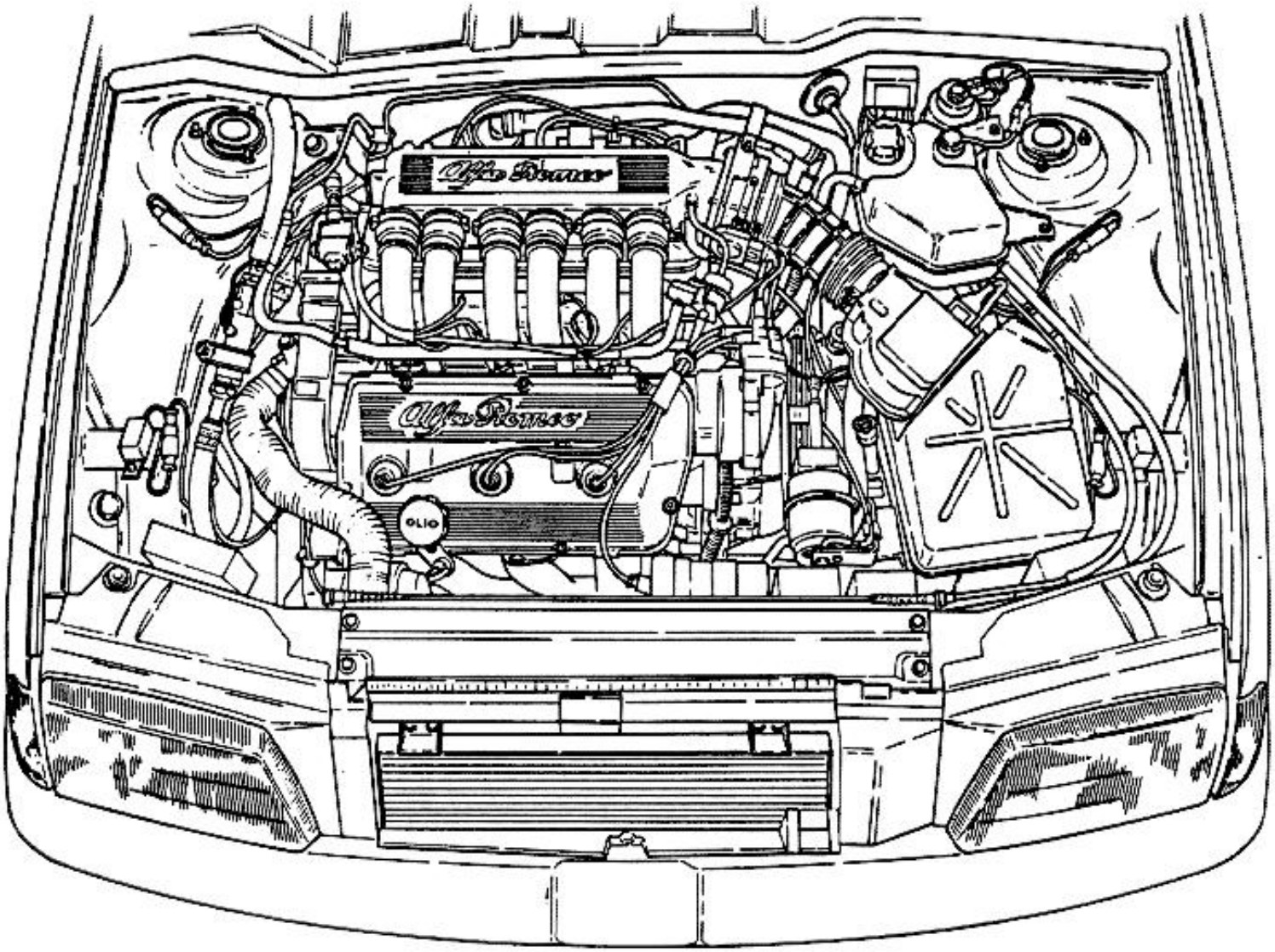
ENGINE REMOVAL/ INSTALLATION

The information and illustrations below allow a rapid removal of the complete engine from its housing in the engine compartment, and subsequent re-installation.

Bench disassembly of single engine components is described in a separate further chapter.

This procedure is considered as a unique and complete procedure; nevertheless, parts of the procedure can be used as required.

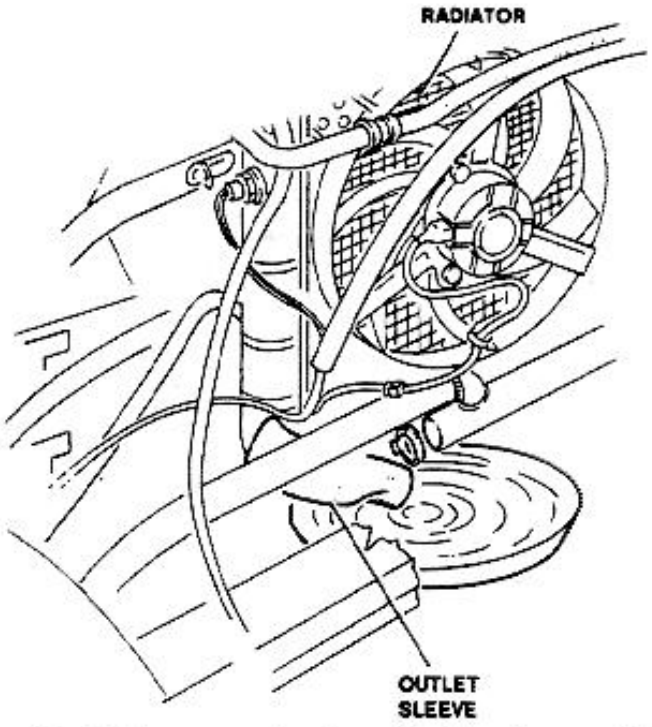
For further information and details refer to the chapters relevant to specific components or groups.



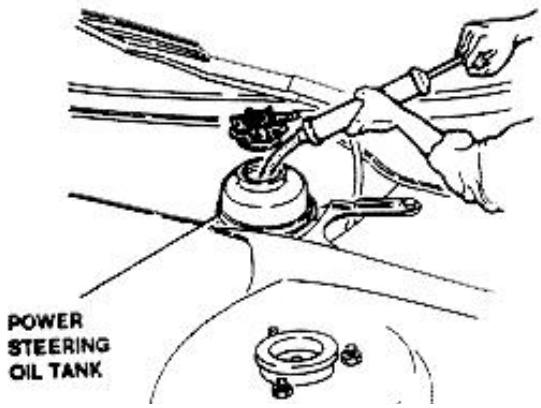
REMOVAL

- Remove header tank cap; disconnect radiator outlet sleeve and drain engine coolant in a suitable container.

CAUTION:
The anti-freezing mixture used as engine coolant is harmful for the paint work: avoid any contact of anti-freezing mixture with painted surfaces.



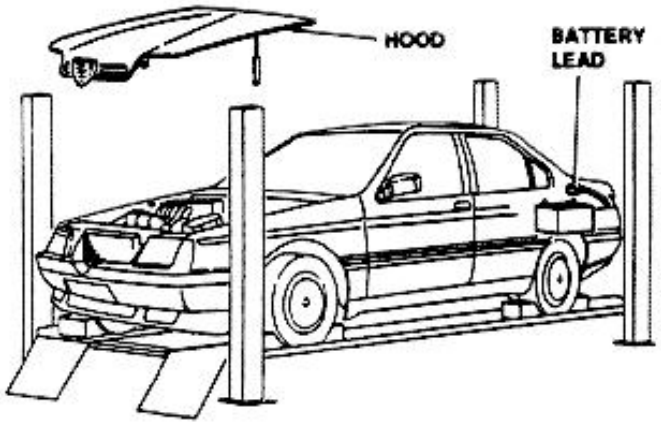
- Empty the power steering oil tank using a suitable syringe.



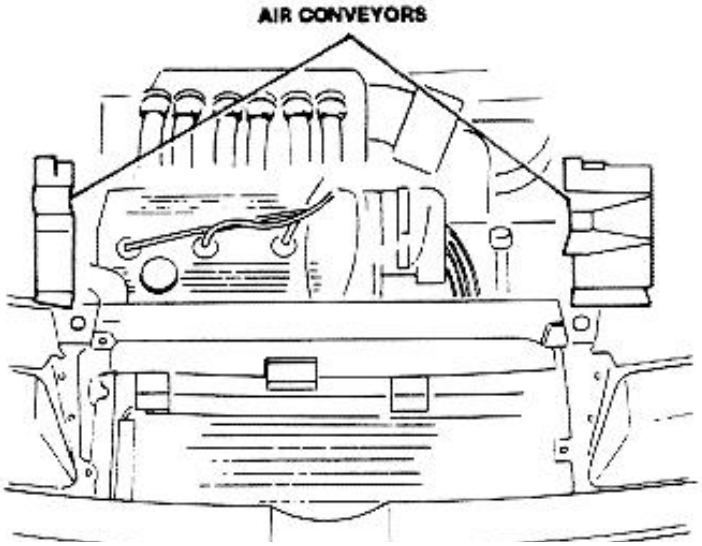
- Position vehicle on auto elevator, block wheels with suitable safety chocks and apply the parking brake.
- Disconnect battery (-) lead.
- Remove engine hood (refer to **Group 56**).

CAUTION:
Protect hood support area with cushioning material to avoid damaging the vehicle body.

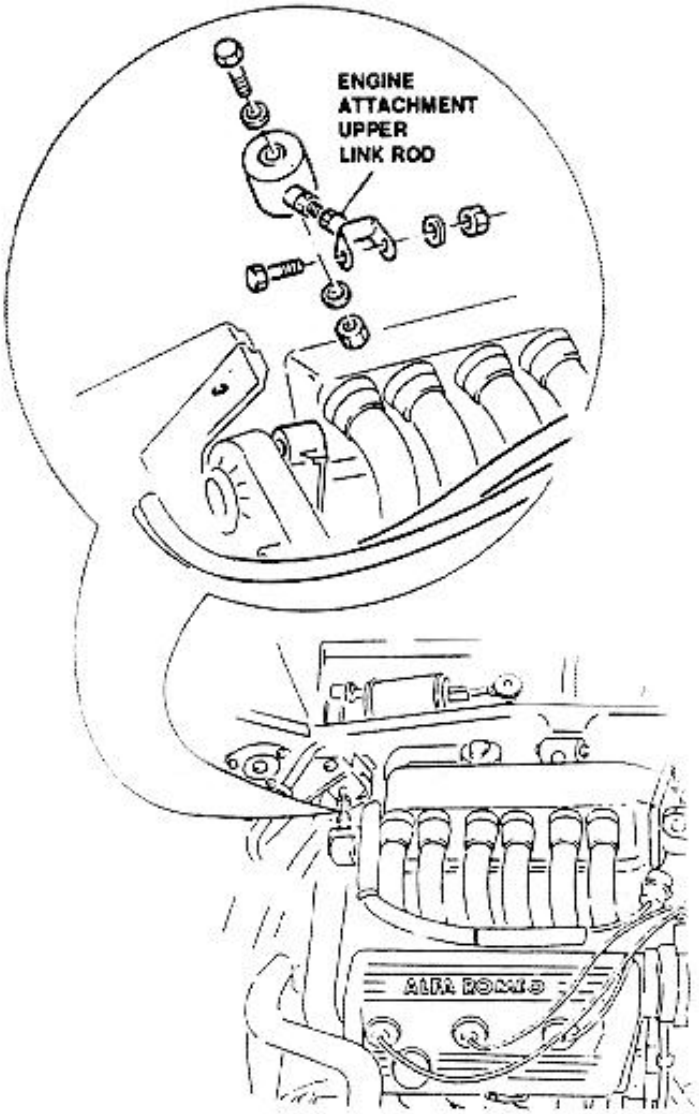
WARNING:
Whenever the engine is still warm, adopt any precaution to avoid scalds.



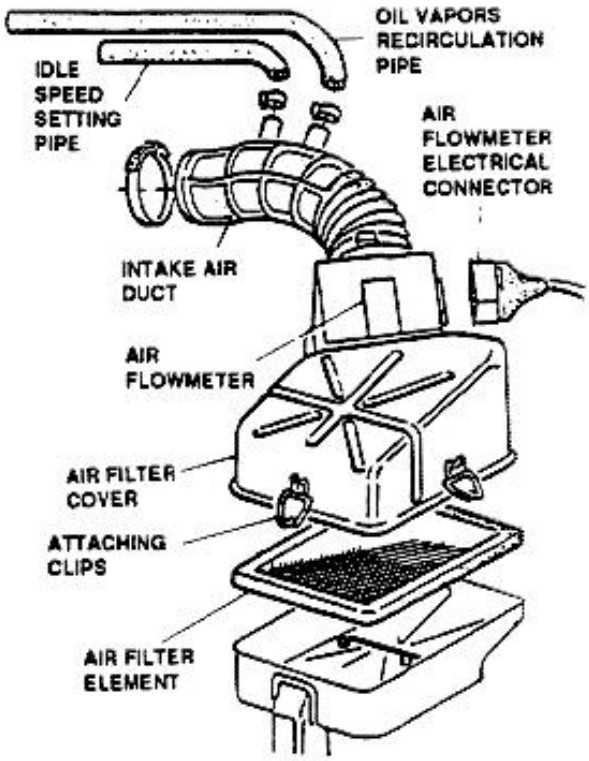
- Remove the two air conveyors located on sides of radiator



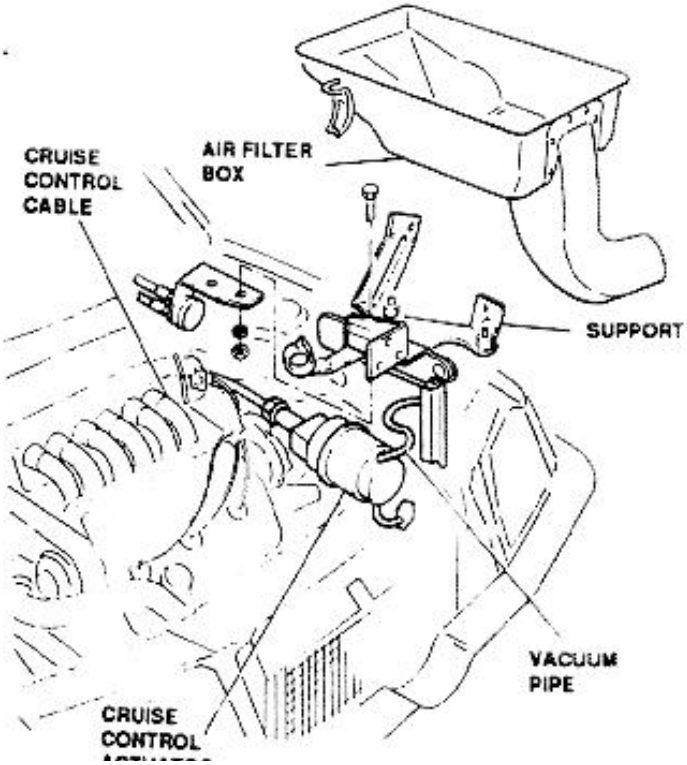
- Disconnect engine attachment upper link rod.



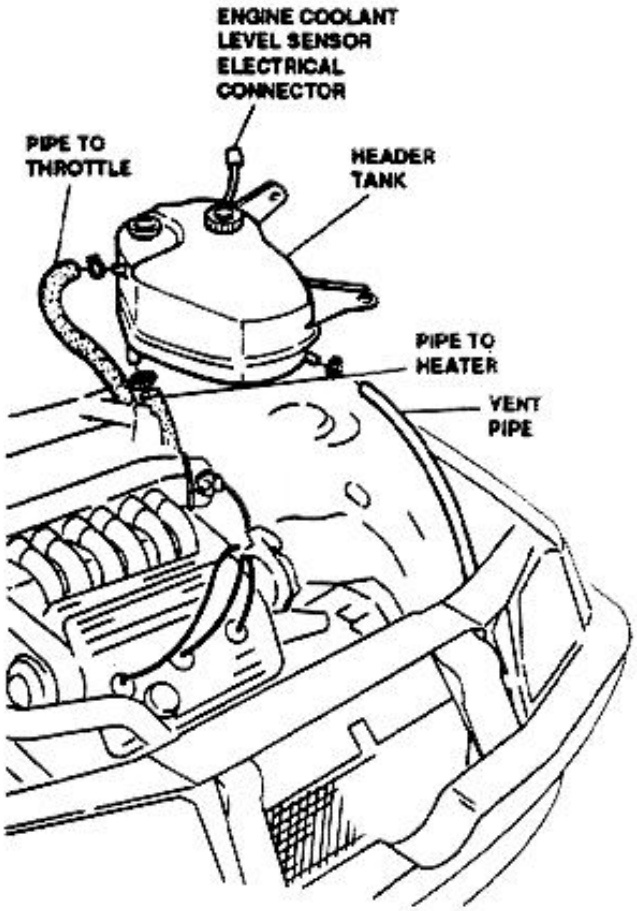
- Disconnect oil vapors recirculation pipe.
- Disconnect idle speed setting pipe.
- Remove clamp and separate duct from intake chamber.
- Disconnect air flowmeter electrical connector.
- Release air filter cover clips.
- Remove cover-air flow meter-intake duct assembly.
- Remove air filter element.
- Remove air filter box.
- Disconnect electrical connector and vacuum pipe, then remove Cruise Control actuator after it has been disconnected from the Cruise Control cable (refer to **Group 04**).



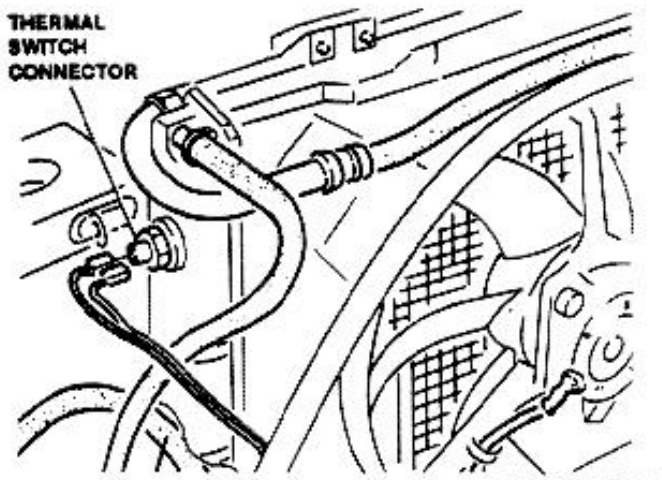
- If the vehicle is equipped with a vibration damper on the clutch circuit, detach the damper fixing bracket from the air filter support, and move it aside without disconnecting the pipes (refer to **Group 12**).
- Remove air filter support.



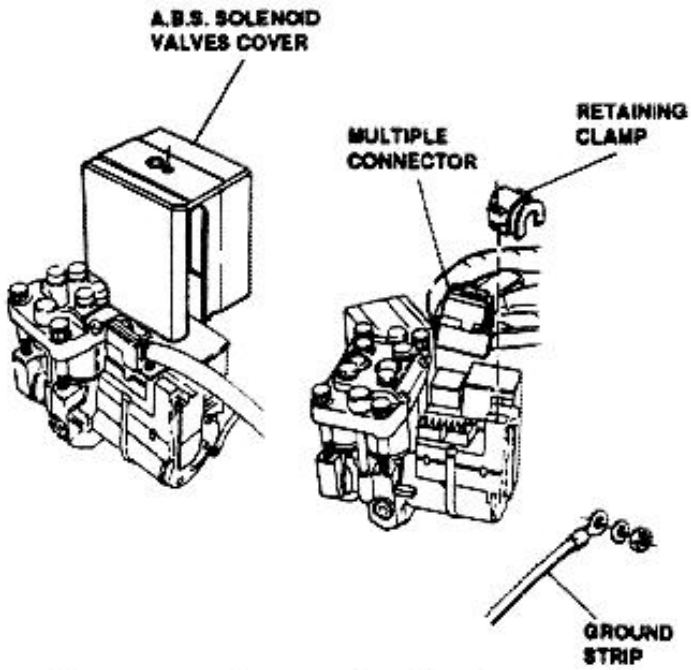
- Disconnect electrical connection of engine coolant level sensor.
- Disconnect vent pipe and pipes to throttle and heater from engine cooling header tank.
- Remove header tank.



- Disconnect radiator thermal switch electrical connector.
- Disconnect electrical cooling fan electrical connector.

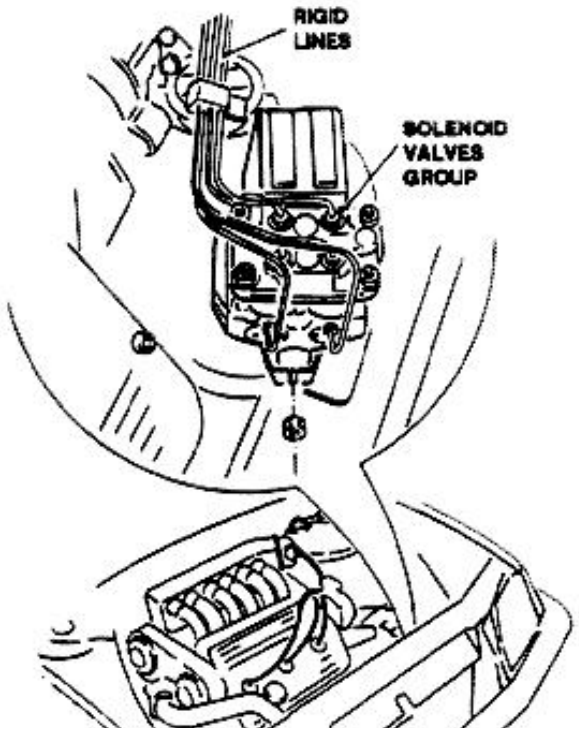


- Disconnect A.B.S. solenoid valves cover; disconnect multiple connector and ground strip; re-install cover.

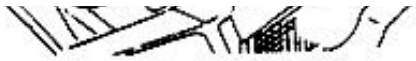


- Disconnect and move solenoid valves group to one side, without disconnecting rigid lines.

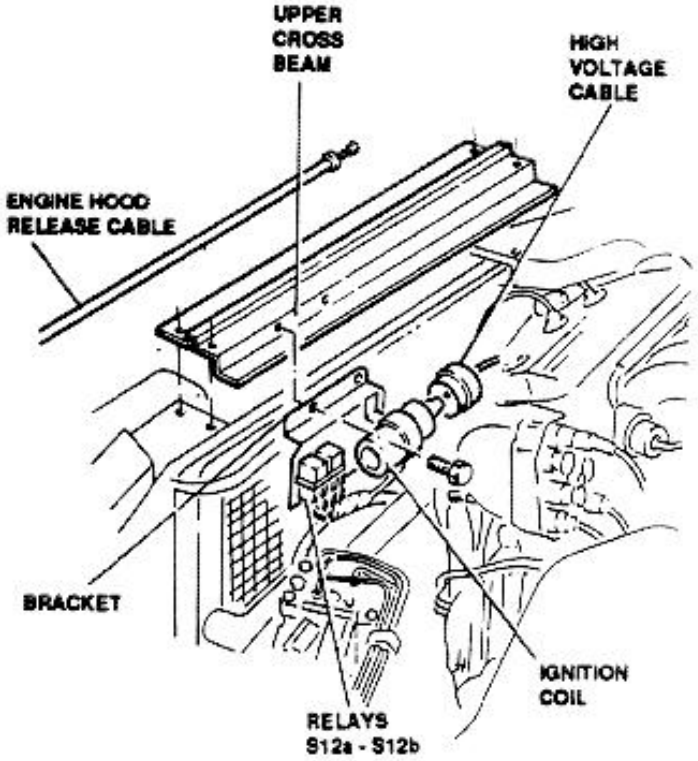
CAUTION:
Take care to prevent damaging the rigid lines.



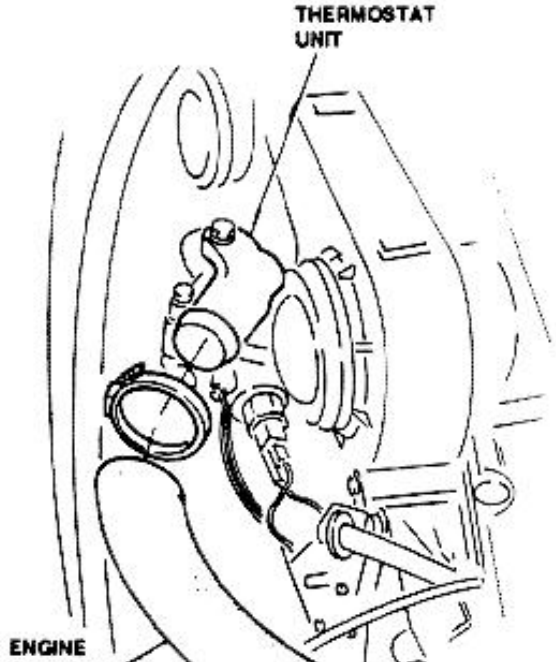
ELECTRICAL FAN
CONNECTOR

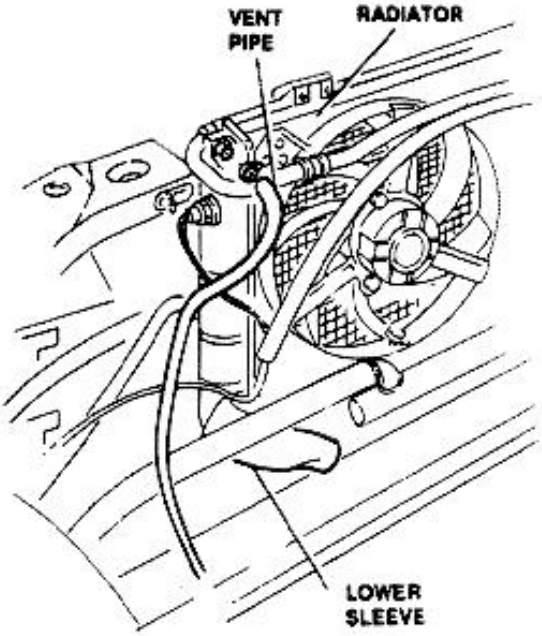


- Disconnect engine hood release cable.
- Disconnect high voltage cable from ignition coil.
- Disconnect ignition coil and relays bracket from upper cross beam and move it to one side.
- Remove upper cross beam.



- Disconnect radiator supply pipe from thermostat unit.
- Disconnect and remove lower sleeve from radiator, and disconnect vent pipe.

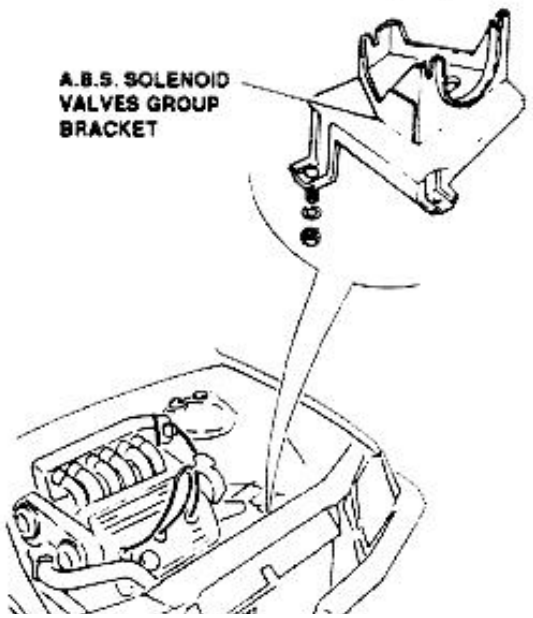




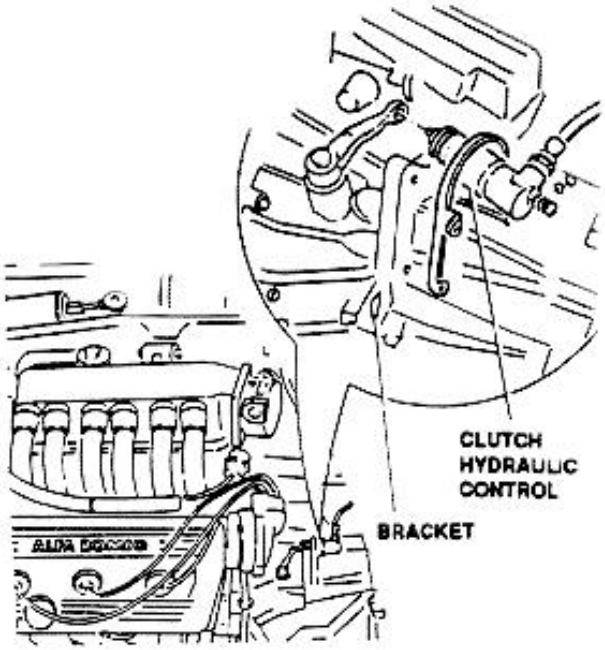
- Remove radiator together with electrical fan and conveyor.

CAUTION:
The air conditioning system condenser must not be removed; take care to prevent damaging its pipes whilst removing the radiator

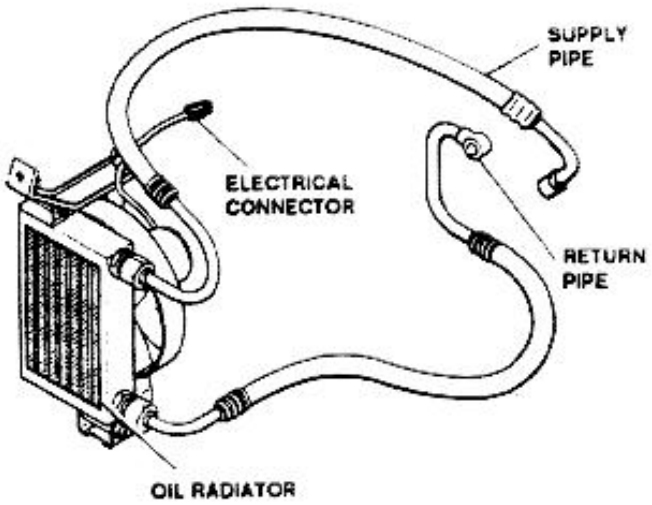
- **Only for vehicles equipped with spacers between engine support frame and bodywork:**
  - Remove shims located between radiator and support frame.
- Remove A.B.S. solenoid valves group bracket.



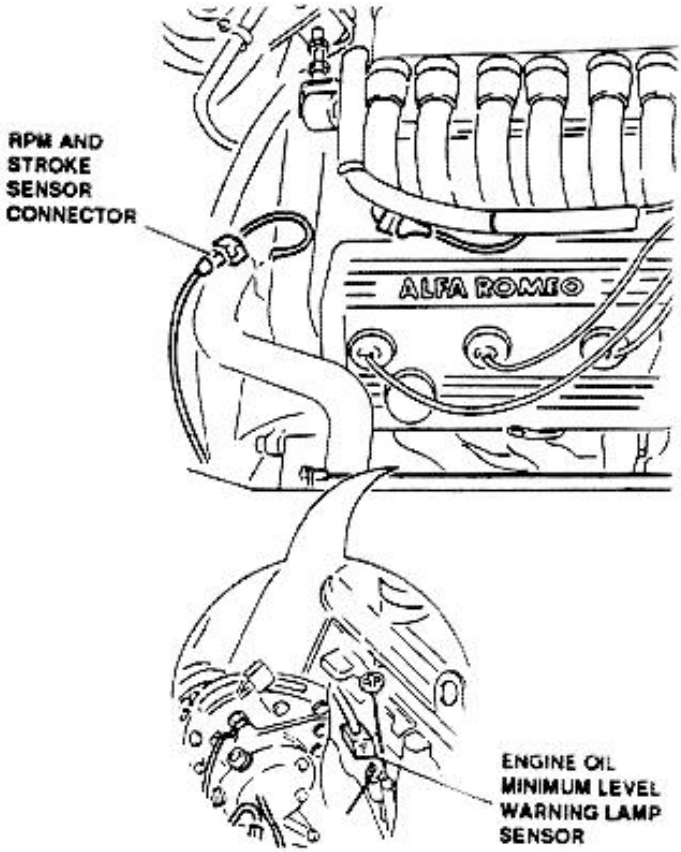
- **On vehicles equipped with Manual Transmission:**
  - Disconnect clutch hydraulic control.
  - Remove bracket together with control cylinder without disconnecting pipe.



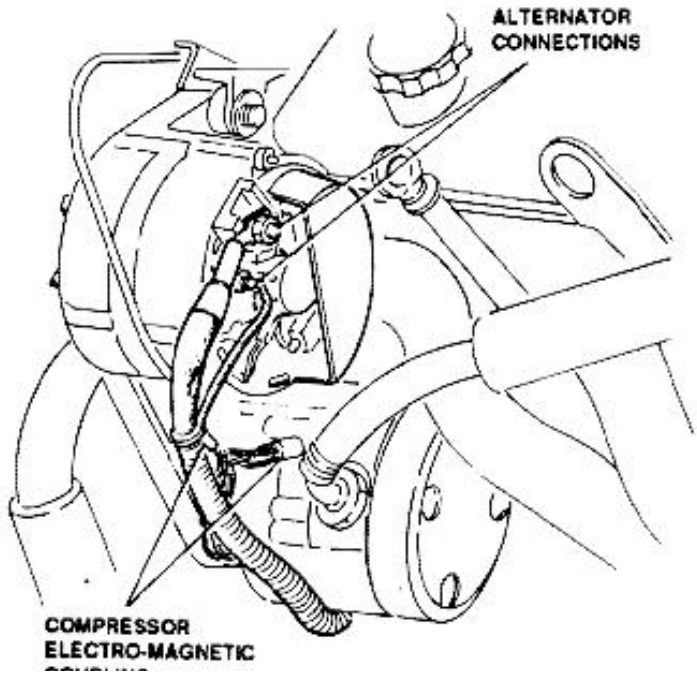
- **On vehicles equipped with Automatic Transmission:**
  - Disconnect oil radiator supply and return lines from automatic transmission.
  - Disconnect oil radiator cooling fan electrical connector.
  - Remove oil radiator.



- Disconnect RPM and stroke sensor electrical connector.
- Disconnect engine oil minimum level warning lamp sensor.

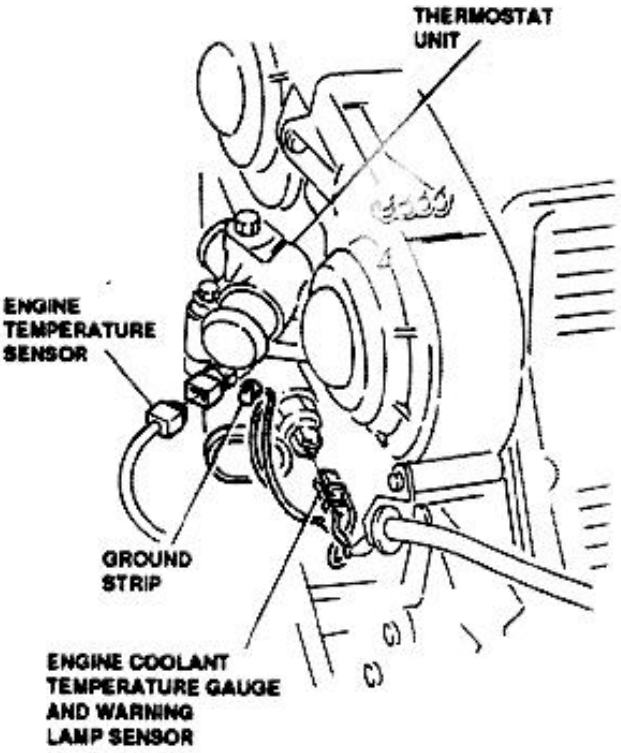


- Disconnect alternator and air conditioning compressor cables.

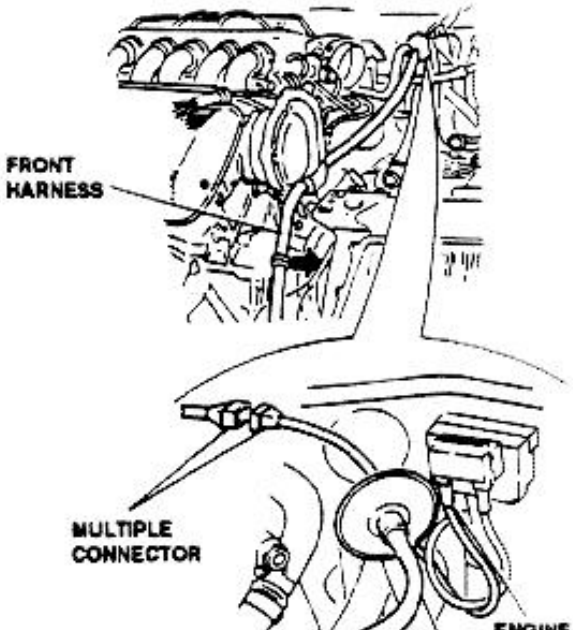


COUPLING
CONNECTOR

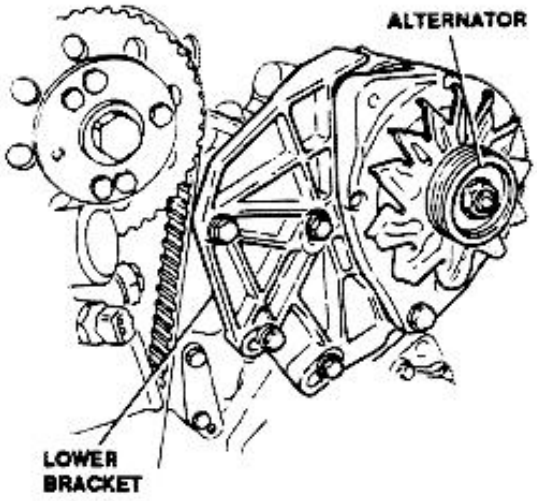
- Disconnect engine temperature sensor.
- Disconnect engine coolant temperature gauge and warning lamp sensor.
- Disconnect ground strip from thermostat unit.



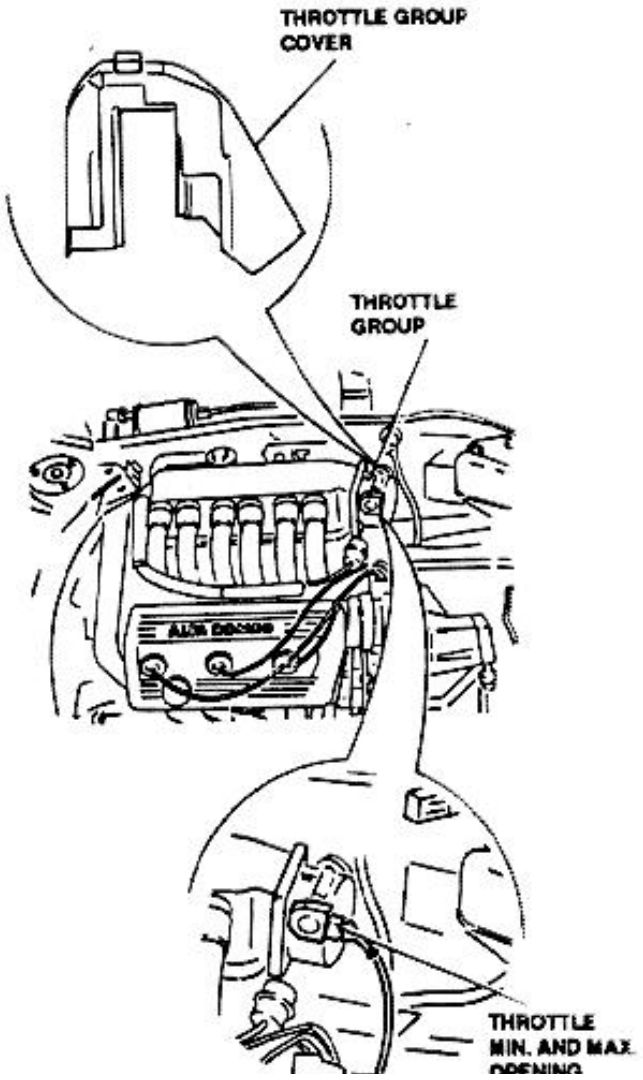
- Move front harness apart to clear access to engine.
- Disconnect multiple connector from inner side of bulkhead.
- Disconnect engine starter harness.



- Remove alternator.



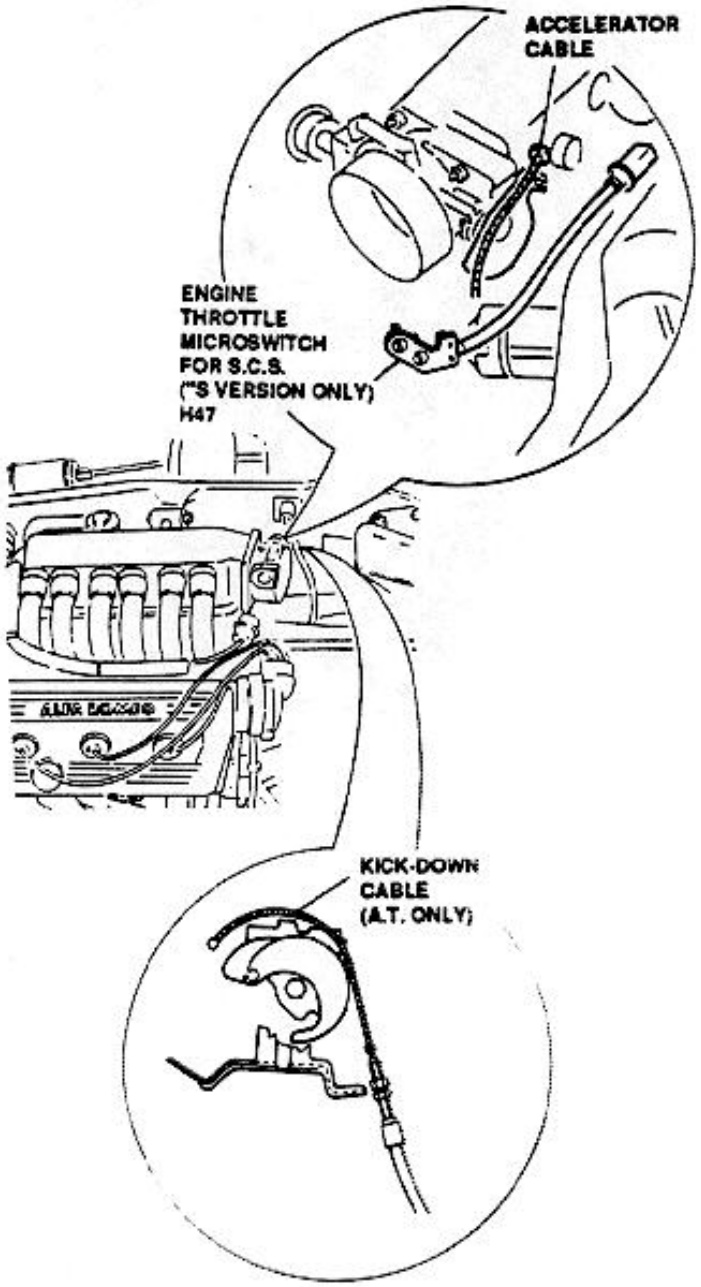
- Disconnect throttle minimum and maximum opening switch connector.
- Remove throttle group cover.



ENGINE
STARTER
HARNESS

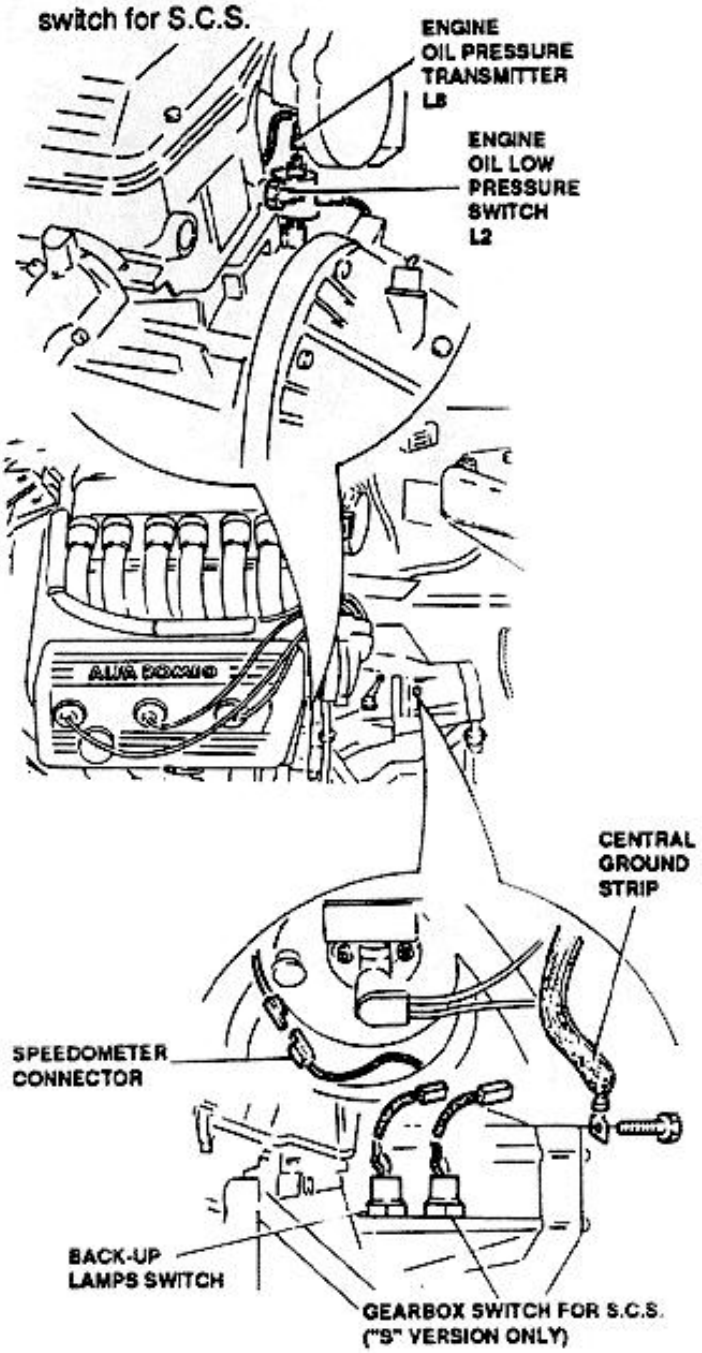
SWITCH CONNECTOR

- Disconnect accelerator cable.
- **On vehicles equipped with Automatic Transmission:** disconnect "kick-down" cable.
- **On "S" Version Vehicles:** remove engine throttle microswitch for S.C.S.



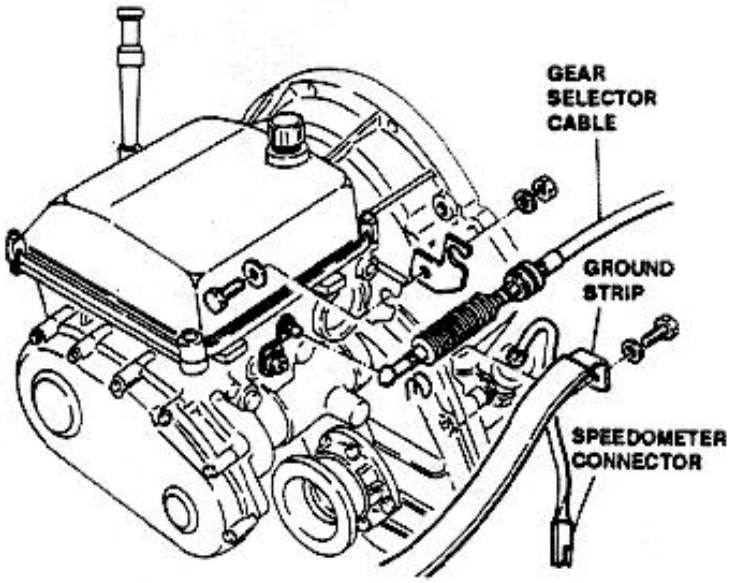
- Disconnect central ground strip.
- Disconnect engine oil low pressure switch electrical connector.
- Disconnect engine oil pressure transmitter.
- Disconnect rear ground strip on cylinder head.

- **On vehicles equipped with Manual Transmission:**
  - Disconnect back-up lamps switch connector.
  - Disconnect speedometer connector.
- **On "S" Version Vehicles:** disconnect gearbox switch for S.C.S.

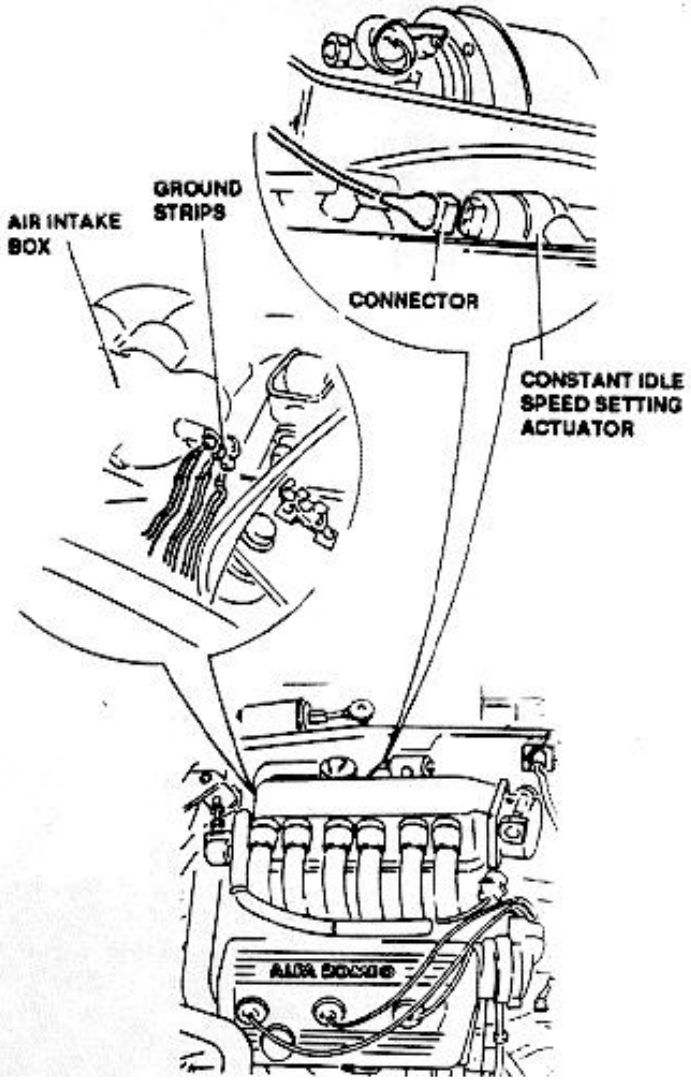


- **On vehicles equipped with Automatic Transmission:**
  - Disconnect gear selector cable.
  - Disconnect speedometer connector.
  - Disconnect gearbox case ground strip.

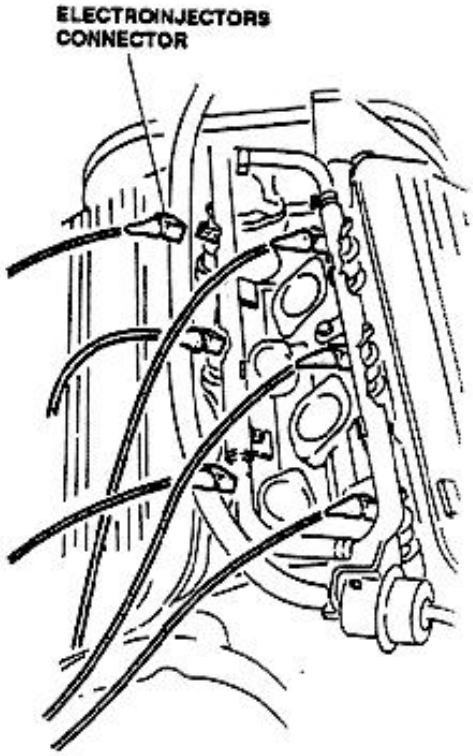
- Disconnect rear ground strip on cylinder head. Disconnect gearbox case ground strip.



- Disconnect constant idle speed setting actuator connector.
- Disconnect ground strips from air intake box.



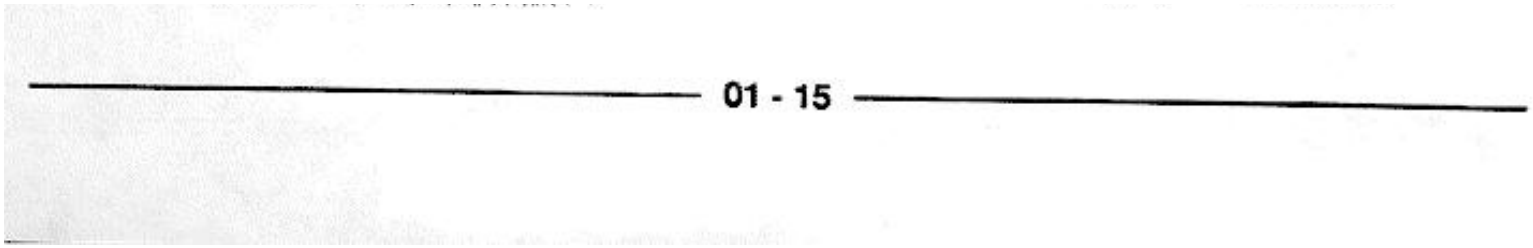
- Disconnect electroinjectors cables support bracket.
- Disconnect electronic injectors connector.



WARNING:
During any activity on fuel system components carefully observe the following precautions:

- **Ensure the workshop is provided with the prescribed safety equipment (fire extinguishers, etc.).**
- **Disconnect battery (-) lead.**
- **Collect fuel drained from the system in a suitable container provided with a safety cap.**
- **The fuel system could be pressurized: act with precaution.**
- **Do not smoke.**

- Disconnect fuel vapor and Cruise Control pipe from air intake box.
- Disconnect fuel pressure regulator control pipe.
- Disconnect fuel supply and return pipes.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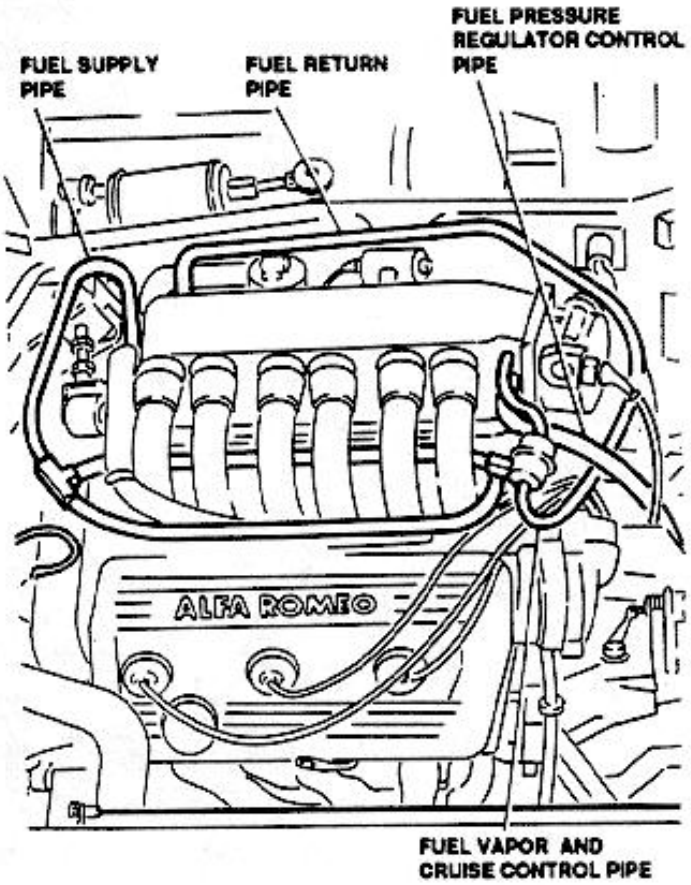
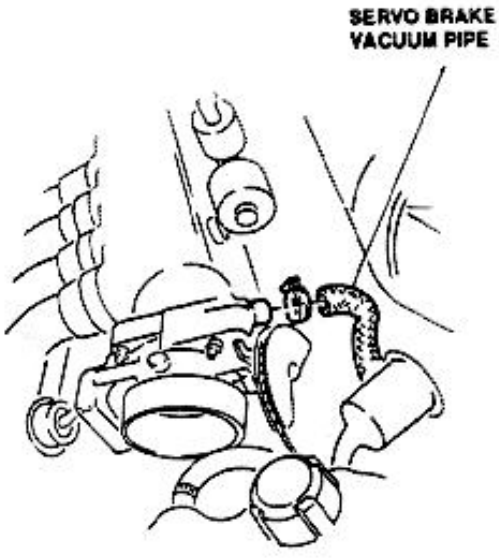
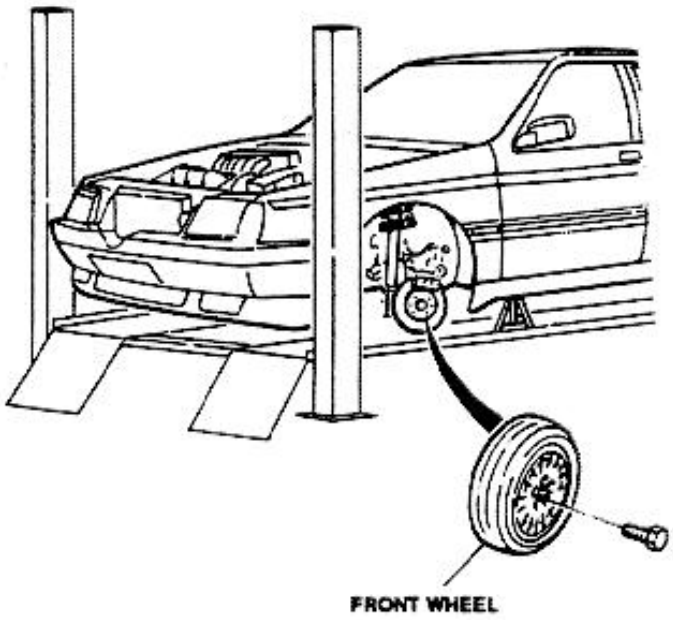


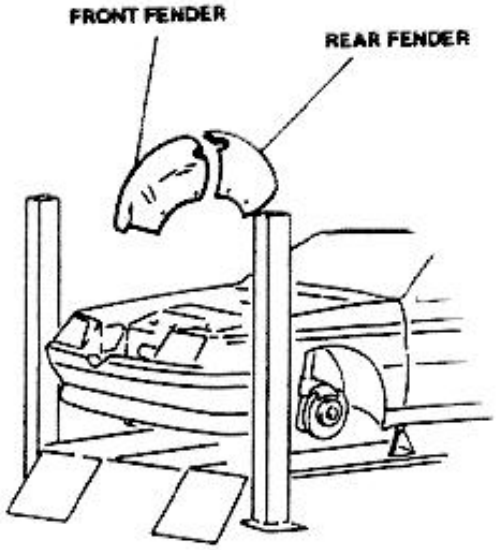
- Disconnect servo-brake vacuum pipe.



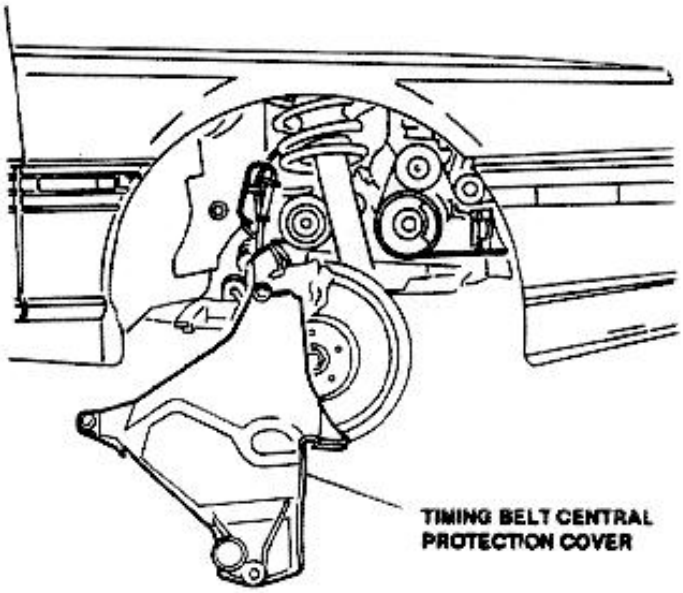
- Place vehicle on suitable jacks and remove front wheels.



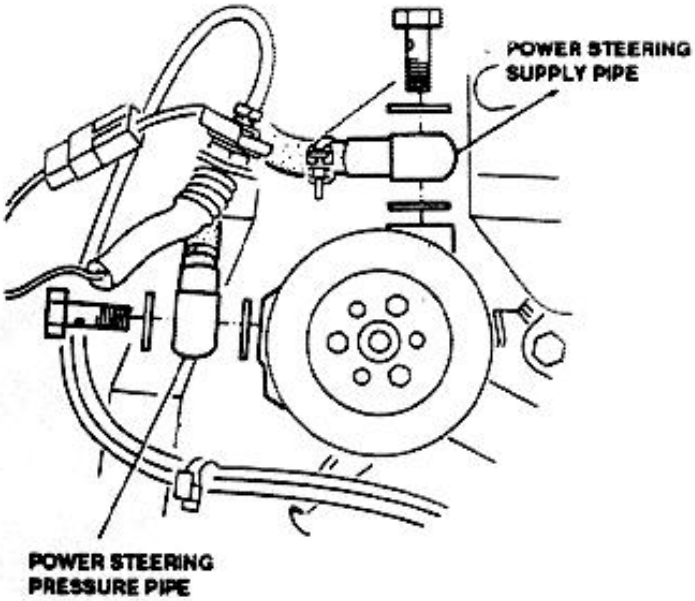
- Remove front and rear fender acting from right wheel bay.



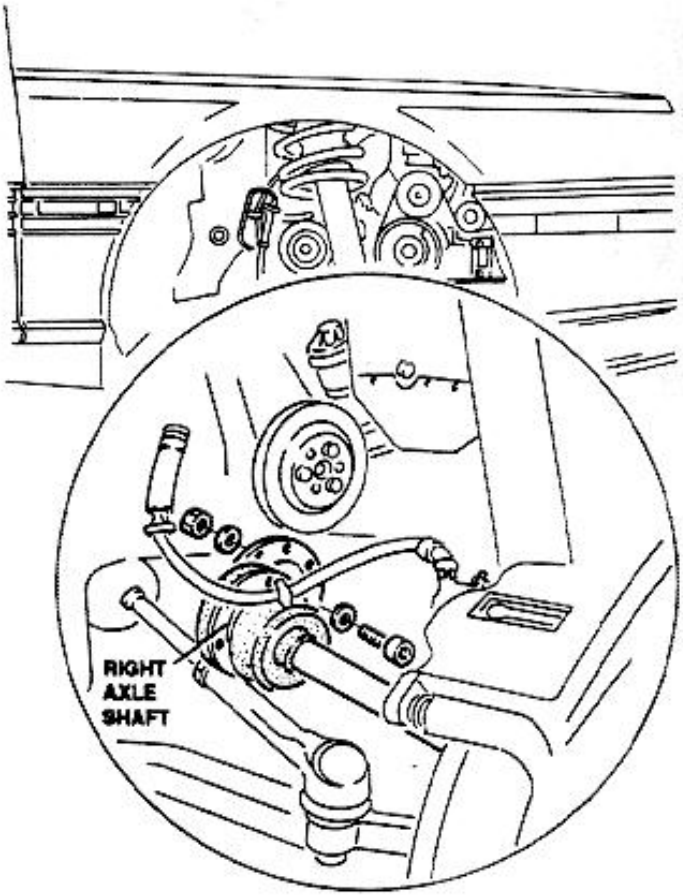
- Disconnect timing belt central protection cover.



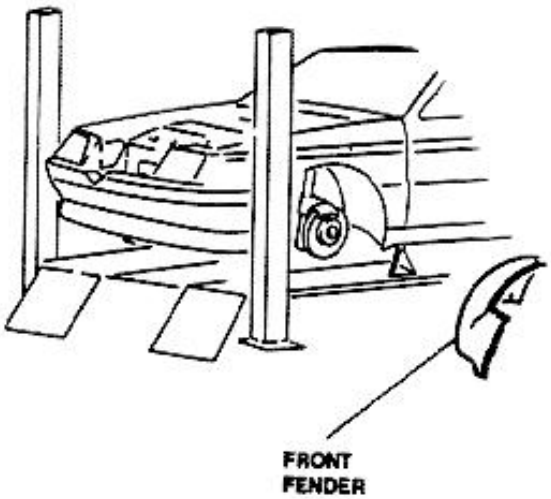
- Loosen power steering pipes.



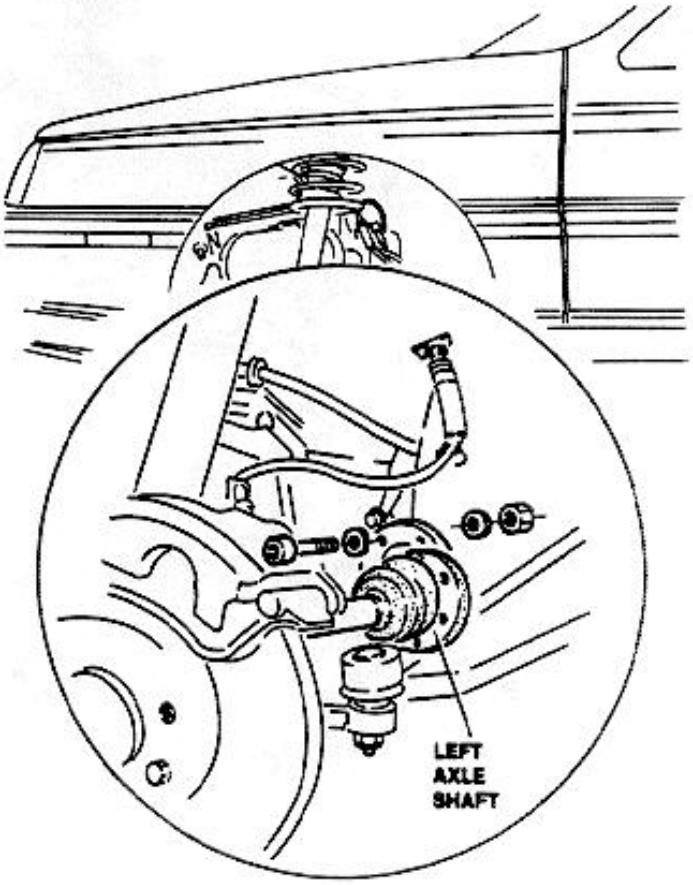
- Disconnect right axle shaft.



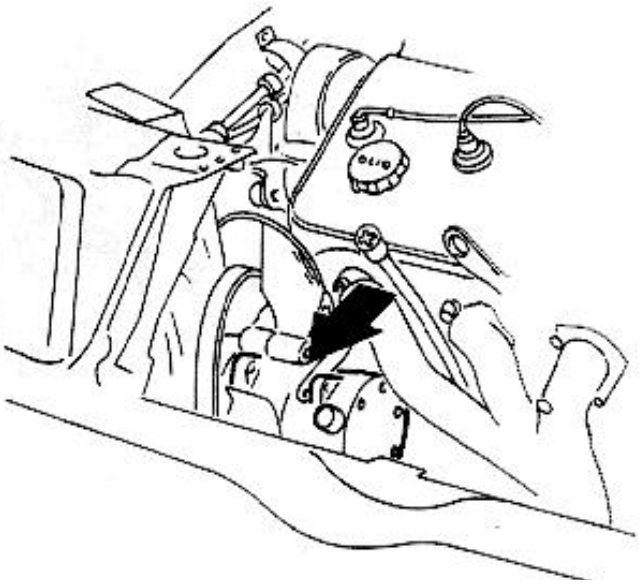
- Disconnect front fender acting from left wheel bay.



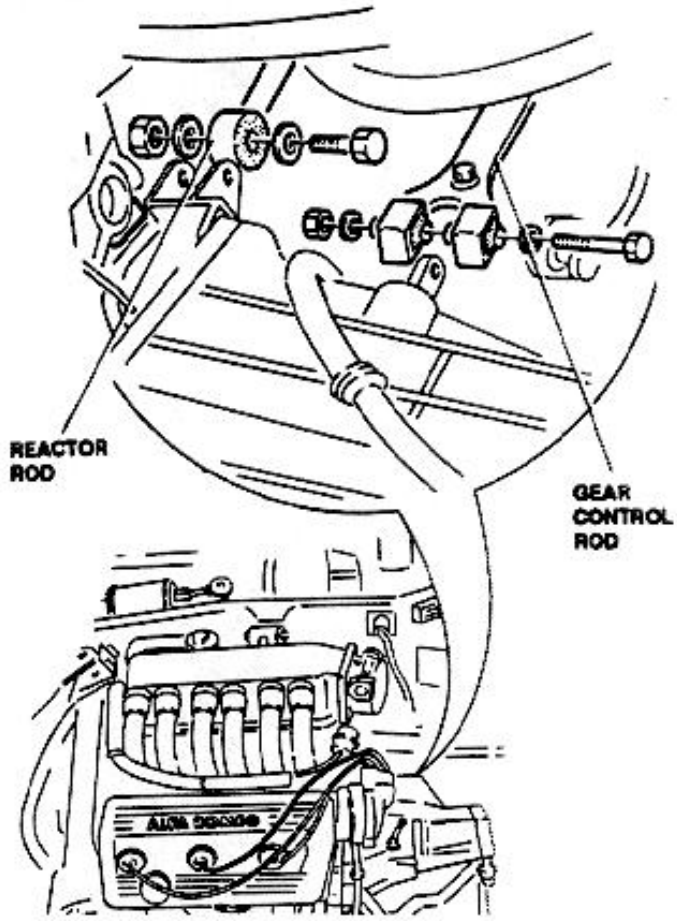
- Disconnect left axle shaft



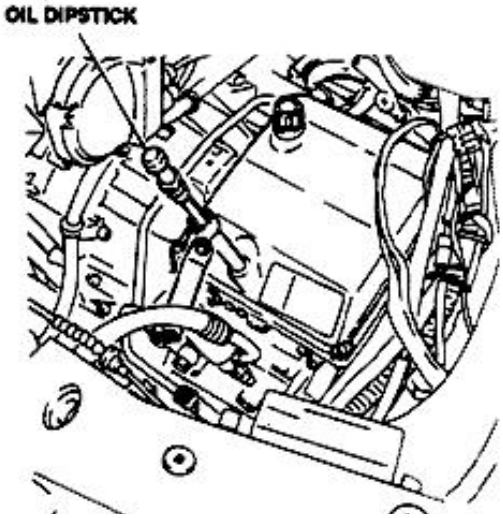
- Acting in engine compartment, move air conditioning apart and lower it into engine compartment



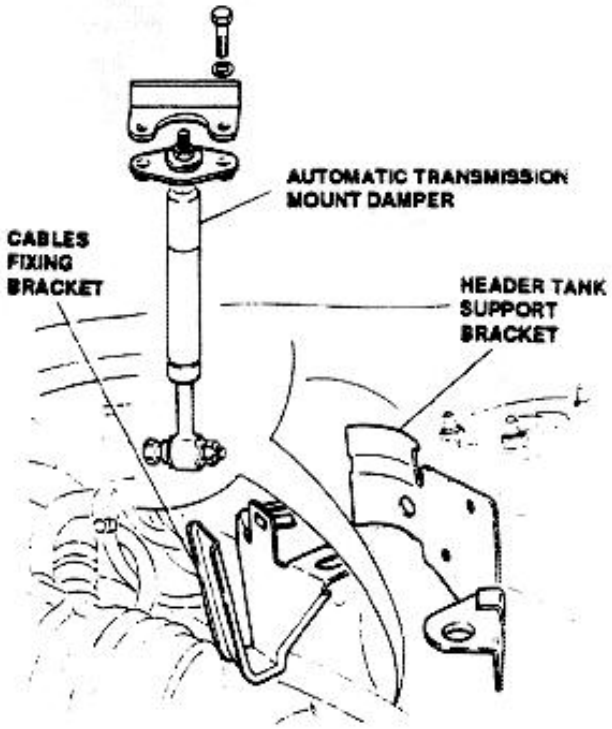
- On vehicles equipped with Manual Transmission:
  - Disconnect gear control rod.
  - Disconnect reactor rod.



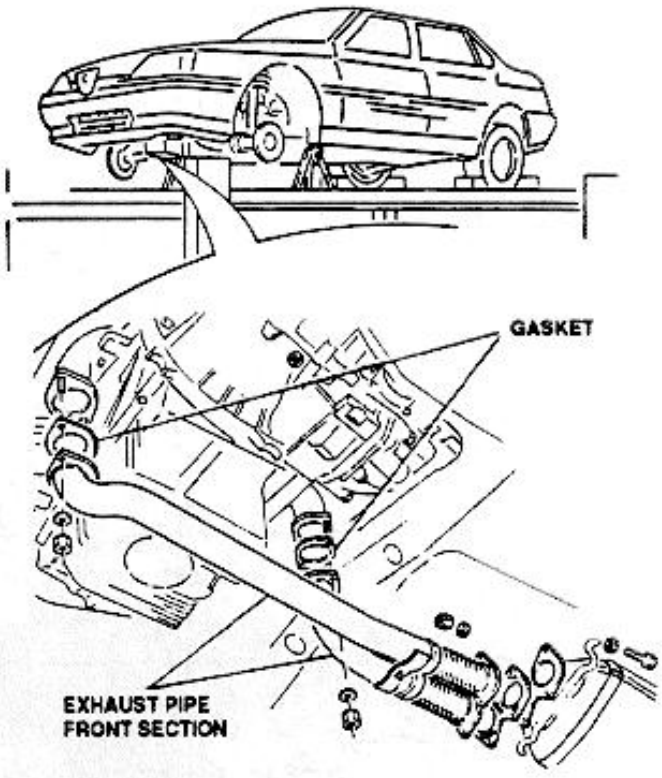
- On vehicles equipped with Automatic Transmission:
  - Remove oil dipstick and plug opening.



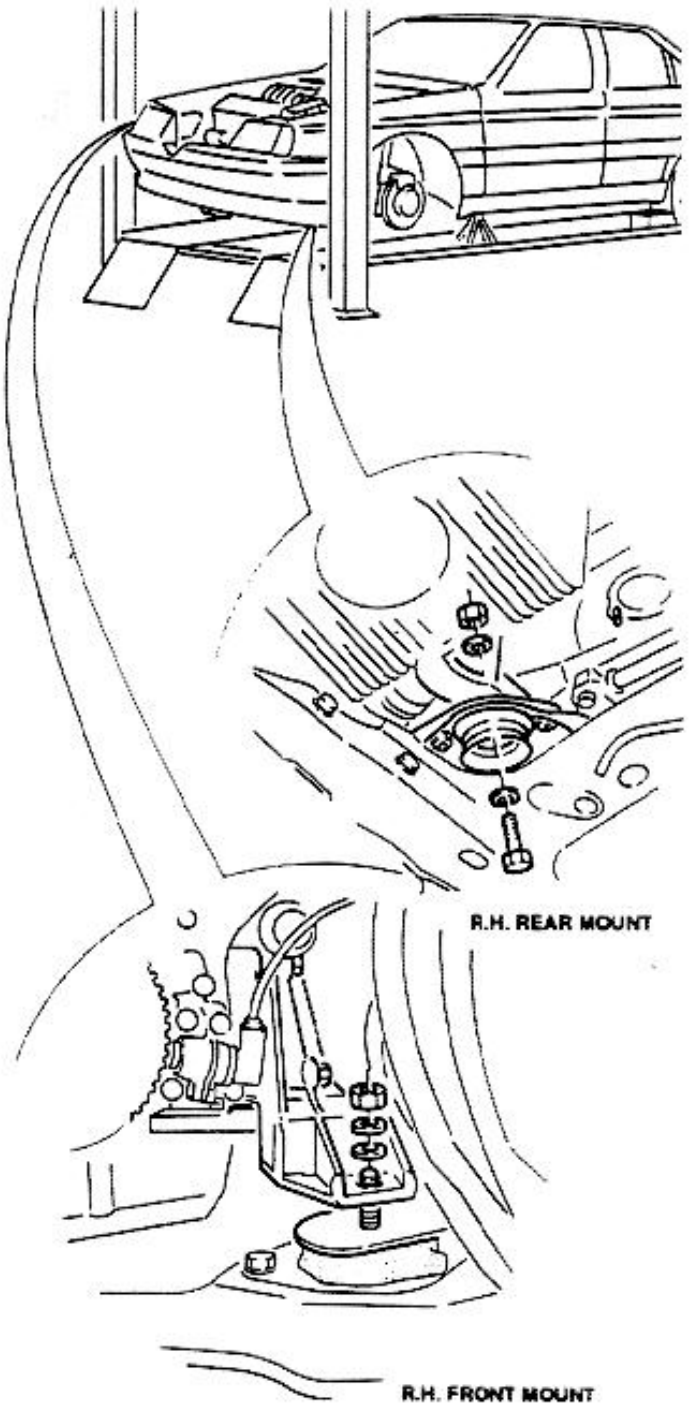
- Disconnect automatic transmission mount damper after the two support brackets have been removed.



- Lift vehicle on auto elevator.
- Disconnect front section of exhaust pipe and remove it; remove gaskets.

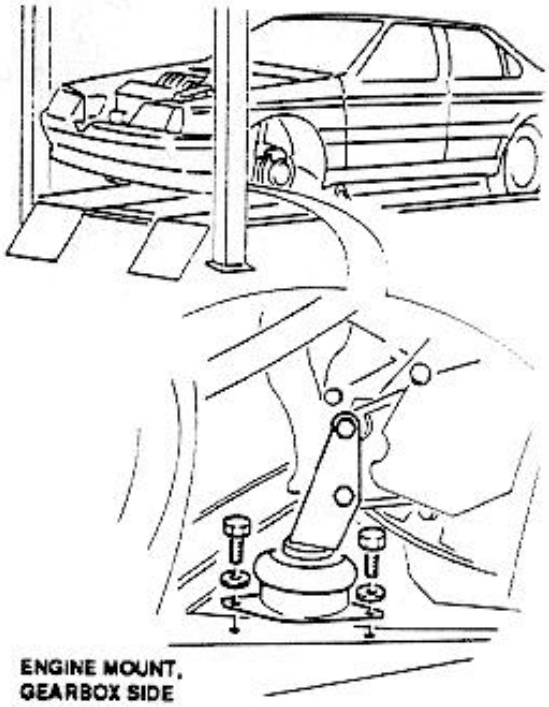


- Remove right front and rear mounts from their attachments



- Place a hydraulic jack below engine compartment, then extend jack until it contacts the gearbox.

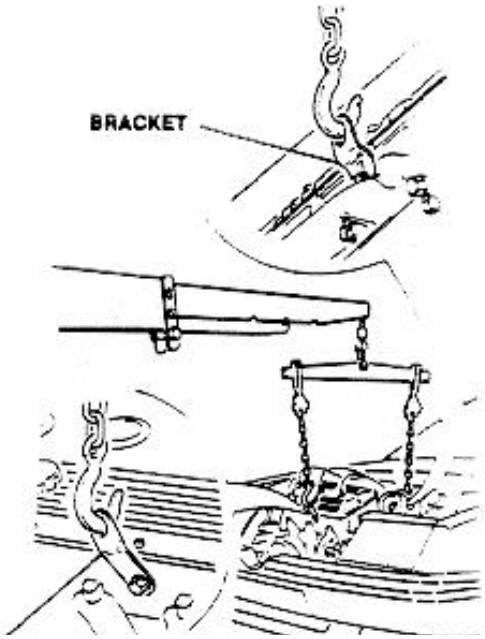
- Disconnect and remove engine mount on gearbox side.



ENGINE MOUNT, GEARBOX SIDE

- Connect hook of a suitable hoist to lifting brackets.

CAUTION:
Clear the electric cables from any clamping device and move them away from engine to prevent any interference during engine removal.



- Lift engine group.

CAUTION:
At the beginning of lifting operation check that all pipes, ducts and electric wires have been disconnected from engine

CAUTION:
Pay necessary attention to prevent damages to any component, and in particular to the power steering box, A.B.S. system rigid lines and to the air conditioning compressor and condenser.

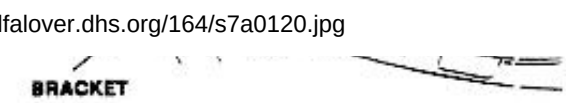
INSTALLATION

Repeat in reverse order the removal procedure, taking into account the following recommendations:

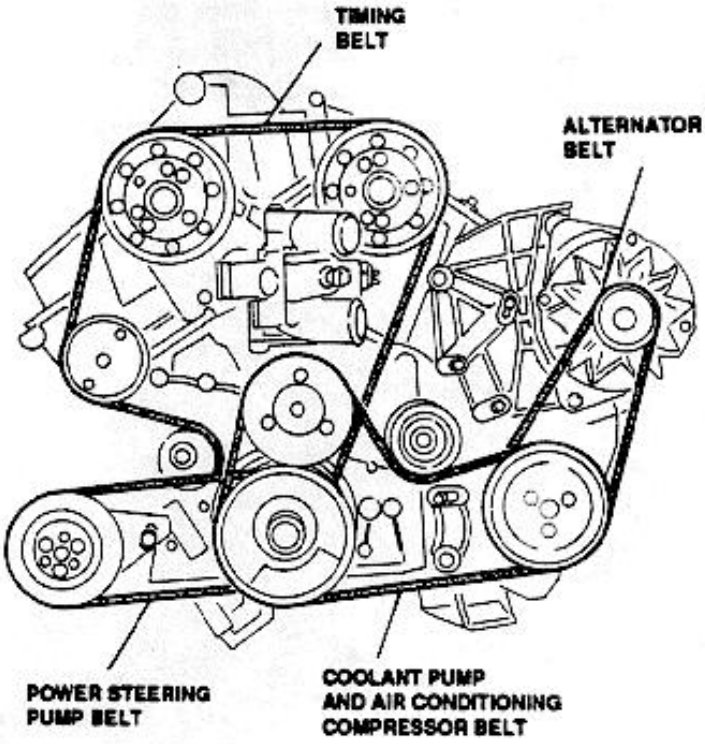
- Prepare engine compartment for insertion of engine group by placing all electric wires, pipes, etc. so that they will not interfere during engine installation.
- Pay necessary attention when lowering engine into its compartment to prevent damaging any component, and in particular the power steering box, A.B.S. system rigid pipes and the air conditioning compressor and condenser.

CAUTION:
Ensure the right side mounts are properly seated in their respective attachment points.

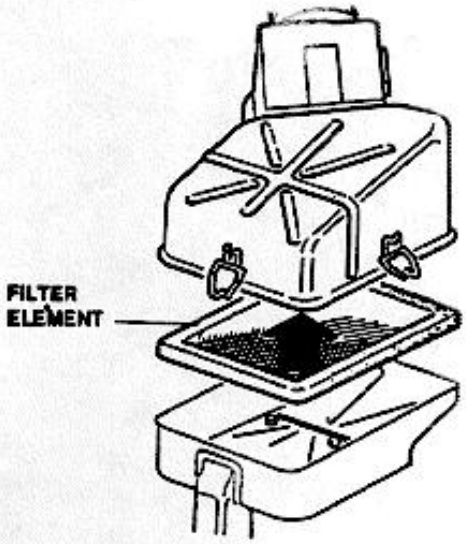
- Following installation, adjust tension of alternator drive belt, and check proper tension of all the other belts (Refer to Group 00).



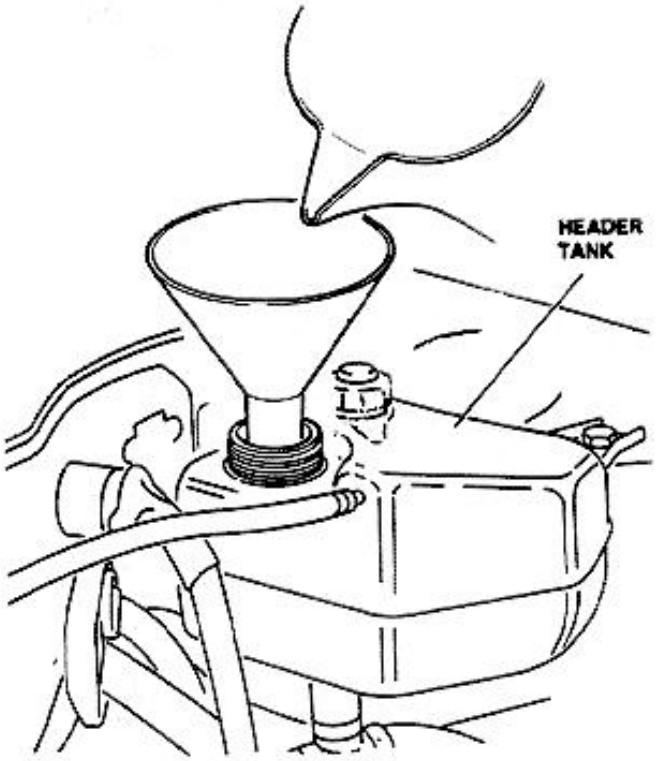
Belts (Refer to Group 00).



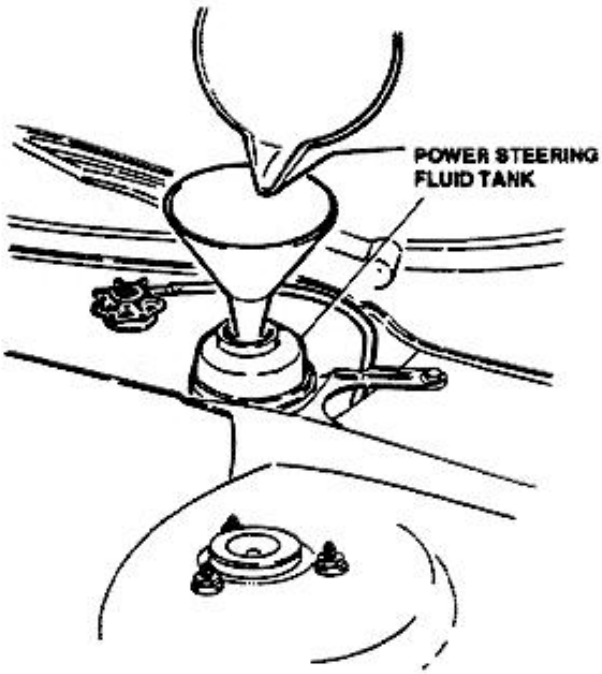
- On installation of air filter, place filter element with screen upside.



- Service engine cooling system with the prescribed quantity of coolant (Refer to **Group 07**)



- Service power steering hydraulic system with the prescribed quantity of fluid (Refer to **Group 23**).



- Check for proper level of all other fluids.
- Perform all prescribed adjstments and checks as stated in **Group 00**.

ENGINE BENCH OVERHAUL

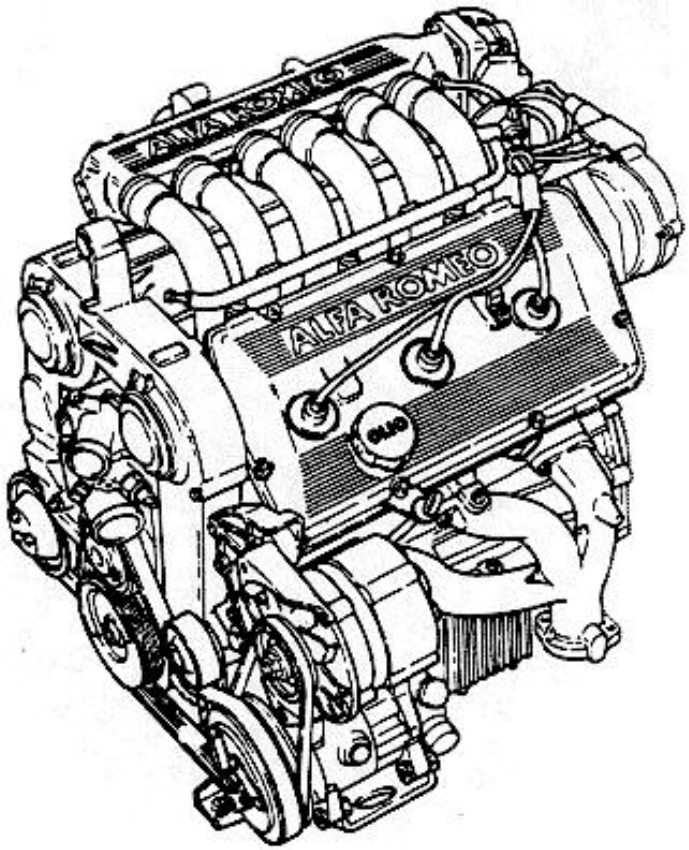
The instructions in the following paragraphs describe the complete engine bench overhaul, after the engine has been removed from the vehicle.
The instructions are divided as follows:

- **Engine disassembly and reassembly**: removal (and subsequent installation) of the gear box, accessories, ecc. off the engine, and disassembly of engine into its major groups.
- **Disassembly and overhaul of cylinder heads**: complete overhaul of cylinder heads, including even the smallest items.
- **Engine block checks and inspections**: complete overhaul of transmission drive components.
- **Precautionary instructions for the reassembly**: include specific reassembly operations that differ totally from disassembly instructions.

All the disassembly procedures stated in the following are applicable for engine reassembly if performed in reverse order, except where specifically stated.

- **Electrical components checks and inspections**: checks and inspections of electrical components installed in engine compartment.

The following procedures refer to the complete overhaul of the complete engine; nevertheless, parts of these procedures may be used separately, when necessary for treatment of specific items.



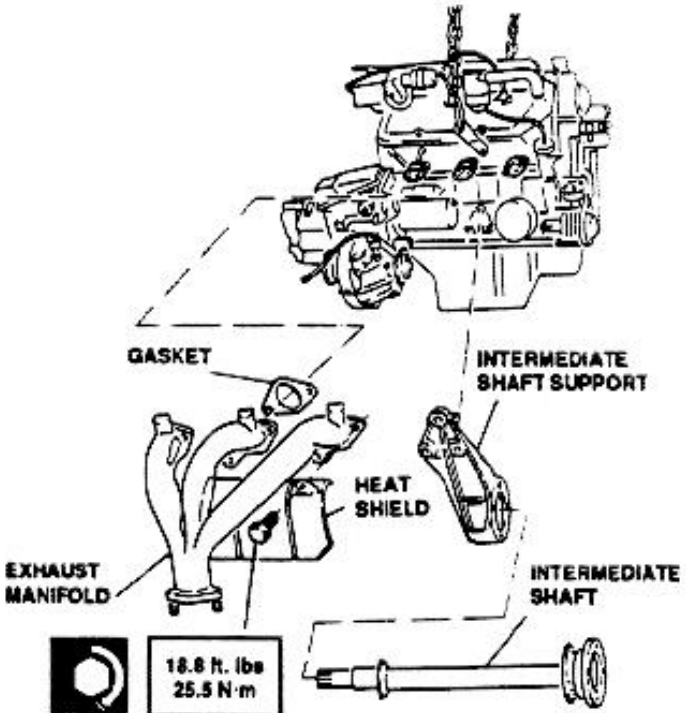
ENGINE DISASSEMBLY AND REASSEMBLY

This paragraph includes:

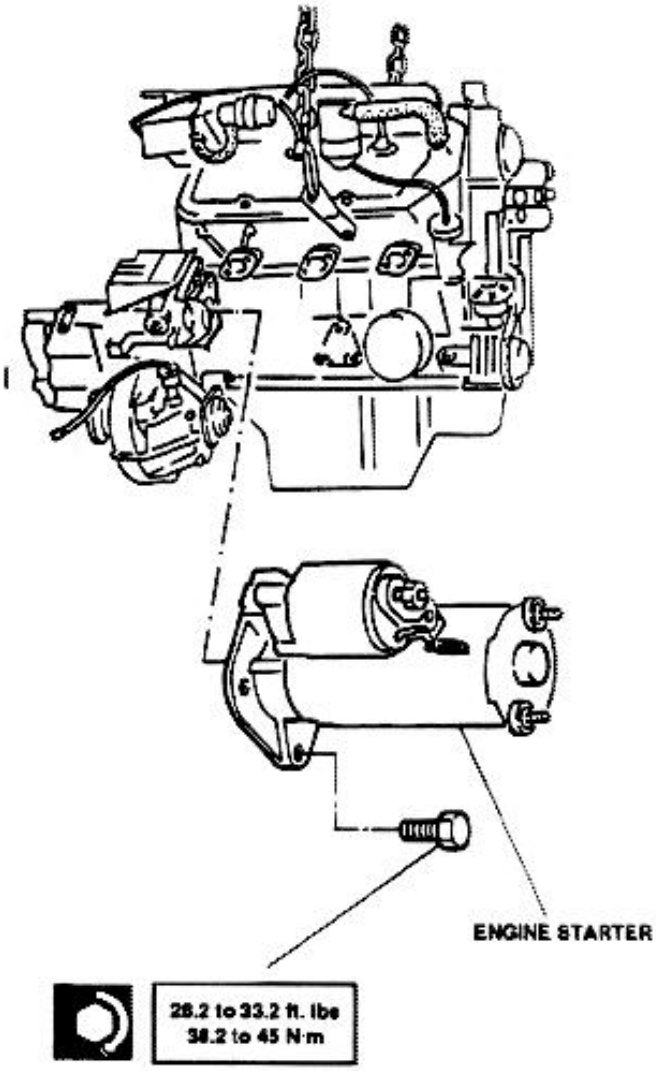
- R.H. side components removal.
- Gearbox-differential unit separation.
- Front side components removal.
- Lubrication system draining.
- Clutch disk removal (manual transmission only).
- Air collector box removal.
- Timing belt removal.
- Cylinder head components removal.
- Cylinder heads removal.
- Hydraulic belt tightener removal.
- Engine block components removal.
- Oil pump disassembly.
- Cylinder liners and pistons removal.
- Engine block components removal (continues).
- Crankshaft removal.

R.H. SIDE COMPONENTS REMOVAL

1. Remove exhaust manifolds.
2. Remove exhaust manifold gaskets.
3. Remove engine starter heat shield.
4. Drain oil from gearbox-differential unit.
5. Disconnect intermediate shaft from differential.
6. Remove intermediate shaft support.

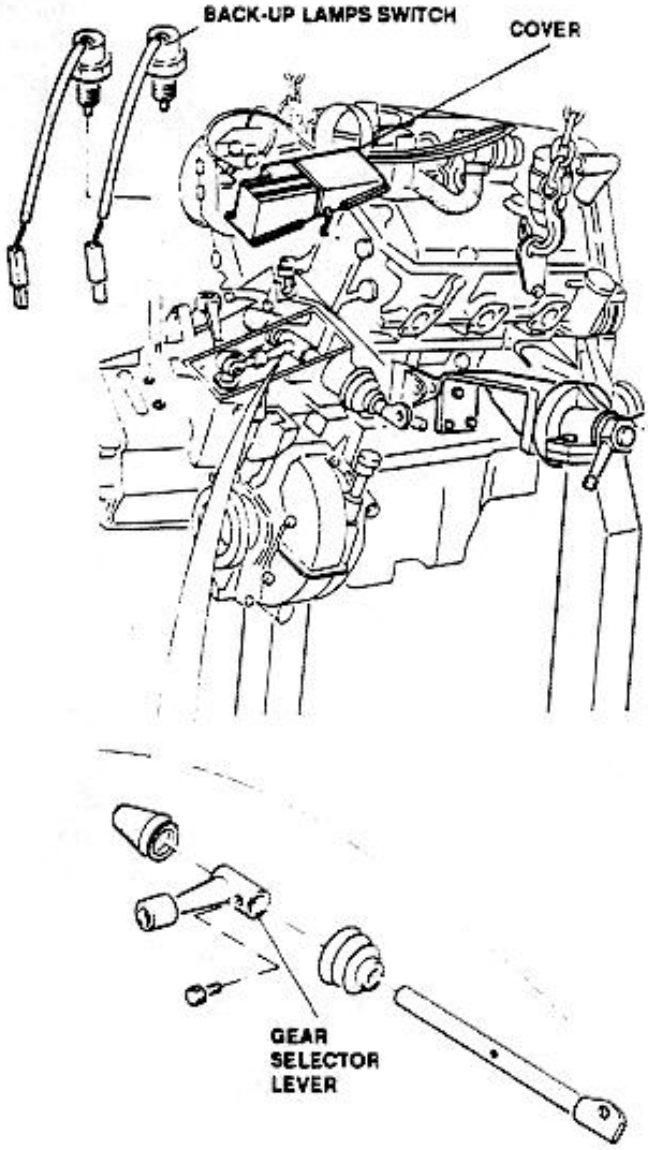


7. Remove engine starter

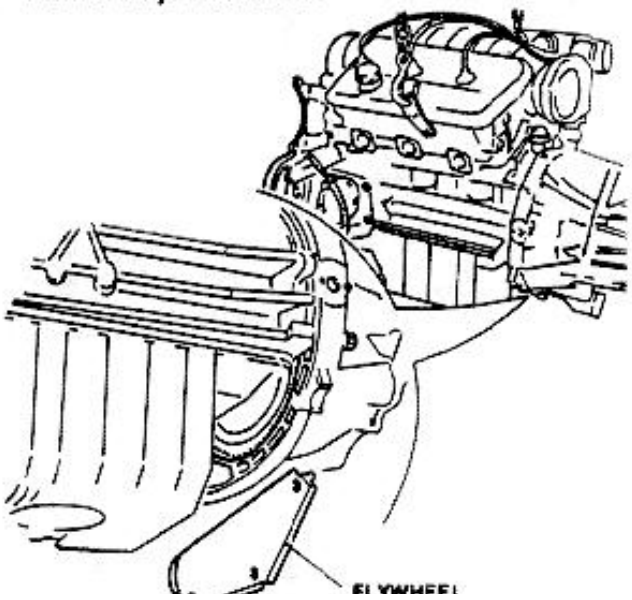


GEARBOX-DIFFERENTIAL UNIT SEPARATION (MANUAL TRANSMISSION)

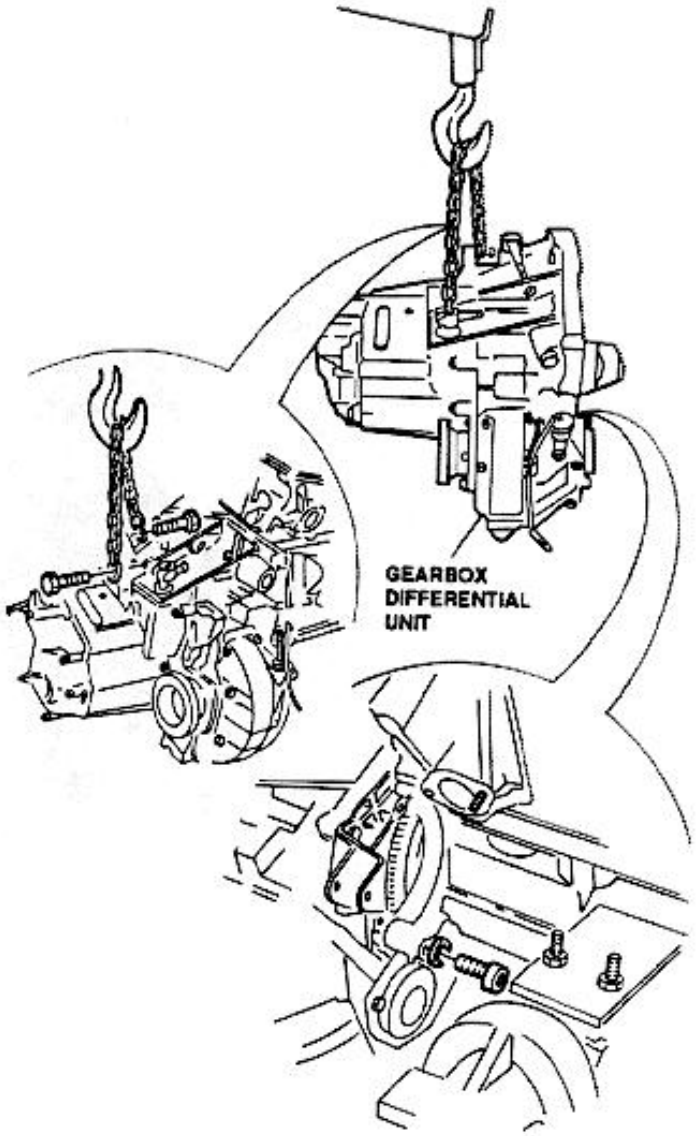
1. Place engine on a suitable work stand.
2. Remove gear selector lever cover.
3. Remove gear selector lever.
4. Remove back-up lamps switch.
5. Remove the gearbox sensor ("S" version only).



5 Remove flywheel cover



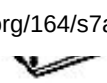
6. Remove gearbox-differential unit using a suitable hydraulic hoist



NOTE: For complete overhaul of manual transmission, refer to Group 13.

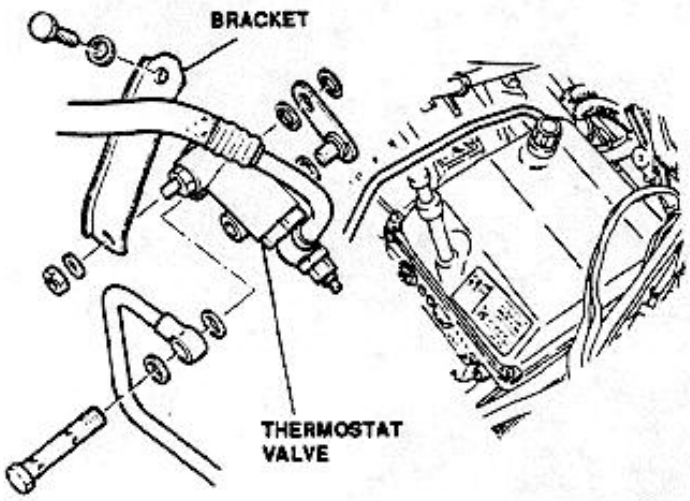
GEARBOX-DIFFERENTIAL UNIT SEPARATION (AUTOMATIC TRANSMISSION)

1. Remove thermostat valve and relevant bracket and

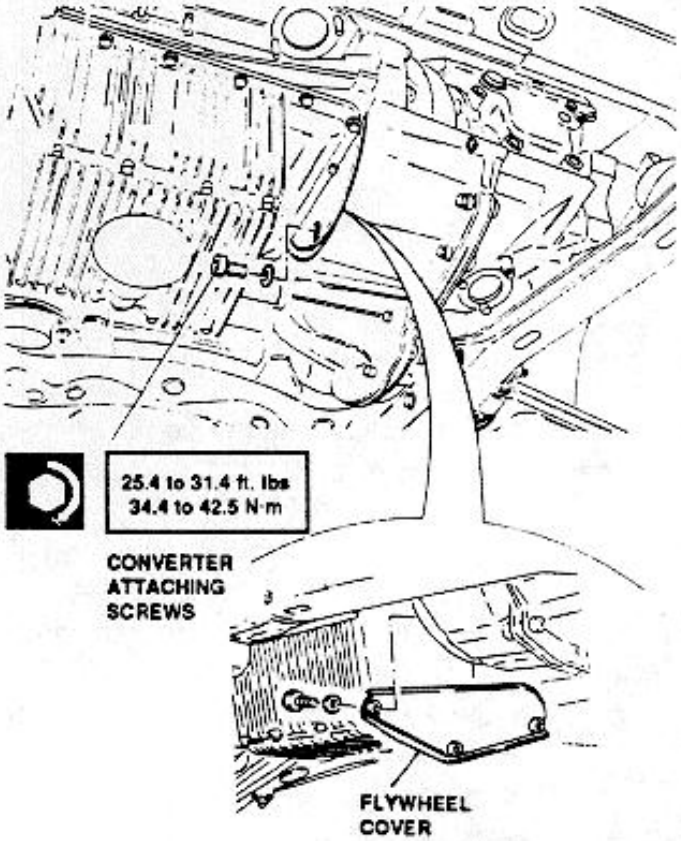


FLYWHEEL
COVER

pipes.

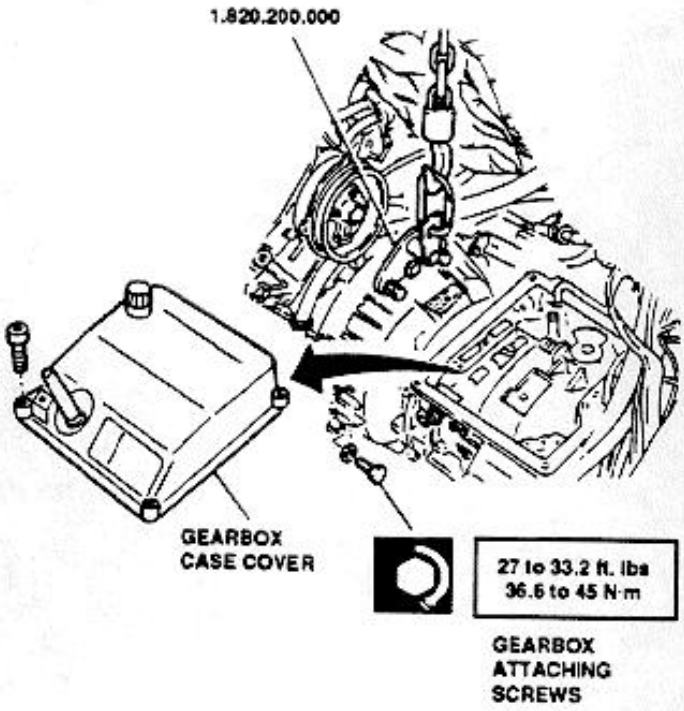


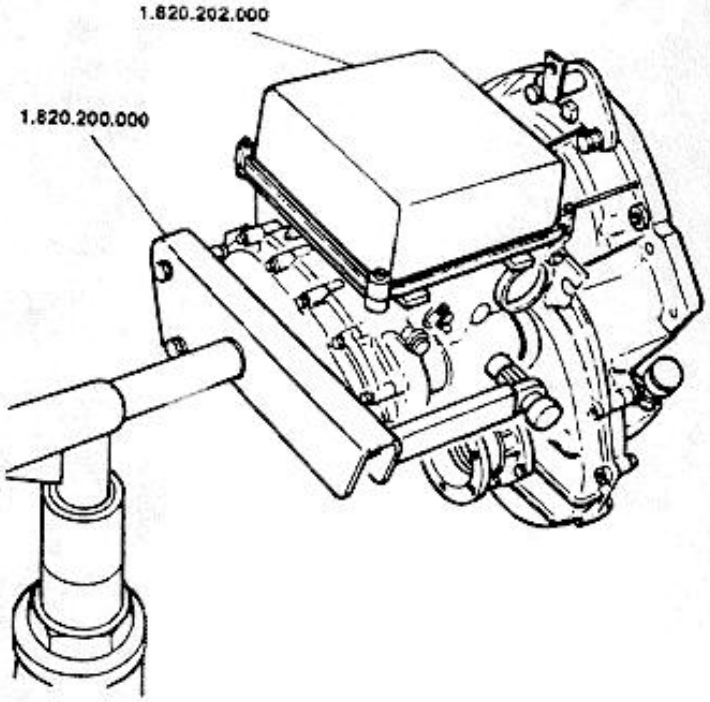
2. Remove flywheel cover.
3. Remove screws attaching converter to flywheel by locking engine pulley with a suitable wrench.



4. Remove screws attaching the gearbox to engine.
5. Remove gearbox cover and install at its place the protection cover **1.820.202.000.**

6. Install tool **1.820.200.000**, connect it to a suitable hoist and separate gearbox from engine.

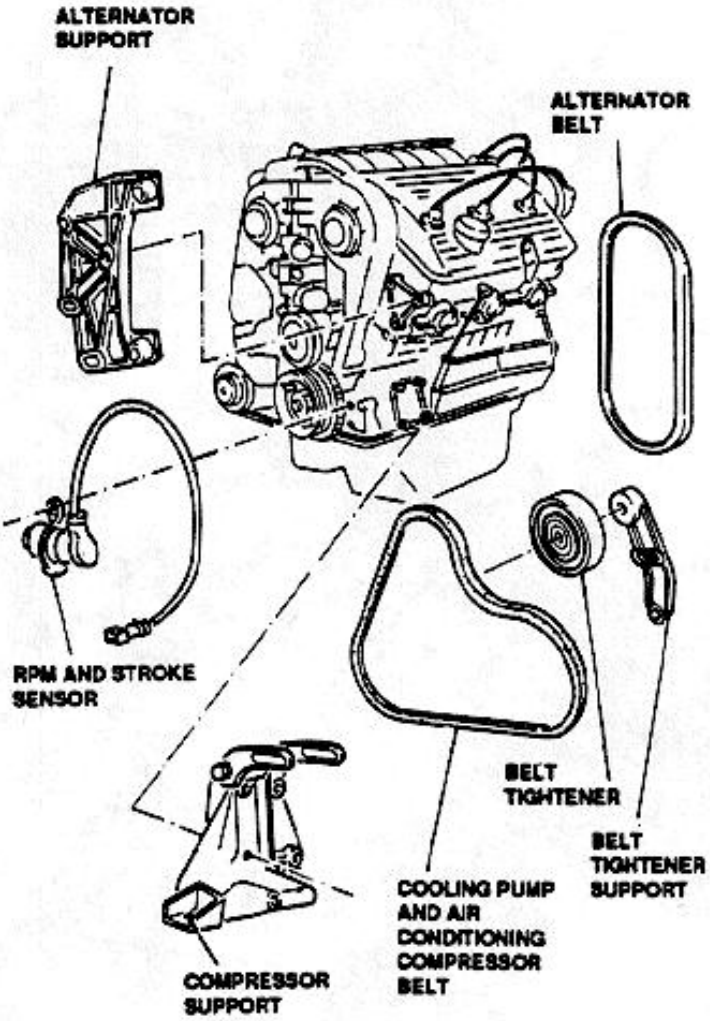




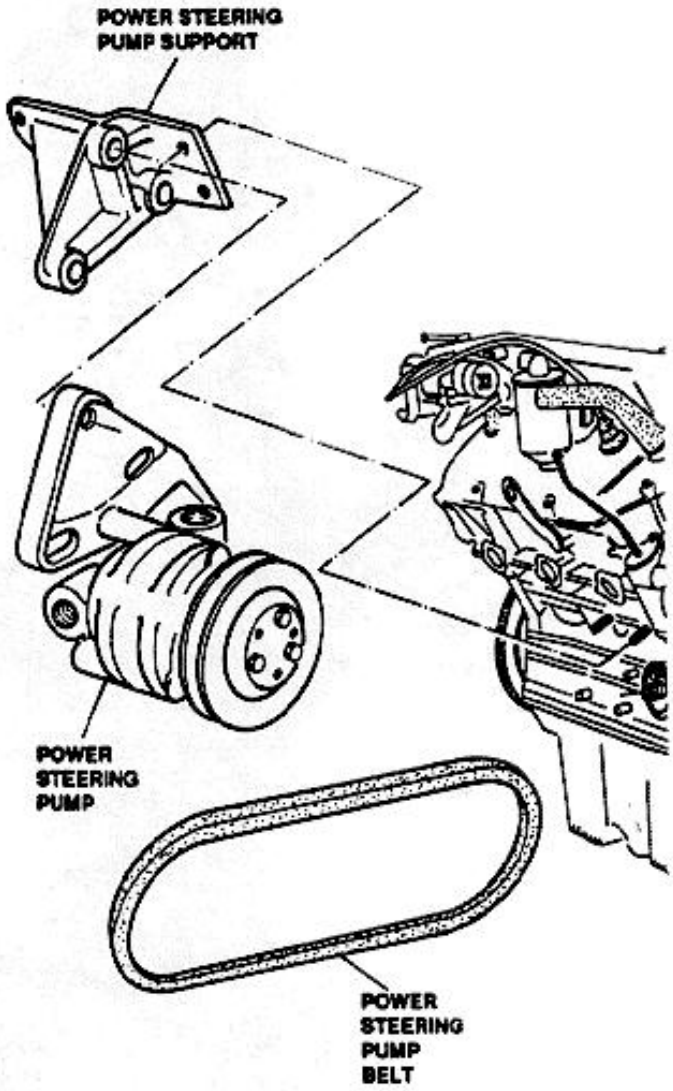
NOTE: **For complete overhaul of automatic transmission refer to Group 16.**

FRONT SIDE COMPONENTS REMOVAL

1. Remove alternator support.
2. Remove air conditioning compressor support and alternator drive belt.
3. Remove coolant pump and air conditioning compressor drive belt tightener and relevant support; remove drive belt.
4. Remove RPM and stroke sensor.



5. Remove power steering pump and support, remove drive belt.



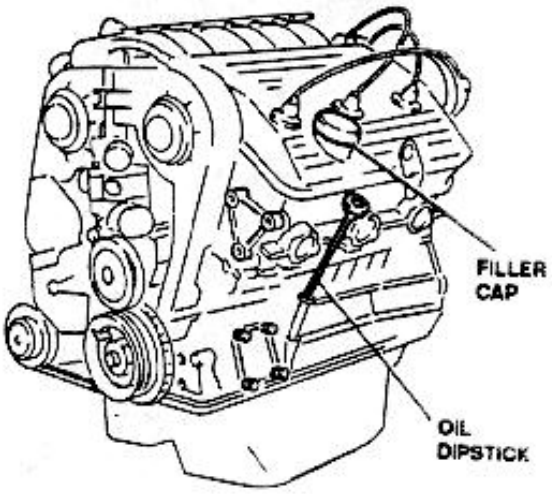
For belt tensioning at reassembly refer to Group 00.

LUBRICATION SYSTEM DRAINING

WARNING:
Engine oil is harmful for body skin; reduce to minimum contact of oil with skin; in case of contact wash the affected parts with water and soap.

1. Remove filler cap.
2. Remove oil dipstick.

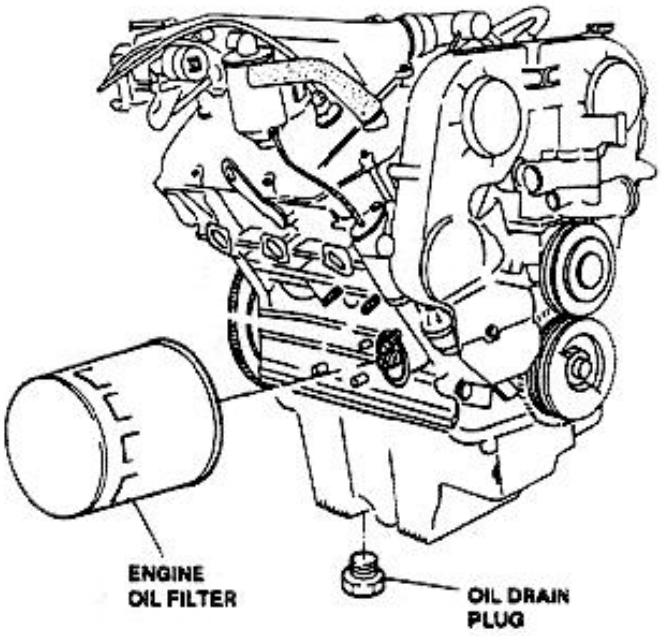
2. Remove oil dipstick.



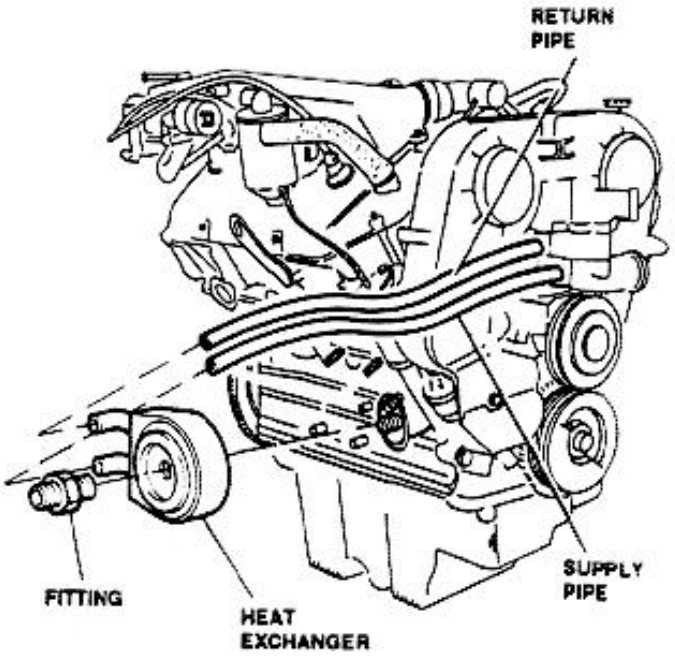
3. Unscrew drain plug and leave oil to drain completely for at least 15 minutes.

WARNING:
Do not disperse used oil to avoid environment pollution; inquire where used oil is safely collected in your area.

4. Unlock and remove oil filter using the proper wrench.

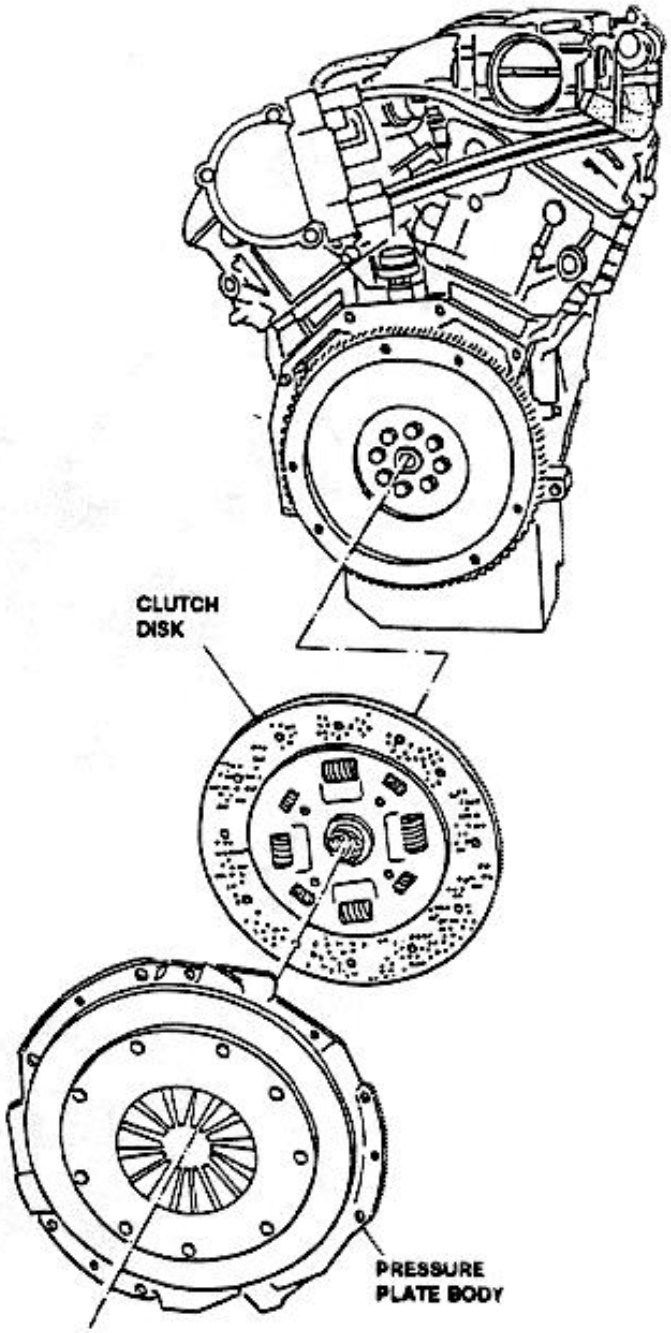


5. Carefully clean drain plug and reinstall on oil sump with relevant seal.
6. **Only for vehicles equipped with water-oil heat exchanger:** disconnect engine coolant supply and return pipes and remove oil filter heat exchanger; remove fitting.



CLUTCH DISK REMOVAL (MANUAL TRANSMISSION ONLY)

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

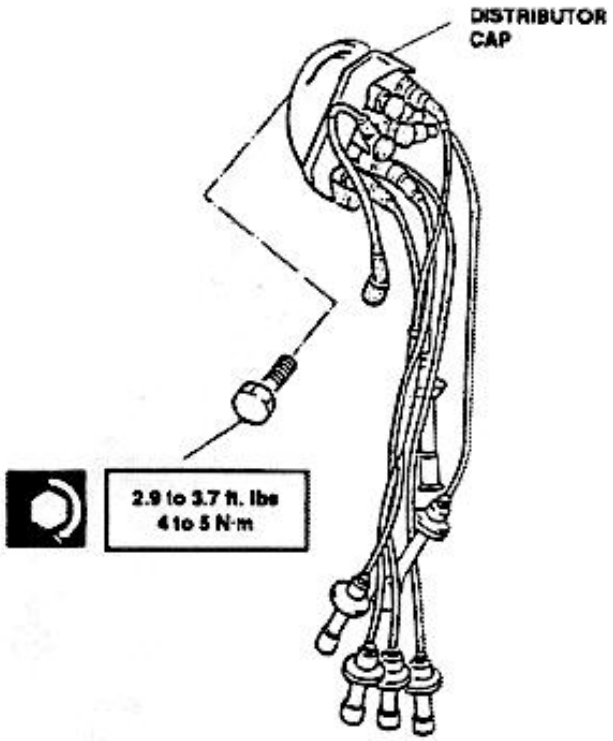


NOTE: For further details on operation of clutch and its components refer to Group 12.

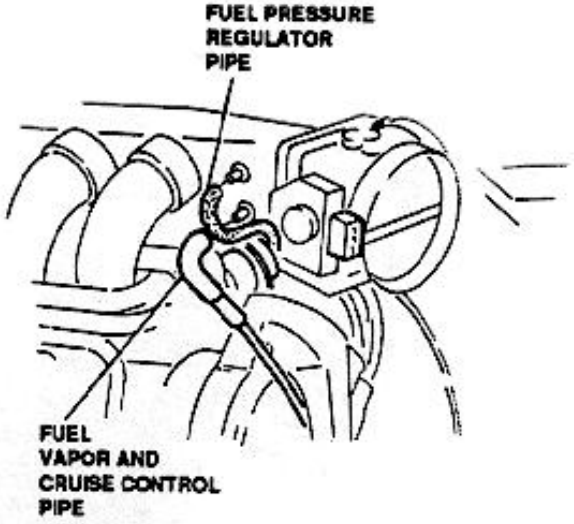
AIR COLLECTOR BOX REMOVAL

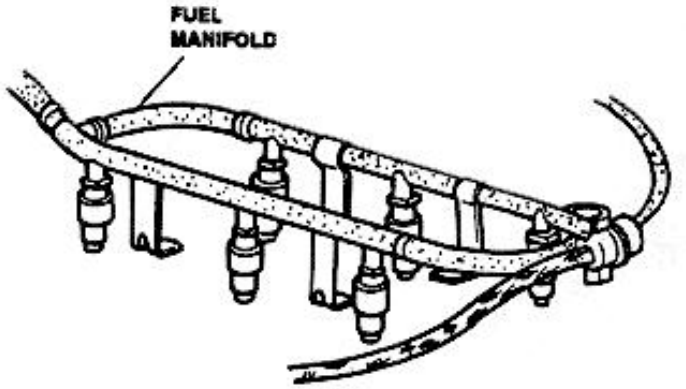
NOTE: For further disassembly and checks of the fuel supply system refer to Group 04.

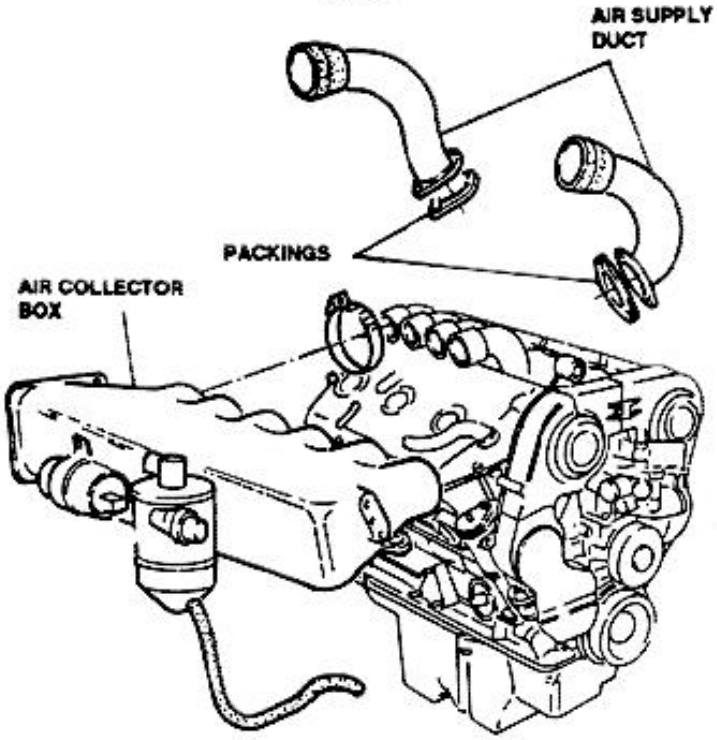
1. Disconnect spark plug leads and remove distributor cap.

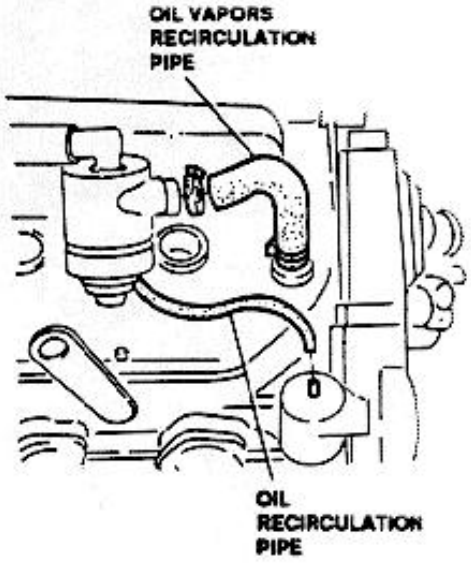


2. Disconnect fuel vapor and Cruise Control pipe.
3. Disconnect fuel pressure regulator pipe.
4. Disconnect oil vapors recirculation.
5. Disconnect oil recirculation pipe.





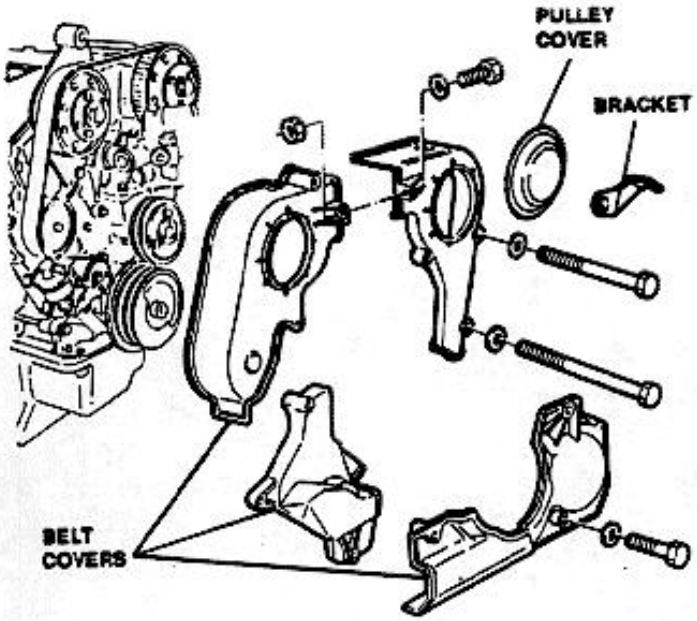


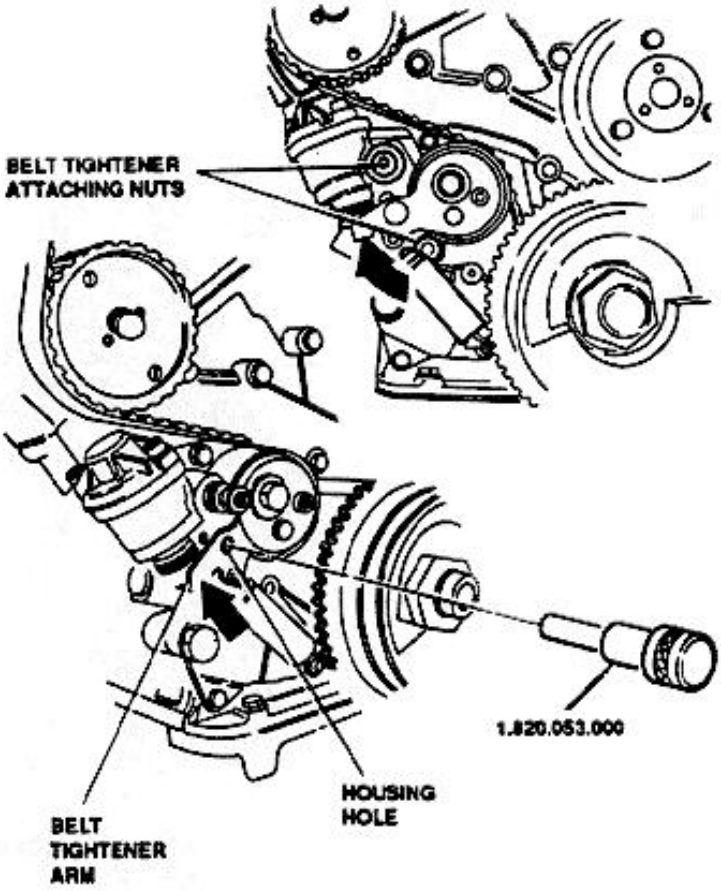


6. Remove air collector box.
7. Remove air supply ducts.
8. Remove air supply duct packings.
9. Remove fuel manifold and electronic injectors.

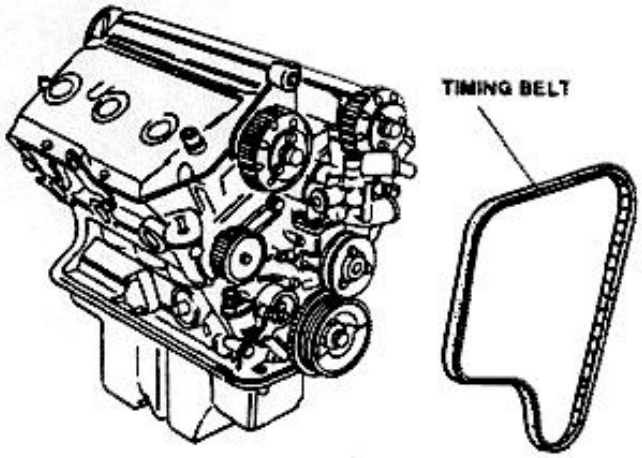
TIMING BELT REMOVAL

1. Remove timing pulley covers.
2. Remove timing belt covers.
3. Remove cable attachment bracket.





7. Remove timing belt from toothed pulley on cylinder heads and remove from crankshaft front pulley.



4. Lift hydraulic belt tightener arm and lock belt tightener using tool **1.820.053.000.**

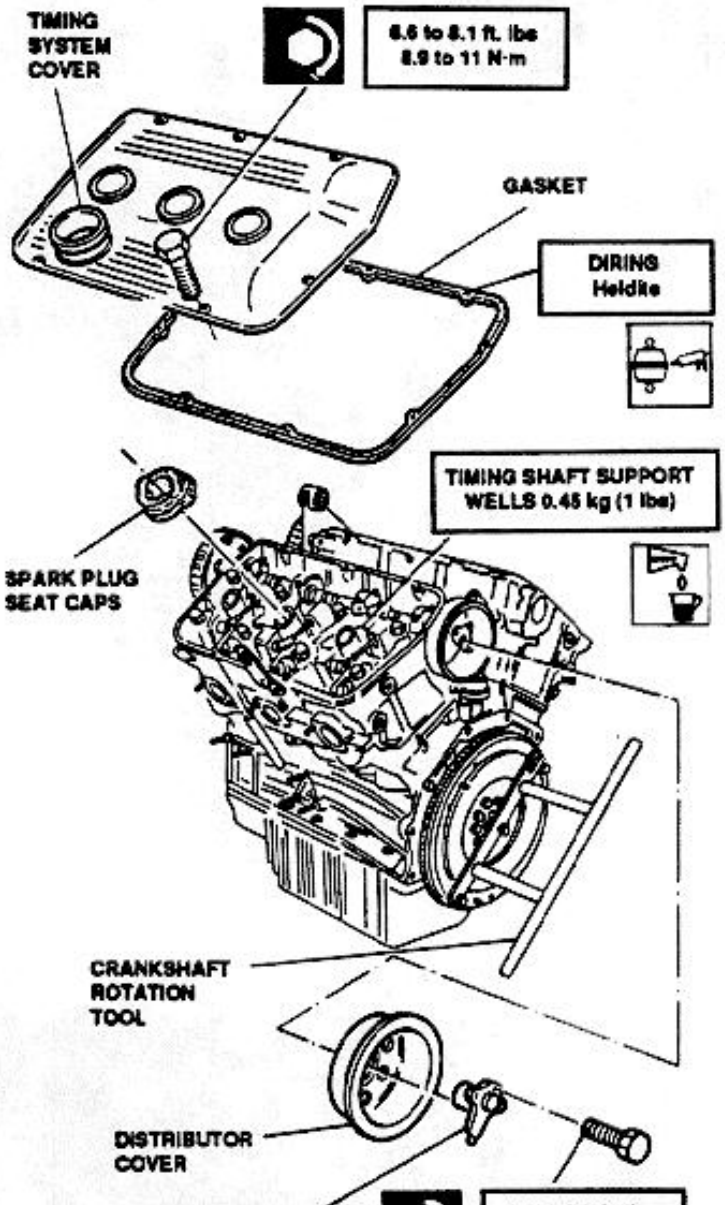
NOTE: Align housing hole to hole on tightener body to allow installation of tool **1.821.053.000.**

5. Loosen the two nuts attaching tightener body to engine block.
6. Turn hydraulic tightener upwards and lock in position by tightening bolt loosened at step 5.

For timing belt installation and checks refer to further relevant paragraph.

CYLINDER HEAD COMPONENTS REMOVAL

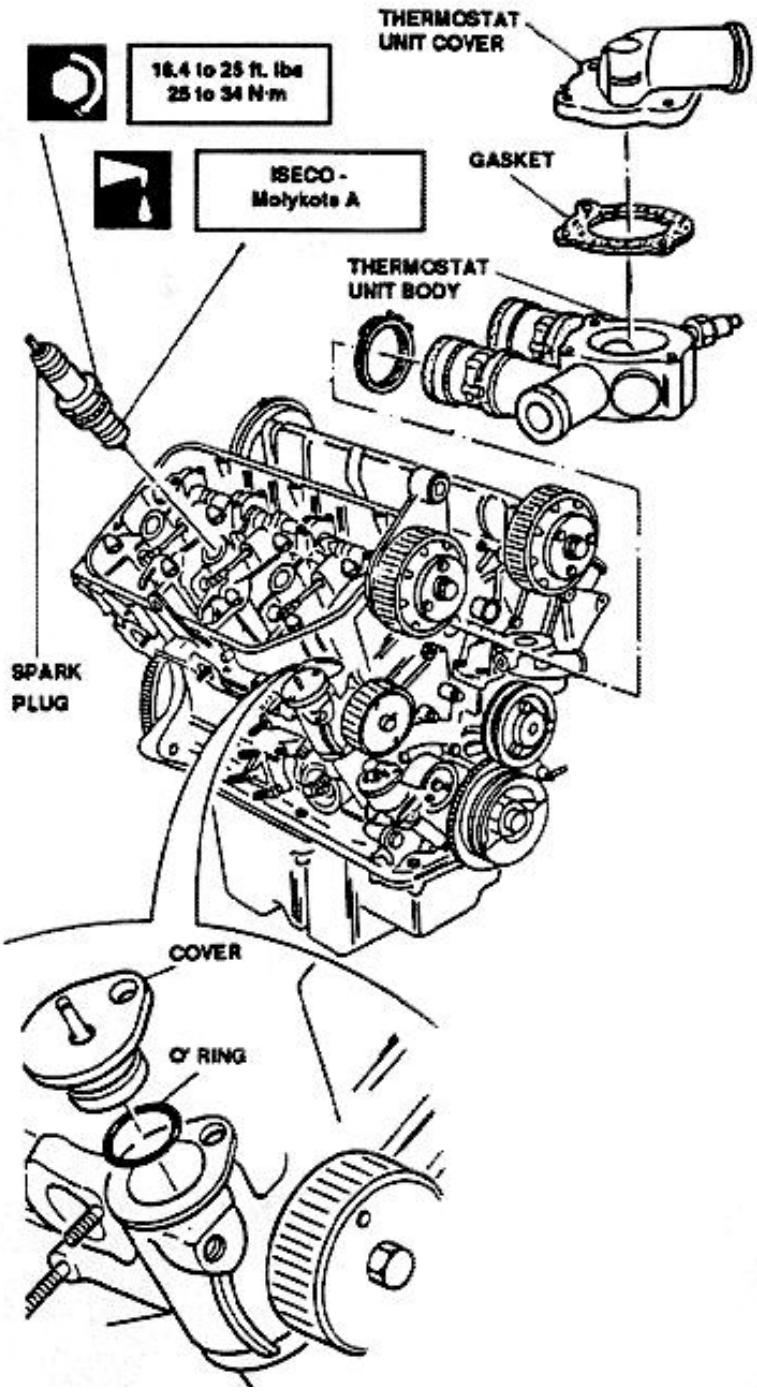
1. Remove distributor rotor arm.
2. Remove cover.
3. Remove timing system covers.
4. Remove gasket between timing system covers and cylinder heads.
5. Remove spark plug seat caps.
6. Install a suitable tool to allow rotation of engine crankshaft.

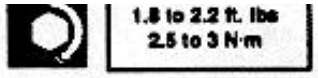


7. Remove thermostat unit cover and gasket.
8. Remove thermostat unit body by disconnecting it from cooling duct of each cylinder head.

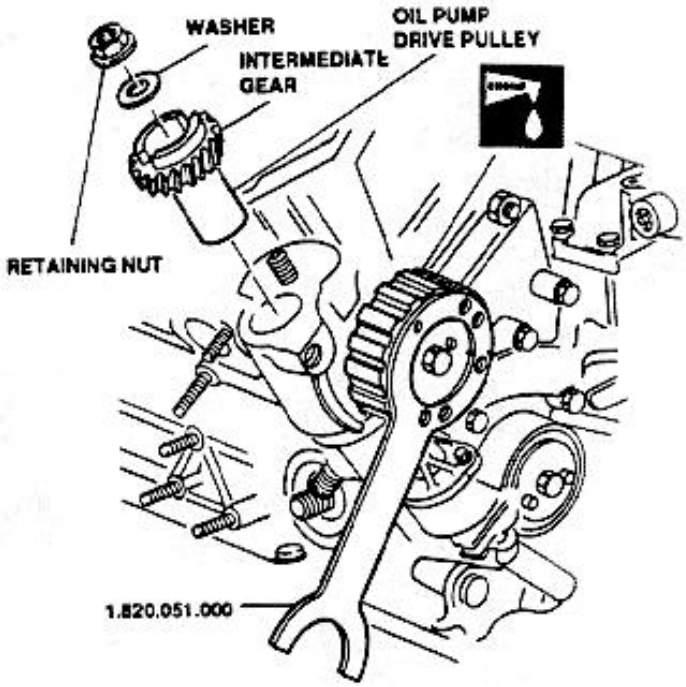
NOTE: For thermostat unit disassembly and inspection refer to **Group 07.**

9. Remove spark plugs.
10. Remove cover and relevant o'ring.



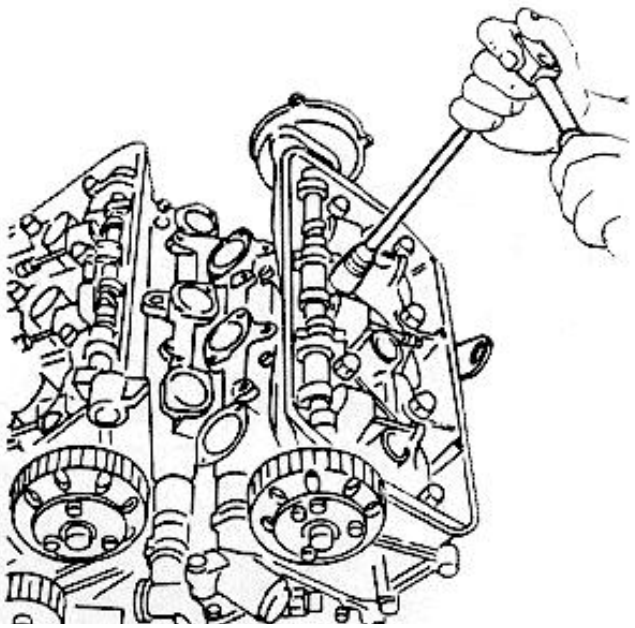


11. Prevent rotation of oil pump drive pulley using tool **1.820.051.000.**
12. Unscrew oil pump drive intermediate gear retaining nut.
13. Remove washer.
14. Remove intermediate gear.



CYLINDER HEADS REMOVAL

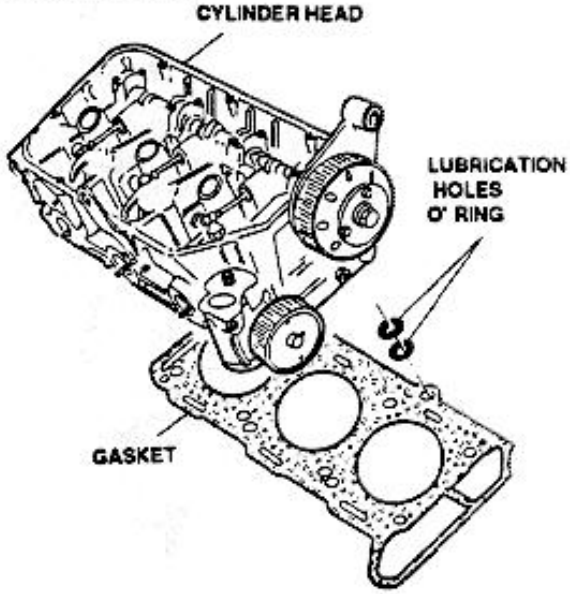
1. Remove nuts and washers (eight for each head) attaching cylinder head to engine block.



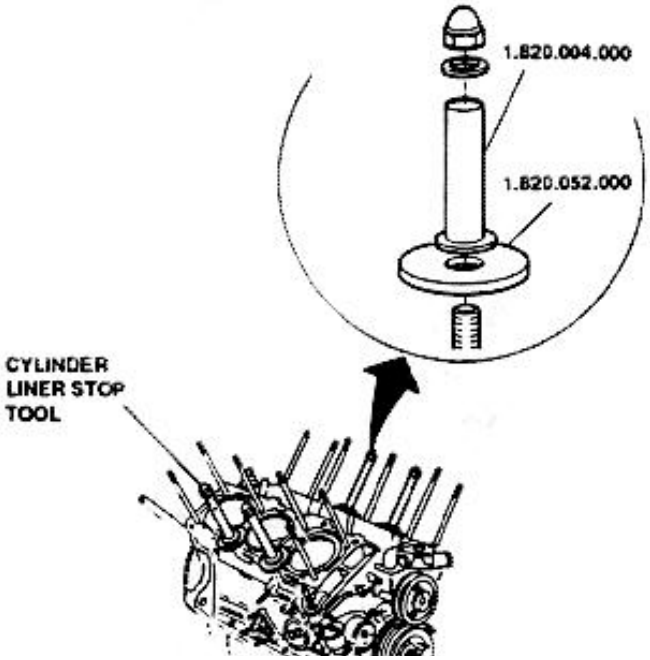
2. Remove cylinder heads.

CAUTION:
Take care not to damage engine block studs during heads removal.

3. Remove gaskets between cylinder heads and engine block.
4. Remove lubrication holes o'rings (two on each side of engine block).



5. Install cylinder liner fixing tool **1.820.004.000** and relevant additional washers **1.820.052.000**.

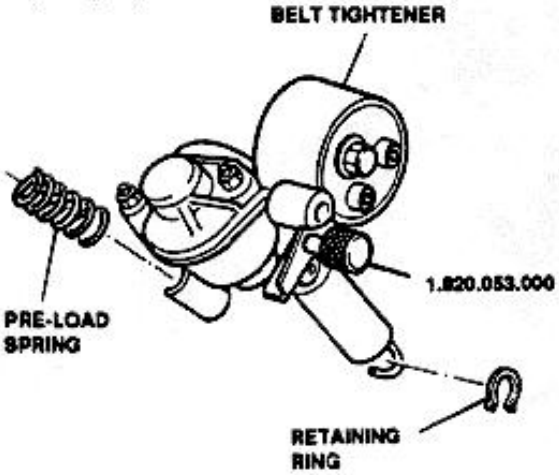


For cylinder head installation , refer to further relevant paragraph

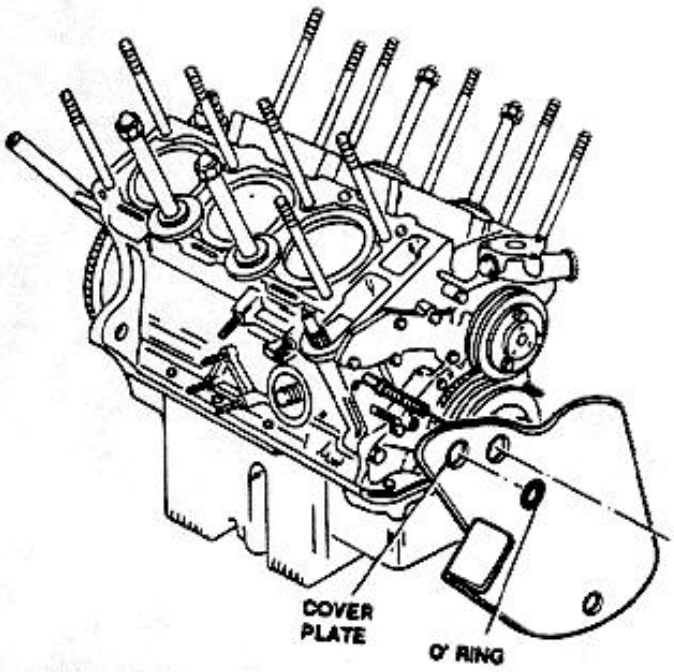
HYDRAULIC BELT TIGHTENER REMOVAL

1. Remove retaining ring.
2. Remove hydraulic belt tightener.
3. Withdraw pre-load spring.

NOTE: For belt tightener overhaul, refer to relevant paragraph



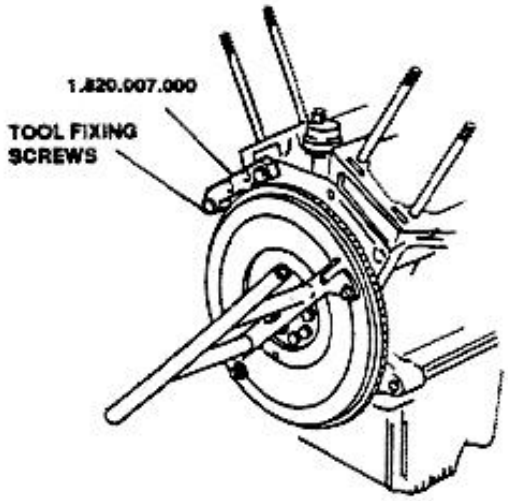
4. Remove spring cover plate.
5. Remove o'ring.



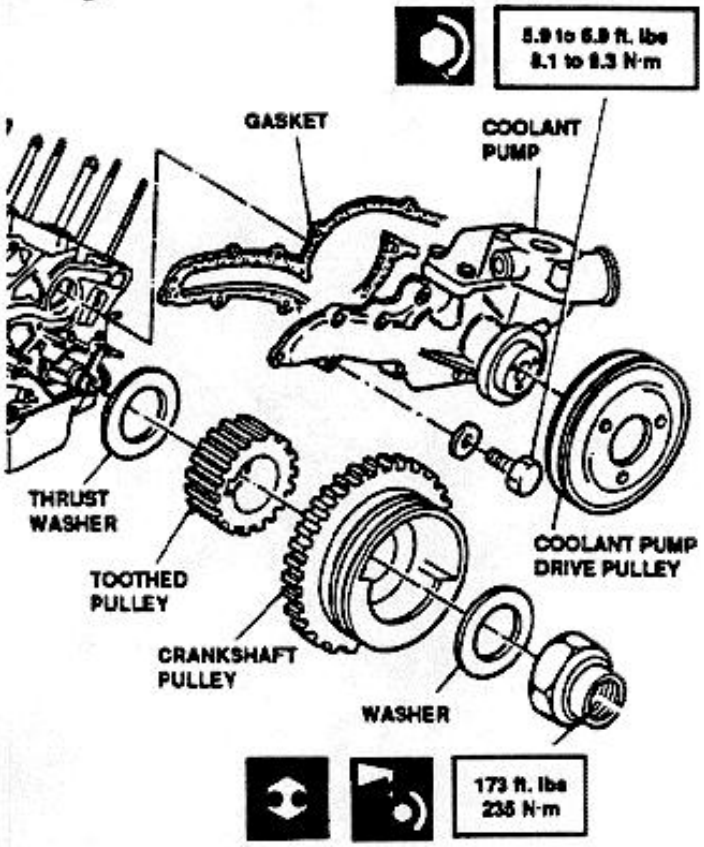
At reassembly, ensure belt tightener is locked with tool **1.820.053.000**.

ENGINE BLOCK COMPONENTS REMOVAL

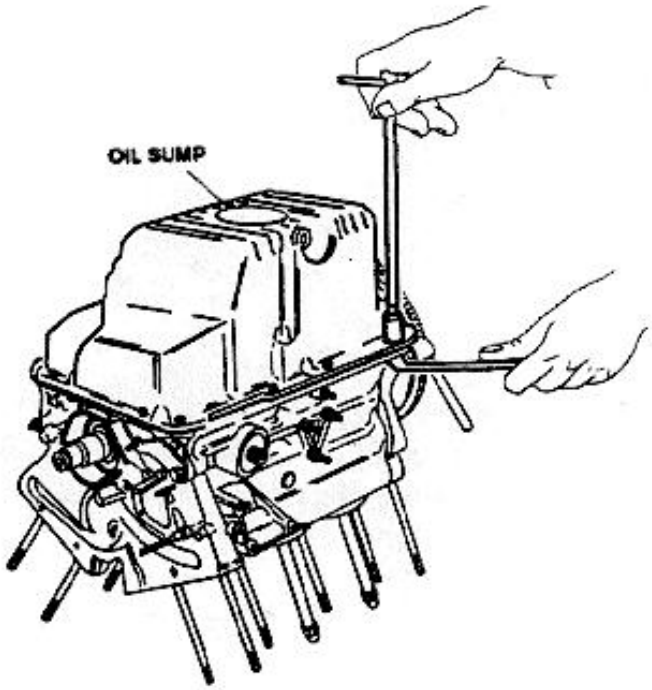
1. Prevent flywheel rotation using tool **1.820.007.000**; before fixing the tool with relevant screws, note that tooth is properly aligned to tooth of flywheel ring gear.



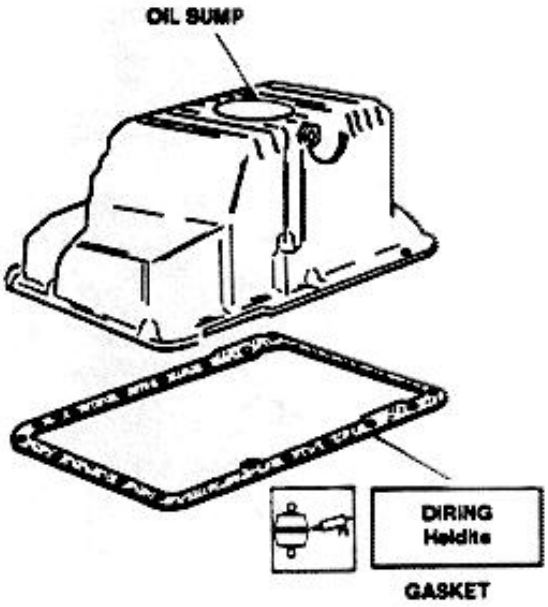
2. Remove coolant pump drive pulley.
3. Remove crankshaft pulley.
4. Remove timing belt toothed drive pulley.
5. Remove washer.
6. Remove thrust washer (at reassembly, the thrust washer convex side must be faced towards front cover).
7. Remove engine coolant pump.
8. Remove coolant pump gasket.



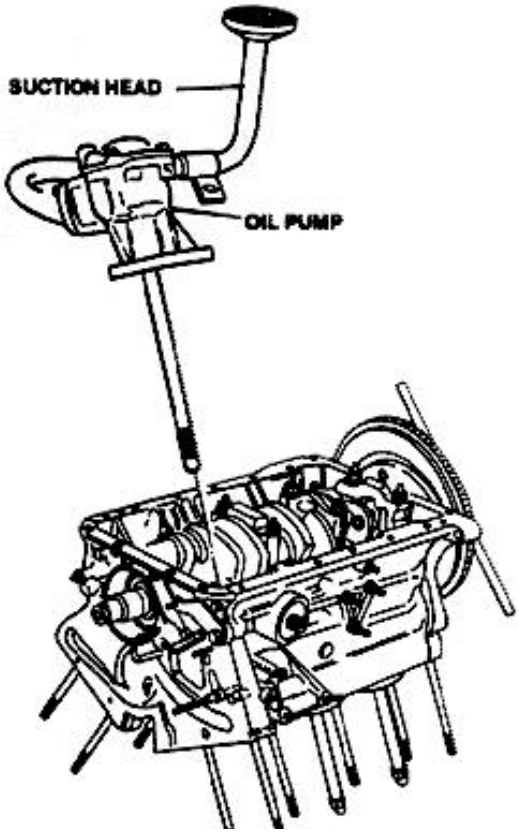
9. Unlock work stand and rotate engine group of 180°.
10. Unscrew all screws fixing oil sump to engine block.



11. Remove the complete oil sump and gasket. If necessary, remove traces of sealing compound from oil sump and engine block.



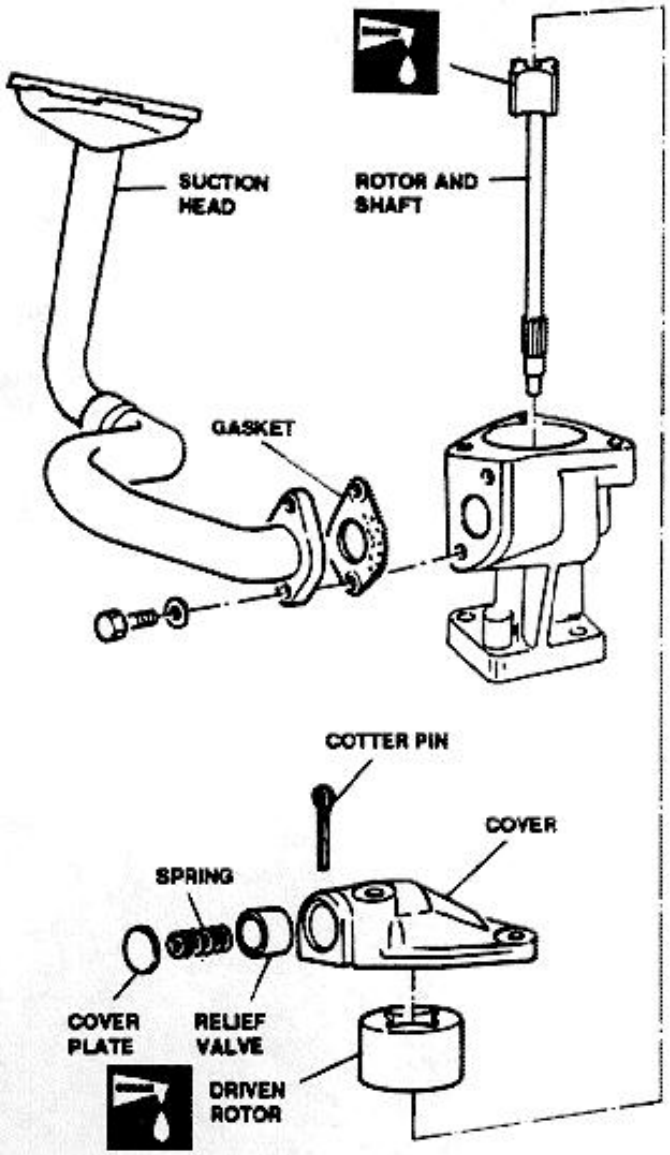
12. Remove oil pump and suction head.



OIL PUMP DISASSEMBLY

1. Remove suction head.
2. Remove gasket between pump body and suction head.
3. Remove cover.
4. Remove cotter pin.
5. Remove cover plate.
6. Remove spring.
7. Remove oil pressure relief valve.
8. Withdraw driven rotor from pump body.
9. Remove inner rotor and shaft from body.

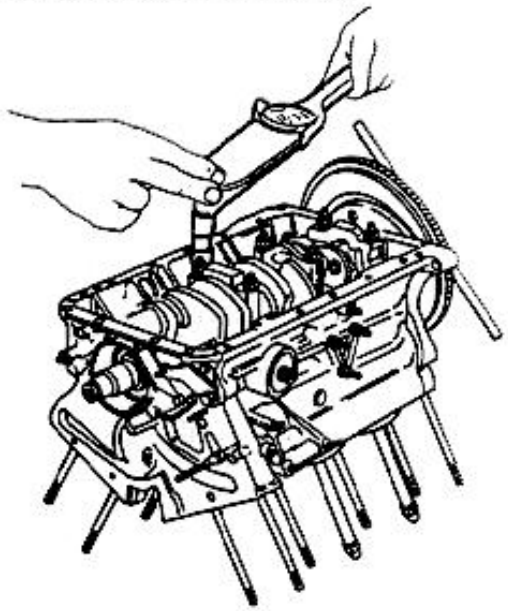
NOTE: Do not remove inner rotor from shaft.



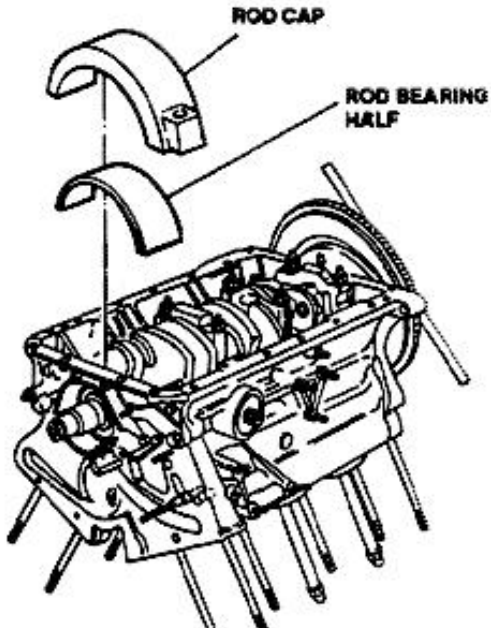
NOTE: For pump complete overhaul, refer to oil pump

CYLINDER LINERS AND PISTONS REMOVAL

1. Operate on right row of cylinders (1st, 2nd and 3rd cylinders).
2. Remove tool 1.820.007.000 that prevents rotation of flywheel.
3. Rotate crankshaft as required to gain access to rod cap attaching screws.
4. Loosen and remove screws.

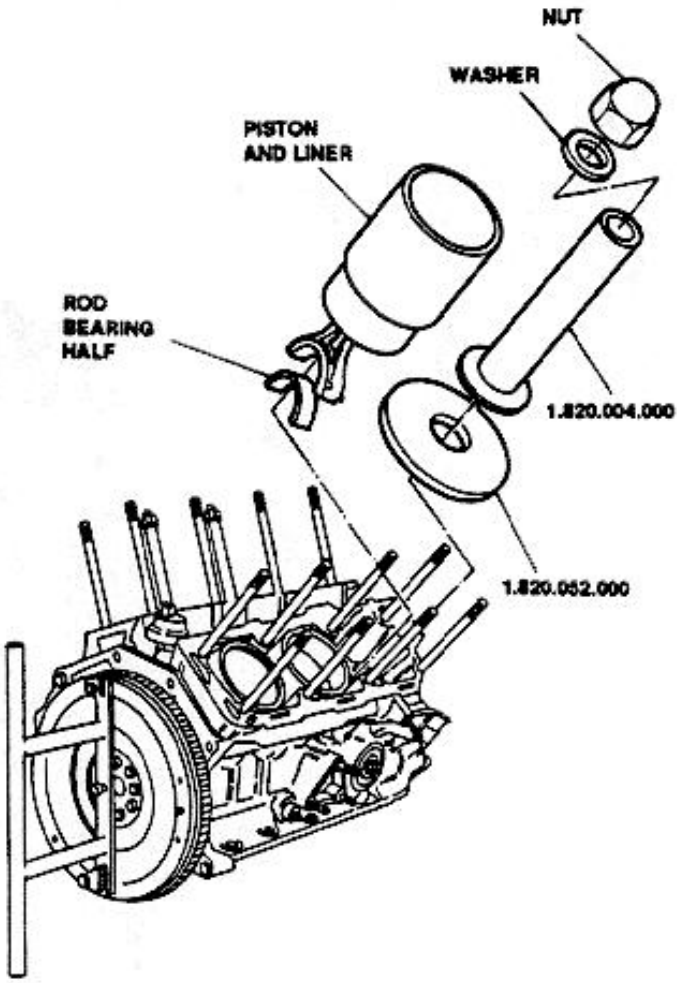


5. Remove rod caps of 1st, 2nd and 3rd cylinder.
6. Remove relevant rod bearing halves.



checks and inspections paragraph.

7. Unlock workstand and rotate engine group of 180°.
8. Remove nut and washer.
9. Remove cylinder liner fixing tool **1.820.004.000** and relevant washers **1.820.052.000** from relevant row of cylinders.
10. Withdraw all piston-rod groups together with cylinder liners from engine block.
11. Remove rod bearing halves.
12. Rotate engine block 180° and act in analogy on opposite row of cylinders (4th, 5th and 6th cylinders).



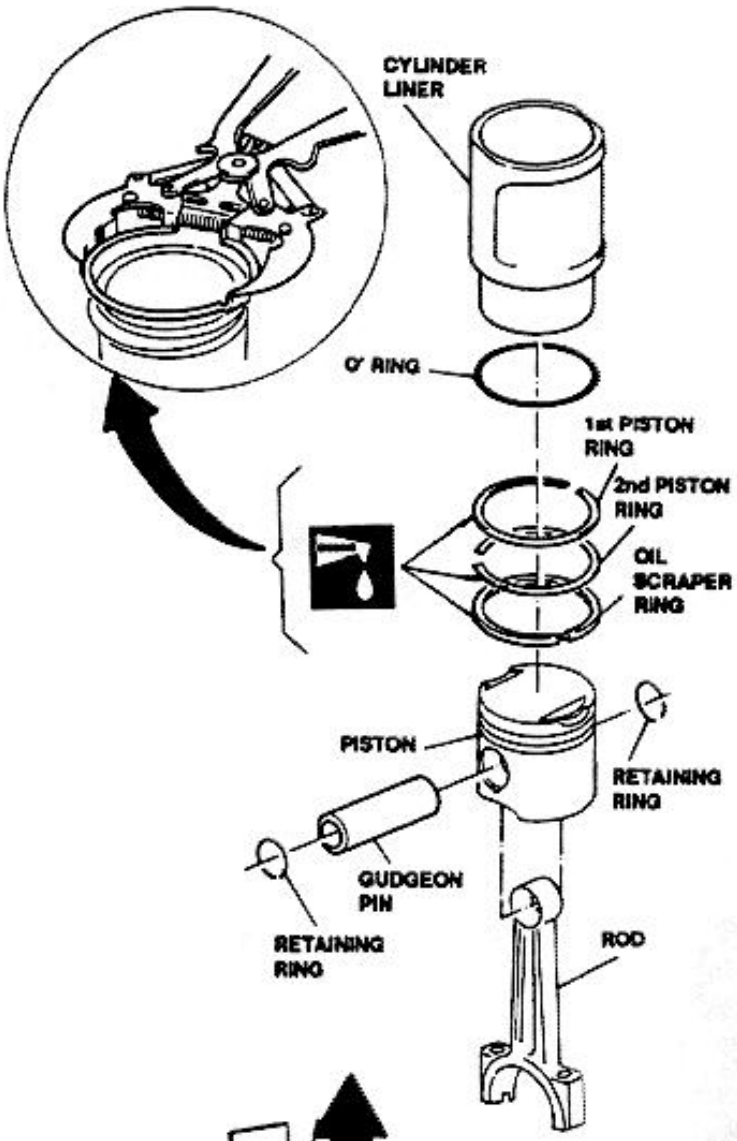
13. Withdraw cylinder liners.
14. Remove o'ring.
15. Withdraw piston rings and oil scraper ring from piston using a suitable tool.

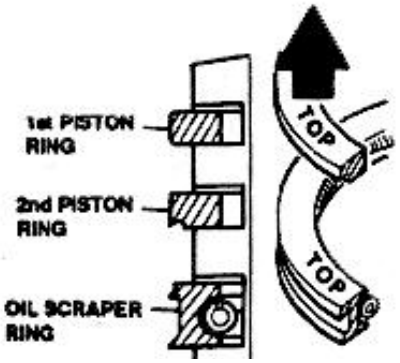
CAUTION:
Operate with precaution to avoid accidental breakage of piston rings, since they could be eventually reused

At reassembly, locate seal rings so that "TOP" marking on rings is faced upwards.

16. Remove retaining rings fixing gudgeon pin.
17. Remove gudgeon pin and separate piston and rod.

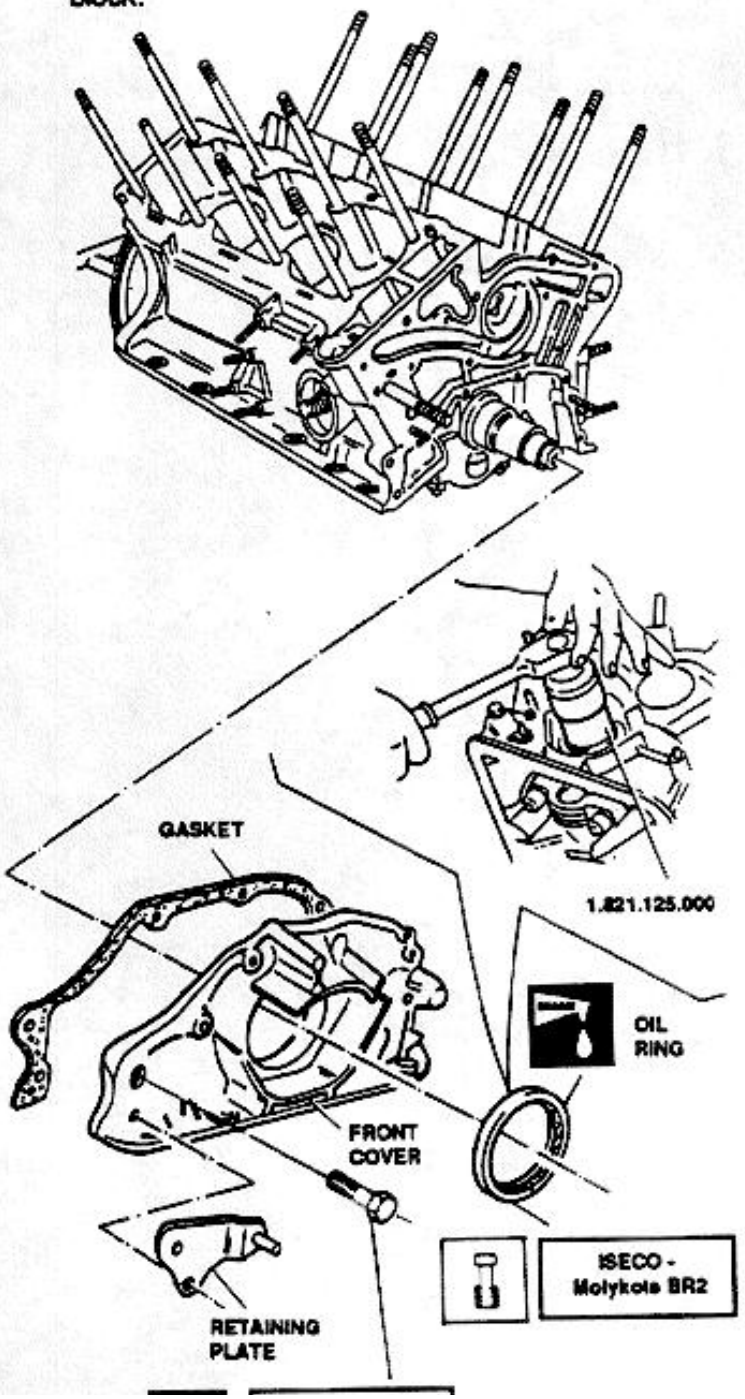
For reassembly refer to cylinder liners, pistons and rods installation paragraph.



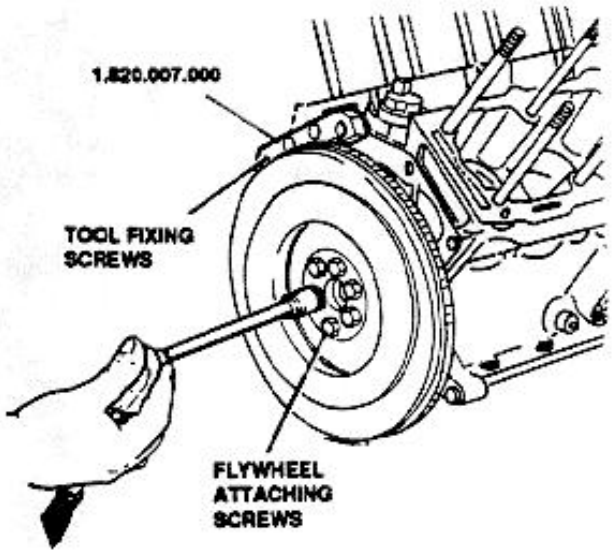


ENGINE BLOCK COMPONENTS REMOVAL (CONTINUES)

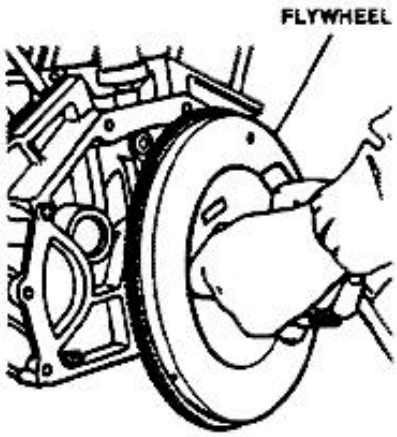
1. Remove front cover.
2. Remove hydraulic belt tightener spring retaining plate.
3. Remove oil ring (for reassembly use inserting tool **1.821.125.000.**
4. Remove gasket between front cover and engine block.



5. Slightly tilt engine block and install tool **1.820.007.000**; lock tool using the relevant fixing screws.
6. Unscrew screws fixing the flywheel to crankshaft.



7. Remove tool **1.820.007.000**.
8. Remove flywheel.



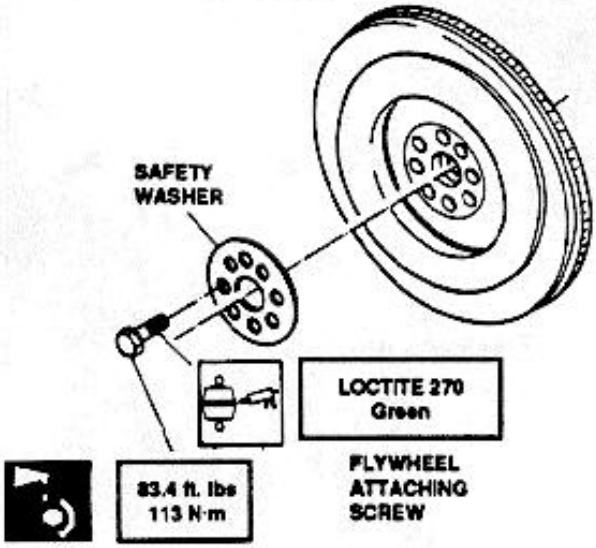
5.9 to 6.9 ft. lbs
8.1 to 9.5 N·m

NOTE: In case of flywheel grinding observe dimensions shown in the **"TECHNICAL CHARACTERISTICS AND SPECIFICATIONS"** paragraph.

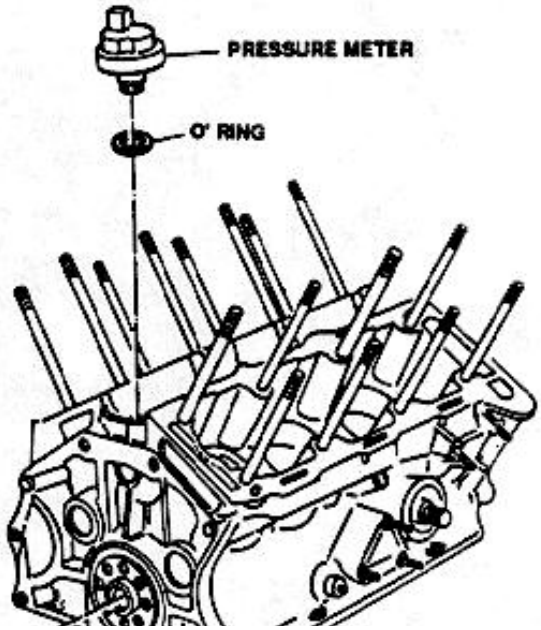
At reassembly, before applying locking compound to screws thread, remove any trace of old locking compound.

NOTE: **Flywheel can be located in one position only due to asymmetric spacing of screw holes.**

9. Remove safety washer.

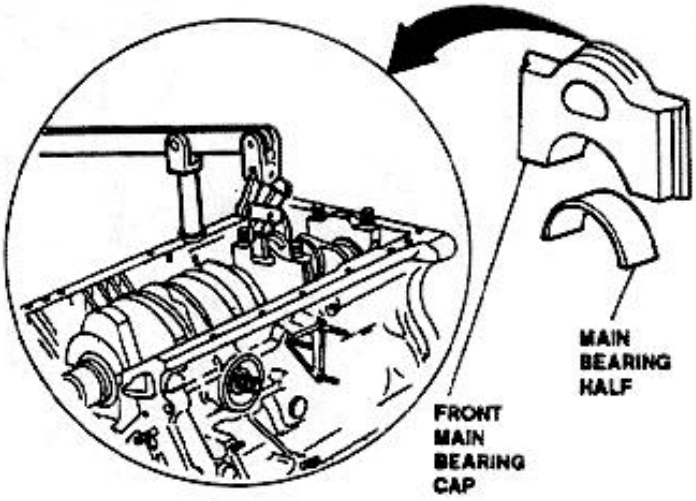


10. Remove engine oil pressure meter and o'ring.

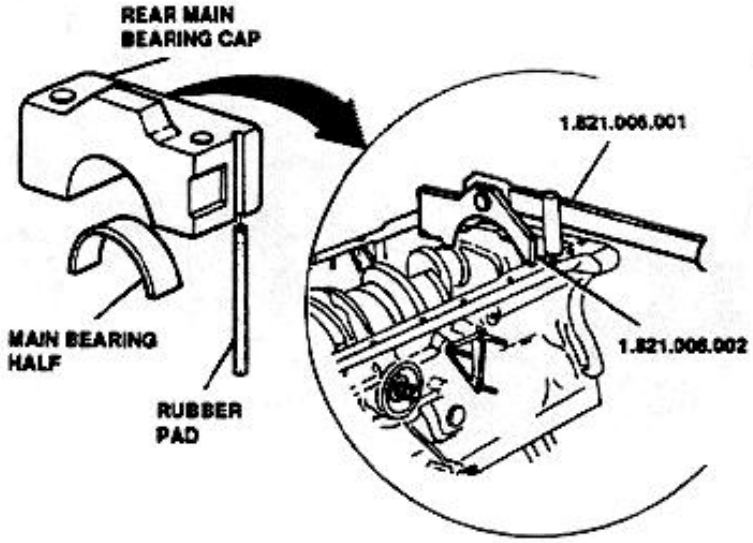


CRANKSHAFT REMOVAL

1. Remove six nuts and screws fixing the front main bearing caps.
2. Remove the three front main bearing caps; if required, used a suitable puller.
3. Remove relevant main bearing half.



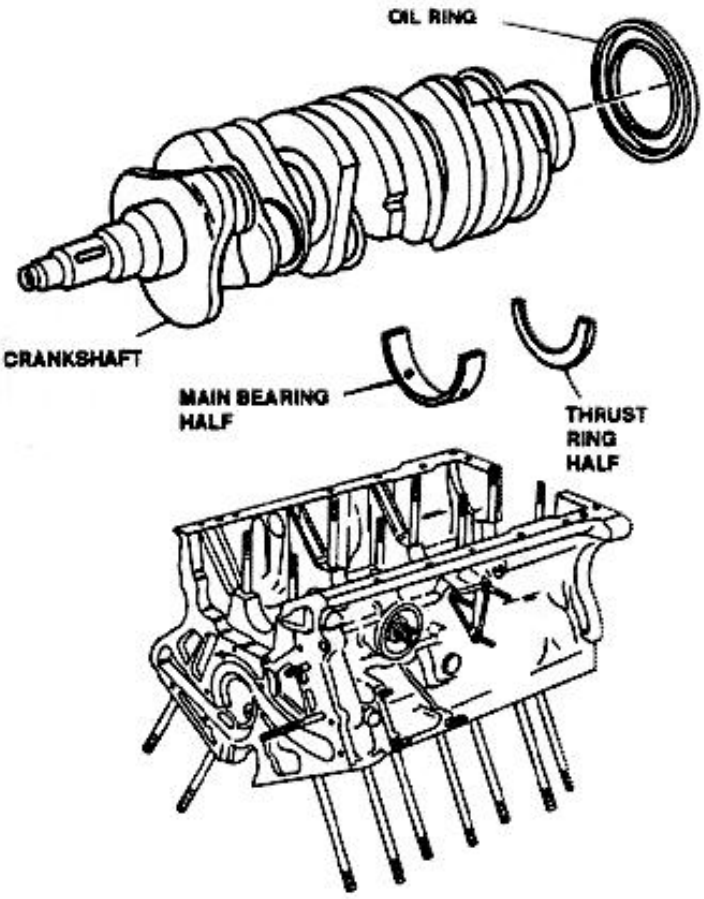
4. Remove rear main bearing cap using puller consisting of lever **1.821.006.001** and fork **1.821.006.002.**
5. Remove relevant main bearing half.
6. Remove rubber pads.



7. Remove oil ring.
8. Remove crankshaft.
9. Remove thrust ring halves.
10. Remove main bearing halves from engine block

NOTE: Note reciprocal position in case the parts are re-used for reassembly

For crankshaft installation observe warnings on relevant paragraph.



CYLINDER HEADS OVERHAUL

This paragraph includes:

CYLINDER HEADS DISASSEMBLY:

- Preliminary operations.
- Camshaft pulley removal.
- Timing distributor removal and disassembly.
- Engine upper mount bracket and oil pump pulley removal.
- Camshaft and rocker arms shaft removal.
- Valves disassembly.
- Intake manifold removal.

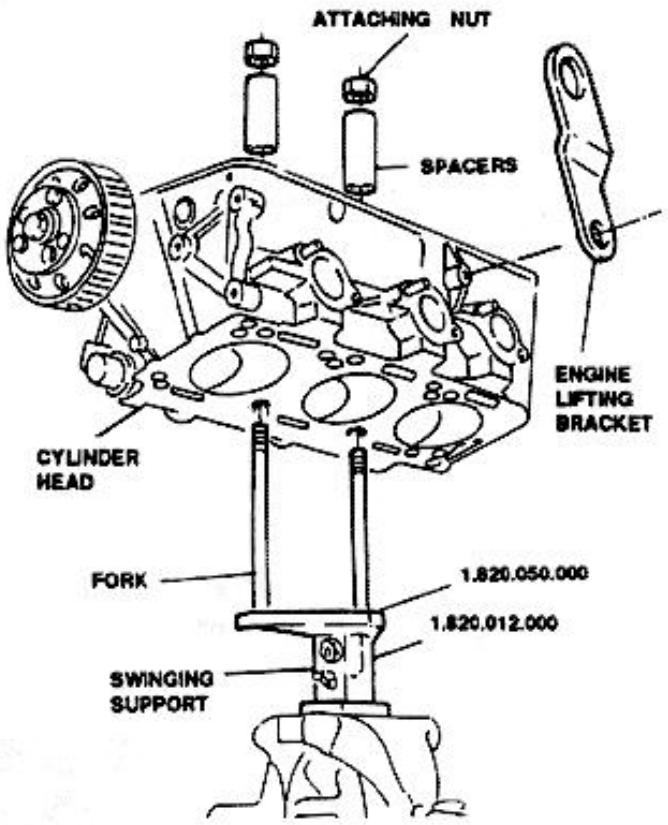
CYLINDER HEADS OVERHAUL:

- Cylinder head lower plane check.
- Cylinder head bushings check.
- Valve seats replacement.
- Clearance between valve guide and valve stem.
- Valve guide replacement.
- Valves.
- Valve seat turning.
- Valve springs.
- Valve cup seats.
- Rocker arms and rocker arms shaft.
- Camshaft and supports.
- Camshaft axial play check.

PRELIMINARY OPERATIONS

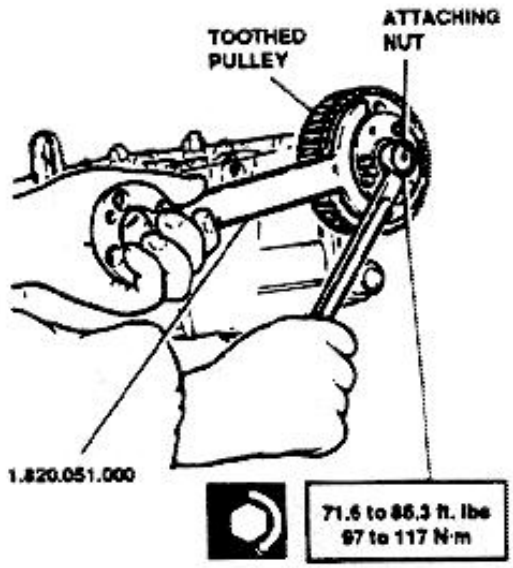
NOTE: **The disassembly procedures described in the following are referred to left cylinder head (except where specifically stated); disassembly of right cylinder head is performed in analogy.**

1. Lock swinging support **1.820.012.000** in a vice.
2. Install fork **1.820.050.000** and lock it to swinging support.
3. Lower cylinder head onto fork studs.
4. Lock cylinder head with two spacers and nuts.
5. Remove engine lifting bracket.

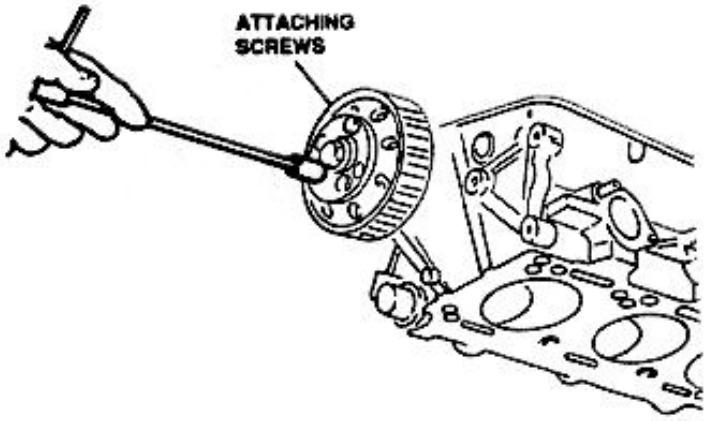


CAMSHAFT PULLEY REMOVAL

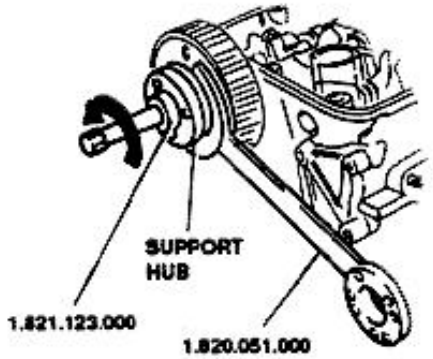
1. Use torque reactor **1.820.051.000** and remove attaching nut.



2. Remove the three screws attaching support hub to toothed pulley.

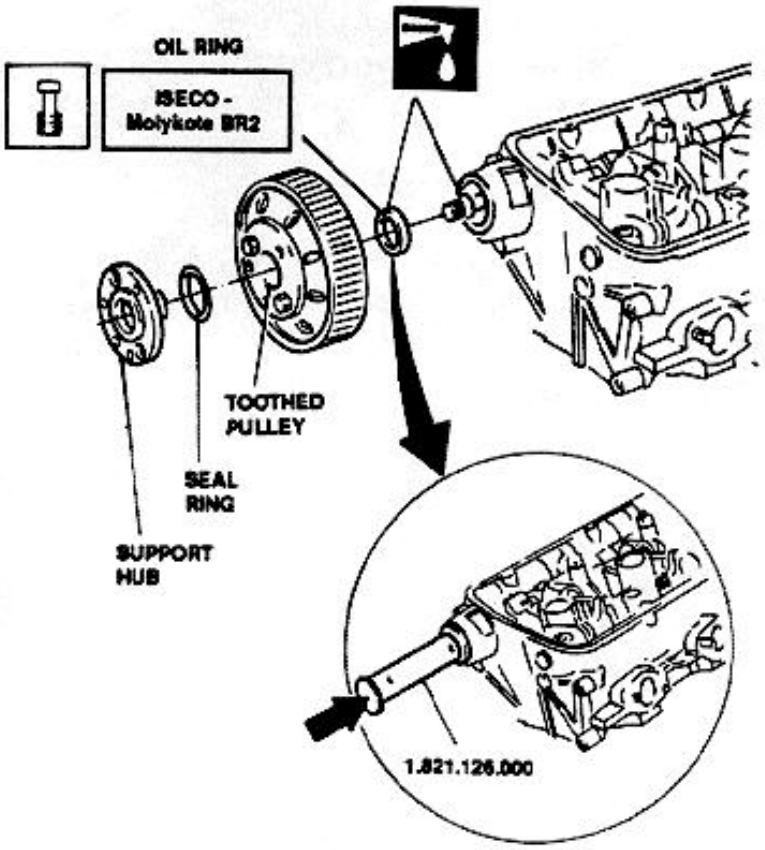


3. Using puller **1.821.123.000** and torque reactor **1.820.051.000**, remove support hub.



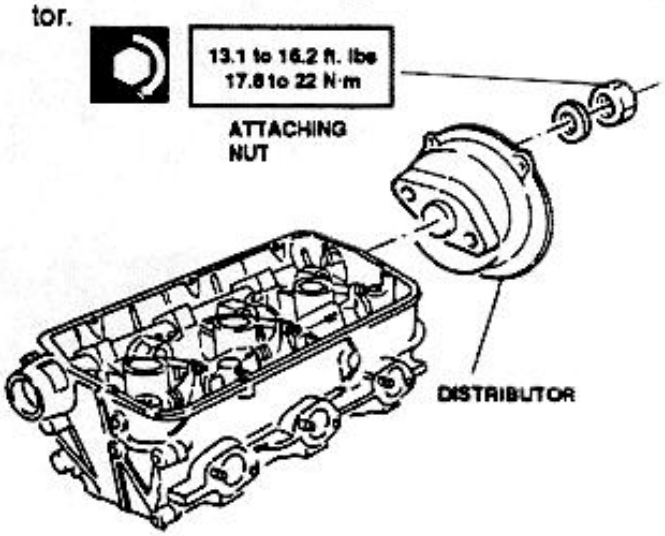
4. Remove seal ring from hub .
5. Remove toothed pulley .
6. Remove oil ring.

At reassembly, use inserting tool **1.821.126.000**.

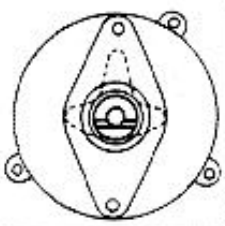


TIMING DISTRIBUTOR REMOVAL AND DISASSEMBLY (left cylinder head only)

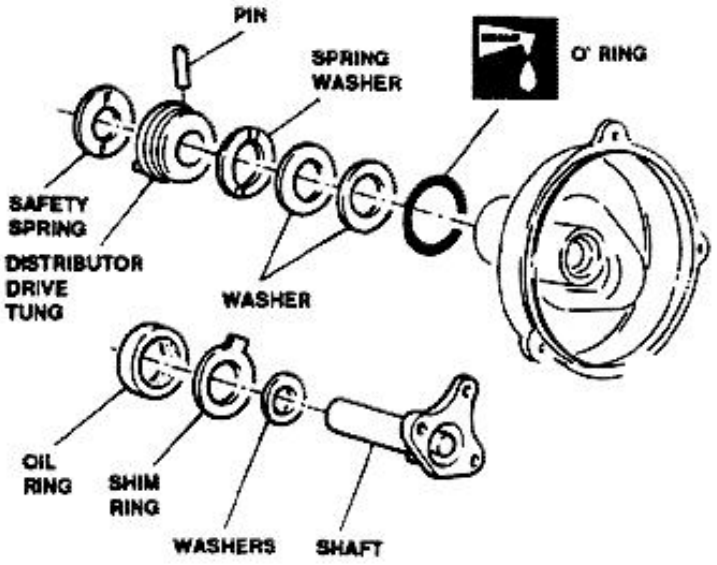
1. Unscrew the two attaching nuts and remove distributor.



At reassembly install the distributor as shown in figure, in order to avoid a 180° timing error.



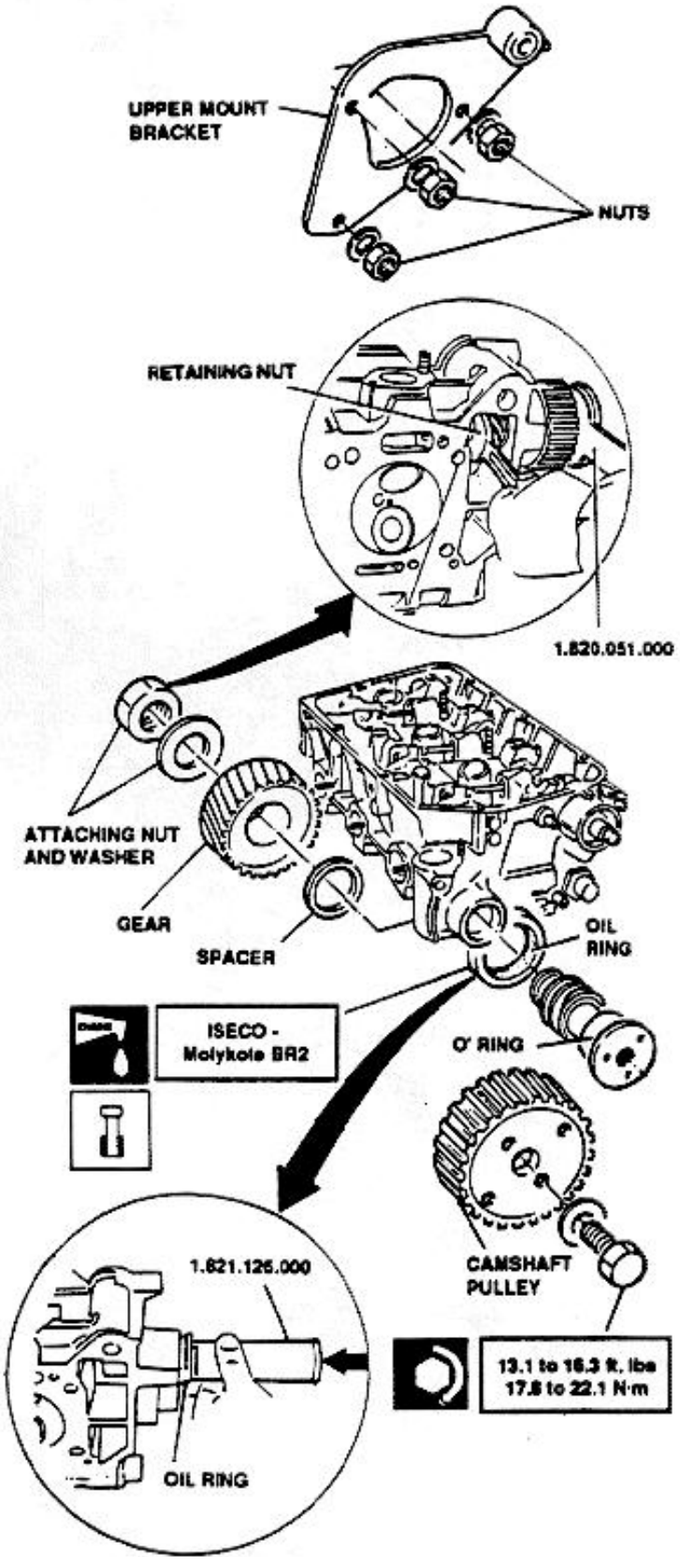
2. Remove o'ring.
3. Remove safety spring.
4. Remove pin.
5. Remove distributor drive tung.
6. Remove spring washer.
7. Remove the two washers.
8. Remove shaft.
9. Remove washer.
10. Remove shim ring.
11. Remove oil ring.



ENGINE UPPER MOUNT BRACKET AND OIL PUMP PULLEY REMOVAL (right cylinder heat only)

1. Remove camshaft pulley.
2. Unscrew the three nuts and remove engine upper mount bracket.
3. Using torque reactor **1.820.051.000** remove retaining nut after the safety lock has been lifted; remove washer.
4. Remove pulley complete of drive shaft.
5. Separate pulley and drive shaft.
6. Remove spacer.
7. Remove oil ring.

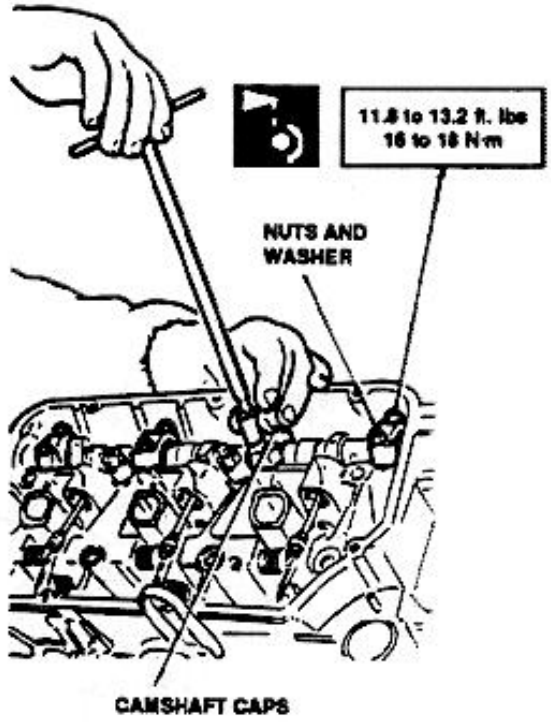
At reassembly, use inserting tool **1.821.126.000**.

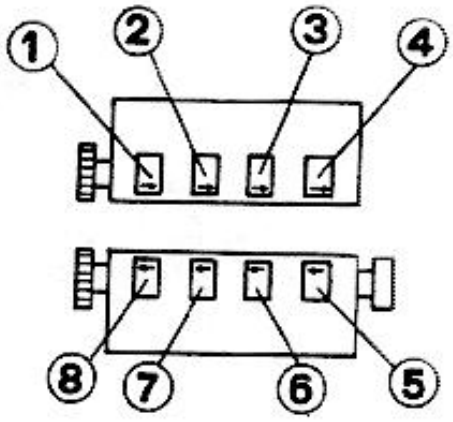


CAMSHAFT AND ROCKER ARMS SHAFT REMOVAL

1. Remove camshaft caps.

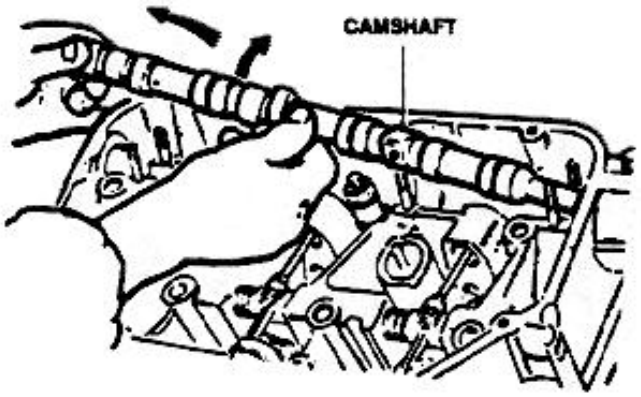
Caps are numbered in sequence (1, 2, 3 and 4 on right cylinder row; 5, 6, 7, and 8 on left cylinder row).
At reassembly, install caps in the same order.





NOTE: If not previously performed, remove timing distributor.

2. Remove camshaft by lifting rear end first, and pulling it out as shown by the arrows in the figure below.

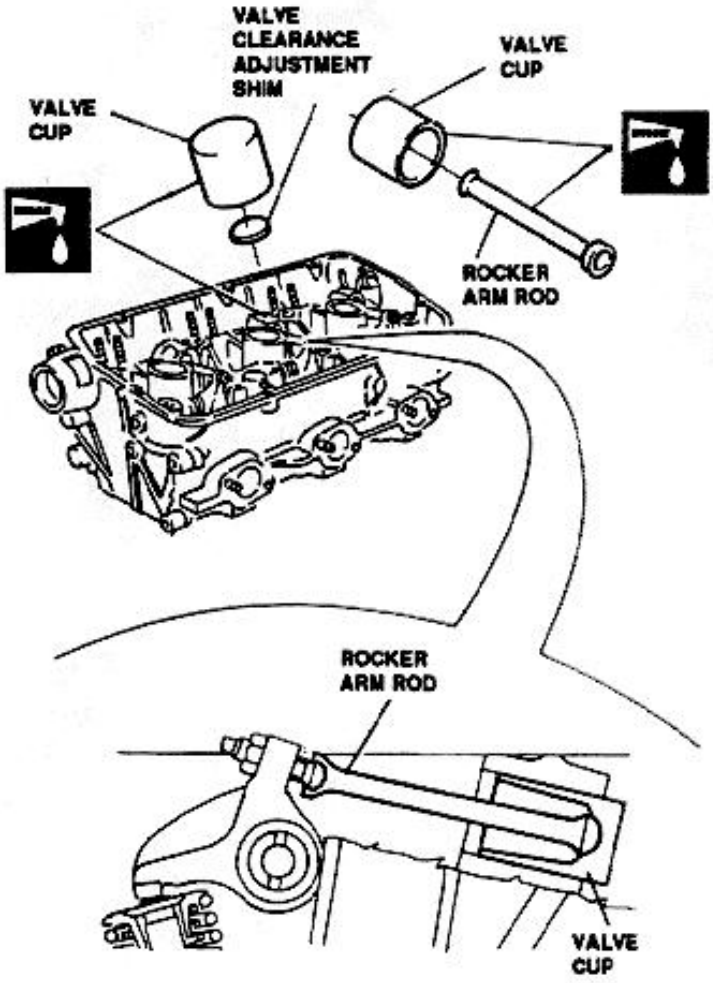


CAUTION:
Operate with precaution: cams and supports mating surfaces could be easily damaged.

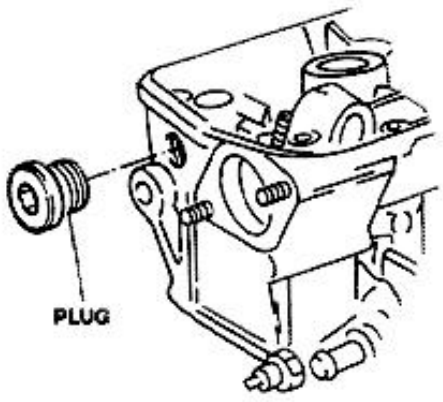
3. Remove intake side valve cups and relevant valve clearance adjustment shims.
4. Remove exhaust side valve cups and relevant rocker arm rods.

NOTE: Place items in sequence order in case they are re-used at reassembly.

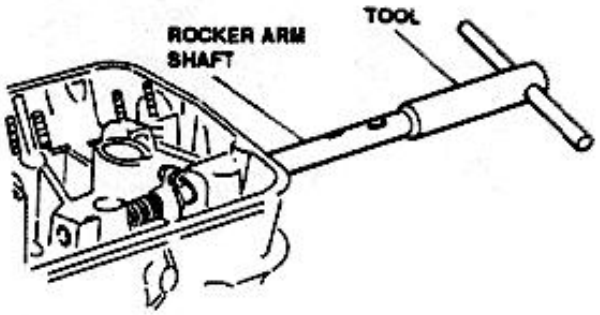
NOTE: For valve clearance check and adjustment observe warnings on relevant paragraph



5. Remove rocker arm shaft plug.

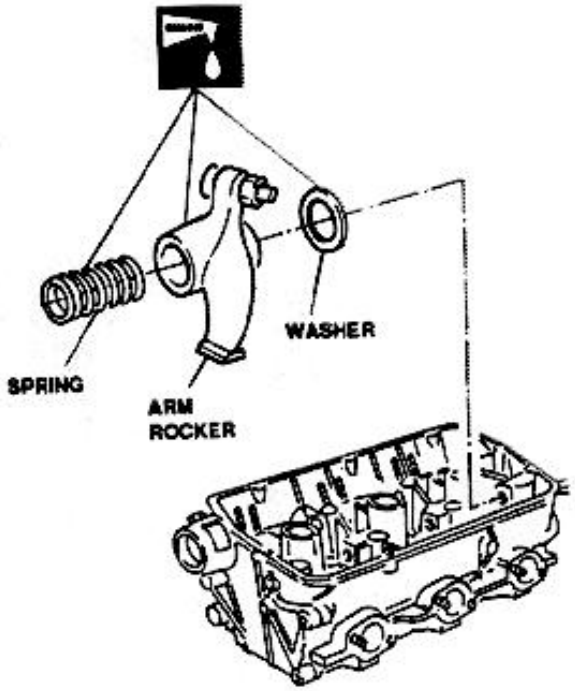


6. Screw a suitable tool onto threaded tug of rocker arm shaft.
7. Gradually withdraw rocker arm shaft.



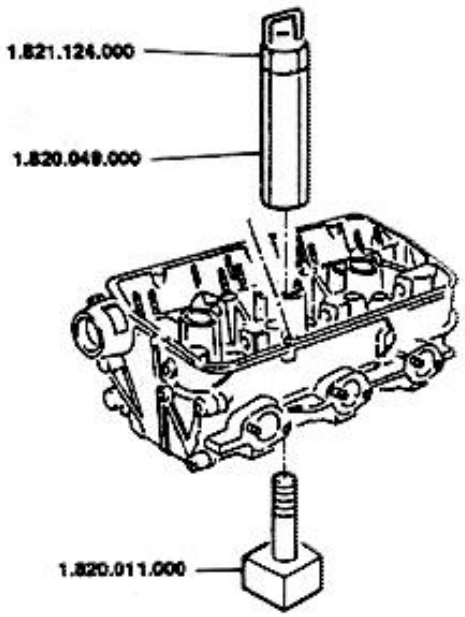
At reassembly, for proper positioning of rocker arm shaft follow warnings in **"ROCKER ARM"** paragraph.

8. Remove springs.
9. Remove rocker arms.
10. Remove washers.

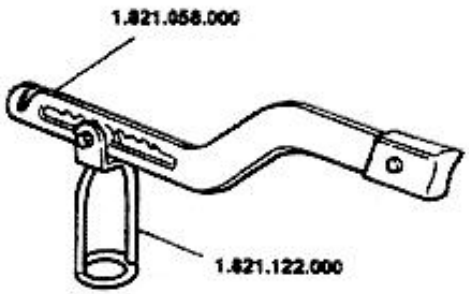


VALVES DISASSEMBLY

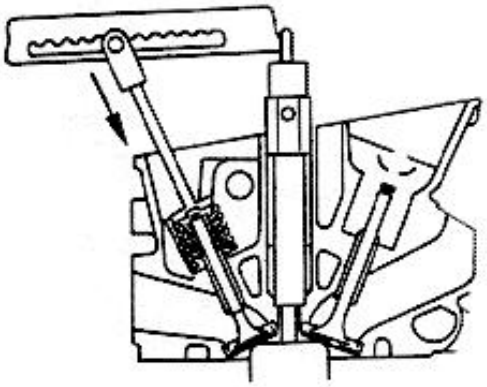
1. Insert valve supporting tool **1.820.011.000** through lower side of spark plug well, and lock tool **1.820.049.000**.
2. Install support tool **1.821.124.000** onto threaded end of tool **1.820.049.000**.



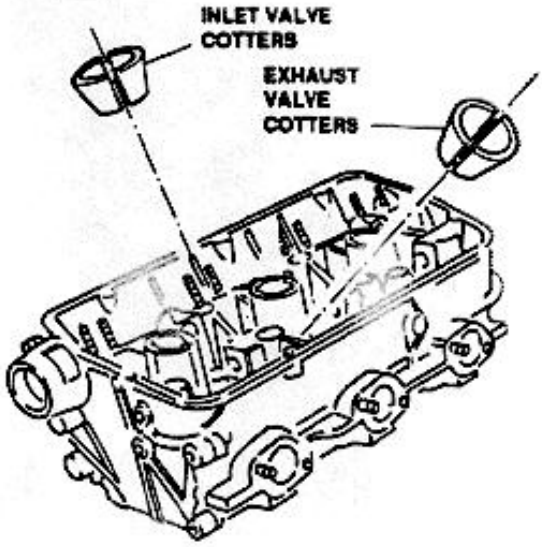
3. Install cone halves disassembly/reassembly cage **1.821.122.000** on tool **1.821.058.000**.



4. Position tools assembled at previous steps as illustrated in figure below.



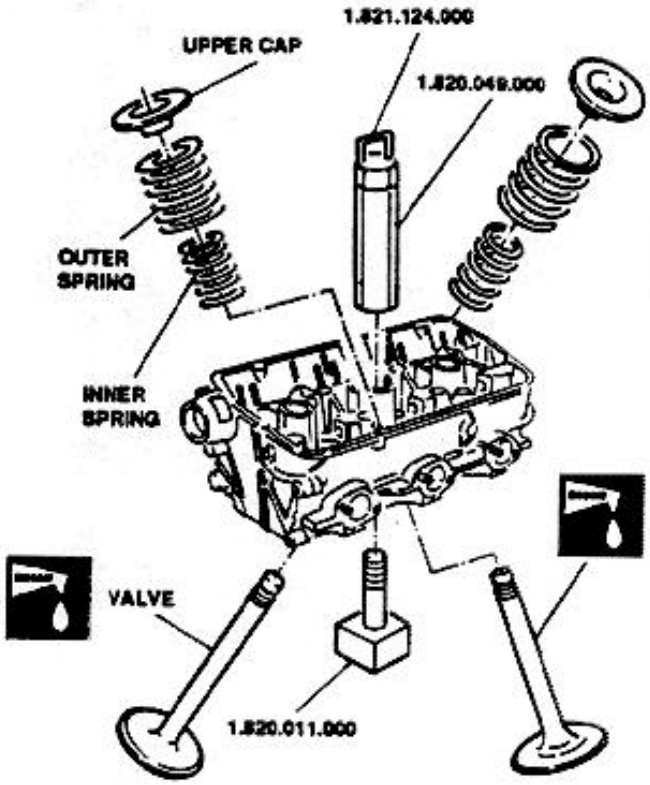
5. Press lever of tool **1.821.058.000** to contrast resistance of valve springs.
6. Remove intake and exhaust valve cotters.



7. Remove upper caps.
8. Remove outer springs.
9. Remove inner springs.
10. Remove tools **1.820.049.000**, **1.821.124.000** and **1.820.011.000**..

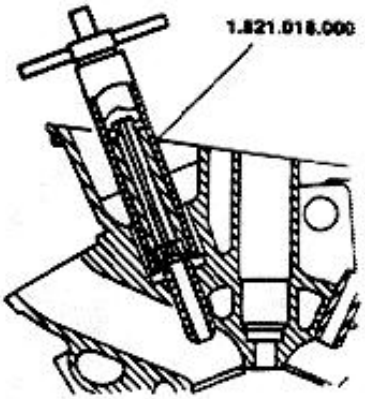
11. Withdraw the two valves (intake and exhaust).

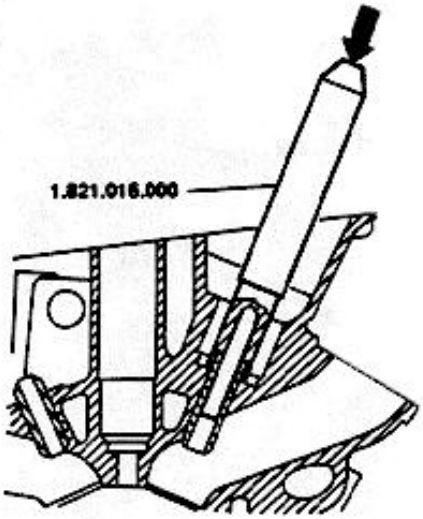
NOTE: Proceed in analogy on the other cylinder heads using the same tools.



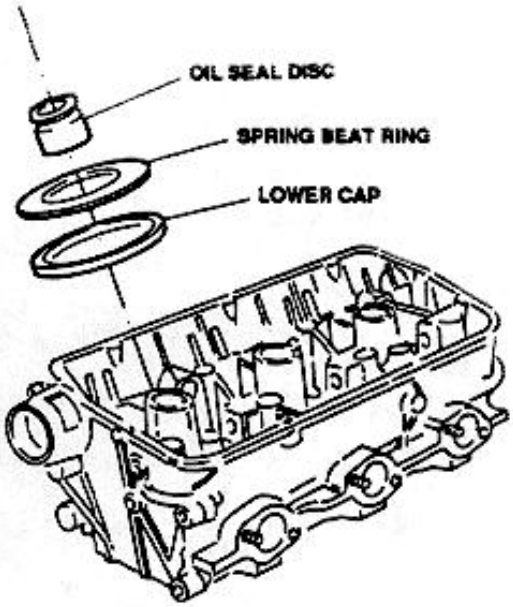
12. Remove the oil sealing pads using tool **1.821.018.000**.

At reassembly, use inserting tool **1.821.016.000**.



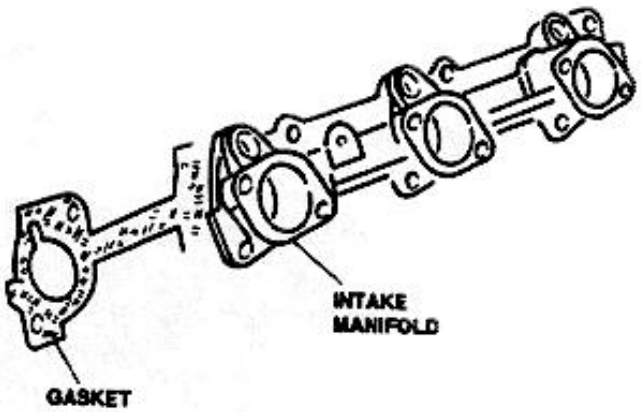


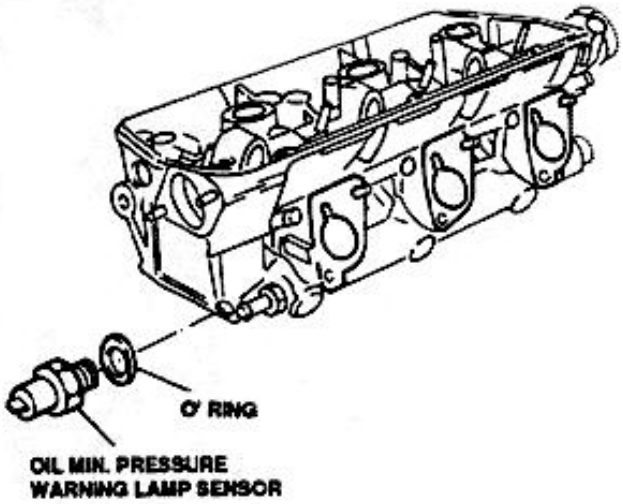
13. Remove lower caps.



INTAKE MANIFOLD REMOVAL

1. Remove intake manifold.
2. Remove gasket between manifold and cylinder head.
3. If required, remove engine oil minimum pressure warning lamp sensor and relevant o'ring (only on the left cylinder head).





CYLINDER HEAD LOWER PLANE CHECK

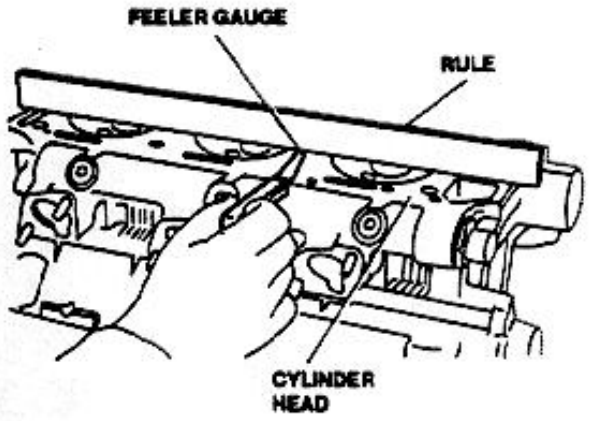
1. Thoroughly clean the cylinder heads plane from any trace of old gasket.
2. Visually inspect cylinder head carefully for presence of cracks, traces of overheating, scoring or excessive

wear.

3. Check lower plane flatness and, if excessively distorted, carry-out facing of lower plane.

NOTE: Facing must be carried-out on both heads.

Max heads lower plane flatness error
0.05 mm (0.0019 in)

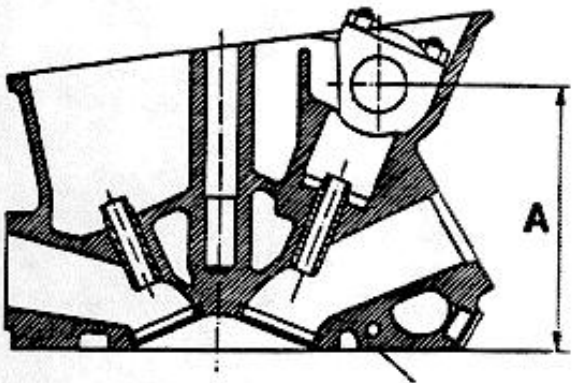


4. After facing, check that head height is above the minimum allowable value.

CAUTION:
Do not exceed minimum allowable value to prevent serious engine malfunction.

5. Check that head lower plane surface finish is of required quality.

Minimum allowable heads height after facing
A = 124.85 to 125.15 mm (4.915 to 4.927 in)

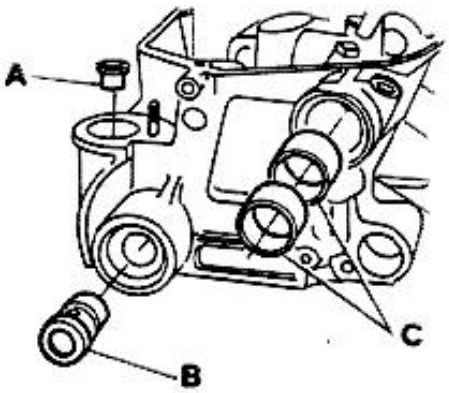


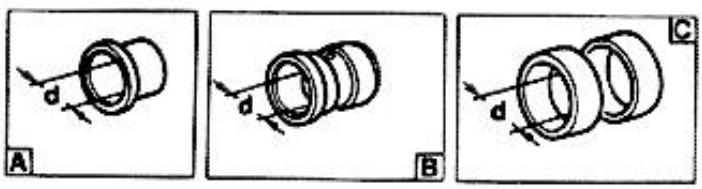
CYLINDER HEAD BUSHINGS CHECK

1. Measure inner diameter "d" of bushings installed on cylinder heads, and verify that dimension is within prescribed limits:

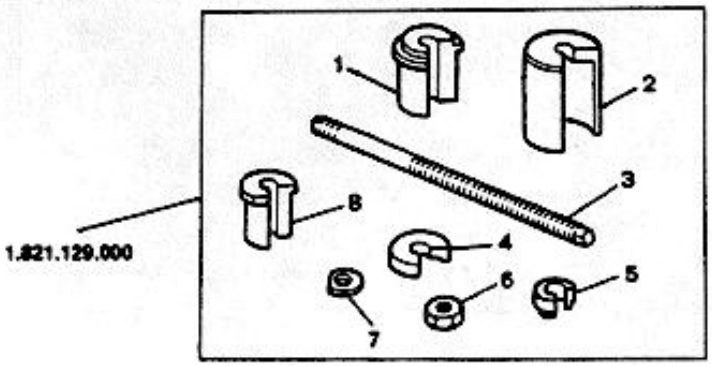
"A" (Right cylinder head only)
Oil pump drive gear bushing.
"B" (Right cylinder head only)
Oil pump drive toothed pulley shaft bushing.
"C" Camshaft drive toothed pulley hub bushings.

"d" bushings inner diameter	
"A"	19.000 to 19.021 mm (0.7480 to 0.7488 in)
"B"	19.000 to 19.021 mm (0.7480 to 0.7488 in)
"C"	32.000 to 32.025 mm (1.2598 to 1.2608 in)





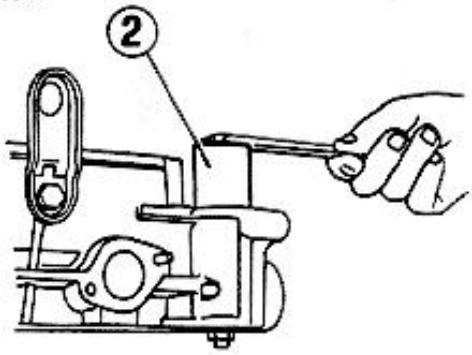
NOTE: If dimension as measured are not within the prescribed limits, replace affected bushings using tool **1.821.129.000** as described in the following paragraphs.

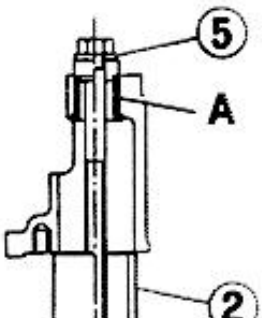


Parts of tool **1.821.129.000**	
1 Reactor block	5 Special washer
2 Cup	6 Nut (M10 x 1.5)
3 Tie rod	7 Formed washer
4 Flange	8 Reactor block

REMOVAL OF BUSHING "A"
(For oil pump drive gear)

1. Withdraw oil pump drive gear bushing "A" using the special washer "5" as a pressure disc, and cup "2" as a reactor.

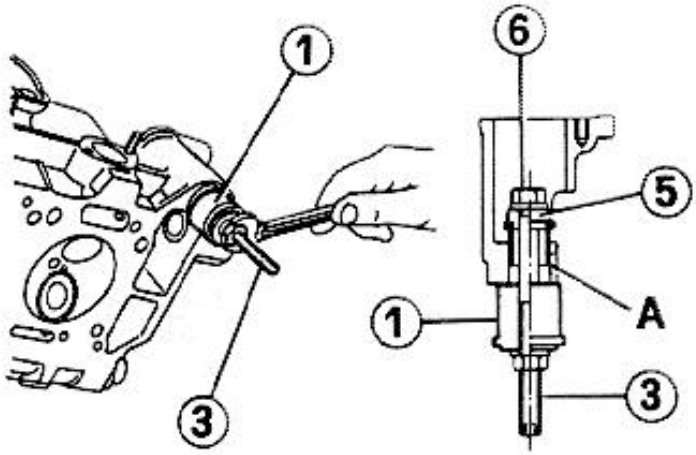




INSERTION OF BUSHING "A"
(For oil pump drive gear)

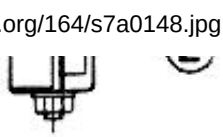
Insert the oil pump drive gear bushing "A" as follows:

1. Position new bushing.
2. Insert tie-rod "3" complete of nut "6" and special washer "5" (acting as a pressure disc).
3. Insert reactor block "1" on opposite end of tie-rod and complete bushing installation.



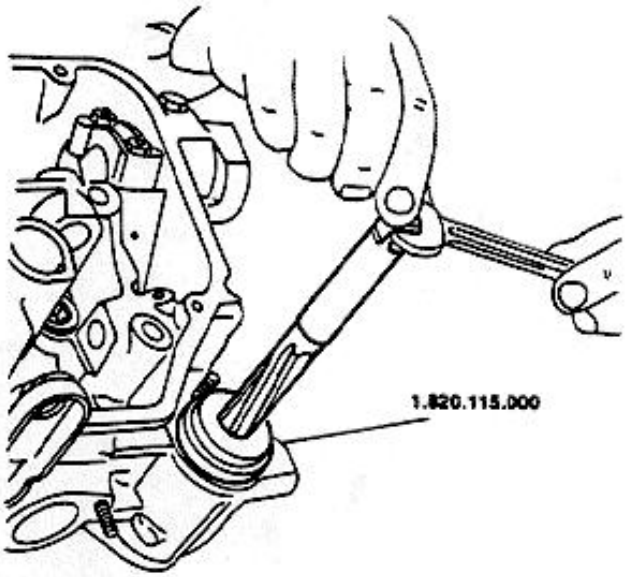
REAMING OF BUSHING "A"
(For oil pump drive gear)

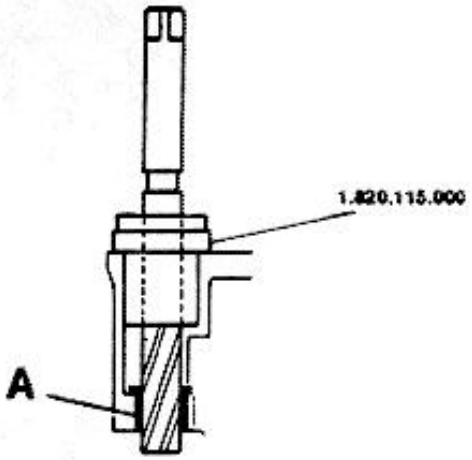
1. After installation, ream bushing "A" to the prescribed dimension using drive tool **1.820.115.000** and a



suitable reamer (19 mm, H7).

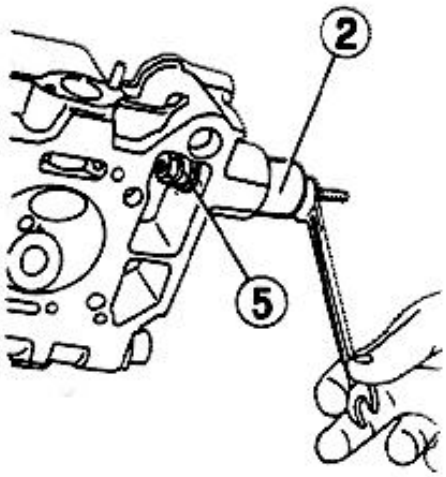
Oil pump drive gear hub bushing inner diameter (reaming)
19.000 to 19.021 mm (0.7480 to 0.7488 in)

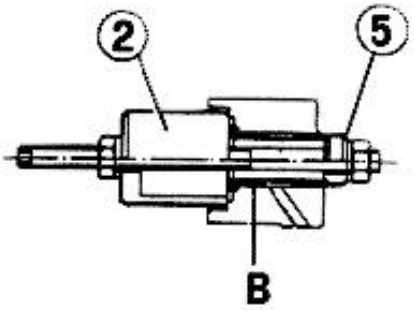




REMOVAL OF BUSHING "B"
(For oil pump drive toothed pulley shaft)

1. Withdraw oil pump drive toothed pulley shaft bushing "B" using the special washer "5" as a pressure disc, and cup "2" as a reactor.

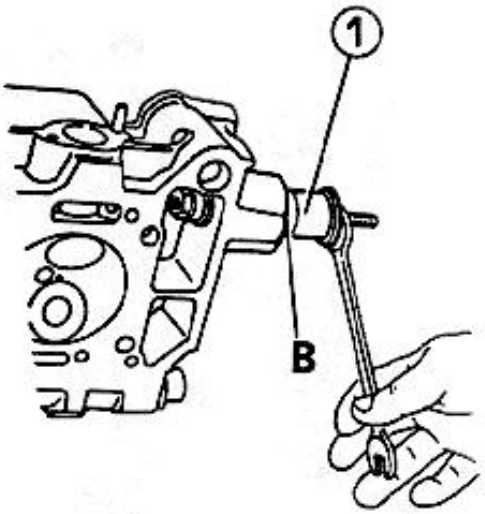


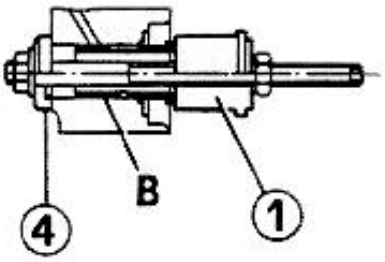


INSERTION OF BUSHING "B"
(For oil pump drive toothed pulley shaft)

1. Insert oil pump drive toothed pulley shaft bushing using block "1" as a pressure tool, and flange "4" as a reactor.

a reactor.

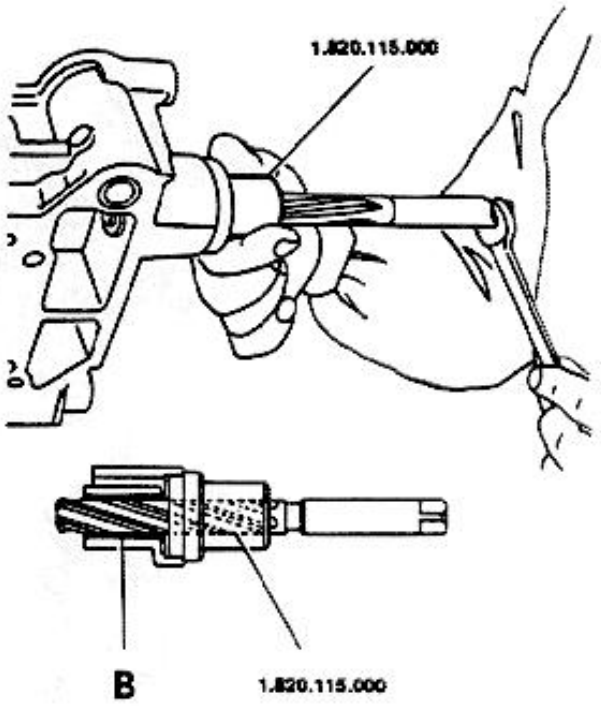




REAMING OF BUSHING "B"
(For oil pump drive toothed pulley shaft)

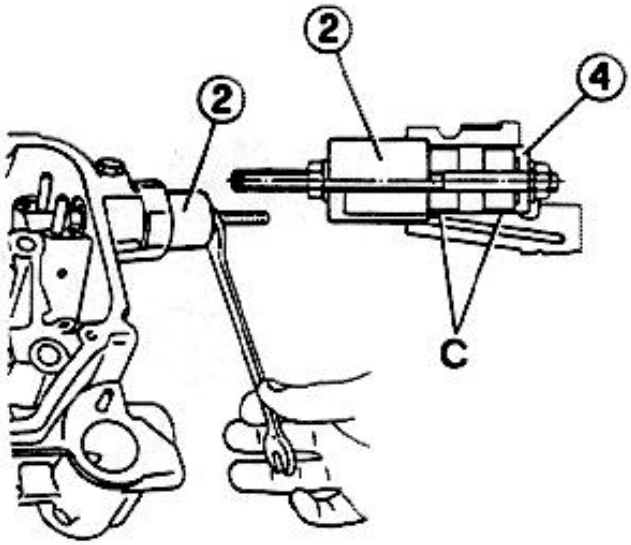
1. After installation, ream bushing **"B"** to the prescribed dimension using drive tool **1.820.115.000** and a suitable reamer **(19 mm, H7)**.

Ø	Oil pump drive gear hub bushing inner diameter (reaming)
	19.000 to 19.021 mm (0.7480 to 0.7488 in)



REMOVAL OF BUSHINGS "C"
(For camshaft drive toothed pulley hub)

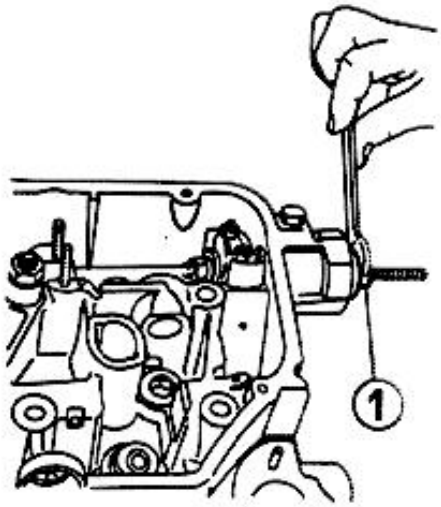
1. Withdraw camshaft drive toothed pulley hub bushings **"C"** using flange **"4"** as a pressure disc, and cup **"2"** as a reactor.

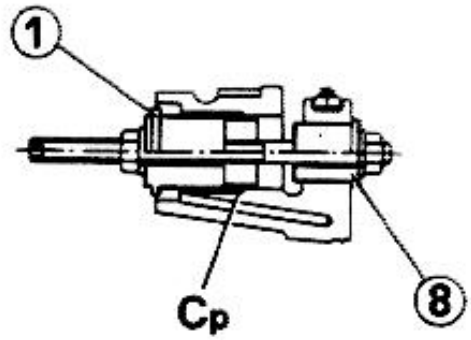


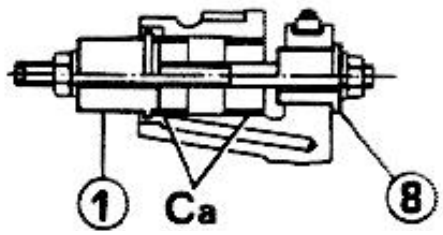
INSERTION OF BUSHINGS "C"
(For camshaft drive toothed pulley hub)

Insert the camshaft drive toothed pulley hub bushings "C" as follows:

1. Install adiacent camshaft cover and lock it with two nuts.
2. Start rear bushing "Cp" identified by lower thickness, until it is sufficiently centered into its seating.
3. Insert bushing "Cp" using block "1" as a pressure block, and block "8" as a reactor.
4. Proceed in analogy to insert bushing "Ca", but using block "1" in reversed position.



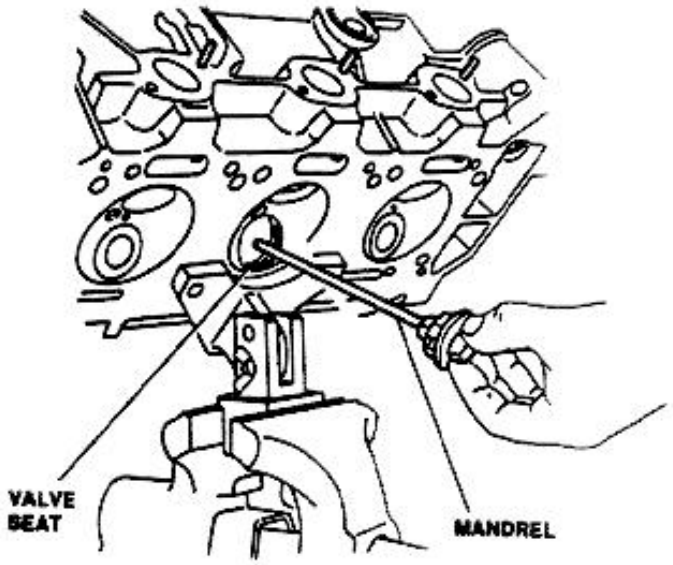




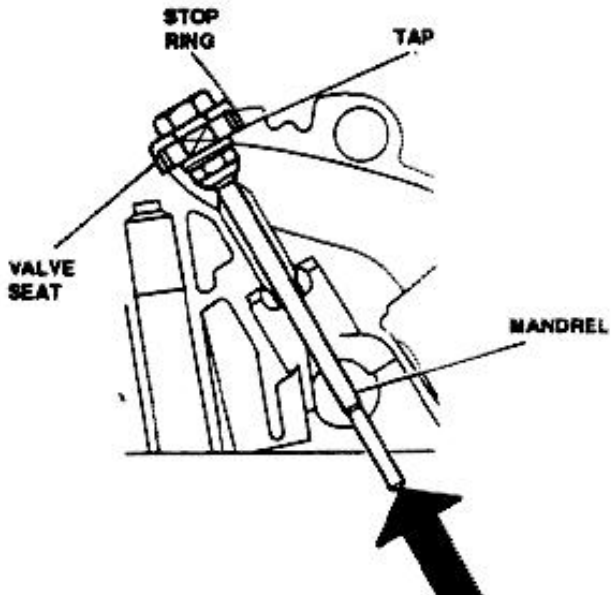
VALVE SEATS REPLACEMENT

Remove worn valve seats using a suitable tool as indicated in figure below; proceed as follows:

1. Install on mandrel the lock ring and tap selected to fit diameter of valve seat to be removed.
2. Insert the assembly prepared at step 1. above into valve guide until tap contacts against the valve seat.
3. Thread valve seat acting with a suitable wrench on mandrel head, until the ring touches the valve seat plane; then unscrew 1/2 turn.

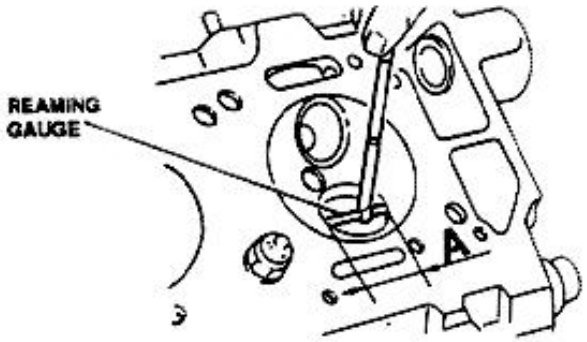


4. Withdraw the valve seat while beating on mandrel end protruding from cylinder head.



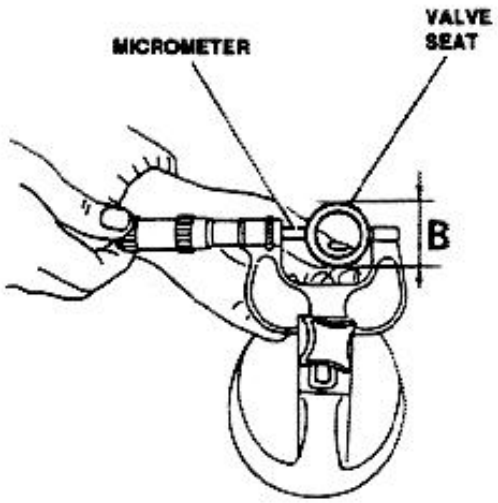
5. Check that diameter of valve seat housing "A" is within prescribed limits.

"A" valve seat housing diameter		
Normal	Intake	45.000 to 45.025 mm (1.7716 to 1.7726 in)
	exhaust	39.000 to 39.025 mm (1.5354 to 1.5364 in)
Oversized	Intake	45.300 to 45.325 mm (1.7835 to 1.7844 in)
	exhaust	39.300 to 39.325 mm (1.5472 to 1.5482 in)

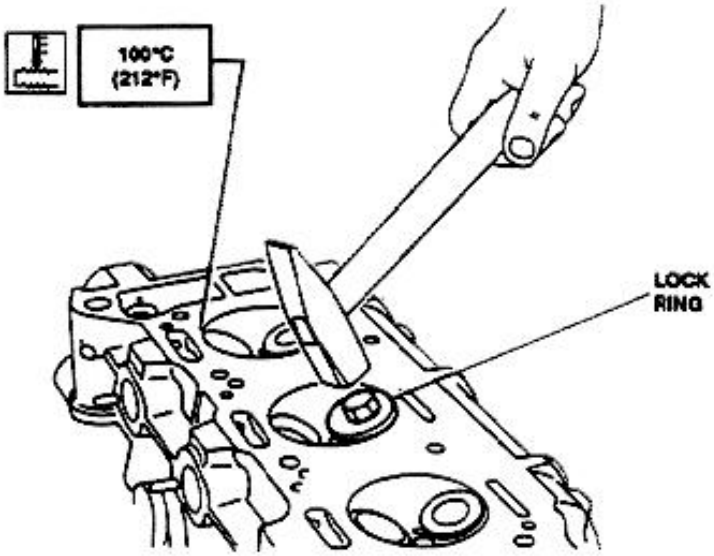


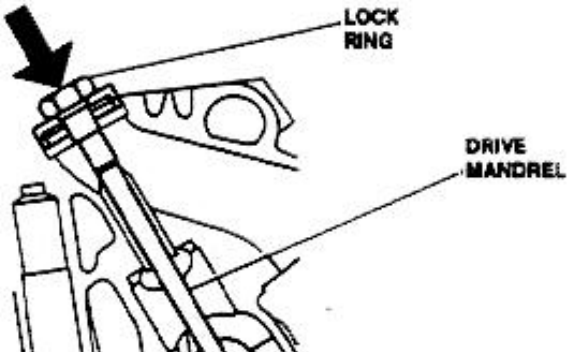
6. Check that outer diameter of replacement valve seat "B" is within prescribed limits.

"B" valve seat outer diameter		
Normal	Intake	45.065 to 45.100 mm (1.7742 to 1.7756 in)
	exhaust	39.065 to 39.100 mm (1.5380 to 1.5393 in)
Oversized	Intake	45.365 to 45.400 mm (1.7860 to 1.7874 in)
	exhaust	39.300 to 39.325 mm (1.5498 to 1.5512 in)



7. Heat head to temperature of about 100°C (212°F).
8. Install and lock on mandrel a lock ring selected to fit diameter of valve seat to be installed.
9. Insert assembly prepared at step 8. above until the lock ring contacts against valve seat.
10. Insert valve seat by beating on mandrel end protruding from cylinder head.

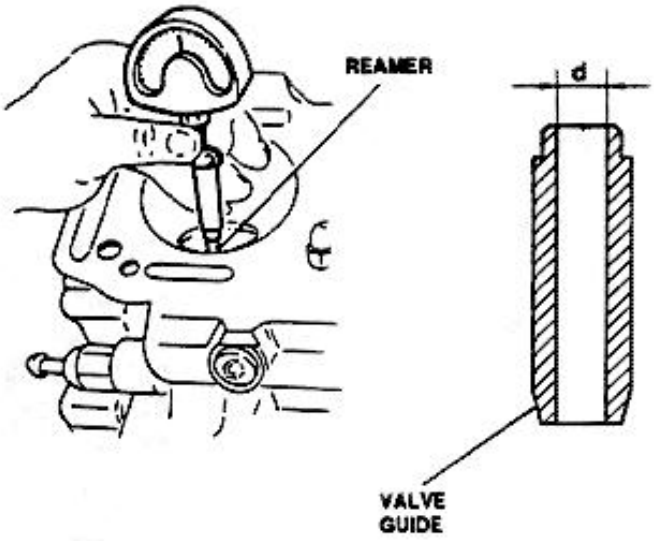




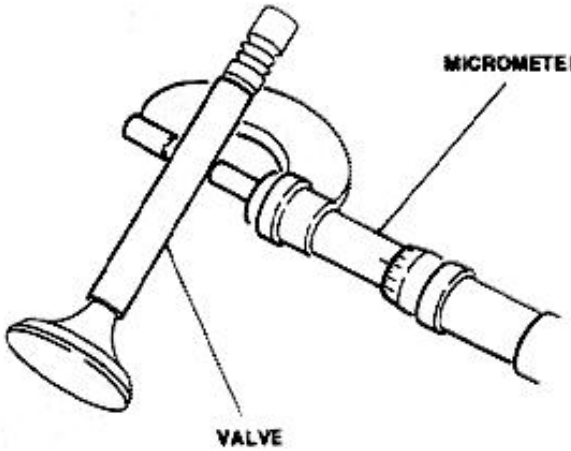
CLEARANCE BETWEEN VALVE GUIDE AND VALVE STEM

1. Measure inner diameter "d" of valve guide and check dimension is within prescribed limits.

"d" valve guide inner diameter	
Intake and exhaust	9.000 to 9.015 mm (0.3543 to 0.3549 In)



2. Measure diameter of valve stem in at least three different locations 90° apart from each other.

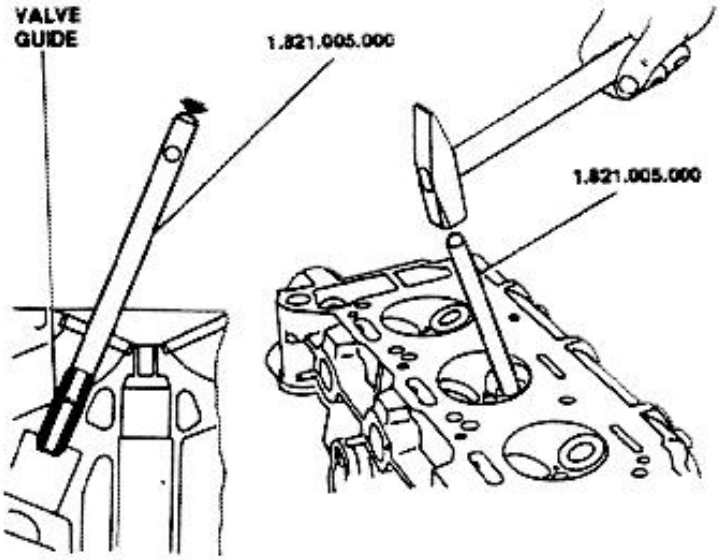


3. Calculate clearance by subtracting the maximum stem dimension from inner diameter of valve guide; replace items if clearance is not within prescribed limits.

Clearance between valve stem and valve guide	
Intake	0.013 to 0.043 mm (0.0005 to 0.0017 In)
exhaust	0.045 to 0.075 mm (0.0018 to 0.0029 In)

VALVE GUIDE REPLACEMENT

1. Visually check the valve guides for absence of nicks, scoring, distortion or displacement from original position of installation.
2. If necessary, withdraw valve guide using puller **1.821.005.000**.



3. Measure diameter of valve guide seat and outer diameter of the new valve guide; the installation interference must be within prescribed tolerances.

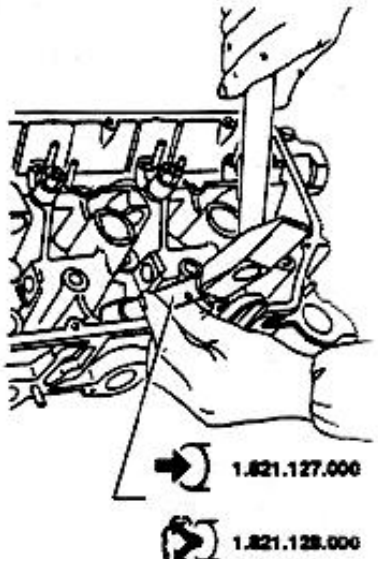
Valve guide seat diameter	
Intake and exhaust	13.990 to 14.018 mm (0.5507 to 0.5519 in)

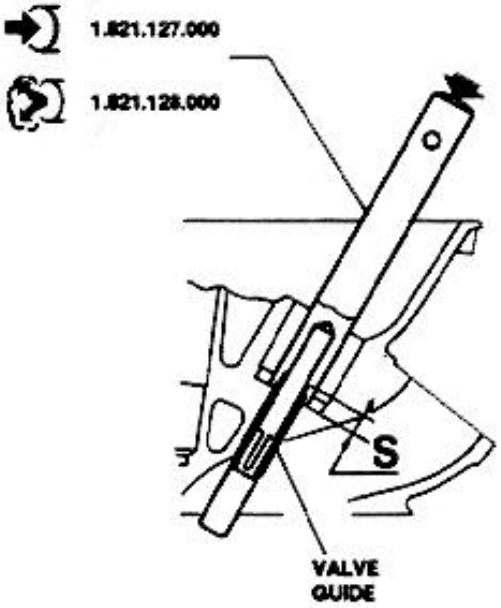
Valve guide outer diameter	
Intake	14.033 to 14.044 mm (0.5525 to 0.5529 in)
exhaust	14.048 to 14.059 mm (0.5531 to 0.5535 in)

Interference between valve guide and valve guide seat	
Intake	0.015 to 0.054 mm (0.006 to 0.0021 in)
exhaust	0.030 to 0.069 mm (0.0011 to 0.0027 in)

4. Insert new valve guides using the special inserting tools that ensure the correct protrusion values are obtained.

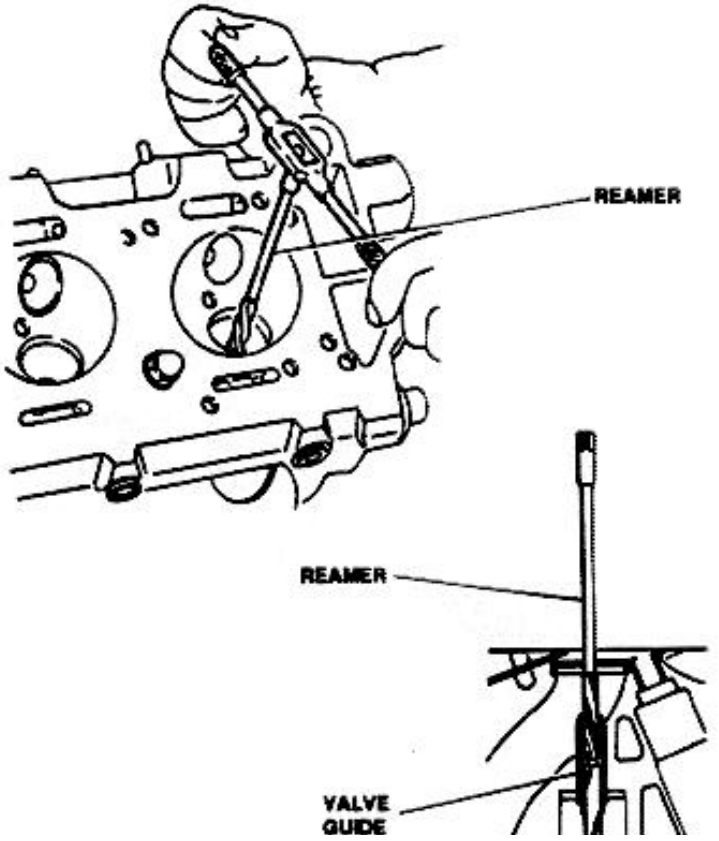
Valve guide "S" protrusion	
Intake and exhaust	10.2 to 10.6 mm (0.40 to 0.42 in)





5. Ream the new valve guides (intake and exhaust) by means of a reamer (dia. **9 mm, H7**) to bring holes to the prescribed diameter.

Valve guide inner diameter	
Intake and exhaust	9.000 to 9.015 mm (0.3543 to 0.3549 in)



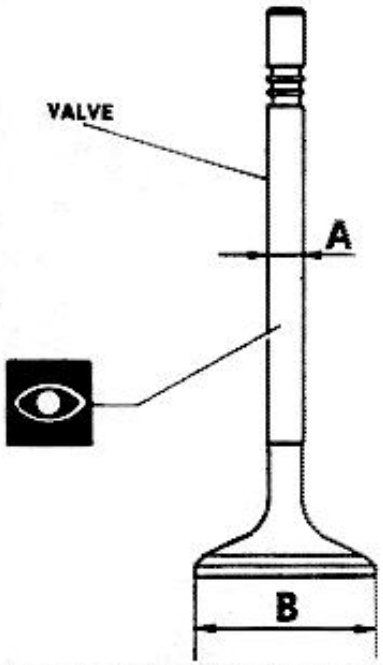
VALVES

1. Check valves for absence of nicks, burnings and noticeable traces of scoring with corresponding seating or cylinder heads; replace valves if necessary.
2. If valves are in good condition proceed to dimensional check of stem and head diameters; verify the diameters are within prescribed limits.

"A" valve stem diameter	
Intake	8.972 to 8.987 mm (0.3532 to 0.3538 in)
exhaust	8.940 to 8.955 mm (0.3520 to 0.3525 in)

"B" valve head diameter	
Intake	43.850 to 44.000 mm (1.7264 to 1.7322 in)
exhaust (*)	38.500 to 38.700 mm (1.5157 to1.5236 in)

(*) for LIVIA type valves: 38.45 to 38.60 mm (1.514 to 1.519 in)



NOTE: If valves are "burned", check proper operation of springs and check valve clearance

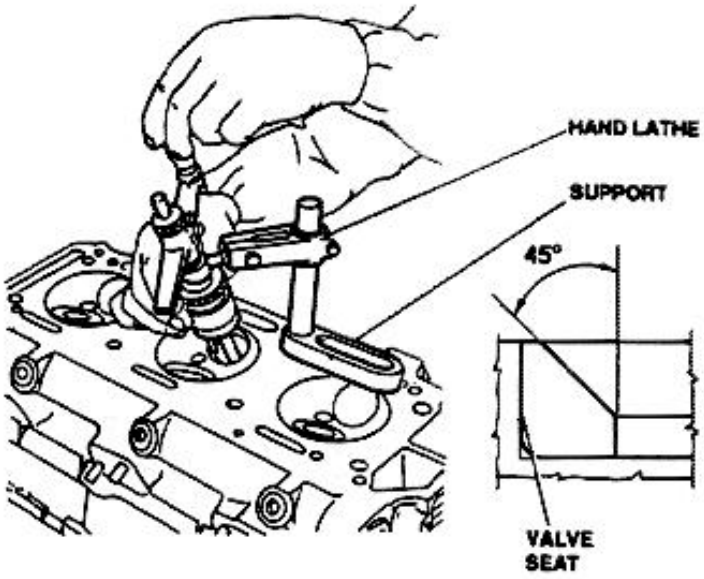
VALVE SEAT TURNING

The turning of valve seats that do not require replacement is useful to remove all minor defects present on working surfaces; however, before carrying-out turning, ascertain that sufficient stock is available.

1. If necessary, carry-out valve seating turning by means of suitable tools.

NOTE: Taper "C" can be obtained by positioning the hand lathe tool to an angle of 45°.

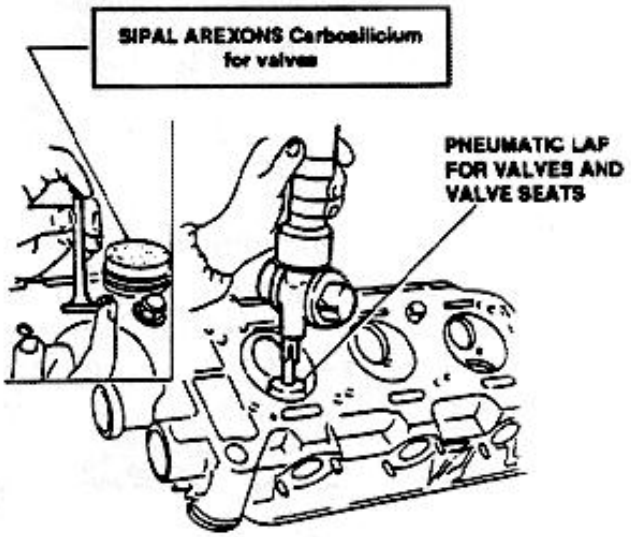
Intake and exhaust valve seat taper
"C" = 90° ± 20°



2. Smear the mating surfaces of valves and relevant seats with abrasive paste (SIPAL-AREXSONS Carbosilicium for valves).
3. Lubricate valve stem with engine oil.
4. Fix inner surface of valve head to the suction cup of a pneumatic lap.
5. Insert valve in relevant guide and carry-out grinding

tion of springs and check valve clearance. 3. Insert valve in relevant guide and carry-out grinding.

6. After grinding, thoroughly clean both valves and relevant seats.



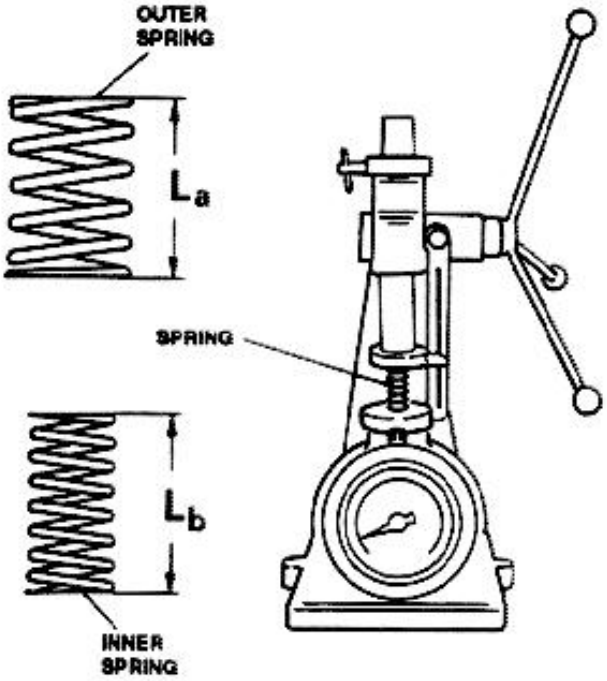
VALVE SPRINGS

1. Check that length of "free" springs is within prescribed limits. The terminal planes must be parallel to each other and perpendicular to spring axis (max. error 2°).
2. Check with a dynamometer that characteristic data of springs are within prescribed limits.

Free spring length	
outer spring La	44.6 mm (1.75 in)
inner spring Lb	44.1 mm (1.73 in)

Outer spring		
spring length	mm (in)	N (lbs)
with valve closed	32.5 (1.28)	243 to 252 (54.6 to 56.6)
with valve open	23.5 (0.92)	470 to 488 (105.6 to 109.7)

Inner spring		
spring length	mm (in)	N (lbs)
with valve closed	30.5 (1.20)	126 to 130 (28.3 to 29.2)
with valve open	21.5 (0.84)	222 to 231 (49.9 to 51.9)

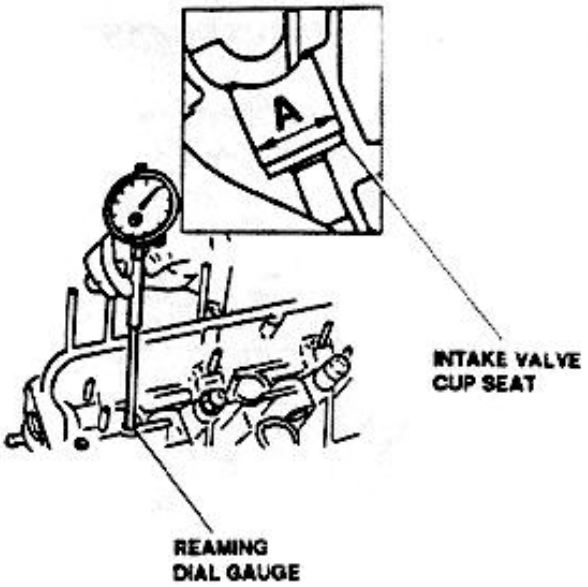


VALVE CUP SEATS

INTAKE SIDE

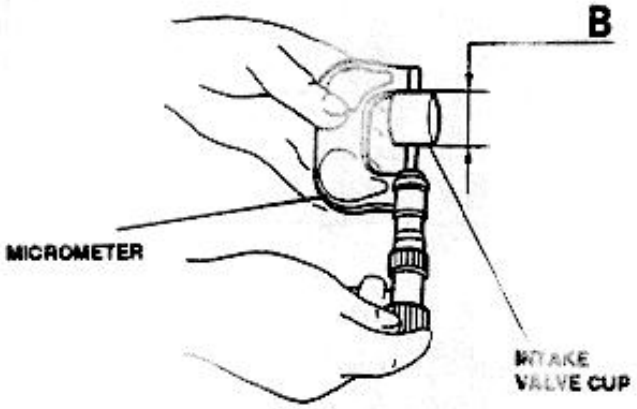
1. Check that outer surfaces of valve cups, and upper plane on which the cams work, are free of any traces of seizing, nicks or abnormal wear. In case the cups are still serviceable proceed to the dimensional check.
2. Check valve cup seats diameter is within prescribed limits.

Intake valve cup seat diameter
A = 35.000 to 35.025 mm (1.3780 to 1.3789 in)



3. Check valve cups outer diameter is within prescribed limits.

Intake valve cup diameter
B = 34.973 to 34.989 mm (1.3769 to1.3775 In)



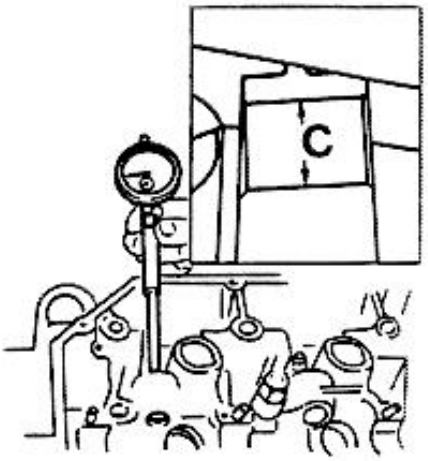
VALVE CUP SEATS

EXHAUST SIDE

1. Check that outer surface of valve cups, and upper plane on which the cams work are free of any traces of seizing, nicks or abnormal wear. In case the cups are still serviceable proceed to the dimensional check.

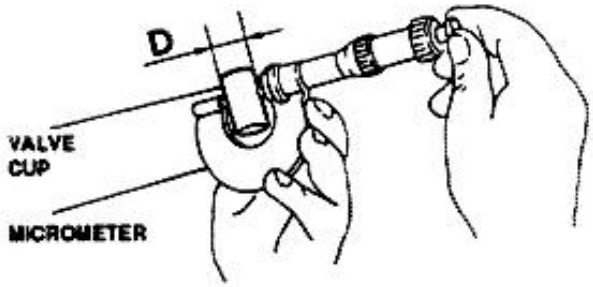
2. Check valve cup seats diameter is within prescribed limits.

Exhaust valve cup seat diameter
C = 22.000 to 22.021 mm (0.8661 to 0.8670 In)



3. Check valve cups outer diameter is within prescribed limits.

Exhaust valve cup diameter
D = 21.971 to 21.989 mm (0.8650 to 0.8657 In)

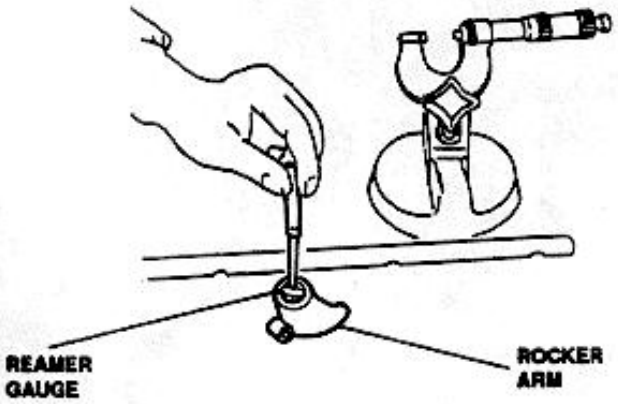


NOTE: **If dimension of cups are not within prescribed limits, the engine will produce excessive noise.**

ROCKER ARMS AND ROCKER ARMS SHAFT

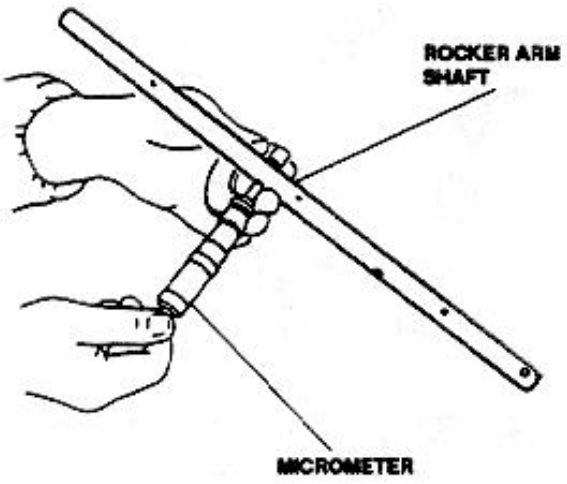
1. Check rocker arms inner diameter is within prescribed limits.

Rocker arm inner bore diameter
16.016 to 16.034 mm (0.6305 to 0.6312 in)



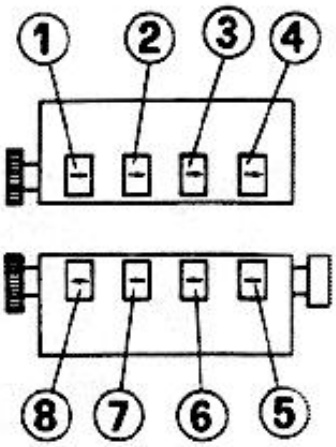
2. Check rocker arms shaft diameter is within prescribed limits.

Rocker arm shaft diameter
15.988 to16.000 mm (0.6294 to 0.6299 in)



CAMSHAFTS AND SUPPORTS

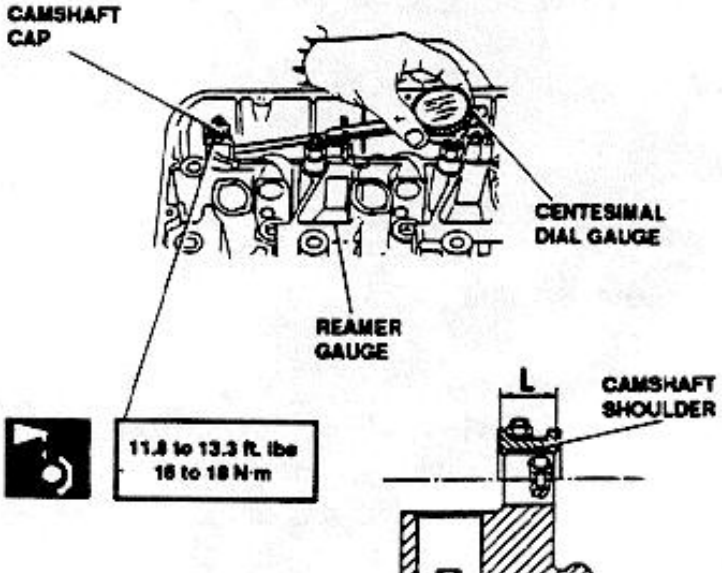
1. Install caps following identification numbers and direction shown by the arrow on the caps; torque lubricated nuts to the prescribed value.



2. Check diameter of camshaft supports is within prescribed limits.
3. Check maximum width "L" of shoulder is within prescribed limits.

Camshaft support diameter
27.000 to 27.033 mm (1.0630 to 1.0643 in)

Support shoulder width "L"
26.851 to 26.940 mm (1.0571 to 1.0606 in)



4. Carefully check the cams and camshaft working surfaces are free of scoring, traces of binding or overheating, and abnormal wear.
5. Check journals diameter "A" is within prescribed limits.
6. Check cams height is above minimum allowable dimension.
7. Check cam shoulder length "B" is within prescribed limits.
8. Check maximum eccentricity between journals does not exceed prescribed limit.

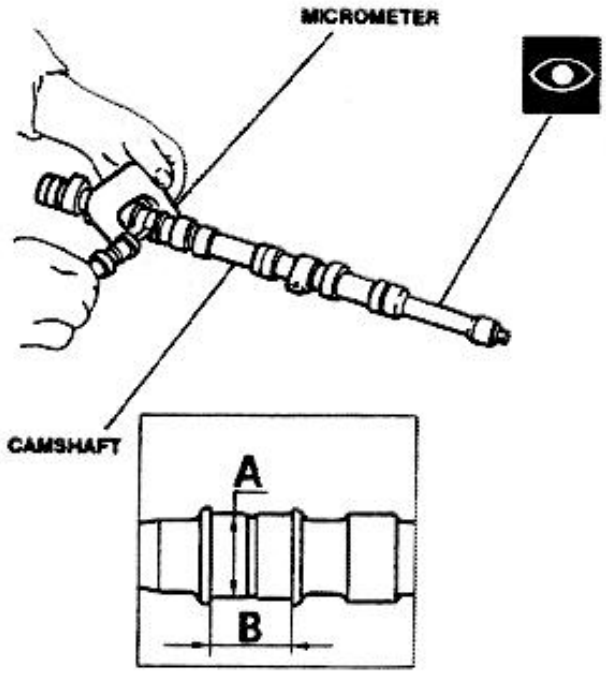
Camshaft journal diameter
A = 26.949 to 26.970 mm (1.0610 to1.0618 in)

Cams minimum height	
Intake	9.1 mm (0.36 in) (*)
Exhaust	6.4 mm (0.25 in)

(*) for "S" version: 10.1 mm (0.40 in)

Shoulder length
B = 27.000 to 27.052 mm (1.0630 to 1.0650 in)

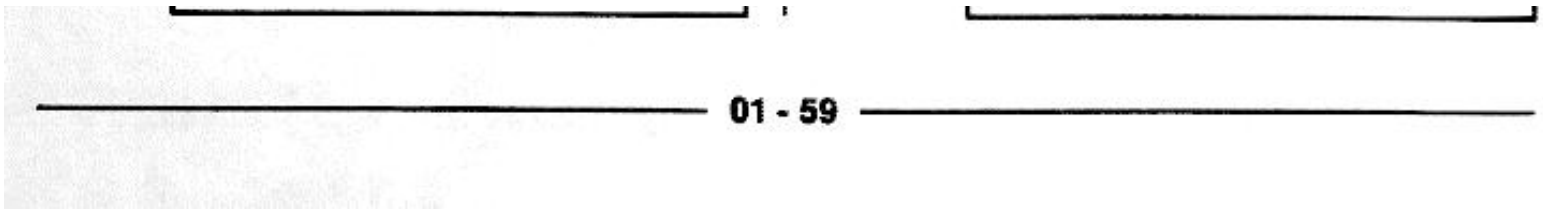
Max eccentricity between camshaft journals
0.03 mm (0.0012 in)



CAMSHAFT AXIAL PLAY CHECK

1. Position camshafts.
2. Install caps following identification numbers and direction shown by the arrow on the caps; torque lubricated nuts 11.8 to 13.2 ft lb (16 to 18 Nm).
3. Apply a centesimal dial gauge and measure axial play "G" of camshafts; verify the play is within prescribed limits.

Camshafts axial play
G = 0.060 to 0.201 mm (0.0023 to 0.0079 in)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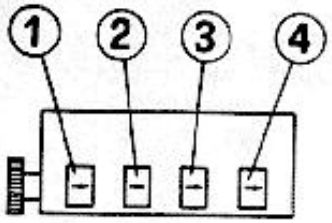
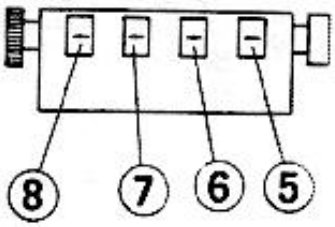
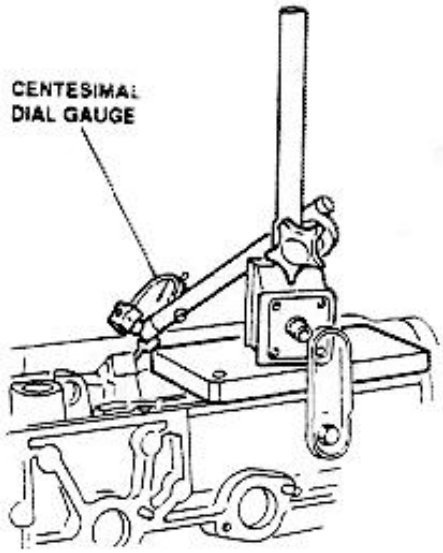
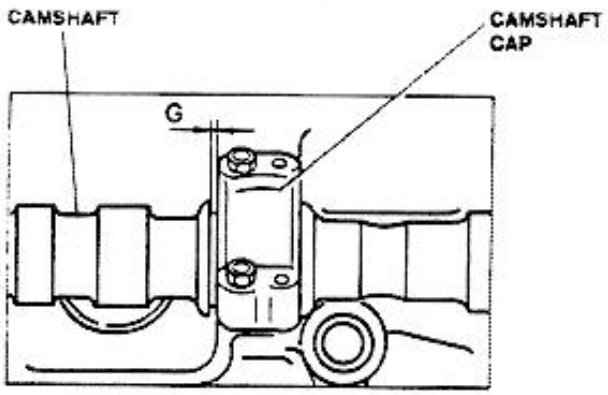








NOTE: **A camshaft, when worn or with dimensions out of prescribed limits, will cause a variation of the correct valve clearance, abnormal and noisy engine operation.**

ENGINE BLOCK CHECKS AND INSPECTIONS

This paragraph includes:

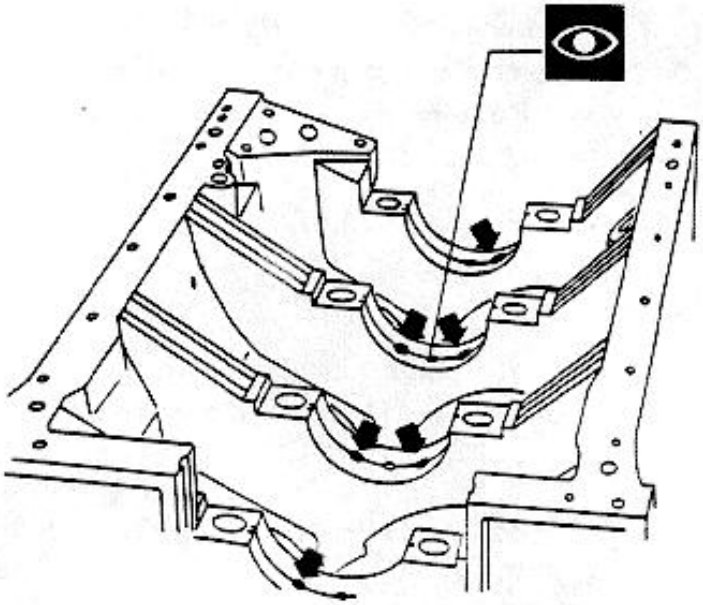
- Piston cooling oil spraying valves.
- Main and rod bearing halves - Thrust rings.
- Crankshaft.
- Main journal caps.
- Cylinder liners.
- Pistons and gudgeon pins.
- Pistons rings and oil scraper rings.
- Rods.
- Weight difference check between single pistons and rods.
- Flywheel ring gear replacement.

PISTON COOLING OIL SPRAYING VALVES

- The engine block is provided with six oil spraying valves (pointed out by arrows in the figure) directly fed by the main journals.
  The task of these oil spraying valves is to cool and lubricate the pistons and the relevant piston gudgeons.

- Carefully clean the spraying valves and check they are not damaged or choked

- Using a compressed air jet, check that the cooling valves open at the prescribed pressure.



Oil spraying valve opening pressure
2.5 ±0.25 bar

Class	Main half-bearing thickness
Green	1.8420 to 1.8465 mm (0.07252 to 0.0727 in)
Blue	1.8375 to 1.8420 mm (0.07234 to 0.07252 in)
Red	1.8330 to 1.8375 mm (0.07216 to 0.07234 in)

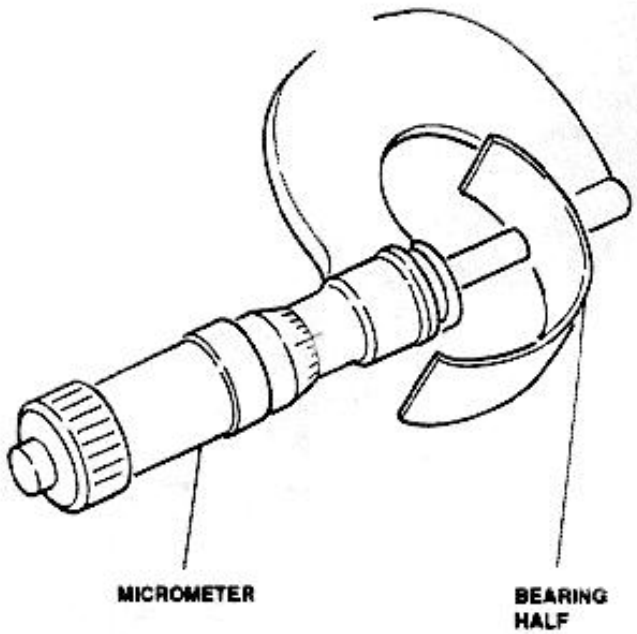
Class	Big end half-bearing thickness
Red	1.17370 to 1.745 mm (0.06839 to 0.0687 in)
Blue	1.741 to 1.749 mm (0.06854 to 0.06886 in)

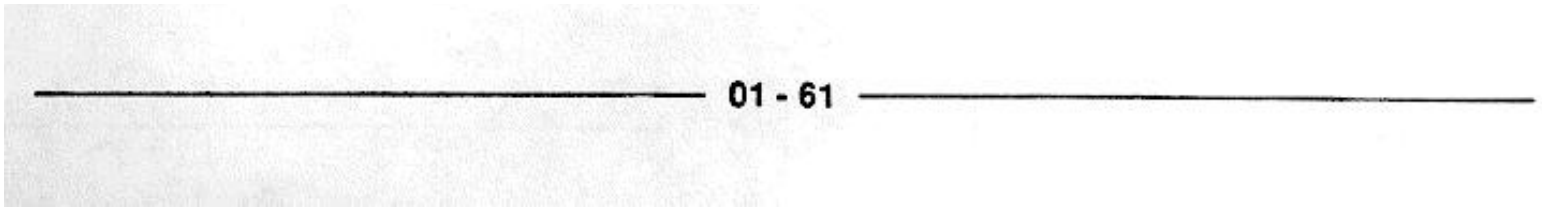
MAIN AND ROD BEARING HALVES - THRUST RINGS

1. Clean main and rod bearing halves and visually check for scoring and traces of binding. Replace all bearing halves if traces of wear are detected .

NOTE: Coupling between main and big end bearing halves, and crankshaft must be carried-out by matching parts of the same dimensional class identified by dots of the same color, RED or BLUE, located on bearing half side and on the relevant crankshaft main journal.

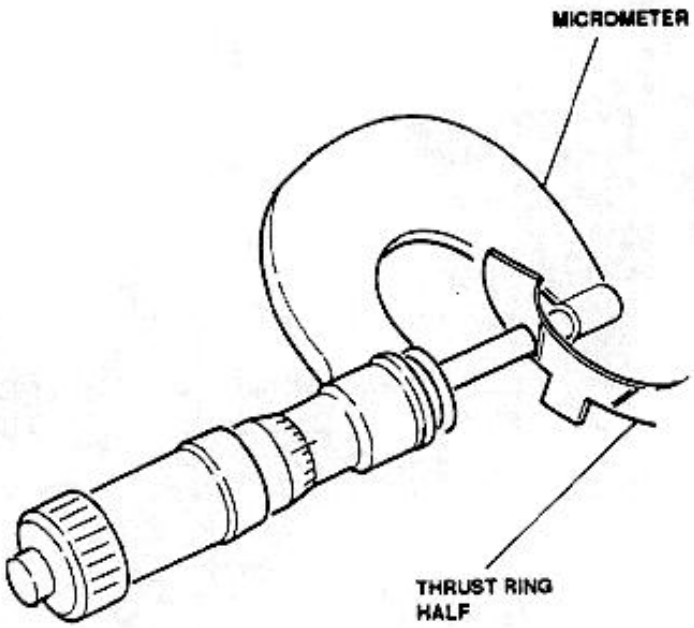
2. Check with a micrometer the thickness of bearing halves, and compare measured dimension with values shown in table.




01 - 61

3. Check thickness of thrust rings is within prescribed limits.

Thrust ring halves thickness
2.310 to 2.360 mm (0.0909 to 0.0929 in)



CRANKSHAFT

MAIN JOURNALS AND ROD JOURNALS

1. Check main and rod journals work surfaces for absence wear, nicks, traces of seizing or overheating.

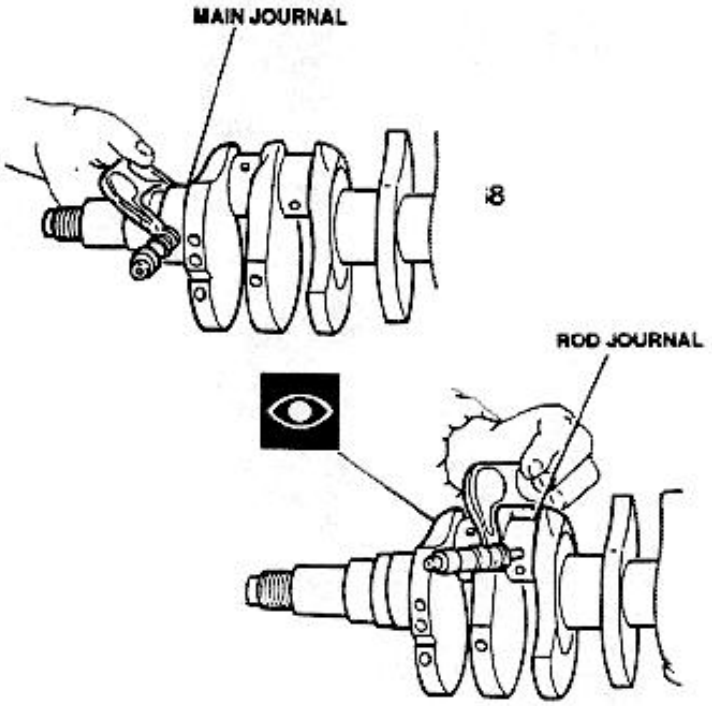
NOTE: The nitring treatment carryed-out on the crankshaft does not allow any grinding operation; replace crankshaft in case of excessive wear.

2. Place crankshaft on bench and dead center and measure diameter of main and rod journals. Compare measured dimension with the prescribed dimension.

NOTE: The crankshaft journals are divided into two classes and are identified by RED and BLUE dots for the rod journals and GREEN-BLUE or RED dots for main journals, according to the operational tolerances.

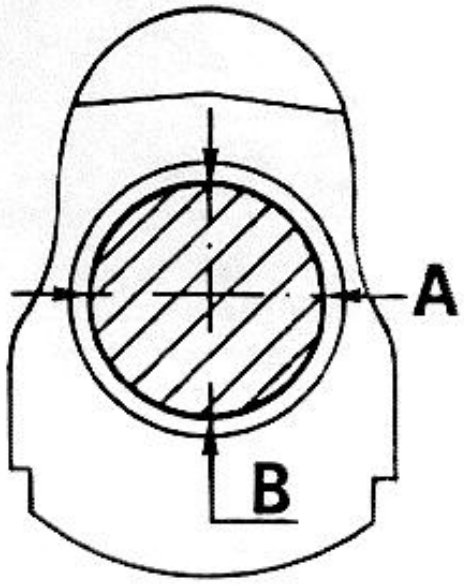
Main journal diameter	
Green	59.961 to 59.967 mm (2.3607 to 2.3609 in)
Blue	59.967 to 59.973 mm (2.3609 to 2.3611 in)
Red	59.973 to 59.979 mm (2.3611 to 2.3614 in)

Rod journal diameter	
Red	51.990 to 52.000 mm (2.0468 to 2.0472 in)
Lt blue	51.980 to 51.990 mm (2.0465 to 2.0468 in)



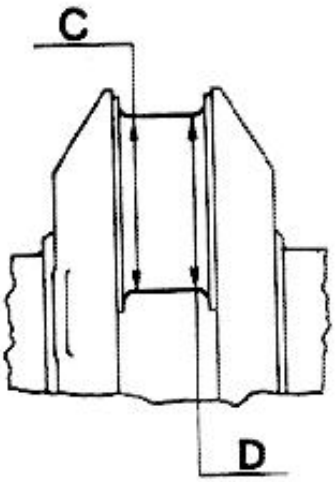
3. Check ovalization of main and rod journals is within prescribed limits.

Main and rod journals max ovalization error
A-B = 0.004 mm (0.0002 in)



4. Check taper of main and rod journals is within prescribed limits.

Main and rod journals max taper error
C-D = 0.010 mm (0.0004 in)



5. Check eccentricity of central main journal and front and rear main journals is within prescribed limits.

Main journals max eccentricity error
C- D = 0.040 mm (0.0016 in)

6. Check parallelism between main and rod journals generatrix.

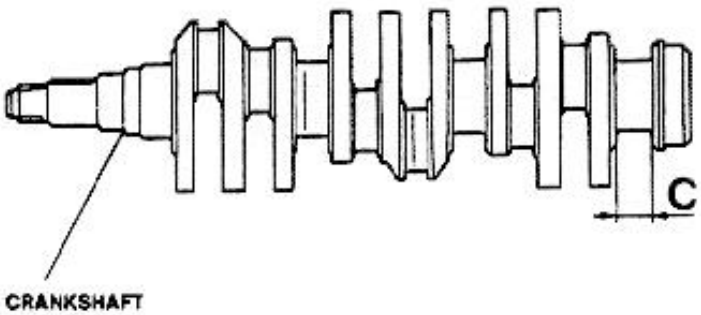
Max parallelism error between main and rod journals
0.015 mm (0.0006 in)

7. Check length "C" of tail journal is within prescribed limits.

Tail journal length
C = 31.300 to 31.335 mm (1.2323 to1.2337 in)

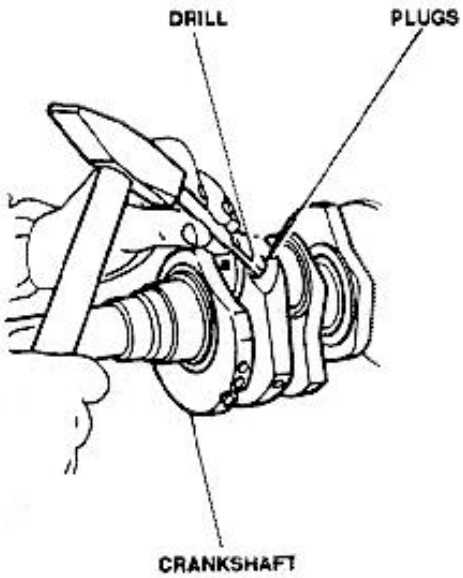
8. Check shifting of crankshaft centerline with respect to main journals centerline is within prescribed limits

Crank centerline max shifting to main journals centerline
0.3 mm (0.0118 in)

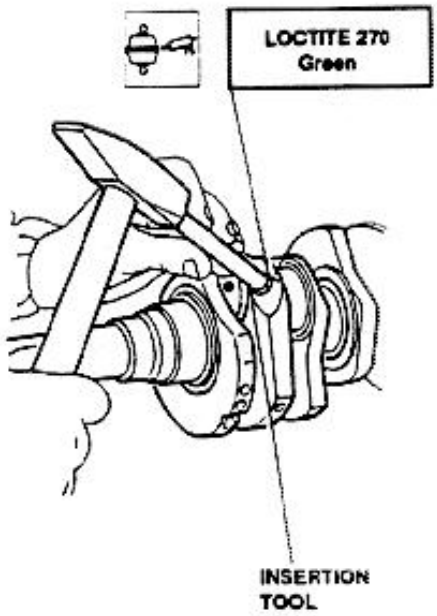


CLEANING OF LUBRICATION GROOVES

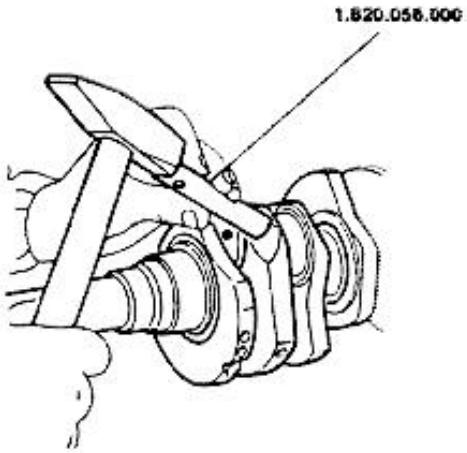
1. Remove oil groove plugs using a drill; clean oil grooves from any burrs of previous staking.



2. Thoroughly clean lubrication grooves using warm petrol, then dry with compressed air.
3. Apply prescribed sealing compound (LOCTITE 270 Green) to new plugs, then insert plugs in the lubrica-



4. Stake plugs using tool **1.820.056.000**.

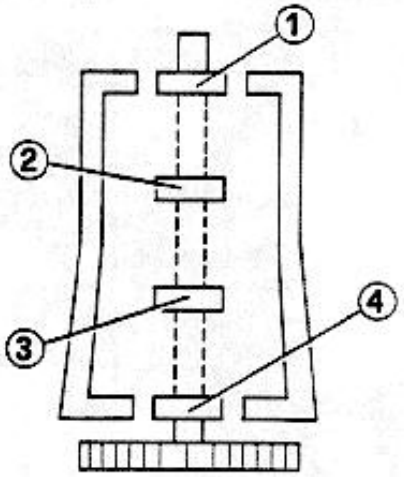


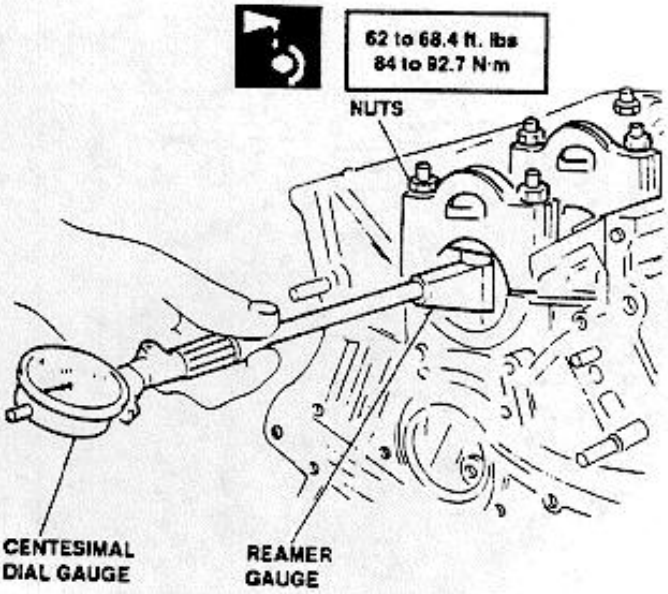
MAIN JOURNAL CAPS

1. Install main journal caps in the position and direction identified by numbering on the cap itself.
2. Torque lubricated nuts to the prescribed value and measure diameter of main bearings with a centesimal dial gauge; check diameter is within prescribed limits.

Ø	Main bearings diameter
	63.657 to 63.676 mm (2.5062 to 2.5069 in)

tion groove orifices using a suitable tool.





3. Check length of tail bearing shoulder is within prescribed limits.

Tail bearing shoulder length
26.45 to 26.50 mm (1.0413 to 1.0433 in)

CYLINDER LINERS

1. Note cylinder liner class.

NOTE: Cylinder liners are selected according to their inner diameter, and are divided in categories A, B and C. The categories are identified with BLUE, PINK or GREEN dots on the outer surface.

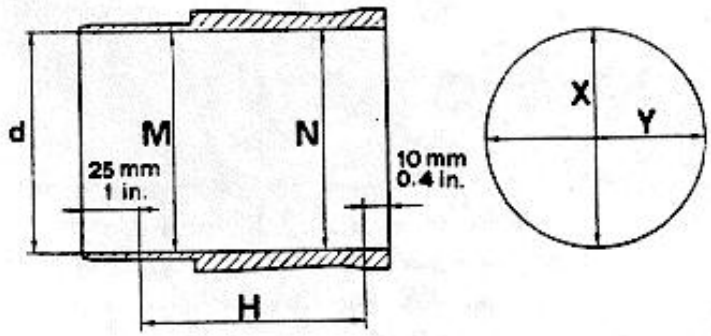
2. Using a reamer applied to a centesimal dial gauge, measure inner diameter of cylinder liners on 120° of the upper and lower median circumferences inside of the "dimensional check zone" shown in figure below.
3. Check inner diameter, taper and ovalization are within prescribed limits.

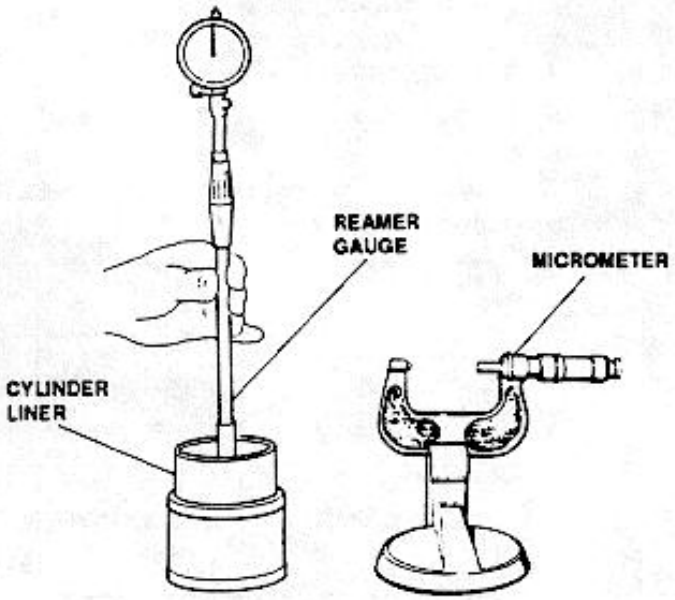
Diameter (d)	
Class A (blue)	92.985 to 92.994 mm (3.6608 to 3.6612 in)
Class B (pink)	92.995 to 93.004 mm (3.6612 to 3.6616 in)
Class C (green)	93.005 to 93.014 (3.6616 to 3.6620 in)

Max taper (M-N)
0.01 mm (0.0004 in)

Max ovalization (X-Y)
0.01 mm (0.0004 in)

H = dimensional check zone





PISTONS AND GUDGEON PINS

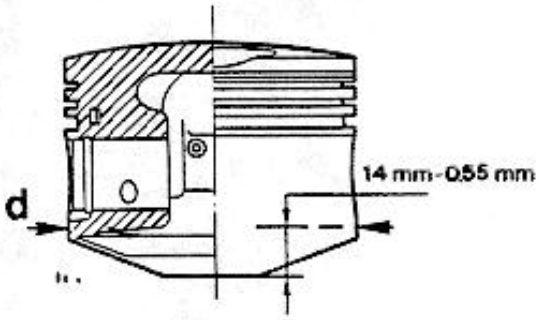
1. Check pistons class.

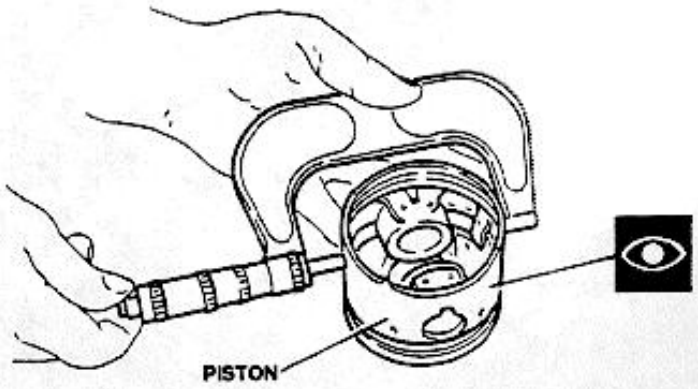
NOTE: As for the cylinder liners, pistons are divided in three classes according to manufacturing tolerances. These classes, identified by the letters A, B and C, are differentiated by BLUE, PINK and GREEN dots on piston ceiling.

2. Check piston outer diameter is within prescribed limits.

NOTE: Piston diameter must be measured perpendicularly to the gudgeon pin hole, and 14 mm (0.55 in) in from lower edge of skirt.

Outer diameter (d)	
Class A (blue)	92.925 to 92.935 mm (3.6584 to 3.6588 in)
Class B (pink)	92.935 to 92.945 mm (3.6588 to 3.6592 in)
Class C (green)	92.945 to 92.955 mm (3.6592 to 3.6596 in)



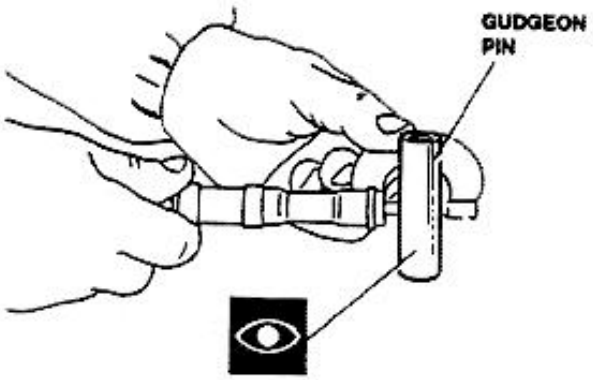


3. Check gudgeon pin class.

NOTE: The gudgeon pins and relevant mating holes on the piston are divided into two classes according to the manufacturing tolerances. These classes are identified with BLACK or WHITE dots on the inner surface of pins and on the outer surface of piston hub.

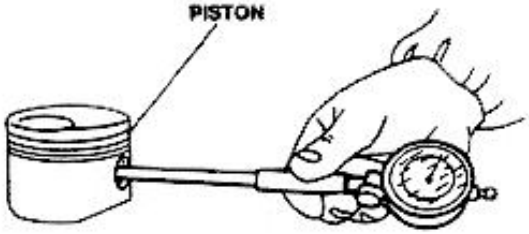
4. Measure with a micrometer the gudgeon pin outer diameter is within prescribed limits.

Gudgeon pin outer diameter	
black	21.994 to 21.997 mm (0.8659 to 0.8660 in)
white	21.997 to 22.000 mm (0.8660 to 0.8661 in)



5. Measure with a reamer gauge the piston hole for gudgeon pin is within prescribed limits.

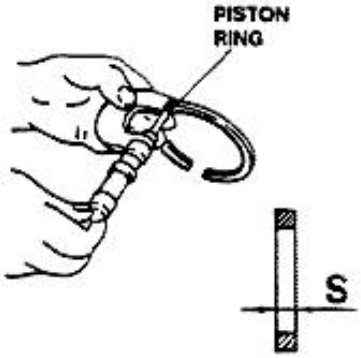
Gudgeon pin hole diameter	
black	22.003 to 22.006 mm (0.8663 to 0.8664 in)
white	22.006 to 22.009 mm (0.8664 to 0.8665 in)



PISTON RINGS AND OIL SCRAPER RINGS

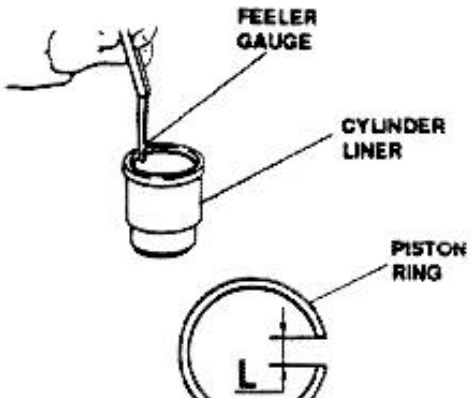
1. Check thickness "S" of piston rings and of oil scraper rings is within prescribed limits.

"S" Thickness	
1st piston ring	1.478 to1.490 mm (0.0581 to 0.0586 in)
2nd piston ring	1.478 to 1.490 mm (0.0581 to 0.0586 in)
Oil scraper ring	3.478 to 3.490 mm (0.1369 to 0.1374 in)



2. Insert piston rings inside cylinder liner and check dimension of gap "L" with a feeler gauge.

"L" Gap	
1st piston ring	0.40 to 0.65 mm (0.016 to 0.026 in)
2nd piston ring	0.40 to 0.65 mm (0.016 to 0.026 in)
Oil scraper ring	0.30 to 0.60 mm (0.012 to 0.023 in)

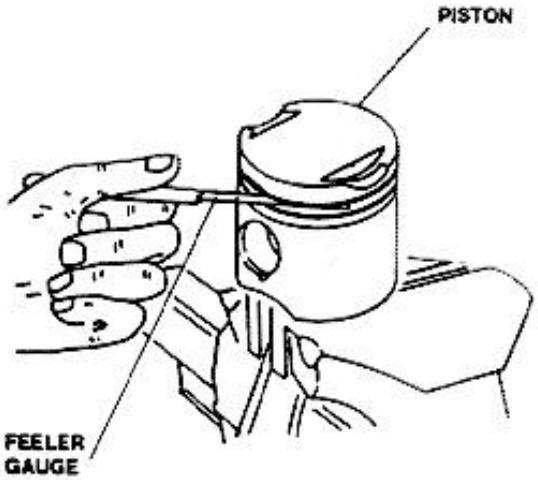


3. Lubricate piston rings with clean engine oil.
4. Insert clips and oil scraper ring in their relevant seating on third piston groove, observing that clips junction is located at 180° from piston ring gap.
5. Insert second piston ring in second piston groove.
6. Insert first piston ring in first piston groove.

At reassembly, locate rings so that TOP marking stenciled on rings is faced upwards.

7. Measure play between piston rings, oil scraper ring and seating on piston using a feeler gauge.

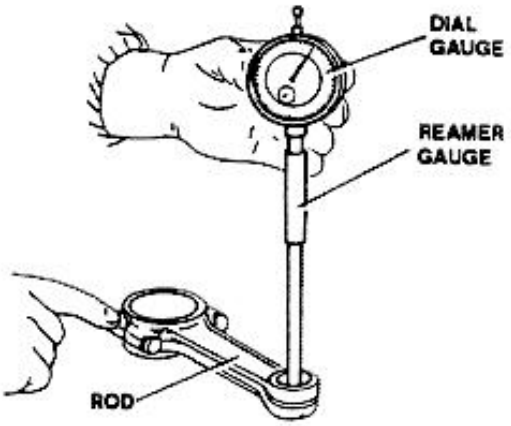
Axial play between oil rings and seatings	
1st piston ring	0.035 to 0.067 mm (0.0014 to 0.0026 in)
2nd piston ring	0.035 to 0.067 mm (0.0014 to 0.0026 in)
Oil scraper ring	0.025 to 0.057 mm (0.0010 to 0.0022 in)



RODS

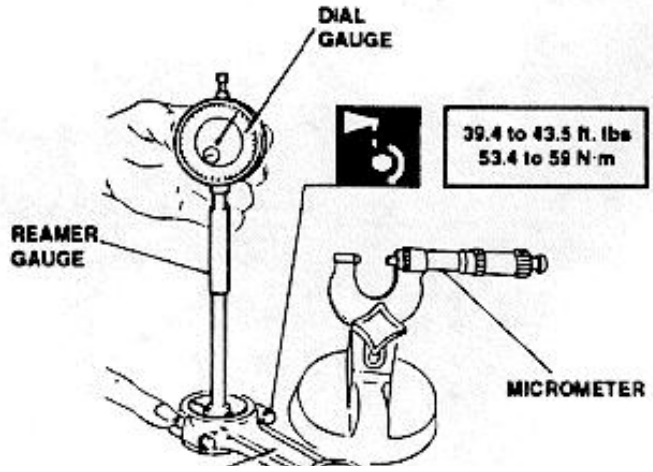
1. Visually check rods for evidence of cracks, scoring and excessive wear.
2. Using a reamer and centesimal dial gauge, measure diameter of rod small end bushing is within prescribed limits.

Rod small end bushing hole diameter
22.005 to 22.015 mm (0.8663 to 0.8667 in)



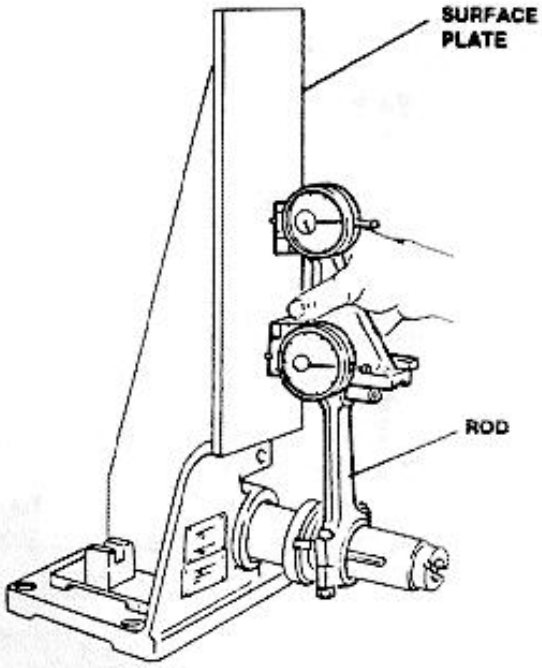
3. Install rod caps, torque lubricated screws to prescribed value.
Measure diameter as described at step 2. above and check it is within prescribed limits.

Rod big end inner diameter
55.511 to 55.524 mm (2.1855 to 2.1860 in)



4. Check rods perpendicularity using a surface plate as show in the illustration.

NOTE: If rod perpendicularity is not appropriate, replace rod to prevent abnormal loads during engine operation, and consequent abnormal wear of piston and rod.



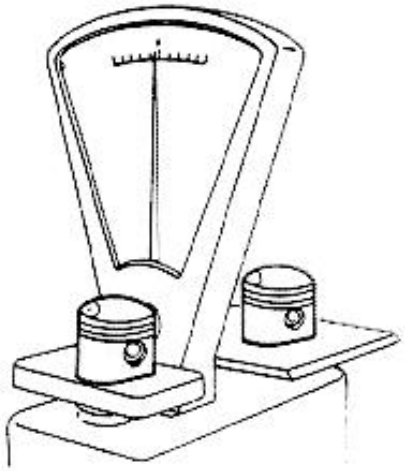
WEIGHT DIFFERENCE CHECK BETWEEN SINGLE PISTONS AND RODS

1. Select matched gudgeon pins and pistons according to the colored dot (having the same color dot, WHITE or BLACK).
   The dot is located on outer surface of hub and on inner surface of pin.

NOTE: Whenever the parts are re-used, ensure the work surfaces are free of any scratches, in particular the gudgeon pin seat.

2. Insert gudgeon pin into piston ensuring the proper class, WHITE or BLACK, has been selected.
3. Lock gudgeon pins using relevant retaining rings, and install piston rings and oil scraper ring.
4. Weigh pistons and check the weight difference is within prescribed limits.

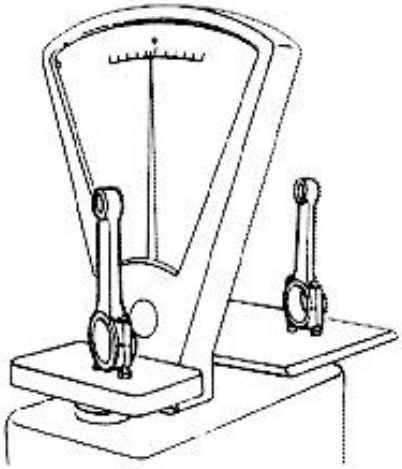
Weight difference between pistons ≤ 4 grams (0.15 oz.)



5. Weight rods (complete of caps, bearing halves and screws) and check the weight difference is within prescribed limits.

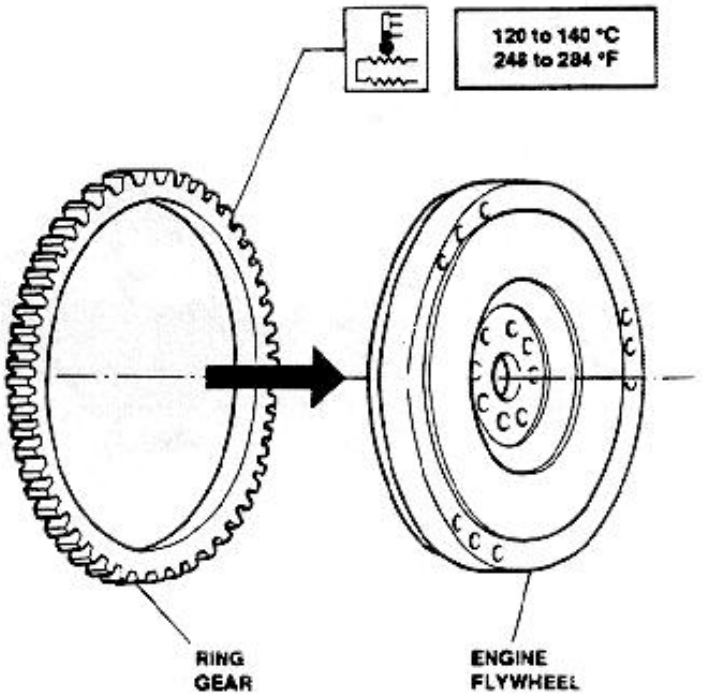
Weight difference between rods ≤ 2 grams (0.07 oz)

To restore correct weight, remove excess metal from points **A** and **B** shown in the illustration.



FLYWHEEL RING GEAR REPLACEMENT

1. Inspect flywheel ring gear and, if required, replace it as follows.
2. Remove old ring gear using a hydraulic press.
3. Thoroughly clean mating surfaces of new ring gear and of flywheel.
4. Pre-heat uniformly the new ring gear to 120 to 140°C (248 to 284°F) and fit it on engine flywheel.
5. Let the parts cool down to ambient temperature; do not force cooling of the parts.



WARNINGS FOR REASSEMBLY

This paragraph includes:

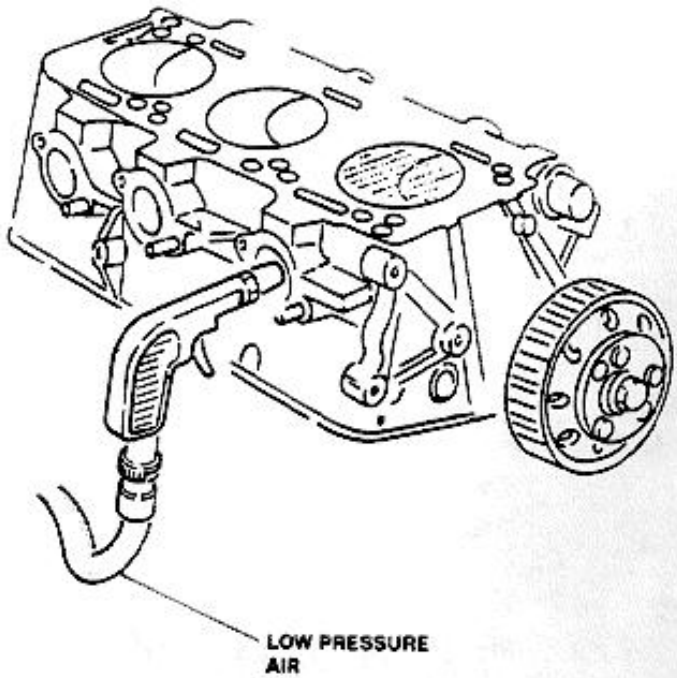
- Valves leakage check
- Correct positioning of rocker arms shaft
- Valve clearance check and adjustment
- Crankshaft installation
- Crankshaft axial play check
- Rear oil seal installation
- Cylinder liners, pistons and rods installation
- Oil pump checks and inspections
- Hydraulic belt tightener overhaul
- Cylinder heads installation
- Timing belt installation and engine timing check
- Engine mount bracket elastic bushing replacement
- Cylinder compression test

For reassembly, carry-out in reverse order the disassembly procedure steps, with the exception of warnings stated in the following.

VALVES LEAKAGE TEST

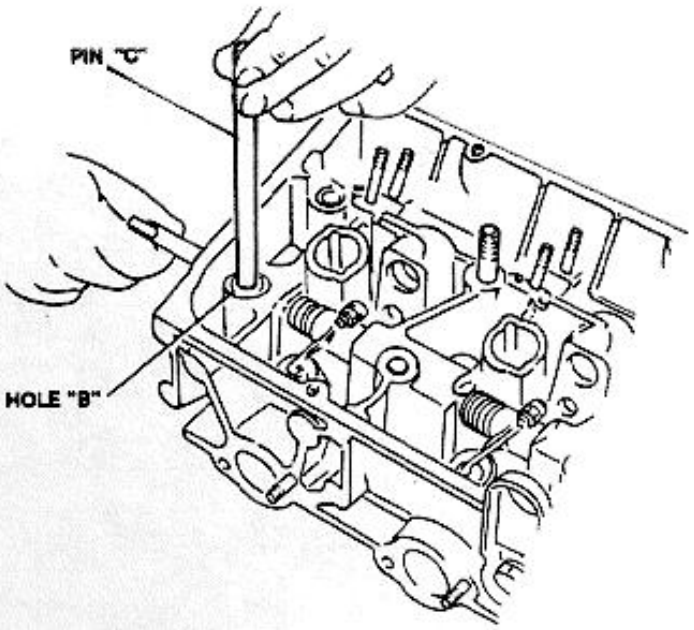
After installing the cone halves, check valve leakage as follows:

1. Screw down spark-plugs in their seats.
2. Pour enough petrol in a combustion chamber so as to cover the valve heads.
3. Blow low-pressure air in the intake and exhaust ports and check that no bubbles come to the surface of petrol; otherwise make sure of the correct assembly and, if necessary, grind the valves seats again.

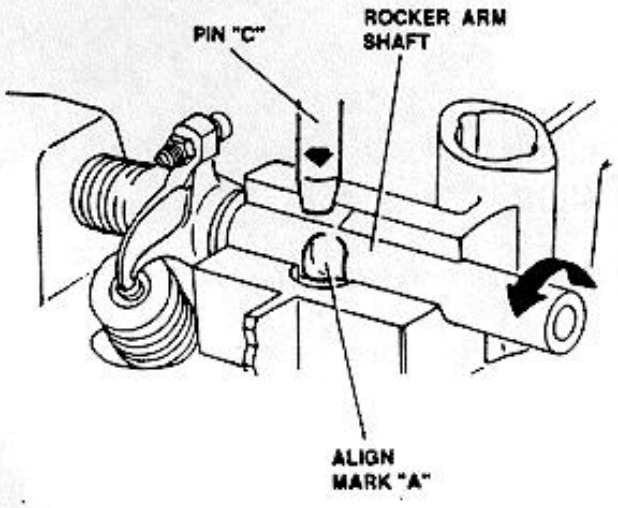


CORRECT POSITIONING OF ROCKER ARMS SHAFT

1. After installation of washers, rocker arms and springs has been completed, rotate shaft to align marks "A" to holes "B" and allow the passage of cylinder head support studs.



2. Use pin "C" (dia. 12 mm - 0.47 in) to ensure proper alignment has been obtained.



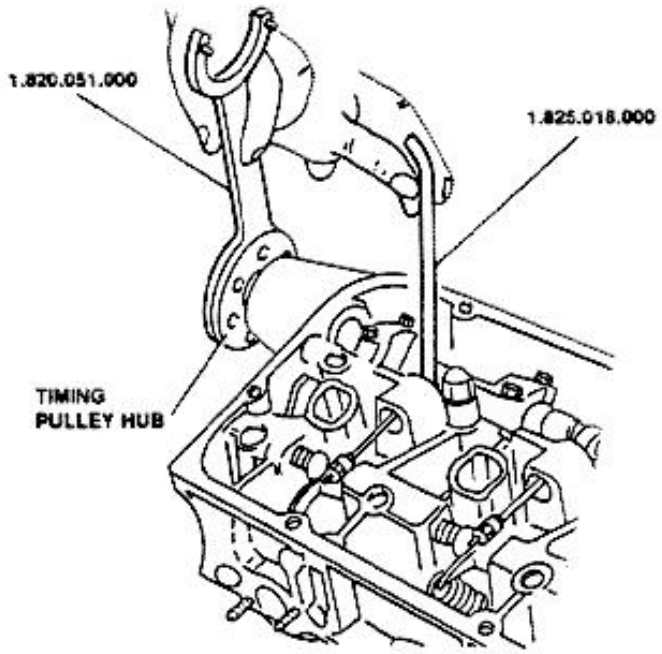
VALVE CLEARANCE CHECK AND ADJUSTMENT

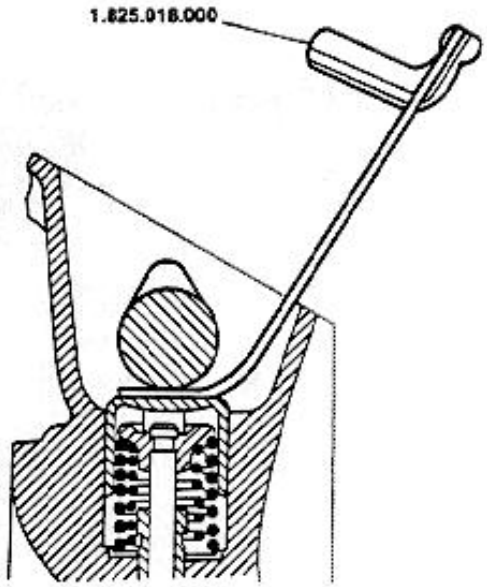
INTAKE VALVES CLEARANCE CHECK

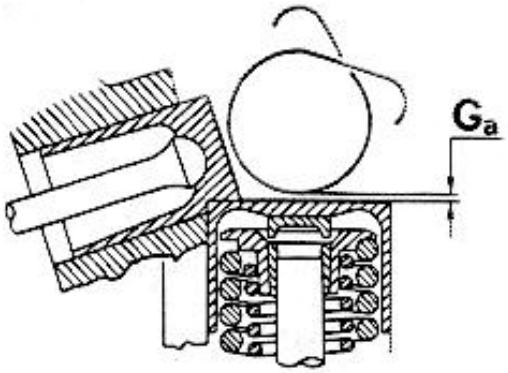
After installation of camshaft check intake valves clearance as follows:

1. Temporarily install timing system drive toothed pulley hub.
2. Using tool **1.820.051.000** for rotation of camshaft and feeler gauge **1.825.018.000** check clearance "Ga" between cams heel radius and valve cups is within prescribed limits; otherwise, replace intake valve caps with another having the required thickness.

Valve clearance Intake side
Ga = 0.475 to 0.500 mm (0.0187 to 0.0197 in)

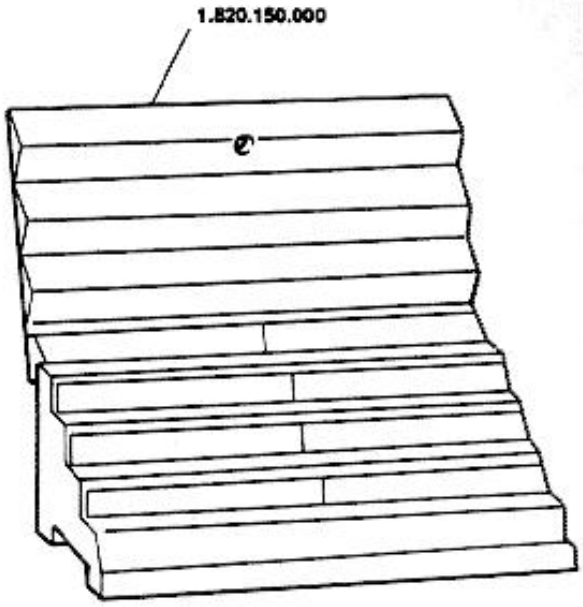


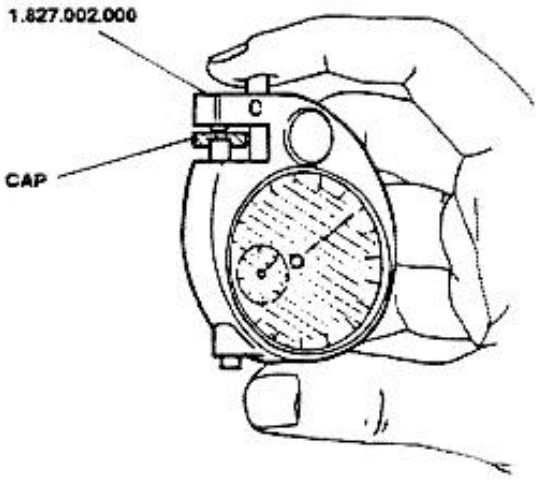




INTAKE VALVES CLEARANCE ADJUSTMENT

1. Remove camshaft caps.
2. Remove camshaft.
3. Remove valve cups and valve clearance adjustment caps.
4. Measure thickness of caps with dial gauge **1.827.002.000** then, for difference with respect to dimension previously measured, select among parts of set **1.820.150.000** the caps of thickness suitable to restore correct valve clearance.
5. Reinstall caps, camshaft and cups; torque camshaft cap nuts to 11.8 to13.2 ft lb (16 to18 Nm) and check valve clearance is within prescribed limits.



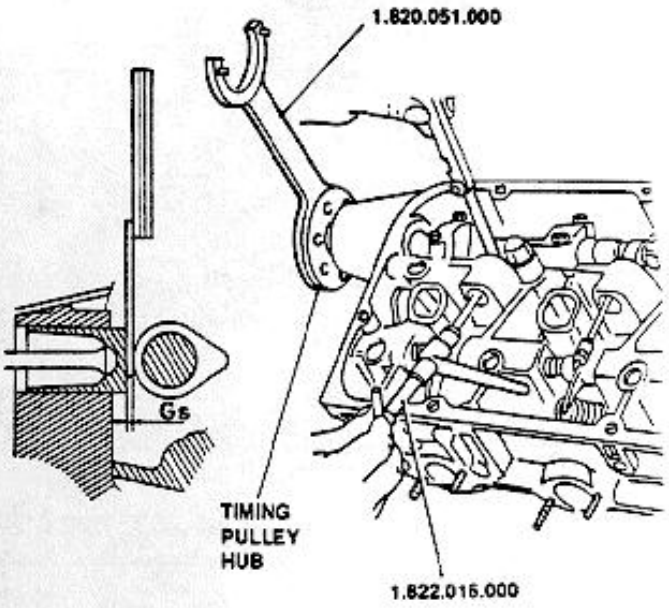


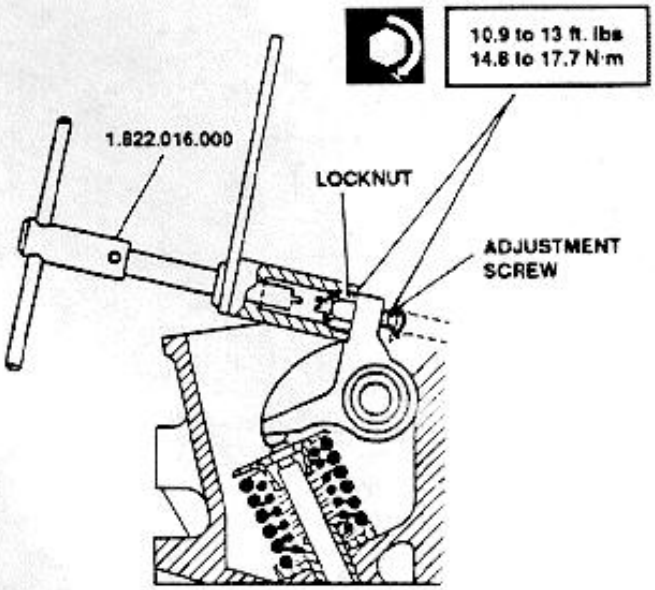
EXHAUST VALVES CLEARANCE CHECK AND ADJUSTMENT

1. Temporarily install timing system drive toothed pulley hub.
2. Using tool **1.820.051.000**, rotate camshaft until the feeler gauge can be inserted between cams heel radius and respective cups.
3. Record values obtained on each valve and compare with prescribed values.

4. If necessary, act on intermediate lever of tool **1.822.016.000** and loosen locknut fixing the adjustment screw.
5. Using the same tool, act on adjustment screw until the prescribed clearance is obtained.
6. Lock locknut and re-check valves clearance.

Valve clearance exhaust side
Gs = 0.225 to 0.250 mm (0.0088 to 0.0098 in)



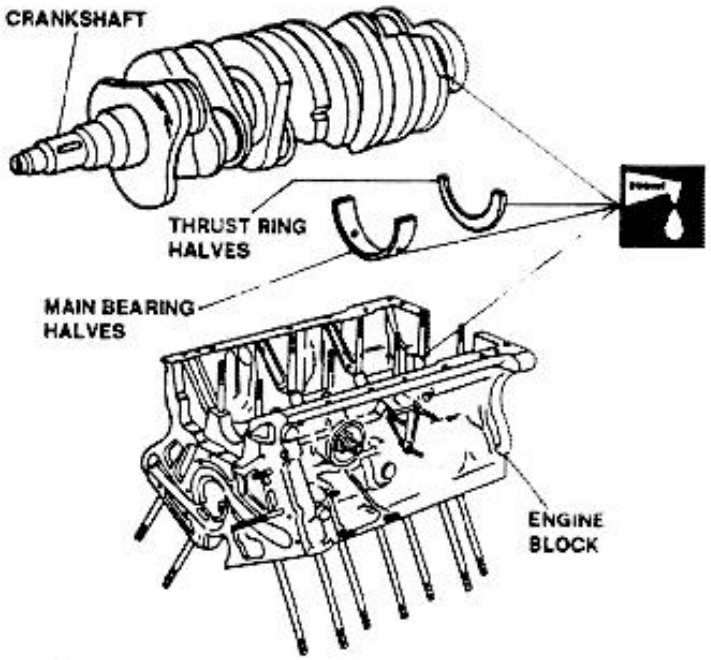


CRANKSHAFT INSTALLATION

1. Seat main bearing halves onto main bearings.

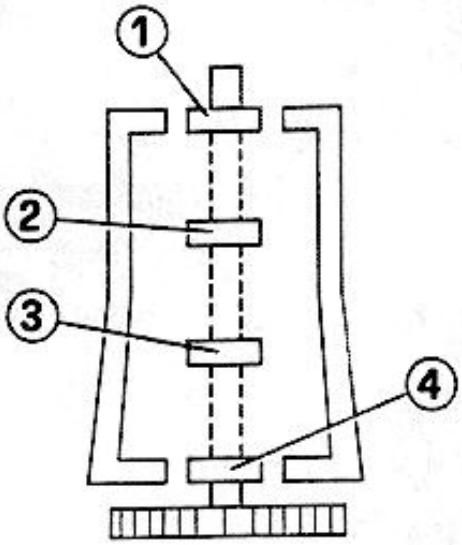
NOTE: The assembly on the crankshaft must be carried-out by matching parts of the same dimensional class (identified by three GREEN, BLUE or RED stripes on side of bearing half, and GREEN, BLUE or RED dots on respective crankshaft journal).

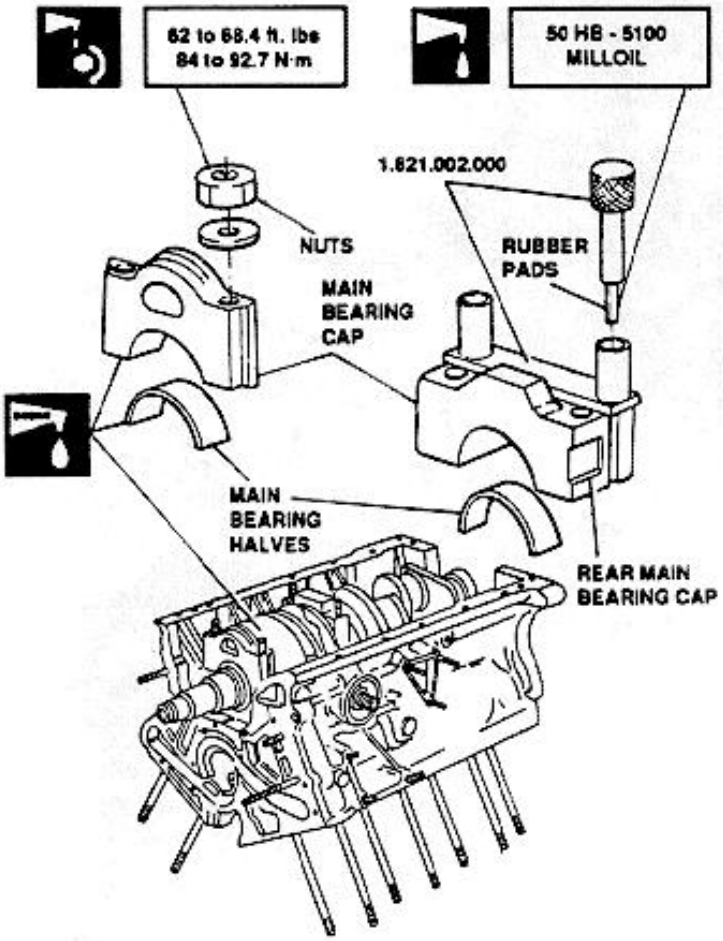
2. Install thrust ring halves in their seatings and ensure the lubrication grooves are faced to crankshaft shoulders.
3. Position crankshaft.



4. Position main bearing halves into main bearing caps.
5. Install the four main bearing caps according to the numbering shown in the illustration (insert one at a time the rubber pads on rear main bearing cap using tool **1.821.002.000**).

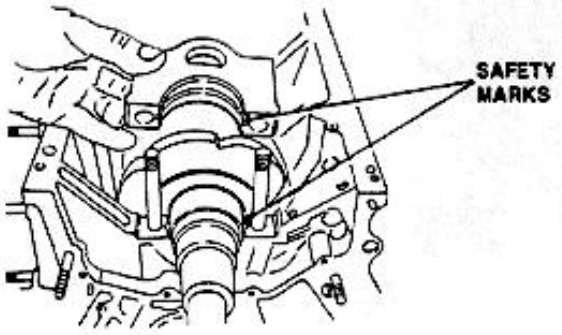
NOTE: Coupling of main bearing half and crankshaft journal must be obtained by matching parts of the same dimensional class (identified by three GREEN, BLUE or RED stripes on side of bearing half, and GREEN, BLUE or RED dots on respective crankshaft journal).





CAUTION:
The safety marks located on engine block and on main bearing caps must be located on the same side as shown in the illustration.

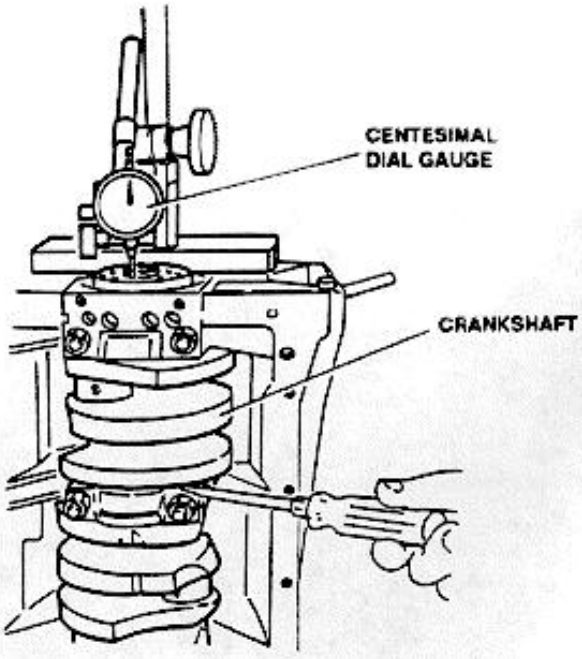
6. Torque lubricated main bearing cap nuts to prescribed value (in two or three stages).



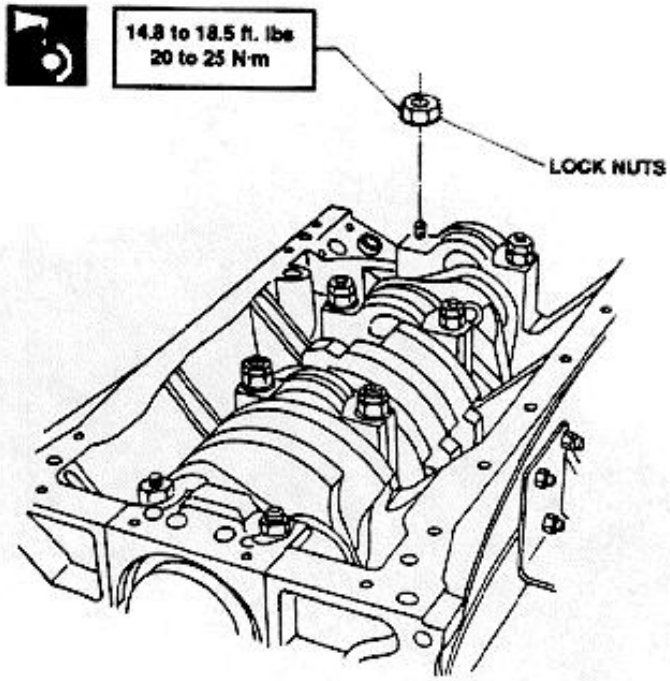
CRANKSHAFT AXIAL PLAY CHECK

1. Check axial play of crankshaft is within prescribed limits using a centesimal dial gauge mounted on a magnetic platform.

Crankshaft axial play
0.080 to 0.265 mm (0.0031 to 0.0104 in)



2. Screw and tighten to the specified torque the lubricated lock nuts on the 1st, 2nd and 3rd main bearing caps.



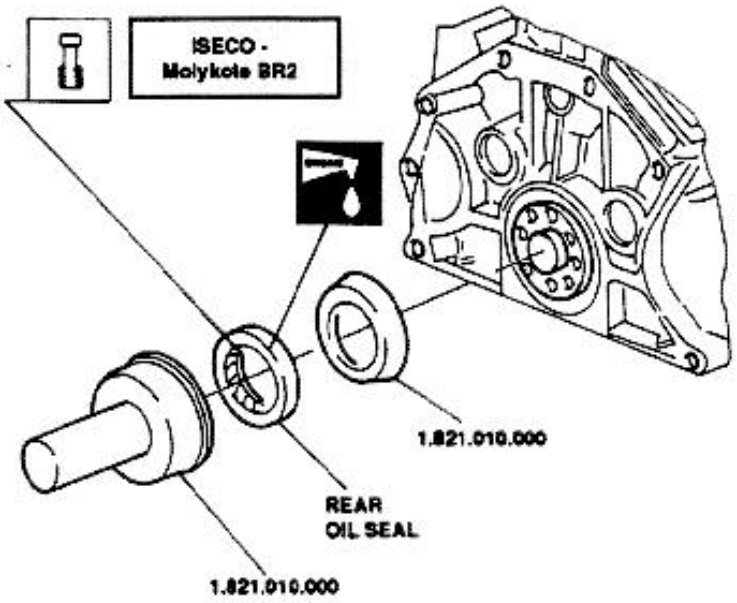
NOTE: **Noisy engine operation can be expected if crankshaft axial and radial plays are excessive.**

REAR OIL SEAL INSTALLATION

1. Install rear oil seals using inserting tool **1.821.010.000.**

NOTE: **Restrain oil seal inner spring with a light coat of grease ISECO MOLYKOTE BR2.**

CAUTION:
Take care during reassembly of correct positioning of inner spring and oil seal.

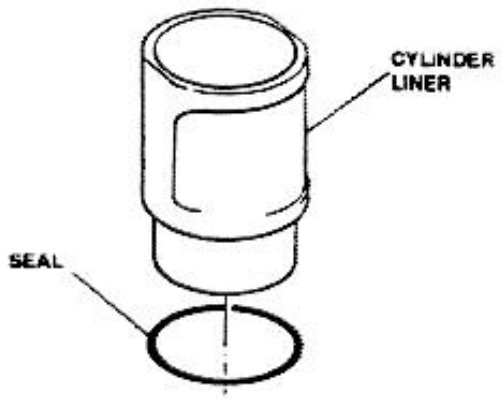


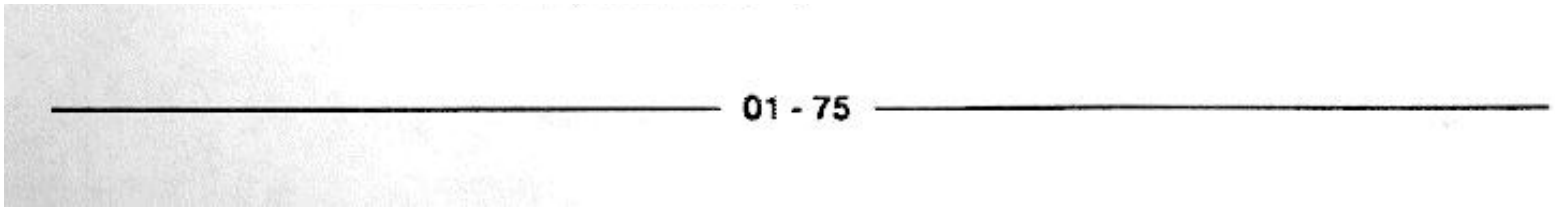
CYLINDER LINERS, PISTONS AND RODS INSTALLATION

NOTE: **Whenever cylinder and pistons are excessively worn, carefully check dimensions and clearances as indicated in the following. Furthermore, ensure the engine oil is of the prescribed type and the air filter is clean and serviceable.**

CYLINDER LINERS PROTRUSION CHECK

1. Install seals in cylinder liners.

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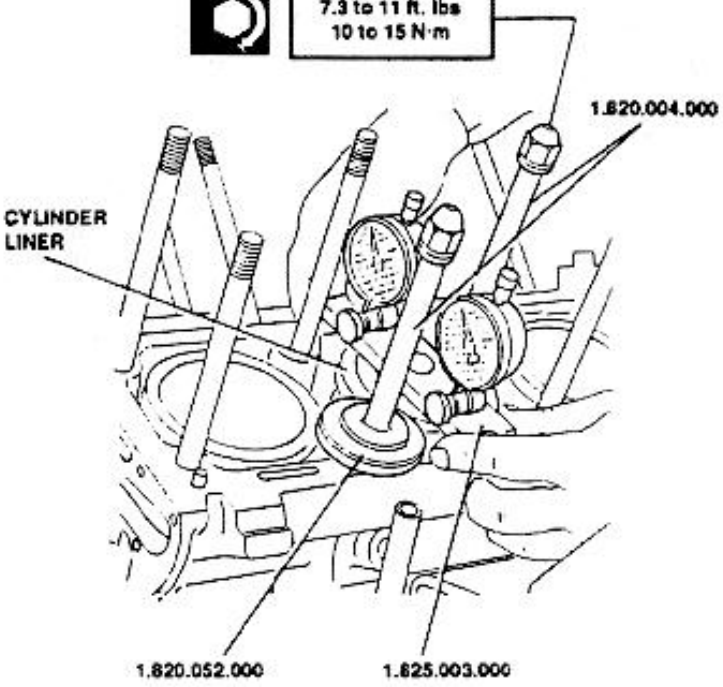
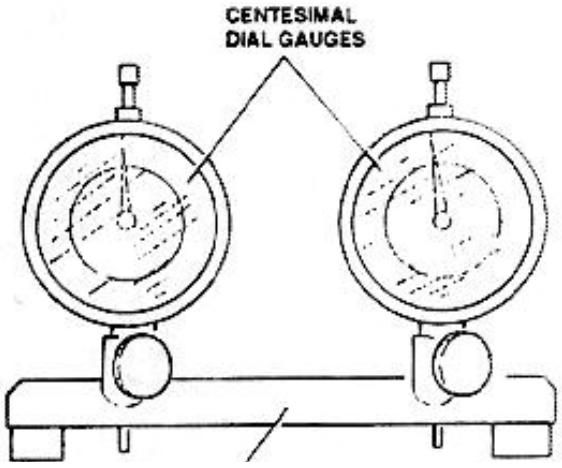
2. Insert cylinder liners into engine block.
3. Fix liners to engine block using cylinder liners fixing tools **1.820.004.000** complete of supplementary rings **1.820.052.000**.
4. Lock liner fixing tool nuts to the prescribed torque.
5. Apply two centesimal dial gauges to the tool **1.825.003.000** and reset them on a datum plane.
6. Place tool **1.825.003.000** on engine block so that dial gauge pins contact the liner edge; check liner protrusion in within prescribed limits.

Cylinder liners protrusion from engine block
0.01 to 0.06 mm (0.004 to 0.024 In)

7.3 to 11 ft. lbs
10 to 15 N·m

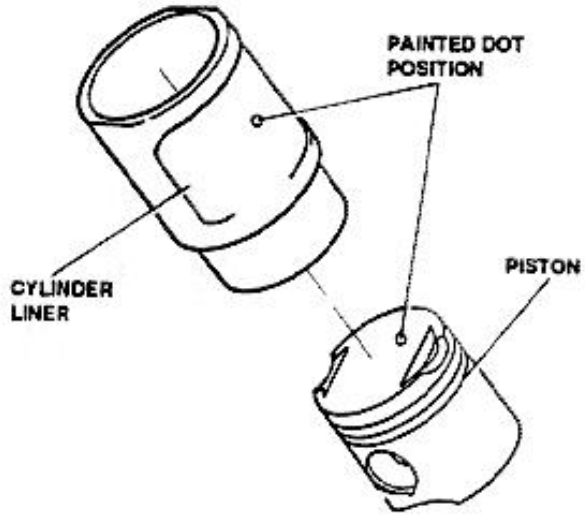




MATCHING OF CYLINDER LINERS AND PISTONS

1. Match parts of the same dimensional class (identified by dots of the same color):
   - A (**BLUE**), B (**PINK**) or C (**GREEN**) on piston top and on outer surface of cylinder liner.

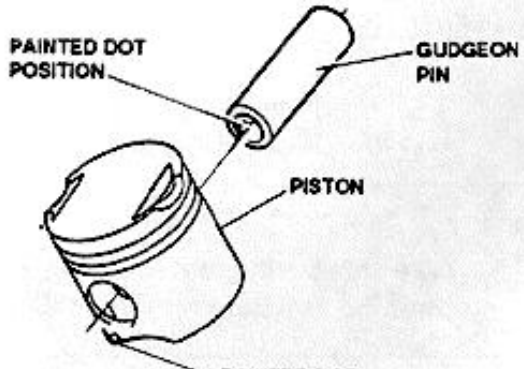
Clearance between cylinder liner and piston
0.050 to 0.069 mm (0.0020 to 0.0027 In)

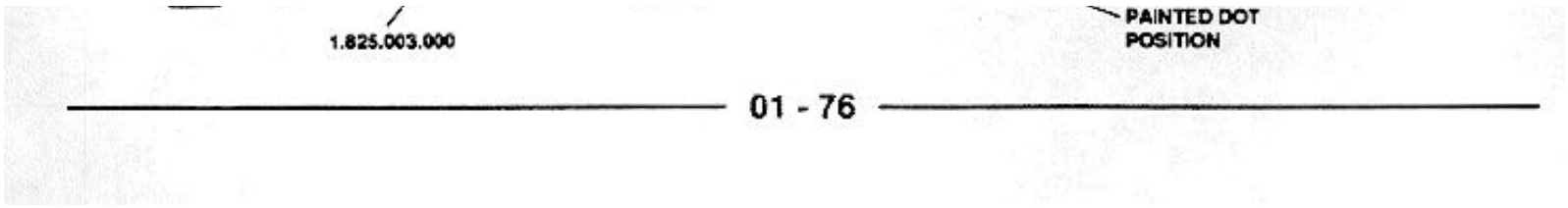


MATCHING OF PISTONS AND GUDGEON PINS

- **BLACK** or **WHITE** on inner surface of gudgeon pin and on outer surface of piston hub.

Clearance between piston hole and gudgeon pin
0.006 to 0.012 mm (0.0002 to 0.0005 In)



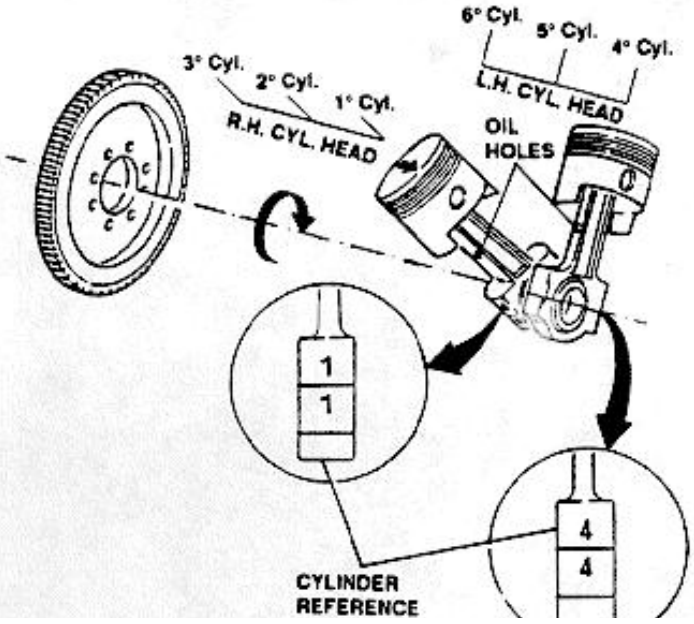

1.825.003.000
PAINTED DOT
POSITION

NOTE: If excessive axial play of gudgeon pin into piston is found during reassembly, replace gudgeon pin to prevent noisy operation of engine.

MATCHING OF PISTONS - RODS AND RODS - CRANKSHAFT

1. Arrow engraved on piston top must be oriented towards front side of engine.
2. Lubricating holes on rod side must be oriented towards right side of engine block (for both the right and left side rods).
3. Each rod is provided with a number on the big end that identifies the respective cylinder number; this number is located on the right side of rods of the right row, and on left side of rods of the left row.
4. Similarly, also the rod caps are provided on their side with a number that identifies the respective cylinder number. At reassembly, these numbers must be located on the same side of that engraved on rod big end.

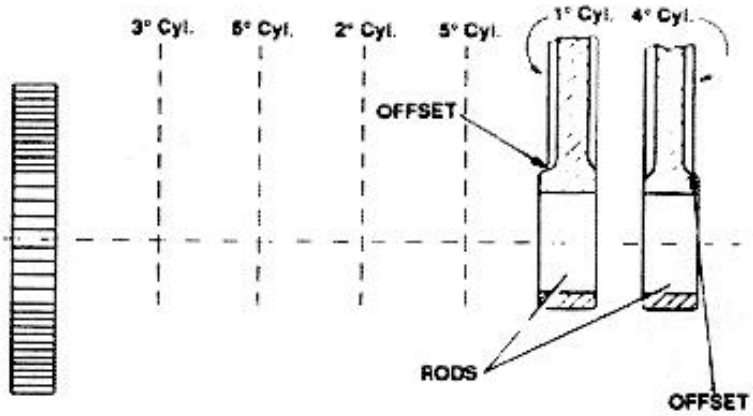
Clearance between rod small end bushing and gudgeon pin	
black	0.008 to 0.021 mm (0.0003 to 0.0008 In)
white	0.005 to 0.018 mm (0.0002 to 0.0007 In)



NOTE: Noisy engine operation can be expected if play between rod, gudgeon pin and piston exceeds the prescribed limits.

5. Rods pertaining to right side of engine (1st, 2nd and 3rd cylinders) shall be installed with the offset facing towards the rear end of engine; rods pertaining to the left side of engine (4th, 5th and 6th cylinders) shall be installed with the offset facing the front end of engine

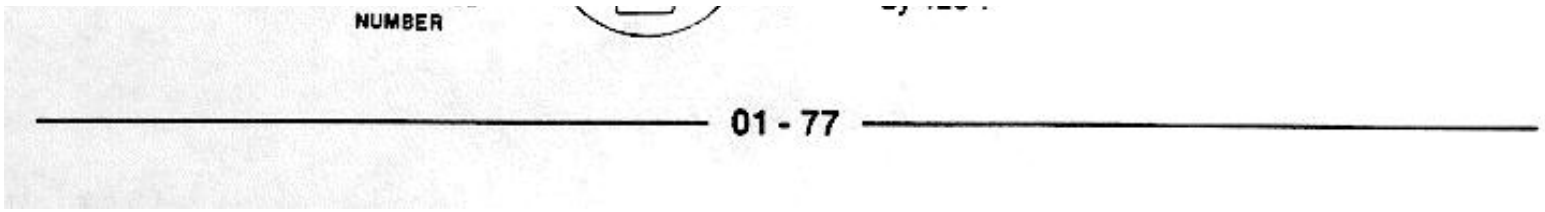
CAUTION:
Rods pertaining to the right side of engine are not interchangeable with rods of the left side and viceversa since, in addition to the offset, correct positioning of lubricating hole on the rods must be observed.



6. Locate rod big end bearing halves on rod big ends.

NOTE: The assembly on the crankshaft must be carried-out by matching parts of the same dimensional class (tagged by RED or BLUE dots on the half-bearing sides and RED or LIGHT BLUE on the relevant crankshaft journal).

7. Insert piston rings on pistons with the gaps staggered by 120°.


NUMBER
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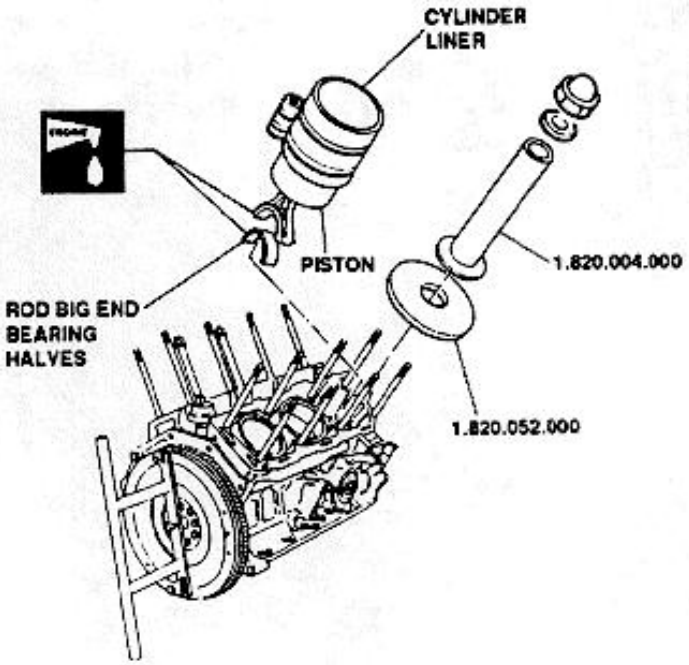
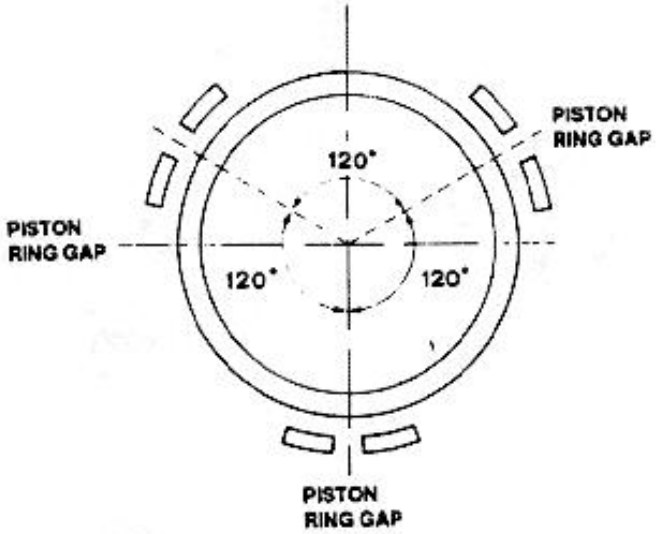
8. By means of suitable tool, install pistons and rods on the cylinders of one row of engine.

CAUTION:
Point the arrow printed on the piston crown towards the engine front side.
Install the connecting rods with their offset facing the right side of engine block.

9. Install the cylinder liner fixing tools **1.820.004.000** complete of supplementary washers **1.820.052.000** on both row of cylinders.





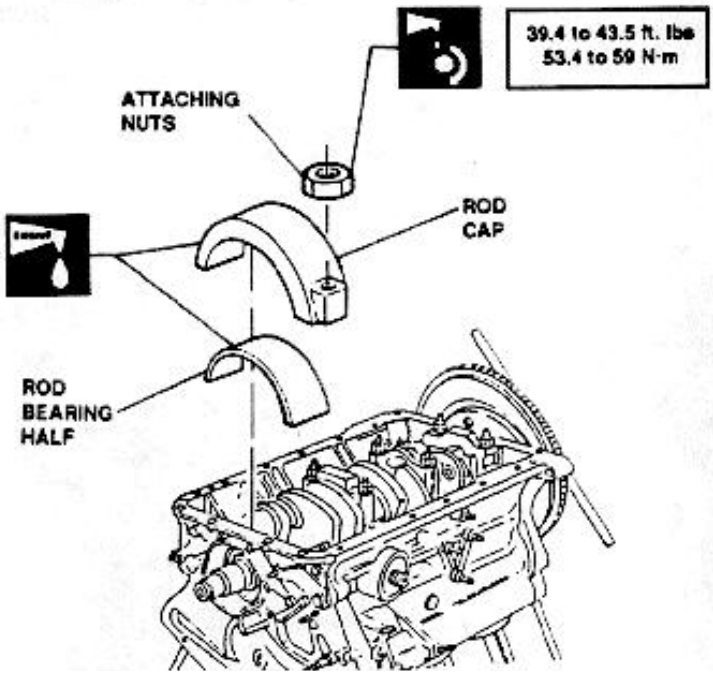
10. Rotate engine block of 180°.
11. Position rod bearing halves in rod caps.

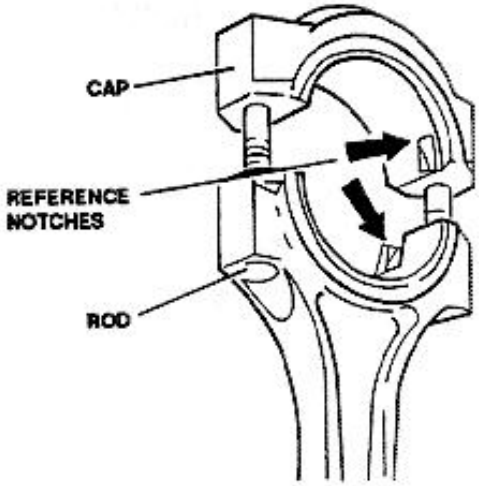
NOTE: The assembly on the crankshaft must be carried-out by matching parts of the same dimensional class (identified by three GREEN, BLUE or RED stripes on side of bearing half, and GREEN, BLUE or RED dots on respective crankshaft journal).

12. Install rod caps of the row of cylinder being reassembled, positioning the reference notch towards the side of the corresponding notch on the rod big end.

CAUTION:
Each rod cap has the number corresponding to its cylinder printed on its side; on assembling, this number must face the side of relevant number printed on the rod big end.

13. Torque to prescribed value lubricated cap nuts.
14. Assembly in analogy pistons and rods of the opposite row of cylinders.

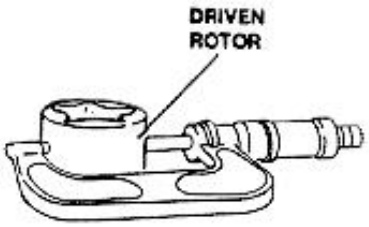


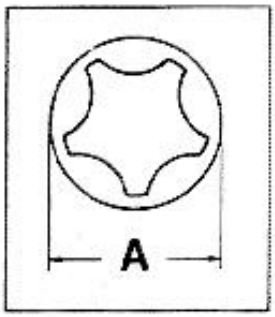


OIL PUMP CHECKS AND INSPECTIONS

1. Check outer diameter of driven rotor is within prescribed limits.

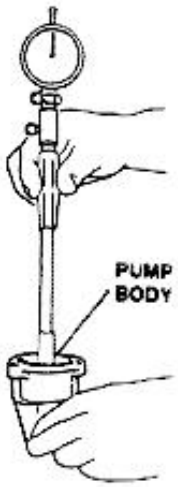
Driven rotor outer diameter
A = 49.100 to 49.155 mm (1.9331 to 1.9352 In)

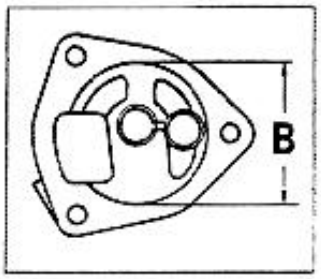




2. Check inner diameter of pump body is within prescribed limits.

Pump body rotor seat diameter
B = 49.325 to 49.375 mm (1.9419 to 1.9439 In)

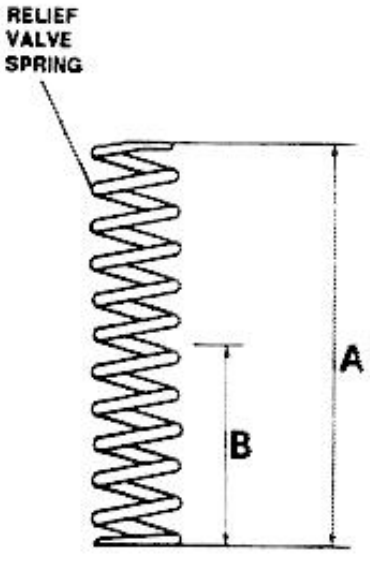


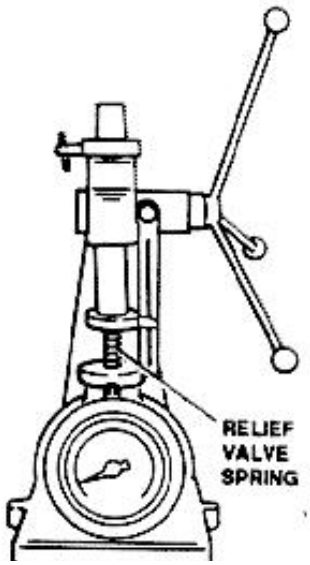


3. Check with a dynamometer the characteristic values of spring actuating the oil pressure relief valve

Spring free length (A)	49.29 mm (1.941 In)
Loaded spring length (B)	31.90 mm (1.256 In)

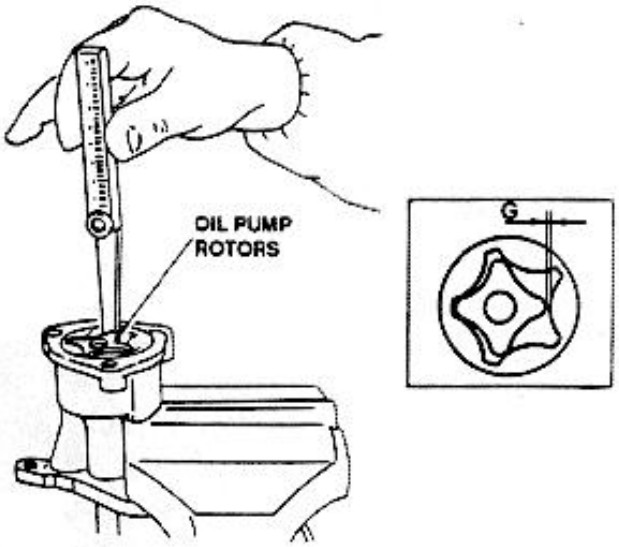
(1) Test load : 170 to176 N (38.2 to 39.6 lbs)





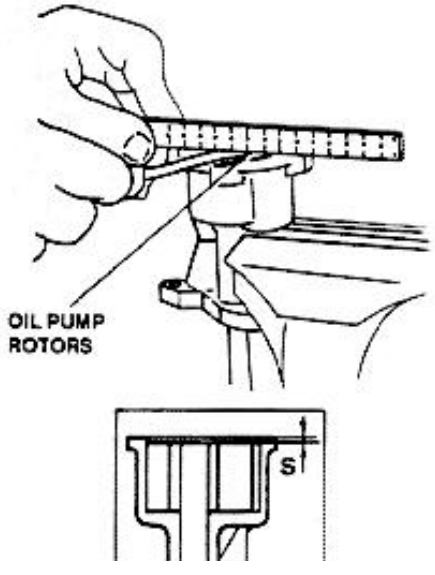
4. Position the two rotors inside the pump body; check clearance "G" between inner rotor lobe and that of driven rotor is within prescribed limits.

Clearance between driven rotor and inner rotor
G = 0.040 to 0.290 mm (0.0016 to 0.0114 in)



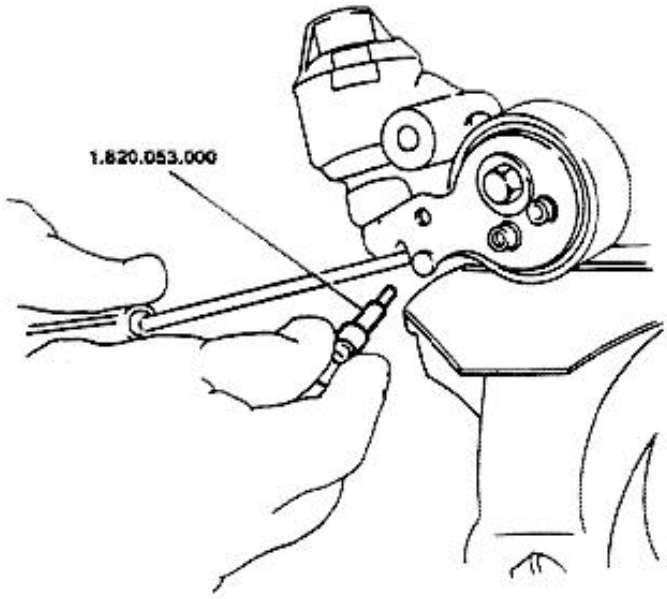
5. Check axial play "S" of the two rotors with respect to pump body plane is within prescribed limits

Axial play between the two rotors with respect to pump body plane
S = 0.025 to 0.075 mm (0.0010 to 0.0030 in)

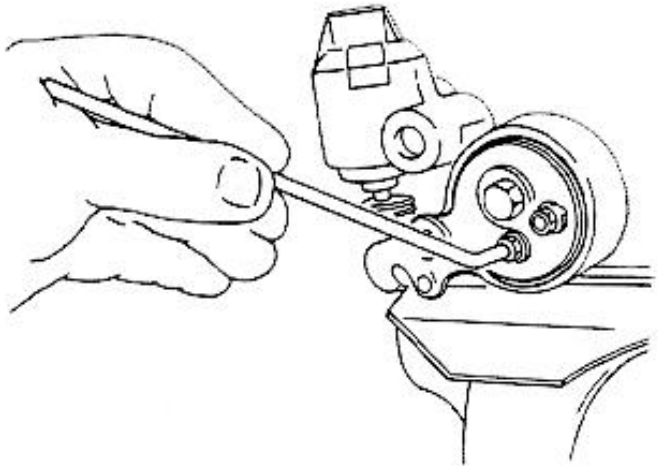


HYDRAULIC BELT TIGHTENER OVERHAUL

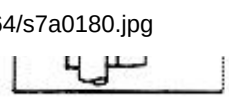
1. Withdraw tool **1.820.053.000** to release inner spring.



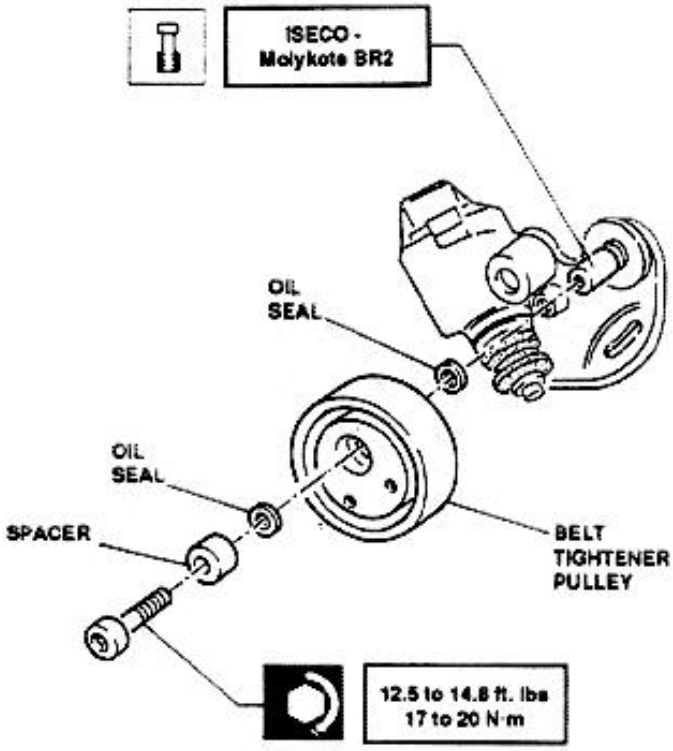
2. Remove belt tightener plate



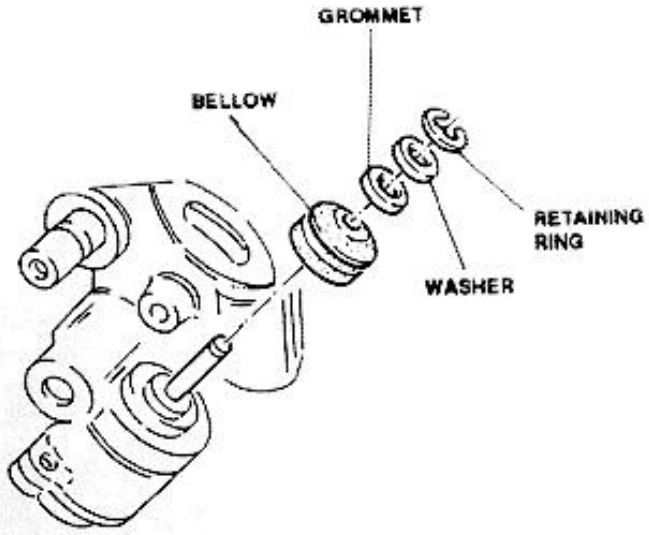
3. Unscrew attachment screw and remove belt tightener pulley.
4. Remove spacer.



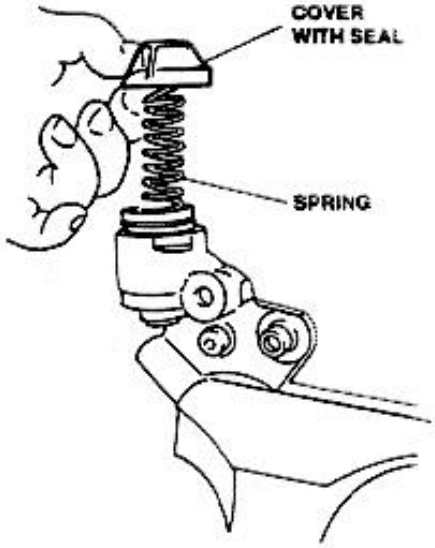
5. Remove oil seals.



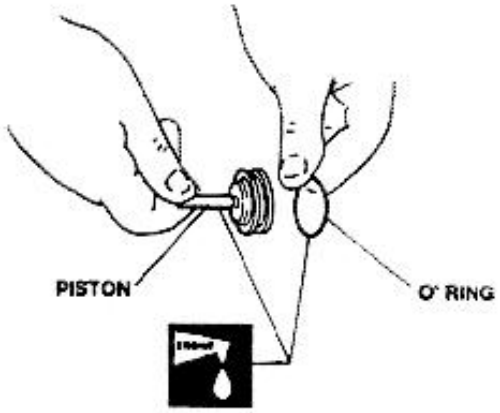
6. Remove retaining ring.
7. Remove washer.
8. Remove grommet.
9. Remove bellow.



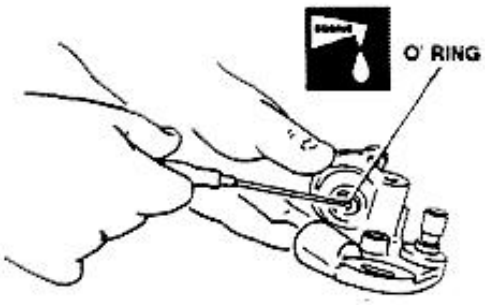
10. Remove cover and relevant seal.
11. Remove spring.



12. Remove piston from tightener body.
13. Remove o'ring.

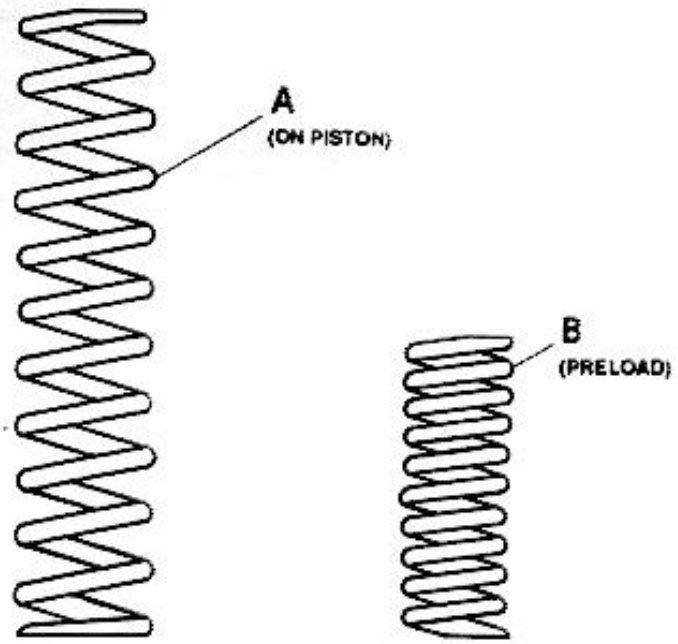


14. Remove o'ring from lower side of tightener body.



15. Carry-out the following inspection of belt tightener:
    a. Examine spring "A" (acting on piston) and spring "B" (preloading the hydraulic belt tightener) and verify the springs characteristic data conform to the prescribed values.

	Spring A	Spring B
Useful number of turns	12	9
Spring free length	93 mm (3.7 In)	45.5 mm (1.8 In)
Static test load	93.16 N (21 lbs)	98 N (22 lbs)
Loaded spring length	48 mm (1.9 In)	30 mm (1.2 In)

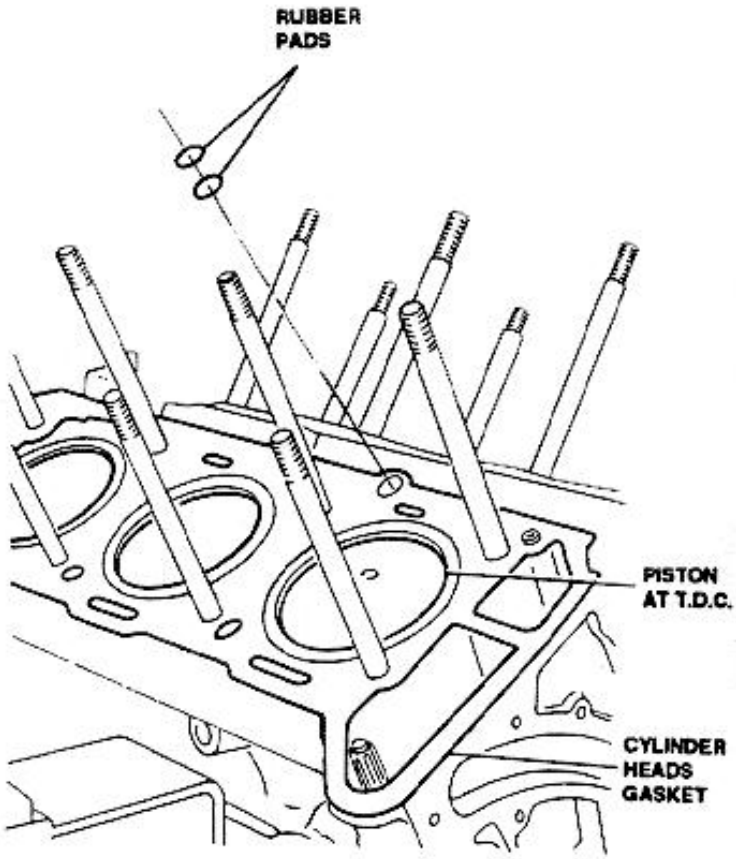


    b. Reassemble hydraulic belt tightener by reversing the order of disassembly procedure.

CAUTION:
It is recommended to replace all seals and o'rings at every overhaul of tightener.

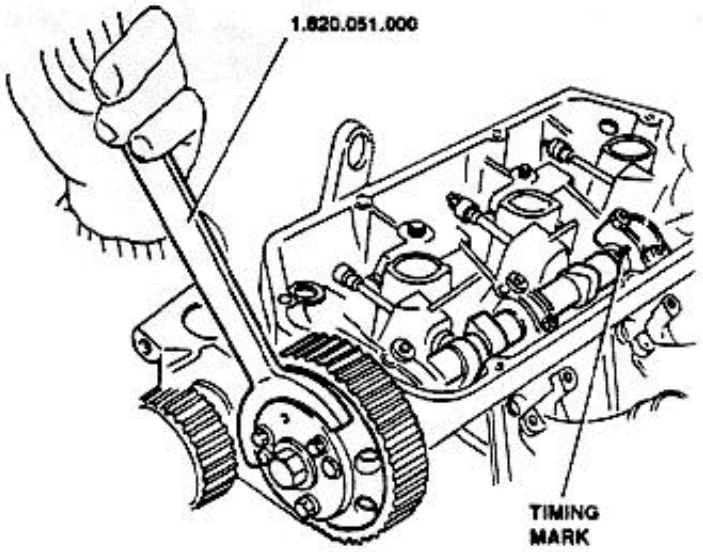
CYLINDER HEADS INSTALLATION

1. Rotate crankshaft as required to bring piston of first cylinder at T.D.C. position.
2. Remove liners fixing tool **1.820.004.000** and supplementary washers **1.820.052.000**.
3. Position cylinder head gaskets.
4. Position rubber pads sealing the oil passages (two for each row of cylinders).

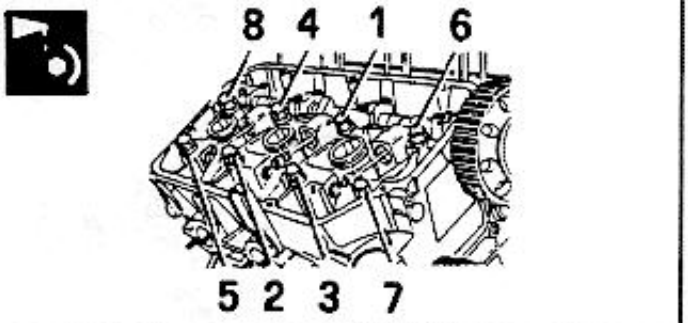


5. Using lever tool **1.820.051.000** rotate camshaft of each cylinder head to align timing marks on camshaft to those on one of the camshaft caps.

NOTE: On right cylinder head the timing mark is located on cap No. 3, while on left cylinder head the mark is located on cap No. 7.



6. Install cylinder heads on engine block.
7. Lubricate with engine oil the nuts thread and washers then torque, in two or three stages, the eight nuts attaching each cylinder head following instructions in the table below.



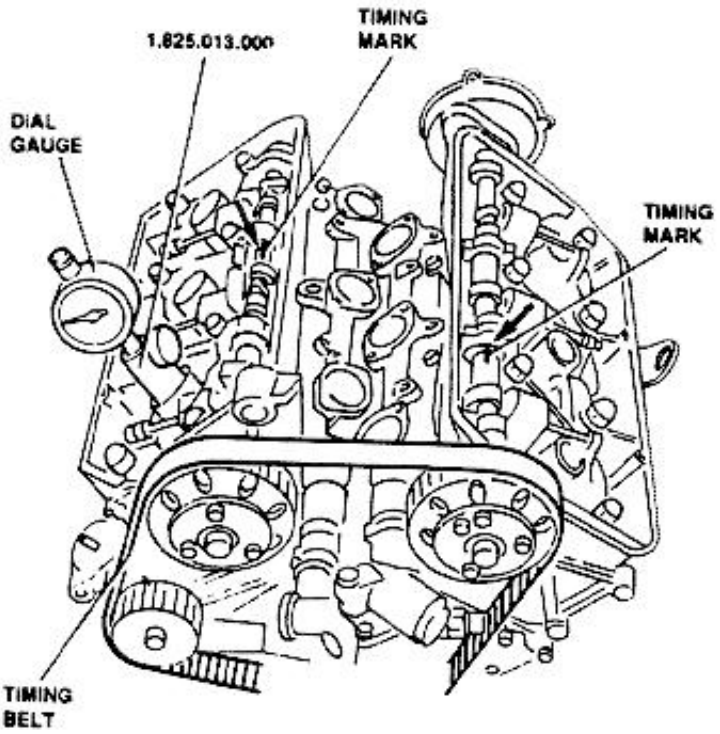
- At reassembly, tighten gradually, in the sequence shown above to the torque of :	65.3 to 72.2 ft lbs 88.5 to 97.8 Nm
- After about 650 miles, and with cold engine, loosen nuts of one turn in the sequence shown above, wipe nuts with engine oil and tighten in the sequence shown above to the torque of:	72.2 to 79.8 ft lbs 97.8 to108.2 Nm

TIMING BELT INSTALLATION AND ENGINE TIMING CHECK

1. Install tool **1.825.013.000** complete of dial gauge into seat of first cylinder spark plug.
2. Rotate crankshaft in normal operating direction and bring piston of first cylinder to exact T.D.C. in firing phase (both valves closed).
3. Verify the alignment of marks engraved on camshafts to those on relevant caps.

CAUTION:
During timing belt installation, check that above mentioned alignment is maintained.

4. Fit timing belt, while keeping in tension the stretched arms, and observing the following order:
   1°- Crankshaft toothed pulley.
   2°- Left cylinder head toothed pulley.
   3°- Right cylinder head toothed pulley.
   4°- Oil pump drive toothed pulley.
   5°- Hydraulic belt tightener pulley.



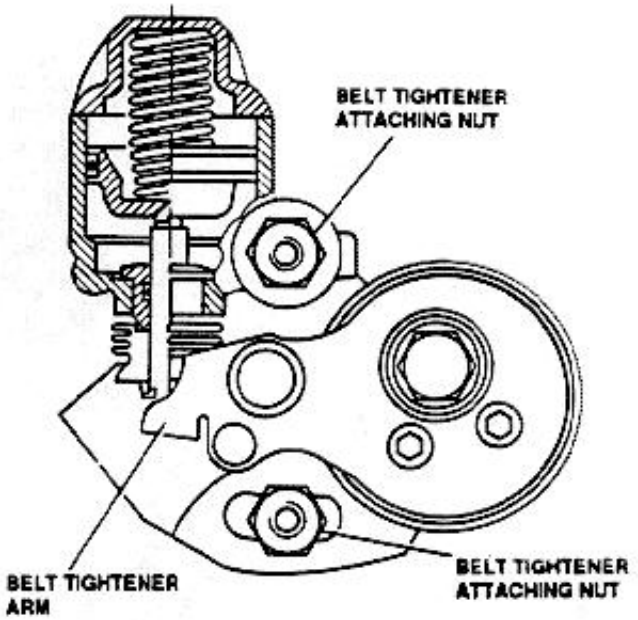
CAUTION:
Prevent oils and solvents from contacting the belt: the belt elasticity could be affected and cause slipping of teeth.

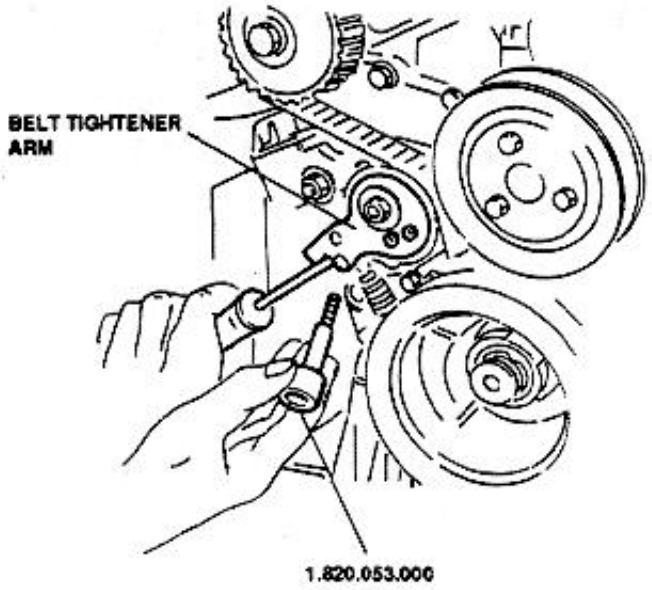
5. Loosen belt tightener attaching nuts.
6. Settle the timing belt by slightly rotating the crankshaft in normal sense of rotation.
7. Rotate crankshaft in normal sense of rotation for two or three complete revolutions, having care to maintain always in tension the drive arms of the toothed belt.

NOTE: **Never turn the crankshaft in direction opposite to normal sense of rotation.**

8. Keep the belt under tension, push tightener pulley against the belt and lock the two previously loosened attaching nuts .
9. Slightly lift belt tightener arm and remove tool **1.820.053.000**.
10. Return piston of first cylinder to T.D.C. in firing phase and check alignment of all timing marks.

NOTE: **If proper alignment of all timing marks is not obtained, check for proper installation of timing belt and, if required, proceed to engine timing adjustment (Refer to Group 00).**

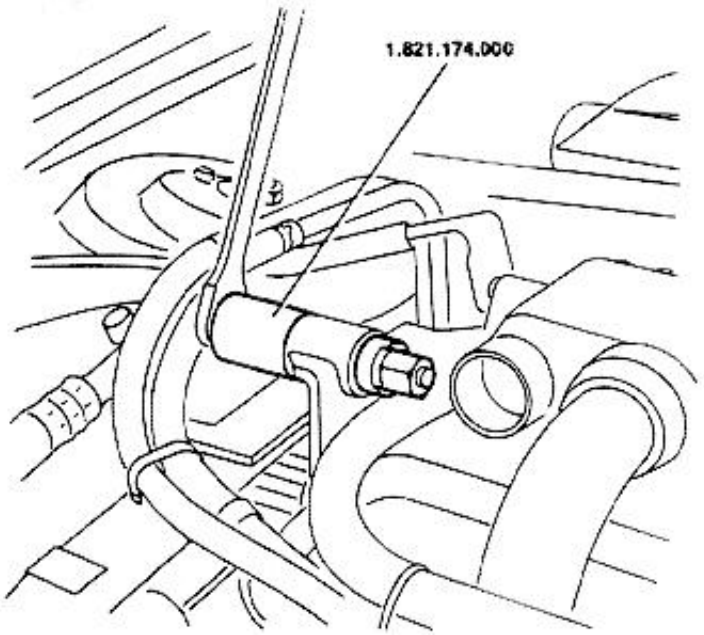




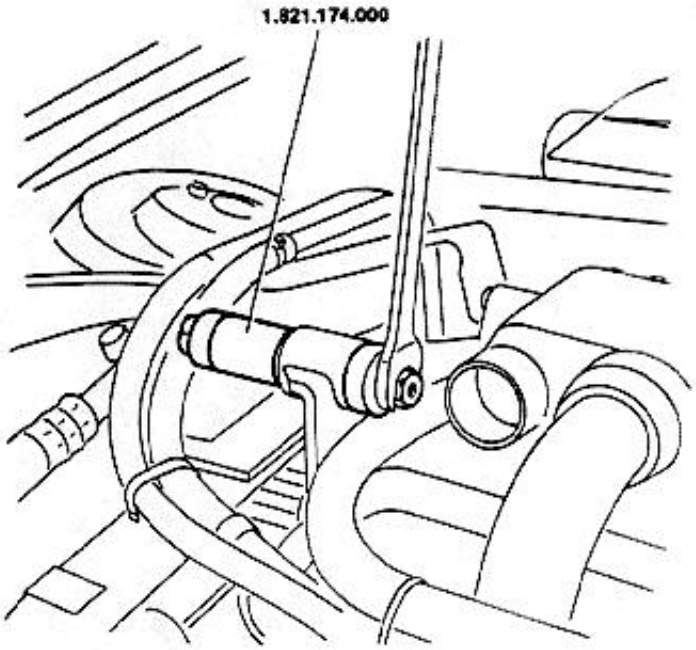
ENGINE MOUNT BRACKET ELASTIC BUSHING REPLACEMENT

During final phase of engine reassembly, check that bushing in upper engine mount bracket is in proper condition, and free of distortion or wear: if damaged or worn replace bushing as follows:

1. Remove upper engine link rod.
2. Remove air intake duct of fourth cylinder.
3. Using tool **1.821.174.000**, remove elastic bushing from the upper engine mount bracket.

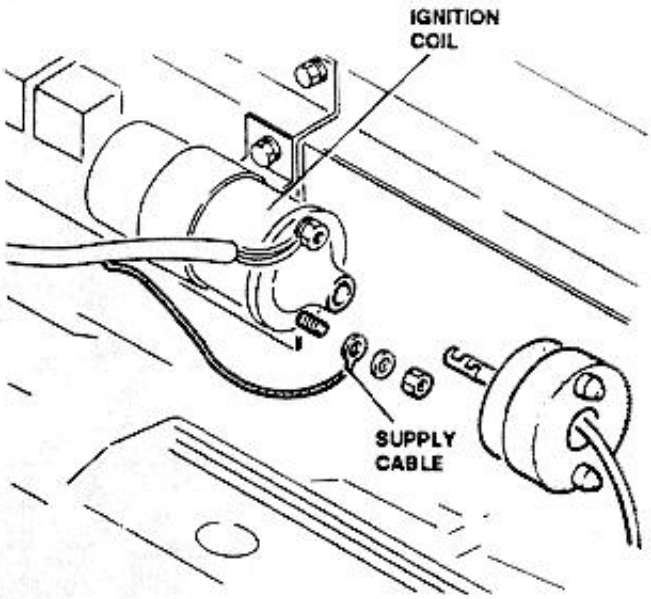


4. Insert new bushing using tool **1.821.174.000.**

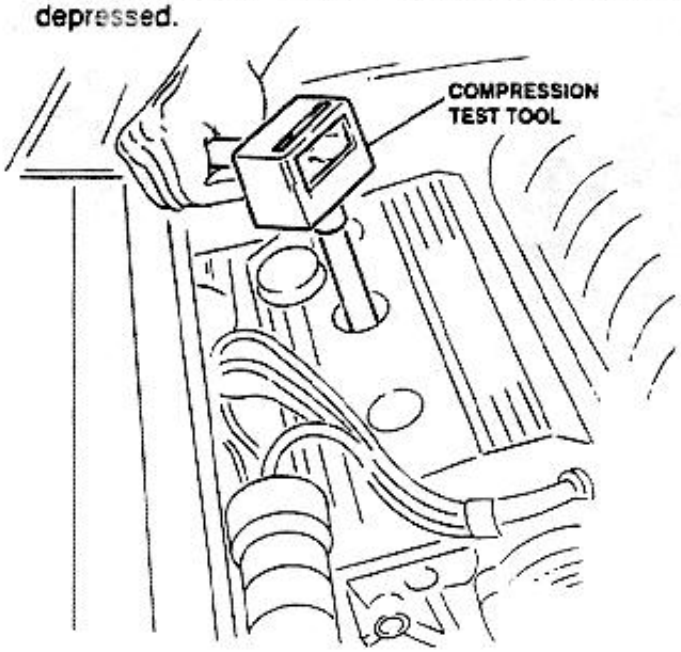


CYLINDERS COMPRESSION TEST

1. Start engine and let it run until normal operating temperature is reached.
2. Remove spark plugs.
3. Disconnect ignition coil supply cable (+15).
4. Disconnect fuel pump relay.



5. Insert compression test tool in the seat of a spark plug.
6. Crank the engine for a few revolutions by means of the starter motor with the accelerator pedal fully depressed.



CAUTION:
Verify for absence of leaks from tool fitting.

7. Repeat the test on the remaining cylinders, resetting the tool writing tip at each test

NOTE: Whenever an excessive difference is noted between pressure readings on the cylinders, troubleshoot the fault by checking the sealing of valves and eventually of pistons and pistons rings.

AT THE COMPLETION OF ENGINE REASSEMBLY, it is always advisable to carry-out the above described CYLINDER COMPRESSION TEST in addition to ALL CHECKS AND INSPECTIONS ESTABLISHED FOR ORDINARY MAINTENANCE (refer to Group 00) and checks relevant to the FUEL SUPPLY SYSTEM (refer to Group 04) and COOLING SYSTEM (refer to Group 07).

ELECTRIC COMPONENTS CHECKS AND INSPECTIONS (located in engine compartment)

- **Engine oil pressure meter.**
- **Minimum engine oil pressure warning lamp sensor.**
- **Minimum engine oil level warning lamp sensor.**
- **Odometer and speedometer pulse generator.**

For the remaining electric components and sensors located in engine compartment refer to the detailed information contained in the specific Groups. e.g.:

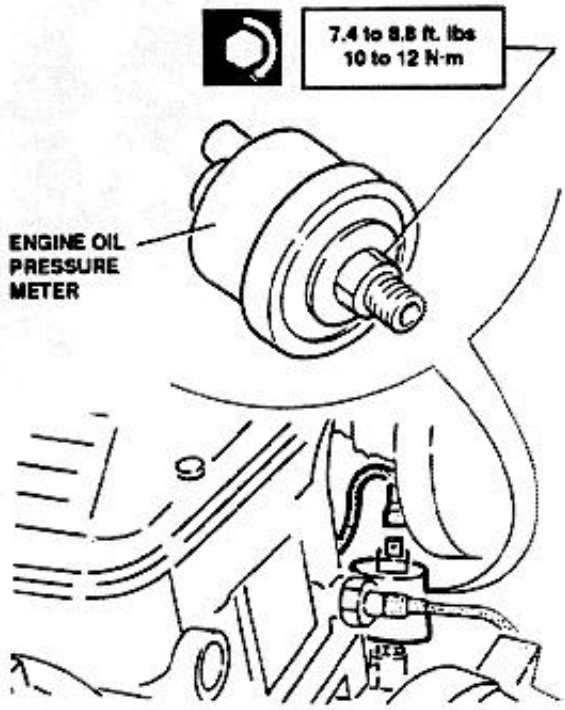
- Motronic system sensors: refer to **Group 04**.
- Automatic transmission oil temperature sensor: refer to **Group 16.**
- A.B.S. hydraulic control unit: refer to **Group 22.**
- Alternator, engine starter, etc.: refer to **Group 05.**

Etc.

ENGINE OIL PRESSURE METER

1. Check calibration of oil pressure meter. Replace meter if correct values are not met.

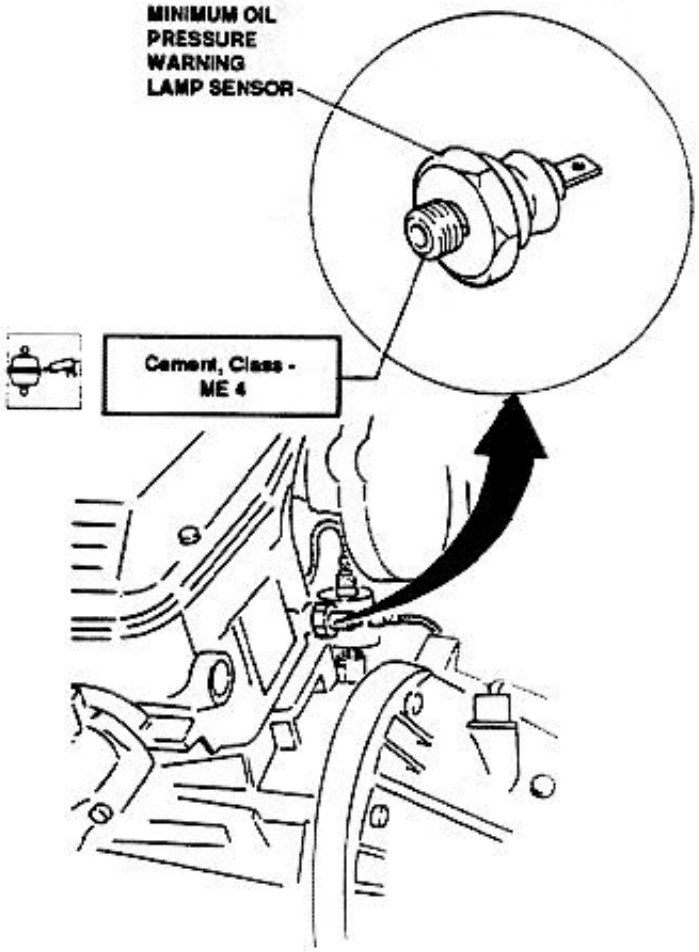
Pressure	Resistence
bar (p.s.i.)	Ω
0	290 to 320
0.4 (5.8)	270 to 300
4 (58)	103 to 133
8 (116)	0 to 25



MINIMUM ENGINE OIL PRESSURE WARNING LAMP SENSOR

1. Check calibration of minimum engine oil pressure warning lamp sensor. Replace sensor if correct values are not met.

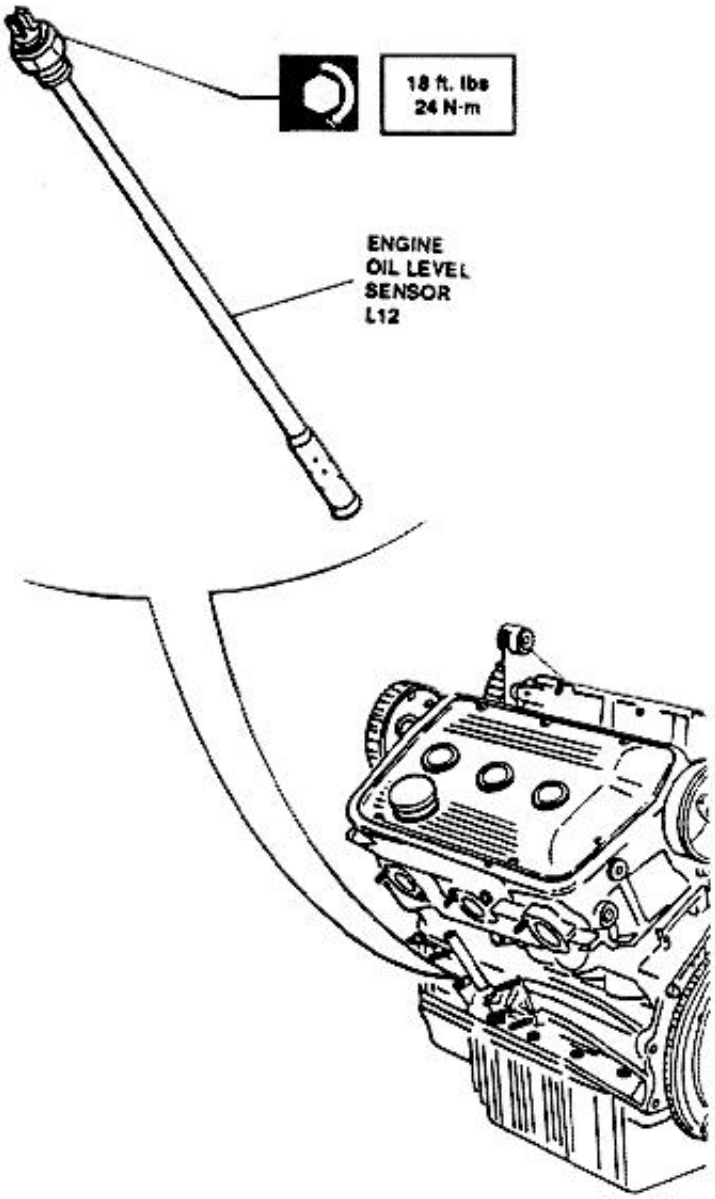
Pressure:	kPa	p.s.i.
test	14.7 to 44.1	2.13 to 6.39
allowance	589	85.42
allowable peak during cold start	981	142.27



MINIMUM ENGINE OIL LEVEL WARNING LAMP SENSOR

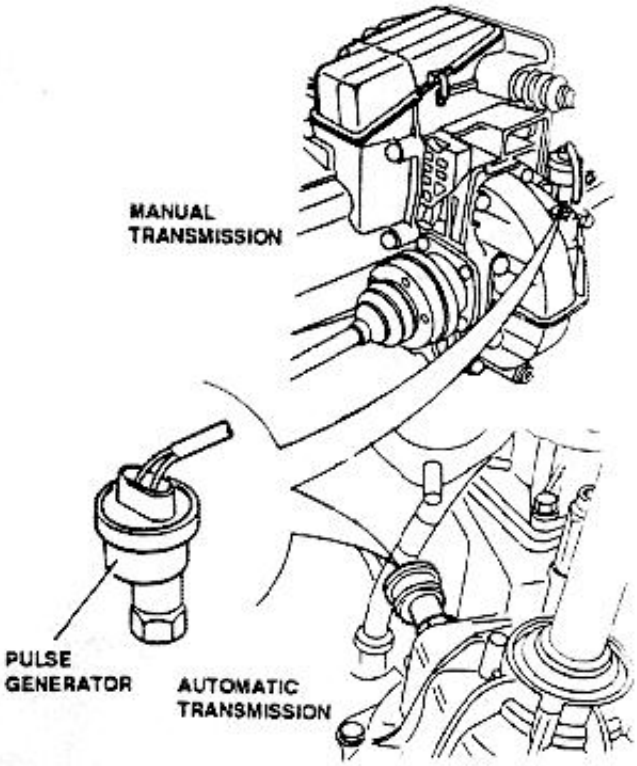
1. Check calibration of engine oil level sensor. Replace sensor if correct values are not met.

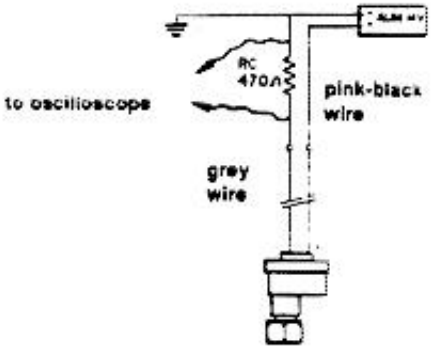
Circuit resistance
12 Ω ± 5%

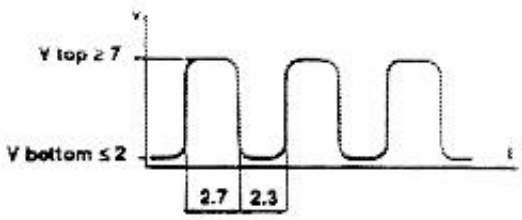


ODOMETER AND SPEEDOMETER PULSE GENERATOR

1. Check calibration of odometer and speedometer pulse generator. Replace pulse generator if correct values are not met.
2. With gearbox to neutral and engine running, check that no tachometer signals are emitted .
3. Connect pulse generator as shown in the illustration and check, with an oscilloscope across the load resistance, that the wave form is the specified one at 3000 r.p.m.







"ON VEHICLE" OPERATIONS

The preceding chapter includes and illustrates the complete engine bench overhaul.
However, some of these operations can be carried-out **"on vehicle"**, without removal of the engine from the vehicle.

NOTE: **However, the decision of removing the engine or perform the required activity "on vehicle" is left to the operator's experience.**

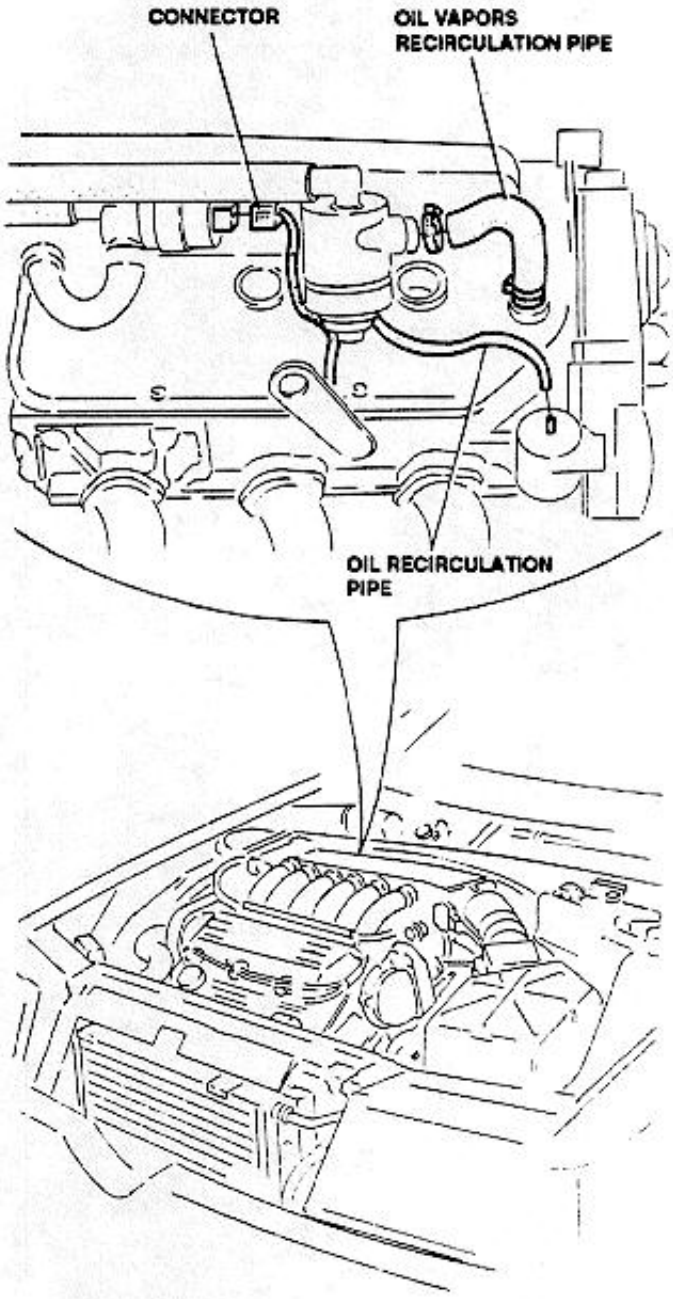
Among the most frequent operations, it is possible to carry-out the cylinder heads **removal/installation** directly "on vehicle" as indicated below.
Other operations as the oil cup removal/installation are not feasible "on vehicle", and require engine removal.

NOTE: **Refer to Group 00 for further details about the most frequent maintenance operations which can be carried-out with engine installed on the vehicle.**

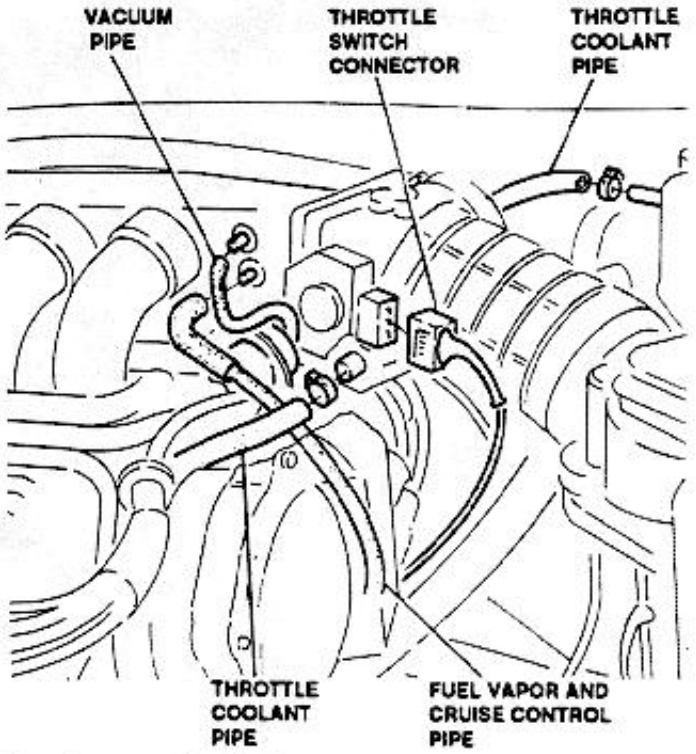
CYLINDER HEADS REMOVAL AND INSTALLATION

NOTE: **The operations described in the following procedure are referred only to right cylinder head (1st, 2nd and 3rd cylinders). Removal and installation of the left cylinder head do not present substantial differences from engine bench DISASSEMBLY and REASSEMBLY procedures.**

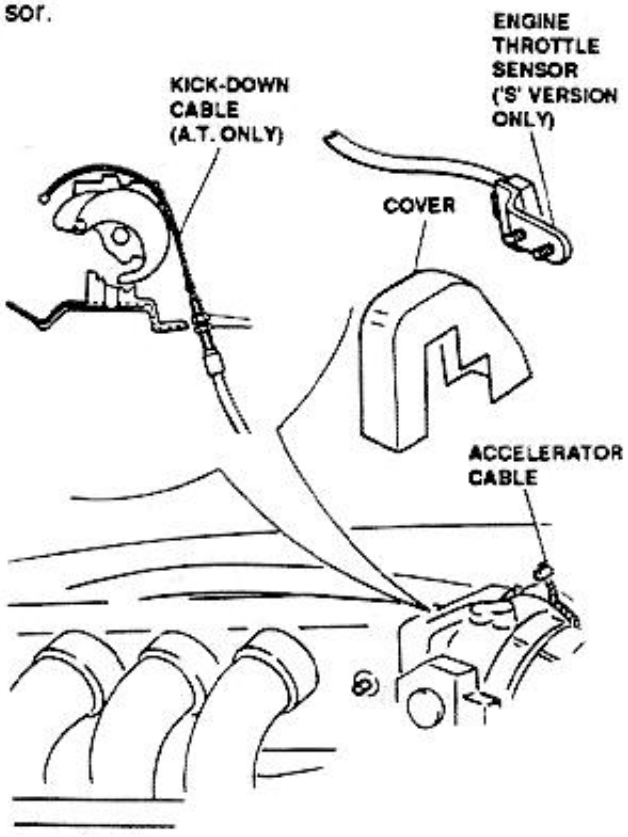
1. Disconnect battery (-) lead.
2. Disconnect connector from constant idle speed actuator.
3. Disconnect oil vapors recirculation pipe and idle speed actuator.
4. Disconnect oil recirculation pipe.



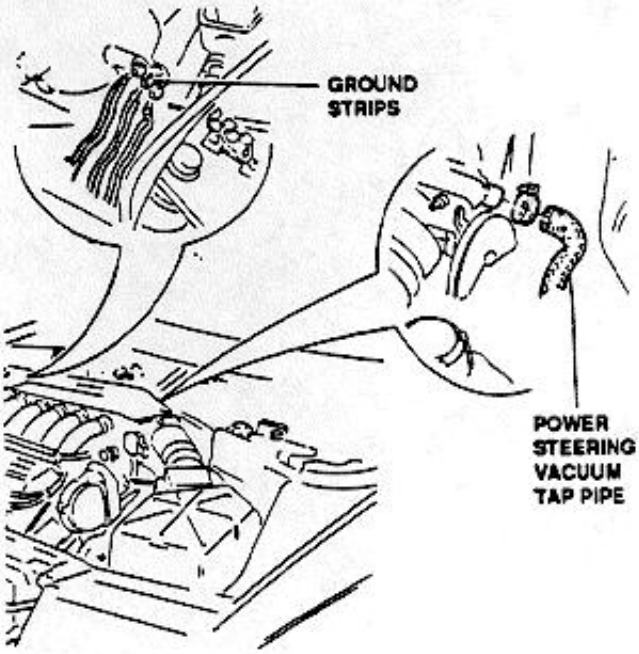
5. Disconnect connector from minimum and maximum throttle opening switch.
6. Disconnect vacuum pipe for fuel pressure regulator and pipe from the fuel vapor solenoid valve and cruise control actuator.
7. Disconnect coolant inlet and outlet pipes from throttle body.



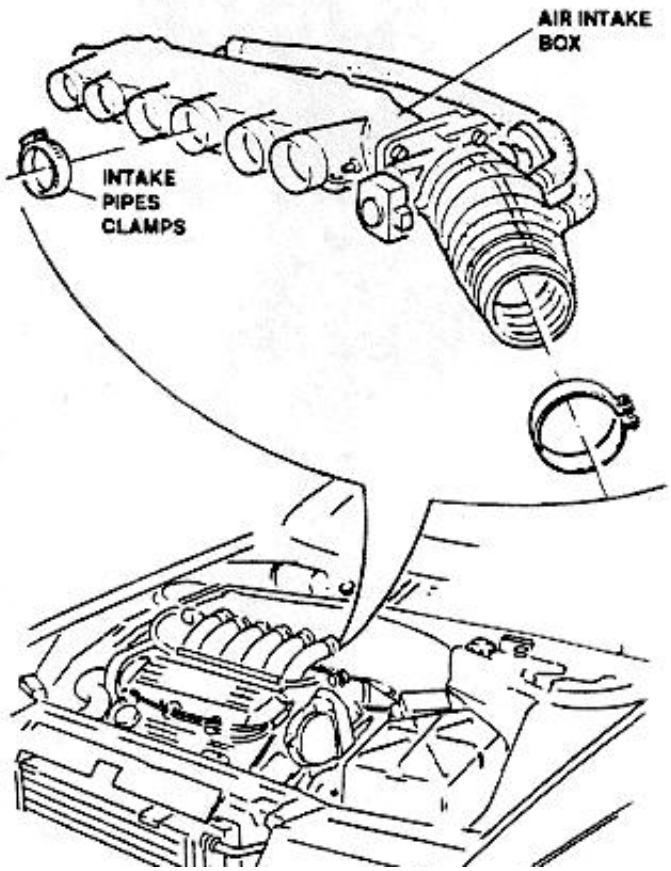
8. Remove throttle body cover.
9. Disconnect accelerator cable.
10. **On vehicles equipped with automatic transmission**: disconnect the "Kick-down" cable.
11. **On "S" version only**: remove engine throttle sensor.



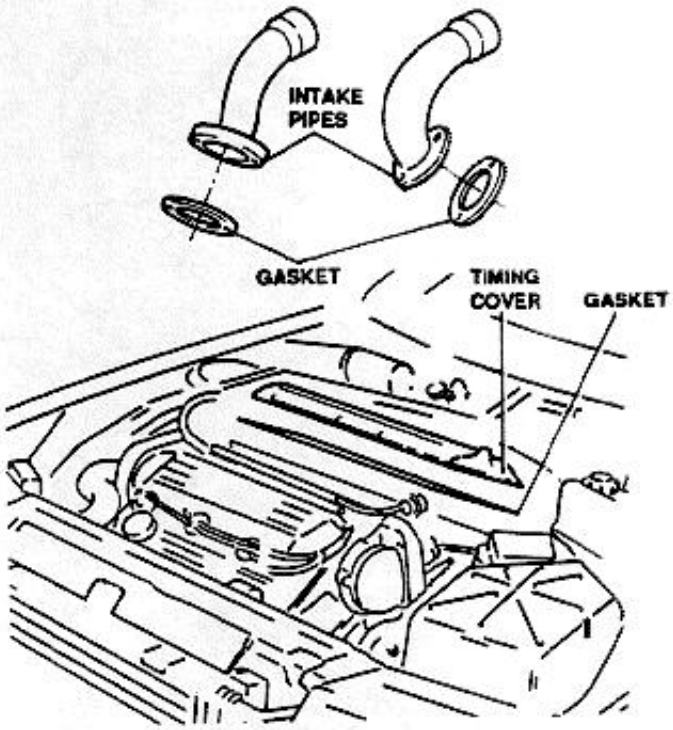
12. Disconnect ground strips.
13. Disconnect power steering vacuum tap pipe.



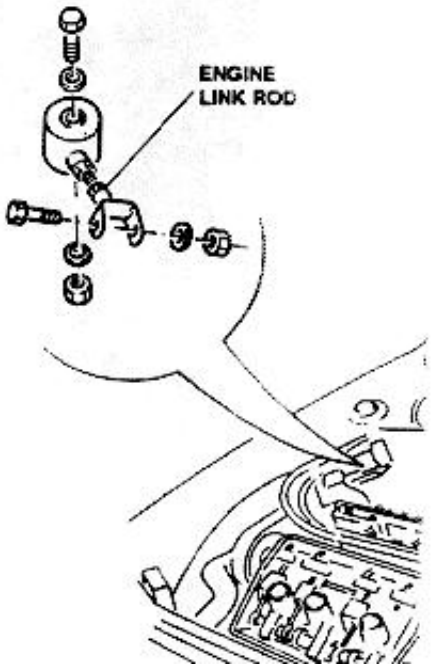
14. Remove three attaching screws and loosen clamps on ducts and intake pipes, them remove the air intake box.



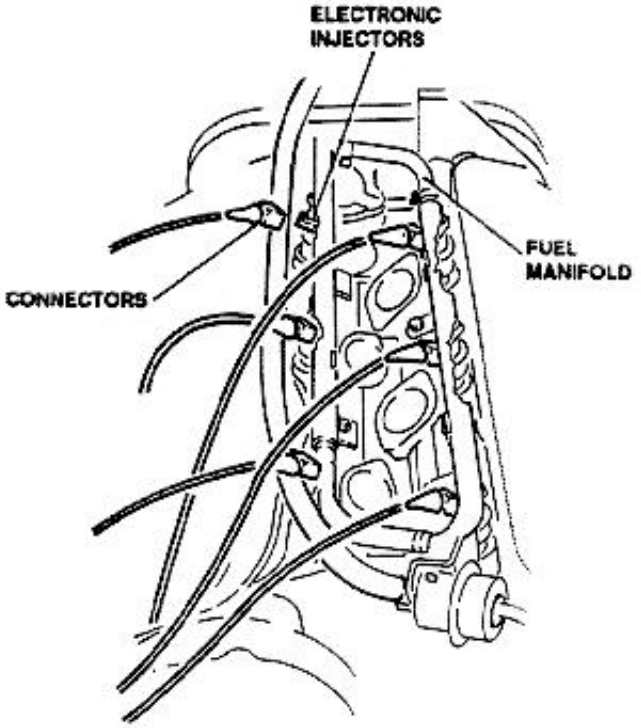
15. Disconnect spark plug leads from 1st, 2nd and 3rd cylinders.
16. Remove the six air intake pipes and relevant gaskets.
17. Remove timing cover and relevant gasket.



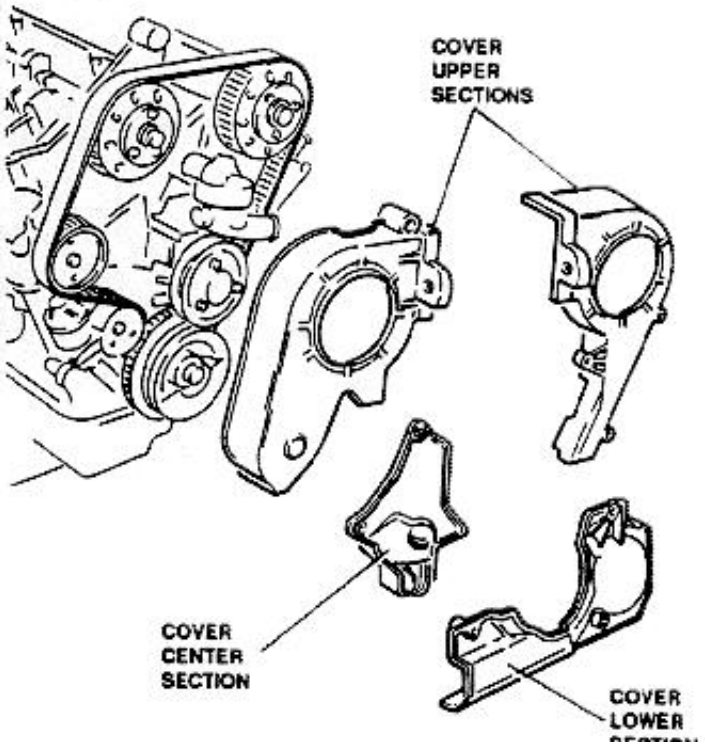
18. Remove upper engine link rod.



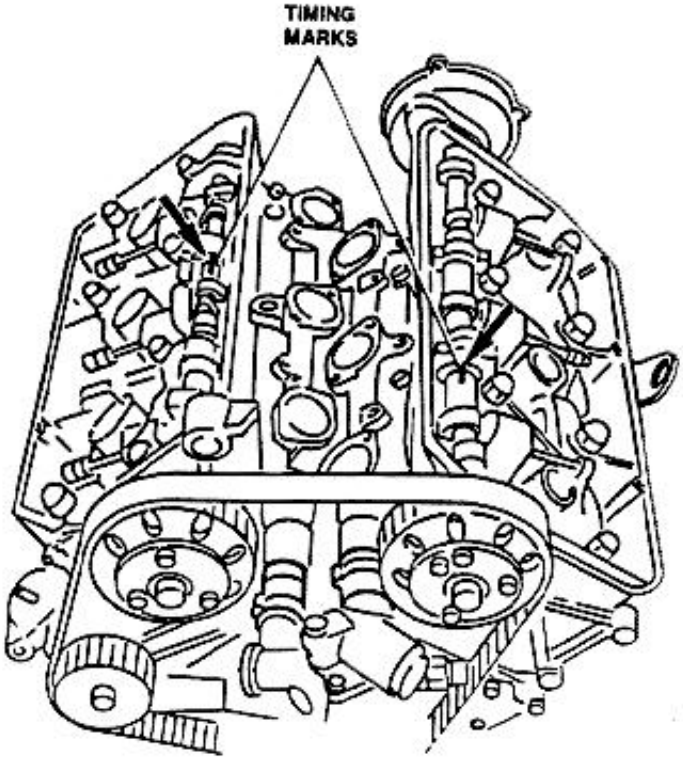
19. Disconnect connector from electronic injectors and remove fuel manifold complete of fuel injectors without disconnecting fuel delivery and return pipes.



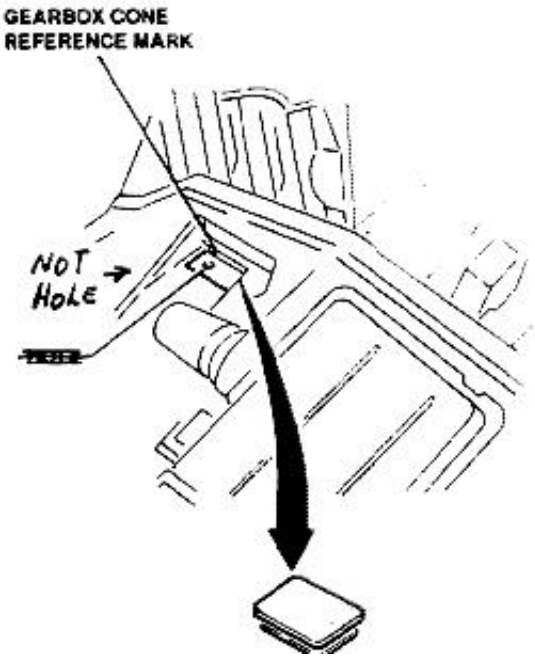
20. Clean spark plug housings, remove spark plugs and cap holes to prevent entry of foreign matter.
21. Remove upper section of timing belt cover.
22. Remove center and lower section of timing belt cover.



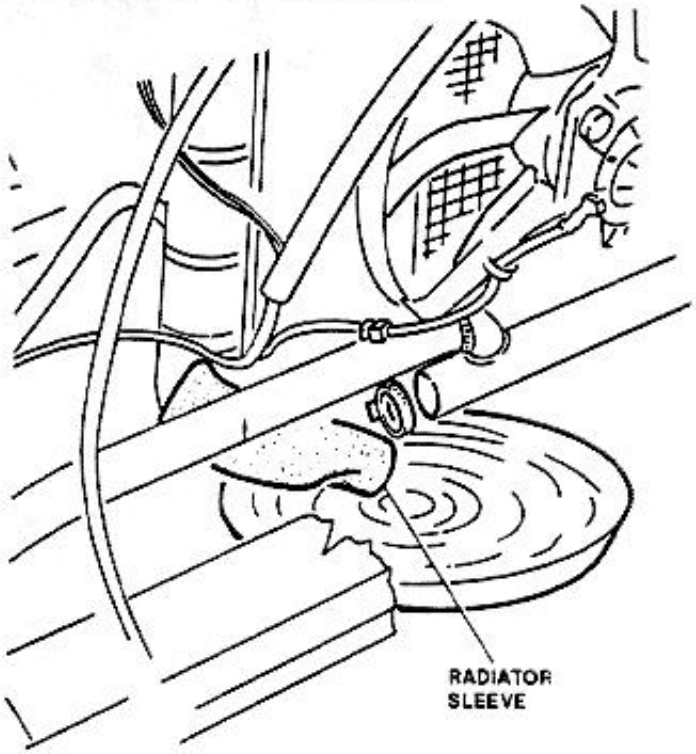
23. Rotate crankshaft and align timing marks on the camshaft to marks on relevant caps.



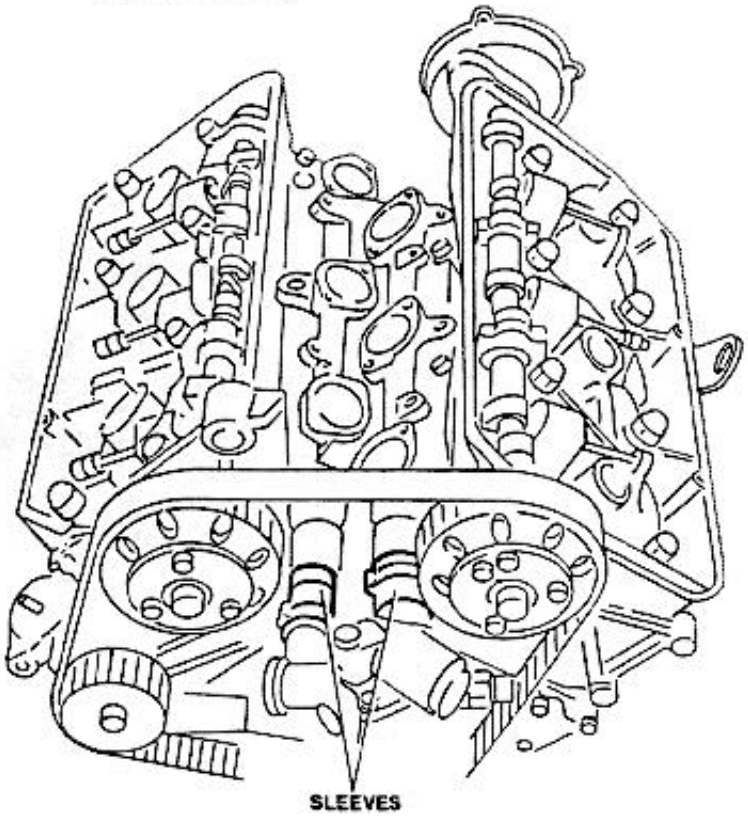
24. In the position determined at step 23. above (cylinder No. 1 at T.D.C. in firing phase), the SCRIBED LINE on the flywheel and the mark engraved on the gearbox cone must be aligned.



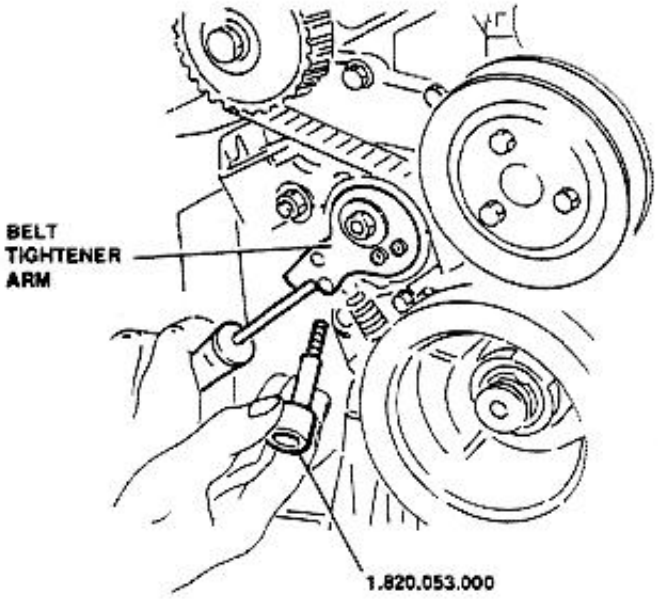
25. Remove header tank cap.
26. Disconnect radiator outlet sleeve and drain engine coolant in a suitable container.



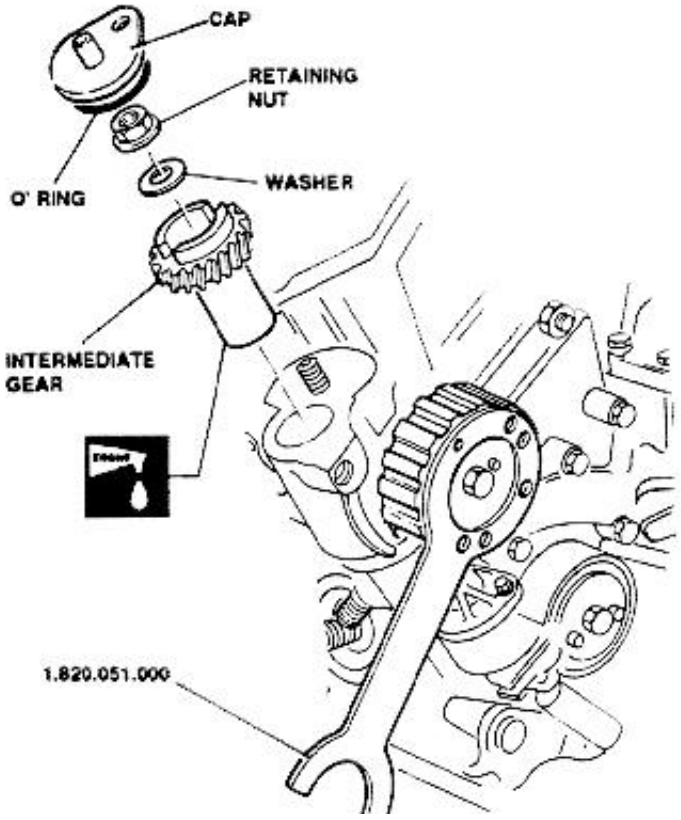
27. Disconnect sleeves connecting cylinder heads to thermostat unit.



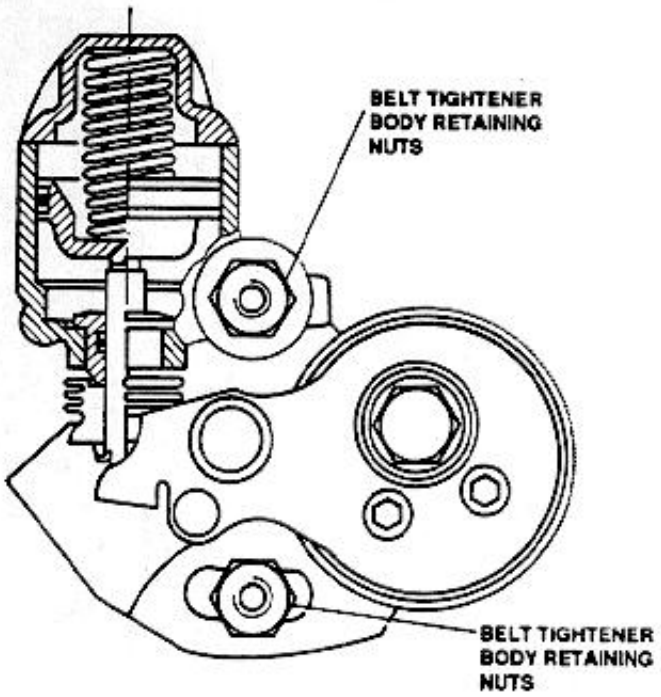
28. Lift hydraulic belt tightener arm and lock the tightener with tool **1.820.053.000**.



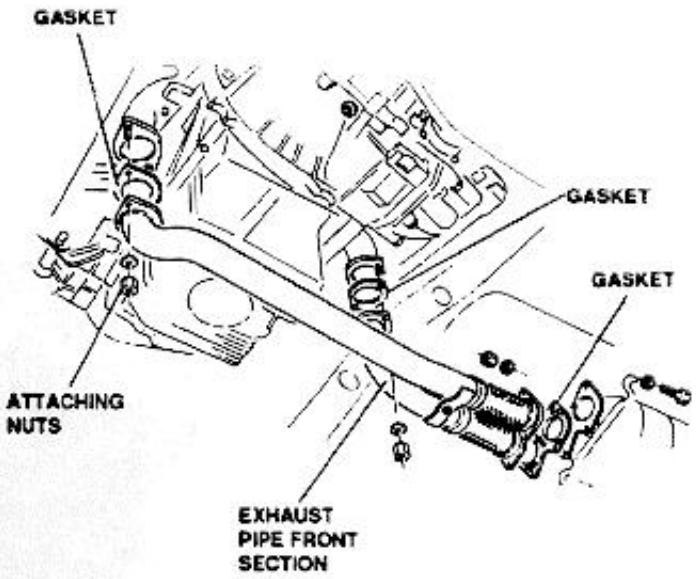
29. Remove cap and relevant o'ring.
30. Prevent rotation of oil pump pulley using tool **1.820.051.000**.
31. Unscrew oil pump intermediate gear retaining nut.
32. Remove washer.
33. Remove intermediate gear.



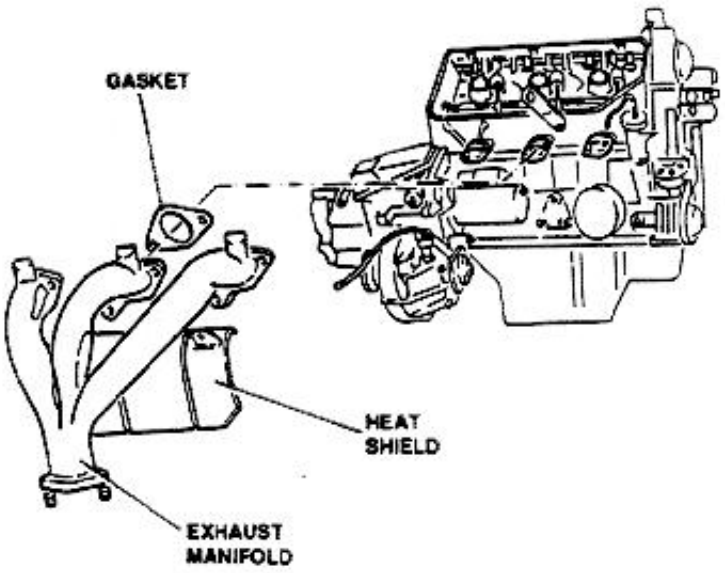
34. Loosen two nuts fixing belt tightener body to engine block.
35. Rotate hydraulic belt tightener upwards and lock in this position by tightening nuts loosened at step 34. above.
36. Remove toothed belt from camshaft drive pulleys.



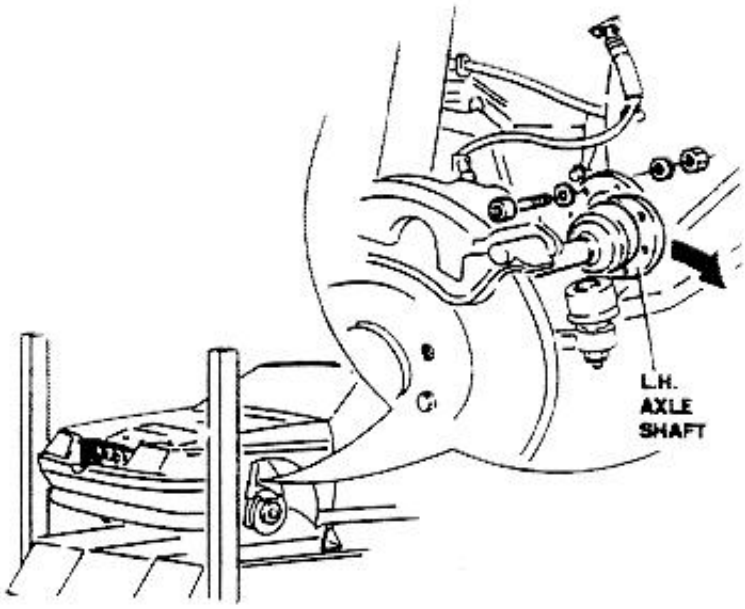
37. Remove front section of exhaust pipes.
38. Remove gaskets.



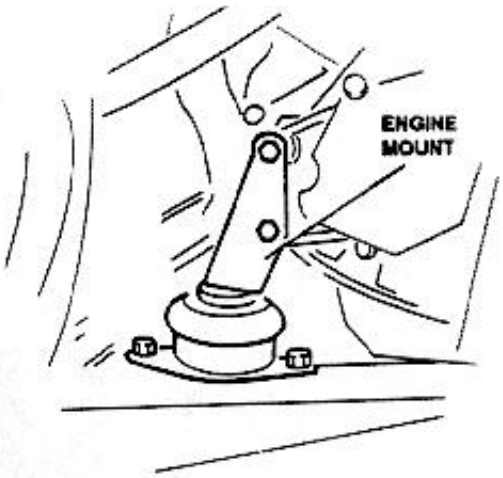
39. Remove exhaust manifold.
40. Remove exhaust manifold gaskets.
41. Remove engine starter heat shield.



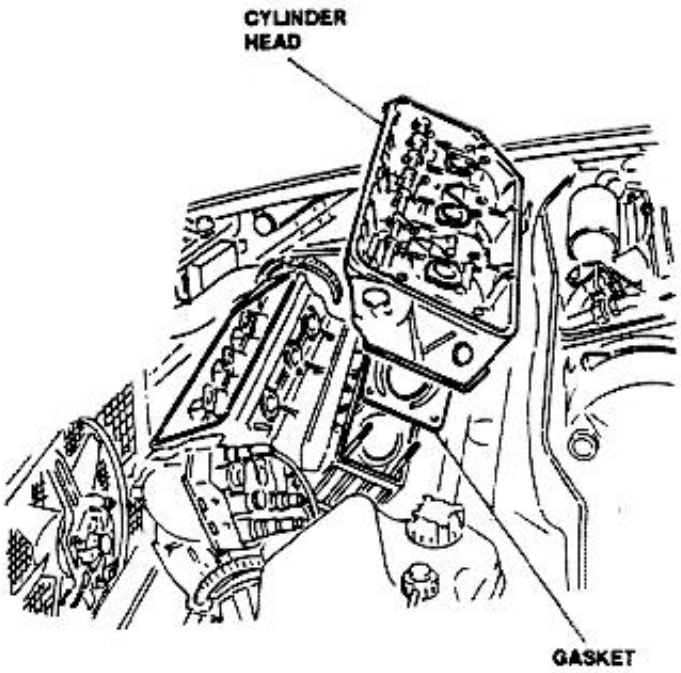
42. Remove left front wheel.
43. Disconnect left axle shaft and move it rearwards so that it will not hamper the following of operations.



44. Disconnect engine mount on gearbox side after a suitable hydraulic jack has been placed below the oil sump.



45. Carefully remove the complete engine mount on gearbox side, and tilt the engine until the gearbox cone comes in contact with the auxiliary frame.
46. Remove right cylinder head and relevant gasket.



TECHNICAL CHARACTERISTICS AND SPECIFICATIONS

All technical, dimensional, checks and inspections characteristics and specifications relevant to 3.0 6V engine are presented below.
The same data have been included in the previously presented repair procedures, and have been synthetically enlarged herein with other useful data necessary for the complete inspection of the engine and relevant units.
The order in which the components are presented is that of overhauled engines reassembly order.

ENGINE SPECIFICATIONS

		164 - 164 "L"	164 "S"
Type		Otto cycle, 4-stroke	
Cylinder numbers and arrangement		6, 60°V	
Cylinder numbering and running direction		R.H. HEAD ①②③ L.H. HEAD ④⑤⑥	
Bore-Stroke Displacement	mm (in) cm³ (cu.in)	93-72.6 (3.66-2.86) 2959 (180.6)	
Combustion chamber volume	cm³ (cu.in)	54.8 (3.3)	
Compression ratio		9.5:1	10:1
Maximum power output (HP - SAE)	HP	183 at 5600 rpm	200 at 5800 rpm
Maximum torque (HP - SAE)	ft.lbs (Nm)	191 (259) at 4400 rpm	195 (265) at 4500 rpm
Mean effective piston speed (1)	m/s (ft/s)	10.04 (46.03)	.....
Engine oil pressure (2) at 800-900 rpm at 5000 rpm	kPa (psi)	80 (11.6) 450 (65.2)	

(1) At maximum output rpm

(2) Check with oil at operating temperature (90°C - 194°F)

ENGINE BLOCK

ENGINE BLOCK

MAIN BEARING DIAMETER	63.657 to 63.676 mm	2.5062 to 2.5069 in
TAIL BEARING SHOULDER LENGTH	26.450 to 26.500 mm	1.0413 to 1.0433 in
PISTON COOLING OIL SPRAYING VALVE OPENING PRESSURE	2.25 to 2.75 kPa	32.63 to 39.87 psi

CRANKSHAFT

MAIN JOURNAL DIAMETER	GREEN	59.961 to 59.967 mm	2.3607 to 2.3609 in
	BLUE	59.967 to 59.973 mm	2.3609 to 2.3611 in
	RED	59.973 to 59.979 mm	2.3611 to 2.3614 in
ROD JOURNAL DIAMETER	RED	51.990 to 52.000 mm	2.0468 to 2.0472 in
	LIGHT BLUE	51.980 to 51.990 mm	2.0465 to 2.0468 in
TAIL JOURNAL LENGTH		31.300 to 31.335 mm	1.2323 to 1.2337 in
MAX. OVALIZATION FOR MAIN AND ROD JOURNAL		0.004 mm	0.0002 in
MAX. TAPER ERROR FOR MAIN AND ROD JOURNAL		0.010 mm	0.0004 in
MAX PARALLELISM ERROR BETWEEN MAIN AND ROD JOURNAL		0.015 mm	0.0006 in
MAX. ECCENTRICITY BETWEEN MAIN JOURNALS		0.040 mm	0.0016 in
MAX. DEVIATION BETWEEN AXES OF CRANK AND AXES OF CRANKPINS		0.300 mm	0.0118 in

MAIN BEARING HALVES

MAIN HALF BEARING THICKNESS	GREEN	1.8420 to 1.8465 mm	0.07252 to 0.07270 in
	BLUE	1.8375 to 1.8420 mm	0.07234 to 0.07252 in
	RED	1.8330 to 1.8375 mm	0.07216 to 0.07234 in
CLEARANCE BETWEEN MAIN BEARING AND MAIN JOURNAL	GREEN	-0.003 to 0.031 mm	-0.00012 to 0.00122 in
	BLUE	0.000 to 0.034 mm	0.0000 to 0.00134 in
	RED	0.003 to 0.037 mm	0.00012 to 0.00146 in

THRUST RING HALVES

THRUST RING HALF THICKNESS	2.310 to 2.360 mm	0.0909 to 0.0929 in
CRANKSHAFT AXIAL PLAY	0.080 to 0.265 mm	0.0031 to 0.0104 in

CYLINDER LINER

CYLINDER LINER DIAMETER	Class A (Blue)	92.985 to 92.994 mm	3.6608 to 3.6612 in
	Class B (Pink)	92.995 to 93.004 mm	3.6612 to 3.6616 in
	Class C (Green)	93.005 to 93.014 mm	3.6616 to 3.6620 in
PROTRUSION OF CYLINDER LINER FROM ENGINE BLOCK		0.01 to 0.06 mm	0.0004 to 0.0024 in
LINER OVALIZATION AND TAPER LIMITS		0.01 mm	0.0004 in

OIL PUMP

CAMSHAFT PULLEY HUB BUSHING DIAMETER	32.000 to 32.025 mm	1.2598 to 1.2608 in
CAMSHAFT PULLEY HUB DIAMETER	31.959 to 31.975 mm	1.2582 to 1.2589 in
OIL PUMP PULLEY HUB BUSHING DIAMETER (1)	19.000 to 19.021 mm	0.7480 to 0.7489 in
OIL PUMP PULLEY HUB DIAMETER (1)	18.967 to 18980 mm	0.7467 to 0.7472 in
OIL PUMP DRIVE GEAR HUB BUSHING DIAMETER (REAMING) (1)	19.000 to 19.021 mm	0.7480 to 0.7489 in
OIL PUMP DRIVE GEAR HUB DIAMETER (1)	18.967 to 18.980 mm	0.7467 to 0.7472 in
DIAMETER OF DRIVEN ROTOR SEAT IN PUMP BODY	49.325 to 49.375 mm	1.9419 to 1.9439 in
OIL PUMP DRIVEN ROTOR OUTER DIAMETER	49.100 to 49.155 mm	1.9331 to 1.9352 in

(1) R.H. CYLINDER HEAD ONLY

CLEARANCE BETWEEN DRIVEN ROTOR AND INNER ROTOR (1)	0.040 to 0.290 mm	0.0016 to 0.0114 in
AXIAL PLAY BETWEEN ROTORS AND PUMP BODY PLANE	0.025 to 0.075 mm	0.0010 to 0.0030 in
CLEARANCE BETWEEN OUTER ROTOR AND PUMP BODY	0.170 to 0.275 mm	0.0067 to 0.0108 in
CLEARANCE BETWEEN CAMSHAFT BUSHING AND PULLEY HUB	0.025 to 0.066 mm	0.0010 to 0.0026 in
CLEARANCE BETWEEN OIL PUMP BUSHING AND PULLEY HUB (2)	0.020 to 0.054 mm	0.0008 to 0.0021 in
CLEARANCE BETWEEN OIL PUMP BUSHING AND GEAR HUB (2)	0.020 to 0.054 mm	0.0008 to 0.0021 in

(1) Measure with rotors in position shown in the illustration

(2) R.H. cylinder head only

OIL PRESSURE RELIEF VALVE SPRING

FREE SPRING LENGTH	49.29 mm	1.941 in
LOADED SPRING LENGTH	31.90 mm	1.256 in
TEST LOAD	170 to 176 N	38.2 to 39.6 lbs

HYDRAULIC TIGHTENER SPRING

SPRING "A" (PISTON)	USEFUL NUMBER OF TURNS	12	
	FREE SPRING LENGTH	93 mm	3.7 in
	LOADED SPRING LENGTH	48 mm	1.9 in
	STATIC TEST LOAD	93.16 N	21 lbs
SPRING "B" (PRE-LOAD)	USEFUL NUMBER OF TURNS	9	
	FREE SPRING LENGTH	45.5 mm	1.8 in
	LOADED SPRING LENGTH	30 mm	1.2 in

	STATIC TEST LOAD	98 N	22 lbs

FLYWHEEL

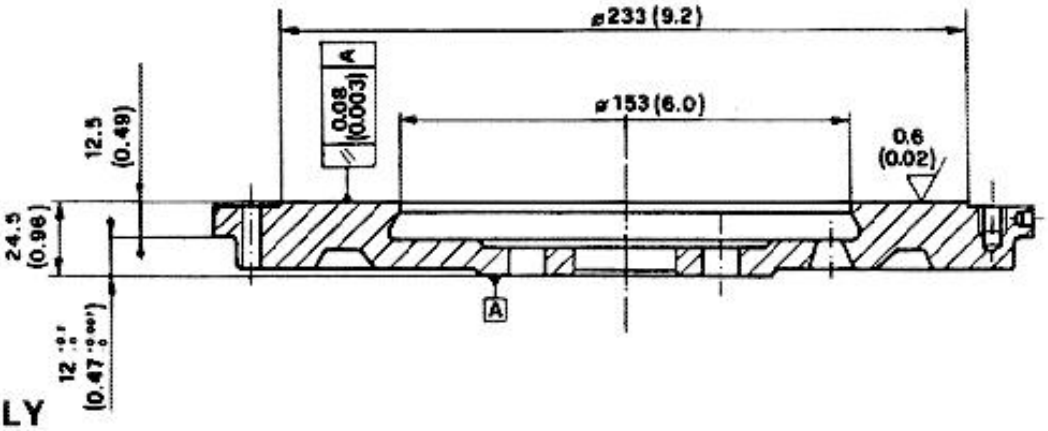
CENTER BUSHING INNER DIAMETER	REAMING	35.000 ± 0.025 mm	1.3780 ± 0.0010

FLYWHEEL RING GEAR INSTALLATION HEATING TEMPERATURE	120 to 140°C	248 to 284°F

FLYWHEEL GRINDING DIMENSIONS AND WORKING TOLERANCES

Dimensions: mm (in)

▽= Roughness: (μm) (μ in)
//= Parallelism: mm (in)



PISTON AND ROD ASSEMBLY

PISTON

PISTON DIAMETER (1)	Class A (BLUE)	92.925 to 92.935 mm	3.6584 to 3.6588 in
	Class B (PINK)	92.935 to 92.945 mm	3.6588 to 3.6592 in
	Class C (GREEN)	92.945 to 92.955 mm	3.6592 to 3.6596 in
1st RING GROOVE HEIGHT		1.525 to 1.545 mm	0.0600 to 0.0608 in
2nd RING GROOVE HEIGHT		1.525 to 1.545 mm	0.0600 to 0.0608 in
OIL SCRAPER RING GROOVE HEIGHT		3.515 to 3.535 mm	0.1384 to 0.1392 in
GUDGEON PIN HOLE DIAMETER	BLACK	22.003 to 22.006 mm	0.8663 to 0.8664 in
	WHITE	22.006 to 22.009 mm	0.8664 to 0.8665 in

(1) Measure perpendicularly to piston pin hole and at 14 mm (0.55 in) from lower edge

CLEARANCE BETWEEN CYLINDER AND PISTON	0.050 to 0.069 mm	0.0020 to 0.0027 in

WEIGHT DIFFERENCE BETWEEN PISTONS	≤4g	≤0.15 oz.

PISTON RINGS

RING THICKNESS	1st RING	1.478 to 1.490 mm	0.0581 to 0.0586 in
	2nd RING	1.478 to 1.490 mm	0.0582 to 0.0587 in
	OIL SCRAPER RING	3.478 to 3.490 mm	0.1369 to 0.1374 in
RING GAP (1)	1st RING	0.40 to 0.65 mm	0.016 to 0.026 in
	2nd RING	0.40 to 0.65 mm	0.016 to 0.026 in
	OIL SCRAPER RING	0.3 to 0.6 mm	0.012 to 0.023 in

(1) Measured in checking fixture or in cylinder liner

AXIAL PLAY BETWEEN SEATINGS AND PISTON RINGS	1st RING	0.035 to 0.067 mm	0.0014 to 0.0026 in
	2nd RING	0.035 to 0.067 mm	0.0014 to 0.0026 in
	OIL SCRAPER RING	0.025 to 0.057 mm	0.0010 to 0.0022 in

GUDGEON PIN

GUDGEON PIN OUTER DIAMETER	BLACK	21.994 to 21.997 mm	0.8659 to 0.8660 in
	WHITE	21.997 to 22.000 mm	0.8660 to 0.8661 in
CLEARANCE BETWEEN PISTON HOLE AND GUDGEON PIN	BLACK	0.006 to 0.012 mm	0.0002 to 0.0005 in
	WHITE	0.006 to 0.012 mm	0.0002 to 0.0005 in

ROD

ROD SMALL END BUSHING HOLE DIAMETER		22.005 to 22.015 mm	0.8663 to 0.8667 in
ROD BIG END INNER DIAMETER		55.511 to 55.524 mm	2.1855 to 2.1860 in
WEIGHT DIFFERENCE BETWEEN RODS		≤2g	≤0.07 oz.
CLEARANCE BETWEEN SMALL END BUSHING AND GUDGEON	BLACK	0.008 to 0.021 mm	0.0003 to 0.0008 in

PIN	WHITE	0.005 to 0.018 mm	0.0002 to 0.0007 in

ROD BEARING HALVES

ROD HALF BEARING THICKNESS	RED	1.737 to 1.745 mm	0.0684 to 0.0687 in
	BLUE	1.741 to 1.749 mm	0.0685 to 0.0688 in
AXIAL PLAY BETWEEN PIN AND BIG END BEARING	RED	0.021 to 0.060 mm	0.0008 to 0.0023 in
	BLUE	0.023 to 0.062 mm	0.0009 to 0.00024 in
BIG END AXIAL PLAY		0.2 to 0.3 mm	0.008 to 0.012 in

CYLINDER HEAD

CYLINDER HEAD

VALVE GUIDE SEAT DIAMETER			13.990 to 14.018 mm	0.5507 to 0.5519 in
VALVE GUIDE PROTRUSION			10.2 to 10.6 mm	0.40 to 0.42 in
VALVE CUP SEAT DIAMETER		INTAKE	35.000 to 35.025 mm	1.3780 to 1.3789 in
VALVE CUP SEAT DIAMETER		EXHAUST	22.000 to 22.021 mm	0.8661 to 0.8670 in
VALVE SEAT MOUSING DIAMETER	Normal	INTAKE	45.000 to 45.025 mm	1.7716 to 1.7726 in
		EXHAUST	39.000 to 39.025 mm	1.5354 to 1.5364 in
	Oversized	INTAKE	45.300 to 45.325 mm	1.7835 to 1.7844 in
		EXHAUST	39.300 to 39.325 mm	1.5472 to 1.5482 in
CYLINDER HEAD MINIMUM ALLOWABLE HEIGHT AFTER FACING			124.85 to 125.15 mm	4.915 to 4.927 in
MAX FLATNESS ERROR OF HEAD LOWER PLANE			0.05 mm	0.0019 in
HEAD UPPER PLANE TILT			7°55' to 8°5'	

VALVE GUIDE

VALVE GUIDE OUTER DIAMETER	INTAKE	14.033 to 14.044 mm	0.5525 to 0.5529 in
	EXHAUST	14.048 to 14.059 mm	0.5531 to 0.5535 in
VALVE GUIDE INNER DIAMETER (AFTER REAMING)		9.000 to 9.015 mm	0.3543 to 0.3549 in
INTERFERENCE BETWEEN VALVE GUIDE AND SEAT	INTAKE	0.015 to 0.054 mm	0.0006 to 0.0021 in
	EXHAUST	0.030 to 0.069 mm	0.0011 to 0.0027 in

VALVE SEAT

VALVE SEAT OUTER DIAMETER	Normal	INTAKE	45.065 to 45.100 mm	1.7742 to 1.7756 in
		EXHAUST	39.065 to 39.100 mm	1.5380 to 1.5393 in
	Oversized	INTAKE	45.365 to 45.400 mm	1.7860 to 1.7874 in
		EXHAUST	39.365 to 39.400 mm	1.5498 to 1.5512 in
VALVE SEAT TAPER			90°±20'	
INTERFERENCE BETWEEN VALVE SEAT AND VALVE SEAT INSERT			0.040 to 0.100 mm	0.0016 to 0.0040 in
CYLINDER HEAD SHRINK-FIT TEMPERATURE FOR VALVE SEAT INSTALLATION			100°C - 212°F	

VALVE

VALVE STEM DIAMETER	INTAKE	8.972 to 8.987 mm	0.3532 to 0.3538 in
	EXHAUST	8.940 to 8.955 mm	0.3520 to 0.3525 in
VALVE HEAD DIAMETER	INTAKE	43.85 to 44.00 mm	1.7264 to 1.7322 in
	EXHAUST	38.50 to 38.70 mm (1)	1.5157 to 1.5236 in (1)

(1) For LIVIA type valves = 38.45 to 38.60 mm (1.514 to 1.519 in)

CLEARANCE BETWEEN VALVE STEM	INTAKE	0.013 to 0.043 mm	0.0005 to 0.0017 in

AND VALVE GUIDE	EXHAUST	0.045 to 0.075 mm	0.0018 to 0.0029 in

VALVE SPRING

FREE VALVE SPRING LENGTH (L1)	OUTER SPRING	44.6 mm	1.75 in
	INNER SPRING	44.1 mm	1.73 in
SPRING LENGTH WITH VALVE CLOSED (L2)	OUTER SPRING	32.5 mm	1.28 in
	INNER SPRING	30.5 mm	1.20 in
SPRING LENGTH WITH VALVE OPEN (L3)	OUTER SPRING	23.5 mm	0.92 in
	INNER SPRING	21.5 mm	0.84 in
LOAD CORRESPONDING TO LENGTH L2	OUTER SPRING	243 to 252 N	(54.6 to 56.6 lbs)
	INNER SPRING	126 to 130 N	(28.3 to 29.2 lbs)
LOAD CORRESPONDING TO LENGTH L3	OUTER SPRING	470 to 488 N	(105.6 to 109.7 lbs)
	INNER SPRING	222 to 231 N	(49.9 to 51.9 lbs)

VALVE CUP

VALVE CUP DIAMETER	INTAKE	34.973 to 34.989 mm	1.3769 to 1.3775 in
	EXHAUST	21.971 to 21.989 mm	0.8650 to 0.8657 in
RADIAL PLAY BETWEEN VALVE CUP AND HOUSING	INTAKE	0.011 to 0.052 mm	0.0004 to 0.0020 in
	EXHAUST	0.011 to 0.050 mm	0.0004 to 0.0020 in

CYLINDER HEAD BUSHINGS

BUSHING "A" INNER DIAMETER	19.000 to 19.021 mm	0.7480 to 0.7488 in
BUSHING "B" INNER DIAMETER	19.000 to 19.021 mm	0.7480 to 0.7488 in
BUSHING "C" INNER DIAMETER	32.000 to 32.025 mm	1.2598 to 1.2608 in

CAMSHAFT

CAMSHAFT JOURNAL DIAMETER	26.949 to 26.970 mm	1.0610 to 1.0618 in
CAMSHAFT SUPPORT DIAMETER	27.000 to 27.033 mm	1.0630 to 1.0643 in
MAX. ECCENTRICITY BETWEEN JOURNALS	0.03 mm	0.0012 in
CAMSHAFT SUPPORT SHOULDER WIDTH	26.851 to 26.940 mm	1.0571 to 1.0606 in

CAMSHAFT SHOULDER LENGTH	27.000 to 27.052 mm	1.0630 to 1.0650 in

RADIAL PLAY BETWEEN CAMSHAFT JOURNAL BEARING AND JOURNAL	0.030 to 0.084 mm	0.0012 to 0.0033 in
CAMSHAFT AXIAL PLAY	0.060 to 0.201 mm	0.0023 to 0.0079 in

ROCKER ARM

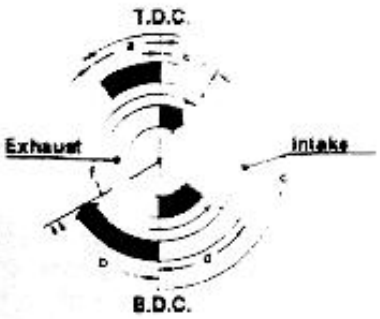
ROCKER ARMS SHAFT DIAMETER	15.988 to 16.000 mm	0.6294 to 0.6299 in
ROCKER ARM INNER BORE DIAMETER	16.016 to 16.034 mm	0.6305 to 0.6312 in
RADIAL PLAY BETWEEN VALVE CUP AND ROCKER ARMS SHAFT	0.016 to 0.046 mm	0.0006 to 0.0018 in

VALVES CLEARANCE

VALVES CLEARANCE (COLD ENGINE)	INTAKE EXHAUST	0.475 to 0.500 mm 0.225 to 0.250 mm	0.0187 to 0.0197 in 0.0088 to 0.0098 in
NOMINAL CAM HEIGHT	INTAKE EXHAUST	9.1 mm* 6.4 mm	0.36 in* 0.25 in
TIMING MARKS POSITION ANGULAR VALUE	R.H. HEAD	15°	
	L.H. HEAD	15°	

* 164S: 10.1 mm (0.40 in)

ANGULAR VALUES OF ACTUAL TIMING DIAGRAM
(Crankshaft cw Sense of Rotation When Viewed From Front Side)



164

INTAKE	OPENING (BTDC)	(a)	32° 30'
	CLOSING (ABDC)	(b)	67° 30'
	INTAKE ANGULAR VALUE	(c)	280°
EXHAUST	OPENING (BBDC)	(d)	59° 55'
	CLOSING (ATDC)	(e)	33° 55'
	EXHAUST ANGULAR VALUE	(f)	263° 50'

164 S

INTAKE	OPENING (BTDC)	(a)	32° 50'
	CLOSING (ABDC)	(b)	73° 50'
	INTAKE ANGULAR VALUE	(c)	286° 40'
EXHAUST	OPENING (BBDC)	(d)	66° 55'
	CLOSING (ATDC)	(e)	29°55'
	EXAUST ANGULAR VALUE	(f)	276° 50'

FLUIDS AND LUBRICANTS

Application	Type	Name	Q.ty-Liters (Gals)
Engine oil	OIL	AGIP Nuovo Sint 2000 10W/40 SHELL Fire & Ice 10W/40	
- full capacity			7.5 (2)
- routine changes (pan and filter)			7 (1.9)
- filter			0.6 (0.16)
- cylinder head sumps			0.51 (0.14)
Cylinder head stud bolts			-
Intake and exhaust valves and cups			-
Camshaft journal bearings			-
Oil pump shaft			-
Distributor oil seal			-
Rear main journal cap seal sleeves	FLUID	MILLOIL compound for rubber channels	-
Oil pump drive shaft		UNION CARBIDE CHEMICALS Co.	-
Crankshaft oil seals		Ucon lubricant 50HB-5100	-
Rear cover			-
Rocker arm rods, rocker arms shaft, rocker arms			-
Hydraulic belt tightener pin	GREASE	ISECO MOLIKOTE BR2	-
Camshaft oil seals			-
Crankshaft oil seals			-
Spark plugs thread	OIL	ISECO MOLIKOTE A	-

SEALING AND LOCKING COMPOUNDS

Application	Type	Name	Q.ty-Liters (Gals)
Hydraulic belt tightener attachment stud	CEMENT	LOCTITE 270 (Green)	-
Flywheel attachment screws			-
Crankshaft oil plugs			-
Cylinder head cover gaskets (head side)	CEMENT	DIRING Heldite DOW CORNING Hermetic	-
Oil sump gasket			-
Min. engine oil pressure warning lamp sensor	CEMENT	Cement, class S-ME4	-

ABRASIVES

Application	Type	Name	Q.ty-Liters (Gals)
Valve seats grinding	GRINDING PASTE	SIPAL AREXONS Carbosilicium	-

TIGHTENING TORQUES

Engine block

Main bearing caps to engine block attaching nuts (1)	62 to 68.4 ft.lbs	84 to 92.7 Nm
Main bearing cap lock nuts (1)	14.8 to 18.5 ft.lbs	20 to 25 Nm
Flywheel to crankshaft attaching screws (with specified sealant)	84.4 ft.lbs	113 Nm
Crankshaft front pulley attaching nut (1)	173 ft.lbs	235 Nm
Rod cap screws (1)	39.4 to 43.5 ft.lbs	53.4 to 59 Nm
Coolant pump to engine block attaching screws	5.9 to 6.9 ft.lbs	8.1 to 9.3 Nm
Tightener pulley attaching screw	12.5 to 14.8 ft.lbs	17 to 20 Nm
Converter attaching screws (vehicles with automatic transmission only)	25.4 to 31.4 ft.lbs	34.4 to 42.5 Nm
Gearbox attaching screws (vehicles with automatic transmission only)	27 to 33.2 ft.lbs	36.6 to 45 Nm
Exhaust manifold attaching screws	18.8 ft.lbs	25.5 Nm
Front cover attaching screws	5.9 to 6.9 ft.lbs	8.1 to 9.3 Nm
Starter tightening	28.2 to 33.2 ft.lbs	38.2 to 45 Nm

Cylinder head

Camshaft bearing cap nuts (1)	11.8 to 13.2 ft.lbs	16 to 18 Nm
Camshaft front hub attaching nut	71.6 to 86.3 ft.lbs	97 to 117 Nm
Spark plugs tightening	18.4 to 25 ft.lbs	25 to 34 Nm
Oil pressure meter	7.4 to 8.8 ft.lbs	10 to 12 Nm
Oil level warning lamp sensor	18 ft.lbs	24 Nm
Distributor cap tightening	2.9 to 3.7 ft.lbs	4 to 5 Nm
Distributor attaching nuts	13.1 to 16.2 ft.lbs	17.8 to 22 Nm
Distributor arm tightening	1.8 to 2.2 ft.lbs	2.5 to 3 Nm
Rocker arm adjustment screw-nut tightening	10.9 to 13 ft.lbs	14.8 to 17.7 Nm
Oil pump drive pulley attaching screws	13.1 to 16.3 ft.lbs	17.9 to 22.1 Nm
Timing system cover attaching screws	6.6 to 8.1 ft.lbs	8.9 to 11 Nm

(1) Lubricate with engine oil

Cylinder head to engine block nuts tightening

Tightening Sequence	At reassembly torque gradually in sequence shown	65.3 to 72.2 ft.lbs	88.5 to 97.8 Nm
	After about 650 miles, with cold engine, loosen nuts for one turn in the sequence shown; smear with engine oil and torque in the sequence	72.2 to 79.8 ft.lbs	97.8 to 108.2 Nm

shown

SPECIAL TOOLS

Tool Number	Description
1.820.004.000	Cylinder liners locking tool (2 pieces)
1.820.007.000	Flywheel locking tool (bench maintenance)
1.820.011.000	Valves support tool
1.820.012.000	Cylinder head support tool base
1.820.049.000	Valve support tool special nut
1.820.050.000	Cylinder head support fork
1.820.051.000	Camshaft pulley and auxiliary units rotation tool
1.820.052.000	Cylinder liners stop tool
1.820.053.000	Hydraulic tightener stop pin
1.820.056.000	Camshaft oil hole plugs staking tool
1.820.200.000	Transmission lifting
1.820.202.000	Protective cover
1.820.115.000	Guide tool for reaming of oil pump shaft seating (with 19 mm reamer)
1.820.150.000	Valve clearance adjustment cups container
1.821.002.000	Rear main journal rubber discs inserting tool
1.821.005.000	Valve guide puller
1.821.006.001	Rear main bearing cap removal lever
1.821.006.002	Rear main bearing cap removal fork
1.821.010.000	Rear crankshaft oil seal insertion tool
1.821.016.000	Valve guide cap inserting tool
1.821.018.000	Valve guide cap puller
1.821.058.000	Valve removal/assembly lever
1.821.122.000	Valve removal/assembly cage
1.821.123.000	Camshaft pulley puller
1.821.124.000	Valve removal/assembly support
1.821.125.000	Crankshaft front oil seal inserting tool
1.821.126.000	Camshaft and auxiliary units drive front oil seal inserting tool
1.821.127.000	Intake valve guide inserting tool
1.821.128.000	Exhaust valve guide inserting tool
1.821.129.000	Camshaft bushings removal/installation tool
1.821.174.000	Upper engine mount bracket elastic bushing replacement tool
1.822.016.000	3mm (0.118 in) wrench, exhaust timing system adjustment
1.825.003.000	Cylinder liner and pistons protrusion from engine block check tool
1.825.013.000	T.D.C. Check tool
1.825.018.000	Valve clearance check curvic feeler gauge
1.827.002.000	Valve cups check comparator

TROUBLESHOOTING PROCEDURE: ENGINE - LUBRICATION

TROUBLES AND SYMPTOMS	FAULT ISOLATION	TEST REFERENCE
OIL LEAKS	Visual detection of oil leaks causing dropping, stains, soiling of engine.	A
LOSS OF OIL PRESSURE	Pressure gauge on instrument panel indicates decrease (sudden or gradual) of engine oil pressure: at very low pressure the relevant warning lamp illuminates. **NOTE**: It is advisable to ascertain first that pressure gauge on instrument panel, pressure meter and min. pressure sensor are operational checking the actual engine oil pressure with a pressure gauge - refer to **WIRING DIAGRAMS AND ELECTRICAL DIAGNOSIS Book - INSTRUMENT PANEL.**	B
EXCESSIVE OIL CONSUMPTION **NOTE**: A high consumption of oil during the **first 5000 miles** must not be considered abnormal, since due to settling of the engine.	Oil consumption noticeably increases with respect to stated values and those noted during life of vehicle.	C

WARNING:

- **Engine oil is harmful for your skin: reduce to minimum the contact or permanence of stains or drops of oil on your skin: wash out oil with soap and water.**
- **Do not disperse exhausted oil! Investigate where exhausted oil is collected in your area.**

OIL LEAKS	TEST A

TEST STEPS	RESULTS	REMEDY
FOREWORD: It is absolutely necessary to identify exactly the engine component or area causing the leak. If cause can not be identified visually, it is suggested to wash the engine with water, dry it, then start it with vehicle standing, or perform a short test run, and wait that leaks become evident. Subsequently, act on affected component reserving to check the other components in a subsequent phase.		
A1 DRAIN PLUG CHECK - Check drain plug for correct torque and absence of damage	OK ▶ ~~OK~~ ▶	Carry-out **step A2** Torque or replace plug, as necessary
A2 OIL SUMP CHECK - Check: • oil sump for damages, distortions or micro-cracks • sealing of gasket between sump and engine block • sump attaching screws for proper torque	OK ▶ ~~OK~~ ▶	Carry-out **step A3** Replace sump or gasket, if necessary. Torque sump screws to prescribed value.
A3 OIL FILTER CHECK - Check for absence of leaks in the oil filter area; verify tightness of seal	OK ▶ ~~OK~~ ▶	Carry-out **step A4** Replace seal and torque filter properly

(Cont.d)

OIL LEAKS	TEST A

TEST STEPS	RESULTS	REMEDY
A4 OIL SEALS CHECK		
- Remove covers and gain access to crankshaft and camshafts oil seals: check for absence of leaks in those areas. Refer to **Group 01 - ENGINE DISASSEMBLY AND REASSEMBLY** for further details	OK ▶ ~~OK~~ ▶	Carry-out **step A5** Replace affected oil seals
A5 HYDRAULIC BELT TIGHTENER CHECK		
- Check for absence of leaks from the hydraulic belt tightener	OK ▶ ~~OK~~ ▶	Carry-out **step A6** Replace hydraulic belt tightener or oil seal
A6 MISCELLANEOUS COMPONENTS CHECK		
- Check for absence of leaks from any other component not listed in the previous test steps; correct fault in analogy to remedies indicated above	~~OK~~ ▶	Replace affected components

End of test A

LOSS OF OIL PRESSURE	TEST B

TEST STEPS		RESULTS	REMEDY
B1	OIL LEVEL CHECK		
- Check with the dipstick that level of engine oil is correct		OK ▶	Carry-out **step B2**
		~~OK~~ ▶	Top-up oil level
B2	OIL AND FILTER GRADES CHECK		
- Check that: • engine oil is of the prescribed type (**SAE 10 W/40**) • engine oil filter is of the prescribed type, and properly installed AGIP NUOVO SINT 2000 10 W/40 SHELL FIRE & ICE MOTOR OIL 10 W/40 Total capacity 2 Gals (7.5 l.) Oil change 1.9 Gals (7.0 l.) Filter 0.15 Gals (0.6 l.)		OK ▶ ~~OK~~ ▶	Carry-out **step B3** Service with prescribed oil to proper level. Replace filter if necessary
B3	OIL PUMP CHECK		
- Check oil pump for traces of binding or overheating of all its components. Furthermore, perform check of dimensions and clearances. Refer to **Group 01 - OIL PUMP CHECKS AND INSPECTIONS**		OK ▶ ~~OK~~ ▶	Carry-out **step B4** Replace defective items

(Cont.d)

LOSS OF OIL PRESSURE	TEST B

TEST STEPS		RESULTS	REMEDY
B4	PRESSURE RELIEF VALVE CHECK		
- Check: • pressure relief valve for proper seal, integrity and cleanliness • valve spring for yielding or breakage		OK ▶ ~~OK~~ ▶	Carry-out **step B5** Replace defective components
B5	OIL PASSAGES CHECK		
In case of **complete engine overhaul** only: - Verify oil passages in engine block and cylinder heads for obstruction caused by oil residues or foreign matter - Check plugs on crankshaft for sealing and integrity. Also refer to **Group 01 - ENGINE DISASSEMBLY AND REASSEMBLY - CLEANING OF LUBRICATION GROOVES**		~~OK~~ ▶	Thoroughly clean affected items; replace if necessary

End of test B

EXCESSIVE OIL CONSUMPTION	TEST C

TEST STEPS	RESULTS	REMEDY
FOREWORD: Check that excessive oil consumption is not caused by leakage. Refer to **Test A**.		
C1 SEEPAGE TROUGH VALVES CHECK - Remove cylinder heads and check for absence of traces of oil in the combustion chambers. In this event check: • dimensions and clearances between valve stem and relevant valve guide, and between valve guide and valve guide seats in cylinder head; • seal pad located above the valves for integrity; • valve stem for traces of binding or scoring	OK ▶ ~~OK~~ ▶	Carry-out **step C2** Replace defective items
C2 SEEPAGE THROUGH PISTON RINGS CHECK - Check for seepage through piston rings. In this event check piston rings for: • breakage or damages; • proper installation (TOP mark faced upwards); • proper distribution of gap along circumference (gaps located at three different angles). • binding into their seating or excessive wear	OK ▶ ~~OK~~ ▶	Carry-out **step C3** Replace defective piston rings
C3 CYLINDER LINERS CHECK - Check: • roughness of cylinder liners (excessive wear could cause an excessively smooth surface) • principal dimensions are within limits. Refer to **Group 01 - ENGINE DISASSEMBLY AND REASSEMBLY - CYLINDER LINERS**	~~OK~~ ▶	Replace affected cylinder liners if necessary

End of test C

TROUBLESHOOTING PROCEDURE: ENGINE - NOISY OPERATION

FOREWORD:

Ascertain noises are really caused by the engine, and not by other components as:

- Coolant pump.
- Alternator.
- Power steering pump.
- Air conditioning compressor.
- Hydraulic belt tightener.

Note if noise is mainly present when engine is cold or in normal operating range, when engine is at idle speed, or if noise increase as engine revs increase.

Noise is produced by the engine if:

- Noise is present when vehicle is standing, and during run.
- Noise is present when clutch is engaged and disengaged.

TROUBLES AND SYMPTOMS	FAULT ISOLATION	TEST REFERENCE
BEAT WHEN ENGINE IS AT IDLE	More or less constant noise is present when engine is at idle, in normal operating temperature; noise comes from the timing system covers area	A
BEAT WITH COLD ENGINE	Continuous beat more or less intense, coming from one or more cylinders NOTE: **Beat disappears when engine is at normal operating temperature.** The affected cylinder can be easily identified disconnecting one spark plug at a time	B
INTENSE AND INCONSTANT BEAT	Very intense beat that can be heard during clutch engagement and disengagement, and during sudden accelerations	C

TROUBLESHOOTING PROCEDURE: ENGINE - NOISY OPERATION

TROUBLES AND SYMPTOMS	FAULT ISOLATION	TEST REFERENCE
BACKGROUND BEAT (DUE TO CRANKING)	Background beat that can be heard when engine is under load, or noise coming from rods-crankshaft and pistons - cylinder liners coupling	**D**

NOTE: Prior to perform the tests indicated in the following, **check oil level, and grade of oil and oil filter.** If necessary, change engine oil and filter using prescribed quantities and grades.

BEAT WHEN ENGINE IS AT IDLE	TEST A

TEST STEPS	RESULTS	REMEDY
A1 VALVES CLEARANCE CHECK - Check clearance between cams heel radius and top of valve cup is within prescribed limits	OK ▶ ~~OK~~ ▶	Carry-out **step A2** Adjust clearance
A2 CAMS AND CUPS VISUAL CHECK - Visually check cuspid of cams and top of cups for absence of wear, scoring, binding, etc.	OK ▶ ~~OK~~ ▶	Carry-out **step A3** Replace defective items
A3 AXIAL PLAY CHECK - Check camshaft axial play is within prescribed limits	OK ▶ ~~OK~~ ▶	Carry-out **step A4** Replace affected camshaft
A4 CUPS AND HOUSINGS CHECK - Check outer diameter of cups and diameter of relevant housings; also check for absence of scoring, binding, etc.	~~OK~~ ▶	Replace affected cups, and/or relevant cylinder head

End of test A

BEAT WITH COLD ENGINE	TEST B

TEST STEPS		RESULTS	REMEDY
B1	PISTON-CYLINDER LINER COUPLING CHECK		
- Check clearance between cylinder liner and piston is within prescribed limits		OK ▶	Carry-out step B2
		~~OK~~ ▶	Replace affected cylinder liner and piston
B2	GUDGEON PIN CHECK		
- Check clearances between piston hole and gudgeon pin, and between rod small end bushing hole and gudgeon pin are within prescribed limits		~~OK~~ ▶	Replace affected items

End of test B

INTENSE AND INCONSTANT BEAT	TEST C

TEST STEPS	RESULTS	REMEDY
C1 CRANKSHAFT PULLEY ATTACHMENT CHECK - Check that nut securing cranks haft pulley is not loosen Tightening torque: 173 ft lbs (235 Nm)	OK ▶ ~~OK~~ ▶	Carry-out step C2 Torque nut to prescribed torque, or replace nut, if defective
C2 FLYWHEEL ATTACHMENT CHECK - Check that screws securing flywheel to crankshaft are not loosen Tightening torque: 84.4 ft lbs (113 Nm)	~~OK~~ ▶	Torque screws to prescribed torque, or replace screws if damaged. Use locking compound LOCTITE 270

End of test C

BACKGROUND BEAT (DUE TO CRANKING)	TEST D

TEST STEPS	RESULTS	REMEDY
D1 MAIN AND ROD BEARING CASTING CHECK		
- Check : • main and rod bearings for absence of traces of overheating, flaking, etc. • crankshaft journals for absence of damages	OK ▶ ~~OK~~ ▶	Carry-out **step D2** Replace crankshaft. Wash engine block lubricating system and overhaul or replace oil pump, if necessary
D2 CONNECTING ROD AND BACKGROUND BEAT CHECK		
Check: • clearances between rod big end and crankshaft, and between crankshaft journals and relevant bearings • tightening torques of main bearings and rod big end are within prescribed limits	OK ▶ ~~OK~~ ▶	Carry-out **step D3** Replace crankshaft and/or affected rod. Torque to prescribed value
D3 CRANKSHAFT BEAT CHECK		
Check crankshaft axial play is within prescribed limits	OK ▶ ~~OK~~ ▶	Carry-out **step D4** Replace thrust half rings

(Cont.d)

BACKGROUND BEAT (DUE TO CRANKING)	TEST D

TEST STEPS		RESULTS	REMEDY
D4	PISTON BINDING BEAT CHECK		
- Visually check mating surfaces of cylinder liners and pistons for absence of overheating, binding, scoring etc., and that piston rings move free into relevant grooves on piston		OK ▶	Carry-out step B
		~~OK~~ ▶	Replace cylinder liner and piston of affected cylinder

End of test D

IMPORTANT NOTE:

For any other trouble that hampers proper operation of engine **REFER TO TROUBLESHOOTING included in Group 04.**

For example:

- engine does not start
- engine stumbles
- irregular engine idle speed
- excessive fuel consumption
- excessive CO percentage
- Etc...